FREIGHTLINER

Run Smart

HEAVY-DUTY TRUCKS SERVICE MANUAL

Models: FLA COE
FLB COE
FLD Conventional
FLL COE

STI-206, S39 (8/10P)

Published by
Daimler Trucks North America LLC
4747 N. Channel Ave.
Portland, OR 97217
Printed in U.S.A.

Foreword

The purpose of this manual is to assist the service technician when the vehicle is serviced. Major drivetrain component service information is not included in this manual, but is located in each manufacturer's service manual.

Instructions and procedures are those recommended by Freightliner Trucks or the component manufacturer.

Maintenance schedules and additional service information are included in the *Heavy-Duty Trucks Maintenance Manual*.

IMPORTANT: Descriptions and specifications in this manual were in effect at the time of printing. Freightliner Trucks reserves the right to discontinue models at any time, or change specifications and design without notice and without incurring obligation. Descriptions and specifications contained in this publication provide no warranty, expressed or implied, and are subject to revision and editions without notice.

Refer to **www.Daimler-TrucksNorthAmerica.com** and **www.FreightlinerTrucks.com** for more information, or contact Daimler Trucks North America LLC at the address below.

Environmental Concerns and Recommendations

Whenever you see instructions in this manual to discard materials, you should attempt to reclaim and recycle them. To preserve our environment, follow appropriate environmental rules and regulations when disposing of materials.

NOTICE: Parts Replacement Considerations

Do not replace suspension, axle, or steering parts (such as springs, wheels, hubs, and steering gears) with used parts. Used parts may have been subjected to collisions or improper use and have undetected structural damage.

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Daimler Trucks North America LLC
Service Systems and Documentation (CVI-SSD)
P.O. Box 3849
Portland, OR 97208-3849

Descriptions of Service Publications

Daimler Trucks North America LLC distributes the following major service publications in paper and electronic (via ServicePro®) formats.

Workshop/Service Manual

Workshop/service manuals contain service and repair information for all vehicle systems and components, except for major components such as engines, transmissions, and rear axles. Each workshop/service manual section is divided into subjects that can include general information, principles of operation, removal, disassembly, assembly, installation, specifications, and troubleshooting.

Maintenance Manual

Maintenance manuals contain routine maintenance procedures and intervals for vehicle components and systems. They have information such as lubrication procedures and tables, fluid replacement procedures, fluid capacities, specifications, and procedures for adjustments and for checking the tightness of fasteners. Maintenance manuals do not contain detailed repair or service information.

Driver's/Operator's Manual

Driver's/operator's manuals contain information needed to enhance the driver's understanding of how to operate and care for the vehicle and its components. Each manual contains a chapter that covers pretrip and post-trip inspections, and daily, weekly, and monthly maintenance of vehicle components. Driver's/operator's manuals do not contain detailed repair or service information.

Service Bulletins

Service bulletins provide the latest service tips, field repairs, product improvements, and related information. Some service bulletins are updates to information in the workshop/service manual. These bulletins take precedence over workshop/service manual information, until the latter is updated; at that time, the bulletin is usually canceled. The service bulletins manual is available only to dealers. When doing service work on a vehicle system or part, check for a valid service bulletin for the latest information on the subject.

IMPORTANT: Before using a particular service bulletin, check the current service bulletin validity list to be sure the bulletin is valid.

Parts Technical Bulletins

Parts technical bulletins provide information on parts. These bulletins contain lists of parts and BOMs needed to do replacement and upgrade procedures.

Web-based repair, service, and parts documentation can be accessed using the following applications on the AccessFreightliner.com website.

ServicePro

ServicePro® provides Web-based access to the most up-to-date versions of the publications listed above. In addition, the Service Solutions feature provides diagnostic assistance with Symptoms Search, by connecting to a large knowledge base gathered from technicians and service personnel. Search results for both documents and service solutions can be narrowed by initially entering vehicle identification data.

PartsPro

PartsPro® is an electronic parts catalog system, showing the specified vehicle's build record.

EZWiring

EZWiring™ makes Freightliner, Sterling, Western Star, Thomas Built Buses, and Freightliner Custom Chassis Corporation products' wiring drawings and floating pin lists available online for viewing and printing. EZWiring can also be accessed from within PartsPro.

Descriptions of Service Publications

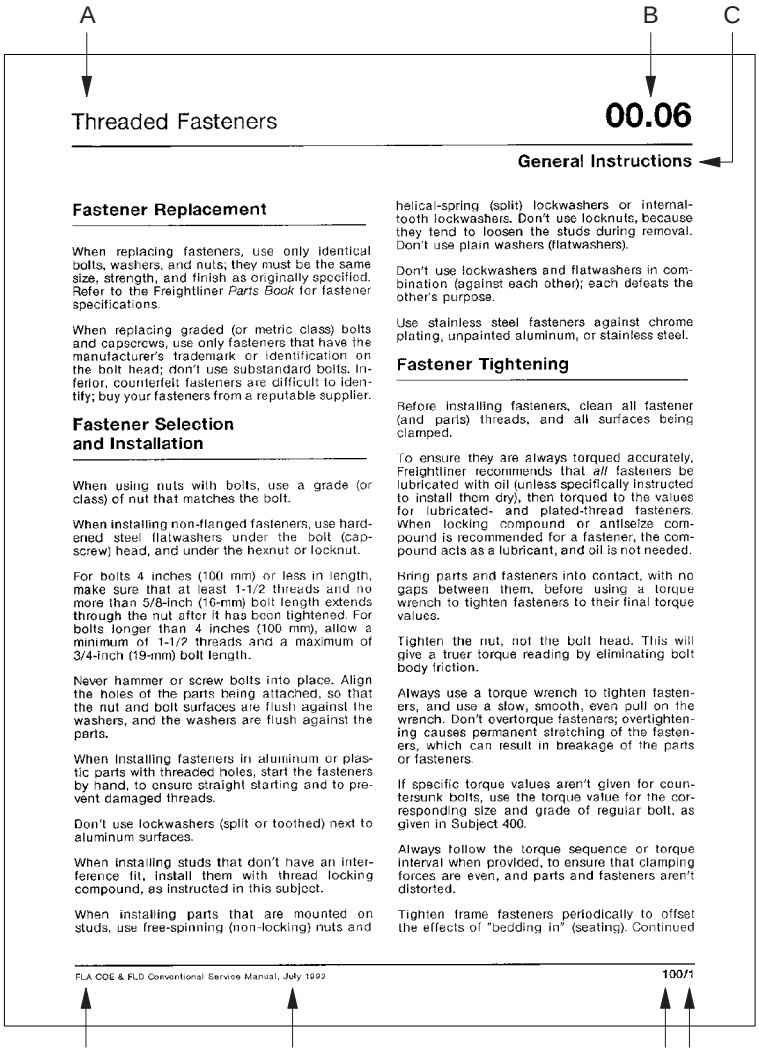
Warranty-related service information available on the AccessFreightliner.com website includes the following documentation.

Recall Campaigns Recall campaigns cover situations that involve service work or replacement of parts in connection with a recall notice. These campaigns pertain to matters of vehicle safety. All recall campaigns are distributed to dealers; customers receive notices that apply to their vehicles.

Field Service Campaigns Field service campaigns are concerned with non-safety-related service work or replacement of parts. All field service campaigns are distributed to dealers; customers receive notices that apply to their vehicles.

Page Description

For an example of a *Heavy-Duty Trucks Service Manual* page, see **Fig. 1**.



A. Section Title
B. Section Number (made up of the Group Number—first two digits, followed by a sequence number—last two digits)
C. Subject Title
D. Manual Title
E. Release (Supplement) Date
F. Subject Number
G. Subject Page Number

Fig. 1, Example of a Heavy-Duty Trucks Service Manual Page

Service Manual Contents

Group No.	Group Title
00	General Information
01	Engine
09	Air Intake
13	Air Compressor
15	Alternators and Starters
20	Engine Cooling/Radiator
25	Clutch
26	Transmission
30	Throttle Control
31	Frame and Frame Components
32	Suspension
33	Front Axle
35	Rear Axle
40	Wheels and Tires
41	Driveline
42	Brakes
46	Steering
47	Fuel
49	Exhaust
54	Electrical, Instruments, and Controls
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83	Heater and Air Conditioner
88	Hood, Grille, and Cab Fenders
90	Fire Suppression Systems
91	Seats and Restraint Systems
98	Paint

List of Abbreviations

The following is a list of definitions for abbreviations and symbols used in Freightliner publications.

A ..... amperes
ABS ..... antilock braking system
ABS ..... acrylonitrile-butadiene-styrene
A/C ..... air conditioner
AC ..... alternating current
acc ..... accessories
ACPU ..... air conditioning protection unit
ADLO ..... auto-disengagement lockout
AGM ..... absorbed glass mat
AGS ..... automated gear shift
a.m. ..... *ante meridiem* (midnight to noon)
AM ..... amplitude modulation
amp(s) ..... ampere(s)
AMT ..... automated mechanical transmission
AMU ..... air management unit
ANSI ..... American National Standards Institute
API ..... American Petroleum Institute
API ..... application programming interface
ARI ..... Air Conditioning and Refrigeration Institute
ASA ..... American Standards Association
ASF ..... American Steel Foundries
ASR ..... automatic spin regulator
assy. ..... assembly
ASTM ..... American Society for Testing and Materials
ATC ..... automatic temperature control
ATC ..... automatic traction control
ATC ..... automatic transmission control
ATD ..... aftertreatment device
ATF ..... automatic transmission fluid
ATS ..... aftertreatment system
attn ..... attention
aux. ..... auxiliary
av ..... *avoirdupois* (British weight system)
AWD ..... all-wheel drive
AWG ..... American wire gauge
AWS ..... American Welding Society
BAT ..... battery
BBC ..... bumper-to-back-of-cab
BHM ..... bulkhead module
BOM ..... bill of material
BTDC ..... before top dead center
Btu(s) ..... British thermal unit(s)
C ..... common (terminal)
CAC ..... charge air cooler
CAN ..... controller area network
CARB ..... California Air Resources Board
CAT ..... Caterpillar
CB ..... circuit breaker
CB ..... citizens' band
CBE ..... cab behind engine
CCA ..... cold cranking amperes
CD-ROM .. compact-disc/read-only memory
CDTC ..... constant discharge temperature control
CEL ..... check-engine light
CFC ..... chlorofluorocarbons (refrigerant-12)
cfm ..... cubic feet per minute
CFR ..... Code of Federal Regulations
CGI ..... clean gas induction
CHM ..... chassis module
CIP ..... cold inflation pressure
CLS ..... coolant level sensor
cm ..... centimeters
cm^3 ..... cubic centimeters
CMVSS .... Canadian Motor Vehicle Safety Standard
Co. ..... company
COE ..... cab over engine
Corp. ..... corporation
CPU ..... central processing unit
CRT ..... cathode ray tube
cSt ..... centistokes (unit of measurement for describing the viscosity of general liquids)
cu ft ..... cubic feet
cu in ..... cubic inches
CUM ..... Cummins
CWS ..... collision warning system
DC ..... direct current
DDA ..... Detroit Diesel Allison (obs)
DDC ..... Detroit Diesel Corporation
DDDL ..... Detroit Diesel Diagnostic Link
DDE ..... Detroit Diesel Engines
DDEC ..... Detroit Diesel Electronic (engine) Control
DDR ..... diagnostic data reader
DDU ..... driver display unit
def ..... defrost
DEF ..... diesel exhaust fluid
DFI ..... direct fuel injection
DGPS ..... differential global positioning system
dia. ..... diameter
DIAG ..... diagnosis
DIP ..... dual inline package (switch)
DLA ..... datalink adaptor
DLM ..... datalink monitor
DLU ..... data logging unit
DMM ..... digital multimeter
DOC ..... diesel oxidation catalyst
DOT ..... Department of Transportation
DPF ..... diesel particulate filter
DRL ..... daytime running lights
DRM ..... dryer reservoir module
DSM ..... district service manager
DTC ..... diagnostic trouble code
DTC ..... discharge temperature control
DVOM ..... digital volt/ohm meter
ea. ..... each
EBS ..... electronic braking system
ECAP ..... electronic control analyzer programmer
ECAS ..... electronically controlled air suspension
ECI ..... electronically controlled injection
ECL ..... engine coolant level
ECM ..... electronic control module
ECT ..... engine coolant temperature
ECU ..... electronic control unit
EDM ..... electronic data monitor
EEPROM .. electrically erasable programmable read-only memory
EFPA ..... electronic foot pedal assembly
EGR ..... exhaust gas recirculation
ELC ..... extended-life coolant
EMC ..... electromagnetic compatibility
EMI ..... electromagnetic interference
EOA ..... electric over air
EP ..... extreme pressure (describes an antiwear agent added to some lubricants)

List of Abbreviations

EPA ..... Environmental Protection Agency
EPS ..... engine position sensor
ESD ..... electrostatic discharge
ESS ..... engine syncro shift (transmission)
etc. ..... *et cetera* (and so forth)
ETEC ..... electronic truck engine control
EUI ..... electronic unit (fuel) injectors
EXM ..... (chassis) expansion module
FAS ..... Freightliner air suspension
FET ..... field effect transistor
Fig. ..... figure
fl oz ..... fluid ounces
FLA ..... post-1984 advancements Freightliner COE
FLB ..... enhanced Freightliner FLA COE
FLC ..... steel-cab Freightliner 112 Conventional
FLD ..... post-1984 advancements Freightliner 112/120 aluminum-cab Conventional
FM ..... frequency modulation
FMCSA .... Federal Motor Carrier Safety Administration
FMEA ..... failure mode effects analysis
FMI ..... failure mode indicator
FMSI ..... Friction Materials Standards Institute
FMVSS .... Federal Motor Vehicle Safety Standard
FRP ..... fiberglass reinforced plastic
FSA ..... field service authorization
FSM ..... fleet service manager
ft ..... feet
ft^3 ..... cubic feet
ft^3/min ..... cubic feet per minute
FTL ..... Freightliner
F.U.E.L. .... fuel usage efficiency level
g ..... grams
gal ..... gallons
GAWR ..... gross axle weight rating
GL ..... gear lubricant
GND ..... ground
gpm ..... gallons per minute
GPS ..... global positioning system
GVWR ..... gross vehicle weight rating
HCOE ..... high cab over engine
HCU ..... hydraulic control unit
HD ..... heavy-duty
HEPA ..... high-efficiency particulate air (filter)
HEST ..... high exhaust system temperature
HEV ..... hybrid electric vehicle
HFC ..... hydrogenated fluorocarbons (refrigerant-134a)
hp ..... horsepower
hp ..... high pressure
HRC ..... Rockwell "C" hardness
hr(s) ..... hour(s)
HSD ..... high-side driver
htr. ..... heater
HVAC ..... heating, ventilating, and air conditioning
H/W ..... hardware
Hz ..... hertz
ICU ..... instrumentation control unit
i.d. ..... inside diameter
ID ..... identification
IFI ..... Industrial Fasteners Institute
IFS ..... independent front suspension
IGN ..... ignition
ILB ..... intelligent lightbar
ILO ..... *in lieu of* (in the place of)
in ..... inches
in^3 ..... cubic inches
Inc. ..... incorporated
inH_2O ..... inches of water
inHg ..... inches of mercury
I/O ..... input/output
IP ..... instrument panel
ISO ..... International Organization for Standardization
IVS ..... idle validation switch
k ..... kilo (1000)
kg ..... kilograms
km ..... kilometers
km/h ..... kilometers per hour
kPa ..... kilopascals
kW ..... kilowatts
L ..... liters
lb ..... pounds
LBCU ..... lightbar control unit
lbf·ft ..... pounds force feet
lbf·in ..... pounds force inches
LCD ..... liquid crystal display
LCOE ..... low cab over engine
LED ..... light-emitting diode
LH ..... left-hand
LH DR ..... left-hand drive
LHK ..... liters per hundred kilometers
LHS ..... low-hydrogen steel
LIN ..... Local Interconnect Network
LLC ..... limited liability company
L/min ..... liters per minute
LPG ..... liquefied petroleum gas
LSD ..... low-side driver
LVD ..... low-voltage disconnect
m ..... meters
max. ..... maximum
M-B ..... Mercedes-Benz
MESA ..... Mining Enforcement Safety Act
mfr. ..... manufacturer
mi ..... miles
MID ..... message identifier
MIL ..... military specification
min. ..... minutes
min. ..... minimum
misc. ..... miscellaneous
mL ..... milliliters
mm ..... millimeters
mod. ..... module
mpg ..... miles per gallon
mph ..... miles per hour
MSF ..... modular switch field
MSHA ..... Mining Safety and Health Administration
MVDA ..... Motor Vehicle Dealers Association
n ..... negative (front axle wheel alignment specification)
N ..... nitrogen
N/A ..... not applicable
N·cm ..... Newton-centimeters
NC ..... normally closed (terminal or switch)
NHTSA .... National Highway Traffic Safety Administration
NIOSH ..... National Institute for Occupational Safety and Health
NLGI ..... National Lubricating Grease Institute
N·m ..... Newton-meters
NO ..... normally open (terminal or switch)
NOAT ..... Nitrited Organic Acid Technology

List of Abbreviations

no. ..... number
NPT ..... national pipe thread
NPTF ..... national pipe thread fitting
NT ..... nylon tube or nylon tubing
NTSB ..... National Transportation Safety Board
OAT ..... Organic Acid Technology
obs ..... obsolete
OC ..... open circuit
OCV ..... open circuit voltage
o.d. ..... outside diameter
O.D. ..... overdrive
OEM ..... original equipment manufacturer
OSHA ..... Occupational Safety and Health Administration
oz ..... ounces
ozf·in ..... ounces force inches
p ..... positive (front axle wheel alignment specification)
PACE ..... programmable electronically controlled engine
PAG ..... polyalkylene glycol (oil)
parm ..... parameter
PC ..... personal computer
PCB ..... printed circuit board
PDC(s) ..... parts distribution center(s)
PDM ..... power distribution module
PEC ..... power electronics carrier
PEEC ..... programmable electronic engine control
PID ..... parameter identifier
PLC ..... power line carrier
PLD ..... *Pumpe-Linie-Düse* (pump-line-nozzle)
p.m. ..... *post meridiem* (noon to midnight)
p/n ..... part number
PRD ..... product requirements document
PSA ..... pressure-sensitive adhesive
PSG ..... pressure sensor governor
psi ..... pounds per square inch
psia ..... pounds per square inch, atmosphere
psig ..... pounds per square inch, gauge
pt ..... pints
PTCM ..... pressure time control module
PTO ..... power takeoff
PTP ..... powertrain protection
pvc ..... polyvinyl chloride
PWM ..... pulse width modulation
pwr ..... power
qt ..... quarts
qty. ..... quantity
R & O ..... rust inhibitors and oxidants
R–12 ..... refrigerant-12 (CFC)
R–134a ..... refrigerant-134a (HFC)
RAM ..... random access memory
RC ..... reserve capacity
recirc. ..... recirculation
Ref(s). ..... reference(s)
regen ..... regeneration
RFI ..... radio frequency interference
RH ..... right-hand
RH DR ..... right-hand drive
R/I ..... removal and installation
RMA ..... return material authorization
ROM ..... read-only memory
rpm ..... revolutions per minute
R/R ..... removal and replacement
RSG ..... road speed governor
RSM ..... regional service manager
RTV ..... room temperature vulcanizing
RV ..... recreational vehicle
SA ..... source address
SAE ..... Society of Automotive Engineers
SB ..... service bulletin
SCA(s) ..... Supplemental Coolant Additive(s)
SCR ..... selective catalyst reduction
SCU ..... system control unit (speedometer)
SD ..... severe-duty
SDU ..... step deployment unit
SEL ..... shutdown engine light
SEM ..... switch expansion module
SEO ..... stop engine override
SHM ..... switch hub module
SI ..... service information
SI ..... *Système International*
SID ..... subsystem identifier
SM ..... system malfunction
SMC ..... sheet molded compound
S/N ..... serial number
SPACE ..... seat pretensioner activation for crash survival enhancement
SPG ..... special purpose grease
SPN ..... suspect parameter number
sq in ..... square inches
SRS ..... synchronous reference sensor
SRT ..... standard repair time
SSD ..... side sensor display
SSID ..... smart switch identification
SST ..... stainless steel
std. ..... standard
S/W ..... software
SW ..... switch
TAM ..... thermocouple amplifier module
TBS ..... turbo boost sensor
TCU ..... transmission control unit
TDC ..... top dead center
TDR ..... technician diagnostic routine
temp ..... temperature
TIG ..... tungsten inert gas
TIR ..... total indicator reading
TPMS ..... tire pressure monitoring system
TPS ..... thermal protection switch
TPS ..... throttle position sensor
TRS ..... timing reference sensor
TSO ..... truck specification order
TSU ..... transmission shift unit
U.D. ..... underdrive
UNC ..... unified national coarse
UNF ..... unified national fine
U.S. ..... United States
U.S.A. ..... United States of America
USC ..... United States customary (measures)
V ..... volts
VCU ..... vehicle control unit
VDC ..... vehicle data computer
Vdc ..... volts, direct current
VIMS ..... vehicle information management system
VIN ..... vehicle identification number
VIP ..... vehicle instrumentation and protection (Kysor)
VIW ..... vehicle interface wiring (connector)
VOC ..... volatile organic compounds

List of Abbreviations

VOM ..... volt-ohmmeter
VRS ..... variable resistance sensor
VSG ..... variable speed governor
VSS ..... vehicle speed sensor
VSU ..... vehicle security unit
WB ..... wire braid
WI ..... work instructions
WIF ..... water-in-fuel
WOT ..... wide open throttle
– ..... minus or negative
+ ..... plus or positive
± ..... plus-or-minus
> ..... greater than
< ..... less than
x ..... by (used in fastener size descriptions)
" ..... inches
° ..... degrees (of an angle)
°C ..... degrees Celsius (centigrade)
°F ..... degrees Fahrenheit
..... number
% ..... percent
& ..... and
© ..... copyright
™ ..... trademark
® ..... registered trademark

U.S. Customary to Metric			Metric to U.S. Customary		
When You Know	**Multiply By**	**To Get**	**When You Know**	**Multiply By**	**To Get**
Length					
inches (in)	25.4	millimeters (mm)	0.03937		inches (in)
inches (in)	2.54	centimeters (cm)	0.3937		inches (in)
feet (ft)	0.3048	meters (m)	3.281		feet (ft)
yards (yd)	0.9144	meters (m)	1.094		yards (yd)
miles (mi)	1.609	kilometers (km)	0.6215		miles (mi)
Area					
square inches (in^2)	645.16	square millimeters (mm^2)	0.00155		square inches (in^2)
square inches (in^2)	6.452	square centimeters (cm^2)	0.15		square inches (in^2)
square feet (ft^2)	0.0929	square meters (m^2)	10.764		square feet (ft^2)
Volume					
cubic inches (in^3)	16387.0	cubic millimeters (mm^3)	0.000061		cubic inches (in^3)
cubic inches (in^3)	16.387	cubic centimeters (cm^3)	0.06102		cubic inches (in^3)
cubic inches (in^3)	0.01639	liters (L)	61.024		cubic inches (in^3)
fluid ounces (fl oz)	29.54	milliliters (mL)	0.03381		fluid ounces (fl oz)
pints (pt)	0.47318	liters (L)	2.1134		pints (pt)
quarts (qt)	0.94635	liters (L)	1.0567		quarts (qt)
gallons (gal)	3.7854	liters (L)	0.2642		gallons (gal)
cubic feet (ft^3)	28.317	liters (L)	0.03531		cubic feet (ft^3)
cubic feet (ft^3)	0.02832	cubic meters (m^3)	35.315		cubic feet (ft^3)
Weight/Force					
ounces (av) (oz)	28.35	grams (g)	0.03527		ounces (av) (oz)
pounds (av) (lb)	0.454	kilograms (kg)	2.205		pounds (av) (lb)
U.S. tons (t)	907.18	kilograms (kg)	0.001102		U.S. tons (t)
U.S. tons (t)	0.90718	metric tons (t)	1.1023		U.S. tons (t)
Torque/Work Force					
inch-pounds (lbf·in)	11.298	Newton-centimeters (N·cm)	0.08851		inch-pounds (lbf·in)
foot-pounds (lbf·ft)	1.3558	Newton-meters (N·m)	0.7376		foot-pounds (lbf·ft)
Pressure/Vacuum					
inches of mercury (inHg)	3.37685	kilo Pascals (kPa)	0.29613		inches of mercury (inHg)
pounds per square inch (psi)	6.895	kilo Pascals (kPa)	0.14503		pounds per square inch (psi)

When You Know	Subtract	Then Divide By	To Get	When You Know	Multiply By	Then Add	To Get
degrees Fahrenheit (°F)	32	1.8	degrees Celsius (°C)		1.8	32	degrees Fahrenheit (°F)

Vehicle Receipt

Prior to signing for vehicle delivery from a transporter company, the dealer is responsible for checking for transporter-related shortages or damages, and noting these discrepancies on the transporter's delivery receipt.

The dealer is also responsible for ensuring that the vehicle was built according to the Truck Sales Order/ Invoice.

Refer to Section 3 of the Daimler Trucks North America LLC *Warranty Manual* for details.

Vehicle Storage

There may be times when a vehicle is stored for long periods before customer delivery. To protect all vehicles from deterioration and weather, they must be properly maintained. Adequate protection and storage of new vehicles is the responsibility of the dealer.

Claims arising from loss and damage to improperly stored vehicles will not be reimbursed.

See Section 3 of the Daimler Trucks North America LLC *Warranty Manual* for instructions on storage of new vehicles.

Pre-Delivery Information

All pre-delivery inspections and services must be performed at an authorized Daimler Trucks North America LLC facility, assigned to fully qualified service personnel and recorded on the "New Vehicle Pre-Delivery Inspection" form.

Refer to Section 3 of the Daimler Trucks North America LLC *Warranty Manual* for details.

It is recommended the pre-delivery inspection be performed within 30 days of vehicle receipt.

Cooling System

1. Cooling system hoses must clear all moving parts by a minimum of 1/4 inch (6 mm).
2. The 1-inch (25-mm) hose from the surge tank to the engine must be free of sumps and have allowance for engine torque.
3. Cooling system hoses should not be twisted or kinked.
4. Cooling system hoses must be routed at least six inches (152 mm) from a heat source if the heat source does not have a heat shield. If a heat shield is provided, the hose must be routed at least three inches (76 mm) from the heat source.

HVAC System

1. Cushion clamps are required to support all A/C lines. Butterfly or figure-8 clamps (two cushion clamps) may be used to prevent rubbing or chafing.
2. Tie straps may only be used to fasten together A/C lines that are parallel to each other.
3. Heater hoses that are protected with convoluted tubing may be fastened with tie straps. If not protected with convoluted tubing, only cushion clamps or butterfly clamps may be used for heater hoses.
4. A/C lines cannot be secured to air lines, fuel lines, or electrical wires.
5. HVAC hoses should be protected from damage by routing them away from hazards of heat, wheel splash (water, gravel, ice), human traffic, and moving parts of the vehicle.
6. HVAC hoses should be routed away from sharp points and edges (such as nuts, bolts, brackets, and frame rail edges), moveable parts, and sources of abrasion, cutting, pinching, or crushing.

NOTE: If hoses are covered with convoluted tubing, they may touch any of the above.

7. Hoses that are protected with convoluted tubing may come in contact with the bends on frame rails and filters.
8. HVAC hoses must be routed at least six inches (152 mm) from a heat source if the heat source does not have a heat shield. If a heat shield is provided, the hose must be routed at least three inches (76 mm) from the heat source.
9. HVAC hoses should be clamped every 12 to 18 inches (305 to 457 mm).
10. All HVAC hoses must be routed so that regularly serviced components, such as fuel filters, fuel/water separators, oil filters, air filters, belts, and fill and drain plugs, are readily accessible for adjustment or replacement without the need to relocate or remove the hoses.
11. All Conventional sleeper heater hoses must be protected with convoluted tubing when they pass through the crossmember, and at the lower frame rail flange.
12. Hose supports for Conventional sleeper heater hoses will be where the brackets are located.

Auxiliary Heater

No additional tie straps or tape are needed when convoluted tubing is installed where the auxiliary heater hose routes past the edge of the frame rail.

Engine Plumbing

1. On vehicles equipped with the Cummins M-11 engine and power steering, no additional tie straps or tape are needed if convoluted tubing is installed on the power steering hose where it routes under the frame rail.
2. The engine oil pressure line should not rub or chafe against the Teflon® discharge line.

Electrical Wiring

1. Wires that are bundled together should be fastened at 8- to 12-inch (203- to 305-mm) intervals. If anchor clamps are more than 12 inches (305 mm) apart, a tie strap must be used between the anchor clamps.
2. Bundles of wires that are located in an exposed area, such as under the cab or outside the frame rail, need to be fastened with heavy-duty cable ties.

3. Any wiring that will be exposed to water or heat must be covered with either loom or convoluted tubing. Loom or convoluted tubing need not butt up against Weather Pack® connectors.
4. Any wiring routed across the vehicle, on the engine crossmember, or across the rear of the engine, must be secured with a clamp or tie strap, and covered with either convoluted tubing or a loom.
5. Any wiring that may come into contact with sharp points and edges (such as nuts, bolts, brackets, and frame rail edges), moveable parts, and sources of abrasion, cutting, pinching, or crushing, must be protected by either a loom or convoluted tubing.
6. Unprotected breakouts (individual wires) of up to eight inches (203 mm) are acceptable as long as these wires are routed safely away from sharp points and edges, moveable parts, and sources of abrasion, cutting, pinching, or crushing.
7. Gray, flame-retardant convoluted tubing may be used to protect wiring in the cab or the chassis. Black nylon convoluted tubing may only be used in the chassis.
8. All wiring must be routed so that regularly serviced components, such as fuel filters, fuel/water separators, oil filters, air filters, belts, and fill and drain plugs, are readily accessible for adjustment or replacement without the need to relocate or remove any wiring.
9. In exposed locations, such as the road light harness near the headlights, loose loops of wire must be secured with tie straps.
10. All wiring should be routed a minimum of four inches (102 mm) from the exhaust. In situations where the wiring is less than four inches (102 mm) from the exhaust, a heat shield must be placed between the wiring and the exhaust.

Battery Cables

1. Battery cables must be routed along an unobstructed path from the starter to the battery box. The cables must **not** rub or chafe on brackets, tanks, air lines, or fuel lines.
2. Battery cables and electrical wiring cannot be tied or secured to fuel lines, discharge lines, or air lines.
3. Battery cables must have support brackets no more than 30 inches (762 mm) apart. Tie straps must be within six inches (152 mm) of both sides of the support brackets, and every 12 inches (305 mm) between the brackets.
4. Battery cables must have convoluted tubing from the frame bracket to the batteries, and from the frame bracket to the starter.

Fuel Lines

1. Fuel lines must not be clamped to A/C lines, battery cables, jumper cables, or any other electrical wiring.
2. Stand-off brackets or clamps may be used to prevent fuel lines from rubbing against the frame.
3. Fuel lines must be routed at least six inches (152 mm) from a heat source. If a heat shield is provided, the fuel line must be at least three inches (76 mm) from the heat source.
4. Fuel lines that are parallel may be fastened together. Fuel lines that cross or that rub on metal, plastic, or electrical parts, need to be separated with butterfly clamps.

Chassis Air Lines and Brake Hoses

1. Hoses may come in contact with each other if they are parallel, or if they are bundled together.
2. If the hoses lie on the curve or flat surface of a bracket or crossmember, they do not need convoluted tubing.
3. Brake hoses may be clamped at the top of the axle housing, and touch or lie against the axle housing in its path to the brake chamber as this assembly moves together.
4. Brake hoses must have slack between the last clamping point on the frame rail and the brake chamber to allow for full range of suspension travel.
5. Brake hoses should have butterfly clamps at breakout points.

6. Air lines and brake hoses that are bundled together should be fastened at 8- to 12-inch (203- to 305-mm) intervals. If anchor clamps are more than 12 inches (305 mm) apart, a tie strap must be used between the anchor clamps. Tie straps may be closer than 12 inches (305 mm) apart.
7. Hoses or lines that may come into contact with the sharp edge of a bracket or frame rail are to be protected by convoluted tubing.
8. Air lines and brake hoses that are parallel may be fastened together. Air lines and brake hoses that cross or that rub on metal, plastic, or electrical parts need to be separated with butterfly clamps.
9. Nylon or STX (wire braid) chassis air lines may be fastened together to prevent rubbing, as long as the lines are stationary.

VIN for Vehicles Built through April 30, 2000

IMPORTANT: See **Subject 060** for the vehicle identification numbering system for vehicles built May 1, 2000, or later.

Federal Motor Vehicle Safety Standard 115 specifies that all vehicles sold in the U.S. be assigned a 17-character Vehicle Identification Number (VIN). Using a combination of letters and numerals, the VIN defines the manufacturer, model, and major characteristics of the vehicle. See **Table 1** for the character positions of a typical Freightliner VIN, 1FUYSTEBXVPA99999.

The VIN can be found on the Vehicle Specification Decal (see the driver's manual for decal location) and stamped on the left frame rail over the front axle about 2 inches (50 mm) from the top of the web or on the top flange of the left frame rail at frame station 30.

NOTE: For Freightliner vehicles assembled and sold in Mexico, the VIN appears on a plate or label attached to the driver's door. Also, a data card placed in the glove box shows the Mexican VIN as the "CHASSIS" number. The "CABIN" number is part of the Freightliner VIN, the last six digits of which are the Freightliner serial number.

IMPORTANT: A new VIN-code structure will be used for all vehicles built after April 30, 2000. Character positions 1 through 4 and 9 through 17 are nearly the same in both versions, but positions 5 through 8 have been assigned slightly different parameters. As a result, the build date of a vehicle must be determined before the VIN can be decoded.

For all vehicles, a check digit (9th character) is determined by assignment of weighted values to the other 16 characters. These weighted values are processed through a series of equations designed to check validity of the VIN and to detect VIN alteration.

NOTE: Always specify the VIN when ordering parts.

Seventeen-Character Vehicle Identification Number (VIN)									
Typical VIN	**1 F U**	**Y**	**S**	**T E**	**B**	**X**	**V**	**P**	**A 9 9 9 9 9**
Character Position	**1, 2, 3**	**4**	**5**	**6, 7**	**8**	**9**	**10**	**11**	**12 thru 17**
Decoding Table *	**Table 2**	**Table 3**	**Table 4**	**Table 5**	**Table 6**	**—**	**Table 7**	**Table 8**	**—**
Code Description									
Manufacturer, Make, Vehicle Type									
Chassis, Front Axle Position, Brakes									
Vehicle Model Series, Cab									
Engine Model, Horsepower Range									
Gross Vehicle Weight Rating (GVWR)									
Check Digit									
Vehicle Model Year									
Plant of Manufacture									
Production Number									

* For corresponding decoding information, see the applicable tables in this subject.

Table 1, Seventeen-Character Vehicle Identification Number (VIN)

VIN Positions 1, 2, and 3 (Manufacturer, Make, Vehicle Type)			
Code	**Vehicle Manufacturer**	**Vehicle Make**	**Vehicle Type**
1FU	Freightliner, U.S.A.	Freightliner	Truck-Tractor

VIN for Vehicles Built through April 30, 2000

VIN Positions 1, 2, and 3 (Manufacturer, Make, Vehicle Type)			
Code	**Vehicle Manufacturer**	**Vehicle Make**	**Vehicle Type**
1FV	Freightliner, U.S.A.	Freightliner	Incomplete Vehicle
2FU	Freightliner, Canada	Freightliner	Truck-Tractor
2FV	Freightliner, Canada	Freightliner	Incomplete Vehicle
3FE	M-B, Mexico (before April 1996)	Freightliner	Truck-Tractor
3FF	M-B, Mexico (before April 1996)	Freightliner	Incomplete Vehicle
3AK	M-B, Mexico (after April 1996)	Freightliner	Truck-Tractor
3AL	M-B, Mexico (after April 1996)	Freightliner	Incomplete Vehicle
AFV	M-B, South Africa	Freightliner	Truck
KFB	AIL, Israel	Freightliner	Truck
RSA	NAI, Saudi Arabia	Freightliner	Incomplete Vehicle
RSB	NAI, Saudi Arabia	Freightliner	Truck-Tractor

Table 2, VIN Positions 1, 2, and 3 (Manufacturer, Make, Vehicle Type)

VIN Position 4 (Chassis, Front Axle Position, Brakes)			
Code	**Chassis**	**Front Axle Position**	**Brakes**
A	4 x 2 Truck	Forward	Hydraulic
B	8 x 4 Truck-Tractor	Setback	Air
C	6 x 6 Truck-Tractor	Setback	Air
D	4 x 4 Truck	Setback	Hydraulic
E	4 x 4 Truck	Setback	Air
F	8 x 4 Truck	Forward	Air
G	8 x 4 Truck-Tractor	Forward	Air
H	4 x 2 Truck	Forward	Air
J	10 x 4 Truck	All	Air
K	4 x 2 Truck-Tractor	Forward	Air
L	6 x 2 Truck	Forward	Air
M	6 x 2 Truck-Tractor	Forward	Air
N	6 x 4 Truck	Forward	Air
P	6 x 4 Truck-Tractor	Forward	Air
R	10 x 6 Truck	Forward	Air
S	10 x 6 Truck-Tractor	Forward	Air
T	6 x 6 Truck	Setback	Air
U	8 x 6 Truck	All	Air
V	8 x 6 Truck-Tractor	All	Air
W	4 x 2 Truck-Tractor	Setback	Air

VIN Position 4 (Chassis, Front Axle Position, Brakes)			
Code	**Chassis**	**Front Axle Position**	**Brakes**
X	6 x 4 Truck	Setback	Air
Y	6 x 4 Truck-Tractor	Setback	Air
Z	6 x 2 Truck	Setback	Air
1	4 x 2 Truck *	Forward	Air/Hydraulic
	10 x 6 Truck †	Setback	Air
2	4 x 4 Truck	Setback	Air
3	4 x 2 Truck	Setback	Hydraulic
4	8 x 4 Truck	Setback	Air
5	6 x 2 Truck-Tractor	Setback	Air
6	4 x 2 Truck	Setback	Air
7	Glider	Setback	Air
8	Glider	Forward	Air
9	4 x 2 Truck	Setback	Air/Hydraulic
0	Glider	Setback	Air

* Starting August 1998.
† Through July 1998; included in code R starting August 1998.

Table 3, VIN Position 4 (Chassis, Front Axle Position, Brakes), January 18,1988 through April 30, 2000

VIN for Vehicles Built through April 30, 2000

VIN Position 5 (Model Series, Cab)	
Code	**Vehicle Model, Cab**
A	FLA High COE
B	FLB High COE
C	120 Conventional XL
D	FLD120 Conventional, Highway
E	FL50 Short Conventional
F	FLD120SD Conventional, Construction
G	FL60 Short Conventional
H	FL70 Short Conventional
J	FL80 Short Conventional
L	112 Conv., Alum. Cab, Hwy., 48RR94MY *
	Argosy High COE
M	120 Conventional, Military
N	Century Class 112 Conventional
P	120 Conv., Alum. Cab, Hwy., 48RR94MY
	Columbia 120 Conventional
R	112 Conventional, Steel Cab, Hwy., RH Drive
S	Century Class 120 Conventional
T	High COE (through 88MY)
	FL112 Conventional
U	120 Conventional XL, 48RR94MY

VIN Position 5 (Model Series, Cab)	
Code	**Vehicle Model, Cab**
V	MB60 Short Conventional (to 95MY)
	Legacy FL112 (00MY)
W	FC80 Freightliner Cargo COE
X	MB70 Short Conventional (to 97MY)
	Legacy FLD120 (00MY)
Y	MB80 Short Conventional (through 98MY)
Z	112 Conventional, Steel Cab, Highway
1	FLC112 Conv., Steel Cab, Constr. (to 98MY)
2	FLC120 Conventional (to 91MY)
	FC60 Freightliner Cargo COE
3	FLD112 Conventional, Alum. Cab, Highway
4	Low COE, Aluminum Cab
5	MB50 Short Conventional
6	FLD112SD Conv., Alum. Cab, Construction
7	FLD120 Conventional, SilverAero (91MY)
	FC70 Freightliner Cargo COE
8	FL106 Short Conventional
9	RIV

* MY = Model Year

Table 4, VIN Position 5 (Model Series, Cab)

VIN Positions 6 and 7 (Engine Manufacturer, Model, Horsepower Range)			
Code	**Engine Manufacturer**	**Engine Model**	**HP Range**
AY	Cummins	NTC / N14	207–251
BD	Mercedes-Benz	MBE4000	353–407
BE	Mercedes-Benz	MBE4000	408–495
BX	Mercedes-Benz	MBE4000	288–352
BY	Cummins	NTC / N14	254–310
CX	Detroit Diesel	S-60, 11.1 L	331–402
CY	Cummins	N14	315–385
DY	Cummins	NTC / N14	389–475
DZ	Cummins	N14	476–580
EB	Caterpillar	C10 / 3176J	225–275
EC	Caterpillar	C10 / 3176J	276–335
ED	Caterpillar	C10 / 3176	336–407

VIN for Vehicles Built through April 30, 2000

VIN Positions 6 and 7 (Engine Manufacturer, Model, Horsepower Range)			
Code	**Engine Manufacturer**	**Engine Model**	**HP Range**
F4	Cummins	B5.9 (propane)	185–224
FA	Cummins	6BT 5.9 (diesel) / ISB	185–224
FB	Cummins	6BT 5.9 (diesel) / ISB	225–275
FF	Cummins	6BT 5.9/ ISB	153–184
FH	Cummins	6BT 5.9–195G (natural gas)	185–224
FV	Cummins	6BT 5.9–195G (natural gas)	126–152
GA	Mercedes-Benz	OM 366LA	185–224
GB	Mercedes-Benz	OM 366LA	225–275
GF	Mercedes-Benz	OM 366LA	153–184
HB	Detroit Diesel	S–50	225–275
HC	Detroit Diesel	S–50	276–335
HD	Detroit Diesel	S–50	336–407
JA	Caterpillar	CFE / 3126 (diesel)	185–224
JB	Caterpillar	CFE / 3126 (diesel)	225–275
JC	Caterpillar	CFE / 3126 (diesel)	276–335
JF	Caterpillar	CFE / 3126 (diesel)	153–184
KY	Cummins	L10	225–275
LA	Cummins	6C 8.3 (diesel) / ISC	185–224
LB	Cummins	6C 8.3 (diesel) / ISC	225–275
LC	Cummins	6C 8.3 (diesel) / ISC	276–335
LD	Cummins	L10	336–407
LE	Cummins	ISC	336–407
LL	Cummins	C 8.3 (natural gas) / ISC	225–276
LY	Cummins	L10	276–330
MC	Cummins	M11 / ISM	276–335
MD	Cummins	M11 / ISM	336–407
ME	Cummins	M11 / ISM	408–495
MW	Cummins	ISM	496–605
NT	Cummins	4B 3.9–130 hp (diesel)	126–152
PY	Detroit Diesel	S-60, 11.1 L	275–330
RY	Caterpillar	3406	270–330
SE	Detroit Diesel	S-60, 12.7 L	408–495
SM	Detroit Diesel	S-60, 12.7 L	276–335
SY	Caterpillar	3406	333–407
SZ	Detroit Diesel	S-60, 12.7 L	496–605

VIN for Vehicles Built through April 30, 2000

VIN Positions 6 and 7 (Engine Manufacturer, Model, Horsepower Range)			
Code	**Engine Manufacturer**	**Engine Model**	**HP Range**
TD	Detroit Diesel	S-55	336–407
TE	Detroit Diesel	S-55	408–495
TJ	Dodge	Magnum V8 (gasoline)	207–253
TR	Dodge	Magnum V10 (gasoline)	270–330
TY	Caterpillar	3408	383–467
UY	Caterpillar	3306	225–275
VY	Caterpillar	3406	225–269
WC	Caterpillar	CFE/3126	276–335
WD	Caterpillar	C12 / 3176L	336–407
WE	Caterpillar	C12 / 3176L	408–495
WY	Caterpillar	3306	276–335
XY	Caterpillar	3406	408–495
XZ	Caterpillar	3406	496–605
YY	Detroit Diesel	S-60, 11.1 L	225–274
ZY	Detroit Diesel	S-60, 12.7 L	333–407
1B	Detroit Diesel	6L–71	225–275
1C	Detroit Diesel	6L–71	276–335
2W	Detroit Diesel	S-60, 14.0L	496–605
3A	Mercedes-Benz	MB904	185–224
4Y	Detroit Diesel	6V–92	239–287
5Y	Detroit Diesel	6V–92	288–352
6A	Mercedes-Benz	MB906	185–224
6B	Mercedes-Benz	MB906	225–275
6C	Mercedes-Benz	MB906	276–335
6Y	Detroit Diesel	8V–92	365–446
7D	Cummins	ISX Signature	336–407
7E	Cummins	ISX Signature	408–495
7W	Cummins	ISX Signature	496–605
8Y	Detroit Diesel	8V–92	302–364
9Y	Detroit Diesel	8V–92	447–522
0Y	No Engine	—	—

Table 5, VIN Positions 6 and 7 (Engine Manufacturer, Model, Horsepower Range)

VIN for Vehicles Built through April 30, 2000

VIN Position 8 (Gross Vehicle Weight Rating)		
Code	**lb**	**kg**
A	26,001–33,000	11 794–14 968
B	33,001 or over	14 969 or over
C	19,501–26,000	8846–11 793
D	16,001–19,500	7258–8845
2	6001–10,000	2722–4536
3	10,001–14,000	4537–6350
4	14,001–16,000	6351–7257
9	N/A: Incomplete Vehicle or Glider	

Table 6, VIN Position 8 (Gross Vehicle Weight Rating)

VIN Position 10 (Vehicle Model Year)	
Code	**Model Year**
J	1988
K	1989
L	1990
M	1991
N	1992
P	1993
R	1994
S	1995
T	1996
V	1997
W	1998
X	1999
Y	2000
1	2001
2	2002

Table 7, VIN Position 10 (Vehicle Model Year)

VIN Position 11 (Plant of Manufacture)	
Code	**Plant of Manufacture**
A	St. Thomas, Ontario
B	Mercedes-Benz, South Africa
C	Gaffney, South Carolina
D	Mercedes-Benz, Mexico, Santiago
F	AIL, Israel

VIN Position 11 (Plant of Manufacture)	
Code	**Plant of Manufacture**
H	Mt. Holly, North Carolina
L	Cleveland, North Carolina
M	Mercedes-Benz, Monterrey
N	Mercedes-Benz, Australia
P	Portland, Oregon
R	American LaFrance, Cleveland, NC
V	Burnaby, British Columbia
W	NAI, Saudi Arabia

Table 8, VIN Position 11 (Plant of Manufacture)

VIN for Vehicles Built from May 1, 2000

IMPORTANT: See **Subject 050** for the vehicle identification numbering system for vehicles built before May 1, 2000.

Federal Motor Vehicle Safety Standard 115 specifies that all vehicles sold in the U.S. be assigned a 17-character Vehicle Identification Number (VIN). Using a combination of letters and numerals, the VIN defines the manufacturer, model, and major characteristics of the vehicle. See **Table 1** for the character positions of a typical Freightliner VIN, 1FUPABAV11PA12345.

The VIN can be found on the Vehicle Specification Decal (see the driver's manual for decal location) and stamped on the left frame rail over the front axle about 2 inches (50 mm) from the top of the web or on the top flange of the left frame rail at frame station 30.

NOTE: For Freightliner vehicles assembled and sold in Mexico, the VIN appears on a plate or label attached to the driver's door. Also, a data card placed in the glove box shows the Mexican VIN as the "CHASSIS" number. The "CABIN" number is part of the Freightliner VIN, the last six digits of which are the Freightliner serial number.

IMPORTANT: A new VIN-code structure will be used for all vehicles built after April 30, 2000. As a result, the build date of a vehicle must be determined before the VIN can be decoded.

Character positions 1 through 4 and 9 through 17 are nearly the same in both versions, but positions 5 through 8 have been assigned slightly different parameters.

Another new feature is that each product line has its own model list; that is, positions 5 and 6 are will be product-specific in the new system. For example, the code AB in positions 5 and 6 for a Freightliner vehicle indicates an FLD112. Code AB in the same position for a Sterling vehicle represents an SC7000 Cargo.

For all vehicles, a check digit (9th character) is determined by assignment of weighted values to the other 16 characters. These weighted values are processed through a series of equations designed to check validity of the VIN and to detect VIN alteration.

NOTE: Always specify the VIN when ordering parts.

Seventeen-Character Vehicle Identification Number (VIN)								
Typical VIN	**1 F U**	**P**	**AB**	**AV**	**1**	**1**	**P**	**A 1 2 3 4 5**
Character Position	1, 2, 3	4	5, 6	7, 8	9	10	11	12–17
Code Description	World Manufacturer Identification	Chassis Configuration	Model, Cab, GVWR	Engine, Brakes	Check Digit Calculation	Model Year	Build Location	Production Serial Number
Decoding Table *	**Table 2**	**Table 3**	**Table 4**	**Table 5**	—	**Table 6**	**Table 7**	—

* For corresponding decoding information, see the applicable tables in this subject.

Table 1, Seventeen-Character Vehicle Identification Number (VIN)

VIN Positions 1, 2, and 3 (World Manufacturer Identification)			
Code	**Vehicle Manufacturer**	**Vehicle Make**	**Vehicle Type**
1FU	Freightliner, U.S.A.	Freightliner	Truck-Tractor
1FV	Freightliner, U.S.A.	Freightliner	Incomplete Vehicle
3AK	M-B, Mexico (after April 1996)	Freightliner	Truck-Tractor
3AL	M-B, Mexico (after April 1996)	Freightliner	Incomplete Vehicle
RSA	NAI, Saudi Arabia	Freightliner	Incomplete Vehicle

VIN for Vehicles Built from May 1, 2000

VIN Positions 1, 2, and 3 (World Manufacturer Identification)			
Code	**Vehicle Manufacturer**	**Vehicle Make**	**Vehicle Type**
RSB	NAI, Saudi Arabia	Freightliner	Truck-Tractor

Table 2, VIN Positions 1, 2, and 3 (World Manufacturer Identification)

VIN Position 4 (Chassis Configuration)	
Code	**Chassis**
A	4 x 2 Truck
B	4 x 2 Truck-Tractor
D	4 x 4 Truck
E	4 x 4 Truck-Tractor
F	6 x 2 Truck
G	6 x 2 Truck-Tractor
H	6 x 4 Truck
J	6 x 4 Truck-Tractor
K	6 x 6 Truck
L	6 x 6 Truck-Tractor
M	8 x 4 Truck
N	8 x 4 Truck-Tractor
P	8 x 6 Truck
R	8 x 6 Truck-Tractor
S	10 x 4 Truck
T	10 x 4 Truck-Tractor
U	10 x 6 Truck-Tractor
V	10 x 6 Truck-Tractor
X	Glider

Table 3, VIN Position 4 (Chassis Configuration)

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**Class (GVWR)**
AA	FLB Glider	COE	Glider
AB	FLD112	Conventional	Class 7 *
AC	FLD112	Conventional	Class 8 †
AD	FLD112 Glider	Conventional	Glider
AE	FLD112 SD	Conventional	Class 8
AF	FLD112 SD Glider	Conventional	Glider

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**Class (GVWR)**
AG	FLD120	Conventional	Class 7
AH	FLD120	Conventional	Class 8
AJ	FLD120 Glider	Conventional	Glider
AK	FLD120 SD	Conventional	Class 7
AL	FLD120 SD	Conventional	Class 8
AM	FLD120 SD Glider	Conventional	Glider
AN	FLD132 XL Classic	Conventional	Class 7
AP	FLD132 XL Classic	Conventional	Class 8
AR	FLD132 XL Classic Glider	Conventional	Glider
AS	FLD120 Military	Conventional	Class 7
AT	FLD120 Military	Conventional	Class 8
AU	FLD120 Mil Glider	Conventional	Glider
AV	Argosy	COE	Class 7
AW	Argosy	COE	Class 8
AX	Argosy Glider	COE	Glider
AY	C112 (Century Class)	Conventional	Class 7
AZ	C112	Conventional	Class 8
A1	C112 Glider	Conventional	Glider
A2	C120 (Century Class)	Conventional	Class 7
A3	C120	Conventional	Class 8
A4	C120 Glider	Conventional	Glider
A5	Columbia 120	Conventional	Class 7
A6	Columbia 120	Conventional	Class 8
A7	Columbia 120 Glider	Conventional	Glider
A8	ST112 (Century Class)	Conventional	Class 7
A9	ST112	Conventional	Class 8
A0	ST112 Glider	Conventional	Glider

VIN for Vehicles Built from May 1, 2000

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**Class (GVWR)**
BA	ST120 (Century Class)	Conventional	Class 7
BB	ST120	Conventional	Class 8
BC	ST120 Glider	Conventional	Glider
BD	FLD120 Classic Legacy	Conventional	Class 8
BE	FLS112 Legacy	Conventional	Class 8
BF	FL112	Conventional	Class 7
BG	FL112	Conventional	Class 8
BH	FL112 Glider	Conventional	Glider
BJ	FL50	Conventional	Class 4 ‡
BK	FL50	Conventional	Class 5 §
BL	FL50	Conventional	Class 6 ¶
BM	FL50	Conventional	Class 7
BN	FL60	Conventional	Class 5
BP	FL60	Conventional	Class 6
BR	FL60	Conventional	Class 7
BS	FC70	Conventional	Class 6
BT	FC70	Conventional	Class 7
BU	FC70	Conventional	Class 8
BV	FC80	Conventional	Class 6
BW	FC80	Conventional	Class 7
BX	FC80	Conventional	Class 8
BY	FL106	Conventional	Class 6
BZ	FL106	Conventional	Class 7
B1	FL106	Conventional	Class 8

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**Class (GVWR)**
B2	FC70 Cargo	COE	Class 6
B3	FC70 Cargo	COE	Class 7
B4	FC70 Cargo	COE	Class 8
B5	FC80 Cargo	COE	Class 6
B6	FC80 Cargo	COE	Class 7
B7	FC80 Cargo	COE	Class 8
B8	RIV	None	Class 8
B9	Sport Chassis	Conventional	Class 6
B0	Sport Chassis	Conventional	Class 7
CA	FL106 Glider	Conventional	Glider
CB	FL60 Glider	Conventional	Glider
CC	FL70 Glider	Conventional	Glider
CD	FL80 Glider	Conventional	Glider
CE	T-2	COE	Class 7
CF	T-2	COE	Class 8

* Class 7 GVWR is 26,001–33,000 lb.
† Class 8 GVWR is 33,001 lb and over.
‡ Class 4 GVWR is 14,001–16,000 lb.
§ Class 5 GVWR is 16,001–19,500 lb.
¶ Class 6 GVWR is 19,501–26,000 lb.

Table 4, VIN Positions 5 and 6 (Model, Cab, Class/GVWR)

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displacement (L)**	**Configuration**	**Brakes**
AA	Caterpillar 3176	Diesel	10.3	I–6	Air
AB	Caterpillar 3176	Diesel	10.3	I–6	Hydraulic
AC	Caterpillar 3176	Diesel	10.3	I–6	Air/Hydraulic

VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displace-ment (L)**	**Config-uration**	**Brakes**
AD	Caterpillar 3406	Diesel	14.6	I–6	Air
AE	Caterpillar 3406	Diesel	14.6	I–6	Hydraulic
AF	Caterpillar 3406	Diesel	14.6	I–6	Air/Hydraulic
AG	Caterpillar 3406E	Diesel	15.8	I–6	Air
AH	Caterpillar 3406E	Diesel	15.8	I–6	Hydraulic
AJ	Caterpillar 3406E	Diesel	15.8	I–6	Air/Hydraulic
AK	Caterpillar 3126/CFE	Diesel	7.2	I–6	Air
AL	Caterpillar 3126/CFE	Diesel	7.2	I–6	Hydraulic
AM	Caterpillar 3126/CFE	Diesel	7.2	I–6	Air/Hydraulic
AN	Caterpillar C10	Diesel	10.3	I–6	Air
AP	Caterpillar C10	Diesel	10.3	I–6	Hydraulic
AR	Caterpillar C10	Diesel	10.3	I–6	Air/Hydraulic
AS	Caterpillar C12	Diesel	12.0	I–6	Air
AT	Caterpillar C12	Diesel	12.0	I–6	Hydraulic
AU	Caterpillar C12	Diesel	12.0	I–6	Air/Hydraulic
AV	Caterpillar C15	Diesel	14.6	I–6	Air
AW	Caterpillar C15	Diesel	14.6	I–6	Hydraulic
AX	Caterpillar C15	Diesel	14.6	I–6	Air/Hydraulic
AY	Caterpillar C16	Diesel	15.8	I–6	Air
AZ	Caterpillar C16	Diesel	15.8	I–6	Hydraulic
A1	Caterpillar C16	Diesel	15.8	I–6	Air/Hydraulic
A2	Cummins L10	Diesel	10.8	I–6	Air
A3	Cummins L10	Diesel	10.8	I–6	Hydraulic
A4	Cummins L10	Diesel	10.8	I–6	Air/Hydraulic
A5	Cummins M11	Diesel	10.8	I–6	Air
A6	Cummins M11	Diesel	10.8	I–6	Hydraulic
A7	Cummins M11	Diesel	10.8	I–6	Air/Hydraulic
A8	Cummins ISM	Diesel	10.8	I–6	Air
A9	Cummins ISM	Diesel	10.8	I–6	Hydraulic
A0	Cummins ISM	Diesel	10.8	I–6	Air/Hydraulic

VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displace-ment (L)**	**Config-uration**	**Brakes**
BA	Cummins NTC	Diesel	14.0	I–6	Air
BB	Cummins NTC	Diesel	14.0	I–6	Hydraulic
BC	Cummins NTC	Diesel	14.0	I–6	Air/Hydraulic
BD	Cummins N14	Diesel	14.0	I–6	Air
BE	Cummins N14	Diesel	14.0	I–6	Hydraulic
BF	Cummins N14	Diesel	14.0	I–6	Air/Hydraulic
BG	Cummins ISX/Signature	Diesel	14.9	I–6	Air
BH	Cummins ISX/Signature	Diesel	14.9	I–6	Hydraulic
BJ	Cummins ISX/Signature	Diesel	14.9	I–6	Air/Hydraulic
BK	Cummins C8.3	Diesel	8.3	I–6	Air
BL	Cummins C8.3	Diesel	8.3	I–6	Hydraulic
BM	Cummins C8.3	Diesel	8.3	I–6	Air/Hydraulic
BN	Cummins B5.9	Diesel	5.9	I–6	Air
BP	Cummins B5.9	Diesel	5.9	I–6	Hydraulic
BR	Cummins B5.9	Diesel	5.9	I–6	Air/Hydraulic
BS	Cummins ISC	Diesel	8.3	I–6	Air
BT	Cummins ISC	Diesel	8.3	I–6	Hydraulic
BU	Cummins ISC	Diesel	8.3	I–6	Air/Hydraulic
BV	Cummins ISB	Diesel	5.9	I–6	Air
BW	Cummins ISB	Diesel	5.9	I–6	Hydraulic
BX	Cummins ISB	Diesel	5.9	I–6	Air/Hydraulic
BY	Cummins B5.9	Propane	5.9	I–6	Air
BZ	Cummins B5.9	Propane	5.9	I–6	Hydraulic
B1	Cummins B5.9	Propane	5.9	I–6	Air/Hydraulic
B2	Cummins B5.9	Natural Gas	5.9	I–6	Air
B3	Cummins B5.9	Natural Gas	5.9	I–6	Hydraulic
B4	Cummins B5.9	Natural Gas	5.9	I–6	Air/Hydraulic
B5	Cummins C8.3	Natural Gas	8.3	I–6	Air
B6	Cummins C8.3	Natural Gas	8.3	I–6	Hydraulic
B7	Cummins C8.3	Natural Gas	8.3	I–6	Air/Hydraulic

VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displace-ment (L)**	**Config-uration**	**Brakes**
B8	Detroit Series 50	Diesel	8.5	I–4	Air
B9	Detroit Series 50	Diesel	8.5	I–4	Hydraulic
B0	Detroit Series 50	Diesel	8.5	I–4	Air/Hydraulic
CA	Detroit Series 55	Diesel	12.0	I–6	Air
CB	Detroit Series 55	Diesel	12.0	I–6	Hydraulic
CC	Detroit Series 55	Diesel	12.0	I–6	Air/Hydraulic
CD	Detroit Series 60	Diesel	11.1	I–6	Air
CE	Detroit Series 60	Diesel	11.1	I–6	Hydraulic
CF	Detroit Series 60	Diesel	11.1	I–6	Air/Hydraulic
CG	Detroit Series 60	Diesel	12.7	I–6	Air
CH	Detroit Series 60	Diesel	12.7	I–6	Hydraulic
CJ	Detroit Series 60	Diesel	12.7	I–6	Air/Hydraulic
CK	Detroit Series 60	Diesel	14.0	I–6	Air
CL	Detroit Series 60	Diesel	14.0	I–6	Hydraulic
CM	Detroit Series 60	Diesel	14.0	I–6	Air/Hydraulic
CN	Mercedes-Benz MBE900	Diesel	4.3	I–4	Air
CP	Mercedes-Benz MBE900	Diesel	4.3	I–4	Hydraulic
CR	Mercedes-Benz MBE900	Diesel	4.3	I–4	Air/Hydraulic
CS	Mercedes-Benz MBE900	Diesel	6.4	I–6	Air
CT	Mercedes-Benz MBE900	Diesel	6.4	I–6	Hydraulic
CU	Mercedes-Benz MBE900	Diesel	6.4	I–6	Air/Hydraulic
CV	Mercedes-Benz MBE4000	Diesel	12.0	I–6	Air
CW	Mercedes-Benz MBE4000	Diesel	12.0	I–6	Hydraulic
CX	Mercedes-Benz MBE4000	Diesel	12.0	I–6	Air/Hydraulic
CY	Cummins ISL	Diesel	8.3	I–6	Air
CZ	Cummins ISL	Diesel	8.3	I–6	Hydraulic
C1	Cummins ISL	Diesel	8.3	I–6	Air/Hydraulic
C2	Cummins B3.9	Diesel	3.9	I–4	Air
C3	Cummins B3.9	Diesel	3.9	I–4	Hydraulic
C4	Cummins B3.9	Diesel	3.9	I–4	Air/Hydraulic

VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displace-ment (L)**	**Config-uration**	**Brakes**
C5	Cummins ISB 3.9	Diesel	3.9	I–4	Air
C6	Cummins ISB 3.9	Diesel	3.9	I–4	Hydraulic
C7	Cummins ISB 3.9	Diesel	3.9	I–4	Air/Hydraulic
00	No Engine	—	—	—	—

Table 5, VIN Positions 7 and 8 (Engine and Brakes)

VIN Position 10 (Model Year)	
Code	**Model Year**
Y	2000
1	2001
2	2002
3	2003
4	2004
5	2005
6	2006
7	2007

Table 6, VIN Position 10 (Model Year)

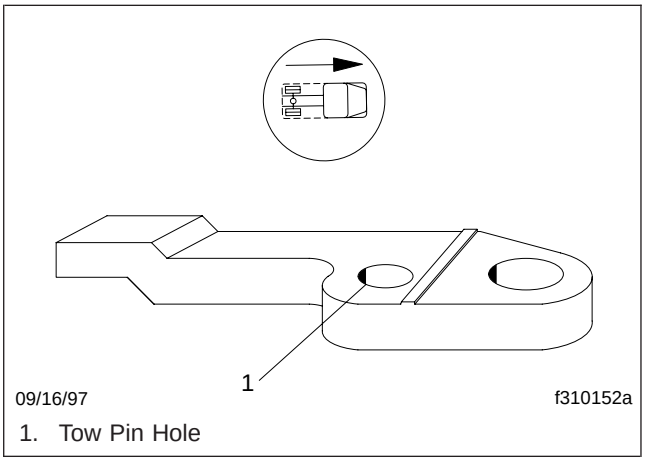
VIN Position 11 (Build Location)	
Code	**Build Location**
D	Mercedes-Benz, Mexico, Santiago
H	Mt. Holly, North Carolina
L	Cleveland, North Carolina
P	Portland, Oregon

Table 7, VIN Position 11 (Build Location)

Decking Devices

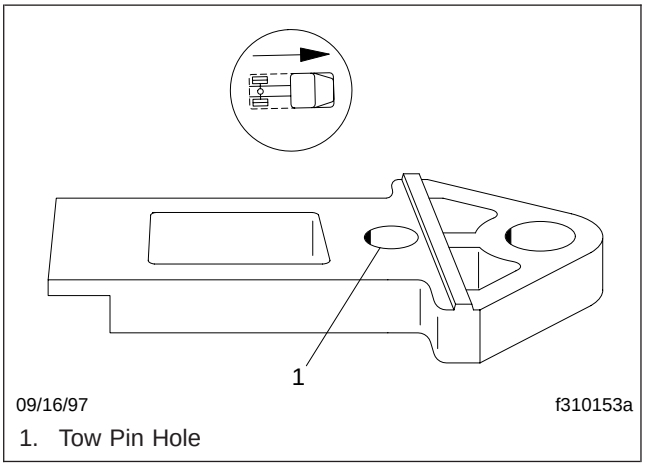
To avoid damaging vehicles during decking and undecking, follow the instructions below for installing and removing—or extending and retracting—decking devices.

For FLAs and FLBs, use one decking device A21–25059–001. See **Fig. 1**. For FLD 120s , use one device A21–25004–000. See **Fig. 2**. On FLD 112s, the two decking devices (tow eyes) are part of the vehicle frame and must be extended through the bumper. See **Fig. 3**.



1. Tow Pin Hole

Fig. 1, Decking Device for FLA and FLB (A21-25059-001)



1. Tow Pin Hole

Fig. 2, Decking Device for FLD 120 (A21-25004-000)

Installation, FLA, FLB and FLD 120 Decking Devices

1. Locate the tow pin behind the center hole of the front bumper, and lift it up and out of the way.
2. Position the decking device so that its rear extension/flange is facing up, as shown in **Fig. 1** and **Fig. 2**.

CAUTION

When installing the decking device in a COE with a down-flow radiator, make sure the decking device stays clear of the radiator outlet hose. Hitting the hose with the device could severely damage the hose.

3. Insert the decking device in the hole at the center of the front bumper, and slide it to the rear until its rear extension/flange rests on the rear flange of the front crossmember. See **Fig. 4**.
4. Position the decking device so that its 2-inch-diameter hole lines up with the crossmember tow-pin hole.
5. Insert the tow pin through the 2-inch-diameter hole in the decking device, and into the crossmember tow-pin hole.

   The vehicle can now be safely hoisted for decking. Make sure the decking area is free of obstacles, has a vertical clearance of at least 14 feet (4.3 m) and a width of at least 12 feet (3.7 m).

Removal, FLA, FLB and FLD 120 Decking Devices

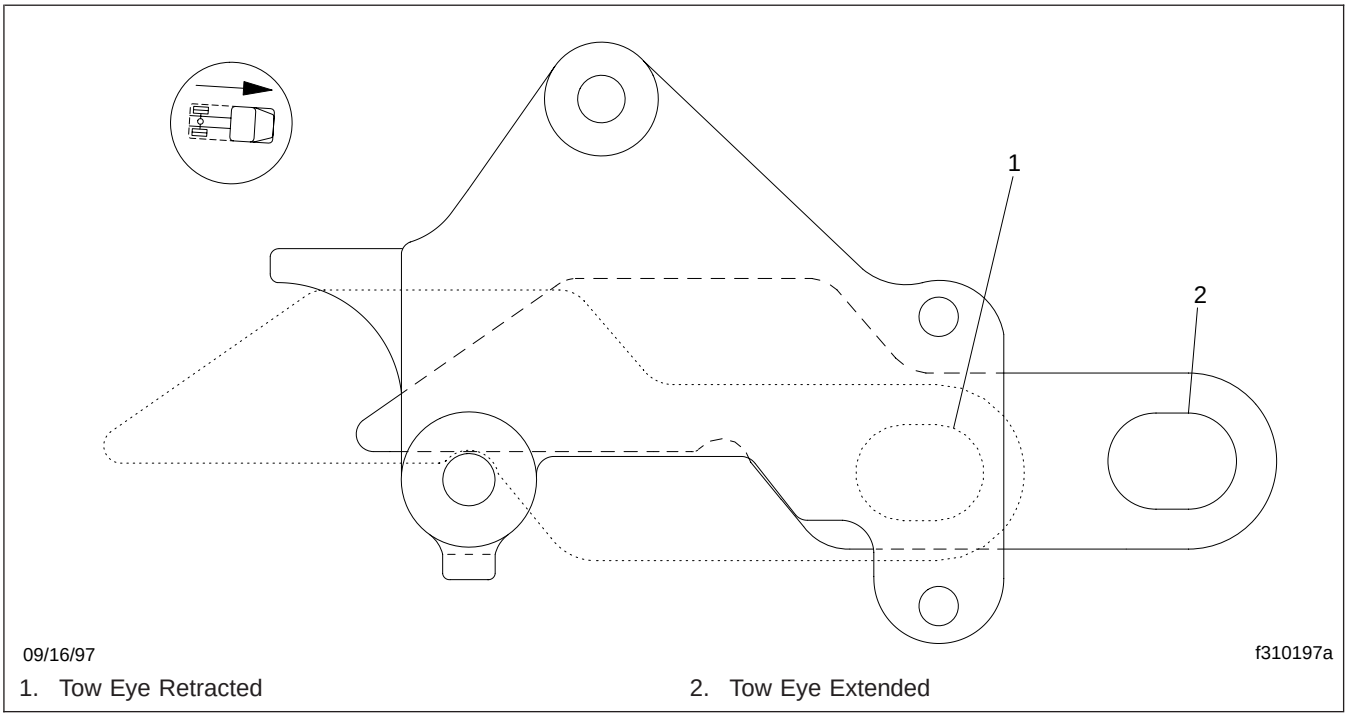
1. Lift the tow pin so that it clears the decking device, then pull out the device.
2. Install the tow pin in the crossmember tow-pin hole.

Extending and Retracting Decking Devices, FLD 112s

1. Tilt the hood.

General Information

2. Locate the retracted decking devices mounted under the forward end of each frame rail.
3. Lift each eye slightly and push it forward through the bumper until it stops. See **Fig. 5**.
5. To retract the decking devices, push them back through the holes in the bumper until they rest in their retracted positions. See **Fig. 3**.



1. Tow Eye Retracted
2. Tow Eye Extended

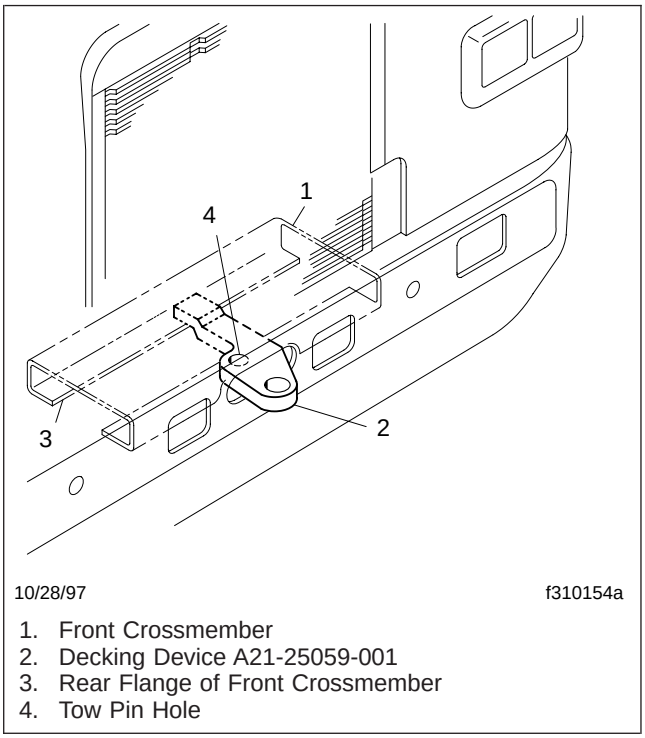
Fig. 3, Decking Device for FLD 112

CAUTION

When lifting the front of the vehicle, it is necessary to use both tow eyes extending from the frame rails. Use a spreader bar measuring approximately 34 inches (86 cm) with chains and clevises attached at the tow eyes. Failure to use a spreader bar could result in damage to the hood or grille caused by contact with the lifting tackle.

4. Return the hood to the operating position, and latch it.

   The vehicle can now be safely hoisted for decking. Make sure the decking area is free of obstacles, has a vertical clearance of at least 14 feet (4.3 m) and a width of at least 12 feet (3.7 m).



1. Front Crossmember
2. Decking Device A21-25059-001
3. Rear Flange of Front Crossmember
4. Tow Pin Hole

Fig. 4, Installing the Decking Device (FLB shown)

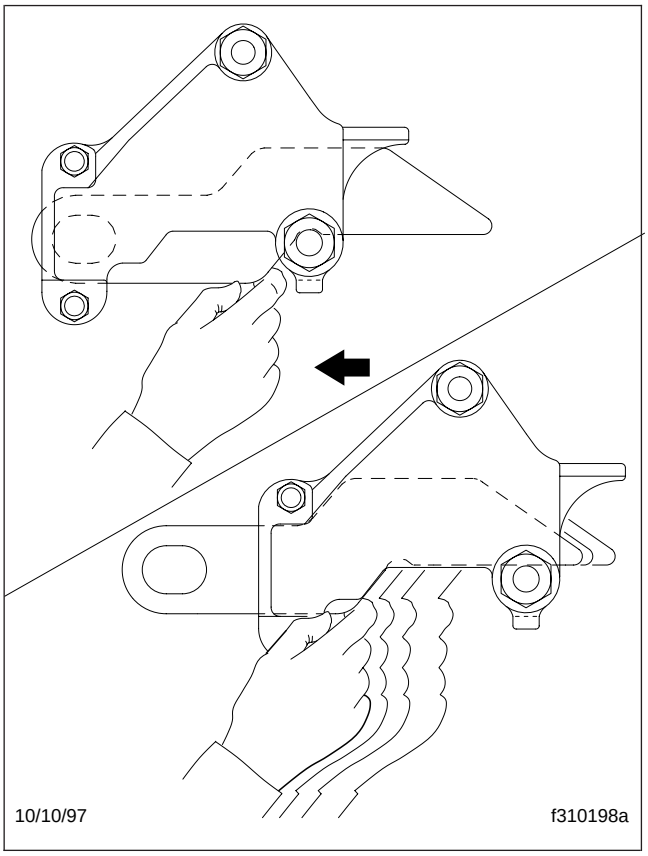


Fig. 5, Extending the Decking Devices

General Information

The majority of threaded fasteners used throughout the vehicle have U.S. customary threads (diameter and pitch are measured in inches). **See Fig. 1**. However, the engine and some items attached to the cab use metric fasteners (diameter and pitch are measured in millimeters).

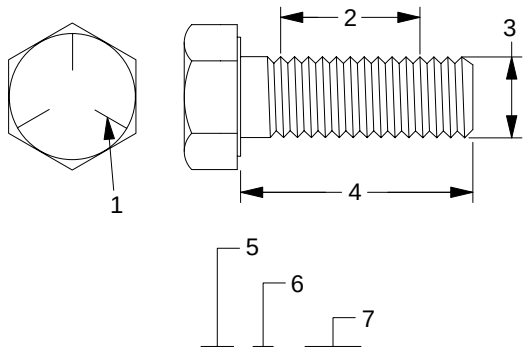
Most fasteners used on the vehicle that are 1/2-inch diameter or larger are plain hex-type fasteners (non-flanged); *all* metric fasteners are non-flanged. Special hardened flatwashers are used under the bolt head, and between the part being attached and the hexnut, to distribute the load, and to prevent localized overstressing of the parts. The washers are cadmium-or zinc-plated, and have a hardness rating of 38 to 45 HRC.

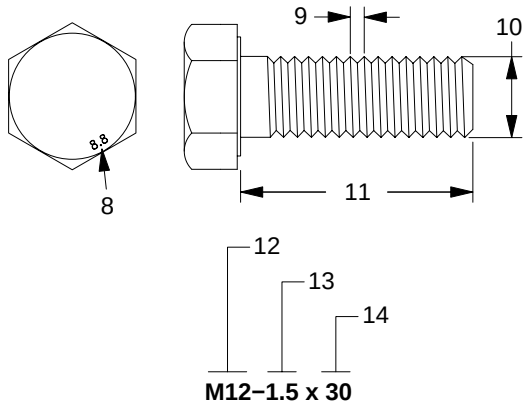
Some fasteners smaller than 1/2-inch diameter are flanged fasteners, which have integral flanges that fit against the parts being fastened. The flanges eliminate the need for washers.

Fastener Grades and Classes

Fasteners with U.S. customary threads are divided into grades established by the Society of Automotive Engineers (S.A.E.) or the International Fastener Institute (I.F.I.). The fastener grades indicate the relative strength of the fastener; the higher the number (or letter), the stronger the fastener. Bolt (capscrew) grades can be identified by the number and pattern of radial lines forged on the bolt head. **See Fig. 2**. Hexnut (and locknut) grades can be identified by the number and pattern of lines and dots on various surfaces of the nut. **See Fig. 3, Fig. 4, Fig. 5, Fig. 6, Fig. 7, Fig. 8, or Fig. 9.** Nearly all of the bolts used on the vehicle are grades 5, 8, and 8.2. Matching grades of hexnuts are always used: grade 5 or grade B hexnuts are used with grade 5 bolts; grade 8, grade C, or grade G (flanged) hexnuts are used with grade 8 or 8.2 bolts.

Fasteners with metric threads are divided into classes adopted by the American National Standards Institute (ANSI). The higher the class number, the stronger the fastener. Bolt classes can be identified by the numbers forged on the head of the bolt. **See Fig. 10**. Hexnut (and locknut) classes can be identified by the marks or numbers on various surfaces of the nut. **See Fig. 11**. Class 8 hexnuts are





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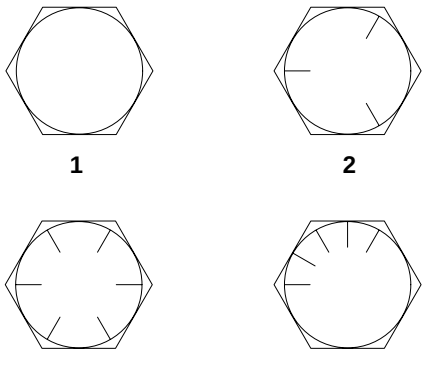
A. 1/2–13 x 1–1/2 U.S. Customary Thread Bolt
B. M12–1.5 x 30 Metric Thread Bolt
1. S.A.E. Grade Marking
2. Thread Pitch
3. Nominal Diameter
4. Bolt Length
5. Nominal Diameter in Inches
6. Thread Pitch in Threads per Inch
7. Bolt Length in Inches
8. Metric Class Marking
9. Thread Pitch
10. Nominal Diameter
11. Bolt Length
12. Nominal Diameter in Millimeters
13. Thread Pitch (Thread Width from Crest to Crest in Millimeters)
14. Bolt Length in Millimeters

Fig. 1

General Information



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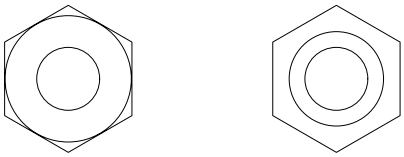
NOTE: Grade 2 bolts have no grade markings; grade 2 bolts are rarely used by Freightliner

These grade markings are used on plain hex-type and flanged bolts (capscrews). In addition to the grade markings, the bolt head must also carry the manufacturer's trademark or identification.

1. Grade 2
2. Grade 5
3. Grade 8
4. Grade 8.2

Fig. 2



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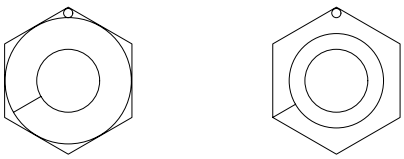
NOTE: S.A.E. grade 2 nuts have no identification marks or notches; they are rarely used by Freightliner. Their strength is compatible with grade 2 bolts.

Fig. 3, S.A.E. Grade 2 Nuts



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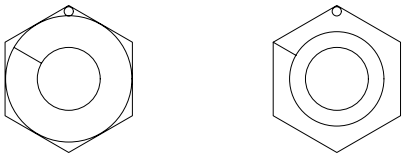
NOTE: The strength of grade 5 nuts is compatible with grade 5 bolts.

Fig. 4, S.A.E. Grade 5 Nuts



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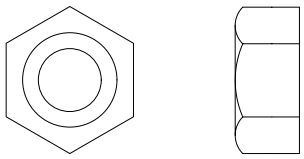
NOTE: The strength of grade 8 nuts is compatible with grade 8 or 8.2 bolts.

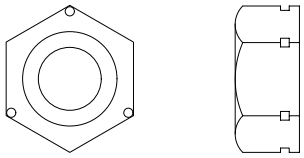
Fig. 5, S.A.E. Grade 8 Nuts



10/19/93 f230038

NOTE: I.F.I. grade A nuts have no identification marks or notches; they are rarely used by Freightliner. Their strength is compatible with grade 2 bolts.

Fig. 6, I.F.I. Grade A Nuts



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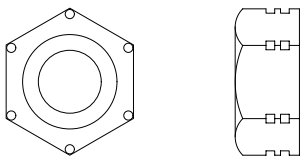
NOTE: I.F.I. grade B nuts have three identification marks at 120 degrees, or 6 notches. Their strength is compatible with grade 5 bolts.

Fig. 7, I.F.I. Grade B Nuts



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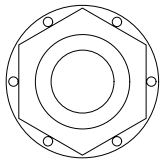
NOTE: I.F.I. grade C nuts have six identification marks at 60 degrees, or 12 notches. Their strength is compatible with grade 8 or 8.2 bolts.

Fig. 8, I.F.I. Grade C Nut

always used with class 8.8 bolts; class 10 hexnuts with class 10.9 bolts.



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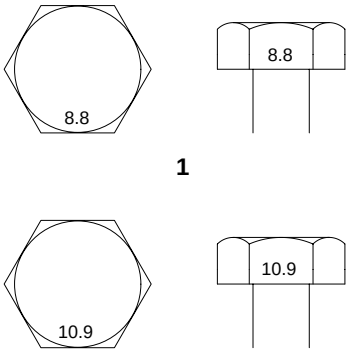
NOTE: I.F.I. grade G (flanged) nuts have six identification marks as shown; each identification mark may be a dot, line, pair of dots or lines, or any other symbol at the manufacturer's option. Their strength is compatible with grade 8 or 8.2 bolts.

Fig. 9, I.F.I. Grade G Nut



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NOTE: In addition to the grade markings, the bolt head must carry the manufacturer's trademark or identification.

1. Class 8.8
2. Class 10.9

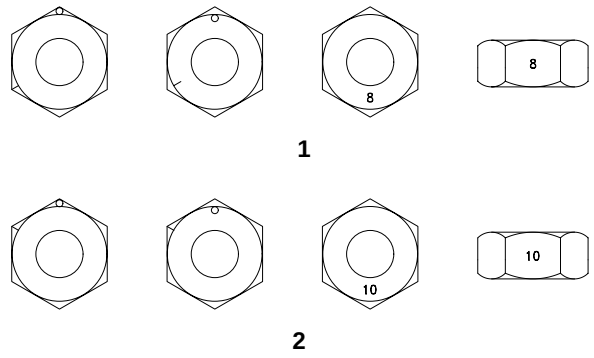
Fig. 10

Frame Fasteners

For most components attached to the frame, grade 8 and 8.2 phosphate-and oil-coated hexhead bolts and grade C cadmium-plated and wax-coated prevailing torque locknuts are used. The prevailing torque locknuts have distorted sections of threads to provide torque retention. For attachments where clearance is minimal, low-profile hexhead bolts and grade C prevailing torque locknuts are used. **See Fig. 12**.

Tightening Fasteners

When a capscrew is tightened to its torque value in a threaded hole, or a nut is tightened to its torque value on a bolt, the shank of the capscrew or bolt is stretched slightly. This stretching (tensioning) results in a preload that reduces fatigue of the fasteners. The torque values given in the tables in Subject 400



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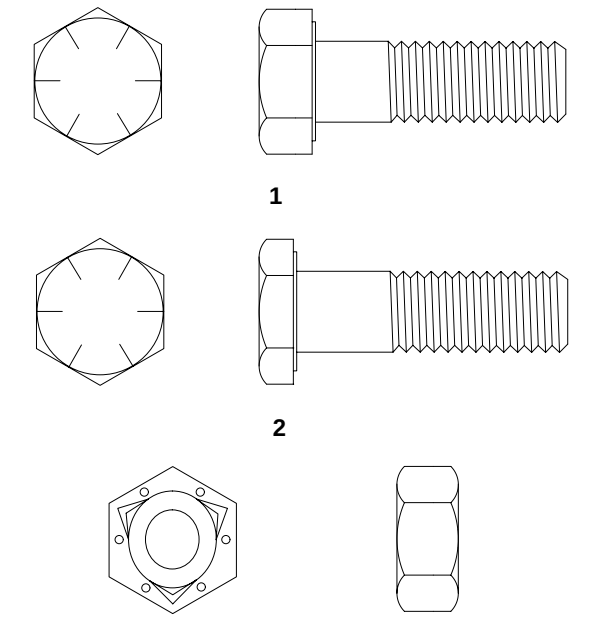
1. Class 8 Nut
2. Class 10 Nut

Fig. 11



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1. Grade 8 Hexhead Bolt
2. Grade 8 Low-Profile Hexhead Bolt
3. Grade C Prevailing Torque Locknut

Fig. 12

General Information

have been calculated to provide enough clamping force on the parts being fastened, and the correct tensioning of the bolt to maintain the clamping force.

Use of a torque wrench to tighten fasteners will help prevent overtensioning them. Overtensioning causes permanent stretching of the fasteners, which can result in breakage of the parts or fasteners.

When torquing a fastener, typically 80 to 90 percent of the turning force is used to overcome friction; only 10 to 20 percent is used to stretch the capscrew or bolt. About 40 to 50 percent of the turning force is needed to overcome the friction between the underside of the capscrew head or nut and the washer. Another 30 to 40 percent is needed to overcome the friction between the threads of the capscrew and the threaded hole, or the friction between the threads of the nut and bolt.

The amount of torque required to tighten a fastener is reduced when the amount of friction is reduced. If a fastener is dry (unlubricated) and plain (unplated), the amount of friction is high. If a fastener is wax-coated or oiled, or has a zinc phosphate coating or cadmium plating, the amount of friction is reduced. Each of these coatings and combinations of coatings has a different effect. Using zinc-plated hardened flatwashers under the bolt (capscrew) head and nut reduces the amount of friction. Dirt or other foreign material on the threads or clamping surfaces of the fastener or clamped part also changes the amount of friction.

Even though each different condition affects the amount of friction, a different torque value cannot be given for each different condition. To ensure they are always torqued accurately, Freightliner recommends that all fasteners be lubricated with oil (unless specifically instructed to install them dry), then torqued to the values for lubricated- and plated-thread fasteners. When locking compound or anti-seize compound is recommended for a fastener, the compound acts as a lubricant, and oil is not needed.

Fastener Replacement

When replacing fasteners, use only identical bolts, washers, and nuts; they must be the same size, strength, and finish as originally specified. See the Freightliner *Parts Book* for fastener specifications.

When replacing graded (or metric class) bolts and capscrews, use only fasteners that have the manufacturer's trademark or identification on the bolt head; don't use substandard bolts. Inferior, counterfeit fasteners are difficult to identify; buy your fasteners from a reputable supplier.

Fastener Selection and Installation

When using nuts with bolts, use a grade (or class) of nut that matches the bolt.

When installing non-flanged fasteners, use hardened steel flatwashers under the bolt (capscrew) head, and under the hexnut or locknut.

For bolts 4 inches (100 mm) or less in length, make sure that at least 1-1/2 threads and no more than 5/8-inch (16-mm) bolt length extends through the nut after it has been tightened. For bolts longer than 4 inches (100 mm), allow a minimum of 1-1/2 threads and a maximum of 3/4-inch (19-mm) bolt length.

Never hammer or screw bolts into place. Align the holes of the parts being attached, so that the nut and bolt surfaces are flush against the washers, and the washers are flush against the parts.

When installing fasteners in aluminum or plastic parts with threaded holes, start the fasteners by hand, to ensure straight starting and to prevent damaged threads.

Don't use lockwashers (split or toothed) next to aluminum surfaces.

When installing studs that don't have an interference fit, install them with thread locking compound, as instructed in this subject.

When installing parts that are mounted on studs, use free-spinning (non-locking) nuts and helical-spring (split) lockwashers or internal-tooth lockwashers. Don't use locknuts, because they tend to loosen the studs during removal. Don't use plain washers (flatwashers).

Don't use lockwashers and flatwashers in combination (against each other); each defeats the other's purpose.

Use stainless steel fasteners against chrome plating, unpainted aluminum, or stainless steel.

Fastener Tightening

Before installing fasteners, clean all fastener (and parts) threads, and all surfaces being clamped.

To ensure they are always torqued accurately, Freightliner recommends that *all* fasteners be lubricated with oil (unless specifically instructed to install them dry), then torqued to the values for lubricated- and plated-thread fasteners. When locking compound or antiseize compound is recommended for a fastener, the compound acts as a lubricant, and oil is not needed.

Bring parts and fasteners into contact, with no gaps between them, before using a torque wrench to tighten fasteners to their final torque values.

Tighten the nut, not the bolt head. This will give a truer torque reading by eliminating bolt body friction.

Always use a torque wrench to tighten fasteners, and use a slow, smooth, even pull on the wrench. Don't overtorque fasteners; overtightening causes permanent stretching of the fasteners, which can result in breakage of the parts or fasteners.

If specific torque values aren't given for countersunk bolts, use the torque value for the corresponding size and grade of regular bolt, as given in Subject 400.

Always follow the torque sequence or torque interval when provided, to ensure that clamping forces are even, and parts and fasteners aren't distorted.

Tighten frame fasteners periodically to offset the effects of "bedding in" (seating). Continued vehicle operation with loose frame fasteners could result in component, bracket, and frame damage. See the Maintenance Schedule(Group 00) and Group 31 of the *Heavy-Duty Trucks Maintenance Manual* for intervals.

Thread Locking Compound Application

When the use of thread locking compound is recommended or desired, for studs, capscrews, and bolts

General Instructions

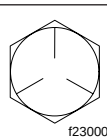
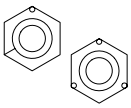
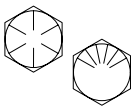
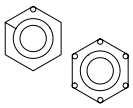
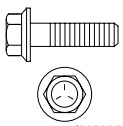
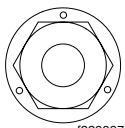
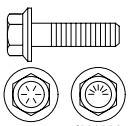
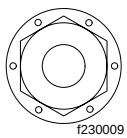
with a thread diameter of 1 inch (25 mm) or less, use Loctite® 271 or Perma-Lok® HM-128.

For thread diameters over 1 inch (25 mm), use Loctite 277.

NOTE: Follow the safety precautions given on the locking compound container.

1. Clean the male and female threads of the fasteners, removing all dirt, oil, and other foreign material. If parts are contaminated, use Stoddard solvent for cleaning; then allow the fasteners to air dry for 10 minutes. Be sure solvent is completely gone before applying adhesive.
2. Transfer a small amount of the locking compound from the container to a paper cup or small non-metal dish.
3. Using a plastic brush (a metal brush will contaminate the compound), apply a small amount of compound to the entire circumference of 3 or 4 of the male threads that will be covered by the nut after it has been tightened. Be sure enough compound is applied to fill the inside of the nut threads, with a slight excess.
4. Install and torque the nut. Readjustment of the nut position is not possible after installation is complete, without destroying the locking effect.

NOTE: To disassemble the fasteners, heat the bond line to 400° F (200° C) before removing the nut. Every time the fasteners are disassembled, replace them. If any parts are damaged by overheating, replace the parts.

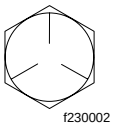
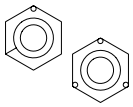
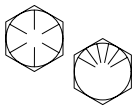
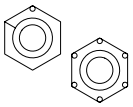
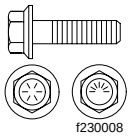
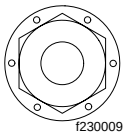
Torque Values for U.S. Customary Thread Fasteners With Lubricated* or Plated Threads†								
Thread Diameter–Pitch	Regular Hex				Flanged			
	Grade 5 Bolt	Grade 5 or B Nut	Grade 8 or 8.2 Bolt	Grade 8 or C Nut	Grade 5 Bolt	Grade B Nut	Grade 8 or 8.2 Bolt	Grade G Nut
	Torque: lbf·ft (N·m)		Torque: lbf·ft (N·m)		Torque: lbf·ft (N·m)		Torque: lbf·ft (N·m)	
	 f230002	 f230003	 f230004	 f230005	 f230006	 f230007	 f230008	 f230009
1/4–20	7 (9)		8 (11)		6 (8)		10 (14)	
1/4–28	8 (11)		9 (12)		7 (9)		12 (16)	
5/16–18	15 (20)		16 (22)		13 (18)		21 (28)	
5/16–24	16 (22)		17 (23)		14 (19)		23 (31)	
3/8–16	26 (35)		28 (38)		23 (31)		37 (50)	
3/8–24	30 (41)		32 (43)		25 (34)		42 (57)	
7/16–14	42 (57)		45 (61)		35 (47)		60 (81)	
7/16–20	47 (64)		50 (68)		40 (54)		66 (89)	
1/2–13	64 (87)		68 (92)		55 (75)		91 (123)	
1/2–20	72 (98)		77 (104)		65 (88)		102 (138)	
9/16–12	92 (125)		98 (133)		80 (108)		130 (176)	
9/16–18	103 (140)		110 (149)		90 (122)		146 (198)	
5/8–11	128 (173)		136 (184)		110 (149)		180 (244)	
5/8–18	145 (197)		154 (209)		130 (176)		204 (277)	
3/4–10	226 (306)		241 (327)		200 (271)		320 (434)	
3/4–16	253 (343)		269 (365)		220 (298)		357 (484)	
7/8–9	365 (495)		388 (526)		320 (434)		515 (698)	
7/8–14	402 (545)		427 (579)		350 (475)		568 (770)	
1–8	—		582 (789)		—		—	
1–12	—		637 (863)		—		—	
1–14	—		652 (884)		—		—	

* Freightliner recommends that all plated and unplated fasteners be coated with oil before installation.

† Use these torque values if either the bolt or nut is lubricated or plated (zinc-phosphate conversion-coated, cadmium-plated, or waxed).

Table 1, Torque Values for U.S. Customary Thread Fasteners With Lubricated or Plated Threads

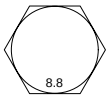
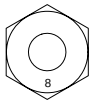
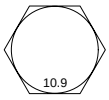
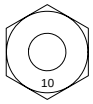
Specifications

Torque Values for U.S. Customary Thread Fasteners With Dry (Unlubricated)* Plain (Unplated) Threads†						
Thread Diameter–Pitch	Regular Hex				Flanged	
	Grade 5 Bolt	Grade 5 or B Nut	Grade 8 or 8.2 Bolt	Grade 8 or C Nut	Grade 8 or 8.2 Bolt	Grade G Nut
	Torque: lbf·ft (N·m)		Torque: lbf·ft (N·m)		Torque: lbf·ft (N·m)	
	 f230002	 f230003	 f230004	 f230005	 f230008	 f230009
1/4–20	8 (11)		10 (14)		—	
1/4–28	9 (12)		12 (16)		—	
5/16–18	15 (20)		22 (30)		22 (30)	
5/16–24	17 (23)		25 (34)		—	
3/8–16	28 (38)		40 (54)		40 (54)	
3/8–24	31 (42)		45 (61)		—	
7/16–14	45 (61)		65 (88)		65 (88)	
7/16–20	50 (68)		70 (95)		—	
1/2–13	70 (95)		95 (129)		95 (129)	
1/2–20	75 (102)		110 (149)		—	
9/16–12	100 (136)		140 (190)		140 (190)	
9/16–18	110 (149)		155 (210)		—	
5/8–11	135 (183)		190 (258)		190 (258)	
5/8–18	155 (210)		215 (292)		—	
3/4–10	240 (325)		340 (461)		340 (461)	
3/4–16	270 (366)		380 (515)		—	
7/8–9	385 (522)		540 (732)		—	
7/8–14	425 (576)		600 (813)		—	
1–8	580 (786)		820 (1112)		—	
1–12	635 (861)		900 (1220)		—	
1–14	650 (881)		915 (1241)		—	

* Threads may have residual oil, but will be dry to the touch.

† Male and female threads (bolt and nut) must both be unlubricated and unplated; if either is plated or lubricated, use **Table 1**. Freightliner recommends that all plated and unplated fasteners be coated with oil before installation.

Table 2, Torque Values for U.S. Customary Thread Fasteners With Dry (Unlubricated) Plain (Unplated) Threads

Torque Values for Metric Thread Fasteners With Lubricated* or Plated Threads†				
Thread Diameter–Pitch	Class 8.8 Bolt	Class 8 Nut	Class 10.9 Bolt	Class 10 Nut
	Torque: lbf·ft (N·m)		Torque: lbf·ft (N·m)	
	 f230010	 f230011	 f230012	 f230013
M6	5 (7)		7 (9)	
M8	12 (16)		17 (23)	
M8 x 1	13 (18)		18 (24)	
M10	24 (33)		34 (46)	
M10 x 1.25	27 (37)		38 (52)	
M12	42 (57)		60 (81)	
M12 x 1.5	43 (58)		62 (84)	
M14	66 (89)		95 (129)	
M14 x 1.5	72 (98)		103 (140)	
M16	103 (140)		148 (201)	
M16 x 1.5	110 (149)		157 (213)	
M18	147 (199)		203 (275)	
M18 x 1.5	165 (224)		229 (310)	
M20	208 (282)		288 (390)	
M20 x 1.5	213 (313)		320 (434)	
M22	283 (384)		392 (531)	
M22 x 1.5	315 (427)		431 (584)	
M24	360 (488)		498 (675)	
M24 x 2	392 (531)		542 (735)	
M27	527 (715)		729 (988)	
M27 x 2	569 (771)		788 (1068)	
M30	715 (969)		990 (1342)	
M30 x 2	792 (1074)		1096 (1486)	

* Freightliner recommends that all plated and unplated fasteners be coated with oil before installation.

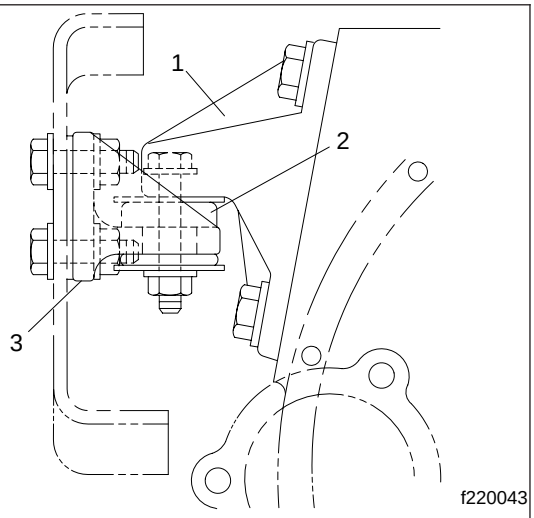
† Use these torque values if either the bolt or nut is lubricated or plated (zinc-phosphate conversion-coated, cadmium-plated, or waxed).

Table 3, Torque Values for Metric Thread Fasteners With Lubricated or Plated Threads

General Information

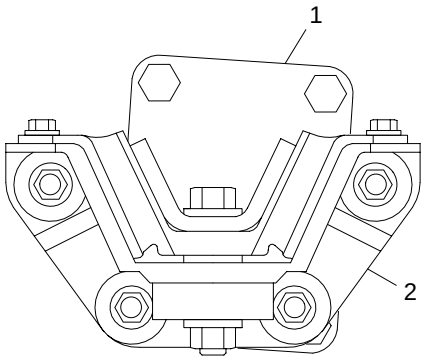
Three mounts support the engine and the transmission, a total of about 3300 lb (1500 kg). Two of the engine mounts support the rear of the engine. The third supports the front.

Each of the rear engine mounts (**Fig. 1** or **Fig. 2**) is bolted to the inside of a frame rail near the flywheel housing. These mounts support brackets (also called "legs") which are bolted to the flywheel housing.



1. Engine Leg
2. Isolator
3. Engine Mount

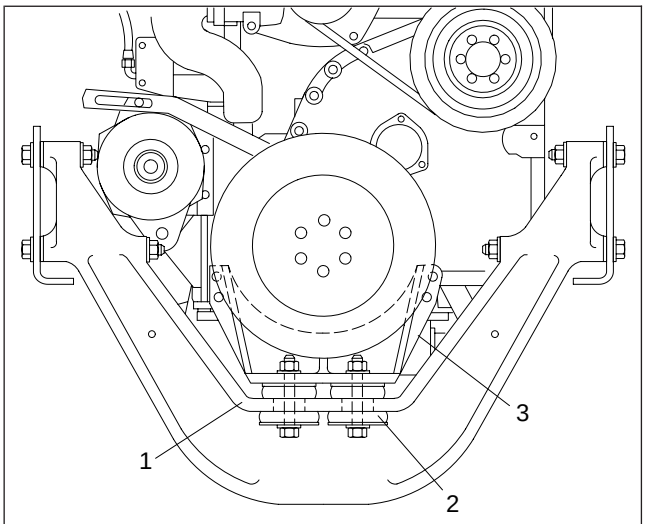
Fig. 1, Typical Rear Engine Mount



1. Engine Leg (bolted to the engine)
2. Engine Mount (bolted to the frame rail)

Fig. 2, Detroit Diesel Series 50 Rear Engine Mount

The front engine mount is an underslung crossmember under the front of the engine. It supports a bracket (**Fig. 3**) which is attached to the engine at each side of the vibration damper pulley.



1. Engine Mount
2. Isolator
3. Engine Bracket

Fig. 3, Typical Front Engine Mount

To isolate the engine and transmission from road shock, and to isolate the vehicle frame from engine vibration, rubber isolators are sandwiched between the engine mount bolted to the frame rail and the bracket (or leg) bolted to the engine. Steel washers protect the isolators from wearing on the brackets, and bolts run through the brackets, washers, and isolators to hold the assembly together and hold the engine on the mount.

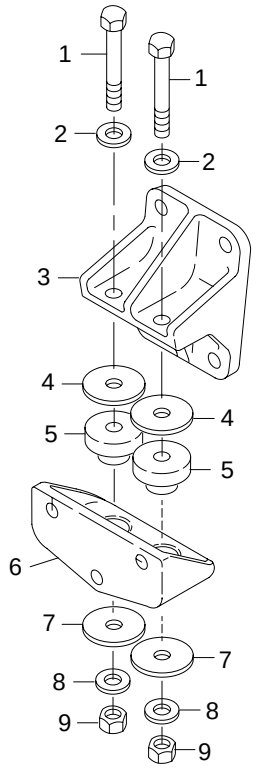
Rear Engine Mount Isolator Replacement

Replacement

1. Apply the parking brakes, chock the tires, and drain the air brake system. As applicable, tilt the cab or the hood. Refer to the vehicle driver's manual for instructions.

NOTE: Replace the isolators in only one engine mount at a time, and when doing so, replace both the isolators in the mount.

2. Disconnect the engine from the applicable rear engine mount. **See Fig. 1** or **Fig. 2.**



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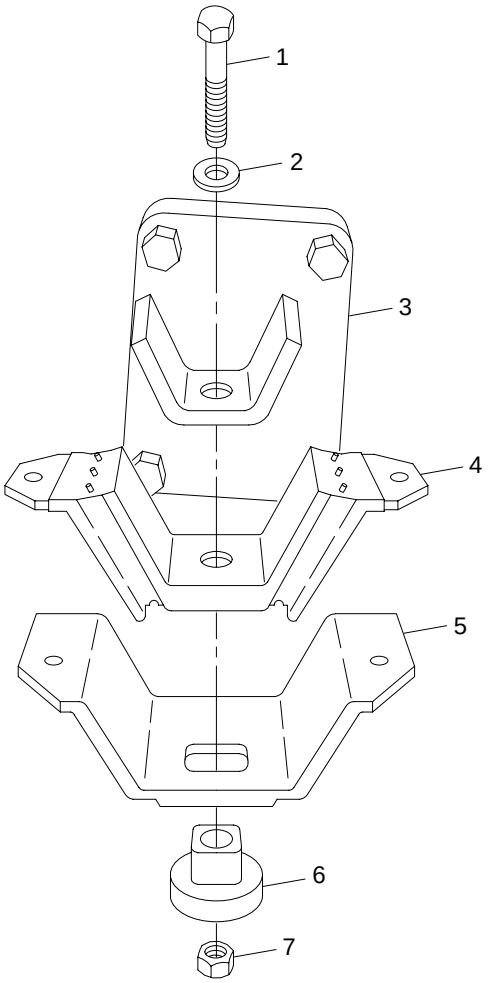
NOTE: Cummins NTC or L10 rear engine mount shown.

1. 5/8-11 Capscrew
2. 5/8-Inch Washer
3. Rear Engine Bracket (Engine Leg)
4. 5/8-Inch Washer (Snubber)
5. Isolator
6. Rear Engine Mount
7. 5/8-Inch Washer (Snubber)
8. 5/8-Inch Washer
9. 5/8-Inch Nut

Fig. 1, Typical Rear Engine Mount Assembly



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1. Capscrew, 3/4-10 x 3.5 Inch
2. Hardened Washer, 3/4-Inch
3. Rear Engine Bracket (Engine Leg)
4. Upper Isolator
5. Rear Engine Mount
6. Lower Isolator
7. Locknut, 3/4-Inch

Fig. 2, Detroit Diesel Series 50 Rear Engine Mount Assembly

WARNING

WARNING: The jack used to lift and lower the engine must be capable of safely lifting and supporting four metric tons. Once the engine mount

Rear Engine Mount Isolator Replacement

is disconnected, immediately support the engine with engine stands. Do not get under an unsecured engine; an unsecured engine may fall, causing personal injury or component damage.

⚠ CAUTION

CAUTION: Before lifting the engine, check the clearance above the engine and transmission assembly. Lift the engine only enough to disconnect the mount. Lifting the engine too high may force it into the underside of the cab, causing component damage.

2.1 Loosen the fan shroud mounting capscrews so the shroud can move downward and will not press against the radiator brace rods as the engine is lifted.

2.2 Place a jack under the rear of the engine, and raise the jack until it's braced against the engine.

2.3 Loosen the bolt(s) which run downward through the rear engine mount that is not being disconnected.

2.4 For the engine mount that is being disconnected, remove the bolt(s) that run downward through the engine bracket, isolators, and engine mount. Save the fasteners and washers. Discard the lower isolator(s).

2.5 Lift the engine until the upper isolator(s) can be lifted out of the engine mount. Place engine stands under the engine to keep it off the engine mount. Remove and discard the upper isolator(s).

⚠ CAUTION

CAUTION: If necessary, lubricate the new isolator(s) with soapy water. Do not lubricate the isolator(s) with oil, grease, or silicone lubricants; they will deteriorate the rubber isolator(s).

3. Install a new upper isolator(s) in the engine mount. If applicable, place washers (snubbers) on the isolators. **See Fig. 1.**

4. Secure the engine to the engine mount.

4.1 If not in place already, set a jack under the rear of the engine, and raise the jack until it's braced against the engine.

4.2 Lift the engine slightly to unload the engine stands. Remove the stands, and carefully lower the engine until the engine bracket rests on the washer(s).

4.3 Install the bolt(s) that runs downward through the engine mount assembly. If applicable, hold the lower isolator in place (**see Fig. 2**). Secure the bolt(s) with a washer(s) and a nut(s). Tighten the nut(s) on both the right and left rear engine mounts as follows:

On Detroit Diesel Series 50 engines, tighten the nuts 241 lbf·ft (327 N·m).

On Detroit Diesel Series 55 engines, tighten the nuts 136 lbf·ft (184 N·m).

On all other engines, tighten the nuts 160 lbf·ft (216 N·m).

4.4 If the fan shroud moved, reposition it, and tighten the fan shroud mounting capscrews.

5. Remove the jack from under the engine, lower the hood or cab, and remove the chocks from the tires.

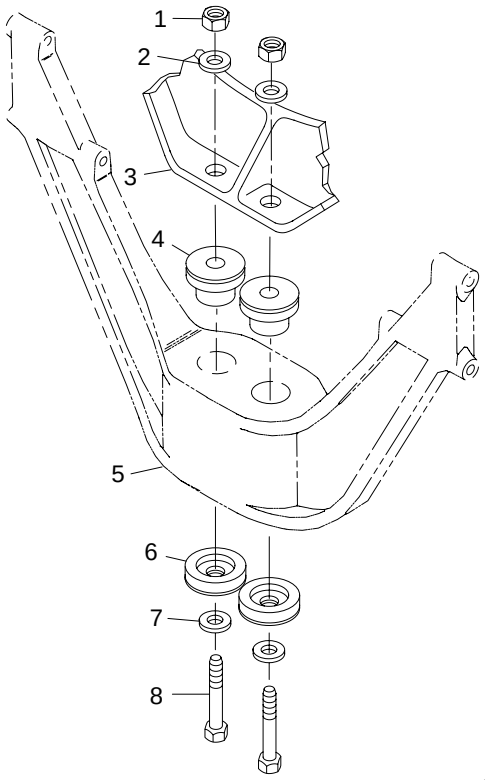
Front Engine Mount Isolator Replacement

Replacement

1. Apply the parking brakes, chock the tires, and drain the air brake system. As applicable, tilt the cab or the hood. Refer to the vehicle driver's manual for instructions.

NOTE: Replace the isolators in only one engine mount at a time, and when doing so, replace all the isolators in the mount.

2. Disconnect the engine from the front engine mount. **See Fig. 1** or **Fig. 2.**



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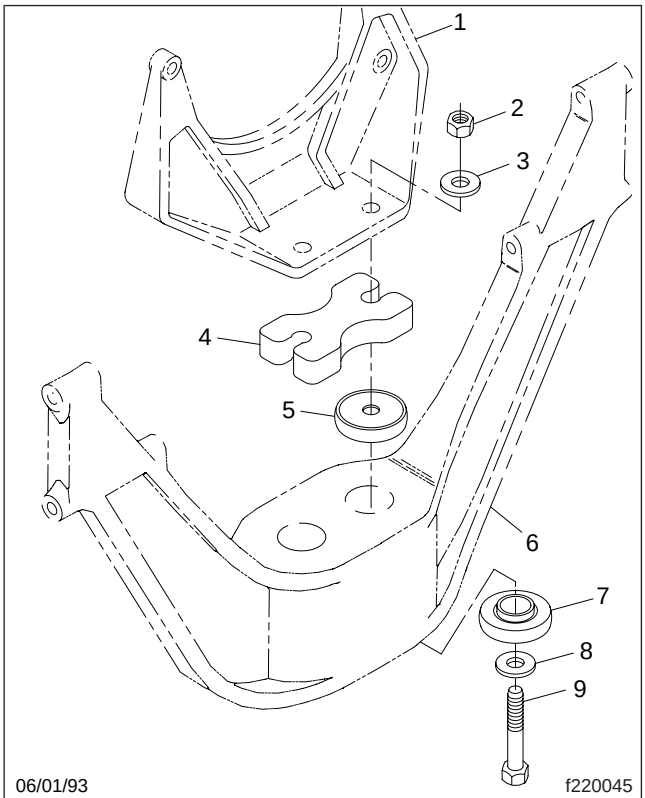
1. 3/4-Inch Nut
2. 3/4-Inch Washer
3. Front Engine Bracket
4. Upper Isolator
5. Front Engine Mount
6. Lower Isolator
7. 3/4-Inch Washer
8. 3/4-Inch Capscrew

Fig. 1, Typical Front Engine Mount Assembly



06/01/93 f220045

1. Front Engine Bracket
2. Locknut, 3/4-Inch
3. Washer, 3/4-Inch
4. Spacer, 1-Inch Thick
5. Upper Isolator
6. Front Engine Mount
7. Lower Isolator
8. Washer, 3/4-Inch
9. Capscrew, 3/4-10 x 5.5 Inch

Fig. 2, Detroit Diesel Series 50 Front Engine Mount

⚠ WARNING

WARNING: The jack used to lift and lower the engine must be capable of safely lifting and supporting four metric tons. Once the engine mount is disconnected, immediately support the engine with engine stands. Do not get under an unsecured engine; an unsecured engine may fall, causing personal injury or component damage.

⚠ CAUTION

CAUTION: Before lifting the engine, check the clearance above the engine and transmission assembly. Lift the engine only enough to disconnect the mount. Lifting the engine too high may

Front Engine Mount Isolator Replacement

force it into the underside of the cab, causing component damage.

2.1 Loosen the fan shroud mounting capscrews so the shroud can move downward and will not press against the radiator brace rods as the engine is lifted.

2.2 Using a chain, connect the engine front lifting eye to a crane, and raise the chain to remove any slack.

2.3 Remove the bolts that run through the front engine mount, isolators, and engine bracket. Save the fasteners and washers. Discard the lower isolators.

2.4 Raise the engine until the two upper isolators can be lifted out of the engine mount. Place engine stands under the engine to keep it off the engine mount. Remove and discard the isolators.

⚠ CAUTION

CAUTION: If necessary, lubricate the new isolators with soapy water. Do not lubricate the isolators with oil, grease, or silicone lubricants; they will deteriorate the rubber isolators.

3. Install two new upper isolators in the engine mount.
4. Secure the engine to the engine mount.

4.1 If not in place already, secure the chain and crane to the front engine lifting eye, and raise the chain to remove any slack.

4.2 Raise the engine slightly to unload the engine stands. Remove the stands, and carefully lower the engine until the engine support bracket rests on the spacer or isolators as applicable.

4.3 Holding the bottom isolators in place, install the bolts through the front engine mount assembly, and secure them with washers and nuts. Tighten the nuts 241 lbf·ft (327 N·m).

4.4 If the fan shroud moved, reposition it. Tighten the fan shroud mounting capscrews.

5. Remove the chain from the lifting eye, lower the hood or cab, and remove the chocks from the tires.

Rear Engine Mount Replacement, EPA07 Engines

Removal

NOTE: The rear engine mounts for EPA07 engines are designed to last for the life of the vehicle, and should not normally need replacing. The isolators are bonded to the brackets and cannot be replaced separately.

If the rear engine mounts need replacing due to damage, or if you are removing and installing the engine, use this procedure.

In the past, substituting softer isolators from the MBE4000 engine was a way to sometimes remedy engine vibration problems with other engines. This will not work with the EPA07 engines, because all the engine isolators now have the same durometer hardness.

1. Shut down the engine, set the parking brake, and chock the tires.
2. Drain the air tanks.
3. Disconnect all the cables from the batteries. Cover them, using dry rags and tie straps.
4. Remove the battery mega-fuse block from the left-side frame rail, underneath the cab. The mounting nuts are inboard of the frame rail.
5. Open the hood.
6. If present, remove the two tow hooks from the right frame rail.
7. Remove the rain tray.
   - 7.1 Mark, then remove the wiper arms.
   - 7.2 Disconnect any hoses or drains from the bottom of the rain tray.
   - 7.3 Remove the fasteners that hold the rain tray to the frontwall.
   - 7.4 Remove the rain tray from the vehicle.
8. Remove the right and left quarter fenders and the inner splash shields.
9. Remove the air intake canister assembly.
10. Remove the mounting bracket for the air intake canister.
11. Remove the turbocharger heat shield.
12. Disconnect the air lines from the primary air tank, then remove the tank from the vehicle.

⚠ DANGER

Aftertreatment Device (ATD) internal temperatures can remain hot enough to cause personal injury, or ignite combustible materials, for hours after the engine is shut down.

To avoid potentially serious burns or material damage:

- Let the ATD cool before handling it; be especially careful when opening it to expose the DPF.
- Wear appropriate protective gear.
- Be careful not to place the ATD where flammable gases or other combustible materials may come into contact with hot interior parts.

13. Make sure the aftertreatment device (ATD) is cool, then remove it from the vehicle.

⚠ CAUTION

The ATD assembly weighs from 125 to 150 pounds (57 to 68 kg) and must be protected from impact or sharp jolts. Dropping the ATD, or subjecting it to jarring impact can crack the diesel particulate filter (DPF) inside, which is built on a ceramic substrate. If that happens, the DPF is ruined and must be replaced.

A secure support is necessary to remove and install the ATD safely. The ATD must be held securely to protect it from falling, or hitting hard against something else.

The horizontal ATD lifting device (TLZ00785) is designed to handle a horizontal ATD. Vertical ATDs require a shop hoist secured to the lifting ears on top.

- 13.1 Put a transmission jack (or equivalent) under the ATD, and strap the ATD to the jack.
- 13.2 Disconnect the five sensors from the ATD.

⚠ WARNING

Wear adequate eye protection, such as safety goggles or a face shield, when working with the ATD mounting bands. The mounting bands are

Rear Engine Mount Replacement, EPA07 Engines

under spring tension, and can cause eye injury or other personal harm if they spring out of control.

13.3 Remove the Marmon clamps from each end of the ATD.

13.4 Disconnect the ATD from the exhaust tubing, and remove it from the vehicle. Keep the ATD strapped to the jack, and make sure it is placed away from any combustible materials.

14. Remove the cab skirts from both sides of the vehicle.
15. Disconnect and remove the exhaust tubing from the turbocharger.
16. As applicable, remove the steps, air fairings, fuel tank(s), and/or the battery box.

    For instructions on removing the fuel tank(s), refer to **Group 47** in this manual.

17. Remove the fasteners that hold the driveline midship-bearing bracket to the frame crossmember.
18. Using suitable straps, secure the driveline and the midship bearing to the frame crossmember. Make sure the driveshaft is supported loosely enough so that the slip joint aft of the midship bearing will be able to extend when the engine is raised.
19. Remove the overslung crossmember from the transmission housing.

    19.1 If present, remove the standoff bracket for the A/C refrigerant line from the top of the overslung crossmember. Leave the line attached to the bracket.

    19.2 Remove the fasteners that hold the overslung crossmember to the transmission housing, then remove it.

20. Disconnect both ends of the clutch linkage and remove it from the vehicle.
21. Remove the shifter and shifter boot from the transmission.
22. Raise the front of the vehicle so the tires are off the ground, and support it with safety stands. Put the safety stands behind the rear spring hangers for the front suspension.

WARNING

Never work around or under a vehicle that is supported only by a jack. Always support the vehicle with safety stands. Jacks can slip, allowing the vehicle to fall, which could result in serious injury or death.

23. From underneath the vehicle, install a suitable lifting bracket or stand, such as an engine shipping stand (for Detroit Diesel Series 60 engines) on the rear of the engine. See **Fig. 1**.

    If using the Detroit Diesel engine shipping stand, there should be two holes on each side of the engine block, just forward of the bell housing. These should match up with the holes in the engine shipping stand. When any stand or bracket is installed correctly, it should not be touching the floor, and should be wide enough and strong enough to support a jack to raise the engine.

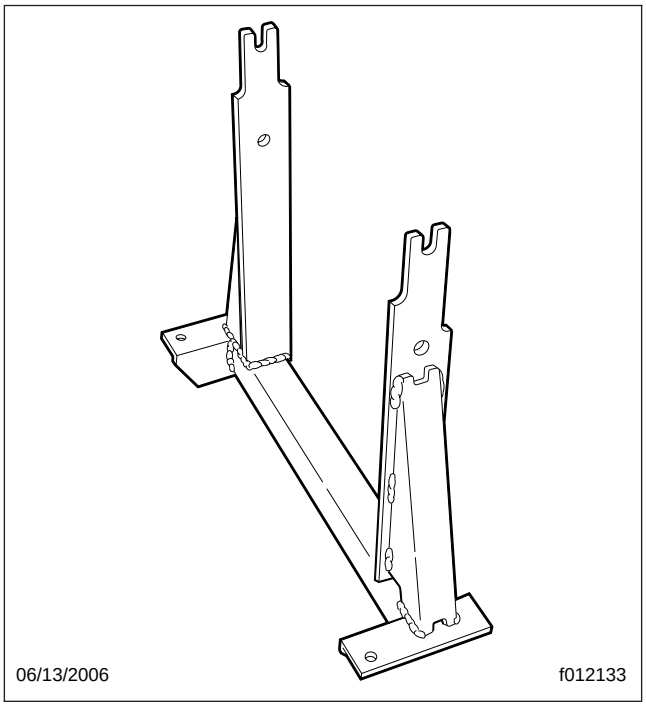
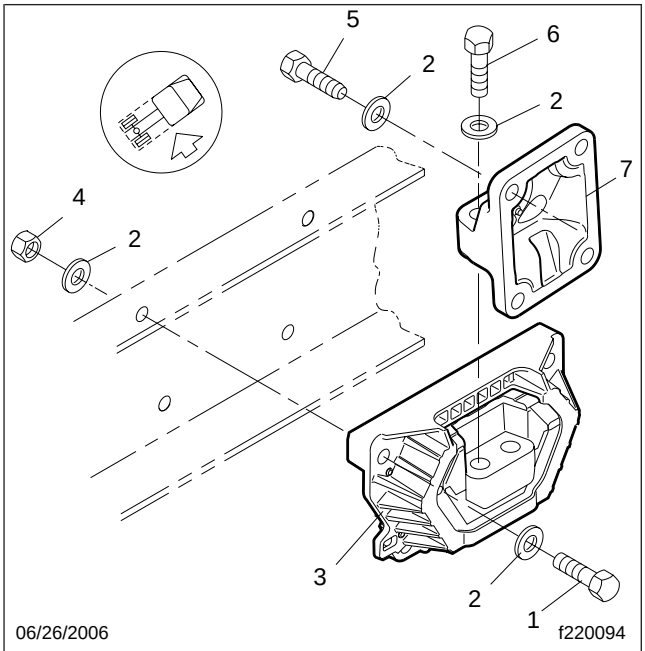


Fig. 1, Engine Shipping Stand, Detroit Diesel Series 60 Engine

24. If present, remove the starting aid bottle from the left-side frame rail.
25. On one side of the vehicle, remove the two mounting hexbolts that hold the engine leg to the

frame-rail engine mount. See **Fig. 2**. If needed, repeat the procedure on the other side of the vehicle.



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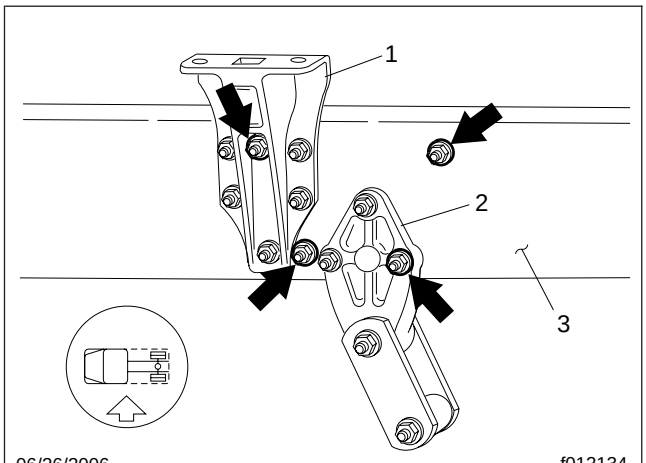
1. Hexbolt, 5/8–11
2. Hardened Washer
3. Rear Engine Mount Assembly
4. Hexnut, 5/8–11
5. Capscrew, 5/8–11
6. Capscrew, 3/4–10
7. Engine Leg

Fig. 2, Rear Engine Mount and Engine Leg

26. Place a jack under the engine shipping stand (or other suitable stand/bracket) attached to the rear of the engine, and gradually raise that side of the engine until the bottom of the engine leg is above the top of the frame rail.
27. Remove the four fasteners that hold the rear engine mount to the frame rail. See **Fig. 3**.
28. Remove the rear engine mount from the vehicle.
29. If needed, remove the four bolts that hold the engine leg to the transmission housing. Remove the engine leg.



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NOTE: The engine mount is not visible in this view.

1. Cab Mounting Bracket
2. Front Spring-Shackle Hanger
3. Frame Rail

Fig. 3, Engine Mount-to-Frame Rail Fasteners

Installation

1. If applicable, install the engine leg on the bell housing. Apply Loctite® 271 (or equivalent) to the threads of the capscrews, and tighten to 320 lbf·ft (434 N·m).
2. With the engine supported, install the rear engine mount on the frame rail. Install the four 5/8–11 hexbolts with the bolt heads inboard. Tighten the hexnuts 136 lbf·ft (184 N·m).
3. If applicable, repeat the above procedure on the other side of the vehicle.
4. Lower the engine onto the rear engine mount.
5. Apply Loctite 271 to the threads of the two 3/4–10 hexbolts. Install them and the hardened washers in the holes of the engine leg and the rear engine mount and tighten to 320 lbf·ft (434 N·m).
6. Remove the fasteners that hold the engine shipping stand to the side of the transmission, and remove the stand.
7. Install the clutch linkage.
8. Install the overslung crossmember.
9. Install the shifter and shifter boot on the transmission.

Rear Engine Mount Replacement, EPA07 Engines

10. Install the standoff bracket for the A/C refrigerant line, then attach the line to the bracket.
11. If it was removed, install the starting aid bottle to the left-side frame rail.
12. Attach the driveline midship bearing and its bracket to the frame crossmember.
13. Connect the exhaust tubing to the turbocharger.
14. Install the cab skirts to the bottom of the cab.
15. Install the ATD to the exhaust tubing. As previously marked, connect the wiring to the sensors on the ATD.
16. Install the primary air tank and connect the air lines to it.
17. In the engine compartment, install the turbocharger heat shield.
18. Install the mounting bracket for the air-intake canister.
19. Install the air-intake canister to the mounting bracket.
20. Install the right and left inner splash shields.
21. Install the right and left quarter fenders.
22. As applicable, install the steps, air fairings, fuel tank(s), and/or the battery box.

    For instructions on installing the fuel tank(s), refer to **Group 47** in this manual.
23. Using the previously removed fasteners, install the rain tray on the frontwall.
24. Connect the hoses and drains to the bottom of the rain tray.
25. As previously marked, install the wiper arms.
26. If they were removed, install the two tow hooks on the side of the right frame rail.
27. Close the hood.
28. Install the battery mega-fuse block on the left-side frame rail, underneath the cab.
29. Connect the battery cables.
30. Remove the chocks.

Specifications

Engine Mount Torques, Pre-EPA07 Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Front Engine Mount Bolt	8	3/4–10	241 (327)
Rear Engine Mount Bolt			
Detroit Diesel Series 50 Engine	8	3/4–10	241 (327)
Detroit Diesel Series 55 Engine	8	5/8–11	136 (184)
All Other Engines	8	5/8–11	160 (216)
Engine Leg-to-Flywheel Bolts			
Detroit Diesel Series 60 Engine	8	5/8 –11 x 1.75 inches	136 (184)
Caterpillar C10/12/13/15/16 Engines	8	3/4 –10 x 2 inches	190 (258)
MBE4000 Engine	10.9	M16 x 1.5 x 50 mm (upper) M16 x 1.5 x 40 mm (lower)	175 (237)

Table 1, Engine Mount Torques, Pre-EPA07 Engines

Engine Mount Torques, EPA07 Engines			
Description	**Fastener Size**	**Grade/ Class**	**Torque: lbf·ft (N·m)**
Engine Mount-to-Frame Rail Capscrew	5/8–11	8	120–152 (163–206)
Engine Leg-to-Flywheel Housing Bolts:			
Detroit Diesel Series 60 Engines	5/8–11 x 2-1/4 Inch	8	136 (184)
MBE4000 Engines	M16 x 1.5 x 60 mm (upper) M16 x 1.5 x 50 mm (lower)	10.9	175 (237)
Caterpillar Engines (C13 & C15)	3/4–10 x 2-3/4 Inch	8	170–210 (230–285)
Engine Leg-to-Engine Mount Capscrew	3/4–10	8	300 (407)
Front Engine Bracket-to-Front Engine Mount Capscrew	3/4–10	8	213–269 (289–365)

Table 2, Engine Mount Torques, EPA07 Engines

General Description and Principles of Operation

Normal engine operation produces a variety of contaminants such, as resins and gums. The bypass oil filter, used with a full-flow filter, traps these contaminants and prevents excessive wear of engine parts.

The Fleetguard model LF 750 bypass filter bleeds a small portion of oil flow from the oil lubrication system and returns filtered oil directly to the engine. The bypass filter removes small contaminants that the full-flow filter does not capture.

Engine oil enters through the inlet check valve assembly, filling the filter housing. **See Fig. 1 .** In the housing, pressure forces the oil through the sides of the filter element. Filtered oil is channeled through openings in the hold-down assembly, then collected in the outlet tube. From the outlet tube, filtered oil goes back to the engine through the outlet check valve assembly.

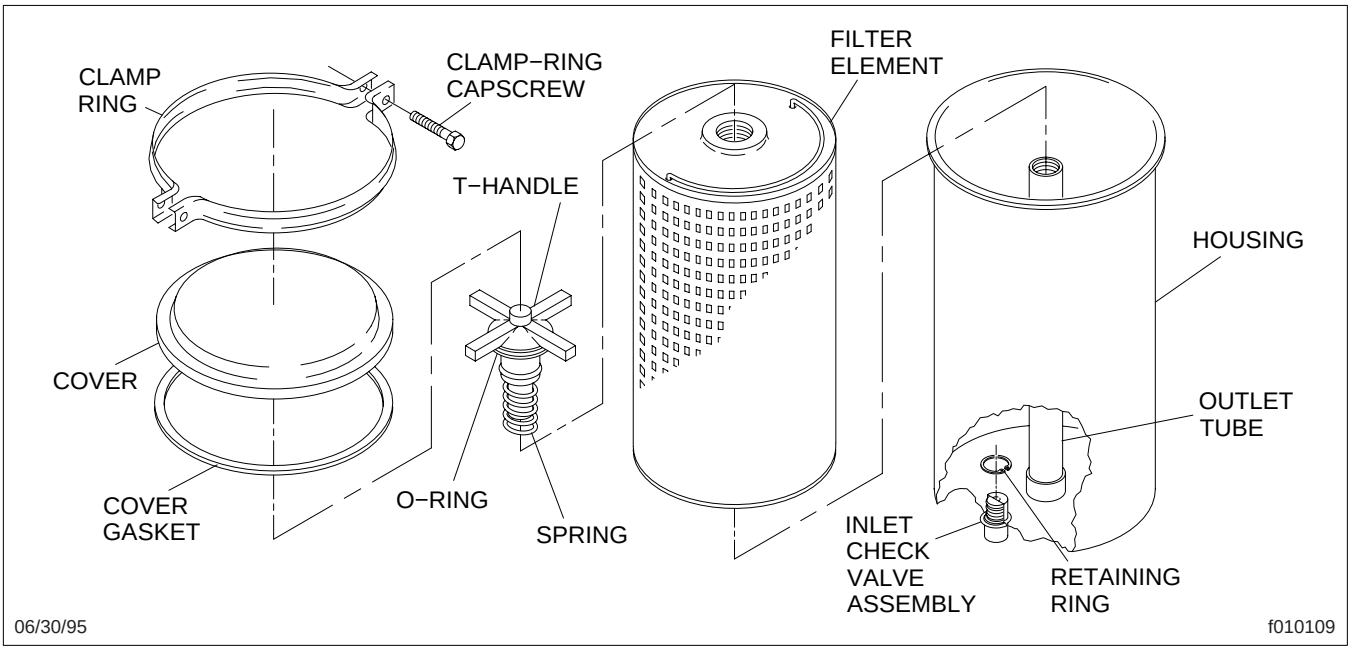


Fig. 1

Replacement (See Fig. 1)

IMPORTANT: Do the following at every scheduled engine oil change. Refer to the vehicle maintenance manual for the quantity of oil that must be added to the lubrication system when replacing the bypass filter.

1. Remove the drain plug and allow the oil to drain.
2. Remove the clamp-ring capscrews. Remove the clamp ring and lift the cover off the filter housing.
3. Unscrew the hold-down assembly T-handle and remove the assembly from the housing. Check the O-ring and spring for damage. Replace if needed.
4. Remove and discard the oil filter element.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

5. Clean the inside of the housing, and the hold-down assembly, with solvent.
6. Install the drain plug.
7. Install a new filter element.
8. Install the hold-down assembly and securely tighten the T-handle.
9. Check the cover gasket for damage, and replace it if needed. Position the gasket on the housing.
10. Position the cover on the housing. Install the clamp ring and capscrews. Alternately tighten the capscrews to ensure a uniform seal between the cover and gasket.
11. Start the engine and let it idle until normal operating oil pressure is reached.
12. Add oil as needed to bring the oil level up to the high ("H") mark on the dipstick.

⚠ CAUTION

CAUTION: Operating the engine with the oil level below the low ("L") mark, or above the high mark, could result in engine damage.

Oil Filter Element Replacement

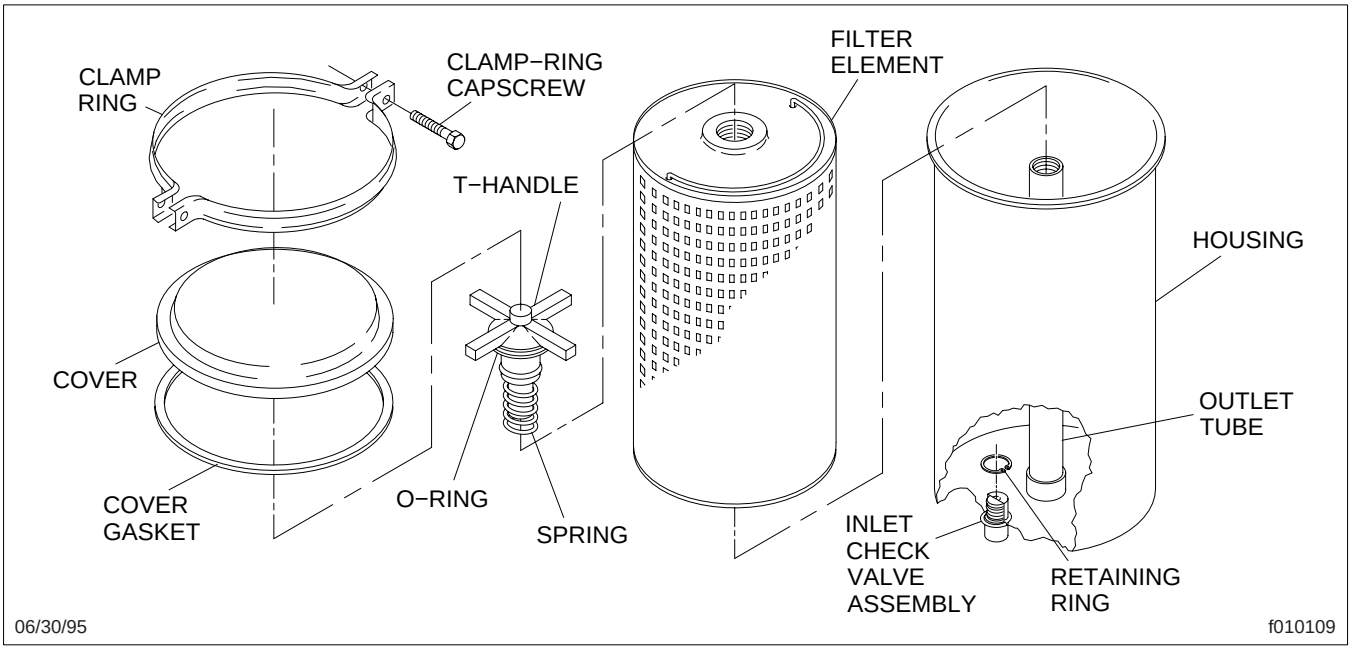


Fig. 1

General Information and Principles of Operation

Normal engine operation produces a variety of contaminants such as resins, and gums. The bypass oil filter, used with a full-flow filter, traps these contaminants and prevents excessive wear of engine parts.

The Luber-finer model 750-CT bypass filter bleeds a small portion of oil flow from the oil lubrication system and returns filtered oil directly to the engine. The bypass filter removes small contaminants that the full-flow filter does not capture.

Engine oil enters through the inlet check valve assembly, filling the filter housing. **See Fig. 1.** In the housing, pressure forces the oil through the sides of the filter element. Filtered oil is channeled through openings in the hold-down assembly, then collected in the outlet tube. From the outlet tube, filtered oil goes back to the engine through the outlet check valve assembly.

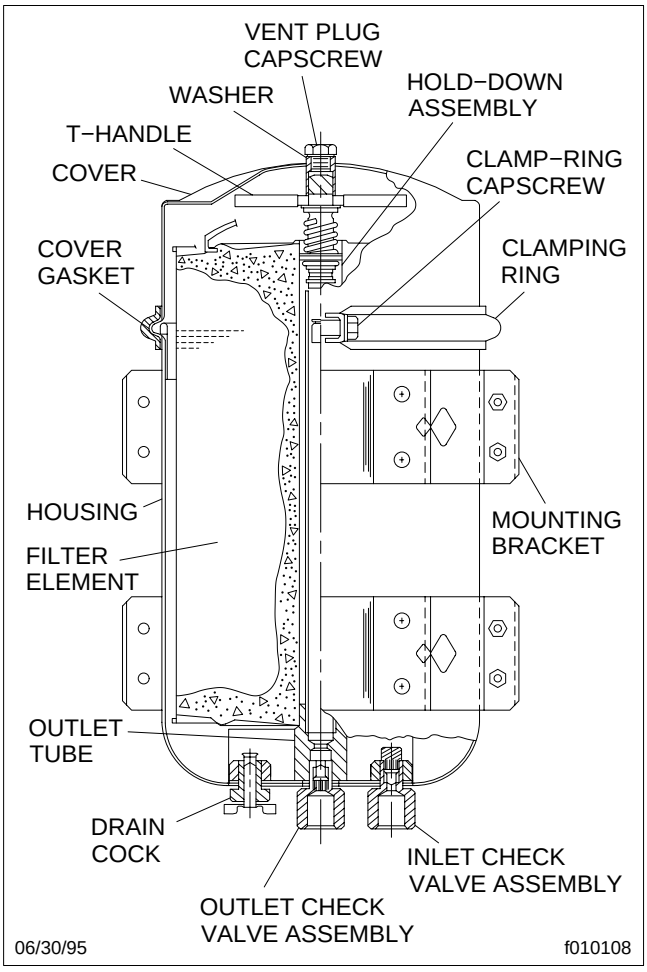


Fig. 1, Luber-finer Model 750-CT Bypass Oil Filter

Replacement (See Fig. 1)

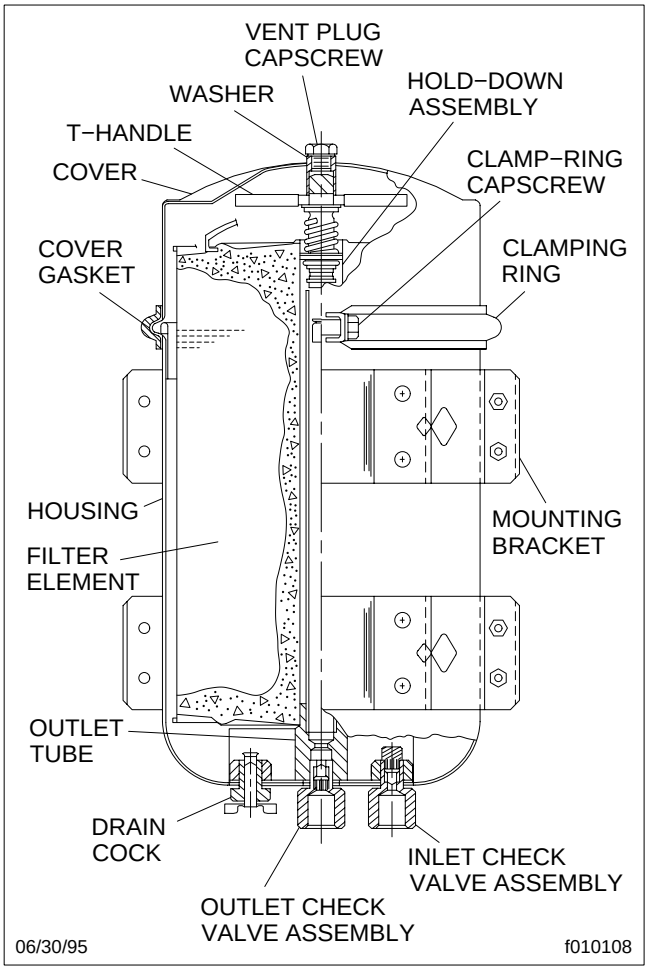


Fig. 1

IMPORTANT: Do the following procedure at every scheduled engine oil change. Refer to the vehicle maintenance manual for the quantity of oil that must be added to the lubrication system when replacing the bypass filter.

1. Loosen the vent plug capscrew, then open the drain cock and allow the oil to drain.
2. Remove the clamp-ring capscrews. Remove the clamp ring and lift the cover off the filter housing.
3. Unscrew the hold-down assembly T-handle and remove the assembly from the housing.
4. Remove and discard the oil filter element.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

5. Clean the inside of the housing, and the hold-down assembly, with solvent.
6. Close the drain cock.
7. Install a new filter element.
8. Check the cover gasket for damage, and replace it if needed.
9. Install the hold-down assembly and securely tighten the T-handle.
10. Position the cover on the housing. Install the clamp ring and capscrews. Alternately tighten the clamp capscrews to ensure a uniform seal between the cover and gasket.
11. Add oil to the crankcase, then start the engine and let it idle until normal operating oil pressure is reached.
12. Loosen the vent plug capscrew and bleed any trapped air from the filter housing. Tighten the vent plug capscrew as soon as oil appears at the fitting.
13. Shut down the engine and add oil as needed to bring the oil level up to the high ("H") mark on the dipstick.

⚠ CAUTION

CAUTION: Operating the engine with the oil level below the low ("L") mark, or above the high mark, could result in engine damage.

General Information (See Fig. 1)

The Caterpillar 3176 electronic engine uses sensors, a personality module, transducer module, speed buffer, and a computer (electronic control module) to automatically control engine timing and fuel injection. The electronic features of this engine include an electronic governor, fuel-to-air ratio control, programmable engine ratings, injection timing control, engine retarder interface, fault analysis and recording, and a data link used for programming customer specified parameters and troubleshooting the system.

There are a few differences between the 1991 and the pre-1991 engines, such as circuit numbers and electrical connectors (see **Fig. 1**). To determine which version an engine is, check the serial number on the Electronic Control Module (see **Fig. 1**). Pre-1991 version engines have "2YG" before the serial number, and 1991 versions have "7LG" before the serial number. See **Table 1** for the major differences between the two versions.

Feature	Pre-1991 Version	1991 Version
Number on Electronic Control Module	2YG	7LG
J7 Vehicle Connector	23-Pin	40-Pin
Throttle Control	Adjustable Mechanical Linkage With Throttle Position Sensor Separate from Throttle Pedal	Electronic Throttle Pedal With Integral Throttle Position Sensor; No Mechanical Linkage

Table 1, Caterpillar 3176 Versions

Mounted directly on the electronic control module are the personality and transducer modules. The personality module contains the operating program and the performance specifications for that particular engine family. The control module stores customer specified parameters for that engine. The transducer module

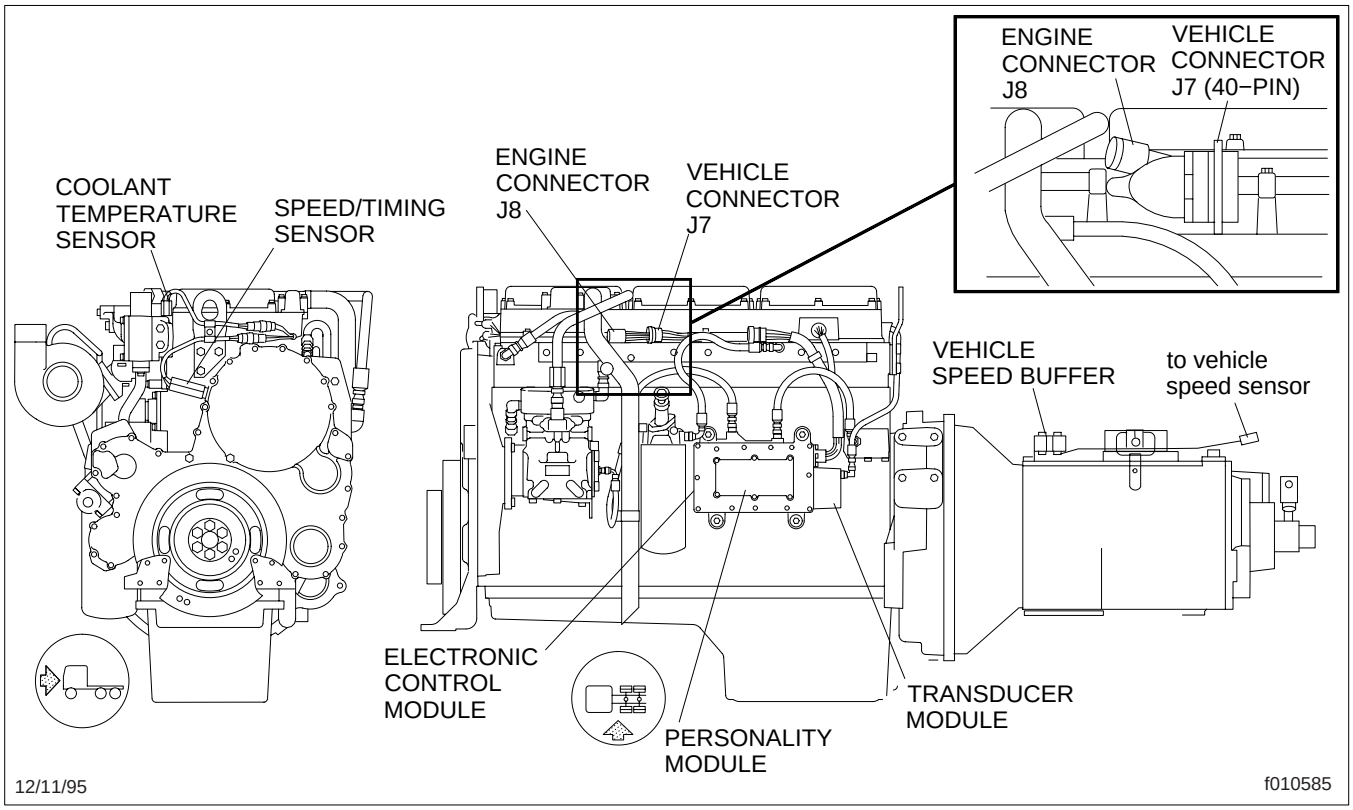


Fig. 1

contains the boost pressure sensor and monitors ambient air pressure through the air cleaner.

Other sensors needed to control the engine through the control module include the speed/ timing sensor, coolant temperature sensor, vehicle speed sensor, and throttle position sensor.

The 3176 electronic engine system is self-diagnostic, providing the operator with codes to indicate both malfunctioning components and engine-related problems. If potentially damaging conditions are detected, the system will limit engine operation, or shut down the engine (depending on installed options).

The 3176 electronic engine system provides the following engine governing modes:

- Vehicle speed limit (VSL), which limits maximum vehicle speed to a preset fuel efficient range. The vehicle speed limit is usually set 2 to 4 mph (3 to 6 km/h) above the maximum cruise control speed.
- Top engine limit (TEL), which limits the maximum engine rpm for fuel efficiency. The top engine limit can be set between the rated engine rpm (minus 79 rpm) and rated engine rpm (plus 20 rpm). For example, if the rated engine rpm is 1800, then the top engine limit can be set between 1721 rpm (1800 minus 79) and 1820 rpm (1800 plus 20).
- Progressive shifting, which limits maximum engine speed while shifting through the gears. This programmable feature limits engine acceleration rates at specified vehicle speeds and gears. Since the engine uses only the rpm needed to get into the next gear, fuel is not wasted by "winding up" the rpm in each gear to gain speed.
- PTO governor designed for power takeoff operations. The PTO governor operates at any engine speed from low idle to a maxi-mum that is less than the rated engine speed.
- Idle shutdown timer, which is a programmed delay of engine shutdown after the vehicle is stopped and the parking brake is applied. This delay can be from 3 to 60 minutes.
- Cruise control, which maintains vehicle speed between operator selected limits.

Two of these operating modes, cruise control and PTO governing, are driver-activated and controlled with two switches mounted to the left of the ignition switch (see **Fig. 2**). The remaining operating modes perform automatically and according to programmed specifications. Refer to the applicable Freightliner driver's manual for operating instructions.

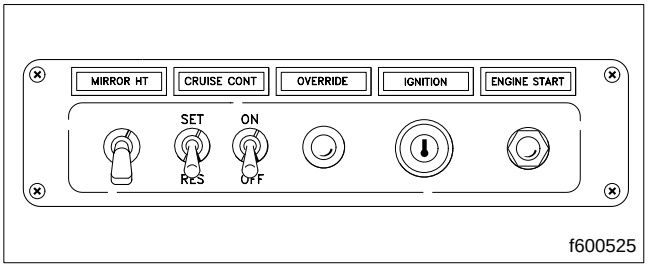


Fig. 2

Caterpillar engines with serial numbers from 7LG07500 have a new engine monitoring system that warns the driver if there are problems with coolant temperature, coolant level, or oil pressure. (The engine serial number is on a plate located on the right rear side of the engine block.) This system has four operating modes:

- *Off*— the monitoring system is not working.
- *Warning*— the system simply alerts the driver if the coolant temperature, coolant level, or oil pressure is outside normal conditions.
- *Derate*— in addition to alerting the driver, the system lowers the maximum speed and horsepower.
- *Shutdown*— in addition to the "warning" and "derate" modes, the system will shut down the engine if conditions require it.

Principles of Operation

FUEL SYSTEM (See Fig. 3)

Fuel flows from the fuel transfer pump through internal passages in the electronic control module housing to cool the module. The fuel is then routed through a 5 micron filter before entering the fuel supply manifold and the unit injectors. A siphon brake is located on the fuel manifold to prevent siphoning and drain-back from the injectors. Unused fuel is returned to the tank by the fuel return manifold.

A pressure relief valve is located on the fuel return manifold outlet to maintain 80 psi (550 kPa) pressure in the system to fill the unit injectors.

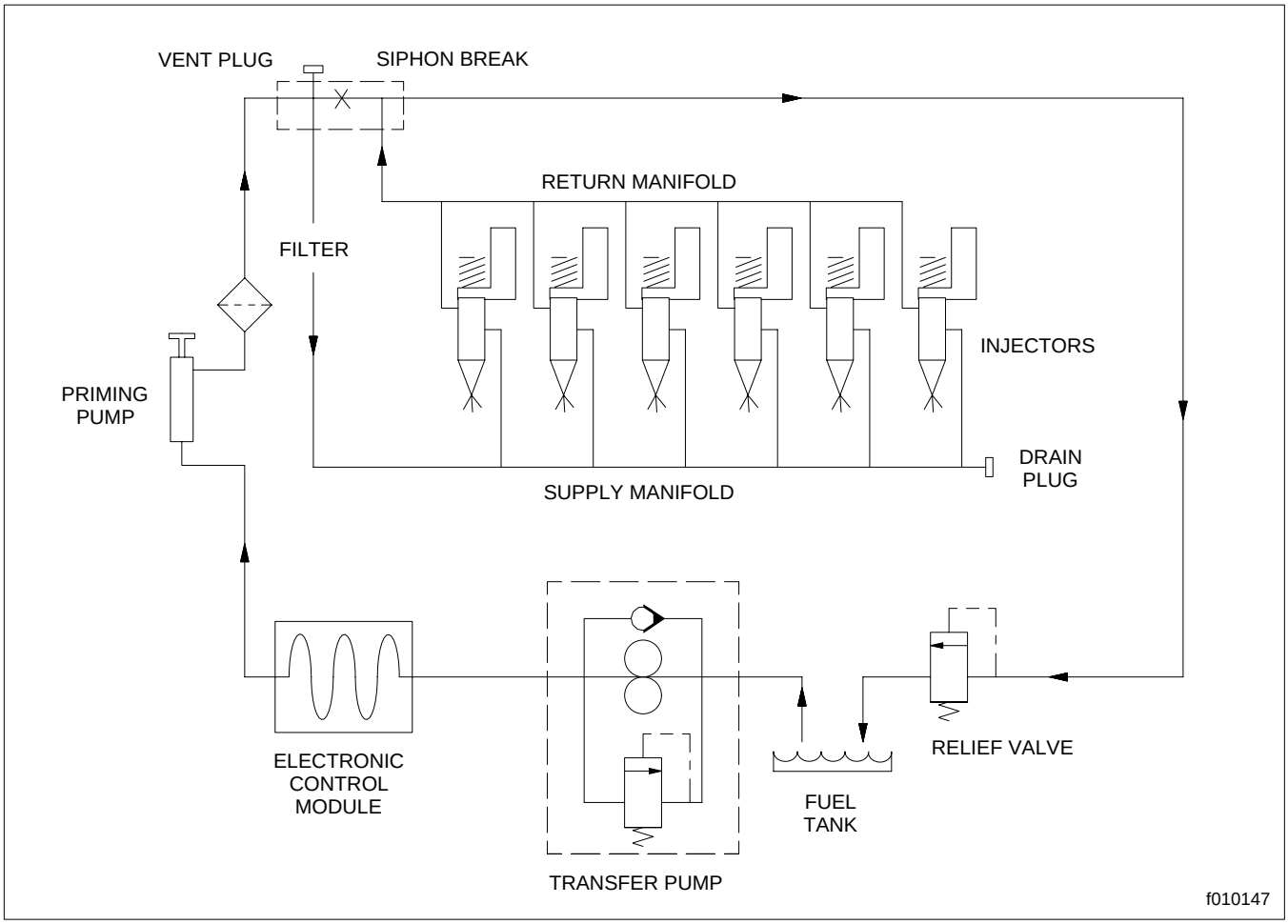


Fig. 3

UNIT INJECTORS

The electronically controlled, mechanically actuated injectors are mounted in the cylinder head. When the camshaft is not applying pressure to the injector plunger (**Fig. 4**), a spring keeps the plunger retracted. Fuel flows through the open fill port into the barrel, and continues through the injector passages fed by the low-pressure fuel transfer pump. During this period, the pressure is too low to unseat the spring-loaded check valve at the injector's tip. Most fuel passes through the injector to the open fuel spill valve and out the spill port to a fuel return manifold and back to the tank. This flow of fuel cools the injector.

As the camshaft turns, it starts to drive the plunger down (see **Fig. 5**). After the plunger closes the fill port, the barrel is full and fuel injection is controlled by the electronic control module. If the control module doesn't send the signal to start injection (by closing the spill valve), the fuel in the injector is displaced through the spill port as the plunger continues to travel down.

When the electronic control module signals to start injection, the solenoid pulls the fuel spill valve up, closing the fuel path to the spill port. With this valve closed, pressure rises quickly at the injector tip as the plunger continues to be driven down by the camshaft. At 5500 psi (38 000 kPa), the force of the spring loaded check valve is overcome and the valve unseats, allowing fuel to be injected into the cylinder (see **Fig. 6**).

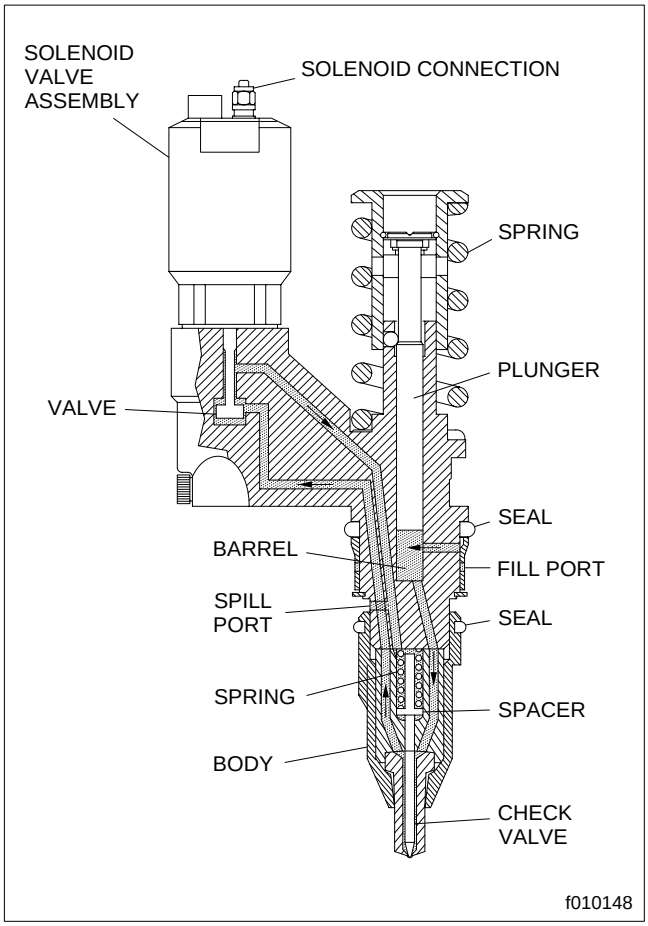


Fig. 4

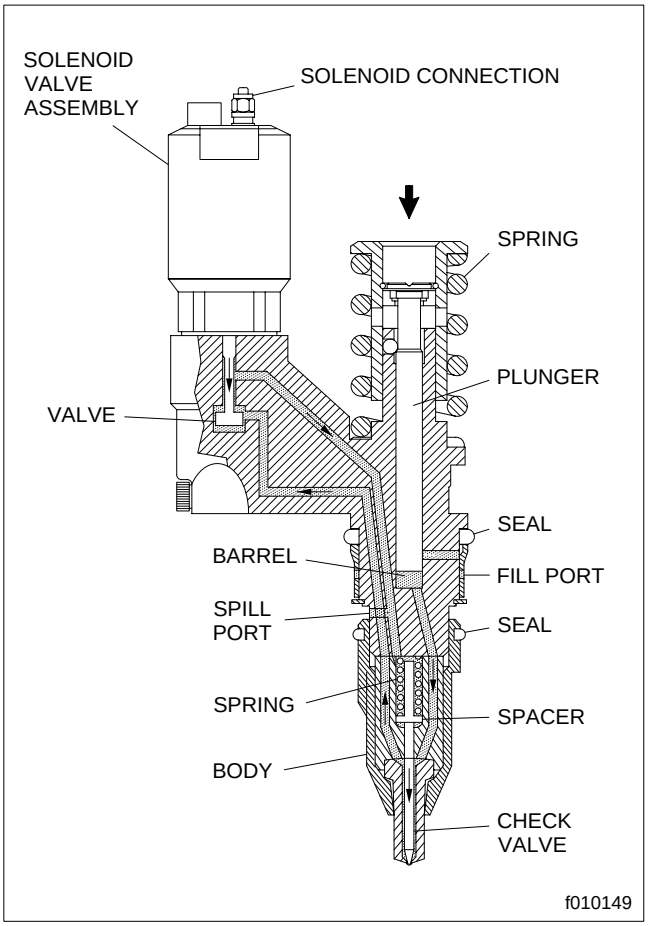


Fig. 5

Fuel is injected until the electronic control module signals the solenoid to open the fuel spill valve. With the fuel spill valve open, fuel passes out of the spill port and the pressure at the injector tip drops, allowing the spring-loaded check valve to reseat and stop fuel injection. The plunger continues down forcing fuel out the spill port.

AIR INLET AND EXHAUST SYSTEM (Fig. 7)

The intake and exhaust systems are located on the right (passenger's) side of the engine and are arranged for air-to-air aftercooling only. After charge air flows through the aftercooler, it goes to the intake manifold where it is distributed to three plenum chambers in the cylinder head, and then through the inlet valves to each cylinder.

To optimize engine performance and acceleration, an exhaust manifold with a divided turbocharger turbine housing is used. It has the front three cylinders connected to one entry on the split turbine housing of the turbocharger, and the rear three cylinders connected to the other entry.

VALVE MECHANISM

The valves and valve mechanism control the flow of inlet air and exhaust gases into and out of the cylinders during engine operation. The camshaft has three cam lobes for each cylinder. Two lobes operate the intake and exhaust valves, and one operates the unit injector mechanism. Each cylinder has two intake and two exhaust valves.

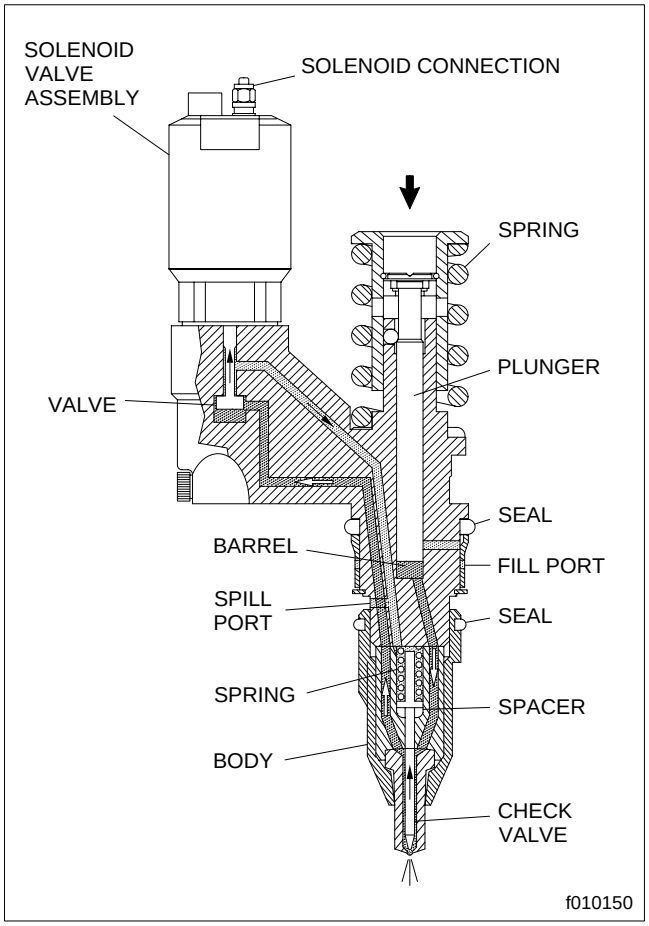


Fig. 6

LUBRICATION SYSTEM (Fig. 8 and Fig. 9)

The oil pump is attached to the back of the front gear train on the lower right hand side of the engine. It is driven by an idler gear from the crankshaft gear.

The lubrication system supplies filtered oil at about 40 psi (275 kPa) under all engine operating conditions. An oil pump bypass valve is controlled by engine oil manifold pressure rather than the oil pump pressure. The oil manifold pressure then becomes independent of the oil filter and oil cooler pressure drop.

The oil cooler bypass valve is thermostatically controlled to maintain 230°F (110°C) oil-to-bearing temperature. A high-pressure relief valve, set to open at

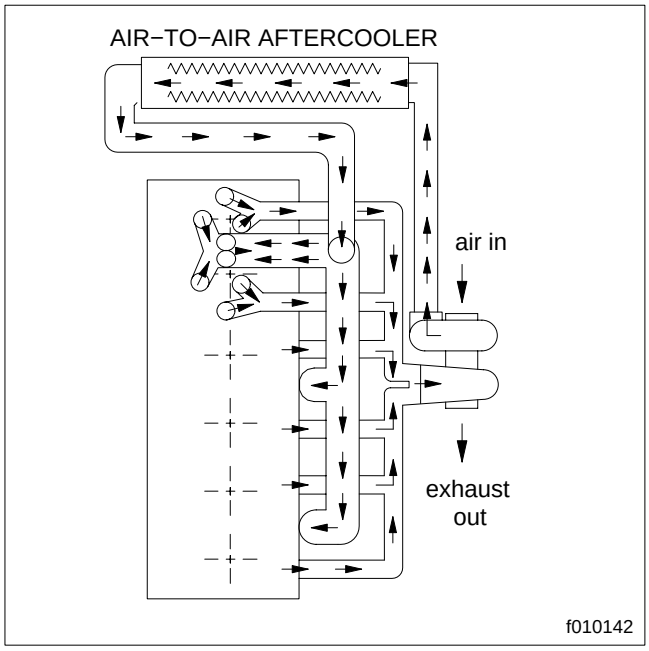


Fig. 7

100 psi (689 kPa), is located in the filter base, and protects the filters and other components during cold starts.

COOLANT FLOW (Fig. 10)

Engine coolant is pumped through the oil cooler and into the supply manifold. The supply manifold, located in the cylinder block spacer block, distributes coolant at each cylinder then flows around and cools the upper portion of the cylinder liner.

At each cylinder, coolant flow from the liner enters the cylinder head, which is divided into two cooling sections. In the cylinder head, coolant flows across the center of the cylinder and the injector seat boss. At the center of the cylinder, coolant flows up around the injector sleeve, over the exhaust port, and exits into the return manifold. The return manifold collects the coolant from each cylinder and directs the flow to the temperature regulator housing.

ENGINE ELECTRONICS

The electronic unit injector system eliminates many of the mechanical components of a "pump and line" system. It also provides increased control of timing and fuel-air ratio. Timing advance is achieved by pre-

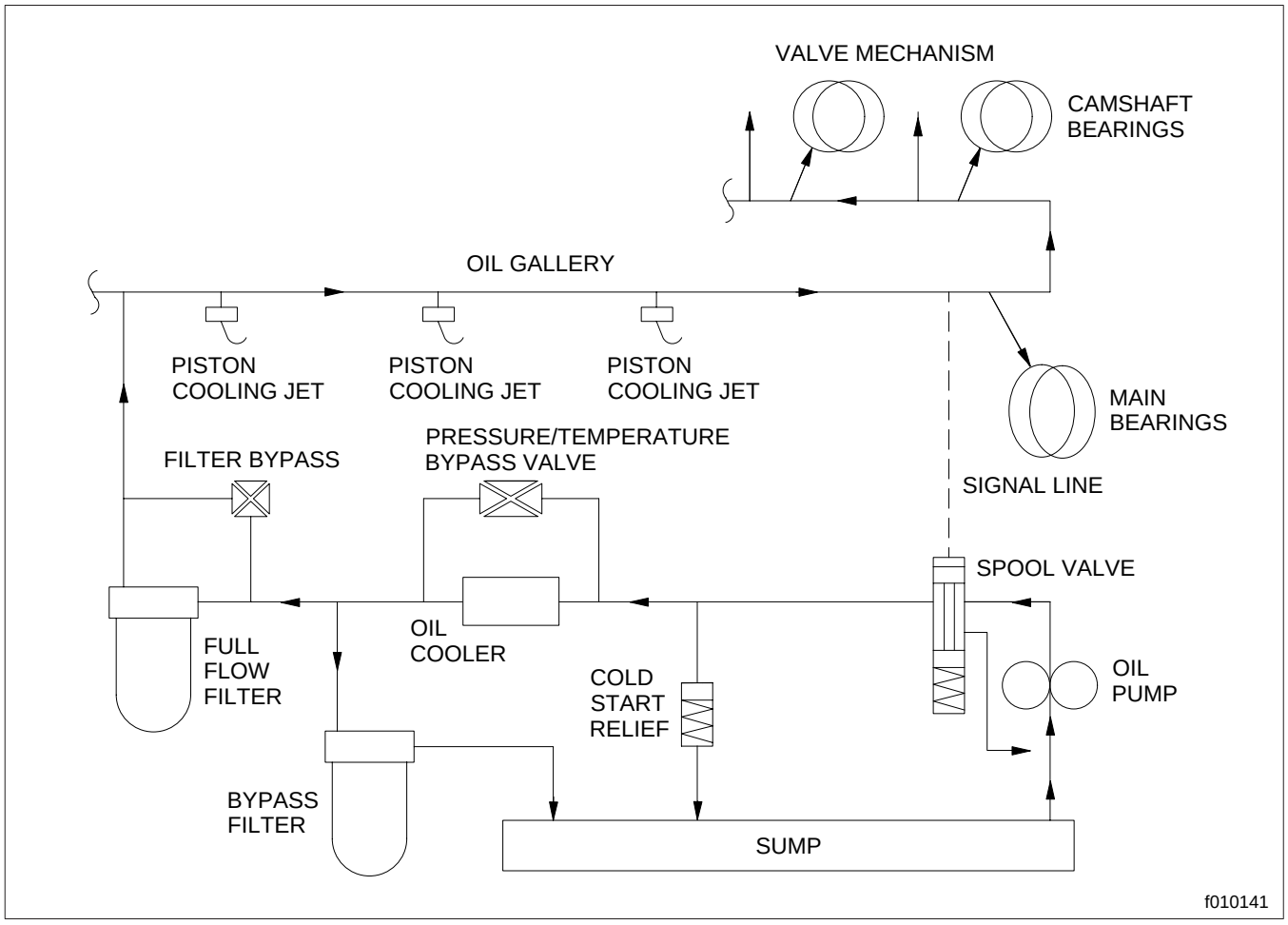


Fig. 8, Lubrication System

cise control of start of injection. Engine rpm is controlled by adjusting the duration of injection.

The engine has built-in diagnostics to ensure that all components are operating properly Intermittent engine system problems are logged and stored in memory. In case of a system component problem, the operator will be alerted to the condition by the "CHK ENG" light in the dashboard lightbar. When the system is not working correctly, the "CHK ENG" light will stay on when the ignition is turned on, instead of going out after ten seconds. Use the cruise control switches to determine the fault as follows:

1. Flip the ON/OFF switch to OFF.
2. Hold the SET/RESUME switch at RESUME.

The "CHK ENG" light will begin a series of flashes that corresponds to a numeric diagnostic code. For example, a code 25 is shown by two flashes, a pause of about 2 seconds, then a series of five short flashes. See **Fig. 11**. If more than one code has been logged into the system, the "CHK ENG" light will flash the codes in sequence, with a pause of about three seconds between codes. See **Table 2** and **Table 3** and **Table 4** for listings of the diagnostic codes.

Also, Caterpillar service tools (Digital Diagnostic Tool or Electronic Control Analyzer Programmer) can be used to read the numerical code of the component or condition causing the problem. For complete information on the use of these service tools, contact a Caterpillar service representative.

Fault Code	Description
21	Sensor Supply Power Fault
22	Not Used
23	Not Used
24	Oil Pressure Sensor Fault
25	Boost Pressure Sensor Fault
26	Not Used
27	Coolant Temperature Sensor Fault
31	Vehicle Speed Signal Fault
32	Throttle Position Sensor Fault
34	Loss of Engine RPM Signal
35	Engine Overspeed Monitoring Fault
36	Vehicle Speed Overspeed
37	Fuel Pressure Sensor Fault
42	Check Sensor Calibrations
43	Not Used
44	Not Used
45	Not Used
46	Low Oil Pressure Monitoring Fault
47	Idle Shutdown Timer
52	ECM or Personality Module Fault
53	ECM Fault
54	Data Link Fault
55	No Detected Faults
56	Check Customer Specified or System Parameters
57	Parking Brake Switch Fault
61	High Coolant Temperature Monitoring Fault
62	Low Coolant Level Monitoring Fault
63	Fuel Pressure Fault
64	High Inlet Air Temperature Monitoring Fault
72	Cylinder 1 or Cylinder 2 Fault
73	Cylinder 3 or Cylinder 4 Fault
74	Cylinder 5 or Cylinder 6 Fault
75	Undetermined Cylinder Fault

Table 2, 3176 System Fault Codes (pre-1991)

Fault Code	Description
01	Override of Idle Shutdown Throttle
25	Boost Pressure Sensor Fault
27	Coolant Temperature Sensor Fault
28	Check Throttle Sensor Adjustment
31	Vehicle Speed Signal Fault
32	Throttle Position Sensor Fault
34	Loss of Engine RPM Signal
35	Engine Overspeed Warning
36	Vehicle Speed Signal Out-of-Range
37	Fuel Pressure Sensor Fault
41	Vehicle Overspeed Warning
42	Check Sensor Calibrations
47	Idle Shutdown Timed Out
51	Intermittent Battery Power to ECM

Table 3, 3176 System Fault Codes (1991)

Fault Code	Description
52	ECM or Personality Module Fault
53	ECM Fault
55	No Detected Faults
56	Check Customer Specified or System Parameters
57	Parking Brake Switch Fault
63	Low Fuel Pressure Warning
72	Cylinder 1 or Cylinder 2 Fault
73	Cylinder 3 or Cylinder 4 Fault
74	Cylinder 5 or Cylinder 6 Fault

Table 4, 3176 System Fault Codes (1991)

Checking (See Fig. 1 or Fig. 2)

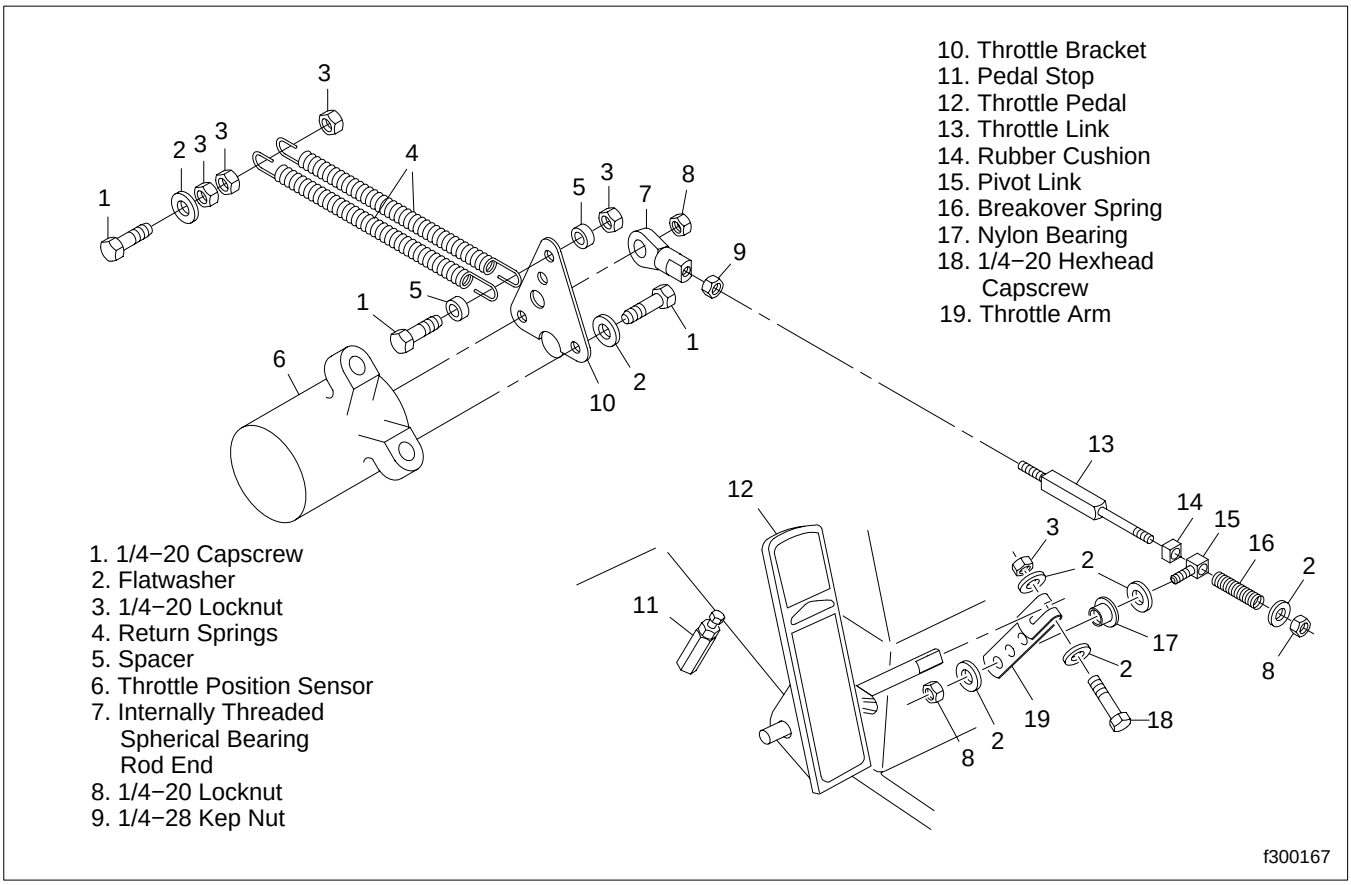


Fig. 1, Caterpillar 3176 Mechanical Throttle Linkage, FLD Conventional shown

NOTE: Most vehicles equipped with the 1991-version Caterpillar 3176 engines do not have a mechanical throttle linkage. These vehicles have an electronic throttle control, which is not adjustable.

1. Check the linkage attachment fasteners (capscrews, locknuts, and hexnuts) for tightness; tighten any that are loose.
2. Operate the linkage by hand, from idle to full throttle, while checking that nothing interferes with its movement. Reposition any parts that interfere.
3. Inspect the return springs for wear, nicks, or other damage that might cause breakage. If needed, install new springs.
4. With the throttle pedal at idle, check the angle of the pedal to the pedal stop. The pedal must be at an angle of 20±2 degrees to the pedal stop. See **Fig. 3**.

   If the throttle pedal angle is too high or too low, loosen the pedal stop jam nut. Turn the head of the pedal stop capscrew until the angle is 20±2 degrees. Tighten the jam nut against the cab deck.
5. Using either the Digital Diagnostic Tool (DDT), or the Electronic Control Analyzer Programmer (ECAP), check the throttle position sensor calibration. The calibration should be 15 to 20 percent at idle, or 80 to 85 percent at full throttle.

   If needed, adjust the throttle position sensor calibration.

Mechanical Throttle Linkage Checking

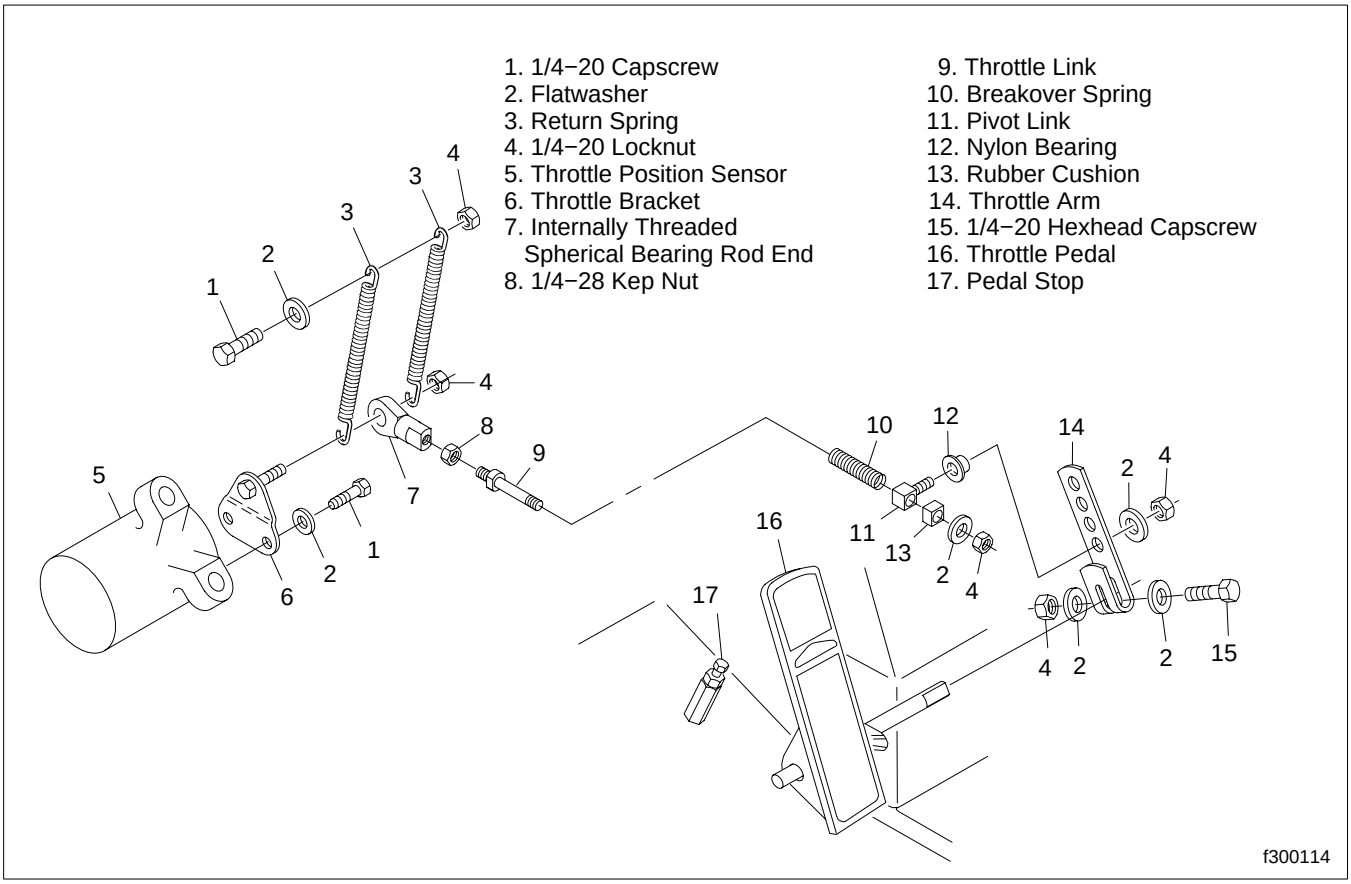


Fig. 2, Caterpillar 3176 Throttle Linkage (FLA COE shown)

NOTE: Checking and adjusting the sensor requires the use of either the DDT, or the ECAP. For complete information on the use of these special tools, contact an authorized Caterpillar dealer.

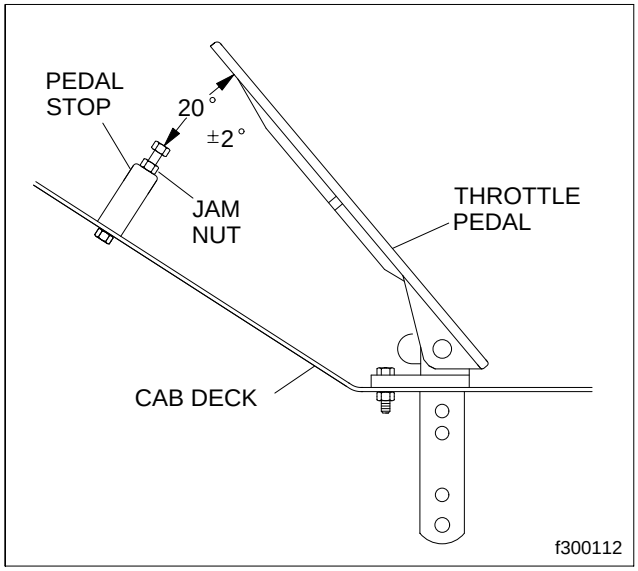
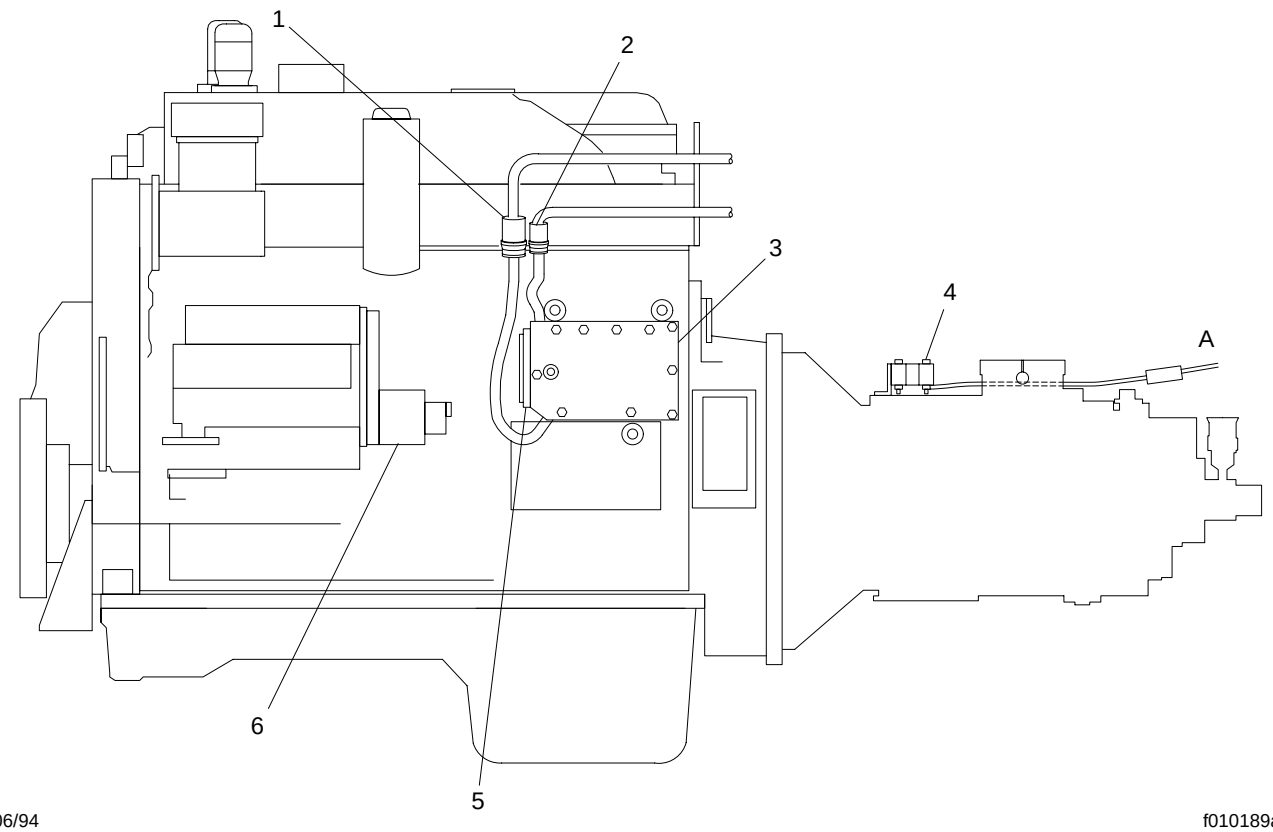


Fig. 3, Thottle Pedal Angle (FLD Conventional shown)

General Information (See Fig. 1)



NOTE: Not all parts are shown.

A. to vehicle speed sensor

1. J2/P2 Connector
2. J1/P1 Connector
3. Electronic Control Module
4. Vehicle Speed Buffer
5. Personality Module
6. Transducer Module

Fig. 1, PEEC Engine

The Caterpillar PEEC and PEEC III systems, available with 3406B engines, provide electronic engine control. The systems use an electronic control module, a transducer module, a timing advance unit, and an electronic governor, all of which are located on the engine. Additional system parts include a throttle position sensor, a vehicle speed buffer, and a data link.

To determine whether an engine is equipped with PEEC or PEEC III , check the Electronic Control Module connectors and serial number (see **Fig. 1** or **Fig. 2**). PEEC systems have two 9-pin connectors, and "8TC" before the serial number; PEEC III systems have one 40-pin connector, and "4CK" before the serial number.

Attached to the forward end of the electronic control module is the personality module, which contains the basic performance program for that particular engine. A PEEC or PEEC III-equipped engine has the following electronic functions:

- Electronic governing
- Control of fuel-to-air-ratio

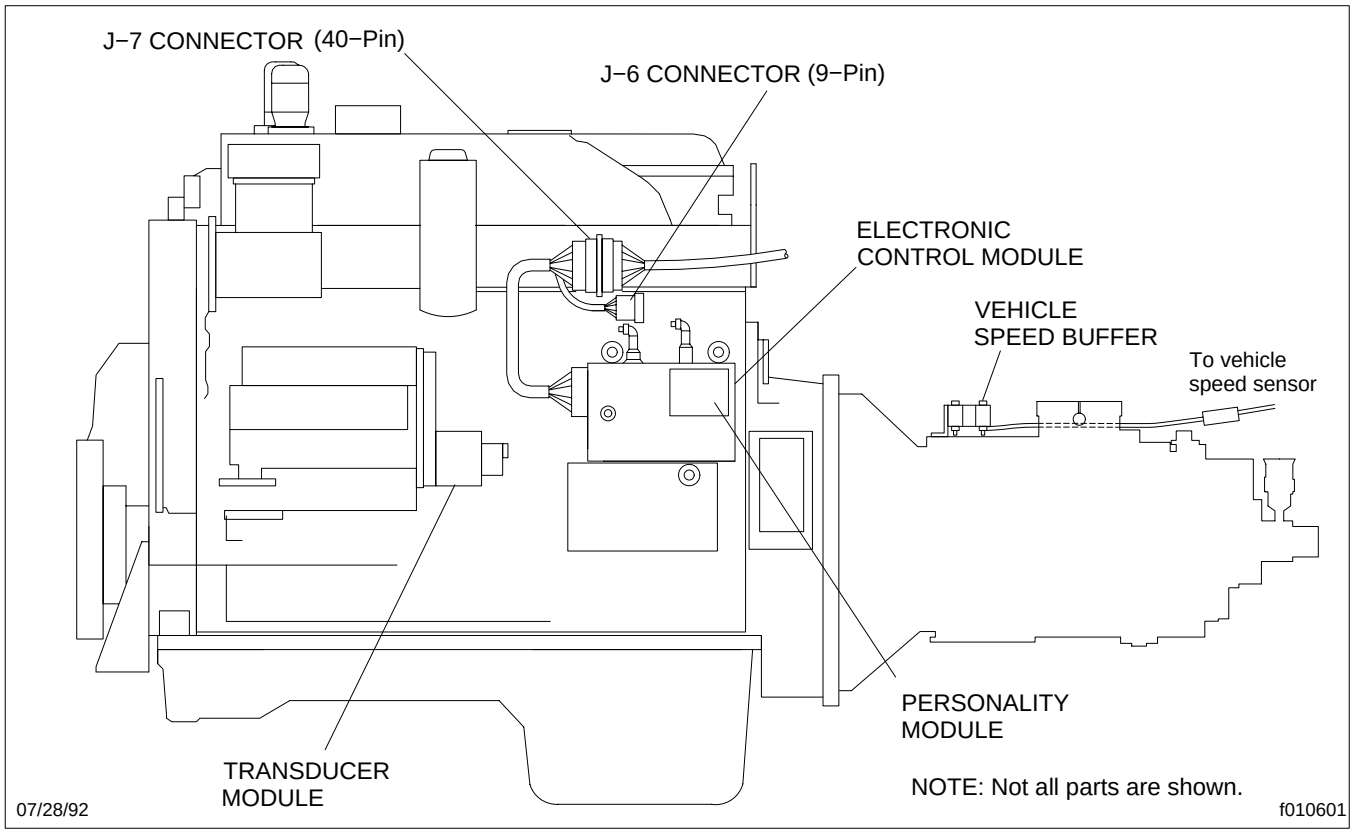


Fig. 2, PEEC III Engine

- Torque rise shaping
- Injection timing control
- System diagnostics
- Vehicle speed limiting
- Progressive shift control
- PTO governor
- Cold mode operation
- Cruise control

Two of these functions—cruise control and PTO governing—are driver-activated, and controlled by two switches mounted to the right of the ignition switch (**Fig. 3**). The remaining functions perform automatically and according to programmed specifications.

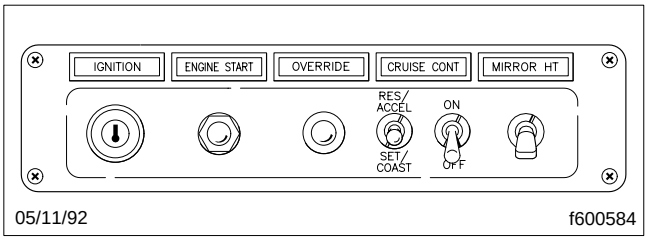


Fig. 3

Principles of Operation

ELECTRONIC CONTROL MODULE

The electronic control module, mounted on the left side of the engine, controls the injection pump and the injection timing. It also provides electronic power to the sensors on the engine, and monitors the overall operation of the system. The electronic control module is cooled by fuel flowing through a cooling

plate, located between the electronic control module and the engine block.

TRANSDUCER MODULE

The transducer module, mounted on the rear of the injection pump, contains an engine oil pressure sensor, an inlet air pressure sensor, and a boost pressure sensor. The transducer module sends signals to the electronic control module for engine speed and the position of the injector pump rack. It also monitors incoming air pressure.

TIMING ADVANCE UNIT

The timing advance unit, mounted on the front of the engine, contains an electronic brushless torque motor, which controls a hydraulic servo. The servo controls the flow of oil to the drive carrier, which advances or retards the engine timing.

VEHICLE SPEED BUFFER

The vehicle speed buffer, located on top of the transmission, amplifies and modulates the signals from the magnetic vehicle speed sensor. These signals are sent to the electronic control module (which interprets them) and any other devices requiring vehicle speed information.

THROTTLE POSITION SENSOR

The throttle position sensor links the throttle pedal with the injection pump by way of the electronic control module. It replaces conventional throttle linkage.

SYSTEM DIAGNOSTICS

A PEEC or PEEC III-equipped engine has built-in diagnostics to ensure that all components are working correctly. Intermittent engine problems are stored in memory, and remain there until the ignition is turned off. If there is a problem with the system, the "CHK ENG" light on the dash lightbar will stay on, instead of going out after 10 seconds.

To determine the system problem, push the "ENG CHK" button, located on the left (driver's) side dash kick panel, near the door post (see **Fig. 4**). The "CHK ENG" light will begin a series of flashes that correspond to a numeric diagnostic code. For example, a code 25 is shown by two flashes, a pause of about two seconds, then five short flashes. See **Fig. 5**. If more than one code has been logged into the system, the "CHK ENG" light will flash the codes in sequence, with a pause of about 3 seconds between each code. See **Table 1** and **Table 2** for a listing of the diagnostic codes.

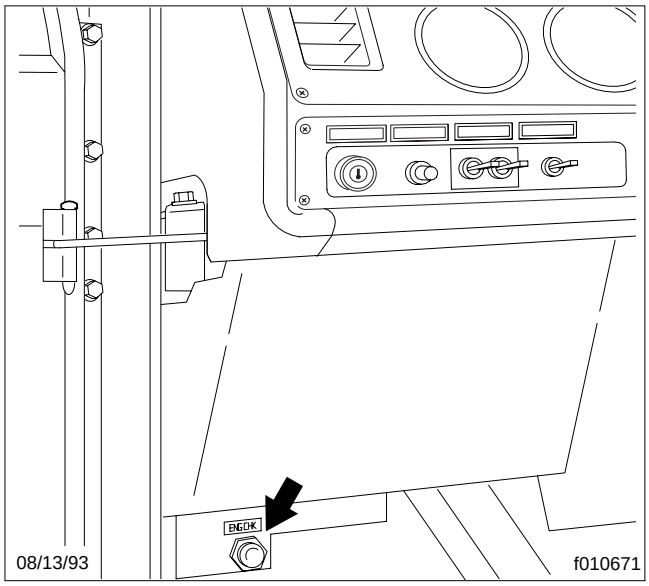


Fig. 4

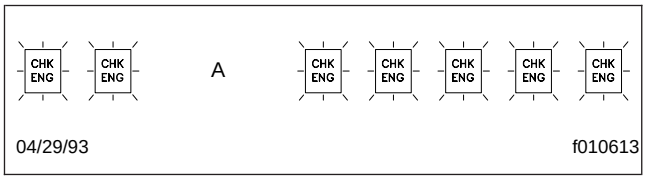


Fig. 5

Diagnostic Flash Codes

Diagnostic Codes	
Fault Code	**Description**
12	Coolant Level Sensor Fault (PEEC III only)
21	Sensor Supply Voltage Fault
22	Rack Position Sensor Fault
23	Timing Position Sensor Fault
24	Oil Pressure Sensor Fault
25	Boost Pressure Sensor Fault
27	Coolant Temperature Sensor Fault (PEEC III only)

28	Check Throttle Sensor Adjustment (PEEC III only)
31	Loss of Vehicle Speed Signal
32	Throttle Position Sensor Fault
33	Engine RPM Signal Out of Range
34	Engine RPM Signal Fault
35	Engine Overspeed Warning
36	Vehicle Speed Signal Fault
41	Vehicle Overspeed (PEEC only)
42	Check Sensor Calibrations
43	Rack Subsystem Fault

Table 1

Diagnostic Flash Codes

Diagnostic Codes	
Fault Code	**Description**
44	Timing Subsystem Fault
45	Shutoff Solenoid Fault
46	Low Oil Pressure Warning
47	Idle Shutdown Occurrence
48	Excessive Engine Power
51	Intermittent Battery Power to the ECM (PEEC III only)
52	Control or Personality Module Fault
53	Electronic Control Module Fault
54	Data Link Fault (PEEC only)
55	No Detected Faults
56	Check Customer or System Parameters
57	Parking Brake Switch Fault
58	Power Train Data Link Fault (PEEC III only)
61	High Coolant Temperature Warning (PEEC III only)
62	Low Coolant Level Warning (PEEC III only)

Table 2

Removal

1. Apply the parking brakes, then chock the tires.
2. Drain the primary and secondary air tanks.
3. Tilt the cab. For instructions, refer to the vehicle driver's manual.
4. Disconnect the battery ground cable at the vehicle frame. Disconnect the positive battery cable from the batteries.
5. Disconnect the air conditioning system as follows:
   - 5.1 Discharge the refrigerant from the air conditioner system, using the instructions in the air conditioning section in this manual.
   - 5.2 Disconnect the hoses from the refrigerant compressor.

     Disconnect the refrigerant hoses from the condenser and the radiator side channel. See **Fig. 1**.

     Plug all hoses, and cap all fittings.
   - 5.3 Remove the fasteners that attach the refrigerant hose clamps to the engine front cover. See **Fig. 2**, Ref. A.
6. Using an overhead hoist or fork lift, remove, as a single unit (as equipped), the radiator, air-to-air aftercooler, and refrigerant condenser. For instructions, refer to the radiator section in this manual.
7. At the elbow fittings on the air compressor governor and air compressor, disconnect the air hoses from the air tank. See **Fig. 2**, Refs. B, C, and D. Plug the hoses, and cap the fittings.
8. Disconnect the hoses from the power steering reservoir and pump. Drain the power steering fluid, then plug the hoses, and cap the fittings.
9. Disconnect the starter motor ground cable from the ground weld-stud in the channel of the left frame rail. Remove the clamp attaching the cable to the frame rail.
10. Disconnect the fuel supply hose from the fuel transfer pump. Disconnect the fuel return hose from the fitting near the rear of the top of the fuel injection pump housing. See **Fig. 2**, Ref. E.

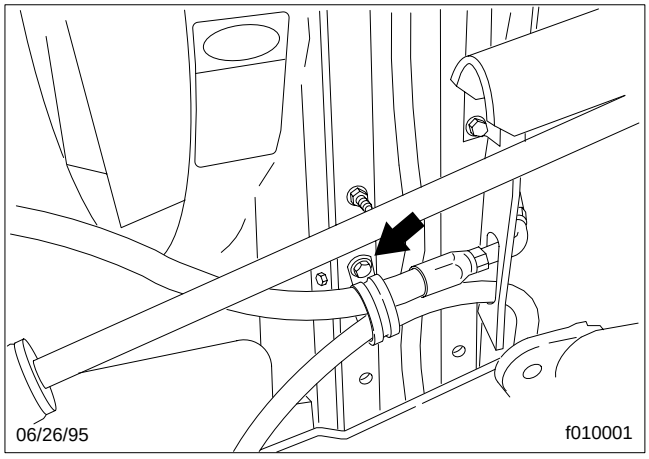


Fig. 1, Refrigerant Hoses Fastened to the Radiator Side Channel

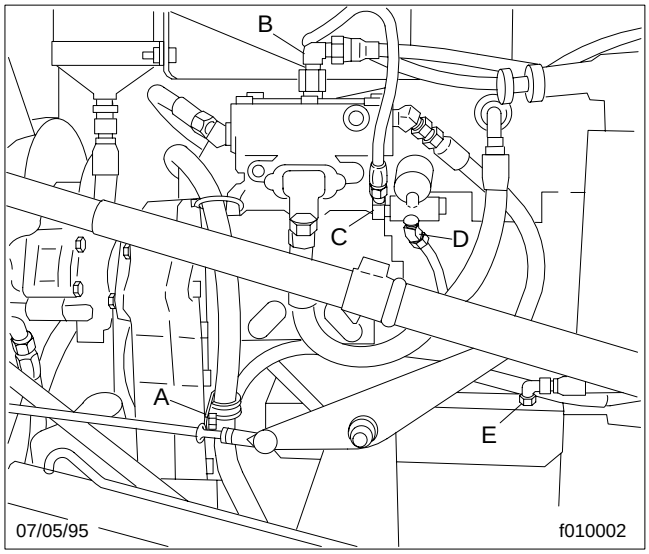


Fig. 2, Hoses and Elbow Fittings

Remove any tie straps or hose clamps that attach the fuel lines to the engine or transmission.

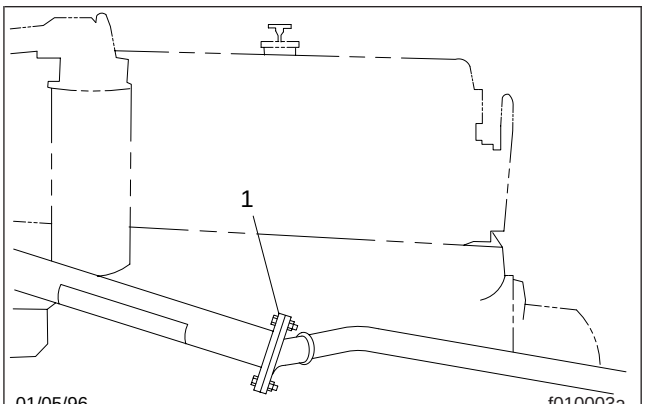
11. Mark the position of the clutch-release lever on the clutch-release shaft, then remove the release lever from the shaft.
12. Remove all wiring harness clamps from the engine. Separate the engine harness from the chassis harness.
13. Disconnect the driveline from the transmission output yoke. Support the driveline on safety stands.

Removal and Installation

14. Remove the three bolts that connect the telescoping shift tube flange to the shift tube extension flange. See **Fig. 3**.
15. Remove the four bolts that attach the shift tower to the top of the transmission. See **Fig. 4**. Remove the shift tower from the transmission.

    Cover the entire shift tower opening in the top of the transmission with a clean piece of cardboard. Fasten the cardboard in place with the shift tower attachment bolts.
16. Disconnect the transmission support spring (if equipped) from the frame rails. See **Fig. 4**.
17. Disconnect all the air lines and wiring from the transmission, and mark them for assembly reference. See **Fig. 5**.

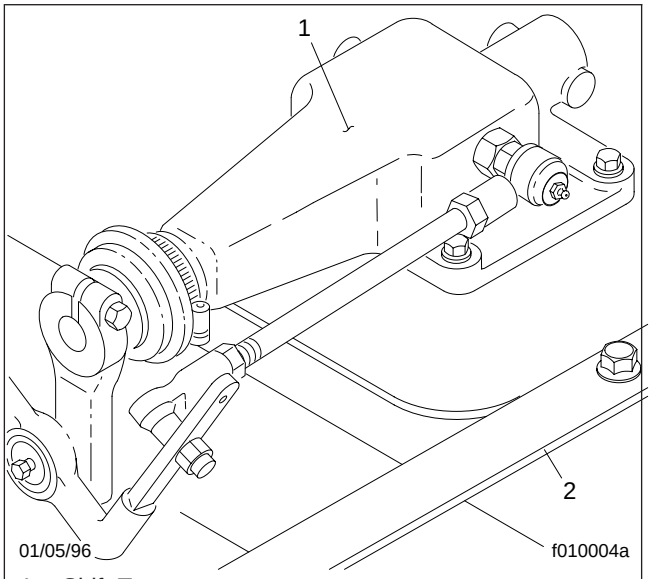
    Plug the lines, and cap the fittings.
18. Disconnect the wiring connector at the oil level sending unit on the oil pan. Disconnect the wiring connections at the speedometer and tachometer magnetic pickup terminals.



1. Shift Tube Extension Flange

Fig. 3, Shift Tube Fasteners

19. Remove and discard the wide-band exhaust clamp from the lower end of the muffler inlet elbow. Remove the flanged hexnuts from the saddle clamp.
20. At the turbocharger exhaust outlet pipe, disconnect the wiring for the pyrometer (if equipped). See **Fig. 6**.
21. Loosen the V-type clamp (**Fig. 6**) at the turbocharger exhaust outlet pipe, and pull the exhaust pipe away from the turbocharger outlet and the muffler inlet elbow.



1. Shift Tower
2. Transmission Support Spring

Fig. 4, Shift Tower on the Top of the Transmission

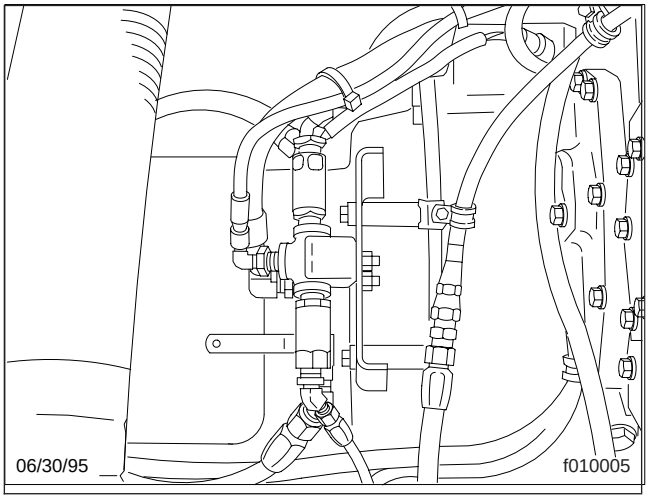
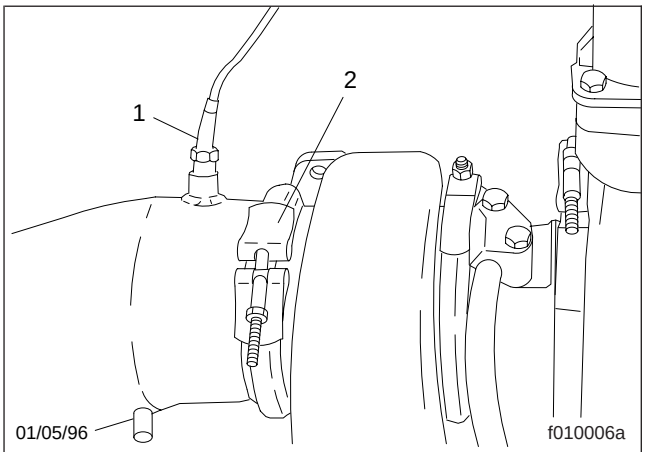


Fig. 5, Air Line and Wiring Connections at the Transmission

22. On vehicles with dual exhausts, remove the wide-band exhaust clamps that attach the exhaust piping to both muffler inlet elbows. Remove the exhaust piping.



1. Pyrometer Wiring Connection
2. V-Type Clamp

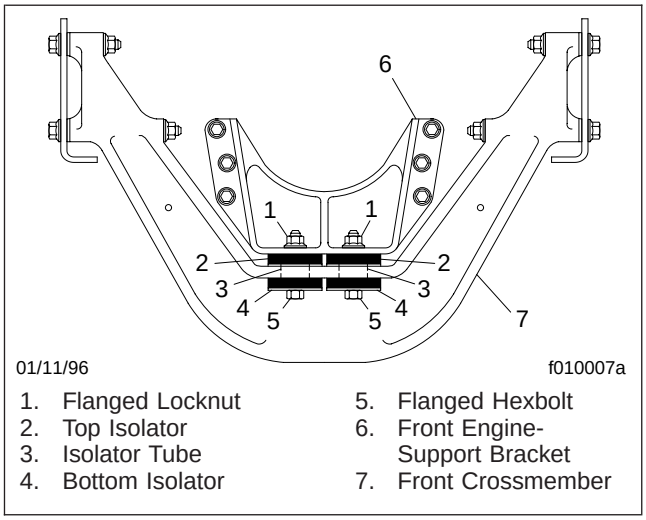
Fig. 6, Exhaust Pipe at the Turbocharger

23. Disconnect the oil check and fill tube from the engine.
24. Disconnect the heater hoses from the engine.
25. Mark the alternator wires, then disconnect them.
26. Attach an appropriate lifting device to an A-frame or an overhead crane. Move the A-frame or crane into place across the engine.

    Attach the lifting device to the front and rear lifting eyes of the engine.
27. Remove the rear engine-support bolts, lower bearing washers, and locknuts.

    Remove the flanged locknuts, bolts, and bottom isolators from the front engine-support bracket and the engine front crossmember. See **Fig. 7**.
28. Mark, then disconnect any electrical wiring that will interfere with engine removal.
29. Lift the engine and transmission up to remove, then set the engine and transmission on an engine stand or other suitable support. Remove the lifting device.
30. Remove the rubber mounts from the rear engine mounts.

    Remove the front engine-support top isolators and isolator tubes from the front crossmember.



1. Flanged Locknut
2. Top Isolator
3. Isolator Tube
4. Bottom Isolator
5. Flanged Hexbolt
6. Front Engine-Support Bracket
7. Front Crossmember

Fig. 7, Front Engine Mounting

Installation

1. Check all of the front and rear engine-support parts for damage or extreme wear. Replace the parts as needed.
2. Install the isolator tubes and top isolators in the engine front crossmember. Coat the rubber mounts with soapy water, and install them in the rear engine mounts.

⚠ CAUTION

Don't lubricate the components with oil, grease, or silicone lubricants, which can soften the rubber and damage the mounts.

3. Attach the lifting device to the engine lifting eyes. Attach the A-frame or overhead crane to the lifting device.
4. Lift the engine and transmission high enough to clear the chassis. Lower the engine and transmission into position on the front and rear engine-support mounts.
5. Install the rear engine-support bolts, bearing washers, and locknuts. Tighten the locknuts 160 lbf·ft (217 N·m).
6. Position the bottom isolators on the front engine support bolts. Install the bolts upward through the engine front crossmember and front engine-

support bracket. Install the flanged locknuts; progressively tighten the locknuts to 210 lbf·ft (285 N·m).

7. Remove the lifting device.
8. Install the clutch-release lever on the clutch-release shaft, aligning the mark on the lever with the mark on the shaft. Tighten the release-lever pinch bolt 40 lbf·ft (54 N·m).
9. Remove the cardboard cover from the opening in the transmission, and lower the shift tower into place. Install the lockwashers and capscrews, and tighten the capscrews 40 lbf·ft (54 N·m).
10. Install the transmission support spring. Tighten the bolts 125 lbf·ft (169 N·m).
11. Install the three bolts that connect the telescoping shift tube flange to the shift tube extension flange. Tighten the nuts 13 lbf·ft (18 N·m).
12. Connect the air lines and wiring to the transmission, as previously marked.
13. Connect the driveline to the transmission output yoke. For instructions, refer to the driveline section in this manual.
14. Install the engine exhaust outlet pipe onto the turbocharger outlet, and tighten the V-type clamp nut 85 lbf·in (940 N·cm).
15. Install a new wide-band exhaust clamp at the muffler inlet elbow(s). For instructions, refer to the exhaust section in this manual. Install the saddle clamp U-bolt that attaches the muffler inlet elbow to the support bracket(s). Tighten the saddle clamp flanged nuts alternately (in three increments), to 24 lbf·ft (33 N·m).
16. Attach the wiring for the pyrometer to the exhaust outlet pipe.
17. Connect the fuel return hose to the fitting near the rear of the top of the fuel injection pump housing. Connect the fuel supply hose to the fuel transfer pump. Use tie straps and hose clamps to attach the fuel lines to the engine and transmission.
18. Connect the terminal of the starter motor ground cable to the ground weld-stud in the channel of the left frame rail. Tighten the nut 23 lbf·ft (31 N·m). Attach the ground cable clamp to the frame rail.
19. Connect the power steering hoses to the power steering reservoir and the power steering pump.
20. Connect the air-tank air hoses to the fittings on the air compressor and air compressor governor. Connect all clamps that attach the air hoses to the engine and transmission. Install new tie straps (as necessary) to attach the air tank-to-governor air hoses to the fuel hose.
21. Install the radiator assembly. For instructions, refer to the radiator section in this manual.
22. Connect the heater hoses to the engine. Attach the radiator hoses and associated clamps to the engine. Tighten the hose clamps snug, but don't overtighten them.
23. Connect the air conditioning system as follows:
    - 23.1 At all refrigerant hose fittings, install a new rubber O-ring, and lubricate the O-rings and fitting threads with refrigerant oil. Apply Loctite® 242 or 592 to the male portion of the fitting threads.
    - 23.2 Connect the refrigerant hoses to the refrigerant condenser.
    - 23.3 Connect the refrigerant hoses to the refrigerant compressor.
24. Attach the refrigerant hose clamps to the engine front cover.
25. Attach the oil check and fill tube to the engine.
26. Connect the electrical wires for the speedometer, tachometer, and the oil level sending unit.
27. Attach all wiring harness clamps to the engine. Connect the engine and chassis harness.
28. Connect the alternator wires.
29. Connect the positive battery cable to the batteries. Connect the battery ground cable to the weld-stud on the vehicle frame.
30. Fill the cooling system with coolant, using the instructions in the engine cooling section in this manual.
31. Fill and bleed the power steering system, using the instructions in the steering section in this manual.
32. Evacuate and charge the air conditioning system, using the instructions in the air conditioning section in this manual.

Engine Support Fasteners		
Description	**Size**	**Torque lbf·ft (N·m)**
Rear Engine-Support Locknuts	5/8-11	160 (217)
Front Engine-Support Locknuts	3/4-10	210 (285)
Engine Leg-to-Flywheel Bolts	M14 x 2 x 45 mm	100 (135)

Table 1, Engine Support Fasteners

General Information and Principles of Operation (See Fig. 1)

PACE is a programmable electronically-controlled engine governing system available on Cummins L10 and NTC engines. This electronic engine system uses sensors, control valves, a power distribution module, and pressure time control module to automatically control engine timing and fuel injection. The PACE system provides the following engine governing modes:

- Variable speed governing, designed for power takeoff operations, which works when the vehicle is stopped.
- Cruise control, which maintains vehicle speed between operator selected limits.
- Road speed governing, which limits the maximum vehicle speed to a preset fuel efficient range.
- Engine speed governing, which limits maximum engine rpm.

Two of these operating modes, cruise control and variable speed governing, are driver-activated and controlled with two switches mounted to the right of the ignition switch **(Fig. 2)**. The remaining operating modes perform automatically and according to programmed specifications. Refer to the vehicle driver's manual for operating instructions.

The pressure time control module (PTCM) is a microprocessor that controls and monitors the system. The PTCM **(Fig. 3)** receives information from the engine and vehicle speed sensors, and from the dash-mounted switches to control fuel pressure. The PTCM has a data link for the Compulink **(Fig. 4)**, a special tool that can be used to program customer specified parameters and troubleshoot the system.

The PACE system uses two sensors: an engine position sensor (EPS) and a vehicle speed sensor (VSS). As the camshaft gear turns, the EPS provides rpm information to the PTCM. On L10 engines, the EPS is located above the accessory drive; on NTC engines, it is located above the lubricating oil pump. **See Fig. 5**. The VSS, mounted in the transmission housing **(Fig. 6)**, senses the movement of the flywheel teeth when the engine is running. The PTCM uses this information to compute vehicle road speed.

The electric fuel control valve (EFC), installed on top of the fuel pump housing **(Fig. 7)**, provides fuel to the injectors in the cylinder head. Depending on the signal received from the PTCM, the EFC valve controls road speed, cruise control, power takeoff, and engine high speed.

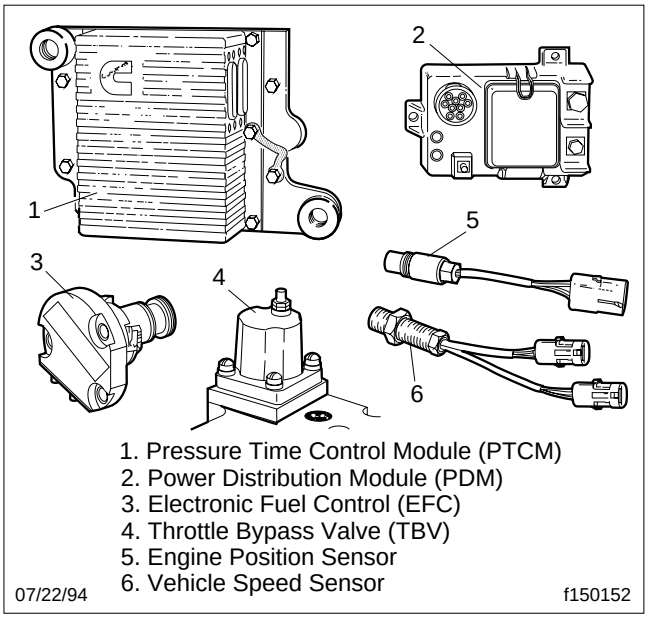


Fig. 1

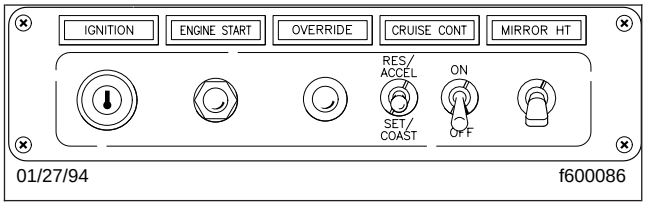


Fig. 2

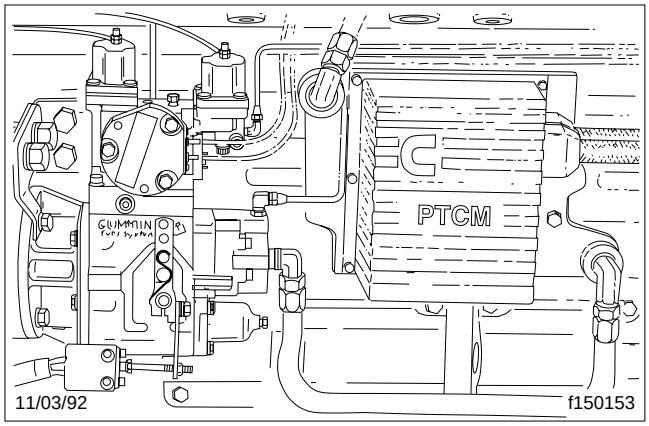


Fig. 3

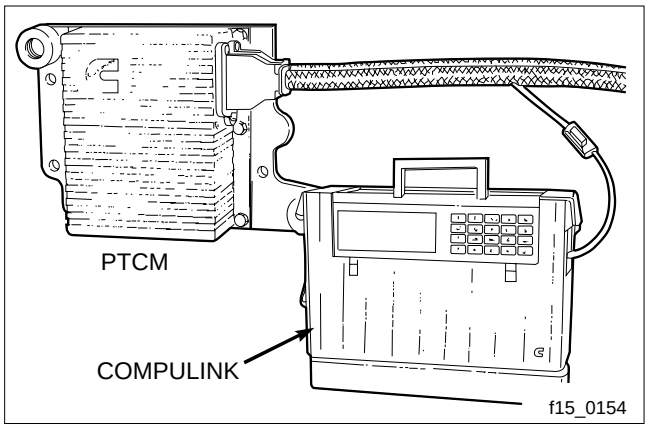


Fig. 4

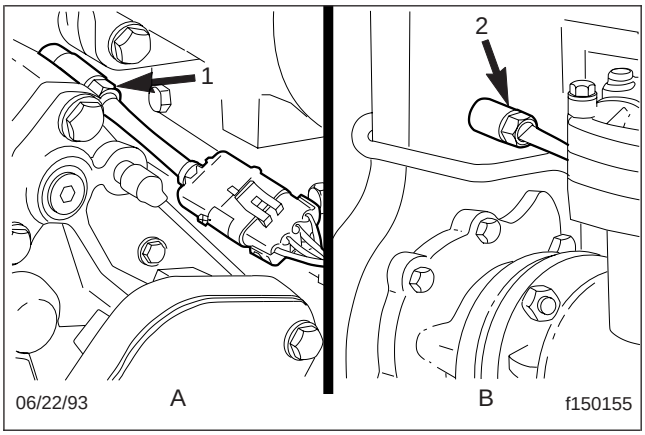


Fig. 5

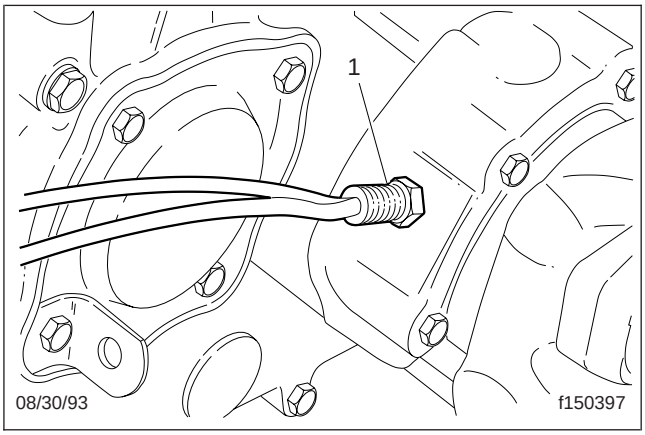


Fig. 6

NOTE: If the engine stops due to loss of power to the EFC valve, or if the valve sticks closed, turn the valve lever **(Fig. 8)** clockwise until it is against the upper stop pin. This allows fuel to bypass the EFC valve so that the vehicle can be safely moved for repairs.

⚠ WARNING

WARNING: Do not use the cruise control or power takeoff if the valve lever has been moved clockwise against the upper stop pin. Use of these features will cause a full throttle condition which could result in loss of vehicle control and possible property damage or personal injury.

The throttle bypass valve (TBV), installed on top of the electronic governor body **(Fig. 7)**, is normally closed, but opens when the cruise control or power takeoff systems are in use. This allows fuel to bypass the throttle through the throttle bypass tube. The amount of fuel is controlled by the EFC valve.

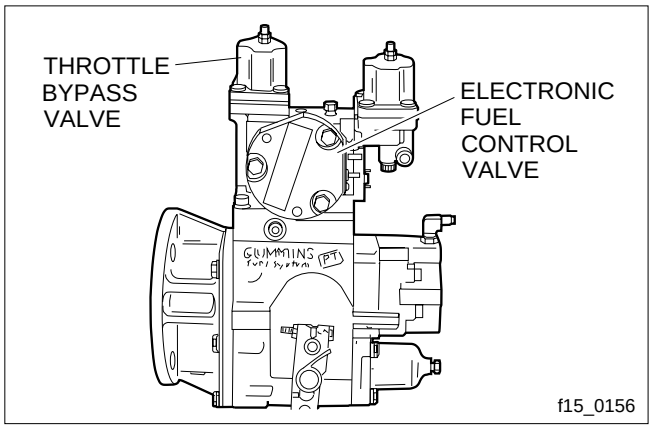


Fig. 7, Fuel Control Valves

The power distribution module (PDM), mounted on the firewall (Conventionals) or the left frame rail near the clutch bellcrank (COEs), is connected to the batteries and supplies power to the PTCM. The PDM also protects the PTCM from excessive voltage. When the ignition switch is turned on, the two lights on the PDM should be on **(Fig. 9)**. Any time the lights on the PDM are off, there is no power to the PTCM.

The engine has built-in diagnostics to ensure that all components are operating properly. There are two dash lights: the yellow "Eng Chk" light and the red "Shutdown" light. Both are located on the dashboard lightbar, and both light up when the ignition is turned

on. If the PACE system and the engine are working normally, both lights will go out after two seconds.

Intermittent engine system problems are logged and stored in memory. Whenever there is an active engine system problem, one of the lights will come on and stay on as long as the problem exists.

Use the "Eng Chk" button, located near the left-side door post, to determine the fault codes. Turn on the ignition, then press and hold the button in.

If no fault codes are recorded, both dash lights will come on and stay on. If fault codes are recorded, both lights will come on momentarily, then the lights will begin to flash the code of the recorded fault.

First, the yellow "Eng Chk" light will flash. There will be a short one or two second pause, then the number of the recorded fault code will flash the red "Shutdown" light. There will be a one or two second pause between each number. For example, a code 244 is shown by one flash of the yellow "Eng Chk" light, a pause of about one or two seconds, followed by two flashes of the red "Shutdown" light, a pause of about one or two seconds, a series of four flashes from the red "Shutdown" light, another pause of about one or two seconds, a series of four more flashes from the red "Shutdown" light, then, after a one or two second pause, one flash of the yellow "Eng Chk" light. **See Fig. 10**. When the number is done flashing, the yellow "Eng Chk" light will come on again before the same sequence is repeated. The lights will continue to flash the same fault code.

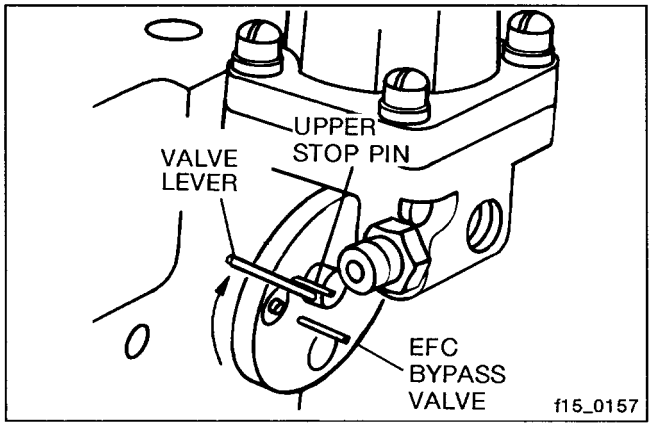


Fig. 8

To check for any additional fault codes, move the cruise control switch to "Set," then release it. To view a previous fault code, move the cruise control switch

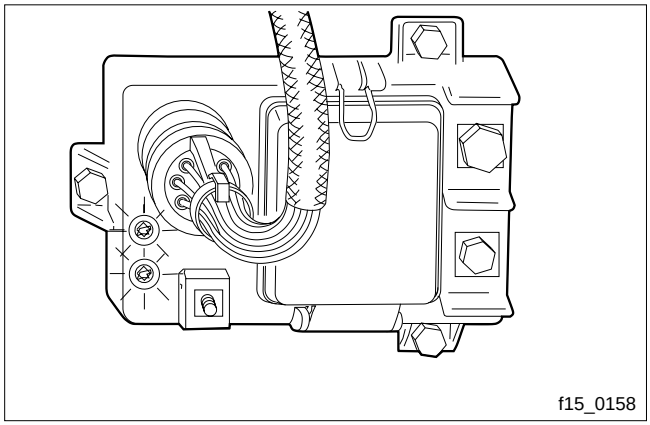


Fig. 9

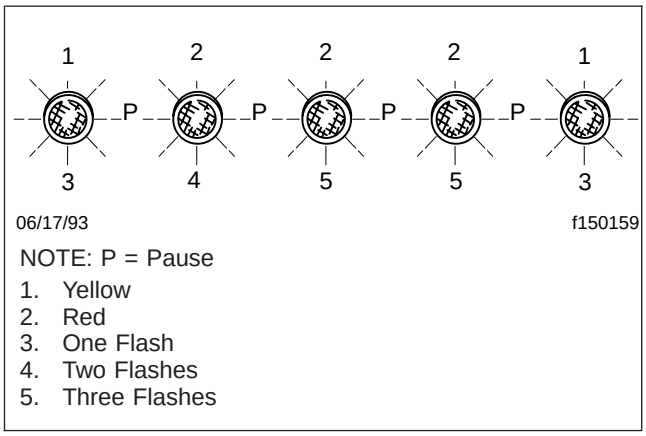


Fig. 10, Diagnostic Fault Code 244

to "Resume," then release it. When you are done checking the fault codes, release the "Eng Chk" button. To clear all fault codes from the PTCM memory, disconnect the nine-pin connector from the PDM for thirty minutes.

The Compulink can be used to read the numerical code of the component or condition causing the problem. For complete information on the use of this service tool, contact a Cummins service representative.

For complete information on fault diagnosis and troubleshooting the PACE electronic engine system, refer to the *Troubleshooting and Repair Manual, PACE Control System*, and the *PACE Fault Code Manual*, available through your Cummins service representative.

Component Testing

Troubleshooting problems within the PACE engine system are not covered in this manual. This section covers only those components that are installed by Freightliner at the factory. Use the Cummins *Troubleshooting and Repair Manual, PACE Control System,* in conjunction with the "Component Testing" section that follows for complete troubleshooting procedures.

A volt/ohmmeter and Cummins service tool 3822747 (for removal/installation of the engine position sensor) are needed for these procedures. Also, a wiring repair kit 3822926 supplied by Cummins is needed, and contains all of the parts **shown in Fig. 1.**

Before doing any troubleshooting procedures, check all of the PACE wiring harness connections for damaged wires or pins. Make sure the connections are tight, clean, and not damaged. Repair or replace damaged wiring as needed.

Use the engine wiring diagram Group 54 of this manual to locate the various electrical circuits installed by Freightliner.

⚠ CAUTION

CAUTION: Before doing any welding on the vehicle, disconnect both the positive and negative battery cables. Make sure that the welding return (ground) connection is not more than one foot (30 cm) from the weld area. Failure to do so could cause severe damage to the PTCM.

Since most volt/ohmmeter readings will be taken at the vehicle harness connector, **see Fig. 2** to locate the test points.

NOTE: If the vehicle harness connector has been removed, always apply a thin coating of Lubriplate DS-ES **(Fig. 3)** to the sealing area of the connector before installation. Push the connector straight into the PTCM. Install and tighten the capscrews 14 to 18 lbf·in (160 to 200 N·cm).

VEHICLE SPEED SENSOR TESTING

1. At the PTCM, remove the capscrews that attach the vehicle harness connector **(Fig. 4).** Carefully pull the connector straight out of the PTCM.
2. Insert the pin from one of the test leads 3822758 (from the repair kit 3822926) into hole 3 **(Fig. 5)** on the connector. Insert the other test lead into hole 7.

   Connect the test leads to the ohmmeter leads. The resistance should be between 500 and 2000 ohms.
3. If the reading in step 2 is not acceptable, check the resistance for circuits N3 and N7 from the PTCM connector to the vehicle speed sensor.

   If the resistance is 10 ohms or less, go to step 4 and check the sensor. If more than 10 ohms, repair or replace the wiring as needed.
4. Disconnect the vehicle speed sensor from the wiring harness. Use the ohmmeter and measure the resistance between the terminals of the sensor connector **(Fig. 6).**

   The resistance should be between 500 and 2000 ohms. If the resistance is not acceptable, replace the sensor.

IMPORTANT: During installation, hand-tighten the sensor until it contacts a gear tooth. Then loosen it one-half to three-quarters of a turn. Holding the sensor securely, tighten the jam nut 25 lbf·ft (35 N·m).

ENGINE POSITION SENSOR

1. At the PTCM, remove the capscrews that attach the vehicle harness connector **(Fig. 4).** Carefully pull the connector straight out of the PTCM.
2. Insert the pin from one of the test leads 3822758 (from the repair kit 3822926) into hole 14 **(Fig. 7)** on the connector. Insert the other test lead into hole 23.

   Connect the test leads to the ohmmeter leads. The resistance should be between 500 and 2000 ohms.
3. If the reading in step 2 is not acceptable, check the resistance for circuits N14 and N23 from the PTCM connector to the engine position sensor.

   If the resistance is 10 ohms or less, go to step 4 and check the sensor. If more than 10 ohms, repair or replace the wiring as needed.
4. Using the Cummins special tool 3822747 **(Fig. 8),** disconnect the EPS from the wiring har-

Component Testing

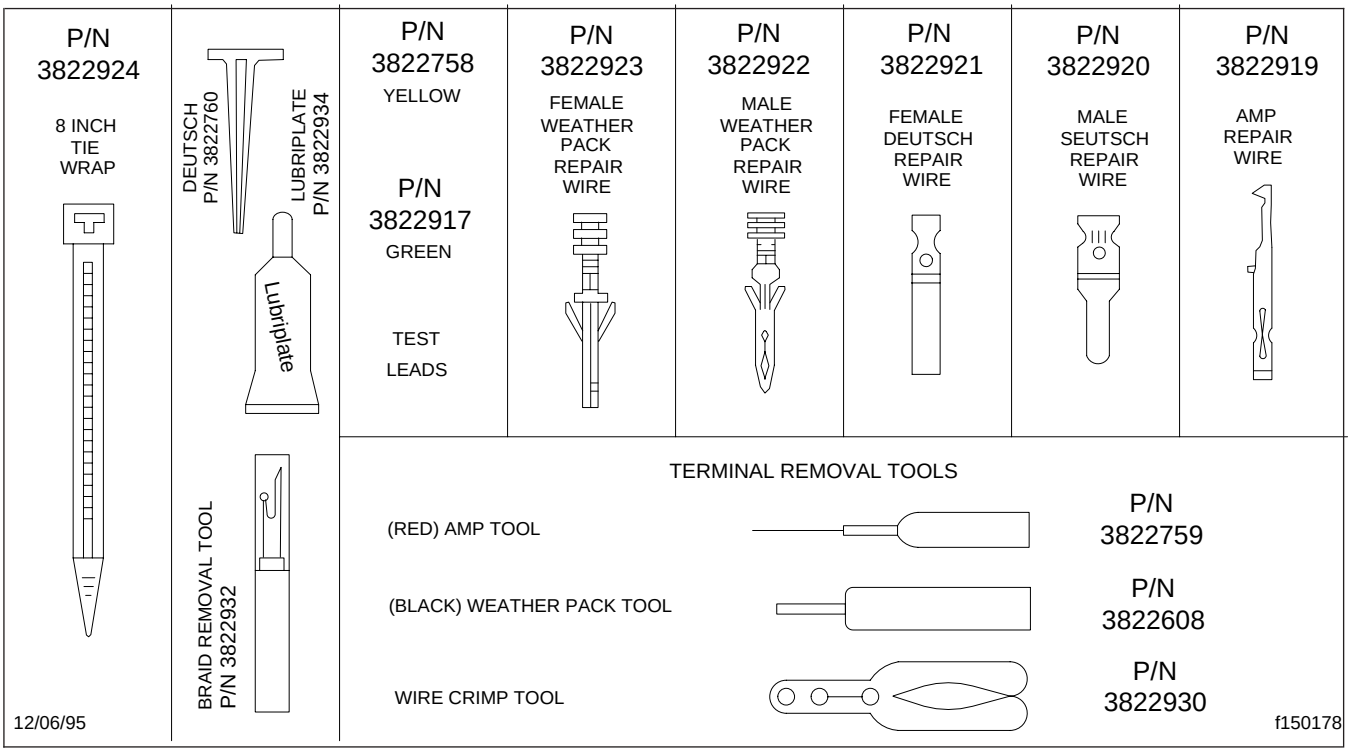


Fig. 1, Cummins Wiring Repair Kit 3822926

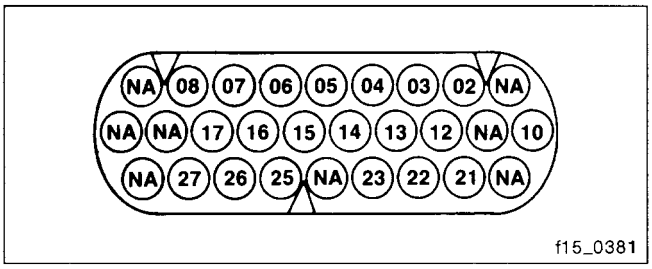


Fig. 2, Vehicle Harness Connector Test Points

ness. Use the ohmmeter and measure the resistance across the two inner terminals (pins "B" and "C") of the sensor connector (**Fig. 9**).

The resistance should be between 500 and 2000 ohms. If the resistance is not acceptable, replace the sensor.

NOTE: Use Cummins special tool 3822747 to install the EPS. Tighten the sensor 25 lbf·ft (35 N·m).

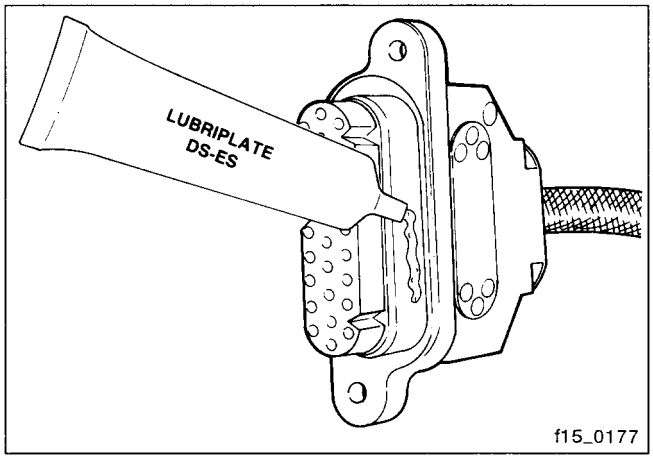


Fig. 3

CLUTCH SWITCH

1. At the PTCM, remove the capscrews that attach the vehicle harness connector **(Fig. 4).** Carefully pull the connector straight out of the PTCM.

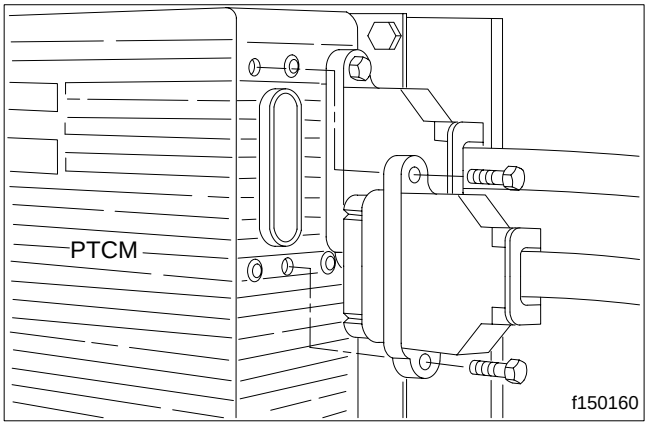


Fig. 4

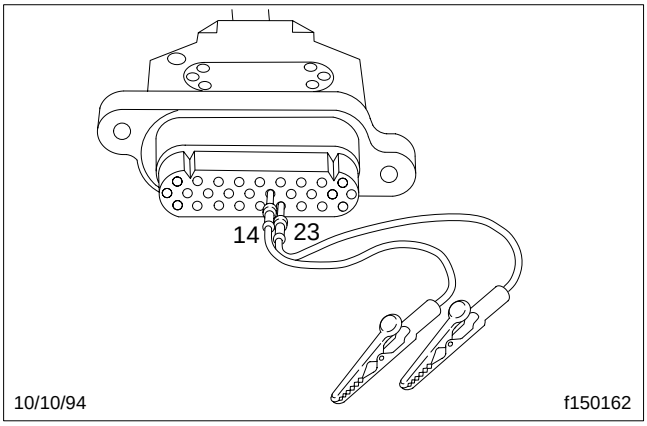


Fig. 7

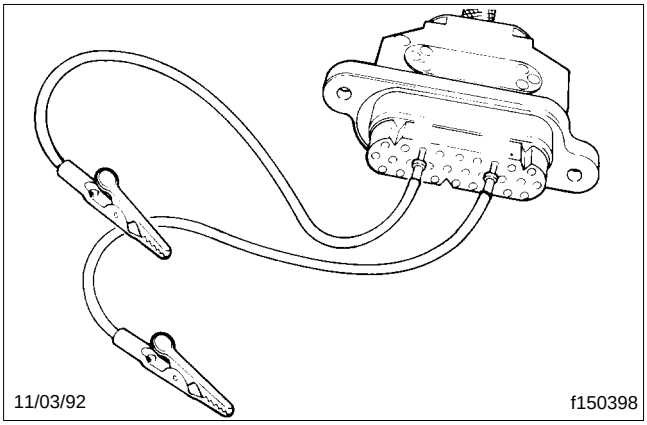


Fig. 5

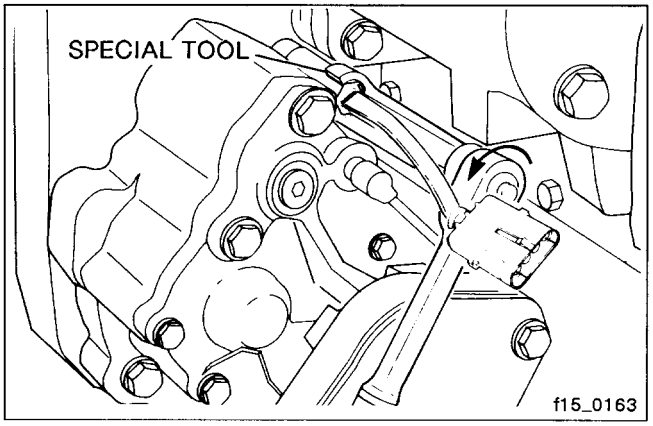


Fig. 8

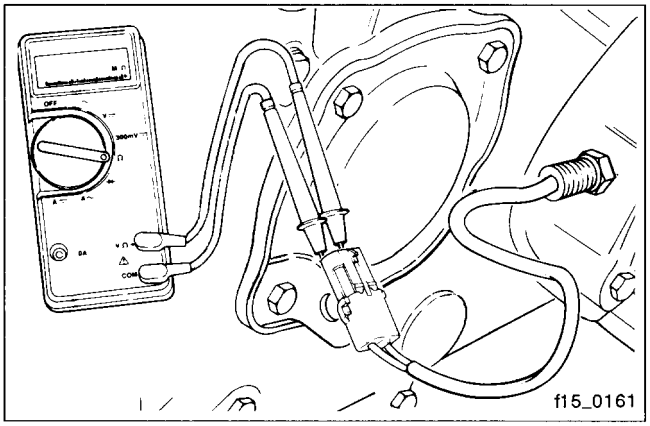


Fig. 6

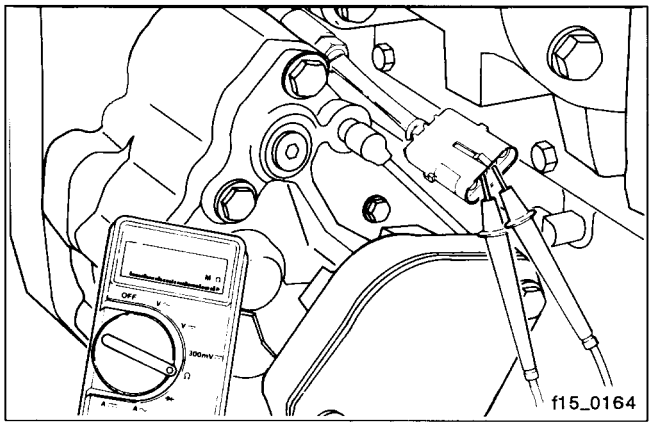


Fig. 9

2. Insert the pin from one of the test leads 3822758 (from the repair kit 3822926) into hole 4 **(Fig. 10)** on the connector. Insert the other test lead into hole 10.

   Connect the test leads to the ohmmeter leads. With the clutch pedal released, the reading should show a closed circuit (between 0.0 and 0.5 ohm).

   Press the clutch pedal to the floor. The reading should show an open circuit.

3. If the readings in the step above are not acceptable, check the clutch switch circuits N4 and N10 for electrical shorts.

   Remove the test lead from hole 10 in the vehicle harness connector. With the clutch pedal released, ground the disconnected test lead. If the ohmmeter shows an open circuit, go to step 4 and check the clutch switch. If the reading shows a closed circuit, repair or replace the wiring as needed.

4. Disconnect the clutch switch from the wiring harness. **See Fig. 11** or **Fig. 12** . Use the ohmmeter and measure the resistance between the terminals of the clutch switch connector.

   With the clutch pedal released, the reading should show a closed circuit. Press the clutch pedal to the floor. The reading should now show an open circuit. If either of the readings are not acceptable, replace the clutch switch.

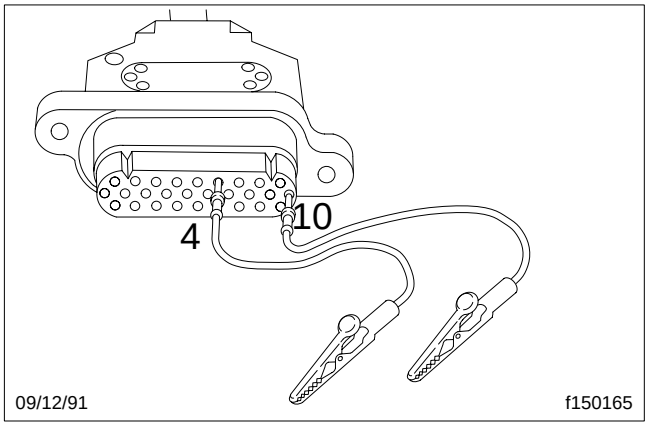


Fig. 10

5. If the readings in the preceding step are acceptable, remove a test lead from one of the clutch switch connector terminals. With the clutch pedal released, ground the disconnected test lead and check for an electrical short. The ohmmeter should show an open circuit. If the reading shows a closed circuit, replace the clutch switch.

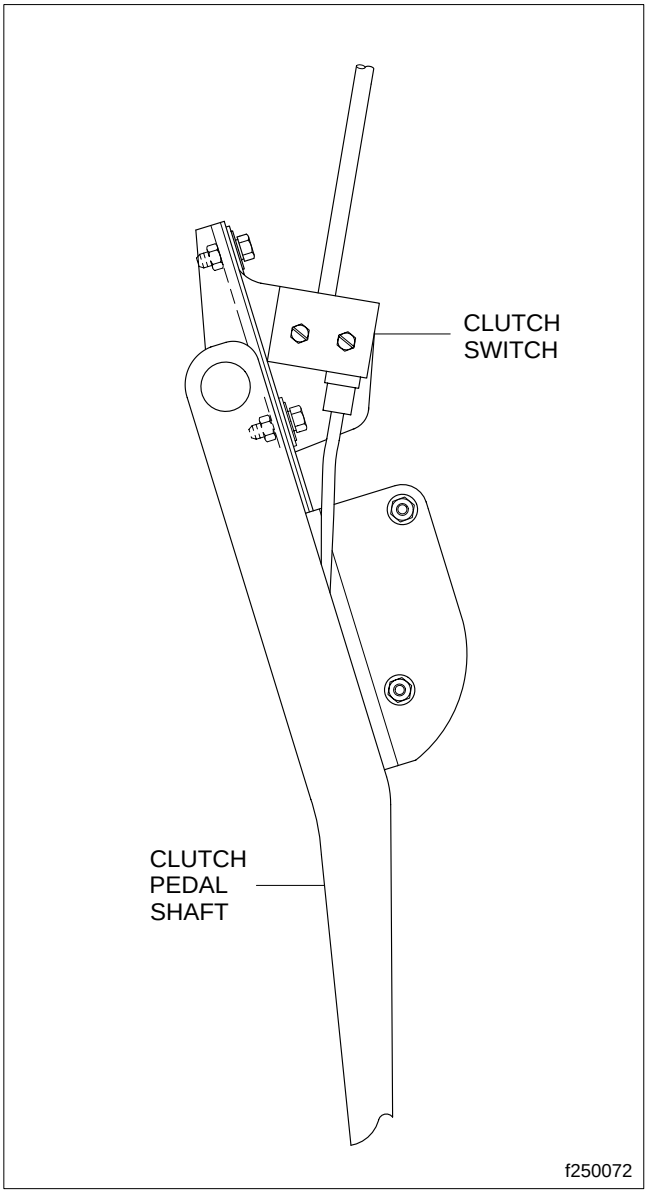


Fig. 11, Clutch Switch Mounting (Conventional shown)

BRAKE SWITCH

NOTE: If necessary, start the engine and build system air pressure to at least 100 psi (689 kPa). Then shut down the engine.

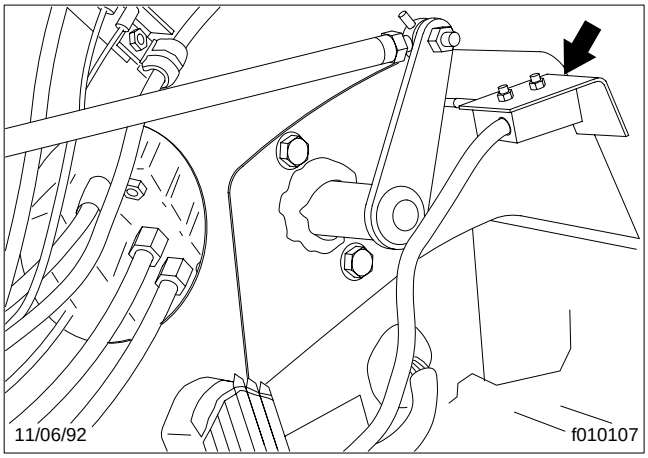


Fig. 12, Clutch Switch Mounting (COE shown)

1. At the PTCM, remove the capscrews that attach the vehicle harness connector **(Fig. 4).** Carefully pull the connector straight out of the PTCM.
2. Insert the pin from one of the test leads 3822758 (from the repair kit 3822926) into hole 10 **(Fig. 13)** on the connector. Insert the other test lead into hole 13.

   Connect the test leads to the ohmmeter leads. With the brake pedal released, the reading should show a closed circuit (between 0.0 and 0.5 ohm).

   Step on the brake pedal. The reading should show an open circuit.
3. If the readings in the step above are not acceptable, check the brake switch circuits N10 and N13 for electrical shorts.

   Remove the test lead from hole 10 in the vehicle harness connector. With the brake pedal released, ground the disconnected

   test lead. If the ohmmeter shows an open circuit, go to the next step and check the brake switch. If the reading shows a closed circuit, repair or replace the wiring as needed.
4. At the air/oil junction block (port number 3), disconnect the brake switch from the wiring harness. **See Fig. 14** or **Fig. 15** . Use the ohmmeter and measure the resistance between the terminals of the brake switch.

   With the brake pedal released, the reading should show a closed circuit. Step on the brake

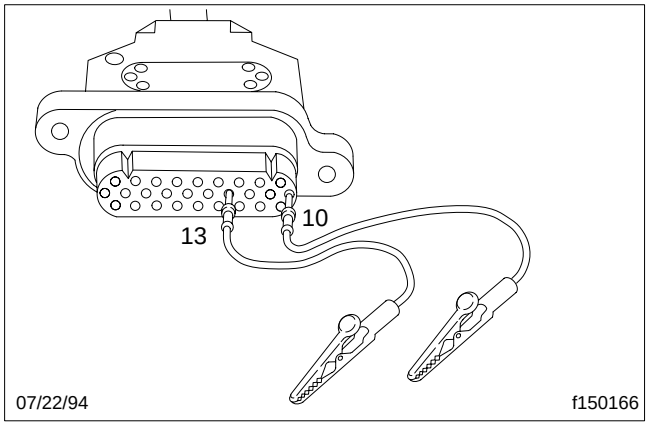


Fig. 13

pedal. The reading should now show an open circuit. If either of the readings are not acceptable, replace the brake switch.

5. If the readings in the step above are acceptable, remove a test lead from one of the brake switch terminals. With the brake pedal released, ground the disconnected testlead and check for an electrical short.

   The ohmmeter should show an open circuit. If the reading shows a closed circuit, replace the brake switch.

THROTTLE SWITCH

1. At the PTCM, remove the capscrews that attach the vehicle harness connector **(Fig. 4).** Carefully pull the connector straight out of the PTCM.
2. Insert the pin from one of the test leads 3822758 (from the repair kit 3822926) into hole 10 **(Fig. 16)** on the connector. Insert the other test lead into hole 6.

   Connect the test leads to the ohmmeter leads. With the throttle pedal released, the reading should show a closed circuit (between 0.0 and 0.5 ohm).

   Step on the throttle pedal. The reading should show an open circuit.
3. If the readings in the step above are acceptable, check the throttle switch circuits N6 and N10 for electrical shorts.

   Remove the test lead from hole 10 in the vehicle harness connector. With the throttle pedal re-

Component Testing

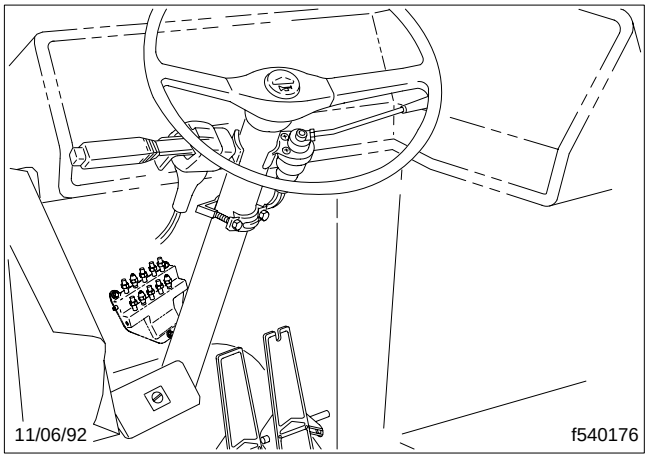


Fig. 14, Conventional Air/Oil Junction Block

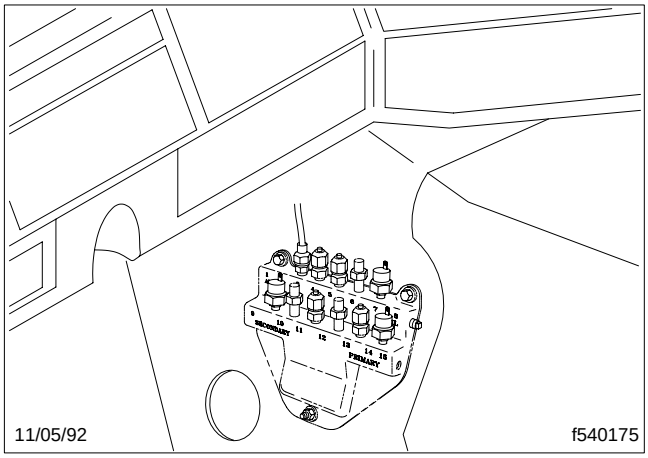


Fig. 15, COE Air/Oil Junction Block

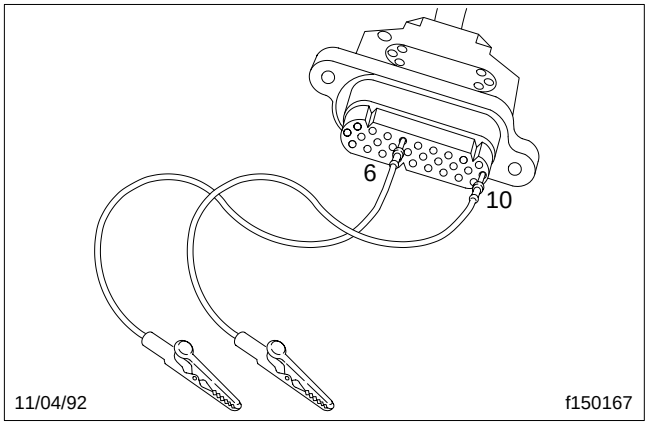


Fig. 16

leased, ground the disconnected test lead to the engine block. If the ohmmeter shows an open circuit, go to the next step and check the throttle switch. If the reading shows a closed circuit, repair or replace the wiring as needed.

4. Disconnect the throttle switch from the wiring harness **(Fig. 17).** Connect the ohmmeter leads to the terminals in the throttle switch connector **(Fig. 18).**

   Move the throttle lever arm counterclockwise **(Fig. 19)** until it stops. The ohmmeter reading should show an open circuit. If the circuit is not open, replace the throttle switch.

   Move the throttle lever arm clockwise **(Fig. 19)** until it stops. The ohmmeter reading should show a closed circuit. If the circuit is open, replace the throttle switch.

IMPORTANT: The throttle lever arm should depress the throttle switch about 1/8 inch (3 mm). If it doesn't depress the switch 1/8 inch (3 mm), adjust the throttle lever arm. If the ohmmeter reading still doesn't show a closed circuit, replace the throttle switch.

5. If the readings in the step above are acceptable, remove a test lead from one of the throttle switch terminals. Move the throttle lever arm clockwise **(Fig. 19)** until it stops. Ground the disconnected test lead and check for an electrical short.

   The ohmmeter should show an open circuit. If the reading shows a closed circuit, replace the brake switch.

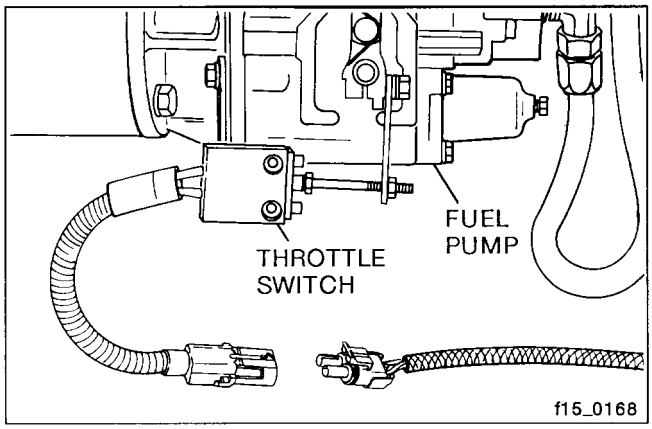


Fig. 17

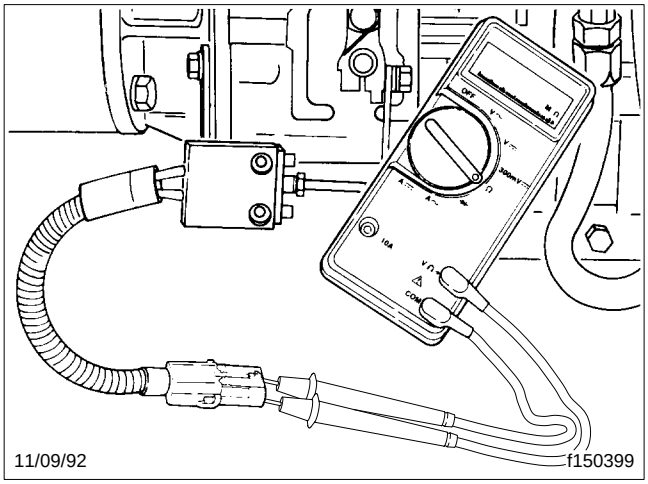


Fig. 18

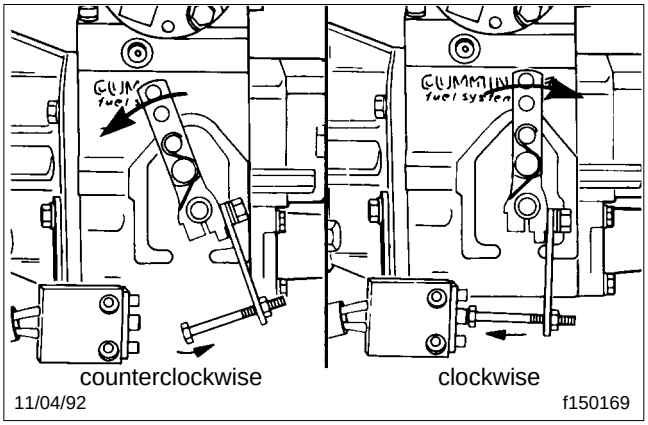


Fig. 19

CRUISE CONTROL SWITCHES

1. At the PTCM, remove the capscrews that attach the vehicle harness connector **(Fig. 4).** Carefully pull the connector straight out of the PTCM.
2. Insert the pin from one of the test leads 3822758 (from the repair kit 3822926) into hole 2 **(Fig. 20)** on the connector. Insert the other test lead into hole 10.

   Connect the test leads to the ohmmeter leads. Move the cruise control "On/Off" switch "Off" **(Fig. 21).** The reading should show an open circuit.

   Move the cruise control "On/Off" switch "On." The reading should show a closed circuit (between 0.0 and 0.5 ohm).
3. If the readings in the preceding step are not acceptable, check the cruise control "On/Off" switch circuits N2 and N10 for electrical shorts.

   Remove the test lead from hole 2 in the vehicle harness connector. With the cruise control switch "On," ground the disconnected test lead. If the ohmmeter shows an open circuit, go to the next step and check the switch. If the reading shows a closed circuit, repair or replace the wiring as needed.

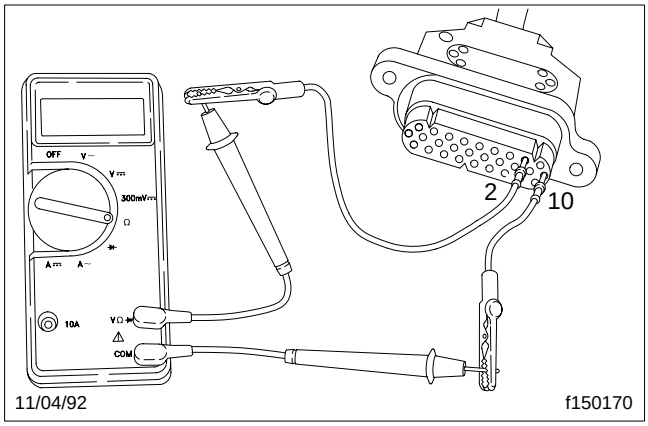


Fig. 20

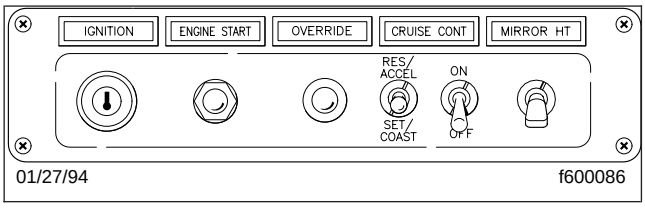


Fig. 21

4. Inside the cab, remove the screws that attach the cruise control panel to the dash. Pull out the panel to access the back of the "On/Off" switch. Disconnect the switch from the wiring harness. Use the ohmmeter and measure the resistance between the terminals of the "On/Off" switch.

   With the switch "Off," the reading should show an open circuit. With the switch "On," the reading should show a closed circuit. If the readings are not acceptable, replace the switch.
5. Insert the pin from one of the test leads 3822758 into hole 10 **(Fig. 22)** on the connector. Insert the other test lead into hole 12.

Connect the test leads to the ohmmeter leads. Hold the cruise control "Set/Resume" switch in the "Set" position. The reading should show a closed circuit (between 0.0 and 0.5 ohm).

Hold the cruise control "Set/Resume" switch in the "Resume" position. The reading should show an open circuit.

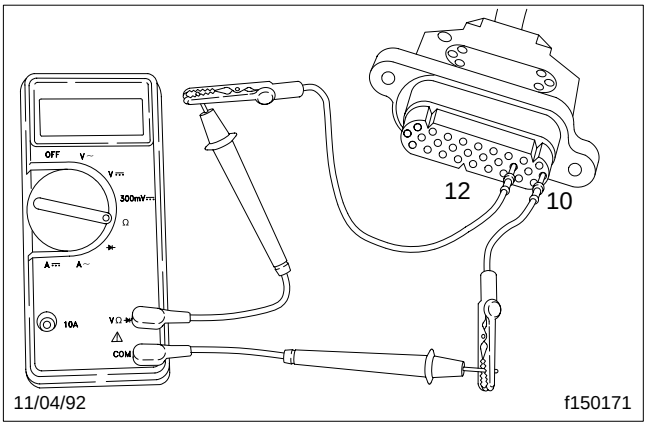


Fig. 22

6. If the readings in the step above are not acceptable, check the cruise control "Set/Resume" switch circuits N10 and N12 for electrical shorts.

   Remove the test lead from hole 12 in the vehicle harness connector. Holding the "Set/ Resume" switch in the "Set" position, ground the disconnected test lead. If the ohmmeter shows an open circuit, do the last two steps under this heading and check the switch. If the reading shows a closed circuit, repair or replace the wiring as needed.

7. Insert the pin from one of the test leads 3822758 into hole 10 **(Fig. 23)** on the connector. Insert the other test lead into hole 22.

   Connect the test leads to the ohmmeter leads. Hold the cruise control "Set/Resume" switch in the "Set" position. The reading should show an open circuit.

   Hold the cruise control "Set/Resume" switch in the "Resume" position. The reading should show a closed circuit (between 0.0 and 0.5 ohm).

8. If the readings in the step above are not acceptable, check the cruise control "Set/Resume" switch circuits N10 and N22 for electrical shorts.

   Remove the test lead from hole 22 in the vehicle harness connector. Holding the "Set/Resume" switch in the "Resume" position, ground the disconnected test lead. If the ohmmeter shows an open circuit, do the next two steps and check the switch. If the reading shows a closed circuit, repair or replace the wiring as needed.

9. At the back of the "Set/Resume" switch, disconnect the switch from the wiring harness. Use the ohmmeter and measure the resistance between the top and center terminals **(Fig. 24)** of the "Set/Resume" switch.

   With the switch in the "Set" position, the reading should show an open circuit. With the switch in the "Resume" position, the reading should show a closed circuit. If either of the readings is not acceptable, replace the switch.

10. At the back of the "Set/Resume" switch, use the ohmmeter and measure the resistance between the bottom and center terminals **(Fig. 25)** of the "Set/Resume" switch.

    With the switch in the "Set" position, the reading should show a closed circuit. With the switch in the "Resume" position, the reading should show an open circuit. If neither reading is acceptable, replace the switch.

ENGINE CHECK BUTTON

1. At the PTCM, remove the capscrews that attach the vehicle harness connector **(Fig. 4).** Carefully pull the connector straight out of the PTCM.

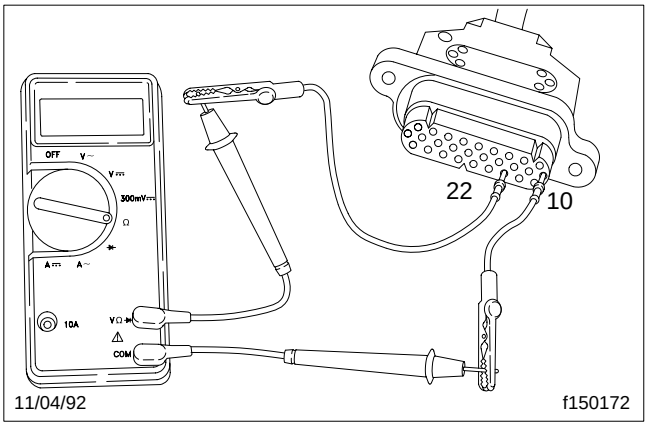


Fig. 23

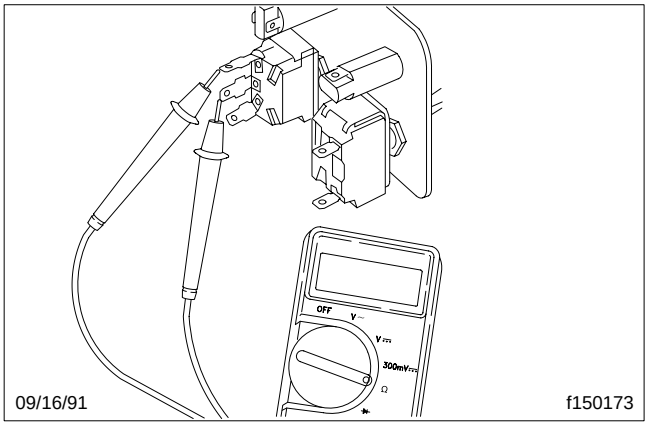


Fig. 24

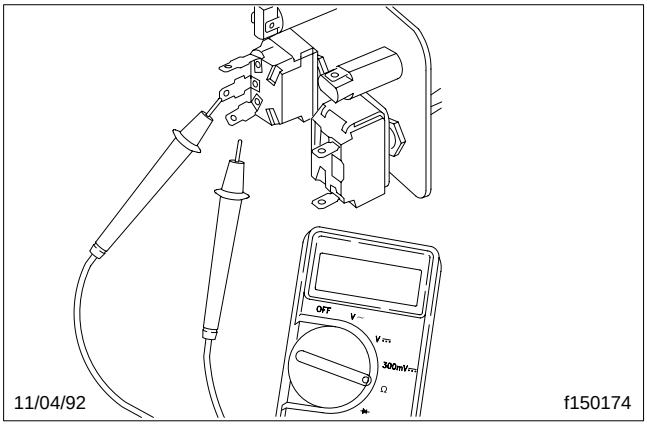


Fig. 25

2. Insert the pin from one of the test leads 3822758 (from the repair kit 3822926) into hole 10 **(Fig. 26)** on the connector. Insert the other test lead into hole 21.

   Connect the test leads to the ohmmeter leads. Push the engine check button in. The reading should show a closed circuit (between 0.0 and 0.5 ohm).

   Release the button. The reading should show an open circuit.

3. If the readings in the step above are not acceptable, check the switch circuits N10 and N21 for electrical shorts.

   Remove the test lead from hole 10 in the vehicle harness connector. Push the engine

   check button in and ground the disconnected test lead. If the ohmmeter shows an open circuit, go to step 4 and check the switch. If the reading shows a closed circuit, repair or replace the wiring as needed.

4. Remove the engine check button from the left-hand door post. Disconnect the check button from the wiring harness. Connect the ohmmeter leads to the two terminals.

   With the button released, the reading should show an open circuit. With the button pushed in, the reading should show a closed circuit.

   If neither reading is acceptable, replace the switch.

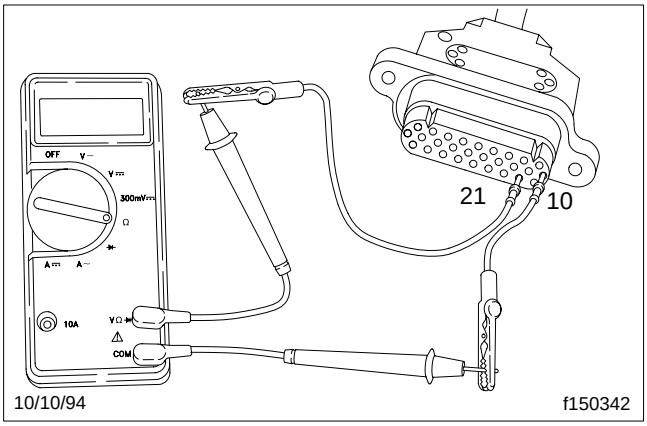


Fig. 26

VEHICLE HARNESS CONNECTOR

1. At the PTCM, remove the capscrews that attach the vehicle harness connector **(Fig. 4).** Carefully pull the connector straight out of the PTCM.

2. Insert the pin from one of the test leads 3822758 (from the repair kit 3822926) into hole 16 **(Fig. 27)** on the connector.

   Connect the other test lead to the engine block. Connect the test leads to the voltmeter. The reading should be 4 to 6 volts.

   Remove the test lead from hole 16, and insert it into hole 25 **(Fig. 28).** With the other lead connected to the engine block, the reading should be 4 to 6 volts.

   If both of the readings are acceptable, go to the next step.

Component Testing

If neither of the above readings is acceptable, replace the vehicle harness connector.

3. Insert the pin from one of the test leads 3822917 (from the repair kit 3822926) into hole 10 on the connector. Connect the other end of the lead to the voltmeter positive lead. Connect the negative voltmeter lead to the engine block.

   Turn on the ignition switch. The reading should be 4 to 6 volts.

   If the above reading is not acceptable, replace the vehicle harness connector.

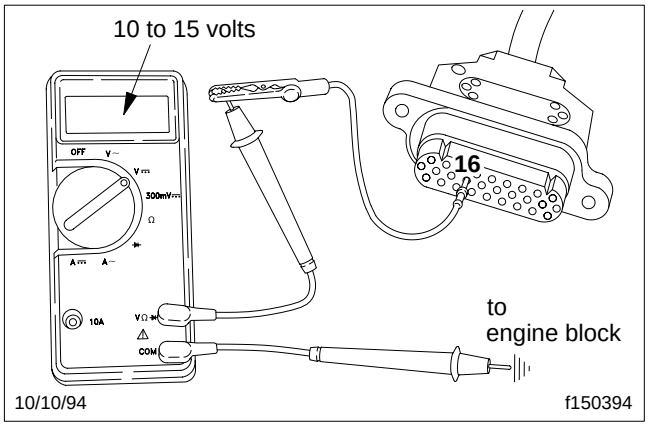


Fig. 27

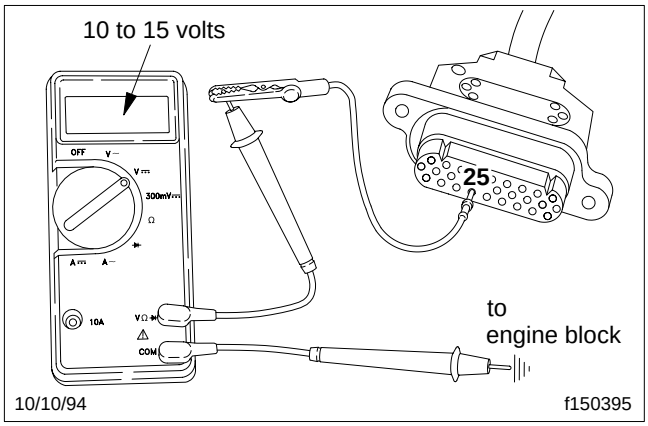


Fig. 28

Removal

1. Apply the parking brakes, then chock the tires.
2. Drain the primary and secondary air tanks.
3. Remove the grille. Refer to the hood section in this manual for instructions.
4. Tilt the hood.
5. Disconnect the battery ground cable at the vehicle frame. Disconnect the positive battery cable from the batteries.

   Remove the battery cables from the standoff brackets under the transmission and the engine. See **Fig. 1**.
6. Block the hood from tilting beyond its full-open position by placing a support between the floor and the front of the hood. Place cardboard, carpeting, rags, or other padding on top of the support to protect the hood. The lowest edge of the hood should rest on the supports. The supports should be as wide and long as the front of the hood. See **Fig. 2**.

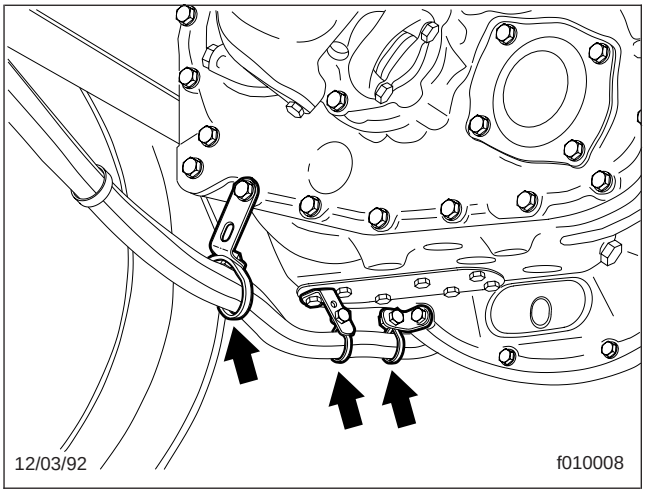


Fig. 1, Battery Cable Stand-Off Brackets

⚠ WARNING

When there is tension on the tilt-assist spring, do not disconnect the tilt-assist cables or spring. If the spring or cables are disconnected while the spring is under tension, they could whip and cause personal injury.

7. Tilt the hood until it is balanced over the pivots to relieve tension from the tilt-assist spring. While a coworker is holding the hood in this position, disconnect the tilt-assist cables from the brackets on top of the radiator at each side.
8. Carefully lower the hood onto the support.
9. If equipped with an air conditioner, proceed as follows:

   9.1 Discharge the refrigerant from the air conditioner system, using the instructions in the air conditioning section in this manual.

   9.2 Disconnect the discharge hose from the refrigerant compressor. See **Fig. 3**. Disconnect the hoses from the condenser. See **Fig. 4**. Plug all hoses, and cap all fittings.

   9.3 Remove any refrigerant hoses that are routed along the top of the engine and secure them with tie straps to the frontwall.
10. Remove the radiator brace rods from the brace-rod brackets at the frontwall.
11. Using an overhead hoist, remove, as a single unit, the radiator, air-to-air aftercooler, and refrigerant condenser, as equipped. For instructions, refer to the radiator assembly section in this manual.
12. Disconnect the hoses from the power steering reservoir and pump. See **Fig. 5**. Drain the power steering fluid, then plug the hoses, and cap the fittings.
13. Disconnect the starter motor ground cable from the ground weld-stud in the channel of the left frame rail. Remove the clamp attaching the cable to the frame rail.

    Mark the starter wires, then disconnect them.
14. Disconnect the fuel supply hose from the fuel filter. See **Fig. 6**. Disconnect the fuel return hose from the engine. Plug the hoses and cap the fittings.
15. At the elbow fittings on the air compressor governor, disconnect the air hoses to the air tank. On the air compressor, remove the discharge line. See **Fig. 7**. Plug the hoses, and cap the fittings.

    Disconnect all clamps that attach the air hoses to the engine and transmission.

Removal and Installation

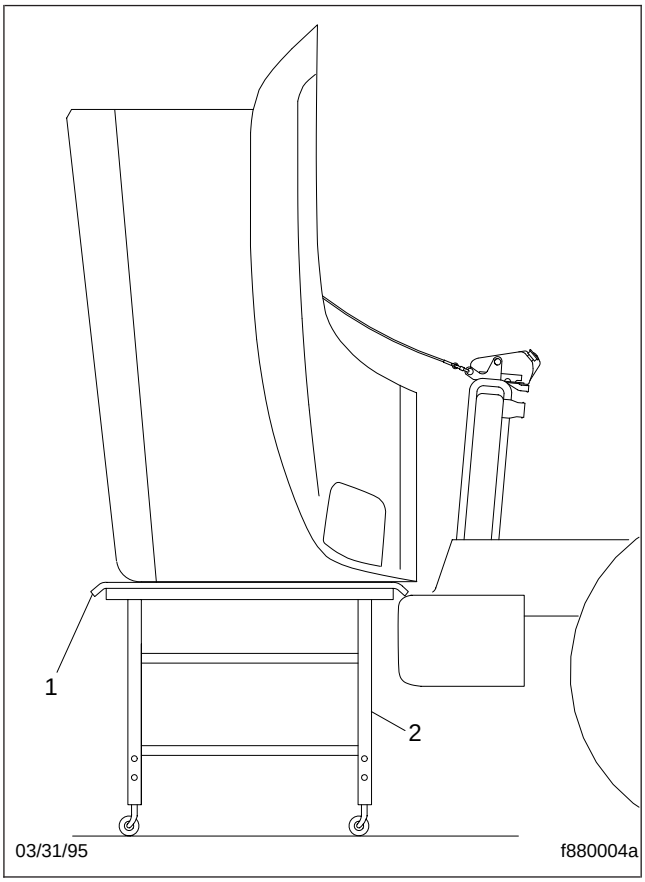


Fig. 2, Hood Tilted Onto Support

16. Disconnect the throttle rod from the throttle pedal arm.
17. Disconnect the heater hoses from the engine and secure them to the frontwall. Remove the radiator hoses and clamps from the engine.
18. At the transmission, disconnect the air lines to the splitter (if equipped), and mark the lines for assembly reference.

    Disconnect the transmission air supply line at the transmission. Mark the line for assembly reference.

    Plug the lines, and cap the fittings.
19. Remove the shift tower from the top of the transmission. Use a tie strap to attach the shift lever to the steering wheel, to keep it up and out of the way.

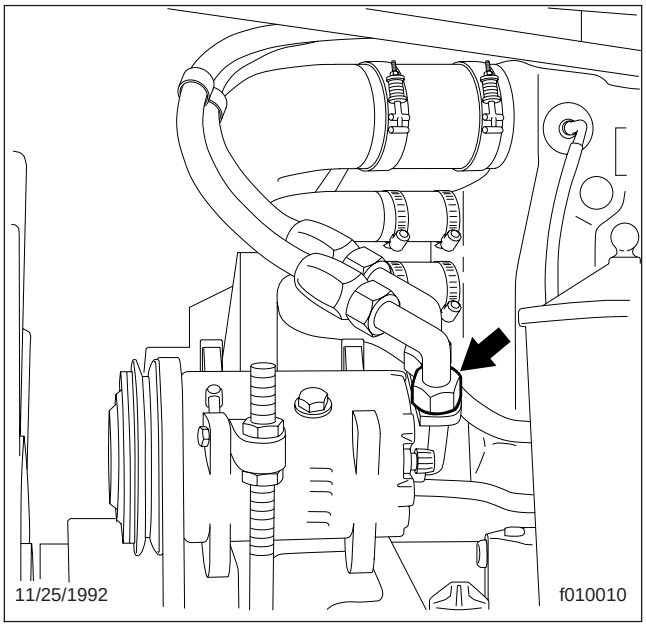


Fig. 3, Refrigerant Discharge Hose

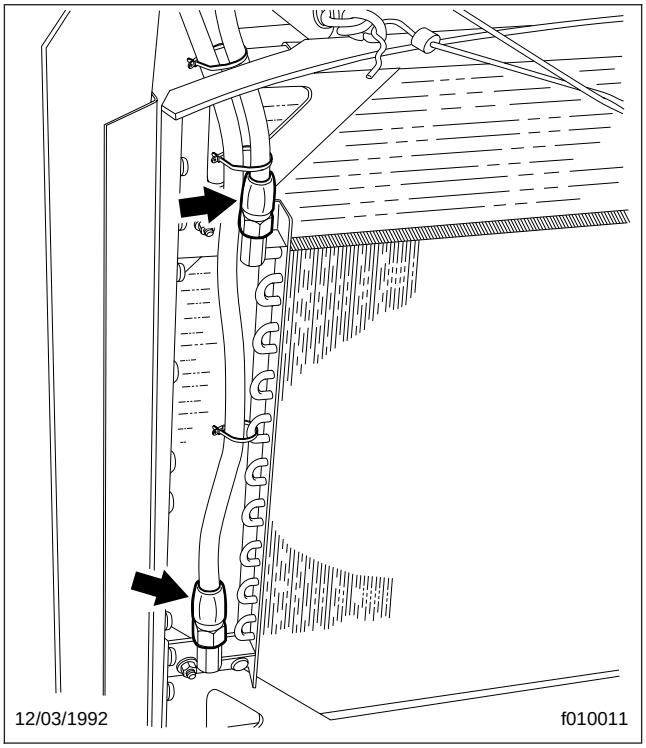
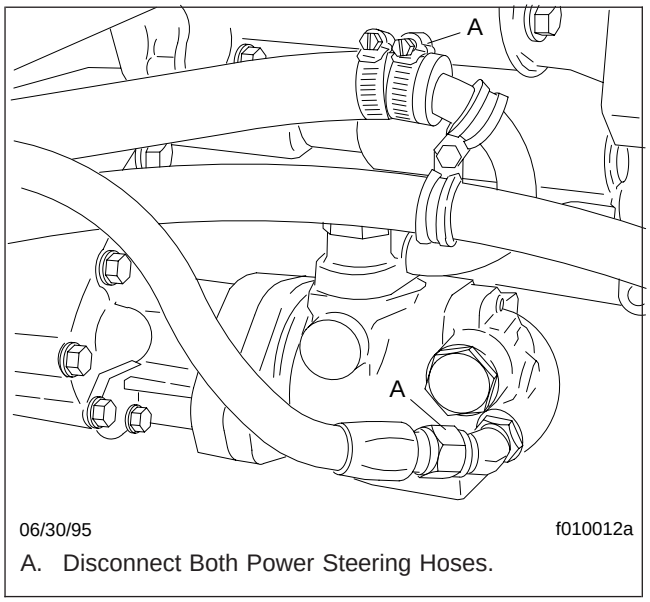


Fig. 4, Refrigerant Hose Connections

Cover the entire shift tower opening in the top of the transmission with a clean piece of cardboard.



A. Disconnect Both Power Steering Hoses.

Fig. 5, Power Steering Hoses

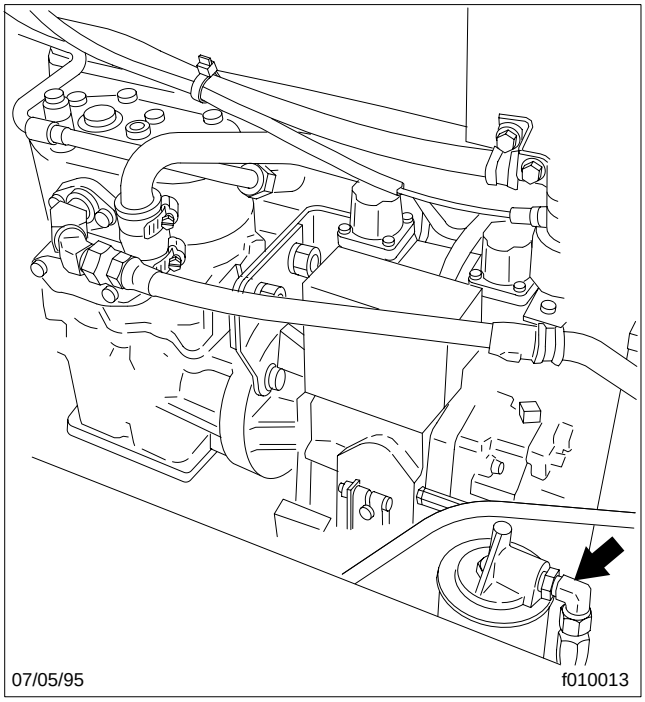


Fig. 6, Fuel Supply Hose

Fasten the cardboard in place with the shift tower attachment bolts.

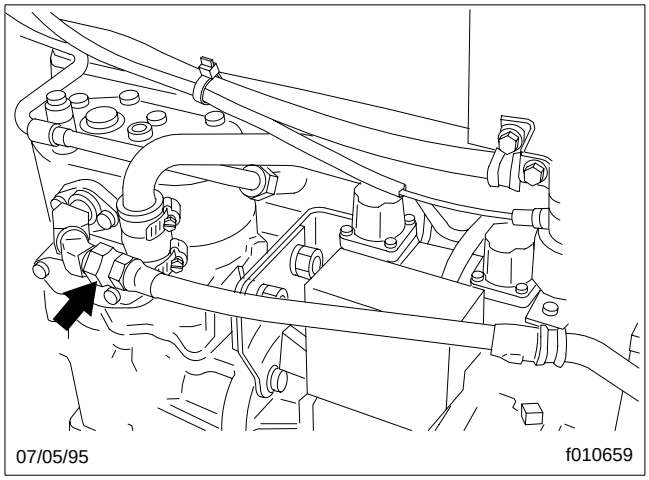


Fig. 7, Air Compressor Discharge Line

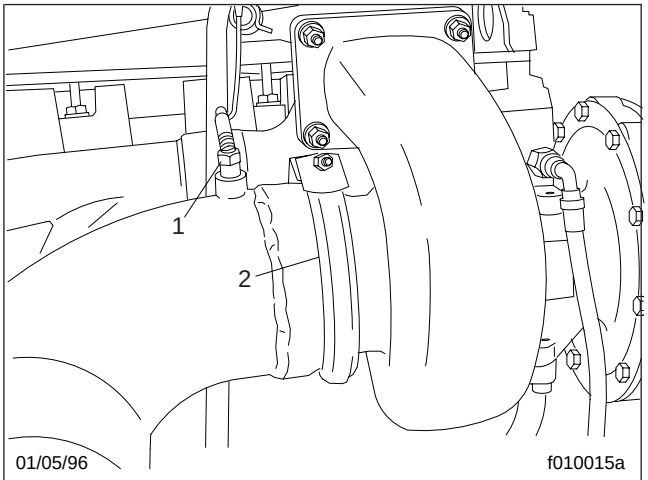
20. Mark the position of the clutch-release lever on the clutch-release shaft, then remove the release lever from the shaft.
21. Disconnect the transmission support spring (if equipped) from the transmission, and remove it.
22. Disconnect the driveline from the transmission output yoke. For instructions, refer to the driveline section in this manual. Support the driveline on safety stands.
23. Remove the bolts, spacers, and nuts that attach the cab-mount (overslung) crossmember to the frame-mounted engine support brackets. Remove the overslung crossmember.
24. Disconnect the oil level sending unit from the oil pan. Disconnect the wiring connections at the speedometer and tachometer magnetic pickup sensors.
25. At the turbocharger exhaust outlet pipe, disconnect the wiring for the pyrometer (if equipped). See **Fig. 8**.

    Loosen the V-type clamp at the turbocharger exhaust outlet pipe, and pull the exhaust pipe away from the turbocharger outlet. See **Fig. 8**.
26. Loosen the hose clamps **(Fig. 9)** and remove the rubber connecting hose that attaches to the air cleaner and the aluminum tube.

    Remove the fasteners that attach the air cleaner to the air intake duct and mounting bracket. See **Fig. 10**. Remove the air cleaner.

Removal and Installation

27. Mark all wires for the PACE engine control system, then disconnect them.
28. Mark the alternator wires, then disconnect them. See **Fig. 11**.



1. Pyrometer Wiring Connection
2. V-Type Clamp

Fig. 8, Exhaust Pipe at the Turbocharger

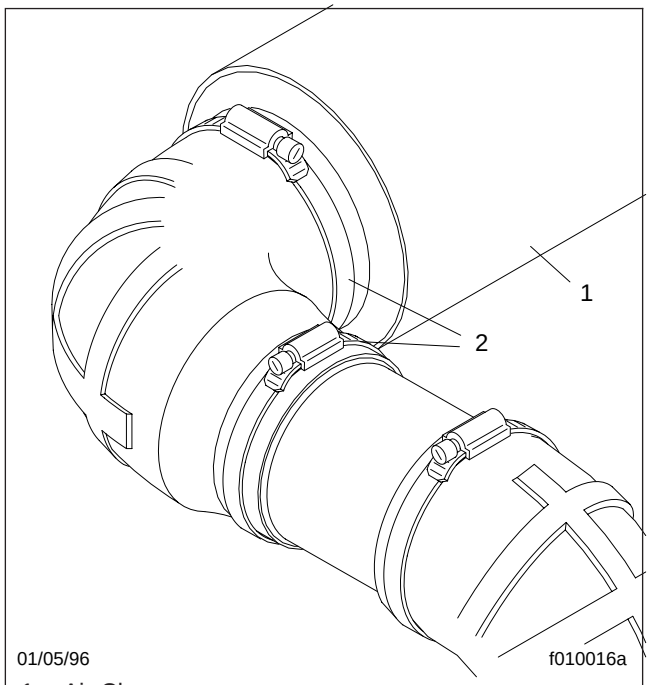
29. Attach an appropriate lifting device to an A-frame or an overhead crane. Move the A-frame or crane into place across the engine.

    Attach the lifting device to the front and rear lifting eyes of the engine.

30. Remove the rear engine-support bolts, lower bearing washers, and locknuts. Remove the flanged locknuts, bolts, and bottom isolators from the front engine-support bracket and the engine front crossmember.

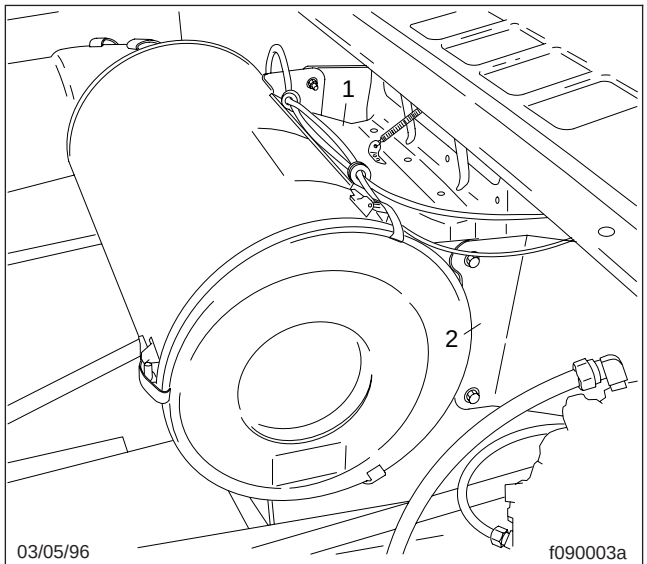
NOTE: To allow removal of the front engine-support fasteners, if needed, remove the relay valve bracket from the engine front crossmember, and move the relay valve and bracket out of the way.

31. Lift the engine and transmission up a few inches; pull the engine forward an inch or two; lift it a few inches more; pull it forward a few inches; then lift it up and forward to remove.
32. Set the engine and transmission on an engine stand or other suitable support, and remove the lifting device.



1. Air Cleaner
2. Hose Clamps

Fig. 9, Air Cleaner Hose



1. Air Intake Duct
2. Mounting Bracket

Fig. 10, Air Cleaner Attachments

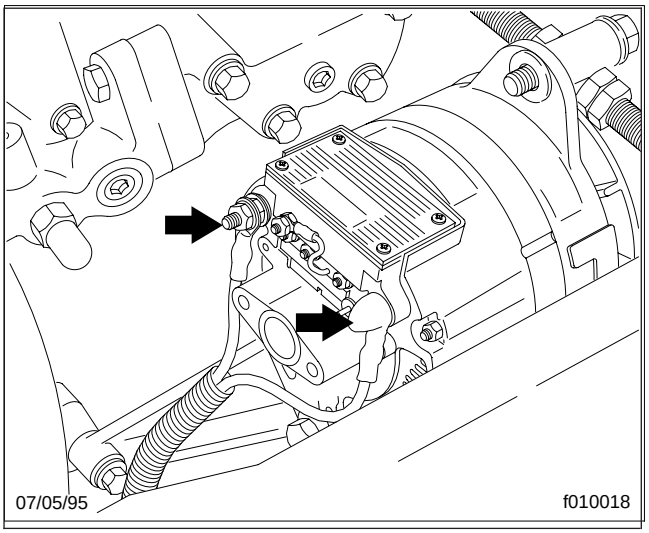


Fig. 11, Alternator Wires

33. Remove the rear engine-support upper bearing washers and upper isolators from both of the frame-mounted engine-support brackets.

    Remove the front engine-support top isolators, isolator tubes, and bushings from the front crossmember.

Installation

1. Check all of the front and rear engine support components for damage and extreme wear. Replace the components as needed.
2. Install the isolator tubes and the top isolators in the engine front crossmember. Coat the rubber mounts with soapy water, and install them in the rear engine mounts.

⚠ CAUTION

Don't lubricate the components with oil, grease, or silicone lubricants, because they will soften the rubber and damage the mounts.

3. Attach the lifting device to the engine lifting eyes. Attach the A-frame or overhead crane to the lifting device.
4. Lift the engine and transmission high enough to clear the chassis. Lower the engine and transmission into position on the front and rear engine-support mounts.
5. Using a floor jack, raise the transmission high enough to allow insertion and alignment of the rear engine-support upper isolators and bearing washers. Support the transmission on a safety stand, just in front of or just behind the floor jack.

   Install and align the upper isolators and bearing washers, and install the rear engine-support bolts. Remove the safety stand, lower the transmission, and remove the floor jack.

⚠ WARNING

Failure to position a safety stand under the transmission could result in personal injury if the engine and transmission assembly were to shift or drop.

6. Position the cab-mount (overslung) crossmember against the back of the frame mounted cab-support brackets. Using new bolts, install the longer attachment bolts with washers in the upper holes, and the shorter bolts with washers in the lower holes. Install new nuts, and progressively tighten them to 70 lbf·ft (95 N·m).
7. Install the lower, rear engine-support isolators, lower bearing washers, and locknuts on the bottom of the rear engine-support bolts. Tighten the locknuts 160 lbf·ft (217 N·m).
8. Position the bearing washers on the front engine-support bolts. Install the bolts upward through the front engine-support bracket and the engine front crossmember. Install the flanged locknuts; progressively tighten the locknuts to 210 lbf·ft (285 N·m).
9. Remove the lifting device.
10. If it was removed, install the relay valve and bracket on the engine front crossmember. Tighten the nuts 13 lbf·ft (18 N·m).
11. Install the clutch-release lever on the clutch-release shaft, aligning the mark on the lever with the mark on the shaft. Tighten the release-lever pinch bolt 40 lbf·ft (54 N·m).
12. Remove the cardboard cover from the opening in the transmission, and lower the shift tower into place. Install the lockwashers and capscrews. Tighten the capscrews 40 lbf·ft (54 N·m).
13. Install the transmission support spring. Tighten the bolts 125 lbf·ft (169 N·m).

Removal and Installation

14. Connect the air lines to the splitter (if so equipped), as previously marked.
15. Connect the transmission air supply line to the transmission.
16. Connect the driveline to the transmission output yoke. For instructions, refer to the driveline section in this manual.
17. Install the engine exhaust outlet pipe onto the turbocharger outlet, and tighten the V-type clamp nut 85 lbf·in (940 N·cm). Connect the wiring for the pyrometer, if equipped.
18. Install the air cleaner on the air intake duct and the mounting bracket. Using hose clamps, install the rubber connecting hose on the air cleaner inlet and the aluminum tube. Tighten the clamp screws 70 to 80 lbf·in (800 to 900 N·cm).
19. Attach the fuel return hose clamp to the fuel filter mounting plate. Connect the fuel return hose to the engine, and the fuel supply hose to the fuel filter.
20. Connect the terminal of the starter motor ground cable to the ground weld-stud in the channel of the left frame rail. Tighten the cap nut 23 lbf·ft (31 N·m). As marked earlier, connect the wiring to the starter.
21. Attach the battery cables to the standoff brackets under the engine and transmission.
22. Attach the throttle rod to the throttle pedal arm. For instructions, refer to the throttle linkage section in this manual.
23. Connect the power steering hoses to the power steering reservoir and the power steering pump.
24. Connect the air-tank air hoses to the elbow fittings on the air compressor governor. Attach the discharge line to the air compressor.
25. Connect all clamps that attach the air hoses to the engine and transmission.
26. Connect the heater hoses to the engine. Attach the radiator hoses and associated clamps to the engine. Tighten the hose clamps snug, but don't overtighten them.
27. Connect the speedometer, tachometer, and the oil level sending unit wiring connections.
28. Inspect the radiator support isolators for wear or damage, and replace them as needed. Place the radiator support lower isolators on the front crossmember.
29. Install the radiator assembly. For instructions, refer to the radiator section in this manual.
30. Connect the three radiator brace rods to the brace rod rear brackets. Tighten the brace rod fasteners 70 lbf·ft (95 N·m).
31. If equipped with an air conditioner:
    - 31.1 At all refrigerant hose fittings, install a new rubber O-ring, and lubricate the O-rings and fitting threads with refrigerant oil. Apply Loctite® 242 or 592 to the male portion of the fitting threads.
    - 31.2 Connect the refrigerant hoses to the refrigerant condenser, and compressor.
32. Tilt the hood until it is balanced over the pivots. While a coworker holds the hood in this position, connect the tilt assist cables to the brackets on top of the radiator at each side. If cable links are used, apply Loctite 242 to the threads on the cable links before screwing them closed.
33. Remove the hood supports from the front of the vehicle and tilt the hood all the way open.
34. As marked earlier, connect the wires for the PACE engine control system.
35. Connect the alternator wires.
36. Connect the positive battery cable to the batteries. Connect the negative battery cables.
37. Fill the cooling system with coolant, using the instructions in the radiator section in this manual.
38. Fill and bleed the power steering system, using the instructions in the steering section in this manual.
39. If equipped with air conditioning, evacuate and charge the system, using the instructions in the air conditioning section in this manual.
40. Install the grill. Refer to the hood section in this manual for instructions.

Engine Support Fasteners		
Description	**Size**	**Torque lbf·ft (N·m)**
Overslung Crossmember Bolts	1/2–13	70 (95)
Rear Engine-Support Locknuts	5/8–11	160 (217)
Front Engine-Support Locknuts	3/4–10	210 (285)
Engine Leg-to-Flywheel Bolts	3/4-10 x 1.75 inches	190 (258)

Table 1, Engine Support Fasteners

Removal, Installation, and Adjustment, Cummins NTC

Removal

REFRIGERANT COMPRESSOR BELT (See Fig. 1)

1. Back off the adjusting nut (Ref. E), then loosen the mounting nuts (Refs. A and F) and the adjusting link bolt (Ref. B) just enough to allow movement of the compressor.
2. Push the loosened compressor toward the accessory drive pulley until the distance between them is short enough to allow belt removal without using force.
3. Remove the belt, without prying or rolling it off of the pulleys.

FAN BELTS (See Fig. 2)

1. Remove the refrigerant compressor belt, if so equipped.
2. Loosen the nuts on the bolts (Ref. A) that secure the fan hub to the fan hub bracket.
3. Turn the fan hub adjusting bolt (Ref. B) until there is minimal distance between the pulley centers.
4. Remove both fan belts by slipping them off of the pulleys and working them over one fan blade at a time. Don't roll or pry the belts off of the pulleys; the distance between the pulley centers must be short enough to allow belt removal without using force.

WATER PUMP BELT (See Fig. 2)

1. Remove the refrigerant compressor belt (if so equipped) and both fan belts.
2. Loosen the locknut that secures the idler pulley (Ref. D) to the water pump.
3. Turn the idler pulley adjusting bolt (Ref. C) until there is minimal distance between the pulley centers.
4. Remove the belt, without prying or rolling it off of the pulleys.

ALTERNATOR BELTS (See Fig. 3)

1. Loosen the fastener (Ref. A) that attaches the adjusting rod to the engine, and loosen the fasteners (Refs. E and F) that attach the alternator to the adjusting link and the mounting bracket.
2. Back off the adjusting nut (Ref. B), to allow the alternator to be moved toward the drive pulley far enough to remove the drive belt without prying or twisting it.
3. Push in on the alternator, and remove the belt.

Installation

ALTERNATOR BELTS (See Fig. 3)

1. Inspect the pulleys and used alternator belts (even if new belts are being installed) as instructed **in Subject 180.**
2. Make sure the distance between the pulleys is short enough to allow belt installation without using force.
3. Install the belts on the pulleys without prying or rolling them into place.
4. Back off the jam nut (Ref. D) to the end of the adjusting rod.
5. While keeping the belts seated in the pulley grooves, turn the adjusting nut (Ref. B) against the adjusting link (Ref. C) to increase belt tension. Use your thumb to apply about 25 lbs (11 kg) of force at the center of the belt free-span to check the tension while turning the nut. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, proceed to "Adjustment: Alternator Belts."

WATER PUMP BELT (See Fig. 2)

1. Inspect the pulleys and used water pump belt (even if a new belt is being installed) as instructed **in Subject 180.**
2. Make sure the distance between the pulleys is short enough to allow belt installation without using force.
3. Install the belt on the pulleys without prying or rolling it into place. Be sure the ribs on the belt are seated in the grooves on each pulley.
4. While keeping the belt seated in the pulley grooves, turn the idler pulley adjusting bolt (Ref. C) to increase belt tension. Use your thumb to apply about 25 lbs (11 kg) of force at the center

Removal, Installation, and Adjustment, Cummins NTC

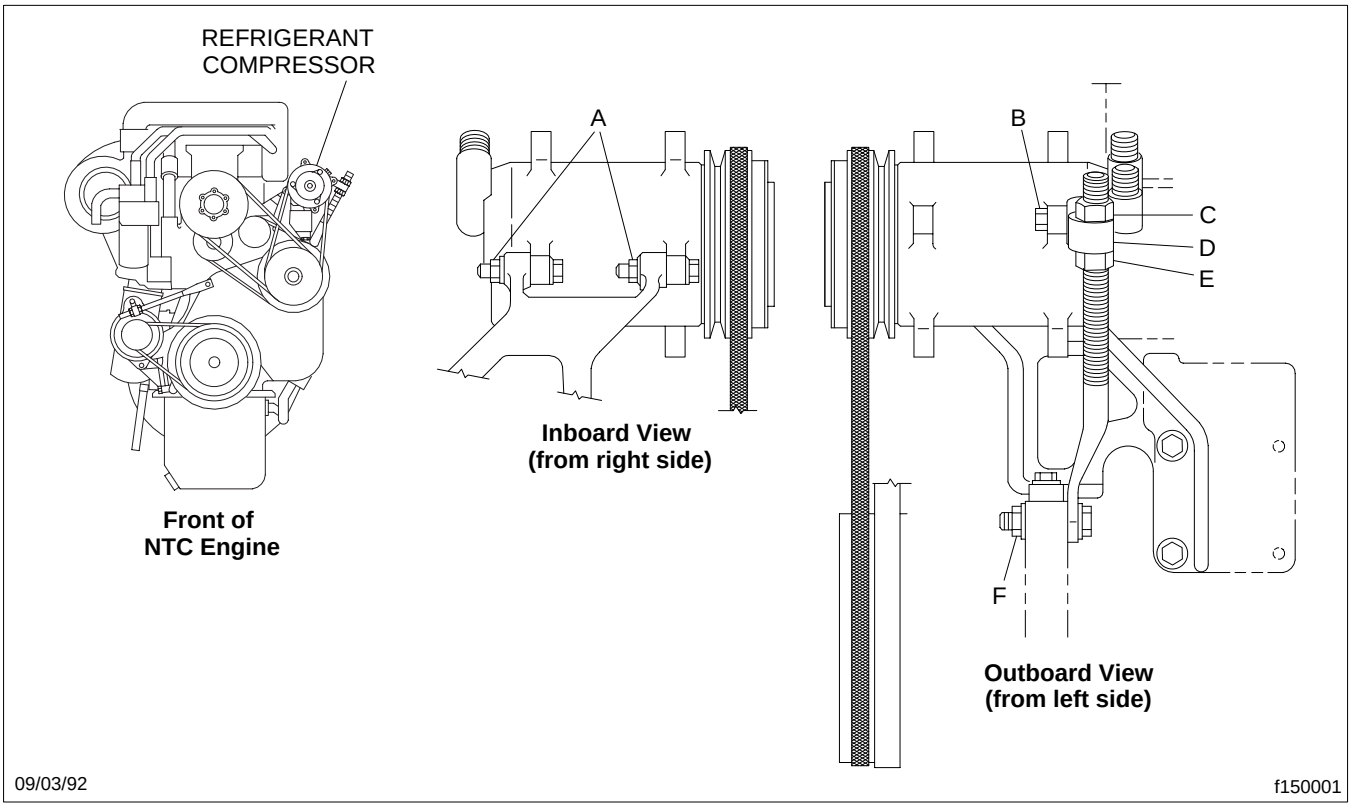


Fig. 1

of the belt free-span to check the tension while turning the bolt. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, proceed to "Adjustment: Water Pump Belt."

FAN BELTS (See Fig. 2)

1. If the water pump belt was removed, install and adjust it first.
2. Inspect the pulleys and used fan belts (even if new belts are being installed) as instructed **in Subject 180.**
3. Make sure the distance between the pulleys is short enough to allow belt installation without using force.
4. Work the belts over the fan blades, one blade at a time. Install the belts on the pulleys without prying or rolling them into place.
5. While keeping the belts seated in the pulley grooves, turn the fan hub adjusting bolt (Ref. B) to increase belt tension. Use your thumb to apply about 25 lbs (11 kg) of force at the center of the belt free-span to check the tension while turning the bolt. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, proceed to "Adjustment: Fan Belts."

REFRIGERANT COMPRESSOR BELT (See Fig. 1)

1. If the water pump belt or fan belts were removed, install and adjust them first.
2. Inspect the pulleys and used refrigerant compressor belt (even if a new belt is being installed) as instructed **in Subject 180.**
3. Make sure the distance between the pulleys is short enough to allow belt installation without using force.
4. Install the belt on the pulleys without prying or rolling it into place.

Removal, Installation, and Adjustment, Cummins NTC

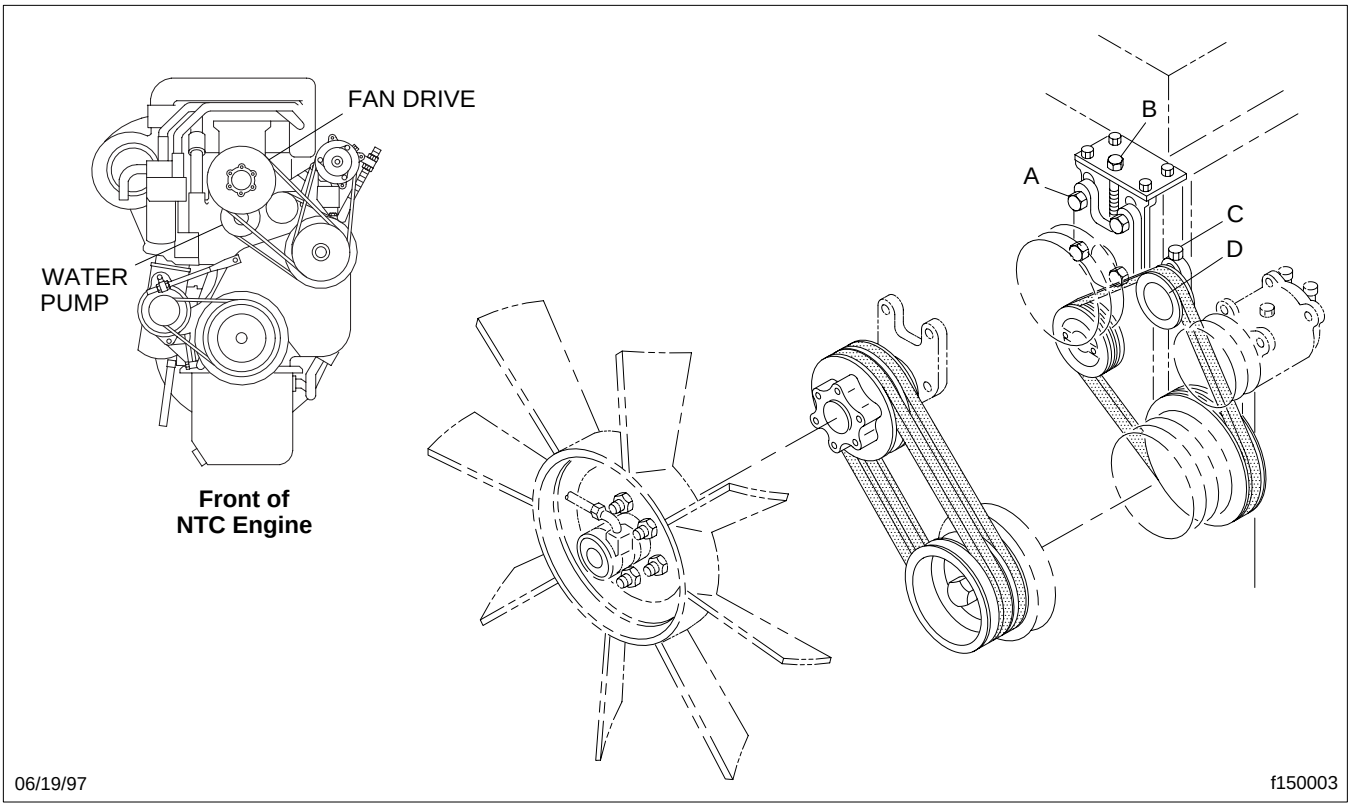


Fig. 2

5. Back off the jam nut (Ref. C) to the end of the adjusting rod.
6. While keeping the belt seated in the pulley grooves, turn the adjusting nut (Ref. E) against the adjusting link (Ref. D) to increase belt tension. Use your thumb to apply about 25 lbs (11 kg) of force at the center of the belt free-span to check the tension while turning the nut. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, proceed to "Adjustment: Refrigerant Compressor Belt."

Adjustment

ALTERNATOR BELTS (See Fig. 3)

1. If not already done, back off the adjusting link jam nut (Ref. D). Loosen the mounting fasteners (Refs. E and F) just enough to allow movement of the alternator, and loosen the fastener (Ref. A) that attaches the adjusting rod to the engine.
2. Install a belt tension gauge at the center of the free-span of one of the belts.
3. Turn the adjusting nut (Ref. B) to adjust the tension to a reading of 130 to 150 lbs (59 to 68 kg) for new belts, or 80 to 120 lbs (36 to 55 kg) for used belts. A used belt is any belt that has been in operation more than ten minutes.

IMPORTANT: Do not overtighten the belts; too much tension shortens belt life and bearing life.

4. Tighten the adjusting link jam nut (Ref. D) 155 lbf·ft (210 N·m).
5. Tighten the alternator mounting fasteners (Refs. E and F) and the adjusting-rod bolt (Ref. A) 70 lbf·ft (95 N·m).
6. Check the belt tension, and adjust it if needed.
7. If new alternator belts were installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

Removal, Installation, and Adjustment, Cummins NTC

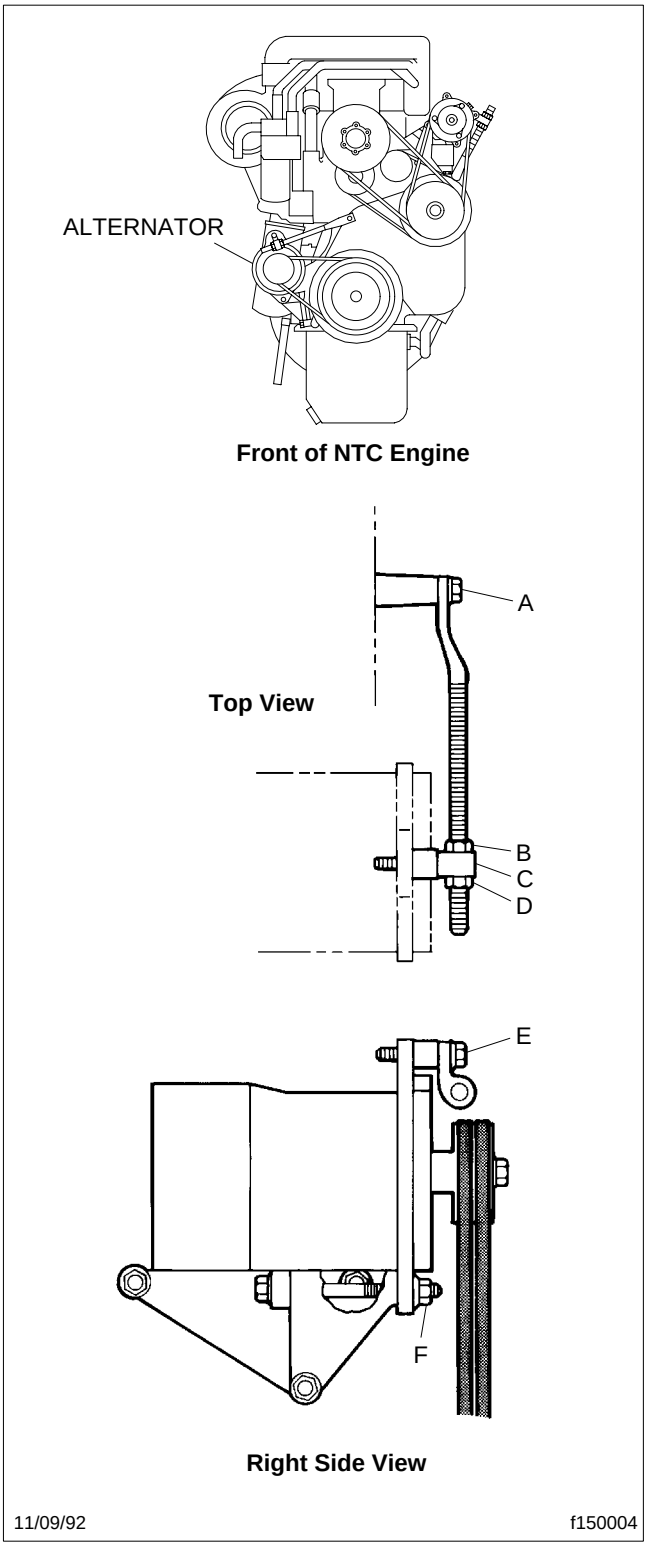


Fig. 3

If the alternator belt tension is not between 80 and 120 lbs (36 to 55 kg), adjust the tension to 120 lbs (55 kg).

WATER PUMP BELT (See Fig. 2)

1. If not already done, loosen the locknut that secures the idler pulley (Ref. D) to the water pump.
2. Install a belt tension gauge at the center of the belt's longest free-span.
3. Turn the idler pulley adjusting bolt (Ref. C) to increase or decrease the belt tension, but do not adjust the tension to the full value with the adjusting bolt; belt tension can increase when the idler pulley shaft locknut is tightened. Final tension must be 140 to 160 lbs (64 to 73 kg) for a new belt, or 90 to 120 lbs (41 to 55 kg) for a used belt. A used belt is any belt that has been in operation more than ten minutes.

IMPORTANT: Do not overtighten the belt; too much tension shortens belt life and bearing life.

4. Tighten the idler pulley shaft locknut 50 lbf·ft (70 N·m).
5. Loosen the idler pulley adjusting bolt one-half turn to prevent breakage.
6. Check the belt tension, and adjust it if needed.
7. Install and adjust both fan belts and the refrigerant compressor belt (if so equipped).
8. If any new belts were installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

   If the water pump belt tension is not between 90 and 120 lbs (41 to 55 kg), adjust the tension to 120 lbs (55 kg).

FAN BELTS (See Fig. 2)

1. If not already done, loosen the nuts on the bolts (Ref. A) that secure the fan hub to the fan hub bracket.
2. Install a belt tension gauge at the center of the free-span of one of the belts.
3. Turn the fan hub adjusting bolt (Ref. B) to increase or decrease belt tension, but do not adjust the tension to the full value with the adjusting bolt; belt tension can increase when the fan

hub bracket nuts are tightened. Final tension must be 130 to 150 lbs (59 to 68 kg) for new belts, or 80 to 120 lbs (36 to 55 kg) for used belts. A used belt is any belt that has been in operation more than ten minutes.

IMPORTANT: Do not overtighten the belts; too much tension shortens belt life and bearing life.

4. Tighten the fan hub bracket nuts 80 lbf·ft (110 N·m).
5. Loosen the fan hub adjusting bolt one-half turn to prevent breakage.
6. Check the belt tension, and adjust it if needed.
7. Install and adjust the refrigerant compressor belt, if so equipped.
8. If any new belts were installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

   If the fan belt tension is not between 80 and 120 lbs (36 to 55 kg), adjust the tension to 120 lbs (55 kg).

REFRIGERANT COMPRESSOR BELT (See Fig. 1)

1. If not already done, back off the adjusting link jam nut (Ref. C) to the end of the adjusting rod, and loosen the mounting nuts (Refs. A and F) and adjusting link bolt (Ref. B) just enough to allow movement of the compressor.
2. Install a belt tension gauge at the center of the belt free-span.
3. Turn the adjusting nut (Ref. E) to adjust the tension to a reading of 130 lbs (59 kg) for a new belt, or 80 to 100 lbs (36 to 45 kg) for a used belt. A used belt is any belt that has been in operation more than ten minutes.

IMPORTANT: Do not overtighten the belt; too much tension shortens belt life and bearing life.

4. Tighten the adjusting link jam nut (Ref. C) 155 lbf·ft (210 N·m).
5. Tighten the compressor mounting nuts (Ref. A) and the adjusting link bolt (Ref. B) 33 lbf·ft (45 N·m). Tighten the adjusting rod nut (Ref. F) 70 lbf·ft (95 N·m).
6. Check the belt tension, and adjust it if needed.
7. If a new refrigerant compressor belt was installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

   If the refrigerant compressor belt tension is not between 80 and 100 lbs (36 to 45 kg), adjust the tension to 100 lbs (45 kg).

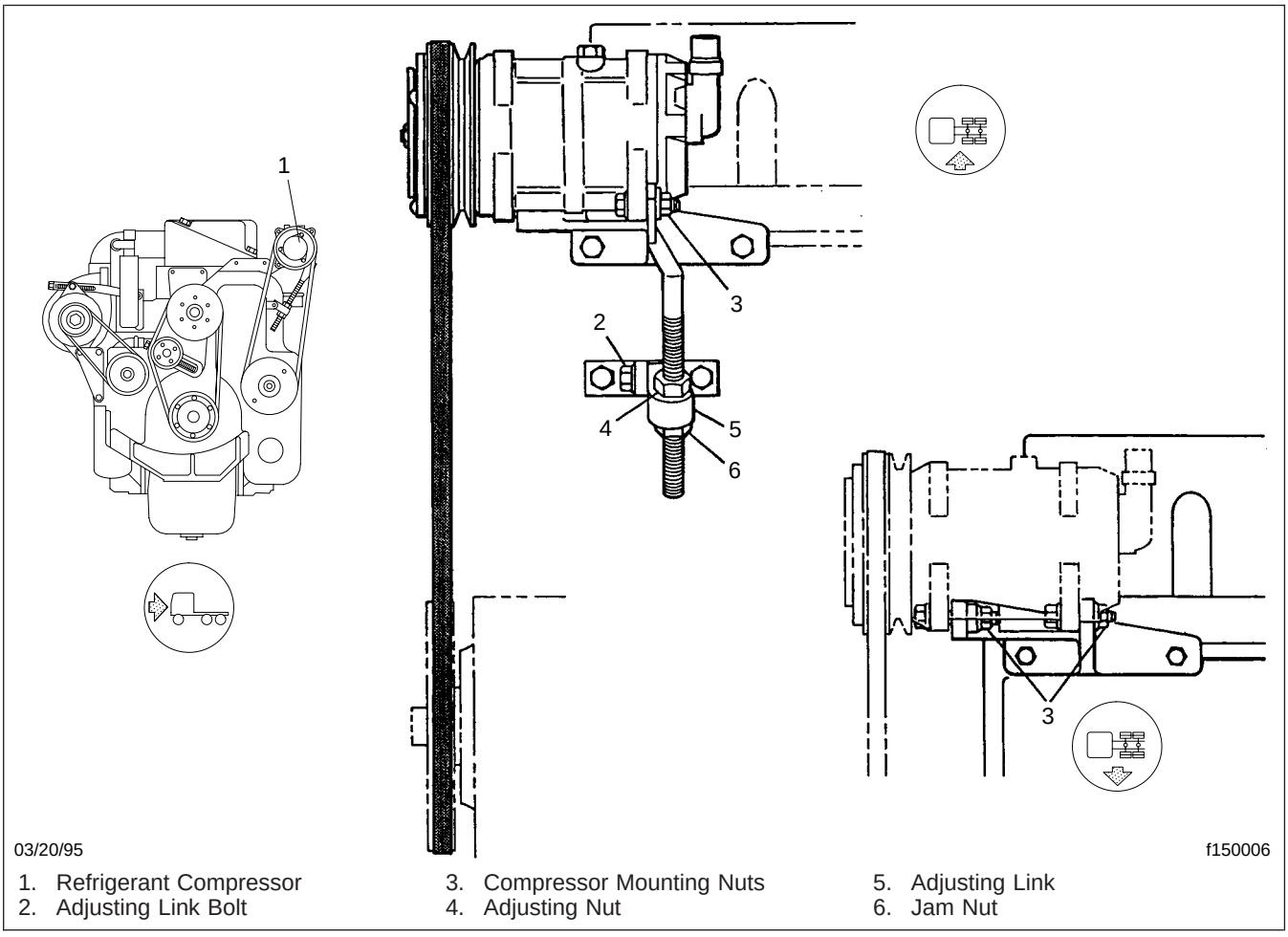
Removal, Installation, and Adjustment, Cummins L10

Removal

REFRIGERANT COMPRESSOR BELT (See Fig. 1 or Fig. 2)

FAN BELT (See Fig. 3)

1. Loosen the locknut that secures the idler pulley to the fan bracket.



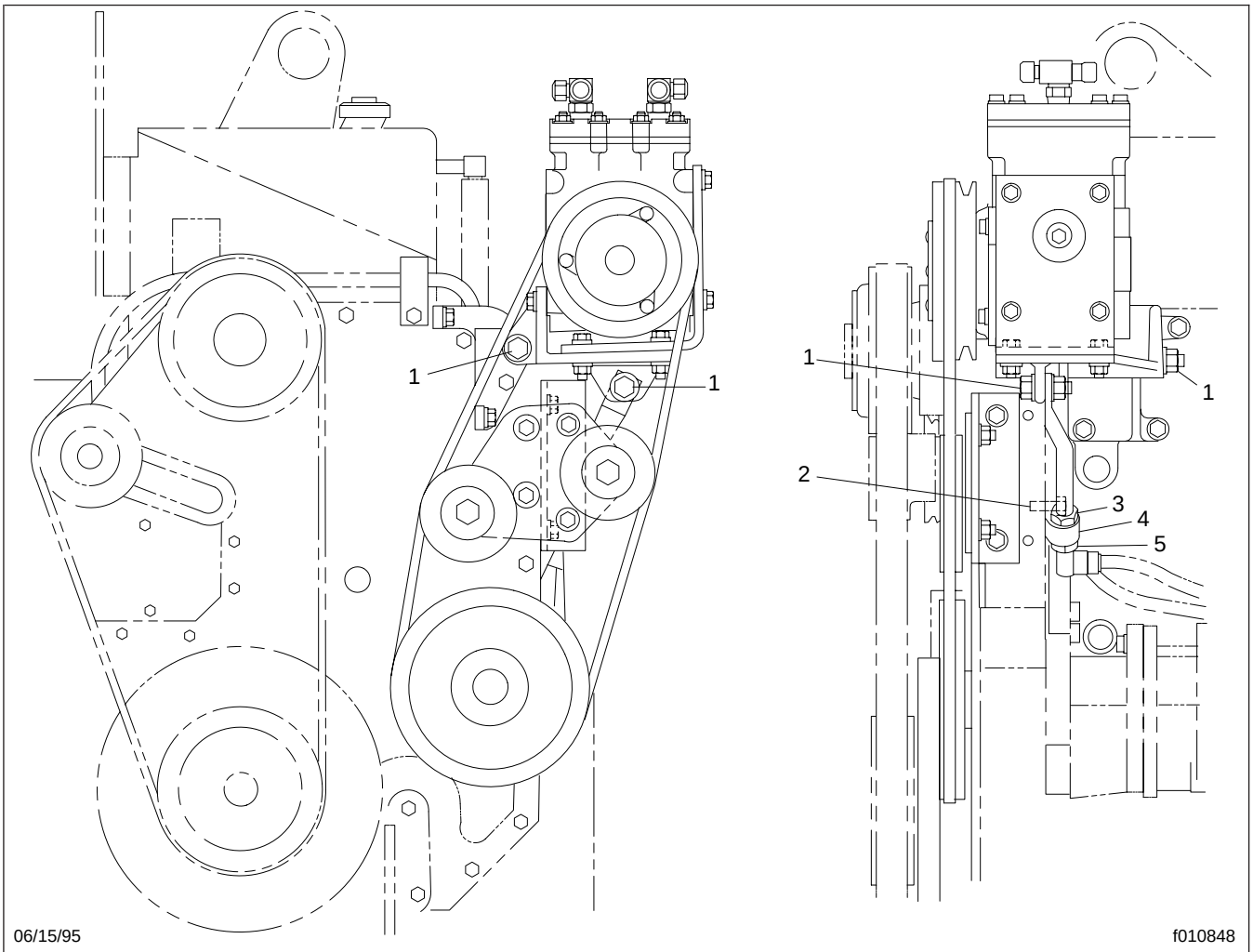
1. Refrigerant Compressor
2. Adjusting Link Bolt
3. Compressor Mounting Nuts
4. Adjusting Nut
5. Adjusting Link
6. Jam Nut

Fig. 1, Refrigerant Compressor Installation, Rotary Type

1. Back off the adjusting nut. Loosen the mounting nuts and the adjusting link bolt just enough to allow movement of the compressor.
2. Push the loosened compressor toward the accessory drive pulley until the distance between them is short enough to allow belt removal without using force.
3. Remove the belt, without prying or rolling it off of the pulleys.

2. Turn the idler pulley adjustment capscrew until there is minimal distance between the pulley centers.
3. Remove the fan belt by slipping it off of the pulleys and working it over one fan blade at a time. Don't roll or pry the belt off of the pulleys; the distance between the pulley centers must be short enough to allow belt removal without using force.

Removal, Installation, and Adjustment, Cummins L10



1. Compressor Mounting Nut
2. Adjusting Link Bolt
3. Adjusting Nut
4. Adjusting Link
5. Jam Nut

Fig. 2, Refrigerant Compressor Installation, Piston Type

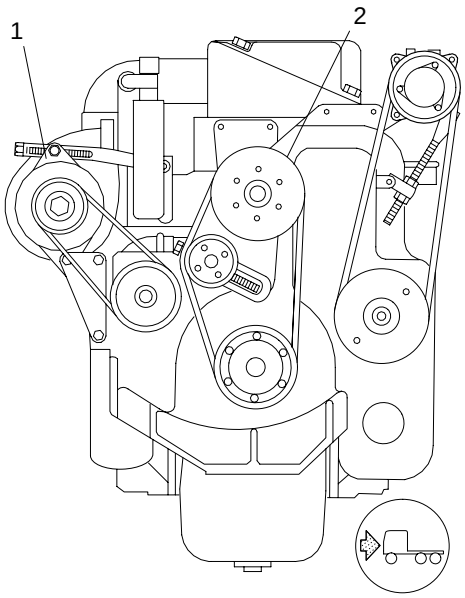
ALTERNATOR BELT (See Fig. 3)

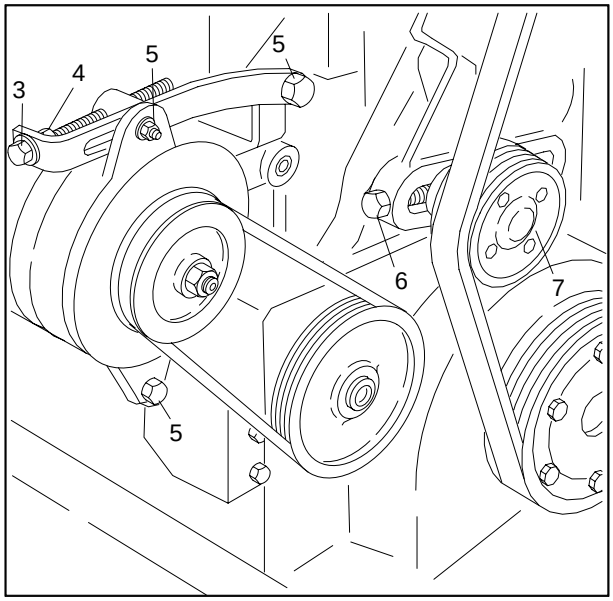
1. Loosen the three mounting fasteners just enough to allow movement of the alternator.
2. Loosen the adjusting screw locknut.
3. Turn the adjusting screw counterclockwise, backing off the alternator toward the drive pulley far enough to allow belt removal without using force.
4. Remove the belt, without prying or rolling it off of the pulleys.

Installation

REFRIGERANT COMPRESSOR BELT (See Fig. 1 or Fig. 2)

1. Inspect the pulleys and used refrigerant compressor belt (even if a new belt is being installed) as instructed under **Subject 180**.
2. Make sure the distance between the pulleys is short enough to allow belt installation without using force.





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1. Alternator
2. Fan Drive
3. Adjusting Screw
4. Adjusting Screw Locknut
5. Alternator Mounting Fastener
6. Idler Pulley Adjustment Capscrew
7. Idler Pulley

Fig. 3, Alternator and Fan Drive

3. Install the belt on the pulleys without prying or rolling it into place.
4. Back off the jam nut to the end of the adjusting rod.
5. While keeping the belt seated in the pulley grooves, turn the adjusting nut against the adjusting link to increase belt tension. Use your thumb to apply about 25 lbs (11 kg) of force at the center of the belt free-span to check the tension while turning the nut. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, proceed to "Adjustment: Refrigerant Compressor Belt."

FAN BELT (See Fig. 3)

1. Inspect the pulleys and used fan belt (even if a new belt is being installed) as instructed under **Subject 180**.
2. Make sure the distance between the pulleys is short enough to allow belt installation without using force.
3. Work the belt over the fan blades, one blade at a time. Install the belt on the pulleys without prying or rolling it into place. Be sure the ribs on the belt are seated in the grooves on each pulley.
4. While keeping the belt seated in the pulley grooves, turn the idler pulley adjustment capscrew to increase the belt tension. Use your thumb to apply about 25 lbs (11 kg) of force at the center of the belt free-span to check the tension while turning the capscrew. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, proceed to "Adjustment: Fan Belt."

ALTERNATOR BELT (See Fig. 3)

1. Inspect the pulleys and used alternator belt (even if a new belt is being installed) as instructed under **Subject 180**.
2. Make sure the distance between the pulleys is short enough to allow belt installation without using force.

3. Install the belt on the pulleys without prying or rolling it into place. Be sure the ribs on the belt are seated in the grooves on each pulley.
4. While keeping the belt seated in the pulley grooves, turn the adjusting screw clockwise to increase the belt tension. Use your thumb to apply about 25 lbs (11 kg) of force at the center of the belt free-span to check the tension while turning the adjusting screw. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, proceed to "Adjustment: Alternator Belt."

Adjustment

REFRIGERANT COMPRESSOR BELT (See Fig. 1 or Fig. 2)

1. If not already done, back off the adjusting link jam nut to the end of the adjusting rod, and loosen the mounting nuts and adjusting link bolt just enough to allow movement of the compressor.
2. Install a belt tension gauge at the center of the belt free-span.
3. Turn the adjusting nut to adjust the tension to a reading of 130 lbs (59 kg) for a new belt, or 80 to 100 lbs (36 to 45 kg) for a used belt. A used belt is any belt that has been in operation more than ten minutes.

IMPORTANT: Do not overtighten the belt; too much tension shortens belt life and bearing life.

4. Tighten the adjusting link jam nut 155 lbf·ft (210 N·m).
5. Tighten the compressor mounting nuts 30 lbf·ft (40 N·m), and the adjusting link bolt 40 lbf·ft (55 N·m).
6. Check the belt tension, and adjust it if needed.
7. If a new refrigerant compressor belt was installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

   If the refrigerant compressor belt tension is not between 80 and 100 lbs (36 to 45 kg), adjust the tension to 100 lbs (45 kg).

FAN BELT (See Fig. 3)

1. If not already done, loosen the locknut that secures the idler pulley to the fan bracket.
2. Install a belt tension gauge at the center of the belt's longest free-span.
3. Turn the idler pulley adjustment capscrew to increase or decrease belt tension, but do not adjust the tension to the full value with the idler pulley adjustment capscrew; belt tension can increase when the idler pulley locknut is tightened. Final tension must be 190 to 210 lbs (86 to 95 kg) for a new belt, or 155 to 165 lbs (70 to 75 kg) for a used belt. A used belt is any belt that has been in operation more than ten minutes.

IMPORTANT: Do not overtighten the belt; too much tension shortens belt life and bearing life.

4. Tighten the idler pulley locknut 120 to 140 lbf·ft (165 to 190 N·m).
5. Loosen the idler pulley adjustment capscrew one-half turn, to prevent breakage.
6. Check the belt tension, and adjust it if needed.
7. If a new fan belt was installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

   If the fan belt tension is not between 155 and 165 lbs (70 to 75 kg), adjust the tension to 165 lbs (75 kg).

ALTERNATOR BELT (See Fig. 3)

1. If not already done, loosen the adjusting screw locknut, and loosen the three mounting fasteners just enough to allow movement of the alternator.
2. Install a belt tension gauge at the center of the belt free-span.
3. Turn the adjusting screw to adjust the tension to a reading of 140 to 160 lbs (64 to 73 kg) for a new belt, or 90 to 120 lbs (41 to 55 kg) for a used belt. A used belt is any belt that has been in operation more than ten minutes.

IMPORTANT: Do not overtighten the belt; too much tension shortens belt life and bearing life.

4. Tighten the adjusting screw locknut 95 lbf·ft (130 N·m).
5. Tighten the alternator mounting fastener 60 lbf·ft (80 N·m), the adjusting block nut 35 lbf·ft (50 N·m), and the adjusting arm bolt 55 lbf·ft (75 N·m).
6. Check the belt tension, and adjust it if needed.
7. If a new alternator belt was installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

   If the alternator belt tension is not between 90 and 120 lbs (41 to 55 kg), adjust the tension to 120 lbs (55 kg).

Removal, Installation, and Adjustment, Caterpillar 3306

Removal

ALTERNATOR AND REFRIGERANT COMPRESSOR BELTS (See Fig. 1)

1. Back off the adjusting nut (Ref. D), then loosen the alternator mounting fasteners (Refs. A and E) just enough to allow movement of the alternator.
2. Push the loosened alternator toward the fan drive pulley until the distance between them is short enough to allow belt removal without using force.
3. Remove both belts by slipping them off of the pulleys and working them over one fan blade at a time.

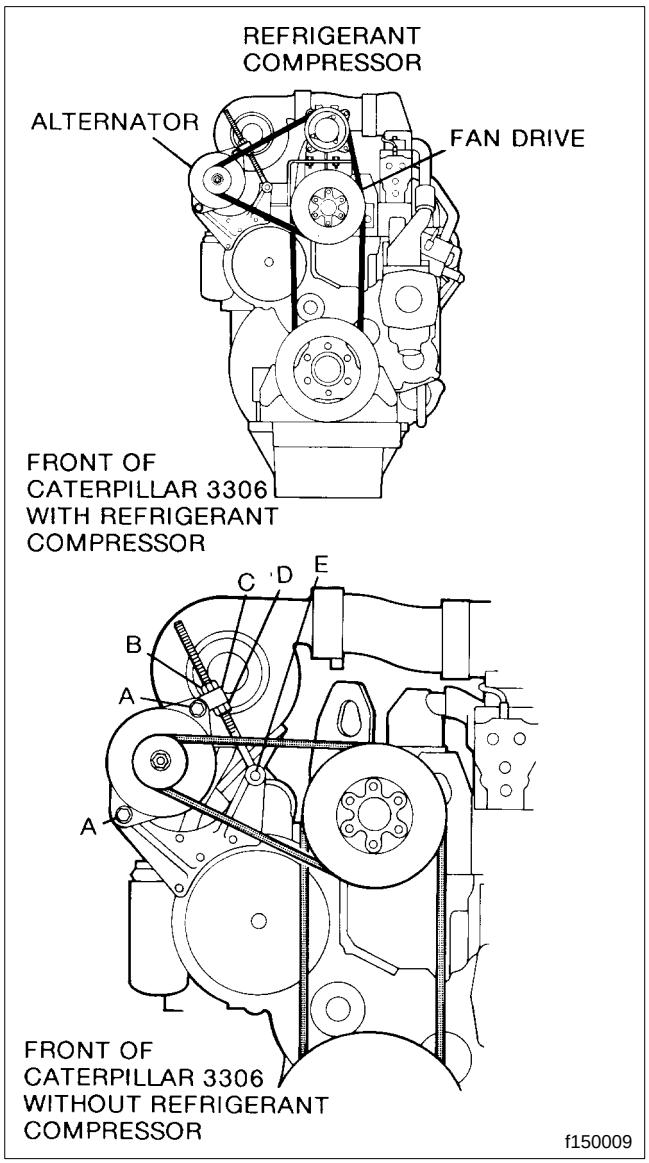


Fig. 1, Alternator and Refrigerant Compressor

FAN BELTS (See Fig. 2)

1. Remove both alternator belts.
2. Loosen the bolts (Ref. B) that secure the fan hub to the fan hub bracket.
3. Turn the fan hub adjusting bolt (Ref. A) until there is minimal distance between the pulley centers.
4. Remove both fan belts by slipping them off of the pulleys and working them over one fan blade at a time. Don't roll or pry the belts off; the distance between the pulley centers must be short enough to allow belt removal without using force.

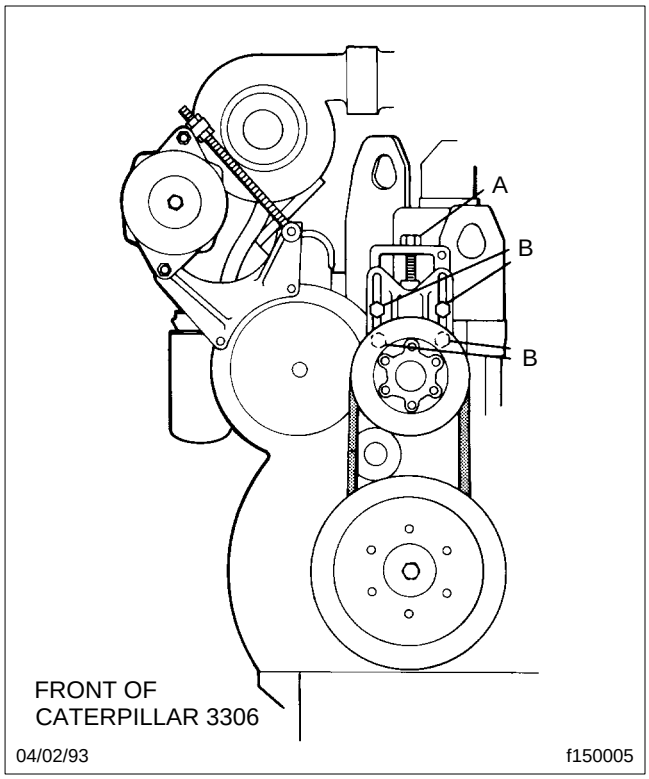


Fig. 2, Fan Drive

Removal, Installation, and Adjustment, Caterpillar 3306

Installation

FAN BELTS (See Fig. 2)

1. Inspect the pulleys and used fan belts (even if new belts are being installed) as instructed in **Subject 180.**
2. Make sure the distance between the pulleys is short enough to allow belt installation without using force.
3. Work the belts over the fan blades, one blade at a time. Install the belts on the pulleys without prying or rolling them into place.
4. While keeping the belts seated in the pulley grooves, turn the fan hub adjusting bolt (Ref. A) to increase the belt tension. Use your thumb to apply about 25 lbs (11 kg) of force at the center of the belt free-span to check the tension while turning the bolt. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, proceed to "Adjustment: Fan Belts."

ALTERNATOR AND REFRIGERANT COMPRESSOR BELTS (See Fig. 1)

1. If the fan belts were removed, install and adjust them first.
2. Inspect the pulleys and used alternator belts (even if new belts are being installed) as instructed in **Subject 180.**
3. Make sure the distance between the pulleys is short enough to allow belt installation without using force.
4. Install the belts on the pulleys without prying or rolling them into place.
5. Back off the jam nut (Ref. B) to the end of the adjusting rod.
6. While keeping the belts seated in the pulley grooves, turn the adjusting nut (Ref. D) against the adjusting link (Ref. C) to increase the belt tension. Use your thumb to apply about 25 lbs (11 kg) of force at the center of the belt free-span to check the tension while turning the nut. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, proceed to "Adjustment: Alternator and Refrigerant Compressor Belts."

Adjustment

FAN BELTS (See Fig. 2)

1. If not already done, loosen the bolts (Ref. B) that secure the fan hub to the fan hub bracket.
2. Install a belt tension gauge on the forwardmost belt, at the center of the belt free-span.
3. Turn the fan hub adjusting bolt (Ref. A) to increase or decrease the belt tension, but do not adjust the tension to the full value with the fan hub adjusting bolt; tension can increase when the fan hub bracket bolts are tightened. Final tension must be 115 to 125 lbs (52 to 57 kg) for new belts, or 80 to 100 lbs (36 to 45 kg) for used belts. A used belt is any belt that has been in operation more than ten minutes.

IMPORTANT: Do not overtighten the belts; too much tension shortens belt life and bearing life.

4. Tighten the fan hub bracket bolts 70 lbf·ft (95 N·m).
5. Loosen the fan hub adjusting bolt one-half turn.
6. Check the belt tension, and adjust it if needed.
7. Install and adjust the alternator belts.
8. If any new belts were installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

   If the fan belt tension is not between 80 and 100 lbs (36 to 45 kg), adjust the tension to 100 lbs (45 kg).

ALTERNATOR AND REFRIGERANT COMPRESSOR BELTS (See Fig. 1)

1. If not already done, back off the adjusting link jam nut (Ref. B) to the end of the adjusting rod, and loosen the alternator mounting fasteners (Refs. A and E) just enough to allow movement of the alternator.
2. Install a belt tension gauge on the forwardmost belt at the center of the belt's longest free-span.
3. Turn the adjusting nut (Ref. D) to adjust the tension to a reading of 115 to 125 lbs (52 to 57 kg) for new belts, or 80 to 100 lbs (36 to 45 kg) for

used belts. A used belt is any belt that has been in operation more than ten minutes.

IMPORTANT: Do not overtighten the belts; too much tension shortens belt life and bearing life.

4. Tighten the adjusting rod jam nut (Ref. B) 95 lbf·ft (130 N·m).
5. Tighten the alternator mounting fasteners (Refs. A and E) 70 lbf·ft (95 N·m).
6. Check the belt tension, and adjust it if needed.
7. If new alternator belts were installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

   If the alternator belt tension is not between 80 and 100 lbs (36 to 45 kg), adjust the tension to 100 lbs (45 kg).

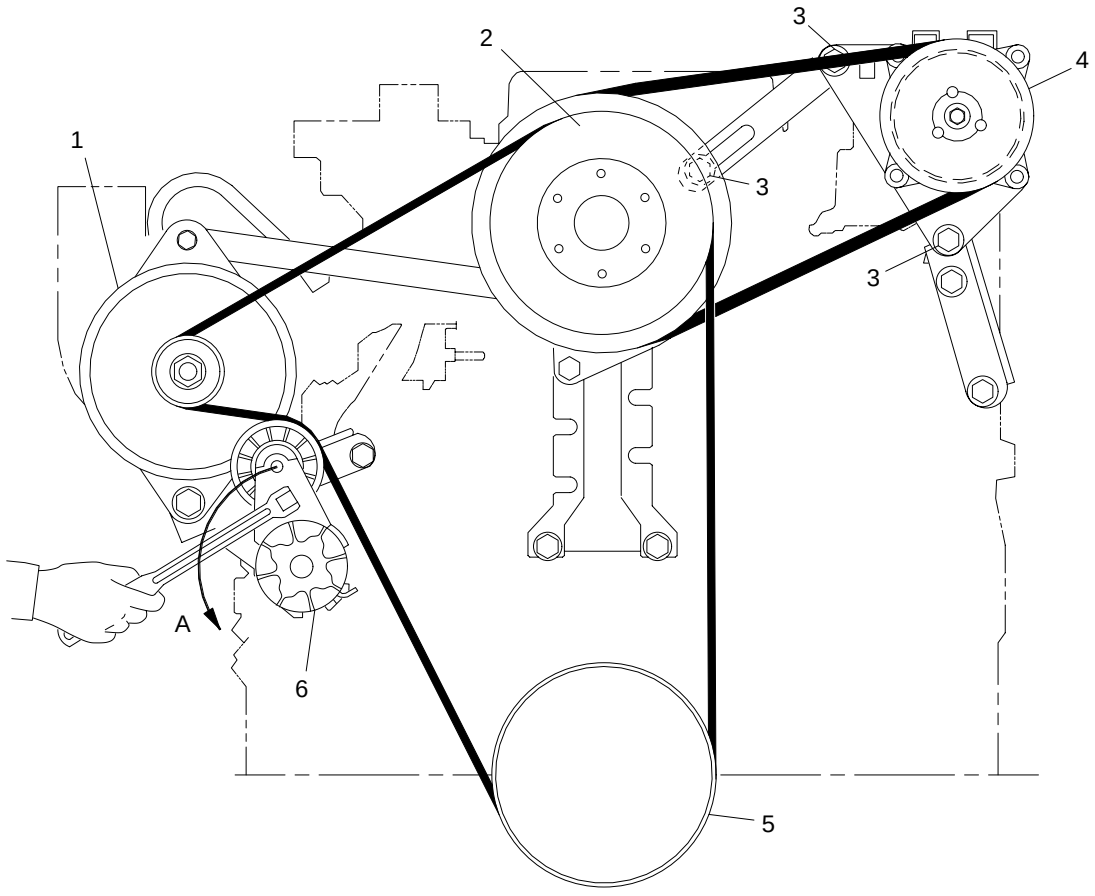
Removal, Installation, and Adjustment, Caterpillar 3176

Removal

FAN AND ALTERNATOR BELT

(See Fig. 1)

1. Remove the belt from the refrigerant compressor pulley and let the belt rest on the fan hub. Refer to the refrigerant compressor belt removal procedure in this subject.
2. Insert a 1/2-inch breaker bar in the belt tensioner and rotate the tensioner down and off the belt.
3. Holding the belt tensioner down, remove the belt from the alternator pulley.
4. Slowly release the belt tensioner, and remove the breaker bar.



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A. Rotate the belt tensioner down and off the belt.
1. Alternator
2. Fan Pulley
3. Refrigerant Compressor Mounting Bolts
4. Refrigerant Compressor
5. Vibration Damper
6. Belt Tensioner

Fig. 1

NOTE: On Kysor and Horton HT550 fan clutches, the air line must be disconnected from the fan clutch cylinder before the fan/alternator belt can be removed.

Removal, Installation, and Adjustment, Caterpillar 3176

5. Lower the belt, and take it off the vibration damper. Raise the belt, and take it off over the fan. Remove the belt from the engine compartment.

REFRIGERANT COMPRESSOR BELT (See Fig. 1 or Fig. 2)

1. If equipped with a swashplate refrigerant compressor (**Fig. 1**), loosen the compressor mounting bolts and move the compressor towards the fan pulley until the belt can be removed from the compressor.

   If equipped with a piston-type refrigerant compressor (**Fig. 2**), loosen the adjusting rod jam nut, back off the adjusting nut, and loosen the compressor mounting bolts. Move the compressor towards the fan pulley until the belt can be removed from the compressor.

2. If equipped with a Horton S fan drive, remove the fan blade and set it forward.

   If equipped with an Eaton viscous fan drive, remove the drive from the fan hub and set the fan and drive (as an assembly) forward.

   If equipped with a Kysor or Horton HT 550 fan drive, remove the fan hub. For instructions, refer to the applicable section in this manual.

⚠ CAUTION

CAUTION: Place a piece of cardboard between the fan and radiator so that the radiator is not damaged during fan or fan clutch removal.

3. Remove the compressor belt from the fan pulley.

Installation

REFRIGERANT COMPRESSOR BELT (See Fig. 1 or Fig. 2)

1. Inspect the pulleys and used belts (even if installing new belts) as instructed in **Subject 180**.
2. If equipped with a Horton S fan drive, loop the belt around the fan pulley, then install the fan. For fan installation instructions, refer to the applicable section in this manual.

   If equipped with an Eaton viscous fan drive, loop the belt around the fan pulley, then install the fan and drive as an assembly. For installation instructions, refer to the applicable section in this manual.

   If equipped with a Kysor or Horton HT 550 fan drive, install the fan hub with the compressor belt on the fan pulley. For fan hub installation instructions, refer to the applicable section in this manual.

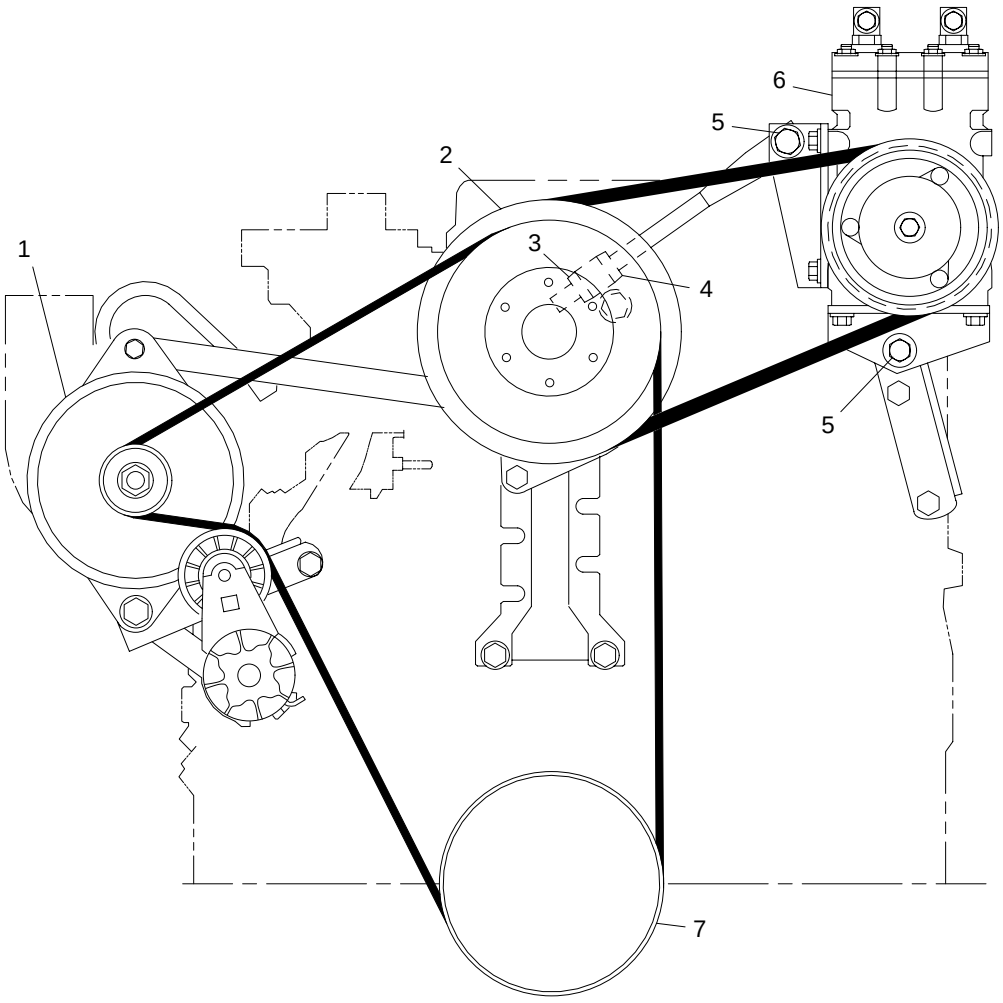
3. While keeping the belt seated in the pulley grooves, move the compressor away from the fan pulley to increase belt tension. Use your thumb to apply about 25 lb (11 kg) of force at the center of the longest belt free-span to check the tension. When belt deflection is about 1/2 to 3/4 inch (13 to 19 mm), proceed to "Adjustment: Refrigerant Compressor."

FAN AND ALTERNATOR BELT

(See Fig. 1)

1. Inspect the pulleys and used belts (even if installing new belts) as instructed in **Subject 180**.
2. If the fan or fan hub was removed to remove the compressor belt, install the fan or fan hub with the compressor belt in the fan pulley groove. Do not attach the compressor belt to the compressor at this time.
3. Loop the fan/alternator belt around the fan and align it in the rear channel of the fan pulley.
4. Loop the belt down and around the vibration damper pulley.
5. Install the refrigerant compressor belt on the compressor. Refer to the refrigerant compressor belt installation instructions in this subject.
6. Insert a 1/2-inch breaker bar in the belt tensioner, and rotate the tensioner down while installing the belt on the alternator pulley.
7. Slowly release the tensioner assembly onto the belt. The tensioner automatically tightens the belt to the correct tension.
8. Remove the breaker bar from the tensioner.
9. On Kysor and Horton HT 550 fan clutches, attach the air line to the fan clutch cylinder and tighten the fitting 84 lbf·in (940 N·cm).

Removal, Installation, and Adjustment, Caterpillar 3176



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1. Alternator
2. Fan Pulley
3. Adjusting Rod Jam Nut
4. Adjusting Nut
5. Refrigerant Compressor Mounting Bolts
6. Refrigerant Compressor
7. Vibration Damper

Fig. 2

Adjustment

REFRIGERANT COMPRESSOR

(See Fig. 1 or Fig. 2)

1. Install a belt tension gauge at the center of the belt's longest free-span.
2. If equipped with a swashplate refrigerant compressor (**Fig. 1**), insert a 1/2-inch breaker bar into the compressor bracket. Turn the compressor away from the fan hub and adjust belt tension to 100 lb (45 kg). Tighten the compressor mounting bolts 70 lbf·ft (95 N·m). Check the belt tension and adjust if needed.

IMPORTANT: Do not overtighten the belts; too much tension shortens belt and bearing life.

3. If equipped with a piston-type refrigerant compressor (**Fig. 2**), turn the adjusting nut to adjust the tension to a reading of 100 lb (45 kg).

Removal, Installation, and Adjustment, Caterpillar 3176

Tighten the adjusting rod jam nut 155 lbf·ft (210 N·m).

Tighten the compressor mounting bolts 70 lbf·ft (95 N·m).

Check the belt tension and adjust it if needed.

IMPORTANT: Do not overtighten the belts; too much tension shortens belt and bearing life.

4. If any new belts were installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

   If the compressor belt tension is not between 80 and 100 lb (36 to 45 kg), adjust the tension to 100 lb (45 kg).

FAN AND ALTERNATOR BELTS

1. The Caterpillar belt tensioner automatically adjusts the fan and alternator belt to the correct tension.
2. If the belt slips, repair or replace the tensioner. For instructions, refer to the Caterpillar 3176 Truck Engine Service Manual.

NOTE: On a joined belt, the Krikit gauge will have a low accuracy of approximately +/– 30 percent. The Kent-Moore gauge is inherently a more accurate device. The belt tension gauge must grip the full width of the belt to get an accurate reading. If the gauge grips only one of the two V's in a Powerband belt, it will not give an accurate reading. The actual tension in the belt will likely be greater than the tension indicated by the gauge. In this case, the Kent-Moore gauge will be no more accurate than the Krikit gauge.

Belt Replacement Without an Automatic Belt Tensioner

Fan Belt

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Remove the belt.

   NOTE: On Kysor and Horton HT 550 fan clutches, the air line must be disconnected from the fan clutch cylinder before the belt can be removed.

   2.1 Loosen the four capscrews that attach the fan hub to the engine. See **Fig. 1**.

   2.2 Loosen the adjusting rod to relieve tension from the belt.

   2.3 Remove the belt by slipping it off the pulleys and working it over one fan blade at a time. Do not roll or pry the belt off the pulleys. The distance between the pulley centers must be short enough to allow belt removal without using force.
3. Install the belt.

   3.1 Inspect the pulleys and the belt (even if installing a new belt) as instructed in **Subject 180**.

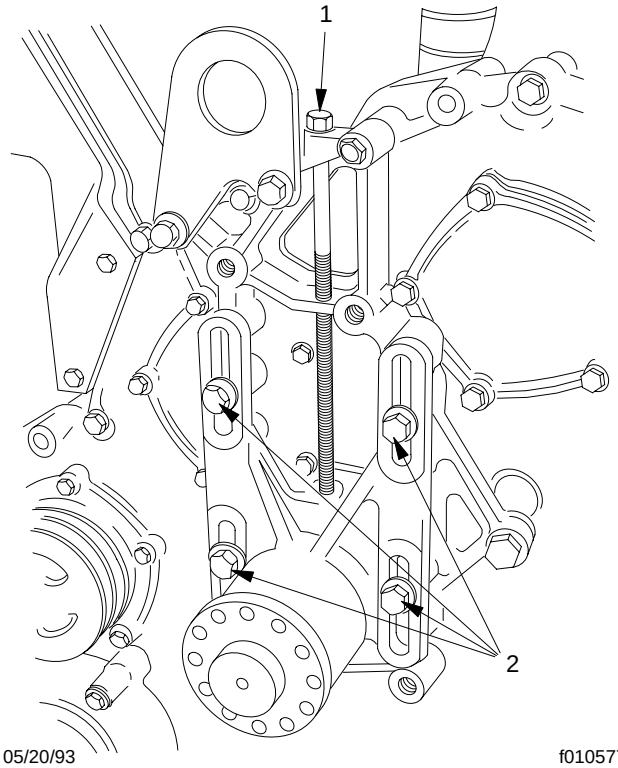
   3.2 Work the belt over the fan blades, one blade at a time. Install the belt on the pulleys without prying or rolling it into place.

   3.3 On Kysor and Horton HT 550 fan clutches, attach the air line to the fan clutch cylinder and tighten the fitting 84 lbf·in (940 N·cm).

   3.4 While keeping the belt seated in the pulley grooves, turn the adjusting rod to increase belt tension. Use your thumb to apply about 25 lbf (111 N) of force at the center of the longest belt free-span to check the tension while turning the adjusting rod. Stop turning the adjusting rod when belt deflection is about 1/2- to 3/4-inch (13- to 19-mm).
4. Adjust the belt.

   4.1 Install a belt tension gauge at the center of the belt's longest free-span.

   IMPORTANT: Do not overtighten the belt. Too much tension shortens belt and bearing life.



1. Adjusting Rod
2. Fan Hub Capscrews

Fig. 1, Fan Hub

Drive Belts Replacement, Detroit Diesel Series 60

4.2 Turn the adjusting rod to increase or decrease belt tension. Final tension must be 60 to 80 lbf (267 to 356 N).

4.3 Tighten the fan hub mounting capscrews 75 to 83 lbf·ft (100 to 112 N·m).

4.4 Check the belt tension and adjust it if needed.

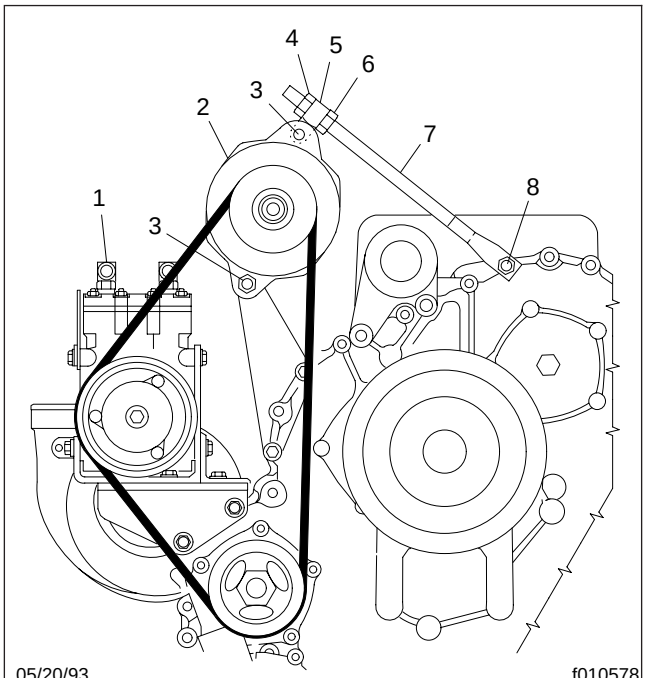
4.5 Remove the chocks from the tires.

4.6 Operate the engine for about 30 minutes or 15 miles (24 km). Recheck the belt tension. Re-tension to a minimum of 75 lbf (334 N). Check again after 8 hours or 250 miles (400 km). Adjust belt tension as needed.

Alternator and Refrigerant Compressor Belt

NOTE: On earlier models, the alternator and refrigerant compressor are driven by the same belt connected to the accessory drive pulley. On later models, the alternator and refrigerant compressor each have their own drive belt.

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Remove the belt. See **Fig. 2**.
   - 2.1 Loosen the adjusting rod bolt that attaches the adjusting rod to the engine, and loosen the alternator mounting bolts that attach the alternator to the adjusting link and the mounting bracket.
   - 2.2 Back off the adjusting nut. Push the loosened alternator toward the engine to allow belt removal without using force.
   - 2.3 Remove the belt without prying or rolling it off the pulleys.
3. Install the belt.
   - 3.1 Inspect the pulleys and the belt (even if installing a new belt) as instructed in **Subject 180**.
   - 3.2 Loop the belt around the pulleys.
   - 3.3 While keeping the belt seated in the pulley grooves, turn the adjusting nut against the adjusting link to increase belt tension.



1. Refrigerant Compressor
2. Alternator
3. Alternator Mounting Bolt
4. Jam Nut
5. Adjusting Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Bolt

Fig. 2, Alternator and Refrigerant Compressor Belt Without an Automatic Belt Tensioner

Use your thumb to apply about 25 lbf (111 N) of force at the center of the longest belt free-span to check the tension while turning the nut. Stop turning the nut when belt deflection is about 1/2- to 3/4-inch (13- to 19-mm).

4. Adjust the belt.
   - 4.1 Install a belt tension gauge at the center of the belt's longest free-span.

   IMPORTANT: Do not overtighten the belt. Too much tension shortens belt and bearing life.

   - 4.2 Turn the adjusting nut to adjust the belt tension to 100 lbf (445 N) per belt, 200 lbf (890 N) if using a joined belt.

4.3 Tighten the adjusting rod jam nut 155 lbf·ft (210 N·m).

4.4 Tighten the alternator mounting fasteners 70 lbf·ft (95 N·m).

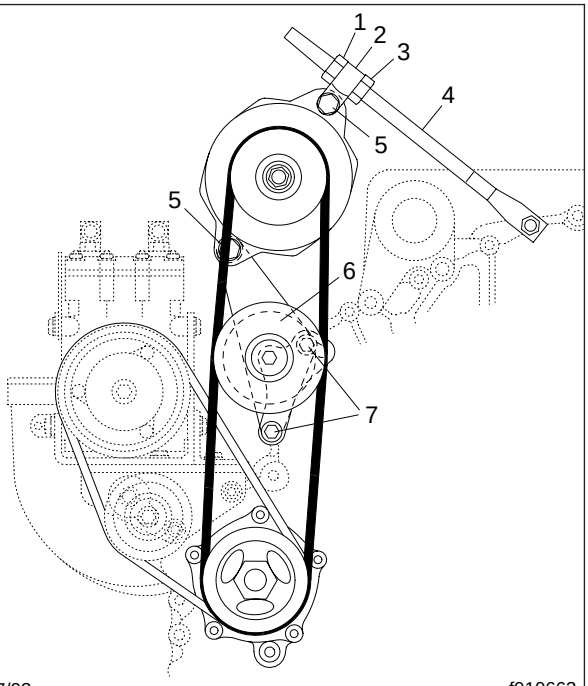
4.5 Check the belt tension and adjust it if needed.

4.6 Remove the chocks from the tires.

4.7 Operate the engine for about 30 minutes or 15 miles (24 km). Recheck the belt tension. Re-tension to a minimum of 75 lbf (334 N) per belt, 150 lbf (668 N) if using a joined belt. Check again after 8 hours or 250 miles (400 km). Adjust belt tension as needed.

Alternator Belt

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Remove the belt. See **Fig. 3**.
   - 2.1 Loosen the fasteners that hold the idler pulley to the engine.
   - 2.2 Loosen the alternator mounting bolts that hold the alternator to the adjusting link and to the mounting bracket.
   - 2.3 Loosen the adjusting nut, and allow the alternator to rotate toward the engine until the belt can be removed.
   - 2.4 Remove the belt without prying or rolling it off the pulleys.
3. Install the belt.
   - 3.1 Inspect the pulleys and the belt (even if installing a new belt) as instructed in **Subject 180**.
   - 3.2 Loop the belt around the pulleys.
   - 3.3 While keeping the belt seated in the pulley grooves, turn the adjusting nut against the adjusting link to increase belt tension. Use your thumb to apply about 25 lbf (111 N) of force at the center of the longest belt free-span to check the tension while turning the nut. Stop turning the nut when belt deflection is about 1/2- to 3/4-inch (13- to 19-mm).



1. Jam Nut
2. Adjusting Link
3. Adjusting Nut
4. Adjusting Rod
5. Alternator Mounting Bolt
6. Idler Pulley
7. Idler Pulley Bracket Mounting Bolts

Fig. 3, Alternator Belt Without an Automatic Belt Tensioner

4. Adjust the belt.
   - 4.1 Install a belt tension gauge at the center of the belt's longest free-span.

   IMPORTANT: Do not overtighten the belt. Too much tension shortens belt and bearing life.

   - 4.2 Turn the adjusting nut to adjust the tension to a reading of 100 lbf (445 N).
   - 4.3 Tighten the adjusting rod jam nut 155 lbf·ft (210 N·m).
   - 4.4 Tighten the alternator mounting fasteners 70 lbf·ft (95 N·m).
   - 4.5 Check the belt tension and adjust it if needed.

Drive Belts Replacement, Detroit Diesel Series 60

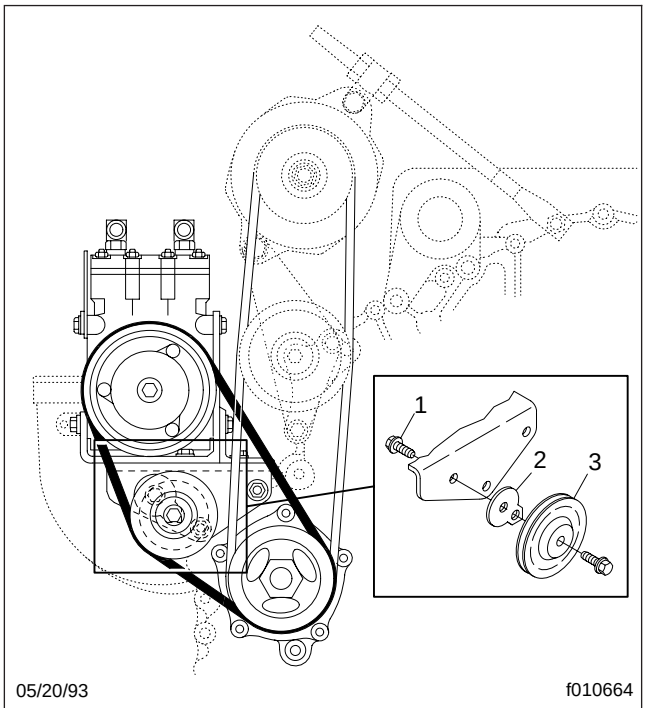
4.6 Allow the idler pulley to center itself. Tighten the pulley bracket mounting bolts 61 lbf·ft (45 N·m).

4.7 Remove the chocks from the tires.

4.8 Operate the engine for about 30 minutes or 15 miles (24 km). Recheck the belt tension. Check again after 8 hours or 250 miles (400 km). Adjust belt tension as needed.

Refrigerant Compressor Belt

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Remove the belt. See **Fig. 4**.
   - 2.1 If necessary, remove the alternator belt.
   - 2.2 Loosen the capscrew that holds the idler pulley in position, and allow the pulley to rotate toward the engine.
   - 2.3 Remove the belt without prying or rolling it off the pulleys.
3. Install the belt.
   - 3.1 Inspect the pulleys and the belt (even if installing a new belt) as instructed in **Subject 180**.
   - 3.2 Loop the belt around the pulleys.
   - 3.3 If necessary, install the alternator belt.
4. Adjust the belt.
   - 4.1 Install a belt tension gauge at the center of the belt's longest free-span.
   - 4.2 Place a wrench securely around the head of the bolt that holds the idler pulley to the bracket. Use the wrench to move the pulley out, away from the engine, and tension the belt 100 lbf (445 N).
   - 4.3 While holding the belt at the proper tension, have an assistant tighten the pulley mounting capscrew 68 lbf·ft (50 N·m).
   - 4.4 Check the belt tension and adjust it if needed.
   - 4.5 Remove the chocks from the tires.



NOTE: Do not remove the idler pulley from its bracket. The two parts are shown separated for clarity.

1. Pulley Mounting Capscrew
2. Pulley Bracket
3. Idler Pulley

Fig. 4, Refrigerant Compressor Belt Without an Automatic Belt Tensioner

4.6 Operate the engine for about 30 minutes or 15 miles (24 km). Recheck the belt tension. Check again after 8 hours or 250 miles (400 km). Adjust belt tension as needed.

Belt Replacement With an Automatic Belt Tensioner

Alternator and Refrigerant Compressor Belt

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Remove the belt. See **Fig. 5**.

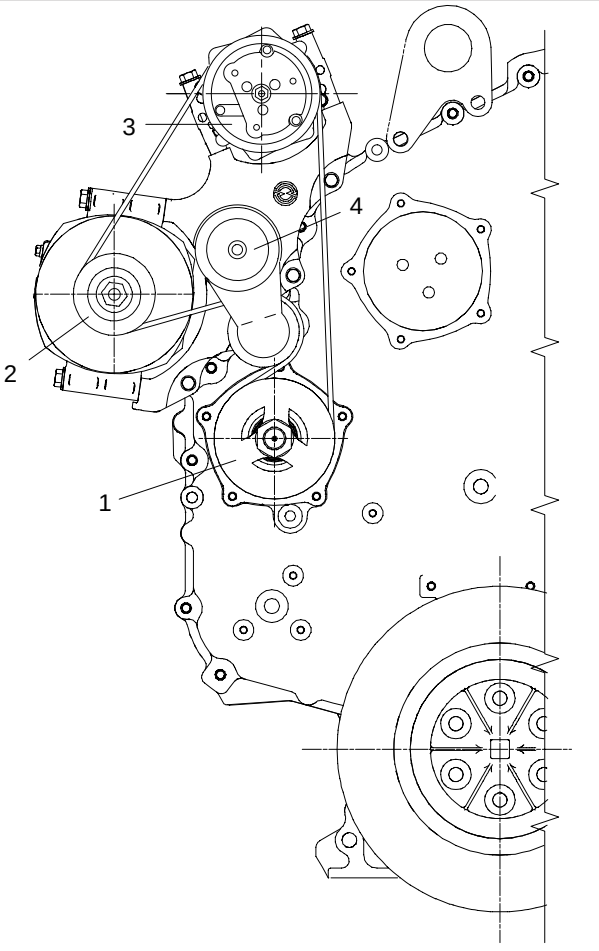
Drive Belts Replacement, Detroit Diesel Series 60

2.1 Insert a 1/2-inch breaker bar in the belt tensioner and rotate the tensioner away from the accessory drive belt.

2.2 Holding the belt tensioner down, remove the belt from the alternator pulley.

2.3 Remove the belt from the refrigerant compressor pulley and the engine pulley.

2.4 Slowly release the belt tensioner and remove the breaker bar.



1. Engine Pulley
2. Alternator Pulley
3. Refrigerant Compressor Pulley
4. Automatic Belt Tensioner

Fig. 5, Alternator and Refrigerant Compressor Belt With an Automatic Belt Tensioner

3. Install the belt.

3.1 Inspect the pulleys and the belt (even if installing a new belt) as instructed in **Subject 180**.

3.2 Install the belt onto the engine pulley and the refrigerant compressor pulley.

3.3 Insert a 1/2-inch breaker bar into the belt tensioner and rotate it out while installing the belt onto the alternator pulley.

3.4 Slowly release the belt tensioner and remove the breaker bar. The belt tensioner will automatically apply the correct tension on the belt.

4. Remove the chocks from the tires.

Fan Belt

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Remove the belt. See **Fig. 6**.

2.1 Insert a 1/2-inch breaker bar in the belt tensioner and rotate the tensioner away from the fan drive belt.

2.2 Holding the belt tensioner down, remove the belt from the fan pulley and the engine pulley.

2.3 Slowly release the belt tensioner and remove the breaker bar.

3. Install the belt.

3.1 Inspect the pulleys and the belt (even if installing a new belt) as instructed in **Subject 180**.

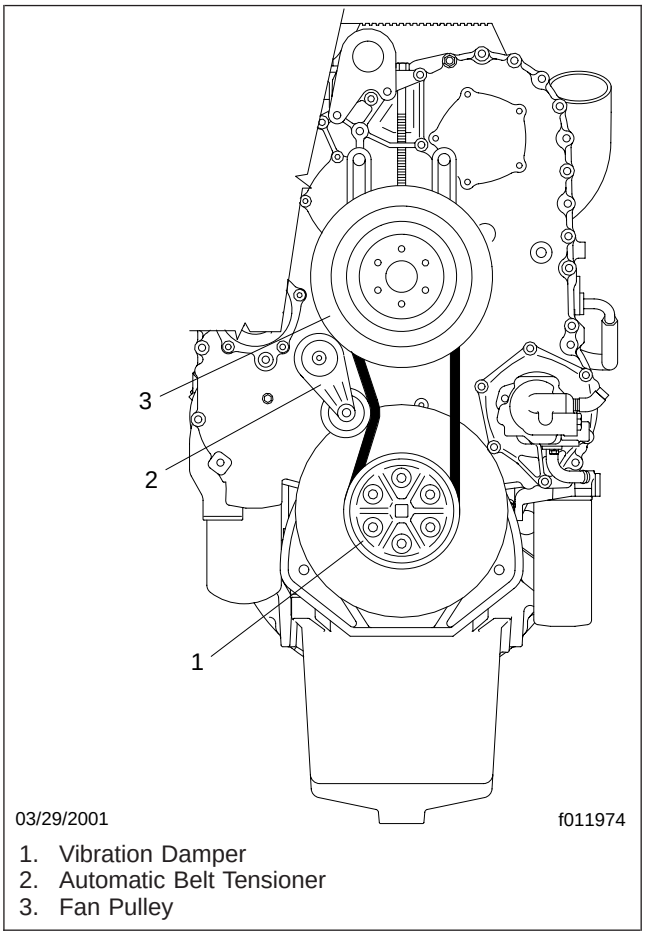
3.2 Install the belt onto the fan pulley.

3.3 Insert a 1/2-inch breaker bar into the belt tensioner and rotate it out while installing the belt onto the engine pulley.

3.4 Slowly release the belt tensioner and remove the breaker bar. The belt tensioner will automatically apply the correct tension on the belt.

4. Remove the chocks from the tires.

Drive Belts Replacement, Detroit Diesel Series 60



1. Vibration Damper
2. Automatic Belt Tensioner
3. Fan Pulley

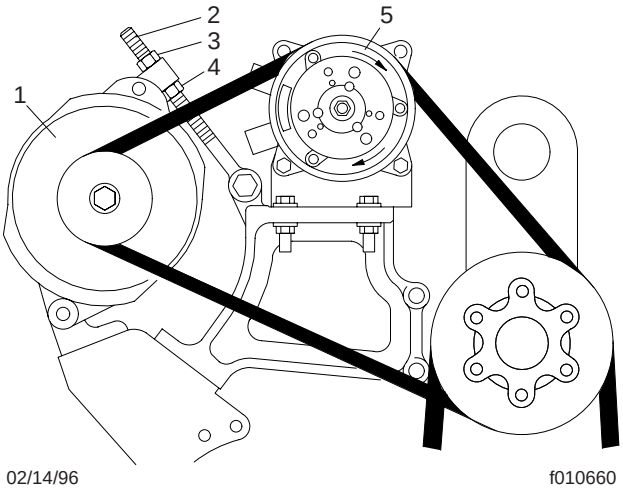
Fig. 6, Fan Belt With an Automatic Belt Tensioner

Removal, Installation, and Adjustment, Caterpillar 3406

Removal

ALTERNATOR AND REFRIGERANT COMPRESSOR BELTS (See Fig. 1 or Fig. 2)

1. Back off the adjusting nut, then loosen the alternator mounting fasteners enough to allow movement of the alternator.



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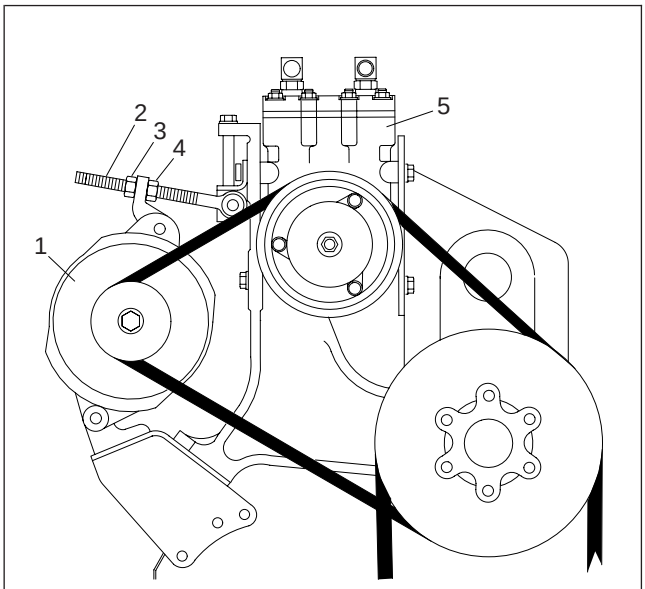
1. Alternator
2. Adjusting Rod
3. Jam Nut
4. Adjusting Nut
5. Refrigerant Compressor

Fig. 1, Alternator and Swash-Plate Refrigerant Compressor

2. Push the loosened alternator toward the fan drive pulley until the distance between them is short enough to allow belt removal without using force.
3. Remove both belts by slipping them off of the pulleys and working them over one fan blade at a time.

FAN BELTS (See Fig. 3)

1. Remove both alternator belts. For instructions, refer to the applicable procedure in this subject.
2. Loosen the fan hub mounting bolts.
3. Turn the fan hub adjusting bolt until there is minimal distance between the pulley centers.



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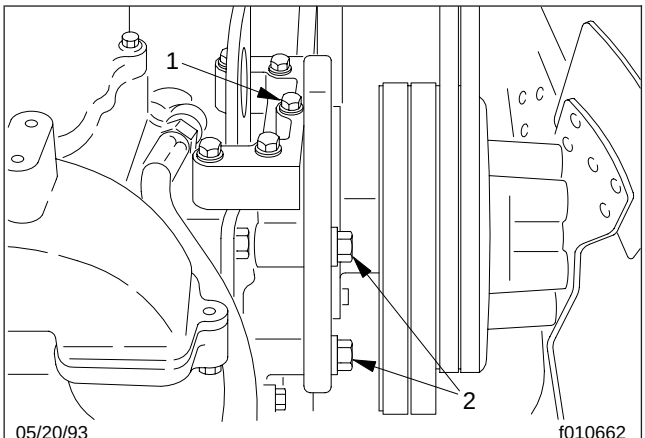
1. Alternator
2. Adjusting Rod
3. Jam Nut
4. Adjusting Nut
5. Refrigerant Compressor

Fig. 2, Alternator and Piston-Type Refrigerant Compressor

4. Remove both fan belts by slipping them off of the pulleys and working them over one fan blade at a time. Don't roll or pry the belts off; the distance between the pulley centers must be short enough to allow belt removal without using force.



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1. Fan Hub Adjusting Bolt
2. Fan Hub Mounting Bolts

Fig. 3, Fan Drive

Removal, Installation, and Adjustment, Caterpillar 3406

Installation

FAN BELTS (See Fig. 3)

1. Inspect the pulleys and used fan belts (even if new belts are being installed) as instructed in **Subject 180.**
2. Make sure the distance between the pulleys is short enough to allow belt installation without using force.
3. Work the belts over the fan blades, one blade at a time. Install the belts on the pulleys without prying or rolling them into place.
4. While keeping the belts seated in the pulley grooves, turn the fan hub adjusting bolt to increase the belt tension. Use your thumb to apply about 25 lb (11 kg) of force at the center of the belt free-span to check the tension while turning the bolt. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, proceed to "Adjustment: Fan Belts."

ALTERNATOR AND REFRIGERANT COMPRESSOR BELTS (See Fig. 1 or Fig. 2)

1. If the fan belts were removed, install and adjust them first. For instructions, refer to the applicable procedure in this subject.
2. Inspect the pulleys and used alternator belts (even if new belts are being installed) as instructed in **Subject 180.**
3. Make sure the distance between the pulleys is short enough to allow belt installation without using force.
4. Install the belts on the pulleys without prying or rolling them into place.
5. Back off the jam nut.
6. While keeping the belts seated in the pulley grooves, turn the adjusting nut against the adjusting link to increase the belt tension. Use your thumb to apply about 25 lb (11 kg) of force at the center of the belt free-span to check the tension while turning the nut. When belt deflection equals one belt thickness per foot (305 mm) of pulley-center distance, proceed to "Adjustment: Alternator and Refrigerant Compressor Belts."

Adjustment

FAN BELTS (See Fig. 3)

1. If not already done, loosen the fan hub mounting bolts.
2. Install a belt tension gauge on the forwardmost belt, at the center of the belt free-span.
3. Turn the fan hub adjusting bolt to increase or decrease the belt tension, but do not adjust the tension to the full value with the fan hub adjusting bolt; tension can increase when the fan hub bracket bolts are tightened. Final tension must be 115 to 125 lb (52 to 57 kg) for new belts, or 80 to 100 lbs (36 to 45 kg) for used belts. A used belt is any belt that has been in operation more than ten minutes.

IMPORTANT: Do not overtighten the belts; too much tension shortens belt life and bearing life.

4. Tighten the fan hub mounting bolts 70 lbf·ft (95 N·m).
5. Loosen the fan hub adjusting bolt one-half turn.
6. Check the belt tension, and adjust it if needed.
7. Install and adjust the alternator belts.
8. If any new belts were installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

   If the fan belt tension is not between 80 and 100 lb (36 to 45 kg), adjust the tension to 100 lb (45 kg).

ALTERNATOR AND REFRIGERANT COMPRESSOR BELTS (See Fig. 1 or Fig. 2)

1. If not already done, back off the adjusting link jam nut, and loosen the alternator mounting fasteners just enough to allow movement of the alternator.
2. Install a belt tension gauge on the forwardmost belt, at the center of the belt's longest free-span.
3. Turn the adjusting nut to adjust the tension to a reading of 115 to 125 lb (52 to 57 kg) for new belts, or 80 to 100 lb (36 to 45 kg) for used belts.

A used belt is any belt that has been in operation more than ten minutes.

IMPORTANT: Do not overtighten the belts; too much tension shortens belt life and bearing life.

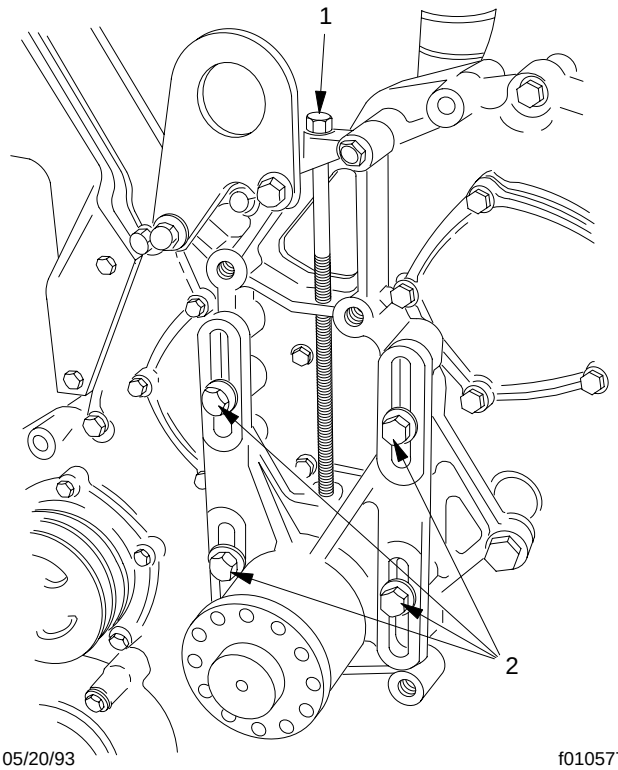
4. Tighten the adjusting rod jam nut 95 lbf·ft (130 N·m).
5. Tighten the alternator mounting fasteners 70 lbf·ft (95 N·m).
6. Check the belt tension, and adjust it if needed.
7. If new alternator belts were installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

   If the alternator belt tension is not between 80 and 100 lb (36 to 45 kg), adjust the tension to 100 lb (45 kg).

Removal, Installation, and Adjustment, Detroit Diesel Series 50

Removal

FAN BELT (See Fig. 1)



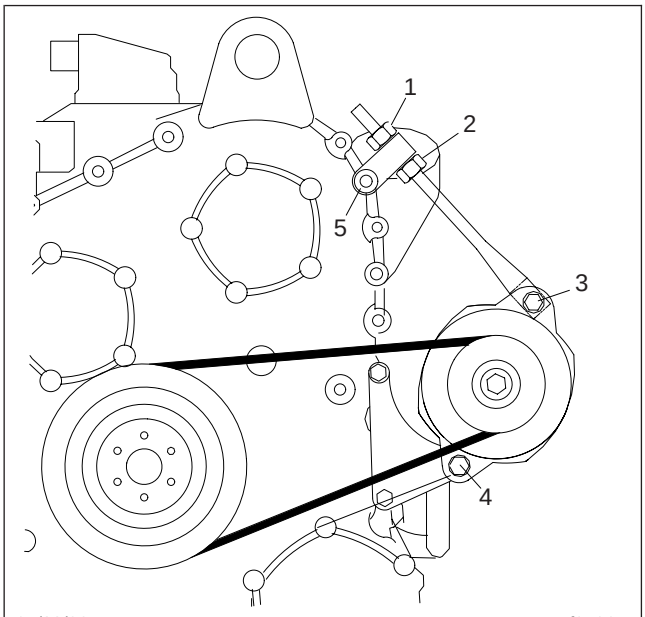
1. Adjusting Rod
2. Mounting Capscrews

Fig. 1, Fan Belt Adjustment

1. Loosen the four mounting capscrews that attach the fan hub to the engine.
2. Loosen the adjusting rod to relieve tension from the belts.
3. Remove the belts by slipping them off the pulleys and working them over one fan blade at a time. On some vehicles, it may be necessary to remove the fan. For instructions, refer to the engine cooling section of this manual. Don't roll or pry the belts off the pulleys; the distance between the pulley centers must be short enough to allow belt removal without using force.

ALTERNATOR BELT (See Fig. 2)

1. Back off the adjusting rod nut.



1. Adjusting Rod Jam Nut
2. Adjusting Rod Nut
3. Adjusting Rod Mounting Bolt
4. Alternator Mounting Bolt
5. Adjusting Rod Guide Mounting Bolt

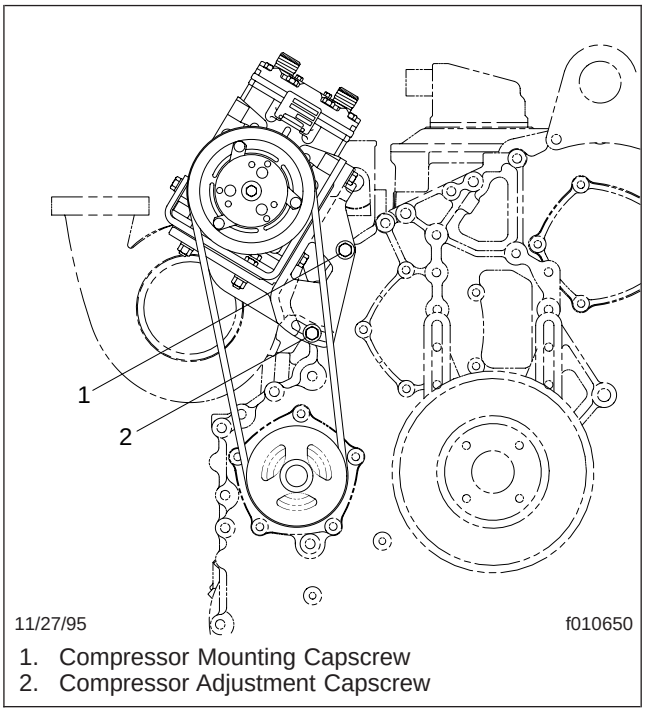
Fig. 2, Alternator Belt Adjustment

2. Loosen the adjusting rod guide mounting bolt.
3. Loosen the adjusting rod mounting bolt.
4. Loosen the alternator mounting bolt.
5. Turn the adjusting rod jam nut to rotate the alternator up and toward the engine. Turn the nut until the alternator is close enough to the engine to allow belt removal.
6. Remove the belts by slipping them off the pulleys and working them over one fan blade at a time. Don't roll or pry the belts off the pulleys; the distance between the pulley centers must be short enough to allow belt removal without using force.

REFRIGERANT COMPRESSOR BELT (See Fig. 3)

1. Loosen the compressor mounting capscrew and the compressor adjustment capscrews that attach the compressor bracket to the engine.
2. Rotate the compressor downward, toward the engine to allow belt removal without using force.

Removal, Installation, and Adjustment, Detroit Diesel Series 50



1. Compressor Mounting Capscrew
2. Compressor Adjustment Capscrew

Fig. 3, Refrigerant Compressor Belt Adjustment

3. Remove the belt without rolling or prying it off the pulleys.

Installation

FAN BELT (See Fig. 1)

1. Inspect the pulleys and used belts (even if installing new belts) as instructed in **Subject 180.**
2. Work the belts over the fan blades, one blade at a time. Install the belts on the pulleys without rolling or prying them into place.
3. While keeping the belts seated in the pulley grooves, turn the adjusting rod to increase belt tension.

ALTERNATOR BELT (See Fig. 2)

1. Inspect the pulleys and belt (even if installing a new belt) as instructed in **Subject 180.**
2. Work the belt over the fan blades, one blade at a time. Install the belt on the pulleys without prying or rolling it into place.
3. While keeping the belt seated in the pulley grooves, turn the adjusting nut to rotate the alternator away from the engine and to increase belt tension.

REFRIGERANT COMPRESSOR BELT (See Fig. 3)

1. Inspect the pulleys and used belt (even if installing a new belt) as instructed in **Subject 180.**
2. Loop the belt around the pulleys.
3. While keeping the belt seated in the pulley grooves, rotate the compressor up and away from the engine.

Adjustment

FAN BELT (See Fig. 1)

1. Install a belt tension gauge at the center of the belts' longest free-span.
2. Turn the adjusting rod to increase belt tension to 60 to 80 lb (27 to 36 kg).

IMPORTANT: Do not overtighten the belts; too much tension shortens belt and bearing life.

3. Tighten the fan hub mounting capscrews 75 to 83 lbf·ft (100 to 112 N·m).
4. Check the belt tension and adjust it if needed.
5. Operate the engine for about 30 minutes (or 15 miles), then check the belt tension. Check again after 8 hours of operation (or 250 miles). Adjust the belt tension as needed.

ALTERNATOR BELT (See Fig. 2)

1. Install a belt tension gauge at the center of the belt's longest free-span.
2. Turn the adjusting rod nut to rotate the alternator out, away from the engine until the belt is tensioned 60 to 80 lb (27 to 36 kg).

IMPORTANT: Do not overtighten the belt; too much tension shortens belt and bearing life.

3. Tighten the adjusting rod jam nut 130 lbf·ft (176 N·m).
4. Tighten the alternator mounting bolt and the adjusting rod mounting bolt 91 lbf·ft (123 N·m).

5. Tighten the adjusting rod guide mounting bolt 34 lbf·ft (46 N·m).
6. Operate the engine for about 30 minutes (or 15 miles), then check the belt tension. Check again after 8 hours of operation (or 250 miles). Adjust the belt tension as needed.

REFRIGERANT COMPRESSOR BELT **(See Fig. 3)**

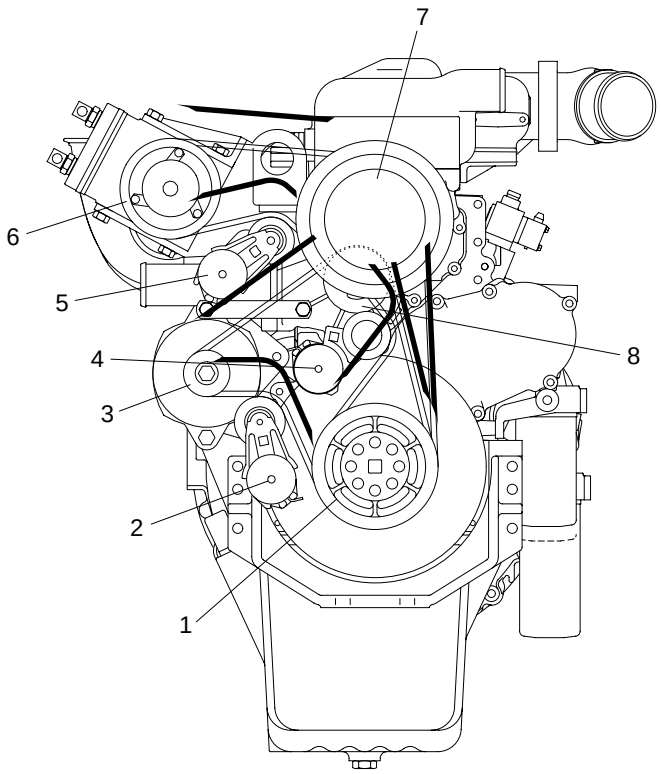
1. Rotate the compressor up and away from the engine until belt tension is 90 to 100 lb (41 to 45 kg).

IMPORTANT: Do not overtighten the belts; too much tension shortens belt and bearing life.

2. Tighten the compressor mounting and adjustment capscrews 34 lbf·ft (46 N·m).
3. Operate the engine for about 30 minutes (or 15 miles), then check the belt tension. Check again after 8 hours of operation (or 250 miles). Adjust the belt tension as needed.

Drive Belt Replacement, Detroit Diesel Series 55

Belt Replacement (See Fig. 1)



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1. Vibration Damper
2. Alternator Belt Tensioner
3. Alternator Pulley
4. Fan Belt Tensioner
5. Refrigerant Compressor Belt Tensioner
6. Refrigerant Compressor Pulley
7. Fan Pulley
8. Water Pump Pulley

Fig. 1, Drive Belts, Detroit Diesel Series 55

The fan belt must be removed to remove the refrigerant compressor belt, and both these belts must be removed in order to remove the alternator/water pump belt.

FAN BELT (See Fig. 1)

1. Remove the fan belt.
   - 1.1 Insert a breaker bar in the belt tensioner and rotate the tensioner counterclockwise off the belt.
   - 1.2 Holding the belt tensioner up, remove the belt from the vibration damper.
   - 1.3 Slowly release the belt tensioner, and remove the breaker bar.
   - 1.4 Raise the belt, and take it off over the fan. Remove the belt from the engine compartment.
2. Install the fan belt.
   - 2.1 Inspect the pulleys and used belts (even if installing new belts) as instructed in **Subject 180**.
   - 2.2 Loop the belt around the fan and align it in the fan pulley.
   - 2.3 Insert a breaker bar in the belt tensioner, and rotate the tensioner up while installing the belt around the vibration damper pulley.

Drive Belt Replacement, Detroit Diesel Series 55

2.4 Slowly release the tensioner assembly onto the belt. The tensioner automatically tightens the belt to the correct tension.

2.5 Remove the breaker bar from the tensioner.

3. Adjust the fan belt tension.

3.1 The Detroit Diesel belt tensioner automatically adjusts the belt to the correct tension.

3.2 If the belt slips, repair or replace the tensioner. For instructions, refer to the engine manufacturer's service literature.

REFRIGERANT COMPRESSOR BELT (See Fig. 1)

NOTE: To remove the refrigerant compressor belt, you must first remove the fan belt.

1. Remove the refrigerant compressor belt.

1.1 Insert a breaker bar in the belt tensioner and rotate the tensioner clockwise off the belt.

1.2 Holding the belt tensioner down, remove the belt from the refrigerant compressor.

1.3 Slowly release the belt tensioner, and remove the breaker bar.

1.4 Lower the belt, and take it off over the fan. Remove the belt from the engine compartment.

2. Install the refrigerant compressor belt.

2.1 Inspect the pulleys and used belts (even if installing new belts) as instructed in **Subject 180**.

2.2 Loop the refrigerant compressor belt around the fan and align it in the fan pulley.

2.3 Insert a breaker bar in the belt tensioner, and rotate the tensioner clockwise while installing the belt on the refrigerant compressor pulley.

2.4 Slowly release the tensioner assembly onto the belt. The tensioner automatically tightens the belt to the correct tension.

2.5 Remove the breaker bar from the tensioner.

3. Adjust the refrigerant compressor belt tension.

3.1 The Detroit Diesel belt tensioner automatically adjusts the belt to the correct tension.

3.2 If the belt slips, repair or replace the tensioner. For instructions, refer to the engine manufacturer's service literature.

ALTERNATOR/WATER PUMP BELT (See Fig. 1)

NOTE: To remove the alternator belt, you must first remove the fan belt and refrigerant compressor belt.

1. Remove the alternator/water pump belt.

1.1 Insert a breaker bar in the alternator belt tensioner and rotate the tensioner counterclockwise off the belt.

1.2 Holding the belt tensioner down, remove the belt from the alternator pulley.

1.3 Slowly release the belt tensioner, and remove the breaker bar.

1.4 Lower the belt, and take it off the vibration damper. Raise the belt, and take it off over the fan. Remove the belt from the engine compartment.

2. Install the alternator/water pump belt.

2.1 Inspect the pulleys and used belts (even if installing new belts) as instructed in **Subject 180**.

2.2 Loop the belt around the fan and align it in the grooves of the water pump pulley.

2.3 Loop the belt down and around the vibration damper pulley.

2.4 Insert a breaker bar in the belt tensioner, and rotate the tensioner down while installing the belt on the alternator pulley.

2.5 Slowly release the tensioner assembly onto the belt. The tensioner automatically tightens the belt to the correct tension.

2.6 Remove the breaker bar from the tensioner.

3. Adjust the alternator/water pump belt tension.

   3.1 The Detroit Diesel belt tensioner automatically adjusts the belt to the correct tension.

   3.2 If the belt slips, repair or replace the tensioner. For instructions, refer to the engine manufacturer's service literature.

Inspection

1. Inspect all used drive belts (including those that are being replaced) for the following conditions **(see Fig. 1):**

   NOTE: For an installed belt, gently twist the belt about 90 degrees so you can see the sidewalls and bottom.

   1.1 Inspect for glazing (shiny sidewalls). See Ref. A. Glazing is caused by friction created when a loose belt slips in the pulleys. It can also be caused by oil or grease on the pulleys.

   1.2 Inspect for separating layers. See Ref. B. Oil, grease, or belt dressings can cause the belt to fall apart in layers. If engine parts are leaking, repair the oil leaks. Do not use belt dressings on any belt.

   1.3 Check for jagged or streaked sidewalls. See Ref. C. These are the result of a foreign object (such as sand or small gravel) in the pulley, or a rough pulley wall surface.

   1.4 Check for tensile breaks (breaks in the cord body). See Ref. D. Cuts in a belt are usually caused by large foreign objects in the pulley, or by prying or forcing the belt during installation or removal.

   1.5 On poly-V belts, check for uneven ribs. See Ref. E. Foreign objects in the pulley will erode the undercord ribs, causing the belt to lose its gripping power.

   1.6 Inspect for cracks. See Ref. F. Small, irregular cracks are usually signs of an old belt.

   Replace the belt if any of the above conditions are found. Replace both belts of a set, at the same time. Matched belts must be from the same manufacturer.

2. Check all pulley bearings for roughness. Replace the bearings if they're rough.

3. Inspect all pulleys for foreign objects, oil, or grease in the grooves. Use a nonflammable cleaning solvent to remove oils. Use a wire brush to remove rust, and a file to remove burrs.

4. Inspect the pulleys for wear on the inner walls. Hold a small straightedge against the inside of the pulley walls **(Fig. 2),** or use your little finger or fingernail to find grooves in the inner walls. If there are any grooves, replace the pulley.

5. Check alignment of pulleys. Use a thin straightedge that is longer than the longest span between the pulleys. Place the straightedge into the V-grooves of two pulleys at a time. The straightedge should be parallel to the outer edges of the pulleys; if not, the pulleys are misaligned.

   Pulley misalignment must not be more than 1/16-inch for each foot (1.5 mm for each 30.5 cm) of distance between pulley centers.

   If there is misalignment of the pulleys, adjust the pulleys or brackets if their positions are adjustable. **See Fig. 3**. Replace bent or broken pulleys, pulley brackets, or shafts.

6. Check all drive component mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners. Repair or replace cracked or damaged brackets.

Pulley and Drive Belt Inspection

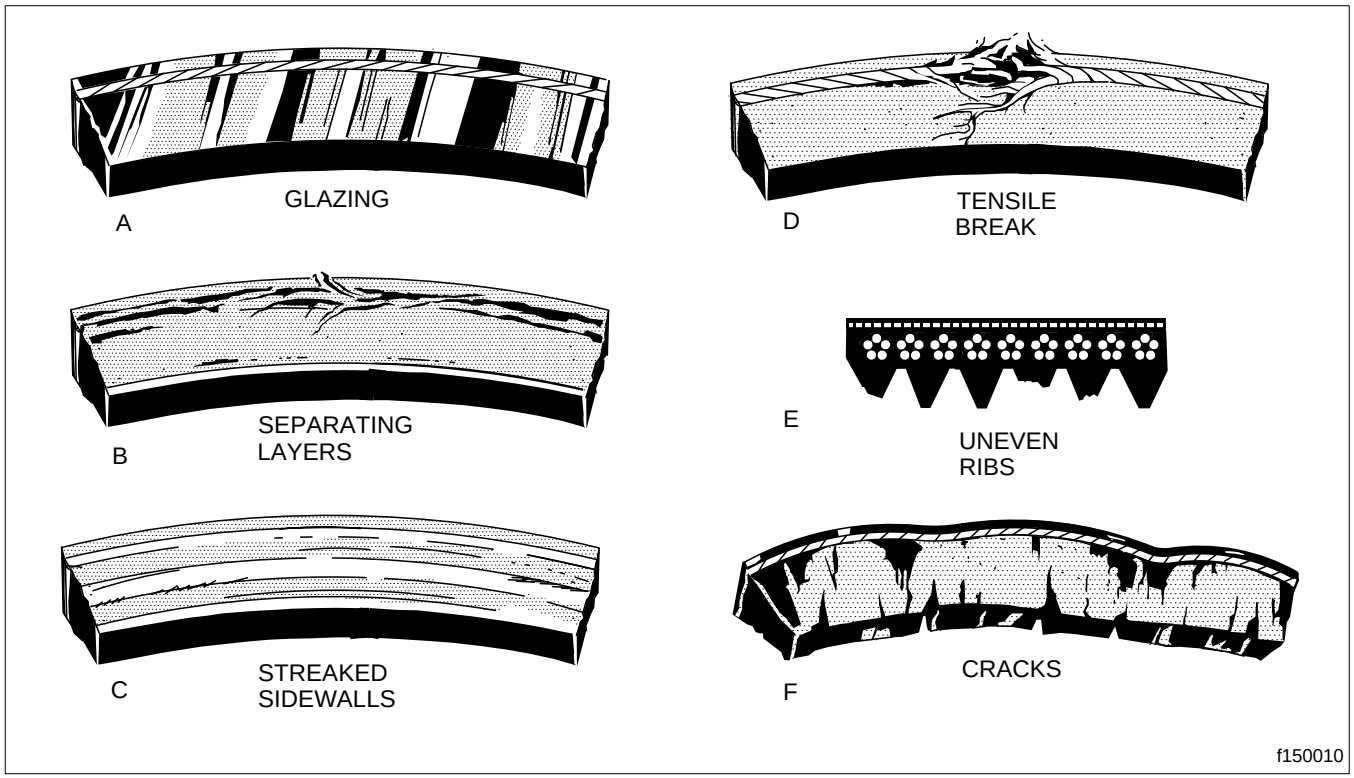


Fig. 1

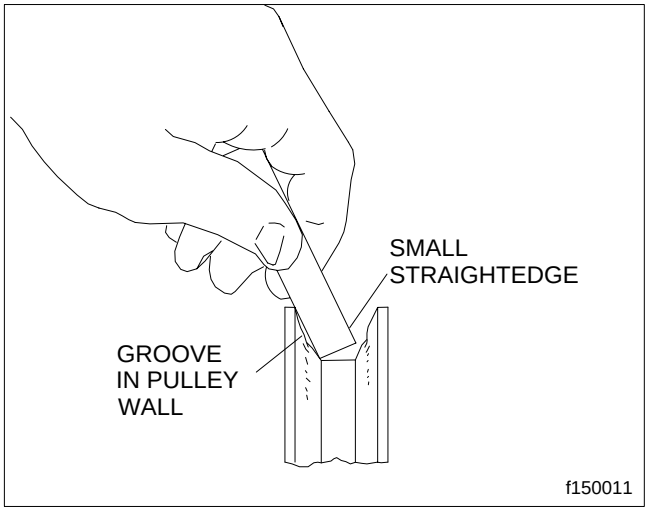


Fig. 2

Pulley and Drive Belt Inspection

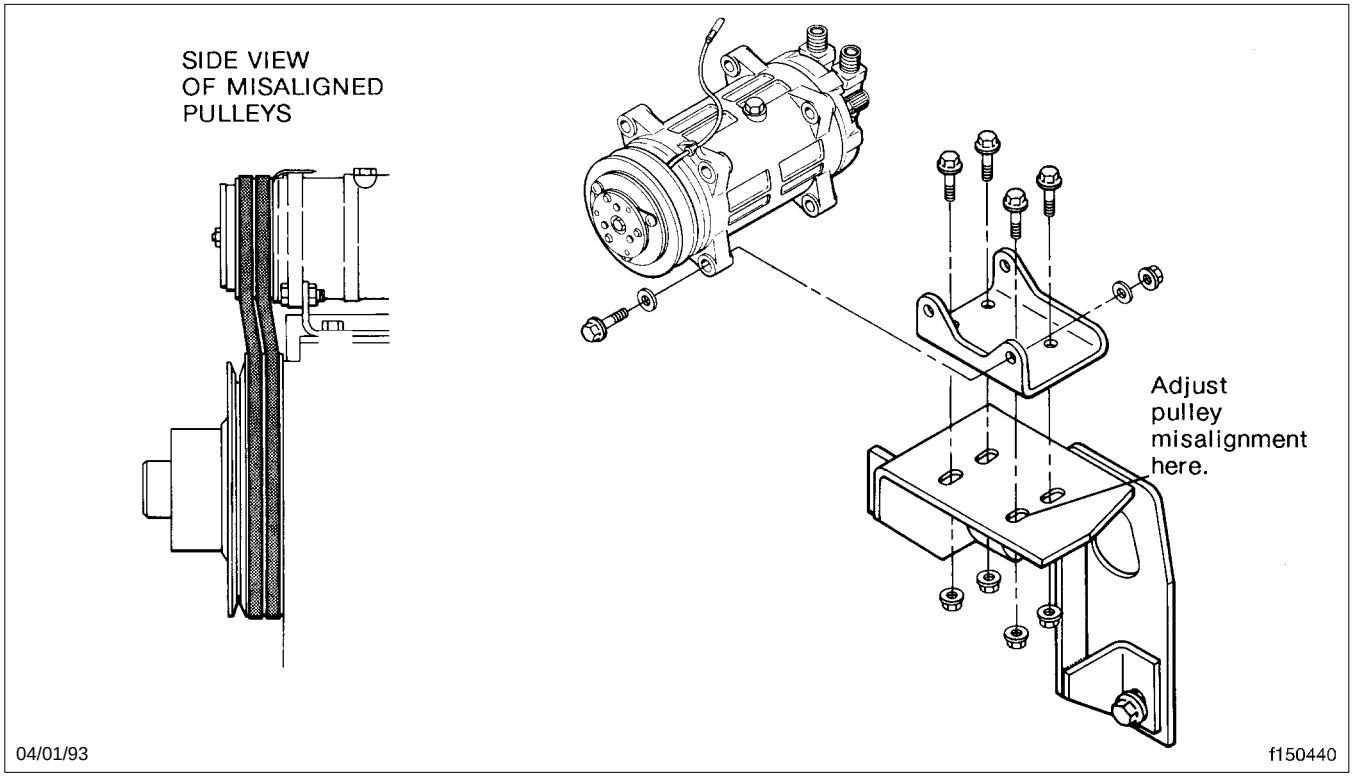


Fig. 3

General Information

Engine noise panels are installed to reduce engine noise emissions. The use and installation of noise panels varies depending on the engine rating.

IMPORTANT: If any of the engine noise panels are damaged, replace them. Failure to do so could result in non-compliance with Federal and California noise emissions standards.

Gear Cover Noise Panel Replacement, Cummins L10

Replacement (See Fig. 1)

1. Remove the self-tapping screws that attach the noise panel to the front gear cover. Remove the noise panel.
2. Place the new noise panel on the front gear cover. Install the self-tapping screws and tighten them 15 lbf·ft (20 N·m).

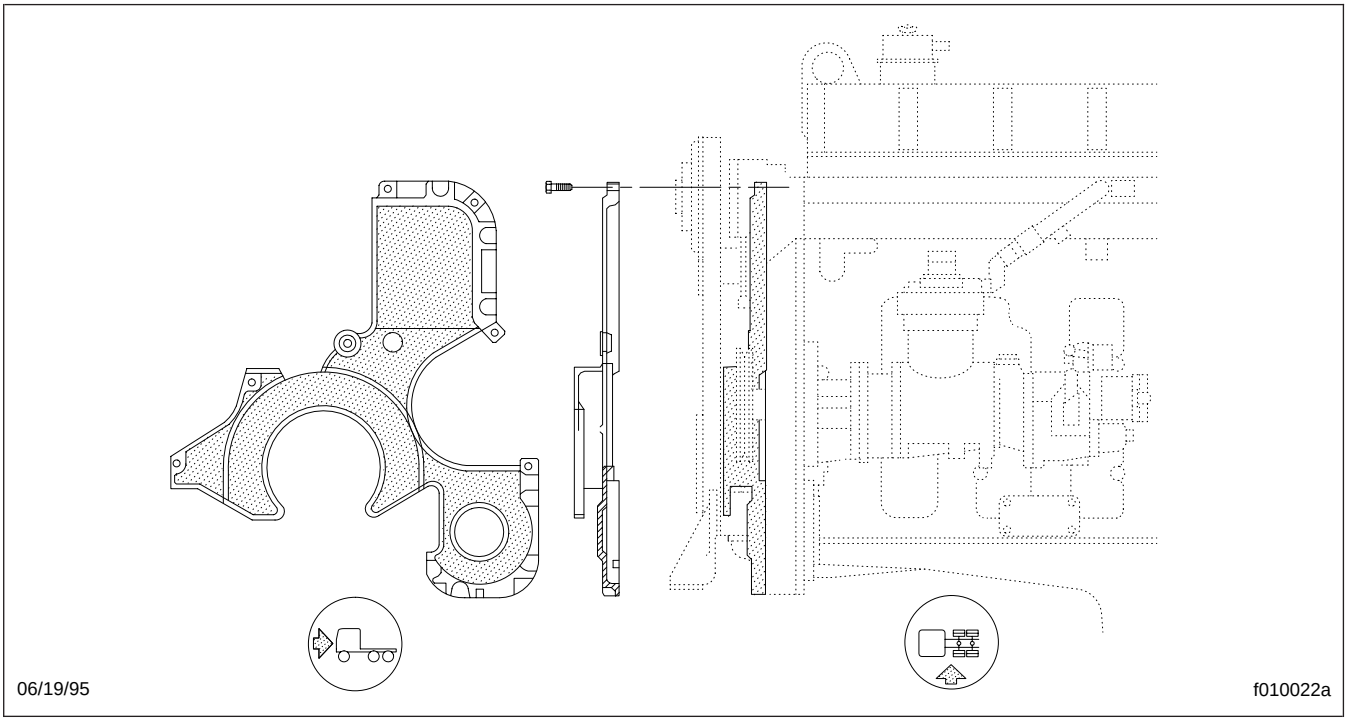


Fig. 1, L10 Front Gear Cover Noise Panel

Replacement (See Fig. 1 or Fig. 2)

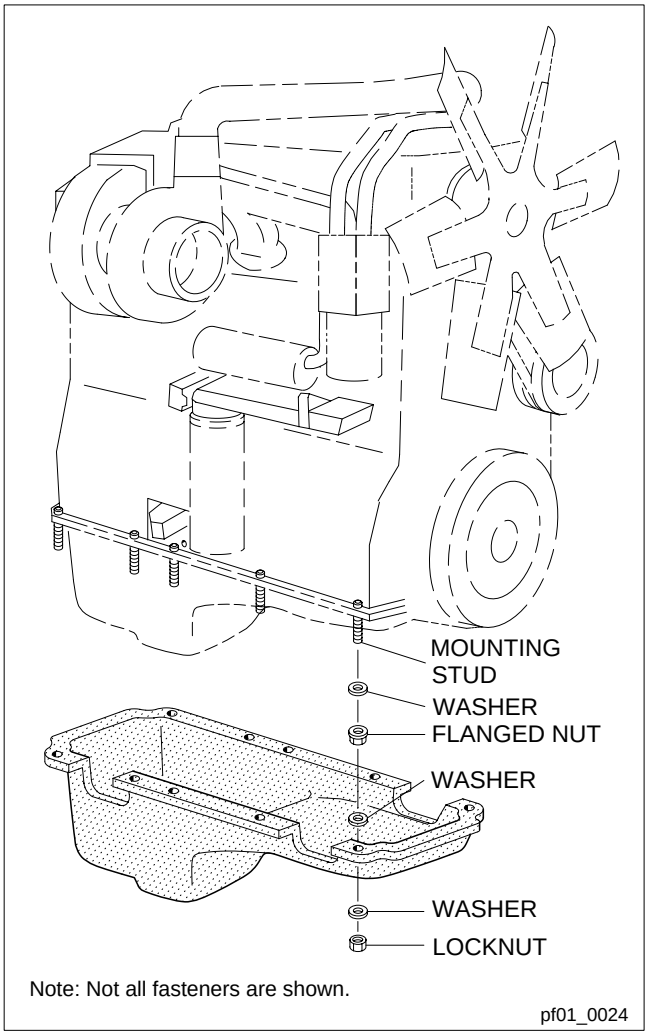


Fig. 1, Oil Pan Noise Panel (Cummins installation shown)

1. Remove the locknuts and washers (Cummins engines) or bolts and washers (Caterpillar engines) that attach the oil pan noise panel to the oil pan. Remove the noise panel.
2. Place the new noise panel into position under the oil pan, then install the washers and locknuts, or bolts. Tighten the locknuts 15 lbf·ft (20 N·m). Tighten the bolts until secure.

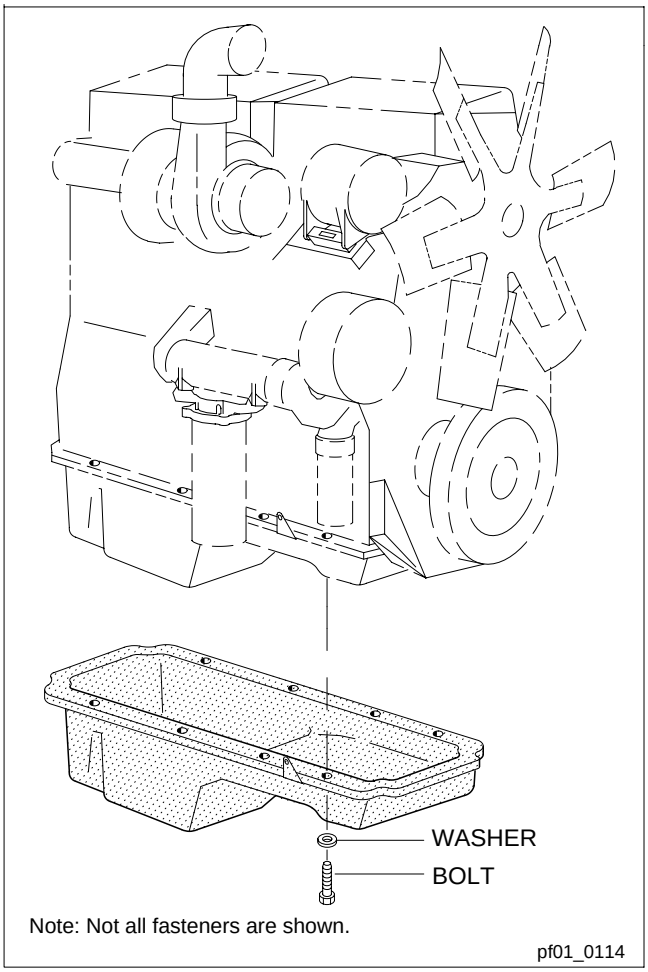


Fig. 2, Oil Pan Noise Panel (Caterpillar 3406 installation shown)

Engine Block Noise Panel Replacement, Cummins NTC Big Cam IV

Replacement (See Fig. 1)

EXHAUST-SIDE (RIGHT) NOISE PANELS

1. On the rear panel, remove the two 3/8-inch capscrews and washers from the bottom of the panel.

   Remove the two 1/2-inch capscrews and washers from the top of the panel. Slide the rear panel off the engine.

2. On the front panel, remove the 3/8-inch capscrew and washer from the bottom hole at the front of the panel.

   Remove the two 1/2-inch capscrews and washers from the top of the panel.

   Loosen the capscrew that secures the panel bracket near the dipstick tube housing. **See Fig. 2**. Slide the front panel off the engine.

3. Slide the new front panel behind the oil filter, then position it over the attachment holes.

   Install the 1/2-inch capscrews and washers in the top of the panel. Tighten the capscrews 70 lbf·ft (95 N·m).

   Install the 3/8-inch capscrew and washer in the bottom hole at the front of the panel. Tighten the capscrew 28 lbf·ft (38 N·m).

   At the dipstick tube housing, place the panel bracket over the panel. Install and tighten the capscrew 40 lbf·ft (54 N·m).

4. Place the new rear panel on the engine. Install the two 1/2-inch capscrews and washers in the top of the panel. Tighten the capscrews 70 lbf·ft (95 N·m).

   Install the two 3/8-inch capscrews and washers in the bottom of the panel. Tighten the capscrews 28 lbf·ft (38 N·m).

INTAKE-SIDE (LEFT) NOISE PANEL

1. Disconnect the positive battery cable from the batteries.
2. Mark the starter wires, then disconnect them.
3. Remove the starter from the engine. **See Fig. 3**.
4. Remove the power steering pump. For instructions, refer to the index in this manual.
5. Move any plumbing hoses or electrical wiring out of the way. Remove the noise panel mounting fasteners. Remove the noise panel.
6. Position the new panel on the engine. Install the 5/16-inch nuts and washers. Tighten the nuts 15 lbf·ft (20 N·m).
7. At the bottom of the panel, install the mounting brackets under the head of the oil pan mounting flange.

   On each mounting bracket, install a 5/16-inch capscrew, washer, and spacer. Tighten the capscrews 15 lbf·ft (20 N·m).

8. Install the starter, and tighten the mounting fasteners 130 lbf·ft (176 N·m).

   As marked earlier, connect the wiring to the starter.

9. Install the power steering pump. For instructions, refer to the index in this manual.
10. Connect the positive battery cable to the batteries.
11. Replace any plumbing hoses or electrical wiring moved out of the way for panel replacement.

Engine Block Noise Panel Replacement, Cummins NTC Big Cam IV

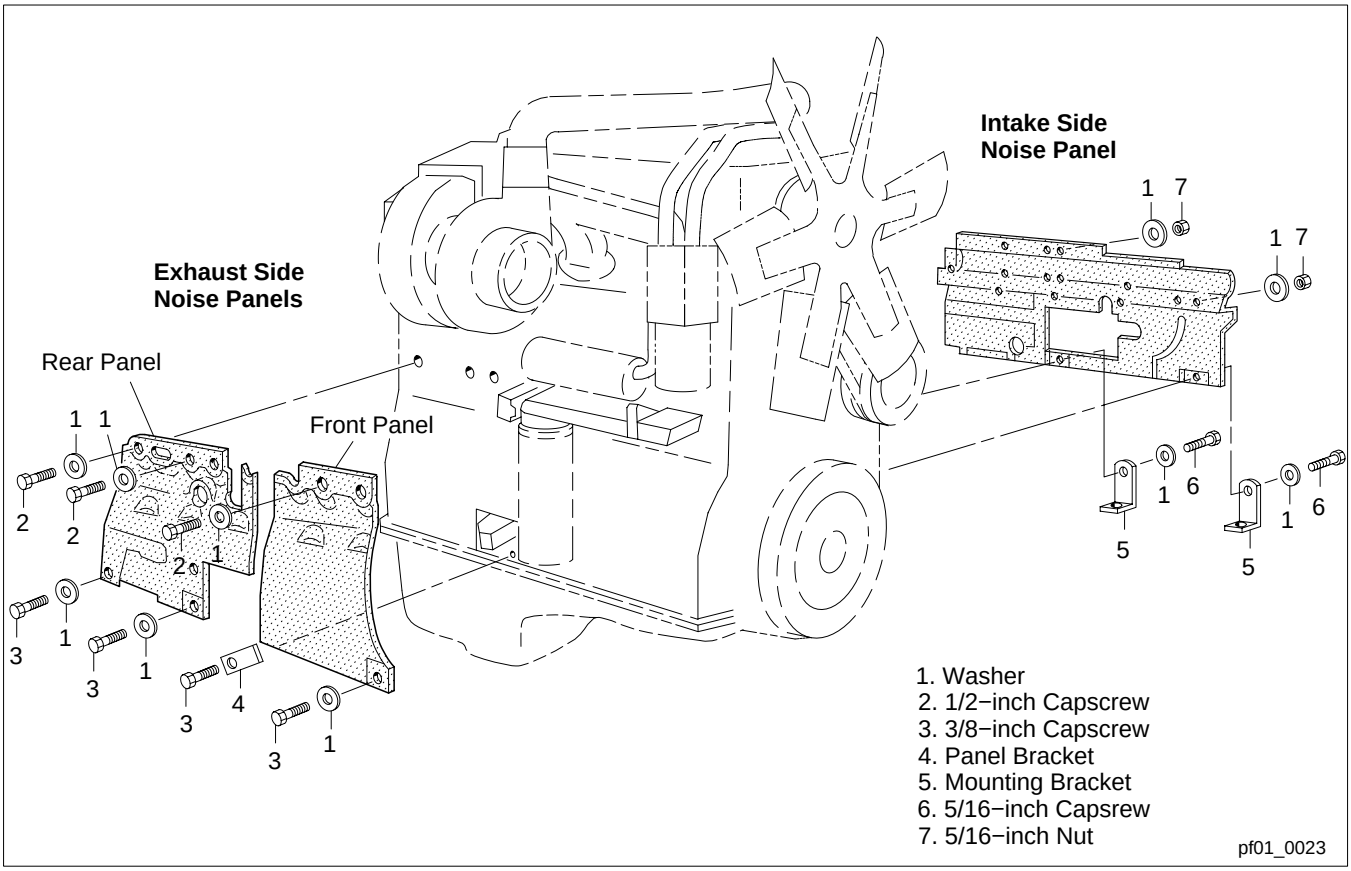


Fig. 1

Engine Block Noise Panel Replacement, Cummins NTC Big Cam IV

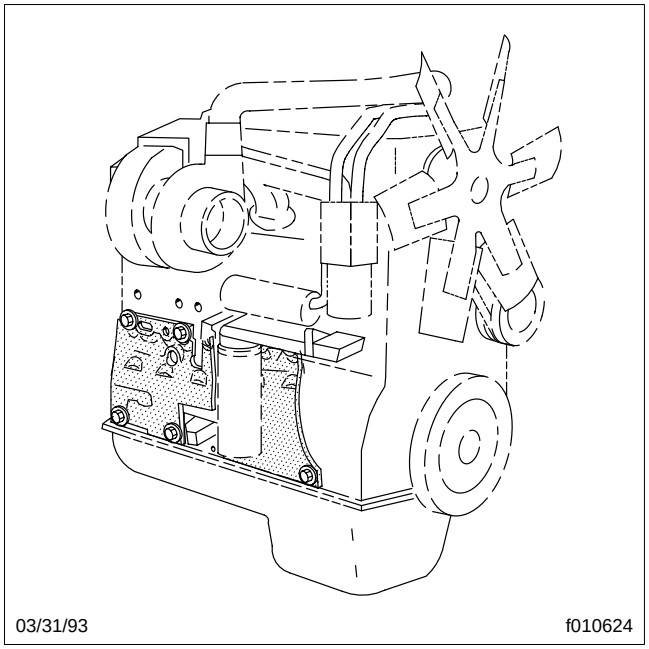


Fig. 2, Exhaust-Side Noise Panels

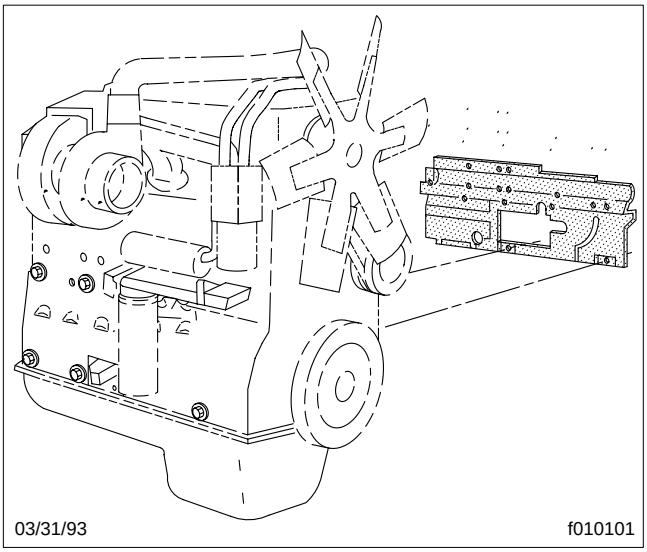


Fig. 3, Intake-Side Noise Panel

General Description and Principles of Operation (See Fig. 1 and Fig. 2)

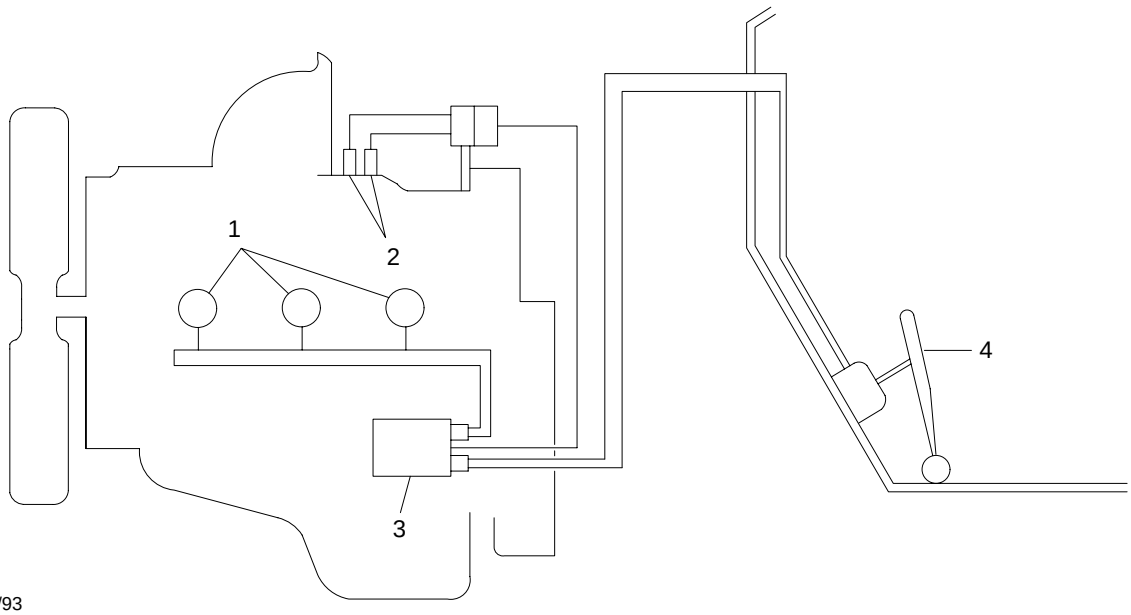
The DDEC II system is an electronic engine control system that is available on Detroit Diesel Series 50 and Series 60 engines. The system controls engine timing and fuel injection, and monitors various engine functions. The DDEC II system is self-diagnostic, providing the operator with codes to indicate both malfunctioning components and engine-related problems. If potentially damaging engine conditions are detected, the system is capable (depending on installed options) of limiting engine operation, or completely shutting down the engine.

The driver controls the system by using the electronic foot pedal assembly (EFPA), which operates like a standard, mechanical accelerator pedal.

The "Chk Eng" light (CEL), and the "Shutdown" light inform the driver of potential problems. The CEL can also be used to read diagnostic engine codes.

ELECTRONIC CONTROL MODULE (ECM)

The electronic control module (**Fig. 3** or **Fig. 4**) is the center of the system. It is a microprocessor that controls and monitors the system, sending commands to the various engine components, and receiving data from them. The ECM contains an electrically



1. Electronic Unit Injectors
2. Sensors
3. Electronic Control Module (ECM)
4. Electronic Accelerator Pedal

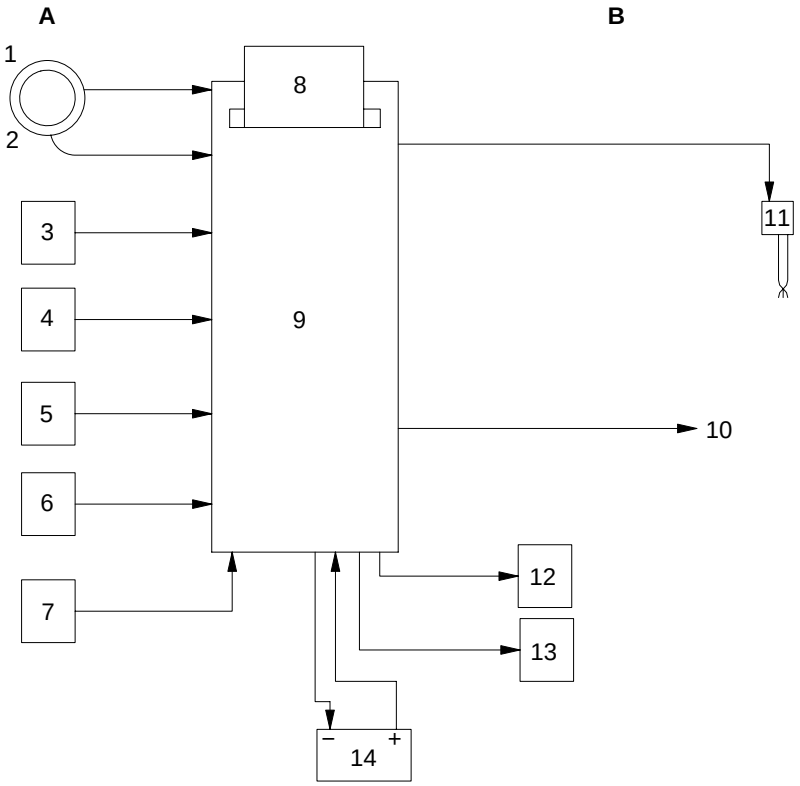
Fig. 1

The center of the system is a microprocessor called the electronic control module (ECM), which controls and monitors the system. The ECM receives data from the various sensors on or near the engine, and sends commands to the electronic unit injectors on the engine, thus controlling engine speed and fuel consumption.

eraseable, programmable read-only memory (EEPROM), which is encoded with engine performance data such as rated horsepower, torque curve, maximum engine speed, and optional protection features.

The ECM is located on the lower left side of the engine.

General Description and Principles of Operation



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A. Inputs
B. Outputs

1. Timing Reference
2. Synch Reference
3. Turbo-Boost Pressure
4. Throttle Position
5. Oil Temperature
6. Oil Pressure
7. Coolant Level
8. EEPROM
9. Electronic Control Module
10. Diagnostic Data Link (DDL)
11. Injectors
12. Shutdown Light
13. Check Engine Light
14. Battery

Fig. 2

ELECTRONIC ACCELERATOR PEDAL

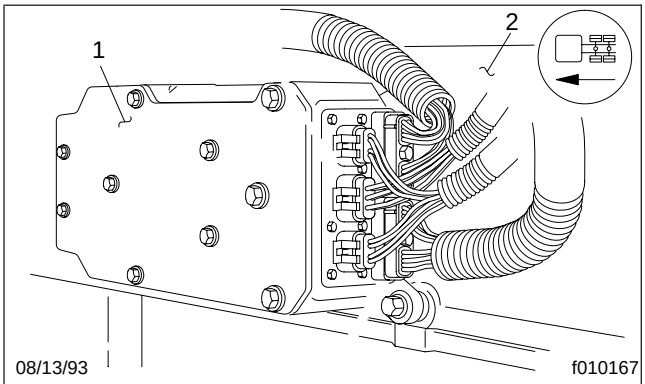
The electronic accelerator pedal operates much like a mechanical accelerator pedal, controlling the amount of fuel injected into the cylinders, and thus engine speed. There is no mechanical throttle linkage in the DDEC II system.

ELECTRONIC UNIT INJECTORS

The electronic unit injectors are located under the valve cover of the engine, and are not externally visible. They are controlled by the ECM, via the electronic foot pedal assembly.

SYNCHRONOUS REFERENCE SENSOR

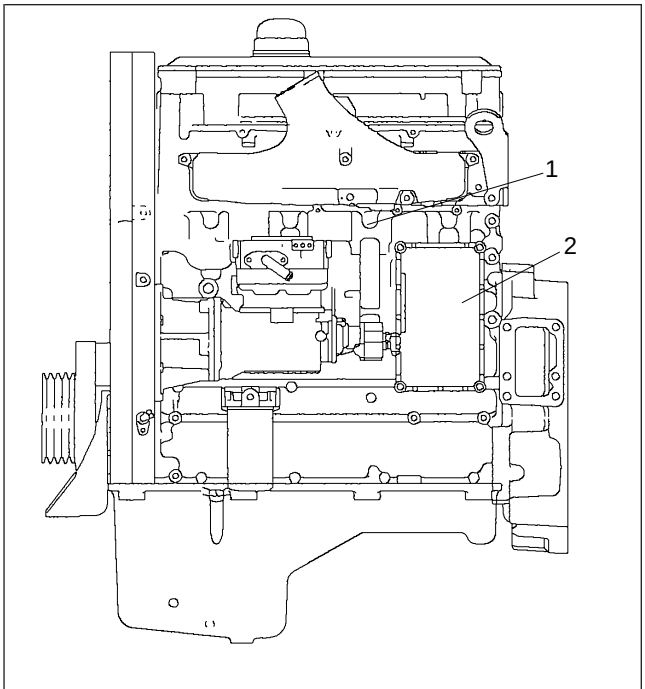
The synchronous reference sensor, located at the rear of the engine gear case, senses when the num-



NOTE: Detroit Diesel Series 60 engine shown.

1. Electronic Control Module (ECM)
2. Engine Block

Fig. 3



NOTE: Detroit Diesel Series 50 engine shown.

1. Turbo-Boost Pressure Sensor
2. Electronic Control Module (ECM)

Fig. 4

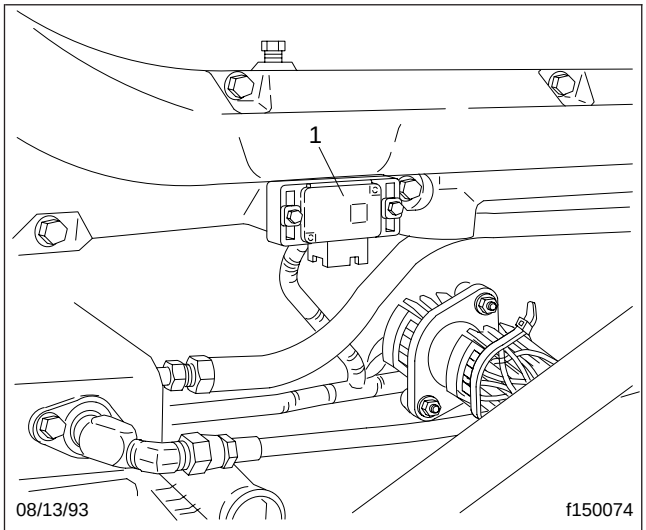
ber one piston reaches about 45 degrees before top-dead-center (BTDC). This information is sent to the ECM, which uses it to determine engine speed.

TIMING REFERENCE SENSOR

The timing reference sensor, located near the teeth of the timing wheel, senses when each piston reaches 10 degrees BTDC. The ECM uses this information to monitor engine rpm.

TURBO BOOST PRESSURE SENSOR (TBS)

The turbo boost pressure sensor (**Fig. 4** or **Fig. 5**), located on the intake manifold, monitors the amount of air entering the engine, and transmits this information to the ECM. The ECM uses this information to regulate the fuel supply in order to control engine smoke.



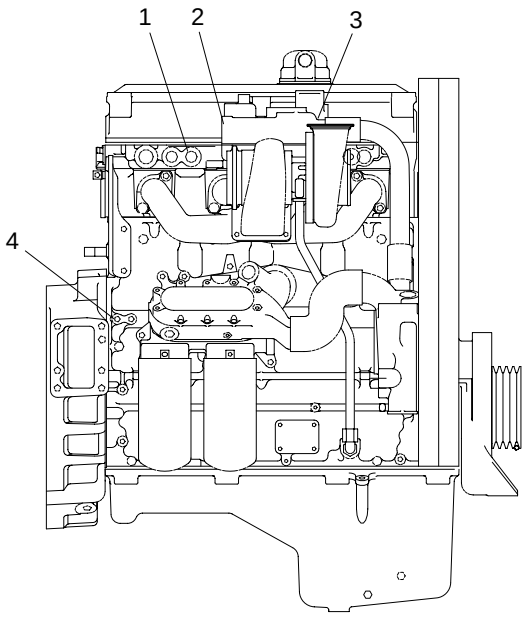
NOTE: Detroit Diesel Series 60 engine shown.

1. Turbo Boost Pressure Sensor

Fig. 5

OIL PRESSURE SENSOR

The oil pressure sensor, which is connected to the main oil gallery (**see Fig. 6**), sends continuous electrical signals to the ECM, telling what the oil pressure is at any given speed. If a low oil pressure signal is detected by the ECM for more than seven seconds, the ECM signals the dash warning light ("Shutdown"), and if the system is so equipped, begins to shut down the engine.



01/22/96 f010658

NOTE: Detroit Diesel Series 50 engine shown.

1. Coolant Temperature Light Switch Port
2. Coolant Temperature Gauge Port
3. Fan Control Switch Port
4. Oil Pressure Sensor Port

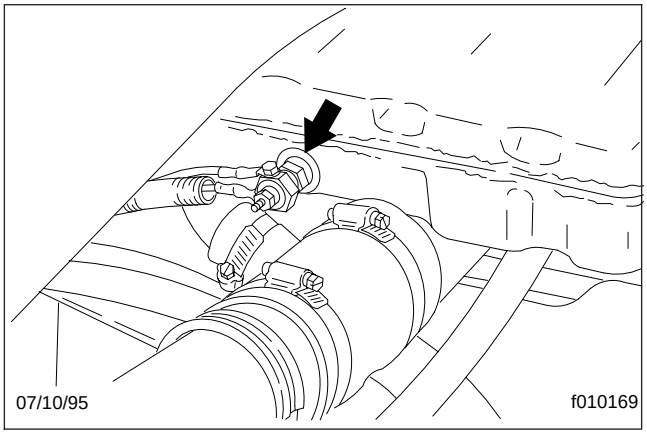
Fig. 6

OIL TEMPERATURE SENSOR

The oil temperature sensor monitors the temperature of the engine oil, and relays this information to the ECM. The ECM changes the engine speed according to this information, improving cold weather starts and providing faster warm-ups. If the oil temperature is too high for more than two seconds, the "Shutdown" dash light will come on, and if the vehicle is equipped with engine shutdown options, the engine will shut down.

COOLANT LEVEL SENSOR (CLS)

The coolant level sensor, which is located on the radiator top or surge tank (**see Fig. 7**), monitors the level and temperature of the coolant in the radiator, and relays this information to the ECM. If the coolant level is too low, the ECM will turn on the dash "Shutdown" light, and if the vehicle is equipped with an engine shutdown option, the engine will shut down.

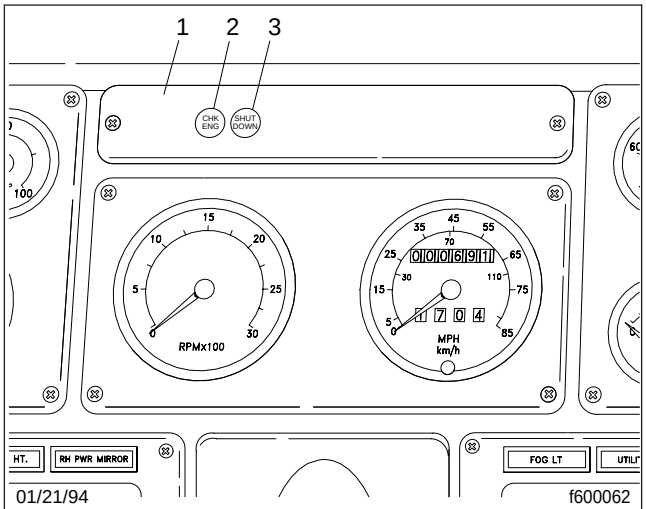


07/10/95 f010169

Fig. 7

DASH LIGHTS AND CONTROLS

There are two standard dash lights, the "Chk Eng" light and the "Shutdown" light. Both are located on the dashboard lightbar (**see Fig. 8**), and both light up when the ignition is turned on. If the DDEC II system and the engine are functioning normally, both lights will go out after three to eight seconds.



01/21/94 f600062

1. VIGIL Lightbar
2. Check Engine Light
3. Engine Shutdown Light

Fig. 8

If the vehicle is equipped with a cruise control, the cruise control system is connected to the main

DDEC II system; it doesn't operate as a separate system. **See Fig. 9** for the location of the cruise control switches on the dash.

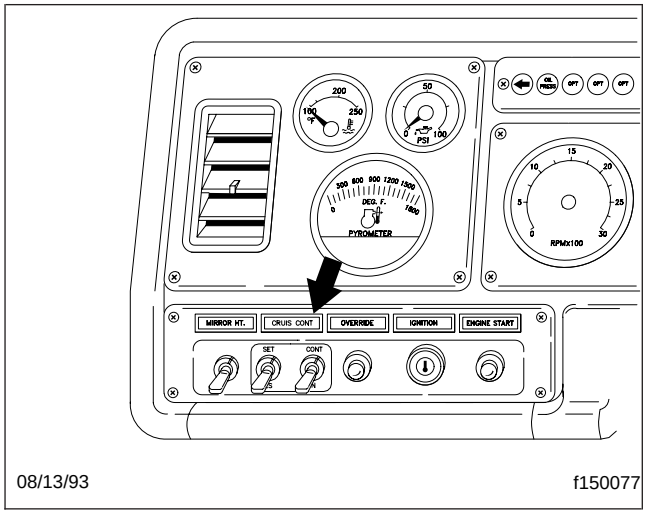
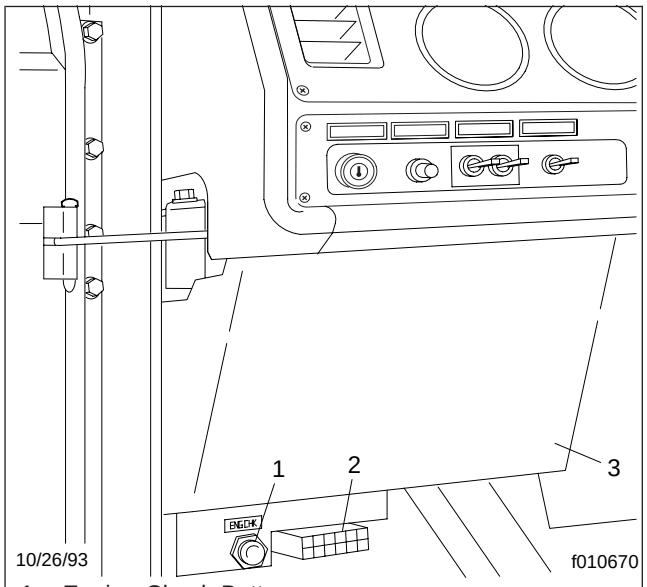


Fig. 9

The "Eng Chk" button (**Fig. 10**), below the left side of the upper steering column cover panel, is used to read the diagnostic codes from the "Chk Eng" light.



1. Engine Check Button
2. DDL Connector (6-Pin or 12-Pin)
3. Upper Steering Column Cover Panel

Fig. 10

On vehicles with the engine shutdown option, an "Override" button allows the driver to get the vehicle off the road if the engine begins to shut down. It is on the left-side lower dash (**see Fig. 9**).

General Description and Principles of Operation

The Turner Quick-Start (**Fig. 1**) is an ether injection system which, when activated, distributes a small amount of ether in the engine intake manifold, by way of an atomizer (**Fig. 2**). During cold weather, the ether injection system assists in starting the engine.

Electric models are operated by a dash-mounted pushbutton, with one circuit to the ignition, and another to a thermostatically controlled solenoid valve. The solenoid valve is attached to the mechanical valve body, from which a nylon tube is routed to an ether atomizer. The ether is stored in a fuel cylinder mounted on the firewall, frame rail, or other location.

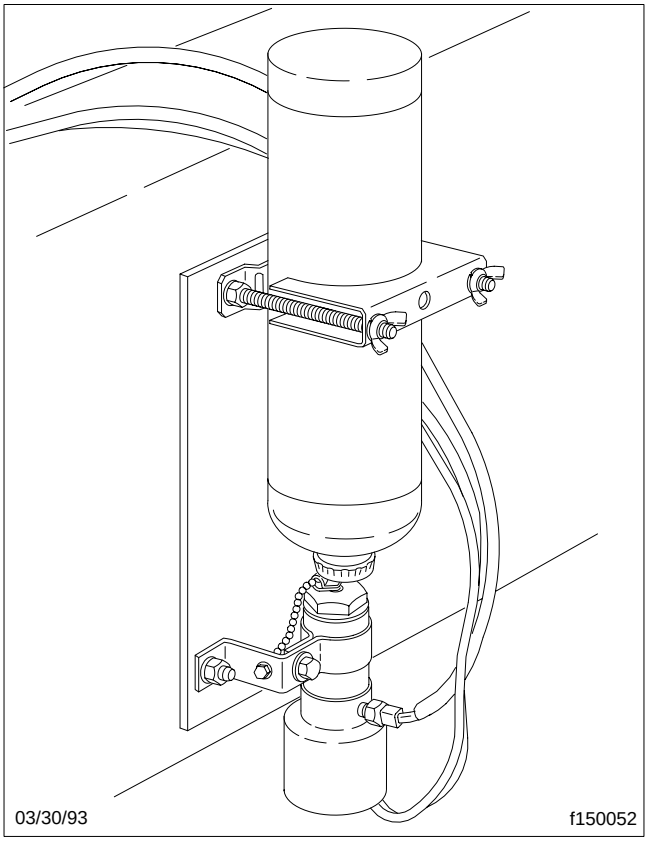


Fig. 1, Turner Quick-Start

NOTE: Refer to the Freightliner driver's manual for operating instructions.

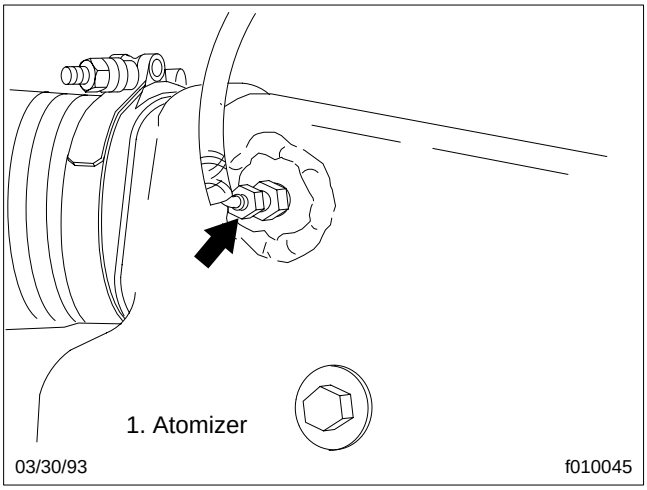


Fig. 2, Atomizer (Cummins NTC Installation)

NOTE: During cold weather start-ups, heat generated in the engine cylinders due to air compression may not be high enough to ignite the fuel and start the engine. When the electric pushbutton is activated, a measured amount of ether is discharged through the nylon tube from the ether reservoir to the atomizer. The atomizer sprays a fine mist of ether in the intake manifold.

As the engine is cranked, the heat generated by air compression ignites the highly combustible ether fumes. This, in turn, fires the diesel fuel until sufficient engine heat and pressure are built up to sustain combustion.

NOTE: A thermostat ground-interrupt opens at 95± 10°F (35± 6°C), and closes at 70°(21°C), preventing ether injection when it is not needed or recommended.

Safety Precautions

⚠ WARNING

WARNING: Ether is extremely flammable, toxic, and harmful or fatal if swallowed. If splashed in the eyes, ether can cause serious injury or blindness. Perform all service operations in a well-ventilated area away from heat, open flames, or sparks; wear goggles to prevent eye injury. Make sure the valve, tube, and atomizer openings are pointed away from you and other persons.

If ether is swallowed, DO NOT INDUCE VOMITING. Contact a doctor immediately. Avoid contact with your skin and eyes, and do not breathe the fumes. If ether gets in your eyes, rinse them with plenty of clean water for 15 minutes. Contact an eye specialist.

⚠ CAUTION

CAUTION: Whenever ether-conducting components (nylon tube, atomizer, valve body) are disconnected, cap the components to prevent any dirt or other foreign material from entering. Dirt inside the ether-injection system can clog parts and damage the system.

Fuel Cylinder (See Fig. 1)

IMPORTANT: Before removing and installing a fuel cylinder, refer to the manufacturer's caution located on the cylinder.

1. Wipe all dirt from the exterior of the valve body.
2. Loosen the wing nuts on the cylinder clamp. Remove the cylinder from the valve body.
3. Replace the valve gasket (in the valve opening) with a new one.
4. Remove the cap from the new cylinder. Install the cylinder hand-tight on the valve body.
5. Tighten the cylinder clamp wing nuts snug. Make sure the front saddle of the clamp firmly holds the cylinder in place.

Valve Body/Solenoid (See Fig. 1)

1. Remove the fuel cylinder, as described under "Fuel Cylinder." Cap the cylinder.

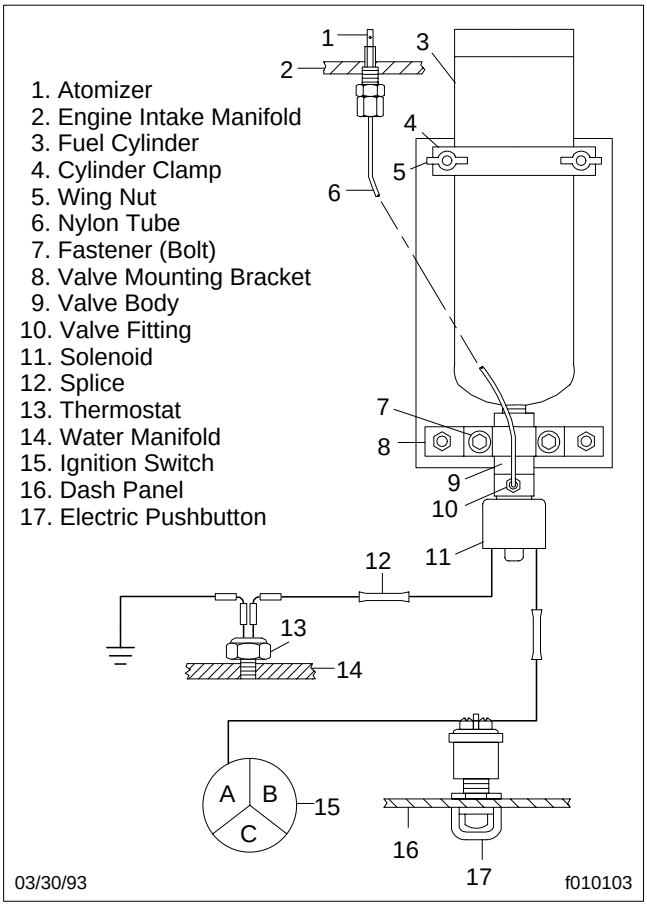


Fig. 1, Turner Quick-Start Installation

2. Remove the valve fitting and tube assembly from the valve body. Cap the fitting.
3. Mark, and then disconnect the solenoid valve wires at the splices.
4. Remove the fasteners attaching the valve body and solenoid valve to the mounting bracket. Remove the valve body.
5. Place the new valve body on the mounting bracket and install the fasteners. Tighten the nuts 84 to 120 lbf·in (940 to 1360 N·cm).
6. Remove the cap from the valve fitting and tube assembly, and attach the fitting to the valve. Us-

ing a wrench, tighten the fitting a few turns. The fitting should not bottom in the valve.

7. Connect the wires at the splices of the solenoid valve, as previously marked.
8. Remove the cap from the fuel cylinder. Install the cylinder hand-tight on the valve. Tighten the cylinder clamp wing nuts, making sure the front saddle of the clamp holds the cylinder firmly in place.

Atomizer (See Fig. 2)

1. Remove the tube ferrule and nut assembly. Disconnect the tube from the atomizer and cap the tube.
2. Remove the atomizer from the intake manifold; install a new one. Tighten the atomizer a few turns until secure.

IMPORTANT: The orifices in the atomizer must point toward the turbocharger on L10 engines, and toward the front of NTC engines.

3. Remove the cap from the tube, and attach the tube to the atomizer. Tighten the tube ferrule and nut assembly a few turns until secure.

Tube (See Fig. 1)

1. Remove the tube ferrule and nut assemblies. Disconnect the tube from the valve fitting and the atomizer and cap the fitting and atomizer.
2. Insert one end of the new tube in a new ferrule and nut assembly. Remove the cap from the valve fitting, and insert the tube until it bottoms in the fitting. Turn the ferrule and nut assembly a few turns to secure the tube in the fitting. Make sure that the tube can't be pulled out of the fitting. Repeat for the other tube end at the water manifold.

Electric Pushbutton (See Fig. 3)

1. To prevent an accidental short in the electrical circuit, disconnect the battery ground cable at the vehicle frame.
2. Remove the rubber cap from the pushbutton switch.

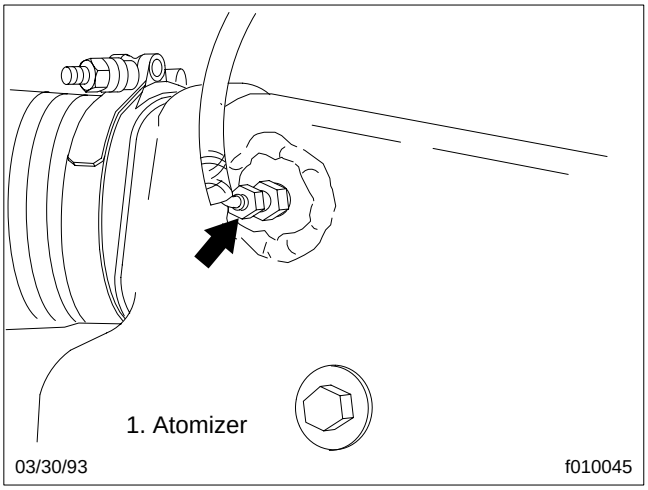


Fig. 2, Atomizer (Shown Installed on Cummins NTC)

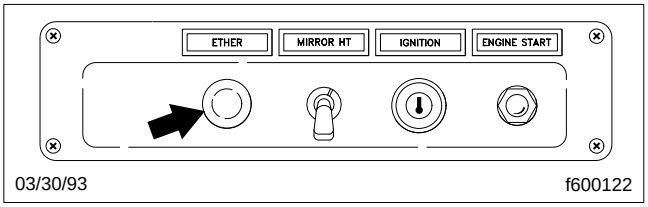


Fig. 3, Electric Pushbutton

3. Remove the screws that attach the control panel to the dash. Move the panel away from the dash.
4. Remove the knurled nut from the pushbutton switch.
5. Reference, then disconnect the wires from the switch. Remove the pushbutton switch from the panel.
6. Install the switch using the above instructions in reverse order.

Troubleshooting

⚠ WARNING

WARNING: Ether is extremely flammable, toxic, and harmful or fatal if swallowed. If splashed in the eyes, ether can cause serious injury or blindness. Perform all service operations in a well-ventilated area away from heat, open flames, or sparks; wear goggles to prevent eye injury. Make sure the valve, tube, and atomizer openings are pointed away from you and other persons.

If ether is swallowed, DO NOT INDUCE VOMITING. Contact a doctor immediately. Avoid contact with your skin and eyes, and do not breathe the fumes. If ether gets in your eyes, rinse them with plenty of clean water for 15 minutes. Contact an eye specialist.

If the ether-injection system is not working, do the following:

1. Remove the cylinder from the valve, and check the fuel supply. An empty cylinder weighs about 17 oz (480 g); a full one weighs about 37 oz (1050 g). Replace the cylinder if damaged or empty. After installing the partially full or new fuel cylinder, check for leaks; make sure the cylinder is hand-tightened securely on the valve.

IMPORTANT: Before replacing the cylinder, replace the valve gasket with a new one.

NOTE: For the following steps, ambient temperatures must be below the thermostat ground interrupt of 95± 10°F (35± 6°C).

2. Disconnect the nylon tube at the valve fitting. Have someone operate the valve from inside the cab; catch the ether discharge in a cloth or paper towel. If no ether is discharged, the valve body or solenoid valve is clogged or damaged. Replace the valve assembly.
3. If ether was discharged in the step above, connect the nylon tube to the valve; disconnect the other end of the tube from the atomizer. Again, operate the valve, and catch the ether discharge in a cloth or paper towel. If no ether is discharged, the tube is clogged. Replace the tube.
4. If ether was discharged in the step above, connect the nylon tube to the atomizer. Remove the atomizer from the engine intake manifold. Again, operate the valve, and catch the ether discharge in a cloth or paper towel. If no ether is discharged, the atomizer is clogged or damaged. Replace the atomizer.

General Description and Principles of Operation

Jacobs engine brake housings are installed on the engine rocker housings. Model 404 (used on Cummins L10 engines) has two engine brake housings that operate three cylinders each. Each engine brake housing has a solenoid valve, control valve, ball check valve, master piston, and slave piston.

Engine brake controls consist of: two dashmounted toggle switches (**Fig. 1**), a clutch switch mounted under the dash for 120 Conventionals (**Fig. 2**), or under the cab for COEs (**Fig. 3**), and the throttle switch mounted on the engine fuel pump. The switches are wired in series so that all of the switches must be closed to operate the engine brake. The engine brake is activated when one or both of the dash switches is on (up), and the clutch and throttle pedals are released. The dash switches enable the driver to operate the engine brake partially or fully.

Model 404 engine brakes can be operated at one-half or full capacity (three or six cylinders).

When activated, the engine brake converts a power-producing diesel engine to a power absorbing air compressor. This is accomplished by motion transfer through a master-slave piston arrangement which opens the engine cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust. The blow-down of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the expansion (power) stroke. This results in a net energy loss because the work done in compressing the cylinder charge is not returned during the expansion process. Exhaust blowdown occurs as follows (**see Fig. 4**):

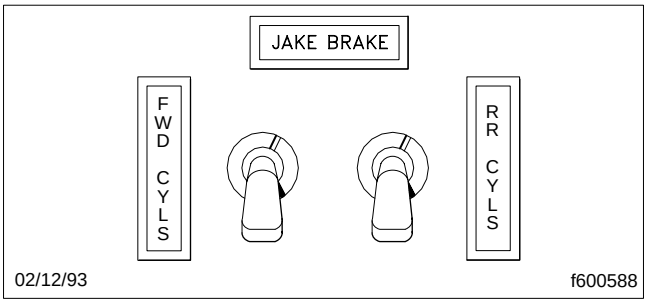


Fig. 1, Engine Brake Dash Switches

1. Activating the engine brake energizes the solenoid valve, allowing engine oil to flow under pressure through the control valve to both the master piston and the slave piston.

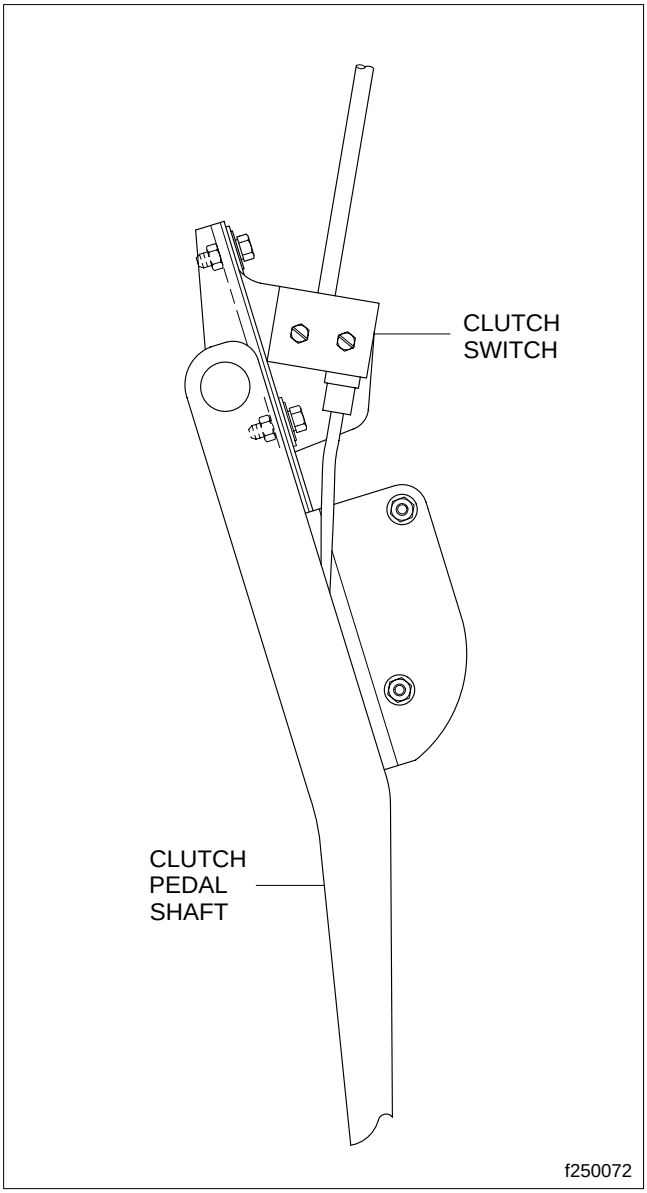


Fig. 2

2. Oil pressure causes the master piston to move down, coming to rest on the injector rocker lever adjusting screw.

General Description and Principles of Operation

3. The injector rocker lever adjusting screw begins upward travel (as in the normal injection cycle) forcing the master piston upward and creating a high-pressure oil flow to the slave piston. The ball check valve in the control valve holds the high-pressure oil in the master-slave piston system.
4. When the engine piston is near top dead center, the slave piston moves down under the influence of the high-pressure oil flow. This momentarily opens one of the exhaust valves, releasing compressed cylinder air to the exhaust manifold.
5. Compressed air is released to the atmosphere, completing a compression braking cycle.

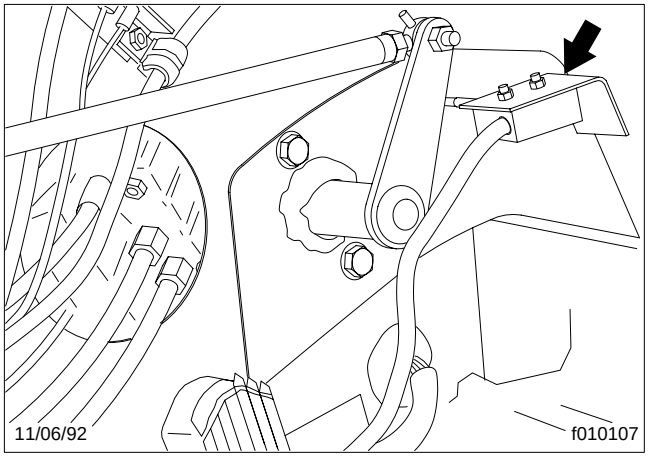


Fig. 3

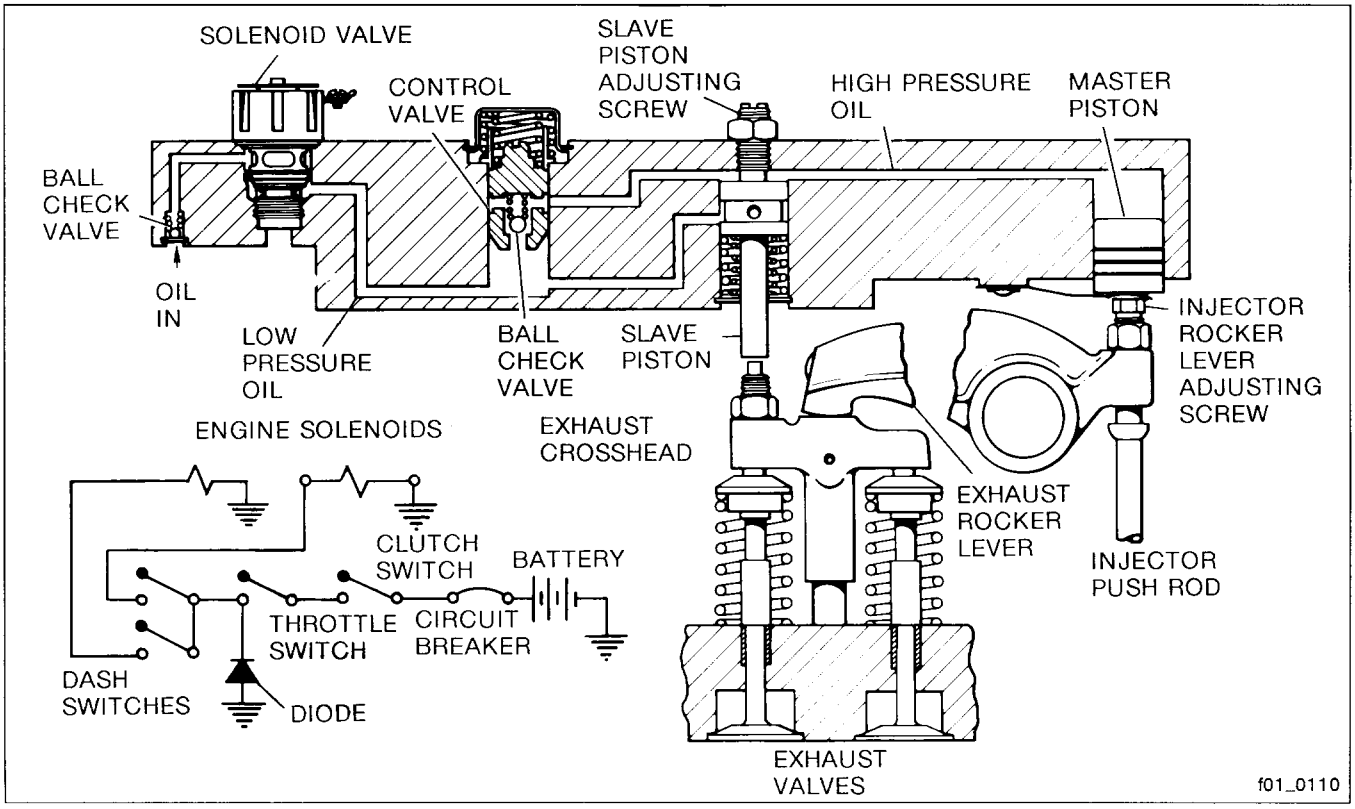

SOLENOID VALVE
CONTROL VALVE
SLAVE PISTON ADJUSTING SCREW
HIGH PRESSURE OIL
MASTER PISTON
BALL CHECK VALVE
OIL IN
LOW PRESSURE OIL
BALL CHECK VALVE
SLAVE PISTON
INJECTOR ROCKER LEVER ADJUSTING SCREW
ENGINE SOLENOIDS
EXHAUST CROSSHEAD
EXHAUST ROCKER LEVER
INJECTOR PUSH ROD
CLUTCH SWITCH
BATTERY
THROTTLE SWITCH
CIRCUIT BREAKER
DASH SWITCHES
DIODE
EXHAUST VALVES
f01_0110

Fig. 4

Dash Switch Replacement

NOTE: **See Fig. 1** for the engine brake wiring diagram.

1. Park the vehicle and disconnect the battery.
2. Remove the screws that attach the control panel to the dash. Lift the panel to a serviceable level.
3. Remove the switch cap nut, and remove the switch from the panel.
4. Mark the wires for later reference, then disconnect them from the switch.
5. Connect the wires to the new switch, as previously marked.
6. Install the switch through the rear of the panel, and attach it with the cap nut.
7. Place the panel in the dash, and attach it with the screws.
8. Connect the battery.

Throttle Switch Replacement

NOTE: **See Fig. 1** for the engine brake wiring diagram.

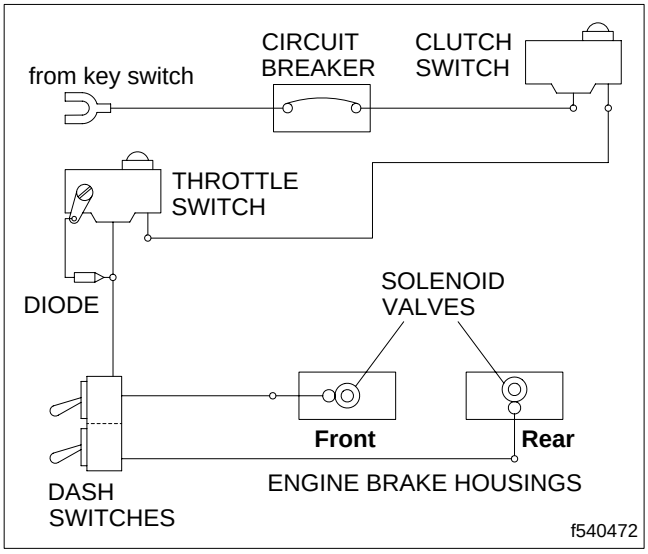


Fig. 1, Wiring Diagram

1. Tilt the cab or hood. For instructions, refer to the vehicle driver's manual.
2. Mark the wires for later reference, and disconnect them from the throttle switch.
3. Remove the screws that attach the throttle switch to the switch bracket on the fuel pump governor housing. Remove the throttle switch.
4. If replacing the actuating arm, remove the nut that attaches the actuating arm to the fuel pump throttle shaft. Remove the actuating arm.
5. Install the switch on the fuel pump governor housing and attach it with the screws.
6. If previously removed, attach the actuating arm to the fuel pump throttle shaft with the nut. The arm may be bent or manipulated to obtain the proper position for switch contact. Adjust the screw in the actuating arm to a point where an audible click is heard when the throttle arm moves to the idle position (throttle pedal released).

IMPORTANT: After installing the actuating arm, check the fuel pump throttle shaft to ensure that the throttle pedal will move the shaft to the full fuel position.

7. Connect the wires to the switch, as previously marked.

IMPORTANT: The throttle switch terminal with the diode must be connected to the load (solenoid valve) side of the circuit. **See Fig. 1**.

8. Return the cab or hood to the operating position.

Clutch Switch Replacement

NOTE: **See Fig. 1** for the engine brake wiring diagram.

1. Apply the parking brakes, and chock the tires.
2. Mark the wires for later reference; disconnect them from the clutch switch.
3. Remove the nuts, washers, and screws that attach the switch to the mounting bracket. Remove the switch.
4. Place the new switch on the bracket, and loosely install the screws, washers, and nuts. **See Fig. 2** or **Fig. 3**.

Switch Replacement

The switch arm should deflect 1 to 1-1/2 inches (25 to 38 mm) when the clutch is engaged. **See Fig. 2**. Tighten the switch mounting nuts securely.

5. Connect the wires to the switch, as previously marked.
6. Remove the chocks from the tires.

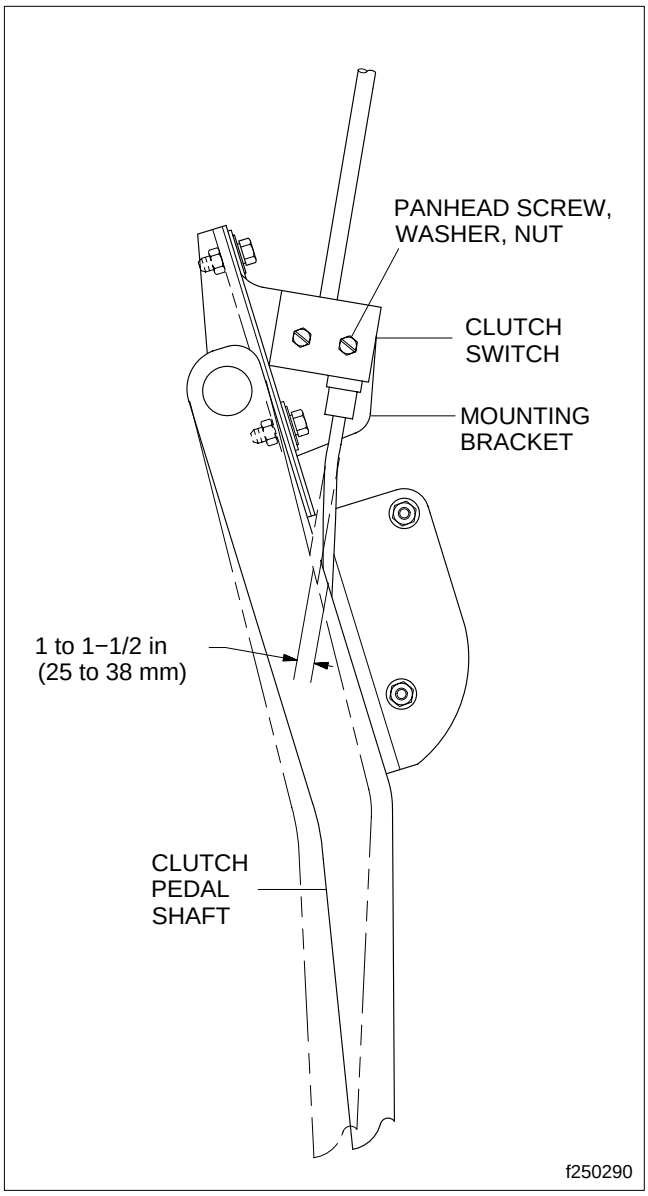


Fig. 2, Clutch Switch Mounting (FLD Conventional shown)

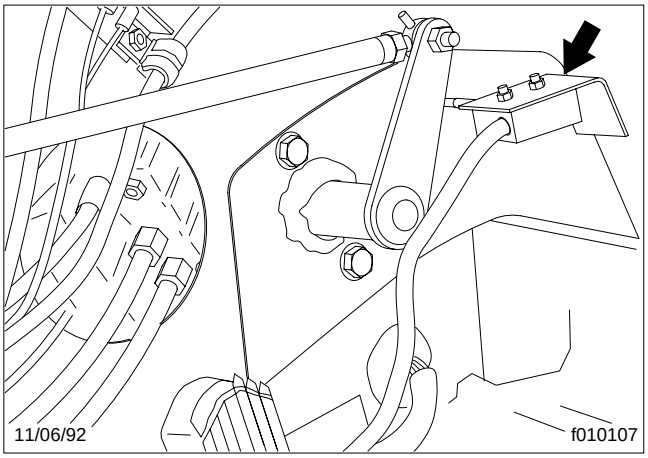


Fig. 3, Clutch Switch Mounting (COE shown)

Engine Brake Housing (See Fig. 1)

REMOVAL

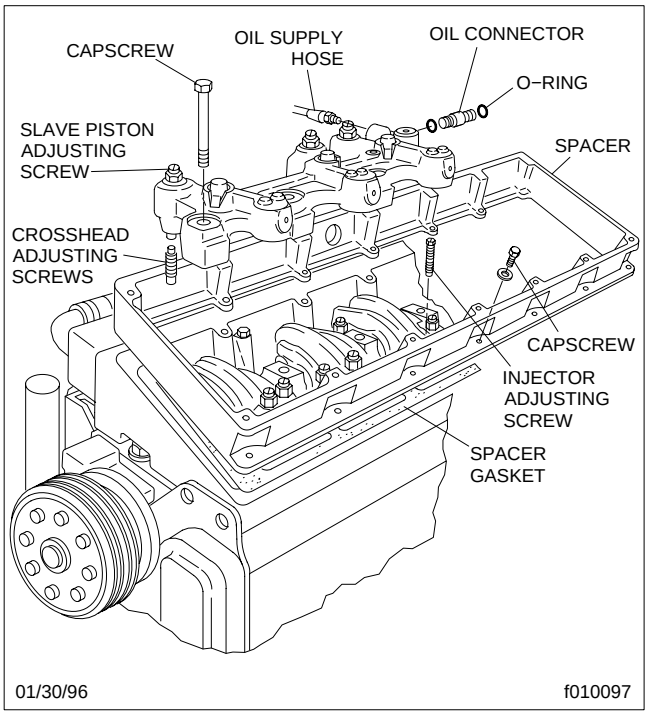


Fig. 1

⚠ WARNING

WARNING: To avoid personal injury, never remove any engine brake component with the engine running.

1. Tilt the cab or hood. For instructions, refer to the vehicle driver's manual.
2. Wipe clean the engine brake housing area. Remove the rocker housing cover capscrews, and remove the cover and gasket from the spacer.
3. Disconnect the solenoid electrical harness from the terminal leadout in the spacer. **See Fig. 2**.
4. Remove the steel plates, O-ring, and gasket from the spacer. **See Fig. 3**. Disconnect the oil hose from the front brake housing, and remove it through the hole in the spacer. **See Fig. 4**.

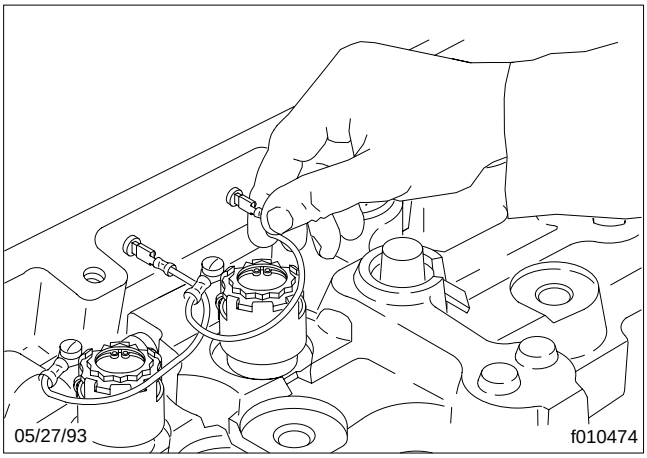


Fig. 2

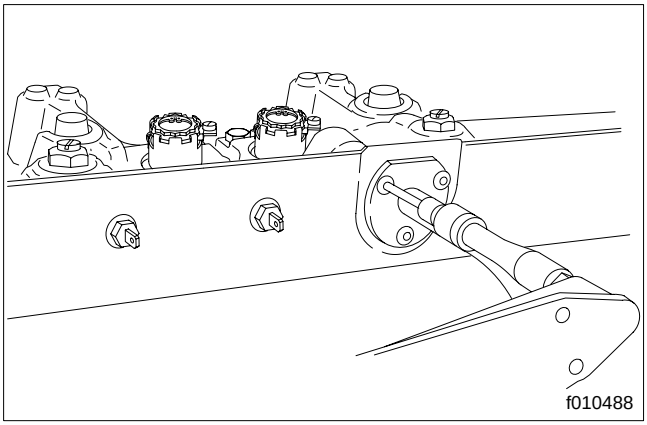


Fig. 3

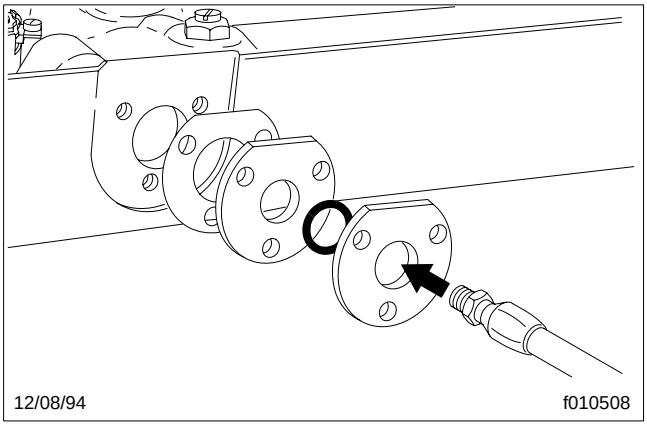


Fig. 4

5. Remove the engine brake housing holddown capscrews. **See Fig. 5**.

Component Removal, Inspection, Adjustment,and Installation

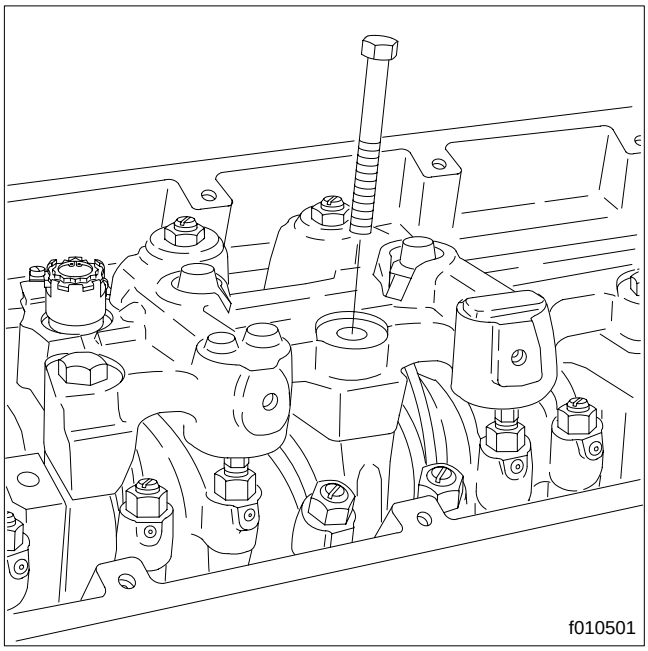


Fig. 5

6. Remove the engine brake housing from the rocker-shaft supports.

INSTALLATION

1. If the oil connector was previously removed from the front housing, then install the connector and O-ring into the front housing as far as it will go (**Fig. 6**).
2. Back out the slave-piston adjusting screws until the slave pistons are fully retracted (screws are loose). **See Fig. 7**.
3. Place the rear brake housing on the rockershaft supports over cylinders 4, 5, and 6. Loosely install four Jacobs holddown capscrews. **See Fig. 5**. Lubricate the threads and underside of the capscrew heads.

NOTE: No washers are used with the capscrews.

4. Place the front brake housing on the rocker-shaft supports over cylinders 1, 2, and 3. Carefully insert the oil connector into the rear housing.

   Loosely install four Jacobs hold-down capscrews. **See Fig. 8**. Lubricate the threads and underside of the capscrew heads. Make sure that the oil connector is centered between the housings. **See Fig. 9**.

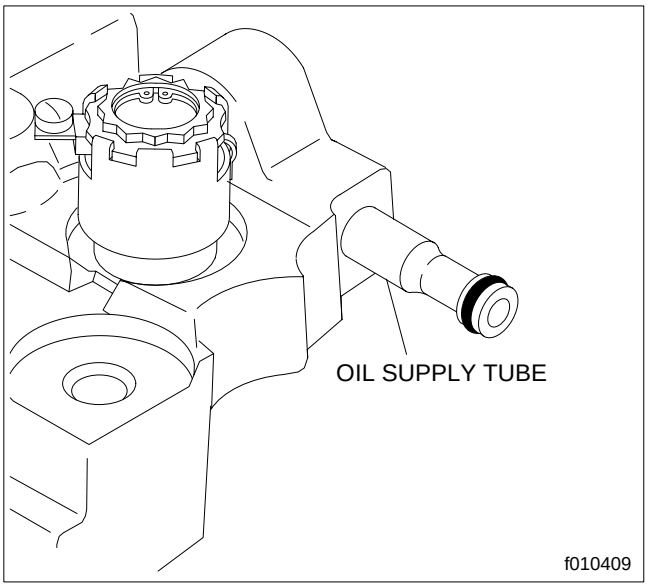


Fig. 6

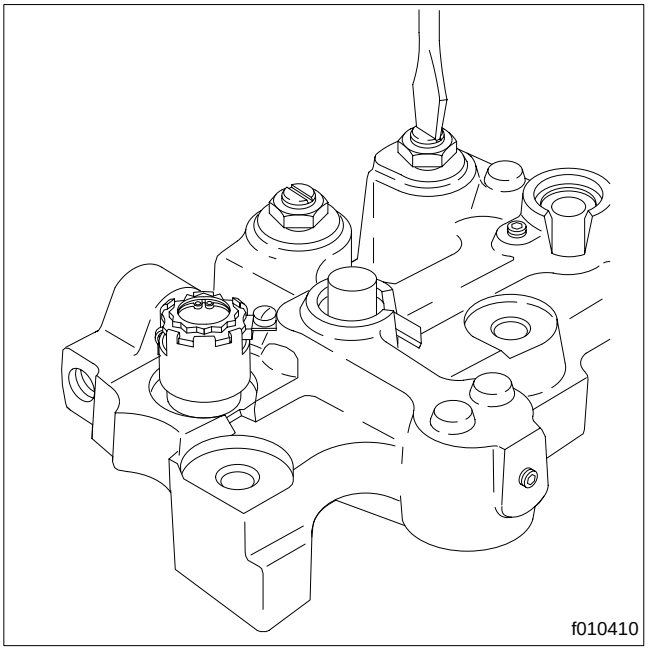


Fig. 7

NOTE: No washers are used with the capscrews.

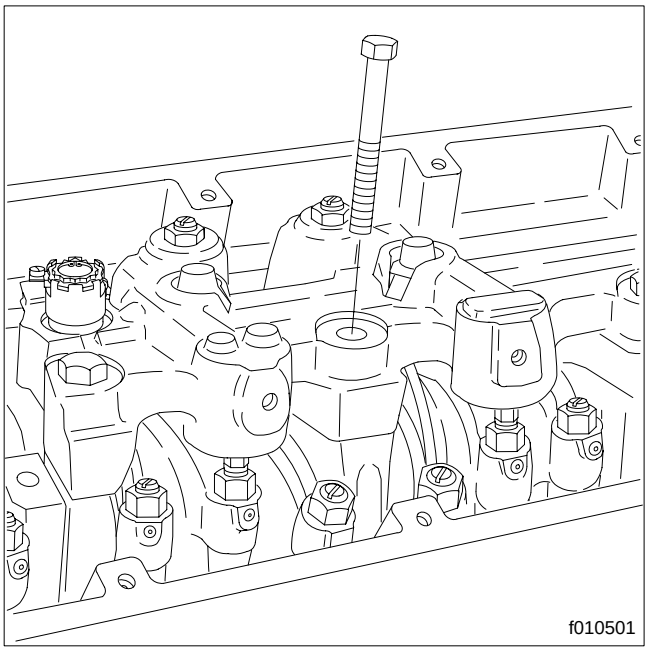


Fig. 8

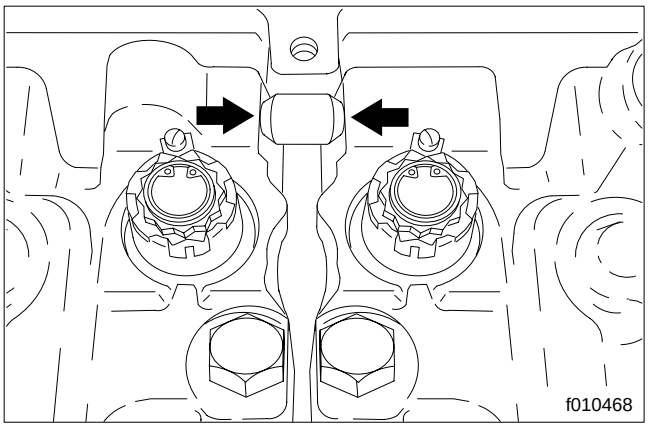


Fig. 9

5. Slide the number 5 support as far forward as possible. **See Fig. 10** for the next several steps.
6. Align the rear brake housing so that the slave pistons are over the Jacobs actuating pins in the exhaust crossheads on all three cylinders (4, 5, and 6). **See Fig. 11**. Swing each crosshead through its free side play.
7. All three Jacobs actuating pins should remain completely under the slave pistons. **See Fig. 12**. If necessary, tap the housing gently with a soft mallet to obtain proper alignment. Be sure the number 5 support remains in the most forward position.
8. Tighten the number 5 rocker-lever support hold-down capscrew 60 lbf·in (680 N·cm).
9. Put a 0.022-inch (0.56-mm) feeler-gauge between the number 5 support and the rocker lever on the number 4 cylinder. Set the side clearance. **See Fig. 13**.

   With the feeler gauge in position, slide the number 6 support as far forward as possible. Tighten the capscrew 60 lbf·in (680 N·cm).
10. Put the feeler gauge between the number 6 support and the rocker lever on the number 5 cylinder. Set the side clearance.

    With the feeler gauge in position, slide the number 7 support as far forward as possible. Tighten the capscrew 60 lbf·in (680 N·cm).

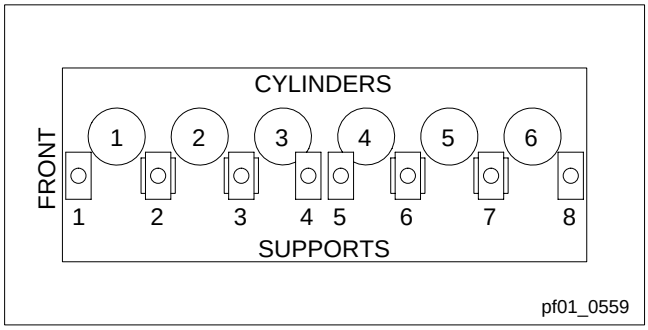


Fig. 10

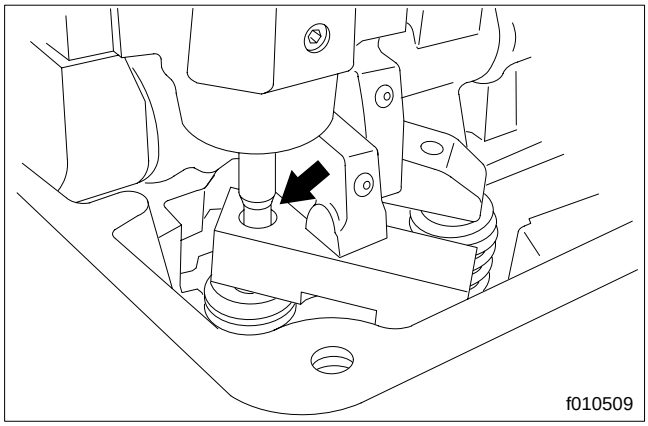


Fig. 11

Component Removal, Inspection, Adjustment,and Installation

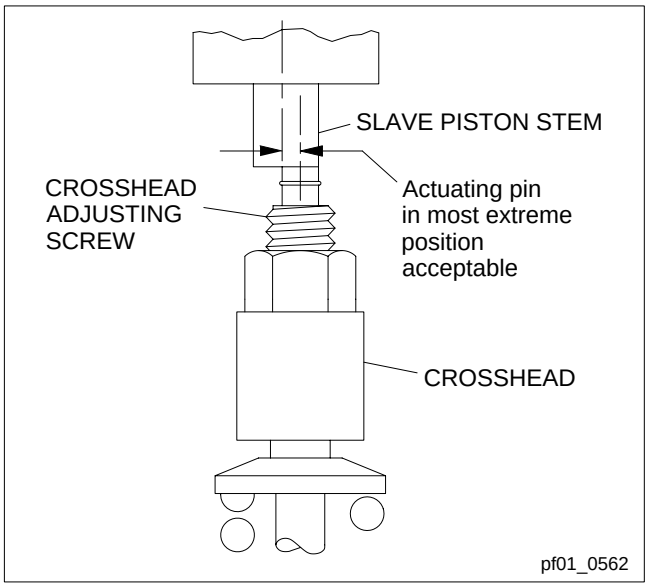


Fig. 12

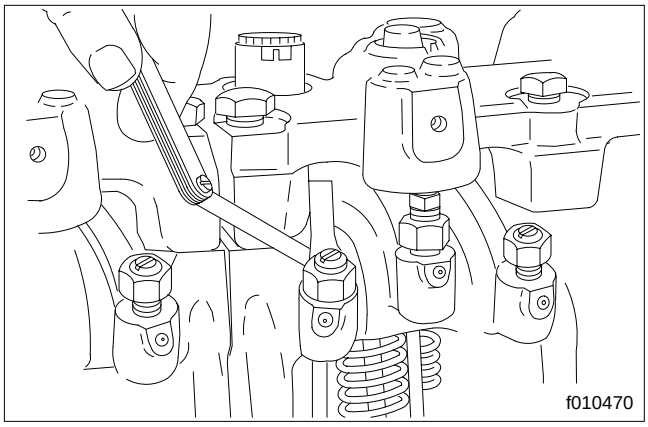


Fig. 13

11. Put the feeler gauge between the number 7 support and the rocker lever on the number 6 cylinder. Set the side clearance.

    With the feeler gauge in position, slide the number 8 support as far forward as possible. Tighten the capscrew 60 lbf·in (680 N·cm).

12. Check the rear brake housing slave piston-to-exhaust crosshead actuating pin alignment.

13. Slide the number 4 support as far back as possible.

14. Check the front brake housing alignment as previously outlined for the rear brake housing. After the brake housing is properly aligned, tighten the number 4 support hold-down capscrew 60 lbf·in (680 N·cm).

15. Put the feeler gauge between the number 4 support and the rocker lever on the number 3 cylinder. Set the side clearance.

    With the feeler gauge in position, slide the number 3 support as far back as possible. Tighten the capscrew 60 lbf·in (680 N·cm).

16. Put the feeler gauge between the number 3 support and the rocker lever on the number 2 cylinder. Set the side clearance.

    With the feeler gauge in position, slide the number 2 support as far back as possible. Tighten the capscrew 60 lbf·in (680 N·cm).

17. Put the feeler gauge between the number 2 support and the rocker lever on the number 1 cylinder. Set the side clearance.

    With the feeler gauge in position, slide the number 1 support as far back as possible. Tighten the capscrew 60 lbf·in (680 N·cm).

18. Check that all side clearances are within 0.020 to 0.025 inch (0.51 to 0.64 mm).

19. Check the alignment of the front brakehousing slave pistons to the crosshead actuating pins.

20. Tighten the hold-down capscrews on each housing. **See Fig. 14**. First, tighten the two middle capscrews (**Fig. 15** , Ref. A) 45 lbf·ft (61 N·m); tighten the two outside capscrews (**Fig. 15** , Ref. B) the same amount. Second, using the same sequence, tighten the capscrews 75 lbf·ft (102 N·m). Finally, tighten the middle capscrews, then the outside capscrews 95 lbf·ft (129 N·m).

21. Adjust the injectors first, then the valves, using Cummins' L10 engine troubleshooting and repair manual. Note that the valves to be adjusted are not on the same cylinder as the injector being set. Follow the Cummins 10 Liter sequence chart. The Cummins dial indicator extension can be positioned so that the indicator extension can reach any injector. **See Fig. 16**. Use the long stem extension, Cummins PN 3376749. Make sure the extension is clear of all engine and engine brake components (moves freely).

22. If installing a new engine brake housing, or if the slave piston was removed, adjust the slave pis-

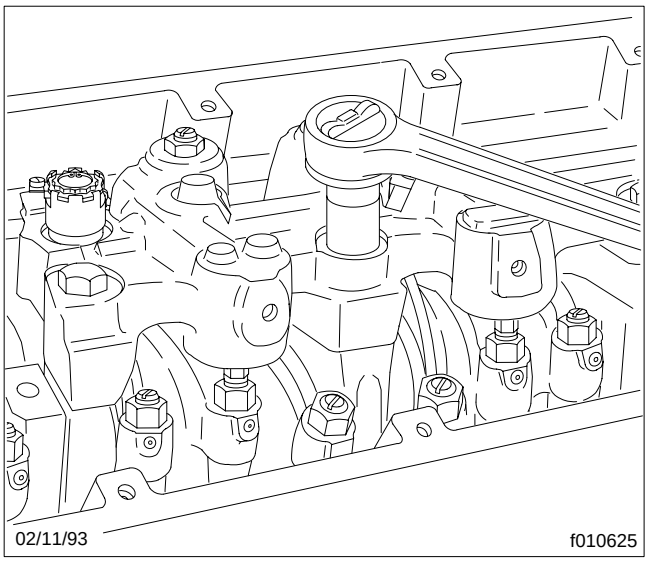


Fig. 14

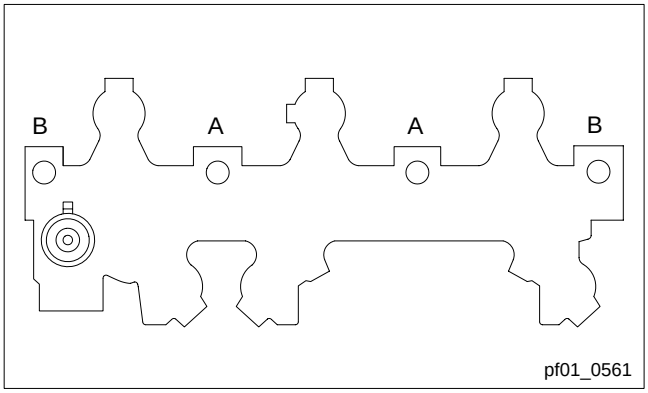


Fig. 15

ton using the instructions under "Slave Piston Adjustment." If the previously removed engine brake is being installed and the slave piston was not removed, proceed to the next step.

23. Slide a new Jacobs oil-hose gasket over the male end of the Jacobs oil-hose assembly. **See Fig. 17**.

24. Insert the male end of the oil-hose assembly through the hole in the Jacobs spacer and install it in the front brake housing. **See Fig. 4**.

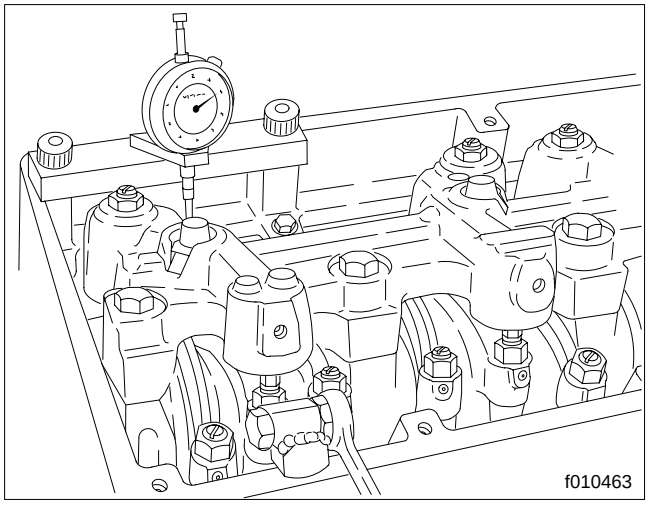


Fig. 16

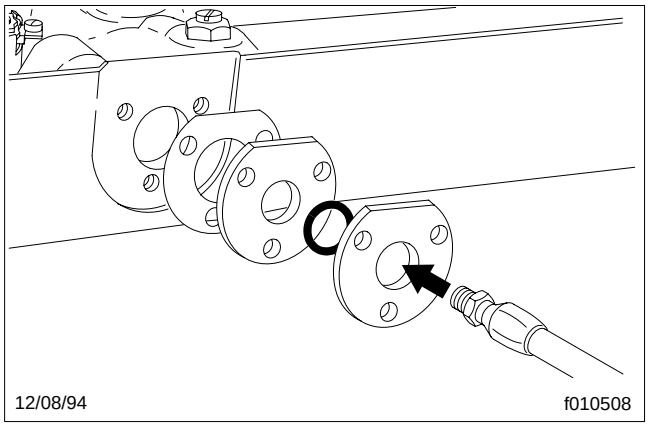


Fig. 17

⚠ WARNING

WARNING: Keep the oil hose clear of all hot engine components and free from rubbing on the engine or chassis. A ruptured hose will spray hot oil and could cause heavy smoke or fire upon hitting hot engine components.

25. Slide the gasket, O-ring, and steel plates up to the spacer. Secure them in place with button-head screws. Tighten the screws to 10 lbf·ft (14 N·m). Be careful to draw the plate up to the gasket evenly. **See Fig. 3**.

26. Connect the solenoid harness from each solenoid valve to the closest terminal leadout in the spacer. **See Fig. 2**.

Component Removal, Inspection, Adjustment,and Installation

27. To bleed the brake units and check their operation, start the engine and allow it to run 5 to 10 minutes.

    Accelerate the engine to approximately 1800 rpm. Release the throttle, then manually depress each solenoid armature. **See Fig. 18**. This procedure should be done five or six times to permit engine oil to completely fill the brake housing passages.

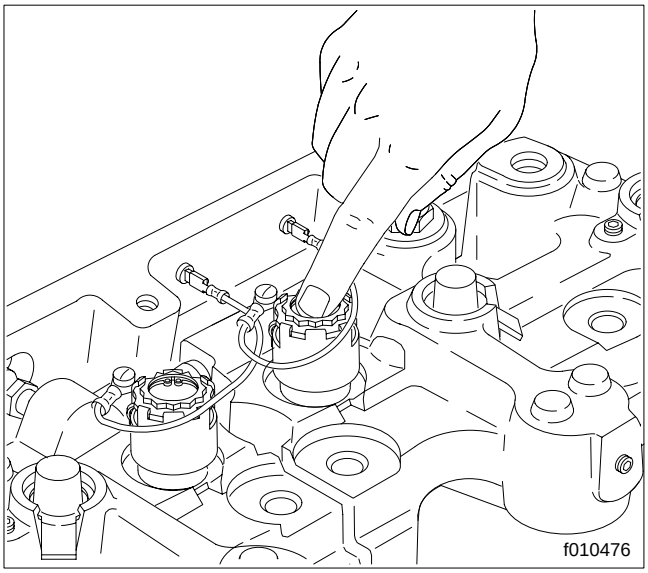


Fig. 18

⚠ WARNING

WARNING: When the engine is running with the valve covers removed, there is significant oil splash in the engine brake area. Wear eye protection; do not expose your face over the engine area. Take precautions to prevent oil leakage down on the engine.

28. With the engine shut down, check the electrical system by turning the ignition switch on. With the dash switch labeled "RR CYLS" in the up position, the rear brake housing solenoid valve should activate. With the dash switch labeled "FWD CYLS" in the up position, the front brake housing solenoid valve should activate.

29. Install the rocker housing cover (**Fig. 19**), as follows:

    29.1 Remove the old cover gasket.

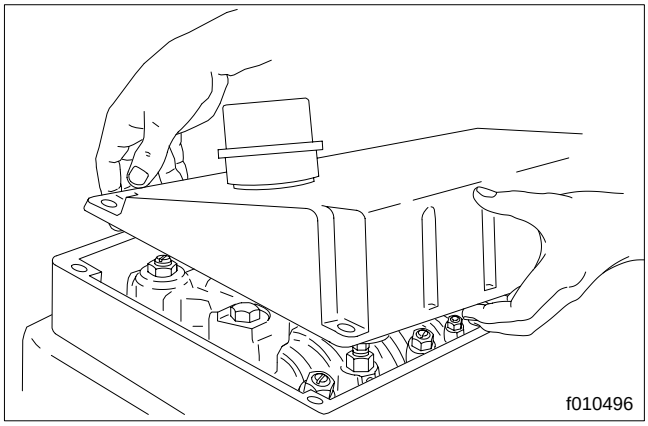


Fig. 19

29.2 Apply a 1/16-inch (2 mm) bead of Cummins black RTV sealant or an equivalent, to the gasket sealing surface on the cover.

29.3 Set the new gasket on the cover, then place the cover on the spacer.

29.4 Install the capscrews and hold-downs.

29.5 Using the sequence in **Fig. 20**, in 45 lbf·in (500 N·cm) increments on each pass, tighten the rocker-housing-cover capscrews 130 lbf·in (1460 N·cm).

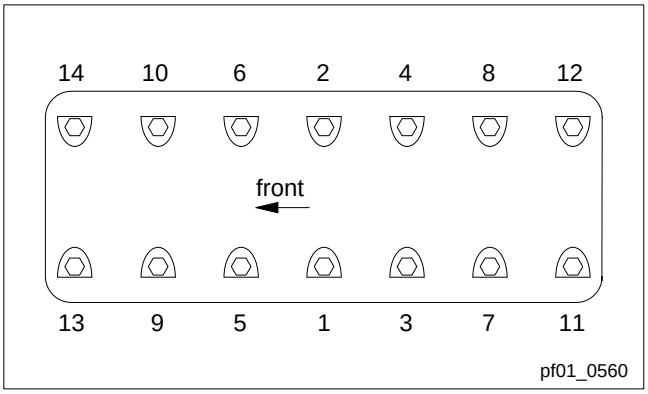


Fig. 20

30. Return the cab or hood to the operating position.

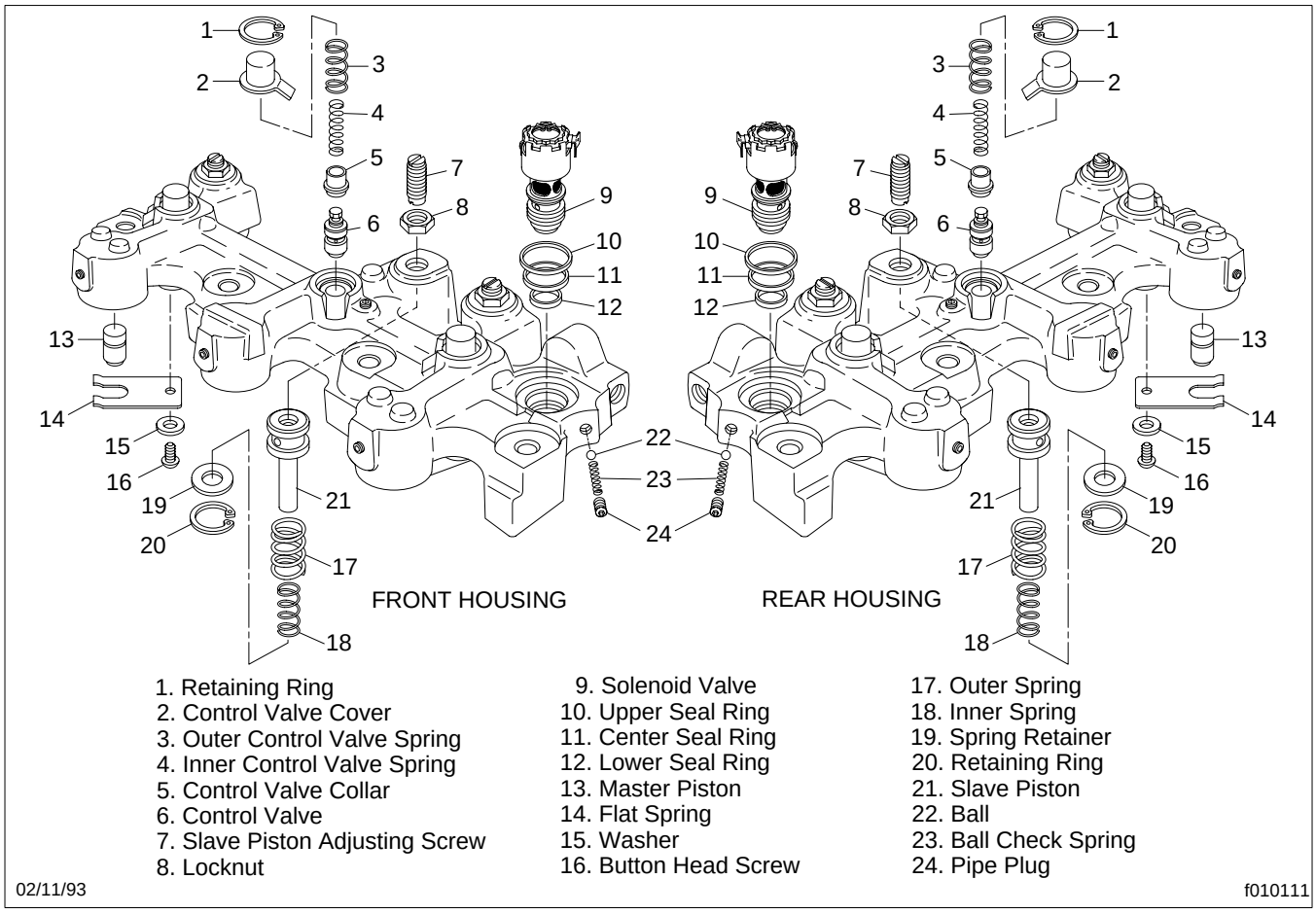


Fig. 21

Control Valve

REMOVAL (See Fig. 21)

1. Tilt the cab or hood. For instructions, refer to the vehicle driver's manual.
2. Wipe the engine brake housing area clean. Remove the rocker-housing-cover capscrews and the rocker housing cover. **See Fig. 19**.
3. Apply pressure on the control valve cover, and remove the retaining ring, using retaining ring pliers. **See Fig. 22**.

⚠ WARNING

WARNING: The control valve covers are under load from the control valve springs. Remove them carefully to avoid personal injury.

4. Carefully remove both control valve springs and the collar. **See Fig. 23**.
5. Using needle nose pliers or your fingertips, carefully pull the control valve straight up and out of its bore. **See Fig. 24**.

INSPECTION

If binding occurs during removal, inspect the control valve parts for damage or wear, and replace them if necessary.

Component Removal, Inspection, Adjustment,and Installation

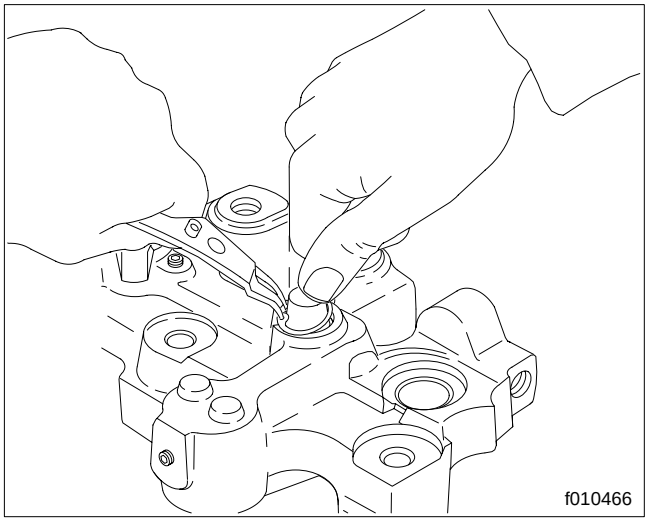


Fig. 22

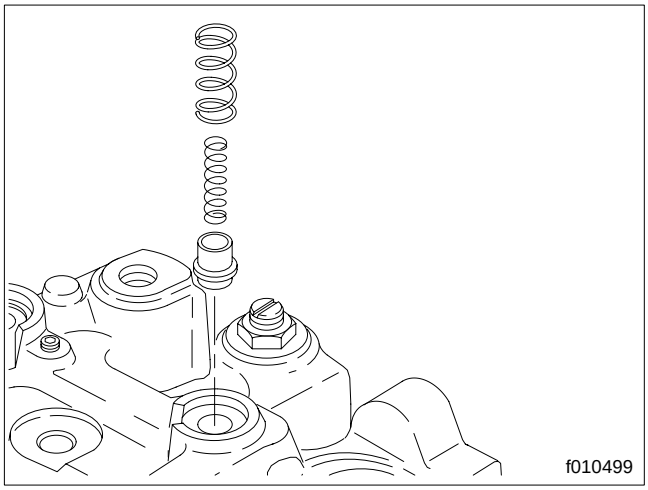


Fig. 23

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

If there is no damage, clean the parts in an approved cleaning solvent.

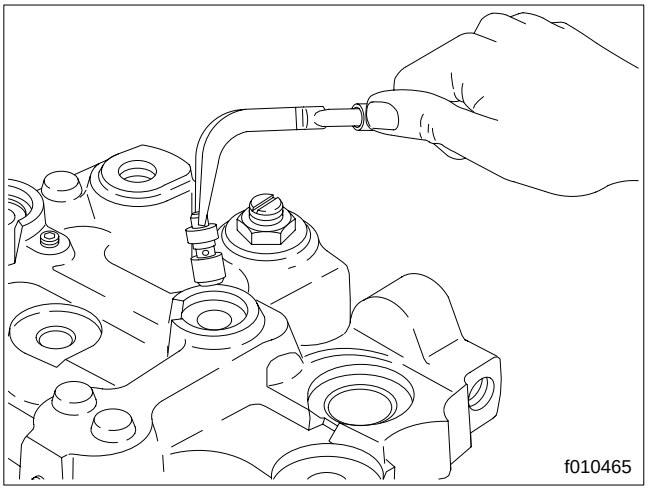


Fig. 24

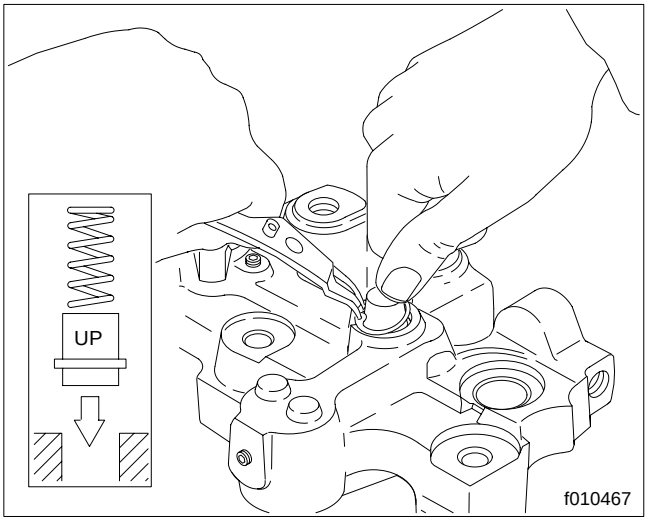


Fig. 25

INSTALLATION

⚠ CAUTION

CAUTION: Make sure the control valve collar is installed with the longer sleeve area up. See Fig. 25 . If the collar is installed upside down, engine damage may result.

1. Install the control valve, collar, and springs. Make sure the retaining ring ears are positioned opposite the oil drain slot in the housing. **See Fig. 25**.

2. Install the rocker housing cover on the spacer. Follow the instructions in the applicable step under "Engine Brake Housing Installation."
3. Return the cab or hood to the operating position.

Solenoid Valve (See Fig. 21)

REMOVAL

1. Tilt the cab or hood. For instructions, refer to the vehicle driver's manual.
2. Wipe the engine brake housing area clean. Remove the rocker housing cover capscrews and the rocker housing cover. **See Fig. 19**.
3. Disconnect the solenoid harness from the solenoid. Using a 7/8-inch socket and extension, remove the solenoid valve. **See Fig. 26**.

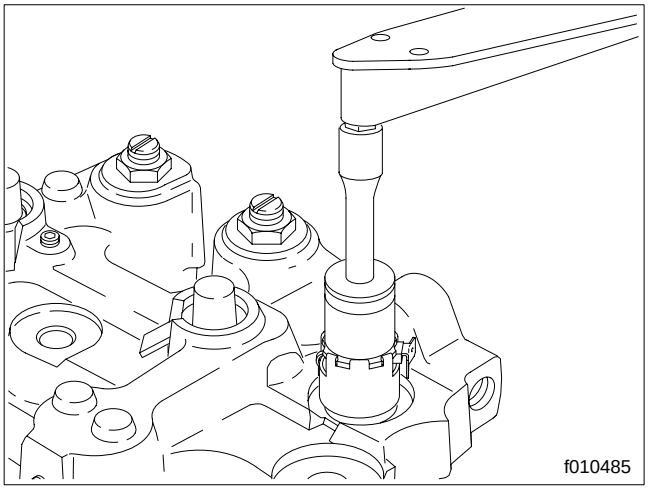


Fig. 26

INSPECTION

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

Inspect the oil filter screen and solenoid valve. **See Fig. 27**. If the screen or solenoid valve is damaged, replace it. If it is not damaged, clean it in an approved cleaning solvent.

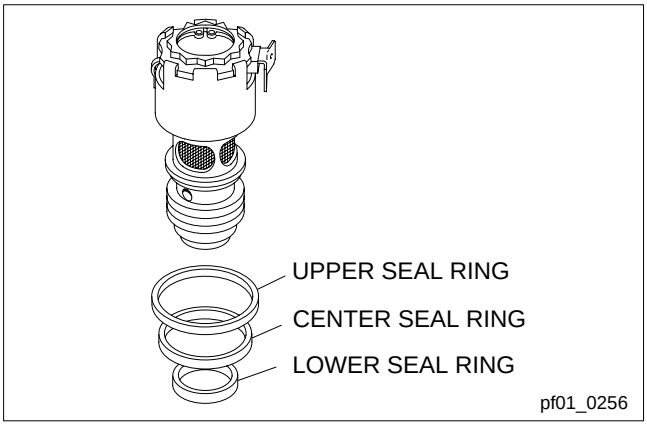


Fig. 27

INSTALLATION

1. Install the solenoid using new seal rings. First, seat the lower seal ring on the bottom surface of the housing bore. Place the upper and center seal rings on the solenoid, and lubricate them with engine oil. **See Fig. 27** for seal locations. When installing the solenoid valve, make sure the seals are seated properly, then gently screw the solenoid into the housing without unseating the seals. **See Fig. 28**. Tighten the solenoid valve 60 lbf·in (680 N·cm).

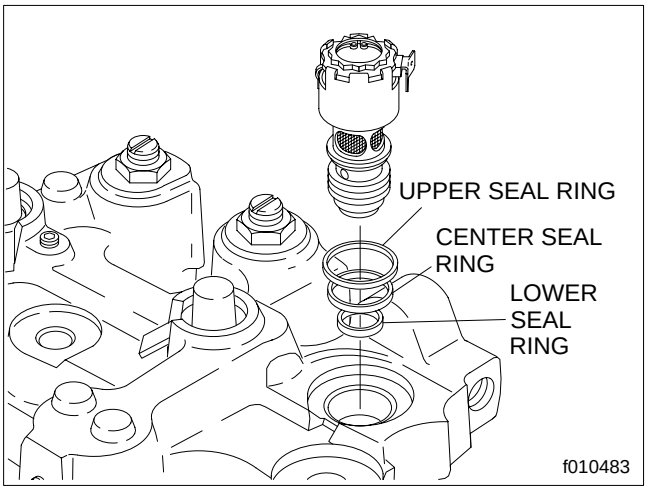


Fig. 28

2. Install the solenoid harness.

3. Install the rocker housing cover on the spacer. Follow the instructions in the applicable step under "Engine Brake Housing Installation."
4. Return the cab or hood to the operating position.

Ball Check Valve (See Fig. 21)

REMOVAL

1. Remove the engine brake housing from the vehicle. For instructions, refer to "Engine Brake Housing Removal."
2. Remove the hex socket pipe plug. **See Fig. 29**. Be careful during final turns to avoid loss of the spring and ball. Remove the spring and ball.

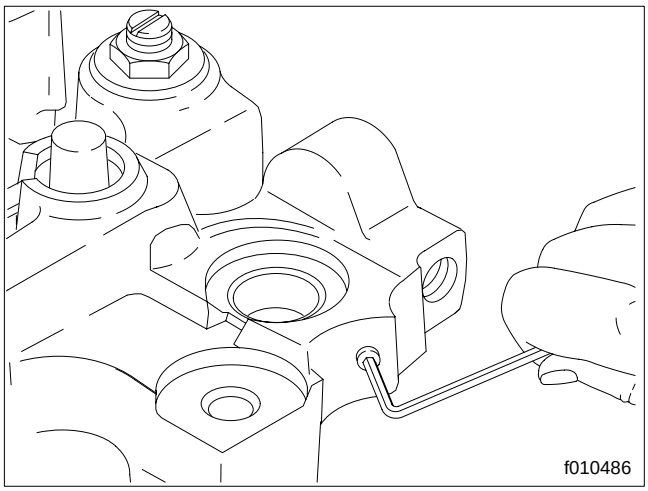


Fig. 29

INSPECTION

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

Inspect the parts for wear, then clean them in an approved cleaning solvent, or replace them if necessary.

1. Assemble the ball check valve by first inserting the ball, then the spring, and then tighten the plug. **See Fig. 30**.

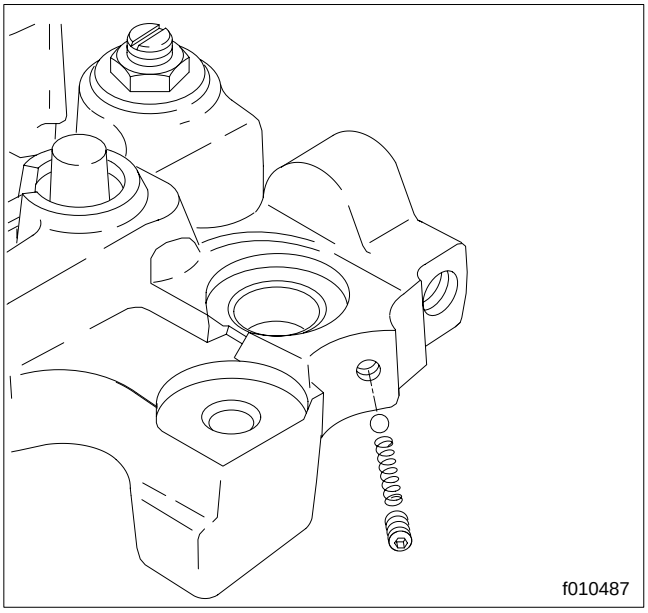


Fig. 30

⚠ CAUTION

CAUTION: Make certain the parts are installed in the order shown in Fig. 30. Improper installation may result in engine damage.

2. Install the engine brake housing using the instructions under "Engine Brake Housing Installation."

Slave Piston (See Fig. 21)

REMOVAL

⚠ WARNING

WARNING: The slave piston is retained by springs that are under heavy compression. If the following instructions are not followed and proper tools are not used, the springs could be discharged with enough force to cause personal injury. Wear safety glasses.

Use the single-valve slave-piston clamp fixture, PN 012359, and the following instructions to remove the slave piston:

1. Remove the engine brake housing from the vehicle using the instructions under "Engine Brake Housing Removal."
2. Remove the locknut on the slave piston adjusting screw. **See Fig. 31** . Back out the adjusting screw until the slave piston is fully retracted (screw is loose).

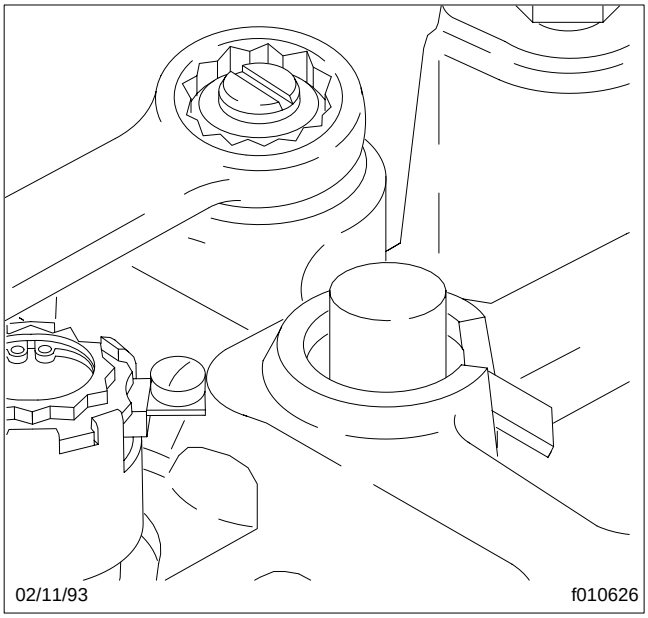


Fig. 31

3. Place the hole in the clamp fixture over the slave piston adjusting screw. **See Fig. 32**. While holding the fixture in position, screw the holder down over the slave piston until the washer is depressed about 0.04 inch (1 mm), so that the retaining ring is loose in the groove. Remove the retaining ring. **See Fig. 33**. Back out the holder and remove the fixture.
4. Remove all slave piston components. **See Fig. 34**.

INSPECTION

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

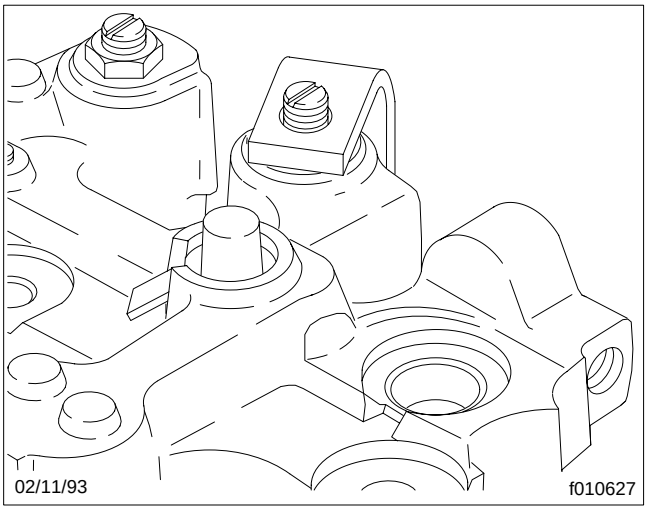


Fig. 32

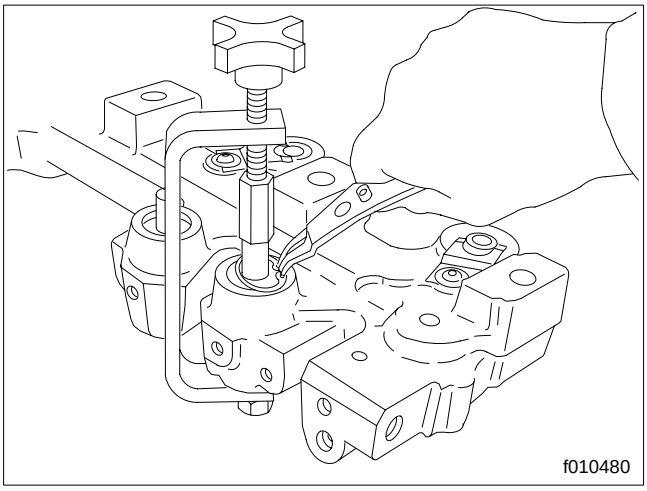


Fig. 33

Check for binding or burrs during removal. Clean the components in an approved cleaning solvent, or replace them if they are damaged. Make sure all components are assembled in the proper order.

INSTALLATION

1. Use the clamp fixture to install the piston and springs. Make sure the retaining ring is placed on the washer before screwing the clamp holder down over the slave piston. **See Fig. 35**.
2. Push the slave piston and springs down until the washer is about 0.04 inch (1 mm) below the retaining ring groove. Install the retaining ring.

Component Removal, Inspection, Adjustment,and Installation

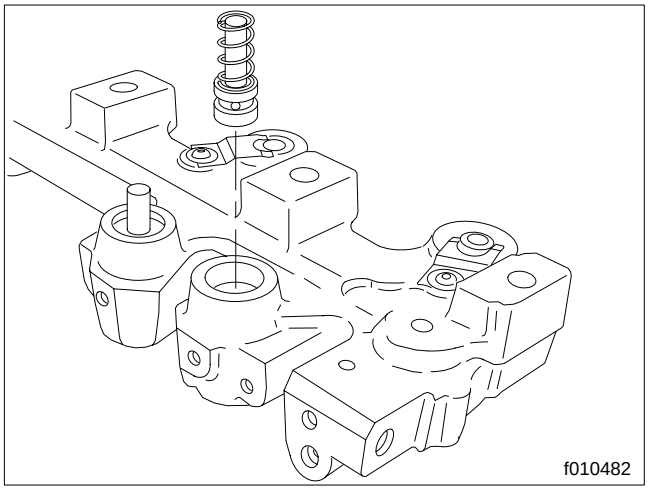


Fig. 34

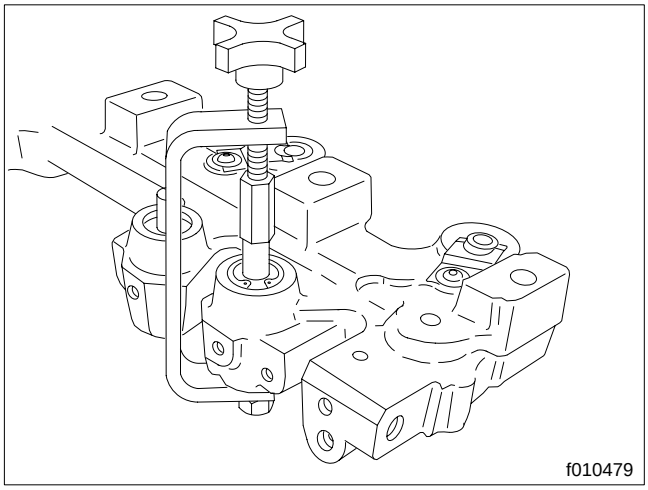


Fig. 35

Make sure the retaining ring is fully seated in the groove. Remove the clamp fixture.

3. Remove, inspect, and install the slave piston adjusting screw using the instructions under "Slave Piston Adjusting Screw Removal, Inspection, and Installation."

Adjustment

When adjusting an engine overhead, the most efficient time to adjust the slave piston lash is after setting the exhaust valves on each cylinder.

IMPORTANT: Slave piston adjustment must be made with the engine stopped and cold. The exhaust valves on the cylinder to be adjusted must be closed.

⚠ CAUTION

CAUTION: To ensure maximum engine brake efficiency, and to prevent engine damage by piston-to-valve contact, follow the instructions carefully.

Adjust the slave piston lash as follows:

1. Insert a 0.015-inch Jacobs feeler gauge between the slave piston and the actuating pin in the crosshead. Turn the adjusting screw until you feel a light drag on the feeler gauge. **See Fig. 36**.

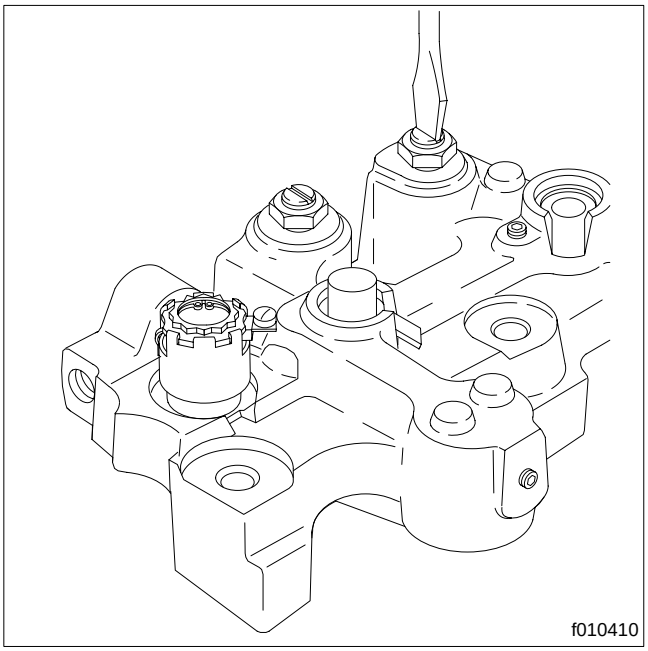


Fig. 36

2. Hold the screw in position with a screwdriver. Using a crowfoot wrench (**Fig. 37**), tighten the locknut 22 lbf·ft (30 N·m).

⚠ CAUTION

CAUTION: Pay special attention to this adjustment. After the slave-piston adjusting-screw lock-

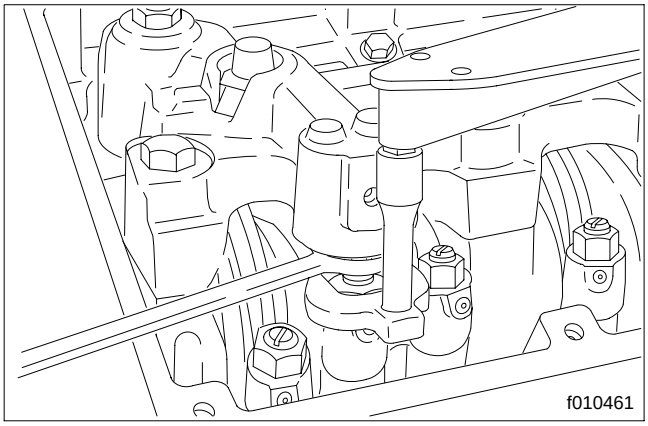


Fig. 37

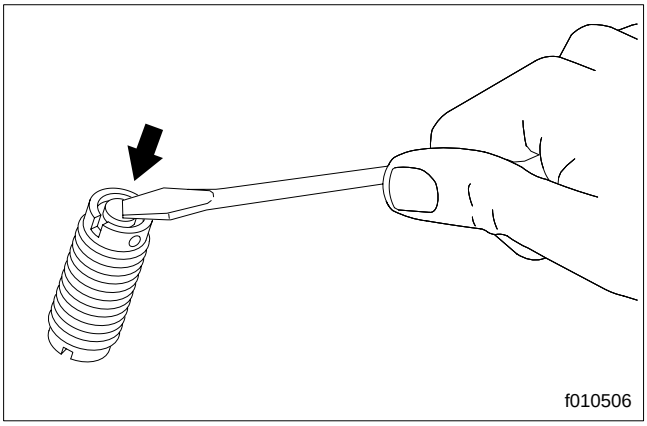


Fig. 38

nut is properly tightened, check the clearance with the Jacobs feeler gauge. Over-tightening Jacobs screws could cause engine damage.

3. Adjust all six slave pistons using this procedure.

Slave Piston Adjusting Screw (See Fig. 21)

REMOVAL

1. Tilt the cab or hood. For instructions, refer to the vehicle driver's manual.
2. Wipe the engine brake housing area clean. Remove the rocker housing cover capscrews and the rocker housing cover. **See Fig. 19**.
3. Loosen the slave piston adjusting screw locknut, and remove the adjusting screw from the housing. **See Fig. 31**.

INSPECTION

1. Inspect the slave piston adjusting screw. The plunger should have light spring pressure apparent when depressed, and should move freely. **See Fig. 38**. Make sure the retaining ring is fully engaged in its groove.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

2. If the screw is damaged, replace it. If the screw is not damaged, clean it in an approved cleaning solvent.

⚠ CAUTION

CAUTION: Don't attempt to adjust or tamper with the adjusting screw. This could result in engine damage.

INSTALLATION

1. Install the adjusting screw and attach the locknut. **See Fig. 31**.
2. If the engine brake housing has been removed from the engine, install the engine brake housing, and adjust the slave piston using the instructions under "Engine Brake Housing Installation" and "Slave Piston Adjustment."

   If the engine brake housing was not removed from the engine, adjust the slave piston using the instructions under "Slave Piston Adjustment." Install the rocker housing cover. Follow the instructions in the applicable step under "Engine Brake Housing Installation."

Component Removal, Inspection, Adjustment,and Installation

Master Piston (See Fig. 21)

REMOVAL

1. Remove the engine brake housing from the vehicle. For instructions, refer to "Engine Brake Housing Removal."
2. Remove the screw, washer, and master piston spring from the bottom of the housing. **See Fig. 39** .

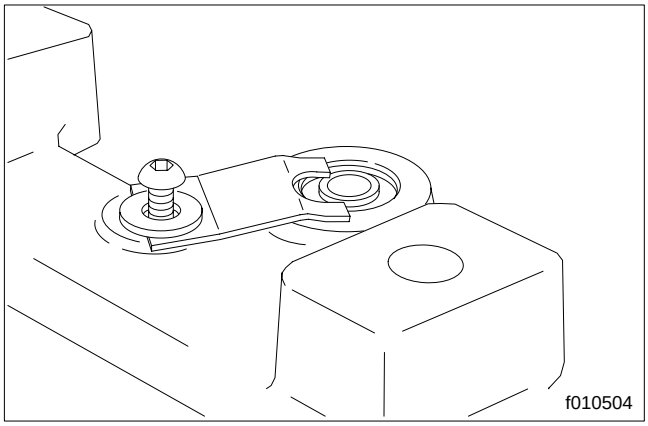


Fig. 39

3. Remove the master piston from its bore; needle-nose pliers are usually needed to initially pull the piston up. **See Fig. 40**.

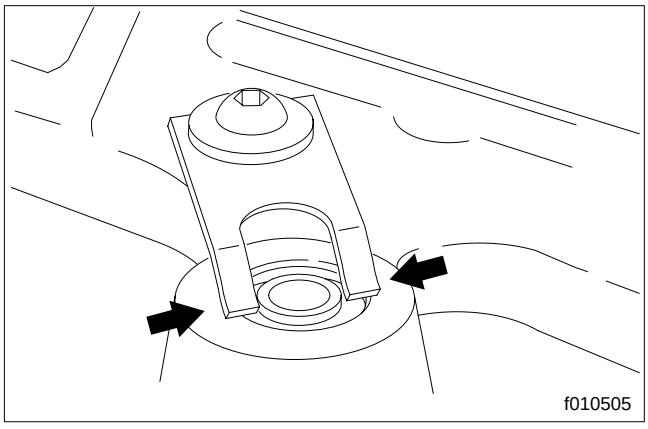


Fig. 40

INSPECTION

WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

If binding occurs during removal, check for burrs, or contaminants in the lube oil. If the piston is damaged, replace it. If the piston is not damaged, clean it in an approved cleaning solvent.

INSTALLATION

1. Install the piston, spring, washer, and screw. Make sure that when tightening the capscrew, the two tabs of the spring do not interfere with the sides of the center raised portion of the master piston. **See Fig. 39**.
2. Install the engine brake housing using the instructions under "Engine Brake Housing Installation."

Torque Values		
Description	**Torque lbf·ft (N·m)**	**Torque lbf·in (N·cm)**
Solenoid Valve	—	60 (680)
Engine Brake Housing Hold-Down Capscrews	95 (129)	—
Slave Piston Adjusting Screw Locknuts	22 (30)	—
Oil Hose Connection Button-Head Screws	10 (14)	—
Oil Connector Screw Locknut	25 (34)	—
Rocker Housing Cover Capscrews	—	130 (1460)

Table 1, Torque Values

General Description and Principles of Operation

Jacobs engine brake housings are installed on the engine rocker housings. Model 430 (used on Cummins 88NT engines) has three engine brake housings that operate two cylinders each. Each engine brake housing has a solenoid valve, control valve, master piston, and slave piston. See **Fig. 1**.

Engine brake controls consist of: two dashmounted toggle switches (**Fig. 2**), a clutch switch mounted under the dash for FLD Conventionals (**Fig. 3**), or under the cab for FLA COEs (**Fig. 4**), and the throttle switch mounted on the engine fuel pump. The switches are wired in series so that all of the switches must be closed to operate the engine brake. The engine brake is activated when one or both of the dash switches is on (up), and the clutch and throttle pedals are released. The dash switches enable the driver to operate the engine brake partially or fully.

Model 430 engine brakes can be operated at one-third, two-thirds, or full capacity (two, four or six cylinders).

When activated, the engine brake converts a power-producing diesel engine to a powerabsorbing air compressor. This is accomplished by motion transfer through a master-slave piston arrangement which opens the engine cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust. The blowdown of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the expansion (power) stroke. This results in a net energy loss because the work done in compressing the cylinder charge is not returned during the expansion process. Exhaust blowdown occurs as follows (refer to **Fig. 5**):

1. Activating the engine brake energizes the solenoid valve, allowing engine oil to flow under pressure through the control valve to both the master piston and the slave piston.
2. Oil pressure causes the master piston to move down, coming to rest on the injector rocker lever adjusting screw.
3. The injector rocker lever adjusting screw begins upward travel (as in the normal injection cycle) forcing the master piston upward and creating a high-pressure oil flow to the slave piston. The ball check valve in the control valve holds the high-pressure oil in the master-slave piston system.
4. When the engine piston is near top dead center, the slave piston moves down under the influence of the high-pressure oil flow. This momentarily opens one of the exhaust valves, releasing compressed cylinder air to the exhaust manifold.
5. Compressed air is released to the atmosphere, completing a compression braking cycle.

General Description and Principles of Operation

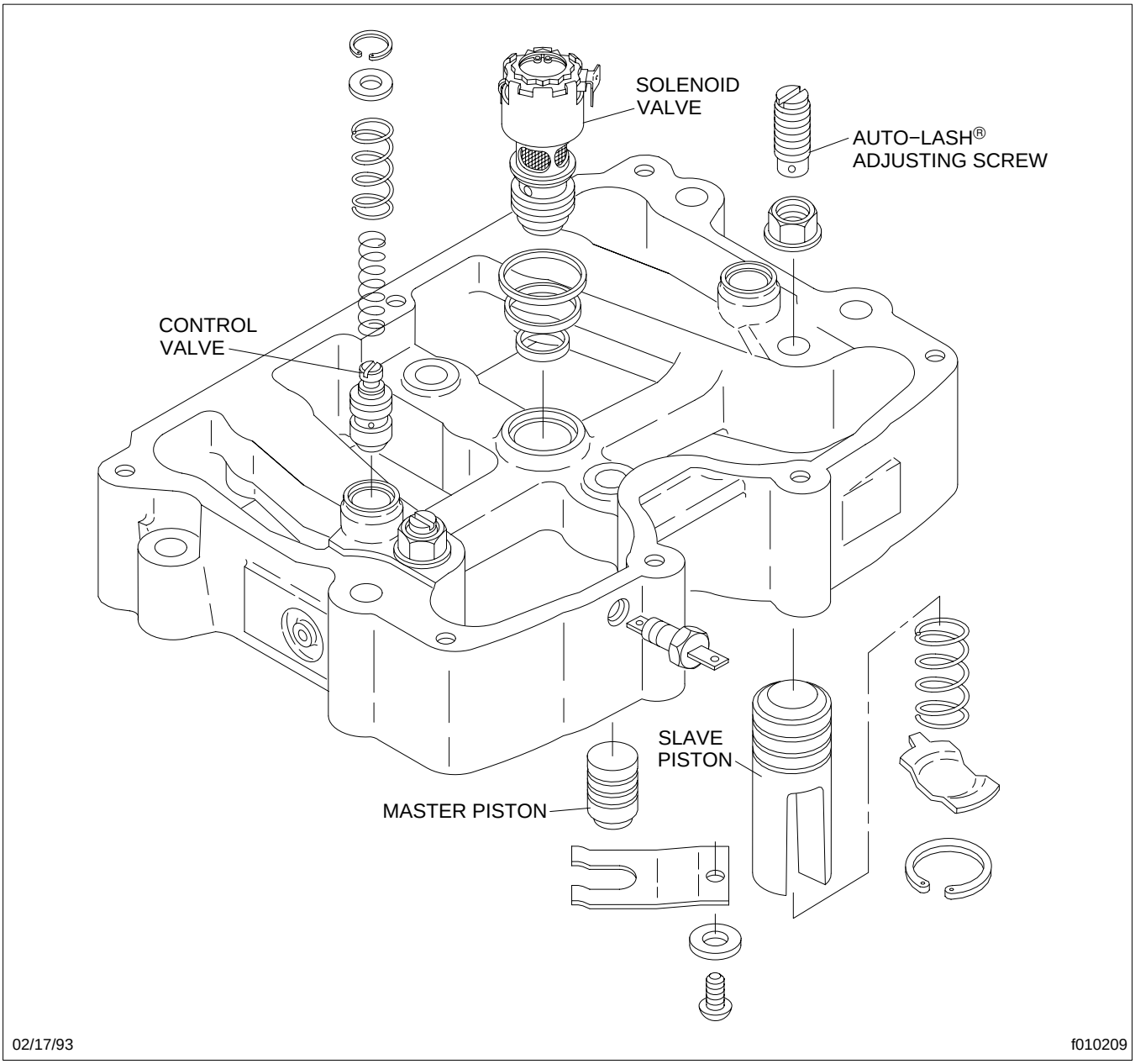


Fig. 1, Jacobs Engine Brake, Model 430

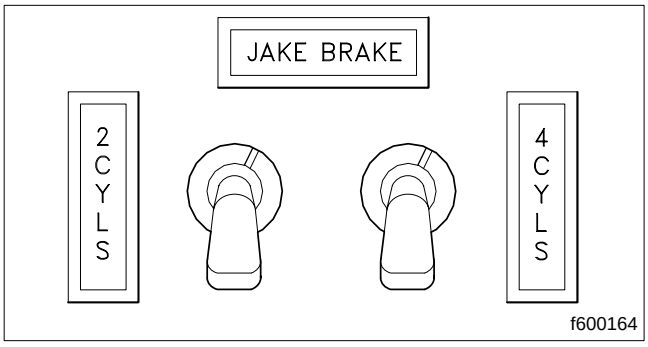
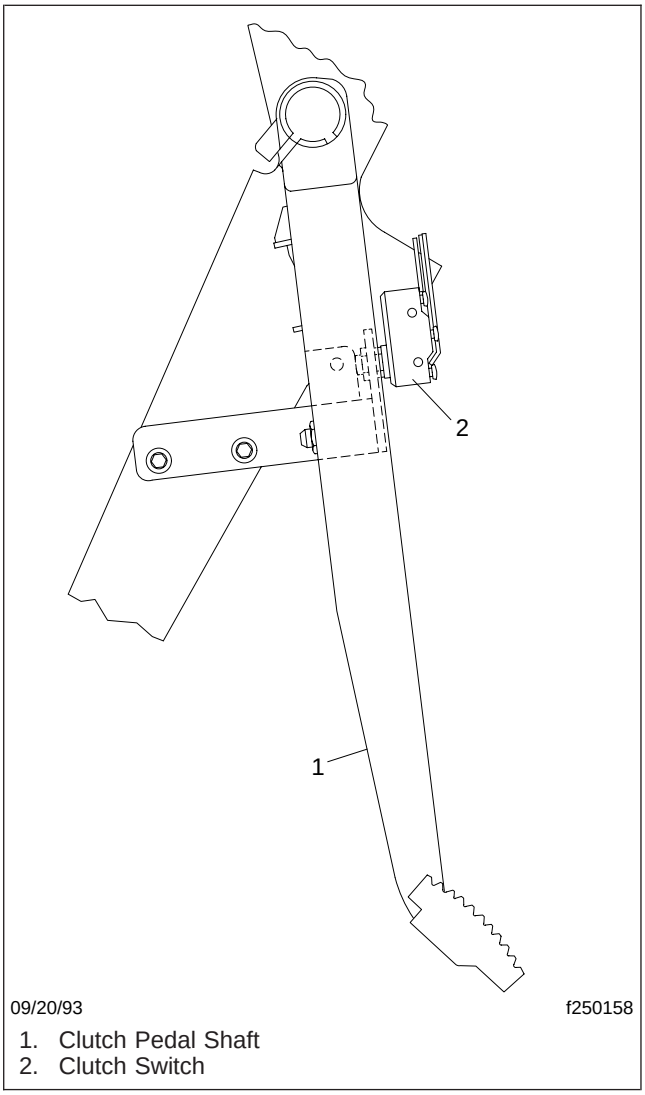


Fig. 2, Engine Brake Dash Switches



1. Clutch Pedal Shaft
2. Clutch Switch

Fig. 3

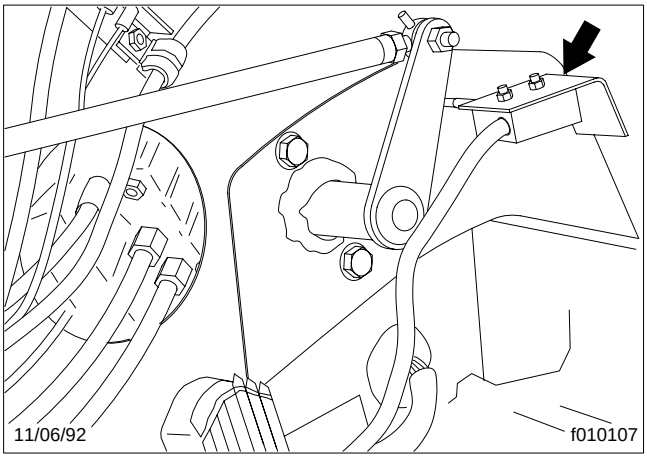


Fig. 4

General Description and Principles of Operation

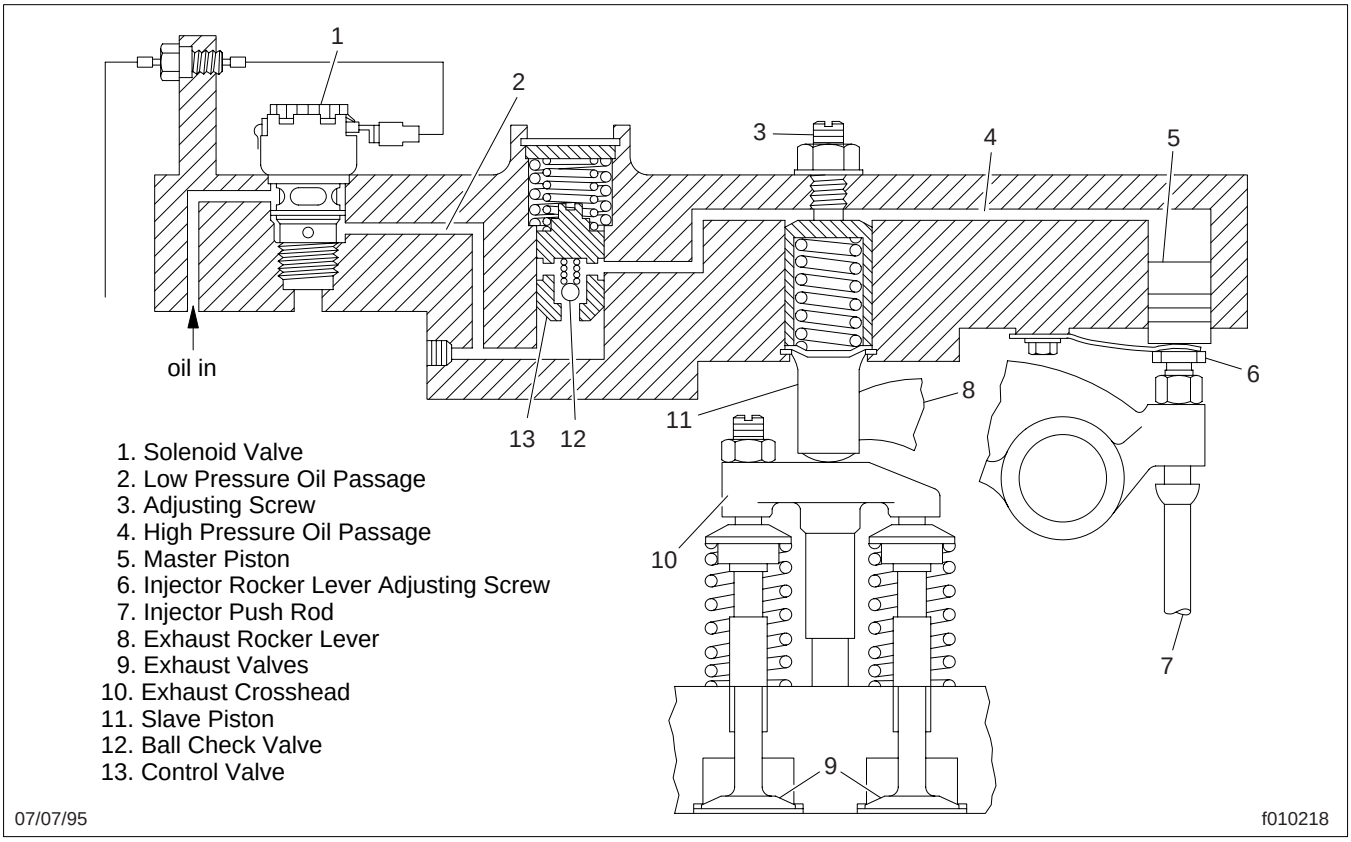


Fig. 5, Schematic Diagram of Engine Brake Operation

Dash Switch Replacement

NOTE: **See Fig. 1** for the engine brake wiring diagram.

1. Park the vehicle and disconnect the battery.
2. Remove the screws that attach the control panel to the dash. Lift the panel to a serviceable level.
3. Remove the switch cap nut, and remove the switch from the panel.
4. Mark the wires for later reference, then disconnect them from the switch.
5. Connect the wires to the new switch, as previously marked.
6. Install the switch through the rear of the panel, and attach it with the cap nut.
7. Place the panel in the dash, and attach it with the screws.
8. Connect the battery.

Throttle Switch Replacement

NOTE: **See Fig. 1** for the engine brake wiring diagram.

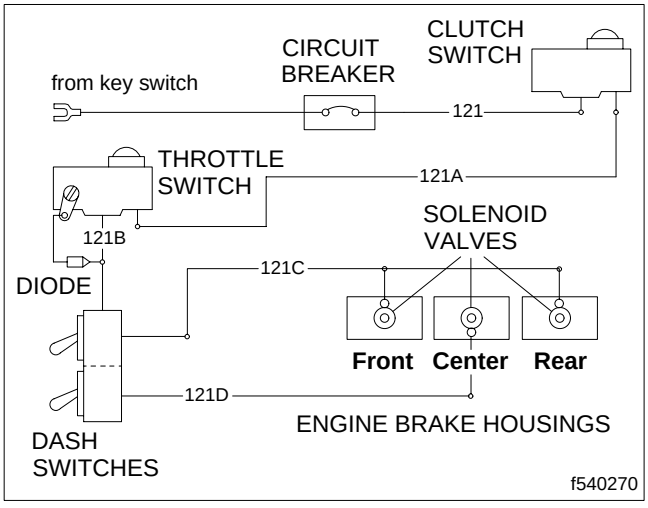


Fig. 1, Wiring Diagram

1. Tilt the cab or hood. For instructions, refer to the vehicle driver's manual.
2. Mark the wires for later reference, and disconnect them from the throttle switch.
3. Remove the screws that attach the throttle switch to the switch bracket on the fuel pump governor housing. Remove the throttle switch.
4. If replacing the actuating arm, remove the nut that attaches the actuating arm to the fuel pump throttle shaft. Remove the actuating arm.
5. Install the switch on the fuel pump governor housing and attach it with the screws.
6. If previously removed, attach the actuating arm to the fuel pump throttle shaft with the nut. The arm may be bent or manipulated to obtain the proper position for switch contact. Adjust the screw in the actuating arm to a point where an audible click is heard when the throttle arm moves to the idle position (throttle pedal released).

IMPORTANT: After installing the actuating arm, check the fuel pump throttle shaft to ensure that the throttle pedal will move the shaft to the full fuel position.

7. Connect the wires to the switch, as previously marked.

IMPORTANT: The throttle switch terminal with the diode must be connected to the load (solenoid valve) side of the circuit. **See Fig. 1** .

8. Return the cab or hood to the operating position.

Clutch Switch Replacement

NOTE: **See Fig. 1** for the engine brake wiring diagram.

1. Apply the parking brakes, and chock the tires.
2. Mark the wires for later reference; disconnect them from the clutch switch at the top of the clutch pedal shaft.
3. Remove the nuts, washers, and screws that attach the switch to the mounting bracket. Remove the switch.
4. Place the new switch on the bracket, and loosely install the screws, washers, and nuts. **See Fig. 2** or **Fig. 3**.

Dash, Throttle, and Clutch Switch Replacement

Adjust the plunger-type switch side to side so that the center of the plunger contacts the center of the clutch lever rib. Add or remove starwashers as shown in **Fig. 4** to adjust the plunger travel.

On the arm-type switch, the switch arm should deflect 1 to 1-1/2 inches (25 to 38 mm) when the clutch is engaged. **See Fig. 2** . Tighten the switch mounting nuts securely.

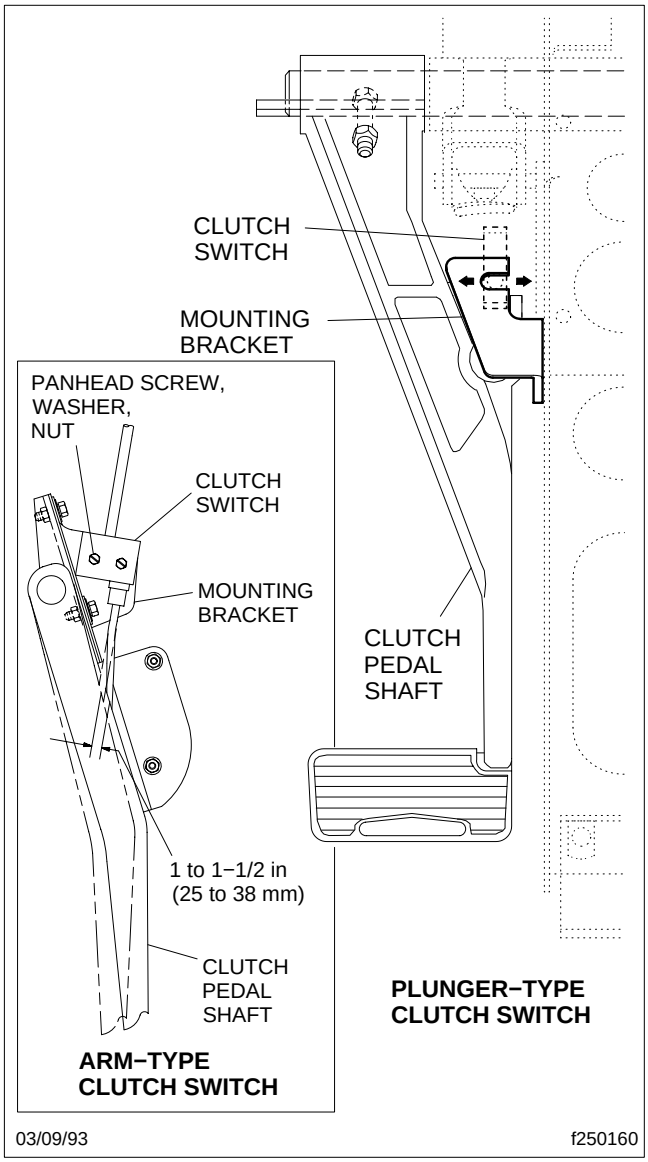


Fig. 2, Clutch Switch Mounting (FLD Conventional shown)

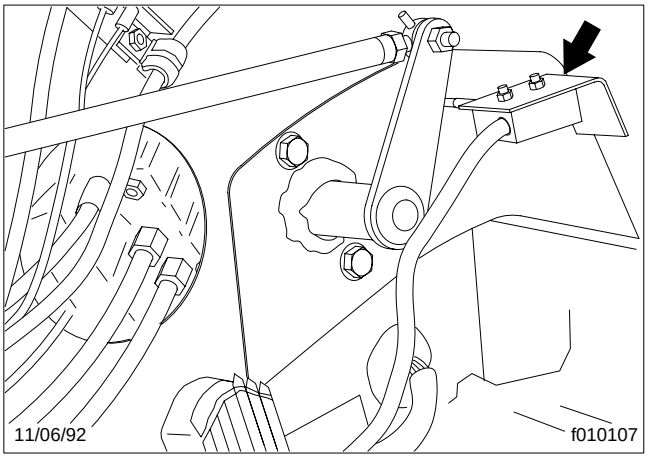
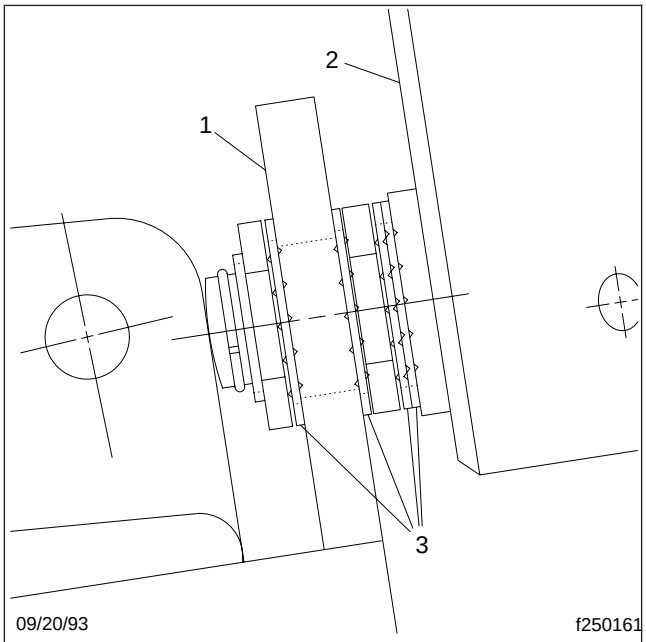


Fig. 3, Clutch Switch Mounting (COE shown)



1. Mounting Bracket
2. Switch
3. Starwashers

Fig. 4

5. Connect the wires to the switch, as previously marked.
6. Remove the chocks from the tires.

Removal

⚠ WARNING

WARNING: To avoid personal injury, never remove any engine brake component with the engine running.

1. Tilt the cab or hood. For instructions, refer to the vehicle driver's manual.
2. Wipe the engine brake housing area clean. Remove the rocker housing cover capscrews; remove the cover and gasket from the housing.
3. Remove the Jacobs holddown nuts.
4. Remove the engine brake housing.

Installation

1. Check the rocker housing surface to make sure it is clean and smooth. Install a Jacobs gasket on the rocker housing. **See Fig. 1**. Make sure the slot for the oil supply aligns with the slot in the rocker housing. If it doesn't, turn the gasket over.
2. Before placing the brake units on the engine, loosen and back out the slave piston adjusting screw until the slave piston is seated in its bore. **See Fig. 2**.

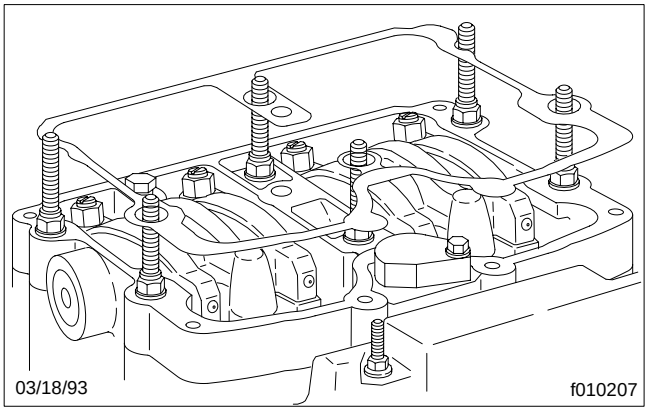


Fig. 1

3. Install the engine brake units on the engine. Units must go into place without rocker lever interference. **See Fig. 3**.
4. Install Jacobs spacers and Cummins brackets on the studs from which they were removed. **See Fig. 4**.
5. Install the Jacobs holddown nuts. **See Fig. 5**. Tighten them 30 lbf·ft (40 N·m) in the sequence shown in **Fig. 6**. Then, tighten them 60 lbf·ft (80 N·m) in the same sequence.

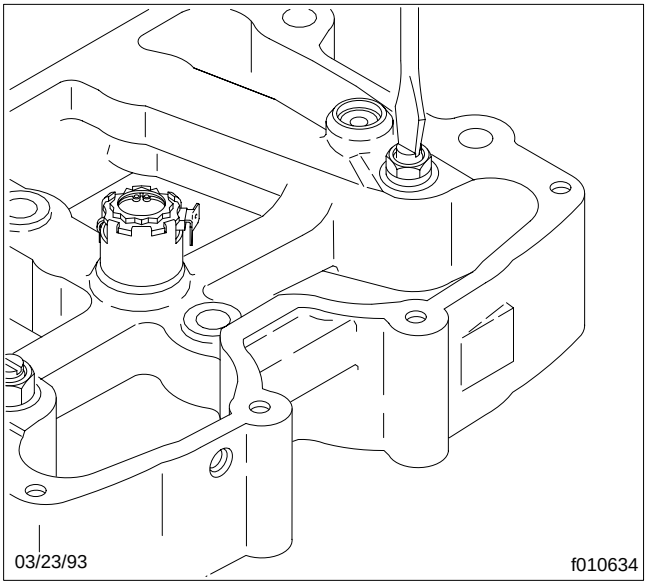


Fig. 2

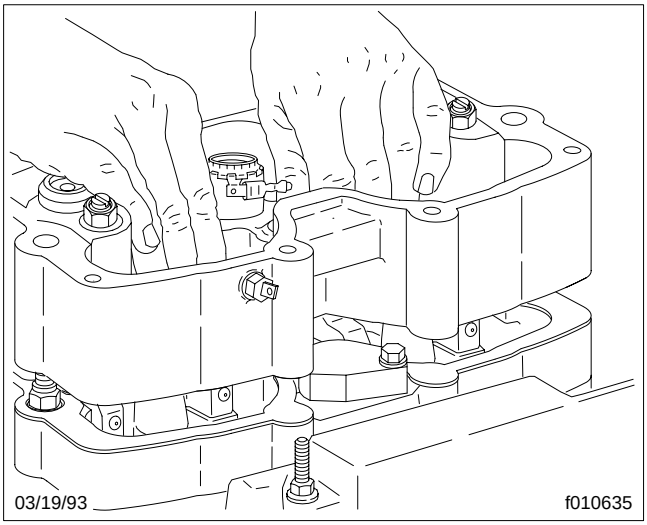


Fig. 3

Engine Brake Housing Removal and Installation

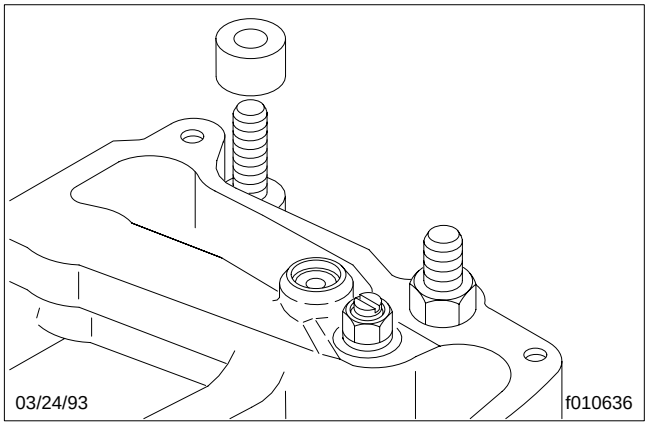


Fig. 4

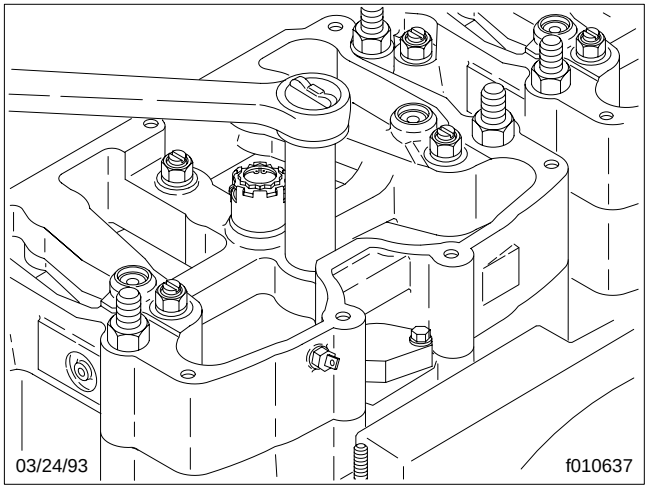


Fig. 5

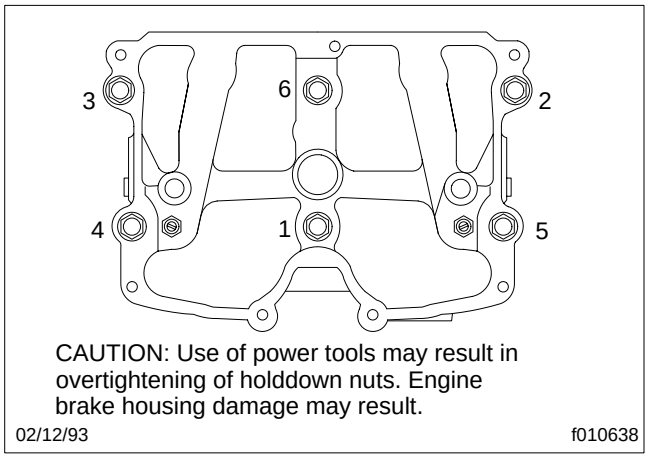


Fig. 6

⚠ CAUTION

CAUTION: Do not use power tools to tighten the holddown nuts. This could cause the nuts to be overtightened, possibly resulting in engine brake housing damage.

6. If installing a new engine brake housing, or if the slave piston was removed, adjust the slave piston using the instructions under **Subject 140.** If the adjusting screw was loosened in an earlier step, adjust it.

NOTE: On engines with step timing control (STC) connect the oil line to the elbow fitting at the rear engine brake housing and to the STC valve located on the fuel pump side of the engine.

7. Install the gasket and the rocker housing cover.
8. Install the capscrews and tighten them 15 lbf·ft (20 N·m).

Control Valve Removal, Inspection, and Installation

Removal

1. Tilt the cab or hood. For instructions, refer to the vehicle driver's manual.
2. Wipe the engine brake housing area clean. Remove the capscrews from the rocker housing cover; then, remove the rocker housing cover.
3. Press down on the control valve cover to relieve the spring pressure. Using retaining ring pliers, remove the retaining ring. **See Fig. 1** .

IMPORTANT: The control valve covers are under load from the control valve springs. Remove them carefully to avoid personal injury.

4. Slowly remove the cover until it is no longer under spring pressure. Then, remove the two control valve springs. **See Fig. 2**.
5. Using needle-nose pliers, reach into the bore and grasp the stem of the control valve. Pull the valve straight up and out of its bore. **See Fig. 3**.

Inspection

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

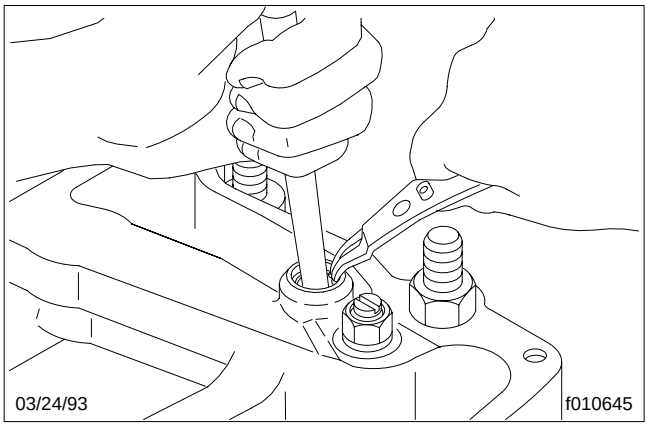


Fig. 1

1. Wash the control valves with approved cleaning solvent.
2. Push a wire through the hole in the base of the valve to make sure that the ball check is free. The ball should lift with light pressure on the wire.

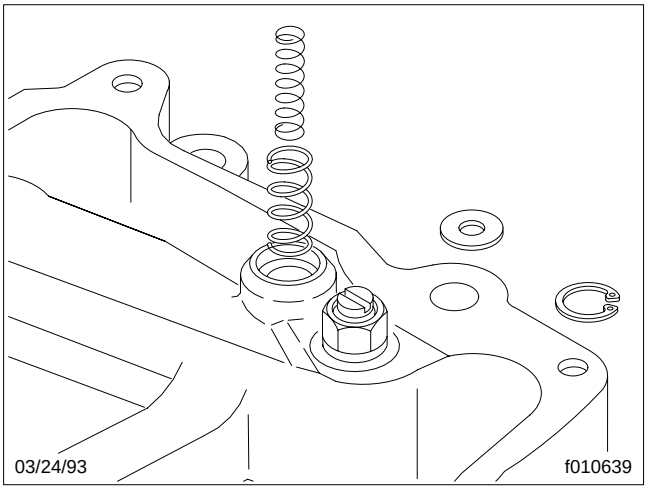


Fig. 2

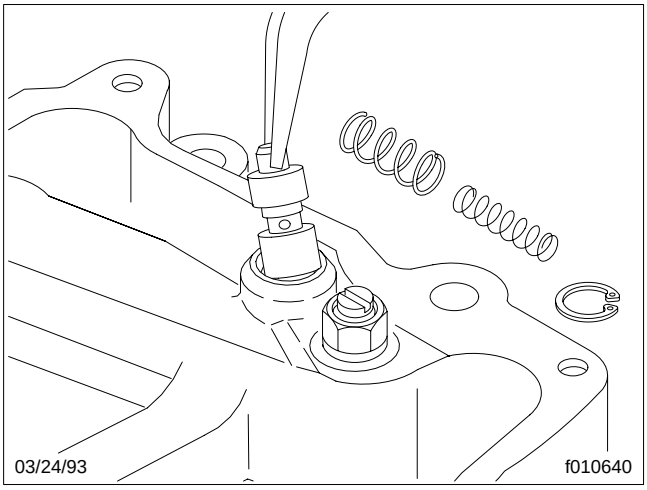


Fig. 3

3. Dry the valve with compressed air and wipe it clean with a paper towel.
4. Using clean paper towels, thoroughly clean the control valve bore in the housing.
5. Dip the control valves in clean engine oil. Holding the valve by the stem, let the valve drop into its bore. If it binds or if the ball is stuck in the valve, replace the control valve.

Control Valve Removal, Inspection, and Installation

Installation

1. Install the control valve and the two springs as shown in **Fig. 4**

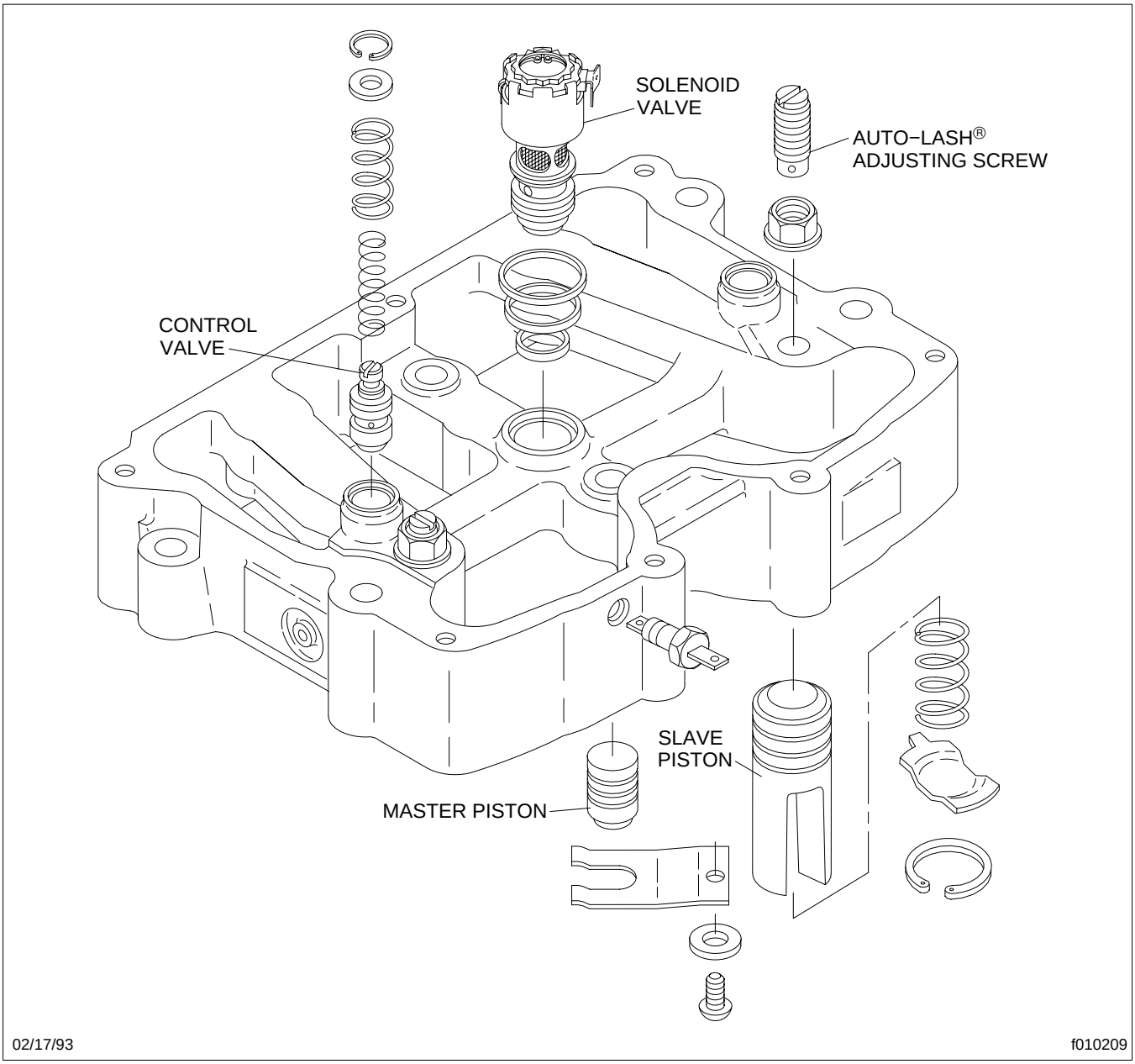


Fig. 4

2. Install the control valve cover. While pressing down on the cover, install the retaining ring in the housing. Then, install the gasket and the rocker housing cover, and insert the capscrews and tighten to 15 lbf·ft (20 N·m).

Solenoid Valve Removal, Inspection, and Installation

Removal

1. Disconnect the solenoid harness.
2. Using a 7/8-inch socket and extension, unscrew the solenoid valve. **See Fig. 1**.

⚠ CAUTION

CAUTION: Do not disassemble or tamper with the solenoid valve. Engine damage could result.

3. Remove and discard the three rubber seal rings. **See Fig. 2**. If the lower ring stays in the bottom of the solenoid bore in the housing, remove it with a piece of wire.

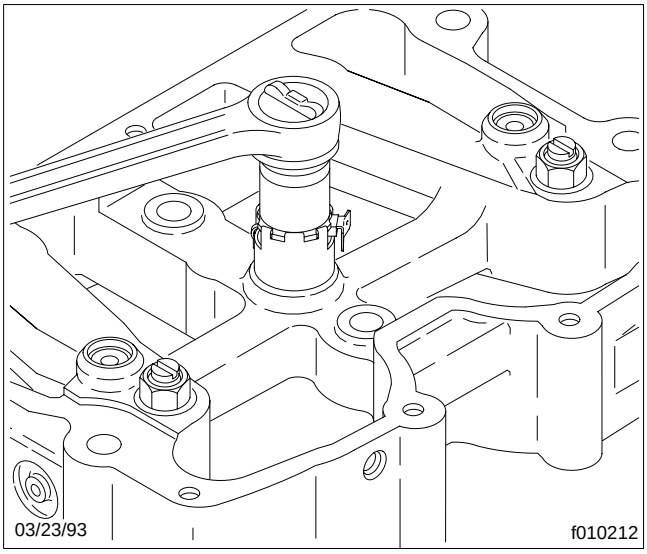


Fig. 1

Inspection

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Wash out the solenoid valve with approved cleaning solvent. Use a brush to clean the oil screen.
2. Dry the solenoid valve with compressed air.
3. Using clean paper towels, clean out the solenoid valve bore in the housing. Do not use rags, since they can leave lint and residue, which can plug the oil passageways.

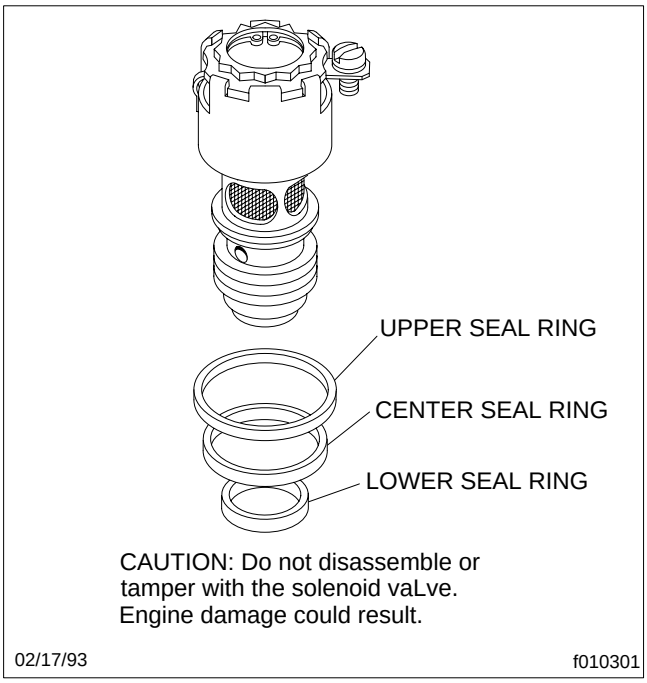


Fig. 2

Installation

1. Coat a new set of solenoid seal rings with clean lubricating oil. Install the upper and middle seal rings on the solenoid body and the lower seal ring into the bottom of the solenoid bore in the housing. **See Fig. 3**.
2. Make sure the seals are seated properly and not twisted. Carefully screw the solenoid into the housing without unseating the seals.
3. Tighten the valve 60 lbf·in (680 N·cm).
4. Connect the solenoid harness.

Solenoid Valve Removal, Inspection, and Installation

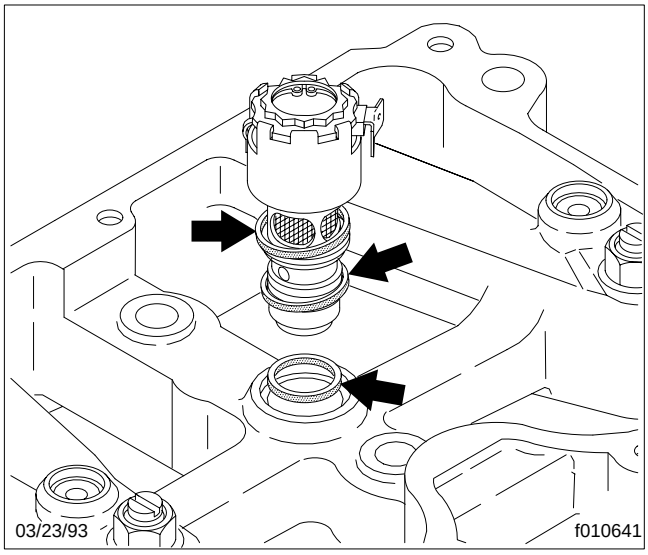


Fig. 3

Slave Piston Removal, Inspection, Installation, and Adjusting

Removal

⚠ WARNING

WARNING: The slave piston is retained by springs that are under heavy compression. If the following instructions are not followed and proper tools are not used, the springs could be discharged with enough force to cause personal injury. Wear safety glasses and remove the slave piston carefully.

NOTE: Use slave piston clamp fixture PN 012398 and the following procedure to remove the slave piston:

1. Remove the engine brake housing from the vehicle using the instructions in **Subject 110.**
2. Remove the locknut from the slave piston adjusting screw. Back out the adjusting screw until the slave piston is fully retracted (the screw is loose). **See Fig. 1**.
3. Place the clamp fixture hole over the slave piston adjusting screw. **See Fig. 2**. Install the locknut and tighten it snug to hold the fixture securely.
4. While holding the fixture in position, screw the holder down over the slave piston until the retainer is contacted.

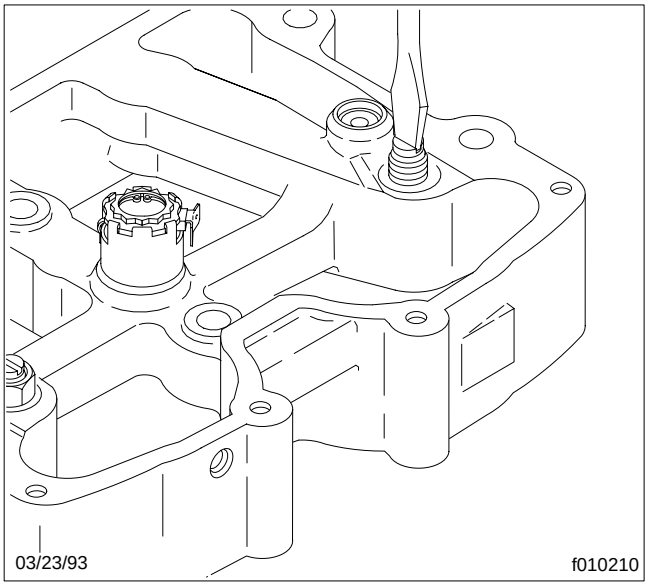


Fig. 1

5. Turn the handle slowly until the retainer is depressed about 0.04 inch (1 mm), relieving pressure against the retaining ring.
6. Using retaining ring pliers, remove the retaining ring. **See Fig. 3**. Back out the holder until the springs are loose. Remove the fixture.

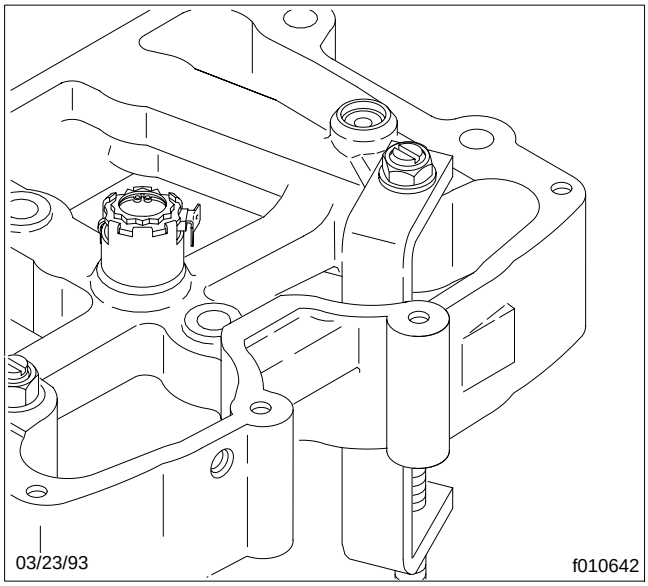


Fig. 2

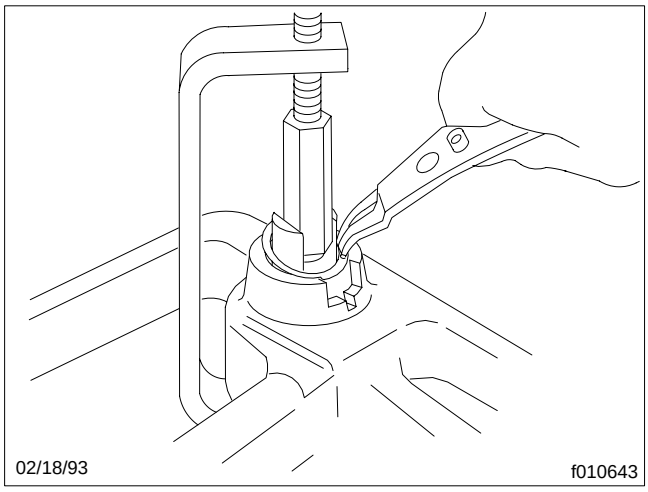


Fig. 3

7. Remove all slave piston components. **See Fig. 4**.

Slave Piston Removal, Inspection, Installation, and Adjusting

Inspection

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Clean the components in a solvent that meets OSHA guidelines.
2. Make sure there are no burrs or binding.
3. Replace any damaged components.

Installation

1. Using the slave piston clamp fixture, install the piston and springs. Make sure the retaining ring is placed on the retainer before screwing the clamp holder down over the slave piston. **See Fig. 5**.
2. Compress the slave piston and springs until the retainer is about 0.04 inch (1 mm) below the retaining ring groove. Install the retaining ring. Be sure the retaining ring is fully seated in the groove.
3. Remove the clamp fixture slowly to ensure proper seating of the retaining ring.

⚠ CAUTION

CAUTION: Do not leave the open portion of the retaining ring aligned with the opening in the housing. This can allow the spring retainer to work loose when the engine brake is operating. Serious engine damage will result.

4. Install the engine brake housing on the engine using the instructions in **Subject 110.**

Adjusting

⚠ CAUTION

CAUTION: Use only the following adjusting procedure. Any other method of adjusting the slave piston clearance is not authorized by Jacobs and may result in serious engine or engine brake damage.

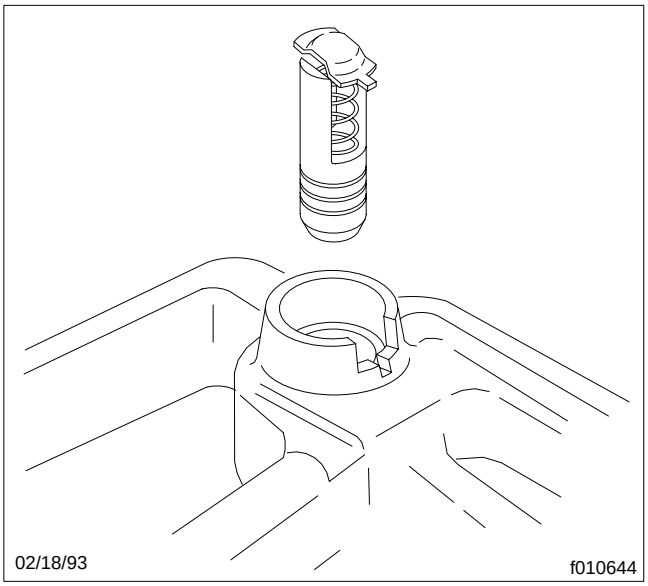


Fig. 4

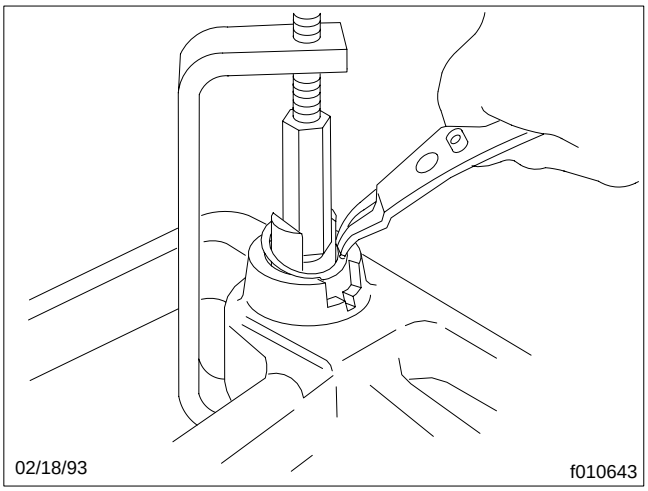


Fig. 5

1. Back out the adjusting screw on the cylinder with the exhaust valves closed and insert the correct Jacobs feeler gauge between the slave piston and crosshead. **See Fig. 6**. Be sure to use the correct gauge for your application. Refer to the table on clearance settings **in "Specifications, 400."**

Slave Piston Removal, Inspection, Installation, and Adjusting

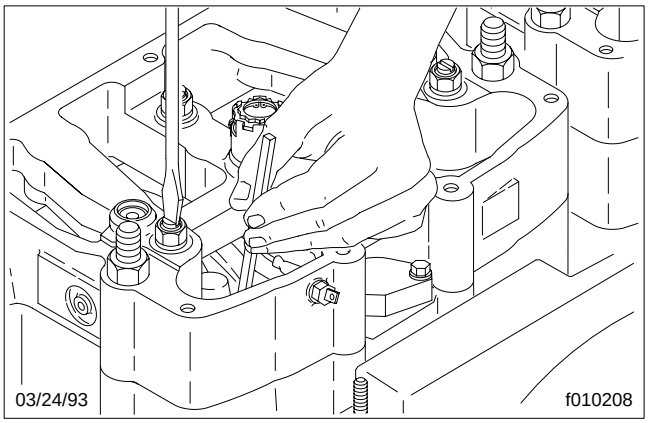


Fig. 6

2. Turn the adjusting screw in, until a light drag is felt on the feeler gauge. **See Fig. 7**.
3. Tighten the locknut 25 lbf·ft (35 N·m). **See Fig. 8**.

NOTE: If a crowfoot wrench is used, tighten the locknut 22 lbf·ft (30 N·m).

4. Continue turning the engine in the normal direction of rotation and set the slave piston clearance on the remaining cylinders in the firing order sequence.

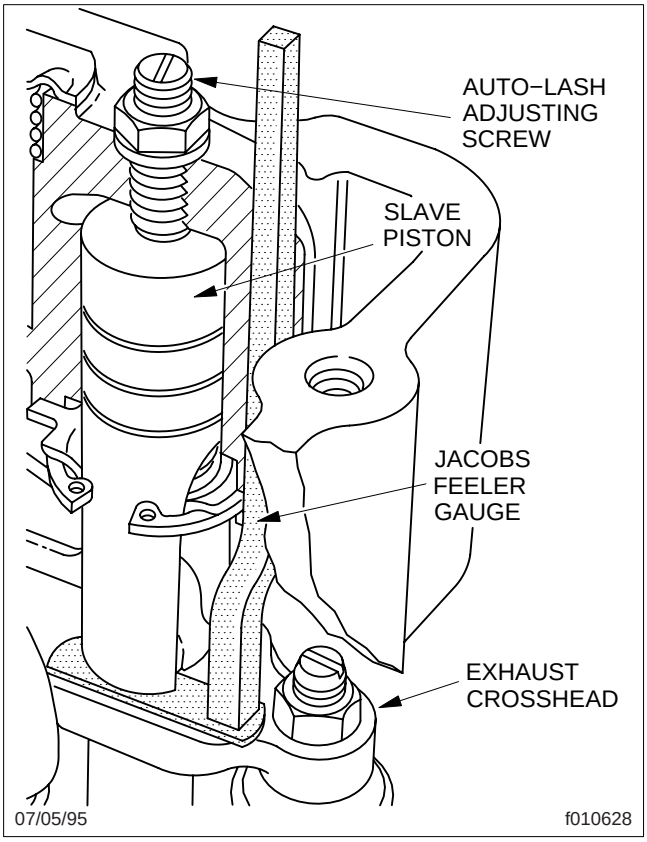


Fig. 7

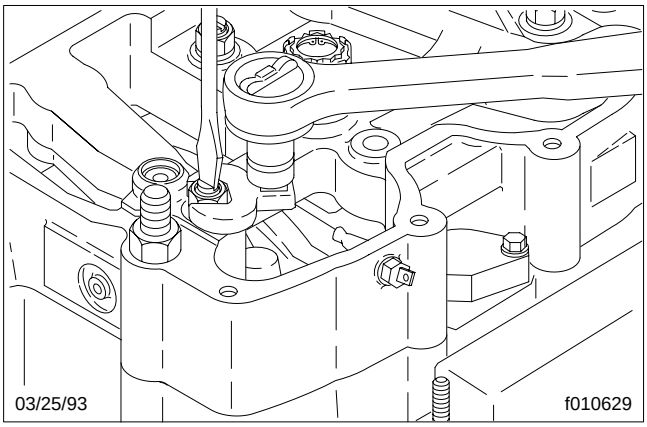


Fig. 8

Slave Piston Adjusting Screw Removal, Inspection,and Installation

Removal

Loosen the slave piston adjusting screw locknut and remove the adjusting screw from the housing. **See Fig. 1**.

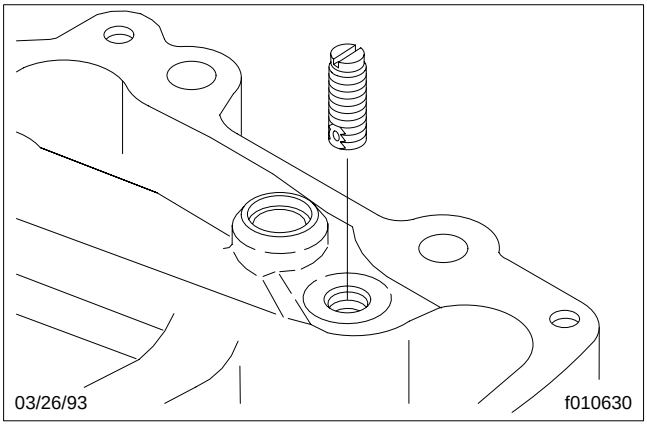


Fig. 1

Inspection

1. Inspect the slave piston adjusting screw. The plunger should protrude from the bottom of the screw. **See Fig. 2**. Approximately 12 lbs force (53 N) is required to move the plunger. Make sure the retaining pin is fully engaged in its groove.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

2. Clean the adjusting screw in an approved cleaning solvent, or replace the entire screw, as necessary. The screw assembly is not serviceable in the field.

⚠ CAUTION

CAUTION: Do not disassemble or tamper with the slave piston adjusting screw assembly. Engine damage could result.

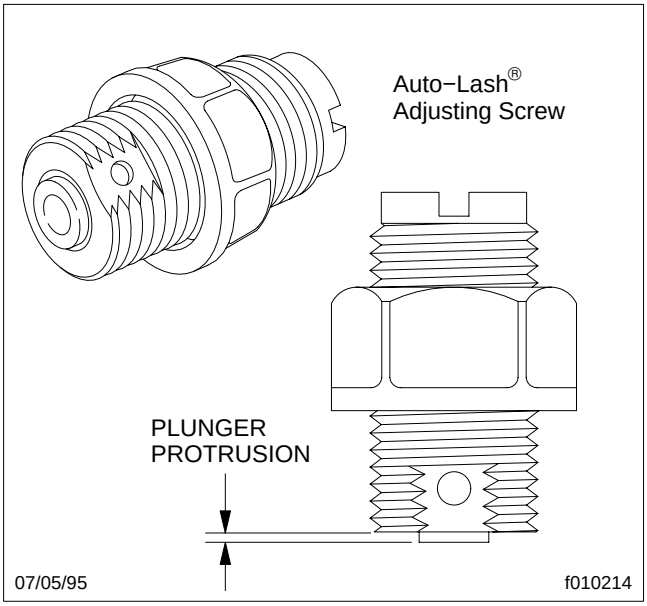


Fig. 2

Installation

1. Screw the slave piston adjusting screw into the housing.
2. Adjust it following the procedure in **Subject 140.**

Master Piston Removal, Inspection, and Installation

Removal

1. Remove the engine brake housing from the vehicle. For instructions, refer to **Subject 110.**
2. Remove the capscrew, washer, and master piston spring from the bottom of the housing. **See Fig. 1**.
3. Remove the master piston from its bore using needle nose pliers to pull the piston out if necessary. **See Fig. 2**. If the piston binds, check for burrs or contaminants in the oil.

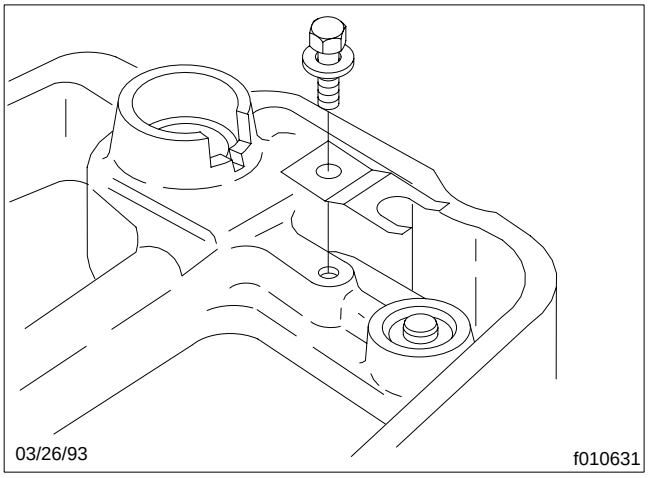


Fig. 1

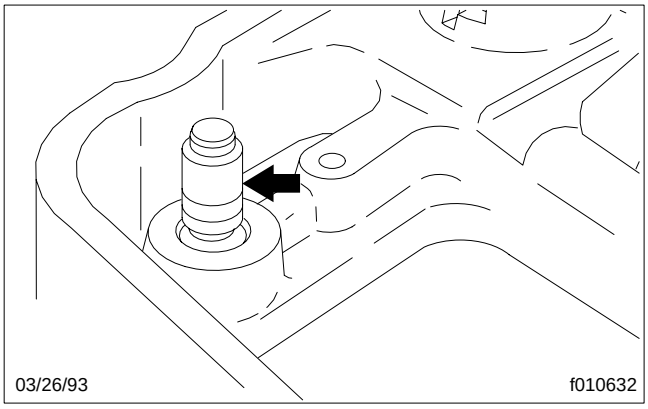


Fig. 2

Inspection

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Clean the master piston in a solvent that meets OSHA guidelines.
2. Inspect the hard face surface. Pitted, chipped, cracked, or galled pistons should be replaced.
3. If the hard facing is damaged, inspect the corresponding rocker arm adjusting screws for excessive wear or pitting. Replace any damaged components.

Installation

1. Assemble the parts in reverse order.
2. Tighten the capscrew 15 lbf·ft (20 N·m). Make sure the two spring tabs do not interfere with the sides of the master piston central raised area. **See Fig. 3**.

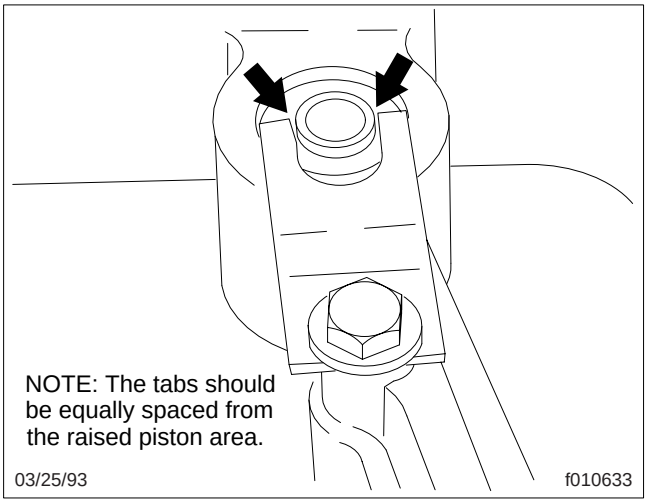


Fig. 3

Checking the Engine Brake Housing Oil Pressure

To properly troubleshoot the engine brake, the mechanic must know the supply oil pressure reading at the engine brake housing. The oil pressure reading on the instrument panel gauge is not the same as at the engine brake housings.

1. Make an oil pressure gauge adapter as follows:
   - 1.1 Remove the metal cap from a used solenoid valve and press off the coil assembly.
   - 1.2 Using a hex wrench, remove the bottom screw. Remove the internal components from the valve, oil screen, and retainer.
   - 1.3 Fill the four small holes directly below the center O-ring with steel rod and braze them. Install the bottom screw and braze closed the hex hole and surrounding screw area. Flats can be ground in the sides of the valve so it can be tightened with a wrench.
   - 1.4 Clean the valve body and wire brush the hole in the top of the body. A gauge with a range of 0 to 100 psi (0 to 689 kPa) will generally require a 1/8 NPT tap.
   - 1.5 Install a hose in the adapter and install the pressure gauge on the hose.
2. Using a 7/8-inch 12-point socket (or Jacobs wrench 11494 on older-style solenoid valves), remove the valve from the housing being checked.
3. Insert the oil pressure gauge (from earlier step) into the solenoid bore. The three solenoid seal rings must be used on the solenoid adapter.
4. Start the engine and allow it to warm up.
5. Record the oil pressure readings at low idle speed.
6. Increase the engine speed to 1000 rpm. Record the pressure.
7. Increase the engine speed to 1500 rpm. Record the pressure.
8. Increase the engine speed to high idle speed and record the pressure.
9. Allow the engine to return to low idle speed.
10. Repeat the oil pressure checks in all the housings equipped with solenoid valves.
11. Shut down the engine. Remove the control valve covers and make sure the correct control valve springs are used.
12. The full-flow oil pressure range for the model 430 is 15 to 80 psi (103 to 551 kPa). An overpressure of 90 psi (621 kPa) can cause engine brake malfunction. If the engine is not within specifications, it should be examined by an authorized facility and repaired if necessary.

Troubleshooting Chart

Problem—Engine Will Not Start

Possible Cause	Remedy
The solenoid valve is stuck in the "on" position.	Make sure the electrical current to the engine brake is off. If the solenoid valve stays "on" (cap down) with the current off, replace the solenoid valve.

Problem—Engine Brake Will Not Function

Possible Cause	Remedy
A circuit breaker is tripped.	Look for a short circuit in the wiring. Replace any chafed wires. Check the solenoid tab for signs of shorting; replace it if needed. Reset the circuit breaker.
An electrical lead is open.	Replace any broken wires.
The dash switches, the clutch switch, or the throttle switch is malfunctioning or out of adjustment.	**⚠ WARNING** **WARNING: Do not touch the electrical connections when the engine brake system is energized. Touching the connections could possibly cause electrical shock.** Use a volt/ohmmeter to make sure there is electrical current at both terminals of each switch. Adjust the switch if needed. If voltage will not pass through the switch, replace it.
The engine oil pressure is too low.	Determine the oil pressure at the engine brakes. **Refer to Subject 170.** If the oil pressure is below specifications, repair the engine following the manufacturer's procedures.

Problem—Engine Brake Engages With the Switches Off

Possible Cause	Remedy
The solenoid valve center seal ring is damaged.	Remove the solenoid. Replace the center seal ring.
The engine brake is incorrectly wired.	Check the wiring against the Jacobs wiring diagram.

Problem—Engine Brake Weak or Slow to Engage

Possible Cause	Remedy
The lubricating oil is too cold and thick.	Allow the engine to warm up before operating the Jake Brake.

Troubleshooting

Possible Cause	Remedy
The slave piston is adjusted incorrectly or is binding in its bore.	**⚠ WARNING** **WARNING: Slave piston springs are under heavy compression. Remove the slave piston carefully when disassembly is necessary. Use either an arbor press or C-clamp. Failure to follow this procedure could result in personal injury.** Adjust the slave piston. Make sure it responds smoothly to the adjusting screw—loosen the jam nut and screw the adjusting screw through its full range for full slave piston travel. Make sure the piston travels the full range without binding or sticking.
The solenoid lower seal is damaged, allowing oil to escape the housing.	Remove the solenoid valve and replace the lower seal ring.
The solenoid screen is clogged, stopping the supply of oil to the engine brake.	Remove the solenoid valve; clean or replace the screen.
The master piston is not moving in its bore.	Inspect the master piston and bore for scoring or burrs. If any are present, clean the surface with crocus cloth. If the burrs cannot be removed, replace the piston or housing. Inspect the lubricating oil for signs of contaminates. If any are present, replace the oil and filters, and correct the cause of the contamination.
The control valves are binding in the housing bores.	Remove each control valve. If the body is scored, replace the valve. Check for contaminants in the lubricating oil. Clean the housing and control valve. If it still binds, replace the housing.
The control valves are malfunctioning.	**⚠ WARNING** **WARNING: To prevent skin irritation, wear chemical resistant gloves when working with diesel fuel or kerosene. Also, do not expose these fluids to flames or heat exceeding 100°F (38°C); both are combustible, and could cause personal injury if ignited.** Remove each control valve. Make sure the check ball is seating in the bore and that it can be moved off the seat. Make sure there is spring pressure against the ball. Flush the valve in diesel fuel. Replace the control valve if needed.
Dash switches, clutch switch, or throttle switch has sluggish operation.	Adjust or replace the switch. Check the throttle or clutch return springs for proper operation.

Possible Cause	Remedy
The electrical insulation of the solenoid valve is breaking down.	**⚠ WARNING** **WARNING: Do not touch the electrical connections when the engine brake system is energized. Touching the connections could possibly cause electrical shock.** Make sure the solenoid valve meets electrical specifications. **See "Specifications, 400."** If not, replace the solenoid valve. Alternate procedure: With ignition key on, brake switches on, and engine off, activate the solenoid electrically. Make sure the solenoid cap depresses. Leave it electrically depressed for 20 to 30 minutes. Slip a fingernail beneath the cap and try to pull it up. If the cap can be raised, replace the solenoid.
The engine brake housing plugs are leaking.	Check the plugs for signs of leaks. If leaks are found, remove the plugs, clean the threads, and install the plugs. Thread locking compound may help. Tighten the plugs 115 lbf·in (1300 N·cm).
The outer control valve spring is broken, or the engine oil pressure is extremely high.	Replace the outer control valve spring. Refer to the engine manufacturer's service manual for causes of high oil pressure.
The upper solenoid seal ring is damaged, causing oil pressure to drop below the minimum required for engine brake operation.	Remove the solenoid. Inspect the seal ring and replace it if needed.
The oil supply seals under or between the housings are damaged, causing oil pressure to drop below the minimum required for engine brake operation.	Remove the housings and replace the seals. Check for cracked or broken oil connectors. Replace the seals.
There is air in the lubricating oil, causing oil pressure to drop below the minimum required for engine brake operation.	Check for aeration of the oil. Turn the engine brake on, then off. Watch the escape oil coming from under the control valve cover. If the oil has bubbles or is foamy, air is present in the system. Aeration can be caused by an over-or underfilled crankcase, by cracks in the oil pickup tube, or by leaks in the oil suction tube or hose. Refer to the engine manufacturer's service manual for corrective measures.
The lubricating oil is being diluted by diesel fuel, causing oil pressure to drop below the minimum required for engine brake operation.	Have the lubricating oil analyzed to determine if fuel is present. Refer to the engine manufacturer's service manual for corrective measures.
The engine oil is low, causing oil pressure to drop below the minimum required for engine brake operation.	Refer to the engine manufacturer's service manual for specifications. Add oil or recalibrate the dipstick as required.
The engine rocker arm bushings are worn, causing oil pressure to drop below the minimum required for engine brake operation.	Replace the bushings. Refer to the engine manufacturer's service manual for instructions.
Oil is leaking around the cylinder heads, causing oil pressure to drop below the minimum required for engine brake operation.	Repair the cause of the leaks. Refer to the engine manufacturer's service manual for instructions.
Restrictions in the oil passage leading to the engine brake are causing oil pressure to drop below the minimum required for engine brake operation.	Inspect all the passageways; remove anything restricting the oil flow.

Troubleshooting

Problem—Engine Stalls or One or More Cylinders Continue Braking With the Dash Switches Off

Possible Cause	Remedy
The control valve inner spring is broken.	Replace the inner spring.
One or more control valves are stuck in the "on" (up) position.	Check the control valves for binding. Remove and clean or replace them if necessary. Inspect the lubrication oil for contaminants.
The solenoid valve is sticking in the "on" position.	If the solenoid valve cap remains down with no electric current being supplied, replace the solenoid valve.
The center solenoid seal ring is damaged, allowing oil to enter the engine brake with the solenoid valve closed.	Remove the solenoid and replace the seal ring.
The solenoid valve exhaust is plugged.	Remove any restrictions at the exhaust (bottom) of the solenoid valve.
The clutch switch or the throttle switch is stuck in the "on" position or is out of adjustment.	Check for correct switch operation. Adjust or replace the switch as needed.

Problem—Engine Misses or Loses Power

Possible Cause	Remedy
The slave piston is adjusted too tight.	Adjust the slave piston. **Refer to Subject 140.**
There is not enough clearance between the exhaust crosshead and the underside of the exhaust rocker arm.	Pass a 0.020 inch (0.5 mm) wire gauge between the back section of the crosshead and the underside of the rocker lever. If there is not 0.020 inch (0.5 mm) clearance, change the crosshead with another cylinder and measure it again. If there is still not enough clearance, check for a bent crosshead guide pin or an enlarged rocker arm. Replace parts as needed.
The Auto-Lash plunger is in the fully extended position.	Check for overtightening of the locknut. Tighten 25 lbf·ft (34 N·m) maximum. If the plunger remains in the extended position, replace the Auto-Lash screw.

Problem— Sudden Drop in Engine Lubrication Oil Pressure

Possible Cause	Remedy
The oil inlet supply seal is missing or damaged.	Replace the seal.
The upper solenoid valve seal is missing or damaged.	Remove the solenoid and replace the upper seal ring.
The external oil supply hoses or fittings are cracked and leaking.	Inspect all hoses and fittings for tightness, chafing, or cuts.

Torque Values	
Component	**Torque lbf·ft (N·m)**
Exhaust Valve Crosshead Adjusting Screw Locknuts	25 (35)
Rocker Housing Studs	70 (95)
Engine Brake Holddown Nuts	60 (80)
Slave Piston Adjusting Screw Locknuts	25 (35)
Rocker Lever Adjusting Screw Locknuts	45 (60)

Table 1, Torque Values

Slave Piston Clearance Settings			
Engine Timing		**Clearance Setting (inches)**	**Feeler Gauge Part Number**
Fixed Timing (FT)		0.024	016560
Step Timing Control (STC)	Housing no. 014878	0.040	016704
	Housing no. 016007	0.046	016683
Electronically Controled Injection (ECI)		0.030	015877

Table 2, Slave Piston Clearance Settings

Solenoid Valve Electrical Specifications		
Description	**Cold 70°F (21°C)**	**Hot 180° to 220°F (82° to 104°C)**
Resistance (Ohms)	9.75 to 10.75	11.8 to 14.3
Current Draw (Amps)	1.23 to 1.12	1.02 to 0.84
Minimum Pull-In Voltage	7.5	8.5

Table 3, Solenoid Valve Electrical Specifications

General Description and Principles of Operation

Jacobs engine brake housings are installed on the engine rocker housings. Model C-317 (used on Caterpillar 3176 engines) has three engine brake housings that operate two cylinders each. Each engine brake housing has a solenoid valve, control valves, master pistons, slave pistons, and lash adjusting screws. **See Fig. 1**.

The engine brake electronic control is designed to interface with the Caterpillar 3176 electronic control through a pulse width modulated signal. The dash switches or optional dash module enables the driver to operate the engine brake partially or fully. Self diagnostics are provided for the solenoids, the installation wiring, and the pulse width modulated signal when the optional dash module is installed.

The Model C-317 engine brake can be operated at one-third, two-thirds, or full capacity (two, four, or six cylinders).

When activated, the engine brake converts a power-producing diesel engine to a power-absorbing air compressor. This is accomplished by motion transfer through a master/slave piston arrangement which opens the engine cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to the exhaust system. The blowdown of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the expansion (power) stroke. This results in a net energy loss because the work done in compressing the cylinder charge is not returned during the expansion process. Exhaust blowdown occurs as follows (**see Fig. 2**):

1. Activating the engine brake energizes the solenoid valve, allowing engine oil to flow under pressure through the control valve to both the master piston and the slave piston.
2. Oil pressure causes the master piston to move down, coming to rest on the injector rocker arm.
3. The injector rocker arm begins its travel as in the normal injection cycle, forcing the master piston upward and creating a high-pressure oil flow to the slave piston. The ball check valve in the control valve holds the high-pressure oil in the master/slave piston system.
4. High-pressure oil causes the slave piston to move down, momentarily opening the exhaust valve, while the engine piston is near its top dead center position, releasing compressed cylinder air to the exhaust manifold.
5. Near the end of the slave piston travel the slave piston separates from the clip valve located in the adjusting screw, uncovering the hole in the center of the slave piston. The oil then flows to the bottom of the control valve. The clip valve has two functions:
   - Its plunger protrusion limits the slave piston travel.
   - It permits the slave piston to retract from the bridge pin, allowing the bridge to be "balanced" for the normal exhaust valve cycle.
6. Compressed air escapes to the atmosphere completing a compression braking cycle.

General Description and Principles of Operation

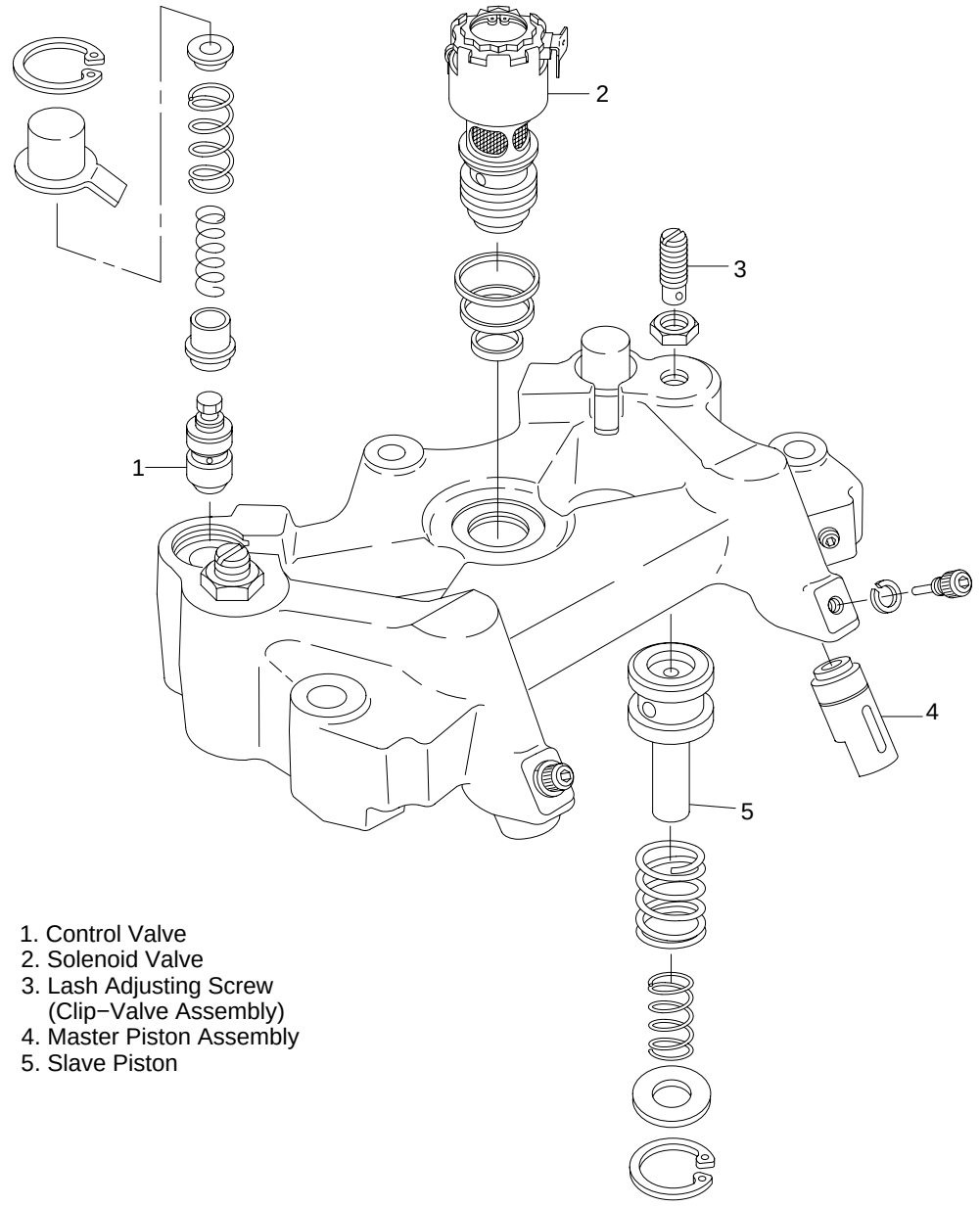


Fig. 1, Exploded View (Model C-317 Housing Assembly)

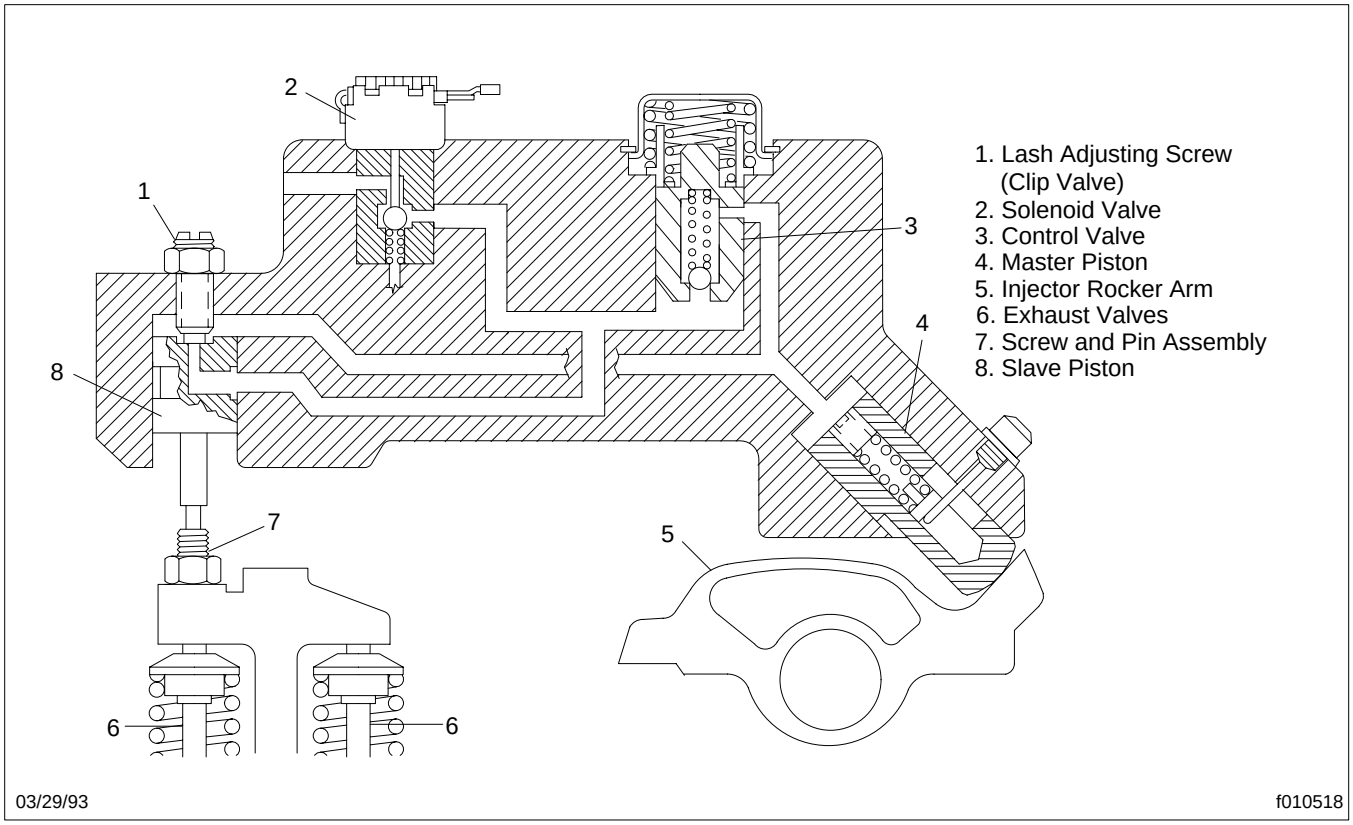


Fig. 2, Model C-317 Operating Diagram

Dash Switch (or Dash Module) Replacement

NOTE: **See Fig. 1** for the engine brake wiring diagram.

1. Park the vehicle and disconnect the batteries.
2. Remove the screws that attach the control panel to the dash. Lift the panel to a serviceable level.
3. Remove the cap nut on the switches. Remove the switches. If the optional dash module is used, remove the two nuts and the bracket from the back of the dash module.
4. Mark the wires for later reference, then disconnect them from the switches. If the dash module is used, disconnect the ribbon cable from the module.
5. Connect the wires to the new switches as previously marked. If the dash module is used, connect the ribbon cable to the module.
6. Install the switches (or dash module) through the rear of the panel, and attach it with the cap nut (or the bracket and nuts).
7. Place the panel in the dash, and attach it with the screws.
8. Connect the batteries.

Control Module Replacement

To replace the control module, disconnect the two wiring harnesses. If the optional dash module is used, disconnect the ribbon cable harness. Remove the two control module mounting screws. Mount the new control module and connect the harnesses.

⚠ CAUTION

CAUTION: Do not allow the control module to hang unmounted or tie wrapped behind the dash. The control module will be stressed and could malfunction.

Switch and Control Module Replacement

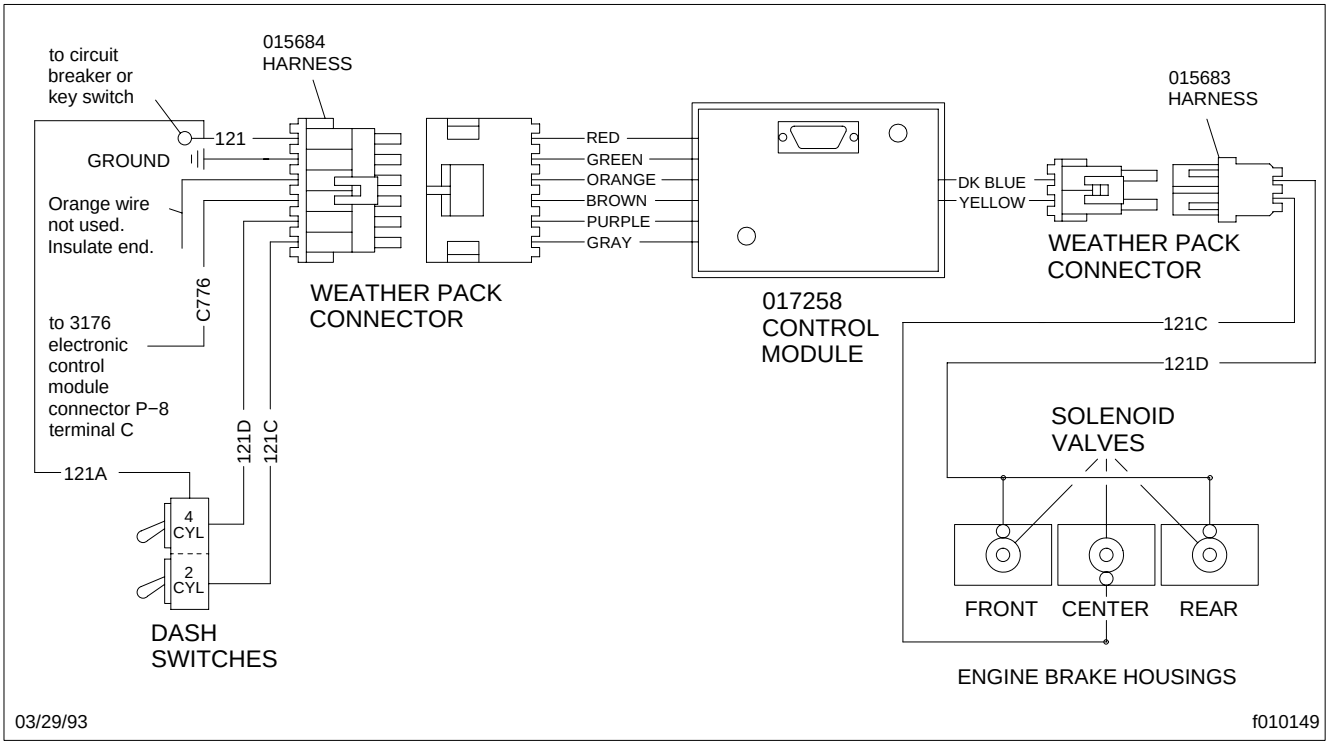


Fig. 1

Removal

WARNING

WARNING: To avoid personal injury, never remove any engine brake component with the engine running.

1. Tilt the cab or hood. For instructions, refer to the vehicle driver's manual.
2. Wipe the engine brake housing area clean. Remove the rocker housing cover capscrews; remove the cover and gasket from each spacer.
3. Remove the bolts (**Fig. 1**, Ref. 2) and the hold-down nuts (Ref. 1).
4. Remove the engine brake housing.

Installation

1. Position the engine brake housings on the rocker arm supports.
2. Install the Jacobs hold-down nuts on the extension studs. Do not tighten the nuts at this time.
3. Install the bolts through the housing into the head bolt extension (one per housing). Do not tighten the bolts at this time.
4. Make sure the slave piston foot is aligned squarely over the bridge screw and pin assembly to ensure full contact with the exhaust valve stem. **See Fig. 2**. Reposition the housing if necessary.
5. Tighten the hold-down nuts 83 lbf·ft (112 N·m). **See Fig. 1**, Ref. 1.
6. Tighten the bolts 41 lbf·ft (55 N·m). **See Fig. 1**, Ref. 2.
7. Adjust the slave piston lash to 0.045 inch (1.1 mm).
8. Using a new gasket, install the rocker housing cover. Tighten the capscrews 62 lbf·in (700 N·cm).

Engine Brake Housing Removal and Installation

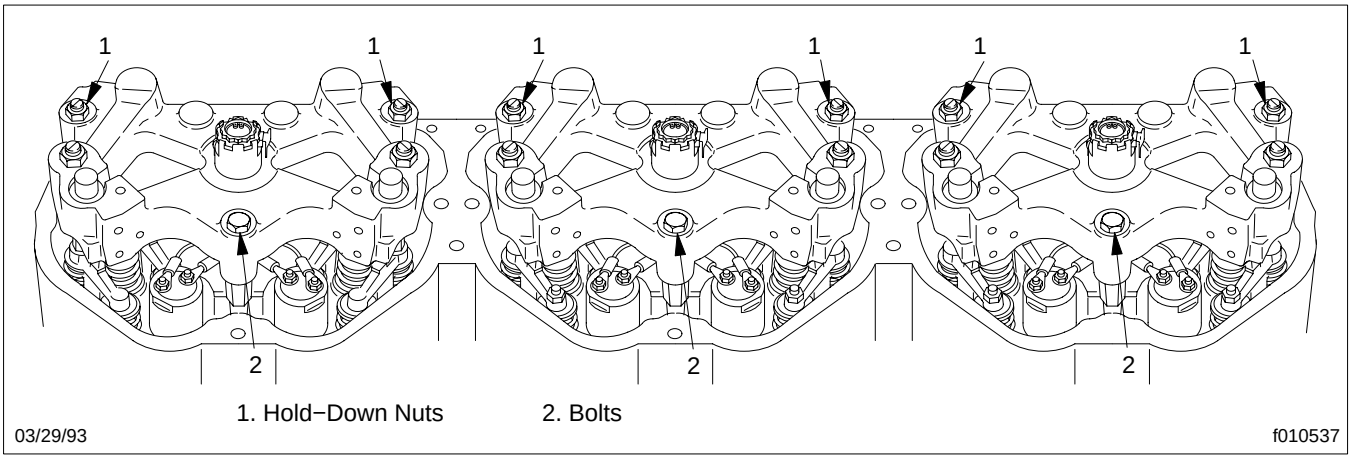


Fig. 1, Removal of Hold-Down Nuts, and Bolts

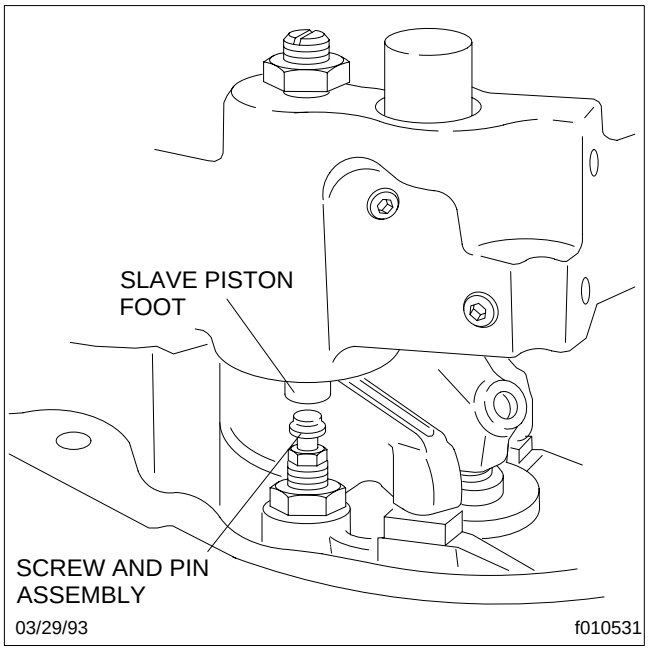


Fig. 2, Slave Piston Foot Alignment

Control Valve Removal, Inspection, and Installation

Removal

WARNING

WARNING: The control valve covers are under load from the control valve springs. Remove the covers carefully to avoid personal injury.

1. Apply pressure on the control valve cover and rotate the retaining ring ears to the slot in the housing. Remove the ring using retaining ring pliers. **See Fig. 1**.
2. Slowly remove the cover until the spring pressure is released. Remove the control valve springs, the insert, and the collar. **See Fig. 2**.
3. Using needle-nose pliers, reach into the bore and grasp the stem of the control valve. Remove the control valve. **See Fig. 3**.

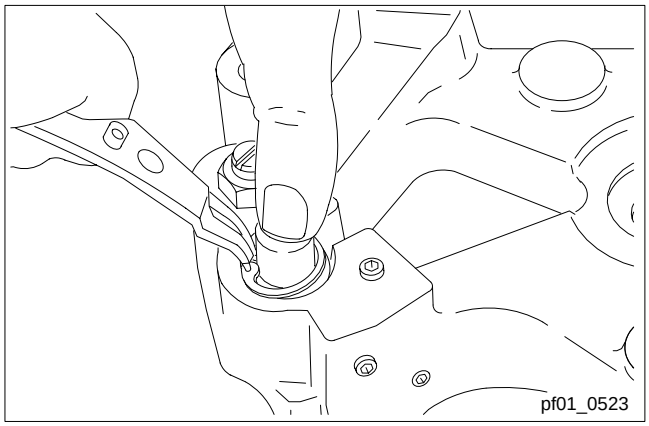


Fig. 1

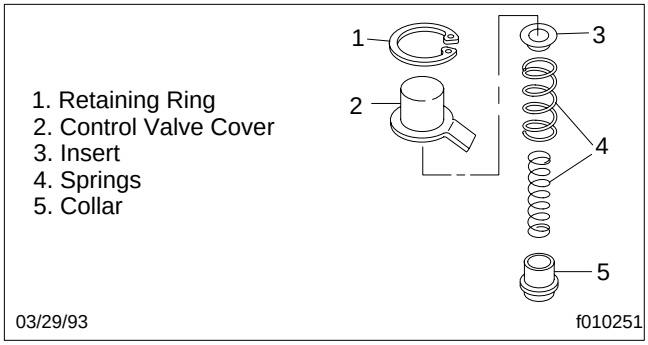


Fig. 2

Inspection

WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Wash the control valves in a cleaning solvent that meets OSHA guidelines.
2. Push a wire into the hole in the base of the valve far enough to ensure that the ball check is free. The ball should lift with light pressure on the wire.
3. Dry the valve with compressed air and wipe it clean with a paper towel.
4. Using clean paper towels, thoroughly clean the control valve bore in each housing.
5. Dip the control valves in clean lubricating oil. Holding the valve by the stem, let the valve drop into its bore. If it binds or if the ball is stuck in the valve, replace the control valve.

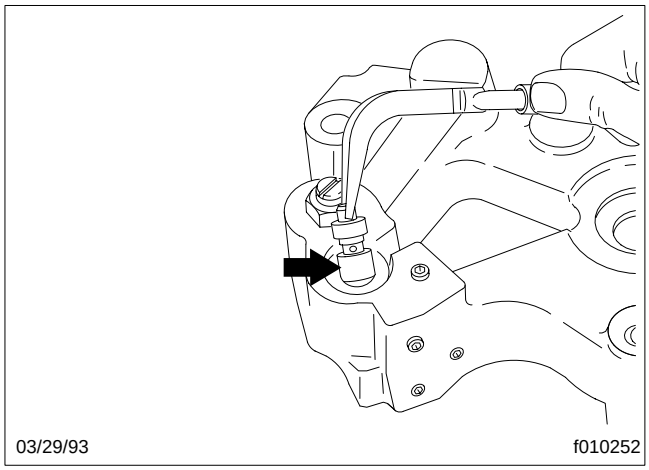


Fig. 3

Installation

1. Assemble the parts by reversing the removal procedure.

Control Valve Removal, Inspection, and Installation

⚠ CAUTION

CAUTION: Be sure the control valve collar is installed with the longer sleeve area up. See Fig. 2 and Fig. 4. If the collar is installed upside down, engine damage may result.

2. Rotate the retaining ring so that the ears are located away from the slot in the housing. **See Fig. 5**.

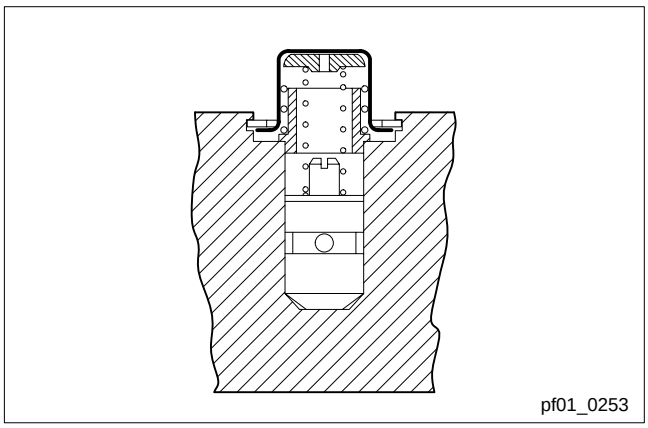


Fig. 4

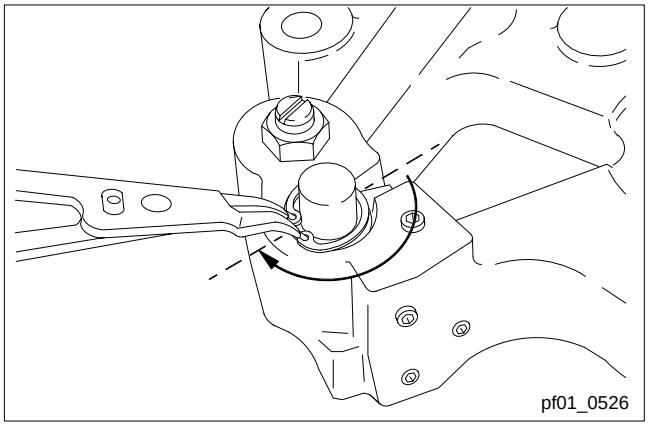


Fig. 5

Solenoid Valve Removal, Inspection,and Installation

Removal

1. Disconnect the solenoid harness. Using a 7/8-inch socket and extension, unscrew the solenoid valve. **See Fig. 1**.

CAUTION

CAUTION: Do not disassemble or tamper with the solenoid valve. Engine damage could result.

2. Remove and discard the three rubber seal rings. **See Fig. 2**. If the lower ring stays in the bottom of the housing solenoid bore, remove it with a piece of wire.

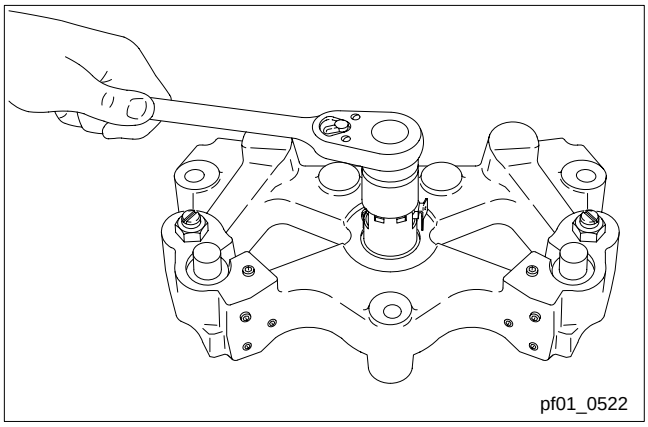


Fig. 1

Inspection

WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Wash out the solenoid valve with a cleaning solvent that meets OSHA guidelines. Use a brush to clean the oil screen. When clean, dry the valve with compressed air.
2. Clean out the solenoid valve bore in the housing. Use clean paper towels. Never use rags, since they may leave lint and residue, which can plug the oil passageways.

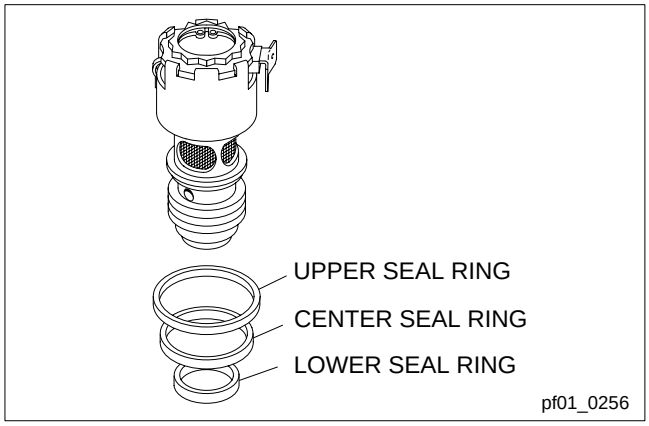


Fig. 2

Installation

1. Coat a set of new solenoid seal rings with clean lubricating oil.
2. Install the upper and center seal rings on the solenoid body. Install the lower seal ring into the bottom of the solenoid bore in the housing.
3. Make sure the seals are seated properly. Being careful not to twist or unseat the seals, screw the solenoid into the housing. Tighten the valve 680 N·cm (60 lbf·in).

Slave Piston Removal, Inspection, Installation,and Adjusting

Removal

⚠ WARNING

WARNING: Wear safety glasses and remove the slave piston carefully. The slave piston is held in by springs that are under heavy compression. If the instructions below are not followed and proper tools are not used, the springs will be discharged with enough force to cause personal injury.

1. Remove the locknut on the slave piston adjusting screw. Back out the adjusting screw until the slave piston is fully retracted (screw is loose). **See Fig. 1**.
2. Place the hole in the clamp fixture over the slave piston adjusting screw.
3. While holding the fixture in position, screw the holder down over the slave piston until the spring retainer is contacted.
4. Turn the handle slowly until the retainer is depressed about 1/32 inch (1 mm), relieving pressure against the retaining ring.
5. Using retaining ring pliers, remove the retaining ring. **See Fig. 2**. Back out the holder until the springs are loose. Remove the fixture.
6. Remove all components. **See Fig. 3**.

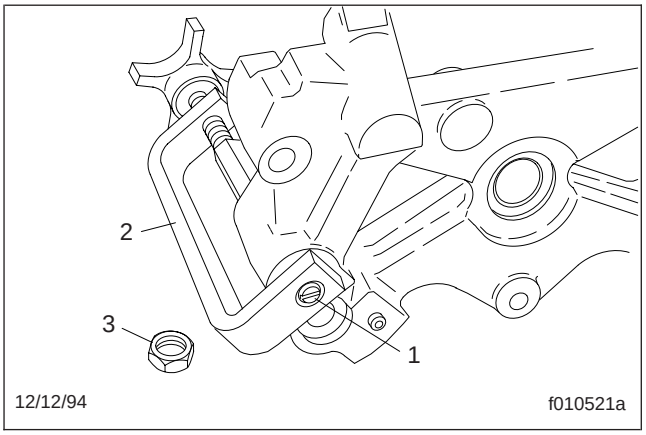


Fig. 1

Inspection

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

Make sure there is no binding or burrs. Clean all parts in a cleaning solvent that meets OSHA guidelines, or replace them as necessary.

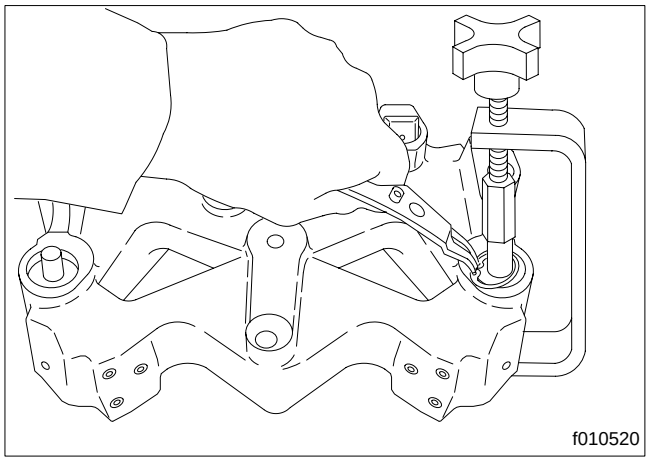


Fig. 2

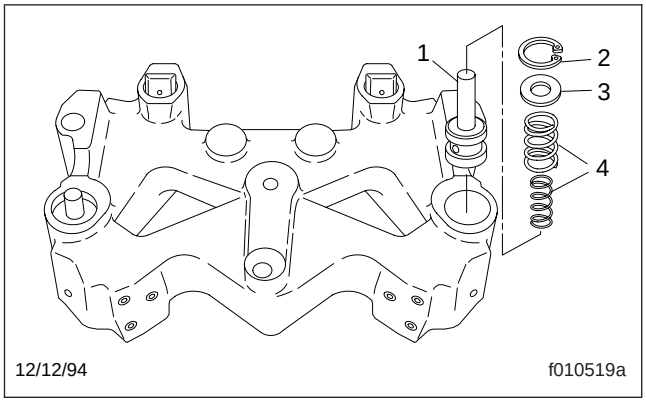


Fig. 3

Installation

1. Assemble all components in the proper order.

Slave Piston Removal, Inspection, Installation,and Adjusting

2. Using the clamp fixture, install the piston and springs. Be sure the retaining ring is placed on the retainer before screwing the clamp holder down over the slave piston.
3. Compress the slave piston springs until the retainer is about 1/32 inch (1 mm) below the retaining ring groove. Install the retaining ring. Make sure the retaining ring is fully seated in the groove.
4. Remove the clamp fixture slowly to ensure proper seating of the retaining ring.

Adjusting

NOTE: Adjust the slave pistons with the engine stopped and cold. The exhaust valves must be closed on the cylinder to be adjusted.

1. Rotate the engine until piston no. 1 is at top dead center of the compression stroke.
2. Adjust the slave piston clearance for cylinders 1, 3, and 5 as follows:
   - 2.1 Insert a 0.045-inch feeler gauge between the slave piston and the actuating pin in the bridge adjusting screw. **See Fig. 4**.
   - 2.2 Turn the slave piston adjusting screw clockwise until there is a slight drag on the feeler gauge.
   - 2.3 While holding the adjusting screw in this position, tighten the locknut 35 N·m (26 lbf·ft).
3. Rotate the engine 360 degrees so that piston no. 6 is at top dead center of the compression stroke.
4. Adjust the slave piston clearance for cylinders 2, 4, and 6, following the procedure in the substeps above.

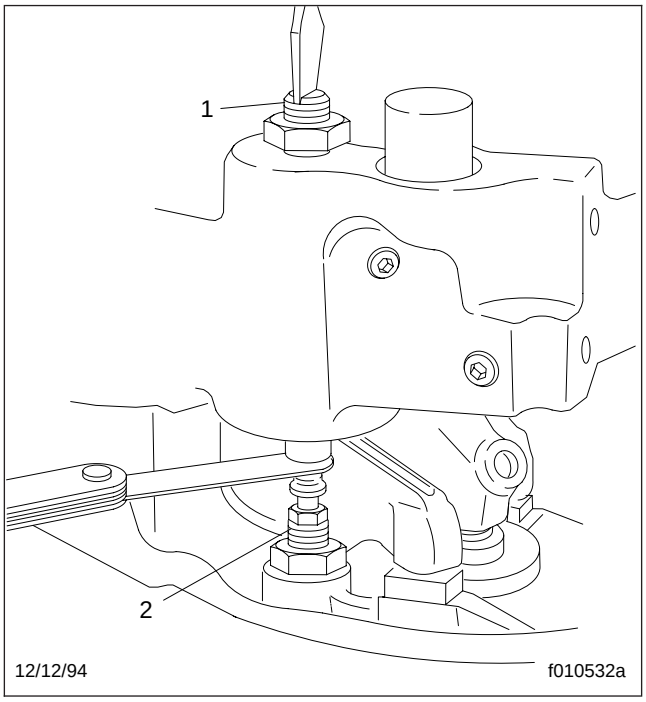


Fig. 4

Slave Piston Adjusting Screw (Clip Valve) Removal, Inspection, and Installation

Removal

Loosen the slave piston adjusting screw locknut and remove the adjusting screw from the housing.

Inspection

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Clean the adjusting screws in a solvent that meets OSHA guidelines.
2. Inspect the adjusting screws. The plunger should protrude from the bottom of the screw, should have light spring pressure when depressed, and should move freely. If any defect is found, replace the entire screw assembly.

⚠ CAUTION

CAUTION: Do not disassemble or tamper with the slave piston adjusting screw assembly. Engine damage could result.

Installation

⚠ CAUTION

CAUTION: Use only Jacobs clip valve assemblies (see Fig. 1) in the Model C-317 housings. Use of any other type of adjusting screw assembly will cause engine and engine brake damage.

NOTE: The part number for the clip valve, and other assemblies, is located at the top of the screw next to the screwdriver slot.

1. Screw the slave piston adjusting screw into the housing.
2. Tighten the locknut 26 lbf·ft (35 N·m).

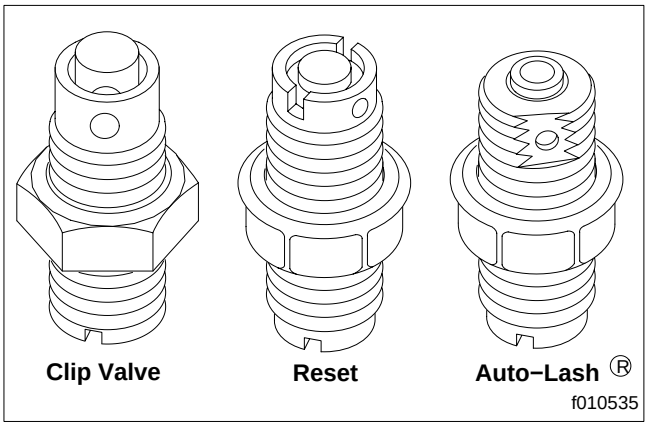


Fig. 1

Master Piston Removal, Inspection, and Installation

Removal (See Fig. 1)

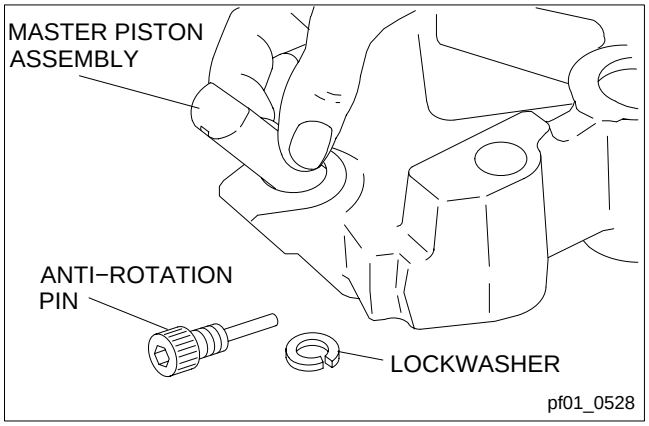


Fig. 1

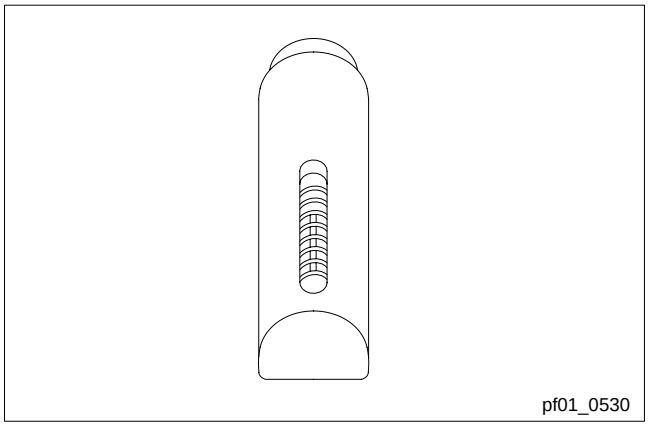


Fig. 2

1. Remove the anti-rotation pin assembly and lockwasher from the housing.
2. Remove the master piston assembly.

NOTE: The master piston return spring is contained inside the master piston. **See Fig. 2**. Do not disassemble the master piston assembly in the field.

Inspection

Inspect the master piston for damage. The piston surface must be free of score or wear marks, and must move freely in the housing bore. Inspect the spring to make sure it is not broken.

Installation

1. Using a pick or probe, compress the return spring. While holding the spring compressed, insert a small diameter pin into the access hole and remove the probe. **See Fig. 3**.

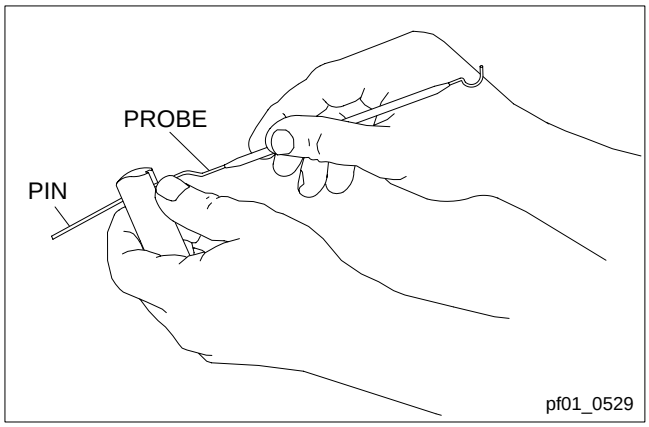


Fig. 3

2. Insert the master piston into the housing bore. **See Fig. 4**.

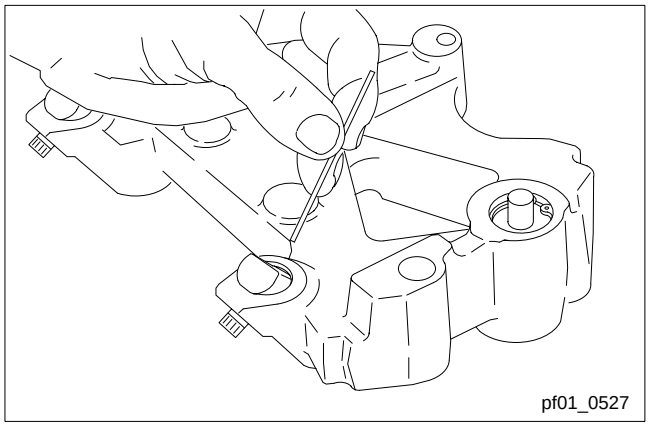


Fig. 4

3. Install the anti-rotation pin in the housing together with the lockwasher. Remove the long, narrow pin so that the spring is retained by the anti-rotation pin.
4. Using a 3/16-inch hex key wrench, tighten the anti-rotation pin. Move the piston in and out to be sure it moves freely and that the spring returns the piston to the bottom of the bore.

Checking

To properly troubleshoot the engine brake, the mechanic must know the supply oil pressure reading at the engine brake housing. The oil pressure reading on the instrument panel gauge is not the same as at the engine brake housings.

1. Make an oil pressure gauge adapter as follows:
   - 1.1 Remove the metal cap from a used solenoid valve and press off the coil assembly.
   - 1.2 Using a hex wrench, remove the bottom screw. Remove the internal components from the valve and the oil screen and retainer.
   - 1.3 Insert steel rods in the four small holes directly below the center O-ring, and braze them. Install the bottom screw and braze closed the hex hole and surrounding screw area. Flats can be ground in the sides of the valve so it can be tightened with a wrench.
   - 1.4 Clean the valve body and wire-brush the hole in the top of the body. A gauge with a range of 0 to 100 psi (0 to 689 kPa) will generally require a 1/8 NPT tap.
   - 1.5 Install a hose in the adapter and install the pressure gauge on the hose.
2. Using a 7/8-inch 12-point socket (or Jacobs wrench 11494 on older-style solenoid valves), remove the valve from the housing being checked.
3. Insert the oil pressure gauge (from earlier step) into the solenoid bore. The three solenoid seal rings must be used on the solenoid adapter.
4. Start the engine and allow it to warm up.
5. Record the oil pressure readings at low idle speed.
6. Increase the engine speed to 1000 rpm. Record the pressure.
7. Increase the engine speed to 1500 rpm. Record the pressure.
8. Increase the engine speed to high idle speed and record the pressure.
9. Allow the engine to return to low idle speed.
10. Repeat the oil pressure checks in all the housings equipped with solenoid valves.
11. Shut down the engine. Remove the control valve covers and make sure the correct control valve springs are used.
12. The full-flow oil pressure range for the Model C-317 is 25 to 56 psi (172 to 386 kPa). An overpressure of 78 psi (538 kPa) can cause engine brake malfunction. If the engine is not within specifications, have it examined by an authorized facility and repaired if necessary.

Troubleshooting Chart

Problem—Engine Will Not Start

Possible Cause	Remedy
The solenoid valve is stuck in the "on" position.	Make sure the electrical current to the engine brake is off. If the solenoid valve stays "on" (cap down) with the current off, replace the solenoid valve.

Problem—Engine Brake Will Not Function

Possible Cause	Remedy
A circuit breaker is tripped.	Look for a short circuit in the wiring. Replace any chafed wires. Check the solenoid tab for signs of shorting; replace it if needed. The circuit breaker resets automatically after the short is repaired.
An electrical lead is open.	Replace any broken wires.
The dash switches are malfunctioning or out of adjustment.	**⚠ WARNING** **WARNING: Do not touch the electrical connections when the engine brake system is energized. Touching the connections could possibly cause electrical shock.** Use a volt/ohmmeter to make sure there is electrical current at both terminals of each switch. Adjust the switch if needed. If voltage will not pass through the switch, replace it.
The engine oil pressure is too low.	Determine the oil pressure at the engine brakes. **Refer to Subject 170.** If the oil pressure is below specifications, repair the engine following the manufacturer's procedures.

Problem—Engine Brake Engages With the Switches Off

Possible Cause	Remedy
The solenoid valve center seal ring is damaged.	Remove the solenoid. Replace the center seal ring.
The engine brake is incorrectly wired.	Check the wiring against the Jacobs wiring diagram.

Problem—Engine Brake Weak or Slow to Engage

Possible Cause	Remedy
The lubricating oil is too cold and thick.	Allow the engine to warm up before operating the Jake Brake.

Troubleshooting

Possible Cause	Remedy
The slave piston is adjusted incorrectly or is binding in its bore.	**⚠ WARNING** **WARNING: Slave piston springs are under heavy compression. Remove the slave piston carefully when disassembly is necessary. Use either an arbor press or C-clamp. Failure to follow this procedure could result in personal injury.** Adjust the slave piston. Make sure it responds smoothly to the adjusting screw— loosen the jam nut and screw the adjusting screw through its full range for full slave piston travel. Make sure the piston travels the full range without binding or sticking.
The solenoid lower seal is damaged, allowing oil to escape the housing.	Remove the solenoid valve and replace the lower seal ring.
The solenoid screen is clogged, stopping the supply of oil to the engine brake.	Remove the solenoid valve; clean or replace the screen.
The master piston is not moving in its bore.	Inspect the master piston and bore for scoring or burrs. If any are present, clean the surface with a crocus cloth. If the burrs cannot be removed, replace the piston or housing. Inspect the lubricating oil for signs of contaminants. If any are present, replace the oil and filters, and correct the cause of the contamination.
The control valves are binding in the housing bores.	Remove each control valve. If the body is scored, replace the valve. Check for contaminants in the lubricating oil. Clean the housing and control valve. If it still binds, replace the housing.
The control valves are malfunctioning.	**⚠ WARNING** **WARNING: To prevent skin irritation, wear chemical resistant gloves when working with diesel fuel or kerosene. Also, do not expose these fluids to flames or heat exceeding 100°F (38°C); both are combustible, and could cause personal injury if ignited.** Remove each control valve. Make sure the check ball is seating in the bore and that it can be moved off the seat. Make sure there is spring pressure against the ball. Flush the valve in diesel fuel. Replace the control valve if needed.
Dash switches have sluggish operation.	Adjust or replace the switch. Check the throttle or clutch return springs for proper operation.

Possible Cause	Remedy
The electrical insulation of the solenoid valve is breaking down.	**⚠ WARNING** **WARNING: Do not touch the electrical connections when the engine brake system is energized. Touching the connections could possibly cause electrical shock.** Make sure the solenoid valve meets electrical specifications. **See "Specifications, 400."** If not, replace the solenoid valve. Alternate procedure: With ignition key on, brake switches on, and engine off, activate the solenoid electrically. Make sure the solenoid cap depresses. Leave it electrically depressed for 20 to 30 minutes. Slip a fingernail beneath the cap and try to pull it up. If the cap can be raised, replace the solenoid.
The engine brake housing plugs are leaking.	Check the plugs for signs of leaks. If leaks are found, remove the plugs, clean the threads, and install the plugs. Thread locking compound may help. Tighten the plugs 115 lbf·in (1300 N·cm).
The outer control valve spring is broken, or the engine oil pressure is extremely high.	Replace the outer control valve spring. Refer to the engine manufacturer's service manual for causes of high oil pressure.
The upper solenoid seal ring is damaged, causing oil pressure to drop below the minimum required for engine brake operation.	Remove the solenoid. Inspect the seal ring and replace it if needed.
The oil supply seals under or between the housings are damaged, causing oil pressure to drop below the minimum required for engine brake operation.	Remove the housings and replace the seals. Check for cracked or broken oil connectors. Replace the seals.
There is air in the lubricating oil, causing oil pressure to drop below the minimum required for engine brake operation.	Check for aeration of the oil. Turn the engine brake on, then off. Watch the escape oil coming from under the control valve cover. If the oil has bubbles or is foamy, air is present in the system. Aeration can be caused by an over-or underfilled crankcase, by cracks in the oil pickup tube, or by leaks in the oil suction tube or hose. Refer to the engine manufacturer's service manual for corrective measures.
The lubricating oil is being diluted by diesel fuel, causing oil pressure to drop below the minimum required for engine brake operation.	Have the lubricating oil analyzed to determine if fuel is present. Refer to the engine manufacturer's service manual for corrective measures.
The engine oil is low, causing oil pressure to drop below the minimum required for engine brake operation.	Refer to the engine manufacturer's service manual for specifications. Add oil or recalibrate the dipstick as required.
The engine rocker arm bushings are worn, causing oil pressure to drop below the minimum required for engine brake operation.	Replace the bushings. Refer to the engine manufacturer's service manual for instructions.
Oil is leaking around the cylinder heads, causing oil pressure to drop below the minimum required for engine brake operation.	Repair the cause of the leaks. Refer to the engine manufacturer's service manual for instructions.
Restrictions in the oil passage leading to the engine brake are causing oil pressure to drop below the minimum required for engine brake operation.	Inspect all the passageways; remove anything restricting the oil flow.

Troubleshooting

Problem—Engine Stalls or One or More Cylinders Continue Braking With the Dash Switches Off

Possible Cause	Remedy
The control valve inner spring is broken.	Replace the inner spring.
One or more control valves are stuck in the "on" (up) position.	Check the control valves for binding. Remove and clean or replace them if necessary. Inspect the lubrication oil for contaminants.
The solenoid valve is sticking in the "on" position.	If the solenoid valve cap remains down with no electric current being supplied, replace the solenoid valve.
The center solenoid seal ring is damaged, allowing oil to enter the engine brake with the solenoid valve closed.	Remove the solenoid and replace the seal ring.
The solenoid valve exhaust is plugged.	Remove any restrictions at the exhaust (bottom) of the solenoid valve.
The clutch switch or the throttle switch is stuck in the "on" position or is out of adjustment.	Check for correct switch operation. Adjust or replace the switch as needed.

Problem—Engine Misses or Loses Power

Possible Cause	Remedy
The slave piston is adjusted too tight.	Adjust the slave piston. **Refer to Subject 140.**
There is not enough clearance between the exhaust crosshead and the underside of the exhaust rocker arm.	Pass a 0.020 inch (0.5 mm) wire gauge between the back section of the crosshead and the underside of the rocker lever. If there is not 0.020 inch (0.5 mm) clearance, change the crosshead with another cylinder and measure it again. If there is still not enough clearance, check for a bent crosshead guide pin or an enlarged rocker arm. Replace parts as needed.

Problem— Sudden Drop in Engine Lubrication Oil Pressure

Possible Cause	Remedy
The oil inlet supply seal is missing or damaged.	Replace the seal.
The upper solenoid valve seal is missing or damaged.	Remove the solenoid and replace the upper seal ring.
The external oil supply hoses or fittings are cracked and leaking.	Inspect all hoses and fittings for tightness, chafing, or cuts.

See Fig. 1 for a wiring diagram.

Torque Values		
Component	**Torque**	
	lbf·ft (N·m)	**lbf·in (N·cm)**
Cylinder Head Stud	203 (275)	—
Valve Bridge Adjusting Screw Locknut	18 (25)	—
Exhaust Rocker Arm Adjusting Screw Locknut	18 (25)	—
Injector Rocker Arm Adjusting Screw	41 (55)	—
Cylinder Head Bolt Extension	70 (95)	—
Extended Studs	32 (44)	—
Housing Hold-Down Nuts	83 (112)	—
Housing Hold-Down Bolts	41 (55)	—
Slave Piston Adjusting Screw Locknut	26 (35)	—
Spacer Bolts	—	60 (680)
Solenoid Valve	—	60 (680)

Table 1, Torque Values

Solenoid Valve Electrical Specifications		
Description	**Cold 70°F (21°C)**	**Hot 180°to 220°F (82°to 104° C)**
Resistance (Ohms)	9.75 to 10.75	11.8 to 14.3
Current Draw (Amps)	1.23 to 1.12	1.02 to 0.84
Minimum Pull-In Voltage	7.5	8.5

Table 2, Solenoid Valve Electrical Specifications

Specifications

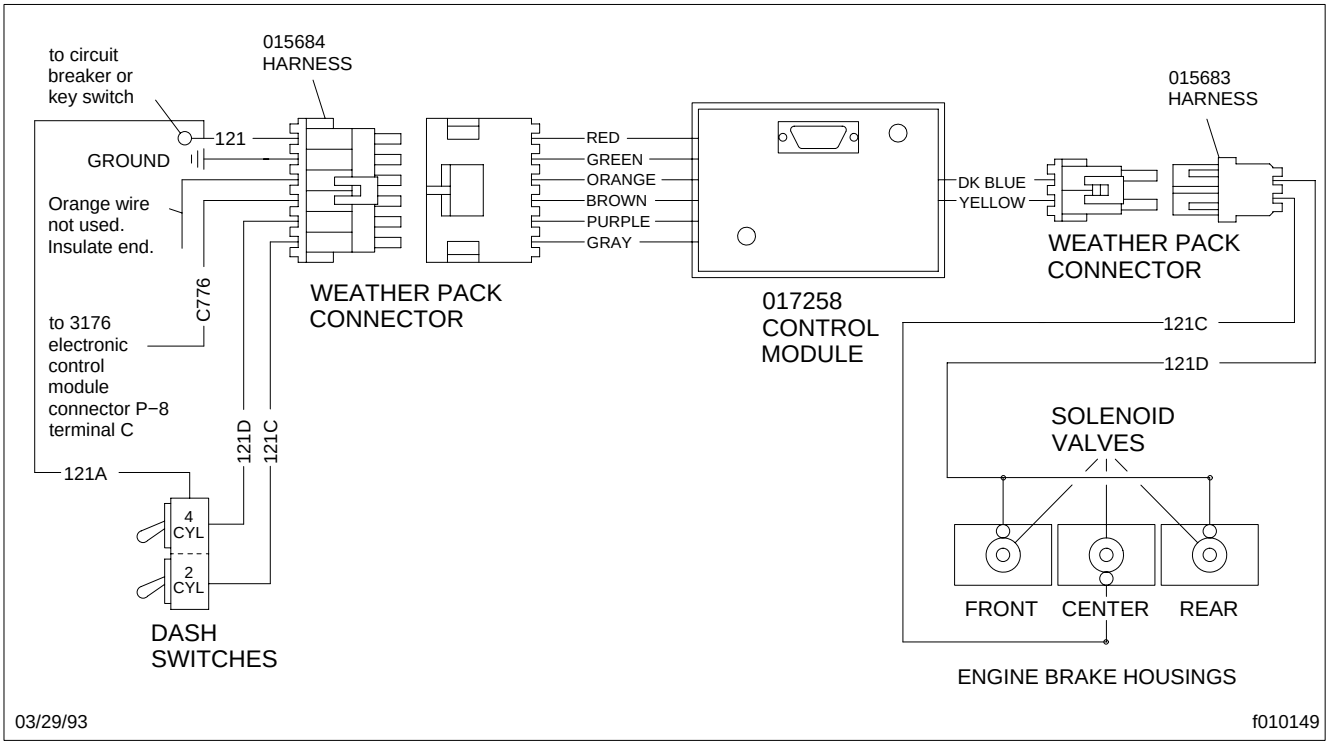


Fig. 1, Wiring Diagram

General Description

Jacobs engine brake housings are installed on the engine rocker housings. Model 760 (used on Detroit Diesel Series 60 12.7 liter engines) has three engine brake housings that operate two cylinders each. Each engine brake housing has a solenoid valve, control valves, ball check valves, master pistons, and slave pistons. See **Fig. 1**.

Engine brake controls consist of: dash switches (**Fig. 2**) and a clutch switch. The clutch switch is mounted under the dash for Conventionals (**Fig. 3** or **Fig. 4**), or under the cab for COEs (**Fig. 5**). The engine brake is activated when the dash switches are on and the clutch and throttle pedals are released. The dash switches enable the driver to operate the engine brake partially or fully. Vehicles equipped with an Allison automatic transmission do not use the clutch switch.

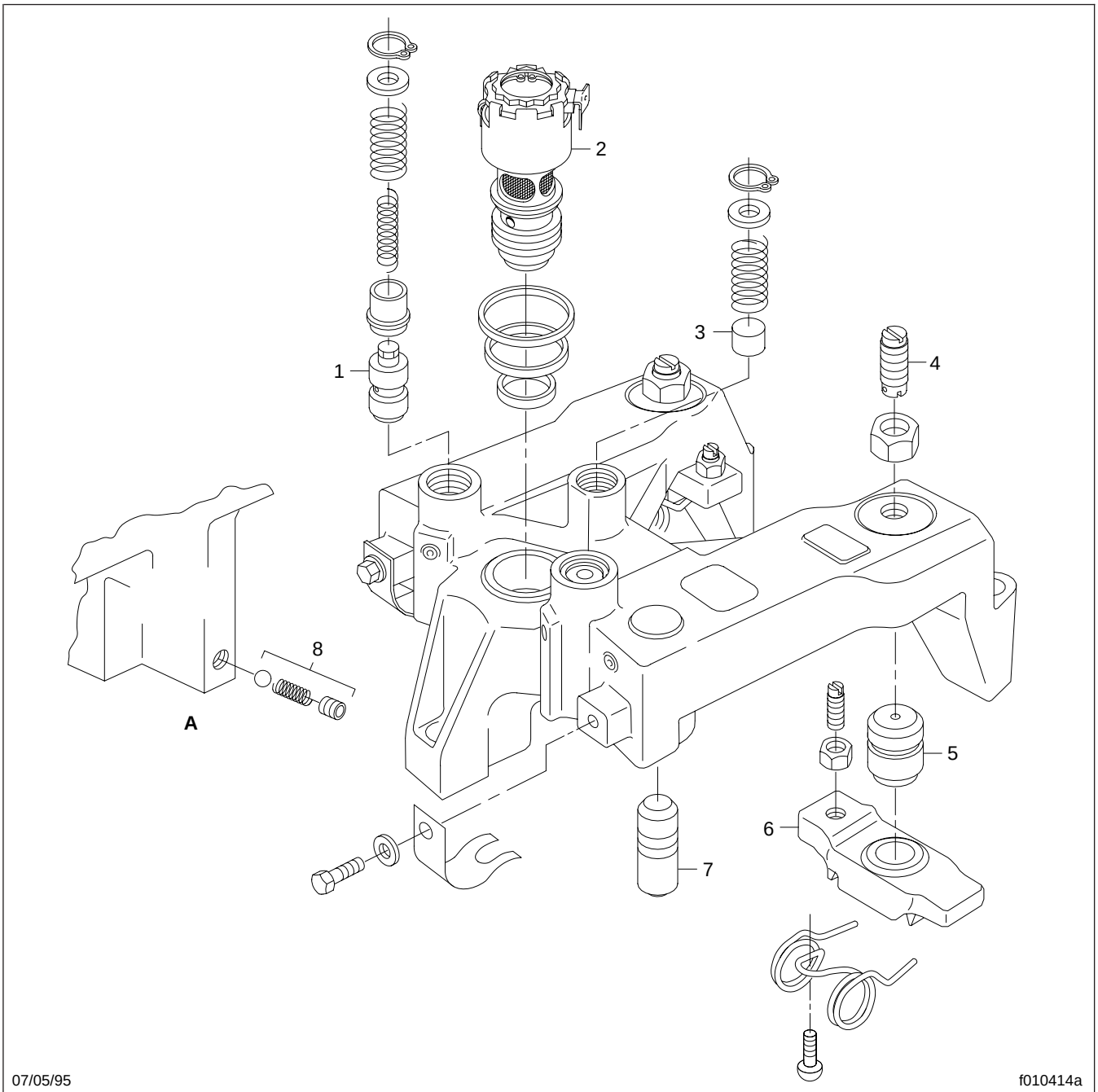
The Model 760 engine brake can be operated at one-third, two-thirds, or full capacity (two, four, or six cylinders).

Principles of Operation

When activated, the engine brake converts a power-producing diesel engine to a power-absorbing air compressor. This is accomplished by motion transfer through a master-slave piston arrangement which opens the engine cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust. The blow-down of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the expansion (power) stroke. This results in a net energy loss because the work done in compressing the cylinder charge is not returned during the expansion process. Exhaust blowdown occurs as follows (see **Fig. 6**):

1. Activating the engine brake energizes the solenoid valve, allowing engine oil to flow under pressure through the control valve to both the master piston and the slave piston.
2. Oil pressure causes the master piston to move down, coming to rest on the injector rocker arm roller.
3. The injector rocker arm begins upward travel (as in the normal injection cycle) forcing the master piston upward and creating a high-pressure oil flow to the slave piston. The ball check valve in the control valve holds the high-pressure oil in the master-slave piston system.
4. When the engine piston is near top dead center, the slave piston moves down under the influence of the high-pressure oil flow. This momentarily opens the exhaust valves, releasing compressed cylinder air to the exhaust manifold.
5. At the bottom of its stroke the slave piston separates from the valve in the slave piston reset adjusting screw, allowing high-pressure oil to flow into the accumulator. This reduces the pressure in the high-pressure circuit, permitting the slave piston to retract and the exhaust valves to close in preparation for the normal exhaust valve cycle. The oil pressure reserved in the accumulator ensures that the hydraulic circuit is fully charged for the next cycle.
6. Compressed air escapes to the atmosphere completing a compression braking cycle.

General Description and Principles of Operation



A. Front Underside of Housing
1. Control Valve
2. Solenoid Valve
3. Accumulator Piston
4. Slave Piston Adjusting Screw (Reset)
5. Slave Piston
6. Bridge
7. Master Piston
8. Ball Check Valve

Fig. 1, Exploded View, Model 760 Housing Assembly

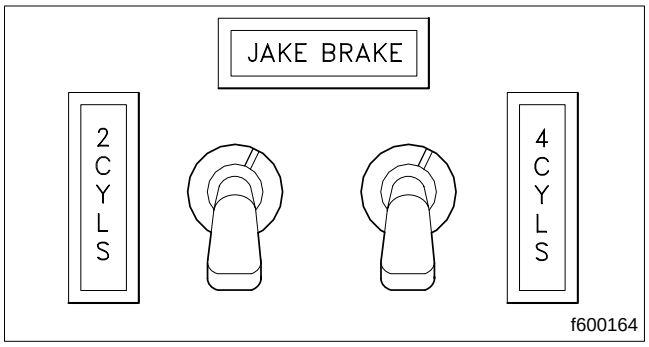


Fig. 2, Engine Brake Dash Switches

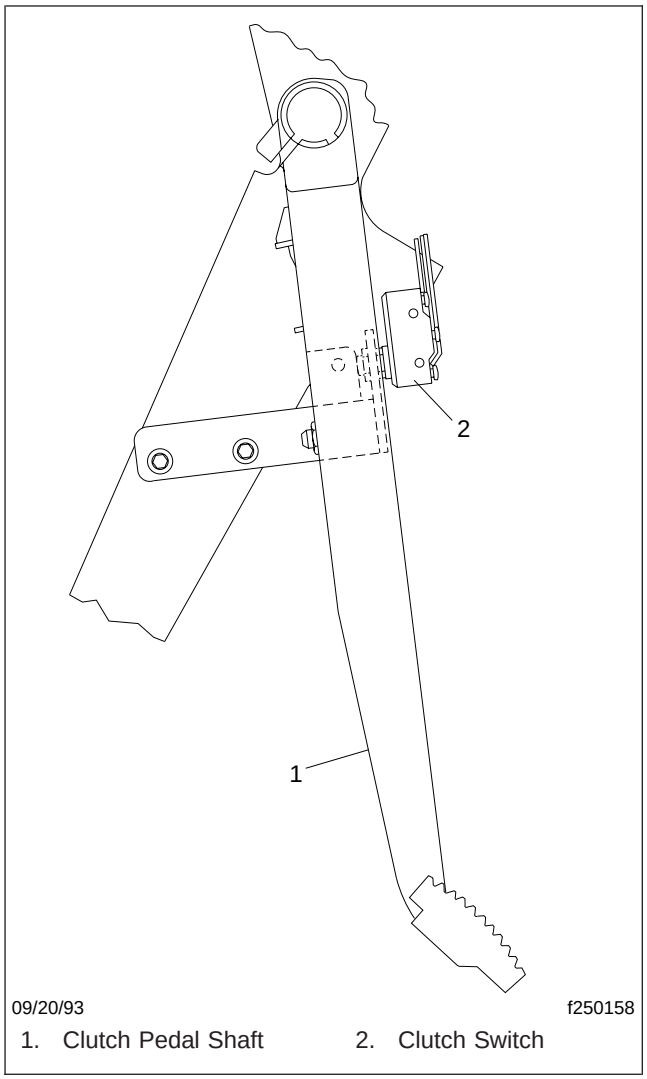


Fig. 3, Plunger-Type Clutch Switch

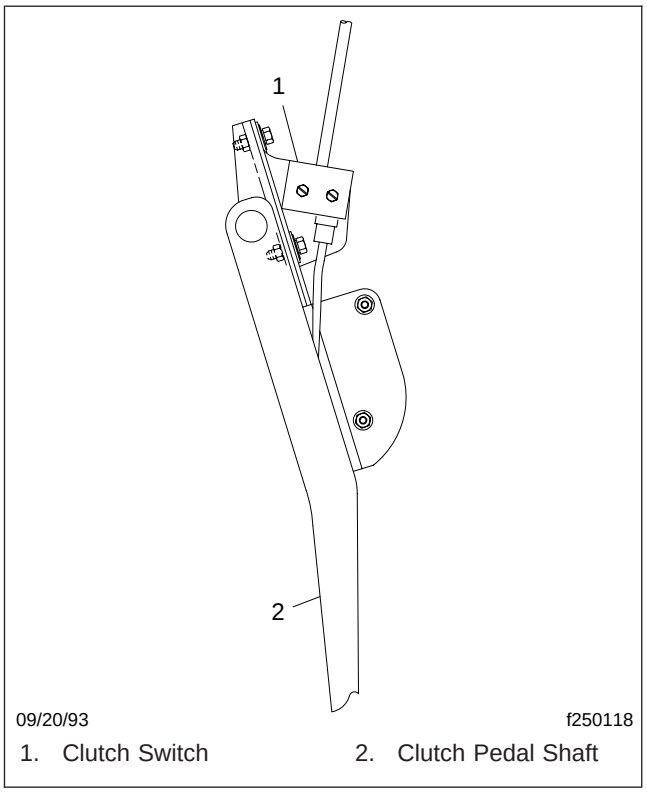


Fig. 4, Arm-Type Clutch Switch

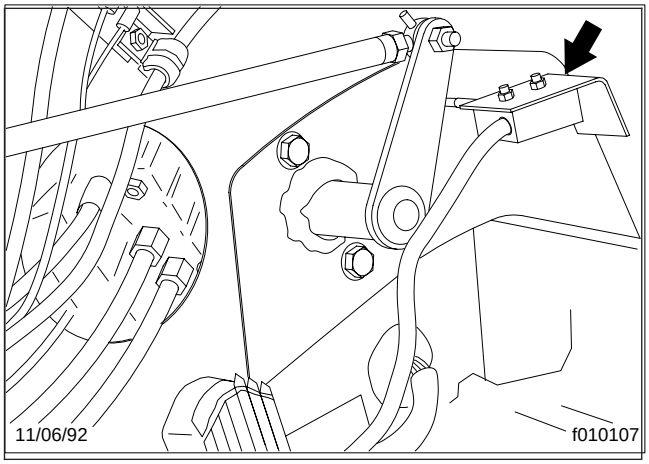
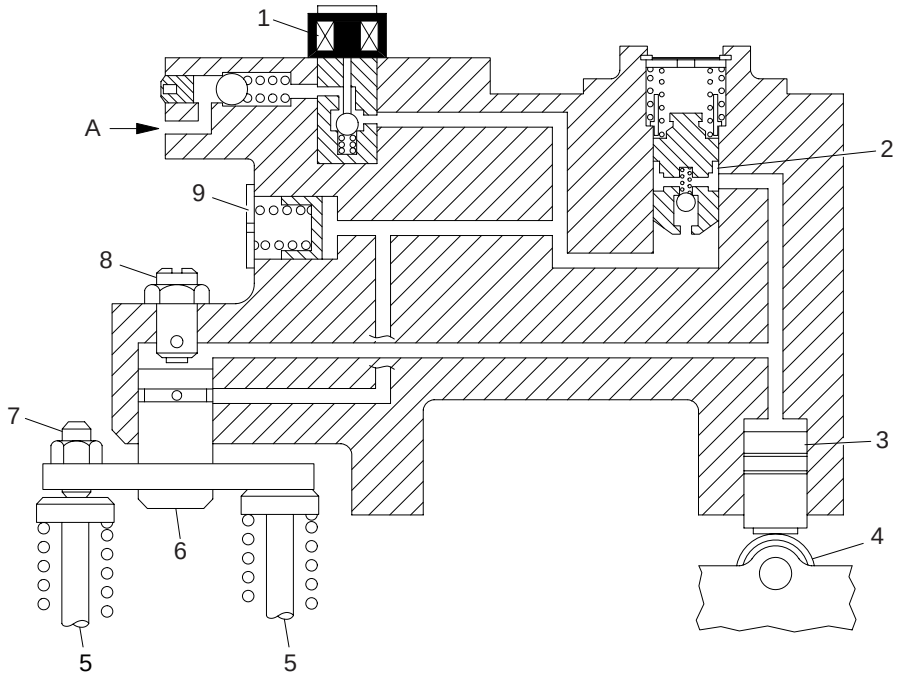


Fig. 5

General Description and Principles of Operation



06/29/95 f010415

A. Oil In
1. Solenoid Valve
2. Control Valve
3. Master Piston
4. Injector Pin and Roller
5. Exhaust Valve
6. Slave Piston Assembly
7. Leveling Screw
8. Slave Piston Adjusting Screw (Reset)
9. Accumulator

Fig. 6

Dash Switch Replacement

NOTE: See **Fig. 1** or **Fig. 2** for the applicable engine brake wiring diagram.

1. Park the vehicle and disconnect the battery.
2. Remove the screws that attach the control panel to the dash. Lift the panel to a serviceable level.

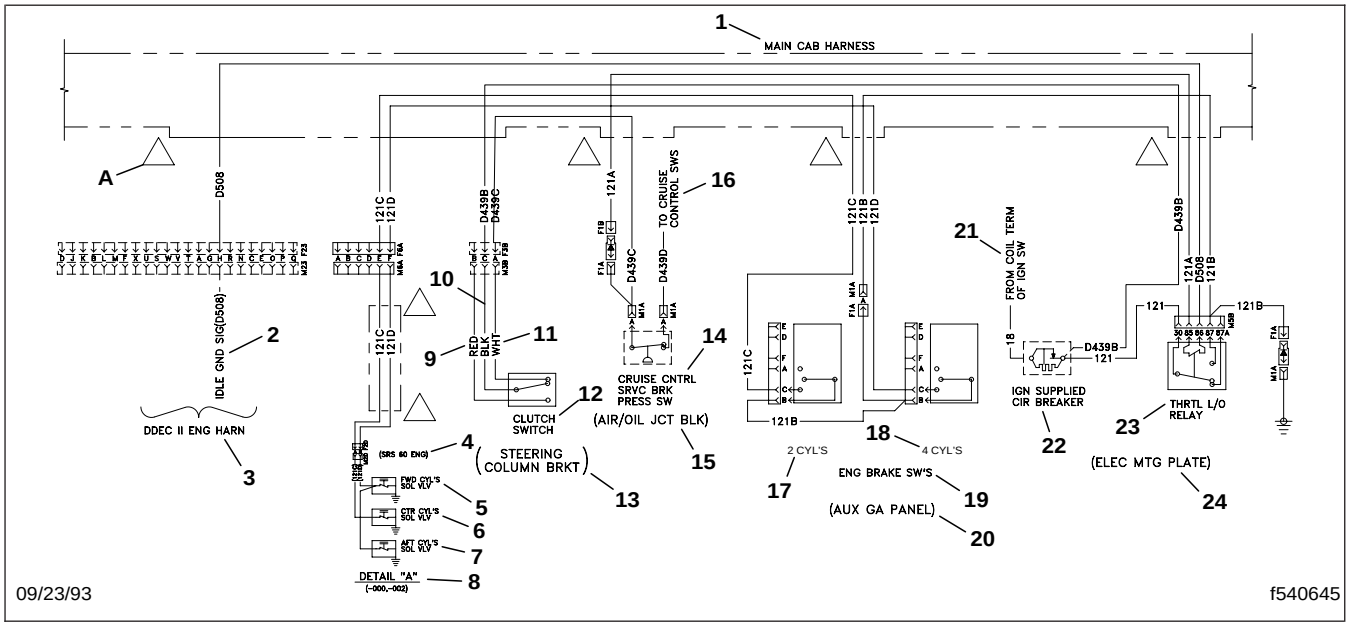


Fig. 1, Jake Brake With Cruise Control

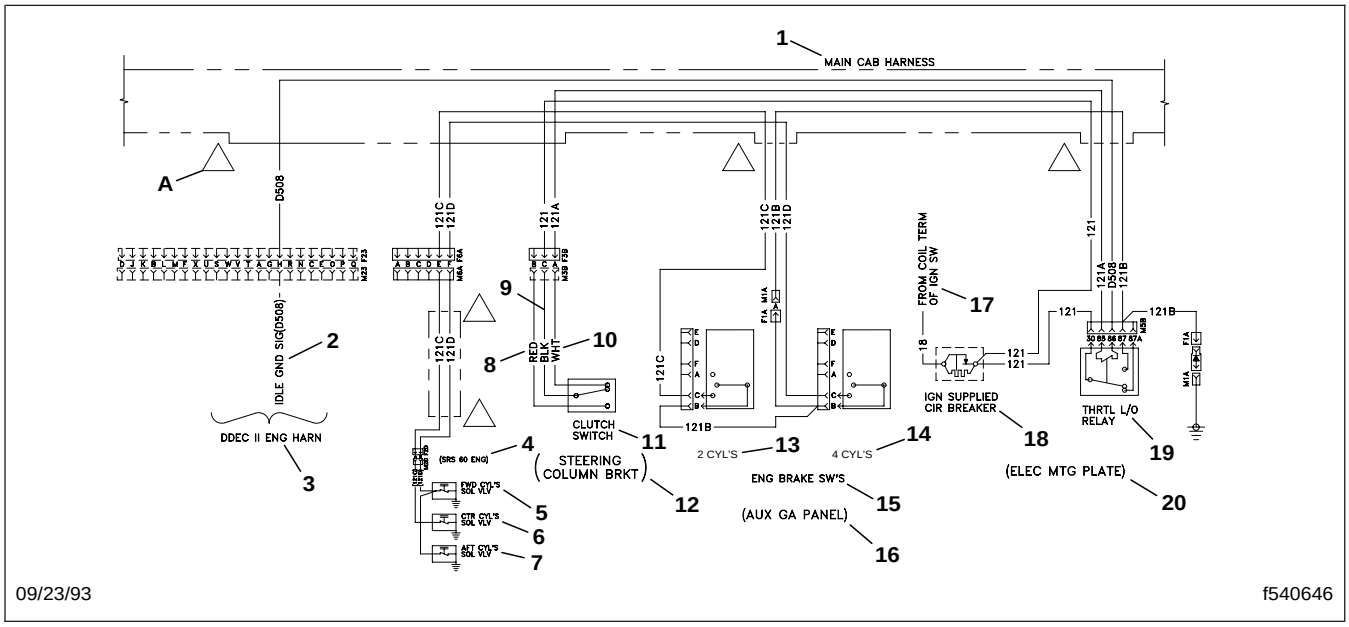


Fig. 2, Jake Brake Without Cruise Control

Switch and Control Module Replacement

3. Remove the switch cap nut, and remove the switch from the panel.
4. Mark the wires for later reference, then disconnect them from the switch.
5. Connect the wires to the new switch, as previously marked.
6. Install the switch through the rear of the panel, and attach it with the cap nut.
7. Place the panel in the dash, and attach it with the screws.
8. Connect the battery.

Clutch Switch Replacement

NOTE: See **Fig. 1** or **Fig. 2** for the applicable engine brake wiring diagram.

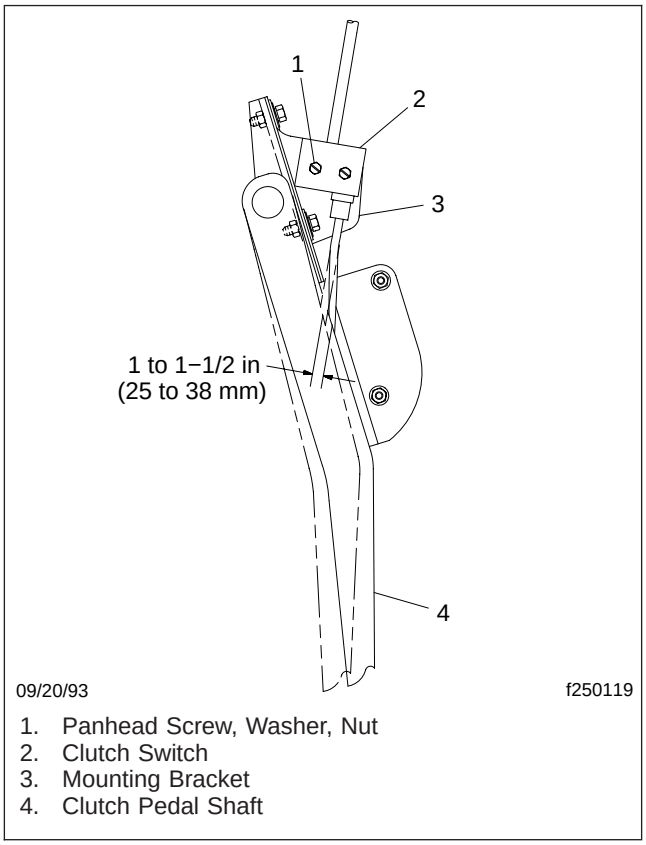
1. Set the parking brake, then chock the tires.
2. Mark the wires for later reference; disconnect them from the clutch switch at the top of the clutch pedal shaft.
3. Remove the nuts, washers, and screws that attach the switch to the mounting bracket. Remove the switch.
4. Place the new switch on the bracket, and loosely install the screws, washers, and nuts. See **Fig. 3**, **Fig. 4**, or **Fig. 5**.

   Adjust the plunger-type switch side-to-side so that the center of the plunger contacts the center of the clutch lever rib. Add or remove starwashers as shown in **Fig. 6** to adjust the plunger travel. Tighten the switch mounting nuts securely.

   On the arm-type switch, the switch arm should deflect 1 to 1-1/2 inches (25 to 38 mm) when the clutch is engaged. See **Fig. 3**. Tighten the switch mounting nuts securely.
5. Connect the wires to the switch, as previously marked.
6. Remove the chocks from the tires.

Control Module Replacement

To replace the control module, disconnect the two wiring harnesses. Remove the two control module mounting screws. Mount the new control module, install and tighten the screws, and connect the harnesses.

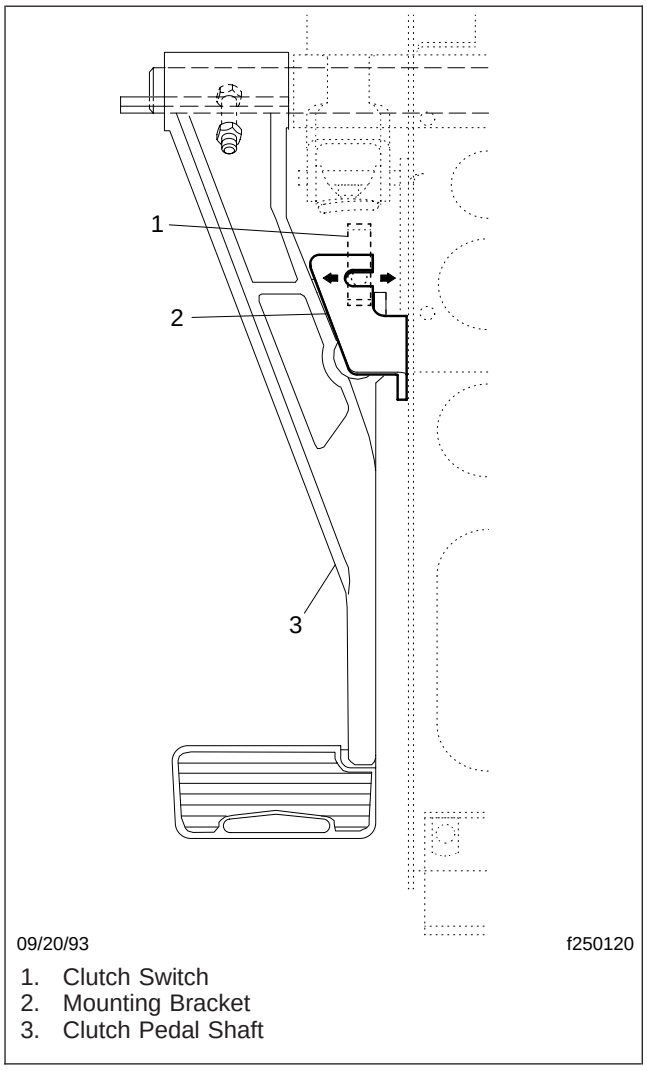


1. Panhead Screw, Washer, Nut
2. Clutch Switch
3. Mounting Bracket
4. Clutch Pedal Shaft

Fig. 3, Arm-Type Clutch Switch (FLD Conventional shown)

⚠ CAUTION

Do not allow the control module to hang unmounted or merely tie-wrapped behind the dash. The control module will be stressed and could malfunction.



1. Clutch Switch
2. Mounting Bracket
3. Clutch Pedal Shaft

Fig. 4, Plunger-Type Clutch Switch (FLD Conventional shown)

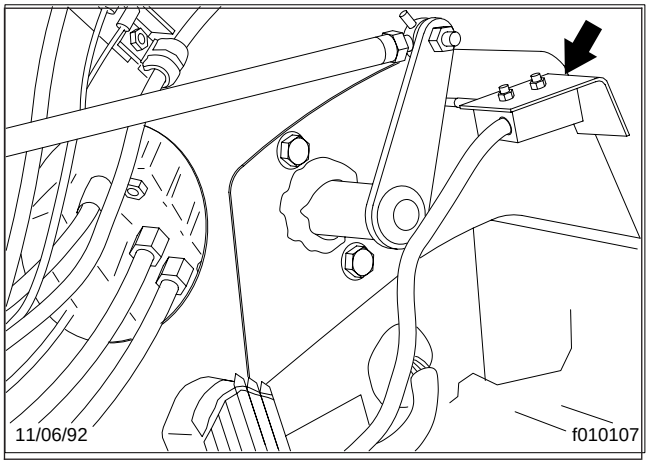
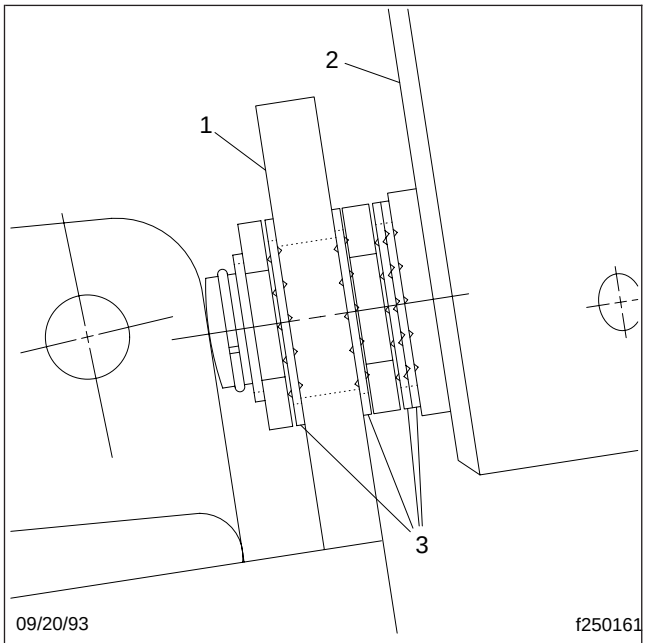


Fig. 5, Clutch Switch Mounting (COE shown)



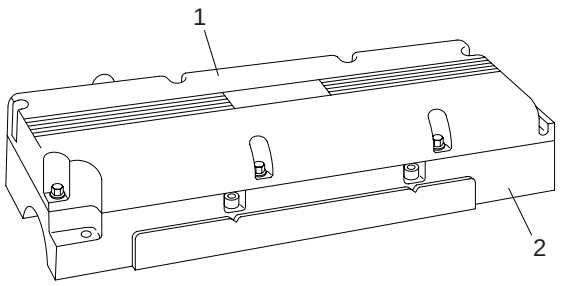
1. Mounting Bracket
2. Switch
3. Starwashers

Fig. 6

NOTE: The Model 760 engine brake has been designed to fit on the Series 60 engine with no additional valve cover spacers. On engines equipped with aluminum valve cover caps (**Fig. 1** and **Fig. 2**), it is not necessary to remove the valve cover bases to remove and install the engine brake housings.

Removal

1. Remove each valve cover and gasket.
2. Remove the engine brake housing hold-down capscrews. There is one capscrew per housing on the camshaft side of the engine. There are two capscrews per housing on the exhaust manifold side of the engine.
3. Remove the spacer bar between the exhaust side of each head and each engine brake housing mounting pad.
4. Lift each engine brake housing off the rocker shaft.



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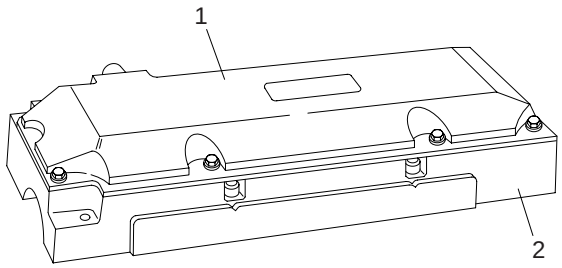
1. Valve Cover Cap — Aluminum Style 1
2. Valve Cover Base

Fig. 1

Installation

1. Place the spacer bars between the cylinder head and the engine brake mounting pads on the exhaust manifold side of the head. **See Fig. 3** and **Fig. 4**.
2. Place each engine brake housing over the rocker shaft with the solenoid valves toward the camshaft side of the engine. Make sure the housings don't interfere with the wiring harness.

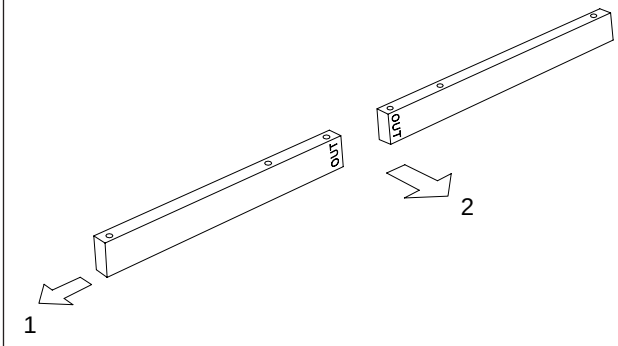


07/10/95 f010417

1. Valve Cover Cap — Aluminum Style 2
2. Valve Cover Base

Fig. 2

3. Apply "Never Seize" to the threads and underside of the head of the housing hold-down capscrews.
4. Install the 4-3/4 inch (120 mm) long capscrews and their washers in each engine brake housing on the exhaust manifold side. There are two capscrews per housing. **See Fig. 5**.



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1. Rear
2. Exhaust Manifold

Fig. 3

5. Install the 4-3/8 inch (110 mm) long capscrew and its washer into each engine brake housing on the camshaft side. **See Fig. 6**. There is one capscrew per housing.
6. Before tightening the engine brake hold-down capscrew, move the housing from side to side, and then locate the housing in the center position of the movement. **See Fig. 7**.

Engine Brake Housing Removal and Installation

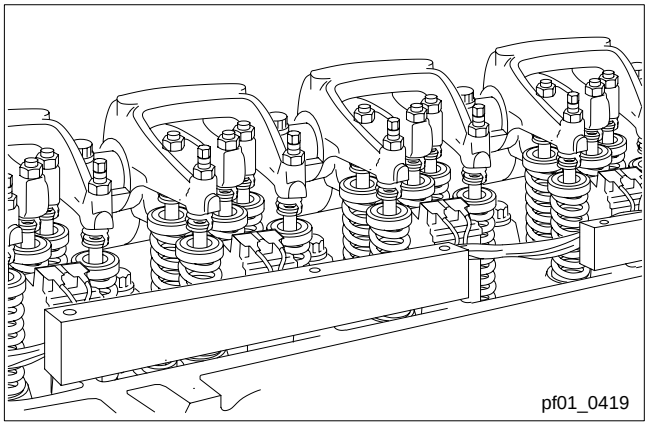


Fig. 4

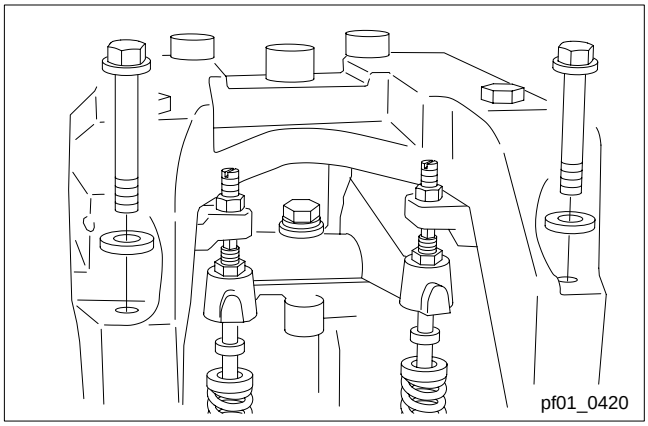


Fig. 5

7. Tighten the engine brake housing hold-down capscrews as follows:
   - 7.1 Tighten the three capscrews on the camshaft side of the engine 40 lbf·ft (55 N·m).
   - 7.2 Tighten the six capscrews on the exhaust manifold side of the engine 40 lbf·ft (55 N·m).
   - 7.3 In the same sequence, tighten all capscrews 80 lbf·ft (110 N·m).
8. Using plastic ties, secure the wiring harnesses to the spacer bars.
9. Adjust the slave piston lash. For instructions **refer to Subject 140.**
10. Install the valve covers. For instructions, refer to the Detroit Diesel Engine service manual.

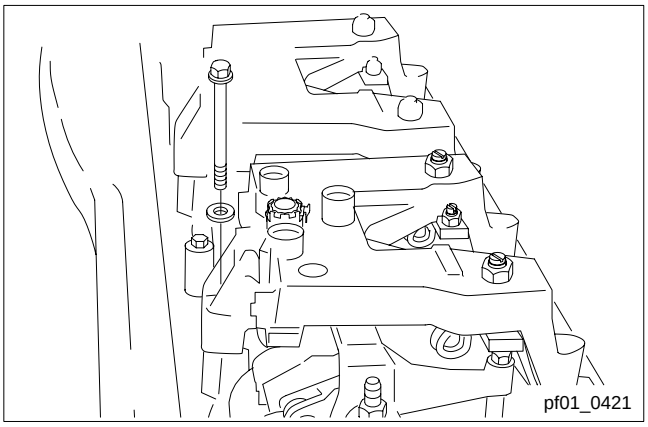


Fig. 6

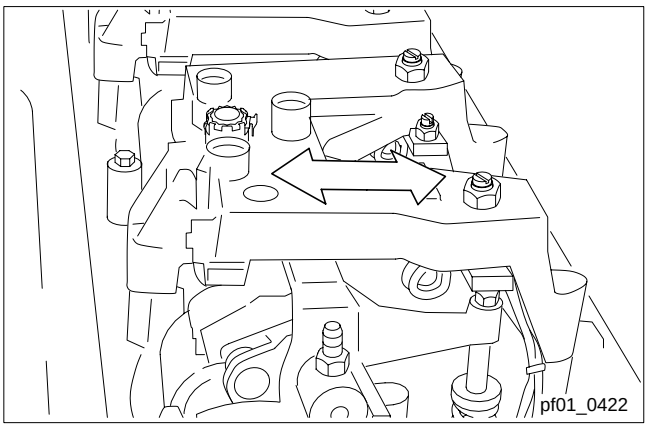


Fig. 7

Control Valve Removal, Inspection, and Installation

Removal

⚠ WARNING

WARNING: Never remove any engine brake component with the engine running. Personal injury may result.

1. Tilt the cab or open the hood. For instructions, refer to the applicable driver's manual.
2. Wipe the engine brake housing area clean. Remove the capscrews from the valve cover; then, remove the valve cover.
3. Press down on the control valve cover to relieve spring pressure. **See Fig. 1**.
4. Remove the retaining ring using retaining ring pliers.
5. Slowly remove the cover until the spring pressure is released; then, remove the two control valve springs and the collar. **See Fig. 2**.
6. Using needle nose pliers, reach into the housing bore and grasp the stem of the control valve. Remove the control valve. **See Fig. 3**.

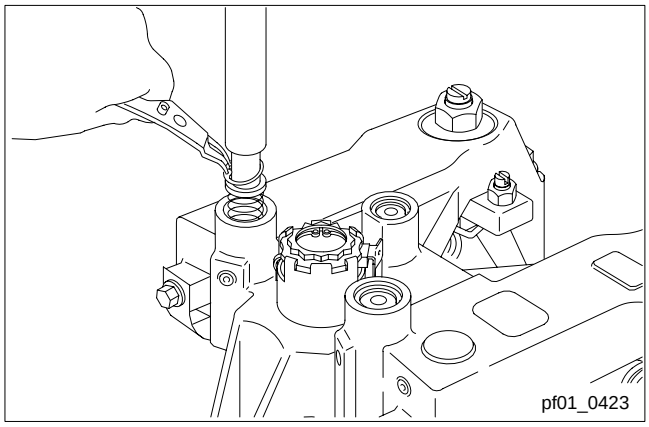


Fig. 1

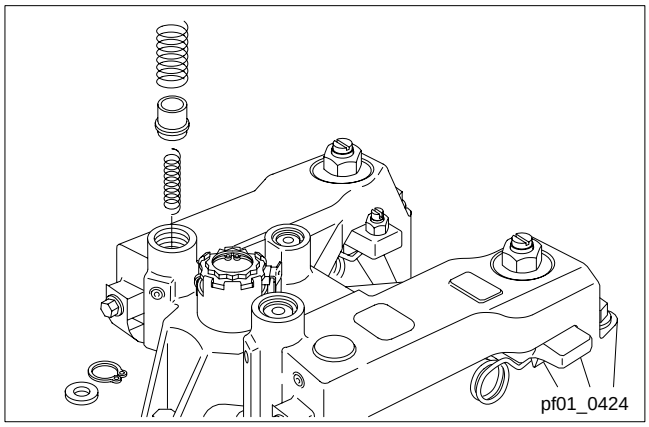


Fig. 2

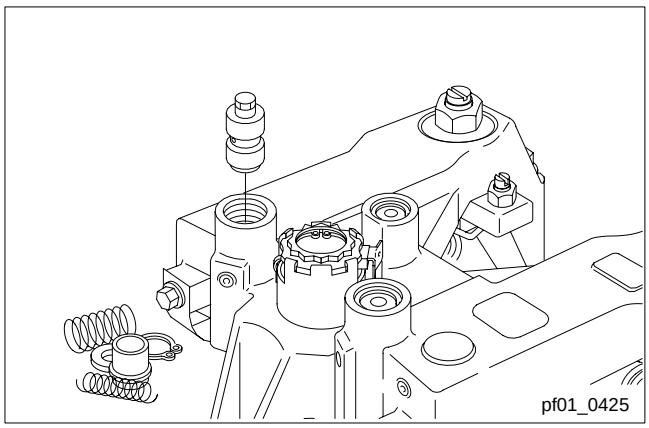


Fig. 3

Inspection

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Wash the control valves with a cleaning solvent that meets OSHA guidelines.
2. Push a wire through the hole in the base of the valve to make sure the ball check is free. The ball should lift with light pressure on the wire.
3. Dry the valve with compressed air and wipe it clean with a paper towel.
4. Using clean paper towels, thoroughly clean the control valve bore in the housing.
5. Dip the control valves in clean lubricating oil. Holding the valve by the stem, let the valve drop into its bore. If it binds or if the ball is stuck in the valve, replace the control valve.

Control Valve Removal, Inspection, and Installation

Installation

IMPORTANT: Be sure to coat all parts with clean lubricating oil before installing them.

1. Install the control valve reversing the removal procedure.

NOTE: Make sure the control valve collar is installed with the longer sleeve area up. **See Fig. 4**. If the collar is installed upside down, the engine brake cylinder will not operate.

2. Make sure the retaining ring ears are rotated 90 degrees after installation.

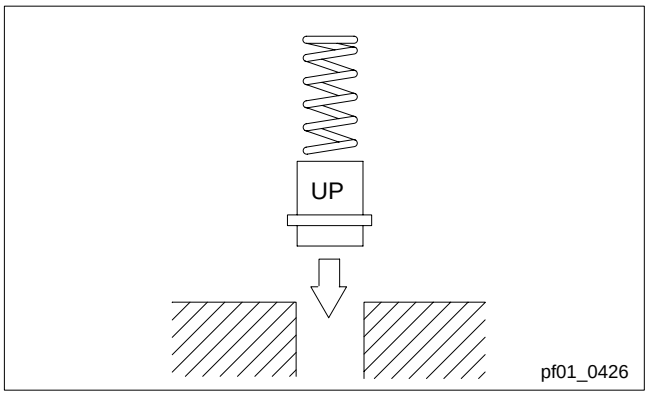


Fig. 4

Solenoid Valve Removal and Installation

Removal

1. Disconnect the solenoid harness.
2. Using a 7/8-inch socket and extension, unscrew the solenoid valve. **See Fig. 1**.

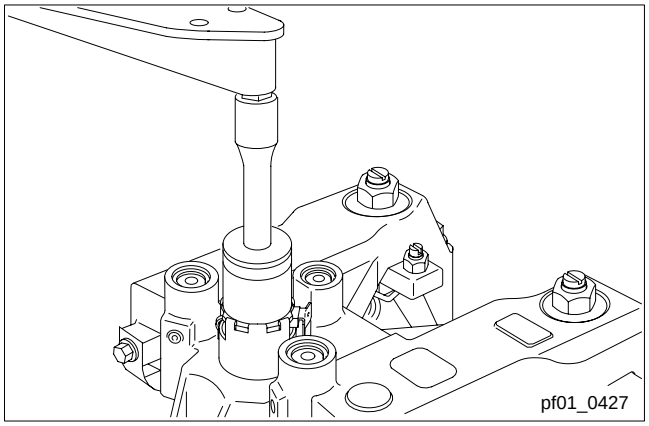
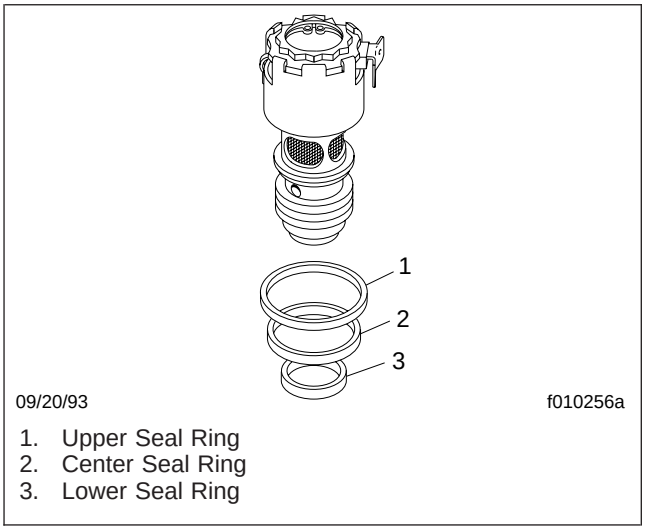


Fig. 1

CAUTION

CAUTION: Do not disassemble or tamper with the solenoid valve. Engine damage could result.

3. Remove and discard the three rubber seal rings. **See Fig. 2**. If the lower ring stays in the bottom of the solenoid bore in the housing, remove it with a piece of wire.



1. Upper Seal Ring
2. Center Seal Ring
3. Lower Seal Ring

Fig. 2

WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

4. Wash out the solenoid valve with a cleaning solvent that meets OSHA guidlines. Use a brush to clean the oil screen.
5. Dry the valve with compressed air.
6. Using clean paper towels, clean out the solenoid valve bore in the housing. Do not use rags, since they can leave lint and residue, which can plug the oil passageways.

Installation

1. Coat a new set of solenoid seal rings with clean lubricating oil. Install the upper and middle seal rings on the solenoid body and the lower seal ring into the bottom of the solenoid bore in the housing. **See Fig. 3**.

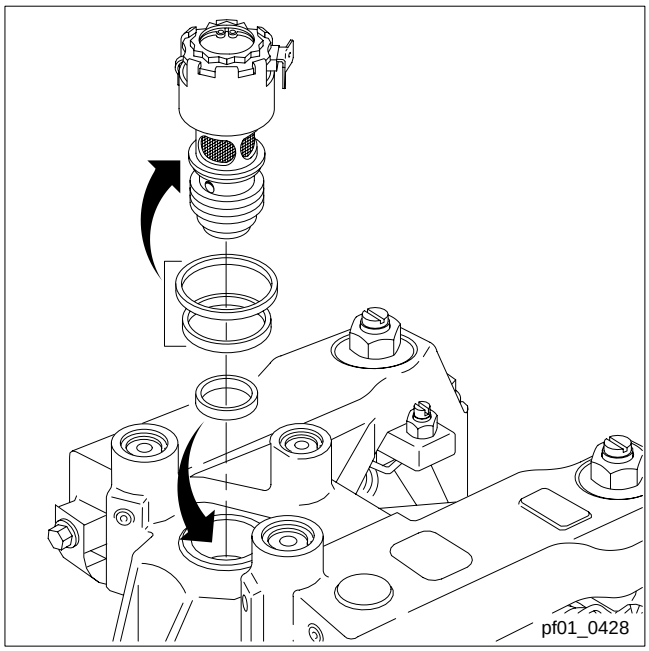


Fig. 3

Solenoid Valve Removal and Installation

2. Make sure the seals are seated properly and not twisted. Carefully screw the solenoid into the housing without unseating the seals.
3. Tighten the valve 60 lbf·in (680 N·cm).
4. Connect the solenoid harness.

Slave Piston Removal, Inspection, Installation, and Adjusting

Removal

1. Remove the engine brake housing from the vehicle using the instructions in **Subject 110.**
2. Remove the screw and spring that retain the slave piston assembly. **See Fig. 1**.
3. Remove the bridge and the slave piston. **See Fig. 2**.
4. Loosen the leveling screw locknut and remove the leveling screw from the bridge. **See Fig. 3**.

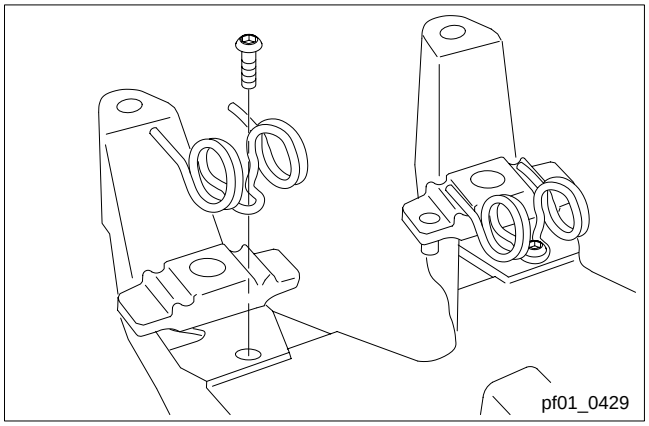


Fig. 1

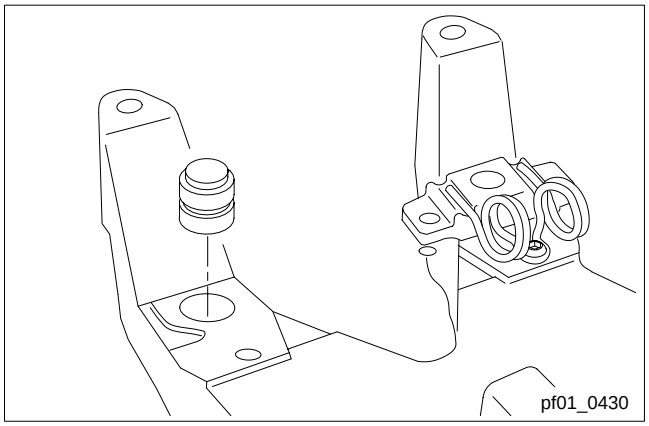


Fig. 2

Inspection

1. Inspect all components for excessive wear and for damage.
2. Replace parts as needed.

Installation

1. Install the leveling screw in the bridge. **See Fig. 3**. Tighten the locknut 25 lbf·ft (35 N·m).
2. Install the slave piston and the bridge with the leveling screw toward the center of the housing. **See Fig. 4**.

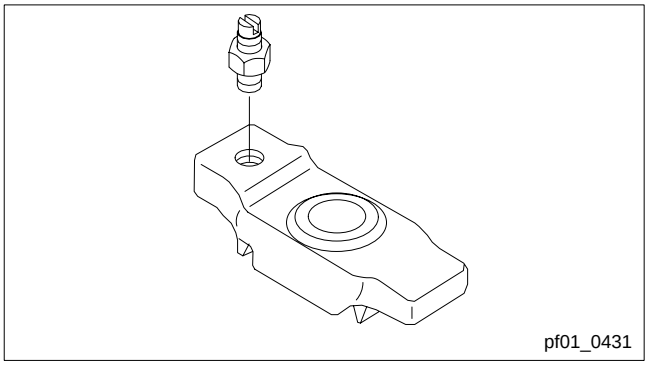


Fig. 3

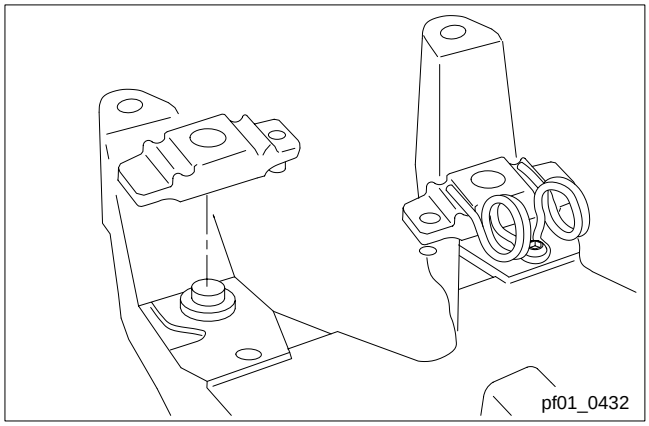


Fig. 4

3. Install the slave piston assembly retaining spring with the ends over the bridge. **See Fig. 5**.
4. Install the screw over the center part of the spring. Tighten the screw 15 lbf·ft (20 N·m).
5. Install the engine brake housing on the engine using the instructions in **Subject 110.**

Slave Piston Removal, Inspection, Installation, and Adjusting

Adjusting

CAUTION

CAUTION: Follow the slave piston adjustment procedure exactly. Failure to use the correct adjustment procedure will result in poor engine brake performance and serious engine damage.

NOTE: Make the following adjustment with the engine stopped and the oil temperature 140°F (60°C) or lower. Rotate the engine until the exhaust valves on the cylinder to be adjusted are closed (rocker arm is loose).

1. Back out the *leveling screw* in the slave piston assembly until the end of the screw is beneath the surface of the bridge in the slave piston assembly. **See Fig. 6**.

NOTE: The leveling screw is the screw located in the bridge member of the slave piston assembly.

2. Place the correct feeler gauge between the solid side of the *bridge* (the side without the leveling screw) and the exhaust rocker arm adjusting screw. **See Fig. 7**. **See Table 1** for the correct feeler gauge.

NOTE: A "G" in position 5 of the model number indicates a 12.7 liter engine; "W" indicates an 11.1 liter engine. Typical model numbers: 6067GU40 or 6067WU40. The model number is stamped on the engine block beneath the intake manifold. **See Fig. 8**.

3. Turn the slave piston adjusting screw clockwise until a light drag is felt on the feeler gauge.

Engine Model (Displacement)	Feeler Gauge inches (mm)
12.7 liter	0.020 (0.5)
11.1 liter	0.040 (1.0)

Table 1

4. While holding the screw in this position, tighten the locknut 25 lbf·ft (35 N·m). **See Fig. 9**.

IMPORTANT: The slave piston adjusting screws used in the Model 760 Engine Brake are reset screws. Do not disassemble these reset screws in the field.

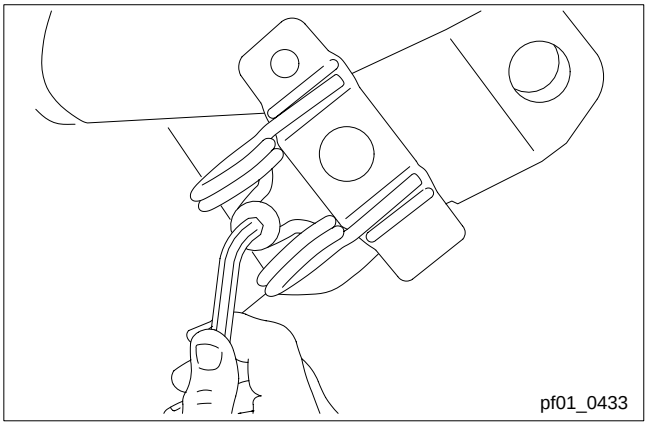


Fig. 5

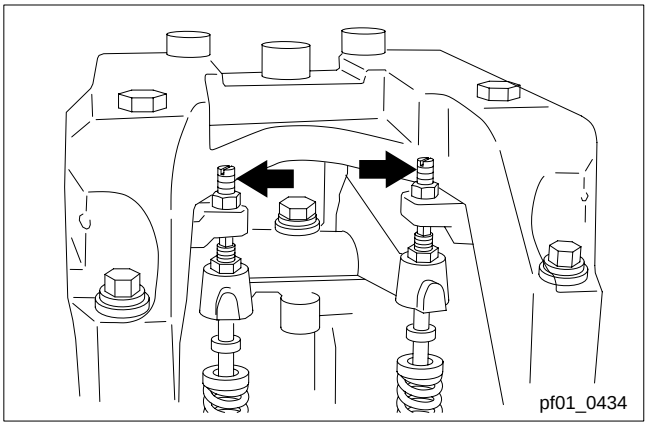


Fig. 6

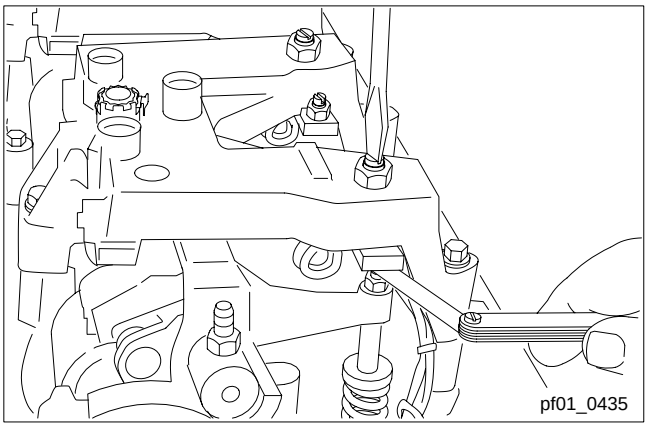
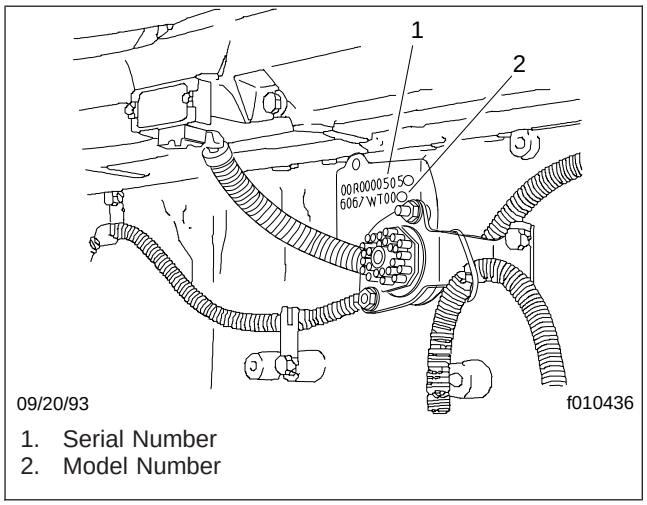


Fig. 7

5. Following the same procedure, set 0.020-inch (0.5-mm) clearance between the slave piston



1. Serial Number
2. Model Number

Fig. 8

leveling screw and the rocker arm adjusting screw. **See Fig. 10**.

6. While holding the leveling screw in this position, tighten the locknut 35 lbf·ft (47 N·m).
7. Repeat the steps above for slave pistons of the remaining cylinders. Rotate the engine to close the exhaust valves for the cylinder being adjusted.

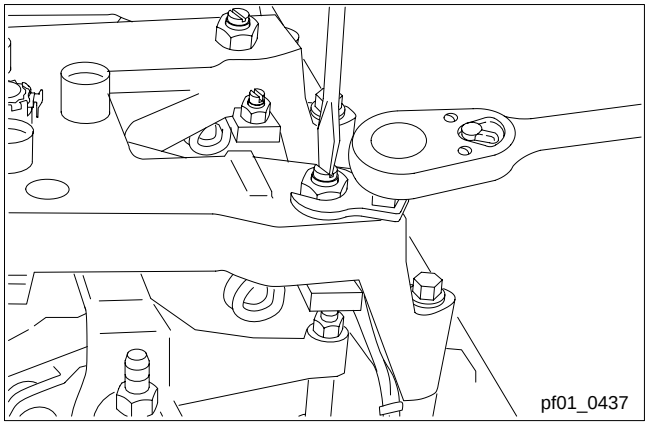


Fig. 9

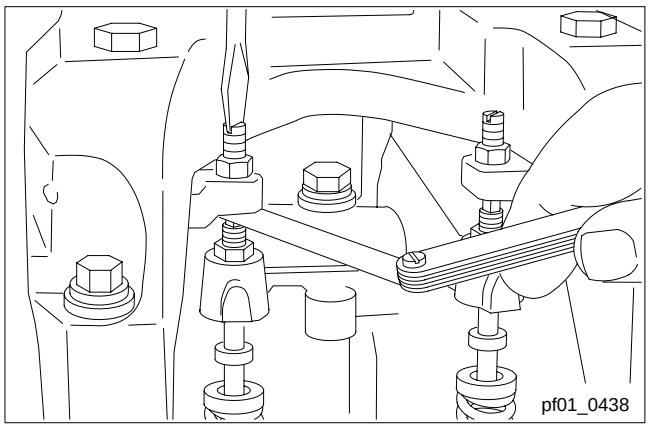


Fig. 10

Slave Piston Adjusting Screw Removal, Inspection, and Installation

Removal

Loosen the slave piston adjusting screw locknut and remove the adjusting screw from the housing. **See Fig. 1**.

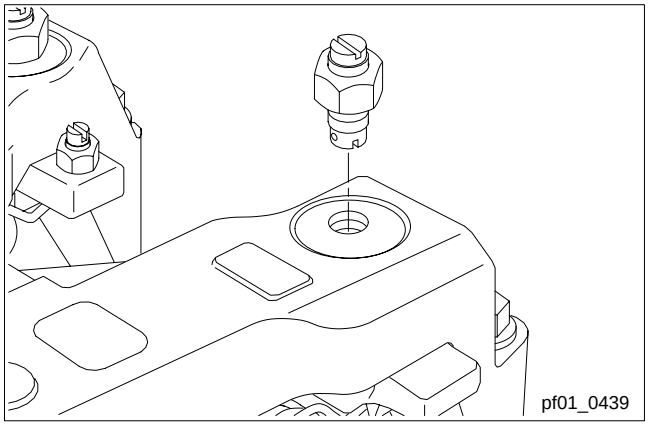


Fig. 1

Inspection

WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Clean the adjusting screw in cleaning solvent.
2. Inspect the slave piston adjusting screw. The plunger should protrude from the bottom of the screw. There should be light spring pressure when the plunger is depressed, and the plunger should move freely. **See Fig. 2** . If any defect is found, replace the entire screw assembly.

CAUTION

CAUTION: Do not disassemble or tamper with the slave piston adjusting screw assembly. Engine damage could result.

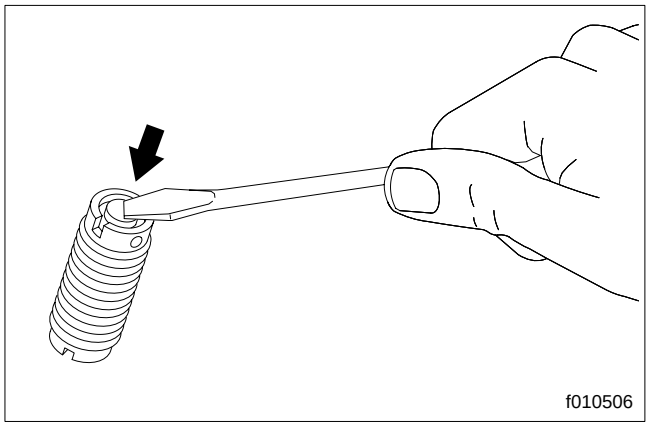


Fig. 2

Installation

CAUTION

CAUTION: Do not use Auto-Lash® adjusting screws or solid screws in Model 760 engine brakes. The Model 760 slave piston adjusting screws (reset type) are not the same as those used in other brake models. See Fig. 3. For proper identification, refer to the Model 760 parts manual. The part number is stamped on the top of the adjusting screw. Using other than Jacobs-recommended parts may result in engine damage.

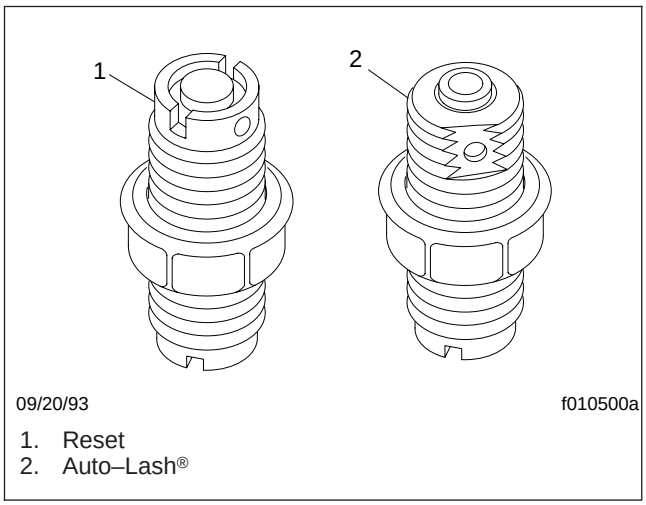


Fig. 3

Slave Piston Adjusting Screw Removal, Inspection, and Installation

1. Screw the slave piston adjusting screw into the housing.
2. Tighten the locknut 25 lbf·ft (34 N·m).

Master Piston Removal, Inspection, and Installation

Removal

1. Remove the engine brake housing from the vehicle. For instructions, refer to **Subject 110.**
2. Remove the screw, washer, and master piston spring from the housing. **See Fig. 1**.
3. Using needle nose pliers if necessary, pull out the master piston. **See Fig. 2**.

Inspection

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Clean the piston in a cleaning solvent that meets OSHA guidelines.
2. Inspect the piston for excessive wear and for damage. Replace the piston if necessary.

Installation

1. Install the master piston, spring, washer, and screw in the housing. **See Fig. 3**.

NOTE: Make sure the spring legs are centered around the master piston boss.

2. Tighten the screw 100 lbf·in (1120 N·cm).
3. Install the engine brake housing on the vehicle. For instructions, refer to **Subject 110.**

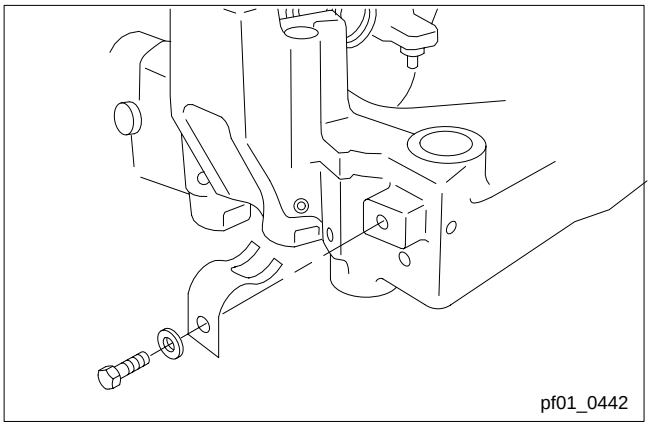


Fig. 1

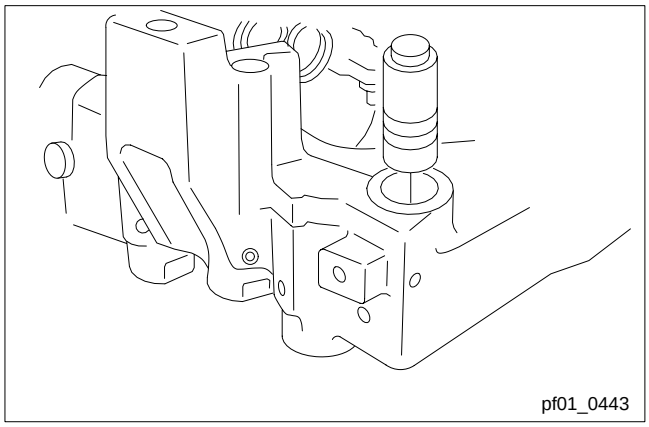


Fig. 2

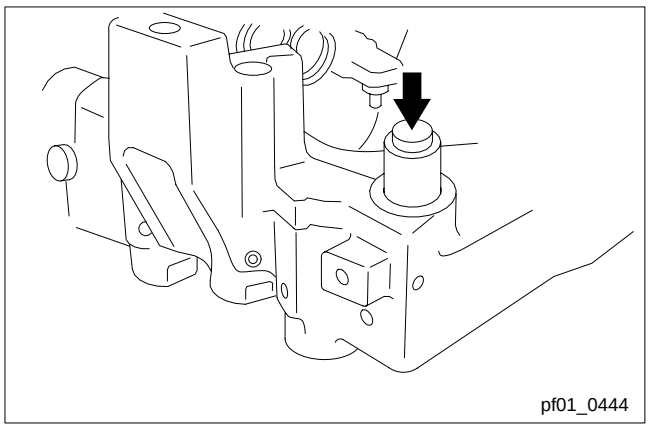


Fig. 3

Accumulator Removal, Inspection, and Installation

Removal

⚠ WARNING

WARNING: The accumulator spring is under strong compression. Be careful when removing the retaining ring and cover. Wear safety glasses. If the spring is accidentally released, personal injury could result.

1. Remove the engine brake housing from the vehicle. For instructions, refer to **Subject 110.**
2. Push down on the accumulator cover and remove the retaining ring. **See Fig. 1**.
3. Remove the cover and spring. **See Fig. 2**.
4. Using a magnet, remove the piston from the accumulator bore. **See Fig. 3**.

Inspection

Inspect the parts for wear and damage. Replace parts as needed.

Installation

1. Install the piston, spring, cover, and retaining ring.
2. Install the engine brake housing. For instructions, refer to **Subject 110.**

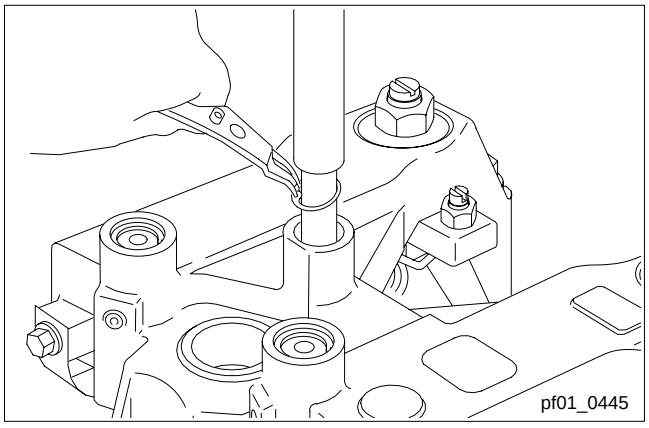


Fig. 1

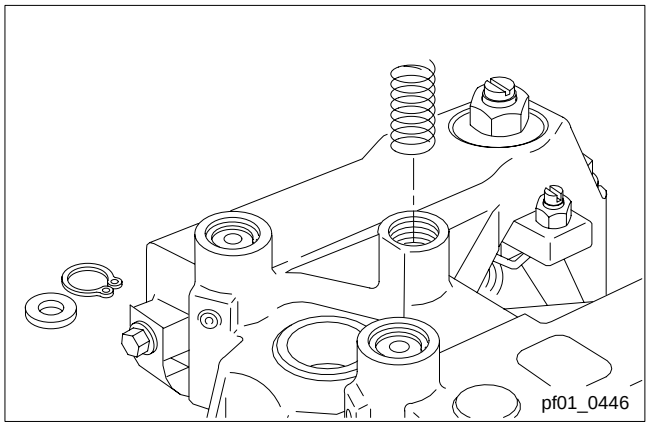


Fig. 2

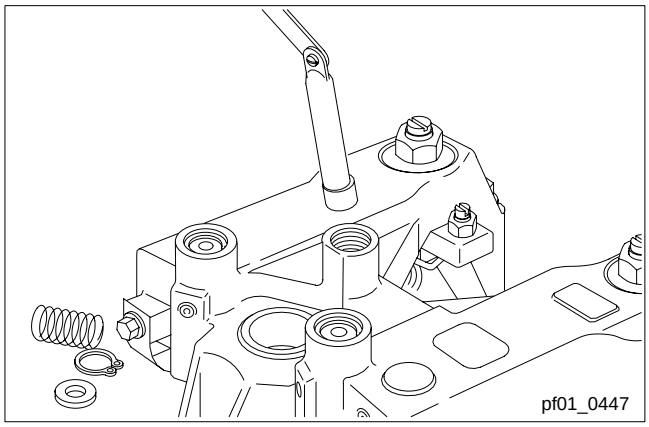


Fig. 3

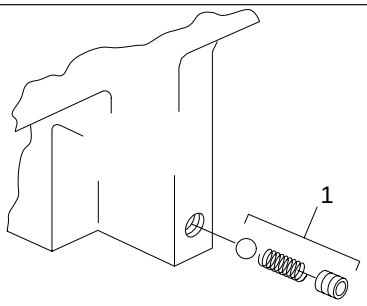
Ball Check Valve Removal and Installation

Removal

1. Remove the plug to remove the ball check valve and spring. **See Fig. 1**.
2. Clean the ball and spring as needed.

Installation

1. Install the ball, spring, and plug, making sure the ball does not bind.
2. Tighten the plug firmly.



1. Ball Check Valve

Fig. 1, Front Underside of Housing

Master Piston Pin and Roller Removal, Inspection, and Installation

NOTE: The injector rocker arm contains a pin and roller for actuating the engine brake master piston. If the roller is excessively worn or damaged, replace the entire injector rocker arm. Pins and rollers are not available as service parts. Injector rocker arm assemblies are available from Detroit Diesel Corporation.

Removal

1. Remove the engine brake housings. For instructions, refer to **Subject 110.**
2. Loosen the locknuts on the intake, exhaust, and injector adjusting screws.
3. Remove the spacers, nuts, and bolts from the rocker shafts. **See Fig. 1**.

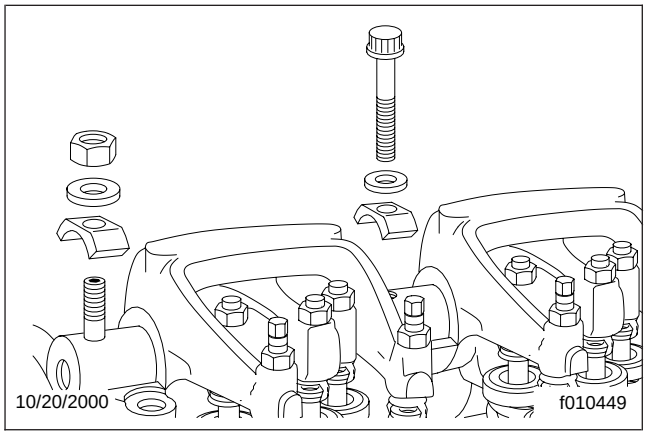


Fig. 1

4. Lift off the rocker shaft assembly with the rocker arms in place. **See Fig. 2**.
5. Slide the rocker arms off the shaft, marking the parts so they may be installed later in the same positions. **See Fig. 3**.

Inspection

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

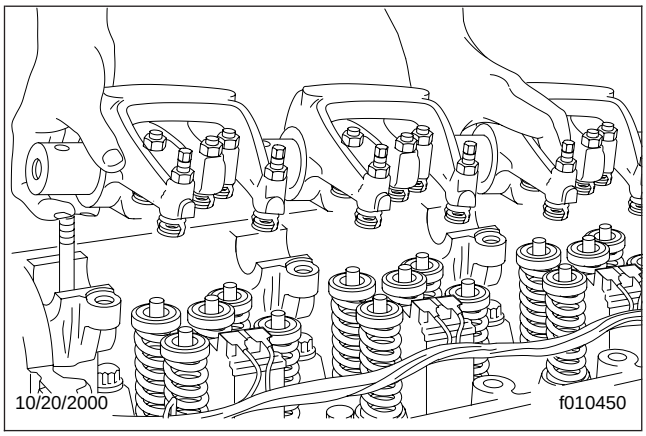


Fig. 2

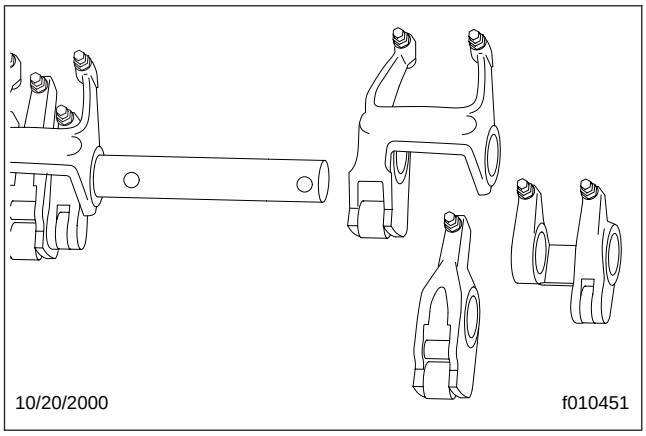


Fig. 3

1. Clean the rocker arms and rocker arm shafts in a cleaning solvent that meets OSHA guidelines. Blow them dry with compressed air.
2. If the roller is excessively worn or damaged, replace the injector rocker arm.

Installation

1. Assemble the rocker arms on the rocker shaft. **See Fig. 4**.
2. Check the torque on the rocker shaft studs to make sure they were not loosened when the nuts were removed. Tighten the studs 80 lbf·ft (110 N·m). **See Fig. 5**.
3. Mount the rocker shaft to the head using the bolts, end spacers, and nuts removed earlier.

Master Piston Pin and Roller Removal, Inspection, and Installation

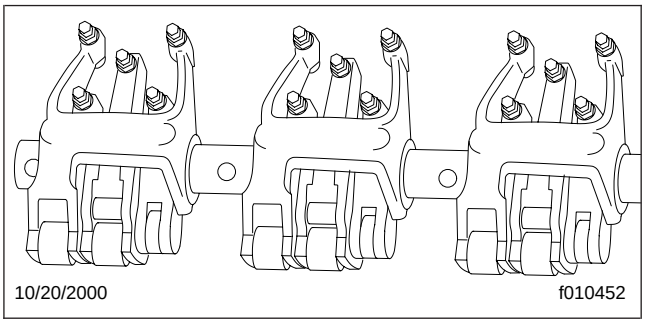


Fig. 4

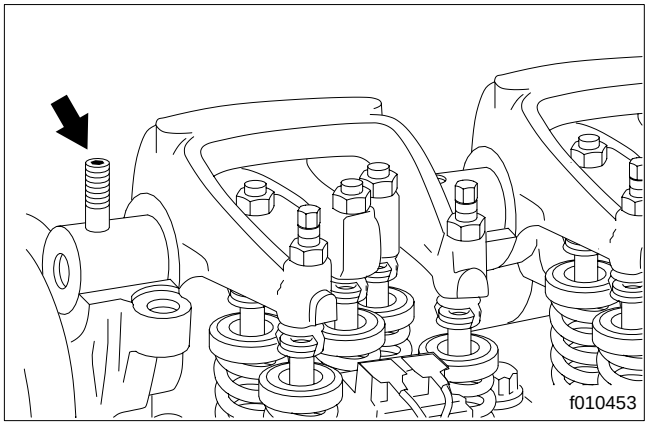


Fig. 5

Tighten the bolts and nuts 80 lbf·ft (110 N·m) in the sequence shown in **Fig. 6** .

4. Adjust the valve clearance and injector height. Refer to the Detroit Diesel Engine service manual for instructions.
5. Install the engine brake housing. For instructions, refer to **Subject 110.**

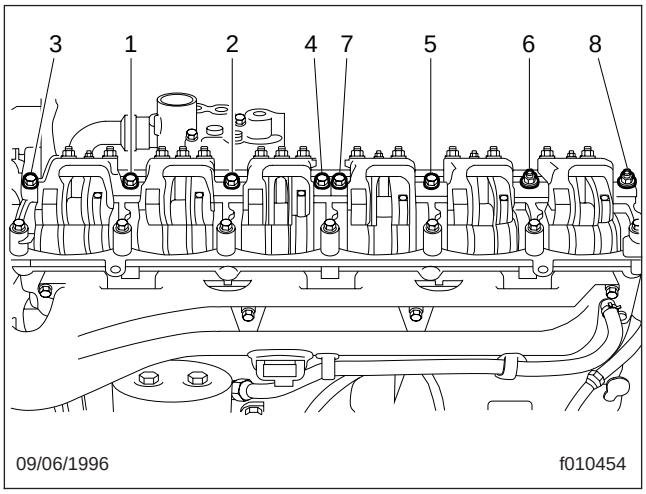


Fig. 6

Checking

To properly troubleshoot the engine brake, the mechanic *must* know the supply oil pressure reading at the engine brake housing. The oil pressure reading on the instrument panel gauge is *not* the same as at the engine brake housings.

1. Make an oil pressure gauge adapter as follows:
   - 1.1 Remove the tin cap from a used solenoid valve and press off the coil assembly.
   - 1.2 Using a hex wrench, remove the bottom screw. Remove the internal components from the valve and the oil screen and retainer.
   - 1.3 Fill the four small holes directly below the center O-ring with steel rod and braze them. Install the bottom screw and braze closed the hex hole and surrounding screw area.
   - 1.4 Clean the valve body and wire brush the hole in the top of the body. A gauge with a range of 0 to 100 psi (0 to 689 kPa) will generally require a 1/8 NPT tap.
   - 1.5 Install a hose in the adapter and install the pressure gauge on the hose. Flats can be ground in the sides of the valve so it can be tightened with a wrench.
2. Using Jacobs wrench 11494, remove the solenoid valve from the housing being checked.
3. Insert the oil pressure gauge (from earlier step) into the solenoid bore. The three solenoid seal rings must be used on the solenoid adapter.
4. Start the engine and allow it to warm up.
5. Record the oil pressure readings at low idle speed.
6. Increase the engine speed to 1000 rpm. Record the pressure.
7. Increase the engine speed to 1500 rpm. Record the pressure.
8. Increase the engine speed to high idle speed and record the pressure.
9. Allow the engine to return to low idle speed.
10. Repeat the oil pressure checks in all the housings equipped with solenoid valves.
11. Shut down the engine. Remove the control valve covers and make sure the correct control valve springs are used.
12. The full-flow oil pressure range for the Model 760 is 25 to 56 psi (172 to 386 kPa). Pressure over 78 psi (538 kPa) can cause engine brake malfunction. If the engine is not within specifications, it should be examined by an authorized facility and repaired if necessary.

Troubleshooting Chart

Problem—Engine Will Not Start

Possible Cause	Remedy
The solenoid valve is stuck in the "on" position.	Make sure the electrical current to the engine brake is off. If the solenoid valve stays "on" (cap down) with the current off, replace the solenoid valve.

Problem—Engine Brake Will Not Function

Possible Cause	Remedy
A circuit breaker is tripped.	Look for a short circuit in the wiring. Replace any chafed wires. Check the solenoid tab for signs of shorting; replace it if needed. Reset the circuit breaker.
An electrical lead is open.	Replace any broken wires.
The dash switches, the clutch switch, or the throttle switch is malfunctioning or out of adjustment.	**⚠ WARNING** **WARNING: Do not touch the electrical connections when the engine brake system is energized. Touching the connections could possibly cause electrical shock.** Use a volt/ohmmeter to make sure there is electrical current at both terminals of each switch. Adjust the switch if needed. If voltage will not pass through the switch, replace it.
The engine oil pressure is too low.	Determine the oil pressure at the engine brakes. **Refer to Subject 200.** If the oil pressure is below specifications, repair the engine following the manufacturer's procedures.

Problem—Engine Brake Engages With the Switches Off

Possible Cause	Remedy
The solenoid valve center seal ring is damaged.	Remove the solenoid. Replace the center seal ring.
The engine brake is incorrectly wired.	Check the wiring against the Jacobs wiring diagram.

Problem—Engine Brake Weak or Slow to Engage

Possible Cause	Remedy
The lubricating oil is too cold and thick.	Allow the engine to warm up before operating the Jake Brake.

Troubleshooting

Possible Cause	Remedy
The slave piston is adjusted incorrectly or is binding in its bore.	**⚠ WARNING** **WARNING: Slave piston springs are under heavy compression. Remove the slave piston carefully when disassembly is necessary. Use either an arbor press or C-clamp. Failure to follow this procedure could result in personal injury.** Adjust the slave piston. Make sure it responds smoothly to the adjusting screw— loosen the jam nut and screw the adjusting screw through its full range for full slave piston travel. Make sure the piston travels the full range without binding or sticking.
The solenoid lower seal is damaged, allowing oil to escape the housing.	Remove the solenoid valve and replace the lower seal ring.
The solenoid screen is clogged, stopping the supply of oil to the engine brake.	Remove the solenoid valve; clean or replace the screen.
The master piston is not moving in its bore.	Inspect the master piston and bore for scoring or burrs. If any are present, clean the surface with a crocus cloth. If the burrs cannot be removed, replace the piston or housing. Inspect the lubricating oil for signs of contaminants. If any are present, replace the oil and filters, and correct the cause of the contamination.
The control valves are binding in the housing bores.	Remove each control valve. If the body is scored, replace the valve. Check for contaminants in the lubricating oil. Clean the housing and control valve. If it still binds, replace the housing.
The control valves are malfunctioning.	**⚠ WARNING** **WARNING: To prevent skin irritation, wear chemical resistant gloves when working with diesel fuel or kerosene. Also, do not expose these fluids to flames or heat exceeding 100°F (38°C); both are combustible, and could cause personal injury if ignited.** Remove each control valve. Make sure the check ball is seating in the bore and that it can be moved off the seat. Make sure there is spring pressure against the ball. Flush the valve in diesel fuel. Replace the control valve if needed.
Dash switches, clutch switch, or throttle switch has sluggish operation.	Adjust or replace the switch. Check the throttle or clutch return springs for proper operation.

Possible Cause	Remedy
The electrical insulation of the solenoid valve is breaking down.	**⚠ WARNING** **WARNING: Do not touch the electrical connections when the engine brake system is energized. Touching the connections could possibly cause electrical shock.** Make sure the solenoid valve meets electrical specifications. **See "Specifications, 400."** If not, replace the solenoid valve. Alternate procedure: With ignition key on, brake switches on, and engine off, activate the solenoid electrically. Make sure the solenoid cap depresses. Leave it electrically depressed for 20 to 30 minutes. Slip a fingernail beneath the cap and try to pull it up. If the cap can be raised, replace the solenoid.
The engine brake housing plugs are leaking.	Check the plugs for signs of leaks. If leaks are found, remove the plugs, clean the threads, and install the plugs. Thread locking compound may help. Tighten the plugs 115 lbf·in (1300 N·cm).
The outer control valve spring is broken, or the engine oil pressure is extremely high.	Replace the outer control valve spring. Refer to the engine manufacturer's service manual for causes of high oil pressure.
The upper solenoid seal ring is damaged, causing oil pressure to drop below the minimum required for engine brake operation.	Remove the solenoid. Inspect the seal ring and replace it if needed.
The oil supply seals under or between the housings are damaged, causing oil pressure to drop below the minimum required for engine brake operation.	Remove the housings and replace the seals. Check for cracked or broken oil connectors. Replace the seals.
There is air in the lubricating oil, causing oil pressure to drop below the minimum required for engine brake operation.	Check for aeration of the oil. Turn the engine brake on, then off. Watch the escape oil coming from under the control valve cover. If the oil has bubbles or is foamy, air is present in the system. Aeration can be caused by an over-or underfilled crankcase, by cracks in the oil pickup tube, or by leaks in the oil suction tube or hose. Refer to the engine manufacturer's service manual for corrective measures.
The lubricating oil is being diluted by diesel fuel, causing oil pressure to drop below the minimum required for engine brake operation.	Have the lubricating oil analyzed to determine if fuel is present. Refer to the engine manufacturer's service manual for corrective measures.
The engine oil is low, causing oil pressure to drop below the minimum required for engine brake operation.	Refer to the engine manufacturer's service manual for specifications. Add oil or recalibrate the dipstick as required.
The engine rocker arm bushings are worn, causing oil pressure to drop below the minimum required for engine brake operation.	Replace the bushings. Refer to the engine manufacturer's service manual for instructions.
Oil is leaking around the cylinder heads, causing oil pressure to drop below the minimum required for engine brake operation.	Repair the cause of the leaks. Refer to the engine manufacturer's service manual for instructions.
Restrictions in the oil passage leading to the engine brake are causing oil pressure to drop below the minimum required for engine brake operation.	Inspect all the passageways; remove anything restricting the oil flow.

Troubleshooting

Problem—Engine Stalls or One or More Cylinders Continue Braking With the Dash Switches Off

Possible Cause	Remedy
The control valve inner spring is broken.	Replace the inner spring.
One or more control valves are stuck in the "on" (up) position.	Check the control valves for binding. Remove and clean or replace them if necessary. Inspect the lubrication oil for contaminants.
The solenoid valve is sticking in the "on" position.	If the solenoid valve cap remains down with no electric current being supplied, replace the solenoid valve.
The center solenoid seal ring is damaged, allowing oil to enter the engine brake with the solenoid valve closed.	Remove the solenoid and replace the seal ring.
The solenoid valve exhaust is plugged.	Remove any restrictions at the exhaust (bottom) of the solenoid valve.
The clutch switch or the throttle switch is stuck in the "on" position or is out of adjustment.	Check for correct switch operation. Adjust or replace the switch as needed.

Problem—Engine Misses or Loses Power

Possible Cause	Remedy
The slave piston is adjusted too tight.	Adjust the slave piston. **Refer to Subject 140.**

Problem— Sudden Drop in Engine Lubrication Oil Pressure

Possible Cause	Remedy
The oil inlet supply seal is missing or damaged.	Replace the seal.
The upper solenoid valve seal is missing or damaged.	Remove the solenoid and replace the upper seal ring.
The external oil supply hoses or fittings are cracked and leaking.	Inspect all hoses and fittings for tightness, chafing, or cuts.

Torque Values		
Component	**Torque**	
	lbf·ft (N·m)	**lbf·in (N·cm)**
Engine Brake Housing Hold-Down Capscrews: Stage 1	40 (55)	—
Stage 2	80 (110)	—
Solenoid Valve in Housing	—	60 (680)
Slave Piston Adjusting Screw Locknut	25 (34)	—
Slave Piston Leveling Screw Locknut	35 (47)	—
Slave Piston Retaining Spring Screw	15 (20)	—
Master Piston Screw	—	100 (1120)
Rocker Shaft Studs	80 (110)	—
Rocker Shaft Bolts and Nuts	80 (110)	—

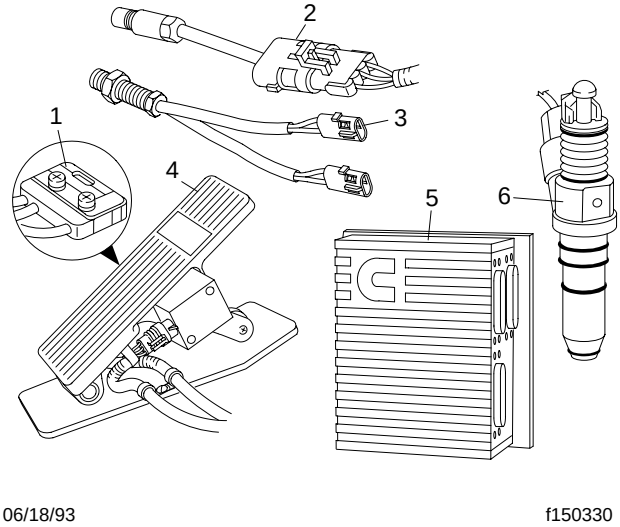
Table 1, Torque Values

Solenoid Valve Electrical Specifications		
Description	**Cold 70°F (21°C)**	**Hot 180° to 220°F (82° to 104°C)**
Resistance (Ohms)	9.75 to 10.75	11.8 to 14.3
Current Draw (Amps)	1.23 to 1.12	1.02 to 0.84
Minimum Pull-In Voltage	7.5	8.5

Table 2, Solenoid Valve Electrical Specifications

General Information and Principles of Operation

(See **Fig. 1**)



1. Idle Validation Switch
2. Engine Position Sensor (EPS)
3. Vehicle Speed Sensor (VSS)
4. Electronic Foot Pedal Assembly
5. Electronic Control Module (ECM)
6. Electronic Injector

Fig. 1

CELECT and CELECT IV are programmable electronically-controlled engine governing systems available on Cummins L10 and N14 engines. These electronic engine systems use sensors, electronic injectors, an electronic foot pedal assembly, and an electronic control module (ECM) to automatically control engine timing and fuel injection. These systems also monitor oil pressure, oil temperature, coolant temperature, and intake manifold pressure. If potentially damaging engine conditions are detected, the red "Shutdown" light in the VIGIL lightbar will come on and the engine power will be gradually reduced. With the CELECT IV system, the engine shuts down 30 seconds after the light comes on. The ignition switch will restart the engine after emergency shutdown, but if the potentially damaging condition still exists, the engine will operate at the reduced speed or torque level allowed just prior to emergency shutdown. The CELECT systems provide the following engine governing modes:

- PTO control, designed for power takeoff operations, which works when the vehicle is stopped.
- Cruise control, which maintains vehicle speed within operator-selected limits.
- Road speed governing, which limits the vehicle speed in the upper and lower gears to a preset fuel efficient range.
- Engine speed governing, which limits maximum engine rpm.
- Idle shutdown timer, which is a programmable delay of engine shutdown after the vehicle is stopped and the parking brake is applied. This delay can be from 3 to 60 minutes.
- Progressive shifting, which limits maximum engine speed while shifting through the gears. This programmable feature limits engine acceleration rates at specified vehicle speeds and gears. Since the engine uses only the rpm needed to get into the next gear, fuel is not wasted by "winding up" the rpm in each gear to gain speed.
- Low idle adjustment, which is used to increase or decrease idle speed during engine warmup.

Three of these operating modes are driver-activated and controlled. Cruise control and PTO control are activated using two switches mounted to the right of the ignition switch (**Fig. 2**). Low idle adjustment is controlled with a switch located near the left side door post (**Fig. 3**).The remaining operating modes perform automatically and according to programmed specifications. Refer to the vehicle driver's manual for operating instructions.

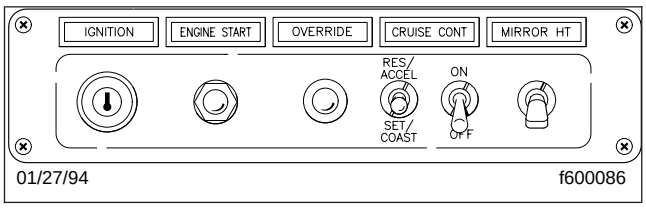
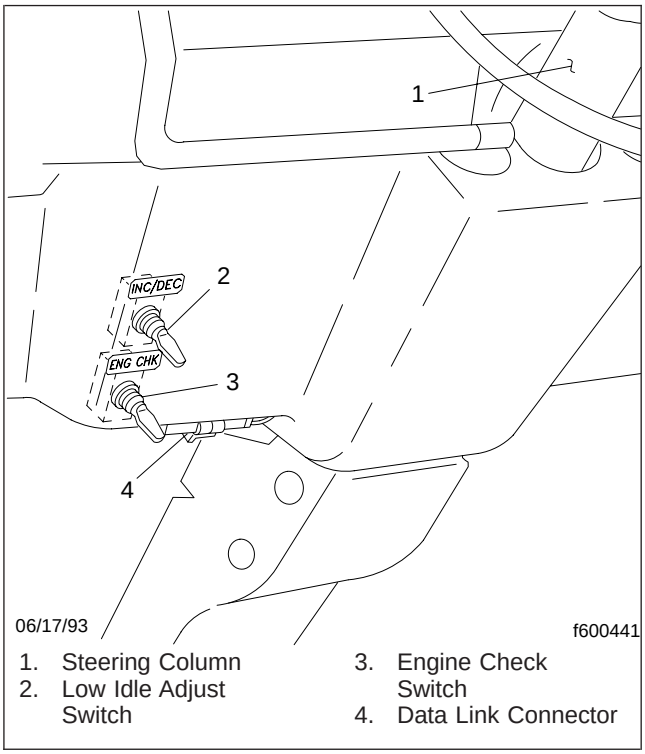


Fig. 2

Identification

To determine whether a vehicle is equipped with CELECT or with CELECT IV, find the engine wiring harness connector plugged into the rear of the electronic control module. If the system is a CELECT IV,



1. Steering Column
2. Low Idle Adjust Switch
3. Engine Check Switch
4. Data Link Connector

Fig. 3

there will be a branch harness coming out of the main harness about 4-6 inches (10-15 cm) back from the ECM connector. This branch harness will be about 4 inches (10 cm) long and will use a flat, 4-pin connector to attach to the low coolant level sensor harness. For FLD 112 Conventionals, the low coolant level sensor is installed in the surge tank on the firewall; for FLD 120 Conventionals and FLA COEs, the sensor is installed in the rear of the radiator top tank. If the vehicle isn't equipped with a low coolant level sensor, the 4-inch branch harness will connect with a jumper wire.

The CELECT system can be used with either a VIGIL I warning lightbar or a VIGIL II warning and shutdown lightbar. CELECT IV is used only with the VIGIL I.

Engine Electronics

The ECM controls current to the electronic injectors and determines fuel metering and injection timing based on data received from the system sensors and switches. Input from the sensors also allows the ECM to monitor critical engine temperatures, pressures, and the coolant level.

As the camshaft gear turns, the engine position sensor (EPS) provides engine speed and piston location information to the ECM. On L10 engines, the EPS is located above the accessory drive; on N14 engines, the EPS is located just below the accessory drive. See **Fig. 4**.

The vehicle speed sensor (VSS), mounted in the transmission housing (**Fig. 5**), senses the movement of the output-shaft gear teeth when the vehicle is moving. The ECM uses this information to compute vehicle road speed.

The intake manifold temperature sensor (**Fig. 6**), located on the intake manifold, measures turbocharged air temperature. This information is used by the ECM to control the fan clutch circuit (if equipped).

The turbo boost pressure sensor (**Fig. 6**), located on the intake manifold, monitors the amount of air entering the engine, and transmits this information to the ECM. The ECM uses this information to regulate the fuel supply to control engine smoke.

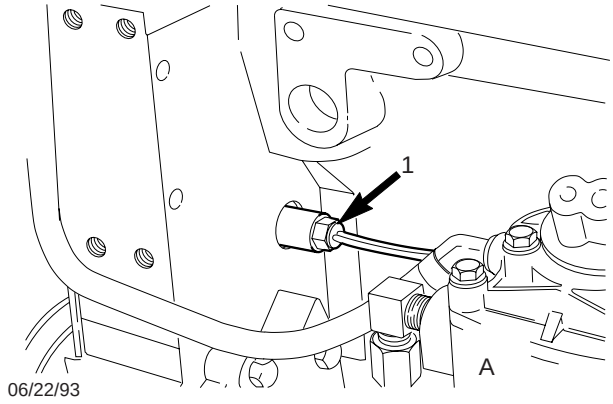
The ambient air pressure sensor (installed only on N14 engines) monitors atmospheric pressure. The ECM uses this information to adjust fuel supply to prevent turbocharger overspeeding. The sensor (**Fig. 7**) is located on the cylinder block, above the fuel supply pump.

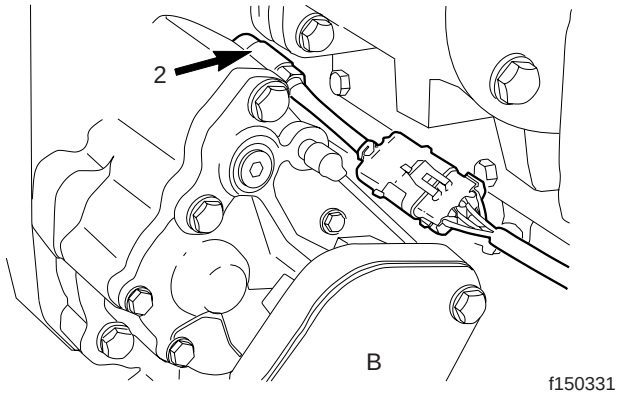
The oil pressure and oil temperature sensors (**Fig. 8**) send electrical signals to the ECM for the engine protection system. If a low oil level or high oil temperature condition is detected, the dash warning light ("Shutdown") will come on and engine power will be gradually reduced.

The coolant temperature sensor (**Fig. 9**), installed in the thermostat housing, provides information used by the ECM to control injection timing during cold starting conditions to reduce engine emissions.

The electronic foot pedal assembly contains the throttle position sensor and the idle validation switch. The throttle position sensor sends a variable electrical signal (based on throttle pedal angle) to the ECM. The idle validation switch is an on/off switch that indicates whether the pedal is at idle or not.

The engine has built-in diagnostics to ensure that all components are operating properly. There are two dash lights: the yellow "Eng Chk" light and the red "Shutdown" light. Both are located on the dashboard

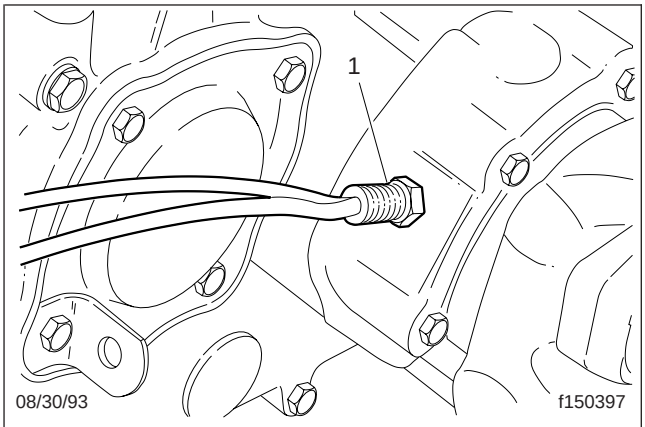




A. L10 Engine Shown
B. N14 Engine Shown

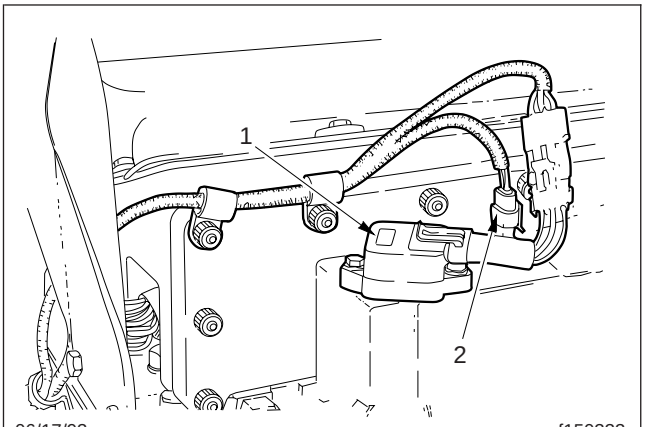
1. Engine Position Sensor
2. Engine Position Sensor

Fig. 4



1. Vehicle Speed Sensor

Fig. 5



NOTE: L10 Engine Shown

1. Boost Pressure Sensor
2. Intake Manifold Temperature Sensor

Fig. 6

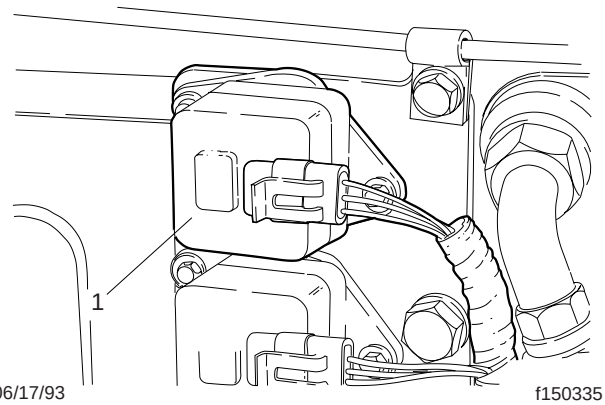
lightbar, and both light up when the ignition is turned on. If the CELECT or CELECT IV system and the engine are working normally, both lights will go out after two seconds.

Intermittent engine system problems are logged and stored in memory. Whenever there is an active engine system problem, either the yellow "Eng Chk" light or the red "Shutdown" light will come on and stay on as long as the problem exists.

Use the "Eng Chk" switch (**Fig. 10**), located near the left-side door post, to determine the fault codes. Turn on the ignition switch, then move the "Eng Chk" switch up (on position). If no fault codes are recorded, both dash lights will come on and stay on. If fault codes are recorded, both lights will come on momentarily, then the lights will begin to flash the code of the recorded fault.

First, the yellow "Eng Chk" light will flash. There will be a short one- or two-second pause, then the number of the recorded fault code will flash the red "Shutdown" light. There will be a one or two second pause after each number. For example, a code 244 is shown by one flash of the yellow "Eng Chk" light, a pause of about one or two seconds, followed by two flashes of the red "Shutdown" light, a pause of about one or two seconds, a series of four flashes

from the red "Shutdown" light, another pause of about one or two seconds, a series of four more flashes from the red "Shutdown" light, then, after a one or two second pause, one flash of the yellow "Eng Chk" light. See **Fig. 11**. When the number is done flashing, the yellow "Eng Chk" light will come on again before the same sequence is repeated. The lights will continue to flash the same fault code.



1. Ambient Air Pressure Sensor

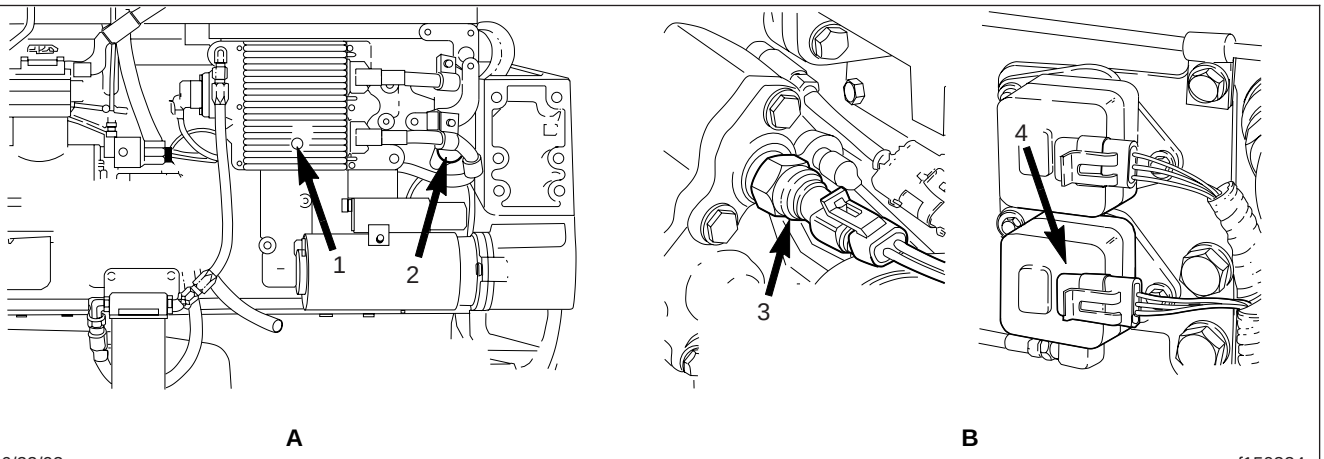
Fig. 7

To check for any additional fault codes, move the low idle adjust switch up, then release it. To view a previous fault code, move the low idle adjust switch to down, then release it.

When you are done checking the fault codes, move the "Eng Chk" switch down (off position), and turn off the ignition switch.

The Compulink can be used to read the numerical code of the component or condition causing the problem. For complete information on the use of this service tool, contact a Cummins service representative.

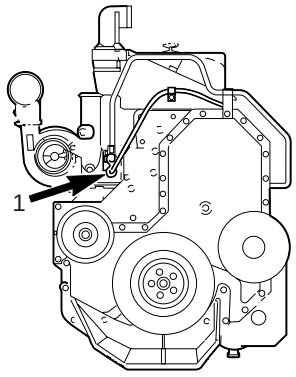
For complete information on fault diagnosis and troubleshooting the electronic engine system, refer to either the L10 or N14 engine manual entitled *Troubleshooting and Repair Manual, CELECT System,* available through your Cummins service representative.



A. L10 Engine Shown
B. N14 Engine Shown

1. Oil Temperature Sensor (behind ECM)
2. Oil Pressure Sensor
3. Oil Temperature Sensor (located in the lubricating oil pump housing)
4. Oil Pressure Sensor (located behind the ECM)

Fig. 8



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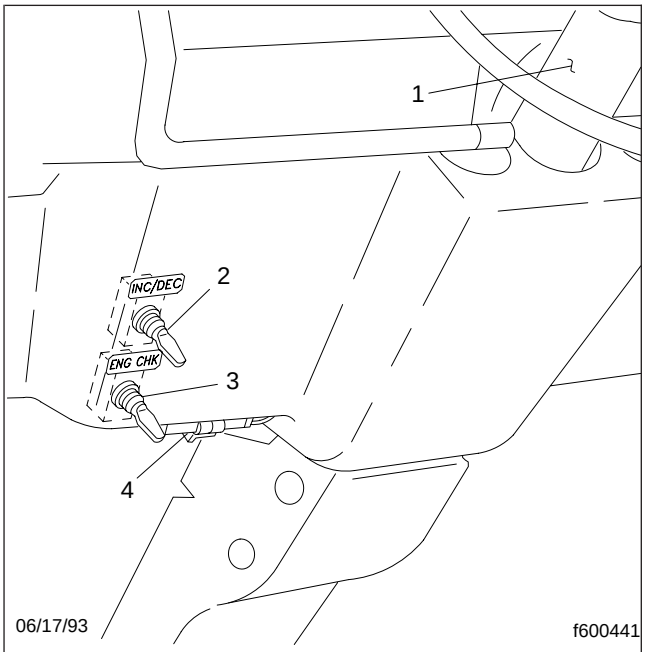
1. Coolant Temperature Sensor

Fig. 9



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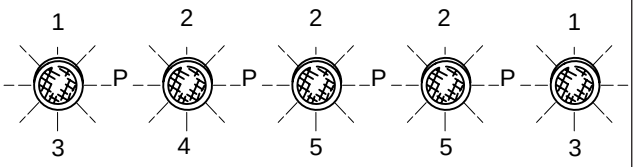
1. Steering Column
2. Low Idle Adjust Switch
3. Engine Check Switch
4. Data Link Connector

Fig. 10



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NOTE: P = Pause

1. Yellow
2. Red
3. One Blink
4. Two Blinks
5. Four Blinks

Fig. 11, Fault Code 244

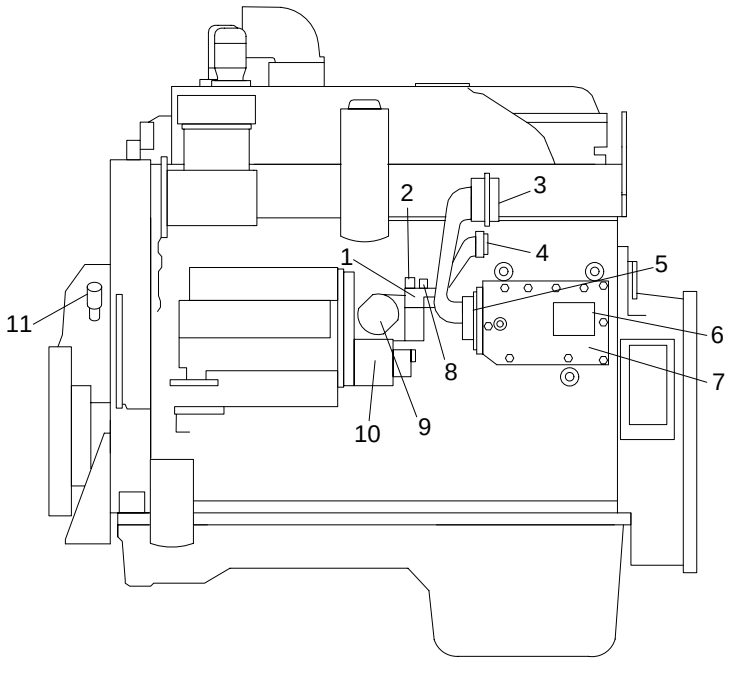
General Information (See Fig. 1)

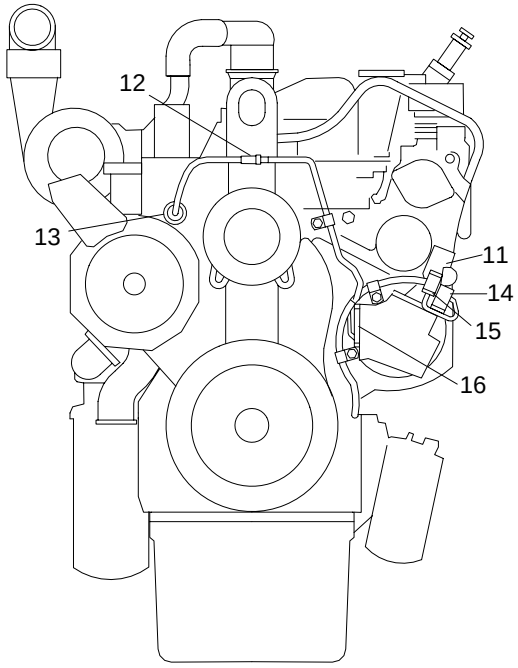
The Caterpillar Electronic Engine System—available on 3406C engines—provides electronic engine control and engine warning and shutdown features to prevent engine damage.

Under normal operating conditions, the system controls the engine with an electronic control module, a transducer module, a timing advance unit, and an electronic governor, all of which are located on the engine. Additional parts include a throttle position sensor and a data link (**see Fig. 2**). Inside the cab, the cruise control switches, exhaust brake switch, service brake and clutch switches and the parking brake switch also control the engine system.

When an emergency occurs—a loss of oil pressure for example, or low engine coolant—the Electronic Engine System has optional engine protection features that will warn the driver, then cut the vehicle speed and shut down the engine, depending on the level of protection the customer prefers.

Attached to the outboard side of the electronic control module is the personality module, which contains the basic performance program for that particular engine. A 3406C engine has the following electronic functions:





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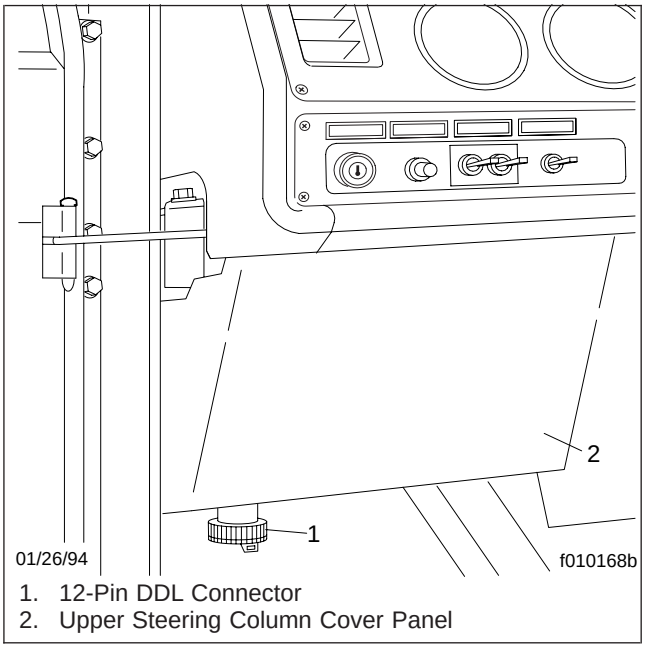
1. Shutoff Solenoid
2. Shutoff Solenoid Connector J13/P13
3. Vehicle Connector J7 (40 Pin)
4. Engine Data Link Connector
5. ECM Connector J4/P4
6. Personality Module
7. Electronic Control Module
8. Rack Solenoid Connector J3/P3 (3 Pin)
9. Rack Solenoid
10. Transducer Module
11. Timing Position Sensor
12. Coolant Temperature Sensor Connector J10/P10 (3 Pin)
13. Coolant Temperature Sensor
14. Timing Position Sensor Connector J2/P2
15. Timing Solenoid BTM Connector J6/P6
16. Timing Solenoid BTM

Fig. 1, Caterpillar 3406C Electronic Engine



1. 12-Pin DDL Connector
2. Upper Steering Column Cover Panel

Fig. 2

- Electronic governing
- Control of fuel-to-air ratio
- Torque rise shaping
- Injection timing control
- System diagnostics
- Vehicle speed limiting
- Progressive shift control
- PTO governor
- Cold mode operation
- Cruise control

Two of these functions—cruise control and PTO governing—are driver-activated, and are controlled by two switches mounted to the right of the ignition switch or in the accessory gauge panel (**Fig. 3** or **Fig. 4**). When the vehicle is parked, the switches control the PTO; when moving, the switches control the cruise control. The remaining functions perform automatically and according to programmed specifications.

Vehicles equipped with the Electronic Engine System use a VIGIL I lightbar. **See Fig. 5**. When an emergency occurs, the check-engine light and/or a specific warning light (low air pressure, low oil pressure,

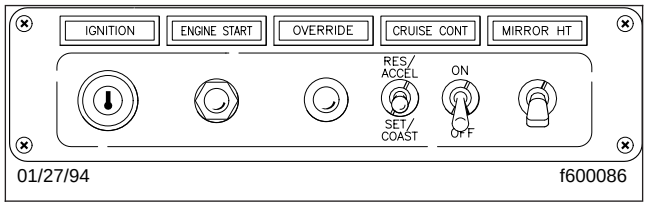


Fig. 3, Cruise Control Switches, Standard Location

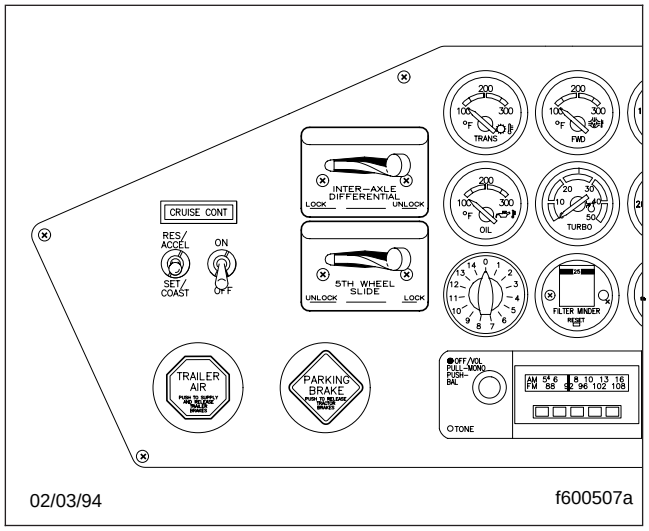
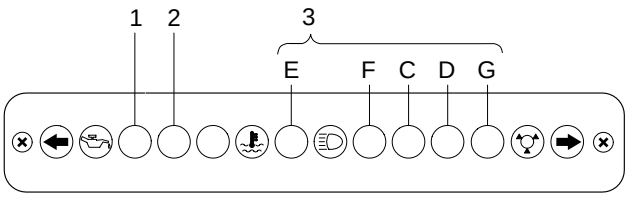


Fig. 4, Cruise Control Switches, Optional Location

etc.) on the lightbar will activate as a warning to the driver. For low oil pressure or high coolant temperature, a warning buzzer will also activate. Since the oil pressure and the coolant temperature are monitored by both the VIGIL and the Caterpillar systems, either one or both systems can activate in an emergency. If the Caterpillar system activates, only the check-engine light will light. If the VIGIL system activates, either the low oil pressure or coolant temperature lights will activate. The parameters are about the same for the Caterpillar and VIGIL high coolant temperature warning systems, so those systems should activate simultaneously. The Caterpillar low oil pressure warning system is more sensitive that the VIGIL—the Caterpillar system judges the oil pressure in relation to engine rpm—so the Caterpillar system may indicate an emergency before the VIGIL system.

NOTE: On 3406C Electronic Engines, the VIGIL I lightbar is not equipped with a warning light for low coolant level. If coolant is needed, only the check-engine light will activate.



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1. Check Engine Light
2. Shutdown Light (or Stop Engine Light if the derate protection mode is specified)
3. Lightbar Options

Fig. 5, VIGIL I Lightbar

Caterpillar 3406C Electronic Engines have the following optional engine protection warning and shutdown features:

- Low Oil Pressure
- High Coolant Temperature
- Low Coolant Level

Depending on the customer's preference, the 3406C engine protection system can be set at one of two levels. At the first level, the system will activate the warnings when an emergency situation occurs and then cut engine power if the situation worsens—but will not shut down the engine. At the second level of engine protection, the system will activate the warnings, cut engine power and shut down the engine as the emergency situation worsens.

Each vehicle is programmed with the level of emergency engine protection specified by the customer. To change that level, the customer can return the vehicle to a Caterpillar or Freightliner dealership for reprogramming with a Caterpillar ECAP (Electronic Control Analyzer Programmer) service tool.

Principles of Operation

ELECTRONIC CONTROL MODULE

The electronic control module, mounted on the left side of the engine, controls the injector pump and the injection timing. It also provides power to the sensors on the engine, and monitors the overall operation of the system. The electronic control module is cooled by fuel flowing through a cooling plate, located between the electronic control module and the engine block.

TRANSDUCER MODULE

The transducer module, mounted on the rear of the injector pump, contains an engine oil pressure sensor, an inlet air pressure sensor, and a boost pressure sensor. The transducer module sends signals to the electronic control module for engine speed and the position of the injector pump rack. It also monitors incoming air pressure.

TIMING ADVANCE UNIT

The timing advance unit, mounted on the front of the engine, contains an electronic brushless torque motor, which controls a hydraulic servo. The servo controls the flow of oil to the drive carrier, which advances or retards the engine timing.

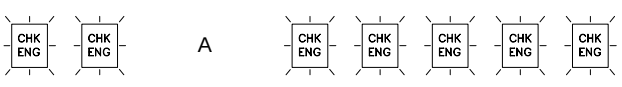
THROTTLE POSITION SENSOR

The throttle position sensor links the throttle pedal with the injector pump by way of the electronic control module. It replaces conventional throttle linkage.

SYSTEM DIAGNOSTICS

A Caterpillar Electronic Engine has built-in diagnostics to ensure that all components are working correctly. Intermittent engine problems are stored in memory, and remain there until the ignition is turned off. If there is a problem with the system, the "CHK ENG" light on the dash lightbar will stay on, instead of going out after 10 seconds.

To determine the system problem, turn the ignition key to the "on" position. The "CHK ENG" light will begin a series of flashes that correspond to a numeric diagnostic code. For example, a code 25 is shown by two flashes, a pause of about two seconds, then five short flashes. **See Fig. 6**. If more than one code has been logged into the system, the "CHK ENG" light will flash the codes in sequence, with a pause of about 3 seconds between codes. **See Table 1** for a list of the diagnostic codes.



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A. Two Second Pause

Fig. 6, Diagnostic Code Example, Code 25

ENGINE PROTECTION FEATURES

The 3406C Electronic Engine monitors oil pressure, coolant temperature, and coolant level.

The oil pressure sensor is in the transducer module (**see Fig. 1**), mounted on the rear of the fuel injector pump. The sensor measures oil pressure from 0 PSI (0 kPa) to 45 psi (312 kPa), with any pressure above that displayed as 45 psi (312 kPa). This measurement is about 1 psi (10 kPa) less than oil pressure in the galley.

The sensor measures oil pressure only after the engine has been running for about 10 seconds, this way system oil pressure has a chance to build to operating levels at engine start up. If after the first 10 seconds of engine operation the oil pressure drops below 45 psi (312 kPa) for two seconds, the lightbar check-engine light activates. *Depending on the level of engine protection selected by the customer,* after 10 seconds of low oil pressure, the system cuts engine horsepower to 160, engine RPM to 1350, and vehicle speed to 45 mph (72 Km/h). If oil pressure is low for more than 30 seconds, the system shuts down the engine.

The coolant temperature sensor is mounted in the water jacket, in the front of the engine housing (**see Fig. 1**). When coolant temperature is below 40°F (4°C) the system puts the engine in Cold Mode, limiting engine power, retarding timing, and increasing the low idle to improve warm-up time. The system will keep the engine in Cold Mode until coolant temperature rises above 68°F (20°C) or until the engine has been running for 15 minutes. The system will then stop the Cold Mode and allow the engine to operate normally.

If the engine coolant rises above 216°F (102°C) for more than two seconds, the system activates the lightbar check-engine light. *Depending on the level of protection specified by the customer,* the system cuts engine power ten seconds after the temperature reaches 219°F (104°C). The system cuts engine horsepower to 160 and vehicle speed to 45 mph (72 Km/h). Thirty seconds later, if the problem persists, the shutdown light comes on, and the engine shuts down.

The low coolant level sensor is installed in the radiator top or surge tank. *Depending on the level of protection specified by the customer,* if the coolant in the tank drops below the sensor for 10 seconds, the system cuts engine output to 160 horsepower, and vehicle speed to 45 mph (72 Km/h). If the coolant level drops below the sensor for 30 seconds, the system shuts down the engine.

Fault Code	Description
12	Coolant Level Sensor Fault (PEEC III only)
21	Sensor Supply Voltage Fault
22	Rack Position Sensor Fault
23	Timing Position Sensor Fault
24	Oil Pressure Sensor Fault
25	Boost Pressure Sensor Fault
27	Coolant Temperature Sensor Fault (PEEC III only)
28	Check Throttle Sensor Adjustment (PEEC III only)
31	Loss of Vehicle Speed Signal
32	Throttle Position Sensor Fault
33	Engine RPM Signal Out of Range
34	Engine RPM Signal Fault
35	Engine Overspeed Warning
36	Vehicle Speed Signal Fault
41	Vehicle Overspeed (PEEC only)
42	Check Sensor Calibrations
43	Rack Subsystem Fault
44	Timing Subsystem Fault
45	Shutoff Solenoid Fault
46	Low Oil Pressure Warning
47	Idle Shutdown Occurence
48	Excessive Engine Power
51	Intermittent Battery Power to the ECM (PEEC III only)
52	Control or Personality Module Fault
53	Electronic Control Module Fault
54	Data Link Fault (PEEC only)
55	No Detected Faults
56	Check Customer or System Parameters
57	Parking Brake Switch Fault
58	Power Train Data Link Fault (PEEC III only)
61	High Coolant Temperature Warning (PEEC III only)

Fault Code	Description
62	Low Coolant Level Warning (PEEC III only)

Table 1, Diagnostic Flash Codes

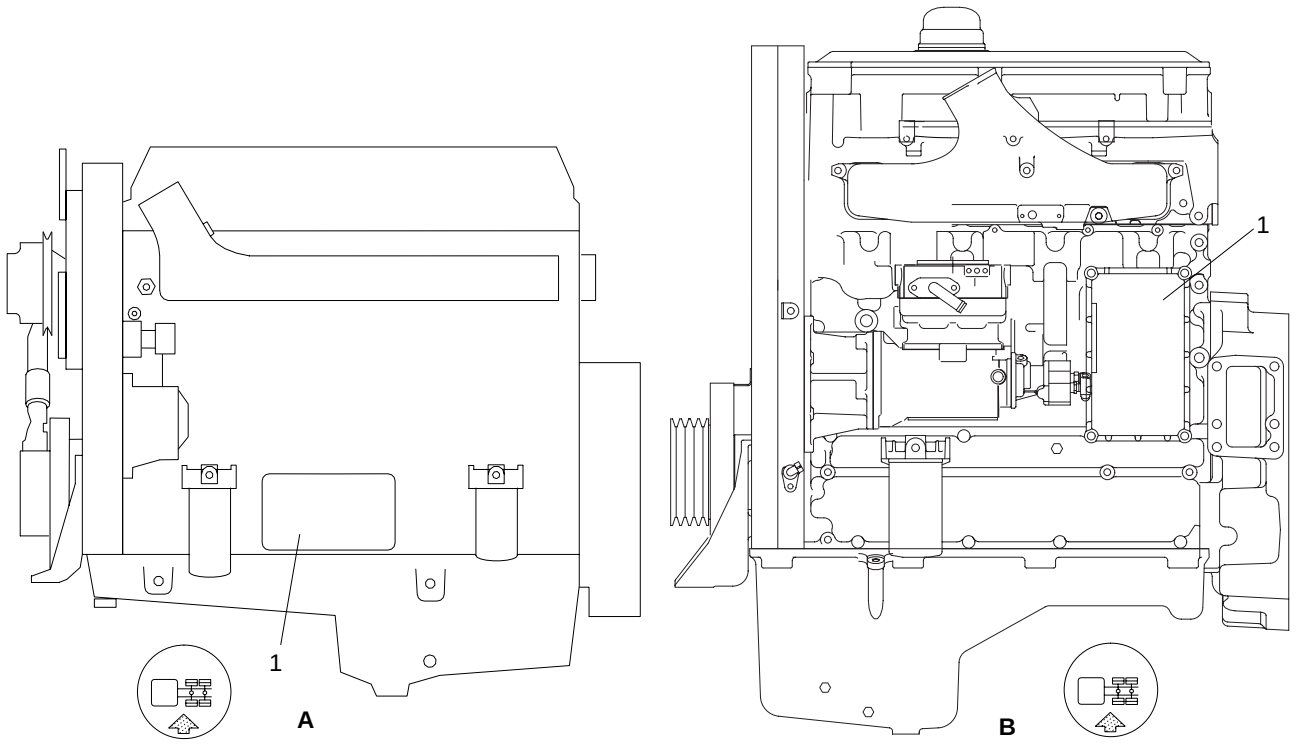
General Description

This is a general description of, first, the standard features of the Detroit Diesel Electronic Control System (DDEC III) as installed on Freightliner vehicles, and second, the components that make up DDEC III. This section has a brief description of different ways to troubleshoot the DDEC III, but doesn't have the actual troubleshooting procedures. For troubleshooting procedures and specifications, refer to the *Detroit Diesel DDEC III Troubleshooting Guide*.

To tell if an engine is equipped with DDEC II or DDEC III, find the Electronic Control Module (ECM) on the left side of the engine. **See Fig. 1.** A DDEC II Electronic Control Module will have two 30-pin connectors and a 5-pin connector, and all three connectors will plug into *one* end of the ECM.

A DDEC III ECM will have wiring harnesses plugged into *two* ends: The Detroit Diesel wiring harnesses (one 30-pin connector and two smaller connectors) will plug into one end of the ECM; the Freightliner wiring harnesses (one 30-pin connector, plus a 5-pin and a 6-pin connector) will plug into the opposite end of the ECM. A short, pigtail harness branches off the harness coming from the 30-pin connector on the Detroit Diesel side of the ECM. This pigtail harness wraps around the ECM and ends in a 3-pin connector near the Freightliner side. The pigtail harness connects with the Freightliner electrical engine harness.

To tell if the engine is programmed to shut down in emergencies, look at the lightbar in the dash. Engines with the shutdown option will have a "Shutdown Engine Light" (SEL). **See Fig. 2.** Engines with-

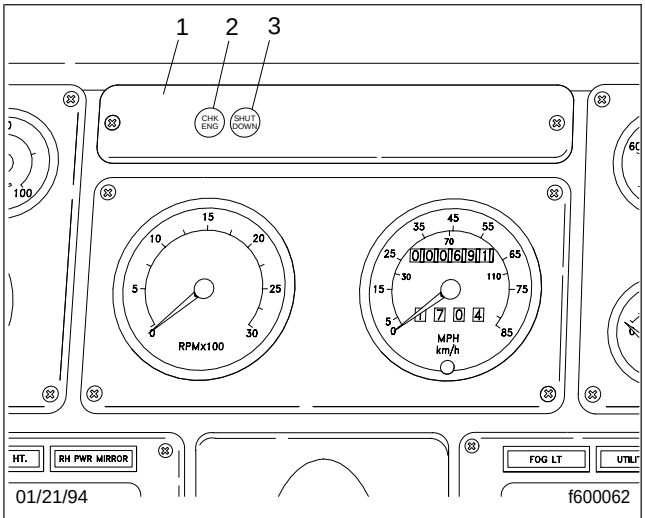


A. Detroit Diesel Series 60 Engine
1. Electronic Control Module (ECM)

B. Detroit Diesel Series 50 Engine

Fig. 1, Electronic Control Module Locations

out the shutdown option will have an "Engine Warning" light in place of the shutdown light.



1. VIGIL I Lightbar
2. Check Engine Light
3. Shutdown Engine Light

Fig. 2, DDEC III Warning Lights

FEATURES

The Detroit Diesel Electronic Control System (DDEC III) controls and monitors Detroit Diesel Series 50 and Series 60 engines installed in Freightliner vehicles. DDEC III, first offered with Detroit Diesel 1994 engines, can protect the engines from serious damage caused by:

- High Coolant Temperature
- High Oil Temperature
- Low Coolant Level
- Low Oil Pressure

If coolant or oil temperatures rise too high, or if coolant level or oil pressure drop too low, dash warning lights will light and a buzzer will sound.

The brain of the DDEC III system is an electronic control module (ECM). The ECM receives information from the engine sensors provided on the engine by Detroit Diesel, and information from the electronic throttle pedal, vehicle speed sensor, and coolant level sensor provided by Freightliner. Comparing this information with the calibration tables in its memory, the ECM controls the fuel timing and quantity of fuel that the electronic unit (fuel) injectors deliver to the engine. This control improves fuel economy and lowers exhaust emissions.

The DDEC III system also provides limiting and variable speed governing. The Limiting Speed Governor fuels the engine according to the driver's use of the throttle. An optional Variable Speed Governor will hold the engine at a constant requested speed (within engine capabilities) regardless of load changes such as hills or winds. The Variable Speed Governor is usually used to provide steady, even power to a PTO (controlled with the cruise control switches while the vehicle is parked), and it will hold the engine speed constant without increased use of the hand throttle or throttle pedal.

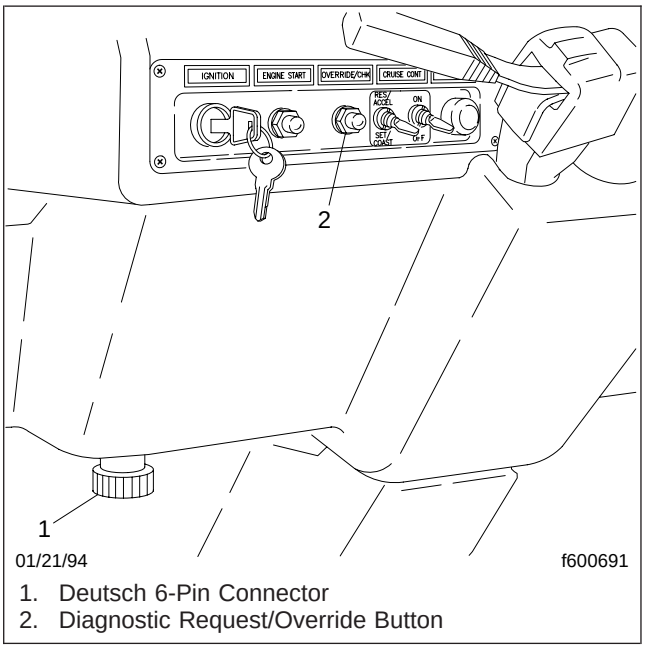
While controlling fuel delivery to the unit injectors, the ECM also monitors sensor reports about oil temperature, fuel pressure, etc. If any of the sensors report a problem, the ECM activates first the "Check Engine Light" (CEL) and then the "Shutdown Engine Light" (SEL) in the VIGIL I lightbar. **See Fig. 2.** The CEL will light if the problem is minor enough that it can be solved as soon as convenient. If the problem resolves itself, for example, if the coolant temperature drops back down into the acceptable range, the CEL will go out. However, if the problem gets worse: For example, if the coolant or oil temperature continues to rise, the ECM will reduce engine power by cutting the fuel to the injectors. As the problem gets worse, the ECM will continue to cut fuel until engine power is reduced by 30 percent. At that point, (if the engine is programmed with the shutdown option) the ECM will turn on the SEL. Thirty seconds after that, the ECM will shut down the engine by not delivering any fuel to the injectors.

NOTE: Immediately after the SEL comes on, the driver must press the Diagnostics Request/Override button if the driver cannot move the vehicle to safety within the thirty seconds before engine shutdown. Pressing the button just before shutdown will keep the engine running for thirty more seconds.

If the engine is not programmed to shut down, the ECM will continue to cut fuel delivery to the injectors until the engine is running at 40 percent of original power.

After an emergency engine shutdown, the Diagnostic Request/Override button allows the driver to re-start the engine for thirty seconds and move the vehicle to a new location. Turn the ignition off and then on, and

press the override button. **See Fig. 3.** For additional time, the driver must press the override button again, every thirty seconds. Emergency engine warning, power derate, and engine shutdown are standard on engines equipped with DDEC III, but an engine can be programmed to give a warning and then cut engine power without shutting down. If an engine is not programmed with the shutdown option, the shutdown light in the lightbar will be replaced with a "Engine Warning" light. To re-program engine options, contact your nearest Freightliner dealer.



1. Deutsch 6-Pin Connector
2. Diagnostic Request/Override Button

Fig. 3, Diagnostic Connector and Button

Information about coolant temperature and oil pressure travels from the engine sensors, through the ECM, to a Kysor Electronic Data Monitor (EDM). **See Fig. 4.** The EDM translates this information from a digital signal to an analog signal that controls the dash gauges and warning lights. The EDM makes it possible for a single sensor to control several components, such as the engine fan, dash gauges, and dash warning lights. Using a single sensor prevents problems caused by conflicting information from multiple sensors. For example, a coolant sensor that controls the engine shutdown feature might be in a hotter area of the engine, and this sensor might activate the dash warning light before a sensor in a cooler area turns on the engine fan. With a single sensor, and the EDM to translate the sensor signal, problems like this won't happen.

Diagnostics

If the DDEC III reports an engine problem, you have three ways to diagnose it:

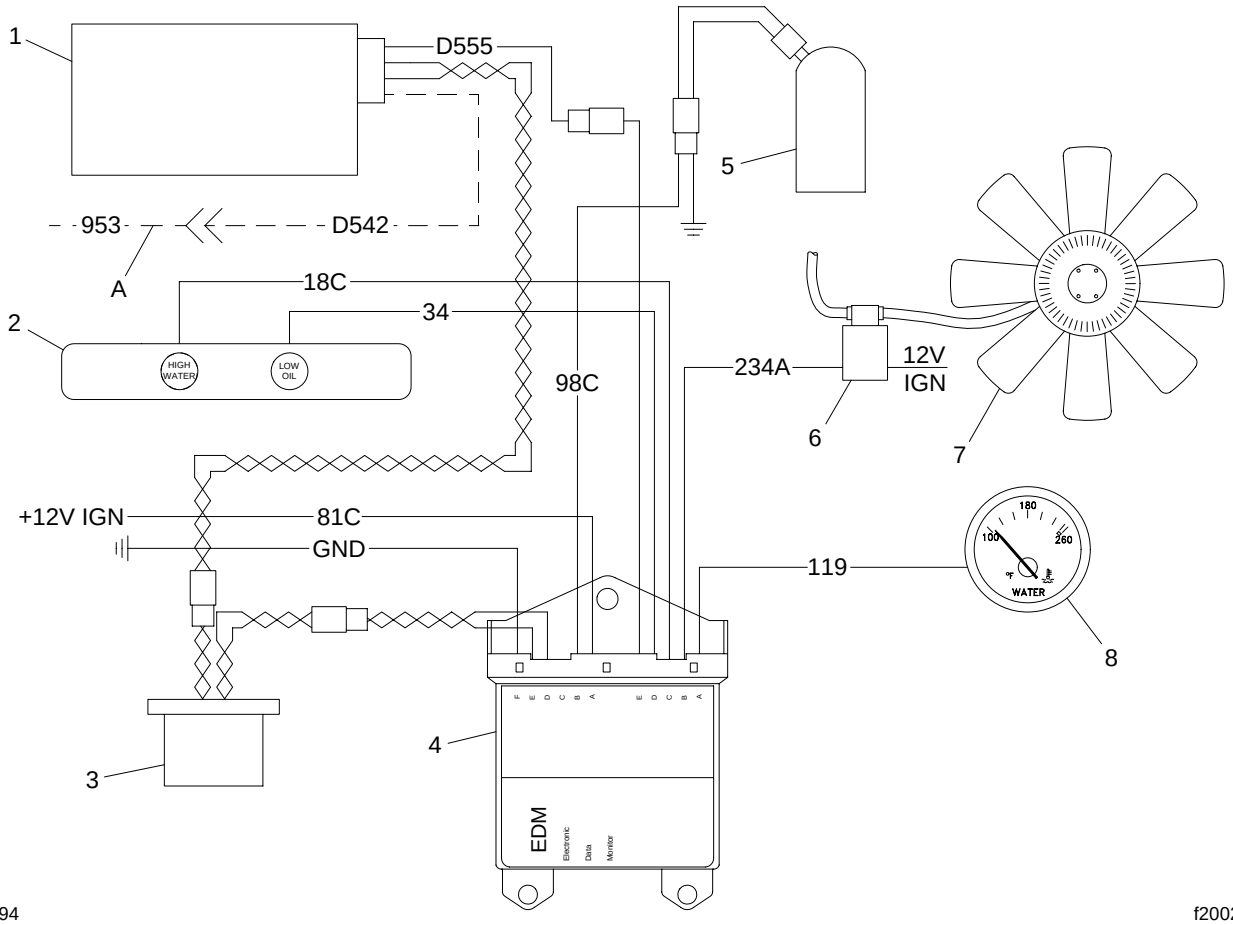
- Press the Diagnostic Request/Override button (on the left switch panel, near the start button) and watch the codes flashed by the CEL and SEL lights. Two types of flash codes represent engine problems. The first type, active codes, represent existing problems and keep the CEL or SEL lighted. The second type, historical codes, represent problems that are logged in the ECM but are not active.

  When you switch the ignition on, all the lightbar lights will activate for five seconds as a self-check of the warning system. If the CEL and SEL stay on after that time, the engine has a problem, and the DDEC III has a flash code ready to represent that problem. To read the flash code, turn on the ignition or idle the engine, and wait for five seconds. Then press and hold the Diagnostic Request/Override button. The SEL will flash a number of times to represent the code for the problem. For example, the code 13 would be one SEL flash followed by a pause, then three more flashes. If the engine has more than one problem, a code for each of the problems will flash with a pause of several seconds between them. **See Fig. 5.** After all the active codes have flashed, or if there are no actives codes, the SEL will flash code 25. After that, the CEL will flash any historical codes for problems that are not active but are logged in the ECM. After all the historical codes have flashed, or if there are no historical codes, the CEL will flash code 25. For the meaning of the flash codes, refer to the *Detroit Diesel DDEC III Troubleshooting Guide*.

- Use a hand-held Diagnostic Data Reader (DDR) equipped with a DDEC III cartridge. With the ignition turned on or the engine idling, connect the reader to the Deutsch six-pin connector under the lower, left dash panel. **See Fig. 3.** If using a DDR, choose reader Mode 01 to read the active codes, and choose Mode 02 to read the historical codes.

- Use a personal computer connected to the ECM.

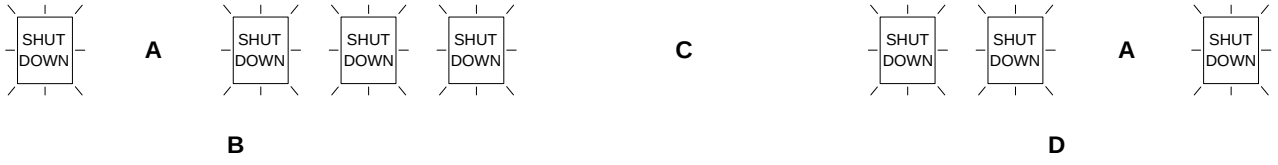
General Description and Principles of Operation



A. This wire was installed on only some early Freightliner vehicles.

1. Electronic Control Module
2. VIGIL I Lightbar
3. Diagnostic Connector
4. Kysor Electronic Data Monitor
5. Receiver Drier
6. Fan Control Solenoid Valve
7. Air-Controlled Fan Clutch
8. Coolant Temperature Gauge

Fig. 4, Electronic Data Monitor



A. Short Pause (1/2 Second)
B. Flash Code 13
C. Long Pause (3 Seconds)
D. Flash Code 21

Fig. 5, DDEC III Flash Codes

Idle Shutdown Timer

The same system that shuts down the engine during a problem also shuts down the engine if the customer requests the optional idle shutdown time. With an idle shutdown timer, the engine automatically shuts down after idling for a predetermined number of minutes. That length of time can be set anywhere between two minutes and 99 minutes. To start the engine after the idle shutdown timer has shut it down, turn the key all the way off, then turn the key on. To make the engine idle longer than the predetermined length of time, release and immediately reapply the parking brake, or press the throttle pedal while the engine is idling and rev the engine slightly. Ninety seconds before the engine shuts down, the CEL will flash. Step on the throttle pedal and rev the engine during this time, and the engine will idle indefinitly.

COMPONENTS

Electronic Control Module

The Electronic Control Module (ECM) is mounted on the lower left side of Detroit Diesel Series 50 and 60 engines. Four wiring harnesses connect to the ECM. Two Detroit Diesel harness plug into one end of the ECM; two Freightliner harnesses plug into the opposite end.

On the Freightliner end, the first harness, the power harness, runs from the batteries to the ECM, and includes a single 15 amp fuse. **See Fig. 6**, **Fig. 7**, and **Fig. 8**. The fuse is mounted on the battery box, and if the fuse fails, the engine will not run. At the engine, the five-pin power harness connector plugs into the ECM, and the harness's single-pin connector plugs into a connector on the Freightliner electrical engine wiring harness.

NOTE: Before troubleshooting the DDEC III system, make sure the fuse for the power harness and the ignition circuit are good.

The second harness, the Freightliner electrical engine wiring harness, connects the ECM and the sensors installed by Freightliner (the low coolant level sensor and the vehicle speed sensor) to the cab wiring. **See Fig. 7**, **Fig. 8**, and **Fig. 9.** This engine wiring harness also connects the ECM to the tachometer. Three of the wiring harness's connectors plug into the ECM. Two of these connectors, the 30-pin connector and the six-pin connector plug into the Freightliner end of the ECM; the third connector, the 3-pin connector, plugs into a short pigtail harness that is routed around from the opposite end of the ECM. A fourth connector near the ECM, plugs into the single-pin connector on the power harness. At the firewall, the cab interface connector plugs the harness into the cab wiring harness. The low coolant level sensor branch of the harness plugs into the sensor in the radiator top tank or surge tank. The vehicle speed sensor branch of the harness plugs into the sensor at the transmission output.

On the Detroit Diesel end of the ECM are one 30-pin connector and two smaller connectors.

The 30-pin connector is on the third wiring harness: The harness that connects the ECM to the turbo boost pressure sensor, the timing and synchronous reference sensors, the temperature sensors for the air, oil, fuel, and coolant, and pressure sensors for the fuel, oil, and coolant. **See Fig. 10** and **Fig. 11.** This harness includes a smaller pigtail harness that runs from the Detroit Diesel end of the ECM and ends in a 3-pin connector near the Freightliner end. This pigtail harness connects to a 3-pin connector at the end of the Freightliner electrical engine wiring harness.

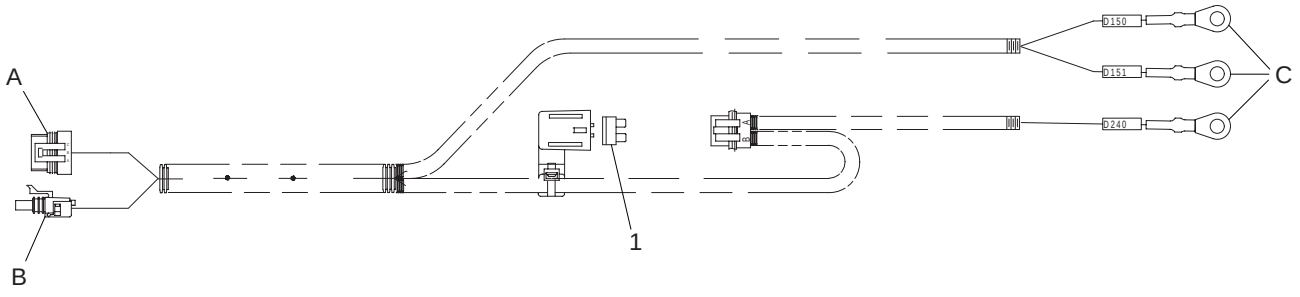
The two smaller wiring connectors plugged into the Detroit Diesel end of the ECM belong to the fourth wiring harness. This harness connects the ECM to the electronic fuel injectors.

A fifth wiring harness, the Freightliner non-electronic component wiring harness (**see Fig. 12**, **Fig. 13**, and **Fig. 14**), connects cab and chassis wiring at the bulkhead connectors to parts within the engine compartment, including:

- The air conditioning pressure switch
- The magnetic switch
- The starter
- The back-up light and alarm switch
- The transmission oil temperature sender
- The ether start system
- The fan solenoid
- The alternator
- The ammeter shunt

The ECM makes continuous self-diagnostic checks and monitors the DDEC III system from ignition through all engine operating modes. The ECM con-

General Description and Principles of Operation



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A. Connect to the Freightliner end of the ECM.
B. Connect to the Freightliner electrical engine wiring harness.
C. Connect to the batteries.
1. 15 Amp Fuse

Fig. 6, Power Harness

tains an Electronically Erasable Programmable Read Only Memory (EEPROM), which controls the basic engine functions, including:

- Rated Speed and Power
- Fuel Injection Timing
- Engine Governing
- Torque Shaping
- Cold Start Logic
- Transient Fuel Delivery
- Diagnostics
- Engine Protection

For precise fuel delivery and improved fuel economy, the control logic uses calibration tables to determine the duration and timing of fuel delivery to the electronic unit injectors.

ECM Programming

In production, Freightliner programs the Electronically Erasable Programmable Read Only Memory (EEPROM) with the standard engine operating features and any options the customer has specified. Currently, the standard program includes engine shutdown, but the option is available only to derate engine power in emergency situations. To re-program the EEPROM, take the vehicle to the nearest Freightliner or Detroit Diesel dealership.

[1] The fan will stay on for three minutes after the air conditioner is turned off

Electronic Data Monitor

Although the Electronic Data Monitor (EDM) is not made by Detroit Diesel, Freightliner installs it on Detroit engines with DDEC III. **See Fig. 4.** On FLB COEs, the EDM is on top of the tunnel; on FLD Conventionals, the EDM is just below the electrical mounting plate on the cab firewall.

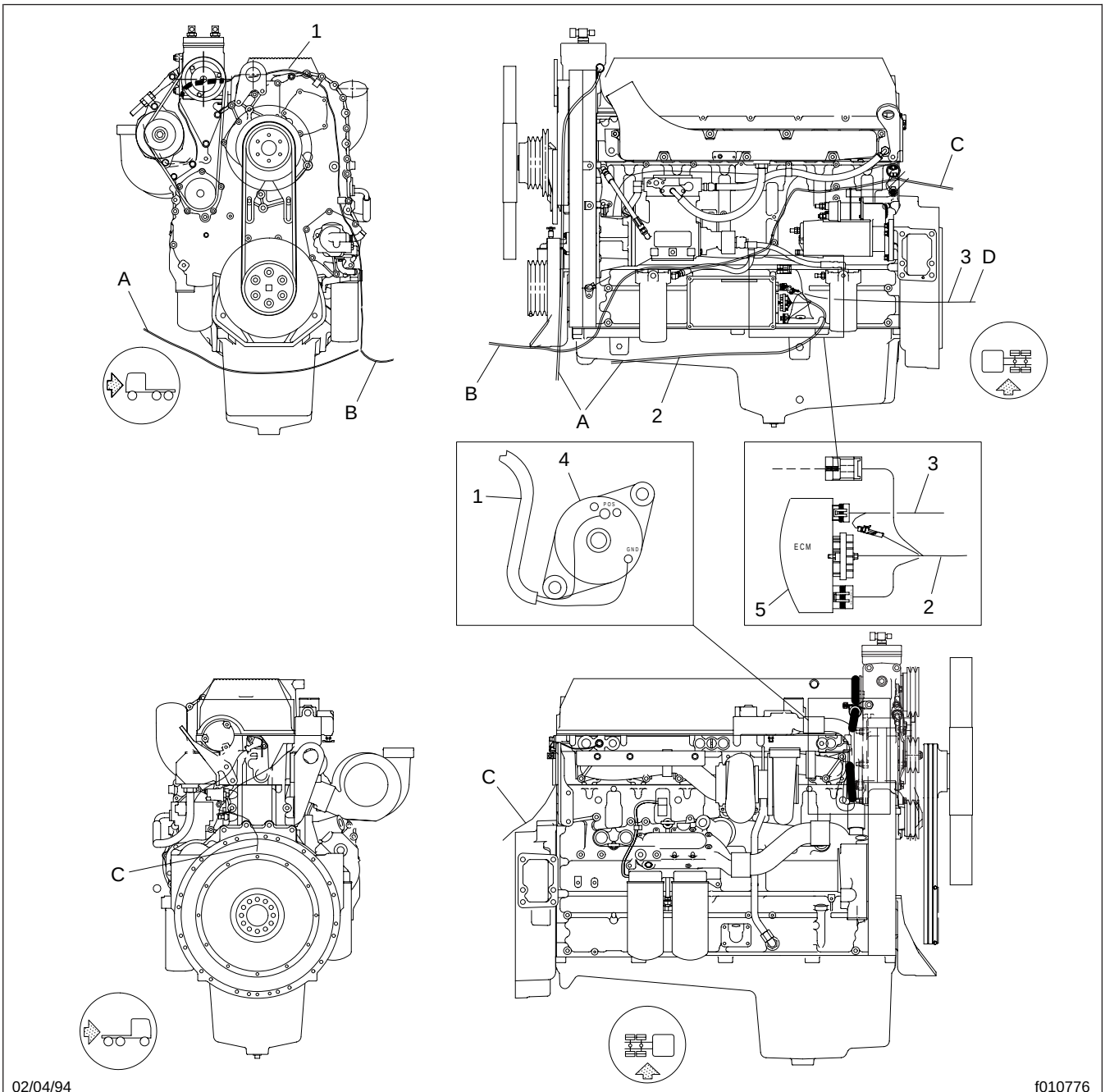
The EDM receives signals from ECM and translates those signals from digital to analog signals that control the coolant temperature gauge, the low oil pressure warning light, and the high coolant temperature warning light.

The EDM uses signals from the ECM to control the engine fan. The EDM will turn the fan on if any of the following occur:

- The oil temperature rises above 230°F (110°C)
- The coolant temperature rises to 205°F (96°C)
- The intake air temperature rises above 151°F (66°C)
- The air conditioner is turned on [1]
- The oil, coolant, or air temperature sensor fails
- The fan control override switch is turned on

Electronic Unit Injectors

The Electronic Unit (fuel) Injectors (EUI) operate the same as Detroit Diesel mechanical unit injectors: The cam/rocker arm system powers the high fuel delivery



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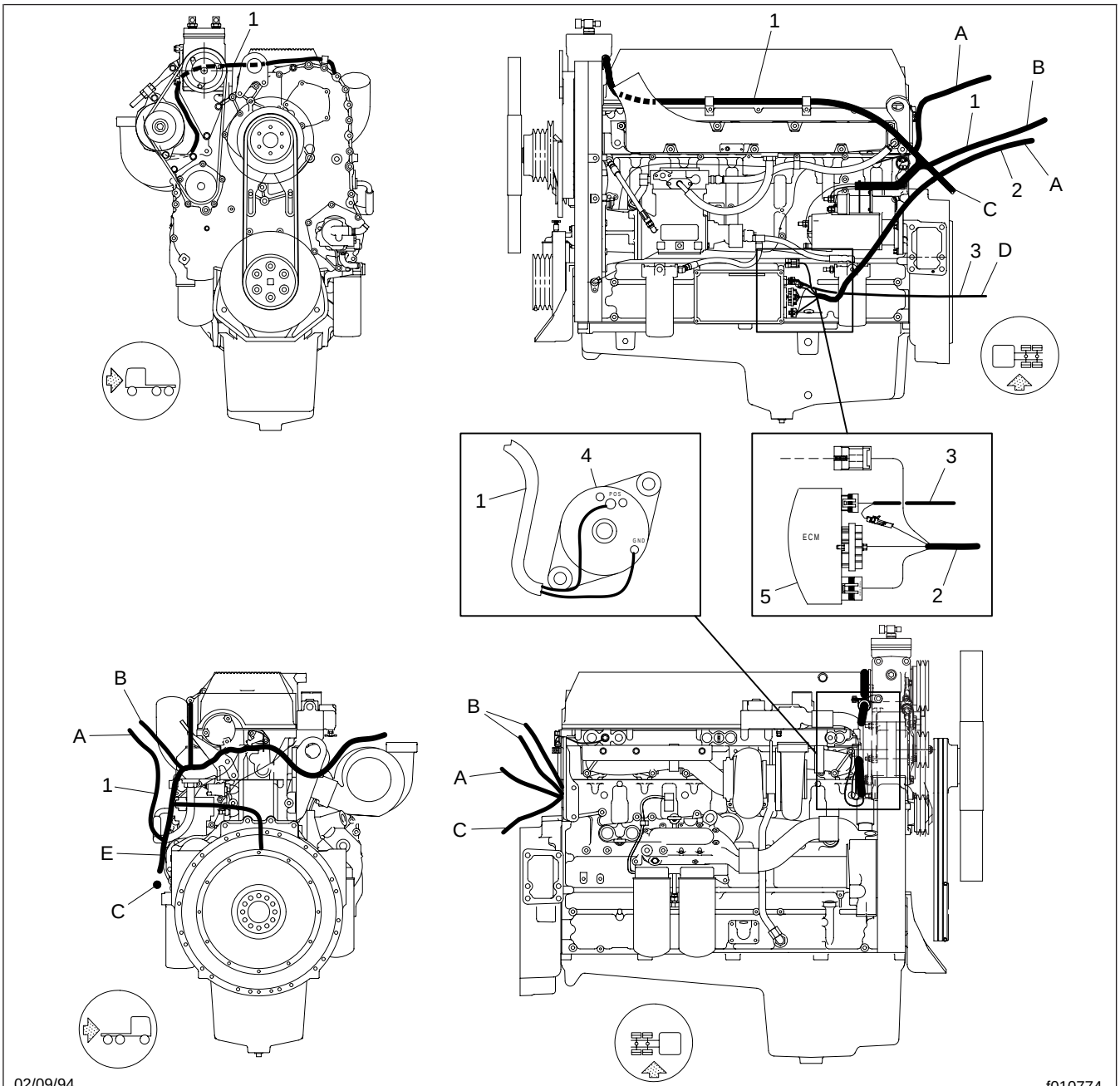
A. Route to the cab.
B. Route to the magnetic switch.
C. Route to the transmission.
D. Route to the batteries.

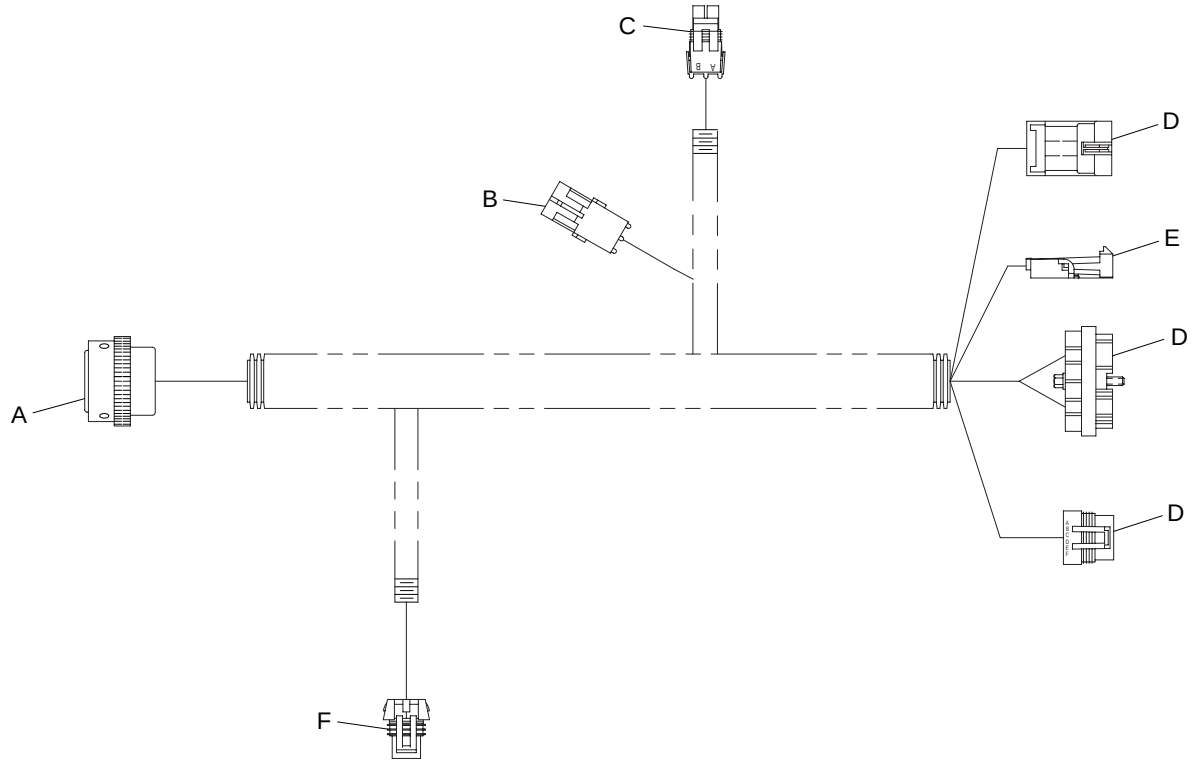
1. Freightliner Non-Electronic Component Wiring Harness
2. Freightliner Electrical Engine Wiring Harness
3. Power Harness
4. Alternator
5. Electronic Control Module

Fig. 7, Freightliner Engine Harnesses, Detroit Diesel Series 60 in an FLB COE



A. Route to the cab.
B. Route to the firewall.
1. Freightliner Non-Electronic Component Wiring Harness
C. Route to the transmission.
D. Route to the batteries.
2. Freightliner Electrical Engine Wiring Harness
3. Power Harness
E. Route to the starter.
4. Alternator
5. Electronic Control Module

Fig. 8, Freightliner Engine Harnesses, Detroit Diesel Series 60 in an FLD Conventional



A. Connect to the cab interface connector.
B. Connect to the tachometer.
C. Connect to the vehicle speed sensor.
D. Connect to the electronic control module.
E. Connect to the power harness.
F. Connect to the low coolant level sensor.

Fig. 9, Freightliner Electrical Engine Wiring Harness

pressure. However, on the EUI, a solenoid controlled by the ECM controls fuel injection timing and fuel quantity. When the solenoid valve closes, fuel injection begins. When the solenoid opens, fuel injection ends. As long as the ECM keeps the solenoid closed, the unit injector injects fuel into the cylinder.

Timing and Synchronous Reference Sensors

The timing reference sensor (TRS) tells the ECM the engine rpm. This sensor is installed in front of the air compressor, below the air compressor drive. **See Fig. 10** and **Fig. 11.** The synchronous reference sensor (SRS) indicates a specific cylinder in the firing order. It is installed in front of the air compressor, above the air compressor drive.

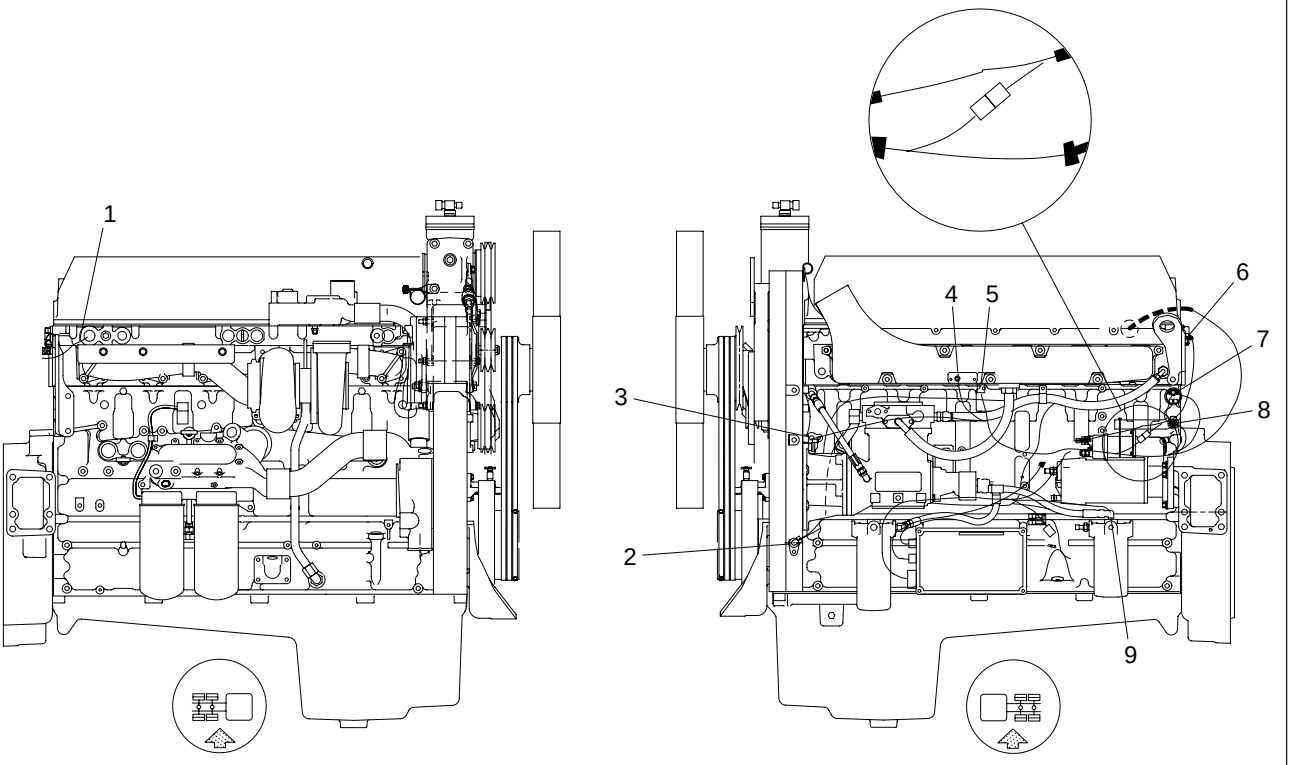
Turbo Boost Pressure Sensor

The Turbo Boost Sensor (TBS) is installed in the side of the air intake manifold, and monitors the pressure of the engine intake air after it has been pressurized by the turbocharger and cooled by the aftercooler. **See Fig. 10** and **Fig. 11.** The ECM uses information from the TBS to control engine smoke.

Oil Pressure Sensor (See Fig. 10 and Fig. 11)

The oil pressure sensor is installed in the engine block, right below the rear end of the air intake manifold. This sensor tells the ECM if the engine oil pressure in the gallery falls below a certain pressure in relation to the engine rpm. **See Fig. 15.** If oil pressure falls to that pressure, the ECM turns on the CEL and SEL, and the EDM turns on the low oil pressure warning light and buzzer. Thirty seconds later, the

General Description and Principles of Operation



1. Coolant Temperature Sensor
2. Timing Reference Sensor
3. Synchronous Reference Sensor
4. Turbo Boost Sensor
5. Intake Air Temperature Sensor
6. Electronic Unit Injectors
7. Oil Pressure Sensor
8. Oil Temperature Sensor
9. Fuel Temperature Sensor

Fig. 10, Detroit Diesel Wiring Harnesses and Sensors on Series 60 Engine With DDEC III

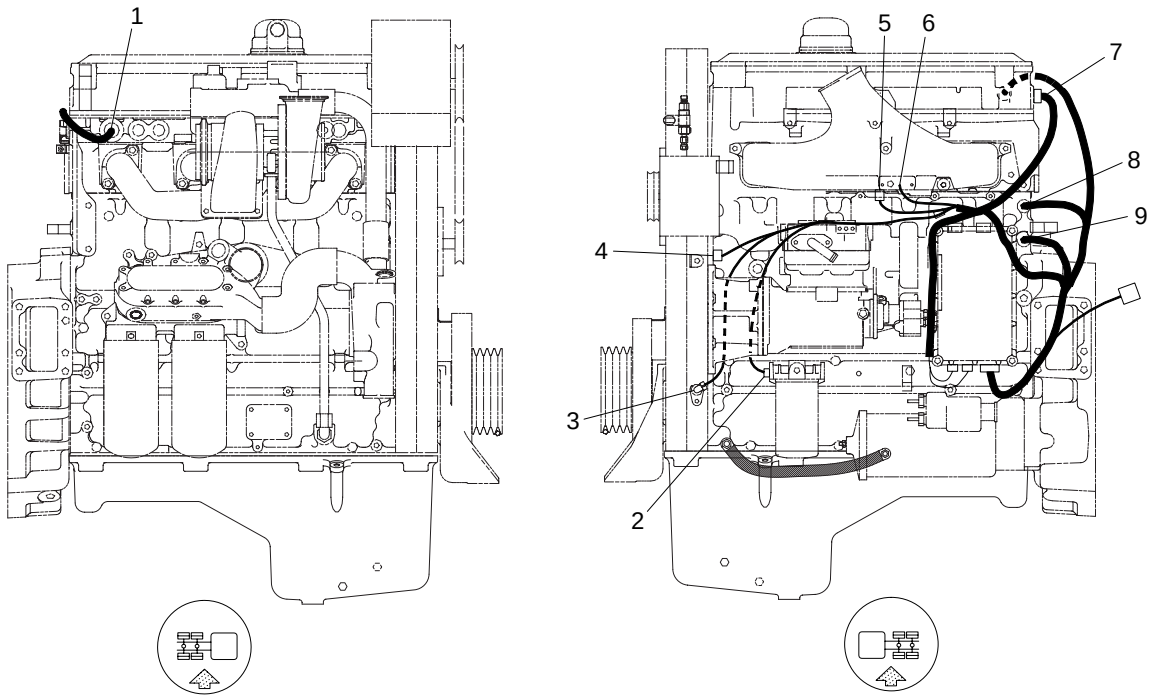
ECM shuts down the engine (if the engine is programmed with shutdown protection).

Fuel, Air, Coolant, and Oil Temperature Sensors (See Fig. 10 and Fig. 11)

The fuel temperature sensor, installed in the secondary fuel filter, measures fuel temperatures for the ECM to use when calculating fuel consumption and fuel input compensation. If the fuel temperature rises above 100°F (38°C), the ECM will increase fuel delivery to the injectors. This increase in volume compensates for the warmer, less dense fuel. If the fuel temperature rises to 140°F (60°C), the ECM will no longer increase the fuel delivery to the injectors. The ECM drops fuel delivery back to the original rate because, at this temperature, the fuel and engine are too hot.

The air temperature sensor, installed in the underside of the air intake manifold, reports engine intake air temperature to the ECM so the ECM can vary the hot idle speed and injection timing for better cold starts and less white smoke.

The coolant temperature sensor, installed in the coolant jacket above the rear end of the exhaust manifold, tells the ECM if coolant temperature exceeds 217°F (103°C). At that temperature, the EDM turns on the high coolant temperature light and buzzer, and the ECM turns on the CEL and begins to cut engine power. If the coolant reaches 223°F (106°C), the ECM turns on the SEL and shuts down the en-



1. Coolant Temperature Sensor
2. Fuel Temperature Sensor
3. Timing Reference Sensor
4. Synchronous Reference Sensor
5. Intake Air Temperature Sensor
6. Turbo Boost Pressure Sensor
7. Electronic Unit Injectors
8. Oil Pressure Sensor
9. Oil Temperature Sensor

Fig. 11, Detroit Diesel Wiring Harnesses and Sensors on Series 50 Engine With DDEC III

gine (if the engine is programmed with shutdown protection).

The oil temperature sensor is installed below the oil pressure sensor, below the rear end of the intake air manifold. **See Fig. 10** and **Fig. 11.** It reports oil temperature to the ECM so the ECM can vary idle speed and injection timing for better cold starts and less white smoke. If oil temperature exceeds 250°F (121°C), the EDM activates the high oil temperature warning light and buzzer, and the ECM activates the CEL and begins to cut engine power. If the oil temperature reaches 260°F (127°C) the ECM turns on the SEL and shuts down the engine (if the engine is programmed with shutdown protection).

Throttle Position Sensor

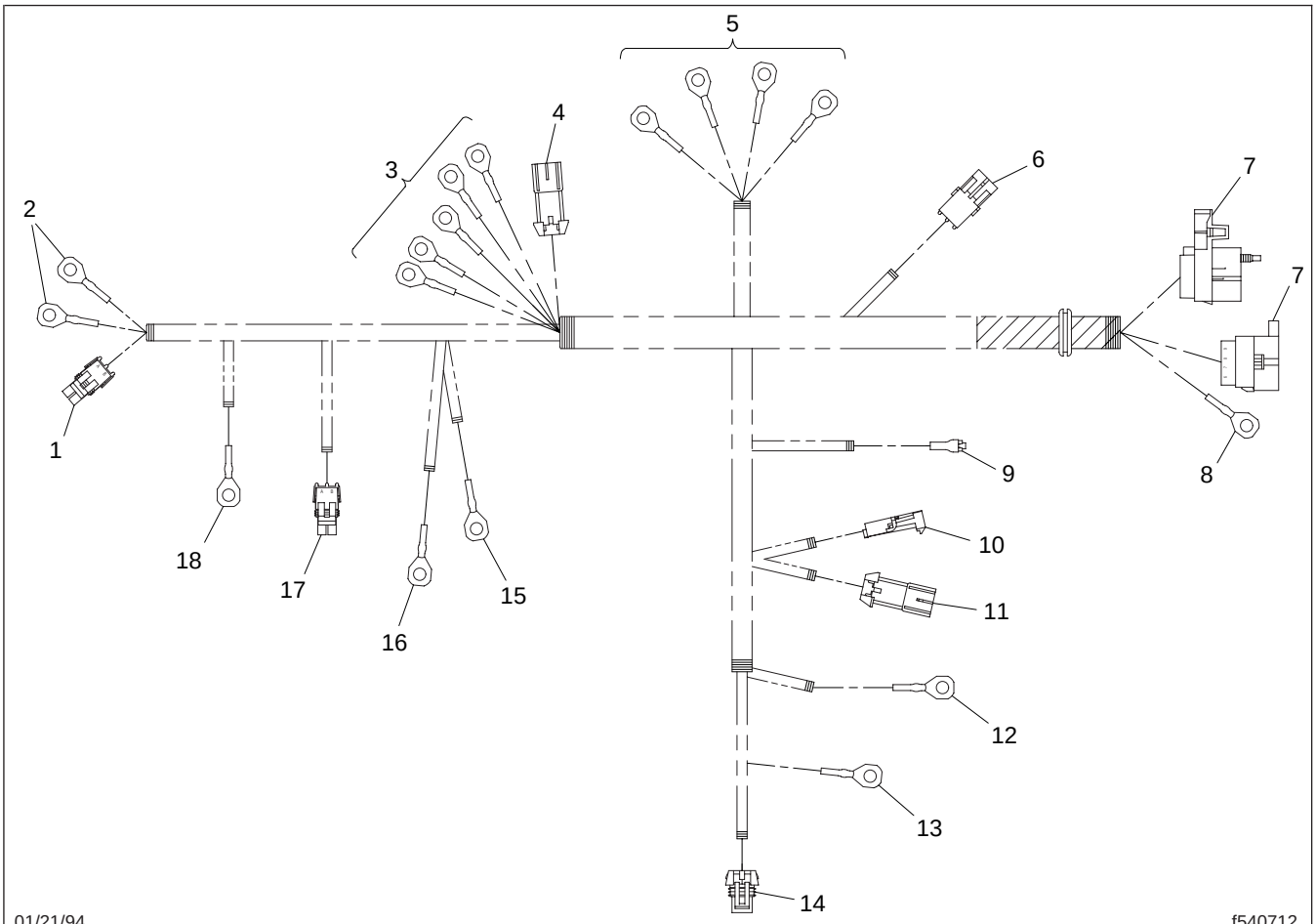
The throttle position sensor is part of the electronic foot pedal assembly. Freightliner uses the Williams Electronic throttle pedal with DDEC III systems. There is no mechanical throttle linkage.

NOTE: Williams throttle pedals made to work with DDEC II will work with DDEC III, but the reverse is not true.

Coolant Level Sensor

Freightliner installs the coolant level sensor in the radiator top tank or surge tank. The coolant grounds the sensor, so if the coolant level drops below the sensor for more than seven to ten seconds, the low coolant level warnings begin. The warning means more than 10% of the engine coolant is missing, and this early warning will prevent coolant aeration and water jacket cavitation.

General Description and Principles of Operation

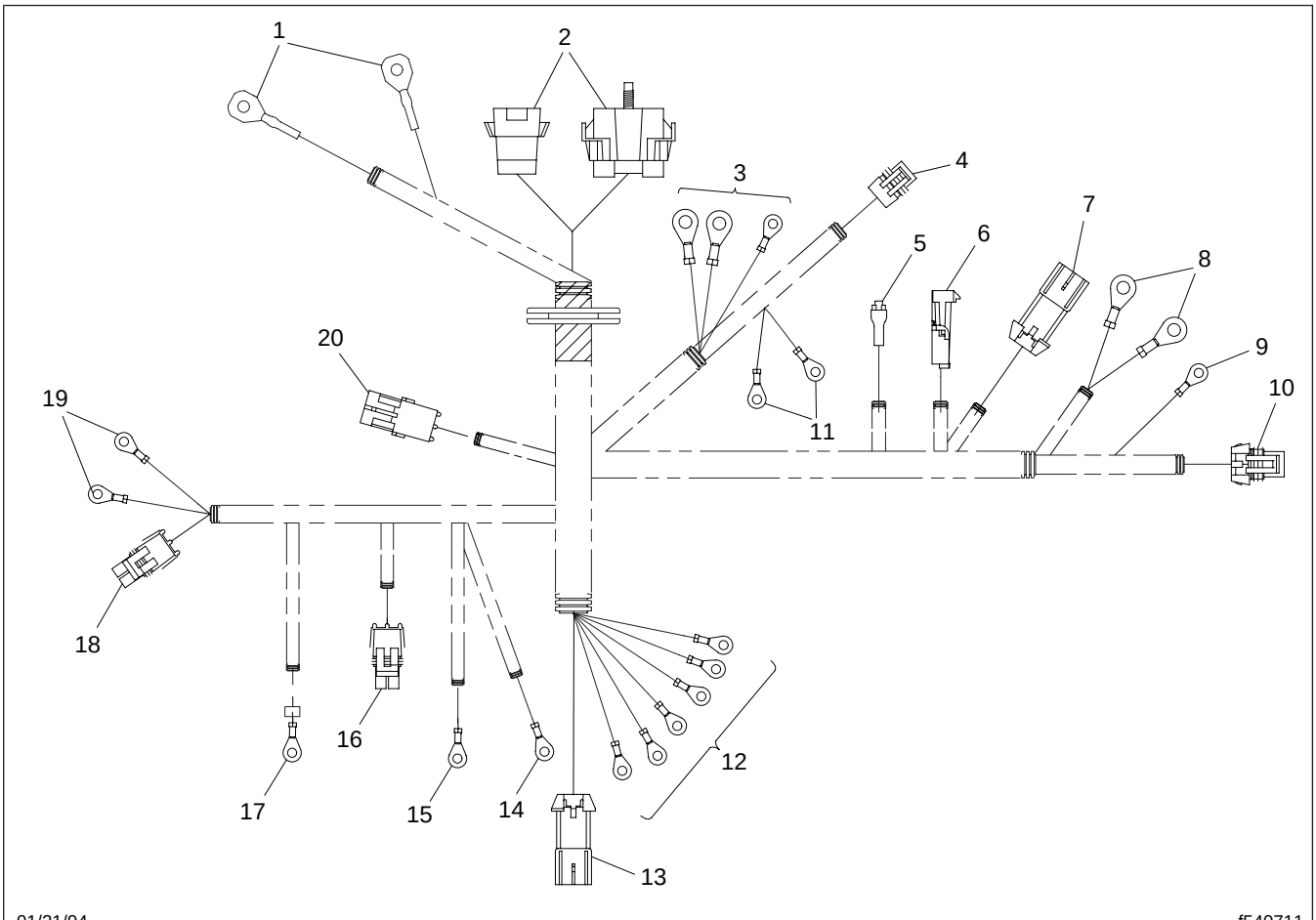


1. Speedometer Sensor
2. Back-Up Light Switch
3. Starter
4. Ammeter Shunt
5. Magnetic Switch
6. Air Conditioning Pressure Switch
7. Bulkhead Connections
8. Power Stud
9. Ether Start
10. Air Conditioning Refrigerant Compressor Clutch
11. Fan Solenoid
12. Alternator
13. Fan Temperature Switch
14. Coolant Temperature Gauge Sender (not used with EDM)
15. Engine Oil Temperature Sensor
16. Coolant Temperature Switch (not used with EDM)
17. Tachometer Sensor
18. Transmission Oil Temperature Sensor

Fig. 12, Freightliner Non-Electronic Component Wiring Harness, Detroit Diesel Series 60 Engine in an FLB COE

Vehicle Speed Sensor

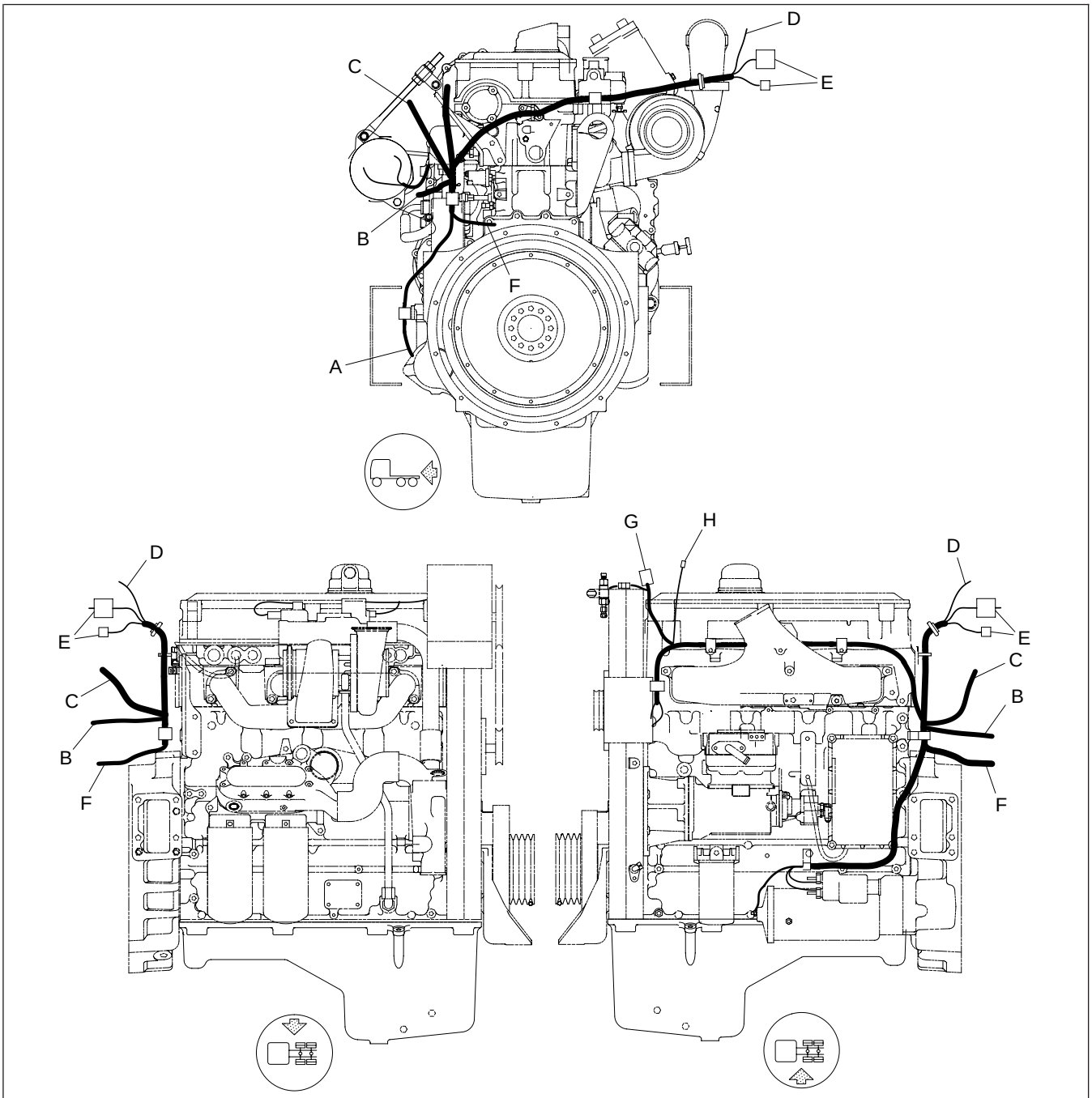
The vehicle speed sensor is installed in the transmission output, and sends vehicle speed signals to the speedometer and to the ECM. The ECM uses this signal for cruise control and for vehicle speed limiting.



1. Power Stud
2. Bulkhead Connections
3. Magnetic Switch
4. Electric Horn
5. Ether Start
6. Air Conditioner Refrigerant Compressor Clutch
7. Fan Solenoid
8. Alternator
9. Fan Temperature Switch
10. Coolant Temperature Gauge Sensor (not used with EDM)
11. Ground
12. Starter
13. Ammeter
14. Coolant Temperature Switch (not used with EDM)
15. Engine Oil Temperature Sensor
16. Tachometer Sensor
17. Transmission Oil Temperature Sensor
18. Speedometer Sensor
19. Back-Up Switch
20. Air Conditioning Pressure Switch

Fig. 13, Freightliner Non-Electronic Component Wiring Harness, Detroit Diesel Series 60 Engine in an FLD Conventional

General Description and Principles of Operation



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A. Route to the starter.
B. Route to air conditioning pressure switch on the receiver drier.
C. Route to the magnetic switch and the horn.
D. Route to the power stud.
E. Route to the bulkhead connectors.
F. Route to the transmission (back-up switch, vehicle speed sensor, tachometer sensor).
G. Route to the refrigerant compressor.
H. Route to the ether start.

Fig. 14, Freightliner Non-Electronic Component Wiring Harness, Detroit Diesel Series 50 Engine

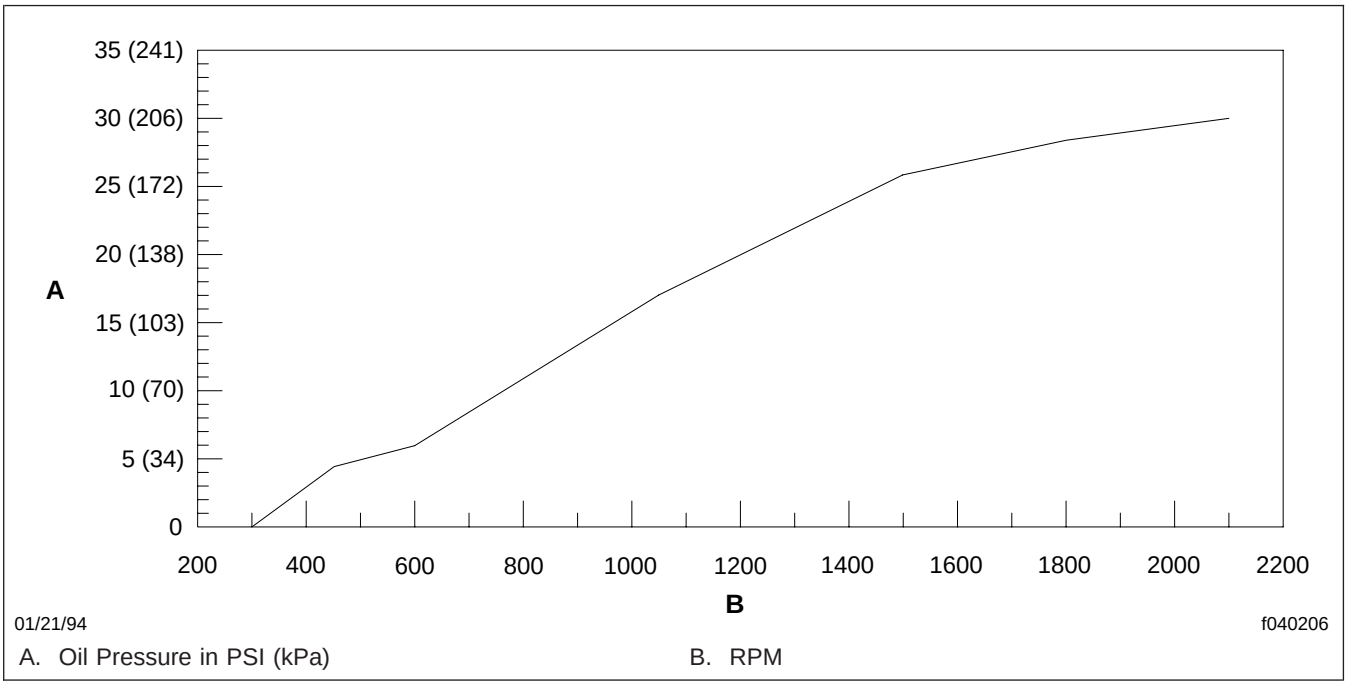


Fig. 15, Low Oil Pressure Limits, Detroit Diesel Series 50 and 60 Engines with DDEC III

Since model year 1994, Freightliner models FLD and FLD 112 conventionals and FLB COEs equipped with Detroit Diesel Series 50 and 60 DDEC III engines use a fan clutch control module supplied by Kysor. This Electronic Data Monitor (EDM) connects to the DDEC III data link and to the DDEC III "fan request" circuit. These two connections have replaced the following four sensors:

- Temperature gauge sensor,
- Fan control temperature sensor,
- Overheat warning temperature sensor,
- Low oil pressure warning sensor.

IMPORTANT: Do not confuse EDM (electronic data monitor) with ECM (DDEC III electronic control module).

Information about coolant temperature and oil pressure travels from engine sensors, through the ECM, to the EDM. The EDM translates this information from a digital signal to an analog signal that controls the dash gauges and warning lights. The EDM makes it possible for a single sensor to control several components, such as the engine fan, dash gauges, and dash warning lights. Using a single sensor prevents problems caused by conflicting information from multiple sensors. For example, a coolant sensor that controls the engine shutdown feature might be in a hotter area of the engine, and this sensor might activate the dash warning light before a sensor in a cooler area turns on the engine fan. With a single sensor, and the EDM to translate the sensor signal, problems like this are less likely to happen.

Conditions That Cause the Fan Clutch to Be On

NOTE: If the vehicle is equipped with a fan override switch, the fan will go on in response to this switch, independent of DDEC III or EDM control.

DDEC III Commands to the Fan

(see Table 1)

With engine brake dynamic braking, the ECM commands the fan on when the compression brake is selected high and active. This is an optional feature selected at the time the engine is ordered.

These parameters are programmable, and values listed above are default settings. With the EDM, the DDEC controller does not directly control the fan solenoid. Rather, the DDEC controller sends its commands to the Kysor EDM over circuit D555. On receiving this signal, the EDM acts as a relay to control the solenoid valve ground via circuit 234A.

Kysor EDM Commands to the Fan

A/C Pressure Switch Open

When the normally closed refrigerant pressure switch opens, the EDM commands the fan on. When the refrigerant pressure is lowered to the point that the switch closes, the EDM continues to command the fan on for an additional 30 seconds, and then turns the fan off.

Active DDEC III High Coolant Diagnostic

When the EDM has received an active DDEC III diagnostic over the data bus for coolant temperature out of range (high), the EDM commands the fan on, regardless of the state (high or low) of the D555 circuit.

DDEC III Command to Turn the Fan On

When the EDM receives a command from the DDEC III controller over circuit D555 to turn the fan on, the EDM, acting as a relay, commands the fan on.

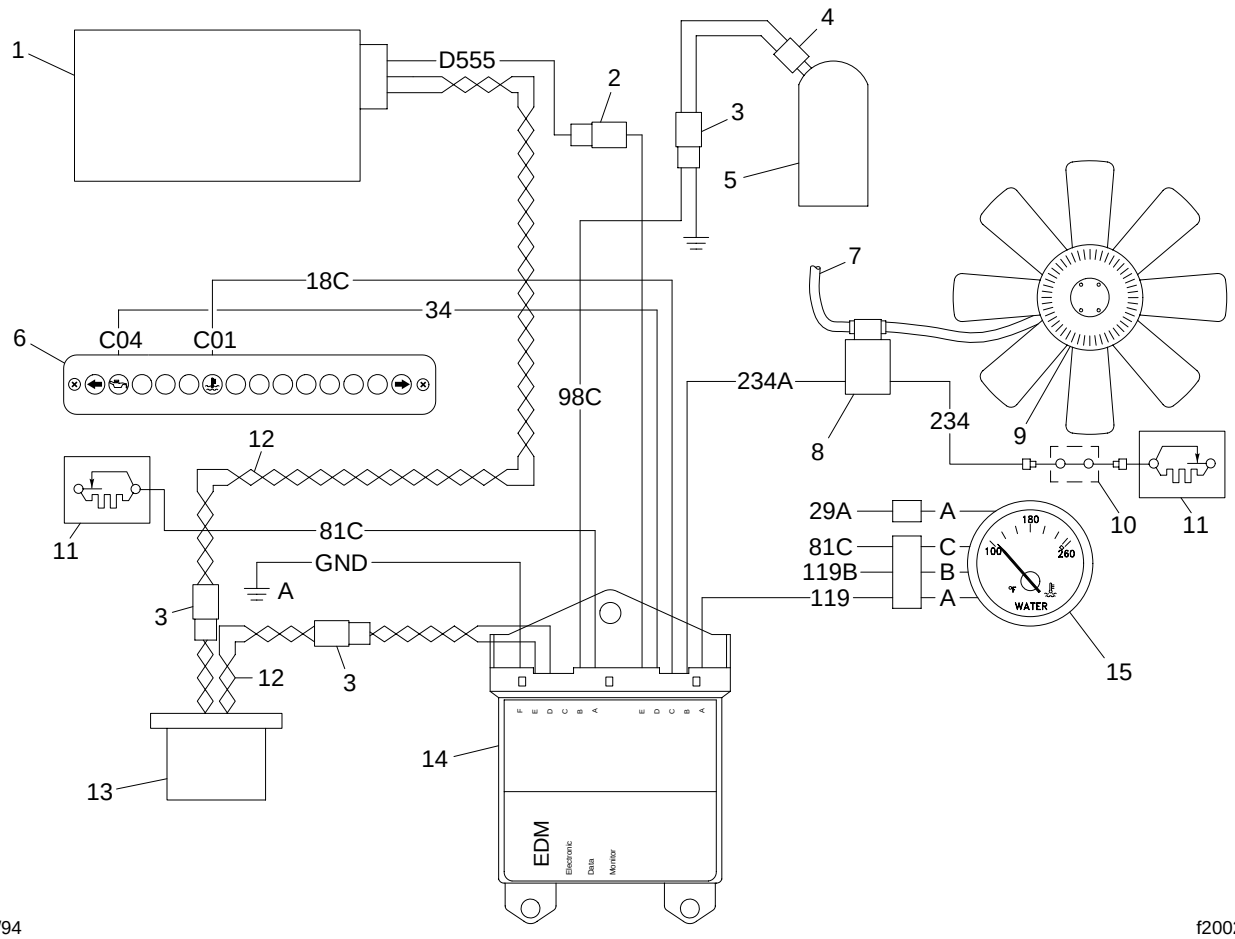
Data Bus Connection Open

If the data bus connection between the EDM and the DDEC III controller opens, the EDM commands the fan on. This is an abnormal condition, indicated by a "wagging" coolant gauge needle, and should be corrected. The EDM controls the coolant temperature gauge, and causes the needle to swing slowly between approximately 100°F (38°C) and 150°F (66° C).

RELATIONSHIP BETWEEN DDEC III AND KYSOR EDM

(see Fig. 1)

a volt). The Kysor EDM senses this, and responds by holding line 234A low, which energizes the fan control solenoid valve. The Kysor EDM operates as a relay in response to circuit D555. When D555 is released (now measuring a few volts when connected to the EDM), the EDM releases line 234A, the fan solenoid valve de-energizes and the fan is on.



A. Grounded to component mounting plate.

1. DDEC III ECM
2. One-Way Connector
3. Two-Way Connector
4. A/C Pressure Switch (NC)
5. A/C Receiver-Drier (mounted on the firewall (FLD) or the RH fwd frame rail (FLB))
6. Vigil Lightbar
7. Air Line
8. Fan Control Solenoid Valve
9. Air-Controlled Fan Clutch
10. Fan Override Switch (optional)
11. Ignition-Controlled Circuit Breaker (10 amp)
12. J1587 (+) & (–) Twisted Pair (data bus)
13. Diagnostic Connector (LH dash panel)
14. Kysor EDM (component mounting plate)
15. Coolant Temperature Gauge

Fig. 1, DDEC III/Kysor EDM Wiring Connections

Circuit D555

If the DDEC III controller wants the fan off, it holds circuit D555 near to "ground" (within a few tenths of

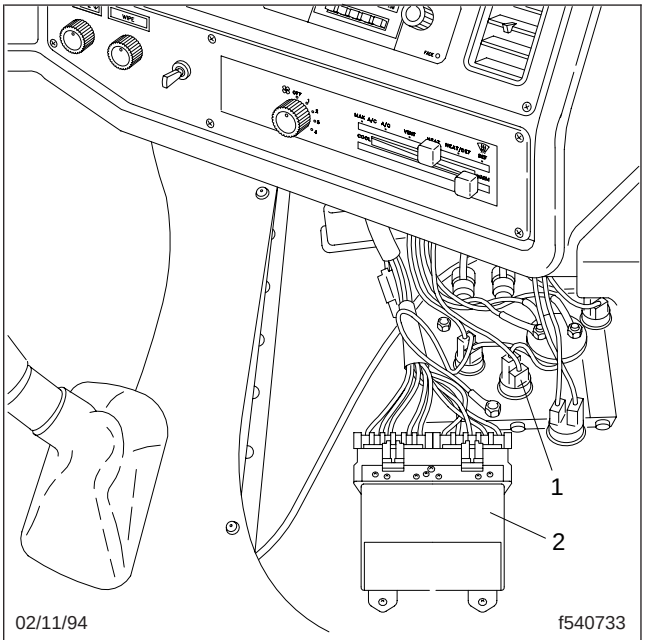
J1587 Data Bus

The Kysor EDM responds to the digital information on these circuits (twisted pair of wires) for coolant temperature, high coolant temperature warning, and low oil pressure warning. It uses this information to drive the coolant gauge (circuit 119) and to illuminate the Vigil warning lamps and buzzer (circuit 18C for high coolant temperature and circuit 34 for low oil pressure).

Fan Status	Coolant Temperature	Oil Temperature	Intake Air Temperature
Fan On	205° F (96°C)	230° F (110°C)	151° F (66°C)
Fan Off	198° F (92°C)	219° F (104°C)	120° F (49°C)

Table 1, DDEC III Fan Switching Temperatures

Replacement (see Fig. 1 or Fig. 2)



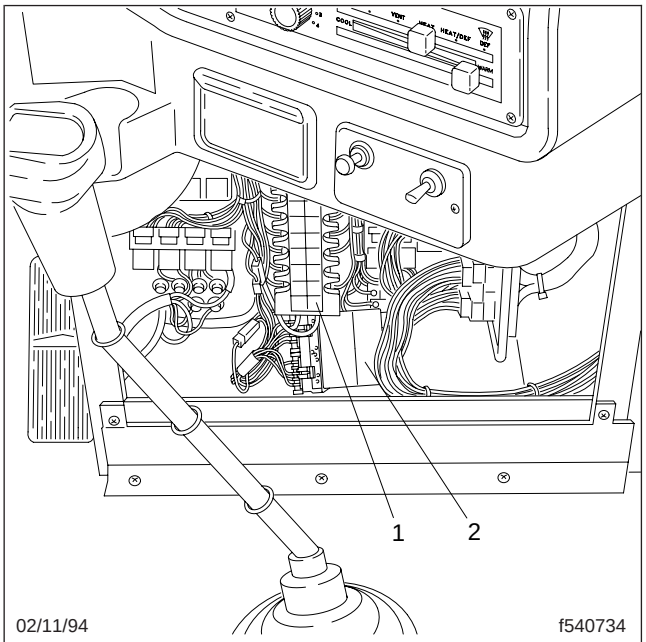
1. Electrical Center
2. EDM

Fig. 1, EDM Location in COE Vehicles

1. Park the vehicle, set the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the electrical center cover.

   On FLB COEs, the electrical center is inside the cab, on top of the tunnel. Remove the screw that holds the center cover, and lift the cover off the electrical center.

   On FLD Conventionals, the electrical center is inside the cab, below the dash, and between the driver and passenger seats. Remove the three screws that hold the cover, then lift the cover up and pull it back, off the electrical center.
4. Remove the EDM.
   - 4.1 Disconnect the two wiring harness connectors that plug into the EDM.
   - 4.2 Remove the screws that hold the EDM to the electrical center, and remove the EDM.
5. Install the new EDM.



1. Electrical Center
2. EDM

Fig. 2, EDM Location in Conventional Vehicles

   - 5.1 Plug the two wiring harness connectors into the new EDM.
   - 5.2 Place the new EDM in the electrical center, and secure it with the screws removed from the old EDM.
   - 5.3 Install the electrical center cover.
6. Connect the batteries.
7. Remove the chocks from the tires.

System Checks

Fan Solenoid Valve Plumbing

The valve should be plumbed so that the fan is off when the solenoid is energized electronically. This can be checked by disconnecting circuit 234A from the EDM and energizing the solenoid valve by connecting 234A to ground. Vehicle air pressure must be up, and the key switch in the run position, so that the valve will have 12 volts supplied to it. The valve can be heard operating when the engine is not running. If the fan locks up under these conditions, it is plumbed with the wrong logic.

D555 Input to EDM

If the Kysor EDM is operating correctly, it is possible to see that it responds to circuit D555 by "grounding" this input of the EDM. There is an inline connector on this circuit near the EDM that can be unplugged to do this check. When the input is "grounded" (with a clip lead or jumper wire), the fan should be off. When the input is open, (disconnected from ground), the fan should be on or locked up. This check works only if everything else in the system is ok. It is a good way to determine if the EDM is installed correctly. (When doing this check, the A/C should be off so that the A/C pressure switch is closed.)

A/C Pressure Switch Input to EDM

If the Kysor EDM is operating correctly, it is possible to see that it responds to the pressure switch input by disconnecting the EDM from the pressure switch. The switch is on the receiver-drier, and there is an inline two-way connector near this switch. With the engine at idle and the A/C off, the fan should engage (go on) when the EDM is disconnected from the pressure switch. On the other hand, to check that the fan will go off in response to this input, connect circuit 98C to "ground" (the fan should go off in about 30 seconds). A quick way to do this is to short the two-way connector pins together. This will supply a ground to circuit 98C (this also ensures that the ground wire in the two-way connector is grounded). If the fan does not go off with the EDM disconnected from the pressure switch, measure the voltage at circuit 98C (the wire end that goes to the EDM). With the inline two-way connector disconnected, the EDM end of circuit 98C should read approximately 12 volts.

A/C Pressure Switch

The switch should be closed when the A/C is off. This can be checked with an ohmmeter. If it is suspected that the refrigerant charge is wrong, and is keeping the switch open, quickly unscrew the pressure switch from the receiver-drier and, using an ohmmeter, check that the switch is closed. If it is closed, the switch may be ok, and it may be necessary to recharge the A/C system. However, it is also possible that the switch has lost its correct opening and closing pressure settings. But if the switch is open when removed from the receiver-drier, it is definitely either the wrong switch, or it is malfunctioning.

Open Data Bus

If the data bus is open or the data bus lines have been reversed, the coolant needle "wags" or swings back and forth (between approximately 100° F and 150° F) to indicate that the Kysor EDM has lost its data bus connection to the engine. Probably it has become unplugged at the two-way inline connector near the SAE (Deutsch) 6-pin diagnostic connector. The two-way connector is located behind the panel on which the data bus connector is mounted. On initial startup, it is important to wait 10 seconds to observe whether the coolant gauge needle is swinging. The EDM goes through a normal startup check (sweeps the coolant gauge needle and illuminates the high coolant temperature and low oil pressure lamps), then waits 10 seconds before indicating that the data bus is disconnected. The fan stays on if the data bus is disconnected.

DDEC Diagnostic Tool

This tool may be used to observe air intake temperature, coolant temperature, oil pressure, and the state of line D555 (port A2 on the DDEC III controller). When reading the state of port A2, the DDEC reader says FAN ON when the fan is physically off. The reader is really saying that the output transistor for port A2 is on. When the ouput transistor is on, the line goes low, and a low into the EDM on line D555 means the fan is off. Thus, when the reader says A2 FAN OFF, the fan is on; when the reader says A2 FAN ON, the fan is off. The tool may also be used to toggle the output on and off in an interactive test.

DDEC III Temperature Sensor Diagnostics

The engine controller will not report a failure for these sensors (oil and coolant) until after the engine has been running for eight minutes. According to Detroit Diesel, the controller cannot distinguish between an inoperative sensor and a cold sensor, so it is necessary to heat up the engine before valid checks are possible for sensors out of range.

Troubleshooting

For an applicable troubleshooting flow chart, **see Fig. 1, Fig. 2, Fig. 3,** or **Fig. 4 .**

NOTE: **Figure 1** shows the EDM power up sequence, and **Figure 2** shows how the EDM normally operates. These figures are provided to help give a better understanding of how the system operates.

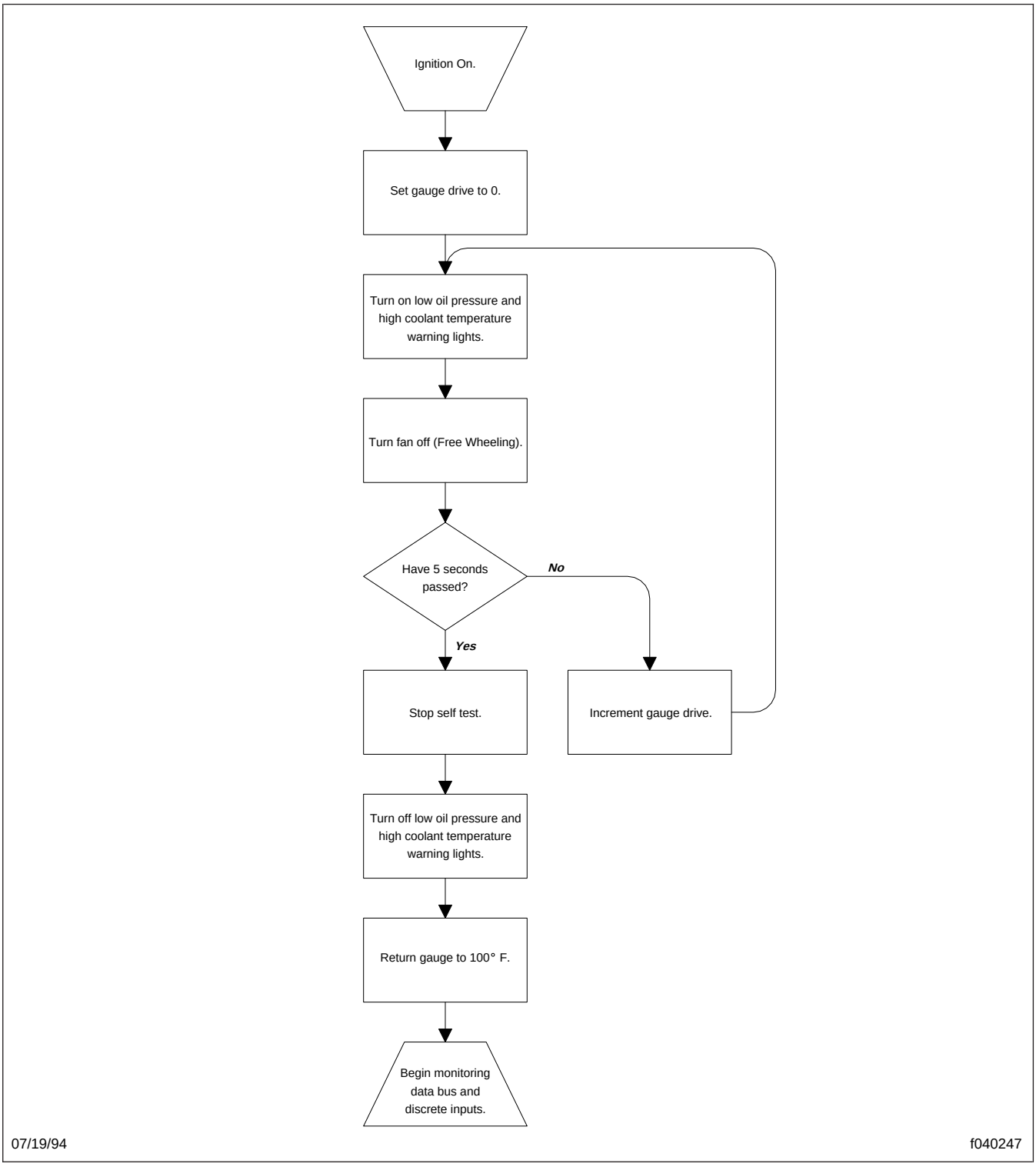


Fig. 1, EDM Power Up Sequence

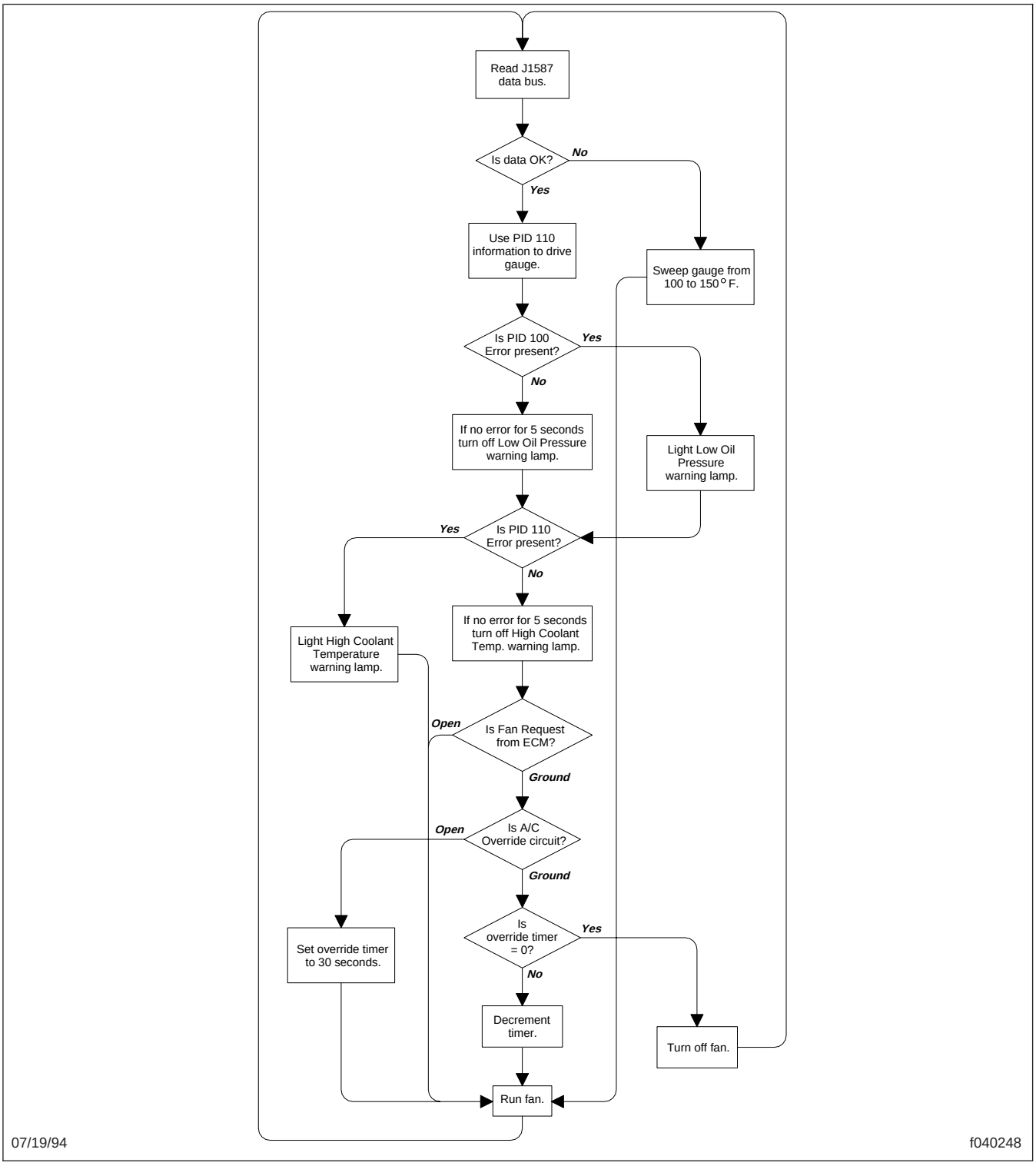


Fig. 2, EDM Normal Operation

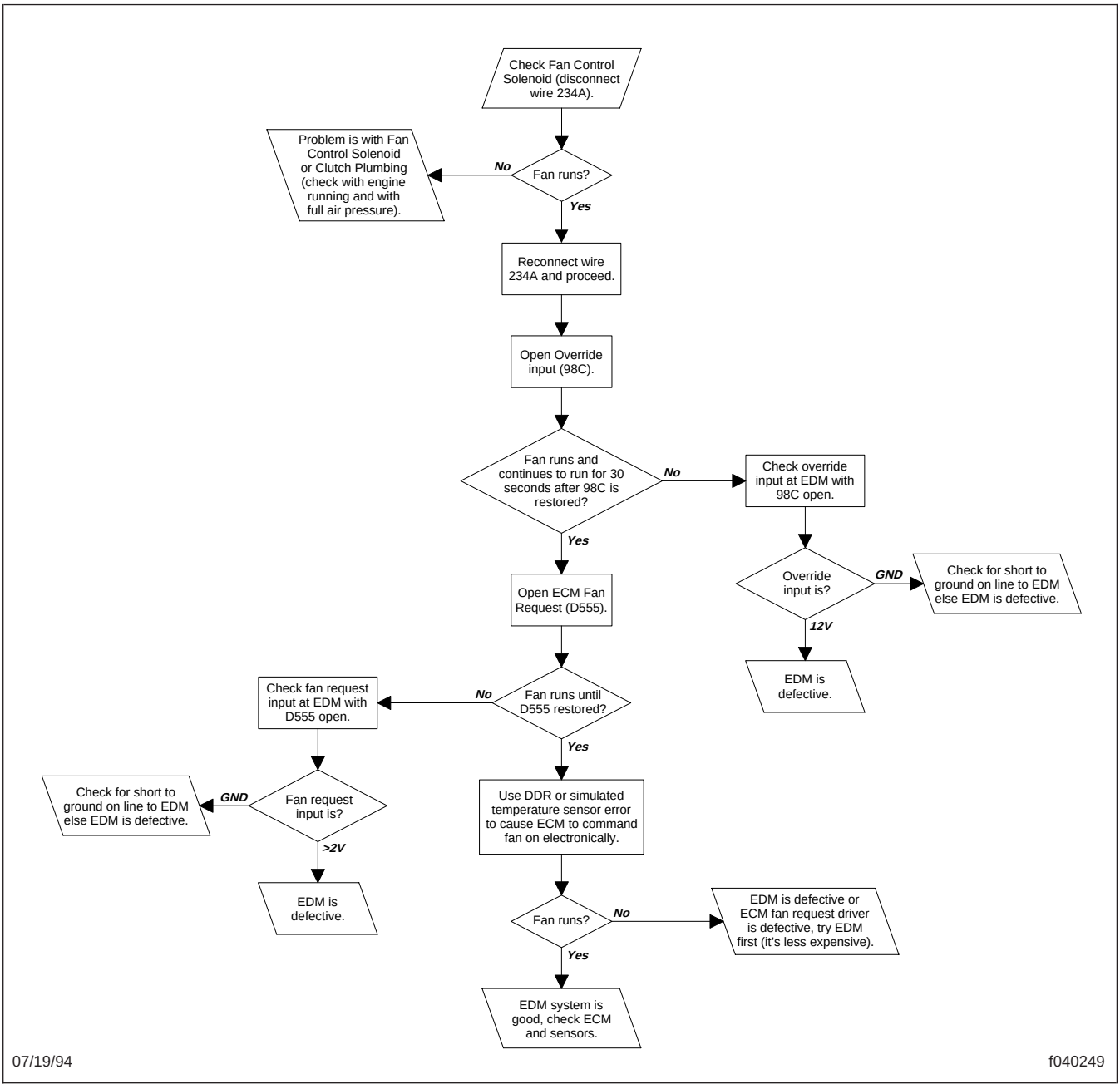


Fig. 3, EDM Troubleshooting Guide (Fan Never Runs or Fails to Run When it Should)

Troubleshooting

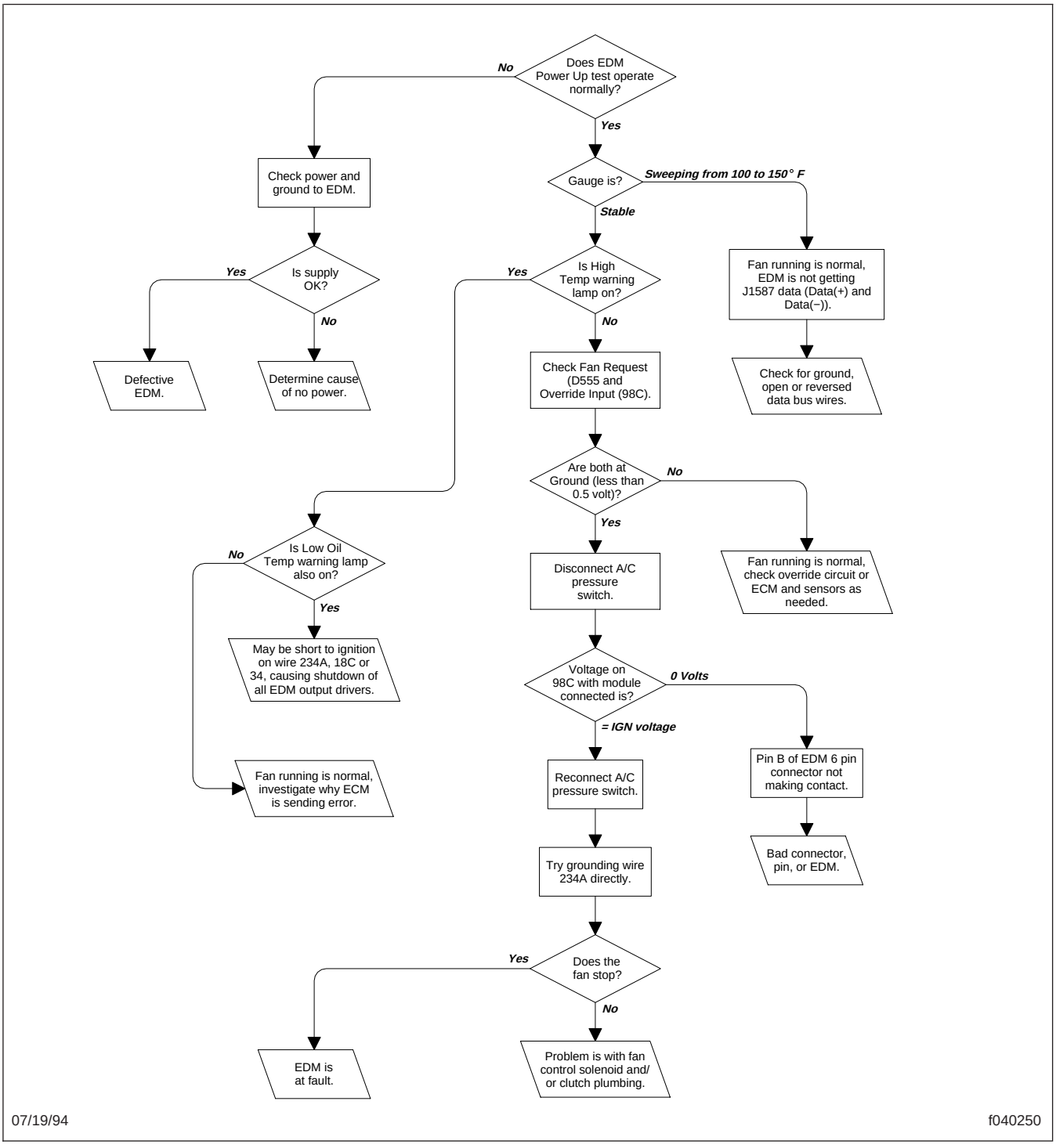
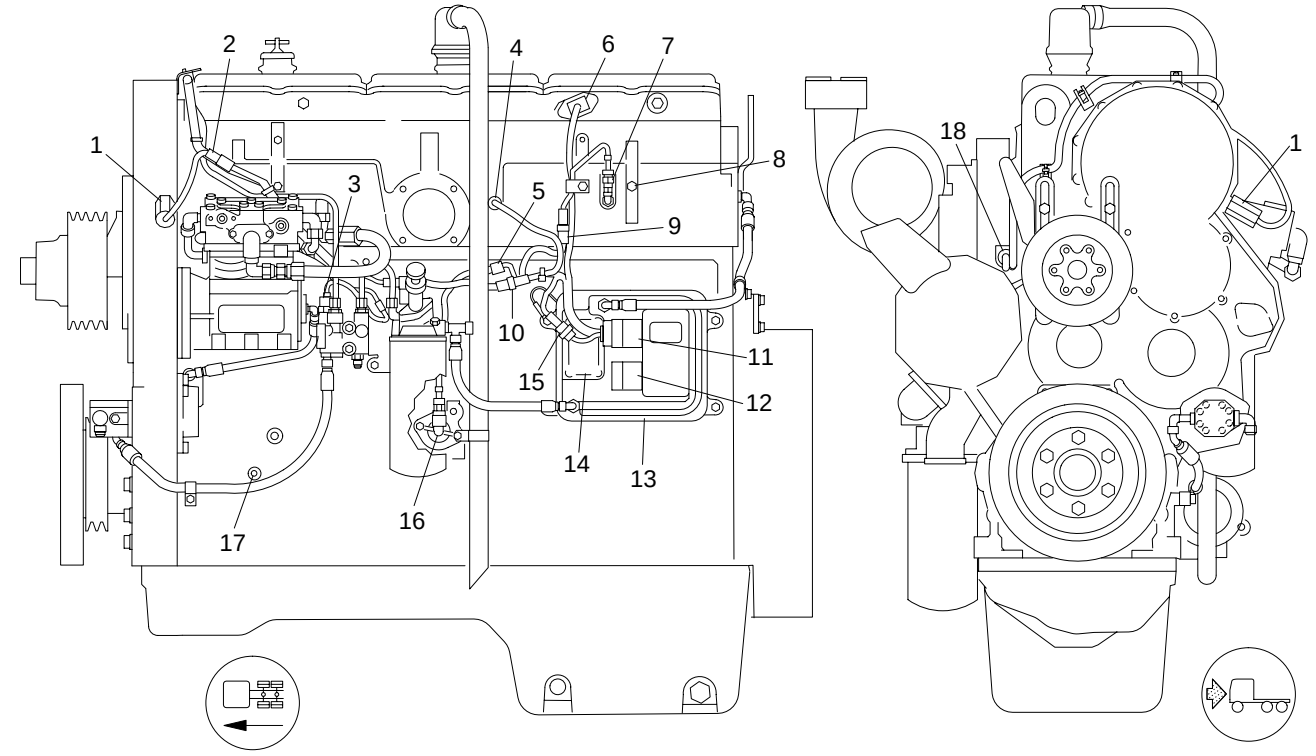


Fig. 4, EDM Troubleshooting Guide (Fan Runs All the Time)

General Information (See Fig. 1)

The Caterpillar 3406E electronic engine system provides electronic engine control and engine warning and shutdown features to prevent engine damage.

switch, service brake and clutch switches and the parking brake switch also control the engine system. Additional parts include a throttle position sensor and a standard SAE diagnostic communications data link (see Fig. 2).



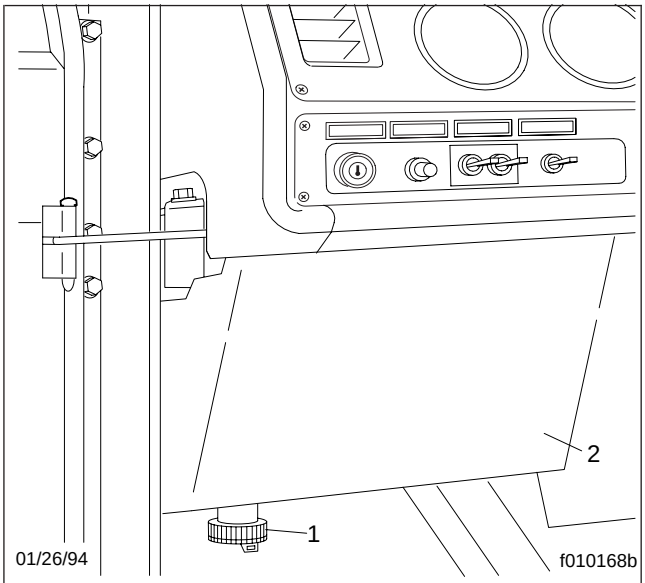
1. Engine Speed/Timing Sensor
2. Engine Speed/Timing Sensor Connector P9/J9
3. Fuel Temperature Sensor
4. Intake Manifold Air Temperature Sensor.
5. Atmospheric Pressure Sensor Connector P22/J122.
6. Injector Connector J5/P5.
7. Boost Pressure Sensor.
8. Engine Cylinder Head Ground Stud.
9. Boost Pressure Sensor Connector P3/J3.
10. Intake Manifold Air Temperature Sensor Connector J21/P21
11. ECM Connector J2/P2.
12. ECM Connector J1/P1.
13. Electronic Control Module (ECM)
14. Personality Module (not used on 1996 engines)
15. Vehicle Speed/TDC Connector P24/J24.
16. Atmospheric Pressure Sensor
17. Timing Calibration Port
18. Coolant Temperature Sensor

Fig. 1, Caterpillar 3406E Electronic Engine

Under normal operating conditions, the system controls the engine with an electronic control module (ECM), a timing advance unit, and an electronic governor, all of which are located on the engine. Inside the cab, the cruise control switches, engine brake

When an emergency occurs (a loss of oil pressure for example, or low engine coolant) the electronic engine system has optional engine protection features that will warn the driver, then cut the vehicle

General Information



1. 6-Pin SAE J1587/1708 Diagnostic Connector
2. Upper Steering Column Cover Panel

Fig. 2, Diagnostic Data Link Location

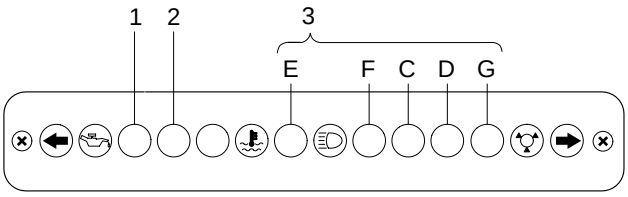
speed and shut down the engine, depending on the level of protection the customer prefers.

A personality module or ratings personality module is attached inside of the ECM. It contains all of the instructions (software) for the ECM and performance maps for a specific horsepower family. A 3406E engine has the following electronic functions:

- Electronic governing
- Control of fuel-to-air ratio
- Torque rise shaping
- Injection timing control
- System diagnostics
- Customer specified parameters
- Vehicle speed limiting
- Progressive shift control
- PTO governor
- Cold mode operation
- BrakeSaver (optional)
- Jake brake (optional)
- Idle shutdown timer
- Cruise control

Five of these functions: cruise control, idle shutdown timer, BrakeSaver (optional), Jake brake (optional), and PTO governing, are driver-activated, and are controlled by switches mounted to the right of the ignition switch. When the vehicle is parked, the switches control the PTO; when moving, the switches control the cruise control. With the vehicle parked and the engine not running, the cruise control switches are used to check the ECM. The remaining functions occur automatically and according to programmed specifications.

Vehicles equipped with the electronic engine system use a VIGIL I lightbar. **See Fig. 3**. When an emergency occurs, the "check engine" light and/or a specific warning light (low oil pressure, etc.) on the lightbar will come on as a warning to the driver. For low oil pressure, low air pressure, or high coolant temperature, a warning buzzer will also sound. Since the oil pressure and the coolant temperature are monitored by both the VIGIL and the Caterpillar systems, either one or both systems can activate in an emergency. If the Caterpillar system activates, only the "check engine" light will light. If the VIGIL system activates, either the low oil pressure or coolant temperature lights will go on. The parameters are about the same for the Caterpillar and VIGIL high coolant temperature warning systems, so those systems should activate simultaneously. The Caterpillar low oil pressure warning system is more sensitive than the VIGIL, the Caterpillar system judges the oil pressure in relation to engine rpm so the Caterpillar system may indicate an emergency before the VIGIL system.



1. Check Engine Light
2. Shutdown Light (or Stop Engine Light if the derate protection mode is specified)
3. Lightbar Options

Fig. 3, VIGIL I Lightbar

NOTE: On 3406E electronic engines, the VIGIL I lightbar is not equipped with a warning light for low coolant level. If coolant is needed, only the "check engine" light will come on.

Caterpillar 3406E electronic engines have the following optional engine protection warning and shutdown features:

- Low oil pressure
- High coolant temperature
- Intake manifold air temperature
- Low coolant level

Depending on the customer's preference, the 3406E engine protection system can be set at one of four levels. At the first level, the system is off. The second level will activate the warnings. The third level will activate the warnings when an emergency situation occurs and then cut engine power if the situation worsens, but will not shut down the engine. At the fourth level of engine protection, the system will activate the warnings, cut engine power and shut down the engine as the emergency situation worsens.

Each vehicle is programmed with the level of emergency engine protection specified by the customer. To change that level, the customer can return the vehicle to a Caterpillar or Freightliner dealership for reprogramming with a Caterpillar electronic control analyzer programmer (ECAP) service tool.

ELECTRONIC CONTROL MODULE

The electronic control module, mounted on the left rear side of the engine cylinder block, controls the injection pump and the injection timing. It also provides electrical power to all of the engine mounted sensors and actuators, and monitors the overall operation of the system. Reverse voltage polarity protection and resistance to vehicle power system voltage "swings" or "surges" (due to sudden alternator load, etc.) have been designed into the ECM. The electronic control module is cooled by fuel circulating through a manifold between two circuit boards in the control module.

TIMING ADVANCE UNIT

Injection timing depends on engine rpm, load, and other operation factors. The ECM knows where top center of cylinder number one is from the signal provided by the engine speed/timing sensor. It decides when injection should occur relative to top center and provides the signal to the injector at the desired time.

THROTTLE POSITION SENSOR

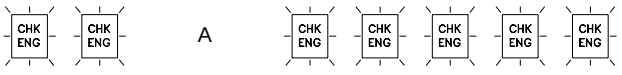
The throttle position sensor links the throttle pedal with the injector pump by way of the electronic control module. It replaces conventional throttle linkage.

SYSTEM DIAGNOSTICS

A Caterpillar electronic engine has built-in diagnostics to ensure that all components are working correctly. Intermittent engine problems are stored in memory, and remain there until the ignition is turned off. If there is a problem with the system, the "check engine" light on the dash lightbar will stay on instead of going out after 10 seconds.

If the "check engine" light comes on and stays on after initial startup the system has detected a fault. The "check engine" light or service tools can be used to identify the fault code.

The dash-mounted cruise control switches are used to check the ECM for system faults. With the cruise control switch OFF, move the SET/RESUME switch to the resume position. The "check engine" light will begin to flash to indicate a two-digit diagnostic code while the SET/RESUME switch is held in the RESUME position. This sequence of flashes represents the system diagnostic message. The first sequence of flashes adds up to the first digit of the diagnostic code. After a one second pause, a second sequence of flashes will occur which represents the second digit of the diagnostic code. **See Fig. 4**. Any additional diagnostic codes will follow, after a three second pause, and will be displayed in the same manner. **See Table 1** for a list of the diagnostic codes.



A. Two Second Pause

Fig. 4, Diagnostic Code Example, Code 25

CUSTOMER SPECIFIED PARAMETERS

The customer specified parameters include:

- Engine power rating
- Vehicle identification number

- PTO vehicle speed limit (PTO VSL)
- PTO engine RPM limit (PTO RPM)
- Low gears limit
- Intermediate gears limit
- Engine RPM at vehicle speed limit (engine RPM at VSL)
- Geardown protection
- Top engine limit (TEL)
- Vehicle speed limit (VSL)
- High gear turn on speed (HiGrOn)
- Low cruise control set limit (LCC)
- High cruise control speed set limit (HCC)
- Retarder coast/latch
- Idle shutdown timer

The customer specified parameters may be secured by customer passwords. An ECM may have all parameters programmed or any combination of parameters programmed. A brief explanation of each of the customer specified parameters can be found in the *Caterpillar 3406E Operation and Maintenance Manual*.

JAKE BRAKE (OPTIONAL)

The Jake brake is controlled from the ECM and aids the operator in slowing and controlling the vehicle on grades and curves, or anytime when speed reduction is necessary but long applications of the service brakes are not desired. In downhill operation, or any slowdown condition, the engine crankshaft is turned by the rear wheels (through the differential, driveshaft, transmission, and clutch).

When the Jake brake is activated, braking power is accomplished by opening the engine's exhaust valves near the top of the compression stroke to release the highly compressed air, with the energy it represents, into the exhaust system. No combustion occurs to produce positive force on the piston since the Jake brake can only be activated (providing the retarding or slowing effect) when the engine is in a "no fuel" mode. The release of the compressed air pressure to the atmosphere prevents the return of energy to the engine piston on the expansion (power) stroke. The result is an energy loss, since the work done by compression of the cylinder charge is not returned by the expansion process. This loss of energy results in vehicle braking at the rear wheels.

BRAKESAVER (OPTIONAL)

The BrakeSaver permits the operator to control the speed reduction of the vehicle on grades, curves, or at any time when speed reduction is necessary but long applications of the service brakes are not desired.

During downhill operation, the crankshaft is turned by the rear wheels (through the differential, driveshaft, transmission, and clutch). To reduce the speed of the vehicle, an application of a braking force can be made to the crankshaft. The BrakeSaver does this by converting the energy of rotation into heat which is removed by the engine cooling system.

ENGINE PROTECTION FEATURES

The Caterpillar 3406E engine electronic control consists of two main components: the electronic control module and the personality module. The ECM is the computer and the personality module is the software for the computer (the personality module also stores the operating maps that define horsepower, torque curves, rpm, etc). The two work together (along with sensors to "see" and solenoids/injectors to "act") to control the engine. Neither one can do anything by itself.

The electronic control module monitors engine oil pressure, coolant temperature, intake manifold air temperature, and coolant level. There are four customer programmable levels for Caterpillar engine monitoring:

- Off
- Warning (factory default)
- Derate
- Shutdown

The sensor measures absolute oil pressure from 0 PSI (0 kPa) to 100 psi (690 kPa) at the gallery. The difference between the pressure measured by this sensor (oil pressure) and atmospheric pressure is oil pressure as displayed by service tools and communicated over the data link. The ECM uses this sensor input only if the parameter for engine monitoring is programmed to warning, derate, or shutdown.

The sensor measures oil pressure only after the engine has been running for about 10 seconds. This way system oil pressure has a chance to build to operating levels at engine startup. If after the first 10 seconds of engine operation the oil pressure drops below 45 psi (312 kPa) for two seconds, the lightbar "check engine" light activates. *Depending on the level of engine protection selected by the customer,* after 10 seconds of low oil pressure, the system cuts engine horsepower to 160, engine RPM to 1350, and vehicle speed to 45 mph (72 km/h). If oil pressure is low for more than 30 seconds, the engine is shut down.

The coolant temperature sensor is mounted in the water jacket, in the front of the engine housing (**see Fig. 1**). When coolant temperature is below 64°F (18°C) the system puts the engine in cold mode, limiting engine power, advance timing, and adjusting the low idle to 600 rpm to improve warm-up time. The system will keep the engine in cold mode until coolant temperature rises above 64°F (18°C) or until the engine has been running for 12 minutes. The system will then stop the cold mode and allow the engine to operate normally.

If the engine coolant temperature rises above 216°F (102°C) for more than two seconds, the lightbar "check engine" light comes on. *Depending on the level of protection specified by the customer,* the system cuts engine power ten seconds after the temperature reaches 219°F (104°C). The system cuts engine horsepower to 160 and vehicle speed to 45 mph (72 km/h). Thirty seconds later, if the problem persists, the shutdown light comes on, and the engine is shut down.

The low coolant level sensor is installed in the radiator top or surge tank. *If specified by the customer,* if the coolant in the tank drops below the sensor for 10 seconds, the system cuts engine output to 160 horsepower, and vehicle speed to 45 mph (72 km/h). If the coolant level drops below the sensor for 30 seconds, the engine is shut down.

To conserve fuel, the idle shutdown timer can be programmed to shut down the engine. *Depending on the level of protection specified by the customer,* the engine will shut down if it operates under reduced load with the vehicle stationary for a customer-defined period of time. This feature does not shut down the vehicle electrical power. The following conditions must be met to enable the idle shutdown timer:

- Idle shutdown timer has been selected
- Engine must be at operating temperature
- Vehicle must be at "0" mph
- No engine load

Ninety seconds before the programmed idle time is reached, the diagnostic lamp will start to flash at a rapid rate. The ability to override the idle shutdown timer is determined via customer parameter "Allow Idle Shutdown Override". If programmed to allow an override, and the operator moves the clutch or service brake during this final ninety second warning, the timer is overridden until it is reset (a diagnostic event code is also logged). A reset occurs when the ECM detects the vehicle has moved.

Diagnostic Flash Codes

Fault Code	Description
00	Brake Switch Fault
01	Idle Shutdown Override
02	Event Recorder Data Lost
12	Coolant Level Sensor Fault
13	Fuel Temperature Sensor Fault
14	Retarder Solenoid Fault
15	Injection Actuation Pressure Sensor Fault
17	Injection Actuation Pressure Out of Range
18	Injection Actuation Pressure Control Valve Driver Fault
19	A/C High Pressure Switch Open Circuit
21	Sensor Supply Voltage Fault
22	Rack Sensor Fault
23	Timing Sensor Fault
24	Oil Pressure Sensor Fault
25	Boost Pressure Sensor Fault
26	Atmospheric Pressure Sensor Fault
27	Coolant Temperature Sensor Fault
28	Throttle Sensor Calibration Fault
29	PTO Throttle Sensor Fault
31	Loss of Vehicle Speed Signal
32	Throttle Position Sensor Fault
34	Engine RPM Signal Fault

General Information

Diagnostic Flash Codes

Fault Code	Description
35	Engine Overspeed Warning
36	Vehicle Speed Signal Fault
37	Fuel Pressure Sensor Fault
38	Intake Manifold Temperature Sensor Fault
39	Injection Actuator Pressure System Fault
41	Vehicle Overspeed Warning
42	Sensor Calibration Fault
43	Rack System Fault
44	Timing System Fault
45	Shutoff Solenoid Fault
46	Low Oil Pressure Warning
47	Idle Shutdown Occurrence
48	Excessive Engine Power
49	Inlet Air Heater Fault
51	Intermittent Battery Power to the ECM
52	Personality Module Fault
53	Electronic Control Module Fault
55	No Detected Faults
56	Check Customer- or System Parameters
58	Powertrain Data Link Fault
59	Incorrect Engine Software
61	High Coolant Temperature Warning
62	Low Coolant Level Warning
63	Low Fuel Pressure Warning
64	High Intake Manifold Temperature Warning
65	High Fuel Temperature Warning
72	Cylinder 1 or 2 Fault
73	Cylinder 3 or 4 Fault
74	Cylinder 5 or 6 Fault

Table 1, Diagnostic Flash Codes

Engine Port Diagrams

Use the following diagrams to identify engine ports:

- For a Caterpillar 3176 Engine, see **Fig. 1** .
- For a Caterpillar 3406 Engine, see **Fig. 2**.
- For a Caterpillar C–10 or C–12 Engine, see **Fig. 3**.
- For a Cummins M11 Engine, see **Fig. 4**.
- For a Cummins N14 Engine, see **Fig. 5**.
- For a Detroit Diesel Series 50 Engine, see **Fig. 6**.
- For a Detroit Diesel Series 55 Engine, see **Fig. 7**.
- For a Detroit Diesel Series 60 Engine, see **Fig. 8**.

Engine Port Diagrams

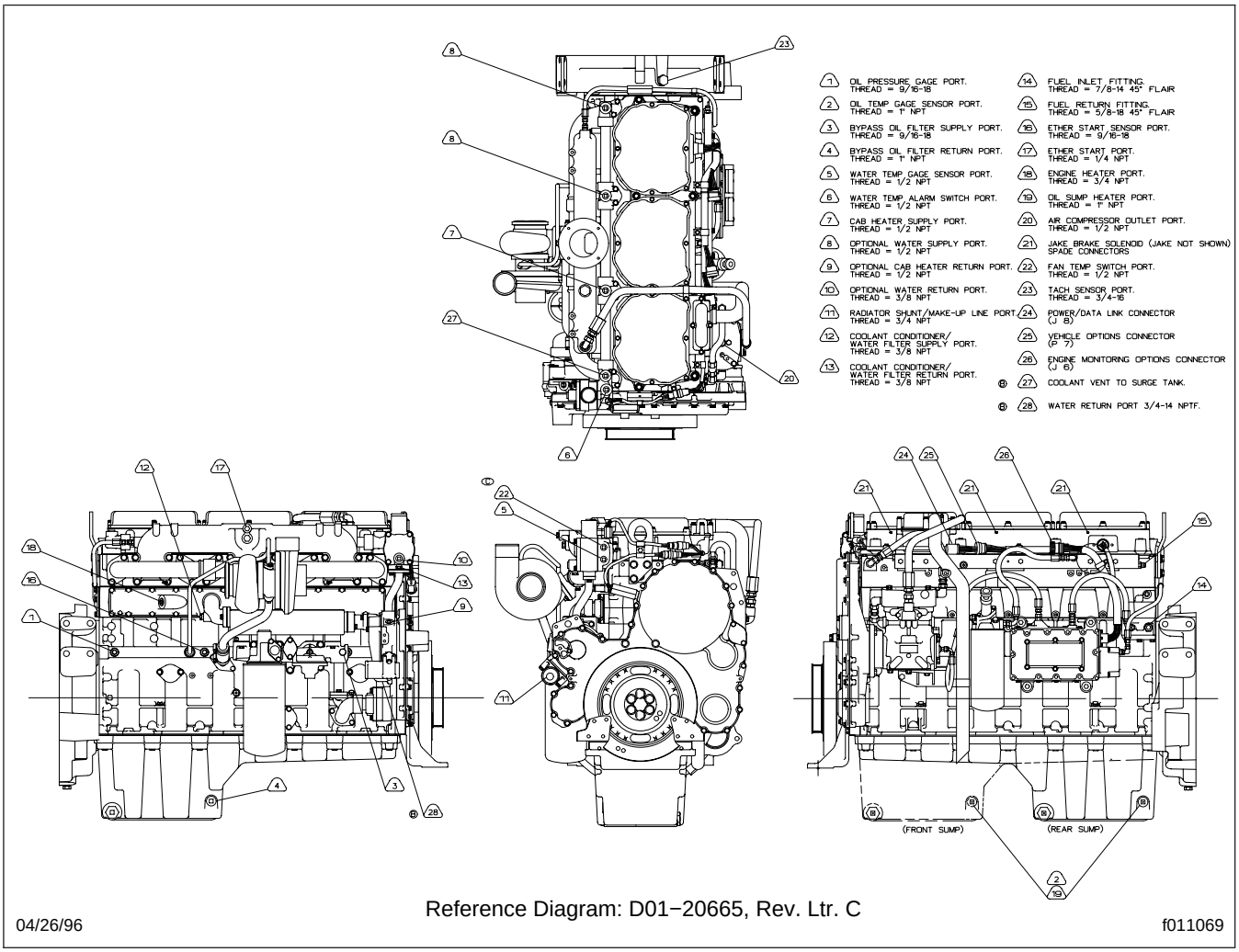


Fig. 1, Caterpillar 3176 Engine Ports

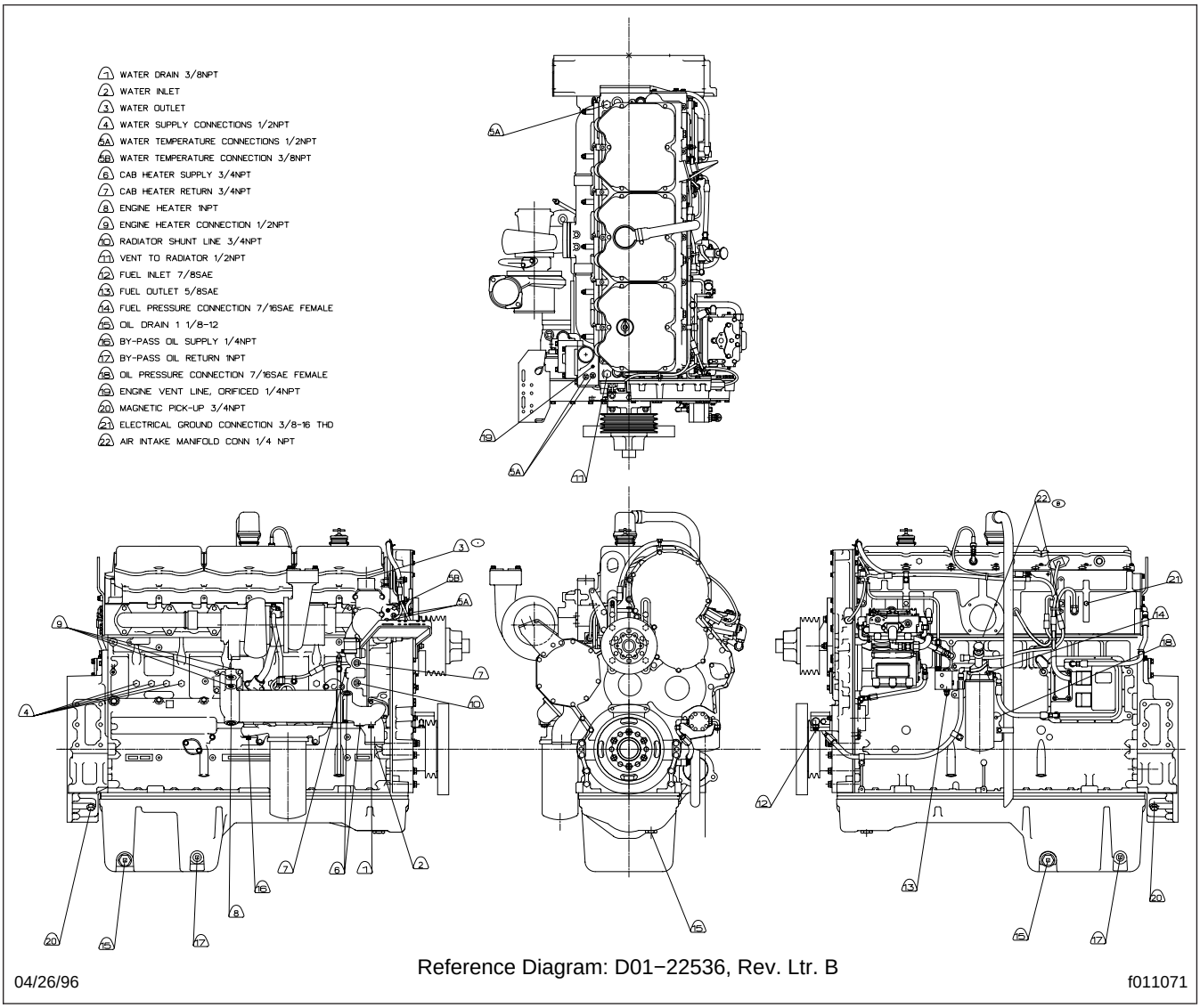


Fig. 2, Caterpillar 3406 Engine Ports

Engine Port Diagrams

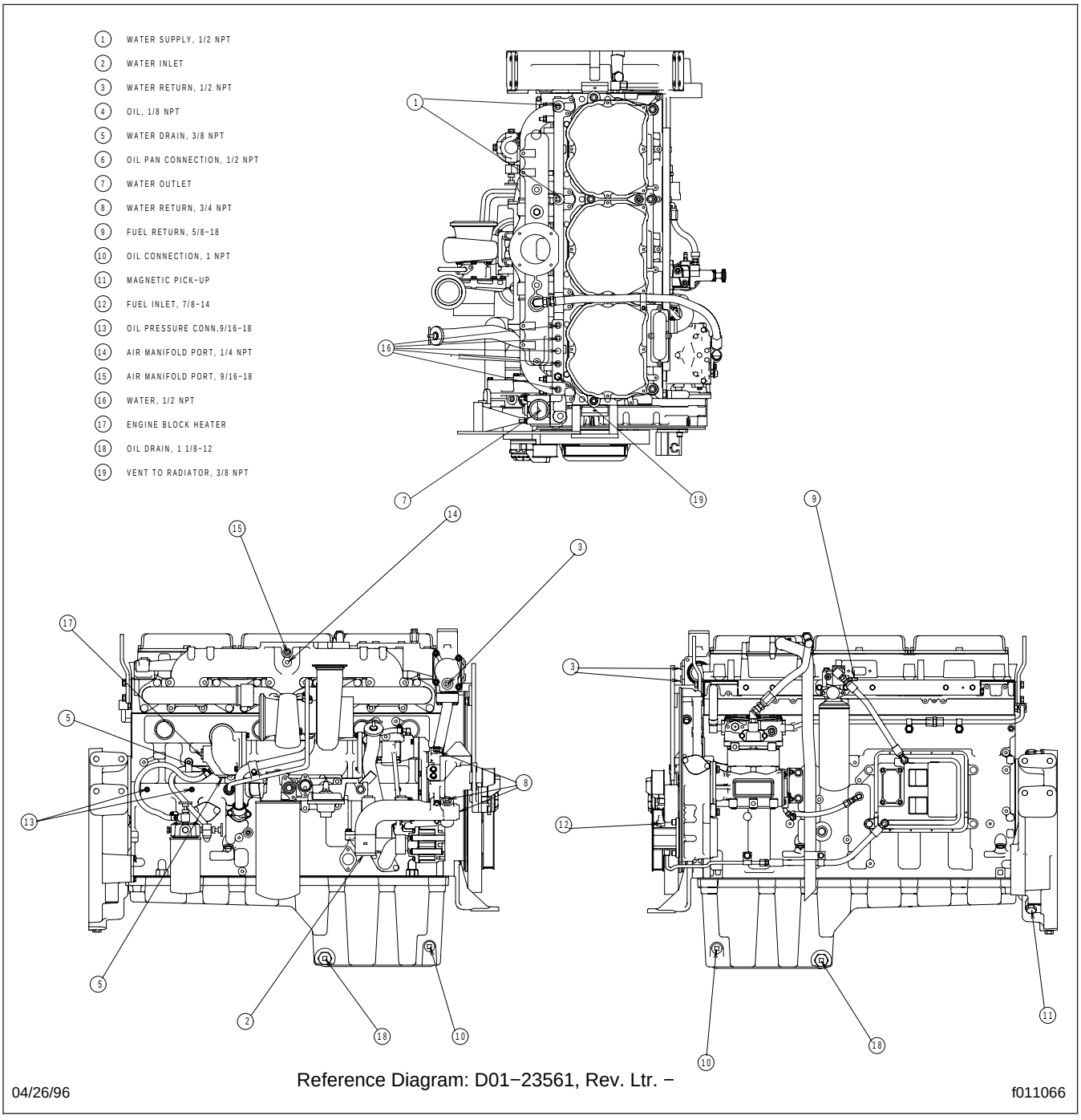


Fig. 3, Caterpillar C-10 and C-12 Engine Ports

Engine Port Diagrams

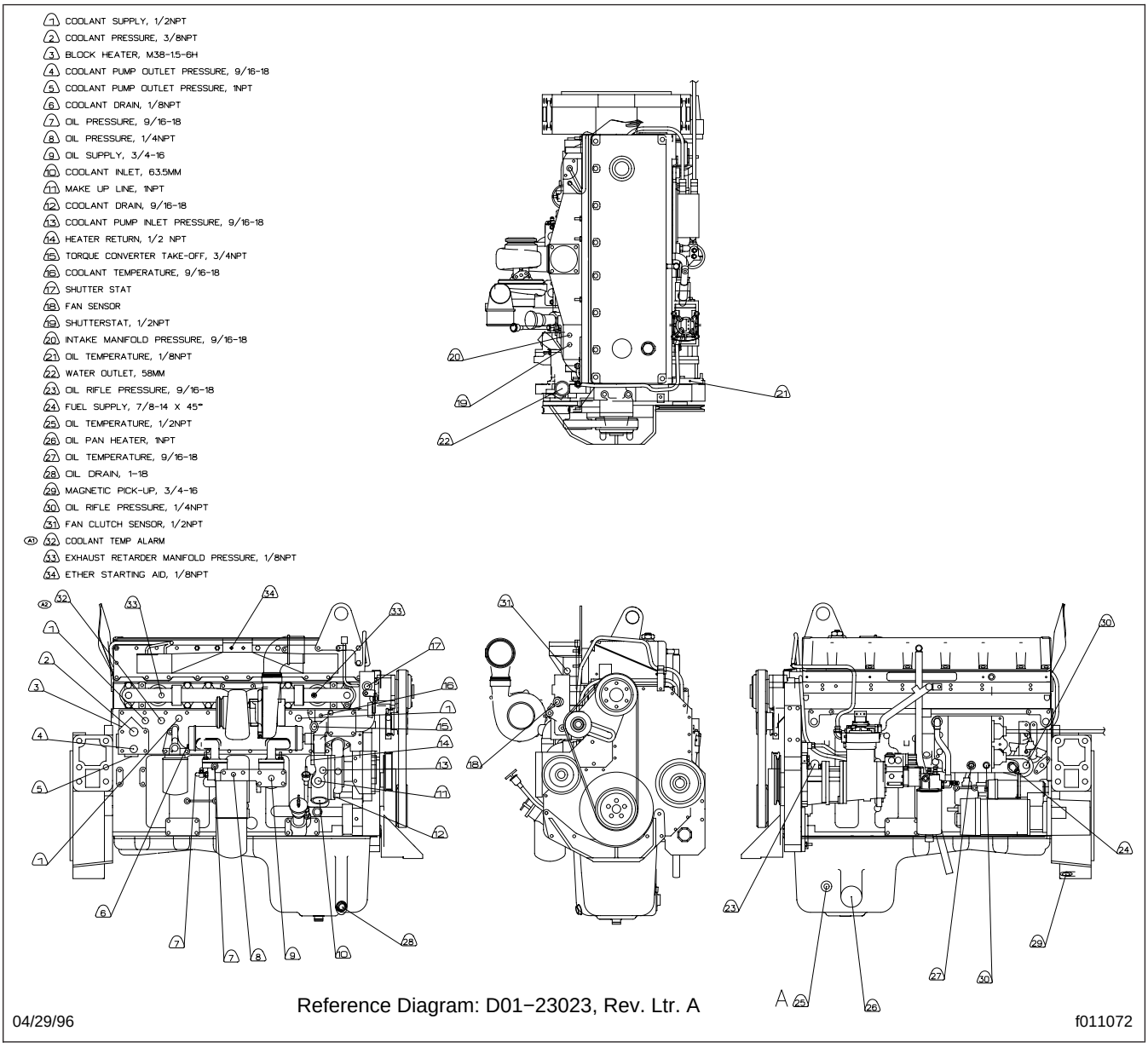


Fig. 4, Cummins M11 Engine Ports

Engine Port Diagrams

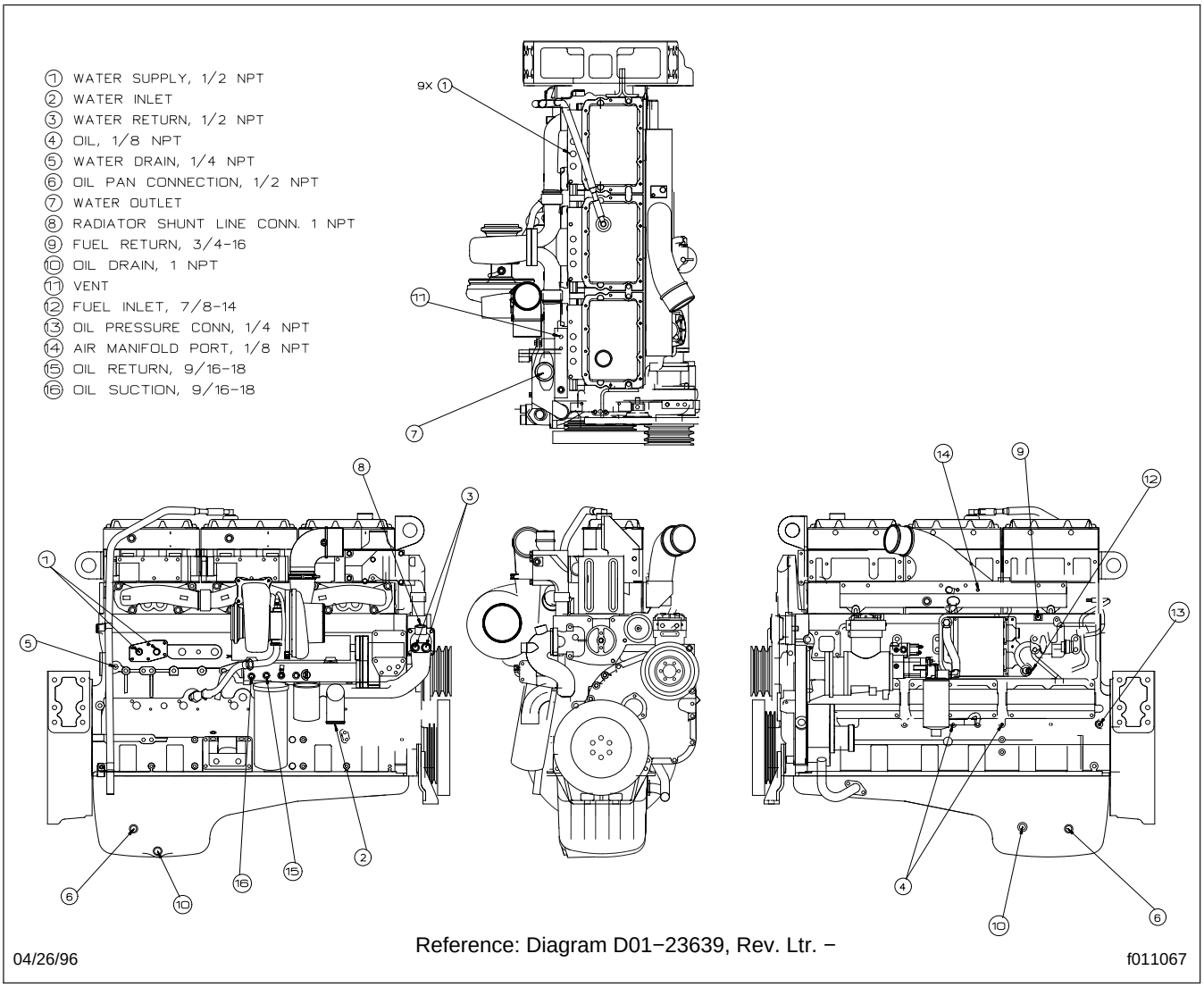


Fig. 5, Cummins N14 Engine Ports

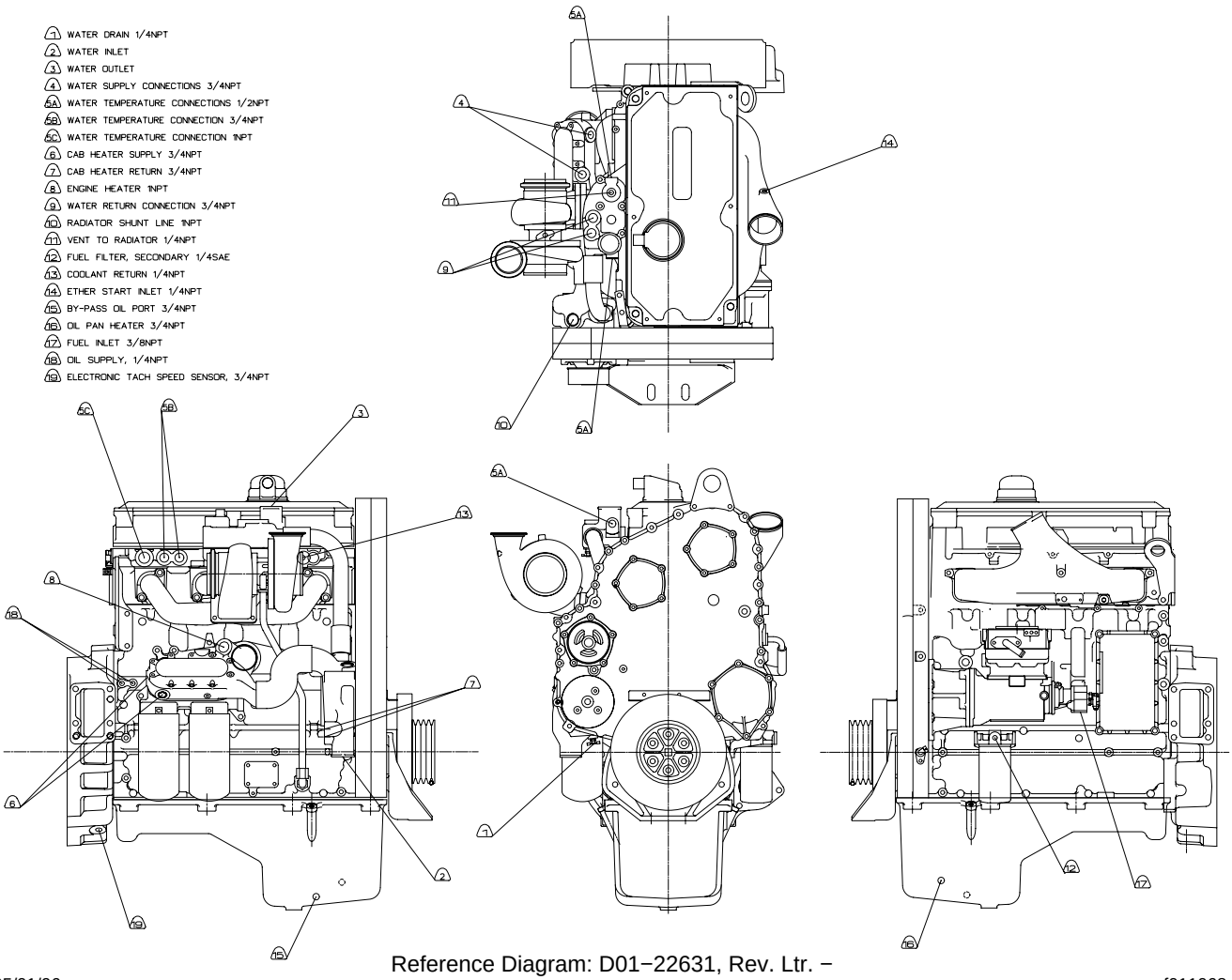


Fig. 6, Detroit Diesel Series 50 Engine Ports

Engine Port Diagrams

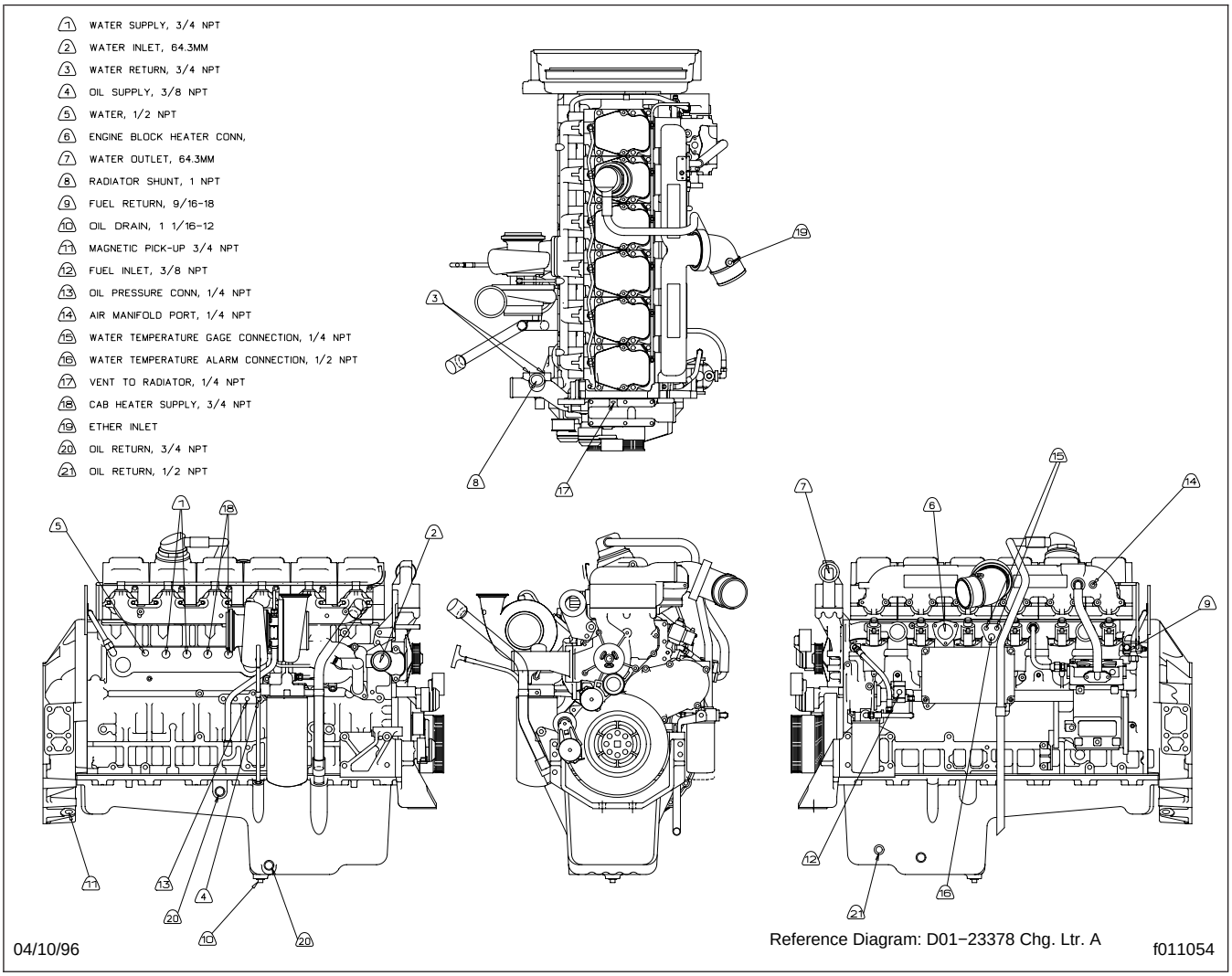
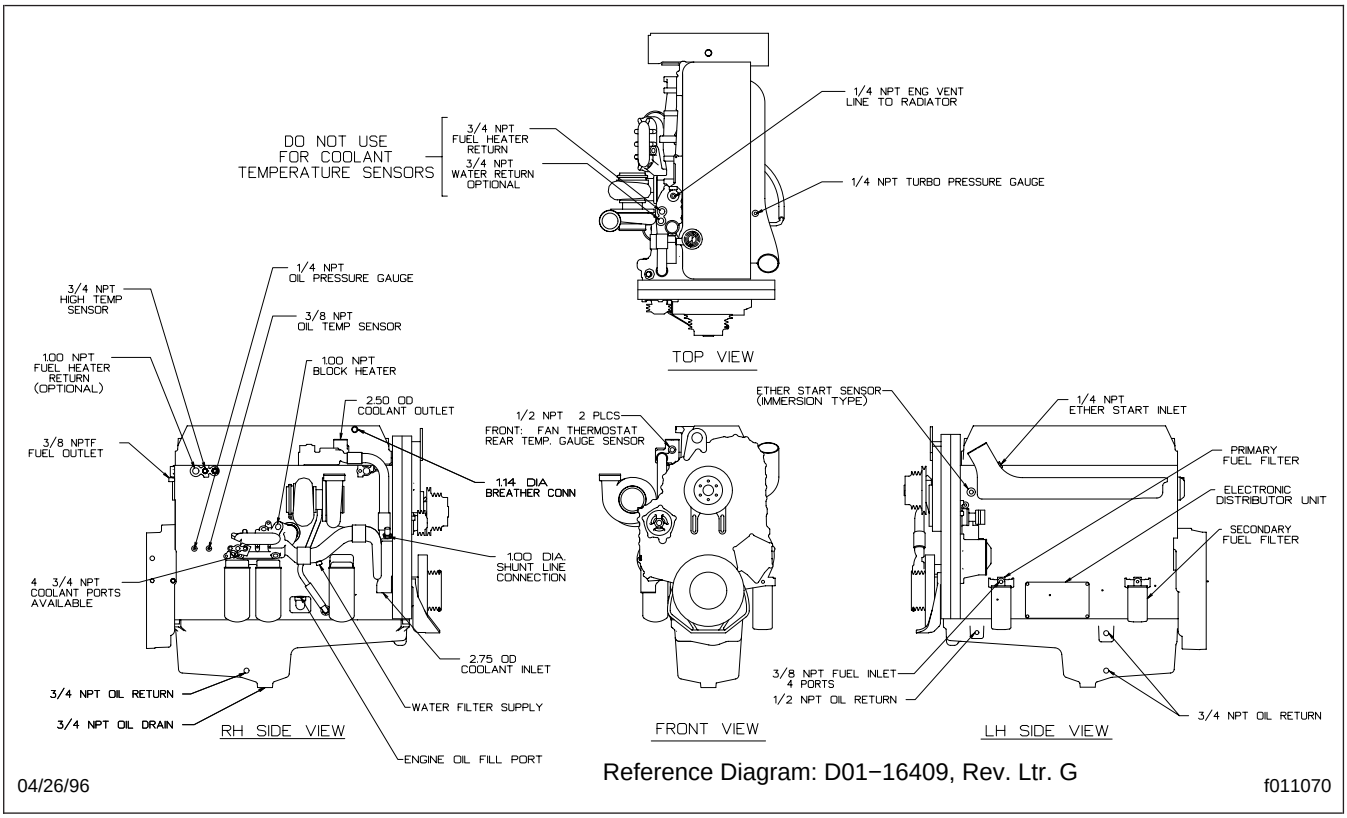


Fig. 7, Detroit Diesel Series 55 Engine Ports

Engine Port Diagrams



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Reference Diagram: D01−16409, Rev. Ltr. G

f011070

Fig. 8, Detroit Diesel Series 60 Engine Ports

Principles of Operation

The Environmental Protection Agency (EPA) mandated that all engines built after December 31, 2006 meet lower exhaust emissions levels:

- 1.1 grams per brake horsepower hour (g/bhp-hr) of nitrogen oxides (NOx)
- 0.01 g/bhp-hr of particulate matter (PM)

To meet the EPA07 requirements, most engine manufacturers developed an aftertreatment system (ATS). The ATS varies according to engine and vehicle configuration, but instead of a muffler, an ATS has an aftertreatment device (ATD) that outwardly resembles a muffler.

Inside the ATD on Cummins, Detroit Diesel, and Mercedes-Benz engines, the exhaust first passes over the diesel oxidation catalyst (DOC), which uses a chemical process to break down pollutants into less harmful components. The exhaust then passes through the diesel particulate filter (DPF), which traps soot particles. See **Fig. 1**.

Caterpillar ATDs have a DPF, but do not have a DOC. Instead, CAT engines burn diesel fuel at the regeneration head to superheat the exhaust and reduce it to less harmful components. CAT engines also utilize Clean Gas Induction (CGI), a process in which some of the exhaust gas downstream of the DPF is recirculated into the air intake system. See **Fig. 2**.

The DPF core in all ATDs is comprised of ceramic channels that are blocked off at alternate ends to force the exhaust through the porous walls.

As soot accumulates in the DPF, it periodically needs to be converted to its basic parts: carbon dioxide, water, and ash. The conversion takes place through an event in the ATD referred to as regeneration (regen). If the exhaust temperature is high enough, the trapped soot is reduced to ash in a process called passive regen, which occurs as the vehicle is driven normally.

Passive regen, however, cannot always keep the DPF clean, so the ATD must also periodically undergo active regen. During active regen, extra fuel is injected into the exhaust stream to superheat and reduce the soot trapped in the DPF to ash. Active regen happens only when the vehicle is moving above a certain speed, as determined by the engine manufacturer.

Both active and passive regen happen automatically, without driver input. When operating conditions do not allow for active or passive regen, the vehicle may require a driver-activated parked regen, which takes 20 to 60 minutes, depending on ambient conditions.

Over time, ash collects in the ATS and needs to be removed through cleaning at specific intervals. For ATS maintenance and repair information, see the engine manufacturer's service literature.

Service Literature Coverage

Engine service procedures in this manual are limited to components installed by Daimler Trucks North America. See the following sections for information on EPA07-compliant parts and systems installed by Daimler Trucks North America:

- **Section 01.00**, Engine Mounts
- **Section 30.05**, Electronic Throttle Control, Williams
- **Section 49.03**, Aftertreatment System, EPA07

Complete engine coverage including engine adjustment, preventive maintenance, and engine repair are covered in each engine manufacturer's service literature:

- Caterpillar: www.cat.com
- Cummins: www.cummins.com
- Detroit Diesel: www.detroitdiesel.com
- Mercedes-Benz: www.detroitdiesel.com

Periodic inspection of the ATS is required. For instructions, see the *Heavy-Duty Trucks Maintenance Manual*.

For driver pre- and post-trip inspection information, see the *FLD Conventional Driver's Manual*.

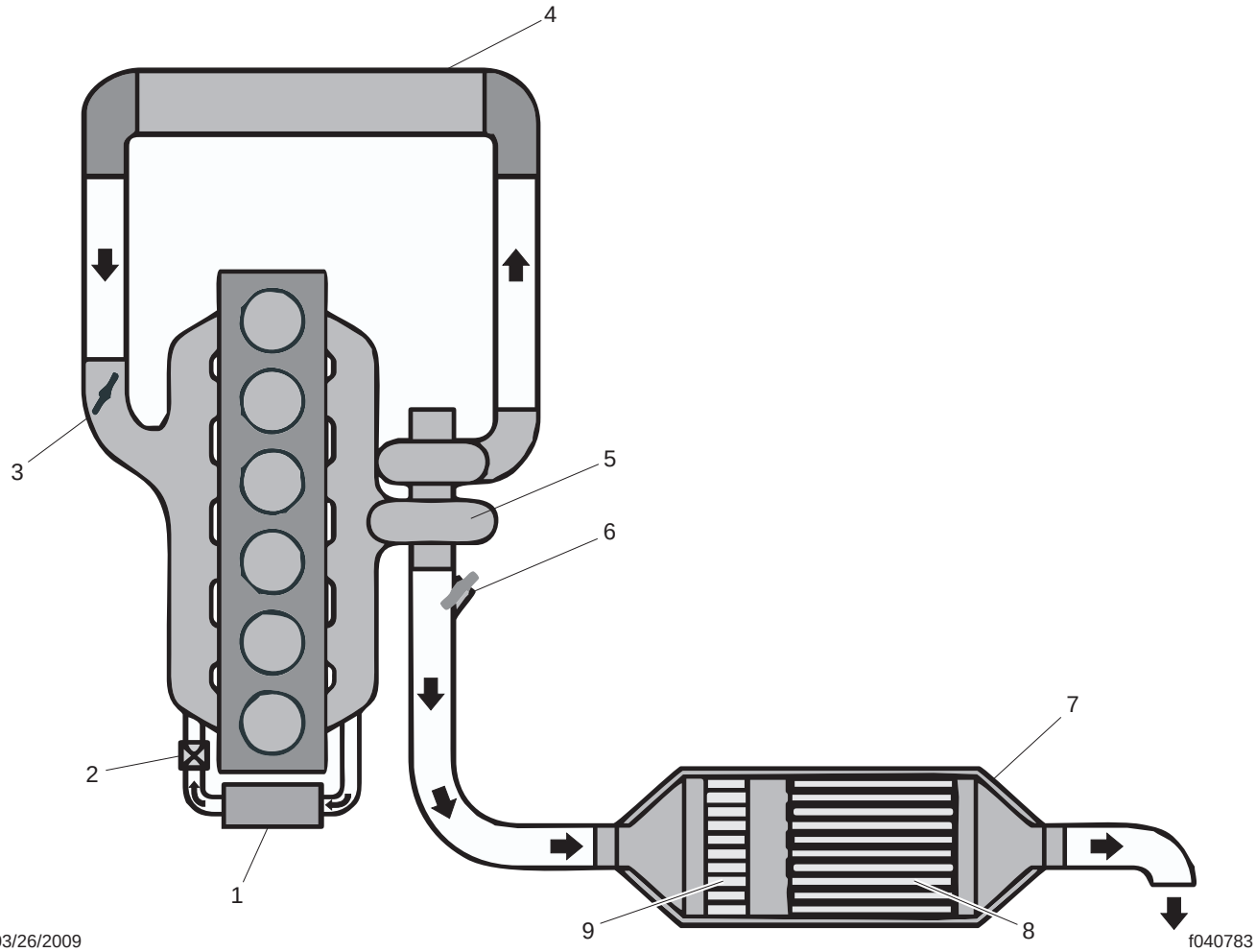
Definition of Terms

Refer to the following terms for a better understanding of EPA07 engines.

Ash Unburnable solids that remain after regeneration in the ATD.

Aftertreatment Device (ATD) A device that removes pollutants from exhaust gas after the gas leaves the combustion chamber.

General Information



1. Exhaust Gas Recirculation (EGR) Cooler
2. EGR Valve
3. Intake Throttle Valve
4. Charge Air Cooler (CAC)
5. Turbocharger
6. Hydrocarbon Doser
7 Aftertreatment Device (ATD)
8. Diesel Particulate Filter (DPF)
9. Diesel Oxidation Catalyst (DOC)

Fig. 1, ATS (Detroit Diesel engine shown)

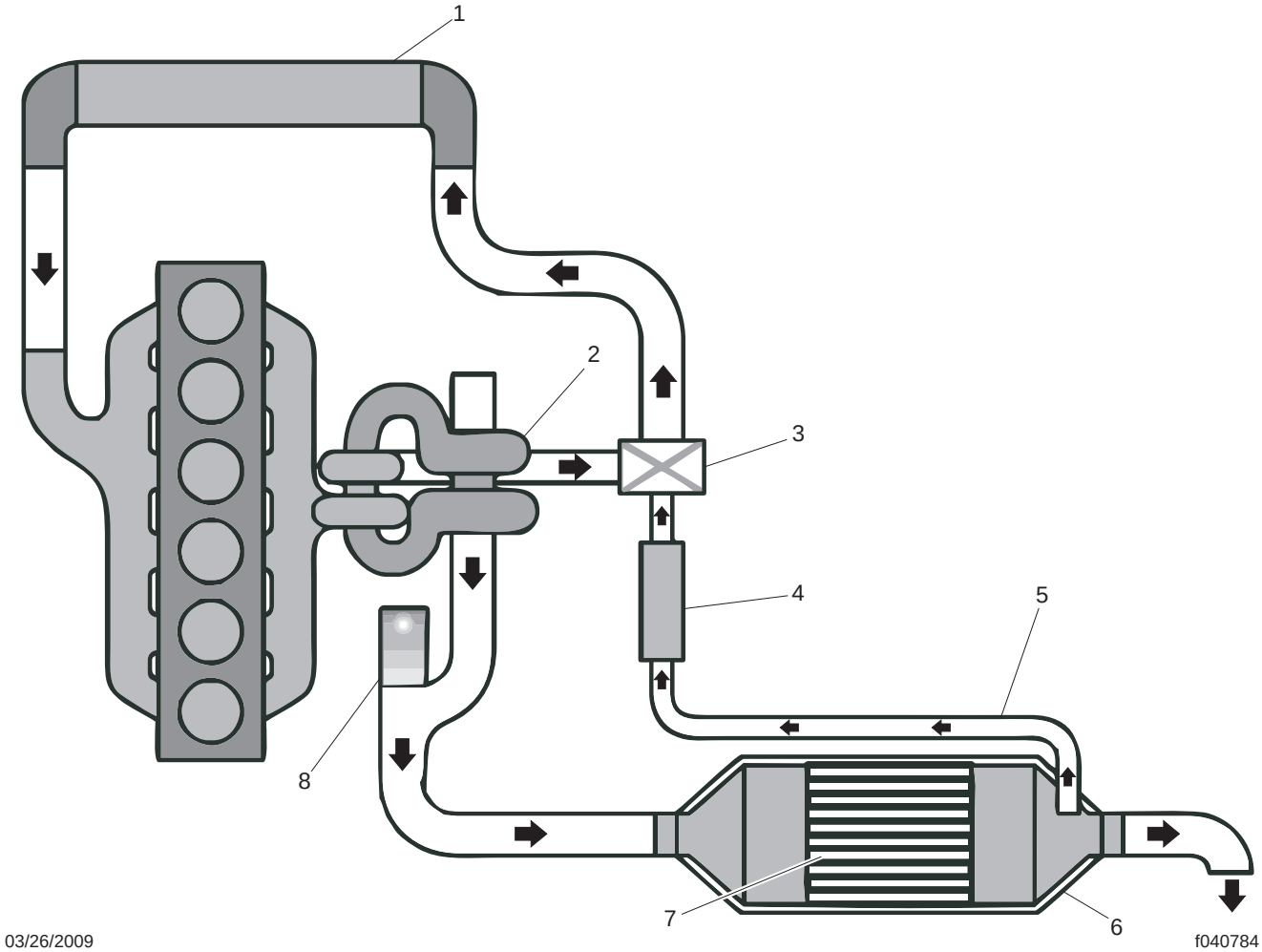
Aftertreatment System (ATS) The entire exhaust system from the turbocharger to the exhaust stack or tail pipe.

Clean Gas Induction (CGI) A process whereby small amounts of exhaust gas are drawn downstream of the DPF and recirculated into the air intake system. CGI is used in CAT engines only.

Diesel Oxidation Catalyst (DOC) A flow-through device that enhances the oxidation of hydrocarbons in the ATD on Cummins, Detroit Diesel, and Mercedes-Benz engines.

Diesel Particulate Filter (DPF) A component inthe ATD that captures particulate matter from the exhaust gas, preventing discharge from the tailpipe.

Exhaust Gas Recirculation (EGR) A process whereby exhaust is recirculated into the air intake system, creating lower cylinder temperatures. EGR is used in Cummins, Detroit Diesel, and Mercedes-Benz engines only.



1. Charge Air Cooler (CAC)
2. Dual-Stage Turbocharger
3. Clean Gas Induction (CGI) Mixing Valve
4. CGI Cooler
5. CGI Line
6. Aftertreatment Device (ATD)
7. Diesel Particulate Filter (DPF)
8. Regeneration Head

Fig. 2, ATS (Caterpillar engine shown)

Nitrogen Oxides (NOx) Air pollutants composed of nitrogen and oxygen in various forms that contribute to the formation of smog.

Particulate Matter (PM) Soot particles formed by incomplete combustion of fuel that contribute to atmospheric pollution.

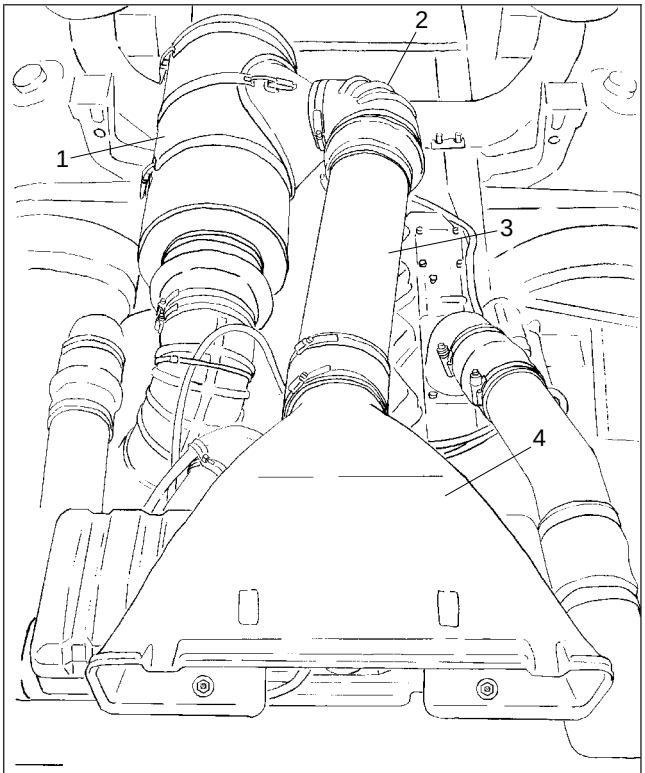
Regeneration (Regen) A process that occurs inside the ATD whereby accumulated soot is superheated and burned to ash, carbon dioxide, and water.

General Information

An average diesel truck engine needs over 10,000 gallons (38 000 liters) of clean air for each gallon (3.8 liters) of fuel burned. So that complete combustion occurs in each engine cylinder, more clean air than is needed is present in each cylinder. The air intake system routes this supply of outside air through an air cleaner, which filters out dust, dirt, abrasive particles, and other foreign material from the intake air, without restricting air flow.

From there, the air intake ducting routes this clean air to the engine.

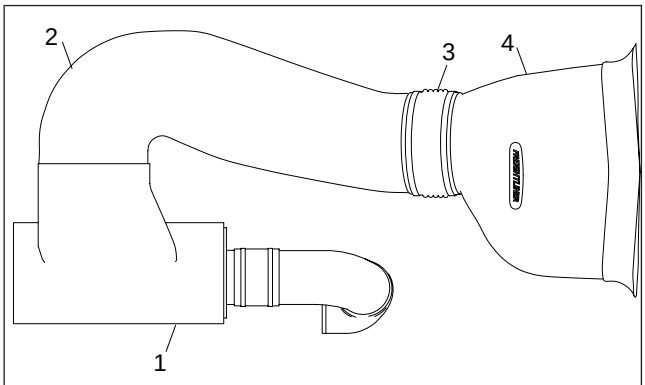
On COEs, a frontal air duct is mounted on brackets above the radiator. See **Fig. 1**, and **Fig. 2**.



1. Air Cleaner
2. Rubber Elbow
3. Aluminum Tubing
4. Frontal Duct

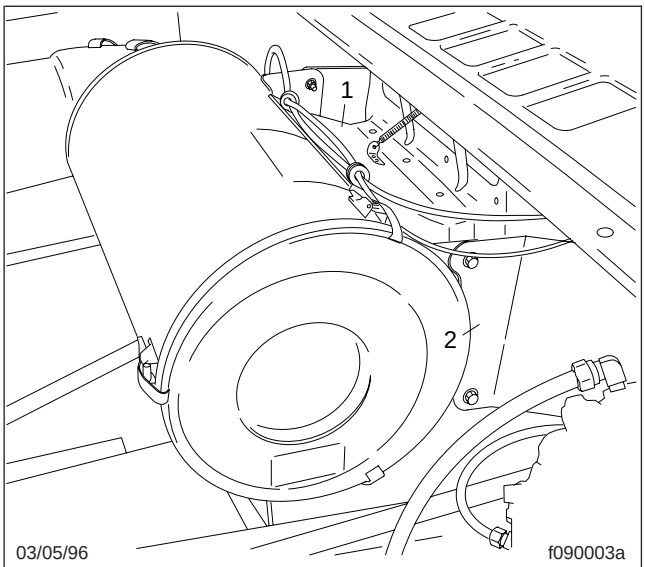
Fig. 1, Frontal Air Intake System (COE vehicles built before February, 1993)

On 120 Conventionals, the frontal air duct is mounted on the underside of the cowl inlet. See **Fig. 3**.



1. Air Cleaner
2. Intermediate Duct
3. Bellows
4. Frontal Duct

Fig. 2, Frontal Air Intake System (COE vehicles built from February, 1993)



1. Air Intake Duct
2. Mounting Bracket

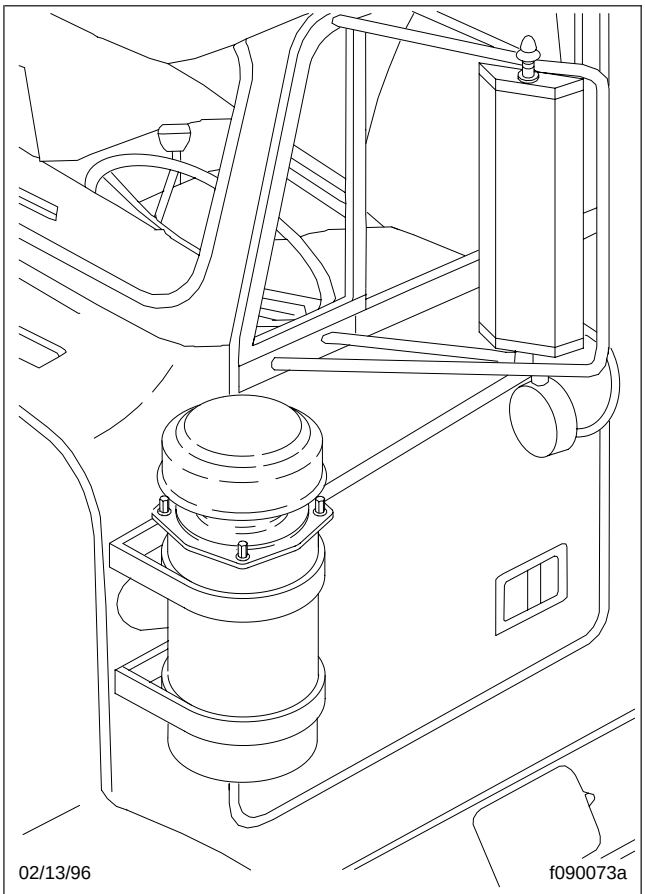
Fig. 3, Frontal Air Intake System (120 Conventionals)

On Conventionals with cowl-mounted air cleaners, the air intake ducting is routed through the side cowl skin. See **Fig. 4**.

A lock-up air restriction indicator mounts in a safety filter in the under-hood ducting. As an option, the air restriction indicator or an air restriction gauge mounts in the dashboard. Nylon tubing connects the remote-mounted indicator or gauge to the safety filter in the

General Information

ducting. The air restriction indicator or gauge indicates when the air cleaner filter element needs to be cleaned or replaced. The safety filter protects the clean-side of the air intake system in case the air restriction indicator or nylon tubing leaks or is damaged.

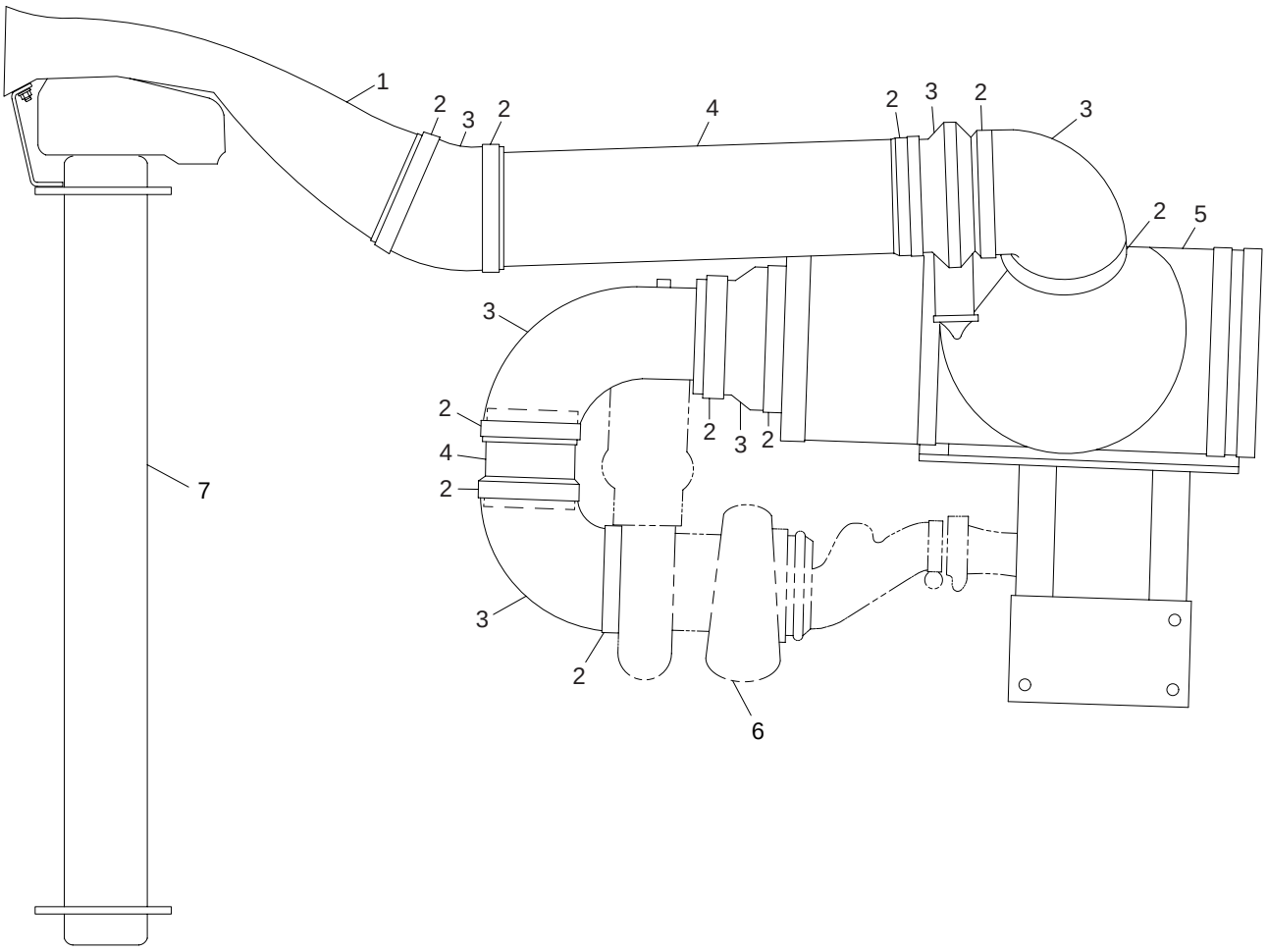


NOTE: Left air cleaner shown.

Fig. 4, Cowl-Mounted Air Cleaner and Bonnet (Conventional)

Replacement

(See Fig. 1,Fig. 2,Fig. 3, or Fig. 4)



1. Frontal Air Duct
2. Hose Clamp
3. Rubber Connecting Hose
4. Aluminum Tube
5. Air Cleaner
6. Turbocharger
7. Radiator

Fig. 1, Intake Ducting (COE vehicles built before February, 1993)

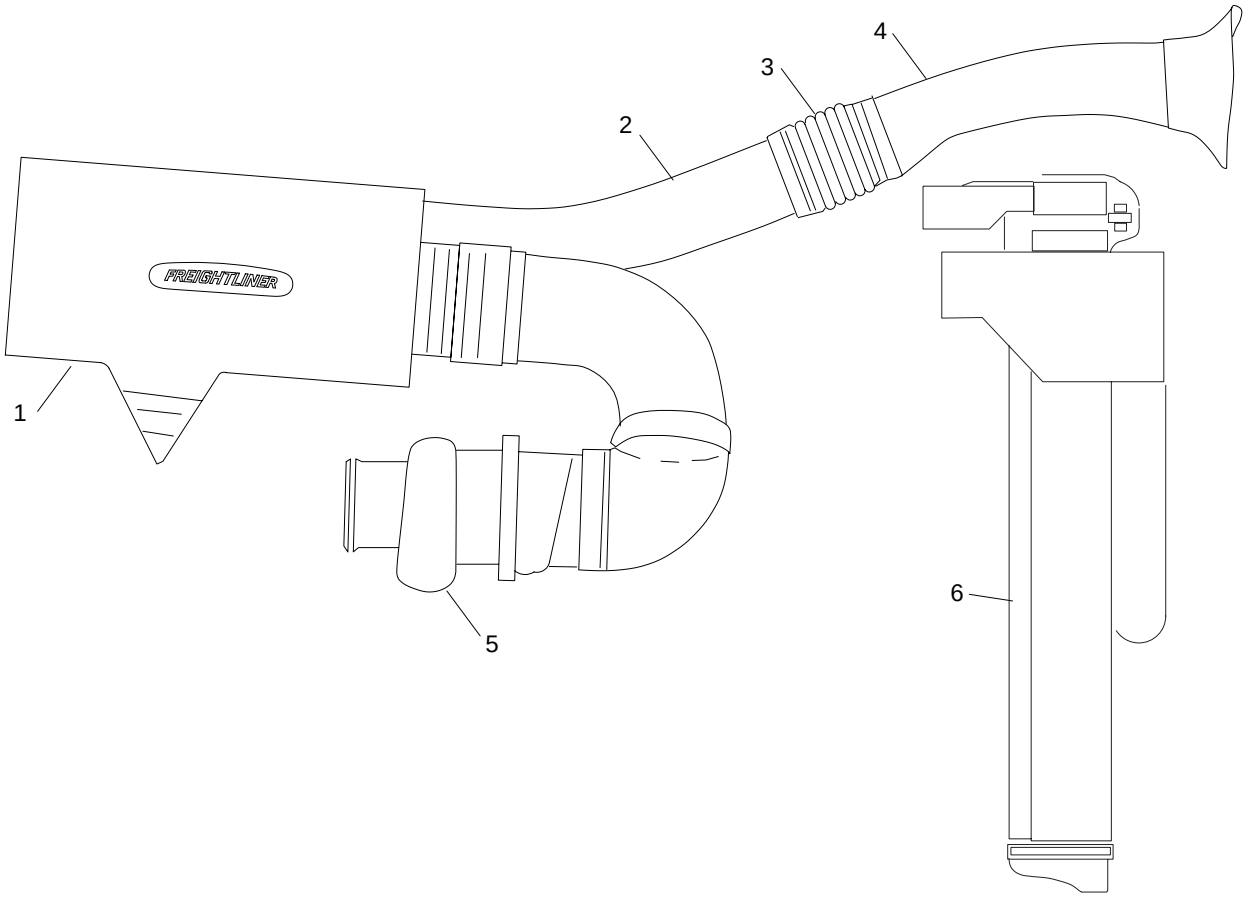
⚠ WARNING

Do not operate the engine with any under-hood component of the air intake system removed. Serious personal injury can occur if the turbocharger impeller is touched when it is rotating.

⚠ CAUTION

Do not operate the engine with the air filter element or any air intake component removed. All air intake parts and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Much of the dirt

Intake Ducting Replacement



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1. Air Cleaner
2. Intermediate Duct
3. Bellows
4. Frontal Duct
5. Turbocharger
6. Radiator

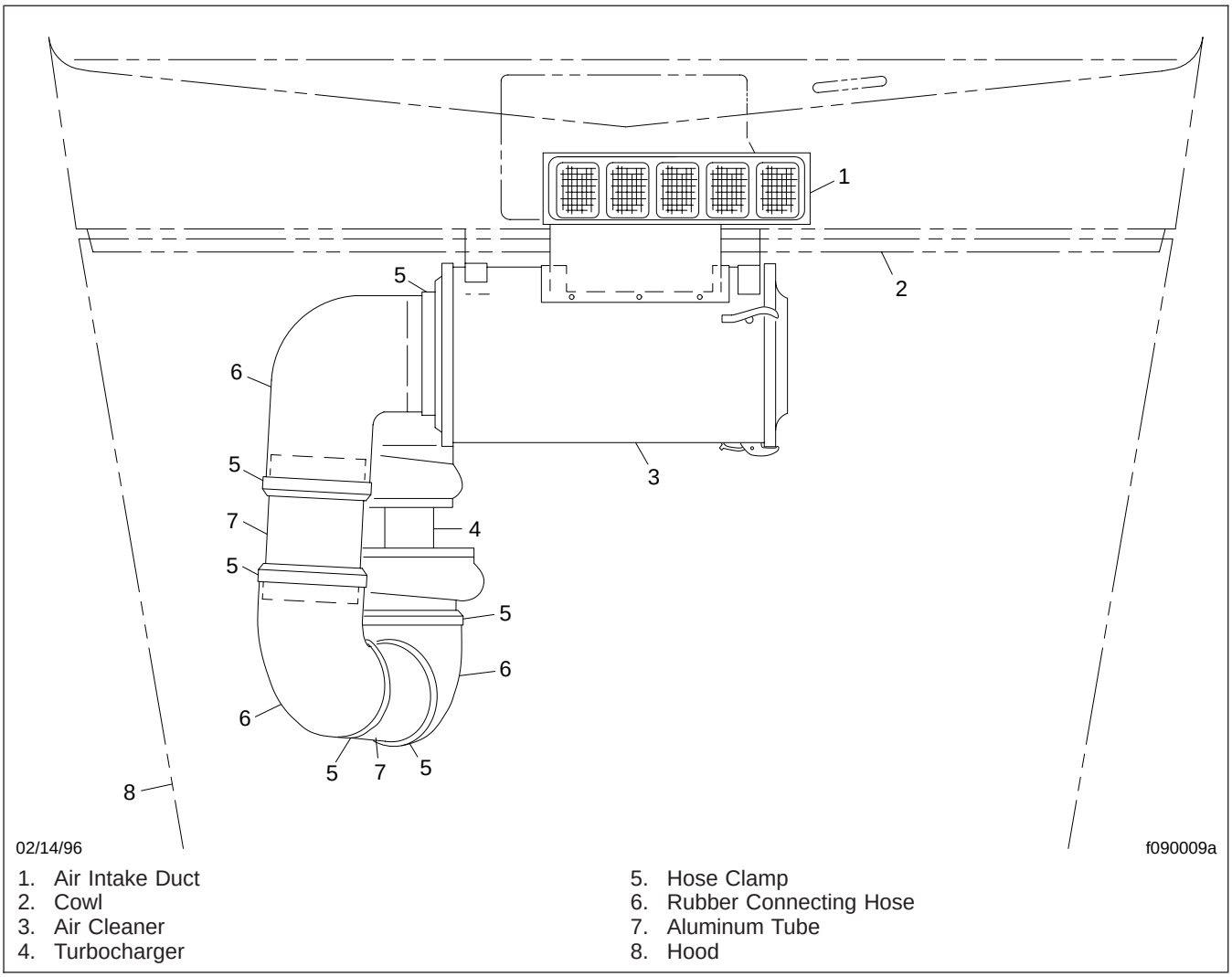
Fig. 2, Intake Ducting (COE vehicles built from February, 1993)

and dust are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners.

1. Tilt the cab or hood. For instructions, see the vehicle service manual.
2. Loosen the hose clamp screws.
3. For 120 conventionals and COE vehicles built before February, 1993, remove the rubber hoses from the aluminum tubing, air cleaner ports, the engine inlet, and the frontal duct (COEs).

   For COE vehicles built from February, 1993, remove the ducting and the bellows between the frontal duct and the air cleaner. Also, remove the ducting between the air cleaner and the engine inlet.
4. On COEs, remove the nuts, washers, and bolts that attach the frontal duct to the mounting brackets. See **Fig. 5**. Remove the frontal duct.
5. Replace any damaged parts with new identical parts.

IMPORTANT: Rubber hoses that have been enlarged, extended, or modified by bonding after



1. Air Intake Duct
2. Cowl
3. Air Cleaner
4. Turbocharger
5. Hose Clamp
6. Rubber Connecting Hose
7. Aluminum Tube
8. Hood

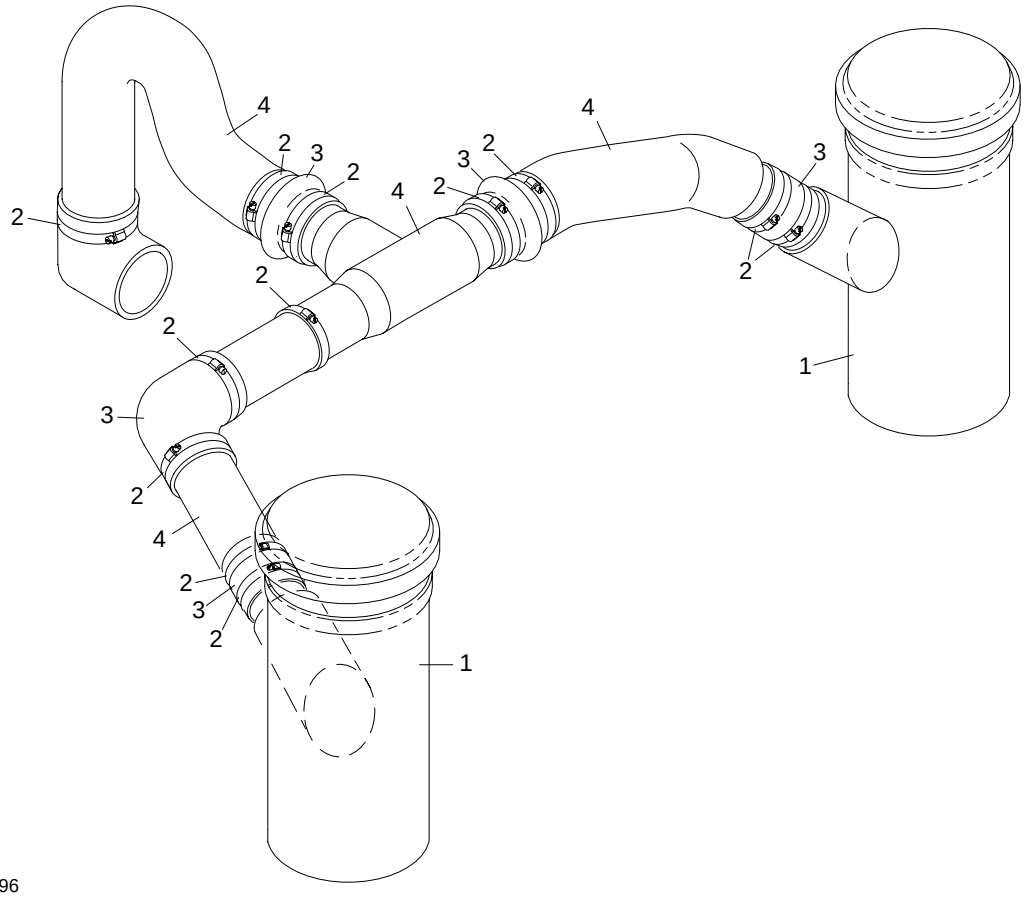
Fig. 3, Intake Ducting (120 Conventional)

original molding, are not acceptable for installation between the air cleaner and the engine.

6. On COEs, align the frontal duct mounting holes with the mounting bracket holes. Install the washers, nuts, and bolts. Tighten the nuts 108 lbf·in (1220 N·cm).
7. For 120 conventionals and COE vehicles built before February, 1993, attach the rubber hoses to the aluminum tubing, air cleaner ports, the engine inlet, and the frontal duct (COEs). Pull the rubber hoses onto each connection until they overlap at least 1 inch (25 mm).

   For COE vehicles built from February, 1993, attach the ducting and bellows between the air cleaner and the frontal duct. Also, attach the ducting between the air cleaner and the engine inlet.
8. Tighten all hose clamps 70 to 80 lbf·in (800 to 900 N·cm).
9. Return the cab or hood to the operating position.

Intake Ducting Replacement



1. Air Cleaner
2. Hose Clamp
3. Rubber Connecting Hose
4. Intake Ducting

Fig. 4, Cowl-Mounted Intake Ducting (120 Conventional)

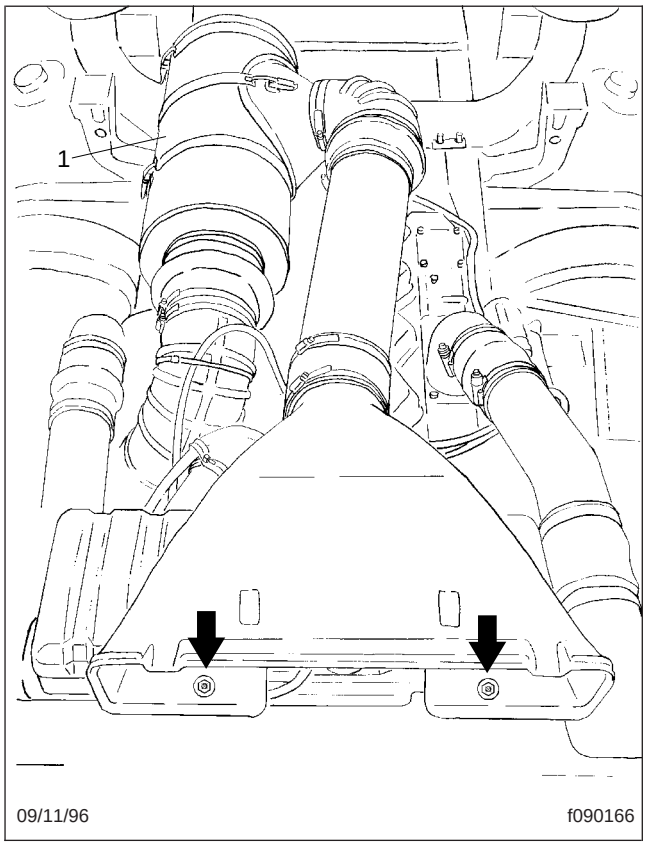
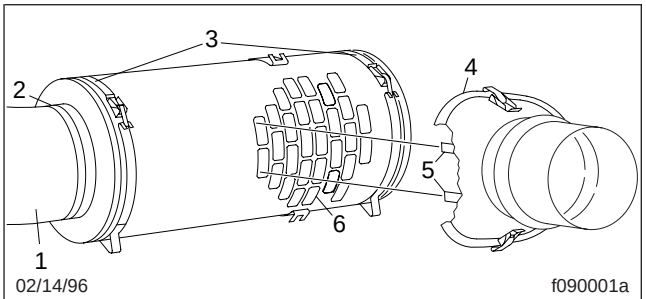


Fig. 5, Frontal Duct Fasteners

Farr Air Cleaner Element Replacement

1. Loosen the clamp that attaches the air outlet tube to the air cleaner. See **Fig. 1** for a COE or **Fig. 2** for an FLD Conventional.



1. Air Outlet Tube
2. Clamp
3. Mounting Bracket
4. Inlet Adapter
5. Inlet Adapter Locator Tabs
6. Inlet Grid

Fig. 1, Farr Air Cleaner, COE

2. On a COE, open the clamps on the mounting brackets and on the inlet adapter.

   On an FLD Conventional, open the clamps on the mounting brackets and on the air intake assembly. Remove the mounting straps.

3. Break the seal of the clean air fitting by slightly twisting the air cleaner element and lifting it at the same time. Remove the air cleaner element.

NOTE: If a tool must be used, use care not to puncture or damage the rubber fitting.

4. Before discarding the element, check for signs of soot or oil. If there is soot inside the element, check for leaks in the engine exhaust system, exhaust blow-back into the air intake, or exhaust from other equipment. If the element appears oily, check for fumes escaping from the engine crankcase breather. Excessive oil mist shortens the life of any dry-type filter and must be corrected.

5. Discard the element. Never attempt to clean and reuse an element.

6. Inspect all the ducts, clamps, and fittings for visible damage. Repair or replace damaged parts.

   Inspect the new element for shipping damage. If the element is damaged, do not use it.

7. On a COE, install a new element on the mounting bracket. Make sure the inlet adapter is lined up with the inlet grid.

   On an FLD 120, install a new element so that the inlet grid is lined up with the air intake assembly. Install the mounting straps and secure the clamps.

NOTE: On Farr air cleaners, the clamps may require a minor adjustment. To increase clamp tension, the length of the latch must be slightly shortened. Increase the arc of the spring latch by gently squeezing it with water pump pliers. See **Fig. 3**. To decrease clamp tension, the length of the latch must be slightly increased. Reduce the arc of the spring latch a little at a time by placing it on a flat surface and applying pressure from above until the arc provides minimum tension when installed.

8. Place the air outlet tube in the rubber fitting, but do not tighten the clamp.

IMPORTANT: Place the inlet adapter on the air cleaner element. The sealing gasket on the inlet adapter must be in full contact with the air cleaner element. There should be no gaps. Make sure the inlet adapter completely covers the inlet grid on the air cleaner element. None of the openings on the inlet grid should be visible.

9. On a COE, rotate the element so that the inlet adapter locator tabs fit into the two inlet grid openings as shown in **Fig. 1**.

   Secure the clamps on the mounting brackets and on the inlet adapter.

10. Tighten the clamp that attaches the air outlet tube to the air cleaner element.

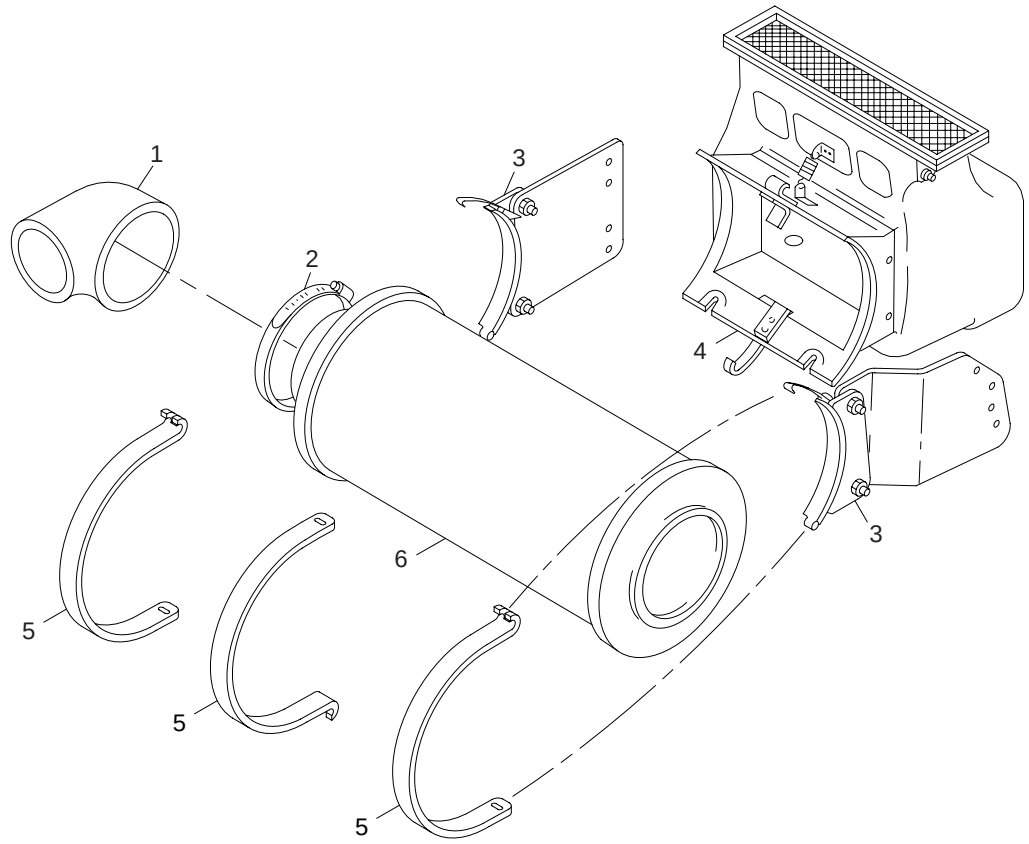
11. Reset the air restriction indicator and check the air restriction. Initial restriction readings with a new element will vary with air cleaner design and installation. Air restriction of 3 to 10 inH_2O is normal.

    If air restriction remains abnormally high after replacing the air cleaner element, check for plugged intake screens, damaged rain caps, or ducts plugged with snow, leaves, or debris. If

Air Cleaner Element Replacement

debris or snow has plugged the duct, see **Section 54.09**, Subject 300, for instructions.

engine crankcase breather. Excessive oil mist shortens the life of any dry-type filter and must



1. Air Outlet Tube
2. Clamp
3. Mounting Bracket
4. Air Intake Assembly
5. Mounting Strap
6. Air Cleaner

Fig. 2, Farr Air Cleaner, FLD Conventional

Donaldson Air Cleaner Element Replacement

1. Open the three clamps or remove the three capnuts on the air cleaner housing, and remove the housing end cover. See **Fig. 4**.
2. Remove the air cleaner filter element.
3. Before discarding the used element, check for signs of soot or oil. If there is soot inside the element, check for leaks in the engine exhaust system, exhaust blow-back into the air intake, or exhaust from other equipment. If the element appears oily, check for fumes escaping from the engine crankcase breather. Excessive oil mist shortens the life of any dry-type filter and must be corrected.
4. Check the housing and sealing surfaces for damage or dirt buildup that may cause sealing problems. Remove all dirt.

NOTICE

Do not leave any dirt inside the air cleaner housing. If dirt gets inside the filter element, it may get into the engine and cause damage.

5. Wipe the inside of the air cleaner housing with a clean damp cloth.

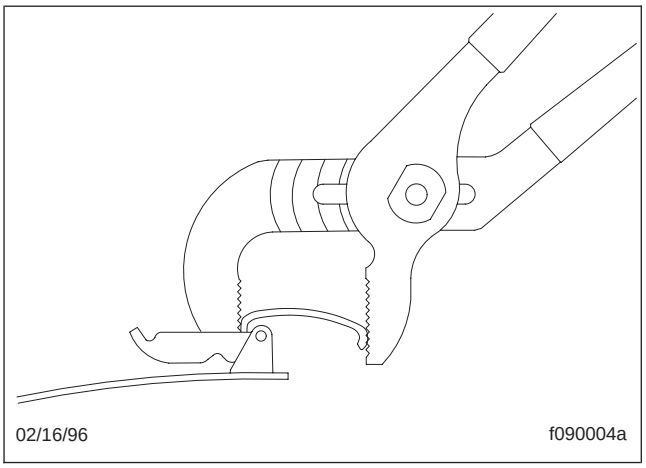
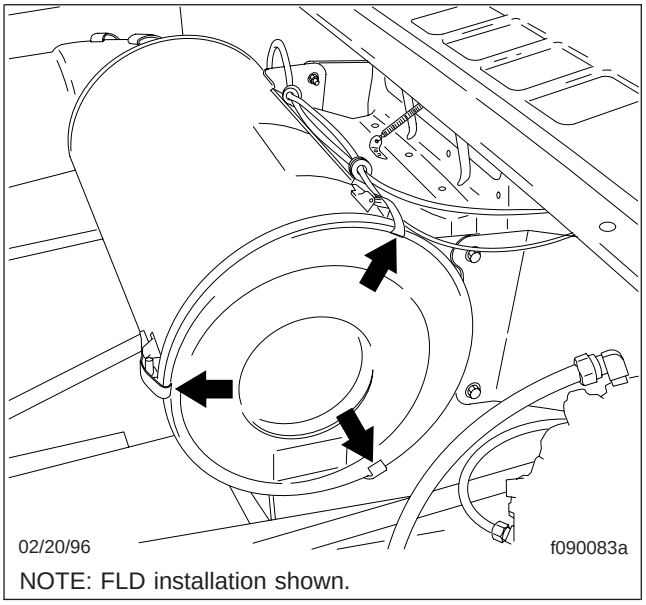


Fig. 3, Increasing Clamp Tension



NOTE: FLD installation shown.

Fig. 4, Clamps, Donaldson Air Cleaner

6. Check all ducts, clamps, and fittings for visible damage. Replace damaged parts that cannot be repaired.

NOTICE

Do not clean or reuse air filter elements. Cleaning and reusing the elements increases the chances of dirt entering the engine. Always replace with a new one.

7. Install a new filter element. Place the end cover on the housing, then secure the clamps or install the three capnuts on the air cleaner housing. Torque the capnuts 8 lbf·ft (11 N·m).

NOTE: On Donaldson air cleaners, the clamps may require a minor adjustment. To increase clamp tension, the length of the latch must be slightly shortened. Increase the arc of the spring latch by gently squeezing it with water pump pliers. See **Fig. 3**. To decrease clamp tension, the length of the latch must be slightly increased. Reduce the arc of the spring latch a little at a time by placing it on a flat surface and applying pressure from above until the reduced arc provides minimum tension when installed.

8. Reset the air restriction indicator and check air restriction. Initial restriction readings with a new element will vary with air cleaner design and installation. Air restriction of 3 to 10 inH_2O is normal.

   If air restriction remains abnormally high after replacing the filter element, check for plugged intake screens, damaged rain caps, or ducts plugged with snow, leaves, or debris. If debris or snow has plugged the duct, see **Section 54.09**, Subject 300, for instructions.

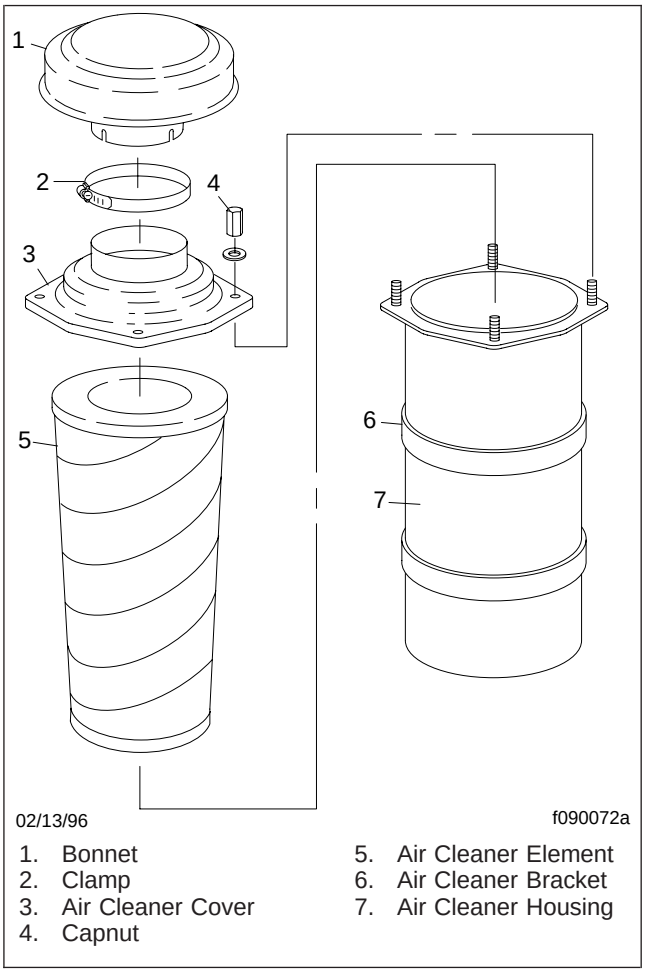
Cowl-Mounted Air Cleaner Element Replacement

1. Remove the four capnuts on the air cleaner cover. See **Fig. 5**.

NOTE: If the vehicle is equipped with cowl-mounted mirrors, remove the lower cowl-side mirror brace.

2. Remove the air cleaner cover from the air cleaner housing.
3. Remove the air cleaner filter element.
4. Before discarding the used element, check for signs of soot or oil. If there is soot inside the element, check for leaks in the engine exhaust system, exhaust blow-back into the air intake, or exhaust from other equipment. If the element appears oily, check for fumes escaping from the engine crankcase breather. Excessive oil mist shortens the life of any dry-type filter and must be corrected.

Air Cleaner Element Replacement



1. Bonnet
2. Clamp
3. Air Cleaner Cover
4. Capnut
5. Air Cleaner Element
6. Air Cleaner Bracket
7. Air Cleaner Housing

Fig. 5, Cowl-Mounted Air Cleaner, Nelson Air Cleaner Element

5. Check the housing and sealing surfaces for damage or dirt buildup that may cause sealing problems. Remove all dirt.

NOTICE

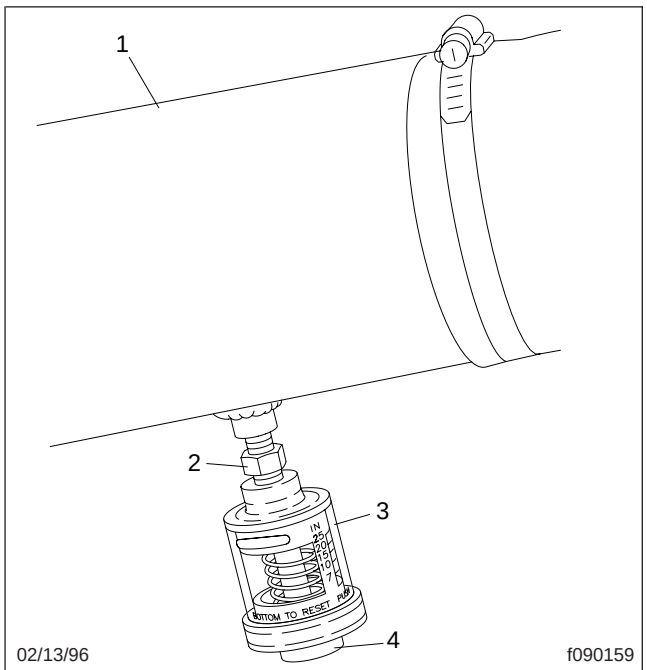
Do not leave any dirt inside the air cleaner housing. If dirt gets inside the filter element, it may get into the engine and cause damage.

6. Wipe the inside of the housing with a damp cloth.
7. Check all ducts, clamps, and fittings for visible damage. Replace damaged parts that cannot be repaired.
8. Install a new air cleaner element. Never attempt to clean and reuse an element.
9. Install the air cleaner housing cover and capnuts. Torque the capnuts in a cross pattern to 96 lbf·in (1080 N·cm).

Element Restriction Checking

The restriction of air flow through the air cleaner element is measured at the tap in the air transfer tube joined to the cleaner outlet.

On vehicles with an intake-duct-mounted restriction indicator (manual- or automatic-reset), the indicator is mounted in a safety fitting in the air intake piping. See **Fig. 1**.



1. Air Intake Piping
2. Safety Fitting
3. Air Restriction Indicator
4. Reset Button

Fig. 1, Standard Intake-Duct-Mounted Manual-Reset Air Restriction Indicator

NOTICE

Use the air intake restriction gauge rather than visual inspection to determine if servicing the air filter element is necessary. Removal of the air filter element can cause damage to the primary seal, which may allow contaminants into the engine, potentially causing engine damage.

On vehicles with a dash-mounted restriction indicator (manual-reset) (**Fig. 2**) or air restriction gauge (automatic-reset) (**Fig. 3**), a hose connects the indicator or gauge to the safety fitting in the air intake piping.

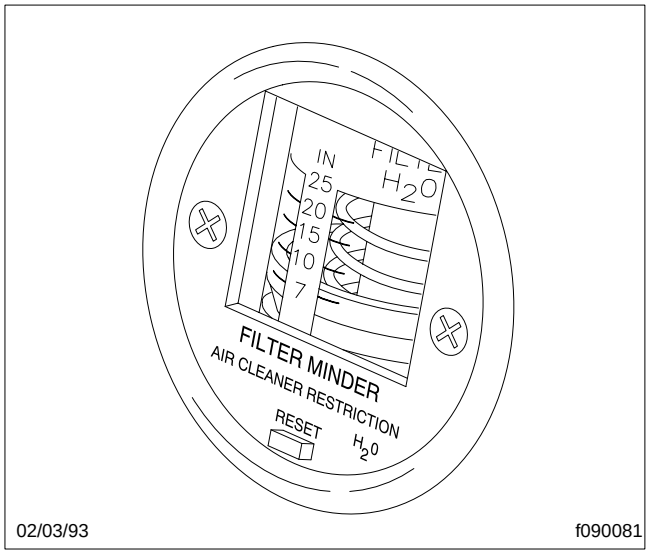


Fig. 2, Optional Dash-Mounted Manual-Reset Air Restriction Indicator

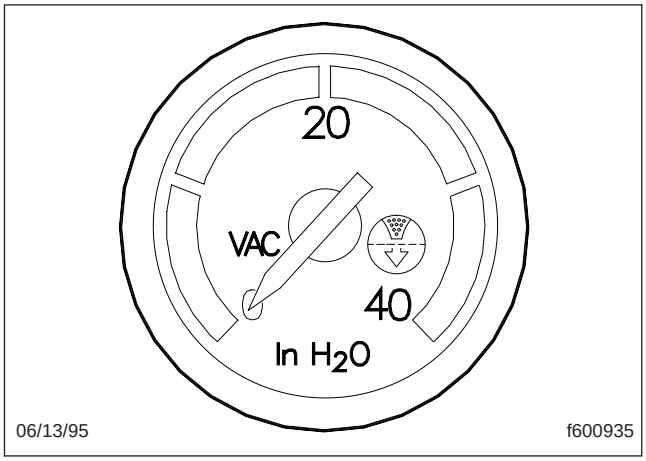


Fig. 3, Optional Dash-Mounted Automatic-Reset Air Restriction Gauge

On vehicles *without* an indicator or gauge, a water manometer or a service gauge must be connected to the air intake ducting to check element restriction.

– For a vehicle with a manual-reset air restriction indicator, check the indicator with the engine off to see if air restriction equals or exceeds the value shown in **Table 1** for maximum air restriction at *full load* and governed rpm. If air

Air Cleaner Element Restriction Checking

restriction is at or above the maximum, push the reset button on the dash-mounted or intake-duct-mounted indicator, then operate the engine at *no-load* and governed rpm, and compare the indicator reading with the value shown in **Table 1** for maximum air restriction at *no-load* and governed rpm.

– For a vehicle with an air restriction gauge, or a restriction indicator that resets automatically when the engine is shut down, operate the engine at *no-load* and governed rpm, and compare the gauge/indicator reading with the value shown in **Table 1** for maximum air restriction at *no-load* and governed rpm.

– For a vehicle without a gauge or indicator, test restriction with a water manometer or a service gauge. Refer to the test equipment manufacturer's literature for test procedures. Operate the engine at *no-load* and governed rpm, and compare the reading with the value shown in **Table 1** for maximum air restriction at *no-load* and governed rpm.

If air restriction equals or exceeds the value shown in **Table 1** for maximum air restriction at *no-load* and governed rpm, replace the air cleaner element.

Maximum Air Restriction in Inches of Water (inH_2O)		
Engine	**At Full Load and Governed RPM**	**At No-Load and Governed RPM**
Caterpillar	25	12
Cummins	25	12
Detroit Diesel	20	10

Table 1, Maximum Air Restriction in Inches of Water (inH_2O)

General Information

The charge air cooler is attached to the front of the radiator. The charge air cooler is similar to a radiator; outside ambient air passing through the charge-air-cooler core cools the engine's intake air charge. The air charge leaving the turbocharger is hot compressed air, about 275 to 325°F (135 to 162°C), depending on the ambient temperature. The charge air cooler reduces this temperature to about 110°F (43°C), at 77°F (25°C) ambient, before the air charge enters the engine intake manifold. This temperature decrease lowers exhaust emissions, improves fuel economy, and increases horsepower.

In May 1994, the solid-mount CAC used on FLD 120s (including Classic XLs) with 1200 square-inch metal-end-tank radiators was superseded with a soft-mount version.

In October 1994, the large and small solid-mount charge air coolers installed on FLAs and FLBs were superseded by soft-mount charge air coolers. The small CAC (also called low-horsepower CAC) has a core that measures 18.5 inches (47 cm) tall. The large CAC (also called high-horsepower CAC) has a core that measures 23.4 inches (60 cm) tall.

The soft-mount CAC can be retrofitted to these vehicles.

Removal

FLA/FLB Solid-Mount

1. Apply the parking brakes and chock the tires.
2. Tilt the cab. For instructions, see **Group 60**.
3. Loosen the hose clamps at both ends of the hoses that attach the inlet and outlet air piping to the charge air cooler (CAC) connections. Push the clamps and hoses back onto the piping until they are not touching the CAC. See **Fig. 1**.
4. At each of the two CAC upper mounting tabs, loosen the two radiator top tank mounting bolts until they are just finger-tight.
5. At each of the two CAC lower mounting tabs, remove the locknut, washer, and hexhead bolt.
6. Support both sides of the CAC, then remove the fasteners from the CAC upper mounting tabs. Remove the CAC from the vehicle.

FLA/FLB Soft-Mount

1. Apply the parking brakes and chock the tires.
2. Remove the grille (FLAs), or grille and surround assembly (FLBs). Remove the tunnel cross-braces (FLBs).
3. Tilt the cab. For instructions, see **Group 60**.
4. Loosen the hose clamps at both ends of the convoluted hoses that attach the inlet and outlet air piping to the CAC. Push the clamps and hoses back onto the piping, until they are not touching the CAC. See **Fig. 1**.
5. At each of the two CAC lower mounting tabs, loosen the CAC mounting fasteners until they are just finger-tight.
6. At each of the two CAC upper mounting tabs, remove the two CAC upper mounting fasteners and washers.
7. While a second person supports the CAC, remove the CAC mounting fasteners and washers from the CAC lower mounting tabs. With the assistance of the second person, remove the CAC from the vehicle by taking it out through the grille opening.

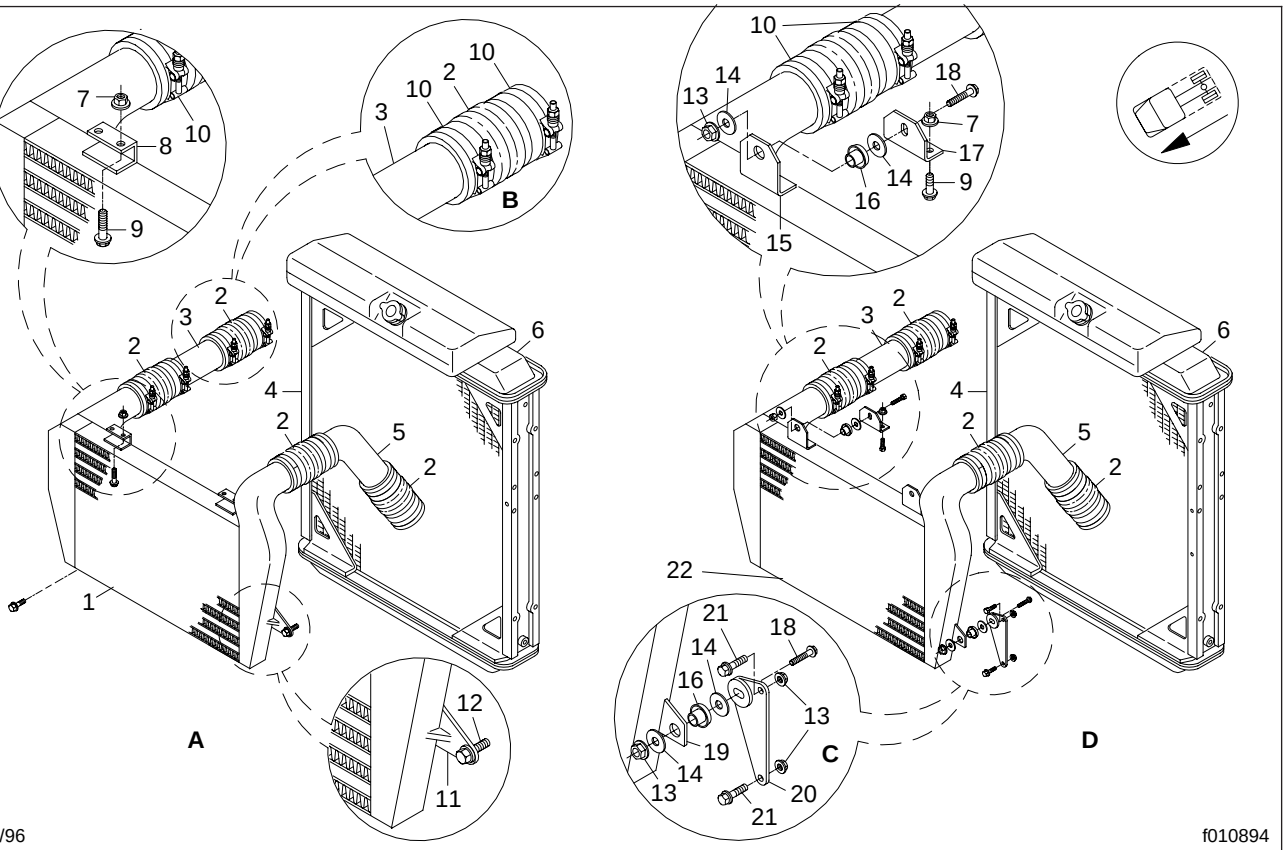
FLD 120/Classic XL Solid-Mount

1. Apply the parking brakes and chock the tires.
2. Open the hood.
3. Loosen the clamps at both ends of the hoses that attach the inlet and outlet air piping to the CAC connections. Push the clamps and hoses back onto the piping until they are not touching the CAC. See **Fig. 2**.
4. Remove the flanged bolts and nuts that attach the CAC to the lower mounting brackets at the forward sides of the radiator.
5. Remove the forward flanged nuts that attach the radiator surge tank and the brace-rod bracket assemblies to the radiator top channel.
6. Slide the CAC off the radiator and remove it from the vehicle.
7. For a CAC that is mounted on a 1350-square-inch radiator that has aluminum CAC baffles attached to the radiator support channels, remove the six Torx® fasteners that secure the baffles to the radiator. Discard the aluminum CAC baffles.

FLD 120/Classic XL Soft-Mount

1. Apply the parking brakes and chock the tires.
2. Remove the grille.
3. Open the hood.
4. Loosen the hose clamps at both ends of the convoluted hoses that attach the inlet and outlet air piping to the CAC. Push the clamps and hoses back onto the piping until they are not touching the CAC. See **Fig. 2**.
5. At each of the two CAC lower mounting tabs, loosen the CAC mounting fasteners until they are just finger-tight.
6. Have a second person support the CAC; then, at each of the two CAC upper mounting tabs, remove the CAC mounting fasteners and washers.
7. With the second person supporting the CAC, remove the CAC mounting fasteners and washers from the CAC lower mounting tabs. With the assistance of the second person, remove the CAC from the vehicle, by taking it out through the grille opening.
8. For a CAC that is mounted on a 1350-square-inch radiator that has aluminum CAC baffles at-

CAC Removal and Installation



NOTE: Air-recirculation baffles and aluminum CAC baffles are not shown.

A. Solid-Mount CAC Installation
B. Convoluted Hose Attachment (typical)
C. Small CAC Lower Attachment (typical) and Large CAC Lower Driver-Side Attachment
D. Soft-Mount CAC Installation

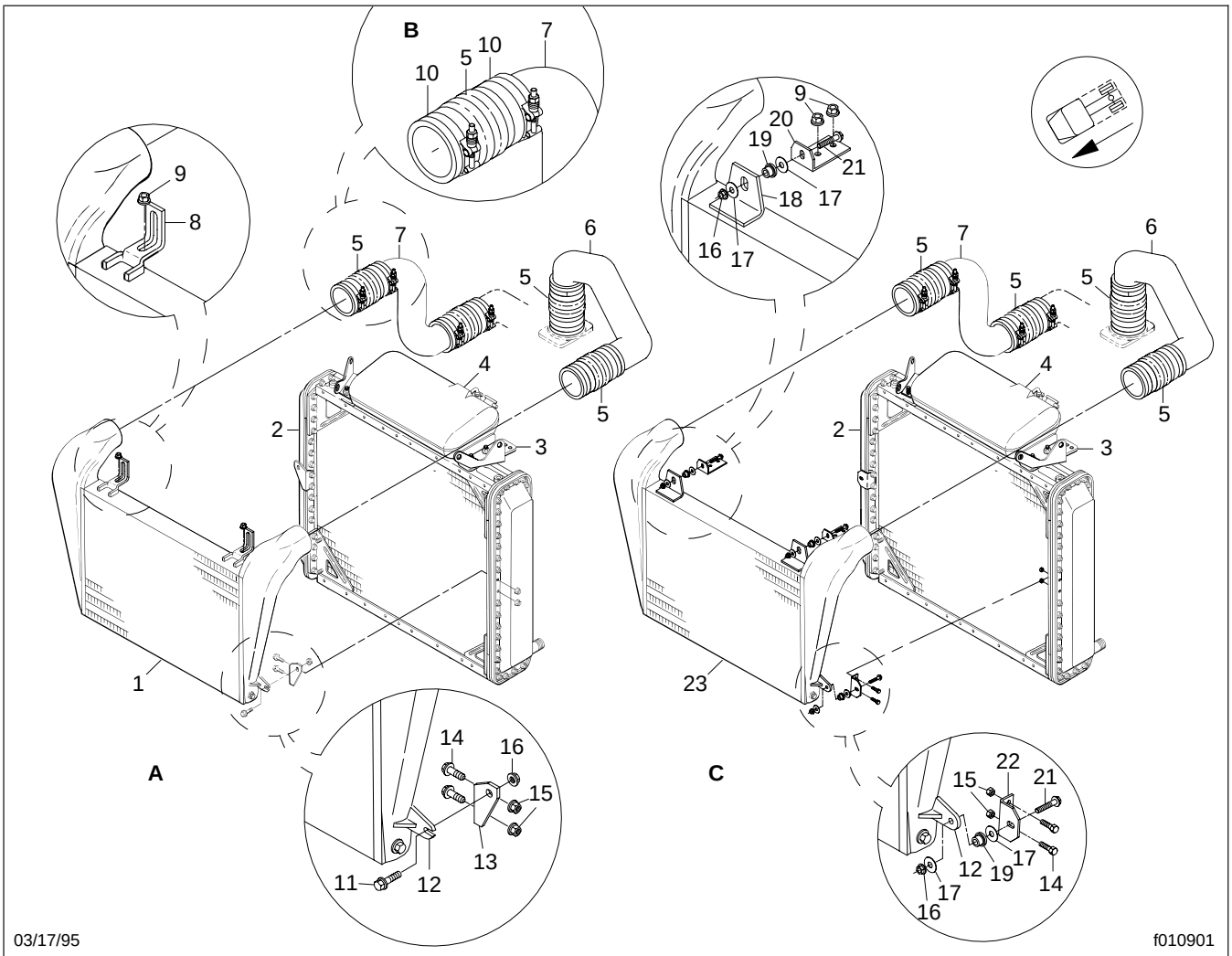
1. CAC, Solid-Mount (large CAC shown)
2. Convoluted Hose
3. CAC Inlet Air Piping
4. Radiator
5. CAC Outlet Air Piping
6. Radiator Top Tank
7. CAC-to-Radiator-Top-Tank Locknut, 5/16" Flanged
8. CAC Upper Mounting Tab (solid-mount)
9. CAC-to-Radiator-Top-Tank Bolt, 5/16" Flanged
10. Constant Tension Hose Clamp
11. CAC Lower Mounting Tab (solid-mount)
12. Lower Mounting Flatwasher and 3/8" Bolt (solid-mount)
13. Mount Locknut, 3/8–16 Flanged
14. Plated Steel Washer, 3/8" x 1-1/4"
15. CAC Upper Mounting Tab (soft-mount)
16. Elastomer Isolator
17. CAC Upper Mounting Bracket
18. CAC-Mount Bolt, 3/8–16 x 2" Long, Flanged
19. CAC Lower Mounting Tab (soft-mount)
20. CAC Lower Mounting Bracket (soft-mount)
21. CAC-Mount-Bracket Bolt, 3/8–16 x 1" Long, Flanged
22. CAC, Soft-Mount (large CAC shown)

Fig. 1, CAC Installation, FLA/FLB

tached to the radiator support channels, remove the six Torx fasteners that secure the baffles to the radiator. Discard the aluminum CAC baffles.

FLD 112 Conventional

1. Apply the parking brakes and chock the tires.



NOTE: Air-recirculation baffles and aluminum CAC baffles are not shown.

A. Solid-Mount CAC Installation
B. Convoluted Hose Attachment (typical)
C. Soft-Mount CAC Installation

1. CAC, Solid-Mount
2. 1200-Square-Inch Radiator With Metal End Tanks
3. Radiator Brace-Rod Bracket
4. Radiator Surge Tank
5. Convoluted Hose
6. CAC Outlet Air Piping
7. CAC Inlet Air Piping
8. CAC Upper Mounting Tab (solid-mount)
9. Flanged Locknut (installs on stud for brace rod bracket)
10. Constant Tension Hose Clamp
11. Lower Mounting Bracket Bolt, 3/8", Flanged (solid-mount)
12. CAC Lower Mounting Tab
13. CAC Lower Mounting Bracket (solid-mount)
14. Radiator End-Tank Bolt, 5/16", Flanged
15. Radiator End-Tank Locknut, 5/16", Flanged
16. Mount-Bracket Locknut, 3/8", Flanged
17. Plated Steel Washer, 3/8" x 1-1/4"
18. CAC Upper Mounting Tab (soft-mount)
19. Elastomer Isolator
20. CAC Upper Mounting Bracket (retrofit-only item)
21. Mount-Bracket Bolt, 3/8–16 x 2" Long, Flanged
22. CAC Lower Mounting Bracket (soft-mount)
23. CAC, Soft-Mount

Fig. 2, CAC Installation, FLD 120/Classic XL with 1200 Square-Inch Metal-End-Tank Radiator

CAC Removal and Installation

2. Open the hood halfway and support it.
3. Remove any hose clamps from the radiator brace rods.
4. Remove the hood straps and the brace rods from the top of the radiator. Tilt the hood all the way and support it.

IMPORTANT: Do not disconnect the refrigerant lines from the condenser.

5. Remove the four fasteners that attach the condenser (if equipped) to the radiator support channels. Move the condenser out of the way, and support it so that it is not damaged during removal of the CAC. See **Fig. 3**.
6. Loosen the clamps at both ends of the hoses that attach the inlet and outlet air piping to the CAC connections. Push the clamps and hoses back onto the piping until they are not touching the CAC.
7. Remove the two fasteners that attach the fan shroud to the upper radiator support channel.
8. Remove the locknuts that clamp the upper support channel in place. Remove the support channel.
9. Remove the CAC.
10. For a CAC that is mounted on a 1350-square-inch radiator that has aluminum CAC baffles attached to the radiator support channels, remove the six Torx fasteners that secure the baffles to the radiator. Discard the aluminum CAC baffles.

Installation

FLA/FLB Solid-Mount

1. Place the CAC in front of the radiator, with the holes in the CAC upper mounting tabs aligned with the empty holes in the radiator top tank. Install the flanged bolts and flanged locknuts, and tighten the locknuts 15 lbf·ft (20 N·m). See **Fig. 1**.
2. Install the hexhead bolts, hardened washers, and prevailing torque locknuts in the CAC lower mounting tabs. Tighten the locknuts 26 lbf·ft (35 N·m).

NOTE: If a new radiator was installed, backdrill through the mounting tab holes into the radiator side channels. Make sure that you do not drill into the radiator core.

3. Pull the hoses and constant tension hose clamps forward until the hoses cover about 1-1/2 inches (38 mm) of the CAC inlet and outlet connections. See **Fig. 4**.

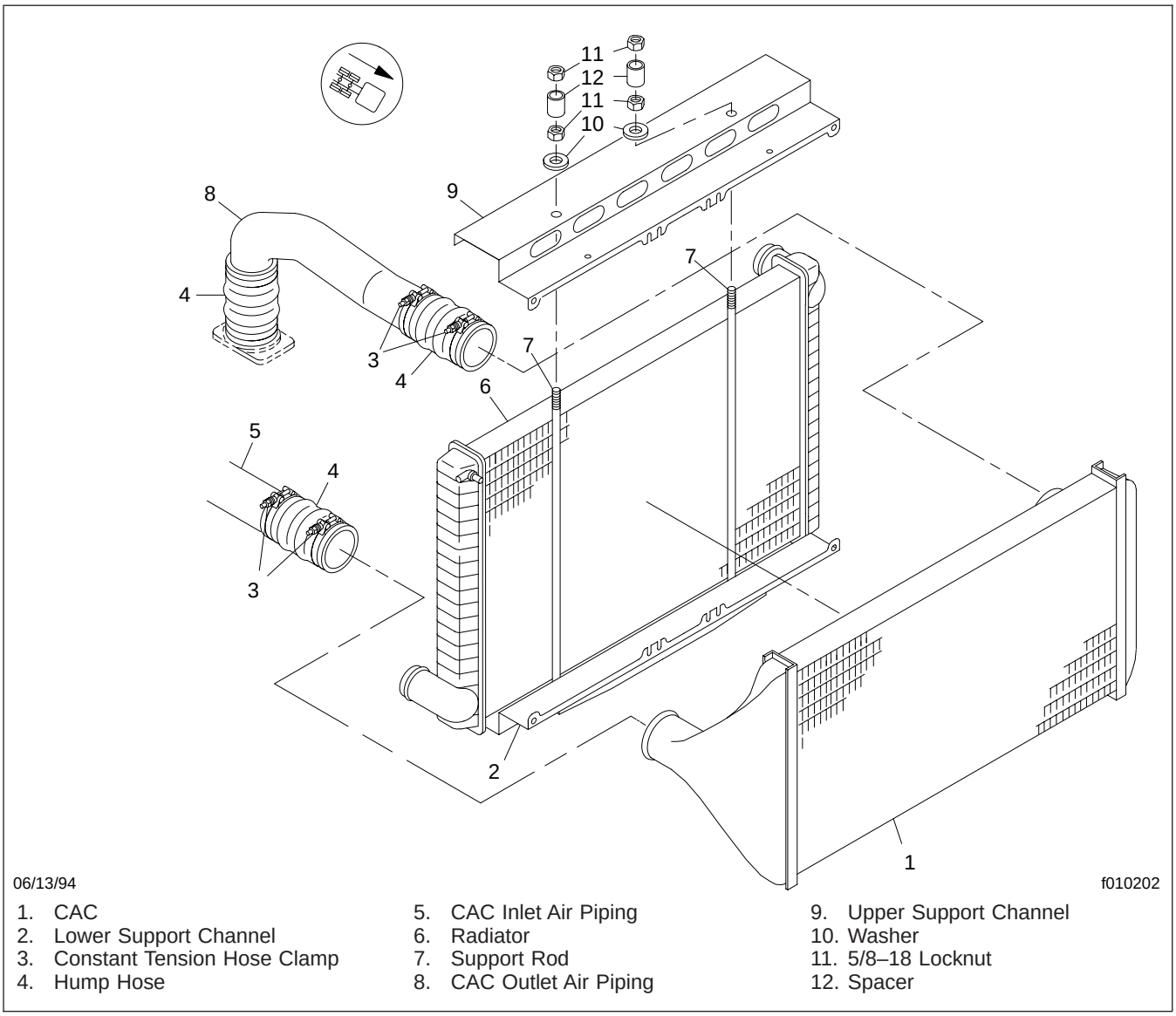
   Turn the clamps so the clamp springs are under or to the inside of the hoses. Tighten the clamp nuts 45 lbf·in (500 N·cm).
4. Return the cab to the upright position.

FLA/FLB Soft-Mount

1. From the rear of the brackets, insert the 3/8–16 by 2-inch-long flanged CAC mounting bolt in each CAC upper mounting bracket, then install a 3/8-inch i.d. by 1-1/4-inch o.d. plated steel washer on each bolt.

NOTE: If a new radiator was installed, backdrill through the mounting tab holes into the radiator side channels. Make sure that you do not drill into the radiator core.

2. From the rear of the tabs, insert the elastomer isolators removed from the old CAC into each of the upper and lower mounting tabs of the new CAC.
3. Working through the grille opening, and with the assistance of a second person, position the new CAC in place on the radiator. Have the second person support it from falling or tipping.
4. Push the 2-inch-long flanged mounting bolts through the elastomer isolator in each of the upper mounting tabs, then install another 1-1/4-inch o.d. plated steel washer and the mounting locknut on each of the bolts. Tighten the locknuts finger-tight.
5. From the rear of the brackets, insert a new 3/8–16 by 2-inch-long flanged mounting bolt in each of the lower mounting brackets, then install a 3/8-inch i.d. by 1-1/4-inch o.d. plated steel washer on each bolt.
6. Push the 2-inch-long flanged mounting bolts through the elastomer isolator in each of the lower mounting tabs, then install another 1-1/4-inch o.d. plated steel washer and the mounting locknut on each of the bolts.

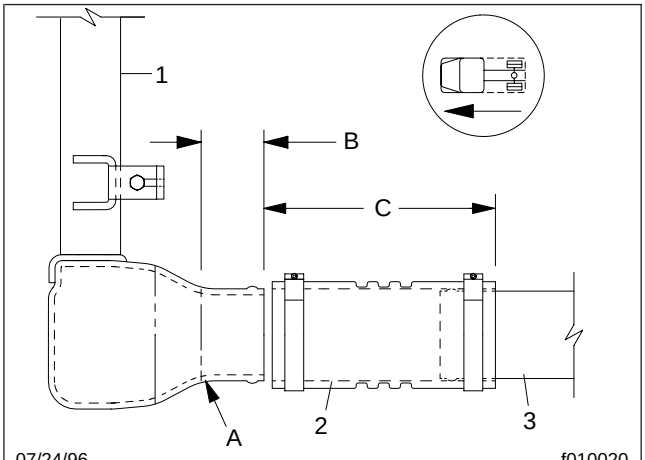


1. CAC
2. Lower Support Channel
3. Constant Tension Hose Clamp
4. Hump Hose
5. CAC Inlet Air Piping
6. Radiator
7. Support Rod
8. CAC Outlet Air Piping
9. Upper Support Channel
10. Washer
11. 5/8–18 Locknut
12. Spacer

Fig. 3, CAC, FLD 112 Conventional Installation

7. Tighten the upper mounting locknuts 23 lbf·ft (31 N·m). Tighten the lower mounting locknuts to the same torque value. Do not overtighten the fasteners.
8. Pull the convoluted hoses and hose clamps onto the CAC inlet and outlet connections until they cover about 1-1/2 inches (38 mm) of the connections. Turn the clamps so the clamp springs are under or on the inboard side of the hoses. At both ends of the hoses, tighten the clamp nuts 45 lbf·in (500 N·cm).
9. Return the cab to the upright position.
10. Install the tunnel cross-braces, and the grille and surround assembly (FLBs), or install the grille (FLAs).

CAC Removal and Installation



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NOTE: The convoluted hoses must cover the CAC outlet and inlet connections to point *A* at each connection.

A. Point A
B. Measurement: 1-1/2 inches (38 mm)
C. Measurement: 6 inches (152 mm)

1. CAC
2. Convoluted Hose
3. Outlet Air Piping

Fig. 4, Correct Hose Positioning

FLD 120/Classic XL Solid-Mount

1. Slide the CAC upper mounting tabs over the forward radiator studs on the radiator surge tank and brace-rod bracket assembly. Start the flanged nuts on the studs.
2. Install the flanged bolts and nuts that attach the CAC to its lower mounting brackets at the forward sides of the radiator, and tighten the nuts 28 lbf·ft (38 N·m).
3. Tighten the nuts at the brace-rod brackets 45 lbf·ft (61 N·m).
4. Pull the hoses and constant tension hose clamps forward until the hoses cover about 1-1/2 inches (38 mm) of the CAC inlet and outlet connections. See **Fig. 4**.

   Turn the clamps so the clamp springs are under or to the inside of the hoses. Tighten the clamp screws 45 lbf·in (500 N·cm).

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fastener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

5. Return the hood to the operating position.

FLD 120/Classic XL Soft-Mount

1. From the rear of the upper mounting brackets, insert the 3/8–16 by 2-inch-long flanged mounting bolt in each bracket, then install a 3/8-inch i.d. by 1-1/4-inch o.d. plated steel washer on each bolt.
2. From the rear of the tabs, insert the elastomer isolators removed from the old CAC into each of the upper and lower mounting tabs of the new CAC.
3. Working through the grille opening, and with the assistance of a second person, position the new CAC in place on the radiator. Have the second person support it from falling or tipping.
4. Push the 2-inch-long flanged mounting bolts through the elastomer isolator in each of the upper mounting tabs, then install another 1-1/4-inch o.d. plated steel washer and a new mounting locknut on each of the bolts. Tighten the locknuts finger-tight.
5. From the rear of the lower mounting brackets, insert a new 3/8–16 by 2-inch-long flanged mounting bolt in each of the brackets, then install a 3/8-inch i.d. by 1-1/4-inch o.d. plated steel washer on each bolt.
6. Push the 1-inch-long flanged mounting bolts through the elastomer isolator in each of the lower mounting tabs, then install another 1-1/4-inch o.d. plated steel washer and a new CAC mounting locknut on each of the bolts.
7. Tighten the upper mounting locknuts 23 lbf·ft (31 N·m). Tighten the lower mounting locknuts to the same torque value. Do not overtighten the fasteners.
8. Pull the convoluted hoses and hose clamps onto the CAC inlet and outlet connections until they cover about 1-1/2 inches (38 mm) of the connections. Turn the clamps so the clamp springs are under or on the inboard side of the hoses. At

both ends of the hoses, tighten the clamps nuts 45 lbf·in (500 N·cm).

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fastener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

9. Return the hood to the operating position and install the grille.

FLD 112 Conventional

1. Position the CAC against the front of the radiator.
2. Position the upper support channel over the radiator support rods and on top of the radiator assembly.
3. On each support rod, install a washer and locknut. Tighten the locknuts 155 lbf·ft (210 N·m).
4. Install the spacers, hood straps, brace rods, and locknuts. Tighten the locknuts 155 lbf·ft (210 N·m).
5. Move the fan shroud into place and fasten it to the radiator support channel. Tighten the self-tapping screws 15 lbf·ft (20 N·m).
6. Move the condenser into place and fasten it to the radiator. Tighten the fasteners 15 lbf·ft (20 N·m).
7. Pull the CAC hoses and constant tension hose clamps forward until the hoses cover about 1-1/2 inches (38 mm) of the CAC inlet and outlet connections. See **Fig. 4**.

   Turn the clamps so the clamp springs are under or to the inside of the hoses. Tighten the clamp screws 45 lbf·in (500 N·cm).

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fastener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

8. Return the hood to the operating position .

Inspection

1. Apply the parking brakes and chock the tires.
2. Check the charge air cooler (CAC) convoluted hoses and the inlet and outlet piping for holes or other damage. Also check for loose or damaged constant tension hose clamps. Replace damaged parts. If hose clamps are loose, turn them so their tightening screws are under the hoses or facing inboard. Tighten the screws 45 lbf·in (500 N·cm).

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fastener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

3. Check the CAC core fins. If the fins are bent, use a small pair of needlenose pliers or a small screwdriver to straighten them.
4. Check the CAC core for clogged fins. Use compressed air or water to dislodge any material restricting airflow through the core.
5. Perform the "CAC Core Leakage Test."

CAC Core Leakage Test

Charge air coolers are designed in such a way that they may leak an insignificant amount of air. The allowable leakage mentioned in **Table 1** represents a loss of less than 0.1 percent of charge airflow. Based on this rate, there should be no measurable loss of performance.

Leakage Rate Specifications		
Engine	**Pressure Drop in 15 Seconds: psi (kPa)**	**Start Pressure: psi (kPa)**
Caterpillar	5 (34)	30 (207)
Cummins	7 (48)	30 (207)
Detroit Diesel	5 (34)	25 (172)

Table 1, Leakage Rate Specifications

The CAC core leakage test should be performed using a CAC test kit, part number 5039, which can be purchased from Kent-Moore/SPX at 1-800-328-6657.

1. Apply the parking brakes and chock the tires.
2. Connect the test equipment to the CAC core, as follows. See **Fig. 1**.
   - 2.1 Remove the inlet and outlet air piping from the convoluted hoses that attach them to the CAC air inlet and air outlet.
   - 2.2 Slip a safety ring with thumbscrew over each convoluted hose and onto the CAC air inlet and air outlet. Turn the rings so the thumbscrews are facing outboard and the safety chains are inboard. Tighten the thumbscrews securely.
   - 2.3 Install an additional constant tension hose clamp on each convoluted hose.
   - 2.4 Install the test plug without an adaptor in the CAC air inlet and turn the plug so the safety chain is inboard. Tighten each constant tension hose clamps 72 lbf·in (810 N·cm).
   - 2.5 Install the test plug with adapter in the CAC air outlet and turn the plug so the safety chain is inboard. Tighten each constant tension hose clamp 72 lbf·in (810 N·cm).

⚠ WARNING

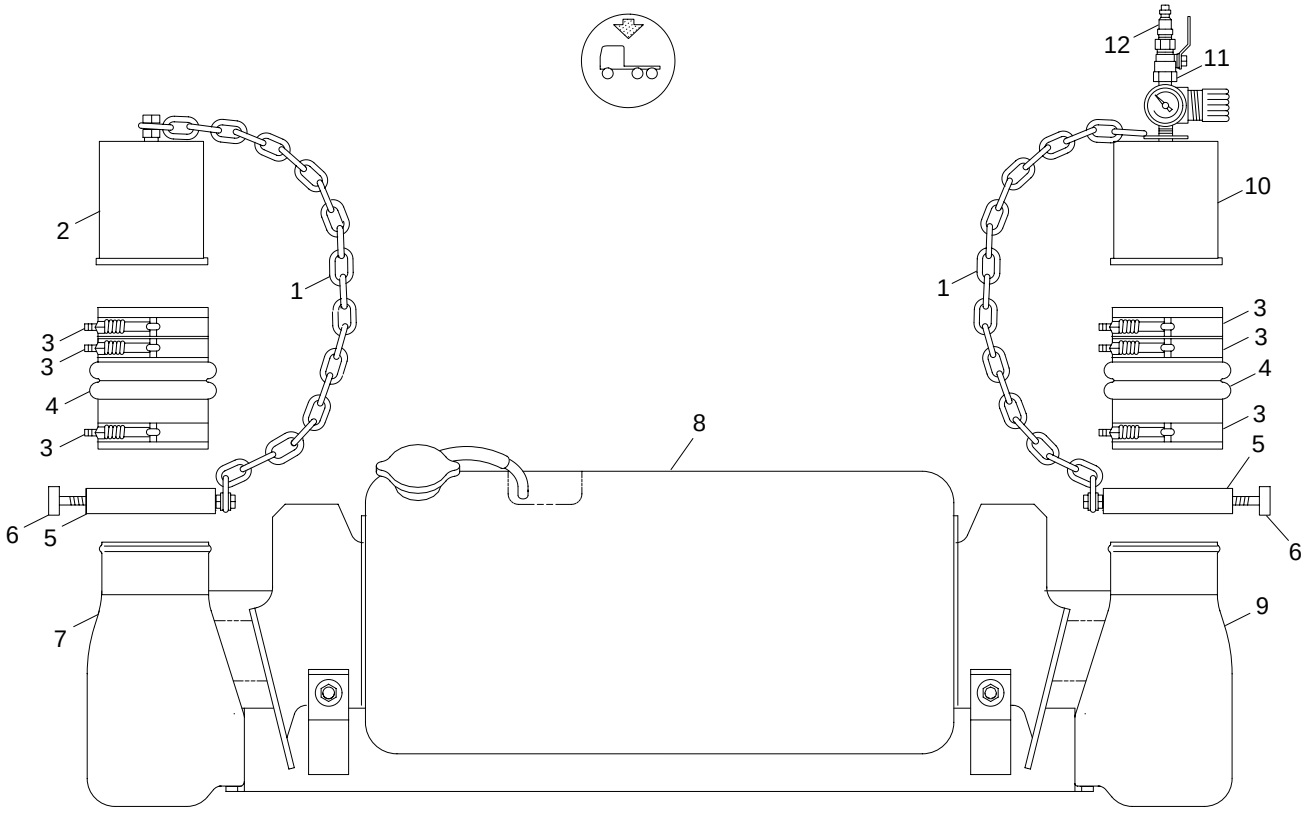
Always secure the test plugs with the safety rings. Test pressures could blow out an unsecured test plug at high speed, possibly causing eye injury or other serious personal injury.

   - 2.6 If not already installed, install a test valve/gauge assembly and air chuck in the test plug with adaptor.
   - 2.7 Attach a pressurized air line to the air chuck on the pressure regulator valve.
3. Test the CAC core as follows.

⚠ WARNING

Always wear safety glasses when doing this procedure. Do not stand in front of the test plugs while the core is pressurized. A plug could sud-

CAC Inspection and Leakage Test



1. Safety Chain
2. Test Plug without Adaptor
3. Constant Tension Hose Clamp
4. Convoluted Hose
5. Safety Ring
6. Thumbscrew
7. CAC Air Inlet
8. Radiator Surge Tank
9. CAC Air Outlet
10. Test Plug with Adaptor
11. Test Valve/Gauge Assembly
12. Air Chuck

Fig. 1, CAC Core Testing

denly release debris at high speed, possibly resulting in eye injury or other serious personal injury.

3.1 Open the test valve, then slowly open the pressure regulator valve and allow the CAC to gradually fill with air to the start pressure. See **Table 1**.

3.2 Close the test valve and watch the gauge for 15 seconds. If there is more than the specified drop in the CAC pressure in 15 seconds, replace the CAC. See **Table 1**.

IMPORTANT: Do not attempt to repair the CAC.

3.3 When testing is completed, reduce the pressure on the pressure regulator valve to bleed air from the CAC.

4. Remove the test equipment (and the additional constant tension hose clamps) from the convoluted hoses.
5. Pull the convoluted hoses and constant tension hose clamps rearward until the hoses cover about 1-1/2 inches (38 mm) of the CAC air inlet and air outlet piping.
6. Turn the clamps so their tightening screws are under the hoses or facing inboard. Tighten the screws 45 lbf·in (500 N·cm).

CAC Inspection and Leakage Test

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fastener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

Flushing

If the charge air cooler (CAC) is suspected of being contaminated, flush the CAC.

1. Apply the brakes and chock the tires.
2. Remove the CAC. For instructions, see **Subject 100**.
3. Set the CAC in a horizontal position with the inlet and outlet ports facing up.

IMPORTANT: Use only naphtha or mineral spirits to clean the charge air cooler. Do not use caustic solutions such as those that are commonly used in radiator shops. Do not use steam or high-temperature cleaning operations. Caustic solutions, steam, and high-temperature cleaning operations will damage the RTV that seals the charge air cooler tubes to the headers, which may result in leaking.

4. Pour a filtered naphtha or mineral spirits solution into the CAC until it is 40 percent full.
5. Cap the inlet and outlet ports on the CAC.
6. Rock the CAC back and forth so that the solvent travels from one tank, through the tubes, to the other tank and back. Repeat this process ten times.

NOTE: Do not leave the solvent in the CAC for more than 10 minutes.

7. Remove the caps from the inlet and outlet ports.
8. Drain the CAC and properly dispose of the solvent.
9. Leave the caps off and allow the residual solvent to evaporate.
10. Install the CAC. For instructions, see **Subject 100**.

Restriction Test

After flushing the charge air cooler (CAC) because of turbocharger or engine damage, test the pressure drop across the CAC and air piping, as follows:

1. Remove the pipe plug from the tapped hole in the turbocharger air outlet elbow.

   Remove the pipe plug, or the nylon tube and atomizer for the ether start system (if so equipped), or the air line to the turbocharger air-pressure gauge (if so equipped), from the tapped hole in the rear left-hand side of the intake manifold.

   Install an air pressure gauge in each tapped hole.

2. Operate the engine at rated speed and horsepower; there is no need to operate the engine at its peak torque rating. While operating the engine, read both air pressure gauges.

   Because of the turbulence of the air at the turbocharger outlet, subtract 0.3 inHg (1 kPa) from the pressure measurement taken at this point, to make it a true reading.

   From that reading, subtract the reading taken at the intake manifold. This is the pressure drop of the CAC.

   If the pressure drop is more than 4 inHg (14 kPa), flush or replace the CAC as needed.

General Information and Principles of Operation

The Tu-Flo 501 and the Tu-Flo 700 are two cylinder, single-stage, reciprocating air compressors. The Tu-Flo 501 has a rated displacement of 12 cfm (340 L/min) of air at 1250 rpm. The Tu-Flo 700 has a rated displacement of 15.5 cfm (440 L/min) of air at 1250 rpm.

Tu-Flo 501s (**Fig. 1**) have two major subassemblies: the cylinder head and the crankcase. The cylinder head houses the discharge valving, and is installed on top of the crankcase, which is a one-piece casting. The cylinder block portion of the casting houses the cylinder bores, inlet valving, and the unloader mechanism; the crankcase portion houses the crankshaft and main bearings. Governor mounting pads are provided on each end of the upper part of the crankcase.

Tu-Flo 700s (**Fig. 2**) have three major subassemblies: the cylinder head, cylinder block, and the crankcase. The cylinder head houses the discharge valving, and is installed on top of the cylinder block. The cylinder block houses the cylinder bores, inlet valving, and the unloader mechanism, and is installed between the cylinder head and the crankcase. The crankcase houses the crankshaft and main bearings. Governor mounting pads are provided on each end of the cylinder block.

During operation, each compressor is watercooled and air-cooled. Coolant from the engine's cooling system flows through a connecting line to the Tu-Flo 501's cylinder head, where it passes through a water jacket surrounding the discharge valves and discharge port, then out the cylinder head through another connecting line. Engine coolant enters the Tu-Flo 700's cylinder block, and passes through water jackets in both the cylinder block and cylinder head before flowing out of the cylinder head. The compressor crankcase of both compressor styles is cooled by airflow through the engine compartment, from the action of the engine fan and the movement of the vehicle. The cylinder block portion of the Tu-Flo 501 crankcase has external fins to improve air cooling.

Tu-Flo compressors use the engine's pressurized oil system to lubricate their internal moving parts. Oil enters the compressor either through a passage in the flange adapter, the end cover, or the driven end of the crankshaft, depending on the engine model. Oil is fed to the crankshaft main bearings and the connecting rod bearings through passages drilled in the crankshaft. The piston wrist pins are lubricated by oil dripping from a boss inside the piston.

The compressor provides compressed air to operate air brake and auxiliary air system components. Tu-Flo compressors are gear-driven by the engine, and operate continuously while the engine is running. Actual compression of air is controlled by the air governor and the compressor's unloader mechanism. The governor maintains the brake system air pressure between preset maximum and minimum levels.

INTAKE AND COMPRESSION OF AIR (LOADED)

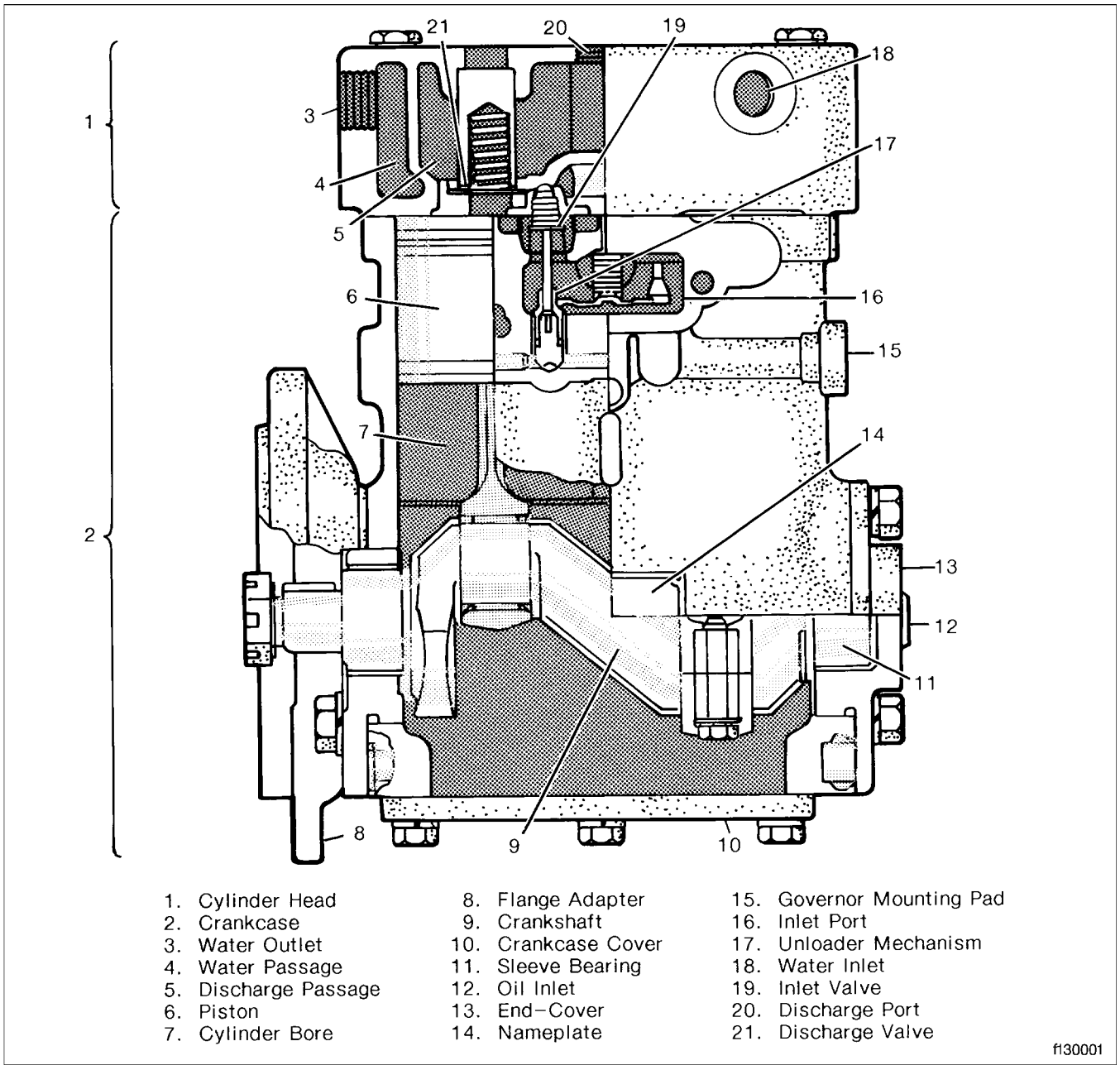
During the downstroke (intake stroke) of each piston, a slight vacuum is created between the top of the piston and the cylinder head, causing the inlet valve for that cylinder to move up and off its seat, see **Fig. 3**. Air from the engine air-intake system is drawn into the cylinder, past the open inlet valve.

As the piston begins its upward stroke, the air that was drawn into the cylinder on the downstroke is being compressed. Air pressure against the top of the inlet valve, and the force of the inlet valve spring, return the inlet valve to its seat. As the piston continues its upward stroke, air above the piston is compressed until the pressure lifts the discharge valve, and the compressed air flows into the discharge line, and on to the reservoirs. When the piston reaches the top of its stroke and starts down, the discharge valve spring and air pressure in the discharge line return the discharge valve to its seat. This prevents compressed air in the discharge line from returning to the cylinder bore as the intake and compression cycle is repeated.

NON-COMPRESSION OF AIR (UNLOADED)

When air pressure in the reservoir reaches the cut-out setting of the governor, compressed air passes through the governor, into the cavity beneath the unloader pistons, see **Fig. 4**. This lifts both of the unloader pistons and plungers. The plungers move up, and hold both inlet valves off their seats. With the inlet valves held off their seats, the inlet cavity forms a passage between the cylinders. During the upward

General Information and Principles of Operation



1. Cylinder Head
2. Crankcase
3. Water Outlet
4. Water Passage
5. Discharge Passage
6. Piston
7. Cylinder Bore
8. Flange Adapter
9. Crankshaft
10. Crankcase Cover
11. Sleeve Bearing
12. Oil Inlet
13. End–Cover
14. Nameplate
15. Governor Mounting Pad
16. Inlet Port
17. Unloader Mechanism
18. Water Inlet
19. Inlet Valve
20. Discharge Port
21. Discharge Valve

Fig. 1, Tu-Flo 501 Air Compressor (typical Caterpillar application shown)

stroke of the pistons, air is pumped back and forth between the two cylinders, and compression is stopped.

When air is used from the reservoir, and air pressure drops to the cut-in setting of the governor, the governor closes off and exhausts the air from beneath the unloader pistons. The unloader saddle spring forces the saddle, unloader pistons, and plungers down. This returns the inlet valves to their seats, and compression starts again.

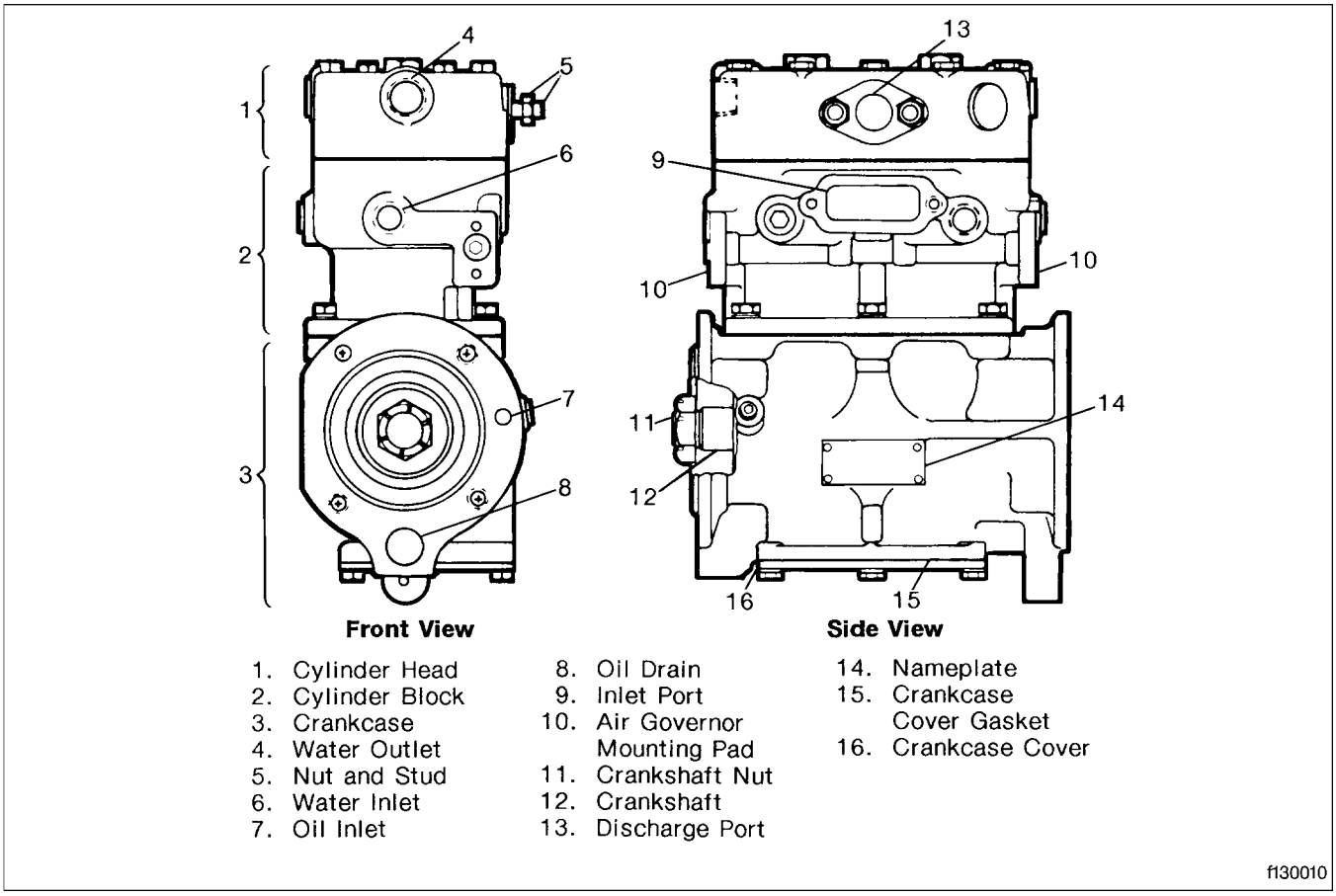
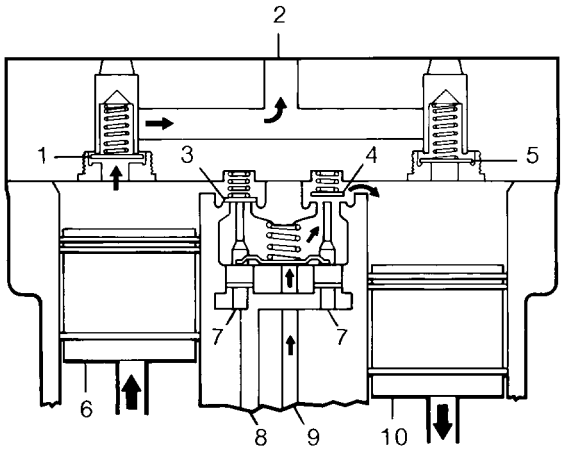


Fig. 2, Tu-Flo 700 Air Compressor (typical Cummins application shown)

General Information and Principles of Operation



1. Discharge Valve (Open)
2. Discharge Port
3. Inlet Valve (Closed)
4. Inlet Valve (Open)
5. Discharge Valve (Closed)
6. Piston (on Compression Stroke)
7. Unloader Piston (Down)
8. Passage from Governor (Closed)
9. Inlet Port from Engine Air Cleaner
10. Piston (on Intake Stroke)

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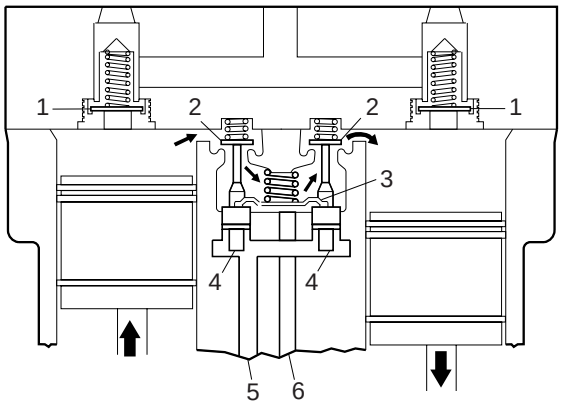
Fig. 3, Intake and Compression of Air (Loaded)



1. Discharge Valve (Closed)
2. Inlet Valve (Open)
3. Unloader Spring Saddle
4. Unloader Piston and Plunger (Raised)
5. Passage from Governor (Open)
6. Inlet Port from Engine Air Cleaner

f130019

Fig. 4, Non-Compression of Air (Unloaded)

Removal

1. Chock the tires, then drain the air from all air reservoirs.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

2. Using a cleaning solvent, remove road dirt and grease from the outside of the compressor, then dry the compressor with compressed air.
3. Drain the radiator coolant. For instructions, refer to the radiator section in this manual.
4. Disconnect the air discharge line and the water lines from the compressor cylinder head, and drain the coolant from the cylinder head (and cylinder block of Tu-Flo 700s).
5. On Caterpillar engines, disconnect the air governor from its mounting bracket.
6. Remove the cylinder head capscrews. Remove any brackets, spacers, or clamps held in place by the capscrews, after noting their positions.
7. Tap the cylinder head with a soft mallet to break the gasket seal. Remove the cylinder head.

Installation

1. Remove the inlet valve springs from the cylinder head.
2. Scrape off any gasket material from the cylinder head and the crankcase or cylinder block.
3. Using compressed air, blow dirt particles or gasket material from all cylinder head cavities.
4. Install the inlet valve springs in the cylinder head by turning each spring after it's in the head. The turning motion should dig the spring wire into the spring seat in the bottom of the spring bore in the head. If several tries prove unsuccessful, use a very small amount of grease to hold the springs in place; just enough to keep them from falling out.
5. Place the cylinder head gasket on the crankcase or cylinder block.
6. Position the cylinder head on the crankcase or cylinder block, being careful to align the inlet valve springs with the inlet valves.
7. Position on the cylinder head any brackets, spacers, or clamps that were removed. Then install the cylinder head capscrews, and tighten them evenly in increments to their final torque. For Tu-Flo 501s, final torque is 25 to 30 lbf·ft (35 to 40 N·m). For Tu-Flo 700s, final torque is 175 to 225 lbf·in (1980 to 2540 N·cm).
8. Connect the air discharge line and the water lines to the cylinder head. On Caterpillar engines, attach the air governor to its mounting bracket.
9. Fill the engine cooling system. For instructions, refer to the radiator section in this manual.

Unloader Mechanism Replacement

1. Remove the air compressor cylinder head. For instructions, refer to **Subject 100**.
2. Remove the intake adapter, baffle, and gaskets.
3. On Cummins engines, remove the air governor and governor mounting gasket.

   On Caterpillar engines, disconnect the air governor unloader line from the elbow fitting at the governor mounting pad of the compressor. Remove the line and governor as an assembly. Remove the elbow fitting from the mounting pad.
4. Remove the inlet valves from their guides in the crankcase or cylinder block. See **Fig. 1**.
5. Remove the inlet valve guides from around the inlet valve seats, taking care not to damage the seats.

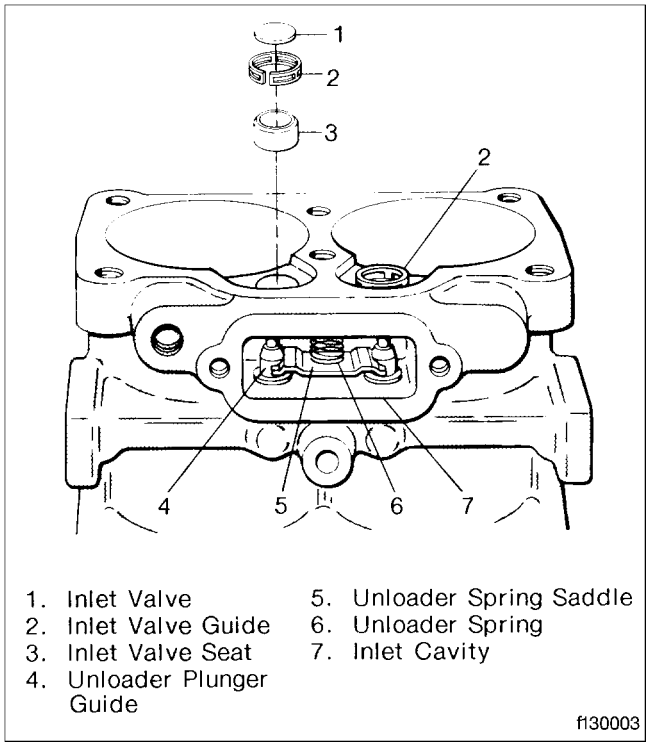


Fig. 1, Inlet Valves and Unloader Mechanism

6. Using needle-nose pliers, remove the unloader spring, spring saddle, and unloader spring seat from the inlet cavity of the crankcase or cylinder block. Discard the removed parts.
7. Remove and discard the unloader plungers and guides.
8. Cover the inlet cavity and inlet valve ports with a shop rag. Apply compressed air to the unloader port of the governor mounting pad, to blow the unloader pistons out of their bores, and into the inlet cavity. Remove and discard the unloader pistons.
9. Check the condition of the unloader bore bushings. If they are worn, rusted, or damaged, replace both of them as follows:

   9.1 Remove each bushing by running a 1/8-27 pipe tap into it. Remove the tap, and install a 1/8-27 threaded rod into the bushing, then pull it straight up.

   IMPORTANT: Do not use an easyout for removing the bushings.

   9.2 Remove the unloader port plug from the air governor mounting pad that is opposite the pad where the governor was mounted or the governor unloader line was attached.

   9.3 Using a rag, plug the unloader bore openings in the bottom of the inlet cavity. Then use compressed air, through either of the governor unloader ports, to blow any particles out of the unloader passage.

   9.4 Use compressed air to blow any particles out of the inlet cavity.

   9.5 Clean the unloader port plug, and apply a small amount of Loctite® 242, or equivalent sealant, to its threads. For Caterpillar engines, also clean the unloader-line elbow fitting, and apply the sealant to its threads.

⚠ CAUTION

CAUTION: Make sure excess sealant will not get inside the air compressor. Loose material inside the air compressor or governor could cause damage.

   9.6 Install and tighten the port plug and (on a Caterpillar engine) the elbow fitting.

Unloader Mechanism Replacement

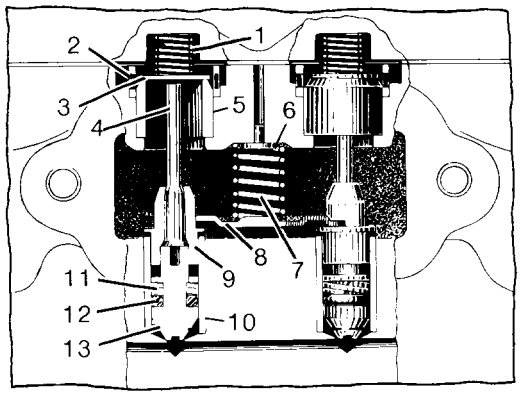
9.7 Using a soft metal drift, drive in the new bushings.

10. Install the new unloader pistons in their bores, being careful not to cut the O-rings or distort the backup rings. See **Fig. 2**.

NOTE: New unloader pistons are prelubricated with a special lubricant, and need no additional lubrication.

11. Insert the unloader plungers in their guides, then place them over the tops of the pistons.
12. Insert the pin of the unloader spring seat into the small hole in the crankcase or cylinder block.
13. Position the unloader spring saddle between the unloader plunger guides, so its forks are centered on the guides.
14. Install the unloader spring, making sure it seats over both spring seats, in the crankcase (or cylinder block) and on the saddle.
15. Install the inlet valve guides, then drop the inlet valves into them, with the best side of each valve facing the seat. There should be a loose sliding fit between the guides and the valves.
16. On Caterpillar engines, attach the air governor unloader line, with the air governor attached, to the unloader-line elbow fitting.

    On Cummins engines, clean the mounting pad on both the compressor and the governor, and be sure the compressor unloader port is clear. Install a new governor mounting gasket, then install the governor. Tighten the mounting bolts 11 to 15 lbf·ft (15 to 20 N·m).
17. Install the cylinder head on the compressor. For instructions, refer to **Subject 100**.
18. Test the operation of the unloader mechanism; refer to **"Troubleshooting, 300."**
19. Insert the intake adapter bolts through the intake adapter. Install a gasket, the baffle, then another gasket over the intake adapter bolts. Install the adapter on the compressor, and tighten the bolts.



Cutaway View

1.	Inlet Valve Spring	7.	Unloader Spring
2.	Inlet Valve Guide	8.	Unloader Spring Saddle
3.	Inlet Valve	9.	Unloader Plunger Guide
4.	Unloader Plunger	10.	Unloader Bore Bushing
5.	Inlet Valve Seat	11.	Unloader Piston O-Ring
6.	Unloader Spring Seat	12.	Unloader Piston Grommet
		13.	Unloader Piston

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Fig. 2, Unloader Mechanism and Inlet Valve Components

Repair and Testing of Tu-Flo 501

1. Remove the air compressor cylinder head. For instructions, refer to **Subject 100**.
2. Using a vernier caliper, measure the travel (fully closed to fully open) of both discharge valves. Valve travel must not be more than 0.057 inch (1.45 mm). See **Fig. 1**, Ref. *A*.

   If valve travel is within the limit, go to the next step.

   If valve travel is more than the limit, replace the valve stops, as follows:

   2.1 Remove the discharge valve seats, taking care not to damage them. See **Fig. 1**. Remove and discard the discharge valves and springs.

   2.2 Support the machined surface of the cylinder head on an arbor press bed, allowing enough clearance for the stops between the press bed and the bottom of the cylinder head. Gently press the stops from the top of the head, and out the bottom.

   2.3 Inspect the valve stop bores in the cylinder head for severe scoring. If scoring is severe, replace the cylinder head.

   2.4 Measure the inside diameter of both valve stop bores, and the outside diameter of both new discharge valve stops. For a correct press fit, the diameter of each bore must be 0.0008 to 0.0028 inch (0.020 to 0.071 mm) larger than its respective valve stop. If the size of the bores is not within these limits, replace the cylinder head.

   2.5 Apply a small amount of Loctite Retaining Compound No. 75, or an equivalent sealant, to the outside curved surface of each stop.

⚠ CAUTION

CAUTION: Make sure excess sealant will not get inside the air compressor. Loose material inside the air compressor or governor could cause damage.

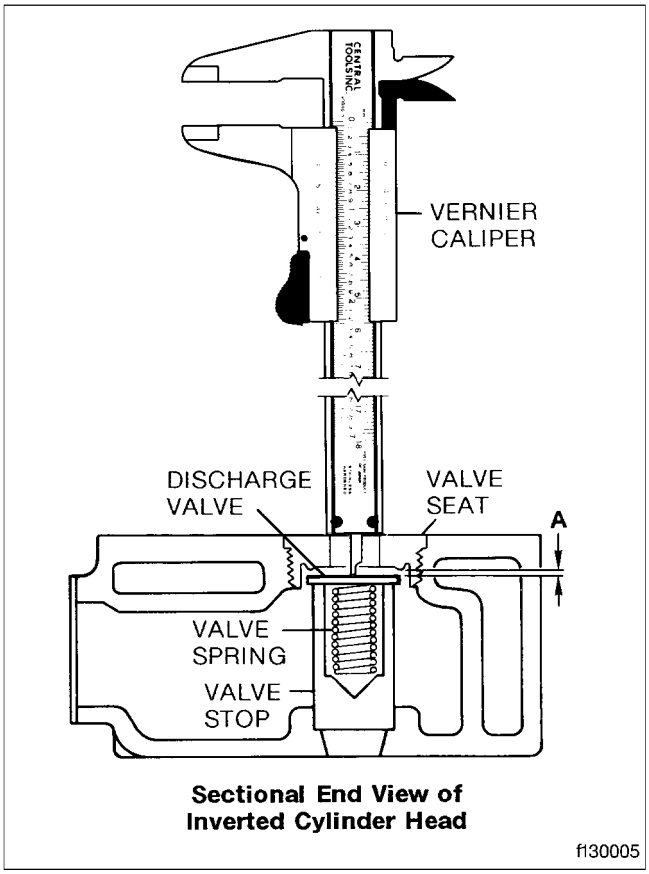


Fig. 1, Measuring Discharge Valve Travel

   2.6 Noting their location and position, remove any fittings from the cylinder head.

   2.7 Support the cylinder head casting, all the way around the outside top, on the arbor press bed. Press in the new stops from the bottom of the casting.

   2.8 Clean any fittings that were removed, and apply a small amount of Loctite 242, or an equivalent sealant, to the threads on the fittings. Install and tighten the fittings.

3. If not already done, remove the discharge valve seats, valves, and springs. See **Fig. 1**. Discard the valves and springs.
4. Inspect the discharge valve seats for nicks, cracks, or extreme wear; replace them if necessary. If they show signs of slight wear, use a lapping stone, grinding compound, and a grinding tool to dress them.

Discharge Valve Repair and Leak-Testing

5. Install new discharge valve springs and valves. Install and tighten the discharge valve seats until the discharge valve travel measures between 0.041 and 0.057 inch (1.04 to 1.45 mm).
6. Test for discharge valve leakage, as follows:
   - 6.1 Apply compressed air at 100 psi (690 kPa) pressure through the cylinder head discharge port.
   - 6.2 Apply a soap solution to the discharge valves and seats.
   - 6.3 A slight leakage in the form of soap bubbles is okay.

     If there's extreme leakage, leave the air pressure applied, and with a hardwood dowel and a hammer, tap the discharge valves off their seats several times. This will improve the seal between the valve and the valve seat, and should reduce leakage.

     If there's still extreme leakage, replace the valve seats.
   - 6.4 With the air pressure still applied, apply the soap solution to the discharge valve stops (exposed on the top of the cylinder head). No leakage is allowed.
   - 6.5 Remove the compressed-air hose.
7. Install the cylinder head. For instructions, refer to **Subject 100**.

Repair and Testing of Tu-Flo 700

1. Remove the air compressor cylinder head. For instructions, refer to **Subject 100**.
2. Using a vernier caliper, measure the travel (fully closed to fully open) of both discharge valves. Valve travel must not be more than 0.046 inch (1.17 mm). See **Fig. 1**, Ref. *A*.

   If valve travel is within the limit, go to the next step.

   If valve travel is more than the limit, replace the valve stops (capnuts).
3. Remove the discharge valve seats, valves, valve guides, and springs. See **Fig. 1**. Discard the valves, valve guides, and springs.
4. Inspect the discharge valve seats for nicks, cracks, or extreme wear; replace them if necessary. If they show signs of slight wear, use a lapping stone, grinding compound, and a grinding tool to dress them.
5. Install new discharge valve springs, valve guides, and valves. Install and tighten the discharge valve seats until the discharge valve travel measures between 0.030 and 0.046 inch (0.76 to 1.17 mm).
6. Test for discharge valve leakage, as follows:
   - 6.1 Apply compressed air at 100 psi (690 kPa) pressure through the cylinder head discharge port.
   - 6.2 Apply a soap solution to the discharge valves and seats.
   - 6.3 A slight leakage in the form of soap bubbles is okay.

     If there's extreme leakage, leave the air pressure applied, and with a hardwood dowel and a hammer, tap the discharge valves off their seats several times. This will improve the seal between the valve and the valve seat, and should reduce leakage.

     If there's still extreme leakage, replace the valve seats.
   - 6.4 With the air pressure still applied, apply the soap solution to the discharge valve cap nuts (on top of the cylinder head). No leakage is allowed.
   - 6.5 Remove the compressed-air hose.
7. Install the cylinder head. For instructions, refer to **Subject 100**.

Removal

1. Chock the tires, then drain the air from all air reservoirs.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

2. Using a cleaning solvent, remove road dirt and grease from the outside of the compressor, then dry the compressor with compressed air.
3. Drain the radiator coolant; refer to the radiator section in this manual for instructions.
4. Disconnect the air discharge line and the water lines from the compressor cylinder head (and cylinder block of Tu-Flo 700s), and drain the coolant from the cylinder head (and block). Remove any clamps that attach the lines to the compressor.
5. At the air governor, disconnect the air line that runs from the air reservoir.
6. Remove the air governor, and (for a Cummins engine) the governor mounting gasket.

   On Caterpillar engines, also remove the governor unloader line from the elbow fitting at the governor mounting pad of the compressor.
7. Remove the intake adapter, baffle, and gaskets.
8. If the compressor is on a Cummins engine, remove the fuel pump and gasket; refer to the Cummins engine shop manual or rebuild manual for instructions.
9. Remove the compressor support bracket, if so equipped.
10. Support the compressor, and remove the bolts that attach it to the auxiliary drive housing, accessory drive, or timing gear plate. Remove the compressor, gasket, and splined coupling (if so equipped).

Installation

1. Install the compressor gasket and splined coupling (if so equipped). Hold the compressor in place, and install the bolts that attach it to the auxiliary drive housing, accessory drive, or timing gear plate.
2. Install the compressor support bracket, if so equipped.
3. On Cummins engines, install the Cummins fuel pump and gasket; refer to the Cummins engine shop manual or rebuild manual for instructions.
4. Insert the intake adapter bolts through the intake adapter. Install a gasket, the baffle, then another gasket over the intake adapter bolts. Install the adapter on the compressor, and tighten the bolts.
5. On Caterpillar engines, attach the air governor unloader line, with the air governor attached, to the unloader-line elbow fitting. Attach the governor to its mounting bracket.

   On Cummins engines, clean the mounting pad on both the compressor and the governor, and be sure the compressor unloader port is clear. Install a new governor mounting gasket, then install the governor, and tighten the mounting bolts 11 to 15 lbf·ft (15 to 20 N·m).
6. At the air governor, connect the air line that runs from the air reservoir.
7. Connect the air discharge line and the water lines to the compressor cylinder head. Install any clamps that attach the lines to the compressor.
8. Fill the engine cooling system. For instructions, refer to the radiator section in this manual.

Disassembly

1. Remove the air compressor. For instructions, refer to **Subject 130.**
2. Remove all compressor attachments, such as inlet fittings, discharge fittings, and pipe plugs, see **Fig. 1** or **Fig. 2**.
3. Before disassembling the compressor, use a metal scribe to mark the parts with matching numbers or lines.

   Mark both the front and rear end-covers (or flange adapters) in relation to the crankcase. Mark the front end-cover and the crankcase in relation to the drive end of the crankshaft. Mark the crankcase cover in relation to the crankcase. On Tu-Flo 501s, mark the cylinder head in relation to the crankcase; on Tu-Flo 700s, mark the cylinder head in relation to the block, and the block in relation to the crankcase.

IMPORTANT: Do not use a marking method, such as chalk, that can be wiped off during rebuilding.

4. Remove the cylinder head bolts. Remove any brackets, spacers, or clamps held in place by the bolts, after noting their positions.

   Tap the cylinder head with a soft mallet to break the gasket seal. Remove the cylinder head.
5. Remove the inlet valve springs from the cylinder head, and the inlet valves from their guides in the crankcase or cylinder block. Remove the guides from around the inlet valve seats, taking care not to damage the seats. See **Fig. 3**. Discard the inlet valves, valve springs, and guides.
6. Before disassembling the discharge valves, inspect the valve stops for severe peening. Using a vernier caliper, measure the travel (fully closed to fully open) of both discharge valves. See **Fig. 4**, Ref. *A*. Measure to the nearest thousandth of an inch (hundredth of a millimeter), and record the measurements.
7. Unscrew the discharge valve seats from the head, being careful not to damage them. See **Fig. 4**. Remove the discharge valves and springs (and valve guides, on Tu-Flo 700s); discard the valves and springs.
8. Remove the crankcase cover capscrews, then tap the crankcase cover with a soft mallet to break the gasket seal and remove the cover.
9. On Tu-Flo 501s, straighten the prongs of the rod cap lock straps. See **Fig. 1**, Ref. 32.
10. On Tu-Flo 501s and 700s, before removing the connecting rods, mark each connecting rod and its cap.

    Remove the rod bolts and bearing caps. Push the pistons, with the rods attached, out the top of the cylinders. Remove and discard the connecting rod journal bearings. Install the bearing caps on their respective connecting rods.

IMPORTANT: Each rod is matched to its own cap for correct bearing fit. These parts must not be interchanged.

11. From the pistons, remove and discard the piston rings.
12. On Tu-Flo 700s, remove the bolts that fasten the cylinder block to the crankcase, then separate the two. See **Fig. 2**, Ref. 9.
13. Using needle-nose pliers, remove and discard the unloader spring, spring saddle, and unloader spring seat from the inlet cavity of the crankcase or cylinder block. See **Fig. 3**. Remove and discard the unloader plungers and guides.
14. Cover the inlet cavity and inlet valve ports with a shop rag. Apply compressed air to the unloader port of one governor mounting pad, while blocking the unloader port of the opposite pad. This will blow the unloader pistons out of their bores, and into the inlet cavity. Discard the unloader pistons.
15. Remove the capscrews, then each end-cover or flange adapter (as equipped), taking care not to damage the crankshaft oil seals and main bearings, if any.
16. On Tu-Flo 501s, remove all of the small seal rings from the crankcase, and remove the O-rings or gaskets from the end-covers (or flange adapters). See **Fig. 1**. If the rear end-cover has an oil seal, press it from the cover.

    On Tu-Flo 700s, remove the end-cover (or flange adapter) gaskets and oil seals. See **Fig. 2**. Discard the gaskets.

Air Compressor Rebuilding

1. Inlet Valve Spring
2. Inlet Valve
3. Inlet Valve Guide
4. Inlet Valve Seat
5. Unloader Spring Seat
6. Unloader Spring
7. Unloader Spring Saddle
8. Unloader Plunger Guide
9. Unloader Plunger
10. Unloader Piston O-Ring
11. Unloader Piston Grommet
12. Unloader Piston
13. Unloader Bore Bushing
14. End-Cover Capscrew
15. Coupling
16. Sleeve Bearing
17. Adapter Flange
18. Thrustwasher
19. O-Ring Seal
20. Crankshaft Key
21. Crankshaft
22. Pipe Plug
23. Seal Ring
24. Crankcase Cover Capscrew
25. Crankcase Cover
26. Crankcase Cover Gasket
27. Crankcase
28. Inlet Adapter Gaskets and Baffle
29. Nameplate
30. End-Cover
31. Rod Cap Bolt
32. Rod Cap Lock Strap
33. Connecting Rod Cap
34. Rod Cap Bearing Insert
35. Connecting Rod Bearing Insert
36. Connecting Rod
37. Connecting Rod Bushing
38. Wrist Pin Teflon Button
39. Wrist Pin
40. Piston
41. Stud and Locknut
42. Discharge Port Gasket
43. Cylinder Head
44. Cylinder Head Bolt
45. Discharge Valve Spring
46. Discharge Valve
47. Discharge Valve Seat
48. Cylinder Head Gasket
49. Piston Rings

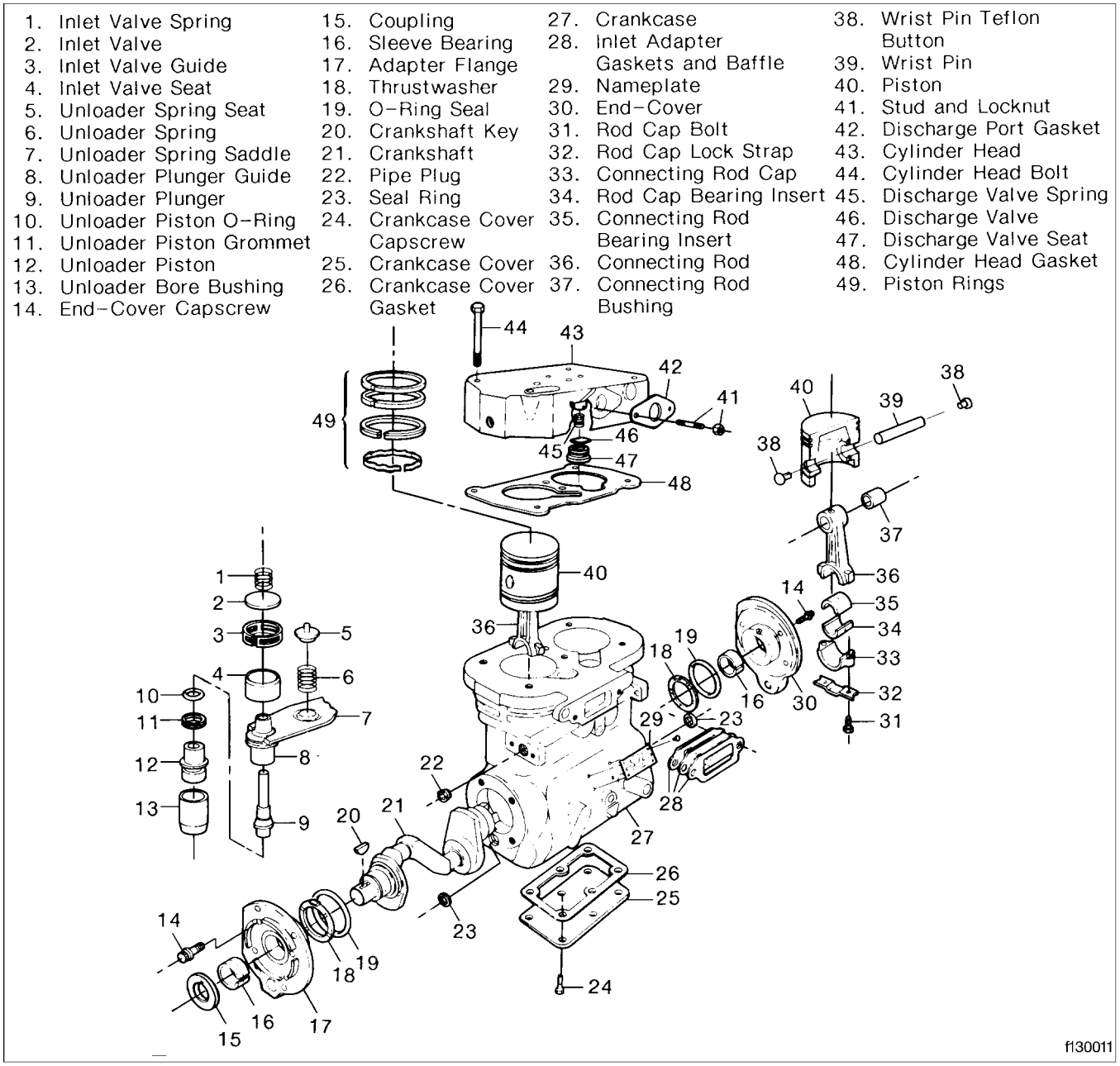


Fig. 1, Tu-Flo 501 Compressor Parts (typical)

Remove any thrustwashers from the endcovers (or flange adapters).

17. Remove any oil seal rings from the crankshaft.
18. If the compressor has sleeve main bearings, remove the crankshaft from the crankcase.

If the compressor has ball-type main bearings, press the crankshaft and ball bearings from the crankcase, then press the ball bearings from the crankshaft.

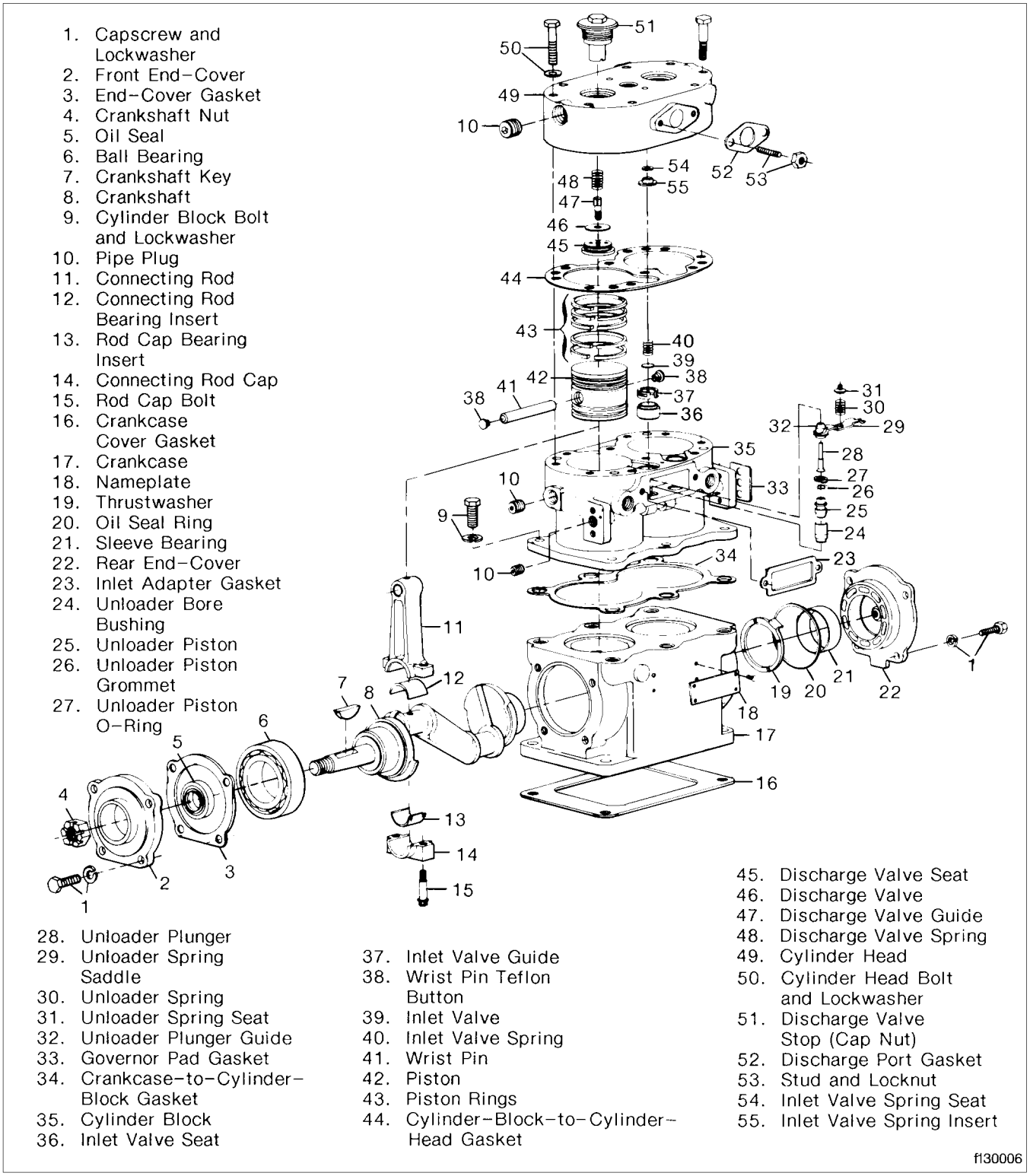


Fig. 2, Tu-Flo 700 Compressor Parts (typical)

Air Compressor Rebuilding

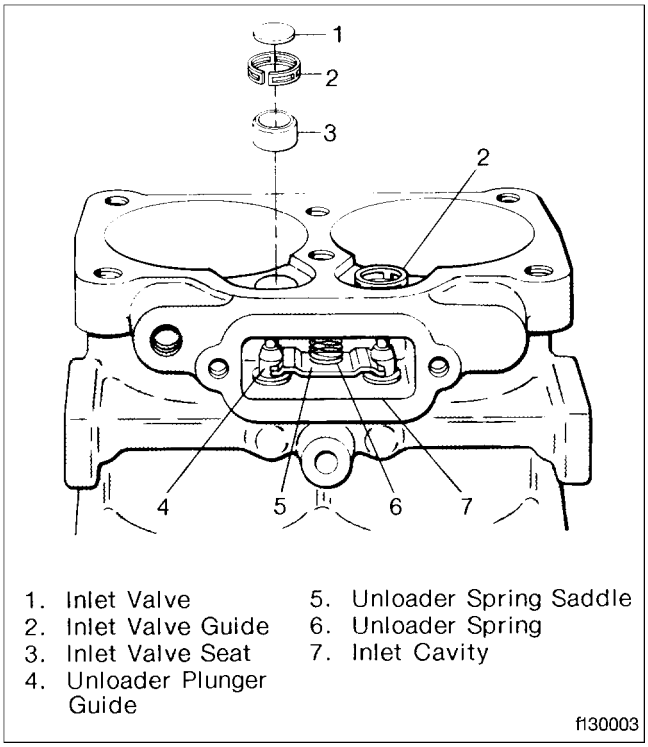


Fig. 3, Inlet Valves and Unloader Mechanism

Cleaning, Inspection, and Repair

1. Scrape off any gasket material from the bottom of the cylinder head, top and bottom of the crankcase, front and back of the crankcase, end-covers, crankcase cover, and (on Tu-Flo 700s) the top and bottom of the cylinder block.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

2. Clean all parts with solvent before inspecting them, and dry the parts with compressed air.
3. Remove all carbon deposits from the cylinder head discharge cavities.

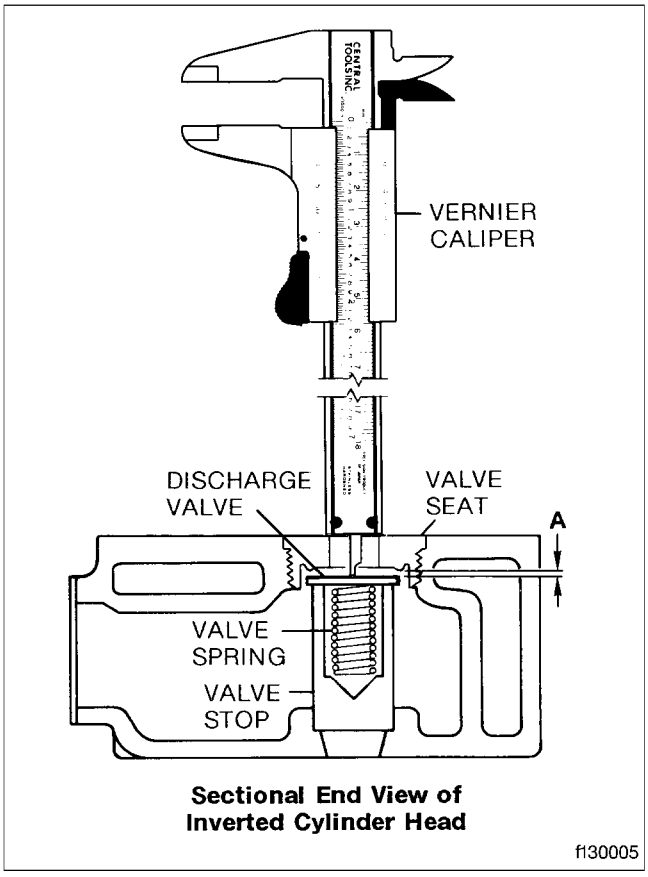


Fig. 4, Measuring Discharge Valve Travel

4. Remove all rust and scale from the cooling cavitites of the cylinder head, and from the cylinder block of Tu-Flo 700s.
5. Clean the carbon and dirt from the inlet and unloader passages.
6. Clean all oil passages through the crankshaft, crankcase, end-covers (or flange adapters), and crankcase cover. Inspect the passages with a wire to be sure they are clear.
7. Use compressed air to blow loosened particles from all cavitites and passages.
8. Inspect the cylinder head (and cylinder block of Tu-Flo 700s) for cracks and damage. Apply compressed air to one of the coolant ports, with all others plugged. Check for leakage by applying a soap solution to the outside of the head (and cylinder block). If leaks are seen, replace the part.

9. On Tu-Flo 700s, remove the discharge valve stops (capnuts) and inspect them for wear. Replace them if they are worn.

   On Tu-Flo 501s and 700s, check for excessive peening of the discharge valve stops: compare the maximum allowable discharge valve travel with the value recorded at "Air Compressor Rebuilding, 140: Disassembly."

   For Tu-Flo 700s, if the recorded valve travel is more than 0.046 inch (1.17 mm), replace the valve stops (capnuts).

   For Tu-Flo 501s, if the recorded valve travel is more than 0.057 inch (1.45 mm), replace the valve stops, as follows:

   9.1 Support the machined surface of the cylinder head on an arbor press bed, allowing enough clearance for the stops between the press bed and the bottom of the cylinder head. Gently press the stops from the top of the head, and out the bottom.

   9.2 Inspect the valve stop bores in the cylinder head for severe scoring. If scoring is severe, replace the cylinder head.

   9.3 Measure the inside diameter of both valve stop bores, and the outside diameter of both new discharge valve stops. For a correct press fit, the diameter of each bore must be 0.0008 to 0.0028 inch (0.020 to 0.071 mm) larger than its respective valve stop. If the size of the bores is not within these limits, replace the cylinder head.

⚠ CAUTION

CAUTION: Make sure excess sealant will not get inside the air compressor. Loose material inside the compressor or governor could cause damage.

   9.4 Apply a small amount of Loctite Retaining Compound No. 75, or an equivalent sealant, to the outside curved surface of each stop.

   9.5 Support the cylinder head casting, all the way around the outside top, on the arbor press bed. Press in the new stops from the bottom of the casting.

10. Inspect the discharge valve seats for nicks, cracks, and extreme wear. Replace them if necessary. If they show signs of slight wear, use a lapping stone, grinding compound, and a grinding tool to dress them.

11. Inspect the inlet valve seats for damage. If there are slight nicks or scratches, they can be dressed with a fine piece of emery cloth, or by a lapping stone, grinding compound, and a grinding tool. If the seats are damaged to the extent that they can't be reclaimed by dressing them, replace them.

12. Check the condition of the unloader bore bushings. If they are not worn, rusted, or damaged, don't remove them. If they are worn, rusted, or damaged, replace both of them as follows:

    12.1 Remove each bushing by running a 1/8-27 pipe tap into it. Remove the tap, and install a 1/8-27 threaded rod into the bushing, then pull it straight up.

    IMPORTANT: Do not use an easyout for removing the bushings.

    12.2 Using a rag, plug the unloader bore openings in the bottom of the inlet cavity. Then use compressed air, through either of the governor unloader ports, to blow any particles out of the unloader passage.

    12.3 Use compressed air to blow any particles out of the inlet cavity.

    12.4 Using a soft metal drift, drive in the new bushings.

13. Check all of the crankcase surfaces for cracks and damage; replace the crankcase if necessary.

14. For compressors having ball-type main bearings, measure the outside diameter of the ball bearing's outer race, and the inside diameter of the crankcase hole. To maintain a correct press fit, the difference between the two measurements must be 0 to 0.0015 inch (0 to 0.038 mm). Replace the crankcase if the fit is too loose.

15. Check the end-covers or flange adapters for cracks and damage; replace them as necessary.

16. For compressors having sleeve main bearings, check the bearings for flat spots and extreme wear. Replace the end-cover or main bearing if damaged or worn.

Air Compressor Rebuilding

Measure the outside diameter of the crankshaft main journal, and the inside diameter of the main bearing. For Tu-Flo 501s, if the difference in measurements is more than 0.0065 inch (0.165 mm), or for Tu-Flo 700s, more than 0.005 inch (0.13 mm), replace the end-cover or main bearing.

17. Check the crankshaft splines, gear teeth, tapered ends, and all machined and ground surfaces for wear, scores, or damage. Repair the damage, or replace the crankshaft if needed.
18. For crankshafts fitted with oil seal rings, check the seal ring groove or grooves for wear. The ring groove walls must have a good finish and they must be square. If the ring grooves are worn or damaged, replace the crankshaft.
19. For compressors having ball-type main bearings, check for a snug fit of the bearings on the crankshaft main journals. If there is not a snug fit, replace the crankshaft.
20. Check the crankshaft connecting rod journals for extreme scoring and measure them for out-of-round wear. Standard crankshaft journals are 1.1242 to 1.1250 inches (28.555 to 28.575 mm) in diameter. If the crankshaft is extremely scored or worn out-of-round, and cannot be reground, replace it.

NOTE: If the crankshaft needs to be reground or replaced, do so before continuing to the next step. For compressors having reground crankshafts, connecting rod bearing inserts are available in 0.010-inch, 0.020-inch, and 0.030-inch undersizes.

21. Check the clearance between the crankshaft journals and the new connecting rod bearings, as follows:

    21.1 Remove the connecting rod bolts and bearing cap from one connecting rod.

    IMPORTANT: Each rod is matched to its own cap for correct bearing fit. Do not interchange the parts.

    21.2 Install the new crankshaft journal bearing segments in the connecting rod and cap. Position a strip of Plastigage® on the rod cap bearing segment.

    21.3 Position the connecting rod on the number one crankshaft journal (the one nearer the driven end). Install the rod cap, with the locking slots of the connecting rod and the cap positioned next to each other. Tighten the rod bolts evenly in increments to a final torque of 125 to 140 lbf·in (1420 to 1580 N·cm).

    21.4 Remove the connecting rod, and paint a small "1" on the side of it for later assembly reference.

    21.5 Determine the clearance between the connecting rod journal and the connecting rod bearing. The clearance must not be less than 0.0003 inch (0.008 mm) or more than 0.0021 inch (0.053 mm).

    21.6 Install the cap on the rod.

    21.7 Repeat all of the substeps above for the number two crankshaft journal and other connecting rod (paint a small "2" on the side of it).

    21.8 If bearing clearance is not within limits, replace the bearings with ones that are the correct size, or regrind the crankshaft rod journals and replace the bearings.

22. Using inside micrometers or calipers, measure the cylinder bores in the crankcase (Tu-Flo 501s) or cylinder block (Tu-Flo 700s), and record the measurements. See **Fig. 5**.

    Cylinder bores must be smooth, straight, and round. If the bores are scored, are out of round by more than 0.001 inch (0.025 mm), or are tapered more than 0.002 inch (0.05 mm), they must be rebored or honed oversize. Clearance between the cast iron pistons and the cylinder bores should be between 0.002 and 0.004 inch (0.05 and 0.10 mm).

NOTE: Oversized pistons and piston rings are available in 0.010-inch, 0.020-inch, and 0.030-inch oversizes.

23. Check the pistons for scores, cracks, or enlarged ring grooves. Replace the pistons if any of these conditions are found.

    Using an outside micrometer, measure the diameter of both pistons (whether new or used). Compare the piston measurements to the cylinder bore measurements recorded in the step above, to be sure the clearance is between 0.002 and 0.004 inch (0.05 and 0.10 mm).

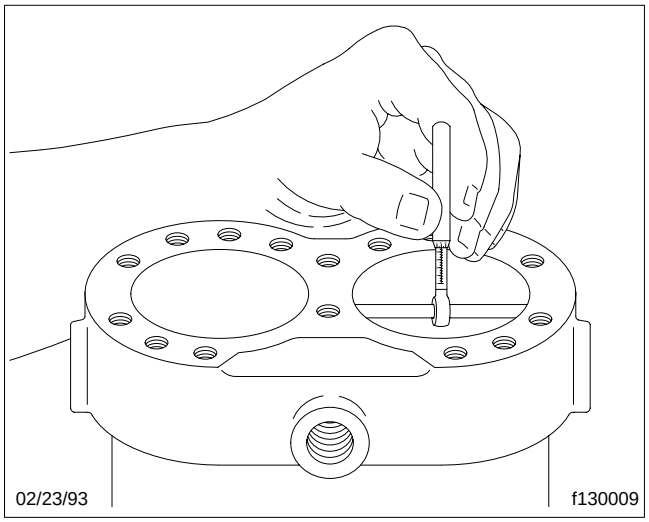


Fig. 5

24. Remove the wrist pin Teflon® buttons from the pistons. Check the fit of the wrist pins in the pistons by pressing the pins back and forth. The wrist pin should be a light press fit in the piston. If the fit is loose, replace the piston and pin assembly.
25. Check the fit of the wrist pins in the connecting rod bushings by rocking the pistons. The clearance between the pin and the bushing should not be more than 0.0007 inch (0.0178 mm).

    For aluminum connecting rods, if the wrist pin bushing is worn, discard the rod assembly and replace it with a new one.

    For steel connecting rods, if the wrist pin bushing is worn, press it out. Press a new bushing in the connecting rod so that the oil hole in the bushing lines up with the one in the rod. Ream or hone the new bushings to between 0.5314 and 0.5317 inch (13.498 to 13.505 mm), to provide between 0.0001 and 0.0006 inch (0.0025 to 0.0152 mm) clearance on the wrist pin.

Assembly and Testing

NOTE: All torque values in this procedure are assembly torque values and can be expected to decrease after assembly is completed. Do not retorque after the initial assembly torque decreases.

1. Check the fit of the new piston rings in the piston ring grooves.

   Tu-Flo 501 pistons have two compression rings above the wrist pin, and one oil ring below it. See **Fig. 6**. Groove clearance for compression (upper) rings is 0.002 to 0.004 inch (0.05 to 0.10 mm). Groove clearance for the oil ring is 0.001 to 0.003 inch (0.025 to 0.076 mm).

   Tu-Flo 700 pistons have two narrow piston rings and one wide piston ring above the wrist pin, and one narrow and one wide piston ring below it. See **Fig. 7**. Groove clearance for each of the five rings is 0.002 to 0.004 inch (0.05 to 0.10 mm).
2. To check the ring gap, install each of the piston rings in the cylinder bores. For Tu-Flo 501s and Tu-Flo 700s the gap must be 0.002 to 0.010 inch (0.051 to 0.254 mm). See **Fig. 6** and **Fig. 7**.
3. Position the connecting rods in the pistons (if they were removed) and press in the wrist pins. Secure the wrist pins by installing a Teflon button at each end.
4. Install the piston rings in the correct grooves of the pistons, with the ring bevel up. See **Fig. 6** and **Fig. 7** . Stagger the position of the ring gaps.
5. For Tu-Flo 501s, go to the step after the next step.

   For Tu-Flo 700s, position a new gasket on the crankcase, then carefully align the cylinder block on the gasket. Install the bolts and lockwashers, and tighten the bolts evenly in increments to their final torque of 28 lbf·ft (40 N·m).
6. For Tu-Flo 700s (see **Fig. 2**), install the crankshaft and end-covers or flange adapters, as follows:

   6.1 If the crankshaft is fitted with oil seal rings, install the rings in the crankshaft grooves.

   6.2 If *one* end of the crankcase is counterbored for a ball bearing, position the ball bearing and crankshaft in the crankcase, making certain the crankshaft is installed through the correct end of the crankcase, and that the drive end of the crankshaft is positioned in the crankcase as marked before disassembly.

   If *both* ends of the crankcase are counterbored for ball bearings, position the ball

Air Compressor Rebuilding

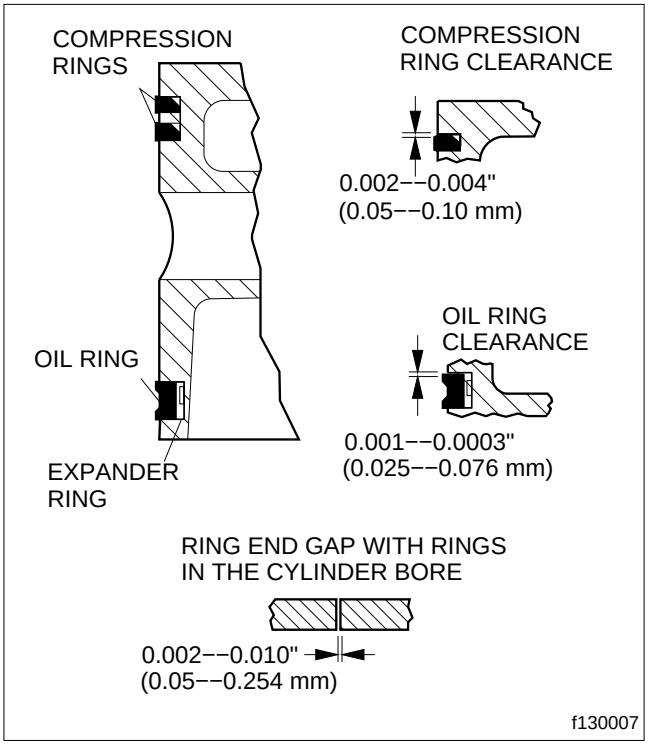


Fig. 6, Tu-Flo 501 Piston Ring Groove Clearance and End Gap Specifications

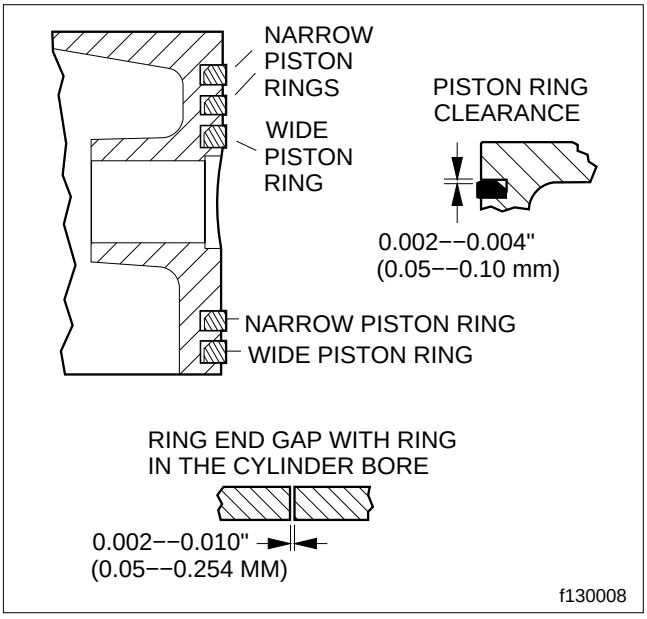


Fig. 7, Tu-Flo 700 Piston Ring Groove Clearance and End Gap Specifications

bearings and crankshaft in the crankcase, making certain that the drive end of the crankshaft is positioned in the crankcase as marked before disassembly.

Using an arbor press, carefully press the crankshaft and bearing(s) into the crankcase.

6.3 Install a new end-cover gasket at the rear of the crankcase, and align the oil hole in the gasket with the oil hole in the crankcase.

6.4 Install an oil seal ring (if so equipped) on the rear end-cover or adapter flange.

6.5 Install the thrustwasher (if so equipped) on the rear end-cover or adapter flange.

6.6 Install the rear end-cover (or adapter flange) on the crankcase, and align the oil hole in the cover with the oil holes in the gasket and crankcase. Install the capscrews and lockwashers, and tighten the capscrews 175 to 225 lbf·in (1980 to 2540 N·cm).

6.7 If needed, press a new oil seal into the front end-cover or adapter flange.

6.8 Install the thrustwasher (if so equipped) on the front end-cover or adapter flange.

6.9 Install a new, front end-cover gasket. To avoid damage to the new oil seal, carefully install the end-cover (or adapter flange) over the crankshaft and onto the crankcase. Install the capscrews and lockwashers, and tighten the capscrews 175 to 225 lbf·in (1980 to 2540 N·cm). Go to the step after the next step.

7. For Tu-Flo 501s (see **Fig. 1**), install the crankshaft and end-covers or flange adapters, as follows:

7.1 If the compressor uses a ball-type main bearing, press the ball bearing onto the correct end of the crankshaft, so that the drive end of the crankshaft will be positioned in the crankcase as marked before disassembly.

Using an arbor press, carefully press the ball bearing and the crankshaft into the crankcase.

7.2 For compressors with a sleeve main bearing either front or rear, install two small seal rings in the countersunk holes in the crankcase. Install an O-ring seal in the groove around the flange adapter or end-cover. Install the thrustwasher on the flange adapter or end-cover.

IMPORTANT: All flange-mounted compressors must be assembled without a gasket between the crankcase and flange adapter. Also, some compressors do not require gaskets on the end-cover.

⚠ CAUTION

CAUTION: Install new crankcase gaskets only where they were removed during disassembly. Damage to the compressor will occur if gaskets are used where they don't belong.

7.3 Install the flange adapter or end-cover in the position that was marked before disassembly, taking care not to damage the sleeve bearing.

7.4 For compressors with a front ball bearing, install two small seal rings in the countersunk holes at the front of the crankcase. Install an end-cover gasket on the front of the crankcase.

Press a new oil seal into the front end-cover if one was removed during disassembly.

Install the front end cover in the position that was marked before disassembly, taking care not to damage the new oil seal.

7.5 For compressors with a rear ball bearing, install two small seal rings in the counterbore at the rear of the crankcase. In addition, install a gasket on the rear of the crankcase, or install a large O-ring in the counterbore at the rear of the crankcase, depending on what was previously installed.

Install the rear end-cover in the position that was marked before disassembly.

7.6 Using capscrews, secure the front or rear end-cover or flange adapter to the crankcase.

For all end-covers using 5/16-inch capscrews (or studs and nuts), tighten them 15 to 18 lbf·ft (20 to 25 N·m).

For die-cast aluminum end-covers, tighten 7/16-inch capscrews 25 to 30 lbf·ft (35 to 40 N·m).

For through-drive compressors with a cast iron end-cover, tighten 7/16-inch capscrews 25 to 30 lbf·ft (35 to 40 N·m).

For cast iron flange adapters, tighten 7/16-inch capscrews 38 to 45 lbf·ft (50 to 60 N·m).

8. Install the pistons and connecting rods as follows:

8.1 Remove the connecting rod bolts and bearing cap from the connecting rod that has a small "1" painted on its side.

8.2 Turn the crankshaft so its number one rod journal (the one nearer the drive end) is down and centered.

8.3 Apply clean engine oil to both pistons, the piston rings, wrist pins, and connecting rod bearings.

8.4 Insert the number one connecting rod and piston through the top of the number one cylinder.

8.5 Install the rod cap, with the locking slots of the connecting rod and the locking slots of the cap positioned next to each other.

For Tu-Flo 501s, install the lock strap on the cap, before installing new rod bolts.

Tighten the new rod bolts evenly in increments to a final torque of 125 to 140 lbf·in (1420 to 1580 N·cm).

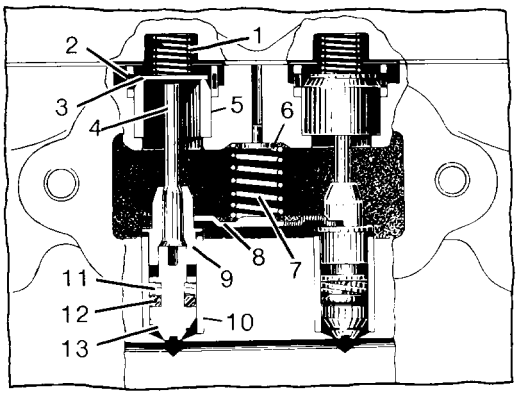
For Tu-Flo 501s, bend the lock strap prongs against the hexhead of the bolts.

8.6 Turn the crankshaft so its number two connecting rod journal is in the downward, center position.

Install the number two connecting rod and piston in the same manner as described above.

9. Install a new unloader assembly (see **Fig. 8**), as follows:

Air Compressor Rebuilding



Cutaway View

1. Inlet Valve Spring
2. Inlet Valve Guide
3. Inlet Valve
4. Unloader Plunger
5. Inlet Valve Seat
6. Unloader Spring Seat
7. Unloader Spring
8. Unloader Spring Saddle
9. Unloader Plunger Guide
10. Unloader Bore Bushing
11. Unloader Piston O–Ring
12. Unloader Piston Grommet
13. Unloader Piston

f130004

Fig. 8, Unloader Mechanism and Inlet Valve Componenets

NOTE: The unloader pistons provided in a new unloader kit are prelubricated with a special lubricant, and need no additional lubrication before assembly.

9.1 Install the unloader pistons in their bores in the crankcase (Tu-Flo 501s) or cylinder block (Tu-Flo 700s), being careful not to cut the O-rings or distort the back-up rings.

9.2 Position the unloader plungers in their guides and slip them in and over the tops of the unloader pistons.

9.3 Install the unloader spring seat in the inlet cavity; a small hole is drilled in the crankcase (Tu-Flo 501s) or cylinder block (Tu-Flo 700s) for this purpose.

9.4 Position the unloader saddle between the plunger guides, so its forks are centered on the guides.

9.5 Install the unloader spring, making sure it seats over the spring seats in both the crankcase (or cylinder block) and on the saddle.

10. Install and leak-test the discharge valves, as follows:

10.1 Install new discharge valve springs and valves. For Tu-Flo 700s, install the discharge valve guides.

10.2 For Tu-Flo 501s, install and tighten the valve seats until valve travel measures between 0.041 and 0.057 inch (1.04 to 1.45 mm). See **Fig. 4**, Ref. *A*.

For Tu-Flo 700s, install and tighten the valve seats until valve travel measures between 0.030 and 0.046 inch (0.76 to 1.17 mm). See **Fig. 4**, Ref. *A*.

10.3 Using compressed air, apply 100 psi (690 kPa) pressure through the cylinder head discharge port.

10.4 Apply a soap solution to the discharge valves and seats. A slight leakage in the form of soap bubbles is okay.

If there's extreme leakage, leave the air pressure applied, and with a hardwood dowel and a hammer, tap the discharge valves off their seats several times. This will improve the seal between the valve and the valve seat, and should reduce the leakage. If there's still extreme leakage, replace the valve seats.

10.5 With the pressure still applied, apply the soap solution to the discharge valve stops (Tu-Flo 501s) or discharge valve capnuts (Tu-Flo 700s). No leakage is allowed.

10.6 Remove the compressed-air hose.

11. Install the inlet valve guides, then drop the new inlet valves in their guides. The inlet valves should be a loose sliding fit in the guides.

12. Install the inlet valve springs in the cylinder head by turning each spring after it is in the head. The turning motion should dig the spring wire into the spring seat in the bottom of the spring bore in the head. If several tries prove unsuccessful, use a very small amount of grease to hold the springs in place; just enough to keep them from falling out.

13. Align a new cylinder head gasket on the crankcase or cylinder block. Place the cylinder head on the crankcase or cylinder block, being careful to align the inlet valve springs with the inlet valves.
14. Position on the cylinder head any brackets, spacers, or clamps that were removed from it. Then install the cylinder head bolts, and tighten them evenly in increments to their final torque.

    For Tu-Flo 501s, final torque is 25 to 30 lbf·ft (35 to 40 N·cm); for Tu-Flo 700s, it's 175 to 225 lbf·in (1980 to 2540 N·cm).
15. Align the crankcase cover gasket on the crankcase, and install the cover as marked before disassembly. Tighten its bolts evenly in increments to their final torque.

    For Tu-Flo 501s, final torque is 12 to 16 lbf·ft (16 to 22 N·m).

    For Tu-Flo 700s with 1/4-20 bolts, final torque is 85 to 115 lbf·in (960 to 1300 N·cm); with 5/16-18 bolts, it's 95 to 125 lbf·in (1080 to 1420 N·cm).
16. Install all compressor attachments, such as inlet fittings, discharge fittings, and pipe plugs. Do not install the intake adapter.
17. Test the rebuilt compressor, as follows:

    IMPORTANT: To properly test a compressor under operating conditions, a test rack is necessary for correct mounting, cooling, lubricating, and driving the compressor.

    17.1 Connect an oil supply line of at least 15 psi (100 kPa) pressure to the compressor.

    17.2 Connect an oil return line to the compressor, to keep the crankcase drained.

    17.3 To the compressor discharge port, connect a reservoir with a volume of 1500 in^3 (24 580 cm^3), including the volume of the connecting line. Install a pressure gauge on the reservoir.

    17.4 Operate the compressor at 2100 rpm, while checking the amount of time needed to raise the reservoir pressure from 85 psi (585 kPa) to 100 psi (690 kPa).

    For Tu-Flo 501s, the time must not exceed seven seconds.

    For Tu-Flo 700s, the time must not exceed five seconds.

    17.5 While operating the compressor, check it for gasket leaks and noisy operation.

    17.6 Install an air governor on one of the compressor mounting pads. Attach an air line between the reservoir and the governor. Check the unloader operation of the compressor.

    17.7 Operate the compressor, and check for internal (valve) leakage.

    17.8 Drain the air pressure, then remove the test attachments and the air governor.
18. If the compressor will not be installed immediately, plug all compressor ports before storing the compressor.

Troubleshooting

AIR LEAKAGE TEST

1. Build up air system pressure until the governor cuts out, then stop the engine.
2. Remove the air intake adapter from the compressor.
3. With the engine stopped, listen for escaping air at the compressor intake port.
4. If there is noticeable leakage, drain the air from all air reservoirs, then remove the air governor. Attach a compressed-air hose to the unloader port, apply air pressure, and again listen for escaping air at the compressor intake port.

   If there is no longer any noticeable leakage, air was escaping past the discharge valves; refer to **Subject 120.**

   If there is still noticeable leakage, the unloader pistons are leaking; refer to **Subject 110.**

Fastener Torque Values		
Application	**Torque**	
	lbf·in (N·cm)	**lbf·ft (N·m)**
Governor Mount Bolts, Cummins Engine	—	11-15 (15-20)
Connecting Rod Bolts	125-140 (1420-1580)	—
Crankcase-to-Cylinder-Block Bolts, Tu-Flo 700	—	28 (40)
End-Cover or Flange Adapter Capscrews, Tu-Flo 700	175-225 (1980-2540)	—
End-Cover 5/16-Inch Capscrews or Studs and Nuts, Tu-Flo 501	—	15-18 (20-25)
Die Cast Aluminum End-Cover 7/16-Inch Capscrews, Tu-Flo 501	—	25-30 (35-40)
Cast Iron End-Cover 7/16-Inch Capscrews, Tu-Flo 501	—	38-45 (50-60)
Cast Iron Flange Adapter 7/16-Inch Capscrews, Tu-Flo 501	—	38-45 (50-60)
Cylinder Head Bolts:		
Tu-Flo 700	175-225 (1980-2540)	—
Tu-Flo 501	—	25-30 (35-40)
Crankcase Cover:		
1/4-20 Bolts, Tu-Flo 700	85-115 (960-1300)	—
5/16-18 Bolts, Tu-Flo 700	95-125 (1080-1420)	—
Crankcase Cover Bolts, Tu-Flo 501	—	12-16 (16-22)

Table 1, Fastener Torque Values

Compressor Rebuild Specifications	
Description	**inches (mm)**
Discharge Valve Travel, Minimum/Maximum:	
Tu-Flo 700	0.030/0.046 (0.76/1.17)
Tu-Flo 501	0.041/0.057 (1.04/1.45)
Fit Between Discharge Valve Stop and Bore, Tu-Flo 501	0.0008-0.0028 (0.020-0.071)
Fit Between Crankcase Bore and Ball-Type Main Bearings	0-0.0015 (0-0.038)
Clearance for Crankshaft Main Journals to i.d. of Sleeve-Type Main Bearing, Maximum:	
Tu-Flo 700	0.005 (0.13)
Tu-Flo 501	0.0065 (0.165)
Crankshaft Main Journal Standard Diameter	1.1242-1.1250 (28.555-28.575)
Clearance Between Crankshaft Rod Journals and Connecting Rod Bearing, Minimum/Maximum	0.0003/0.0021 (0.008/0.053)
Crankshaft Rod Journal Standard Diameter *	1.1242-1.1250 (28.555-28.575)
Cylinder Bore Out-of-Round, Maximum	0.001 (0.03)
Cylinder Bore Taper, Maximum	0.002 (0.05)

Specifications

Compressor Rebuild Specifications	
Description	**inches (mm)**
Clearance Between Cylinder Bore and Cast Iron Piston, Minimum/ Maximum †	0.002/0.004 (0.05/0.10)
Clearance Between Wrist Pins and Connecting Rod Bushings, Maximum	0.007 (0.0178)
Piston Pin Bearing Bore (Reamed)	0.5314-0.5317 (13.498-13.505)
Clearance Between Wrist Pins and New (Reamed) Connecting Rod Bushings	0.0001-0.0006 (0.003-0.015)
Piston Ring Groove Clearance, Tu-Flo 700	0.002-0.004 (0.05-0.10)
Compression (Upper) Ring Groove Clearance, Tu-Flo 501	0.002-0.004 (0.05-0.10)
Oil (Lower) Ring Groove Clearance, Tu-Flo 501	0.001-0.003 (0.025-0.075)
Ring Gap (Installed in Cylinder)	0.002-0.010 (0.05-0.255)

* For compressors having reground crankshafts, connecting rod bearing inserts are available in 0.010-inch, 0.020-inch, and 0.030-inch undersizes.

† Oversized pistons and piston rings are available in 0.010-inch, 0.020-inch, and 0.030-inch oversizes.

Table 2, Compressor Rebuild Specifications

General Description

The Tu-Flo 550 and the Tu-Flo 750 are two cylinder, single-stage, reciprocating air compressors, which supply compressed air to the vehicle air system. The Tu-Flo 550 has a rated displacement of 13.2 cfm (374 L/min) of air at 1250 rpm.

The Tu-Flo 750 has a rated displacement of 16.5 cfm (468 L/min) of air at 1250 rpm. The compressor draws air from the air intake pipe, compresses the air, and delivers it to the air system supply reservoir. The compressor runs continuously but has "loaded" and "unloaded" modes, which are regulated by the air governor and the compressor loading assembly. When the governor sends an air signal to the unloader assembly, the unloader assembly holds the compressor air intake valve open so that no more compressed air is forced into the air system. As air in the system is used, its pressure drops, and at 90 psi (620 kPa), the air governor stops the signal to the compressor. Without the signal, the unloader assembly automatically closes the compressor air intake valve to force more air into the system.

On vehicles with air dryers, when the system reaches the cut-out pressure of 120 psi (825 kPa), the air governor also sends an air signal to open the sludge ejector in the air dryer.

Removal

1. Apply the parking brakes, chock the tires, and drain the air system.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer. Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

2. Using a cleaning solvent, remove road dirt and grease from the outside of the compressor, then dry the compressor with compressed air.
3. Drain the radiator coolant; refer to the cooling section in the vehicle service manual for instructions.
4. Marking their locations and positions, disconnect all air, coolant, and oil lines attached to the compressor.
5. Remove the air governor, and the governor mounting gasket.
6. On Cummins and DDE engines, disconnect the wire to the fuel shutoff valve (if so equipped). Remove the fuel pump and gasket; refer to the engine shop manual or rebuild manual for instructions.
7. Remove the compressor support bracket, if so equipped.
8. Support the compressor, and remove the bolts that attach it to the auxiliary drive housing, accessory drive, or timing gear plate. Remove the compressor, gasket, and splined coupling, if so equipped.
9. Discard all mounting gaskets.

Installation

IMPORTANT: Be sure the gasket surfaces are cleaned and not damaged.

1. Install the splined coupling (if so equipped) and a new compressor gasket. Hold the compressor in place, and install the bolts that attach it to the auxiliary drive housing, accessory drive, or timing gear plate. Refer to the engine shop manual or rebuild manual for final torque specification.
2. Install the compressor support bracket, if so equipped.
3. On Cummins and DDE engines, install a new gasket, install the fuel pump. Connect the wire to the fuel shutoff valve (if so equipped). Refer to the engine shop manual or rebuild manual for instructions.
4. With a new air governor mounting gasket, install the air governor.
5. Identify and connect all air, coolant, and oil lines to the compressor.
6. Fill the engine cooling system; refer to the cooling section in the vehicle service manual for instructions.
7. Operate the engine and check for leaks.

Removal

1. Chock the tires; then drain the air from all air reservoirs.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer. Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

2. Using a cleaning solvent, remove road dirt and grease from the outside of the compressor, then dry the compressor with compressed air.
3. Drain the radiator coolant; refer to the cooling section in the vehicle service manual for instructions.
4. Remove the cylinder head from the crankcase (**see Fig. 1**).

   4.1 Scribe an alignment mark across the cylinder head and the crankcase, for assembly alignment.

   IMPORTANT: Do not use a marking method, such as chalk, that can be wiped off during assembling.

   4.2 Note positions of any attached components, then remove the cylinder head capscrews.

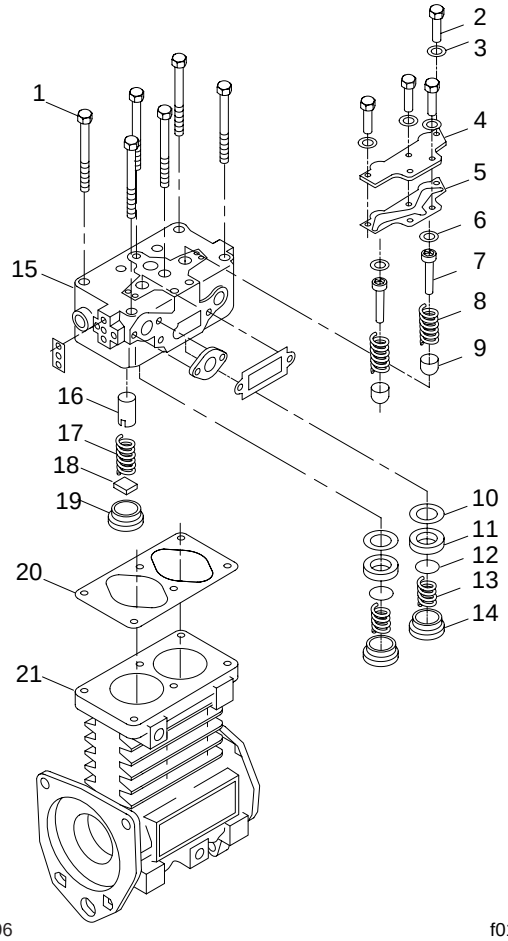
   4.3 Tap the cylinder head with a soft mallet to break the gasket seal. Remove the cylinder head.

Installation

1. Scrape off any gasket material from the cylinder head and the crankcase.

⚠ WARNING

WARNING: Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.



1. Cylinder Head Capscrew
2. Unloader Plate Capscrew
3. Unloader Plate Lockwasher
4. Unloader Plate
5. Unloader Plate Gasket
6. O-Ring
7. Unloader Piston
8. Spring
9. Unloader Bushing
10. Gasket
11. Inlet Valve Seat
12. Inlet Valve
13. Inlet Valve Spring
14. Inlet Valve Stop
15. Cylinder Head
16. Discharge Valve Stop
17. Discharge Valve Spring
18. Discharge Valve
19. Discharge Valve Seat
20. Cylinder Head Gasket
21. Crankcase

Fig. 1, Cylinder Head Assembly

2. Using compressed air, blow dirt particles or gasket material from all cylinder cavities.
3. Install the cylinder head on the compressor crankcase.

Cylinder Head Removal and Installation

3.1 Place a new cylinder head gasket on the crankcase. If the cylinder head gasket has a bead on one side, install the gasket with the bead side up.

3.2 Using the previously marked alignment, position the cylinder head on the crankcase.

3.3 Position on the cylinder head any brackets, spacers, or clamps that were removed; then install the cylinder head capscrews and tighten them evenly, in a cross pattern 37 to 42 lbf·ft (50 to 57 N·m).

4. Connect the air discharge line and the water lines to the cylinder head.
5. Fill the engine cooling system; refer to cooling section in the vehicle service manual.
6. Operate the engine and make sure there are no coolant leaks.

Cylinder Head Disassembly, Cleaning and Inspection, and Assembly

Disassembly

NOTE: For an illustation of the cylinder head assembly, see **Fig. 1**.

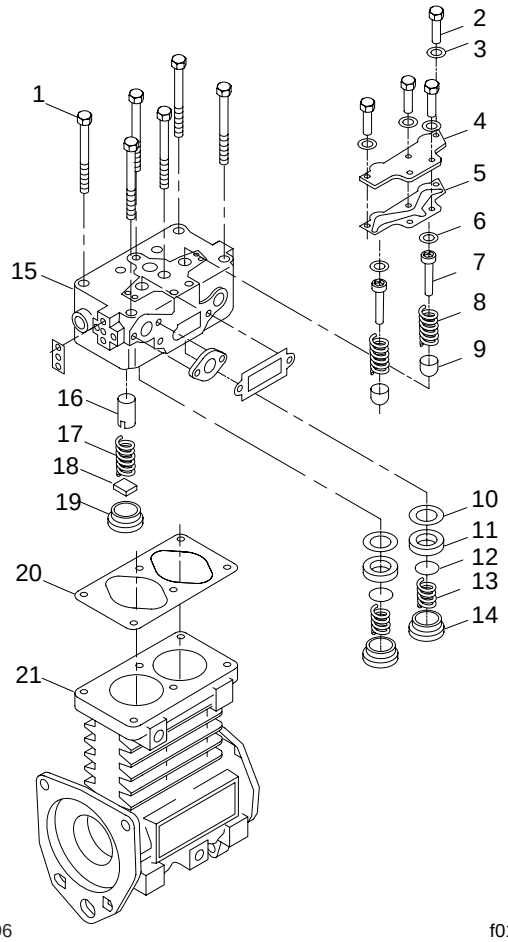
1. Remove the compressor from the vehicle. For instructions, see **Subject 100.**
2. Place the compressor on a suitable work surface. Remove the cylinder head from the crankcase. For instructions, see **Subject 110.**
3. Remove the unloader mechanism.
   - 3.1 Remove the unloader plate capscrews, lockwashers, and the unloader plate. Scrape off any gasket material from the unloader plate and the cylinder head.
   - 3.2 Remove and discard the unloader pistons, O-rings, and springs.
4. Check the unloader piston bushings. If damaged or worn excessively, replace the compressor.

NOTE: Before disassembling the discharge valve mechanism, measure and record the discharge valve travel from closed to completely open. If the measurement exceeds 0.046 inch (1.17 mm), replace the compressor. If the measurement is within 0.046 inch, proceed to the next step.

5. Using a 9/16-inch Allen wrench, remove and discard the discharge valve seats, discharge valves, and discharge valve springs.
6. Remove and discard the inlet valve stops and springs, along with the inlet valves, inlet valve seats, and gaskets.

Cleaning and Inspection

1. Remove carbon deposits from the discharge cavity, rust and scale from the cooling cavities.
2. Clean carbon and dirt from the inlet and unloader passages.
3. Scrape all foreign material from the body surfaces.



1. Cylinder Head Capscrew
2. Unloader Plate Capscrew
3. Unloader Plate Lockwasher
4. Unloader Plate
5. Unloader Plate Gasket
6. O-Ring
7. Unloader Piston
8. Spring
9. Unloader Bushing
10. Gasket
11. Inlet Valve Seat
12. Inlet Valve
13. Inlet Valve Spring
14. Inlet Valve Stop
15. Cylinder Head
16. Discharge Valve Stop
17. Discharge Valve Spring
18. Discharge Valve
19. Discharge Valve Seat
20. Cylinder Head Gasket
21. Crankcase

Fig. 1, Cylinder Head Assembly (exploded view)

Cylinder Head Disassembly, Cleaning and Inspection, and Assembly

WARNING

Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer. Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

4. Using solvent, thoroughly clean all metal parts removed from the cylinder head. Using shop air, blow the dirt particles from the cavities and passages.
5. Check that all cavities and passages are clear, including the inlet and unloader.
6. Check that all mating surfaces are clean of old gasket material. Remove any old material.
7. Inspect the cylinder head for cracks or damage.
8. With the cylinder head and head gasket secured to a flat surface or to the crankcase, apply shop air pressure to one of the coolant ports with all other ports plugged.
9. Check for leaks by applying a soap solution to the exterior of the body. If leakage is detected, replace the compressor.

Assembly

NOTE: For an illustation of the cylinder head assembly, see **Fig. 1**.

1. Install the unloader mechanism.
   - 1.1 With the unloader pistons being prelubricated from the manufacturer, install the new unloader springs, and the new unloader pistons. The unloader piston O-rings are pre-installed on the unloader pistons.
   - 1.2 Install the new unloader plate gasket and the unloader plate.
   - 1.3 Install the unloader plate lockwashers and capscrews. Tighten the capscrews 15 to 18 lbf·ft (20 to 25 N·m) in a cross pattern.
2. Install the inlet valve mechanism.
   - 2.1 Install the new inlet valve gaskets, new inlet valve seats, new inlet valves, and the new inlet valve springs into their bores.
   - 2.2 Install the new inlet valve stops and tighten 70 to 90 lbf·ft (95 to 122 N·m).
3. Install the new discharge valve springs, new discharge valves, and the new discharge valve seats into their bores. Tighten the seats 70 to 90 lbf·ft (95 to 122 N·m). The discharge valve travel should be 0.030 inches to 0.046 inch (0.762 mm to 1.17 mm).
4. Test for leakage at the discharge valves by applying 100 psi (690 kPa) through the cylinder head discharge port and apply soap solution to the discharge valve and seat. Leakage in the form of soap bubbles is permissible.

   If there's extreme leakage, leave the air pressure applied and with a hardwood dowel and a hammer, tap the discharge valves off of their seats several times. This will improve the seal between the discharge valve and the valve seat and should reduce leakage.

   If there's still extreme leakage, replace the discharge valve seats.

   With the air pressure still applied at the discharge port of the cylinder head, check for leakage around the discharge valve stop on top of the cylinder head. No leakage is permitted.
5. Install the compressor cylinder head. For instructions, see **Subject 110.**
6. Tighten the unloader plate capscrews 15 to 18 lbf·ft (20 to 25 N·m).
7. Install the compressor on the engine. For instructions, see **Subject 100.**

Crankcase Disassembly, Cleaning and Inspection, and Assembly

Disassembly

1. Remove the compressor from the vehicle and place it on a suitable work surface. For instructions, see **Subject 100**.
2. Remove the air compressor cylinder head. For instructions, see **Subject 110**.
3. Before disassembling the compressor, use a metal scribe to mark the parts with matching numbers or lines.

IMPORTANT: Do not use a marking method, such as chalk, that can be wiped off during assembling.

4. Remove the pistons and connecting rods. See **Fig. 1**.
   - 4.1 Remove the base plate capscrews.
   - 4.2 Tap the base plate with a soft mallet to break the gasket seal.
   - 4.3 Scrape off any gasket material from the crankcase and base plate.
   - 4.4 Remove the connecting rod bolts and connecting rod caps.
   - 4.5 Push the pistons and connecting rods out through the cylinder bore of the crankcase. Discard the pistons and connecting rod assemblies including the connecting rod caps and the connecting rod bolts.
5. Remove the crankshaft.
   - 5.1 Remove the key or keys from the crankshaft and any burrs from the crankshaft where the key or keys were removed.

   NOTE: Some compressors may have a crankshaft key at each end.

   - 5.2 Remove the end-cover capscrews, the end cover, end-cover seal, and the rear thrustwasher.
   - 5.3 If the compressor has sleeve bearings, remove and discard the sleeve bearings from the crankcase and the end cover.
   - 5.4 If the compressor has a ball-type main bearing, remove the rear snap ring (if so equipped). Press the crankshaft and ball bearing from the crankcase; then press the ball bearing from the crankshaft.
   - 5.5 Remove and discard the front and rear thrustwashers.

Cleaning and Inspection

1. Scrape off any gasket material from the top and bottom of the crankcase.

⚠ WARNING

Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer. Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

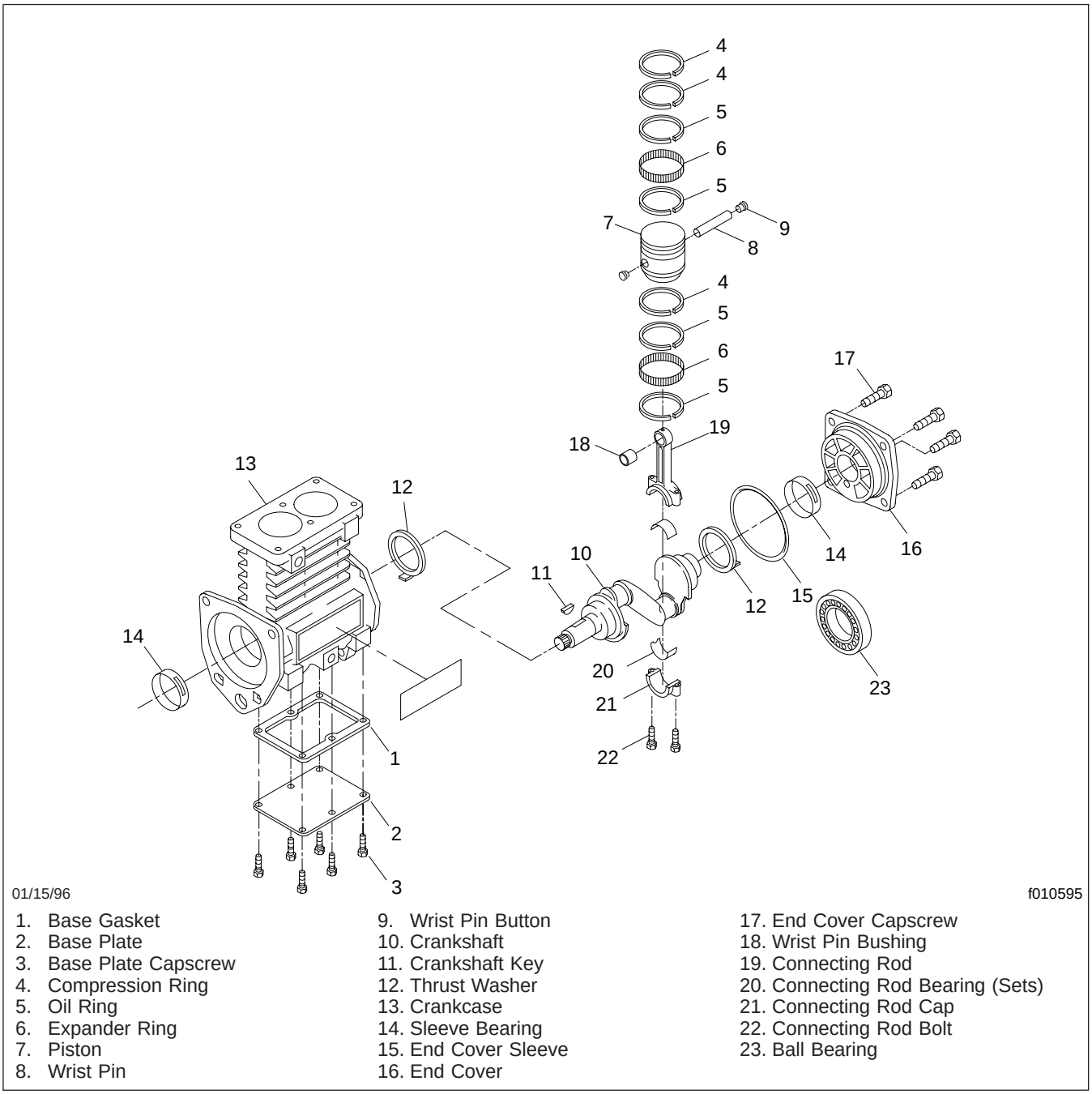
2. Clean all parts with solvent, before inspecting them, and dry the parts with compressed air.
3. Clean all oil passages through the crankshaft, crankcase, end cover, and base plate. Inspect the passages with a wire to be sure they are clear.
4. Check the fit of the new pistons, piston rings, and connecting rods.
   - 4.1 The pistons for the Tu-Flo 750 compressor are similar to the Tu-Flo 550 and may be identified by the distance from the center of the wrist pin to the top of the piston. See **Fig. 2**.
   - 4.2 To check the ring gap, place the ring in the top of the cylinder bore and, using a piston, push the ring to mid-point of the cylinder bore and check the ring gap. The gap for compression rings must be 0.002 to 0.013 inch (0.051 to 0.33 mm).

     The gap for oil ring and expander ring must be 0.010 to 0.040 inch (0.255 to 1.016 mm). See **Fig. 3**, and **Table 1**.

Ring	End Gap: inch (mm)
Compression	0.002–0.013 (0.051–0.33)
Oil and Expander	0.010–0.040 (0.255–1.016)

Table 1

Crankcase Disassembly, Cleaning and Inspection, and Assembly

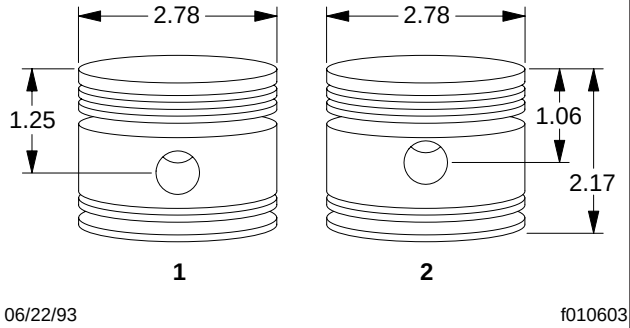


1. Base Gasket
2. Base Plate
3. Base Plate Capscrew
4. Compression Ring
5. Oil Ring
6. Expander Ring
7. Piston
8. Wrist Pin
9. Wrist Pin Button
10. Crankshaft
11. Crankshaft Key
12. Thrust Washer
13. Crankcase
14. Sleeve Bearing
15. End Cover Sleeve
16. End Cover
17. End Cover Capscrew
18. Wrist Pin Bushing
19. Connecting Rod
20. Connecting Rod Bearing (Sets)
21. Connecting Rod Cap
22. Connecting Rod Bolt
23. Ball Bearing

Fig. 1

4.3 Check the fit of the piston rings in the piston ring grooves. Groove clearance for the compression ring is 0.002 to 0.004 inch (0.051 to 0.10 mm). Groove clearance for the expander and oil rings is 0.000 to 0.006 inch (0.000 to 0.152 mm).

5. Inspect the crankcase.



1. Tu-Flo 550 Compressor Piston
2. Tu-Flo 750 Compressor Piston

Fig. 2, Piston Comparison

5.1 Check the crankcase surfaces for cracks and damage.

5.2 On compressors where main ball bearings are used, measure the difference between the outside diameter of the ball bearing outer race and the inside diameter of the crankcase bore should be 0.0003 inch (0.008 mm) tight to 0.0023 inch (0.058 mm) loose. This is to maintain a correct fit. Replace the compressor if the fit is too loose.

5.3 Check the end cover for cracks and damage; replace them as necessary.

5.4 Check the cylinder bore with an inside micrometer or with calipers. Cylinder bores which are scored, out-of-round, or tapered more than 0.0005 inch (0.013 mm) should be rebored and honed oversize. Oversized pistons and piston rings are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm) oversize.

6. Inspect the crankshaft.

6.1 Check the crankshaft splines, gear teeth, tapered ends, and all machined and ground surfaces for wear, scoring, or damage. Repair the damage, or replace the crankshaft if needed.

6.2 Check the crankshaft connecting rod journals for extreme scoring, and measure them for out-of-round wear. Standard crankshaft journals are 1.1242 to 1.1250 inches (28.555 to 28.575 mm) in diameter. If the crankshaft is extremely scored or worn out-of-round, and cannot be reground, replace it.

NOTE: If the crankshaft needs to be reground or replaced, do so before proceeding to the next step. For compressors having reground crankshafts, connecting rod bearing inserts are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm) undersize.

Assembly (See Fig. 1)

1. For compressor with sleeve bearings, install the crankshaft and end cover as follows:

1.1 Press the new sleeve bearings into the end cover and crankcase. Make sure the slot in the bearings line up with the oil passages in the end cover and crankcase.

If there is no oil passage present in the crankcase, press the sleeve bearing into the crankcase with the slot located 90 degrees from vertical.

1.2 Install the new front thrustwasher with the tang inserted in the slot toward the flange.

1.3 Insert the crankshaft and the rear thrustwasher with the tang toward the end cover of the compressor.

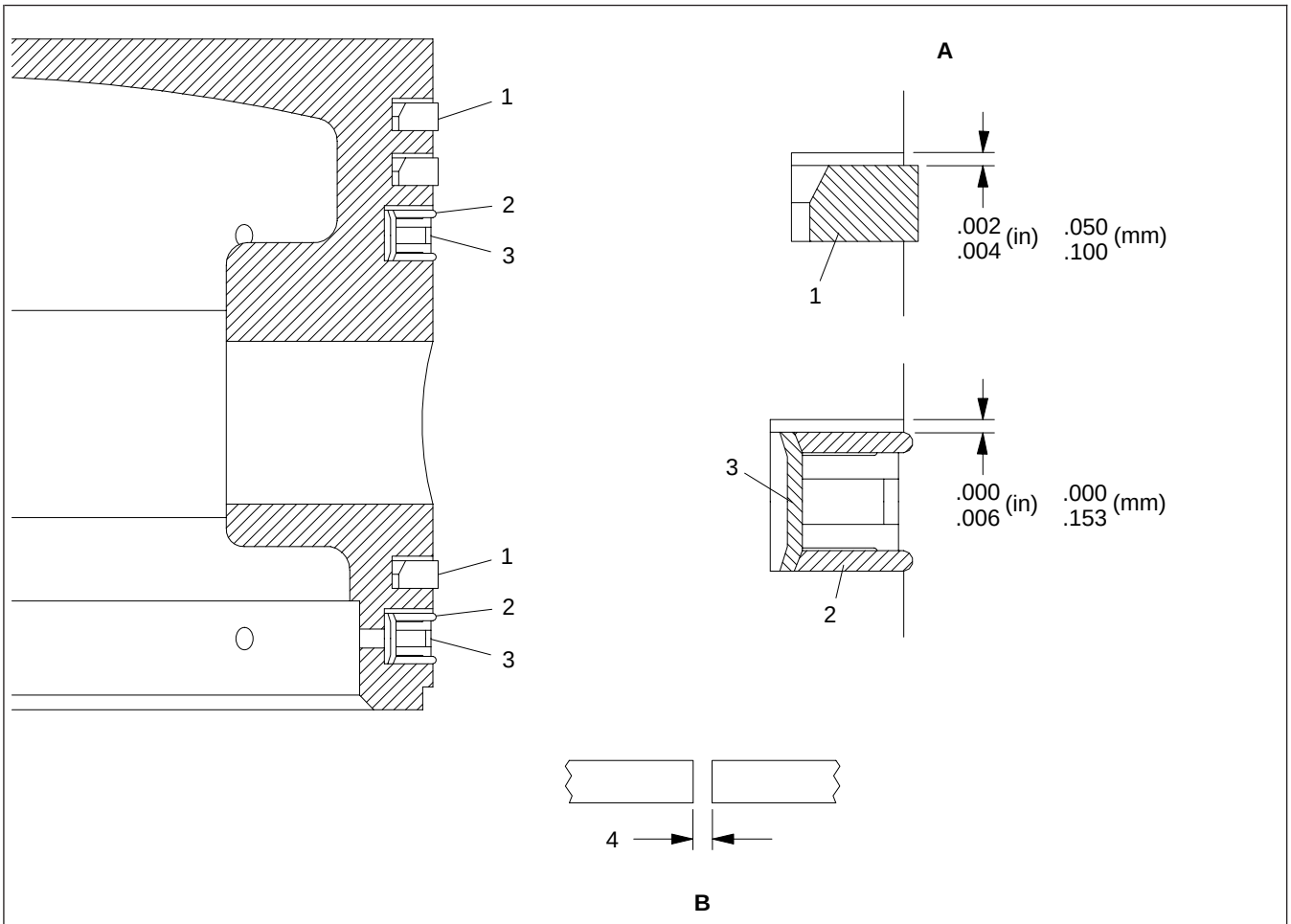
1.4 Place the end-cover seal on the boss of the end cover.

1.5 Install the end cover making sure not to pinch the end cover seal and the tang of the rear thrustwasher is inserted in the slot of the end cover. Install the capscrews and tighten the capscrews 15 to 18 lbf·ft (20 to 25 N·m) in a cross pattern.

2. If one end of the compressor uses a ball-type main bearing, install the crankshaft and endcovers as follows:

2.1 Press the new sleeve bearings into the crankcase. Make sure the slots in the bearings line up with the oil passage in the end cover and crankcase.

Crankcase Disassembly, Cleaning and Inspection, and Assembly



A. Side Clearance
1. Compression Ring
2. Oil Ring
B. Ring End Gap With Ring In The Cylinder Bore
3. Expander Ring
4. End Gap

Fig. 3

If there is no oil passage present in the crankcase, press the sleeve bearing into the crankcase with the slot located 90 degrees from vertical.

2.2 Install the new front thrustwasher with the tang inserted in the slot toward the flange.

2.3 Press the ball bearing onto the correct end of the crankshaft, so that the drive end of the crankshaft will be positioned in the crankcase as marked before disassembly. Using an arbor press, carefully press the ball bearing and the crankshaft into the crankcase. Install the retainer ring if so equipped.

3. Assemble the new piston rings on the new pistons.

IMPORTANT: To properly test a compressor under operating conditions, a test rack is necessary for correct mounting, cooling, lubricating, and driving the compressor.

NOTE: Install the piston rings on the pistons starting at the center of the piston and mov-

ing outward. Rotate the piston rings in their respective grooves so that the end gap is at least 90 degrees from the previous ring's end gap.

3.1 Install the expander ring in the piston groove. The ends of the expander ring must butt and must not overlap.

3.2 Install the bottom oil ring by inserting one end below the expander ring in the ring groove, and wind the ring into position. Install the top oil ring in the same manner above the expander ring making sure the gap is staggered from the bottom oil ring and the expander ring.

3.3 Install the compression rings in the correct grooves, with the bevel or "pip" mark (if any) toward the top of the piston.

4. Assemble the new connecting rods on the new pistons.

4.1 Lubricate the wrist pins and the wrist pin bushings in the connecting rods with clean engine oil.

4.2 Position the connecting rods in the pistons and press in the wrist pins. Secure the wrist pins by installing the wrist pin buttons in the ends of the wrist pins.

5. Install the new pistons and new connecting rods.

5.1 Apply clean engine oil to both pistons, the piston rings, the wrist pins, the connecting rod caps and the new connecting rod bearings.

5.2 Turn the crankshaft so its number-one rod journal (the one nearer the drive end) is down and centered.

5.3 Using a piston ring compressor, insert the number-one connecting rod and piston through the top of the number-one cylinder bore.

NOTE: The connecting rods and connecting rod caps are matched sets, therefore the caps must not be switched or rotated end for end.

5.4 Install the connecting rod bearings on the connecting rod and connecting rod cap.

5.5 Tighten the new connecting rod bolts evenly in increments of 11 to 13 lbf·ft (15 to 17 N·m).

5.6 Turn the crankshaft so its number-two connecting rod journal is in the downward, center position.

5.7 Install the number-two connecting rod and piston in the same manner as described above.

6. Before replacing the cylinder head on the crankcase, ensure that the correct pistons have been used by turning the crankshaft one complete revolution such that each piston moves to its maximum upward stroke. At the upward stroke position, each piston should move to the top of the crankcase. If the piston does not approach the top of the crankcase, the piston is incorrect and if not replaced could result in compressor damage.

7. Install the base plate.

7.1 Position the gasket on the crankcase. Install the base plate on the crankcase as marked before disassembly.

7.2 Tighten the six capscrews 15 to 18 lbf·ft (20 to 25 N·m) in a cross pattern.

8. Install the cylinder head on the crankcase,and the compressor on the engine. For instructions, see **Subject 110**.

9. Operate the engine and check for leaks.

Problem—Excessive Oil Passage

Problem—Excessive Oil Passage	
Possible Cause	**Remedy**
Restricted air intake.	Check engine air filter and replace if necessary. Check compressor air inlet for kinks and excessive bends. Repair as needed.
Restricted oil return line to engine.	Check for excessive bends, kinks, and restrictions in oil return line. Return line must descend from compressor to engine crankcase. Repair as needed.
Damaged oil seal ring or loose end cover.	Inspect oil seal ring for wear or damage. Repair as needed. Check the end cover capscrew torques and tighten as necessary.
Insufficient compressor cooling (compressor runs hot).	Remove grease, grime, or dirt from the cooling fins of the compressor. Check for damaged cooling fins. Replace components found damaged. Check for correct coolant line sizes. Check the coolant flow through the compressor. Minimum allowable flow is 2.5 gallons per minute at maximum engine governed speed, and minimum allowable flow is 0.5 gallons per minute at engine idle. If low, inspect the coolant lines for rust scale, kinks, and restrictions. Repair or replace as necessary.
Compressor runs loaded an excessive amount of time.	Check air lines and connections for leakage. Repair or replace lines and connections until leakage is eliminated.
Back pressure from the engine crankcase.	Check for excessive engine crankcase pressure. Repair or replace ventilation components as necessary. NOTE: An indication of crankcase pressure is a loose or partially lifted dipstick.
Excessive engine oil pressure.	Check the engine oil pressure with a test gauge, and compare the reading to the engine specification. Do not restrict the compressor oil supply line.
Malfunctioning compressor.	Replace or repair the compressor after making certain none of the preceding conditions exist.

Problem—Noisy Compressor Operation

Problem—Noisy Compressor Operation	
Possible Cause	**Remedy**
Loose drive coupling or gear (as indicated).	Inspect the fit of the drive coupling and gear on the compressor crankshaft. Tighten or replace the components. If the crankshaft keyway is damaged, replace the compressor.
Compressor cylinder head or discharge line restrictions.	Inspect the compressor discharge port and discharge line for carbon build-up. If carbon is detected, remove the carbon and check for proper coolant flow to the compressor. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Air compressor bearing damaged or worn.	Replace the bearings.
Malfunctioning compressor.	Rebuild or replace the compressor after making certain none of the preceding conditions exist.

Troubleshooting

Problem—Excessive Build-Up and Recovery Time

Problem—Excessive Build-Up and Recovery Time	
Possible Cause	**Remedy**
Restricted air intake.	Check engine air filter and replace if necessary. Check compressor air inlet for kinks and excessive bends. Repair as needed.
Restricted discharge or compressor discharge cavity.	Inspect the compressor discharge port and line for restrictions and carbon build-up. If carbon is detected, remove the carbon. Check for proper cooling to the compressor. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Slipping drive components.	Check for faulty drive gears and coupling, and replace as necessary.
Excessive air system leakage (not including the air compressor).	Check all valves, air lines, and connections for leakage. Repair or replace valves and lines until leakage is eliminated.
Unloader pistons seized.	Check the operation of the unloading mechanism. Check for corrosion and contamination of unloader pistons. Check for correct operation of the compressor air governor. If the governor is operating properly, repair or replace the unloading mechanism.
Malfunctioning compressor.	Rebuild or replace the compressor after making certain none of the preceding conditions exist.

Problem—Compressor Fails to Unload

Problem—Compressor Fails to Unload	
Possible Cause	**Remedy**
Faulty or worn unloader pistons or bores.	Inspect for worn, dirty, or corroded unloader pistons and bores. Replace as necessary.
Malfunctioning governor.	Check the setting with an accurate test gauge. Repair or replace the air governor.
Unloader air lines from governor damaged.	Inspect the air lines to and from the governor for kinks or restrictions. Repair or replace the air lines.

Specifications

Torque Values	
Description	**Torque: lbf·ft (N·m)**
Cylinder Head	37–42 (50–57)
Unloader Cover Plate	15–18 (20–25)
Discharge Valve Seat	70–90 (95–122)
Inlet Valve Stop	70–90 (95–122)
End Cover	15–18 (20–25)
Connecting Rod	11–13 (15–17)

Torque Values	
Description	**Torque: lbf·ft (N·m)**
Bottom Cover	15–18 (20–25)
Inlet Fitting	15–18 (20–25)
Discharge Fitting	15–18 (20–25)
Governor or Governor Adaptor	15–18 (20–25)

Table 1, Torque Values

Compressor Specifications	
Description	**inches (mm)**
Discharge Valve Travel (Minimum/Maximum)	0.030/0.046 (0.76/1.17)
Fit Between Crankcase Bore and Ball-Type Main Bearing (Minimum/Maximum)	0.0003/0.0023 (0.008/0.058)
Clearance for Crankshaft Main Journals to i.d. of Sleeve-Type Main Bearing (Maximum)	0.005 (0.13)
Crankshaft Main Journal Standard Diameter	1.1242-1.1250 (28.555-28.575)
Clearance Between Crankshaft Rod Journals and Connecting Rod Bearing (Minimum/Maximum)	0.0003/0.0021 (0.008/0.053)
Crankshaft Rod Journal Standard Diameter*	1.1242-1.1250 (28.555-28.575)
Cylinder Bore Out-of-Round (Maximum)	0.0005 (0.013)
Cylinder Bore Taper (Maximum)	0.0005 (0.013)
Clearance Between Cylinder Bore and Cast Iron Piston (Minimum/Maximum)†	0.002/0.004 (0.05/0.10)
Clearance Between Wrist Pins and Connecting Rod Bushings (Maximum)	0.0007 (0.0178)
Compression Ring Groove Clearance	0.002-0.004 (0.05-0.10)
Oil and Expander Ring Groove Clearance	0.00-0.006 (0.00-0.153)
Compression Ring Gap (Installed in Cylinder)	0.002-0.013 (0.05-0.176)
Oil and Expander Ring Gap (Installed in Cylinder)	0.010-0.040 (0.255-1.016)

* For compressors having reground crankshafts, undersize connecting rod bearing inserts are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm).

† Oversized pistons and piston rings are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm).

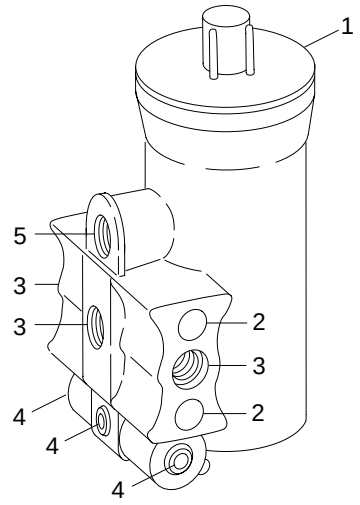
Table 2, Compressor Specifications

General Description

The governor **(Fig. 1)**, operating in conjunction with the compressor unloading mechanism, automatically controls the air pressure in the air brake or air supply system between the desired, predetermined maximum and minimum pressures. Normal air pressure in all Freightliner vehicles is 95 to 125 psi (655 to 862 kPa). The compressor runs continuously while the engine runs, but the actual compression of air is controlled by the governor actuating the compressor unloading mechanism, which stops or starts compression when the maximum or minimum reservoir pressures are reached. The D-2 governor has a piston upon which air pressure acts to overcome the pressure setting spring, and control the inlet and exhaust valve to either admit or exhaust air to or from the compressor unloading mechanism.

D-2 governors have mounting holes, which allow for direct mounting to the compressor.

Porting consists of 3 reservoir ports (1/8-inch NPT), 3 unloader ports (1/8-inch NPT), and 1 exhaust port (1/8-inch NPT).



1. Top Cover
2. Mounting Hole
3. Unloader Port
4. Reservoir Port
5. Exhaust Port

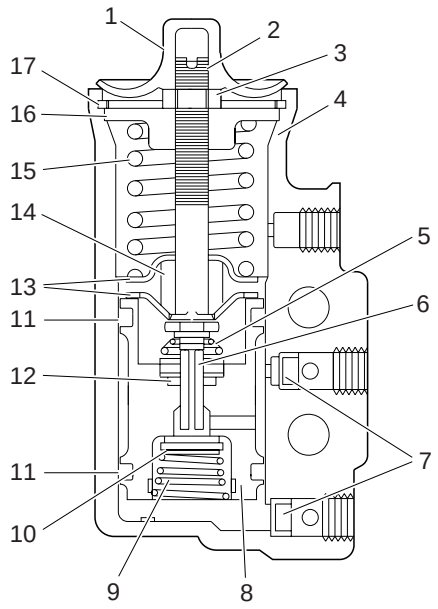
Fig. 1

Principles of Operation

Pressurized air enters the D-2 governor at one of its reservoir ports, and acts on the area of the piston and beneath the inlet and exhaust valve. See **Fig. 2.** As air pressure builds up, the piston moves against the resistance of the pressure-setting spring. The piston and inlet and exhaust valve move up when the reservoir air pressure reaches the cut-out setting of the governor. The exhaust stem seats on the inlet and exhaust valve, and then the inlet passage opens. Reservoir air then flows by the open inlet valve, through the passage in the piston, and out the unloader port to the compressor unloading mechanism. Air also flows around the piston, and acts upon the additional area of the piston. This added force, which results from a larger area on the piston, ensures a positive action and fully opens the inlet valve.

As the system reservoir air pressure drops to the cut-in setting of the governor, the force exerted by the air pressure on the piston will be reduced so that the pressure-setting spring will move the piston down. The inlet valve will close and the exhaust will open. With the exhaust open, the air in the unloader line will escape back through the piston, through the exhaust stem and out the exhaust port.

General Description and Principles of Operation



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1. Cover
2. Adjusting Screw
3. Adjusting Screw Locknut
4. Body
5. Exhaust Stem Spring
6. Exhaust Stem
7. Filters
8. Piston
9. Inlet and Exhaust Valve Spring
10. Inlet and Exhaust Valve
11. O-Rings
12. Exhaust Stem O-Ring
13. Lower Spring Seats
14. Spring Guide
15. Pressure-Setting Spring
16. Upper Spring Seat
17. Retaining Ring

Fig. 2

Tests

The following test should be performed whenever the vehicle air pressure is incorrect and the causes are unknown.

If the air governor does not function as described or if leakage is excessive, replace it with a new or remanufactured unit, or repair it using genuine Bendix parts and the instructions in this section.

1. Apply the parking brakes and chock the tires. Tilt the cab or hood. For cab tilt instructions, see **Group 60**.
2. Start the engine and build up air pressure in the air brake system.

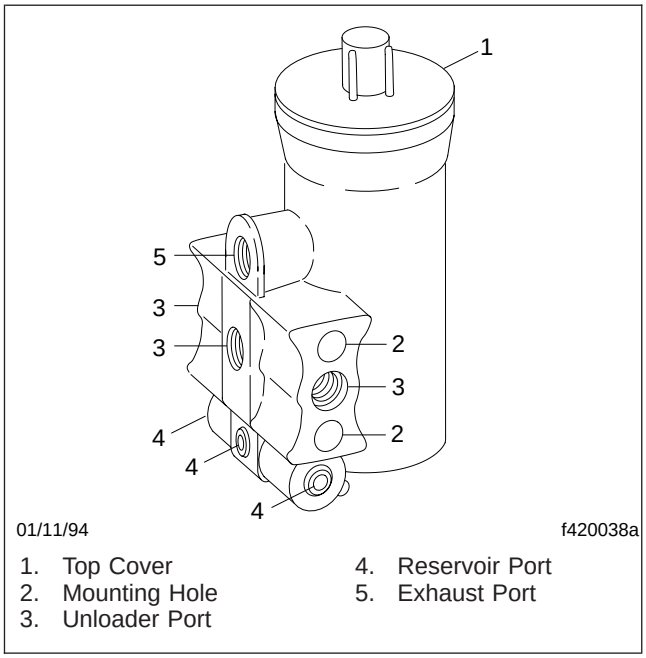
IMPORTANT: Make sure the test gauge is registering accurately before using it to check or adjust the air governor.

3. Using a test gauge attached to the supply reservoir, check the pressure at the time the air governor cuts out. The cut-out pressure should be 120 to 130 psi (827 to 896 kPa).
4. With the engine still running, make a series of brake applications to reduce the air pressure and observe at what pressure the air governor cuts in the compressor. The minimum cut-in pressure should be 100 psi (689 kPa).
5. If either the cut-out or cut-in pressures are incorrect, proceed to **Subject 130**.
6. Test the leakage on the air governor in both the cut-in and cut-out positions, as follows:

   6.1 With the compressor in the cut-in position, apply a soap solution to the air governor exhaust port. See **Fig. 1**. A slight bubble leakage is permitted. Excessive leakage indicates that the inlet valve or lower piston O-ring is worn out.

   6.2 With the compressor in the cut-out position, apply a soap solution to the air governor exhaust port. See **Fig. 1**. A slight bubble leakage is permitted. Excessive leakage indicates that the exhaust valve seat, stem, O-ring, or upper piston O-ring is worn out.

7. Return the cab or hood to the operating position and remove the chocks from the tires. For cab tilt instructions, see **Group 60**.



1. Top Cover
2. Mounting Hole
3. Unloader Port
4. Reservoir Port
5. Exhaust Port

Fig. 1, Air Governor

Removal

1. Chock the tires, and drain the air brake system. Tilt the cab or hood. Refer to the vehicle driver's manual for instructions.
2. Disconnect the reservoir and unloader port air lines. Mark the lines for later reference. Cap the air lines tightly to keep out contaminants.
3. Remove the governor mounting bolts, and remove the governor, see **Fig. 1**.

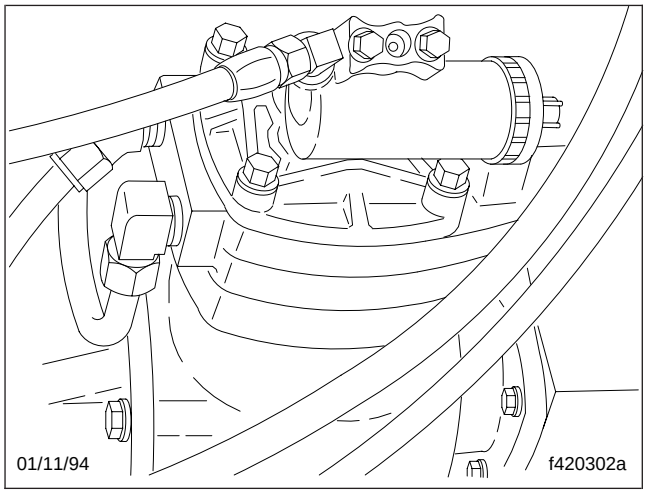


Fig. 1, Air Governor Removal

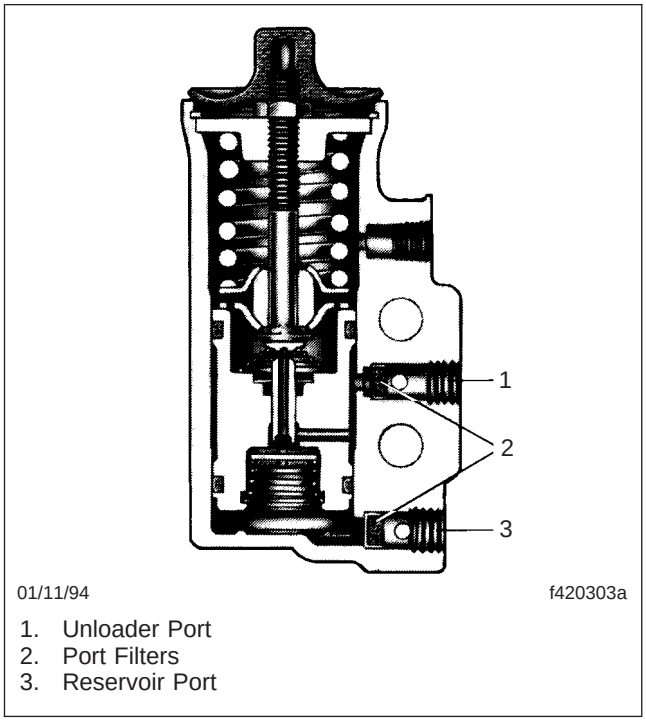
Installation

1. Clean the mounting pad on both the compressor and the governor block, and be sure the compressor unloading port is clear and clean.
2. Using a new governor mounting gasket, install the governor and its mounting bolts. Tighten the bolts 11 to 15 lbf·ft (15 to 20 N·m).
3. Clean the connecting lines after removing the caps, and apply Loctite® 242, or equivalent sealant in small quantities, to the reservoir and unloader fittings.

⚠ CAUTION

CAUTION: Make sure excess sealant does not get inside the fittings. Loose material inside the plumbing may clog the governor or other components, causing damage.

4. Connect the reservoir and unloader port air lines (**Fig. 2**) as referenced earlier. Tighten the fittings 11 to 13 lbf·ft (15 to 18 N·m).



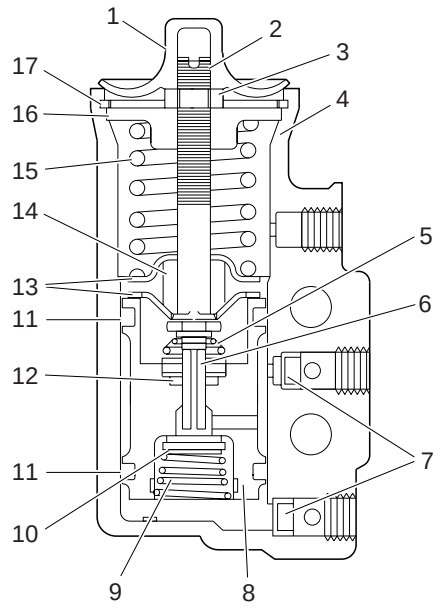
1. Unloader Port
2. Port Filters
3. Reservoir Port

Fig. 2, Air Governor Cross Section

5. Perform the operating and leakage tests in **Subject 100.**
6. After the tests have been completed and the governor is operating properly, screw the top cover on tightly until it seals the body, preventing the entry of any foreign matter.
7. If necessary, install new filters in the reservoir and unloader ports. These cup-shaped filters can be installed with the head of a pencil.
8. Return the cab or hood to the operating position, and remove the chocks from the tires. Refer to the vehicle driver's manual for instructions.

Disassembly

1. Remove the governor (see **Fig. 1**) from the vehicle, using the instructions in **Subject 110.**



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1. Cover
2. Adjusting Screw
3. Adjusting Screw Locknut
4. Body
5. Exhaust Stem Spring
6. Exhaust Stem
7. Filters
8. Piston
9. Inlet and Exhaust Valve Spring
10. Inlet and Exhaust Valve
11. O-Rings
12. Exhaust Stem O-Ring
13. Lower Spring Seats
14. Spring Guide
15. Pressure-Setting Spring
16. Upper Spring Seat
17. Retaining Ring

Fig. 1, Air Governor Cross-Section

2. Clean the governor exterior of road dirt and grease.
3. Unscrew the top cover (Ref. 1).
4. With a pair of retaining ring pliers, remove the spring assembly retaining ring (Ref. 17).
5. Remove the adjusting screw (Ref. 2) and spring assembly.
6. Remove the locknut (Ref. 3), then the hex-shaped upper spring seat (Ref. 16) from the adjusting screw.
7. Remove the pressure-setting spring (Ref. 15), lower spring seat (Ref. 13), spring guide (Ref. 14), and the other lower spring seat (Ref. 13) from the adjusting screw.
8. Remove the exhaust stem and its spring from the top of the piston. With the body in the inverted position, tap lightly and remove the piston.
9. Remove the inlet and exhaust valve spring (Ref. 9) and the valve (Ref. 10) from the piston.
10. Remove the two piston O-rings (Ref. 11), and with a hooked wire, remove the exhaust stem O-ring (Ref. 12).
11. Clean or remove the unloader and reservoir port filters (Ref. 7).

Cleaning and Inspecting

1. Clean all metal parts in mineral spirits.
2. Wipe all rubber parts dry, using a clean cloth.
3. Inspect the governor body for cracks or other damage. Be particularly careful that all air passages in the body, filters, exhaust stem, and piston are not obstructed.
4. Check the springs for cracks, distortion, or corrosion.
5. Replace all worn or damaged parts.

Assembly

Prior to assembly, lubricate the lower body bore, the top of the piston, the piston grooves, piston O-rings, and the spring guide and adjusting screw with Dow Corning 55-M pneumatic grease, or equivalent.

1. Install the exhaust stem O-ring (Ref. 12) in its groove in the stem bore of the piston.
2. Install the upper and lower piston O-rings (Ref. 11).
3. Drop the inlet and exhaust valve (Ref. 10) into place at the bottom of the piston.
4. Install the inlet and exhaust valve spring (Ref. 9) with the small end against the valve. Press the

Disassembly, Cleaning and Inspection, and Assembly

spring down until the larger coiled end snaps into the groove inside the piston.

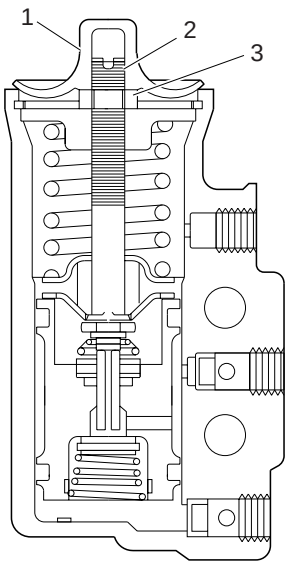
5. Position the exhaust stem spring (Ref. 5) over the exhaust stem. Carefully press the stem into the stem bore of the piston.
6. Install the piston in the body.
7. Install one lower spring seat (Ref. 13), spring guide (Ref. 14), the other lower spring seat (Ref. 13), pressure-setting spring (Ref. 15), and the hex-shaped upper spring seat (Ref. 15) on the adjusting screw, in that order. Screw the upper spring seat (Ref. 16) down until the distance from the top of the seat to the bottom of the stem head is about 1-7/8 inches (48 mm).
8. Install the locknut (Ref. 3).
9. Before placing the adjusting screw and stem assembly in the governor body, check that the exhaust stem (Ref. 6) and its spring are in place in the piston.
10. Install the adjusting screw (Ref. 2) and spring assembly, and the retaining ring (Ref. 17).
11. Install the governor on the vehicle, using the instructions in **Subject 110.**

Adjustment

NOTE: An air governor with a dryer reservoir module (DRM) is not adjustable.

If the pressure settings of the governor are inaccurate or if they need to be changed, proceed as follows:

1. Apply the parking brakes and chock the tires. Tilt the cab or hood.
2. Remove the top cover from the governor and loosen the adjusting screw locknut. See **Fig. 1**.



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1. Top Cover
2. Adjusting Screw
3. Adjusting Screw Locknut

Fig. 1, Air Governor

3. To raise the pressure settings, turn the adjusting screw counterclockwise. To lower the pressure setting, turn the adjusting screw clockwise.

NOTE: The pressure range between cut in and cut out is not adjustable.

If these adjustments do not correct the pressure settings, repair or replace the governor using the instructions in this section.

4. Tighten the adjusting screw locknut and install the top cover.
5. Return the cab or hood to the operating position and remove the chocks from the tires.

General Information

The Cummins 18.7 cfm compressor is used on the ISM, ISX, ISC, N14 and Signature 600 engine. This compressor is a single cylinder engine-driven, piston-type compressor that supplies compressed air to operate air powered actuators on the vehicle. The compressor is geared directly to the engine which serves to operate the compressor and any accessory that is connected on the rear flange. The compressor will deliver air out of the exhaust port when the unloader port is at atmospheric pressure and will stop air delivery when the unloader port is pressurized to the system pressure between 100 to 125 psi (689 to 862 kPa). A governor determines the "cut-in" (start of pumping) and "cut-out" (termination of pumping) of the compressor by supplying the proper control signal to the unloader port. The governor is sensing the pressure in the air supply tank or "wet tank." If the output air pressure is inadvertently blocked or required to exceed 250 psi (1724 kPa), the compressor will stop air delivery. The air will be recycled within the compressor and no mechanical harm will be done.

Air Compressor Removal and Installation

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.

⚠ DANGER

Before tilting the cab or returning the cab to the normal operating position, read the instructions and hazard notices in Section 60.04. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

2. Tilt the hood or cab.
3. Drain the air reservoirs.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

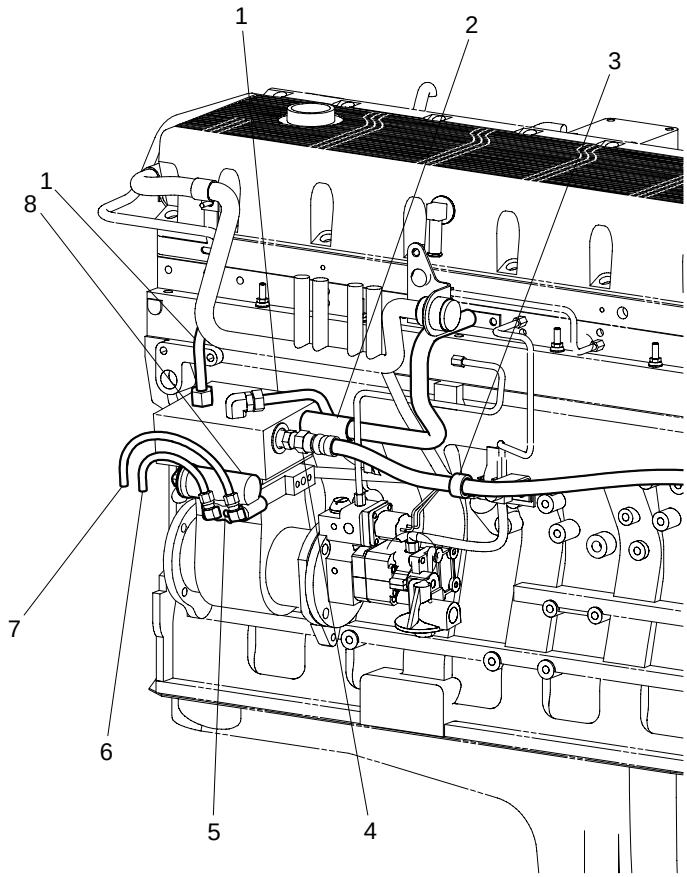
4. Using a cleaning solvent, remove road dirt and grease from the outside of the air compressor, then dry the air compressor with compressed air.
5. Drain the radiator coolant below the level of the air compressor. See **Group 20** for instructions.
6. Marking their locations and positions, disconnect all air, coolant, and oil lines attached to the air compressor and governor. Remove cushion clamps and tie straps as needed to move the lines out of the way. See **Fig. 1** and **Fig. 2**.
7. If equipped with a compressor mounted fuel pump disconnect the wire to the fuel shutoff valve (if equipped). Remove the fuel pump and gasket; refer to the engine shop manual or rebuild manual for instructions.
8. If equipped with a compressor mounted steering pump remove the pump leaving the hoses connected. refer to the engine shop manual or rebuild manual for instructions.
9. Support the pump and tie it out of the way.
10. Remove the air compressor.
    - 10.1 Remove the air governor and mounting gasket from the compressor.
    - 10.2 Remove the compressor rear support bracket, if equipped.
    - 10.3 Support the air compressor, and remove the bolts that attach it to the auxiliary drive housing, accessory drive, or timing gear plate. Remove the compressor, gasket and splined coupling.
    - 10.4 Lift or lower the air compressor out of the engine compartment.
    - 10.5 Remove and discard the air compressor mounting gasket, and clean the mating surfaces.

Installation

IMPORTANT: Be sure the gasket surfaces are cleaned and not damaged.

1. Install the air compressor.
    - 1.1 Install the splined coupling (if equipped) and a new compressor gasket. Hold the compressor in place, and install the bolts that attach it to the auxiliary drive housing, accessory drive, or timing gear plate. Refer to the engine shop manual or rebuild manual for final torque specification.
    - 1.2 Install the compressor support bracket If equipped.
    - 1.3 Using a new air governor mounting gasket, install the air governor on the compressor.
2. Using a new gasket install the fuel pump on the air compressor. Connect the wire to the fuel shutoff valve (if equipped). Refer to the engine shop manual or rebuild manual for final torque specification.
3. Install the steering pump on the air compressor. Refer to the engine shop manual or rebuild manual for instructions.
4. Identify and connect all air, coolant, and oil lines to the compressor and governor. Secure the lines as needed with cushion clamps and tie straps.
5. Fill the engine cooling system. See **Group 20** for instructions.
6. Operate the engine and check for leaks.

Air Compressor Removal and Installation



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1. Coolant Line
2. Compressor Air Inlet
3. Cushion Clamp
4. Compressor Air Outlet
5. Air Governor Mounting Bolt
6. Line to Air Dryer
7. Line to Wet Tank
8. Air Governor

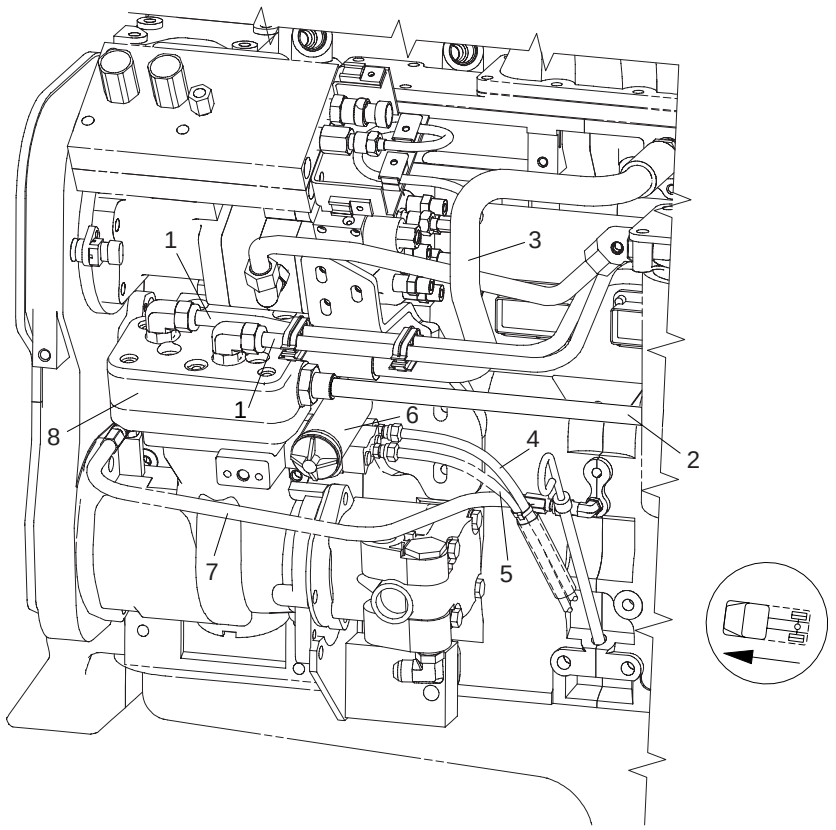
Fig. 1, ISM With Compressor Mounted Fuel Pump (other engines similar)

7. Remove the chocks from the rear tires. and

DANGER

Before tilting the cab or returning the cab to the normal operating position, read the instructions and hazard notices in Section 60.04. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

8. Return the hood or cab to the operating position.



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1. Coolant Line
2. Air Dryer/Wet Tank Line
3. Compressor Air Inlet Hose
4. Air Reservoir Line
5. Air Dryer Line
6. Air Governor
7. Oil Feed Line
8. Cylinder Head

Fig. 2, ISC With Compressor Mounted Steering Pump (other engines similar)

Replacement

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Drain the air from all air reservoirs.
3. Remove the compressor from the vehicle. See **Subject 100** for instructions.
4. Mount the compressor on a suitable holding fixture.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

5. Using a cleaning solvent, remove road dirt and grease from the outside of the compressor, then dry the compressor with compressed air.
6. Remove the cylinder head assembly from the crankcase.

   6.1 Scribe an alignment mark across the cylinder head and the crankcase, for assembly alignment.

   IMPORTANT: Do not use a marking method, such as chalk, that can be wiped off during assembling.

   NOTE: There is no need to remove the smaller screws.

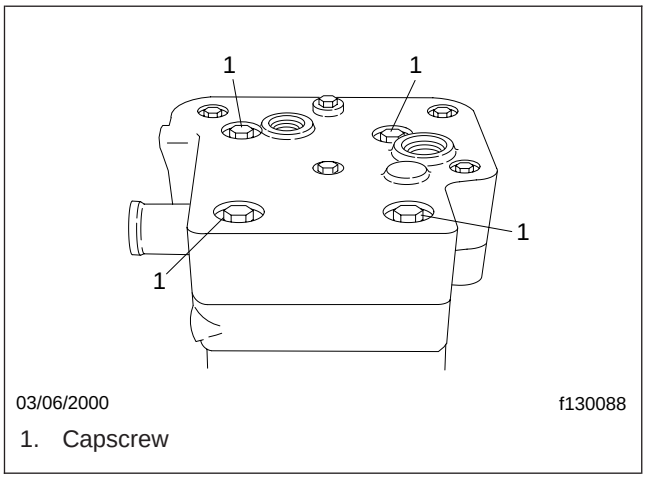
   6.2 Note the positions of any attached components, then remove the four M8 cylinder head capscrews. Discard the capscrews. See **Fig. 1**.

   6.3 Tap the cylinder head with a soft mallet to break the gasket seal. Remove the cylinder head assembly and discard the gasket. See **Fig. 2**. Note the position of the ports with respect to the crankcase for reassembly.

   6.4 Remove the coolant and air fittings for reuse. Discard the original cylinder head.

7. Clean the crankcase.

   7.1 Rotate the crankshaft until the piston is at the top of the cylinder bore.



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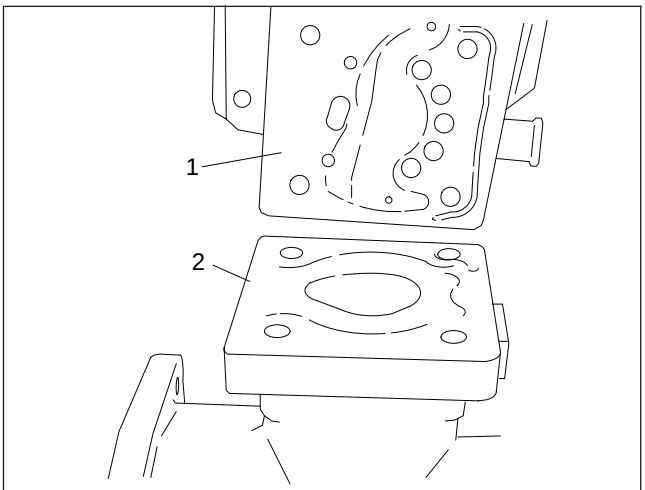
1. Capscrew

Fig. 1, Cylinder Head Capscrews



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1. Cylinder Head Assembly
2. Upper Crankcase

Fig. 2, Cylinder Head Removal

NOTE: Avoid the use of abrasive products similar to Scotch Brite® because of damage and abrasive grit left behind.

7.2 Remove any accumulated carbon and varnish by carefully scraping and light application of solvents. Avoid getting debris and solvents into the clearance between the piston and bore. Avoid the use of abrasive products similar to Scotch Brite because of damage and abrasive grit left behind.

Cylinder Head Replacement

WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

7.3 Using compressed air, blow dirt particles or gasket material from all cylinder cavities.

8. Inspect the top crankcase surface. It should be smooth and free of scratches to enable resealing on assembly.
9. Transfer the alignment marks from the original cylinder head to the replacement cylinder head.
10. Install the coolant and air fittings on the replacement cylinder head.
11. Install the cylinder head on the compressor crankcase.

    11.1 Position the sliding valve and the guide pins in the correct direction to enter the larger diameters in the valve body and crankcase.

    11.2 Align the marks on the cylinder head and crankcase.

    11.3 Using a new cylinder head gasket, position the gasket and head assembly on the crankcase.

    Note: You should find five cover bolts loosely holding the head assembly together.

    11.4 Install new capscrews.

CAUTION

A torque angle gauge and Inch pound torque wrench must be used to perform the torque-turn capscrew tightening sequence. The tightening sequence listed in Table 1 must be followed to prevent damage to the cylinder head assembly.

11.5 Tighten the capscrews using the bolt tightening sequence In **Table 1**.

12. Install the compressor. See **Subject 100** for instructions.
13. Fill the engine cooling system. See **Group 20** for instructions.
14. Operate the engine and check the compressor operation. Make sure there are no coolant or air leaks.
15. Remove the chocks from the rear tires.

Bolt Tightening Sequence			
Step	**Bolt**	**Torque: lbf·in (N·cm)**	**Rotation Degrees**
1	A	177 to 221 (2000 to 2500)	—
2	B	177 to 221 (2000 to 2500)	—
3	C	177 to 221 (2000 to 2500)	—
4	D	177 to 221 (2000 to 2500)	—
5	A	—	85 to 105
6	B	—	85 to 105
7	C	—	85 to 105
8	D	—	55 to 75
9	E	48 to 58 (540 to 660)	—
10	F	48 to 58 (540 to 660)	—
11	G	48 to 58 (540 to 660)	—
12	H	48 to 58 (540 to 660)	—
13	I	48 to 58 (540 to 660)	—
14	E	—	85 to 105
15	F	—	85 to 105
16	G	—	85 to 105
17	H	—	85 to 105
18	I	—	85 to 105

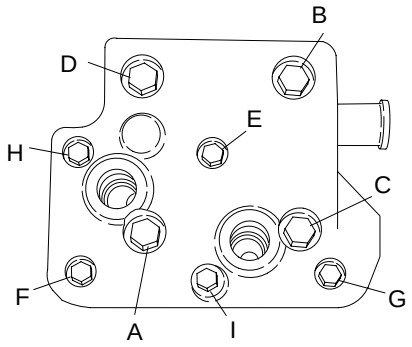

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Table 1, Bolt Tightening Sequence

Troubleshooting Tables

Problem—Excessive Oil Passage

Problem—Excessive Oil Passage	
Possible Cause	**Remedy**
Restricted air intake.	Check engine air filter and replace if necessary. Check compressor air inlet for kinks and excessive bends. Repair as needed.
Restricted oil return hole in front of compressor.	Remove compressor and check the oil return hole for restrictions. Repair as needed.
Defective or worn seal in the rear bearing cap.	Replace seal.
Compressor runs loaded an excessive amount of time.	Check air lines and connections for leakage. Check for a defective governor or restricted line. Replace the governor if necessary. Repair or replace lines and connections until leakage is eliminated.
Back pressure from the engine crankcase.	Check for excessive engine crankcase pressure. Repair or replace ventilation components as necessary. NOTE: An indication of crankcase pressure is a loose or partially lifted dipstick.
Excessive engine oil pressure.	Check the engine oil pressure with a test gauge, and compare the reading to the engine specification. Do not restrict the compressor oil supply line.
Malfunctioning compressor.	Replace the compressor after making certain none of the preceding conditions exist.

Problem—Noisy Compressor Operation

Problem—Noisy Compressor Operation	
Possible Cause	**Remedy**
Loose drive coupling or gear (as indicated).	Inspect the fit of the drive coupling and gear on the compressor crankshaft. Tighten or replace the components. If the crankshaft keyway is damaged, replace the compressor.
Compressor cylinder head or discharge line restrictions.	Inspect the compressor discharge port and discharge line for carbon build-up. If carbon is detected, remove the carbon and check for proper coolant flow to the compressor. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Compressor internal engine components damaged or worn.	Replace the compressor.

Problem—Excessive Build-Up and Recovery Time

Problem—Excessive Build-Up and Recovery Time	
Possible Cause	**Remedy**
Restricted air intake.	Check engine air filter and replace if necessary. Check compressor air inlet for kinks and excessive bends. Repair as needed.

Troubleshooting

Problem—Excessive Build-Up and Recovery Time	
Possible Cause	**Remedy**
Restricted discharge or compressor discharge cavity.	Inspect the compressor discharge port and line for restrictions and carbon build-up. If carbon is detected, remove the carbon. Check for proper cooling to the compressor. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Slipping drive components.	Check for faulty drive gears and coupling, and replace as necessary.
Excessive air system leakage (not including the air compressor).	Check all valves, air lines, and connections for leakage. Repair or replace valves and lines until leakage is eliminated.
Unloader piston seized.	Check the operation of the unloading mechanism. Check for corrosion and contamination of unloader pistons. Check for correct operation of the compressor air governor. If the governor is operating properly, replace the compressor.
Damaged compressor rings, valves, and gaskets.	Replace the compressor.

Problem—Compressor Fails to Unload

Problem—Compressor Fails to Unload	
Possible Cause	**Remedy**
Malfunctioning governor.	Check the setting with an accurate test gauge. Repair or replace the air governor.
Unloader air lines from governor damaged.	Inspect the air lines to and from the governor for kinks or restrictions. Repair or replace the air lines.
Faulty or worn unloader piston or bore.	Replace the compressor.

Problem—Air in Water System/Water in Air System

Problem—Air in Water System/Water in Air System	
Possible Cause	**Remedy**
Internal gasket leakage.	Replace the compressor.
Internal casting porosity.	Replace the compressor.

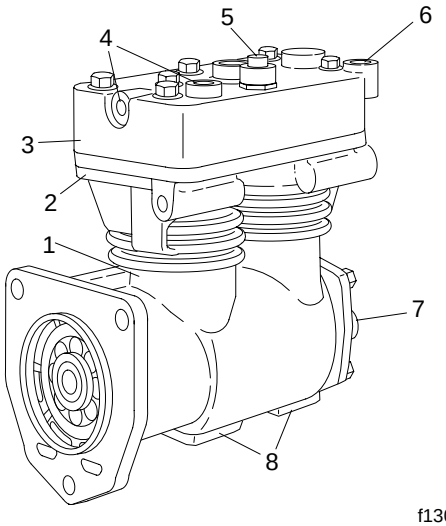
General Information

The DuraFlo 596 air compressor is a two-cylinder reciprocating compressor with a rated displacement of 27 cubic feet per minute. The compressor consists of a water-cooled cylinder head and valve body assembly and an air-cooled integral crankcase and cylinder block. See **Fig. 1**. The cylinder head is an aluminum casting that contains the required air and water ports as well as inlet check valves for each cylinder. The valve body assembly consists of steel upper and lower halves, each of which incorporates various valve openings and channels for conducting air and engine coolant in to and out of the cylinder head. The discharge valves for each cylinder are part of the valve body assembly.

The DuraFlo 596 compressor incorporates an unloader system that features and energy saving system (ESS) which reduces compressor power consumption by approximately 80 percent in the unloaded mode. The ESS also reduces compressor oil consumption (oil passing) when the compressor is in the unloaded mode.

Operation

The compressor is driven by the vehicle engine and functions continuously while the engine is in operation. Actual compression of air is controlled by the compressor unloading mechanism operating in conjunction with a remote mounted governor and synchro valve. The governor and synchro valve combination maintains brake system air pressure between a preset maximum and minimum pressure level.



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1. Crankcase
2. Valve Body Assembly
3. Cylinder Head
4. Water Inlet Port
5. Discharge Safety Valve
6. Water Outlet Port
7. Rear Cover Oil Port
8. Crankcase Bottom Cover

Fig. 1, DuraFlo 596 Air Compressor

Replacement

1. Apply the parking brakes, chock the tires, shut down the engine, and open the hood.
2. Drain the air system.
3. Disconnect the batteries.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent eye injury could result from flying debris.

4. Using a cleaning solvent, remove road dirt and grease from the outside of the compressor, then dry the compressor with compressed air.
5. Drain the radiator coolant. For instructions, see **Group 20**.
6. Identify and disconnect all air, water, and oil lines attached to the compressor. Remove tie straps as needed to move the lines out of the way.
7. Note the position of the discharge and inlet fittings before removing the fittings.
8. Remove the signal booster valve that is mounted on the air compressor.
9. Remove the nuts that attach the air compressor to the engine and remove the compressor.

IMPORTANT: The replacement air compressor may not have a drive gear. If the replacement air compressor does not have a drive gear, follow the instructions in the next step. If the replacement air compressor does have a drive gear, skip the next step.

10. Use a gear puller to remove the drive gear from the air compressor crankshaft and install it on the replacement air compressor. Torque the crankshaft nut 125 lbf·ft (169 N·m).
11. Install the drive gear and torque the crankshaft nut 125 lbf·ft (169 N·m).
12. Install the gasket on the drive flange of the compressor. Make sure that the oil supply or return holes in the gasket are properly aligned with the compressor and engine.
13. Install the compressor on the engine using nuts.
14. Make sure the threads on the discharge and inlet fittings are clean and free of corrosion. Replace the fittings if necessary. Install the discharge and inlet fittings on the compressor in the same positions as noted earlier.
15. Inspect all air and water lines and fittings before attaching them to the compressor. Make sure the O-rings are in good condition. Replace the O-rings if necessary. Tighten all hose clamps and secure the lines with tie straps as needed.
16. Fill the engine cooling system. For instructions, see **Group 20**.
17. Connect the batteries.
18. Clean the oil supply line. Before connecting the oil line to the compressor, run the engine briefly to be sure oil is flowing freely through the supply line.
19. Install the signal booster valve on the compressor.
20. Turn on the engine and check for leaks.
21. Remove the chocks from the tires and lower the hood.

Problem—Excessive Oil Passage

Problem—Excessive Oil Passage	
Possible Cause	**Remedy**
Restricted air intake.	Check engine or compressor air filter and replace if necessary. Check compressor air inlet for kinks, excessive bends, and be certain inlet lines have the minimum specified inside diameter. Recommended maximum air inlet restriction is 25 inches of water.
Restricted oil return to engine.	Make certain oil drain passages in the compressor and mating engine surfaces are unobstructed and aligned. Correct gaskets must be used. Special care must be taken when sealants are used with, or instead of, gaskets.
Poorly filtered air inlet.	Check for a damaged or dirty air filter on the engine or compressor. Check for leaking or damaged compressor air intake components such as induction line, fittings, gaskets, and filter bodies. The compressor intake should not be connected to any part of the exhaust gas recirculation (E.G.R.) system on the engine.
Insufficient compressor cooling (compressor runs hot).	For air-cooled portions of the compressor: • Remove accumulated grease and dirt from the cooling fins. Replace components found damaged. • Check for damaged cooling fins. Replace compressor if found damaged. For water-cooled portions of the compressor: • Check for proper coolant line sizes. Minimum recommended line i.d. is 3/8 inch. • Check the coolant flow through the compressor. Minimum allowable flow is 2.5 gallons per minute at engine governed speed. If low coolant flow is detected, inspect the coolant lines and fittings for accumulated rust scale, kinks, and restrictions. • Water temperature should not exceed 200°F (93°C). • Optimum cooling is achieved when engine coolant flows as shown in **Fig. 1**.
Contaminants not being regularly drained from system reservoirs.	Check reservoir drain valves to insure that they are functioning properly. It is recommended that the vehicle should be equipped with functioning automatic drain valves or have all reservoirs drained to zero psi daily, or optimally, to be equipped with a desiccant-type air dryer prior to the reservoir system.
Compressor runs loaded an excessive amount of time.	Vehicle system leakage should not exceed 1 psi pressure drop per minute without brakes applied and 3 psi pressure drop per minute with brakes applied. If leakage is excessive, check for system leaks and repair.
Excessive engine crankcase pressure.	Test for excessive engine crankcase pressure and repair or replace ventilation components as necessary. NOTE: An indication of crankcase pressure is a loose or partially lifted dipstick.
Excessive engine oil pressure.	Check the engine oil pressure with a test gauge and compare the reading to the engine specifications. Do not restrict the compressor oil supply line. Minimum oil supply line size is 3/16-inch i.d.
Malfunctioning compressor.	Replace or repair the compressor only after making certain none of the preceding conditions exist.

Troubleshooting

Problem—Noisy Compressor Operation

Problem—Noisy Compressor Operation	
Possible Cause	**Remedy**
Loose drive gear or components.	Inspect the fit of the drive gear on the compressor crankshaft. The gear or coupling must be completely seated and the crankshaft nut must be tight. If the compressor crankshaft surface is damaged, it is an indication of loose drive components. If damage to the compressor crankshaft is detected, replace the compressor. When installing the drive gear or pulley, torque the crankshaft nut to the appropriate torque specifications and use care when pressing drive components on to the crankshaft. Do not back off the crankshaft nut once it is tightened to the proper torque. Do not use impact wrenches to install the crankshaft nut.
Excessively worn drive couplings or gears.	Inspect drive gear, couplings, and engine for excessive wear. Replace as necessary. NOTE: Nonmetallic gears should be replaced when the compressor is changed.
Compressor cylinder head or discharge line restrictions.	Inspect the compressor discharge port and discharge line for carbon buildup. If carbon is detected, check for proper compressor cooling. See the remedy for insufficient compressor cooling in the previous table. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Worn or burned out bearings.	Check for proper oil pressure in the compressor. Minimum required oil pressure is 15 psi when engine is idling and 15 psi maximum at governed engine rpm. Check for excessive oil temperature; oil temperature should not exceed 240°F (115°C).
Malfunctioning compressor.	Repair or replace the compressor after making certain none of the preceding conditions exist.

Problem—Excessive Buildup and Recovery Time

Problem—Excessive Buildup and Recovery Time *	
Possible Cause	**Remedy**
Dirty induction air filter.	Inspect engine or compressor air filter and replace if necesary.
Restricted induction line.	Inspect the compressor air induction line for kinks and restrictions and replace as necessary.
Restricted discharge line or compressor discharge cavity.	Inspect the compressor discharge port and line for restrictions and carbon buildup. If carbon buildup is found, check for proper compressor cooling. Replace faulty sections of the discharge line.
Slipping drive components.	Check for faulty drive gears and couplings and replace as necessary. Check the condition of drive belts and replace or tighten, whichever is appropriate.
Excessive air system leakage.	Test for excessive system leakage and repair as necessary. Use the following as a guide. Build system pressure to governor cutout and allow the pressure to stabilize for one minute. Using a test gauge, note the system pressure drop after two minutes. The pressure should not exceed: • 2 psi in each reservoir for a single vehicle; • 6 psi in each reservoir for a tractor and trailer; • 8 psi in each reservoir for a tractor and two trailers.

Problem—Excessive Buildup and Recovery Time *	
Possible Cause	**Remedy**
Sticking unloader pistons.	Check the operation of the unloading mechanism. Check for proper operation of the compressor air governor and synchro valve. Make certain the air connections between the governor and synchro valve are correct. See **Fig. 2**. If the governor and synchro valve are operating properly, replace the unloader mechanism. Inspect for bent, linked, or blocked tubing leading to or from the governor and synchro valve.
Malfunctioning compressor.	Repair or replace the compressor after making certain none of the preceding conditions exist.

* Compressor should be capable of building air system pressure from 85 to 100 psi in 40 seconds with engine at full governed rpm. Minimum compressor performance is certified to meet Federal requirements by the vehicle manufacturer. Do not downsize the original compressor.

Problem—Compressor Does Not Unload

Problem—Compressor Does Not Unload	
Possible Cause	**Remedy**
Malfunctioning governor and synchro valve.	Test the governor and synchro valve for proper operation and inspect air lines to and from both components for kinks or restrictions. Repair or replace the governor, synchro valve, or connecting air lines.
Malfunctioning or worn unloader pistons or bores.	Inspect for worn, dirty, or corroded unloader pistons and their bores. Replace as necessary.

Problem—Compressor Leaks Oil

Problem—Compressor Leaks Oil	
Possible Cause	**Remedy**
Damaged mounting gasket.	Check the compressor mounting bolt torque. If the mounting bolt torque is low, replace the compressor mounting gasket before retorqueing the mounting bolts.
Cracked crankcase or end cover.	Visually inspect the compressor exterior for cracked or broken components. Cracked or broken crankcases or mounting flanges can be caused by loose mounting bolts. The end cover can be cracked by overtorquing fittings or plugs installed in the end cover. Repair or replace the compressor as necessary.
Loose crankcase end cover or bottom cover.	Check the capscrew torques and tighten as necessary. Replace gaskets or O-rings.
Loose oil supply or return line fittings.	Check the torque of external oil line fittings and tighten as necessary.
Porous compressor casting.	Replace the compressor if porosity is found.
Mounting flange or end cover, O-ring or gasket missing, cut, or damaged.	Replace as necessary.

Problem—Compressor Constantly Cycles; Compressor Remains Unloaded for a Very Short Time

Problem—Compressor Constantly Cycles; Compressor Remains Unloaded for a Very Short Time	
Possible Cause	**Remedy**
Leaking compressor unloader pistons.	Repair or replace as necessary.

Troubleshooting

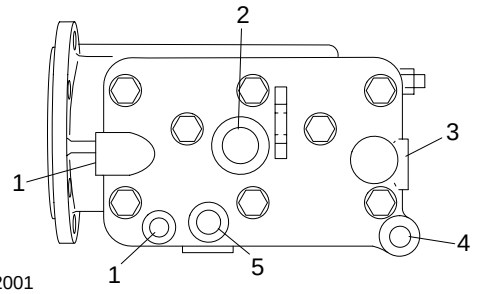
Problem—Compressor Constantly Cycles; Compressor Remains Unloaded for a Very Short Time	
Possible Cause	**Remedy**
Malfunctioning governor and synchro valve.	Test the governor and synchro valve for proper operation and inspect air lines to and from both components for kinks or restrictions. Repair or replace the governor, synchro valve, or connecting air lines.
Excessive air system leakage.	Test for excessive system leakage and repair as necessary. Use the following as a guide. Build system pressure to governor cutout and allow the pressure to stabilize for one minute. Using a test gauge, note the system pressure drop after two minutes. The pressure should not exceed: • 2 psi in each reservoir for a single vehicle; • 6 psi in each reservoir for a tractor and trailer; • 8 psi in each reservoir for a tractor and two trailers.
Excessive reservoir contaminants.	Drain reservoirs.

Problem—Compressor Leaks Coolant

Problem—Compressor Leaks Coolant	
Possible Cause	**Remedy**
Improperly installed plugs and coolant line fittings.	Check torque of fittings and plugs and tighten as necessary. Overtorqued fittings and plugs can crack the head or block casting.
Freeze cracks due to improper antifreeze strength.	Test antifreeze and strengthen as necessary. Check coolant flow through compressor to assure the proper antifreeze mixture reaches the compressor.
Malfunctioning compressor due to porous castings.	If casting porosity is detected, replace the compressor.

Problem—Compressor Head Gasket Malfunction

Problem—Compressor Head Gasket Malfunction	
Possible Cause	**Remedy**
Restricted discharge line.	Clear restriction or replace line.
Loose cylinder head capscrews.	Tighten evenly to a torque of 265 to 292 lbf·in (2990 to 3300 N·cm).
Malfunctioning compressor or head gasket.	Check for rough or poorly machined head or block surfaces. Replace compressor as necessary.



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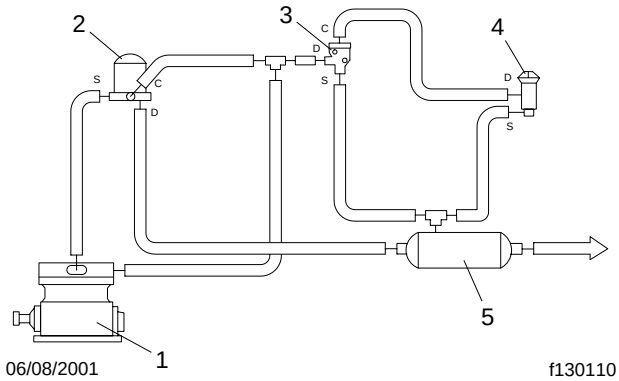
NOTE: The cylinder head connection ports are identified with the following numbers:

- Atmospheric Air In: 0
- Compressed Air Out: 2
- Coolant In: 91
- Coolant Out: 92

1. Coolant In or Out (One of the two ports is plugged.)
2. Inlet Port
3. Discharge Port
4. Coolant In or Out
5. Discharge Safety Valve

Fig. 1, Cylinder Head Port Identification



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1. DuraFlo 596 Compressor
2. Air Dryer
3. Synchro Valve
4. Governor
5. Supply Reservoir

Fig. 2, Plumbing Diagram

DuraFlo 596 Specifications

- Flow capacity at 1800 rpm and 120 psi: 21.4 cfm
- Operation: naturally aspirated
- Horsepower required at 1800 rpm and 120 psi: loaded 7.6, unloaded 1.1
- Swept air displacement at 1250 rpm: 27 cfm
- Maximum recommended rpm: 3000
- Minimum governor cutout pressure: 130 psi
- Maximum inlet air temperature: 250°F (121°C)
- Maximum inlet restriction: 25 inH_2O
- Maximum discharge air temperature: 400°F (204°C)
- Minimum oil pressure required at engine idle speed: 15 psi
- Minimum oil pressure required at maximum governed engine speed: 15 psi
- Number of cylinders: 2
- Weight: 50 pounds (23 kilograms)
- Length: 10.9 inches (28 centimeters)
- Height: 13.3 inches (34 centimeters)
- Width: 5.5 inches (14 centimeters)

Fastener Torque Values	
Description	**Torque: lbf·in (N·cm)**
13 mm Cylinder Head Capscrews	265 to 292 (2990 to 3300)
10 mm Valve Capscrews	101 to 111 (1140 to 1250)
Rear End Cover Capscrews	195 to 212 (2200 to 2400)
Bottom Cover Capscrews	97 to 115 (1100 to 1300)
Crankshaft Nut	148 to 184 lbf·ft (200 to 250 N·m)

Table 1, Fastener Torque Values

General Information

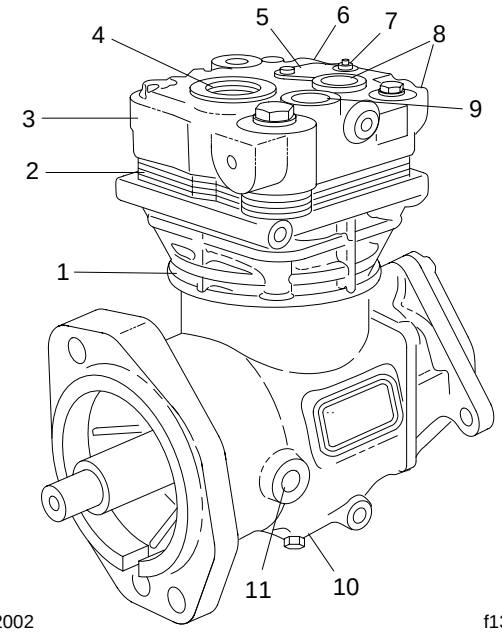
The BA-921 air compressor is a single-cylinder reciprocating compressor with a rated displacement of 15.8 cubic feet per minute at 1250 rpm. The compressor consists of a water-cooled cylinder head and valve plate assembly and an air-cooled integral crankcase and cylinder block. See **Fig. 1**. The cylinder head is an aluminum casting that contains the required air and water ports as well as an unloader piston. The valve plate assembly consists of laminated and brazed steel plates that incorporate various valve openings and channels for conducting air and engine coolant in to and out of the cylinder head.

The discharge valves are part of the valve plate assembly. The cylinder head, with the valve plate, comprise a complete cylinder head assembly. The cast iron crankcase and cylinder block assembly, houses the piston, connecting rod, crankshaft, and related bearings.

The BA-921 crankcase cover is stamped with information identifying the compressor model, customer piece number, Bendix piece number, and serial number. See **Fig. 2**.

Operation

The compressor is driven by the vehicle engine and functions continuously while the engine is in operation. Actual compression of air is controlled by the compressor unloading mechanism operating in conjunction with a governor.



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1. Crankcase
2. Valve Plate Assembly
3. Cylinder Head
4. Air Inlet Port
5. Unloader Cover
6. Water Port
7. Governor Connection
8. Discharge Port
9. Water Port
10. Crankcase Cover
11. Oil Port

Fig. 1, BA-921 Air Compressor

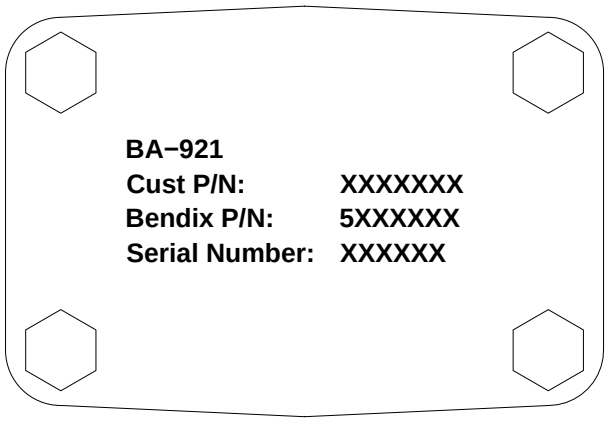

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Fig. 2, BA-921 Crankcase Cover

Replacement

1. Apply the parking brakes, chock the tires, shut down the engine, and open the hood or tilt the cab.
2. Drain the air system.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent eye injury could result from flying debris.

3. Using a cleaning solvent, remove road dirt and grease from the outside of the air compressor. Then dry the compressor with compressed air.
4. Drain the radiator coolant. For instructions, see **Group 20**.
5. Identify and disconnect all air, water, and oil lines attached to the air compressor.
6. Remove the air governor and the air governor mounting gasket.
7. Remove any components attached to the air compressor, such as a fuel pump or power steering pump.
8. Support the air compressor and remove the capscrews that attach the compressor to the gear case. Remove the air compressor.
9. Discard all gaskets.

IMPORTANT: Be sure the new gaskets are clean and not damaged.

10. Install a new air compressor gasket on the compressor.
11. Using capscrews, attach the air compressor to the gear case. For torque specifications, see the engine manufacturer's service manual.
12. Install any components that were removed from the air compressor, such as a fuel pump or power steering pump.
13. Install a new gasket on the air governor. Then install the air governor on the engine.
14. Identify and connect the air, coolant, and oil lines to the air compressor.
15. Fill the engine cooling system. For instructions, see **Group 20**.
16. Turn on the engine and check for leaks.
17. Remove the chocks from the tires and lower the hood or tilt the cab.

Troubleshooting Tables

Problem—Excessive Oil Passage

Problem—Excessive Oil Passage*	
Possible Cause	**Remedy**
Restricted air intake.	Check engine air cleaner and replace if necessary. Check compressor air inlet for kinks and excessive bends, and be certain inlet lines have the minimum specified inside diameter. Recommended maximum air inlet restriction is 25 inches of water.
Restricted oil return to engine.	Oil return to the engine should not be in any way restricted. Make certain oil drain passages in the compressor and mating engine surfaces are unobstructed and aligned. Correct gaskets must be used. Special care must be taken when sealants are used with, or instead of, gaskets.
Poorly filtered air inlet.	Check for a damaged or dirty air filter on the engine or compressor. Check for leaking or damaged compressor air intake components such as induction line, fittings, gaskets, and filter bodies. The compressor intake should not be connected to any part of the exhaust gas recirculation (E.G.R.) system on the engine.
Insufficient compressor cooling (compressor runs hot).	For air-cooled portions of the compressor: • Remove accumulated grease and dirt from the cooling fins. Replace damaged components. • Check for damaged cooling fins. Replace compressor if damaged. For water-cooled portions of the compressor: • Check for proper coolant line sizes. Minimum recommended line i.d. is 3/8 inch (10 mm). • Check the coolant flow through the compressor. Minimum allowable flow is 2.5 gallons (9 L) per minute at engine governed speed. If low coolant flow is detected, inspect the coolant lines and fittings for accumulated rust scale, kinks, and restrictions. • Water temperature should not exceed 200°F (93°C). • Optimum cooling is achieved when engine coolant flows as shown in **Fig. 1**.
Contaminants not being regularly drained from system reservoirs.	Check reservoir drain valves to insure that they are functioning properly. It is recommended that the vehicle be equipped with functioning automatic drain valves or have all reservoirs drained to zero psi daily, or optimally, to be equipped with a desiccant-type air dryer prior to the reservoir system.
Compressor runs loaded an excessive amount of time.	Vehicle system leakage should not exceed 1 psi (7 kPa) pressure drop per minute without brakes applied and 3 psi (21 kPa) pressure drop per minute with brakes applied. If leakage is excessive, check for system leaks and repair any leaks.
Excessive engine crankcase pressure.	Test for excessive engine crankcase pressure and repair or replace ventilation components as necessary. NOTE: An indication of crankcase pressure is a loose or partially lifted dipstick.

Troubleshooting

Problem—Excessive Oil Passage*	
Possible Cause	**Remedy**
Excessive engine oil pressure.	Check the engine oil pressure with a test gauge and compare the reading to the engine specifications. Bendix does not recommend restricting the compressor oil supply line because of the possibility of plugging the restriction with oil contaminants. Minimum oil supply line size is 3/16-inch (5-mm) i.d. tubing.
Malfunctioning compressor.	Replace or repair the compressor only after making certain none of the preceding conditions exist.

* Compressor passes excessive oil as evidenced by presence of oil at the exhaust ports of valving.

Problem—Noisy Compressor Operation

Problem—Noisy Compressor Operation	
Possible Cause	**Remedy**
Loose drive gear or components.	Inspect the fit of the drive gear on the compressor crankshaft. The gear or coupling must be completely seated and the crankshaft nut must be tight. If the compressor crankshaft surface is damaged, it is an indication of loose drive components. If damage to the compressor crankshaft is detected, replace the compressor. When installing the drive gear or pulley, torque the crankshaft nut to the appropriate torque specifications and use care when pressing drive components on to the crankshaft. Do not back off the crankshaft nut once it is tightened to the proper torque. Do not use impact wrenches to install the crankshaft nut.
Excessively worn drive couplings or gears.	Inspect drive gear, couplings, and engine for excessive wear. Replace as necessary. NOTE: Nonmetallic gears should be replaced when the compressor is changed.
Compressor cylinder head or discharge line restrictions.	Inspect the compressor discharge port and discharge line for carbon buildup. If carbon is detected, check for proper cooling to the compressor. See the remedy for insufficient compressor cooling in the table titled Problem—Excessive Oil Passage. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Worn or burned out bearings.	Check for proper oil pressure in the compressor. Minimum required oil pressure is 15 psi (103 kPa) when engine is idling and 15 psi (103 kPa) maximum at governed engine rpm. Check for excessive oil temperature; oil temperature should not exceed 240°F (115°C).
Malfunctioning compressor.	Repair or replace the compressor after making certain none of the preceding conditions exist.

Problem—Excessive Buildup and Recover Time

Problem—Excessive Buildup and Recover Time*	
Possible Cause	**Remedy**
Dirty induction air filter.	Inspect engine or compressor air filter and replace if necessary.
Restricted induction line.	Inspect the compressor air induction line for kinks and restrictions and replace as necessary.

Problem—Excessive Buildup and Recover Time*	
Possible Cause	**Remedy**
Restricted discharge line or compressor discharge cavity.	Inspect the compressor discharge port and line for restrictions and carbon buildup. If carbon buildup is found, check for proper compressor cooling. Replace faulty sections of the discharge line.
Slipping drive components.	Check for faulty drive gears and couplings and replace as necessary. Check the condition of drive belts and replace or tighten, whichever is appropriate.
Excessive air system leakage.	Test for excessive system leakage and repair as necessary. Use the following as a guide. Build system pressure to governor cutout and allow the pressure to stabilize for one minute. Using a test gauge, note the system pressure and the pressure drop after two minutes. The pressure drops should not exceed: • 2 psi (14 kPa) in each reservoir for a single vehicle; • 6 psi (41 kPa) in each reservoir for a tractor and trailer; • 8 psi (55 kPa) in each reservoir for a tractor and two trailers.
Sticking unloader pistons.	Check the operation of the unloading mechanism. Check for proper operation of the compressor air governor. Make certain the air connections between the governor and compressor are correct. See **Fig. 2**. If the governor is operating properly, replace the unloader mechanism. Inspect for bent, kinked, or blocked tubing leading to or from the governor.
Malfunctioning compressor.	Repair or replace the compressor after determining none of the preceding conditions exist.

* Compressor should be capable of building air system pressure from 85 to 100 psi (586 to 689 kPa) in 40 seconds with engine at full governed rpm. Minimum compressor performance is certified to meet Federal requirements by the vehicle manufacturer. Do not downsize the original equipment compressor.

Problem—Compressor Does Not Unload

Problem—Compressor Does Not Unload	
Possible Cause	**Remedy**
Malfunctioning governor or installation.	Test the governor for proper operation and inspect air lines to and from it for kinks or restrictions. Repair or replace the governor or connecting air lines.
Malfunctioning or worn unloader pistons or bores.	Inspect for worn, dirty, or corroded unloader piston and bore. Replace as necessary.

Problem—Compressor Leaks Oil

Problem—Compressor Leaks Oil	
Possible Cause	**Remedy**
Damaged mounting gasket.	Check the compressor mounting capscrew torque. If the mounting capscrew torque is low, replace the compressor mounting gasket before retorquing the mounting capscrews.
Cracked crankcase or end cover.	Inspect the compressor exterior for cracked or broken components. Cracked or broken crankcases or mounting flanges can be caused by loose mounting bolts. The end cover can be cracked by overtorquing fittings or plugs installed in the end cover. Repair or replace the compressor as necessary.
Loose crankcase end cover or bottom cover.	Check the capscrew torques and tighten as necessary. Replace gaskets or O-ring.
Loose oil supply or return line fittings.	Check the torque of external oil line fittings and tighten as necessary.

Troubleshooting

Problem—Compressor Leaks Oil	
Possible Cause	**Remedy**
Porous compressor casting.	Replace the compressor if porosity is found.
Mounting flange or end cover, O-ring or gasket missing, cut, or damaged.	Replace as necessary.

Problem—Compressor Constantly Cycles; Compressor Remains Unloaded for a Very Short Time

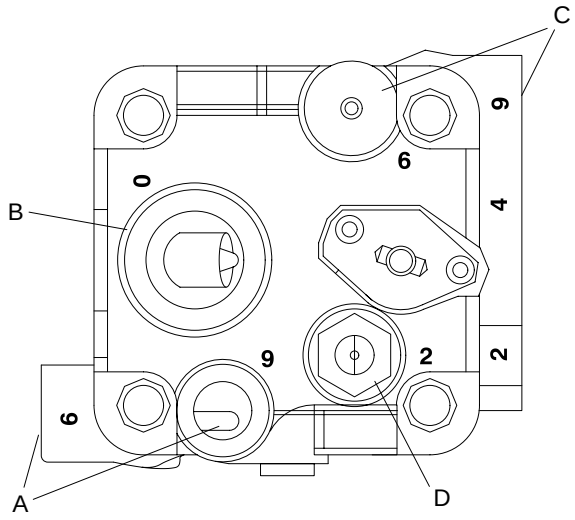
Problem—Compressor Constantly Cycles; Compressor Remains Unloaded for a Very Short Time	
Possible Cause	**Remedy**
Leaking compressor unloader pistons.	Repair or replace as necessary. Remove the compressor inlet air strainer or fitting. With the compressor unloaded (not compressing air), listen for air escaping.
Malfunctioning governor and installation.	Test the governor for proper operation and inspect air lines for kinks or restrictions. Repair or replace the governor or connecting air lines as required.
Excessive system leakage.	Test for excessive system leakage and repair as necessary. Use the following as a guide. Build system pressure to governor cutout and allow the pressure to stabilize for one minute. Using a test gauge, note the system pressure and the pressure drop after two minutes. The pressure drops should not exceed: • 2 psi (14 kPa) in each reservoir for a single vehicle; • 6 psi (41 kPa) in each reservoir for a tractor and trailer; • 8 psi (55 kPa) in each reservoir for a tractor and two trailers.
Excessive reservoir contaminants.	Drain reservoirs.

Problem—Compressor Leaks Coolant

Problem—Compressor Leaks Coolant	
Possible Cause	**Remedy**
Improperly installed plugs and coolant line fittings.	Check torque of fittings and plugs and tighten as necessary. Overtorqued fittings and plugs can crack the head or block casting.
Freeze cracks due to improper antifreeze strength.	Test antifreeze and strengthen as necessary. Check coolant flow through compressor to assure the proper antifreeze mixture reaches the compressor.
Malfunctioning compressor due to porous castings.	If casting porosity is detected, replace the compressor.

Problem—Compressor Head Gasket Malfunction

Problem—Compressor Head Gasket Malfunction	
Possible Cause	**Remedy**
Restricted discharge line.	Clear restriction or replace line.
Loose cylinder head capscrews.	Tighten evenly to a torque of 265 to 292 lbf·in (2990 to 3300 N·cm).
Malfunctioning compressor or head gasket.	Check for rough or poorly machined head or block surfaces. Replace compressor as necessary.



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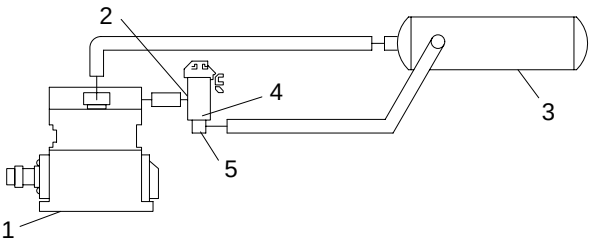
NOTE: The cylinder head connection ports are identified with the following numbers which are cast into the compressor: 0–Air In; 2–Compressed Air Out; 9–Coolant In or Out; 4–Governor Control.

A. Coolant In or Out (One of the two ports is plugged.)
B. Inlet Port
C. Coolant In or Out (One of the two ports is plugged.)
D. Discharge Safety Valve

Fig. 1, Cylinder Head Port Identification



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1. Compressor
2. Governor Unloader Port
3. Supply Reservoir
4. Governor
5. Reservoir Port

Fig. 2, Plumbing Diagram

Specifications

BA-921 Specifications

- Flow capacity at 1800 rpm and 120 psi (827 kPa): 11.8 cfm
- Flow capacity at 3000 rpm and 120 psi (827 kPa): 16.5 cfm
- Approximate horsepower required:
  - loaded 1800 rpm at 120 psig (827 kPa): 4.5 hp
  - unloaded 1800 rpm: 1.3 hp
- Minimum governor cutout pressure: 130 psi (896 kPa)
- Maximum inlet air temperature: 250°F (121°C)
- Maximum discharge air temperature: 400°F (204°C)
- Minimum oil pressure required at engine idle speed: 15 psi (103 kPa)
- Minimum oil pressure required at maximum governed engine speed: 15 psi (103 kPa)
- Number of cylinders: 1
- Weight: 28 pounds (13 kilograms)

Fastener Torque Values	
Description	**Torque lbf·in (N·cm)**
Cylinder Head Capscrews	265 to 292 (2990 to 3300)
Unloader Cover Capscrew	62 to 71 (700 to 800)
Rear End Cover Capscrews	195 to 213 (2200 to 2400)
Governor Adapter	300 to 325 (3390 to 3672)
Crankcase Cover Capscrew	62 to 71 (700 to 800)
Crankshaft Nut	220 to 254 lbf·ft (298 to 344 N·m)

Table 1, Fastener Torque Values

Removal

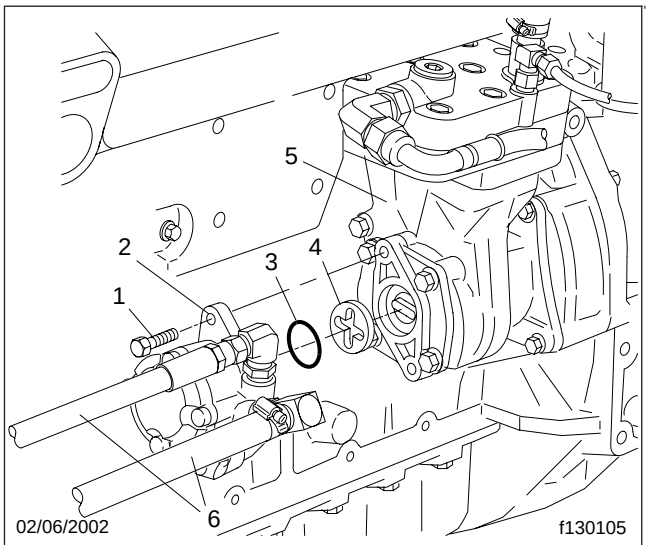
1. Apply the parking brakes and chock the tires.
2. Drain the air tanks.
3. Open the hood. Clean the fittings and hose connections on the air compressor and power steering pump.
4. Drain the radiator coolant. For instructions, see **Group 20**.

IMPORTANT: Do not remove the power steering lines. Secure the lines and the pump so that they are out of the way.

5. Remove the two capscrews that attach the power steering pump to the air compressor and move the pump away from the compressor. See **Fig. 1**.

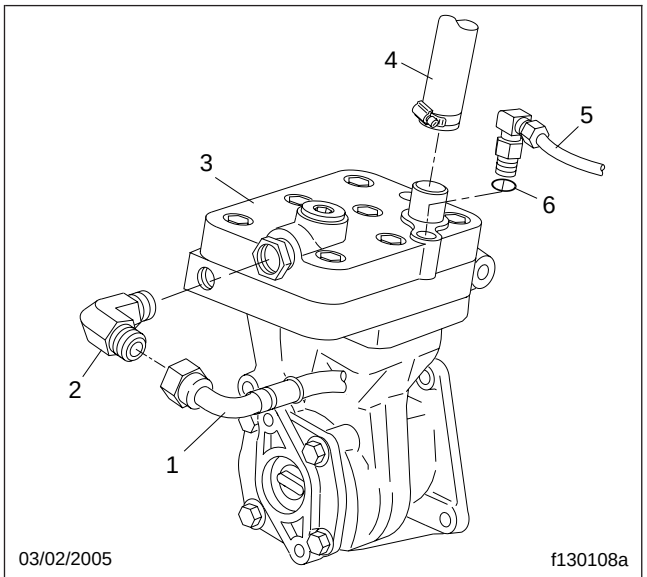
NOTE: Depending on vehicle configuration, it may be necessary to remove the brackets that attach the transmission cooler lines to the engine in order to obtain enough room to remove the compressor.

6. Remove and discard the O-ring located between the power steering pump and the cross plate.
7. Remove the cross plate located between the air compressor and the power steering pump.
8. Remove the three air lines from the air compressor (see **Fig. 2**), as follows.
   - 8.1 Remove the discharge air line and the elbow fitting. Check inside the discharge air line for carbon deposits and replace if necessary.
   - 8.2 Remove the unloader air line. Check the fittings for damage and replace if necessary.
   - 8.3 Loosen the hose clamp and remove the intake air line.
9. Remove all air fittings from the top of the compressor.
10. Remove the engine trim cover.
11. Remove the coolant delivery and return lines. Discard the seal rings. See **Fig. 3**.
12. Remove the four capscrews that attach the air compressor to the engine and remove the compressor. See **Fig. 4**.



1. Capscrew
2. Power Steering Pump
3. O-Ring
4. Cross Plate
5. Air Compressor
6. Hydraulic Lines

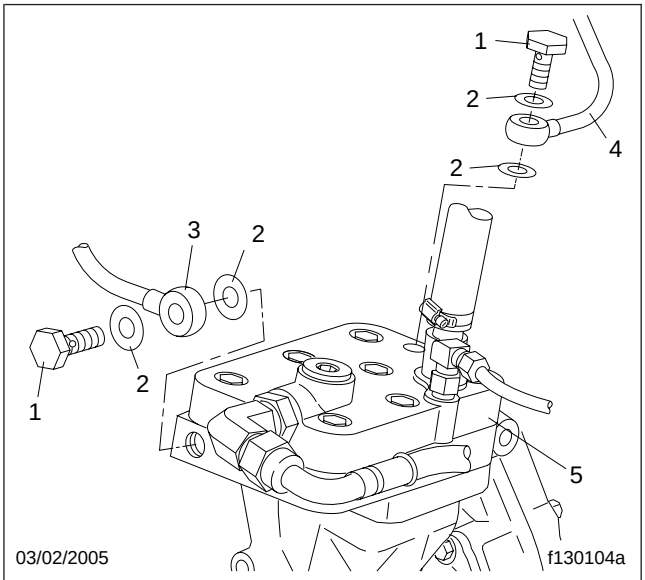
Fig. 1, Power Steering Pump Removal



1. Discharge Air Line
2. Elbow Fitting
3. Air Compressor
4. Intake Air Line
5. Unloader Air Line
6. O-Ring

Fig. 2, Air Compressor Air Lines

Removal, Inspection, and Installation



1. Hollow-Core Banjo Capscrew
2. Seal Ring
3. Coolant Return Line
4. Coolant Delivery Line
5. Air Compressor

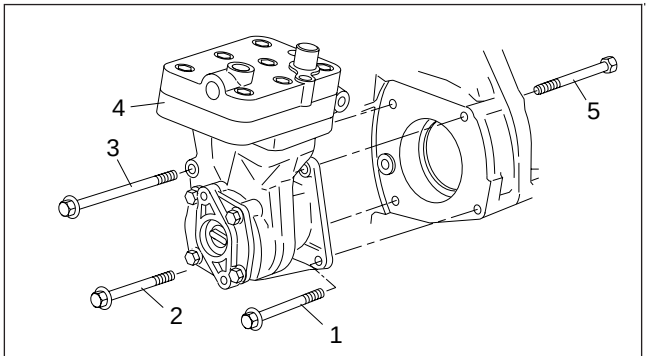
Fig. 3, Air Compressor Coolant Lines

NOTE: The capscrews that attach the air compressor to the engine are different lengths. Be sure to note where each capscrew is located.

13. Slide the drive gear away from the flywheel. Catch any oil that runs out and dispose of it properly.

Inspection

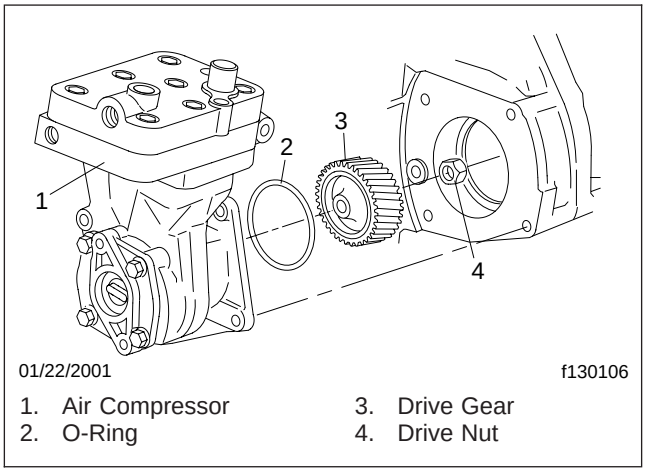
1. Install an SPX Kent-Moore locking device (J 46177) on the air compressor where the power steering pump connects to the air compressor. Tighten the capscrews until the air compressor drive is locked. This device locks the driveshaft to allow removal of the drive nut.
2. Remove the drive gear from the air compressor, as follows.
   - 2.1 Place the air compressor and locking device in a vise. Make sure the locking device is tightly secured and cannot slip out of the vise.
   - 2.2 Using an impact wrench, remove the drive nut from the drive gear.



1. Outboard Lower Capscrew
2. Inboard Lower Capscrew
3. Inboard Upper Capscrew
4. Air Compressor
5. Outboard Upper Capscrew

Fig. 4, Air Compressor Removal

   - 2.3 Remove the drive gear from the air compressor, using a gear puller if necessary.
   - 2.4 Discard the O-ring that seals the compressor housing to the engine block.
3. Inspect the drive gear for worn or broken teeth, spalling, and corrosion. If necessary, replace the drive gear.
4. Install a new O-ring on the air compressor housing. Install the drive gear. Tighten the drive nut 214 lbf·ft (290 N·m). See **Fig. 5**.



1. Air Compressor
2. O-Ring
3. Drive Gear
4. Drive Nut

Fig. 5, Air Compressor Drive Gear Installation

Installation

1. Using four capscrews, attach the air compressor to the engine. Tighten the capscrews 44 lbf·ft (60 N·m).

NOTE: Be sure to use the correct capscrew at each mounting location.

2. Install new seal rings on the coolant lines, then install the coolant lines on the air compressor. Tighten the hollow-core banjo capscrews 22 lbf·ft (30 N·m).
3. Install the engine trim cover.
4. Install the air fittings on top of the air compressor.
5. Install the three air lines on the air compressor, as follows.
   - 5.1 Install the discharge and unloader air lines. Make sure the O-rings are correctly installed on the fittings.
   - 5.2 Tighten the discharge and unloader air line fittings 60 lbf·ft (80 N·m).
   - 5.3 Install the intake air line and tighten the hose clamp.
6. Install the cross plate on the compressor output drive. Use grease to hold it in place while installing the power steering pump.
7. Install a new O-ring between the power steering pump and the cross plate.
8. Using two capscrews, attach the power steering pump to the air compressor. Tighten the capscrews 30 lbf·ft (40 N·m).
9. If the brackets that attach the transmission cooler lines to the engine were removed, install the brackets.
10. Fill the cooling system. For instructions, see **Group 20**.
11. Turn on the engine and check air line and coolant fittings for leaks. Correct any leaks as necessary.

Special tools can be ordered from:

SPX Kent-Moore
28635 Mount Road
Warren, Michigan 48092-3499
1-800-328-6657

SPX Kent-Moore Tools	
Tool	**Part Number**
Air Compressor Locking Device	J-46177

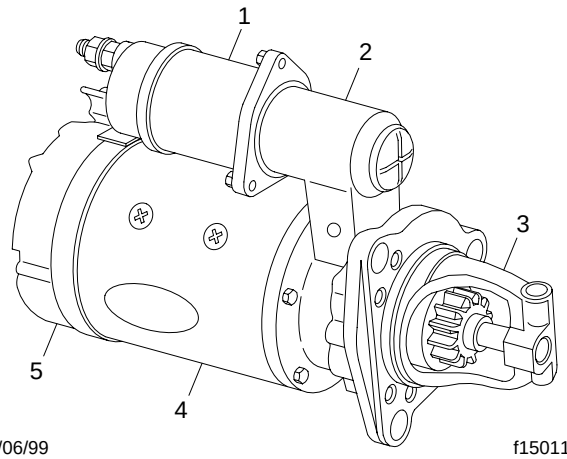
Table 1, SPX Kent-Moore Tools

Torque Values	
Description	**Torque: lbf·ft (N·m)**
Air Compressor Capscrews	44 (60)
Air Line Fittings	60 (80)
Coolant Line Hollow-Core Banjo Bolts	22 (30)
Drive Nut	214 (290)
Power Steering Pump Mounting Capscrews	30 (40)

Table 2, Torque Values

General Information

The Delco Remy starter (see **Fig. 1**) is located at the forward face of the flywheel bell housing on the driver's side of the vehicle.



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1. Solenoid
2. Lever Housing
3. Nose Housing
4. Field Frame
5. End Cap

Fig. 1, Starter Motor and Solenoid Assembly (42-MT starter shown)

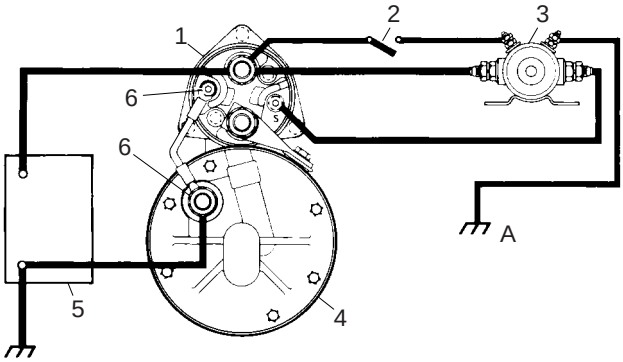
The starter has a shift lever and solenoid plunger that is totally enclosed to protect it from exposure to dirt, icing conditions, and splash. The starter is equipped with a drive, solenoid, and brush rigging with one-piece brushes. The commutator end cap can be removed to inspect the brushes.

Lubrication is provided in the sintered bronze bushings by an oil saturated wick. Oil can be added to each wick by removing an oil reservoir cup, which is accessible on the outside of the motor.

The pinion is moved into mesh with the ring gear by the action of the solenoid. The pinion remains engaged until the solenoid circuit is interrupted. In case of a butt engagement, the motor is not energized, preventing damage to the pinion and gear teeth.

Under normal operating conditions, no maintenance will be required between engine overhaul periods. At the time of engine overhaul, disassemble, inspect, and test the starter as described in this section.

For the complete starting circuit wiring diagram, see Section 54.00, **Specifications, 400**. The basic starting circuit is shown in **Fig. 2**.



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A. Connect to ground (may be direct ground, as shown or through starter temperature switch, ADLO relay, oil pressure switch, fuel pressure switch, or other control unit).
1. Solenoid
2. Start Switch
3. Magnetic Switch
4. Starting Motor
5. Battery
6. Ground Return Terminals

Fig. 2, Starter Wiring Circuit

When the start switch is closed, the magnetic switch contacts close, and the solenoid windings are connected to the battery. The resulting plunger and shift lever movement causes the pinion to engage the engine flywheel ring gear and the solenoid main contacts to close, and cranking takes place. When the engine starts, pinion overrun protects the armature from excessive speed until the switch is opened, at which time the return spring causes the pinion to disengage.

To prevent overrun and damage to the drive and armature windings, the switch must be opened immediately when the engine starts. A cranking period should never exceed 30 seconds without stopping to allow the motor to cool for at least two minutes.

The 30-second limit also applies to motors equipped with an optional thermostat. If overcranking should occur, the thermostat will open and the cranking cycle will stop to protect the motor. After the motor cools, usually in 1 to 6 minutes, the thermostat will close and then a new start attempt can be made.

Removal

Before removing the starter from the vehicle for repair, perform "Preliminary Checks," in **Section 300**.

1. Turn off all electrical loads such as lights, ignition, and accessories.

⚠ WARNING

WARNING: Batteries release a gas mixture which is explosive if exposed to intense heat such as a cigarette or open flame. The acid is also extremely harmful if splashed in the eyes or on the skin. A load on the battery may cause arcing between the battery terminal and the cable end when the cable is being removed or connected. Therefore, allow sufficient venting of the battery box before removing or connecting the battery cables.Extinguish all flames, and remove any sources of intense heat in the area of the batteries. Wear safety glasses when working around batteries. Review the battery safety precautions located in the electrical section in this manual.

2. Disconnect the batteries.
3. Tilt the hood or cab. Remove the throttle return spring.
4. Disconnect the wires attached to the starter. Mark the wires for later assembly reference.
5. Remove the bolts and lockwashers (**Fig. 1**) that attach the starter to the engine. Remove the starter.

Installation

1. Insert the starter nose housing through the mounting hole in the flywheel housing.
2. Install the three starter mounting bolts and lockwashers. Refer to fastener and torque values table in **Subject 400**.
3. Connect the wires to the starter as previously marked. Tighten the nuts 16 to 30 lbf·in (180 to 340 N·cm).
4. Install the throttle return spring and return the hood or cab to the operating position.
5. Turn off all electrical loads such as lights, ignition switches, and accessories.

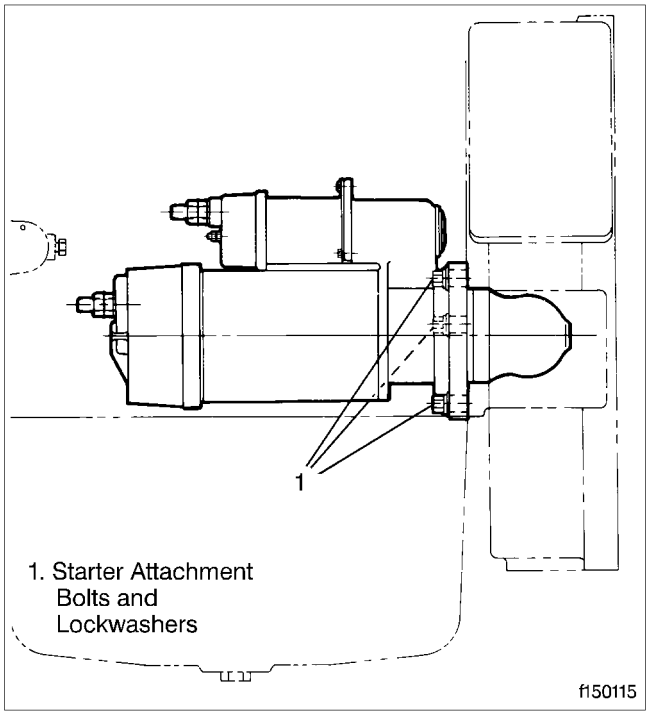


Fig. 1

6. Read the warning listed under "Removal." Then connect the battery cable to the batteries.

Troubleshooting Table

Problem—Starter Cranks Slowly Or Not At All

Problem—Starter Cranks Slowly Or Not At All	
Possible Cause	**Remedy**
The drive belt is loose.	Check the drive belt. See the drive belt subject in the appropriate engine section in **Section 01.07** for instructions. If necessary, tighten to the manufacturer's specifications. Start the engine and check the alternator voltage and output. See the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The drive belt is damaged or missing.	Check the drive pulleys for locked bearings. Repair or replace any damaged components. Replace the drive belt and start the engine. Check the alternator voltage and output. See the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The batteries are undercharged.	Do a load test on the batteries. See **Section 54.02, Subject 140** for instructions. Charge or replace batteries as needed. If the batteries were discharged, check the alternator voltage and output. See the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The battery cables do not deliver sufficient voltage to the starter.	Check the available cranking voltage. Go to "Available Cranking Voltage Test" for instructions.
The starter solenoid circuit is broken.	Check the starter solenoid circuit. Go to "Starter Solenoid Circuit Test" for instructions. Make repairs as needed. Start the engine to verify the repair.
The control circuit is broken.	Check the starter wiring. Go to "Starter Wiring Test" for instructions. Make repairs as needed. Start the engine to verify the repair.
The magnetic switch is broken.	Replace the magnetic switch. Go to **Section 54.04, Subject 100** for replacement instructions.
The starter does not stay engaged.	Go to "Cold Weather Starting Test" for instructions.
The starter ring gear or pinion gear is damaged.	Visually check the ring and pinion gears. Go to "Ring and Pinion Gear Test" for instructions.
The starter is damaged.	Replace the starter.
There is a mechanical problem in the engine.	See **Group 01** or the engine manufacturer's manuals.

Troubleshooting Chart

Problem—Starter Spins, But Does Not Crank

For troubleshooting instructions, see **Fig. 1**.

Problem—Starter Makes Clicking Noise, But Does Not Crank (Or Cranks Intermittently)

For troubleshooting instructions, see **Fig. 1**.

Available Cranking Voltage Test

BATTERY CABLE TEST

1. Connect the positive lead of a carbon pile tester to the starter solenoid "B" terminal. Connect the negative lead of the carbon pile to the starter "G" (ground) terminal. See **Fig. 2**.

Troubleshooting

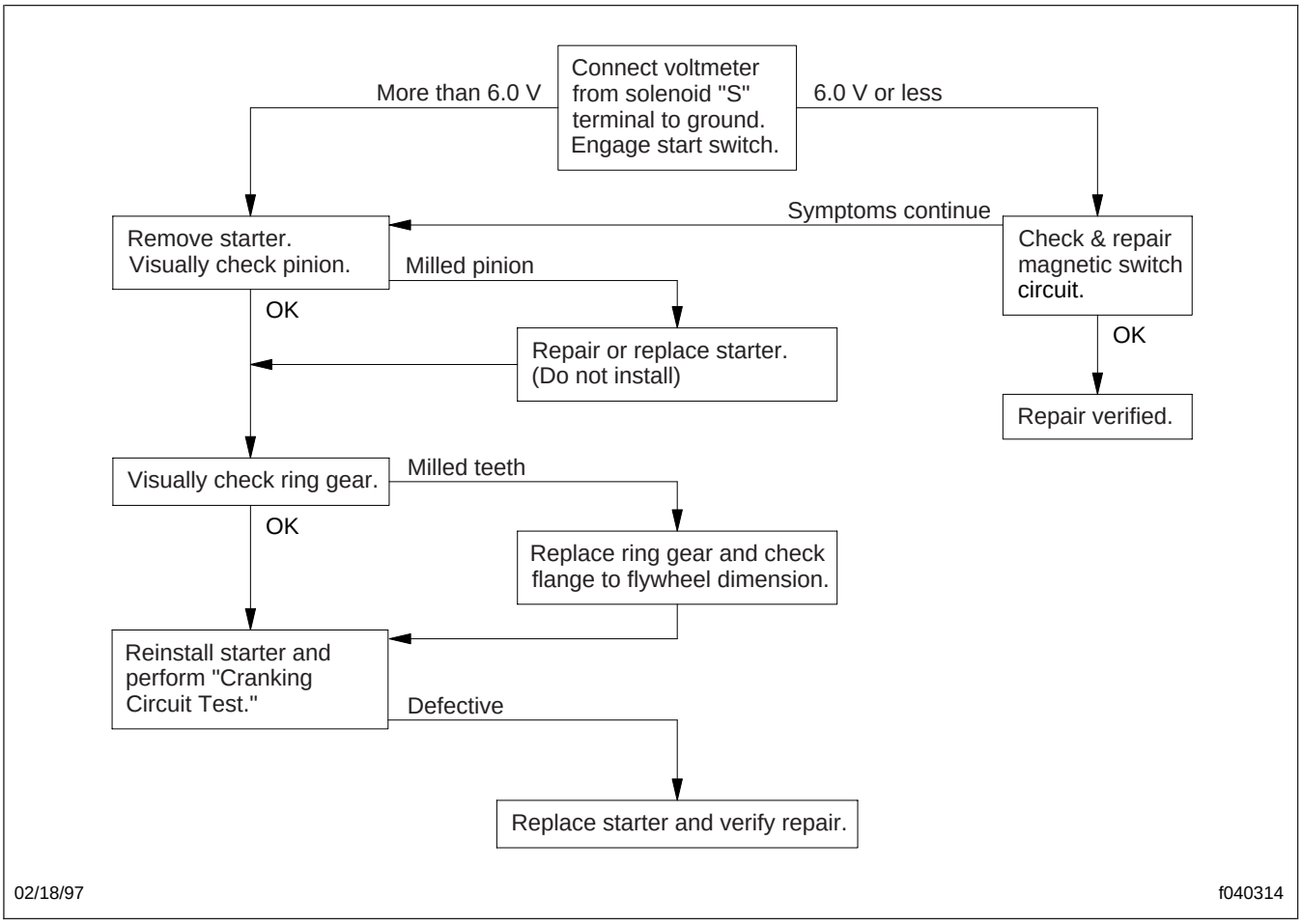


Fig. 1, Troubleshooting Chart: Milled Pinion Symptoms

IMPORTANT: Connect the voltmeter to the starter "B" terminal, not to the carbon pile clamp.

2. Set a digital voltmeter on the low scale (2V, 3V, or 4V, depending on type of meter) and connect the positive lead to the battery positive (+) terminal. Connect the negative lead to the starter "B" (battery) terminal.
3. Turn on the carbon pile and adjust it to a 500-amp load. Read and record the voltage (V1) on the voltmeter. Turn off the carbon pile.
4. Now connect the digital voltmeter (still set on the low scale) to the battery negative (–) terminal and the starter "G" (ground) terminal.

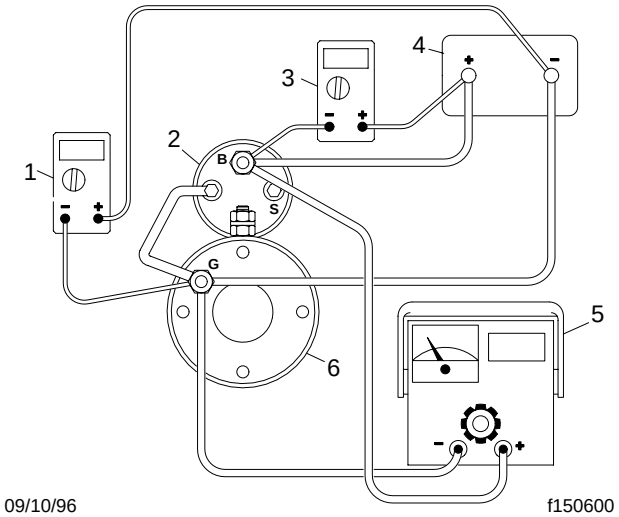
IMPORTANT: Connect the voltmeter to the starter "G" terminal, not to the carbon pile clamp.

5. Turn on the carbon pile again and adjust it to a 500-amp load, as before. Read and record the voltage (V2) on the voltmeter. Turn off the carbon pile.

NOTE: Ignore the minus (–) sign.

6. Add the positive (V1) and the negative (V2) voltage loss readings together. If the total voltage loss is 0.500 volts or less, the battery cables are OK.

   Add the positive (V1) and the negative (V2) voltage loss readings together. If the total voltage



1. Voltmeter (recording V2, negative side voltage loss)
2. Cranking Motor
3. Voltmeter (recording V1, positive side voltage loss)
4. Battery
5. Carbon Pile
6. Starter Solenoid

Fig. 2, Battery Cable Test

loss is more than 0.500 volts, repair or replace as necessary.

7. Disconnect the carbon pile and the voltmeter. Reconnect the magnetic switch to the starter "S" terminal.

INTERCONNECTING CABLE TEST

1. This test requires two persons. While the first person cranks the engine, the second person uses a voltmeter to measure the voltage across the starter solenoid "B" (battery) and "G" (ground) terminals.
2. If the voltage is 9.0 volts or less while cranking (18.0 volts on a 24V system), check the battery interconnecting cables.
   - 2.1 While cranking, measure the voltage across each battery.
   - 2.2 If the difference between any two batteries in the same battery box is more than 0.5 volt, check and replace the interconnecting cables as required.
   - 2.3 If any cable or connection feels warm to the touch, check and replace the interconnecting cables as required.
3. If the starter still does not crank, go to "Ring and Pinion Gear Test."

Starter Solenoid Circuit Test

The starter solenoid circuit includes the starter solenoid, cranking motor, magnetic switch, and ignition keyswitch. It is part of the cranking circuit. For cranking circuit wiring, see Section 54.00, **Specifications, 400**.

If there is excessive voltage loss in the starter solenoid circuit, the starter may not engage the flywheel at all, or it may drop out too soon when battery voltage goes down. Do the following test to check for excessive voltage loss in the starter solenoid circuit.

1. Disconnect, at the solenoid, the lead from the magnetic switch to the "S" terminal on the starter solenoid.
2. Use a small clamp or 8-gauge jumper wire to connect this lead to the positive lead of a carbon pile tester. Connect the negative lead of the carbon pile to the starter "G" (ground) terminal. See **Fig. 3**.
3. Set a digital voltmeter on the high (20V) scale and connect the positive lead to the starter "B" (battery) terminal. Connect the negative lead to the magnetic switch terminal to which the carbon pile is already connected.
4. Read and record (as V3) the battery voltage shown on the meter, about 12.6V.

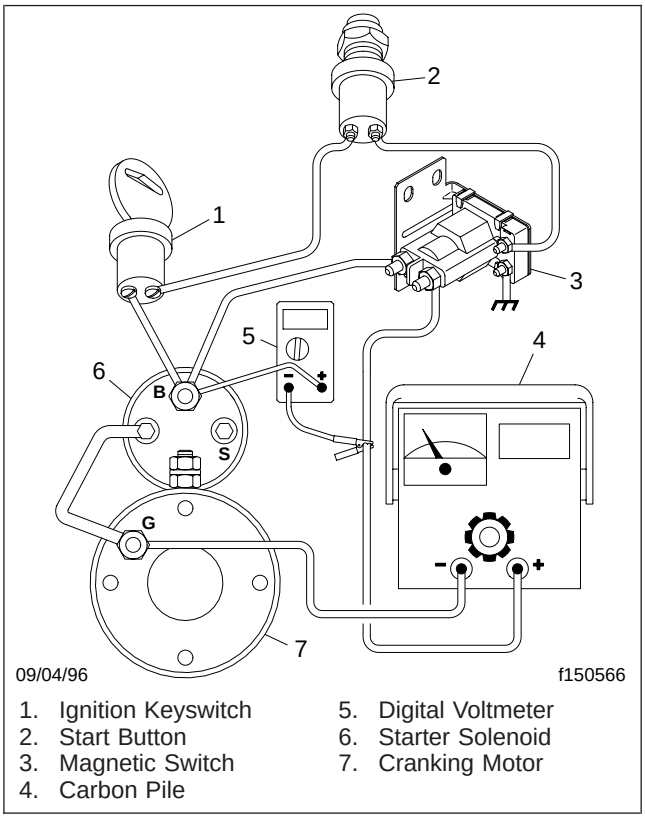
NOTE: This step requires two persons.

5. Have one person turn the ignition keyswitch to the START position and then push the start button, while the other person listens for the clicking sound of the magnetic switch closing. Read the voltage on the voltmeter. It should read very low voltage, less than 0.1V.

IMPORTANT: If the magnetic switch does not close, do the "Magnetic Switch Circuit Test." For instructions, see **Section 54.04**.

6. Check the starter solenoid circuit voltage loss.

Troubleshooting



1. Ignition Keyswitch
2. Start Button
3. Magnetic Switch
4. Carbon Pile
5. Digital Voltmeter
6. Starter Solenoid
7. Cranking Motor

Fig. 3, Starter Solenoid Circuit Test

6.1 Turn the ignition keyswitch to the START position and push the start button; then turn on the carbon pile and adjust it to a 100-amp load.

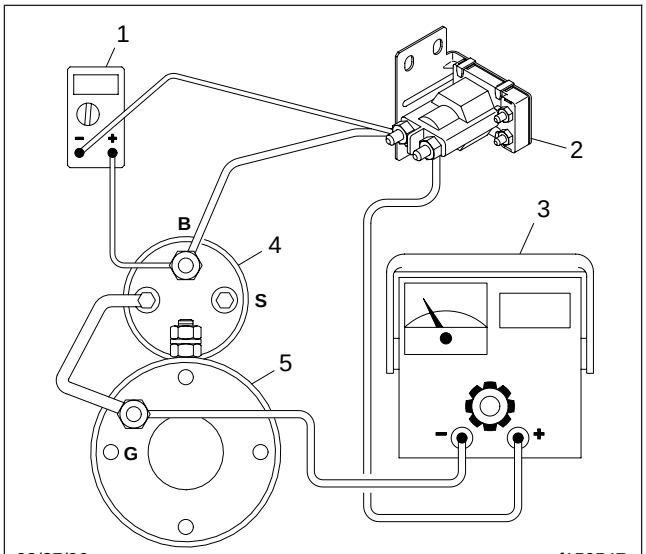
6.2 Now read and record (as V4) the voltage on the voltmeter. Turn off the carbon pile.

6.3 If the voltage drop (V4–V3) is 1.0V or less, the starter solenoid circuit is OK. Do the "Magnetic Switch Circuit Test." For instructions, see **Section 54.04**.

If the voltage drop (V4–V3) is more than 1.0V, the voltage loss is excessive. Go to "Starter Wiring Test."

Starter Wiring Test

1. Disconnect the lead from the magnetic switch to the "S" terminal on the starter solenoid (leave as in "Starter Solenoid Circuit Test").
2. Connect this lead to the positive lead of a carbon pile tester. Connect the negative lead of the carbon pile to the starter "G" (ground) terminal (leave as in "Starter Solenoid Circuit Test").
3. Set a digital voltmeter on the low scale and connect the positive lead of the voltmeter to the starter solenoid "B" (battery) terminal. Connect the negative lead of the voltmeter to the large terminal of the magnetic switch that is connected to the starter "B" terminal (circuit 82). See **Fig. 4**. If any voltage shows, reconnect to the other large terminal.



1. Digital Voltmeter
2. Magnetic Switch
3. Carbon Pile
4. Starter Solenoid
5. Cranking Motor

Fig. 4, Starter Wiring Test—First Wire Voltage Loss (V5)

NOTE: If desired, do a continuity check on the circuit to be sure that it is connected to the correct terminal. Low resistance indicates that the connections are correct.

4. Have a second person push and hold in the start button momentarily.

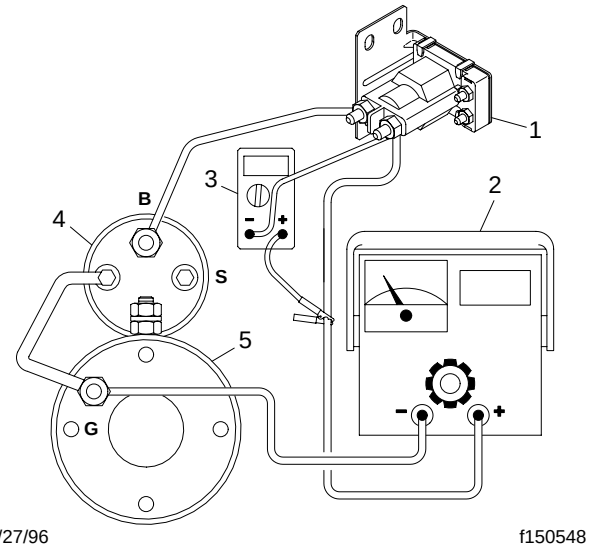
IMPORTANT: If the magnetic switch does not close, do the "Magnetic Switch Circuit Test." For instructions, see **Section 54.04**.

5. Check the first wire voltage loss (V5).

5.1 Turn the ignition keyswitch to the START position and push the start button; then turn on the carbon pile and adjust it to a 100-amp load.

5.2 Now read and record the voltage (V5) on the voltmeter. Turn off the carbon pile.

6. Now connect the positive lead of the digital voltmeter (still set on the low scale) to the magnetic switch lead which is already connected to the carbon pile (as in "Starter Solenoid Circuit Test"). Connect the negative lead of the voltmeter to the other large terminal on the magnetic switch (circuit 74). See **Fig. 5**.



1. Magnetic Switch
2. Carbon Pile
3. Digital Voltmeter
4. Starter Solenoid
5. Cranking Motor

Fig. 5, Starter Wiring Test—Second Wire Voltage Loss (V6)

7. Have a second person start the engine momentarily.

8. Check the second wire voltage loss (V6).

NOTE: Ignore the minus (–) sign.

8.1 Turn the ignition keyswitch to the START position and push the start button; then turn on the carbon pile and again adjust it to a 100-amp load.

8.2 Now read and record the voltage (V6) on the voltmeter. Turn off the carbon pile.

8.3 Add the two voltages (V5 and V6) together to get the total wire voltage loss. If the total wire voltage loss adds up to 0.8 volts or less, the wiring is OK. Replace the magnetic switch. For instructions, see **Section 54.04, Subject 100**.

If the total wire voltage loss adds up to more than 0.8 volts, check the wire connections for tightness and the terminals for corrosion. Repair or replace as necessary.

9. Disconnect the carbon pile and the voltmeter. Reconnect the magnetic switch to the starter "S" terminal.

10. Check all wiring and connections and repair or replace as needed. For instructions on wire repair, see **Section 54.00**.

Magnetic Switch Circuit Test

For the "Magnetic Switch Circuit Test," see **Section 54.04**.

Ring and Pinion Gear Test

1. This test requires two persons. While the first person bars the engine over, the second person visually checks the entire ring gear and pinion gear visually (check all the teeth in both gears).

2. If the pinion teeth are damaged, replace the starter. If the ring gear teeth are damaged, replace the ring gear.

NOTE: For ring gear replacement procedures, see the engine manufacturer's manuals.

3. If the engine still does not crank properly after replacing the starter, look for a mechanical problem in the engine. For instructions, see **Group 01** or the engine manufacturer's manuals.

Cold Weather Voltage Test

In cold weather, the starter may fail to engage, even though it performed well at higher temperatures. Do the following test to check for cold weather voltage loss in the cranking circuit.

Troubleshooting

1. With the ignition keyswitch on, clamp a heavy battery jumper cable between the two large studs on the magnetic switch. Remove the jumper immediately to stop the engine from cranking.
2. If the engine starts with the jumper in place, do the "Starter Wiring Test." Repair/replace the wiring connections, terminals, and/or magnetic switch as necessary.
3. If the engine now starts properly, check the starter mounting bolts for tightness and do the "Alternator Wiring Test." See the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
4. If the engine still does not start properly, go to "Available Cranking Voltage Test."

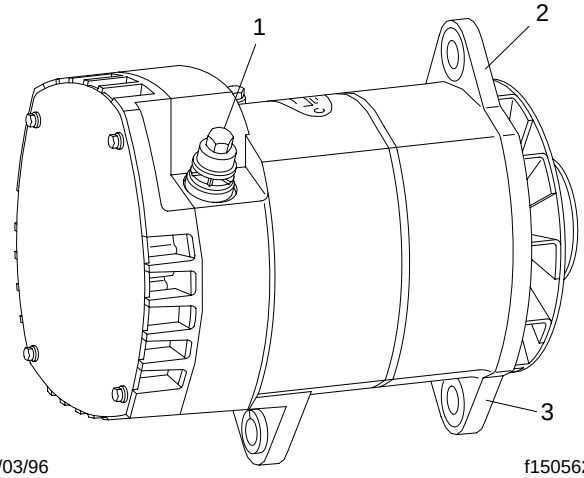
Specifications

Fastener Torque Values			
Description	**Size**	**Torque**	
		lbf·ft (N·m)	**lbf·in (N·cm)**
Nose Housing Bolts	5/16–18	13–17 (18–23)	—
Frame Capscrews (Grade 8)	1/4–28	—	144–192 (1620–2160)
Solenoid Mounting Bolts (Grade 8)	1/4–20	—	150–200 (1700–2260)
Copper Terminals	1/2–13	20–25 (27–34)	—
Solenoid Side Terminals	10–32	—	16–30 (180–340)
Brush Screw	8–32	—	18–24 (200–280)
Frame Plug	1-3/8–18	—	48–72 (540–820)
Starter–Motor to Flywheel–Housing Bolts			
Detroit Diesel (Steel Housing)	5/8–16	137–147 (186–199)	—
Detroit Diesel (Aluminum Housing)	5/8–16	85–95 (115–129)	—
Caterpillar (Steel or Aluminum Housing)	5/8–16	130–170 (176–230)	—
Cummins (Steel or Aluminum Housing)	5/8–16	130–170 (176–230)	—

Table 1, Fastener Torque Values

General Description

The Delco Remy 25–SI series alternator (see **Fig. 1**) is a self-rectifying, brushless unit featuring a built-in voltage regulator. The only moving part in the assembly is the rotor, which is mounted on a ball bearing at the drive end, and a roller bearing at the rectifier end. The field winding, stator windings, six rectifying diodes, and the regulator circuit components are all stationary. The regulator and diodes are enclosed in a sealed compartment.



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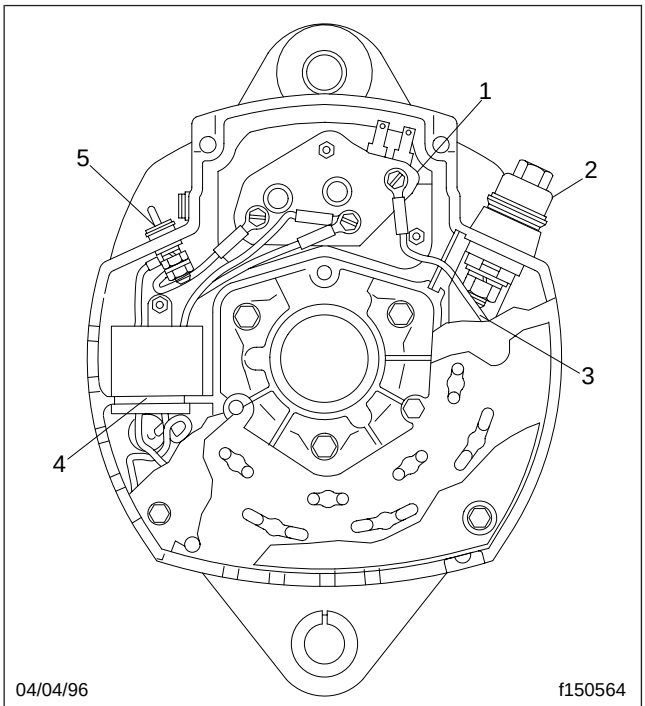
1. Output (BAT) Terminal
2. Adjusting Lug
3. Mounting Lug

Fig. 1, 25/26-SI Alternator

The 26–SI alternator is an improved version of the 25–SI. The integrated-circuit regulator is designed for low-speed start-up. See **Fig. 2**. A special diode trio/capacitor assembly provides superior radio frequency interference (RFI) suppression.

The electronic parts of the 26–SI are protected in two ways. Standard load dump protection guards against voltage spikes caused by loose connections or interruptions in the charging line. Total environmental sealing physically protects against dirt, road salt, and other corrosive materials.

On both 26–SI and 25–SI alternators, a fan located on the drive end provides airflow for cooling. Extra-large grease reservoirs contain an adequate supply of lubricant so that no periodic maintenance is required. For 26–SI internal components (side view), see **Fig. 3**. For 25–SI internal components (side and rear view), see **Fig. 4**.



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1. Voltage Regulator
2. Output (BAT) Terminal
3. Sensing Lead
4. Diode Trio/Capacitor
5. Relay (R) Terminal

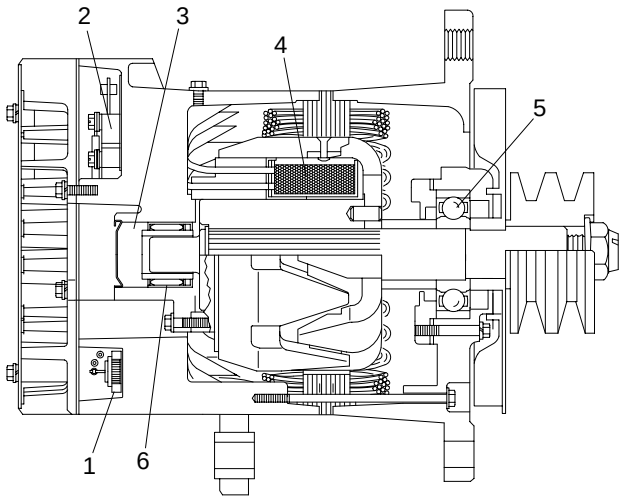
Fig. 2, 26-SI Alternator Components (view from rectifier end)

Only one wire connects the alternator to the battery, along with a ground return. The specially designed output terminal is connected directly to the battery. Since the vehicle's electrical system is negative ground, the output terminal connects to the battery's positive terminal. A relay terminal labeled "R" is available for use in some circuits to operate auxiliary equipment. The hex-head bolt on the output terminal is electrically insulated; no voltage reading can be obtained by connecting to the hex-head bolt.

Principles of Operation

As the rotor begins to turn, the permanent magnetism within induces voltages in the stator windings. The voltages across the six diodes cause current to flow, charging the battery. See **Fig. 5**.

General Information



1. Rectifiers
2. Voltage Regulator
3. Grease Reservoir
4. Field Coil
5. Ball Bearing
6. Roller Bearing

Fig. 3, 26-SI Alternator Components (side view)

Current from the stator flows through the three diodes to resistor R6 and the base-emitter of TR2 and TR1, to turn on these transistors. Current also flows from the stator through the diode trio (D1, D2, and D3), the field coil and transistor TR1, returning to the stator through the other three diodes. All stator current, except through the diode trio (D1, D2, and D3) flows through the six diodes connected to the stator.

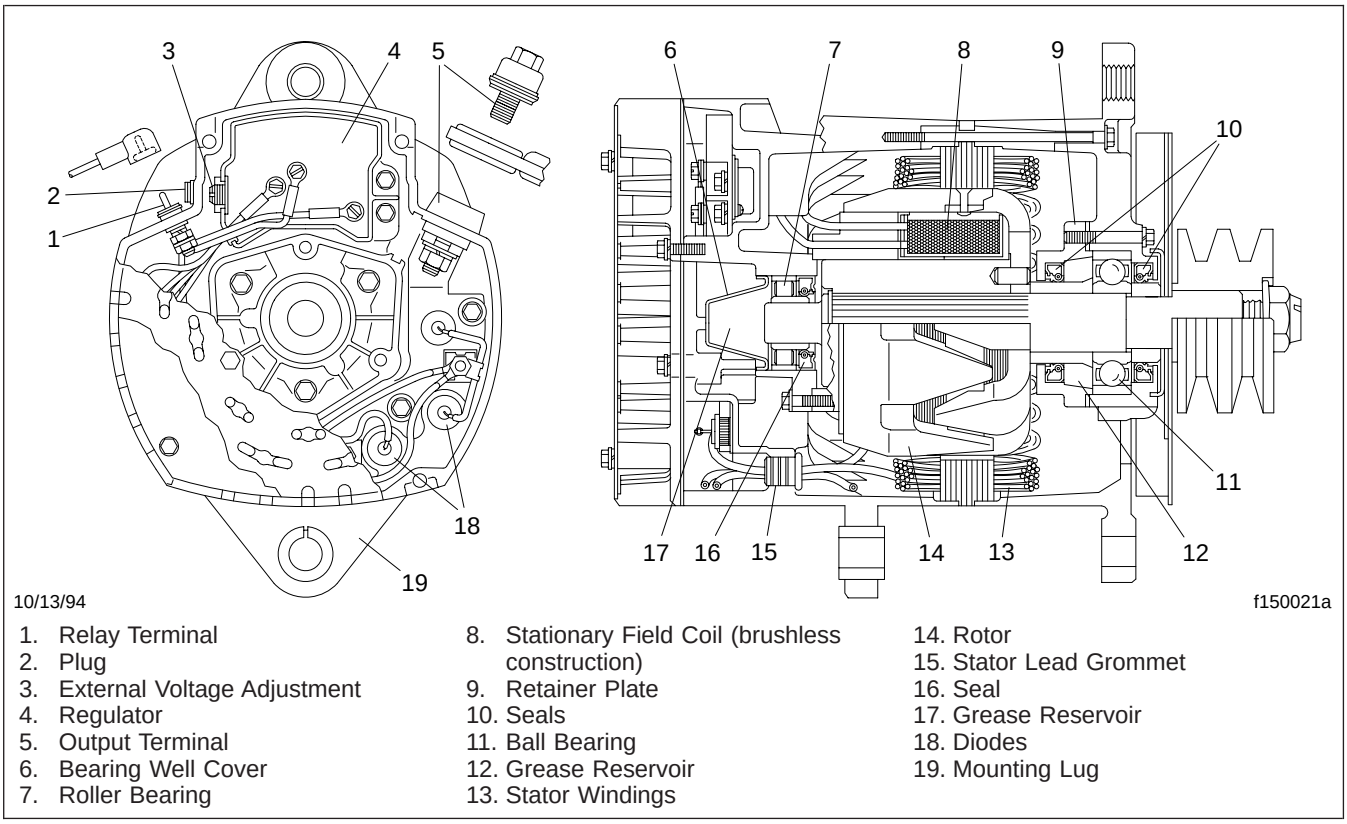
Current flow through R1, R2, and R3 causes voltage to appear at the zener diode D4. When the voltage becomes high enough due to increasing alternator speed, D4 and the base-emitter of TR3 conduct current and turn on TR3. TR2 and TR1 then turn off, decreasing the field current and the system voltage. The voltage at D4 decreases; D4 and TR3 turn off; TR2 and TR1 turn back on and the system voltage increases. This cycle then repeats many times per second, limiting the system voltage as determined by the setting of R2 and R3.

The capacitor C1 protects the diodes from high transient voltages and suppresses radio interference.

The resistor R5 prevents current leakage through TR3 at high temperatures.

The diode D5 prevents high transient voltages in the field coil when the field current is decreasing.

The resistor R7, capacitor C3, and resistor R4 all cause transistors TR2 and TR1 to turn on and off quickly.



1. Relay Terminal
2. Plug
3. External Voltage Adjustment
4. Regulator
5. Output Terminal
6. Bearing Well Cover
7. Roller Bearing
8. Stationary Field Coil (brushless construction)
9. Retainer Plate
10. Seals
11. Ball Bearing
12. Grease Reservoir
13. Stator Windings
14. Rotor
15. Stator Lead Grommet
16. Seal
17. Grease Reservoir
18. Diodes
19. Mounting Lug

Fig. 4, 25-SI Alternator Components

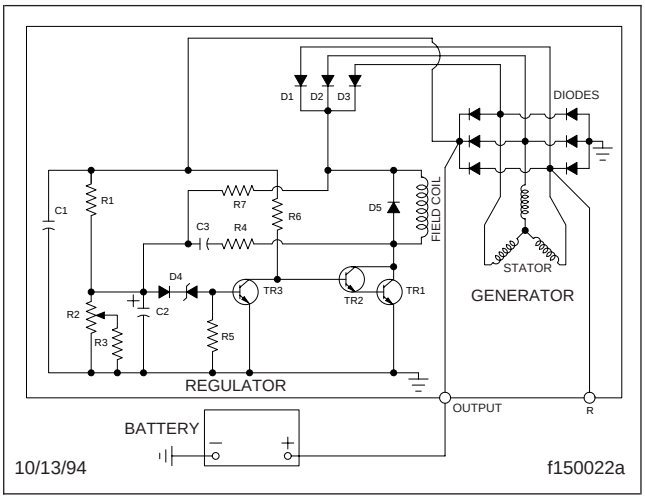


Fig. 5, Wiring Diagram, Negative Ground Circuit

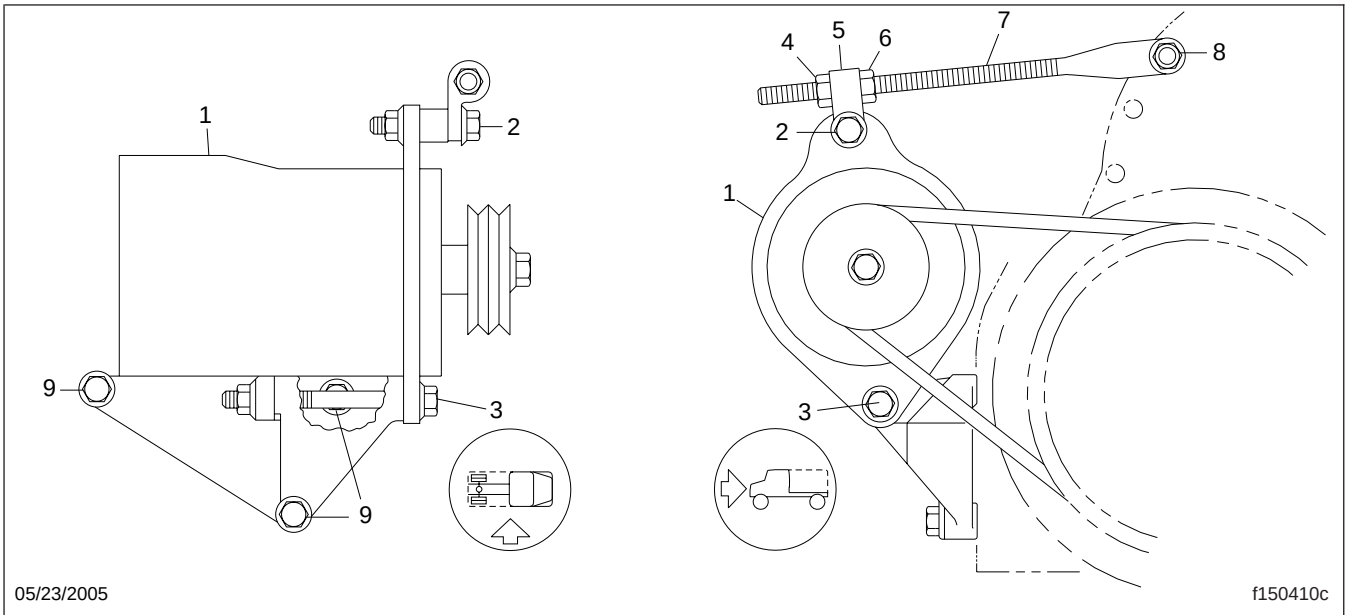
25/26–SI Alternator Removal and Installation, Cummins N14/NTC

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Loosen the adjusting rod mounting capscrew (see **Fig. 1**, Ref. 8).

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine with the end link attached. Install the alternator mounting capscrew, but do not tighten it yet.



1. 25/26–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Capscrew

Fig. 1, Alternator Installation, Cummins N14/NTC Engine

4. Loosen the end link mounting capscrew and the alternator mounting capscrew (see **Fig. 1**, Refs. 2 and 3). Turn the adjusting nut (Ref. 6) counterclockwise, backing the alternator toward the drive pulley far enough to remove the drive belt without prying or twisting the belt. Remove the drive belt from the vehicle.
5. Remove the adjusting rod jam nut (Ref. 4) and alternator mounting capscrew. Remove the alternator from the vehicle with the end link attached.
6. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley.
4. Tighten the adjusting nut (see **Fig. 1**, Ref. 6) until the belt is correctly tensioned. For belt tightening specifications, see **Section 01.07, Subject 100**. While holding the adjusting nut in place, install the adjusting rod jam nut and tighten it 95 lbf·ft (130 N·m).
5. Tighten the end link mounting capscrew and the alternator mounting capscrew 65 lbf·ft (88 N·m). Tighten the adjusting rod mounting capscrew 50 lbf·ft (68 N·m).

25/26–SI Alternator Removal and Installation, Cummins N14/NTC

6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

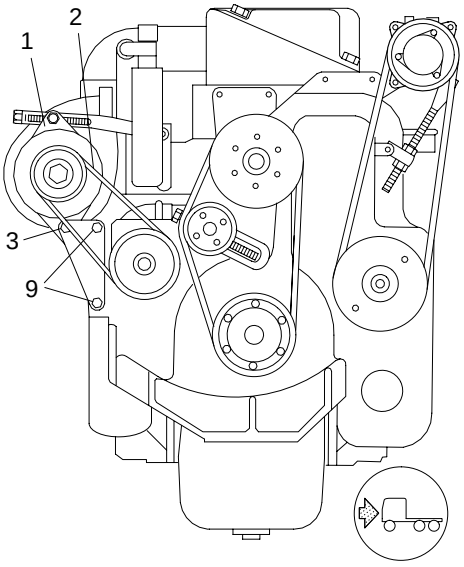
25/26–SI Alternator Removal and Installation, Cummins M11/L10

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Loosen the adjusting block mounting bolt, adjusting arm mounting capscrew, and alternator mounting capscrew just enough to allow movement of the alternator. See **Fig. 1**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine. Install the adjusting block mounting bolt and the alternator mounting capscrew, but do not tighten them yet.
3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley.



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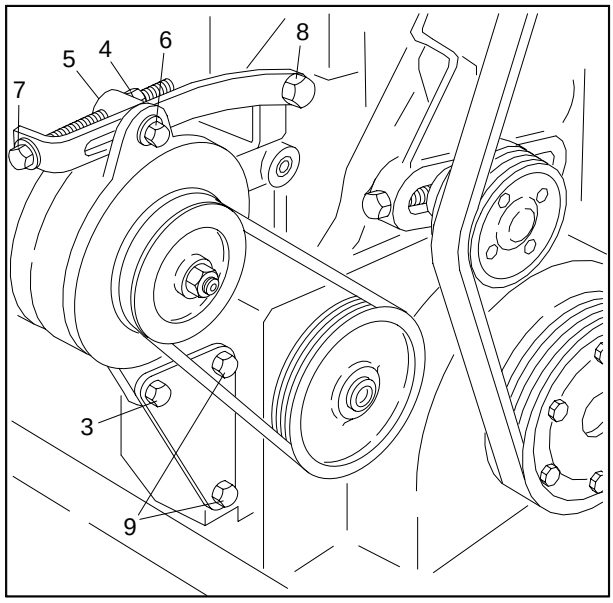

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1. 25/26–SI Alternator
2. Drive Belt
3. Alternator Mounting Capscrew
4. Adjusting Screw Locknut
5. Adjusting Block
6. Adjusting Block Mounting Bolt
7. Adjusting Screw
8. Adjusting Arm Mounting Capscrew
9. Alternator Bracket Fasteners

Fig. 1, Alternator Installation, Cummins M11/L10 Engine

4. Loosen the adjusting screw locknut. See **Fig. 1**, Ref. 4. Turn the adjusting screw (Ref. 7) counterclockwise, backing off the alternator toward the drive pulley far enough to remove the drive belt without prying or twisting the belt. Remove the drive belt from the vehicle.
5. Remove the adjusting block mounting bolt and the alternator mounting capscrew. Remove the alternator from the vehicle.
6. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

4. Turn the adjusting screw (see **Fig. 1**, Ref. 7) clockwise until the belt is correctly tensioned. For belt tightening specifications, see **Section 01.07, Subject 110**. Tighten the adjusting screw locknut (Ref. 4) 95 lbf·ft (130 N·m).
5. Tighten the alternator mounting capscrew (see **Fig. 1**, Ref. 3) 65 lbf·ft (88 N·m); tighten the adjusting block mounting bolt (Ref. 6) 30 lbf·ft (41 N·m); tighten the adjusting arm mounting capscrew (Ref. 8) 55 lbf·ft (75 N·m).

25/26–SI Alternator Removal and Installation, Cummins M11/L10

6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

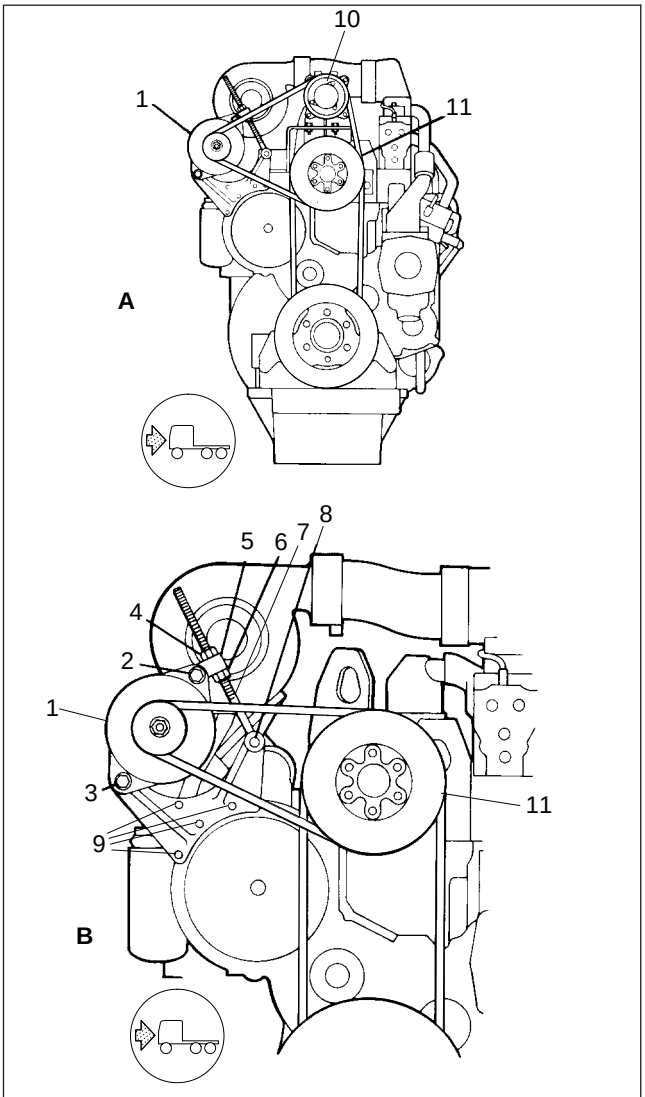
25/26–SI Alternator Removal and Installation, Caterpillar 3306

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Loosen the end link and alternator mounting capscrews (see **Fig. 1**, Ref. 2 and 3) and the adjusting rod mounting capscrew (Ref. 8).
4. Back off the adjusting nut (see **Fig. 1**, Ref. 6) on the adjusting rod, allowing the alternator to be moved far enough toward the drive pulley to remove the fan drive belt without prying or twisting the belt. Remove the drive belt from the vehicle.
5. Remove the end link and alternator mounting capscrews. Remove the alternator from the vehicle.
6. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine. Install the end link and alternator mounting capscrews, but do not tighten them yet.
3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley.
4. Loosen the adjusting rod jam nut (see **Fig. 1**, Ref. 4). Then, tighten the adjusting nut (Ref. 6) until the belt is correctly tensioned. For belt tightening specifications, see **Section 01.07, Subject 120**. While holding the adjusting nut in place, tighten the adjusting rod jam nut 65 lbf·ft (88 N·m).
5. Tighten the end link mounting capscrew, the alternator mounting capscrew, and the adjusting rod mounting capscrew 65 lbf·ft (88 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.



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A. With Refrigerant Compressor
B. Without Refrigerant Compressor

1. 25/26–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners
10. Refrigerant Compressor
11. Fan Drive

Fig. 1, Alternator Installation, Caterpillar 3306 Engine

25/26–SI Alternator Removal and Installation, Caterpillar 3306

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Trouble-shooting, 300**.

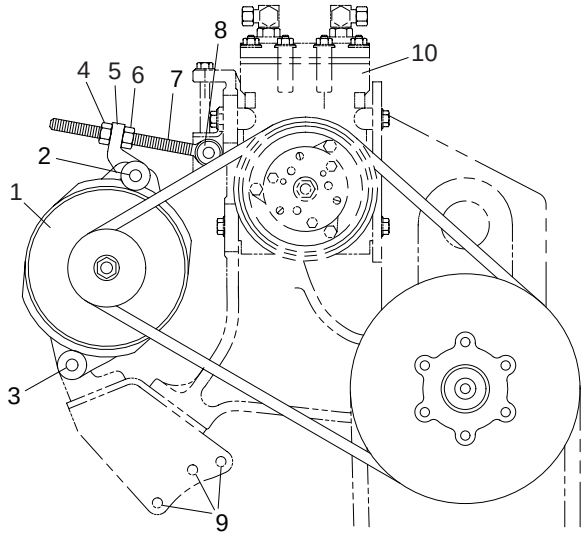
25/26–SI Alternator Removal and Installation, Caterpillar 3406

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.

NOTE: Three different installations are possible-.For vehicles with a piston-type refrigerant compressor, see **Fig. 1**. For vehicles with a rotary (swash-plate) refrigerant compressor, see **Fig. 2**. For vehicles with no air conditioning, see **Fig. 3**.

3. Back off the adjusting nut (Ref. 6, all figures). Loosen the end link mounting capscrew and the alternator mounting capscrew enough to allow movement of the alternator.



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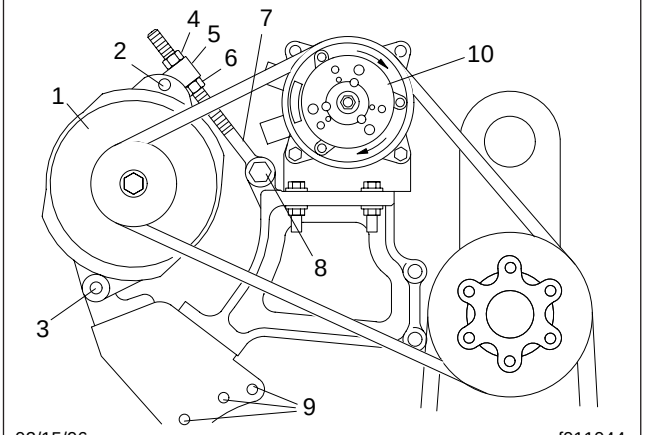
1. 25/26–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners
10. Refrigerant Compressor

Fig. 1, Alternator Installation, Caterpillar 3406 Engine with Piston-Type Refrigerant Compressor



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1. 25/26–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners
10. Refrigerant Compressor

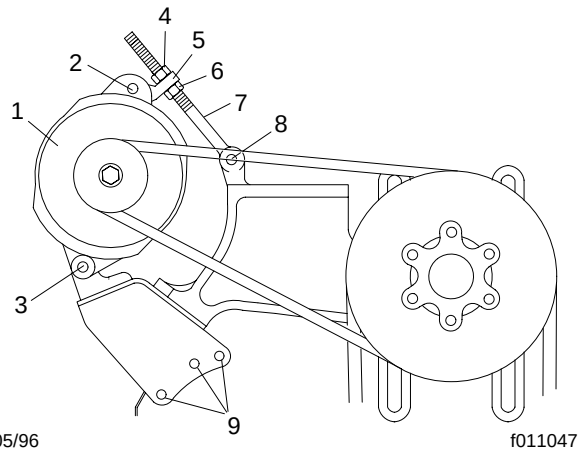
Fig. 2, Alternator Installation, Caterpillar 3406 Engine with Rotary Refrigerant Compressor

4. Push the loosened alternator far enough toward the fan drive pulley to allow removal of the drive belts without using force.
5. Slip each drive belt (dual drive belts) off the pulleys and work it over one fan blade at a time. Remove both belts from the vehicle.
6. Remove the two mounting capscrews already loosened. Remove the alternator from the vehicle.
7. Inspect the drive belts. For instructions, see **Section 01.07, Subject 180**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine. Install the end link mounting capscrew and the alternator mounting capscrew, but do not tighten them yet.

25/26–SI Alternator Removal and Installation, Caterpillar 3406



1. 25/26–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners

Fig. 3, Alternator Installation, Caterpillar 3406 Engine with No Air Conditioning

3. Make sure the distance between the pulleys is short enough to allow belt installation without using force.
4. Work each belt over the fan blades, one blade at a time. Install both drive belts on the pulleys without prying or rolling them into place. For belt tightening procedures and specifications, see **Section 01.07, Subject 150**.
5. After each belt has been correctly tensioned, tighten the adjusting rod jam nut 65 lbf·ft (88 N·m).
6. Tighten both the end link and the alternator mounting capscrew 65 lbf·ft (88 N·m).
7. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
8. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

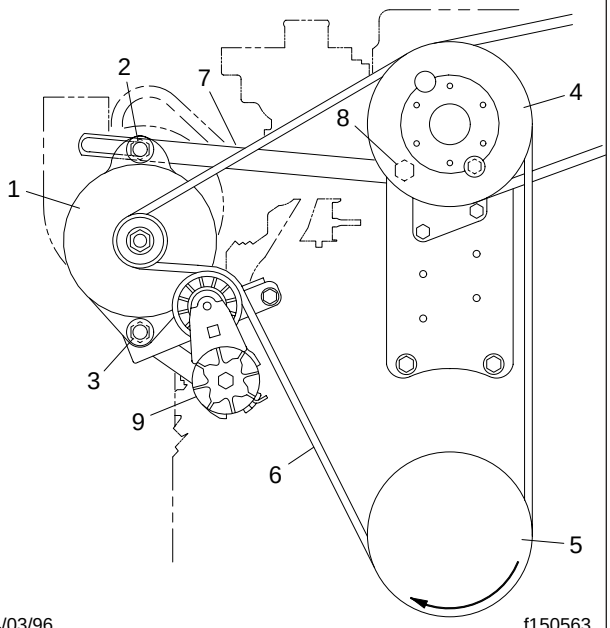
Table 1, Approved Dielectric Red Enamel

9. Connect the batteries.
10. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

25/26–SI Alternator Removal and Installation, Caterpillar 3176/C–10

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Insert a 1/2-inch breaker bar in the belt tensioner and rotate the tensioner down and off the alternator drive belt. See **Fig. 1** for slotted-strap alternators. See **Fig. 2** for fixed-strap alternators.

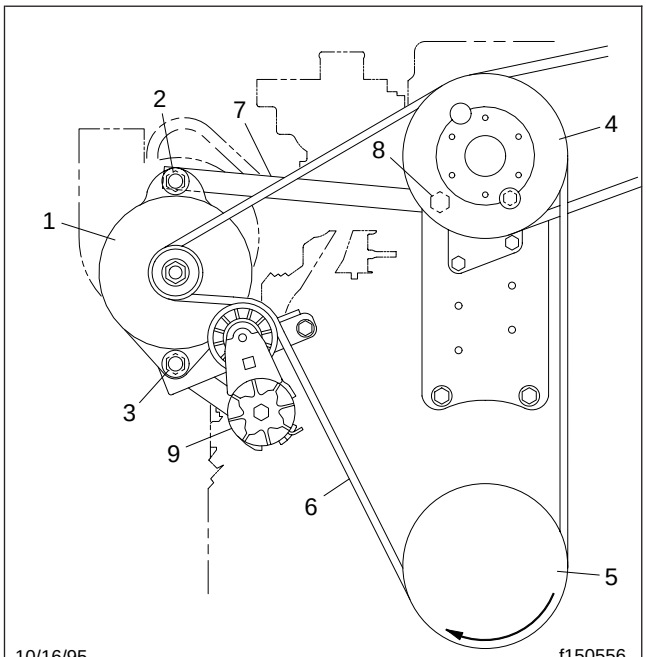


Rotate the belt tensioner down and off the belt.

1. 25/26–SI Alternator
2. Alternator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Fan Pulley
5. Vibration Damper
6. Alternator Drive Belt
7. Adjusting Strap
8. Adjusting Strap Mounting Capscrew
9. Belt Tensioner

Fig. 1, Alternator Installation, Caterpillar 3176/C-10 Engine, Slotted Strap

NOTE: There are two drive belts to remove. Before removing the alternator belt, it is necessary to remove the refrigerant compressor belt from its pulleys.



Rotate the belt tensioner down and off the belt.

1. 25/26–SI Alternator
2. Alternator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Fan Pulley
5. Vibration Damper
6. Alternator Drive Belt
7. Adjusting Strap
8. Adjusting Strap Mounting Capscrew
9. Belt Tensioner

Fig. 2, Alternator Installation, Caterpillar 3176 Engine, Fixed Strap

4. Holding the belt tensioner down, remove each drive belt from its pulley. Slowly release the belt tensioner and remove the breaker bar.
5. Lower each drive belt, and take it off the vibration damper. It is not necessary to remove either belt from the vehicle.
6. Remove both alternator mounting capscrews. Remove the alternator from the vehicle.

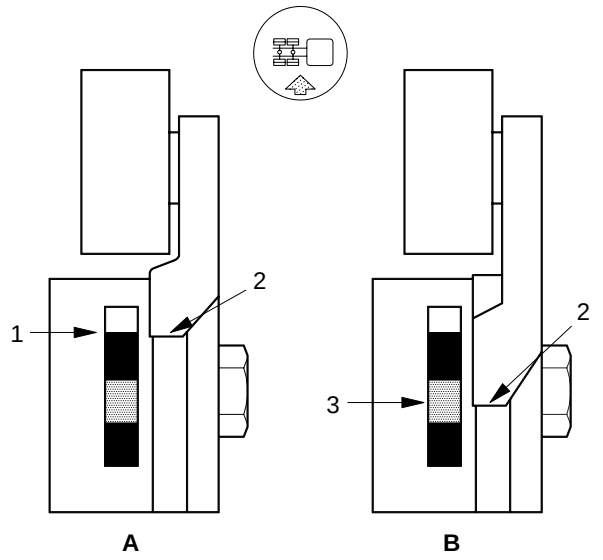
NOTE: It is not necessary to remove the adjusting strap from the engine.

7. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

25/26–SI Alternator Removal and Installation, Caterpillar 3176/C–10

Installation

1. Check the torque of the adjusting strap mounting capscrew. If necessary, tighten it 65 lbf·ft (88 N·m).
2. Install the alternator on the engine. If the alternator adjusting strap is slotted, install the alternator at the inboard edge of the slot initially. Install the top and bottom alternator mounting capscrews, but do not tighten them yet.
3. Install the drive belts on the pulleys. For belt tightening procedures and specifications, see **Section 01.07, Subject 130**.
4. On slotted straps, verify that the edge of the tensioner arm is within the green zone on the decal. See **Fig. 3**. If within the red zone, pivot the alternator outboard until the tensioner arm enters the green zone.



A. Belt Off, No Tension
B. Belt On, Correct Tension
1. Decal
2. Edge of Tensioner Arm
3. Green Zone (operating range)

Fig. 3, Belt Tensioner With Decal

NOTE: If the belt slips, repair or replace the tensioner. For instructions, see the Caterpillar 3176 or C–10 Truck Engine Service Manual.

5. When the alternator is correctly positioned, tighten both alternator mounting capscrews 65 lbf·ft (88 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

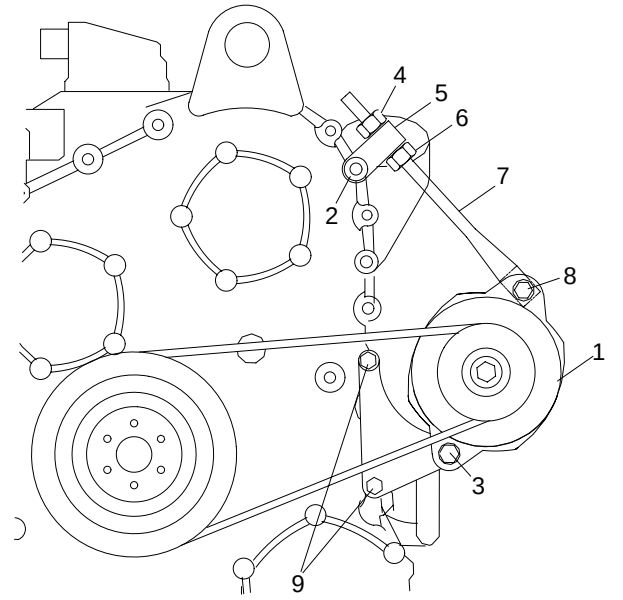
Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

25/26–SI Alternator Removal and Installation, DDC 50

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Loosen the end link mounting capscrew (see **Fig. 1** Ref. 2), the adjusting rod mounting capscrew (Ref. 8), and the alternator mounting capscrew (Ref. 3).



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1. 25/26–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners

Fig. 1, Alternator Installation, Detroit Diesel Series 50

4. Back off the adjusting nut (see **Fig. 1**, Ref. 6). Turn the adjusting rod jam nut (Ref. 4) to rotate the alternator up and toward the engine. Make sure the distance between the pulley centers is now short enough to allow belt removal without using force.
5. When the alternator is close enough to the engine, slip the drive belt off the pulleys without rolling or prying the belt. Remove the drive belt from the vehicle, working the belt over one fan blade at a time.
6. Remove the alternator and adjusting rod mounting capscrews. Remove the alternator from the vehicle.
7. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 43 to 54 lbf·ft (58 to 73 N·m).
2. Install the alternator on the engine. Install the alternator mounting capscrew and the adjusting rod mounting capscrew, but do not tighten them yet.
3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley.
4. Loosen the adjusting rod jam nut (see **Fig. 1**, Ref. 4). Then, tighten the adjusting nut (Ref. 6) until the belt is at the correct tension. For belt tightening specifications, see **Section 01.07, Subject 160**. While holding the adjusting nut in place, tighten the adjusting rod jam nut 95 lbf·ft (130 N·m).
5. Tighten the alternator mounting capscrew and the end link mounting capscrew 65 lbf·ft (88 N·m).
6. Tighten the adjusting rod mounting capscrew 45 lbf·ft (61 N·m).
7. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
8. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC

25/26–SI Alternator Removal and Installation, DDC 50

Protectant Material	Approved Brands
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

9. Connect the batteries.
10. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Trouble-shooting, 300**.

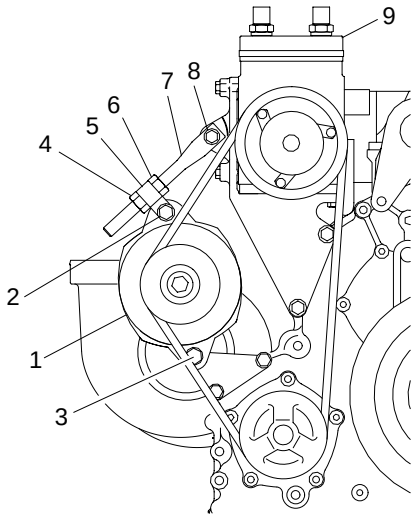
25/26–SI Alternator Removal and Installation, DDC 60

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.

NOTE: Three different installations are possible. For DDEC III vehicles with air conditioning (top-mounted refrigerant compressor), see **Fig. 1**. For DDEC II vehicles with air conditioning (side-mounted refrigerant compressor), see **Fig. 2**. For vehicles with no air conditioning, see **Fig. 3**.

3. Loosen the adjusting rod mounting capscrew (Ref. 8, all figures), the end link mounting capscrew (Ref. 2), and the alternator mounting capscrew (Ref. 3). Loosen these three mounting capscrews enough to allow movement of the alternator.



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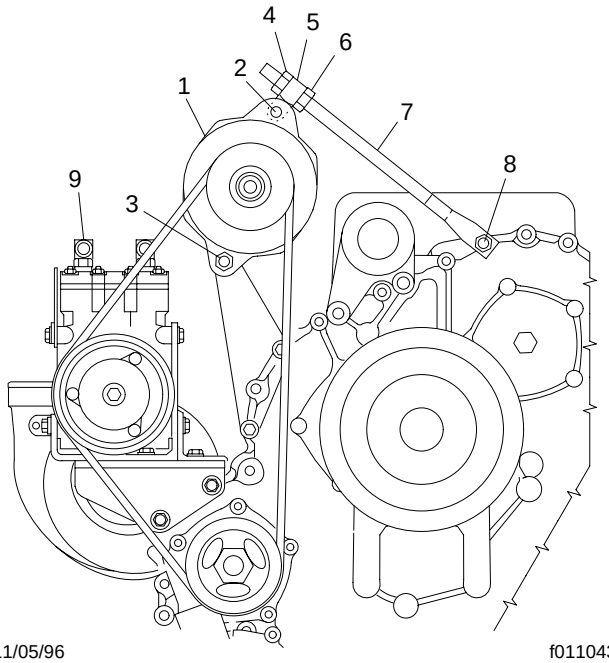
1. 25/26–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Refrigerant Compressor

Fig. 1, Alternator Installation, DDEC III with Air Conditioning

4. Back off the adjusting nut (see **Fig. 1**, Ref. 6). Push the loosened alternator far enough toward the fan drive pulley to allow removal of the drive belts without using force.



11/05/96 f011043

1. 25/26–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Refrigerant Compressor

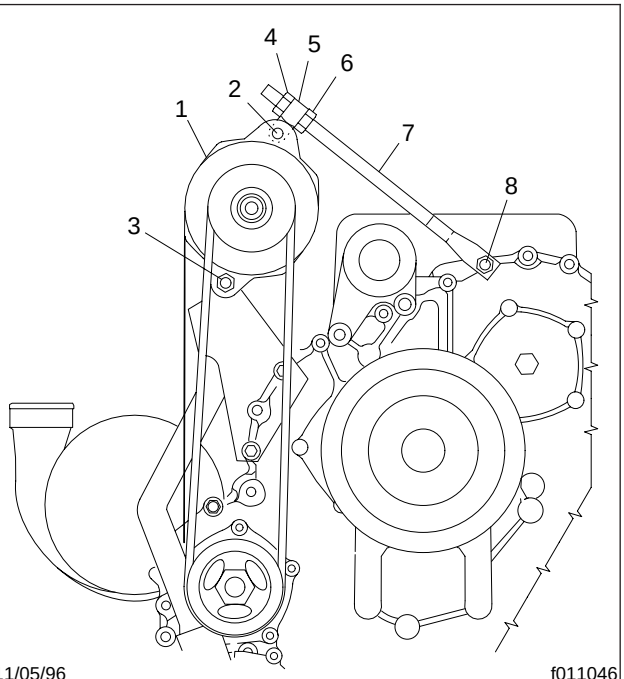
Fig. 2, Alternator Installation, DDEC II with Air Conditioning

5. Remove the drive belt from the pulleys without prying or twisting the belt.
6. Remove the end link mounting capscrew and the alternator mounting capscrew. Remove the alternator from the vehicle.
7. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 50 lbf·ft (68 N·m).

25/26–SI Alternator Removal and Installation, DDC 60



1. 25/26–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew

Fig. 3, Alternator Installation, All Detroit Diesel Series 60 Engines without Air Conditioning

2. Install the alternator on the engine. Install the end link mounting capscrew and the alternator mounting capscrew, but do not tighten them yet.
3. Loop the drive belt around the pulleys.
4. Install the drive belt on the pulleys without prying or rolling it into place. For belt tightening procedures and specifications, see **Section 01.07, Subject 140**.
5. After the belt has been correctly tensioned, tighten the adjusting rod jam nut 95 lbf·ft (130 N·m).
6. Tighten the end link mounting capscrew and the alternator mounting capscrew 65 lbf·ft (88 N·m). Tighten the adjusting rod mounting capscrew 34 lbf·ft (46 N·m).
7. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
8. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

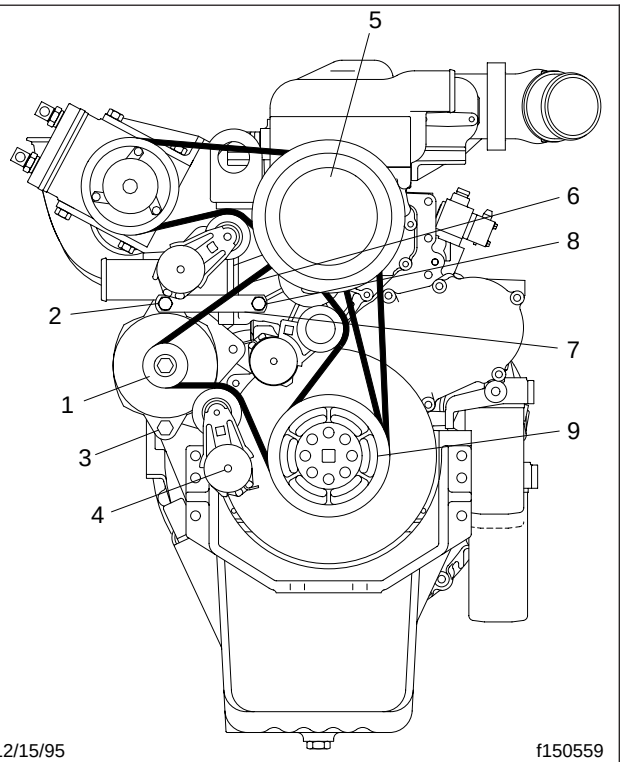
Table 1, Approved Dielectric Red Enamel

9. Connect the batteries.
10. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

25/26–SI Alternator Removal and Installation, DDC 55

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Insert a breaker bar in the alternator belt tensioner (see **Fig. 1**, Ref. 4) and rotate the tensioner down and off the alternator drive belt.



Rotate the belt tensioner down and off the belt.

1. 25/26–SI Alternator
2. Altenator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Alternator Belt Tensioner
5. Fan Pulley
6. Alternator Drive Belt
7. Alternator Adjusting Strap
8. Alternator Adjusting Strap Mounting Capscrew
9. Vibration Damper

Fig. 1, Alternator Installation, Detroit Diesel Series 55 Engine

NOTE: There are two drive belts to remove. Before removing the alternator belt, it is necessary to remove the refrigerant compressor belt from its pulleys.

4. Holding the belt tensioner down, remove each drive belt from its pulley. Slowly release each belt tensioner and remove the breaker bar.
5. Lower each belt, and take it off the vibration damper. Raise each belt, and take it off over the fan. Remove the drive belts from the vehicle.
6. Remove the top and bottom alternator mounting capscrews. If necessary to remove the alternator from the vehicle, loosen the adjusting strap mounting capscrew. It is not necessary to remove the adjusting strap.
7. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

Installation

1. Check the torque of the adjusting strap mounting capscrew. If necessary, tighten it 65 lbf·ft (88 N·m).
2. Install the alternator on the engine. Install the two alternator mounting capscrews (top and bottom), but do not tighten them yet.
3. Install the drive belts on the pulleys. For belt tightening procedures and specifications, see **Section 01.07, Subject 170**.

NOTE: The Detroit Diesel belt tensioner automatically adjusts the drive belts to the correct tension. If the belt slips, repair or replace the tensioner. For instructions, see the engine manufacturer's service literature.

4. Tighten both alternator mounting capscrews 65 lbf·ft (88 N·m).
5. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
6. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

25/26–SI Alternator Removal and Installation, DDC 55

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

7. Connect the batteries.
8. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Trouble-shooting, 300**.

Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/Charging System Testing."

Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

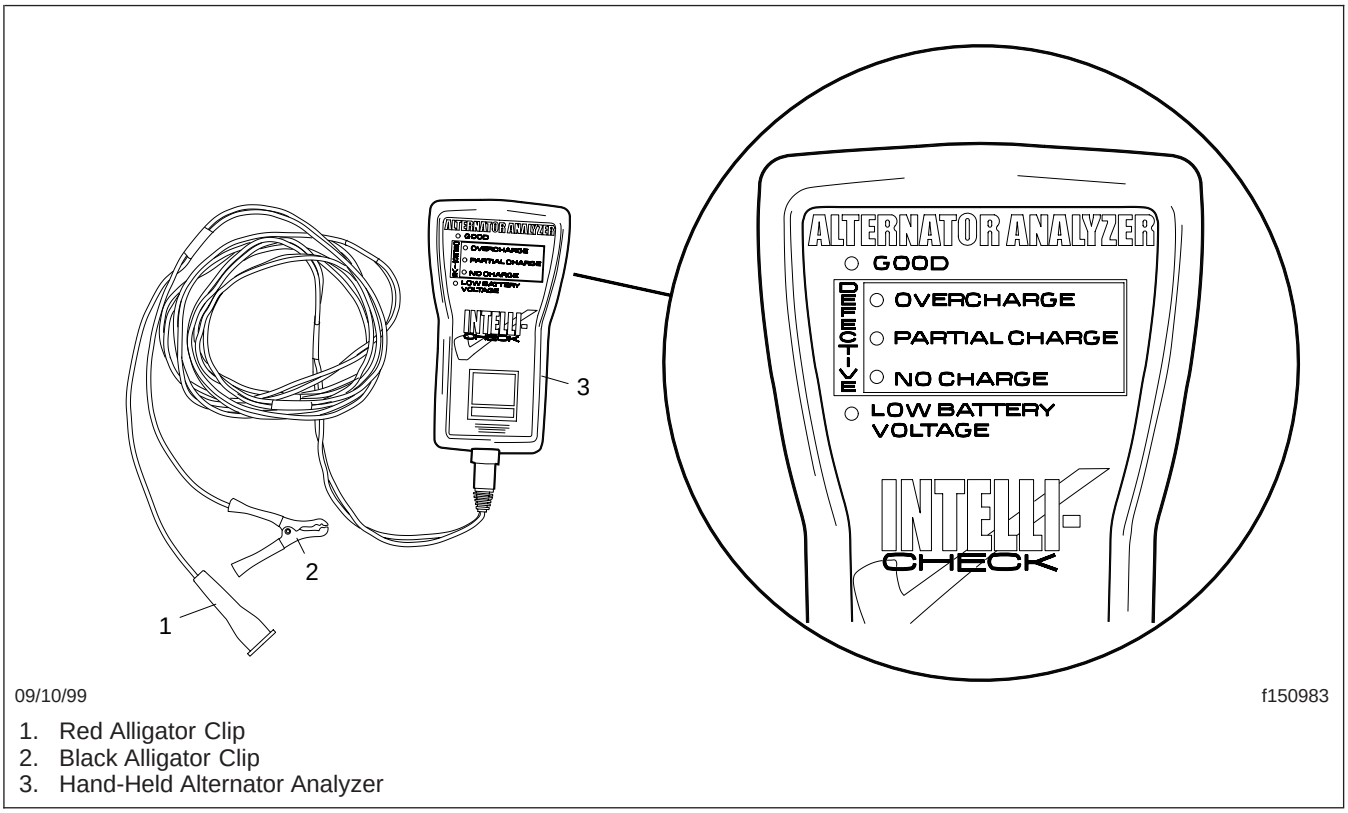
Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.
3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
   - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
     A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
     B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
     C. Repeat the applicable steps of the Pre-Test Procedure.
   - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
   - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
   - If the **GOOD** (green) LED illuminates, proceed to the next step.
   - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
   - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging

Troubleshooting



1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 1, Delco Remy Intelli-Check Alternator Analyzer

system using the instructions in "Alternator/Charging System Testing."

4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/ Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing".

Alternator/Charging System Testing

Battery Open Circuit Voltage Test, Alternator Output Voltage Test and Alternator Amperage Output Test

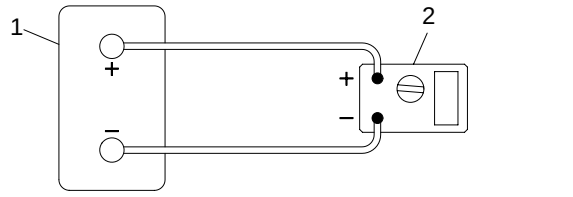
1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

   If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

   If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

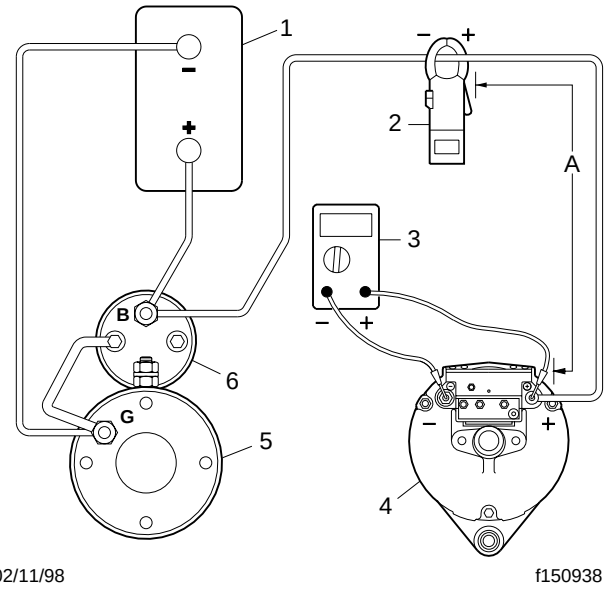
IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

2. Check the alternator output without a load. See **Fig. 3**.



1. Battery
2. Digital Voltmeter

Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)



A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 3, Setup 2: Alternator Output Test

2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3**.

2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.

3. Check the alternator output under load. See **Fig. 3**.

3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

- Both front and rear heater blowers (on HIGH)
- Headlights (high beams)
- Road lights
- Interior lights

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

4. Perform an alternator amperage output test.

4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2**.

Troubleshooting

NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

NOTE: Ensure that the alternator is turning at maximum available rpms and keep adjusting the tester dial until the ammeter reads its highest value.

4.4 Turn off the tester and shut down the engine.

4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3**.

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables and terminals.

6.1 Check all connections between the battery, starter and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

See **Fig. 1** for a Delco Remy 25/26–SI alternator wiring diagram.

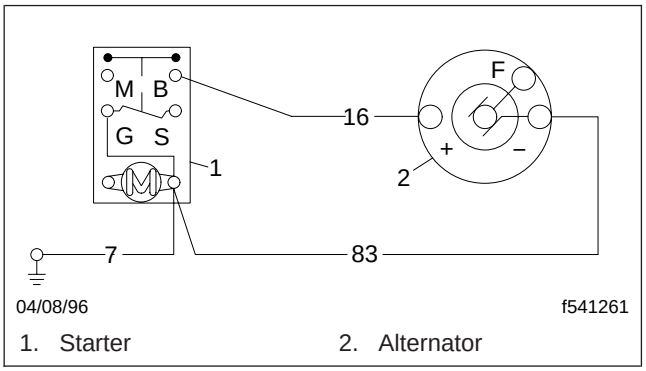


Fig. 1, Delco Remy 25/26-SI Alternator Wiring Diagram

Mounting Fastener Torques, Caterpillar Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Caterpillar 3306 and 3406 Engines			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Jam Nut	5	1/2	65 (88)
Alternator Bracket Fasteners	5PO	3/8–16	34 (46)
Caterpillar 3176/C–10 Engine			
Alternator Mounting Capscrews	8PO	1/2–13	65 (88)
Adjusting Strap Mounting Capscrew	10.9PO	M12	65 (88)

Table 1, Mounting Fastener Torques, Caterpillar Engines

Mounting Fastener Torques, Cummins Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Cummins N14/NTC Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	8PO	7/16–20	50 (68)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Alternator Bracket Fasteners	5PO	3/8–16	34 (46)
Cummins M11/L10 Engine			
Adjusting Block Mounting Bolt	8	3/8	30 (41)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Screw Locknut	5	5/8	95 (130)
Adjusting Arm Mounting Capscrew	5	1/2–13	55 (75)

Specifications

Mounting Fastener Torques, Cummins Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Alternator Bracket Fasteners	5PO	3/8–16	34 (46)

Table 2, Mounting Fastener Torques, Cummins Engines

Mounting Fastener Torques, Detroit Diesel Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Detroit Diesel Series 50 Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	8PO	7/16–14	45 (61)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Alternator Bracket Fasteners	5PO	3/8–16	43–54 (58–73)
Detroit Diesel Series 60 Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	10.9PO	M10	34 (46)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Alternator Bracket Fasteners	8PO	7/16–20	50 (68)
Detroit Diesel Series 55 Engine			
Alternator Mounting Capscrews	8PO	1/2–13	65 (88)
Adjusting Strap Mounting Capscrew	8PO	1/2–13	65 (88)

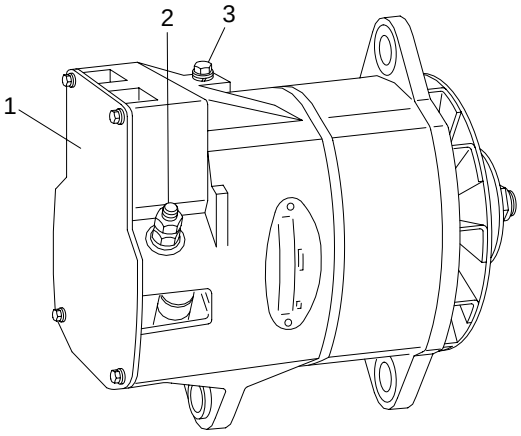
Table 3, Mounting Fastener Torques, Detroit Diesel Engines

Description	**Grade**	**Size**	**Torque: lbf·in (N·cm)**
Alternator Output ("BAT") Terminal Nut	5	5/16–18	100 (1140)
Alternator Ground ("G") Terminal Nut	5	1/4–20	65 (740)
Instrument ("I") or Relay ("R") Terminal Nut	8.8	M4	20 (220)

Table 4, Terminal Fastener Torques, All Engines

General Information and Principles of Operation

The Delco Remy 30-SI and 30-SITR series alternators (see **Fig. 1** and **Fig. 2**) feature a solid-state regulator that is mounted inside the end frame. The only movable part in the assembly is the rotor, which is mounted on a ball bearing at the drive end, and a roller bearing at the rectifier end. See **Fig. 3** and **Fig. 4**. All current-carrying conductors are stationary. These conductors are the field-winding stator components. The regulator and diodes are enclosed in a sealed compartment.



1. End Plate
2. Output Terminal
3. Ground Screw

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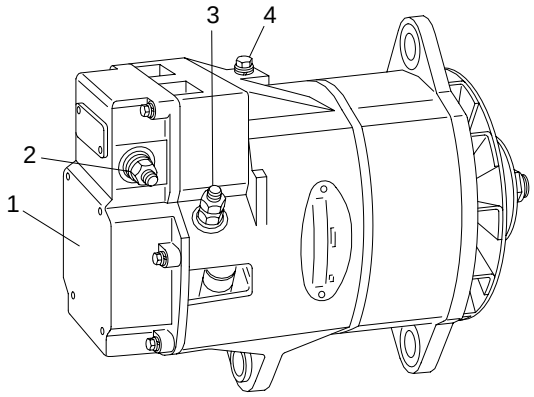
Fig. 1, 30-SI Alternator

A fan located on the drive end provides airflow for cooling. All bearings are sealed so that no periodic maintenance is required.

Only one wire connects the alternator to the battery, along with a ground return. Since the vehicle's system is negative ground, the output terminal connects to the battery's positive terminal. A relay terminal labeled "R" is available for use in some circuits to operate auxiliary equipment.

The 30-SITR is a standard 30-SI with a transformer-rectifier (TR unit) mounted on the end frame. The TR unit provides a separate voltage to charge a cranking battery. The cranking battery is connected in series with the system battery to provide 24-volt cranking. When the engine is running, the cranking battery is



1. Transformer Rectifier (TR unit)
2. 24 Volt Output Terminal
3. 12 Volt Output Terminal
4. Ground Screw

01/26/93 f150404

Fig. 2, 30-SITR Alternator

charged at a low rate to maintain its full state of charge. The vehicle electrical system, except for the cranking motor, is 12 volts. The 30-SITR eliminates the need for a series-parallel switch and associated wiring.

As the rotor begins to turn, the permanent magnetism within induces voltages in the stator windings. The voltages across the diodes cause current to flow, charging the battery. Refer to **Fig. 5** or to **Fig. 6**.

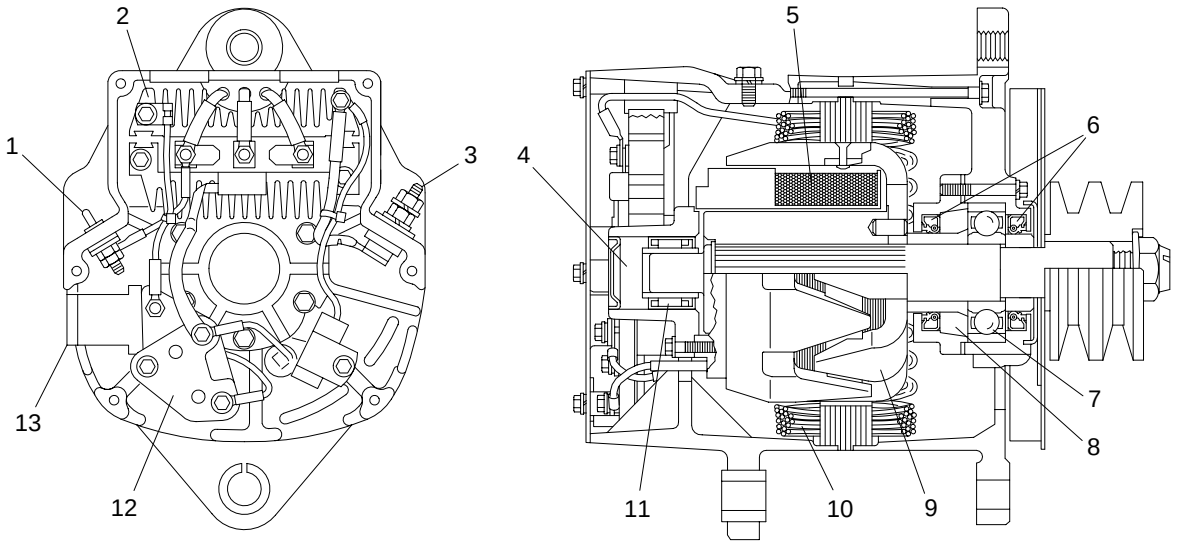
Current from the stator flows through the diode trio to resistor R5 and the base-emitter of TR3 and TR1, to turn on these transistors. Current also flows from the stator through the diode trio, the field coil, and transistor TR1, returning to the stator through the diodes in the rectifier bridge.

When the voltage becomes high enough due to increasing alternator speed, current flow through R2 and R3 causes voltage at the zener diode D1. Transistor TR2 turns on, and transistors TR1 and TR3 turn off. As the field current and the system voltage decrease, D1 blocks current flow, causing TR1 and TR3 to turn on again and increase system voltage.This cycle then repeats many times per second limiting the system voltage to the adjusted value.

Capacitor C1 smooths out the voltage across R3; resistor R4 prevents current leakage through TR1 at high temperatures; and diode D2 prevents high transient voltages in the field coil when TR1 turns off.

General Information and Principles of Operation

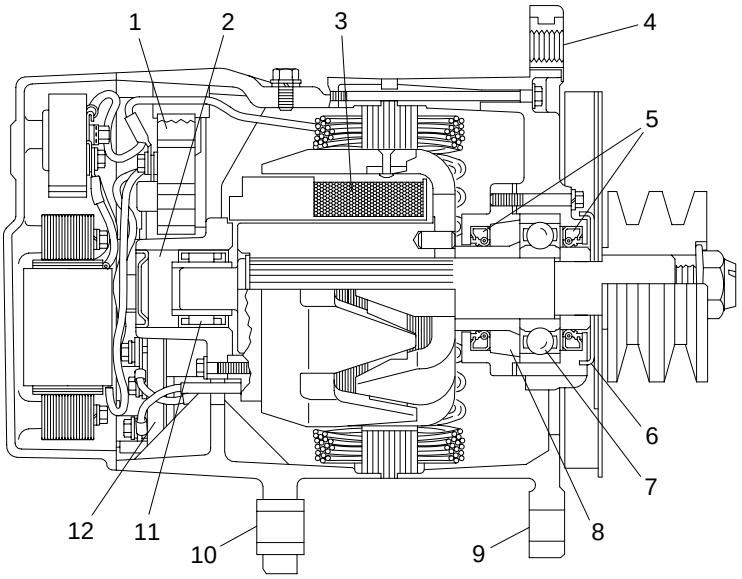
If equipped with the transformer-rectifier unit, the batteries are connected in series and provide 24 volts for starting. The delta primary of the TR unit is connected to the delta stator (**see Fig. 6**). The alternating current voltages in the stator cause current flow in the delta primary. This creates magnetic fields that induce voltages in the TR unit's secondary winding. The secondary winding then provides current through the rectifier bridge to charge the charging battery.



1. Relay Terminal
2. Rectifier Bridge
3. Output Terminal
4. Grease Reservoir
5. Stationary Field Coil (brushless construction)
6. Lip Seals
7. Heavy−Duty Ball Bearing
8. Grease Reservoir
9. Rotor
10. Stator
11. Heavy−Duty Roller Bearing with Lip Seal
12. Integrated−Circuit Regulator
13. External Voltage Adjustment

02/17/93 f150405

Fig. 3, 30-SI Sectional View



1. Generator Rectifier Bridge
2. Grease Reservoir
3. Stationary Field Coil (brushless construction)
4. Steel Bushing with Locking Thread
5. Lip Seal
6. Labyrinth Seal
7. Heavy−Duty Ball Bearing
8. Grease Reservoir
9. Steel Mounting Bushing
10. Steel Adjustable Mounting Bushing
11. Heavy−Duty Roller Bearing with Lip Seal
12. Integrated−Circuit Regulator

02/17/93 f150406

Fig. 4, 30-SITR Sectional View

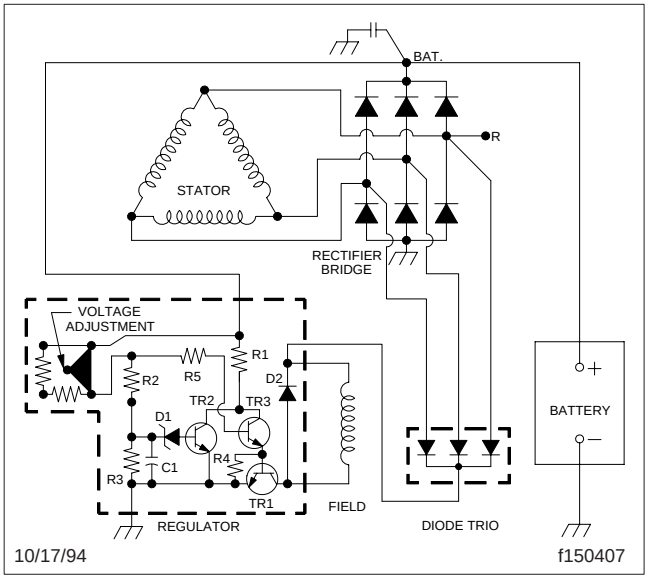


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Fig. 5, 30-SI Wiring Diagram, Negative Ground Circuit

General Information and Principles of Operation

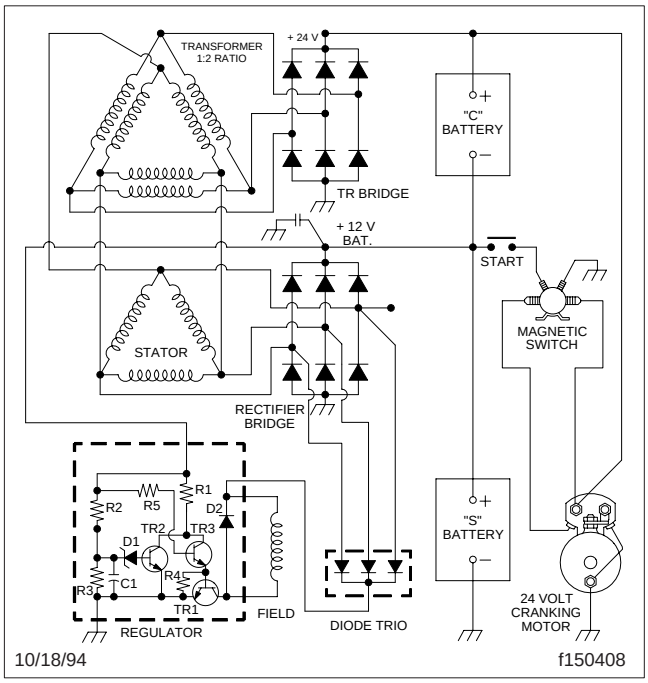


Fig. 6, 30-SITR Wiring Diagram, Negative Ground Circuit

Removal

1. Disconnect the batteries.
2. Disconnect and mark the battery lead wire on the alternator.
3. Loosen the three mounting fasteners (**Fig. 1**, **Fig. 2**, or **Fig. 3**, Refs. A, B, and E).
4. On Cummins L10 installations, loosen the adjusting screw locknut. **See Fig. 1**, Ref. D. Turn the adjusting screw (Ref. C) counterclockwise, backing off the alternator toward the drive pulley far enough to remove the drive belt without prying or twisting the belt.

   On Cummins NTC and Caterpillar 3306 installations, back off the inner jam nut (**Fig. 2** or **Fig. 3**, Ref. D) on the alternator adjusting rod, allowing the alternator to be moved toward the drive pulley far enough to remove the drive belt without prying or twisting the belt.
5. Remove the two fasteners that attach the alternator to the engine, and remove the alternator.
6. Inspect the drive belt. For instructions, refer to the engine section in this manual.

Installation

1. Check the torque of the alternator-bracket fasteners (**Fig. 1**, **Fig. 2**, or **Fig. 3**, Ref.F). On Cummins installations, tighten the fasteners 33 lbf·ft (45 N·m). On Caterpillar 3306 installations, tighten them 110 lbf·ft (150 N·m).
2. Install the alternator on the engine; install the two mounting fasteners.
3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley.
4. On Cummins L10 installations, turn the adjusting screw (**Fig. 1**, Ref. C) clockwise until the belt is correctly tensioned. Refer to the engine section in this manual for belt tightening specifications. Tighten the adjusting screw locknut (Ref.D) 95 lbf·ft (130 N·m).

   On Cummins NTC and Caterpillar 3306 installations, loosen the outer jam nut (Ref. C) on the alternator adjusting rod, then tighten the inner jam nut (Ref. D) until the belt is correctly tensioned. Refer to the engine section in this manual for belt tightening specifications. While holding the inner jam nut in place, tighten the outer jam nut on Cummins NTC installations 155 lbf·ft (210 N·m); tighten the outer jam nut on Caterpillar 3306 installations 95 lbf·ft (130 N·m).

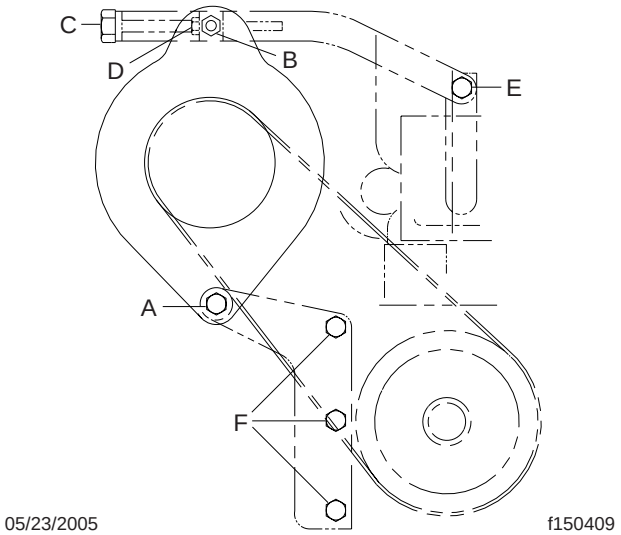


Fig. 1, Alternator Installation, L10

5. On Cummins L10 installations, tighten the lower-mounting bolt nut (**Fig. 1**, Ref. A) 60 lbf·ft (80 N·m); tighten the upper-mounting fastener (Ref. B) 35 lbf·ft (50 N·m); tighten the adjusting arm bolt (Ref. E) 55 lbf·ft (75 N·m).

   On Cummins NTC and Caterpillar 3306 installations, tighten the mounting fasteners 95 lbf·ft (130 N·m). On Cummins NTC installations, tighten the adjusting rod capscrew 70 lbf·ft (95 N·m). On Caterpillar 3306 installations, tighten the adjusting rod capscrew 95 lbf·ft (130 N·m).
6. Connect the battery lead wire to the back of the alternator as previously marked. Torque the output terminal bolt 100 to 110 lbf·in (1140 to 1240 N·cm) when attaching the cable.
7. Connect the batteries.
8. Magnetize the rotor by momentarily connecting a jumper lead from the battery positive post to the relay terminal.

   On the 30-SITR alternator, make sure the jumper is connected to the positive post of the system battery.

Alternator Removal and Installation

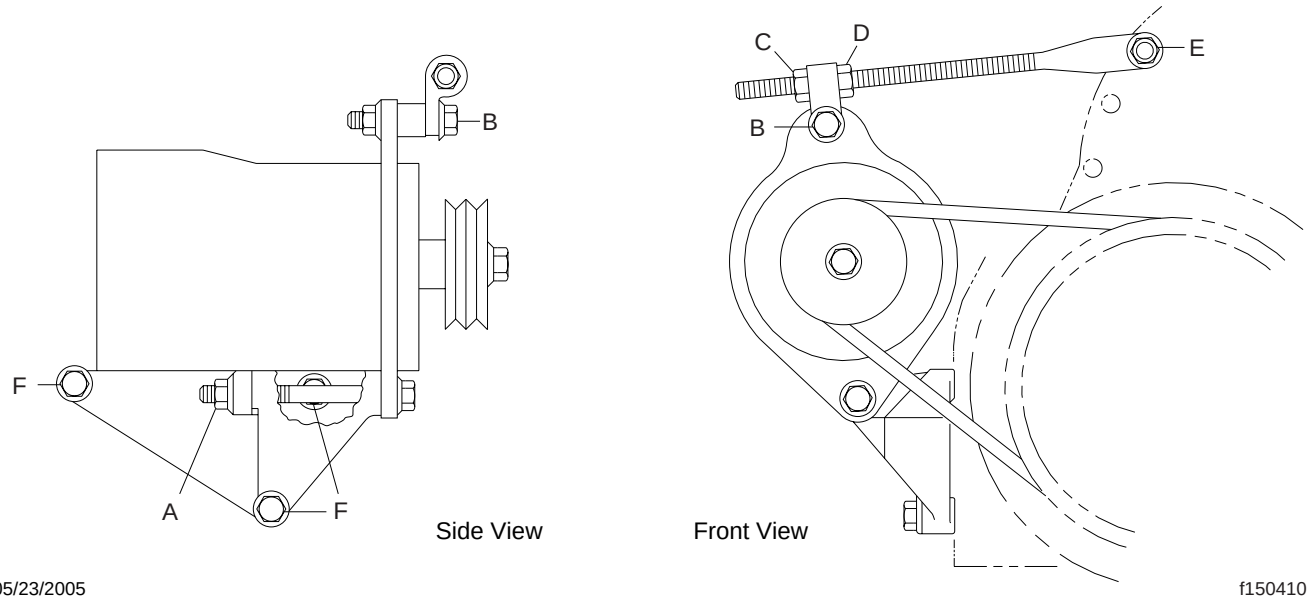


Fig. 2, Alternator Installation, NTC

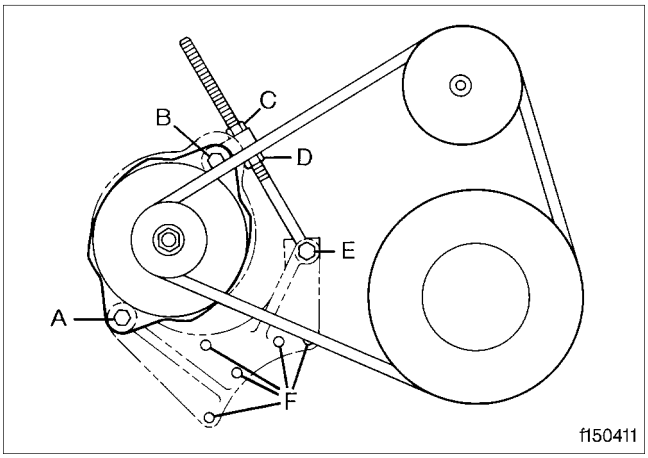


Fig. 3, Alternator Installation, Caterpillar 3306 Engine

On alternators without a relay terminal, remove the end plate and connect a jumper lead from the battery positive post to one of the stator lead terminals on the rectifier bridge.

Checking

NOTE: Remove the alternator from the vehicle. For instructions, refer to Subject 100. Remove the transformer-rectifier unit (on 30-SITR alternators), cover plate, cover, and gasket. The rectifier end frame components should be exposed to view. Note carefully the proper connections before proceeding.

FIELD COIL CHECKS (See Fig. 1)

To check for grounds, connect an ohmmeter to one field coil lead and to the end frame. If the ohmmeter reading is low, the field coil is grounded.

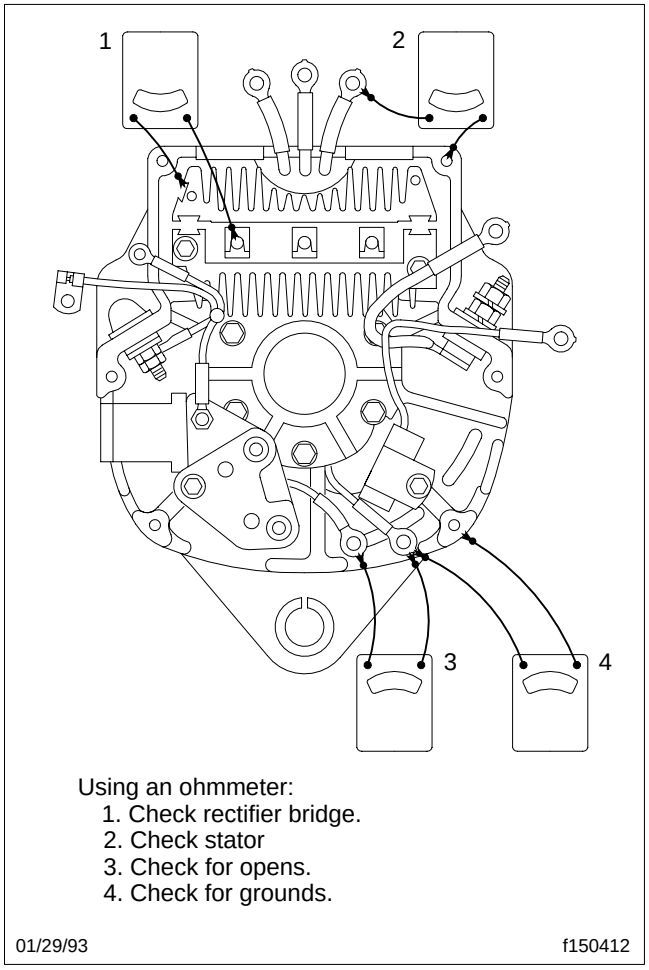


Fig. 1, Electrical Checks, 30-SI Alternator

To check for opens, connect the ohmmeter to the field coil leads. If the ohmmeter reading is high, the field coil is open.

To check the winding for short-circuits, connect a battery and ammeter in series with the field coil. The ammeter reading should be within 3.6 to 4.3 amps. A higher reading means the windings are shorted. An alternate method is to check the resistance of the field by connecting an ohmmeter to the field coil. If the resistance reading is below 2.8 ohms, the winding is shorted.

DIODE CHECKS (See Fig. 2)

Remove the diode trio from the end frame. Connect an ohmmeter to the single connector and to one of the diode leads. Using the lowest range scale, observe the reading. Then reverse the ohmmeter lead connections. If both readings are the same, replace the diode. A good diode will give one high and one low reading. Check each of the diode leads.

STATOR CHECKS (See Fig. 1)

NOTE: Skip this section if the condition is an overcharged battery.

Check the stator windings with an ohmmeter. Make the connection from either stator lead to the end frame.

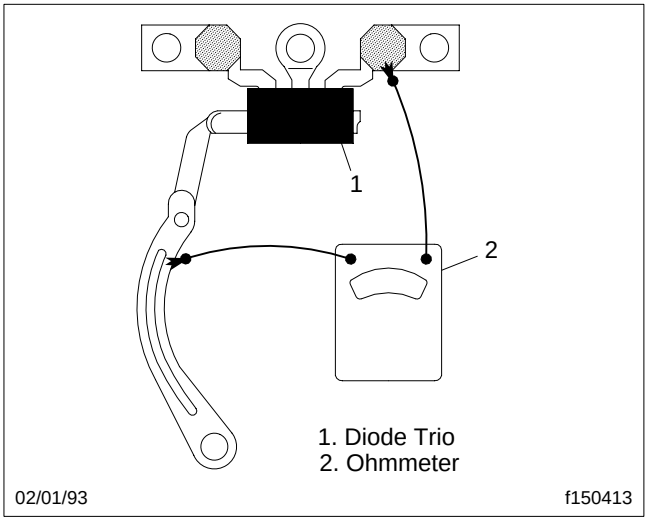


Fig. 2

Alternator Checking

If the reading is not infinite, replace the stator. If all other electrical checks are normal and the alternator fails to supply rated output, replace the stator.

RECTIFIER BRIDGE CHECK

(See Fig. 1 and Fig. 3)

NOTE: Skip this section if the condition is an overcharged battery.

Connect an ohmmeter to a heat sink and one of the three stator terminals. Observe the reading. Then, reverse the lead connections to the same heat sink and the same terminal.

If both readings are the same, replace the rectifier bridge. A good rectifier bridge will give one high and one low reading. Repeat this same test between the same heat sink and the other two terminals; then, between the other heat sink and each of the three terminals.

NOTE: If the rectifier bridge has flat metal clips at the three studs, press down firmly on the clips. Do not press on the threaded stud.

On the 30-SITR alternator, use the same procedure above to check the rectifier bridge on the transformer–rectifier. **See Fig. 3** for test connections.

TRANSFORMER-RECTIFIER CHECKS (See Fig. 3)

Using an ohmmeter, make the connections and electrical checks as shown at points A, B, and C in **Fig. 3**. If the readings are not high (infinite), replace the TR unit.

Install the TR unit on the alternator. Disconnect the 24-volt lead on the alternator. Make sure that the lead does not touch ground. Connect an ammeter between the disconnected lead and the 24 volt terminal on the TR unit.

Connect a 5- to 20-amp load (one or two 12-volt headlamps) across the cranking battery. Operate the engine as required to obtain maximum current output. If the TR unit's charging rate is less than 5 amps, replace the TR unit.

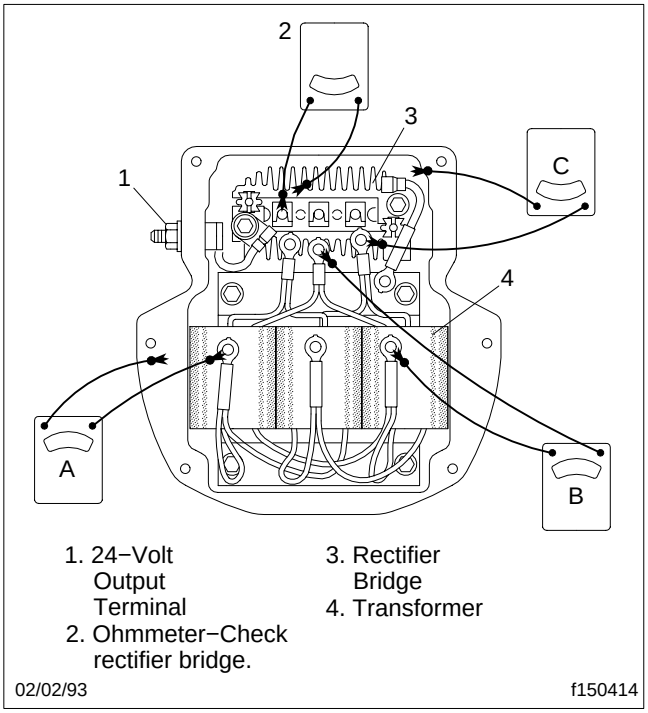


Fig. 3, Electrical Checks, Transformer-Rectifier Unit

Replacement

The bearings normally will not need servicing between engine overhauls. At the time of engine overhaul, replace the bearings and seals, and add a fresh supply of lubricant to the reservoirs.

DRIVE END BEARING

Replace the drive end bearing as follows:

1. Remove the alternator from the vehicle. For instructions, **refer to Subject 100**.
2. Remove the screws, end plate, pulley, fan, and the four retainer plate bolts. Then remove the rotor, collar, and bearing assembly from the end frame.
3. Pull the bearing from the rotor shaft, separate the retainer plate and collar from the shaft, and discard the seals of the retainer plate and end frame.
4. Add Delco Remy lubricant no. 1948791, or an equivalent, so each reservoir between the bearing and seal are only three-quarters full after assembly. Add enough lubricant so a portion will contact the bearing after assembly. Otherwise the oil in the lubricant will not bleed to the bearing. Also, add lubricant to each seal lip and fill the cavity with lubricant between the rubber lip and steel case of each seal. Assemble the seals so that the seal lip is toward or next to the bearing.
5. Lubricate the collar, then install the collar and retainer plate. Press against the inner race to install the new bearing onto the shaft against the collar.
6. Install the rotor, collar, and bearing assembly on the end frame. Install the four retainer plate bolts, fan, pulley, end plate, and screws.
7. Install the alternator on the vehicle. For instructions, **refer to Subject 100**.

RECTIFIER END FRAME BEARING

Replace the rectifier end frame bearing as follows:

1. Remove the alternator from the vehicle. For instructions, **refer to Subject 100**.
2. Remove the cover plate, cover, and gasket.
3. Pull the shaft and bearing inner race from the end frame.
4. Assemble the new inner race and bearing. Position the bearing seal toward the drive end. Press against the seal end of the bearing to install the housing.
5. Fill the reservoir half full with Delco Remy lubricant no. 1948791, or an equivalent. Add enough lubricant so a portion will touch the bearing when assembled.
6. Install the gasket, cover, and cover plate.
7. Install the alternator on the vehicle. For instructions, **refer to Subject 100**.

Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/Charging System Testing."

Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

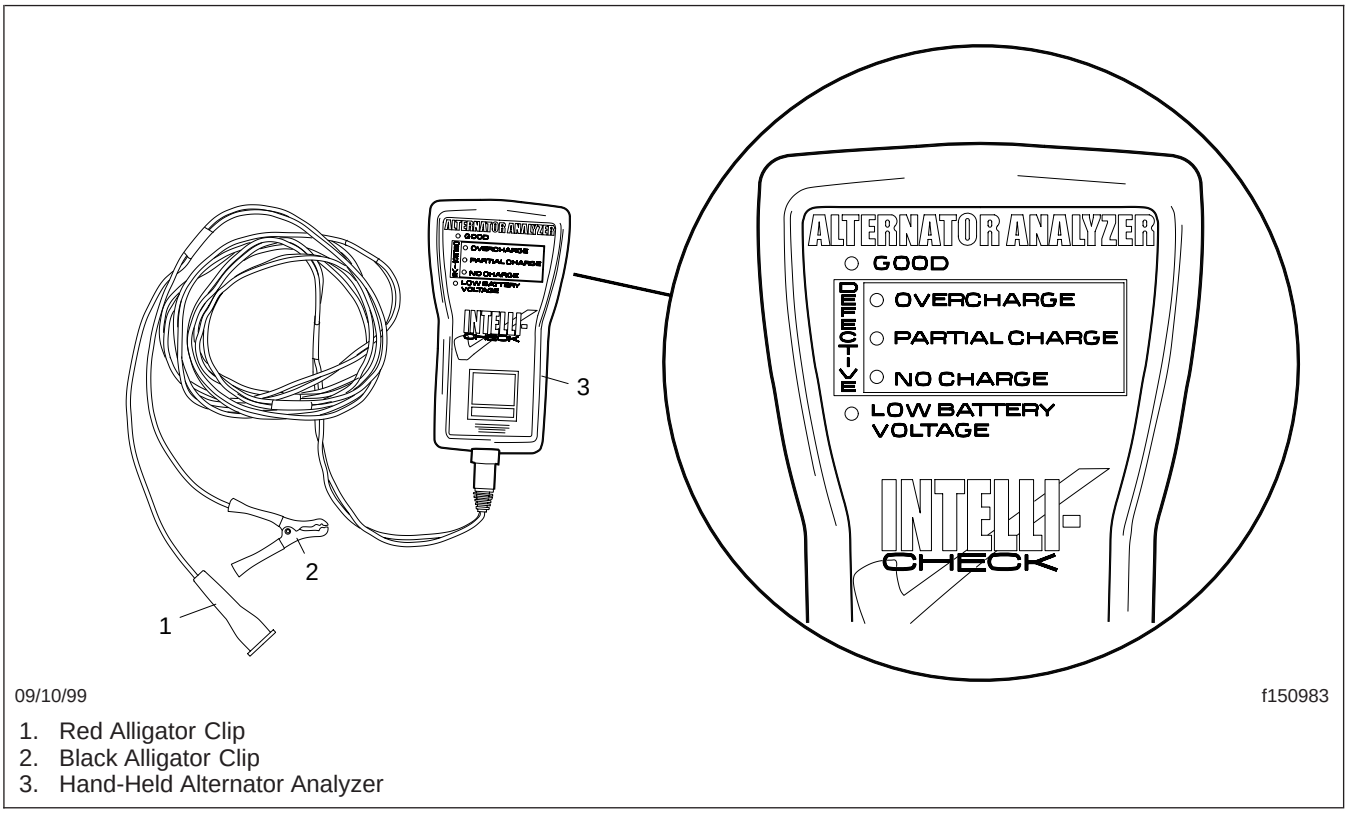
Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.
3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
    - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
        A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
        B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
        C. Repeat the applicable steps of the Pre-Test Procedure.
    - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
    - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
    - If the **GOOD** (green) LED illuminates, proceed to the next step.
    - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
    - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging

Troubleshooting



1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 1, Delco Remy Intelli-Check Alternator Analyzer

system using the instructions in "Alternator/Charging System Testing."

4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/ Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing".

Alternator/Charging System Testing

Battery Open Circuit Voltage Test, Alternator Output Voltage Test and Alternator Amperage Output Test

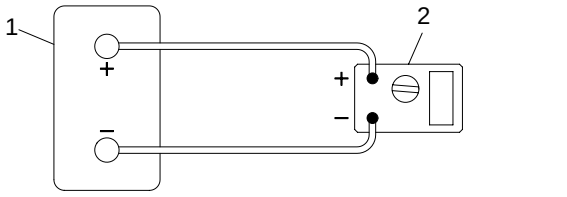
1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

   If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

   If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

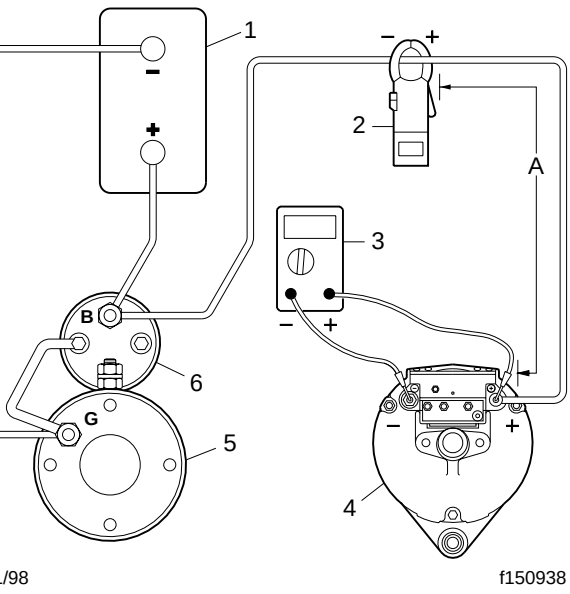
IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

2. Check the alternator output without a load. See **Fig. 3**.



1. Battery
2. Digital Voltmeter

Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)



A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 3, Setup 2: Alternator Output Test

2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3**.

2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.

3. Check the alternator output under load. See **Fig. 3**.

3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

- Both front and rear heater blowers (on HIGH)
- Headlights (high beams)
- Road lights
- Interior lights

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

4. Perform an alternator amperage output test.

4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2**.

Troubleshooting

NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

NOTE: Ensure that the alternator is turning at maximum available rpms and keep adjusting the tester dial until the ammeter reads its highest value.

4.4 Turn off the tester and shut down the engine.

4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3**.

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables and terminals.

6.1 Check all connections between the battery, starter and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

General Description

The Leece-Neville JB series alternator is a 14-volt self-load-limiting alternator equpped with a three-step adjustable voltage regulator. See **Fig. 1**. For voltage regulator adjustment procedures, see **Subject 180**.

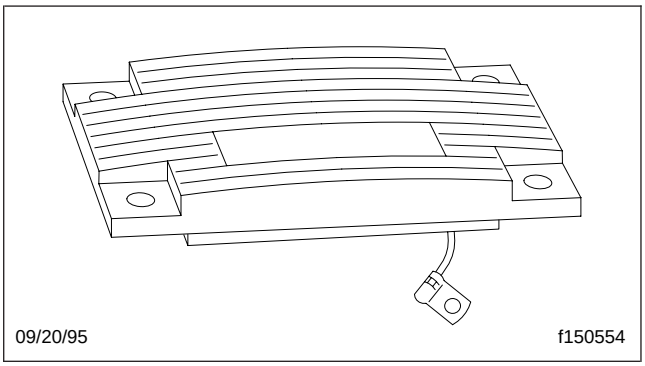


Fig. 1, Three-Step Adjustable Voltage Regulator

The optional SmartChek™ models feature a light-emitting diode (LED) that changes color to simplify troubleshooting. When the LED is green, the alternator is OK. When the LED is red, the alternator needs replacing.

Six silicon diodes mounted in heat-sinks convert alternating current from the delta-wound stator into direct current. A capacitor connected between the heat-sinks helps suppress transient voltage spikes, which could possibly damage the diodes.

The brushes and voltage regulator are located in a waterproof housing that may be removed for replacement or inspection. An external relay terminal is also provided for operation of a no-charge indicator light, starter interrupt relay, or other accessories that might require power from such a source.

The voltage regulator is also equipped with transient voltage protection and will withstand instantaneous opening of the charging circuit under full load conditions.

Mounting hardware and vehicle wiring require periodic inspection. See the vehicle maintenance manual for instructions.

Principles of Operation

Current is produced by rotating a magnet inside a stationary winding. The rotating magnet is called a rotor and the stationary winding is called a stator. See **Fig. 2**.

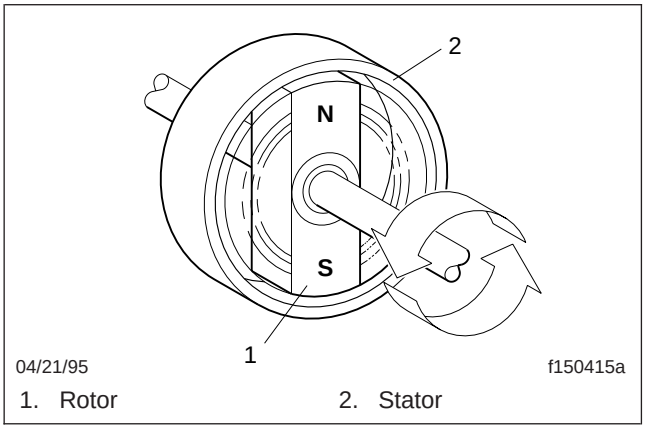


Fig. 2, Producing the Current

The rotor is electrically magnetized by a small current flowing through the brushes, riding on smooth slip rings. See **Fig. 3**. Alternating current is then produced as the magnetic poles of the rotor pass the coil windings of the stator.

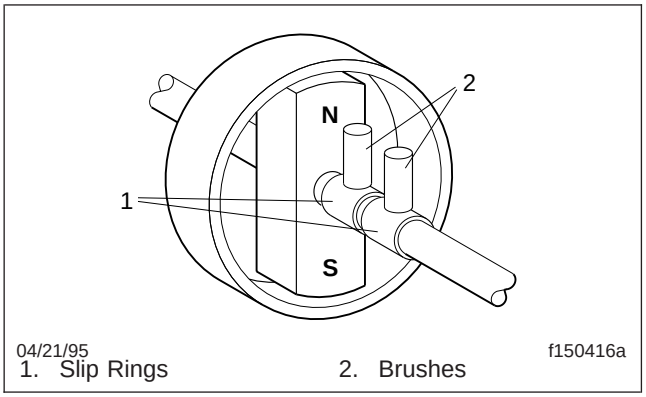


Fig. 3, Magnetizing the Rotor

These alternators have 12 magnetic poles in the rotor (see **Fig. 4**) and three separate windings in the stator (see **Fig. 5**). Since the rotor produces alternating current as it passes the coil windings of the stator, increased engine speed produces more current.

Rectifier assemblies convert alternating current to direct current for storage in the batteries. Rectifiers consist of silicon diodes that work as electrical switches and permit current flow in only one direction. They are mounted in an aluminum casting,

General Information

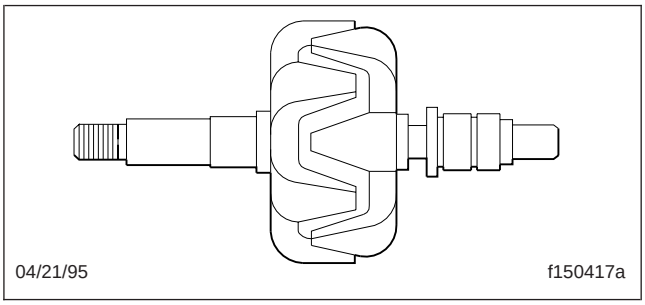


Fig. 4, Rotor

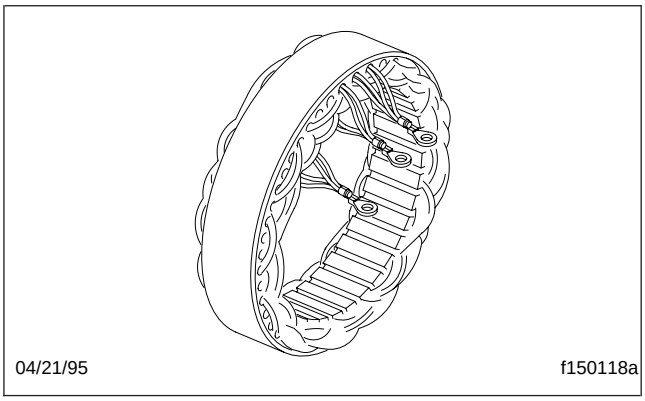


Fig. 5, Stator

which is finned to dissipate heat. This is called a heat sink. See **Fig. 6**.

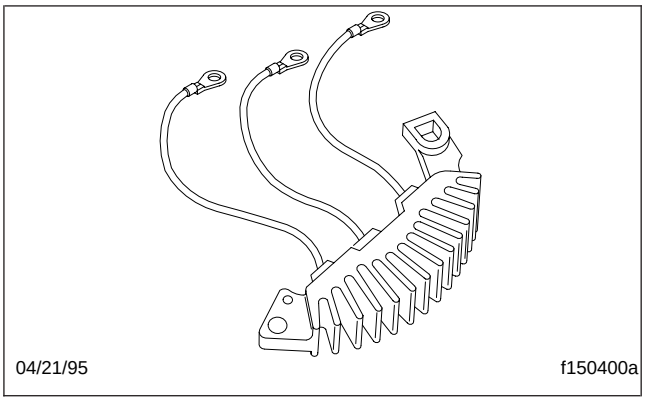


Fig. 6, Heat Sink

The voltage regulator (see **Fig. 1**) controls the alternator output and the state of charge of the batteries. It is used in the charging system to regulate the battery voltage to the vehicle.

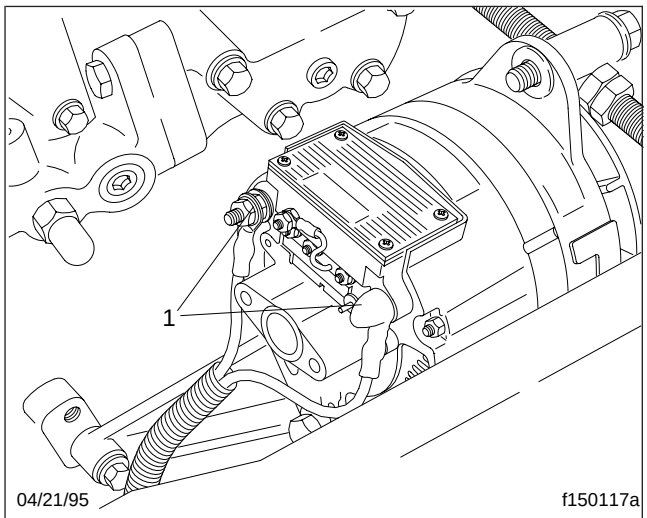
The diode trio converts a small amount of alternating current from the stator into direct current which is used as a signal to turn on the regulator.

When the battery is charged, the regulator reduces the field current flow to the rotor. Reducing the field current flow, in turn, reduces the alternator output. When the headlights or accessories place a load on the battery, the regulator increases the current flow to the rotor, and alternator output increases, to maintain voltage.

JB Series Alternator Removal and Installation, Cummins N14/NTC

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator. See **Fig. 1**.



1. Lead Connections

Fig. 1, Battery Lead Connections

3. Loosen the adjusting rod mounting capscrew (see **Fig. 2**, Ref. 8).
4. Loosen the end link mounting capscrew and the alternator mounting capscrew (see **Fig. 2**, Refs. 2 and 3). Turn the adjusting nut (Ref. 6) counterclockwise, backing the alternator toward the drive pulley far enough to remove the drive belt without prying or twisting the belt. Remove the drive belt from the vehicle.
5. Remove the adjusting rod jam nut (Ref. 4) and alternator mounting capscrew. Remove the alternator from the vehicle with the end link attached.
6. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

Installation

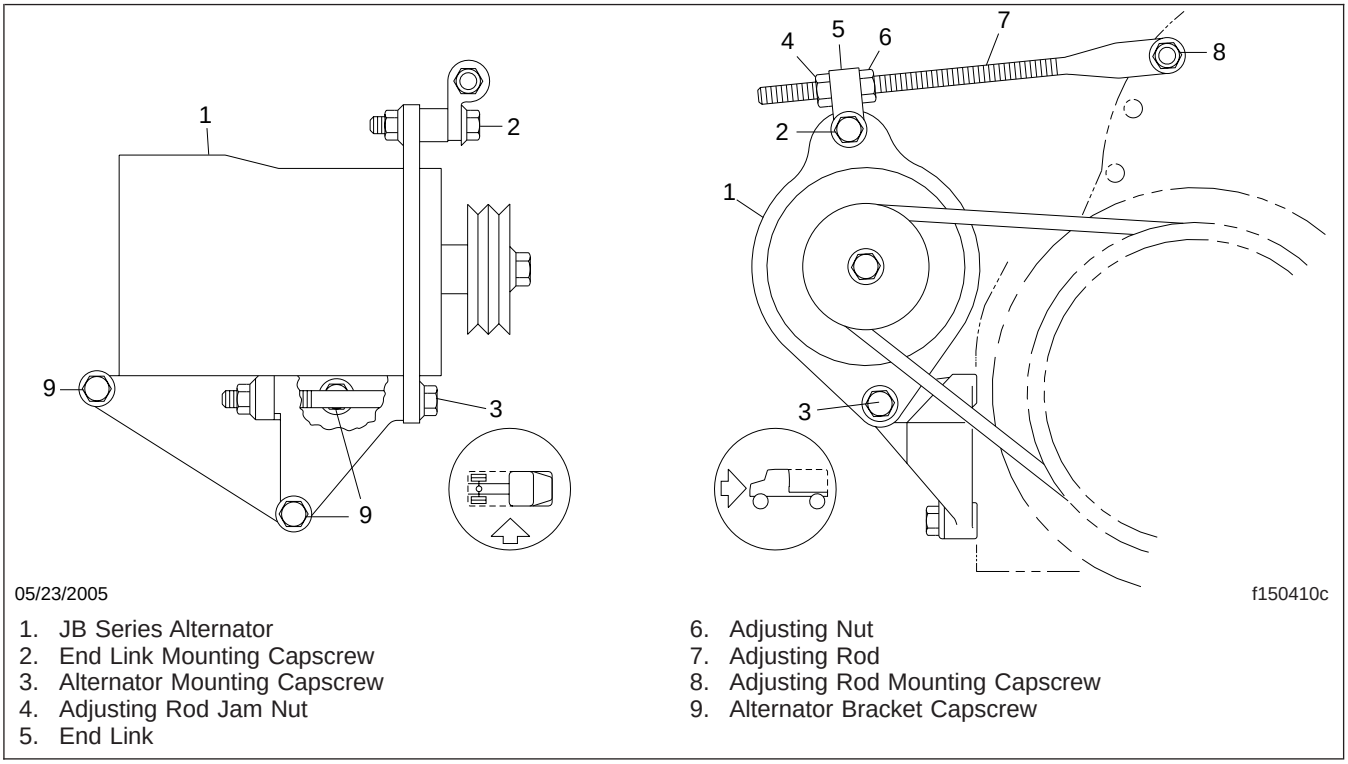
1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine with the end link attached. Install the alternator mounting capscrew, but do not tighten it yet.
3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m).
4. Tighten the adjusting nut (see **Fig. 2**, Ref. 6) until the belt is correctly tensioned. For belt tightening specifications, see **Section 01.07, Subject 100**. While holding the adjusting nut in place, install the adjusting rod jam nut and tighten it 95 lbf·ft (130 N·m).
5. Tighten the end link mounting capscrew and the alternator mounting capscrew 65 lbf·ft (88 N·m). Tighten the adjusting rod mounting capscrew 50 lbf·ft (68 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting, 300**.

JB Series Alternator Removal and Installation, Cummins N14/NTC



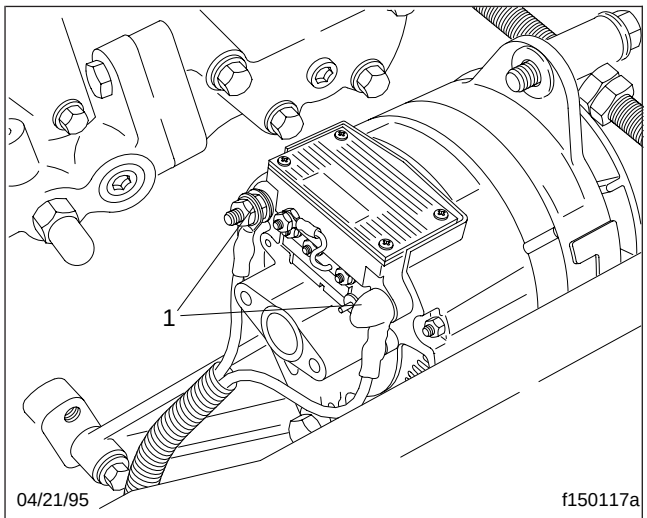
1. JB Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Capscrew

Fig. 2, Alternator Installation, Cummins N14/NTC Engine

JB Series Alternator Removal and Installation, Cummins M11/L10

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator. See **Fig. 1**.



1. Lead Connections

Fig. 1, Battery Lead Connections

3. Loosen the adjusting block mounting bolt, adjusting arm mounting capscrew, and alternator mounting capscrew just enough to allow movement of the alternator. See **Fig. 2**.
4. Loosen the adjusting screw locknut. See **Fig. 2**, Ref. 4. Turn the adjusting screw (Ref. 7) counterclockwise, backing off the alternator toward the drive pulley far enough to remove the drive belt without prying or twisting the belt. Remove the belt from the vehicle.
5. Remove the adjusting block mounting bolt and the alternator mounting capscrew. Remove the alternator from the vehicle.
6. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

Installation

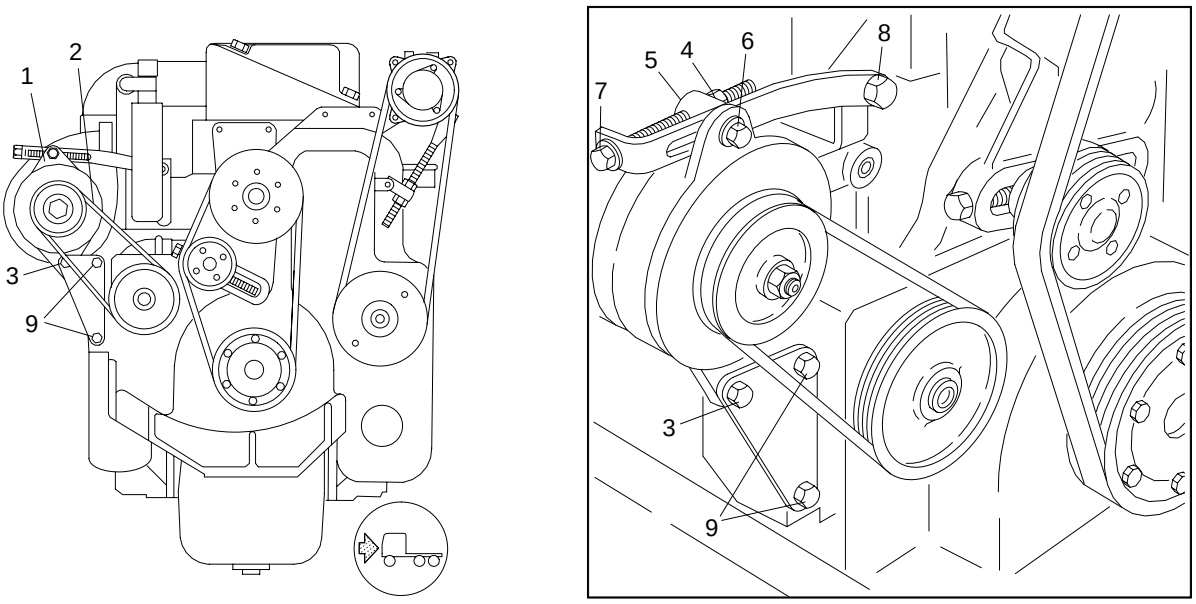
1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine. Install the adjusting block mounting bolt and the alternator mounting capscrew, but do not tighten them yet.
3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m).
4. Turn the adjusting screw (see **Fig. 2**, Ref. 7) clockwise until the belt is correctly tensioned. For belt tightening specifications, see **Section 01.07, Subject 110**. Tighten the adjusting screw locknut (Ref. 4) 95 lbf·ft (130 N·m).
5. Tighten the alternator mounting capscrew (see **Fig. 2**, Ref. 3) 65 lbf·ft (88 N·m); tighten the adjusting block mounting bolt (Ref. 6) 30 lbf·ft (41 N·m); tighten the adjusting arm mounting capscrew (Ref. 8) 55 lbf·ft (75 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting, 300**.

JB Series Alternator Removal and Installation, Cummins M11/L10



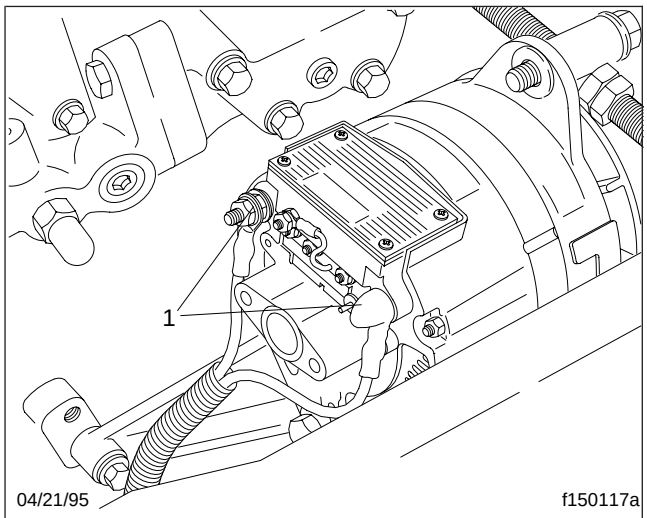
1. JB Series Alternator
2. Drive Belt
3. Alternator Mounting Capscrew
4. Adjusting Screw Locknut
5. Adjusting Block
6. Adjusting Block Mounting Bolt
7. Adjusting Screw
8. Adjusting Arm Mounting Capscrew
9. Alternator Bracket Fasteners

Fig. 2, Alternator Installation, Cummins M11/L10 Engine

JB Series Alternator Removal and Installation, Caterpillar 3306

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator. See **Fig. 1**.



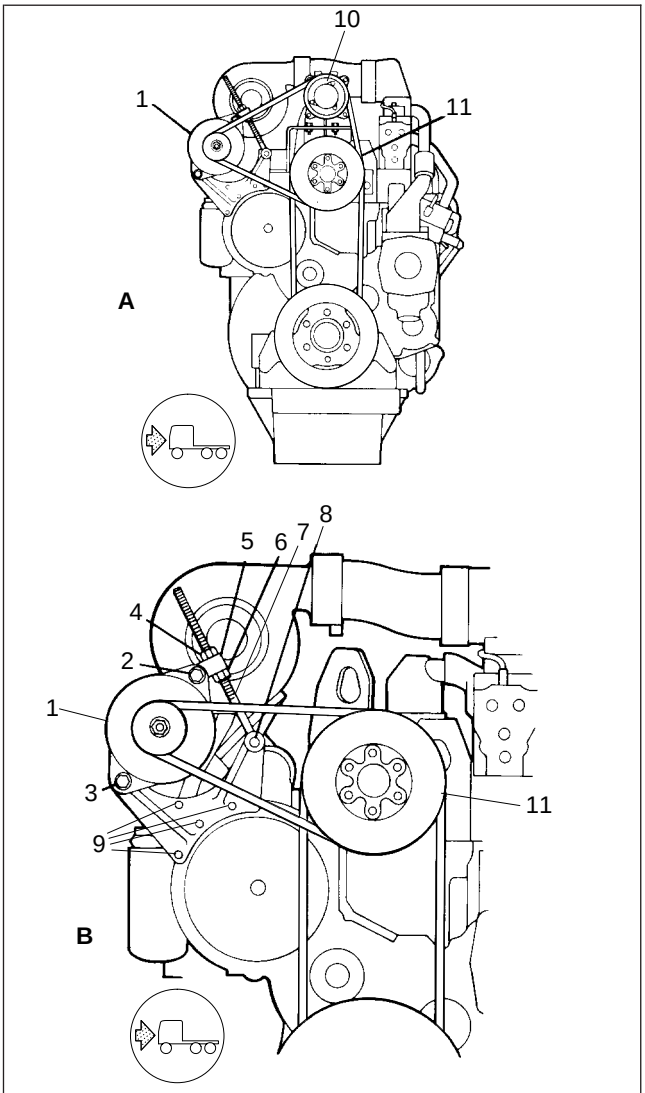
1. Lead Connections

Fig. 1, Battery Lead Connections

3. Loosen the end link and alternator mounting capscrews (see **Fig. 2**, Ref. 2 and 3) and the adjusting rod mounting capscrew (Ref. 8).
4. Back off the adjusting nut (see **Fig. 2**, Ref. 6) on the adjusting rod, allowing the alternator to be moved far enough toward the drive pulley to remove the fan drive belt without prying or twisting the belt. Remove the drive belt from the vehicle.
5. Remove the end link and alternator mounting capscrews. Remove the alternator from the vehicle.
6. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine. Install the end link and alternator mounting capscrews, but do not tighten them yet.



A. With Refrigerant Compressor
B. Without Refrigerant Compressor

1. JB Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners
10. Refrigerant Compressor
11. Fan Drive

Fig. 2, Alternator Installation, Caterpillar 3306 Engine

JB Series Alternator Removal and Installation, Caterpillar 3306

3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m).
4. Loosen the adjusting rod jam nut (see **Fig. 2**, Ref. 4). Then, tighten the adjusting nut (Ref. 6) until the belt is correctly tensioned. For belt tightening specifications, see **Section 01.07, Subject 120**. While holding the adjusting nut in place, tighten the adjusting rod jam nut 65 lbf·ft (88 N·m).
5. Tighten the end link mounting capscrew, the alternator mounting capscrew, and the adjusting rod mounting capscrew 65 lbf·ft (88 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

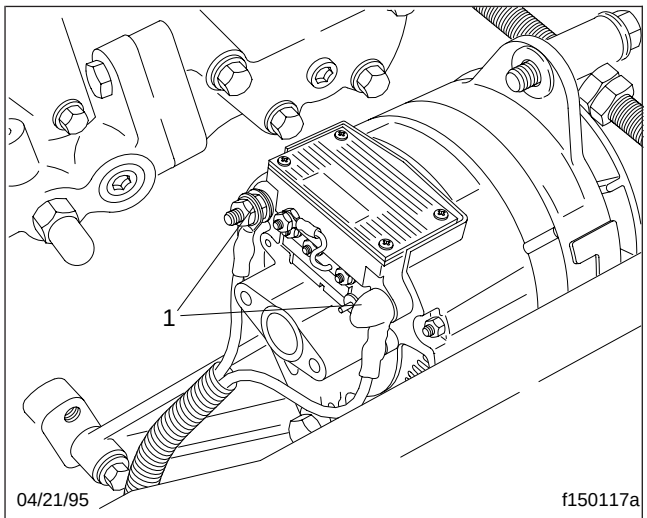
Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

JB Series Alternator Removal and Installation, Caterpillar 3406

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator. See **Fig. 1**.

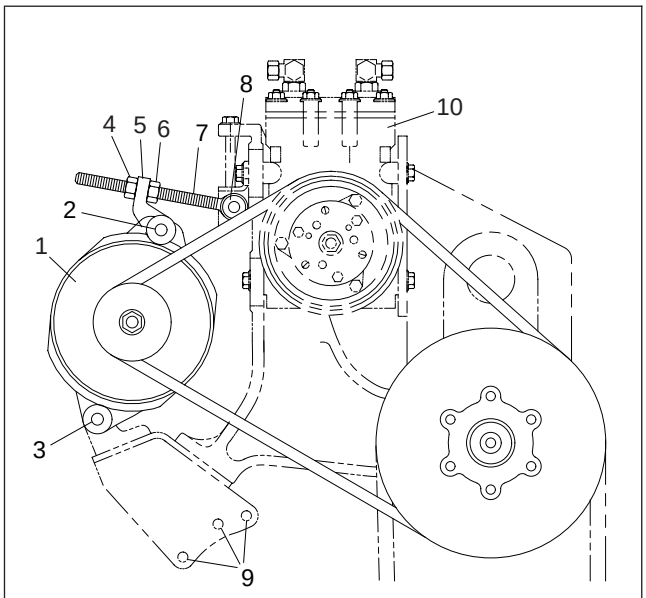


1. Lead Connections

Fig. 1, Battery Lead Connections

NOTE: Three different installations are possible-.For vehicles with a piston-type refrigerant compressor, see **Fig. 2**. For vehicles with a rotary (swash-plate) refrigerant compressor, see **Fig. 3**. For vehicles with no air conditioning, see **Fig. 4**.

3. Back off the adjusting nut. Loosen the end link mounting capscrew and the alternator mounting capscrew enough to allow movement of the alternator.
4. Push the loosened alternator far enough toward the fan drive pulley to allow removal of the drive belts without using force.
5. Slip each drive belt (dual drive belts) off the pulleys and work it over one fan blade at a time. Remove both drive belts from the vehicle.
6. Remove the two mounting capscrews already loosened. Remove the alternator from the vehicle.
7. Inspect the drive belts. For instructions, see **Section 01.07, Subject 180**.



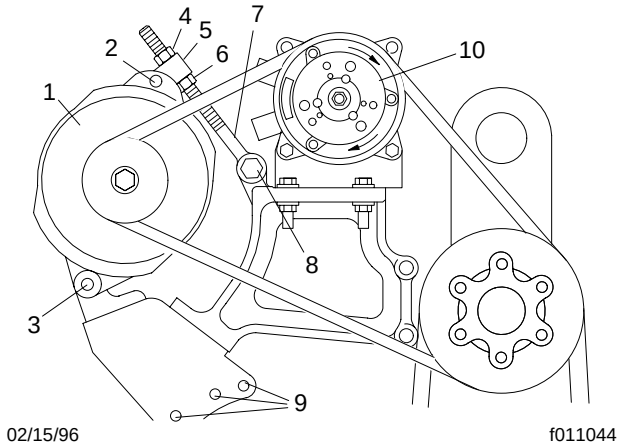
1. JB Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners
10. Refrigerant Compressor

Fig. 2, Alternator Installation, Caterpillar 3406 Engine with Piston-Type Refrigerant Compressor

Installation

1. Check the torque of the alternator bracket fasteners. Tighten the fasteners 34 lbf·ft (46 N·m).
2. Install the alternator on the engine. Install the end link mounting capscrew and the alternator mounting capscrew, but do not tighten them yet.
3. Make sure the distance between the pulleys is short enough to allow belt installation without using force.
4. Work each belt over the fan blades, one blade at a time. Install both drive belts on the pulleys without prying or rolling them into place. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening

JB Series Alternator Removal and Installation, Caterpillar 3406



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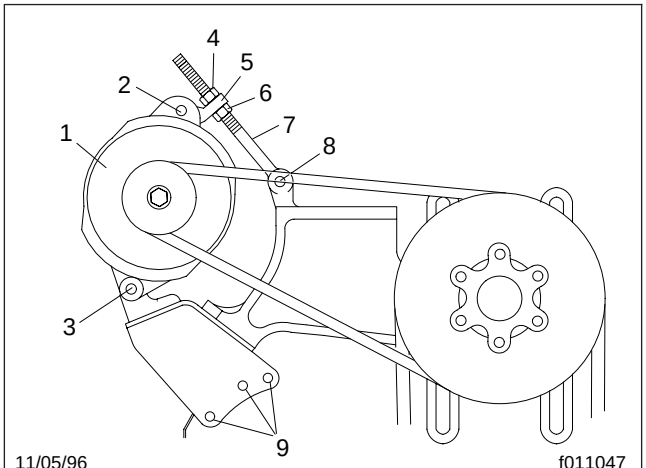
1. JB Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners
10. Refrigerant Compressor

Fig. 3, Alternator Installation, Caterpillar 3406 Engine with Rotary Refrigerant Compressor

procedures and specifications, see **Section 01.07, Subject 150**.

5. After each belt has been correctly tensioned, tighten the adjusting rod jam nut 65 lbf·ft (88 N·m).
6. Tighten both the end link and alternator mounting capscrews 65 lbf·ft (88 N·m).
7. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
8. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.



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1. JB Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners

Fig. 4, Alternator Installation, Caterpillar 3406 Engine with No Air Conditioning

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

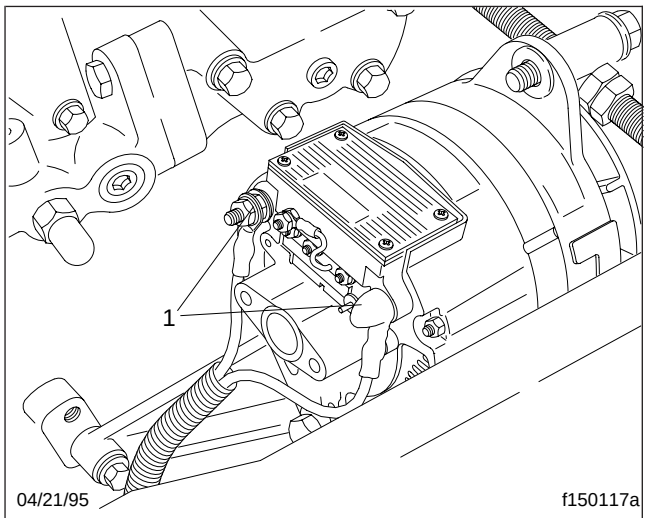
Table 1, Approved Dielectric Red Enamel

9. Connect the batteries.
10. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting, 300**.

JB Series Alternator Removal and Installation, Caterpillar 3176/C–10

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator. See **Fig. 1**.



1. Lead Connections

Fig. 1, Battery Lead Connections

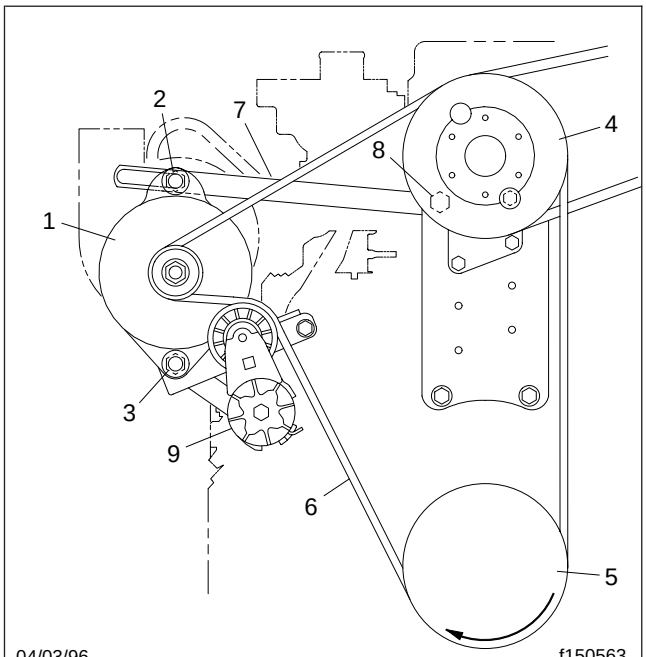
3. Insert a 1/2-inch breaker bar in the belt tensioner and rotate the tensioner down and off the alternator drive belt. See **Fig. 2** for slotted-strap alternators. See **Fig. 3** for fixed-strap alternators.

NOTE: There are two drive belts to remove. Before removing the alternator belt, it is necessary to remove the refrigerant compressor belt from its pulleys.

4. Holding the belt tensioner down, remove each drive belt from its pulley. Slowly release the belt tensioner and remove the breaker bar.
5. Lower each drive belt, and take it off the vibration damper. It is not necessary to remove either belt from the vehicle.
6. Remove both alternator mounting capscrews. Remove the alternator from the vehicle.

NOTE: It is not necessary to remove the adjusting strap from the engine.

7. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.



Rotate the belt tensioner down and off the belt.

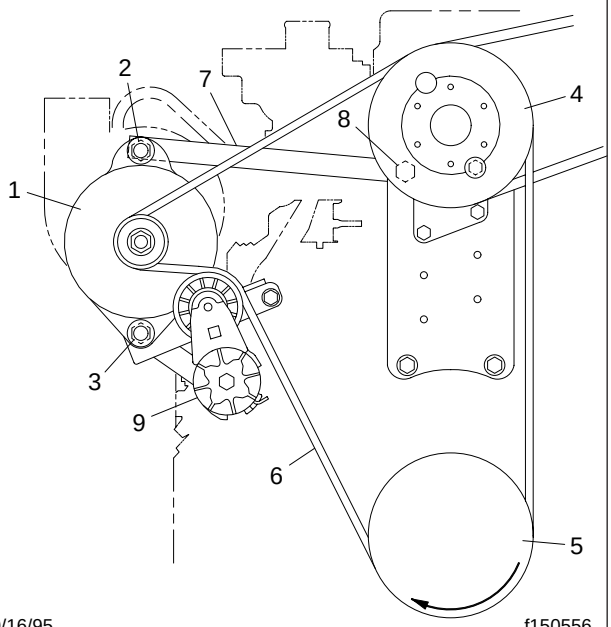
1. JB Series Alternator
2. Alternator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Fan Pulley
5. Vibration Damper
6. Alternator Drive Belt
7. Alternator Adjusting Strap
8. Adjusting Strap Mounting Capscrew
9. Belt Tensioner

Fig. 2, Alternator Installation, Caterpillar 3176/C-10 Engine, Slotted Strap

Installation

1. Check the torque of the adjusting strap mounting capscrew. If necessary, tighten it 65 lbf·ft (88 N·m).
2. Install the alternator on the engine. If the alternator adjusting strap is slotted, install the alternator at the inboard edge of the slot initially. Install the top and bottom alternator mounting capscrews, but do not tighten them yet.
3. Install the drive belt on the pulleys. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Section 01.07, Subject 130**.

JB Series Alternator Removal and Installation, Caterpillar 3176/C–10



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Rotate the belt tensioner down and off the belt.

1. JB Series Alternator
2. Alternator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Fan Pulley
5. Vibration Damper
6. Alternator Drive Belt
7. Alternator Adjusting Strap
8. Adjusting Strap Mounting Capscrew
9. Belt Tensioner

Fig. 3, Alternator Installation, Caterpillar 3176 Engine, Fixed Strap

4. On slotted straps, verify that the edge of the tensioner arm is within the green zone on the decal. See **Fig. 4**. If within the red zone, pivot the alternator outboard until the tensioner arm enters the green zone.

NOTE: If the belt slips, repair or replace the tensioner. For instructions, see the Caterpillar 3176 or C–10 Truck Engine Service Manual.

5. When the alternator is correctly positioned, tighten both alternator mounting capscrews 65 lbf·ft (88 N·m).

6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).

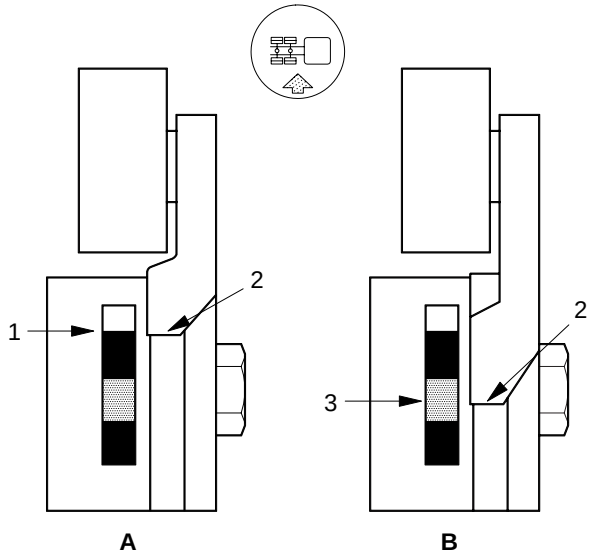
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.

9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting, 300**.



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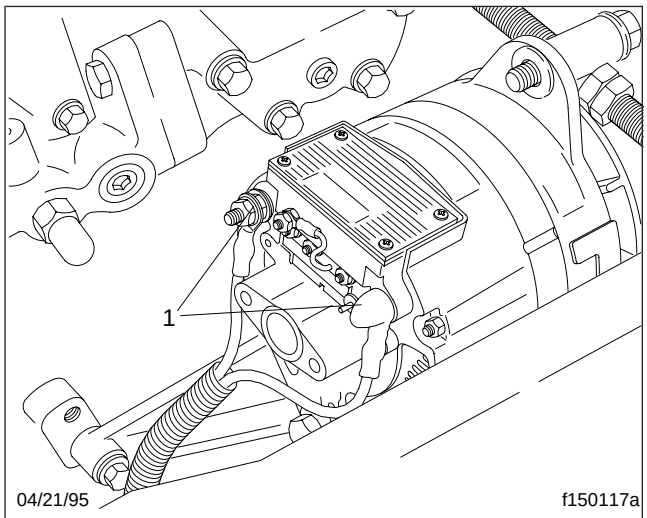
A. Belt Off, No Tension
B. Belt On, Correct Tension
1. Decal
2. Edge of Tensioner Arm
3. Green Zone (operating range)

Fig. 4, Belt Tensioner With Decal

JB Series Alternator Removal and Installation, DDC 50

Removal

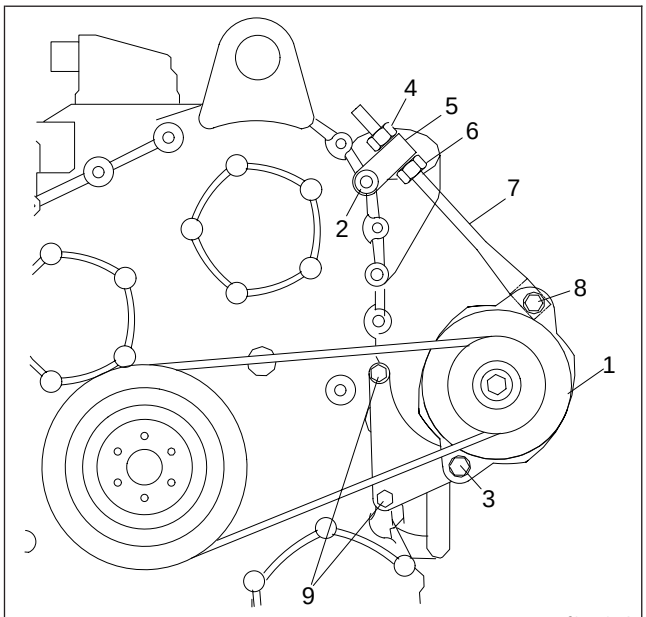
1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator. See **Fig. 1**.



1. Lead Connections

Fig. 1, Battery Lead Connections

3. Loosen the end link mounting capscrew (see **Fig. 2** Ref. 2), the adjusting rod mounting capscrew (Ref. 8), and the alternator mounting capscrew (Ref. 3).
4. Back off the adjusting nut (see **Fig. 2**, Ref. 6). Turn the adjusting rod jam nut (Ref. 4) to rotate the alternator up and toward the engine. Make sure the distance between the pulley centers is now short enough to allow belt removal without using force.
5. When the alternator is close enough to the engine, slip the drive belt off the pulleys without rolling or prying the belt. Remove the drive belt from the vehicle, working the belt over one fan blade at a time.
6. Remove the alternator and adjusting rod mounting capscrews. Remove the alternator from the vehicle.
7. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.



1. JB Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners

Fig. 2, Alternator Installation, Detroit Diesel Series 50

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 43 to 54 lbf·ft (58 to 73 N·m).
2. Install the alternator on the engine. Install the alternator mounting capscrew and the adjusting rod mounting capscrew, but do not tighten them yet.
3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m).
4. Loosen the adjusting rod jam nut (see **Fig. 2**, Ref. 4). Then, tighten the adjusting nut (Ref. 6) until the belt is at the correct tension. For belt tightening specifications, see **Section 01.07, Subject 160**. While holding the ad-

JB Series Alternator Removal and Installation, DDC 50

justing nut in place, tighten the adjusting rod jam nut 95 lbf·ft (130 N·m).

5. Tighten the alternator mounting capscrew and the end link mounting capscrew 65 lbf·ft (88 N·m).
6. Tighten the adjusting rod mounting capscrew 45 lbf·ft (61 N·m).
7. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
8. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

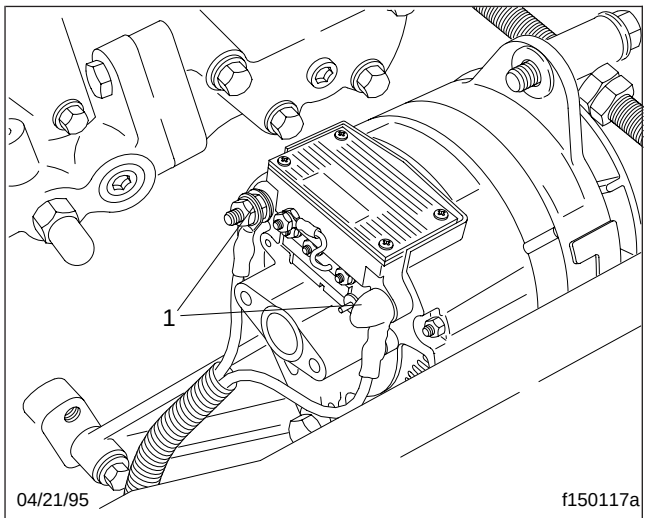
Table 1, Approved Dielectric Red Enamel

9. Connect the batteries.
10. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

JB Series Alternator Removal and Installation, DDC 60

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator. See **Fig. 1**.

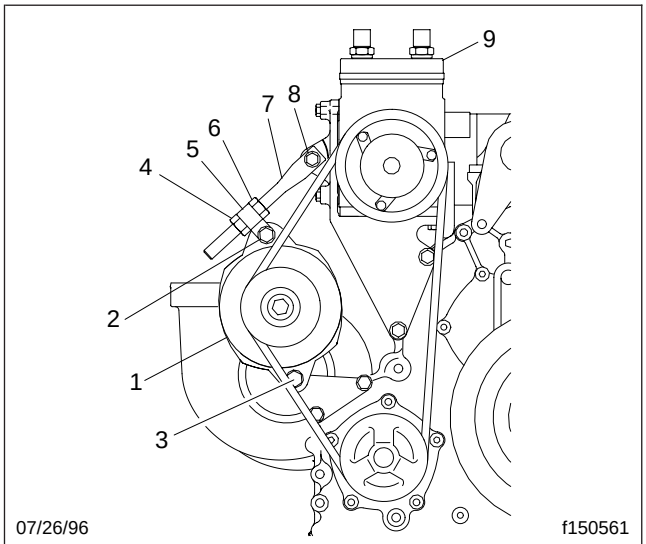


1. Lead Connections

Fig. 1, Battery Lead Connections

NOTE: Three different installations are possible. For DDEC III vehicles with air conditioning (top-mounted refrigerant compressor), see **Fig. 2**. For DDEC II vehicles with air conditioning (side-mounted refrigerant compressor), see **Fig. 3**. For vehicles with no air conditioning, see **Fig. 4**.

3. Loosen the adjusting rod mounting capscrew (see **Fig. 2**, Ref. 8), the end link mounting capscrew (Ref. 2), and the alternator mounting capscrew (Ref. 3). Loosen these mounting capscrews enough to allow movement of the alternator.
4. Back off the adjusting nut. Push the loosened alternator far enough toward the fan drive pulley to allow removal of the drive belts without using force.
5. Remove the drive belt from the pulleys without prying or twisting the belt.
6. Remove the end link mounting capscrew and the alternator mounting capscrew. Remove the alternator from the vehicle.



1. JB Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Refrigerant Compressor

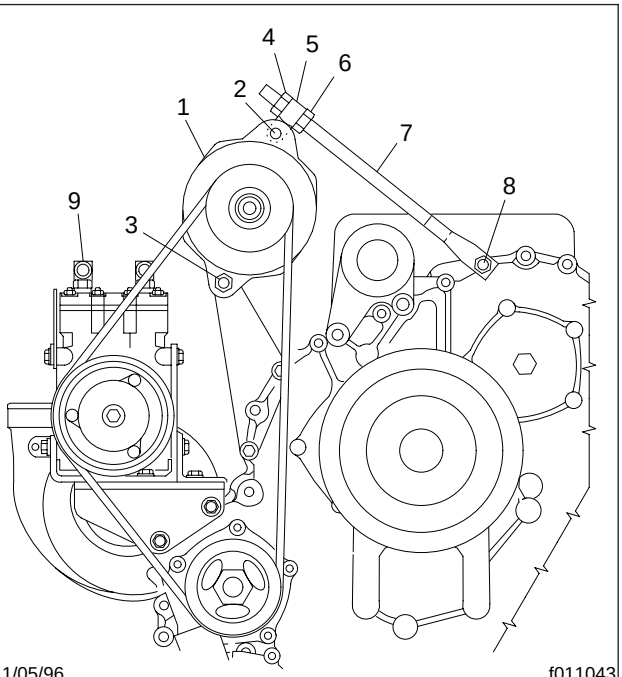
Fig. 2, Alternator Installation, Detroit Diesel Series 60 Engine

7. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

Installation

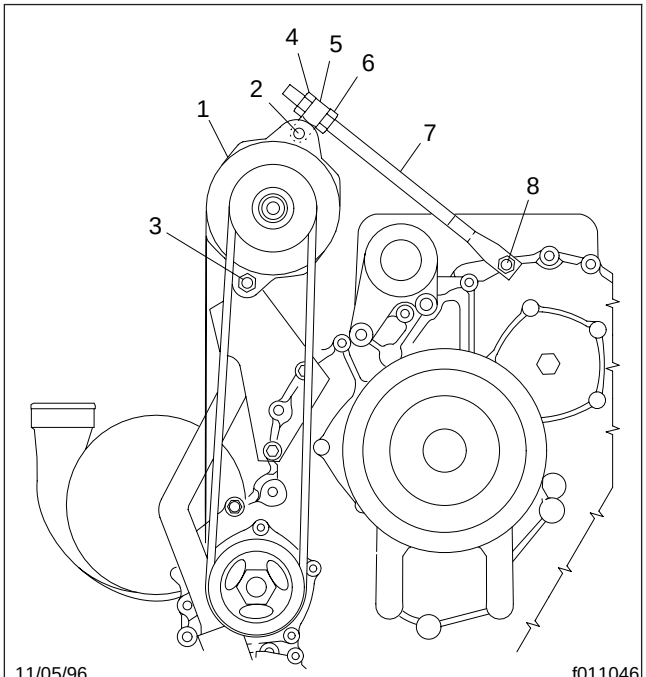
1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 50 lbf·ft (68 N·m).
2. Install the alternator on the engine. Install the end link mounting capscrew and the alternator mounting capscrew, but do not tighten them yet.
3. Loop the drive belt around the pulleys.
4. Install the drive belt on the pulleys without prying or rolling it into place. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Section 01.07, Subject 140**.
5. After the belt has been correctly tensioned, tighten the adjusting rod jam nut 95 lbf·ft (130 N·m).

JB Series Alternator Removal and Installation, DDC 60



1. JB Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Refrigerant Compressor

Fig. 3, Alternator Installation, DDEC II with Air Conditioning



1. JB Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew

Fig. 4, Alternator Installation, All Detroit Diesel Series 60 Engines without Air Conditioning

6. Tighten the end link mounting capscrew and the alternator mounting capscrew 65 lbf·ft (88 N·m). Tighten the adjusting rod mounting capscrew 34 lbf·ft (46 N·m).
7. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
8. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

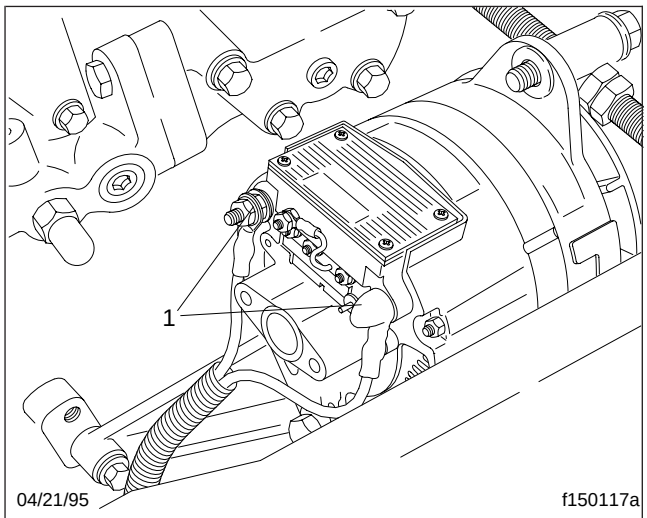
Table 1, Approved Dielectric Red Enamel

9. Connect the batteries.
10. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting, 300**.

JB Series Alternator Removal and Installation, DDC 55

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator. See **Fig. 1**.



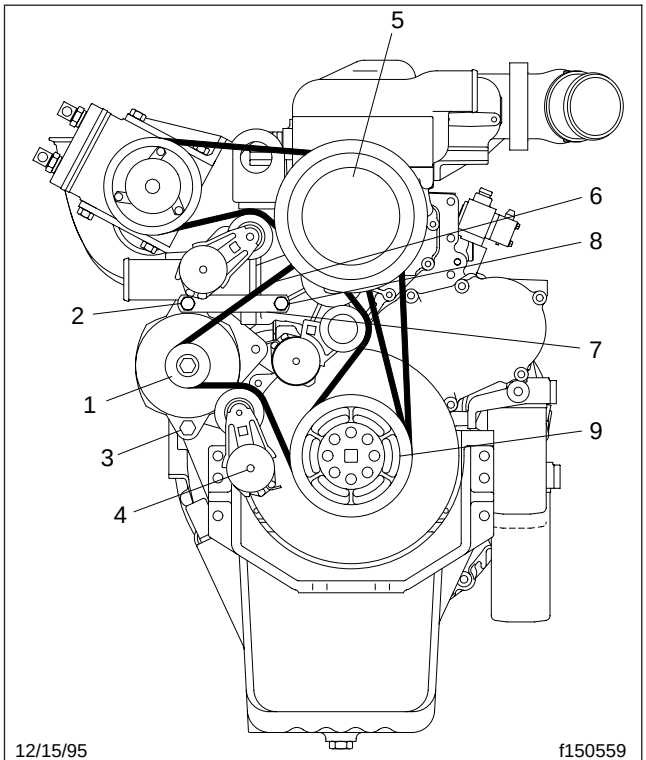
1. Lead Connections

Fig. 1, Battery Lead Connections

3. Insert a breaker bar in the alternator belt tensioner (see **Fig. 2**, Ref. 4) and rotate the tensioner down and off the alternator drive belt.

NOTE: There are two drive belts to remove. Before removing the alternator belt, it is necessary to remove the refrigerant compressor belt from its pulleys.

4. Holding the belt tensioner down, remove each drive belt from its pulley. Slowly release the belt tensioner and remove the breaker bar.
5. Lower each drive belt, and take it off the vibration damper. It is not necessary to remove either belt from the vehicle.
6. Remove the top and bottom alternator mounting capscrews. Remove the alternator from the vehicle.
7. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.



1. JB Series Alternator
2. Altenator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Alternator Belt Tensioner
5. Fan Pulley
6. Alternator Drive Belt
7. Alternator Adjusting Strap
8. Alternator Adjusting Strap Mounting Capscrew
9. Vibration Damper

Fig. 2, Alternator Installation, Detroit Diesel Series 55 Engine

Installation

1. Check the torque of the adjusting strap mounting capscrew. If necessary, tighten it 65 lbf·ft (88 N·m).
2. Install the alternator on the engine. Install the two alternator mounting capscrews (top and bottom), but do not tighten them yet.
3. Install the alternator drive belt on the pulleys. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Section 01.07, Subject 170**.

JB Series Alternator Removal and Installation, DDC 55

NOTE: The Detroit Diesel belt tensioner automatically adjusts the alternator drive belt to the correct tension. If the belt slips, repair or replace the tensioner. For instructions, see the engine manufacturer's service literature.

4. Tighten both alternator mounting capscrews 65 lbf·ft (88 N·m).
5. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
6. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

7. Connect the batteries.
8. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting, 300**.

Adjustment

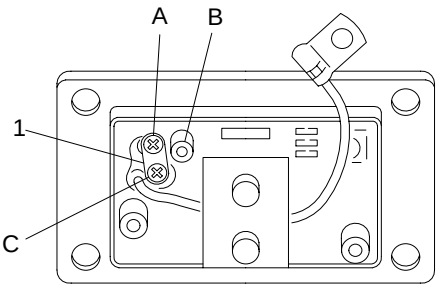
NOTE: Before checking or adjusting the alternator voltage, check the wiring, connections, and belt tension.

1. Turn off all accessories. Run the engine at fast idle (approximately 1200 RPM) and charge the batteries.
2. Connect an accurate voltmeter across the batteries to determine the charging voltage.
3. If the charging voltage needs adjusting, reposition the adjustment strap.

   3.1 Shut down the engine. Disconnect the battery ground cable.

   3.2 Disconnect the diode trio lead. Remove the four screws from the regulator cover, then lift the regulator off the alternator far enough to expose the voltage adjustment strap.

   3.3 If needed, move the adjustment strap to any one of the three positions to adjust the voltage. The three positions available are: A and B (low), A and C (medium), and C and B (high). See **Fig. 1**.



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The adjustment strap can be set to the following positions.

A and B. Low
A and C. Medium
C and B. High

1. Adjustment Strap

Fig. 1, Voltage Adjustment

NOTE: If the adjustment strap is in the A and C (medium) position, changing it to the A and B (low) position decreases the voltage 0.4 volt. Moving the strap to the C and B (high) position would increase the voltage 0.4 volt.

3.4 Install the regulator and connect the diode trio lead. Connect the battery.

Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

To troubleshoot the SmartChek™ diagnostic alternator perform the following steps:

1. With the engine off, clean the top of the regulator using a shop cloth until you can see the SmartChek indicator.
2. Start the engine. If the SmartChek indicator glows red, replace the alternator.

   If the indicator glows green, go to the next step.
3. Turn on several vehicle accessories, such as lights and heater fans. If the green indicator changes to red, replace the alternator.

   If the indicator continues to glow green, the alternator is OK. Check the other components of the electrical system.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/Charging System Testing."

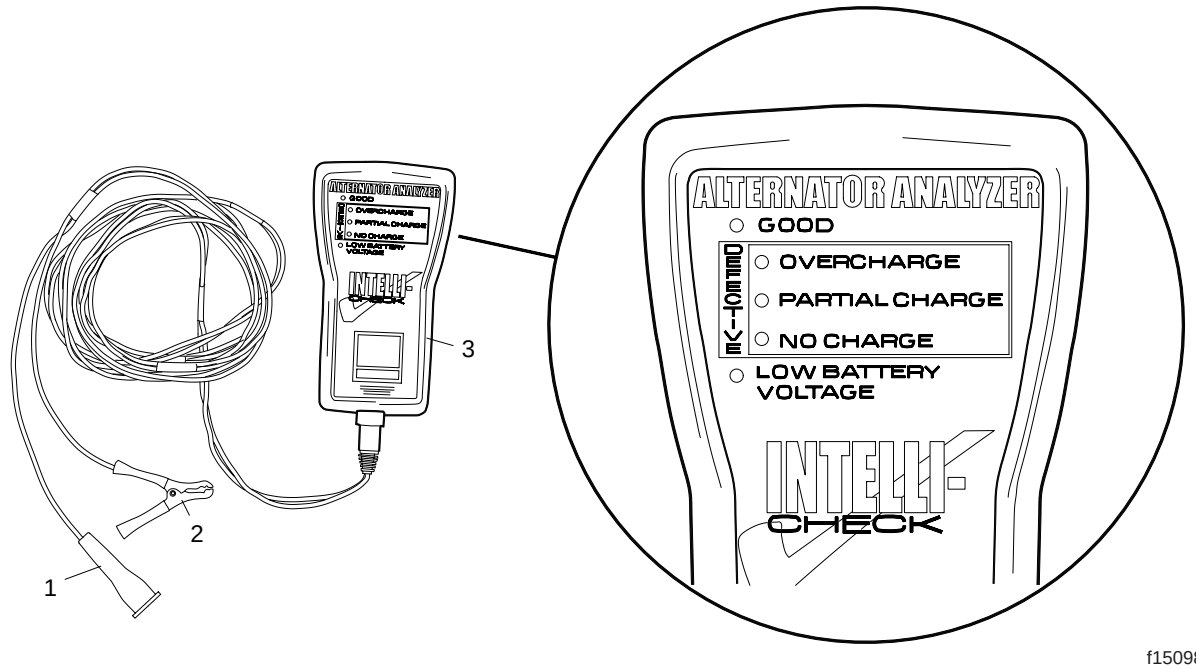
Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.
3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
   - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
     A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
     B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
     C. Repeat the applicable steps of the Pre-Test Procedure.
   - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
   - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

Troubleshooting



1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 1, Delco Remy Intelli-Check Alternator Analyzer

Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
   - If the **GOOD** (green) LED illuminates, proceed to the next step.
   - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
   - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing."
4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/ Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.

8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing."

Alternator/Charging System Testing

Battery Open Circuit Voltage Test, Alternator Output Voltage Test and Alternator Amperage Output Test

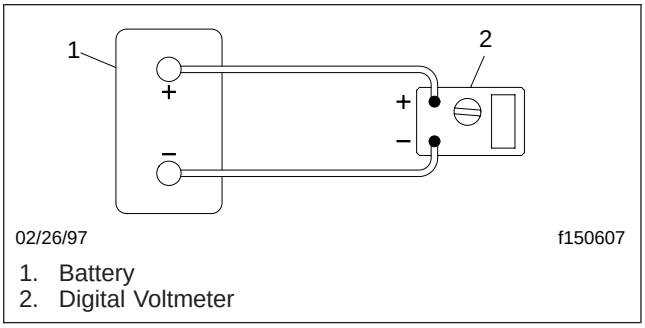
1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

   If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

   If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

2. Check the alternator output without a load. See **Fig. 3**.

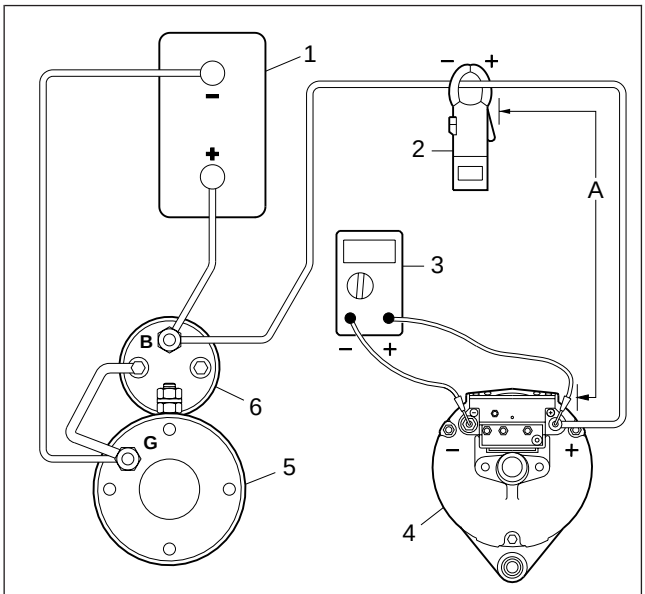


1. Battery
2. Digital Voltmeter

Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)

2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3**.



A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 3, Setup 2: Alternator Output Voltage

2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.

3. Check the alternator output under load. See **Fig. 3**.

   3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

   3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

   - Both front and rear heater blowers (on HIGH)

Troubleshooting

- Headlights (high beams)
- Road lights
- Interior lights

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

4. Perform an alternator amperage output test.

4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2**.

NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

NOTE: Ensure that the alternator is turning at maximum available rpms and keep adjusting the tester dial until the ammeter reads its highest value.

4.4 Turn off the tester and shut down the engine.

4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3**.

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables and terminals.

6.1 Check all connections between the battery, starter and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

See **Fig. 1** for a Leece-Neville JB Series alternator wiring diagram.

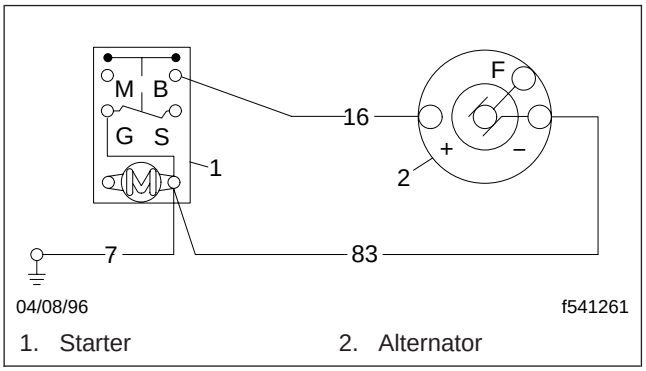


Fig. 1, Leece-Neville JB Series Alternator Wiring Diagram

Mounting Fastener Torques, Caterpillar Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Caterpillar 3306 and 3406 Engines			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Jam Nut	5	1/2	65 (88)
Alternator Bracket Fasteners	5PO	3/8–16	34 (46)
Caterpillar 3176/C–10 Engine			
Alternator Mounting Capscrews	8PO	1/2–13	65 (88)
Adjusting Strap Mounting Capscrew	10.9PO	M12	65 (88)

Table 1, Mounting Fastener Torques, Caterpillar Engines

Mounting Fastener Torques, Cummins Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Cummins N14/NTC Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	8PO	7/16–20	50 (68)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Alternator Bracket Fasteners	5PO	3/8–16	34 (46)
Cummins M11/L10 Engine			
Adjusting Block Mounting Bolt	8	3/8	30 (41)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Screw Locknut	5	5/8	95 (130)
Adjusting Arm Mounting Capscrew	5	1/2–13	55 (75)

Specifications

Mounting Fastener Torques, Cummins Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Alternator Bracket Fasteners	10.9PO	M10	34 (46)

Table 2, Mounting Fastener Torques, Cummins Engines

Mounting Fastener Torques, Detroit Diesel Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Detroit Diesel Series 50 Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	8PO	7/16–14	45 (61)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Alternator Bracket Fasteners	5PO	3/8–16	43–54 (58–73)
Detroit Diesel Series 60 Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	10.9PO	M10	34 (46)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Alternator Bracket Fasteners	8PO	7/16–20	50 (68)
Detroit Diesel Series 55 Engine			
Alternator Mounting Capscrews	8PO	1/2–13	65 (88)
Adjusting Strap Mounting Capscrew	8PO	1/2–13	65 (88)

Table 3, Mounting Fastener Torques, Detroit Diesel Engines

Description	**Grade**	**Size**	**Torque: lbf·in (N·cm)**
Alternator Output ("BAT") Terminal Nut	5	5/16–18	100 (1140)
Alternator Ground ("G") Terminal Nut	5	1/4–20	65 (740)
Instrument ("I") or Relay ("R") Terminal Nut	8.8	M4	20 (220)

Table 4, Terminal Fastener Torques, All Engines

Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Pulley Nut	8PO	1/2–20	75 (102)

Table 5, Pulley Nut Torque, All Engines

General Description

The Delco Remy 21–SI series alternator (see **Fig. 1**) features a solid-state voltage regulator mounted inside the end frame. The only moving part is the rotor, which is mounted on a ball bearing at the drive end, and a roller bearing at the rectifier end. See **Fig. 2**.

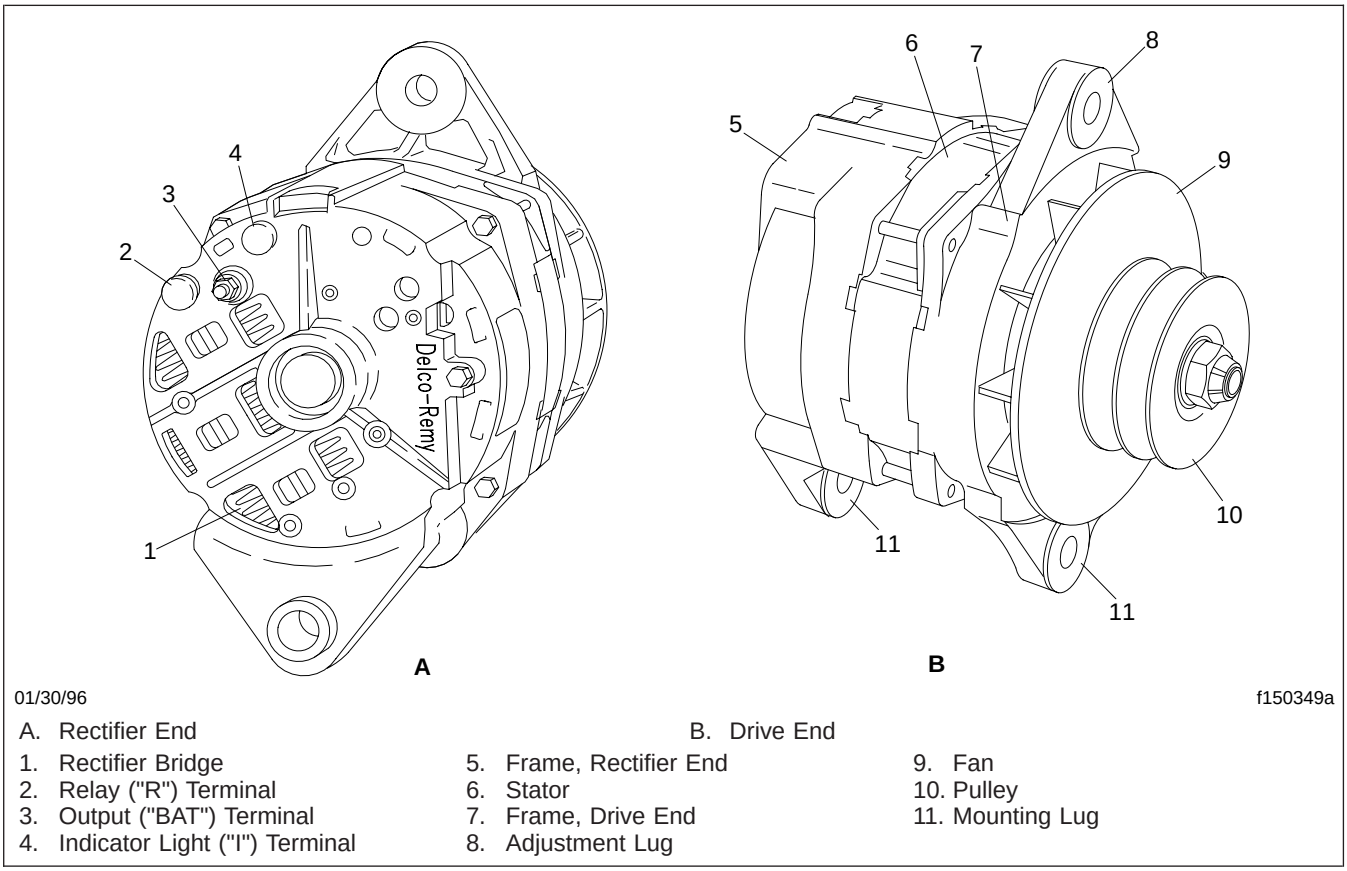
All bearings are sealed so that no periodic maintenance is required. The regulator and diodes are enclosed in a sealed compartment. A fan located on the drive end provides air flow for cooling.

As the rotor begins to turn, the permanent magnetism within it induces voltages in the stator windings. The voltages across the diodes cause current to flow, charging the battery.

Normally only one wire connects the alternator to the battery at the starter, along with a ground return.

Since the vehicle's system is a negative ground, the output terminal connects to the starter's positive terminal.

On vehicles built on or after September 12, 1995, a low-speed start-up circuit supplies ignition power directly to the alternator "I" terminal. For a circuit diagram, see **Specifications, 400**.

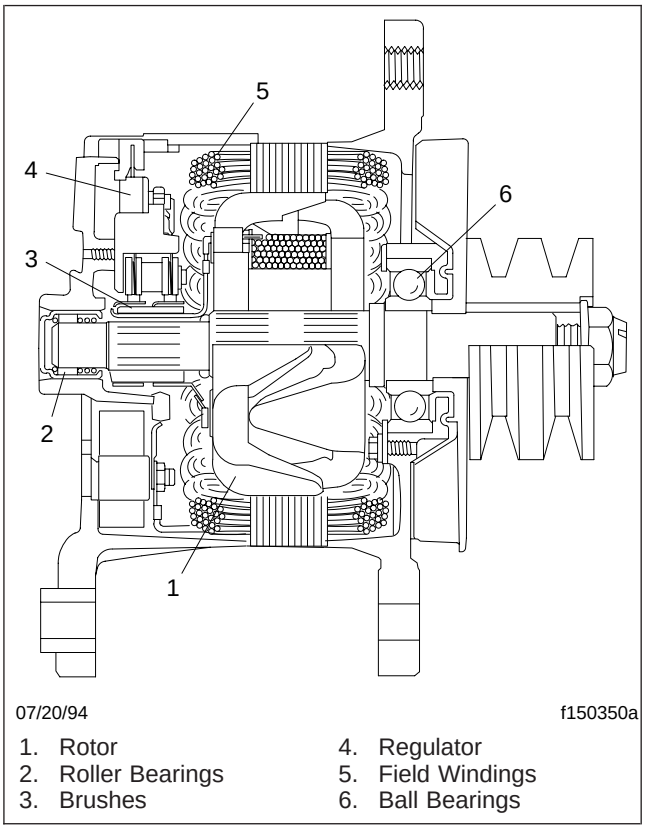


A. Rectifier End
B. Drive End

1. Rectifier Bridge
2. Relay ("R") Terminal
3. Output ("BAT") Terminal
4. Indicator Light ("I") Terminal
5. Frame, Rectifier End
6. Stator
7. Frame, Drive End
8. Adjustment Lug
9. Fan
10. Pulley
11. Mounting Lug

Fig. 1, Delco Remy 21-SI Alternator (exterior view)

General Information



1. Rotor
2. Roller Bearings
3. Brushes
4. Regulator
5. Field Windings
6. Ball Bearings

Fig. 2, Delco Remy 21-SI Alternator (cutaway view)

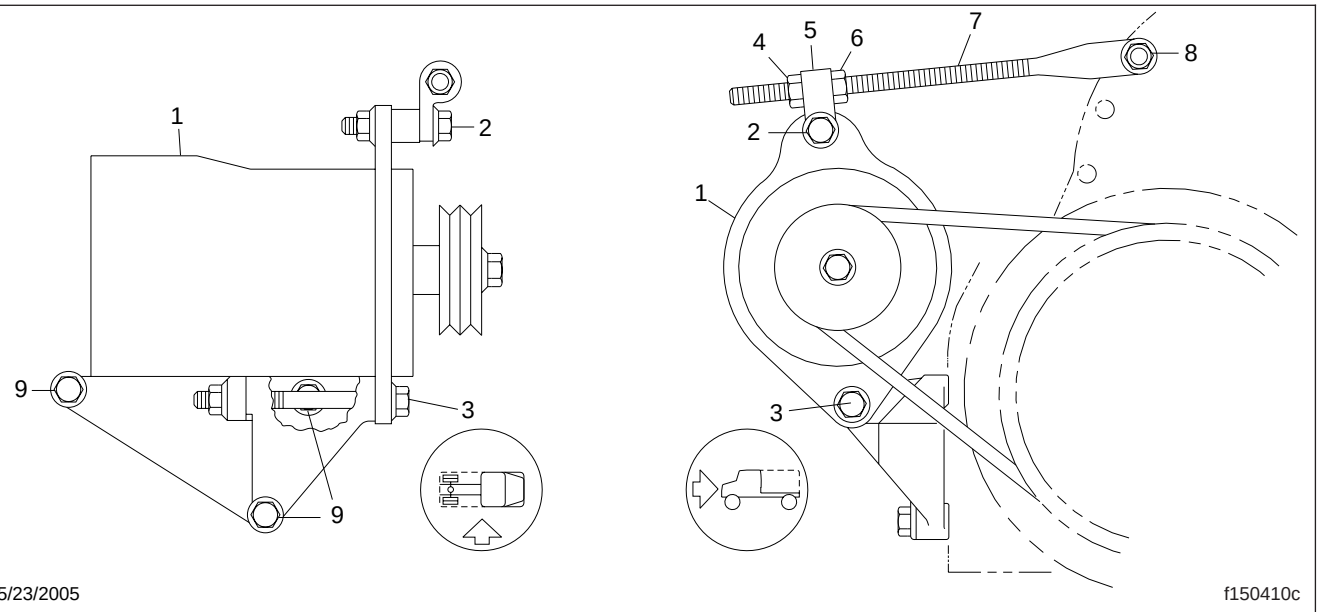
21–SI Alternator Removal and Installation, Cummins N14/NTC

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Loosen the adjusting rod mounting capscrew (see **Fig. 1**, Ref. 8).

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine with the end link attached. Install the alternator mounting capscrew, but do not tighten it yet.



1. 21–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Capscrew

Fig. 1, Alternator Installation, Cummins N14/NTC Engine

4. Loosen the end link capscrew and the alternator mounting capscrew (see **Fig. 1**, Refs. 2 and 3). Turn the adjusting nut (Ref. 6) counterclockwise, backing the alternator toward the drive pulley far enough to remove the drive belt without prying or twisting the belt. Remove the drive belt from the vehicle.
5. Remove the adjusting rod jam nut (Ref. 4) and alternator mounting capscrew. Remove the alternator from the vehicle with the end link attached.
6. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley.
4. Tighten the adjusting nut (see **Fig. 1**, Ref. 6) until the belt is correctly tensioned. For belt tightening specifications, see **Section 01.07, Subject 100**. While holding the adjusting nut in place, install the adjusting rod jam nut and tighten it 155 lbf·ft (210 N·m).
5. Tighten the end link mounting capscrew and the alternator mounting capscrew 68 lbf·ft (92 N·m). Tighten the adjusting rod mounting capscrew 50 lbf·ft (68 N·m).

21–SI Alternator Removal and Installation, Cummins N14/NTC

6. Connect all electrical leads to the back of the alternator as removed. Tighten the output terminal nut and ground terminal nut 100 lbf·in (1140 N·cm). Tighten the "I" and/or "R" terminal nut(s) 20 lbf·in (220 N·cm), as necessary.
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

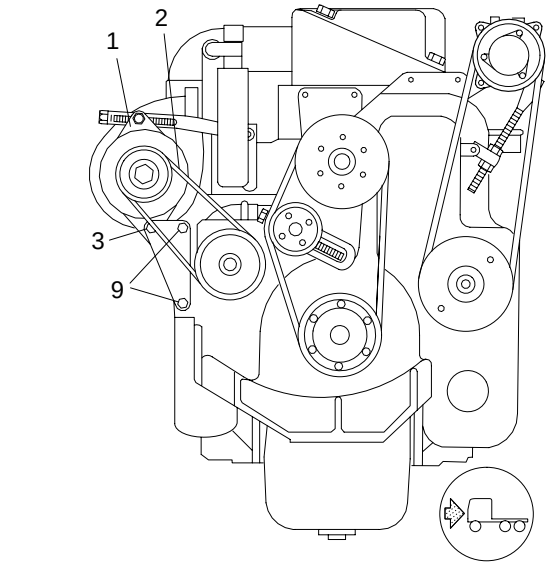
21–SI Alternator Removal and Installation, Cummins M11/L10

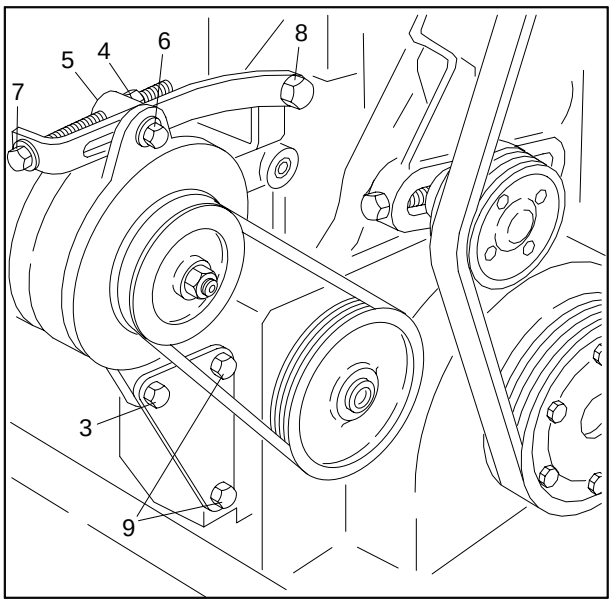
Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Loosen the adjusting block mounting bolt, adjusting arm mounting capscrew, and alternator mounting capscrew just enough to allow movement of the alternator. See **Fig. 1**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine. Install the adjusting block mounting bolt and the alternator mounting capscrew, but do not tighten them yet.
3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley.





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1. 21–SI Alternator
2. Drive Belt
3. Alternator Mounting Capscrew
4. Adjusting Screw Locknut
5. Adjusting Block
6. Adjusting Block Mounting Bolt
7. Adjusting Screw
8. Adjusting Arm Mounting Capscrew
9. Alternator Bracket Fasteners

Fig. 1, Alternator Installation, Cummins M11/L10 Engine

4. Loosen the adjusting screw locknut. See **Fig. 1**, Ref. 4. Turn the adjusting screw (Ref. 7) counterclockwise, backing off the alternator toward the drive pulley far enough to remove the drive belt without prying or twisting the belt. Remove the drive belt from the vehicle.
5. Remove the adjusting block nut and the alternator mounting capscrew. Remove the alternator from the vehicle.
6. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

4. Turn the adjusting screw (see **Fig. 1**, Ref. 7) clockwise until the belt is correctly tensioned. For belt tightening specifications, see **Section 01.07, Subject 110**. Tighten the adjusting screw locknut (Ref. 4) 95 lbf·ft (130 N·m).
5. Tighten the alternator mounting capscrew (see **Fig. 1**, Ref. 3) 60 lbf·ft (81 N·m); tighten the adjusting block mounting bolt (Ref. 6) 35 lbf·ft (47 N·m); tighten the adjusting arm mounting capscrew (Ref. 8) 55 lbf·ft (75 N·m).

21–SI Alternator Removal and Installation, Cummins M11/L10

6. Connect all electrical leads to the back of the alternator as removed. Tighten the output terminal nut and ground terminal nut 100 lbf·in (1140 N·cm). Tighten the "I" and/or "R" terminal nut(s) 20 lbf·in (220 N·cm), as necessary.
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

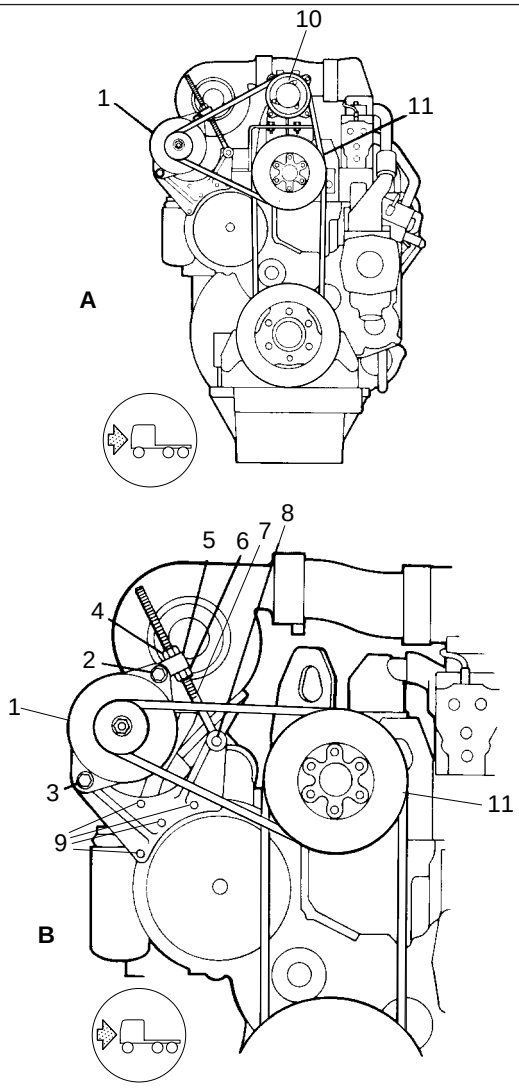
21–SI Alternator Removal and Installation, Caterpillar 3306

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Loosen the end link and alternator mounting capscrews (see **Fig. 1**, Ref. 2 and 3) and the adjusting rod mounting capscrew (Ref. 8).
4. Back off the adjusting nut (see **Fig. 1**, Ref. 6) on the adjusting rod, allowing the alternator to be moved far enough toward the drive pulley to remove the fan drive belt without prying or twisting the belt. Remove the drive belt from the vehicle.
5. Remove the end link and alternator mounting capscrews. Remove the alternator from the vehicle.
6. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine. Install the end link and alternator mounting capscrews, but do not tighten them yet.
3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley.
4. Loosen the adjusting rod jam nut (see **Fig. 1**, Ref. 4). Then, tighten the adjusting nut (Ref. 6) until the belt is correctly tensioned. For belt tightening specifications, see **Section 01.07, Subject 120**. While holding the adjusting nut in place, tighten the adjusting rod jam nut 95 lbf·ft (130 N·m).
5. Tighten the end link mounting capscrew, the alternator mounting capscrew, and the adjusting rod mounting capscrew 68 lbf·ft (92 N·m).
6. Connect all electrical leads to the back of the alternator as removed. Tighten the output terminal nut and ground terminal nut 100 lbf·in (1140 N·cm). Tighten the "I" and/or "R" terminal nut(s) 20 lbf·in (220 N·cm), as necessary.
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.



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A. With Refrigerant Compressor
B. Without Refrigerant Compressor

1. 21–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners
10. Refrigerant Compressor
11. Fan Drive

Fig. 1, Alternator Installation, Caterpillar 3306 Engine

21–SI Alternator Removal and Installation, Caterpillar 3306

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Trouble-shooting, 300**.

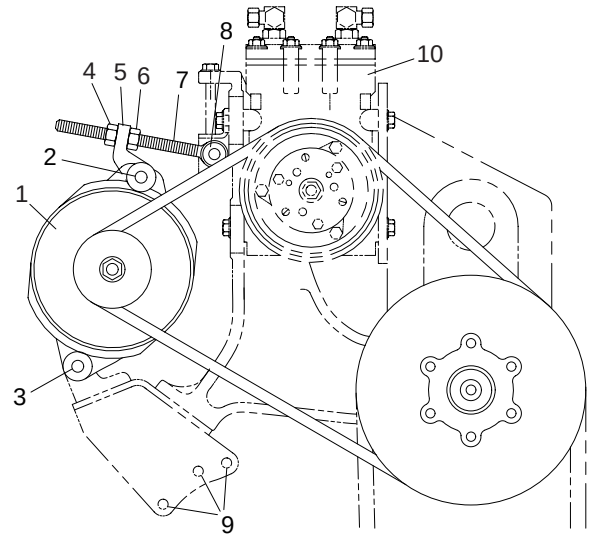
21–SI Alternator Removal and Installation, Caterpillar 3406

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.

NOTE: Three different installations are possible. For vehicles with a piston-type refrigerant compressor, see **Fig. 1**. For vehicles with a rotary (swash-plate) refrigerant compressor, see **Fig. 2**. For vehicles with no air conditioning, see **Fig. 3**.

3. Back off the adjusting nut (Ref. 6, all figures). Loosen the end link mounting capscrew and the alternator mounting capscrew enough to allow movement of the alternator.



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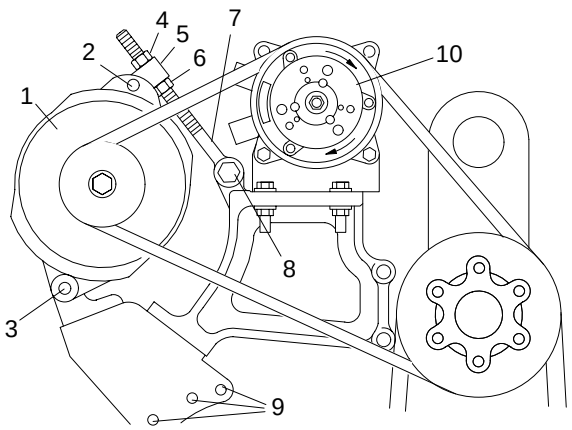
1. 21–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners
10. Refrigerant Compressor

Fig. 1, Alternator Installation, Caterpillar 3406 Engine with Piston-Type Refrigerant Compressor



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1. 21–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners
10. Refrigerant Compressor

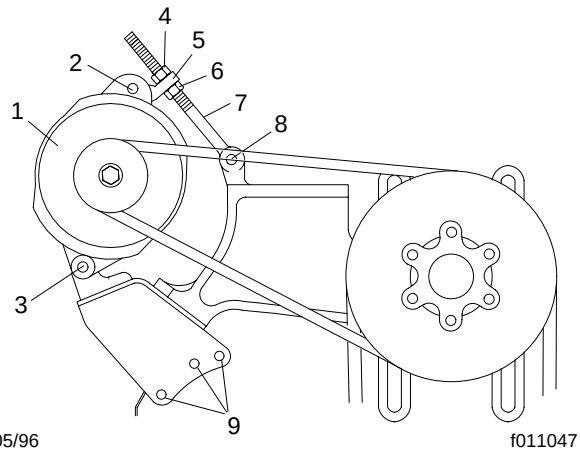
Fig. 2, Alternator Installation, Caterpillar 3406 Engine with Rotary Refrigerant Compressor

4. Push the loosened alternator far enough toward the fan drive pulley to allow removal of the drive belts without using force.
5. Slip each drive belt (dual drive belts) off the pulleys and work it over one fan blade at a time. Remove both drive belts from the vehicle.
6. Remove the two mounting capscrews already loosened. Remove the alternator from the vehicle.
7. Inspect the drive belts and pulleys. For instructions, see **Section 01.07, Subject 180**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine. Install the end link mounting capscrew and the alternator mounting capscrew, but do not tighten them yet.

21–SI Alternator Removal and Installation, Caterpillar 3406



1. 21–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners

Fig. 3, Alternator Installation, Caterpillar 3406 Engine with No Air Conditioning

3. Make sure the distance between the pulleys is short enough to allow belt installation without using force.
4. Work each belt over the fan blades, one blade at a time. Install the dual drive belts on the pulleys without prying or rolling them into place. For belt tightening procedures and specifications, see **Section 01.07, Subject 150**.
5. After each belt has been correctly tensioned, tighten the adjusting rod jam nut 95 lbf·ft (130 N·m).
6. Tighten both the end link and the alternator mounting capscrew 68 lbf·ft (92 N·m).
7. Connect all electrical leads to the back of the alternator as removed. Tighten the output terminal nut and ground terminal nut 100 lbf·in (1140 N·cm). Tighten the "I" and/or "R" terminal nut(s) 20 lbf·in (220 N·cm), as necessary.
8. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1.**

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

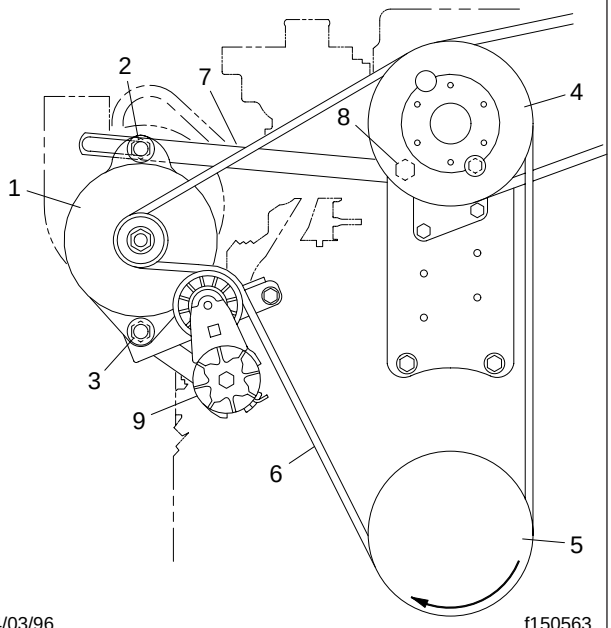
Table 1, Approved Dielectric Red Enamel

9. Connect the batteries.
10. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

21–SI Alternator Removal and Installation, Caterpillar 3176/C–10

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Insert a 1/2-inch breaker bar in the belt tensioner and rotate the tensioner down and off the alternator drive belt. See **Fig. 1** for slotted-strap alternators. See **Fig. 2** for fixed-strap alternators.

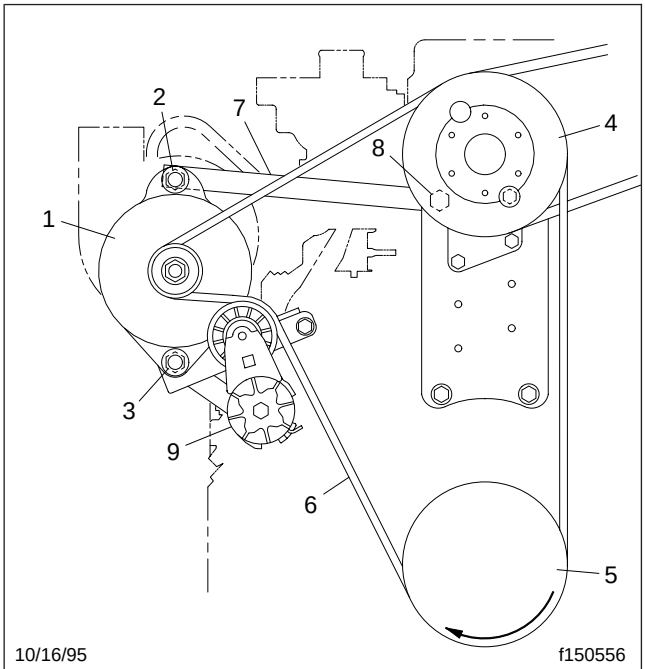


Rotate the belt tensioner down and off the belt.

1. 21–SI Alternator
2. Alternator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Fan Pulley
5. Vibration Damper
6. Alternator Drive Belt
7. Adjusting Strap
8. Adjusting Strap Mounting Capscrew
9. Belt Tensioner

Fig. 1, Alternator Installation, Caterpillar 3176/C-10 Engine, Slotted Strap

NOTE: There is only one drive belt to remove. It is not necessary to remove the refrigerant compressor belt from its pulleys.



Rotate the belt tensioner down and off the belt.

1. 21–SI Alternator
2. Alternator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Fan Pulley
5. Vibration Damper
6. Alternator Drive Belt
7. Adjusting Strap
8. Adjusting Strap Mounting Capscrew
9. Belt Tensioner

Fig. 2, Alternator Installation, Caterpillar 3176 Engine, Fixed Strap

4. Holding the belt tensioner down, remove the drive belt from the alternator pulley. Slowly release the belt tensioner and remove the breaker bar.
5. Lower the drive belt, and take it off the vibration damper. It is not necessary to remove the belt from the vehicle.
6. Remove both alternator mounting capscrews. Remove the alternator from the vehicle.

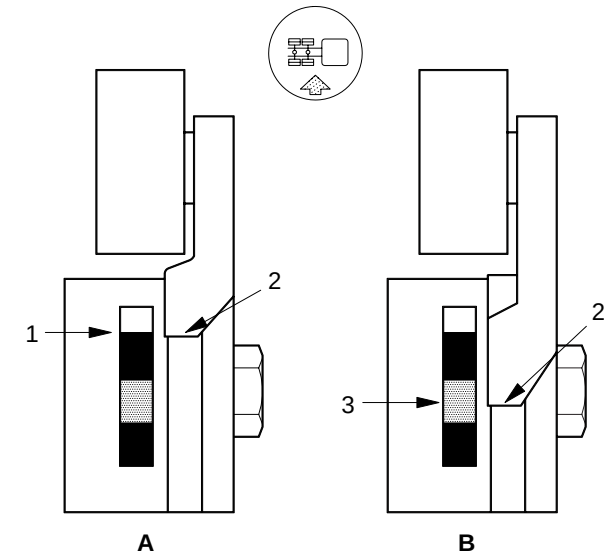
NOTE: It is not necessary to remove the adjusting strap from the engine.

7. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

21–SI Alternator Removal and Installation, Caterpillar 3176/C–10

Installation

1. Check the torque of the adjusting strap mounting capscrew. If necessary, tighten it 60 lbf·ft (81 N·m).
2. Install the alternator on the engine. If the alternator adjusting strap is slotted, install the alternator at the inboard edge of the slot initially. Install the top and bottom alternator mounting capscrews, but do not tighten them yet.
3. Install the drive belt on the pulleys. For belt tightening procedures and specifications, see **Section 01.07, Subject 130**.
4. On slotted straps, verify that the edge of the tensioner arm is within the green zone on the decal. See **Fig. 3**. If within the red zone, pivot the alternator outboard until the tensioner arm enters the green zone.



A. Belt Off, No Tension
B. Belt On, Correct Tension
1. Decal
2. Edge of Tensioner Arm
3. Green Zone (operating range)

Fig. 3, Belt Tensioner With Decal

NOTE: If the belt slips, repair or replace the tensioner. For instructions, see the Caterpillar 3176 or C–10 Truck Engine Service Manual.

5. When the alternator is correctly positioned, tighten both alternator mounting capscrews 68 lbf·ft (92 N·m).
6. Connect all electrical leads to the back of the alternator as removed. Tighten the output terminal nut and ground terminal nut 100 lbf·in (1140 N·cm). Tighten the "I" and/or "R" terminal nut(s) 20 lbf·in (220 N·cm), as necessary.
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

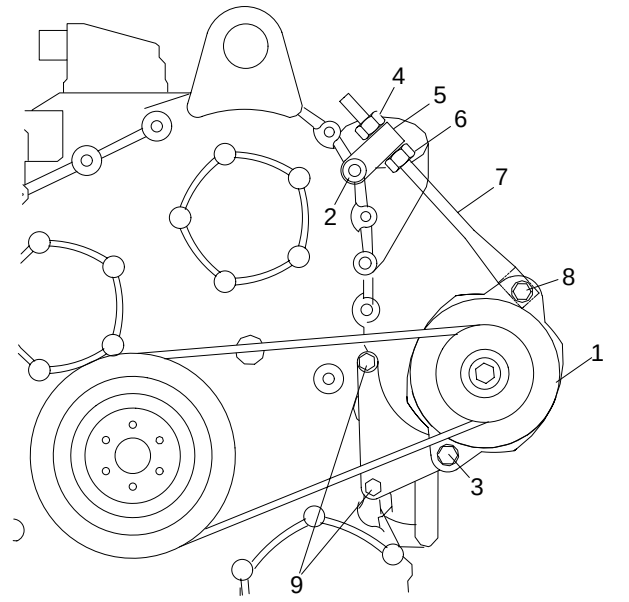
Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

21–SI Alternator Removal and Installation, DDC 50

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Loosen the end link mounting capscrew (see **Fig. 1** Ref. 2), the adjusting rod mounting capscrew (Ref. 8), and the alternator mounting capscrew (Ref. 3).



11/05/96 f011042

1. 21–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners

Fig. 1, Alternator Installation, Detroit Diesel Series 50

4. Turn the adjusting rod jam nut (see **Fig. 1**, Ref. 4) to rotate the alternator up and toward the engine. Back off the adjusting nut as needed. Make sure the distance between the pulley centers is now short enough to allow belt removal without using force.
5. When the alternator is close enough to the engine, slip the drive belt off the pulleys without rolling or prying the belt. Remove the drive belt from the vehicle, working the belt over one fan blade at a time.
6. Remove the alternator and adjusting rod mounting capscrews. Remove the alternator from the vehicle.
7. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 43-54 lbf·ft (58-73 N·m).
2. Install the alternator on the engine. Install the alternator mounting capscrew and the adjusting rod mounting capscrew, but do not tighten them yet.
3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley.
4. Loosen the adjusting rod jam nut (see **Fig. 1**, Ref. 4). Then, tighten the adjusting nut (Ref. 6) until the belt is at the correct tension. For belt tightening specifications, see **Section 01.07, Subject 160**. While holding the adjusting nut in place, tighten the adjusting rod jam nut 128 lbf·ft (173 N·m).
5. Tighten the alternator mounting capscrew and the adjusting rod capscrew 68 lbf·ft (92 N·m).
6. Tighten the end link mounting capscrew 45 lbf·ft (61 N·m).
7. Connect all electrical leads to the back of the alternator as removed. Tighten the output terminal nut and ground terminal nut 100 lbf·in (1140 N·cm). Tighten the "I" and/or "R" terminal nut(s) 20 lbf·in (220 N·cm), as necessary.
8. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

9. Connect the batteries.

21–SI Alternator Removal and Installation, DDC 50

10. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Trouble-shooting, 300**.

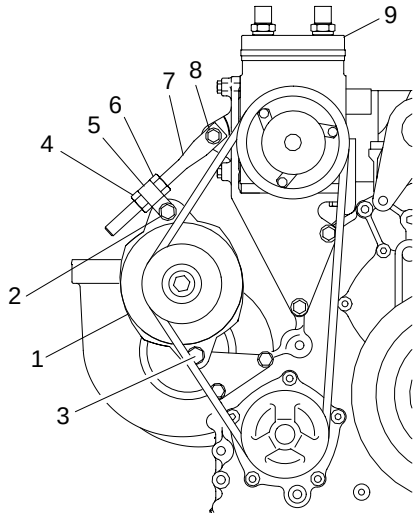
21–SI Alternator Removal and Installation, DDC 60

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.

NOTE: Three different installations are possible. For DDEC III vehicles with air conditioning (top-mounted refrigerant compressor), see **Fig. 1**. For DDEC II vehicles with air conditioning (side-mounted refrigerant compressor), see **Fig. 2**. For vehicles with no air conditioning, see **Fig. 3**.

3. Loosen the adjusting rod mounting capscrew (Ref. 8, all figures), the end link mounting capscrew (Ref. 2), and the alternator mounting capscrew (Ref. 3). Loosen these three mounting capscrews enough to allow movement of the alternator.



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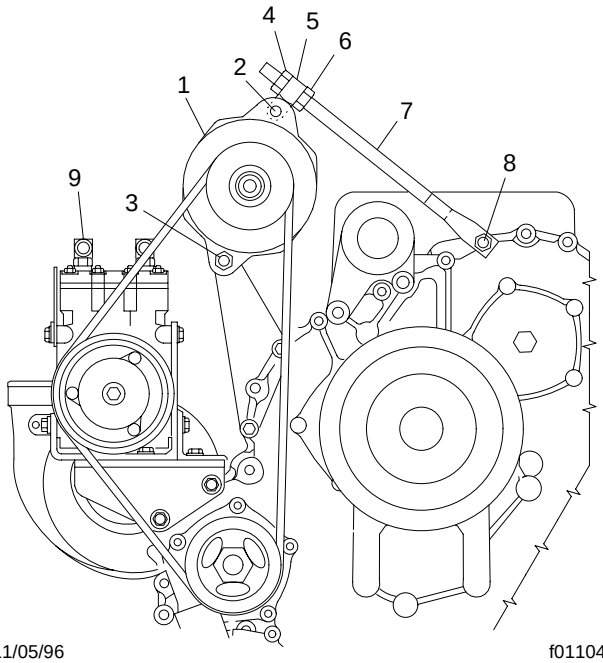
1. 21–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Refrigerant Compressor

Fig. 1, Alternator Installation, DDEC III with Air Conditioning

4. Back off the adjusting nut (see **Fig. 1**, Ref. 6). Push the loosened alternator far enough toward the fan drive pulley to allow removal of the drive belt without using force.
5. Remove the drive belt from the pulleys without prying or twisting the belt.
6. Remove the end link mounting capscrew and the alternator mounting capscrew. Remove the alternator from the vehicle.
7. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.



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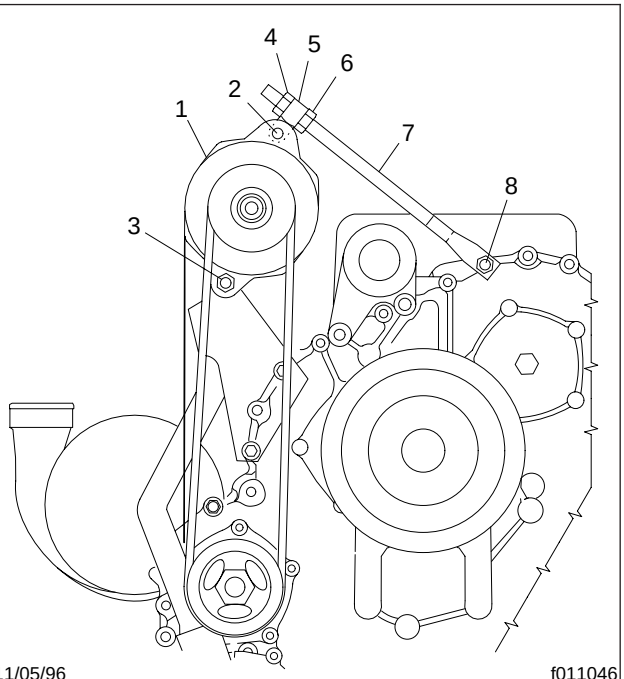
1. 21–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Refrigerant Compressor

Fig. 2, Alternator Installation, DDEC II with Air Conditioning

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).

21–SI Alternator Removal and Installation, DDC 60



1. 21–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew

Fig. 3, Alternator Installation, All Detroit Diesel Series 60 Engines without Air Conditioning

2. Install the alternator on the engine. Install the end link mounting capscrew and the alternator mounting capscrew, but do not tighten them yet.
3. Loop the drive belt around the pulleys.
4. Install the drive belt on the pulleys without prying or rolling it into place. For belt tightening procedures and specifications, see **Section 01.07, Subject 140**.
5. After the belt has been correctly tensioned, tighten the adjusting rod jam nut 155 lbf·ft (210 N·m).
6. Tighten the end link mounting capscrew and the alternator mounting capscrew 68 lbf·ft (92 N·m). Tighten the adjusting rod mounting capscrew 34 lbf·ft (46 N·m).
7. Connect all electrical leads to the back of the alternator as removed. Tighten the output terminal nut and ground terminal nut 100 lbf·in (1140 N·cm). Tighten the "I" and/or "R" terminal nut(s) 20 lbf·in (220 N·cm), as necessary.
8. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

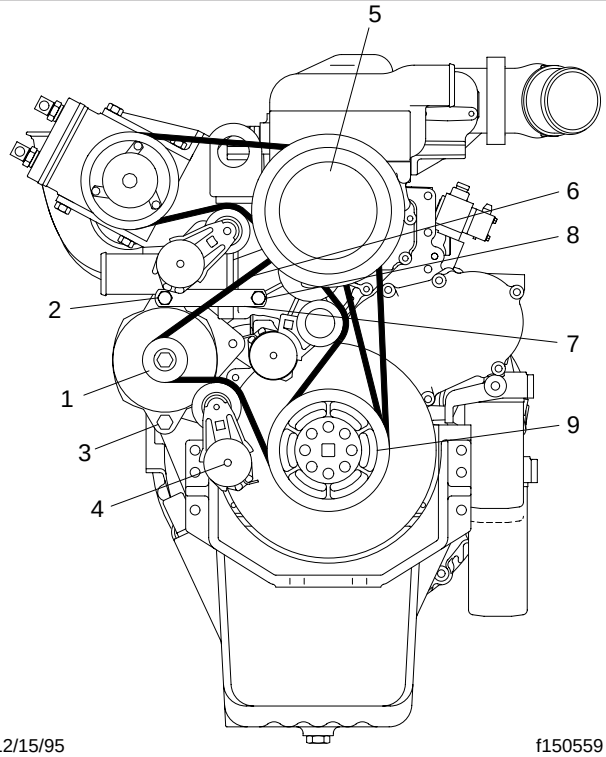
Table 1, Approved Dielectric Red Enamel

9. Connect the batteries.
10. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

21–SI Alternator Removal and Installation, DDC 55

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Insert a breaker bar in the alternator belt tensioner (see **Fig. 1**, Ref. 4) and rotate the tensioner down and off the alternator drive belt.



Rotate the belt tensioner down and off the belt.

1. 21–SI Alternator
2. Altenator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Alternator Belt Tensioner
5. Fan Pulley
6. Alternator Drive Belt
7. Alternator Adjusting Strap
8. Alternator Adjusting Strap Mounting Capscrew
9. Vibration Damper

Fig. 1, Alternator Installation, Detroit Diesel Series 55 Engine

NOTE: There is only one drive belt to remove. It is not necessary to remove the fan belt or the refrigerant compressor belt.

4. Holding the belt tensioner down, remove the alternator belt from the alternator pulley. Slowly release the belt tensioner and remove the breaker bar.
5. Lower the belt, and take it off the vibration damper. Raise the belt, and take it off over the fan. Remove the alternator drive belt from the vehicle.
6. Remove the top and bottom alternator mounting capscrews. If necessary to remove the alternator from the vehicle, loosen the adjusting strap mounting capscrew. It is not necessary to remove the adjusting strap.
7. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

Installation

1. Check the torque of the adjusting strap mounting capscrew. If necessary, tighten it 68 lbf·ft (92 N·m).
2. Install the alternator on the engine. Install the two alternator mounting capscrews (top and bottom), but do not tighten them yet.
3. Install the alternator belt on the pulleys. For belt tightening procedures and specifications, see **Section 01.07, Subject 170**.

NOTE: The Detroit Diesel belt tensioner automatically adjusts the alternator belt to the correct tension. If the belt slips, repair or replace the tensioner. For instructions, see the engine manufacturer's service literature.

4. Tighten both alternator mounting capscrews 68 lbf·ft (92 N·m).
5. Connect all electrical leads to the back of the alternator as removed. Tighten the output terminal nut and ground terminal nut 100 lbf·in (1140 N·cm). Tighten the "I" and/or "R" terminal nut(s) 20 lbf·in (220 N·cm), as necessary.
6. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

21–SI Alternator Removal and Installation, DDC 55

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel

7. Connect the batteries.
8. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Trouble-shooting, 300**.

Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/Charging System Testing."

Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

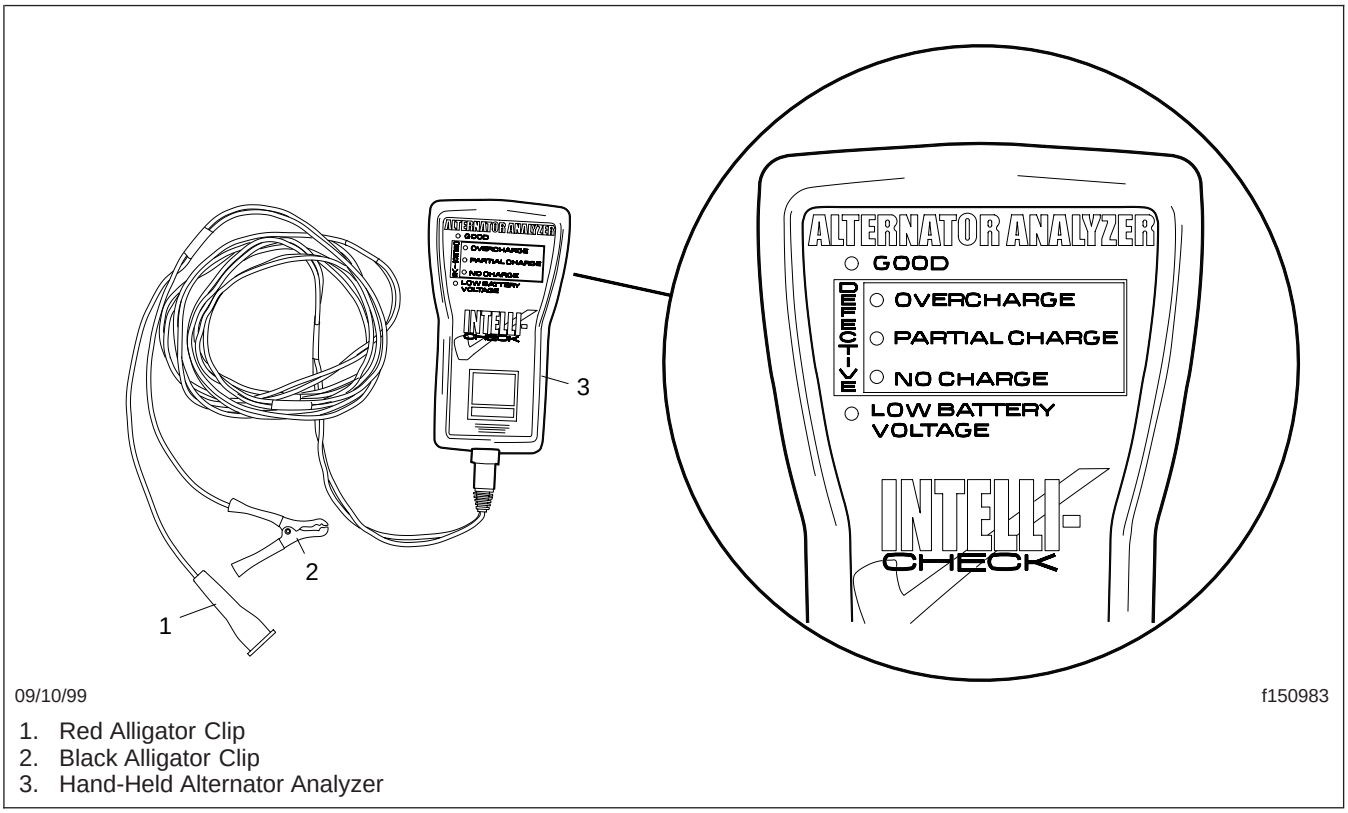
Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.
3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
   - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
     A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
     B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
     C. Repeat the applicable steps of the Pre-Test Procedure.
   - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
   - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
   - If the **GOOD** (green) LED illuminates, proceed to the next step.
   - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
   - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging

Troubleshooting



1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 1, Delco Remy Intelli-Check Alternator Analyzer

system using the instructions in "Alternator/Charging System Testing."

4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/ Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing".

Alternator/Charging System Testing

Battery Open Circuit Voltage Test, Alternator Output Voltage Test and Alternator Amperage Output Test

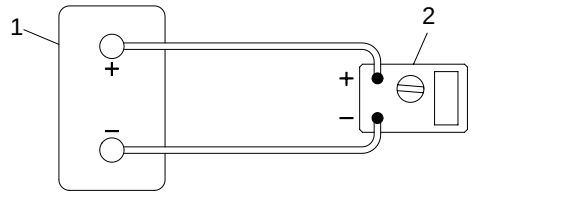
1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

   If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

   If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

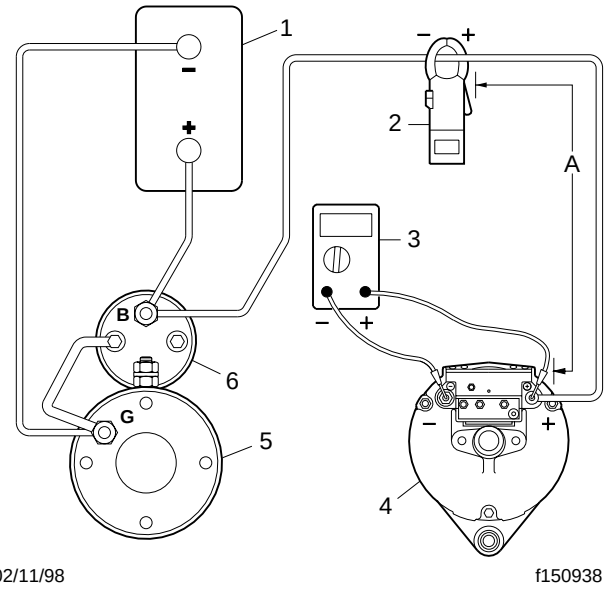
IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

2. Check the alternator output without a load. See **Fig. 3**.



1. Battery
2. Digital Voltmeter

Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)



A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 3, Setup 2: Alternator Output Test

2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3**.

2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.

3. Check the alternator output under load. See **Fig. 3**.

3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

- Both front and rear heater blowers (on HIGH)
- Headlights (high beams)
- Road lights
- Interior lights

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

4. Perform an alternator amperage output test.

4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2**.

Troubleshooting

NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

NOTE: Ensure that the alternator is turning at maximum available rpms and keep adjusting the tester dial until the ammeter reads its highest value.

4.4 Turn off the tester and shut down the engine.

4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3**.

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables and terminals.

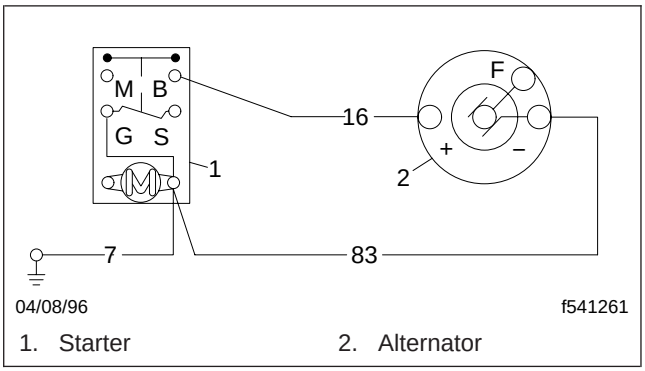
6.1 Check all connections between the battery, starter and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

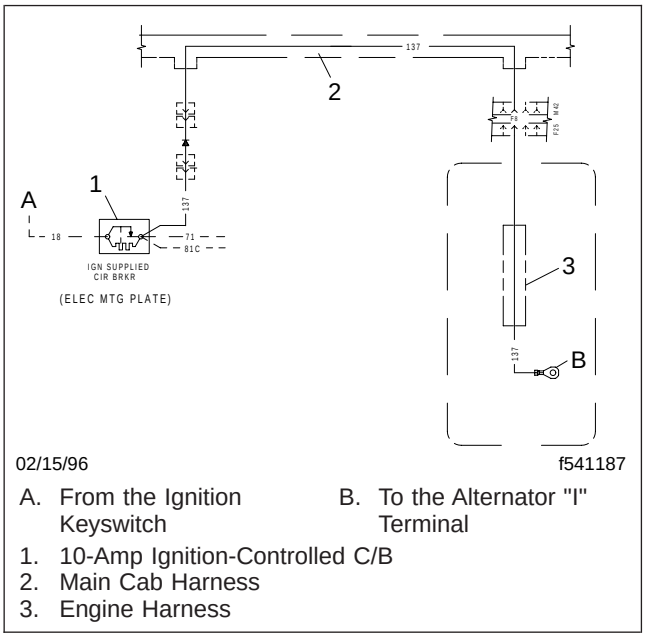
See **Fig. 1** for a Delco Remy 21–SI alternator wiring diagram.

See **Fig. 2** for a diagram of the low-speed start-up circuit.



1. Starter
2. Alternator

Fig. 1, Delco Remy 21-SI Alternator Wiring Diagram



A. From the Ignition Keyswitch
B. To the Alternator "I" Terminal
1. 10-Amp Ignition-Controlled C/B
2. Main Cab Harness
3. Engine Harness

Fig. 2, 21-SI Alternator Low-Speed Start-Up Circuit

Mounting Fastener Torques, Caterpillar Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Caterpillar 3306 and 3406 Engines			
End Link Mounting Capscrew	8PO	1/2–13	68 (92)
Alternator Mounting Capscrew	8PO	1/2–13	68 (92)
Adjusting Rod Mounting Capscrew	8PO	1/2–13	68 (92)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Alternator Bracket Fasteners	5PO	3/8–16	34 (46)
Caterpillar 3176/C–10 Engine			
Alternator Mounting Capscrews	8PO	1/2–13	68 (92)
Adjusting Strap Mounting Capscrew	10.9PO	M12	60 (81)

Table 1, Mounting Fastener Torques, Caterpillar Engines

Mounting Fastener Torques, Cummins Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Cummins N14/NTC Engine			
End Link Mounting Capscrew	8PO	1/2–13	68 (92)
Alternator Mounting Capscrew	8PO	1/2–13	68 (92)
Adjusting Rod Mounting Capscrew	8PO	7/16–20	50 (68)
Adjusting Rod Jam Nut	5	5/8	155 (210)

Specifications

Mounting Fastener Torques, Cummins Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Alternator Bracket Fasteners	5PO	3/8–16	34 (46)
Cummins M11/L10 Engine			
Adjusting Block Mounting Nut	5	1/2	35 (47)
Alternator Mounting Capscrew	8PO	1/2–13	60 (81)
Adjusting Screw Locknut	5	1/2	95 (130)
Adjusting Arm Mounting Capscrew	5	1/2–13	55 (75)
Alternator Bracket Fasteners	10.9PO	M10	34 (46)

Table 2, Mounting Fastener Torques, Cummins Engines

Mounting Fastener Torques, Detroit Diesel Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Detroit Diesel Series 50 Engine			
End Link Mounting Capscrew	8PO	1/2–13	68 (92)
Alternator Mounting Capscrew	8PO	1/2–13	68 (92)
Adjusting Rod Mounting Capscrew	8PO	7/16–14	45 (61)
Adjusting Rod Jam Nut	5	5/8	128 (173)
Alternator Bracket Fasteners	10.9PO	M10	43-54 (58-73)
Detroit Diesel Series 60 Engine			
End Link Mounting Capscrew	8PO	1/2–13	68 (92)
Alternator Mounting Capscrew	8PO	1/2–13	68 (92)
Adjusting Rod Mounting Capscrew	10.9PO	M10	34 (46)
Adjusting Rod Jam Nut	5	5/8	155 (210)
Alternator Bracket Fasteners	5PO	3/8–16	34 (46)
Detroit Diesel Series 55 Engine			
Alternator Mounting Capscrews	8PO	1/2–13	68 (92)
Adjusting Strap Mounting Capscrew	8PO	1/2–13	68 (92)

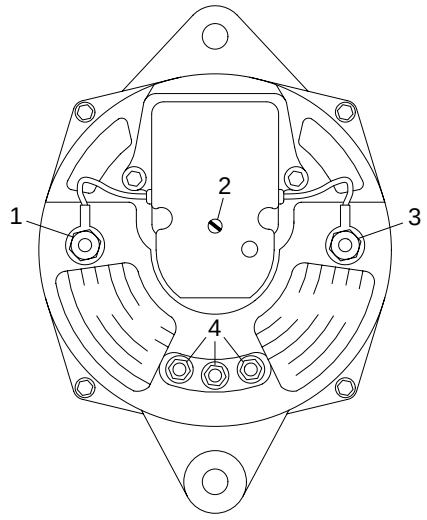
Table 3, Mounting Fastener Torques, Detroit Diesel Engines

Description	**Grade**	**Size**	**Torque: lbf·in (N·cm)**
Alternator Output ("BAT") Terminal Nut	8.8	M6	100-110 (1140-1240)
Ground ("G") Terminal Nut	8.8	M6	100-110 (1140-1240)
Indicator Light ("I") or Relay ("R") Terminal Nut	8.8	M4	20 (220)

Table 4, Terminal Fastener Torques, All Engines

General Information

The Leece-Neville 110 series alternator (see **Fig. 1**) is a self-exciting charging system. Alternating current (AC) is produced by a rotating electromagnetic field (rotor) inside a three-phase stator. The AC energy is changed to direct current (DC) by passing through a three-phase full wave rectifier using six rectifier diodes.



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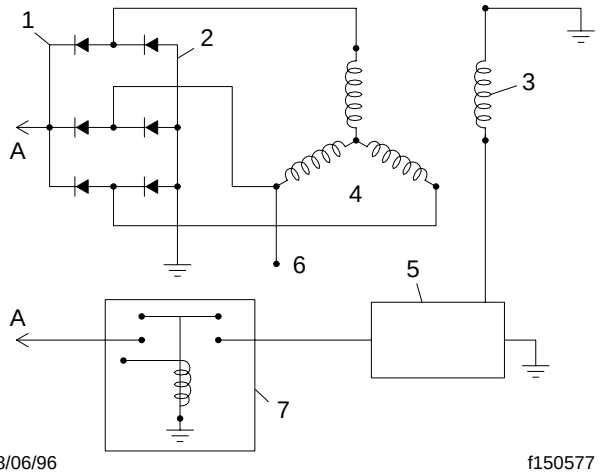
1. Negative Output (G) Terminal
2. Voltage Regulator Adjustment Pot
3. Positive Output (BAT) Terminal
4. Stator Taps

Fig. 1, Leece-Neville 110 Series Alternator

An externally-mounted bidirectional fan provides airflow for cooling. Air must be pulled through the rear of the alternator and expelled through the front housing.

The alternator does not require an isolation or field diode (diode trio). As the alternator shaft turns, the small signal developed at the stator tap activates the voltage regulator, allowing normal regulation of system voltage. See **Fig. 2**.

The optional SmartChek™ models feature a light-emitting diode (LED) that changes color to simplify troubleshooting. When the LED is green, the alternator is OK. When the LED is red, the alternator needs replacing.



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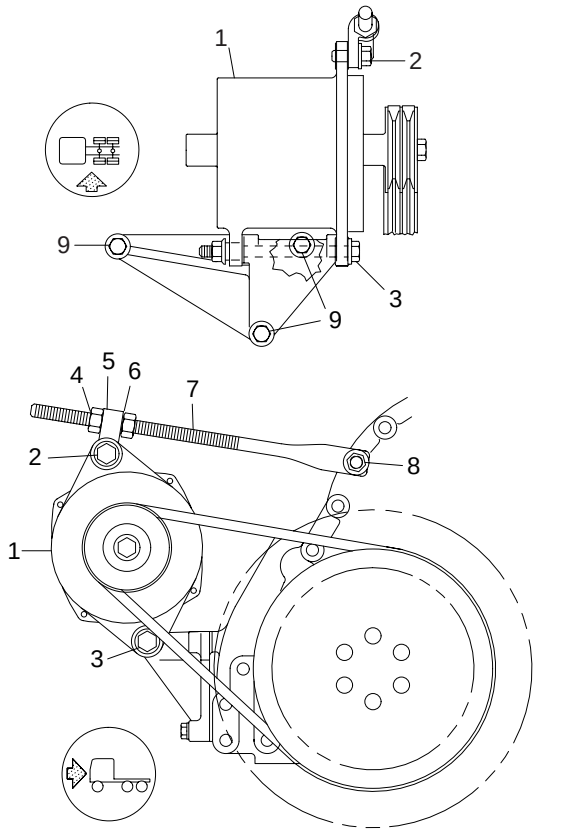
A. To Battery
1. Positive Diode Assy.
2. Negative Diode Assy.
3. Rotor Winding
4. Stator
5. Regulator
6. Stator Tap
7. Relay

Fig. 2, Wiring Diagram, Negative Ground Circuit

110 Series Alternator Removal and Installation, Cummins N14/NTC

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Loosen the adjusting rod mounting capscrew (see **Fig. 1**).



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1. 110 Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Capscrew

Fig. 1, Alternator Installation, Cummins N14/NTC Engine

4. Loosen the end link mounting capscrew and the alternator mounting capscrew. Turn the adjusting nut counterclockwise, backing the alternator toward the drive pulley far enough to remove the drive belt without prying or twisting the belt. Remove the belt from the vehicle.
5. Remove the adjusting rod jam nut and alternator mounting capscrew. Remove the alternator from the vehicle with the end link attached.
6. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine with the end link attached. Install the alternator mounting capscrew, but do not tighten it yet.
3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m).
4. Tighten the adjusting nut until the belt is correctly tensioned. For belt tightening specifications, see **Section 01.07, Subject 100**. While holding the adjusting nut in place, install the adjusting rod jam nut and tighten it 95 lbf·ft (130 N·m).
5. Tighten the end link mounting capscrew and the alternator mounting capscrew 65 lbf·ft (88 N·m). Tighten the adjusting rod mounting capscrew 50 lbf·ft (68 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC

110 Series Alternator Removal and Installation, Cummins N14/NTC

Protectant Material	Approved Brands
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting, 300**.

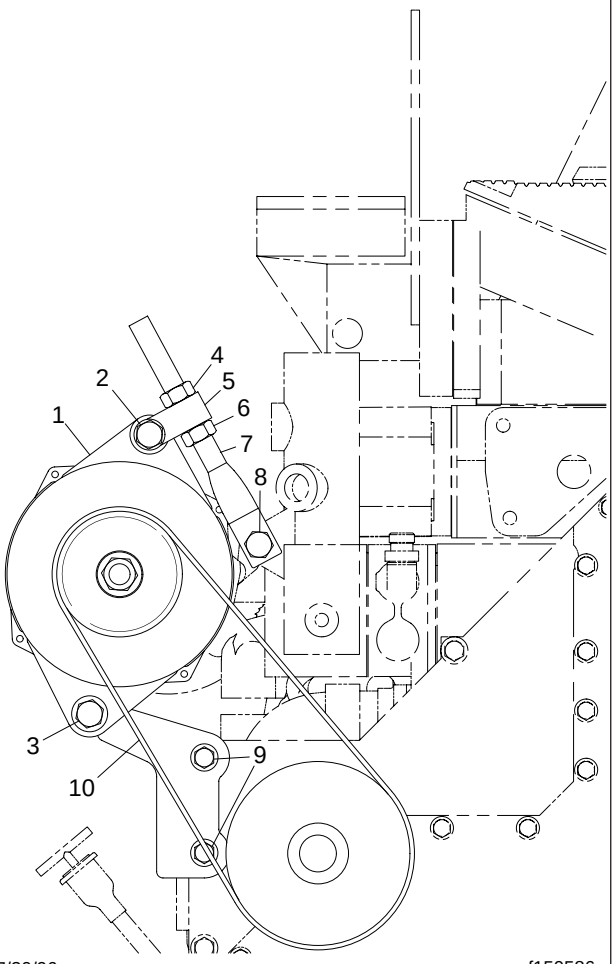
110 Series Alternator Removal and Installation, Cummins M11/L10

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Loosen the adjusting rod mounting capscrew just enough to allow movement of the alternator. See **Fig. 1**.
4. Loosen the end link mounting capscrew and the alternator mounting capscrew. Turn the adjusting nut counterclockwise, backing off the alternator toward the drive pulley far enough to remove the drive belt without prying or twisting the belt. Remove the belt from the vehicle.
5. Remove the adjusting rod jam nut and the alternator mounting capscrew. Remove the alternator from the vehicle with the end link attached.
6. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine with the end link attached. Install the adjusting rod mounting capscrew and the alternator mounting capscrew, but do not tighten them yet.
3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m).
4. Turn the adjusting nut clockwise until the belt is correctly tensioned. For belt tightening specifications, see **Section 01.07, Subject 110**. Tighten the adjusting rod jam nut 95 lbf·ft (130 N·m).
5. Tighten the end link mounting capscrew and the alternator mounting capscrew 65 lbf·ft (88 N·m); tighten the adjusting rod mounting capscrew 50 lbf·ft (68 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).



1. 110 Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners
10. Drive Belt

Fig. 1, Alternator Installation, Cummins M11/L10 Engine

7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

110 Series Alternator Removal and Installation, Cummins M11/L10

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting, 300**.

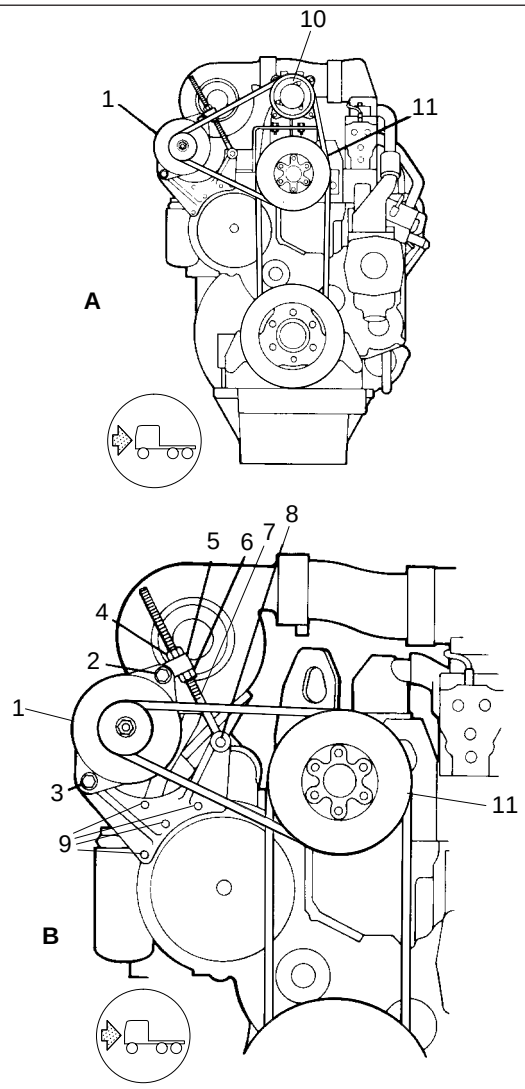
110 Series Alternator Removal and Installation, Caterpillar 3306

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Loosen the end link and alternator mounting capscrews (see **Fig. 1**) and the adjusting rod mounting capscrew.
4. Back off the adjusting nut on the adjusting rod, allowing the alternator to be moved far enough toward the drive pulley to remove the fan drive belt without prying or twisting the belt. Remove the drive belt from the vehicle.
5. Remove the end link and alternator mounting capscrews. Remove the alternator from the vehicle.
6. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 34 lbf·ft (46 N·m).
2. Install the alternator on the engine. Install the end link and alternator mounting capscrews, but do not tighten them yet.
3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m).
4. Loosen the adjusting rod jam nut. Then, tighten the adjusting nut until the belt is correctly tensioned. For belt tightening specifications, see **Section 01.07, Subject 120**. While holding the adjusting nut in place, tighten the adjusting rod jam nut 65 lbf·ft (88 N·m).
5. Tighten the end link mounting capscrew, the alternator mounting capscrew, and the adjusting rod mounting capscrew 65 lbf·ft (88 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).



11/05/96 f150527

A. With Refrigerant Compressor
B. Without Refrigerant Compressor

1. 110 Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners
10. Refrigerant Compressor
11. Fan Drive

Fig. 1, Alternator Installation, Caterpillar 3306 Engine

110 Series Alternator Removal and Installation, Caterpillar 3306

7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

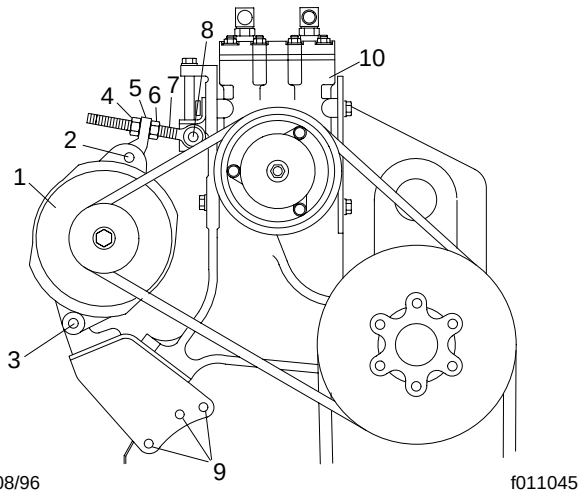
110 Series Alternator Removal and Installation, Caterpillar 3406

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.

NOTE: Three different installations are possible. For vehicles with a piston-type refrigerant compressor, see **Fig. 1**. For vehicles with a rotary (swash-plate) refrigerant compressor, see **Fig. 2**. For vehicles with no air conditioning, see **Fig. 3**.

3. Back off the adjusting nut. Loosen the end link mounting capscrew and the alternator mounting capscrew enough to allow movement of the alternator.

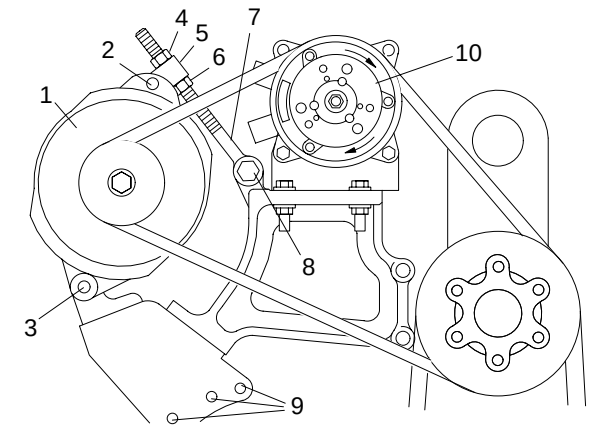


04/08/96 f011045

1. 110 Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners
10. Refrigerant Compressor

Fig. 1, Alternator Installation, Caterpillar 3406 Engine with Piston-Type Refrigerant Compressor

4. Push the loosened alternator far enough toward the fan drive pulley to allow removal of the drive belts without using force.



02/15/96 f011044

1. 110 Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners
10. Refrigerant Compressor

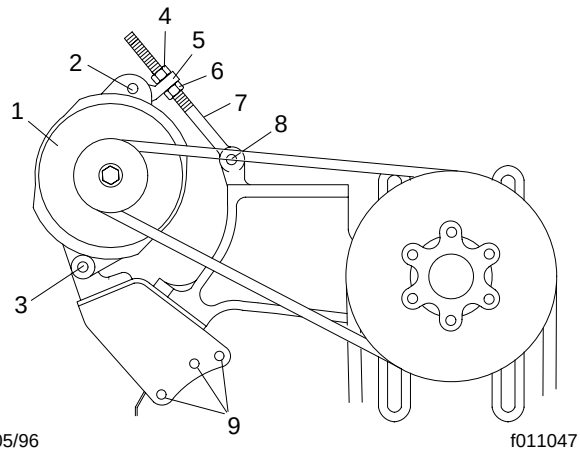
Fig. 2, Alternator Installation, Caterpillar 3406 Engine with Rotary Refrigerant Compressor

5. Slip each drive belt (dual drive belts) off the pulleys and work it over one fan blade at a time. Remove both drive belts from the vehicle.
6. Remove the two mounting capscrews already loosened. Remove the alternator from the vehicle.
7. Inspect the drive belts. For instructions, see **Section 01.07, Subject 180**.

Installation

1. Check the torque of the alternator bracket fasteners. Tighten the fasteners 34 lbf·ft (46 N·m).
2. Install the alternator on the engine. Install the end link mounting capscrew and the alternator mounting capscrew, but do not tighten them yet.
3. Make sure the distance between the pulleys is short enough to allow belt installation without using force.

110 Series Alternator Removal and Installation, Caterpillar 3406



1. 110 Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners

Fig. 3, Alternator Installation, Caterpillar 3406 Engine with No Air Conditioning

4. Work each belt over the fan blades, one blade at a time. Install both drive belts on the pulleys without prying or rolling them into place. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Section 01.07, Subject 150**.
5. After each belt has been correctly tensioned, tighten the adjusting rod jam nut 65 lbf·ft (88 N·m).
6. Tighten both the end link and alternator mounting capscrews 65 lbf·ft (88 N·m).
7. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
8. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

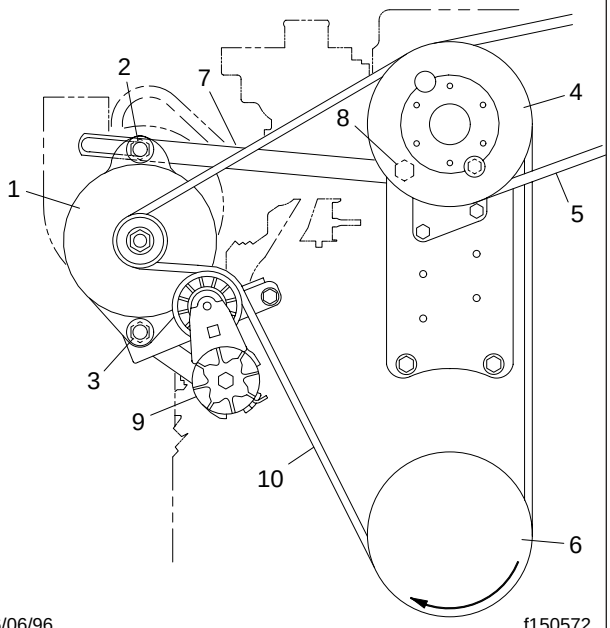
Table 1, Approved Dielectric Red Enamel

9. Connect the batteries.
10. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting, 300**.

110 Series Alternator Removal and Installation, Caterpillar 3176/C–10/C–12

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Insert a 1/2-inch breaker bar in the belt tensioner and rotate the tensioner down and off the alternator drive belt. See **Fig. 1** for slotted-strap alternators. See **Fig. 2** for fixed-strap alternators.



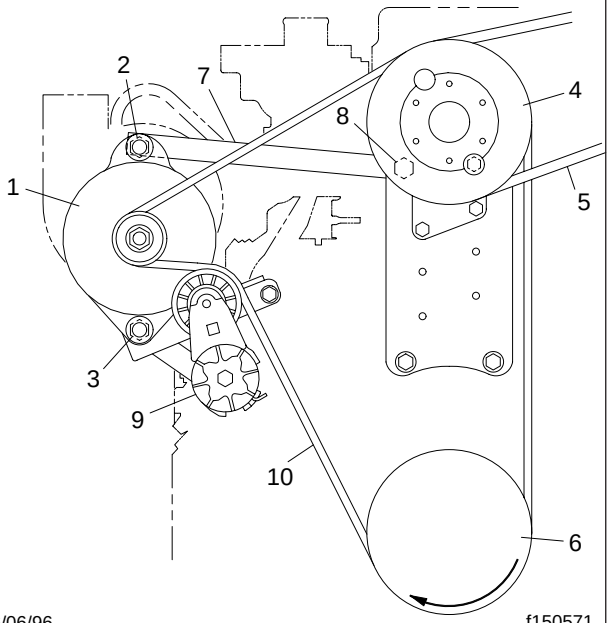
06/06/96 f150572

Rotate the belt tensioner down and off the belt.

1. 110 Series Alternator
2. Alternator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Fan Pulley
5. Refrigerant Compressor Drive Belt
6. Vibration Damper
7. Alternator Adjusting Strap
8. Adjusting Strap Mounting Capscrew
9. Belt Tensioner
10. Alternator Drive Belt

Fig. 1, Alternator Installation, Caterpillar 3176/C-10/C-12 Engine, Slotted Strap

NOTE: There are two drive belts to remove. Before removing the alternator belt, it is necessary to remove the refrigerant compressor belt from its pulleys.



06/06/96 f150571

Rotate the belt tensioner down and off the belt.

1. 110 Series Alternator
2. Alternator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Fan Pulley
5. Refrigerant Compressor Drive Belt
6. Vibration Damper
7. Alternator Adjusting Strap
8. Adjusting Strap Mounting Capscrew
9. Belt Tensioner
10. Alternator Drive Belt

Fig. 2, Alternator Installation, Caterpillar 3176 Engine, Fixed Strap

4. Holding the belt tensioner down, remove each drive belt from its pulley. Slowly release the belt tensioner and remove the breaker bar.
5. Lower each drive belt, and take it off the vibration damper. It is not necessary to remove either belt from the vehicle.
6. Remove both alternator mounting capscrews. Remove the alternator from the vehicle.

NOTE: It is not necessary to remove the adjusting strap from the engine.

7. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

110 Series Alternator Removal and Installation, Caterpillar 3176/C–10/C–12

Installation

1. Check the torque of the adjusting strap mounting capscrew. If necessary, tighten it 65 lbf·ft (88 N·m).
2. Install the alternator on the engine. If the alternator adjusting strap is slotted, install the alternator at the inboard edge of the slot initially. Install the top and bottom alternator mounting capscrews, but do not tighten them yet.
3. Install the drive belt on the pulleys. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Section 01.07, Subject 130**.
4. On slotted straps, verify that the edge of the tensioner arm is within the green zone on the decal. See **Fig. 3**. If within the red zone, pivot the alternator outboard until the tensioner arm enters the green zone.

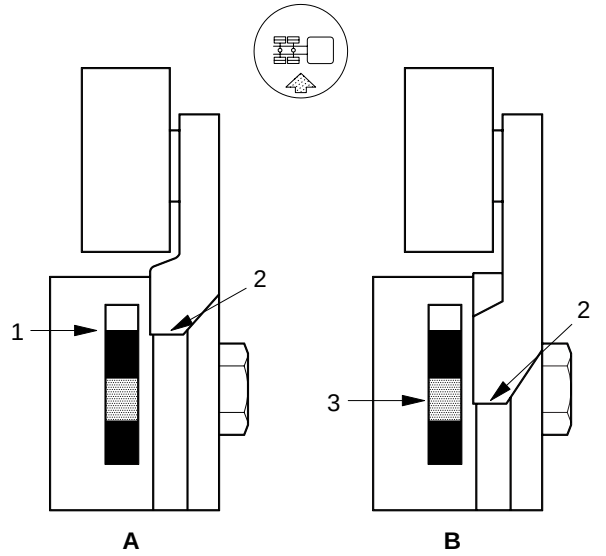
NOTE: If the belt slips, repair or replace the tensioner. For instructions, see the Caterpillar 3176 or C–10/C–12 Diesel Truck Engine Service Manual.

5. When the alternator is correctly positioned, tighten both alternator mounting capscrews 65 lbf·ft (88 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting, 300**.



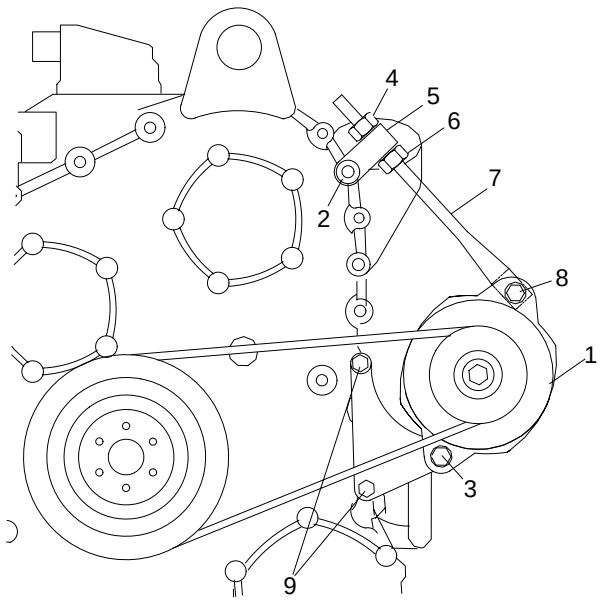
A. Belt Off, No Tension
B. Belt On, Correct Tension
1. Decal
2. Edge of Tensioner Arm
3. Green Zone (operating range)

Fig. 3, Belt Tensioner With Decal

110 Series Alternator Removal and Installation, DDC 50

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Loosen the end link mounting capscrew, the adjusting rod mounting capscrew, and the alternator mounting capscrew. See **Fig. 1**.



11/05/96 f011042

1. 110 Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners

Fig. 1, Alternator Installation, Detroit Diesel Series 50

4. Back off the adjusting nut. Turn the adjusting rod jam nut to rotate the alternator up and toward the engine. Make sure the distance between the pulley centers is now short enough to allow belt removal without using force.
5. When the alternator is close enough to the engine, slip the drive belt off the pulleys without rolling or prying the belt. Remove the drive belt from the vehicle, working the belt over one fan blade at a time.
6. Remove the alternator and adjusting rod mounting capscrews. Remove the alternator from the vehicle.
7. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 43 to 54 lbf·ft (58 to 73 N·m).
2. Install the alternator on the engine. Install the alternator mounting capscrew and the adjusting rod mounting capscrew, but do not tighten them yet.
3. Install the drive belt on the pulleys. Do not pry or twist the belt over the pulley. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m).
4. Loosen the adjusting rod jam nut. Then, tighten the adjusting nut until the belt is at the correct tension. For belt tightening specifications, see **Section 01.07, Subject 160**. While holding the adjusting nut in place, tighten the adjusting rod jam nut 95 lbf·ft (130 N·m).
5. Tighten the alternator mounting capscrew and the end link mounting capscrew 65 lbf·ft (88 N·m).
6. Tighten the adjusting rod mounting capscrew 45 lbf·ft (61 N·m).
7. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
8. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC

110 Series Alternator Removal and Installation, DDC 50

Protectant Material	Approved Brands
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

9. Connect the batteries.
10. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Trouble-shooting, 300**.

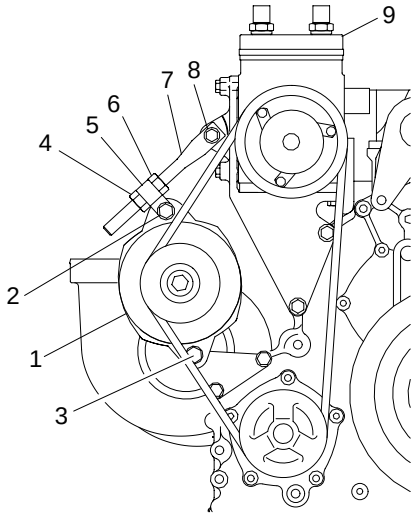
110 Series Alternator Removal and Installation, DDC 60

Removal

1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.

NOTE: Three different installations are possible. For DDEC III vehicles with air conditioning (top-mounted refrigerant compressor), see **Fig. 1**. For DDEC II vehicles with air conditioning (side-mounted refrigerant compressor), see **Fig. 2**. For vehicles with no air conditioning, see **Fig. 3**.

3. Loosen the adjusting rod mounting capscrew, the end link mounting capscrew, and the alternator mounting capscrew. Loosen these mounting capscrews enough to allow movement of the alternator.



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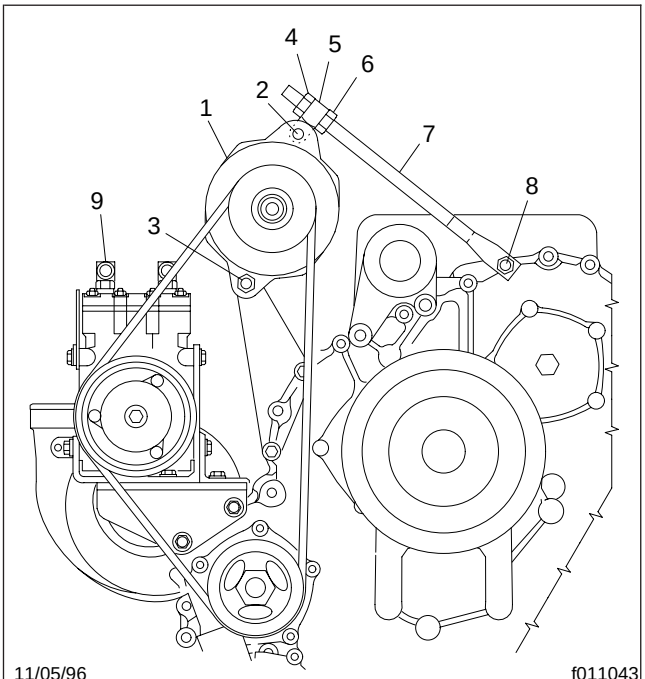
1. 110 Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Refrigerant Compressor

Fig. 1, Alternator Installation, Detroit Diesel Series 60 Engine, DDEC III with Air Conditioning



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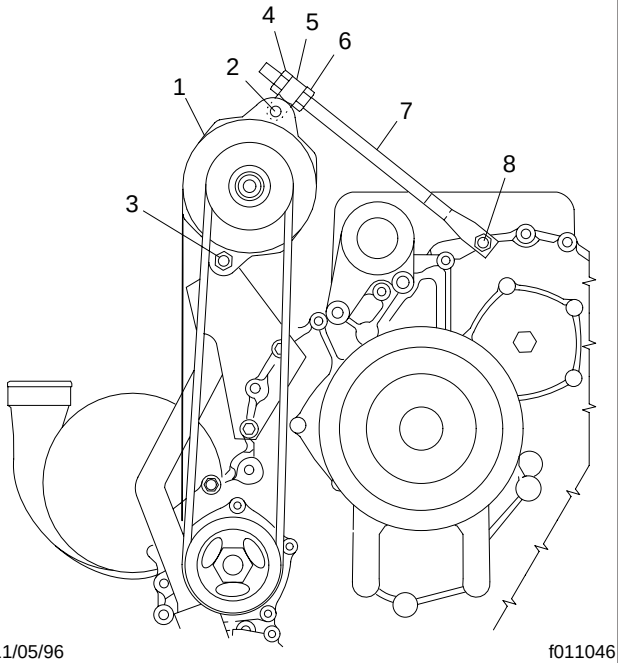
1. 110 Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Refrigerant Compressor

Fig. 2, Alternator Installation, DDEC II with Air Conditioning

4. Back off the adjusting nut. Push the loosened alternator far enough toward the fan drive pulley to allow removal of the drive belts without using force.
5. Remove the drive belt from the pulleys without prying or twisting the belt.
6. Remove the end link mounting capscrew and the alternator mounting capscrew. Remove the alternator from the vehicle.
7. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

110 Series Alternator Removal and Installation, DDC 60



1. 110 Series Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew

Fig. 3, Alternator Installation, All Detroit Diesel Series 60 Engines without Air Conditioning

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 50 lbf·ft (68 N·m).
2. Install the alternator on the engine. Install the end link mounting capscrew and the alternator mounting capscrew, but do not tighten them yet.
3. Loop the drive belt around the pulleys.
4. Install the drive belt on the pulleys without prying or rolling it into place. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Section 01.07, Subject 140**.
5. After the belt has been correctly tensioned, tighten the adjusting rod jam nut 95 lbf·ft (130 N·m).
6. Tighten the end link mounting capscrew and the alternator mounting capscrew 65 lbf·ft (88 N·m). Tighten the adjusting rod mounting capscrew 50 lbf·ft (68 N·m).
7. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
8. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

9. Connect the batteries.
10. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting, 300**.

110 Series Alternator Removal and Installation, DDC 55

Removal

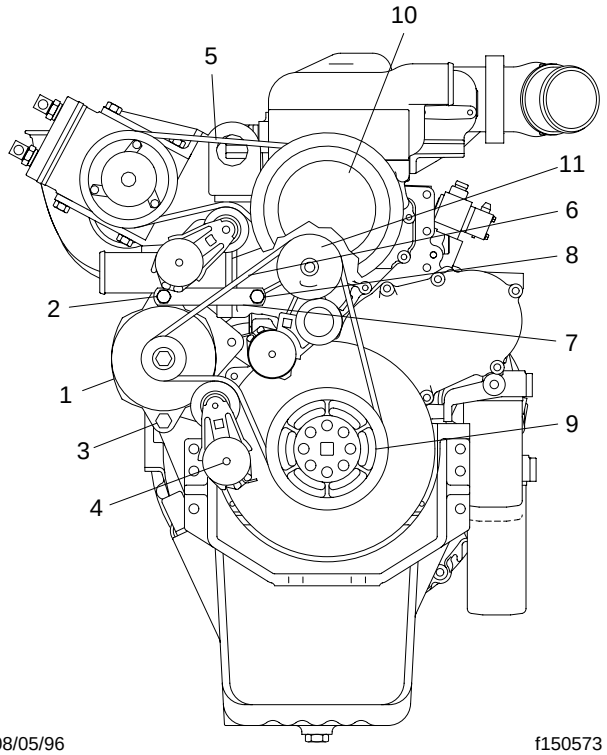
1. Disconnect the batteries.
2. Mark all electrical leads and disconnect them from the alternator.
3. Insert a breaker bar in the alternator belt tensioner (see **Fig. 1**) and rotate the tensioner down and off the alternator drive belt.
4. Holding the belt tensioner down, remove the alternator drive belt from the alternator pulley. Slowly release the belt tensioner and remove the breaker bar.
5. Lower each drive belt, and take it off the vibration damper. It is not necessary to remove either belt from the vehicle.
6. Remove the top and bottom alternator mounting capscrews. Remove the alternator from the vehicle.
7. Inspect the drive belt. For instructions, see **Section 01.07, Subject 180**.

Installation

1. Check the torque of the adjusting strap mounting capscrew. If necessary, tighten it 65 lbf·ft (88 N·m).
2. Install the alternator on the engine. Install the two alternator mounting capscrews (top and bottom), but do not tighten them yet.
3. Install the alternator drive belt on the pulleys. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Section 01.07, Subject 170**.

NOTE: The Detroit Diesel belt tensioner automatically adjusts the drive belt to the correct tension. If the belt slips, repair or replace the tensioner. For instructions, see the engine manufacturer's service literature.

4. Tighten both alternator mounting capscrews 65 lbf·ft (88 N·m).
5. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
6. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.



Rotate the belt tensioner down and off the belt.

NOTE: Fan pulley cut away and fan drive belt removed to show water pump pulley and alternator drive belt more clearly.

1 110 Series Alternator
2. Altenator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Alternator Belt Tensioner
5. Refrigerant Compressor Drive Belt
6. Alternator Drive Belt
7. Alternator Adjusting Strap
8. Alternator Adjusting Strap Mounting Capscrew
9. Vibration Damper
10. Fan Pulley
11. Water Pump Pulley

Fig. 1, Alternator Installation, Detroit Diesel Series 55 Engine

110 Series Alternator Removal and Installation, DDC 55

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

7. Connect the batteries.
8. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting, 300**.

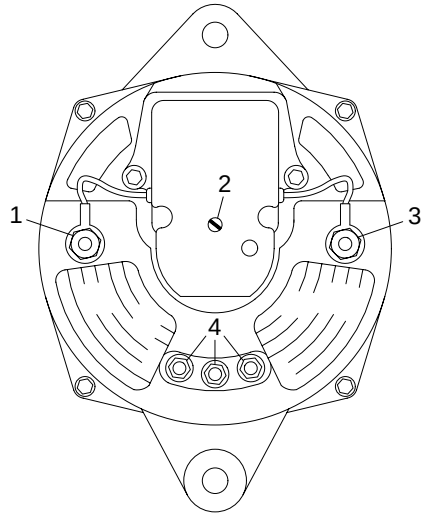
Adjustment

NOTE: Before checking or adjusting the alternator voltage, check the wiring, connections, and belt tension.

1. Turn off all accessories. Run the engine at fast idle (approximately 1200 RPM) and charge the batteries.
2. Connect an accurate voltmeter across the batteries to determine the charging voltage. If the charging voltage is less than 14.0 volts or more than 14.8 volts, adjust the voltage regulator.

NOTE: Do not attempt to adjust the voltage regulator until the engine is at operating temperature. The voltage regulator has temperature compensating circuitry that increases the voltage slightly in cold weather and decreases it slightly in warm weather.

3. Using a small screwdriver, turn the voltage adjustment pot (potentiometer) up or down until the voltmeter reading is in the required range. See **Fig. 1**.



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1. Negative Output (G) Terminal
2. Voltage Regulator Adjustment Pot
3. Positive Output (BAT) Terminal
4. Stator Taps

Fig. 1, Voltage Regulator Adjustment

Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

To troubleshoot the SmartChek™ diagnostic alternator perform the following steps:

1. With the engine off, clean the top of the regulator using a shop cloth until you can see the SmartChek indicator.
2. Start the engine. If the SmartChek indicator glows red, replace the alternator.

   If the indicator glows green, go to the next step.
3. Turn on several vehicle accessories, such as lights and heater fans. If the green indicator changes to red, replace the alternator.

   If the indicator continues to glow green, the alternator is OK. Check the other components of the electrical system.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/Charging System Testing."

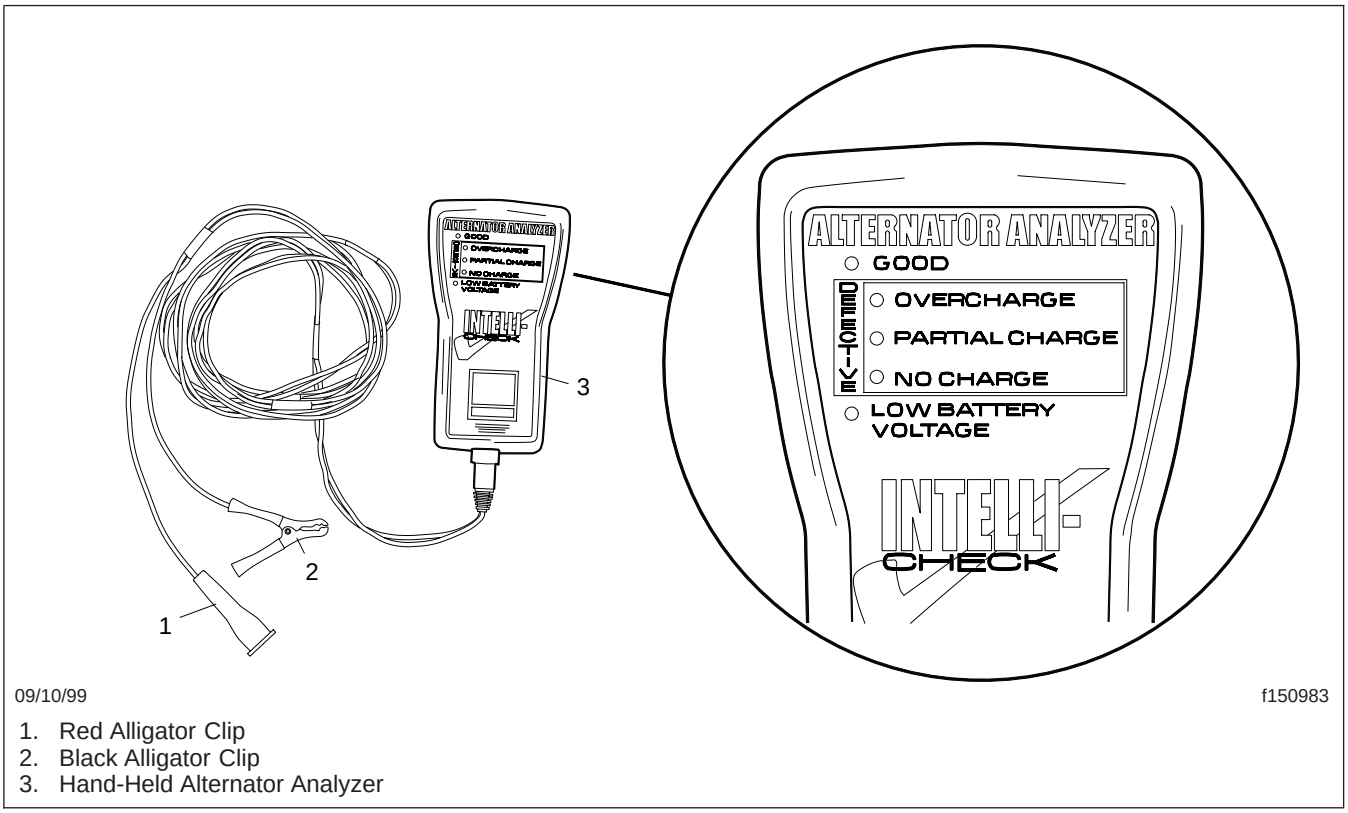
Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.
3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
   - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
     A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
     B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
     C. Repeat the applicable steps of the Pre-Test Procedure.
   - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
   - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

Troubleshooting



1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 1, Delco Remy Intelli-Check Alternator Analyzer

Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
   - If the **GOOD** (green) LED illuminates, proceed to the next step.
   - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
   - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing."
4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/ Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.

8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing."

Alternator/Charging System Testing

Battery Open Circuit Voltage Test, Alternator Output Voltage Test and Alternator Amperage Output Test

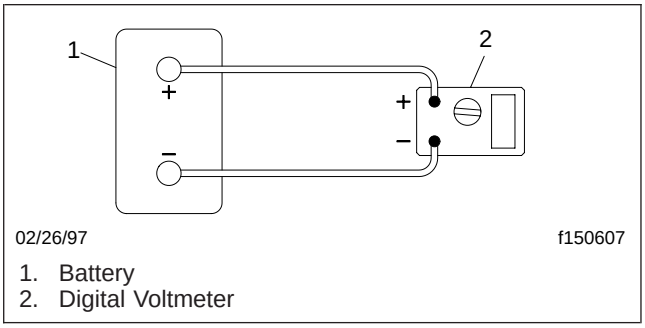
1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

   If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

   If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

2. Check the alternator output without a load. See **Fig. 3**.

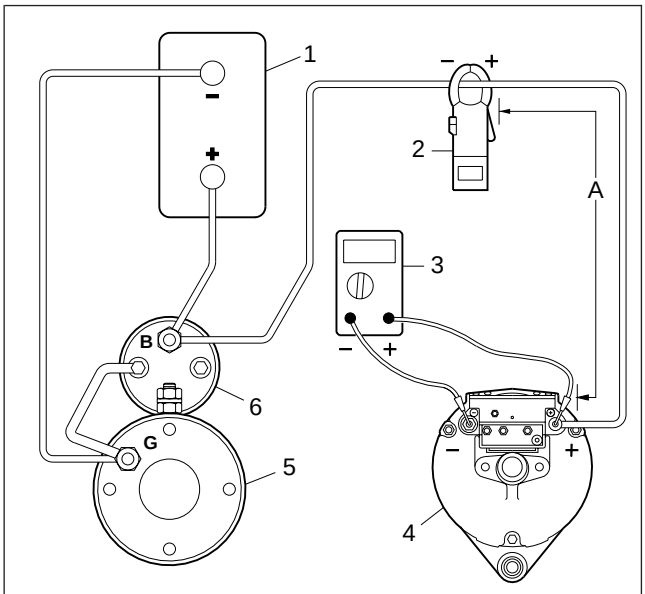


1. Battery
2. Digital Voltmeter

Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)

2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3**.



A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 3, Setup 2: Alternator Output Voltage

2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.

3. Check the alternator output under load. See **Fig. 3**.

   3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

   3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

   - Both front and rear heater blowers (on HIGH)

Troubleshooting

- Headlights (high beams)
- Road lights
- Interior lights

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

4. Perform an alternator amperage output test.

4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2**.

NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

NOTE: Ensure that the alternator is turning at maximum available rpms and keep adjusting the tester dial until the ammeter reads its highest value.

4.4 Turn off the tester and shut down the engine.

4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3**.

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables and terminals.

6.1 Check all connections between the battery, starter and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

See **Fig. 1** for a Leece-Neville 110 Series alternator wiring diagram.

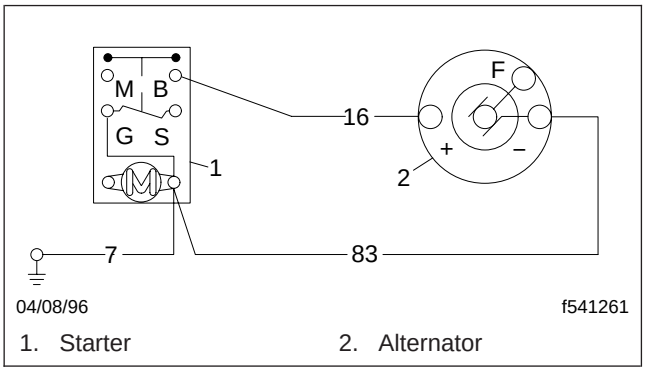


Fig. 1, Leece-Neville 110 Series Alternator Wiring Diagram

Mounting Fastener Torques, Caterpillar Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Caterpillar 3306 and 3406 Engines			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Jam Nut	5	1/2	65 (88)
Alternator Bracket Fasteners	5PO	3/8–16	34 (46)
Caterpillar 3176/C–10/C–12 Engine			
Alternator Mounting Capscrews	8PO	1/2–13	65 (88)
Adjusting Strap Mounting Capscrew	10.9PO	M12	65 (88)

Table 1, Mounting Fastener Torques, Caterpillar Engines

Mounting Fastener Torques, Cummins Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Cummins N14/NTC Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	8PO	7/16–20	50 (68)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Alternator Bracket Fasteners	5PO	3/8–16	34 (46)
Cummins M11/L10 Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Adjusting Rod Mounting Capscrew	8PO	7/16–20	50 (68)

Specifications

Mounting Fastener Torques, Cummins Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Alternator Bracket Fasteners	10.9PO	M10	34 (46)

Table 2, Mounting Fastener Torques, Cummins Engines

Mounting Fastener Torques, Detroit Diesel Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Detroit Diesel Series 50 Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	8PO	7/16–14	45 (61)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Alternator Bracket Fasteners	5PO	3/8–16	43–54 (58–73)
Detroit Diesel Series 60 Engine			
End Link Mounting Capscrew	8PO	1/2–13	65 (88)
Alternator Mounting Capscrew	8PO	1/2–13	65 (88)
Adjusting Rod Mounting Capscrew	10.9PO	M10	50 (68)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Alternator Bracket Fasteners	10.9PO	M10	50 (68)
Detroit Diesel Series 55 Engine			
Alternator Mounting Capscrews	8PO	1/2–13	65 (88)
Adjusting Strap Mounting Capscrew	8PO	1/2–13	65 (88)

Table 3, Mounting Fastener Torques, Detroit Diesel Engines

Description	**Grade**	**Size**	**Torque: lbf·in (N·cm)**
Alternator Output ("BAT") Terminal Nut	5	5/16–18	100 (1140)
Alternator Ground ("G") Terminal Nut	5	1/4–20	65 (740)
Instrument ("I") or Relay ("R") Terminal Nut	8.8	M4	20 (220)

Table 4, Terminal Fastener Torques, All Engines

Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Pulley Nut	8PO	1/2–20	75 (102)

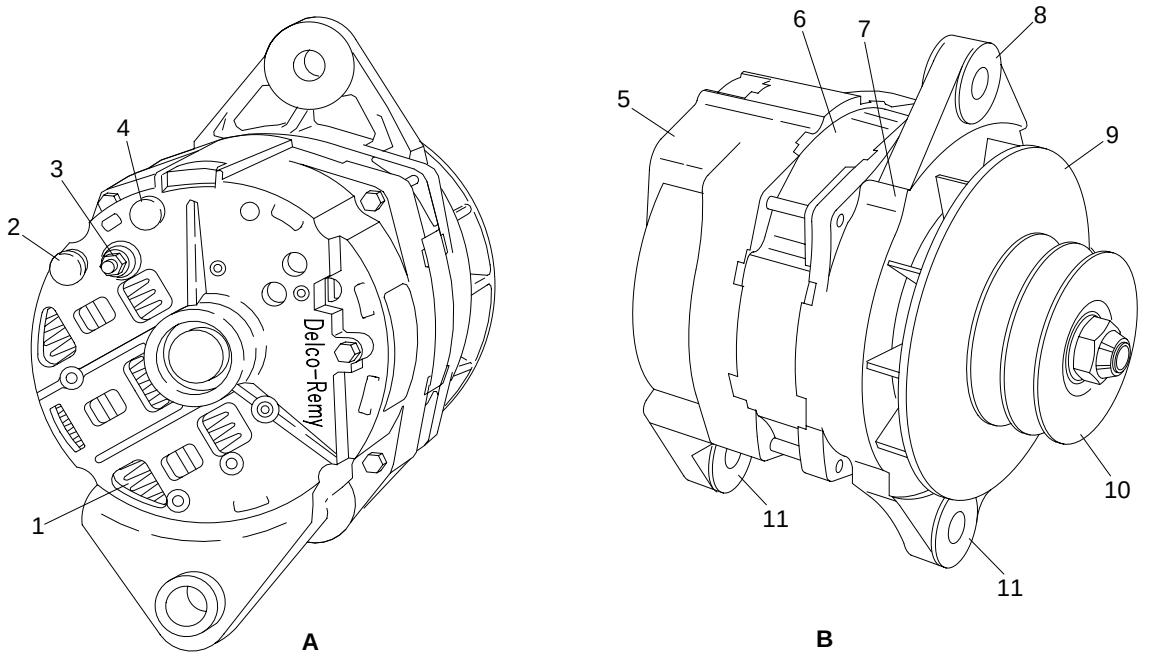
Table 5, Pulley Nut Torque, All Engines

General Information

The Delco Remy 22–SI series alternator (see **Fig. 1** and **Fig. 2**) features a solid-state voltage regulator mounted inside the end frame. The only moving part is the rotor, which is mounted on a ball bearing at the drive end, and a roller bearing at the rectifier end. See **Fig. 3**.

start-up come from the ignition switch to the alternator terminal "I". In a three-wire system, rotor magnetism is boosted at start-up by field current entering through the #1 regulator terminal then flowing through the rotor windings.

Normally only one wire connects the alternator to the battery at the starter, along with a ground return.



A. Rectifier End
B. Drive End

1. Rectifier Bridge
2. Relay ("R") Terminal
3. Output ("BAT") Terminal
4. Indicator Light ("I") Terminal
5. Frame, Rectifier End
6. Stator
7. Frame, Drive End
8. Adjustment Lug
9. Fan
10. Pulley
11. Mounting Lug

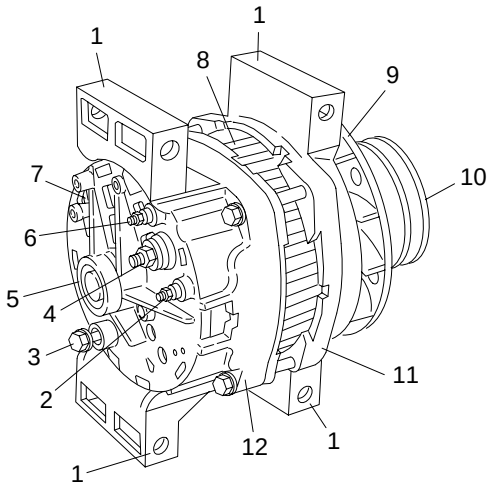
Fig. 1, Delco Remy 22-SI Alternator (exterior view)

All bearings are sealed so that no periodic maintenance is required. The regulator and diodes are enclosed in a sealed compartment. A fan located on the drive end provides air flow for cooling.

The Delco Remy 22-SI alternator is available in either a one-wire, two-wire, or three-wire configuration. These wire configurations refer to the minimum number of lead wire connections necessary for alternator operation. In a one-wire system, the voltages at start-up are generated by residual magnetism within the rotor. In a two-wire system, the voltages at

Since the vehicle's system is a negative ground, the output terminal connects to the starter's positive terminal.

General Information



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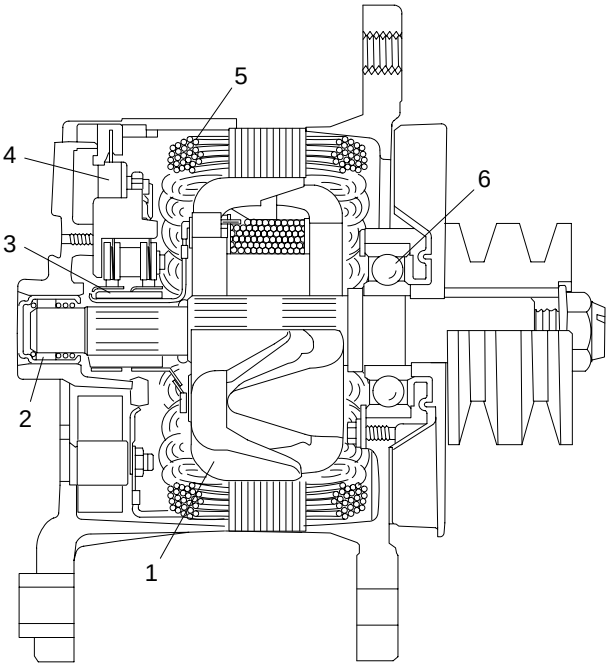
1. Quadramount Mounting System
2. Indicator Light ("I") Terminal
3. Ground Terminal
4. Output ("BAT") Terminal
5. Radial Brush Module
6. Relay ("R") Terminal
7. Rectifier Bridge
8. Stator
9. Fan
10. Pulley
11. Frame, Drive End
12. Frame, Rectifier End

Fig. 2, Delco Remy 22-SI Quadramount Alternator



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1. Rotor
2. Roller Bearings
3. Brushes
4. Regulator
5. Field Windings
6. Ball Bearings

Fig. 3, Delco Remy 22-SI Alternator (cutaway view)

Alternator Removal and Installation, DDC 50

Removal

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.

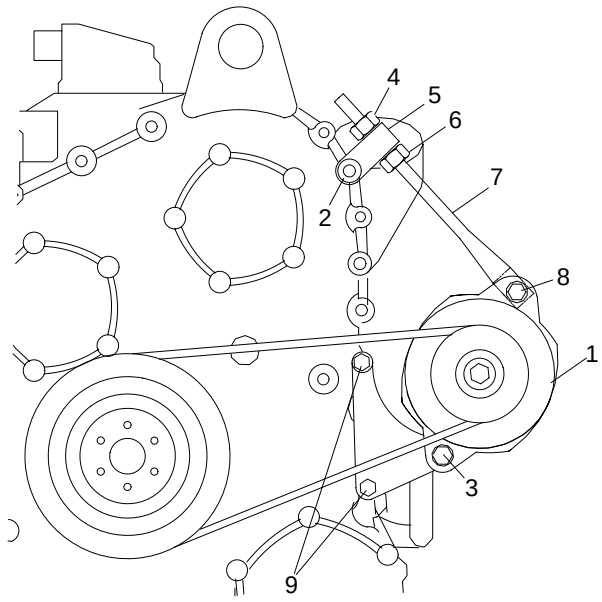
⚠ WARNING

Before disconnecting the batteries, read the instructions and Danger and Warning notices in Section 54.02 of this workshop manual. Keep sparks, flames, burning cigarettes, etc. away from batteries. Batteries generate explosive gases, which could cause a battery to explode, causing serious personal injury, including blindness.

3. Disconnect the batteries.
4. Mark all electrical leads and disconnect them from the alternator.
5. Remove the alternator drive belt. For instructions, see **Section 01.07**.
6. Remove the alternator and adjusting rod mounting capscrews. Remove the alternator from the vehicle. See **Fig. 1**.
7. Inspect the drive belt. For instructions, see **Section 01.07**, Subject 180.

Installation

1. Install a new pulley, if applicable, and tighten the shaft nut to 75 lbf·ft (102 N·m).
2. Check the torque of the alternator bracket fasteners. If necessary, tighten, see **Specifications 400**.
3. Install the alternator on the engine. Install the alternator mounting capscrew and the adjusting rod mounting capscrew, but do not tighten them yet.
4. Install and tension the drive belt on the pulleys. Do not pry or twist the belt over the pulley. For instructions, see **Section 01.07**.
5. Connect all leads to the back of the alternator as previously marked and tighten. See **Specifications 400**.



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1. 22–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Alternator Bracket Fasteners

Fig. 1, Alternator Installation, Detroit Diesel Series 50

6. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

7. Connect the batteries.
8. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" or use the Delco Intelli-Check Alternator Analyzer (if available) in **Troubleshooting, 300**.

Alternator Removal and Installation, DDC 50

9. Close the hood.
10. Remove the tire chocks.

Alternator Removal and Installation, DDC 60

Removal

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.

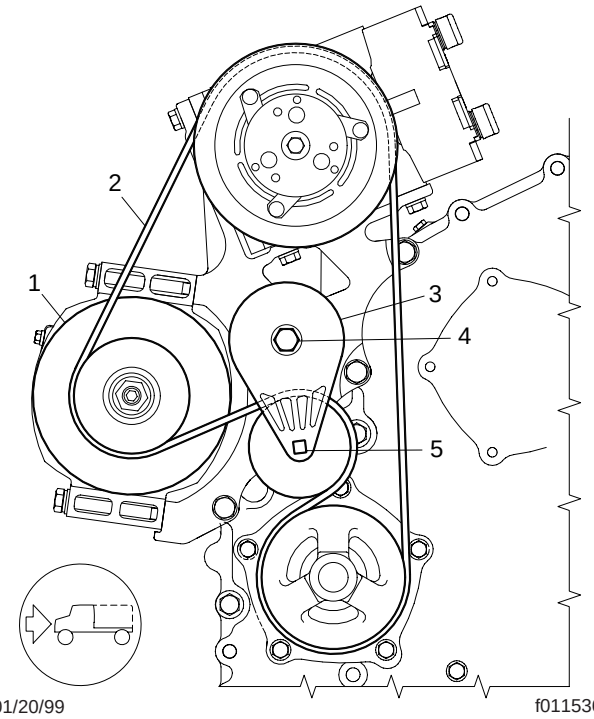
⚠ WARNING

Before disconnecting the batteries, read the instructions and Danger and Warning notices in Section 54.02. Keep sparks, flames, burning cigarettes, etc. away from batteries. Batteries generate explosive gases, which could cause a battery to explode, causing serious personal injury, including blindness.

3. Disconnect the batteries.
4. Mark all electrical leads and disconnect them from the alternator.
5. Remove the serpentine belt. See Fig. 1.
   - 5.1 Find the drive belt tensioner on the front of the engine.
   - 5.2 Insert a 1/2-inch ratchet drive into the square hole in the belt tensioner. Turn the tensioner clockwise to relieve the belt tension.
   - 5.3 Remove the belt.
6. Remove the alternator mounting capscrews. Remove the alternator from the vehicle.
7. Inspect the drive belt. For instructions, see Section 01.07, Subject 180.

Installation

1. Position the alternator on the engine. Install the four mounting capscrews, and tighten 65 lbf·ft (88 N·m).
2. Install the serpentine belt. See Fig. 1.
   - 2.1 Position the drive belt over all the pulleys *except the alternator*.
   - 2.2 Insert a 1/2-inch rachet drive into the square hole in the belt tensioner, and turn the tensioner clockwise.



1. 22–SI Quadramount Alternator
2. Serpentine Belt
3. Belt Tensioner
4. Tensioner Mounting Bolt
5. Square Hole for Moving the Tensioner

Fig. 1, Alternator Installation, Detroit Diesel Series 60

   - 2.3 Position the belt on the alternator, release the tensioner, and remove the rachet drive from the tensioner.
3. Connect all leads to the back of the alternator as previously marked and tighten. See Specifications 400.
4. Spray any exposed terminal connectors with dielectric red enamel. See Table 1.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

Alternator Removal and Installation, DDC 60

5. Connect the batteries.
6. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" or use the Delco Intelli-Check Alternator Analyzer (if available) in **Troubleshooting, 300**.
7. Close the hood.
8. Remove the tire chocks.

Alternator Removal and Installation, Caterpillar Engines

Removal

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.

⚠ WARNING

Before disconnecting the batteries, read the instructions and Danger and Warning notices in Section 54.02 of this workshop manual. Keep sparks, flames, burning cigarettes, etc. away from batteries. Batteries generate explosive gases, which could cause a battery to explode, causing serious personal injury, including blindness.

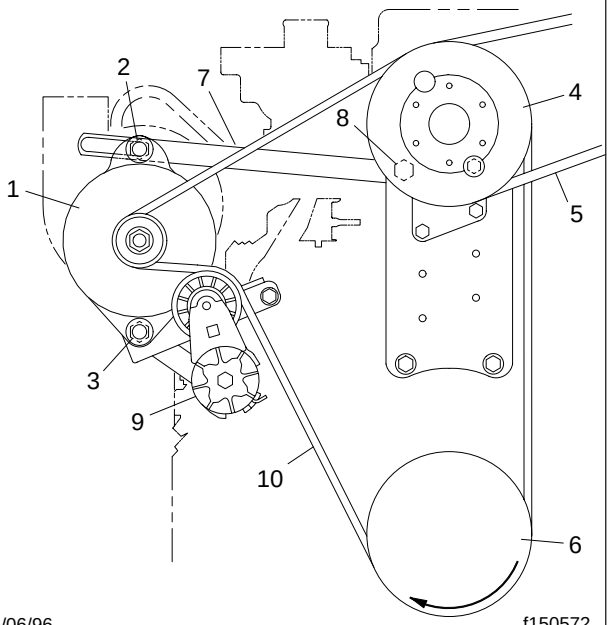
3. Disconnect the batteries.
4. Mark all electrical leads and disconnect them from the alternator.
5. Insert a 1/2-inch rachet drive into the square hole in the belt tensioner, and turn the tensioner down and off the belt. See **Fig. 1**.

NOTE: There are two drive belts to remove. Before removing the alternator belt, it is necessary to remove the refrigerant compressor belt from the fan pulley.

6. Holding the belt tensioner down, remove the drive belt from the alternator pulley. Slowly release the belt tensioner and remove the breaker bar.
7. Lower the drive belt, and take it off the vibration damper. It is not necessary to remove the belt from the vehicle.
8. Remove both alternator mounting capscrews. Remove the alternator from the vehicle.

NOTE: It is not necessary to remove the adjusting strap from the engine.

9. Inspect the drive belt. For instructions, see **Section 01.07**.



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Rotate the belt tensioner down and away from the belt.

1. 22–SI Alternator
2. Alternator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Fan Pulley
5. Refrigerant Compressor Drive Belt
6. Vibration Damper
7. Alternator Adjusting Strap
8. Adjusting Strap Mounting Capscrew
9. Belt Tensioner
10. Alternator Drive Belt

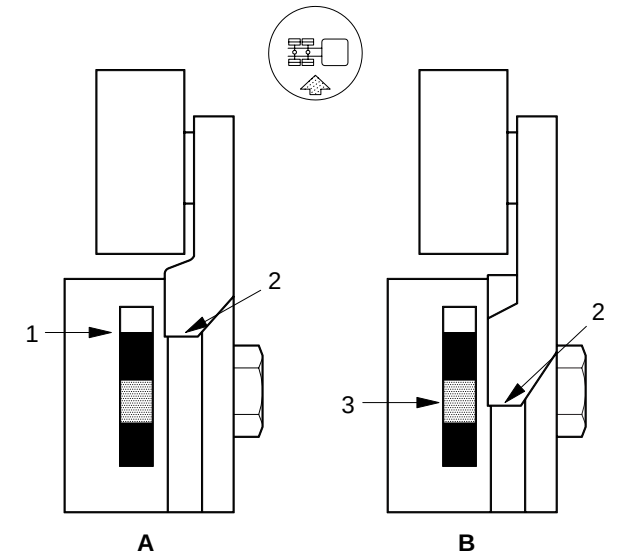
Fig. 1, Alternator Installation, Caterpillar C-10/C-12 Engine Mounting Shown

Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten, see **Specifications 400**.
2. Install the alternator on the engine. Install the alternator at the inboard edge of the slot initially. Install the top and bottom alternator mounting capscrews, but do not tighten them yet.
3. Install the drive belts on the pulleys, as removed. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Section 01.07**.

Alternator Removal and Installation, Caterpillar Engines

4. Verify that the edge of the tensioner arm is within the green zone on the decal. See **Fig. 2**. If within the red zone, pivot the alternator outboard until the tensioner arm enters the green zone.



A. Belt Off, No Tension
B. Belt On, Correct Tension
1. Decal
2. Edge of Tensioner Arm
3. Green Zone (operating range)

Fig. 2, Belt Tensioner With Decal

NOTE: If the belt slips, repair or replace the tensioner. For instructions, see the appropriate Caterpillar Diesel Truck Engine Service Manual.

5. When the alternator is correctly positioned, tighten both alternator mounting capscrews 65 lbf·ft (88 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

8. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" or use the Delco Intelli-Check Alternator Analyzer (if available) in **Troubleshooting, 300**.
9. Close the hood.
10. Remove the tire chocks.

Alternator Removal and Installation, Cummins Engines

Removal

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.

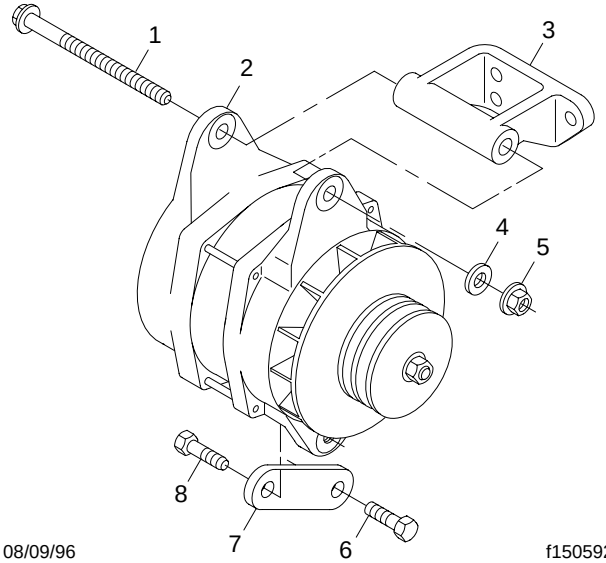
⚠ WARNING

Before disconnecting the batteries, read the instructions and Danger and Warning notices in Section 54.02. Keep sparks, flames, burning cigarettes, etc. away from batteries. Batteries generate explosive gases, which could cause a battery to explode, causing serious personal injury, including blindness.

3. Disconnect the batteries.
4. Mark all electrical leads and disconnect them from the alternator.
5. Remove the drive belts and note the routing. For instructions, see **Section 01.07**.
6. Remove the alternator. See **Fig. 1**.
   - 6.1 Remove the alternator mounting capscrew (Ref. 8) from the link (Ref. 7).
   - 6.2 Remove the nut and washer (Refs. 5 and 4) from the pivot bolt (Ref. 1).
   - 6.3 Securely hold the alternator to prevent it from falling, and remove the pivot bolt.
   - 6.4 Remove the alternator from the vehicle.
7. Inspect the drive belt. For instructions, see **Section 01.07**, Subject 180.

Installation

1. Install a new pulley, if applicable, and tighten the shaft nut to 75 lbf·ft (102 N·m).
2. Install the alternator on the pivot bracket. See **Fig. 1**.
   - 2.1 Position the alternator on the bracket.
   - 2.2 Insert the pivot bolt (Ref. 1) through the alternator and the bracket.
   - 2.3 Install the washer and nut (Refs. 4 and 5) on the end of the pivot bolt.



1. Pivot Capscrew
2. Mounting Lug
3. Pivot Bracket
4. Washer
5. Pivot Nut
6. Alternator Link Fastener
7. Alternator Link
8. Alternator Mounting Capscrew

Fig. 1, Mounting Hardware (Cummins engine mounting shown)

3. Check the torque of the alternator bracket fasteners. If necessary, tighten, see **Specifications 400**.
4. Install the alternator mounting capscrew, and tighten it 65 lbf·ft (88 N·m). Tighten the pivot nut 65 lbf·ft (88 N·m).
5. Install the drive belt on the pulley as removed. For instructions, see **Section 01.07**.

NOTE: The belt tensioner automatically adjusts the drive belt to the correct tension. If the belt slips, repair or replace the tensioner. For instructions, see the engine manufacturer's service literature.

6. Connect all leads to the back of the alternator as previously marked and tighten. See **Specifications 400**.
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1** for approved brands.

Alternator Removal and Installation, Cummins Engines

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" or use the Delco Intelli-Check Alternator Analyzer (if available) in **Troubleshooting, 300**.
10. Close the hood.
11. Remove the tire chocks.

Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/Charging System Testing."

Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

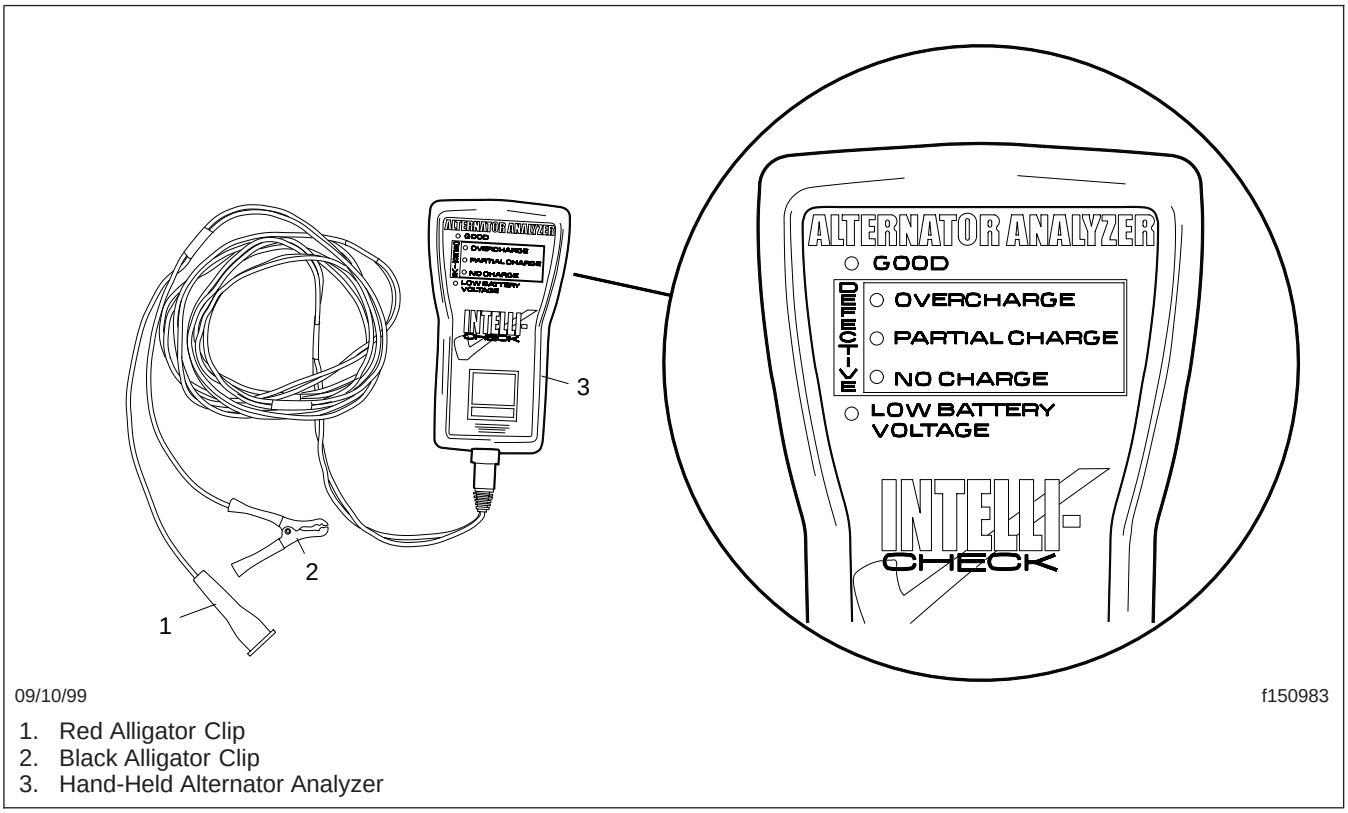
Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.
3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
    - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
        A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
        B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
        C. Repeat the applicable steps of the Pre-Test Procedure.
    - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
    - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
    - If the **GOOD** (green) LED illuminates, proceed to the next step.
    - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
    - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging

Troubleshooting



1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 1, Delco Remy Intelli-Check Alternator Analyzer

system using the instructions in "Alternator/Charging System Testing."

4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/ Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing".

Alternator/Charging System Testing

Battery Open Circuit Voltage Test, Alternator Output Voltage Test and Alternator Amperage Output Test

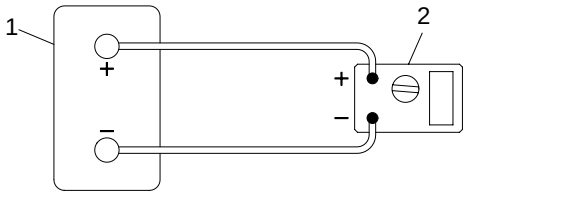
1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

   If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

   If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

2. Check the alternator output without a load. See **Fig. 3**.



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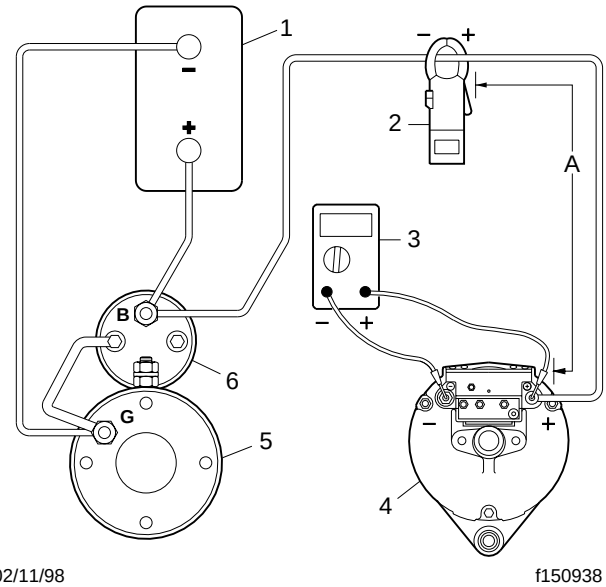
1. Battery
2. Digital Voltmeter

Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)



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A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 3, Setup 2: Alternator Output Test

2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3**.

2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.

3. Check the alternator output under load. See **Fig. 3**.

3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

- Both front and rear heater blowers (on HIGH)
- Headlights (high beams)
- Road lights
- Interior lights

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

4. Perform an alternator amperage output test.

4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2**.

Troubleshooting

NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

NOTE: Ensure that the alternator is turning at maximum available rpms and keep adjusting the tester dial until the ammeter reads its highest value.

4.4 Turn off the tester and shut down the engine.

4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3**.

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables and terminals.

6.1 Check all connections between the battery, starter and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

Specifications

Mounting Fastener Torques, Cummins Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Cummins N14/NTC Engine			
End Link Mounting Capscrew	8PO	1/2–13	68 (92)
Alternator Mounting Capscrew	8PO	1/2–13	68 (92)
Adjusting Rod Mounting Capscrew	8PO	7/16–20	50 (68)
Adjusting Rod Jam Nut	5	5/8	155 (210)
Alternator Bracket Fasteners	5PO	3/8–16	34 (46)
Cummins M11/L10 Engine			
Adjusting Block Mounting Nut	5	1/2	35 (47)
Alternator Mounting Capscrew	8PO	1/2–13	60 (81)
Adjusting Screw Locknut	5	1/2	95 (130)
Adjusting Arm Mounting Capscrew	5	1/2–13	55 (75)
Alternator Bracket Fasteners	10.9PO	M10	34 (46)

Table 1, Mounting Fastener Torques, Cummins Engines

Mounting Fastener Torques, Caterpillar Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Caterpillar 3306 and 3406 Engines			
End Link Mounting Capscrew	8PO	1/2–13	68 (92)
Alternator Mounting Capscrew	8PO	1/2–13	68 (92)
Adjusting Rod Mounting Capscrew	8PO	1/2–13	68 (92)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Alternator Bracket Fasteners	5PO	3/8–16	34 (46)
Caterpillar 3176/C–10 Engine			
Alternator Mounting Capscrews	8PO	1/2–13	68 (92)
Adjusting Strap Mounting Capscrew	10.9PO	M12	60 (81)

Table 2, Mounting Fastener Torques, Caterpillar Engines

Mounting Fastener Torques, Detroit Diesel Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Detroit Diesel Series 50 Engine			
End Link Mounting Capscrew	8PO	1/2–13	68 (92)
Alternator Mounting Capscrew	8PO	1/2–13	68 (92)
Adjusting Rod Mounting Capscrew	8PO	7/16–14	45 (61)
Adjusting Rod Jam Nut	5	5/8	128 (173)
Alternator Bracket Fasteners	10.9PO	M10	43-54 (58-73)
Detroit Diesel Series 55 Engine			

Specifications

Mounting Fastener Torques, Detroit Diesel Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Alternator Mounting Capscrews	8PO	1/2–13	68 (92)
Adjusting Strap Mounting Capscrew	8PO	1/2–13	68 (92)

Table 3, Mounting Fastener Torques, Detroit Diesel Engines

Terminal Fastener Torques, All Engines			
Description	**Grade**	**Size**	**Torque: lbf·in (N·cm)**
Alternator Output ("BAT") Terminal Nut	8.8	M6	100-110 (1130-1240)
Ground ("G") Terminal Nut	8.8	M6	55-60 (620-670)
Indicator Light ("I") or Relay ("R") Terminal Nut	8.8	M4	20 (226)

Table 4, Terminal Fastener Torques, All Engines

General Information

Two types of radiators are used in Freightliner COEs and FLD Conventionals: high-flow (traditional), and low-flow.

High-flow and low-flow radiators are either single-pass vertical flow radiators with top and bottom tanks, or single-pass cross flow radiators with end-tanks.

NOTE: Radiators on FLA COEs are vertical flow with top and bottom tanks. On FLD Conventionals, the radiators are cross-flow with end-tanks.

In high-flow cooling systems, most of the coolant in a warm engine is routed through the radiator. The coolant moves relatively quickly through the radiator in a single pass.

In low-flow cooling systems, no more than 15 percent of the coolant moves through the radiator; the remainder is pumped constantly through the engine.

All Caterpillar and Cummins engine installations have a fill (shunt) line in the cooling system. The fill line uses gravity to prevent water pump cavitation (bubble formation around the impeller) by maintaining a slight amount of coolant pressure at the water pump inlet. The fill line also helps remove air from the system when it is being filled with coolant.

CATERPILLAR 3306 COOLANT PLUMBING (See Fig. 1)

Coolant flows from the radiator outlet to the water pump (Ref. 7), with some going to the jacket-water aftercooler (Ref. 3), if so equipped. From the aftercooler, coolant moves to the oil cooler bonnet (Ref. 9). There it mixes with coolant that passed through the oil cooler (Ref. 8) from the water pump. From the bonnet, coolant flows into the engine block.

Inside the block, coolant flows around the cylinders, into the cylinder head, and then to the temperature regulator (thermostat) housing (Ref. 4). If still cool, coolant is directed back to the water pump. As it warms, coolant is directed to the radiator by the temperature regulator (thermostat). The regulator keeps the engine temperature in the optimum range by controlling the two flows.

The vent lines (Ref. 2) from the temperature regulator housing and the aftercooler route air and vapor from the engine to the radiator surge tank.

CATERPILLAR 3406 COOLANT PLUMBING (See Fig. 2)

When the engine is cold, coolant flows from the temperature regulator to the water pump (Ref. 6), which forces the coolant through the oil cooler (Ref. 7) and into the engine block. From the block, it flows to the cylinder head, then back to the temperature regulator (thermostat) housing (Ref. 4). As the engine warms, the temperature regulator directs coolant to the radiator. The regulator keeps the engine temperature in the optimum range by controlling the two flows.

On engines with a jacket-water aftercooler (Ref. 1), a small amount of coolant flows from the oil cooler bonnet (Ref. 8), through the aftercooler, and into the engine block.

The temperature regulator housing vent line (Ref. 2) routes air and vapor from the engine to the radiator surge tank.

CATERPILLAR 3176 COOLANT PLUMBING (See Fig. 3)

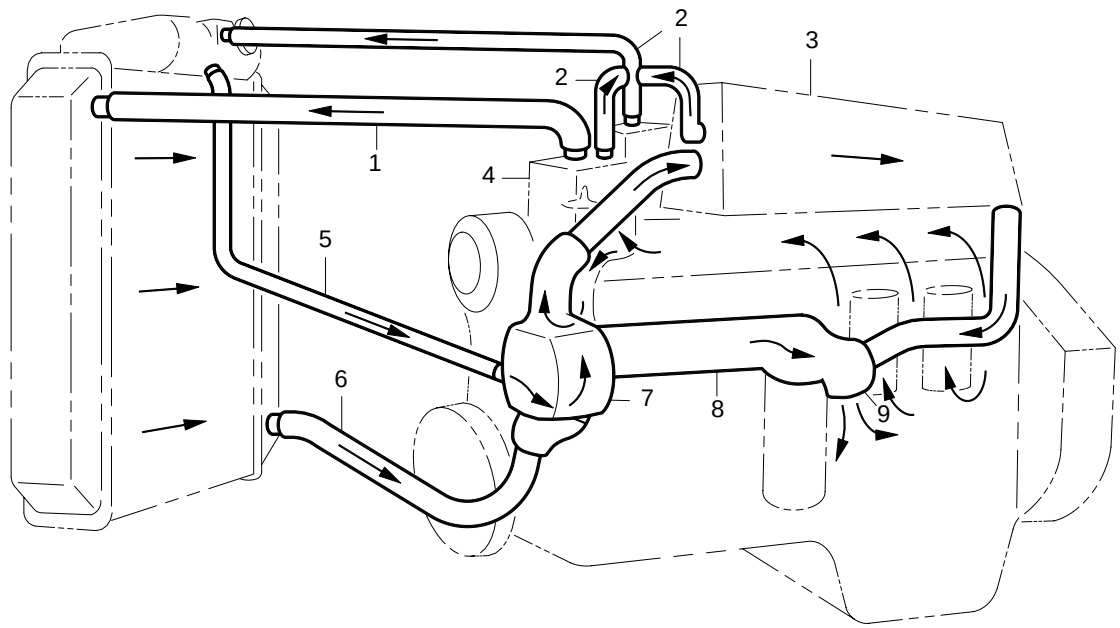
Coolant flows from the radiator outlet to the water pump (Ref. 8). There it is pumped through the oil cooler (Ref. 5) and into the supply manifold. The supply manifold, located in the cylinder block spacer block, distributes coolant at each cylinder then flows around and cools the upper portion of the cylinder liner.

At each cylinder, coolant flow from the liner enters the cylinder head, which is divided into two cooling sections. In the cylinder head, coolant flows across the center of the cylinder and the injector seat boss. At the center of the cylinder, coolant flows up around the injector sleeve, over the exhaust port, and exits into the return manifold. The return manifold collects the coolant from each cylinder and directs the flow to the temperature regulator (Ref. 7). Depending on engine temperature, the temperature regulator directs all, part, or none of the coolant through the radiator.

CUMMINS BIG CAM III COOLANT PLUMBING (See Fig. 4)

When the engine is cold, coolant flows from the temperature regulator to the water pump (Ref. 6). Some is pumped through the oil cooler (Ref. 7) to the upper water manifold (Ref. 5); most is pumped to the engine block. From the block, coolant flows to the cylinder heads, and into the upper water manifold. Some

General Information



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1. Radiator Inlet Hose
2. Vent Lines
3. Jacket-Water Aftercooler
4. Temperature Regulator (Thermostat) Housing
5. Shunt Line
6. Radiator Outlet Hose
7. Water Pump
8. Oil Cooler
9. Oil Cooler Bonnet

Fig. 1, Caterpillar 3306 Coolant Plumbing (FLD 120 Conventional)

of the flow from the block is piped through the aftercooler (Ref. 3) and back to the water pump.

The upper water manifold is connected to the thermostat housing (Ref. 4). When the engine is cool, the thermostat directs coolant back to the water pump. As the engine warms, coolant is directed to the radiator. The thermostat keeps the engine temperature in the optimum range by controlling the two flows.

The vent line (Ref. 1) from the upper water manifold routes air and vapor from the engine to the surge tank.

CUMMINS BIG CAM IV COOLANT PLUMBING **(See Fig. 5)**

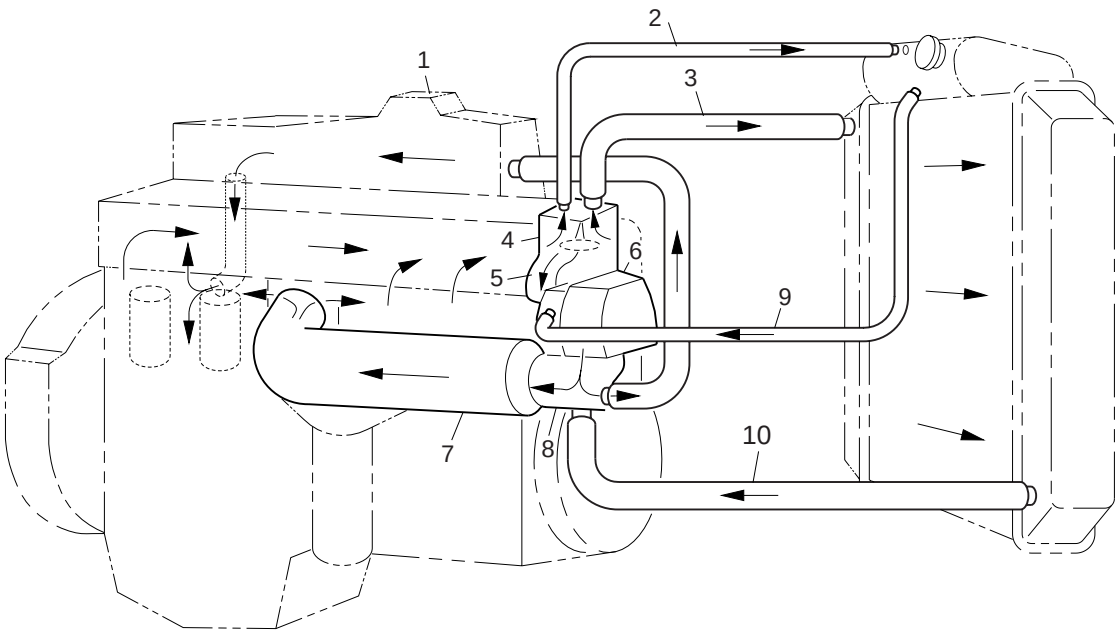
From the radiator, coolant is drawn through the thermostat housing (Ref. 4) to the aftercooler (Ref. 2), where it warms the intake air for more efficient combustion. With the engine at operating temperature, about 85 percent of the coolant is pumped from the water pump through the block and cylinder heads.

The remainder moves through the oil cooler (Ref. 8) to the thermostat housing (Ref. 4).

The thermostat housing has a bypass thermostat and a radiator thermostat (see detail). The bypass thermostat controls the amount of warmed coolant that flows to the aftercooler, bypassing the radiator. The radiator thermostat controls the amount of hot coolant that passes through the radiator.

Between 175°F (79°C) and 185°F (85°C), the two thermostats work together to control the flow and temperature of coolant to the aftercooler.

Above 185°F (85°C) coolant temperature, the bypass thermostat is fully closed, and the radiator thermostat continues to open. At 195°F (91°C) the radiator thermostat is fully open, and there is maximum flow through the radiator.



1. Jacket-Water Aftercooler
2. Vent Line
3. Radiator Inlet Hose
4. Temperature Regulator (Thermostat) Housing
5. Water Elbow
6. Water Pump
7. Oil Cooler
8. Oil Cooler Bonnet
9. Shunt Line
10. Radiator Outlet Hose

Fig. 2, Caterpillar 3406 Coolant Plumbing (FLD 120 Conventional)

CUMMINS L10 COOLANT PLUMBING, OPTIMIZED AFTERCOOLING (See Fig. 6)

With the engine at operating temperature, coolant is drawn through the aftercooler (Ref. 2) to the water pump (Ref. 7), where it mixes with the engine block coolant.

Coolant flows through the engine block into the cylinder head, then into the upper water manifold cavity. A portion of the block coolant is routed through the oil cooler (Ref. 6) and into the upper manifold cavity. From there, coolant moves into the thermostat housing (Ref. 5). About 85 percent is routed directly to the water pump. The remainder is controlled by a thermostat (see detail) that has two valves — a radiator-bypass valve, and a radiator-flow valve.

Below 175°F (79°C) coolant temperature, the radiator-bypass valve is open, and the radiator-flow valve is closed. Hot coolant flows to the aftercooler.

Between 175°F (79°C) and 185°F (85°C), the radiator-bypass valve closes, while the radiator-flow valve opens; some of the coolant passes through the radiator before it flows to the aftercooler.

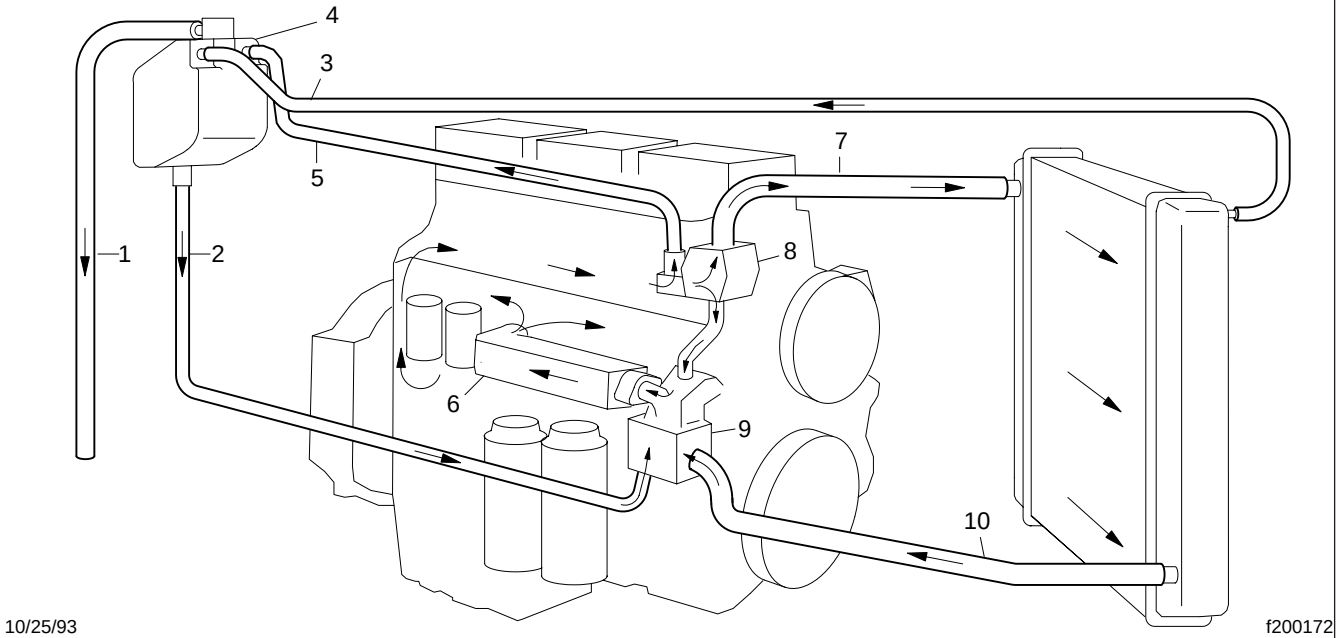
Above 185°F (85°C), the radiator-bypass valve is closed. The radiator-flow valve continues to open. At 195°F (91°C), the radiator-flow valve is completely open, and all of the coolant flowing through the aftercooler first goes through the radiator.

The vent line (Ref. 3) from the aftercooler inlet joins the cylinder head vent line (Ref. 1), which carries air and vapor from the engine to the surge tank.

CUMMINS C SERIES COOLANT PLUMBING (See Fig. 7)

Coolant is drawn from the radiator by the integrally mounted water pump. There it is pumped through the oil cooler and into the upper water manifold. A portion of the coolant then flows through the coolant filter and returns to the lower manifold, while the rest

General Information



1. Overflow Vent
2. Fill Line
3. Deaeration Line
4. Surge Tank
5. Vent Line
6. Oil Cooler
7. Radiator Inlet Hose
8. Temperature Regulator (Thermostat) Housing
9. Water Pump
10. Radiator Outlet Hose

Fig. 3, Caterpillar 3176 Coolant Plumbing (FLD 112 Conventional)

of the coolant flows through each cylinder up to the cylinder head.

From each cylinder the coolant flows through cast openings into the lower manifold and on to the thermostat housing (Ref. 6). When the engine is below operating temperature, the thermostats are closed and coolant is bypassed to the water pump inlet. As the coolant temperature increases, both thermostats begin to open allowing some coolant to flow through the radiator outlet hose (Ref. 7) to the radiator. At normal operating temperature, the bypass circuit and both thermostats are closed.

CUMMINS L10 COOLANT PLUMBING, CHARGE AIR COOLING

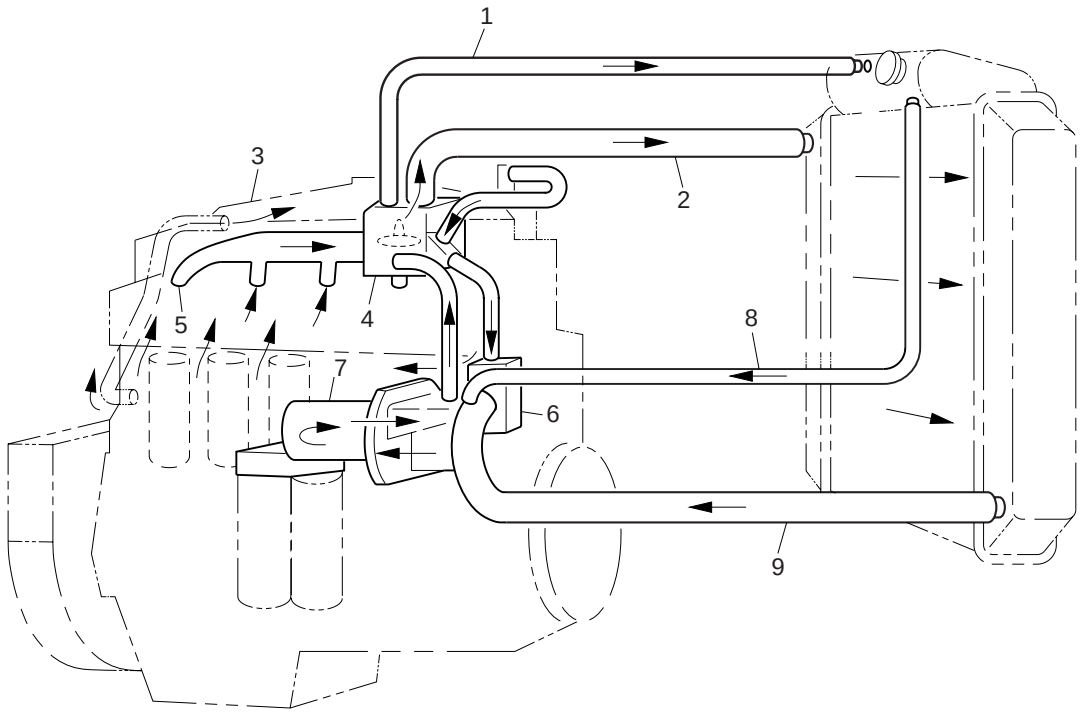
(See Fig. 8)

Coolant is drawn from the radiator by the water pump. There it is pumped through the oil cooler and into the upper water manifold. A portion of the coolant then flows through the coolant filter and returns to the lower manifold, while the rest of the coolant flows through each cylinder up to the cylinder head.

From each cylinder the coolant flows through cast openings into the lower manifold and on to the thermostat housing (Ref. 6). When the engine is below operating temperature, the thermostats are closed and coolant is bypassed to the water pump inlet. As the coolant temperature increases, both thermostats begin to open allowing some coolant to flow through the radiator outlet hose (Ref. 7) to the radiator. At normal operating temperature, the bypass circuit and both thermostats are closed.

DETROIT DIESEL SERIES 50 COOLANT PLUMBING **(See Fig. 9)**

The water pump draws engine coolant from the lower portion of the radiator and forces it through the oil cooler and into the cylinder block. From the cylinder block, the coolant passes up through the cylinder head.



1. Vent Line
2. Radiator Inlet Hose
3. Aftercooler
4. Thermostat Housing
5. Upper Water Manifold
6. Water Pump
7. Oil Cooler
8. Fill Line
9. Radiator Outlet Hose

Fig. 4, Cummins Big Cam III Coolant Plumbing (FLD Conventionals)

When the coolant temperature is below about 186 to 193°F (86 to 89°C), the thermostat valves stay closed and block the flow of coolant from the engine to the radiator. When this happens, coolant passes from the thermostat housing back to the water pump through the bypass tube. As the coolant temperature rises above 186 to 193°F (86 to 89°C), the thermostat valves start to open and permit some coolant to circulate through the radiator. When the coolant temperature reaches about 207°F (97°C), the thermostat valves are fully open, the bypass tube is blocked off, and all of the coolant is then circulated through the radiator.

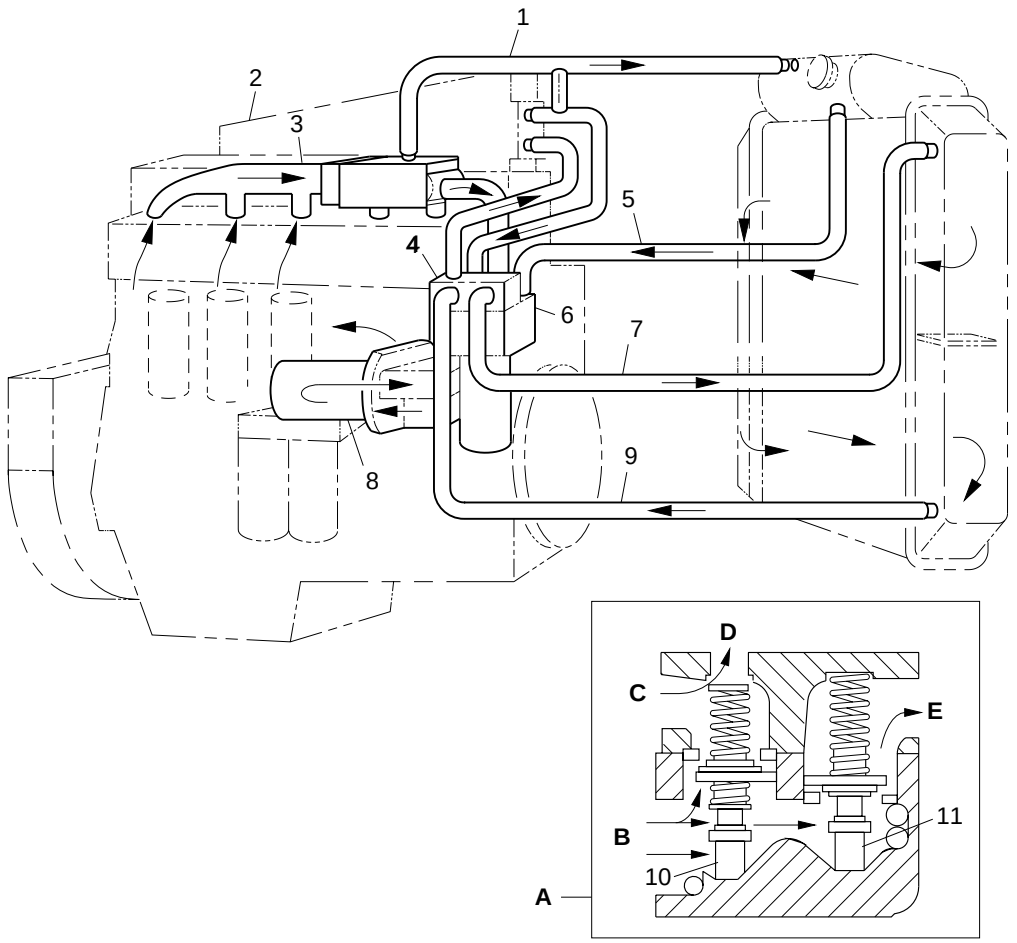
A line from the top of the water pump carries excess coolant to and from the surge tank. When the coolant is hot, it expands, pushing up to the surge tank. When the coolant is cold, it contracts, and the coolant stored in the surge tank flows down to replenish the engine cooling system.

DETROIT DIESEL SERIES 55 COOLANT PLUMBING **(See Fig. 10)**

The water pump draws engine coolant from the lower portion of the radiator and forces it through the oil cooler and into the cylinder block. From the cylinder block, the coolant passes up through the cylinder head.

When the coolant temperature is below about 186 to 193°F (86 to 89°C), the thermostat valves stay closed and block the flow of coolant from the engine to the radiator. When this happens, coolant passes from the thermostat housing back to the water pump through the bypass tube. As the coolant temperature rises above 186 to 193°F (86 to 89°C), the thermostat valves start to open and permit some coolant to circulate through the radiator. When the coolant temperature reaches about 207°F (97°C), the thermostat valves are fully open, the bypass tube is blocked off, and all of the coolant is then circulated through the radiator.

General Information

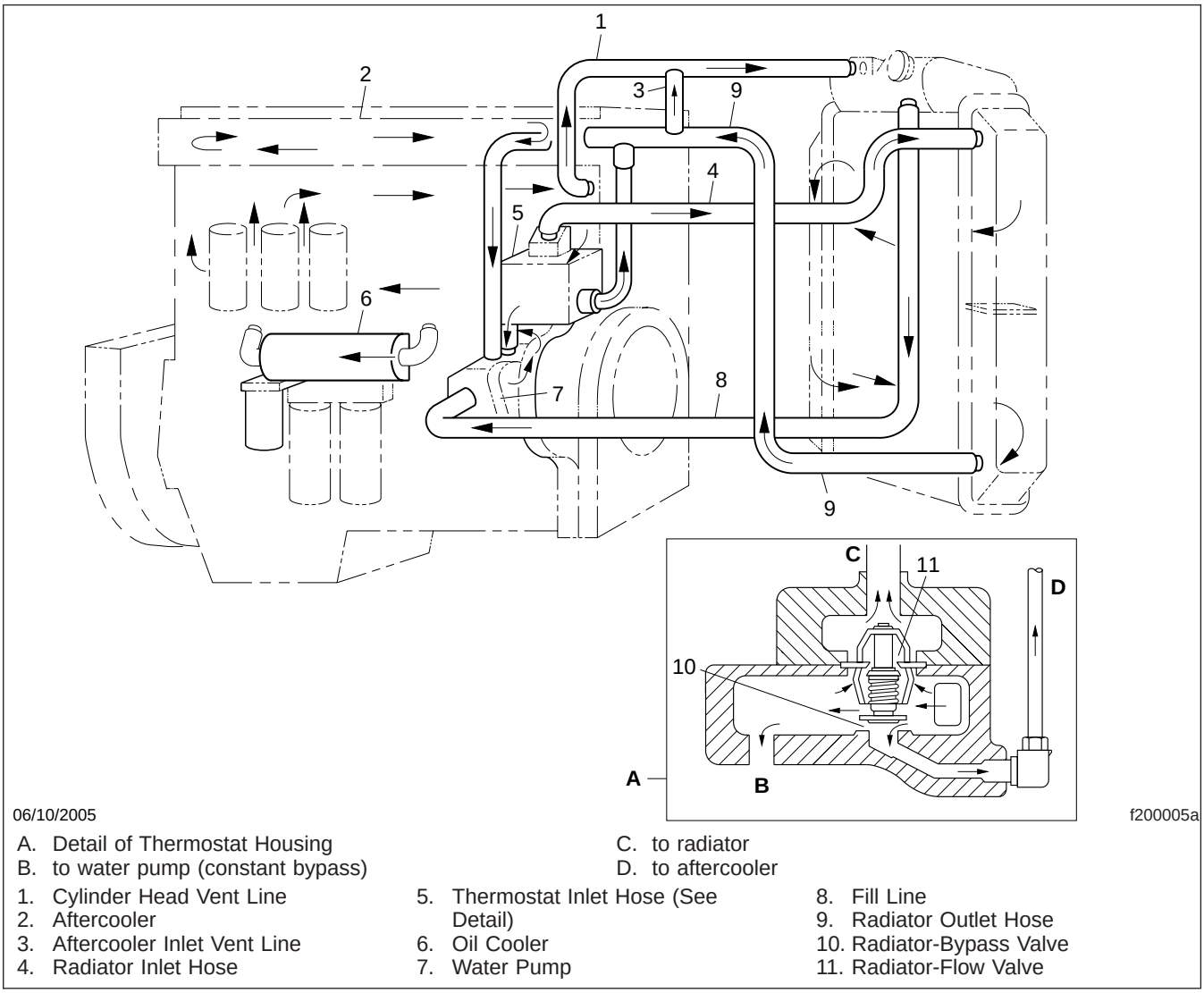


A. Detail of Thermostat Housing
B. from oil cooler
C. from radiator
D. to aftercooler
E. to radiator

1. Vent Line
2. Aftercooler
3. Upper Water Manifold
4. Thermostat Housing (See Detail)
5. Fill Line
6. Water Pump
7. Radiator Inlet Hose
8. Oil Cooler
9. Radiator Outlet Hose
10. Bypass Thermostat
11. Radiator Thermostat

Fig. 5, Cummins Big Cam IV Coolant Plumbing (FLD Conventionals)

A line from the top of the water pump carries excess coolant to and from the surge tank. When the coolant is hot, it expands, pushing up to the surge tank. When the coolant is cold, it contracts, and the coolant stored in the surge tank flows down to replenish the engine cooling system.

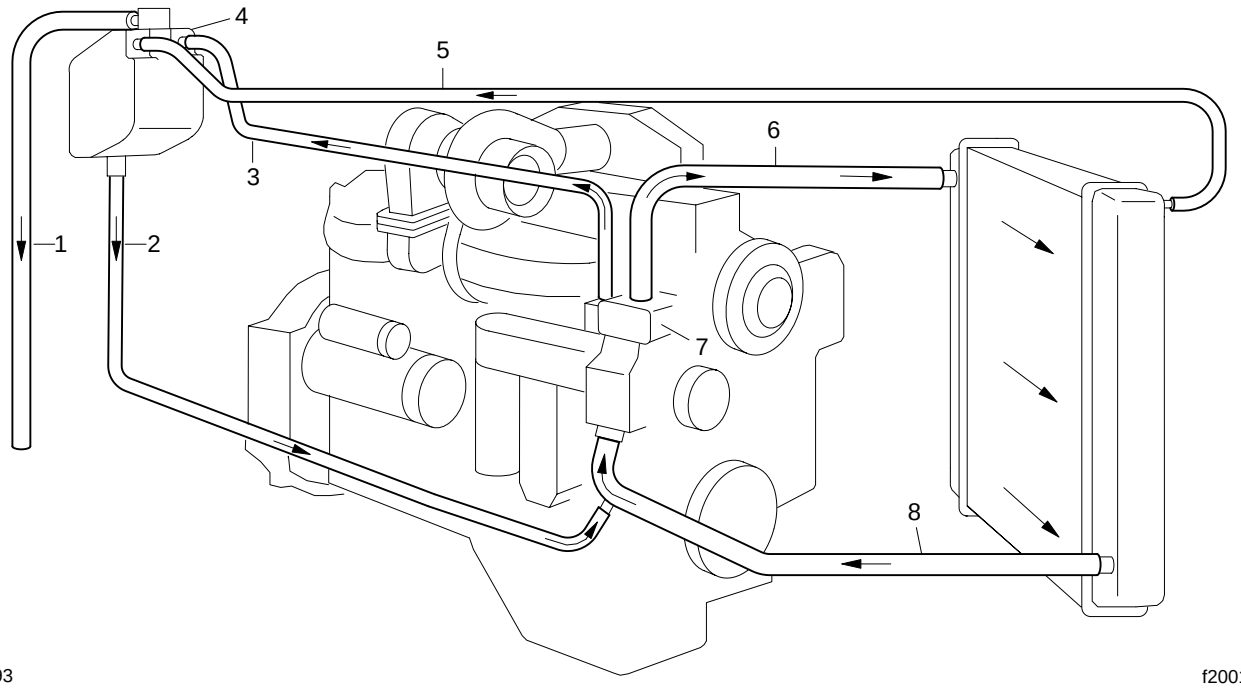


A. Detail of Thermostat Housing
B. to water pump (constant bypass)
C. to radiator
D. to aftercooler

1. Cylinder Head Vent Line
2. Aftercooler
3. Aftercooler Inlet Vent Line
4. Radiator Inlet Hose
5. Thermostat Inlet Hose (See Detail)
6. Oil Cooler
7. Water Pump
8. Fill Line
9. Radiator Outlet Hose
10. Radiator-Bypass Valve
11. Radiator-Flow Valve

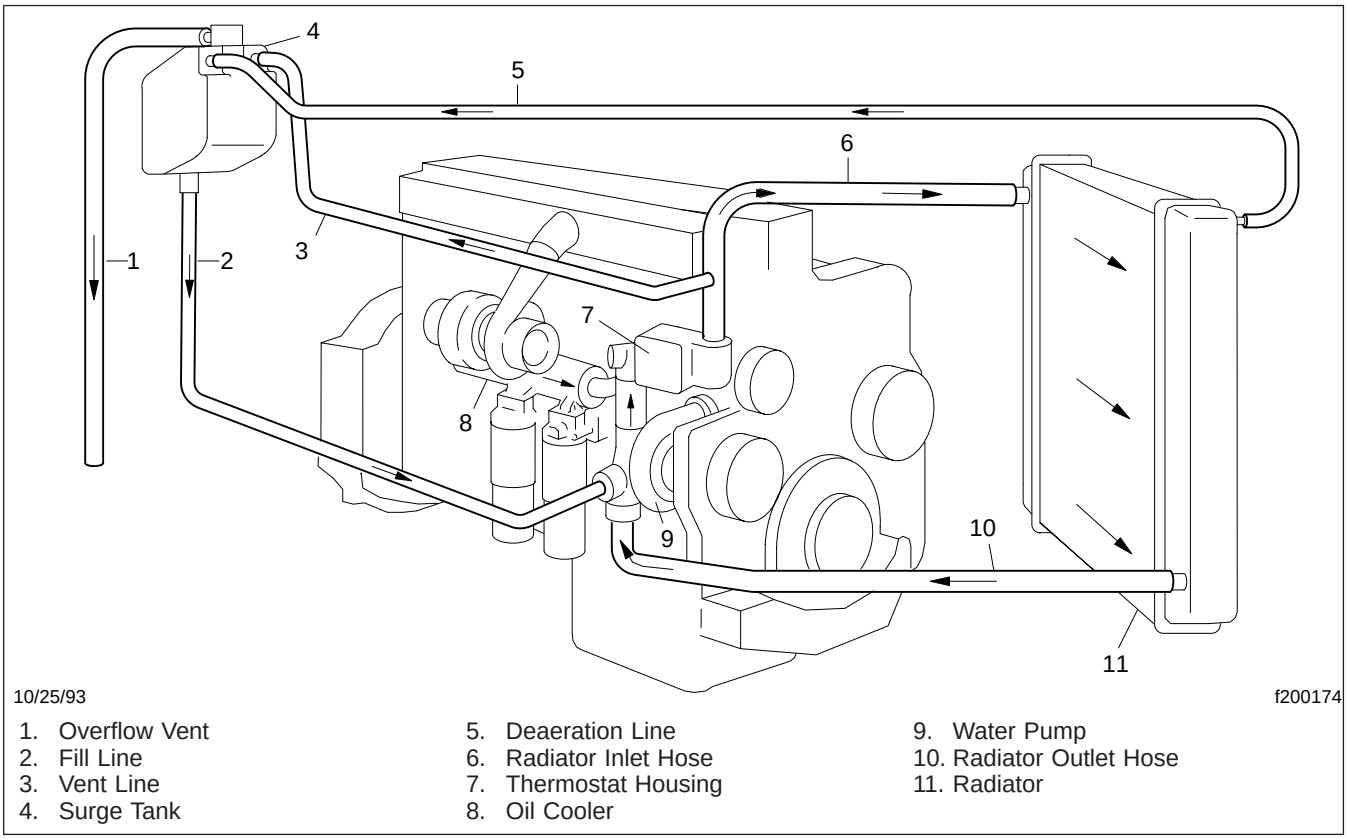
Fig. 6, Cummins L10 Coolant Plumbing (FLA COE)

General Information



1. Overflow Vent
2. Fill Line
3. Vent Line
4. Surge Tank
5. Deaeration Line
6. Radiator Inlet
7. Thermostat Housing
8. Radiator Outlet Hose

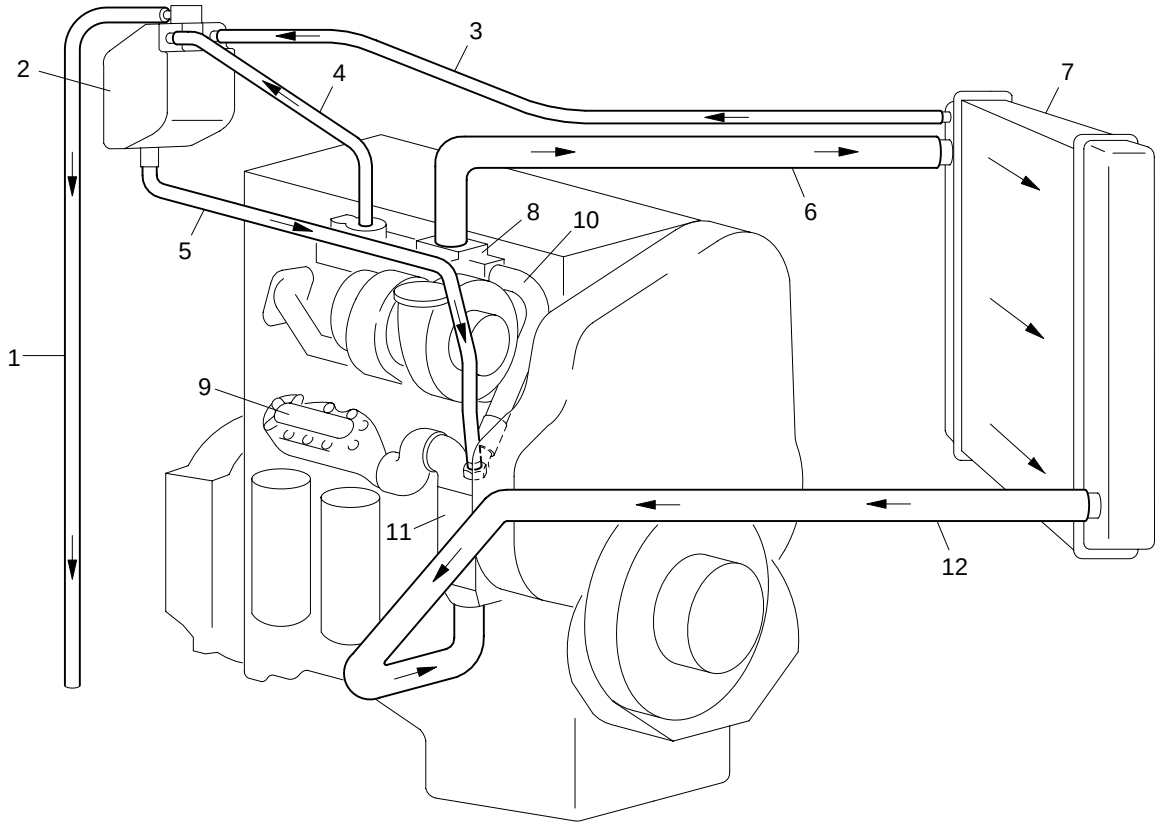
Fig. 7, Cummins C Series Coolant Plumbing (FLD 112 Conventional)



1. Overflow Vent
2. Fill Line
3. Vent Line
4. Surge Tank
5. Deaeration Line
6. Radiator Inlet Hose
7. Thermostat Housing
8. Oil Cooler
9. Water Pump
10. Radiator Outlet Hose
11. Radiator

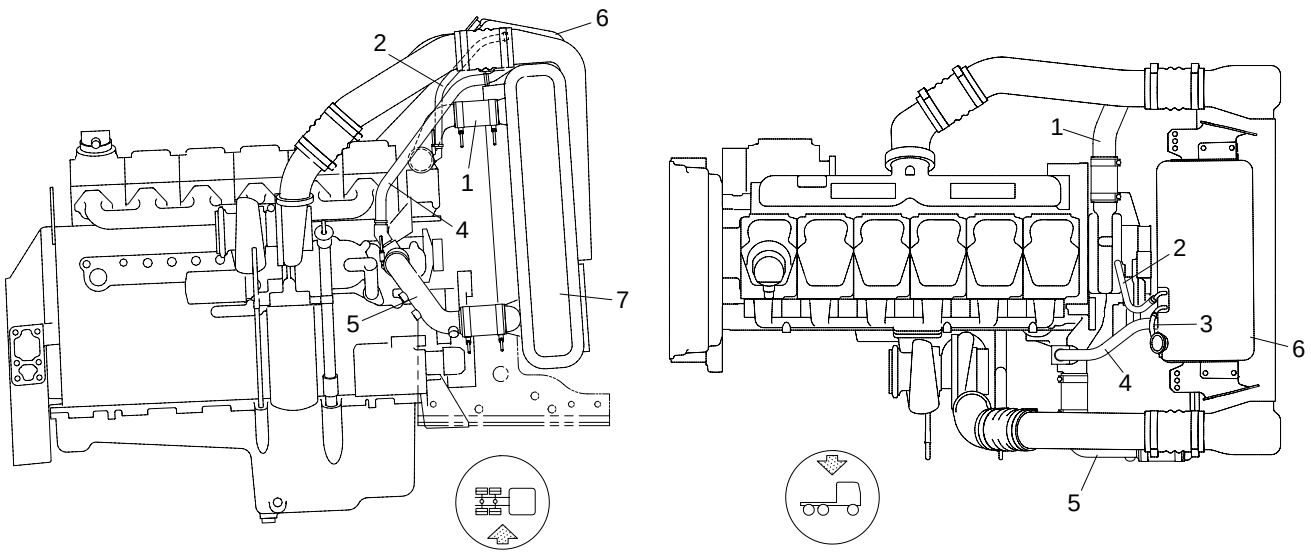
Fig. 8, Cummins L10 Coolant Plumbing (FLD 112 Conventional)

General Information



1. Overflow Vent
2. Surge Tank
3. Radiator Vent Line
4. Engine Vent Line
5. Fill Line
6. Radiator Inlet Hose
7. Radiator
8. Thermostat Housing
9. Oil Cooler
10. Bypass Tube
11. Water Pump
12. Radiator Outlet Hose

Fig. 9, Detroit Diesel Series 50 Coolant Plumbing (FLD 112 Conventional)



1. Radiator Inlet Hose
2. Engine Vent Line
3. Radiator Vent Line
4. Fill Line
5. Radiator Outlet Line
6. Surge Tank
7. Radiator

Fig. 10, Detroit Diesel Series 55 Coolant Plumbing (FLD 120 Conventional)

Troubleshooting

Possible causes of hot or cold engine coolant temperatures are listed below. For repairs, refer to other sections of this manual or to the engine and component manufacturers' service publications.

Problem—Coolant Temperature Above Normal

Possible Cause	Remedy
Coolant leakage (see possible sources below) is causing a low coolant level. External Leakage: hoses and hose connections radiator seams, core, draincock, and cap block core and drain plugs water pump thermostat housing(s) overflow and surge tank heater hoses and core temperature sending unit(s) cylinder head(s) mating (gasket) surfaces coolant filter oil cooler(s) Internal Leakage: cylinder head gasket warped head or block surfaces cracked cylinder head or block cylinder head capscrews loose, missing, or tightened unevenly oil cooler air compressor cylinder head and gasket cylinder liners, liner seals aftercooler	Perform the repairs necessary to stop leakage. Fill to the bottom of the radiator fill neck with the correct mixture of antifreeze and water.
The temperature gauge is not working.	Check the gauge circuit wires, circuit breaker, and sending unit. If the gauge circuit is okay, replace the temperature gauge. If the gauge circuit is broken, repair it and then check temperature gauge operation
The radiator fins, the aftercooler, or the air conditioner condenser fins are clogged.	Clean the outside of the core, the aftercooler, and the condenser with compressed air directed from the fan side, or with water and a mild laundry soap. Straighten bent fins.
A radiator hose is collapsed or plugged.	Replace hoses.
A fan drive belt or the water pump belt is loose.	Adjust belt tension.
The cooling fan shroud is damaged.	Repair or replace the shroud.
The radiator cap is incorrect or malfunctioning.	Make sure the correct radiator cap is installed. If the cap does not hold the correct pressure, replace it.
The on-off fan clutch is not working.	Check the solenoid valve in the fan clutch air supply line, the sending unit for the valve, and the operating air pressure to the valve. If valve operation and air pressure are okay, repair or replace the fan clutch. If the valve doesn't work or if air pressure is low, make repairs and then check fan clutch operation.
The viscous fan drive is not operating to specifications.	Check for unobstructed airflow through the radiator core to the fan clutch sensor. Check that the radiator core is getting hot in front of the fan clutch (core is not clogged in that area) so that the sensor is getting a correct reading. Replace the fan clutch if no radiator problems exist.
The engine oil level is incorrect.	Fill to the high (H) mark on the dipstick.
There is too much antifreeze or coolant additive in the system.	Clean and flush the cooling system. Refill the system with the correct mixture of antifreeze and water, and install the correct additive and filter, or treatment filter.

Troubleshooting

Possible Cause	Remedy
One or both of the thermostats is incorrect or inoperative.	Make sure the correct thermostat is installed. Test the thermostat according to the engine manufacturer's instructions. Replace it if it does not operate correctly.
The water pump is not working correctly.	Repair or replace the water pump.
The radiator core is internally plugged or damaged.	To check for blockages, warm the engine to normal operating temperature. Turn off the engine, and run your hand over the finned surface of the radiator. If there is a blockage in the radiator, it should cause an obvious temperature difference from one area of the core to another. An obvious difference between inlet and outlet temperature is normal. If blockage is suspected, clean and flush the cooling system. Repair or replace a damaged core.
Air or combustion gases are entering the cooling system.	Check the cylinder head(s), head gasket(s), cylinder liners, aftercooler, air compressor cylinder head, and fan/shutter air control valve (if applicable) for leaks. Repair or replace parts, as necessary.
The aftercooler filter screen is plugged (Cummins Big Cam IV only).	Clean or replace the screen in the thermostat housing cover.
The water manifold sealing rings are worn or there are rings missing (Cummins Big Cam IV only).	Remove the sealing rings and check the ring counterbores in the cylinder heads. Repair the counterbores if necessary, and install new sealing rings.
The aftercooler is plugged or damaged.	Repair or replace the aftercooler.
The oil cooler is plugged or damaged.	Repair or replace the oil cooler.
The engine is receiving too much fuel.	Refer to the engine manufacturer's fuel delivery system adjustment procedures
The wrong fan (replacement unit) is installed.	Install the correct fan.
The wrong radiator (replacement unit) is installed.	Install the correct radiator.
There is exhaust blockage.	Repair the exhaust system.
There is frozen coolant in the radiator.	Use the proper antifreeze-to-water ratio needed for winter temperatures.

Problem—Coolant Temperature Below Normal

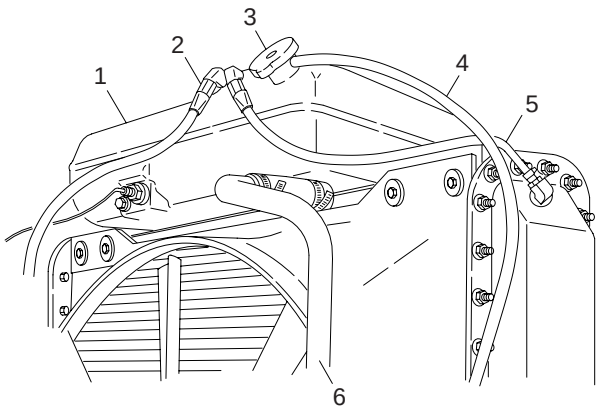
Possible Cause	Remedy
The temperature gauge is not working.	Check the gauge circuit wires, circuit breaker, and sending unit. If the gauge circuit is okay, replace the temperature gauge. If the gauge circuit is broken, repair it and then check temperature gauge operation.
The on-off fan clutch operates continuously.	Check the solenoid valve in the fan clutch air supply line, the sending unit for the valve, and the operating air pressure to the valve. If valve operation and air pressure are okay, repair or replace the fan clutch. If the valve doesn't work or if air pressure is low, make repairs and then check fan clutch operation.
The viscous fan drive operates continuously.	Replace the fan drive.

Possible Cause	Remedy
One or both thermostats are incorrect or inoperative.	Make sure the correct thermostat is installed. Test the thermostat according to the engine manufacturer's instructions. Replace it if it does not operate correctly.
The thermostat seal is damaged or missing (Cummins Big Cam III engines, California only).	Replace the thermostat seal.
The thermostat seats are damaged or missing (Cummins Big Cam IV only)	Replace the thermostat seats.
The radiator check valve leaks (Cummins Big Cam IV and L10 only).	Replace the check valve.

General Description and Principles of Operation

The main function of a cooling system is to keep the engine at its optimum operating temperature. This results in the most efficient use of fuel and allows the engine oil to provide a good lubricating film.

The central component of the cooling system, the radiator assembly, includes the surge tank, the radiator, and the radiator cap. **See Fig. 1** .



1. Surge Tank
2. Engine Vent Line
3. Radiator Cap
4. Overflow Tube
5. Radiator Vent Line
6. Fill Line (Cummins) or Shunt Line (Caterpillar)

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Fig. 1

After the engine is started and warmed up, the engine thermostat opens to allow the water pump to draw coolant from the radiator. The water pump circulates the coolant through water jackets in the engine block and cylinder head, where heat is absorbed from the cylinder walls, combustion chambers, and valve assemblies. The heated coolant then flows through the tubes of the radiator core, which dissipates the heat to the air drawn in by the engine fan. By the time coolant travels through the radiator core to the outlet tube, much of the heat has been transferred to the air; coolant then is pumped back through the engine to absorb more heat.

The surge tank (Ref. 1) provides reserve coolant capacity, expansion space for heated coolant, and deaeration space. The radiator cap (Ref. 3) keeps a pressure of 10 psi (69 kPa) in the system, which raises the boiling point of the coolant. If the cooling system overheats, and the pressure exceeds 10 psi (69 kPa), excess coolant is expelled through the radiator overflow tube (Ref. 4).

There are two types of radiators used in COE and 120 Conventional trucks: high-flow (traditional), and low-flow.

High-flow and low-flow radiators are either single-pass vertical-flow radiators (with top and bottom tanks), or single-pass cross-flow radiators (with end-tanks). **See Fig. 2** and **Fig. 3**.

On 120 Conventionals, cross-flow radiators with end-tanks are used.

On COEs, vertical-flow radiators with top and bottom tanks are used.

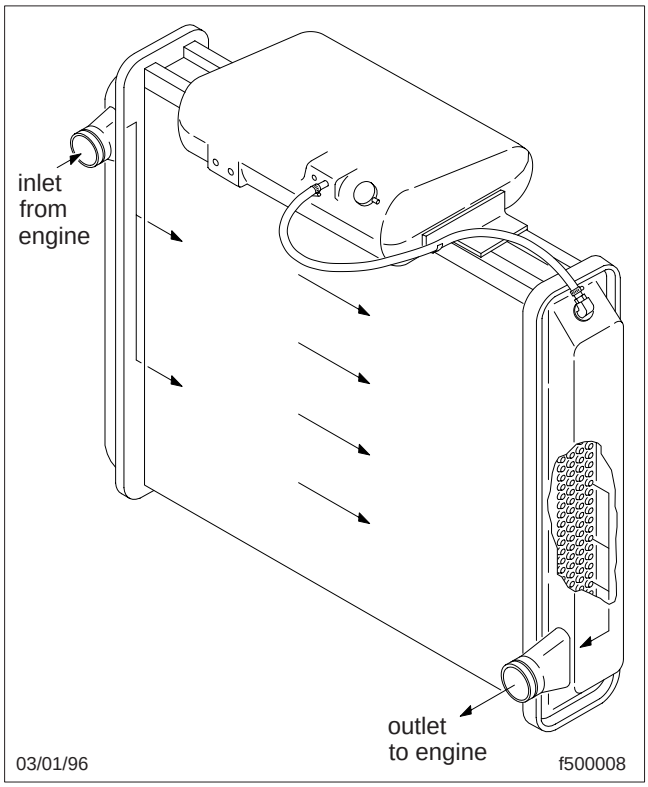

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Fig. 2, High-Flow Radiator, Cross-Flow

On cross-flow radiators, coolant flows from the inlet at the top of the left end-tank, across the core to the right end-tank, and out the radiator at the bottom of the right end-tank. On vertical-flow radiators, coolant flows from the inlet on the top tank, down through the core, and out the radiator at the bottom tank.

General Description and Principles of Operation

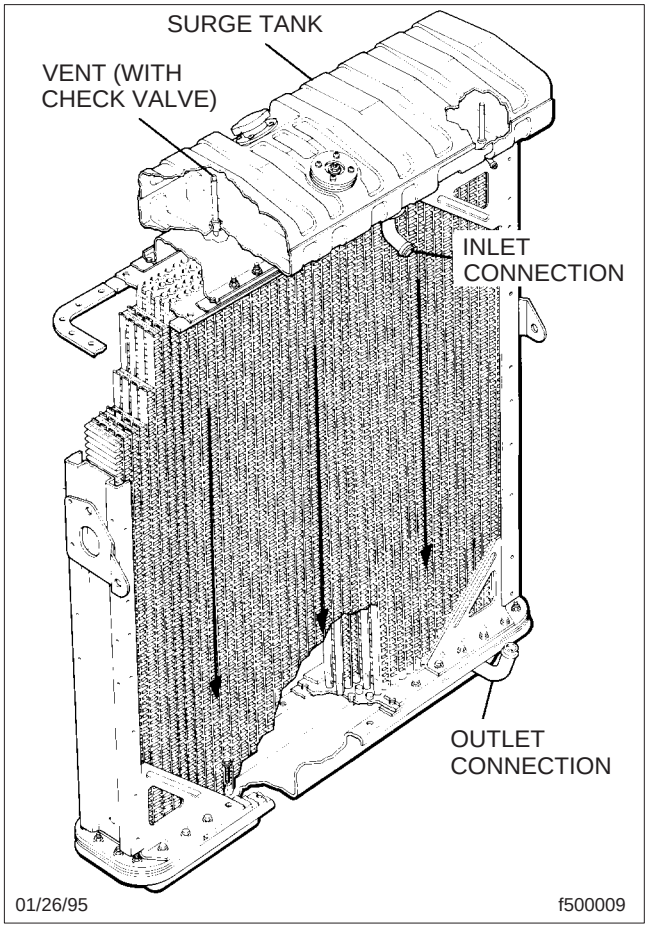


Fig. 3, Low-Flow Radiator, Vertical-Flow

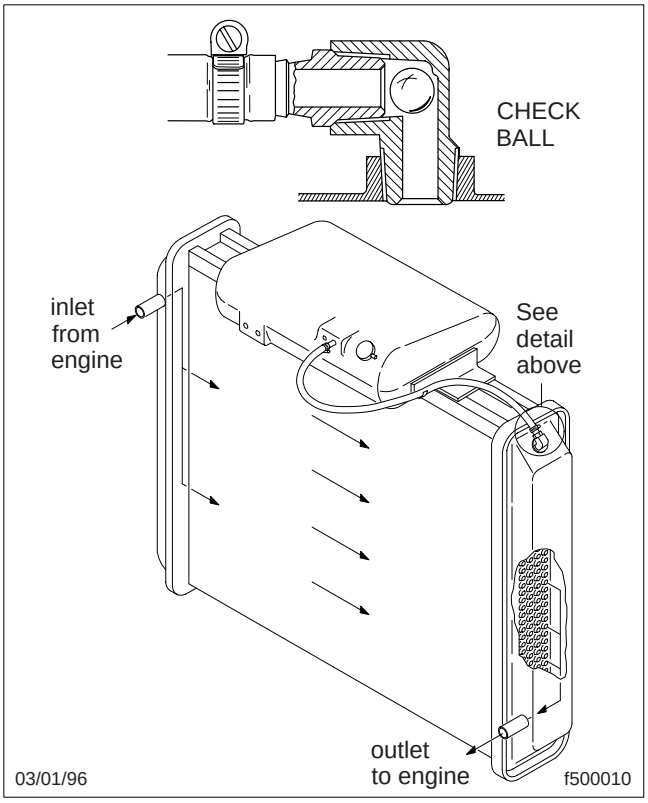


Fig. 4, Low-Flo Radiator, Cross-Flow

On low-flow radiators, either the top tank or the right end-tank (**Fig. 4**) has a check ball to limit coolant flow through the vent line. Low-flow radiator cores have turbulated tubes, which have internal baffles that constantly mix the coolant, providing more heat transfer than standard tubes.

Coolant flowing from a low-flow radiator has been pumped more slowly and is cooler than that from a high-flow radiator. This cooler coolant is routed directly to the aftercooler, where it lowers the charge-air temperature more than would a high-flow system.

Removal

1. Apply the parking brakes and chock the tires.

IMPORTANT: COE models require tilting the cab for access to the engine cooling system. Tilting the cab must be done correctly. See **Group 60** for the proper cab tilting procedure and precautions.

2. On 120 Conventionals, tilt the hood halfway and support it. Disconnect the hood cables from the radiator brace-rod brackets. Tilt the hood all the way, and support it.

   On COEs, remove the radiator grille from the front of the cab. Tilt the cab to the full-open position.

⚠ WARNING

Do not drain the coolant while the engine is hot. To avoid personal injury from scalding coolant, wait until the engine has cooled before draining the coolant.

3. Drain the coolant from the radiator. See **Fig. 1**, for typical COE radiator configuration, or **Fig. 2** for typical conventional radiator configuration.

   3.1 With the engine cool, loosen the radiator cap to release any pressure in the radiator, then tighten the cap.

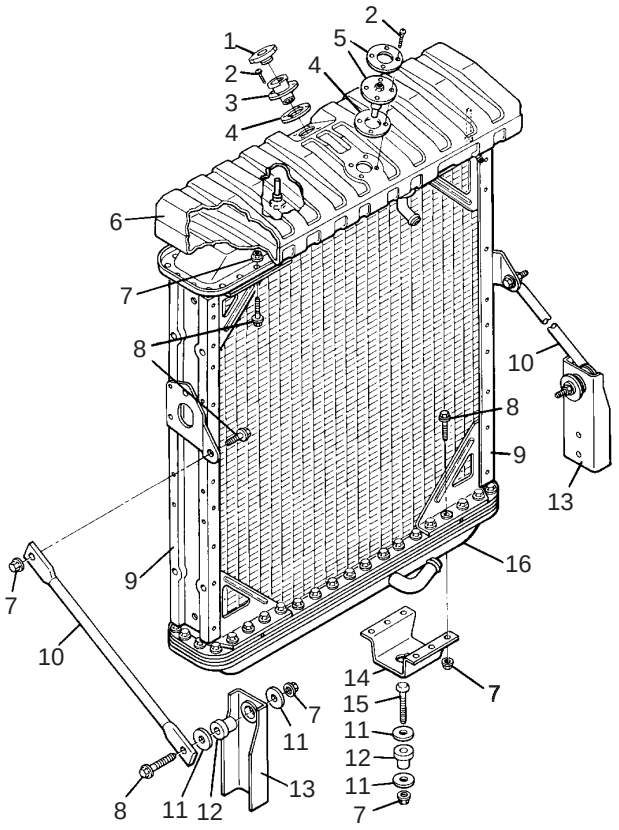
   3.2 On radiators with a bottom tank, place a clean drain pan under the bottom tank.

   On radiators with end-tanks, place a clean drain pan under the drain located on the bottom of the left end-tank.

   Remove the drain plug, or open the drain valve. If necessary, use a deflector to channel coolant away from the aerodynamic cover into the pan.

   NOTE: On some Caterpillar and Detroit Diesel engines, the radiator drain plug is located on the forward end of the coolant outlet pipe. See **Fig. 3**. On these vehicles, remove the aerodynamic cover to access the drain plug.

   3.3 Remove the radiator cap and allow the radiator to drain completely. Loosen the inlet and outlet hose clamps; disconnect the hoses and allow them to drain. Seal the hoses to prevent entry of dirt.



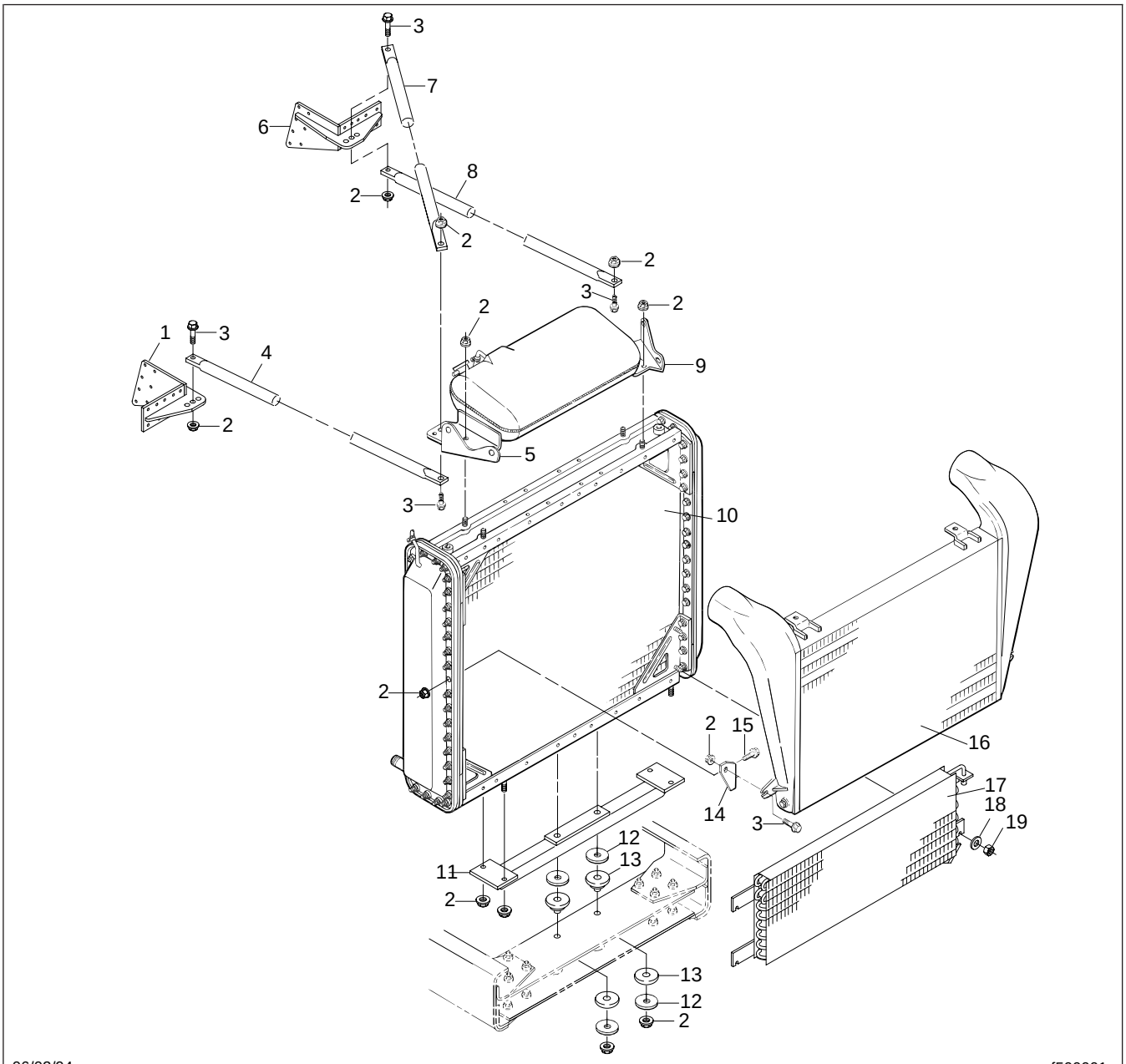
1. Radiator Cap
2. Panhead Screw With Lockwasher
3. Filler Neck
4. Filler Gasket
5. Low-Coolant Probe
6. Top Tank and Surge Tank
7. Nut
8. Bolt
9. Side Channel
10. Stay Rod
11. Washer
12. Isolator
13. Stay Rod Bracket
14. Lower Support
15. Square-Neck Bolt
16. Bottom Tank

Fig. 1, Radiator Installation, COE Mounting Shown

4. Loosen the coolant hose clamps and fittings from the radiator and surge tank. Disconnect the hoses; seal them to prevent entry of dirt.

IMPORTANT: Don't disconnect the refrigerant lines from the A/C condenser.

Removal and Installation



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1. Rear Right-Side Brace-Rod Bracket
2. Flanged Hexnut
3. Flanged Capscrew
4. Right-Side Brace Rod
5. Right-Side Brace-Rod Bracket
6. Rear Left-Side Brace-Rod Bracket
7. Diagonal Brace Rod
8. Left-Side Brace Rod
9. Left-Side Brace-Rod Bracket
10. Radiator
11. Radiator Mount Assembly
12. Center Support Bracket Washer
13. Radiator Support Isolator
14. Lower Aftercooler Mount Bracket (if equipped)
15. Serrated-Flange Bolt
16. Charge Air Cooler
17. A/C Condenser
18. Bearing Washer
19. Locknut

Fig. 2, Radiator Installation, 120 Conventional Mounting Shown

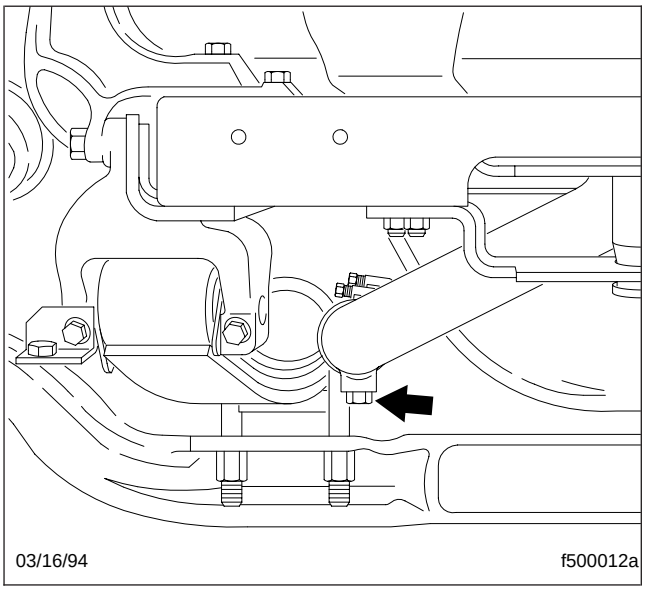


Fig. 3, Radiator Drain Plug

5. Remove the fasteners holding the A/C condenser (if equipped) to the radiator. Move the condenser out of the way, and support it so that it is not damaged during radiator removal.
6. Remove the air intake ducting, if equipped. For instructions, see **Group 09**.
7. Remove the charge air cooler, if equipped. For instructions, see **Group 09**.
8. Disconnect the wire from the low-coolant probe in the surge tank, if equipped. Remove the self-tapping screws that attach the electric horn bracket to the left side channel. See **Fig. 4**. Remove any clamps that attach electrical wiring to the radiator side channels or end-tanks.

   On radiators with end-tanks, disconnect the ground wire from the left end-tank. See **Fig. 5**.
9. On radiators with end-tanks, disconnect the three radiator brace rods from the brackets on top of the radiator assembly.

   Attach a lift strap to both ends of the top radiator side channel. Connect the strap to an overhead hoist. Remove any slack in the strap, so that the radiator assembly is supported when the other mounting fasteners are removed.

   Remove the hexnuts and washers from each lower support isolator.

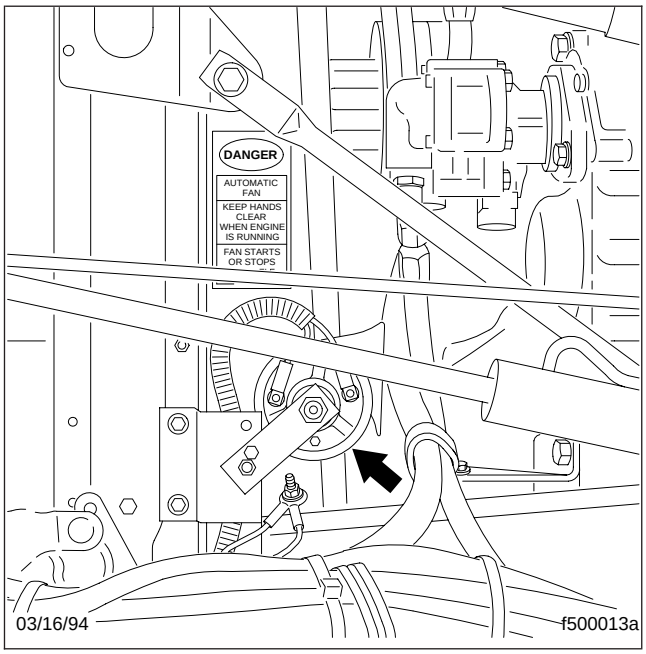


Fig. 4, Electric Horn and Bracket

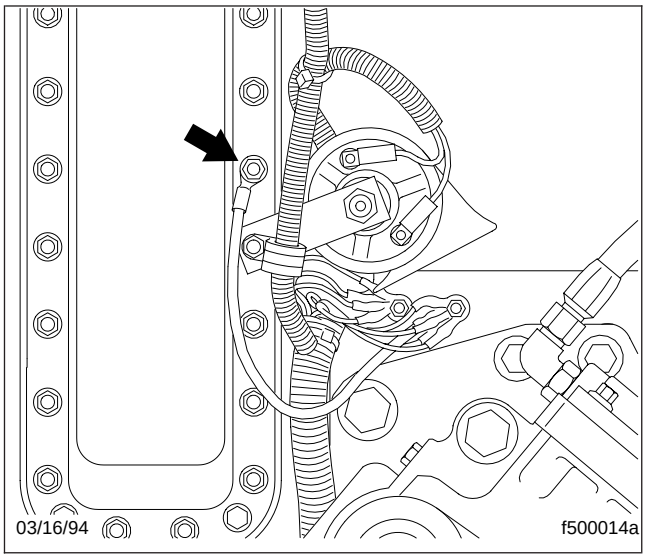


Fig. 5, Disconnect Ground Wire

10. On radiators with top and bottom tanks, remove the hexnut and washer from the square-neck bolt in each lower support isolator.

    On FLD 120 Conventionals with 1350-square-inch radiators, remove the nuts from the radiator mounting bolts at the bottom of the module support bracket, under the charge air cooler.

Removal and Installation

Remove the flanged bolts and nuts from the stay rods at the radiator side channels. See **Fig. 6**.

With one person holding each side of the radiator, tilt the top forward until the fan shroud clears the fan; move the fan shroud up or down as necessary. Lift one side of the radiator, then push the radiator toward the opposite side until the head of the square-neck bolt is dislodged from the keyway in the lower support on the opposite side. With the radiator still tilted forward at the top, lower the raised side, and push the radiator back to the other side until the other square-neck bolt clears its keyway.

Using the overhead hoist, lift the radiator from the chassis. Lower, then remove the strap from the radiator.

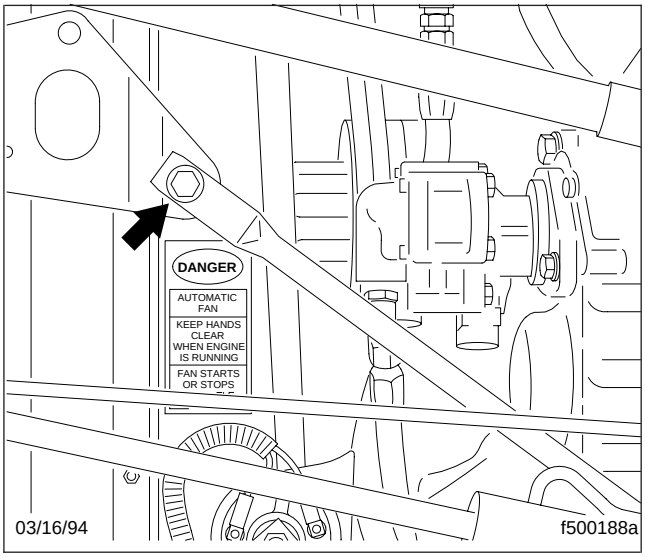


Fig. 6, Remove Stay Rod Fasteners

Installation

NOTE: If replacing the radiator, use the steps in "Disassembly and Assembly" that cover removal and installation of the radiator cap, overflow tube, low-coolant probe and ground wire, charge air cooler mount brackets, and fan shroud (as equipped). These parts are not included with replacement radiators.

1. On radiators with end-tanks, attach a lift strap to both ends of the top radiator side channel, and connect the strap to an overhead hoist. Using the hoist, lift the radiator, and move it onto the radiator mount assembly.

   Fasten the bottom of the radiator to the mount assembly. Tighten the flanged hexnuts 190 lbf·ft (260 N·m).

2. On radiators with top and bottom tanks, attach a lift strap to both radiator side channels, and connect the strap to an overhead hoist. Using the hoist, lift the radiator, and move it over the radiator mount assembly.

   Position the square-neck bolts in the square portion of the keyway in each lower support. See **Fig. 7**.

   With one person at each side of the radiator, align the square-neck bolts with the washers and isolators, then swing the bottom of the radiator into place on the chassis.

   Tilt the radiator upright, and install, but do not tighten, the flanged bolts and nuts in the stay rods and stay rod attachment ears.

   Place a thick washer, then a flanged nut, on each square-neck bolt. Tighten the flanged nuts on the square-neck bolts 55 lbf·ft (75 N·m); then tighten the stay rod bolts 80 lbf·ft (110 N·m).

3. Remove the lift strap. Secure the top of the radiator.

   3.1 Place the surge tank on the radiator (if previously removed).

   3.2 Install the charge air cooler (if equipped). For instructions, see **Group 09**.

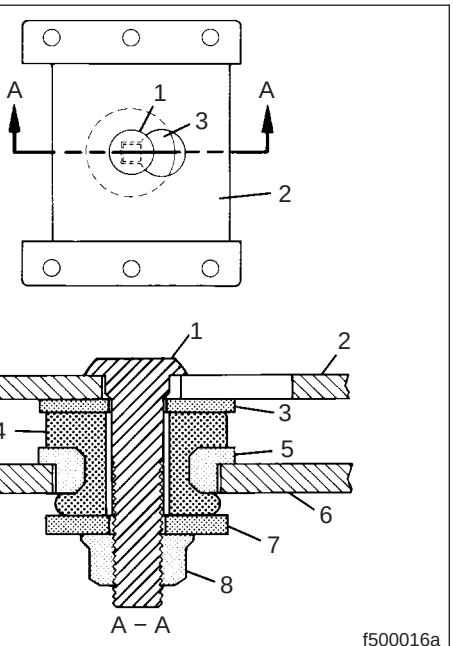
4. On radiators with end-tanks, install the radiator brace rods; tighten the fasteners 70 lbf·ft (95 N·m).

   Connect the low-coolant wiring harness (if equipped) to the connector under the right end-tank.

5. On radiators with top and bottom tanks, remove the filler cover plate, and install the low-coolant probe. Tighten the panhead screws 120 lbf·in (1360 N·cm).

6. Move the A/C condenser into place and fasten it to the radiator. Tighten the locknuts 15 lbf·ft (20 N·m).

7. Adjust the position of the fan shroud.



1. Square-Neck Bolt
2. Lower Support
3. Thin Snubbing Washer
4. Rubber Isolator
5. Socket
6. Front Crossmember
7. Thick Snubbing Washer
8. Flanged Locknut

Fig. 7, Square-Neck Bolt Positioning

7.1 Adjust the shroud so there is about 1 inch (25 mm) clearance between the right side of the fan blade and the fan shroud, and about 3/4 inch (19 mm) clearance on the left side. This allows for engine-torque movement.

7.2 Adjust the shroud so the vertical clearance between the top of the fan blade and the fan shroud opening is within 1/8 inch (3 mm) of the clearance between the bottom of the blade and the shroud opening.

7.3 Tighten the self-tapping screws 15 lbf·ft (20 N·m).

CAUTION

Do not use any lubricants or sealants to coat the ends of the hoses. They could soften the rubber and damage the hoses.

8. Remove the seals from the coolant hose ends, and connect the hoses. Your hose clamps might be T-bolt clamps, (see **Fig. 8**) Breeze Constant-Torque clamps, (see **Fig. 9**) or ABA radial worm-drive hose clamps, (see **Fig. 10**).

T-bolt type hose clamps are now standard on hoses with an inside diameter greater than 2 inches (51mm). When working with T-bolt type hose clamps, tighten the clamps 55 lbf·in (620 N·cm).

Breeze Constant-Torque hose clamps must be tightened so that the screw tip of the clamp extends about 1/4 inch (6 mm) from the clamp housing, and the Belleville washer stacks must be collapsed almost flat. Use a torque wrench to install these hose clamps correctly. The correct installation torque for Breeze Constant-Torque hose clamps is as follows:

For Breeze Constant-Torque hose clamps with a 5/16-inch tightening screw hex: 55 lbf·in (620 N·cm).

For Breeze Constant-Torque hose clamps with a 3/8-inch tightening screw hex: 90 lbf·in (1020 N·cm).

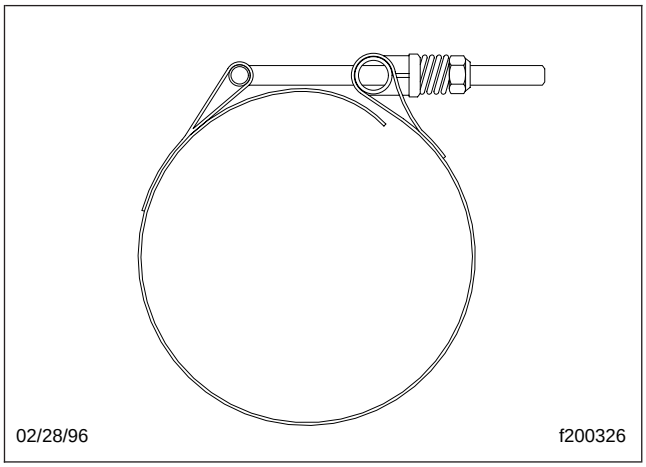
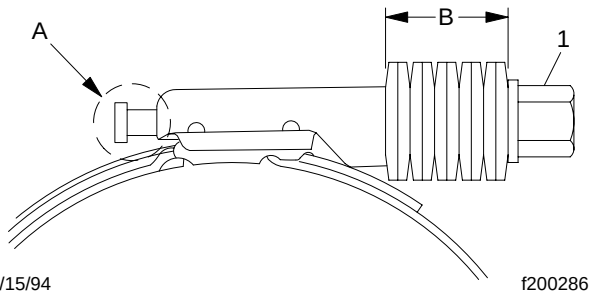


Fig. 8, T-Bolt Type Hose Clamp

NOTE: All hose clamp adjusters lose torque after installation, due to cold-flow of the hose material from under the clamp. Breeze Constant Torque clamps typically show a 30 percent loss of torque shortly after installation; a 50 percent loss after heat-cycling, and up to 80 percent loss after time and repeated heat cycles. However, when correctly installed, Breeze Constant-Torque clamps adjust automatically, holding

Removal and Installation



A. The screw tip must extend about 1/4 inch (6 mm).
B. The Belleville washer stacks must be collapsed until the washers are almost flat.
1. Tightening Screw Hex

Fig. 9, Breeze Constant-Torque Hose Clamp Installation

enough torque to keep consistent sealing pressure. During vehicle operation and shutdown, the screw tip may adjust in and out, according to temperature and pressure changes. The torque may need to be adjusted for individual applications.

ABA Radial worm-drive hose clamps may lose 30 percent of their torque at the screw adjuster, shortly after being correctly tightened. This is due to cold-flow of the hose material, not an actual loosening of the clamp. This is the way they are designed to work, they should not be tightened further. To check the torque of an ABA clamp, it must be loosened completely, then torqued to the proper value listed in **Table 1**. Over-tightening an ABA Radial worm-drive hose clamp can result in coolant leaks.

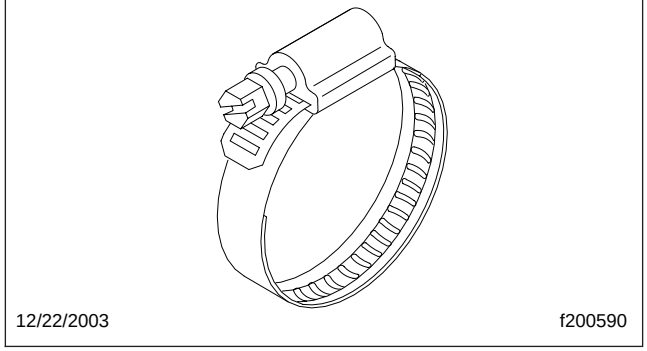


Fig. 10, ABA Radial Worm-Drive Hose Clamp (typical)

9. Insert the overflow tube in the clamps which hold it to the radiator, then tighten the fasteners 120 lbf·in (1360 N·cm).
10. Install the air intake ducting, if equipped. For instructions, see **Group 09**.
11. Close the drain valve, or install the drain plug. Tighten the drain plug (if equipped) 1-1/2 turns beyond finger-tight.

Hose Clamp Torque Values		
Clamp Type	**Size**	**Torque: lbf·in (N·cm)**
T-Bolt	All	55 (620)
Breeze Constant-Torque	5/16-inch tightening screw hex	90 (1020)
	3/8-inch tightening screw hex	90 (1020)
ABA	1.26-inch Diameter	31 (360)
	1.50-inch Diameter	35 (400)
	1.73-inch Diameter	35 (400)
	1.97-inch Diameter	35 (400)
	2.28-inch Diameter	35 (400)
	2.68-inch Diameter	40 (460)
	3.03-inch Diameter	40 (460)

Table 1, Hose Clamp Torque Values

12. Install the charge air cooler connecting hoses, if equipped. See **Fig. 11**.

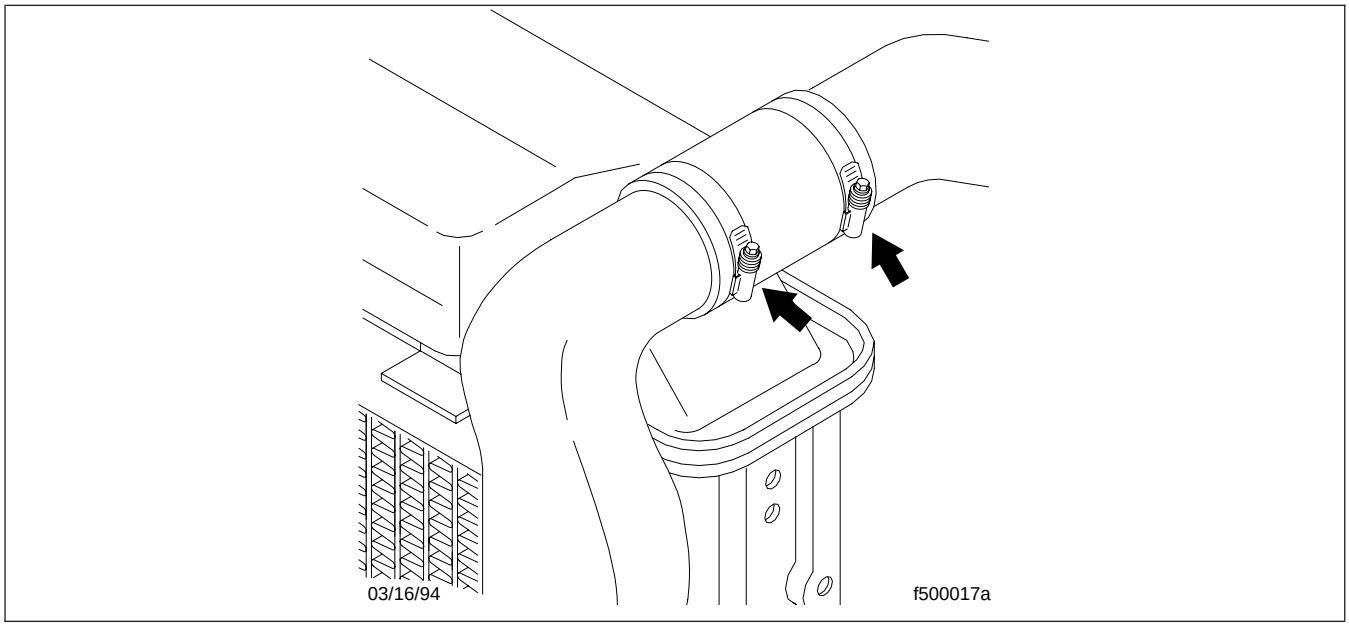


Fig. 11, Charge Air Cooler Hose Connection, COE Installation Shown

CAUTION

Coolant must be filled to the bottom of the radiator filler neck. Low coolant could cause engine overheating, which could damage the engine.

13. Fill the radiator with coolant to the bottom of the radiator filler neck. For coolant specifications, see the vehicle maintenance manual, and the engine manufacturer's maintenance and operation manual. Do not install the radiator cap yet.
14. Start the engine, and check for coolant leaks in the hoses, hose connections, and radiator core. Run the engine at fast idle for at least 3 minutes, then stop the engine. Check the coolant level in the radiator, and add coolant as needed.
15. Install the radiator cap.
16. On COEs, return the cab to the operating position. See **Group 60**. Install the radiator grille, and tighten the nuts 70 lbf·in (780 N·cm).

    On FLD 120 Conventionals, support the hood in the half-tilt position and attach the hood cables to the forwardmost holes in the brackets at the top of the radiator.

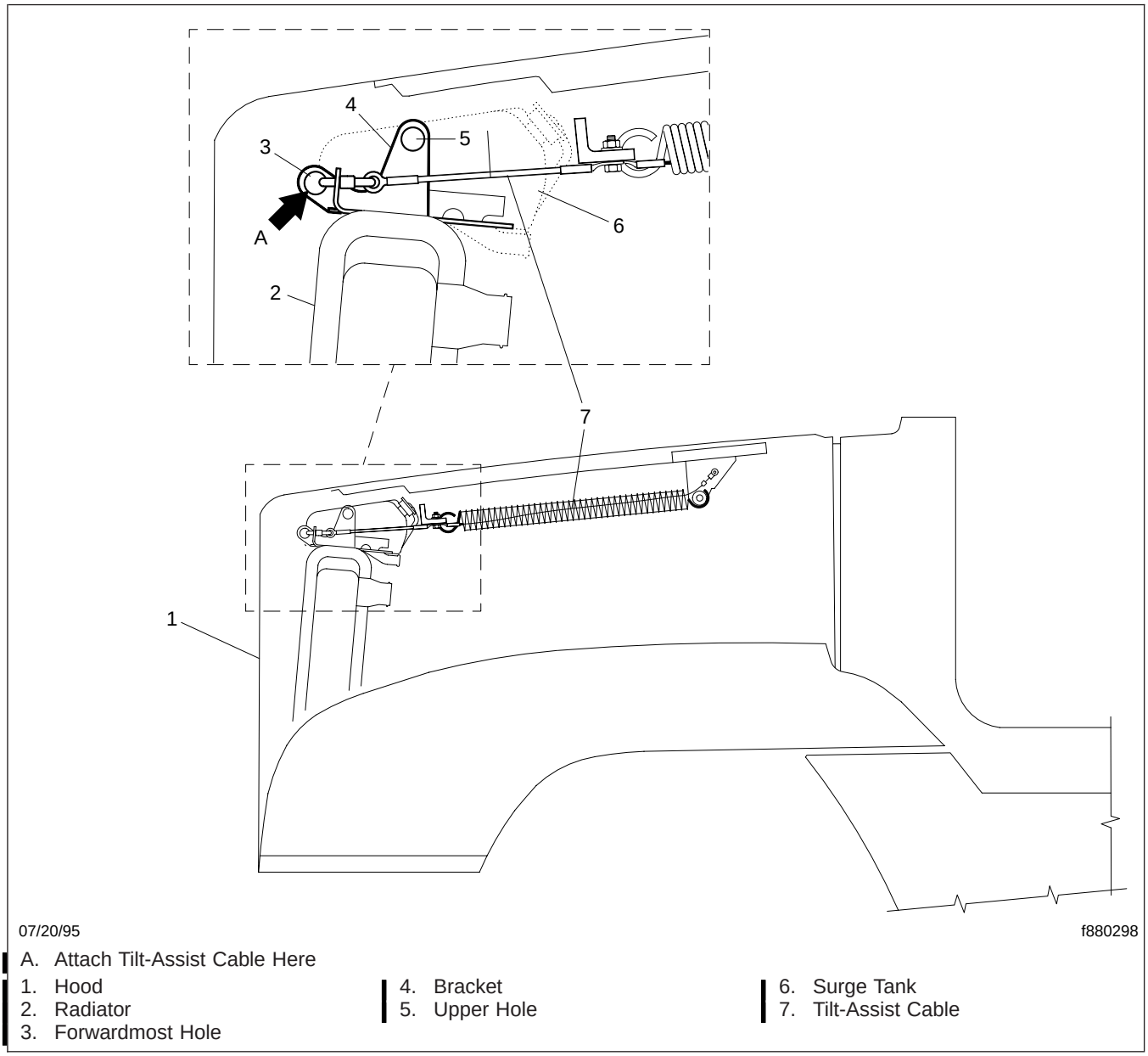
WARNING

Attach the hood tilt-assist cables to the brackets at the forwardmost holes. Attaching at any other hole could cause the tilted hood to be less stable, possibly resulting in personal injury or property damage.

NOTE: The upper holes are used for the tilt-assist attachment on FLC 112 Conventionals, but are not to be used on FLD 120 Conventionals. See **Fig. 12**.

17. Remove the chocks from the tires.

Removal and Installation



A. Attach Tilt-Assist Cable Here

1. Hood
2. Radiator
3. Forwardmost Hole
4. Bracket
5. Upper Hole
6. Surge Tank
7. Tilt-Assist Cable

Fig. 12, Hood Tilt-Assist Cable and Bracket (with detail)

Disassembly

Before disassembling the radiator, pressure-flush it and check the radiator cap, following the instructions in the radiator section of the vehicle maintenance manual. Clean and check the exterior of the radiator, following the instructions in the vehicle driver's manual.

RADIATORS WITH TOP AND BOTTOM TANKS (See Fig. 1)

1. Remove the radiator from the vehicle; **see Subject 100**.
2. Remove the fan shroud from the radiator.
3. Set the radiator upright on its lower supports, and brace it in this position.
4. Remove and save the radiator cap, panhead screws and internal-toothed lockwashers, filler neck and overflow tube, and low-coolant probe. Remove and discard the gaskets.
5. Remove the bolts and nuts that attach the top tank to the upper header. Remove each header bar and horseshoe bolting plate as soon as each part is no longer held in place by the bolts.

   Lift off the top tank. Remove and discard the upper header gasket.
6. Lay the radiator front-face down on a table or workbench so the bottom tank hangs over the edge. Place blocks under the side channels, as needed to prevent the radiator from tipping, and to allow access to all bottom tank attachment bolts.
7. Remove the bolts and nuts that attach the bottom tank to the lower header. Remove each lower support, header bar, and horseshoe bolting plate, as soon as each part is no longer held in place by bolts. Lift off the bottom tank.
8. Remove the blocks that were placed under the side channels. Move the radiator so that the upper and lower headers are resting on the table or workbench. Remove the side channels.

RADIATORS WITH METAL END-TANKS (See Fig. 2)

1. Remove the radiator from the vehicle; **see Subject 100**.
2. Remove the fan shroud from the radiator.
3. Disconnect one end of the vent hose that runs between the surge tank and the right side-tank. Disconnect the low-coolant probe wire and ground wire (if equipped).
4. Remove the nuts that attach the brace-rod brackets and surge tank (if still attached) to the top side channel; remove the brackets, spacers, and surge tank.
5. Lay the radiator front-face down on a workbench, with the right end-tank hanging over the edge. Place blocks under the side channels as needed to keep the radiator from tipping, and to get to all of the end-tank attachment bolts.
6. Mark the locations of the aftercooler mounting brackets (if used), and the clamps of the low-coolant probe harness and overflow tube. Remove all of the bolts and nuts holding the end-tank to the side header. Remove each header bar and horseshoe plate, as soon as each part is no longer held in place by bolts. Remove the end-tank, and remove and discard the radiator gasket.

   Remove the left end-tank by repeating steps as required.
7. Remove the blocks that were placed under the side channels. Move the radiator so that the side headers are resting on the workbench. Remove the side channels.

⚠ CAUTION

CAUTION: Don't rod out low-flow radiators. Rodding out low-flow radiators will damage the dimpled tubes and cause coolant leaks.

IMPORTANT: On both types of radiators, check the tubes of the radiator core for scale deposits. If the radiator has been pressure-flushed, and the tubes are still clogged, the radiator should be rodded or boiled out with acid by an experienced radiator shop. Otherwise, replace the core.

RADIATORS WITH PLASTIC END-TANKS (See Fig. 3)

IMPORTANT: Disassembling and assembling the 1000-square-inch radiator with plastic end-tanks requires the special tools listed in **Table 1**.

Special Tools	
Description	**Qty**
Plastech II® Tanking Machine With Five 2-Inch Cylinders	1
T-Bar	1
Hooked-End Bar	1
Wave Form Bar	1

Table 1

Order these tools from:

RAD PAL
2381 17 St.
Detroit,, MI 48216

1. Remove the radiator from the vehicle; for instructions, **see Subject 100**.

CAUTION

CAUTION: Use care when handling or supporting the plastic end-tanks. Failure to do so could damage the tanks.

2. Remove the side channels from the radiator assembly.
   - 2.1 Remove the four spring clips (Ref. 9) that hold the side channel mounting pins in place. Insert a screwdriver blade in the open end of each clip, and pry the clip open until it clears the edge of the mounting pin. Then, slip the clip off the pin.
   - 2.2 Use a rubber mallet and a punch to tap out the channel mounting pins (Ref. 1).
   - 2.3 Remove the nuts and lockwashers (Refs. 11 and 10) from the top and the bottom of the radiator, and remove the radiator brace rod (Ref. 12).
   - 2.4 Slip the side channels off the radiator core and tank assembly. If necessary, spread the channels so they clear the end-tank bosses.
3. Remove the end-tanks.
   - 3.1 Place the radiator core and tank assembly in the disassembly/assembly fixture, and clamp the assembly securely in place. **See Fig. 4.**
   - 3.2 Position the tank clamping cylinders evenly across the top of the tank. Make sure the cylinders' rubber plungers will not press against breakable fittings, such as vent tube ports.

CAUTION

CAUTION: Apply only enough pressure to compress the sealing gasket. Too much pressure will crack the plastic tank.

   - 3.3 Apply pressure evenly across the top of the tank until the tank-to-core sealing gasket is compressed enough to show a small gap between the bottom of the dimple wave lock crimp and the tank sealing flange.

CAUTION

CAUTION: In some places, especially around the tank ports, the wave crimps may have to be unlocked with a screwdriver. When using a screwdriver, be careful not to crack or gouge the plastic tank.

   - 3.4 Place the T-bar into the T-bar groove in the disassembly/assembly fixture. **See Fig. 5.**
   - 3.5 Slide the hooked-end bar over the T-bar. Place the hook over the top of the wave crimp and pull the T-bar back to unlock the crimp. **See Fig. 5.**
   - 3.6 Slide the hooked-end bar and T-bar down the T-bar groove to the next wave crimp, and repeat steps as required until all the wave crimps are unlocked.
4. Once all the wave crimps are unlocked, remove the tank.

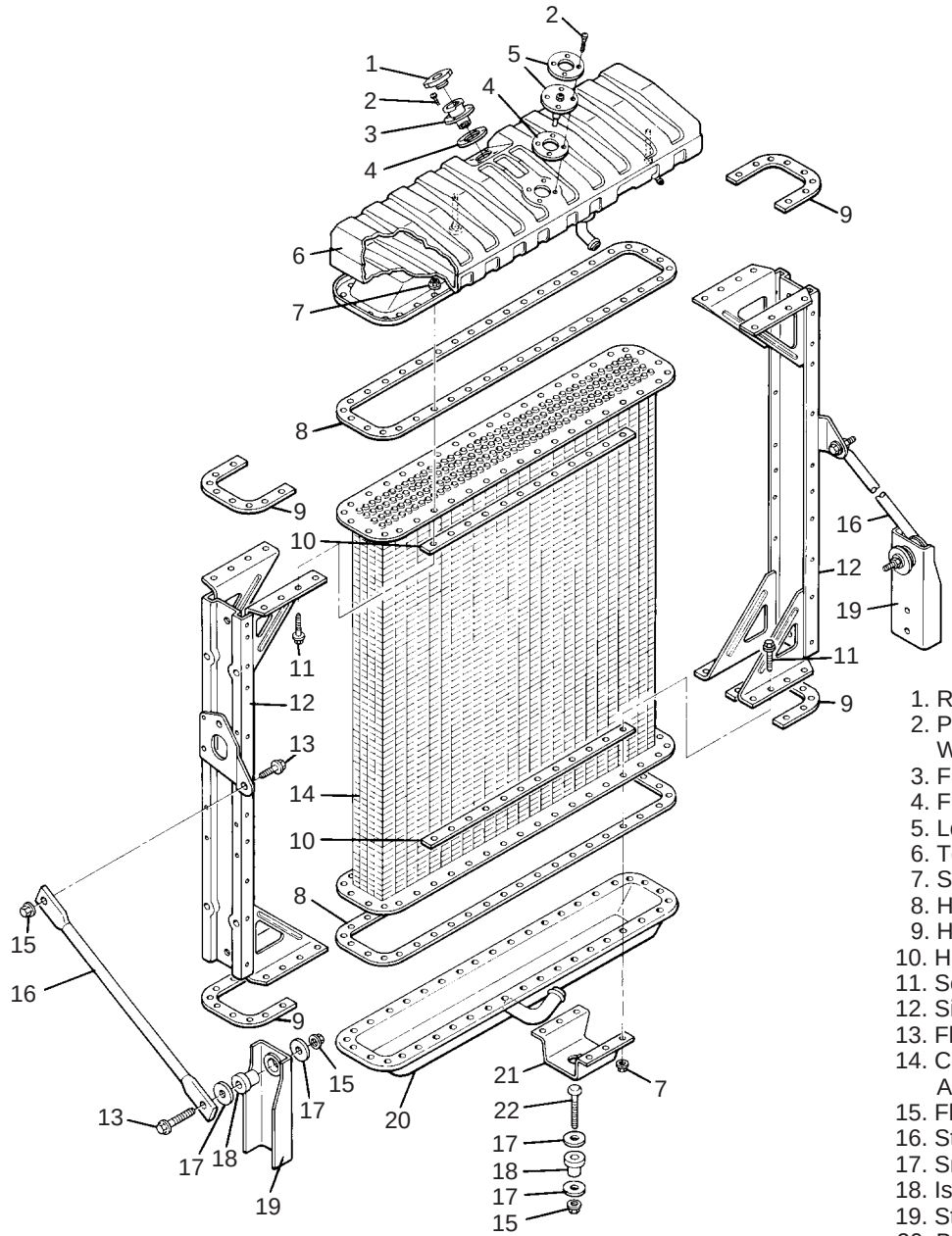


Fig. 1, Radiator Assembly, COE

Disassembly, Assembly, and Pressure-Testing

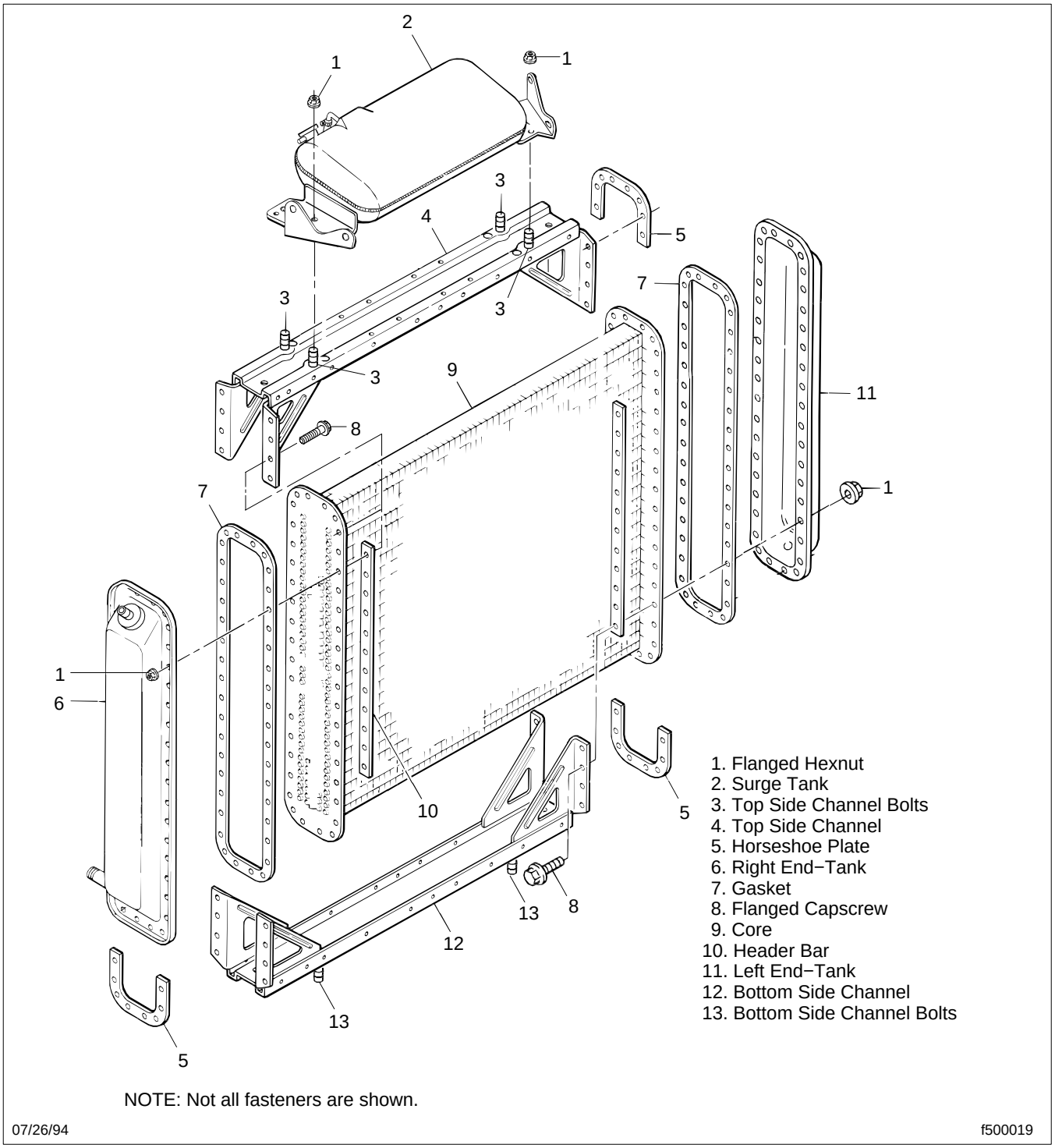


Fig. 2, Radiator Assembly With Metal End-Tanks, 120 Conventional

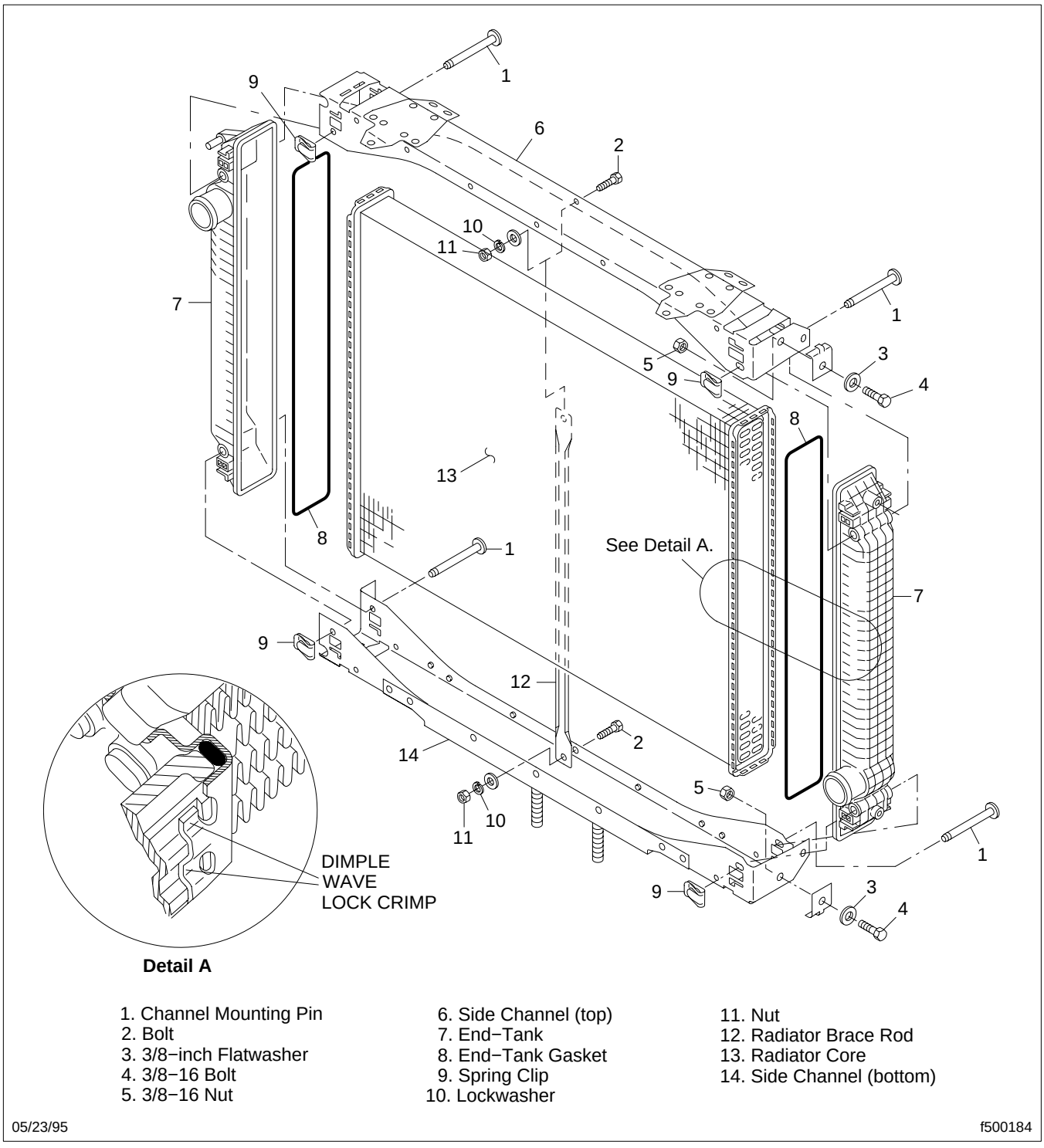


Fig. 3, Radiator With Plastic End-Tanks

Disassembly, Assembly, and Pressure-Testing

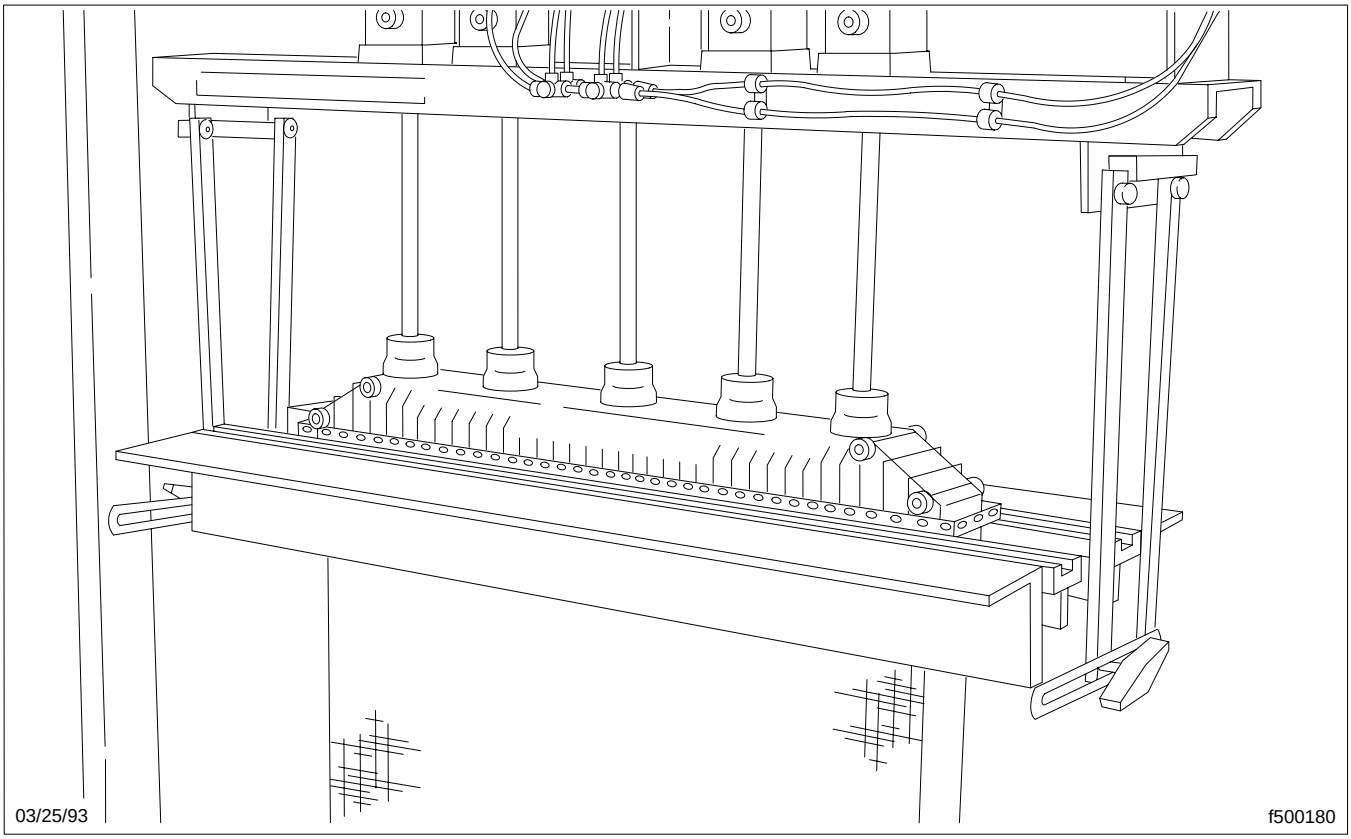


Fig. 4

4.1 Release the pressure from the tank, and move the clamping cylinders off the radiator core and tank assembly.

CAUTION

CAUTION: When removing the end-tank, do not use a screwdriver against the tank sealing flange. A screwdriver blade may damage the flange and prevent a good seal after the tank is installed.

4.2 Lift the tank from the forward side — the side opposite the tank ports. If needed, use a rubber mallet or the heel of your hand and tap the side of the tank to loosen it. Remove the plastic tank from the radiator core.

4.3 Remove the sealing gasket from the sealing surface of the radiator core header. **See Fig. 6.**

4.4 Clean the sealing surface of the radiator core header.

CAUTION

CAUTION: If a leak is in the end-tank, replace it. Welding or soldering too close to the end-tank can damage it.

4.5 Repair any leaks. If the leak is in the core, but within 7.5 cm (3 inches) of the tank, remove the tank before repairing the leak.

4.6 Repeat required steps above to remove the opposite tank.

IMPORTANT: Check the tubes of the radiator core for scale deposits. If the radiator has been pressure-flushed, and the tubes are still clogged, the radiator should be rodded or boiled out with acid by an experienced radiator shop. Otherwise, replace the core.

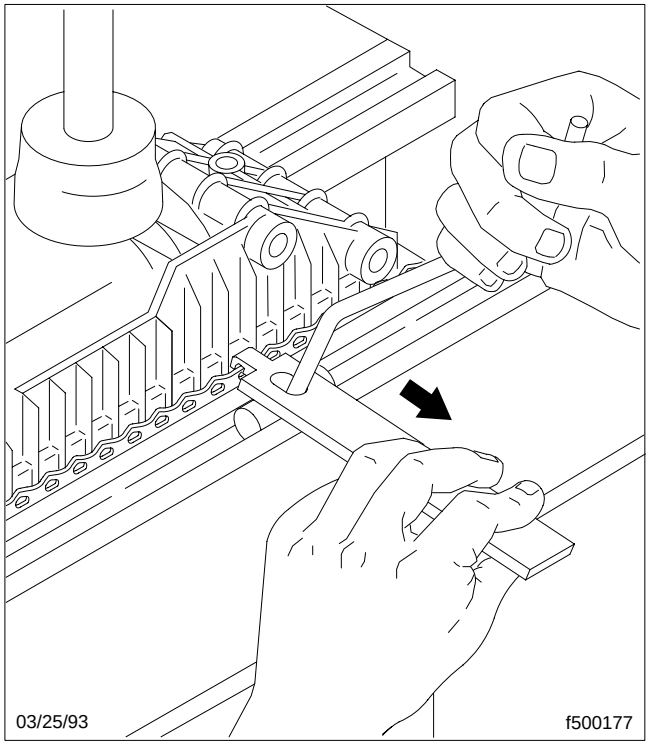


Fig. 5

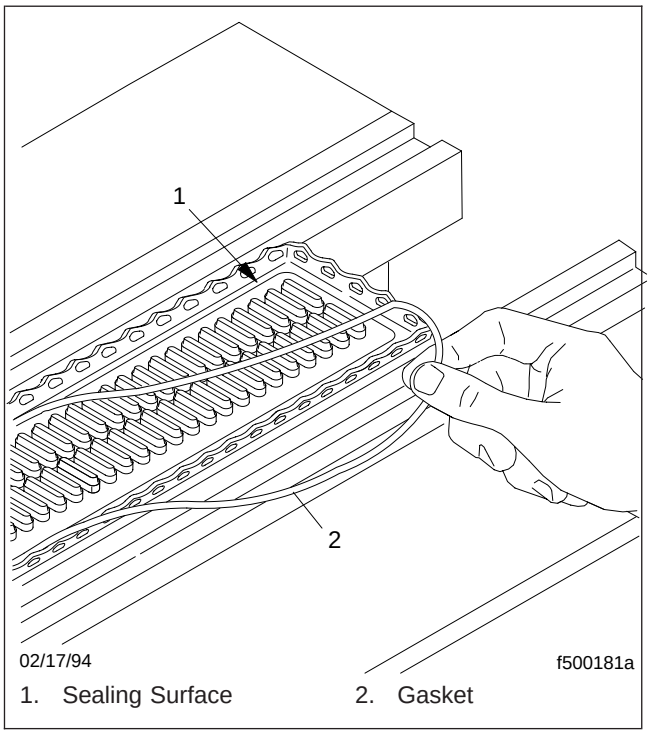


Fig. 6

Assembly

RADIATORS WITH TOP AND BOTTOM TANKS

1. With the radiator core lying front-face down on a workbench, and resting on the front edges of the upper and lower headers, spread a thin coating of grease on one surface of each of the new header gaskets; press the greased surface of each gasket against its header.
2. Position both side channels on the core, with the stay rod attachment ears pointing toward the lower end of the back of the radiator.
3. Install the bottom tank.
   - 3.1 On the back of the radiator, insert a header bar between the header and the inboard end of the side channels.
   - 3.2 Install a horseshoe bolting plate between the outboard end of each side channel and the header. With the bottom tank inlet and outlet connections at the back of the radiator, push the bottom tank into place against the header and header gasket. Hold the tank in place.
   - 3.3 From the bottom, insert 5/16 x 5/8-inch bolts in all of the holes labeled "A" **in Fig. 7**. Install the nuts, and tighten them until the bottom tank contacts the gasket.
   - 3.4 Position one of the lower supports against the bottom tank, **as shown in Fig. 7**, Ref. B. The square end of the lower support keyway must be outboard of the round hole in the keyway. From the top, install 5/16 x 1-inch bolts in all of the holes labeled "C" **in Fig. 7**. Install nuts on all of these bolts, and tighten them finger-tight.
   - 3.5 Install the other lower support (**Fig. 7**, Ref. D). **See Fig. 7**, Ref. E, for bolt locations.
   - 3.6 Set the radiator upright on the lower supports, and install one of the header bars at the front of the lower header.

Disassembly, Assembly, and Pressure-Testing

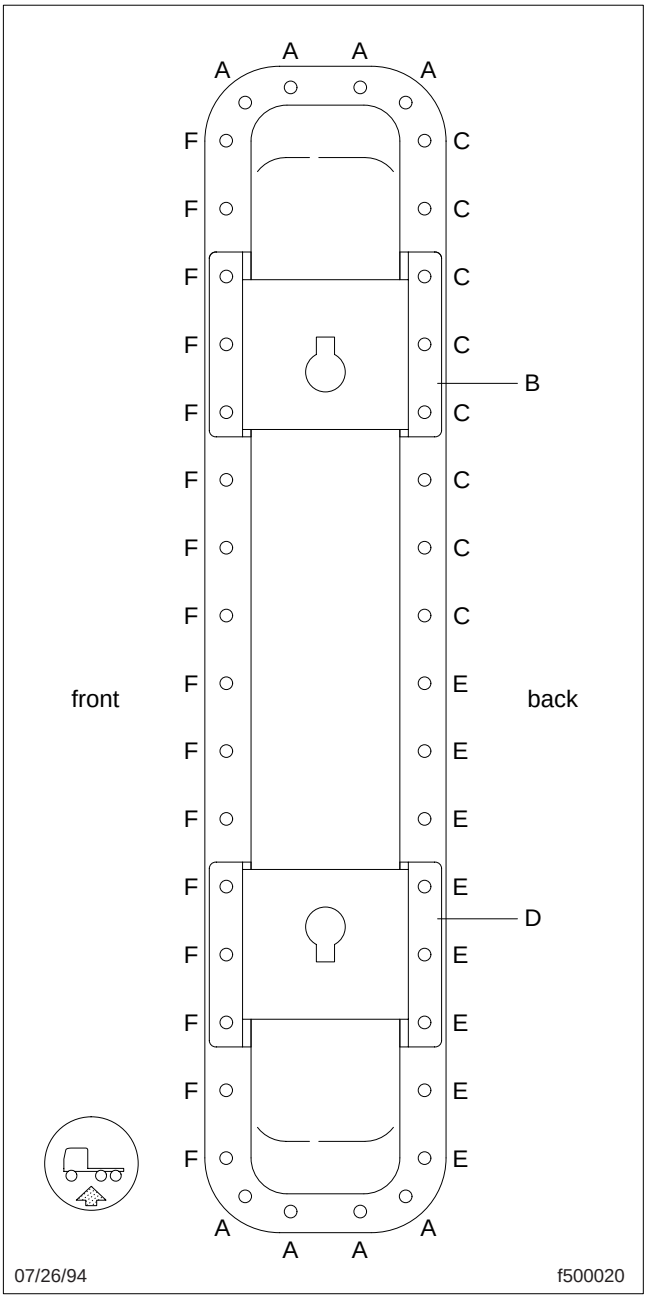


Fig. 7

From the top, install the remaining bolts and nuts, and tighten the nuts fingertight. **See Fig. 7**, Ref. F.

4. Install the top tank.

4.1 With the radiator sitting upright on its lower supports, insert the header bars between the upper header and the inboard ends of the side channels at the front and back of the radiator.

4.2 Install a horseshoe bolting plate between the outboard end of each side channel and the upper header.

4.3 Place the top tank on the upper header, with the longer overhang of the surge tank toward the back of the radiator. **See Fig. 8.**

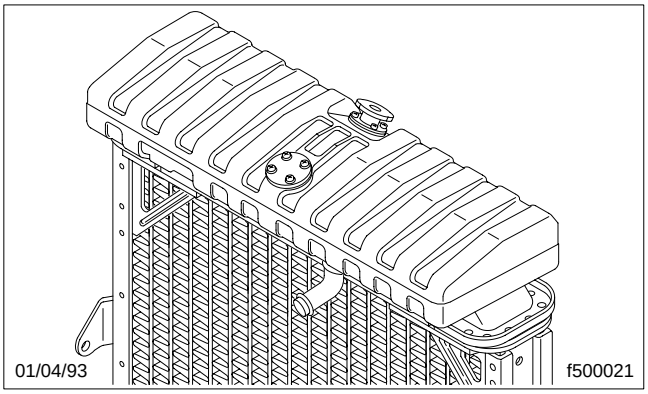


Fig. 8

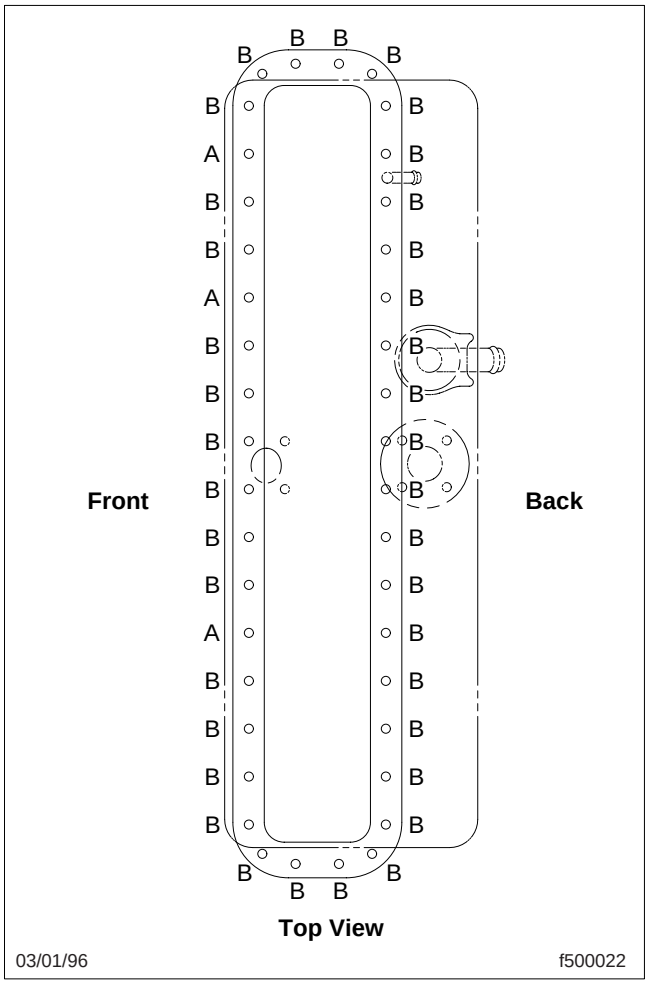
4.4 At the front of the radiator, install a nut and a 1-1/4 inch (32 mm) long bolt into each of the three locations labeled "A" **in Fig. 9**. Insert the bolts from the bottom, and tighten them finger-tight.

From the bottom, install all of the remaining bolts and nuts (**Fig. 9**, Ref. B), and tighten the nuts finger-tight.

4.5 Using the tightening sequence **in Fig. 10**, tighten all of the top and bottom tank fasteners 120 lbf·in (1360 N·cm). Again using the tightening sequence **in Fig. 10**, tighten all of the top and bottom tank fasteners 15 lbf·ft (20 N·m).

4.6 If a new top tank was installed, place new filler gaskets around both of the filler neck openings in the surge tank.

4.7 Install the filler neck in the forward opening, and install the low-coolant probe in the rear opening. Position the filler neck so that the overflow-tube vent is pointing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Disassembly, Assembly, and Pressure-Testing

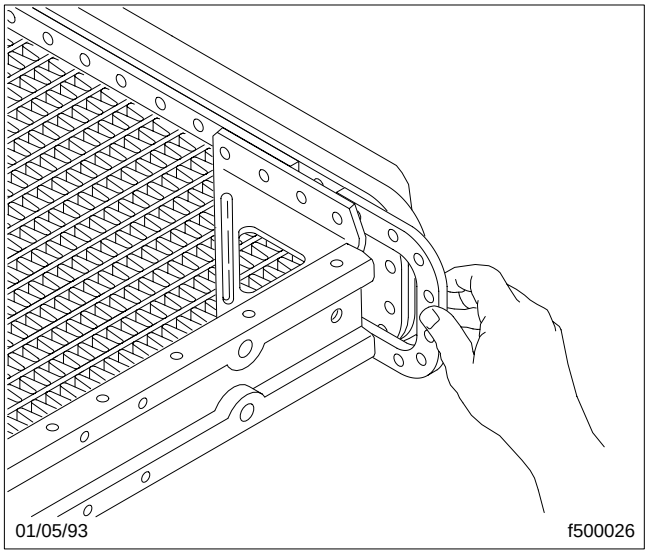


Fig. 11

in Fig. 12. Install the nuts, and tighten them until the end-tank contacts the gasket.

4.3 From the core side, install 5/16 x 3/4-inch bolts through the holes labeled "B" **in Fig. 12**.

4.4 From the core side, install 5/16 x 1-1/2 inch bolts through the holes labeled "C" **in Fig. 12**. Loosely install the nuts.

4.5 From the tank side, install 5/16 x 1-inch bolts through the holes labeled "D" **in Fig. 12**. Loosely install the nuts.

4.6 Turn over the radiator. Allow the left end-tank to overhang the edge of the workbench, so as to not damage the inlet. Install the other header bar. From the core side, install the 5/16 x 1-1/2 inch bolts through the holes labeled "C" **in Fig. 12**; loosely install the nuts. As marked earlier, loosely attach the headlight wiring harness and aftercooler mounting brackets (if used) to the radiator.

4.7 From the tank side, install the bolts labeled "D" **in Fig. 12**. Loosely install the nuts.

4.8 Following the sequence **in Fig. 12**, tighten all of the end-tank fasteners 120 lbf·in (1360 N·cm).

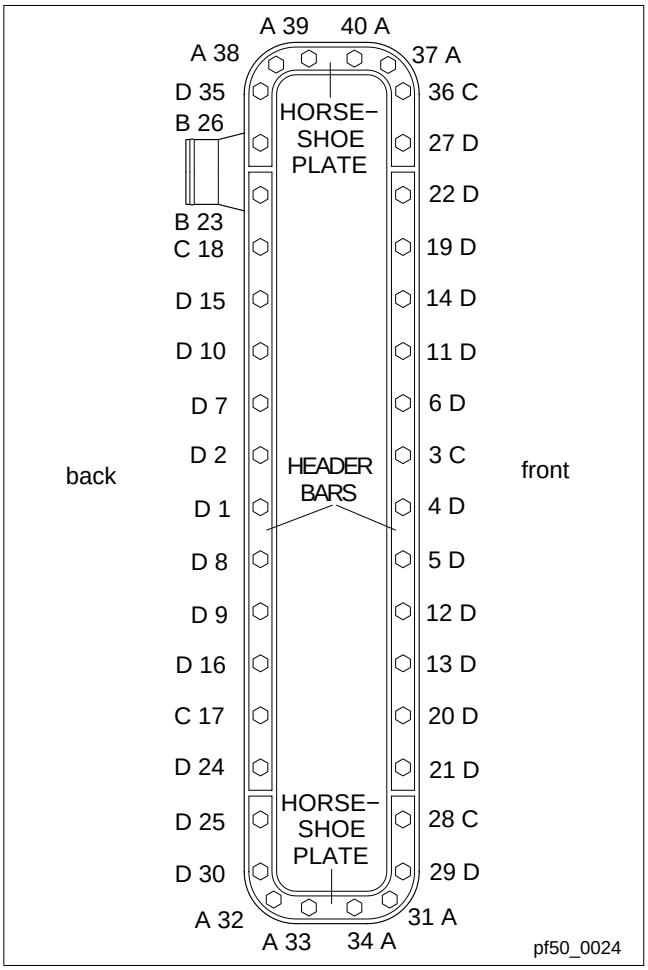


Fig. 12

Following the same sequence, tighten all of the end-tank fasteners 15 lbf·ft (20 N·m).

5. Turn the radiator core front-face down on the workbench, then attach the right end-tank.

5.1 On the back of the radiator, insert a header bar between the header and the inboard ends of the side channels. Install a horseshoe plate between the outboard end of each side channel and the header.

5.2 Position the tank against the header gasket, with the outlet facing to the rear.

5.3 While keeping the tank from moving, install 5/16 x 3/4-inch bolts from the tank side through all of the holes labeled "A"

in Fig. 13. Be sure to install the clamps for the low-coolant probe harness (if equipped) and the overflow tube, as referenced earlier. Install the nuts, and tighten them until the tank contacts the gasket.

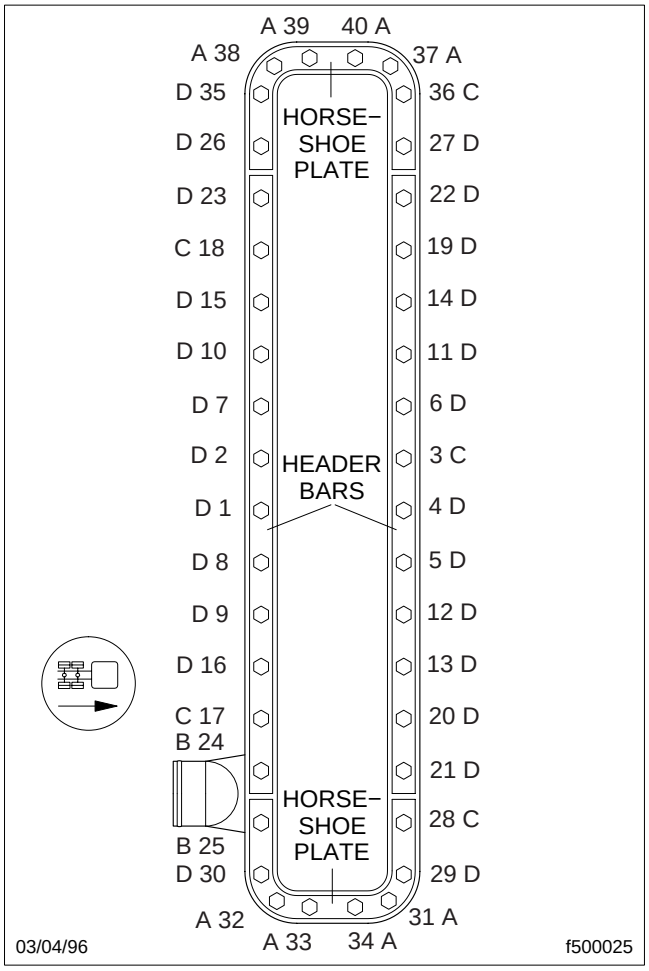


Fig. 13

5.4 From the core side, install the 5/16 x 3/4-inch bolts in the holes labeled "B" **in Fig. 13**.

5.5 From the core side, install 5/16 x 1-1/2 inch bolts through holes labeled "C" **in Fig. 13**. Loosely install the nuts.

5.6 From the tank side, install 5/16 x 1-inch bolts through the holes labeled "D" **in Fig. 13**. Loosely install the nuts.

5.7 Turn the radiator over, and allow the end-tank to overhang the edge of the work-bench, so as not to damage the outlet.Install the other header bar. From the core side, install the 5/16 x 1-1/2 inch bolts labeled "C" **in Fig. 13**. As referenced earlier, attach the headlight wiring harness and aftercooler mounting brackets (if used); loosely install all of the nuts.

5.8 From the tank side, install all of the bolts labeled "D" **in Fig. 13**; loosely install the last of the nuts.

5.9 Following the sequence **in Fig. 13**, tighten all of the end-tank fasteners 120 lbf·in (1360 N·cm).

Following the same sequence, tighten all of the end-tank fasteners 15 lbf·ft (20 N·m).

5.10 Position the surge tank on the top side channel and install the mounting nuts finger-tight. Install the hose that connects the surge tank to the radiator, and tighten the hose clamps.

RADIATORS WITH PLASTIC END-TANKS **(See Fig. 3)**

1. Install the plastic end-tanks on the radiator core.

1.1 With the radiator securely clamped in the disassembly/assembly fixture, header sealing surface up, make sure the bottom of the radiator core and tank assembly is completely supported, and that the header sealing surface is free of any dents, tool marks, or foreign particles.

1.2 Lubricate a new sealing gasket with a soap and water solution, and position the gasket on the header sealing surface. **See Fig. 6**. To make sure the gasket is not twisted, run a finger along the gasket as it lays on the sealing surface. The mold lines of the gasket should be on the outside and inside diameters of the gasket; if you can feel a mold line cross over the top of the gasket, the gasket is twisted.

1.3 Inspect the tank sealing flange. The flange must be clean and free of defects. If the sealing flange is damaged, replace the tank.

1.4 Place the tank on the gasket, and tap the tank with a rubber mallet or the heel of your hand to seat the tank. Make sure the tank ports are facing the correct direction.

1.5 Position the tank clamping cylinders evenly across the top of the tank. Make sure the cylinders' rubber plungers will not press against breakable fittings, such as vent tube ports. **See Fig. 4.**

CAUTION

CAUTION: Too much pressure will crack the plastic tank.

1.6 Apply pressure evenly across the top of the tank until the tank-to-core sealing gasket is compressed enough to show a small gap between the bottom of the dimple wave lock crimp and the tank sealing flange. Apply only enough pressure to compress the sealing gasket.

1.7 Place the T-bar into the T-bar groove in the disassembly/assembly fixture. **See Fig. 14.**

1.8 Slide the wave form bar over the T-bar, and center the bar in front of the wave crimp slot.

CAUTION

CAUTION: Do not push the wave crimp until it touches the side of the plastic tank, or the tank may crack.

1.9 Push the T-bar forward to crimp the header's edge until it almost touches the tank's side. **See Fig. 14.**

1.10 Slide the tools down the T-bar groove to the next wave crimp slot, and repeat steps as required until all the wave crimps are crimped.

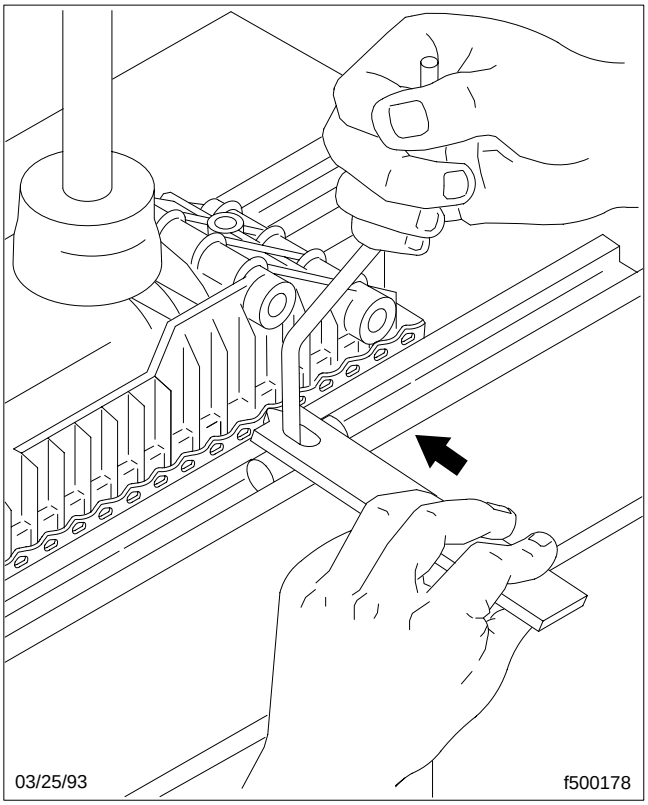


Fig. 14

CAUTION

CAUTION: In some places, especially around the tank ports, the wave crimps may have to be crimped with a screwdriver. When using a screwdriver, use care not to crack or gouge the plastic tank.

1.11 Release the pressure from the tank, and move the clamping cylinders off the radiator core and tank assembly.

1.12 Repeat the step to install the opposite tank.

2. Install the radiator side channels.

2.1 Slide the side channels onto the radiator core and tank assembly. If necessary, spread the channels to clear the end-tank bosses.

2.2 Using a rubber mallet and a punch, install the four mounting pins through the side channel holes and tanks.

2.3 Install four new spring clips to secure the mounting pins in position. To install each clip, place the clip over the end of the mounting pin, and slide the clip until it engages the groove in the pin and the open end of the clip snaps over the edge of the pin. If necessary, use a clamp to compress the side channel while installing the clips.

2.4 Install the radiator brace rod (**Fig. 3**, Ref. 12) and secure it with the nuts and lockwashers (Refs. 11 and 10).

3. Install the radiator in the vehicle. For instructions, **see Subject 100**.

Pressure-Testing

1. Pressure-test the radiator.

1.1 Plug the inlet, outlet, and all other ports on the radiator assembly.

CAUTION

CAUTION: Don't apply a higher amount of air pressure than specified below; too much pressure will damage the radiator core.

1.2 Remove the radiator cap, and install a pressure regulator and gauge. Using a hand pump, apply 20 psi (138 kPa) air pressure through the filler neck.

1.3 Submerge the radiator in a tank of water and check it for leaks. Remove the radiator from the water.

1.4 Remove the plugs and the testing gauge, and install the radiator cap. Repair the radiator, if necessary.

2. Place the fan shroud against the back of the radiator, and install the flatwashers and screws holding it to the side channels; do not tighten the screws snug at this time. Install the radiator, **see Subject 100**.

Troubleshooting

NOTE: For additional troubleshooting information, refer to the cooling system troubleshooting section in this manual.

VISUAL CHECK

It is a sound service practice to give the cooling system a quick visual check whenever you tilt the hood. Look for signs of frayed or damaged belts and hoses. Also look for signs of visible leaks (or the stains they leave), especially on the engine block. A final check is to look at the inside of the oil breather cap for signs of a milky substance-which means that coolant is leaking into the oil.

AIR CONDITIONER CONDENSER

Since the condenser is right in front of the radiator, air must pass through it to get to the radiator. That same air must then pass through the radiator. For the heat transfer process to take place, the fins of both the radiator and the condenser must be free of blockages and deposits such as dirt or bugs. Clean the surfaces with compressed air or water and a mild laundry soap.

Also remember that because the two heat-transfer parts are so close to each other, heat will pass back and forth between them. A blocked condenser will transfer its heat to the radiator and a hot radiator will transfer its heat to the condenser.

RADIATOR CAP

The radiator cap is the most often ignored part in the cooling system. If it is suspect, replace it. An inspection means checking the cap with a pressure tester. A radiator cap in good condition will keep system pressure at about 10 psi (69 kPa). A visual check is also in order: look for signs of deterioration of the inner gasket. Also look for cracks or breaks in the spring retainer in the cap and for corrosion or deposits on the spring itself. If the spring is not in perfect condition, it has probably lost tension; replace it.

ENGINE COOLANT

Check the level of the coolant in the radiator. It should be up to the bottom of the radiator fill-neck.

If the engine coolant is dirty or its color is beginning to fade, change it. It should also be replaced if it has a dead fish smell.

Be sure that the mixture is correct. Refer to the vehicle maintenance manual for specifications.

RADIATOR

Radiator problems are limited to external leaks, which can be spotted visually, and internal blockages, assuming that there is good airflow and that the radiator is large enough to get the job done.

To check for blockages, warm the engine to normal operating temperature. Shut down the engine, and pass your hand in front of the finned surface of the radiator. If there is a blockage in the radiator it should cause an obvious temperature difference from one area of the core to another. An obvious difference between inlet and outlet temperatures, however, is to be expected.

General Information and Principles of Operation (See Fig. 1 and Fig. 2)

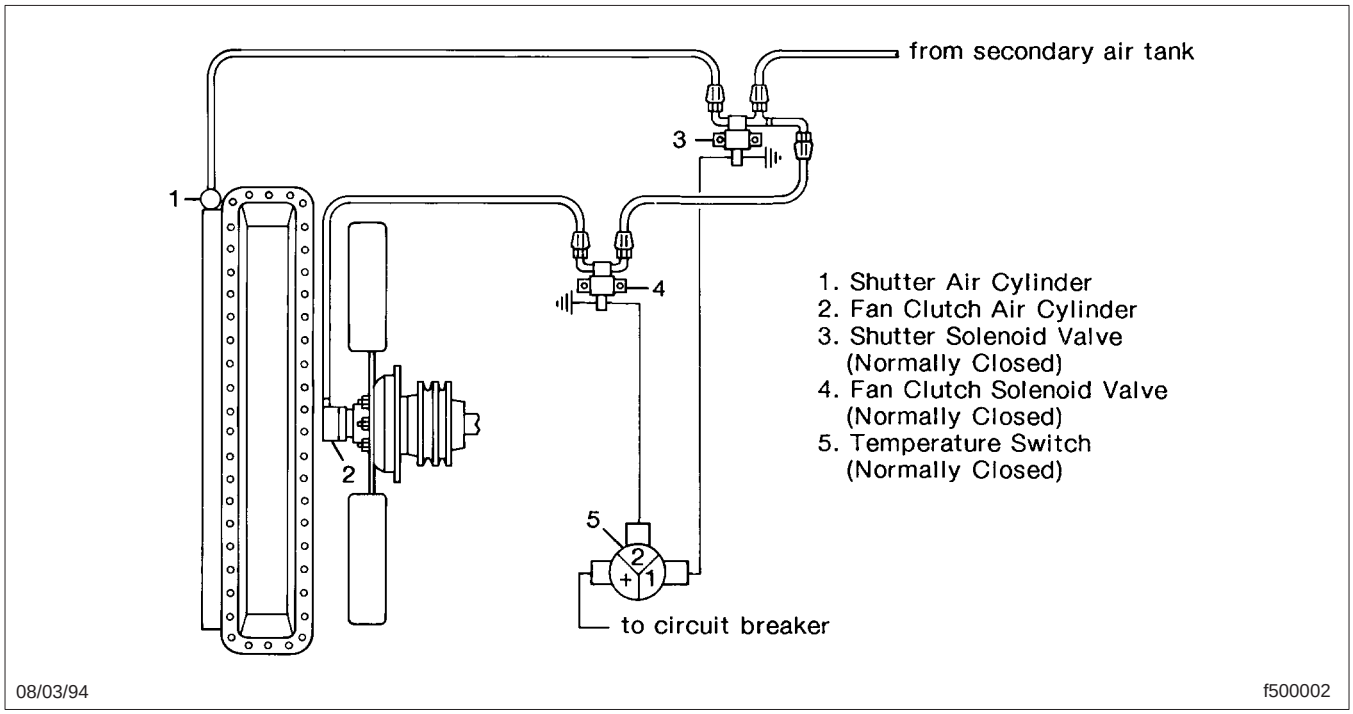


Fig. 1, Shutter and Fan Clutch Piping and Wiring

The radiator shutter, together with the radiator fan, maintains engine temperature by controlling airflow through the radiator. The shutter is mounted in front of the radiator and single-row air conditioner condenser.

The shutter opens when the coolant temperature is above the specified range, or when the air conditioner is turned on. The shutter must be open when the fan clutch is engaged.

The shutter is held open by a spring and is closed by an air-operated cylinder mounted on the shutter. Compressed air to the cylinder is controlled by a solenoid valve, which is controlled by a coolant temperature switch.

When a cold engine is started, the temperature switch is closed, activating the solenoid. The solenoid valve admits compressed air to the shutter cylinder, closing the shutter.

When the coolant warms to the setting of the shutter temperature switch, the switch opens. The shutter solenoid valve closes and releases compressed air from the shutter cylinder, allowing the spring to open the shutter.

When the coolant warms to the setting of the fan clutch temperature switch, the fan clutch engages. It remains engaged until the coolant temperature drops to the fan clutch temperature switch setting. If the coolant temperature continues to drop, the shutter closes again.

NOTE: The temperature switches for both the shutter and the fan clutch are combined in a single unit. The switches have different settings and operate independently. Refer to the table **in "Specifications, 400."**

On vehicles with an air conditioner (**Fig. 2**), the shutter solenoid valve is connected to the air condi-

General Information and Principles of Operation

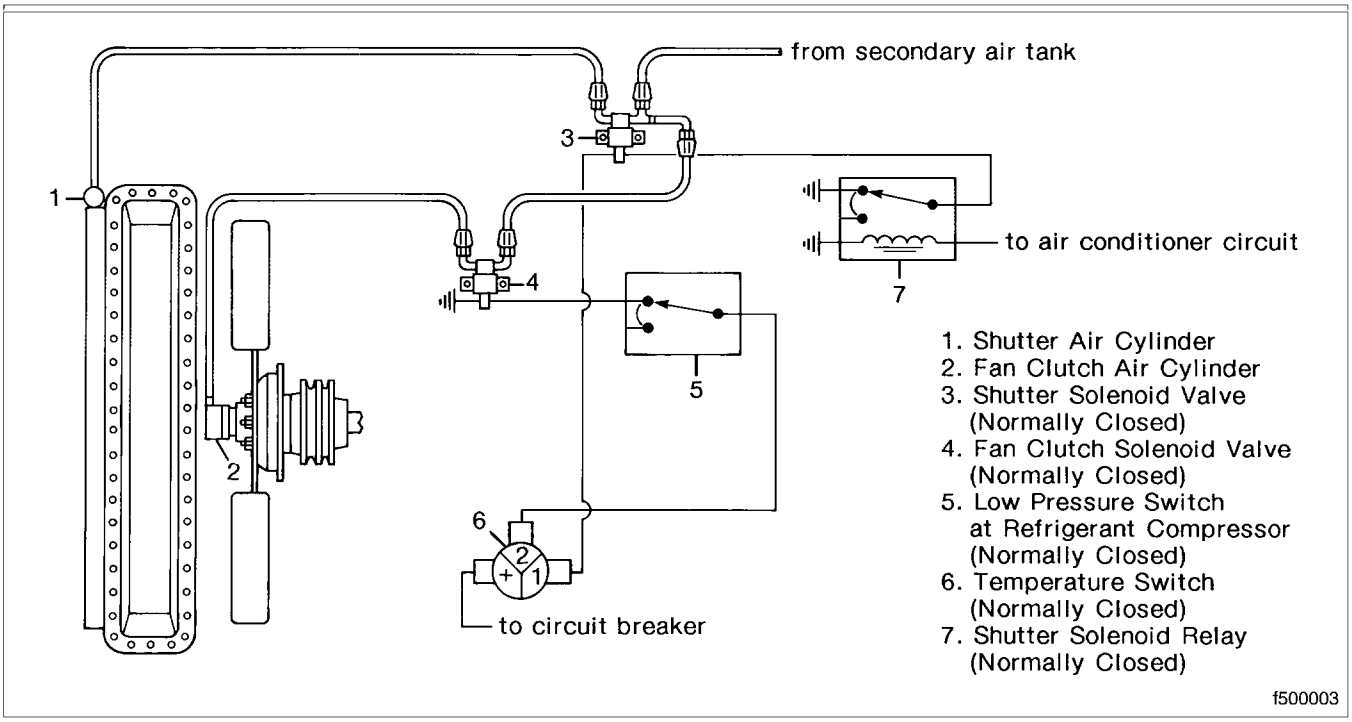


Fig. 2, Shutter and Fan Clutch Piping and Wiring With Air Conditioning

tioner electrical circuit by a shutter solenoid relay. When the air conditioner is turned on, the relay opens the shutter solenoid circuit. This closes the solenoid valve, allowing the shutter to open and preventing condenser overheating.

Replacement (See Fig. 1)

1. Apply the parking brakes, and chock the tires.
2. Disconnect the air line from the shutter cylinder.
3. Remove the hex machine screws holding the shutter to the radiator. Remove the shutter.
4. Using the hex machine screws, fasten the shutters to the radiator. Tighten the screws 140 lbf·in (1580 N·cm).
5. Connect the air line to the cylinder.
6. Remove the chocks from the tires.

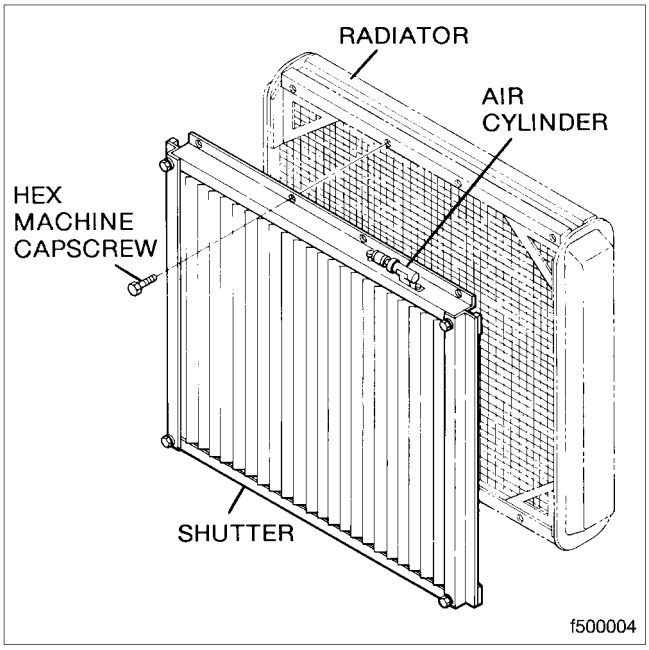


Fig. 1

Testing

1. Start the engine and run it at governed rpm. Watch the coolant temperature gauge; coolant temperature should stay within the normal operating range while the shutter and fan clutch complete one cycle. For faster cycling, use a piece of cardboard to partially block radiator airflow.

   Check that the shutter and fan clutch engage at the correct temperatures. Refer to the settings in the table in **"Specifications, 400."** The shutter must open before the fan clutch engages, and close only after the fan clutch disengages.

2. Check that the shutter opens when the air conditioner is turned on.

See **Fig. 1** for shutter and fan clutch piping and wiring without air conditioning

See **Fig. 2** for shutter and fan clutch piping and wiring with air conditioning

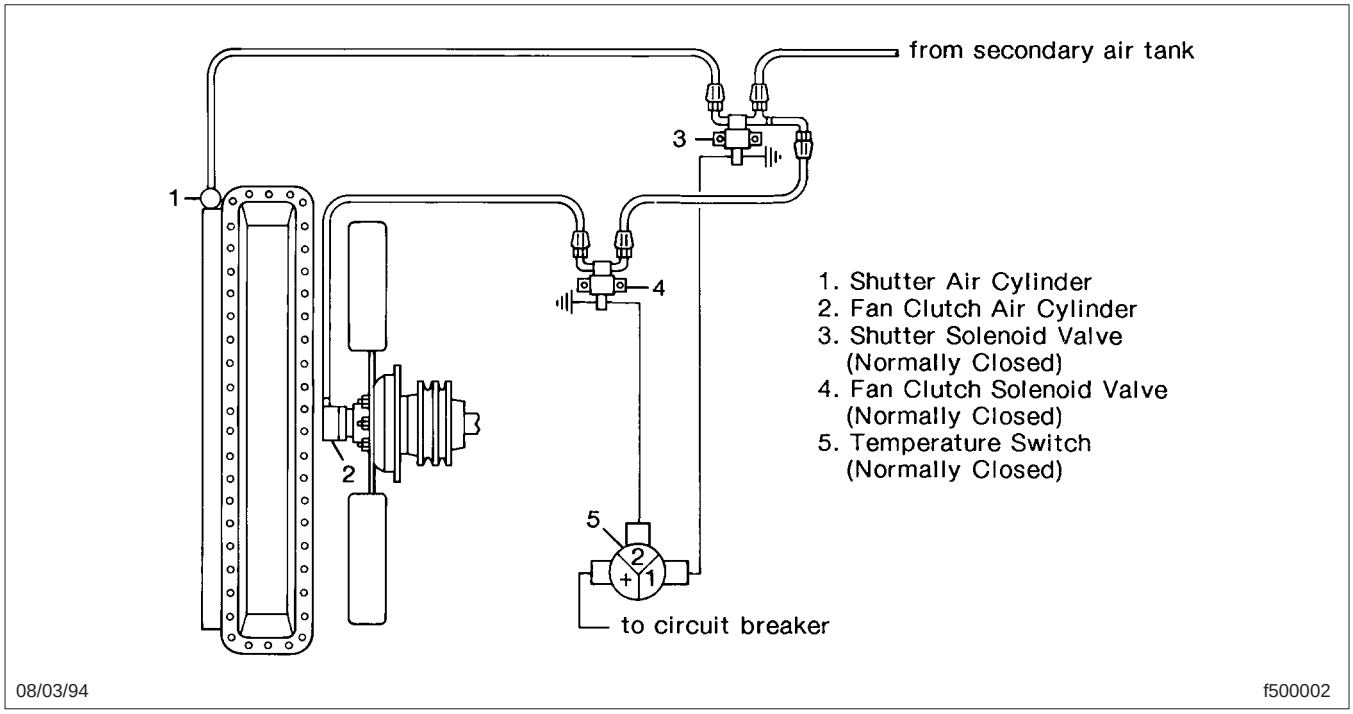


Fig. 1, Shutter and Fan Clutch Piping and Wiring Without Air Conditioning

Temperature Switch	Engine Model	
	Caterpillar °F (°C)	Cummins °F (°C)
Shutter:		
Open	200 (93)	185 (85)
Close	193 (89)	178 (81)
Fan Clutch:		
Engage	205 (96)	200 (93)
Disengage	198 (92)	193 (98)

Table 1, Temperature Switch Operating Specifications

Specifications

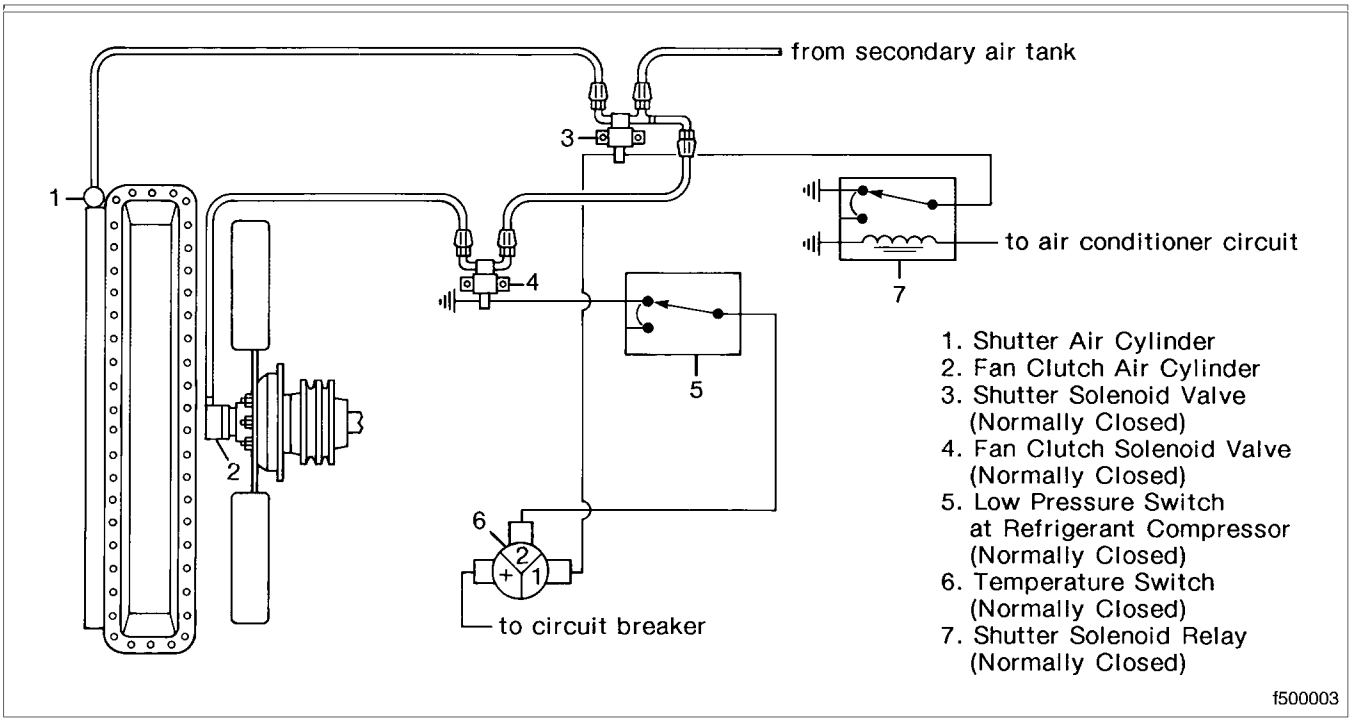


Fig. 2, Shutter and Fan Clutch Piping and Wiring With Air Conditioning

General Information and Principles of Operation

(See Fig. 1 and Fig. 2)

The fan drive (**Fig. 3**) is an air-operated, temperature-controlled clutch for the engine cooling fan. Its purpose is to maintain engine temperature by engaging or disengaging the fan. The fan clutch is disengaged by spring pressure when the coolant temperature is below the specified temperature range; the fan clutch is engaged by air pressure when the coolant temperature rises above the range.

When the coolant temperature drops to the temperature switch cutoff setting, compressed air is exhausted from the cylinder, disengaging the clutch.

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-dryer. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch opens and supplies power to the solenoid valve, which supplies air to the cylinder and engages the fan clutch.

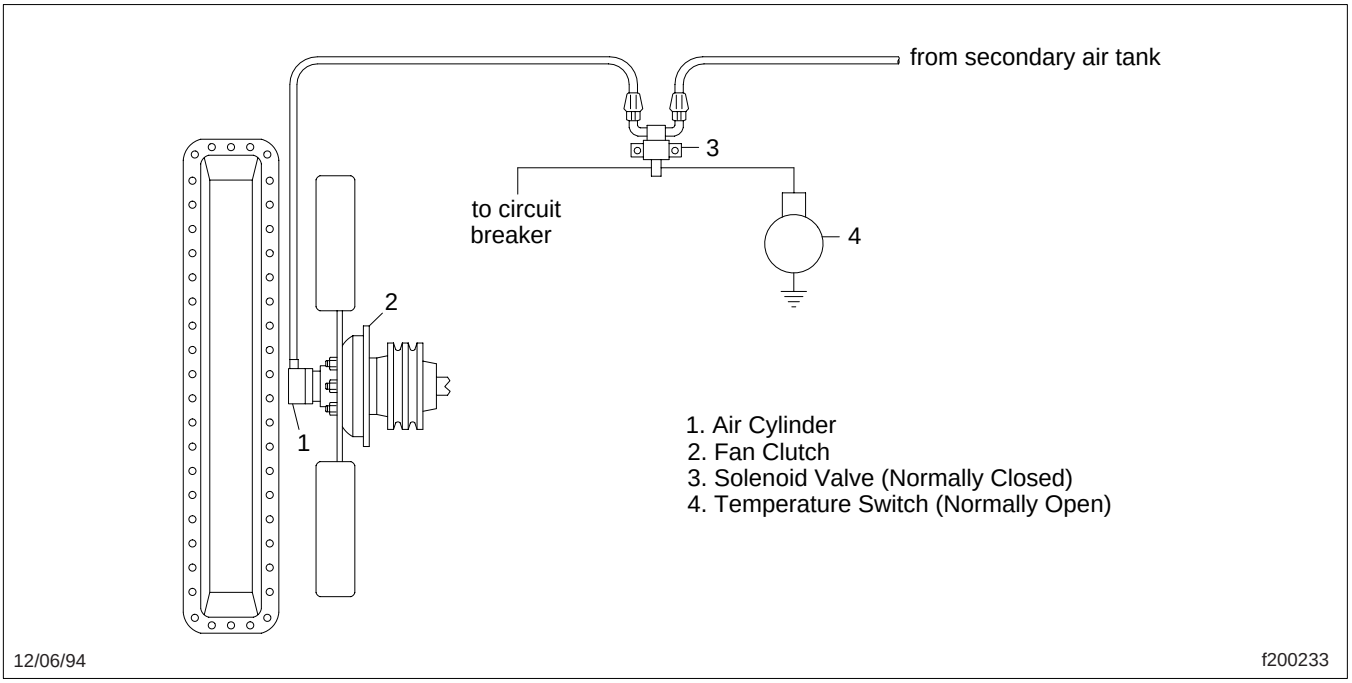


Fig. 1, Fan Clutch Piping and Wiring, Vehicle Without Air Conditioning

Air pressure to an air cylinder on the fan clutch is controlled by a solenoid valve; the solenoid valve is controlled by a temperature switch that is installed in the thermostat housing.

When a cold engine is started, air pressure to the cylinder is restricted by the solenoid valve, and the fan clutch remains disengaged.

When the coolant temperature rises to the temperature switch setting, the solenoid valve releases the compressed air to the cylinder, and the fan clutch engages.

General Information and Principles of Operation

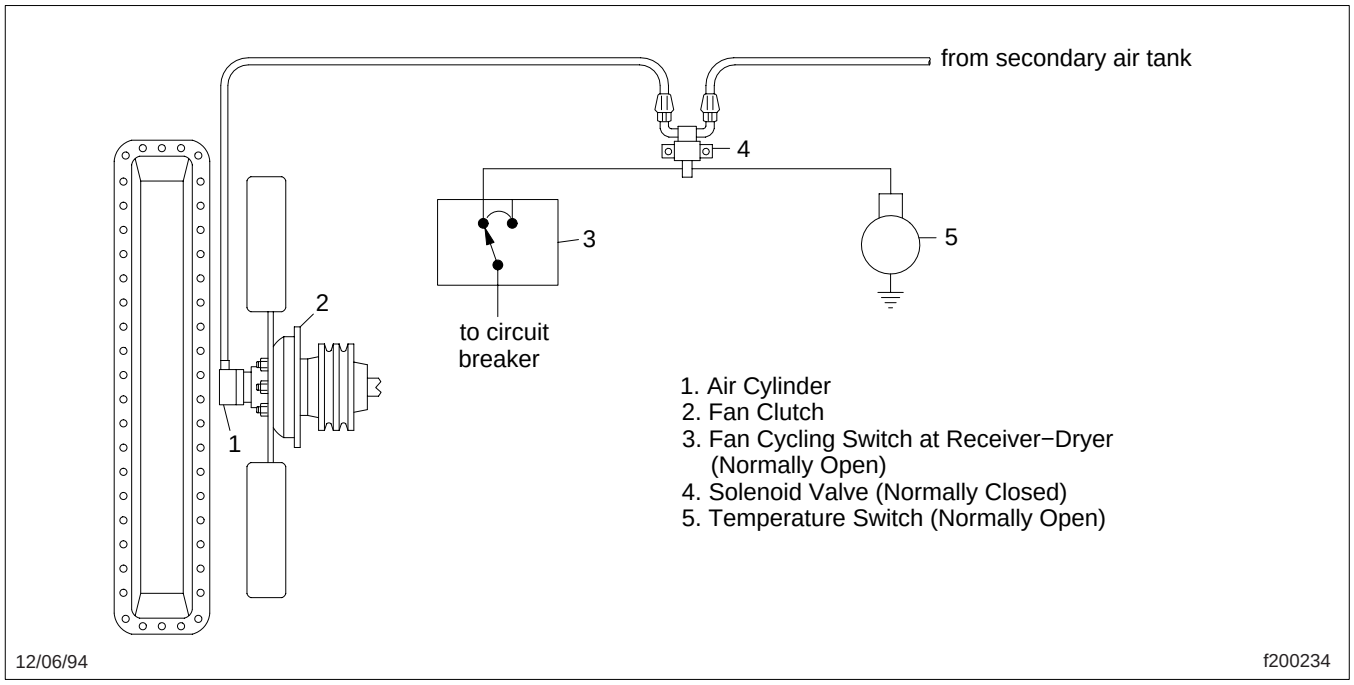


Fig. 2, Fan Clutch Piping and Wiring, Vehicle With Air Conditioning

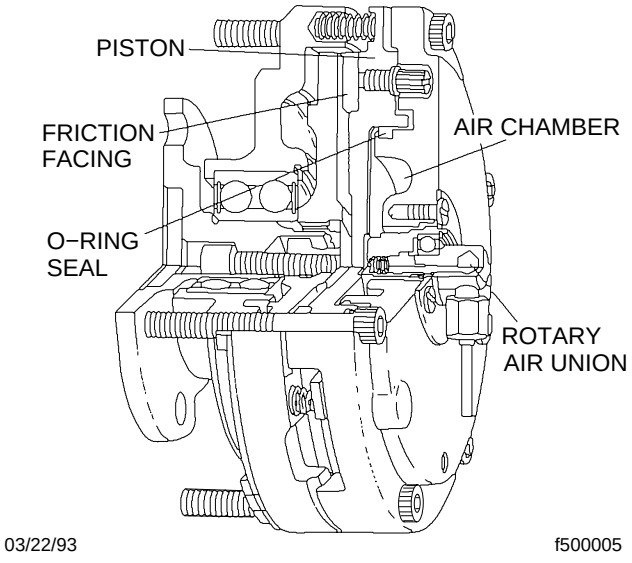


Fig. 3

Removal (See Fig. 1)

1. Apply the parking brakes, and chock the tires.

⚠ WARNING

WARNING: Use care when loosening the air line fitting. The line could be under pressure and may have dirt or sludge in the air stream. If quickly disconnected, the line may whip, possibly causing eye injury or other bodily injury.

2. Disconnect the air line from the fan clutch cylinder.
3. If necessary, disconnect any radiator hoses that may interfere with fan removal.

NOTE: Use a drain bucket to catch any coolant that may spill.

4. On 120 Conventionals, tilt the hood halfway and support it. Disconnect the hood cables from the radiator brace-rod brackets. Tilt the hood all the way, and support it.

   Disconnect the three radiator brace rods from the brackets on top of the radiator assembly. Loosen the locknuts on each lower support isolator.

   On COEs, loosen the locknut on the square-neck bolt in each lower support isolator. Remove the flanged bolts and nuts from the stay rods at the radiator side channels.
5. With one person holding each side of the radiator, tilt the top of the radiator forward, until the fan shroud clears the fan.
6. Remove the six capscrews and the flatwashers and lockwashers (Refs. 6, 7, and 11) that attach the fan and fan clutch assembly to the pulley. Remove the fan and fan clutch assembly.
7. Remove the nuts and washers (Refs. 8 and 9) that attach the fan to the fan clutch. Remove the fan.

Installation (See Fig. 1)

1. Position the fan on the fan clutch and install the nuts and washers. Tighten the nuts 15 lbf·ft (20 N·m).
2. Apply Loctite® 620, or an equivalent, on the threads of the capscrews that attach the fan clutch assembly to the pulley. Install the washers, then position the fan clutch assembly on the pulley.
3. Tighten the fan clutch assembly mounting fasteners 35 lbf·ft (50 N·m).
4. Attach the air line to the fan clutch, and tighten the fitting 84 lbf·in (940 N·cm).
5. Tilt the radiator upright.

   On COEs, install, but do not tighten, the flanged bolts and nuts in the stay rods at the radiator side channels. Tighten the locknuts on the square-neck bolts 55 lbf·ft (75 N·m); then tighten the stay rod bolts 80 lbf·ft (110 N·m).

   On 120 Conventionals, install the radiator brace rods; tighten the locknuts 70 lbf·ft (95 N·m). Tighten the locknuts on each lower support isolator 190 lbf·ft (260 N·m). Support the hood in the half-tilt position and attach the hood cables to the radiator brace-rod brackets.
6. Connect any radiator hoses that were disconnected earlier. Make sure that the radiator is filled with coolant to the bottom of the filler neck.
7. Check the fan clutch for proper operation. For instructions, refer to the cooling system section in the vehicle maintenance manual.

Removal and Installation

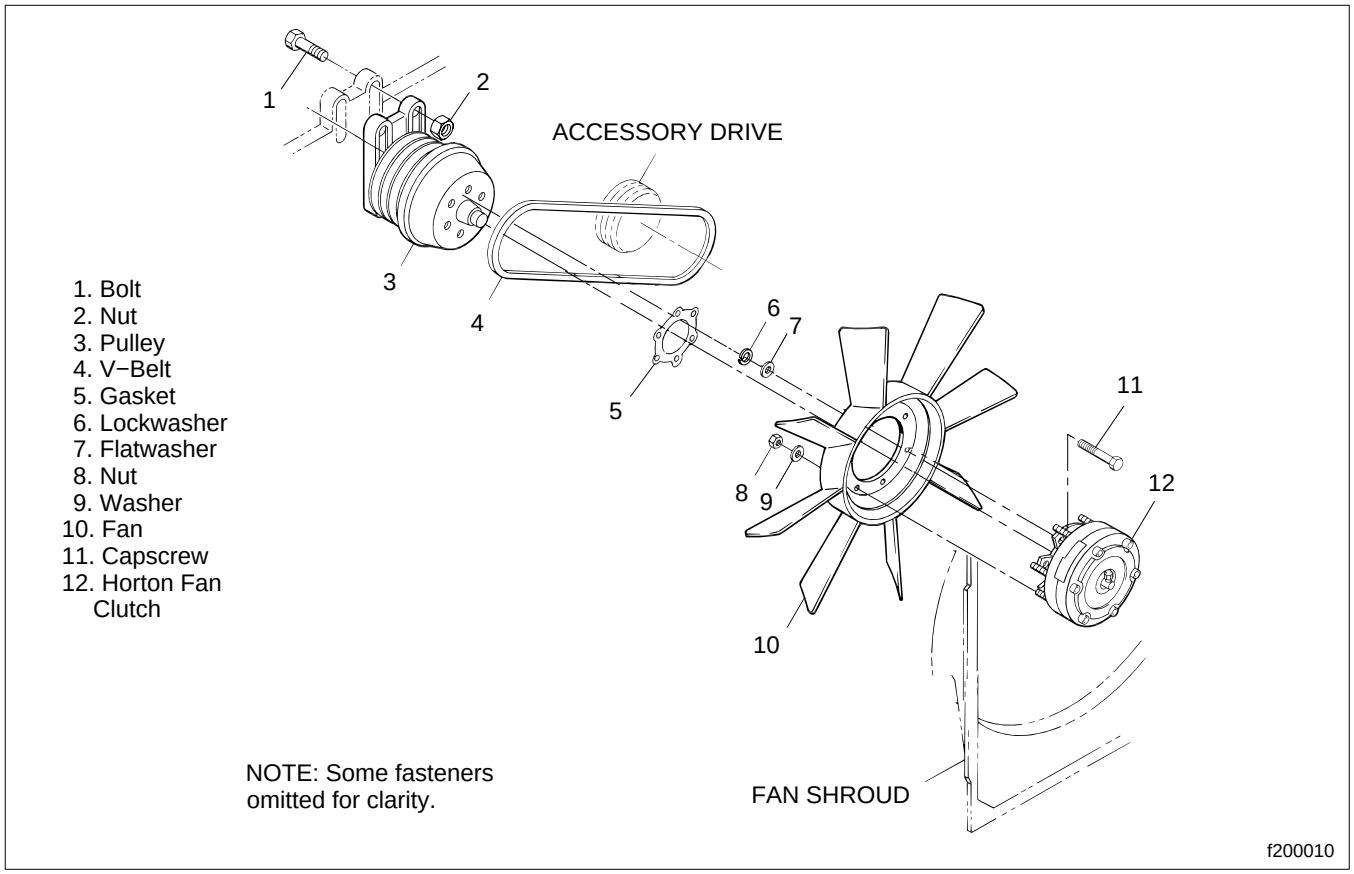


Fig. 1, Horton HT 550 Fan Clutch (Cummins NTC Installation Shown)

Disassembly (See Fig. 1)

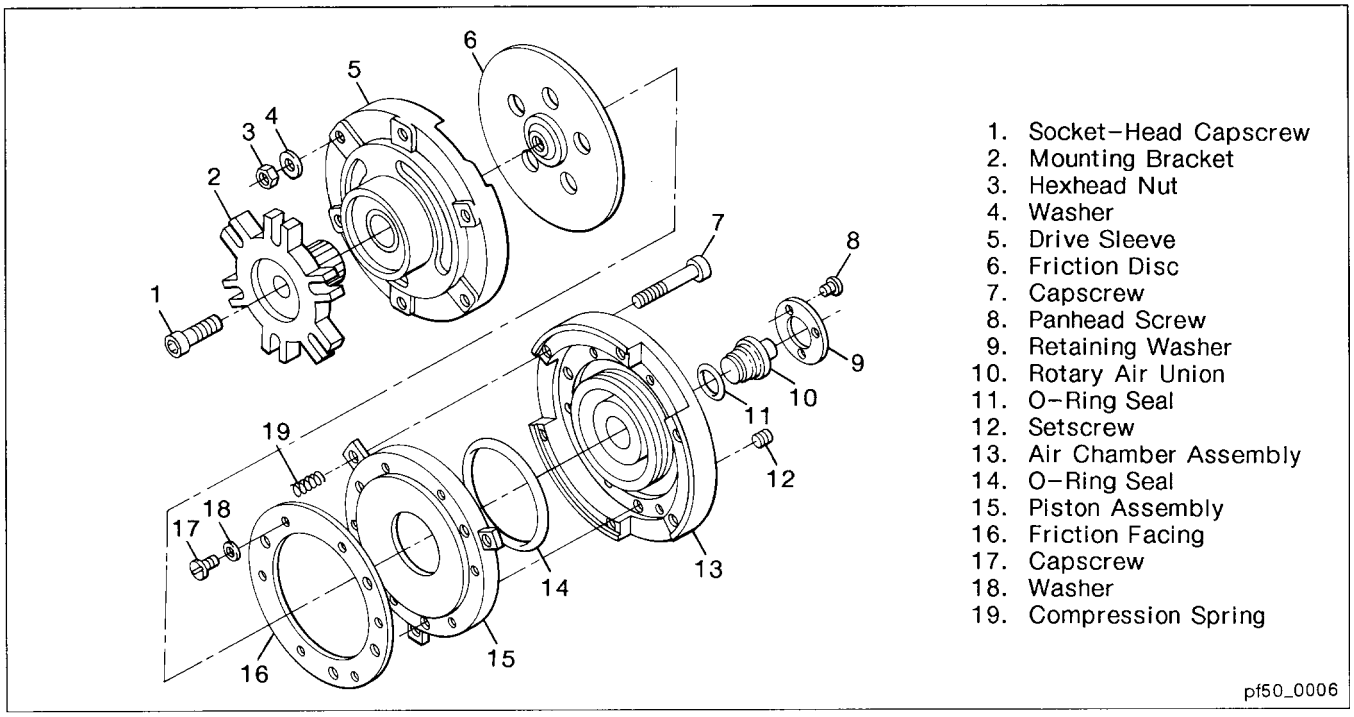


Fig. 1, Horton HT 550 Fan Clutch

1. Remove the fan and fan clutch assembly from the vehicle. **Refer to Subject 100.**
2. Remove the three panhead screws and the retaining washer (**Fig. 2**) from the air chamber assembly.
3. Remove the rotary air union and O-ring. **See Fig. 3.**
4. Remove the six socket-head capscrews from the air chamber assembly. **See Fig. 4.**
5. Separate the piston and air chamber assemblies. **See Fig. 5.**
6. Remove the compression springs.
7. Remove the O-ring seal from the air chamber. **See Fig. 6.**
8. Remove the six capscrews and washers that attach the friction facing to the piston assembly. **See Fig. 7.**

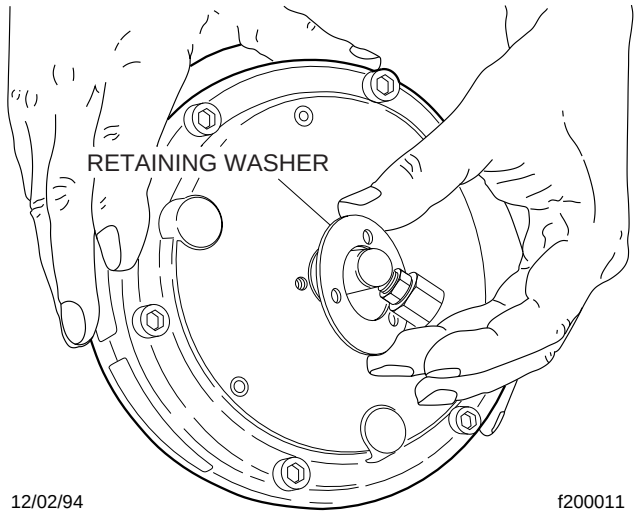


Fig. 2

9. Remove the socket-head capscrew from the mounting bracket and separate the mounting bracket, drive sleeve, and friction disc.

Disassembly and Assembly

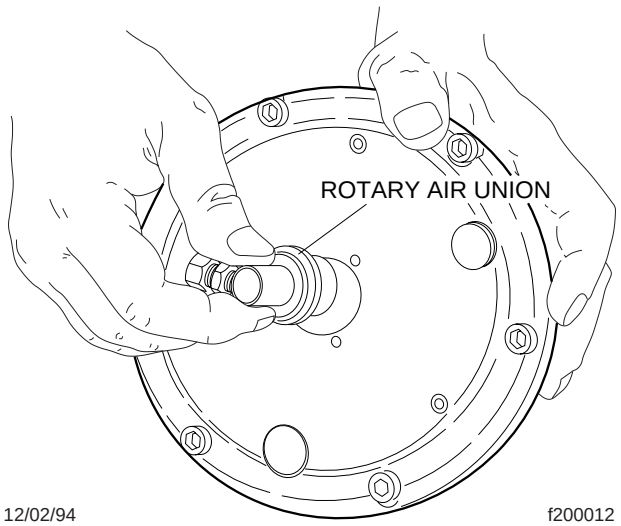


Fig. 3

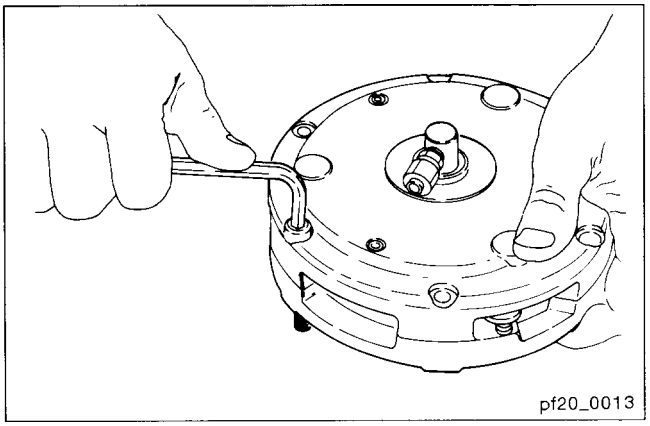


Fig. 4

Assembly (See Fig. 1)

1. Apply Loctite® 242, or an equivalent, to the threads of the mounting bracket socket-head capscrew.
2. Place a new drive sleeve, and the friction disc on the mounting bracket. Install the socket-head capscrew and tighten it 45 to 50 lbf·ft (60 to 65 N·m).
3. Apply Loctite 242, or an equivalent, on the threads of the capscrews that attach the friction facing to the piston assembly.

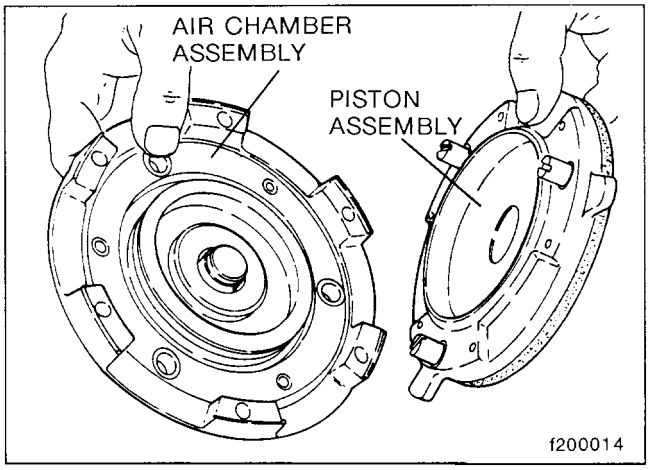


Fig. 5

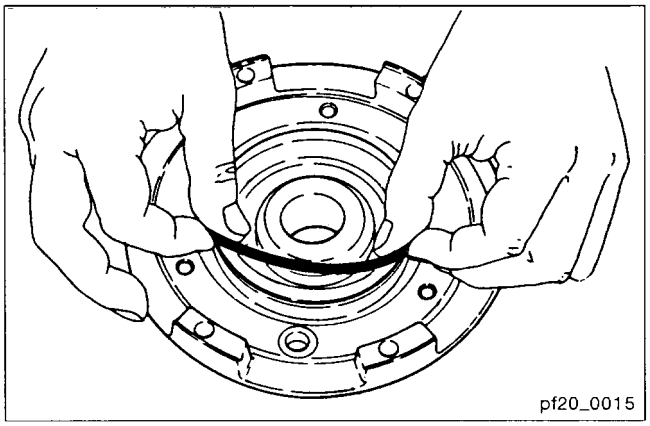


Fig. 6

4. Using a new friction facing, install the capscrews and washers. Following a star pattern, tighten the capscrews 20 lbf·in (220 N·cm).

NOTE: The friction facing must be replaced if its thickness is less than 7/32-inch (5.6 mm).

5. Remove any dust and debris from the air chamber.
6. Coat a new O-ring and the air chamber contact surface with an approved lubricant; **see Specifications, 400**. Install the O-ring in the air chamber.
7. Install new compression springs. **See Fig. 8.**
8. Press the piston and air chamber assemblies together. Position the piston and air chamber assembly on the drive sleeve. Install the six socket-

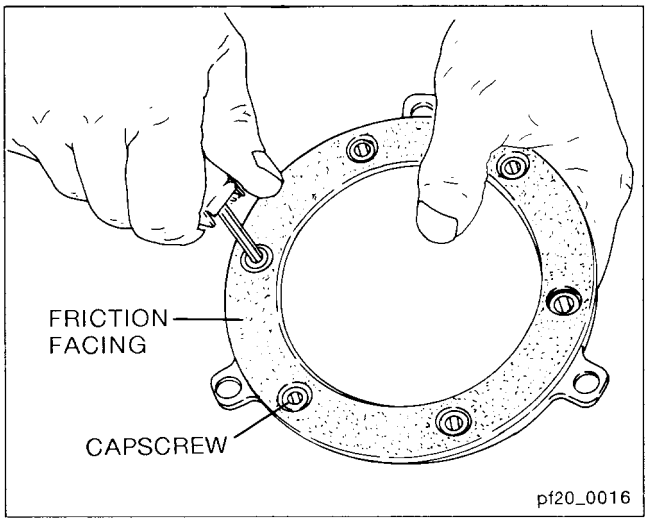


Fig. 7

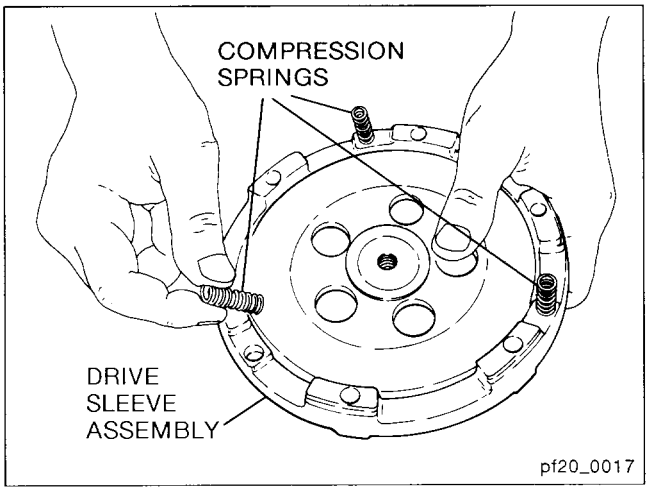


Fig. 8

head capscrews. Following a star pattern, tighten the capscrews 20 lbf·ft (27 N·m).

9. Coat a new O-ring seal (**Fig. 9,** Ref. 1) with an approved lubricant. Place the O-ring seal and a new rotary air union (Ref. 2) in the air chamber. Install the retaining washer (Ref. 3) and the three panhead screws (Ref. 4).
10. Install the fan and clutch assembly on the engine. **Refer to Subject 100.**

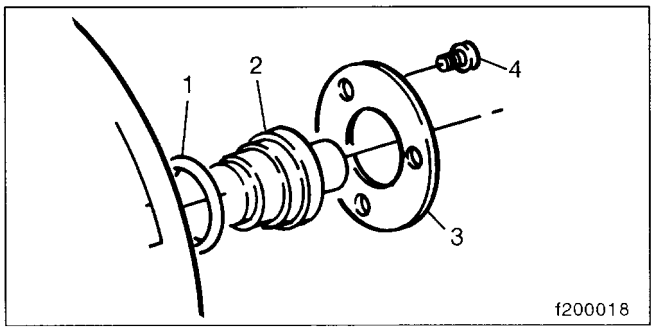


Fig. 9

Problem—Air Is Leaking from the Fan Clutch

Possible Cause	Remedy
The face seal or air cartridge (**Fig. 1**, Ref. A) is bad.	Install a new seal kit.
The O-ring seals (**Fig. 1**, Ref. B or C) are bad.	Install a new seal kit.

Problem—The Fan Clutch Fails to Engage

Possible Cause	Remedy
There's no power to the fan clutch control circuit.	Check all electrical connections, and repair or replace wiring as needed.
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally open, not normally closed. Replace the switch if it is damaged or if the switch is the wrong type.
The solenoid valve is malfunctioning.	Replace the solenoid valve.
The fan clutch is leaking.	Install a new seal kit.
The air supply to the fan clutch is restricted.	Make sure the fan clutch air lines are not leaking or pinched. Repair the lines as needed.

Problem—The Fan Clutch Engages, But the Engine Still Overheats

Possible Cause	Remedy
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
There is a problem somewhere else in the cooling system.	Refer to the cooling system troubleshooting section in this group.

Problem—The Fan Clutch Does Not Disengage

Possible Cause	Remedy
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally open, not normally closed. Replace the switch if it is damaged or if the switch is the wrong type.
A restricted air line doesn't allow air to vent from the clutch.	Make sure the air lines are not pinched or plugged. Repair the air lines as needed.
The solenoid is not exhausting.	Make sure the solenoid exhaust port is not plugged.
The piston friction disc is seized due to contamination or worn splines.	Replace the piston friction disc, and make sure the fan clutch air supply is clean.

Problem—The Fan Clutch Cycles Frequently

Possible Cause	Remedy
The fan clutch control circuit has a loose connection or is poorly grounded.	Check all wiring connections, and repair the circuit as needed.

Troubleshooting

Possible Cause	Remedy
The temperature control settings are incorrect.	Check the fan clutch control setting of the temperature switch, according to the engine installed in the vehicle. Repair or replace the temperature switch as needed.
The fan cycling switch at the receiver-dryer is set too low.	Check the switch at the receiver-dryer, and if needed, replace the switch with a switch with a higher setting.
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
The temperature switch is malfunctioning.	Replace the temperature switch.

Problem—The Fan Clutch Engages, But the Engine Still Overheats

Possible Cause	Remedy
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
There is a problem somewhere else in the cooling system.	Refer to the cooling system troubleshooting section in this group.

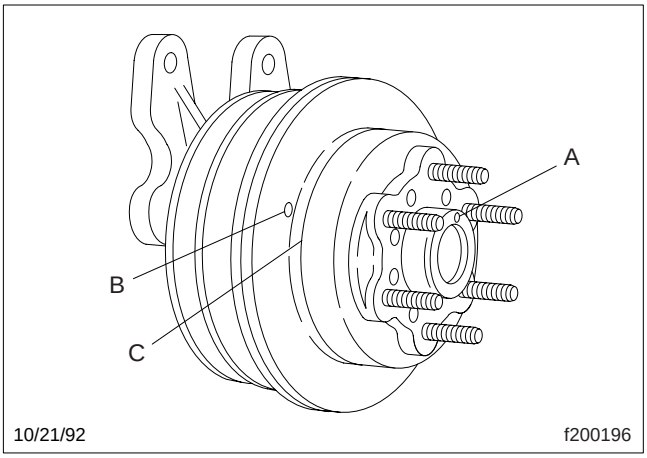


Fig. 1, Possible Fan Clutch Air Leaks

Torque Values		
Fastener	Torque	
	lbf·ft (N·m)	lbf·in (N·cm)
Fan Nut	15 (20)	—
Air Cylinder Nut	—	84 (940)
Air Chamber Capscrew	20 (27)	—
Friction Facing Capscrew	—	20 (220)
Fan Clutch Mounting Capscrews	35 (47)	—
Mounting Bracket Socket-Head Capscrew	45-50 (61-68)	—

Table 1, Torque Values

Approved Lubricants

Parker O-Ring Lube

Horton O-Ring Lube No. 13220

Wiring

See Fig. 1 for the fan clutch wiring diagram.

Specifications

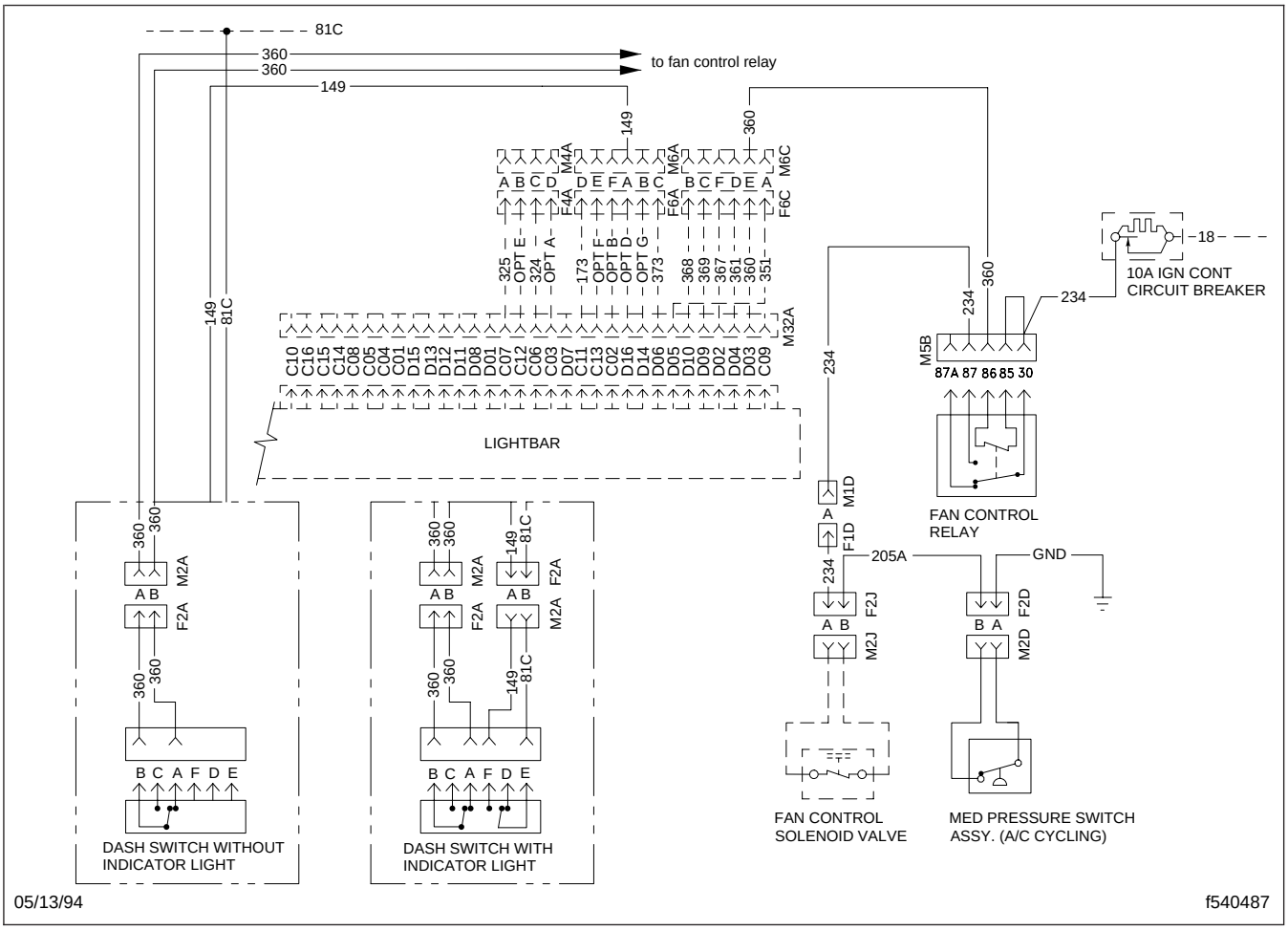
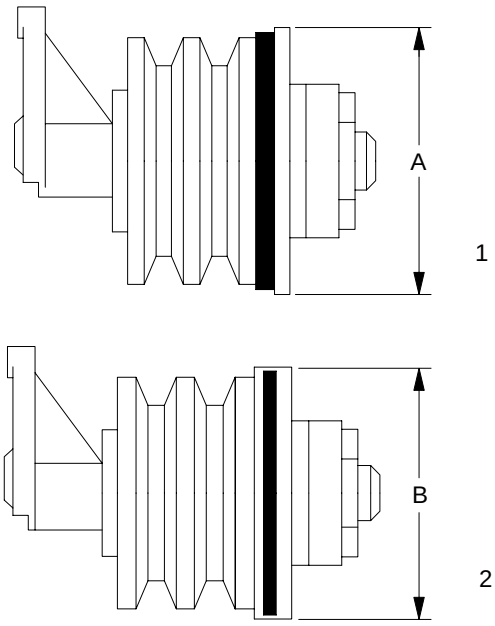


Fig. 1, Fan Clutch Wiring Diagram

General Information and Principles of Operation

The fan drive is a temperature-controlled, air-operated clutch for the engine cooling fan. It controls engine temperature by engaging or disengaging the fan. Internal spring pressure disengages the fan clutch when the coolant temperature is below the specified temperature range; internal air pressure engages the fan clutch when the coolant temperature rises above that range. Freightliner uses two models of Horton Type S fan clutches: The type S, and the type HT/S. **See Fig. 1.**



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A. 7.5 inches (187.5 mm)
B. 9.5 inches (237.5 mm)
1. "S" Type Fan Clutch
2. "HT/S" Type Fan Clutch

Fig. 1

Air pressure to the fan clutch is controlled by a solenoid valve; the solenoid valve is controlled by a temperature switch that is installed in the thermostat housing. **See Fig. 2** and **Fig. 3**.

When you start a cold engine, the solenoid valve restricts air pressure to the cylinder, and the fan clutch remains disengaged.

When the coolant temperature rises to the temperature switch setting, the switch provides power to the solenoid valve, and the valve releases compressed air to engage the fan clutch.

When the coolant temperature drops to the temperature switch cutoff setting, the solenoid stops the compressed air, and the clutch disengages.

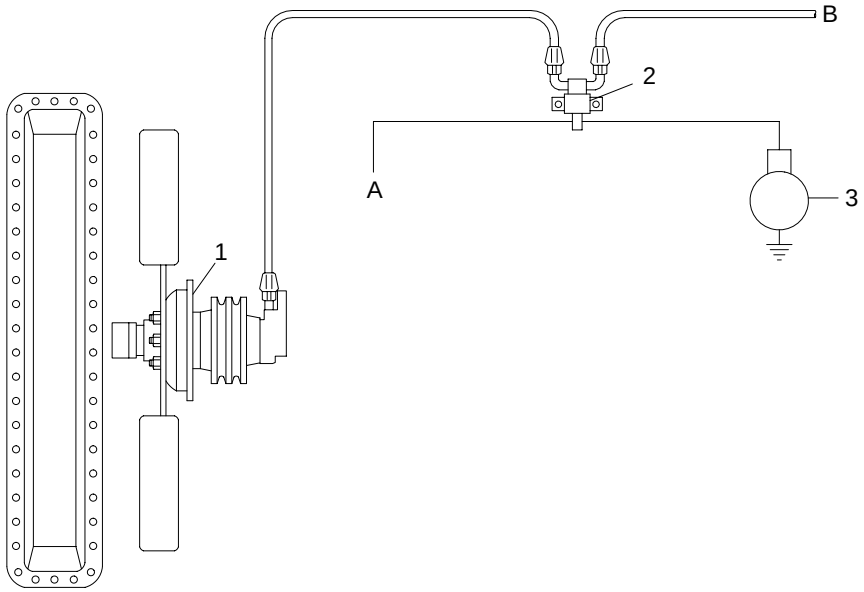
On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-dryer. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies power to the solenoid valve, which supplies air to engage the fan clutch.

Some models of Horton type S and HT/S fan clutches include System Sentry™ fuses that protect the fan clutch from overheating. **See Fig. 4.** The System Sentry fuse is a brass fitting in the piston friction disc; the fitting uses lead alloy solder to hold a brass plug. If anything causes the fan clutch to slip excessively, heat from the slippage will melt the solder and release the plug. Air pressure inside the clutch will escape, and the clutch will release before heat build-up can damage the clutch bearings. The fuse is balanced by two counterweights.

If the fan clutch includes the System Sentry fuse, and the clutch will not engage, check to see if the fuse is melted, and check to see what might be making the fan clutch slip excessively.

For the fan clutch model number and serial number, refer to the side of the air chamber. **See Fig. 5.**

General Information and Principles of Operation



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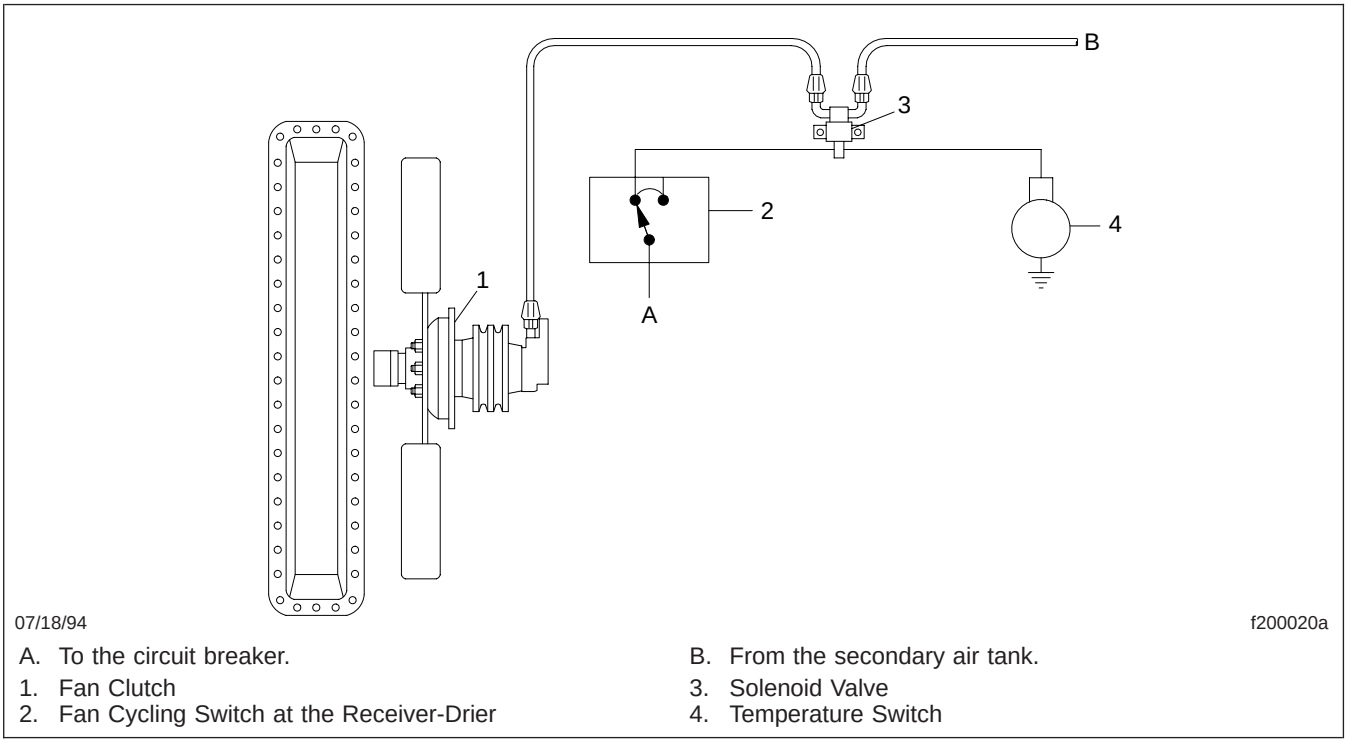
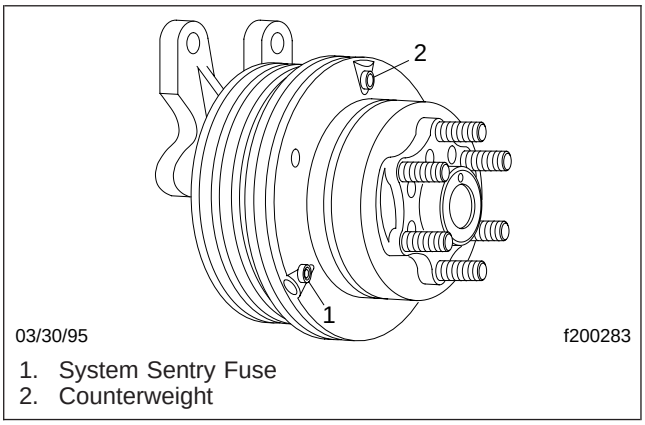
A. To the circuit breaker.
B. From the secondary air tank.
1. Fan Clutch
2. Solenoid Valve
3. Temperature Switch

Fig. 2, Fan Clutch Piping and Wiring, Vehicle Without Air Conditioning



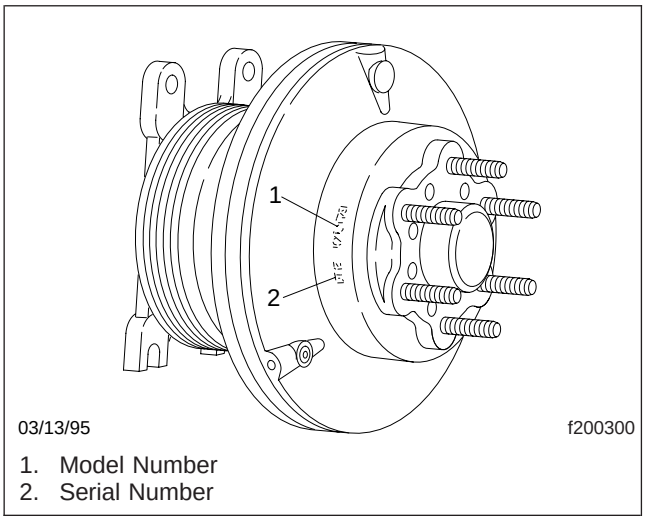
A. To the circuit breaker.
B. From the secondary air tank.
1. Fan Clutch
2. Fan Cycling Switch at the Receiver-Drier
3. Solenoid Valve
4. Temperature Switch

Fig. 3, Fan Clutch Piping and Wiring, Vehicle With Air Conditioning



1. System Sentry Fuse
2. Counterweight

Fig. 4, Horton Fan Clutch with System Sentry Fuse



1. Model Number
2. Serial Number

Fig. 5, Fan Clutch Information, Model HTS 981144 Shown

Removal

1. Apply the parking brakes, and chock the tires.

⚠ WARNING

Use care when loosening the air line fitting. The line could be under pressure and may have dirt or sludge in the air stream. If quickly disconnected, the line may whip, possibly causing eye injury or other bodily injury.

2. Disconnect the air line from the mounting bracket assembly.
3. If necessary, disconnect any radiator hoses that may interfere with fan removal.

NOTE: Use a drain bucket to catch any coolant that may spill.

4. On Conventionals, tilt the hood half-way and support it. Disconnect the hood cables from the radiator brace-rod brackets. Tilt the hood all the way, and support it.

   Disconnect the three radiator brace rods from the brackets on top of the radiator assembly. Loosen the locknuts on each lower support isolator.

   On COEs, loosen the locknut on the square-neck bolt in each lower support isolator. Remove the flanged bolts and nuts from the stay rods at the radiator side channels.
5. With one person holding each side of the radiator, tilt the top of the radiator forward, until the fan shroud clears the fan.
6. Remove the nuts that attach the fan to the fan clutch assembly. Remove the fan.
7. Remove the fan belts. For instructions, refer to **Group 01**.
8. Remove the bolts (or nuts) and washers that attach the fan clutch and hub assembly to the engine. Remove the fan clutch and hub assembly.

Installation

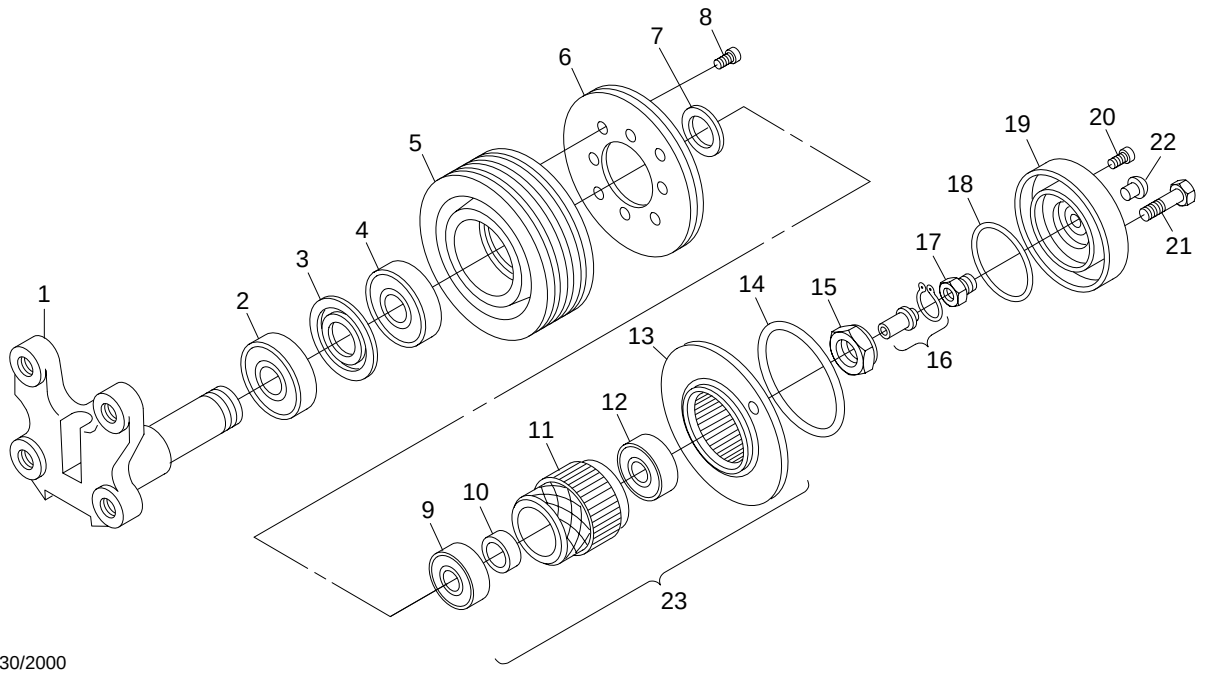
1. Position the fan clutch and hub assembly on the engine and install the bolts (or nuts) and washers. Tighten the mounting fasteners just enough to hold the assembly in place, and allow for later fan belt adjustment.
2. Install the fan belts. For instructions, refer to **Group 01**.
3. Tighten the clutch and hub assembly mounting fasteners 85 lbf·ft (115 N·m).
4. Apply Loctite® 242, or an equivalent, to the threads of the fan attachment bolts. Position the fan on the fan clutch. Install the nuts and tighten them 15 lbf·ft (20 N·m).
5. Tilt the radiator upright.

   On COEs , install, but do not tighten, the flanged bolts and nuts in the stay rods at the radiator side channels. Tighten the locknuts on the square-neck bolts 55 lbf·ft (75 N·m); then tighten the stay rod bolts 80 lbf·ft (110 N·m).

   On Conventionals, install the radiator brace rods; tighten the locknuts 70 lbf·ft (95 N·m). Tighten the locknuts on each lower support isolator 190 lbf ·ft (260 N·m). Support the hood in the half-tilt position and attach the hood cables to the radiator brace-rod brackets.
6. Attach the air line to the mounting bracket assembly, and tighten the fitting 84 lbf·in (940 N·cm).
7. Connect any radiator hoses that were disconnected earlier. Make sure that the radiator is filled with coolant to the bottom of the filler neck.
8. Check the fan clutch for proper operation. For instructions, refer to the cooling system section in the vehicle maintenance manual.

Disassembly (See Fig. 1)

NOTE: This procedure involves a major rebuild of the Horton Advantage fan clutch, using parts from the manufacturer's Major or Super Kit. If you are replacing just the air cartridge, System Sentry® fuse, or the face seal, go to **Subject 120**.



1. Mounting Bracket Assembly
2. Rear Sheave Bearing
3. Inner and Outer Bearing Spacers
4. Forward Sheave Bearing
5. Sheave
6. Friction Facing
7. Journal Spacer
8. Socket-Head Capscrew
9. Rear Hub Bearing
10. Bearing Spacer
11. Splined Hub
12. Forward Hub Bearing
13. Piston Friction Disc
14. Large O-Ring
15. Locknut
16. Air Cartridge Assembly
17. Face Seal
18. Small O-Ring
19. Air Chamber
20. Socket-Head Capscrew
21. Hexbolt (some vehicles equipped with studs)
22. Rubber Umbrella Valve
23. Disc and Piston Assembly

Fig. 1, Horton Advantage Fan Clutch

1. Remove the fan and clutch assembly from the vehicle. For instructions, refer to **Subject 100**.
2. Clamp the fan clutch in a vise. See **Fig. 2**.
3. On some vehicles, the fan clutch has threaded studs on the air chamber and the fan is attached with nuts. On other vehicles, the fan is attached to the air chamber with hexbolts.

   If hexbolts were used to attach the fan, install two of the removed hexbolts in the air chamber so that a screwdriver can be used to keep the air chamber from rotating. See **Fig. 3**.

   Remove the socket-head capscrews from the air chamber.
4. If applicable, remove the two hexbolts previously installed.

⚠ WARNING

Apply air pressure slowly to the fan clutch. A sudden blast of air might blow the air chamber off the clutch, resulting in possible injury.

Fan Clutch Major Rebuild

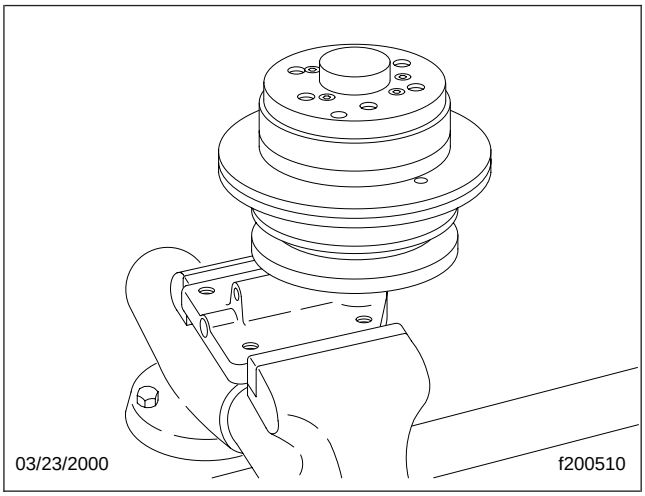


Fig. 2, Fan Clutch Placed in a Vise

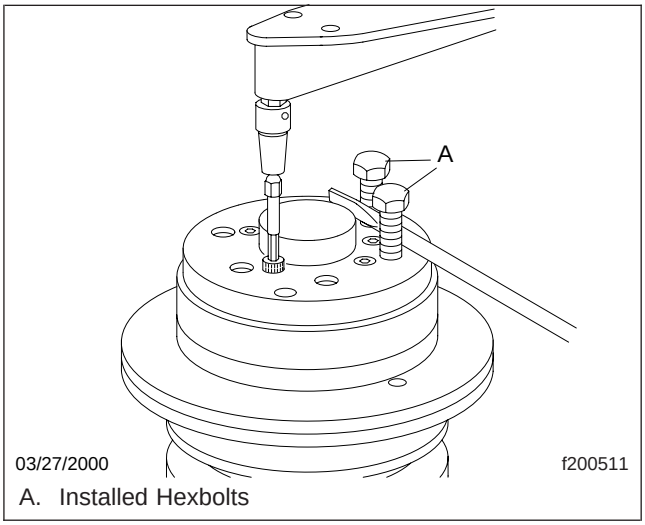


Fig. 3, Remove the Socket-Head Capscrews

5. Connect a shop air hose to the cylinder inlet. See **Fig. 4** . Slowly apply air pressure, and remove the air chamber assembly.
6. Remove and discard the O-rings from the air chamber and the piston friction disc. Clean the O-ring contact surfaces.
7. Remove the face seal from the air chamber.
8. Remove the System Sentry fuse from the piston friction disc. *Note that it is a left-hand thread.*
9. Remove the rubber umbrella valve from the air chamber.

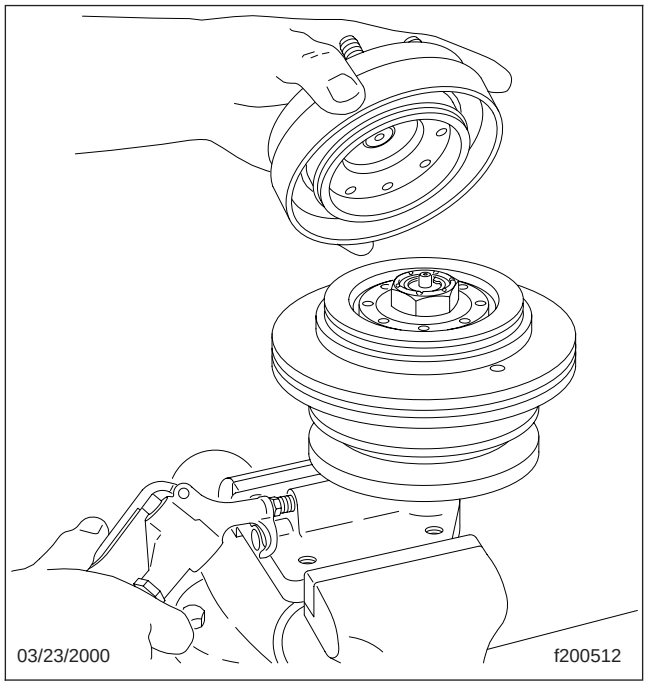


Fig. 4, Remove the Air Chamber

10. Remove the adjusting nut. See **Fig. 5**.

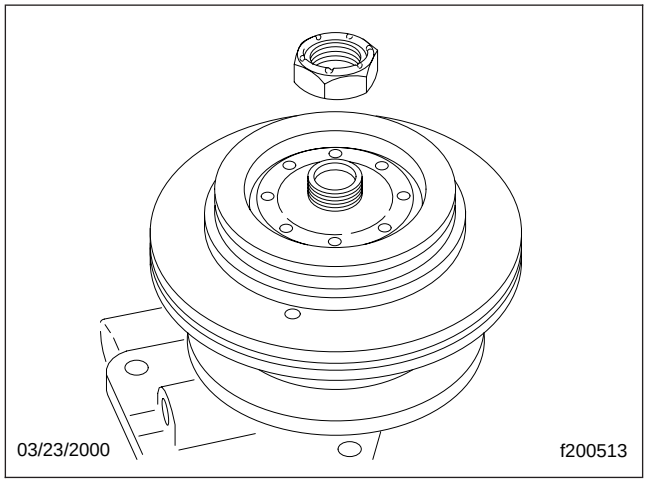


Fig. 5, Remove the Adjusting Nut

11. Remove the disc and piston assembly, and the journal spacer. See **Fig. 6**.
12. Slide the sheave and bearings off the mounting bracket assembly. See **Fig. 7**.
13. Remove the socket-head capscrews from the friction facing. Remove the friction facing.

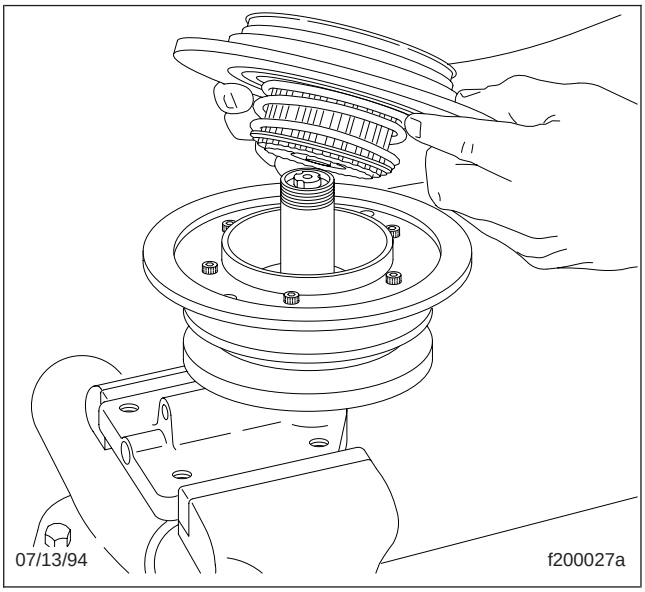


Fig. 6, Remove the Disc and Piston

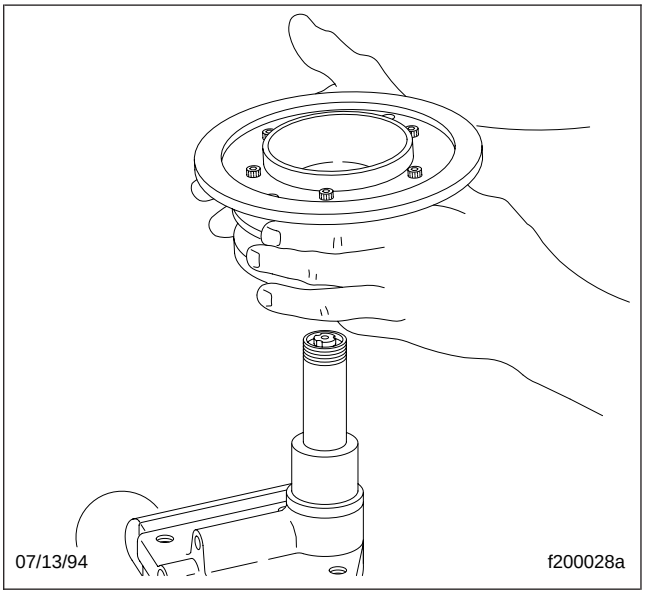


Fig. 7, Slide Off the Sheave and Bearings

14. Remove the retaining ring from the air cartridge assembly. See **Fig. 8**.

    Remove the cartridge assembly from the mounting bracket assembly. See **Fig. 9**.

15. Support the sheave and press out the bearings.

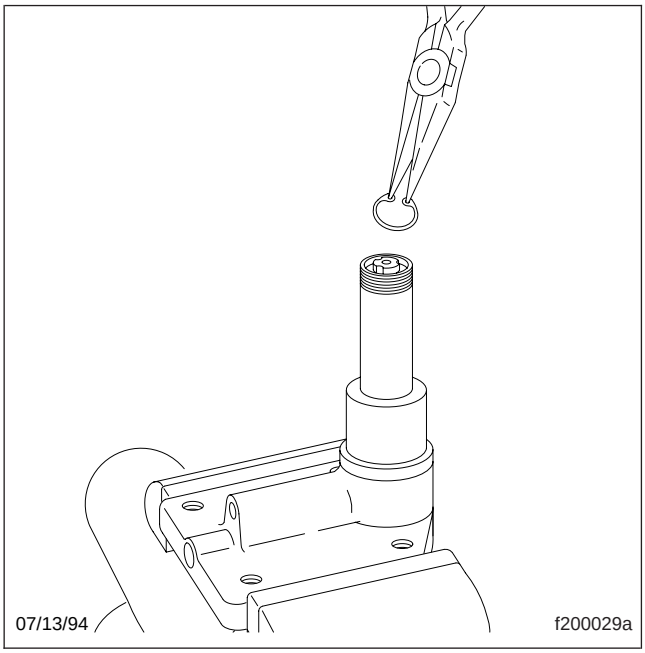


Fig. 8, Remove the Retaining Ring

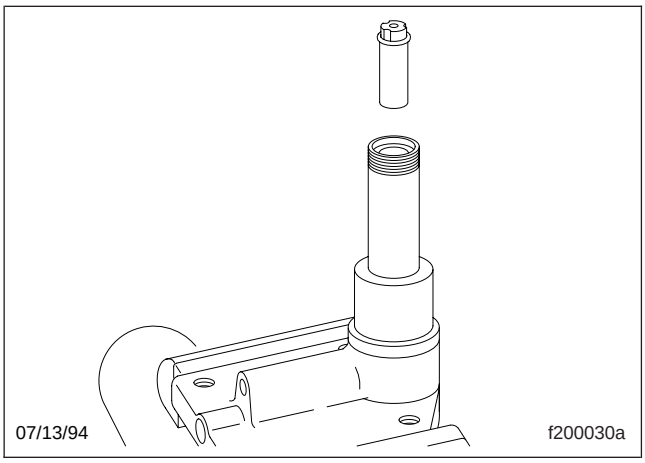


Fig. 9, Remove the Air Cartridge Assembly

Assembly

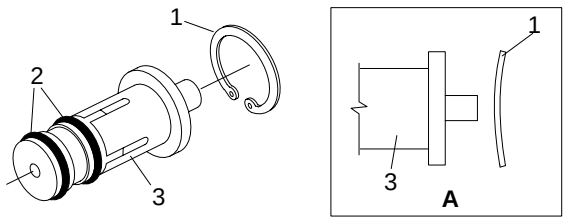
1. Coat the new sheave bearings with grease and press them into the sheave.

NOTE: Some models have a spacer between the bearings. Install the spacer if equipped.

2. Install a new air cartridge assembly in the mounting bracket assembly. Note that the retaining ring

Fan Clutch Major Rebuild

is curved. Make sure the ring is installed with the convex surface toward the air cartridge. See **Fig. 10** .



A. Convex Surface of Retaining Ring Toward the Air Cartridge
1. Retaining Ring
2. O-Rings
3. Air Cartridge

Fig. 10, Air Cartridge Assembly

3. Slide the sheave and bearings onto the mounting bracket assembly.
4. Install a new friction facing onto the sheave. Following a star pattern, tighten the socket-head capscrews 60 lbf·in (680 N·cm).

CAUTION

Never fill more than one-third of the bearing void with grease. Too much grease can cause overheating and possible bearing damage.

5. Install the journal spacer, and the disc and piston assembly. Make sure that the lip on the journal spacer is facing up. See **Fig. 11**.
6. Install the adjusting nut. Tighten 150 lbf·ft (203 N·m).
7. Remove any dust and debris from the air chamber.
8. Coat the new O-rings with an approved lubricant and install them. See **Fig. 12**.
9. Install the new face seal in the air chamber. Tighten 50 lbf·in (565 N·cm).
10. Install the new rubber umbrella valve in the air chamber.
11. Install the new System Sentry fuse in the piston friction disc. *Note that it is a left-hand thread.*

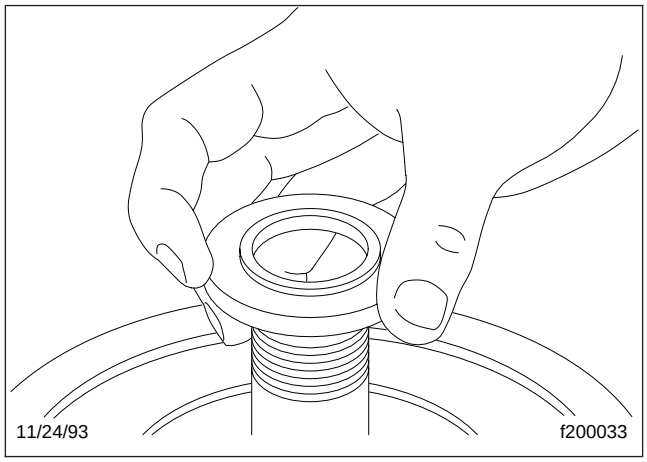


Fig. 11, Check the Journal Lip

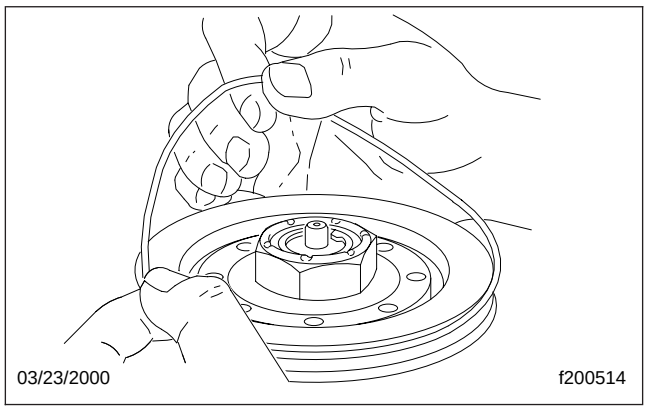


Fig. 12, Install New O-Rings

12. Slide the air chamber assembly onto the clutch. If applicable, install two of the hexbolts that hold the fan in place.
13. Using a screwdriver to keep the air chamber from rotating, install the socket-head capscrews. Following a star pattern, tighten 15 lbf·ft (20 N·m).
14. If applicable, remove the two hexbolts previously installed.
15. Install the fan and clutch assembly on the engine. For instructions, refer to **Subject 100**.

Disassembly

NOTE: This procedure involves replacing only the air cartridge, System Sentry® fuse, the face seal, and the O-rings, using parts from the manufacturer's Seal Kit. If doing a major rebuild, go to **Subject 110**.

1. Remove the fan and clutch assembly from the vehicle. For instructions, refer to **Subject 100**.
2. Clamp the fan clutch in a vise. See **Fig. 1**.

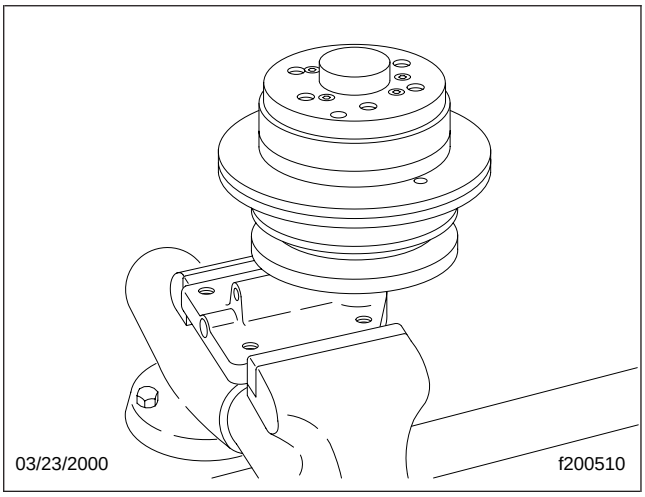


Fig. 1, Fan Clutch Placed in a Vise

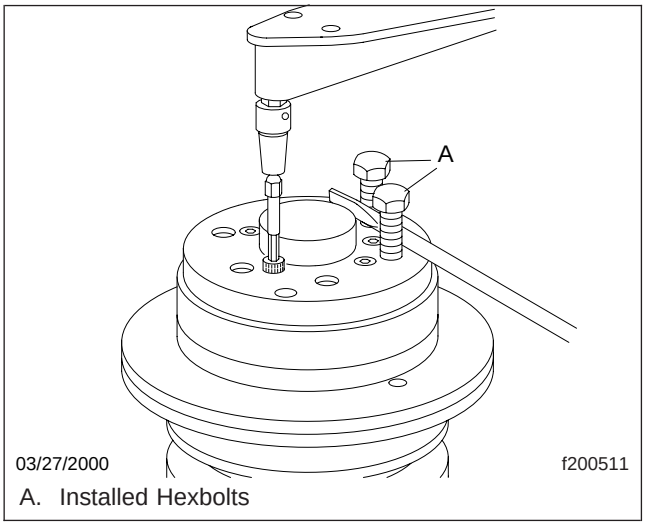
3. On some vehicles, the fan clutch has threaded studs on the air chamber and the fan is attached with nuts. On other vehicles, the fan is attached with hexbolts.

   If hexbolts were used to attach the fan, install two of the removed hexbolts in the air chamber so a screwdriver can be used to keep the air chamber from rotating. See **Fig. 2**.

   Remove the socket-head capscrews from the air chamber.
4. If applicable, remove the two hexbolts previously installed.

⚠ WARNING

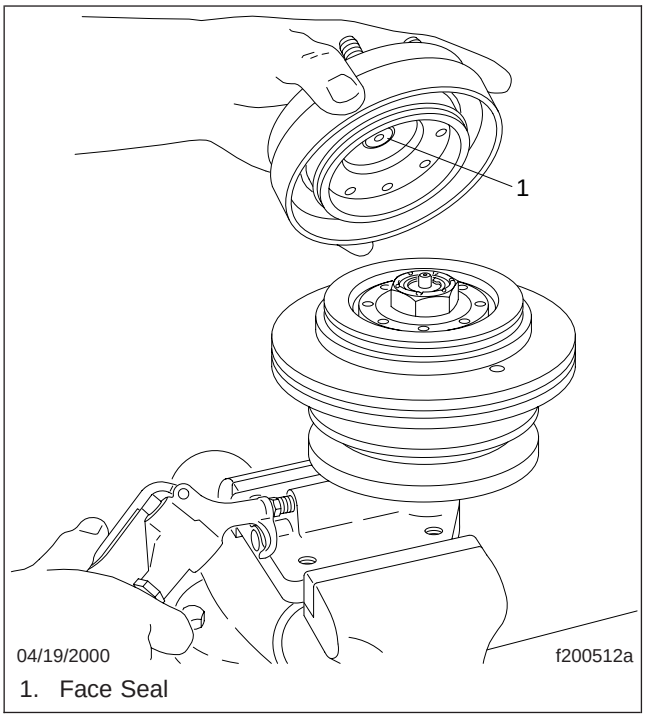
Apply air pressure slowly to the fan clutch. A sudden blast of air might blow the air chamber off the clutch, resulting in possible injury.



A. Installed Hexbolts

Fig. 2, Remove the Socket-Head Capscrews

5. Connect a shop air hose to the cylinder inlet. See **Fig. 3** . Slowly apply air pressure, and remove the air chamber assembly.



1. Face Seal

Fig. 3, Remove the Air Chamber

Fan Clutch Minor Rebuild

6. Remove and discard the O-rings from the air chamber and the piston friction disc. Clean the O-ring contact surfaces.
7. Remove the face seal from the air chamber. See **Fig. 3** .
8. Remove the System Sentry fuse from the piston friction disc. *Note that it is a left-hand thread.*
9. Remove the rubber umbrella valve from the air chamber.
10. Remove the adjusting nut. See **Fig. 4**.

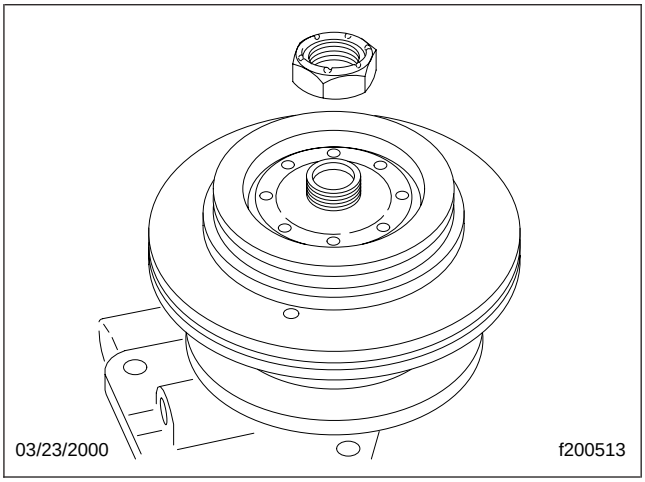


Fig. 4, Remove the Adjusting Nut

11. Remove the retaining ring from the air cartridge assembly. See **Fig. 5**.

    Remove the cartridge assembly from the mounting bracket assembly. See **Fig. 6**.

Assembly

1. Install a new air cartridge assembly in the mounting bracket assembly. Note that the retaining ring is curved. Make sure the ring is installed with the convex surface toward the air cartridge. See **Fig. 7** .
2. Install the adjusting nut. Tighten 150 lbf·ft (203 N·m).
3. Remove any dust and debris from the air chamber.
4. Coat the new O-rings with an approved lubricant and install them. See **Fig. 8**.

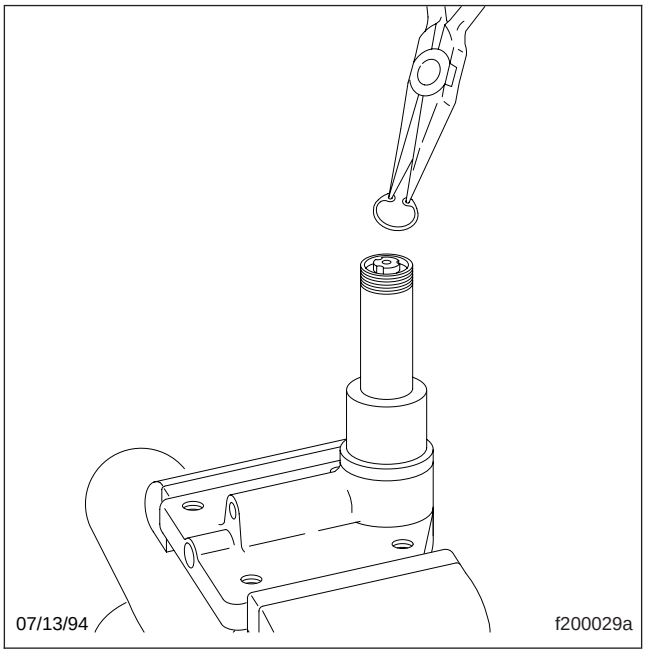


Fig. 5, Remove the Retaining Ring

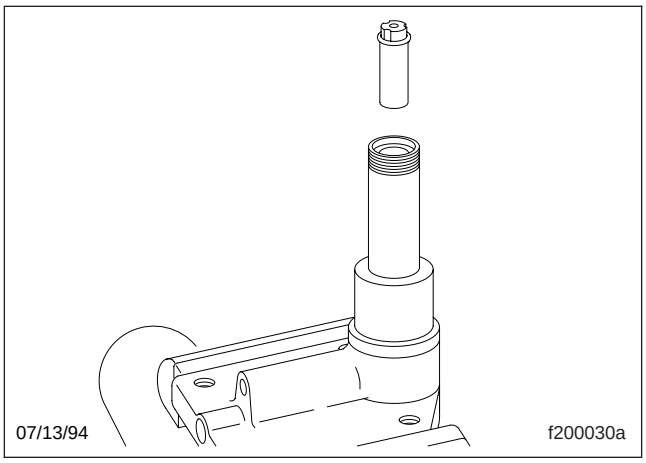
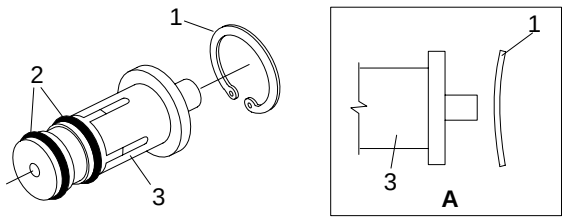


Fig. 6, Remove the Air Cartridge Assembly

5. Install the new face seal in the air chamber. Tighten 50 lbf·in (565 N·cm).
6. Install the new rubber umbrella valve in the air chamber.
7. Install the new System Sentry fuse in the piston friction disc. *Note that it is a left-hand thread.*
8. Slide the air chamber assembly onto the clutch. If applicable, install two of the hexbolts that held the fan in place.



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A. Convex Surface of Retaining Ring Toward the Air Cartridge
1. Retaining Ring
2. O-Rings
3. Air Cartridge

Fig. 7, Air Cartridge Assembly

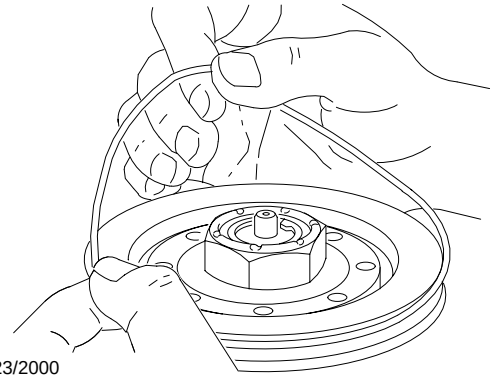

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Fig. 8, Install New O-Rings

9. Using a screwdriver to keep the air chamber from rotating, install the socket-head capscrews. Following a star pattern, tighten 15 lbf·ft (20 N·m).
10. If applicable, remove the two hexbolts previously installed.
11. Install the fan and clutch assembly on the engine. For instructions, refer to **Subject 100**.

Problem—Air Is Leaking from the Fan Clutch

Possible Cause	Remedy
The face seal or air cartridge (**Fig. 1**, Ref. A) is bad.	Install a new seal kit.
The O-ring seals (**Fig. 1**, Ref. B or C) are bad.	Install a new seal kit.

Problem—The Fan Clutch Fails to Engage

Possible Cause	Remedy
There's no power to the fan clutch control circuit.	Check all electrical connections, and repair or replace wiring as needed.
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally open, not normally closed. Replace the switch if it is damaged or if the switch is the wrong type.
The solenoid valve is malfunctioning.	Replace the solenoid valve.
The fan clutch is leaking.	Install a new seal kit.
The air supply to the fan clutch is restricted.	Make sure the fan clutch air lines are not leaking or pinched. Repair the lines as needed.

Problem—The Fan Clutch Does Not Disengage

Possible Cause	Remedy
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally open, not normally closed. Replace the switch if it is damaged or if the switch is the wrong type.
A restricted air line doesn't allow air to vent from the clutch.	Make sure the air lines are not pinched or plugged. Repair the air lines as needed.
The solenoid is not exhausting.	Make sure the solenoid exhaust port is not plugged.
The piston friction disc is seized due to contamination or worn splines.	Replace the piston friction disc, and make sure the fan clutch air supply is clean.

Problem—The Fan Clutch Cycles Frequently

Possible Cause	Remedy
The fan clutch control circuit has a loose connection or is poorly grounded.	Check all wiring connections, and repair the circuit as needed.
The temperature control settings are incorrect.	Check the fan clutch control setting of the temperature switch, according to the engine installed in the vehicle. Repair or replace the temperature switch as needed.
The fan cycling switch at the receiver-dryer is set too low.	Check the switch at the receiver-dryer, and if needed, replace the switch with a switch with a higher setting.
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
The temperature switch is malfunctioning.	Replace the temperature switch.

Troubleshooting

Problem—The Fan Clutch Engages, But the Engine Still Overheats

Possible Cause	Remedy
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
There is a problem somewhere else in the cooling system.	Refer to the cooling system troubleshooting section in this group.

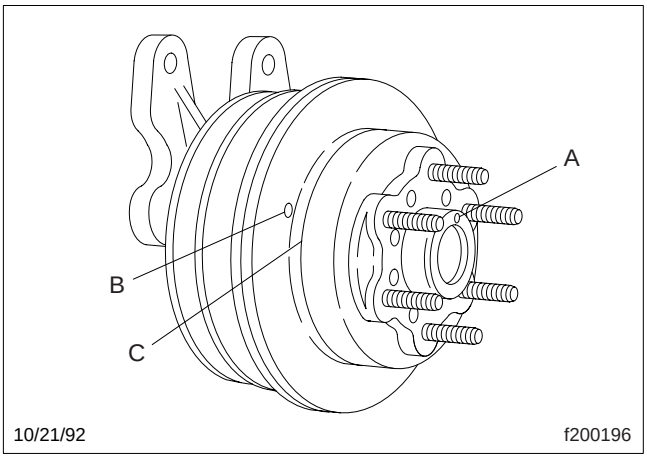


Fig. 1, Possible Fan Clutch Air Leaks

Torque Values		
Fastener	Torque	
	lbf·ft (N·m)	lbf·in (N·cm)
Fan Nut	15 (20)	—
Air Cylinder Nut	—	84 (940)
Air Chamber Capscrew	20 (27)	—
Friction Facing Capscrew	—	20 (220)
Fan Clutch Mounting Capscrews	35 (47)	—
Mounting Bracket Socket-Head Capscrew	45-50 (61-68)	—

Table 1, Torque Values

Approved Greases

Amoco Rykon Premium No. 2 EP

Chevron SRI-2

Texaco Premium RB No. 2

Exxon Unirex No. 2

Shell Dolium Grease No. 2

Approved Lubricants

Parker O-Ring Lube

Horton O-Ring Lube No. 13220

Wiring

See Fig. 1 for the fan clutch wiring diagram.

Specifications

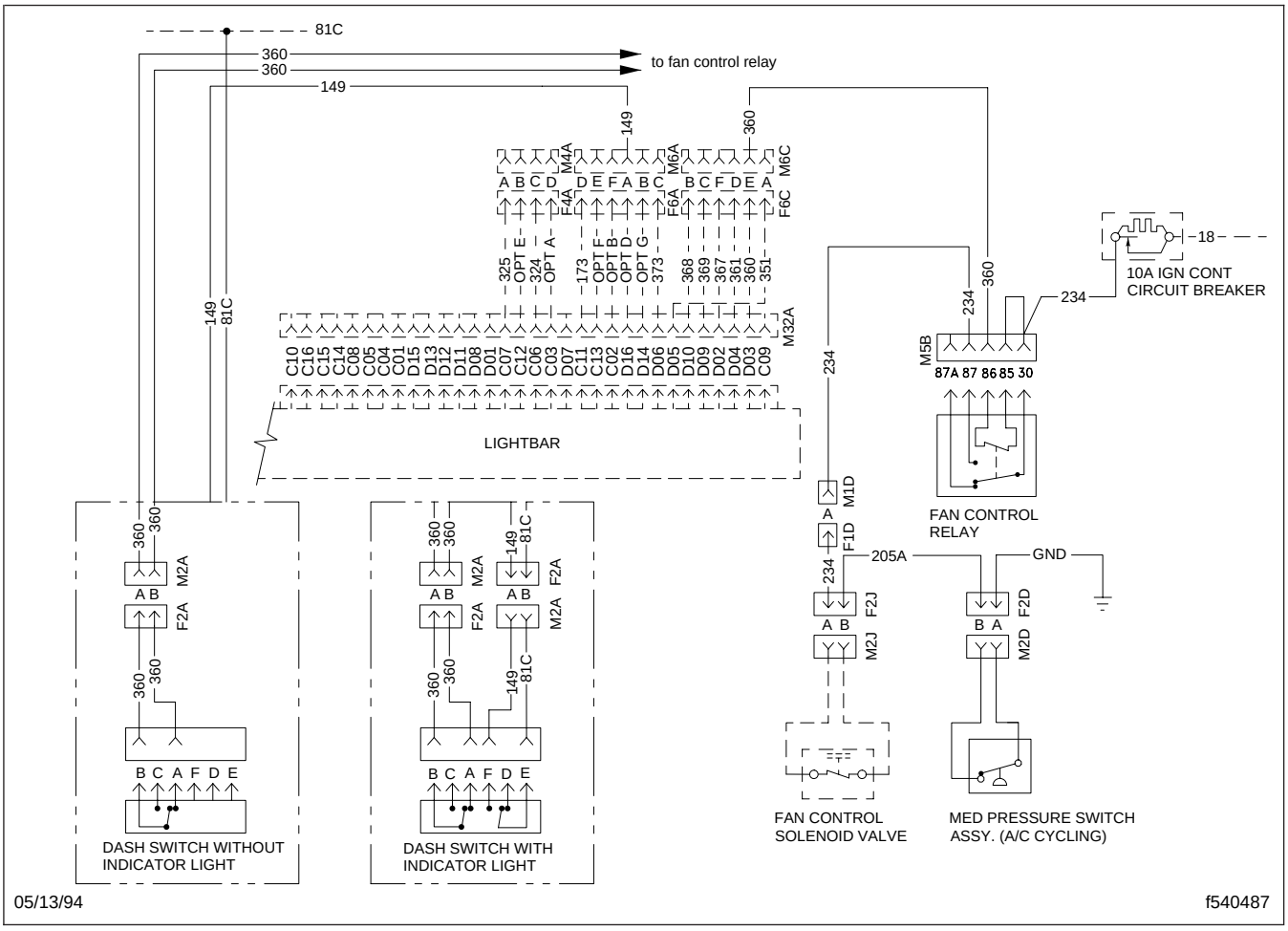


Fig. 1, Fan Clutch Wiring Diagram

General Information and Principles of Operation

The fan drive senses the temperature of air behind the radiator core, and engages or disengages the fan depending on this temperature. An increase or decrease in the amount of heat from the radiator coolant causes a change in the air temperature behind the radiator core. A fan drive sensor detects the temperature change; the fan clutch is engaged when more cooling (airflow) is needed, and disengaged when there is enough cooling.

The fan clutch uses a fluid shearing action to supply the force needed to turn the fan blade. A one-piece input shaft and disc assembly is bolted to a fan hub; the disc is lined with ring-shaped grooves that face matching grooves on the inside of the drive chamber. **See Fig. 1**. Two bearing assemblies allow the drive chamber to be free-wheeling in relation to the input disc.

The centrifugal force of the spinning input disc causes silicon fluid to flow from the drive chamber to the outer edges of the disc. The spacing between the input disc and the drive chamber remains the same, which controls the fluid shearing action as the fluid is forced over the ridges between the grooves. This shearing action causes the drive chamber and fan blade to spin, increasing in speed as all of the grooves are filled with silicon.

The relative speeds of the input disc and the drive chamber, the configuration of the outer edge of the input disc, and spacing between the drive chamber wall and the edge of the input disc, all contribute to the pumping system built into the clutch drive. This pumping system causes a natural circulation of the fluid away from the drive chamber, and directs it into a reservoir chamber. When the temperature of the air leaving the radiator is low, a sensor built into the reservoir closes off a discharge port so that the fluid cannot flow back into the groove area, reducing the fan speed to a controlled minimum value. As the temperature of the air leaving the radiator rises, the sensor opens the port, allowing fluid into the groove area, which increases the fan speed.

General Information and Principles of Operation

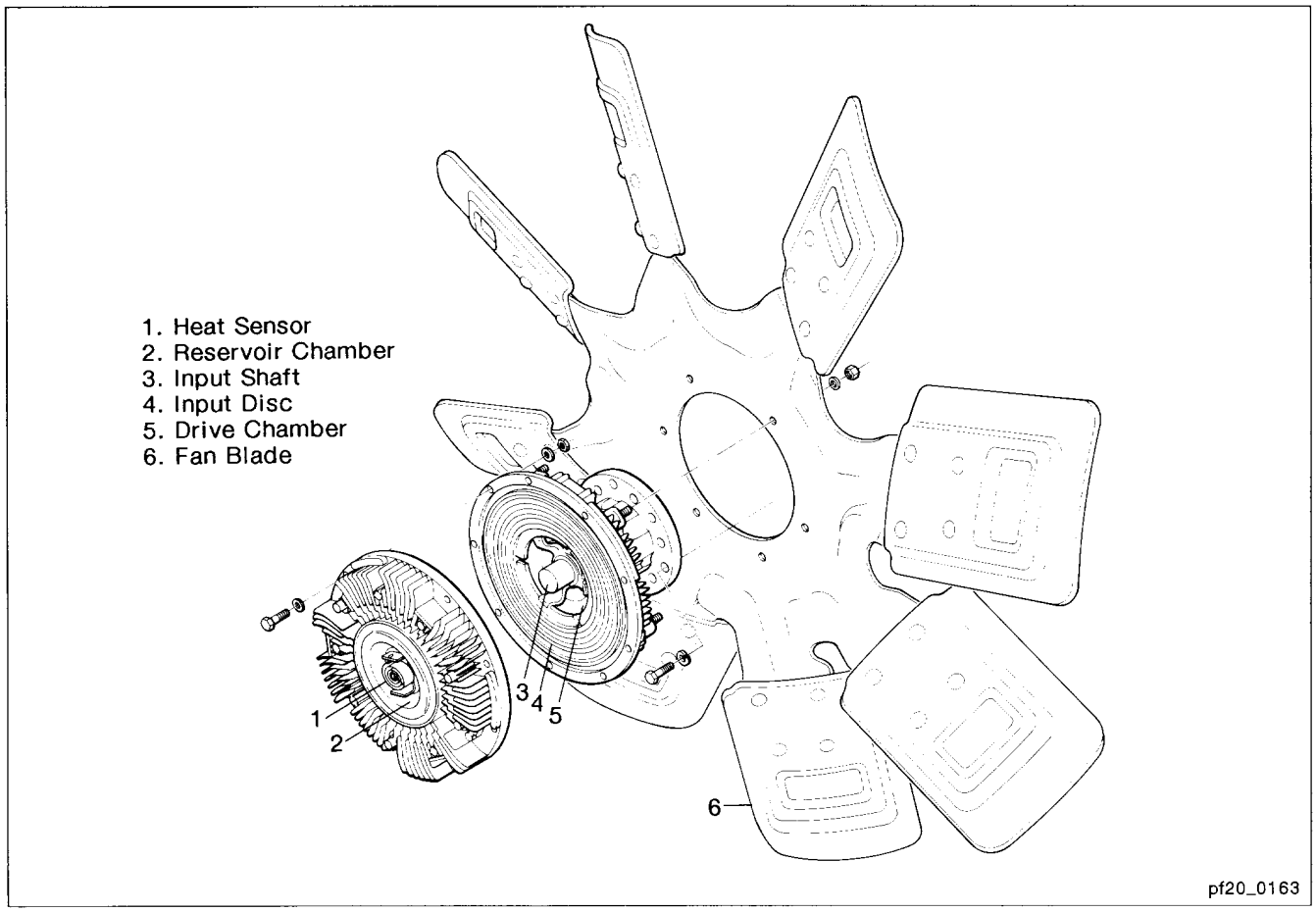


Fig. 1

Inspection

CAUTION

CAUTION: If the fan drive assembly is damaged, replace the unit as soon as possible. Operating a seized or otherwise damaged clutch reduces fuel economy, and could cause serious engine damage.

The fan drive is only one part of the cooling system and will function right if all the other parts of the system are working right. All parts of the system should be checked if there is a cooling problem. If there are damaged or inoperative parts, replace them with new parts.

1. With the engine off, rotate the fan at least one full turn by hand. It should have a smooth, steady drag. If it doesn't, replace the fan clutch.
2. Check for physical damage to the fan or fan shroud.
3. Check the fan clutch mounting.
   - 3.1 Check the torque of the nuts holding the two halves of the fan clutch together. They should be tightened 25 to 30 lbf·ft (34 to 41 N·m).
   - 3.2 Check for correct drive belt alignment and tension. For specifications, refer to the engine section (drive belts) in this manual.
   - 3.3 Check for wear of the fan clutch bearings. There should be no side-to-side or in-and-out movement of the fan clutch.
4. Do all of the checks in the cooling system troubleshooting section in this group.
5. Check the fuel flow rate and exhaust temperature. Overfueling could cause engine overheating and high exhaust temperatures.

Operation Checking

Use the following procedure to check for correct engagement and disengagement of the fan clutch.

1. Coolant temperature in the radiator should be below 140°F (60°C) before you start the test; the outside temperature should be above 50°F (10°C). Ideally, a temperature probe placed about 1/2 inch (13 mm) from the fan clutch sensor is needed to see if the fan clutch engages at the right temperature.
2. Disconnect any hydraulic pumps (such as the power steering pump) to prevent oil overheating.
3. Get a piece of cardboard that is large enough to block the entire front of the radiator. Cut a round seven-inch hole in the cardboard; locate the hole so that it lines up with the fan clutch. Don't put the cardboard in front of the radiator yet.
4. Turn off the air conditioner, if so equipped. Start the engine, and let it idle until the oil pressure is normal.

WARNING

WARNING: Before starting the engine, make sure people's hands and all other objects are away from the fan blades. It is extremely dangerous to get too close to the fan blades when the engine is on, because the fan could start operating without warning. Don't try to restrict fan blade rotation when the engine is on.

5. As soon as there is normal oil pressure, bring the engine up to high idle (about 80 percent of governed engine speed) and lock the throttle at this speed.

   If the engine has been idle for more than eight hours, the fan clutch may engage as soon as the engine is started. If this happens, the usual noise from the fan will be heard; the noise will stop after five minutes or less, when the fan clutch disengages.
6. After the fan clutch disengages, put the cardboard in front of the radiator.
7. Look at the temperature gauge and note at what point the engine thermostat opens. As the engine warms up, the coolant temperature will rise steadily and then seem to level off after the thermostat opens. It will then start rising again, before the fan clutch engages.
8. Keep watching the coolant temperature and, if possible, the temperature of the air in front of the fan clutch, until the clutch engages. Note the temperature(s) at which the clutch engages. When the air at the fan clutch sensor rises to about 165° to 170°F (74° to 77°C) and the cool-

Inspection and Operation Checking

ant rises to about 205°F (96°C), the fan should engage. With the clutch engaged, the coolant temperature will keep rising, at a slower rate, as long as the radiator is blocked with cardboard.

9. Remove the cardboard from in front of the radiator. Keep watching the coolant temperature while the clutch is engaged; you should notice a decrease after the cardboard is removed.
10. When the coolant temperature drops to about 190°F (88°C), the fan should disengage.

    If the coolant temperature keeps rising, even though the fan is engaged and the cardboard has been removed, the fan clutch may be working okay; there may be a problem in another part of the cooling system.

IMPORTANT: If the air temperature in front of the clutch is being tested, and it does not rise as the coolant temperature rises, then the problem could be a clogged radiator or a stuck engine thermostat.

If the coolant temperature still rises, even though everything described above checks out okay, use a stroboscope to check the fan pulley speed and the peak fan speed. The fan speed should be at least 85 percent of the fan pulley speed when the clutch is fully engaged.

Example:

2160 = Fan pulley speed

x .85

1836 = 85 percent of fan pulley speed

Fan speed must be greater than 1836 rpm when the fan clutch is fully engaged.

Viscous Fan Clutch Replacement, Fan Blade Replacement

Replacement (See Fig. 1)

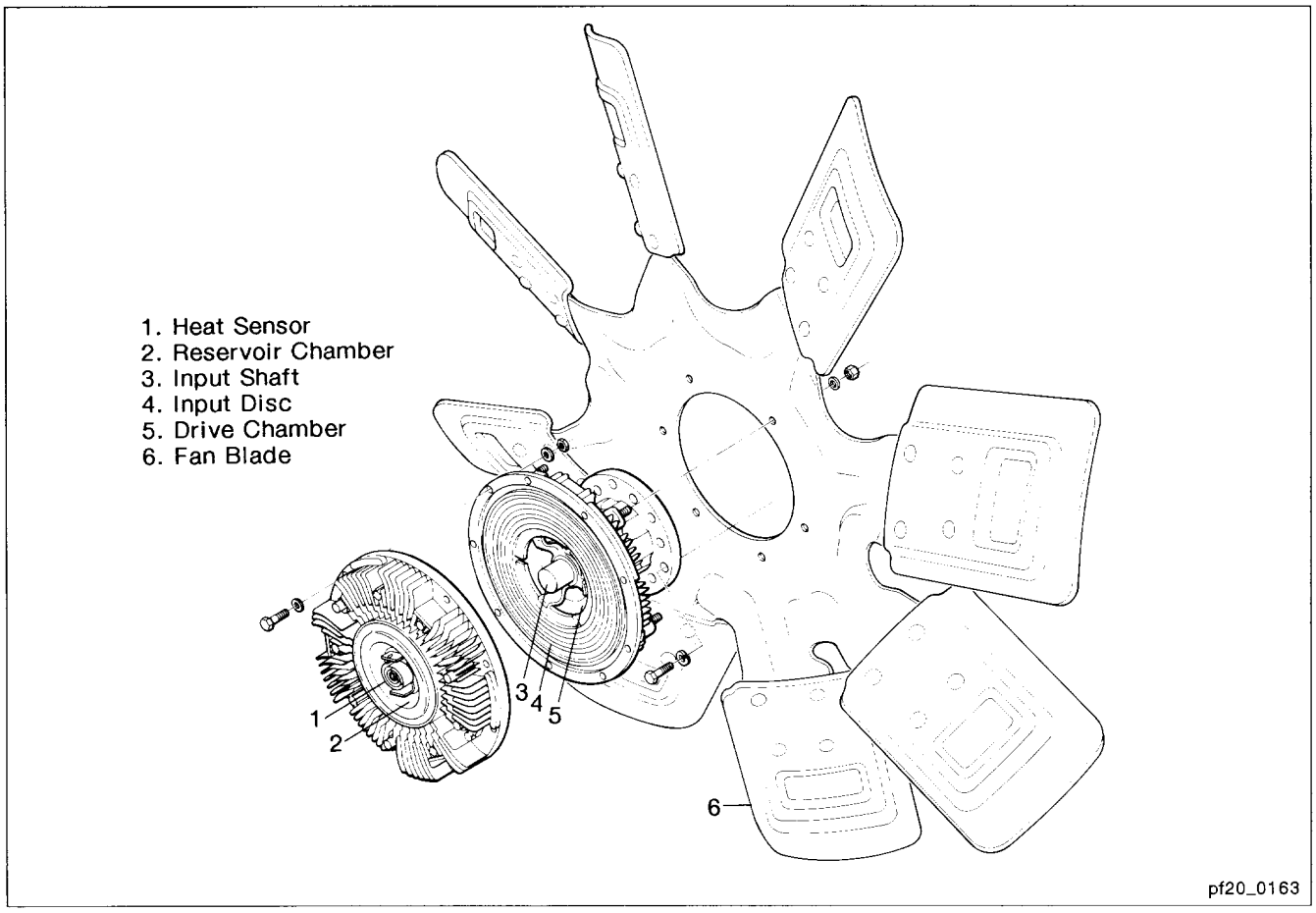


Fig. 1

1. Apply the parking brakes, and chock the tires.
2. If necessary, disconnect any radiator hoses that may interfere with fan removal.

NOTE: Use a drain bucket to catch any coolant that may spill.

3. On 120 Conventionals, tilt the hood halfway and support it. Disconnect the hood cables from the radiator brace-rod brackets. Tilt the hood all the way, and support it.

   Disconnect the three radiator brace rods from the brackets on top of the radiator assembly. Loosen the locknuts on each lower support isolator.

   On COEs, loosen the locknut on the square-neck bolt in each lower support isolator. Remove the flanged bolts and nuts from the stay rods at the radiator side channels.
4. With one person holding each side of the radiator, tilt the top of the radiator forward, until the fan shroud clears the fan.
5. Remove the capscrews and lockwashers holding the clutch to the fan hub. Remove the clutch from the engine.
6. Remove the nuts and lockwashers holding the fan blade to the clutch. Remove the blade.
7. Install the fan blade, lockwashers, and nuts on the clutch. Tighten the nuts 13 to 17 lbf·ft (18 to 23 N·m).

Viscous Fan Clutch Replacement, Fan Blade Replacement

⚠ CAUTION

CAUTION: Do not allow the capscrews in the fan clutch housing to loosen while you attach the fan blade. If they are loosened, there will be a loss of fluid, causing miscalibration and a shortened fan life.

NOTE: Use only approved fans, as specified in the *Freightliner Parts Book* . Never go over the maximum input speeds, and do not make changes to the engine that will raise the operating speed of the fan.

8. Install the fan clutch assembly on the fan hub. Make sure the assembly is aligned okay, using the pilot on the fan hub.
9. Install the lockwashers and capscrews holding the fan clutch assembly to the fan hub. Tighten the capscrews 25 to 30 lbf·ft (34 to 41 N·m).
10. Tilt the radiator upright.

    On COEs, install, but do not tighten the flanged bolts and nuts in the stay rods at the radiator side channels. Tighten the locknuts on the square-neck bolts 55 lbf·ft (75 N·m); then tighten the stay rod bolts 80 lbf·ft (110 N·m).

    On 120 Conventionals, install the radiator brace rods; tighten the locknuts 70 lbf·ft (95 N·m). Tighten the locknuts on each lower support isolator 190 lbf·ft (260 N·m). Support the hood in the half-tilt position and attach the hood cables to the radiator brace-rod brackets.
11. Connect any radiator hoses that were disconnected earlier. Make sure that the radiator is filled with coolant to the bottom of the filler neck.

General Information

The fan drive is an air-operated, temperature-controlled clutch for the engine cooling fan. Its purpose is to maintain engine temperature by engaging or disengaging the fan. The fan clutch is disengaged when the coolant temperature is in or below the specified temperature range; the fan clutch engages when the coolant temperature rises above the range.

Principles of Operation (See Fig. 1 and Fig. 2)

The fan clutch is spring-loaded in the engaged position. It is disengaged when air pressure is applied to the cylinder on the front of the unit. Air pressure to the cylinder is controlled by a solenoid valve; the solenoid is controlled by a temperature switch that is immersed in engine coolant.

When a cold engine is started, the temperature switch is open, which activates the solenoid. The solenoid valve allows compressed air to enter the cylinder. When the pressure reaches about 90 psi (621 kPa), the fan clutch disengages.

When the coolant temperature rises to the temperature switch setting, the switch closes. The solenoid valve releases the compressed air from the cylinder, and the fan clutch spring engages the clutch.

When the coolant temperature drops to the temperature switch cutoff setting, the switch opens, activating the solenoid. Compressed air passes to the cylinder, disengaging the clutch.

On vehicles with air conditioning, the fan clutch solenoid valve is connected to the fan cycling switch. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch closes the circuit to the solenoid valve, which exhausts air from the cylinder and engages the fan clutch.

When disengaged, it is normal for the housing (and fan) to spin at about 170 rpm. When the compressed air is released and the clutch engages, the housing and fan move forward about 1/10-inch (2.5 mm).

NOTE: For information on fan clutch system operation on vehicles with a radiator shutter, refer to the radiator shutter section in this group.

General Information and Principles of Operation

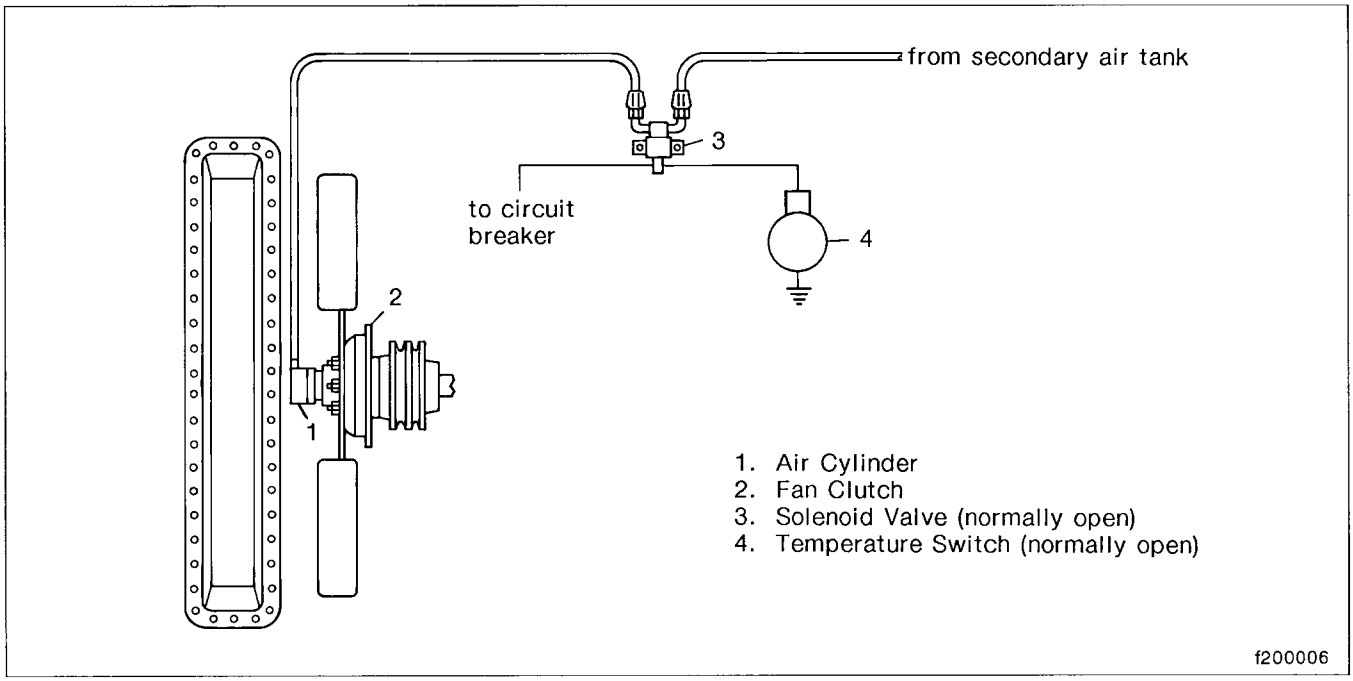


Fig. 1, Fan Clutch Piping and Wiring, Vehicle Without Air Conditioning

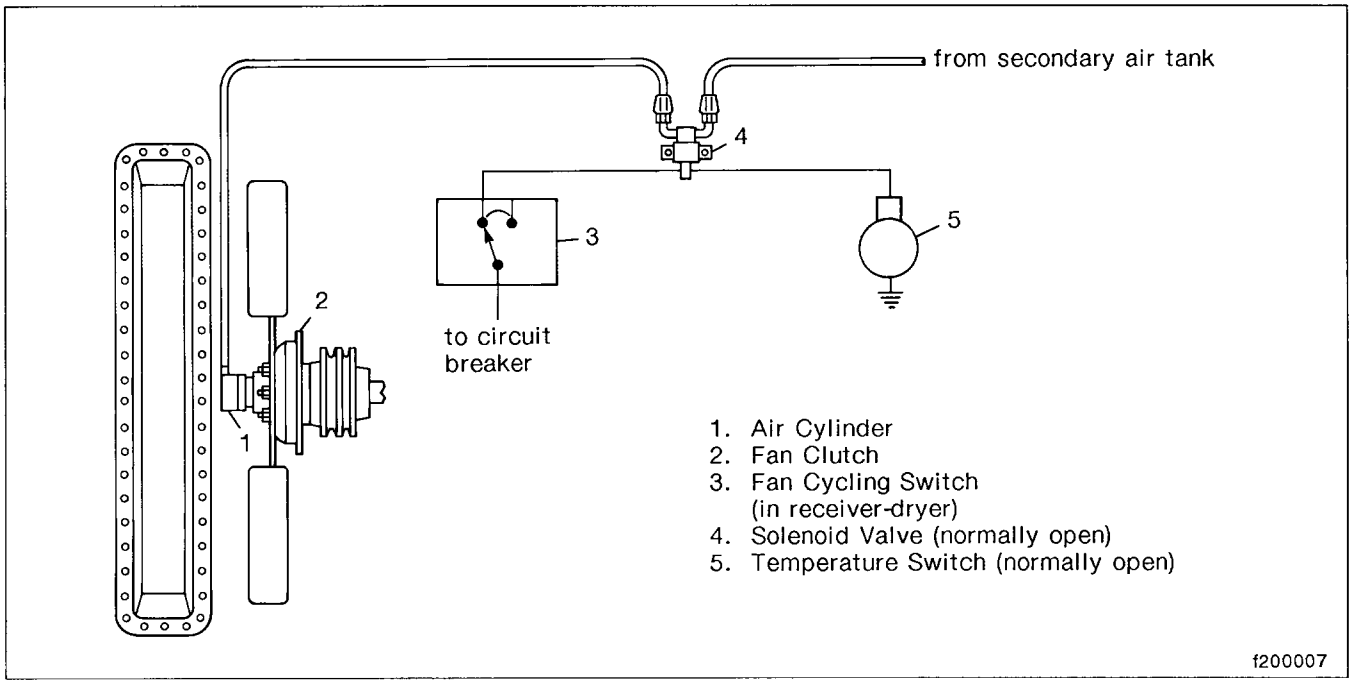


Fig. 2, Fan Clutch Piping and Wiring, Vehicle With Air Conditioning

Removal

See Fig. 1

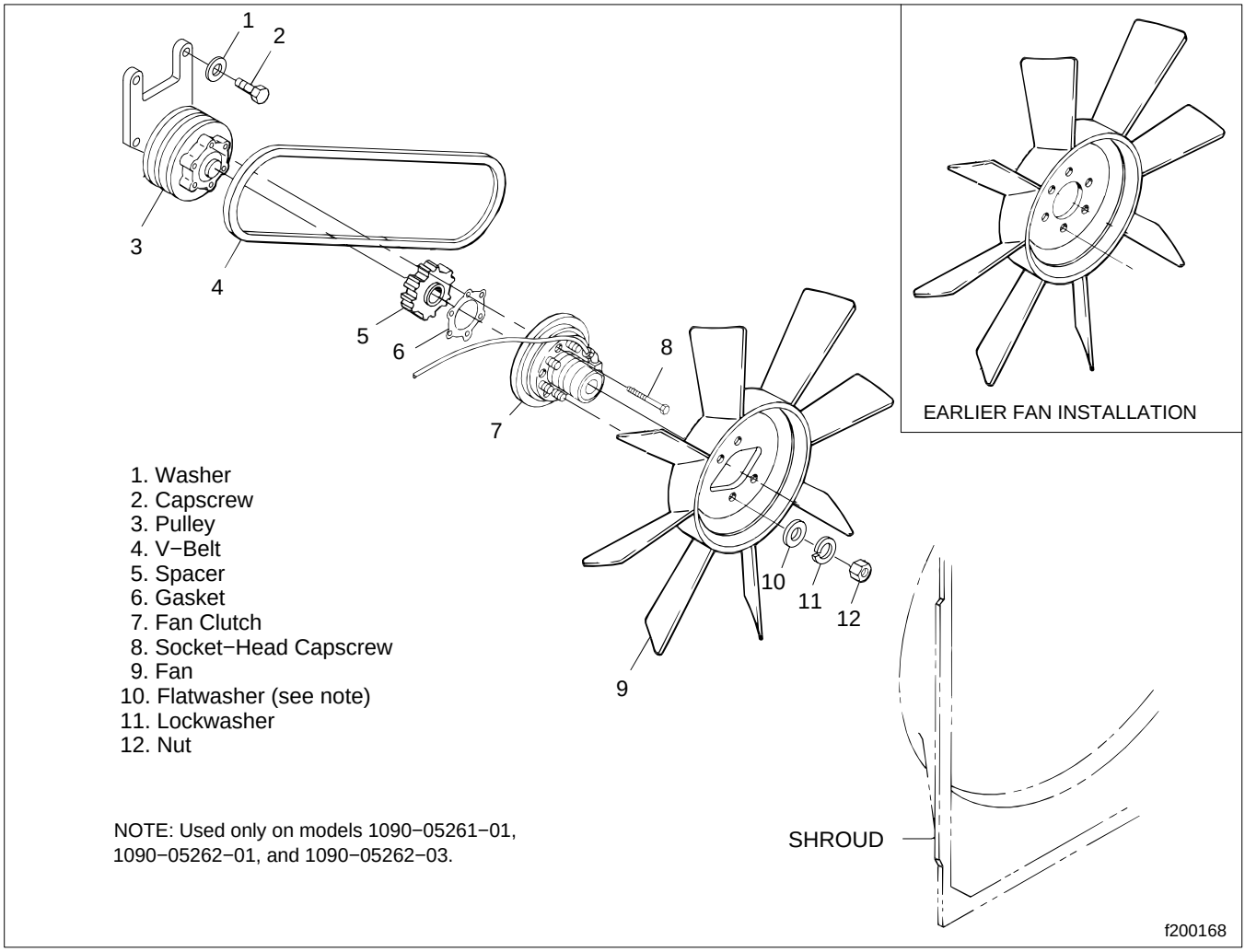


Fig. 1

CUMMINS L10

1. Apply the parking brakes, and chock the tires.
2. Tilt the hood or cab as applicable.
3. Disconnect the air line from the clutch cylinder.
4. Loosen the V-belt adjustments.
5. Remove the entire fan-and-drive assembly from the engine as follows:

5.1 Attach a sling to the fan-and-drive assembly. Remove the four capscrews that hold the pulley hub to the engine.

5.2 Take the V-belts off the rear of the pulley. Lift the assembly out of the engine compartment.

On some vehicles, you may need to tilt the radiator forward. Support the hood as described in the hood section in this manual. Loosen the brace rod fasteners (FLD Conventionals) or stay rod fasteners

(COEs) and the lower radiator fasteners. Have an assistant tilt the radiator as you remove the fan-and-drive assembly.

CATERPILLAR AND CUMMINS NTC

1. Apply the parking brakes, and chock the tires.
2. Tilt the hood or cab as applicable.
3. Disconnect the air line from the clutch cylinder.
4. Support the hood as described in the hood section in this manual.
5. Loosen the brace rod fasteners (FLD Conventionals) or stay rod fasteners (COEs) and the lower radiator fasteners. Tilt the radiator forward and brace it in place.
6. Remove the nuts and washers that hold the fan on the clutch, and remove the fan.

   If the fan doesn't clear the air cylinder, remove the cylinder air line fitting. If there still is not enough room, remove the locknut, tabwasher, and the air cylinder. Remove the fan.
7. If they were removed, install the air cylinder, tabwasher, and locknut. Connect a shop air hose to the air cylinder inlet, and apply 90 to 120 psi (621 to 827 kPa) to disengage the clutch.
8. Turn the clutch housing until the holes line up with the socket-head capscrews that hold the clutch assembly to the hub. Disconnect the shop air hose.
9. Remove the socket-head capscrews, and remove the clutch assembly.

Installation (See Fig. 1)

CUMMINS L10

1. Using a sling, lower the fan-and-drive assembly into place on the front of the engine.
2. Place the V-belts over the pulley.
3. Fasten the hub to the engine. Tighten the capscrews 35 lbf·ft (47 N·m).
4. Tighten the radiator fasteners if they were loosened.
5. Check that there is about 1-inch (25-mm) clearance between the fan blade and the shroud on the right side, and about 3/4-inch (19-mm) clearance on the top, bottom, and left sides; this allows for engine torque movement. Reposition the shroud if needed.
6. Adjust the V-belts.
7. Attach the air line to the cylinder; do not overtighten the nut. Using the adjustment provided at the shroud, place enough tension on the tube so that its front-to-rear or side-to-side play does not exceed 1/2 inch (13 mm).

CATERPILLAR AND CUMMINS NTC

1. Apply Loctite 242® to the socket-head capscrews. Position the spacer and gasket (if used), and clutch assembly on the fan hub. Install the socket-head capscrews, and tighten them 44 lbf·ft (60 N·m).
2. With the radiator tilted forward and braced in place, install the fan. If more clearance is needed, remove the air cylinder fitting, or remove the air cylinder. Install the fan, washers, and locknuts. Tighten the locknuts 44 lbf·ft (60 N·m).
3. If they were removed, install the air cylinder, tabwasher, and locknut. Make sure the tabwasher is seated. Tighten the locknut 84 lbf·in (940 N·cm).
4. Return the radiator to the operating position. Tighten bottom radiator fasteners 30 lbf·ft (41 N·m). Tighten round brace-rod nuts 90 lbf·ft (122 N·m). Tighten flat brace-rod fasteners 70 lbf·ft (95 N·m).
5. Check that there is about 1-inch (25 mm) clearance between the fan blade and the shroud on the right side, and about 3/4-inch (19 mm) clearance on the top, bottom, and left sides; this allows for engine torque movement. Reposition the shroud if needed.
6. Attach the air line to the cylinder; do not overtighten the nut. Using the adjustment provided at the shroud, place enough tension on the tube so that its front-to-rear or side-to-side play does not exceed 1/2 inch (13 mm).

Testing

1. Start the engine. As air pressure builds to about 90 psi (621 kPa) the clutch should disengage.
2. Allow air pressure to build to over 100 psi (690 kPa), then shut down the engine. Check that the fan rotates freely. Check for air leaks.
3. With the fan clutch still disengaged, check the bearing play by measuring fan tip fore-and-aft movement as follows:

   On 1090-05261 and 1090-05262 models, there should be minimal bearing play when a fan blade tip is rocked fore and aft.

   On 1090-06060, 1090-06620, and 1090-08000 models:

   3.1 Place a ruler against a fixed engine surface, next to a fan blade tip.

   3.2 Rock the fan blade fore and aft, using a blade next to the one being measured. Maximum allowable movement at the tip is 0.170 inch (4.3 mm), about 3/16 inch.

NOTE: The fan clutch model number is stamped on the tag on the air cylinder. Also, the model can be identified by the type of retaining plate fasteners used. See the appropriate table **in "Specifications, 400."**

4. Start the engine and run it at governed rpm. Watch the coolant temperature gauge; coolant temperature should stay within the normal operating range while the fan clutch completes one cycle. For faster cycling, use a piece of cardboard to partially block radiator airflow.

   The temperature switch should open at about 200°F (93°C), engaging the fan clutch. The switch should close at about 194°F (90°C) to disengage the clutch. For temperature switch settings on vehicles with a radiator shutter, refer to the radiator shutter section in this group.

NOTE: On 1090-06060-02 and 1090-06620-01 models, fore-and-aft fan tip movement or wobble is normal when the clutch is disengaged.

5. Check for clutch slippage, as follows:

   5.1 Disconnect the clutch air supply tube from the solenoid valve to release the air pressure and engage the clutch.

   5.2 Run the engine at rated rpm. Using a photo tachometer, compare the fan rpm with the pulley rpm. If there is a difference, the clutch is slipping and needs to be overhauled.

6. Check clutch lining wear. Refer to the engine cooling section in the vehicle maintenance manual.

Disassembly

NOTE: **See Fig. 1 or Fig. 2** for parts identification.

See Fig. 3. Remove the capscrews and separate the fan drive from the spacer and pulley. Use care not to damage the spacer gasket.

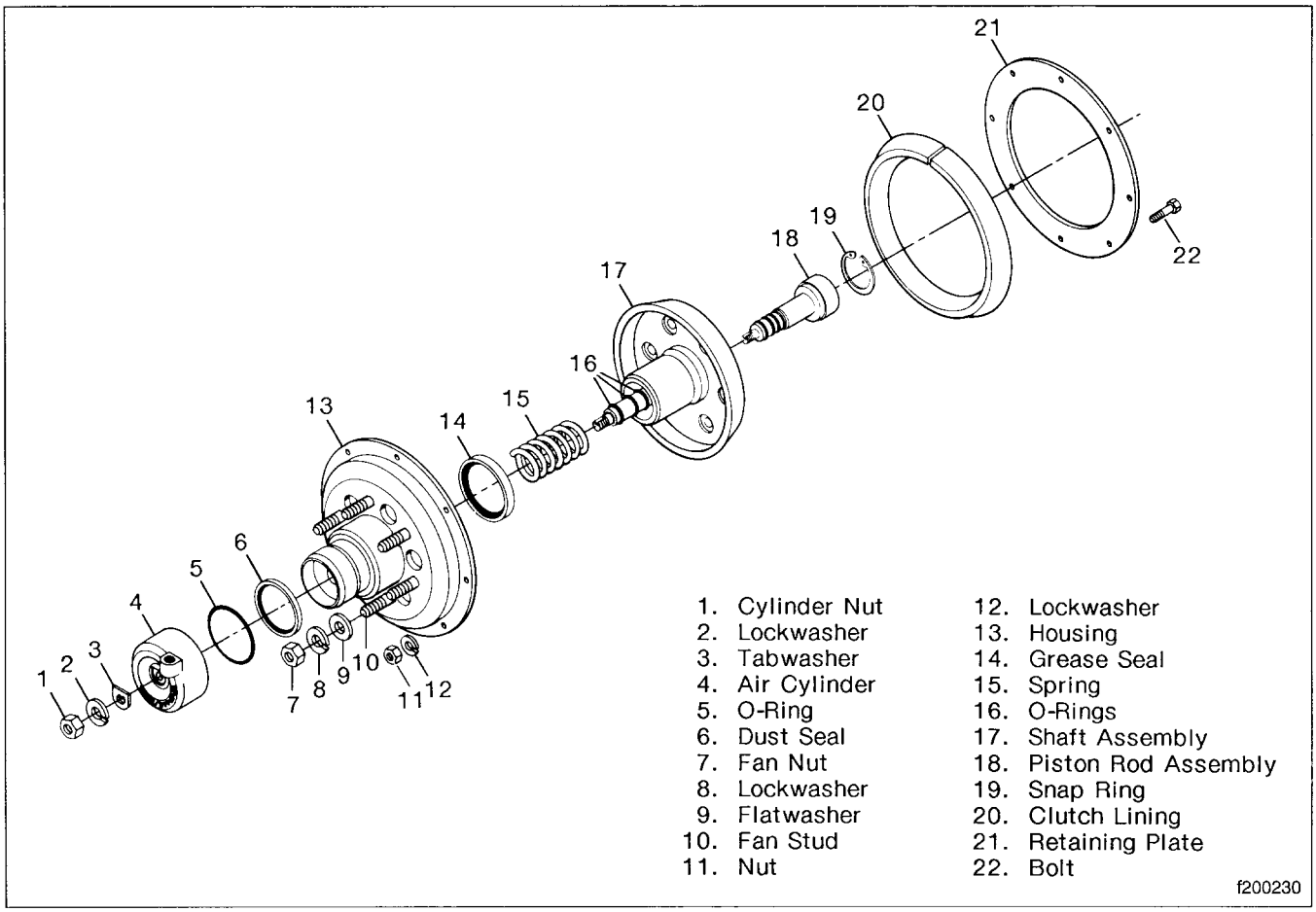


Fig. 1, Series 1090 Fan Clutch, Models 05261 and 05262

1. Remove the fan and clutch assembly from the vehicle. **Refer to Subject 100.**
2. Remove the retaining plate(s) as follows:
   - 2.1 On Cummins L10 installations, remove the nuts and washers that secure the fan, then remove the fan.

     Connect a shop air hose to the cylinder inlet. Apply 90 to 120 psi (621 to 827 kPa) to disengage the clutch.

     Rotate the housing until the holes line up with the socket-head cap-screws.

     With the air pressure still applied, remove the retaining plate fasteners. Remove the plate(s) and lining.

   - 2.2 On Caterpillar and Cummins NTC installations, connect a shop air hose to the cylinder inlet. Apply 90 to 120 psi (621 to 827 kPa) to disengage the clutch.

     Remove the retaining plate fasteners. Remove the plate(s) and lining.
3. Disconnect the air hose. Remove the nut and tabwasher from the cylinder. Remove the cylin-

Disassembly, Inspection, and Assembly

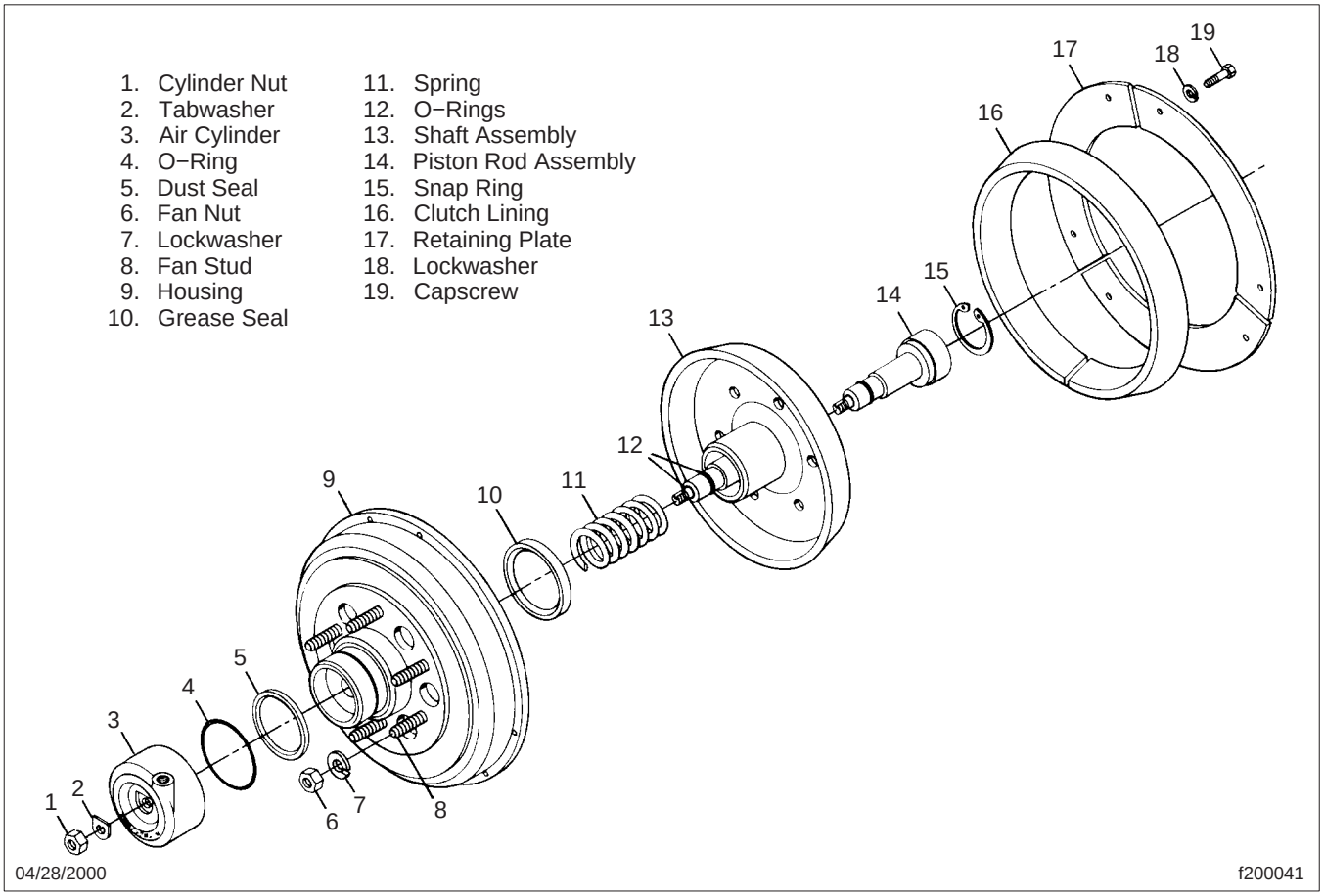


Fig. 2, Series 1090 Fan Clutch, Models 06060 and 06620

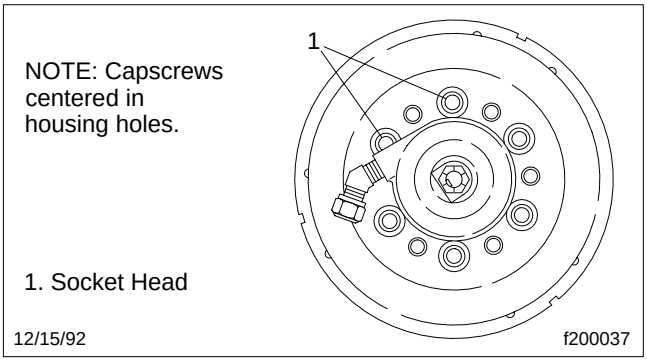


Fig. 3

der. If it is difficult to remove, apply 5 to 10 psi (34 to 68 kPa).

4. Remove and discard the cylinder O-ring.
5. Pull the shaft assembly out of the housing. Remove and discard the spring.
6. Remove and discard the piston-rod O-rings (**Fig. 4**).
7. Note the position of the lip on the housing grease seal, then remove and discard the seal.

Inspection

NOTE: **See Fig. 1 or Fig. 2** for parts identification.

1. Inspect the air cylinder for cracks or deformation; replace if damaged. If the dust seal shows wear or damage, replace it also.
2. Inspect the housing as follows (**see Fig. 5**):

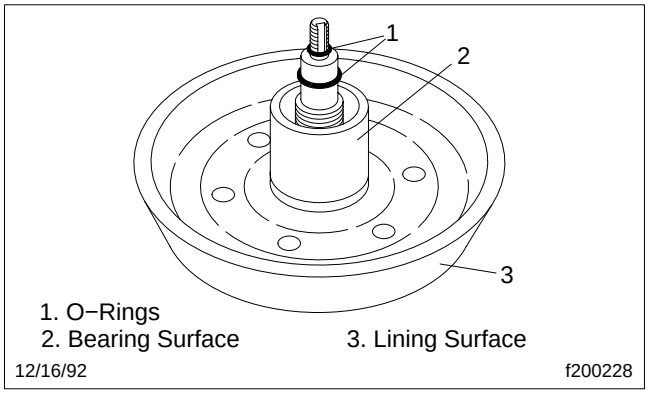


Fig. 4

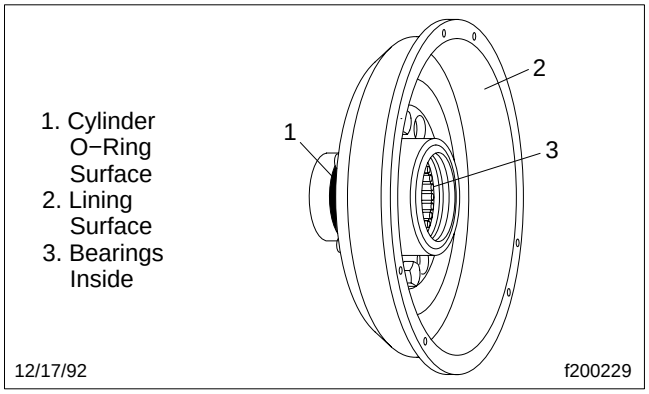


Fig. 5

2.1 Check for scoring, burning, or cracking in the lining area; replace the housing if damaged. Don't attempt to resurface it.

2.2 Check for scoring on the air cylinder O-ring surface; replace the housing if scored. Don't attempt to resurface it.

2.3 Push on and turn the sealed ball bearing while feeling for roughness. If the bearing feels rough, replace the housing.

2.4 Check that all needle bearings are present and roll freely; replace the housing if there is a problem.

3. Inspect the shaft assembly as follows (**see Fig. 4**):

3.1 Check for scoring, burning, or cracking in the lining area; replace the shaft assembly if damaged. Don't attempt to resurface it.

3.2 Inspect the bearing surface for scoring; replace the shaft assembly if scored.

3.3 Turn the piston rod to check for roughness in the sealed ball bearing. If the bearing feels rough, replace the piston rod assembly.

Assembly

NOTE: **See Fig. 1** or **Fig. 2** for parts identification.

1. Wipe the air cylinder clean, then coat a new O-ring with approved grease (**see "Specifications, 400"**) and install it. Install the dust seal.
2. Assemble the housing as follows:

2.1 Clean off dust and debris from the inside of the housing.

2.2 Remove the old grease from the needle bearings with a clean, lint-free rag.

NOTE: Don't wash the needle bearings in solvent.

2.3 Lightly grease the needle bearings with approved grease.

2.4 Install a new grease seal with the lip facing the direction noted earlier. Lightly grease the seal lip.

3. Remove dust and debris from the shaft assembly. Coat the new O-rings with grease and install them on the piston rod.
4. Place a new spring over the piston rod.
5. Insert the shaft assembly into the housing; turn the housing slightly to ease assembly. **See Fig. 6.**

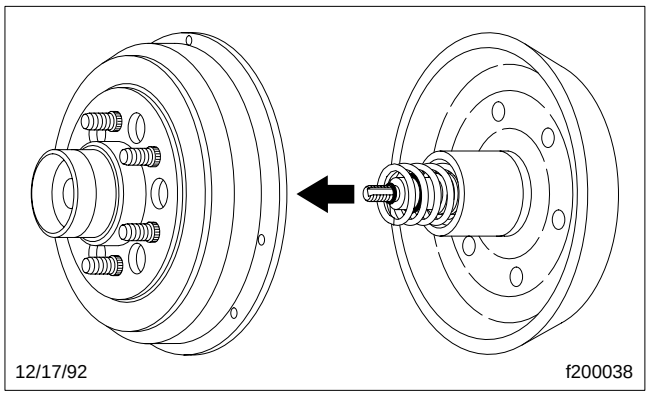


Fig. 6

Disassembly, Inspection, and Assembly

6. Place the air cylinder on the housing so the flat side of the tabwasher cavity faces the notch in the piston rod. **See Fig. 7.**

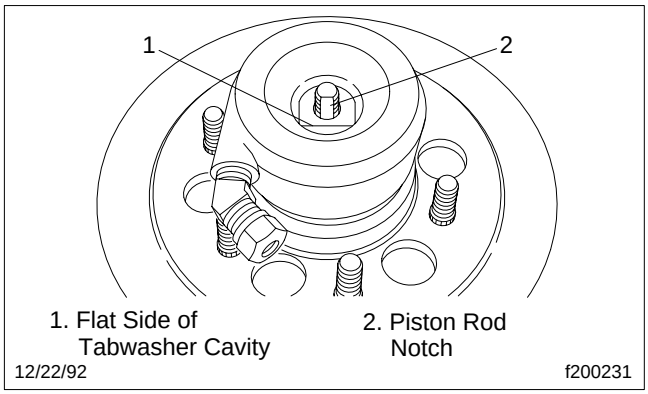


Fig. 7

7. Using two welding clamps, squeeze the housing and the shaft assembly together until the piston rod juts out of the cylinder far enough to install the tabwasher and nut. **See Fig. 8.** Tighten the nut 84 lbf·in (940 N·cm).

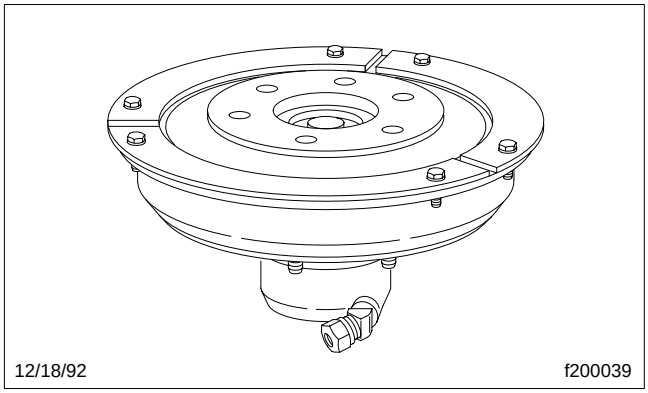


Fig. 8

8. Using a shop air hose, apply 90 to 120 psi (621 to 827 kPa) to the air cylinder. Remove the welding clamps.
9. Install the new lining. Attach the retaining plates and tighten the capscrews or nuts 30 lbf·in (340 N·cm). **See Fig. 9.**
10. With the air pressure still applied, rotate the housing so the holes line up with the pulley mounting holes. Disconnect the air hose.
11. Again, tighten the air cylinder nut 84 lbf·in (940 N·cm).

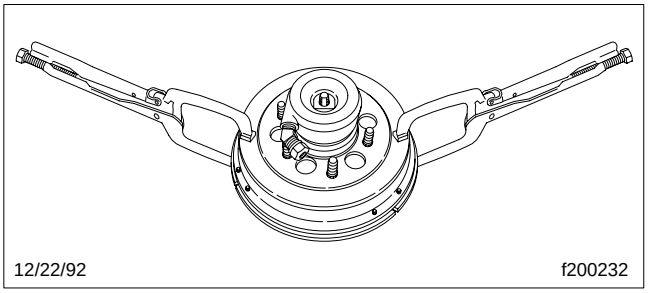


Fig. 9

12. For Cummins L10:
    - 12.1 Apply Loctite 242® to the socket-head capscrews. Place the spacer and gasket on the pulley, then tighten the capscrews 44 lbf·ft (60 N·m).
    - 12.2 Install the fan, using the washers and locknuts. Tighten the nuts 44 lbf·ft (60 N·m).
13. Install the assembly on the vehicle using the instructions **in Subject 100**.

Troubleshooting Chart

Possible causes of fan clutch problems are listed below. For more information, refer to the cooling system troubleshooting section in this group.

Problem—Clutch Does Not Engage

Possible Cause	Remedy
The clutch is worn.	Overhaul the clutch assembly.
The solenoid valve is not relieving air pressure.	Check the solenoid valve and temperature switch.

Problem—Clutch Does Not Disengage

Possible Cause	Remedy
Air pressure is low.	Repair the air system to supply a minimum of 90 psi (621 kPa) to the air cylinder.
The clutch is seized.	Apply 90 to 120 psi (621 to 827 kPa) to the cylinder. The housing should move rearward, and the fan should turn easily by hand. If the fan does not move, try to free the clutch by lightly tapping the housing. If the fan still does not turn easily, overhaul the clutch assembly.

Fan Clutch Bearing Play		
Model Number	**Retaining Plate Fasteners**	**Maximum Bearing Play (measured at fan blade tip) inch (mm)**
1090-05261-01	Bolt, Lockwasher, and Nut	—
1090-05262-01		
1090-05262-03		
1090-06620-01	Capscrew and Lockwasher	0.170 (4.3) about 3/16"
1090-06060-02		
1090-08000-01		

Table 1, Fan Clutch Bearing Play

Torque Values		
Fastener	**Torque**	
	lbf·ft (N·m)	**lbf·in (N·cm)**
Fan Nut	44 (60)	—
Air Cylinder Nut	—	84 (940)
Pulley Socket-Head Capscrew *		—
Retaining Plate Nut or Capscrew	—	30 (340)

* Apply Loctite 242 to the threads.

Table 2, Torque Values

Approved Greases

Amoco Rykon Premium No. 2 EP

Chevron SRI-2

Shell Aero Grease 5

Shell Alvania Grease 3

Texaco Premium RB

Refer to the figures in this subject as follows:

Fig. 1, Fan Clutch Piping and Wiring, Vehicle Without Air Conditioning and **Fig. 2, Fan Clutch Piping and Wiring, Vehicle With Air Conditioning.**

Specifications

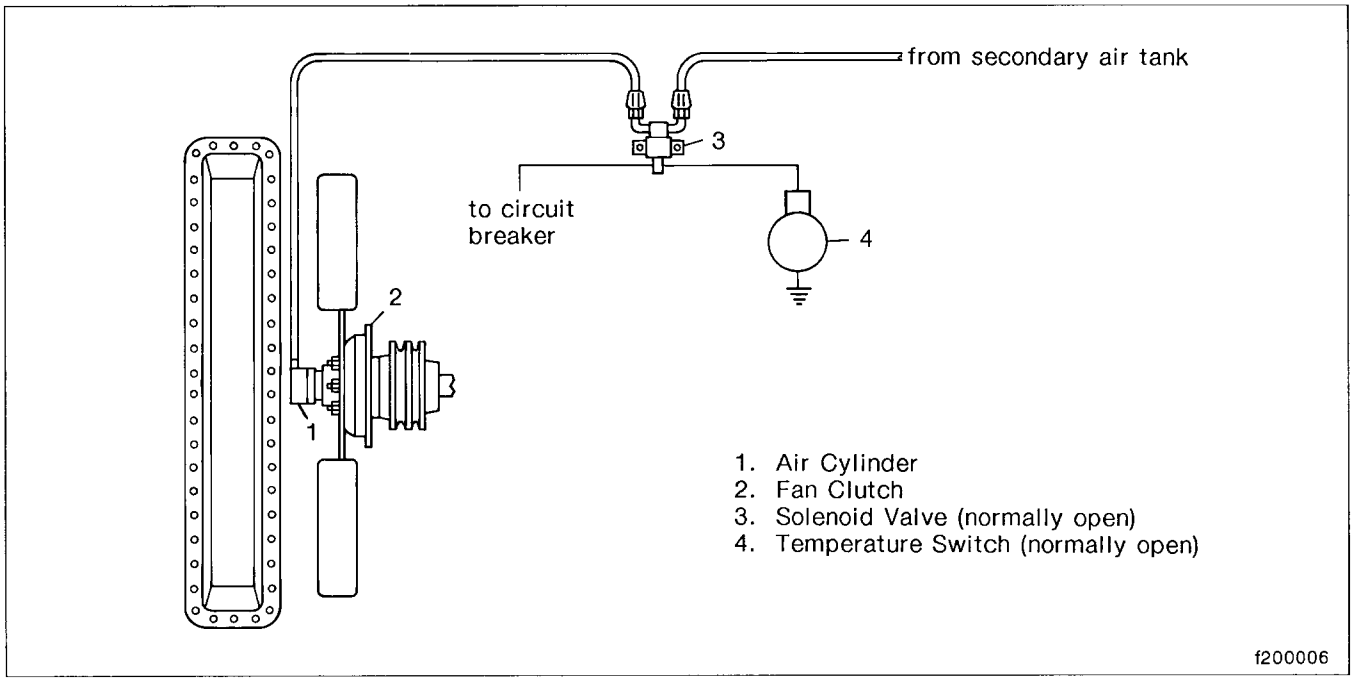


Fig. 1, Fan Clutch Piping and Wiring, Vehicle Without Air Conditioning

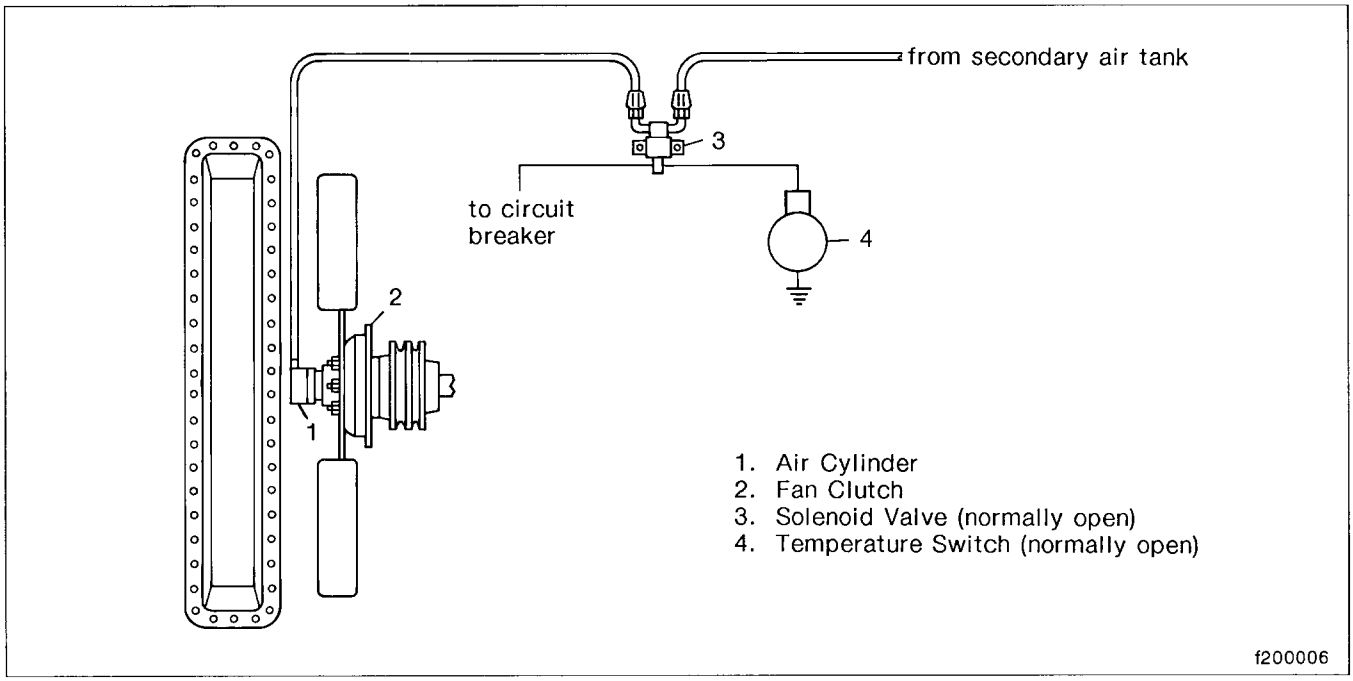
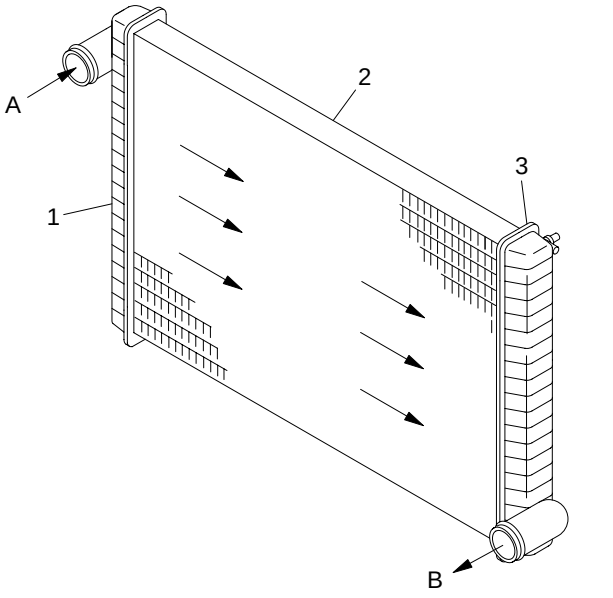


Fig. 2, Fan Clutch Piping and Wiring, Vehicle With Air Conditioning

General Description and Principles of Operation

The main function of a cooling system is to keep the engine at its optimum operating temperature. This results in the most efficient use of fuel and allows the engine oil to provide a good lubricating film.

High-flow radiators (with end tanks) are used in FLD 112 Conventionals. **See Fig. 1**. In these radiators, coolant flows from the inlet at the top of the left end-tank, across the core to the right end-tank, and out the radiator at the bottom of the right end-tank.

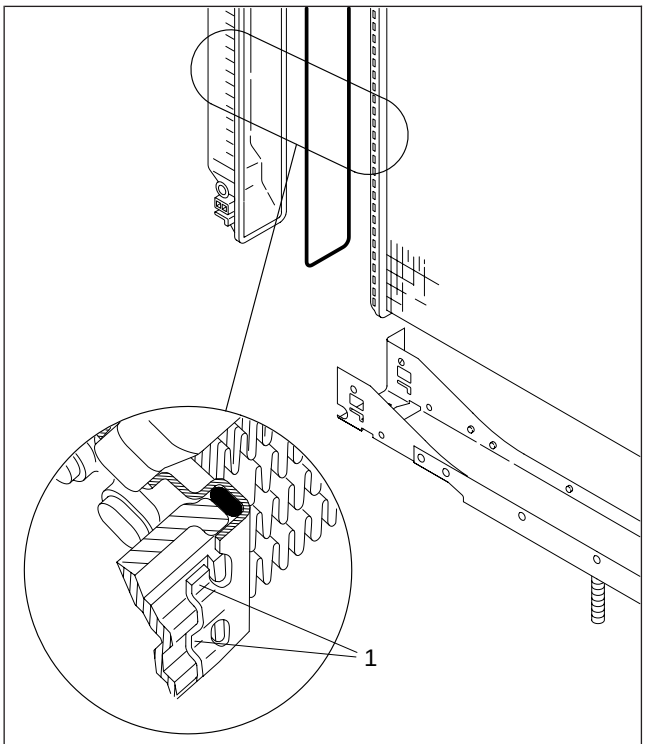


A. inlet from engine
B. outlet to engine
1. Nylon End Tank
2. Radiator Core
3. Header Sealing Surface/Tank Flange

Fig. 1, High-Flow Radiator, Cross-Flow

After the engine is started and warmed up, the engine thermostat opens and allows the water pump to draw coolant from the radiator. The water pump circulates the coolant through water jackets in the engine block and cylinder walls, combustion chambers, and valve assemblies. The heated coolant then flows through the tubes of the radiator core, which dissipates the heat to the air drawn in by the engine fan. By the time coolant travels through the radiator core to the outlet tube, much of the heat has been transferred to the air; coolant is then pumped back through the engine to absorb more heat.

The radiator uses glass-filled nylon end tanks. The edges of the radiator core header are compressed in either one of two ways to hold the tanks to the header sealing surface. The first way is a "dimple wave lock crimp"; **see Fig. 2**. The second method is a "tabbed header crimp"; **see Fig. 3**. The tanks and core are held in steel channels along the top and bottom of the radiator, and bolts running down from the bottom channel mount to an underslung cross-member. Rubber isolators protect the radiator from chassis and road vibration. The radiator is also secured by brace rods that run between the top of the radiator and the firewall. The fins of the radiator core are reinforced along their forward edge to resist damage from road debris and pressure washing.

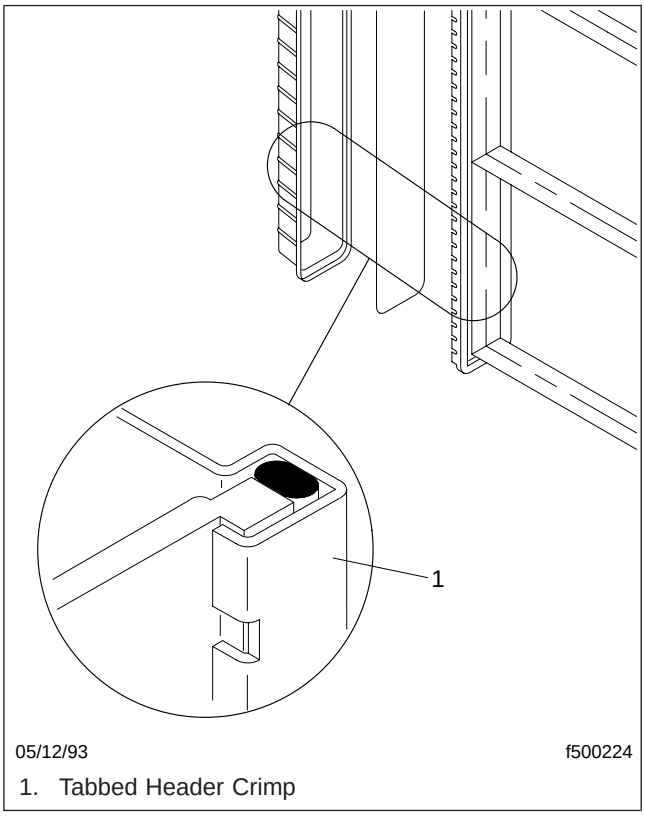


1. Dimple Wave Lock Crimp

Fig. 2, Dimple Wave Lock Crimp

Because crimping holds the nylon top and bottom tanks in place, the radiators can be disassembled and assembled.

General Description and Principles of Operation



1. Tabbed Header Crimp

Fig. 3, Tabbed Header Crimp

The surge tank, mounted on the firewall next to the air cleaner, provides reserve coolant capacity, expansion space for heated coolant, and deaeration space. The radiator cap keeps a pressure of 9 psi (62 kPa) in the system, which raises the boiling point of the coolant. If the cooling system overheats, excess coolant is expelled through the radiator overflow tube.

Removal (See Fig. 1)

1. Apply the parking brakes, and chock the tires.
2. Tilt the hood halfway and support it.
3. Remove any hose clamps from the radiator brace rods.
4. Remove the hood straps and the brace rods from the top of the radiator. Tilt the hood all the way, and support it.

⚠ WARNING

WARNING: Don't drain the system while the engine is hot. To avoid personal injury from scalding coolant, wait until the engine has cooled before draining the system.

5. Drain the coolant from the radiator as follows:
   - 5.1 With the engine cool, loosen the radiator cap on the surge tank to release any pressure in the radiator, then tighten the cap.
   - 5.2 Place a clean drain pan under the drain located on the bottom of the coolant outlet pipe. Remove the drain plug.
   - 5.3 Remove the deaeration hose from the top of the right end-tank. Loosen the inlet and outlet hose clamps; disconnect the hoses and allow them to drain. Seal the hoses to prevent entry of dirt.

     Allow the radiator to drain completely.

IMPORTANT: Don't disconnect the refrigerant lines from the condenser.

6. Remove the four fasteners that attach the condenser to the radiator support channels. Move the condenser out of the way, and support it so that it is not damaged during radiator removal.
7. Remove any clamps that attach electrical wiring or hoses to the radiator end-tanks.
8. Remove the air line (if equipped) from the fan.
9. Loosen the clamps at both ends of the hoses (**Fig. 2**) that attach the inlet and outlet air piping to the charge air cooler connections. Push the clamps and hoses back onto the piping, until they aren't touching the charge air cooler.
10. Remove the four fasteners that attach the fan shroud to the radiator. Move the shroud back away from the radiator assembly.
11. Attach a lift strap through the upper radiator support channel. Connect the strap to an overhead hoist. Remove any slack in the strap, so that the radiator assembly will be supported when the mounting fasteners are removed.

    Remove the locknuts and washers from each lower support isolator.

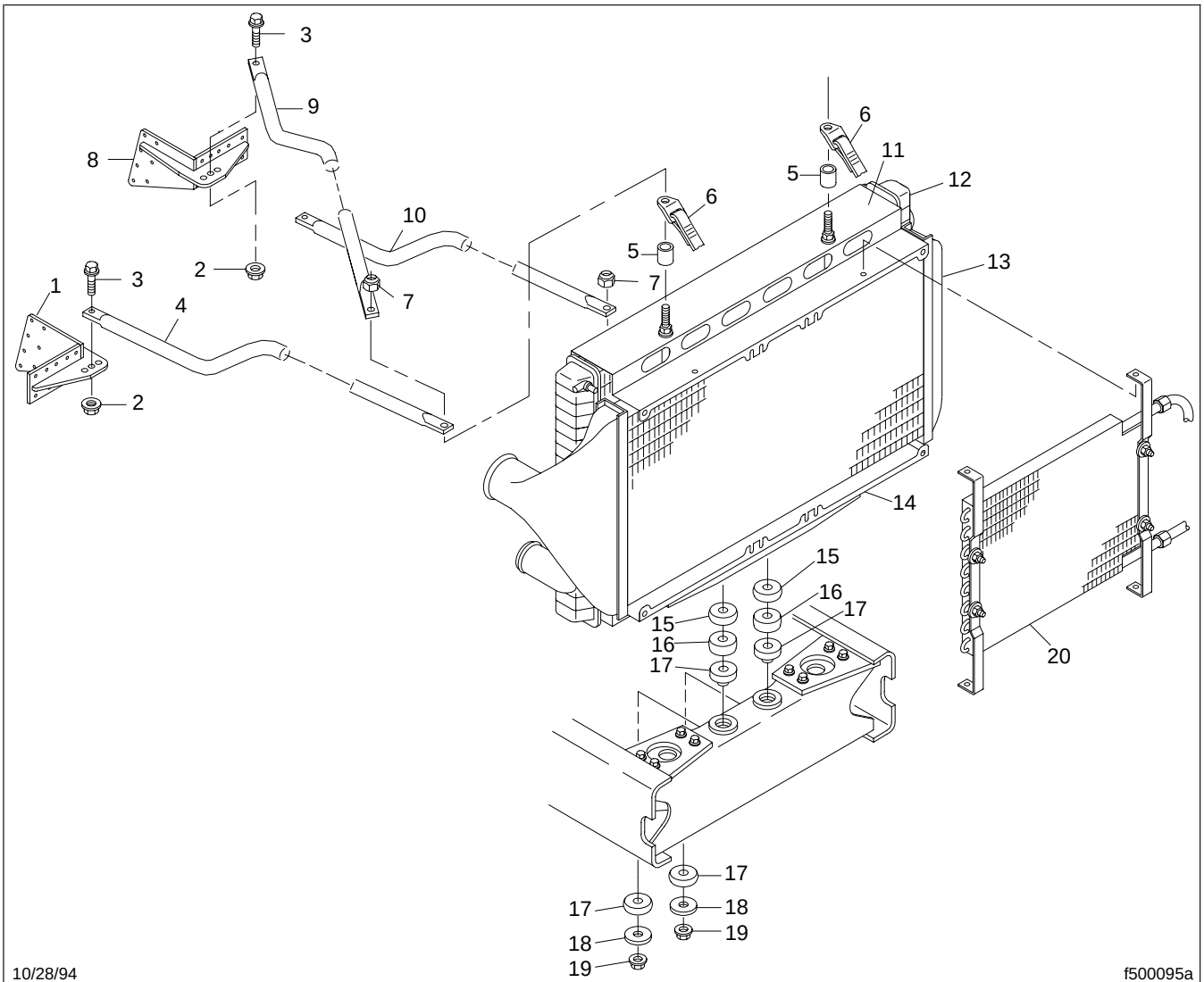
    Using the overhead hoist, lift the radiator from the chassis. Remove the strap from the radiator.

Installation

1. Attach a lift strap through the upper radiator support channel, and connect the strap to an overhead hoist. Using the hoist, lift the radiator, and move it onto the radiator mount assembly.

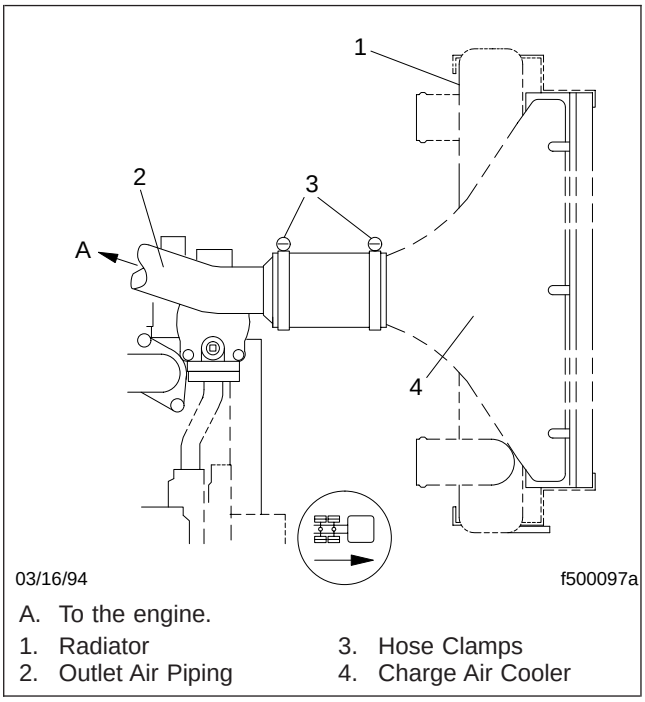
   Fasten the bottom of the radiator to the mount assembly. Tighten the flanged locknuts 165 lbf·ft (224 N·m). Remove the lift strap.
2. Support the hood in the half-tilt position and attach the hood straps and the radiator brace rods on top of the radiator. Tighten the locknuts 155 lbf·ft (210 N·m).
3. Move the fan shroud into position.
   - 3.1 Adjust the shroud so there is about 1-inch (25-mm) clearance between the right side of the fan blade and the fan shroud, and about 3/4-inch (19-mm) clearance on the left side. This allows for engine-torque movement.
   - 3.2 Adjust the shroud so the vertical clearance between the top of the fan blade and the fan shroud opening is equal within 1/8 inch (3 mm) to the clearance between the bottom of the blade and the shroud opening.
   - 3.3 Tighten the self-tapping screws 15 lbf·ft (20 N·m).
   - 3.4 Attach the air line (if equipped) to the fan.
4. Move the condenser in place and fasten it to the radiator. Tighten the fasteners 15 lbf·ft (20 N·m).

Removal and Installation



1. Rear Right-Side Brace-Rod Bracket
2. Flanged Hexnut
3. Flanged Capscrew
4. Right-Side Brace Rod
5. Spacer
6. Hood Strap
7. 5/8–18 Nut
8. Rear Left-Side Brace-Rod Bracket
9. Diagonal Brace Rod
10. Left-Side Brace Rod
11. Upper Support Channel
12. Radiator
13. Charge Air Cooler
14. Lower Support Channel
15. 3/4-Inch Spacer
16. 1-Inch Spacer
17. Isolator
18. Washer
19. 5/8–11 Locknut
20. Condenser

Fig. 1, Radiator Installation



A. To the engine.
1. Radiator
2. Outlet Air Piping
3. Hose Clamps
4. Charge Air Cooler

Fig. 2, Hose Clamp Locations

CAUTION

CAUTION: Don't use any lubricants or sealants to coat the ends of the hoses, because they will soften the rubber and damage the hoses.

5. Remove the seals from the coolant hose ends, and connect the hoses. Your hose clamps can be either T-bolt clamps (**Fig. 3**) or Breeze Constant-Torque clamps (**Fig. 4**).

   When working with T-bolt type hose clamps, tighten the clamps 55 lbf·in (620 N·cm). These clamps are now standard on hoses with an inside diameter greater than 2 inches (51 mm).

   When installing the Breeze Constant-Torque hose clamps, the clamps must be tightened to the correct torque. The screw tip of the clamp must extend about 1/4 inch (6 mm) from the clamp housing, and the belleville washer stacks must be collapsed almost flat. Use a torque wrench to install these hose clamps correctly. The correct installation torque for Breeze Constant-Torque hose clamps is as follows:

   For Breeze Constant-Torque hose clamps with a 5/16-inch tightening screw hex: 55 lbf·in (620 N·cm).

   For Breeze Constant-Torque hose clamps with a 3/8-inch tightening screw hex: 90 lbf·in (1020 N·cm).

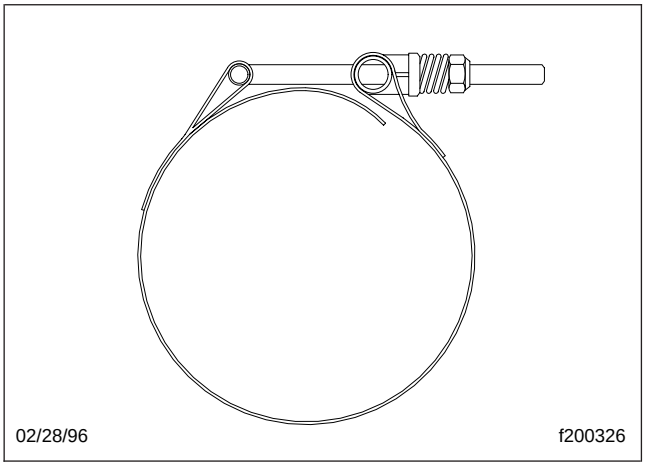
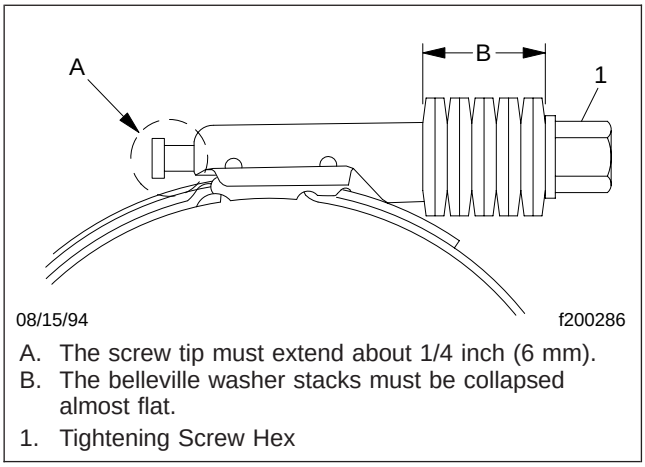


Fig. 3, T-Bolt Type Hose Clamp



A. The screw tip must extend about 1/4 inch (6 mm).
B. The belleville washer stacks must be collapsed almost flat.
1. Tightening Screw Hex

Fig. 4, Breeze Constant-Torque Hose Clamp Installation

NOTE: All hose clamps will lose torque after installation due to "compression set." However, when correctly installed, Breeze Constant-Torque clamps will hold enough torque to automatically adjust and keep consistent sealing pressure. During vehicle operation and shutdown, the screw tip may adjust according to

Removal and Installation

temperature and pressure changes. The torque may need to be adjusted for individual applications.

6. Install the drain plug. Tighten the plug 1-1/2 turns beyond finger-tight.
7. Install the charge air cooler connecting hoses.

⚠ CAUTION

CAUTION: Coolant must be filled to the bottom of the surge tank filler neck. Low coolant could cause engine overheating, which could damage the engine.

8. Fill the radiator with coolant to the level of the bottom of the surge tank filler neck. Don't install the radiator cap. For coolant specifications, see the vehicle maintenance manual, and the engine manufacturer's maintenance and operation manual.
9. Start the engine, and check for coolant leaks in the hoses, hose connections, and radiator core. Run the engine at fast idle for at least 3 minutes; then, stop the engine. Check the coolant level in the radiator, and add coolant as needed.
10. Install the radiator cap.
11. Return the hood to the operating position.
12. Remove the chocks from the tires.

NOTE: The radiators in FLD 112 vehicles use one of two different kinds of crimping to hold the nylon end tank to the radiator core. The two types of crimping— dimple wave lock crimps or tabbed header crimps—are described in **Subject 050**. When disassembling the radiator, use the procedure applicable for the type of crimping involved.

Disassembly

RADIATORS WITH TABBED HEADER CRIMPS

Before disassembling the radiator, pressure-flush it and check the radiator cap, following the instructions in the cooling system section of the vehicle maintenance manual. Clean and check the exterior of the radiator, following the instructions in the vehicle driver's manual.

Use a Johnson's Wide Tab Tool 414-01W (or equivalent) to disassemble radiators with tabbed header crimps. Order the Johnson's tool from:

Johnson Manufacturing Company
114 Lost Grove Road
Princeton, IA 52768-0096

1. Remove the radiator from the vehicle; **refer to Subject 100**.
2. Remove the aftercooler from the radiator. For instructions, refer to the air intake section in this manual.

CAUTION

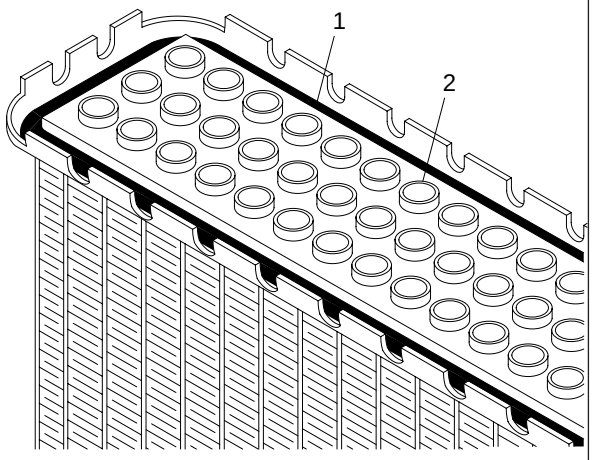
CAUTION: Use care when handling or supporting the plastic end-tank. Failure to do so could damage the end-tank.

3. Set the radiator upright on one of its end tanks, and support it in this position. **See Fig. 1**.
4. Using Johnson's Wide Tab Tool 414-01W (or an equivalent), lift each header tab up and away from the end-tank. Lift the tabs just far enough for the tank to clear during removal.

CAUTION

CAUTION: Use the heel of your hand or a rubber mallet on the side of the end-tank to tap it loose, if needed. Do not use a screwdriver to pry off the tank, as this could damage the tank or header surface.

5. Remove the end-tank, and remove and discard the radiator gasket.
6. Clean the gasket groove on the radiator core header. Straighten any bends or dents in the groove.
7. Inspect the end-tank flange (**Fig. 2**). The flange seats against the gasket, and should be smooth and straight. If repair is needed, make sure that all excess epoxy or filler rod is filed smooth.
8. Repeat the steps above for removal of the other end-tank.



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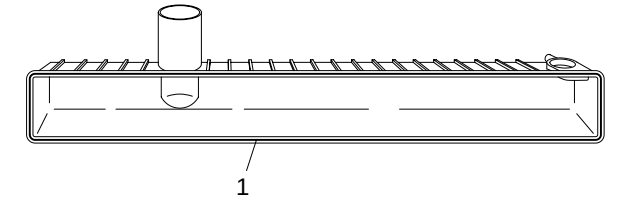
1. Gasket
2. Radiator Core Header

Fig. 1

IMPORTANT: Check the tubes of the radiator core for scale deposits. If the radiator has been pressure-flushed, and the tubes are still clogged, the radiator should be rodded or boiled out with acid by an experienced radiator shop. Otherwise, replace the core.

Disassembly and Assembly



1. Flange

Fig. 2

RADIATORS WITH DIMPLE WAVE LOCK CRIMPS

IMPORTANT: Disassembling and assembling nylon top- and bottom-tank radiators requires the special tools listed in **Table 1**:

Description	Qty.
Plastech II® Tanking Machine With Five 2-Inch Cylinders	1
T-Bar	1
Hooked-End Bar	1
Wave Form Bar	1

Table 1

Order these tools from:

RAD PAL
2381 17 St.
Detroit, MI 48216

Before disassembling the radiator, pressure flush it and check the surge tank, following the instructions in the radiator group of the vehicle maintenance manual. Clean and check the exterior of the radiator, following the instructions in the vehicle driver's manual.

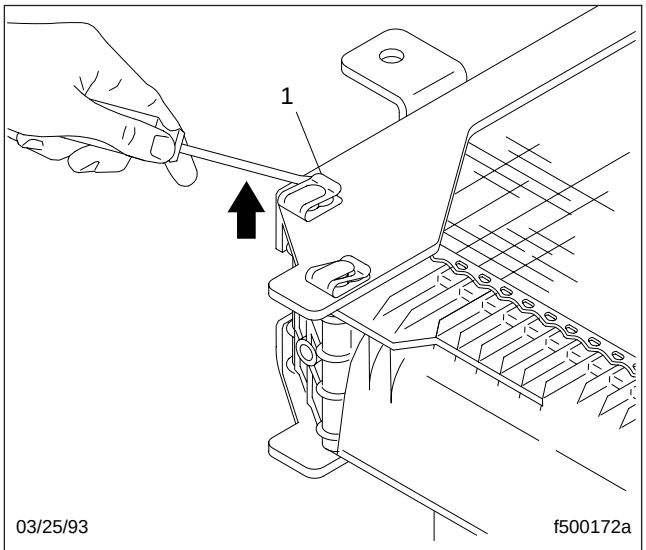
1. Remove the radiator from the vehicle; for instructions, refer to **Subject 100.**

CAUTION

CAUTION: Use care when handling or supporting the nylon top and bottom tanks. Failure to do so could damage the tanks.

2. Remove the side channels from the radiator assembly.

   2.1 Remove the eight spring clips that hold the side channel mounting pins in position. **See Fig. 3**. Insert a screwdriver blade in the open end of each clip, and pry the clip open until it clears the edge of the mounting pin. Then, slip the clip off the pin.



1. Spring Clip

Fig. 3

   2.2 Use a rubber mallet and a punch to tap out the eight mounting pins. **See Fig. 4**.

   2.3 Slip the side channels off the radiator core and tank assembly. **See Fig. 5**.

3. Leak test the radiator core and tank assembly.

   3.1 Securely plug all tank ports.

CAUTION

CAUTION: Don't apply a higher amount of pressure than specified below; too much pressure will damage the radiator core.

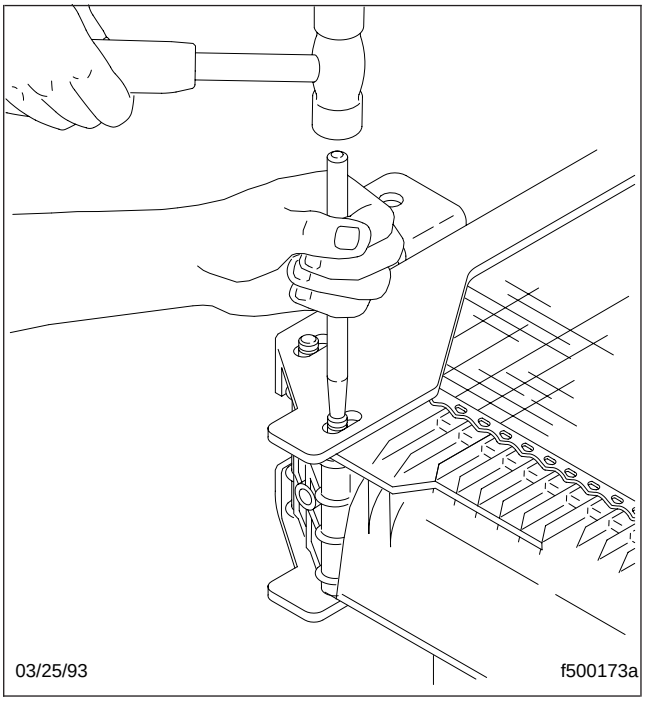
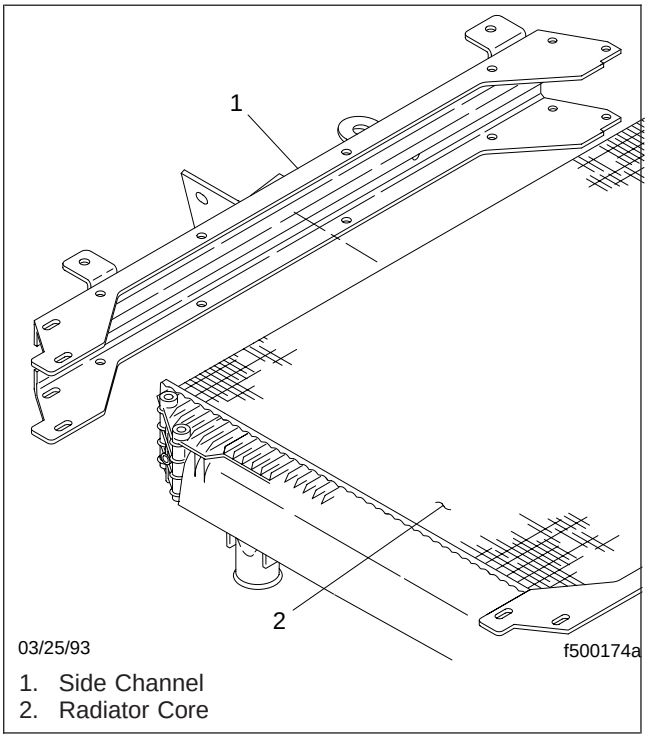


Fig. 4



1. Side Channel
2. Radiator Core

Fig. 5

3.2 At one tank port, install a pressure regulator and gauge. Using a hand pump, apply 138 kPa (20 psi) air pressure through the port.

3.3 Submerge the radiator in a tank of water and check it for leaks. Mark any leaks for repair. If a leak is between the radiator core header and a tank, remove the tank and inspect the tank flange, the header sealing surface, and the sealing gasket. If the leak is in the core, but within 7.5 cm (3 inches) of the tank, remove the tank before repairing the leak. If the leak is in the tank, replace the tank.

4. Remove the top and bottom tanks.

4.1 Place the radiator core and tank assembly in the disassembly/assembly fixture, and clamp the assembly securely in place. **See Fig. 6**.

4.2 Position the tank clamping cylinders evenly across the top of the tank. Make sure the cylinders' rubber plungers will not press against breakable fittings, such as vent tube ports.

CAUTION

CAUTION: Apply only enough pressure to compress the sealing gasket. Too much pressure will crack the nylon tank.

4.3 Apply pressure evenly across the top of the tank until the tank-to-core sealing gasket is compressed enough to show a small gap between the bottom of the dimple wave lock crimp and the tank sealing flange.

CAUTION

CAUTION: In some places, especially around the tank ports, the wave lock crimps may have to be unlocked with a screwdriver. When using a screwdriver, use care not to crack or gouge the nylon tank.

4.4 Place the T-bar into the T-bar groove in the disassembly/assembly fixture. **See Fig. 7**.

Disassembly and Assembly

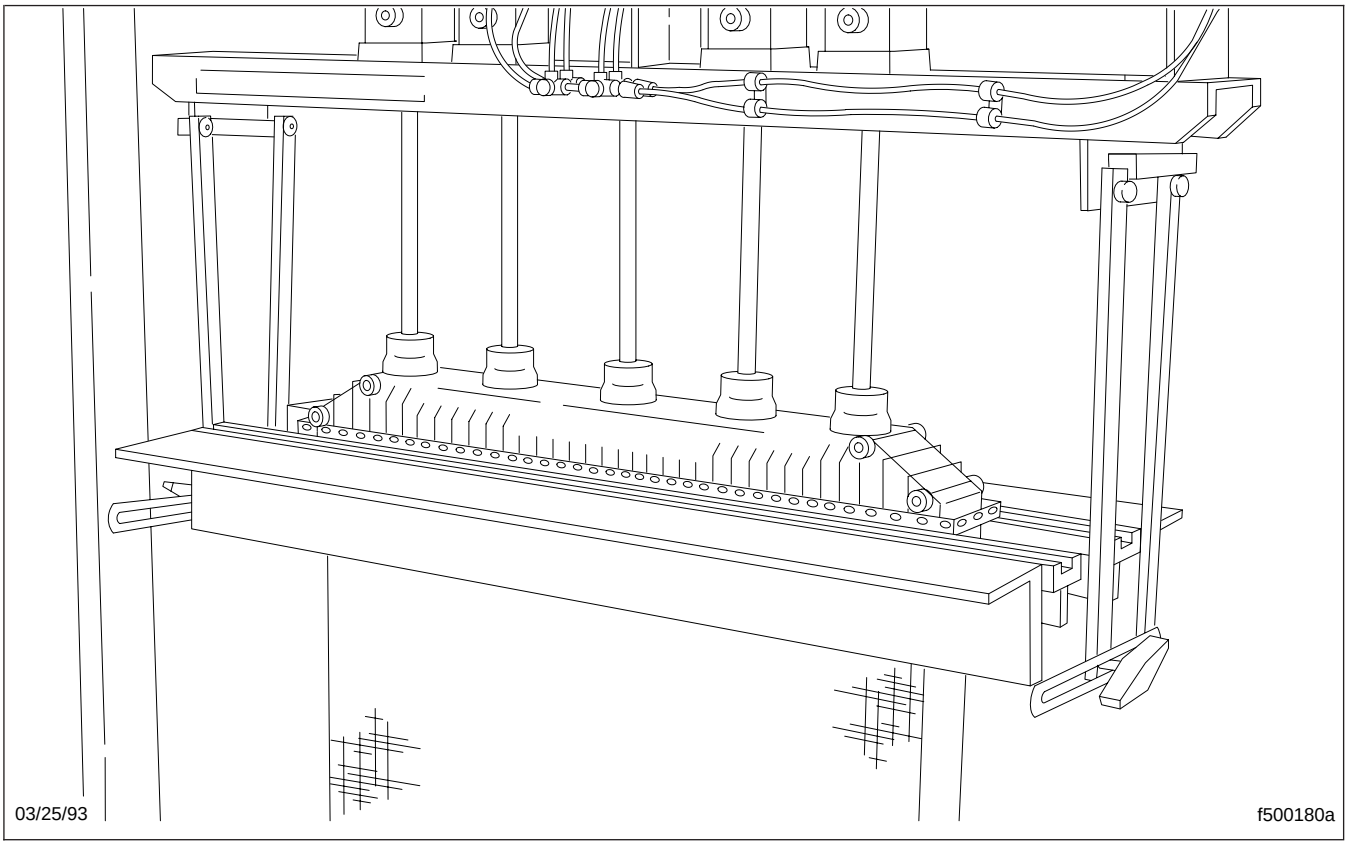


Fig. 6

4.5 Slide the hooked-end bar over the T-bar. Place the hook over the top of the wave crimp and pull the T-bar back to unlock the crimp. **See Fig. 7**.

4.6 Slide the hooked-end bar and the T-bar down the T-bar groove to the next wave crimp, and repeat the previous step until all the wave crimps are unlocked.

5. Once the wave crimps are unlocked, remove the tank.

5.1 Release the pressure from the tank, and move the clamping cylinders off the radiator core and tank assembly.

⚠ CAUTION

CAUTION: If needed, use a rubber mallet or the heel of your hand and tap the side of the tank to loosen it. Do not use a screwdriver against the tank sealing flange. A screwdriver blade may damage the flange and prevent a good seal after the tank is installed.

5.2 Lift the tank from the forward side, the side opposite the tank ports. Remove the nylon tank from the radiator core. **See Fig. 8**.

5.3 Remove the sealing gasket from the sealing surface of the radiator core header. **See Fig. 9**.

5.4 Clean the sealing surface of the radiator core header.

5.5 Repair any leaks marked during leak testing.

5.6 Repeat this procedure to remove the opposite tank.

IMPORTANT: Check the tubes of the radiator core for scale deposits. If the radiator has been pressure-flushed, and the tubes

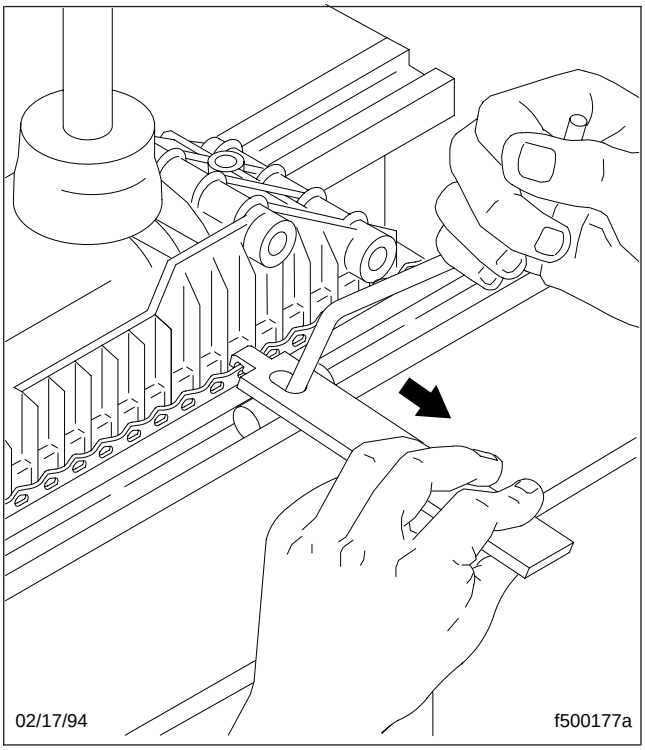


Fig. 7

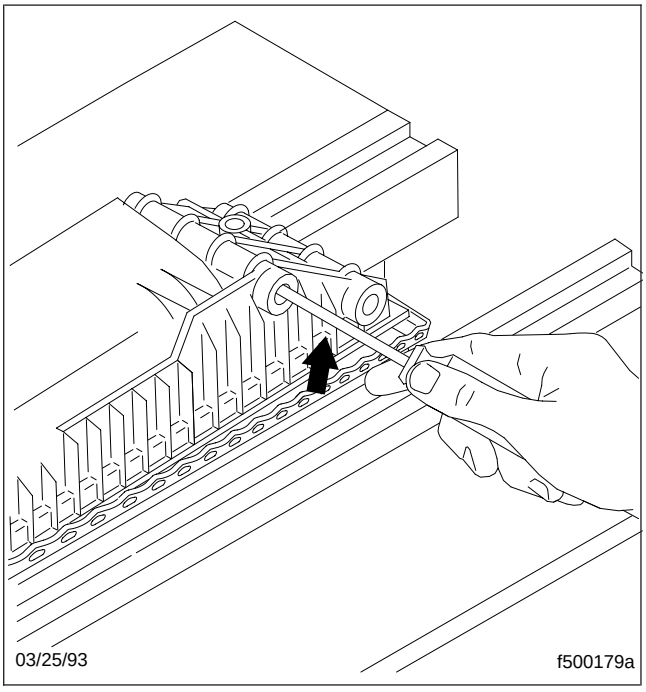


Fig. 8

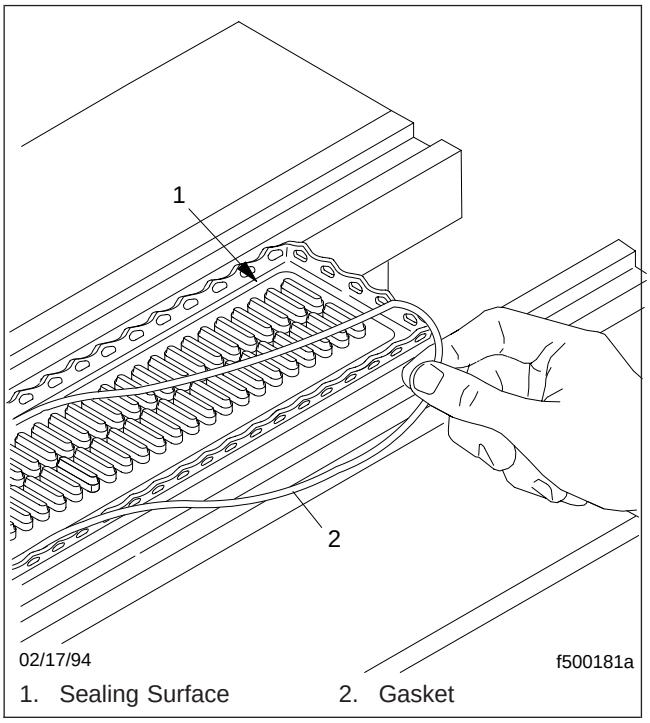


Fig. 9

are still clogged, the radiator should be rodded or boiled out with acid by an experienced radiator shop. Otherwise, replace the core.

Assembly

RADIATORS WITH TABBED HEADER CRIMPS

1. With the radiator core supported and the header facing up, place the new gasket in the groove.
2. Place the end-tank on the gasket.

NOTE: If the end-tank is warped or bowed in the center, place it in hot water. This will make it more flexible and help to ensure a good seal.

3. Evenly space five header clamps across the end-tank. Starting with the middle clamps, apply equal clamping pressure across the end-tank.

IMPORTANT: Make sure that the header clamps are tightened enough to compress the gasket.

Disassembly and Assembly

4. Repeat the preceding steps for the other end-tank.
5. Pressure-test the radiator as follows:
   - 5.1 Plug the inlet and outlet ports on the radiator assembly.

CAUTION

CAUTION: Don't apply a higher amount of air pressure than specified below; too much pressure will damage the radiator core.

   - 5.2 At the port near the top of the right end-tank (hose connection to the surge tank), install a pressure regulator and gauge. Using a hand pump, apply 20 psi (138 kPa) air pressure through the port.
   - 5.3 Submerge the radiator in a tank of water and check it for leaks. If a leak is detected, crimp the tabs near the leak and retest. Remove the radiator from the water.
6. Starting at the center of one end-tank, use a pliers to squeeze each tab (not blocked by a header clamp) inward to its original position (**Fig. 10**).
7. Install a hexnut on the adjusting screw of a pair of locking-type pliers (**Fig. 11**).
8. Close and lock the jaws of the pliers. Turn the adjusting screw to position the jaws against the shank of an 11/32-inch diameter drill bit (**Fig. 12**).
9. Tighten the hexnut on the adjusting screw against the handle to lock the jaws in place.
10. Starting at the center, use the locking-type pliers and crimp each tab over the lip of the end-tank.
11. Remove the center clamp and crimp the tabs. Crimp the remaining tabs as soon as each header clamp is removed.
12. Install the aftercooler on the radiator. For instructions, refer to the air intake section in this manual.
13. Install the radiator in the vehicle; **refer to Subject 100** for instructions.

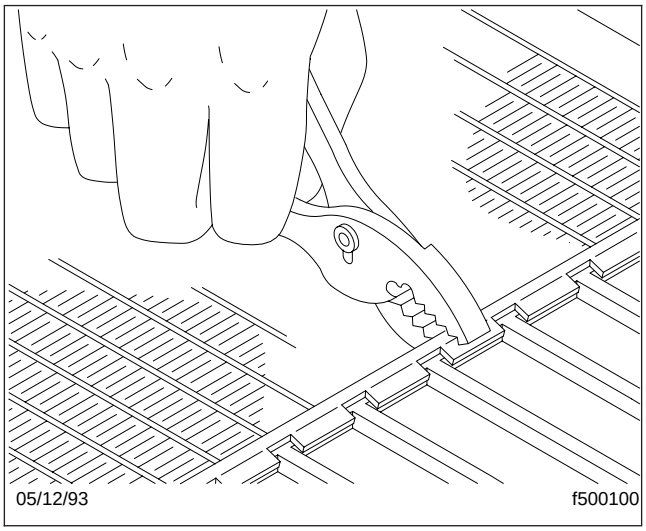
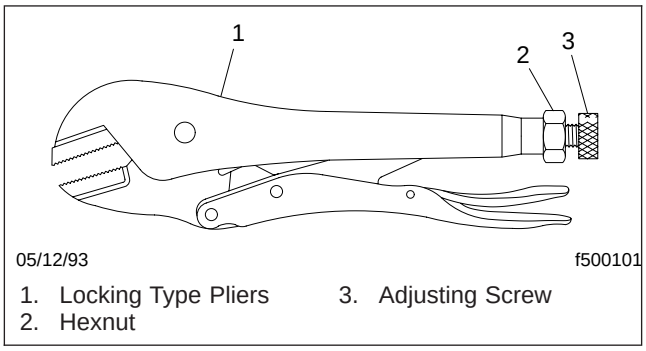
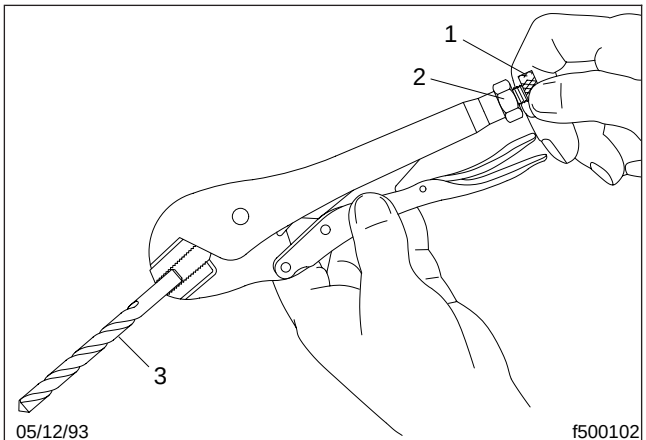


Fig. 10



1. Locking Type Pliers
2. Hexnut
3. Adjusting Screw

Fig. 11



1. Adjusting Screw
2. Hexnut
3. 11/32-Inch Diameter Drill Bit

Fig. 12

RADIATORS WITH DIMPLE WAVE LOCK CRIMPS

1. Install the nylon top and bottom tanks on the radiator core.

   1.1 With the radiator securely clamped in the disassembly/assembly fixture, header sealing surface up, make sure the bottom of the radiator core and tank assembly is completely supported, and that the header sealing surface is free of any dents, tool marks, or foreign particles.

   1.2 Lubricate a new sealing gasket with a soap and water solution, and position the gasket on the header sealing surface. **See Fig. 9**. To make sure the gasket is not twisted, run your finger along the gasket as it lies on the sealing surface. The mold lines of the gasket should be on the outside and inside diameters of the gasket; if you can feel a mold line cross over the top of the gasket, the gasket is twisted.

   1.3 Inspect the tank sealing flange. The flange must be clean and free of defects. If the sealing flange is damaged, replace the tank.

   1.4 Place the tank on the gasket, and tap the tank with a rubber mallet or the heel of your hand to seat the tank. Make sure the tank ports are facing the correct direction.

   1.5 Position the tank clamping cylinders evenly across the top of the tank. Make sure the cylinders' rubber plungers will not press against breakable fittings, such as vent tube ports. **See Fig. 6**.

⚠ CAUTION

CAUTION: Apply only enough pressure to compress the sealing gasket. Too much pressure will crack the nylon tank.

   1.6 Apply pressure evenly across the top of the tank until the tank-to-core sealing gasket is compressed enough to show a small gap between the bottom of the dimple wave lock crimp and the tank sealing flange.

   1.7 Place the T-bar into the T-bar groove in the disassembly/assembly fixture.

   1.8 Slide the wave form bar over the T-bar, and center the bar in front of the wave crimp slot.

⚠ CAUTION

CAUTION: Do not push the wave crimp until it touches the side of the nylon tank, or the tank may crack.

   1.9 Push the T-bar forward to crimp the header's edge until it almost touches the tank's side. **See Fig. 13**.

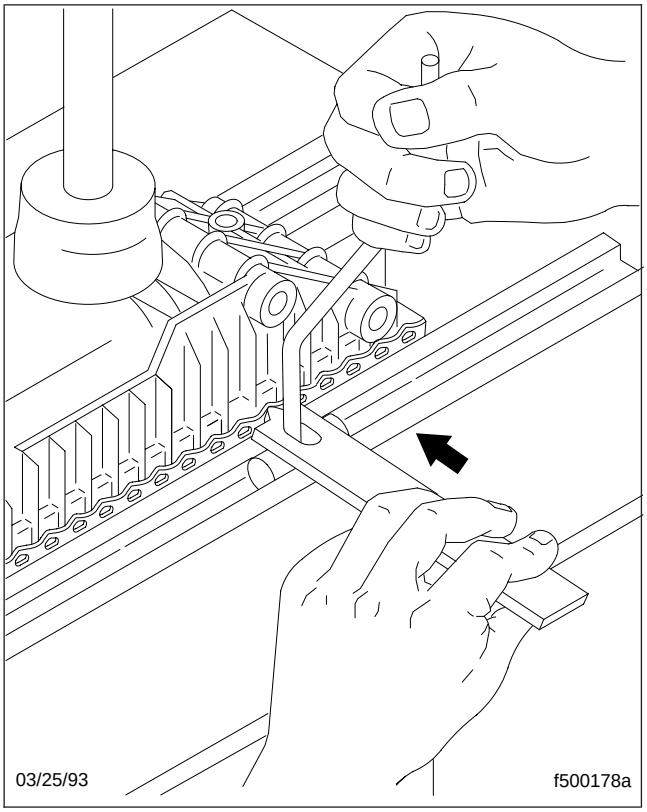


Fig. 13

   1.10 Slide the tools down the T-bar groove to the next wave crimp slot, and repeat this procedure until all the wave crimps are crimped.

Disassembly and Assembly

CAUTION

CAUTION: In some places, especially around the tank ports, the wave crimps may have to be crimped with a screwdriver. When using a screwdriver, use care not to crack or gouge the nylon tank.

1.11 Release the pressure from the tank, and move the clamping cylinders off the radiator core and tank assembly.

1.12 Repeat this procedure to install the opposite tank.

2. Leak test the radiator core and tank assembly. For instructions, refer to "Disassembly."

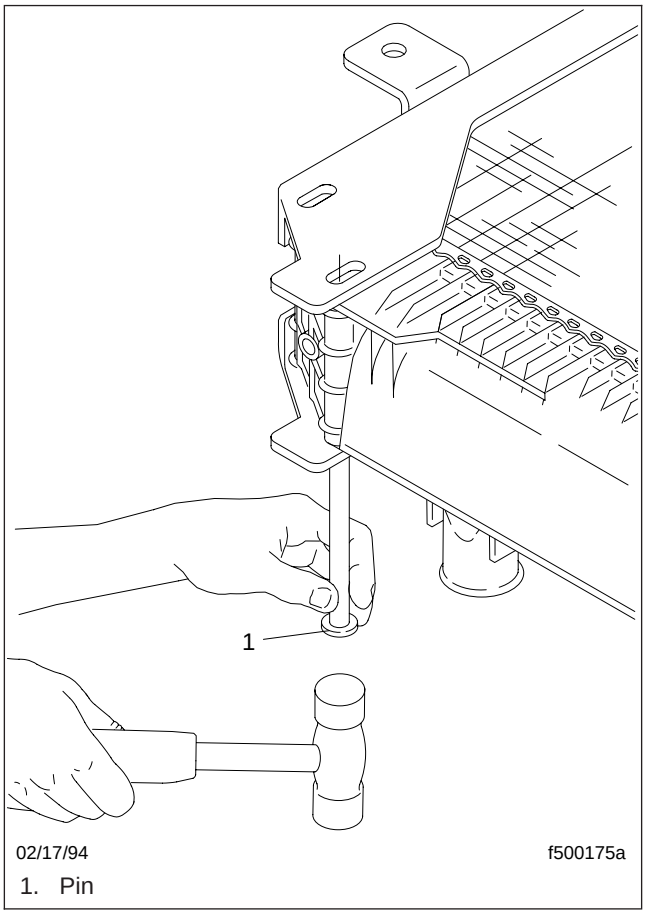
3. Install the radiator side channels.

3.1 Slide the side channels onto the radiator core and tank assembly.

3.2 Using a rubber mallet and a punch, install the eight mounting pins through the side channel holes and tank bosses. **See Fig. 14**.

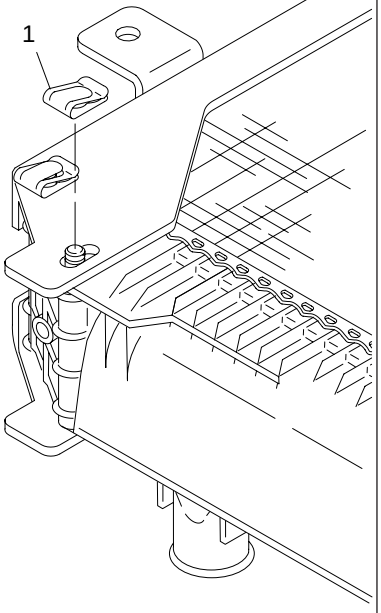
3.3 Install the eight spring clips to secure the mounting pins in position. **See Fig. 15**. To install each clip, place the clip over the end of the mounting pin, and slide the clip until it engages the groove in the pin and the open end of the clip snaps over the edge of the pin. If necessary, use a clamp to compress the side channel while installing the clips.

4. Install the radiator in the vehicle. For instructions, **refer to Subject 100.**



1. Pin

Fig. 14



1. Spring Clip

Fig. 15

Checking [1]

NOTE: For troubleshooting information, refer to the engine cooling troubleshooting section in this manual.

VISUAL CHECK

It is a sound service practice to give the cooling system a quick check whenever you tilt the hood. Look for signs of frayed or damaged belts and hoses. Also look for signs of visible leaks (or the stains they leave), especially on the engine block. A final check is to look at the inside of the oil breather cap for signs of milky substance — which means that coolant is leaking into the oil.

AIR CONDITIONER CONDENSER AND AFTERCOOLER

Since the condenser and aftercooler are right in front of the radiator, air must pass through them to get to the radiator. That same air must then pass through the radiator. Also remember that because these heat-transfer parts are so close to each other, heat will pass back and forth between them. For the heat transfer process to take place, the fins of the radiator, aftercooler, and the condenser must be free of blockages and deposits such as dirt or bugs. Clean the surfaces with compressed air or water and a mild laundry soap.

RADIATOR CAP

The radiator cap is the most often ignored part in the cooling system. If it is suspect, replace it. An inspection means checking the cap with a pressure tester. A radiator cap in good condition will keep system pressure at about 10 psi (69 kPa). A visual check is also in order: look for signs of deterioration of the inner gasket. Also look for cracks or breaks in the spring retainer in the cap and for corrosion or deposits on the spring itself. If the spring is not in perfect condition, it has probably lost tension; replace it.

ENGINE COOLANT

Check the level of the coolant in the radiator. It should be up to the bottom of the surge tank fill-neck.

If the engine coolant is dirty or its color is beginning to fade, change it. It should also be replaced if it has a dead fish smell.

Be sure that the mixture is correct. Refer to the vehicle maintenance manual.

RADIATOR

Radiator problems are limited to external leaks, which can be spotted visually, and internal blockages, assuming that there is good airflow and that the radiator is large enough to get the job done.

To check for blockages, warm the engine to normal operating temperature. Shut down the engine, and pass your hand in front of the finned surface of the radiator. If there is a blockage in the radiator it should cause an obvious temperature difference from one area of the core to another. An obvious difference between inlet and outlet temperatures, however, is to be expected.

[1] Portions of this information courtesy of DRAF Industries, Inc.

General Information

The K22RA fan drive unit is an air-operated, temperature-controlled clutch for the engine cooling fan. Its purpose is to maintain engine temperature by engaging or disengaging the fan. The fan clutch is disengaged when the coolant temperature is at or below the specified temperature range. The fan clutch engages when the coolant temperature rises above the range.

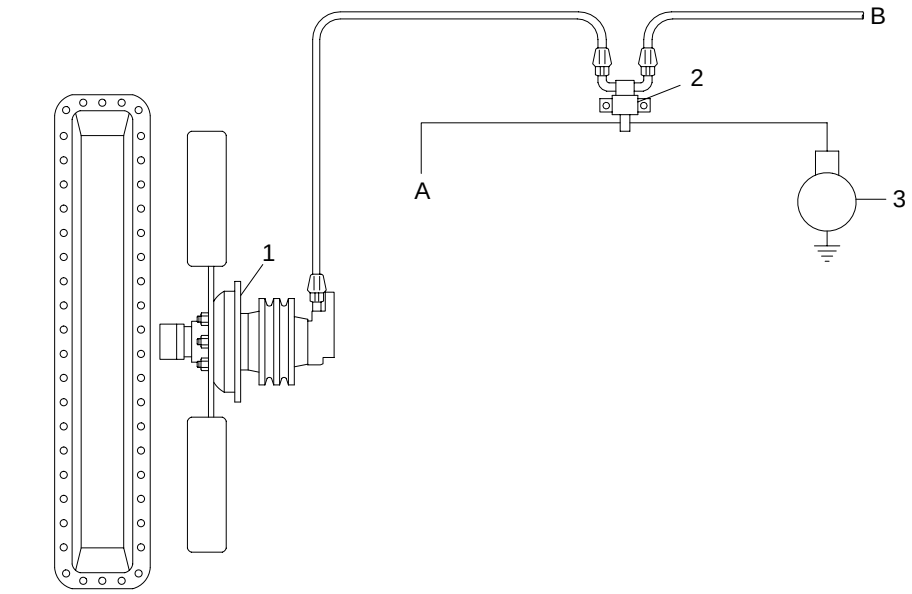
Air pressure to the fan clutch is controlled by a solenoid valve; the solenoid valve is controlled by a temperature switch that is installed in the thermostat housing. See **Fig. 1**.

lenoid is controlled by a temperature switch that is immersed in the engine coolant.

When a cold engine is started, the temperature switch is open, which activates the solenoid. The solenoid valve allows compressed air to enter the cylinder, and the fan clutch remains disengaged. The fan does not turn.

When the coolant temperature rises to the temperature switch setting, the switch closes. The solenoid valve releases the compressed air from the cylinder. The fan clutch spring engages the clutch and the fan turns.

When the coolant temperature drops to the tempera-



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A. To the circuit breaker
B. From the secondary air tank
1. Fan Clutch
2. Solenoid Valve
3. Temperature Switch

Fig. 1, Fan Clutch Piping and Wiring, Vehicle Without Air Conditioning

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-drier. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies power to the solenoid valve. See **Fig. 2**.

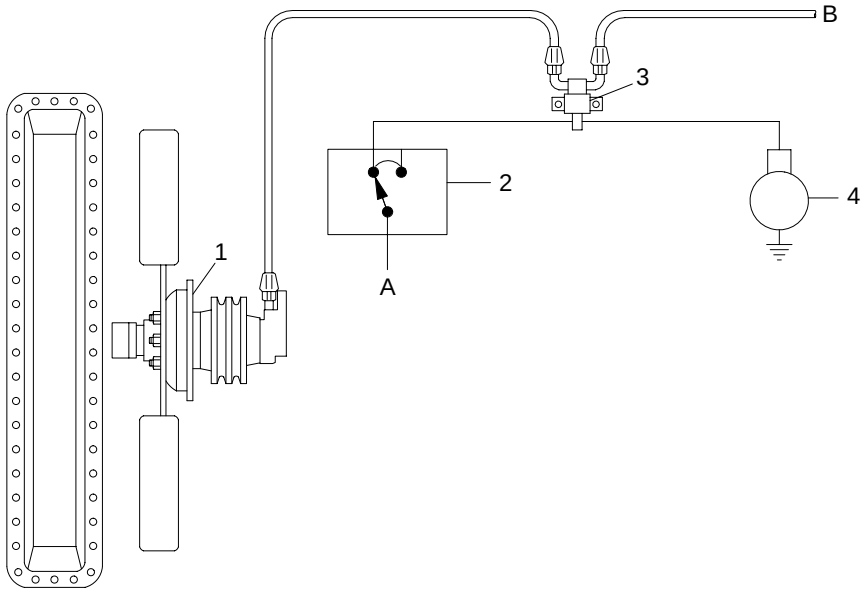
The fan clutch is spring-loaded in the engaged position. It is disengaged when air pressure is applied to the cylinder on the front of the unit. Air pressure to the cylinder is controlled by a solenoid valve: the solenoid is controlled by a temperature switch that is immersed in the engine coolant.

When a cold engine is started, the temperature switch is open, which activates the solenoid. The solenoid valve allows compressed air to enter the cylinder, and the fan clutch remains disengaged. The fan does not turn.

When the coolant temperature rises to the temperature switch cutoff setting, the switch opens, activating the solenoid. Compressed air passes to the cylinder disengaging the clutch.

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-drier. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies power to the solenoid valve, which stops air flow and allows the internal spring to engage the fan clutch.

General Information



A. To the circuit breaker
B. From the secondary air tank
1. Fan Clutch
2. Fan Cycling Switch at the Receiver-Drier
3. Solenoid Valve
4. Temperature Switch

Fig. 2, Fan Clutch Piping and Wiring, Vehicle With Air Conditioning

NOTE: When disengaged, it is normal for the housing and fan to spin at about 300 rpm. When the compressed air is released and the clutch engages, the bearing housing and fan move forward approximately 1/10th-inch (2.5 mm).

Fan Clutch Removal and Installation

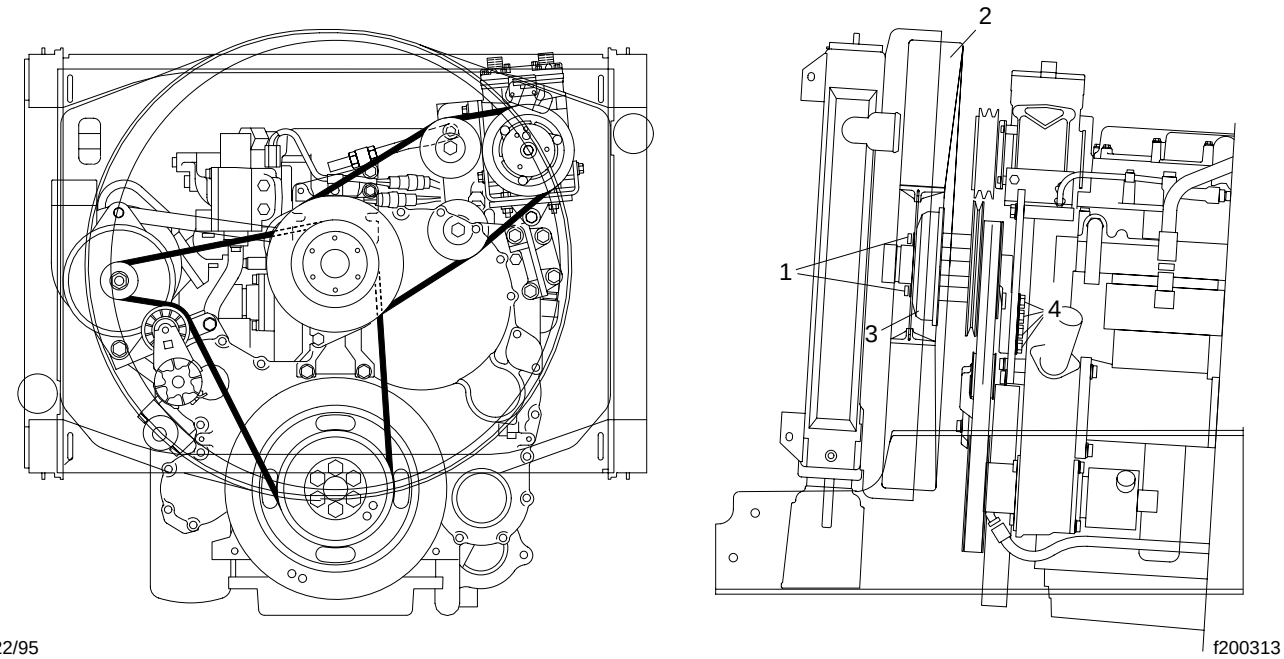
Removal

Refer to the following figures for the fan clutch installation for your engine.

- For Caterpillar 3176 and C–10/C–12 engines, see **Fig. 1**.

WARNING

WARNING: Use care when loosening the air line fitting. The line could be under pressure and may have dirt or sludge in the air stream. If quickly disconnected, the line may whip, possibly causing eye injury or other bodily harm.



1. Fan Mount Nut 3/8–24, grade 5; Washer
2. Fan
3. Fan Clutch
4. Fan Clutch Mount Capscrew M12 x 35 mm, grade 8.8; Washer

Fig. 1, Caterpillar 3176 and C-10/C-12 Engines, Kysor Fan Clutch

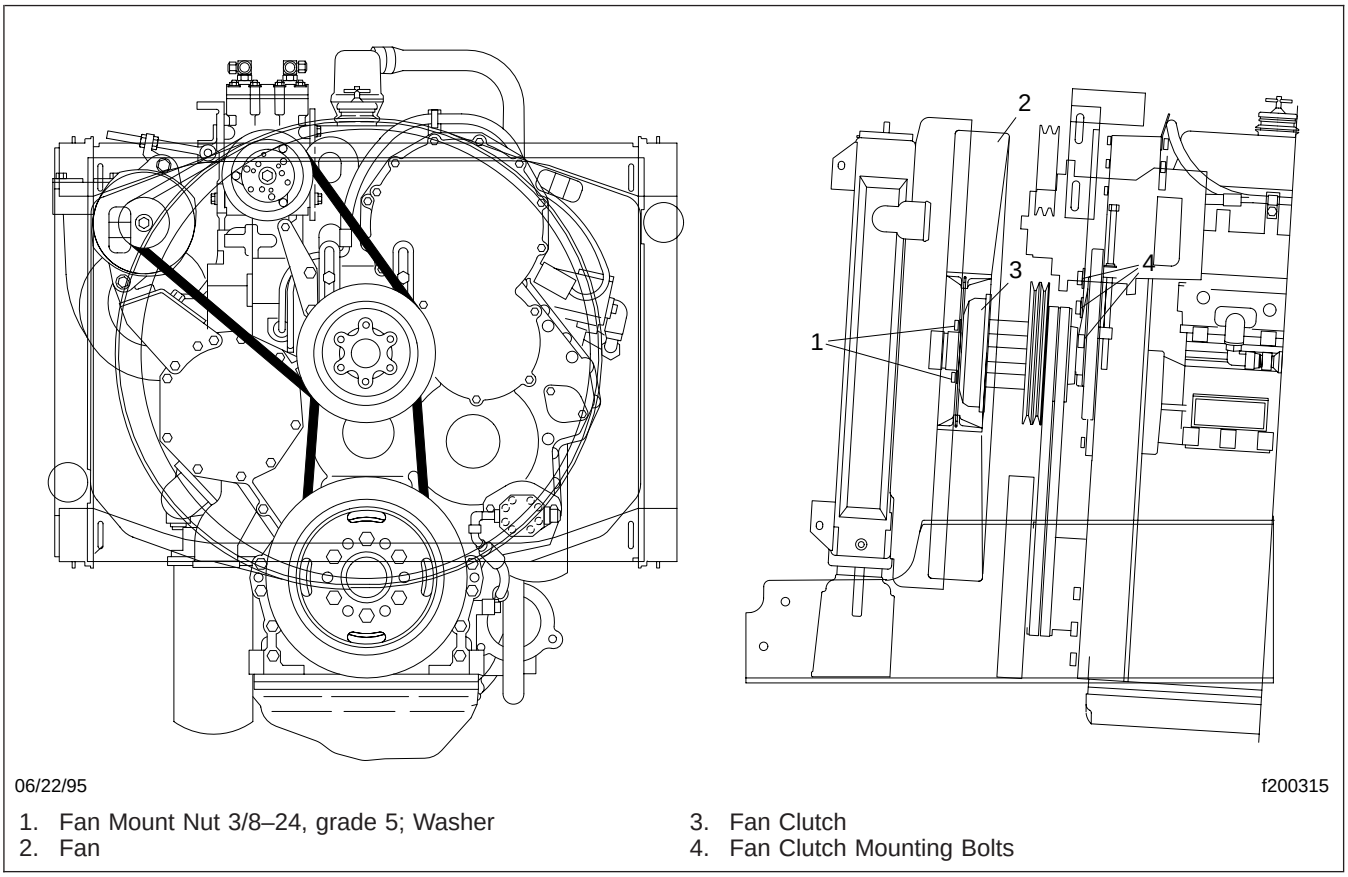
- For Caterpillar 3406 engines, see **Fig. 2**.
- For Cummins M11 engines, see **Fig. 3**.
- For Cummins N14 engines, see **Fig. 4**.
- For Detroit Diesel Series 50 and 60 engines, see **Fig. 5**.
- For Detroit Diesel Series 55 engines, see **Fig. 6**.

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Disconnect the air line from the fan clutch.

NOTE: It may be possible to unbolt the fan, carefully place it against the radiator, and have access to the fan clutch without disconnecting the radiator hoses, mounts, or fan shroud.

3. Remove the fan shroud from the radiator, and move the shroud back against the engine.
4. Disconnect the radiator from all hoses and mounts. For instructions, refer to the applicable "Radiator Assembly" section in this group. With one person holding each side of the radiator, tilt the top of the radiator forward.

Fan Clutch Removal and Installation



1. Fan Mount Nut 3/8–24, grade 5; Washer
2. Fan
3. Fan Clutch
4. Fan Clutch Mounting Bolts

Fig. 2, Caterpillar 3406 Engine, Kysor Fan Clutch

5. With the radiator tilted forward, remove the fan.
6. Remove the fan belts. For instructions, refer to "Drive Belts," Section 01.07 in this manual.

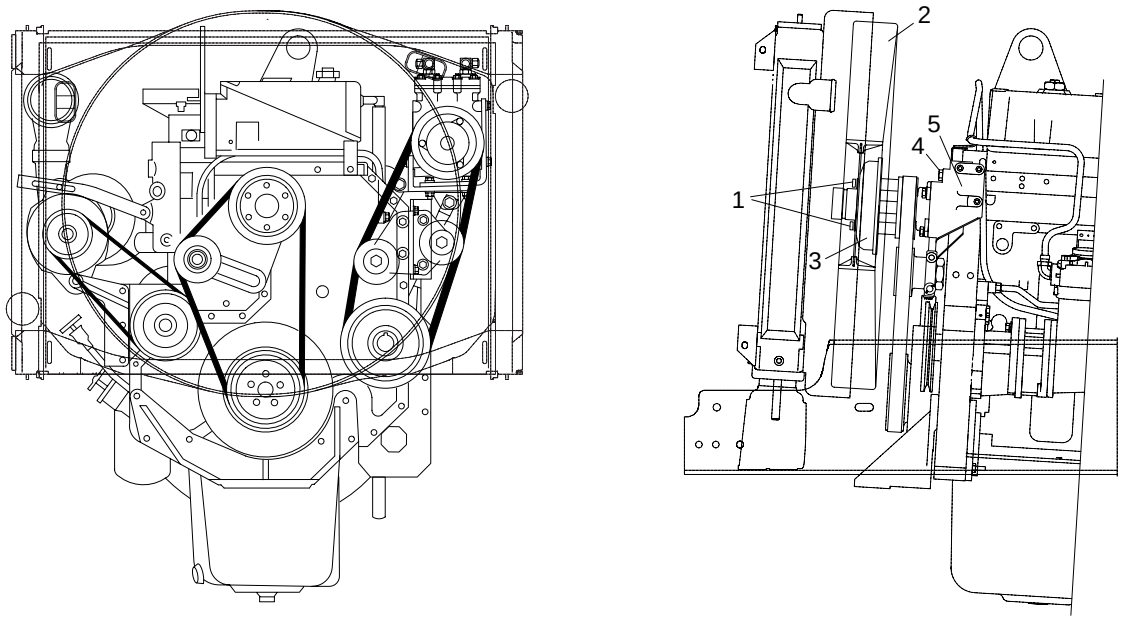
⚠ WARNING

WARNING: To keep the clutch disengaged, you must supply the fan clutch with between 90 and 120 psi (6.1 and 8.2 bar) of air pressure throughout this procedure. If the fan clutch engages, it may cause personal injury.

7. Apply between 90 and 120 psi (6.1 and 8.2 bar) of air pressure to the fan clutch to disengage the clutch.
8. Line up the access holes with the 5/16-inch allen screws. See **Fig. 7**.
9. Remove the air pressure from the fan clutch, and allow the fan to engage.
10. Remove the fan clutch from the fan clutch hub. It may be necessary to gently pry the clutch from the hub.

Installation

1. Position the fan clutch on the fan clutch hub, and line up the access holes in the clutch with the holes for the allen screws in the clutch hub.
2. Install the allen screws, and tighten them 44 lbf·ft (60 N·m).
3. Install the fan belts. For instructions, refer to "Drive Belts," Section 01.07 in this manual.
4. Install the fan.
5. Install the radiator on the radiator mounts, and connect all radiator hoses. For instructions, refer to the applicable "Radiator Assembly" section in this group.



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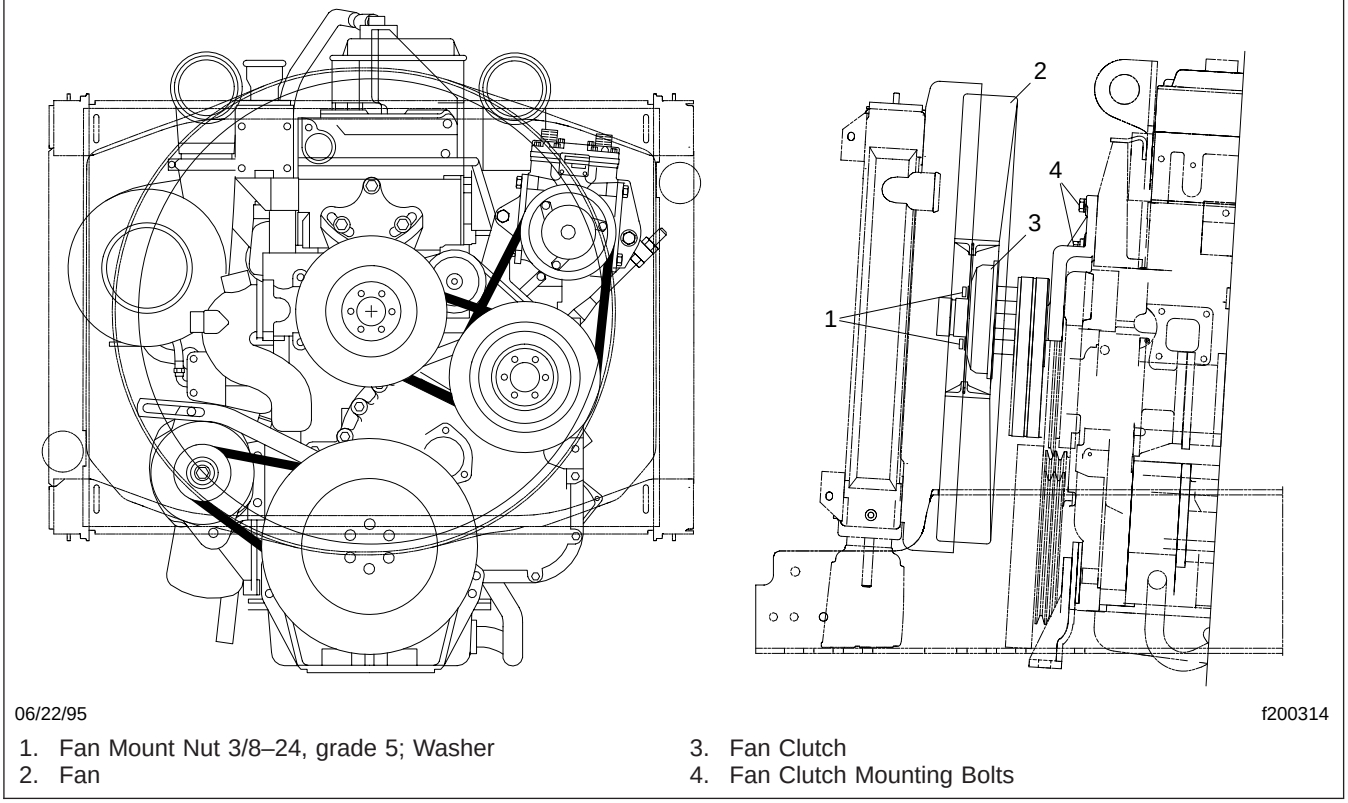
1. Fan Mount Nut 3/8–24, grade 5; Washer
2. Fan
3. Fan Clutch
4. Fan Clutch Mount Screw, M12 x 1.75x90
5. Fan Support Bracket

Fig. 3, Cummins M11 Engine, Kysor Fan Clutch

6. Install the fan shroud.
7. Connect the air line to the fan clutch.
8. Remove the chocks from the tires.

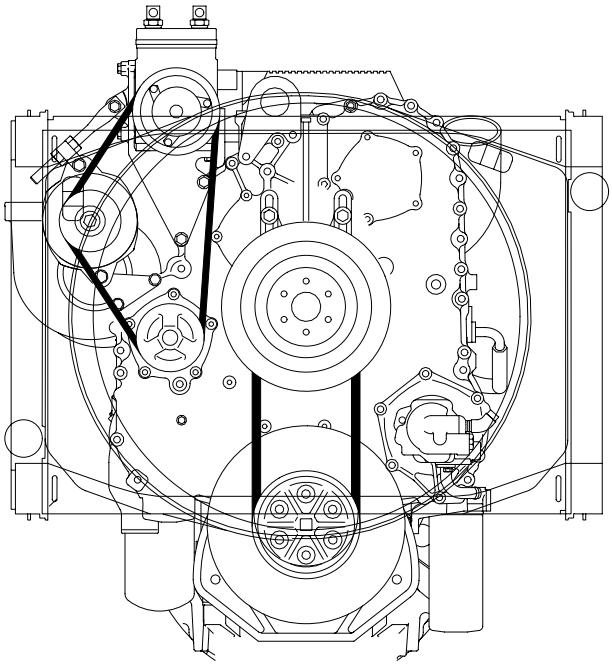
Fan Clutch Removal and Installation

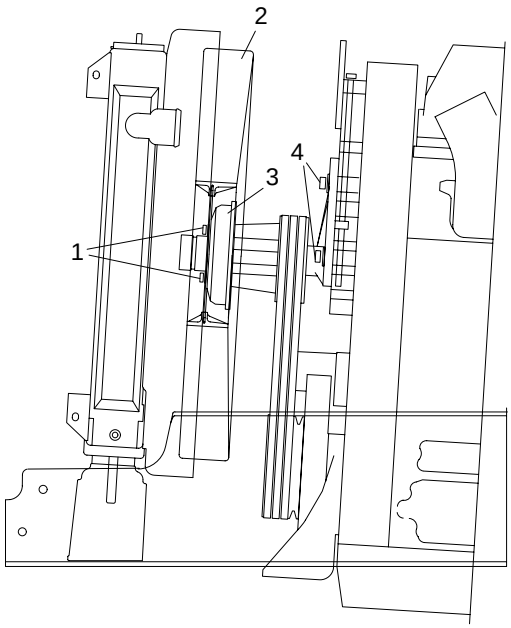


1. Fan Mount Nut 3/8–24, grade 5; Washer
2. Fan
3. Fan Clutch
4. Fan Clutch Mounting Bolts

Fig. 4, Cummins N14 Engine, Kysor Fan Clutch

Fan Clutch Removal and Installation





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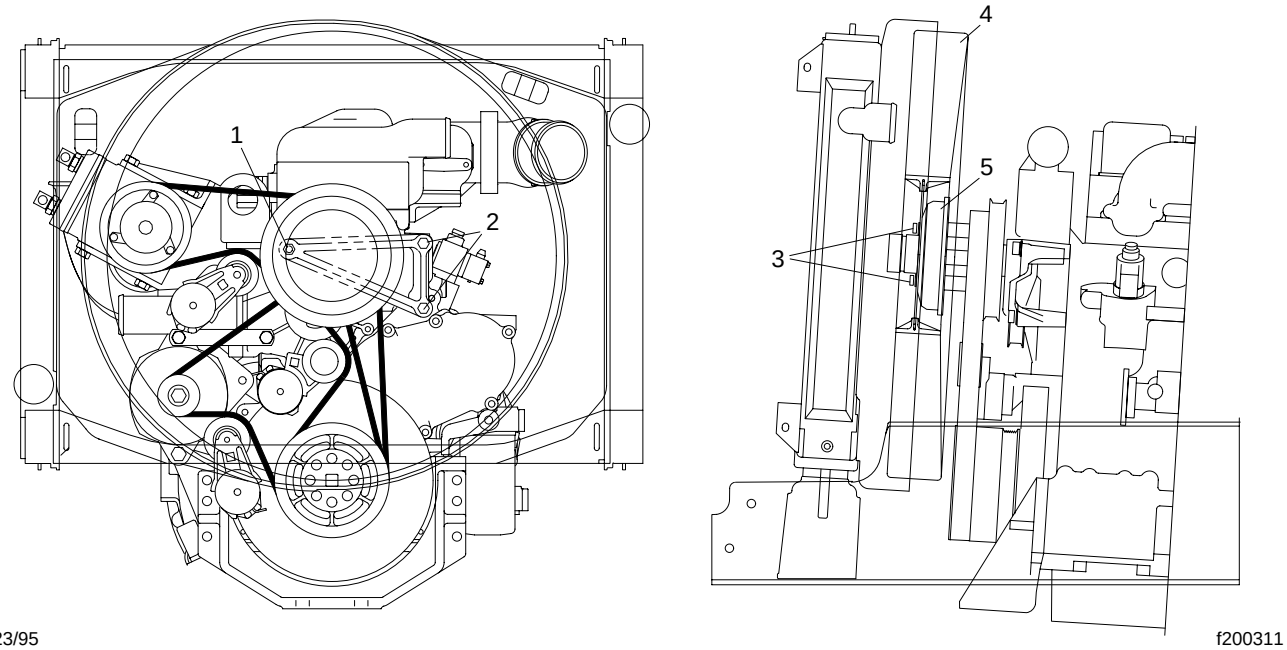
1. Fan Mount Nut 3/8–24, grade 5; Washer
2. Fan
3. Fan Clutch
4. Fan Clutch Mount Flanged Bolt, M12 x 35mm, grade 10.9; Washer

Fig. 5, Detroit Diesel Series 50 and 60 Engine, Kysor Fan Clutch

Fan Clutch Removal and Installation



1. Fan Clutch Mount Locknut M14
2. Fan Clutch Mount Flanged Bolt M12 x 100 mm, grade 10.9
3. Fan Mount Nut 3/8–24, grade 5; Washer
4. Fan
5. Fan Clutch

Fig. 6, Detroit Diesel Series 55 Engine, Kysor Fan Clutch

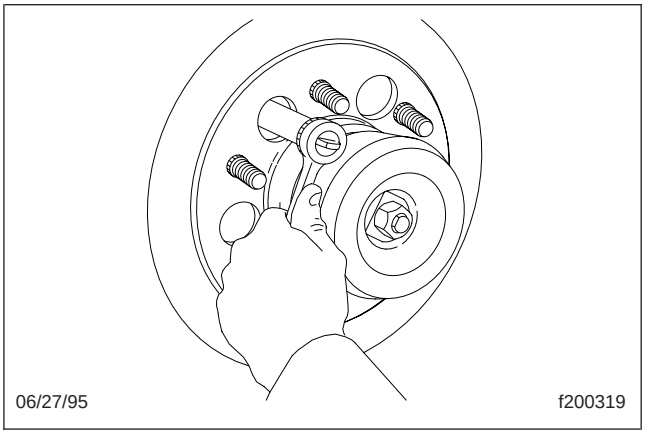


Fig. 7, Line Up the Access Holes

Fan Clutch Minor Rebuild, Kysor K22RA

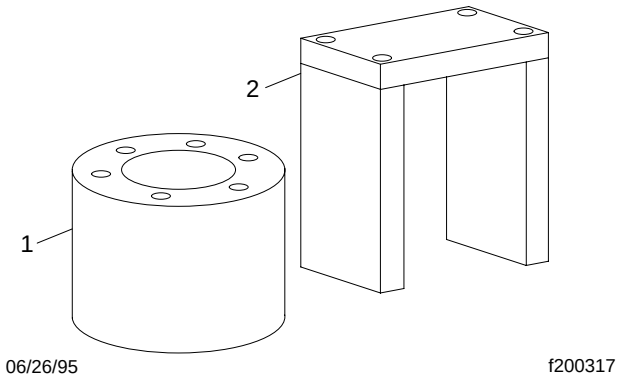
Special Tools

IMPORTANT: Special tools are recommended, but not required for this procedure. See **Table 1** for the special tool set.

Special Tools		
Description	**Part Number**	**Order From**
Support and Compressor (see **Fig. 1**)	1090-00000-02	Wright Brothers Enterprises 8171 Hibma Marion, MI 49665 Telephone: 231-825-2939

Table 1, Special Tools

Rebuild



1. Support
2. Compressor

Fig. 1, Special Tools

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Remove the fan clutch from the vehicle. For instructions, refer to **Subject 100**.

CAUTION

When caging and compressing the engagement spring of the fan clutch, depress the clutch shaft only enough to relieve the pressure on the retaining plates (about 1/16-inch, or 1.5 mm). Applying additional force after the clutch shaft bottoms in the housing can damage the housing and may ruin it.

NOTE: There are two methods of caging the engagement spring. One uses the special tools and a press. The other uses carriage bolts, washers, and wingnuts. Either method is effective.

3. Cage the engagement spring.

   If using the special support and compressor tools, place the fan clutch in a press to cage the engagement spring. See **Fig. 2**.

   If using the optional method of caging the engagement spring, do the following:

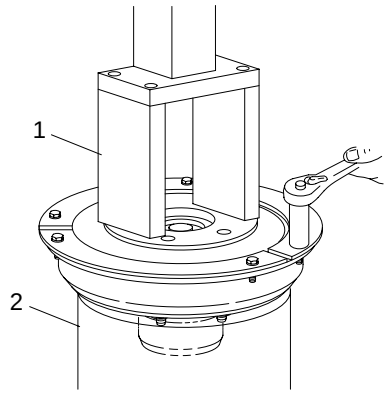
   3.1 With the access holes in the housing assembly aligned with those in the shaft assembly, install two 3-1/2-inch (89-mm) long carriage bolts and suitable washers on opposite sides of the clutch assembly.

   3.2 On the shaft assembly side, install about a 1/2-inch (13-mm) thickness of washers onto each carriage bolt.

   3.3 Install a wingnut on the end of each carriage bolt and tighten the wingnuts evenly until the engagement spring is caged.

4. Remove the lining retaining plates and the lining. See **Fig. 2** and **Fig. 3**.

Fan Clutch Minor Rebuild, Kysor K22RA



1. Compressor Tool
2. Support Tool

Fig. 2, Caging the Engagement Spring and Removing the Lining Retaining Plates

CAUTION

Do not press on the cylinder during this step, or the cylinder will be damaged. Use a 5/8-inch wrench as shown in Fig. 4 on the piston rod flats.

5. If applicable, turn the clutch over in the press, and use the special compressor tool to cage the engagement spring while removing the cylinder nut and cylinder. See **Fig. 4**.
6. Inspect the fan clutch. See **Fig. 3**
   - 6.1 Inspect the two surfaces where the lining rides.
   - 6.2 Inspect the needle bearing race on the shaft.
   - 6.3 Inspect the needle bearings inside the clutch housing.
   - 6.4 Inspect the piston bearing by rotating the piston.
7. If you find cracking or scoring on any surface, or if the bearings are rough, loose, or missing, replace the fan clutch.

NOTE: If you find metal particles in the existing grease, replace the fan clutch or contact Kysor for the training needed to perform a major fan clutch rebuild. Kysor will not provide parts for a major rebuild until the technician has completed rebuild training provided by Kysor.

IMPORTANT: Do not wash the clutch parts in solvent.

8. Using **Fig. 3** as a reference, lubricate the following rebuild parts with lubricant supplied with the rebuild kit (if the lubricant is unavailable, use one of the approved lubricants listed in **Specifications, 400)** :
   - The piston seal (pack the seal groove also)
   - The dust seal (pack the seal groove also)
   - The needle bearings inside the housing
   - The inside of the engagement spring
   - The outside of the piston rod assembly
   - The inside of the piston rod assembly
   - The inside of the cylinder assembly
   - Pack the lip of the grease seal

CAUTION

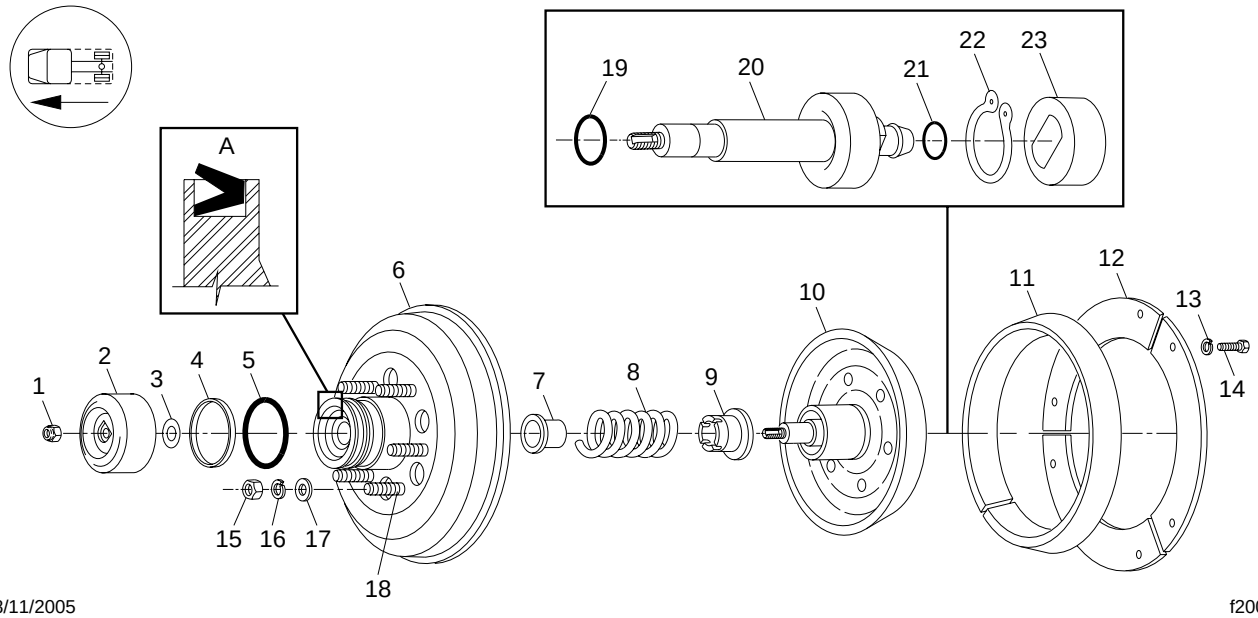
When caging the engagement spring, make sure the bottom edges of the housing assembly and the shaft assembly are flush and aligned all the way around. Failure to do so will cause the engagement spring pressure to affect the torque of the cylinder nut. This could result in the cylinder nut not being tight enough to effectively compress the piston seal washer, which could cause leakage and eventual fan clutch failure.

IMPORTANT: When caging the engagement spring, compress the clutch shaft only 1/16-inch (1.5 mm).

9. Assemble the fan clutch parts according to **Fig. 3**. Using either the special tools and a press, or carriage bolts, washers, and wingnuts, cage the engagement spring when installing the cylinder and lining. Be careful to depress the clutch shaft only 1/16-inch (1.5 mm).

   The piston rod seal washer is the last item to install before the cylinder goes on. See **Fig. 5**.
10. Tighten the cylinder nut 84 lbf·in (940 N·cm).
11. Tighten the lining screws 30 lbf·in (340 N·cm).
12. As applicable, remove the fan clutch from the press or remove the carriage bolts, washers, and wing nuts.

Fan Clutch Minor Rebuild, Kysor K22RA



A. If a lip seal is used, install it so that it faces away from the fan studs.

1. Cylinder Nut
2. Cylinder Assembly
3. Piston Rod Seal Washer
4. Lip Seal (may be O-Ring)
5. Dust Seal
6. Housing Assembly
7. Engagement Spring End Cap
8. Engagement Spring
9. Engagement Spring Carrier
10. Shaft Assembly
11. Lining
12. Lining Retaining Plates
13. Lockwasher
14. Screw
15. Fan Nut
16. Lockwasher
17. Flatwasher
18. Fan Stud
19. O-Ring
20. Piston Rod Assembly
21. O-Ring
22. Snap Ring
23. Coupling

Fig. 3, Kysor K22RA Fan Clutch (exploded view)

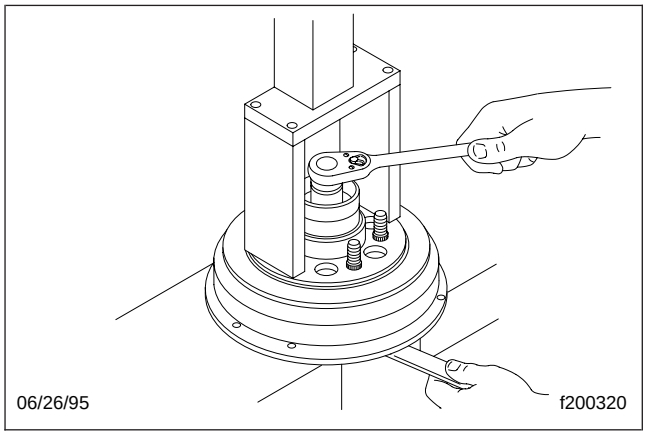


Fig. 4, Removing the Cylinder Nut and Cylinder

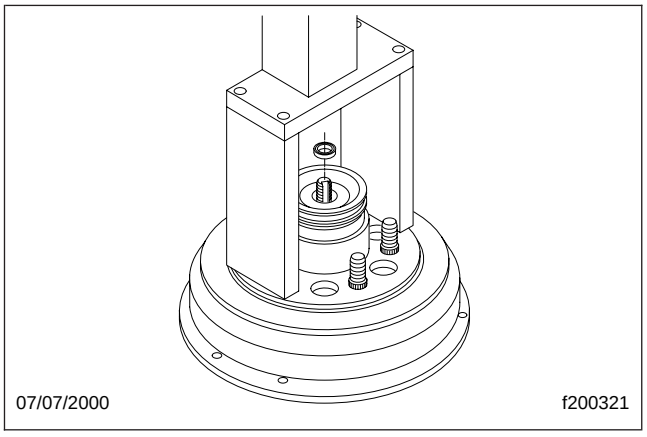


Fig. 5, Installing the Piston Rod Seal Washer

13. Check the front-to-rear travel of the fan clutch. For instructions, refer to Group 20 in the *Heavy Duty Trucks Maintenance Manual*.

14. Install the fan clutch on the engine. For instructions, refer to **Subject 100**.

Fan Clutch Minor Rebuild, Kysor K22RA

15. Close the hood and remove the chocks from the tires.

Fan Clutch Relining, Kysor K22RA

Relining

IMPORTANT: Premature wearing of the fan clutch lining is due to either insufficient air pressure necessary to fully disengage the clutch (allowing the clutch to remain partially engaged, thus increasing wear), or a problem in the control circuit for the fan. Before putting the fan clutch back in service, check the fan control and air supply systems and make any necessary repairs.

1. Park the vehicle on a level surface, apply the parking brake, and shut down the engine. Chock the tires.

⚠ WARNING

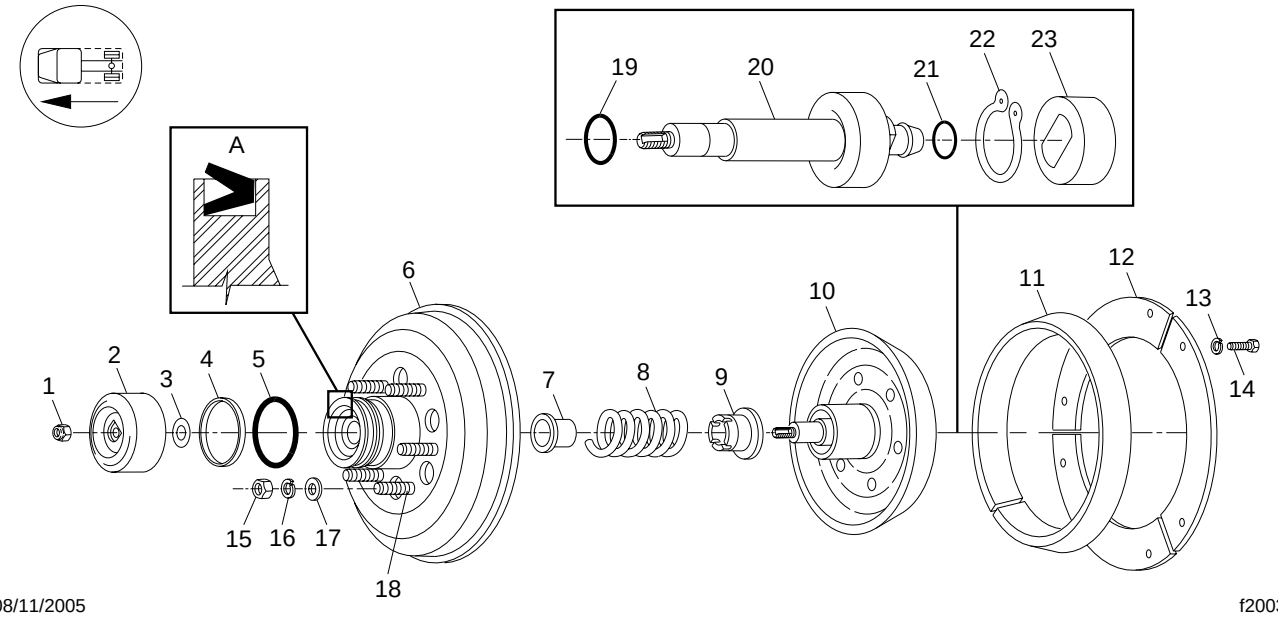
If the fan clutch engages during the next step, it could cause personal injury. Keep the fan clutch disengaged throughout this procedure by maintaining between 90 and 120 psi (620 and 827 kPa) of air pressure.

2. Bleed all the air from the primary and secondary tanks.
3. Disconnect the air line from the fan drive, and apply 90 to 110 psi (620 to 760 kPa) shop air pressure to the fan drive.
4. Remove the six lining plate screws, and remove the three lining plates. See **Fig. 1**.
5. Remove the old lining. If the lining sticks, use a hammer and a screwdriver to free it by tapping on the dividing cut in the lining.
6. Inspect the clutch shaft. If lining residue is present, or if the surface appears glazed over (non-metallic), temporarily release the air pressure from the clutch to allow shaft to protrude, and use a ScotchBrite to break the glaze.

NOTE: Some applications may be too tight to spread the lining and slip it over the pulley. If necessary, the lining can be cut in half with a hacksaw for installation.

7. Apply air pressure to the clutch again, and install the new lining. See **Fig. 2**.
8. Install the new lining plates. Tighten the screws 30 lbf·in (340 N·cm).
9. Remove the air pressure from the fan clutch, and allow the fan to engage.
10. Disconnect the shop air, and connect the air line to the fan drive.

Fan Clutch Relining, Kysor K22RA



A. If a lip seal is used, install it so that it faces away from the fan studs.

1. Cylinder Nut
2. Cylinder Assembly
3. Piston Rod Seal Washer
4. Lip Seal (may be O-Ring)
5. Dust Seal
6. Housing Assembly
7. Engagement Spring End Cap
8. Engagement Spring
9. Engagement Spring Carrier
10. Shaft Assembly
11. Lining
12. Lining Retaining Plates
13. Lockwasher
14. Screw
15. Fan Nut
16. Lockwasher
17. Flatwasher
18. Fan Stud
19. O-Ring
20. Piston Rod Assembly
21. O-Ring
22. Snap Ring
23. Coupling

Fig. 1, Kysor K22RA Fan Clutch (exploded view)

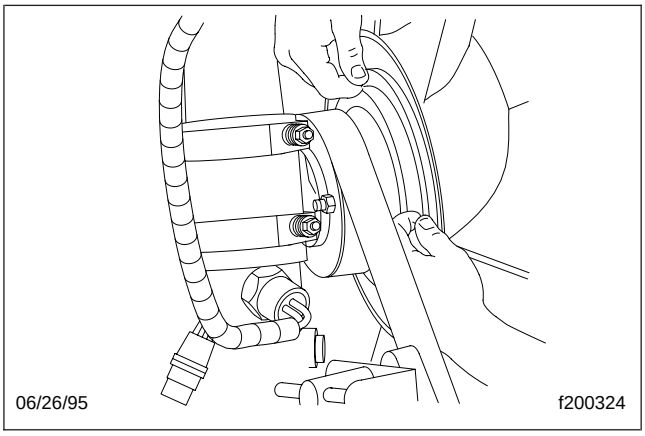


Fig. 2, Removing the Lining Plates

Problem—Fan Clutch Fails to Engage

Problem—Fan Clutch Fails to Engage	
Possible Cause	**Remedy**
There is no power to the fan clutch control circuit.	Check all electrical connections, and repair or replace wiring as needed.
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally closed, not normally open. Replace the switch if it is damaged or if the switch is the wrong type.
The solenoid valve is malfunctioning.	Replace the solenoid valve.
The fan clutch is leaking.	Install a new seal kit.
The air supply to the fan clutch is restricted.	Make sure the fan clutch air lines are not leaking or pinched. Repair the lines as needed.

Problem—Fan Clutch Does Not Disengage

Problem—Fan Clutch Does Not Disengage	
Possible Cause	**Remedy**
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally closed, not normally open. Replace the switch if it is damaged or if the switch is the wrong type.
A restricted air line does not allow air to vent from the clutch.	Make sure the air lines are not pinched or plugged. Repair the air lines as needed.
The solenoid is not exhausting.	Make sure the solenoid exhaust port is not plugged.

Problem—Fan Clutch Cycles Frequently

Problem—Fan Clutch Cycles Frequently	
Possible Cause	**Remedy**
The fan clutch control circuit has a loose connection or is poorly grounded.	Check all wiring connections and repair the circuit as needed.
The temperature control settings are incorrect.	Check the fan clutch control setting of the temperature switch according to the engine installed in the vehicle. Repair or replace the temperature switch as needed.
The fan cycling switch at the receiver-dryer is set too low.	Check the switch at the receiver-dryer and, if needed, replace the switch with a switch with a higher setting.
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
The temperature switch is malfunctioning.	Replace the temperature switch.

Problem—Fan Clutch Engages, But the Engine Still Overheats

Problem—Fan Clutch Engages, But the Engine Still Overheats	
Possible Cause	**Remedy**
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.

Troubleshooting

Problem—Fan Clutch Engages, But the Engine Still Overheats	
Possible Cause	**Remedy**
There is a problem somewhere else in the cooling system.	Refer to "Cooling System Troubleshooting," Section 20.00 in this group.

Specifications

If the lubricant that comes with the rebuild kit for the Kysor K22RA fan clutch is unavailable, use one of the following approved lubricants:

- Aeroshell 5
- Shell Alvania R3
- Chevron SR12
- Amoco Rykon Premium #2EP
- Texaco RB Premium

Kysor K22RA Fan Clutch Torques		
Description	Torque	
	lbf·ft (N·m)	lbf·in (N·cm)
Clutch-to-Hub Fasteners	45 (61)	—
Fan-to-Clutch Fasteners	26 (35)	—
Front Piston Nut	—	84 (950)
Lining Plate Screws	—	30 (340)

Table 1, Kysor K22RA Fan Clutch Torques

General Description

The Espar D7W is a diesel-fired 24,000 BTU/HR coolant heater, which is designed to provide a means of preheating or maintaining heat in a water cooled engine. For ease of installation and protection, the coolant heater is enclosed in a weather resistant steel box.

The coolant heater is installed within the coolant flow of the cooling system and simply pumps coolant from the engine, heats it, and returns it to the engine. The main purpose of the coolant heater is to provide heat to the cab and sleeper while the engine is off. The coolant heater is completely independent of the engine; it runs on both diesel fuel and a 12 or 24 volt power source. A temperature regulating switch in the unit senses the coolant temperature between the low temperature point of 176°F (80°C) and the high temperature point of 210°F (94°C).

The coolant heater may be operated from the vehicle cab by an on/off (pull/push) switch, a preselect timer, or a combination of both.

The coolant heater system has three major components:

- The control unit (**Fig. 1** and **Fig. 2**);
- The fuel metering pump (**Fig. 3**);
- The heater unit (**Fig. 4**).

Except for the on/off switch or preselect timer, the main components of the heater are contained in the steel box. See **Fig. 5**.

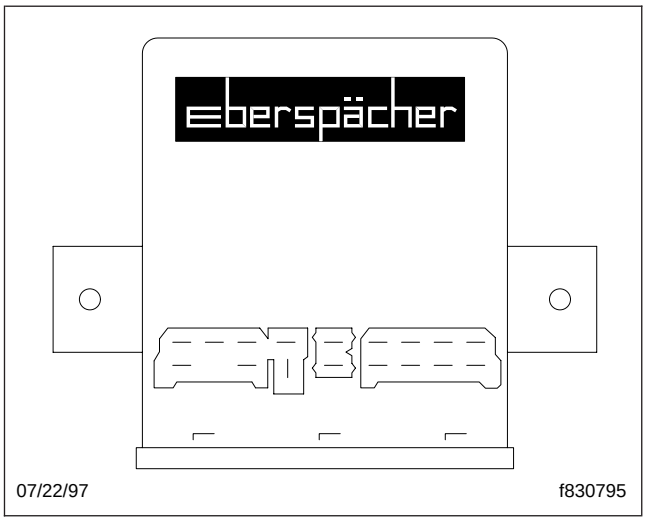


Fig. 1, Control Unit (model 25-1666)

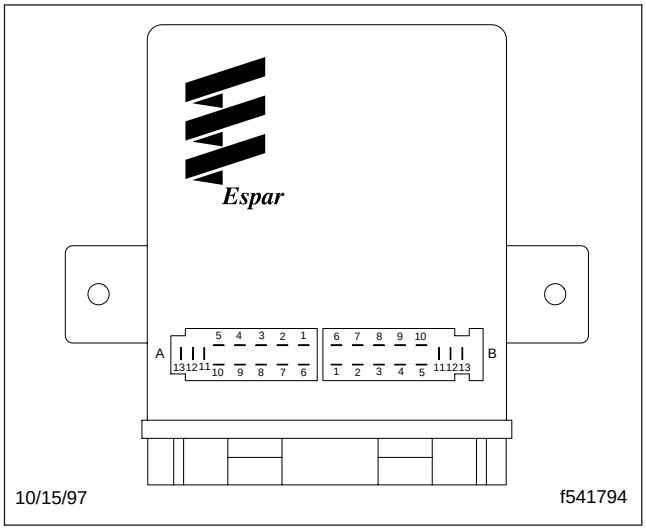


Fig. 2, Control Unit (model 25-1807)

Principles of Operation

Switch On and Start Up

Once the coolant heater is switched on, the following sequence of events will take place:

1. The combustion air blower starts.
2. The coolant pump starts.
3. The control unit checks all functions.
4. The glow plug begins to preheat the combustion chamber (20 to 50 seconds dependant on input voltage, the preheat time is longer if the voltage is lower).
5. The control unit checks the input voltage (under or over voltage will cause the heater to shut down).
6. After the 20 to 50 second combustion chamber preheat, the fuel pump will start.
7. Once the ignition takes place, the flame sensor will automatically switch the glow plug off (there is a 1 to 3 minute maximum ignition time).

NOTE: If the coolant heater fails to start the first time, it will automatically attempt a second start.

General Information

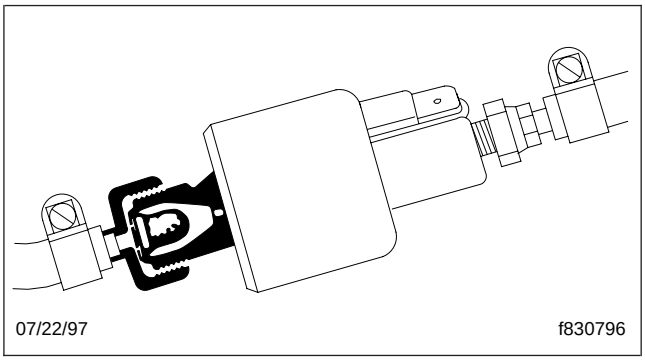


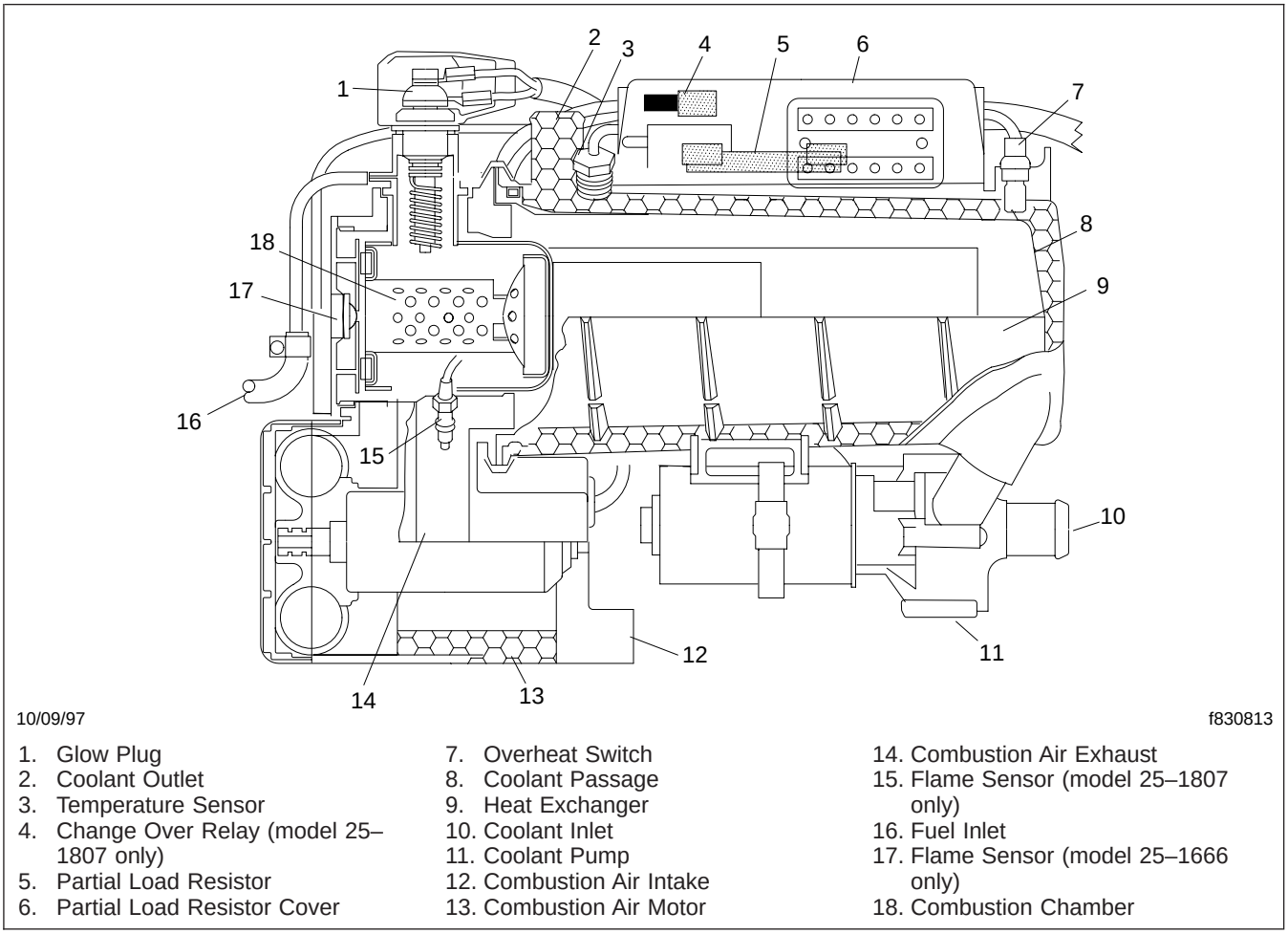
Fig. 3, Fuel Metering Pump

NOTE: On initial start up the heater may require several start attempts to self prime the fuel system.

Running

After ignition, the following operations or events will take place:

1. The coolant heater runs in full heat mode.
2. Once the coolant temperature reaches 194°F (90°C), the coolant heater automatically switches to low heat mode and continues to run.

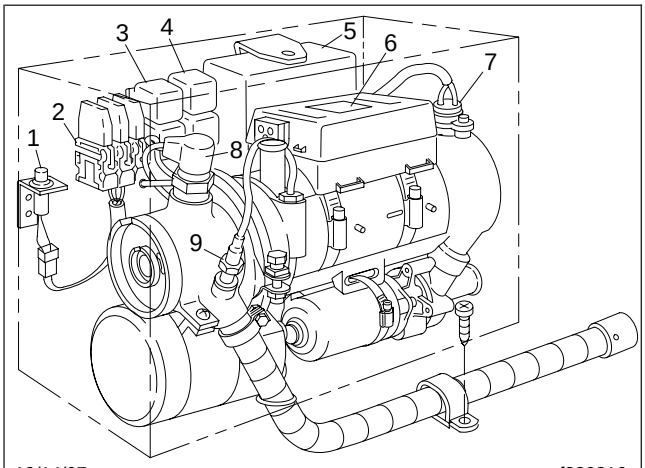


1. Glow Plug
2. Coolant Outlet
3. Temperature Sensor
4. Change Over Relay (model 25–1807 only)
5. Partial Load Resistor
6. Partial Load Resistor Cover
7. Overheat Switch
8. Coolant Passage
9. Heat Exchanger
10. Coolant Inlet
11. Coolant Pump
12. Combustion Air Intake
13. Combustion Air Motor
14. Combustion Air Exhaust
15. Flame Sensor (model 25–1807 only)
16. Fuel Inlet
17. Flame Sensor (model 25–1666 only)
18. Combustion Chamber

Fig. 4, Coolant Heater Unit

If unsuccessful, the coolant heater will shut down completely.

3. If the coolant temperature drops to 176°F (80°C), the coolant heater will automatically switch back to full heat mode.



1. Diagnostic LED
2. Fuse Bank
3. Glow Plug Relay
4. Relay to Switch, Vehicle Fan
5. Control Unit
6. Model Identification Plate
7. Overheat Switch
8. Glow Plug
9. Flame Sensor

Fig. 5, Model 25-1807 Coolant Heater

4. If the coolant temperature increases to 201°F (94°C), the coolant heater will automatically switch off.

NOTE: As long as the coolant heater is switched on, the coolant pump will continue to run regardless of whether the heater is ignited or not (provided a malfunction shut down has not occurred).

5. The coolant pump will continue to circulate coolant to allow the heater to monitor the engine temperature.
6. If the coolant heater cycles off, it will automatically restart once the coolant temperature reaches 176°F (80°C).
7. The coolant heater will continue to run as described above until it is switched off, either manually, automatically by a timer, or if a heater malfunction shut down occurs.

NOTE: While in running mode, if the coolant heater should shut down due to flame out it will automatically attempt one restart. If the restart is successful, the heater will continue to run. If the restart is not successful, then the heater will shut down completely.

During operation, the coolant heater continually senses the input voltage from the batteries. If the input voltage drops to approximately 10.5 volts (21 volts for a 24 volt system), then the coolant heater will automatically shut down.

Switching Off

Once the coolant heater is switched off, the following cool down cycle will take place:

⚠ WARNING

The coolant heater must be switched off while any fuel tank on the vehicle is being filled. Ignition of fuel vapors (a fire or explosion) could occur, which could result in both personal injury and property damage.

⚠ WARNING

Do not operate the heater in poorly ventilated areas or enclosed spaces. Exhaust fumes could cause breathing impairment, which could result in personal injury or death.

1. The fuel metering pump stops delivering fuel and the flame is extinguished.
2. The glow plug is re-energized for a 15 second after glow.
3. The combustion air blower and water pump continue to run for a three minute cool down cycle, then they switch off.

Safety Equipment

The control unit, the overheat switch, and the flame sensor continually monitor the coolant heater functions and will shut down the heater in the case of a malfunction. The flame is monitored by the flame sensor, while the overheat temperature is monitored by the overheat switch. Events or conditions that can cause a automatic malfunction shutdown include:

1. If the ignition fails to take place within 90 seconds of starting the fuel metering pump, the starting procedure will be repeated. If the coolant heater again fails to ignite after 90 seconds of

General Information

fuel being pumped, then an automatic malfunction shutdown will occur.

2. If the flame goes out spontaneously during operation, the coolant heater automatically attempts to restart. If the coolant heater fails to ignite within 90 seconds of the fuel being pumped, or if it ignites but goes out again within 3 minutes, an automatic malfunction shutdown will occur.
3. If the coolant heater overheats (due to lack of coolant, a restriction, or a poorly bled coolant system), the overheat switch trips, which cuts off the fuel supply, and starts a malfunction shutdown.
4. If at any time the voltage drops below 10.5 volts (12 volt system) or 21.0 volts (24 volt system) or rises above 15 volts or 30.0 volts (depending on voltage system), an automatic shutdown will follow after a 20 second delay.
5. The coolant heater will not start if the glow plug doesn't work or if the electrical cable to the metering pump is broken.
6. The function of the combustion air blower motor is checked once when the coolant heater is started. If it fails to start, the coolant heater indicates a malfunction.

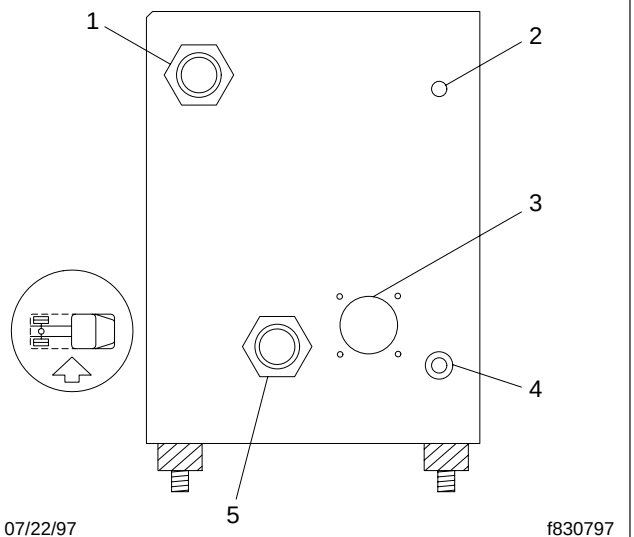
⚠ CAUTION

During electrical welding work on the vehicle, disconnect power to the coolant heater in order to protect the control unit. Failure to do this could damage the control unit.

Coolant Heater Removal and Installation

Removal

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the hood or cab.
2. Disconnect the batteries.
3. Disconnect the electrical connections to the coolant heater assembly.



1. Coolant Outlet
2. 25 AMP Circuit Breaker (model 25–1666 only)
3. Electrical Quick Connect Coupler
4. Fuel Line
5. Coolant Inlet

Fig. 1, Coolant Heater Connections

NOTE: Separate the electrical harnesses from the quick connect coupler at the coolant heater assembly. All external electrical harnesses (the power harness, the on/off switch harness and the fuel pump harness) enter the coolant heater assembly through an electrical quick connect coupler. See **Fig. 1**.

⚠ WARNING

Drain the coolant only when the coolant and the engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

4. Drain the coolant into a suitable clean container. See **Section 20.01** in this manual for instructions.
5. Mark the coolant inlet and outlet positions on the coolant heater assembly and on the heater hoses for later reference. Loosen the hose clamps and remove the heater hoses from the coolant heater assembly. See **Fig. 1** and **Fig. 2**.
6. Using caution to avoid fuel spilling fuel, remove the 9/32-inch (7-mm) hose clamp from the rubber fuel line connection at the coolant heater assembly. Separate the fuel line from the rubber fuel line connection. See **Fig. 1** for location.
7. Remove the fasteners from the coolant heater exhaust pipe support brackets. Pull the exhaust pipe away from the frame. See **Fig. 3**.
8. Remove the four mounting nuts and washers from the bottom of the coolant heater assembly bracket. Remove the coolant heater assembly with the four rubber shock mounts from the mounting bracket. See **Fig. 2**.

Installation

⚠ WARNING

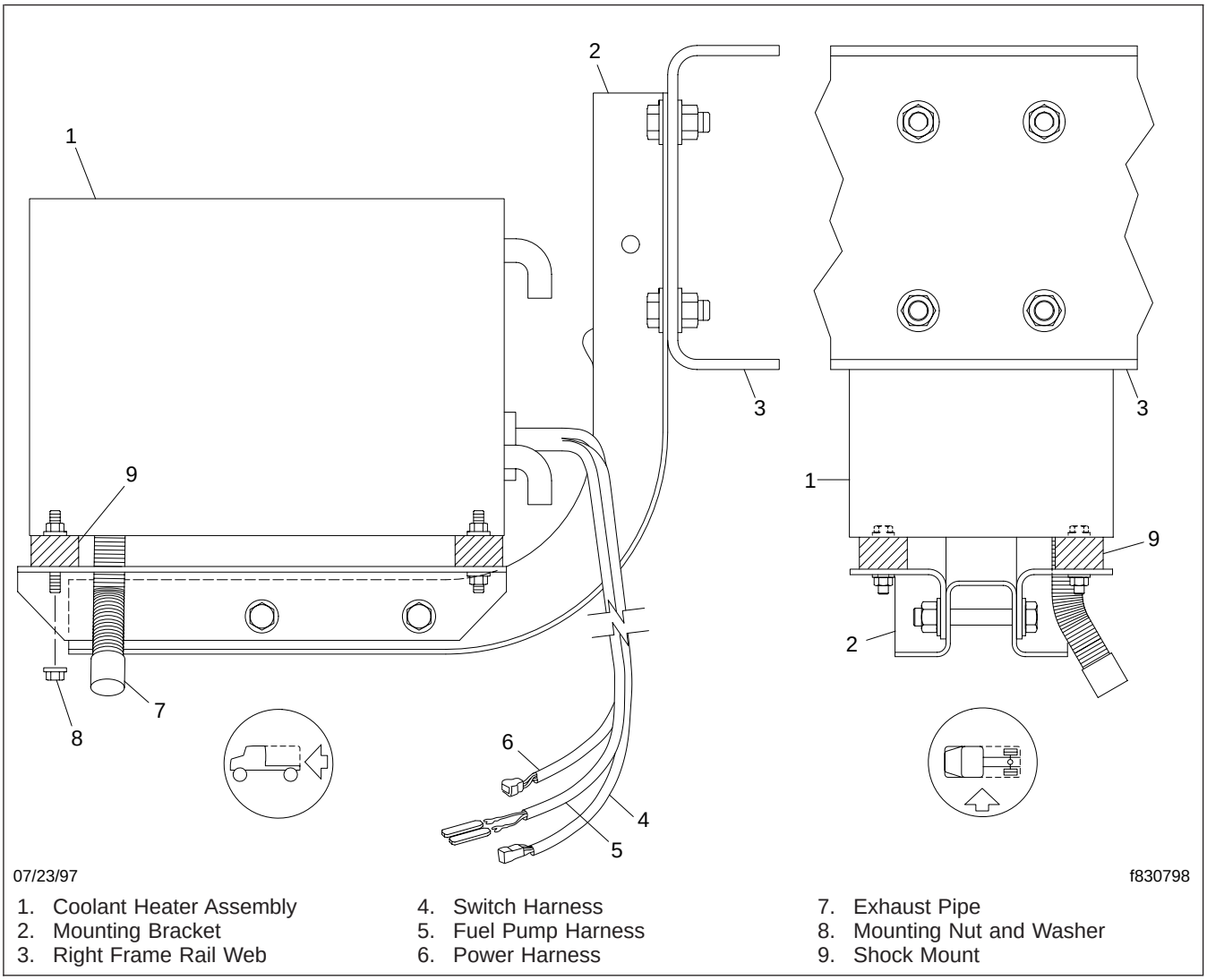
Make sure the batteries have been disconnected before proceeding with this installation. The coolant heater has both a battery power connection and diesel fuel connection. If an electrical spark were to occur during the installation, a fire could start and cause personal injury and property damage.

1. Position the coolant heater assembly with the four rubber shock mounts over the mounting bracket. Locate the rubber shock mount studs over the four mounting holes in the bracket. Lower the coolant heater assembly on the bracket. See **Fig. 2**.

NOTE: For severe vibration applications a heavy shock mounting kit is available from Espar Heater Systems. The part number is CA000012.

2. Install the four mounting nuts and washers on the bottom of the coolant heater assembly bracket. Tighten the mounting nuts snugly. See **Fig. 2**.

Coolant Heater Removal and Installation



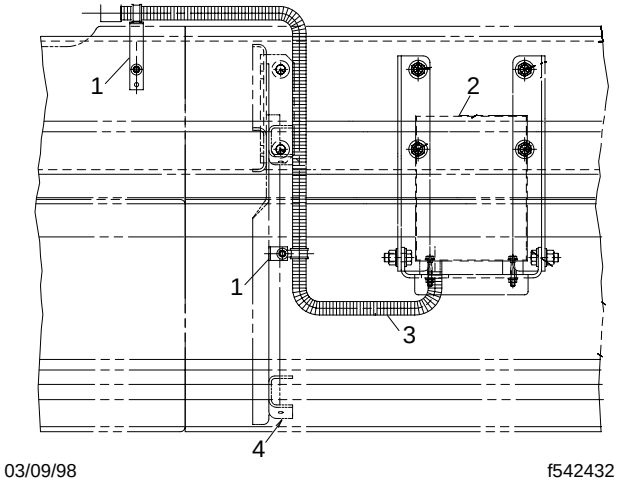
1. Coolant Heater Assembly
2. Mounting Bracket
3. Right Frame Rail Web
4. Switch Harness
5. Fuel Pump Harness
6. Power Harness
7. Exhaust Pipe
8. Mounting Nut and Washer
9. Shock Mount

Fig. 2, Coolant Heater Installation

3. Position the coolant heater exhaust pipe on the frame rail. Install the fasteners through the exhaust pipe support brackets and into the existing holes. Tighten the fasteners snugly. See **Fig. 3**.
4. Using caution to avoid spilling fuel, connect the fuel line to the rubber fuel line connection at the coolant heater assembly. Attach and secure the 9/32-inch (7-mm) hose clamp around the rubber fuel line connection. See **Fig. 1** for the fuel line location.
5. Connect the electrical connections to the coolant heater assembly.

NOTE: Connect the electrical harnesses to the quick connect coupler at the coolant heater assembly. All external electrical harnesses (the power harness, the on/off switch harness and the fuel pump harness) enter the coolant heater assembly through an electrical quick connect coupler. See **Fig. 1**.

6. As marked during removal, install the two heater hoses and hose clamps to the proper inlet and outlet coolant fittings on the coolant heater assembly. See **Fig. 4** or **Fig. 5**.



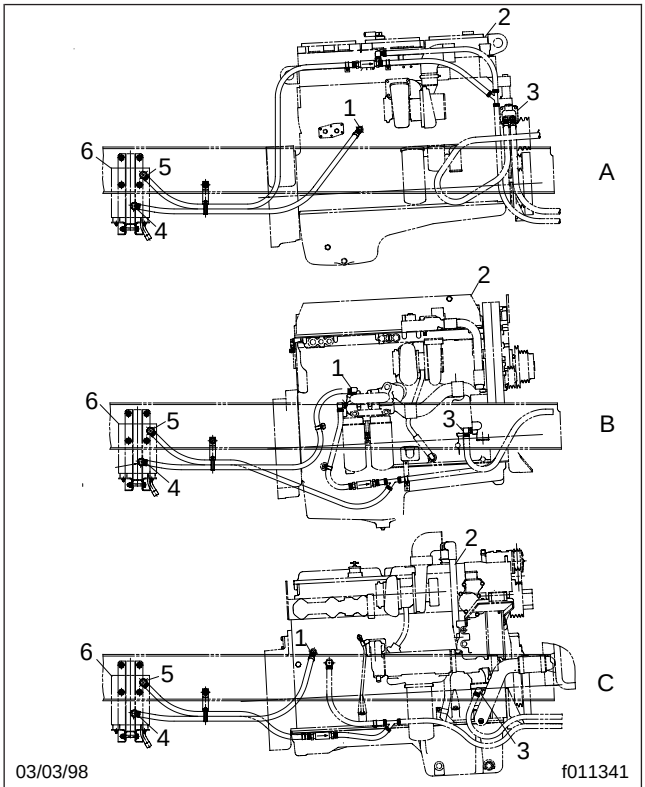
1. Exhaust Pipe Support Bracket
2. Espar Coolant Heater
3. Exhaust Pipe
4. Fairing Support Bracket

Fig. 3, Coolant Heater Exhaust Mounting

7. Tighten the two heater hose clamps snugly.
8. Connect the batteries.
9. Bleed the cooling system.
   - 9.1 Fill the radiator with coolant.
   - 9.2 In the cab, set the heater control to the maximum heat position.
   - 9.3 Start the engine and run it until the radiator thermostat has opened.
   - 9.4 Switch the coolant heater on by pulling out the on/off switch. This will start the electric coolant pump in the coolant heater. The coolant pump will bleed the air out of the system as it circulates coolant through the heater.

   NOTE: The coolant heater's ignition may cycle on during the previous substep.

   - 9.5 Stop the engine.
   - 9.6 Fill the radiator and pressure test the cooling system for leaks. If leaks are found, tighten the hose clamps and/or replace the hoses. Fill the radiator if needed.



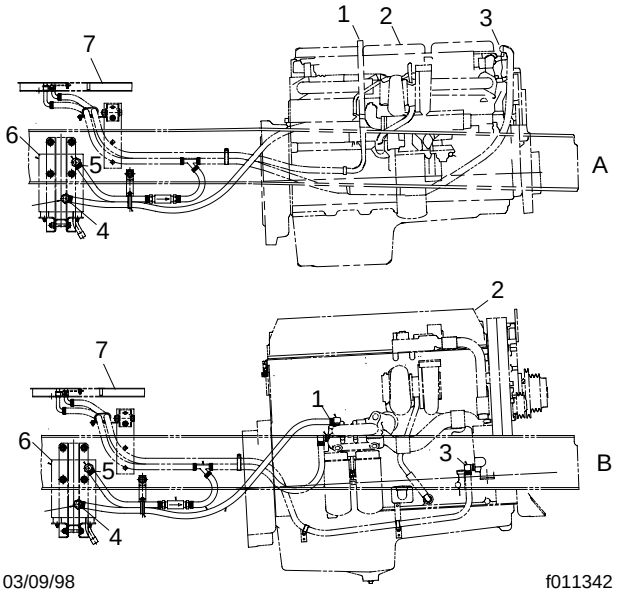
A. Cummins N14 Engine
B. Detroit Diesel DDC S60 Engine
C. Caterpillar 3406 Engine

1. Coolant Heater Supply Port
2. Engine
3. Coolant System Return Port
4. Coolant Heater Supply Fitting
5. Coolant Heater Return Fitting
6. Espar Coolant Heater

Fig. 4, Day Cab Heater Plumbing

- 9.7 Stop the coolant heater by pushing in on the on/off switch.
- 9.8 Return and secure the hood or cab in the operating position.
- 9.9 Remove the chocks from the tires.

Coolant Heater Removal and Installation



A. Caterpillar 3176 Engine
B. Detroit Diesel DDC S60 Engine
1. Coolant Heater Supply Port
2. Engine
3. Coolant System Return Port
4. Coolant Heater Supply Fitting
5. Coolant Heater Return Fitting
6. Espar Coolant Heater
7. SleeperCab Deck

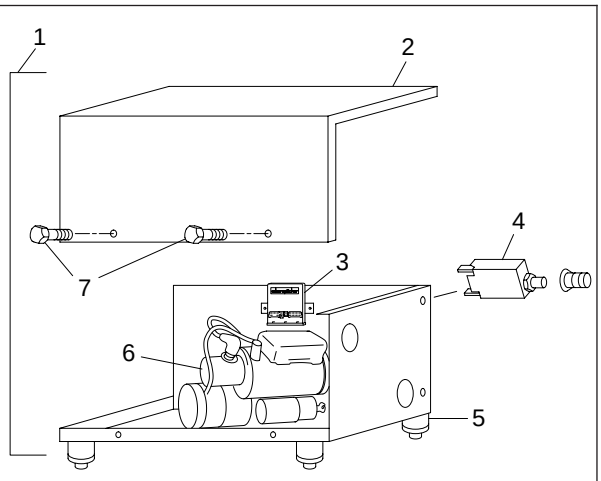
Fig. 5, SleeperCab Heater Plumbing

Glow Plug Removal and Installation

NOTE: To remove the glow plug, the lid of the coolant heater assembly box must be removed. If the location of the coolant heater assembly box hinders the removal of the lid, then it may be necessary to move the coolant heater assembly off its mounting bracket. For instructions, see **Subject 100**.

Removal

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the hood or cab.
2. Disconnect the batteries.
3. Remove the two capscrews at the bottom of the coolant heater assembly box lid.
4. Slide the three-sided lid off the base of the coolant heater assembly box. This will expose both the heater unit and the control unit. See **Fig. 1**.



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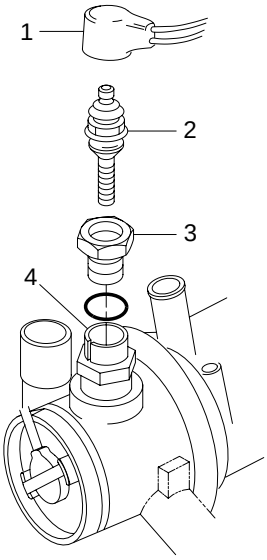
1. Coolant Heater Assembly Box
2. Coolant Heater Assembly Box Lid
3. Control Unit
4. 30 Amp Circuit Breaker (model 25–1666 only)
5. Rubber Shock Mount
6. Heater Unit
7. Lid Capscrew

Fig. 1, Coolant Heater Box Assembly

5. Remove the glow plug protective cap. See **Fig. 2**.
6. Remove the hexnut holding the glow plug cable and remove the cable.



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1. Glow Plug Protective Cap
2. Glow Plug
3. Glow Plug Reducer
4. Glow Plug Strainer

Fig. 2, Glow Plug Assembly

7. Unscrew the glow plug. Inspect the glow plug and heating coil for breaks or metal fatigue. Check and remove any accumulated coke (carbon) from the glow plug heating coil.

   See **Subject 300**, for glow plug replacement recommendations. Replace the glow plug as necessary.

8. Unscrew the glow plug reducer and take the glow plug strainer out.

   Using varsol, a brass brush, and compressed air, remove any carbon build up inside the glow plug strainer. Replace the glow plug strainer if it is damaged during this cleaning procedure.

   Clean and remove any carbon build up inside the glow plug chamber.

Installation

1. Install the glow plug strainer and the glow plug reducer.
2. Install the glow plug and tighten it 60 to 96 lbf·in (680 to 1080 N·cm).

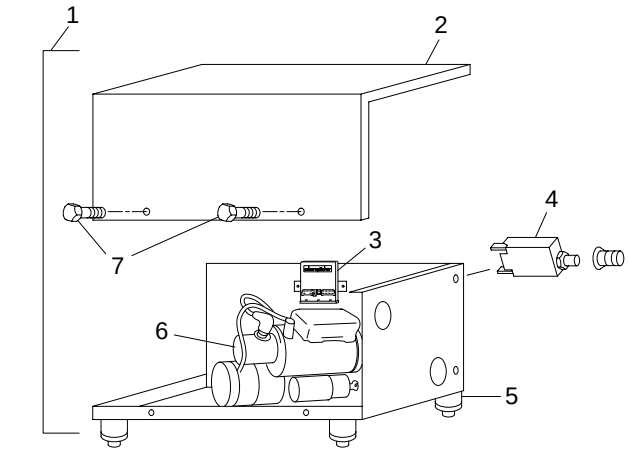
Glow Plug Removal and Installation

3. Install the glow plug cable and protective cap. See **Fig. 2**.
4. Slide the three-sided lid onto the base of the coolant heater assembly box.
5. Install the two capscrews at the bottom of the coolant heater assembly box lid. Tighten the capscrews 10 lbf·ft (14 N·m).
6. Connect the batteries.
7. Return and secure the hood or cab in the operating position.
8. Remove the chocks from the tires.

Temperature Sensor Replacement

NOTE: To replace the temperature sensor, the lid of the coolant heater assembly box must be removed. If the location of the coolant heater assembly box hinders the removal of the lid, then it may be necessary to move the coolant heater assembly off its mounting bracket. For instructions, see **Subject 100**.

Replacement (See Fig. 1 and Fig. 2)



1. Coolant Heater Assembly Box
2. Coolant Heater Assembly Box Lid
3. Control Unit
4. 30 Amp Circuit Breaker (model 25–1666 only)
5. Rubber Shock Mount
6. Heater Unit
7. Lid Capscrew

Fig. 1, Coolant Heater Box Assembly

WARNING

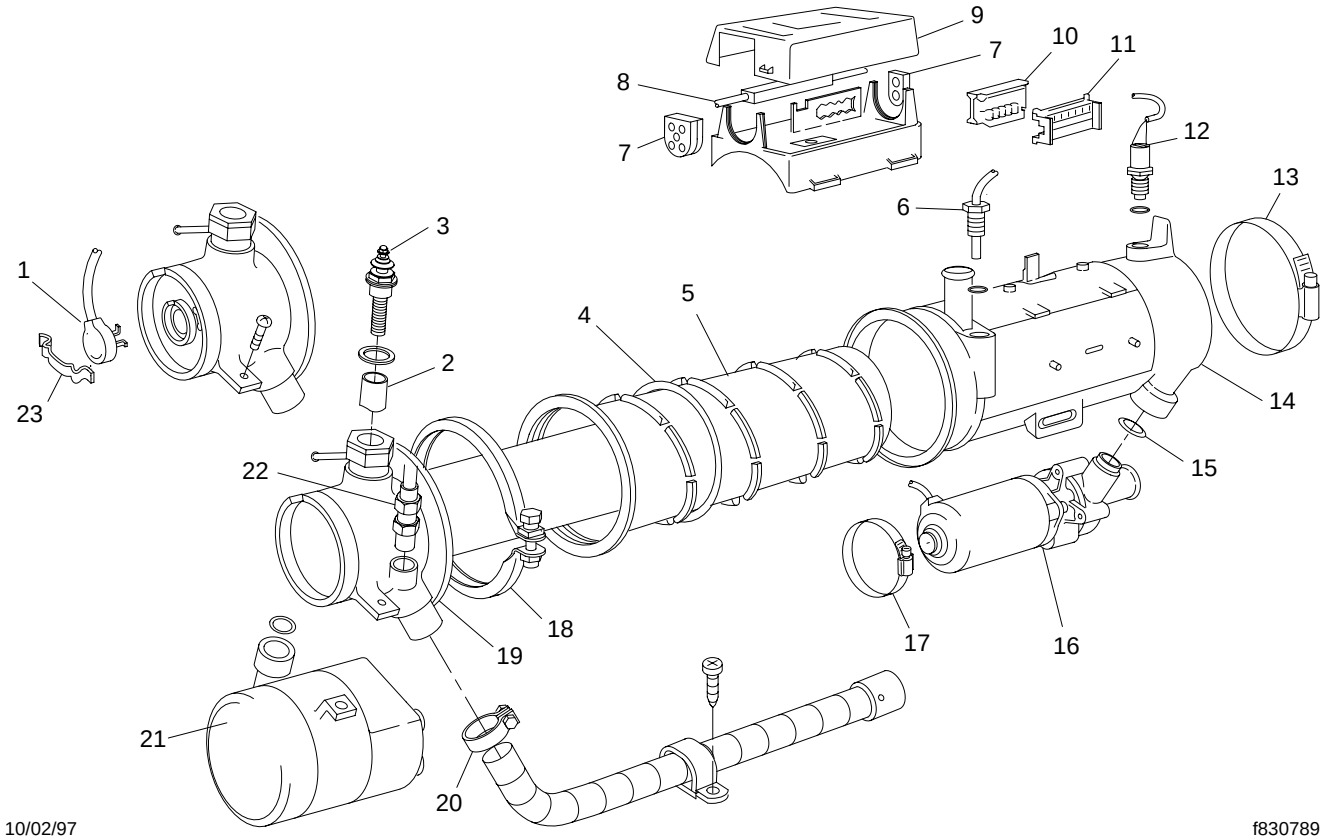
To avoid personal injury from scalding coolant, wait until the engine has cooled to room temperature before removing the temperature sensor.

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the hood or cab.
2. Disconnect the batteries.
3. Remove the two capscrews at the bottom of the coolant heater assembly box lid.
4. Slide the three-sided lid off the base of the coolant heater assembly box. This will expose both the heater unit and the control unit. See **Fig. 1**.
5. Remove the radiator pressure cap to minimize the cooling system pressure.
6. At the coolant heater, clamp off both the coolant heater hoses, to prevent the coolant from flowing out.
7. Remove the partial load resistor cover (**Fig. 2**, Ref. 9).
8. Unclip the 12-pin connector plug from the holder (Ref. 11). Remove the 12-pin connector plug.

NOTE: The following step may require the use of special tools for certain connectors and terminals. See **Group 54** (wiring) in this manual for information on special terminals and connectors, and special tools.

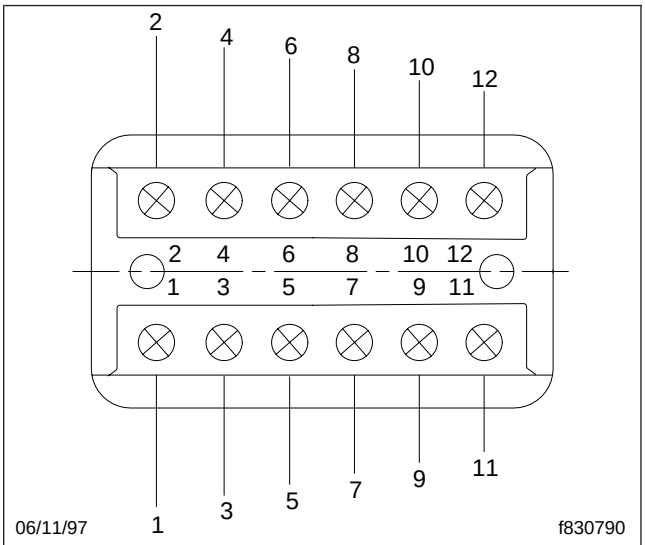
9. Take pins 8 and 10 out of the 12-pin connector plug housing (**Fig. 3** or **Fig. 4**, Refs. 8 and 10).
10. Loosen and remove the temperature sensor (**Fig. 2**, Ref. 6).
11. Install new temperature sensor and tighten 12 to 24 lbf·in (135 to 271 N·cm).
12. Install the connector pins, of the new temperature sensor, into the 12-pin connector plug housing (positions 8 and 10).
13. Install the 12-pin connector plug firmly into the holder and install the partial load resistor cover.
14. Slide the three-sided lid onto the base of the coolant heater assembly box.
15. Install the two capscrews at the bottom of the coolant heater assembly box lid. Tighten the capscrews 10 lbf·ft (14 N·m).
16. Remove clamps from both the coolant heater hoses, at the coolant heater.
17. Connect the batteries.
18. Bleed cooling system. For instructions, see **Subject 100**.
19. Return and secure the hood or cab in the operating position.
20. Remove the chocks from the tires.

Temperature Sensor Replacement



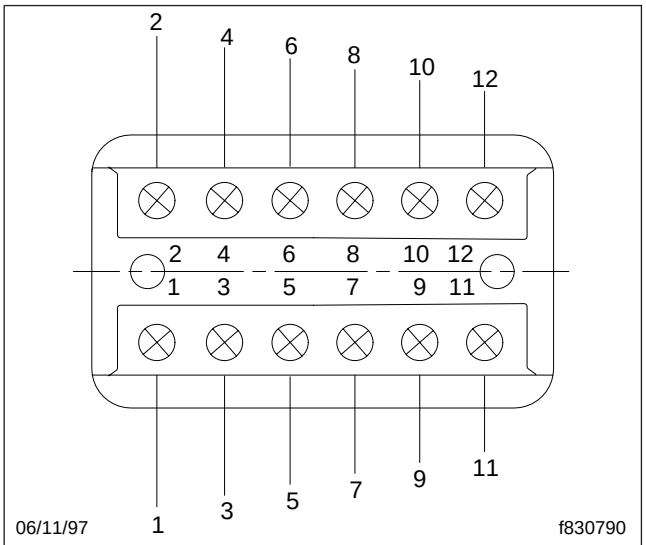
1. Flame Sensor (model 25–1666 only)
2. Glow Plug Strainer
3. Glow Plug
4. O-Ring
5. Heat Exchanger
6. Temperature Sensor
7. Grommet
8. Partial Load Resistor
9. Partial Load Resistor Cover
10. 12-Pin Connector Plug Housing
11. 12-Pin Connector Plug
12. Overheat Switch
13. Mounting Clamp
14. Coolant Jacket
15. Coolant Pump O-Ring
16. Coolant Pump
17. Coolant Pump Clamp
18. Burner Connector Clamp
19. Burner
20. Exhaust Pipe Clamp
21. Combustion Air Blower
22. Flame Sensor (model 25–1807 only)
23. Retaining Spring (model 25–1666 only)

Fig. 2, Heater Unit Assembly



1. Coolant Pump (black)
2. Coolant Pump (brown)
3. Combustion Air Blower (brown)
4. Combustion Air Blower (violet)
5. Partial-Load Resistor (red)
6. Partial-Load Resistor (red)
7. Flame Sensor (brown)
8. Temperature Sensor (brown)
9. Flame Sensor (gray)
10. Temperature Sensor (grey)
11. Overheat Switch (white)
12. Overheat Switch (white)

Fig. 3, Model 25-1666 12-Pin Connector Plug



1. Coolant Pump (black)
2. Coolant Pump (brown)
3. Combustion Air Blower (brown)
4. Not Used
5. Speed Change Relay (black)
6. Combustion Air Blower and Speed Change Relay (black/red)
7. Flame Sensor (gray)
8. Temperature Sensor (brown)
9. Flame Sensor (gray)
10. Temperature Sensor (grey)
11. Overheat Switch (white)
12. Overheat Switch (white)

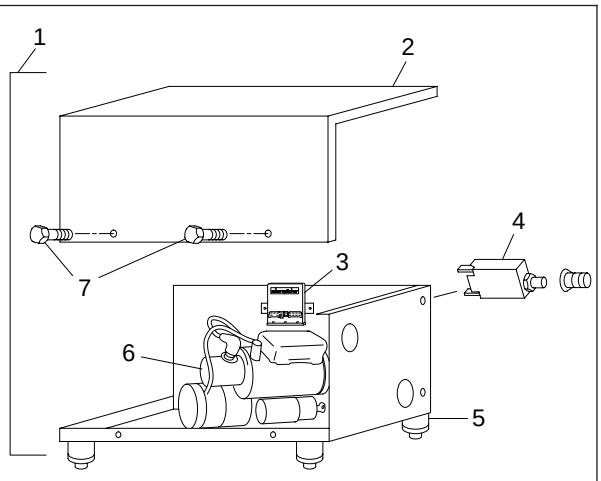
Fig. 4, Model 25-1807 12-Pin Connector Plug

Model 25–1666 Flame Sensor Removal and Installation

NOTE: To remove the flame sensor, the lid of the coolant heater assembly box must be removed. If the location of the coolant heater assembly box hinders the removal of the lid, then it may be necessary to move the coolant heater assembly off its mounting bracket. For instructions, see **Subject 100**.

Removal (See Fig. 1 and Fig. 2)

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the hood or cab.
2. Disconnect the batteries.
3. Remove the two capscrews at the bottom of the coolant heater assembly box lid.
4. Slide the three-sided lid off the base of the coolant heater assembly box. This will expose both the heater unit and the control unit. See **Fig. 1**.



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1. Coolant Heater Assembly Box
2. Coolant Heater Assembly Box Lid
3. Control Unit
4. 30 Amp Circuit Breaker
5. Rubber Shock Mount
6. Heater Unit
7. Lid Capscrew

Fig. 1, Coolant Heater Box Assembly

5. Remove the partial load resistor cover (**Fig. 2**, Ref. 9).
6. Unclip the 12-pin connector plug from the holder (Ref. 11). Remove the 12-pin connector plug.

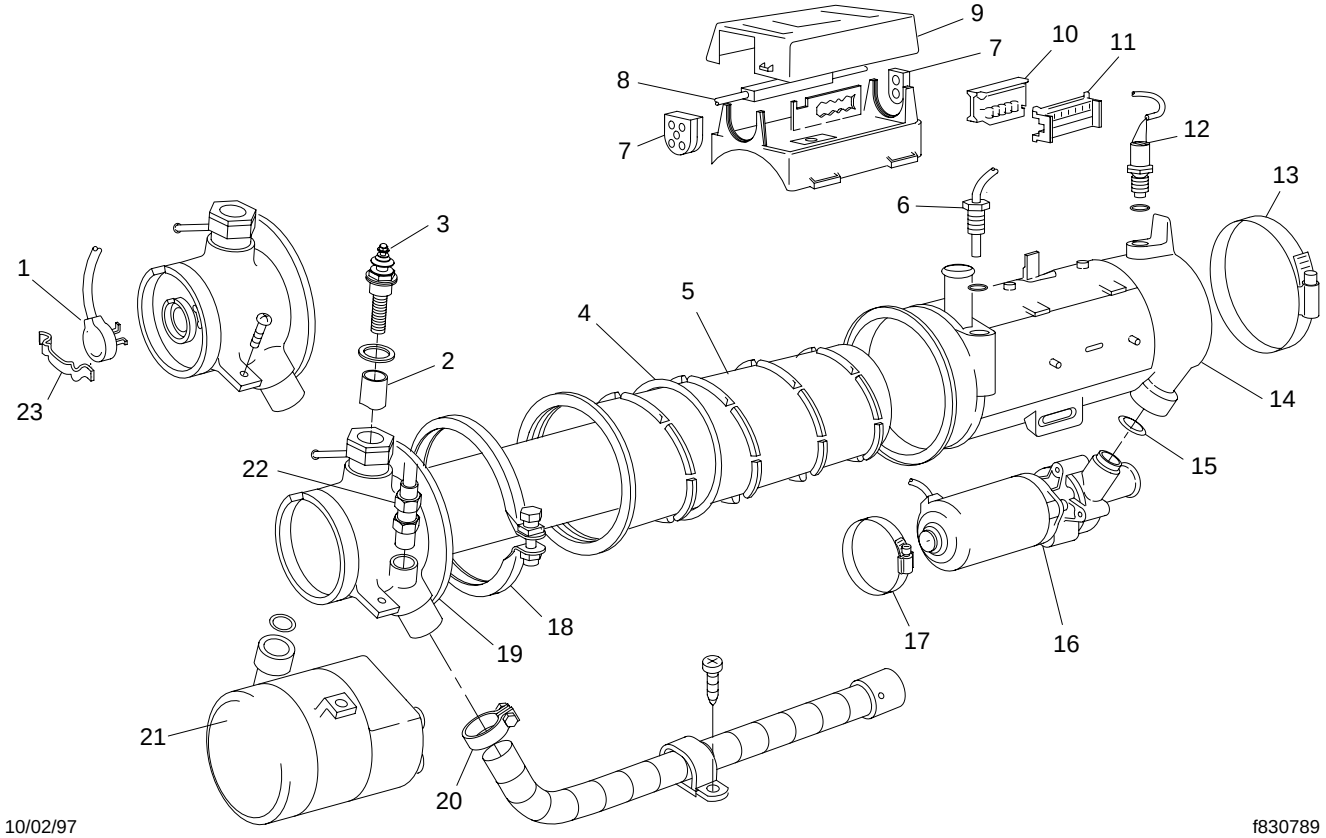
NOTE: The following step may require the use of special tools for certain connectors and terminals. See **Group 54** (wiring) in this manual for information on special terminals and connectors, and special tools.

7. Take pins 7 and 9 out of the 12-pin connector plug housing (**Fig. 3**, Refs. 7 and 9).
8. Unclip the retaining spring (**Fig. 2**, Ref. 22) and remove the flame sensor (Ref. 1) from the holder.
9. Using a soft cloth clean the flame sensor.
10. See **Subject 300**, for flame sensor replacement recommendations. Inspect and replace the flame sensor if necessary.

Installation

1. Install the flame sensor and clip the retaining spring into the holder.
2. Install the flame sensor connector pins into the 12-pin connector plug housing (positions 7 and 9).
3. Install the 12-pin connector plug firmly into the holder and install the partial load resistor cover.
4. Slide the three-sided lid onto the base of the coolant heater assembly box.
5. Install the two capscrews at the bottom of the coolant heater assembly box lid. Tighten the capscrews 10 lbf·ft (14 N·m).
6. Connect the batteries.
7. Return and secure the hood or cab in the operating position.
8. Remove the chocks from the tires.

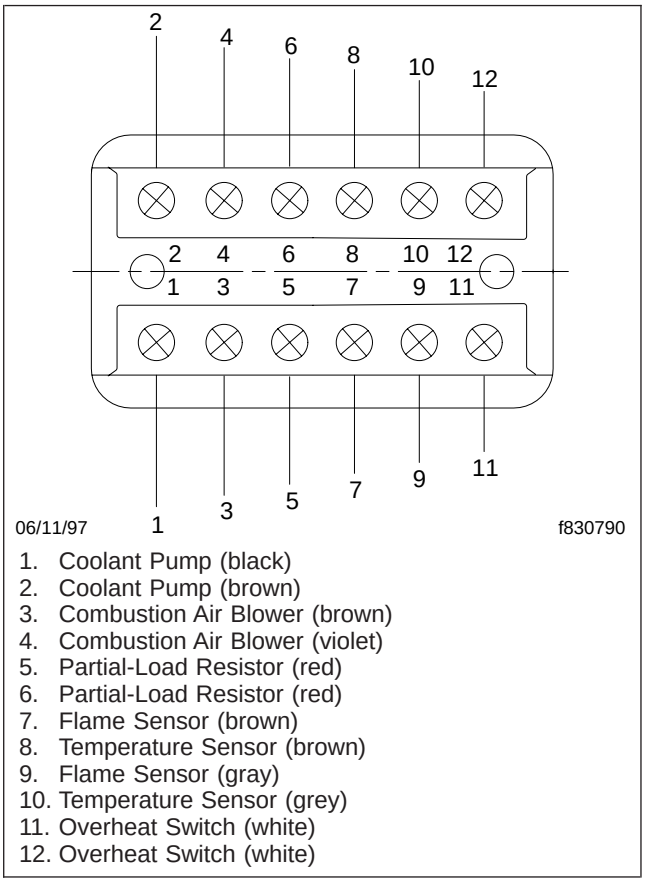
Model 25–1666 Flame Sensor Removal and Installation



1. Flame Sensor (model 25–1666)
2. Glow Plug Strainer
3. Glow Plug
4. O-Ring
5. Heat Exchanger
6. Temperature Sensor
7. Grommet
8. Partial Load Resistor
9. Partial Load Resistor Cover
10. 12-Pin Connector Plug Housing
11. 12-Pin Connector Plug
12. Overheat Switch
13. Mounting Clamp
14. Coolant Jacket
15. Coolant Pump O-Ring
16. Coolant Pump
17. Coolant Pump Clamp
18. Burner Connector Clamp
19. Burner
20. Exhaust Pipe Clamp
21. Combustion Air Blower
22. Flame Sensor (model 25–1807 only)
23. Retaining Spring (model 25–1666 only)

Fig. 2, Heater Unit Assembly

Model 25–1666 Flame Sensor Removal and Installation



1. Coolant Pump (black)
2. Coolant Pump (brown)
3. Combustion Air Blower (brown)
4. Combustion Air Blower (violet)
5. Partial-Load Resistor (red)
6. Partial-Load Resistor (red)
7. Flame Sensor (brown)
8. Temperature Sensor (brown)
9. Flame Sensor (gray)
10. Temperature Sensor (grey)
11. Overheat Switch (white)
12. Overheat Switch (white)

Fig. 3, 12-Pin Connector Plug

Model 25–1666 Overheat Switch Replacement

NOTE: To remove the overheat switch, the lid of the coolant heater assembly box must be removed. If the location of the coolant heater assembly box hinders the removal of the lid, then it may be necessary to move the coolant heater assembly off its mounting bracket. For instructions, see **Subject 100**.

Replacement (See Fig. 1 and Fig. 2)

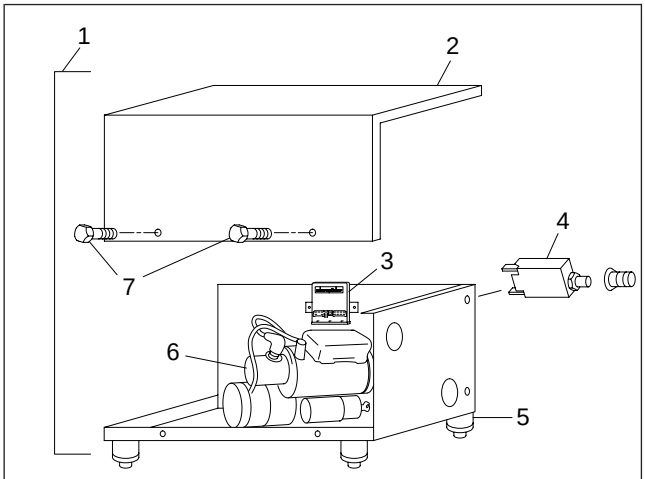
WARNING

To avoid personal injury from scalding coolant, wait until the engine has cooled to room temperature before removing the overheat switch.

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the hood or cab.
2. Disconnect the batteries.
3. Remove the two capscrews at the bottom of the coolant heater assembly box lid.
4. Slide the three-sided lid off the base of the coolant heater assembly box. This will expose both the heater unit and the control unit. See **Fig. 1**.
5. Remove the radiator pressure cap to minimize the cooling system pressure.
6. At the coolant heater, clamp off both the coolant heater hoses, to prevent the coolant from flowing out.
7. Remove the partial load resistor cover (**Fig. 2**, Ref. 9).
8. Unclip the 12-pin connector plug from the holder (Ref. 11). Remove the 12-pin connector plug.

NOTE: The following step may require the use of special tools for certain connectors and terminals. See **Group 54** (wiring) in this manual for information on special terminals and connectors, and special tools.

9. Take pins 11 and 12 out of the 12-pin connector plug housing (**Fig. 3**, Refs. 11 and 12).
10. Unscrew and remove the overheat switch (**Fig. 2**, Ref. 12).

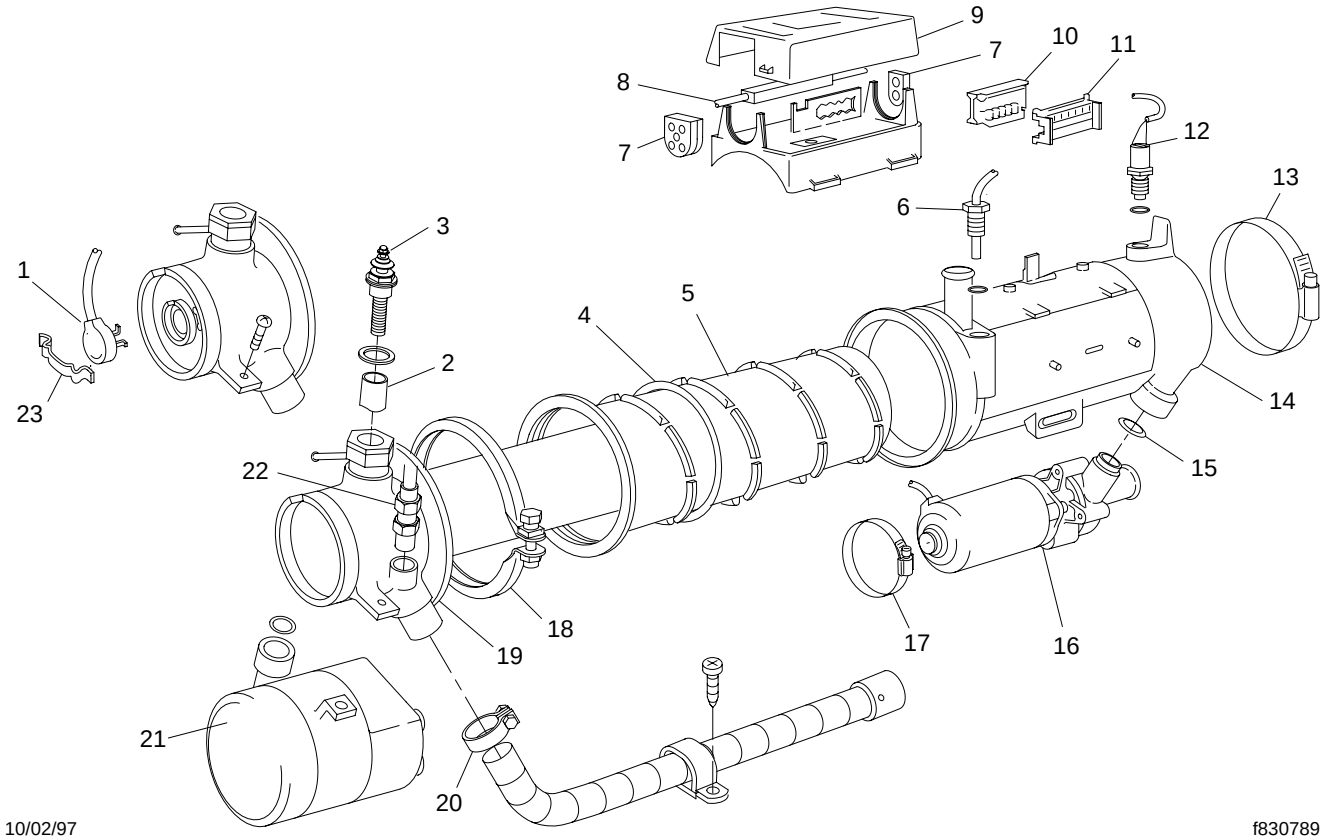


1. Coolant Heater Assembly Box
2. Coolant Heater Assembly Box Lid
3. Control Unit
4. 30 Amp Circuit Breaker
5. Rubber Shock Mount
6. Heater Unit
7. Lid Capscrew

Fig. 1, Coolant Heater Box Assembly

11. Lubricate the new overheat switch O-ring with Vaseline and position it on the new overheat switch.
12. Grease the threads of the new overheat switch with Molykote paste.
13. Screw in the new overheat switch until resistance can clearly be felt from contact with the heat exchanger. Tighten the overheat switch 12 to 24 lbf·in (135 to 271 N·cm).
14. Install the connector pins, of the new overheat switch, into the 12-pin connector plug housing (positions 11 and 12).
15. Install the 12-pin connector plug firmly onto the holder and install the partial load resistor cover.
16. Slide the three-sided lid onto the base of the coolant heater assembly box.
17. Install the two capscrews at the bottom of the coolant heater assembly box lid. Tighten the capscrews 10 lbf·ft (14 N·m).
18. Remove clamps from both the coolant heater hoses, at the coolant heater.

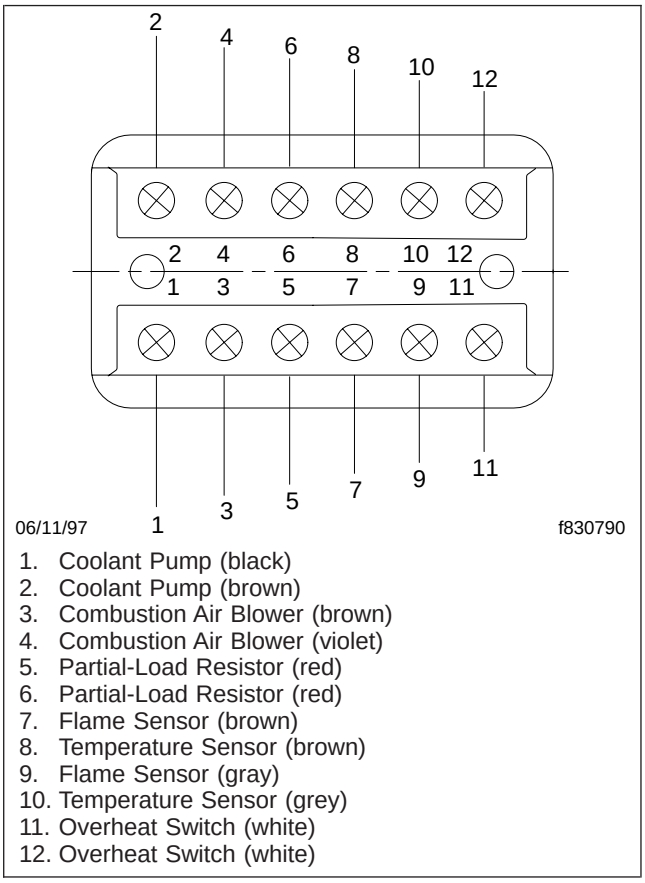
Model 25–1666 Overheat Switch Replacement



1. Flame Sensor (model 25–1666 only)
2. Glow Plug Strainer
3. Glow Plug
4. O-Ring
5. Heat Exchanger
6. Temperature Sensor
7. Grommet
8. Partial Load Resistor
9. Partial Load Resistor Cover
10. 12-Pin Connector Plug Housing
11. 12-Pin Connector Plug
12. Overheat Switch
13. Mounting Clamp
14. Coolant Jacket
15. Coolant Pump O-Ring
16. Coolant Pump
17. Coolant Pump Clamp
18. Burner Connector Clamp
19. Burner
20. Exhaust Pipe Clamp
21. Combustion Air Blower
22. Flame Sensor (model 25–1807 only)
23. Retaining Spring (model 25–1666 only)

Fig. 2, Heater Unit Assembly

19. Connect the batteries.
20. Bleed cooling system. For instructions, see **Subject 100**.
21. Return and secure the hood or cab in the operating position.
22. Remove the chocks from the tires.



1. Coolant Pump (black)
2. Coolant Pump (brown)
3. Combustion Air Blower (brown)
4. Combustion Air Blower (violet)
5. Partial-Load Resistor (red)
6. Partial-Load Resistor (red)
7. Flame Sensor (brown)
8. Temperature Sensor (brown)
9. Flame Sensor (gray)
10. Temperature Sensor (grey)
11. Overheat Switch (white)
12. Overheat Switch (white)

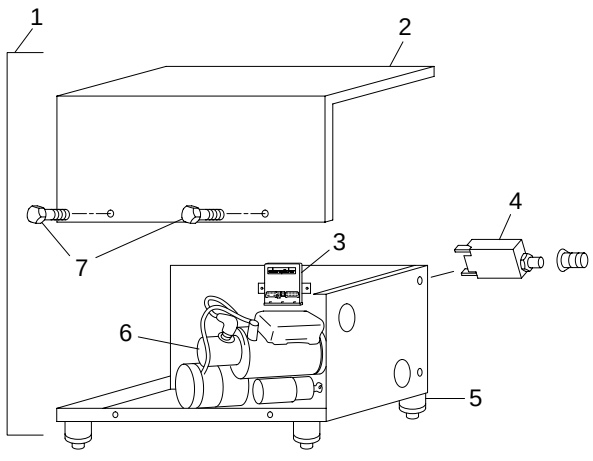
Fig. 3, 12-Pin Connector Plug

Partial Load Resistor Replacement

NOTE: To remove the partial load resistor, the lid of the coolant heater assembly box must be removed. If the location of the coolant heater assembly box hinders the removal of the lid, then it may be necessary to move the coolant heater assembly off its mounting bracket. For instructions, see **Subject 100**.

Replacement (See Fig. 1 and Fig. 2)

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the hood or cab.
2. Disconnect the batteries.
3. Remove the two capscrews at the bottom of the coolant heater assembly box lid.
4. Slide the three-sided lid off the base of the coolant heater assembly box. This will expose both the heater unit and the control unit. See **Fig. 1**.



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1. Coolant Heater Assembly Box
2. Coolant Heater Assembly Box Lid
3. Control Unit
4. 30 Amp Circuit Breaker (model 25–1666 only)
5. Rubber Shock Mount
6. Heater Unit
7. Lid Capscrew

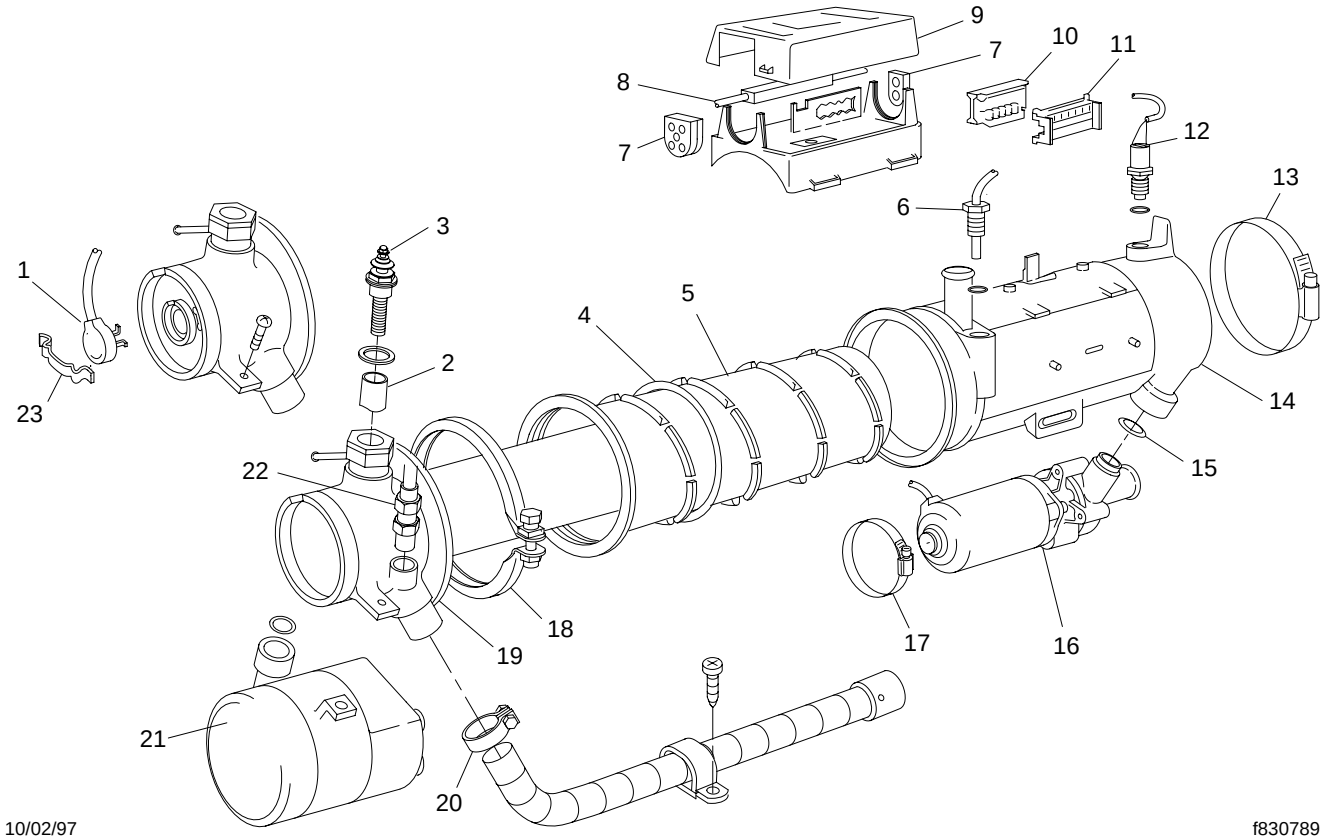
Fig. 1, Coolant Heater Box Assembly

5. Remove the partial load resistor cover (**Fig. 2**, Ref. 9).
6. Unclip the 12-pin connector plug from the holder (Ref. 11). Remove the 12-pin connector plug.

NOTE: The following step may require the use of special tools for certain connectors and terminals. See **Group 54** (wiring) in this manual for information on special terminals and connectors, and special tools.

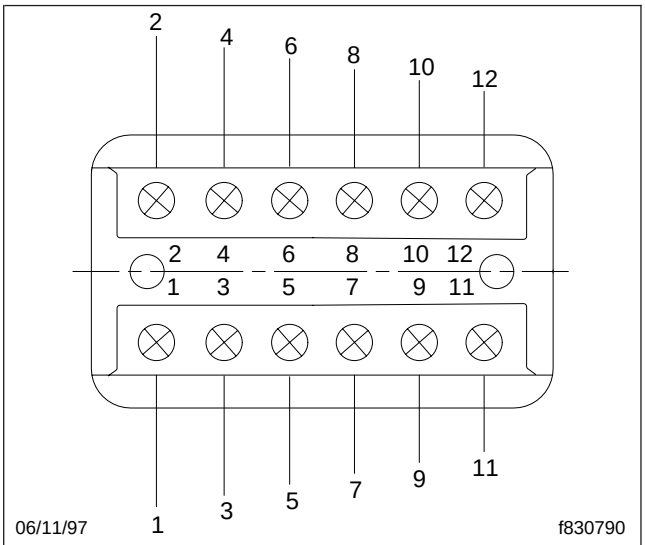
7. Take pins 5 and 6 out of the 12-pin connector plug housing (**Fig. 3** or **Fig. 4**, Refs. 5 and 6).
8. Remove retaining clips from the partial load resistor.
9. Remove the partial load resistor (**Fig. 2**, Ref. 8).
10. Install the new partial load resistor and fasten its retaining clips.
11. Install the connector pins, of the new partial load resistor, into the 12-pin connector plug housing (positions 5 and 6).
12. Install the 12-pin connector plug firmly into the holder and install the partial load resistor cover.
13. Slide the three-sided lid onto the base of the coolant heater assembly box.
14. Install the two capscrews at the bottom of the coolant heater assembly box lid. Tighten the capscrews 10 lbf·ft (14 N·m).
15. Connect the batteries.
16. Return and secure the hood or cab in the operating position.
17. Remove the chocks from the tires.

Partial Load Resistor Replacement



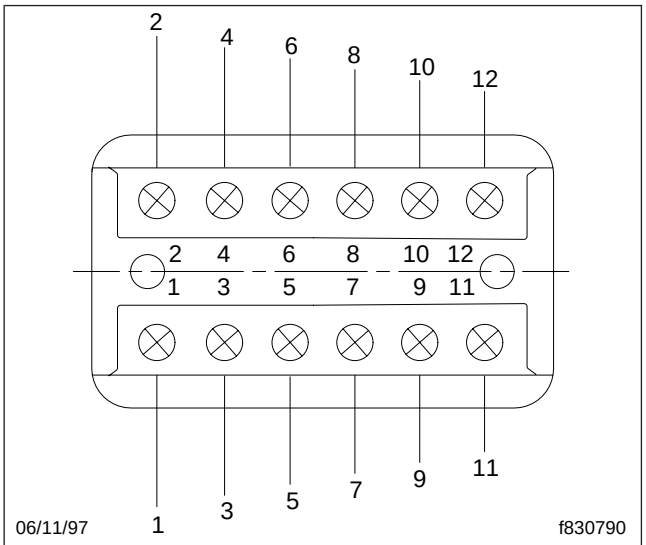
1. Flame Sensor (model 25–1666 only)
2. Glow Plug Strainer
3. Glow Plug
4. O-Ring
5. Heat Exchanger
6. Temperature Sensor
7. Grommet
8. Partial Load Resistor
9. Partial Load Resistor Cover
10. 12-Pin Connector Plug Housing
11. 12-Pin Connector Plug
12. Overheat Switch
13. Mounting Clamp
14. Coolant Jacket
15. Coolant Pump O-Ring
16. Coolant Pump
17. Coolant Pump Clamp
18. Burner Connector Clamp
19. Burner
20. Exhaust Pipe Clamp
21. Combustion Air Blower
22. Flame Sensor (model 25–1807 only)
23. Retaining Spring (model 25–1666 only)

Fig. 2, Heater Unit Assembly



1. Coolant Pump (black)
2. Coolant Pump (brown)
3. Combustion Air Blower (brown)
4. Combustion Air Blower (violet)
5. Partial-Load Resistor (red)
6. Partial-Load Resistor (red)
7. Flame Sensor (brown)
8. Temperature Sensor (brown)
9. Flame Sensor (gray)
10. Temperature Sensor (grey)
11. Overheat Switch (white)
12. Overheat Switch (white)

Fig. 3, Model 25-1666 12 Pin-Connector Plug



1. Coolant Pump (black)
2. Coolant Pump (brown)
3. Combustion Air Blower (brown)
4. Not Used
5. Speed Change Relay (black)
6. Combustion Air Blower and Speed Change Relay (black/red)
7. Flame Sensor (gray)
8. Temperature Sensor (brown)
9. Flame Sensor (gray)
10. Temperature Sensor (grey)
11. Overheat Switch (white)
12. Overheat Switch (white)

Fig. 4, Model 25-1807 12 Pin-Connector Plug

Coolant Pump Replacement

NOTE: To remove the coolant pump, the lid of the coolant heater assembly box must be removed. If the location of the coolant heater assembly box hinders the removal of the lid, then it may be necessary to move the coolant heater assembly off its mounting bracket. For instructions, see **Subject 100**.

Replacement (See Fig. 1 and Fig. 2)

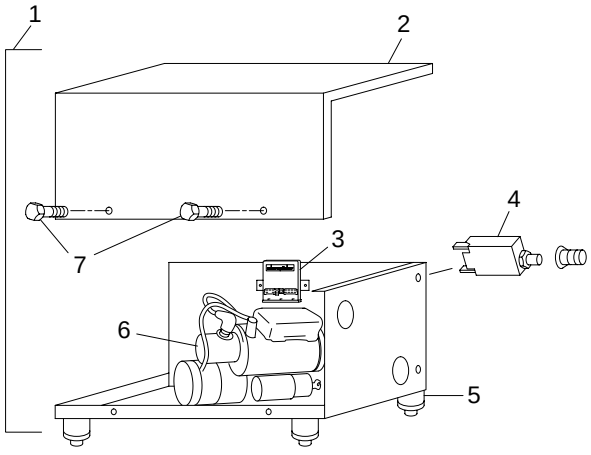
WARNING

To avoid personal injury from scalding coolant, wait until the engine has cooled to room temperature before removing the coolant pump.

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the hood or cab.
2. Disconnect the batteries.
3. Remove the two capscrews at the bottom of the coolant heater assembly box lid.
4. Slide the three-sided lid off the base of the coolant heater assembly box. This will expose both the heater unit and the control unit. See **Fig. 1**.
5. Remove the radiator pressure cap to minimize the cooling system pressure.
6. At the coolant heater, clamp off both the coolant heater hoses, to prevent the coolant from flowing out.
7. Remove the partial load resistor cover (**Fig. 2**, Ref. 9).
8. Unclip the 12-pin connector plug from the holder (Ref. 11). Remove the 12-pin connector plug.

NOTE: The following step may require the use of special tools for certain connectors and terminals. See **Group 54** (wiring) in this manual for information on special terminals and connectors, and special tools.

9. Take pins 1 and 2 out of the 12-pin connector plug housing (**Fig. 3** or **Fig. 4**, Refs. 1 and 2).
10. Loosen and remove the coolant pump clamp (**Fig. 2**, Ref. 17).
11. Remove the coolant pump.

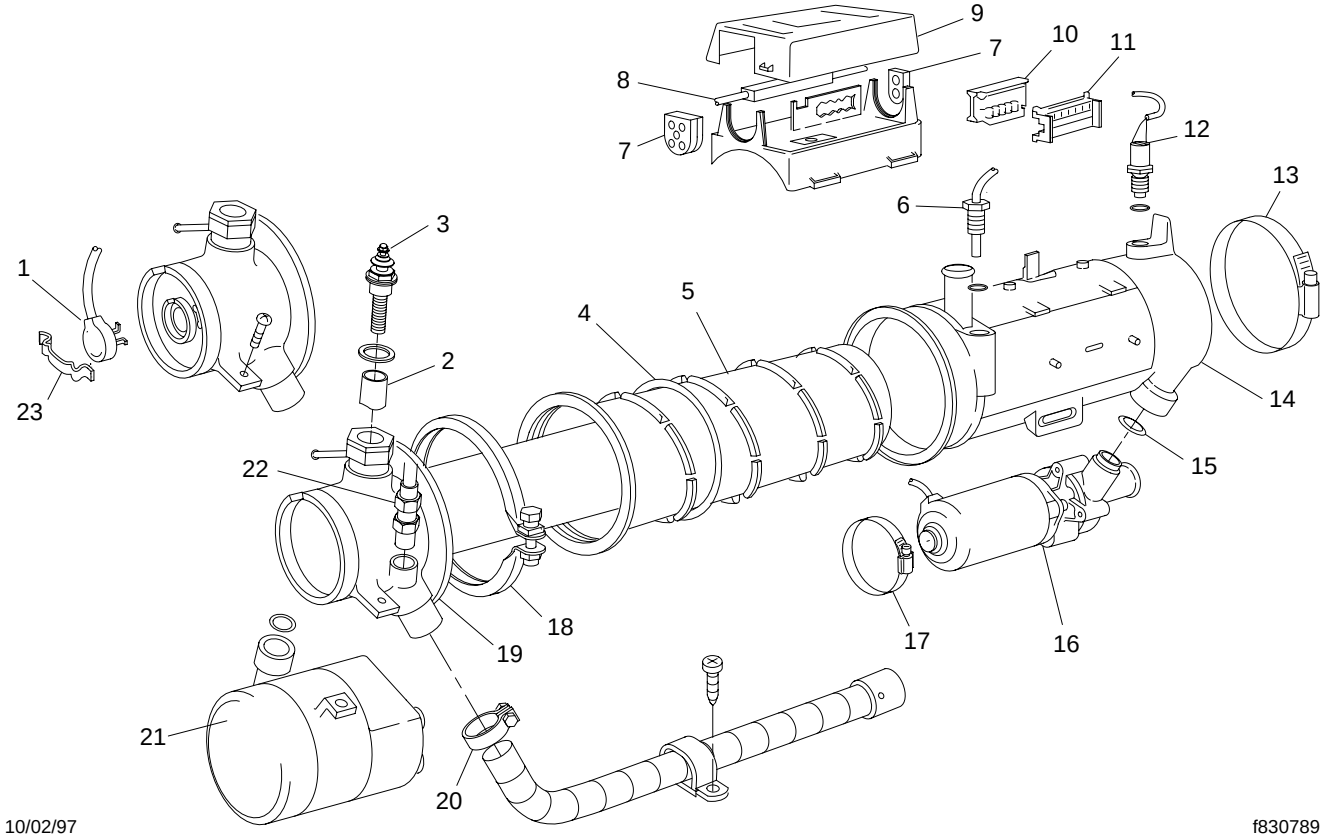


1. Coolant Heater Assembly Box
2. Coolant Heater Assembly Box Lid
3. Control Unit
4. 30 Amp Circuit Breaker (model 25–1666 only)
5. Rubber Shock Mount
6. Heater Unit
7. Lid Capscrew

Fig. 1, Coolant Heater Box Assembly

12. Grease the new coolant pump O-ring with Vaseline and position it on to the new coolant pump.
13. Install the new coolant pump, into the coolant jacket.
14. Install and tighten snugly the coolant pump clamp.
15. Install the connector pins, of the new coolant pump, into the 12-pin connector plug housing (positions 1 and 2).
16. Install the 12-pin connector plug firmly into the holder and install the partial load resistor cover.
17. Slide the three-sided lid onto the base of the coolant heater assembly box.
18. Install the two capscrews at the bottom of the coolant heater assembly box lid. Tighten the capscrews 10 lbf·ft (14 N·m).
19. Remove clamps from both the coolant heater hoses, at the coolant heater.
20. Connect the batteries.
21. Bleed cooling system. For instructions, see **Subject 100**.

Coolant Pump Replacement

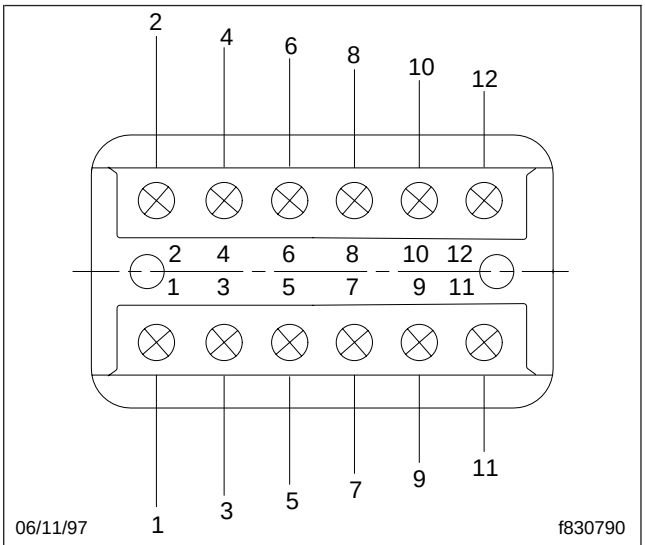


1. Flame Sensor (model 25–1666 only)
2. Glow Plug Strainer
3. Glow Plug
4. O-Ring
5. Heat Exchanger
6. Temperature Sensor
7. Grommet
8. Partial Load Resistor
9. Partial Load Resistor Cover
10. 12-Pin Connector Plug Housing
11. 12-Pin Connector Plug
12. Overheat Switch
13. Mounting Clamp
14. Coolant Jacket
15. Coolant Pump O-Ring
16. Coolant Pump
17. Coolant Pump Clamp
18. Burner Connector Clamp
19. Burner
20. Exhaust Pipe Clamp
21. Combustion Air Blower
22. Flame Sensor (model 25–1807 only)
23. Retaining Spring (model 25–1666 only)

Fig. 2, Heater Unit Assembly

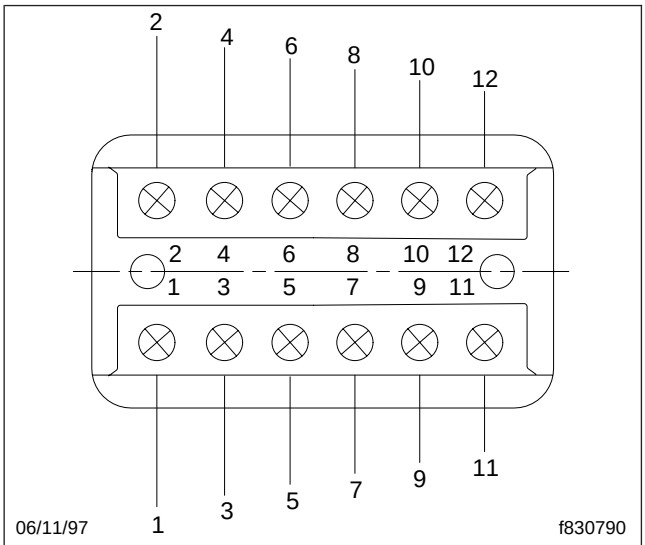
22. Return and secure the hood or cab in the operating position.

23. Remove the chocks from the tires.



1. Coolant Pump (black)
2. Coolant Pump (brown)
3. Combustion Air Blower (brown)
4. Combustion Air Blower (violet)
5. Partial-Load Resistor (red)
6. Partial-Load Resistor (red)
7. Flame Sensor (brown)
8. Temperature Sensor (brown)
9. Flame Sensor (gray)
10. Temperature Sensor (grey)
11. Overheat Switch (white)
12. Overheat Switch (white)

Fig. 3, Model 25-1666 12 Pin-Connector Plug



1. Coolant Pump (black)
2. Coolant Pump (brown)
3. Combustion Air Blower (brown)
4. Not Used
5. Speed Change Relay (black)
6. Combustion Air Blower and Speed Change Relay (black/red)
7. Flame Sensor (gray)
8. Temperature Sensor (brown)
9. Flame Sensor (gray)
10. Temperature Sensor (grey)
11. Overheat Switch (white)
12. Overheat Switch (white)

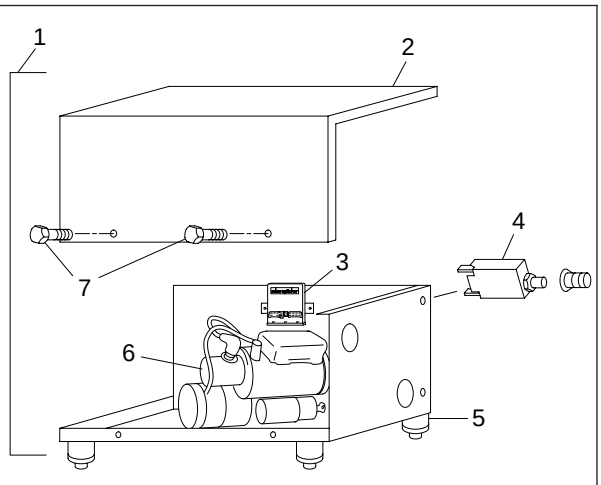
Fig. 4, Model 25-1807 12 Pin-Connector Plug

Combustion Air Blower Replacement

NOTE: To remove the combustion air blower, the lid of the coolant heater assembly box must be removed. If the location of the coolant heater assembly box hinders the removal of the lid, then it may be necessary to move the coolant heater assembly off its mounting bracket. For instructions, see **Subject 100**.

Replacement (See Fig. 1 and Fig. 2)

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the hood or cab.
2. Disconnect the batteries.
3. Remove the two capscrews at the bottom of the coolant heater assembly box lid.
4. Slide the three-sided lid off the base of the coolant heater assembly box. This will expose both the heater unit and the control unit. See **Fig. 1**.



07/22/97 f830794

1. Coolant Heater Assembly Box
2. Coolant Heater Assembly Box Lid
3. Control Unit
4. 30 Amp Circuit Breaker (model 25–1666 only)
5. Rubber Shock Mount
6. Heater Unit
7. Lid Capscrew

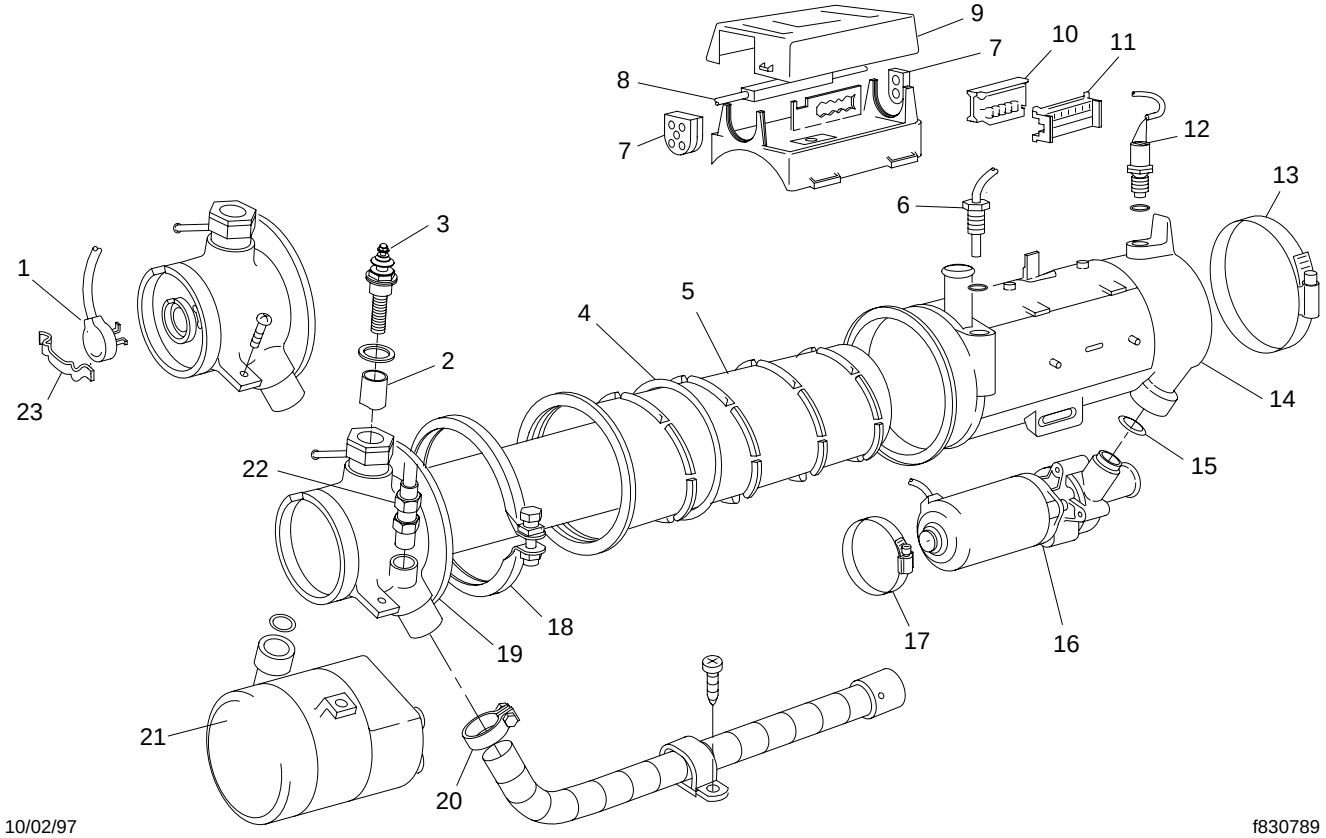
Fig. 1, Coolant Heater Box Assembly

5. Remove the partial load resistor cover (**Fig. 2**, Ref. 9).
6. Unclip the 12-pin connector plug from the holder (Ref. 11). Remove the 12-pin connector plug.

NOTE: The following step may require the use of special tools for certain connectors and terminals. See **Group 54** (wiring) in this manual for information on special terminals and connectors, and special tools.

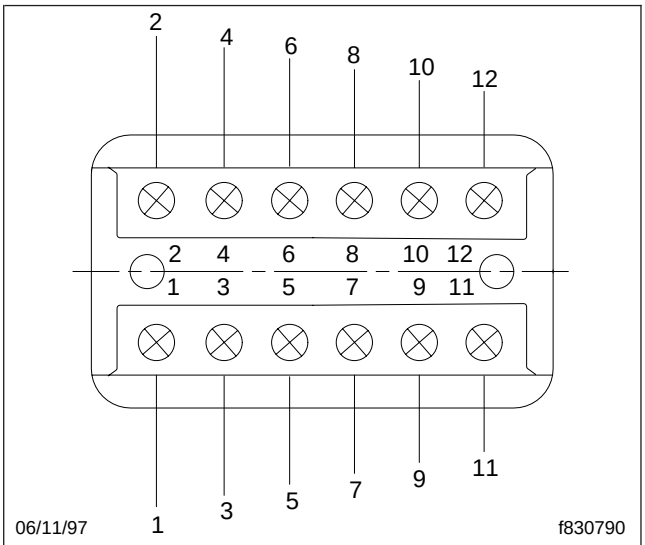
7. For model 25–1666, take pins 3 and 4 out of the 12-pin connector plug housing (**Fig. 3**, Refs. 3 and 4). For model 25–1807, take pin 3 out of the 12-pin connector (**Fig. 4**, Ref. 3) and disconnect the connector to the speed change relay.
8. Loosen the combustion air blower fastening screw.
9. Remove the combustion air blower (**Fig. 2**, Ref. 21).
10. Grease the new O-ring on the combustion air blower connection with Vaseline and install the new combustion air blower.
11. Install and tighten snugly the combustion air fastening screw.
12. For model 25–1666, install the connector pins, of the new combustion air blower, into the 12-pin connector plug housing (positions 3 and 4). For model 25–1807, install the new combustion air blower connectors; connect the connector pin to position 3 of the 12-pin connector plug; and connect the connector to the speed change relay.
13. Install the 12-pin connector plug firmly into the holder and install the partial load resistor cover.
14. Slide the three-sided lid onto the base of the coolant heater assembly box.
15. Install the two capscrews at the bottom of the coolant heater assembly box lid. Tighten the capscrews 10 lbf·ft (14 N·m).
16. Connect the batteries.
17. Return and secure the hood or cab in the operating position.
18. Remove the chocks from the tires.

Combustion Air Blower Replacement



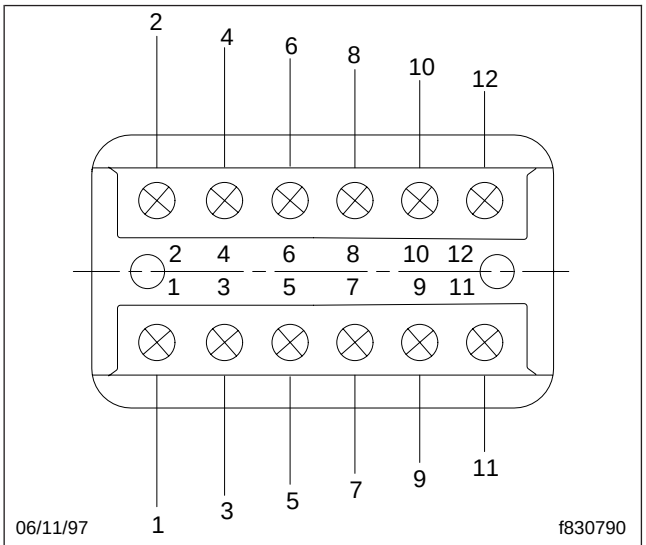
1. Flame Sensor (model 25–1666 only)
2. Glow Plug Strainer
3. Glow Plug
4. O-Ring
5. Heat Exchanger
6. Temperature Sensor
7. Grommet
8. Partial Load Resistor
9. Partial Load Resistor Cover
10. 12-Pin Connector Plug Housing
11. 12-Pin Connector Plug
12. Overheat Switch
13. Mounting Clamp
14. Coolant Jacket
15. Coolant Pump O-Ring
16. Coolant Pump
17. Coolant Pump Clamp
18. Burner Connector Clamp
19. Burner
20. Exhaust Pipe Clamp
21. Combustion Air Blower
22. Flame Sensor (model 25–1807 only)
23. Retaining Spring (model 25–1666 only)

Fig. 2, Heater Unit Assembly



1. Coolant Pump (black)
2. Coolant Pump (brown)
3. Combustion Air Blower (brown)
4. Combustion Air Blower (violet)
5. Partial-Load Resistor (red)
6. Partial-Load Resistor (red)
7. Flame Sensor (brown)
8. Temperature Sensor (brown)
9. Flame Sensor (gray)
10. Temperature Sensor (grey)
11. Overheat Switch (white)
12. Overheat Switch (white)

Fig. 3, Model 25-1666 12-Pin Connector Plug



1. Coolant Pump (black)
2. Coolant Pump (brown)
3. Combustion Air Blower (brown)
4. Not Used
5. Speed Change Relay (black)
6. Combustion Air Blower and Speed Change Relay (black/red)
7. Flame Sensor (gray)
8. Temperature Sensor (brown)
9. Flame Sensor (gray)
10. Temperature Sensor (grey)
11. Overheat Switch (white)
12. Overheat Switch (white)

Fig. 4, Model 25-1807 12-Pin Connector Plug

Heat Exchanger Removal and Installation

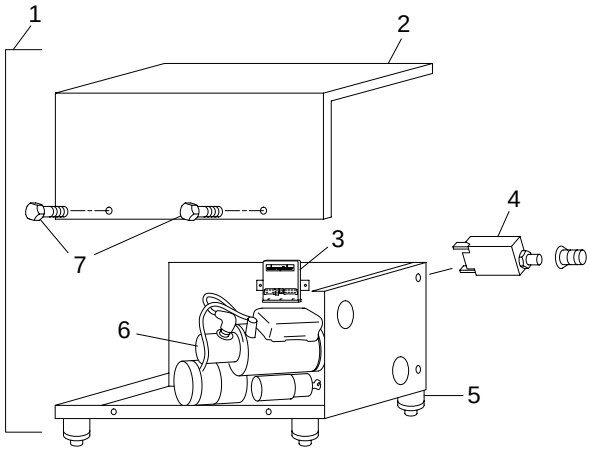
NOTE: To remove the heat exchanger, the lid of the coolant heater assembly box must be removed. If the location of the coolant heater assembly box hinders the removal of the lid, then it may be necessary to move the coolant heater assembly off its mounting bracket. For instructions, see **Subject 100**.

Removal (See Fig. 1 and Fig. 2)

⚠ WARNING

To avoid personal injury from scalding coolant, wait until the engine has cooled to room temperature before removing the heat exchanger.

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the hood or cab.
2. Disconnect the batteries.
3. Remove the two capscrews at the bottom of the coolant heater assembly box lid.
4. Slide the three-sided lid off the base of the coolant heater assembly box. This will expose both the heater unit and the control unit. See **Fig. 1**.
5. Remove the radiator pressure cap to minimize the cooling system pressure.
6. At the coolant heater, clamp of both the coolant heater hoses, to prevent the coolant from flowing out.
7. Loosen the hose clamps and remove the heater hoses form the coolant heater.
8. Clamp of the fuel hose, at the coolant heater, to prevent the fuel from flowing out.
9. Loosen the hose clamp and remove the fuel hose from the coolant heater.
10. Unclip the 12-pin connector plug from the holder (**Fig. 2**, Ref. 9). Remove the 12-pin connector plug cable.
11. Remove the combustion air blower. For instructions, see **Subject 170**.
12. Remove the flame sensor. For instructions, see **Subject 130** (model 25–1666) or **Subject 190** (model 25–1807).

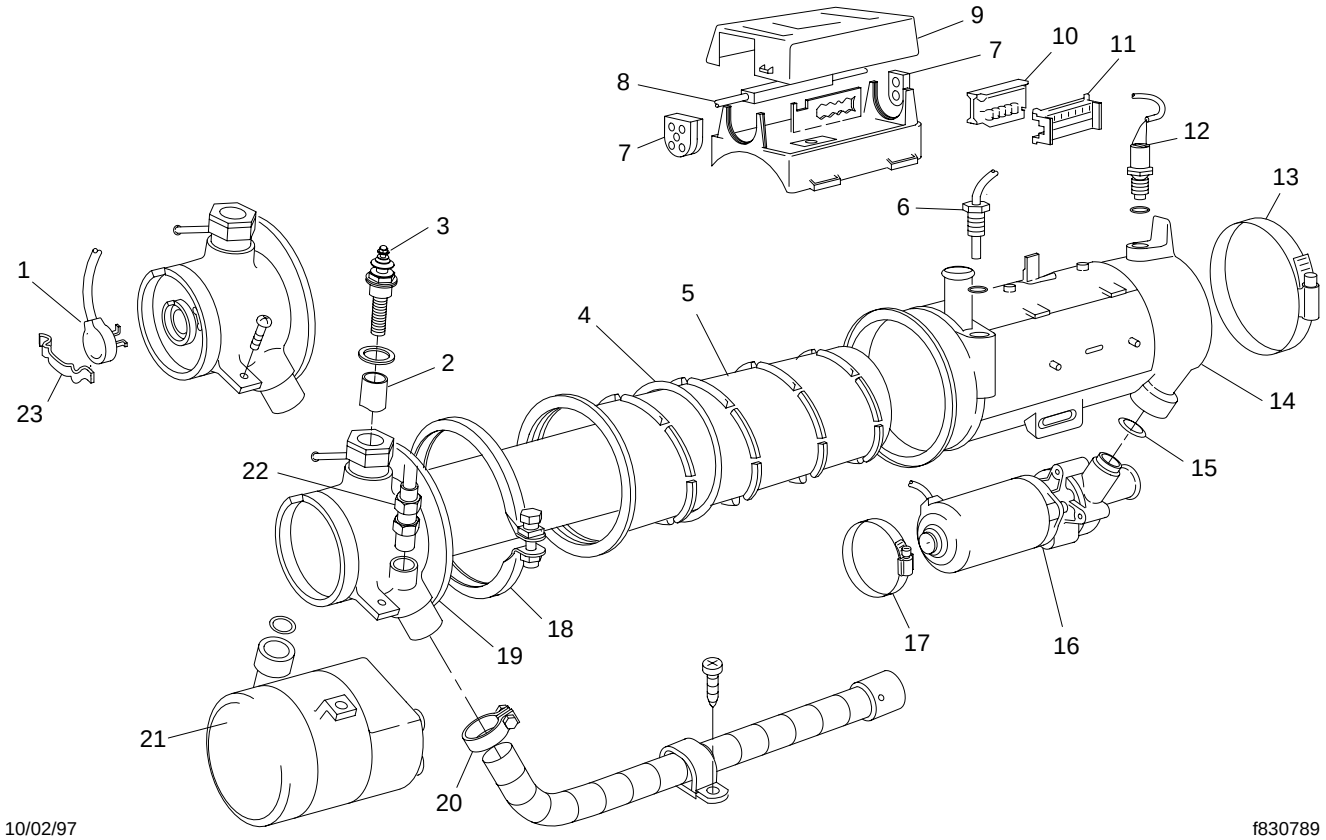


1. Coolant Heater Assembly Box
2. Coolant Heater Assembly Box Lid
3. Control Unit
4. 30 Amp Circuit Breaker (model 25–1666 only)
5. Rubber Shock Mount
6. Heater Unit
7. Lid Capscrew

Fig. 1, Coolant Heater Box Assembly

13. Loosen and remove the exhaust pipe clamp (Ref. 20) from the burner. Pull the exhaust pipe away from the burner.
14. Loosen and remove the mounting clamp (Ref. 13) from the heater unit.
15. Remove the heater unit from the coolant heater assembly box and stand it up on a work bench.
16. Loosen and remove the burner connector clamp and remove burner. See **Fig. 3**
17. Remove the overheat switch. For instructions, see **Subject 140** (model 25–1666) or **Subject 200** (model 25–1807).
18. Remove the temperature sensor. For instructions, see **Subject 120**.
19. Using a lever, pry the heat exchanger out of the coolant jacket. See **Fig. 4**
20. Remove the O-ring and Inspect and clean the heat exchanger.

Heat Exchanger Removal and Installation



1. Flame Sensor (model 25–1666 only)
2. Glow Plug Strainer
3. Glow Plug
4. O-Ring
5. Heat Exchanger
6. Temperature Sensor
7. Grommet
8. Partial Load Resistor
9. Partial Load Resistor Cover
10. 12-Pin Connector Plug Housing
11. 12-Pin Connector Plug
12. Overheat Switch
13. Mounting Clamp
14. Coolant Jacket
15. Coolant Pump O-Ring
16. Coolant Pump
17. Coolant Pump Clamp
18. Burner Connector Clamp
19. Burner
20. Exhaust Pipe Clamp
21. Combustion Air Blower
22. Flame Sensor (model 25–1807)
23. Retaining Spring (model 25–1666 only)

Fig. 2, Heater Unit Assembly

Installation

1. Grease the new O-ring and position it onto the heat exchanger .
2. Install the heat exchanger.
3. Install the temperature sensor. For instructions, see **Subject 120**.
4. Install the overheat switch. For instructions, see **Subject 140** (model 25–1666) or **Subject 200** (model 25–1807).
5. Install the burner. Check that the O-ring is seated correctly and tighten snugly the burner connector clamp.
6. Install the heater unit into the coolant heater assembly box.
7. Install and tighten snugly the heater unit mounting clamp.
8. Position the exhaust pipe into the burner and snugly tighten the exhaust pipe clamp.

Heat Exchanger Removal and Installation

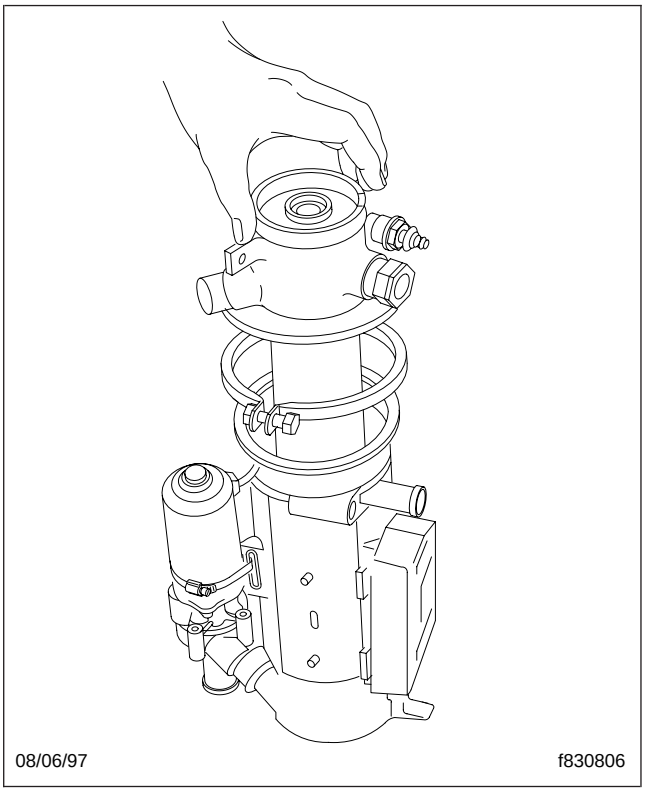


Fig. 3, Removing the Burner

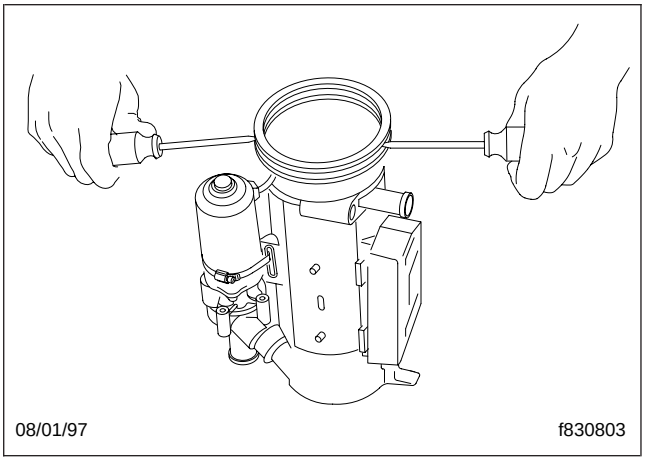


Fig. 4, Removing the Heat Exchanger

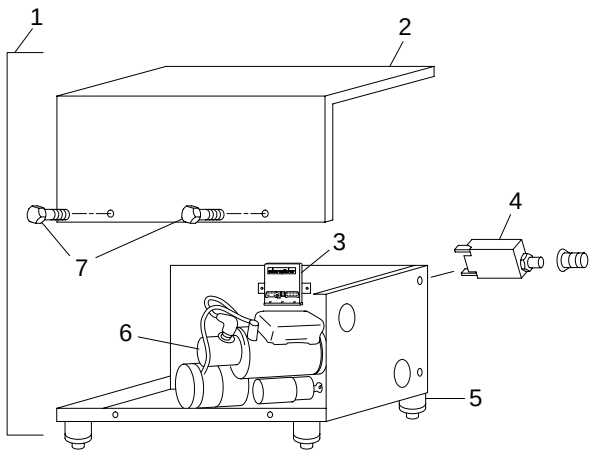
9. Install the flame sensor. For instructions, see **Subject 130** (model 25–1666) or **Subject 190** (model 25–1807).
10. Install the combustion air blower. For instructions, see **Subject 170**.
11. Install the 12-pin connector plug firmly into the holder.
12. Attach and secure the heater hoses and the fuel hose.
13. Slide the three sided-lid onto the base of the coolant heater assembly box.
14. Install the two capscrews at the bottom of the coolant heater assembly box lid. Tighten the capscrews 10 lbf·ft (14 N·m).
15. Connect the batteries.
16. Bleed cooling system. For instructions, see **Subject 100**.
17. Return and secure the hood or cab in the operating position.
18. Remove the chocks from the tires.

Model 25–1807 Flame Sensor Replacement

NOTE: To remove the flame sensor, the lid of the coolant heater assembly box must be removed. If the location of the coolant heater assembly box hinders the removal of the lid, then it may be necessary to move the coolant heater assembly off its mounting bracket. For instructions, see **Subject 100**.

Replacement (See Fig. 1 and Fig. 2)

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the hood or cab.
2. Disconnect the batteries.
3. Remove the two capscrews at the bottom of the coolant heater assembly box lid.
4. Slide the three-sided lid off the base of the coolant heater assembly box. This will expose both the heater unit and the control unit. See **Fig. 1**.



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1. Coolant Heater Assembly Box
2. Coolant Heater Assembly Box Lid
3. Control Unit
4. 30 Amp Circuit Breaker (model 25–1666 only)
5. Rubber Shock Mount
6. Heater Unit
7. Lid Capscrew

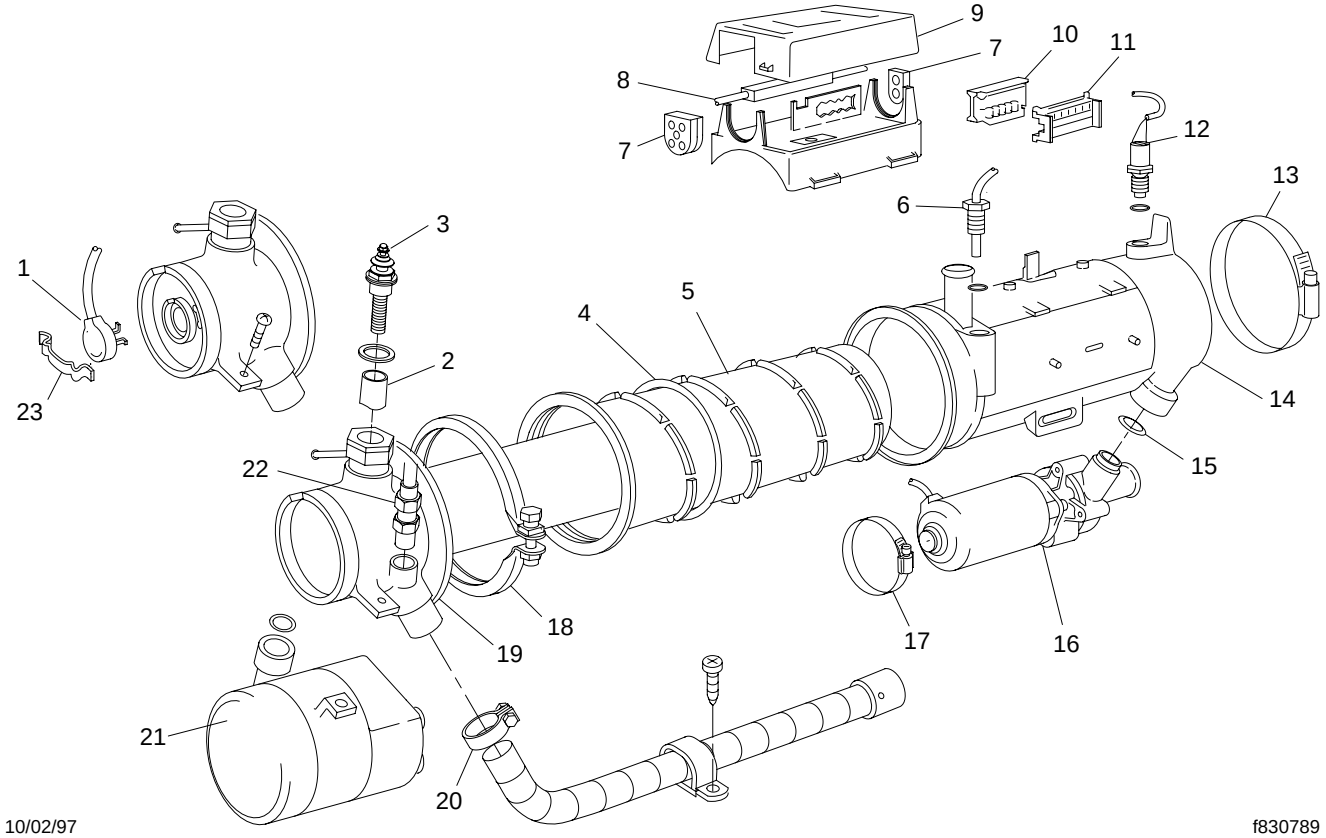
Fig. 1, Coolant Heater Box Assembly

5. Remove the partial load resistor cover (**Fig. 2**, Ref. 9).
6. Unclip the 12-pin connector plug from the holder (Ref. 11). Remove the 12-pin connector plug.

NOTE: The following step may require the use of special tools for certain connectors and terminals. See **Group 54** (wiring) in this manual for information on special terminals and connectors, and special tools.

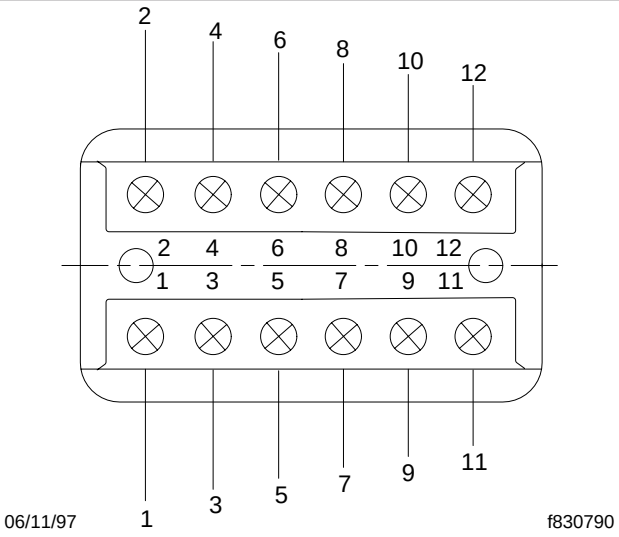
7. Take pins 7 and 9 out of the 12-pin connector plug housing (**Fig. 3**, Refs. 7 and 9).
8. Unscrew and remove the flame sensor from the heat exchanger exhaust port (**Fig. 2**, Ref. 22).
9. Install the new flame sensor into the heat exchanger exhaust port. Tighten the flame sensor down. The final torque is 12 to 24 lbf·in (135 to 271 N·cm).
10. Install the flame sensor connector pins into the 12-pin connector plug housing (positions 7 and 9).
11. Install the 12-pin connector plug firmly into the holder and install the partial load resistor cover.
12. Slide the three-sided lid onto the base of the coolant heater assembly box.
13. Install the two capscrews at the bottom of the coolant heater assembly box lid. Tighten the capscrews 10 lbf·ft (14 N·m).
14. Connect the batteries.
15. Return and secure the hood or cab in the operating position.
16. Remove the chocks from the tires.

Model 25–1807 Flame Sensor Replacement



1. Flame Sensor
2. Glow Plug Strainer
3. Glow Plug
4. O-Ring
5. Heat Exchanger
6. Temperature Sensor
7. Grommet
8. Partial Load Resistor
9. Partial Load Resistor Cover
10. 12-Pin Connector Plug Housing
11. 12-Pin Connector Plug
12. Overheat Switch
13. Mounting Clamp
14. Coolant Jacket
15. Coolant Pump O-Ring
16. Coolant Pump
17. Coolant Pump Clamp
18. Burner Connector Clamp
19. Burner
20. Exhaust Pipe Clamp
21. Combustion Air Blower
22. Flame Sensor (model 25–1807 only)
23. Retaining Spring (model 25–1666 only)

Fig. 2, Heater Unit Assembly



1. Coolant Pump (black)
2. Coolant Pump (brown)
3. Combustion Air Blower (brown)
4. Not Used
5. Speed Change Relay (black)
6. Combustion Air Blower and Speed Change Relay (black/red)
7. Flame Sensor (gray)
8. Temperature Sensor (brown)
9. Flame Sensor (gray)
10. Temperature Sensor (grey)
11. Overheat Switch (white)
12. Overheat Switch (white)

Fig. 3, 12-Pin Connector Plug

Model 25–1807 Overheat Switch Replacement

NOTE: To remove the overheat switch, the lid of the coolant heater assembly box must be removed. If the location of the coolant heater assembly box hinders the removal of the lid, then it may be necessary to move the coolant heater assembly off its mounting bracket. For instructions, see **Subject 100**.

Replacement (See Fig. 1 and Fig. 2)

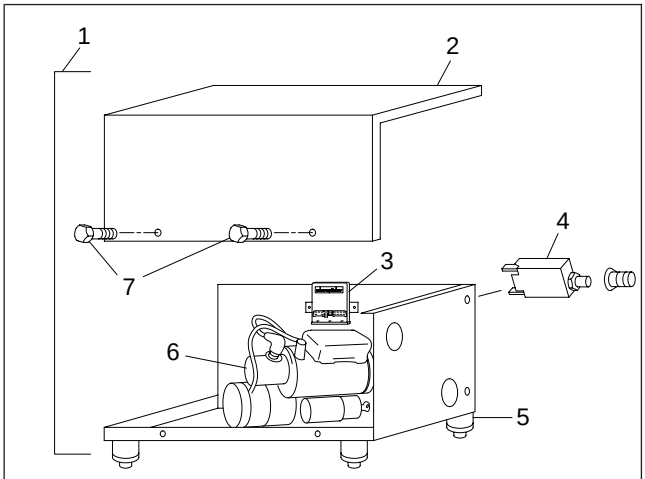
⚠ WARNING

To avoid personal injury from scalding coolant, wait until the engine has cooled to room temperature before removing the overheat switch.

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the hood or cab.
2. Disconnect the batteries.
3. Remove the two capscrews at the bottom of the coolant heater assembly box lid.
4. Slide the three-sided lid off the base of the coolant heater assembly box. This will expose both the heater unit and the control unit. See **Fig. 1**.
5. Remove the radiator pressure cap to minimize the cooling system pressure.
6. At the coolant heater, clamp off both the coolant heater hoses, to prevent the coolant from flowing out.
7. Remove the partial load resistor cover (**Fig. 2**, Ref. 9).
8. Unclip the 12-pin connector plug from the holder (Ref. 11). Remove the 12-pin connector plug.

NOTE: The following step may require the use of special tools for certain connectors and terminals. See **Group 54** (wiring) in this manual for information on special terminals and connectors, and special tools.

9. Take pins 11 and 12 out of the 12-pin connector plug housing (**Fig. 3**, Refs. 11 and 12).
10. Unscrew and remove the overheat switch cross-recessed screws (**Fig. 4**).
11. Remove the spring loaded overheat switch (**Fig. 4**).

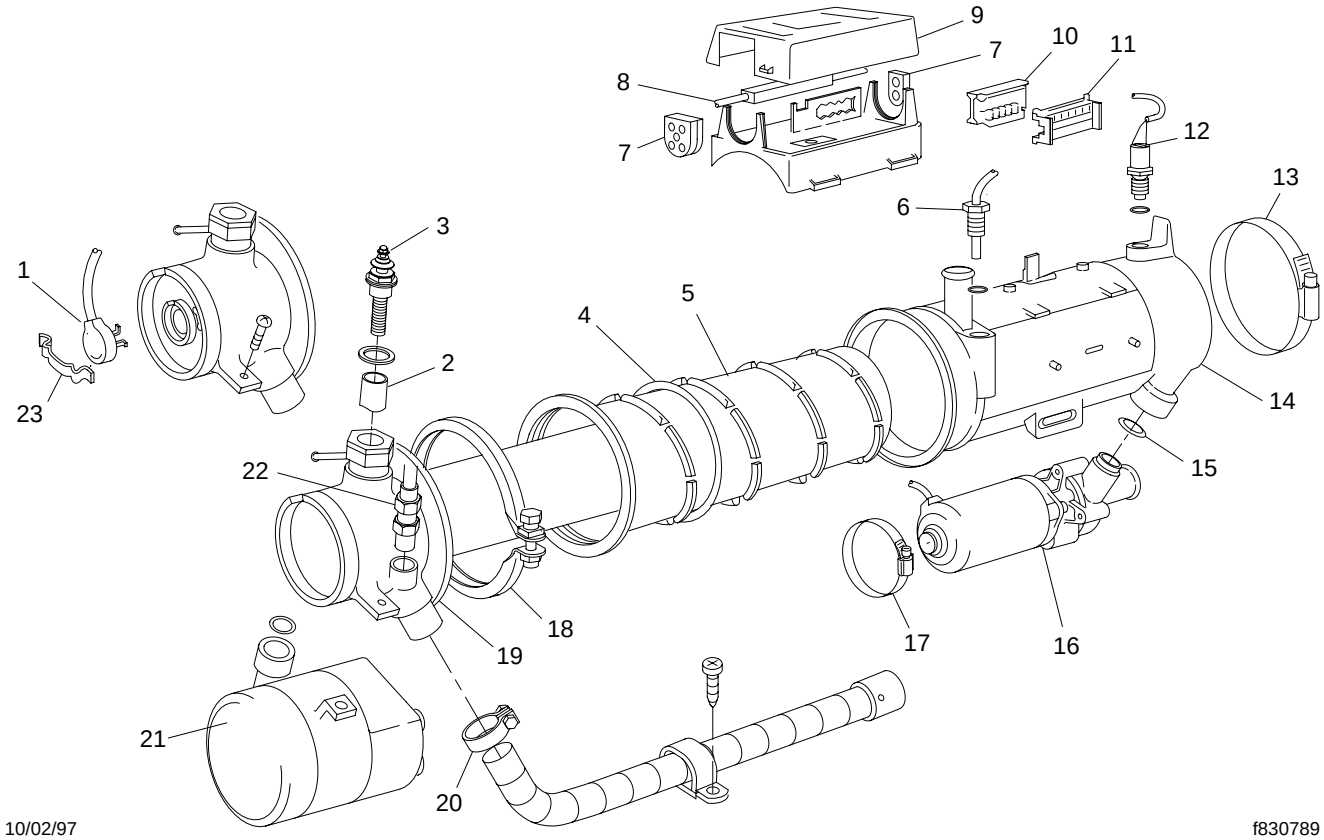


1. Coolant Heater Assembly Box
2. Coolant Heater Assembly Box Lid
3. Control Unit
4. 30 Amp Circuit Breaker (model 25–1666 only)
5. Rubber Shock Mount
6. Heater Unit
7. Lid Capscrew

Fig. 1, Coolant Heater Box Assembly

12. Lubricate the new overheat switch O-ring with Vaseline and position it on the new overheat switch.
13. Install the new overheat switch into the water jacket.
14. Install the cross-recessed screws and tighten them snugly.
15. Install the connector pins, of the new overheat switch, into the 12-pin connector plug housing (positions 11 and 12).
16. Install the 12-pin connector plug firmly onto the holder and install the partial load resistor cover.
17. Slide the three-sided lid onto the base of the coolant heater assembly box.
18. Install the two capscrews at the bottom of the coolant heater assembly box lid. Tighten the capscrews 10 lbf·ft (14 N·m).
19. Remove clamps from both the coolant heater hoses, at the coolant heater.
20. Connect the batteries.

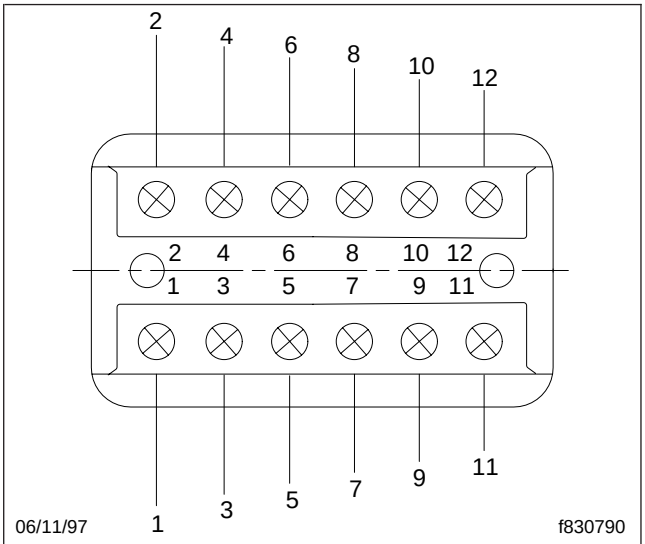
Model 25–1807 Overheat Switch Replacement



1. Flame Sensor (model 25–1666 only)
2. Glow Plug Strainer
3. Glow Plug
4. O-Ring
5. Heat Exchanger
6. Temperature Sensor
7. Grommet
8. Partial Load Resistor
9. Partial Load Resistor Cover
10. 12-Pin Connector Plug Housing
11. 12-Pin Connector Plug
12. Overheat Switch
13. Mounting Clamp
14. Coolant Jacket
15. Coolant Pump O-Ring
16. Coolant Pump
17. Coolant Pump Clamp
18. Burner Connector Clamp
19. Burner
20. Exhaust Pipe Clamp
21. Combustion Air Blower
22. Flame Sensor (model 25–1807 only)
23. Retaining Spring (model 25–1666 only)

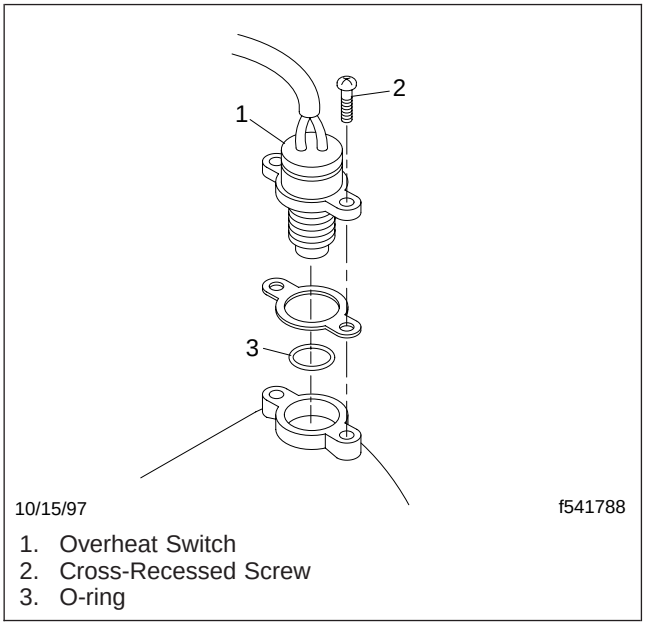
Fig. 2, Heater Unit Assembly

21. Bleed cooling system. For instructions, see **Subject 100**.
22. Return and secure the hood or cab in the operating position.
23. Remove the chocks from the tires.



1. Coolant Pump (black)
2. Coolant Pump (brown)
3. Combustion Air Blower (brown)
4. Not Used
5. Speed Change Relay (black)
6. Combustion Air Blower and Speed Change Relay (black/red)
7. Flame Sensor (gray)
8. Temperature Sensor (brown)
9. Flame Sensor (gray)
10. Temperature Sensor (grey)
11. Overheat Switch (white)
12. Overheat Switch (white)

Fig. 3, 12-Pin Connector Plug



1. Overheat Switch
2. Cross-Recessed Screw
3. O-ring

Fig. 4, Replace Overheat Switch

Preliminary Checks

If the coolant heater fails to operate, check the following before troubleshooting the system.

- The circuit breaker or fuses on the power harness for continuity;
- The glow plug for a good electrical connection;
- The electrical lines and connections for continuity;
- The combustion air inlet and exhaust pipe outlet for blockage;
- The coolant pump; If the coolant pump does not start running after the heater is switched on, check for voltage at the coolant pump motor. If voltage is present, replace the coolant pump. If voltage is not present, replace the control unit.
- The overheat switch for being triggered. If the overheat switch was triggered, then reset it by pressing the raised knob down to the rubber cover on the switch. See **Fig. 1**.

If the heater still does not function properly, then proceed with the following troubleshooting methods. There are four methods for troubleshooting the operation of the D7W coolant heater, which include:

A. Troubleshooting using the troubleshooting tables;

B. Troubleshooting using a test light or the LED;

C. Troubleshooting using a D5W/D7W circuit tester;

D. and, Troubleshooting the fuel supply.

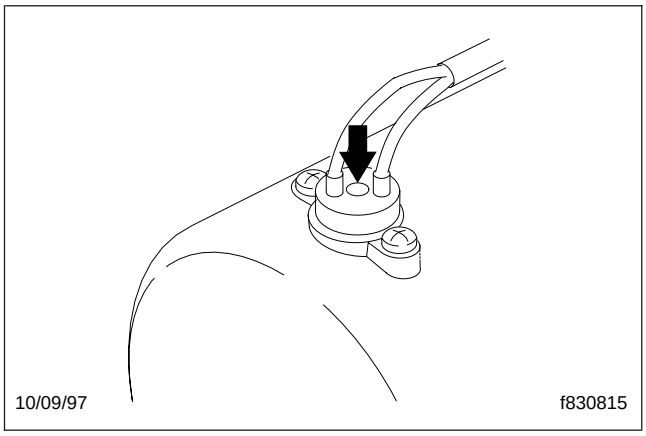


Fig. 1, Reset the Overheat Switch

Troubleshooting Tables (Model 25–1666 and Model 25–1807)

Problem—At Start, the Heater Runs Thirty Seconds Then Shuts Off

Problem—At Start, the Heater Runs Thirty Seconds then Shuts Off	
Possible Cause	**Remedy**
An under voltage condition exists.	Check and charge the battery.
An overvoltage condition exists.	Check the vehicles charging system.
The electrical connections are corroded.	Clean the electrical connections.

Problem—In Low Position, the Flame Goes Out By Itself

Problem—In Low Position, the Flame Goes Out By Itself	
Possible Cause	**Remedy**
The heater is not getting enough fuel from the fuel metering pump.	Measure the fuel quantity.
The blower speed is not reducing from high to low.	Replace the partial load resistor. Replace the control unit. Replace the change over relay (model 25–1807 only).

Troubleshooting

Problem—The Heater Failed to Ignite After Ninety Seconds of Fuel Being Pumped, Resulting in an Automatic Malfunction Shutdown

Problem—The Heater Failed to Ignite After Ninety Seconds of Fuel Being Pumped, Resulting in an Automatic Malfunction Shutdown	
Possible Cause	**Remedy**
The heater is not getting enough fuel from the fuel metering pump.	Measure the fuel quantity.
The glow plug is damaged.	Replace the glow plug.
No fuel present.	Fill the fuel tank.
The fuel metering pump is seized.	Replace the fuel metering pump.
The fuel metering pump has a short circuit.	Check the electrical plug at the fuel metering pump for a loose connection.
The fuel metering pump is not receiving electrical pulses from the control unit.	Replace the control unit.

Problem—Automatic Malfunction Shutdown After Three to Five Minutes

Problem—Automatic Malfunction Shutdown After Three to Five Minutes	
Possible Cause	**Remedy**
The flame sensor leads are reversed.	Check that the brown wire is a common and the white wire is connected to the glow plug voltage regulator at terminal 30.
The flame sensor is fouled.	Remove and clean the flame sensor (model 25–1666 only).
The flame sensor is damaged.	Replace the flame sensor.
The heater is not getting enough fuel from the fuel metering pump.	Measure the fuel quantity.

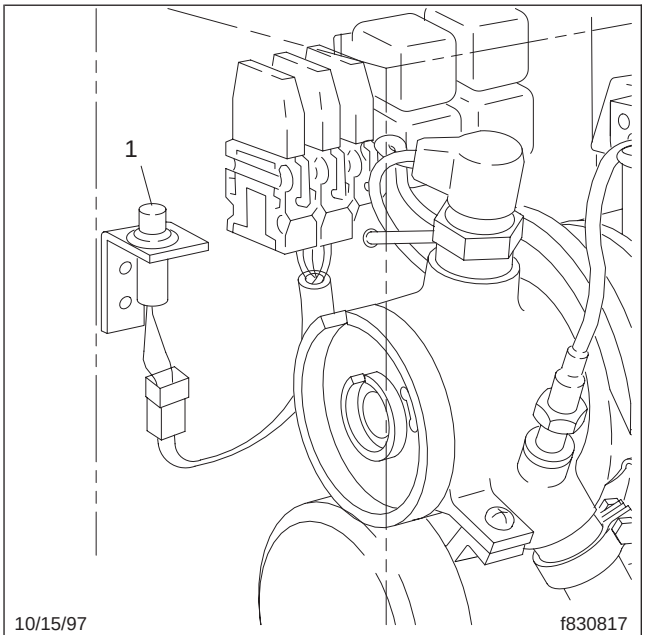
Troubleshooting Using a Test Light or LED

The D7W coolant heater is equipped with an automatic testing capability which can be used to check the cause of failure. To use this troubleshooting feature, model 25–1666 requires the use of an electrical test light (Espar part number CA1–05–001), model 25–1807 is equipped with a troubleshooting LED (**Fig. 2**) that provides a full time diagnostic display.

1. If you are troubleshooting a model 25–1807 coolant heater, proceed to the next step, otherwise, set up the test light by connecting it to the pins marked "TEST" and "S" on the control unit. See **Fig. 3**.
2. Turn the coolant heater on and watch the light signals displayed at the test light or LED. The light signals will repeat. Compare (identify) the displayed light signal to a fault signal/flashing code in the appropriate chart (**Fig. 4** [model 25–1666] or **Fig. 5** [model 25–1807]).
3. Once the displayed light signal is identified with a fault signal/flashing code (signal number in the chart), use the signal number (fault signal/flashing code) and the applicable problem table that follows to identify what component is at fault.

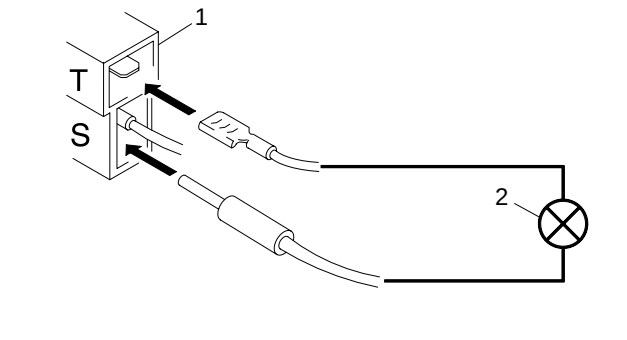
DISPLAY SIGNAL TROUBLESHOOTING TABLES (MODEL 25–1666)

For signal number identification, see **Fig. 4**.



1. Troubleshooting LED

Fig. 2, Troubleshooting LED (model 25-1807)



1. Control Unit Connector
2. Test Light

Fig. 3, Test Light Set Up

Signal #	Fault Signal/Flashing Code
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	No Flashing Code

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Fig. 4, Model 25-1666 Signal Code Chart

Troubleshooting

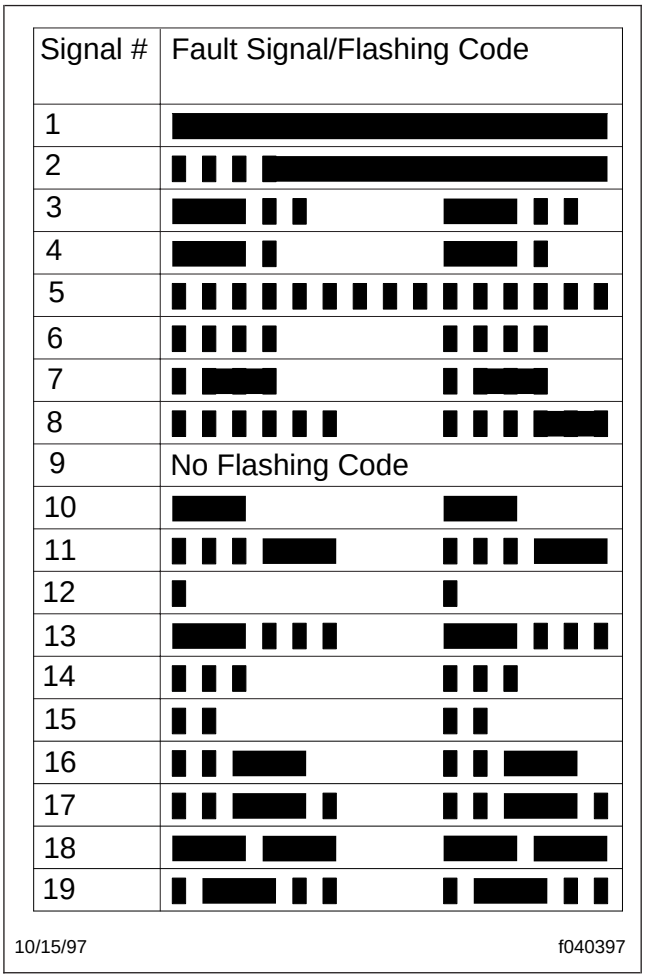


Fig. 5, Model 25-1807 Signal Code Chart

Problem—No Problem, Trouble-Free Operation

Problem—No Problem, Trouble-Free Operation		
Signal Number	**Possible Cause**	**Remedy**
1	The heater is in the start mode, the glow plug is preheating.	No action required.

Problem—No Problem, Trouble-Free Operation

Problem—No Problem, Trouble-Free Operation		
Signal Number	**Possible Cause**	**Remedy**
2	The heater is running under normal operating conditions.	No action required.

Problem—During Running, Delayed Shut Off and Restart

Problem—During Running, Delayed Shut Off and Restart		
Signal Number	**Possible Cause**	**Remedy**
3	The heater is not shut off.	Wait until the end of the delayed shut-off.
3	The water temperature is still above the triggering point for the temperature sensor (158°F/70°C).	Wait until the temperature has fallen below the triggering point.
3	The flame sensor is damaged.	Replace the flame sensor.
3	The temperature sensor is damaged.	Replace the temperature sensor.

Problem—Overheating, Automatic Malfunction Shutdown

Problem—Overheating, Automatic Malfunction Shutdown		
Signal Number	**Possible Cause**	**Remedy**
5	The wiring to the coolant pump is interrupted.	Check electrical connections to and from the coolant pump.
5	The coolant level is low.	Fill the radiator with coolant.
5	The engine cooling system is not properly bled.	Bleed the cooling system.
5	The engine water pump is damaged.	Replace the engine water pump.
5	The overheat switch tripped.	Reset the overheat switch.

Troubleshooting

Problem—Flame Sensor Short Circuit

Problem—Flame Sensor Short Circuit		
Signal Number	**Possible Cause**	**Remedy**
6	There is a short circuit in the flame sensor.	Remove and clean the flame sensor.

Problem—In High Position, the Flame Goes Out By Itself

Problem—In High Position, the Flame Goes Out By Itself		
Signal Number	**Possible Cause**	**Remedy**
8	The heater is not getting enough fuel from the fuel metering pump.	Measure the fuel quantity.
8	There is a vapor lock in the fuel line.	If the fuel line is getting to hot, reposition the fuel line.
8	The flame sensor is fouled or damaged.	Replace the flame sensor.

Problem—Glow Plug Failure

Problem—Glow Plug Failure		
Signal Number	**Possible Cause**	**Remedy**
9	The glow plug fuse (16 amp) is damaged.	Replace the glow plug fuse.
9	The glow plug is damaged.	Replace the glow plug.

Problem—Cut-Out Due to Under Voltage

Problem—Cut-Out Due to Under Voltage		
Signal Number	**Possible Cause**	**Remedy**
11	The battery charge is low.	Check the battery and charge if needed.
11	The electrical connections are corroded.	Clean the electrical connections.

Problem—Cut-Out Due to Overvoltage

Problem—Cut-Out Due to Overvoltage		
Signal Number	**Possible Cause**	**Remedy**
12	The voltage to the heater is too high.	Check the controller. Connect the heater directly to the battery (this will bypass the dynamo regulator).

Problem—Automatic Malfunction Shutdown After Three to Five Minutes

Problem—Automatic Malfunction Shutdown After Three to Five Minutes		
Signal Number	**Possible Cause**	**Remedy**
13	The flame sensor leads are reversed.	Check that the brown wire is a common and the white wire is connected to the glow plug voltage regulator at terminal 30.
13	The flame sensor is fouled.	Remove and clean the flame sensor.
13	The flame sensor is damaged.	Replace the flame sensor.
13	The heater is not getting enough fuel from the fuel metering pump.	Measure the fuel quantity.

Problem—Sooty Combustion

Problem—Sooty Combustion		
Signal Number	**Possible Cause**	**Remedy**
14	The combustion air line or exhaust line is clogged up.	Remove the clog in either the combustion air line or exhaust line.
14	The fuel metering pump is delivering to much fuel.	Measure the fuel quantity.
14	The combustion air blower speed is too low.	Replace the combustion air blower motor.
14	The heat exchanger is dirty.	Remove and clean the heat exchanger.

DISPLAY SIGNAL TROUBLESHOOTING TABLES (MODEL 25–1807)

For signal number identification, see **Fig. 5**.

Problem—No Problem, Trouble-Free Operation

Problem—No Problem, Trouble-Free Operation		
Signal Number	**Possible Cause**	**Remedy**
1	The heater is running under normal operating conditions	No action required.

Troubleshooting

Problem—Warning Voltage (Under/Over)

Problem—Warning Voltage (Under/Over)		
Signal Number	**Possible Cause**	**Remedy**
2	An overvoltage condition has been detected during pre-heating.	The voltage at the control unit (between the connector pins A12 and B12) is greater than 14.5 volts.
2	An under voltage condition has been detected during pre-heating.	The voltage at the control unit (between the connector pins A12 and B12) is less than 11 volts.

Problem—Under Voltage

Problem—Under Voltage		
Signal Number	**Possible Cause**	**Remedy**
4	A low voltage shutdown has occurred.	For more than 20 seconds, the voltage at the control unit (between the connector pins A12 and B12) has been less than 10.2 volts.

Problem—Overheating

Problem—Overheating		
Signal Number	**Possible Cause**	**Remedy**
5	The engine coolant temperature is too high.	The overheating switch has triggered. Check the water flow, clear any restrictions in the cooling system, open the heating valves, bleed the cooling system.
5	The heat exchanger temperature is too high.	The flame sensor has reported a temperature greater than 1022°F/ 560°C (which corresponds to 3000 ohms). Check the flame sensor connections at the control unit (connector pins A4 and A5).

Problem—Glow Plug Relay

Problem—Glow Plug Relay		
Signal Number	**Possible Cause**	**Remedy**
7	There is an interruption in the current regulator.	Check the coil connection at the glow plug relay (connections 85 and 86). Check the connections to the control unit.

Problem—Glow or Overheating

Problem—Glow or Overheating		
Signal Number	**Possible Cause**	**Remedy**
8	There is a short circuit in the current regulator coil.	Check the coil connection at the glow plug relay (connections 85 and 86). Check the connection to the control unit at the connector pin B6.
8	The coolant pump does not rotate.	Check the coolant pump (external triggering). Check the connections to the control unit at connector pins A11 and A13.

Problem—Glow or Overheating		
Signal Number	**Possible Cause**	**Remedy**
8	The water Temperature is rising too quickly.	Check the water circulation, the overheating switch has triggered. Clear any restrictions in the cooling system, open the heating valves, bleed the cooling system. Check the connections at the temperature sensor. Check the connections to the control unit at the connector pins A5 and A6.

Problem—Combustion Air Fan

Problem—Combustion Air Fan		
Signal Number	**Possible Cause**	**Remedy**
10	The combustion air fan does not rotate.	Check the combustion air fan. Check the motor speed relay (see wiring diagram in **Subject 400**). Check connections to the control unit at the connector pins A11 and B1.

Problem—Fuel Metering Pump

Problem—Fuel Metering Pump		
Signal Number	**Possible Cause**	**Remedy**
11	There is a short circuit in the fuel metering pump.	Check the fuel metering pump. Check the connections to the control unit at the connector pins A10 and B10.

Problem—No Start Safety Time Exceeded

Problem—No Start Safety Time Exceeded		
Signal Number	**Possible Cause**	**Remedy**
13	The heater has failed to start, the safety time has expired.	No flame was detected during the start up phase of operation. The flame sensor temperature value is less than 194°F/90°C (corresponding to 1350 ohms). Check the fuel supply, the glow plug, the exhaust piping, the combustion air piping, and the flame sensor (the set points are: 900 ohms at -13°F/-25°C; 1100 ohms at 77°F/25°C).

Problem—Flame Out

Problem—Flame Out		
Signal Number	**Possible Cause**	**Remedy**
14	During the high mode of operation, the flame went out.	The heater has started (flame detected) and, for the selected mode setting, a flame loss has been indicated. Check the fuel flow rate, the blower speed, the fuel supply, the exhaust piping, and the combustion air piping. If the combustion is okay, check the flame sensor (the set points are: 900 ohms at -13°F/-25°C; 1100 ohms at 77°F/25°C) and, if necessary, replace it.

Troubleshooting

Problem—Temperature Sensor

Problem—Temperature Sensor		
Signal Number	**Possible Cause**	**Remedy**
16	The temperature sensor is either interrupted or has a short circuit.	The measured temperature lies outside the measured range. Check the sensor (the set points are: 650 ohms at -13°F/-25°C; 1000 ohms at 77°F/ 25°C). Check the connections to the control unit at the connector pins A5 and A6.

Problem—Flame Sensor

Problem—Flame Sensor		
Signal Number	**Possible Cause**	**Remedy**
17	The flame sensor is either interrupted or has a short circuit.	The measured temperature lies outside the measured range. Check the sensor (the set points are: 900 ohms at -13°F/-25°C; 1100 ohms at 77°F/ 25°C). Check the connections to the control unit at the connector pins A4 and A5.

Problem—External Electrical Interference

Problem—External Electrical Interference		
Signal Number	**Possible Cause**	**Remedy**
19	There is external interference (voltage).	Check the voltage supply. Check the connections to the control unit at the connector pins A12 and B12.

Troubleshooting Using a D5W/ D7W Circuit Tester

This method of troubleshooting helps troubleshoot problems faster and more accurately; it requires the use of an Espar D5W/D7W circuit tester. See **Fig. 6**.

This method performs three operations of analysis: testing the resistance of the individual components; checking for continuity of each circuit; and running the heater manually.

NOTE: To use this tester (part number CA1–05–010) with model 25–1807, Adapter (part number CA1–05–023) is required.

D5W/D7W CIRCUIT TESTER INITIAL SET UP

1. Turn off all the switches, on the D5W/D7W circuit tester.
2. Plug in the connectors from the tester to the corresponding connectors on the heater harness.
3. Ensure proper power, fuel, and coolant connections.

D5W/D7W CIRCUIT TESTER OPERATING INSTRUCTIONS

1. Move the power switch to the on position. The voltmeter will indicate the voltage across the control unit. The voltage must range from 10 to 14 volts or 20 to 28 volts on a 12 volt or 24 volt system respectively.
2. Test the resistance of the individual components.
   - 2.1 Move any of the nine switches on the right hand side of the tester to the check position. Do not measure the resistance of more than one component at a time. Eight switches must always remain in the off position.
   - 2.2 Take note of the measured resistance of each component in the system. The ohmmeter will indicate the resistance value of each component as high or low resistance. See **Table 1** for the component re-

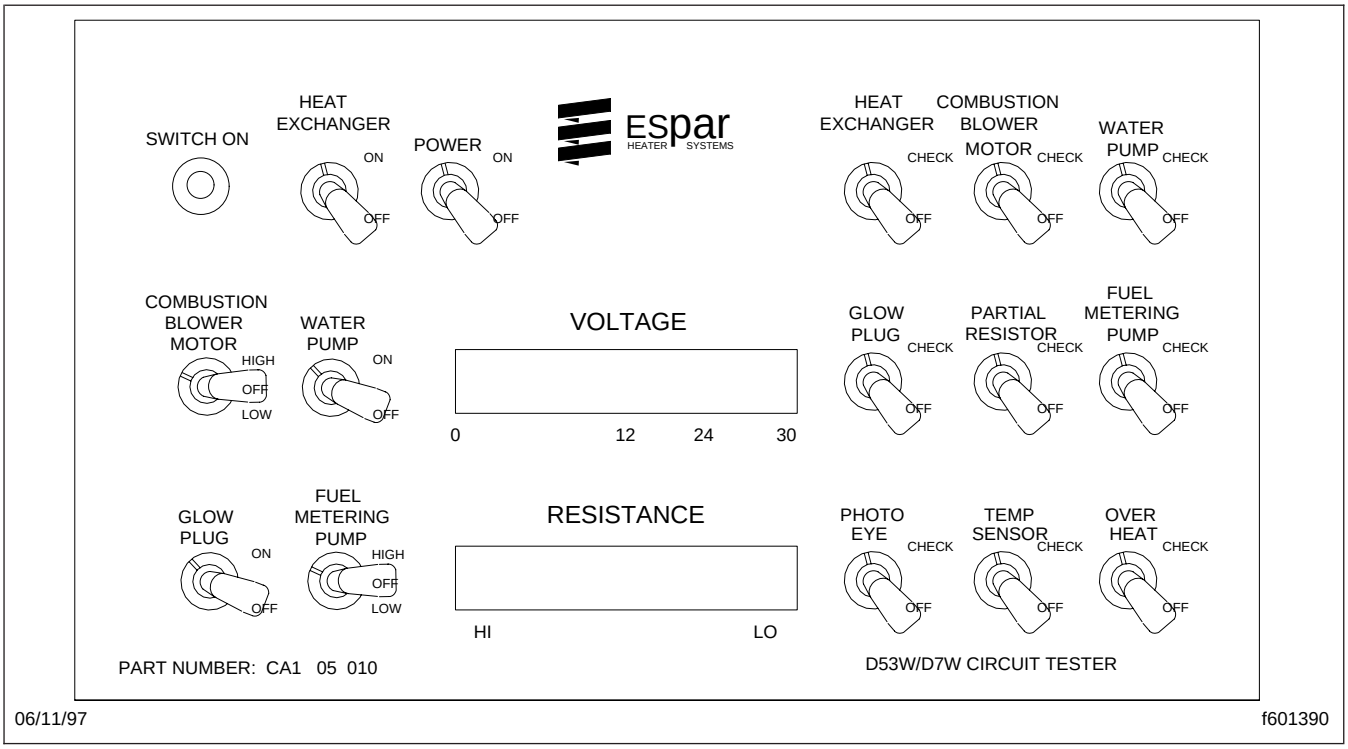


Fig. 6, Espar D5W/D7W Circuit Tester

sistance values. If any measured resistance values deviate from the required values (**Table 1**), then the component should be replaced.

Component Resistance Table	
Component	**Resistance Value**
Combustion Blower	Low
Water Pump	Low
Glow Plug	Low
Overheat Switch	Low
Fuel Metering Pump	Low
Temperature Sensor	Medium
Flame Sensor (photo eye) Model 25–1666	High (in the dark), Decreasing to Low (when exposed to light)
Flame Sensor (temperature) Model 25–1807	High (heat exchanger cool), Low (heat exchanger warm)
Partial Load Resistor	Low
Heat Exchanger	Low

Table 1, Component Resistance Table

3. Test the operation of the coolant heater on/off switch or timer.

3.1 Move the coolant heater on/off switch or timer to the on position.

3.2 Take note of the red (switch-on) LED on the left side of the circuit tester. When this LED is illuminated, it indicates that the on/off switch or timer is manually turned on.

MANUALLY RUNNING THE HEATER

Start Up

1. Move the combustion blower motor switch to the high position. The combustion blower motor will run at high speed.
2. Move the water pump switch to the on position. The water pump will pump coolant through the system.
3. Move the glow plug switch to the on position and wait for 30 seconds. The glow plug begins pre-heating.

NOTE: The combustion blower motor speed will decrease due to a voltage drop (voltmeter reading will drop).

4. Move the fuel metering pump switch to the high position. The fuel metering pump will pump fuel to the combustion chamber and establish a flame.

NOTE: If the fuel metering pump does not receive the electric pulses then the overheat switch may be tripped. Reset the overheat switch. Check the fuse in the circuit tester and if blown replace it with a AGC-1 fuse.

High Heat

1. Once a flame is established (the sound of combustion is heard) wait 30 seconds and switch the glow plug off.

NOTE: The combustion blower motor speed and the fuel metering pump pulse frequency will increase due to voltage increase.

2. The heater is now running at high heat.

Low Heat

1. Move the combustion blower motor switch to the low position.
2. Move the fuel metering pump switch to the low position.
3. The heater is now running at low heat.

Cool Down

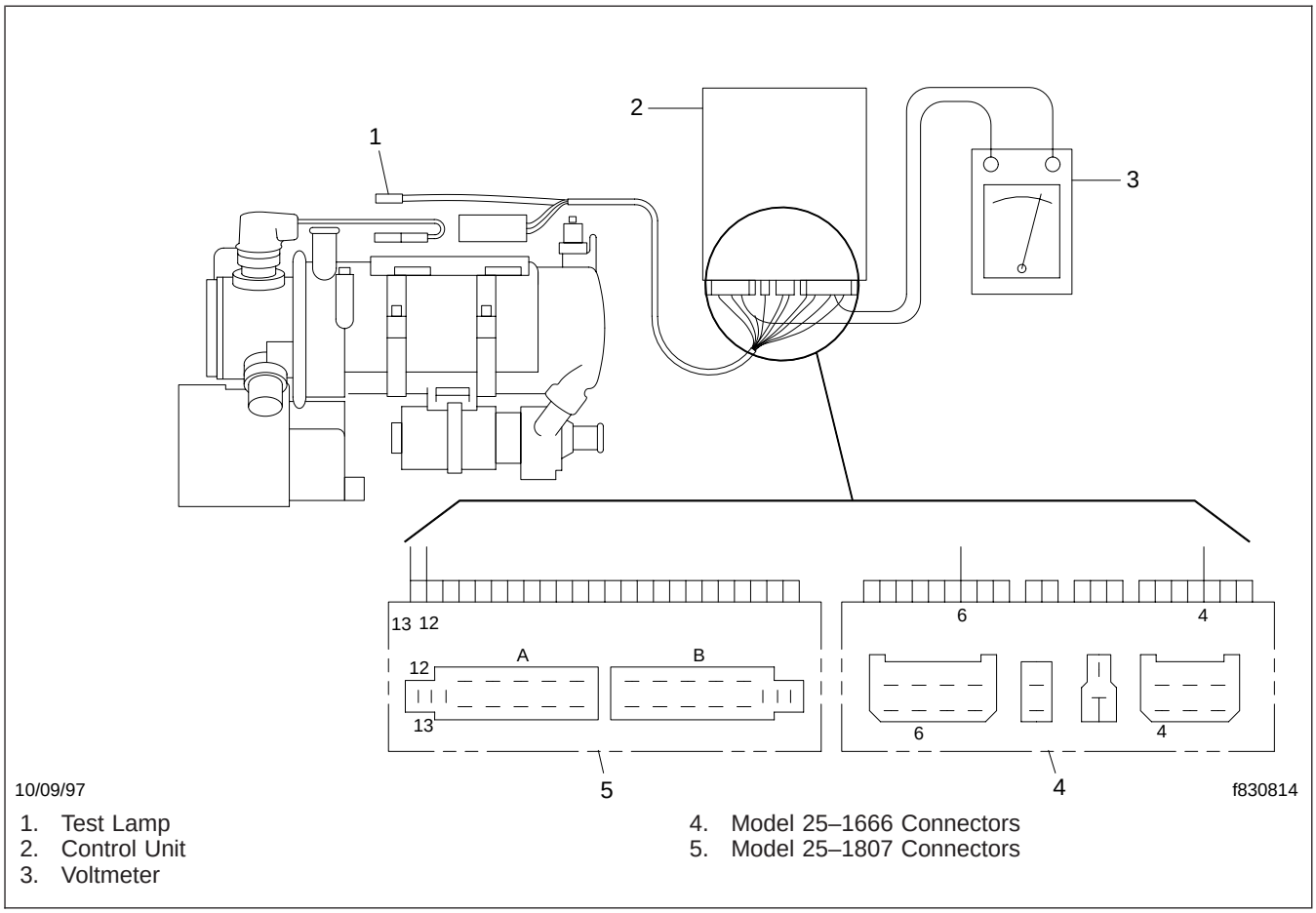
1. Move the fuel metering pump switch to the off position.
2. Move the blower motor switch to the high position. Wait for 180 seconds (3 minutes) for the heater to cool down.
3. Move the combustion blower motor switch to the off position.
4. Move the water pump switch to the off position.
5. The heater is now off. Turn the power switch off and disconnect the tester.

Troubleshooting the Fuel Supply

The fuel quantity should be tested if the heater has difficulty starting or maintaining a flame.

IMPORTANT: Only measure the fuel quantity when the battery is sufficiently charged. While conducting this procedure, the voltage to the control unit must be within a range of 11 to 13 volts (22 to 26 volts for 24 volt systems).

1. Disconnect the electrical plug terminal between the control unit and the glow plug. Connect a test lamp on the control unit side of the plug. See **Fig. 7**.
2. Detach the fuel line from the coolant heater and insert it into a measuring glass.
3. Connect the voltmeter to the control unit. For model 25–1666, the negative line of the voltmeter connects to terminal four of the six pin plug and the positive line of the voltmeter connects to terminal six of the eight pin plug. For model 25–1807, the negative line of the voltmeter connects to connector pin A12 and the positive line of the voltmeter connects to connector pin A13. See **Fig. 7**.
4. To fill and bleed the fuel line, turn the heater switch on and allow the fuel to fill the measuring glass (the fuel will start to pump 25 to 55 seconds after the heater is switched on). Turn off the heater and empty the glass.
5. Turn on the heater switch. Fuel will begin to pump 25 to 55 seconds after the heater is



1. Test Lamp
2. Control Unit
3. Voltmeter
4. Model 25–1666 Connectors
5. Model 25–1807 Connectors

Fig. 7, Test Light and Voltmeter Connections

switched on. Hold the fuel line in the measuring glass while fuel is being delivered.

6. Hold the measuring glass at the level of the plug terminal while taking this measurement.
7. Use a stop watch to time the period that the fuel metering pump delivers fuel to the measuring glass.
8. Record the voltage at the voltmeter (volt). The fuel feed will cutoff automatically after the fuel has pumped for 60 to 90 seconds. Record the time period that the fuel was pumped (60s or 90s).
9. Turn off the heater.
10. Record the fuel quantity in the measuring glass in milliliters (ml).
11. Transpose the fuel quantity and the voltage readings to the appropriate diagram (**Fig. 8**).
12. The fuel consumption is okay if the intersection of the two readings is with in the limit curves. If the intersection is outside the limit curves, replace the fuel metering pump.

NOTE: Do not adjust the fuel metering pump. Adjustments will only provide a temporary repair.

Troubleshooting

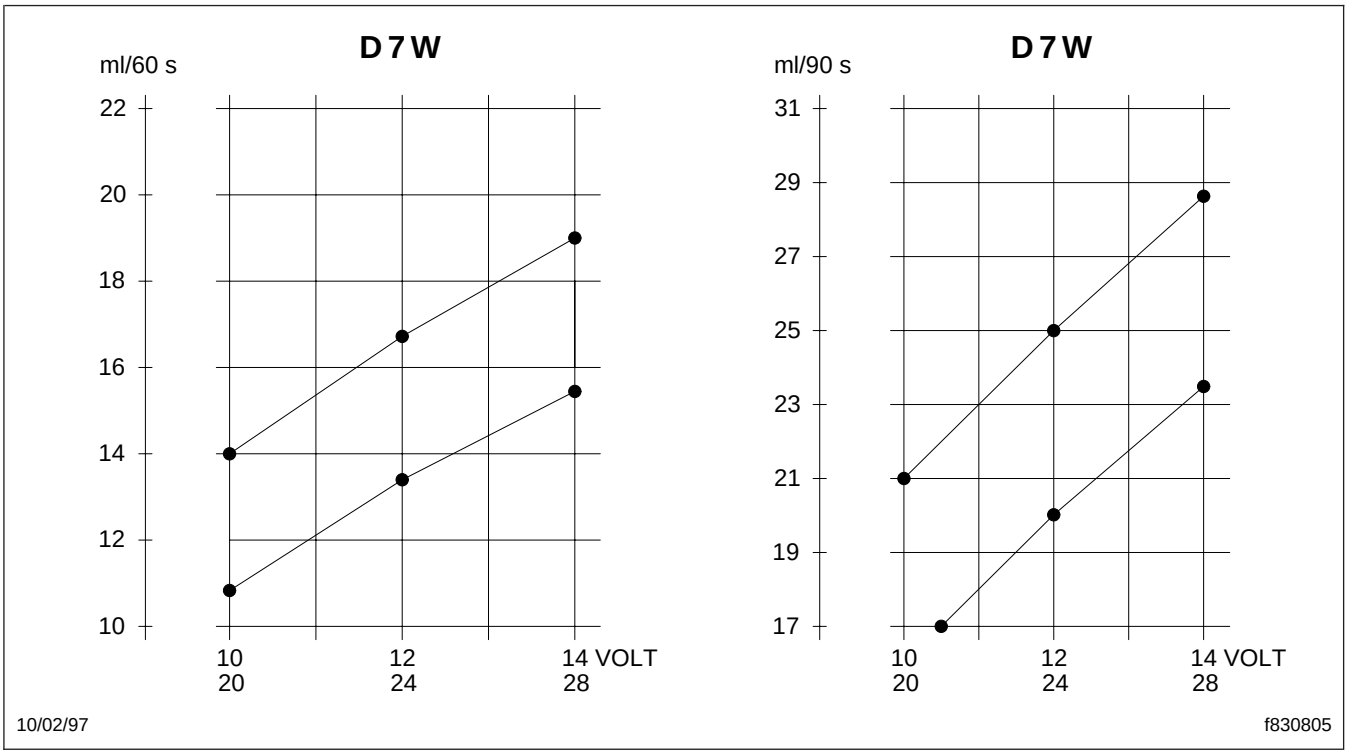


Fig. 8, Fuel Quantity Limit Diagrams

Specification Tables

Heat Output Specifications	
Heat Output ±10%	
High	24,000 BTU (7 Kw)
Low	6,000 BTU (1.75 Kw)

Table 1, Heat Output Specifications

Current Specifications (model 25-1666 only)	
Current at 12 Volts ±10%	
Start (1 to 2 minutes)	26 amps/hr
Running High	7.5 amps/hr
Running Low	4.2 amps/hr

Table 2, Current Specifications (model 25-1666 only)

Current Specifications (model 25-1807 only)	
Current at 12 Volts ±10%	
Start (1 to 2 minutes)	24.6 amps/hr
Running High	5.8 amps/hr
Running Low	4.2 amps/hr

Table 3, Current Specifications (model 25-1807 only)

Current Specifications (model 25-1666 only)	
Current at 24 Volts ±10%	
Start (1 to 2 minutes)	22 amps/hr
Running High	3.8 amps/hr
Running Low	2 amps/hr

Table 4, Current Specifications (model 25-1666 only)

Fuel Consumption Specifications	
Fuel Consumption ±5%	
Low Heat	High Heat
0.06 US Gal/hr (0.22 Liter/hr)	0.24 US Gal/hr (0.90 Liter/hr)

Table 5, Fuel Consumption Specifications

Coolant Pump Flow Specifications
Coolant Pump Flow ±10%
420 US Gal/hr (1600 Liter/hr)

Table 6, Coolant Pump Flow Specifications

Temperature Specifications	
Temperature Limits	
Coolant Temperature Range ±5%	176 to 201°F (80 to 95°C)
Overheat Temperature ±10%	275°F (135°C)

Table 7, Temperature Specifications

Voltage Specifications (model 25-1666)	
Operating Voltage Range	
12 Volt System	10.5 to 14.0 Volts
24 Volt System	21 to 28 Volts

Table 8, Voltage Specifications (model 25-1666)

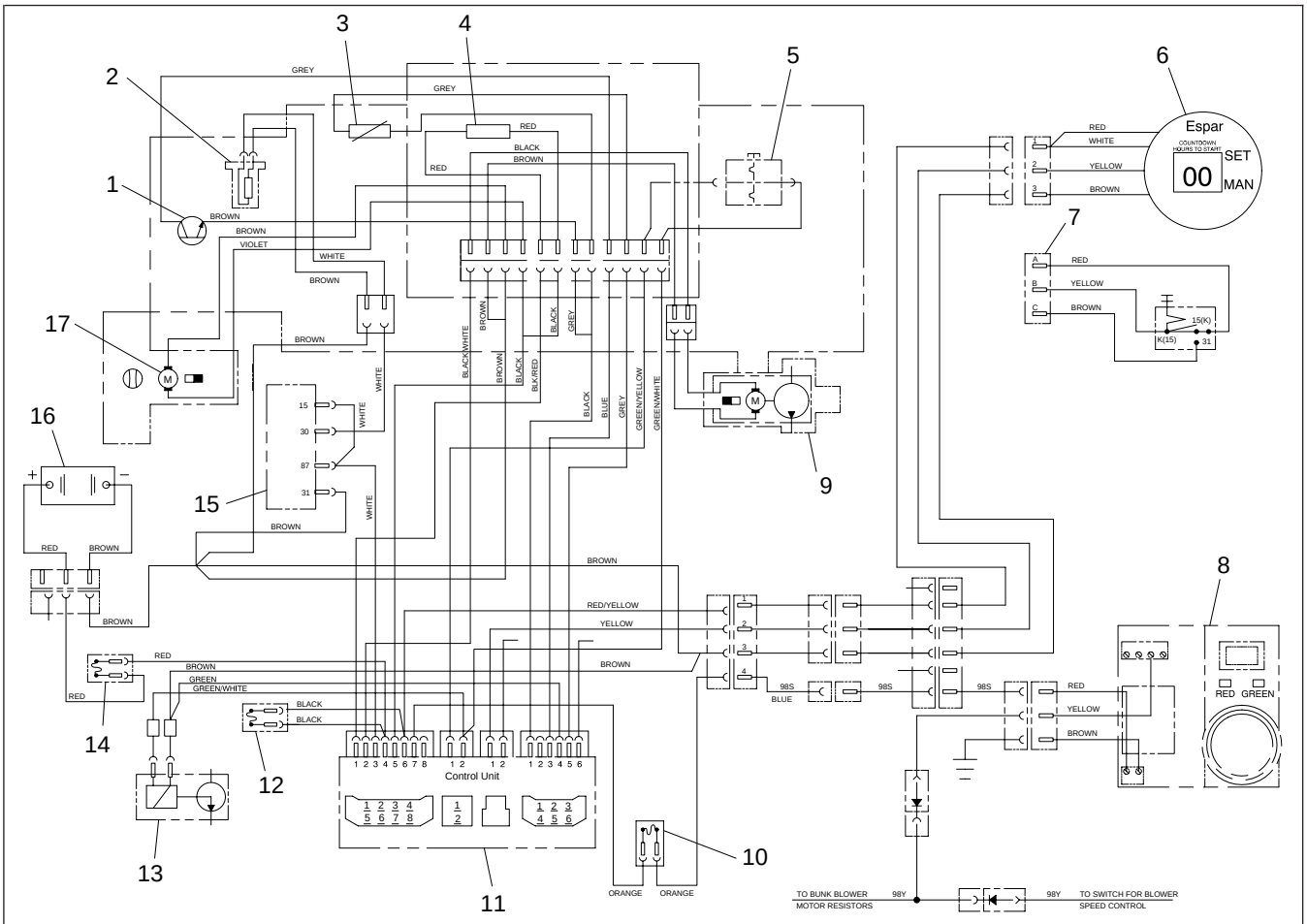
Voltage Specifications (model 25-1807)
Operating Voltage Range
12 Volt System
10.5 to 15.0 Volts

Table 9, Voltage Specifications (model 25-1807)

Wiring Diagrams

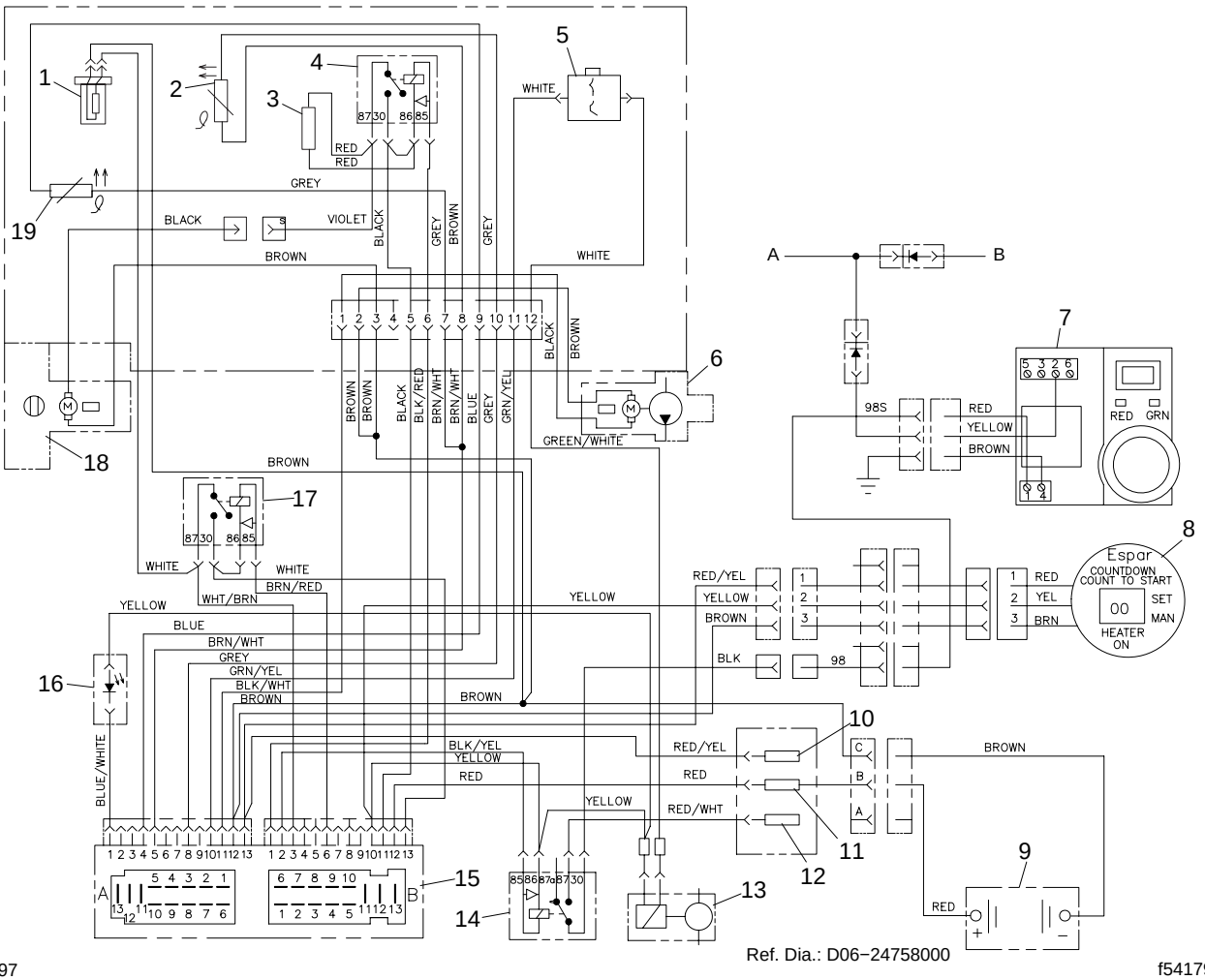
For electrical troubleshooting, consult the wiring diagrams. See **Fig. 1**, **Fig. 2**, **Fig. 3**, **Fig. 4**, or **Fig. 5**.

Specifications



1. Flame Sensor
2. Glow Plug
3. Temperature Sensor
4. Partial Load Resistor
5. Overheat Switch
6. 99 Hour Digital Timer
7. On/Off Switch
8. Room Thermostat
9. Coolant Pump
10. Heat Exchanger Blower Fuse 3A
11. Control Unit
12. Coolant Pump & Blower Fuse 15A
13. Fuel Metering Pump
14. Main Fuse 30A
15. Glow Plug Voltage Regulator
16. Battery
17. Burner Motor

Fig. 1, Espar Heater Wiring Diagram (model 25-1666)

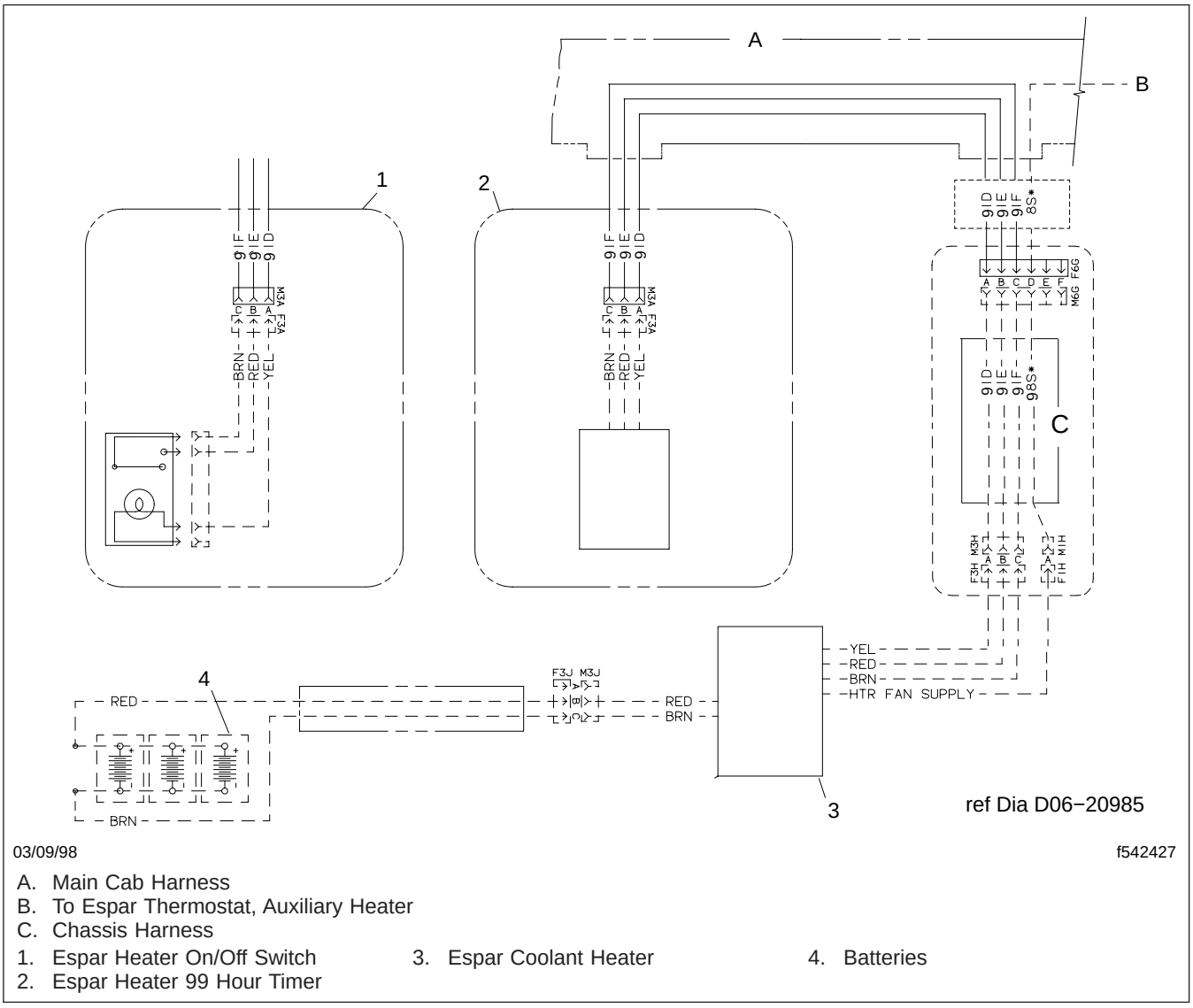


A. To Bunk Blower Motor Resistor (98 Y)
B. To Switch for Blower Speed Control (98 Y)

1. Glow Plug
2. Temperature Sensor
3. Partial Load Resistor
4. Change Over Relay
5 Overheat Switch
6. Coolant Pump
7. Room Thermostat
8. 99 Hour Digital Timer
9. Battery
10. Coolant Pump/Blower Fuse, 15 Amp
11. Main Fuse, 25 Amp
12. Vehicle Blower Fuse, 10 Amp
13. Fuel Metering Pump
14. Relay For Vehicle Blower
15. Control Unit
16. Diagnostic LED
17. Glow Plug Relay
18. Burner Motor
19. Flame Sensor

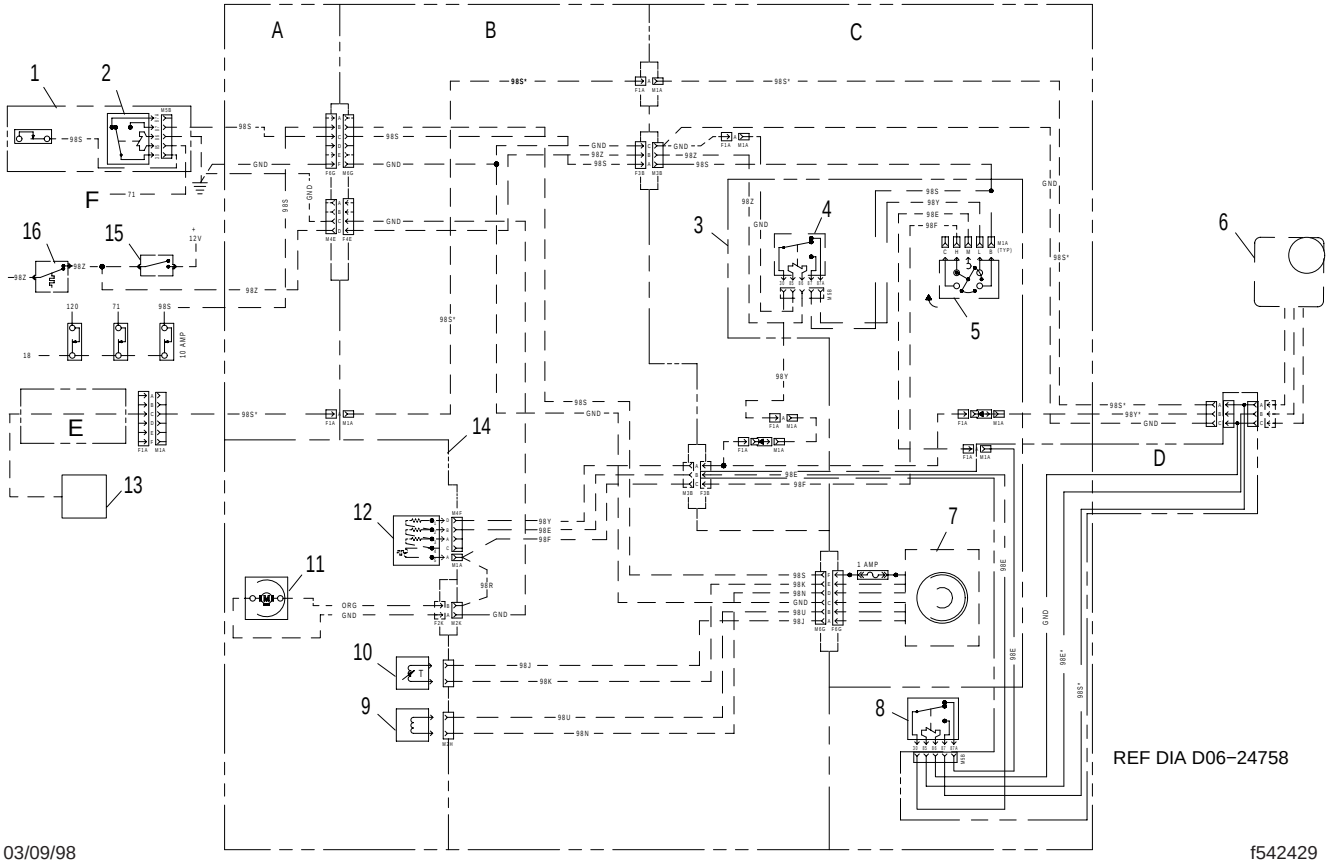
Fig. 2, Espar Heater Wiring Diagram (model 25-1807)

Specifications



A. Main Cab Harness
B. To Espar Thermostat, Auxiliary Heater
C. Chassis Harness
1. Espar Heater On/Off Switch
2. Espar Heater 99 Hour Timer
3. Espar Coolant Heater
4. Batteries

Fig. 3, FLB and FLD Espar Heater Cab Wiring

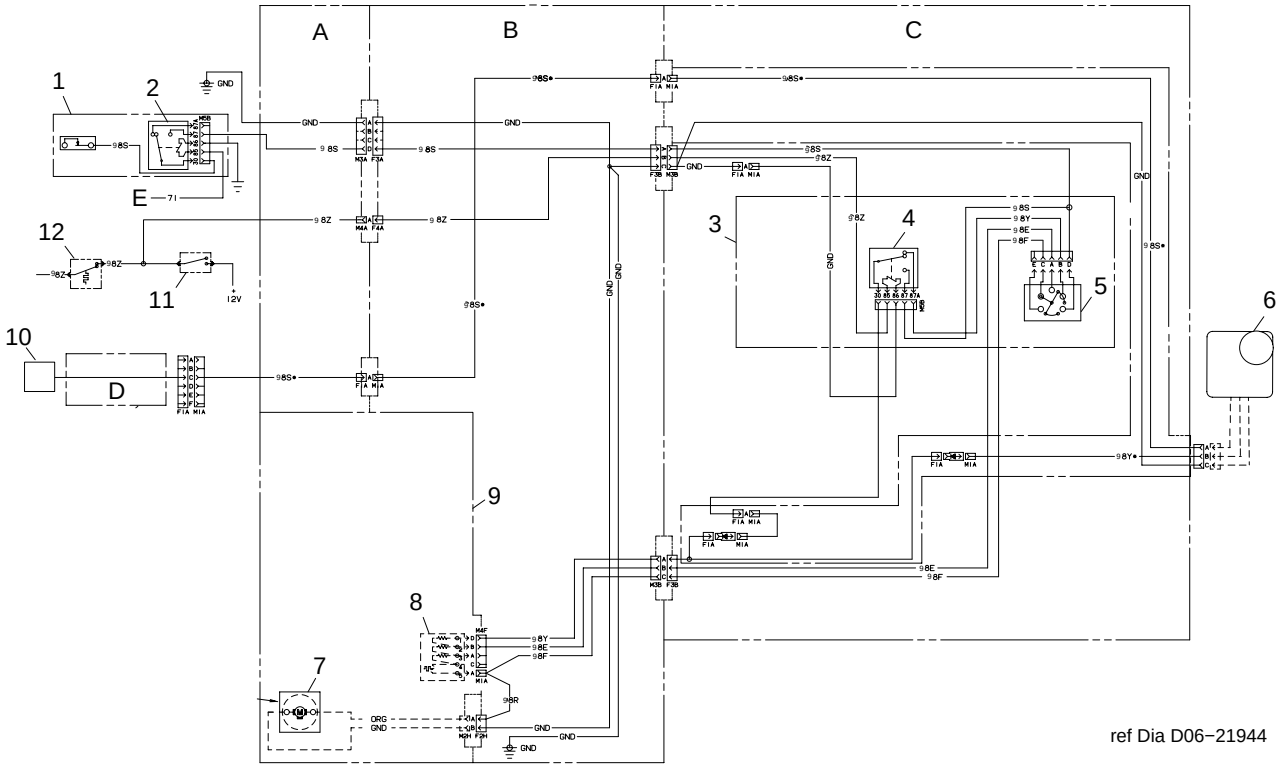


A. Main Cab Harness
B. Bunk Harness
C. Heater Control Harness
D. Thermostat Harness
E. Chassis Harness
F. From Ignition Switch

1. Component Mounting Plate
2. Relay
3. Control Panel
4. Relay
5. Fan Switch, Off
6. Espar Thermostat
7. ATC Board Assembly
8. Medium Speed Relay
9. Water Valve
10. Thermistor
11. Motor
12. Resistor
13. Espar Coolant Heater
14. Behr Auxiliary Heater Unit
15. A/C On/Off Switch
16. Main Combination Thermostat

Fig. 4, Cab Auxiliary Heater Wiring (model 25-1807)

Specifications



A. Main Cab Harness
B. Overhead Harness
C. Heater Control Harness
D. Chassis Harness
E. From Ignition Switch

1. Component Mounting Plate
2. Relay
3. Control Panel
4. Relay
5. Fan Switch, Off
6. Espar Thermostat
7. Motor
8. Resistor
9. Red Dot Auxiliary Heater
10. Espar Coolant Heater
11. A/C On/Off Switch
12. Main Combination Thermostat

Fig. 5, Cab Auxiliary Heater Wiring (model 25-1666)

General Information

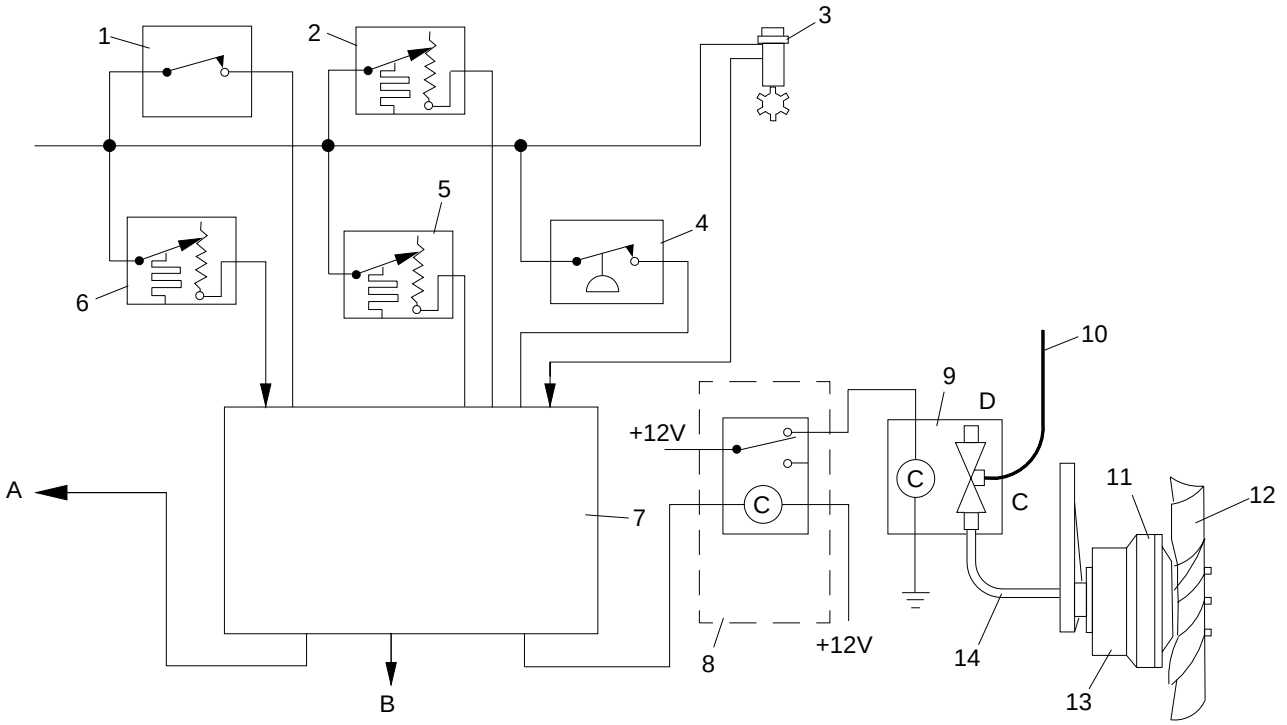
The Horton DriveMaster® fan clutch is a temperature-controlled, air-operated clutch for the engine cooling fan. It is spring engaged, and controls the engine temperature by engaging or disengaging the fan.

When the coolant temperature is below a specified range, air pressure keeps the fan disengaged to save engine power. When the coolant temperature rises above the specified range, air pressure to the fan clutch is cut off and internal spring pressure engages the fan.

Air pressure to the fan clutch is controlled by a solenoid valve; the solenoid valve is controlled by a temperature switch installed in the thermostat housing. The temperature switch is connected to the engine ECM, which controls the solenoid valve. See **Fig. 1**. When you start a cold engine, the solenoid valve allows air pressure to the fan clutch and the clutch remains disengaged. When the coolant temperature rises to the temperature switch setting, the switch provides power to the solenoid valve and the valve cuts off compressed air to engage the fan.

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-dryer. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies power to the solenoid valve, which cuts off air to the fan clutch, engaging the fan.

General Information



A. To Indicators and Gauges
B. To Electronic Injectors and Other Actuators
C. Normally Closed
D. Normally Open

1. Fan Override Switch
2. Air Temperature Sensor
3. Engine Speed Sensor
4. A/C Pressure Switch
5. Coolant Temperature Sensor
6. Foot Throttle
7. Engine ECM
8. Fan Relay (not present in all systems)
9. Solenoid Valve
10. Air Supply from Reservoir
11. Fan Clutch
12. Air Supply to Fan Clutch

Fig. 1, Fan Clutch Schematic (engine ECM controlled)

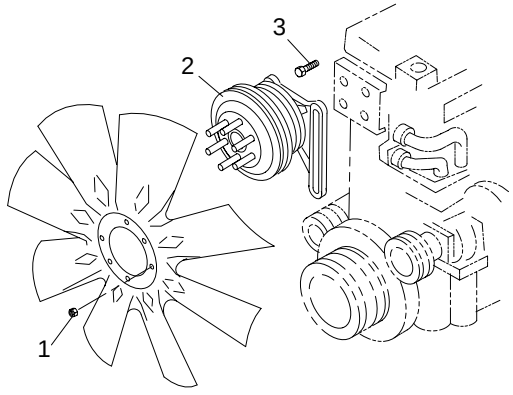
Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires.

⚠ WARNING

Wear safety goggles when draining the air system or disconnecting an air line because dirt and sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnected pressurized air lines, as they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

2. Drain the air tanks.
3. Tilt the hood.
4. Disconnect the left-side hose from the charge air cooler.
5. Remove the drive belts from the engine.
6. Disconnect the air line from the fan hub.
7. Remove the fan.
8. Remove the fan clutch assembly from the engine. See **Fig. 1**.



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1. Hexnut
2. Fan Clutch Assembly
3. Hexbolt,

Fig. 1, Fan Clutch Removal (typical)

8.1 If equipped with a metal fan ring, remove the two top fasteners holding the upper mounting bracket for the fan ring.

8.2 Remove the fasteners holding the fan clutch mounting bracket to the front of the engine.

⚠ WARNING

The fan clutch assembly may weigh up to 55 lbs. (25 kg). Be careful when lifting it. Use a helper or a hoist, if necessary. Failure to use care when lifting the fan clutch could cause the assembly to fall, which could result in injury or component damage.

8.3 Remove the fan clutch assembly from the vehicle. If equipped with a metal fan ring, carefully push the ring forward to allow removal of the fan clutch assembly.

Installation

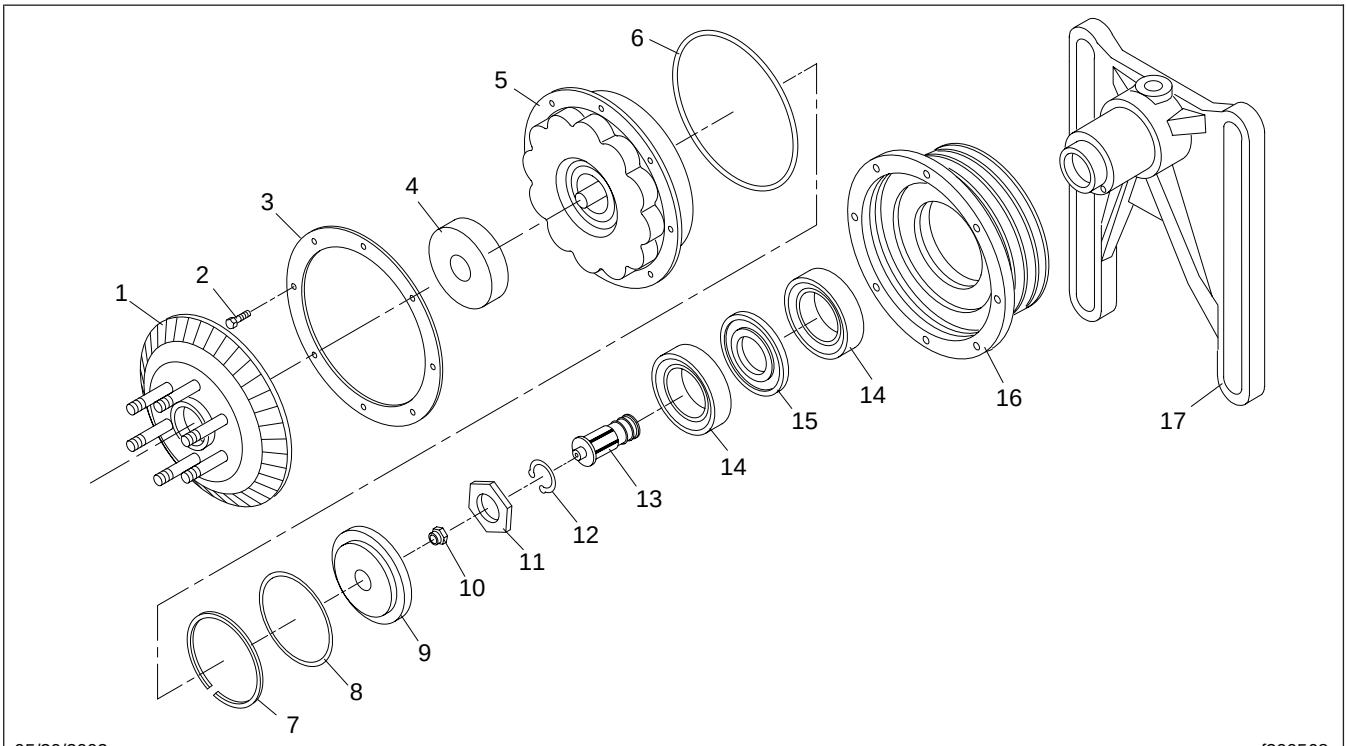
1. Using either a helper or a hoist, position the fan clutch assembly in place on the front of the engine, aligning the holes in the mounting bracket with those in the front of the engine.
2. Install the fasteners.

   If equipped with a metal fan ring, don't tighten the upper fan clutch fasteners completely.
3. Install the drive belts.
4. Connect the air line to the fan clutch.
5. Install the fan. Tighten the fan mounting nuts firmly.
6. Tighten the M8 fan-clutch mounting fasteners 15 lbf·ft (20 N·m).
7. Connect the left-side hose to the charge air cooler.
8. Lower the hood.
9. Remove the chocks from the tires.

Disassembly

NOTE: This procedure involves a major rebuild of the Horton DriveMaster® fan clutch, using parts from the manufacturer's Super Kit. If you are replacing just the seals or the air cartridge, see **Subject 120** for the minor rebuild procedure.

Refer to **Fig. 1** for this procedure.



1. Fan Mounting Disc
2. Torx®-Head Screw (8 qty.)
3. Friction Lining
4. Cage Nut (supplied with repair kit)
5. Spring Housing/Piston Assembly
6. Air Chamber Seal
7. Air Chamber Cap Retaining Ring
8. O-Ring
9. Air Chamber Cap
10. Face Seal
11. Bearing Nut
12. Air Cartridge Retaining Ring
13. Air Cartridge Assembly
14. Sheave Bearings
15. Bearing Spacer
16. Sheave
17. Journal Bracket

Fig. 1, Horton DriveMaster Fan Clutch

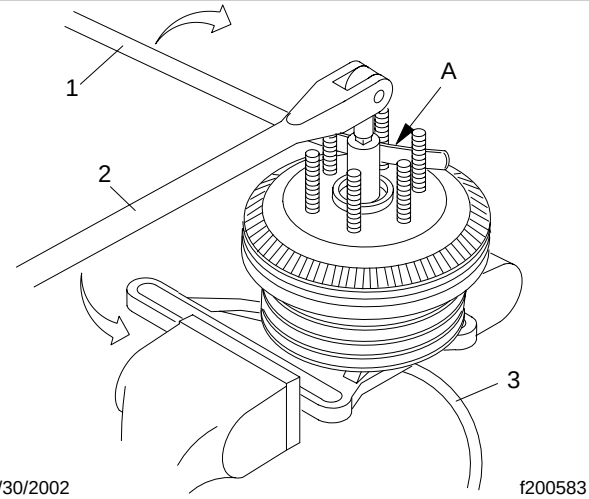
1. Remove the fan clutch assembly from the vehicle. For instructions, see **Subject 100**.
2. Put the fan clutch assembly in a vise.
3. Connect a shop air hose to the fan clutch air inlet.
4. Apply 80 to 120 psi (552 to 827 kPa) to the fan clutch to lift the fan mounting disc off the spring housing/piston assembly.

CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

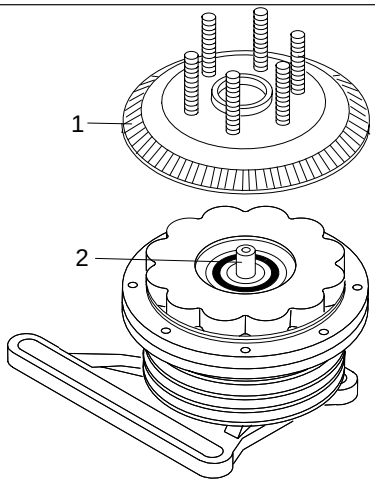
5. Using a pry bar, wrench, and a T55 Torx® bit, loosen the jack bolt (left-hand thread) by turning it counterclockwise. See **Fig. 2**.
6. Unscrew the fan mounting disc from the jack bolt. See **Fig. 3**

Fan Clutch Major Rebuild



A. Place the pry bar here.
1. Pry Bar (push clockwise)
2. Torx Bit and Wrench (turn counterclockwise)
3. Shop Air Hose (connected to the inlet port)

Fig. 2, Loosening the Jack Bolt



1. Fan Mounting Disc
2. Jack Bolt (left-hand thread)

Fig. 3, Fan Mounting Disc Removal and Installation

7. Inspect the fan mounting disc for wear or damage.

WARNING

Do not disassemble the spring housing from the piston. The interior springs are very strong, and if released could eject the housing with considerable force, possibly resulting in serious injury. Always use the cage nut to hold the spring housing and the piston together.

8. Using a wrench and a T55 Torx bit to hold the jack bolt, install the cage nut from the kit onto the jack bolt (left-hand thread). Hand tighten it onto the spring housing.

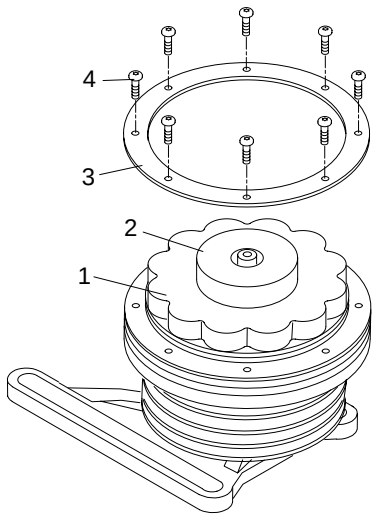
   The cage nut will keep the spring housing and piston together as an assembly. It will also maintain pressure on the internal springs after the Torx-head screws holding the friction lining in place are removed.

9. Release the air pressure from the fan clutch.

WARNING

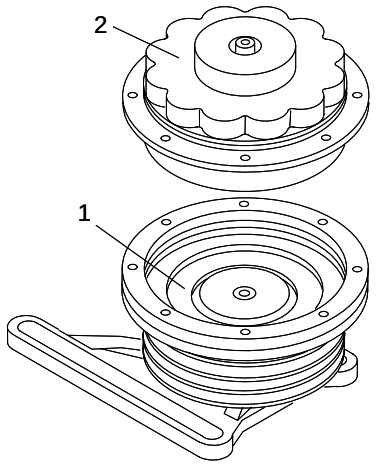
Release the air pressure from the fan clutch before removing the friction lining Torx-head screws. Failure to release the air pressure could result in the spring housing/piston assembly being ejected with force, which could result in personal injury.

10. Using a T27 Torx bit, remove the eight Torx-head screws holding the friction lining in place.
11. Remove the friction lining. See **Fig. 4**.
12. *Keeping the cage nut installed and tightened,* remove the spring housing/piston assembly. See **Fig. 5** .
13. Remove the air chamber seal. See **Fig. 6** .
14. Examine the inside of the air chamber for signs of moisture and/or contaminants.
15. Remove the air chamber cap retaining ring. See **Fig. 6** .
16. Using two small screwdrivers placed 180 degrees apart, gently and evenly pry the air chamber cap out of the sheave.
17. Remove the O-ring seal from the air chamber cap. See **Fig. 6** .
18. Remove the face seal. See **Fig. 6** .



1. Spring Housing/Piston Assembly
2. Cage Nut
3. Friction Lining
4. Torx-Head Screws

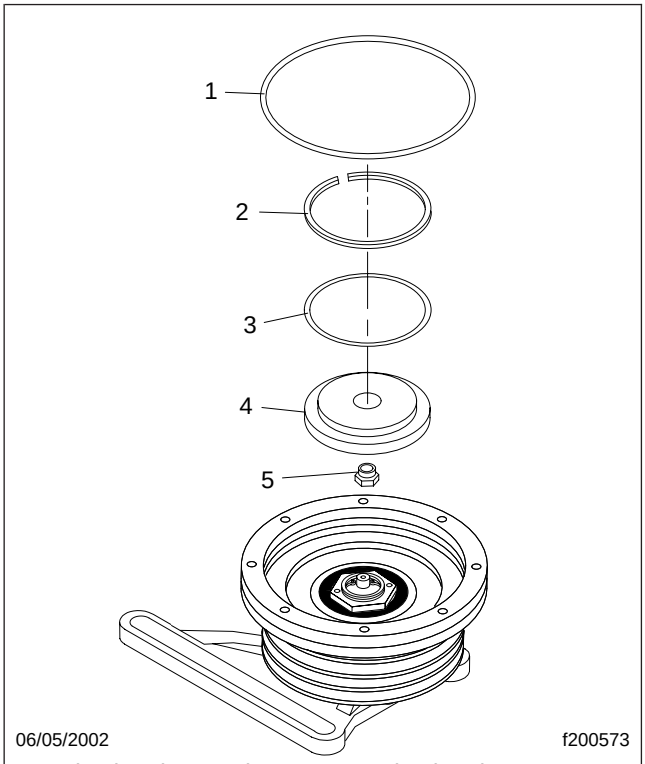
Fig. 4, Friction Lining Removal and Installation



1. Air Chamber
2. Spring Housing/Piston Assembly (with cage nut installed)

Fig. 5, Spring Housing/Piston Assembly Removal and Installation

19. Inspect the face seal for signs of wear. Wear indicates that dirt may exist in the air system



1. Air Chamber Seal
2. Retaining Ring
3. O-Ring Seal
4. Air Chamber Cap
5. Face Seal

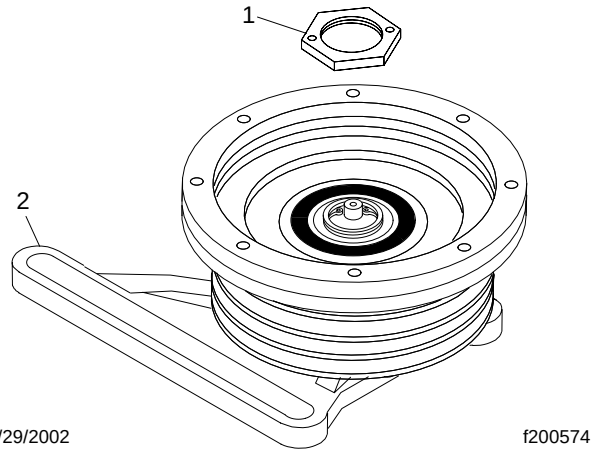
Fig. 6, Air Chamber Seal Removal and Installation

20. Remove the bearing nut from the mounting bracket. See **Fig. 7** .
21. Remove the sheave from the mounting bracket. See **Fig. 8** .
22. If replacing the bearings, support the sheave and press them out.
23. Clean and remove any dirt, debris, or corrosion that may be present.
24. Remove the air cartridge.
    - 24.1 Remove the retaining ring. See **Fig. 9**.
    - 24.2 Remove the air cartridge assembly. See **Fig. 10** .

Assembly

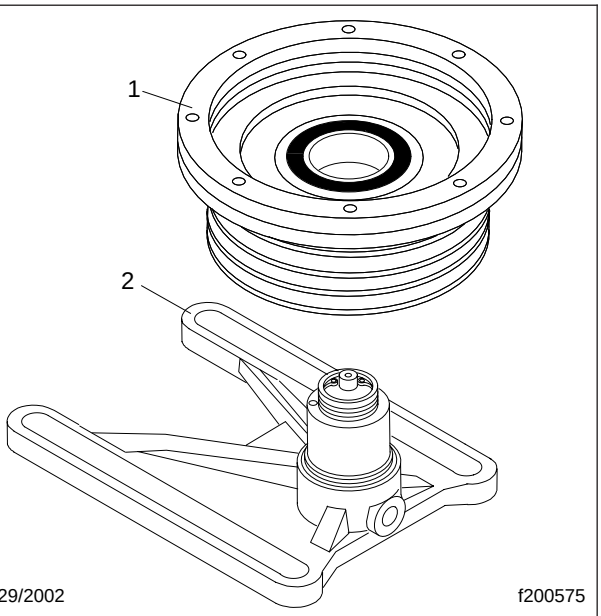
1. If necessary, clean the air cartridge bore in the mounting bracket.

Fan Clutch Major Rebuild



1. Bearing Nut
2. Mounting Bracket

Fig. 7, Bearing Nut Removal and Installation



1. Sheave
2. Mounting Bracket

Fig. 8, Removing the Sheave

NOTE: The sheave bearings do not require lubrication.

2. If replacing the sheave bearings, do the following:

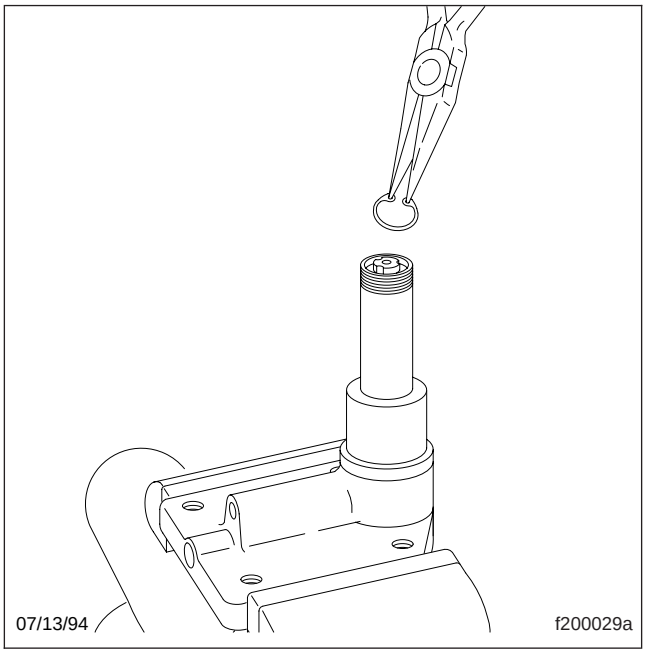
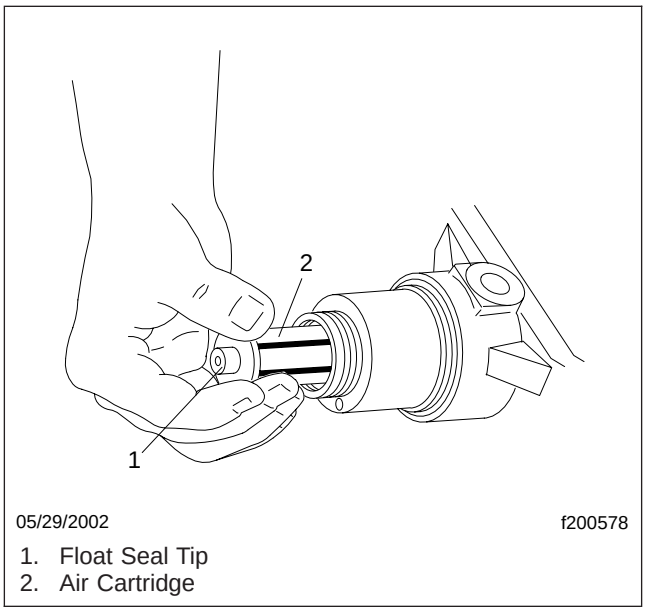


Fig. 9, Retaining Ring Removal and Installation

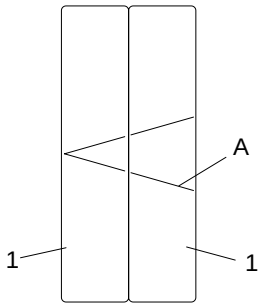


1. Float Seal Tip
2. Air Cartridge

Fig. 10, Removing the Air Cartridge

2.1 If equipped with two bearings, assemble the bearings so the markings on their edges line up to form an arrow. See

Fig. 11 . It doesn't matter which way the arrow faces when the bearings are installed.



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A. Align the markings to form an arrow.
1. Sheave Bearing

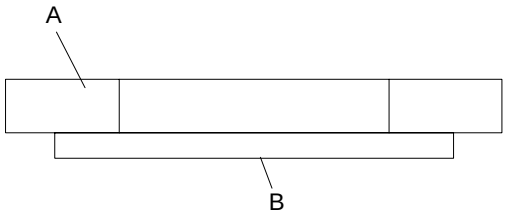
Fig. 11, Aligning the Bearings

IMPORTANT: If the fan clutch uses spacers, be sure to install them between the bearings.

2.2 Supporting the sheave, press the new sheave bearings — and spacers, if applicable — into place. Note the position of the lip inside the sheave.

2.3 Slide the sheave onto the mounting bracket. See **Fig. 8** .

2.4 Making sure that the bearing nut hex is facing up, install the bearing nut. See **Fig. 12** . Tighten 130 lbf·ft (176 N·m). See **Fig. 7** .



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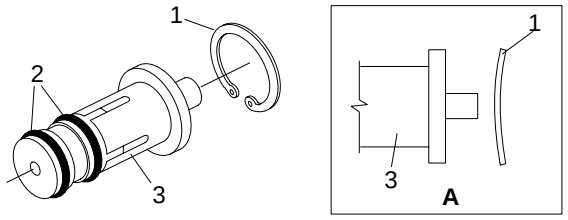
A. Hex faces up.
B. Relief faces toward mounting bracket and bearings.

Fig. 12, Correct Bearing Nut Orientation

3. Apply O-ring lubricant from the kit to the outside O-rings of the new air cartridge assembly. See **Fig. 13** .



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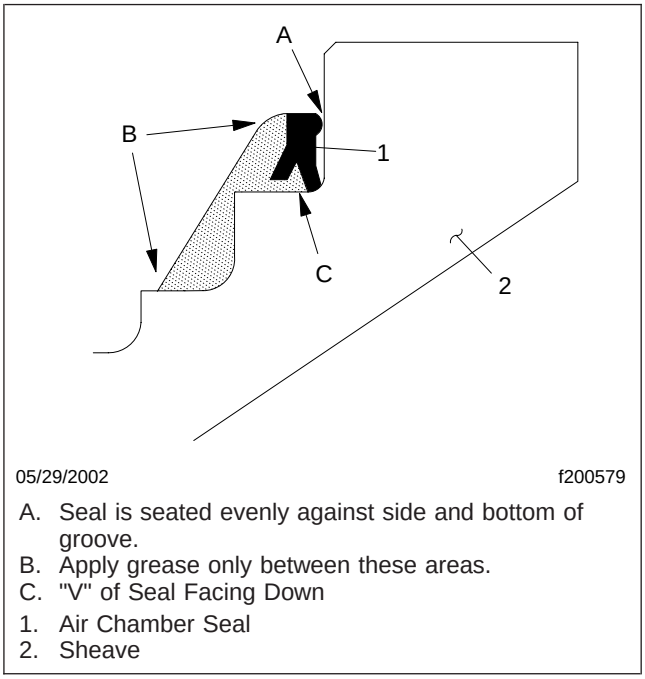
A. Convex surface of the retaining ring goes toward the air cartridge.
1. Retaining Ring
2. O-Rings
3. Air Cartridge

Fig. 13, Installing the Air Cartridge Retaining Ring

4. Install the new air cartridge assembly into the mounting bracket.
5. Install the retaining ring, making sure the convex surface of the ring is toward the air cartridge. See **Fig. 13** .
6. Using a clean, dry cloth, clean both the float seal tip of the air cartridge and the face seal of the air chamber cap.
7. Assemble the air chamber cap and face seal. See **Fig. 6** .

   Tighten the face seal 75 to 100 lbf·in (850 to 1130 N·cm).
8. Lubricate the O-ring seal with the fresh lubricant from the kit.
9. Install the O-ring seal on the air chamber cap. See **Fig. 6** .
10. Carefully set the air chamber cap into the sheave. See **Fig. 6** .
11. Install the retaining ring. See **Fig. 6** .
12. Install the air chamber seal into the sheave. Be sure the seal is evenly seated against the side and bottom of the groove surfaces, and the "V" of the seal is facing down. See **Fig. 14** .
13. Lubricate contact surfaces with the fresh lubricant from the kit.

Fan Clutch Major Rebuild



A. Seal is seated evenly against side and bottom of groove.
B. Apply grease only between these areas.
C. "V" of Seal Facing Down
1. Air Chamber Seal
2. Sheave

Fig. 14, Correct Installation of Air Chamber Seal (cross-section view)

WARNING

The new spring housing/piston assembly from the kit has a cage nut installed on it. Do not remove the cage nut. This will cause the spring housing to be forcibly ejected from the piston assembly, which could result in serious injury.

14. Carefully set the new spring housing/piston assembly into position. See **Fig. 6** . Note that the new assembly has a cage nut installed on it.
15. Rotate the new spring housing/piston assembly to align the mounting holes with those of the sheave.

IMPORTANT: Handle the new friction liner by the edges to avoid contamination.

16. Set the new friction liner from the kit into place, being careful to touch only the edges.
17. Using a T27 Torx bit, install the eight Torx-head screws. See **Fig. 4** . Tighten alternately 80 lbf·in (900 N·cm).
18. Apply a minimum of 80 psi (552 kPa) of clean air to the air inlet.
19. Remove the cage nut from the spring housing/piston assembly.
20. Install the new fan mounting disc from kit.

CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

21. Using a suitable wrench, a T55 Torx bit, and a pry bar, tighten the jack bolt (left-hand thread) 100 lbf·ft (136 N·m). Turn the wrench clockwise and push the pry bar counterclockwise.
22. Using shop air, actuate the fan clutch and check for correct engagement and disengagement of the fan mounting disc. If there is a problem, it must be corrected before installing the fan clutch onto the engine.
23. Check for air leaks at the bleed hole and around the spring housing/piston assembly.
24. Install the fan clutch assembly onto the engine. See **Subject 100** for instructions.

Disassembly

NOTE: This procedure involves a minor rebuild of the Horton DriveMaster® fan clutch, using parts from the manufacturer's Seal Kit. If a major rebuild of the fan clutch is needed, see **Subject 110**.

1. Remove the fan clutch assembly from the vehicle. For instructions, see **Subject 100**.
2. Put the fan clutch assembly in a vise.
3. Connect a shop air hose to the fan clutch air inlet.
4. Apply 80 to 120 psi (552 to 827 kPa) to the fan clutch to lift the fan mounting disc off the spring housing/piston assembly.

⚠ CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

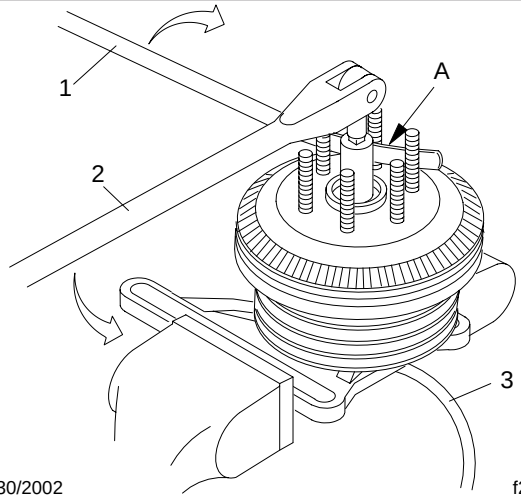
5. Using a pry bar, wrench, and a T55 Torx® bit, loosen the jack bolt (left-hand thread) by turning it counterclockwise. See **Fig. 1**.
6. Unscrew the fan mounting disc from the jack bolt. See **Fig. 2**.
7. Inspect the fan mounting disc for wear or damage.

⚠ WARNING

Do not disassemble the spring housing from the piston. The interior springs are very strong, and if released could eject the housing with considerable force, possibly resulting in serious injury. Always use the cage nut to hold the spring housing and the piston together.

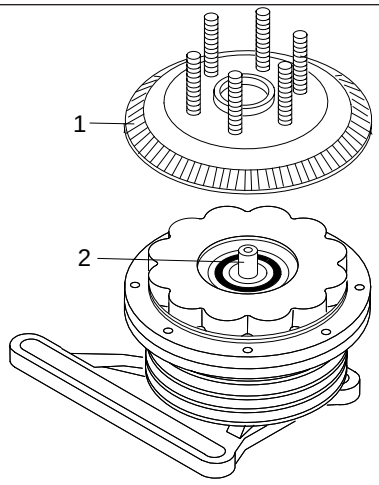
8. Using a wrench and T55 Torx bit to hold the jack bolt, install the cage nut from the kit onto the jack bolt (left-hand thread). Hand tighten it onto the spring housing.

   The cage nut will keep the spring housing and piston together as an assembly. It will also maintain pressure on the internal springs after the Torx-head screws holding the friction lining in place are removed.
9. Release the air pressure from the fan clutch.



A. Place the pry bar here.
1. Pry Bar (push clockwise)
2. Torx Bit and Wrench (turn counterclockwise)
3. Shop Air Hose (connected to the inlet port)

Fig. 1, Loosening the Jack Bolt



1. Fan Mounting Disc
2. Jack Bolt (left-hand thread)

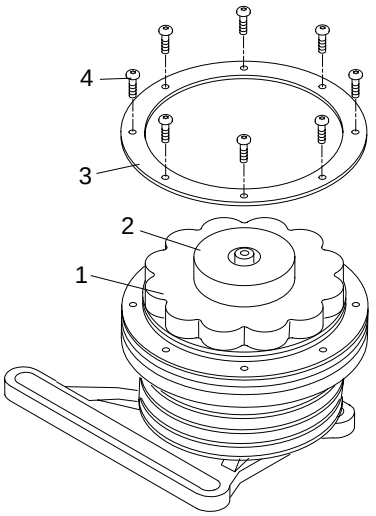
Fig. 2, Fan Mounting Disc Removal and Installation

Fan Clutch Minor Rebuild

WARNING

Release the air pressure from the fan clutch before removing the friction lining Torx-head screws. Failure to release the air pressure could result in the spring housing/piston assembly being ejected with force, which could result in personal injury.

10. Using a T27 Torx bit, remove the eight Torx-head screws holding the friction lining in place.
11. Remove the friction lining. See **Fig. 3**.



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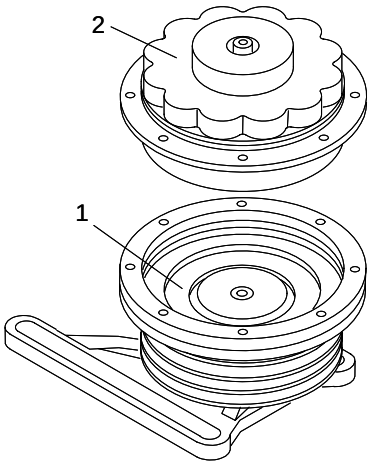
1. Spring Housing/Piston Assembly
2. Cage Nut
3. Friction Lining
4. Torx-Head Screws

Fig. 3, Friction Lining Removal and Installation

12. *Keeping the cage nut installed and tightened,* remove the spring housing/piston assembly. See **Fig. 4** .
13. Remove the air chamber seal. See **Fig. 5** .
14. Examine the inside of the air chamber for signs of moisture and/or contaminants.
15. Remove the air chamber cap retaining ring. See **Fig. 5** .
16. Using two small screwdrivers placed 180 degrees apart, gently and evenly pry the air chamber cap out of the sheave.



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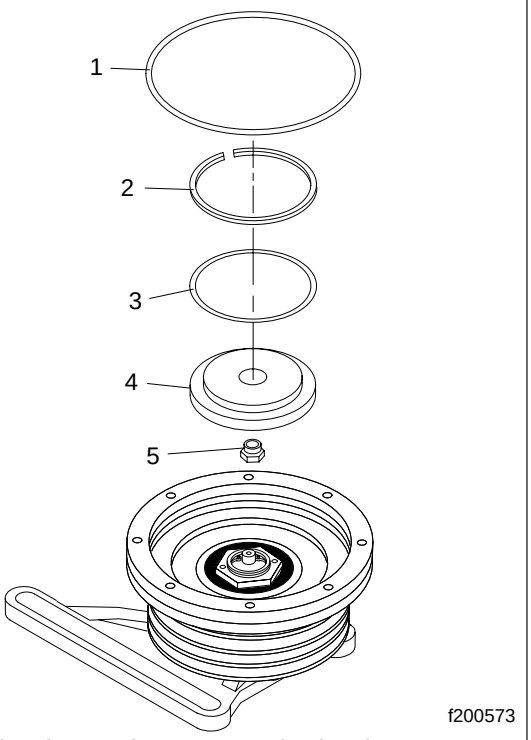
1. Air Chamber
2. Spring Housing/Piston Assembly (with cage nut installed)

Fig. 4, Spring Housing/Piston Assembly Removal and Installation

17. Remove the O-ring seal from the air chamber cap. See **Fig. 5** .
18. Remove the face seal. See **Fig. 5** .
19. Inspect the face seal for signs of wear. Wear indicates that dirt may exist in the air system.
20. Remove the air cartridge.
    - 20.1 Remove the retaining ring. See **Fig. 6**.
    - 20.2 Remove the air cartridge assembly. See **Fig. 7** .

Assembly

1. Clean the mounting bracket bore if necessary.
2. Apply O-ring lubricant from the kit to the outside O-rings of the new air cartridge assembly. See **Fig. 8** .
3. Install the new air cartridge assembly into the mounting bracket.
4. Install the retaining ring, making sure the convex surface of the ring is toward the air cartridge. See **Fig. 8** .



1. Air Chamber Seal
2. Retaining Ring
3. O-Ring Seal
4. Air Chamber Cap
5. Face Seal

Fig. 5, Air Chamber Seal Removal and Installation

5. Using a clean, dry cloth, clean both the float seal tip of the air cartridge and the face seal of the air chamber cap.
6. Assemble the air chamber cap and face seal. See **Fig. 5** .

   Tighten the face seal 75 to 100 lbf·in (850 to 1130 N·cm).
7. Lubricate the O-ring seal with the fresh lubricant from the kit.
8. Install the O-ring seal on the air chamber cap. See **Fig. 5** .
9. Carefully set the air chamber cap into the sheave. See **Fig. 5** .
10. Install the retaining ring. See **Fig. 5** .
11. Install the air chamber seal into the sheave. Be sure the seal is evenly seated against the side and bottom of the groove surfaces, and the "V" of the seal is facing down. See **Fig. 9** .
12. Lubricate contact surfaces with the fresh lubricant from the kit.

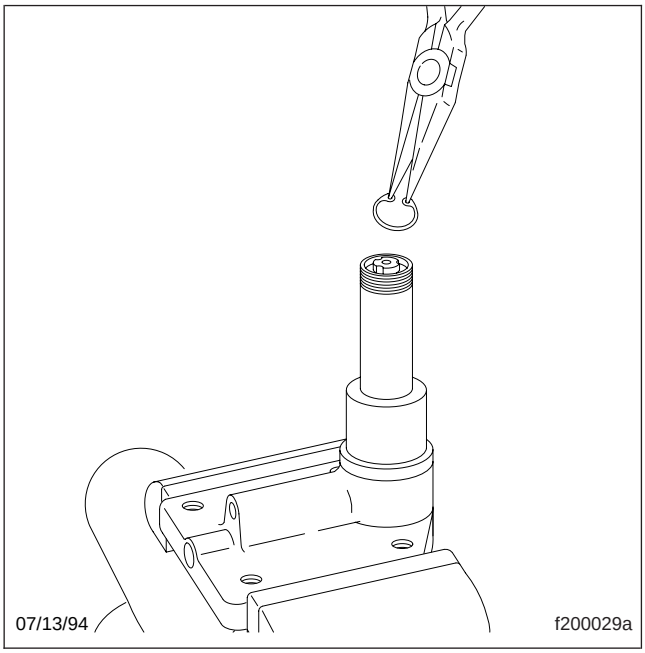
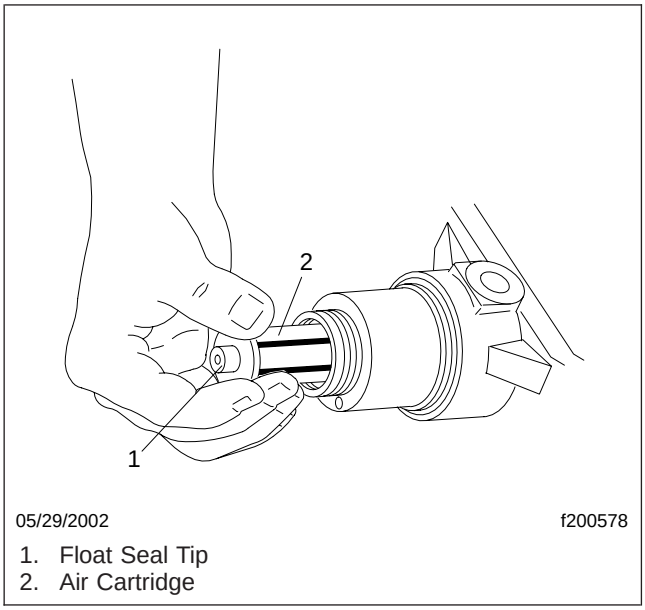


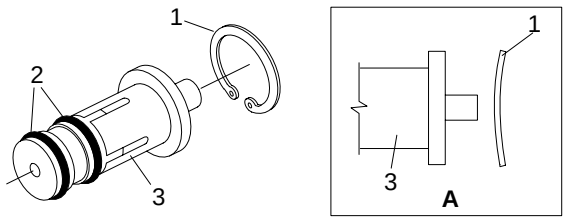
Fig. 6, Retaining Ring Removal and Installation (sheave not shown)



1. Float Seal Tip
2. Air Cartridge

Fig. 7, Removing the Air Cartridge (sheave not shown)

Fan Clutch Minor Rebuild



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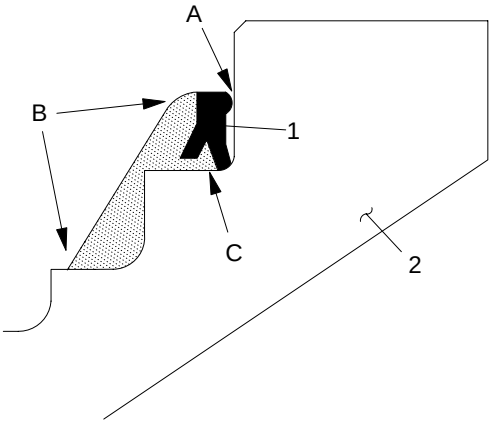
A. Convex surface of the retaining ring goes toward the air cartridge.
1. Retaining Ring
2. O-Rings
3. Air Cartridge

Fig. 8, Installing the Air Cartridge Retaining Ring



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A. Seal is seated evenly against side and bottom of groove.
B. Apply grease only between these areas.
C. "V" of Seal Facing Down
1. Air Chamber Seal
2. Sheave

Fig. 9, Correct Installation of Air Chamber Seal (cross-section view)

⚠ WARNING

The new spring housing/piston assembly from the kit has a cage nut installed on it. Do not remove the cage nut. This will cause the spring housing to be forcibly ejected from the piston assembly, which could result in serious injury.

13. Carefully set the new spring housing/piston assembly into position. See **Fig. 4** . Note that the new assembly has a cage nut installed on it.
14. Rotate the new spring housing/piston assembly to align the mounting holes with those of the sheave.
15. Set the friction liner from the kit into place, being careful to touch only the edges.
16. Using a T27 Torx bit, install the eight Torx-head screws. See **Fig. 3** . Tighten alternately 80 lbf·in (900 N·cm).
17. Apply a minimum of 80 psi (552 kPa) of clean air to the air inlet.
18. Remove the cage nut from the spring housing/piston assembly.

⚠ CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

19. Using a suitable wrench, a T55 Torx bit, and a pry bar, tighten the jack bolt (left-hand thread) 100 lbf·ft (136 N·m). Turn the wrench clockwise and the pry bar counterclockwise.
20. Using shop air, actuate the fan clutch and check for correct engagement and disengagement of the fan mounting disc. If there is a problem, it must be corrected before installing the fan clutch onto the engine.
21. Check for air leaks at the bleed hole and around the spring housing/piston assembly.
22. Install the fan clutch assembly onto the engine. See **Subject 100** for instructions.

Troubleshooting Tables

Problem—Air Is Leaking from the Fan Clutch

Problem—Air Is Leaking from the Fan Clutch	
Possible Cause	**Remedy**
The face seal or air cartridge is damaged or worn.	Install a new seal kit.
The O-ring seals are damaged or worn.	Install a new seal kit.

Problem—The Fan Clutch Fails to Engage

Problem—The Fan Clutch Fails to Engage	
Possible Cause	**Remedy**
There's no power to the fan clutch control circuit.	Check all electrical connections, and repair or replace wiring as needed. Check the circuit breaker for the engine fan and repair or replace as needed.
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally open, not normally closed. Replace the switch if it is damaged or if the switch is the wrong type.
The solenoid valve is malfunctioning.	Replace the solenoid valve.
The solenoid is not exhausting.	Make sure the solenoid exhaust port is not plugged.

Problem—The Fan Clutch Does Not Disengage

Problem—The Fan Clutch Does Not Disengage	
Possible Cause	**Remedy**
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally open, not normally closed. Replace the switch if it is damaged or if the switch is the wrong type.
A restricted air line doesn't allow air supply to the clutch.	Make sure the air lines are not pinched or plugged. Repair the air lines as needed.
The fan clutch is leaking.	Install a new seal kit.
The air supply to the fan clutch is restricted.	Make sure the fan clutch air lines are not leaking or pinched. Repair the lines as needed.
The piston is seized due to contamination or dry seals.	Clean the air supply. Do a major rebuild.

Problem—The Fan Clutch Cycles Frequently

Problem—The Fan Clutch Cycles Frequently	
Possible Cause	**Remedy**
The fan clutch control circuit has a loose connection or is poorly grounded.	Check all wiring connections, and repair the circuit as needed. Check the circuit breaker for the engine fan and repair or replace as needed.

Troubleshooting

Problem—The Fan Clutch Cycles Frequently	
Possible Cause	**Remedy**
The temperature control settings are incorrect.	Check the fan clutch control setting of the temperature switch, according to the engine installed in the vehicle. Repair or replace the temperature switch as needed.
The fan cycling switch at the receiver-dryer is set too low.	Check the switch at the receiver-dryer, and if needed, replace the switch with a switch with a higher setting. Check the ACPU switch and unit.
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
The engine temperature is too high.	Check the programmable engine control parameters, and reprogram as needed.
The temperature switch is malfunctioning.	Replace the temperature switch.

Problem—The Fan Clutch Engages, But the Engine Still Overheats

Problem—The Fan Clutch Engages, But the Engine Still Overheats	
Possible Cause	**Remedy**
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
There is a problem somewhere else in the cooling system.	Refer to the cooling system troubleshooting section, **Section 20.00**.

Specifications

Horton DriveMaster® Repair Kits		
Kit Description *	**Part Number**	**When Used**
Super Kit	HOR994347	Fan Clutch Major Rebuild
Seal Kit	HOR994346	Replacing Seals and Air Cartridge
Friction Disc Kit	HOR994348	Replacing Fan Mounting Disc and Friction Lining
Friction Liner Kit	HOR994349	Replacing Friction Lining Only

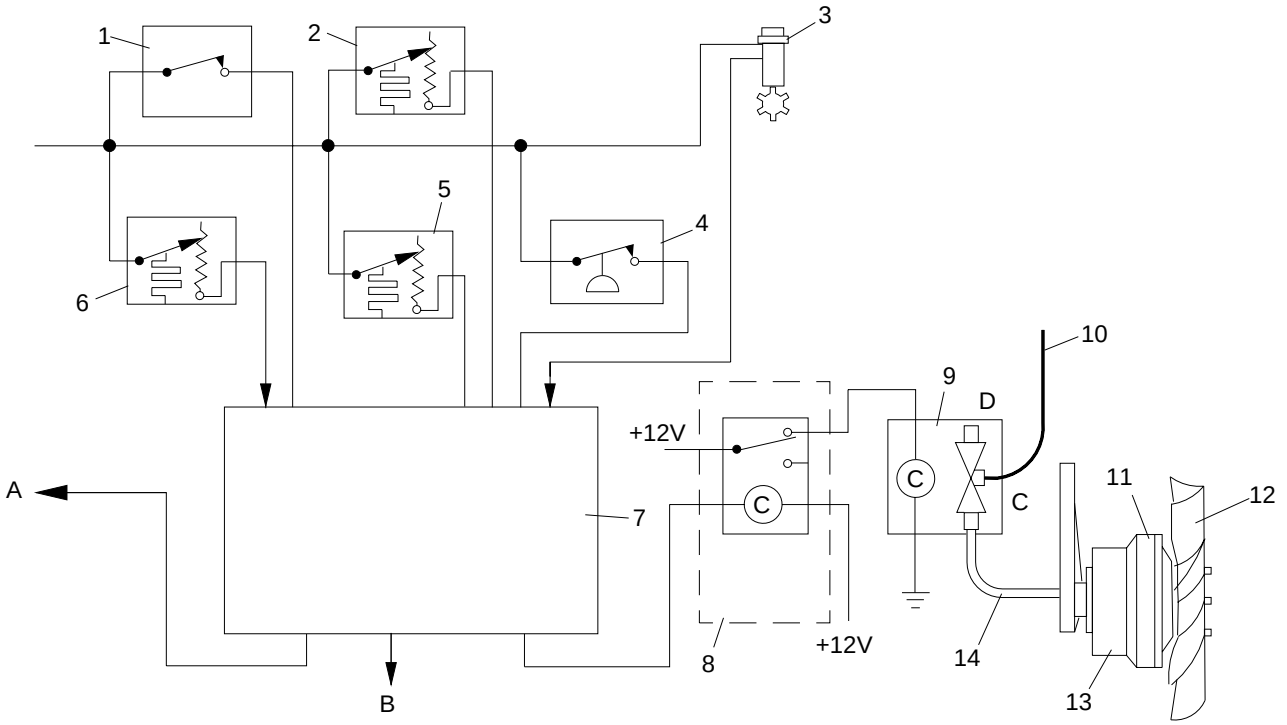
* All kits are available from the PDCs.

Table 1, Horton DriveMaster Repair Kits

Description	Torque	
	lbf·in (N·cm)	**lbf·ft (N·m)**
Friction Lining Screws	80 (900)	—
Face Seal	75 to 100 (850 to 1130)	—
Bearing Nut	—	130 (176)
Jack Bolt	—	100 (136)

Table 2, Torque Values

Specifications



A. To Indicators and Gauges
B. To Electronic Injectors and Other Actuators
C. Normally Closed
D. Normally Open

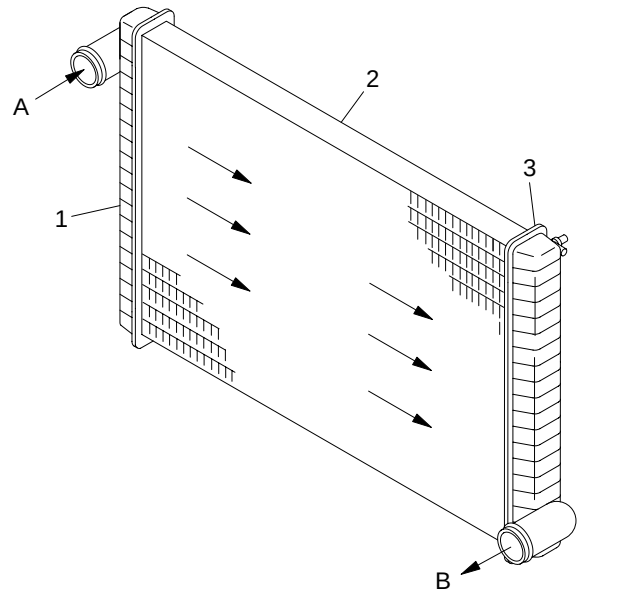
1. Fan Override Switch
2. Air Temperature Sensor
3. Engine Speed Sensor
4. A/C Pressure Switch
5. Coolant Temperature Sensor
6. Foot Throttle
7. Engine ECM
8. Fan Relay (not present in all systems)
9. Solenoid Valve
10. Air Supply from Reservoir
11. Fan Clutch
12. Air Supply to Fan Clutch

Fig. 1, Fan Clutch Schematic (engine ECM controlled)

General Description

The main function of a cooling system is to keep the engine at its optimum operating temperature. This results in the most efficient use of fuel and allows the engine oil to provide a good lubricating film.

High-flow radiators are used in FLD Classic and XL models. See **Fig. 1**. In these radiators, coolant flows from the inlet at the top of the left end-tank, across the core to the right end-tank, and out of the radiator at the bottom of the right end-tank.

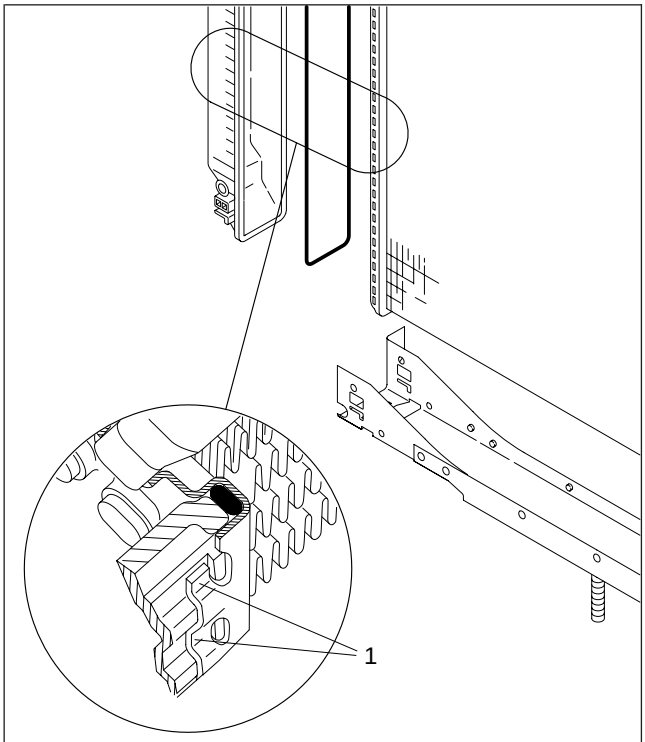


A. Inlet from Engine
B. Outlet to Engine
1. Nylon End Tank
2. Radiator Core
3. Header Sealing Surface/Tank Flange

Fig. 1, High-Flow Radiator, Cross-Flow

After the engine is started and warmed up, the engine thermostat opens and allows the water pump to draw coolant from the radiator. The water pump circulates the coolant through water jackets in the engine block and cylinder walls, combustion chambers, and valve assemblies. The heated coolant then flows through the tubes of the radiator core, which dissipates the heat to the air drawn in by the engine fan. By the time coolant travels through the radiator core to the outlet tube, much of the heat has been transferred to the air; coolant is then pumped back through the engine to absorb more heat.

The radiator uses glass-filled nylon end tanks. The edges of the radiator core header are compressed to hold the tanks to the header sealing surface using a "dimple wave lock crimp". See **Fig. 2**. The tanks and core are held in steel channels along the top and bottom of the radiator, and bolts running down from the bottom channel mount to an underslung crossmember. Rubber isolators protect the radiator from chassis and road vibration. The radiator is also secured by brace rods that run between the top of the radiator and the firewall. The fins of the radiator core are reinforced along their forward edge to resist damage from road debris and pressure washing.



1. Dimple Wave Lock Crimp

Fig. 2, Dimple Wave Lock Crimp

Because crimping holds the nylon end tanks in place, the radiators can be disassembled and assembled.

The surge tank provides reserve coolant capacity, expansion space for heated coolant, and deaeration space. The radiator cap keeps a pressure of 9 psi (62 kPa) in the system, which raises the boiling point

General Information

of the coolant. If the cooling system overheats, excess coolant is expelled through the radiator overflow tube.

NOTICE

If the radiator is being replaced due to a failure of the transmission cooler, cleaning contamination from the transmission is necessary. Failure to do so can lead to a transmission failure.

Allison automatic transmissions: It is required to test the transmission fluid for contamination. The presence of water and/or any trace of ethylene glycol coolant mixtures in the transmission oil in an Allison transmission is detrimental to the internal components. Refer to the Allison service literature for more information and proper procedures, or contact an authorized Allison service facility.

Standard transmissions: The presence of water and/or ethylene glycol coolant mixtures in the lubricant in standard transmissions decreases the effectiveness of the lubricant and causes rust and wear to internal parts. If contamination is detected, refer to the transmission manufacturer's service literature for proper procedures.

Radiator, EPA07, Removal and Installation

Radiator Removal

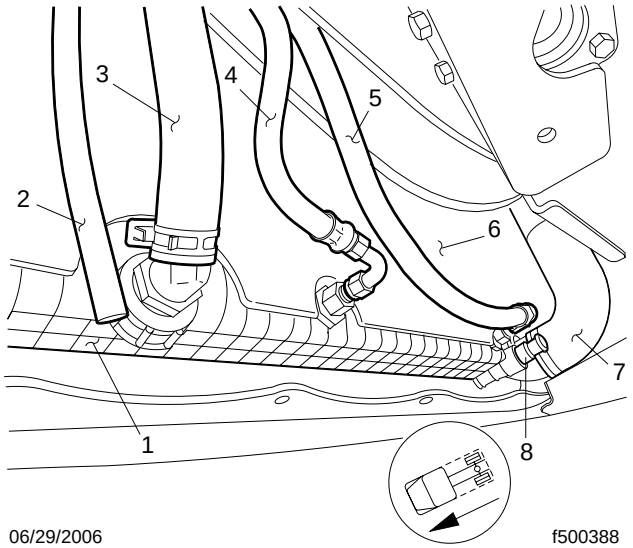
1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Remove the front bumper.

WARNING

During operation and for some time afterward, the contents of the cooling system are hot and highly pressurized. Opening the system when it is pressurized can allow scalding hot, pressurized coolant to erupt from the cooling system with considerable force, and can cause severe personal injury.

Be very careful when venting or opening the cooling system, and use appropriate protective gear.

4. Remove the surge tank cap.
5. Place a clean 14-gallon (53-liter) container near the radiator drain.
6. Connect a 1/2-inch hose to the drain fitting on the radiator (see **Fig. 1**) and place the other end in the container.
7. Drain the radiator into the container.



1. Radiator Bottom Tank
2. Surge Tank Vent Hose
3. Surge Tank Hose
4. Transmission Oil Cooler Hose
5. Transmission Oil Cooler Hose
6. Lower Fan Shroud
7. Lower Radiator Hose
8. 1/2-Inch Radiator Drain Fitting

Fig. 1, Bottom of Installed Radiator

NOTE: If the oil drained from the transmission in the next step is relatively fresh and kept clean, it can be reused. If you wish to reuse the oil, be sure the drain container is clean, and be sure the drain ports on the transmission are clean before disconnecting the lines.

8. Place a container of at least 2-gallon (7.5-liter) capacity under the transmission, and drain the transmission oil into it. It will probably be easier to do this by disconnecting the oil cooler lines below the drain plug.

Radiator Removal and Installation

NOTICE

Do not attempt to turn the QLD fittings; you may destroy the fitting and severely damage the radiator.

IMPORTANT: The transmission oil cooler lines in some early EPA07 vehicles attach to the radiator with quick-disconnect (QLD) fittings. Removal and installation of these fittings must be done correctly, to prevent damage to the fittings and the radiator.

9. Where QLD fittings are fitted, the female ports are brazed into the radiator. They are not threaded.

   See the heading, "Gates Quick-Disconnect QLD Fittings" below, for work procedures on QLD fittings.

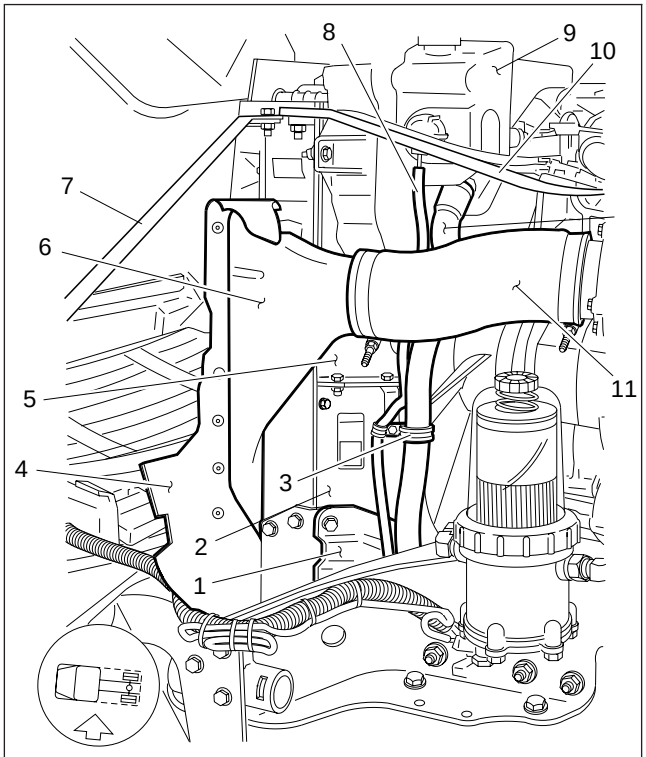
10. Disconnect the transmission oil cooler lines from the radiator, and let them drain into another container; see **Fig. 1**.

NOTE: The small amount of transmission oil drained at the radiator-end of the lines, after the transmission has been drained, may be contaminated with coolant as the radiator is drained. That oil should not be reused.

11. Remove the lower elbow from the radiator end tank.
12. Put a ratchet strap in position on the passenger side of the vehicle, to support the hood when the hood supports are disconnected.

    Attach one end of the ratchet strap to the underside of the hood, or the hole in the hood above the hood latch. Attach the other end to the rear hood support, on top of the inner splash shield.

13. Remove the upper radiator struts.
14. Disconnect the hood straps from the radiator. With help from another person, adjust the length of the ratchet strap so that the hood position will allow the radiator to be hoisted up, and clear of the vehicle.
15. Disconnect the charge air cooler (CAC) hoses from the CAC; see **Fig. 2** and **Fig. 3**.
16. Remove the lower elbow from the radiator end tank.



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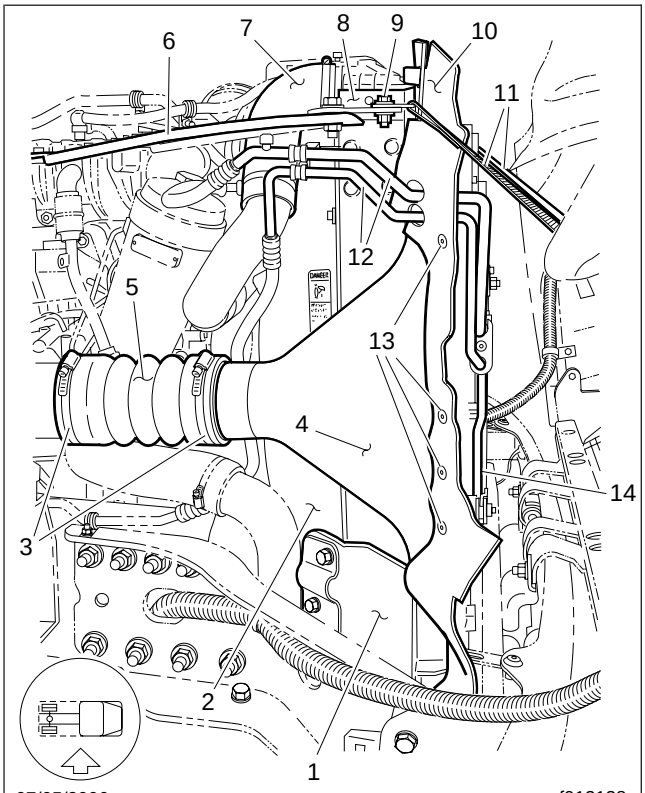
NOTE: Typical installation, others are similar.

1. Radiator Module Support
2. Lower Fan Shroud
3. Surge Tank Hose P-Clamp
4. Recirculation Baffle
5. Upper Fan Shroud
6. Charge Air Cooler (CAC)
7. Hood Support
8. Surge Tank Vent Hose
9. Surge Tank
10. Upper Radiator Support
11. CAC Hose

Fig. 2, Left Side of Radiator

17. Disconnect the shunt line and radiator vent line, but leave the P-clamp in place on the back of the radiator module support; see **Fig. 2**.
18. Disconnect the electrical sensors on the radiator.
19. Remove the surge tank.
20. Place alignment marks on the upper and lower fan shrouds, and mark the shroud-to-channel positions, so the shrouds can be installed in the same position on the radiator and other components.
21. Remove the four fasteners that connect the upper and lower fan shrouds.



NOTE: Typical installation, others are similar.

1. Radiator Module Support
2. Lower Fan Shroud
3. CAC Hose Clamps
4. Charge Air Cooler (CAC)
5. CAC Hose
6. Upper Radiator Support
7. Upper Radiator Hose
8. Upper Radiator Tank
9. Radiator Support Fastener
10. Recirculation Baffle
11. Hood Support
12. Air Conditioner (A/C) Refrigerant Tubes
13. Reusable Plastic Recirculation Baffle Rivets
14. A/C Condenser

Fig. 3, Right Side of Radiator

22. Remove the fasteners that hold the fan shrouds to the radiator.
23. Remove the upper fan shroud.
24. Remove the six hexscrews that hold the fan to the fan clutch, and remove the fan.
25. Disconnect the fasteners that hold the air-conditioner (A/C) system soft lines, to allow enough soft line flexibility so that the A/C condenser can be placed on the passenger-side tire.
26. Remove the four hexnuts that hold the A/C condenser to the radiator, and place the condenser on top of the passenger-side tire.
27. Remove the lower side recirculation baffle from the radiator. Use a screwdriver to pry the baffle off; it is held by push-on, reusable plastic rivets.
28. Attach an engine hoist to the radiator using the flanges and fasteners, where the upper radiator struts attached.
29. Remove the six hexscrews that hold the radiator to the module support.
30. Lift the radiator about 6 inches (15 cm). Remove the bottom recirculation baffle from the radiator.
31. Lift the radiator clear of the vehicle.
32. Remove the lower fan shroud from the radiator.
33. Set the radiator on a workbench, with the CAC up.
34. Remove the bolts that hold the CAC to the radiator, then remove the CAC and set it aside.
35. Use a paint pen to mark the position of the channels on the radiator.
36. Remove the fasteners that hold the channels to the radiator, and remove the channels.

Gates Quick-Disconnect QLD Fittings

As part of the changes made for EPA07 engines, the transmission oil cooler was moved into the radiator, and some early EPA07 vehicles used transmission oil cooler lines equipped with Gates Quick-Disconnect (QLD) connectors.

In July 2007, the Gates QLD connectors were superseded by JIC fittings. Only JIC-equipped radiators are available as replacements.

The Kent-Moore QLD tool (see **Fig. 4**) is the proper tool to use when disconnecting QLD connectors. One set of tools was sent to each dealer in December 2006. The tool is available from Kent-Moore in two sizes; J-48548-1 (the larger one) is used on Allison automatic transmissions, tool J-48548-2 is used for all other transmissions.

Radiator Removal and Installation

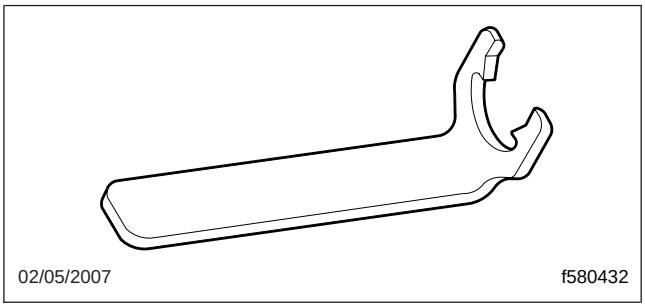
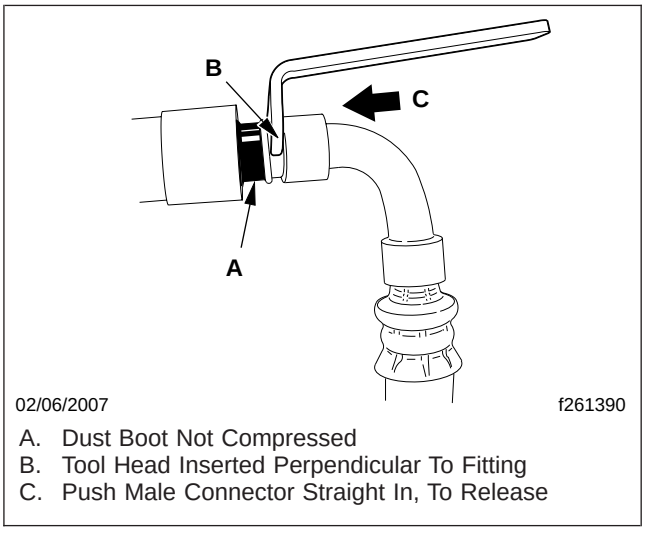


Fig. 4, Kent-Moore Tool J-48548

Quick-Disconnect Connectors, Removal and Installation

Removal

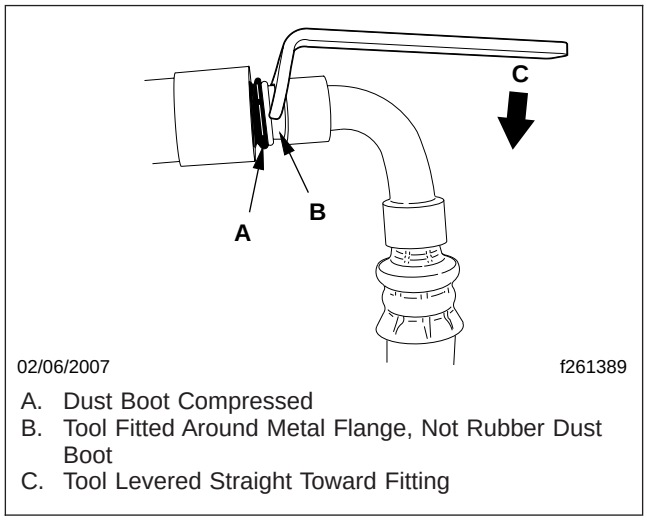
1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the tires.
2. Thoroughly clean the area around the fitting.
3. Put the tool on the fitting as shown in **Fig. 5**.
4. Push the installed connector straight into the port until it stops with the rubber dust boot compressed; see **Fig. 6**.



A. Dust Boot Not Compressed
B. Tool Head Inserted Perpendicular To Fitting
C. Push Male Connector Straight In, To Release

Fig. 5, QLD Fitting with Tool J-48548 in Place

NOTE: WD-40, or a similar substance, can be helpful if the quick-disconnect fitting is difficult to release. Clean the fitting, then spray it with the lubricant. Push and pull the fitting straight in and out, to distribute the lubricant so it eases disassembly, then use the tool to disconnect the fitting.



A. Dust Boot Compressed
B. Tool Fitted Around Metal Flange, Not Rubber Dust Boot
C. Tool Levered Straight Toward Fitting

Fig. 6, QLD Fitting Removal with Tool J-48548

5. **While holding the male fitting compressed into the female port,** squeeze the flat face of the tool handle toward the male fitting, to release the snap connection; see **Fig. 5**. Use the tool so that pressure is equal on both ears where they push against the lower male fitting. Do not twist the tool sideways, or apply unequal pressure to either ear of the tool where it forks around the fitting. The rubber dust boot should compress, releasing the fitting so that it can separate.
6. Pull the male fitting from the radiator port. Protect the openings of the connectors when they are disconnected, to keep dirt out.

Installation

1. Apply WD-40 to the fitting, to aid assembly. Push the male connector into the port as far as possible, until the snap ring clicks into engagement.
2. Test the connection by pulling the male connector straight out, with a 10-lb (4.5-kg) force. It should hold solidly in place.

Adapting QLD-Equipped Transmission Oil Cooler Lines to a JIC-Equipped Radiator

To enable using existing QLD-fitted transmission oil cooler lines with replacement JIC radiators, an adapter fitting p/n GT 7213 0003 (see **Fig. 7**) is available. It screws into the replacement radiator and allows the existing QLD-equipped lines to connect to the JIC connectors in the radiator.

The adapter fittings are installed only at the radiator; the original QLD connections continue to be used at the transmission.

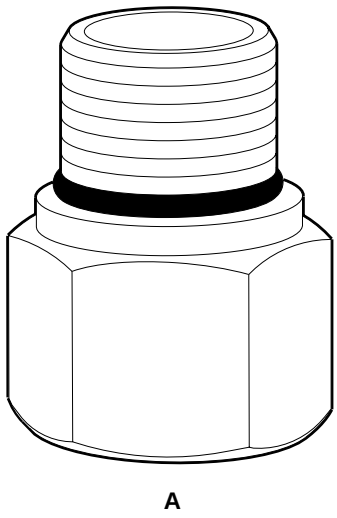
Thread the adapters into the transmission oil cooler; tighten them 53 lbf·ft (70 N·m).

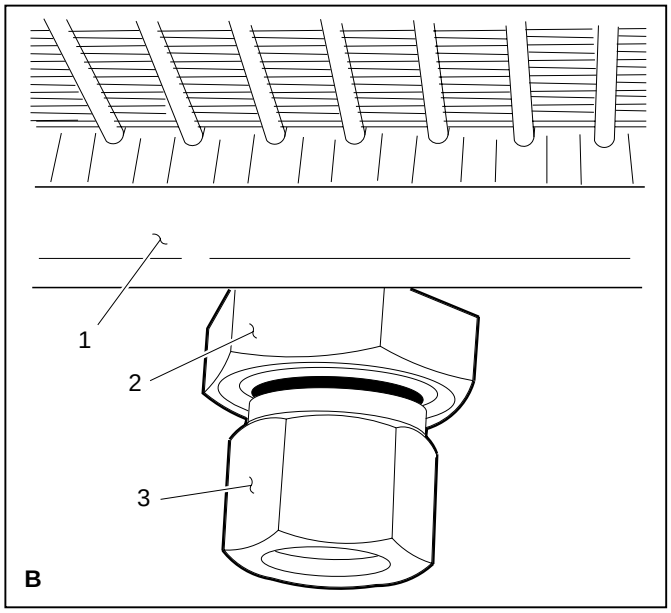
Insert the transmission oil cooler line QLD connectors into the fitting adapters, as stated above.

Test the connection by pushing the QLD fitting straight into the adapter, then pulling straight out with 10-lb (4.5-kg) force.

Radiator Installation

1. Install the channels onto the core. Leave the channel fasteners loose, so their position can be adjusted in final installation.
2. Install the CAC onto the radiator channels, and tighten the fasteners that hold the channels and CAC to the radiator.
3. Lift the radiator with the engine hoist, and install the lower fan shroud on the radiator. Align the lower fan shroud with the alignment marks made earlier.
4. Move the radiator into position about six inches above the module support.
5. Install the bottom radiator recirculation baffle.
6. Apply Loctite 242 to the threads of the fasteners, then attach the fan. Tighten the fasteners 30 lbf·ft (40 N·m).





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A. QLD-to-JIC Adapter
1. Lower Radiator
2. JIC Female Fitting on Transmission Oil Cooler

B. Adapter Installed in Lower Radiator
3. QLD-to-JIC Adapter Installed

Fig. 7, QLD-to-JIC Adapter, p/n GT 7213 0003

7. Align the marks to position the upper fan shroud on the radiator, then install the fasteners that hold it to the radiator and the lower fan shroud.

NOTE: Fan tip to fan shroud clearance should be 9/32 inch (7 mm). This is closer than on pre-EPA07 models, and clearance must be carefully checked.

8. Install the side recirculation baffles.
9. Install the upper fan shroud.
10. Install the radiator.
11. Install the A/C condenser, and attach the P-clamps that hold the A/C soft lines.
12. Install the surge tank.
13. Connect the radiator strut rods.
14. Connect the hood support straps, and remove the temporary support straps.
15. Connect the lower radiator elbow and transmission cooler lines. If the fittings are quick-disconnect, do the following:

    15.1 If the fitting is new, remove the plastic end cap.

    15.2 Align the male connector directly with the female port.

    15.3 Push the connector into the port as far as possible, until the snap ring clicks into engagement.

    NOTE: WD-40 or a similar substance may be used to ease assembly.

    15.4 Test the connection by pulling the male connector with a 10-lb (4.5-kg) force, straight out from the female port. It should be held solidly in place.

16. Fill the cooling system with coolant.
17. Fill the transmission with transmission oil, and check the level.
18. Install the bumper.
19. Close the hood and remove the tire chocks.
20. Test drive the vehicle.
21. Check for leaks and for correct transmission oil level.

Pre-EPA2007 Radiator Removal and Installation

IMPORTANT: This procedure covers radiator removal and installation for FLD Classic and XL models manufactured from November 2002 to December 2006.

Removal

See **Fig. 8** for the 1400-square-inch radiator installation. The 1200-square-inch radiator installation is similar.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Open the hood and have an assistant support it in a position that relieves tension from the tilt assist spring cables and the support straps.
3. Disconnect the hood tilt assist spring cables and support straps.
4. Move the hood out of the way and support it with a padded table or bench.

⚠ WARNING

Drain the coolant system only when the engine/system is cool. Serious personal injury may result from contact with hot fluids.

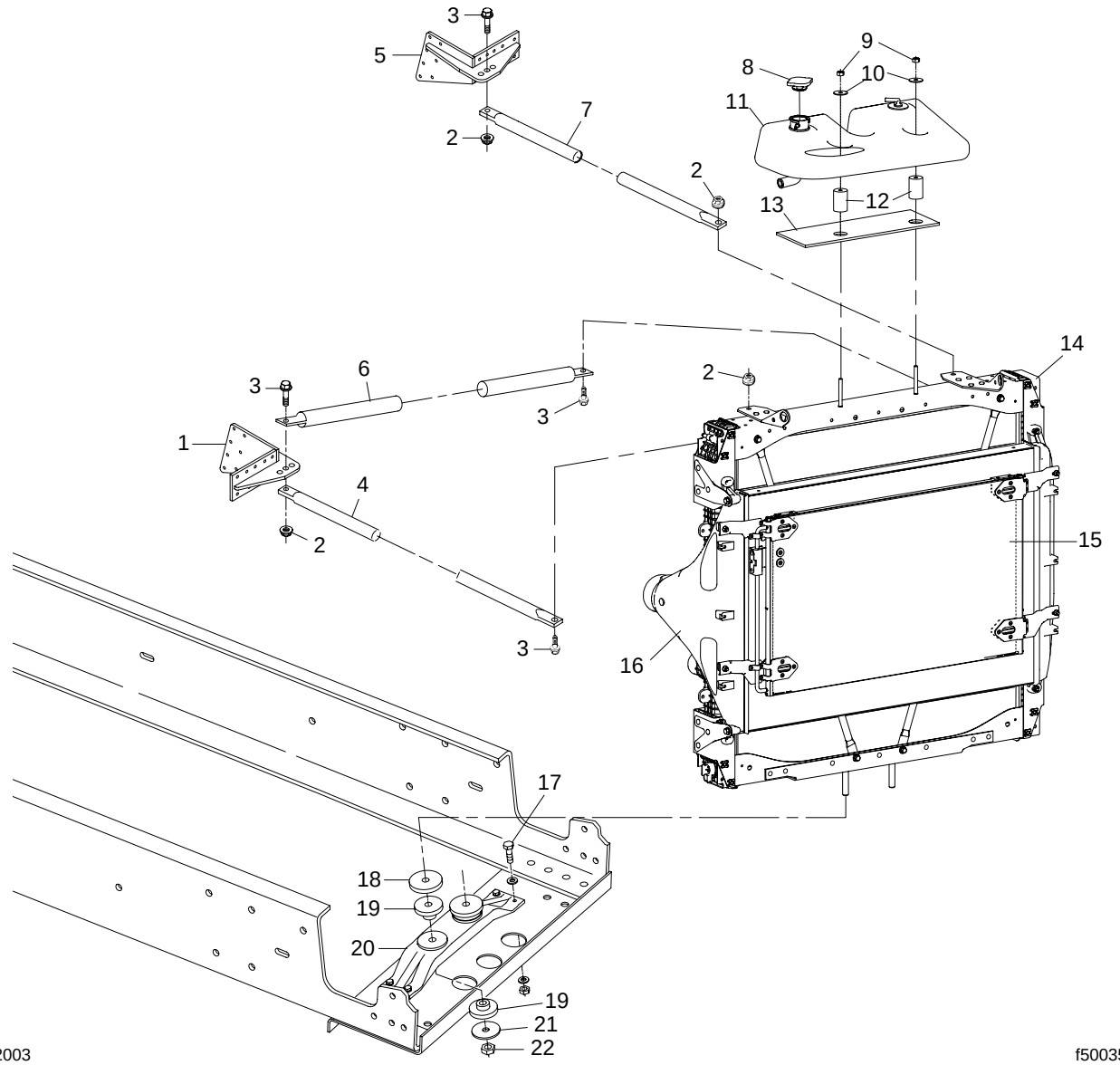
5. Drain the coolant.

    5.1 With the engine cool, loosen the surge tank cap to release any pressure in the radiator, then tighten the cap.

    5.2 Place a clean drain pan under the drain located on the bottom of the right end-tank.

    Remove the drain plug, or open the drain valve. If necessary, use a deflector to channel coolant away from the aerodynamic cover into the pan.

    NOTE: On some engines, the radiator drain plug is located on the coolant outlet pipe. On these vehicles, remove the aerodynamic cover to access the drain plug. See **Fig. 9** for an example.



NOTE: Figure shows typical installation. Actual installation may vary depending on vehicle configuration.

1. Rear Right-Side Strut-Rod Bracket
2. Flanged Hexnut
3. Flanged Capscrew
4. Right-Hand Radiator Strut Rod
5. Rear Left-Side Strut-Rod Bracket
6. Bias Radiator Strut Rod
7. Left-Hand Radiator Strut Rod
8. Surge-Tank Filler Cap
9. Nut
10. Washer
11. Surge Tank
12. Spacer, Surge Tank
13. Pad, Rubber
14. Radiator
15 A/C Condenser
16. Charge Air Cooler
17. Capscrew, 3/8–16, Grade 8; Washer; Nut
18. Spacer (used only with 11-inch frame rails)
19. Isolator
20. Radiator Support Bracket
21. Washer
22. Hexnut, 1/2–13, Grade 8

Fig. 8, Radiator Installation, 1400-Square-Inch Shown (1200-square-inch is similar)

Radiator Removal and Installation

5.3 Remove the surge tank cap and allow the radiator to drain completely.

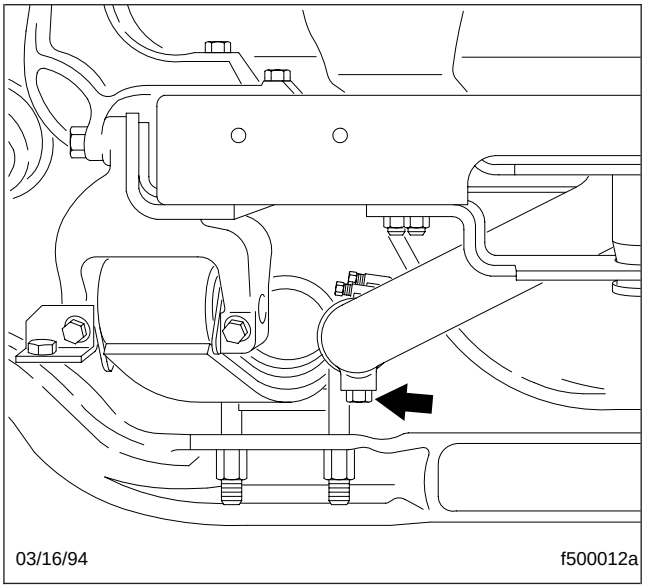


Fig. 9, Drain Plug at Coolant Outlet Pipe (typical)

6. Loosen the coolant hose clamps from the radiator and surge tank. Disconnect the hoses; seal them to prevent entry of dirt.
7. On radiators with attached surge tanks, disconnect the wire to the low-coolant probe in the surge tank.

IMPORTANT: Do not disconnect the refrigerant lines from the A/C condenser.

8. Remove the condenser mount bolts and any refrigerant hose stand-off brackets as needed. Move the A/C condenser aside without disconnecting the refrigerant lines. Cover the condenser with cardboard and secure it out of the way.
9. Remove the top and side recirculation shields.
10. Disconnect the hoses from the charge air cooler.
11. Remove the mount bolts from the fan shroud and lay the shroud back against the engine.
12. Attach chains and a lifting device to the hood strap attachment points on the top of the radiator.

    Remove any slack in the chains, so that the radiator assembly is supported when the mounting fasteners are removed.
13. Disconnect the three strut-rods from the radiator and swing them out slightly to clear the radiator.
14. Remove the 1/2–13 hexnuts holding the radiator to the lower mounting bracket on the front crossmember.
15. With one person holding each side of the radiator, tilt the top of the radiator assembly forward until it clears the radiator strut rods. Using the lifting device, lift the radiator assembly from the chassis. After lowering, remove the chains from the radiator assembly.
16. If needed, remove the CAC and lower recirculation shield from the radiator assembly.

Installation

1. If removed, install the CAC and lower recirculation shield on the radiator assembly before installing the assembly in the vehicle.
2. Using a lifting device secured to the radiator assembly with chains, lift the radiator assembly to position it in the chassis.

    Put the radiator assembly in place, making sure the mounting bolts on the bottom of the radiator line up with the holes in the crossmember.
3. Install the 1/2–13 hexnuts on the radiator mounting bracket at the bottom of the radiator. Tighten the nuts 241 lbf·ft (327 N·m).
4. Remove the lifting chains from the radiator.
5. Attach the strut rods to the radiator. Tighten the strut rod fasteners 68 lbf·ft (92 N·m).
6. Remove the seals and connect the coolant hoses to the radiator and surge tank. Position the hose clamps and tighten 48 to 60 lbf·in (540 to 680 N·cm)
7. On radiators with attached surge tanks, connect the wire to the low-coolant probe in the surge tank.
8. Connect the hoses to the charge air cooler.
9. Install the fan shroud. Center it around the fan before tightening the bolts.
10. Install the top and side recirculation shields.
11. Carefully release the A/C condenser from its protected position and install it onto the front of the CAC. Be careful not to kink the refrigerant lines. Install any stand-off brackets that were removed.

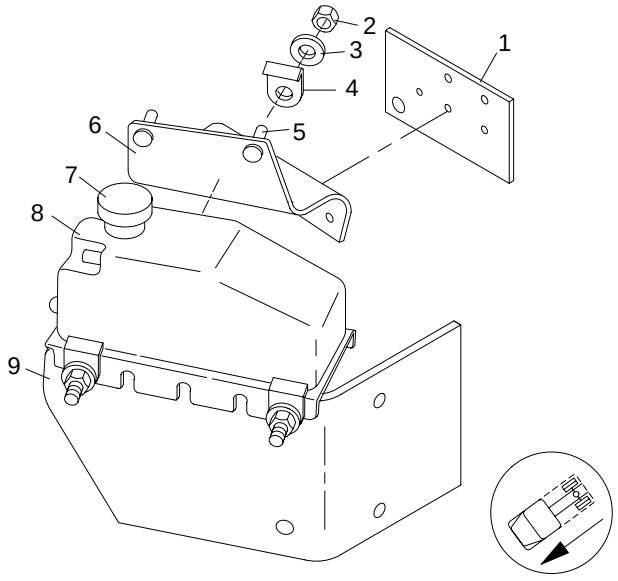
NOTICE

Coolant must be filled to the proper level in the cooling system. Low coolant could cause engine overheating, which could damage the engine.

12. Fill the cooling system with coolant to between the "min" the "max" level line on the radiator surge tank. Do not install the filler cap. For coolant specifications, see Group 20 of the *Heavy-Duty Trucks Maintenance Manual*, and the engine manufacturer's maintenance and operation manual.
13. Start the engine, and check for coolant leaks in the hoses, hose connections, and radiator core. Run the engine for 10 minutes; then, stop the engine. Check the coolant level in the surge tank, and add coolant as needed.
14. Install the filler cap.
15. With the help of an assistant, raise the hood from the support and connect the hood tilt assist spring cables and support straps.
16. Return the hood to the operating position.

Removal

NOTE: See **Fig. 1** for 1200-square-inch-radiator surge tank removal and installation. See **Fig. 2** for 1400-square-inch-radiator surge tank removal and installation.



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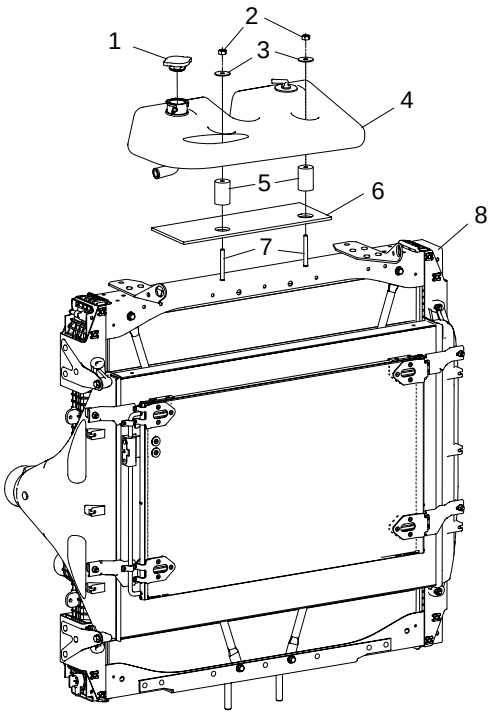
1. Spacer
2. Hexnut
3. Washer
4. Retainer
5. Stud
6. Support Bracket
7. Filler Cap
8. Surge Tank
9. Support Bracket

Fig. 1, Surge Tank Installation, 1200-Square-Inch Radiator

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Open the hood.
3. Place a clean drain pan under the radiator.

⚠ WARNING

Drain the coolant system only when the engine/system is cool. Serious personal injury may result from contact with hot fluids.



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1. Filler Cap
2. Hexnut
3. Washer
4. Surge Tank
5. Spacer
6. Pad, Rubber
7. Mounting Studs
8. Radiator

Fig. 2, Surge Tank Installation, 1400-Square-Inch Radiator

4. Drain coolant from the system until no coolant remains in the surge tank. See Group 20 of the *Heavy-Duty Trucks Maintenance Manual* for procedure.
5. Disconnect the hoses from the surge tank, but be careful to avoid spilling coolant from the hoses. Cap the hoses to prevent dirt from entering the system.
6. Disconnect the wiring from the low-coolant-level sensor.
7. Remove the nuts and washers that attach the tank to the support bracket.
8. Remove the surge tank from the vehicle.

Surge Tank Removal and Installation

Installation

1. Position the surge tank on the mounting bracket.
2. Install the nuts and washers, and tighten the nuts 28 lbf·ft (38 N·m).
3. Connect the wiring from the low-coolant-level sensor.
4. Remove the seals and connect the hoses to the tank.
5. Fill the coolant system. See Group 20 of the *Heavy-Duty Trucks Maintenance Manual* for procedure.
6. Remove the chocks.

Disassembly

IMPORTANT: Disassembling and assembling nylon top- and bottom-tank radiators requires the special tools listed in **Table 1**.

Special Tools	
Description	**Qty**
Plastech II® Tanking Machine With Five 2-Inch Cylinders	1
T-Bar	1
Hooked-End Bar	1
Wave Form Bar	1

Table 1

Order these tools from:

RAD PAL
2381 17 St.
Detroit, MI 48216

Before disassembling the radiator, pressure flush it and check the surge tank, following the instructions in Group 20 of the *Heavy-Duty Trucks Maintenance Manual*. Clean and check the exterior of the radiator, following the instructions in the *FLD Conventional Driver's Manual.*

1. Remove the radiator from the vehicle; for instructions, refer to **Subject 100.**

CAUTION

Use care when handling or supporting the nylon top and bottom tanks. Failure to do so could damage the tanks.

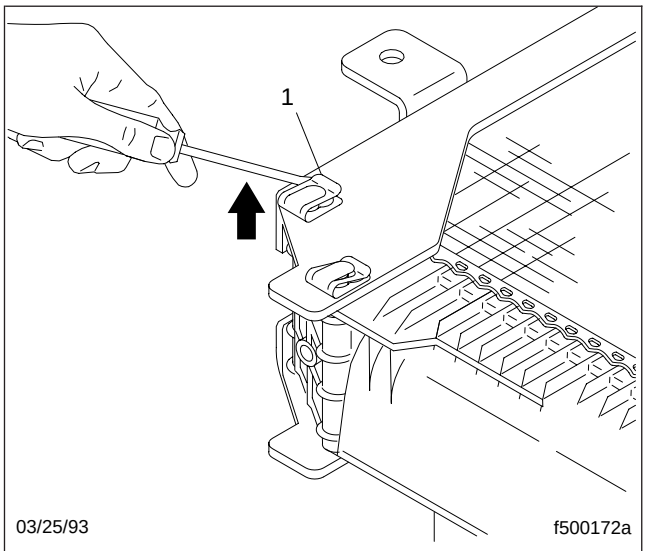
2. Remove the side channels from the radiator assembly.

   2.1 Remove the eight spring clips that hold the side channel mounting pins in position. See **Fig. 1**. Insert a screwdriver blade in the open end of each clip, and pry the clip open until it clears the edge of the mounting pin. Then, slip the clip off the pin.

   2.2 Use a rubber mallet and a punch to tap out the eight mounting pins. See **Fig. 2**.

   2.3 Slip the side channels off the radiator core and tank assembly. See **Fig. 3**.

3. Leak test the radiator core and tank assembly.



1. Spring Clip

Fig. 1, Remove the Spring Clips

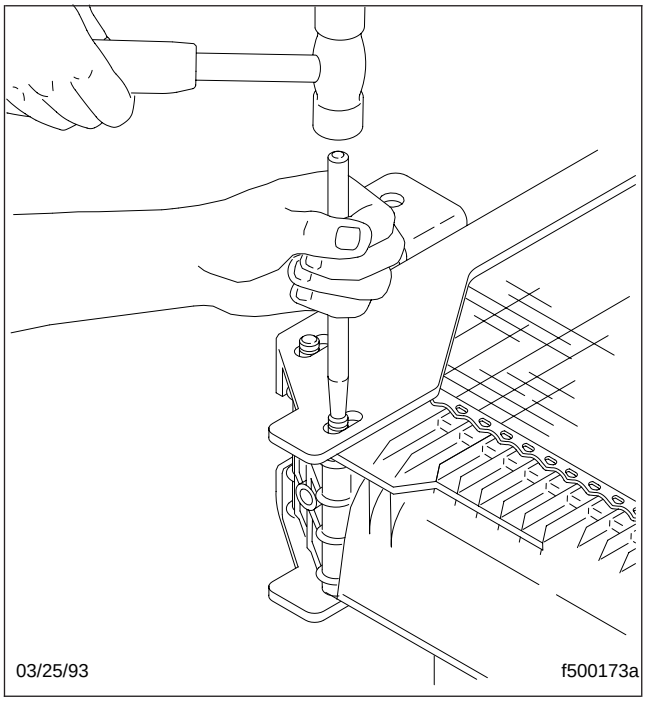
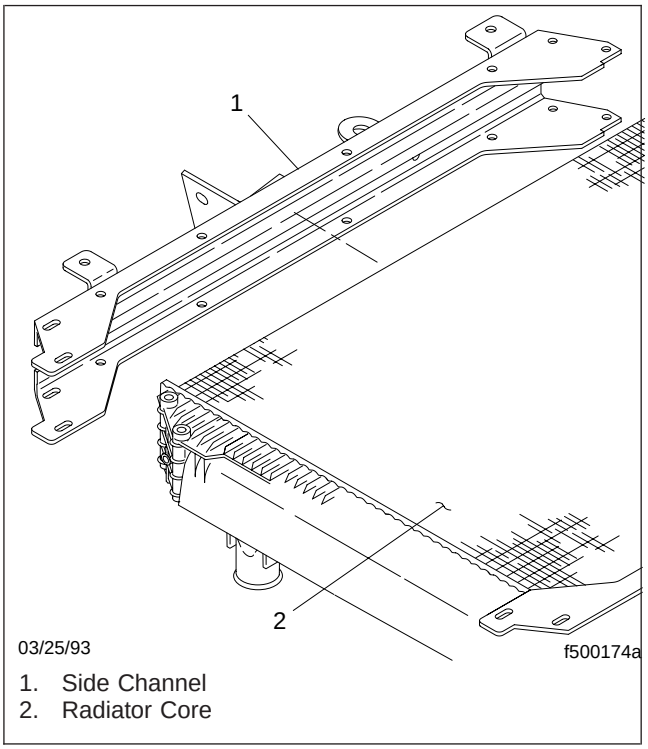


Fig. 2, Remove the Mounting Pins

3.1 Securely plug all tank ports.

Disassembly and Assembly



1. Side Channel
2. Radiator Core

Fig. 3, Remove Side Channels

CAUTION

Don't apply a higher amount of pressure than specified below; too much pressure will damage the radiator core.

3.2 At one tank port, install a pressure regulator and gauge. Using a hand pump, apply 20 psi (138 kPa) air pressure through the port.

3.3 Submerge the radiator in a tank of water and check it for leaks. Mark any leaks for repair. If a leak is between the radiator core header and a tank, remove the tank and inspect the tank flange, the header sealing surface, and the sealing gasket. If the leak is in the core, but within 3 inches (7.5 cm) of the tank, remove the tank before repairing the leak. If the leak is in the tank, replace the tank.

4. Remove the top and bottom tanks.

4.1 Place the radiator core and tank assembly in the disassembly/assembly fixture, and clamp the assembly securely in place. See **Fig. 4**.

4.2 Position the tank clamping cylinders evenly across the top of the tank. Make sure the cylinders' rubber plungers will not press against breakable fittings, such as vent tube ports.

CAUTION

Apply only enough pressure to compress the sealing gasket. Too much pressure will crack the nylon tank.

4.3 Apply pressure evenly across the top of the tank until the tank-to-core sealing gasket is compressed enough to show a small gap between the bottom of the dimple wave lock crimp and the tank sealing flange.

CAUTION

In some places, especially around the tank ports, the wave lock crimps may have to be unlocked with a screwdriver. When using a screwdriver, use care not to crack or gouge the nylon tank.

4.4 Place the T-bar into the T-bar groove in the disassembly/assembly fixture. See **Fig. 5**.

4.5 Slide the hooked-end bar over the T-bar. Place the hook over the top of the wave crimp and pull the T-bar back to unlock the crimp. See **Fig. 5**.

4.6 Slide the hooked-end bar and the T-bar down the T-bar groove to the next wave crimp, and repeat the previous step until all the wave crimps are unlocked.

5. Once the wave crimps are unlocked, remove the tank.

5.1 Release the pressure from the tank, and move the clamping cylinders off the radiator core and tank assembly.

CAUTION

If needed, use a rubber mallet or the heel of your hand and tap the side of the tank to loosen it. Do not use a screwdriver against the tank sealing

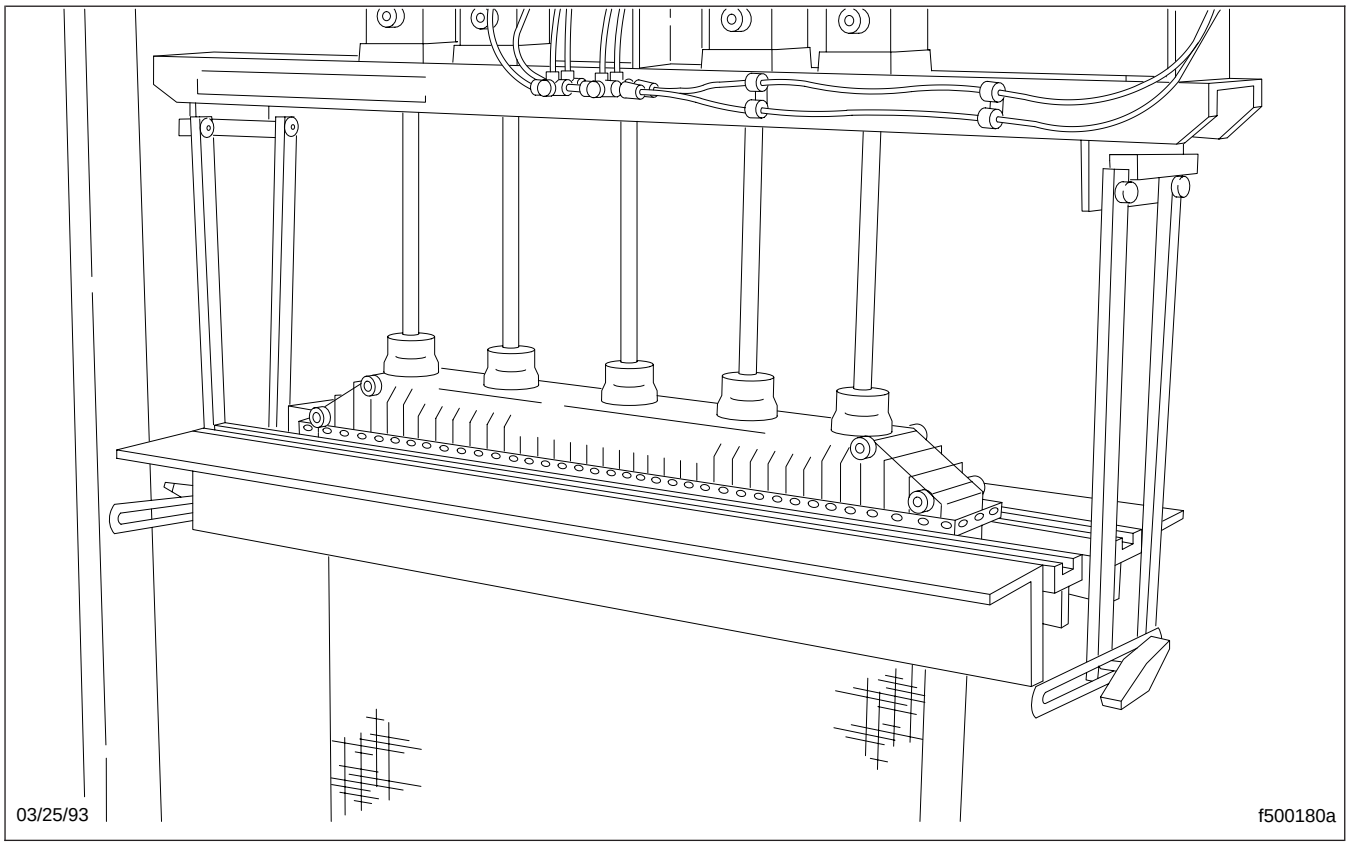


Fig. 4, Disassembly/Assembly Fixture

flange. A screwdriver blade may damage the flange and prevent a good seal after the tank is installed.

5.2 Lift the tank from the forward side, the side opposite the tank ports. Remove the nylon tank from the radiator core. See **Fig. 6**.

5.3 Remove the sealing gasket from the sealing surface of the radiator core header. See **Fig. 7**.

5.4 Clean the sealing surface of the radiator core header.

5.5 Repair any leaks marked during leak testing.

5.6 Repeat this procedure to remove the opposite tank.

IMPORTANT: Check the tubes of the radiator core for scale deposits. If the radiator has been pressure-flushed, and the tubes are still clogged, the radiator should be rodded or boiled out with acid by an experienced radiator shop. Otherwise, replace the core.

Assembly

1. Install the nylon top and bottom tanks on the radiator core.

1.1 With the radiator securely clamped in the disassembly/assembly fixture, header sealing surface up, make sure the bottom of the radiator core and tank assembly is completely supported, and that the header sealing surface is free of any dents, tool marks, or foreign particles.

1.2 Lubricate a new sealing gasket with a soap and water solution, and position the

Disassembly and Assembly

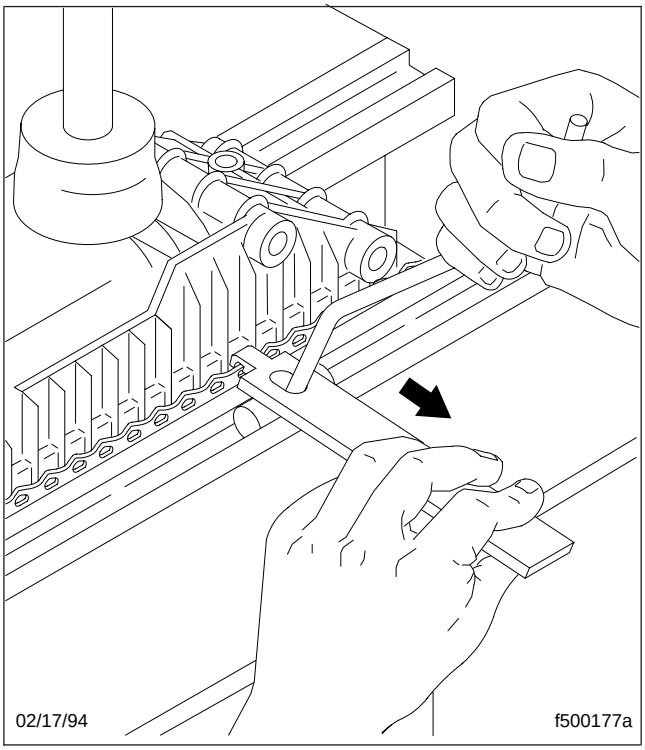


Fig. 5, Unlock the Crimp

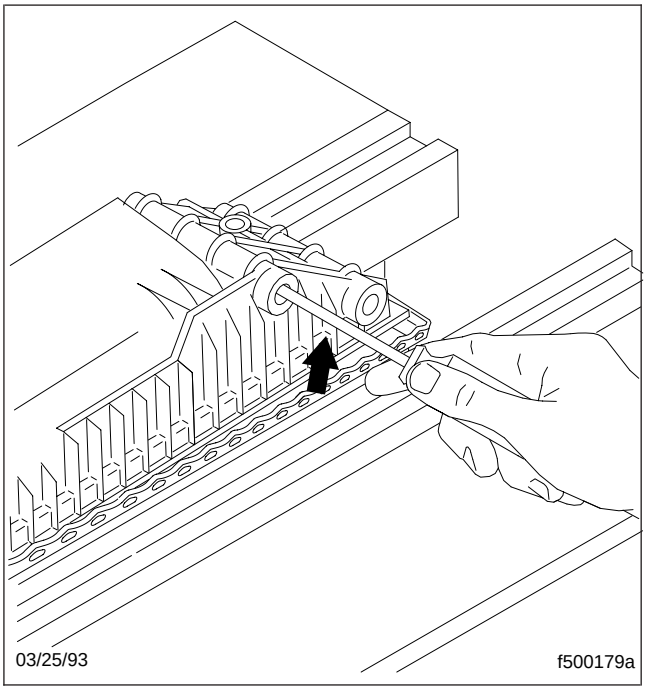


Fig. 6, Remove the Tank

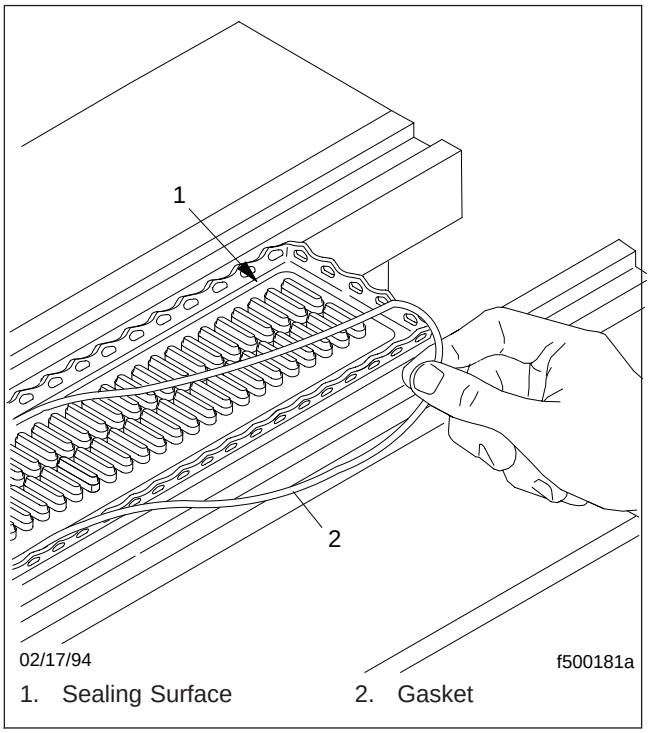


Fig. 7, Remove the Gasket

gasket on the header sealing surface. See **Fig. 7**. To make sure the gasket is not twisted, run your finger along the gasket as it lies on the sealing surface. The mold lines of the gasket should be on the outside and inside diameters of the gasket; if you can feel a mold line cross over the top of the gasket, the gasket is twisted.

1.3 Inspect the tank sealing flange. The flange must be clean and free of defects. If the sealing flange is damaged, replace the tank.

1.4 Place the tank on the gasket, and tap the tank with a rubber mallet or the heel of your hand to seat the tank. Make sure the tank ports are facing the correct direction.

1.5 Position the tank clamping cylinders evenly across the top of the tank. Make sure the cylinders' rubber plungers will not press against breakable fittings, such as vent tube ports. See **Fig. 4**.

CAUTION

Apply only enough pressure to compress the sealing gasket. Too much pressure will crack the nylon tank.

1.6 Apply pressure evenly across the top of the tank until the tank-to-core sealing gasket is compressed enough to show a small gap between the bottom of the dimple wave lock crimp and the tank sealing flange.

1.7 Place the T-bar into the T-bar groove in the disassembly/assembly fixture.

1.8 Slide the wave form bar over the T-bar, and center the bar in front of the wave crimp slot.

CAUTION

Do not push the wave crimp until it touches the side of the nylon tank, or the tank may crack.

1.9 Push the T-bar forward to crimp the header's edge until it almost touches the tank's side. See **Fig. 8**.

1.10 Slide the tools down the T-bar groove to the next wave crimp slot, and repeat this procedure until all the wave crimps are crimped.

CAUTION

In some places, especially around the tank ports, the wave crimps may have to be crimped with a screwdriver. When using a screwdriver, use care not to crack or gouge the nylon tank.

1.11 Release the pressure from the tank, and move the clamping cylinders off the radiator core and tank assembly.

1.12 Repeat this procedure to install the opposite tank.

2. Leak test the radiator core and tank assembly. For instructions, refer to "Disassembly."

3. Install the radiator side channels.

3.1 Slide the side channels onto the radiator core and tank assembly.

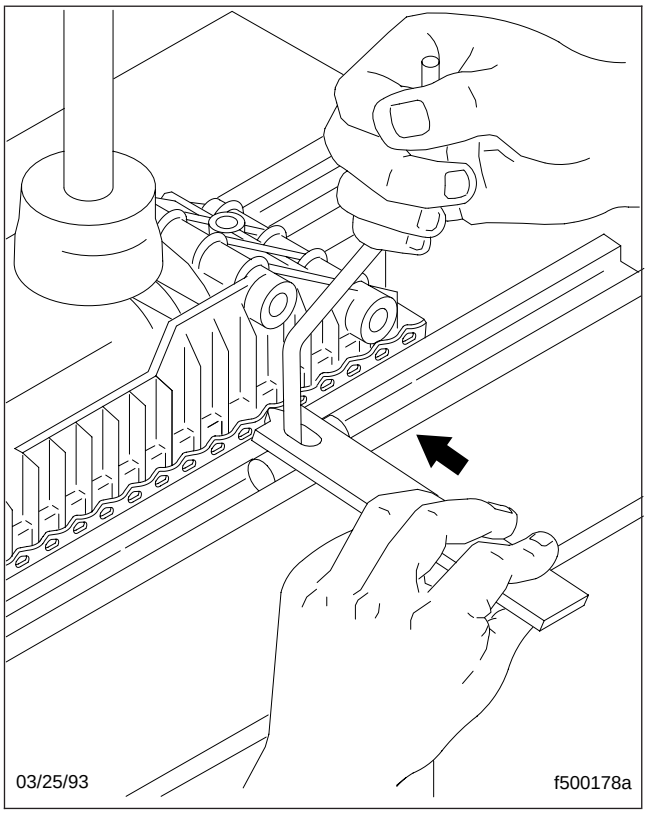


Fig. 8, Crimp the Header Edge

3.2 Using a rubber mallet and a punch, install the eight mounting pins through the side channel holes and tank bosses. See **Fig. 9**.

3.3 Install the eight spring clips to secure the mounting pins in position. See **Fig. 10**. To install each clip, place the clip over the end of the mounting pin, and slide the clip until it engages the groove in the pin and the open end of the clip snaps over the edge of the pin. If necessary, use a clamp to compress the side channel while installing the clips.

4. Install the radiator in the vehicle. For instructions, refer to **Subject 100**.

Disassembly and Assembly

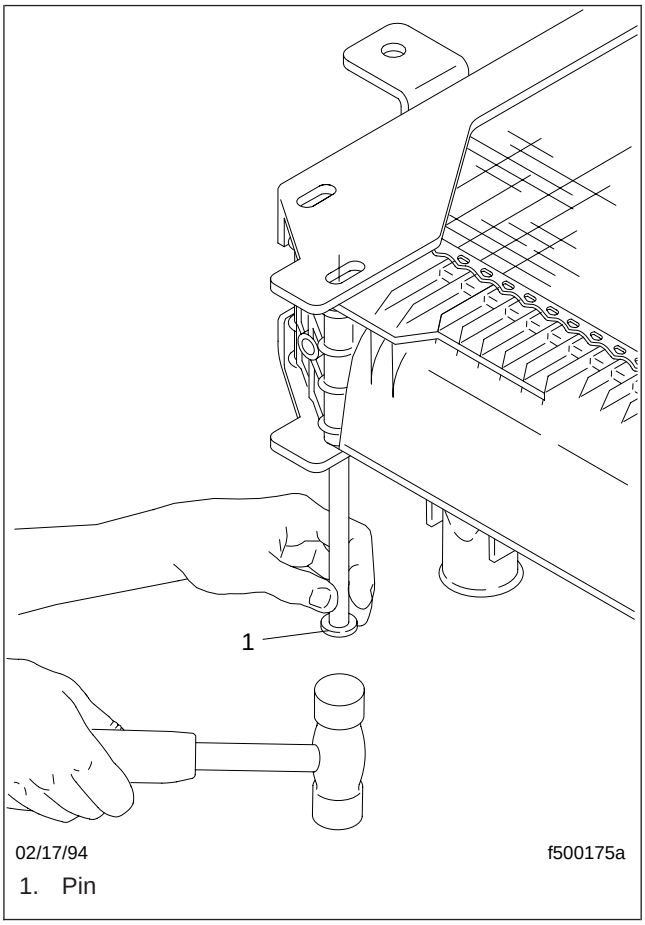


Fig. 9, Install the Mounting Pins

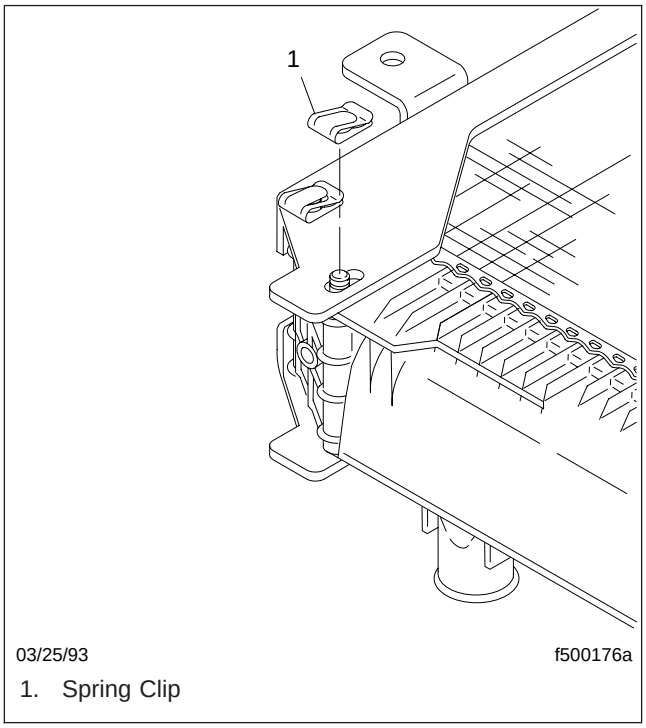
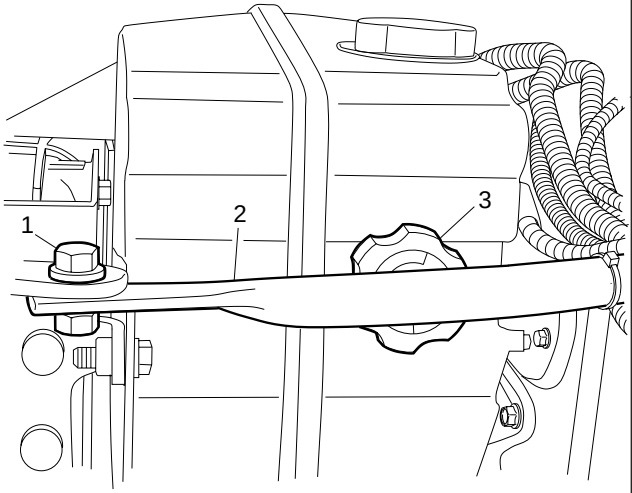


Fig. 10, Install the Spring Clips

Engine Mounted Radiator, Cooling System Pressure Testing

NOTE: If the engine-mounted radiator strut rod blocks access to the surge tank pressure cap, remove the strut as follows.

1. Unbolt the driver's side radiator strut rod from the radiator and the engine. Set the strut rod on the engine, and do not disconnect anything that might be attached to it. See **Fig. 1**.



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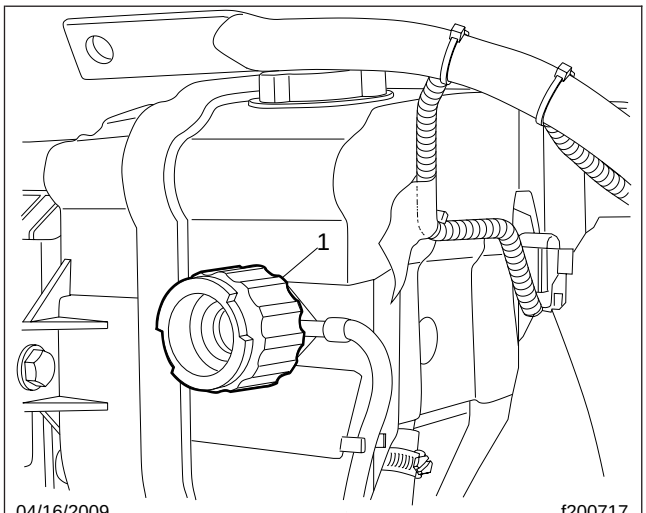
1. Strut Rod Mounting Capscrew and Nut
2. Strut Rod
3. Pressure Cap

Fig. 1, Radiator Strut Rod Installation

2. Remove the pressure cap and attach the appropriate adaptor tool (J-42401-3 or J-42401-1A) to the surge tank. See **Fig. 2**.

NOTE: These are Kent-Moore/SPX part numbers. Other companies sell these adaptors, Snap-On, Mac, Cornwell, etc. These are the same adaptors that are used on cars.

3. Attach a radiator-pressure hand pump, and apply no more than 20 psi (138 kPa) of pressure to the cooling system. See **Fig. 3**.
4. Check for leaks. Repair as needed.



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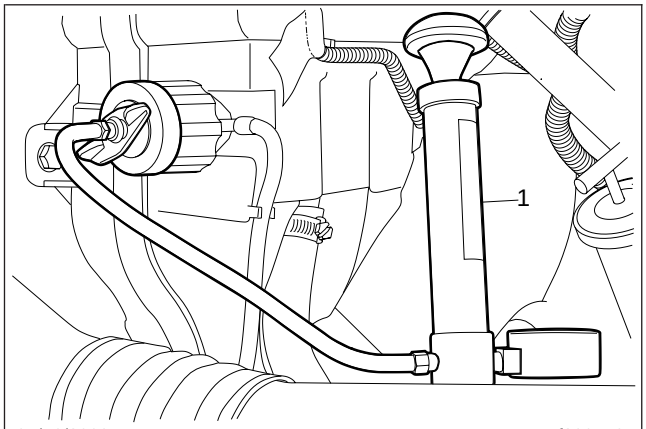
1. Adaptor

Fig. 2, Adaptor Installation



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1. Hand Pump

Fig. 3, Hand Pump Installation

5. Remove the pump and adaptor tool, and install the radiator cap.
6. Install the strut rod, tighten 68 lbf·ft (92 N·m).

Out of Vehicle Radiator Pressure Testing

1. Remove the radiator from the vehicle. For instructions, refer to **Subject 100**.

Radiator Pressure Testing

2. Pressure-test the radiator.
   2.1 Plug the inlet, outlet, and all other ports on the radiator assembly.

NOTICE

Don't apply a higher amount of air pressure than specified below; too much pressure will damage the radiator core.

   2.2 Remove the radiator cap, and install a pressure regulator and gauge. Using a hand pump, apply 20 psi (138 kPa) air pressure through the filler neck.
   2.3 Submerge the radiator in a tank of water and check it for leaks. Remove the radiator from the water.
   2.4 Remove the plugs and the testing gauge, and install the radiator cap. Repair the radiator, if necessary.
3. Install the radiator in the vehicle. For instructions, refer to **Subject 100**.

General Description

Eaton® Fuller® Solo™ and Easy-Pedal™ 2000 clutches are pull-type clutches of a dry-disc design. They are both available in 15.5-inch (394-mm) two-plate assemblies used in heavy-duty applications.

The intermediate plate separating the driven discs is carried on four lugs within the cover assembly, which is mounted on a flat flywheel. Four positive separator pins™ (roll pins) ensure an equal gap on all sides of the intermediate plate and increase the life of the clutch. Four return straps are attached to the cover assembly to retract the pressure plate when the clutch is disengaged.

Solo 15.5-Inch Clutch

Eaton Fuller Solo clutches are totally adjustment-free. See **Fig. 1**. As the clutch wears, its innovative wear-adjusting technology monitors clutch components and makes any necessary adjustments. The wear-adjusting technology comes from two sliding cams, which rotate to maintain the proper adjustment. Atop the upper cam, a wear indicating tab mirrors the cam's movement, letting you know when it's time to replace the clutch. See **Fig. 2**. This tab cannot be used as a mechanism for adjusting the clutch.

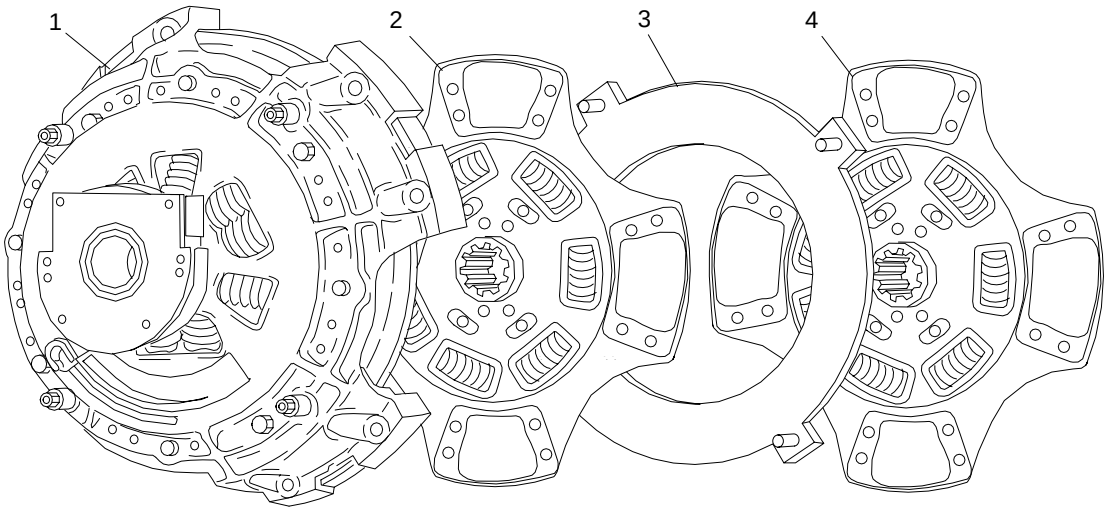
Heavy-duty Solo clutch discs are offered in one standard configuration (see **Fig. 3**) and one optional configuration (see **Fig. 4**):

- Seven spring dampers with four ceramic facings are standard.
- Six spring dampers with six ceramic facings and vibration control technology (VCT™plus) are optional.

NOTE: An earlier version of vibration control technology (VCT™) had a disc with six spring dampers and six ceramic facings. This disc has now been replaced by VCT™plus.

Modern high-torque engines require higher performance from a clutch. The extended-lube (XL-100) clutches have a special roller yoke and a ribbed release bearing housing that reduces bearing wear and extends the service interval for lubrication. XL-100 clutches are not available for Severe Service applications.

On older vehicles, clutch discs with eight, nine, or ten spring dampers may be installed. These older types of vibration dampers are not adequate for modern high-horsepower engines that operate at lower peak torques.



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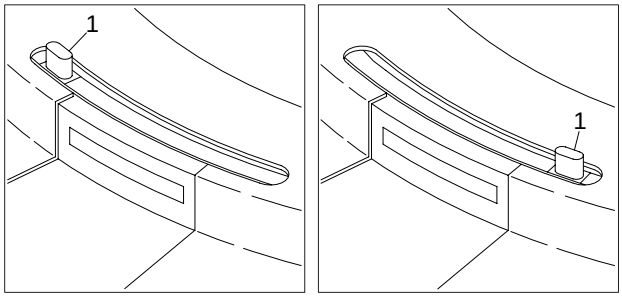
1. Clutch Cover
2. Rear Driven Disc
3. Intermediate Plate
4. Front Driven Disc

Fig. 1, Solo Heavy-Duty Clutch



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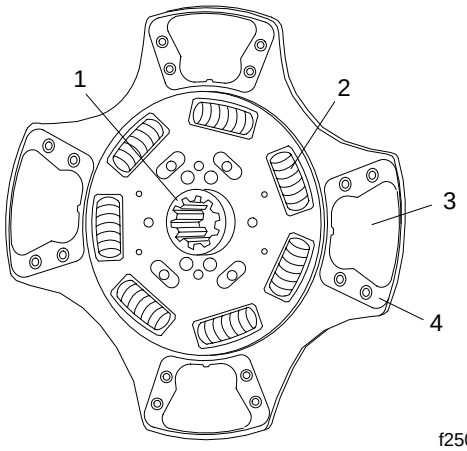
NOTE: "NEW" position on the left, "REPLACE" position on the right.

1. Wear Indicating Tab

Fig. 2, Wear Indicator



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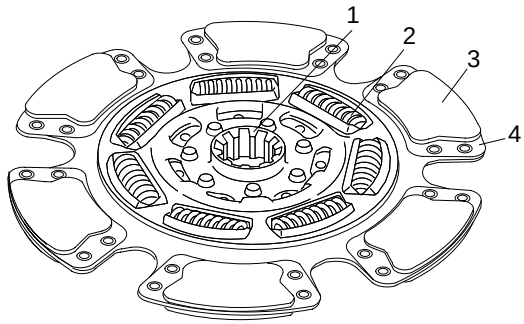
1. Hub
2. Damper
3. Facing
4. Paddle

Fig. 3, Driven Disc With Four Ceramic Facings

CAUTION

If your vehicle was originally equipped with six- or seven-spring discs, do not substitute eight- or ten-spring discs. This could cause excessive torsional vibration and component damage.

For clutch capacities, see the appropriate Solo clutch table in **Specifications, 400**.



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1. Hub
2. Damper
3. Facing
4. Paddle

Fig. 4, Driven Disc With Six Ceramic Facings

Easy-Pedal 2000 15.5-Inch Clutch

Eaton® Fuller® Easy-Pedal 2000 clutches are easily adjustable using the Kwik-Adjust™ mechanism. See **Fig. 5**.

Easy-Pedal heavy-duty clutch discs are available in two optional configurations:

- Seven spring dampers with four ceramic facings. See **Fig. 3**.
- Six spring dampers with six ceramic facings and vibration control technology (VCT™plus) See **Fig. 4**.

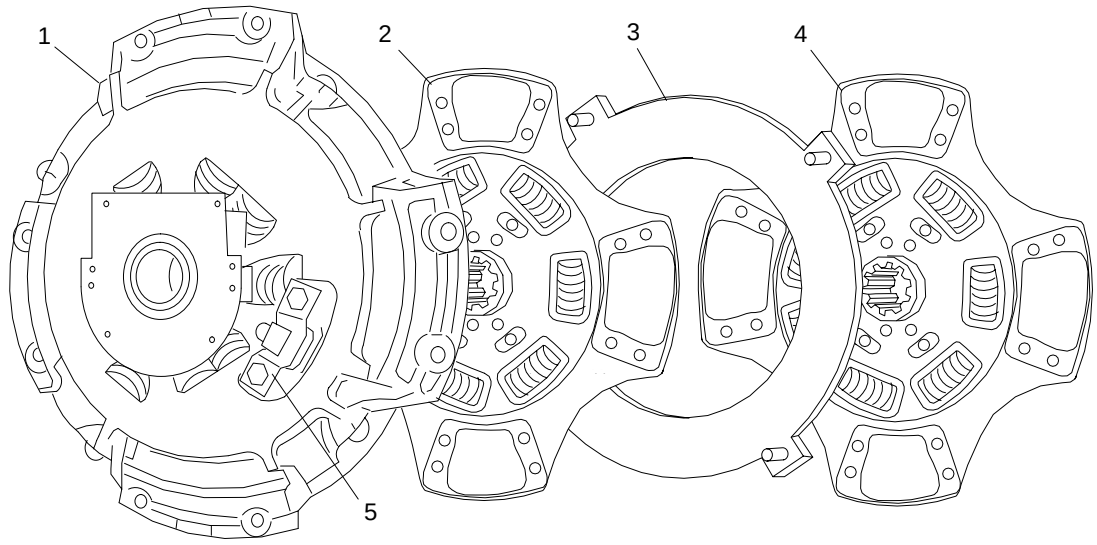
NOTE: An earlier version of vibration control technology (VCT™) had a disc with six spring dampers and six ceramic facings. This disc has now been replaced by VCT™plus.

On older vehicles, clutch discs with eight, nine, or ten spring dampers may be installed. These older types of vibration dampers are not adequate for modern high-horsepower engines that operate at lower peak torques.

CAUTION

If your vehicle was originally equipped with six- or seven-spring discs, do not substitute eight- or ten-spring discs. This could cause excessive torsional vibration and component damage.

Clutch capacity is indicated by the color code of the pressure springs in the cover assembly. See the ap-



1. Clutch Cover
2. Rear Driven Disc
3. Intermediate Plate
4. Front Driven Disc
5. Kwik-Adjust Mechanism

Fig. 5, Easy-Pedal Heavy-Duty Clutch

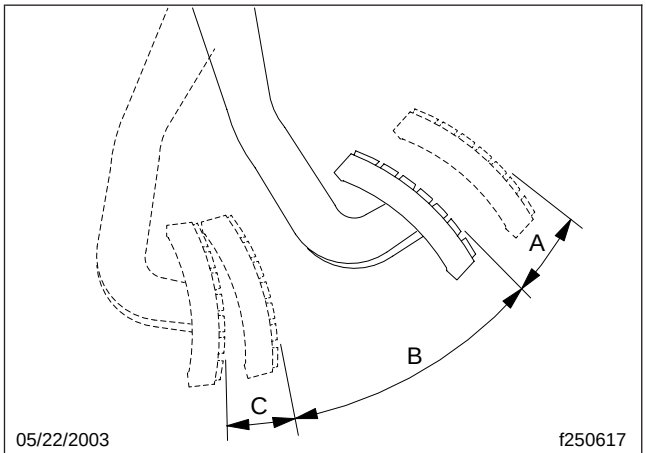
propriate table for Easy-Pedal clutches in **Specifications, 400**.

Principles of Operation

The primary purpose of the clutch is to transfer the power of the engine from the engine flywheel to the transmission. At the point where clutch engagement begins (clutch pedal partially released), the transmission input shaft may be stationary, as when the vehicle is not moving, or it may be rotating at a different speed than the flywheel, as in the case of upshifting or downshifting. Once the clutch is fully engaged (clutch pedal fully released), both the engine flywheel and the transmission input shaft will be rotating at the same speed.

The secondary purpose of the clutch is to damp unwanted vibrations that normally exist in the driveline system. The springs within each driven disc provide a flexible link between the friction surfaces and the disc hubs. Damped clutch discs are specifically designed to prolong the life of drivetrain components by reducing vibrations from the engine, non-uniform U-joint angles, and road dips and bumps.

When the clutch pedal is first pressed down, the first 1/2-inch to 1-inch (12.7 to 25.4 mm) of pedal movement (clutch free-pedal) causes the release yoke fingers to move into contact with the wear pads of the release bearing (release yoke free-travel). See **Fig. 6**. The release yoke pulls the release bearing away from the pressure plate inside the clutch cover. This compresses the pressure springs, allowing the driven discs to slip freely, and at a different speed from the drive discs.



A. Clutch Free-Pedal
B. Clutch Release-Pedal
C. Clutch Brake Squeeze

Fig. 6, Clutch Pedal Movement

General Information

Further downward movement of the clutch pedal (clutch release-pedal), causes the release bearing to move into contact with the clutch brake (release bearing travel). The pressure springs force the pressure plate toward the engine flywheel, applying friction to the driven discs. Slippage occurs between the drive and driven discs because of the difference in their speeds.

In the last 1 inch to 1-1/4 inches (25 to 33 mm) of downward pedal movement, the clutch brake and the release bearing are pressed together (clutch brake squeeze). The friction between the discs increases, and the slippage and difference in speeds decreases. When the pedal is fully released, pressure and friction are sufficient to stop the discs from slipping. With no slippage, the driving and driven members turn at the same speed.

When the vehicle is stationary, the clutch brake permits shifting into first gear or reverse gear without severe gear clash. The clutch brake is between the release bearing housing and the transmission bearing cap, and is engaged by tangs to the transmission input shaft. When the pedal is fully depressed, the clutch brake is squeezed between the release bearing housing and the transmission bearing cap, stopping the rotation of the main drive gear.

The clutch brake may be a disc-type or a torque-limiting type. To prevent overloads to it, the torque-limiting clutch brake is designed to slip when loads of 20 to 25 lbf·ft (27 to 34 N·m) are reached. Clutch brakes are not designed for upshifting.

NOTE: The following procedures apply only to Eaton® Fuller® Easy-Pedal® clutches. Solo™ clutches are adjustment-free.

Release yoke free-travel is the distance between the release bearing wear pads and the release yoke. At the factory, the release yoke free-travel is set to 0.105 to 0.145 inch (2.7 to 3.7 mm). This setting produces approximately two inches (51 mm) of clutch free-pedal.

IMPORTANT: When clutch free pedal is less than about 3/4 inch (19 mm), adjust the clutch internally according to the procedures in this subject. Take care to do all procedures in the proper order.

Release bearing travel is the clearance between the aft end of the release bearing housing and the forward surface of the clutch brake disc. For the clutch to release properly, the release bearing travel measurement must be between 1/2 and 9/16 inch (12.7 to 14.3 mm).

As the clutch wears, the release bearing moves towards the engine flywheel, reducing release yoke free-travel and increasing release bearing travel. If internal clutch adjustments are not made, the release yoke fingers will eventually ride against the wear pads. This could cause the following problems:

- Worn bearing wear pads and release yoke
- Damaged release bearing and housing
- Eventual clutch slippage and burn-up

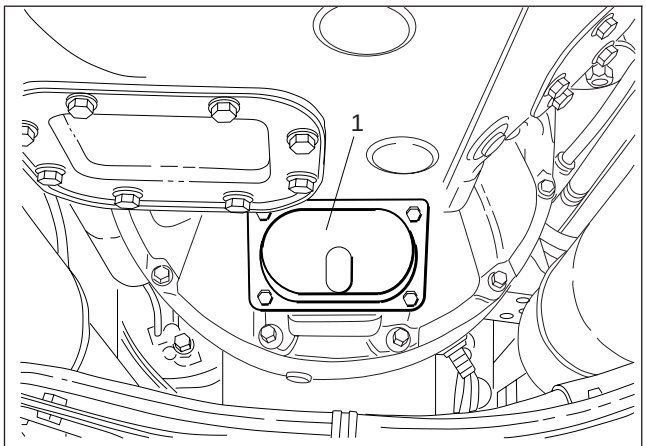
Release Bearing Travel

Measurement

CAUTION

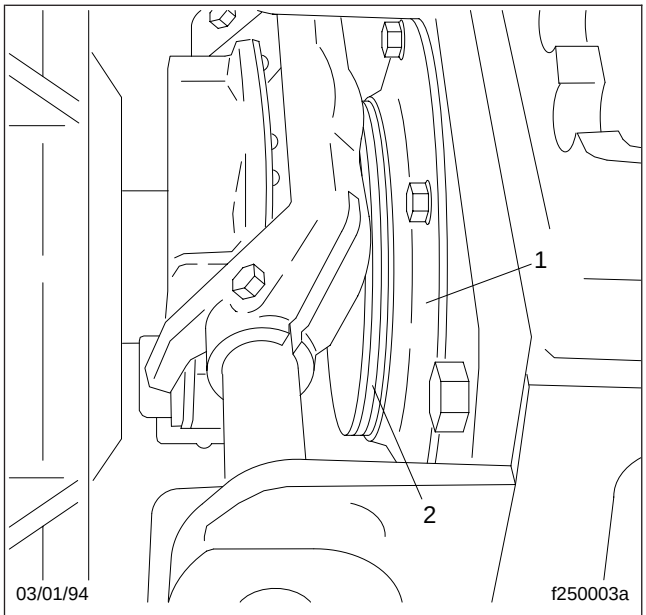
Make sure the internal adjustment is correct before making any linkage adjustments. Incorrect adjustments can cause transmission gear clash, slipping, and burning of clutch components.

1. Apply the parking brakes and chock all the tires.
2. Remove the clutch inspection cover from the bottom of the bell housing. See **Fig. 1**.
3. Slide the clutch brake (either the one-piece torque-limiting clutch brake, or the two-piece disc-type clutch brake with washer) tight against the transmission input-shaft bearing cap. See **Fig. 2**. Also, slide the release bearing as far as possible towards the transmission.



1. Clutch Inspection Cover

Fig. 1, Remove the Clutch Inspection Cover



1. Transmission Input-Shaft Bearing Cap
2. Clutch Brake

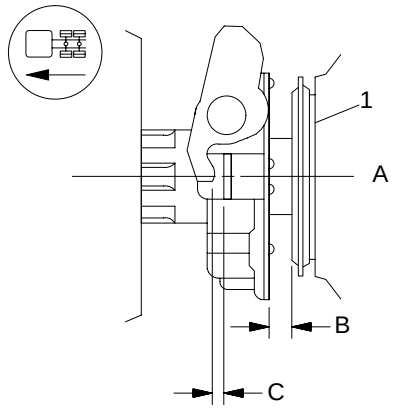
Fig. 2, Position the Clutch Brake

IMPORTANT: Release bearing travel tool A02–12419 is available through the PDCs. One end

Clutch Adjustments

of the tool has green tape on it and is 0.50 inch (12.7 mm) in diameter; the other end has blue tape on it and is 0.56 inch (14.3 mm) in diameter.

4. Measure the release bearing travel. See **Fig. 3** for the correct dimension to measure. Using both ends of the release bearing travel tool (**Fig. 4**), check this gap as follows:



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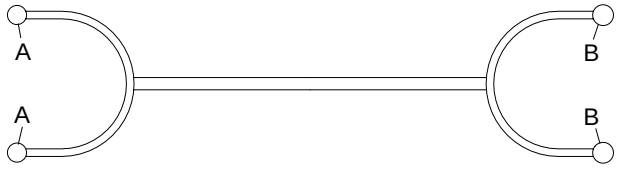
A. Check both dimensions: release bearing travel (B) and release yoke free-travel (C).
B. Release bearing travel: 1/2 to 9/16 inch (12.7 to 14.3 mm) between release bearing housing and clutch brake.
C. Release yoke free-travel: approximately 0.105 to 0.145 inch (2.7 to 3.7 mm) between yoke and wear pads.

1. Torque-Limiting Clutch Brake

Fig. 3, Clutch Dimensions



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A. 0.50 inch (12.7 mm) B. 0.56 inch (14.3 mm)

Fig. 4, Release Bearing Travel Tool A02-12419

4.1 Position the tool so that the legs straddle the transmission input shaft.

4.2 Insert the blue 0.56-inch (14.3-mm) end. If it fits loosely, the gap is too wide and adjustment is needed. See "Adjustment."

4.3 If the blue 0.56-inch (14.3-mm) end can't be inserted in the gap, then try to insert the green 0.50-inch (12.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.

4.4 If the green end of the tool can't be inserted in the gap, adjustment is needed. See "Adjustment."

5. If no internal clutch adjustment is necessary, go to "Release Yoke Free-Travel."

Adjustment

To adjust Easy-Pedal clutches, use the Eaton Fuller Kwik-Adjust® mechanism (see **Fig. 5**).

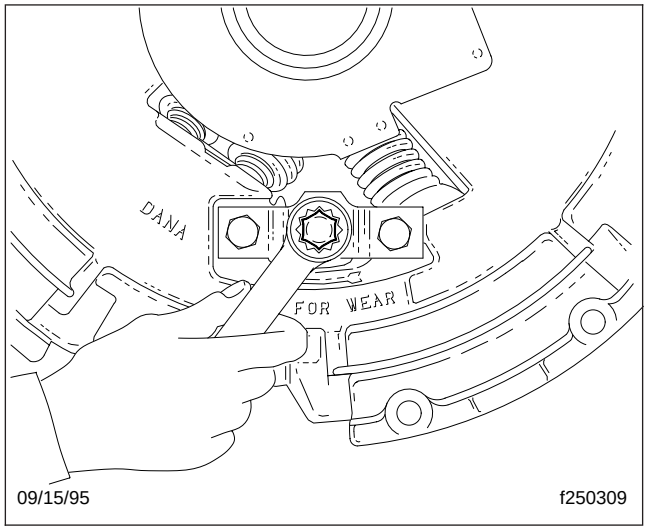

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Fig. 5, Adjustment with Kwik-Adjust

1. Turn the engine flywheel until the lockstrap is aligned with the clutch inspection-cover opening. See **Fig. 1** and **Fig. 5**.
2. Release the clutch by depressing the pedal. Block the pedal in the released position, or have someone assist you by holding the pedal down during the adjustment procedure.

NOTE: An open-end wrench is not recommended for the following step.

3. Adjust the clutch, using a 5/8-inch box-end or socket wrench on the adjustment bolt.

3.1 Insert the 5/8-inch box-end or socket wrench through the inspection cover opening.

3.2 To begin the adjustment, release the adjustment bolt by pressing down on the bolt head.

NOTE: Normal wear increases the gap between the release bearing and the transmission.

3.3 *To decrease the gap*: If clearance between the release bearing housing and the clutch brake is *more than* 9/16-inch (14.3 mm), turn the adjustment bolt clockwise (the release bearing moves toward the transmission).

To increase the gap: If clearance between the release bearing housing and the clutch brake is *less than* 1/2-inch (12.7 mm), turn the adjustment bolt counterclockwise (the release bearing moves toward the engine).

3.4 When the adjustment is complete, make sure the adjustment bolt is locked (pulled up flush with the mounting bolts).

NOTE: On Easy-Pedal 2000 clutches, each complete turn of the adjustment bolt represents about 1/8-inch (3.2 mm) of release bearing movement. On earlier Easy-Pedal models, each complete turn of the adjustment bolt represents about 0.02-inch (0.5 mm) of release bearing movement.

4. After adjusting, release the pedal and check the clearance between the release bearing housing and the clutch brake. When the clearance is 1/2 to 9/16 inch (12.7 to 14.3 mm), the adjustment is complete.

Release Yoke Free-Travel

IMPORTANT: Release yoke free-travel tool A02–12254 is available through the PDCs. The legs on one end of the tool have green tape on them and are 0.105 inch (2.7 mm) thick; the legs on the other end have blue tape on them and are 0.145 inch (3.7 mm) thick.

1. Measure the release yoke free-travel. See **Fig. 3** for the correct dimension to measure. Using both ends of the free-travel tool (**Fig. 6**), check the gap as follows:

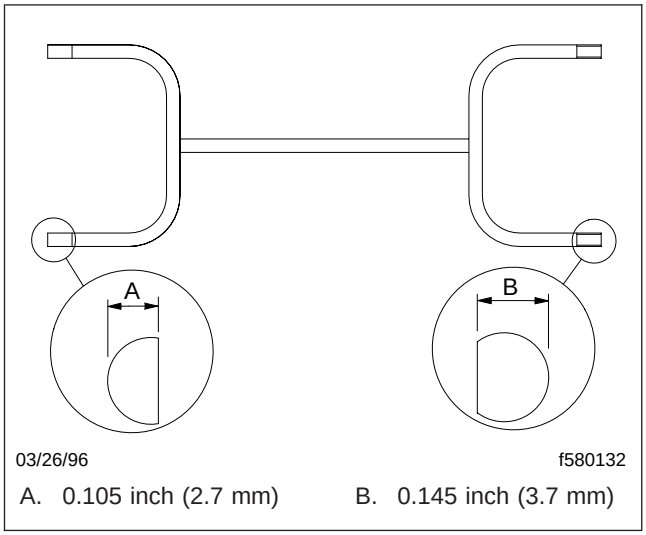


Fig. 6, Release Yoke Free-Travel Tool A02-12254

2. Position the tool so that the legs straddle the release yoke.
3. Insert the blue 0.145-inch (3.7-mm) end. If it fits loosely, the gap is too wide and linkage adjustment is needed. See the appropriate subject in **Section 25.03**.
4. If the blue 0.145-inch (3.7-mm) end can't be inserted in the gap, then try to insert the green 0.105-inch (2.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.
5. If the green end of the tool can't be inserted in the gap, linkage adjustment is needed. See the appropriate subject in **Section 25.03**.

Clutch Brake Squeeze

NOTE: This procedure requires two persons: one under the vehicle with access to the release bearing, and the other in the vehicle to depress the clutch pedal and measure the pedal travel.

The distance the pedal moves (from the fully depressed position) to free the feeler gauge is the clutch brake squeeze measurement.

Clutch Adjustments

1. Apply the parking brakes and chock all the tires.
2. Remove the clutch inspection cover from the bottom of the bell housing. See **Fig. 1**.
3. Insert a 0.010 inch (0.25 mm) feeler gauge (a business card works well if a feeler gauge is not available) between the release bearing and clutch brake.
4. Depress the clutch pedal to the end of its stroke.
5. Slowly let the pedal up. Stop when the feeler gauge can be pulled out. The pedal should be 1/2 to 1 inch (12.7 to 25.4 mm) from the end of the stroke.
6. If necessary to obtain proper clutch brake squeeze, check the linkage for worn or damaged components. If necessary, adjust the clutch brake squeeze by changing the length of the upper pedal stop.
7. Adjust the linkage to compensate for the increased or decreased stroke. See the procedures in the appropriate subject in **Section 25.03**, Subject 100. If necessary, check the clutch brake squeeze again until it is correct.

Removal

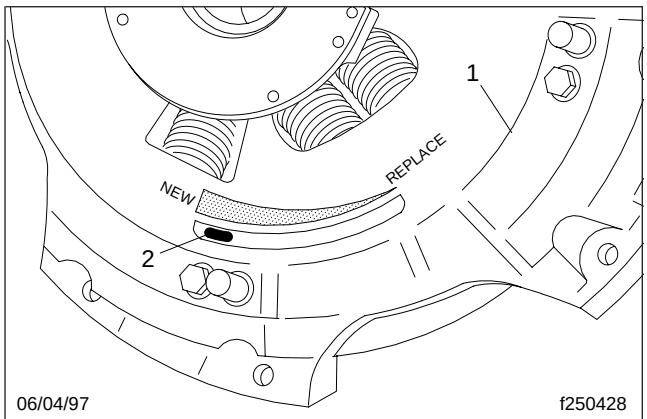
Solo™ Heavy-Duty Clutch

CAUTION

For proper installation of the Solo clutch, the wear indicating tab must be reset. Failure to reset this tab will prevent clutch release and result in possible clutch damage.

NOTE: This procedure requires two persons: one under the vehicle with access to the wear indicating tab, and the other in the vehicle to press the clutch pedal.

1. Reset the wear indicating tab with the clutch in the vehicle.
   - 1.1 From inside the cab, press the clutch pedal all the way down. Hold the clutch pedal down until the wear indicating tab is reset.
   - 1.2 Through the clutch inspection cover, slide the wear indicating tab to the left until it is at the "NEW" position on the indicator. See **Fig. 1**.



With the clutch pedal down, set the tab to the "NEW" position on the indicator.
1. Clutch Cover
2. Wear Indicating Tab

Fig. 1, Resetting the Wear Indicating Tab

IMPORTANT: Take note of the position of the wear indicating tab on the clutch cover. If the wear indicating tab is near the "REPLACE" position on the indicator, it is time to replace the clutch.

- 1.3 From inside the cab, release the clutch pedal. Check to be sure the wear indicating tab stays at the "NEW" position on the indicator.

NOTE: Before pulling the transmission from the bell housing, disconnect the external clutch linkage and rotate the release yoke so the yoke will clear the release bearing when it is removed.

2. Remove the transmission. See **Section 26.01**.

CAUTION

Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Taking these precautions will prevent bending and distortion of the clutch discs.

3. Remove the clutch brake from the transmission input shaft. See **Fig. 2**.

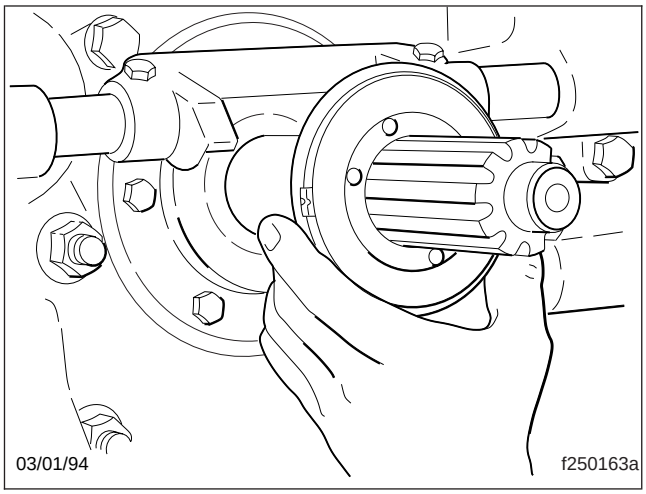


Fig. 2, Clutch Brake Removal

4. Install a spline aligning tool into the release bearing assembly, and through the driven discs. See **Fig. 3**. An old transmission input shaft may be used for this purpose.
5. Locate the four 7/16–14 x 1-3/4 shipping bolts (hexhead machine screws). These shipping bolts were installed on the clutch cover prior to installation.

Clutch Removal

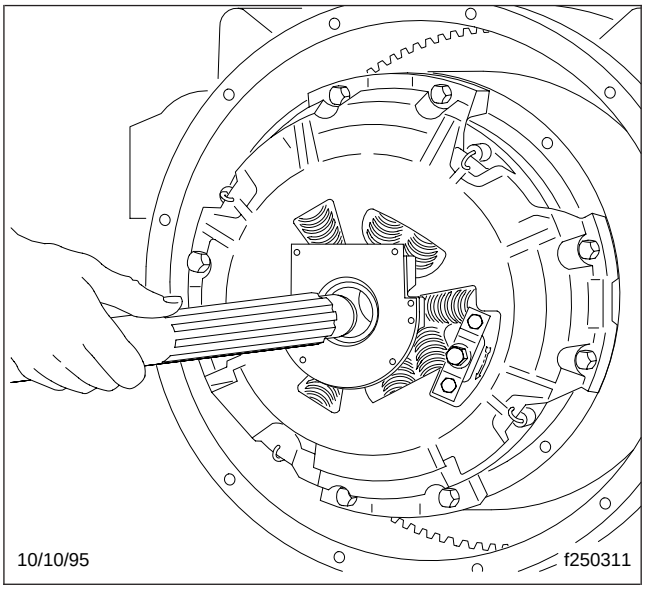
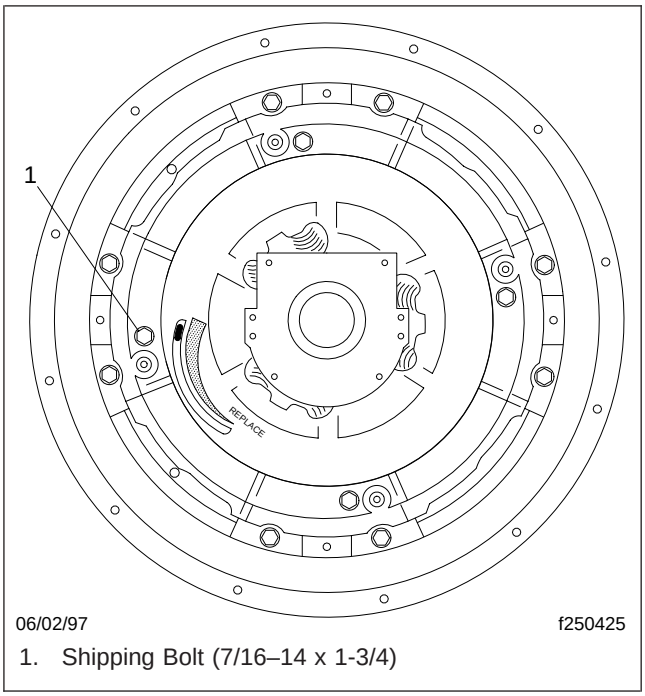


Fig. 3, Installing a Spline Aligning Tool

6. Install the four 7/16–14 x 1-3/4 shipping bolts into the four clutch cover holes and fasten them finger-tight. See **Fig. 4**.



1. Shipping Bolt (7/16–14 x 1-3/4)

Fig. 4, Install the Shipping Bolts

7. Remove the two top mounting capscrews from the cover assembly. Install two 7/16–14 x 5 guide studs in the open holes to help support the clutch assembly during removal. See **Fig. 5**.

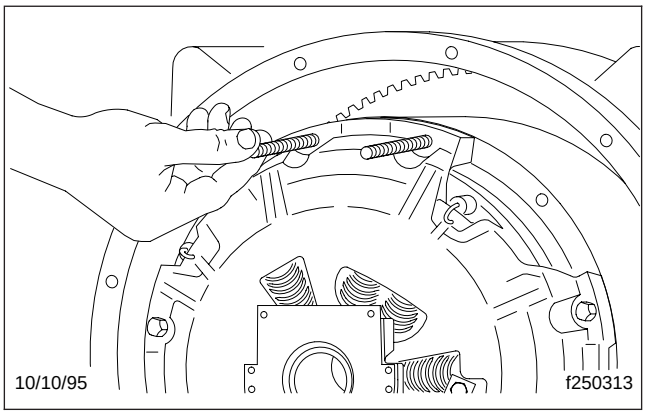


Fig. 5, Install the Guide Studs

8. Progressively loosen each of the mounting capscrews in the pattern shown in **Fig. 6**. This will prevent warping or bending within the clutch, and will ease removal of the clutch mounting capscrews.

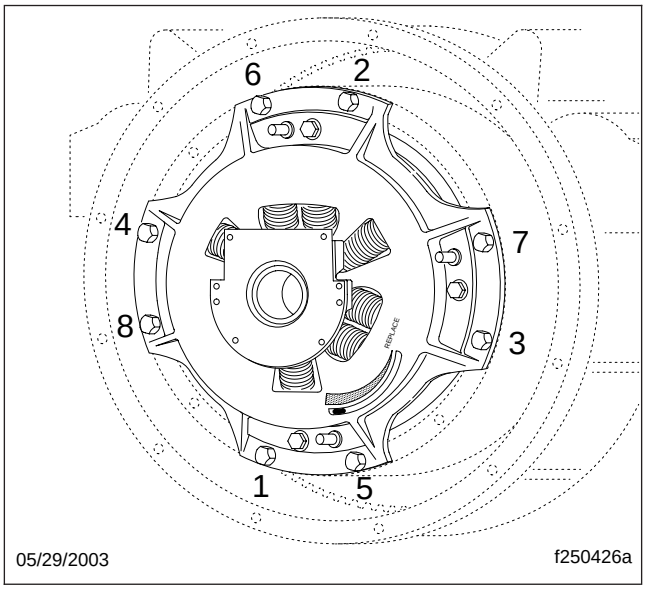


Fig. 6, Loosening Sequence, Solo

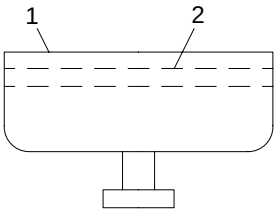
WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

9. Remove the mounting capscrews, and carefully remove the clutch assembly together with the spline aligning tool.

NOTE: For installation, mark the proper position of the discs and intermediate plate adaptor ring.

10. Reset the pressure plate wear pins. See **Fig. 7**.



NOTE: The wear pins will be reset when the pressure plate is 0.525 inches (13.3 mm) below the mounting surface.

1. Mounting Surface
2. Pressure Plate

Fig. 7, Reset Wear Pins

10.1 Progressively tighten the four shipping bolts in a crisscross pattern.

10.2 Measure the depth of the pressure plate. When the face of the pressure plate is 0.525 inches (13.3 mm) below the mounting surface, the wear pins are reset.

NOTE: Resetting the pressure plate wear pins will allow the clutch to release after installation.

11. Use an appropriate puller to remove the pilot bearing. Inspect the old pilot bearing for any unusual wear or damage. Discard the pilot bearing.

Resetting the Wear Indicating Tab (clutch out of vehicle)

CAUTION

Use this procedure if the transmission and clutch were removed without resetting the wear indicating tab. Resetting the wear indicating tab allows the clutch to release and prevents possible clutch damage.

1. Remove the four shipping bolts (if installed).
2. Support the clutch cover in an arbor press with the release bearing facing down. When setting up the arbor press, allow at least 1 inch (25 mm) clearance for both movement of the release bearing and access to install shipping bolts. See **Fig. 8**.

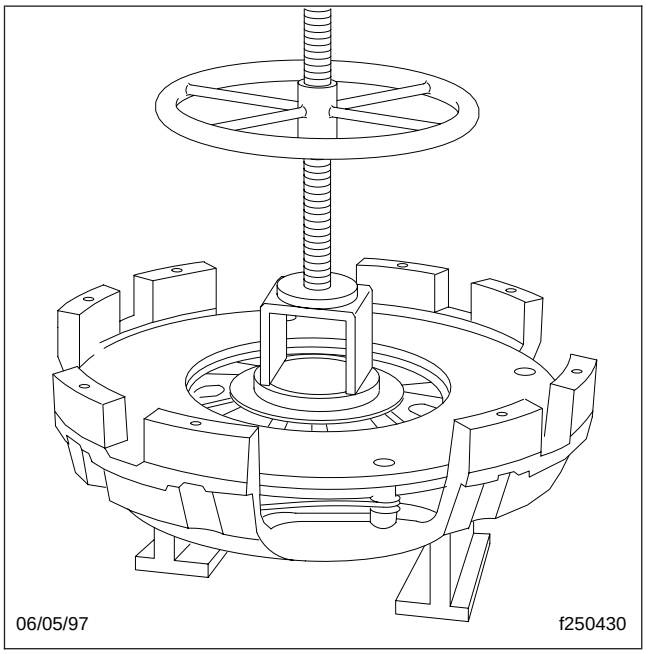


Fig. 8, Arbor Press Setup

3. Center the ram and press downward on the retainer until it comes to a stop. Lock the ram in position.
4. Slide the wear indicating tab to the left until it is at the new position of the indicator (**Fig. 1**) and hold it in position with a magnet.
5. Locate the four 7/16–14 x 1-3/4 shipping bolts.
6. Install the four 7/16–14 x 1-3/4 shipping bolts into the four clutch cover holes and fasten them finger-tight. See **Fig. 4**.

NOTE: You may need to temporarily install slightly longer bolts to allow access of the shipping bolts.

7. Reset the pressure plate wear pins. See **Fig. 7**.

Clutch Removal

7.1 Progressively tighten the four shipping bolts in a crisscross pattern.

7.2 Measure the depth of the pressure plate. When the face of the pressure plate is 0.525 inches (13.3 mm) below the mounting surface, the wear pins are reset.

NOTE: Resetting the pressure plate wear pins will allow the clutch to release after installation.

Easy-Pedal™ Clutch

NOTE: Before pulling the transmission from the bell housing, disconnect the external clutch linkage and rotate the release yoke so the yoke will clear the release bearing when it is removed.

1. Remove the transmission. See **Section 26.01**.

⚠ CAUTION

Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Taking these precautions will prevent bending and distortion of the clutch discs.

2. Remove the clutch brake from the transmission input shaft. See **Fig. 2**.
3. Install a spline aligning tool into the release bearing assembly, and through the driven discs. See **Fig. 3**. An old transmission input shaft may be used for this purpose.
4. Use a release tool and two 5/8-inch (16 mm) spacer blocks to pull the bearing back. See **Fig. 9**. The spacer blocks relieve the internal spring load in the clutch assembly, and facilitate clutch removal.
5. Remove the two top mounting bolts from the cover assembly. Install 7/16–14 x 5 guide studs in the open holes to help support the clutch assembly during removal. See **Fig. 5**.
6. Progressively loosen each of the mounting bolts in the pattern shown in **Fig. 10**. This will prevent warping or bending within the clutch, and will ease removal of the clutch mounting bolts.

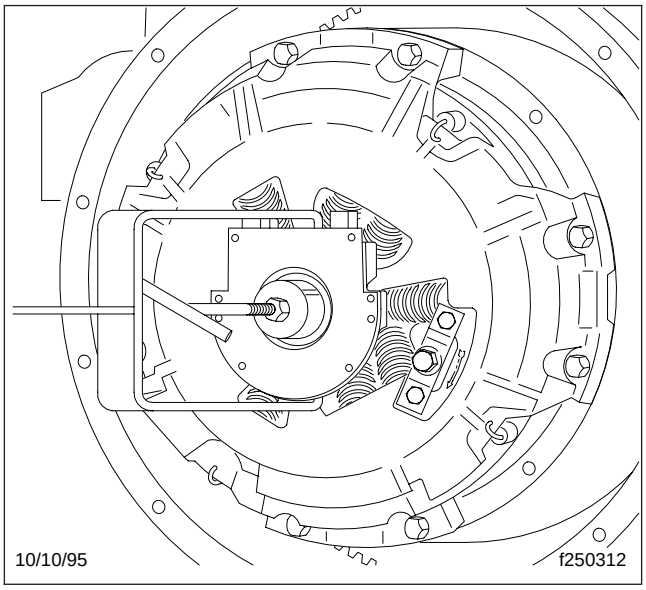


Fig. 9, Pulling the Bearing

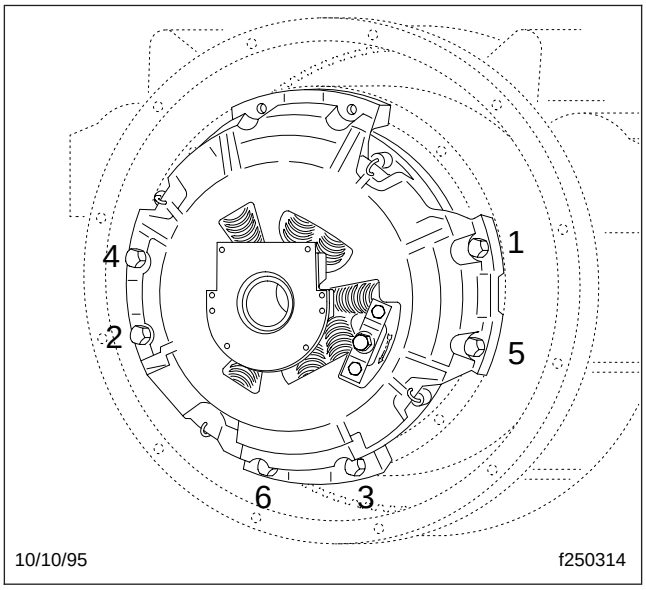


Fig. 10, Loosening Sequence, Easy-Pedal

⚠ WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

7. Remove the mounting bolts, and carefully remove the clutch assembly.

   Be careful to keep the spline aligning tool in place to retain the discs and intermediate plate. Remove the spline aligning tool, the rear driven disc, the intermediate plate, and the front driven disc.

8. Use an appropriate puller to remove the pilot bearing. Inspect the old pilot bearing. Correct the cause of any unusual wear or damage. Discard the bearing.

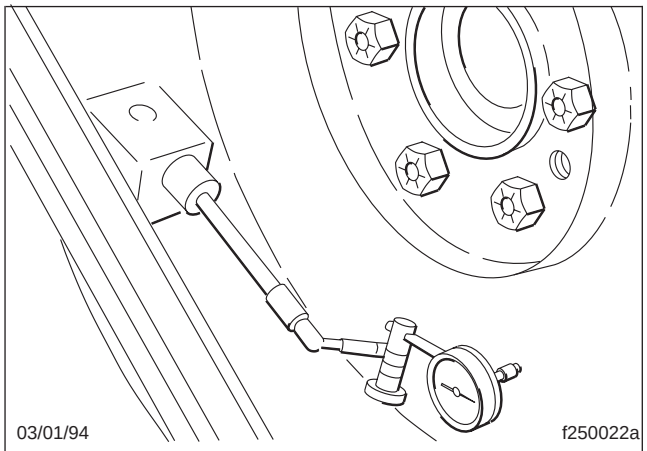
Clutch Inspection

CAUTION

Misalignment of any parts described in these procedures will cause premature wear of drivetrain components.

IMPORTANT: When taking the following readings, rotate the engine by hand; do not crank the engine with the starter. The engine may be rotated by the pulley nut at the front of the crankshaft, the flywheel mounting bolts, or the starter ring-gear on the flywheel.

1. Clean the surfaces being measured to ensure accurate measurements.
2. Measure the runout of the flywheel face (friction surface). See **Fig. 1** for the correct set-up.



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Secure the dial indicator to the flywheel housing, with the gauge finger against the flywheel face, and near the outer edge.

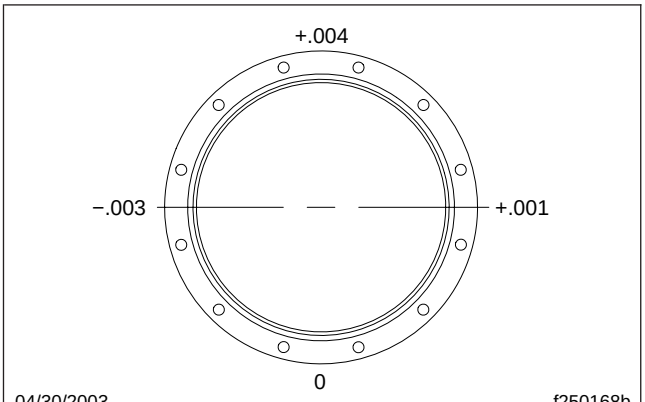
Fig. 1, Measure the Flywheel Face

2.1 Secure the dial indicator to the flywheel housing, with the gauge finger against the face of the flywheel near the outer edge.

2.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the flywheel face.

2.3 The total runout will be the difference between the highest plus and minus readings. To calculate the runout, see **Fig. 2**.

Example: The highest reading is +0.004 at 12 o'clock. The lowest reading is –0.003 at 9 o'clock. Therefore the total runout is 0.007 inch.



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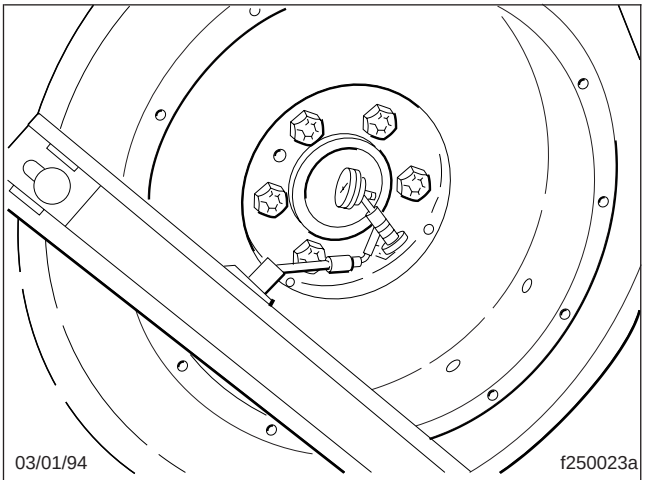
Take four readings, starting with zero at the 6 o'clock position, and going on to 9, 12, and 3 o'clock. Make sure the dial returns to zero at the original start position.

Fig. 2, Calculate the Runout

2.4 The SAE maximum total runout for the flywheel face is 0.008 inch (0.20 mm). If the readings are higher, see the engine manufacturer's manual for instructions.

3. Measure the runout of the pilot-bearing bore in the flywheel. See **Fig. 3** for the correct set-up.



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Secure the dial indicator to the flywheel housing, with the gauge finger on the surface of the pilot-bearing bore.

Fig. 3, Measure the Pilot-Bearing Bore

Clutch Inspection and Pre-Installation Procedures

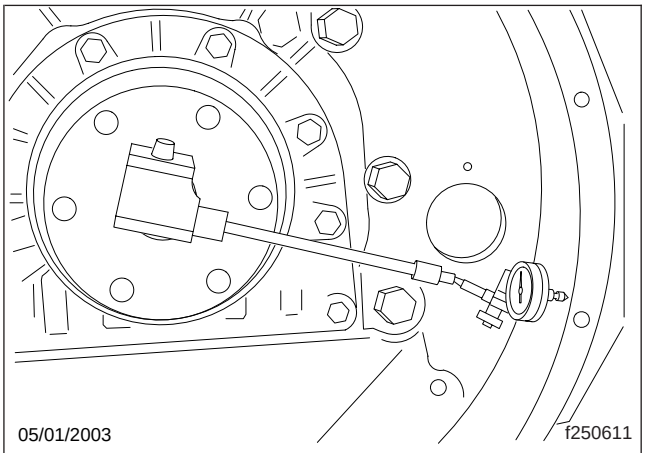
3.1 With the indicator still secured to the flywheel housing, move the gauge finger to contact the surface of the pilot-bearing bore.

3.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the bore of the pilot bearing.

3.3 Calculate the runout as before.

3.4 The SAE maximum total runout for the pilot-bearing bore is 0.005 inch (0.13 mm). If the readings are higher, see the engine manufacturer's manual for instructions.

4. Measure the runout of the flywheel housing bore. See **Fig. 4** for the correct set-up.



Secure the dial indicator to the crankshaft, with the gauge finger against the side of the flywheel housing.

Fig. 4, Measure the Flywheel Housing Bore

4.1 Secure the dial indicator to the crankshaft, with the gauge finger against the side of the flywheel housing.

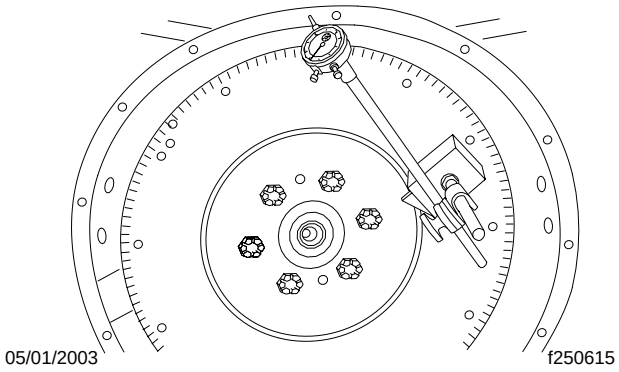
4.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the side of the flywheel housing.

4.3 Calculate the runout as before.

NOTE: Only if you have to reposition the flywheel housing is it necessary to mark the high and low runout readings in clock positions.

4.4 The SAE maximum total runout for the flywheel-housing bore is 0.008 inch (0.20 mm). If readings are higher, replace the flywheel housing. For instructions, see the engine manufacturer's manual.

5. Measure the runout of the face of the flywheel housing. See **Fig. 5** for the correct set-up.



Secure the dial indicator to the outer diameter of the flywheel, with the gauge finger against the face of the flywheel housing.

Fig. 5, Measure the Flywheel Housing Face

5.1 With the dial indicator secured to the outer diameter of the flywheel, move the gauge finger to contact the face of the flywheel housing.

5.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the face of the flywheel housing.

5.3 Calculate the runout as before.

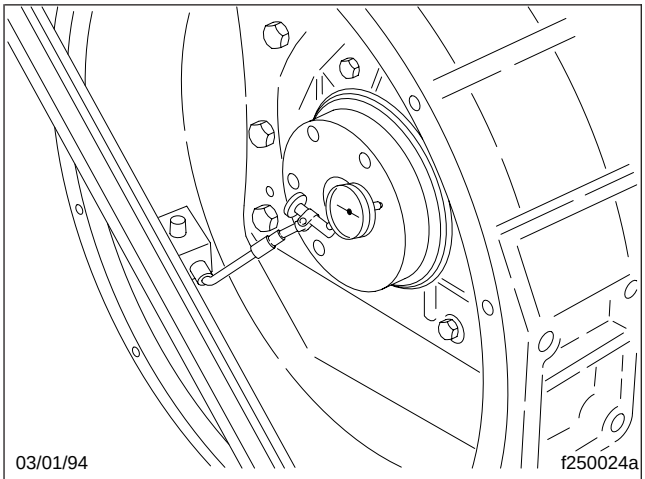
NOTE: Only if you have to reposition the flywheel housing is it necessary to mark the high and low runout readings in clock positions.

5.4 The SAE maximum total runout for the flywheel-housing face is 0.008 inch (0.20 mm). If the readings are higher, replace the housing. For instructions, see the engine manufacturer's manual.

NOTE: Use a case-bore plug and shaft set to measure the bell-housing face and pilot. Case-bore plugs are tapped into the front and rear bores of the transmission case, and have very

close tolerances. The shaft runs through the center of the plugs, and extends to the front far enough to secure a dial indicator and obtain a reading on the bell housing.

6. Measure the runout of the bell housing face and pilot.
   - 6.1 Secure the dial indicator to the case-bore shaft, with the gauge finger against the face of the bell housing.
   - 6.2 Turn the case-bore shaft through one complete revolution. With chalk or soapstone, mark the high and low points on the face of the bell housing.
   - 6.3 Calculate the runout as before.
   - 6.4 The SAE maximum total runout for the bell-housing face is 0.008 inch (0.20 mm). If the readings are higher, replace the bell housing. See the transmission manufacturer's service manual for instructions.
7. Remove the flywheel (see the engine manufacturer's manual), and measure the runout of the flywheel crankshaft face. See **Fig. 6**.



Secure the dial indicator to the flywheel housing, with the gauge finger against the crankshaft face, and near the outer edge.

Fig. 6, Measure the Crankshaft Face Runout

   - 7.1 Secure the dial indicator to the flywheel housing, with the gauge finger against the crankshaft face, and near the outer edge.
   - 7.2 Turn the crankshaft through one complete revolution. With chalk or soapstone, mark the high and low points on the face of the crankshaft.
   - 7.3 Calculate the runout as before.
   - 7.4 See the engine manufacturer's manual for maximum runout, corrective measures, and flywheel installation instructions.

Pre-Installation Procedures

Before installing a new, rebuilt, or used clutch, do the following procedures:

1. Install a new pilot bearing. Be sure that the pilot bearing has a press-fit in the flywheel.

CAUTION

Tap on the outer race only. Tapping on the inner race could damage the pilot bearing.

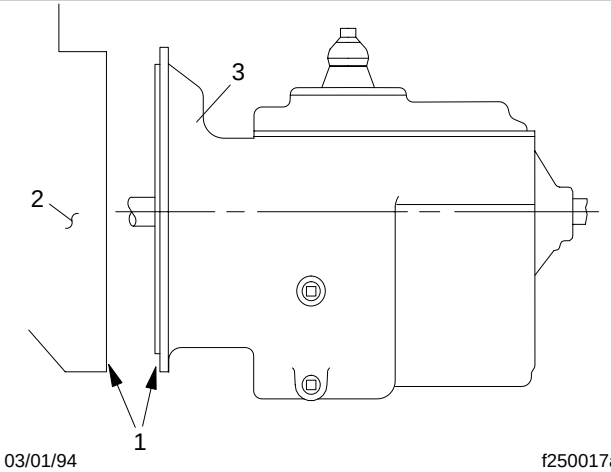
NOTE: To discourage warranty claims for drag or clutch noise, use a premium grade C3/C4 pilot bearing. Due to increased operating temperatures and longer clutch life, the standard pilot bearings and grease are no longer acceptable.

2. Check for wear on the mating surfaces of the flywheel housing and the transmission bell housing. Any noticeable wear on either part causes misalignment. If worn, replace the part. See **Fig. 7**.
3. Check the flywheel for wear caused by the bell housing pilot (projecting lip of the bell housing). The correct dimension is 1/8-inch (3.2 mm). Wear is most likely to appear between the 3 o'clock and 8 o'clock positions. See **Fig. 8**.

NOTE: The pilot (lip) of the bell housing can wear into the flywheel housing. This can be caused by the transmission loosening up, or by road and engine vibration after high mileage.

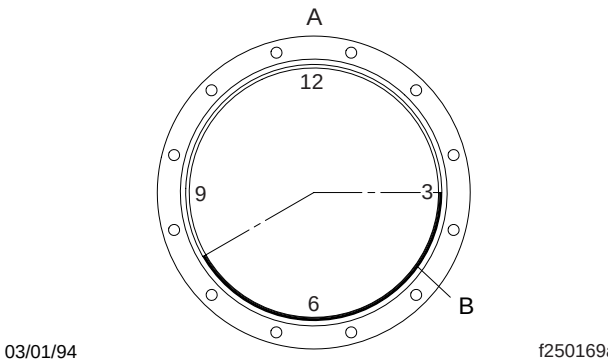
4. Inspect the flywheel. Replace or repair the flywheel if the wear is extreme.
   - 4.1 Visually inspect the friction surface of the flywheel for heat checks and scoring.

Clutch Inspection and Pre-Installation Procedures



1. Mating Surfaces
2. Engine Flywheel Housing
3. Transmission Bell Housing

Fig. 7, Inspect the Mating Surfaces



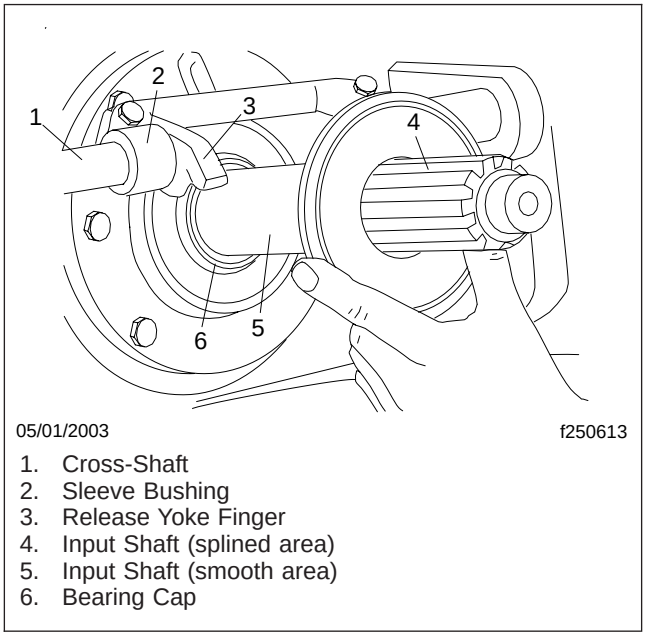
A. Top
B. The most common areas of wear are between the 3 o'clock and 8 o'clock positions.

Fig. 8, Check for Wear

4.2 Measure the friction surface wear with a straightedge and feeler gauge. For instructions, see the engine manufacturer's manual.

5. Inspect the input shaft, both the splined and the smooth area. See **Fig. 9**.

5.1 Check the fit of the splined hubs of the driven discs by sliding them along the splines of the input shaft. The hubs must slide freely so the clutch will release



1. Cross-Shaft
2. Sleeve Bushing
3. Release Yoke Finger
4. Input Shaft (splined area)
5. Input Shaft (smooth area)
6. Bearing Cap

Fig. 9, Clutch Inspection Points

cleanly. If necessary, use a hand stone to dull the sharp edges of the splines.

5.2 If the input shaft splines are worn or notched, or if the hubs still do not slide freely, replace the input shaft. For instructions, see the transmission manufacturer's service manual.

5.3 Inspect the smooth area of the input shaft for wear and/or rough spots. Replace the input shaft if necessary.

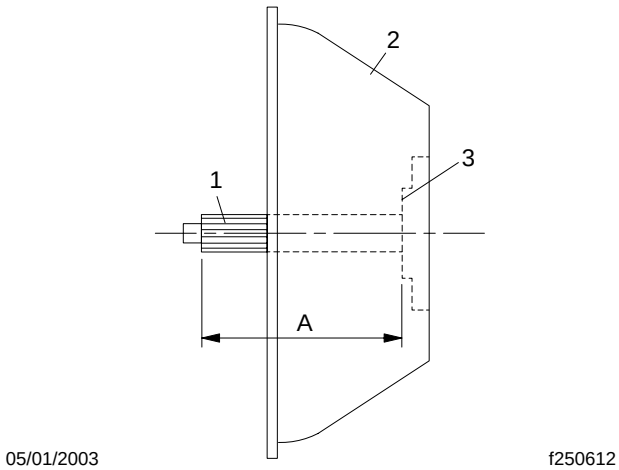
6. To prevent side-loading, inspect all pivot points of the clutch linkage for excessive wear and replace them if necessary. See **Fig. 9**. Pay special attention to the following points:

6.1 Check for excessive wear at the fingers of the release yoke where they contact release bearing wear pads.

6.2 Check the clutch cross-shaft and sleeve bushings for excessive wear. Check the sleeve bushings for walk-out.

7. To prevent clutch brake wear, check the input-shaft bearing cap and measure it as shown in **Fig. 10**.

7.1 Visually check the bearing cap for excessive wear.



A. Length of Input Shaft, from the Splined End to the Bearing Cap

1. Input Shaft
2. Bell Housing
3. Bearing Cap

Fig. 10, Measure the Input Shaft

7.2 Measure the distance between the splined end of the input shaft and the bearing cap (dimension A). If dimension A is greater than 8.71 inches (221.5 mm), replace the bearing cap.

NOTE: Torque-limiting clutch brakes are a one-piece assembly with a large and a small face. When installing a torque-limiting clutch brake on an Eaton® Fuller® or Meritor™ transmission, install the smaller face toward the transmission.

8. Install a new clutch brake on the transmission input shaft, as shown in **Fig. 11**. Slide it tight against the input-shaft bearing cap.
9. Check the diameter of the flywheel bore opening (this is the recessed area for the flywheel bolt circle). See **Table 1** for minimum flywheel bore diameters for each disc type.

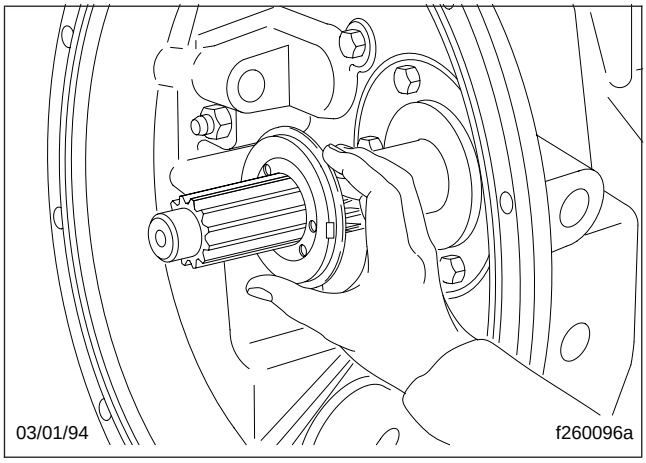


Fig. 11, Install the Clutch Brake

Minimum Flywheel Bores	
Disc Type	**Flywheel Bore in inch (mm)**
10-Spring	8.562 (217.48)
9-Spring	9.750 (247.65)
8-Spring	7.250 (184.15)
7-Spring	9.750 (247.65)
6-Spring	9.750 (247.65)

Table 1, Minimum Flywheel Bores

Installation

Solo™ Heavy-Duty Clutch

NOTE: Do the clutch inspection and pre-installation procedures in **Subject 120** before installing the clutch.

1. If not already installed, insert two 7/16–14 x 5 guide studs in the upper mounting holes of the flywheel. See **Fig. 1**. Rotate the flywheel to level the guide studs.

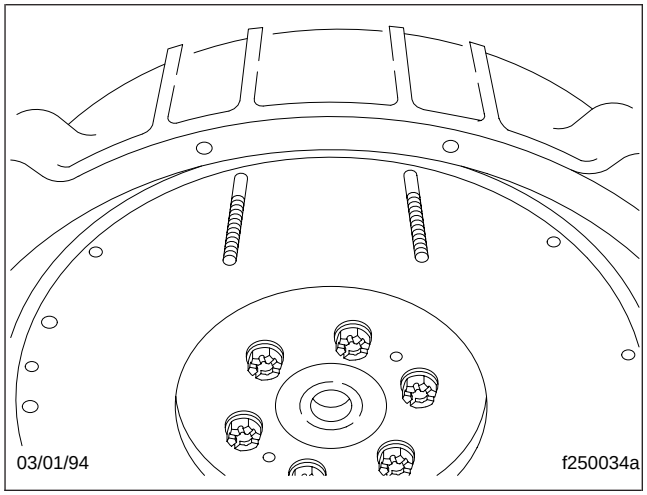


Fig. 1, Install the Guide Studs

2. If installed (on new clutches), remove the protective coating from the pressure plate and the intermediate plate.
3. Set the clutch cover upright, and insert a spline aligning tool through the release bearing sleeve. See **Fig. 2**.

NOTE: Six-spring driven discs are identical, front and rear. Either disc can be installed first on the aligning tool.

4. Install the rear driven disc and intermediate plate.
   - 4.1 Install the rear driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing away from the clutch cover. See **Fig. 3**.
   - 4.2 Place the intermediate plate in the clutch cover. Align the drive lugs of the plate with the notches in the cover. See **Fig. 4**.

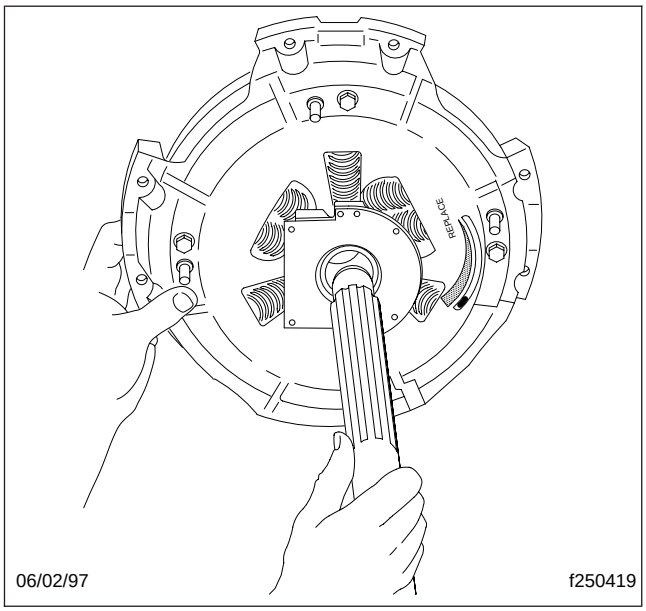


Fig. 2, Insert an Aligning Tool, Solo

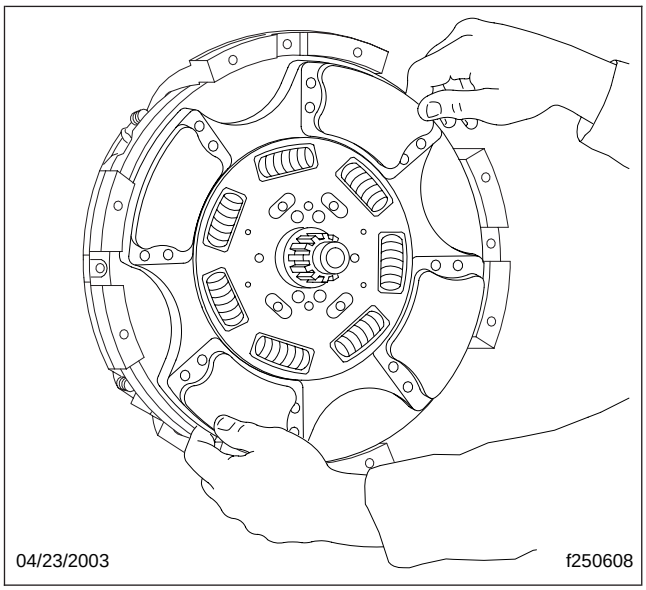
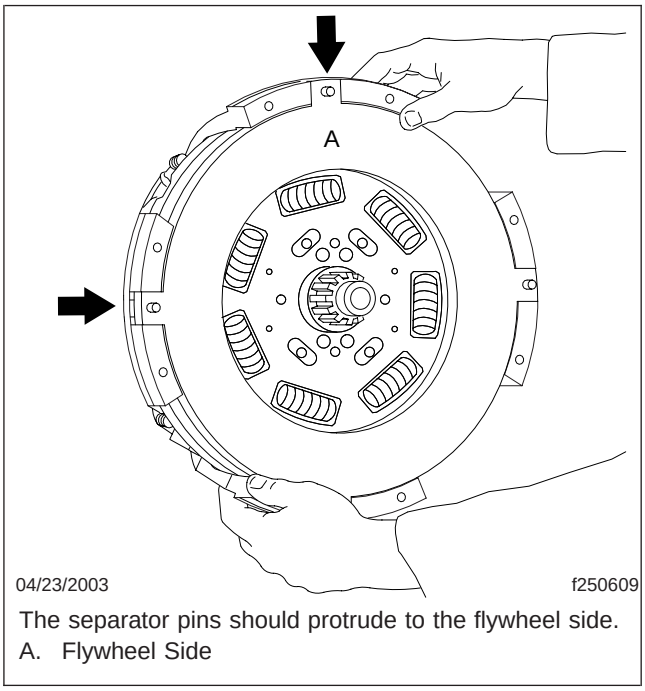


Fig. 3, Installing the Rear Driven Disc

   - 4.3 Make sure the positive separator pins™ protrude toward the flywheel side. See **Fig. 4**. The pins should be flush on the pressure-plate side.
5. Install the front driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing the intermediate plate. See **Fig. 5**.

Clutch Installation



The separator pins should protrude to the flywheel side.
A. Flywheel Side

Fig. 4, Positioning the Intermediate Plate

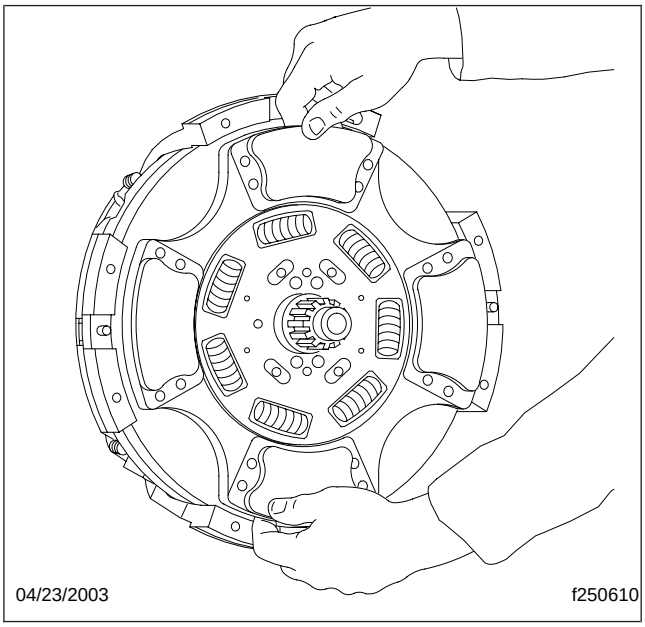


Fig. 5, Installing the Front Driven Disc

WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

6. Position the clutch over the two guide studs, and slide the assembly forward until contact is made with the flywheel surface. See **Fig. 6**.

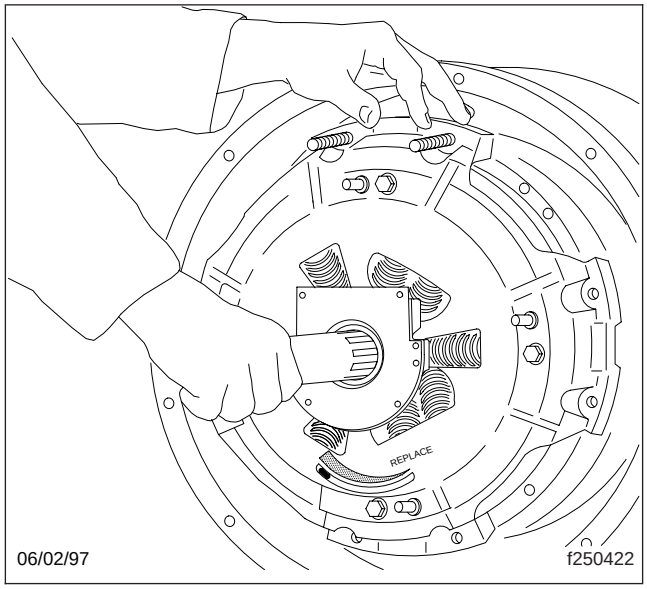


Fig. 6, Positioning the Clutch Cover, Solo

7. Install the mounting capscrews. See **Fig. 7**.
   - 7.1 Start six 7/16–14 x 2-1/4 (grade 5 or better) mounting capscrews with lockwashers, and fasten them finger-tight.
   - 7.2 Tap the aligning tool to make sure it is centered and seated in the pilot bearing.
   - 7.3 Remove the two guide studs and replace them with the two remaining 7/16–14 x 2-1/4 mounting capscrews and lockwashers.
8. Tighten the eight mounting capscrews progressively, in a crisscross pattern as shown in **Fig. 8**. The final torque is 40 to 50 lbf·ft (54 to 68 N·m).

IMPORTANT: Failure to tighten the bolts according to this procedure can have the following effects:

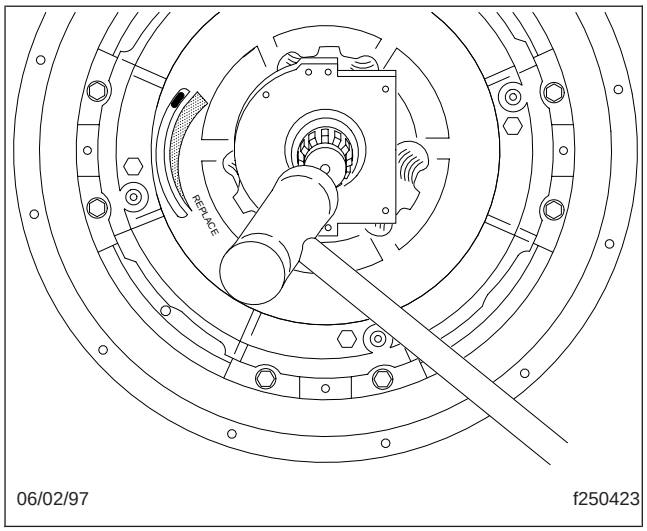


Fig. 7, Tap Aligning Tool

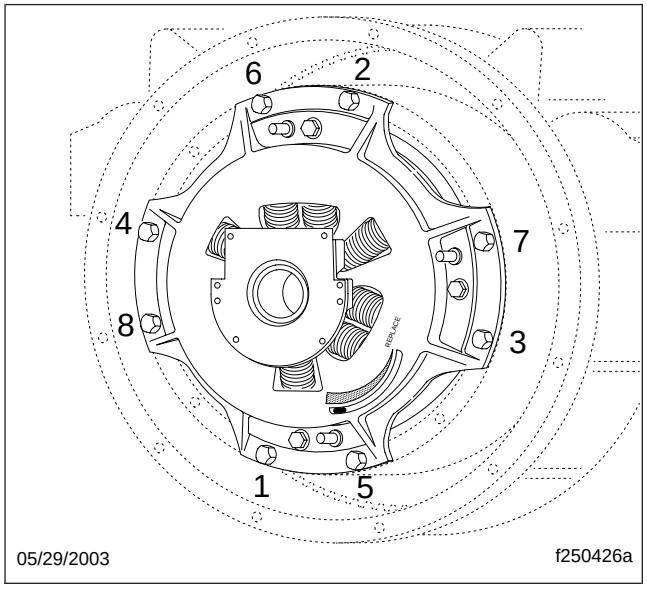


Fig. 8, Tightening Sequence, Solo

- prevent the clutch cover from centering into the pilot area of the flywheel;
- cause the clutch assembly to be out-of-balance with the flywheel;
- cause permanent damage to the clutch cover.

9. Following a crisscross pattern, remove and retain the four yellow shipping bolts from the clutch cover. See **Fig. 9**.

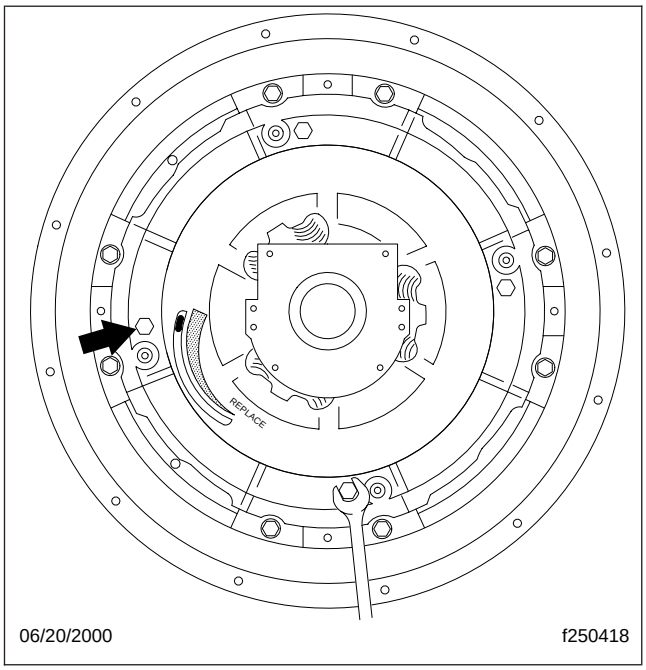


Fig. 9, Remove the Shipping Bolts

NOTE: Retain these four shipping bolts. These bolts will be needed in the future to secure the clutch assembly during removal and installation.

10. Remove the aligning tool. On maintenance-free clutches only, remove the input shaft sleeve.

NOTE: Do not be concerned if the release bearing housing touches the clutch cover.

11. Set the positive separator pins.

    11.1 Locate the pin access holes. See **Fig. 10**.

⚠ WARNING

Wear safety goggles when tapping the pins. If any of the metal parts were to chip, flying pieces of metal could possibly cause eye injury.

    11.2 Using a 1/4-inch (6-mm) diameter flat nose punch, *lightly* tap each of the four positive separator pins toward the flywheel through the access holes. This step verifies that all the four pins are flush against the flywheel. See **Fig. 11**.

NOTE: Failure to perform this step properly may cause the clutch to drag (clutch does not release). If necessary, after the transmission has

Clutch Installation

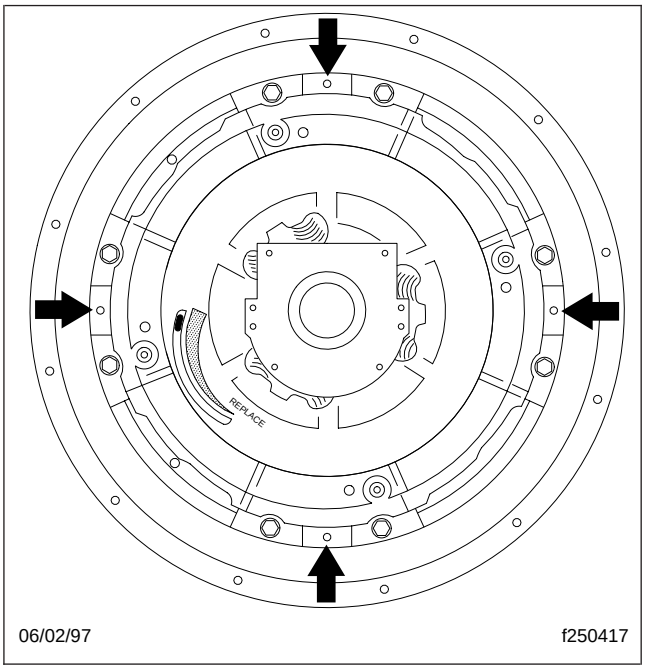
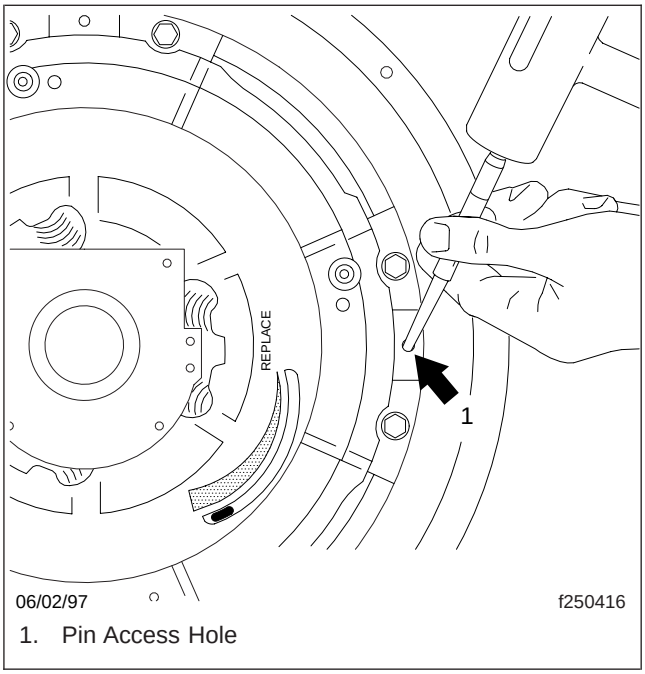


Fig. 10, Pin Access Holes, Solo



1. Pin Access Hole

Fig. 11, Tapping the Pin, Solo

been installed, the four pins can be set through the inspection opening of the transmission bell housing.

12. Using a clean cloth, remove all grease from the input shaft.
13. Shift the transmission into gear so that during assembly the transmission input shaft can be rotated into line with the clutch driven-disc hub splines.
14. Install the transmission and attach the clutch linkage.

⚠ CAUTION

Avoid springing the driven discs when the transmission is being installed. Do not excessively force the transmission into the clutch assembly or engine housing. If it doesn't enter freely, investigate the cause of the problem and then make any necessary changes. Don't let the transmission drop or hang unsupported in the driven discs. If this should occur, the rear disc will become bent or distorted, causing the clutch to drag (not release).

IMPORTANT: Be sure the release yoke clears the bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 12**. Align the splines by turning the transmission output shaft.

15. Lubricate the release bearing and cross-shaft bushings. For instructions and recommended lubricants, see Group 25 of the *Heavy-Duty Trucks Maintenance Manual*.

Easy-Pedal™ Clutch

NOTE: Do the clutch inspection and pre-installation procedures in **Subject 120** before installing the clutch.

1. If not already installed, insert two 7/16–14 x 5 guide studs in the upper mounting holes of the flywheel. See **Fig. 1**. Rotate the flywheel to level the guide studs.
2. If the clutch is new, remove the protective coating from the pressure plate and the intermediate plate.

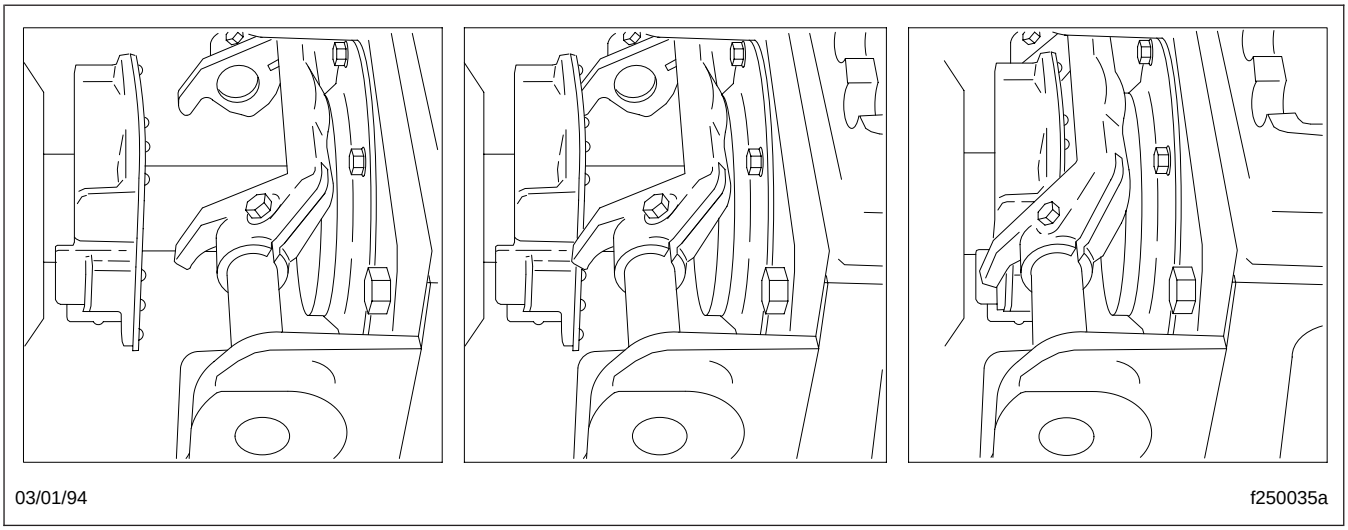


Fig. 12, Make Sure the Release Yoke Clears the Bearing

3. Set the clutch cover upright, and insert a spline aligning tool through the release bearing sleeve. See **Fig. 13**.

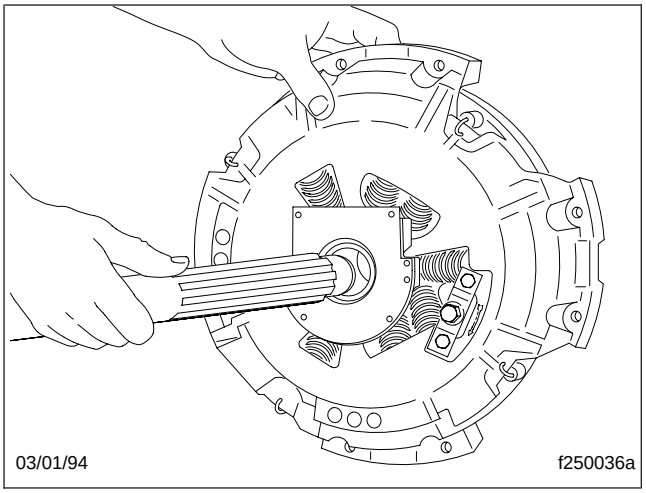


Fig. 13, Insert an Aligning Tool, Easy-Pedal

NOTE: Six-spring driven discs are identical, front and rear. Either disc can be installed first on the aligning tool.

4. Install the rear driven disc and intermediate plate.

   4.1 Install the rear driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing away from the clutch cover. See **Fig. 3**.

   NOTE: On 8-, 9-, and 10-spring discs, this side will be stamped *FLYWHEEL SIDE*.

   4.2 Place the intermediate plate in the clutch cover. Align the drive lugs of the plate with the notches in the cover. See **Fig. 4**.

   4.3 Make sure the positive separator pins™ protrude toward the flywheel side. See **Fig. 4**. The pins should be flush on the pressure-plate side.

5. Install the front driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing the intermediate plate. See **Fig. 5**.

   Be sure that both driven discs are aligned as shown in **Fig. 14**.

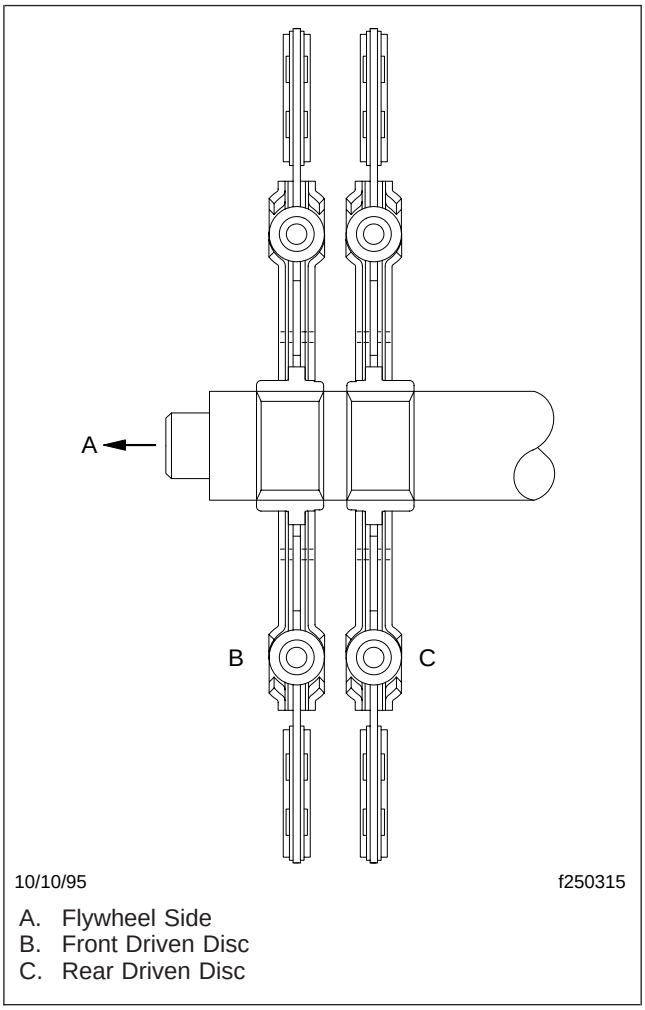
NOTE: On 8-, 9-, and 10-spring discs, this side is stamped *FLYWHEEL SIDE*.

⚠ WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

6. Position the clutch over the two guide studs, and slide the assembly forward until it starts in the flywheel pilot. See **Fig. 15**.
7. Start six 7/16–14 x 2-1/4 (grade 5 or better) mounting bolts with lockwashers, and fasten

Clutch Installation



A. Flywheel Side
B. Front Driven Disc
C. Rear Driven Disc

Fig. 14, Checking Disc Alignment

them finger-tight. Tap the aligning tool to make sure it is centered and seated in the pilot bearing, then remove the two guide studs and replace them with 7/16–14 x 2-1/4 bolts and lockwashers.

8. Tighten the eight clutch mounting bolts progressively, in the sequence shown in **Fig. 16**. The final torque is 40 to 50 lbf·ft (54 to 68 N·m).

CAUTION

If the bolts are not tightened in sequence, it may cause permanent damage to the clutch cover and create an out-of-balance condition.

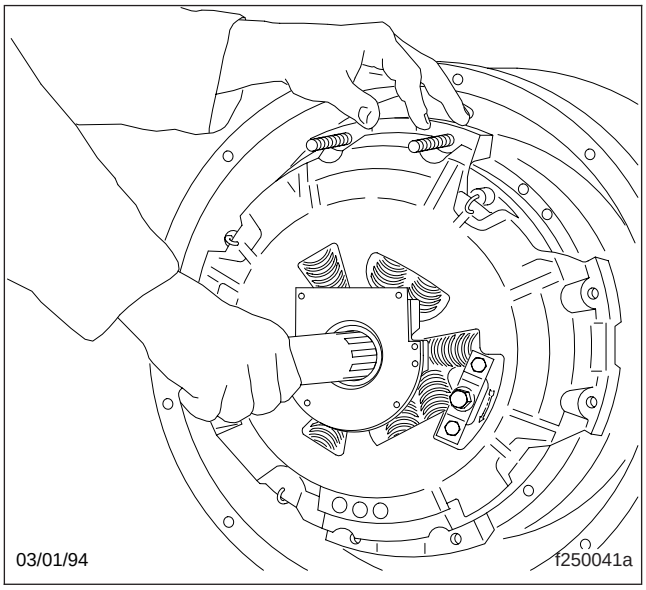


Fig. 15, Positioning the Clutch, Easy-Pedal

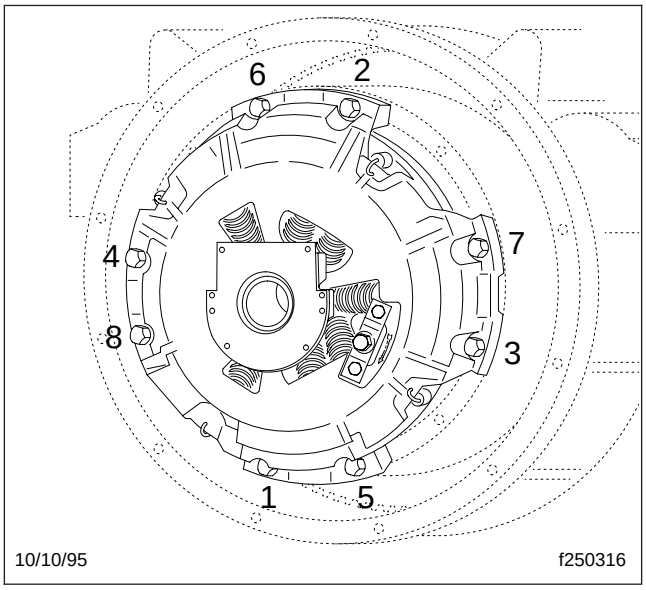


Fig. 16, Tightening Sequence, Easy-Pedal

9. As the capscrews are tightened, the release bearing spacers should fall free. If they don't, remove them. This may require light taps with a mallet on the end of the aligning tool.
10. Remove the aligning tool.
11. Set the positive separator pins.

    11.1 Locate the pin access holes. See **Fig. 17**.

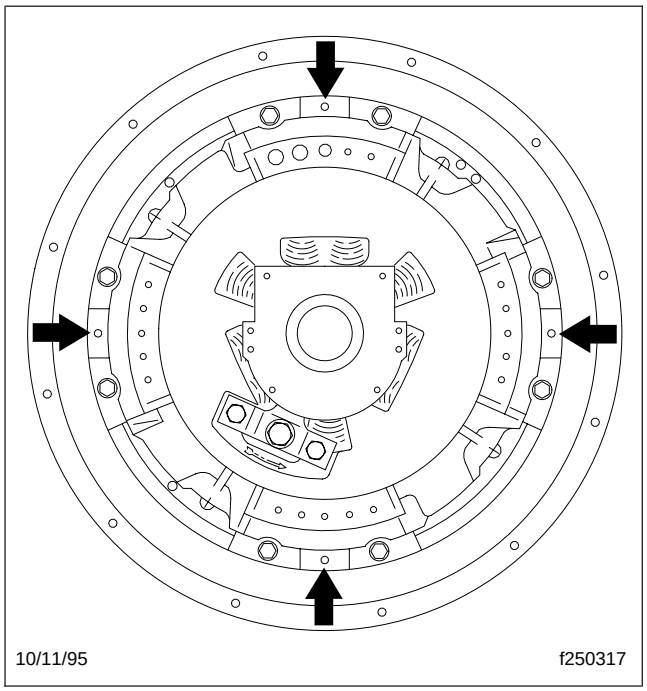


Fig. 17, Pin Access Holes, Easy-Pedal

⚠ WARNING

Wear safety goggles when tapping the pins. If any of the metal parts were to chip, flying pieces of metal could possibly cause eye injury.

11.2 Using a 1/4-inch (6-mm) diameter flat nose punch, *lightly* tap each of the four positive separator pins toward the flywheel through the access holes. This step verifies that all the four pins are flush against the flywheel. See **Fig. 18**.

NOTE: Failure to perform this step properly may cause the clutch to drag (clutch does not release). If necessary, after the transmission has been installed, the four pins can be set through the inspection opening of the transmission bell housing.

12. Using a clean cloth, remove all grease from the input shaft.
13. Shift the transmission into gear. Rotate the transmission input shaft to line up with the clutch driven-disc hub splines during assembly.

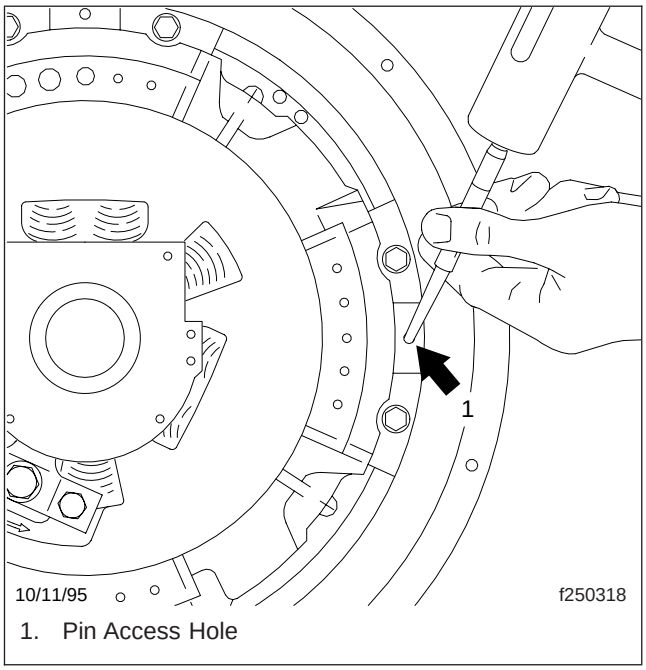


Fig. 18, Tapping the Pin, Easy-Pedal

14. Install the transmission and attach the clutch linkage.

IMPORTANT: Be sure the release yoke clears the bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 12**. Align the splines by turning the transmission output shaft.

⚠ CAUTION

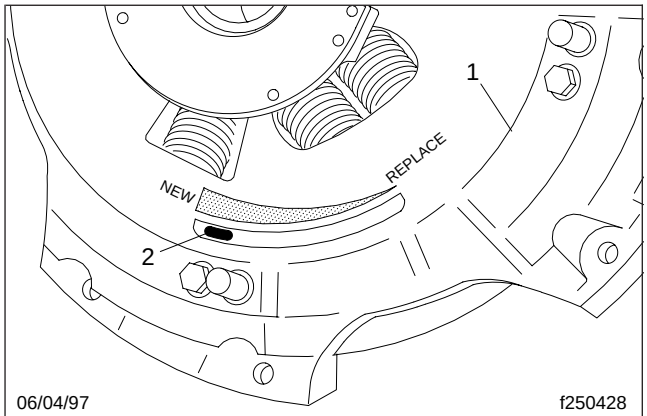
Avoid springing the driven discs when the transmission is being installed. Don't force the transmission into the clutch or flywheel housing if it doesn't enter freely. Don't let the transmission drop or hang unsupported in the driven discs. These practices can damage the clutch assembly.

15. Grease the release bearing and release shafts. For instructions and recommended lubricants, See Group 25 of the *Heavy-Duty Trucks Maintenance Manual*.
16. Adjust the clutch according to the procedures in **Subject 100**.

Resetting

NOTE: This procedure requires two persons; one under the vehicle with access to the wear indicating tab, and the other in the vehicle to operate the clutch pedal.

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Inside the cab, press the clutch pedal all the way down, and hold it there until instructed to release it later in this procedure.
3. Through the clutch cover, use moderate force to slide the wear indicating tab leftward until it is at the "NEW" position on the indicator. See **Fig. 1**. If the tab does not move, follow the instructions under the heading "Releasing a Seized Cam".



With the clutch pedal down, set the tab to the "NEW" position on the indicator.
1. Clutch Cover 2. Wear Indicating Tab

Fig. 1, Resetting the Wear Indicating Tab

4. Release the clutch pedal.
5. To remove the gap between the sleeve and the pin, install four 7/16–14 x 1-3/4 bolts (shipping bolts may be used when available), and use a hand tool to tighten them until the gap is removed and the bolts are snug. See **Fig. 2**.
6. Remove the bolts.
7. Press the clutch pedal all the way down, and squeeze the clutch brake five times to reposition the bearing.

Releasing a Seized Cam

A seized cam may be caused by grease, dust, or other debris accumulated around the outer perimeter of the cam. The cam must operate freely for the clutch to work properly. The Eaton Seized Cam Adjustment Tool is designed specifically for releasing a seized cam. See **Table 1**.

1. While an assistant holds down the clutch pedal, insert the tip of the Seized Cam Adjustment Tool through the access panel and position it under the bearing. See **Fig. 3**.
2. Align the tool so that the threaded bolt extends into the slot in the cam. See **Fig. 3**.

IMPORTANT: Use the Seized Cam Adjustment Tool carefully. Do not use heavy force on it; heavy force can break the cam.

3. Using the tool, carefully try to move the cam toward the right or "Replace" position.

   If the cam moves easily, move it back to the left to verify that spring tension will pull it back to the right. If it returns to the right, then the cam has been released and you can continue with the resetting procedure. If it will not return to the right, the cam spring may be broken.

   If the cam does not move easily, continue to the next step.

IMPORTANT: Use WD-40® only. Do not substitute another penetrant for WD-40.

4. Use sideways pressure to the right and lightly pull the tool away from the engine to separate the top cam from the bottom cam. If the cam moves slightly to the right, let up on the clutch pedal. If the cam is still seized, spray WD-40 into the cam slot and three spring perches. To access all three perches, rotate the engine as needed.

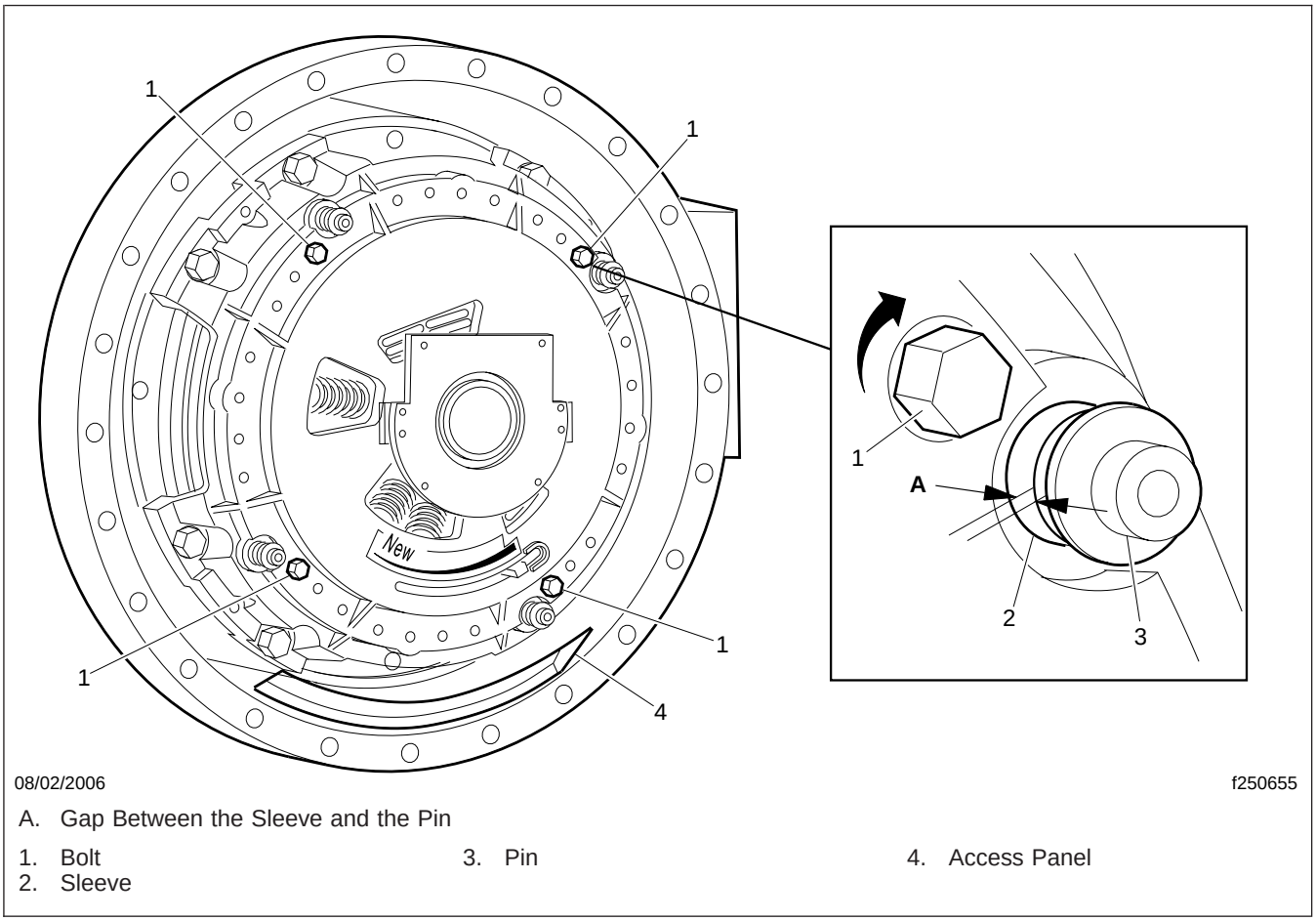
   If the cam is still seized, do the following.

   4.1 Again spray WD-40 into the cam slot and all three spring perches.

   4.2 Inside the cab, release the clutch pedal, then press it all the way down. Next, with the clutch pedal pressed down, jiggle the tool in the cam slots to apply pressure in all directions.

5. Remove the tool.

Resetting the Clutch



A. Gap Between the Sleeve and the Pin

1. Bolt
2. Sleeve
3. Pin
4. Access Panel

Fig. 2, Removing the Gap Between the Sleeve and the Pin

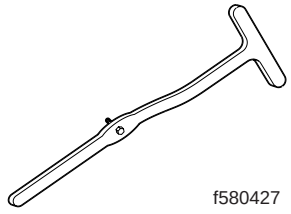
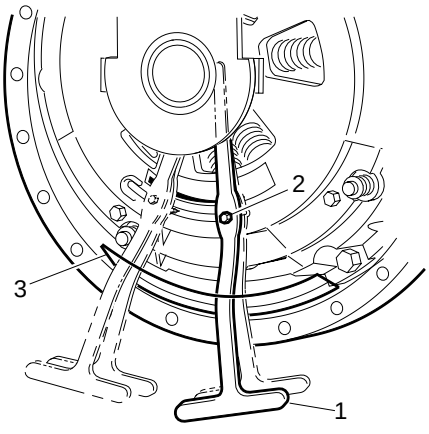
Tool	Description	Eaton Tool Part Code
 f580427	Seized Cam Adjustment Tool	CLPI-SOLOTOOL

Table 1, Special Tool for Releasing a Seized Cam



1. Seized Cam Adjustment Tool
2. Threaded Bolt
3. Access Panel

Fig. 3, Releasing a Seized Cam

Troubleshooting Tables

Problem—The Clutch Does Not Release Completely

Problem—The Clutch Does Not Release Completely	
Possible Cause	**Remedy**
The clutch pedal height is incorrect.	Adjust the clutch to obtain the following settings: • 1/2 to 9/16 inch (12.7 to 14.3 mm) release bearing travel; • 0.105 to 0.145 inch (2.7 to 3.7 mm) release yoke free-travel; and • 1/2 to 1 inch (12.7 to 25.4 mm) clutch brake squeeze.
The bushing in the release bearing sleeve assembly is damaged.	Replace the clutch cover.
The clutch cover assembly is not properly seated into the flywheel.	Re-seat the clutch cover assembly into the flywheel. Use a crisscross pattern when tightening the mounting bolts.
The intermediate plate and/or pressure plate is cracked or broken.	Replace any damaged parts.
The cross shafts protrude through the release yoke (a side-loading condition exists).	Check for protruding cross shafts. Repair or replace as necessary.
The release yoke fingers are bent or worn (a side-loading condition exists).	Install a new release yoke.
The engine housing and bell housing are misaligned (a side-loading condition exists).	Check for loose transmission mounting bolts. Tighten the transmission mounting bolts to the proper torque.
The clutch linkage is set up improperly (a side-loading condition exists).	Thoroughly examine the clutch linkage and adjust as necessary.
The driven discs are distorted or warped.	Replace any distorted or warped driven discs. If the transmission is allowed to hang unsupported during clutch installation, the driven discs may become distorted.
The driven discs are installed backwards, or the front and rear driven discs were switched with each other.	Install new driven discs. Also, check the clutch cover for any damage. Replace the clutch cover if damaged.
The input shaft spline is worn.	Replace the input shaft. Also, check the driven disc hubs for wear. Replace the driven discs if worn.
The input shaft spline is coated with grease, anti-seize compound, etc.	Clean and dry the input shaft spline before installation.
The input shaft splines are twisted.	Select a new driven disc and slide it along the full length of the splines. If the disc does not slide freely, replace the input shaft.
The input-shaft bearing cap is worn.	Replace the input-shaft bearing.
The flywheel pilot bearing fits either too tight or too loose in the flywheel and/or end of input shaft.	Check the pilot bearing for proper fit and replace it if worn.
The pilot bearing is dry or damaged.	Replace the pilot bearing.
The positive separator pins are bent, damaged or incorrectly set.	Be sure to use the proper tool when setting the positive separator pins. Also, take great care when handling the intermediate plate. For procedures, see **Subject 130**.

Troubleshooting

Problem—The Clutch Does Not Release Completely	
Possible Cause	**Remedy**
The clutch brake is damaged and/or not functioning.	Install a new clutch brake.
The driven disc faces are coated with oil or grease.	Replace the driven disc assemblies. Cleaning the old driven discs is not recommended.
There is foreign material (dirt, chaff, salt, etc.) inside the clutch cover.	Remove the foreign material and make sure the clutch inspection cover is installed.
The drive pins are cocked, causing the intermediate plate to stick on the drive lugs (Easy-Pedal only).	The drive pins must be ninety degrees square to the flywheel surface with a 0.006-inch (0.15-mm) minimum clearance between drive pins and intermediate plate slots. Repair or replace as necessary.
The pressure plate is not fully retracting (Easy-Pedal only).	Check the pressure plate return springs through the clutch inspection cover. If any are bent, stretched, or broken, replace them as necessary.
The release bearing travel is excessive and is causing the lever to contact the pressure plate (Easy-Pedal only).	Adjust the release bearing travel from 1/2 to 9/16 inch (12.7 to 14.3 mm).
The three anti-rattle springs were installed backwards (Easy-Pedal only).	Install the anti-rattle springs so the rounded sections are pointed toward the flywheel/engine.

Problem—The Clutch Rattles or Is Noisy

Problem—The Clutch Rattles or Is Noisy	
Possible Cause	**Remedy**
There is excessive flywheel runout.	Repair or replace the flywheel. For procedures, see the engine manufacturer's manual.
There is corrosion between the input shaft spline and the driven disc hubs.	Clean the mating parts between the input shaft and driven discs to ensure that the discs slide freely over the input shaft spline.
The engine idle is too fast.	Readjust engine idle to proper idling speed.
The clutch release bearing is dry or damaged.	Lubricate the clutch release bearing. If the noise persists, install a new clutch cover.
The flywheel pilot bearing is dry or damaged.	Replace the flywheel pilot bearing.
The bridge of the release yoke is hitting the clutch cover (an over-stroking condition exists).	Check for a worn, broken or missing clutch brake. Also, check the release yoke and input-shaft bearing cap for wear. Replace any worn parts.
The release yoke fingers are hitting the clutch cover.	Check if the release bearing, clutch cover, or release yoke fingers are worn or broken. Replace worn parts.
The clutch inspection cover is not installed.	Re-install the clutch inspection cover.
The sleeve bushings are worn.	Investigate for any side-loading conditions on the release bearing housing. If there is a side-loading condition, determine its cause. Also, before installing the new clutch, make sure that the side-loading condition has been corrected.
The clutch linkage is rattling excessively.	Clean, lubricate and reassemble or replace missing/worn parts.
An idle gear rattle is coming from the transmission.	Specify low-vibration driven discs. Check the engine for correct idle speed. For procedures, consult the engine manufacturer's manual.

Problem—The Clutch Rattles or Is Noisy	
Possible Cause	**Remedy**
The damper spring cover of the driven disc assembly is interfering with the flywheel.	Install the correct clutch assembly.
The rivets of the rear driven disc are interfering with the retainer assembly (Easy-Pedal only).	Adjust the clutch internally (via the adjustment bolt). For procedures, see **Subject 100**.

Problem—The Clutch Vibrates

Problem—The Clutch Vibrates	
Possible Cause	**Remedy**
The flywheel is loose.	Retighten the flywheel mounting bolts to the proper specifications.
The universal joints are worn.	Replace the worn parts.
The driveshaft is not properly phased.	Investigate and correct the phasing of the driveshaft.
The driveshaft is not balanced.	Balance and straighten the driveshaft.
The driveline angles are incorrect.	Shim the drivetrain components to equalize universal joint angles.
The flywheel is not balanced.	Balance the flywheel.
The pilot area of the clutch is not completely seated into the flywheel.	Ensure that no dirt, burrs, etc., are preventing the clutch cover from completely seating into the flywheel mounting surface.
The engine mounts are loose, damaged, or worn out.	Replace any worn or damaged parts. Retighten all bolts to proper specifications.
The engine is misfiring.	The engine is not in tune. To correct the problem, see the engine manufacturer's manual.
There is excessive flywheel runout.	Repair or replace the flywheel. For procedures, see the engine manufacturer's manual.
The rivets of the rear driven disc are interfering with the retainer assembly (Easy-Pedal only).	Adjust the clutch internally (via the adjustment bolt). For procedures, see **Subject 100**.

Problem—The Clutch Needs Frequent Adjustments

Problem—The Clutch Needs Frequent Adjustments	
Possible Cause	**Remedy**
The release yoke free-travel is insufficient.	After first adjusting the clutch for 1/2 to 9/16 inch (12.7 to 14.3 mm) release bearing travel, adjust the clutch linkage to obtain release yoke free-travel of 0.105 to 0.145 inch (2.7 to 3.7 mm).
The clutch specification is incorrect.	Check the clutch specifications in **Subject 400**. Install a new clutch with the proper specifications, if necessary.
The cross shafts and/or clutch linkage system is worn.	Investigate the entire clutch linkage system to determine if it is binding or operating sporadically and/or worn excessively.
The clutch driven discs are worn down to the rivets.	Install a new clutch. For procedures, see **Subject 130**.

Troubleshooting

Problem—The Clutch Needs Frequent Adjustments	
Possible Cause	**Remedy**
The crankshaft has excessive end play.	Repair or replace the crankshaft. Consult the engine manufacturer's manual for procedures.

Problem—The Clutch Slips

Problem—The Clutch Slips	
Possible Cause	**Remedy**
The clutch pedal has no free travel.	Readjust the clutch.
The clutch is overloaded.	Verify that the proper clutch has been specified for the particular vehicle application.
The release mechanism is binding.	Free up the release mechanism and linkage. Also, check the clutch linkage adjustment.
The driven disc faces are coated with oil or grease.	Replace the driven disc assembly.
The driver is riding the clutch pedal.	Use correct driving procedures.
The input shaft spline is worn.	Replace the input shaft.

Problem—The Clutch Grabs or Chatters

Problem—The Clutch Grabs or Chatters	
Possible Cause	**Remedy**
The clutch is worn out.	Replace the clutch and all worn components.
The linkage system is not operating freely.	Check the clutch linkage for binding or excessive wear. Replace all worn parts.
The driven disc faces are coated with oil or grease.	Replace the driven disc assembly.
The engine mounts are loose.	Retighten the engine mounts to manufacturer's specifications.
The release yoke fingers and/or the release bearing wear pads are worn excessively.	Replace all the worn parts.

All Heavy-Duty Clutches

Clutch Torque Values in lbf·ft (N·m)				
Description	**Size**	**Grade**	**Easy-Pedal™**	**Solo™ Heavy-Duty**
Mounting Bolts, Clutch Cover to Flywheel	7/16–14 x 2-1/4	5	40–50 (54–68)	40–50 (54–68)

Table 1, Clutch Torque Values

Clutch Adjustments		
Dimension	**Definition**	**Specification in inch (mm)**
Release Bearing Travel (internal adjustment)	The distance between the release bearing and the clutch brake.	1/2–9/16 (12.7–14.3)
Release Yoke Free-Travel (linkage adjustment)	The distance between the release yoke fingers and the release bearing wear pads.	0.105–0.145 (2.7–3.7)
Clutch Brake Squeeze (pedal adjustment)	The movement of the clutch pedal from the time that the clutch brake contacts the release bearing until the pedal reaches the end of its stroke.	1/2–1 (12.7–25.4)

Table 2, Clutch Adjustments

Clutch Inspection Tolerances			
Measurement	**Dial Indicator at**	**Gauge Finger at**	**Maximum Runout in inch (mm)**
Flywheel Face Runout	Flywheel Housing	Flywheel Face	0.008 (0.20)
Pilot Bearing Bore Runout	Flywheel Housing	Pilot Bearing Bore	0.005 (0.13)
Flywheel Housing Bore Runout	Crankshaft	Flywheel Housing Bore	0.008 (0.20)
Flywheel Housing Face Runout	Flywheel Outer Diameter	Flywheel Housing Face	0.008 (0.20)

Table 3, Clutch Inspection Tolerances

Minimum Flywheel Bores	
Disc Type	**Minimum Flywheel Bore in inch (mm)**
10-Spring	8.562 (217.48)
9-Spring	9.750 (247.65)
8-Spring	7.250 (184.15)
7-Spring	9.750 (247.65)
6-Spring	9.750 (247.65)

Table 4, Minimum Flywheel Bores

Solo Heavy-Duty Clutches

Specifications

Solo Heavy-Duty Clutch Specifications					
Solo Part Number		Flywheel Bore in inch (mm)	Damper Style	No. of Springs	No. of Facings
Standard Yoke	Roller Yoke				
109701–81	N/A	7.0 (178)	Free Travel	8	4
109701–74	N/A	8.5 (216)	Free Travel	10	4
109701–82	109705–82Y	10.0 (254)	Low Rate	7	4
109701–20	109705–20Y	10.0 (254)	VCTplus	7	6
109701–25	109705–25Y	10.0 (254)	VCTplus	7	6
N/A	109706–32Y	10.0 (254)	VCTplus	7	6

Table 5, Solo Heavy-Duty Clutch Specifications

Solo Heavy-Duty Clutch Capacity				
Solo Part Number		Plate Load in lbf (N)	Torque in lbf·ft (N·m)*	Pressure Spring Color Code
Standard Yoke	Roller Yoke			
109701–81	N/A	3600 (16 000)	1400 (2000)	White
109701–74	N/A	3600 (16 000)	1650 (2235)	Plain
109701–82	109705–82Y	4000 (18 000)	1700 (2305)	Plain
109701–20	109705–20Y	4000 (18 000)	1860 (2520)	Red
109701–25	109705–25Y	4000 (18 000)	2050 (2780)	White
N/A	109706–32Y	4000 (18 000)	2250 (3050)	Green

* The clutch torque rating must equal or exceed the rated torque of the engine.

Table 6, Solo Heavy-Duty Clutch Capacity

Solo Clutch Pressure Plate Wear Pin Resetting	
Component	Depth in inch (mm)
Pressure Plate Face	0.525 (13.3)

Table 7, Solo Clutch Pressure Plate Wear Pin Resetting

Easy-Pedal Clutches

Easy-Pedal Clutch Specifications				
Easy-Pedal Part Number	Flywheel Bore in inch (mm)	Damper Style	No. of Springs	No. of Facings
108391–81	7.0 (178)	Free Travel	8	4
108391–74B	8.5 (216)	Free Travel	10	4
108925–82B	10.0 (254)	Low Rate	7	4
108925–20	10.0 (254)	VCTplus	7	6
108925–25	10.0 (254)	VCTplus	7	6

Table 8, Easy-Pedal Clutch Specifications

Specifications

Easy-Pedal Clutch Capacity			
Easy-Pedal Part Number	**Plate Load in lbf (N)**	**Torque in lbf·ft (N·m) ***	**Pressure Spring Color Code**
108391–81B	3600 (16 000)	1400 (2000)	White
108391–74B	3600 (16 000)	1650 (2235)	Plain
108925–82B	4000 (18 000)	1700 (2305)	Plain
108925–20	4000 (18 000)	1860 (2520)	Red
108925–25	4000 (18 000)	2050 (2780)	White

* The clutch torque rating must equal or exceed the rated torque of the engine.

Table 9, Easy-Pedal 15-1/2 Inch Clutch Capacity

Easy-Pedal Clutch Component Dimensions		
Dimension	**Standard Duty in inch (mm)**	**Super Duty in inch (mm)**
Driven Disc Thickness (new)	0.450 (11.43)	0.360 (9.43)
Intermediate Plate Thickness (new)	0.580–0.630 (14.73–16.00)	0.750–0.810 (19.05–20.57)

Table 10, Easy-Pedal Clutch Component Dimensions

General Description and Principles of Operation

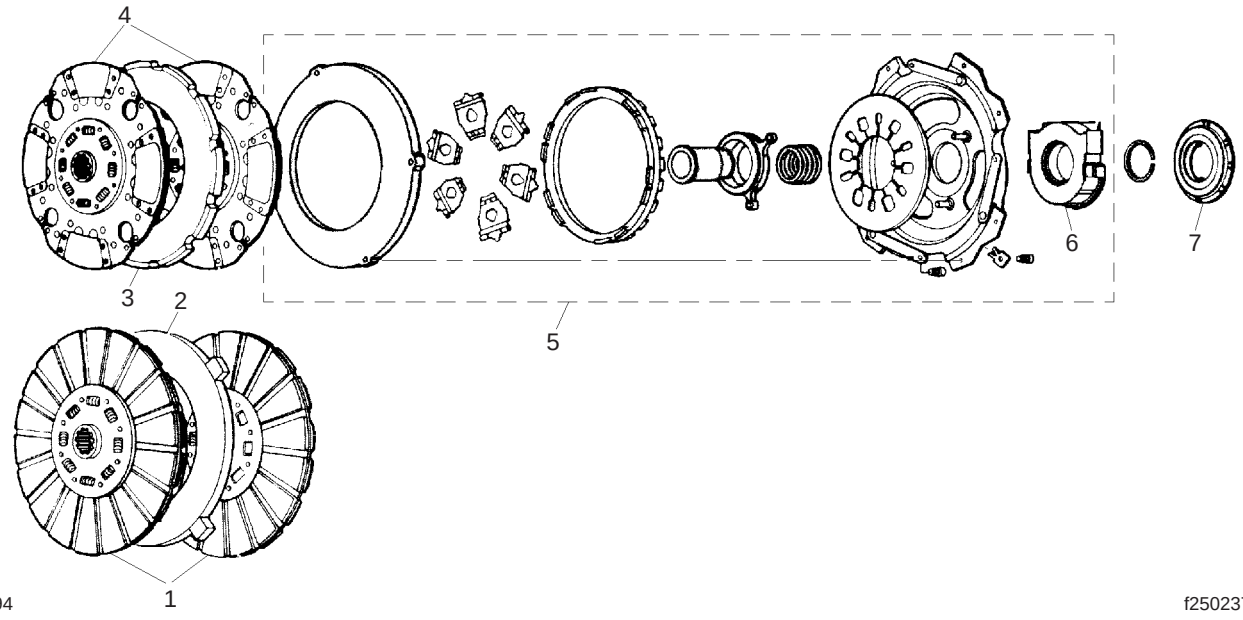
Rockwell clutches (**Fig. 1**) are available in 14-inch and 15-1/2 inch models in Freightliner trucks. An identification plate is located on the front cover. Rockwell clutches feature the following design characteristics:

- Two-plate
- Diaphragm-spring
- Pull-type
- Dry-disc
- Eight-hole installation pattern

mounted on the flywheel. In the 15-1/2 inch model, the center plate has tabs that fit into slots on the clutch cover assembly.

A splined transmission input shaft projects through the cover assembly and driven discs and rests in a pilot bearing in the center of the flywheel. The splined hubs of the driven discs mesh with the splined input shaft to transmit power from the engine to the transmission. The rest of the clutch assembly can spin freely around the input shaft when the clutch pedal is depressed.

A clutch brake stops the transmission gears from rotating when the truck is stopped and when shifting into first or reverse gears. This lets the gears engage quickly without gear clash.



1. Molded Organic Discs
2. Center Plate (15-1/2 Inch Clutch)
3. Center Plate (14-Inch Clutch)
4. Ceramic Discs
5. Pressure Plate and Cover Assembly
6. Release Bearing
7. Clutch Brake

Fig. 1, Rockwell Two-Plate Clutch

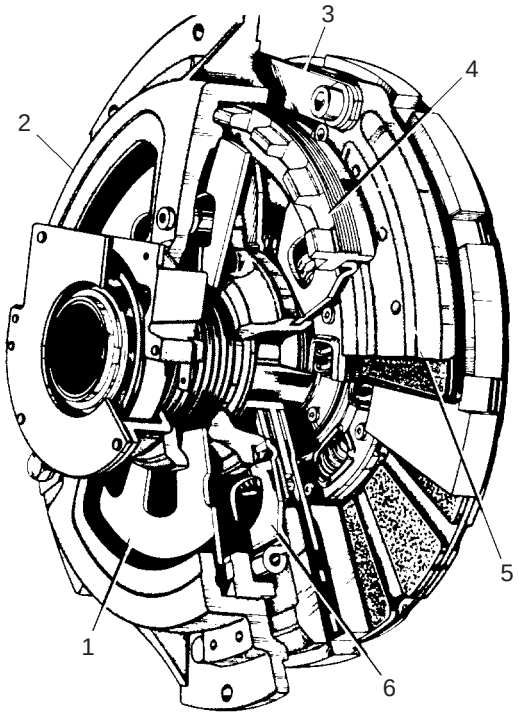
Mounted directly on the flywheel, the clutch cover assembly houses most of the components, including the pressure plate. A diaphragm-type spring provides the force necessary to push the pressure plate forward and engage the clutch.

In the 14-inch model, the center plate, which separates the driven discs, is carried on drive pins

The release bearing assembly transfers the movement of the clutch linkage to engage or disengage the clutch. The release bearing assembly is available with a grease fitting or as a "lubed for life" assembly. Ball bearings permit the release bearing to rotate freely. A coil spring is installed on the sleeve between the release bearing and the hub. The coil spring

General Description and Principles of Operation

holds the sleeve on the retainer in a "ball joint" arrangement. This prevents vibration and allows for minor misalignment that may occur between the transmission and the engine due to tolerances between the mounting surface dimensions.



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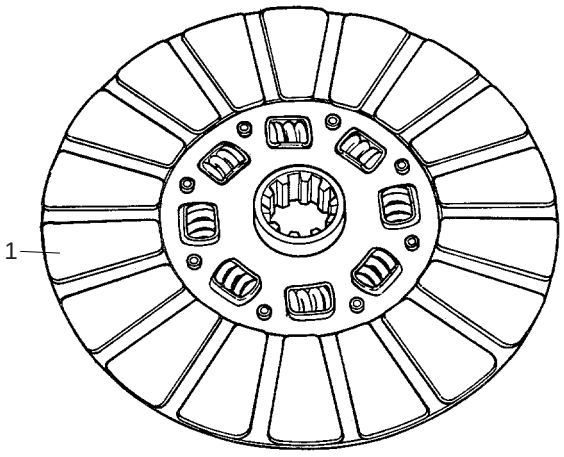
1. Diaphragm Spring
2. Cover
3. Strap
4. Adjusting Ring
5. Pressure Plate
6. Lever

Fig. 2, Clutch Components

The pressure plate and cover assembly apply the force necessary to engage the clutch. The following parts are in the pressure plate and cover assembly. **See Fig. 2**.

- The *cover* is the housing for the diaphragm spring, adjusting ring, levers, retainer, and the release bearing sleeve. Three holes in the cover provide air flow to remove heat from the clutch.
- The *diaphragm spring* is a one-piece unit that produces the pressure to lock the discs between the pressure plate, the center plate, and the flywheel. The spring is located and held in the cover by the retainer. The diaphragm spring design reduces the clutch pedal effort as compared to a coil spring design.
- Six *levers* connect the cover assembly to the release bearing sleeve. The levers multiply and transfer the force of the diaphragm spring from the retainer to the pressure plate.
- The *adjusting ring*, located inside the cover and in front of the pressure plate, controls the release bearing clearance. The clearance must be adjusted periodically to compensate for clutch lining wear.
- The *pressure plate* applies the force from the diaphragm spring and locks the clutch discs between the center plate and the flywheel.

The clutch discs are splined to allow movement along the transmission input shaft. Power is transmitted from the flywheel, pressure plate, and center plate through the discs to the transmission. Both dampened and rigid discs are available. **See Fig. 3** and **Fig. 4**. Dampened clutch discs absorb vibration with spring washers, friction material, and co-axial torsion springs. The co-axial torsion springs also absorb torque shock during engagement. Rigid discs do not use any material to absorb vibration or torque shock.



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1. Molded Organic Lining

Fig. 3, Dampened Disc

Two kinds of lining are available on the discs: molded organic linings (on rigid and dampened discs) and ceramic linings (on dampened discs only).

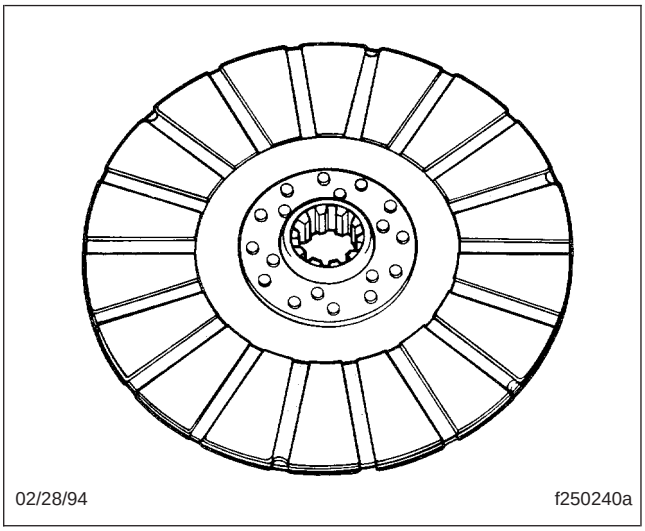
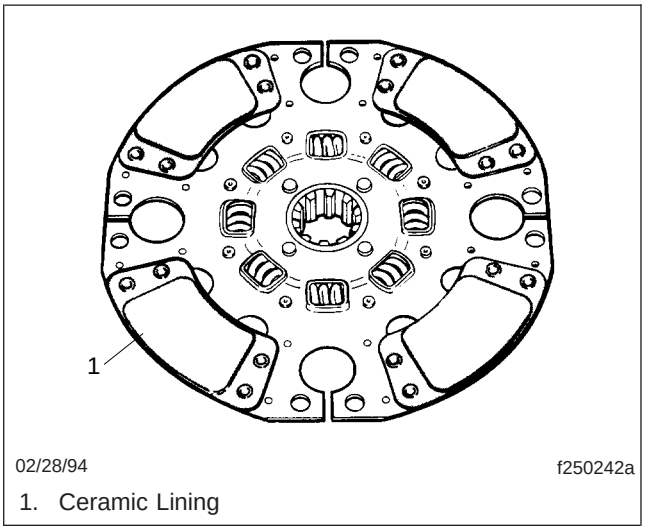


Fig. 4, Rigid Disc

Molded organic linings (**Fig. 3**), are made from a non-asbestos material. The organic material is integrally molded directly onto the disc. The groove pattern of the molded organic lining removes dust formed during lining wear and also promotes cooling. Clutch engagement with the organic lining is less abrupt than with the ceramic lining.

Ceramic disc linings (**Fig. 5**), are made from ceramic and bronze material. Rivets fasten the ceramic lining to the disc. The ceramic lining provides positive clutch engagement.



1. Ceramic Lining

Fig. 5, Ceramic-Lined Disc

The center plate increases the service life of the clutch by increasing the surface area for power transfer. The 14-inch clutch center plate is driven by pins in the flywheel housing, which fit into slots on the plate. The 15-1/2 inch clutch center plate is driven by tabs on the plate which fit into slots on the clutch cover.

Clutch Internal Adjustments

NOTE: Clutch linkage adjustment is required only after repair or replacement of the clutch or clutch linkage components. Refer to the clutch linkage section in this manual for procedures.

Internal clutch adjustments should be done whenever:

- the clutch is removed or installed
- any component of the clutch linkage is serviced
- the free travel of the clutch pedal is less than 1/2 inch (13 mm).

Make sure of the following before adjusting the clutch:

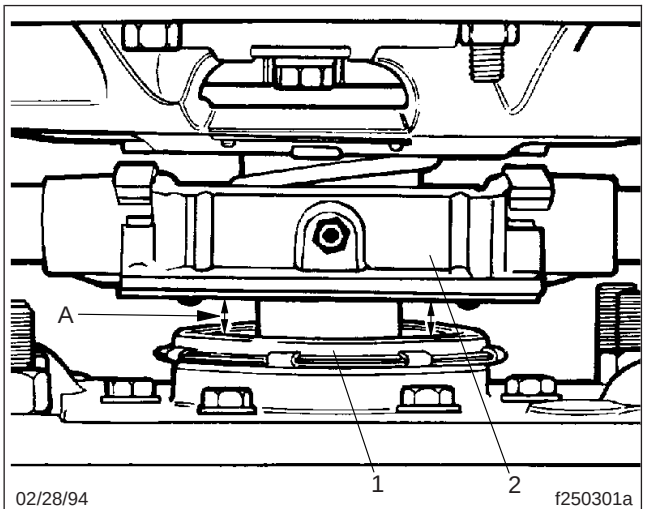
- The clutch system is in good condition.
- The linkage is tight but moves freely during operation.
- There is no "false" free travel. Keep the clutch lever from moving and depress the clutch pedal. If the pedal moves more than 1/2 inch (13 mm), "false free travel" is in the linkage. Inspect the linkage and all pivot points for wear or damage. Repair or replace worn or damaged parts.
- The release fork moves when the clutch pedal moves.

Release-Bearing Clearance Check

1. Remove the inspection hole cover on the clutch housing.
2. Measure the distance between the end of the release bearing and the clutch brake. **See Fig. 1.** This distance must be 1/2 to 9/16 inch (12.7 to 14.3 mm).

NOTE: While checking this dimension, pull the release bearing toward the transmission, using your hand or a screwdriver.

IMPORTANT: An inspection tool A02–12419 (available through the PDCs) can be used to check the distance between the release bearing and the clutch brake. **See Fig. 2.** One end of the tool has green tape on it and is 0.50 inch



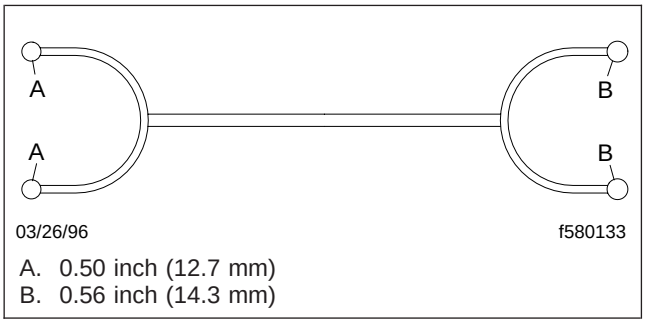
A = 1/2 to 9/16 inch (12.7 to 14.3 mm) Clearance

1. Clutch Brake
2. Release Bearing

Fig. 1, Measure the Distance Between the Release Bearing and the Clutch Brake

(12.7 mm) in diameter; the other end has blue tape on it and is 0.56 inch (14.3 mm) in diameter.

3. If using tool A02–12419 to check the distance between the release bearing and the clutch brake, position the tool so that the legs straddle the transmission input shaft. Check the gap with both ends of the tool as follows:



A. 0.50 inch (12.7 mm)
B. 0.56 inch (14.3 mm)

Fig. 2, Inspection Tool A02-12419

3.1 Insert the blue 0.56-inch (14.3-mm) end. If it fits loosely the gap is too wide and adjustment is needed. Go to the next step.

3.2 If the blue 0.56-inch (14.3-mm) end can't be inserted in the gap, then try to insert

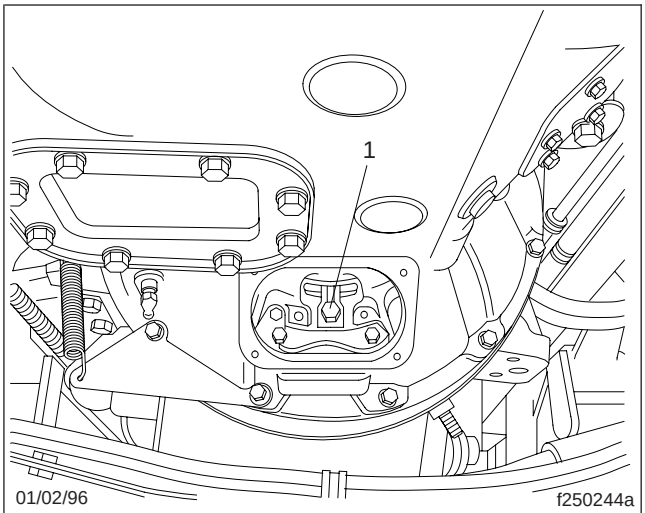
Clutch Internal Adjustments

the green 0.50-inch (12.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.

3.3 If the green end of the tool can't be inserted in the gap, adjustment is needed. Go to the next step.

4. If the release bearing clearance is not correct, adjust the clutch.

4.1 Turn the flywheel so that the lock plate is seen through the inspection cover. **See Fig. 3.**



1. Lock Plate

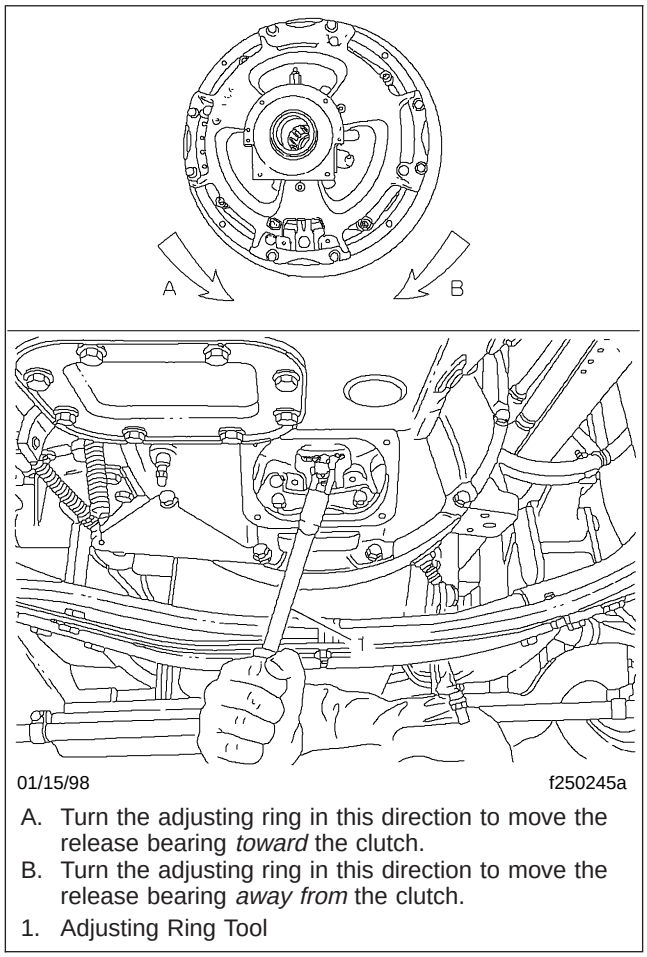
Fig. 3, Remove the Lock Plate

NOTE: Do not use the starter to move the flywheel. Turn the crankshaft with a socket wrench on the front pulley. If the front pulley is difficult to turn, use a spanner wrench on the teeth of the flywheel. See the engine manufacturer's manual for further information.

4.2 Push the clutch pedal to the bottom of its travel. Have another person hold the pedal at the bottom of its travel (or use a block of wood to hold the pedal).

4.3 Remove the capscrew and lockwasher that fasten the lock plate to the clutch cover. **See Fig. 3.**

4.4 Turn the adjusting ring to obtain the specified release bearing clearance. Using a screwdriver or an adjusting tool as a lever against the notches in the ring, move the adjusting ring. **See Fig. 4.** When the adjusting ring is moved one notch, the release bearing will move 1/32 inch (about 0.5 mm).



A. Turn the adjusting ring in this direction to move the release bearing *toward* the clutch.
B. Turn the adjusting ring in this direction to move the release bearing *away from* the clutch.
1. Adjusting Ring Tool

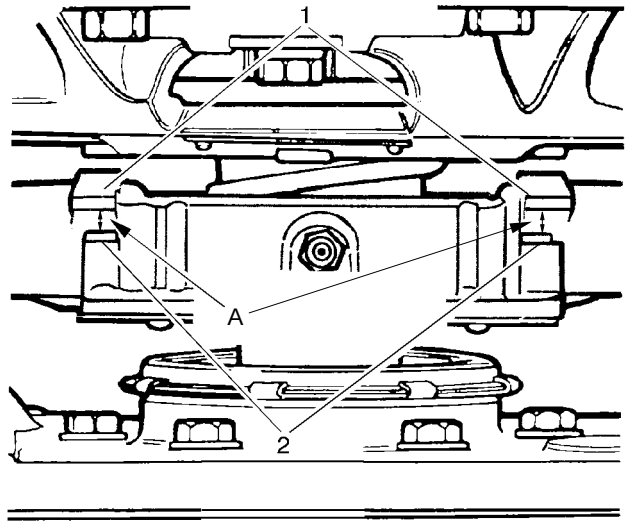
Fig. 4, Turn the Adjusting Ring

NOTE: The adjusting tool is available from: Kent-Moore Tools, part number J 36216; Owatonna Tools, part number 7028; or, Snap-on Tools, part number GA454.

4.5 Install the lock plate. Install the capscrew that fastens the lock plate to the clutch cover. Tighten the capscrew 25 to 30 lbf·ft (34 to 40 N·m).

4.6 Release the clutch pedal.

5. Check the clearance between the tips of the release fork and the bosses on the release bearing. The distance must be 0.105 to 0.145 inch (2.7 to 3.7 mm). **See Fig. 5 .** If necessary, adjust the clutch linkage.



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NOTE: A = 0.105–0.145 inch (2.7–3.7 mm) Clearance

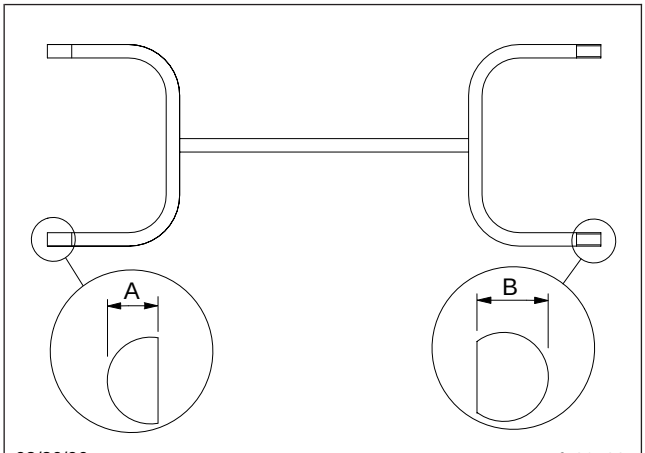
1. Release Fork
2. Boss on Release Bearing

Fig. 5, Check the Clearance

NOTE: The pedal must be released to check the release bearing clearance.

IMPORTANT: An inspection tool A02–12254 (available through the PDCs) can be used to check the distance between the bosses on the release bearing and the tips of the release fork (free travel). **See Fig. 6.**The legs on one end of the tool have green tape on them and are 0.105 inch (2.7 mm) thick; the legs on the other end have blue tape on them and are 0.145 inch (3.7 mm) thick.

6. If using tool A02–12254 to check the distance between the release bearing and the release fork, position the tool so it straddles the fork to ensure that there won't be any misalignment. Check the distance with both ends of the tool as follows:



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A. 0.105 inch (2.7 mm)
B. 0.145 inch (3.7 mm)

Fig. 6, Inspection Tool A02-12254

6.1 Insert the blue 0.145-inch (3.7-mm) end. If it fits loosely the gap is too wide and adjustment is needed. Go to the section on clutch linkage adjustment in this group.

6.2 If the blue 0.145-inch (3.7-mm) end can't be inserted in the gap, then try to insert the green 0.105-inch (2.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.

6.3 If the green end of the tool can't be inserted in the gap, adjustment is needed. Go to the section on clutch linkage adjustment in this group.

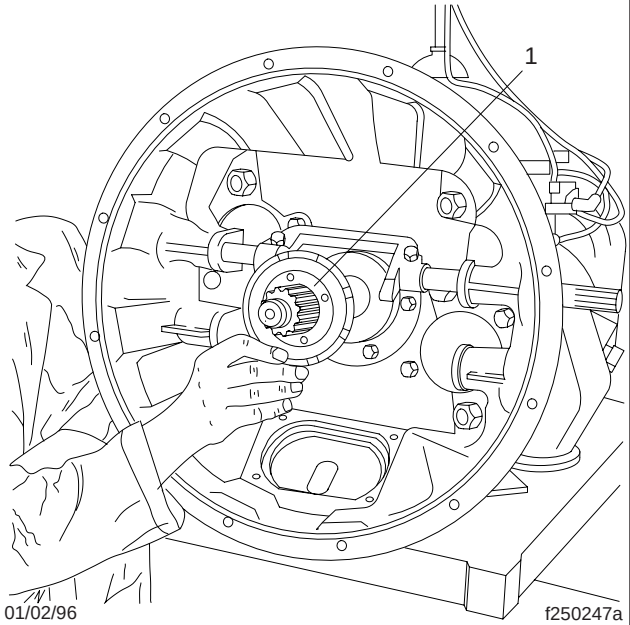
Removal

1. Remove the transmission. Follow the procedures in the **transmission group** of this manual.

CAUTION

CAUTION: Do not let the rear of the transmission drop, and do not let the transmission hang unsupported by the input shaft in the pilot bearing bore in the flywheel. Taking these precautions will prevent damage to the clutch assembly and the pilot bearing.

2. Remove the clutch brake assembly from the transmission input shaft. **See Fig. 1**.

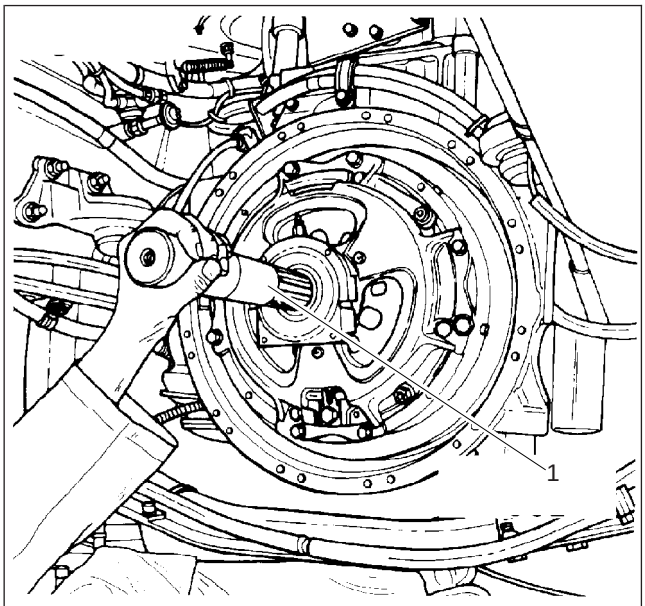


1. Clutch Brake

Fig. 1

3. Install a clutch alignment tool through the clutch and into the flywheel pilot bearing to support the clutch assembly during removal. Use the correct tool so that the splines of the tool match the splines in the clutch. **See Fig. 2**.

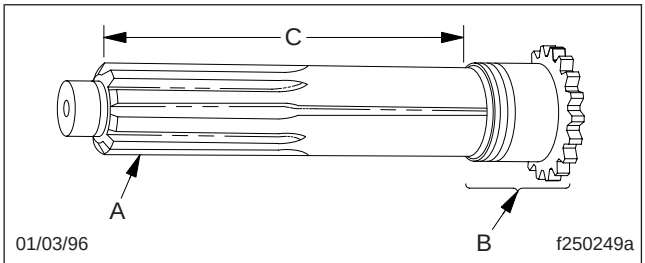
NOTE: If an alignment tool is not available, use an input shaft from a manual transmission. Remove the gear from the end of the input shaft. **See Fig. 3**.



1. Alignment Tool

Fig. 2

4. Remove the top two bolts that fasten the pressure plate and cover assembly to the flywheel. Install two guide studs in the holes. **See Fig. 4**. The studs can be made by removing the head from two capscrews. Use 3/8-inch capscrews for the 14-inch clutch and 7/16-inch capscrews for the 15-1/2 inch clutch.

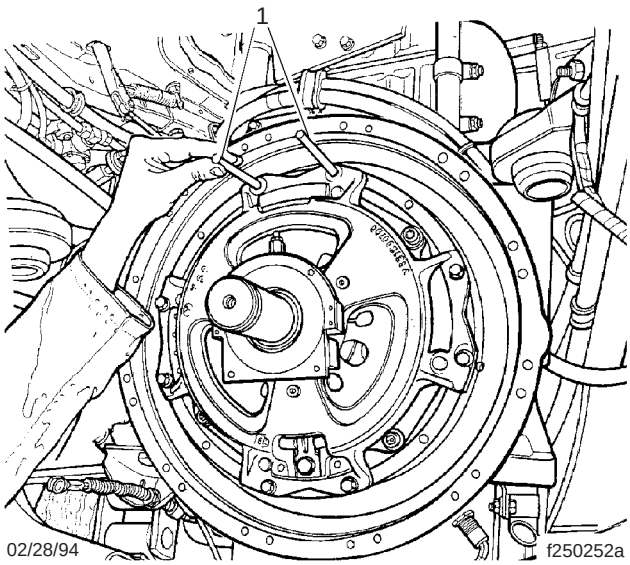


A. Make sure the splines are not damaged.
B. Remove the gear assembly from an input shaft.
C. 13 Inches (33 cm)

Fig. 3

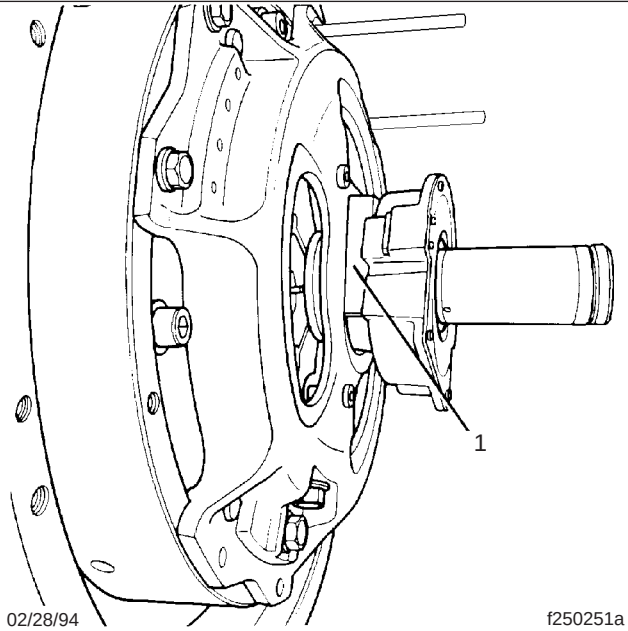
5. Make two wooden spacer blocks 1/2 to 5/8 inch (13 to 16 mm) thick. Insert them between the release bearing assembly and the clutch cover. The wooden spacer blocks ease removal and installation of the clutch. **See Fig. 5**.

Clutch Removal



1. Guide Studs

Fig. 4



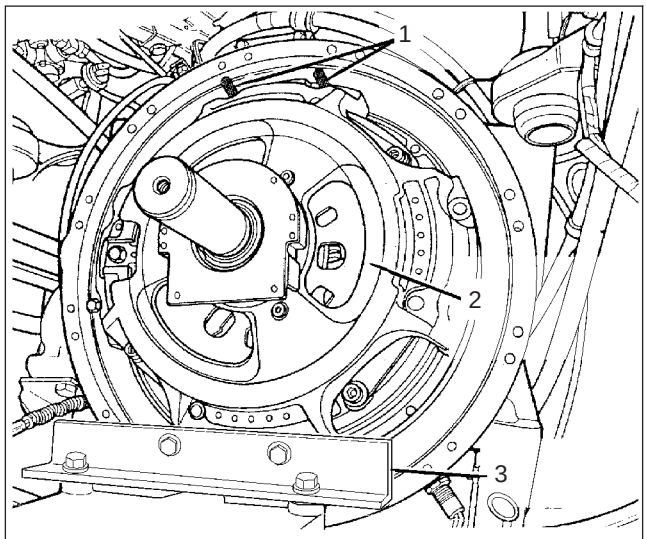
1. 1/2 to 5/8-inch (13 to 16 mm) Spacers

Fig. 5

WARNING

WARNING: The pressure plate and cover assembly is heavy and should be removed only with a lifting device. If the assembly is lifted improperly or dropped, it could cause serious physical injury.

6. On 15-1/2 inch clutches, connect a lifting device to the pressure plate and cover assembly because of the weight. **See Fig. 6**.



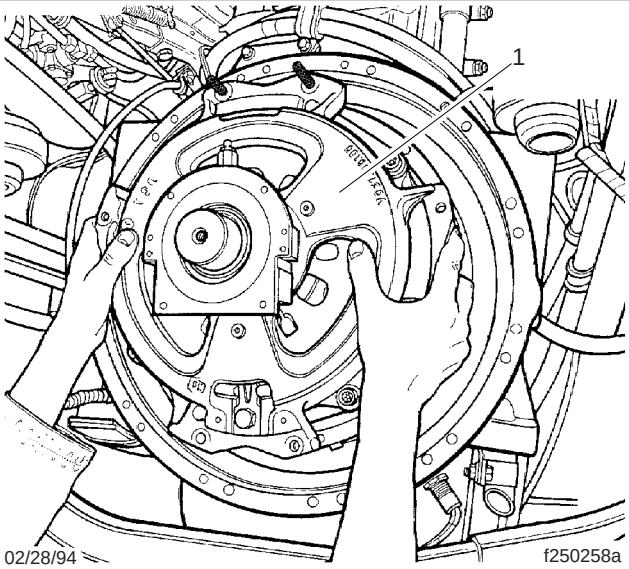
1. Guide Studs
2. 15-1/2 Inch Clutch Assembly
3. Lifting Device

Fig. 6

7. Remove the remaining bolts that fasten the pressure plate and cover assembly to the flywheel.

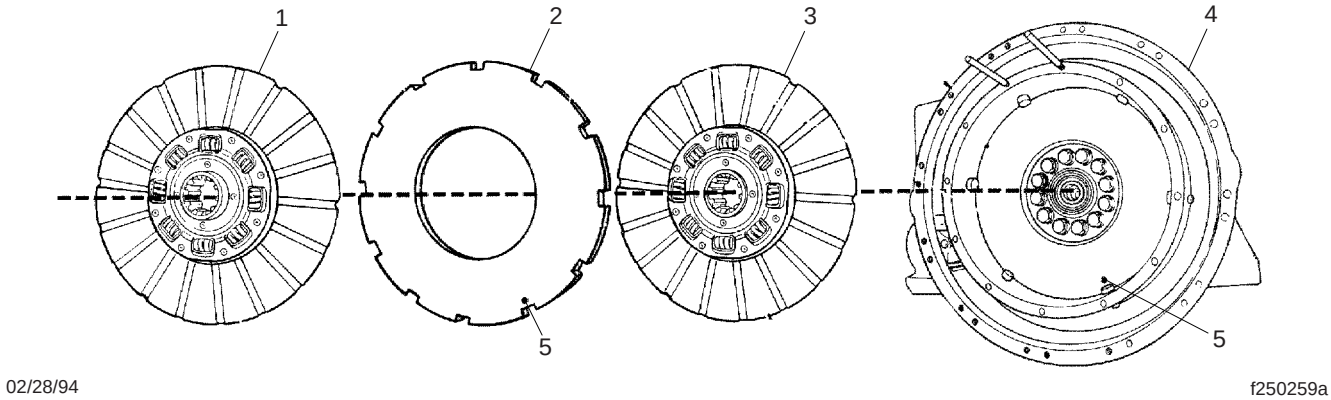
NOTE: When removing the 15-1/2 inch clutch, the discs and the pressure plate can stay in the cover.

8. Lift the pressure plate and cover assembly over the alignment tool and off the flywheel. **See Fig. 7**.
9. Remove the rear disc, the center plate, and the front disc. **See Fig. 8**.
10. Remove the alignment tool from the flywheel.
11. Whenever the clutch assembly is serviced or the engine is removed, the pilot bearing in the fly-



1. 14-Inch Clutch Housing

Fig. 7

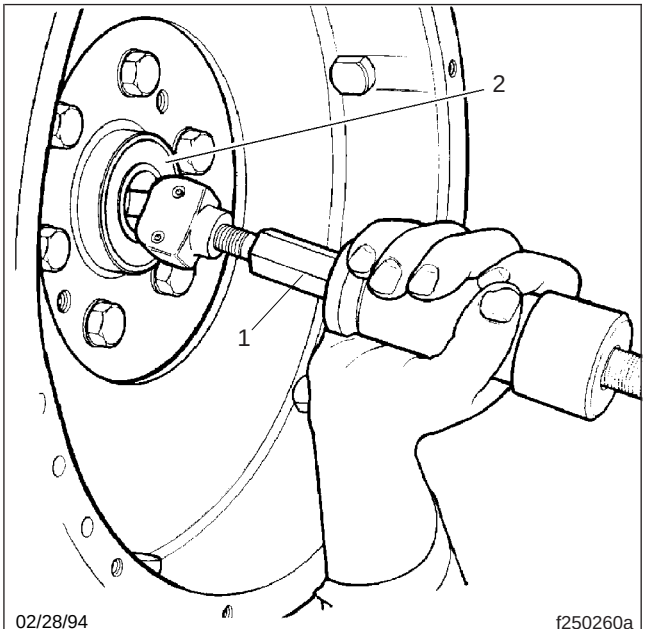


1. Front Clutch Disc
2. Center Plate
3. Rear Clutch Disc
4. Flywheel Housing
5. Alignment Mark

Fig. 8

wheel should be removed and replaced. Use an appropriate internal puller to remove the pilot bearing. Discard the pilot bearing. **See Fig. 9**.

Clutch Removal



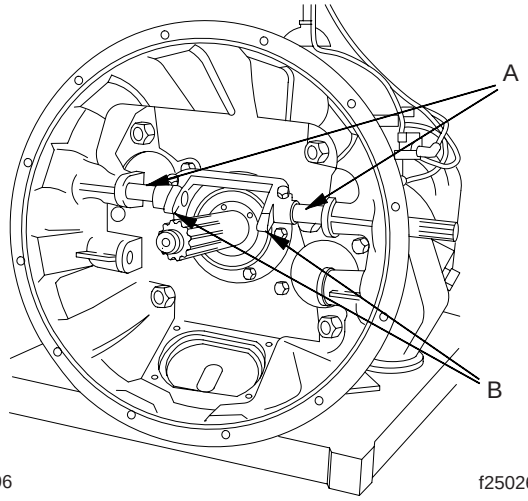
1. Puller Tool
2. Pilot Bearing

Fig. 9

Clutch Inspection

1. Remove the clutch from the vehicle. **Refer to Subject 100** for instructions.
2. Inspect the release fork and the cross shaft. **See Fig. 1**. Make sure the release fork os straight and the tips of the fork are not worn or damaged. Replace forks that are worn or damaged.

   Make sure the cross shaft rotates freely and doesn't have any side-to-side movement in the transmission housing. If used, inspect the bushings for the shaft in the housing. Replace any parts that are worn or damaged.



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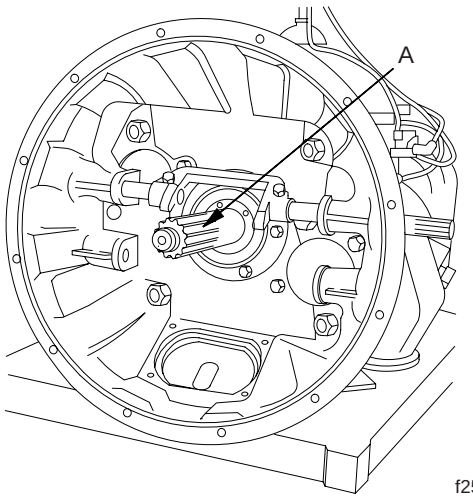
A. The cross shaft must rotate freely.
B. The tips on the fork must not be worn or damaged.

Fig. 1

3. Inspect the splines on the input shaft. **See Fig. 2**. Make sure the splines are not worn or damaged. Inspect the release bearing area of travel for damage. Using an emery cloth, remove small scratches from the input shaft. If the input shaft is worn or damaged, replace it. Any wear or damage on the input shaft causes the clutch to work incorrectly.



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A. The splines must not be worn or damaged.

Fig. 2

⚠ WARNING

Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

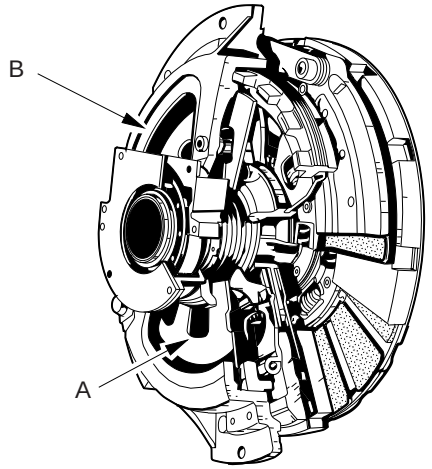
4. Remove dirt and contamination from the pressure plate and cover assembly with non-petroleum based cleaning solvents.
5. Inspect the cover for wear and damage. Make sure the diaphragm spring inside the cover is not broken. **See Fig. 3**. If the diaphragm spring is broken, the clutch cover must be disassembled to replace the spring.
6. Inspect the pressure plate.

   6.1 Visually check the pressure plate for wear or damage. **See Fig. 4**. If the plate is cracked, replace it. Heat marks are normal, and can usually be removed with an emery cloth. If the heat marks can't be removed, replace the pressure plate.

   6.2 Put the pressure plate and cover assembly on a bench with the plate facing up.

   6.3 Using a caliper, measure any scratches or scoring on the pressure plate. **See Fig. 5**. If the damage to the surface of the plate is

Clutch Inspection



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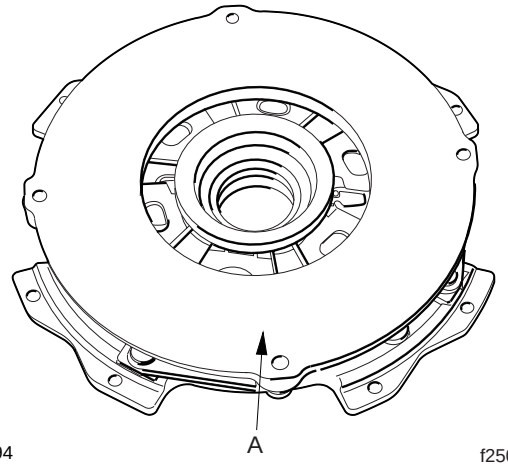
A. Make sure the diaphragm spring is not broken.
B. Make sure the cover is not worn or damaged.

Fig. 3



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A. Inspect the pressure plate surface for wear, cracks, or heat damage.

Fig. 4

more than 0.015 inch (0.38 mm), replace the pressure plate.

6.4 Make sure the surface of the pressure plate is flat. Put a straightedge on the surface of the pressure plate, making sure it crosses the center of the plate. **See Fig. 6**. Using feeler gauge, measure each gap that appears between the straightedge and the pressure plate. Rotate the straightedge through at least four positions. If any gap is more than 0.004 inch (0.10 mm), replace the pressure plate.

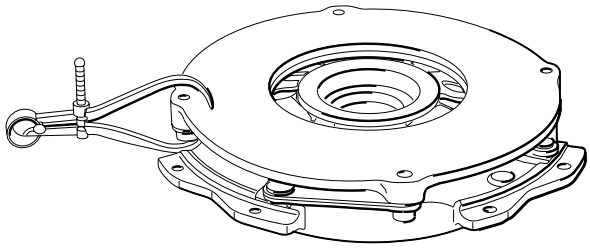

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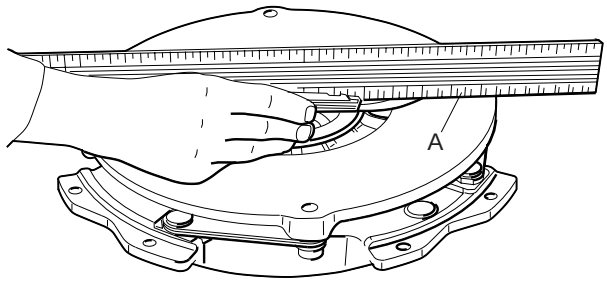
Fig. 5



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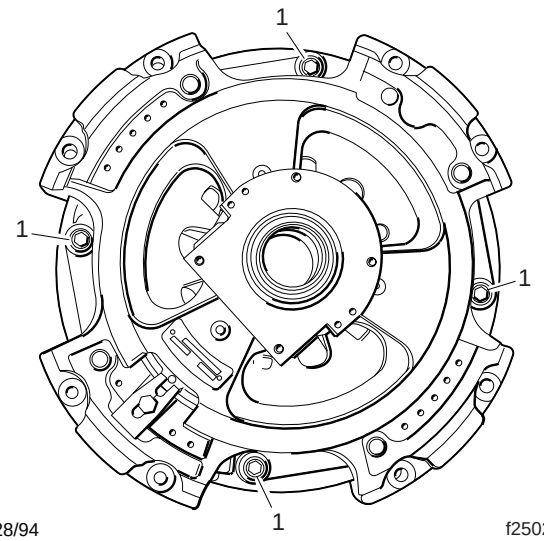
A. Pressure plate flatness gap must not be more than 0.004 inch (0.10 mm).

Fig. 6

6.5 Measure the runout of the pressure plate to make sure the surfaces are parallel to each other. Put marks on a capscrew, strap, and pressure plate location to ensure that the pressure plate is installed in the original position on the cover. Remove the capscrews that fasten the pressure plate to the strap. **See Fig. 7**. Put the pressure plate on a bench so that the smooth surface is up. Put the base of a dial indicator inside the center of the plate.

See Fig. 8. Put the tip of the dial indicator on the surface of the plate. Set the dial indicator to zero. Rotate the dial indicator one complete turn around the surface of the pressure plate. If the reading on the

indicator is more than 0.002 inch (0.05 mm), replace the pressure plate.



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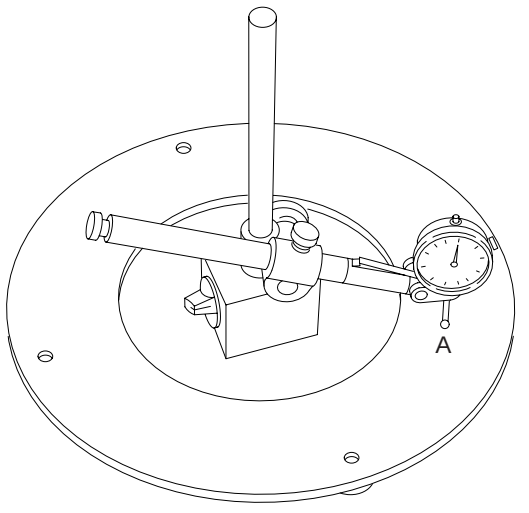
1. Capscrews

Fig. 7



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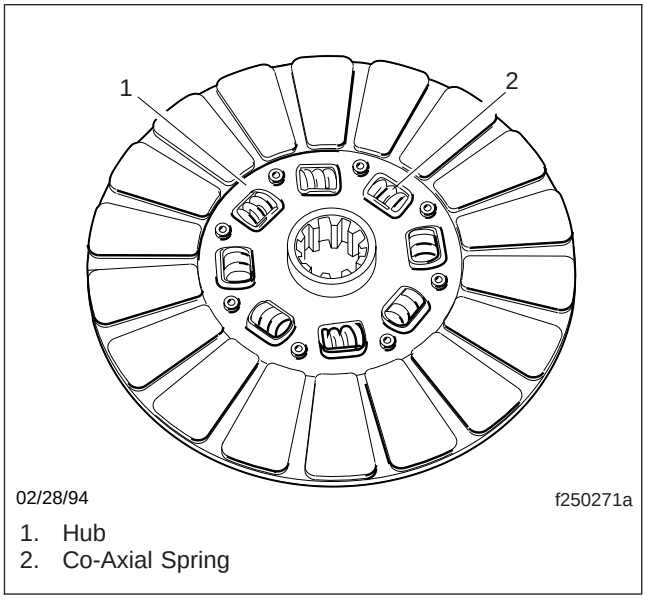
A. Pressure plate runout must not be more than 0.002 inch (0.05 mm).

Fig. 8

7. Inspect the clutch discs.

7.1 Visually check for wear or damage. If any disc is worn, replace it.

7.2 Make sure the co-axial springs are not loose in the hub. **See Fig. 9.** Springs that rattle are not necessarily loose; springs that have any movement are. If any disc has loose springs, replace it.



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1. Hub
2. Co-Axial Spring

Fig. 9

7.3 Make sure the splines in the hub are not damaged. Make sure the hub is fastened to the disc. Replace any disc that is damaged.

⚠ WARNING

Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

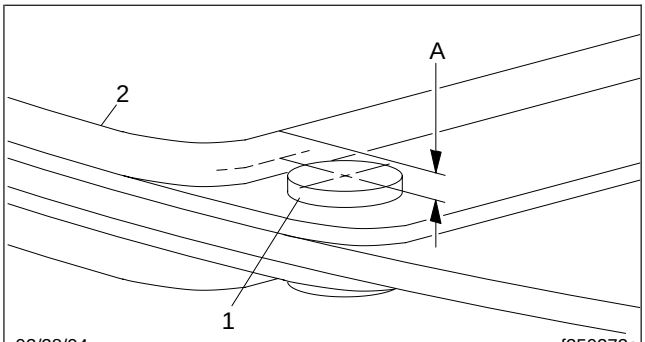
7.4 Using a cleaning solvent with a non-petroleum base, remove grease and oil from the discs. If the grease and oil cannot be removed, replace the disc.

7.5 Ceramic linings are fastened to the disc with rivets. On clutches with ceramic linings, replace the disc if the lining is loose,

Clutch Inspection

damaged, or worn to the top of the rivets. **See Fig. 10.**

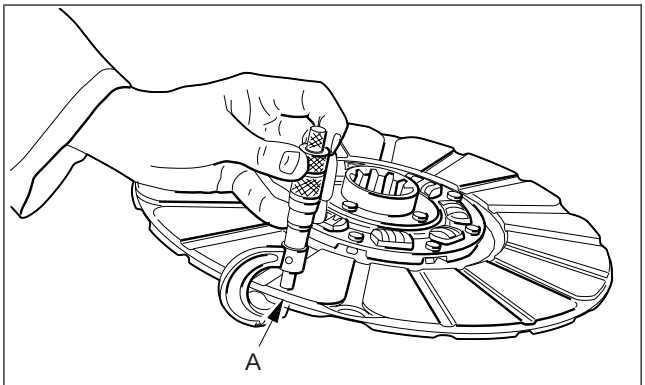
Organic linings are integrally molded onto the disc. Using a micrometer, measure the thickness of the organic lining on the disc. Replace the disc if the organic lining is loose, damaged, or less than 0.283 inch (7.2 mm) thick. **See Fig. 11.**



A. Replace the ceramic disc if the lining is even with or below the top of the rivet.

1. Rivet
2. Lining

Fig. 10



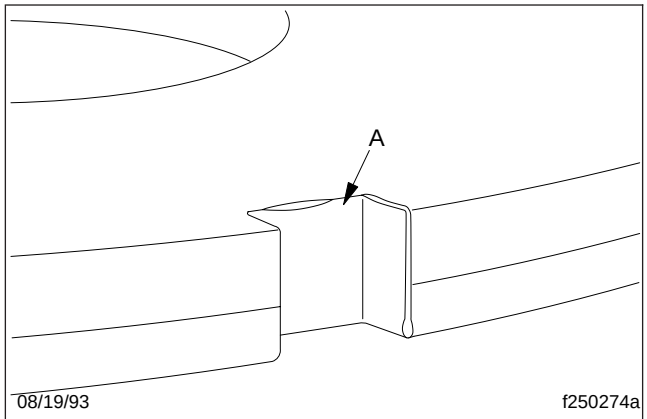
A. Minimum thickness: 0.283 inch (7.2 mm).

Fig. 11

8. Inspect the center plate.

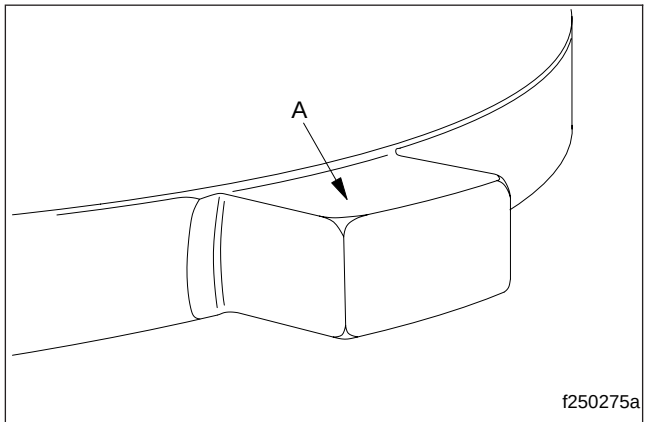
8.1 On 14-inch clutches, check the slots for the drive pins in the center plate. **See Fig. 12.** If the slots are worn, replace the center plate. Go on to the next step and inspect the center plate.

On 15-1/2 inch clutches, inspect the tabs on the outer edge of the center plate. **See Fig. 13.** If the tabs are worn or damaged, replace the center plate. Go on to the next step and inspect the center plate.



A. Make sure the slots are not worn or damaged.

Fig. 12



A. Make sure the tabs are not worn or damaged.

Fig. 13

8.2 Inspect the center plate for wear or damage. If the plate is cracked, replace it. Heat marks are normal, and can usually be removed with an emery cloth. If the heat marks cannot be removed, replace the center plate.

8.3 Using a micrometer or a caliper, measure the thickness of the center plate. **Refer to Table 1** for minimum thickness by clutch type. If the center plate measures less than the minimum thickness, replace it. **See Fig. 14.**

Clutch Type	Minimum Thickness inches (mm)
14-Inch With Ceramic Linings	0.805 (20.07)
14-Inch With Organic Linings	0.672 (17.27)
15-1/2 Inch With Ceramic or Organic Linings	0.742 (18.84)

Table 1, Minimum Center Plate Thickness

8.4 Make sure the surface of the center plate

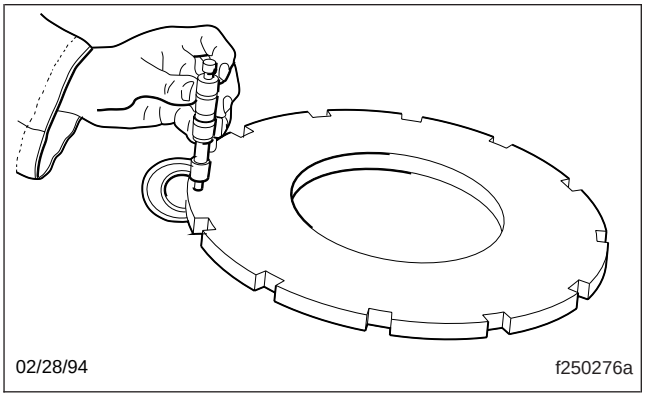
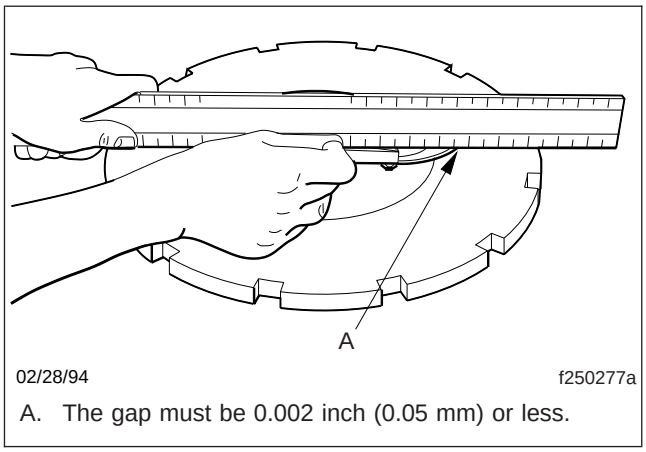


Fig. 14

is flat. Put a straightedge on the surface of the center plate, making sure it crosses the center of the plate. **See Fig. 15.** Using a feeler gauge, measure each gap that appears between the straightedge and the pressure plate. Rotate the straightedge through at least four positions. If any gap is more than 0.002 inch (0.05 mm), grind a new surface on the center plate; if not, go on to the next step.

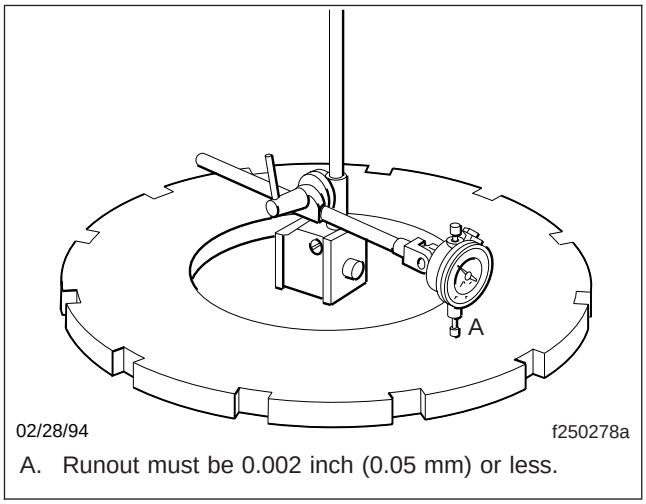
8.5 Measure the runout of the center plate to make sure the surfaces are parallel to each other. **See Fig. 16.** Put the base of the dial indicator inside the center of the plate. Put the tip of the dial indicator on the surface of the plate. Set the dial indicator to zero. Rotate the dial indicator one complete turn around the surface of the



A. The gap must be 0.002 inch (0.05 mm) or less.

Fig. 15

center plate. If the reading on the indicator is more than 0.002 inch (0.05 mm), grind a new surface on the center plate; if not, go on to the next step.



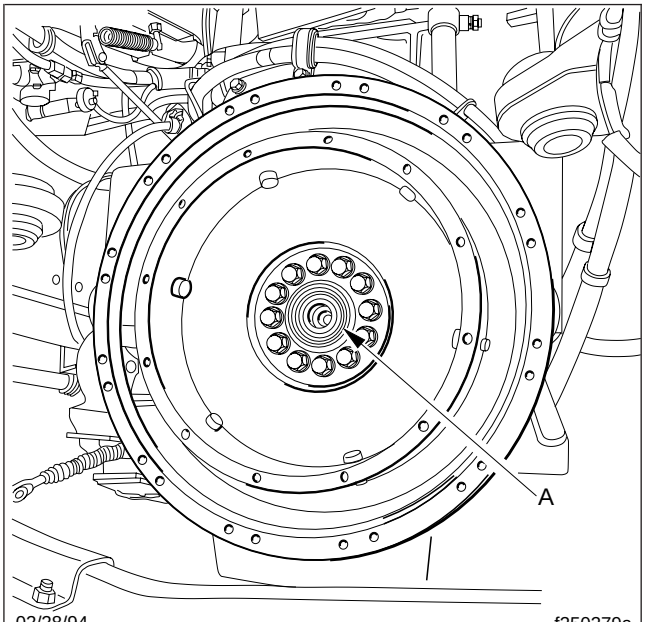
A. Runout must be 0.002 inch (0.05 mm) or less.

Fig. 16

8.6 If either the runout or the flatness of the center plate is more than 0.002 inch (0.05 mm), grind enough material so that the plate is flat, but do not go below the minimum thickness. Refer to the table for minimum thickness by clutch type. Re-check the flatness and runout of the center plate.

9. Although the pilot bearing must be replaced whenever the clutch is removed, inspect the old pilot bearing for wear or damage. **See Fig. 17.** If worn or damaged, correct the cause.

Clutch Inspection



A. Make sure the pilot bearing is not worn or damaged.

Fig. 17

10. Inspect the surface of the flywheel for wear or damage. If the flywheel is cracked, replace it. Heat marks are normal, and can usually be removed with an emery cloth. Some wear or damage can be removed by grinding a new surface on the flywheel. If wear or damage on the surface of the flywheel cannot be removed, replace the flywheel.

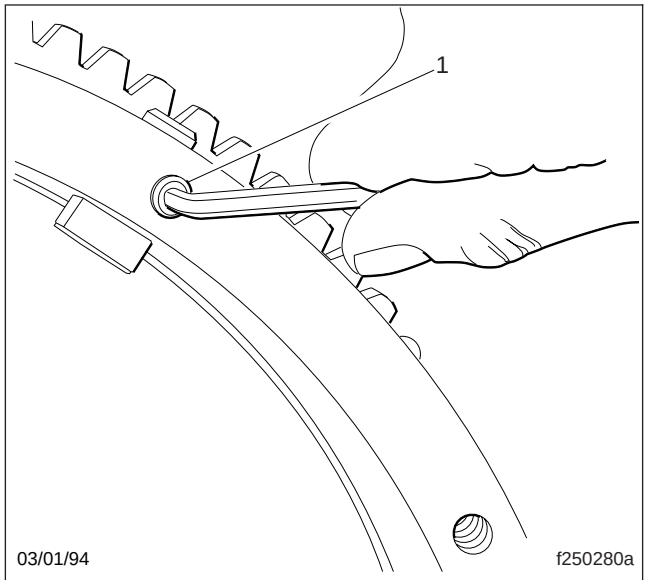
    Refer to the engine manufacturer's service manual for flywheel service procedures.

IMPORTANT: If the flywheel surface is reground, make sure there is still adequate thickness for the capscrews to hold the clutch to the flywheel. The threads for these capscrews are below the surface of some flywheels, requiring the use of capscrews with a shoulder. If some of the flywheel surface is removed, the capscrews may not hold. Use new capscrews that are the correct length.

11. On 14-inch clutches, inspect the drive pins in the flywheel housing.

    11.1 Remove the flywheel. Refer to the engine manufacturer's service manual for instructions.

    11.2 Remove the setscrew(s) that fasten each drive pin in the flywheel housing. **See Fig. 18**.



1. Setscrew

Fig. 18

WARNING

WARNING: Wear eye protection. Do not hit steel parts with a steel hammer. Parts can break and cause injury.

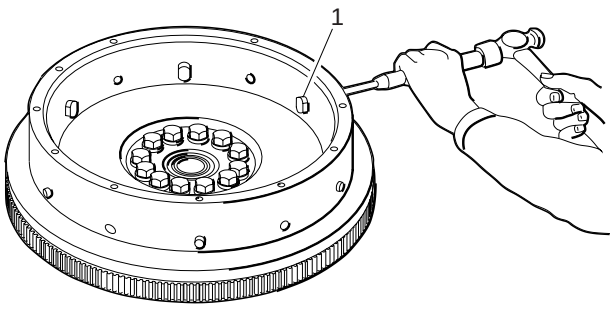
    11.3 Using a hammer and punch, remove the drive pins from the flywheel housing. **See Fig. 19.**

    11.4 Replace any worn or damaged drive pins.

    11.5 Put each new drive pin in the flywheel so that the round sides of the head are toward the top and bottom of the flywheel. Make sure that the flat sides of the pin are at a right angle to the top of the flywheel face. **See Fig. 20.**

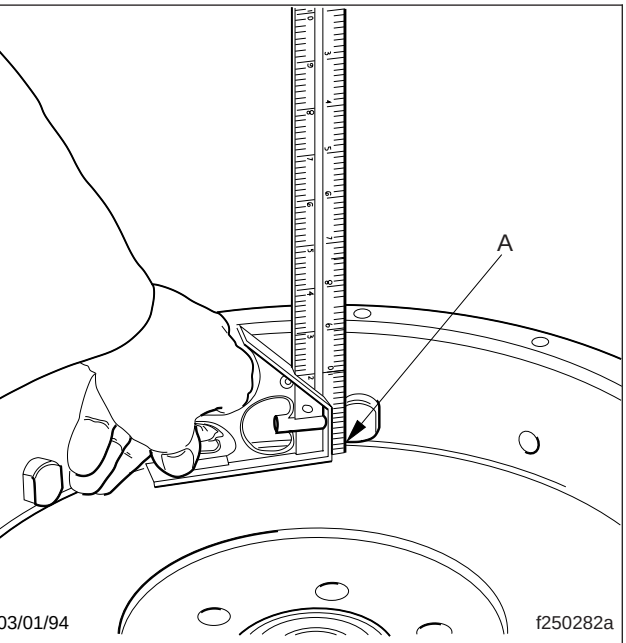
    11.6 Using a drive-pin installation tool and a brass hammer, install the drive pins in the flywheel. **See Fig. 21.**

    If a drive-pin tool is not available, use a C-clamp to install the drive pins in the flywheel.



1. Drive Pin

Fig. 19

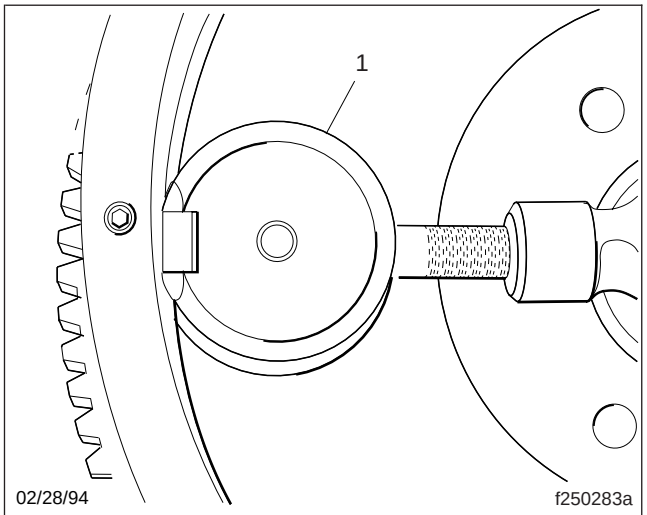


A. The drive pin must be square to the flywheel.

Fig. 20

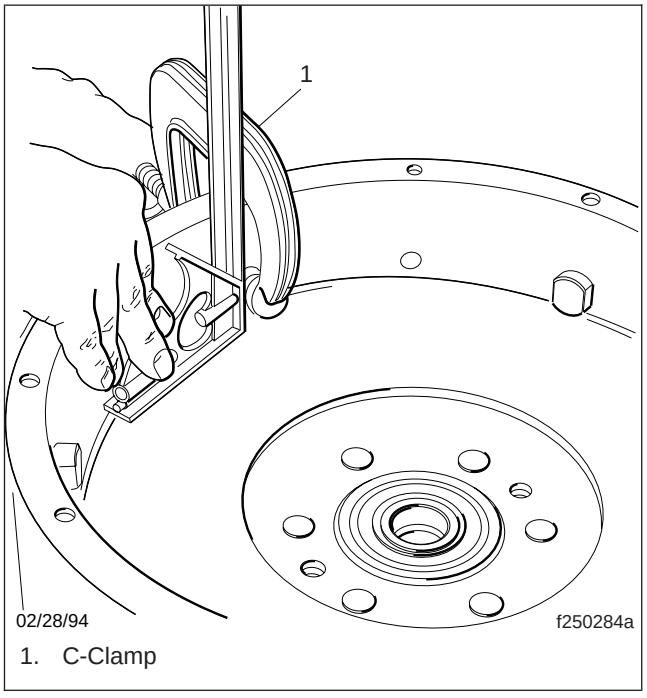
Press each pin into the flywheel until the head of the pin bottoms in the bore. **See Fig. 22.**

11.7 Making sure the slots in the center plate are installed over the drive pins, install the center plate in the flywheel. Rotate the plate so that one side of each slot touches a drive pin.



1. Drive Pin Installation Tool

Fig. 21



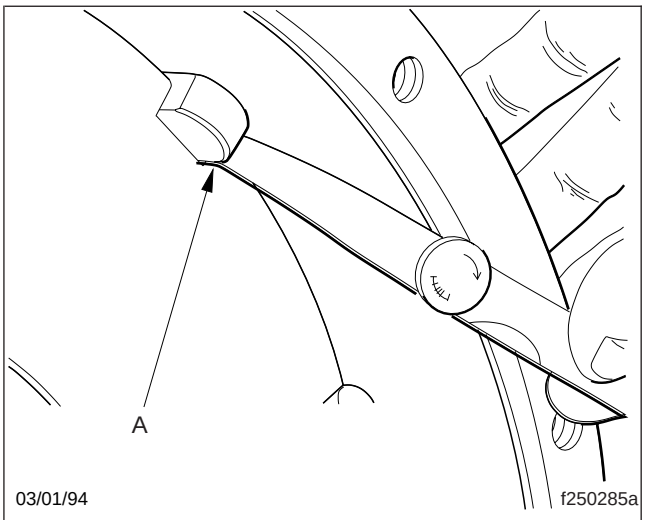
1. C-Clamp

Fig. 22

11.8 Using a feeler gauge, check the clearance between the slot and the opposite side of each drive pin. **See Fig. 23.** The minimum clearance between the drive pin and the slot is 0.006 inch (0.152 mm). If the clear-

Clutch Inspection

ance is less than specified, remove the drive pin and install it again. Do not file the drive pins or the slots in the center plate.



A. Drive pin-to-center plate minimum clearance: 0.006 inch (0.152 mm).

Fig. 23

11.9 Install and tighten the setscrew(s) that fasten each drive pin in the flywheel housing.

11.10 Install the flywheel housing. Refer to the engine manufacturer's service manual for instructions.

12. Inspect the ring gear teeth on the outer surface of the flywheel. If the teeth are worn or damaged, replace the ring gear or the flywheel. Refer to the engine manufacturer's service manual for instructions.

    On 15-1/2 inch clutches, check the tabs on the outer edge of the flywheel. Replace the flywheel if the tabs are worn or damaged.

13. The flywheel surface must be flat for correct clutch operation. Check the runout of the outer surface of the flywheel. Refer to the engine manufacturer's service manual for instructions.

NOTE: In general, maximum runout is 0.0005 inch times the flywheel diameter in inches.

14. Refer to the engine manufacturer's service manual for instructions and check the following:
    - pilot bearing bore runout
    - crankshaft end play
    - runout of the outer surface of the flywheel housing
    - runout of the inside of the flywheel housing

⚠ WARNING

Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

15. Clean the disassembled parts.

    15.1 Using a cleaning solvent or kerosene, clean all ground or polished parts or surfaces.

⚠ CAUTION

CAUTION: Do not clean ground or polished parts in a hot solution tank or with water, steam, or alkaline solutions. These solutions will cause the parts to corrode.

    15.2 Rough parts can be cleaned with the ground or polished parts. The rough parts can also be cleaned in hot solution tanks with a weak alkaline solution. The parts must remain in the tank until they are completely cleaned and heated.

    15.3 Dry the parts with clean paper, shop towels, or compressed air immediately after cleaning.

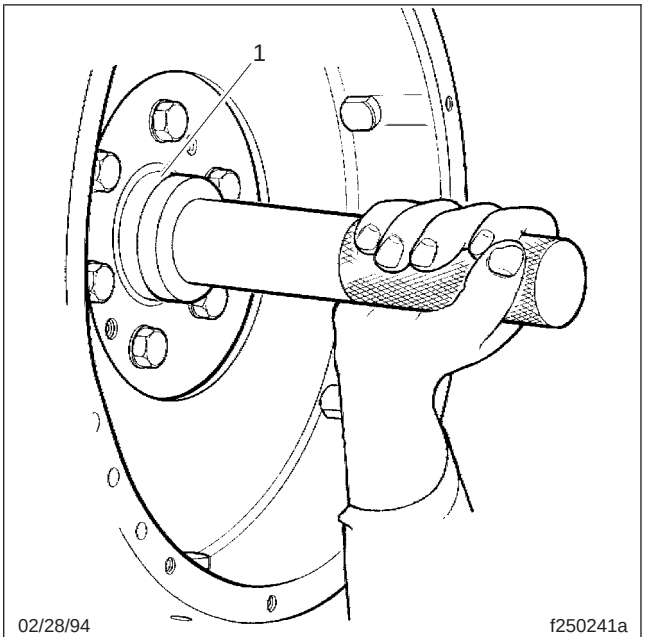
16. Apply lubricant to the cleaned and dried parts that are not damaged and are to be immediately assembled. *Do not* apply lubricant to the linings.

    If parts are to be stored, apply a special material that prevents corrosion and rust to all surfaces. *Do not* apply the material to the linings. Store the parts inside special paper or other material that prevents corrosion and rust.

Installation

NOTE: During clutch removal, spacers or wooden blocks are installed between the release bearing and the clutch cover to facilitate removal. Do not remove the spacers or wooden blocks until after the clutch is installed. The spacers or blocks make installation of the clutch easier by holding the clutch components in position.

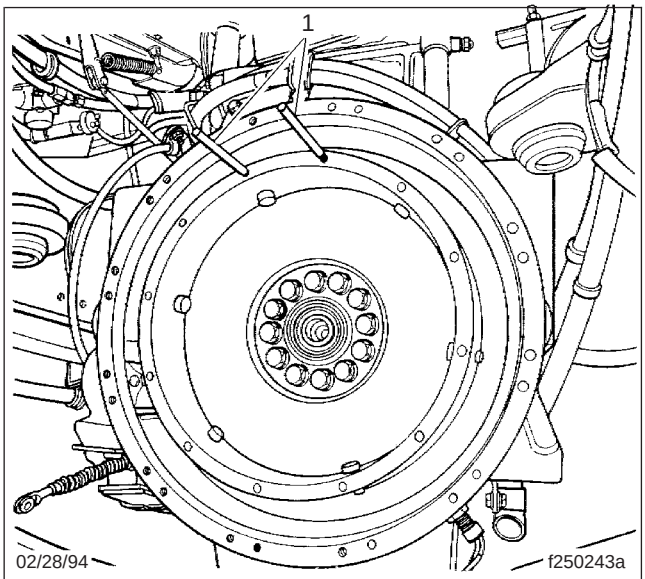
1. Lubricate the bore in the crankshaft for the pilot bearing with the specified lubricant. Do not use too much lubricant. Excess lubricant can contaminate the discs and cause the clutch to slip.
2. Use the correct size of driver to install the pilot bearing in the crankshaft bore. **See Fig. 1**. Refer to the engine manufacturer's service manual for instructions.



1. Pilot Bearing

Fig. 1

3. Do the following on 14-inch clutches (go to the next step for 15-1/2 inch clutches):
   - 3.1 Install 7/16-inch guide studs in two of the upper mounting holes for the cover and pressure plate assembly. **See Fig. 2**.



1. Guide Studs

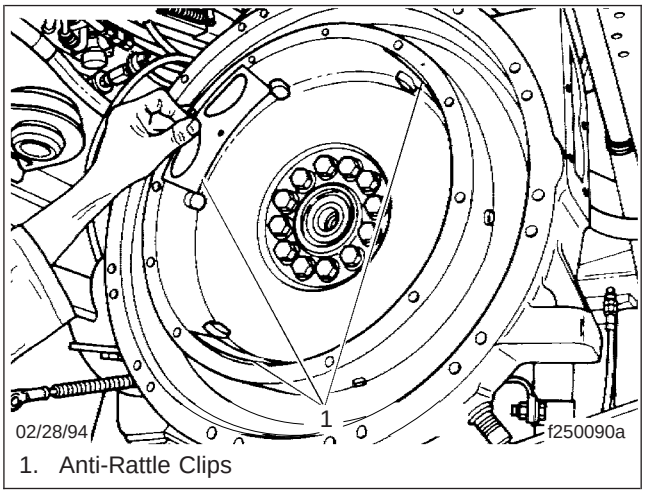
Fig. 2

WARNING

WARNING: Wear gloves when handling anti-rattle clips. Anti-rattle clips are very sharp, and may cut your hands.

- 3.2 Install the anti-rattle clips in the inner bore of the flywheel housing. **See Fig. 3**. The round portion of the holes must face toward the flywheel. Make sure the clips are spaced evenly around the housing.
- 3.3 Install the alignment tool in the flywheel pilot bearing. **See Fig. 4**.
- 3.4 Install the front disc over the alignment tool. **See Fig. 4**. Make sure the words *FLYWHEEL SIDE* on the disc are toward the flywheel.
- 3.5 Install the center plate in the flywheel housing. Make sure the slots in the plate are installed over the drive pins in the housing. **See Fig. 3**. Make sure facings of ceramic clutches are aligned.
- 3.6 Install the rear disc over the alignment tool. Make sure the words *PRESSURE PLATE SIDE* on the disc will be toward the pressure plate. **See Fig. 4**.

Clutch Installation



1. Anti-Rattle Clips

Fig. 3

3.7 Install the pressure plate and cover assembly over the alignment tool and on to the guide studs.

Skip the step on installing 15-1/2 inch clutches, and go on.

4. Do the following on 15-1/2 inch clutches:

4.1 Install 3/8-inch guide studs in two of the upper mounting holes for the cover and pressure plate assembly. **See Fig. 2**.

⚠ WARNING

WARNING: The pressure plate and cover assembly is heavy and should be installed only with a lifting device. If the assembly is lifted improperly or dropped, it could cause serious physical injury.

4.2 Connect a lifting device to the pressure plate and clutch cover assembly. **See Fig. 5**.

4.3 Install the rear disc in the pressure plate and cover assembly. Make sure the words *PRESSURE PLATE SIDE* on the disc are toward the pressure plate. **See Fig. 4**.

4.4 Install the center plate over the disc in the pressure plate and clutch cover assembly. Make sure the tabs on the plate are in the slots on the cover.

4.5 Install the front disc against the center plate. Make sure the words *FLYWHEEL SIDE* on the disc are toward the flywheel. **See Fig. 4**. Make sure the facings of ceramic clutches are aligned.

4.6 Install the alignment tool through the assembly. Rotate the discs so that the splines in the hub are aligned with the splines on the tool. **See Fig. 4**.

⚠ WARNING

WARNING: Tilt the front of the alignment tool up when the clutch assembly is installed. If the tool is not tilted up, components will fall off the tool, causing personal injury and component damage.

4.7 Using a lifting device, lift the clutch assembly on to the guide studs. **See Fig. 5**. Make sure the alignment tool is installed in the flywheel pilot bearing.

4.8 Install the clutch assembly against the flywheel. remove the lifting device.

5. Install and hand-tighten the capscrews that fasten the clutch to the flywheel.

6. Remove the guide studs. Install and hand-tighten the remaining capscrews.

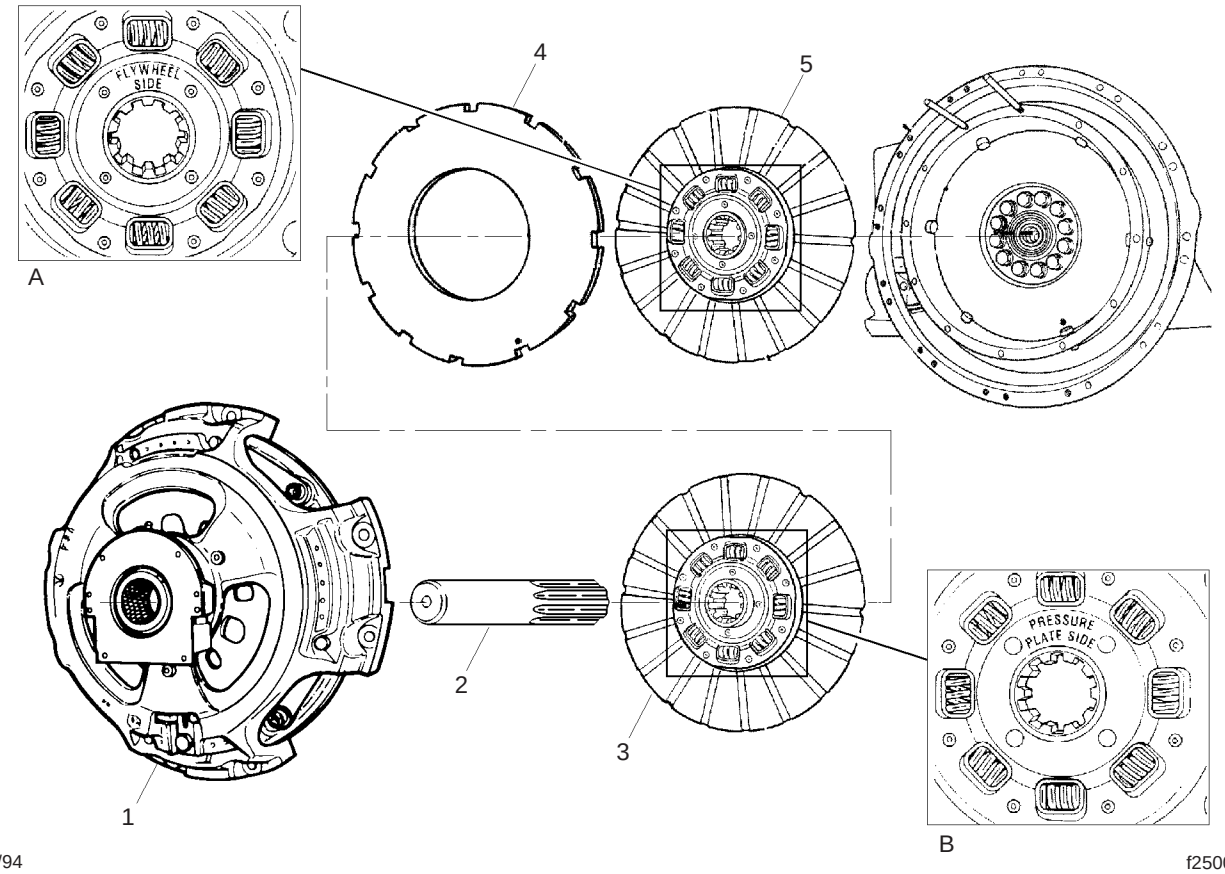
NOTE: When the capscrews are tightened, the wooden blocks or spacers will fall from between the release bearing and the cover.

7. Tighten the capscrews in the pattern **shown in Fig. 6**. Refer to the torque table in **Specifications 400** for torque values.

8. Remove the alignment tool (or the input shaft used as an alignment tool).

9. If used, install the clutch brake on the transmission input shaft. Make sure the tabs on the clutch brake engage the slots on the input shaft. **See Fig. 7**.

10. Install the transmission. Follow the procedures in the **transmission group** of this manual.

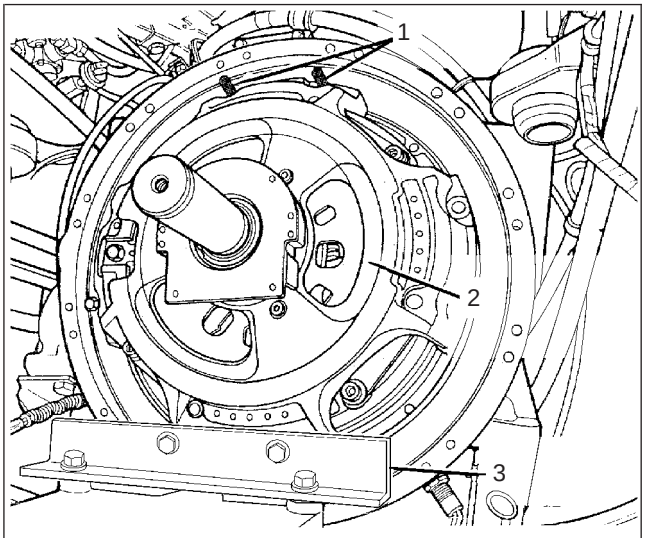


A. Markings must be toward the flywheel.
B. Markings must be toward the pressure plate.

1. Cover
2. Alignment Tool
3. Front Clutch Disc
4. Center Plate
5. Rear Clutch Disc

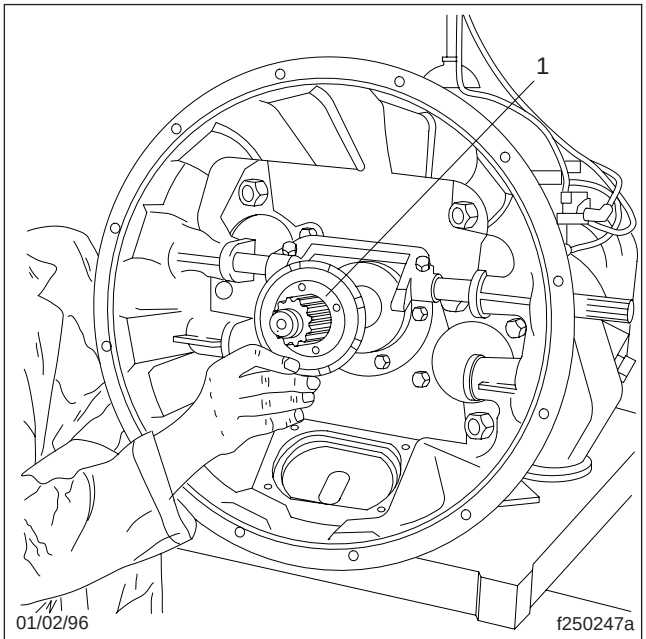
Fig. 4

Clutch Installation



1. Guide Studs
2. 15-1/2 Inch Clutch Assembly
3. Lifting Device

Fig. 5



1. Clutch Brake

Fig. 7

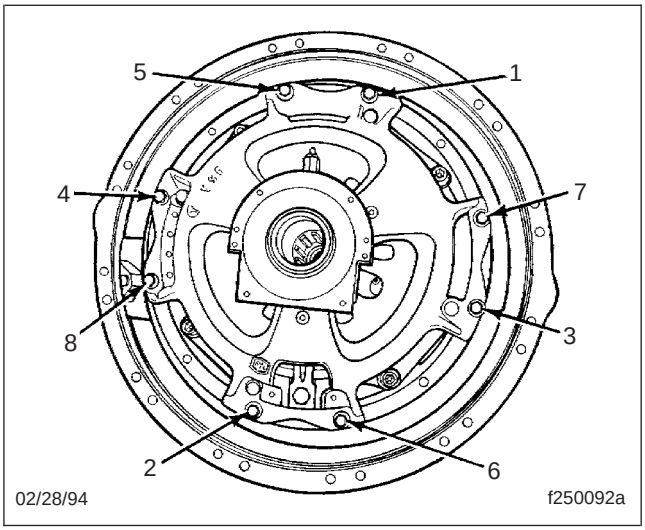


Fig. 6, Clutch Housing Torque Sequence

Troubleshooting Tables

Troubleshooting—Functional Problems

NOTE: Problem entries in the troubleshooting tables in this subject refer to functional or operational problems. Before troubleshooting the clutch, make sure that:

- the engine is operating correctly
- the engine mounts are in good condition
- the driveline angles of the engine, transmission, driveshaft, and rear axle are correct

Problem—The Clutch Does Not Disengage Completely

Possible Cause	Remedy
The clutch linkage and release bearing need adjustment.	Adjust the clutch linkage and release bearing.
The linkage is worn or damaged.	Lubricate the linkage. Make sure the linkage linkage is not loose. If the condition persists, replace the linkage.
The release bearing is worn or damaged.	Lubricate the release bearing. If the condition persists, replace the release bearing.
The input shaft splines are worn or damaged.	Replace the input shaft.
The clutch housing is loose.	Tighten the fasteners to the specified torque. If necessary, replace the fasteners.
The pressure plate is worn or damaged.	Replace the pressure plate and cover assembly.
The center plate is worn or damaged.	Replace the center plate.
The center plate binds.	14–inch clutch: Inspect the drive pins in the flywheel and the slots in the center plate. Service as needed. 15–1/2 inch clutch: Inspect the tabs on the center plate and the slots in the cover. Service as needed.
Damaged clutch disc hub(s).	Replace the clutch discs.
The linings are worn beyond specification.	Replace the clutch discs.
The linings are damaged.	Replace the clutch.
Oil or grease on the linings.	Clean the linings. If the oil or grease cannot be removed, replace the clutch discs.
A clutch with incorrect lining for the vehicle application is installed.	Install a clutch with the correct type of lining.
The pilot bearing is damaged.	Replace the pilot bearing.

Problem—Clutch Pedal Hard to Operate

Possible Cause	Remedy
Damaged bosses on the release bearing assembly.	Replace the bearing assembly. Make sure the clutch is adjusted correctly.
The clutch linkage is worn or damaged.	Lubricate the linkage. If the condition still exists, replace the linkage.
The pressure plate and cover assembly components are worn or damaged.	Replace the pressure plate and cover assembly.

Troubleshooting

Possible Cause	Remedy
The clutch cross shaft binds.	Lubricate the cross shaft. If the condition persists, replace the cross shaft and bushings as required.

Problem—The Clutch Slips

Possible Cause	Remedy
The driver keeps his foot on the clutch pedal.	Use correct driving procedures.
The clutch linkage or release bearing need adjustment.	Adjust the clutch linkage or release bearing.
Pressure plate and cover assembly components are worn or damaged.	Replace the pressure plate and cover assembly.
Linings are worn or damaged.	Replace the clutch discs.
Oil or grease on the linings.	Clean the linings. If the oil or grease cannot be removed, replace the clutch discs.
A clutch with incorrect lining for the vehicle application is installed.	Install a clutch with the correct type of lining.
The flywheel is worn or damaged.	Service the flywheel as needed. For instructions, refer to the engine manufacturer's service manual.

Problem—The Clutch is Noisy

Possible Cause	Remedy
The clutch linkage or release bearing need adjustment.	Adjust the clutch linkage or release bearing.
The linkage is worn or damaged.	Lubricate the linkage. If the condition persists, replace the linkage.
The release bearing is worn or damaged.	Lubricate the release bearing. If the condition persists, replace the release bearing..
The clutch housing is worn or damaged.	Replace the clutch housing.
The clutch housing is loose.	Tighten the fasteners to the specified torque. If necessary, replace the fasteners.
The hub is damaged, or the co-axial spring(s) are broken in the clutch disc.	Replace the clutch discs.
Linings are worn below specified dimensions.	Replace the clutch discs.
Linings are damaged.	Replace the clutch discs.
Oil or grease on the linings.	Clean the linings. If the oil or grease cannot be removed, replace the clutch discs.
The pilot bearing is damaged.	Replace the pilot bearing.

Problem—The Clutch Vibrates

Possible Cause	Remedy
The input shaft splines are damaged.	Replace the input shaft.

Possible Cause	Remedy
The pressure plate and cover assembly are out of balance.	Remove the pressure plate and cover assembly. Check their balance and install them. If the problem persists, replace the pressure plate and cover assembly.
The splines are damaged in the clutch disc hub(s).	Replace the clutch discs.
The flywheel is loose.	Tighten the fasteners to the specified torque. If necessary, replace the fasteners. Check the flywheel mounting surface for damage. If necessary, replace the flywheel.

Troubleshooting—Component Problems

NOTE: Problem entries in the troubleshooting tables in this subject refer to damage to components.

Problem—Broken Tabs on the Clutch Brake

Possible Cause	Remedy
Vibration.	Inspect the clutch disc hubs; check the installation of the clutch. Make sure dampened discs are used.
The clutch linkage is incorrectly adjusted.	Adjust the clutch linkage. Also, check the installation of the clutch.
The driver used the clutch brake while the vehicle is moving.	Use correct driving technique.

Problem—Worn or Damaged Release Bearing Housing

Possible Cause	Remedy
The driver keeps his foot on the pedal.	Use correct driving technique.
The clutch linkage is incorrectly adjusted.	Adjust the clutch linkage. Also, check the installation of the clutch.

Problem—Worn Bosses on the Release Bearing Housing

Possible Cause	Remedy
The linkage is damaged or out of adjustment.	Lubricate and adjust the linkage. Inspect the linkage for wear or damage.
The release yoke is binding.	Lubricate the release yoke shaft. If the yoke does not move freely, replace the shaft and yoke assembly.
The free travel is out of adjustment.	Adjust the free travel to specification.

Problem—Worn or Damaged Input Shaft Splines

Possible Cause	Remedy
The transmission is not aligned.	Make sure the flywheel housing and the clutch housing are aligned to specification.
The transmission is not installed correctly.	Install the transmission correctly.

Troubleshooting

Possible Cause	Remedy
The clutch disc hubs are damaged.	Replace the clutch discs.
The pilot bearing is worn or damaged.	Replace the pilot bearing.
Engine vibration.	Make sure dampened discs are used.

Problem—Pressure Plate Cracked or Damaged by Heat

Possible Cause	Remedy
The driver engages the clutch while coasting.	Use correct driving techniques.
The driver uses the clutch as a brake.	Use correct driving techniques.
The clutch free travel is not adjusted correctly.	Adjust the free travel to specifications.
There is oil or grease on the clutch linings.	Clean the clutch discs. If the oil or grease cannot be removed, replace the clutch discs. Repair the cause of the grease or oil.
The diaphragm spring is worn or damaged.	Replace the pressure plate and the cover assembly.
The driver slips the clutch excessively during engagement.	Use correct driving techniques.

Problem—Grooves Worn in the Pressure Plate

Possible Cause	Remedy
The clutch discs are worn or damaged.	Replace the clutch discs. If damaged, replace the center plate and flywheel.

Problem—The Clutch Disc Hub is Warped

Possible Cause	Remedy
The transmission was not installed correctly.	Replace the clutch discs. Install the transmission correctly.

Problem—The Hub Separates From the Clutch Disc

Possible Cause	Remedy
Excessive engine vibration.	Repair the engine.
The transmission was not installed correctly.	Install the transmission correctly.
The clutch housing is loose.	Tighten the clutch housing to the specified torque.
The driver engages the clutch while the vehicle is coasting.	Use correct driving techniques.
Shock loading.	Use correct driving techniques.

Problem—Heat Damage to the Clutch Disc

Possible Cause	Remedy
The driver keeps his foot on the clutch pedal or slips the clutch.	Use correct driving techniques.
The clutch does not engage or disengage completely.	See "Troubleshooting—Functional Problems: Clutch Does Not Disengage Completely."
The free travel is not adjusted correctly.	Adjust the free travel.
The diaphragm spring is worn or damaged.	Replace the pressure plate and cover assembly.
There is oil or grease on the clutch linings.	Clean the clutch discs. If the oil or grease cannot be removed, replace the clutch discs. Repair the cause of the grease or oil.

Problem—The Linings Separate From the Disc

Possible Cause	Remedy
The linings are worn below the specified dimension.	Replace the clutch discs.
The driver allows the vehicle to coast downhill with the transmission in gear and the clutch pedal depressed.	Use correct driving techniques.

Problem—Heat Damage to the Clutch Disc

Possible Cause	Remedy
The driver does not start the vehicle in the correct gear.	Use correct driving techniques.
The driver engages the clutch while the vehicle is coasting.	Use correct driving techniques.
14–inch clutch: The drive pins on the flywheel housing are worn or damaged.	Make sure the drive pins are correctly installed. Service the drive pins as needed.
15–1/2 inch clutch: The tabs on the center plate are binding in the clutch cover.	Replace the pressure plate and cover assembly.
The clutch does not release.	See "Troubleshooting—Functional Problems: Clutch Does Not Disengage Completely."

Specifications

Description	14-Inch Diameter Clutch	15-1/2-Inch Diameter Clutch
Actuation Type	Pull	
Minimum Clutch Housing Size for Mounting (SAE)	Number 2	
Pressure Plate Actuation	Single Diaphragm Spring	
Clamp Load	2800 lbf (12 454 N)	2800 lbf (12 454 N
	3200 lbf (14 234 N)	3200 lbf (14 234 N)
	—	3600 lbf (16 013 N)
Adjustment	Manual	
Facing Size	13.78 x 7.48 in (350 x 190 mm)	15.35 x 8.66 in (390 x 220 mm)
Lining Availability	Ceramic & Organic (non-asbestos)	
Lining-to-Disc Fastener:		
Ceramic	Rivet	
Organic	Integrally Molded to Plate	

Table 1, General Specifications

Description	Specification
Pressure Plate Runout	0.000 to 0.002 inch (0.00 to 0.05 mm)
Pressure Plate Flatness	0.002 to 0.004 inch (0.05 to 0.10 mm)
Maximum Allowable Wear	0.015 inch (0.38 mm)

Table 2, Pressure Plate Specifications for 14-Inch and 15-1/2 Inch Clutches

Description	14-Inch Diameter Clutch	15-1/2-Inch Diameter Clutch
Center Plate Runout	0.000 to 0.002 inch (0.00 to 0.05 mm)	
Center Plate Flatness	0.000 to 0.002 inch (0.00 to 0.05 mm)	
Center Plate Minimum Thickness:		
Ceramic Linings	0.805 inch (20.07 mm)	0.742 inch (18.84 mm)
Organic Linings	0.672 inch (17.27 mm)	
Center Plate Drive	Drive Pin	Tabs on Center Plate in Clutch Cover
Clearance Between Drive Pin and Center Plate	0.006 inch (0.152 mm)	—

Table 3, Center Plate Specifications

Description	14-Inch Diameter Clutch	15-1/2-Inch Diameter Clutch
Number of Splines on Disc	10	
Spline Diameter	1.75 or 2.00 inch (44.5 or 51.0 mm)	2.00 inch (51.0 mm)

Specifications

Description	14-Inch Diameter Clutch	15-1/2-Inch Diameter Clutch
Minimum Disc Thickness:		
Ceramic linings	To Top of Rivet	
Organic linings	0.283 inch (7.2 mm)	

Table 4, Clutch Disc Specifications

Description	Torque: lbf·ft (N·m)
Adjusting Ring Lock Capscrew	25 to 30 lbf·ft (34 to 40 N·m)
Capscrew Between Cover Assembly and Flywheel:	
14-Inch Clutches	25 to 30 lbf·ft (34 to 40 N·m)
15-1/2 Inch Clutches	45 to 50 lbf·ft (62 to 67 N·m)

Table 5, Torque Values

Vehicle Model	Initial Adjustment inches (mm)	Wear Limit * inches (mm)
COE	3/4 (19) at the stop	1/2 (13)
Conventional		

* Adjust the clutch internally if the free-travel is less than the wear limit.

Table 6, Clutch Pedal Free-Travel Specifications

General Information (See Fig. 1)

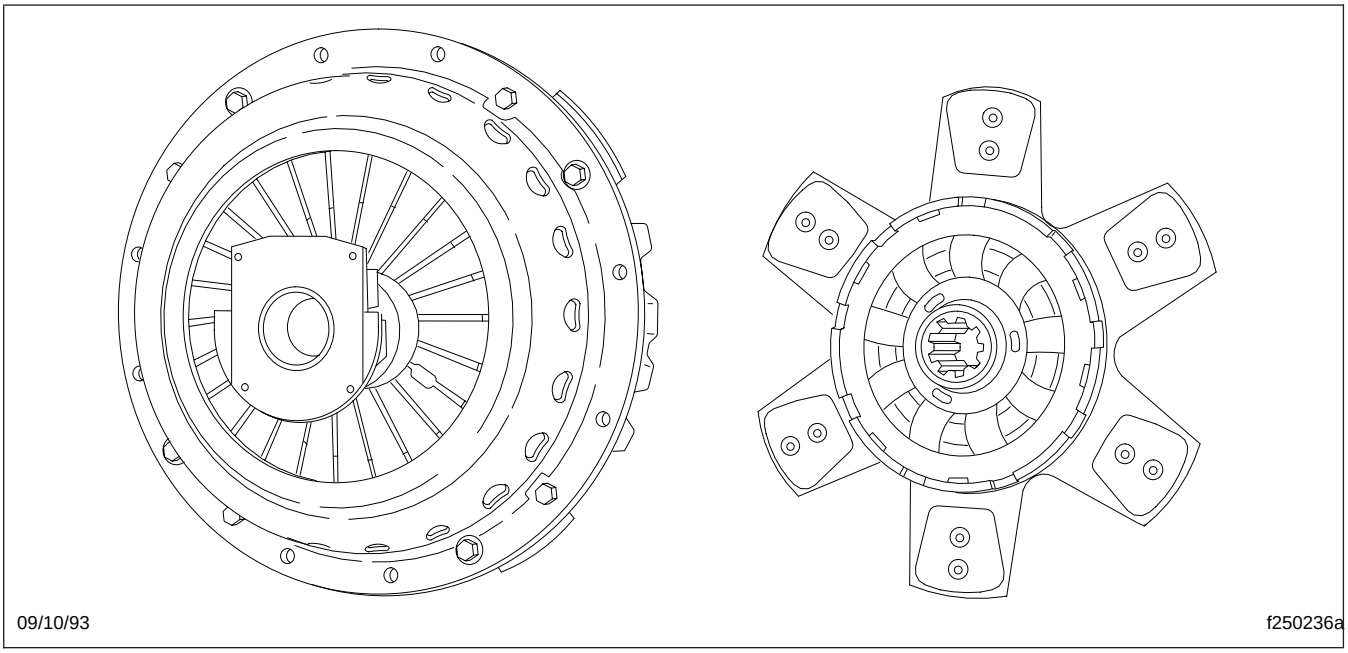


Fig. 1, Eaton Valeo Clutch

Eaton Valeo clutches installed in Freightliner heavy-duty vehicles are available in 14-inch, 16-inch, and 17-inch models. They are single-plate, diaphragm spring, pull-type clutches. A dampened driven disc is standard. The lining is a "cerametallic" material.

The 17-inch clutch is available for both flat and pot-type flywheel designs.

See "Specifications, 400" for additional information.

Special Tools

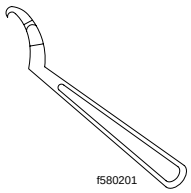
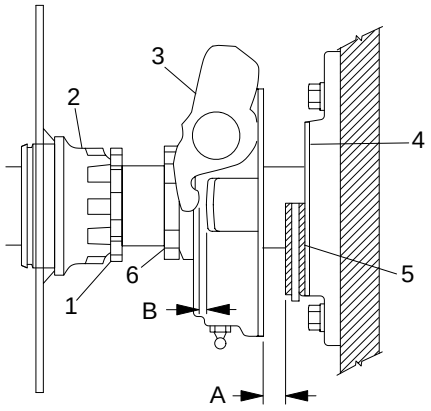
Special Tools			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580201	Adjustable Hook Spaner Wrench	Kent-Moore	J4749

Table 1, Special Tools

Clutch Adjustments

Eaton Valeo clutches require two adjustments: release bearing clearance (this distance must be 1/2 to 9/16 inch (12.7 to 14.3 mm) and clutch free-travel (this distance must be 0.105 to 0.145 inch (2.7 to 3.7 mm). See **Fig. 1**.



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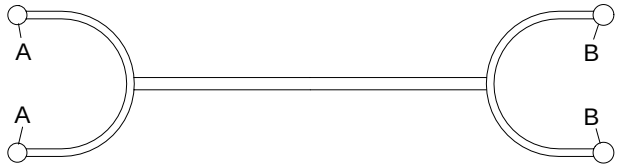
A. 1/2 to 9/16 inch (12.7 to 14.3 mm) With Clutch Brake
B. 0.105–0.145 inch (2.7–3.7 mm)

1. Locknut Ring
2. Release Bearing Coupler
3. Release Yoke
4. Bearing Cover
5. Bearing Pad
6. Adjuster Ring

Fig. 1, Clutch Adjustment Measurements

IMPORTANT: An inspection tool A02–12419 (available through the PDCs) can be used to check the distance between the release bearing and the clutch brake. See **Fig. 2** One end of the tool has green tape on it and is 0.50 inch (12.7 mm) in diameter; the other end has blue tape on it and is 0.56 inch (14.3 mm) in diameter.

1. If using tool A02–12419 to check the distance between the release bearing and the clutch brake, position the tool so that the legs straddle the transmission input shaft. Check the gap with both ends of the tool as follows:



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A. 0.50 inch (12.7 mm)
B. 0.56 inch (14.3 mm)

Fig. 2, Inspection Tool A02-12419

1.1 Insert the blue 0.56-inch (14.3-mm) end. If it fits loosely the gap is too wide and adjustment is needed. Go to the next step.

1.2 If the blue 0.56-inch (14.3-mm) end can't be inserted in the gap, then try to insert the green 0.50-inch (12.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.

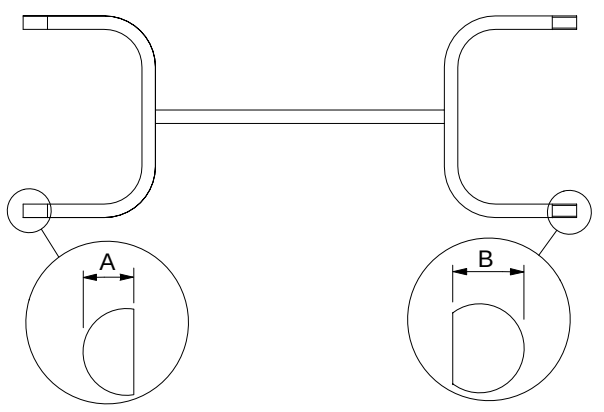
1.3 If the green end of the tool can't be inserted in the gap, adjustment is needed. Go to the next step.

Clutch Adjustments

2. Disconnect the external linkage to allow free movement of the release yoke.
3. Loosen the locknut ring and rotate the sleeve with the adjuster ring to the specified release bearing clearance.
4. Tighten the locknut ring against the release bearing coupler.

IMPORTANT: An inspection tool A02–12254 (available through the PDCs) can be used to check the distance between the release bearing and the release fork (free travel). See **Fig. 3**. The legs on one end of the tool have green tape on them and are 0.105 inch (2.7 mm) thick; the legs on the other end have blue tape on them and are 0.145 inch (3.7 mm) thick.

5. If using tool A02–12254 to check the distance between the release bearing and the release fork, position the tool so it straddles the fork to ensure that there won't be any misalignment. Check the distance with both ends of the tool as follows:



A. 0.105 inch (2.7 mm)
B. 0.145 inch (3.7 mm)

Fig. 3, Inspection Tool A02-12254

5.1 Insert the blue 0.145-inch (3.7-mm) end. If it fits loosely the gap is too wide and adjustment is needed. Connect the external linkage, then go to the section on clutch linkage adjustment in this group.

5.2 If the blue 0.145-inch (3.7-mm) end can't be inserted in the gap, then try to insert the green 0.105-inch (2.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.

5.3 If the green end of the tool can't be inserted in the gap, adjustment is needed. Connect the external linkage, then perform a clutch linkage adjustment. For instructions, see **Section 25.03**.

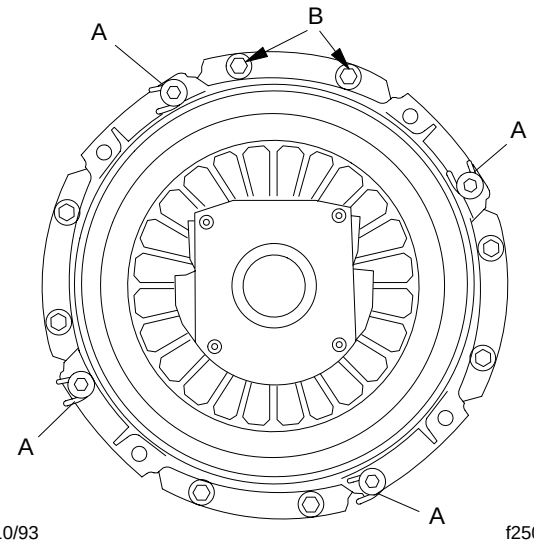
Clutch Removal

1. Remove the transmission. Follow the procedures in the **transmission section** of this manual.

CAUTION

CAUTION: Do not let the transmission drop, and do not let the transmission hang unsupported by the input shaft in the pilot bearing. Taking these precautions will prevent damage to the clutch assembly and the pilot bearing.

2. Remove the clutch brake (if equipped) from the transmission input shaft.
3. To facilitate clutch removal and installation, Eaton Valeo clutches employ four U-clips to hold the pressure plate toward the clutch. Install the four U-clips. **See Fig. 1** and **Fig. 2.**

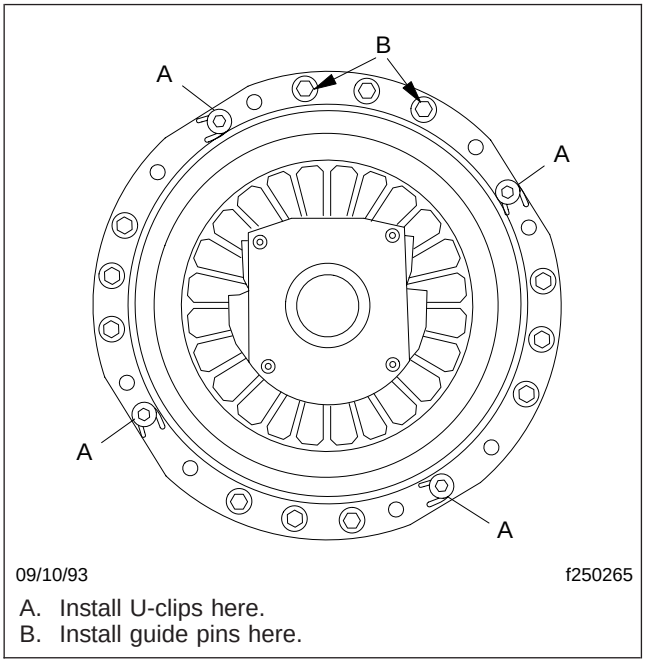


A. Install U-clips here.
B. Install guide pins here.

Fig. 1, 14-Inch and 16-Inch Clutches

4. Install a clutch alignment tool through the clutch and into the flywheel pilot bearing to support the clutch assembly during removal.

NOTE: If an alignment tool is not available, use an input shaft from a manual transmission. Remove the gear from the end of the input shaft.



A. Install U-clips here.
B. Install guide pins here.

Fig. 2, 17-Inch Clutches

5. Remove the top two capscrews from the pressure plate assembly as indicated **in Fig. 1** and **Fig. 2**. Install guide pins in the two holes. If guide pins are not available, they may be made by removing the heads from two capscrews.
6. Remove the remaining capscrews which secure the cover assembly to the flywheel.

WARNING

WARNING: The cover assembly is heavy and should be removed only with a lifting device. If the assembly is lifted improperly or dropped, it could cause serious physical injury.

7. Lift the pressure plate, release bearing, and clutch assembly over the alignment tool and guide pins.
8. Whenever the clutch assembly is serviced or the engine is removed, the pilot bearing in the flywheel should be removed and replaced. Use an appropriate internal puller and a slide hammer to remove the pilot bearing. Install the new pilot bearing with an appropriate driver.

Clutch Inspection

1. Remove the clutch from the vehicle. **Refer to Subject 110** for instructions.
2. Inspect the release fork, the cross shaft, and the shaft bushings. Inspect the transmission input shaft splines. Minor scratches may be removed with emery cloth. Replace any damaged or excessively worn parts.
3. Inspect the flywheel for heat spots, warpage, scoring, or cracks around the bolt holes. If necessary, machine or replace the flywheel.
4. Inspect the pressure plate friction surface for wear or damage. If the plate is cracked, replace it. Heat marks are normally found on a pressure plate after operation. These marks can usually be removed with emery cloth. If you cannot remove heat marks with emery cloth, replace the pressure plate.
5. Inspect the pilot bearing. Although the pilot bearing should be replaced whenever the clutch is removed, any excessive wear or damage to the pilot bearing could indicate other problems which should be remedied.
6. Inspect the clutch release linkage, the shafts, and the yoke for wear or binding. Make any necessary repairs.
7. If a clutch brake is installed, inspect the clutch brake wear surface on the transmission. Replace the transmission front bearing cover if necessary.

Clutch Installation

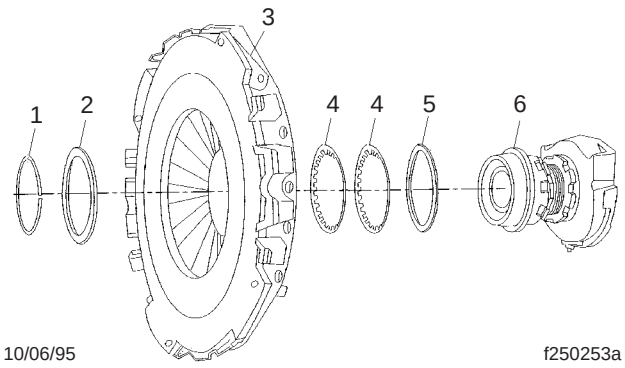
NOTE: If you are installing components which have been in operation, do the steps **in Subject 120** before installing the clutch.

1. Lubricate the bore in the crankshaft for the pilot bearing with the specified lubricant. Do not overlubricate. Excess lubricant can contaminate the disc and cause the clutch to slip.

   Using an appropriate driver, install the pilot bearing. Refer to the engine manufacturer's service manual for instructions.

2. Install guide pins in the top two bolt holes of the flywheel. If guide pins are not available, make them by removing the heads from two capscrews.

3. If necessary, install the release bearing assembly on the pressure plate. **See Fig. 1** for assembly.

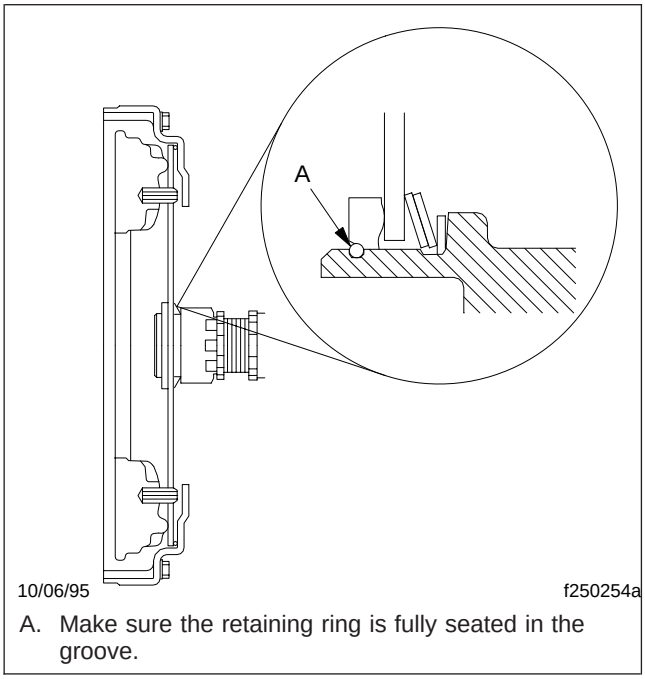


1. Wire Retaining Ring
2. Fulcrum Ring
3. Pressure Plate Cover Assembly
4. Belleville Spring Washer
5. Shim
6. Release Bearing Assembly

Fig. 1

   3.1 Be sure that the Belleville spring fingers are toward the shim, and that the rounded face of the fulcrum ring is toward the diaphragm fingers of the pressure plate.

   3.2 Install the fulcrum ring and the wire retaining ring on the end of the release bearing coupler. Be sure that the wire retaining ring is fully seated in its groove. **See Fig. 2.**



A. Make sure the retaining ring is fully seated in the groove.

Fig. 2

4. Position the clutch alignment tool in the clutch disc so the side of the disc marked *FLYWHEEL SIDE* will face the flywheel. Insert the alignment tool into the pilot bearing.

⚠ WARNING

WARNING: The cover assembly is heavy and should be installed only with a lifting device. If the assembly is lifted improperly or dropped, it could cause serious injury.

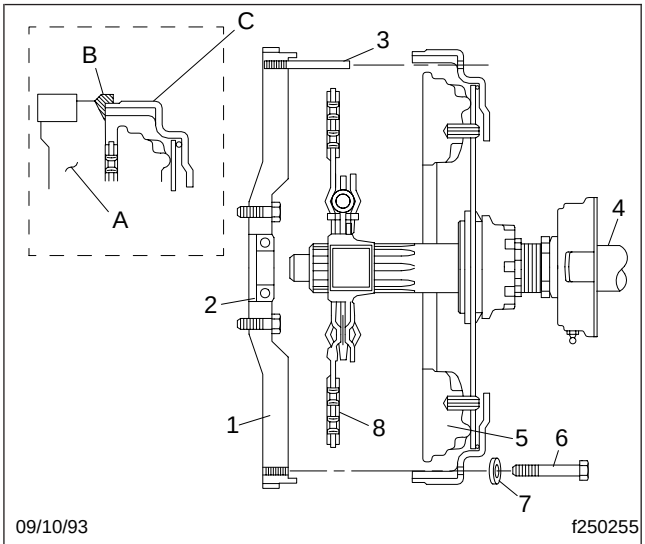
5. Install the pressure plate assembly over the alignment tool and the guide pins. **See Fig. 3** or **Fig. 4.**

6. Install the mounting capscrews finger-tight in the cover assembly.

   For 16-inch clutches, and 17-inch clutches with flat flywheels, be sure the pressure plate cover fits inside the raised step of the flywheel. **Refer to the detail in Fig. 3**.

   For 17-inch clutches with pot-type flywheels, be sure the pressure plate cover fits over the two

Installation



A. Flywheel
B. Raised Step
C. Pressure Plate Assembly

1. Flywheel
2. Pilot Bearing
3. Guide Pin
4. Alignment Tool
5. Pressure Plate Assembly
6. Capscrew
7. Washer
8. Clutch Disc

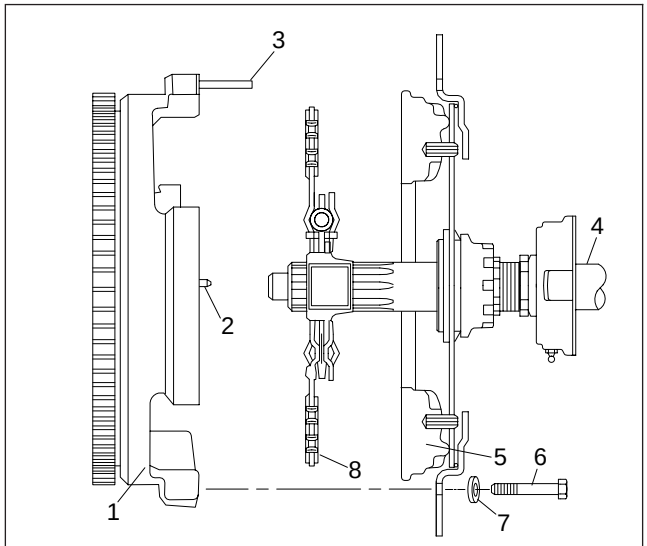
Fig. 3, Clutch Assembly with Flat Flywheel

small dowel pins on the front flange of the flywheel. **See Fig. 4**, Ref. 2.

Remove the two guide pins, and install the remaining two capscrews.

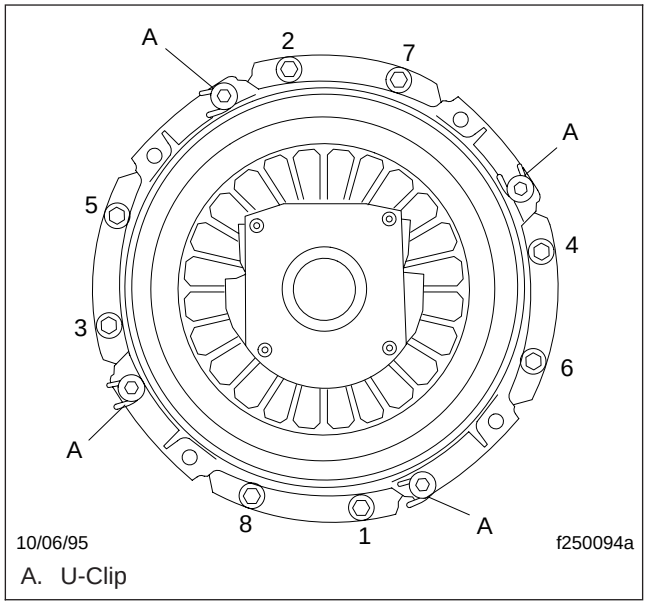
IMPORTANT: Use hardened washers and grade 8 capscrews. Be sure the capscrews are the correct length. Capscrews which are too short will strip; capscrews which are too long will damage the flywheel.

7. Tighten the capscrews one turn at a time until they are snug. Then, tighten the capscrews as specified below. Follow the tightening sequence in **Fig. 5** and **Fig. 6**.
   - 14-Inch Clutches: 35 to 40 lbf·ft (47 to 54 N·m)
   - 16-Inch and 17-Inch Clutches: 40 to 45 lbf·ft (54 to 61 N·m)
8. Remove the four wire U-clips (**Fig. 5** and **Fig. 6**). Remove the clutch alignment tool.



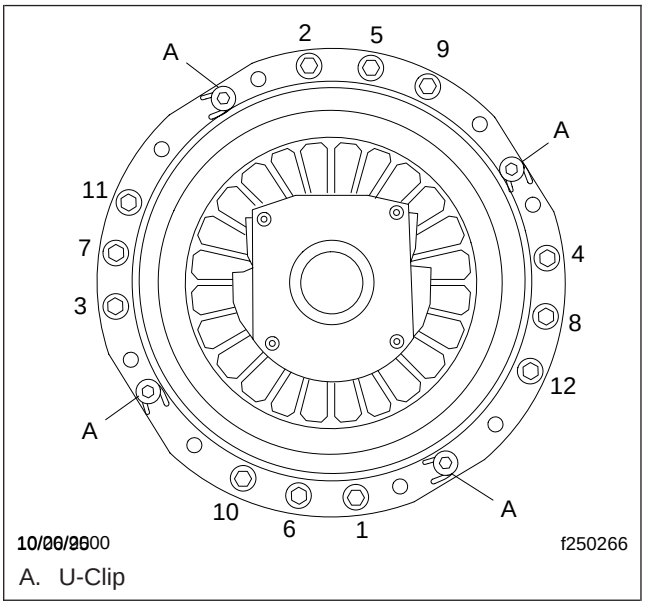
1. Flywheel
2. Dowel Pin
3. Guide Pin
4. Alignment Tool
5. Pressure Plate Assembly
6. Capscrew
7. Washer
8. Clutch Disc

Fig. 4, Clutch Assembly with Pot-Type Flywheel (17-Inch Only)



A. U-Clip

Fig. 5, 14-Inch and 16-Inch Clutch



A. U-Clip

Fig. 6, 17-Inch Clutch

9. Install the clutch brake (if equipped) on the transmission shaft.
10. Install the transmission. Follow the procedures in the **transmission group** of this manual.

CAUTION

CAUTION: Do not let the transmission drop, and do not let the transmission hang unsupported by the input shaft in the pilot bearing bore in the flywheel. Taking these precautions will prevent damage to the clutch assembly and the pilot bearing. If excessive force is required to install the transmission into the flywheel housing, investigate the cause and make necessary corrections.

Specifications

Model Nomenclature	
Designation	**Definition**
EV	Eaton Valeo
115	x 10 = Maximum torque capacity in lbf·ft
16	Clutch size in inches

Table 1, Model Nomenclature

Weight and Torque Ratings				
Model	**Total Weight: lbs (kg)**	**Torque Rating: lbf·ft (N·m)**	**Housing**	**Flywheel**
14-Inch				
EV06514	62 (28)	650 (881)	SAE #2	14-Inch Flat
EV08814	62 (28)	880 (1193)		
EV10514	66 (30)	1050 (1424)		
16-Inch				
EV11516	87 (39)	1150 (1559)	SAE #2	16-Inch Flat
EV12516	91 (41)	1695 (1250)		
EV14016	91 (41)	1400 (1898)		

Table 2, Weight and Torque Ratings

Cover Assembly Torque Values		
Description	**Clutch**	**Torque: lbf·ft (N·m)**
Cover Assembly Capscrews (grade 8)	14-Inch	35–40 (47–54)
	16-Inch	40–45 (54–61)

Table 3, Cover Assembly Torque Values

Adjustment Values	
Description	**Adjustment: mm (inch)**
Release Yoke Finger to Bearing Pad Clearance	1/8 (3)
Clutch Pedal Free Travel (minimum)	3/4 (19)
Release Travel Clearance: Non-Synchronized Transmission With Clutch Brake	1/2 (13)

Table 4, Adjustment Values

Specifications

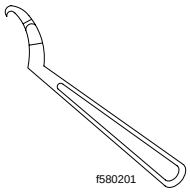
Special Tools			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580201	Adjustable Hook Spaner Wrench	Kent-Moore Tools Kent-Moore Tool Division 28784 Little Mack Roseville, MI 48066	J4749

Table 5, Special Tools

General Description

The clutch linkage transfers the motion of the clutch pedal to the clutch release bearing. The clutch linkage may be adjusted to maintain clutch pedal free-play.

Free-play in the clutch pedal is required to ensure that the release bearing does not run against the fingers of the release yoke. There should not be any play or looseness in the connections and joints of the clutch linkage.

IMPORTANT: Release bearing and release fork clearance are internal clutch adjustments, and *can not be adjusted* by adjusting the clutch linkage. Refer elsewhere in this group for internal clutch adjustments, or to the clutch manufacturer's service literature.

On vehicles with right-hand drive (RH DR), there is an additional crossover linkage mounted on two crossover shaft bearings, one on the left side of the cab, one on the right side. The crossover linkage can be removed and installed without affecting the clutch adjustment.

FLD Clutch Linkage Adjustment

IMPORTANT: Observe the following points before beginning clutch linkage adjustment:

- Be sure internal clutch adjustments are correct before making adjustments to the clutch linkage. See the appropriate section in this manual.
- Adjust clutch linkage only after repair or replacement of the clutch or clutch linkage components.
- Do not attempt to adjust the linkage to compensate for component wear.
- If equipped with cab air-suspension, be sure the air bags are properly inflated. If the air bags are not inflated, the clutch linkage can't be adjusted correctly.

1. Tilt the hood.
2. Remove the clutch inspection cover from the bottom of the bell housing.
3. Measure the distance between the release yoke and the release bearing. If this measurement is 1/8 inch (3.2 mm), no further work is needed. If the measurement is incorrect, do all of the remaining steps.
4. Be sure the clutch pedal is all the way up, against the upper stop.
5. Loosen the rod-end jam nuts at the upper end of the threaded adjusting rod.
6. Disconnect the clutch rod from the lower end of the pedal shaft. See **Fig. 1**. If the clutch rod is fastened to the pedal shaft with rubber washers, note their position for later installation. See **Fig. 2**.

IMPORTANT: A special tool is used to adjust the clutch linkage. The special tool is a 3/4-inch (19-mm) spacer and may be ordered from the PDCs under part number 02–12282–000.

7. Place the special tool (part number 02–12282–000) between the clutch pedal stop bracket and the rubber stop. See **Fig. 3**.
8. Pull the clutch rod forward until it stops (release yoke contacts the release bearing).
9. To obtain a free-travel measurement of 1/8 inch (3.2 mm) between the release yoke and the release bearing, turn the clutch rod end until the center of the rod-end hole is aligned with the center of the hole in the upper clutch lever.

NOTE: Each complete turn of the rod end (or rod) equals about 1/32 inch (1 mm) movement. After lengthening the linkage, at least 3/8 inch (9.5 mm) of thread must remain engaged in each end of the rod.

10. After adjusting the length, connect the clutch rod to the upper clutch lever as follows:

    On FLD Conventionals with rubber washers (see **Fig. 2**), install the flatwashers, rubber washers, fender washers, capscrew, and nut. Tighten the nut until the distance between the upper clutch lever and each fender washer is 5/32 inch (4.0 mm).

    On FLD Conventionals without rubber washers (see **Fig. 4**), install the washers, capscrew, and nut. Tighten the nut 28 lbf·ft (38 N·m).

    Tighten both rod-end jam nuts 30 lbf·ft (40 N·m).

    Remove the special tool from the clutch pedal stop bracket.

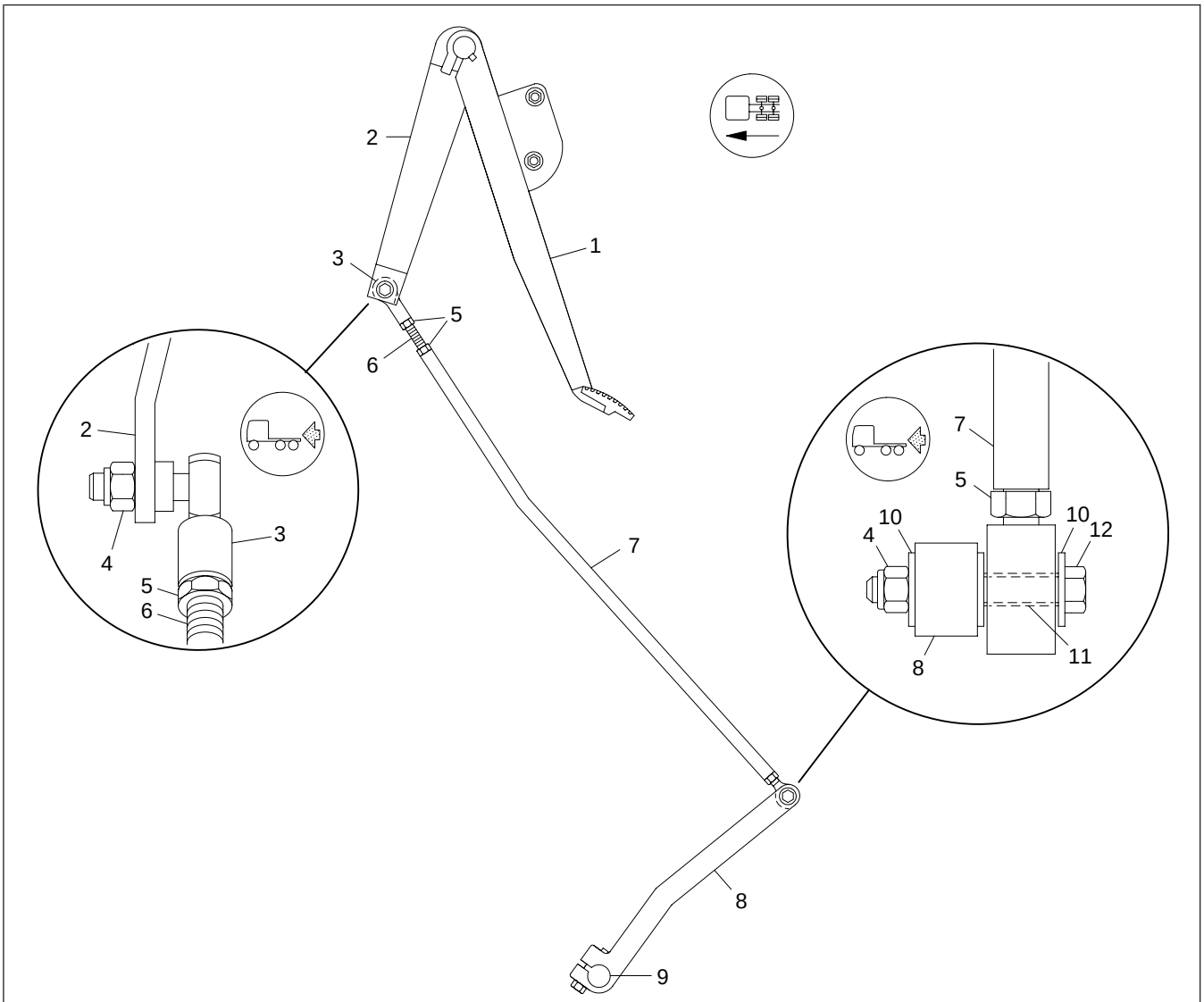
11. Install the inspection cover on the bottom of the bell housing.

FLA and FLB Clutch Linkage Adjustment

IMPORTANT: Observe the following points before beginning clutch linkage adjustment:

- Be sure internal clutch adjustments are correct before making adjustments to the clutch linkage. See the appropriate section in this manual.
- Adjust clutch linkage only after repair or replacement of the clutch or clutch linkage components.
- Do not attempt to adjust the linkage to compensate for component wear.
- Be sure the cab is down and locked in position to adjust the clutch linkage.

Clutch Linkage Adjustment



1. Clutch Pedal
2. Clutch Pedal Shaft
3. Rod End
4. Locknut
5. Rod-End Jam Nut
6. Threaded Adjusting Rod
7. Clutch Rod
8. Clutch Release Lever
9. Clutch Release Shaft
10. Flatwasher
11. Spacer
12. Capscrew

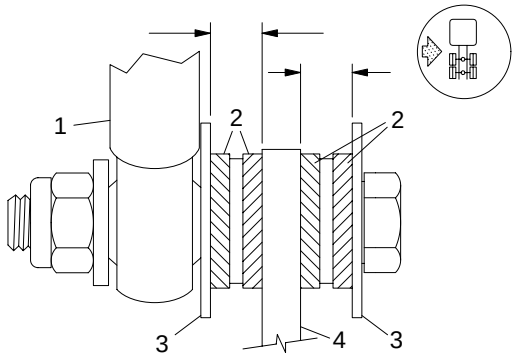
Fig. 1, FLD Conventional Clutch Linkage

- If equipped with cab air-suspension, be sure the air bags are properly inflated. If the air bags are not inflated, the clutch linkage can't be adjusted correctly.

⚠ WARNING

If the clutch linkage needs adjustment, or is adjusted incorrectly on vehicles equipped with a cab air suspension, the clutch could engage as air pressure builds after the engine is started.

Clutch Linkage Adjustment



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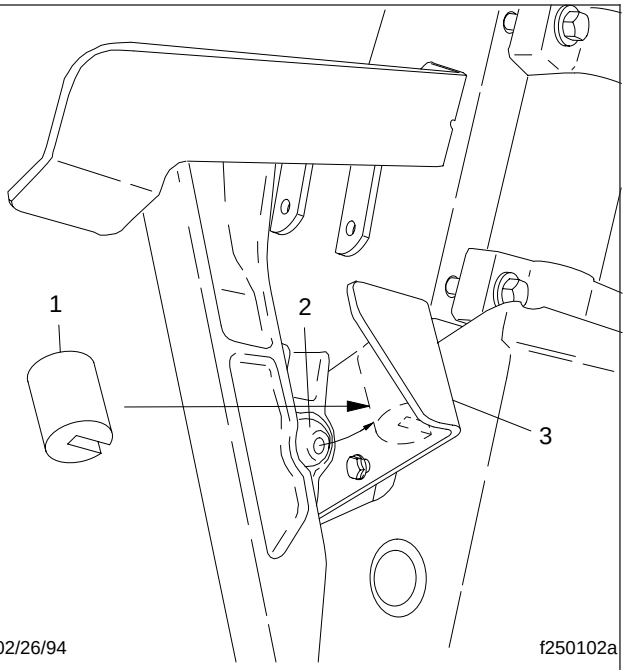
Example shown; installations vary

NOTE: Tighten the capscrew until the distance between the pedal shaft and each fender washer is 5/32 inch (4.0 mm) wide.

1. Clutch Rod
2. Rubber Washers
3. Fender Washer
4. Pedal Shaft

Fig. 2, FLD Conventional Clutch Linkage With Rubber Washers



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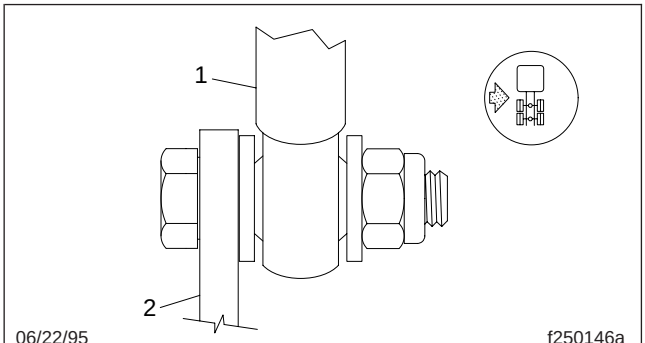
1. Special Tool
2. Rubber Stop
3. Clutch Pedal Stop Bracket

Fig. 3, Position the Special Tool



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Example shown; installations vary

1. Clutch Rod
2. Pedal Shaft

Fig. 4, FLD Conventional Clutch Linkage Without Rubber Washers

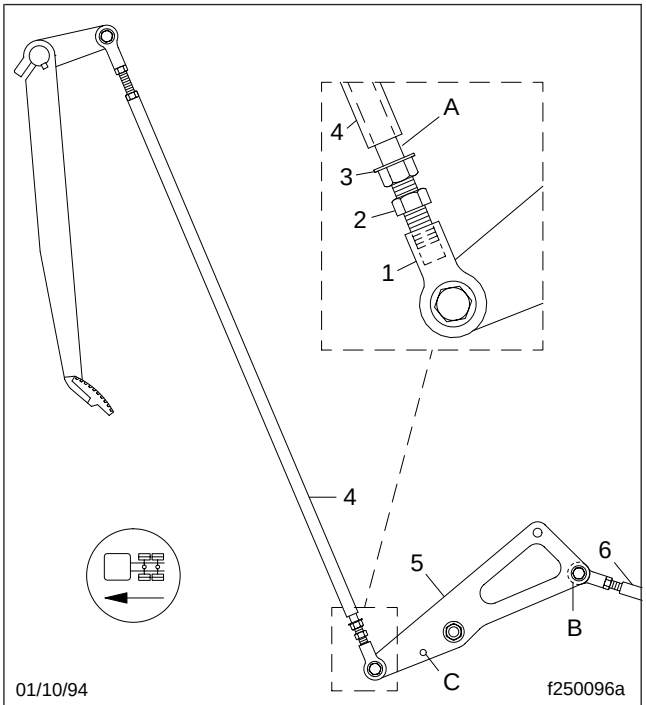
Always start the vehicle with the transmission in neutral. After the cab air suspension (if equipped) is correctly inflated, shut down the engine and adjust the clutch linkage. Failure to follow this procedure on vehicles equipped with a cab air suspension could result in clutch engagement as air pressure builds, possibly resulting in a run-away vehicle and causing serious personal injury or property damage.

The clutch bellcrank has two mounting holes for the horizontal (lower) clutch rod. The mounting hole used on FLA COEs built before April 1992 depended on the type of clutch which was installed. Beginning in April 1992, the horizontal clutch rod was attached to the lower aft hole for all clutch installations. See **Fig. 5**, Ref B. For clutch linkage adjustment on FLA COEs built before April 1992, install the lower clutch rod in the lower aft hole of the bellcrank before beginning the adjustment.

IMPORTANT: The lower clutch rod **must** be installed in the lower aft hole of the bellcrank for all COEs. Before adjusting the clutch linkage, check the location of the lower clutch rod. If the lower clutch rod is installed in the upper hole, reposition it in the lower aft hole. This must be done to ensure correct linkage adjustment.

On FLA COEs built before April 1992, the clutch bellcrank had a 1/8-inch hole which was used for clutch linkage adjustment. See **Fig. 5**. Beginning in April 1992, the 1/8-inch hole for adjustment has been eliminated, and a special tool (see **Fig. 6**, Ref. 2) is used to adjust the clutch linkage. Use this special

Clutch Linkage Adjustment



This bellcrank was installed on vehicles built before April 1992.

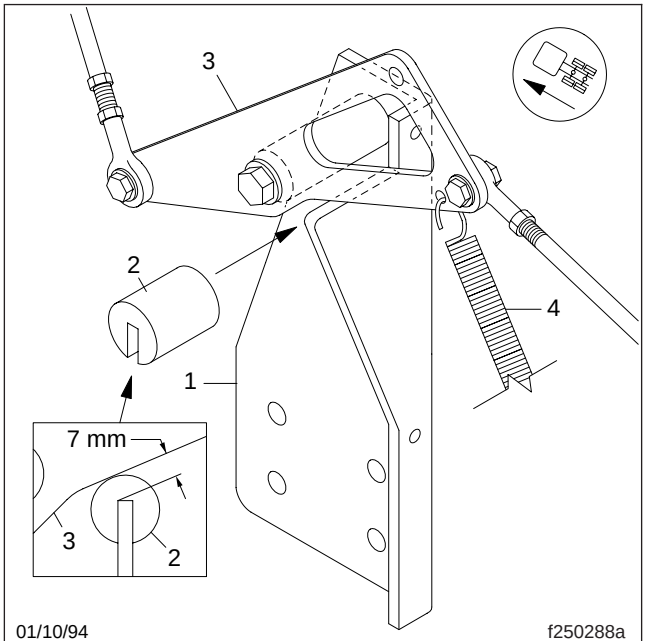
A. Check here for a gap. Adjust if necessary.
B. Attach the lower clutch rod here for all clutch installations.
C. The 1/8-inch hole in the bellcrank is no longer used for adjustment.

1. Rod End
2. Jam Nut
3. Adjusting Nut
4. Upper Clutch Rod (telescoping rod)
5. Bellcrank (FLA COE shown)
6. Lower Clutch Rod (threaded adjusting rod)

Fig. 5, FLA COE Bellcrank (pre-April 1992)

tool (part number 02–12282–000) for adjustment of the clutch linkage on all COEs.

1. Remove the clutch inspection cover from the bottom of the bell housing.
2. Measure the distance between the release yoke and the release bearing. If this measurement is 1/8 inch (3.2 mm), no further work is needed. If the measurement is incorrect, do all of the remaining steps.
3. Turn the front wheels to obtain access to the clutch linkage through the left front wheel well.



This bellcrank was installed on vehicles built from April 1992.

1. Pivot Bracket
2. Special Tool
3. Bellcrank (FLA COE shown)
4. Return Spring

Fig. 6, FLA COE Bellcrank (from April 1992)

4. Be sure the clutch pedal is all the way up, against the upper stop.
5. Disconnect the lower rod from the bellcrank.

IMPORTANT: Do not disconnect the return spring during adjustment.

6. Place the special tool (part number 02–12282–000) on the pivot bracket, as shown in **Fig. 6**. The special tool should fit snugly between the pivot bracket and the bellcrank.
7. Check for a gap between the end of the upper clutch rod and the adjusting nut. See **Fig. 5**, Ref. A. If there is a gap, or if the special tool does not fit snugly between the pivot bracket and the bellcrank, loosen the jam nut (Ref. 2) on the rod end. Turn the rod end by hand until there is no gap, and the special tool fits on the pivot bracket with no pre-load. Tighten the jam nut 14 lbf·ft (19 N·m).

   Remove the special tool from the pivot bracket.

8. Position the special tool between the pedal stop and clutch pedal. See **Fig. 3**.
9. Pull the lower clutch rod forward until it stops. The clutch yoke is now resting against the release bearing.

IMPORTANT: The clutch yoke must be held against the release bearing during adjustment.

10. If necessary, loosen the jam nut, and adjust the linkage so that the rod-end lines up with the lower aft hole of the bellcrank.

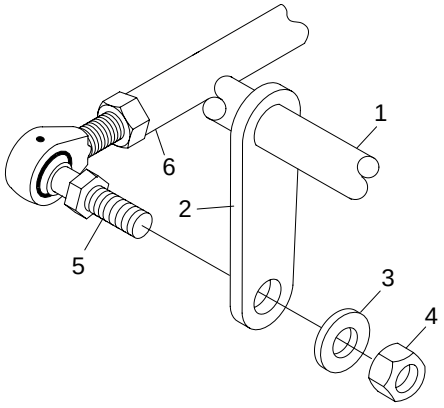
NOTE: Each complete turn of the rod equals about 0.04 inch (1 mm) of movement. After adjusting the linkage, at least 3/8-inch (9.5 mm) of thread must remain engaged in each end of the rod.

11. Install the rod end in the bellcrank. Tighten the jam nut 14 lbf·ft (19 N·m). Tighten the rod-end nut 28 lbf·ft (38 N·m).
12. Remove the special tool from the clutch pedal stop bracket.
13. Install the inspection cover on the bottom of the bell housing.

Clutch Crossover Linkage Removal and Installation, FLB RH DR

Removal

1. Chock the tires.
2. Tilt the cab.
3. Disconnect the ball stud on the telescoping clutch rod from the lever arm on the clutch crossover shaft (left). Thread the removed fasteners back onto the ball stud for use during installation. See **Fig. 1**.

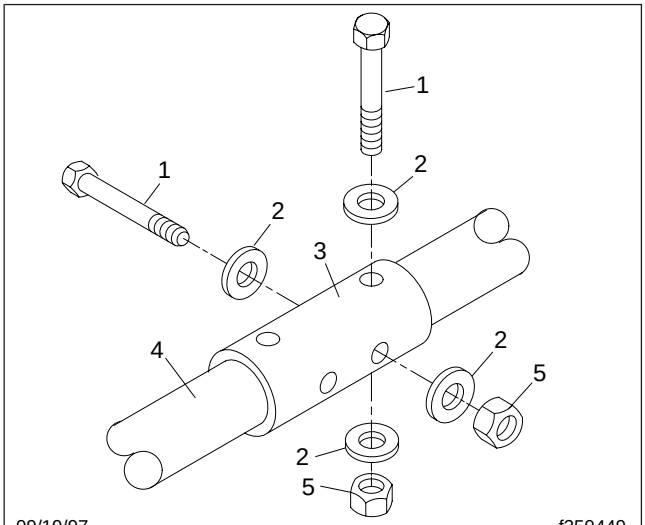


09/19/97 f250448

1. Crossover Shaft (left)
2. Lever Arm
3. Lockwasher
4. 3/8–24 Locknut
5. Ball Stud
6. Clutch Rod

Fig. 1, Disconnect the Crossover Shaft

4. Remove the four capscrews on the sleeve that connects the two parts of the clutch crossover shaft, left and right. See **Fig. 2**.
5. Remove the nuts attaching both crossover shaft bearings to the cab wall. See **Fig. 3**. Loosen the eccentric lock collar on the right-side bearing.
6. Remove the crossover shaft (left) from the vehicle. See **Fig. 4**.
7. Remove the clutch pedal. For instructions, see **Subject 120**.
8. Slide the crossover linkage assembly out of the cab.
9. If necessary to replace the bearing or shaft, remove the right-side bearing from the crossover linkage assembly.



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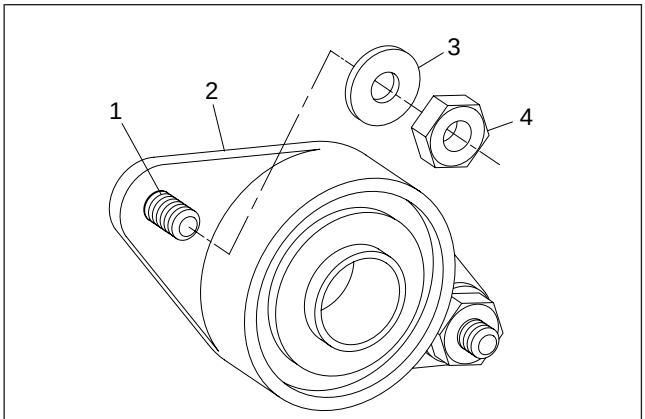
1. 3/8–16 Capscrew
2. Hardened Flatwasher
3. Sleeve
4. Crossover Shaft
5. 3/8–16 Locknut

Fig. 2, Crossover Shaft Sleeve



09/24/97 f250452

1. 3/8–16 Capscrew
2. Bearing
3. Hardened Flatwasher
4. 3/8–16 Hexnut

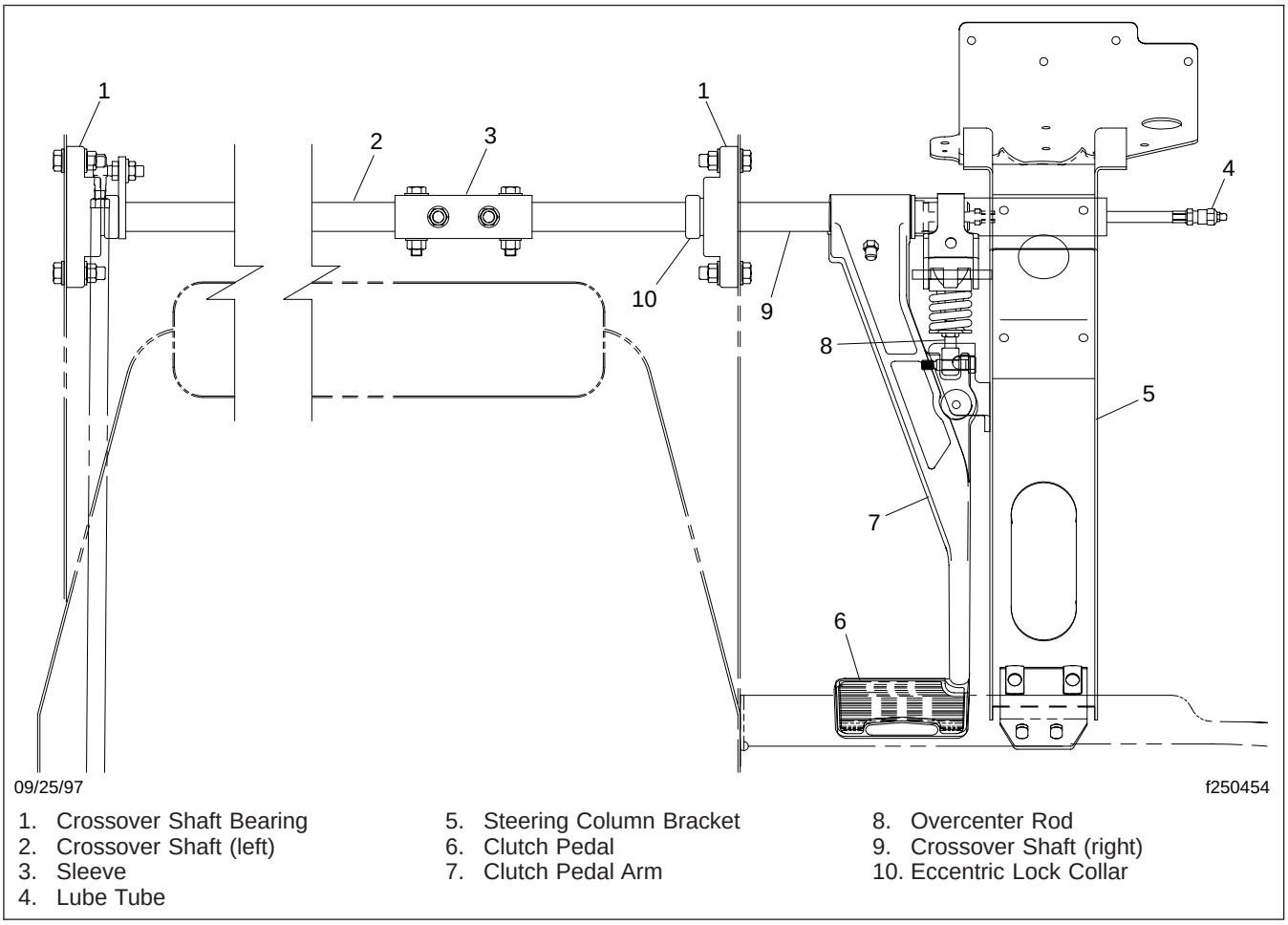
Fig. 3, Crossover Shaft Bearing

Installation

1. If removed, install the right-side bearing on the crossover linkage assembly.

NOTE: Use two persons for the next step, one inside the cab to install the pedal, the other out-

Clutch Crossover Linkage Removal and Installation, FLB RH DR



1. Crossover Shaft Bearing
2. Crossover Shaft (left)
3. Sleeve
4. Lube Tube
5. Steering Column Bracket
6. Clutch Pedal
7. Clutch Pedal Arm
8. Overcenter Rod
9. Crossover Shaft (right)
10. Eccentric Lock Collar

Fig. 4, Crossover Shaft Removal

side the cab to insert the linkage assembly through the cab wall.

2. Install the crossover linkage assembly through the cab wall onto the steering column bracket.
3. Install the clutch pedal. For instructions, see **Subject 120**.

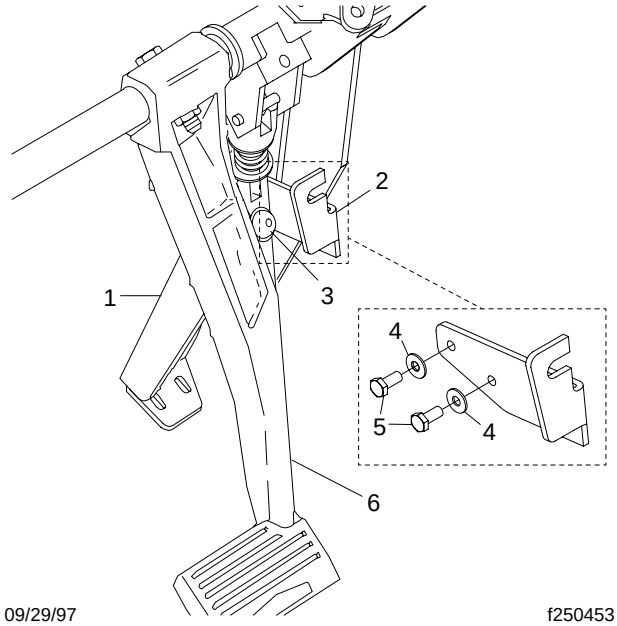
IMPORTANT: Install the bearings with the grease fitting down.

4. Mount the bearings on the cab wall, using the fasteners as removed. Tighten the 3/8–16 locknuts 26 lbf·ft (36 N·m).
5. Tighten the eccentric lock collar firmly against the right-side bearing.
6. Install the crossover shaft (left) on the vehicle. See **Fig. 3**.
7. Install the four capscrews on the sleeve that connects the two parts of the clutch crossover shaft, left and right. Tighten the 3/8–16 locknuts 26 lbf·ft (36 N·m). See **Fig. 2**.
8. Connect the ball stud on the telescoping clutch rod to the lever arm on the clutch crossover shaft (left). Tighten the 3/8–24 hexnut 30 lbf·ft (40 N·m). See **Fig. 1**.
9. Lower the cab.
10. Remove the chocks from the tires.

Clutch Pedal Removal and Installation, FLB RH DR

Removal

1. Remove the dash skirt panel (E-panel).
2. Remove the clutch pedal stop bracket. See **Fig. 1**.



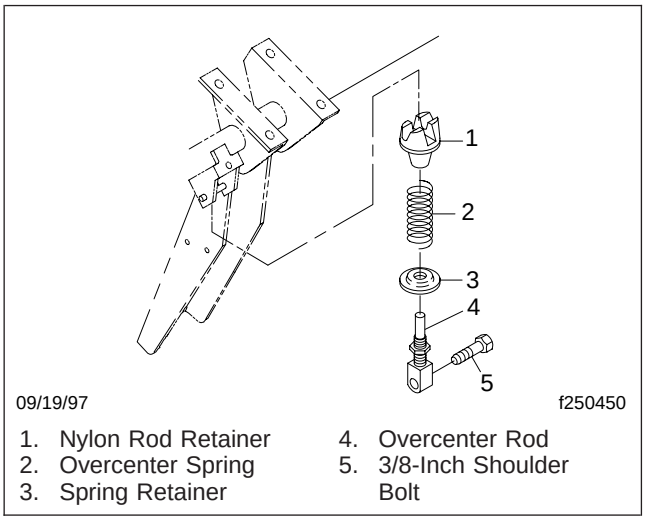
1. Steering Column Bracket
2. Stop Bracket
3. Rubber Stop
4. 1/4-Inch Flatwasher
5. 1/4–20 Capscrew
6. Clutch Pedal Arm

Fig. 1, Remove the Clutch Pedal Stop Bracket

3. Remove the overcenter spring. See **Fig. 2**.
4. Remove the clutch pedal mounting bolt. See **Fig. 3**.

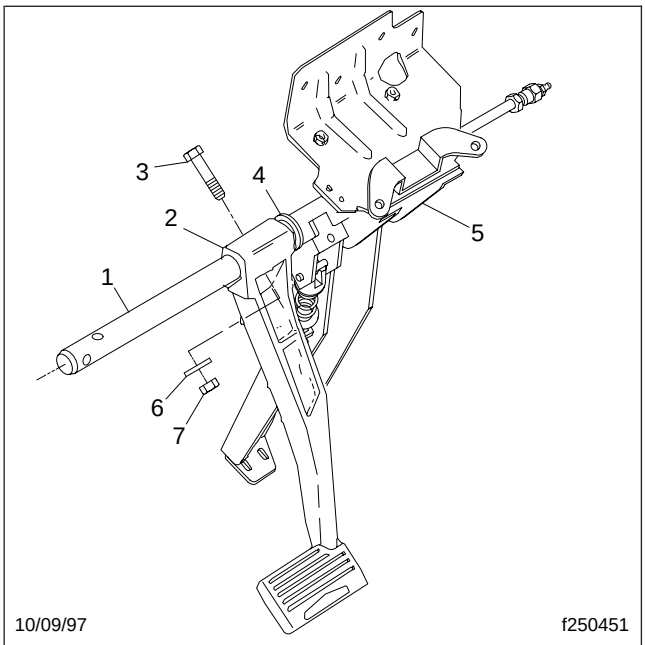
Installation

1. Install the pedal onto the crossover shaft. Tighten the 3/8–16 capscrew 26 lbf·ft (36 N·m).
2. Install the overcenter bolt and spring.
3. Install the clutch pedal stop bracket. Tighten the two 1/4–20 capscrews 84 lbf·in (940 N·cm).
4. Install the dash skirt panel (E-panel).



1. Nylon Rod Retainer
2. Overcenter Spring
3. Spring Retainer
4. Overcenter Rod
5. 3/8-Inch Shoulder Bolt

Fig. 2, Remove the Overcenter Spring



1. Crossover Shaft (right)
2. Clutch Pedal Arm
3. 3/8–16 Capscrew
4. Nylatron Washer
5. Steering Column Bracket
6. Hardened Washer
7. 3/8–16 Locknut

Fig. 3, Remove the Clutch Pedal Mounting Bolt

Specifications

FLD Clutch Linkage Torque Values	
Description	**Torque**
Clutch Linkage Jam Nuts	30 lbf·ft (40 N·m)
Clutch Rod-to-Pedal Shaft *	28 lbf·ft (38 N·m)

* On FLD Conventionals with rubber washers, install the flatwashers, rubber washers, fender washers, capscrew, and nut. Tighten the nut until the distance between the upper clutch lever and each fender washer is 5/32 inch (4.0 mm).

Table 1, FLD Clutch Linkage Torque Values

FLA and FLB Clutch Linkage Torque Values	
Description	**Torque**
Clutch Linkage Jam Nuts	14 lbf·ft (19 N·m)
Clutch Rod-to-Bellcrank	28 lbf·ft (38 N·m)

Table 2, FLA and FLB Clutch Linkage Torque Values

FLB Right-Hand Drive Clutch Crossover Linkage Torque Values	
Description	**Torque**
Clutch Pedal Mounting Nut	26 lbf·ft (36 N·m)
Clutch Pedal Stop Bracket Capscrews	84 lbf·in (940 N·cm)
Clutch Rod-to-Crossover Shaft Hexnut	30 lbf·ft (40 N·m)
Crossover Linkage Sleeve Locknuts	26 lbf·ft (36 N·m)
Crossover Shaft Bearing Mounting Nuts	26 lbf·ft (36 N·m)

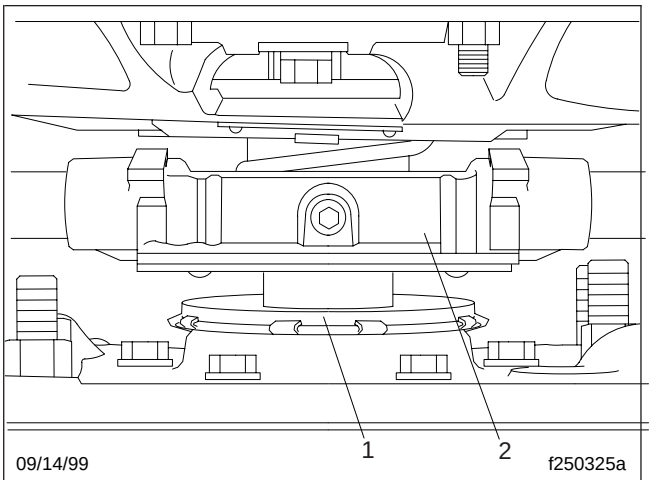
Table 3, FLB Right-Hand Drive Clutch Crossover Linkage Torque Values

General Description

When the vehicle is stationary, a clutch brake permits shifting into first gear or reverse gear without severe gear clash.

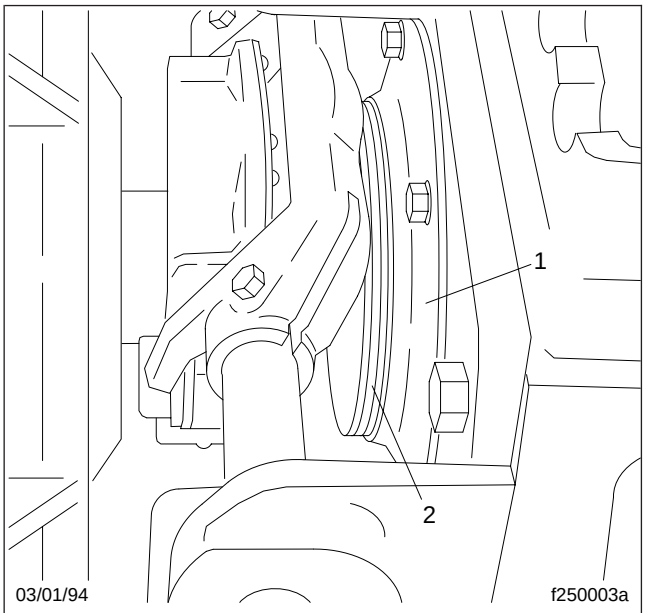
Clutch brake engagement occurs approximately during the last 1 to 1-1/4 inches (25 to 33 mm) of downward pedal travel. The clutch brake is between the release-bearing housing (see **Fig. 1**) and the transmission bearing cap, and is engaged by tangs to the transmission input shaft. When the pedal is fully depressed, the clutch brake is squeezed between the release-bearing housing and the transmission bearing cap (see **Fig. 2**), stopping the rotation of the main drive gear.

The clutch brake may be a disc-type or a torque-limiting type. In addition, the clutch brake may be either a one-piece or two-piece design. To prevent overloads to it, the torque-limiting clutch brake is designed to slip when loads of 20 to 25 lbf·ft (27 to 34 N·m) are reached. Clutch brakes are not designed for upshifting.



1. Clutch Brake
2. Release Bearing

Fig. 1, Clutch Brake and Release Bearing



1. Transmission Input Shaft Bearing Cap
2. Clutch Brake Discs and Washer

Fig. 2, Clutch Brake and Bearing Cap

One-Piece Clutch Brake Replacement

Replacement

1. Shut down the engine, set the parking brake, and chock the tires.
2. Tilt the hood.
3. Drain the air tanks.
4. Disconnect the batteries.
5. Place the transmission in gear.
6. Remove the shift tower from the top of the transmission. See **Group 26** in this manual for instructions.
7. Disconnect the driveline from the rear of the transmission. See **Group 41** in this manual for instructions.
8. Disconnect the midship bearing. See **Group 41** in this manual for instructions. Pull the driveshaft aside and position it out of the way.
9. Remove the fuel tank compression brace. See **Group 47** in this manual for instructions.
10. Disconnect the clutch rod from the clutch release lever. See **Section 25.03** in this group for instructions.
11. Disconnect the transmission wiring.
12. Disconnect the transmission air lines.
13. Remove the auxiliary air tank, if so equipped.
14. Remove the transmission oil cooler and set it aside, out of the way.

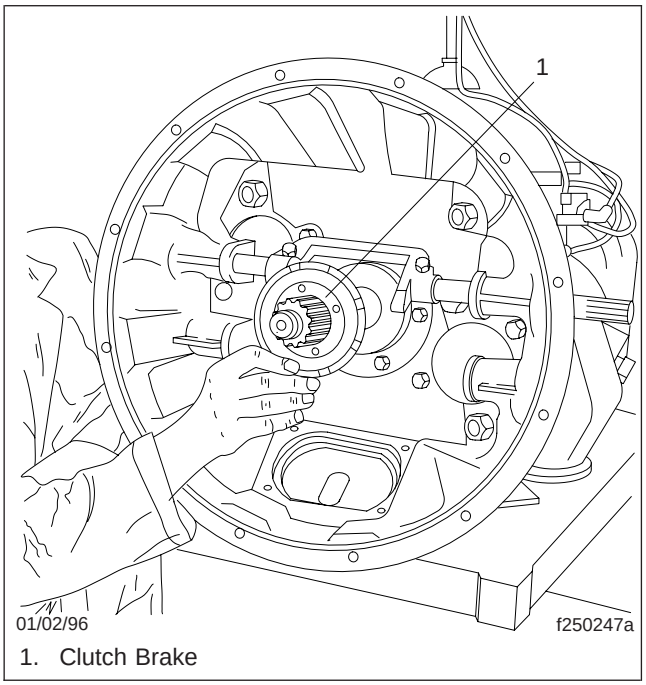
IMPORTANT: Do not disconnect the oil cooler lines.

15. Place a transmission jack in position below the transmission. Adjust the jack to support the transmission.
16. Secure the transmission to the jack.
17. Remove the flywheel housing-to-clutch housing bolts. See **Group 26** in this manual for instructions.

CAUTION

Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Taking these precautions will prevent bending and distortion of the clutch discs.

18. Pull the transmission back until the input shaft clears the flywheel.
19. Remove the old clutch brake from the transmission input shaft. See **Fig. 1**.



1. Clutch Brake

Fig. 1, Clutch Brake Removal

20. Align the tangs of the new clutch brake with the grooves on the input shaft and slide the clutch brake into position. See **Fig. 2**.

CAUTION

Use care to avoid springing the drive discs when the transmission is being installed. Do not force the transmission into the clutch or flywheel housing if it does not enter freely. Do not let the transmission drop or hang unsupported in the driven discs. These practices can damage the clutch assembly.

21. Install the transmission. See **Group 26** in this manual for instructions.
22. Remove the transmission jack.
23. Connect the air lines and the transmission wiring.

One-Piece Clutch Brake Replacement

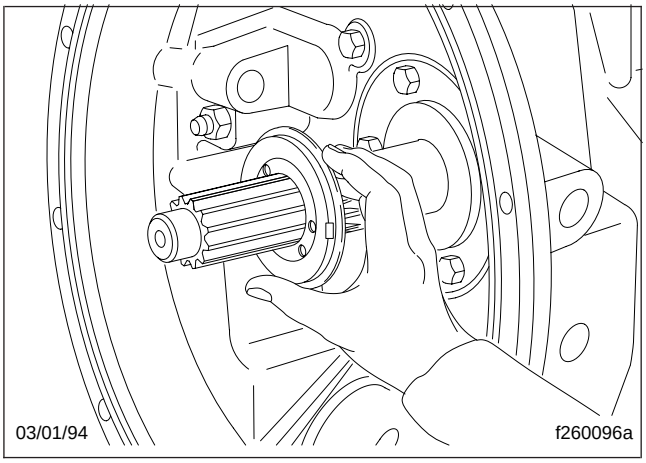


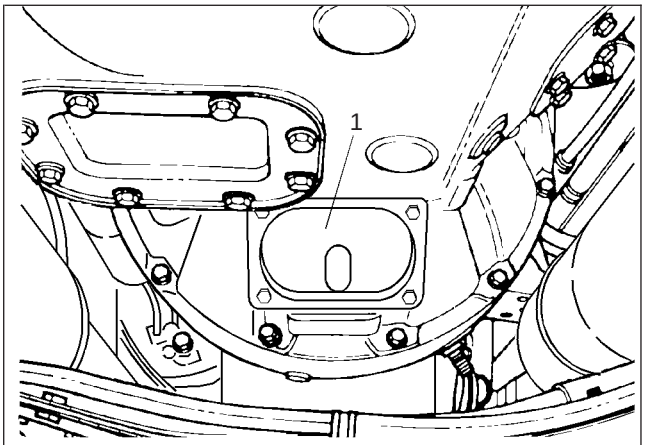
Fig. 2, Clutch Brake Installation

24. Install the fuel tank compression brace. See **Group 47** in this manual for instructions.
25. Install the auxiliary air tank, if so equipped.
26. Install the transmission oil cooler.
27. Install the shift tower on the top of the transmission. See **Group 26** in this manual for instructions.
28. Connect the clutch rod to the clutch release lever. See **Section 25.03** in this group for instructions.
29. Connect the driveline at the rear of the transmission. See **Group 41** in this manual for instructions.
30. Connect the midship bearing. See **Group 41** in this manual for instructions.
31. Ensure that the transmission is out of gear and adjust the clutch. See **Group 25** in this manual for instructions.
32. Connect the batteries.
33. Lower the hood and remove the chocks from the tires.
34. Test drive the vehicle and ensure that the clutch brake and clutch operate properly.

Replacement of a One-Piece Clutch Brake with a Two-Piece Clutch Brake

Replacement

1. Shut down the engine, set the parking brake, and chock the tires.
2. Tilt the hood.
3. Remove the four fasteners and the clutch inspection cover. See **Fig. 1**.



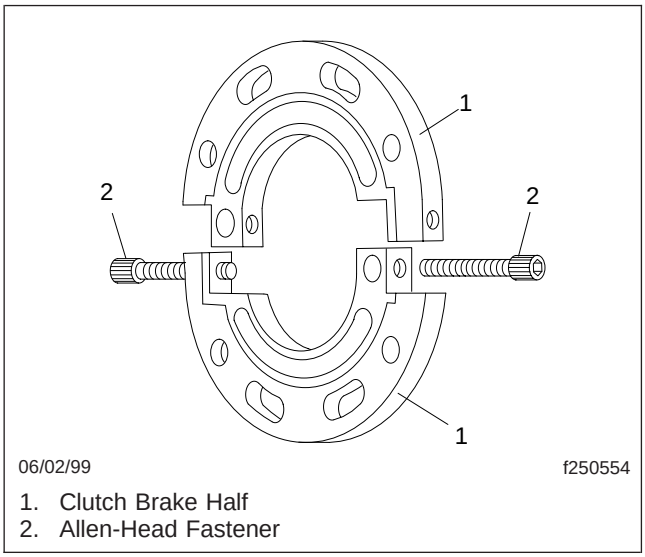
1. Inspection Cover

Fig. 1, Clutch Inspection Cover

⚠ WARNING

Wear safety goggles when cutting off the old clutch brake. If any of the metal parts were to chip, flying pieces of metal could cause eye injury.

4. Using an air chisel, carefully cut off the old clutch brake.
5. Check the orientation and fit of the new two-piece clutch brake halves.
6. Place one half of the new two-piece clutch brake onto the input shaft and rotate it to the top side of the shaft. See **Fig. 2**.
7. Align the lower half with the upper half at the connecting points.
8. Hold both halves together and start the fasteners on both sides.
9. Align the fasteners with the grooves on the input shaft.



1. Clutch Brake Half
2. Allen-Head Fastener

Fig. 2, Two-Piece Clutch Brake (Spicer shown)

10. Tighten Allen-head fasteners 60 lbf·in (675 N·cm).

NOTE: Other types of two-piece clutch brakes use roll pins for fasteners.

⚠ WARNING

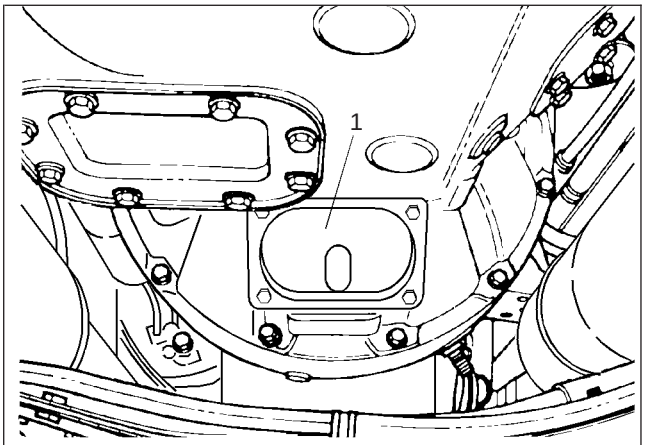
Wear safety goggles when driving in roll pins. If any of the metal parts were to chip, flying pieces of metal could cause eye injury.

11. If the replacement clutch brake uses roll pins, carefully drive in the roll pins equally with a punch and mallet, securing the halves to each other.
12. Install the clutch inspection cover and the four fasteners. Tighten the fasteners securely.
13. Adjust the clutch. See **Group 25** in this manual for instructions.
14. Lower the hood and remove the chocks from the tires.
15. Test drive the vehicle and ensure that the clutch brake and clutch operate properly.

Two-Piece Clutch Brake Replacement

Replacement

1. Shut down the engine, set the parking brake, and chock the tires.
2. Tilt the hood.
3. Remove the four fasteners and the clutch inspection cover. See **Fig. 1**.



1. Inspection Cover

Fig. 1, Clutch Inspection Cover

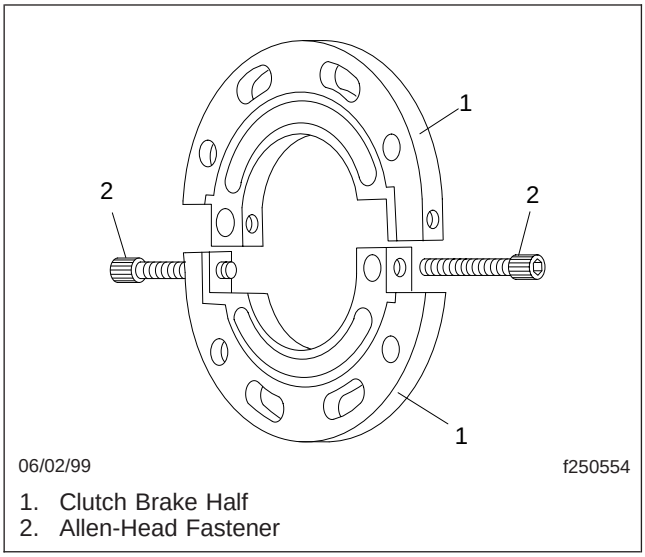
NOTE: Some types of two-piece clutch brakes use roll pins for fasteners.

4. Rotate the input shaft until the Allen-head fasteners or roll pins securing the two clutch brake halves are visible.
5. If the old clutch brake uses Allen-head fasteners, remove the fasteners and remove the two brake halves from the input shaft.

⚠ WARNING

Wear safety goggles when driving out roll pins. If any of the metal parts were to chip, flying pieces of metal could cause eye injury.

6. If the old clutch brake uses roll pins, carefully drive out the pins with a punch and mallet and remove the two brake halves from the input shaft.
7. Check the orientation and fit of the new two-piece clutch brake halves.
8. Place one half of the new two-piece clutch brake onto the input shaft and rotate it to the top side of the shaft. See **Fig. 2**.



1. Clutch Brake Half
2. Allen-Head Fastener

Fig. 2, Two-Piece Clutch Brake (Spicer shown)

9. Align the lower half with the upper half at the connecting points.
10. Hold both halves together and start the fasteners on both sides.
11. Align the fasteners with the grooves on the input shaft.
12. Tighten Allen-head fasteners 60 lbf·in (675 N·cm).

⚠ WARNING

Wear safety goggles when driving in roll pins. If any of the metal parts were to chip, flying pieces of metal could cause eye injury.

13. If the replacement clutch brake uses roll pins, carefully drive in the roll pins equally with a punch and mallet, securing the halves to each other.
14. Install the clutch inspection cover and the four fasteners. Tighten the fasteners securely.
15. Adjust the clutch. See **Group 25** in this manual for instructions.
16. Lower the hood and remove the chocks from the tires.

Two-Piece Clutch Brake Replacement

17. Test drive the vehicle and ensure that the clutch brake and clutch operate properly.

Troubleshooting Tables

Problem—Broken Tabs on the Clutch Brake

Problem—Broken Tabs on the Clutch Brake	
Possible Cause	**Remedy**
Vibration.	Inspect the clutch disc hubs; check the installation of the clutch. Make sure dampened discs are used.
The clutch linkage is incorrectly adjusted.	Adjust the clutch linkage. Also, check the installation of the clutch.
The driver used the clutch brake while the vehicle was moving.	Use correct driving technique.
The driver used the clutch to hold the vehicle on a hill when stopped.	Use correct driving technique.

Problem—Poor Clutch Release

Problem—Poor Clutch Release	
Possible Cause	**Remedy**
The clutch brake is damaged and/or not functioning.	Install a new clutch brake.

General Description

COEs have a shift lever assembly that mounts on the cab tunnel. The system contains a hydraulic latch mechanism and a telescoping tube assembly. This system allows the cab to be tilted while maintaining alignment between the forward and rear section ends of the shift rod assembly. See **Fig. 1**.

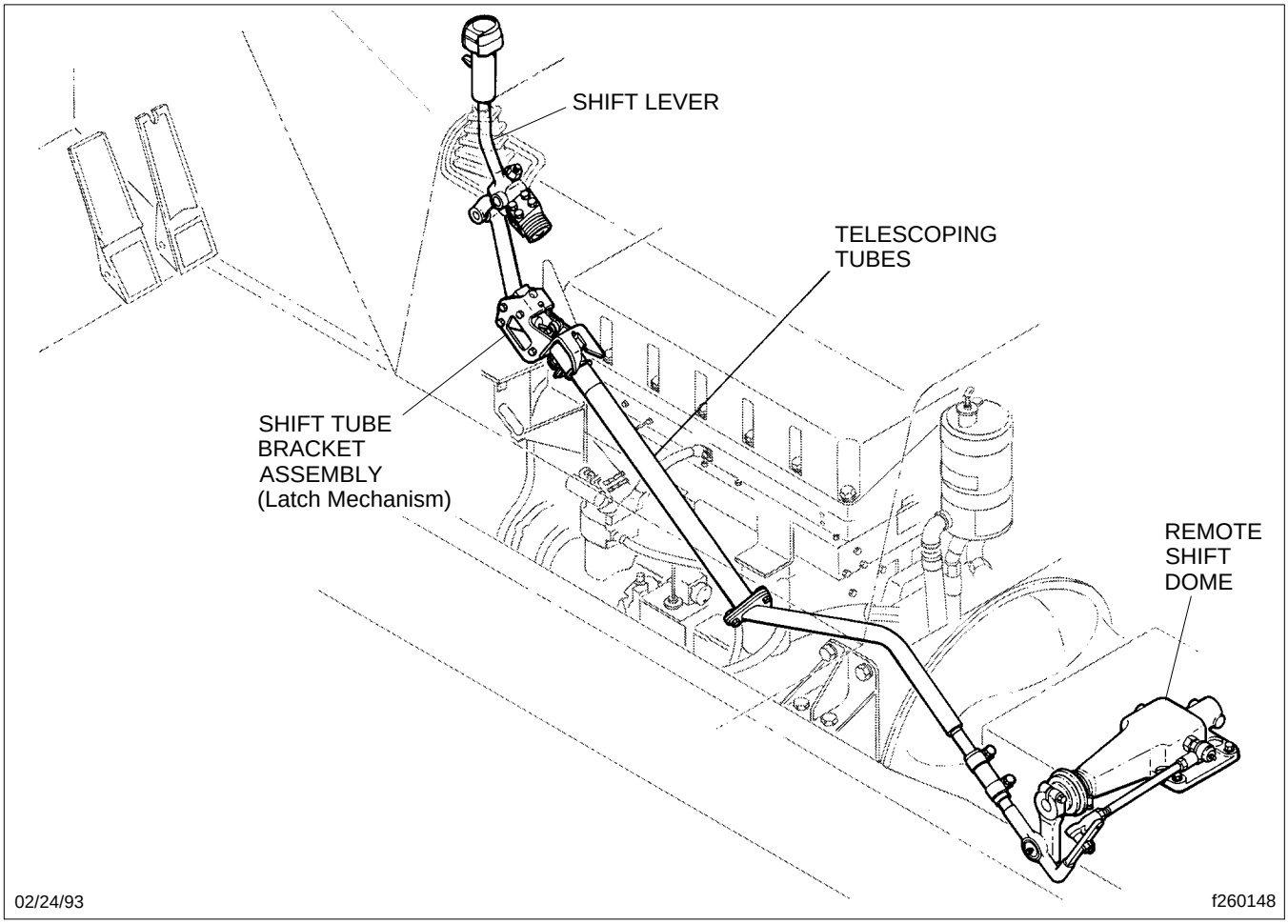


Fig. 1, COE Tunnel Mounted Shifter

Telescoping Tube Assembly Removal and Installation

Removal (See Fig. 1)

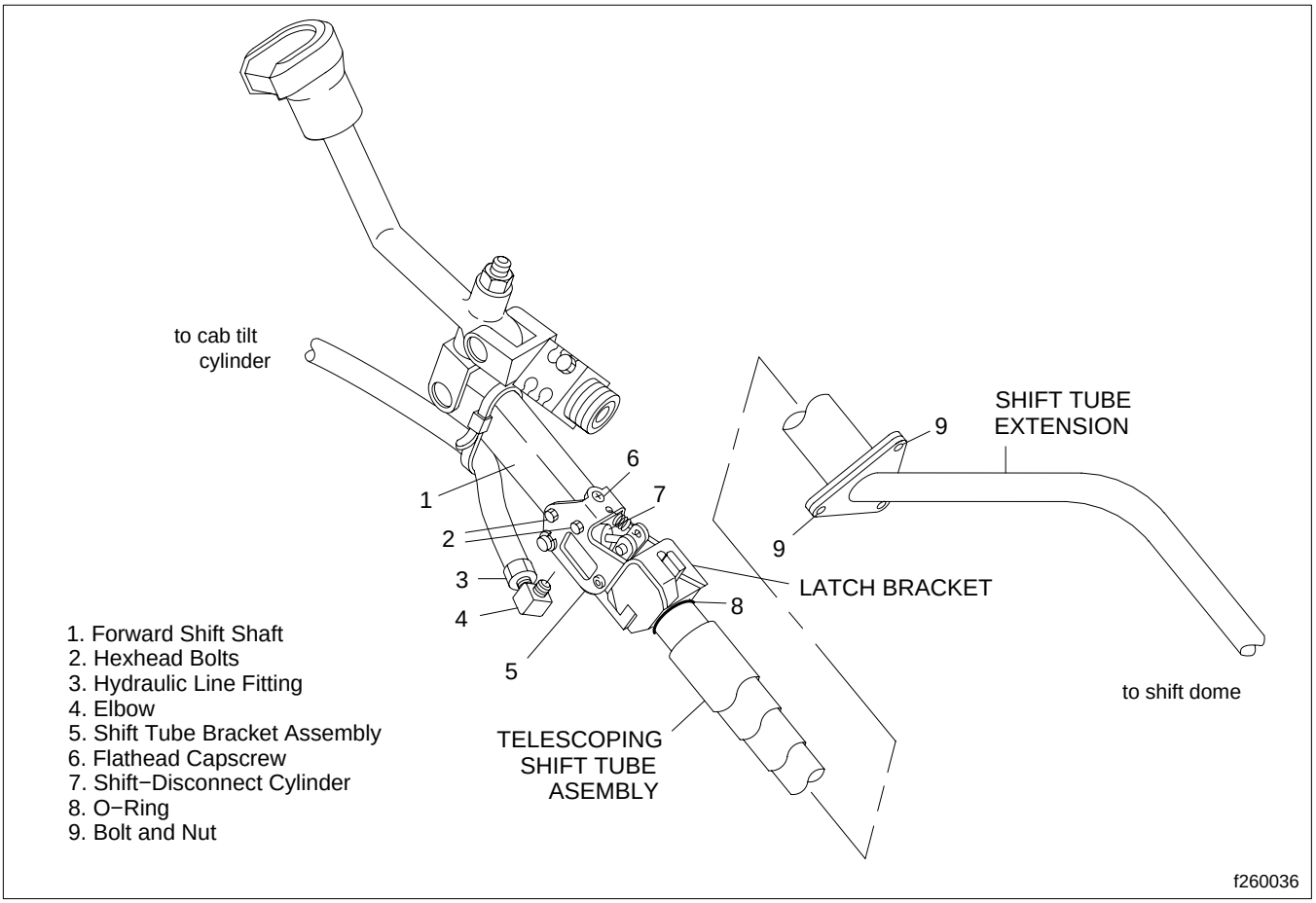


Fig. 1

1. Tilt the cab; for instructions, see **Group 60**.
2. Release the hydraulic pressure by alternately moving the control lever on the tilt pump to the "Raise" and "Lower" positions. Hold the control lever in each position for a few seconds. Allow enough time for the shift-disconnect cylinder (Ref. 7) to empty.
3. Disconnect the hydraulic line (Ref. 3) from the elbow (Ref. 4) on the shift-disconnect cylinder (Ref. 7). Plug the line to prevent dirt from entering the system.
4. Remove the two hexhead bolts (Ref. 2) and the flathead capscrew (Ref. 6) that attach the bracket assembly (Ref. 5) to the forward shift shaft (Ref. 1).
5. Remove the bolts (Ref. 9) and nuts that connect the telescoping shift tube flange to the shift tube extension flange.
6. Place the telescoping tube on a workbench.

Installation (See Fig. 1)

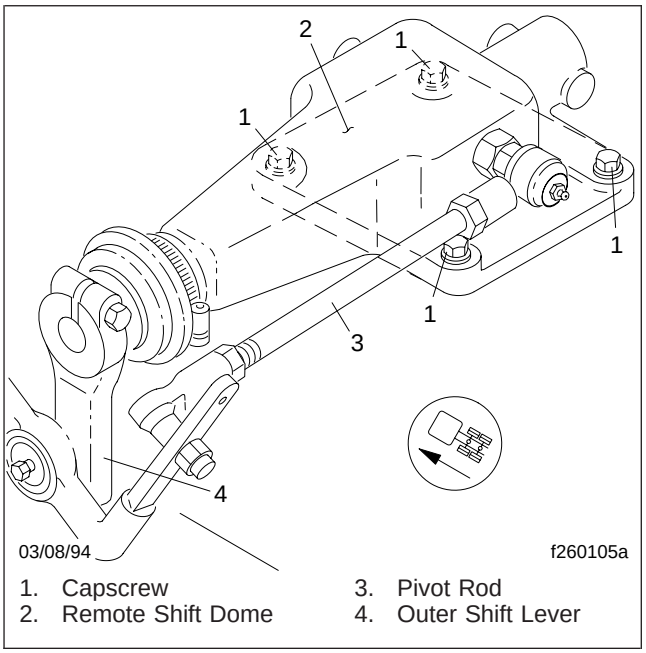
1. Fully extend the telescoping tube, then wipe it off with a clean cloth.
2. Inspect the O-ring (Ref. 8) on the latch bracket tube socket. If worn or damaged, replace it.
3. Apply a light coating of multipurpose chassis grease to the surfaces of the telescoping tubes.

Telescoping Tube Assembly Removal and Installation

4. Install the bolts and nuts that connect the telescoping shift tube flange to the shift tube extension flange. Tighten the nuts 13 lbf·ft (18 N·m).
5. Apply Loctite® 242, or an equivalent, to the threads of the two hexhead bolts and the flathead capscrew that attach the bracket assembly to the forward shift shaft. Install and tighten the hexhead bolts 25 lbf·ft (34 N·m). Install and tighten the flathead capscrew 30 lbf·in (340 N·cm).
6. Connect the hydraulic line to the elbow on the latch cylinder.
7. Return the cab to the operating position; for instructions, see **Group 60**.
8. Loosen the hydraulic line at the elbow on the latch cylinder. Place the tilt pump control lever in the "Raise" position, and operate the tilt pump until a bubble-free stream of hydraulic fluid flows from the fitting. Pump until about 2 oz (60 mL) of hydraulic fluid flows from the fitting to ensure that the entire line is free of air.

   Tighten the line and refill the tilt pump until hydraulic fluid appears in the fill port. See Group 60 of the *Heavy-Duty Trucks Maintenance Manual* for fluid specifications. Install and tighten the fill plug.
9. Before starting the engine, move the shift lever to a forward position. This will apply a backward force against the shift linkage and close the latch in the shift tube bracket assembly.
10. Start the engine. With the engine running, move the shift lever through several gear positions. Check that the shift tube bracket assembly has latched and the linkage is working properly.

Removal (See Fig. 1)



1. Capscrew
2. Remote Shift Dome
3. Pivot Rod
4. Outer Shift Lever

Fig. 1

1. Apply the parking brakes, and chock the tires. Shift the transmission into neutral.
2. Remove the bolts and nuts that connect the telescoping shift tube flange to the shift tube extension flange.
3. Remove the four capscrews that attach the shift dome flange to the top of the transmission. Slowly lift the dome and shift tube extension from the transmission.

IMPORTANT: Take care to remove the shift dome slowly or the three or four poppet (coil) springs may come out. If these springs are removed, mark them for assembly reference.

Cover the entire shift dome opening in the top of the transmission with a clean piece of cardboard. Fasten the cardboard in place with the shift dome attachment capscrews.

Installation (See Fig. 1)

1. Inspect the shift dome gasket. If the gasket is worn or damaged, replace it.
2. Install the poppet (coil) springs as previously marked.
3. Wipe off the underside of the shift dome with a clean cloth.

⚠ WARNING

WARNING: When installing the shift dome, make sure the outer shift lever is pointing straight down or less than five degrees toward the rear of the vehicle. If the lever points forward, the transmission can come out of gear, possibly resulting in personal injury or property damage.

4. Insert a capscrew and hardened flatwasher into the left rear mounting hole, under the pivot rod. Position the outer shift lever so that it points straight down when installed on the transmission.
5. Remove the cardboard cover from the opening in the transmission, and lower the shift dome and shift tube extension into place.
6. Install the remaining hardened flatwashers and capscrews and tighten them 25 lbf·ft (34 N·m).
7. Install the bolts and nuts that connect the telescoping shift tube flange to the shift tube extension flange. Tighten the nuts 13 lbf·ft (18 N·m).

Shift Lever Boot Replacement

Replacement (See Fig. 1)

1. Remove the lower cover from the shift knob; then, disconnect the air lines from the shift knob.
2. Loosen the locknut and remove the shift knob.
3. Remove the screws attaching the shift boot to the tunnel; then, remove the shift boot.
4. Install the new shift boot and securely tighten the screws. Make sure that the shift boot is positioned correctly, or it could tear.
5. Install the shift knob, then securely tighten the locknut.
6. Connect the air lines, then install the lower cover on the shift knob.

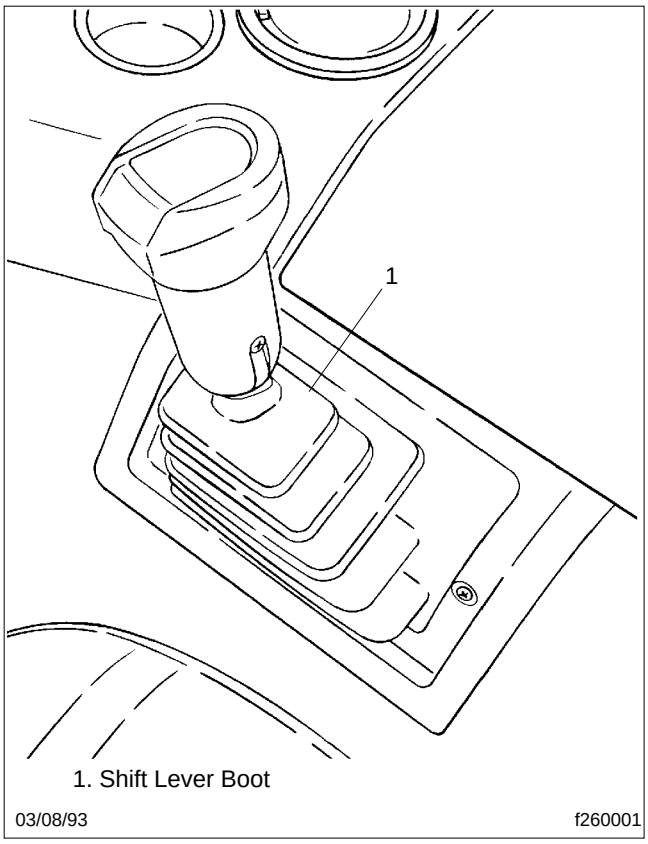


Fig. 1

Removal (See Fig. 1)

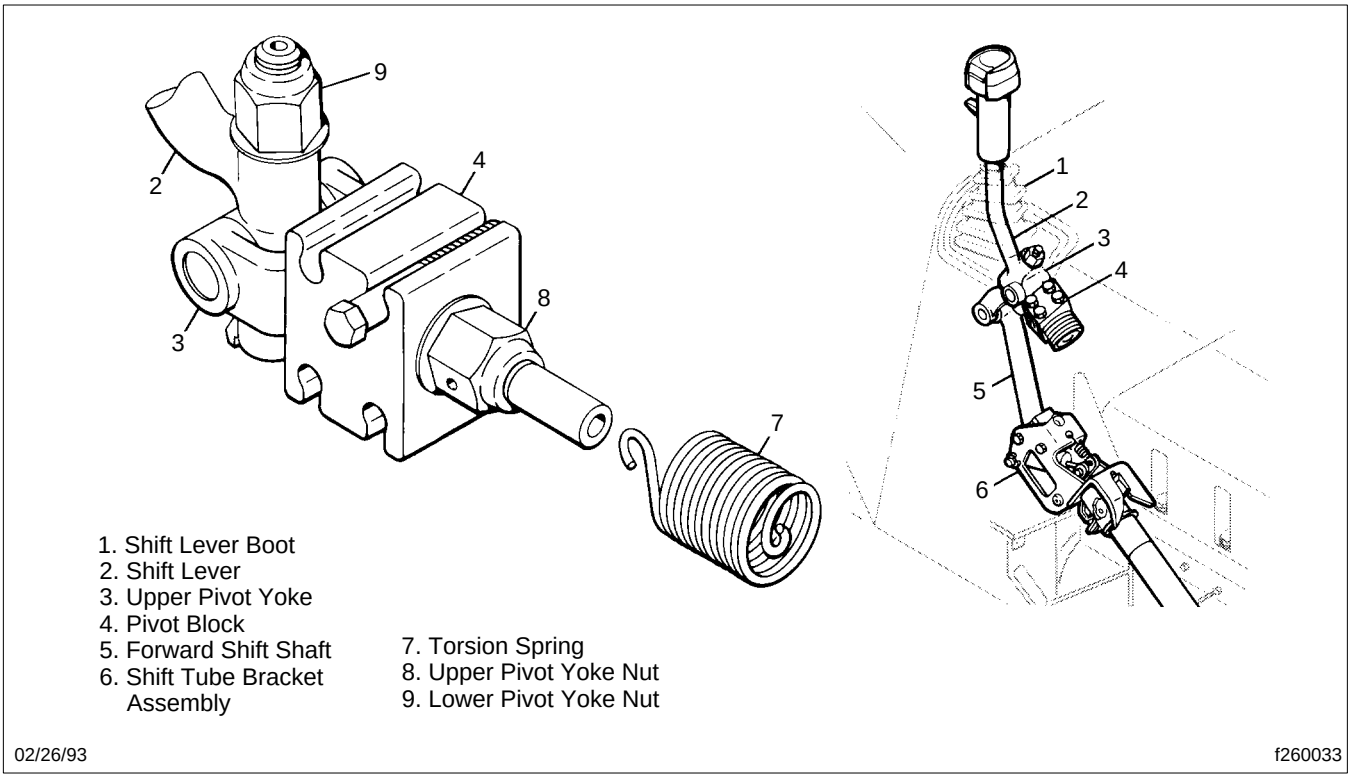


Fig. 1, Pivot Block and Shift Lever Assembly

1. Apply the parking brakes, and chock the tires. Shift the transmission into neutral.
2. Tilt the cab; for instructions, see **Group 60**.
3. Remove the tie strap that attaches the hydraulic line to the forward shift shaft.
4. Remove the two hexhead bolts and the flathead capscrew that attach the bracket assembly to the forward shift shaft.
5. Secure the shift tube assembly so it won't be damaged when the cab is lowered.
6. Return the cab to the operating position; for instructions, see **Group 60**.
7. Remove the shift knob and the shift lever boot. For instructions, see **Subject 120**.
8. Loosen the four pivot block mounting capscrews and remove three of them, leaving the spring-retaining capscrew in the pivot block. See **Fig. 2**. Remove the shift lever and the pivot block assembly.
9. With the upper pivot yoke and shift lever pointing up, clamp the pivot block in a vise.
10. Rotate the yoke away from the roll pin in the pivot block, then remove the roll pin.
11. Turn the yoke slowly until spring tension is relieved. Remove the capscrew that attaches the torsion spring to the pivot block. Turn the yoke shaft away from the spring end, then pry the spring out of the yoke shaft.
12. Remove the nut, spacing washer, and nylon washer from the upper pivot yoke shaft. Remove the pivot block and the nylon washer from the yoke shaft.
13. Remove the nut, spacing washer, and nylon washer from the lower pivot yoke shaft. Remove

Shift Lever and Pivot Block Removal and Installation

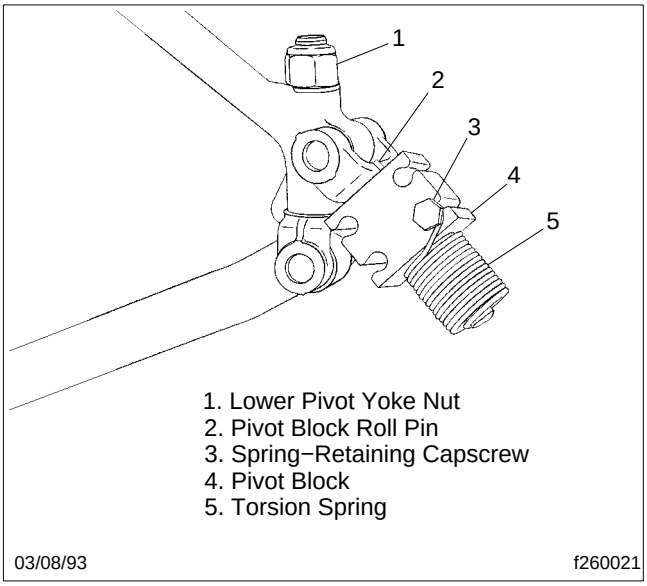


Fig. 2

the shift lever/upper pivot yoke from the lower pivot yoke shaft.

Installation (See Fig. 1)

NOTE: The shift lever is secured to the upper pivot yoke with needle bearings that are press fit and staked in place. If needed, replace the shift lever and the upper pivot yoke as an assembly.

1. Place the shift lever/upper pivot yoke on the lower pivot yoke shaft. Install a nylon washer, spacing washer, and nut. Tighten the nut 100 lbf·in (1120 N·cm).
2. Install a nylon washer on the shaft of the upper pivot yoke. Install the pivot block on the shaft.
3. Install a nylon washer and spacing washer on the shaft. Install the nut and tighten it 100 lbf·in (1120 N·cm). Back off the nut one-quarter turn.
4. Make sure that the spring loop is on the side of the pivot block nearest the roll pin hole. Apply Loctite® 242, or an equivalent, to a mounting capscrew, then attach the torsion spring to the pivot block.
5. Turn the block and spring until the spring end enters the hole near the end of the yoke shaft.
6. Hold the spring and turn the pivot block clockwise (as viewed from the spring end) one full turn.
7. Install the roll pin in the pivot block.
8. Apply Loctite 242, or an equivalent, on the threads of the three remaining pivot block mounting capscrews. Install and tighten the capscrews 13 lbf·ft (18 N·m). Tighten the capscrew that attaches the torsion spring 13 lbf·ft (18 N·m).
9. Install the shift lever boot and shift knob. For instructions, see **Subject 120**.
10. Tilt the cab; for instructions, see **Group 60**.
11. Apply Loctite 242, or an equivalent, to the threads of the two hexhead bolts and the flathead capscrew that attach the bracket assembly to the forward shift shaft. Install and tighten the hexhead bolts 25 lbf·ft (34 N·m). Install and tighten the flathead capscrew 30 lbf·in (340 N·cm).
12. Install a tie strap to attach the hydraulic line to the forward shift shaft.
13. Return the cab to the operating position; for instructions, see **Group 60**.
14. Check the shift lever for correct vertical adjustment. For instructions, see **Subject 160**.

Shift Tube Bracket Assembly Replacement

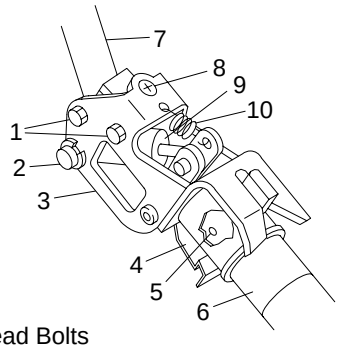
Replacement (See Fig. 1)

1. Tilt the cab. For instructions, refer to the vehicle driver's manual. Shift the transmission into neutral.
2. Release the hydraulic pressure by alternately moving the control lever on the tilt pump to the "Raise" and "Lower" positions. Hold the control lever in each position for a few seconds. Allow enough time for the shift-disconnect cylinder (Ref. 9) to empty.
3. With the shift-disconnect cylinder fully collapsed, remove the fitting on the cylinder. Plug the end of the line to prevent dirt from entering the system.
4. Remove the two hexhead bolts (Ref. 1) and the flathead capscrew (Ref. 8) that attach the bracket assembly (Ref. 3) to the forward shift shaft.
5. Remove the bolts and nuts that connect the telescoping shift tube flange to the shift tube extension flange.
6. Place the telescoping tube on a workbench. Extend the tube fully, then wipe off the tubes with a clean cloth.
7. Remove the shift-disconnect cylinder from the bracket assembly. For instructions, **refer to Subject 150.**
8. Remove the roll pin (Ref. 5) from the bracket assembly. Remove the bracket assembly from the telescoping shift tube.

NOTE: The roll pin is staked at both ends.

9. Install the shift-disconnect cylinder on the new bracket assembly. For instructions, **refer to Subject 150.**
10. Place the bracket assembly on the telescoping shift tube. Install the roll pin and stake it at both ends.
11. Apply a light coating of multipurpose chassis grease to the surfaces of the telescoping tubes.
12. Install the bolts and nuts that connect the telescoping shift tube flange to the shift tube extension flange. Tighten the nuts 13 lbf·ft (18 N·m).
13. Apply Loctite® 242, or an equivalent, to the threads of the two hexhead bolts and the flathead capscrew that attach the bracket assembly to the forward shift shaft. Install and tighten the hexhead bolts 25 lbf·ft (34 N·m). Install and tighten the flathead capscrew 30 lbf·in (340 N·cm).
14. Connect the hydraulic line to the elbow on the latch cylinder.
15. Return the cab to the operating position. For instructions, refer to the vehicle driver's manual.
16. Loosen the hydraulic line at the elbow on the latch cylinder. Place the tilt pump control lever in the "Raise" position, and operate the tilt pump until a bubble-free stream of hydraulic fluid flows from the fitting. Pump until about 2 oz (60 mL) of hydraulic fluid flows from the fitting to ensure that the entire line is free of air.

    Tighten the fitting, and refill the tilt pump until hydraulic fluid appears in the fill port. Refer to the cab section in the vehicle maintenance manual for fluid specifications. Install and tighten the fill plug.
17. Check the shift lever for correct vertical adjustment. For instructions, **refer to Subject 160.**
18. Start the engine. With the engine running, move the shift lever through several gear positions.



1. Hexhead Bolts
2. Shift−Disconnect Cylinder Pivot Pin
3. Shift Tube Bracket Assembly
4. Latch Hook
5. Roll Pin
6. Telescoping Tube
7. Forward Shift Shaft
8. Flathead Capscrew
9. Shift−Disconnect Cylinder
10. Latch Spring

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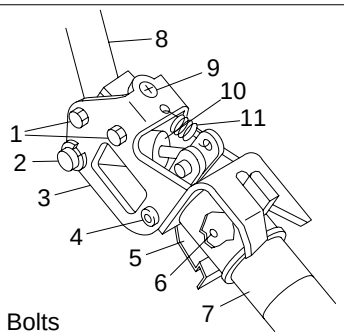
Fig. 1

Shift Tube Bracket Assembly Replacement

Check that the shift tube bracket assembly has latched and the linkage is working properly.

Replacement (See Fig. 1)

1. Tilt the cab. For instructions, refer to the vehicle driver's manual. Shift the transmission into neutral.
2. Release the hydraulic pressure by alternately moving the control lever on the tilt pump to the "Raise" and "Lower" positions. Hold the control lever in each position for a few seconds. Allow enough time for the shift-disconnect cylinder (Ref. 10) to empty.
3. With the shift-disconnect cylinder fully collapsed, remove the fitting on the cylinder. Plug the end of the line to prevent dirt from entering the system.
4. Remove the latch spring (Ref. 11) from the latch hook (Ref. 5).
5. Remove the snap ring from the pivot pin (Ref. 2) that attaches the cylinder to the bracket. Remove the pivot pin.
6. Remove the capscrew and locknut (Ref. 4) that attach the latch hook to the bracket assembly. Remove the cylinder and latch hook from the bracket.
7. Remove the snap ring and pivot pin that attach the cylinder rod to the latch hook.
8. Attach the cylinder rod of the new cylinder to the latch hook, with the pivot pin and snap ring.
9. Position the latch hook in the bracket assembly. Install the capscrew and locknut. Tighten the locknut 25 lbf·ft (34 N·m).
10. Insert the cylinder pivot pin and lock it in place with a snap ring.
11. Install the latch spring.
12. Connect the hydraulic line to the elbow on the shift-disconnect cylinder.
13. Return the cab to the operating position. For instructions, refer to the vehicle driver's manual.
14. Loosen the hydraulic line at the elbow on the shift-disconnect cylinder. Place the tilt pump control lever in the "Raise" position, and operate the tilt pump until a bubble-free stream of hydraulic fluid flows from the fitting. Pump until about 2 oz (60 mL) of hydraulic fluid flows from the fitting to ensure that the entire line is free of air.



1. Hexhead Bolts
2. Shift−Disconnect Cylinder Pivot Pin
3. Shift Tube Bracket Assembly
4. Capscrew and Locknut
5. Latch Hook
6. Roll Pin
7. Telescoping Tube
8. Forward Shift Shaft
9. Flathead Capscrew
10. Shift−Disconnect Cylinder
11. Latch Spring

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Fig. 1

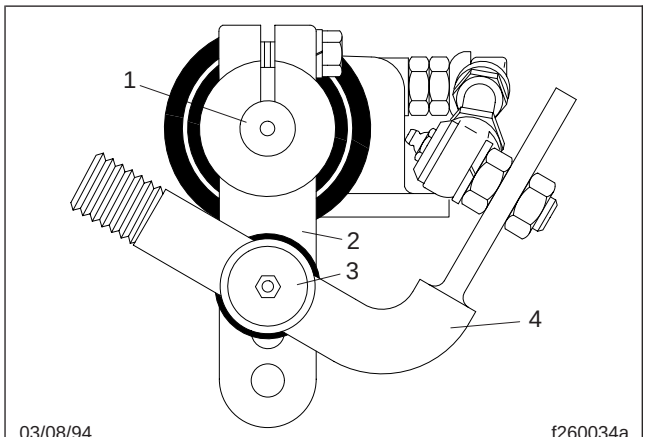
Tighten the fitting, and refill the tilt pump until hydraulic fluid appears in the fill port. Refer to the cab section in the vehicle maintenance manual for fluid specifications. Install and tighten the fill plug.

15. Start the engine. With the engine running, move the shift lever through several gear positions. Check that the shift tube bracket assembly has latched and the linkage is working properly.

Checking

SELECTION LEVER BALL JOINT ATTACHMENT (See Fig. 1)

Check that the ball joint in the selection lever is attached to the outer shift lever hole that is nearest the shifting shaft. Tighten the castle nut 30 lbf·ft (41 N·m), then advance the nut until you can insert and lock the cotter pin.



1. Shifting Shaft
2. Outer Shift Lever
3. Ball Joint
4. Selection Lever

Fig. 1

NOTE: The outer shift lever must point straight down when the transmission is in neutral.

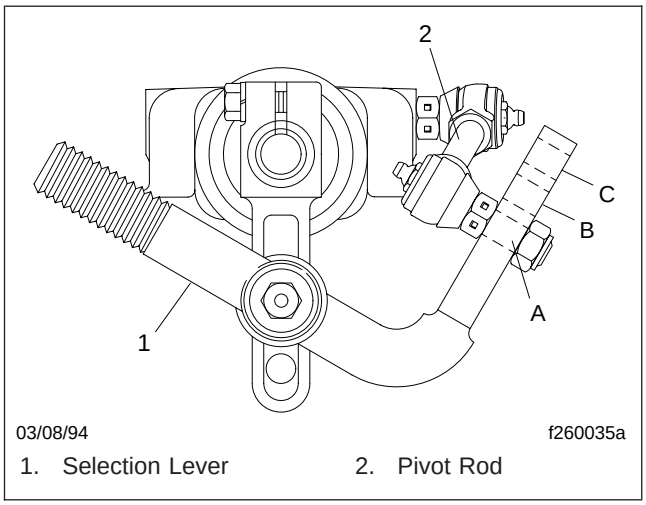
PIVOT ROD ATTACHMENT

(See Fig. 2)

On 3-rail transmissions, check that the pivot rod end is installed in the hole (Ref. A) nearest the right angle in the selection lever. Tighten the locknut 50 lbf·ft (68 N·m).

On 4-rail Spicer transmissions, check that the pivot rod end is installed in the center hole (Ref. B) of the selection lever. Tighten the locknut 50 lbf·ft (68 N·m).

On 4-rail Fuller transmissions, check that the pivot rod end is installed in the hole (Ref. C) farthest from the right angle in the selection lever. Tighten the locknut 50 lbf·ft (68 N·m).



1. Selection Lever
2. Pivot Rod

Fig. 2

NOTE: 3-rail transmissions have 5 or 6 shift lever positions (excluding neutral); 4-rail transmissions have 8 shift lever positions (excluding neutral).

Adjustment

PIVOT ROD

Shift the transmission into neutral. The selection lever should be parallel to the framerail web.

If the selection lever is not parallel to the framerail web, loosen the jam nuts at each end of the pivot rod. Turn the pivot rod to lengthen or shorten it. When the selection lever is parallel to the framerail web, tighten the jam nuts 55 lbf·ft (75 N·m).

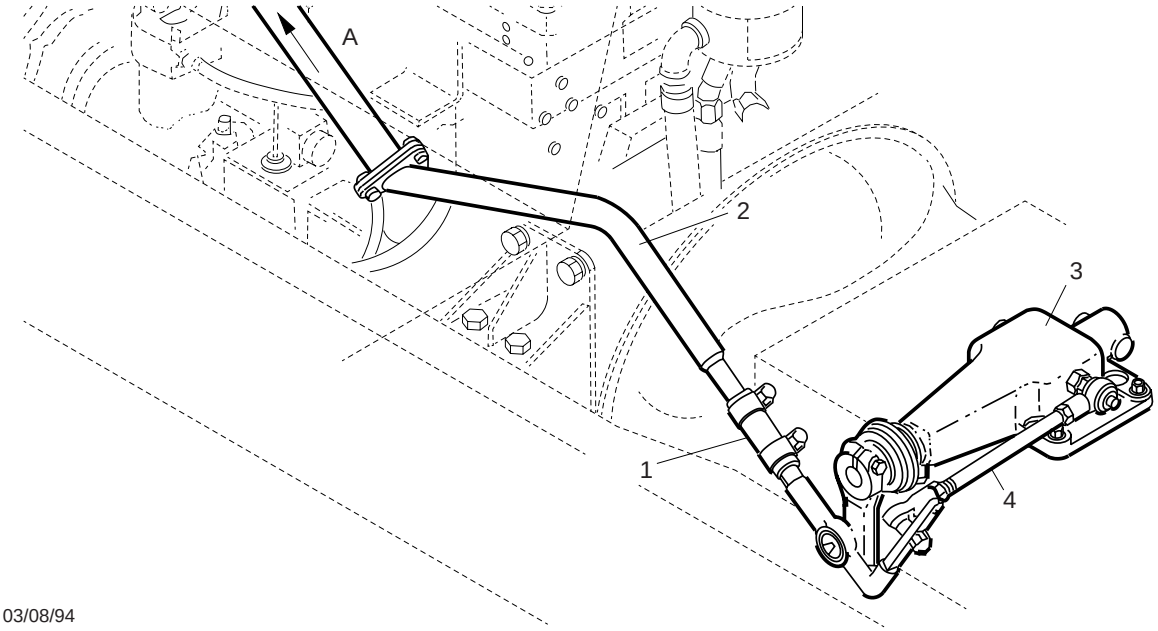
NOTE: Don't use the pivot rod for shift linkage or other transmission adjustments.

SHIFT LEVER ANGLE (See Fig. 3)

Shift the transmission so that the shift lever is at the most inboard and rearmost gear position. The shift lever should be vertical, and not leaning in any other direction. If the shift lever is not vertical, make the following adjustment:

If the shift lever is leaning forward or rearward, loosen the adjustment sleeve clamp capscrews and turn the sleeve until the shift lever is vertical. Tighten the rear adjustment sleeve clamp capscrew 55 lbf·ft (75 N·m). Make sure that the slit in the adjustment

Checking and Adjusting



A. to the shift lever

1. Adjustment Sleeve With Clamps
2. Shift Tube Extension
3. Remote Shift Dome
4. Pivot Rod

Fig. 3

sleeve is turned inboard, and that the capscrews are centered over the slit.

NOTE: Turning the sleeve clockwise shortens the linkage and moves the shift lever forward. Turning the sleeve counterclockwise lengthens the linkage and moves the shift lever rearward.

If the shift lever is leaning left or right, move the shift lever inboard as far as possible; then, move the shift lever out 1 inch (25 mm) from this position. Tighten the forward adjustment sleeve clamp bolt 55 lbf·ft (75 N·m). The shift lever should now tilt only one to six degrees.

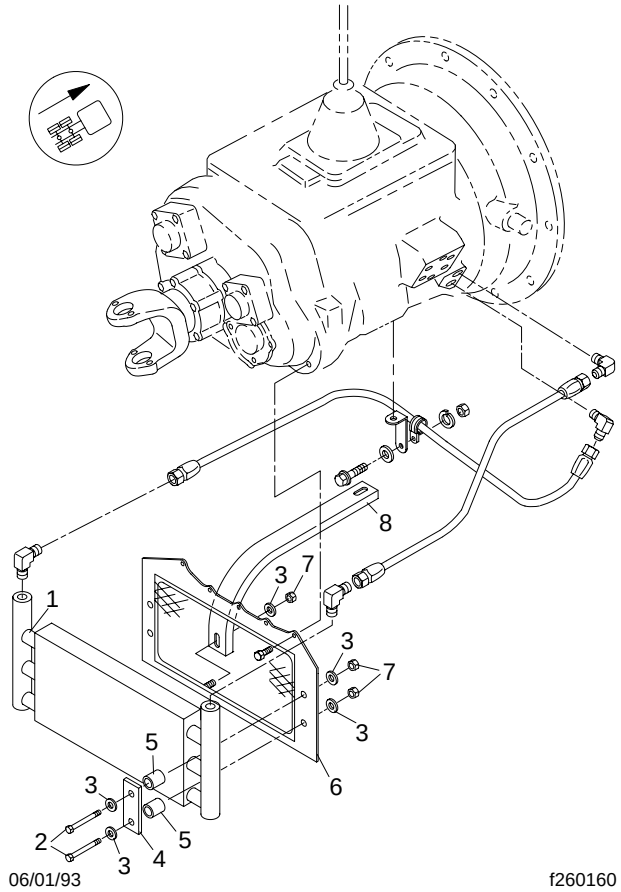
Manual Transmission Removal and Installation

Removal

1. Apply the parking brakes, chock the tires, put the transmission into high gear, and tilt the hood or cab.
2. Drain the air brake system.
3. Disconnect the batteries either manually or with the battery shutoff switch.
4. Remove or disconnect the shift linkage.
   - 4.1 *On FLDs:* Remove the shift tower from inside the cab, and cover the shift tower hole in the top of the transmission to prevent dirt from entering the transmission.
   - 4.2 *On COEs:* Remove the shift dome from the top of the transmission. For instructions, see **Subject 110 in Section 26.00**.
5. If applicable, close the fuel shut off valves or drain the fuel tanks, and disconnect the fuel crossover line.
6. Disconnect the driveline from the transmission output yoke. For instructions, see **Subject 100 in Section 41.00**.
7. Disconnect the driveline midship bearing from the midship bearing bracket, and pull the driveline off to one side, out of the way. For instructions, see **Subject 100 in Section 41.00**.
8. Disconnect the clutch rod from the clutch release lever.
9. Disconnect all wiring at the transmission, including the speedometer sensor at the output yoke, the neutral start switch, and the back-up alarm as applicable. Mark all wires for reassembly.
10. Disconnect all air lines from the transmission, and mark those lines for reassembly. Plug all air lines, and cap all transmission air fittings.
11. If applicable, remove the transmission fluid cooler without disconnecting the fluid hoses. See **Fig. 1**. Move the cooler aside without damaging the cooler fins.

⚠ WARNING

After lifting the front end of the vehicle, do not get under the vehicle until it is securely supported by vehicle stands. If the vehicle is supported only by an axle jack, the vehicle can fall, resulting in personal injury or property damage.



1. Transmission Oil Cooler
2. Capscrew, 5/16–18
3. Washer, 1/4-inch
4. Biscuit Plate
5. Biscuits
6. Oil Cooler Mounting Bracket
7. Locknut, 5/16–18
8. Oil Cooler Support Strut

Fig. 1, Transmission Oil Cooler Mounting

12. Raise the front of the vehicle high enough that you can remove the transmission by rolling it out under the front axle.
13. Position a transmission jack under the transmission, and raise its support plate against the bottom of the transmission. Adjust the support plate to the same angle as the bottom of the transmission.

14. Raise the transmission jack until it fits securely against the bottom of the transmission, then secure the transmission to the jack with a chain.
15. Remove the flywheel-housing-to-clutch-housing attachment bolts.

NOTICE

Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Keep the flange of the clutch housing parallel (all the way around) to the flange of the flywheel housing, until the input shaft is clear of the clutch. Taking these precautions will prevent damage to the clutch discs.

16. Pull the transmission and jack straight back, until the transmission input shaft is clear of the clutch and the engine flywheel housing. Lower the transmission and roll it on the jack, out from under the vehicle.

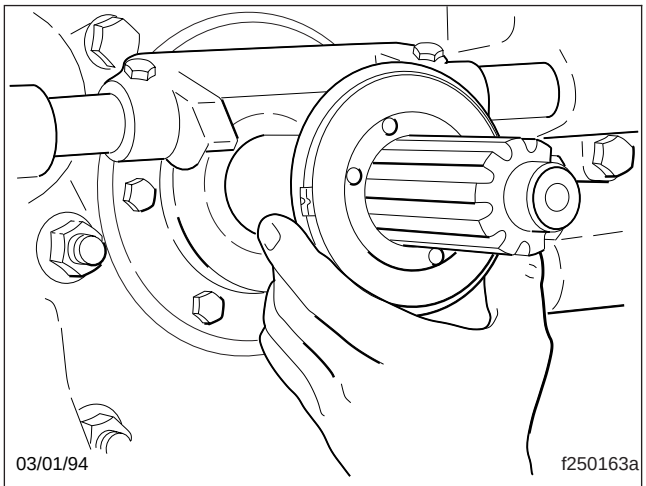
Installation

1. If not already done, apply the parking brakes, chock the tires, and tilt the hood or cab.
2. If the clutch brake was removed, install the clutch brake on the transmission input shaft. See **Fig. 2**. Slide it tight against the input shaft bearing cap.

NOTE: Torque limiting clutch brakes are a one-piece assembly with a larger and a smaller face. When installing a torque limiting clutch brake on a Spicer® transmission, install the *larger* face toward the transmission; when installing it on a Fuller® transmission, install the *smaller* face toward the transmission.

3. Apply a light coating of high-temperature grease to the sides and bottom of the input shaft splines, and a small amount inside the clutch release bearing sleeve.

NOTE: Avoid the common practice of smearing a handful of grease over the splines of the input shaft. Most of this grease will be wiped off by the release bearing sleeve when the transmission is assembled to the clutch.



NOTE: Clutch brake installation for a Fuller transmission is shown here. For a Spicer transmission, the clutch brake would be reversed so the larger face of the brake would be against the transmission.

Fig. 2, Clutch Brake Installation

4. Check for wear on the fingers of the clutch release yoke, release shafts, and the release shaft bushings. Replace any worn parts as necessary.
5. Shift the transmission into gear, so that the transmission input shaft can be rotated during assembly, to line it up with the clutch driven-disc hub splines.

WARNING

After lifting the front end of the vehicle, do not get under the vehicle until it is securely supported by vehicle stands. If the vehicle is supported only by an axle jack, the vehicle can fall, resulting in personal injury or property damage.

6. If the vehicle isn't already raised and supported on stands, raise the front of the vehicle high enough that you can move the transmission into position by rolling it under the front axle.
7. Roll the transmission and jack into alignment behind the engine. Raise the transmission jack support plate until the flange of the clutch housing is parallel (all the way around) to the flange of the flywheel housing. Align the transmission input shaft with the hole in the release bearing sleeve.
8. Push the transmission and jack straight forward, while making sure the flanges remain parallel,

until the transmission input shaft begins to enter the clutch release bearing.

9. Rotate the top of the clutch release yoke rearward, and rotate the release bearing until the flat portion is at the top. Roll the transmission slowly forward. Raise or lower the transmission as required to maintain alignment.

IMPORTANT: Be sure that the release bearing yoke clears the release bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 3**. Align the input shaft splines with the clutch disc splines by turning the transmission output shaft.

NOTICE

Use care to avoid springing the drive discs when the transmission is being installed. Do not force the transmission into the clutch or flywheel housing if it does not enter freely. Do not let the transmission drop or hang unsupported in the driven discs. These practices can damage the clutch assembly.

10. Push the transmission forward until the clutch housing pilot flange enters the flywheel housing pilot bore. Install the flywheel-housing-to-clutch-housing attachment capscrews, and using a crisscross pattern, tighten them finger-tight. Then, using the same crisscross pattern, tighten the capscrews either 43 to 53 lbf·ft (58 to 72 N·m) for Patch-Lok capscrews, or 38 to 45 lbf·ft (52 to 61 N·m) for non-locking capscrews with lockwashers.
11. Remove the chain that secures the transmission to the jack, and remove the jack from under the vehicle.
12. Raise the vehicle enough to remove the vehicle stands. Remove the stands, and lower the vehicle to the ground.
13. Install or connect the shift linkage.
    - 13.1 *On FLDs:* Install the shift tower inside the cab.
    - 13.2 *On COEs:* Install the shift dome on top of the transmission. For instructions, see **Subject 110 in Section 26.00**.
14. Connect the air lines and wiring to the transmission as previously marked.
15. Connect the clutch rod to the clutch release lever. For instructions, see **Subject 110 in Section 25.00**.
16. Connect the driveline to the transmission output yoke. For instructions, see **Subject 100 in Section 41.00**.
17. Connect the midship bearing to the midship bearing bracket. For instructions, see **Subject 100 in Section 41.00**.
18. If applicable, connect the fuel crossover line
19. Connect the batteries or turn on the battery shut-off switch.
20. Grease the clutch release bearing and the release shafts. For instructions, see Group 26 of the *Heavy-Duty Trucks Maintenance Manual*.
21. Check the clutch and clutch linkage for proper clutch pedal free-travel and clutch brake operation. To adjust the clutch, see **Subject 100 in Section 25.00**.
22. Lower the hood or cab, and remove the chocks from the tires.

Manual Transmission Removal and Installation

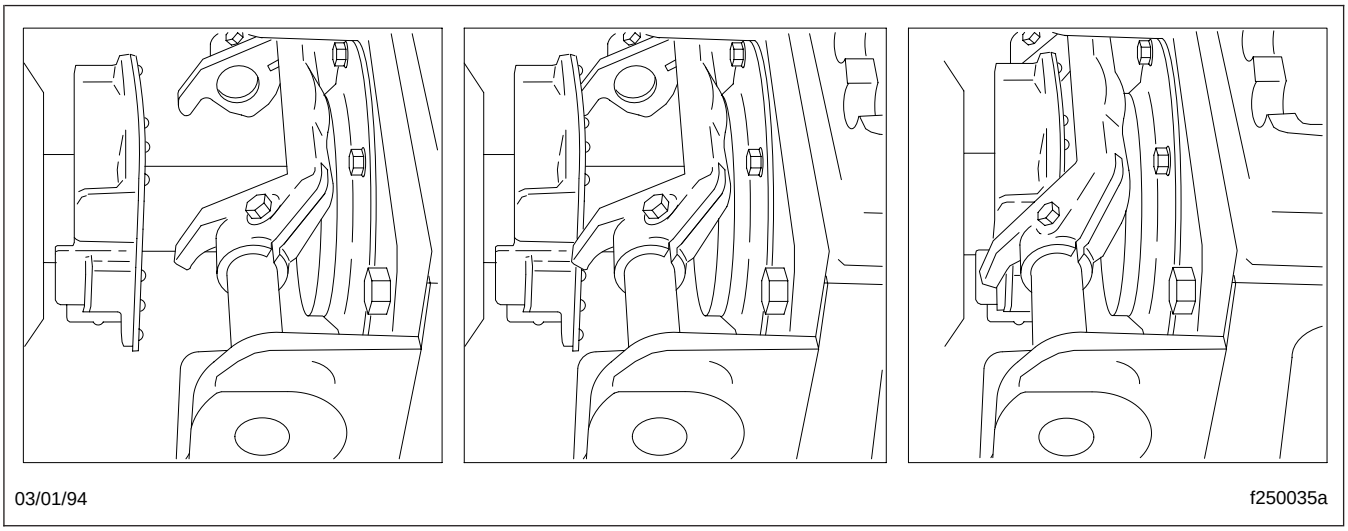


Fig. 3

General Information

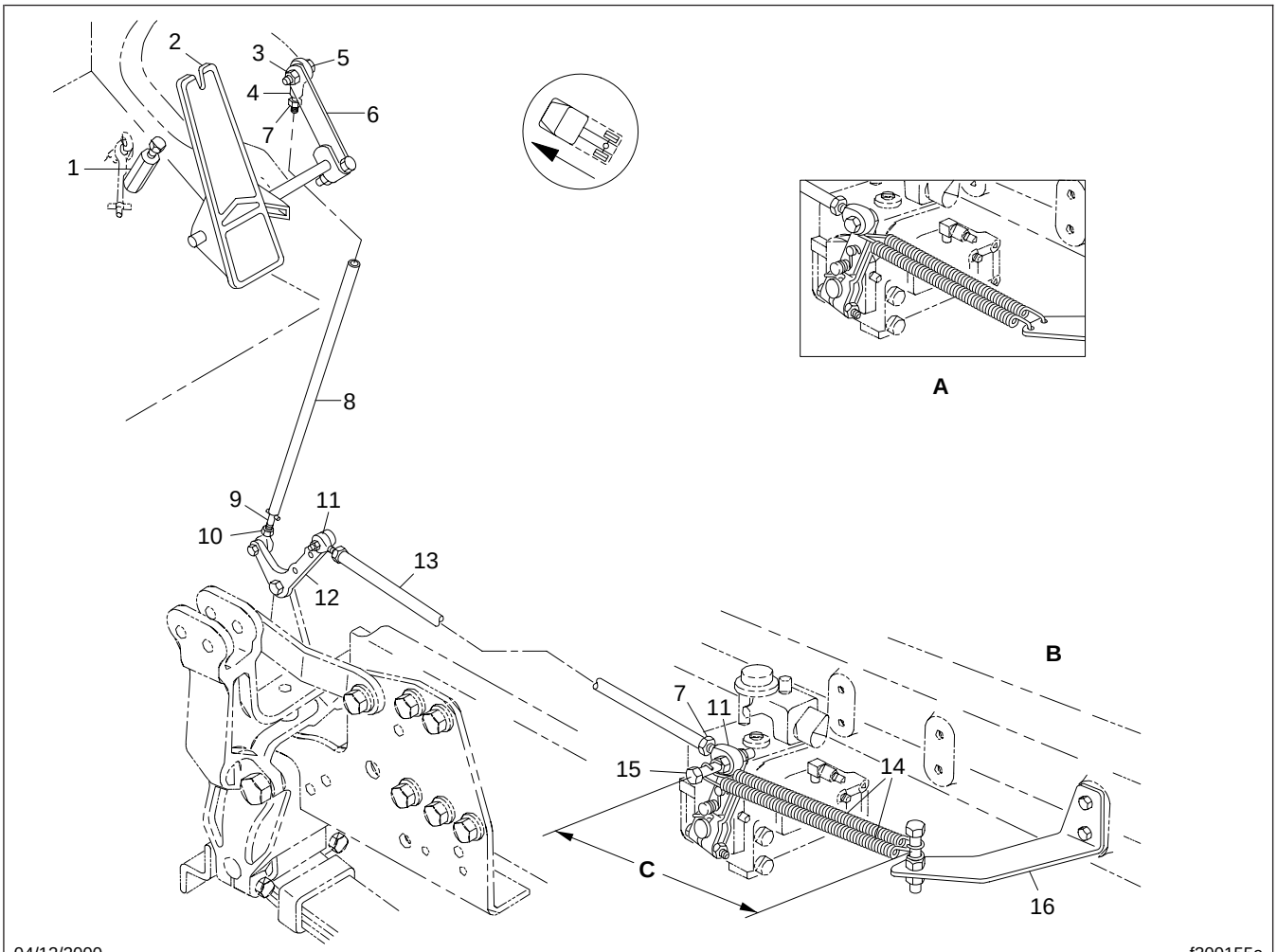
Freightliner throttle controls have a floor-mounted throttle pedal, adjustable-length throttle rods, a strut-mounted bellcrank, dual return springs, and an adjustable pedal stop. See **Fig. 1**.

During engine operation, movement of the throttle pedal and linkage will change the amount of fuel available to the engine. To ensure that the pedal will be at the correct angle when the engine is at idle rpm, the length of the linkage is adjustable by means of spherical bearing rod ends, with the adjustment secured by jam nuts. See **Fig. 2**. The spherical bearings prevent binding of the linkage.

Dual springs return the throttle control parts to their idle positions when the pedal is released.

When the linkage is properly adjusted, the governor shaft can rotate from idle rpm to maximum horsepower. To ensure that maximum horsepower is always reached, the linkage must be able to move just beyond the position where the governor shaft has stopped rotating, without causing damage to the governor. Cummins governor arms consist of two parts held in alignment by a breakover spring. When the part of the governor arm attached to the governor shaft has moved as far as the shaft rotation will allow, the force applied at the pedal overcomes the resistance of the breakover spring. This allows the part of the governor arm attached to the linkage to move into the breakover range. If the governor arm were forced beyond the breakover range, the linkage or governor arm could be damaged. An adjustable pedal stop prevents movement of the linkage beyond the governor arm's breakover range.

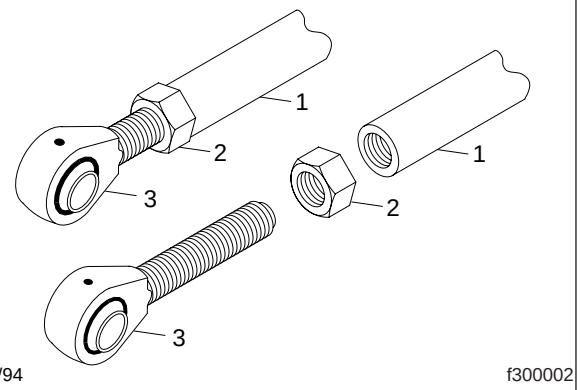
General Information



A. Return spring installation without capscrews
B. Return spring installation with capscrews
C. 9-1/2 to 9-3/4 inches (241 to 248 mm)

1. Throttle Stop
2. Throttle Pedal
3. Locknut
4. Externally Threaded Spherical Bearing Rod End
5. 5/16–24 Capscrew
6. Pedal Throttle Arm
7. 5/16–24 Jam Nut
8. Throttle Guide Tube
9. Vertical Throttle Tube
10. Kep Nut
11. Externally Threaded Spherical Bearing Rod End
12. Bellcrank
13. Horizontal Throttle Rod
14. Return Springs
15. 15/16–18 Capscrew
16. Return-Spring Bracket

Fig. 1, Throttle Linkage (NTC)



1. Internally Threaded Throttle Rod
2. Jam Nut
3. Externally Threaded Spherical Bearing Rod End

Fig. 2, Throttle Rod Parts

Throttle Control Operation Checking

1. Shut down the engine, set the parking brake, and chock the tires.
2. Tilt the cab. For instructions, see **Section 60.04**, Subject 060, in this manual.
3. Check the linkage attachment fasteners (capscrews, locknuts, and hexnuts) for tightness; tighten any that are loose.
4. Operate the linkage by hand, from idle to maximum horsepower, while checking that nothing interferes with movement of the linkage. Reposition any parts that interfere. Check the tightness of the bellcrank shoulder bolt and locknut, and the bellcrank attaching capscrew; if loose, tighten the locknut or capscrew 20 lbf·ft (27 N·m).
5. Check the horizontal rod for binding by rotating the rod in and out. With the rod-end jam nuts tight against the rod, both rod ends must be free to swivel on their spherical bearings. If the rod and rod ends do not rotate in and out, adjust the rod ends and jam nuts as follows:
   - 5.1 Loosen the jam nuts at each end of the throttle rod. See **Fig. 1**.
   - 5.2 Turn the throttle rod to a position that prevents other components from interfering with the rod's movement through full travel.
   - 5.3 Hold the throttle rod in this position and turn each of the spherical bearing rod ends in the direction opposite to the rotation of the throttle linkage. Hold the rod in this position while tightening the rod-end jam nuts 15 lbf·ft (20 N·m).
6. Check the length of the installed return springs. When the throttle lever is at idle, the springs must be 9-1/2 to 9-3/4 inches (241 to 248 mm) long. See **Fig. 1**. If the spring length is incorrect, see **Subject 130**.
7. Inspect the return springs.
   - 7.1 Using a hook (do not use sharply serrated pliers), disconnect the anchor loop of each spring from the governor arm. Do not stretch the springs any further than necessary. Disconnect the opposite ends from the spring bracket.
   - 7.2 Inspect the springs, especially in the area of the anchor loops, for wear, nicks, or other damage that might cause breakage.
   - 7.3 Measure the springs for stretching. The relaxed spring should be no more than 9-3/8 inches (238 mm) long, from the outside of one anchor loop to the outside of the opposite anchor loop.
   - 7.4 If the used springs are worn, damaged, or stretched, install new springs.
   - 7.5 Install the springs by hooking one end of each spring around the capscrew or through the hole in the return-spring bracket. Then, using the hook, place the opposite anchor loop of each spring around the capscrew or through the hole in the governor arm.
8. With the cab in the operating position, and the governor arm at idle, check the angle of the throttle pedal. The pedal must be at an angle of approximately 50 degrees to the cab deck. See **Fig. 2**.

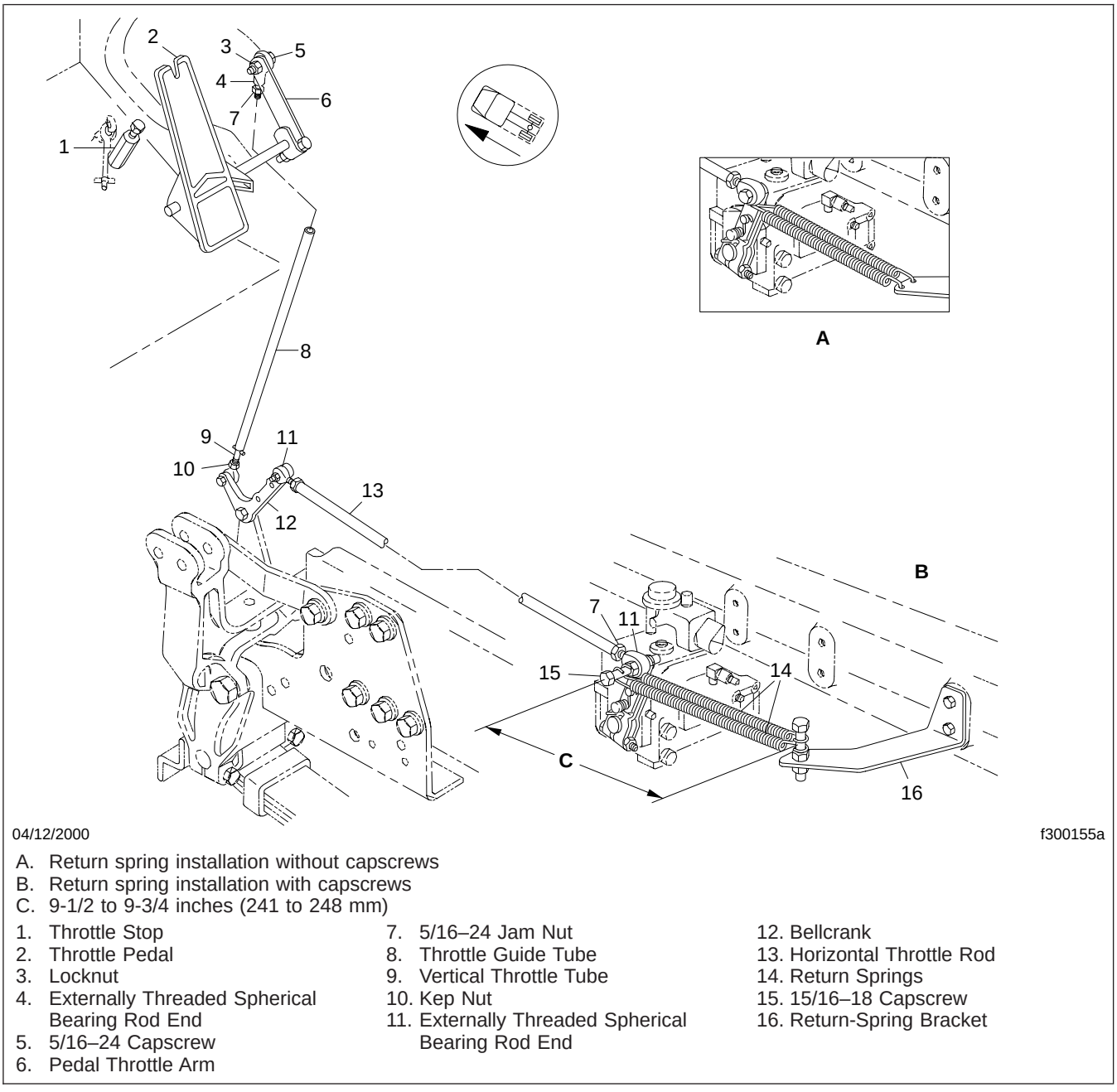
   If the throttle pedal angle is too high or too low, adjust the length of the throttle linkage. See **Subject 110**.
9. Operate the throttle pedal by hand, from idle through full travel, while checking that the governor arm travels at least 5 degrees into the breakover range.

NOTE: The breakover range begins at the point where the two parts of the governor arm begin to have intersecting centerlines. See **Fig. 3**.

On NTCs, you can see the governor arm by looking between the bottom of the cab deck and the top of the frame rail above the right front tire.

On L10s, you cannot see the governor arm when the cab is in the operating position. To check that the governor arm has reached the approximate middle of the breakover range, operate the throttle pedal near the lower end of its travel. With your hand, you should be able to feel the increased resistance that occurs when the governor shaft stops rotating and the break-

Throttle Control Operation Checking



A. Return spring installation without capscrews
B. Return spring installation with capscrews
C. 9-1/2 to 9-3/4 inches (241 to 248 mm)

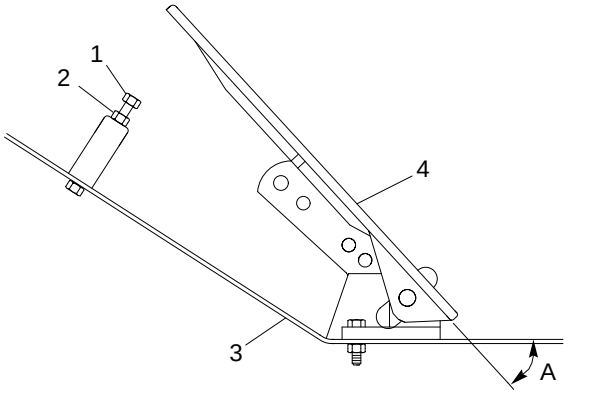
1. Throttle Stop
2. Throttle Pedal
3. Locknut
4. Externally Threaded Spherical Bearing Rod End
5. 5/16–24 Capscrew
6. Pedal Throttle Arm
7. 5/16–24 Jam Nut
8. Throttle Guide Tube
9. Vertical Throttle Tube
10. Kep Nut
11. Externally Threaded Spherical Bearing Rod End
12. Bellcrank
13. Horizontal Throttle Rod
14. Return Springs
15. 15/16–18 Capscrew
16. Return-Spring Bracket

Fig. 1, Throttle Linkage (NTC)

over spring allows the governor arm to move into the breakover range. If the throttle pedal contacts the pedal stop before any increased resistance is felt, the breakover range is not being reached.

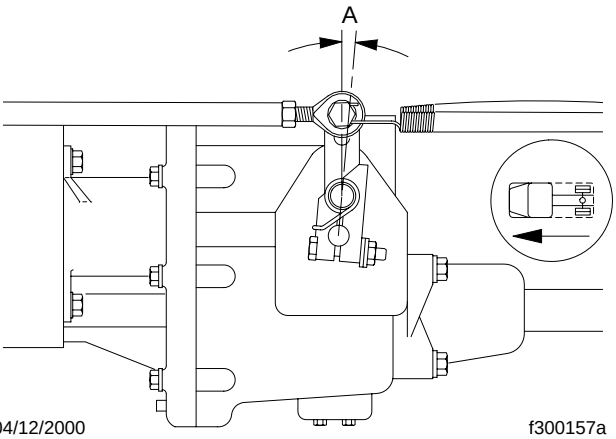
If the governor arm does not travel at least 5 degrees into the breakover range, adjust the pedal stop; see **Subject 120**.

10. Return the cab to the operating position. See **Section 60.04**, Subject 060, in this manual.



A. 50 degrees
1. Throttle Stop Capscrew
2. Jam Nut
3. Cab Deck
4. Throttle Pedal

Fig. 2, Throttle Pedal at Idle



A. 5 degrees

Fig. 3, Governor Arm in the Breakover Range (NTC)

11. Remove the chocks from the tires.
12. Test drive the vehicle and ensure proper operation of the throttle system.

Throttle Linkage Length Adjustment

1. Shut down the engine, set the parking brake, and chock the tires.
2. With the cab in the operating position, remove the radiator grille.
3. When the governor arm is at idle, check the angle of the bellcrank. The shorter arm of the bellcrank must be at an angle of 30 degrees above horizontal. See **Fig. 1** .
4. If the bellcrank is positioned correctly, proceed to step 4. If the bellcrank is not positioned correctly, adjust the length of the horizontal throttle rod as follows:

   4.1 Loosen the jam nuts at each end of the throttle rod.

   4.2 Remove the locknut, flat washer, and capscrew from the long arm of the bellcrank and the spherical bearing rod end.

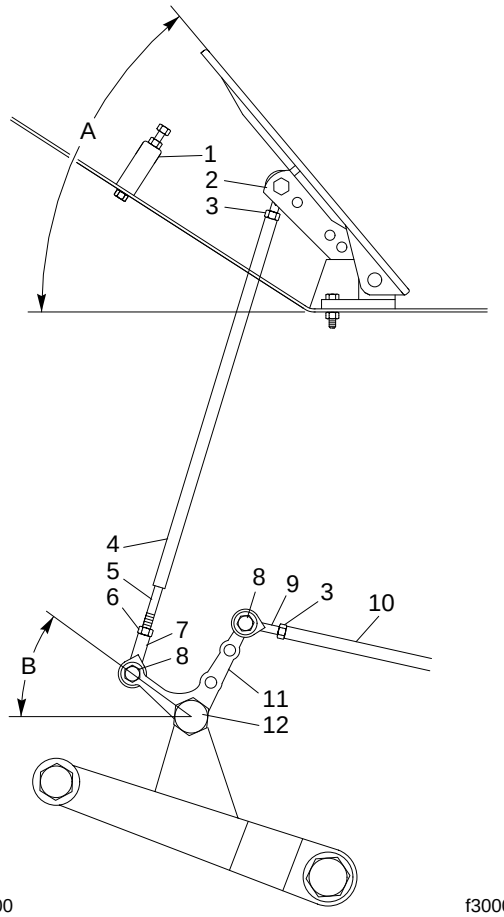
   4.3 Hold the bellcrank so that the shorter arm is at an angle of 30 degrees above horizontal.

   4.4 With the governor arm at idle, turn the rod end until the spherical bearing bore is aligned with the hole nearest the end of the longer bellcrank arm.

⚠ WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod end must remain engaged in the rod. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.

   4.5 At least 5/16 inch (8 mm) of thread on the rod end must remain engaged in the rod. If more adjustment is needed than can be made at the bellcrank end of the rod, turn the rod as needed, to change the thread engagement of the rod at the governor arm.



A. 50 degrees
B. 30 degrees

1. Throttle Stop Assembly
2. Pedal Throttle Arm
3. 5/16–24 Jam Nut
4. Throttle Guide Tube
5. Vertical Throttle Rod
6. Kep Nut
7. Internally Threaded Spherical Bearing Rod End
8. Capscrew, Flat Washer and Locknut
9. Externally Threaded Spherical Bearing Rod End
10. Horizontal Throttle Rod
11. Bellcrank
12. Shoulder Bolt and Locknut

Fig. 1, Bellcrank Short Arm Angle

   4.6 Install a flat washer on the attaching capscrew, then insert the capscrew into the bore of the rod end. From the outside, insert the bolt into the hole nearest the end of the longer bellcrank arm. Install and tighten the locknut 15 lbf·ft (20 N·m).

Throttle Linkage Length Adjustment

4.7 Turn the throttle rod to a position that prevents other components from interfering with the rod's movement through full travel. Hold the throttle rod in this position and turn each of the spherical bearing rod ends in the direction opposite the rotation of the throttle linkage. Hold the rod in this position while tightening the rod-end jam nuts 15 lbf·ft (20 N·m).

4.8 Tilt the cab. For instructions, see **Section 60.04**, Subject 060, in this manual.

5. Adjust the length of the vertical throttle rod as follows:

5.1 Loosen the Kep nut at the bottom of the vertical throttle rod. See **Fig. 1**.

5.2 Turn the vertical throttle rod until the throttle pedal is at an angle of approximately 50 degrees to the cab deck.

⚠ WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod must remain engaged in the rod end. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.

5.3 At least 5/16 inch (8 mm) of thread on the rod must remain engaged in the rod end. If more adjustment is needed than can be made between the vertical throttle rod and the spherical bearing rod end, tighten the Kep nut at the bottom of the vertical throttle rod. Loosen the jam nut at the top of the throttle guide tube and turn the guide tube as needed.

5.4 Tighten the jam nut 15 lbf·ft (20 N·m). Tighten the Kep nut 84 lbf·in (940 N·cm).

6. Return the cab to the operating position. For instructions, see **Section 60.04**, Subject 060, in this manual.

7. Adjust the pedal stop. For instructions, see **Subject 120**.

8. Install the radiator grille.

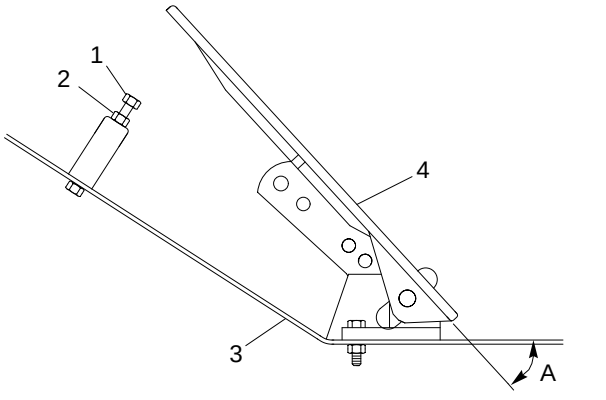
9. Remove the chocks from the tires.

10. Test drive the vehicle and ensure proper operation of the throttle system.

Pedal Stop Adjustment

NOTE: If the throttle linkage is not new, perform the checks under **Subject 100** before adjusting the pedal stop.

1. Shut down the engine, set the parking brake, and chock the tires.
2. Tilt the cab. For instructions, see **Section 60.04**, Subject 060, in this manual.
3. Loosen the pedal stop jam nut, and turn the capscrew in until no threads are showing above or below the jam nut. See **Fig. 1**. This allows maximum pedal travel.



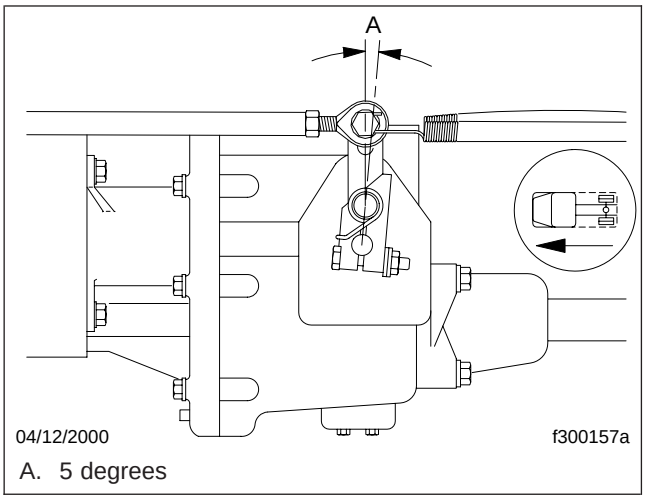
A. 50 degrees
1. Throttle Stop Capscrew
2. Jam Nut
3. Cab Deck
4. Throttle Pedal

Fig. 1, Pedal Stop Adjustment

4. Hold the throttle pedal at the point where the centerlines of the two parts of the governor arm form an angle of 5 degrees. See **Fig. 2**.

   On NTCs, you can see the governor arm by looking between the bottom of the cab deck and the top of the frame rail above the right front tire.

   On L10s, you cannot see the governor arm when the cab is in the operating position. To check that the governor arm has reached the approximate middle of the breakover range, operate the throttle pedal near the lower end of its travel. With your hand, you should be able to feel the increased resistance that occurs when the governor shaft stops rotating and the breakover spring allows the governor arm to move into the breakover range.



A. 5 degrees

Fig. 2, Governor Arm in the Breakover Range (NTC)

5. Position the head of the pedal stop capscrew 1/16 to 1/8 inch (1.5 to 3 mm) from the bottom of the pedal, and tighten the jam nut against the cab deck.
6. Operate the pedal to check the adjustment. Readjust if necessary.
7. Return the cab to the operating position. For instructions, see **Section 60.04**, Subject 060, in this manual.
8. Remove the chocks from the tires.
9. Test drive the vehicle and ensure proper operation of the throttle system.

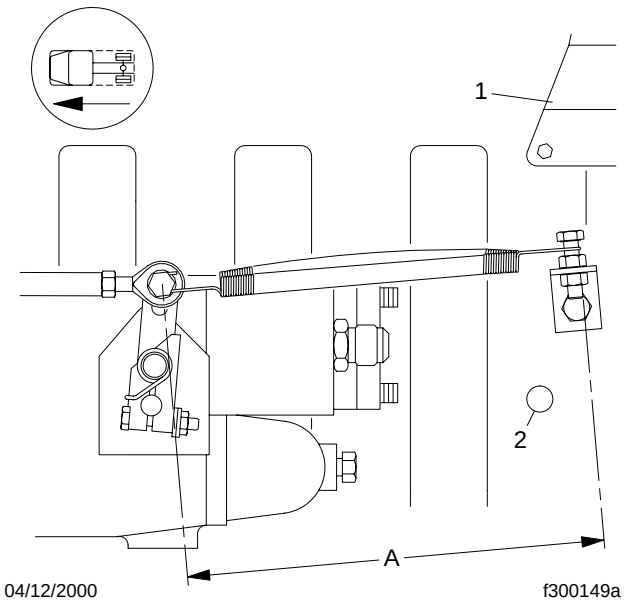
Throttle Control Installation

Use the following procedure if the throttle control is being replaced, removed and reinstalled, or if a new or rebuilt engine is being installed.

1. Shut down the engine, set the parking brake, and chock the tires.
2. Remove the radiator grille.
3. Tilt the cab. For instructions, see **Section 60.04**, Subject 060, in this manual.
4. Install the spring bracket (if not already installed).

   On L10s, attach the bracket to the tapped (metric) hole on the left side of the engine block, just below the fuel filter mounting bracket capscrew, and above the pipe plug hole for the oil pressure pickup. See **Fig. 1**.

   On NTCs, attach the bracket to the next-to-the-last boss on the left side of the engine block. Use 9/16–18 capscrews and lockwashers; tighten the capscrews 95 lbf·ft (130 N·m). See **Fig. 2**.



A. 9-1/2 to 9-3/4 inches (241 to 248 mm)
1. Fuel Filter Mounting Bracket
2. Oil Pressure Pickup

Fig. 1, Throttle-Return Springs and Spring Bracket (L10)

5. On NTCs, with the governor arm pointing upward at 22 degrees aft of vertical, measure the distance between the capscrew in the return-spring bracket and the governor arm hole that is farthest from the governor shaft.

   On L10s, with the governor arm pointing upward at 15 degrees aft of vertical, measure the distance between the capscrew in the return-spring bracket and the governor arm hole that is farthest from the governor shaft. Include the thickness of the bracket capscrew in this measurement.

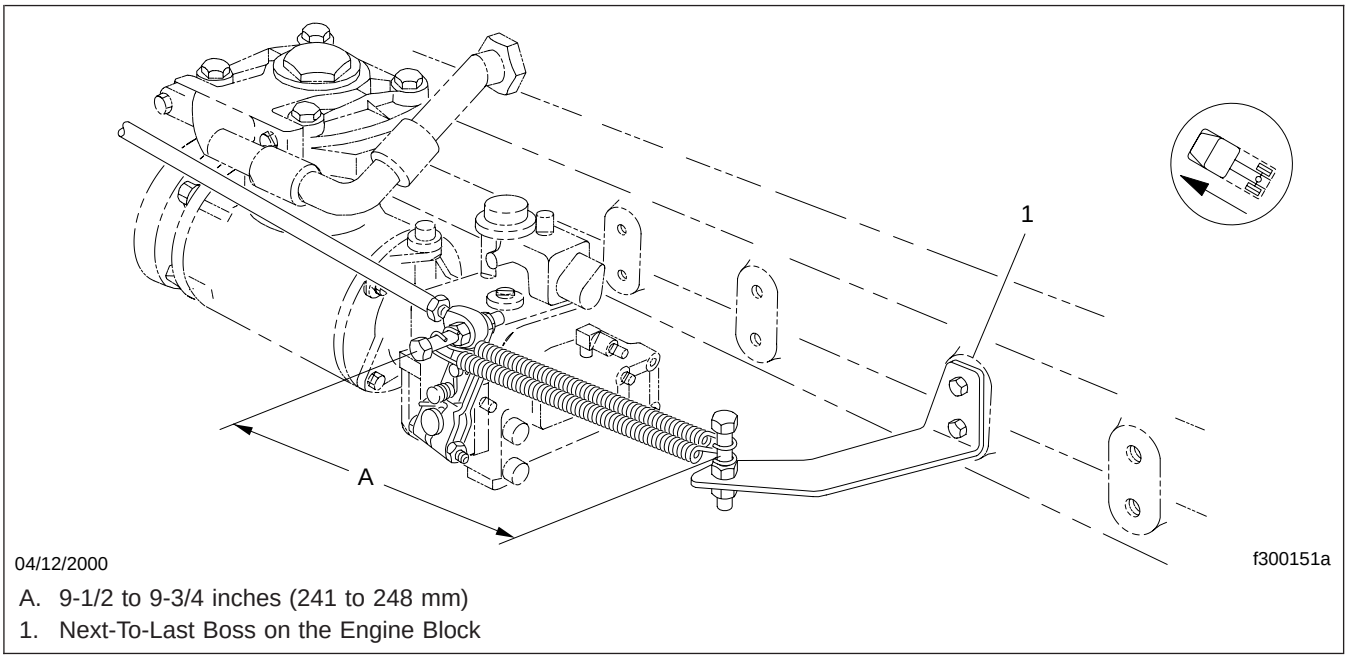
   This distance (the length of the installed springs at idle) must be 9-1/2 to 9-3/4 inches (241 to 248 mm). If the distance is not within this tolerance, remove the nut, washer, and pinch bolt from the governor arm. Remove the arm by spreading the end of it with a screwdriver while pulling outward on it. Install the arm (pointing upward) at an angle that will provide the correct distance. Install and securely tighten the pinch bolt, washer, and nut.
6. Install the jam nuts and spherical bearing rod ends on the throttle rods. On the vertical throttle rod, install a Kep nut and rod end on the lower end. The rod ends should be adjusted to their maximum thread engagement. Do not tighten the jam nuts or Kep nut.
7. Install the return springs as follows:

   7.1 If used springs are being installed, inspect them, especially in the area of the anchor loops, for wear, nicks, or other damage that may cause breakage. Install new springs if the used springs are worn or damaged.

   NOTE: As a product improvement for longer return spring service life, install a capscrew in the governor arm and a capscrew in the return spring bracket to hook the return spring anchor loops around.

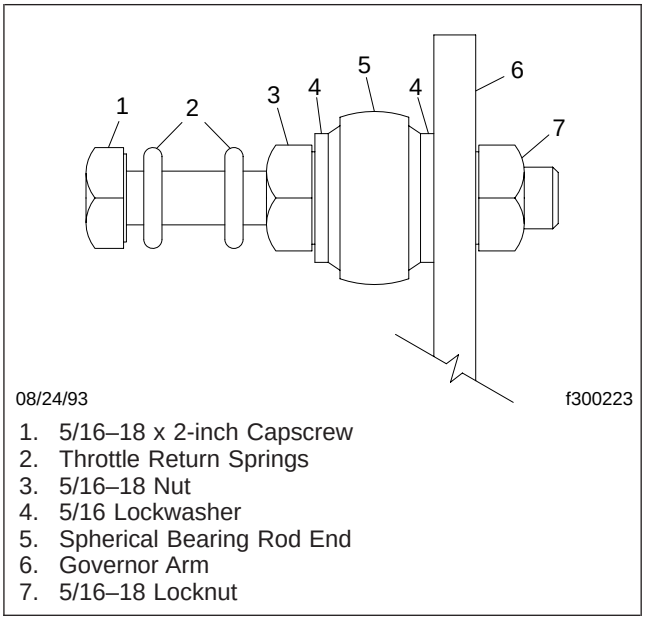
   7.2 To install a capscrew in the governor arm, use two lockwashers, a nut, and a locknut, install a 5/16–18 capscrew through the outboard-side of the spherical bearing rod end and the governor arm hole farthest from the governor shaft. See **Fig. 3**. Tighten the locknut 15 lbf·ft (20 N·m).

Throttle Control Installation



A. 9-1/2 to 9-3/4 inches (241 to 248 mm)
1. Next-To-Last Boss on the Engine Block

Fig. 2, Throttle-Return Springs and Spring Bracket (NTC)



1. 5/16–18 x 2-inch Capscrew
2. Throttle Return Springs
3. 5/16–18 Nut
4. 5/16 Lockwasher
5. Spherical Bearing Rod End
6. Governor Arm
7. 5/16–18 Locknut

Fig. 3, Return Spring Capscrew Installation

7.3 Hook one end of each spring around the capscrew or through the hole in the return-spring bracket.

7.4 Using a hook (do not use sharply serrated pliers), place the opposite anchor loop of each spring around the capscrew in the governor arm. Don't stretch the springs any further than necessary.

8. Install the horizontal throttle rod on the bellcrank as follows:

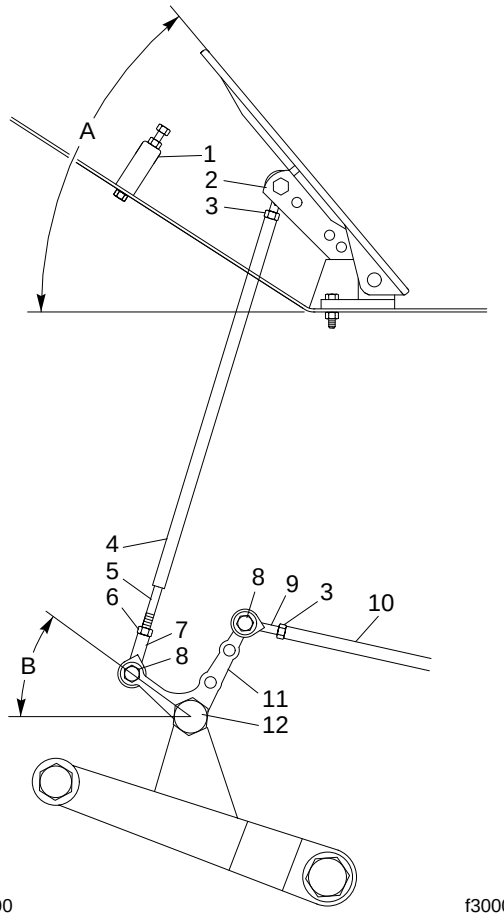
8.1 Hold the bellcrank so that the shorter arm is at a 30 degree angle above horizontal.

8.2 Turn the rod end until the spherical bearing bore is aligned with the hole nearest the end of the longer bellcrank arm. See **Fig. 4**.

⚠ WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod end must remain engaged in the rod. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.

8.3 At least 5/16 inch (8 mm) of thread on the rod end must remain engaged in the rod.



A. 50 degrees
B. 30 degrees

1. Throttle Stop Assembly
2. Pedal Throttle Arm
3. 5/16–24 Jam Nut
4. Throttle Guide Tube
5. Vertical Throttle Rod
6. Kep Nut
7. Internally Threaded Spherical Bearing Rod End
8. Capscrew, Flat Washer and Locknut
9. Externally Threaded Spherical Bearing Rod End
10. Horizontal Throttle Rod
11. Bellcrank
12. Shoulder Bolt and Locknut

Fig. 4, Spherical Bearing Bore Alignment

If more adjustment is needed than can be made at the bellcrank end of the rod, turn the rod as needed, to change the thread engagement at the governor-arm end.

8.4 Install a flat washer on a 5/16–24 capscrew, then insert the capscrew into the bore of the rod end. From the outside, insert the capscrew into the hole nearest the end of the longer bellcrank arm. Install and tighten the locknut 15 lbf·ft (20 N·m).

8.5 Hold the throttle rod in a position that prevents other components from interfering with the rod's movement through full travel. Turn each of the rod ends in the direction opposite the rotation of the throttle linkage. Hold the rod in this position while tightening the rod-end jam nuts 15 lbf·ft (20 N·m).

9. Install the vertical throttle rod.

9.1 Insert the top of the vertical throttle rod in the bottom of the throttle guide tube. Slide the guide tube onto the vertical throttle rod.

9.2 Install a flat washer on a 1/4–20 capscrew. From the inboard-side of the shorter bellcrank arm, insert the capscrew into the bore of the rod end and through the bellcrank. Install and tighten the locknut 15 lbf·ft (20 N·m).

9.3 Insert a 5/16–24 capscrew through the throttle pedal arm, from the floor-board side. Insert the capscrew into the bore of the rod end. Install a locknut and tighten it 15 lbf·ft (20 N·m).

9.4 Return the cab to the operating position. For instructions, see **Section 60.04**, Subject 060, in this manual.

9.5 Loosen the Kep nut at the bottom of the vertical throttle rod. See **Fig. 4**.

9.6 Turn the vertical throttle rod until the throttle pedal is at an angle of approximately 50 degrees to the cab deck. See **Fig. 4**.

⚠ WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod must remain engaged in the rod end. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.

Throttle Control Installation

9.7 At least 5/16 inch (8 mm) of thread on the rod must remain engaged in the rod end. If more adjustment is needed than can be made between the vertical throttle rod and the spherical bearing rod end, tighten the Kep nut at the bottom of the vertical throttle rod. Loosen the jam nut at the top of the vertical throttle guide tube, and turn the guide tube as needed.

9.8 Tighten the jam nut 15 lbf·ft (20 N·m). Tighten the Kep nut 84 lbf·in (940 N·cm).

10. Adjust the pedal stop. For instructions, see **Subject 120**.
11. Install the radiator grille.
12. Remove the chocks from the tires.
13. Test drive the vehicle and ensure proper operation of the throttle system.

Troubleshooting Tables

Problem—Throttle Pedal Angle Is Too High at Idle

Problem—Throttle Pedal Angle Is Too High at Idle	
Possible Cause	**Remedy**
The vertical throttle linkage is too long, or the horizontal throttle linkage is too short.	Adjust the length of the throttle linkage, then adjust the pedal stop.

Problem—Throttle Pedal Angle Is Too Low at Idle

Problem—Throttle Pedal Angle Is Too Low at Idle	
Possible Cause	**Remedy**
Adjust the length of the throttle linkage, then adjust the pedal stop.	The vertical throttle linkage is too short, or the horizontal throttle linkage is too short.

Problem—Excessive Play in the Throttle Pedal

Problem—Excessive Play in the Throttle Pedal	
Possible Cause	**Remedy**
One of the throttle linkage attachment capscrews is loose.	Tighten the throttle linkage attachment capscrews.

Problem—Engine Does Not Reach Maximum Horsepower

Problem—Engine Does Not Reach Maximum Horsepower	
Possible Cause	**Remedy**
One of the throttle linkage attachment capscrews is loose.	Tighten the throttle linkage attachment capscrews.
Interference with the throttle linkage is preventing the governor arm from reaching the breakover range.	Engine components are interfering with the full travel of the throttle linkage. Reposition the components, or the horizontal throttle linkage.
At idle, the throttle pedal angle is too low.	Adjust the length of the throttle linkage, then adjust the pedal stop.
The pedal stop is set too high.	Adjust the position of the pedal stop if it is not allowing full travel of the governor arm (into the breakover range).

Problem—Engine Does Not Return to Idle RPM When the Throttle Pedal Is Released

Problem—Engine Does Not Return to Idle RPM When the Throttle Pedal Is Released	
Possible Cause	**Remedy**
Interference with the throttle linkage is preventing the governor arm from returning to the idle position.	Engine components are interfering with the full travel of the throttle linkage. Reposition the components, or the horizontal throttle linkage.
The installed length of the throttle-return springs is too short.	Check the distance between the spring mounting points. Reposition the governor arm as necessary.
The throttle-return springs are too long (stretched).	Remove the throttle-return springs and check them for stretching. If the springs are stretched, install new springs.

Troubleshooting

Problem—Engine Does Not Return to Idle RPM When the Throttle Pedal Is Released	
Possible Cause	**Remedy**
The throttle-return springs are broken.	Install new throttle-return springs.

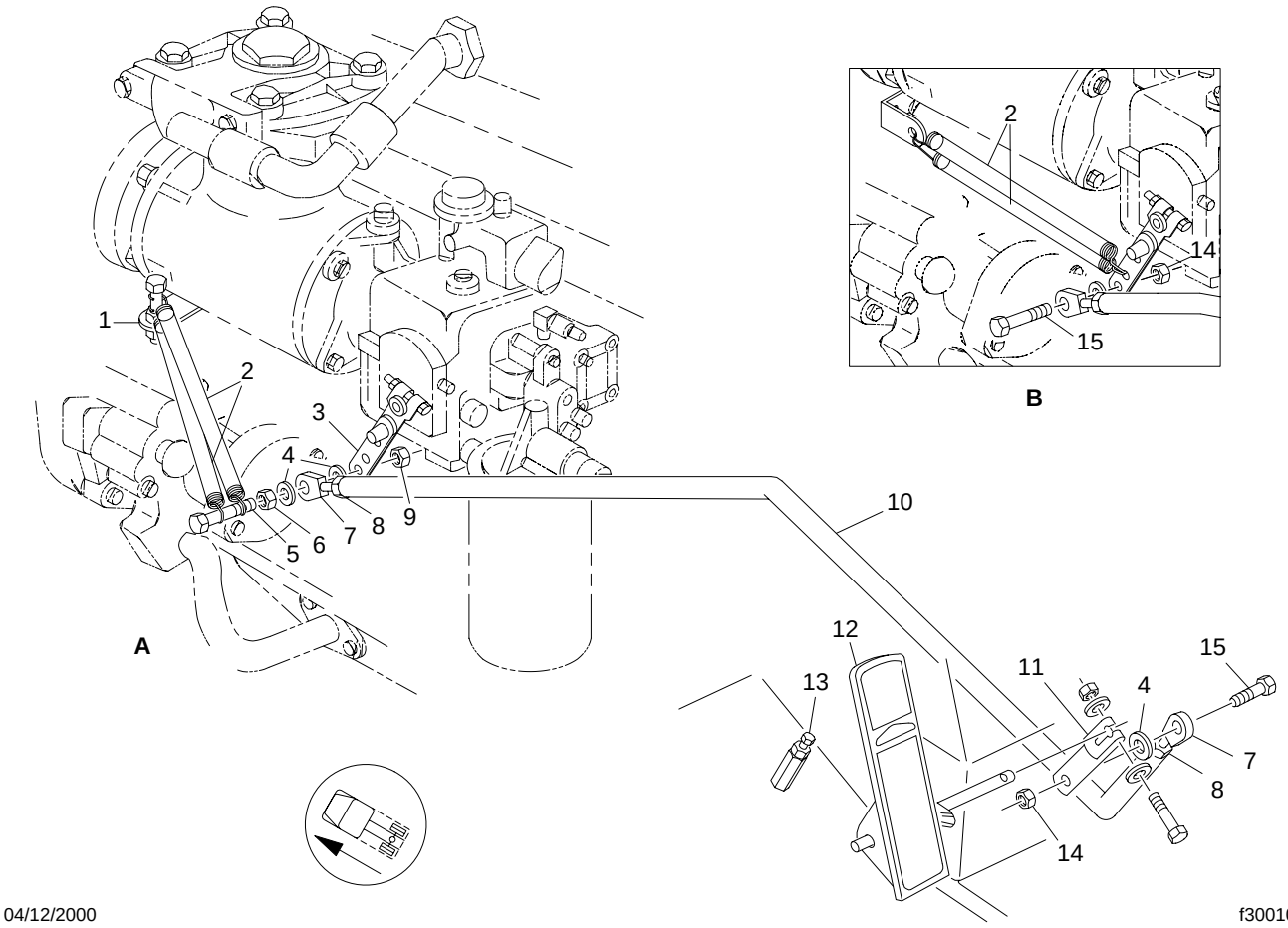
Problem—Excessive Resistance at the Throttle Pedal

Problem—Excessive Resistance at the Throttle Pedal	
Possible Cause	**Remedy**
The throttle linkage is rubbing against engine components.	Engine components are interfering with the throttle linkage. Reposition the components, or the horizontal throttle linkage.
Engine components are interfering with the throttle-return springs.	Reposition the components. Check the return springs for damage, and replace if necessary.
The spherical bearing rod ends at each end of the horizontal throttle rod are rotated to their opposite limits.	Reposition both rod ends.

General Information

Freightliner throttle controls have a floor-mounted throttle pedal, an adjustable-length throttle rod, dual return springs, and an adjustable pedal stop. See **Fig. 1**.

be at the correct angle when the engine is at idle rpm, the length of the linkage is adjustable by means of spherical bearing rod ends, with the adjustment secured by jam nuts. See **Fig. 2**. The spherical bearings prevent binding of the linkage.



A. Return spring installation with capscrews
B. Return spring installation without capscrews

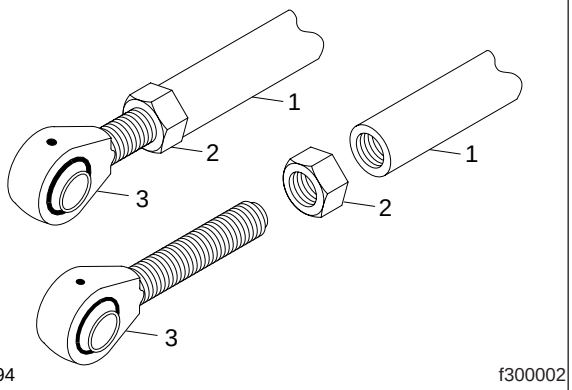
1. Return-Spring Bracket
2. Return Springs
3. Governor Arm
4. Lockwasher
5. 5/16–18 Capscrew
6. 5/16–18 Hexnut
7. Spherical Bearing Rod End
8. Jam Nut
9. 5/16–18 Locknut
10. Throttle Rod
11. Pedal Throttle Arm
12. Throttle Pedal
13. Pedal Stop
14. 5/16–24 Locknut
15. 5/16–24 Capscrew

Fig. 1, Throttle Control Parts (L10)

During engine operation, movement of the throttle pedal and linkage will change the amount of fuel available to the engine. To ensure that the pedal will

Dual springs return the throttle control parts to their idle positions when the pedal is released.

General Information



1. Internally Threaded Throttle Rod
2. Jam Nut
3. Externally Threaded Spherical Bearing Rod End

Fig. 2, Throttle Rod Parts

When the linkage is properly adjusted, the governor shaft can rotate from idle rpm to maximum horsepower. To ensure that maximum horsepower is always reached, the linkage must be able to move just beyond the position where the governor shaft has stopped rotating, without causing damage to the governor. Cummins governor arms consist of two parts held in alignment by a breakover spring. When the part of the governor arm attached to the governor shaft has moved as far as the shaft rotation will allow, the force applied at the pedal overcomes the resistance of the breakover spring. This allows the part of the governor arm attached to the linkage to move into the breakover range. If the governor arm were forced beyond the breakover range, the linkage or governor arm could be damaged. An adjustable pedal stop prevents movement of the linkage beyond the governor arm's breakover range.

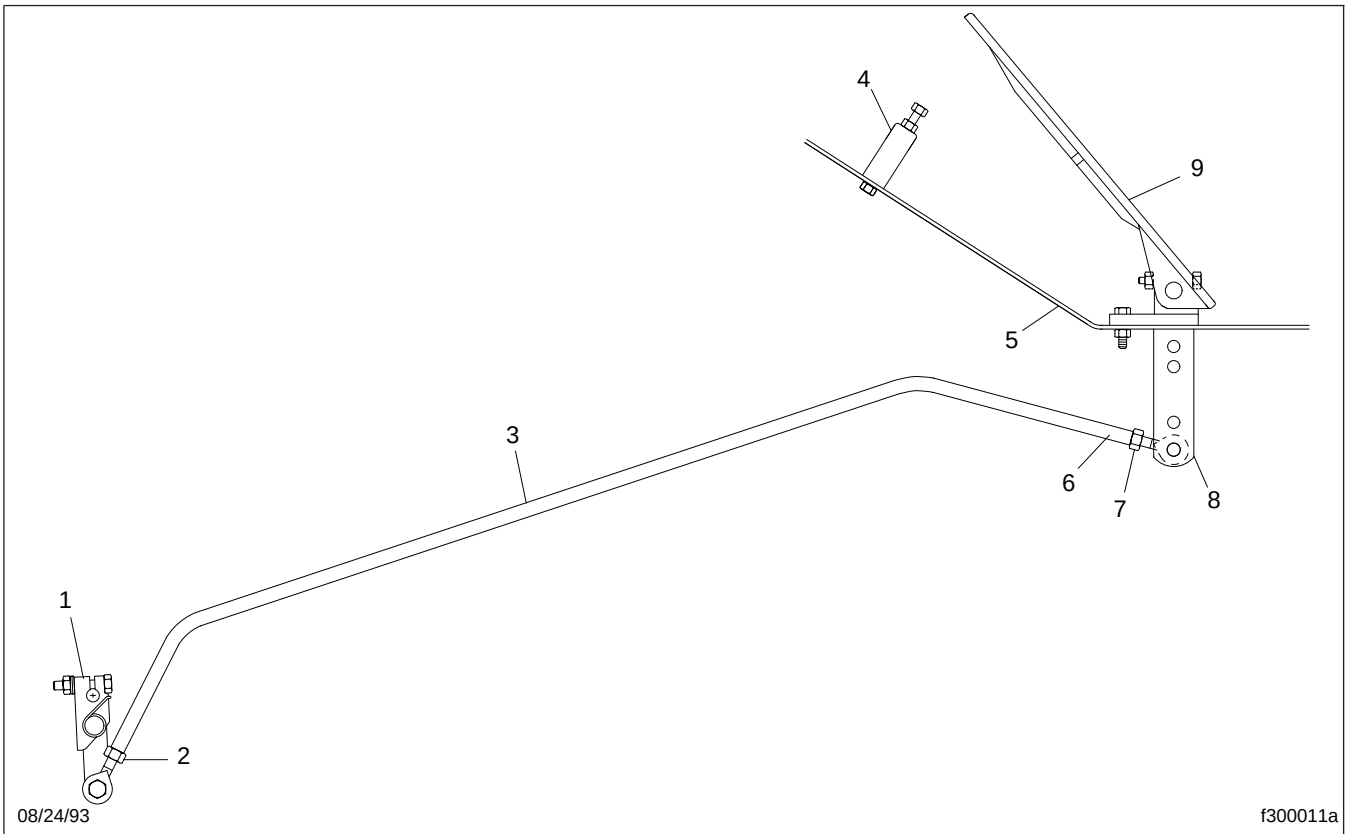
Throttle Control Operation Checking

1. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Check the linkage attachment fasteners (capscrews, locknuts, and jam nuts) for tightness; tighten any that are loose.
4. Operate the throttle pedal by hand, from idle to maximum horsepower, while checking that nothing interferes with movement of the linkage.
5. Check the linkage for binding, by rotating the rod in and out. With the rod-end jam nuts tight against the rod, both rod ends must be free to swivel on their spherical bearings. If the rod and rod ends do not rotate in and out, adjust the rod ends and jam nuts as follows:
   - 5.1 Loosen the jam nuts at each end of the throttle rod. See **Fig. 1**.
   - 5.2 Turn the throttle rod to a position that prevents other components from interfering with the rod's movement through full travel.
   - 5.3 Hold the throttle rod in this position and turn each of the spherical bearing rod ends in the direction opposite the rotation of the throttle linkage. Hold the rod in this position while tightening the rod-end jam nuts 15 lb·ft (20 N·m).
6. Operate the linkage by hand, from idle to maximum horsepower, while checking that nothing interferes with movement of the return springs. Reposition any parts that interfere.
7. Check the length of the installed return springs. When the throttle lever is at idle, the springs must be 9-1/2 to 9-3/4 inches (241 to 248 mm) long. See **Fig. 2**. If the spring length is incorrect, see **Subject 130**.
8. Inspect the return springs.
   - 8.1 Using a hook (do not use sharply serrated pliers), disconnect the anchor loop of each spring from the governor arm. Do not stretch the springs any further than necessary. Disconnect the opposite ends from the spring bracket.
   - 8.2 Inspect the springs, especially in the area of the anchor loops, for wear, nicks, or other damage that might cause breakage.
   - 8.3 Measure the springs for stretching. The relaxed spring should be no more than 9-3/8 inches (238 mm) long, from the outside of one anchor loop to the outside of the opposite anchor loop.
   - 8.4 If the used springs are worn, damaged, or stretched, install new springs.
   - 8.5 Install the springs by hooking one end of each spring around the capscrew or through the hole in the return-spring bracket. Then, using the hook, place the opposite anchor loop of each spring around the capscrew or through the hole in the governor arm.
9. With the governor arm at idle, check the angle of the throttle pedal. The pedal must be at an angle of about 50 degrees to the cab deck. See **Fig. 3**. If the throttle pedal angle is too high or too low, adjust the length of the throttle linkage. See **Subject 110**.
10. Operate the throttle pedal by hand, from idle through full travel, while checking that the governor arm travels at least 5 degrees into the breakover range.

    The breakover range begins at the point where the two parts of the governor arm begin to have intersecting centerlines. See **Fig. 4**.

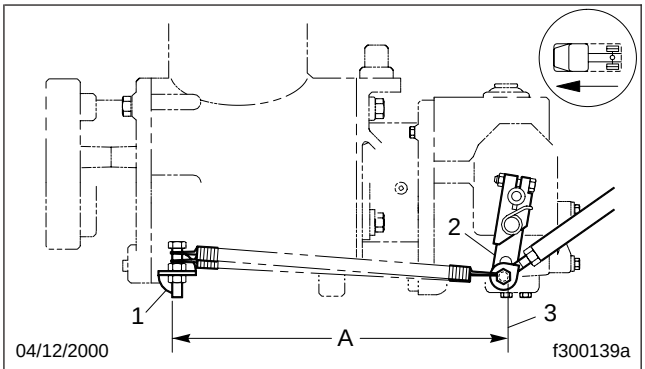
    If the governor arm does not travel at least 5 degrees into the breakover range, adjust the pedal stop. See **Subject 120**.
11. Lower the hood and remove the chocks from the tires.
12. Test drive the vehicle and ensure that the throttle system operates properly.

Throttle Control Operation Checking



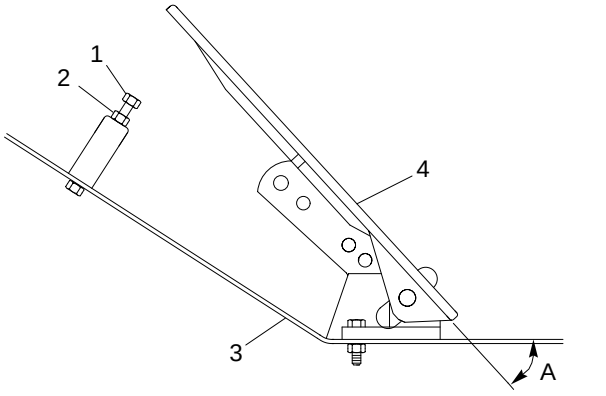
1. Governor Arm
2. Rod-End Jam Nut
3. Throttle Rod
4. Pedal Stop
5. Cab Deck
6. Upper Rod End
7. Rod-End Jam Nut
8. Throttle Pedal Arm
9. Throttle Pedal

Fig. 1, Throttle Rod Installation



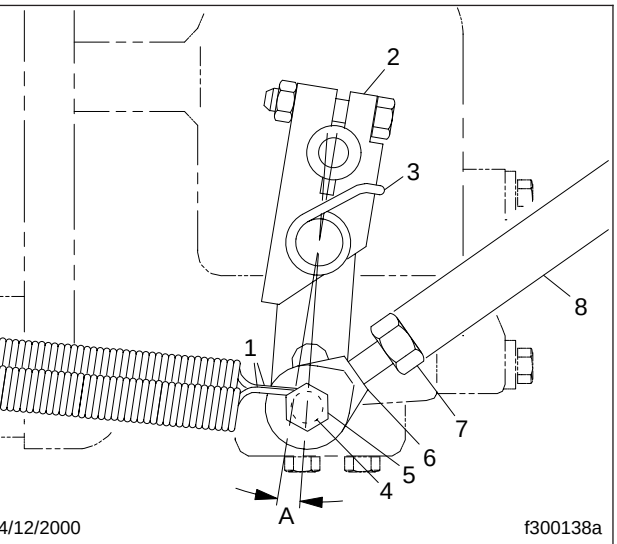
A. 9-1/2 to 9-3/4 inches (241 to 248 mm)
1. Return-Spring Bracket
2. Governor Arm at Idle
3. Vertical Centerline of the Governor Shaft

Fig. 2, Return Spring Length (L10)



A. 50 degrees
1. Pedal Stop Capscrew
2. Jam Nut
3. Cab Deck
4. Throttle Pedal

Fig. 3, Throttle Pedal at Idle



A. 5 degrees
1. Throttle-Return Springs
2. Governor Arm
3. Governor Arm Breakover Spring
4. Return Spring and Throttle Linkage Mounting Hole
5. Capscrew
6. Spherical Bearing Rod End
7. Jam Nut
8. Throttle Rod

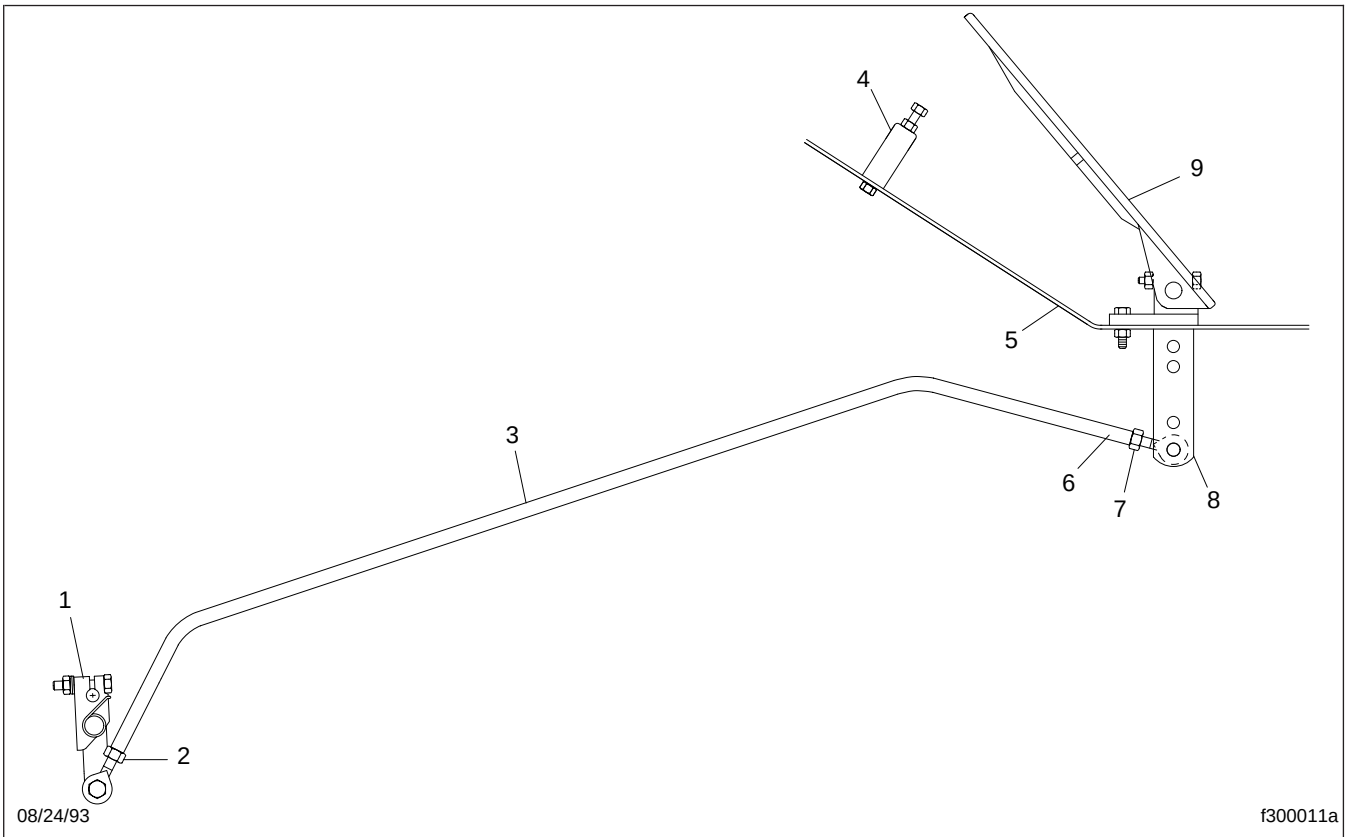
Fig. 4, Governor Arm in the Breakover Range (L10)

Throttle Linkage Length Adjustment

1. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Loosen the jam nuts at each end of the throttle rod. See **Fig. 1**.
6. With the governor arm at idle, turn the lower rod end, until the spherical bearing bore is aligned with the lower hole on the governor arm.

⚠ WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod end must remain engaged in the rod. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.



1. Governor Arm
2. Rod-End Jam Nut
3. Throttle Rod
4. Pedal Stop
5. Cab Deck
6. Upper Rod End
7. Rod-End Jam Nut
8. Throttle Pedal Arm
9. Throttle Pedal

Fig. 1, Throttle Linkage Length Adjustment

4. Remove the locknut, flat washer, and capscrew from the governor arm and spherical bearing rod end.
5. Block the throttle pedal at an angle of approximately 50 degrees to the cab deck.
7. At least 5/16 inch (8 mm) of thread on the rod end must remain engaged in the rod. If more adjustment is needed than can be made at the gov-

Throttle Linkage Length Adjustment

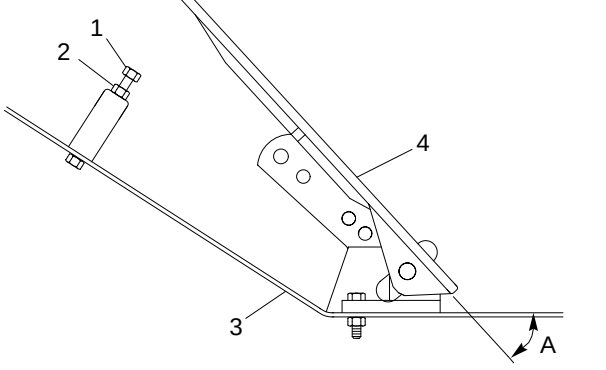
ernor arm, turn the rod as needed, to change the thread engagement of the upper rod end.

8. Insert a capscrew into the bore of the lower rod end. Install a flat washer on the capscrew. Insert the capscrew through the bottom governor arm hole. Install and tighten the locknut 15 lbf·ft (20 N·m).
9. Turn the throttle rod to a position that prevents other components from interfering with the rod's movement through full travel. Hold the throttle rod in this position and turn each of the spherical bearing rod ends in the direction opposite the rotation of the throttle linkage. Hold the rod in this position while tightening the rod-end jam nuts 15 lbf·ft (20 N·m).
10. Adjust the pedal stop. For instructions, see **Subject 120**.
11. Lower the hood and remove the chocks from the tires.
12. Test drive the vehicle and ensure proper operation of the throttle system.

Pedal Stop Adjustment

NOTE: If the throttle linkage is not new, perform the checks in **Subject 100** before adjusting the pedal stop.

1. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Loosen the pedal stop jam nut, and turn the capscrew in until no threads are showing above or below the jam nut. See **Fig. 1**. This allows maximum pedal travel.



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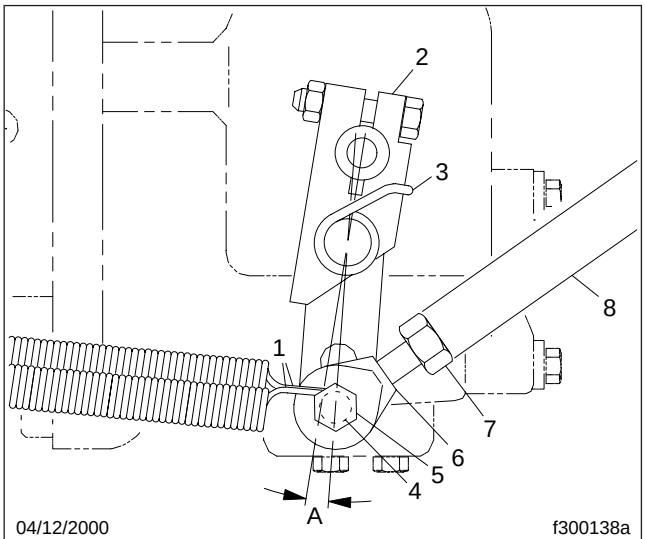
A. 50 degrees
1. Pedal Stop Capscrew
2. Jam Nut
3. Cab Deck
4. Throttle Pedal

Fig. 1, Pedal Stop Installation

4. Hold the throttle pedal at the point where the centerlines of the two parts of the governor arm form an angle of 5 degrees. See **Fig. 2**.
5. Position the head of the pedal stop capscrew 1/16 to 1/8 inch (1.5 to 3 mm) from the bottom of the pedal, and tighten the jam nut against the cab deck. See **Fig. 1**.
6. Operate the pedal to check the adjustment. Readjust if necessary.
7. Lower the hood and remove the chocks from the tires
8. Test drive the vehicle and ensure proper operation of the throttle system.



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A. 5 degrees
1. Throttle-Return Springs
2. Governor Arm
3. Governor Arm Breakover Spring
4. Return Spring And Throttle Linkage Mounting Hole
5. Capscrew
6. Spherical Bearing Rod End
7. Jam Nut
8. Throttle Rod

Fig. 2, Governor Arm in the Breakover Range (L10)

Throttle Control Installation

Use the following procedure if the throttle control is being replaced, removed and reinstalled, or if a new or rebuilt engine is being installed.

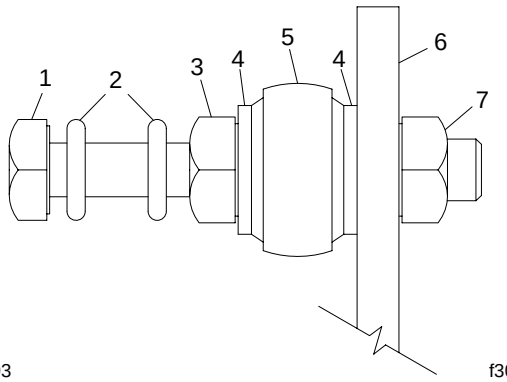
1. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Install the spring bracket (if not already installed).

   On L10s, remove the lower capscrew that attaches the air compressor support to the accessory drive, and use the capscrew to attach the bracket to the compressor support.

   On NTCs, remove the lower capscrew that attaches the air compressor crankcase to the air compressor support, and use the capscrew to attach the bracket to the air compressor.
4. Install the jam nuts and spherical bearing rod ends on the throttle rod. The rod ends should be adjusted to their maximum thread engagement. Do not tighten the jam nuts.
5. Using two lockwashers, a nut, and a locknut, install a 5/16–18 capscrew through the outboard side of the spherical bearing rod end and the governor arm hole farthest from the governor shaft. See **Fig. 1**. Tighten the locknut 15 lbf·ft (20 N·m).
6. Hold the throttle pedal at an angle of approximately 50 degrees to the cab deck.
7. On NTCs, with the governor arm pointing downward at 10 degrees aft of vertical (see **Fig. 2**), measure the distance between the capscrew in the return-spring bracket and the governor arm capscrew. Include the thickness of the capscrews in this measurement.

   On L10s, with the governor arm pointing downward at 15 ± 2 degrees forward of vertical (see **Fig. 3**), measure the distance between the capscrew in the return-spring bracket and the governor arm capscrew.

   This distance (the length of the installed springs at idle) must be 9-1/2 to 9-3/4 inches (241 to 248 mm). If the distance is not within this tolerance, remove the nut, washer, and pinch bolt from the governor arm. Remove the arm by spreading the end of it with a screwdriver while pulling outward on it. Install the arm (pointing downward) at an angle that will provide the correct distance. Install and securely tighten the pinch bolt, washer, and nut.



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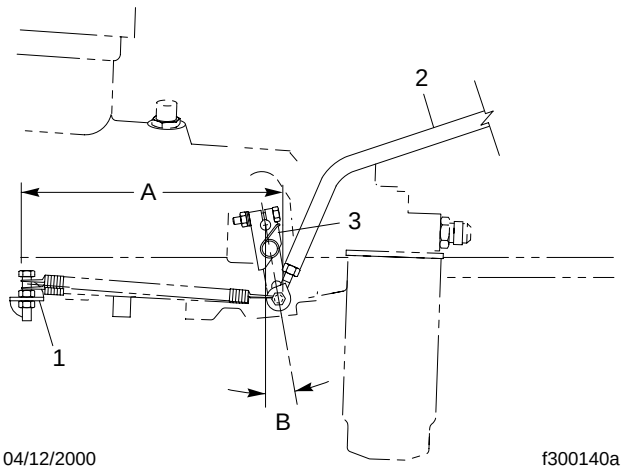
1. 5/16–18 Capscrew
2. Throttle Return Springs
3. 5/16–18 Nut
4. 5/16 Lockwasher
5. Spherical Bearing Rod End
6. Governor Arm
7. 5/16–18 Locknut

Fig. 1, Rod End Installation



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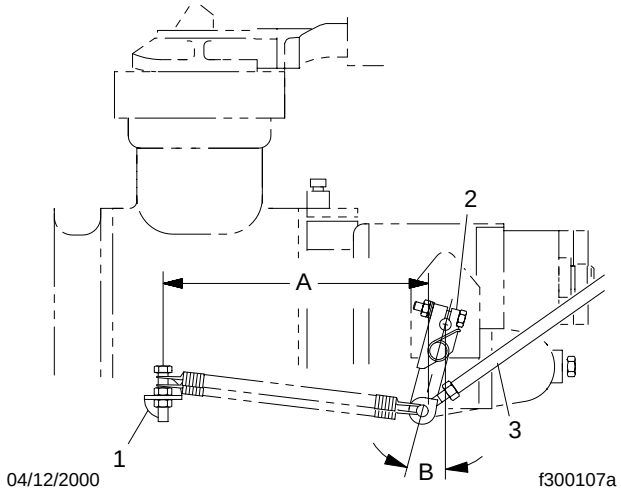
A. 9-1/2 to 9-3/4 inches (241 to 248 mm)
B. 10 degrees

1. Return-Spring Bracket
2. Throttle Rod
3. Governor Arm at Idle

Fig. 2, Governor Arm Position (NTC)

8. Install the return springs.

Throttle Control Installation



A. 9-1/2 to 9-3/4 inches (241 to 248 mm)
B. 15 ± 2 degrees
1. Return-Spring Bracket
2. Governor Arm at Idle
3. Throttle Rod

Fig. 3, Governor Arm Position (L10)

8.1 If used springs are being installed, inspect them, especially in the area of the anchor loops, for wear, nicks, or other damage that may cause breakage. Install new springs if the used springs are worn or damaged.

8.2 Hook one end of each spring around the capscrew in the return-spring bracket.

8.3 Using a hook (do not use sharply serrated pliers) place the opposite anchor loop of each spring around the capscrew in the governor arm. Don't stretch the springs any further than necessary.

9. With the throttle pedal and the governor arm in the idle position, turn the lower rod end, until the spherical bearing bore is aligned with the bottom hole on the governor arm.

⚠ WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod end must remain engaged in the rod. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.

10. At least 5/16 inch (8 mm) of thread on the rod end must remain engaged in the rod. If more adjustment is needed than can be made at the governor arm, turn the rod as needed, to change the thread engagement of the upper rod end.
11. Insert a capscrew into the bore of the lower rod end. Install a flatwasher on the capscrew. Insert the capscrew through the bottom governor arm hole. Install and tighten the locknut 15 lbf·ft (20 N·m).
12. Turn the throttle rod to a position that prevents other components from interfering with the rod's movement through full travel.
13. Hold the throttle rod in this position and turn each of the spherical bearing rod ends in the direction opposite the rotation of the throttle linkage. Hold the rod in this position while tightening the rod-end jam nuts 15 lbf·ft (20 N·m).
14. Adjust the pedal stop. For instructions, see **Subject 120**.
15. Lower the hood and remove the chocks from the tires
16. Test drive the vehicle and ensure proper operation of the throttle system.

Troubleshooting Tables

Problem—Throttle Pedal Angle Is Too High at Idle

Problem—Throttle Pedal Angle Is Too High at Idle	
Possible Cause	**Remedy**
The throttle linkage is too long.	Adjust the length of the throttle linkage, then adjust the pedal stop.

Problem—Throttle Pedal Angle Is Too Low at Idle

Problem—Throttle Pedal Angle Is Too Low at Idle	
Possible Cause	**Remedy**
The throttle linkage is too short.	Adjust the length of the throttle linkage, then adjust the pedal stop.

Problem—Excessive Play in the Throttle Pedal

Problem—Excessive Play in the Throttle Pedal	
Possible Cause	**Remedy**
One of the throttle linkage attachment capscrews is loose.	Tighten the throttle linkage attachment capscrews.

Problem—Engine Does Not Reach Maximum Horsepower

Problem—Engine Does Not Reach Maximum Horsepower	
Possible Cause	**Remedy**
One of the throttle linkage attachment capscrews is loose.	Tighten the throttle linkage attachment capscrews.
Interference with the throttle linkage is preventing the governor arm from reaching the breakover range.	Engine components are interfering with the full travel of the throttle linkage. Reposition the components.
At idle, the throttle pedal angle is too low.	Adjust the length of the throttle linkage, then adjust the pedal stop.
The pedal stop is set too high.	Adjust the position of the pedal stop if it is not allowing full travel of the governor arm (into the breakover range).

Problem—Engine Does Not Return to Idle RPM When the Throttle Pedal Is Released

Problem—Engine Does Not Return to Idle RPM When the Throttle Pedal Is Released	
Possible Cause	**Remedy**
Interference with the throttle linkage is preventing the governor arm from returning to the idle position.	Engine components are interfering with the full travel of the throttle linkage. Reposition the components.
The installed length of the throttle-return springs is too short.	Check the distance between the spring mounting points. Reposition the governor arm as necessary.
The throttle-return springs are too long (stretched).	Remove the throttle-return springs and check them for stretching. If the springs are stretched, install new springs.
The throttle-return springs are broken.	Install new throttle-return springs.

Troubleshooting

Problem—Excessive Resistance at the Throttle Pedal

Problem—Excessive Resistance at the Throttle Pedal	
Possible Cause	**Remedy**
The throttle linkage is rubbing against engine components.	Engine components are interfering with the throttle linkage. Reposition the components.
Engine components are interfering with the throttle-return springs.	Reposition the components. Check the return springs for damage, and replace if necessary.
The spherical bearing rod ends at each end of the throttle rod are rotated to their opposite limits.	Reposition both rod ends.

General Information

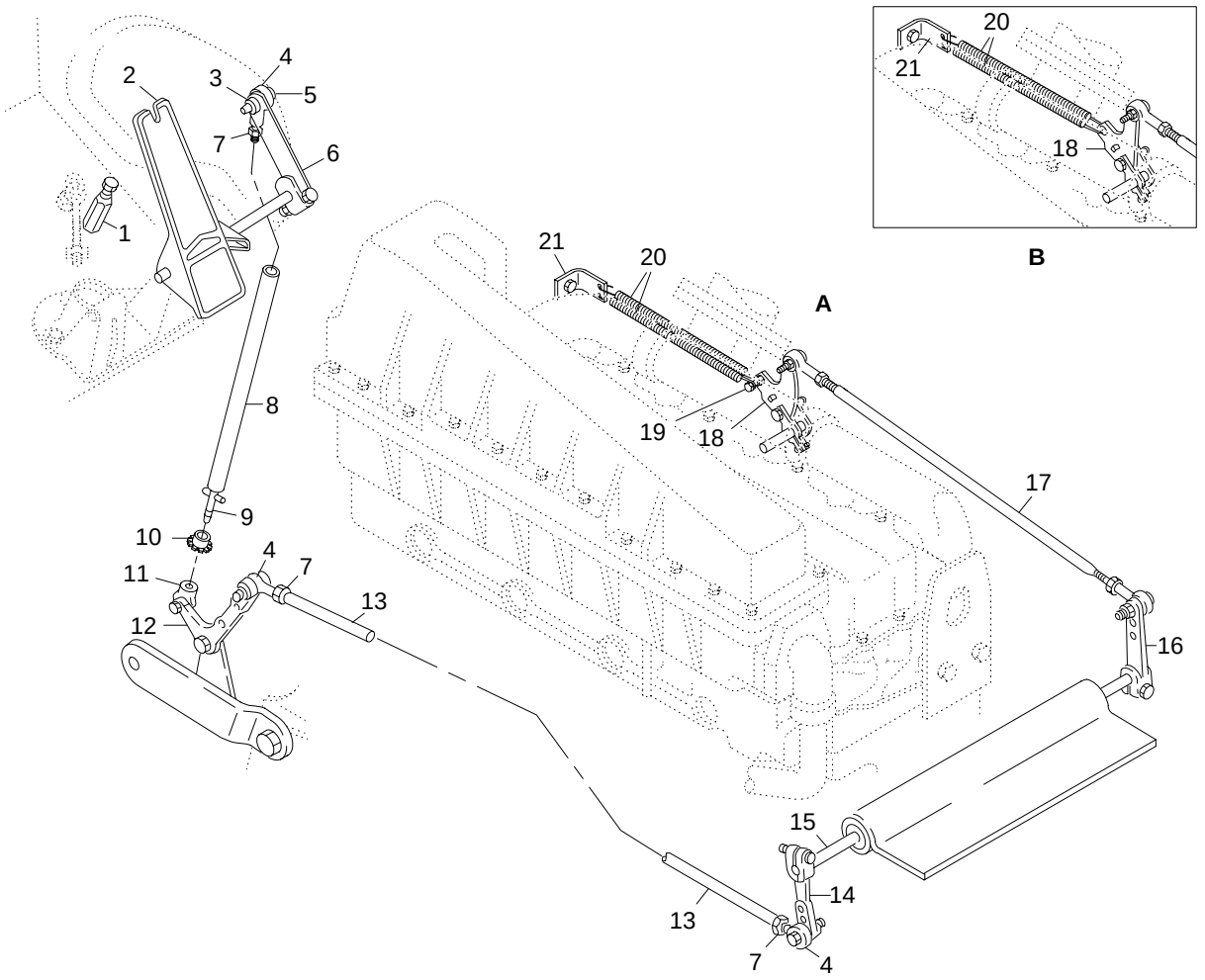
Freightliner throttle controls have a floor-mounted throttle pedal, adjustable-length throttle rods, a strut-mounted bellcrank, dual return springs, and an adjustable pedal stop. See **Fig. 1** and **Fig. 2**. On Caterpillar 3306 engines, the two-piece governor arm, right throttle rod, and cross-shaft assembly are installed by the engine manufacturer. See **Fig. 1**.

During engine operation, movement of the throttle pedal and linkage will change the amount of fuel available to the engine. To ensure that the pedal will be at the correct angle when the engine is at idle rpm, the length of the linkage is adjustable by means of spherical bearing rod ends, with the adjustment secured by jam nuts. See **Fig. 3**. The spherical bearings prevent binding of the linkage.

Dual springs return the throttle control parts to their idle positions when the pedal is released.

When the linkage is properly adjusted, the governor shaft can rotate from idle rpm to maximum horsepower. To ensure that maximum horsepower is always reached, the linkage must be able to move just beyond the position where the governor shaft has stopped rotating, without causing damage to the governor. Caterpillar governor arms consist of two parts held in alignment by a breakover spring. When the part of the governor arm attached to the governor shaft has moved as far as the shaft rotation will allow, the force applied at the pedal overcomes the resistance of the breakover spring. This allows the part of the governor arm attached to the linkage to move into the breakover range. If the governor arm were forced beyond the breakover range, the linkage or governor could be damaged. An adjustable pedal stop prevents movement of the linkage beyond the governor arm's breakover range.

General Information



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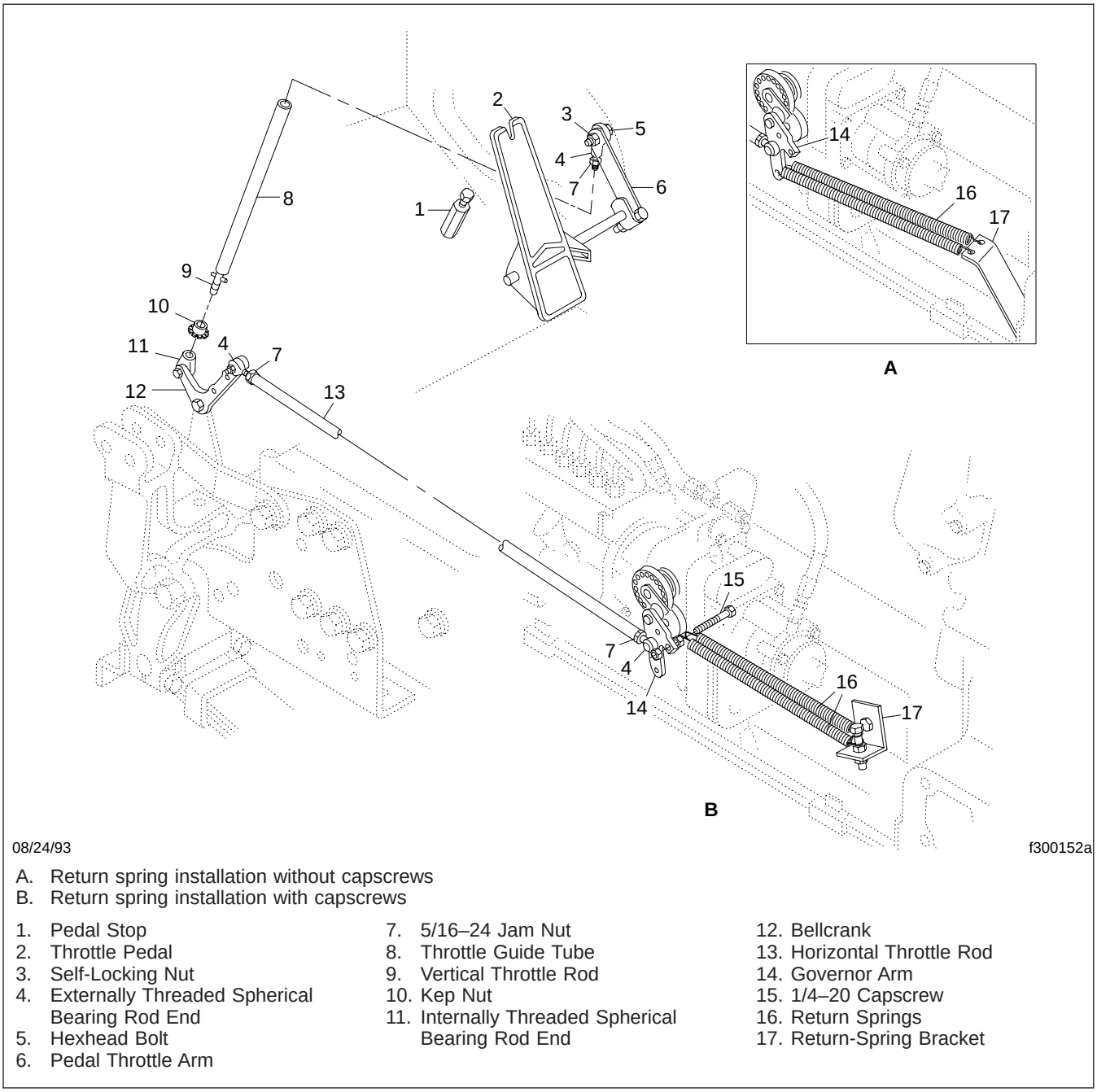
A. Return spring installation with capscrew
B. Return spring installation without capscrews

1. Pedal Stop
2. Throttle Pedal
3. Self-Locking Nut
4. Externally Threaded Spherical Bearing Rod End
5. Hexhead Bolt
6. Pedal Throttle Arm
7. 5/16–24 Jam Nut
8. Throttle Guide Tube
9. Vertical Throttle Rod
10. Kep Nut
11. Internally Threaded Spherical Bearing Rod End
12. Bellcrank
13. Left Horizontal Throttle Rod
14. Left Cross-Shaft Arm
15. Cross-Shaft Assembly
16. Right Cross-Shaft Arm
17. Right Horizontal Throttle Rod
18. Governor Arm
19. 1/4–20 Capscrew
20. Return Springs
21. Return-Spring Bracket

Fig. 1, Throttle Linkage (3306)

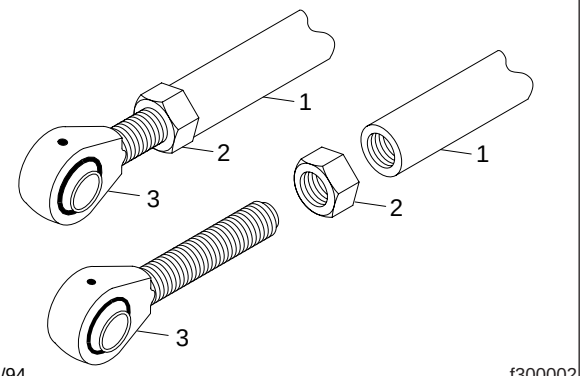


A. Return spring installation without capscrews
B. Return spring installation with capscrews

1. Pedal Stop
2. Throttle Pedal
3. Self-Locking Nut
4. Externally Threaded Spherical Bearing Rod End
5. Hexhead Bolt
6. Pedal Throttle Arm
7. 5/16–24 Jam Nut
8. Throttle Guide Tube
9. Vertical Throttle Rod
10. Kep Nut
11. Internally Threaded Spherical Bearing Rod End
12. Bellcrank
13. Horizontal Throttle Rod
14. Governor Arm
15. 1/4–20 Capscrew
16. Return Springs
17. Return-Spring Bracket

Fig. 2, Throttle Linkage (3406)

General Information



1. Internally Threaded Throttle Rod
2. Jam Nut
3. Externally Threaded Spherical Bearing Rod End

Fig. 3, Spherical Bearings

Throttle Control Operation Checking

1. Shut down the engine, set the parking brake, and chock the tires.
2. Tilt the cab. For instructions, see **Section 60.04**, Subject 060, in this manual.
3. Check the linkage attachment fasteners (capscrews, locknuts, and hexnuts) for tightness; tighten any that are loose. On Caterpillar 3306 engines, also check the cross-shaft attachment fasteners for tightness, and tighten as needed.

   Check the tightness of the bellcrank shoulder bolt and locknut, and the bellcrank attaching capscrew tightness; if loose, tighten the locknut or capscrew 20 lbf·ft (27 N·m).
4. Operate the linkage by hand, from idle to maximum horsepower, while checking that nothing interferes with its movement. On Caterpillar 3306 engines, be sure that none of the engine parts interfere with rotation of the cross-shaft arms. Reposition any parts that interfere.
5. On Caterpillar 3306 engines, check the left throttle rod for binding, by rotating the rod in and out. With the rod-end jam nuts tight against the rod, both rod ends must be free to swivel on their spherical bearings. If the rod and rod ends do not rotate in and out, back off the jam nut at the cross-shaft end of the rod. Turn the loosened rod end until its flat faces are parallel to the flat faces of the rod end at the bellcrank.

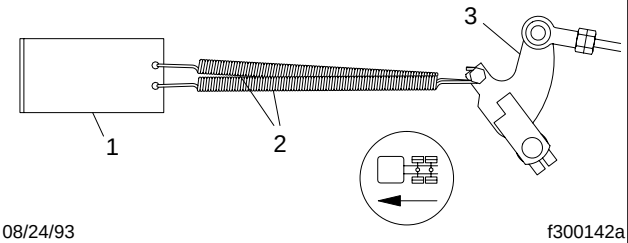
   Hold the rod and rod end in these positions while tightening the jam nut (at the cross-shaft end of the rod) 15 lbf·ft (20 N·m).

   Move the right throttle rod by hand, from idle to maximum horsepower, while checking that nothing interferes with movement of the return springs. Reposition any parts that interfere.
6. On Caterpillar 3406 engines, check the horizontal throttle rod for binding by rotating the rod in and out. Loosen the rod-end jam nuts.

   Rotate the throttle rod to a position that will prevent other components from interfering with its movement through full travel.

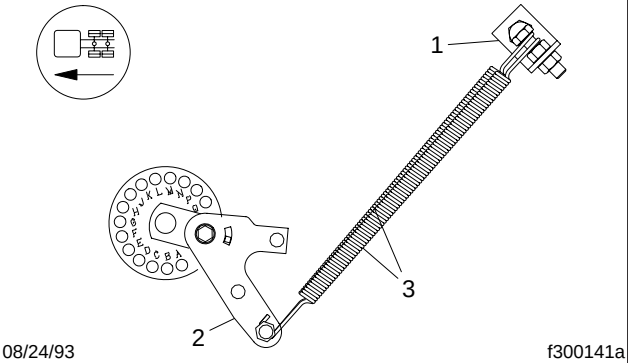
   Hold the throttle rod in this position, and rotate each of the spherical bearing rod ends in a direction opposite the rotation of the throttle rod. Tighten the jam nuts 15 lbf·ft (20 N·m).
7. Inspect the return springs.

   7.1 Using a hook (do not use sharply serrated pliers), disconnect the anchor loop of each spring from the governor arm. See **Fig. 1**, and **Fig. 2**. Do not stretch the springs any further than necessary. Disconnect the opposite ends from the spring bracket.



1. Return-Spring Bracket
2. Throttle-Return Springs
3. Governor Arm

Fig. 1, Throttle-Return Springs at Idle Position (3306)



1. Return-Spring Bracket
2. Governor Arm
3. Throttle-Return Springs

Fig. 2, Throttle-Return Springs at Idle Position (3406)

   7.2 Inspect the springs, especially in the area of the anchor loops, for wear, nicks, or other damage that might cause breakage.

   7.3 Measure the springs for stretching. The relaxed spring should be no more than 9-3/8 inches (238 mm) long, from the outside of one anchor loop to the outside of the opposite anchor loop.

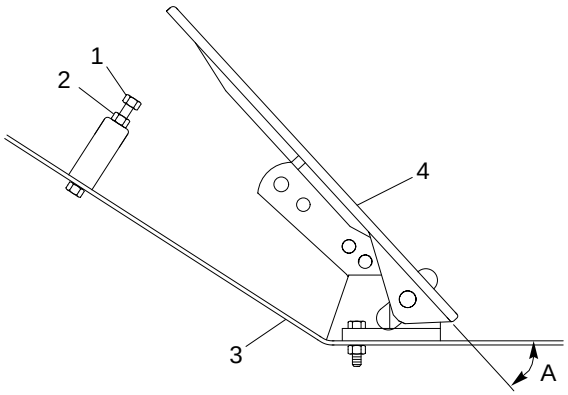
Throttle Control Operation Checking

7.4 If the used springs are worn, damaged, or stretched, install new springs.

7.5 Install the springs by hooking one end of each spring around the capscrew or through the hole in the return-spring bracket; then, using the hook, place the opposite anchor loop of each spring around the capscrew or through the hole in the governor arm.

8. With the cab in the operating position, and the governor arm at idle, check the angle of the throttle pedal. The pedal must be at an angle of approximately 50 degrees to the cab deck. See **Fig. 3**.

   If the throttle pedal angle is too high or too low, adjust the length of the throttle linkage. See **Subject 110**.



04/12/2000 f300003

A. 50 degrees

1. Pedal Stop Capscrew
2. Jam Nut
3. Cab Deck
4. Throttle Pedal

Fig. 3, Throttle Pedal at Idle

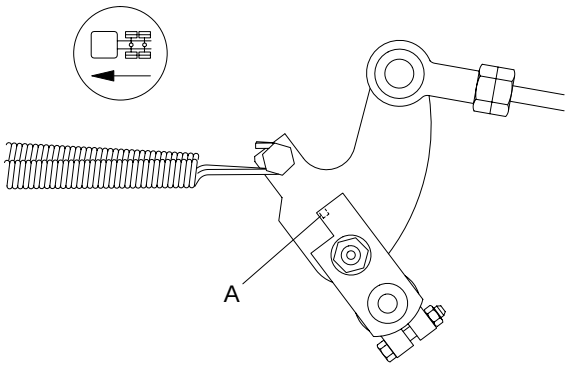
9. Operate the throttle pedal by hand, from idle through full travel, while checking that the governor arm reaches the approximate middle of the breakover range.

10. When the middle of the breakover range is reached, a tang on the governor arm will move to the center of an opening in the governor arm. See **Fig. 4**, or **Fig. 5**.

    On Caterpillar 3306 engines, you can see the governor arm by looking between the bottom of the cab deck and the top of the frame rail above the right front tire.

    On Caterpillar 3406 engines, you cannot see the governor arm when the cab is in the operating position. To check that the governor arm has reached the approximate middle of the breakover range, operate the throttle pedal near the lower end of its travel. With your hand, you should be able to feel the increased resistance that occurs when the governor shaft stops rotating and the breakover spring allows the governor arm to move into the breakover range. If the throttle pedal contacts the pedal stop before any increased resistance is felt, the breakover range is not being reached.

    If the governor arm does not reach the approximate middle of the breakover range, adjust the pedal stop. See **Subject 120**.



08/24/93 f300145a

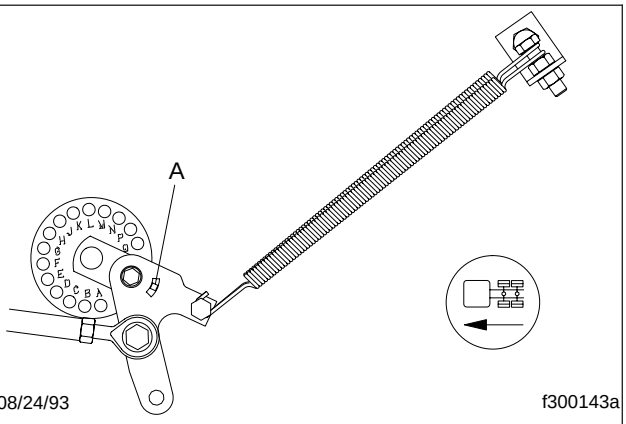
A. The tang must be in the approximate center of the opening

Fig. 4, Check the Tang Position (3306)

11. Return the cab to the operating position. For instructions, see **Section 60.04**, Subject 060, in this manual.

12. Remove the chocks from the tires.

13. Test drive the vehicle and ensure that the throttle system operates properly.



A. The tang must be in the approximate center of the opening

Fig. 5, Check the Tang Position (3406)

Throttle Linkage Length Adjustment

CATERPILLAR 3306 ENGINES

1. Shut down the engine, set the parking brake, and chock the tires.
2. Remove the radiator grille.
3. With the governor arm at idle, check the angle of the bellcrank. The shorter arm of the bellcrank must be at an angle of approximately 30 degrees above horizontal. See **Fig. 1**.

   If the bellcrank is positioned correctly, proceed to the step for returning the cab to the operating position.

   If the bellcrank is not positioned correctly, proceed to the step for repositioning the cross-shaft arm.
4. Tilt the cab. For instructions, see **Section 60.04**, Subject 060, in this manual.
5. With the governor arm at idle, check the angle of the left cross-shaft arm. The left arm must be pointing downward at an angle of approximately 13 degrees aft of vertical. See **Fig. 2**.

   If the left cross-shaft arm is positioned correctly, proceed to the step for returning the cab to the operating position.

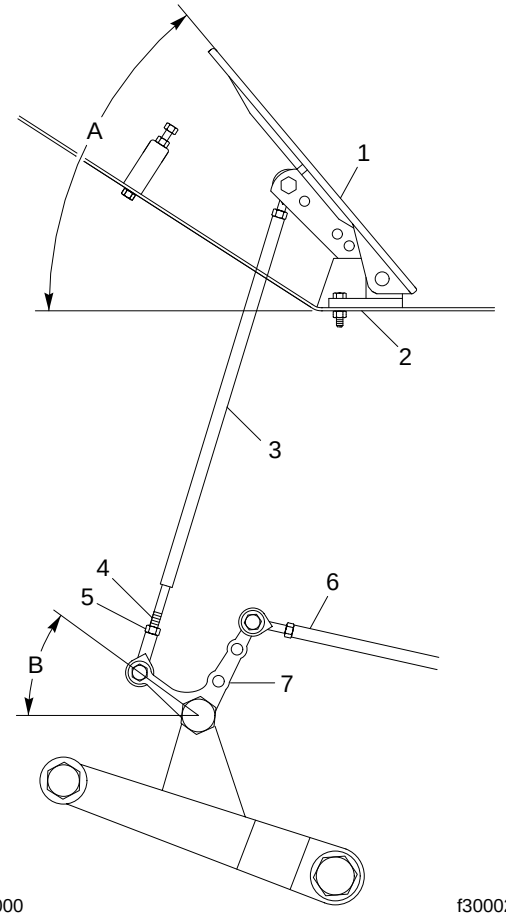
   If the left cross-shaft arm is not positioned correctly, proceed to the next step.
6. Loosen the pinch-bolt nut. Spread the slotted end of the arm with a screwdriver, while pulling outward on the arm, to remove it. Install the arm at the correct angle, as shown in **Fig. 2**. Tighten the pinch-bolt nut, then proceed to the step for returning the cab to the operating position.

IMPORTANT: Do not change the length of the right throttle rod, and do not reposition the governor arm or right cross-shaft arm.

7. Adjust the length of the left (horizontal) throttle rod as follows:

   7.1 Back off the jam nuts at each end of the throttle rod.

   7.2 Remove the locknut, flat washer, and capscrew that attach the left throttle rod to the long arm of the bellcrank.



A. 50 degrees
B. 30 degrees

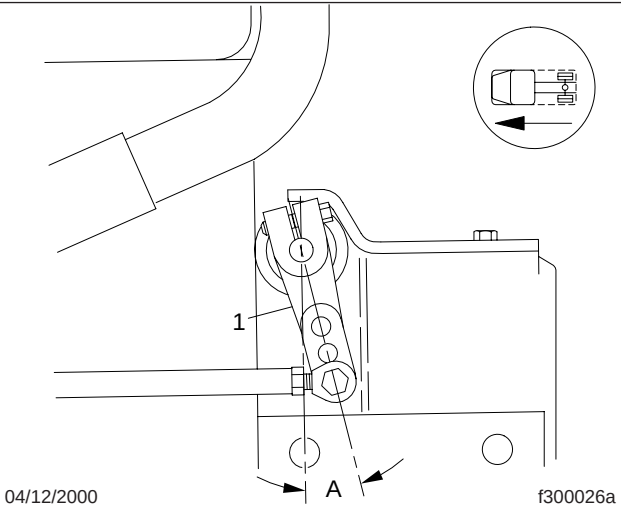
1. Throttle Pedal
2. Cab Deck
3. Throttle Guide Tube
4. Vertical Throttle Rod
5. Kep Nut
6. Horizontal Throttle Rod
7. Bellcrank

Fig. 1, Check the Bellcrank

   7.3 Hold the bellcrank so that the shorter arm is at a 30 degree angle above horizontal.

   7.4 With the governor arm at idle, turn the rod until the spherical bearing bore is aligned with the hole nearest the end of the longer bellcrank arm. See **Fig. 1**.

Throttle Linkage Length Adjustment



A. 13 degrees

1. Left-Side Cross-Shaft Arm

Fig. 2, Check the Angle of the Cross-Shaft Arm

WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod must remain engaged in the rod end. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.

7.5 At least 5/16 inch (8 mm) of thread on the rod must remain engaged in the rod end. If more adjustment is needed than can be made at the bellcrank end of the rod, turn the rod as needed, to change the thread engagement of the rod end at the cross-shaft arm.

7.6 Install a flat washer on the 5/16–24 capscrew, then insert the capscrew into the bore of the rod end. From the outside, insert the capscrew into the hole nearest the end of the longer bellcrank arm. See **Fig. 1**. Install and tighten the locknut 15 lbf·ft (20 N·m).

7.7 Hold the throttle rod and turn each of the rod ends so that the flat faces of both ends are parallel. Hold the rod in this position while tightening the rod-end jam nuts 15 lbf·ft (20 N·m).

8. Adjust the length of the vertical throttle rod as follows:

8.1 Loosen the Kep nut at the bottom of the vertical throttle rod. See **Fig. 3**.

8.2 Turn the vertical throttle rod until the throttle pedal is at an angle of approximately 50 degrees to the cab deck.

WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod must remain engaged in the rod end. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.

8.3 At least 5/16 inch (8 mm) of thread on the rod must remain engaged in the rod end. If more adjustment is needed than can be made between the vertical throttle rod and the spherical bearing rod end, tighten the Kep nut at the bottom of the vertical throttle rod. Then, loosen the jam nut at the top of the throttle guide tube and turn the guide tube as needed.

8.4 Tighten the jam nut 15 lbf·ft (20 N·m). Tighten the Kep nut 84 lbf·in (940 N·cm).

9. Return the cab to the operating position. For instructions, see **Section 60.04**, Section 060, in this manual.

10. Adjust the pedal stop. For instructions, see **Subject 120**.

11. Install the radiator grille.

12. Remove the chocks from the tires.

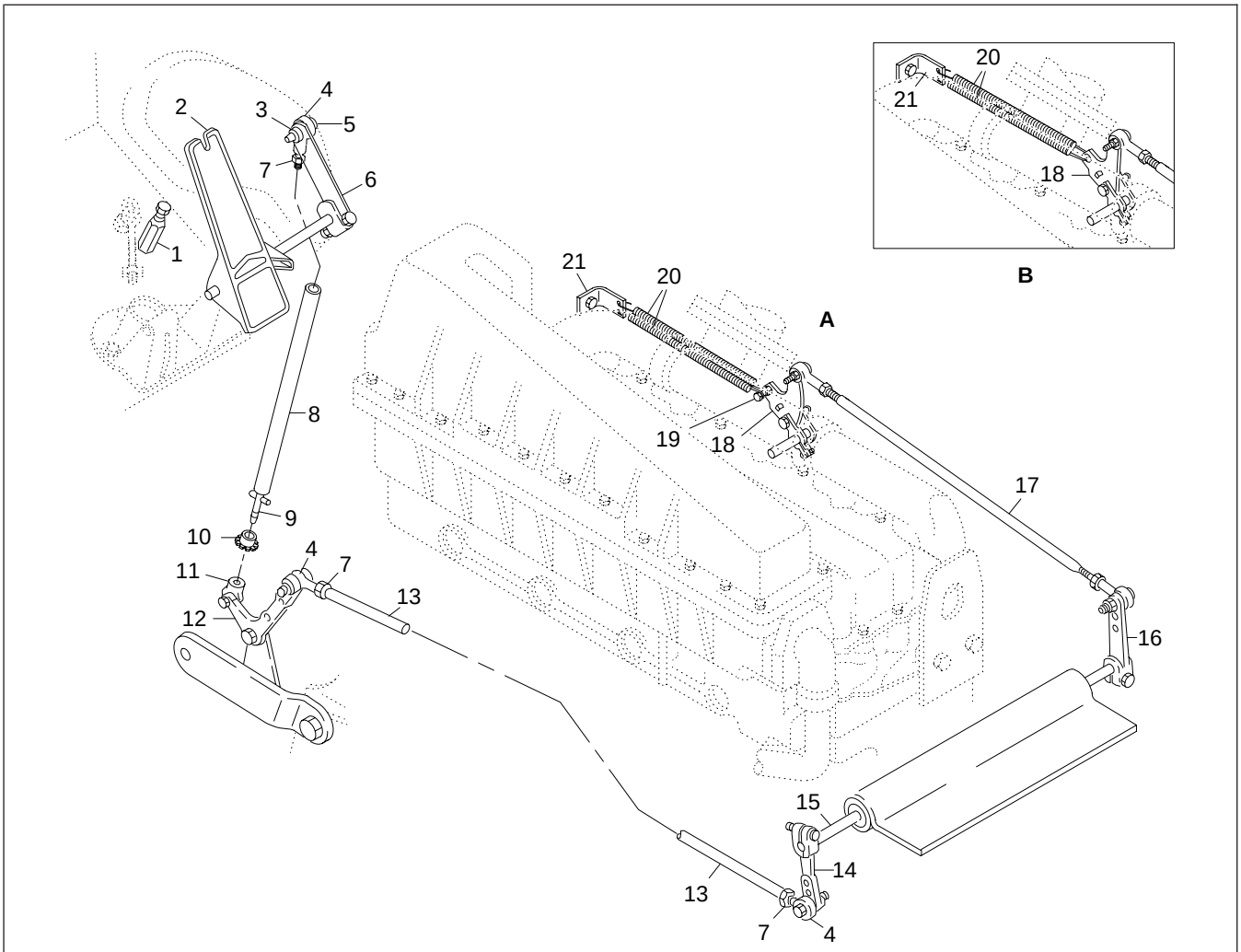
13. Test drive the vehicle and ensure that the throttle system operates properly.

CATERPILLAR 3406

1. Shut down the engine, set the parking brake, and chock the tires.

2. With the cab in the operating position, remove the radiator grille.

Throttle Linkage Length Adjustment



A. Return spring installation with capscrew
B. Return spring installation without capscrews

1. Pedal Stop
2. Throttle Pedal
3. Self-Locking Nut
4. Externally Threaded Spherical Bearing Rod End
5. Hexhead Bolt
6. Pedal Throttle Arm
7. 5/16–24 Jam Nut
8. Throttle Guide Tube
9. Vertical Throttle Rod
10. Kep Nut
11. Internally Threaded Spherical Bearing Rod End
12. Bellcrank
13. Left Horizontal Throttle Rod
14. Left Cross-Shaft Arm
15. Cross-Shaft Assembly
16. Right Cross-Shaft Arm
17. Right Horizontal Throttle Rod
18. Governor Arm
19. 1/4–20 Capscrew
20. Return Springs
21. Return-Spring Bracket

Fig. 3, Throttle Linkage (3306)

3. When the governor arm is at idle, check the angle of the bellcrank. The shorter arm of the bellcrank must be at an angle of approximately 30 degrees above horizontal. See **Fig. 1**.
4. If the bellcrank is positioned correctly, proceed to the step for returning the cab to the operating position.

Throttle Linkage Length Adjustment

If the bellcrank is not positioned correctly, adjust the length of the horizontal throttle rod as follows:

4.1 Tilt the cab. For instructions, see **Section 60.04**, Subject 060, in this manual.

4.2 Loosen the jam nuts (**Fig. 4**) at each end of the throttle rod.

4.3 Remove the locknut, flat washer, and capscrew that attach the spherical bearing rod end to the long arm of the bellcrank.

4.4 Hold the bellcrank so that the shorter arm is at an angle of 30 degrees above horizontal.

4.5 With the governor arm at idle, turn the rod end until the spherical bearing bore is aligned with the hole nearest the end of the longer bellcrank arm.

WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod must remain engaged in the rod end. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.

4.6 At least 5/16 inch (8 mm) of thread on the rod must remain engaged in the rod end. If more adjustment is needed than can be made at the bellcrank end of the rod, turn the rod as needed to change the thread engagement of the rod end at the governor arm.

4.7 Install a flat washer on the attaching capscrew, then insert the capscrew into the bore of the rod end. From the outside, insert the capscrew into the hole nearest the end of the longer bellcrank arm. Install and tighten the locknut 15 lbf·ft (20 N·m).

4.8 Hold the throttle rod and turn each of the rod ends so that the flat faces of both ends are parallel. Hold the rod in this position while tightening the rod-end jam nuts 15 lbf·ft (20 N·m).

5. Adjust the length of the vertical throttle rod as follows:

5.1 Loosen the Kep nut at the bottom of the vertical throttle rod. See **Fig. 4**.

5.2 Turn the vertical throttle rod until the throttle pedal is at an angle of approximately 50 degrees to the cab deck.

WARNING

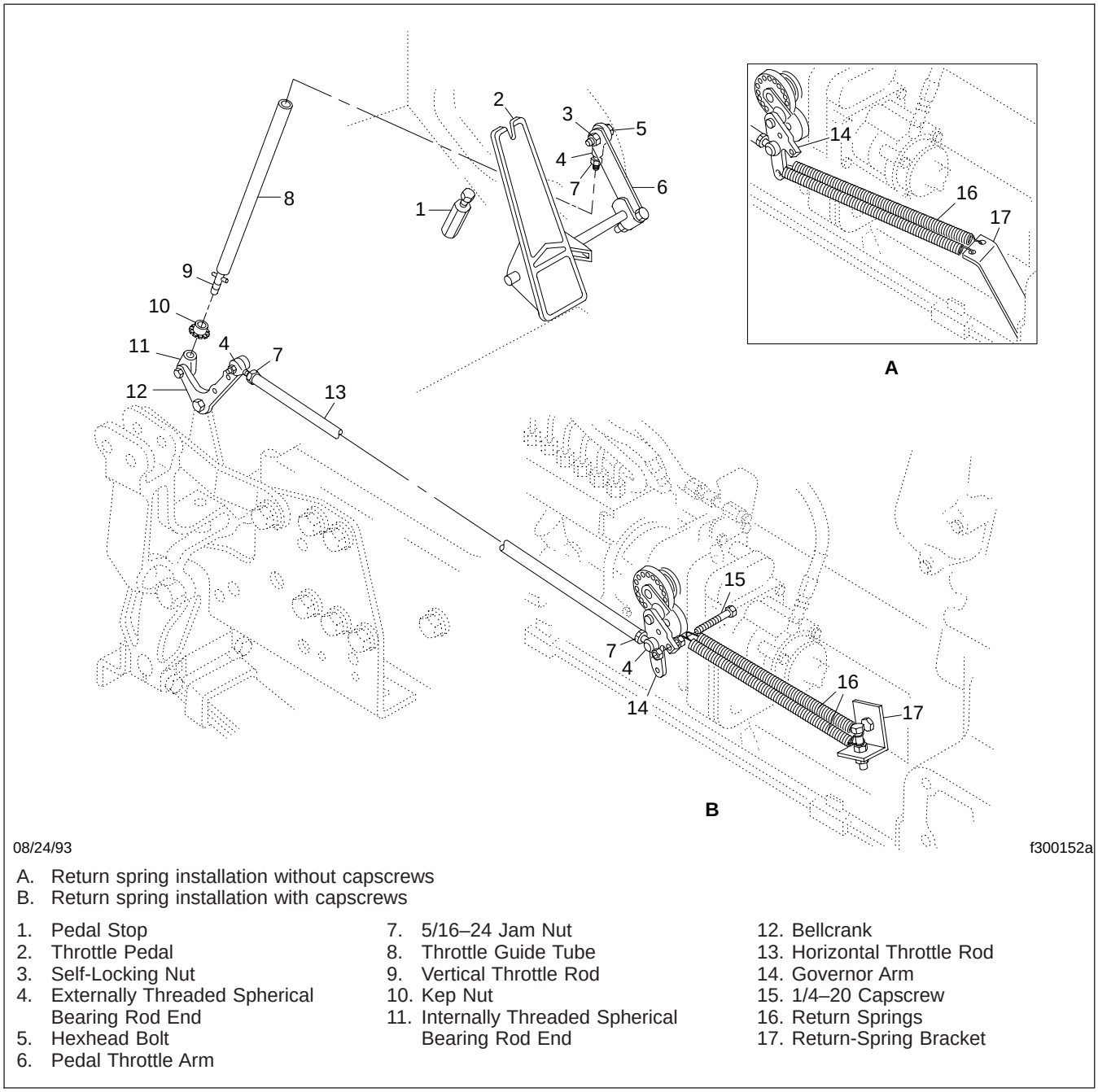
When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod must remain engaged in the rod end. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.

5.3 At least 5/16 inch (8 mm) of thread on the rod must remain engaged in the rod end. If more adjustment is needed than can be made between the vertical throttle rod and the spherical bearing rod end, tighten the Kep nut at the bottom of the throttle rod. Loosen the jam nut at the top of the throttle guide tube and turn the guide tube as needed.

5.4 Tighten the jam nut 15 lbf·ft (20 N·m). Tighten the Kep nut 84 lbf·in (940 N·cm).

6. Return the cab to the operating position. For instructions, see **Section 60.04**, Subject 060, in this manual.
7. Adjust the pedal stop. For instructions, see **Subject 120**.
8. Install the radiator grille.
9. Remove the chocks from the tires.
10. Test drive the vehicle and ensure that the throttle system operates properly.

Throttle Linkage Length Adjustment



A. Return spring installation without capscrews
B. Return spring installation with capscrews

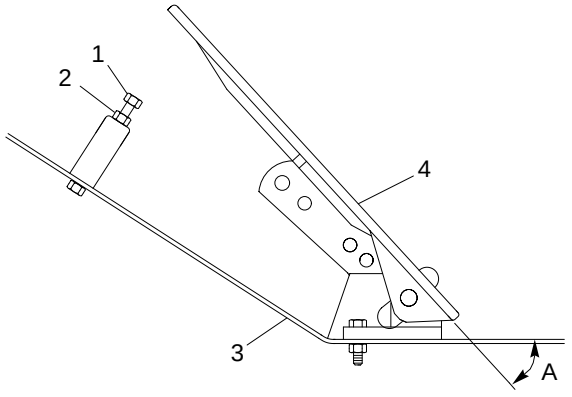
1. Pedal Stop
2. Throttle Pedal
3. Self-Locking Nut
4. Externally Threaded Spherical Bearing Rod End
5. Hexhead Bolt
6. Pedal Throttle Arm
7. 5/16–24 Jam Nut
8. Throttle Guide Tube
9. Vertical Throttle Rod
10. Kep Nut
11. Internally Threaded Spherical Bearing Rod End
12. Bellcrank
13. Horizontal Throttle Rod
14. Governor Arm
15. 1/4–20 Capscrew
16. Return Springs
17. Return-Spring Bracket

Fig. 4, Throttle Linkage (3406)

Pedal Stop Adjustment

NOTE: If the throttle linkage is not new, perform the checks under **Subject 100** before adjusting the pedal stop.

1. Shut down the engine, set the parking brake, and chock the tires.
2. Tilt the cab. For instructions, see **Section 60.04**, Subject 060, in this manual.
3. Loosen the pedal stop jam nut, and turn the capscrew in until no threads are showing above or below the jam nut. See **Fig. 1**. This allows maximum pedal travel.



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A. 50 degrees

1. Pedal Stop Capscrew
2. Jam Nut
3. Cab Deck
4. Throttle Pedal

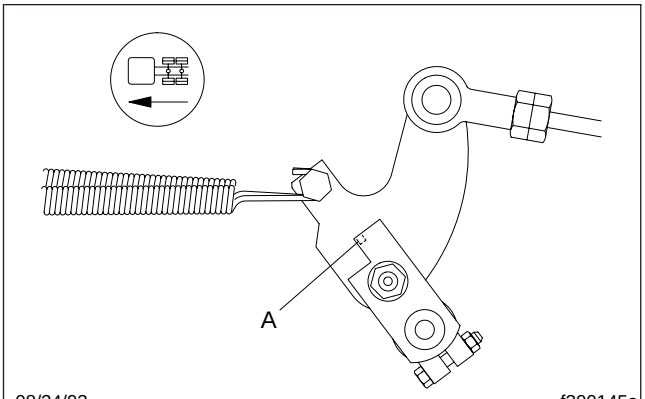
Fig. 1, Pedal Stop Installation

4. Block the governor arm in the middle of its breakover range.

NOTE: When the middle of the breakover range is reached, a tang on the governor arm will move to the center of an opening in the governor arm. See **Fig. 2** and **Fig. 3**. On Caterpillar 3306 engines, you can see the governor arm by looking between the bottom of the cab deck, and the top of the frame rail above the right front tire.

On Caterpillar 3406 engines, you cannot see the governor arm when the cab is in the operating position. To check that the governor arm has reached the approximate middle of the breakover range, operate the throttle pedal near the lower end of its travel. With your hand, you should be able to feel the increased resistance that occurs when the governor shaft stops rotating and the breakover spring allows the governor arm to move into the breakover range.

5. Position the head of the pedal stop capscrew 1/16 to 1/8 inch (1.5 to 3 mm) from the bottom of the pedal, and tighten the jam nut against the cab deck. See **Fig. 1**.



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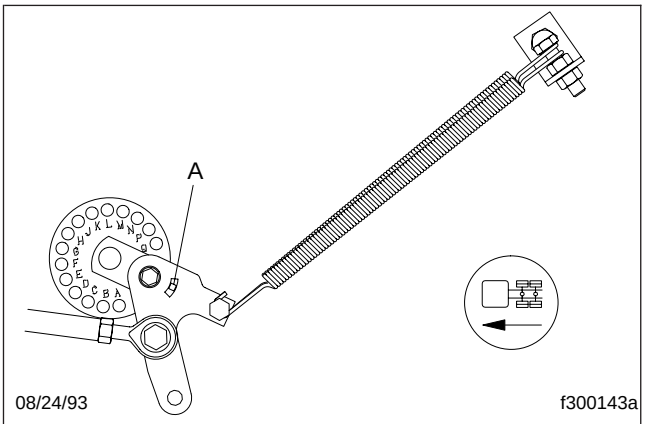
A. The tang must be in the approximate center of the opening

Fig. 2, Governor Arm in the Breakover Range (3306)



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A. The tang must be in the approximate center of the opening

Fig. 3, Governor Arm in the Breakover Range (3406)

Pedal Stop Adjustment

6. Remove the block from the governor arm. Operate the pedal, and check the adjustment. Readjust if necessary.
7. Return the cab to the operating position. For instructions, see **Section 60.04**, Subject 060, in this manual.
8. Remove the chocks from the tires.
9. Test drive the vehicle and ensure that the throttle system operates properly.

Throttle Control Installation

Use the following procedure if the throttle control is being replaced, removed and reinstalled, or if a new or rebuilt engine is being installed.

CATERPILLAR 3306

1. Shut down the engine, set the parking brake, and chock the tires.
2. Remove the radiator grille.
3. Tilt the cab. For instructions, see **Section 60.04**, Subject 060, in this manual.
4. Install the spring bracket (if not already installed). Remove the washer and capscrew from the front housing, and use the capscrew to attach the bracket to the front housing. Discard the washer.
5. Install the return springs as follows:

   5.1 If used springs are being installed, inspect them, especially in the area of the anchor loops, for wear, nicks, or other damage that may cause breakage. Install new springs if the used springs are worn or damaged.

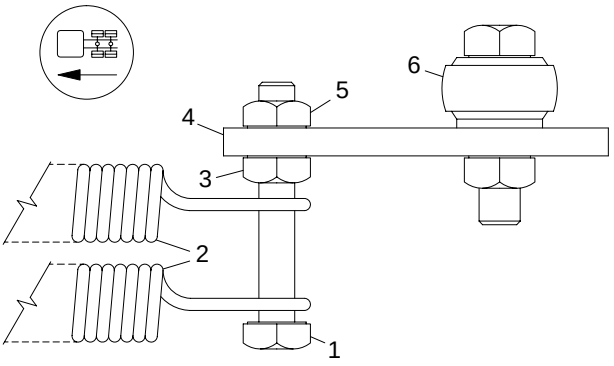
   5.2 Hook one end of each spring around the capscrew in the return spring bracket or into a hole in the bracket.

   NOTE: As a product improvement for longer service life, install a capscrew in the governor arm to hook the return spring anchor loops around.

   5.3 Using a 1/4–20 nut and a 1/4–20 locknut, install a 1/4–20 capscrew through the inboard side of the aft hole of the governor arm. See **Fig. 1**.

   5.4 Using a hook (do not use sharply serrated pliers) place the opposite anchor loop of each spring around the capscrew in the governor arm. Don't stretch the springs any further than necessary.
6. With the governor arm at idle, check the angle of the left cross-shaft arm. The left arm must be pointing downward at an angle of approximately 13 degrees aft of vertical. See **Fig. 2**.

   If not, loosen the pinch-bolt nut, then spread the slotted end of the arm with a screwdriver, while pulling outward on the arm, to remove it. Install the arm at the correct angle, as shown in **Fig. 2**. Tighten the pinch-bolt nut.



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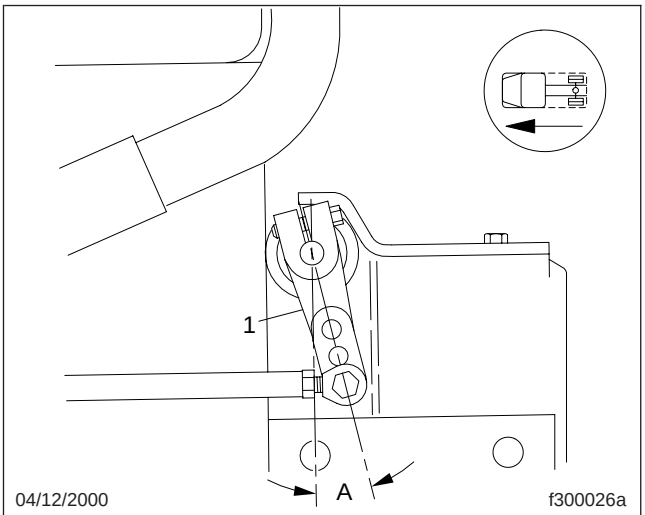
1. 1/4–20 x 1-1/4 inch Capscrew
2. Throttle Return Springs
3. 1/4–20 Nut
4. Governor Arm
5. 1/4–20 Locknut
6. Spherical Bearing Rod End

Fig. 1, Return Spring Capscrew Installation



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A. 13 degrees

1. Left-Side Cross-Shaft Arm

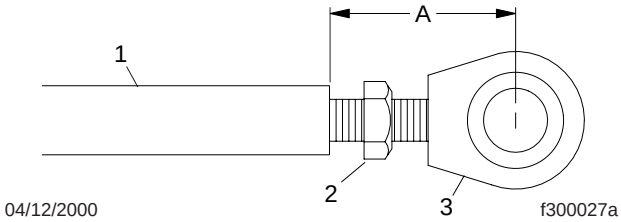
Fig. 2, Check the Angle of the Cross-Shaft Arm

IMPORTANT: Do not change the length of the right throttle rod, and do not reposition the governor arm or right cross-shaft arm.

Throttle Control Installation

7. Install the jam nuts on the externally threaded spherical bearing rod ends, as far as they will go. Install a rod end on each end of the horizontal throttle rod. Turn the rod ends into the throttle rods until the distance from the center of each spherical bearing bore to its end of the rod is 1-3/16 inches (30 mm). See **Fig. 3**.

   On the vertical throttle rod, install a jam nut and rod end on the upper end. See **Fig. 4**.



A. 1-3/16 inches (30 mm)

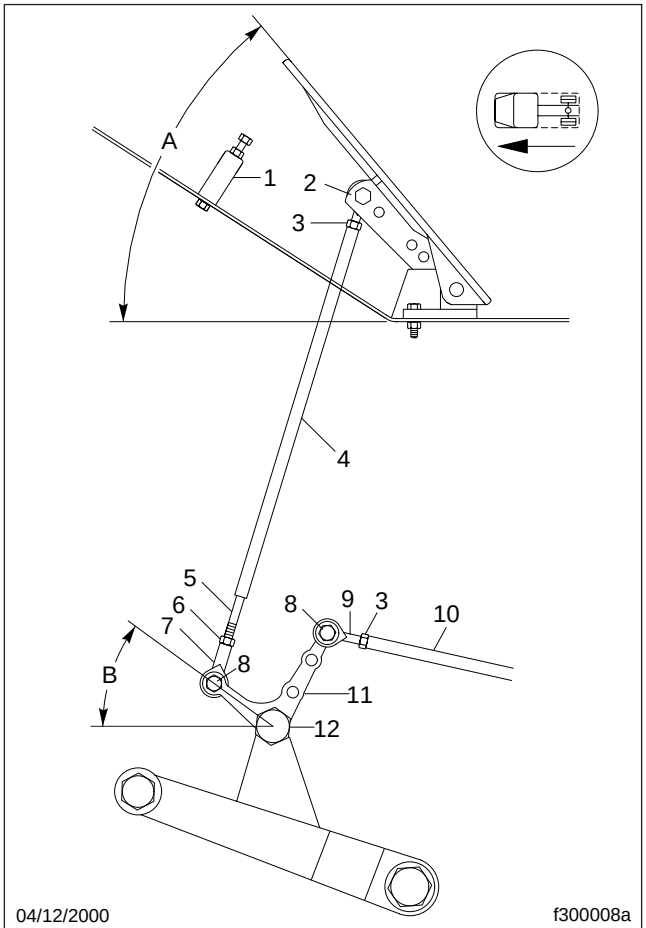
1. Throttle Rod
2. Jam Nut
3. Spherical Bearing Rod End

Fig. 3, Rod End Installation

8. Install a flat washer on a 5/16–24 capscrew. From the outboard-side of the left cross-shaft arm, insert the capscrew into the bore of the rod end; then insert the capscrew through the bottom hole of the cross-shaft arm. Install and tighten the locknut 15 lbf·ft (20 N·m).
9. Install the horizontal throttle rod on the bellcrank.
   - 9.1 Hold the bellcrank so that the shorter arm is at an approximately 30 degree angle above horizontal.
   - 9.2 Turn the rod end until the spherical bearing bore is aligned with the hole nearest the end of the longer bellcrank arm. See **Fig. 4**.

⚠ WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod must remain engaged in the rod end. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.



A. 50 degrees
B. 30 degrees

1. Pedal Stop Assembly
2. Pedal Throttle Arm
3. 5/16–24 Jam Nut
4. Throttle Guide Tube
5. Vertical Throttle Rod
6. Kep Nut
7. Internally Threaded Spherical Bearing Rod End
8. Capscrew, Flat Washer, and Locknut
9. Externally Threaded Spherical Bearing Rod End
10. Horizontal Throttle Rod and Locknut
11. Bellcrank
12. Shoulder Bolt

Fig. 4, Vertical Throttle Rod Installation

   - 9.3 At least 5/16 inch (8 mm) of thread on the rod must remain engaged in the rod end. If more adjustment is needed than can be made at the bellcrank end of the rod, turn the rod as needed to change the thread engagement at the cross-shaft end.

9.4 Install a flat washer on a 5/16–24 capscrew, then insert the capscrew into the bore of the rod end. From the outside, insert the capscrew into the hole nearest the end of the longer bellcrank arm. Install and tighten the locknut 15 lbf·ft (20 N·m).

9.5 Hold the throttle rod and turn each of the rod ends so that the flat faces of both ends are parallel. Hold the rod in this position while tightening the rod-end jam nuts 15 lbf·ft (20 N·m).

10. Install the vertical throttle rod.

10.1 Insert the top of the vertical throttle rod into the bottom of the throttle guide tube. Slide the guide tube onto the vertical throttle rod.

10.2 Install a flat washer on a 1/4–20 capscrew. From the inboard-side of the shorter bellcrank arm, insert the capscrew into the bore of the rod end and through the bellcrank. Install and tighten the locknut 15 lbf·ft (20 N·m).

10.3 Insert a 5/16–24 capscrew through the throttle pedal arm, from the floorboard side. Insert the capscrew into the bore of the rod end. Install a locknut and tighten it 15 lbf·ft (20 N·m).

10.4 Return the cab to the operating position. For instructions, see **Section 60.04**, Subject 060, in this manual.

10.5 Loosen the Kep nut at the bottom of the vertical throttle rod. See **Fig. 4**.

10.6 Turn the vertical throttle rod until the throttle pedal is at an angle of approximately 50 degrees to the cab deck.

⚠ WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod must remain engaged in the rod end. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.

10.7 At least 5/16 inch (8 mm) of thread on the rod must remain engaged in the rod end.

If more adjustment is needed than can be made between the vertical throttle rod and the spherical bearing rod end, tighten the Kep nut at the bottom of the vertical throttle rod. Loosen the jam nut at the top of the throttle guide tube, and turn the throttle guide tube as needed.

10.8 Tighten the jam nut 15 lbf·ft (20 N·m). Tighten the Kep nut 84 lbf·in (940 N·cm).

11. Adjust the pedal stop. For instructions, see **Subject 120**.

12. Install the radiator grille.

13. Remove the chocks from the tires.

14. Test drive the vehicle and ensure that the throttle system operates properly.

CATERPILLAR 3406

1. Shut down the engine, set the parking brake, and chock the tires.

2. Remove the radiator grille.

3. Tilt the cab. For instructions, see **Section 60.04**, Subject 060, in this manual.

4. Install the spring bracket (if not already installed). Remove the upper capscrew that attaches the fuel injection pump housing to the drive housing, and use the bolt to attach the bracket to the pump housing.

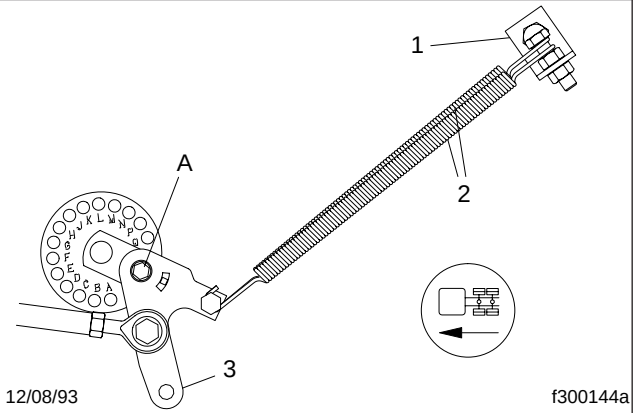
NOTE: As a product improvement for longer service life, if the return spring anchor loops hook through a hole in the return spring bracket, replace the bracket with the current model bracket. Current brackets hold a capscrew, and the spring anchor loops hook around the capscrew. For the current return spring bracket part number for your vehicle, contact a Freightliner dealer.

5. Check the position of the governor arm in the governor disc. The governor arm must be attached at the hole marked "S" in the disc. See **Fig. 5**. If necessary, reposition the arm.

5.1 Loosen the capscrew that attaches the arm to the disc.

5.2 Rotate the arm to the position where the hole in the arm is aligned with the hole that is marked "S" in the disc.

Throttle Control Installation

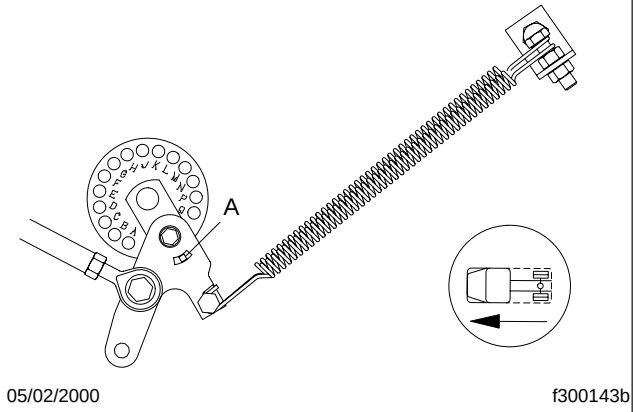


A. Attach the governor arm to the governor disc at hole "S"

1. Return Spring Bracket
2. Throttle Return Springs
3. Governor Arm

Fig. 5, Throttle-Return Springs at Idle Position (3406)

5.3 Tighten the capscrew, then push the long part of the governor arm into the breakover range. The breakover range is reached when the tang on one part of the arm is centered in the opening in the other part of the arm. See **Fig. 6**.



A. The tang must be in the approximate center of the opening

Fig. 6, Governor Arm in the Breakover Range (3406)

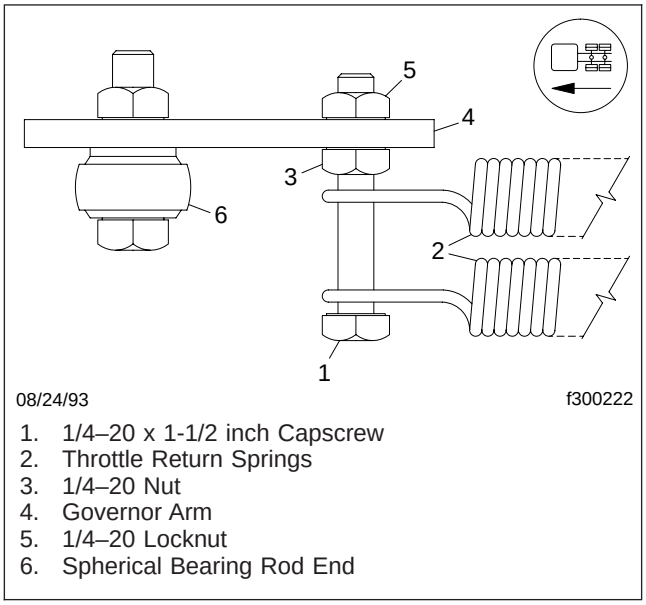
6. Install the return springs.

6.1 If used springs are being installed, inspect them, especially in the area of the anchor loops, for wear, nicks, or other damage that may cause breakage. Install new springs if the used springs are worn or damaged.

NOTE: As a product improvement for longer service life, install a capscrew in the governor arm to hook the return spring anchor loops around.

6.2 Hook one end of each spring around the capscrew in the return-spring bracket.

6.3 Using a 1/4–20 nut and a 1/4–20 locknut, install a 1/4–20 capscrew in the aft hole of the governor arm. See **Fig. 7**.



1. 1/4–20 x 1-1/2 inch Capscrew
2. Throttle Return Springs
3. 1/4–20 Nut
4. Governor Arm
5. 1/4–20 Locknut
6. Spherical Bearing Rod End

Fig. 7, Return Spring Capscrew Installation

6.4 Using a hook (do not use sharply serrated pliers) Place the opposite anchor loop of each spring around the capscrew in the governor arm. Don't stretch the springs any further than necessary.

7. Install the jam nuts on the externally threaded spherical bearing rod ends, as far as they will go. Install a rod end on each end of the horizontal throttle rod. Turn the rod ends into the throttle rods until the distance from the center of each spherical bearing bore to its end of the rod is 1-3/16 inches (30 mm). See **Fig. 3**.

On the vertical throttle rod, install a jam nut and rod end on the upper end.

8. Install a flat washer on a 5/16–24 capscrew. From the outboard-side of the governor arm, insert the bolt into the bore of the rod end; then insert the bolt through the hole nearest the pivot. Install and tighten the locknut 15 lbf·ft (20 N·m).
9. Install the horizontal throttle rod on the bellcrank.
   - 9.1 Hold the bellcrank so that the shorter arm is at a 30 degree angle above horizontal.
   - 9.2 Turn the rod end until the spherical bearing bore is aligned with the hole nearest the end of the longer bellcrank arm. See **Fig. 4**.

⚠ WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod must remain engaged in the rod end. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.

   - 9.3 At least 5/16 inch (8 mm) of thread on the rod must remain engaged in the rod end. If more adjustment is needed than can be made at the bellcrank end of the rod, turn the rod as needed to change the thread engagement at the governor-arm end.
   - 9.4 Install a flat washer on the 5/16–24 capscrew, then insert the capscrew into the bore of the rod end. From the outside, insert the capscrew into the hole nearest the end of the longer bellcrank arm. Install and tighten the locknut 15 lbf·ft (20 N·m).
   - 9.5 Hold the throttle rod and turn each of the rod ends so that the flat faces of both ends are parallel. Hold the rod in this position while tightening the rod-end jam nuts 15 lbf·ft (20 N·m).
10. Install the vertical throttle rod.
   - 10.1 Insert the top of the vertical throttle rod into the bottom of the throttle guide tube. Slide the guide tube onto the vertical throttle rod.
   - 10.2 Install a flat washer on a 1/4–20 capscrew. From the inboard-side of the shorter bellcrank arm, insert the capscrew into the bore of the rod end and through the bellcrank. Install and tighten the locknut 15 lbf·ft (20 N·m).
   - 10.3 Insert a 5/16–24 capscrew through the throttle pedal arm, from the floor-board side. Insert the capscrew into the bore of the rod end. Install a locknut and tighten it 15 lbf·ft (20 N·m).
   - 10.4 Return the cab to the operating position. For instructions, see **Section 60.04**, Subject 060, in this manual.
   - 10.5 Loosen the Kep nut at the bottom of the vertical throttle rod. See **Fig. 4**.
   - 10.6 Turn the vertical throttle rod until the throttle pedal is at an angle of approximately 50 degrees to the cab deck.

⚠ WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod must remain engaged in the rod end. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.

   - 10.7 At least 5/16 inch (8 mm) of thread on the rod must remain engaged in the rod end. If more adjustment is needed than can be made between the vertical throttle rod and the spherical bearing rod end, tighten the Kep nut at the bottom of the vertical throttle rod. Loosen the jam nut at the top of the throttle guide tube, and turn the guide tube as needed.
   - 10.8 Tighten the jam nut 15 lbf·ft (20 N·m). Tighten the Kep nut 84 lbf·in (940 N·m).
11. Adjust the pedal stop. For instructions, see **Subject 120**.
12. Install the radiator grille.
13. Remove the chocks from the tires.
14. Test drive the vehicle and ensure that the throttle system operates properly.

Troubleshooting Tables

Problem—Throttle Pedal Angle Is Too High at Idle

Problem—Throttle Pedal Angle Is Too High at Idle	
Possible Cause	**Remedy**
The throttle rod is too short.	Adjust the length of the throttle rod, then adjust the pedal stop.

Problem—Throttle Pedal Angle Is Too Low at Idle

Problem—Throttle Pedal Angle Is Too Low at Idle	
Possible Cause	**Remedy**
The throttle rod is too long.	Adjust the length of the throttle rod, then adjust the pedal stop.

Problem—Excessive Play in the Throttle Pedal

Problem—Excessive Play in the Throttle Pedal	
Possible Cause	**Remedy**
The throttle linkage attachment capscrews are not tight.	Tighten the throttle linkage attachment capscrews.

Problem—Engine Does Not Reach Maximum Horsepower

Problem—Engine Does Not Reach Maximum Horsepower	
Possible Cause	**Remedy**
One of the throttle linkage attachment capscrews is loose.	Tighten the throttle linkage attachment capscrews.
Interference with the throttle linkage is preventing the governor arm from reaching the breakover range.	Engine parts are interfering with full travel of the throttle linkage. Reposition the parts, or the horizontal throttle linkage.
At idle, the throttle pedal angle is too low.	Adjust the length of the throttle linkage, then adjust the pedal stop.
The pedal stop is set too high.	Adjust the position of the pedal stop if it is not allowing full travel of the governor arm (into the breakover range).
The throttle linkage is attached to the wrong hole in the cross-shaft arm.	Attach the throttle linkage to the correct hole of the left cross-shaft arm.

Problem—Engine Does Not Return to Idle RPM When the Throttle Pedal Is Released

Problem—Engine Does Not Return to Idle RPM When the Throttle Pedal Is Released	
Possible Cause	**Remedy**
Interference with the throttle linkage is preventing the governor arm from returning to idle.	Engine parts are interfering with full travel of the throttle linkage. Reposition the parts, or the horizontal throttle linkage.
The return springs are too long (stretched).	Remove the return springs and check them for stretching. If the springs are stretched, install new ones.
The return springs are broken.	Install new return springs.

Troubleshooting

Problem—Engine Does Not Return to Idle RPM When the Throttle Pedal Is Released	
Possible Cause	**Remedy**
The governor arm is attached to the wrong governor disc hole (3406 engines).	Attach the governor arm to hole "S" on the governor disc.

Problem—Excessive Resistance at the Throttle Pedal

Problem—Excessive Resistance at the Throttle Pedal	
Possible Cause	**Remedy**
Engine parts are interfering with the throttle linkage.	Reposition the parts.
Engine parts are interfering with the return springs.	Reposition the parts. Check the return springs for damage, and replace them if necessary.

General Information

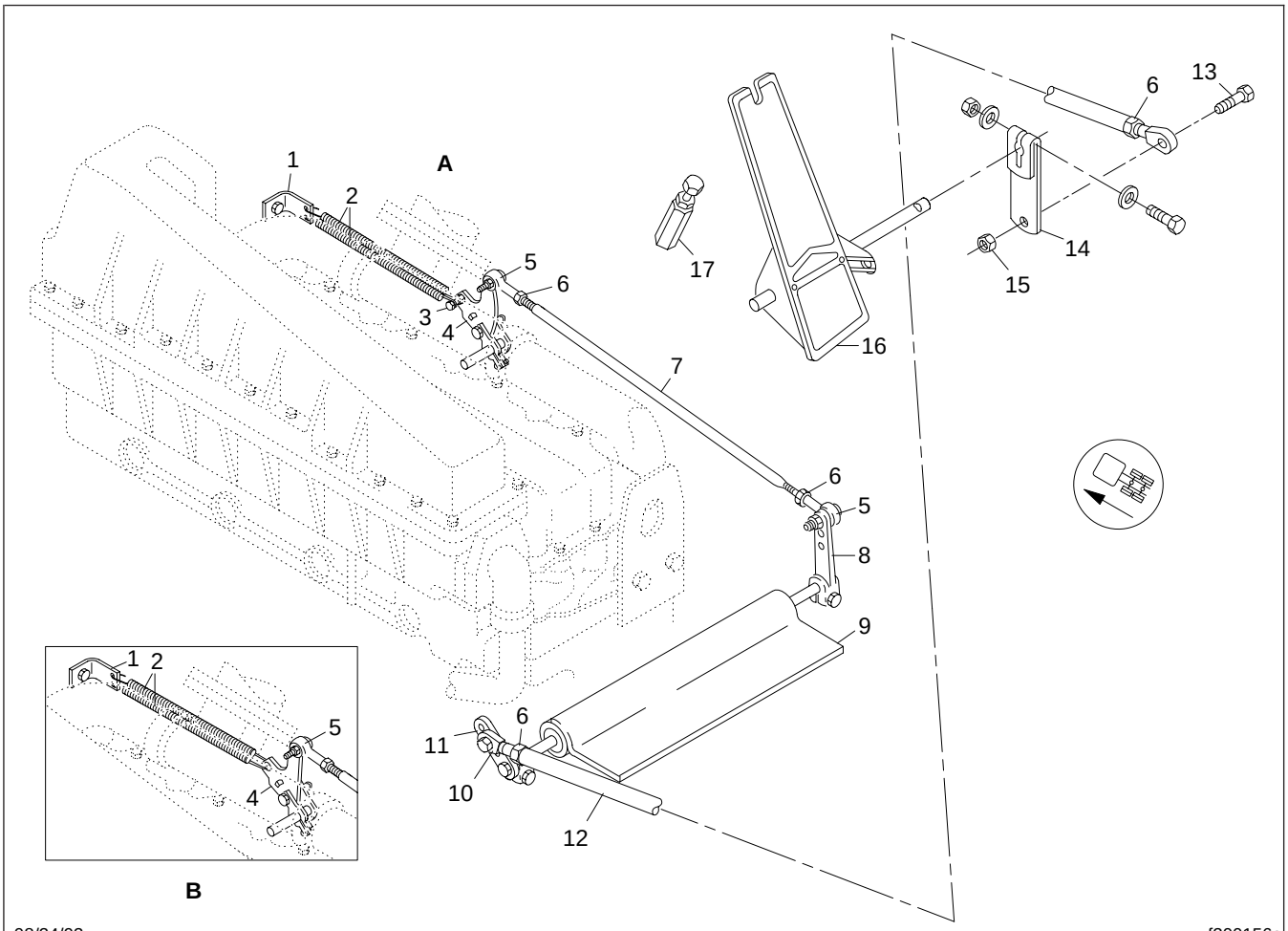
Freightliner throttle controls have a floor-mounted throttle pedal, an adjustable-length throttle rod, dual return springs, and an adjustable pedal stop. See **Fig. 1** and **Fig. 2**. On Caterpillar 3306 engines, the two-piece governor arm, right throttle rod, and cross-shaft assembly are installed by the engine manufacturer. See **Fig. 1**.

During engine operation, movement of the throttle pedal and linkage will change the amount of fuel available to the engine. To ensure that the pedal will be at the correct angle when the engine is at idle rpm, the length of the linkage is adjustable by means of spherical bearing rod ends, with the adjustment secured by jam nuts. See **Fig. 3**. The spherical bearings prevent binding of the linkage.

Dual springs return the throttle control parts to their idle positions when the pedal is released.

When the linkage is properly adjusted, the governor shaft can rotate from idle rpm to maximum horsepower. To ensure that maximum horsepower is always reached, the linkage must be able to move just beyond the position where the governor shaft has stopped rotating, without causing damage to the governor. Caterpillar governor arms consist of two parts held in alignment by a breakover spring. When the part of the governor arm attached to the governor shaft has moved as far as the shaft rotation will allow, the force applied at the pedal overcomes the resistance of the breakover spring. This allows the part of the governor arm attached to the linkage to move into the breakover range. If the governor arm were forced beyond the breakover range, the linkage or governor could be damaged. An adjustable pedal stop prevents movement of the linkage beyond the governor arm's breakover range.

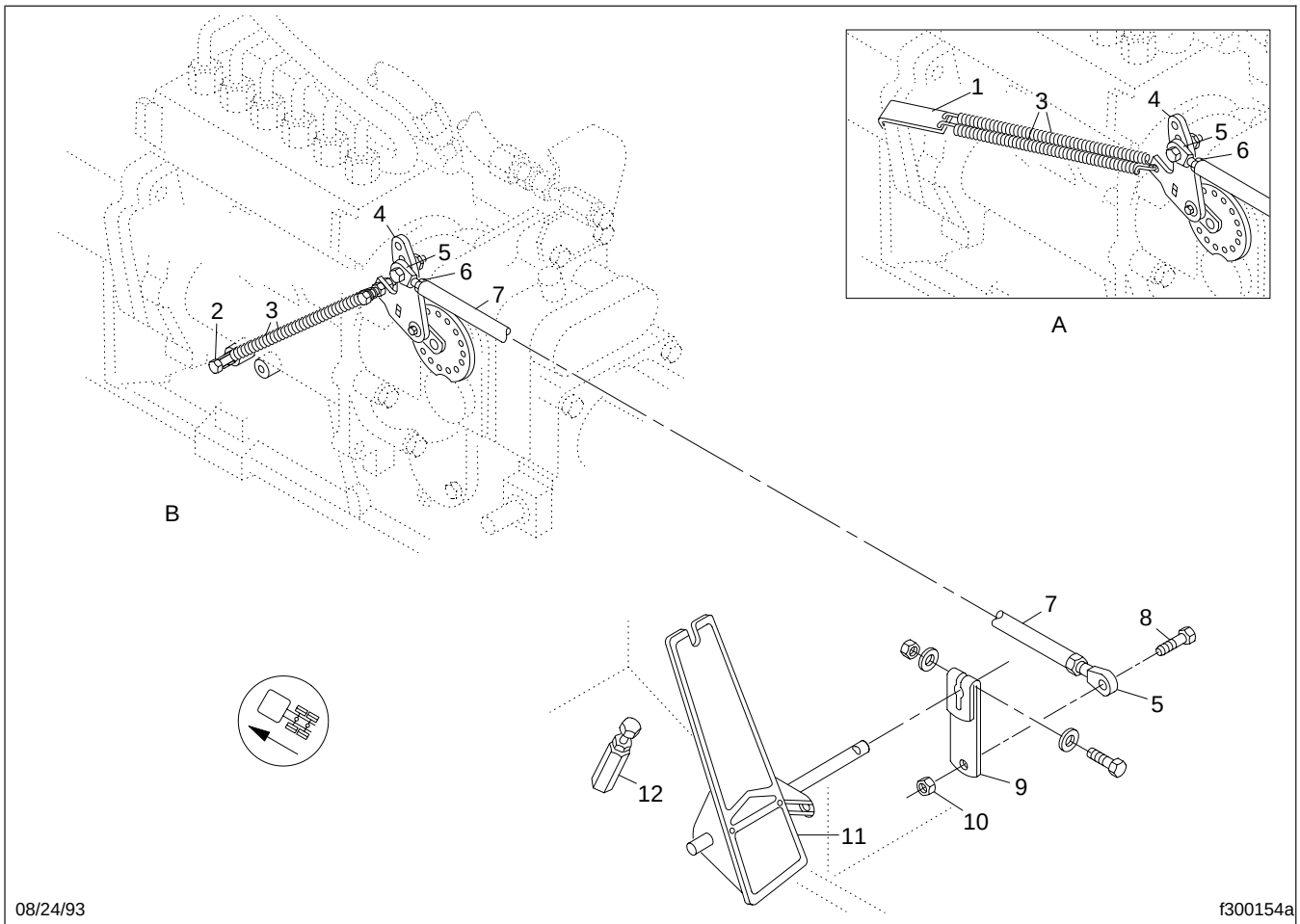
General Information



A. Return spring installation with capscrew
B. Return spring installation without capscrew

1. Return-Spring Bracket
2. Return Springs
3. 1/4–20 Capscrew
4. Governor Arm
5. Internally Threaded Spherical Bearing Rod End
6. 5/16–24 Jam Nut
7. Right Throttle Rod
8. Right Cross-Shaft Arm
9. Cross-Shaft Assembly
10. Externally Threaded Spherical Bearing Rod End
11. Left Cross-Shaft Arm
12. Left Throttle Rod
13. Hexhead Bolt
14. Pedal Throttle Arm
15. Self-Locking Nut
16. Throttle Pedal
17. Throttle Stop

Fig. 1, Throttle Linkage (3306)

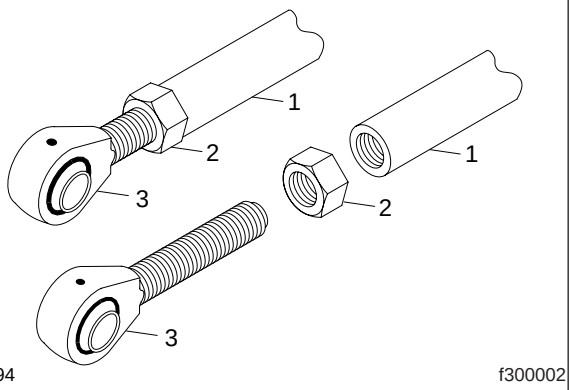


A. Return spring installation without capscrews
B. Return spring installation with capscrews

1. Return-Spring Bracket
2. 5/16–18 Capscrew
3. Return Springs
4. Governor Arm
5. Externally Threaded Spherical Bearing Rod End
6. Jam Nut
7. Throttle Rod
8. Hexhead Bolt
9. Pedal Throttle Arm
10. Prevailing Torque Locknut
11. Throttle Pedal
12. Throttle Stop

Fig. 2, Throttle Linkage (3406)

General Information



1. Internally Threaded Throttle Rod
2. Jam Nut
3. Externally Threaded Spherical Bearing Rod End

Fig. 3, Throttle Rod Parts

Throttle Control Operation Checking

1. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Check the linkage attachment fasteners (capscrews, locknuts, and hexnuts) for tightness; tighten any that are loose. On Caterpillar 3306 engines, also check the cross-shaft attachment fasteners for tightness, and tighten as needed.
4. Operate the linkage by hand, from idle to maximum horsepower, while checking that nothing interferes with its movement. On Caterpillar 3306 engines, be sure that none of the engine parts interfere with rotation of the cross-shaft arms. Reposition any parts that interfere.
5. On Caterpillar 3306 engines, check the left throttle rod for binding, by rotating the rod in and out. With the rod-end jam nuts tight against the rod, both rod ends must be free to swivel on their spherical bearings. If the rod and rod ends do not rotate in and out, back off the lower jam nut (at the cross-shaft end of the rod). Turn the loosened rod end until its flat faces are parallel to the flat faces of the upper rod end. See **Fig. 1**.

   Hold the rod and lower rod end in these positions while tightening the lower jam nut 15 lbf·ft (20 N·m).

   Move the right throttle rod by hand, from idle to maximum horsepower, while checking that nothing interferes with movement of the return springs. Reposition any parts that interfere.
6. On Caterpillar 3406 engines, check the throttle rod for binding by rotating the rod in and out. Loosen the rod-end jam nuts.

   Rotate the throttle rod to a position that will prevent other components from interfering with its movement through full travel.

   Hold the throttle rod in this position, and rotate each of the spherical bearing rod ends in a direction opposite the rotation of the throttle rod. Tighten the jam nuts 15 lbf·ft (20 N·m).
7. Inspect the return springs.

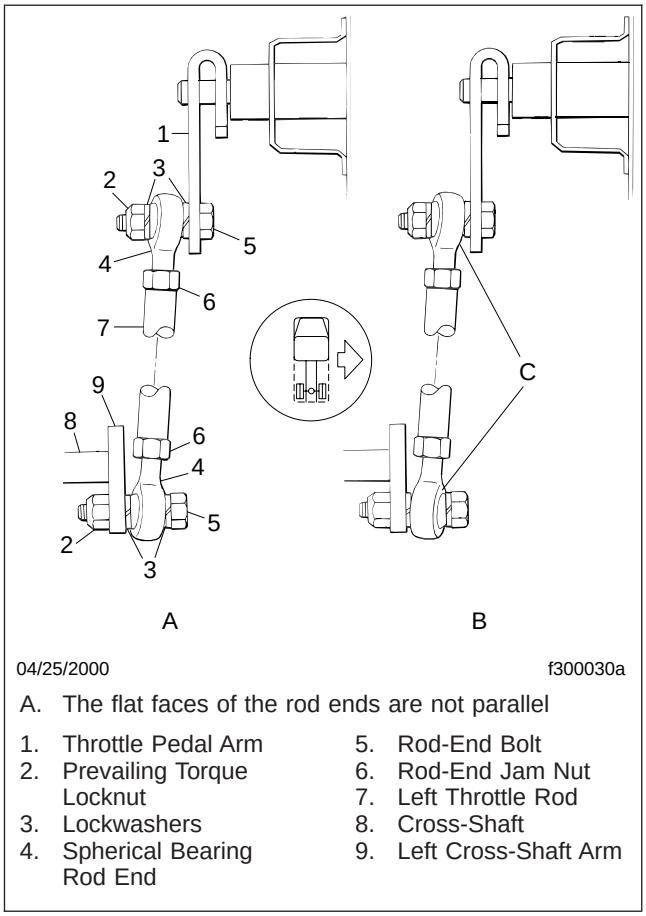
   7.1 Using a hook (do not use sharply serrated pliers), disconnect the anchor loop of each spring from the governor arm. Do not stretch the springs any further than necessary. Disconnect the opposite ends from the spring bracket.

   7.2 Inspect the springs, especially in the area of the anchor loops, for wear, nicks, or other damage that might cause breakage.

   7.3 Measure the springs for stretching. The relaxed spring should be no more than 9-3/8 inches (238 mm) long, from the outside of one anchor loop to the outside of the opposite anchor loop.

   7.4 If the used springs are worn, damaged, or stretched, install new springs.

   7.5 Install the springs by inserting one end of each spring into the holes or around the capscrew in the spring bracket; then,



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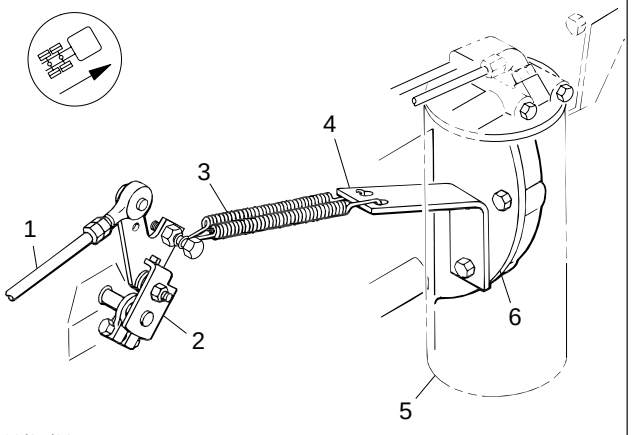
A. The flat faces of the rod ends are not parallel

1. Throttle Pedal Arm
2. Prevailing Torque Locknut
3. Lockwashers
4. Spherical Bearing Rod End
5. Rod-End Bolt
6. Rod-End Jam Nut
7. Left Throttle Rod
8. Cross-Shaft
9. Left Cross-Shaft Arm

Fig. 1, Left Throttle Rod (3306)

Throttle Control Operation Checking

using the hook, install the opposite end around the capscrew or into the forward-most hole in the governor arm. See **Fig. 2** and **Fig. 3**.



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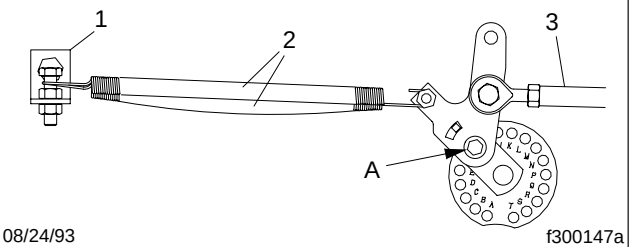
1. Right Throttle Rod
2. Governor Arm
3. Return Springs
4. Spring Bracket
5. Fuel Filter
6. Timing Gear Plate

Fig. 2, Return Spring Installation (3306)



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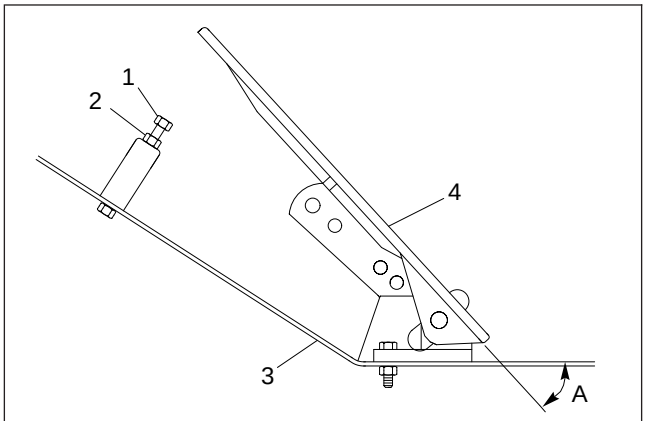
A. Attach the governor arm to the governor disc at hole "G"

1. Return-Spring Bracket
2. Return Springs
3. Throttle Rod

Fig. 3, Return Spring Installation (3406)

8. With the governor arm at idle, check the angle of the throttle pedal. The pedal must be at an angle of approximately 50 degrees to the cab deck. See **Fig. 4**.

If the throttle pedal angle is too high or too low, adjust the length of the throttle linkage. See **Subject 110**.



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A. 50 degrees

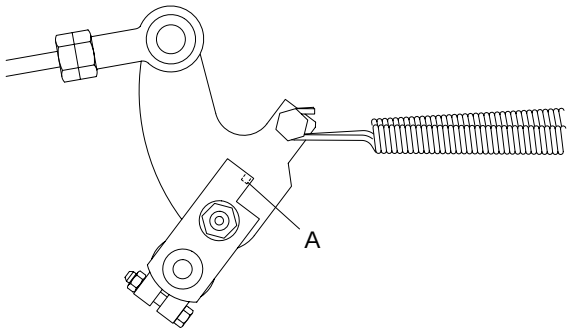
1. Throttle Stop Capscrew
2. Jam Nut
3. Cab Deck
4. Throttle Pedal

Fig. 4, Throttle Pedal at Idle

9. Operate the throttle pedal by hand, from idle through full travel, while checking that the governor arm reaches the approximate middle of the breakover range.

   When the middle of the breakover range is reached, a tang on the governor arm will move to the center of an opening in the governor arm. See **Fig. 5**, or **Fig. 6**.

10. If the governor arm does not reach the approximate middle of the breakover range, adjust the pedal stop. See **Subject 120**.
11. Lower the hood and remove the chocks from the tires.
12. Test drive the vehicle and ensure that the throttle system operates properly.



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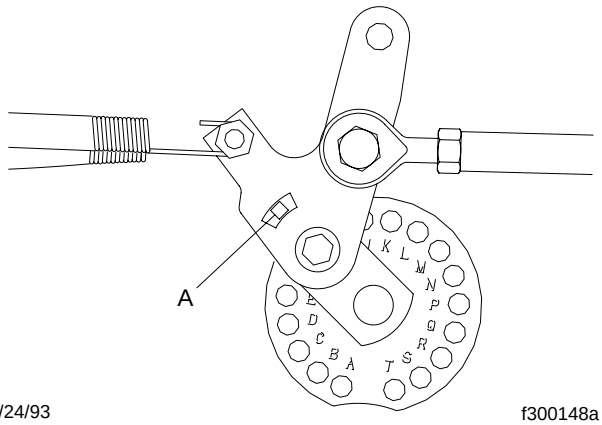
A. The tang must be in the approximate center of the opening

Fig. 5, Governor Arm in the Breakover Range (3306)



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A. The tang must be in the approximate center of the opening

Fig. 6, Governor Arm in the Breakover Range (3406)

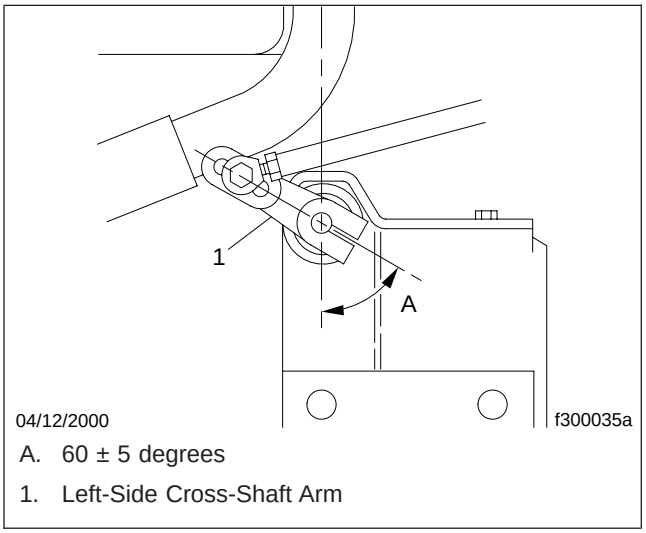
Throttle Linkage Length Adjustment

CATERPILLAR 3306 ENGINES

1. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. When the governor arm is at idle, check the angle of the left cross-shaft arm. The left arm must be pointing upward at an angle of 60 ± 5 degrees forward of vertical. See **Fig. 1**.

   If the left cross-shaft arm is positioned correctly, proceed to the next step.

   If the left arm is not positioned correctly, loosen the pinch-bolt nut. Spread the slotted end of the arm with a screwdriver, while pulling outward on the arm, to remove it. Install the arm at the correct angle, as shown in **Fig. 1**. Tighten the pinch-bolt nut, then proceed to the next step.



A. 60 ± 5 degrees
1. Left-Side Cross-Shaft Arm

Fig. 1, Check the Angle of the Cross-Shaft Arm

IMPORTANT: Do not change the length of the right throttle rod, and do not reposition the governor arm or right cross-shaft arm.

4. Back off the jam nuts at each end of the left throttle rod.
5. Remove the locknut, flat washer, and capscrew that attach the left throttle rod to the cross-shaft arm.
6. Block the throttle pedal at an angle of approximately 50 degrees to the cab deck.
7. With the governor arm at idle, turn the lower rod end, until the spherical bearing bore is aligned with the second hole on the left cross-shaft arm. See **Fig. 1**.

⚠ WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod must remain engaged in the rod end. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.

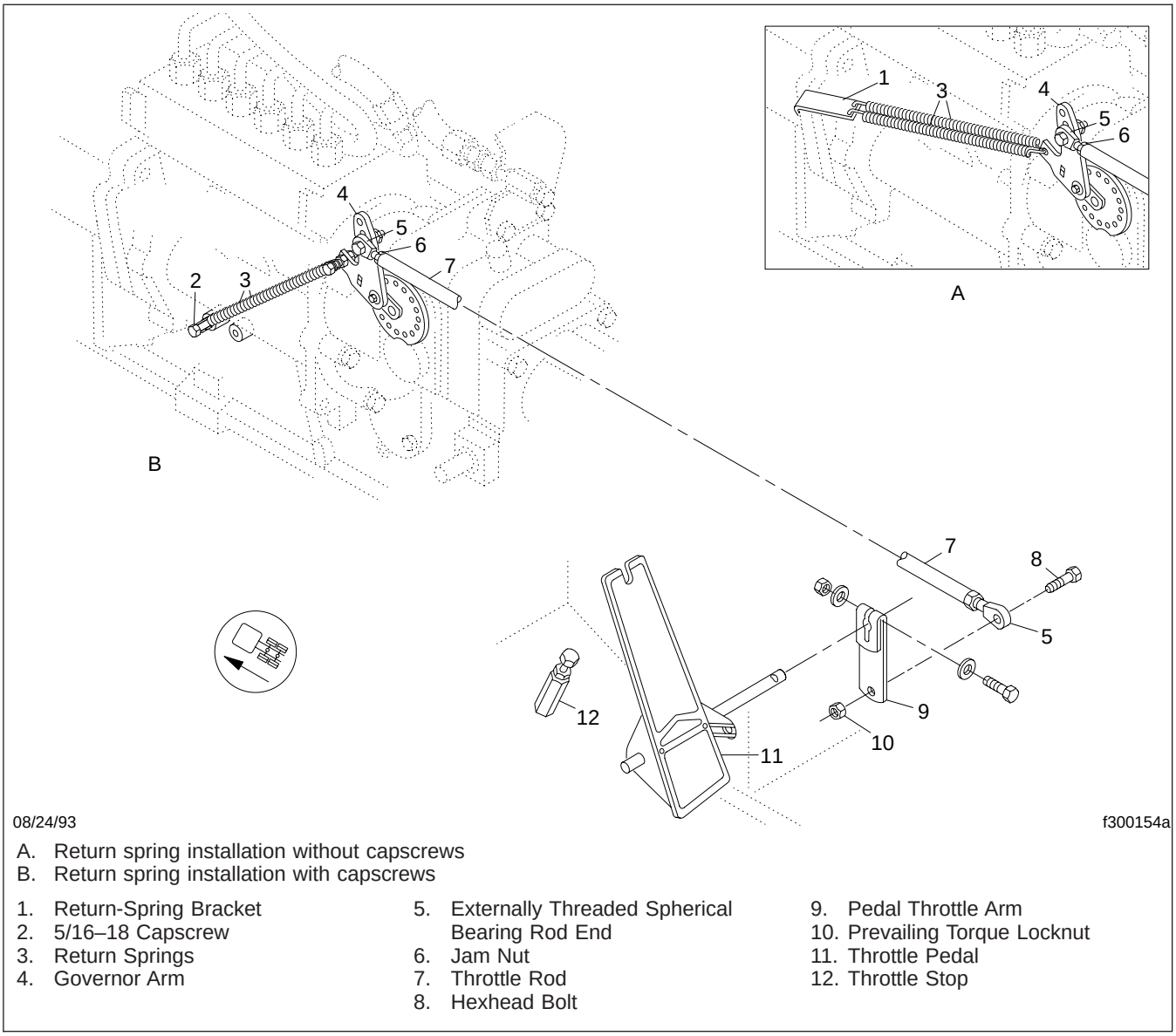
8. At least 5/16 inch (8 mm) of thread on the rod must remain engaged in the rod end. If more adjustment is needed than can be made at the cross-shaft end of the rod, turn the rod as needed, to change the thread engagement of the upper rod end.
9. Install a flat washer on the attaching capscrew, then insert the capscrew into the bore of the lower rod end. From the outside, insert the capscrew into the second hole of the left cross-shaft arm. Install and tighten the locknut 15 lbf·ft (20 N·m).
10. Tighten the upper rod-end jam nut 15 lbf·ft (20 N·m). Hold the rod while turning the lower rod end so that its flat faces are parallel to the flat faces of the upper rod end. Hold the rod and lower rod end in these positions while tightening the lower rod-end jam nut 15 lbf·ft (20 N·m).
11. Adjust the pedal stop. For instructions, see **Subject 120**.
12. Lower the hood and remove the chocks from the tires.
13. Test drive the vehicle and ensure that the throttle system operates properly.

CATERPILLAR 3406

1. Shut down the engine, set the parking brake, and chock the tires.

Throttle Linkage Length Adjustment

2. Open the hood.
3. Loosen the jam nuts (**Fig. 2**) at each end of the throttle rod.
6. With the governor arm at idle, turn the lower rod end, until the spherical bearing bore is aligned with the lower hole on the governor arm.



A. Return spring installation without capscrews
B. Return spring installation with capscrews

1. Return-Spring Bracket
2. 5/16–18 Capscrew
3. Return Springs
4. Governor Arm
5. Externally Threaded Spherical Bearing Rod End
6. Jam Nut
7. Throttle Rod
8. Hexhead Bolt
9. Pedal Throttle Arm
10. Prevailing Torque Locknut
11. Throttle Pedal
12. Throttle Stop

Fig. 2, Throttle Linkage (3406)

4. Remove the locknut, flat washer, and capscrew from the governor arm and spherical bearing rod end.
5. Block the throttle pedal at an angle of approximately 50 degrees to the cab deck.

⚠ WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod must remain engaged in the rod end. Anything less

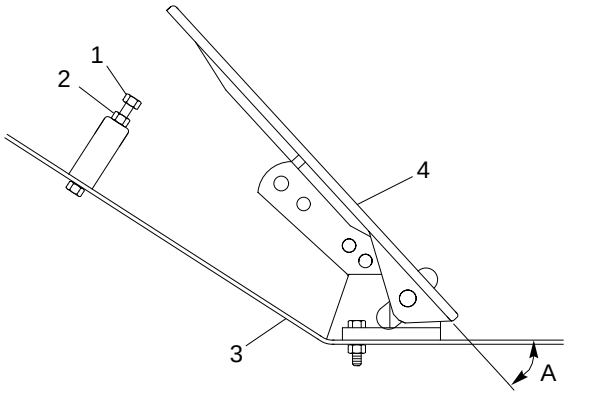
could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.

7. At least 5/16 inch (8 mm) of thread on the rod must remain engaged in the rod end. If more adjustment is needed than can be made at the governor arm, turn the rod as needed to change the thread engagement of the upper rod end.
8. Install a flat washer on the attaching capscrew, then insert the capscrew into the bore of the lower rod end. From the outside, insert the capscrew into the governor arm. Install and tighten the locknut 15 lbf·ft (20 N·m).
9. Tighten the upper rod-end jam nut 15 lbf·ft (20 N·m). Hold the rod while turning the lower rod end so that its flat faces are parallel to the flat faces of the upper rod end. Hold the rod and lower rod end in these positions while tightening the lower rod-end jam nut 15 lbf·ft (20 N·m).
10. Adjust the pedal stop. For instructions, see **Subject 120**.
11. Lower the hood and remove the chocks from the tires.
12. Test drive the vehicle and ensure that the throttle system operates properly.

Pedal Stop Adjustment

NOTE: If the throttle linkage is not new, perform the checks under **Subject 100** before adjusting the pedal stop.

1. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Loosen the pedal stop jam nut, and turn the capscrew in until no threads are showing above or below the jam nut. See **Fig. 1**. This allows maximum pedal travel.



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A. 50 degrees

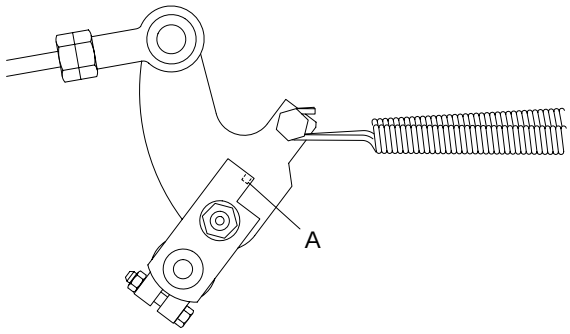
1. Pedal Stop Capscrew
2. Jam Nut
3. Cab Deck
4. Throttle Pedal

Fig. 1, Pedal Stop Installation

4. Block the governor arm in the breakover range.

   NOTE: When the middle of the breakover range is reached, a tang on the governor arm will move to the center of an opening in the governor arm. See **Fig. 2**, and **Fig. 3** .

5. Position the head of the pedal stop capscrew 1/16 to 1/8 inch (1.5 to 3 mm) from the bottom of the pedal, and tighten the jam nut against the cab deck.
6. Remove the block from the governor arm. Operate the pedal, and check the adjustment. Readjust if necessary.



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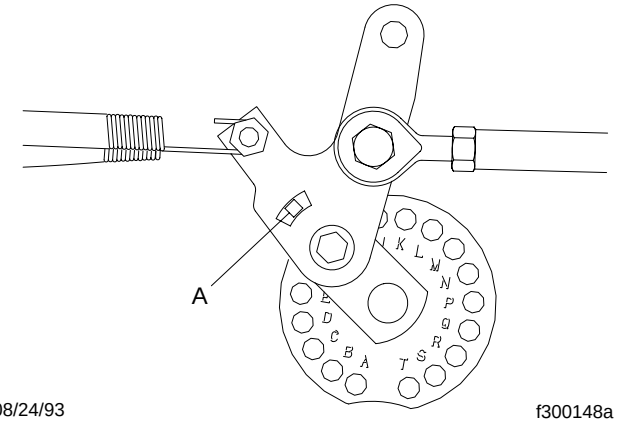
A. The tang must be in the approximate center of the opening

Fig. 2, Governor Arm in the Breakover Range (3306)



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A. The tang must be in the center of the opening

Fig. 3, Governor Arm in the Breakover Range (3406)

7. Lower the hood and remove the chocks from the tires.
8. Test drive the vehicle and ensure that the throttle system operates properly.

Throttle Control Installation

Use the following procedure if the throttle control is being replaced, removed and reinstalled, or if a new or rebuilt engine is being installed.

CATERPILLAR 3306

1. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Install the spring bracket (if not already installed). Remove the washer and nut from the timing gear plate (just below and inboard of the fuel filter), and use the nut to attach the bracket to the plate. Discard the washer. Position the bracket to extend upward, and behind the fuel filter.
4. Install the return springs.

   4.1 If used springs are being installed, inspect them, especially in the area of the anchor loops, for wear, nicks, or other damage that may cause breakage. Install new springs if the used springs are worn or damaged.

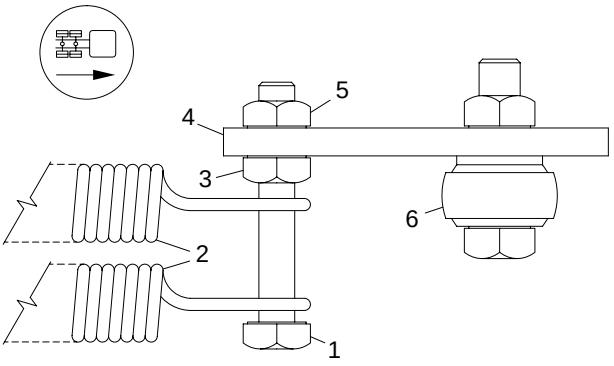
   4.2 Hook one end of each spring into a hole in the bracket.

   NOTE: As a product improvement for longer service life, install a capscrew in the governor arm to hook the return spring anchor loops around.

   4.3 Using a 1/4–20 nut and a 1/4–20 locknut, install a 1/4–20 capscrew through the inboard side of the aft hole of the governor arm. See **Fig. 1**.

   4.4 Using a hook (do not use sharply serrated pliers) place the opposite anchor loop of each spring around the capscrew in the governor arm. Don't stretch the springs any further than necessary.
5. With the governor arm at idle, check the angle of the left cross-shaft arm. The left arm must be pointing upward at an angle of 60 ± 5 degrees forward of vertical. See **Fig. 2**.

   If not, loosen the pinch-bolt nut, then spread the slotted end of the arm with a screwdriver, while pulling outward on the arm to remove it. Install the arm at the correct angle, as shown in **Fig. 2**. Tighten the pinch-bolt nut.



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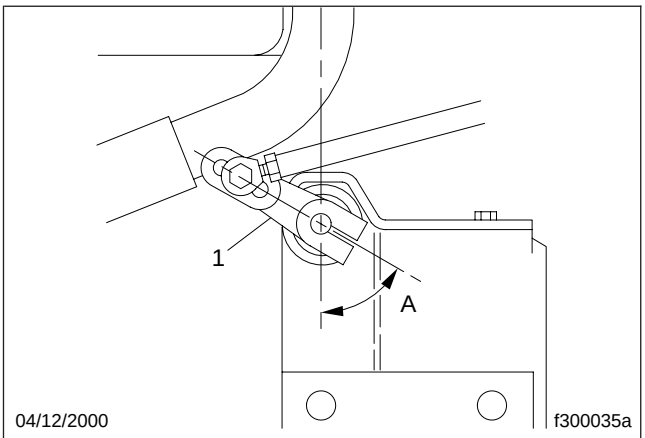
1. 1/4–20 x 1-1/4 inch Capscrew
2. Throttle Return Springs
3. 1/4–20 Nut
4. Governor Arm
5. 1/4–20 Locknut
6. Spherical Bearing Rod End

Fig. 1, Return Spring Capscrew Installation



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A. 60 ± 5 degrees

1. Left-Side Cross-Shaft Arm

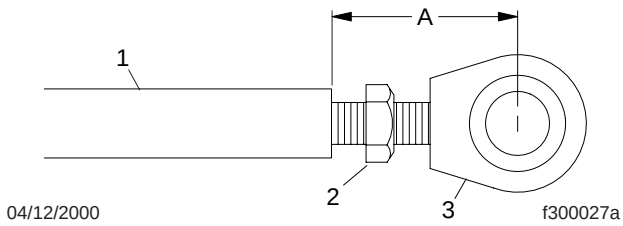
Fig. 2, Return-Spring Bracket (3306)

IMPORTANT: Do not change the length of the right throttle rod, and do not reposition the governor arm or right cross-shaft arm.

6. Install the jam nuts on the spherical bearing rod ends, as far as they will go. Turn the rod ends into the rod until the distance from the center of

Throttle Control Installation

each spherical bearing bore to its end of the rod is 1-3/16 inches (30 mm). See **Fig. 3**.



A. 1-3/16 inches (30 mm)

1. Throttle Rod
2. Jam Nut
3. Spherical Bearing Rod End

Fig. 3, Rod End Installation

7. Insert a 5/16–24 capscrew through the throttle pedal arm, from the floorboard side. Install a flat washer, then one of the rod's spherical bearing rod ends on the capscrew. Install a prevailing torque locknut and tighten it 15 lbf·ft (20 N·m).
8. Block the throttle pedal at an angle of approximately 50 degrees to the cab deck.
9. With the governor arm at idle, turn the lower rod end until the spherical bearing bore is aligned with the lower hole on the governor arm.

⚠ WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod must remain engaged in the rod end. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.

10. At least 5/16 inch (8 mm) of thread on the rod must remain engaged in the rod end. If more adjustment is needed than can be made at the cross-shaft end of the rod, turn the rod as needed to change the thread engagement of the upper rod end.
11. Install a flat washer on the attaching capscrew, then insert the capscrew into the bore of the lower rod end. From the outside, insert the capscrew into the second hole of the left cross-shaft arm. Install and tighten the locknut 15 lbf·ft (20 N·m).
12. Tighten the upper rod-end jam nut 15 lbf·ft (20 N·m). Hold the rod while turning the lower rod end so that its flat faces are parallel to the flat faces of the upper rod end. Hold the rod and lower rod end in these positions while tightening the lower rod-end jam nut 15 lbf·ft (20 N·m).
13. Adjust the pedal stop. For instructions, see **Subject 120**.
14. Lower the hood and remove the chocks from the tires.
15. Test drive the vehicle and ensure that the throttle system operates properly.

CATERPILLAR 3406

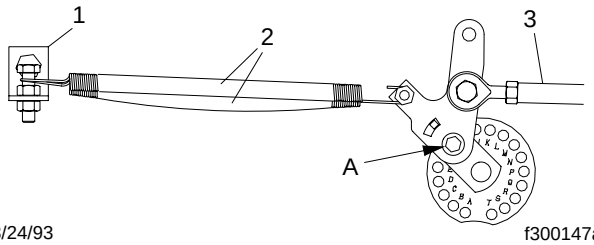
1. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Install the spring bracket (if not already installed). Remove the upper bolt that attaches the fuel injection pump housing to the drive housing, and use the bolt to attach the bracket to the pump housing.

NOTE: As a product improvement for longer service life, if the return spring anchor loops hook through a hole in the return spring bracket, replace the bracket with the current model bracket. Current brackets hold a capscrew, and the spring anchor loops hook around the capscrew. For the current return spring bracket part number for your vehicle, contact a Freightliner dealer.

4. Install the jam nuts and spherical bearing rod ends on the throttle rod. The rod ends should be adjusted to their maximum thread engagement. Do not tighten the jam nuts.
5. Insert a 5/16–24 capscrew through the throttle pedal arm, from the floorboard side. Install a flat washer, then one of the rod's spherical bearing rod ends on the capscrew. Install a prevailing torque locknut and tighten it 15 lbf·ft (20 N·m).
6. Block the throttle pedal at an angle of approximately 50 degrees to the cab deck.
7. Check the position of the governor arm in the governor disc. The governor arm must be at-

tached at the hole marked "G" in the disc. See **Fig. 4**. If necessary, reposition the arm as follows:

7.1 Loosen the capscrew that attaches the arm to the disc.



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A. Attach the governor arm to the governor disc at hole "G"

1. Return-Spring Bracket
2. Return Springs
3. Throttle Rod

Fig. 4, Governor Arm Position

7.2 Rotate the arm to the position where the hole in the arm is aligned with the hole that is marked "G" in the disc.

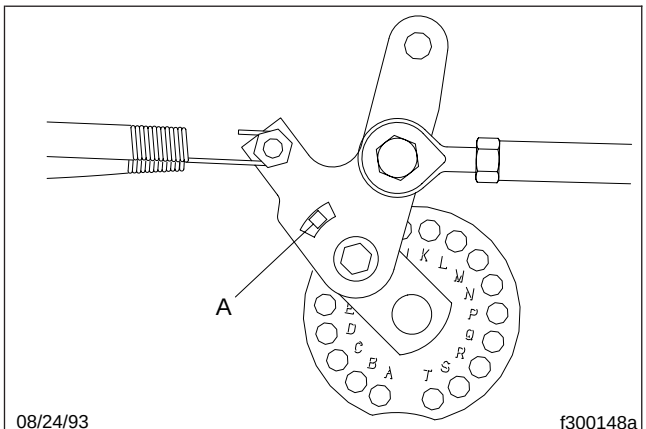
7.3 Tighten the capscrew, then push the long part of the governor arm into the breakover range. The breakover range is reached when the tang on one part of the arm is centered in the opening in the other part of the arm. See **Fig. 5**.

8. With the throttle pedal and the governor arm in the idle position, turn the lower rod end, until the spherical bearing bore is aligned with the lower hole on the governor arm.

⚠ WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod must remain engaged in the rod end. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.

9. At least 5/16 inch (8 mm) of thread on the rod must remain engaged in the rod end. If more adjustment is needed than can be made at the governor arm, turn the rod as needed to change the thread engagement of the upper rod end.



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A. The tang must be in the approximate center of the opening

Fig. 5, Breakover Range

10. Install a flat washer on the attaching capscrew, then insert the capscrew into the bore of the lower rod end. From the outside, insert the capscrew into the governor arm. Install and tighten the locknut 15 lbf·ft (20 N·m).

11. Install the return springs.

11.1 If used springs are being installed, inspect them, especially in the area of the anchor loops, for wear, nicks, or other damage that may cause breakage. Install new springs if the used springs are worn or damaged.

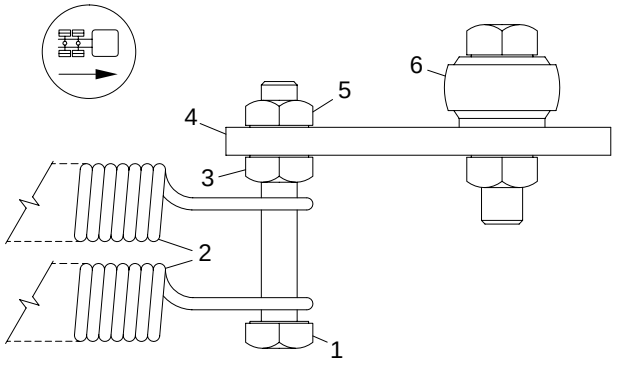
11.2 Hook one end of each spring around the capscrew in the return-spring bracket.

NOTE: As a product improvement for longer service life, install a capscrew in the governor arm to hook the return spring anchor loops around.

11.3 Using a 1/4–20 nut and a 1/4–20 locknut, install a 1/4–20 capscrew in the aft hole of the governor arm. See **Fig. 6**.

11.4 Using a hook (do not use sharply serrated pliers) place the opposite anchor loop of each spring around the capscrew in the governor arm. Don't stretch the springs any further than necessary.

Throttle Control Installation



1. 1/4–20 x 1-1/4 inch Capscrew
2. Throttle Return Springs
3. 1/4–20 Nut
4. Governor Arm
5. 1/4–20 Locknut
6. Spherical Bearing Rod End

Fig. 6, Return Spring Capscrew Installation

12. Tighten the upper rod-end jam nut 15 lbf·ft (20 N·m). Hold the rod while turning the lower rod end so that its flat faces are parallel to the flat faces of the upper rod end. Hold the rod and lower rod end in these positions while tightening the lower rod-end jam nut 15 lbf·ft (20 N·m).
13. Adjust the pedal stop. For instructions, see **Subject 120**.
14. Lower the hood and remove the chocks from the tires.
15. Test drive the vehicle and ensure that the throttle system operates properly.

Troubleshooting Tables

Problem—Throttle Pedal Angle Is Too High at Idle

Problem—Throttle Pedal Angle Is Too High at Idle	
Possible Cause	**Remedy**
The throttle rod is too short.	Adjust the length of the throttle rod, then adjust the pedal stop.

Problem—Throttle Pedal Angle Is Too Low at Idle

Problem—Throttle Pedal Angle Is Too Low at Idle	
Possible Cause	**Remedy**
The throttle rod is too long.	Adjust the length of the throttle rod, then adjust the pedal stop.

Problem—Excessive Play in the Throttle Pedal

Problem—Excessive Play in the Throttle Pedal	
Possible Cause	**Remedy**
The throttle linkage attachment capscrews are not tight.	Tighten the throttle linkage attachment capscrews.

Problem—Engine Does Not Reach Maximum Horsepower

Problem—Engine Does Not Reach Maximum Horsepower	
Possible Cause	**Remedy**
One of the throttle linkage attachment capscrews is loose.	Tighten the throttle linkage attachment capscrews.
Interference with the throttle linkage is preventing the governor arm from reaching the breakover range.	Engine parts are interfering with full travel of the throttle linkage. Reposition the parts.
At idle, the throttle pedal angle is too low.	Adjust the length of the throttle rod, then adjust the pedal stop.
The pedal stop is set too high.	Adjust the position of the pedal stop if it is not allowing full travel of the governor arm (into the breakover range).
The throttle linkage is attached to the wrong hole in the cross-shaft arm.	Attach the throttle linkage to the correct hole of the left cross-shaft arm.

Problem—Engine Does Not Return to Idle RPM When the Throttle Pedal Is Released

Problem—Engine Does Not Return to Idle RPM When the Throttle Pedal Is Released	
Possible Cause	**Remedy**
Interference with the throttle linkage is preventing the governor arm from returning to idle.	Engine parts are interfering with full travel of the throttle linkage. Reposition the parts.
The return springs are too long (stretched).	Remove the return springs and check them for stretching. If the springs are stretched, install new ones.
The return springs are broken.	Install new return springs.

Troubleshooting

Problem—Engine Does Not Return to Idle RPM When the Throttle Pedal Is Released	
Possible Cause	**Remedy**
The governor arm is attached to the wrong governor disc hole (3406 engines).	Attach the governor arm to hole "G" on the governor disc.

Problem—Excessive Resistance at the Throttle Pedal

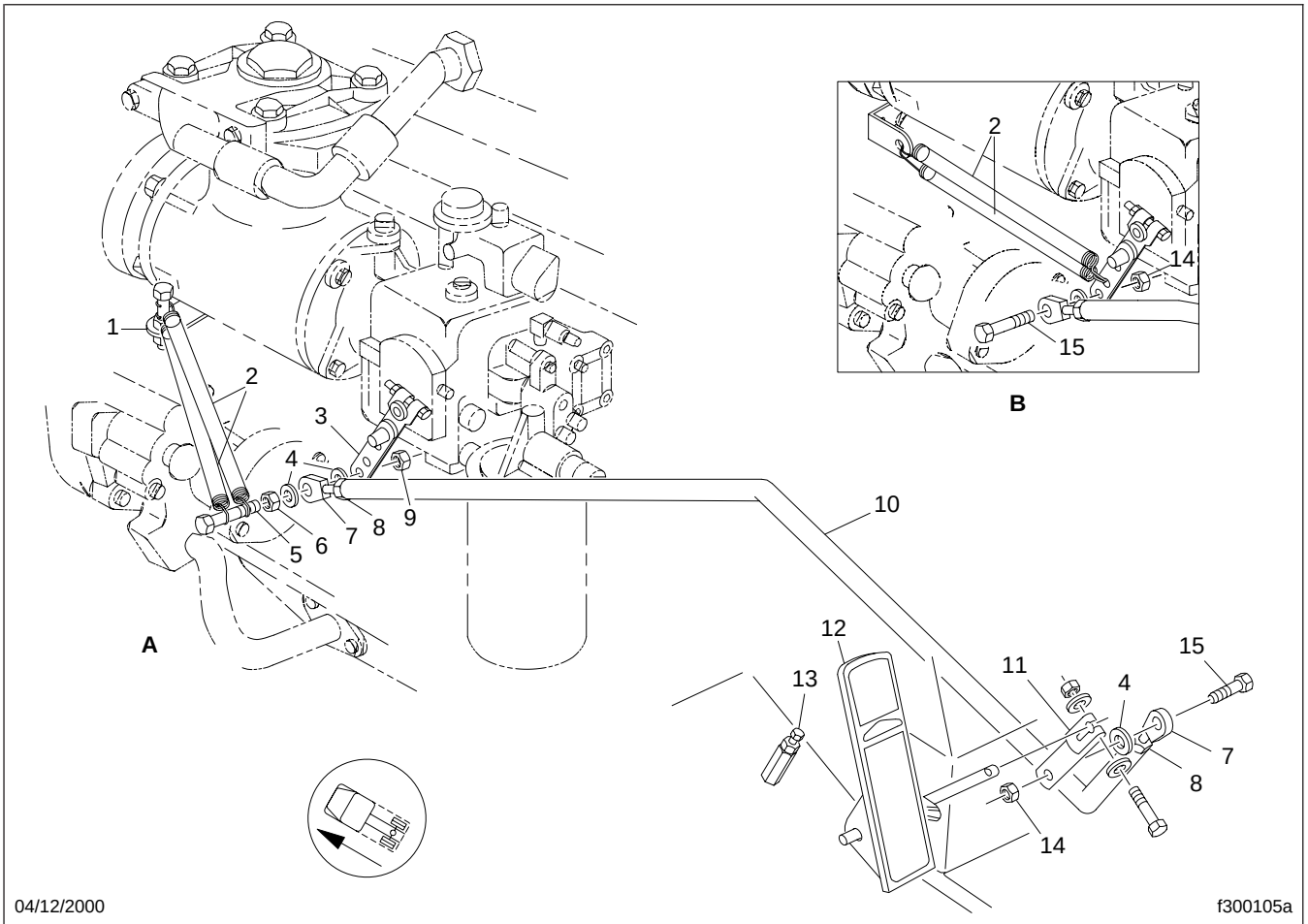
Problem—Excessive Resistance at the Throttle Pedal	
Possible Cause	**Remedy**
Engine parts are interfering with the throttle linkage.	Reposition the parts.
Engine parts are interfering with the return springs.	Reposition the parts. Check the return springs for damage, and replace them if necessary.

General Information

Freightliner throttle controls have a floor-mounted throttle pedal, an adjustable-length throttle rod, dual return springs, and an adjustable pedal stop. See **Fig. 1** or **Fig. 2**.

be at the correct angle when the engine is at idle rpm, the length of the linkage is adjustable by means of spherical bearing rod ends, with the adjustment secured by jam nuts. See **Fig. 3**. The spherical bearings prevent binding of the linkage.

Dual springs return the throttle control parts to their



A. Return spring installation with capscrews
B. Return spring installation without capscrews

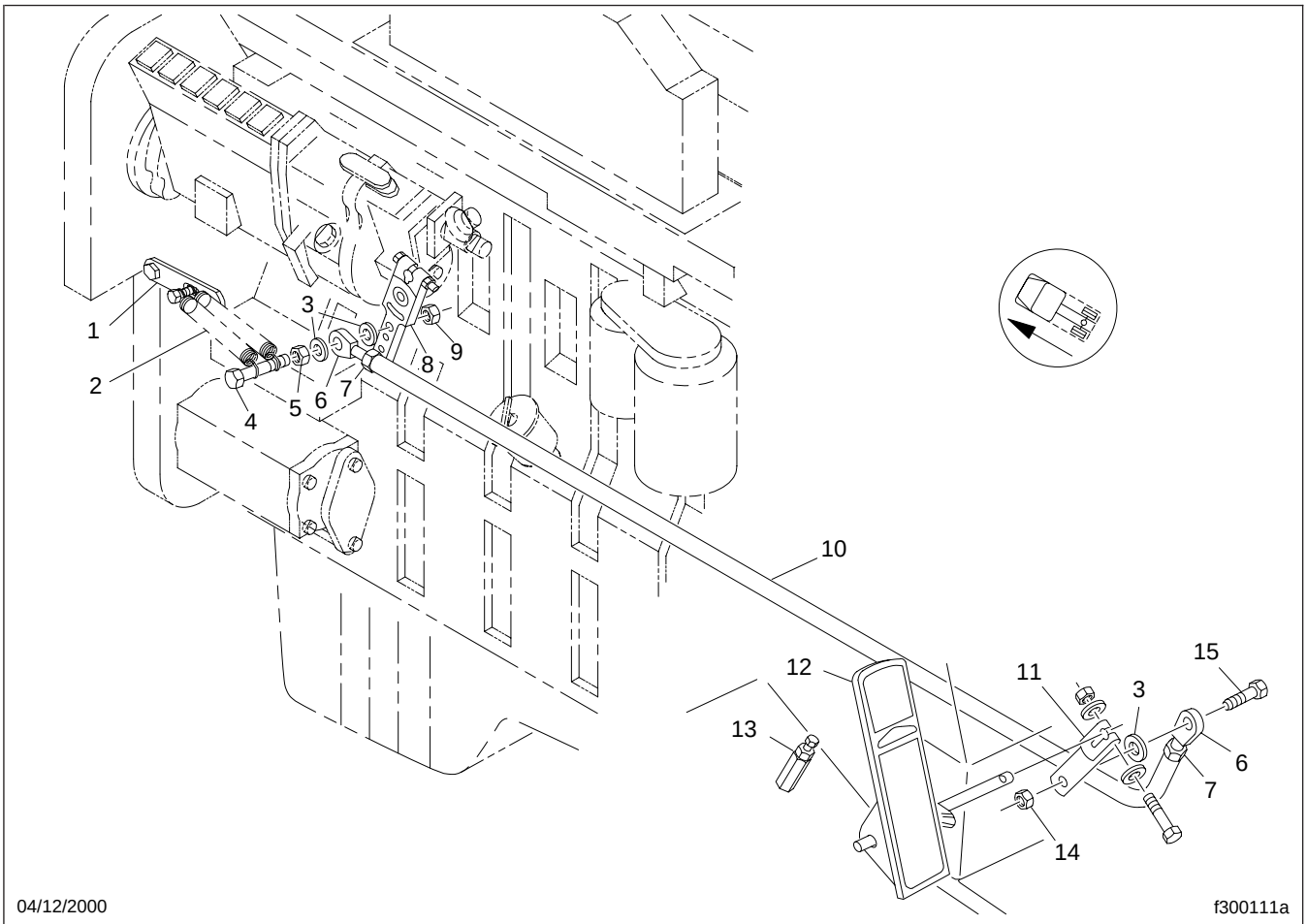
1. Return Spring Bracket
2. Return Springs
3. Governor Arm
4. Lockwasher
5. 5/16–18 Capscrew
6. 5/16–18 Hexnut
7. Spherical Bearing Rod End
8. Jam Nut
9. 5/16–18 Locknut
10. Throttle Rod
11. Pedal Throttle Arm
12. Throttle Pedal
13. Pedal Stop
14. 5/16–24 Locknut
15. 5/16–24 Capscrew

Fig. 1, Throttle Control Parts (L10)

During engine operation, movement of the throttle pedal and linkage will change the amount of fuel available to the engine. To ensure that the pedal will

idle positions when the pedal is released.

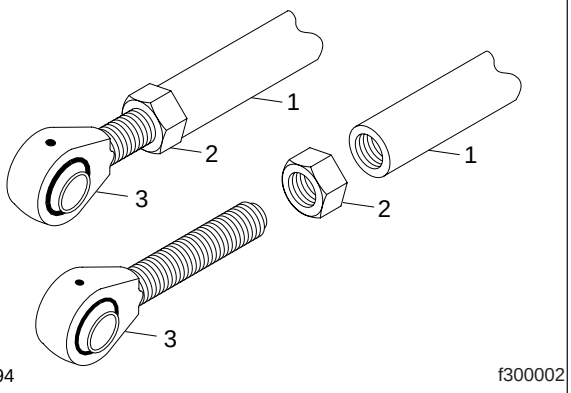
General Information



1. Return Spring Bracket
2. Return Springs
3. Lockwasher
4. 5/16–18 Capscrew
5. 5/16–18 Hexnut
6. Spherical Bearing Rod End
7. Jam Nut
8. Governor Arm
9. 5/16–18 Locknut
10. Throttle Rod
11. Pedal Throttle Arm
12. Throttle Pedal
13. Pedal Stop
14. 5/16–24 Locknut
15. 5/16–24 Capscrew

Fig. 2, Throttle Control Parts (C series)

When the linkage is properly adjusted, the governor shaft can rotate from idle rpm to maximum horsepower. To ensure that maximum horsepower is always reached, the linkage must be able to move just beyond the position where the governor shaft has stopped rotating, without causing damage to the governor. Cummins governor arms consist of two parts held in alignment by a breakover spring. When the part of the governor arm attached to the governor shaft has moved as far as the shaft rotation will allow, the force applied at the pedal overcomes the resistance of the breakover spring. This allows the part of the governor arm attached to the linkage to move into the breakover range. If the governor arm were forced beyond the breakover range, the linkage or governor arm could be damaged. An adjustable pedal stop prevents movement of the linkage beyond the governor arm's breakover range.



1. Internally Threaded Throttle Rod
2. Jam Nut
3. Spherical Bearing Rod End

Fig. 3, Throttle Rod Parts

Throttle Control Operation Checking

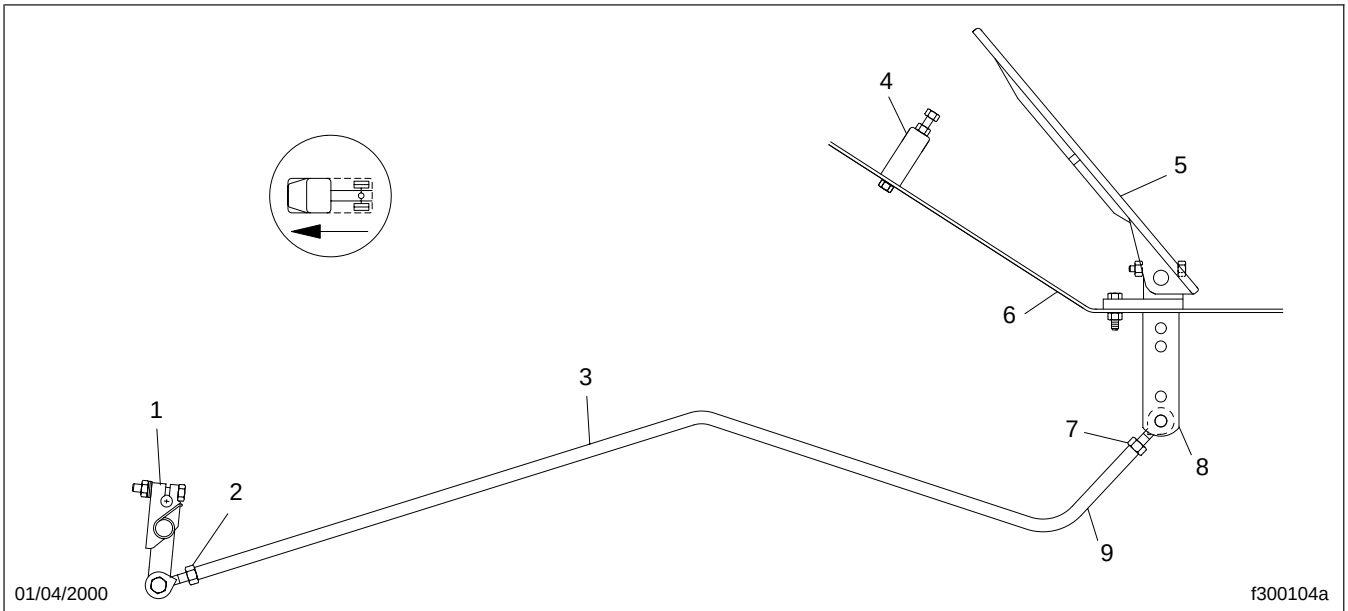
1. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Check the linkage attachment fasteners (capscrews, locknuts, and jam nuts) for tightness; tighten any that are loose.
4. Operate the throttle pedal by hand, from idle to maximum horsepower, while checking that nothing interferes with movement of the linkage.
5. Check the linkage for binding, by rotating the rod in and out. With the rod-end jam nuts tight against the rod, both rod ends must be free to swivel on their spherical bearings. If the rod and rod ends do not rotate in and out, adjust the rod ends and jam nuts as follows:

   5.1 Loosen the jam nuts at each end of the throttle rod. See **Fig. 1**.

   5.2 Turn the throttle rod to a position that prevents other components from interfering with the rod's movement through full travel.

   5.3 Hold the throttle rod in this position and turn each of the spherical bearing rod ends in the direction opposite the rotation of the throttle linkage. Hold the rod in this position while tightening the rod-end jam nuts 15 lbf·ft (20 N·m).
6. Operate the linkage by hand, from idle to maximum horsepower, while checking that nothing interferes with movement of the return springs. Reposition any parts that interfere.
7. Check the length of the installed return springs. When the throttle lever is at idle, the springs must be 9-1/2 to 9-3/4 inches (241 to 248 mm) long. See **Fig. 2**. If the spring length is incorrect, see **Subject 130**.
8. Inspect the return springs, as follows:

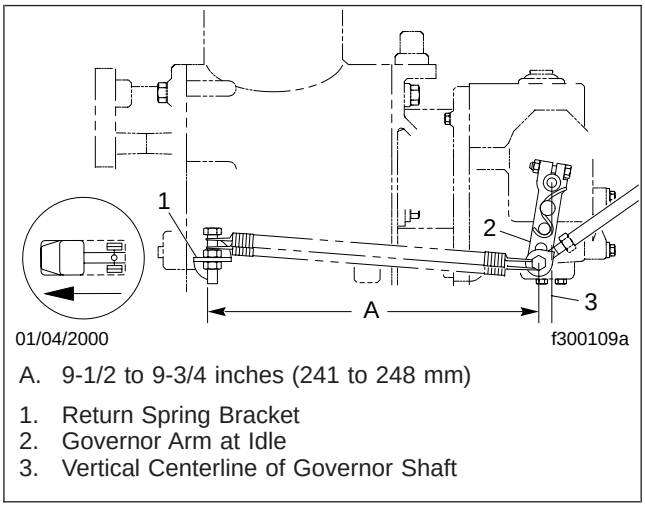
   8.1 Using a hook (do not use sharply serrated pliers), remove the anchor loop of each



1. Governor Arm
2. Rod End Jam Nut
3. Throttle Rod
4. Throttle Stop
5. Throttle Pedal
6. Cab Deck
7. Rod End Jam Nut
8. Throttle Pedal Arm
9. Upper Rod End

Fig. 1, Throttle Linkage

Throttle Control Operation Checking



A. 9-1/2 to 9-3/4 inches (241 to 248 mm)

1. Return Spring Bracket
2. Governor Arm at Idle
3. Vertical Centerline of Governor Shaft

Fig. 2, Return Spring Length (L10)

spring from the capscrew on the governor arm. Do not stretch the springs any further than necessary. Disconnect the opposite ends from the capscrew installed on the spring bracket.

8.2 Inspect the springs, especially in the area of the anchor loops, for wear, nicks, or other damage that might cause breakage.

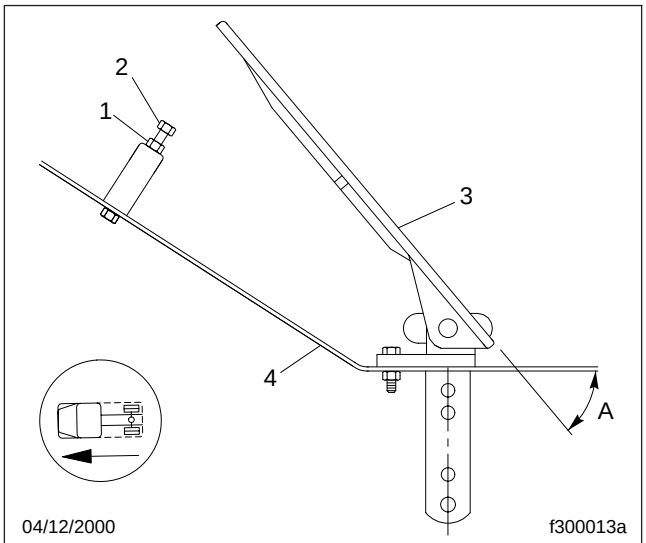
8.3 Measure the springs for stretching. The relaxed spring should be no more than 9-3/8 inches (238 mm) long, from the outside of one anchor loop to the outside of the opposite anchor loop.

8.4 If the used springs are worn, damaged, or stretched, install new springs.

8.5 Install the springs on the spring bracket capscrew; then, using the hook, install the anchor loops on the capscrew that attaches the rod end to the governor arm. See **Fig. 2**.

9. With the governor arm at idle, check the angle of the throttle pedal. The pedal must be at an angle of approximately 50 degrees to the cab deck. See **Fig. 3**. If the throttle pedal angle is too high or too low, adjust the length of the throttle linkage. See **Subject 110**.

10. Operate the throttle pedal by hand, from idle through full travel, while checking that the governor arm travels at least 5 degrees into the breakover range.



A. 50 degrees

1. Jam Nut
2. Pedal Stop Capscrew
3. Throttle Pedal
4. Cab Deck

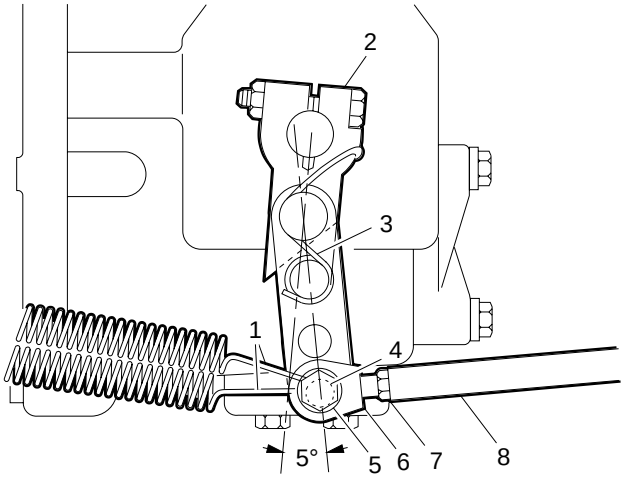
Fig. 3, Throttle Pedal at Idle

NOTE: The breakover range begins at the point where the two parts of the governor arm begin to have intersecting centerlines. See **Fig. 4**.

11. If the governor arm does not travel at least 5 degrees into the breakover range, adjust the pedal stop. See **Subject 120**.

12. Lower the hood and remove the chocks from the tires.

13. Test drive the vehicle and ensure that the throttle system operates properly.



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A. 5 degrees

1. Throttle Return Springs
2. Governor Arm
3. Governor Arm Beakover Spring
4. Throttle Linkage Mounting Hole
5. Capscrew
6. Spherical Bearing Rod End
7. Jam Nut
8. Throttle Rod

Fig. 4, Governor Arm in the Breakover Range (L10)

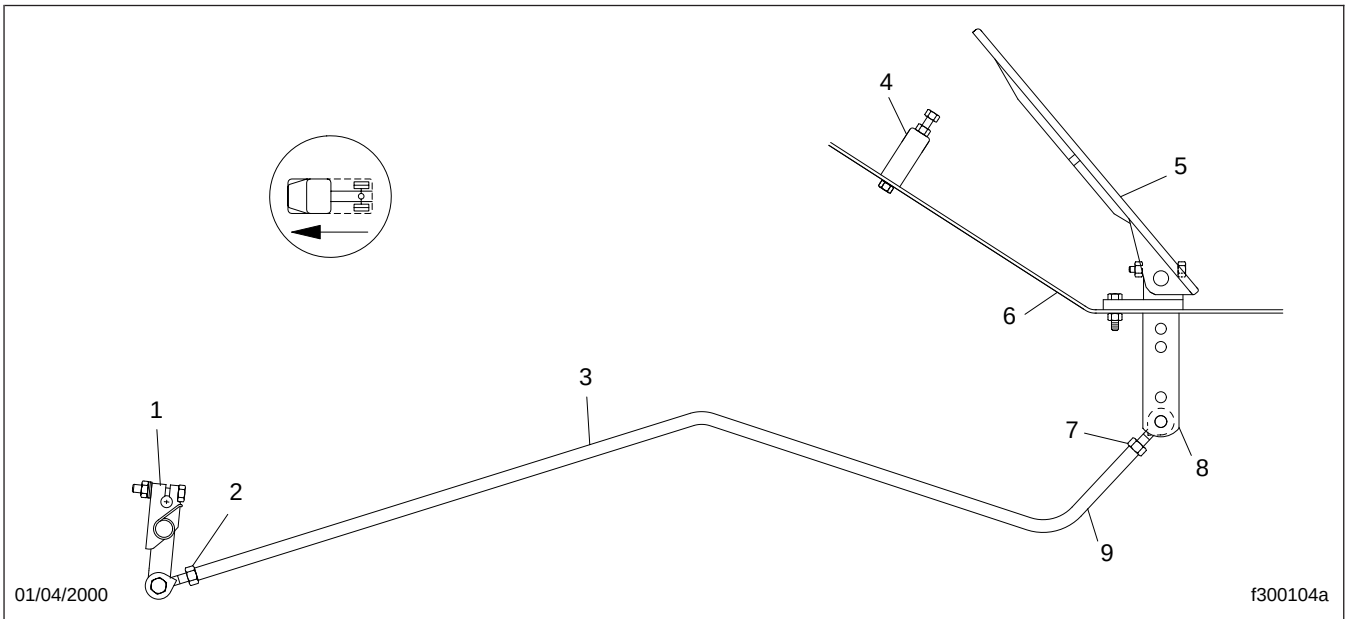
Throttle Linkage Length Adjustment

1. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Remove the return springs from the capscrew at the governor arm.
4. Loosen the jam nuts at each end of the throttle rod. See **Fig. 1**.
5. Remove the locknut, lockwasher, and capscrew from the governor arm and the spherical bearing rod end.
6. Block the throttle pedal at an angle of approximately 50 degrees to the cab deck.
7. With the governor arm at idle, turn the lower rod end, until the spherical bearing bore is aligned with the top (C series engines), or bottom (L10 engines) hole on the governor arm.

WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod end must remain engaged in the rod. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.

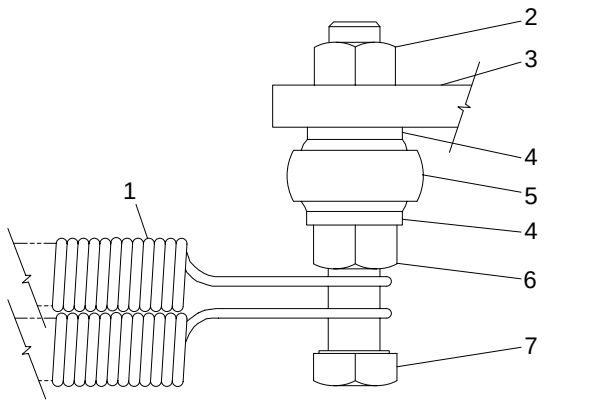
8. At least 5/16 inch (8 mm) of thread on the rod end must remain engaged in the rod. If more adjustment is needed than can be made at the governor arm, turn the rod as needed, to change the thread engagement of the upper rod end.
9. Insert a capscrew, with a hexnut and lockwasher (**Fig. 2**), into the bore of the lower rod end. Insert the capscrew through the top (C series engine), or bottom (L10 engine) hole on the governor arm. Install a lockwasher on the capscrew. Install and tighten the locknut 15 lbf·ft (20 N·m).
10. Turn the throttle rod to a position that prevents other components from interfering with the rod's movement through full travel. Hold the throttle



1. Governor Arm
2. Rod End Jam Nut
3. Throttle Rod
4. Throttle Stop
5. Throttle Pedal
6. Cab Deck
7. Rod End Jam Nut
8. Throttle Pedal Arm
9. Upper Rod End

Fig. 1, Throttle Linkage

Throttle Linkage Length Adjustment



1. Return Springs
2. 5/16–18 Hexnut
3. Governor Arm
4. Lockwasher
5. Spherical Bearing Rod End
6. 5/16–18 Hexnut
7. 5/16–18 Capscrew

Fig. 2, Return Spring Capscrew Installation

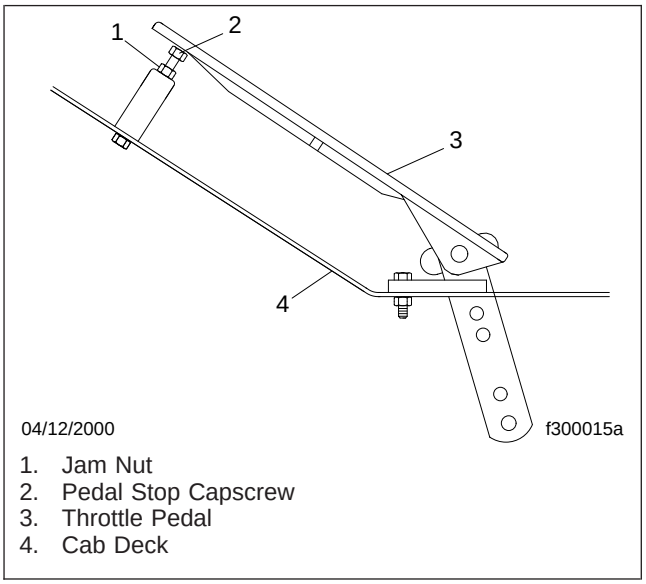
rod in this position and turn each of the spherical bearing rod ends in the direction opposite the rotation of the throttle linkage. Hold the rod in this position while tightening the rod-end jam nuts 15 lbf·ft (20 N·m).

11. Install the return springs on the capscrew at the governor arm.
12. Adjust the pedal stop. For instructions, see **Subject 120**.
13. Lower the hood and remove the chocks from the tires.
14. Test drive the vehicle and ensure that the throttle system operates properly.

Pedal Stop Adjustment

NOTE: If the throttle linkage is not new, perform the checks under **Subject 100** before adjusting the pedal stop.

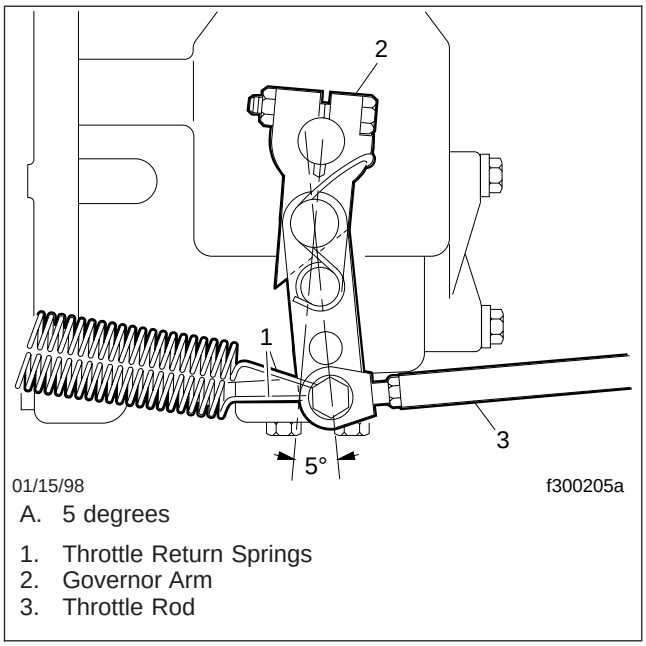
1. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Loosen the pedal stop jam nut, and turn the capscrew in until no threads are showing above or below the jam nut. See **Fig. 1**. This allows maximum pedal travel.
4. Hold the throttle pedal at the point where the centerlines of the two parts of the governor arm form an angle of 5 degrees. See **Fig. 2**.
5. Position the head of the pedal stop capscrew 1/16 to 1/8 inch (1.5 to 3 mm) from the bottom of the pedal, and tighten the jam nut against the cab deck. See **Fig. 1**.
6. Operate the pedal to check the adjustment. Readjust if necessary.



1. Jam Nut
2. Pedal Stop Capscrew
3. Throttle Pedal
4. Cab Deck

Fig. 1, Pedal Stop

7. Lower the hood and remove the chocks from the tires.
8. Test drive the vehicle and ensure that the throttle system operates properly.



A. 5 degrees

1. Throttle Return Springs
2. Governor Arm
3. Throttle Rod

Fig. 2, Governor Arm in the Breakover Range (L10)

Throttle Control Installation

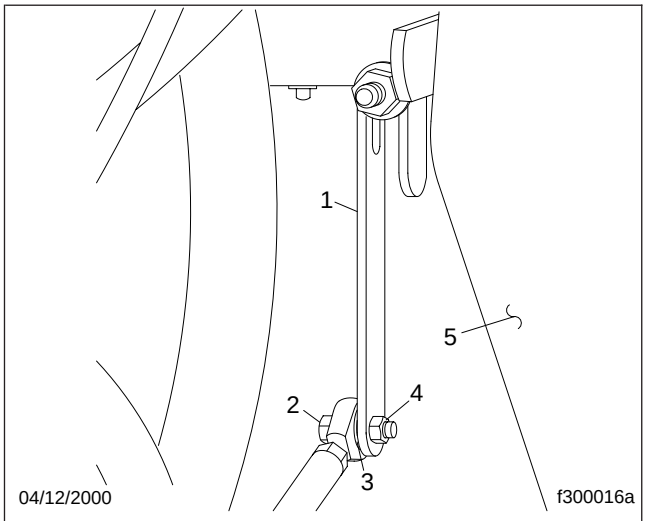
Use the following procedure if the throttle control is being replaced, removed and reinstalled, or if a new or rebuilt engine is being installed.

1. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Install the spring bracket (if not already installed).
4. Install the jam nuts and spherical bearing rod ends on the throttle rod. The rod ends should be adjusted to their maximum thread engagement. Do not tighten the jam nuts.
5. Insert a 5/16–24 capscrew through the upper spherical bearing rod end, from the tunnel side. Install a lockwasher, then install the rod end on the throttle pedal arm. Install a prevailing torque locknut and tighten it 15 lbf·ft (20 N·m). See **Fig. 1**.
6. Hold the throttle pedal at an angle of approximately 50 degrees to the cab deck.
7. With the governor arm pointing downward at 0 ± 2 degrees forward of vertical (L10 engines) or 18 degrees forward of vertical (C series engines), measure the distance between the spring ends on the return-spring bracket and the spring ends attached to the capscrew in the governor arm. See **Fig. 2** and **Fig. 3**.

   This distance (the length of the installed springs at idle) must be 9-1/2 to 9-3/4 inches (241 to 248 mm). If the distance is not within this tolerance, remove the nut, washer, and pinch bolt from the governor arm. Remove the arm by spreading the end of it with a screwdriver while pulling outward on it. Install the arm (pointing downward) at an angle that will provide the correct distance. Install and securely tighten the pinch bolt, washer, and nut.
8. Install the return springs as follows:

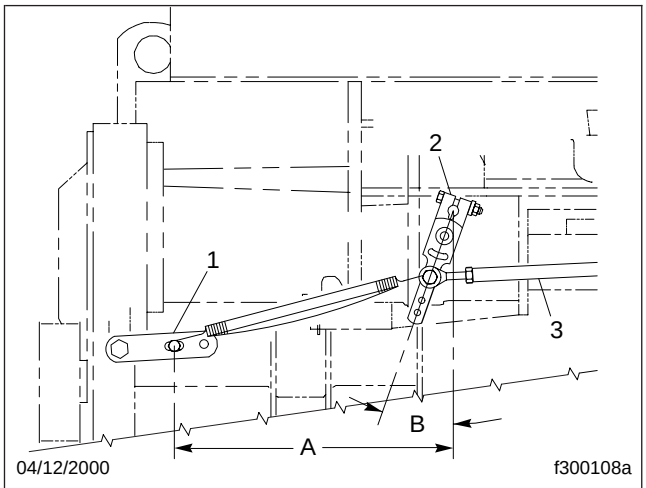
   8.1 If used springs are being installed, inspect them, especially in the area of the anchor loops, for wear, nicks, or other damage that may cause breakage. Install new springs if the used springs are worn or damaged.

   8.2 Install one end of each spring on the spring bracket capscrew.



1. Throttle Pedal Arm
2. Capscrew
3. Washer
4. Prevailing Torque Locknut
5. Floorboard

Fig. 1, Throttle Linkage (C series)



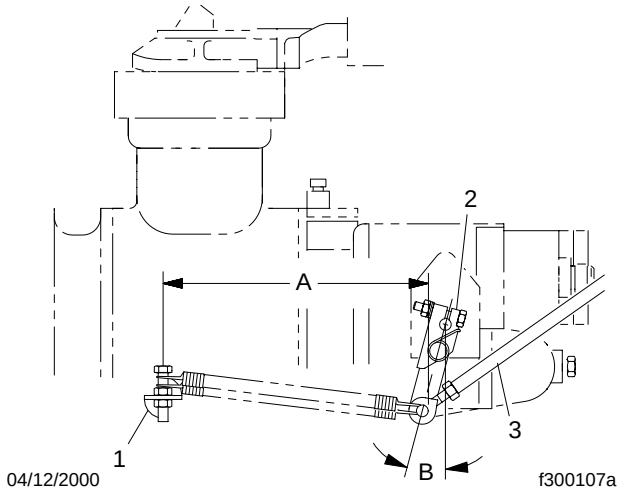
A. 9-1/2 to 9-3/4 inches (241 to 248 mm)
B. 18 degrees

1. Return Spring Bracket
2. Governor Arm (at idle)
3. Throttle Rod

Fig. 2, Governor Arm at Idle (C series)

8.3 Using a hook (do not use sharply serrated pliers), insert the other anchor loops on the capscrew that attaches the rod end to

Throttle Control Installation



A. 9-1/2 to 9-3/4 inches (241 to 248 mm)
B. 0 ± 2 degrees

1. Return Spring Bracket
2. Governor Arm (at idle)
3. Throttle Rod

Fig. 3, Governor Arm at Idle (L10)

the governor arm. Don't stretch the springs any further than necessary.

9. With the throttle pedal and the governor arm in the idle position, turn the lower rod end, until the spherical bearing bore is aligned with the top (C series engines), or bottom (L10 engines) hole on the governor arm.

⚠ WARNING

When lengthening the throttle linkage, at least 5/16 inch (8 mm) of thread on each rod end must remain engaged in the rod. Anything less could result in disengagement of the throttle linkage, which could cause sudden loss of engine power, possibly resulting in personal injury or property damage.

10. At least 5/16 inch (8 mm) of thread on the rod end must remain engaged in the rod. If more adjustment is needed than can be made at the governor arm, turn the rod as needed, to change the thread engagement of the upper rod end.
11. Insert a capscrew, with a locknut and lockwasher, into the bore of the lower rod end. Insert the capscrew through the top (C series engine), or bottom (L10 engine) hole on the governor arm. Install a lockwasher on the capscrew. Install and tighten the locknut 15 lbf·ft (20 N·m).
12. Turn the throttle rod to a position that prevents other components from interfering with the rod's movement through full travel.
13. Hold the throttle rod in this position and turn each of the spherical bearing rod ends in the direction opposite the rotation of the throttle linkage. Hold the rod in this position while tightening the rod-end jam nuts 15 lbf·ft (20 N·m).
14. Adjust the pedal stop. For instructions, see **Subject 120**.
15. Lower the hood and remove the chocks from the tires.
16. Test drive the vehicle and ensure that the throttle system operates properly.

Troubleshooting Tables

Problem—Throttle Pedal Angle Is Too High at Idle

Problem—Throttle Pedal Angle Is Too High at Idle	
Possible Cause	**Remedy**
The throttle linkage is too long.	Adjust the length of the throttle linkage, then adjust the pedal stop.

Problem—Throttle Pedal Angle Is Too Low at Idle

Problem—Throttle Pedal Angle Is Too Low at Idle	
Possible Cause	**Remedy**
The throttle linkage is too short.	Adjust the length of the throttle linkage, then adjust the pedal stop.

Problem— Excessive Play in the Throttle Pedal

Problem— Excessive Play in the Throttle Pedal	
Possible Cause	**Remedy**
One of the throttle linkage attachment capscrews is loose.	Tighten the throttle linkage attachment capscrews.

Problem—Engine Does Not Reach Maximum Horsepower

Problem—Engine Does Not Reach Maximum Horsepower	
Possible Cause	**Remedy**
One of the throttle linkage attachment capscrews is loose.	Tighten the throttle linkage attachment capscrews.
Interference with the throttle linkage is preventing the governor arm from reaching the breakover range.	Engine components are interfering with the full travel of the throttle linkage. Reposition the components.
At idle, the throttle pedal angle is too low.	Adjust the length of the throttle linkage, then adjust the pedal stop.
The pedal stop is set too high.	Adjust the position of the pedal stop if it is not allowing full travel of the governor arm (into the breakover range).

Problem—Engine Does Not Return to Idle RPM When the Throttle Pedal Is Released

Problem—Engine Does Not Return to Idle RPM When the Throttle Pedal Is Released	
Possible Cause	**Remedy**
Interference with the throttle linkage is preventing the governor arm from returning to the idle position.	Engine components are interfering with the full travel of the throttle linkage. Reposition the components.
The installed length of the throttle-return springs is too short.	Check the distance between the spring mounting points. Reposition the governor arm as necessary.
The throttle-return springs are too long (stretched).	Remove the throttle-return springs and check them for stretching. If the springs are stretched, install new springs.
The throttle-return springs are broken.	Install new throttle-return springs.

Troubleshooting

Problem—Excessive Resistance at the Throttle Pedal

Problem—Excessive Resistance at the Throttle Pedal	
Possible Cause	**Remedy**
The throttle linkage is rubbing against engine components.	Engine components are interfering with the throttle linkage. Reposition the components.
Engine components are interfering with the throttle-return springs.	Reposition the components. Check the return springs for damage, and replace if necessary.
The spherical bearing rod ends at each end of the throttle rod are rotated to their opposite limits.	Reposition both rod ends.

Accelerator Pedal Assembly

The Williams electronic accelerator pedal provides an electrical signal to the engine in response to the driver's demand for more engine power. The accelerator pedal converts downward pressure into an electrical signal via the pedal position sensor.

Pedal Position Sensor

Freightliner uses various pedal position sensors, depending on the engine. The pedal position sensor is mounted to the side of the pedal assembly. The sensor and the pedal assembly are both separately replaceable.

NOTE: Left-hand drive (LHD) FLD vehicles manufactured on or after April 2, 2007, do not have replaceable sensors. The new pedal assemblies use thread-forming screws to mount the sensor to the pedal housing. Sensor replacement will strip the threads, so the entire pedal assembly must be replaced when a new sensor is needed.

There are two basic technologies employed on pedal position sensors used with electronic engines on heavy-duty trucks:

- A ratiometric sensor that generates a DC voltage output in proportion to the pedal position. The ratiometric sensor is used on Detroit Diesel, Mercedes-Benz, and pre-EPA07 Cummins engines.
- A pulse-width-modulating (PWM) sensor that generates a series of discrete voltage pulses. The width of the pulses is proportional to the pedal position. A narrower pulse width indicates a smaller accelerator pedal request and a wider pulse width indicates a larger pedal request. The PWM sensor is used on Caterpillar engines.

An idle validation switch (IVS) is integrated into some ratiometric pedal position sensors. The IVS is a single-pole, double-throw switch. Some engine models monitor both switched poles, and some monitor only one pole. When the accelerator pedal returns to idle, the IVS moves to the "idle" position to signal the engine that the pedal has returned to idle. The IVS is not a serviceable part. If the IVS malfunctions, the sensor must be replaced.

Floor-Mounted Pedal Removal and Installation

Vehicles built on or after June 27, 2003, have suspended accelerator pedal assemblies. For instructions on removing or installing a suspended accelerator pedal, see **Subject 110**.

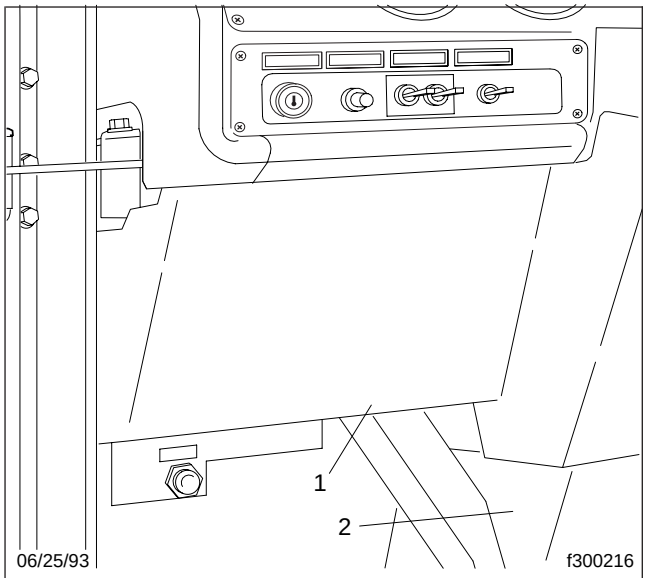
Floor-mounted accelerator pedals can be removed in one of two ways, depending on the pedal base plate type. If the pedal assembly has a steel base plate, the upper assembly can be removed, leaving the base plate attached to the cab floor. If the base plate is cast-aluminum and painted black, the entire pedal and base plate assembly must be removed.

Steel Base Plate (Upper Assembly Only)

Removal

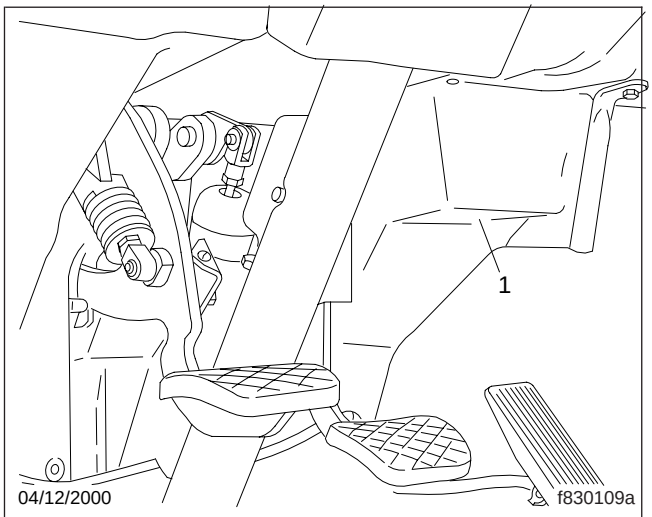
1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries.
3. On FLA/FLBs and FLD 120s without a tilt steering wheel, remove the upper and lower steering column panels. See **Fig. 1**.

   On FLD 112s, remove the two Torx® screws that hold the knee pad in place above the accelerator pedal, then remove the knee pad. See **Fig. 2**.



1. Upper Steering Column Cover Panel
2. Lower Steering Column Cover Panel

Fig. 1, Steering Column Cover Panels



1. Knee Pad

Fig. 2, Knee Pad Removal

4. Remove the carpeting and insulation from the frontwall above the accelerator pedal, and on both sides of the steering column, to expose the wiring harness.
5. Disconnect the pedal position sensor wiring harness from the cab wiring harness.
6. Remove the rubber treadle cover, if equipped.

NOTE: On some pedals, the forward stud on the treadle cover also holds the spring plate. If this is the case, loosen the nut on the forward stud. Then remove the nut from the rear treadle cover stud and lift the treadle cover enough to access the treadle pin.

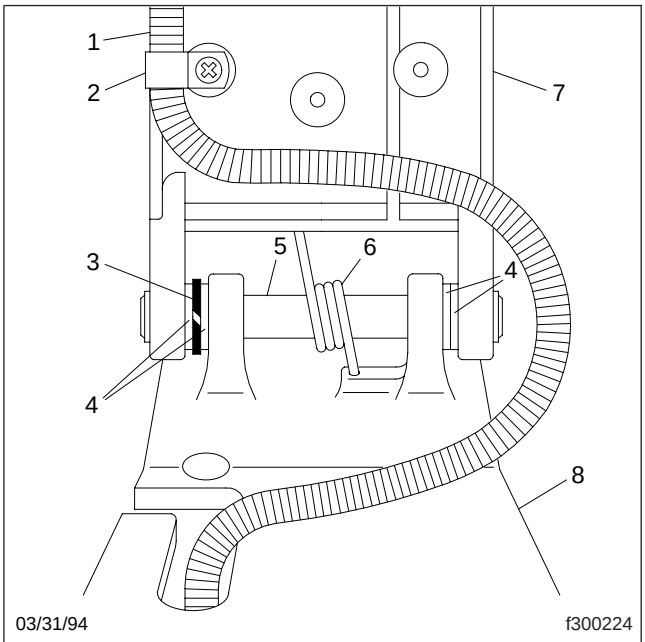
7. Depending on the pedal version, the treadle pin has one or two retaining clips. Note the position of the retaining clip(s) and the bushing. See **Fig. 3** or **Fig. 4**.

   Remove the retaining clip(s) from the treadle pin. Remove the treadle pin and the heel spring (if equipped).
8. Remove the treadle from the base plate.

Installation

1. Position the treadle on the base plate.
2. Make sure that the bushings are in place in the treadle and the base plate. See **Fig. 3** or **Fig. 4**.

Floor-Mounted Pedal Removal and Installation

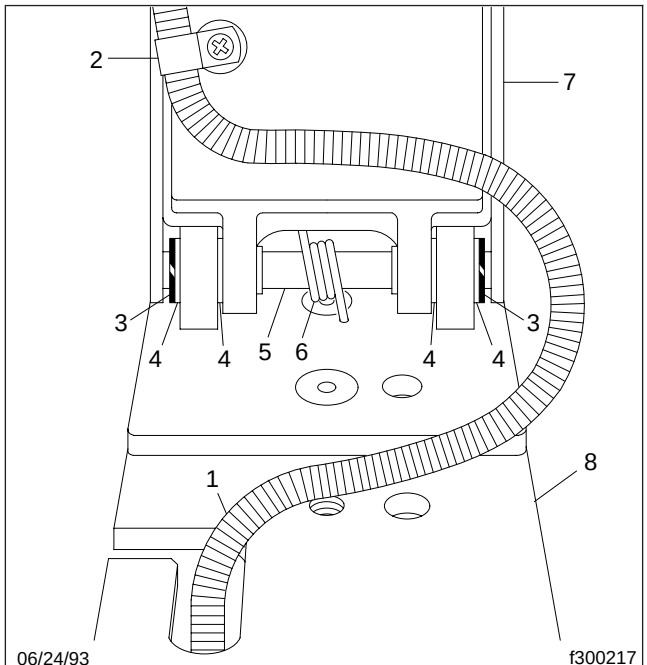


1. Wiring Harness
2. Clamp
3. Retaining Clip
4. Nylon Bushing
5. Treadle Pin
6. Heel Spring
7. Treadle
8. Base Plate

Fig. 3, Pedal Assembly (1 retaining clip)

3. Install the heel spring (if equipped) on the base plate so that the long leg of the spring is in the hole of the base plate.
4. Install the treadle pin through the treadle, heel spring, and base plate.
5. Install the retaining clip(s) onto the treadle pin. Be sure the retaining clip(s) are positioned correctly. See **Fig. 3** or **Fig. 4**.
6. Install the rubber treadle cover, if equipped.
7. Connect the pedal position wiring harness.
8. Install any wiring clamps that were removed, and secure the wiring with tie straps to remove any slack.
9. On FLA/FLBs and FLD 120s, without a tilt steering wheel, install the upper and lower steering column cover panels.

   On FLD 112s, install the knee pad.
10. Position the carpet and insulation over the frontwall.
11. Connect the batteries.



1. Wiring Harness
2. Clamp
3. Retaining Clip
4. Nylon Bushing
5. Treadle Pin
6. Heel Spring
7. Treadle
8. Base Plate

Fig. 4, Pedal Assembly (2 retaining clips)

12. Test the pedal operation using the diagnostic software tool specified in **Table 1**.

Diagnostic Software Tools	
Engine Manufacturer	**Software Tool**
Caterpillar	Caterpillar Electronic Technician (CAT ET)
Cummins	INSITE
Detroit Diesel	Detroit Diesel Diagnostic Link
Mercedes-Benz	Detroit Diesel Diagnostic Link

Table 1, Diagnostic Software Tools

Cast Aluminum Base Plate, Painted Black (Entire Assembly)

Removal

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries.
3. On FLA/FLBs and FLD 120s without a tilt steering wheel, remove the upper and lower steering column panels. See **Fig. 1**.

   On FLD 112s, remove the two Torx screws that hold the knee pad in place above the accelerator pedal, then remove the knee pad. See **Fig. 2**.
4. Remove the carpeting and insulation from the frontwall above the accelerator pedal, and on both sides of the steering column, to expose the wiring harness.
5. Disconnect the pedal position sensor wiring harness from the cab wiring harness.
6. Remove the three fasteners that hold the base plate to the cab floor. See **Fig. 5**.

NOTE: On some installations, the accelerator pedal base plate is fastened to a deck bracket. See **Fig. 6**. To remove the pedal, remove the fasteners that secure the base plate to the deck bracket.

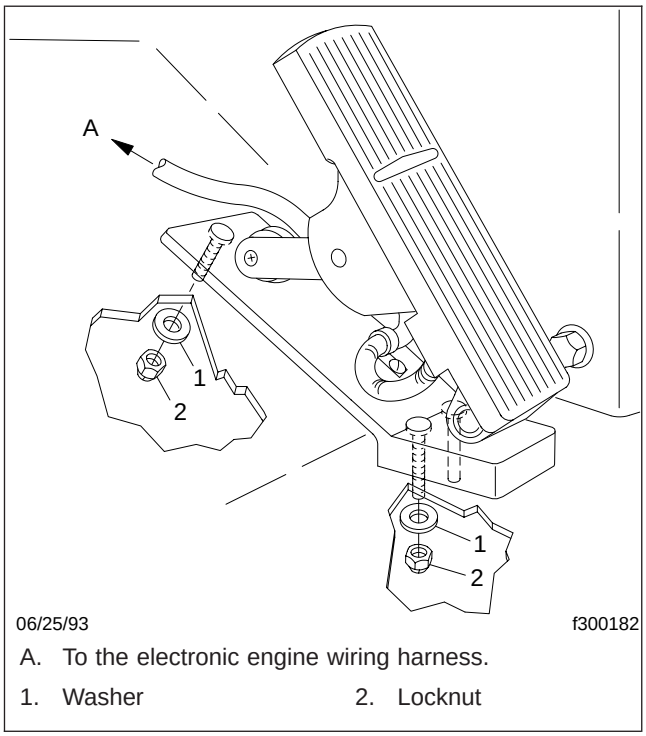
7. Remove the pedal and base plate assembly.

Installation

1. Position the accelerator pedal studs on the three mounting holes in the cab floor.
2. Install the two rear base plate studs in the rear holes. Lower the base plate and install the front base plate stud into the front hole.
3. Secure the base plate to the cab floor. Tighten the locknuts securely.

NOTE: On some installations, the accelerator pedal base plate is fastened to a deck bracket. See **Fig. 6**. To install the base plate on the deck bracket, use two hexbolts and nuts. Tighten the nuts firmly.

4. Connect the pedal position wiring harness.



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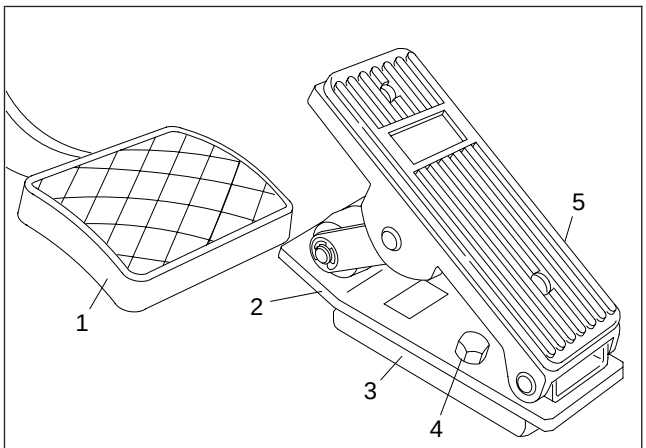
A. To the electronic engine wiring harness.
1. Washer
2. Locknut

Fig. 5, Pedal Base Plate



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1. Brake Pedal
2. Base Plate
3. Deck Bracket
4. Hexbolt
5. Accelerator Pedal

Fig. 6, Base Plate with Deck Bracket

5. Install any wiring clamps that were removed, and secure the wiring with tie straps to remove any slack.

Floor-Mounted Pedal Removal and Installation

6. On FLA/FLBs and FLD 120s without a tilt steering wheel, install the upper and lower steering column cover panels.

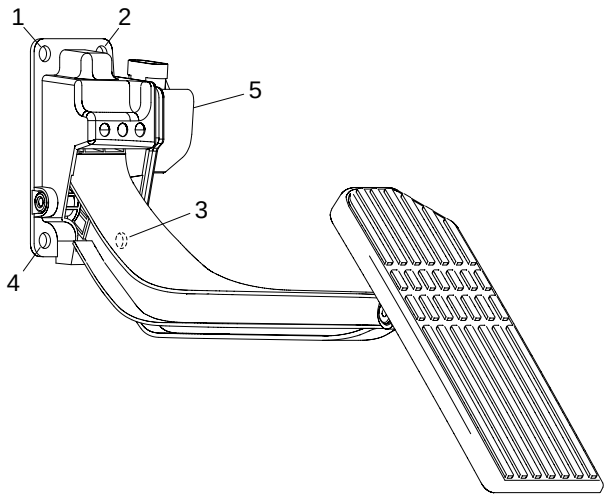
   On FLD 112s, install the knee pad.
7. Position the carpet and insulation to cover the frontwall.
8. Connect the batteries.
9. Test the pedal operation using the diagnostic software tool specified in **Table 1**.

Suspended Pedal Removal and Installation

The following procedures may be performed on suspended pedals only. For instructions on removing or installing a floor-mounted accelerator pedal assembly, see **Subject 100**.

Removal

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries.
3. Disconnect the pedal position sensor wiring harness.
4. Remove the four fasteners that secure the accelerator pedal base cup to the inside of the bulkhead. See **Fig. 1**.
5. Remove the pedal assembly.



1. Fastener #1
2. Fastener #2
3. Fastener #3
4. Fastener #4
5. Pedal Position Sensor

Fig. 1, Accelerator Pedal Assembly

Installation

1. Align the accelerator pedal assembly with the mounting holes on the inside of the bulkhead.

NOTE: Right-hand drive (RHD) vehicles have an adhesive-backed gasket. Ensure that the gasket is in place between the pedal base cup and the bulkhead.

2. Install the pedal assembly mounting fasteners and tighten them 7 to 12 lbf·ft (9 to 16 N·m).
3. Connect the pedal position sensor wiring harness.
4. Depress the accelerator pedal several times and ensure that the pedal does not stick or bind.
5. Connect the batteries.
6. Test the pedal operation using the diagnostic software tool specified in **Table 1**.

Diagnostic Software Tools	
Engine Manufacturer	**Software Tool**
Caterpillar	Caterpillar Electronic Technician (CAT ET)
Cummins	INSITE
Detroit Diesel	Detroit Diesel Diagnostic Link
Mercedes-Benz	Detroit Diesel Diagnostic Link

Table 1, Diagnostic Software Tools

Heel Spring Replacement, Floor-Mounted Pedal

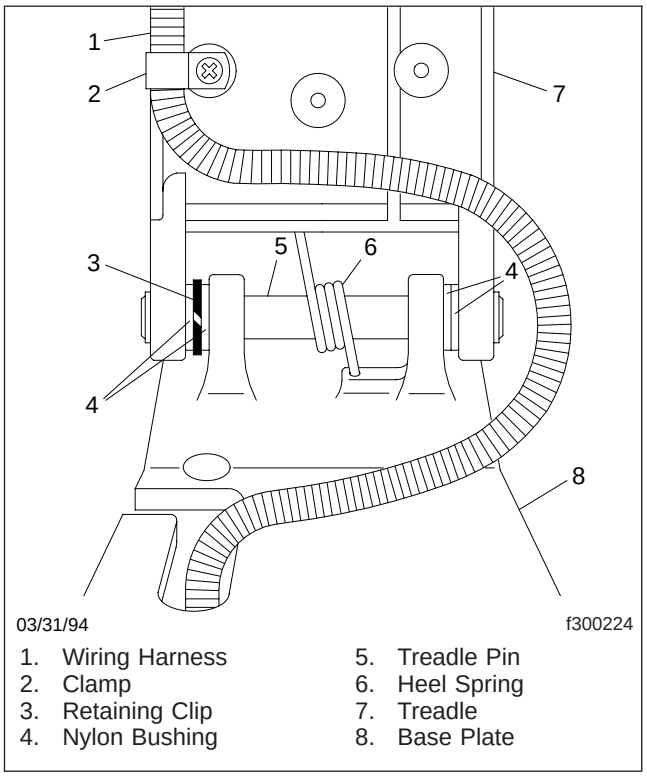
The following procedure can be performed on floor-mounted pedals only.

Replacement

Heel springs can be replaced in one of two ways, depending on the pedal base plate type:

- If the pedal base plate is steel, remove the upper assembly. For instructions, see **Subject 100**. While installing the treadle, discard the old heel spring and install a new one. Install the upper pedal assembly.
- If the pedal base plate is cast-aluminum, painted black, complete the procedure below to replace the heel spring.

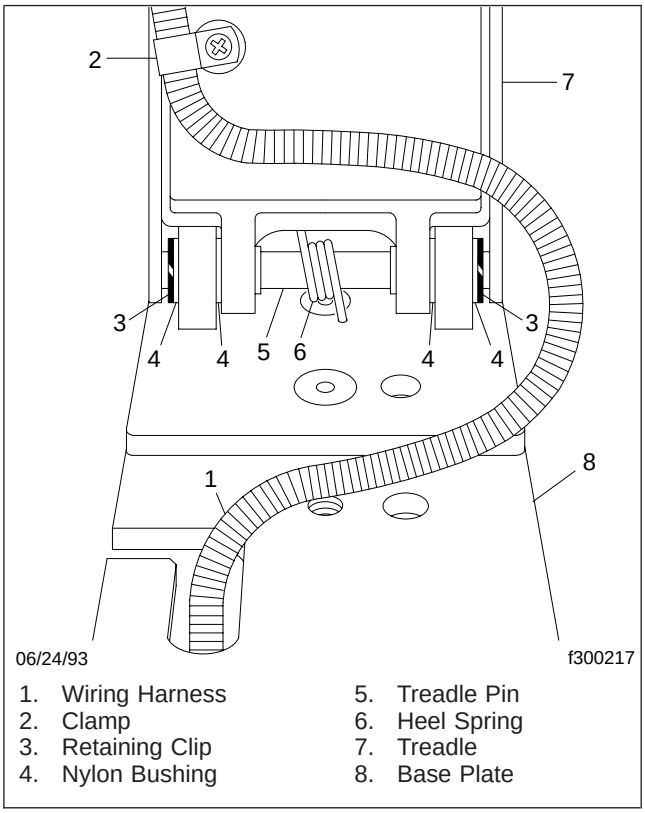
1. Remove the entire pedal assembly. For instructions, see **Subject 100**.
2. Lift the accelerator pedal up from the base plate, find the retaining clip(s) that holds the treadle pin connecting the pedal to the base plate, and remove and discard the clip(s).
3. Remove and discard the treadle pin and the heel spring, then remove the accelerator pedal from the base plate.
4. Remove and discard the nylon bushings from the ears of the pedal treadle and the base plate.
5. Install two new nylon bushings in the treadle and base plate. On pedal assemblies with two retaining clips, install the flanges outboard. On pedals with one retaining clip, install the flanges inboard. See **Fig. 1** or **Fig. 2**.
6. Install the new heel spring on the base plate so that the long leg of the spring sits in the hole of the base plate.
7. Install a new treadle pin through the treadle, heel spring, and base plate.
8. Install the retaining clip(s) onto the treadle pin, between the nylon bushings. See **Fig. 1** or **Fig. 2**.
9. Install the accelerator pedal assembly. For instructions, see **Subject 100**.



1. Wiring Harness
2. Clamp
3. Retaining Clip
4. Nylon Bushing
5. Treadle Pin
6. Heel Spring
7. Treadle
8. Base Plate

Fig. 1, Pedal Assembly (1 retaining clip)

Heel Spring Replacement, Floor-Mounted Pedal



1. Wiring Harness
2. Clamp
3. Retaining Clip
4. Nylon Bushing
5. Treadle Pin
6. Heel Spring
7. Treadle
8. Base Plate

Fig. 2, Pedal Assembly (2 retaining clips)

Left-hand drive (LHD) FLD vehicles manufactured on or after April 2, 2007, do not have replaceable sensors. The new pedal assemblies use thread-forming screws to mount the sensor to the pedal housing. Sensor replacement will strip the threads, so the entire pedal assembly must be replaced when a new sensor is needed. For instructions, see **Subject 110**.

NOTE: Only pedal position sensors with mounting slots are adjustable.

Sensor Adjustment

NOTE: Pedals used with Cummins electronic engines are not adjustable. If the pedal is not operating correctly, replace the sensor or the pedal assembly as necessary.

1. Apply the parking brakes and chock the tires.
2. If necessary, loosen the clamps that secure the wiring harness to the pedal assembly.
3. Loosen the two screws that hold the sensor in the sensor housing.
4. Connect the appropriate diagnostic software tool to the vehicle's electronic datalink. Adjust the sensor by rotating it in its housing until the reader displays the correct idle output. See **Table 1**.
5. Depress the pedal to the full throttle position. Check the output on the reader against the correct full throttle output in **Table 1**.

IMPORTANT: Do not overtighten the sensor screws. Overtightening the screws can damage the sensor.

6. After the sensor is adjusted to the correct specifications, tighten the two sensor screws 10 to 12 lbf·in (110 to 135 N·cm).
7. Tighten the wiring harness clamps.
8. Depress the accelerator pedal several times and ensure that the pedal does not stick or bind.

Pedal Position Sensor Adjustment			
Engine	**Diagnostic Software Tool**	**Idle Output**	**Full Throttle Output**
Caterpillar	Caterpillar Electronic Technician (CAT ET)	5–20% duty cycle	80–95% duty cycle
Detroit Diesel	Detroit Diesel Diagnostic Link	27–29 counts	220–232 counts
Mercedes-Benz	Detroit Diesel Diagnostic Link	27–29 counts	220–232 counts

Table 1, Pedal Position Sensor Adjustment

Treadle Lever Spring Replacement, Floor-Mounted Pedal

The following procedure can be performed on floor-mounted pedals only.

Spring Replacement

1. Remove the accelerator pedal assembly. For instructions, see **Subject 100**.
2. Remove the rubber treadle cover, if equipped.
3. Place the pedal in a vise with the treadle down and the lever arm up.

IMPORTANT: Use a 3/32-inch punch to remove the roller pin from the lever arm. A larger punch could damage the lever arm.

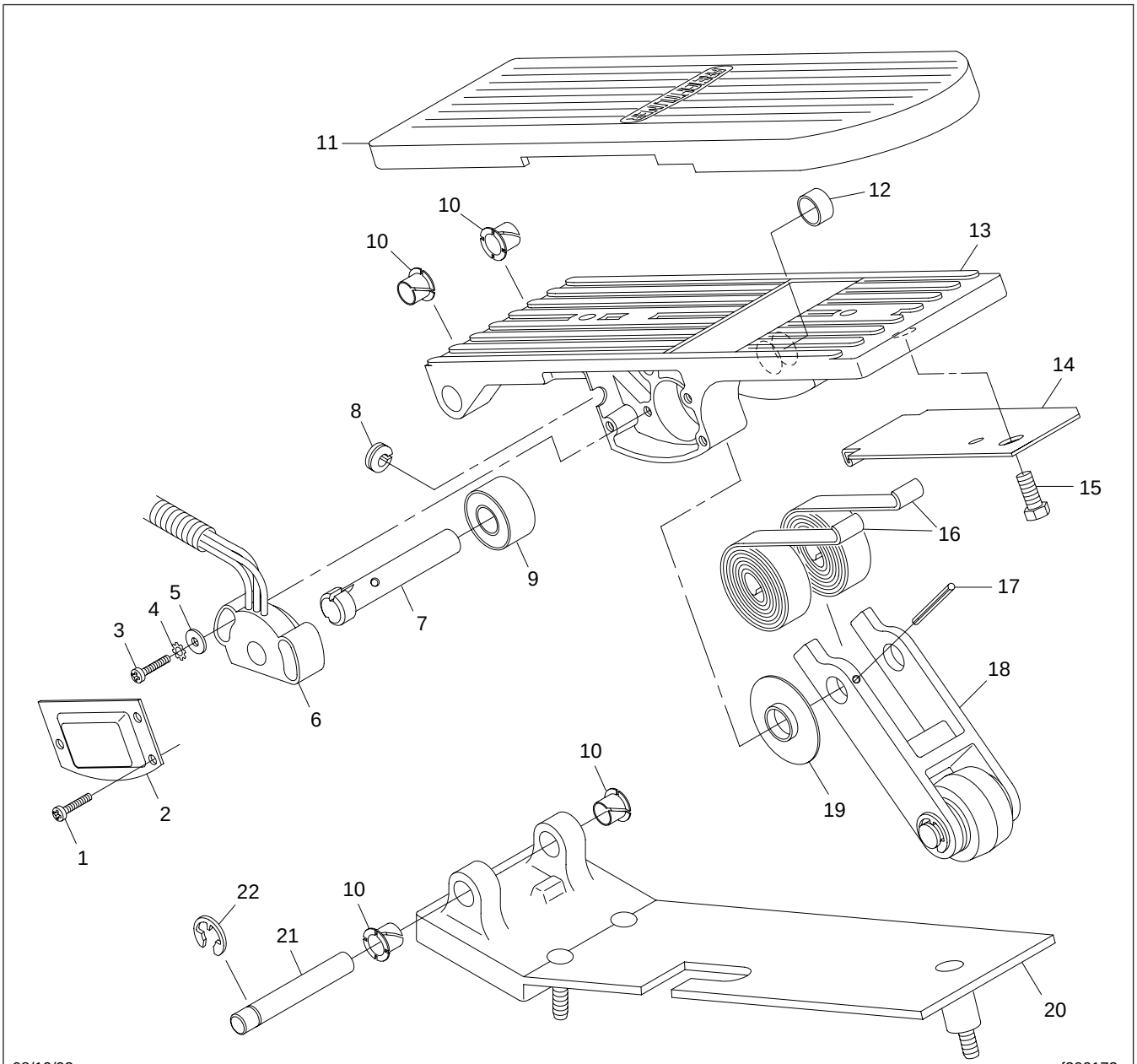
4. Use a 3/32-inch punch to remove the roller pin from the lever arm and sensor shaft. Discard the roller pin.
5. Using a small punch, carefully press the sensor shaft and ball bearing out of the housing. Discard the sensor shaft. Retain the ball bearing.
6. Remove the lever arm, the existing springs, the bushing, and the shim washer.

   Discard the springs. Retain the lever arm, the bushing, and the shim washer.
7. Insert the ball bearing and the shim washer into the sensor housing. Position the springs and the lever arm in the pedal so that the sensor shaft will pass through them.
8. Insert the sensor shaft into the pedal. Align the sensor shaft so that the tangs of the springs engage the grooves in the shaft.

IMPORTANT: Be sure that the external spring tangs hook onto the spring plate or the spring anchor hook cast into the bottom of the treadle. See **Fig. 2**.

9. Use a 3/32-inch punch to install a new roller pin through the lever arm and sensor shaft.
10. Install the rubber treadle cover, if equipped.
11. Install the accelerator pedal assembly. For instructions, see **Subject 100**.

Treadle Lever Spring Replacement, Floor-Mounted Pedal

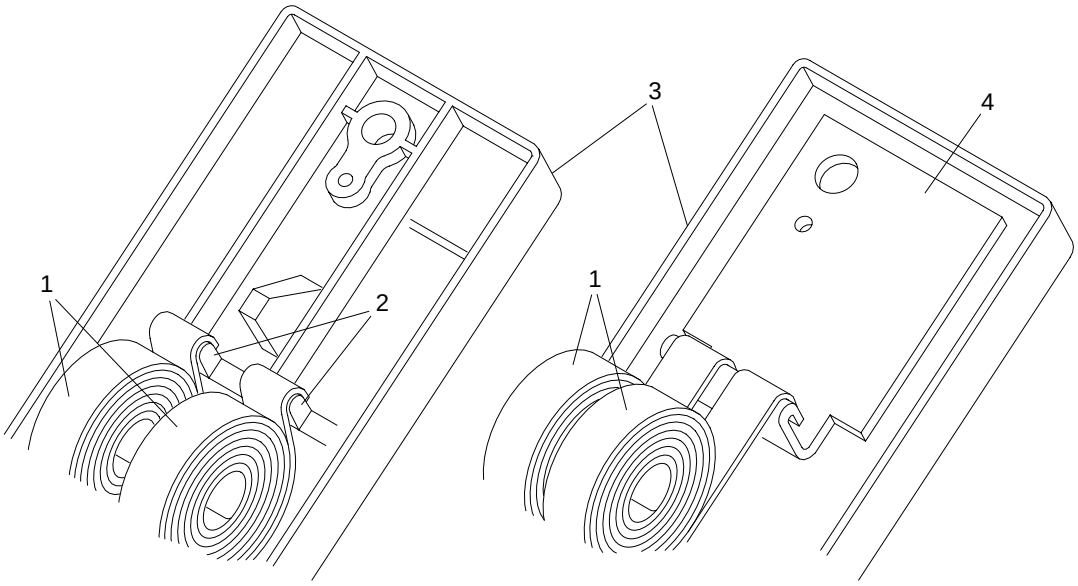


NOTE: Instead of a spring plate, some pedal assemblies have spring anchor hooks cast into the underside of the treadle.

1. Screw
2. Sensor Cover
3. Screw
4. Star Washer
5. Flatwasher
6. Sensor
7. Sensor Shaft
8. Grommet
9. Ball Bearing
10. Bushing
11. Treadle Cover
12. Bushing
13. Treadle
14. Spring Plate
15. Self-Tapping Screw
16. Flat Springs
17. Roller Pin
18. Lever Arm
19. Shim Washer
20. Base Plate
21. Treadle Pin
22. Retaining Clip

Fig. 1, Accelerator Pedal Assembly

Treadle Lever Spring Replacement, Floor-Mounted Pedal



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1. Lever Arm Springs
2. Spring Anchor Hook
3. Treadle
4. Spring Plate

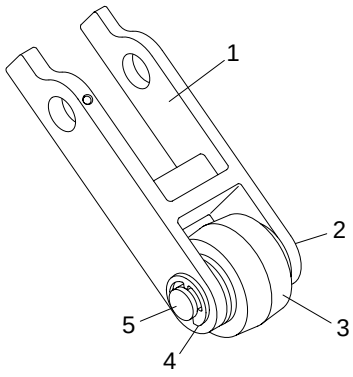
Fig. 2, Spring Anchor Hooks or Spring Plate

Treadle Lever Roller Replacement, Floor-Mounted Pedal

The following procedure can be performed on floor-mounted pedals only.

Roller Replacement

1. Remove the accelerator pedal assembly. For instructions, see **Subject 100**.
2. Remove and discard the retaining rings. See **Fig. 1**.



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1. Lever Arm
2. Retaining Ring (not shown)
3. Roller
4. Retaining Ring
5. Roller Pin

Fig. 1, Treadle Lever and Roller

3. One end of the roller pin is knurled. Clamp the pedal assembly in a vice so that the lever arm is supported, but the roller pin—knurled side down—is not supported.
4. Using a 1/4-inch punch, drive the roller pin out of the lever arm.
5. Discard the roller pin and roller.
6. Place a new roller in the lever arm, and insert a new roller pin. Insert the new pin from the same side the old pin was removed.
7. Use a 1/4-inch punch to drive the roller pin all the way into place, and secure the pin with two new retaining rings.
8. Install the accelerator pedal assembly. For instructions, see **Subject 100**.

Pedal Position Sensor Replacement

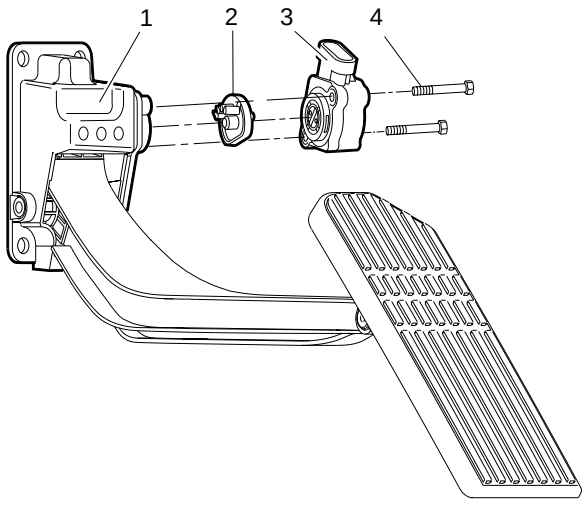
NOTE: Left-hand drive (LHD) FLD vehicles manufactured on or after April 2, 2007, do not have replaceable sensors. The new pedal assemblies use thread-forming screws to mount the sensor to the pedal housing. Sensor replacement will strip the threads, so the entire pedal assembly must be replaced when a new sensor is needed. For instructions, see **Subject 110**.

Replacement

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries.
3. Remove the pedal assembly. For instructions, see **Subject 100** for floor-mounted pedal assemblies, or **Subject 110** for suspended pedal assemblies.

IMPORTANT: Do not remove the pedal assembly from right-hand drive (RHD) vehicles. Disconnect the pedal position sensor wiring harness and proceed with the instructions below.

4. Remove the two mounting fasteners that connect the sensor to the pedal assembly. See **Fig. 1**. Remove the pedal position sensor from the pedal assembly.
5. Align the new sensor with the spline on the pinion gear, then push it into the pedal assembly. Slightly rotate the sensor so the mounting holes line up with the pedal assembly. See **Fig. 1**.
6. Install the sensor mounting fasteners and tighten them 25 to 30 lbf·in (280 to 340 N·cm).
7. Install the pedal assembly (LHD vehicles only). For instructions, see **Subject 100** for floor-mounted pedal assemblies, or **Subject 110** for suspended pedal assemblies.
8. Connect the sensor wiring harness.
9. Connect the batteries.
10. Test the pedal operation using the diagnostic software tool specified in **Table 1**.



1. Accelerator Pedal Assembly
2. Pinion Gear
3. Pedal Position Sensor
4. Mounting Screws

Fig. 1, Pedal Position Sensor Installation

Diagnostic Software Tools	
Engine Manufacturer	**Software Tool**
Caterpillar	Caterpillar Electronic Technician (CAT ET)
Cummins	INSITE
Detroit Diesel	Detroit Diesel Diagnostic Link
Mercedes-Benz	Detroit Diesel Diagnostic Link

Table 1, Diagnostic Software Tools

NOTE: Vehicles built before April 2, 2007, may require pedal position sensor adjustment after the sensor is replaced. For instructions, see **Subject 130**.

Complete the following procedures to diagnose accelerator pedal assembly and pedal position sensor problems.

Common Problems and Indications

The accelerator pedal assembly was designed so that the pedal position sensor will not reach the internal stop points when it is mounted to the pedal assembly. Attempting to modify the sensor or forcing the sensor shaft beyond the internal stop points will result in severe damage to the sensor.

A number of symptoms may be reported that can indicate a problem with the accelerator pedal, pedal position sensor, or wiring to the engine, including:

- low power or poor acceleration
- slow deceleration
- vehicle does not reach top speed
- engine is stuck at idle
- engine brake does not function
- check engine light comes on
- engine fault code indicates a pedal position sensor problem

A thorough diagnosis of the entire sensor system must be performed to ensure that a pedal position sensor is faulty. Symptoms may disappear when the pedal position sensor is replaced even if the sensor is not faulty.

Diagnostics

IMPORTANT: Left-hand drive (LHD) FLD vehicles manufactured on or after April 2, 2007, do not have replaceable sensors. The new pedal assemblies use thread-forming screws to mount the sensor to the pedal housing. Sensor replacement will strip the threads, so the entire pedal assembly must be replaced when a new sensor is needed. For instructions, see **Subject 110**.

1. Connect the vehicle to the appropriate diagnostic software tool. See **Table 1** for a list of diagnostic software tools for each engine.

Diagnostic Software Tools	
Engine Manufacturer	**Software Tool**
Caterpillar	Caterpillar Electronic Technician (CAT ET)
Cummins	INSITE
Detroit Diesel	Detroit Diesel Diagnostic Link
Mercedes-Benz	Detroit Diesel Diagnostic Link

Table 1, Diagnostic Software Tools

NOTE: All desired signal values are approximate. Each individual vehicle and electrical system will exhibit some variation in signal values. The engine control system compensates for this variation. These diagnostic procedures are designed to identify malfunctioning components of the pedal assembly and electrical system.

2. Make a note of the signal values at idle. See **Table 2** for the correct signal values.
3. Slowly depress the accelerator pedal and monitor the signals.

NOTE: There is a short time delay between pedal movement and display of the corresponding data.

4. Make a note of all signal values when the pedal has been pressed halfway.
5. Make a note of all signal values at full throttle.
6. Verify idle validation signal (IVS) inputs, if equipped.

NOTE: The pedal position sensor used with Caterpillar engines is a pulse-width modulated (PWM) sensor. It cannot be diagnosed using a digital multimeter set to measure voltage or resistance. A multimeter capable of measuring "duty cycle" may be used to view the sensor output.

7. If any signal does not change, measure the sensor voltage supply and ground circuits with a digital multimeter as follows.
    - 7.1 Use EZWiring™ in ServicePro or PartsPro to identify the circuit(s) that supply voltage to the pedal position sensor.

Troubleshooting

IMPORTANT: The ignition key must be in the ON position.

7.2 Disconnect the connector nearest the pedal and measure the voltage supply.

8. If a 5-volt supply is not present, look for a fault in the circuit between the pedal and the common powertrain controller (Detroit Diesel and Mercedes-Benz) or the motor control module (Caterpillar and Cummins engines).
9. Inspect and ensure that all connector pins at the pedal position sensor, frontwall, and the engine controller are free of corrosion and are not bent or damaged. Inspect and ensure that the connections between the pins and the wires are secure and also free of corrosion.
10. If the problem has not been resolved, the problem is not with the pedal position sensor. See the engine manufacturer's service literature for further guidance.

Diagnostic Software Values*			
Engine	**Signal**	**Pedal Position**	**Desired Value†**
Caterpillar, pre-EPA07	Throttle Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	Duty Cycle	Idle	15%
		Full throttle	85%
		Between idle/full throttle	Varies smoothly between 15% and 85%
Caterpillar, EPA07	Accelerator Pedal Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	Throttle Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	Duty Cycle	Idle	15%
		Full throttle	85%
		Between idle/full throttle	Varies smoothly between 15% and 85%
Cummins, pre-EPA07	Accelerator Pedal Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	Accelerator Pedal Sensor	Idle	0.5 volts
		Full throttle	4.5 volts
		Between idle/full throttle	Varies smoothly between 0.5 and 4.5 volts
	IVS	Idle	ON
		Full throttle	OFF
	Sensor Supply	Idle	5.0 volts
		Full throttle	5.0 volts
		Between idle/full throttle	5.0 volts

Diagnostic Software Values*			
Engine	**Signal**	**Pedal Position**	**Desired Value†**
Cummins, EPA07	Accelerator Pedal Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	Accelerator Pedal Sensor	Idle	1.0 volts
		Full throttle	4.5 volts
		Between idle/full throttle	Varies smoothly between 1.0 and 4.5 volts
	Accelerator Pedal Sensor 2	Idle	0.5 volts
		Full throttle	2.25 volts
		Between idle/full throttle	Varies smoothly between 0.5 and 2.25 volts
	Sensor Supply (both)	Idle	5.0 volts
		Full throttle	5.0 volts
		Between idle/full throttle	5.0 volts
Detroit Diesel and Mercedes-Benz, pre-EPA07	Accelerator Pedal Raw Sensor	Idle	15%
		Full throttle	75%
		Between idle/full throttle	Varies smoothly between 15% and 75%
	Accelerator Pedal Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	IVS	Idle	ON (grounded)
		Full throttle	OFF (open)
	Supply Analog Accelerator Pedal	Idle	5.0 volts
		Full throttle	5.0 volts
		Between idle/full throttle	5.0 volts

Troubleshooting

Diagnostic Software Values*			
Engine	**Signal**	**Pedal Position**	**Desired Value†**
Detroit Diesel and Mercedes-Benz, EPA07	Accelerator Pedal Raw Sensor	Idle	15%
		Full throttle	75%
		Between idle/full throttle	Varies smoothly between 15% and 75%
	Accelerator Pedal Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	IVS1	Idle	ON (grounded)
		Full throttle	OFF (open)
	IVS2	Idle	OFF (open)
		Full throttle	ON (grounded)
	Supply Analog Accelerator Pedal	Idle	5.0 volts
		Full throttle	5.0 volts
		Between idle/full throttle	5.0 volts

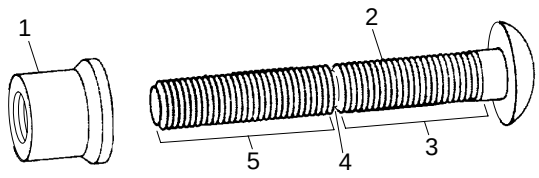
* All desired signal values are approximate. Each individual vehicle and electrical system will exhibit some variation in signal values.

† There is a short time delay between pedal movement and display of the corresponding data.

Table 2, Diagnostic Software Values

General Information

Either Huckbolts® or grade 8 hexhead bolts and grade C prevailing torque locknuts are used for frame attachments. **See Fig. 1 and Fig. 2**. For attachments where clearance is minimal, low-profile hexhead bolts and grade C prevailing torque locknuts are used. For some components, grade 8.2 flanged hexhead bolts and grade G prevailing torque locknuts are used for frame attachments. **See Fig. 3**. Prevailing torque locknuts of all three bolt types have distorted sections of threads to provide torque retention.



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1. Collar
2. Huckbolt
3. Locking Grooves
4. Breakneck
5. Pulling Grooves

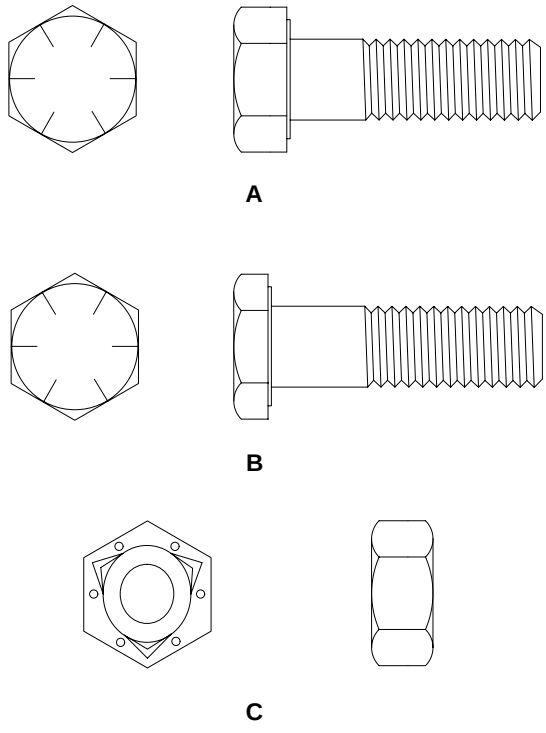
Fig. 1, Huckbolt Fastener

When nonflanged hexhead bolts and locknuts are used on an aluminum frame member or an attached part, a hardened flatwasher is required to prevent the bolt head or nut from embedding in the frame or part. In general, hardened washers are used to distribute the load, and to prevent localized overstressing of the frame rails, brackets, and other parts. They are placed directly against the part, under the nut or bolt head. These special hardened washers are used on aluminum or steel frame rails, and for the engine rear supports, rear suspension brackets, and fifth wheel mountings. They are cadmium-or zinc-plated, and have a hardness rating of 38 to 45 HRC.

Flanged hexhead bolts and locknuts have integral flanges which eliminate the need for washers on steel and aluminum surfaces. The fasteners are placed directly against the frame where the part is attached.

HEXHEAD BOLT REPLACEMENT

Replace hexhead bolts with identical fasteners. Refer to the Freightliner *Parts Book* for fastener specifications.



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A. Grade 8 Hexhead Bolt
B. Grade 8 Low-Profile Hexhead Bolt
C. Grade C Prevailing Torque Locknut

Fig. 2, Hexhead Fasteners

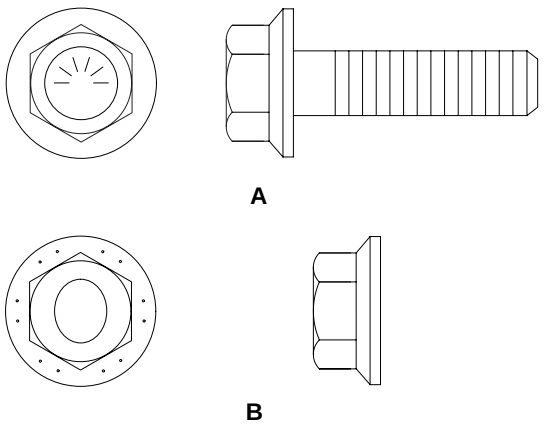
Apply Alumilastic® compound, or an equivalent, to all bolts, nuts, and washers that contact aluminum frame rails or aluminum parts.

⚠ CAUTION

CAUTION: Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the frame or parts.

Never hammer or screw bolts into place. Align the holes of the frame and the part being attached to it, so that the nut and bolt surfaces are flush against the frame and the part. For bolts 4 inches (102 mm) or less in length, make sure that at least 1-1/2 threads and no more than 5/8-inch (16-mm) bolt

General Information



A. Grade 8.2 Flanged Bolt
B. Grade G Prevailing Torque Locknut

Fig. 3, Flanged Hexhead Fasteners

length extend through the self-locking nut after it has been tightened. For bolts longer than four inches (102 mm), allow a minimum of 3 threads and a maximum of 3/4-inch (19-mm) bolt length.

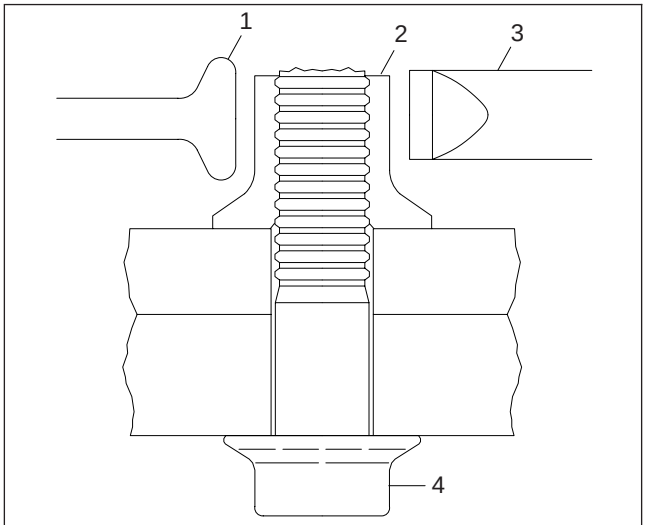
HUCKBOLT REMOVAL

Huckbolt HP8® frame fasteners (**see Fig. 1**) have parallel locking grooves on the lockbolt pintail. The swaged collar cannot be unscrewed. Use the Huck Collar Cutter to remove HP8 fasteners. If the Collar Cutter isn't available, split the collar with an air chisel while supporting the opposite side of the collar with an anvil. **See Fig. 4**. Then, drive out the lockbolt with a punch. Discard the fastener after removing it.

HUCK-FIT® frame fasteners have locking threads instead of grooves; the collar can be removed using a standard impact wrench and sockets. Discard the fastener after removing it.

⚠ CAUTION

CAUTION: Never attempt to reuse any Huck fastener that has been removed. Even though HUCK-FIT fasteners can be removed with a socket wrench, they cannot be correctly installed again. Reusing any Huck frame fastener can result in damage to the vehicle frame or components attached to the frame.



1. Anvil
2. Lockbolt Collar
3. Chisel
4. Lockbolt

Fig. 4, Huckbolt Removal

HUCKBOLT INSTALLATION

NOTE: Huckbolts cannot be installed without the proper Huckbolt installation equipment.

1. Insert the pintail through the prepared hole in the frame or other component. **See Fig. 5**.

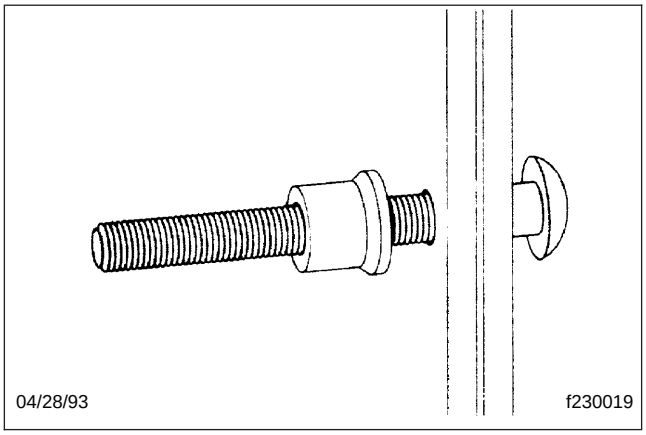


Fig. 5

2. Place the collar over the pintail.
3. Place the Huck installation tool nose assembly over the pintail. **See Fig. 6**. The pintail pulling

grooves ratchet into the chuck jaws, which securely grip the pintail.

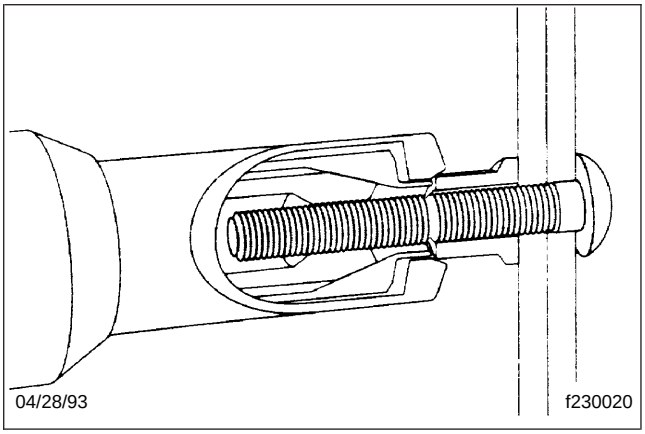


Fig. 6

4. As the installation tool trigger is pulled, the tool piston and chuck jaws move rearward, pulling on the pintail, seating the bolt head, and closing the gap between the work surfaces. As pulling on the pintail continues, the collar is swaged into the locking grooves on the pintail; and the collar is lengthened, developing clamping force. **See Fig. 7**.

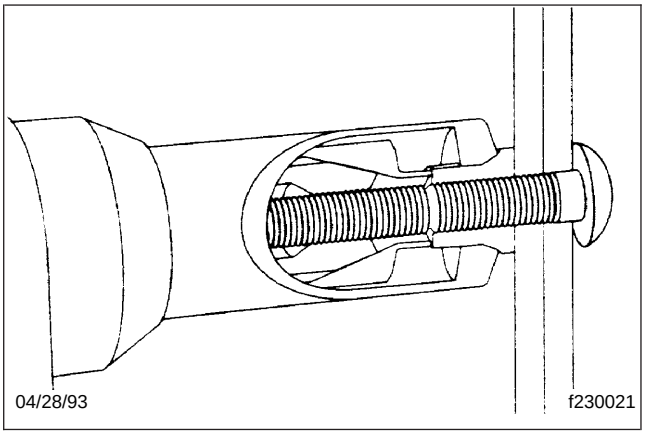


Fig. 7

5. The pintail breaks (**see Fig. 8**), freeing the nose assembly anvil from the swaged collar.

NOTE: Most Huck fasteners have a constriction, the breakneck (**see Fig. 1**), which determines the point where the pintail breaks free. MAGNA-GRIP® fasteners do not have this breakneck;

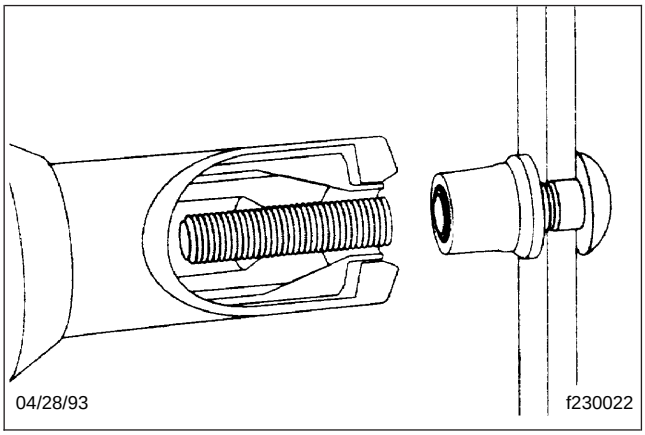


Fig. 8

the pintail should break flush with the top of the collar. No more than two grooves should be visible on the collar after installation. **See Fig. 9** for examples of acceptable and unacceptable MAGNA-GRIP pintail breaks.

FRAME FASTENER TIGHTENING

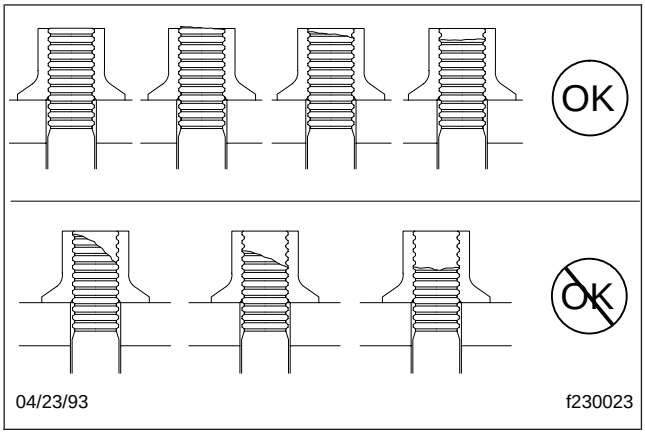


Fig. 9

CAUTION

CAUTION: Continued vehicle operation with loose fasteners could result in component, bracket, and frame damage.

Tighten hexhead bolts and locknuts periodically to offset the effects of "bedding in" (seating). Refer to the Maintenance Schedule and the frame section in the vehicle maintenance manual for intervals.

General Information

When tightening the fasteners, tighten the nut, not the bolt head. This will give a true torque reading by eliminating bolt body friction. For torque specifications, refer to the general information section in the vehicle maintenance manual.

NOTE: Huck fasteners do not require periodic tightening.

General Description

IMPORTANT: This service manual *does not cover* the procedures and calculations necessary to perform frame modifications. For basic information, refer to the *Freightliner Body Builder's Manual*; for more extensive frame modifications, be sure to consult with the Freightliner Engineering Department.

The main body of the frame is two frame rails secured together by crossmembers. See **Fig. 1** and **Fig. 2**. The frame assembly is supported on the front and rear axles, and supports the rest of the chassis and body.

Both frame rails are made of steel or aluminum, and both have identical specifications. Each rail has an upper flange, lower flange, and web (the surface area between the flanges). The inside area of the frame rail is called the channel. See **Fig. 3**.

The crossmembers control axial rotation and longitudinal motion of the rails, and reduce torsional stress transmitted from one rail to the other. Crossmembers are also used for vehicle component mounting, and protecting the wires and tubing that are routed from one side of the vehicle to the other.

Follow the guidelines in this section when servicing the frame. For information on installation of specialized equipment on the frame, refer elsewhere in this section.

FRAME STATIONS

A frame station is a reference point on the frame rail from which the location of each component (mounted on the frame rail) is measured. There are two frame stations on the frame rails: station zero (usually written as 0.00"); and station 100. See **Fig. 4**, **Fig. 5**, **Fig. 6**, and **Fig. 7**.

There is no identifying mark for station zero. On axle forward vehicles (**Fig. 4**), station zero is located 0.25 inch (6.4 mm) to the rear of the centerline of the front suspension's forward spring pin. On Conventionals with a setback axle (**Fig. 6** and **Fig. 7**), station zero is located 15.5 inches (394 mm) forward of the centerline of the front suspension's forward spring pin. On COEs with a setback axle (**Fig. 5**), station zero is located 23.75 inches (603 mm) forward of the centerline of the front suspension's forward spring pin.

Station 100 is located 100 inches (2540 mm) to the rear of station zero. Station 100 is used when station zero is not accessible because of vehicle assembly. On vehicles equipped with steel frame rails, station 100 is identified by a 1/2-inch (13-mm) high "zero" stamped near the top part of the frame rail web. On vehicles equipped with aluminum frame rails, station 100 is identified by a 1/16-inch (2-mm) deep drill point impression near the top of the frame rail web.

The vehicle's frame drilling chart lists the location of each frame rail component. For example: if a component is given a location of 120.00, then that component is installed on the frame rail 120 inches (3048 mm) aft of station zero, or 20 inches (508 mm) aft of station 100.

Handling

Whenever the frame rails are lifted or moved, take care to avoid anything that may scratch, cut, or damage the exposed frame assembly. Cushion all chain hoists or cable slings with a section of heavy hose. If the frame rail is raised with a jack, place a block of wood between the jack and the frame rail.

Never heat the frame rails for straightening purposes. Such work should be done cold, as the frame rails have been heat-treated.

⚠ CAUTION

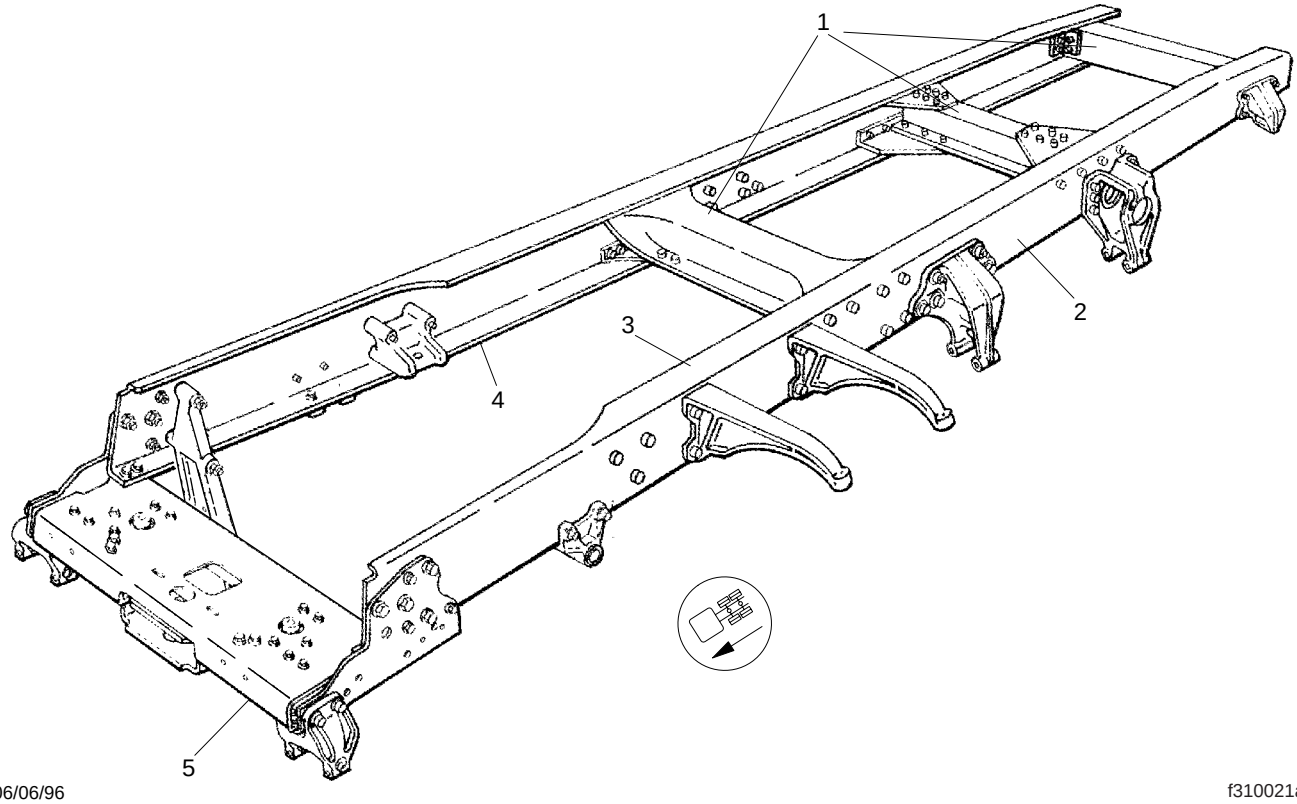
Heating the frame rail for straightening purposes will reduce the strength of the rail in localized areas, which can result in structural failure of the frame rail.

On both steel and aluminum frame rails, use pencil lines or soapstone marking for any work that requires marking of the frame rail. High visibility can be obtained by first chalking the surface of the frame rail, then making the pencil marks.

⚠ CAUTION

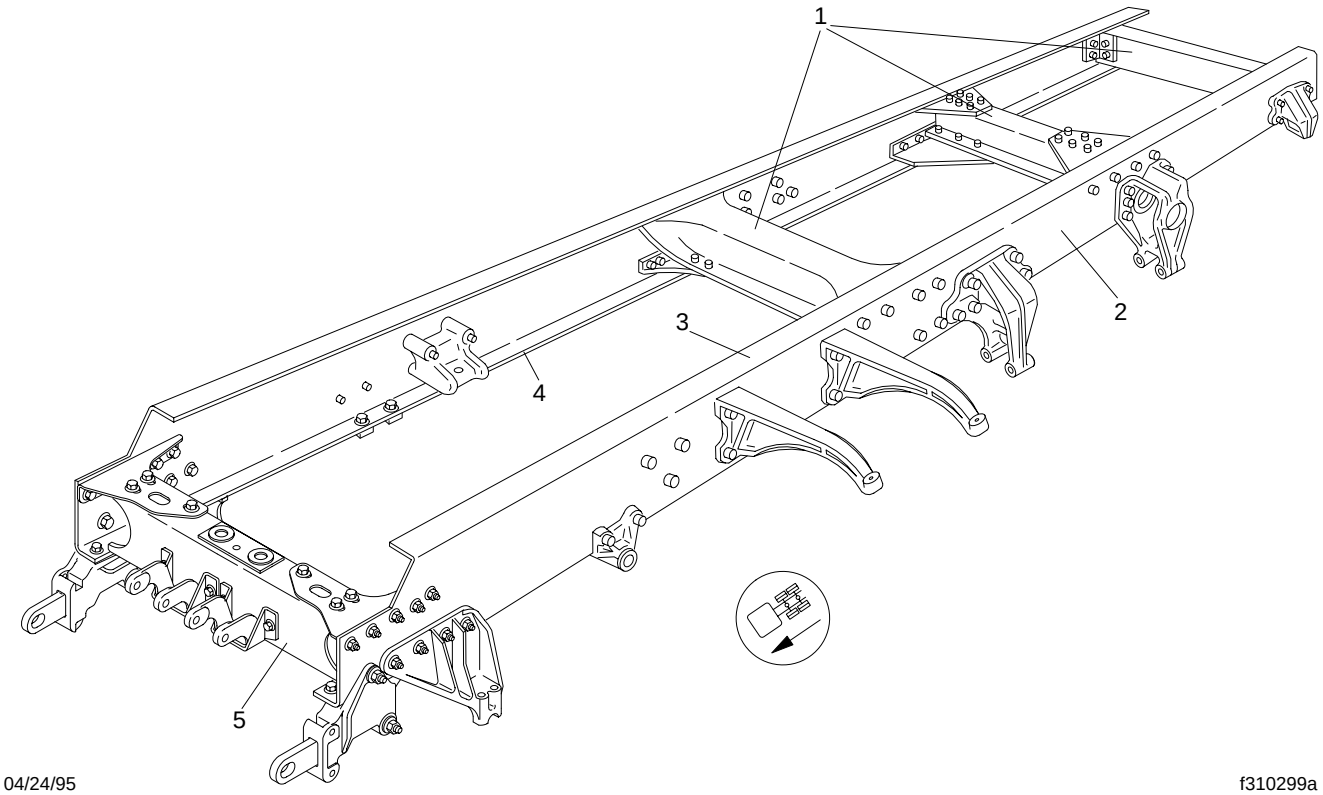
Do not use scribe lines for marking or layout work on aluminum frame rails. Scribe lines, which cut or scratch the metal, can develop into starting points for structural damage to the frame.

General Description and Handling



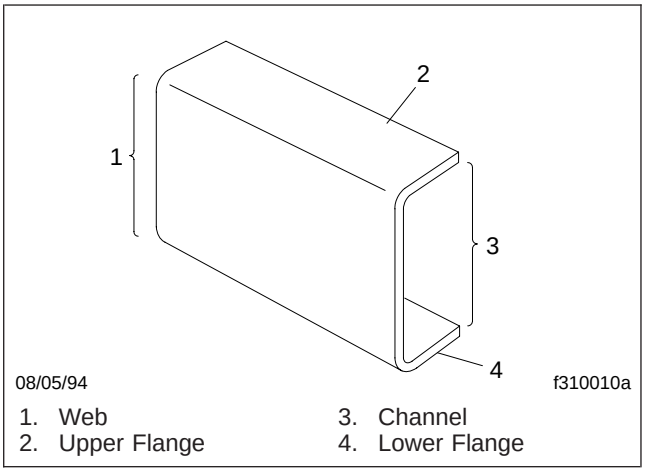
1. Frame Crossmembers
2. Frame Rail Web
3. Upper Flange
4. Lower Flange
5. Front Crossmember

Fig. 1, Frame Assembly, Drop-Style Front Crossmember and Frame Extension (axle forward shown)



1. Frame Crossmembers
2. Frame Rail Web
3. Upper Flange
4. Lower Flange
5. Front Crossmember

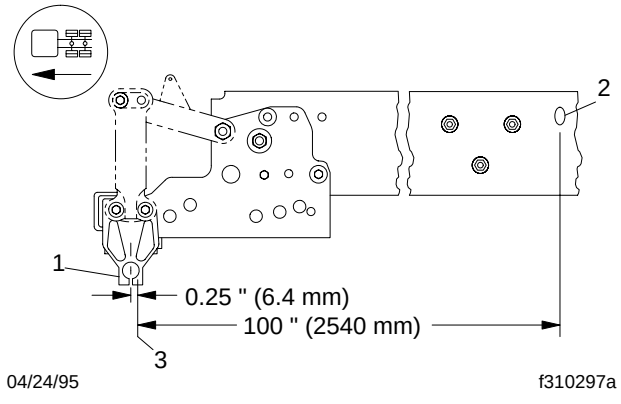
Fig. 2, Frame Assembly, C-Channel Front Crossmember, Without Drop-Style Frame Extension (setback axle FLD Conventional shown)



1. Web
2. Upper Flange
3. Channel
4. Lower Flange

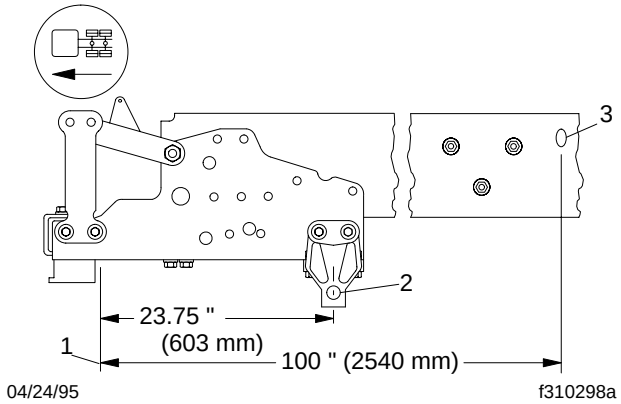
Fig. 3, Frame Terminology

General Description and Handling



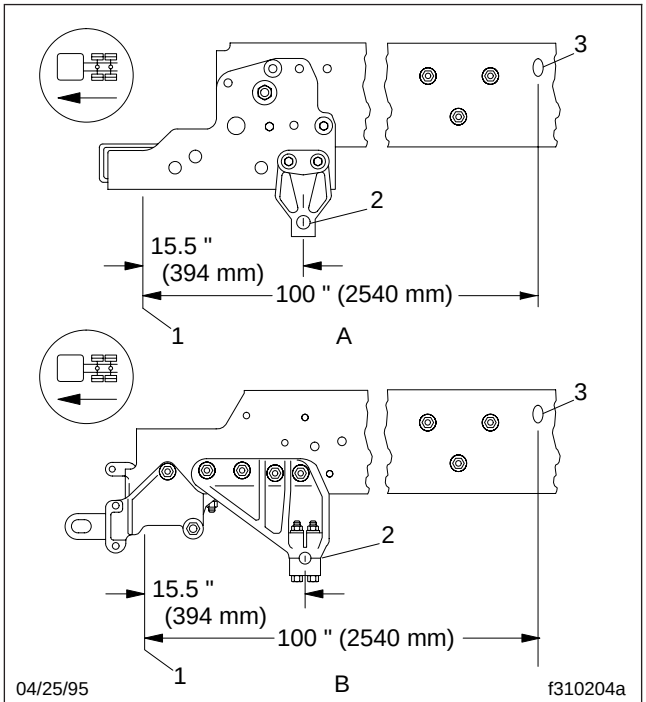
1. Front Suspension Forward Spring Pin
2. Station 100 Mark (Station 100)
3. Station Zero (0.00)

Fig. 4, Frame Rail Stations, Axle Forward FLA COE and FLD 120 Conventional



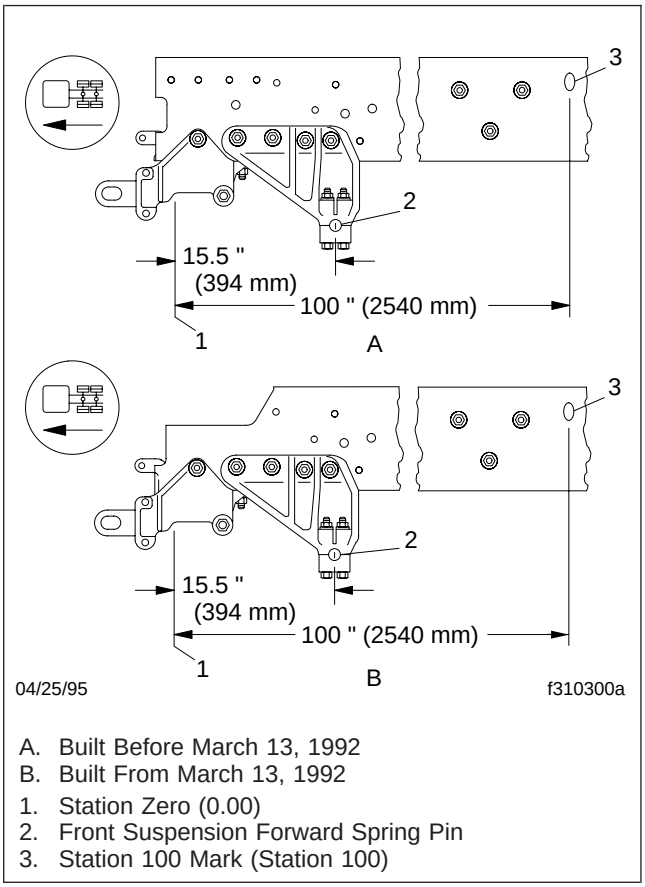
1. Station Zero (0.00)
2. Front Suspension Forward Spring Pin
3. Station 100 Mark (Station 100)

Fig. 5, Frame Rail Stations, Setback Axle FLA COE



A. With Drop-Style Frame Extension
B. Without Drop-Style Frame Extension
1. Station Zero (0.00)
2. Front Suspension Forward Spring Pin
3. Station 100 Mark (Station 100)

Fig. 6, Frame Rail Stations, Setback Axle FLD 120 Conventional



A. Built Before March 13, 1992
B. Built From March 13, 1992
1. Station Zero (0.00)
2. Front Suspension Forward Spring Pin
3. Station 100 Mark (Station 100)

Fig. 7, Frame Rail Stations, Setback Axle FLD 112 Conventional

Repairing Cracks, Filling Unused Holes, and Drilling Holes

Repairing Cracks

IMPORTANT: Daimler Trucks North America LLC recommends that cracked or damaged frame rails be replaced. In some cases it may be necessary to repair minor damage; before attempting any repairs, contact your regional service representative for approval.

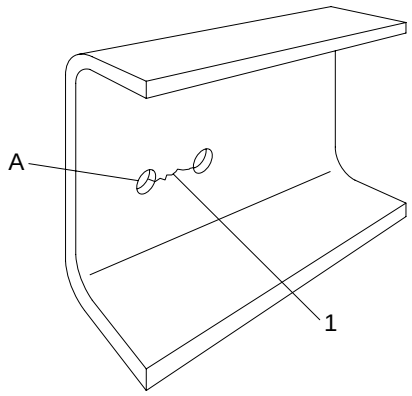
CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and any electronic control units (ECUs) installed on the vehicle. Electric currents produced during electric welding can damage various electrical components on the vehicle, such as alternator diodes and ECUs.

Freightliner vehicle components that typically use ECUs include electronic engine, electronic automatic transmission, and ABS (antilock braking system).

For any ECU with a battery power harness, disconnect its ground terminal from the chassis ground, and disconnect its power terminal from the battery positive post, or disconnect the main connection at the ECU.

1. Drill a 1/8-inch (3-mm) diameter hole at each end of the crack to prevent further spreading of the crack. See **Fig. 1**.



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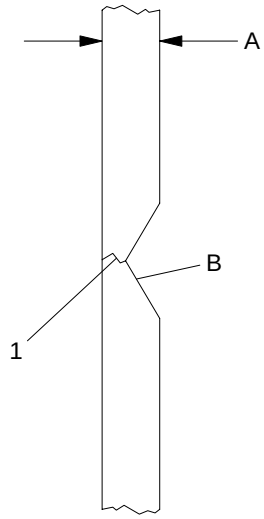
1. Drilled 1/8-inch (3-mm) diameter hole.
2. Crack

Fig. 1, Preventing Cracks from Spreading

2. Vee out the crack to a depth of two thirds of the stock thickness. See **Fig. 2**.

NOTE: If it will not be possible to grind both sides of the frame rail, then grind the vee groove on one side to the full depth of the stock thickness. See **Fig. 3**.

3. Clamp a copper or aluminum bar on the opposite side of the groove. The bar will act as a "chill" strip, minimizing the spread of heat to the surrounding area of the frame rail. See **Fig. 4**. Deposit the weld material using the applicable welding method described in this section.
4. Grind the weld flush with the frame rail. See **Fig. 5**.
5. Cut a deep enough vee groove on the opposite side of the frame rail to reach the weld metal. See **Fig. 6**.
6. Clamp the "chill" strip on the opposite side of the groove. See **Fig. 7**. Weld the vee groove, as instructed above. Make full penetration of the weld.



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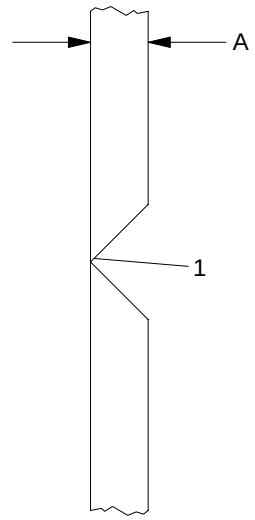
A. Frame Rail Thickness
B. Grind a vee groove to two thirds the depth of the stock thickness.

1. Crack

Fig. 2, Cross-Section View

7. Grind the weld flush with the frame rail. See **Fig. 8**.

Repairing Cracks, Filling Unused Holes, and Drilling Holes



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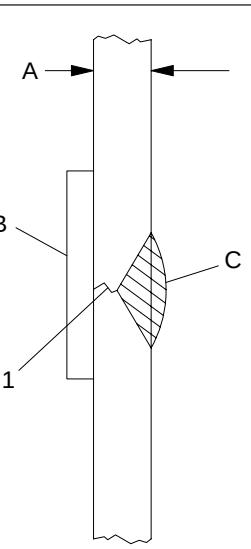
A. Frame Rail Thickness

1. Vee Groove (full depth)

Fig. 3, Full Depth Groove



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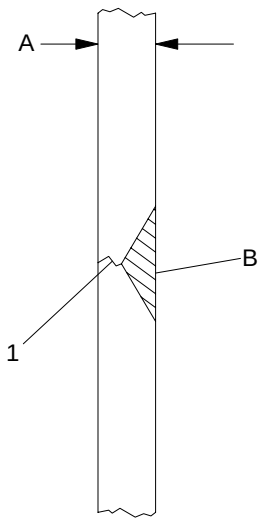
A. Frame Rail Thickness
B. Clamp the "chill" strip on the opposite side of the groove.
C. Deposit weld material.

1. Crack

Fig. 4, Using a Chill Strip



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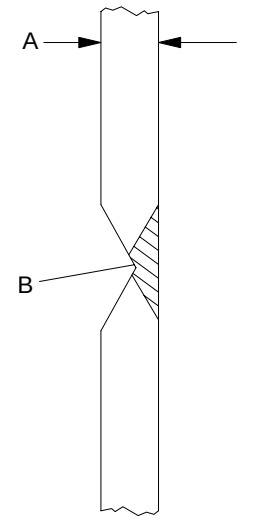
A. Frame Rail Thickness
B. Grind the weld flush with the frame rail.

1. Crack

Fig. 5, Weld Ground Flush



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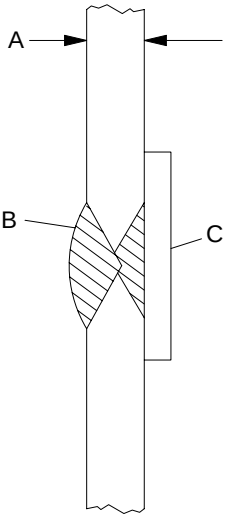
A. Frame Rail Thickness
B. Grind a vee groove deep enough to reach the weld.

Fig. 6, Cross-Section View

Repairing Cracks, Filling Unused Holes, and Drilling Holes



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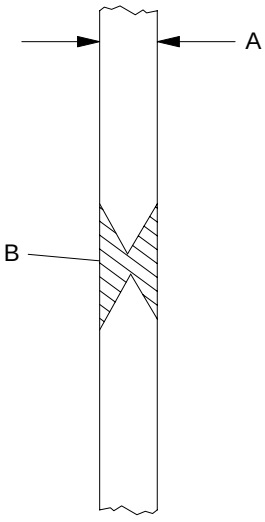
A. Frame Rail Thickness
B. Deposit weld material to penetrate the opposite weld.
C. Clamp the "chill" strip on the opposite side of the groove.

Fig. 7, Second Weld



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A. Frame Rail Thickness
B. Grind the weld flush with the frame rail.

Fig. 8, Second Weld Ground Flush

Filling Unused Holes

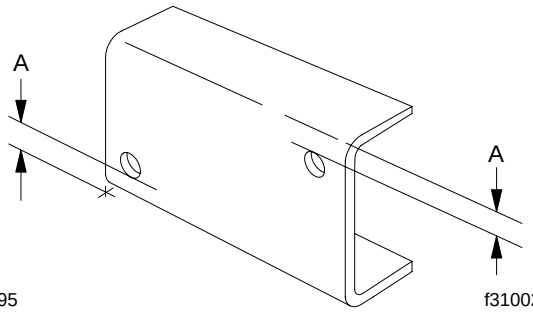
1. Fill all unused holes in the frame assembly with the applicable nut, washer, and bolt combination.
2. If the diameter of a hole is less than 3/8 inch (9.5 mm), enlarge it to 3/8 inch (9.5 mm), and fill it with the applicable nut, washer, and bolt combination.
3. Tighten the fasteners to the applicable torque value. For proper frame fastening instructions, refer elsewhere in this group.

Drilling Holes

During vehicle manufacture, holes are drilled or punched in the frame rail only as specified on the vehicle frame drilling chart. If any additional holes need to be drilled, contact your regional service representative for approval.

A single exception to this rule is that holes may be drilled for tubing clips and the like through the web portion of the channel only, with the following restrictions:

- The *edge* (not the center) of the hole must be no closer than 1-11/32 inches (34 mm) from the outer face of the flange. See **Fig. 9** for the minimum distance to the flanges that holes can be placed on the web.



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A. 1-11/32 inches (34 mm)

Fig. 9, Minimum Distance for Drilling Holes

- Material between the centerline of the hole and the outside of the upper or lower flange must be at least 2-13/32 inches (60 mm).
- Minimum material between hole centerlines must be 2 inches (50 mm).

Repairing Cracks, Filling Unused Holes, and Drilling Holes

- All attaching fasteners must be Grade 8. Flat washers must be made with high-strength steel.
- The minimum material between the rear-suspension bracket and the end of the frame must be at least 2 inches (50 mm).
- Holes between the front-axle centerline and the rear-axle centerline cannot exceed 3/4 inch (19 mm).

Welding Frame Rails

PRECAUTIONS

IMPORTANT: There are very few cases in which welding a heat-treated frame rail is allowable. If possible, avoid direct welding of the frame rail web. Before any welding is done, contact your regional service representative for approval.

⚠ CAUTION

CAUTION: Weld only as instructed in this section; all precautions and methods must be strictly followed. Failure to do so can reduce the structural strength in the welded area of the frame rail.

⚠ CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and any electronic control units (ECUs) installed on the vehicle. Electric currents produced during electric welding can damage various electrical components on the vehicle, such as alternator diodes and ECUs.

Freightliner vehicle components that typically use ECUs include electronic engine, electronic automatic transmission, and ABS (antilock braking system).

For any ECU with a battery power harness, disconnect its ground terminal from the chassis ground, and disconnect its power terminal from the battery positive post, or disconnect the main connection at the ECU.

1. Do not weld attachments to the frame rail. For guidelines on the attachment of equipment on the frame rails, refer elsewhere in this group.
2. Use only the applicable welding method under "Methods for Steel," or "Method for Aluminum."
3. Before welding, clean off any oil, grease, paint, scale, and other contaminants. Wipe dry with a clean cloth.
4. Do not weld in an area that allows drafts from any source such as windows, engines, or fans, as it will affect the soft flow of gas from the welding gun.
5. Do not weld into the radius of the frame rail flanges or along the edge of the flange.
6. Do not weld square with the frame side rail. Make all reinforcing welds at least 30 degrees from square. This will distribute the weld stresses over a larger area.
7. Do not notch, undercut, or leave craters during the welding process.
8. Keep as close to the weld centerline as possible.

METHODS FOR STEEL

Gas-metal arc welding is the recommended method. If gas-metal arc welding is not available, coated-electrode arc welding can be used. For both gas-metal arc welding and coated-electrode arc welding, direct current reverse polarity is recommended, however, alternating current can be used. Use either a short arc beading technique or a narrow weave technique.

1. Review the information under "Precautions." Then, if using the gas-metal arc weld method, proceed to the next step. If using the coated-electrode arc weld method, go to the step after the next, below.
2. For the gas-metal arc welding method, use the following requirements and specifications:
   - 2.1 Use weld wire that meets American Welding Society (AWS) specification A 5.28, Class E110S.
   - 2.2 Use Linde M-5 gas or an equivalent argon-oxygen mixture of 5 percent oxygen.
   - 2.3 For applicable machine settings, refer to the appropriate table under **Specifications, 400.**
3. For the coated-electrode arc welding method, use 1/8-inch thick AWS-E-11018 type weld rod. For amperage and voltage settings of each weld position, refer to the appropriate table under **Specifications, 400.**

IMPORTANT: Always keep the weld rod free of moisture. The welding rod being used should come directly from a hermetically sealed container, or be dried at least one hour in a 700° to 800°F (371° to 427°C) oven. Immediately after

removal from a sealed container or after drying, store the welding rod in an oven at 250°F (121°C). A welding rod that has been exposed to the atmosphere longer than one-half hour must be dried before use.

NOTE: On 1/4-inch thick frame rails only, AWS-E-9018 type weld rod can be used, however, AWS-E-11018 type weld rod is recommended.

METHOD FOR ALUMINUM

The following is for welding on *truck vehicles* with frame rails of aluminum alloy 6061-T6. Use gas-metal arc welding only.

⚠ CAUTION

CAUTION: Do not weld on tractor vehicles with aluminum frame rails. Tractor service imposes high stress in the rear frame area. Welding will result in excessive stress in this area.

⚠ CAUTION

CAUTION: Do not weld frame rails of aluminum alloy 2014-T6. Welding on this alloy can result in hot cracking, and create a heat-affected zone susceptible to stress-corrosion cracking.

1. Review the information under "Precautions."
2. Use Linde welding wire 4043 HG, or equivalent, with a 1/16-inch diameter.
3. Use Linde T Argon gas, or an equivalent plain argon gas, for the inert envelope of the welding arc.
4. Because of various conditions, consult the welding equipment manufacturer to determine the machine setting.

Lengthening Frame Rails

STEEL RAILS

Steel frame rails can be lengthened by welding a frame rail extension onto the rear of the frame rail. The frame rail end and the extension piece are cut so that they overlap each other. Obtain approval from your regional service representative before welding and lengthening the frame rail.

CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and any electronic control units (ECUs) installed on the vehicle. Electric currents produced during electric welding can damage various electrical components on the vehicle, such as alternator diodes and ECUs.

Freightliner vehicle components that typically use ECUs include electronic engine, electronic automatic transmission, and ABS (antilock braking system).

For any ECU with a battery power harness, disconnect its ground terminal from the chassis ground, and disconnect its power terminal from the battery positive post, or disconnect the main connection at the ECU.

1. Cut the frame rail end and extension to the applicable dimensions. **Figure 1** illustrates the cutting dimensions for the frame rail and extension for truck vehicles. **Figure 2** is for tractor vehicles. Refer only to the figure that relates to the vehicle being modified.

NOTE: If the length of the extension is to be 6 inches (152 mm) or less, then straight-cut the frame rail end and extension.

2. Grind the cut ends of the frame rail and extension to the dimensions in **Fig. 3**.
3. Align the cut ends of the extension piece with the cut ends of the frame rail so that there is a 1/16-to 1/8-inch (1.6- to 3.2-mm) gap between them. **See Fig. 3.** Using a torch, heat the cut ends to 70°F (21°C) before welding.

NOTE: A 1/16-inch (1.6-mm) gap is recommended. The ends must not contact each other. Maintain the joint spacing by placing a short piece of clean, 1/16-inch (1.6-mm) diameter bare steel wire between the extension and frame rail. The wire sections must be short enough to be completely fused by the welding process.

4. Using one of the methods in **Subject 110, "Methods for Steel,"** weld the extension to the frame rail, making full penetration **as shown in Fig. 4**. Remove any slag between passes, and back-gouge the root of the first vee before welding the other side.

CAUTION

CAUTION: Residual stresses will occur in the weld if the web area is not welded first, or if the flanges contact each other when welding the web.

IMPORTANT: Weld the web area first, then the flange, working from the inside of the channel. When welding the web, make sure that the flanges do not contact each other.

5. When finished welding, sand the joint for appearance. Hold the sander so that the grind runs parallel with the length of the frame rail.

CAUTION

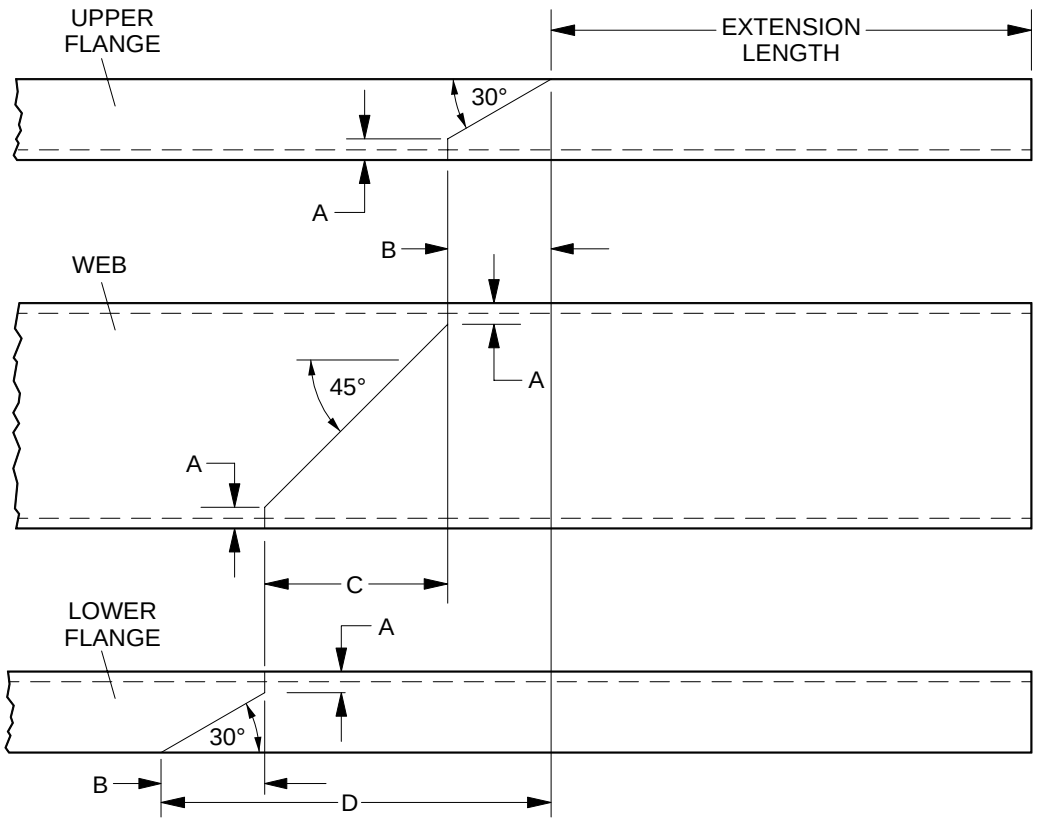
CAUTION: Do not "hollow grind" the weld. Small depressions from improper grinding of the weld will reduce the strength of the frame rail.

ALUMINUM RAILS

Only *truck vehicles* equipped with aluminum frame rails made of aluminum alloy 6061-T6 can be lengthened by welding an extension onto the rear of the frame rail. Obtain approval from your regional service representative before welding and lengthening the frame rail.

NOTE: Refer to spec line numbers 552 and 554 in the frame section in the Vehicle Spec Sheet. If the frame rail part number is 15-09331, the frame rail is aluminum alloy 6061-T6. If the part number is 15-09388, the frame rail is aluminum alloy 2014-T6.

Lengthening Frame Rails



NOTE: Left rail shown; right rail will be opposite dimensions.

FRAME RAIL SIZE inches	DIMENSION			
	A inches (mm)	B inches (mm)	C inches (mm)	D inches (mm)
10.06	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)
10.12	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)
10.38	1.12 (28.6)	5.00 (127.0)	10.00 (254.0)	20.00 (508.0)

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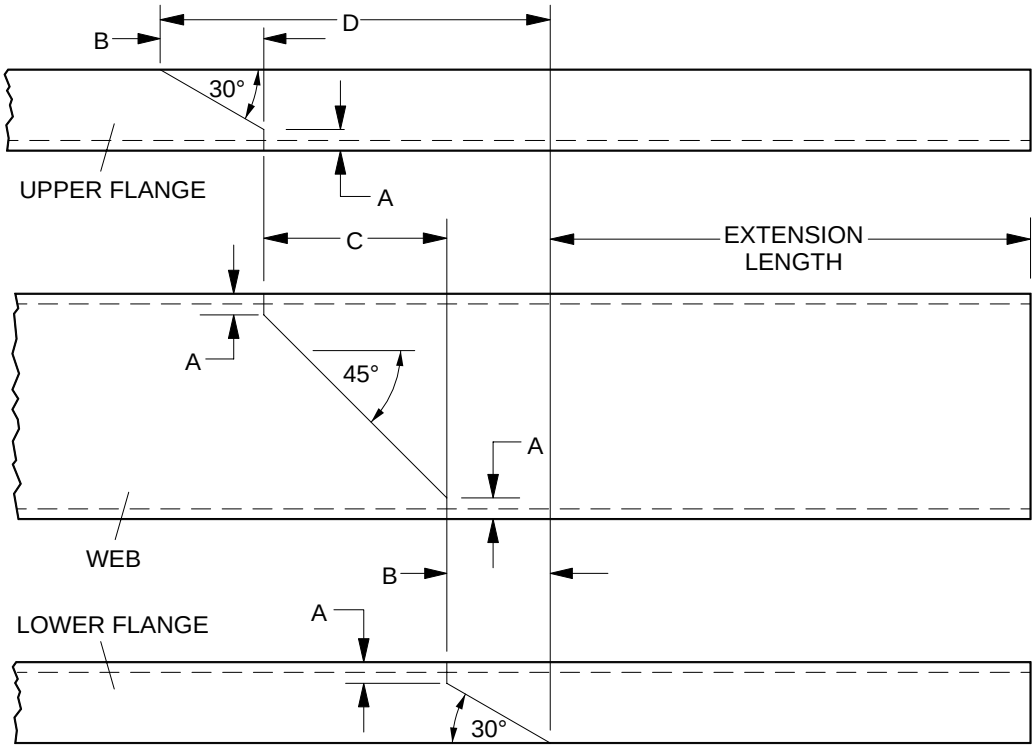
Fig. 1, Steel Frame Rail and Extension Cutting Dimensions for Truck Vehicles

⚠ CAUTION

CAUTION: Do *not* weld extensions on *tractor vehicles* equipped with aluminum frame rails, or on *any* vehicles equipped with frame rails made of aluminum alloy 2014-T6. Tractor service imposes high stress in the rear frame area. Welding in this area could result in excessive frame rail stress.

Welding on aluminum alloy 2014-T6 can result in hot cracking, and create a heat-affected zone susceptible to stress-corrosion cracking.

1. Cut the frame rail end and extension to the applicable dimensions **in Fig. 5**.



NOTE: Left rail shown; right rail will be opposite dimensions.

FRAME RAIL SIZE inches	DIMENSION			
	A inches (mm)	B inches (mm)	C inches (mm)	D inches (mm)
10.06	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)
10.12	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)
10.38	1.12 (28.6)	5.00 (127.0)	10.00 (254.0)	20.00 (508.0)

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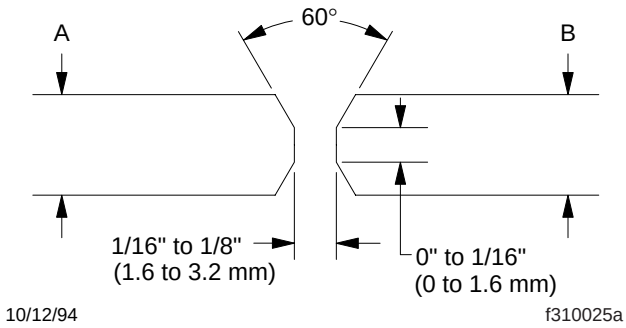
Fig. 2, Steel Frame Rail and Extension Cutting Dimensions for Tractor Vehicles

2. Grind the cut ends of the frame rail and extension, over the full length of the cut, to the dimensions **in Fig. 6**.
3. Clean all surfaces to be joined, with vapor degreasing equipment, or by swabbing with clean, oil-free solvents, or by stainless steel wire brushing.
4. Align the cut ends of the extension piece with the cut ends of the frame rail so that there is a 1/16-to 1/8-inch (1.6- to 3.2-mm) gap between them. **See Fig. 6.**

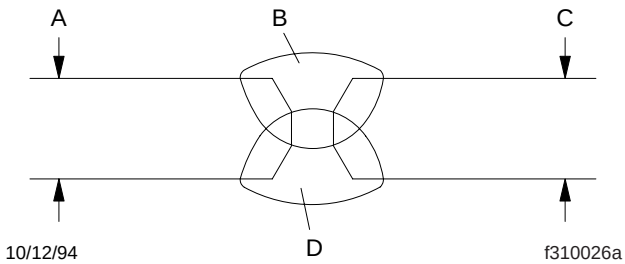
NOTE: A 1/16-inch (1.6-mm) gap is recommended. The ends must not contact each other. Maintain the joint spacing by placing a short piece of clean, 1/16-inch (1.6-mm) diameter aluminum welding wire (E4043) between the extension and frame rail. The wire sections must be short enough to be completely fused by the welding process.

Lengthening Frame Rails



A. Frame Rail Thickness
B. Extension Thickness

Fig. 3, Grinding Dimensions



A. Frame Rail Thickness
B. First Weld
C. Extension Thickness
D. Second weld penetrates the first weld.

Fig. 4, Correct Weld Penetration

5. Using the method **in Subject 110, Method for Aluminum,** weld the extension to the frame rail, making full penetration **as shown in Fig. 4**. Remove any slag between passes, and back-gouge the root of the first vee before welding the other side.

⚠ CAUTION

CAUTION: Residual stresses will occur in the weld if the web area is not welded first, or if the flanges contact each other when welding the web.

IMPORTANT: Weld the web area first, then the flanges, working from the inside of the channel. When welding the web, make sure that the flanges do not contact each other. Lay the filler metal at a relatively high temperature, in a single rapid pass at the bottom of the vee. This will keep total heat input to the joint at a minimum.

6. Without weaving motion of the electrode, make the final fill over the same path, first on the inside of the channel, then the outside.
7. When finished welding, sand the joint for appearance. Hold the sander so that the grind runs parallel with the length of the frame rail.

⚠ CAUTION

CAUTION: Do not "hollow grind" the weld. Small depressions from improper grinding of the weld will reduce the strength of the frame rail.

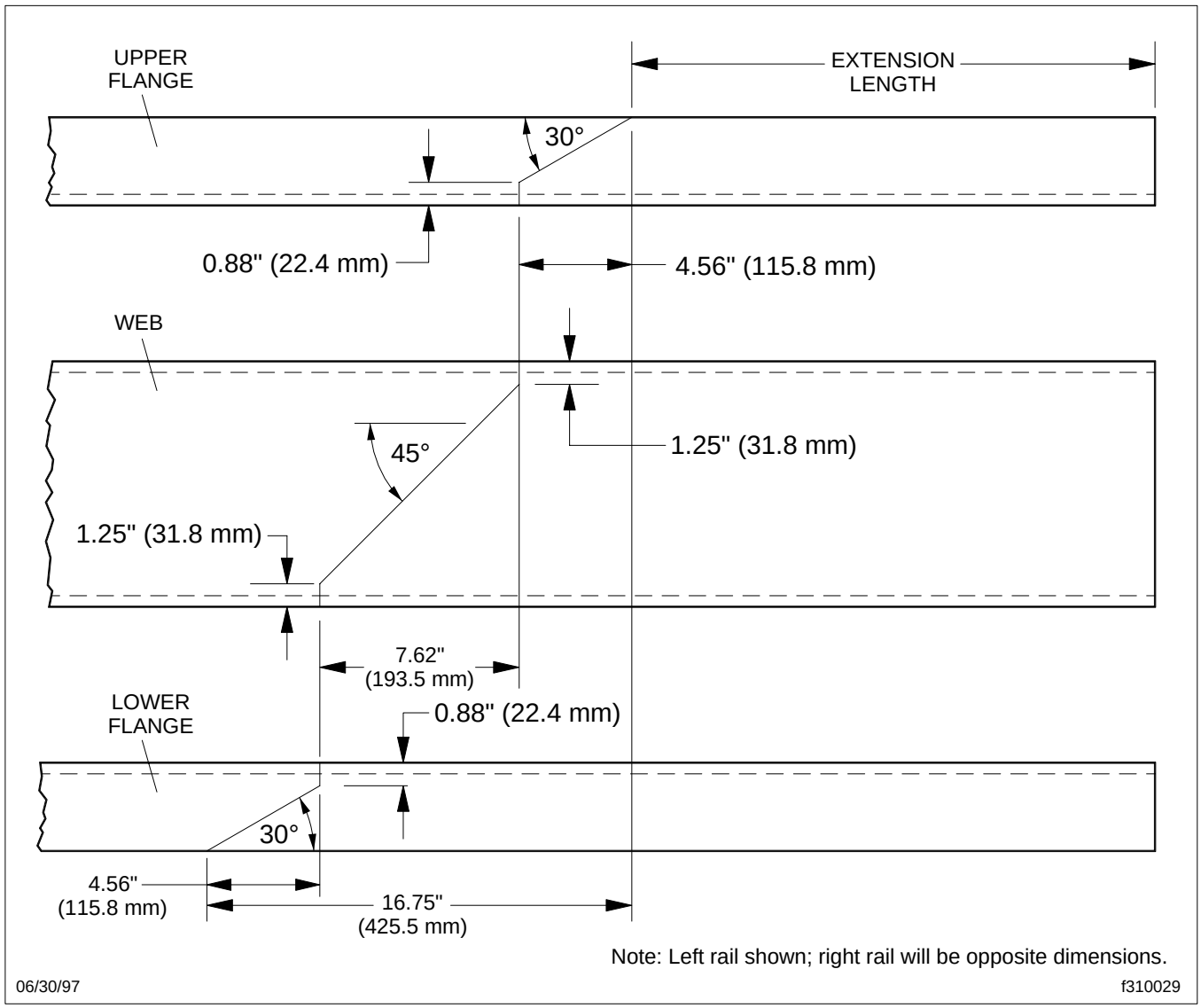


Fig. 5, Aluminum Frame Rail and Extension Cutting Dimensions for Truck Vehicles Only

Lengthening Frame Rails

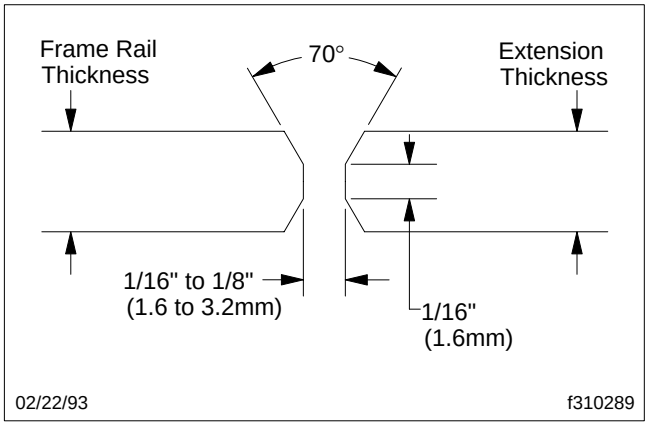


Fig. 6

Crossmember Removal and Installation

Removal

The placement of crossmembers affects the overall stability of the frame. If a crossmember is being eliminated, added, or relocated, contact your regional service representative for instructions and approval.

REAR-CLOSING CROSSMEMBER

1. Chock the tires.
2. Remove the taillights from the rear-closing crossmember. If so equipped, remove the backup alarm.
3. If the relay valve or quick-release valve is attached to the rear-closing crossmember, drain the air reservoirs, then remove the valve(s) from the crossmember.

   Remove any clamps that attach air lines or wiring to the crossmember.
4. Remove the rear mud flap brackets and fasteners.
5. Remove the fasteners that attach the crossmember to the angle brackets.
6. Remove the fasteners that attach the rearmost angle brackets to each frame rail, and remove the rearmost angle brackets. For assembly reference, note the direction that the bolts are installed.
7. Tip the top of the rear-closing crossmember to the rear and down, then slide it out the rear of the frame rails.
8. If needed, remove the forwardmost angle brackets and their fasteners. If the rear spring brackets are attached to the frame rails with the same fasteners that attach the angle brackets, before removing the fasteners, support the rear of the frame at its normal ride height, using safety stands. After removing the fasteners, remove the rear spring brackets from the springs.

CHANNEL CROSSMEMBER

NOTE: If the vehicle is equipped with a fifth wheel, and the fifth wheel interferes with removal of the channel crossmember, refer to the applicable fifth wheel section in this manual, for fifth wheel removal instructions.

1. Disconnect any suspension torque rod bracket(s) that are attached to the crossmember. Note the number and location of any spacers.
2. If the relay valve or quick-release valve is attached to the channel crossmember, drain the air reservoirs, then remove the valve(s) from the crossmember.

   Remove any clamps that attach air lines or wiring to the crossmember.
3. Remove all fasteners that attach the channel crossmember to the upper and lower gussets. Work the crossmember out of the gussets, then work it out of the top or bottom of the frame rails.
4. If removal of the gussets is needed, and if they attach to the frame with the same fasteners as the suspension brackets, chock the tires, and use safety stands to support the frame at its normal unloaded ride height. Remove the fasteners that attach the gussets and frame brackets to the frame rails. For assembly reference, note the direction that the bolts are installed. Remove the gussets and (if equipped) frame spacers.

ALLIGATOR CROSSMEMBER

1. Using the above instructions, remove the rear-closing crossmember and angle brackets, and remove the channel crossmember, gussets, and (if equipped) frame spacers.
2. If air reservoirs are mounted inside the frame rails, remove any air reservoirs that are mounted rearward of the alligator crossmember that must be replaced. Use the air reservoir removal instructions in the applicable brake section in this manual.
3. Remove the alligator crossmember that must be replaced, and any alligator crossmembers mounted rearward of it, as follows:

   3.1 Remove the fasteners that attach the crossmember lower struts to the crossmember, and to the frame rails. For assembly reference, note the direction that the bolts are installed. Remove the lower struts.

   3.2 If removing a midship bearing crossmember, support the driveline on a safety stand, then remove the fasteners that at-

tach the midship bearing bracket to the crossmember.

3.3 If removing the rear cab-mount crossmember from a Conventional, support the fuel tanks, then remove the fasteners from the fuel tank brackets. Using an overhead hoist, support the rear of the cab, then remove the cab suspension bracket from the cab and the crossmember.

3.4 From the weld studs in the frame rails, remove the clamps that attach any wiring or air lines that might interfere with crossmember removal.

3.5 Unbolt the crossmember, then (if equipped) remove the frame spacer from each frame rail. For assembly reference, note the direction that the bolts are installed. Slide the crossmember out the rear of the frame rails, lifting it or lowering it as needed to clear the weld studs.

Installation

ALLIGATOR CROSSMEMBER

NOTE: If more than one alligator crossmember is being installed, begin with the one that belongs farthest toward the front of the vehicle.

1. Slide the crossmember into the opening at the rear of the frame rails, and work it over or under the weld studs until it is approximately aligned with its mounting holes in the frame rails.
2. If equipped, position the correct thickness of frame spacer between each end of the crossmember and the frame rail. Install the fasteners, but do not tighten them at this time. Be sure to install each bolt in the same direction that was noted during removal.
3. If more than one alligator crossmember is being installed, repeat steps above as required for the other crossmember(s).
4. Install any clamps that were removed from the weld studs in the frame rails.
5. Install the lower struts, attaching them to the frame rails, and to the crossmember(s). Do not tighten the fasteners at this time.
6. Using the instructions below, install the channel crossmember, gussets, and (if equipped) frame spacers, then install the rear-closing crossmember and angle brackets.
7. Check the frame rail alignment, and align the frame rails if needed; **refer to Subject 140.**
8. If the rear cab-mount crossmember was installed, attach the fuel tank brackets to the frame rails, if not already done. Tighten the fasteners to the torque values in the general information section in the vehicle maintenance manual.

   Install the cab suspension bracket on the crossmember, lower the cab, remove the overhead hoist, then attach the cab suspension bracket to the cab.
9. If the midship crossmember was installed, attach the midship bearing bracket to the crossmember. Tighten the fasteners to the applicable torque values in the general information section in the vehicle maintenance manual.
10. If any air reservoirs were removed, install them, using the instructions in the brake section in this manual.

CHANNEL CROSSMEMBER

IMPORTANT: If an alligator crossmember is also being installed, install it first.

1. If equipped, position the correct thickness of frame spacer in each channel of the frame.

   If they were removed, install the upper and lower gussets in both sides of the frame, but do not tighten the fasteners at this time. Be sure to install each bolt in the same direction that was noted during removal.
2. Work the channel crossmember into the top or bottom of the frame, then work it into position in the gussets. Install the fasteners that attach the crossmember to the gussets, but do not tighten them at this time.
3. If it was removed from the channel crossmember, install the relay valve or quick-release valve on the crossmember. Securely tighten the fasteners.

   Install any clamps that attach air lines or wiring to the crossmember.

4. If so equipped, attach the suspension torque rod bracket(s) to the crossmember. Be sure the spacers are installed in the same location noted during removal. Tighten the bracket fasteners to the applicable torque value in the general information section in the vehicle maintenance manual.
5. If an alligator crossmember is also being installed, go to "Rear-Closing Crossmember," below.

   If an alligator crossmember is *not* being installed, install the fifth wheel if it was removed; refer to the fifth wheel section in this manual. Tighten the fasteners that attach the channel crossmember gussets to the frame rails, then tighten the fasteners that attach the crossmember to the gussets. Tighten the fasteners to the applicable torque values in the general information section in the vehicle maintenance manual.

REAR-CLOSING CROSSMEMBER

IMPORTANT: If an alligator crossmember(s) is also being installed, install it first.

1. If they were removed, install the forwardmost angle brackets, but do not tighten the fasteners at this time. If the rear spring brackets attach to the frame rails with the same fasteners that attach the angle brackets, install the rear spring brackets at this time. Then, remove the safety stands from under the frame rails. Be sure to install each bolt in the same direction that was noted during removal.
2. Slide the crossmember into the opening at the rear of the frame rails, then turn it upright, to position it against the angle brackets.
3. Attach the rearmost angle brackets to the frame rails, but do not tighten the fasteners at this time.
4. Install but do not tighten the fasteners that attach the crossmember to the angle brackets.
5. Install the rear mud flap brackets,and tighten the fasteners to the applicable torque value in the general information section in the vehicle maintenance manual.
6. If it was removed from the rear-closing crossmember, install the relay valve or quick-release valve on the crossmember. Securely tighten the fasteners.
7. Install the taillights on the rear-closing crossmember. If so equipped,install the backup alarm.

   Install any clamps that attach air lines or wiring to the crossmember.
8. If an alligator crossmember is also being installed, go to "Alligator Crossmember," above.

   If an alligator crossmember is *not* being installed, tighten the fasteners that attach the angle brackets to the frame rails, then tighten the fasteners that attach the crossmember to the angle brackets. Tighten the fasteners to the applicable torque values in the general information section in the vehicle maintenance manual.

Frame Rail Alignment

Frame rail alignment is checked by measuring the distances from two sets of points on the upper flanges of the frame rails. **See Fig. 1**. The rear set of points must be as far back as possible from the forward set of points. There must be no interference, along or between the frame rails, that would prevent measuring from any one of the four points to the other three points; the fifth wheel and deck plate (as equipped) must be removed.

There are no marks or bolt holes in the top flanges of the frame rails. Therefore, the points must be projected from the frame station marks and from the bolt holes on the frame rail webs.

IMPORTANT: Use a pencil or soapstone to make all lines, points, or other marks. Do not use any marker or tool that will scratch the surface of the frame rail. Use a machinist's square to project all points from the webs to the upper flanges, and to measure inboard from the outside face of the frame rails.

1. For each frame rail, project the exact vertical centerline of the frame station 100 mark, from the frame web to the top flange, and mark it with a line across the top flange.

   If, because of interference, frame station 100 cannot be used, choose and mark another matched set of points, as follows:

   1.1 Determine how far forward that the upper flanges of both frame rails are clear.

   1.2 Find a matched set of bolt holes on the frame rail webs, that are aligned with, or just rearward of, the front of the clear area on the flanges. The bolt holes must be in exactly the same location in each frame rail.

   1.3 Project the exact vertical centerline of each bolt hole, and mark a line across the top flange of its respective frame rail.

2. Find the exact center of the width of each upper flange, and mark the point on each projected line. This will be the forward set of points. The forward points must be in identical locations on both frame rails.

3. As equipped, remove the fifth wheel and deck plate from the frame. Refer to the fifth wheel section in this manual for instructions.

4. Measure back along each frame rail, to find a set of bolt holes *at least* 72 inches (183 cm) rearward from the forward set of points. The bolt holes must be in exactly the same location in each frame rail.

IMPORTANT: If, because of interference, the distance must be less than 72 inches (183 cm), the distance must be the maximum that is possible.

5. Project the exact vertical centerline of each bolt hole, and mark a line across the top flange of its respective frame rail.

6. Along each line, measure and mark a point 2 inches (5 cm) inboard from the outside face of its respective frame rail. The rear points must be in identical locations on both frame rails.

7. At the forward set of points, and again at the rear set of points, measure the distance across the frame, from the outside face of each frame rail. At both locations, this distance must be 33.50 inches (851 mm). **See Fig. 1**.

   If the distance at either location is incorrect, check the Freightliner *Parts Book* pages to determine which thickness of frame spacers, if any, belong between the crossmembers and the frame rails. Check for the correct spacers, and add or remove spacers as needed, using the procedures **in Subject 130.**

8. Measure the distance from the forward point on one frame rail to the rear point on the opposite frame rail. **See Fig. 1**. Then measure the distance from the other forward point to the rear point on its opposite frame rail. Compare the two measurements.

   If the values differ by more than 1/8 inch (3mm), proceed to the next step.

   If the measurements are within 1/8 inch (3 mm) of each other, the frame rails do not need to be aligned. If any frame fasteners are loose, tighten as described below. If no fasteners are loose, install the fifth wheel and proceed as described below.

Frame Rail Alignment

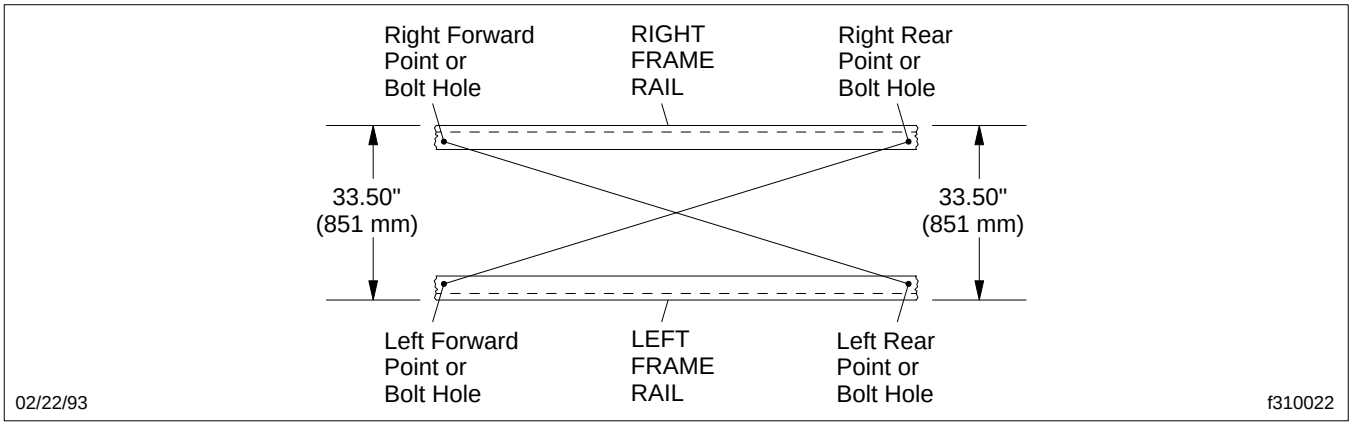


Fig. 1

9. Loosen all of the frame fasteners just enough to allow movement of the parts when force is applied.

IMPORTANT: To align the frame rails, the frame assembly must be assembled with all of the crossmembers in place, but the attachment fasteners not tightened.

10. Using a large hammer and a large wooden block, place the block against the rear end of the frame rail that had its rear point the greater distance from its opposite rail's front point. Tap the block until the measurements are within 1/8 inch (3 mm) of each other.
11. Tighten the fasteners for the front-and rear-closing crossmembers to their applicable torque values; refer to the general information section in the vehicle maintenance manual. Again, check the frame rail alignment (described above).
12. When the measurements are within specifications, install the fifth wheel and deck plate (as equipped); refer to the fifth wheel section in this manual for instructions.
13. Tighten all of the frame fasteners, starting at the middle of the frame and working alternately toward both ends. First, tighten the fasteners that attach crossmembers to the frame. Then, tighten the fasteners that attach the upper and lower struts or gussets to the frame. Finally, tighten the fasteners that attach the lower struts or gussets to the crossmembers. Tighten all fasteners to their applicable torque values, as specified in the general information section in the vehicle maintenance manual.
14. If the frame rails needed aligning, check the axle alignment; refer to the rear axle section in this manual for instructions.

Frame Shaping

IMPORTANT: Obtain approval from your regional service representative before doing any cutting or frame shaping.

If the flange of a frame rail is cut (for relief cuts or notches), shape the edges of the flange to form a smooth ground radius of 0.06 to 0.12 inch (1.5 to 3.0 mm) over the entire length of the cut. **Figure 1** shows this dimension of the edge radius of the frame rail flanges.

NOTE: For information on relief cuts or notches, refer elsewhere in this group.

⚠ WARNING

WARNING: Wear protective eye and facial gear when grinding. Failure to wear this gear can result in personal injury due to flying metal debris from the grinding process.

Using a clean, sharp, rotary drum grinder or flapper wheel grinder, apply light pressure and grind the cut edges in the direction of the length of the frame rail, to form the radius. Do not grind across the edges. See **Fig. 2**.

⚠ CAUTION

CAUTION: Apply light pressure only. Heavy pressure can result in harmful overheating and loss of surface temper. Grind only in the direction of the cut. See Fig. 2. Grinding across the direction of the cut can reduce the structural strength of the frame rail.

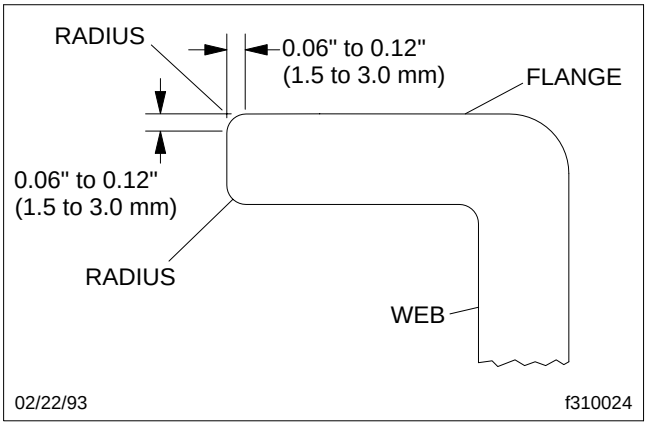


Fig. 1, Radius Dimensions

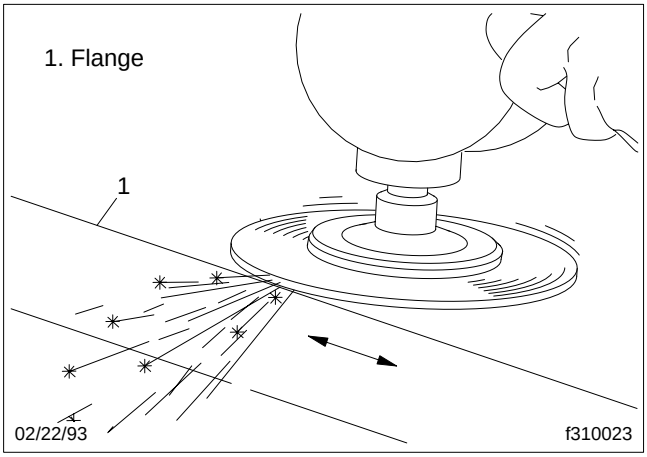


Fig. 2, Direction of Grind

Specifications

Machine Settings for Gas-Metal Arc Welding				
Wire Diameter: inches (mm)	Current		Wire Extension	
	Optimum: amperes	Maximum: amperes	Minimum: inches (mm)	Maximum: inches (mm)
0.045 (1.14)	160	320	1/2 (13)	3/4 (19)
1/16 (1.6)	300	600	3/4 (19)	1-1/8 (29)
5/64 (2.0)	480	960	1 (25)	1-1/2 (38)

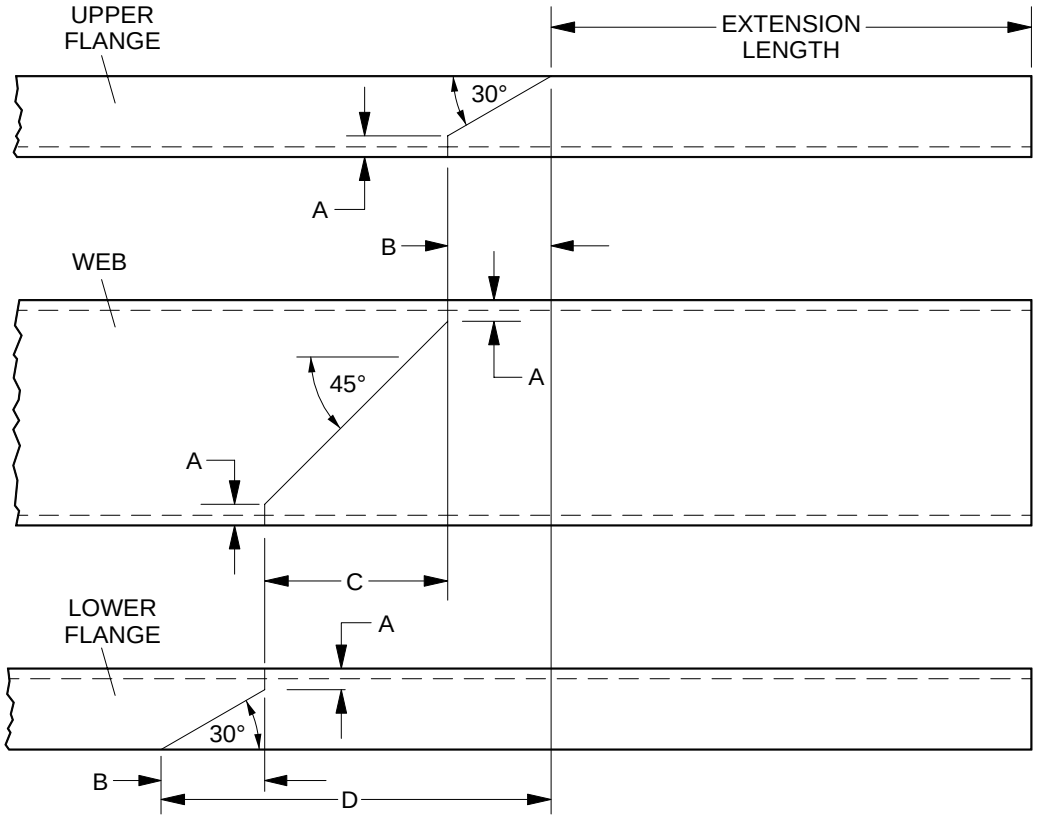
Table 1, Machine Settings for Gas-Metal Arc Welding

Amperage and Voltage Settings for Coated-Electrode Arc Welding		
Weld Position	Amperes	Volts
Downhand	130/140	21/23
Overhead	130/140	21/23
Vertical Up	110/120	22/24

Table 2, Amperage and Voltage Settings for Coated-Electrode Arc Welding

Refer to the figures in this subject as follows: **Fig. 1**, Steel Frame Rail and Extension Cutting Dimensions for Truck Vehicles; **Fig. 2**, Steel Frame Rail and Extension Cutting Dimensions for Tractor Vehicles; and **Fig. 3**, Aluminum Frame Rail and Extension Cutting Dimensions for Truck Vehicles Only.

Specifications



NOTE: Left rail shown; right rail will be opposite dimensions.

FRAME RAIL SIZE inches	DIMENSION			
	A inches (mm)	B inches (mm)	C inches (mm)	D inches (mm)
10.06	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)
10.12	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)
10.38	1.12 (28.6)	5.00 (127.0)	10.00 (254.0)	20.00 (508.0)

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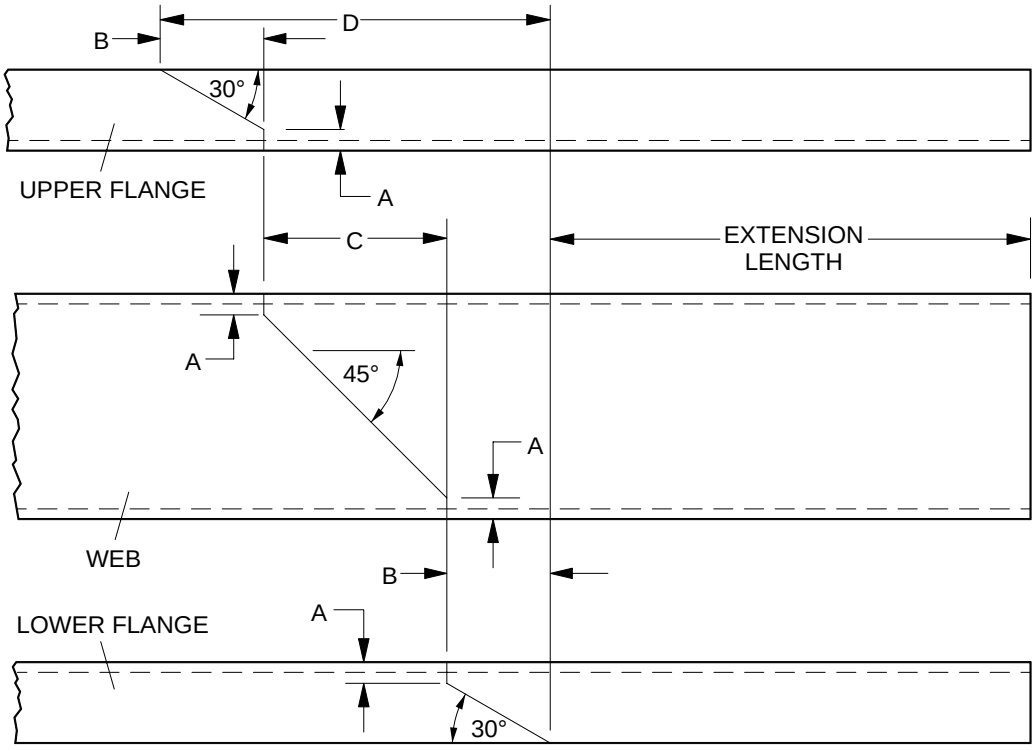
Fig. 1, Steel Frame Rail and Extension Cutting Dimensions for Truck Vehicles



NOTE: Left rail shown; right rail will be opposite dimensions.

FRAME RAIL SIZE inches	DIMENSION			
	A inches (mm)	B inches (mm)	C inches (mm)	D inches (mm)
10.06	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)
10.12	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)
10.38	1.12 (28.6)	5.00 (127.0)	10.00 (254.0)	20.00 (508.0)

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Fig. 2, Steel Frame Rail and Extension Cutting Dimensions for Tractor Vehicles

Specifications

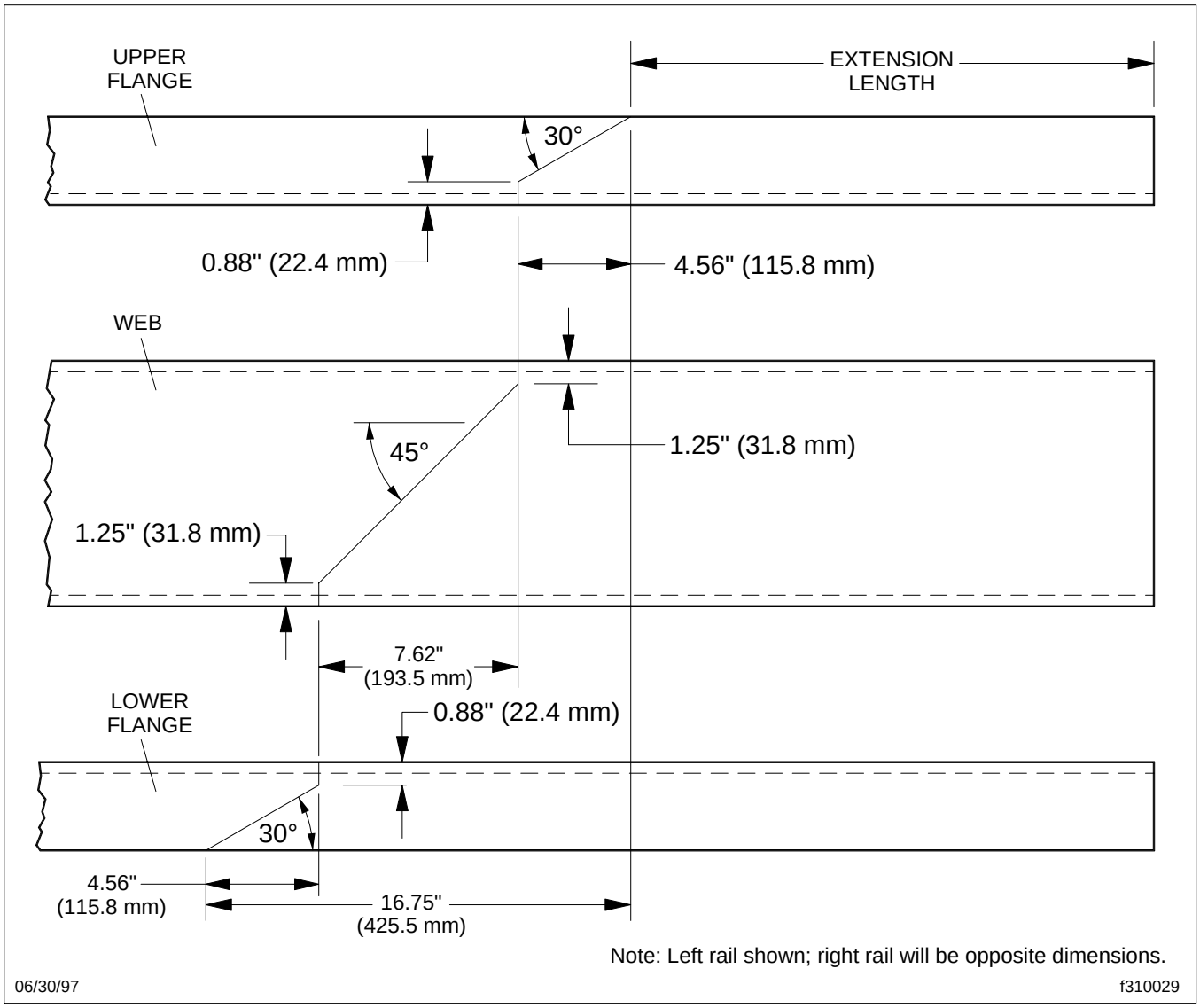


Fig. 3, Aluminum Frame Rail and Extension Cutting Dimensions for Truck Vehicles Only

General Information

Specialized equipment (such as a dump box, tank, hoist, lift, winch, or derrick) is often added to a vehicle by distributors or installers other than the vehicle manufacturer. Usually, the vehicle is equipped with a standard chassis frame and the vehicle manufacturer has not made special provisions for the additional equipment, unless otherwise requested at assembly.

The final-stage manufacturer must be aware of federal requirements for certification, noise, emissions, brakes, lighting systems, fuel systems, and others.

Specialized equipment installers are liable for the safety and durability of their product. The specialized equipment installed by the final manufacturer must comply with all applicable OSHA regulations and Department of Transportation vehicle certification requirements.

Guidelines

Any attachment of specialized equipment to the chassis frame will produce stress concentrations.The addition of holes,welds,clamps, reinforcements,or splices will cause a local increase in stress. **Figure 1** illustrates a number of typical stress concentrations in frame side-rails. The location on the chassis frame, the severity and frequency of the applied load, and the type of concentrator will all serve to determine the effect, if any, the stress concentrations have on the life of the structure.

Notches placed at any location along the side-rail are critical. **Figure 2** illustrates a clearance notch on the side-rail flange, typical of the kind added by final-stage manufacturers. As shown, the side-rail cracked at the notch (after a few months of vehicle use). The probable causes of the crack were the installer's failure to use care in grinding, to ensure that there was a smooth blend over a distance with no nicks or rough edges, and to check first with the vehicle manufacturer to determine the magnitude of stress in this area.

IMPORTANT: The practice of adding clearance notches to the frame side-rails may adversely affect the frame warranty, and the installer may be responsible for any consequences resulting from the notches.

Below, three common methods of attaching specialized equipment to the frame chassis are discussed. Under each method are the general advantages and disadvantages of using that method—they can help the installer decide which method of attachment is best in a given situation. Also included are guidelines that should be followed by the final-stage manufacturer when using a particular method of attachment.

Bolt Attachment

Bolt attachment includes clips, brackets, and fish-plates.

Advantage

When the holes used for bolting are in the least critical areas possible, bolting is preferred for its versatility and strength.

Disadvantages

1. Providing access for drilling holes in the frame may require disassembly of chassis components.
2. Drilling holes in heat-treated frames involves higher pressures and requires special drilling equipment, preferably a positive-feed machine.

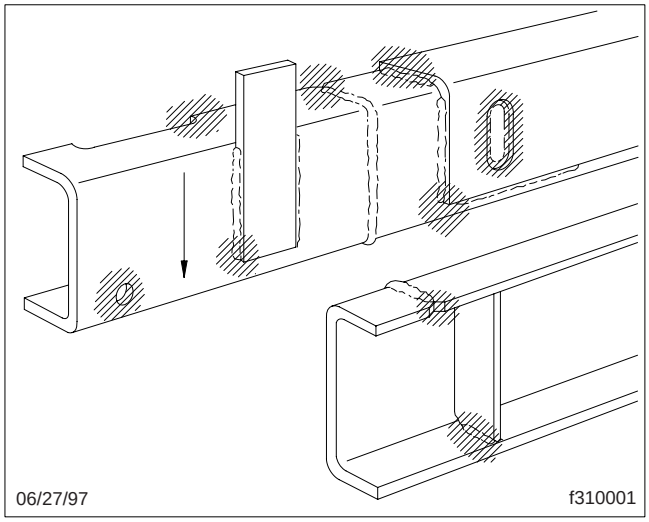


Fig. 1, Typical Side-Rail Stress Concentrations

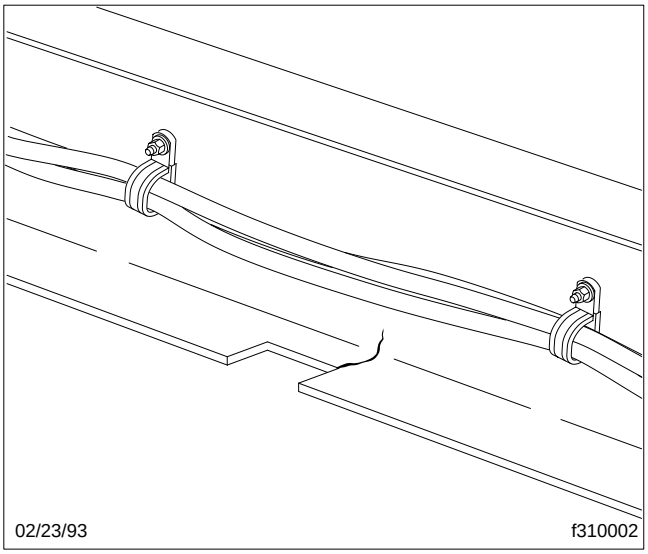


Fig. 2, Damaged Side Rail

Guidelines

The following is intended to emphasize the importance of hole locations in the side-rails, and help

Attachment Guidelines

final-stage manufacturers to avoid some pitfalls which could lead to premature failures.

Figure 3 depicts a channel section frame side-rail loaded as a beam. This type of loading stretches the lower half of the section (produces tension) and compresses the upper half of the section (produces compression), as indicated by the arrows. If the side-rail section was without holes, the highest concentrations of stress (tension and compression) would be in the lower and upper flanges of the rail.

However, **Fig. 3** shows two holes in the lower half of the rail. The uppermost hole is located about one-third of the web depth up from the lower flange. Stress (tension) at the bottom of this hole would be approximately equal to the stress in the lower flange. Any hole located less than this distance (for example, the hole located nearer to the lower flange in **Fig. 3**) will have significantly higher stress than will the flange. The reason for the difference in stress among the holes is that the upper hole is located closer to the neutral axis of the rail, or the area where the forces of tension and compression do not exist.

Based on these conditions, the recommendations below should be followed whenever equipment is to be bolted to the chassis frame:

1. Use existing holes where possible. When holes must be drilled, they should be located no closer to the top and bottom side-rail flanges than the existing holes placed by the factory.
2. Avoid drilling holes in any area of the side-rail web except the central one-third area (the web is the surface area between the flanges). Depending on loading, the top or the bottom of the side-rail can be the tension side. Before drilling holes in the side rails, obtain approval from your regional service representative.
3. In all cases, avoid drilling holes in the side-rail flanges.

U-Bolt and Clamp Attachment

Advantages

1. Generally,clamping devices, such as that shown in **Fig. 4**, are the least time-consuming and least expensive methods of attachment.

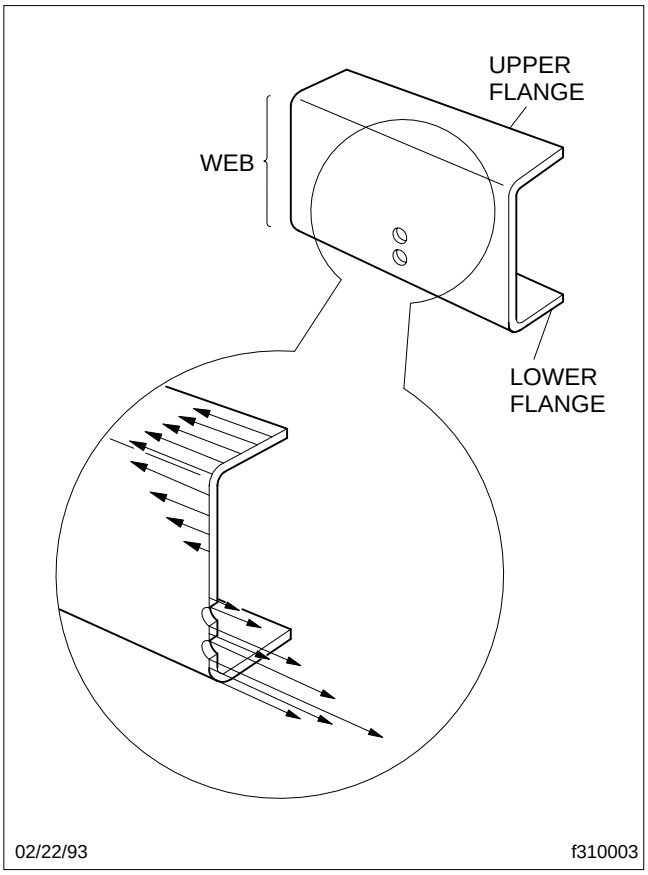


Fig. 3

2. U-bolts avoid frame drilling, which is especially helpful when the vehicle is equipped with a heat-treated frame.

Disadvantages

1. Since U-bolts or clamps are not always attached (locked) to the frame, there is the possibility of heavy equipment moving or being jarred out of place, especially if grease or oil is present on the frame rail.
2. The nuts of the U-bolts or clamps require more frequent retorquing than do those of bolted attachments to the frame.
3. U-bolts and clamps cannot hold high torque loads.
4. U-bolts and clamps cause local stress concentrations.

Guidelines

1. Care should be used to block (with spacers) the side-rail channel to prevent collapse of the flanges when the U-bolts are tightened. Metal blocks are preferred, because wood may shrink and drop out.
2. The blocks utilized to prevent collapse of the side-rail flanges should not interfere with plumbing or wiring routed along the frame rails. In addition, the blocks should not be welded to the side-rail flanges.
3. Since U-bolts and clamping devices depend on friction and a maintained clamping force for attachment, some bolts should directly connect the attachment to the frame side-rail web to prevent the attachment from slipping.
4. Do not notch frame side-rail flanges in order to "force" a U-bolt fit, as shown in **Fig. 5**. If the side-rail flanges are too wide, obtain a larger U-bolt or use another method of attachment.

CAUTION

CAUTION: Notching a side-rail flange severely weakens the structure, and could ultimately result in side-rail fracture. With complete side-rail fracture, other chassis parts could be damaged with consequent substantial increase in repairs.

Weld Attachment

There are very few cases in which welding on a heat treated side-rail is allowable. Direct welding of the side-rail flanges and web should be avoided. To avoid direct welding, equipment bracketry should be welded on a separate reinforcement, and the reinforcement should be bolted to the side-rail. It is recommended that before any direct welding to the side-rails is performed, the Freightliner Corporate Sales Engineering Department be consulted.

Frame Reinforcement Guidelines

Reinforcements are often added to the vehicle frame because of wheelbase change (extension), improper purchase specification by the customer, or change of intended use. If a reinforcement is necessary, bolting is the preferred method of attachment. Use existing holes, adding bolts only where required.

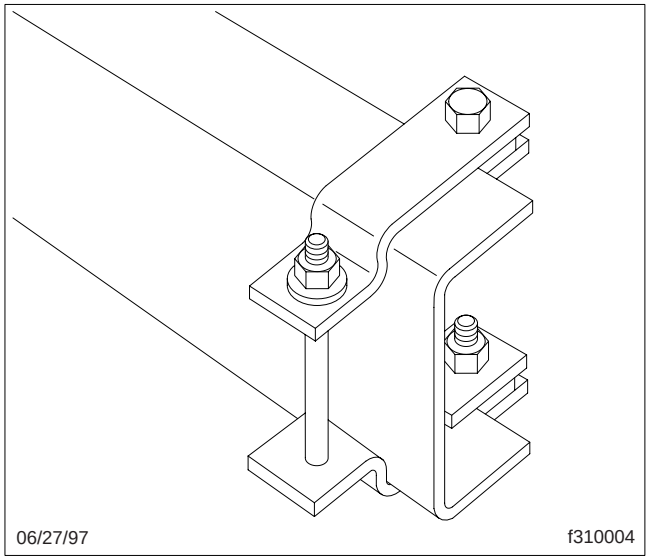


Fig. 4, Side-Rail Clamp

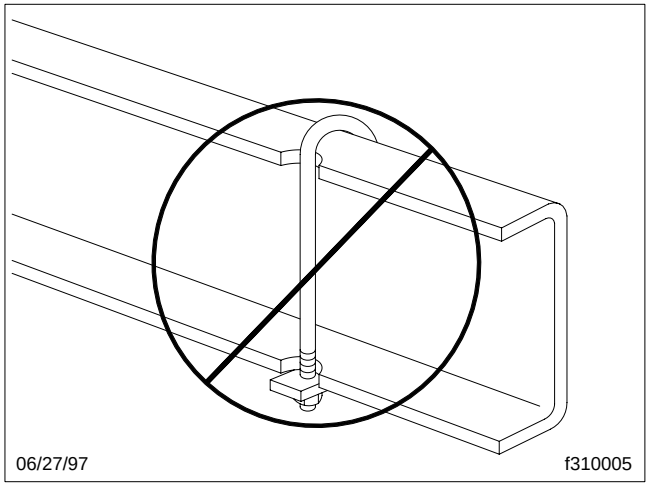


Fig. 5, Side-Rail Clamp

For a full-length reinforcement, the front of the reinforcement should extend past the front spring rear hanger and the rear should extend past the centerline of a single rear axle, or past the centerline between tandem rear axles. Both ends of the reinforcements (short or long) should be tapered for a smoother transition.

IMPORTANT: The frame requirements for stress and deflection with various axle ratings and wheelbases change rapidly as axle loading varies. If an axle rating is changed for any reason, the frame must be evaluated for adequacy.

Bumper Air Dam Removal and Installation

Air Dam Center Section

REMOVAL

1. Using an offset screwdriver, remove the Phillips screw from each end of the top flange. **See Fig. 1**.
2. Remove the fasteners from the center section's lower outer ends, **as shown in Fig. 2**.
3. Remove the fasteners that attach the rear stiffener and the center section's rear edge to each vertical strut angle bracket. **See Fig. 3**.
4. *For a setback-axle vehicle,* remove the fasteners that attach the rear stiffener to the middle of the center section's rear edge. **See Fig. 4**. Remove the rear stiffener.

   For a set-forward-axle vehicle, **if** a new center section is being installed, remove the fasteners that attach the rear stiffener to the middle and to the ends of the center section's rear edge. **See Fig. 5**. Remove the rear stiffener.
5. At the upper edge of the license plate recess, remove the fasteners that attach the center section to the bumper lower flange. **See Fig. 6**.

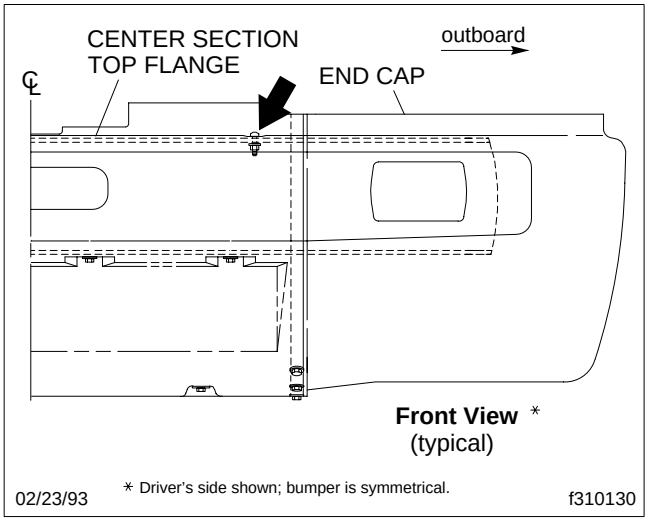


Fig. 1

6. Using the tow pin opening or bumper step openings for handholds, remove the center section by pivoting the bottom forward, then up, until the vertical tabs at the top can be pulled forward from behind the grille.
7. If either or both end caps must be removed, go to "Air Dam End Cap: Removal."

INSTALLATION

1. If either or both end caps were removed, install them; refer to "Air Dam End Cap: Installation."
2. *For a set-forward-axle vehicle,* **if** a new center section is being installed, proceed as follows (otherwise, go to the next step):

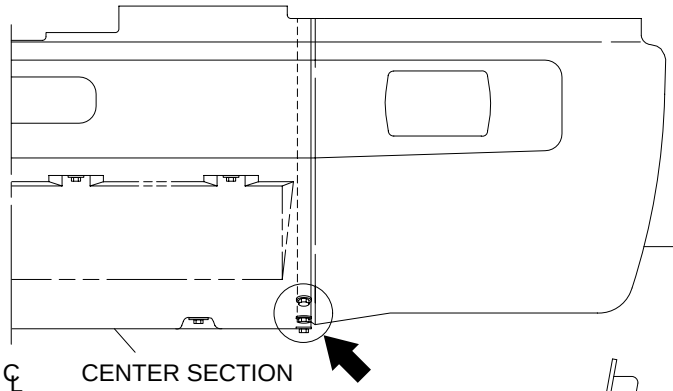
   2.1 Install a bolt with an extra-wide flatwasher up through the rear outboard hole at the driver's side of the new center section. **See Fig. 7**. Install a second extra-wide flatwasher over the bolt, against the top of the center section, as shown in the detail.

   2.2 With the undrilled leg of the rear stiffener to the rear, pointing up, position one end (driver's side) of the drilled leg over the bolt. Install a locknut, but don't tighten it.

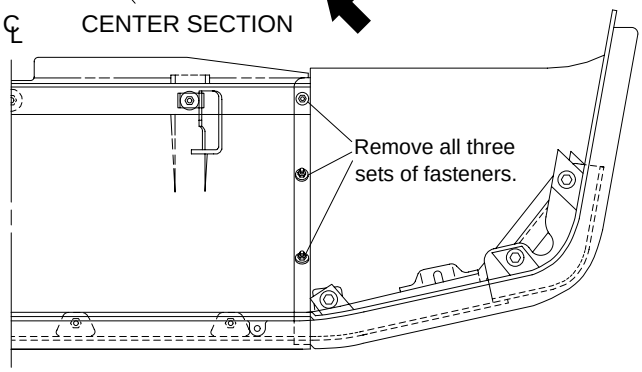
   2.3 Repeat the two substeps for the passenger's side of the center section.
3. With the Conventional hood or the COE cab (as applicable) in the operating position, place the top rear edge of the center section between the grille and the bumper top flange. Pivot the bottom of the center section down into place.
4. At the upper edge of the license plate recess, install the fasteners that attach the center section to the bumper lower flange. **See Fig. 8**. Install the (formed) air dam washers with their 90-degree angle at the back and their 40-degree angle pointing forward and down, as shown in the detail. Don't tighten the bolts.
5. *For a set-forward-axle vehicle* , hold the horizontal part of the installed rear stiffener against the bottom of the vertical strut angle brackets. **See Fig. 9**. At each angle bracket, install the fasteners, as shown in the detail. Don't tighten the locknuts. Go to the step after the next.

   For a setback-axle vehicle, hold the drilled leg of the rear stiffener against the bottom of both vertical strut angle brackets, so the undrilled leg is to the rear, pointing up. **See Fig. 10**. The ends of the stiffener must be above the air dam end caps (Detail B) or bumper air dam extensions, if installed (Detail C). Push the rear edge of the cen-

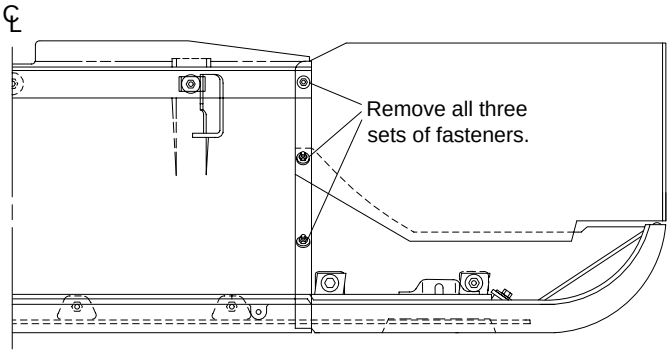
Bumper Air Dam Removal and Installation



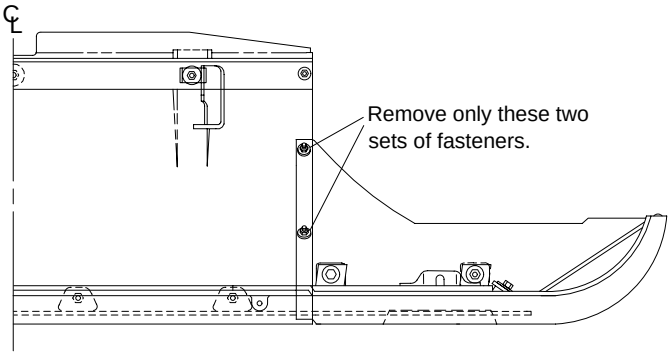
Front View *
(typical)



Top View *
Setback−Axle Conventional



Top View *
Setback−Axle COE



Top View *
Set−Forward−Axle Vehicle

* Driver's side shown; bumper is symmetrical.

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Fig. 2

Bumper Air Dam Removal and Installation

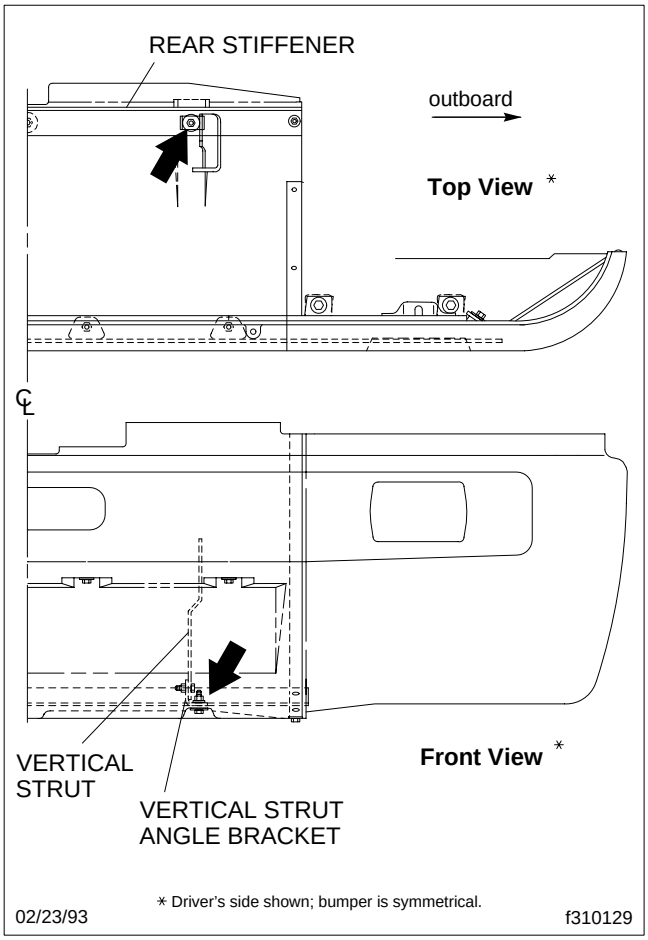


Fig. 3

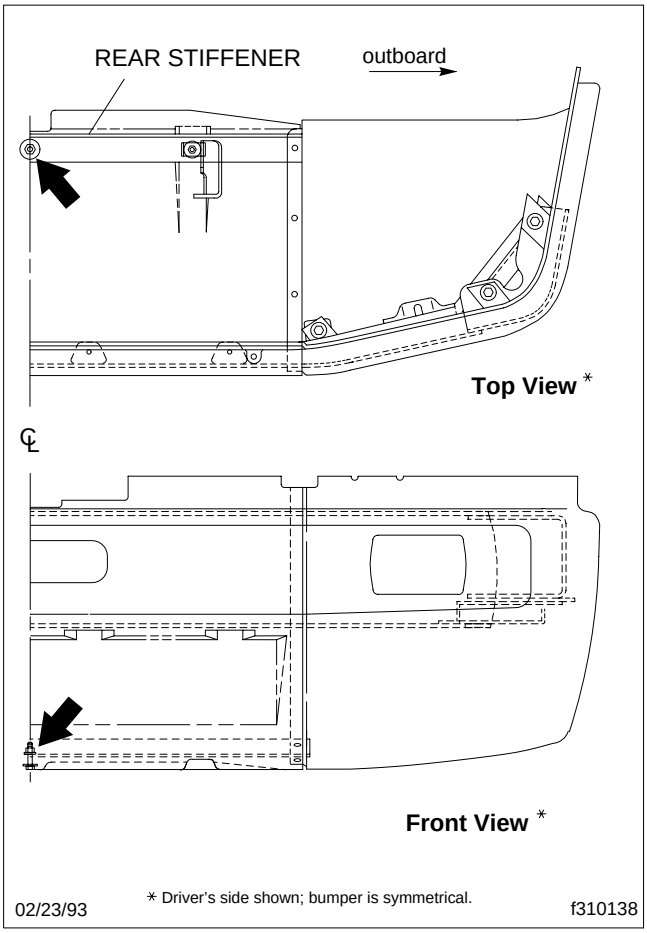


Fig. 4

ter section up, against the stiffener. Install the fasteners at the angle brackets, as shown in Detail A. Don't tighten the locknuts.

6. Install a Phillips screw in each end of the top flange. **See Fig. 11**. Don't tighten the screws.
7. Move the center section, as needed, to align its centerline with the center of the tow pin opening in the bumper. When aligned, tighten the bolts at the license plate recess, as instructed below. **See Fig. 8**.

CAUTION

CAUTION: Overtightening the air dam fasteners may crack or distort the air dam. Don't use an air wrench to tighten any air dam fasteners. Always use the tightening instructions given in this step.

IMPORTANT: Tighten each set of air dam fasteners until the set of fasteners and all fastened parts between them are just drawn into contact (without any spaces). Then tighten the fasteners one additional turn.

8. Using the instructions in the step above, tighten the Phillips screws at the bumper top flange (**Fig. 11**), and the fasteners at the vertical strut angle brackets (**Fig. 9**, or **Fig. 10**, Detail A).
9. If the rear stiffener was removed, install the fasteners in the center hole of the rear stiffener. **See Fig. 12**. Using the instructions in applicable step above, tighten the locknut.

Bumper Air Dam Removal and Installation

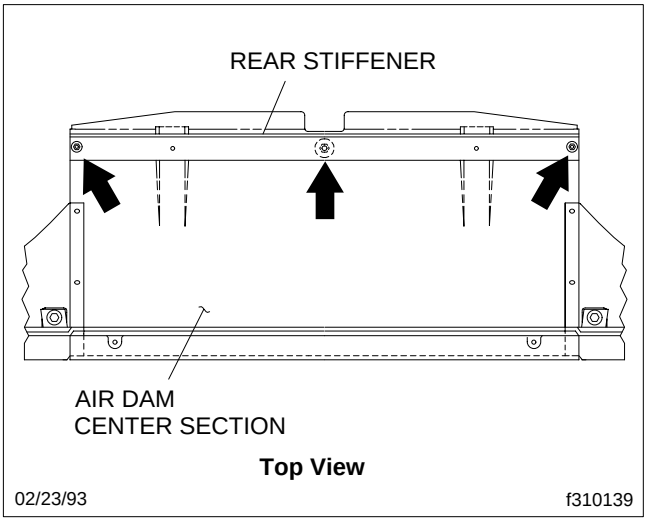


Fig. 5

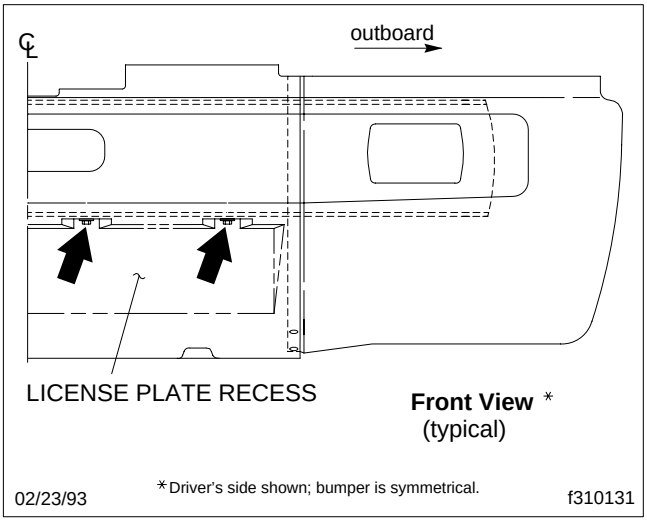


Fig. 6

NOTE: If a new center section is installed, use a 25/64-inch drill bit to backdrill down through the center hole of the rear stiffener, into the center section.

10. If either end cap was replaced or reinstalled, move it until there is a constant gap of 1/8 to 1/4 inch (3 to 6 mm) between the outboard edge of the center section and the forwardmost inboard edge of the end cap. **See Fig. 13**. When the gap is right, tighten all end-cap mounting ear fasteners, using the instructions in the applicable step above. For a setback-axle Conventional,

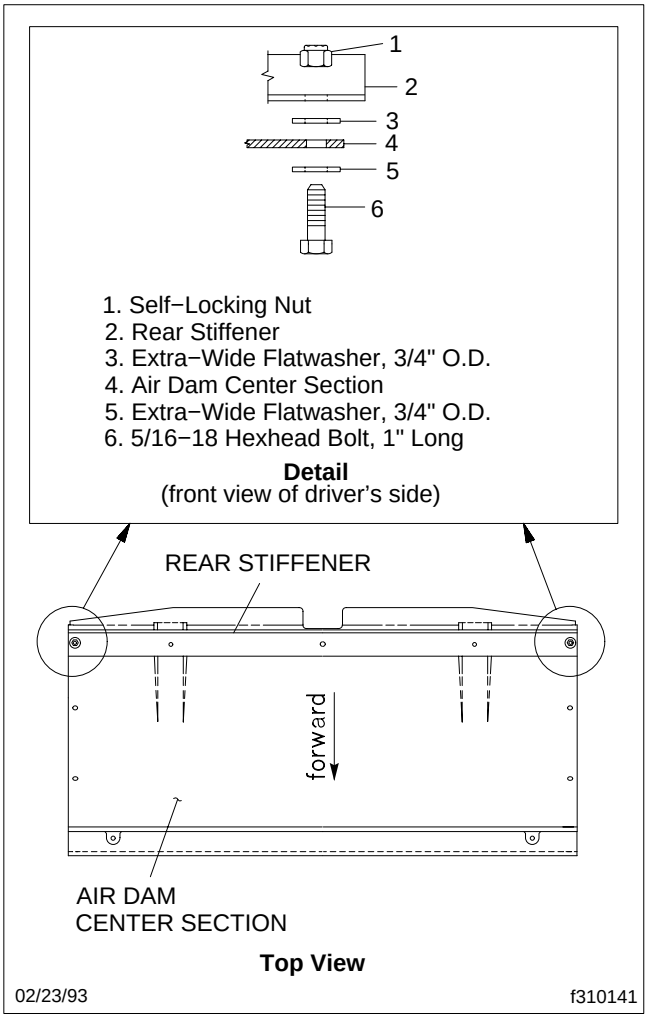


Fig. 7

see Fig. 14; for all vehicles *except* a setback-axle Conventional, **see Fig. 15**.

11. *For a setback-axle Conventional,* tighten the zee bracket fasteners (**Fig. 14**, Ref. 6) 15 lbf·ft (20 N·m).

12. For a setback-axle Conventional, position the inboard rear edge of each end cap between the rear stiffener and the air dam center section. **See Fig. 16**, Detail A. Then, place an extra-wide flatwasher between the rear stiffener and the end cap, as shown in the detail. Install the fasteners in each outboard hole of the center section. See Details A and B. Don't tighten the locknuts. Go to the next step.

Bumper Air Dam Removal and Installation

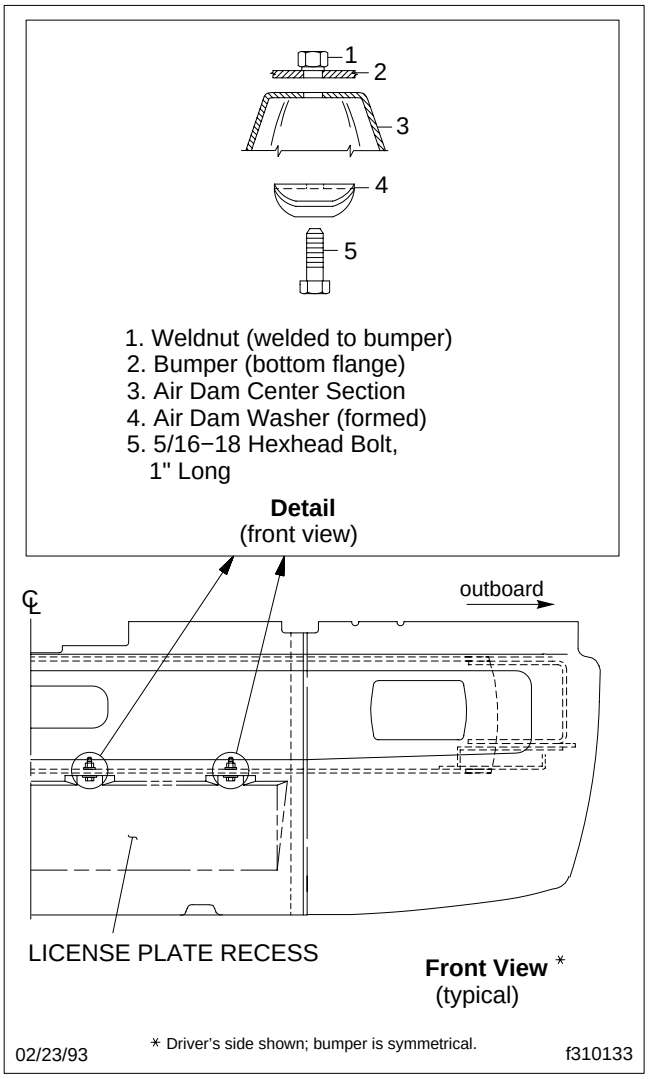


Fig. 8

For all vehicles except a setback-axle Conventional, install the fasteners in the air dam support and the bumper backing plate. **See Fig. 17**, Detail A. Tighten the locknuts 15 lbf·ft (20 N·m).

13. If a *new* end cap is installed, attach a new air dam support to the bumper backing plate, as shown in Detail A. Tighten the locknuts 15 lbf·ft (20 N·m). Use a 13/64-inch drill bit to drill two holes through the rear outboard flange of the new end cap, and the outboard end of the new air dam support. See Detail B. Install two large-flange blind rivets. *For a setback-axle COE,* install the bumper air dam extension (**Fig. 18**); refer elsewhere in this group for instructions.

14. *For a setback-axle COE*, position the forward edge of each bumper air dam extension above the rear edge of the end cap. **See Fig. 18**, Detail B. Position the inboard end of each bumper air dam extension between the rear stiffener and the air dam center section, then place an extra-wide flatwasher between the rear stiffener and the air dam extension. See Detail A. Install the fasteners in each outboard hole of the center section; don't tighten the locknuts. **See Fig. 18**, Details A, B, and C.

    For a set-forward-axle vehicle, install the fasteners in the outboard holes of the center section and the two inboard holes of each end cap; don't tighten the locknuts. **See Fig. 19**.

15. Move the lowest inboard edge of one of the end caps until there is a gap of 1/8- to 1/4-inch (3 to 6 mm) gap between it and the outboard edge of the center section. **See Fig. 13**. Using the instructions in the applicable step above, tighten all of the fasteners in that outboard edge of the center section. **See Fig. 16**, **Fig. 18**, or **Fig. 19**.

    Repeat this step for the other end cap.

Air Dam End Cap

REMOVAL

To remove either of the end caps, if needed, proceed as follows:

1. Remove the air dam center section.
2. For a Conventional, open the hood; for a COE, tilt the cab. Refer to the driver's manual for instructions.
3. *For a setback-axle Conventional,* loosen, but don't remove the zee bracket fasteners. **See Fig. 14**, Ref. 6. Remove the fasteners that attach the end cap to the top and bottom flanges of the bumper and bumper end. **See Fig. 14**, Ref. 1. Remove the end cap.

    For all vehicles except a setback-axle Conventional, remove the fasteners that attach the air dam support to the bumper backing plate. **See Fig. 17**, Detail A. Remove the fasteners that attach the end cap to the top and bottom flanges

Bumper Air Dam Removal and Installation

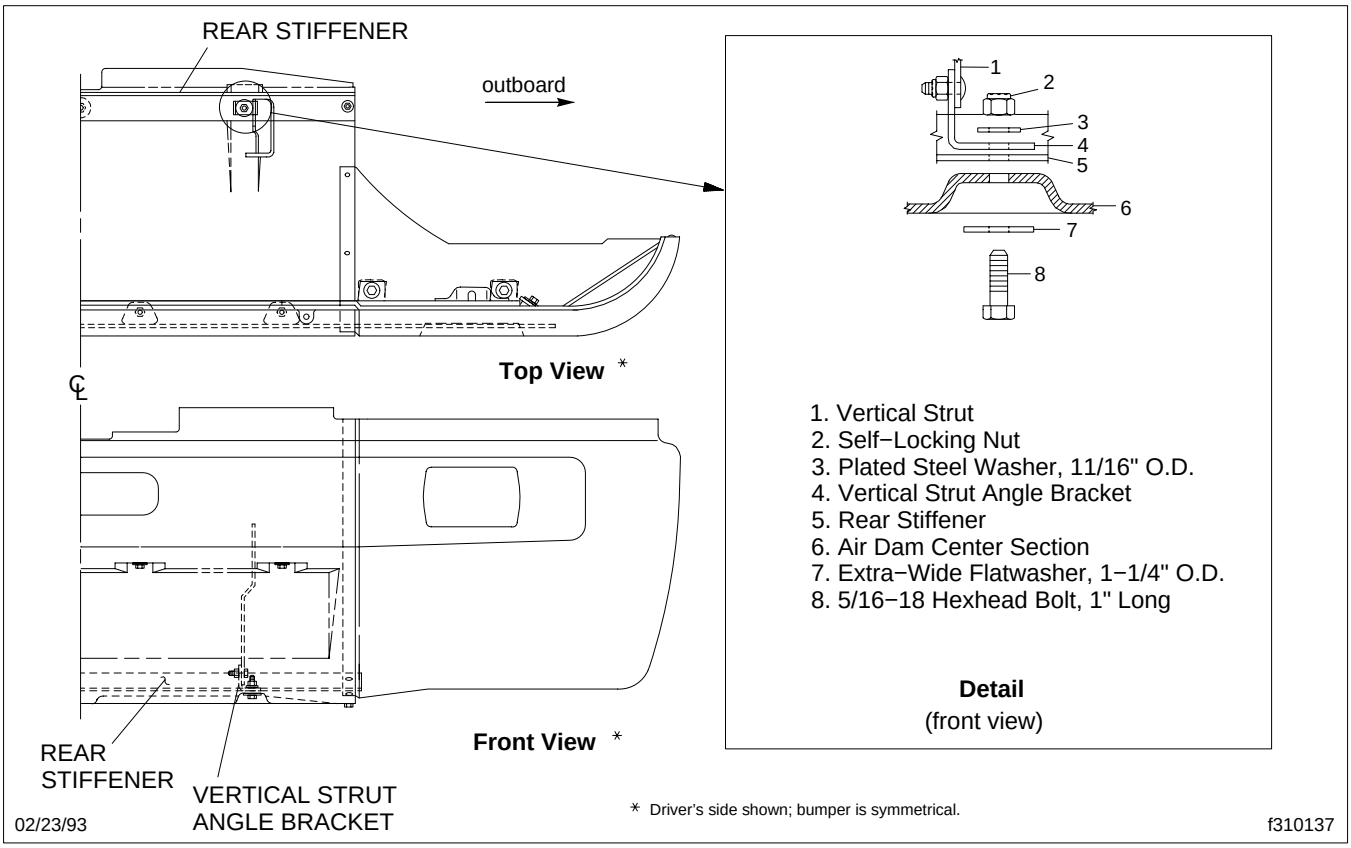


Fig. 9

of the bumper. **See Fig. 15**, Ref. 1. Remove the end cap by pulling it outboard.

INSTALLATION

1. Tilt the cab or hood. Refer to the vehicle driver's manual for instructions.
2. *For a setback-axle Conventional* position the end cap on the bumper and bumper end. Be sure its lower outboard mounting ears are between the top of the zee bracket and the lower flange of the bumper end. **See Fig. 20**, Detail E. If needed, loosen the zee bracket fasteners (Detail C).

   Install the fasteners through the upper mounting ears and the top flange of the bumper (Detail A) and the bumper end (Detail D); don't tighten the locknuts.

   Install the fasteners through the lower inboard mounting ear and the bottom flange of the bumper (Detail B); don't tighten the locknut.

   Install the fasteners through the zee bracket, the lower outboard mounting ears, and the bottom flange of the bumper end (Detail E); don't tighten the locknuts. Go to the next step.

   For all vehicles except a setback-axle Conventional, position the inboard mounting ears of the end cap on the outboard end of the bumper flanges. Push the end cap inboard until its outboard mounting ears are lined up with the outboard mounting holes in the bumper flanges. Install the fasteners through the mounting ears and the bumper flanges, (**Fig. 21**, Details A and B); don't tighten the locknuts.

NOTE: For a setback-axle COE, **if** a new end cap is being installed, remove the bumper air dam extension (**Fig. 22**); refer elsewhere in this group for instructions.

Bumper Air Dam Removal and Installation

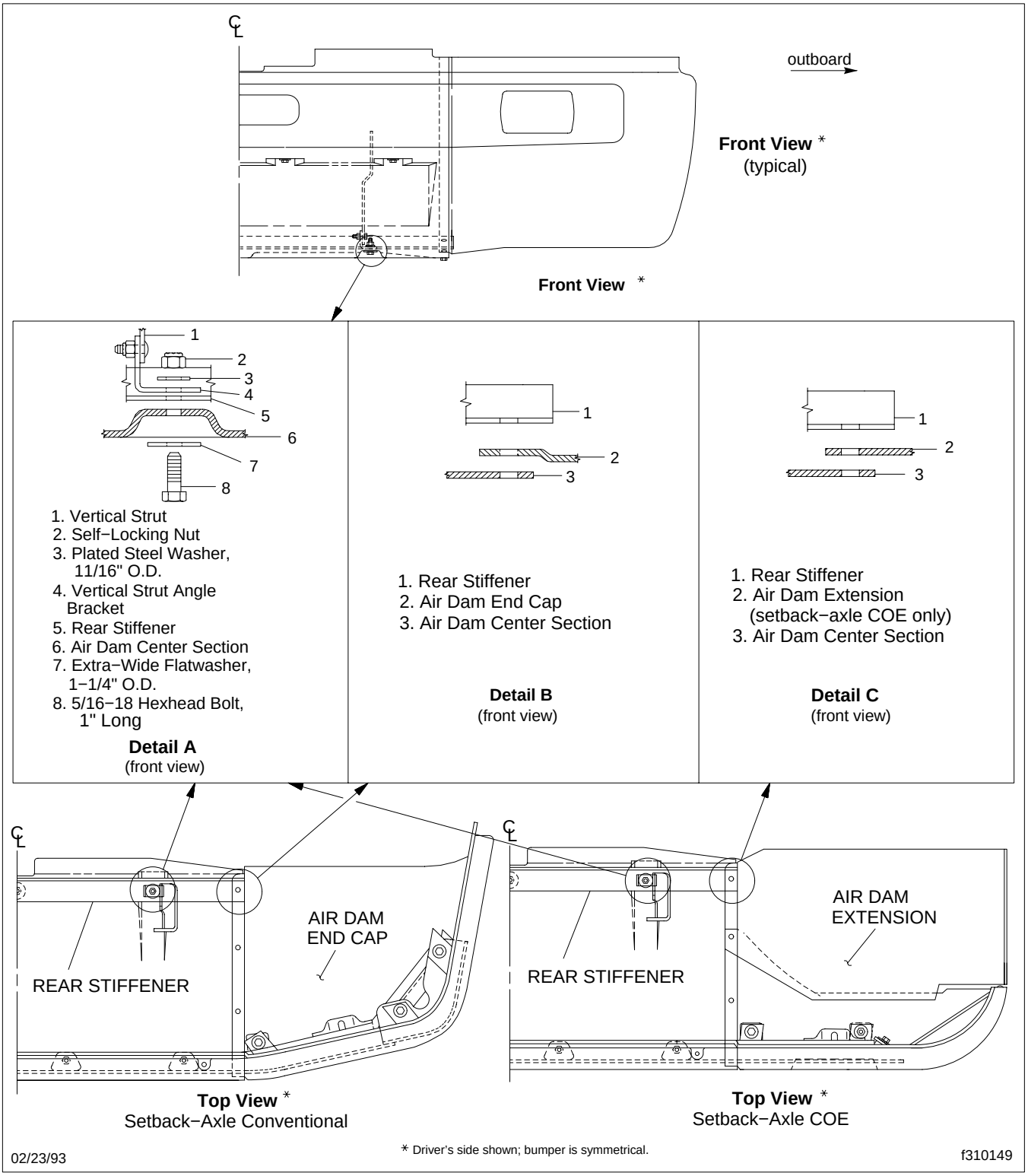


Fig. 10

Bumper Air Dam Removal and Installation

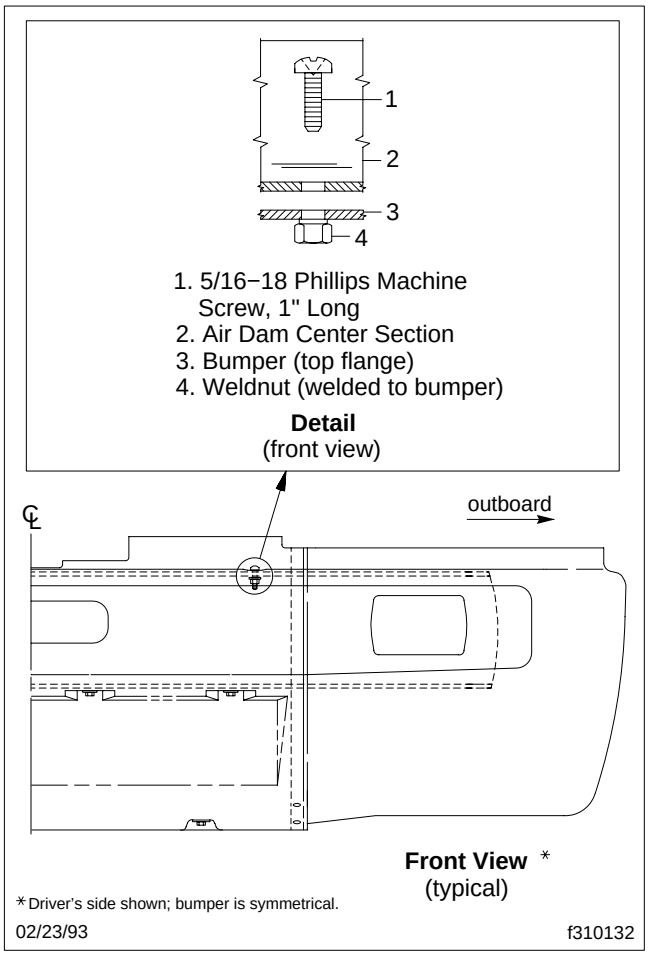


Fig. 11

3. Return the cab or hood to the operating position. Refer to the vehicle driver's manual for instructions.
4. Install the air dam center section.

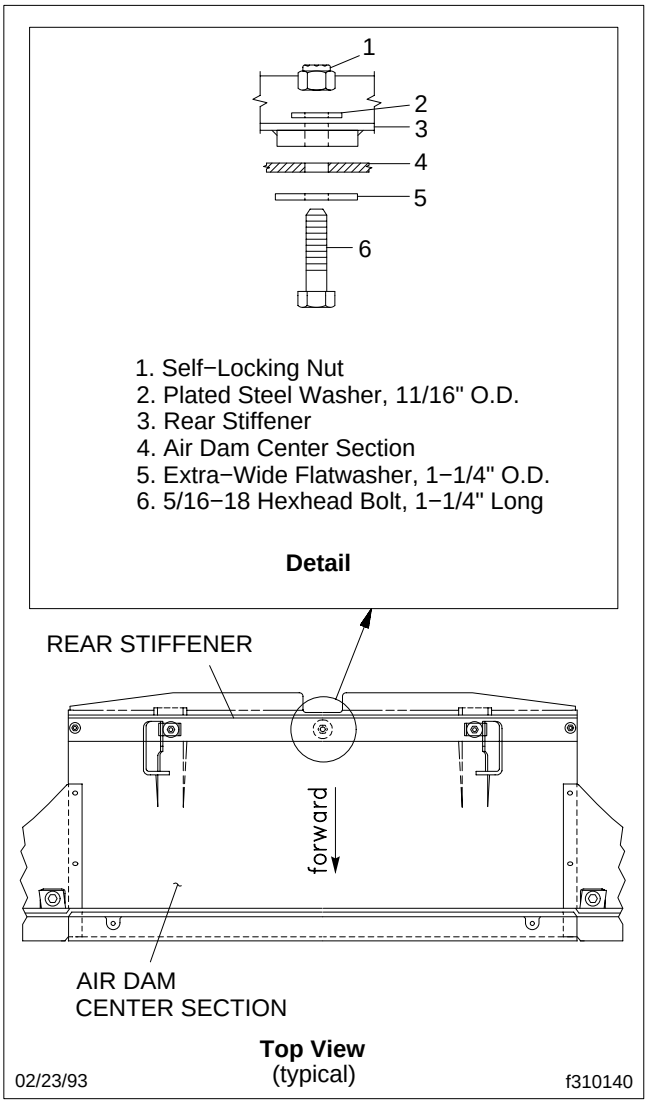


Fig. 12

Bumper Air Dam Removal and Installation

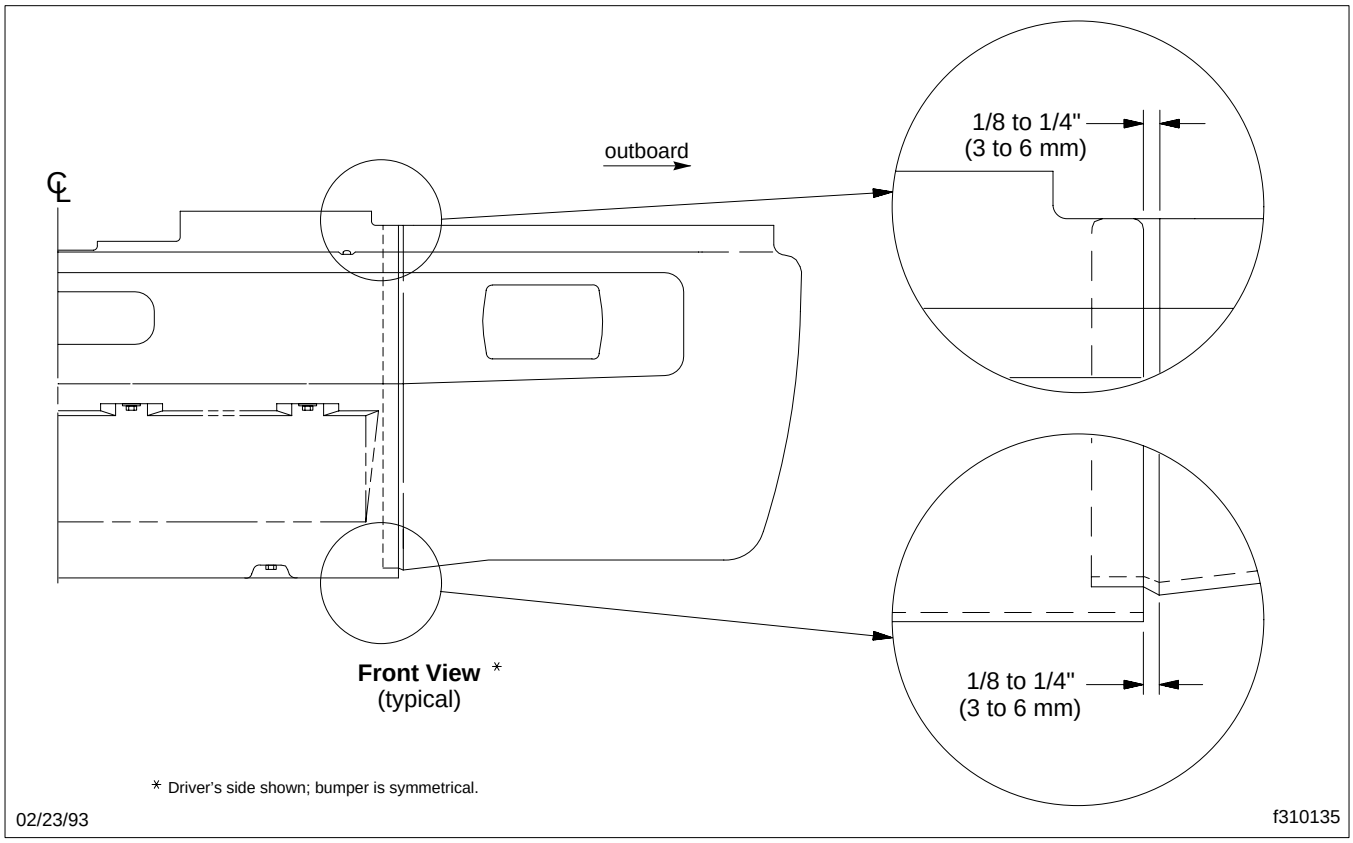
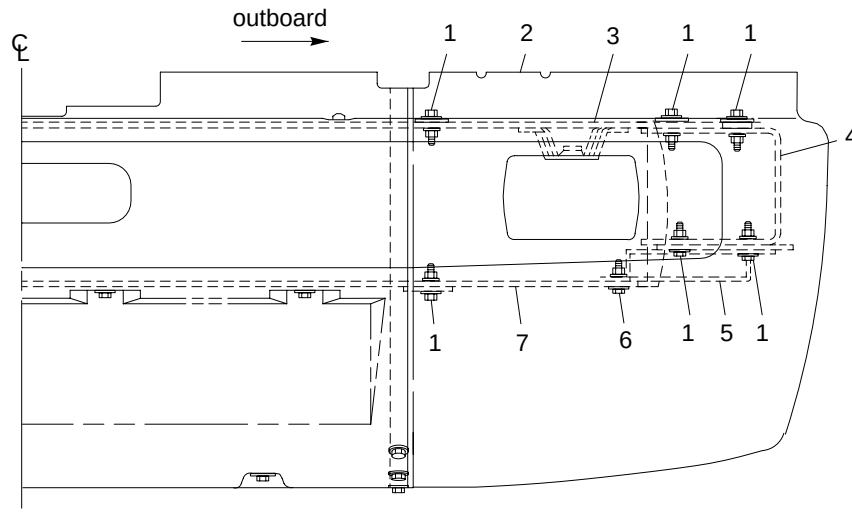


Fig. 13

Bumper Air Dam Removal and Installation



1. End−Cap Mounting Ear Fasteners
2. End Cap
3. Bumper Top Flange
4. Bumper End
5. Zee Bracket
6. Zee Bracket Fasteners
7. Bumper Bottom Flange

Front View *
(Setback−Axle Conventional)

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* Driver's side shown; bumper is symmetrical.

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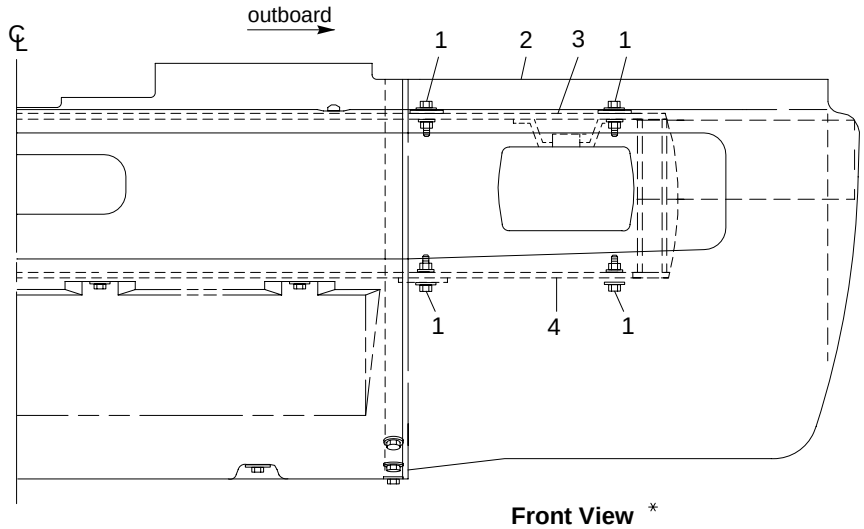
Fig. 14



1. End−Cap Mounting Ear Fasteners
2. End Cap
3. Bumper Top Flange
4. Bumper Bottom Flange

Front View *
(Set−Forward−Axle Vehicles and Setback−Axle COE)

02/23/93

* Driver's side shown; bumper is symmetrical.

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Fig. 15

Bumper Air Dam Removal and Installation

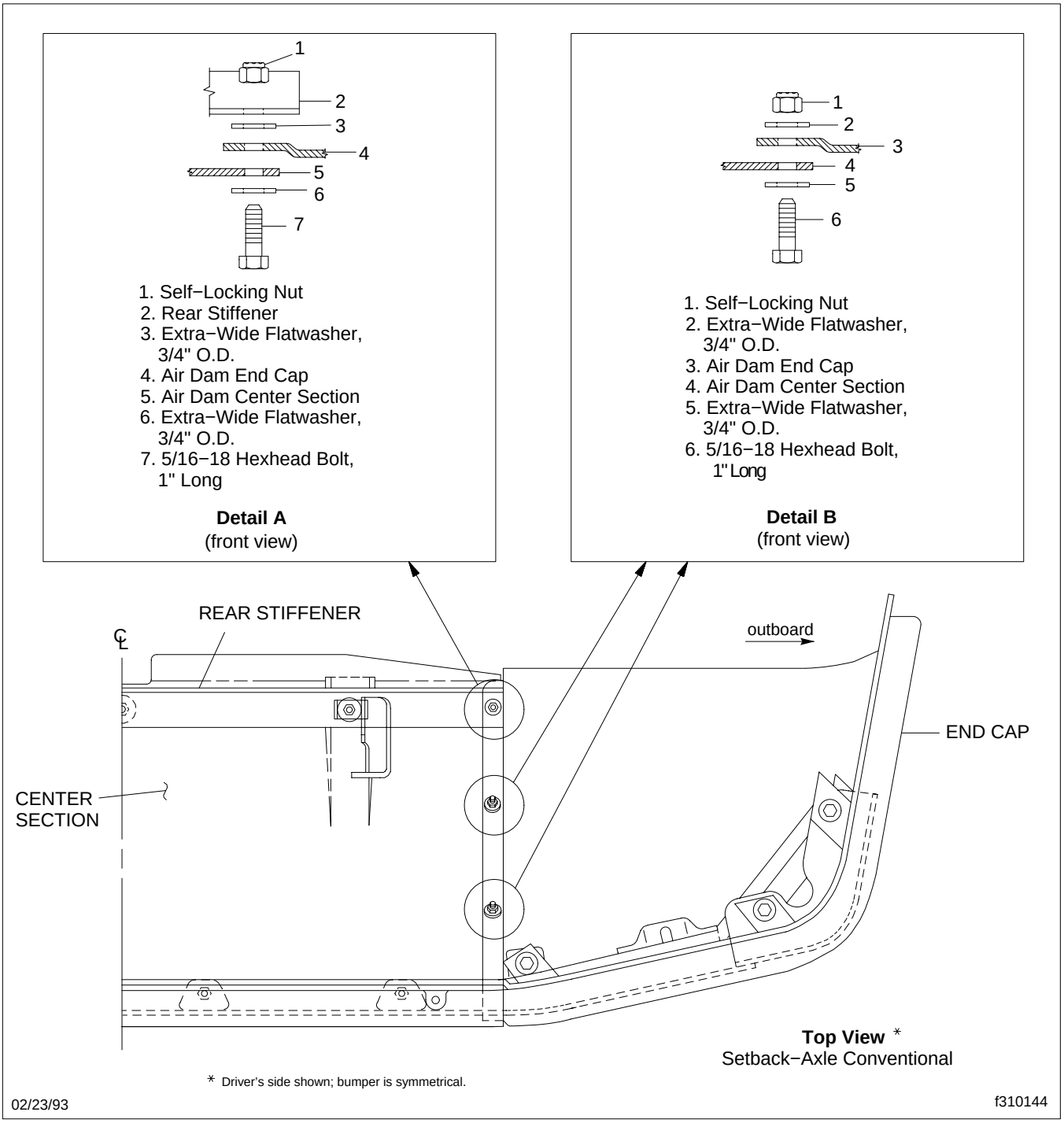


Fig. 16

Bumper Air Dam Removal and Installation

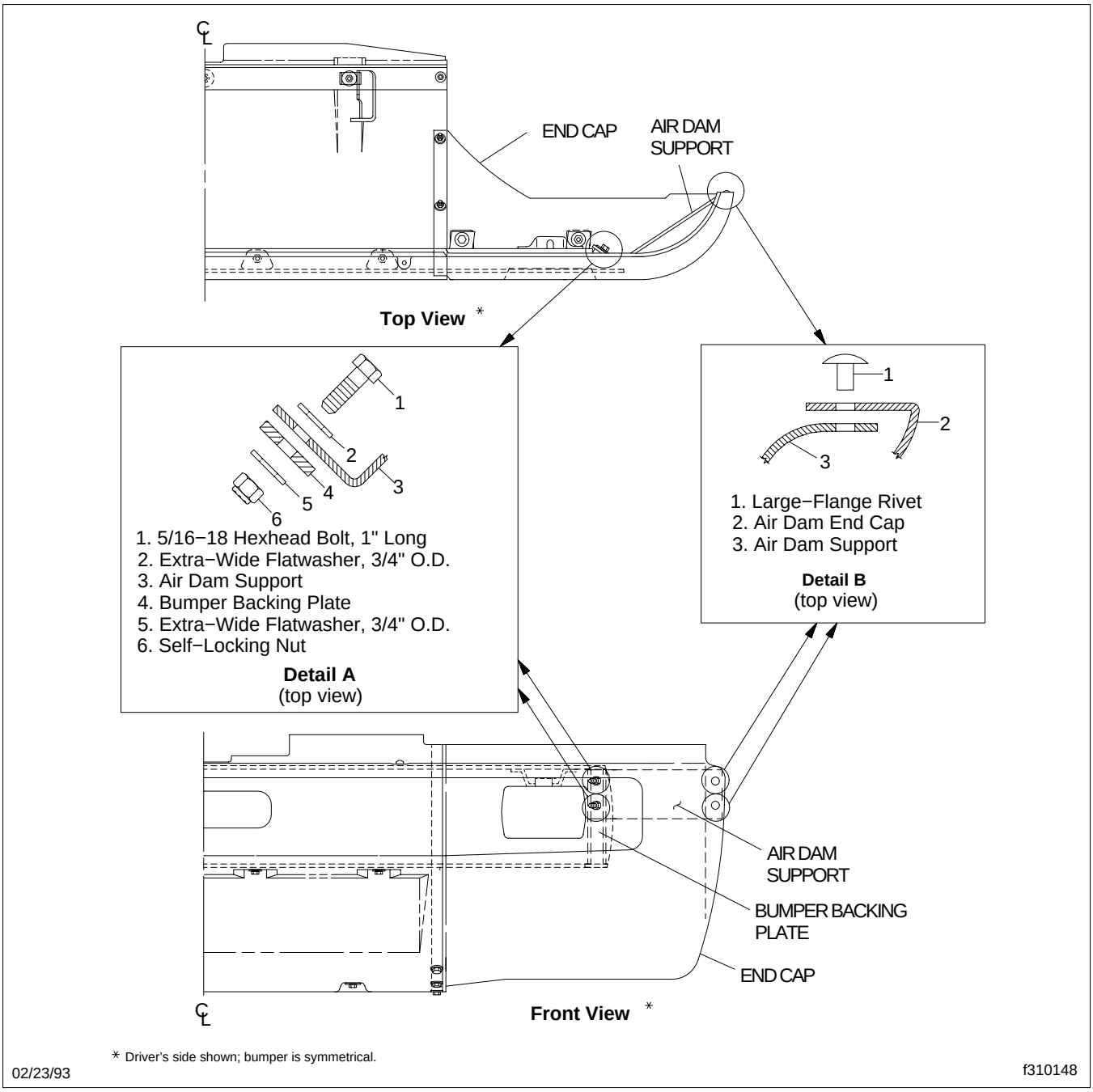


Fig. 17

Bumper Air Dam Removal and Installation

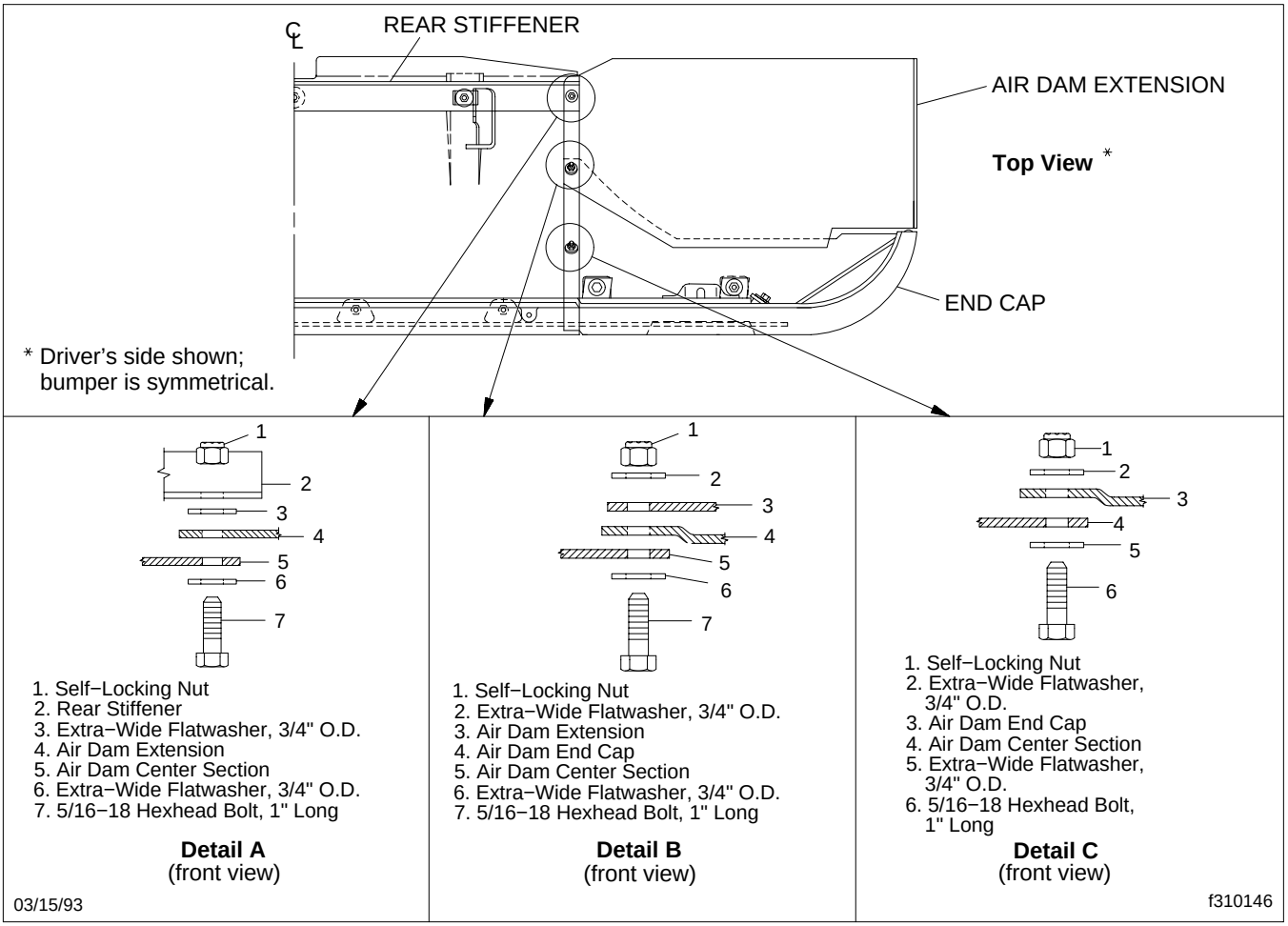


Fig. 18

Bumper Air Dam Removal and Installation

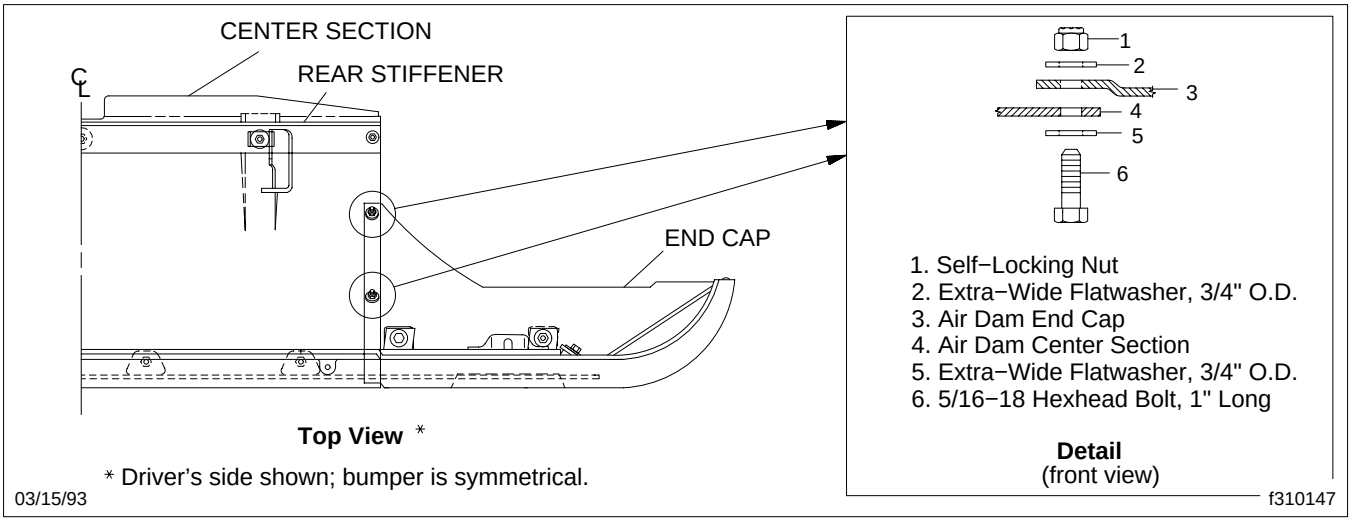
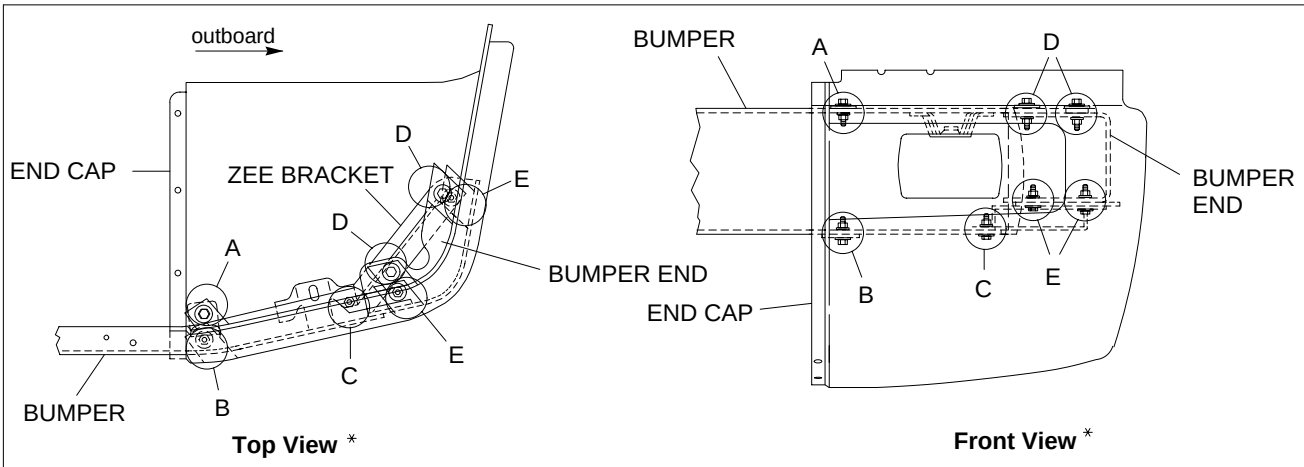


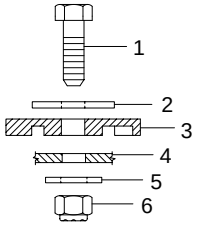
Fig. 19

Bumper Air Dam Removal and Installation



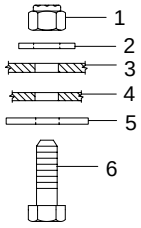
Top View * **Front View** *

* Driver's side shown; bumper is symmetrical.



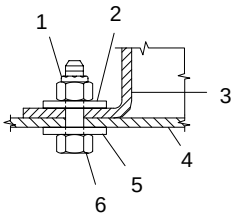
1. 5/16−18 Hexhead Bolt, 1" Long
2. Extra−Wide Flatwasher, 1−1/4" O.D.
3. Air Dam End Cap Mounting Ear
4. Bumper (top flange)
5. Plated Steel Washer, 11/16" O.D.
6. Self−Locking Nut

Detail A



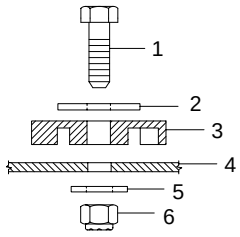
1. Self−Locking Nut
2. Plated Steel Washer, 11/16" O.D.
3. Bumper (bottom flange)
4. Air Dam End Cap Mounting Ear
5. Extra−Wide Flatwasher, 1−1/4" O.D.
6. 5/16−18 Hexhead Bolt, 1" Long

Detail B



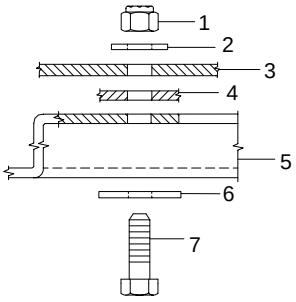
1. Self−Locking Nut
2. Plated Steel Washer, 11/16" O.D.
3. Zee Bracket
4. Bumper (bottom flange)
5. Plated Steel Washer, 11/16" O.D.
6. 5/16−18 Hexhead Bolt, 1" Long

Detail C



1. 5/16−18 Hexhead Bolt, 1−1/2" Long
2. Extra−Wide Flatwasher, 1−1/4" O.D.
3. Air Dam End Cap Mounting Ear
4. Bumper End (top flange)
5. Plated Steel Washer, 11/16" O.D.
6. Self−Locking Nut

Detail D



1. Self−Locking Nut
2. Plated Steel Washer, 11/16" O.D.
3. Bumper End (bottom flange)
4. Air Dam End Cap Mounting Ear
5. Zee Bracket
6. Plated Steel Washer, 11/16" O.D.
7. 5/16−18 Hexhead Bolt, 1−1/4" Long

Detail E

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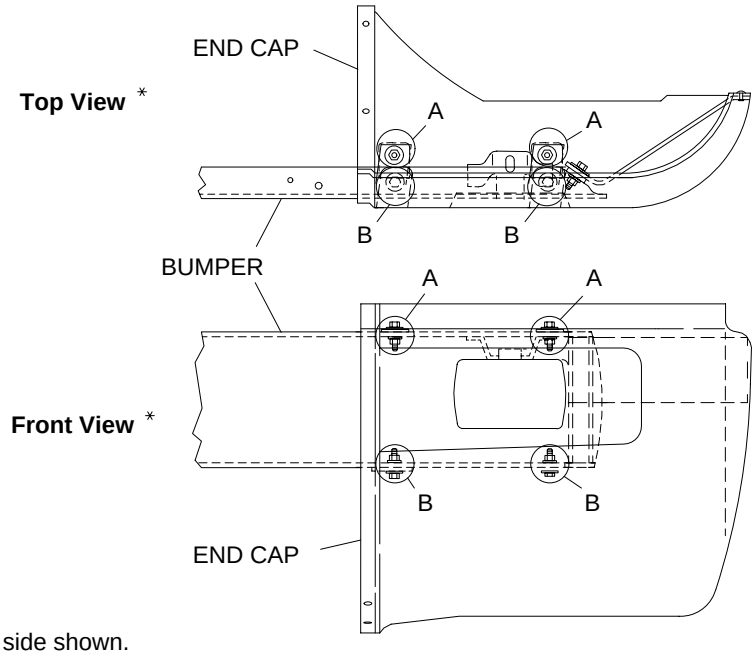
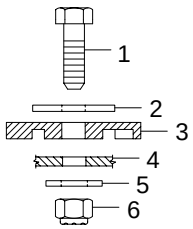
Fig. 20

Bumper Air Dam Removal and Installation

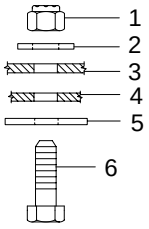


* Driver's side shown.



1. 5/16−18 Hexhead Bolt, 1" Long
2. Extra−Wide Flatwasher, 1−1/4" O.D.
3. Air Dam End Cap Mounting Ear
4. Bumper (top flange)
5. Plated Steel Washer, 11/16" O.D.
6. Self−Locking Nut

Detail A



1. Self−Locking Nut
2. Plated Steel Washer, 11/16" O.D.
3. Bumper (bottom flange)
4. Air Dam End Cap Mounting Ear
5. Extra−Wide Flatwasher, 1−1/4" O.D.
6. 5/16−18 Hexhead Bolt, 1" Long

Detail B

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Fig. 21

Bumper Air Dam Removal and Installation

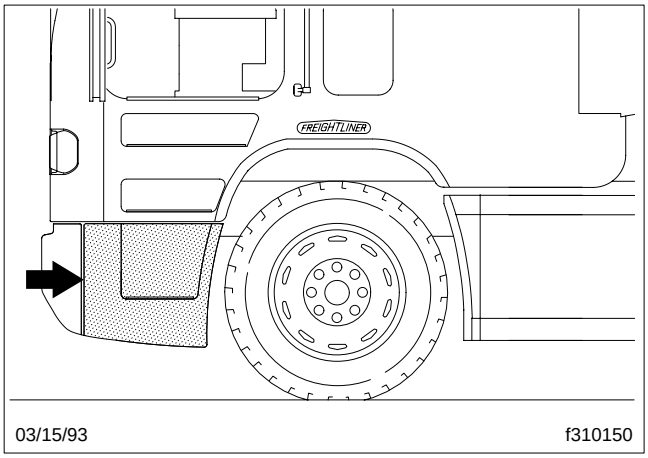


Fig. 22, Bumper Air Dam Extension

General Description

Side fairing assemblies (**Fig. 1**), sized to the cab or wheelbase, ease air turbulence around the fuel tanks and provide access to the sleeper and back of the cab.

Side fairings are fuel-tank and/or frame-rail mounted. The upper portions of fuel-tank-mounted fairings attach to the fuel tank bracket. The lower mount is at the tank band step support bracket. All frame-rail-mounted panels attach to the web area of the rail.

The upper panels on the 120 Conventional are made of fiberglass, and are painted the color of the cab. The lower panels on the 120 Conventional and the entire fairing on the COE are made of ABS material and are dark gray.

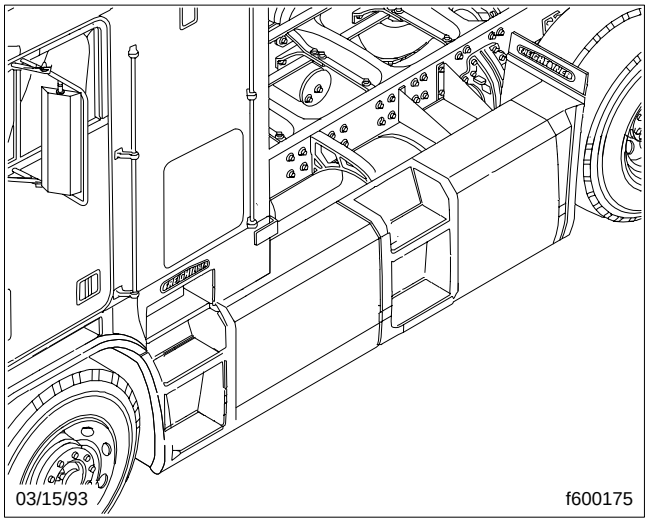


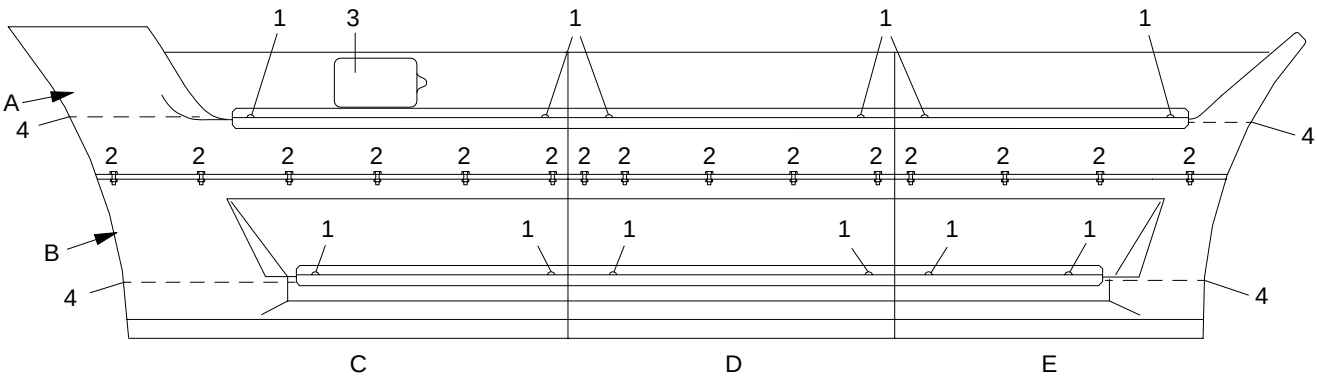
Fig. 1, Side Fairing Assembly (COE shown)

Panel Removal

120 CONVENTIONAL

The fairing section consists of an upper and lower panel. Each set of panels is removed as a unit.

1. Apply the parking brakes, and chock the tires.
2. Remove the attaching bolts holding the lower panel to the fairing bracket. **See Fig. 1**. Remove the upper panel attaching bolts.
2. Remove the attaching bolts and the load-bearing washers (if equipped) holding the panel to the fairing bracket. **See Fig. 5**.
3. On standard vehicles, the mudflaps are attached to the front and the rear panels. Remove the two bolts attaching the rear mudflap to the support bracket. **See Fig. 6**. Tilt the cab to remove the front mudflap attaching bolts. Remove the fairing panels with the mudflap attached.
4. On vehicles with tube-style mounted mudflaps (



NOTE: Center panel size is determined by the vehicle's wheelbase.

A. Upper Panels
B. Lower Panels
C. Front Panel
D. Center Panel
E. Rear Panel
1. Attaching Bolts
2. Panel Assembly Bolts
3. Fuel Fill Door
4. Fairing Bracket

Fig. 1, 120 Conventional Chassis Side Fairing Assembly

3. The mudflaps are attached to the rear panels. Remove the two bolts attaching the rear mudflap to the support bracket. **See Fig. 2**. Tilt the hood to remove the fastener attaching the front panel. **See Fig. 3**. Remove the fairing panels. The rear panel is removed with the mudflap attached.
4. Lift the upper and lower panels as a unit off the brackets. **See Fig. 4**. If necessary, remove the bolts connecting the upper and lower panels, then separate the panels.

COE

Each panel may be removed separately.

1. Apply the parking brakes, and chock the tires.

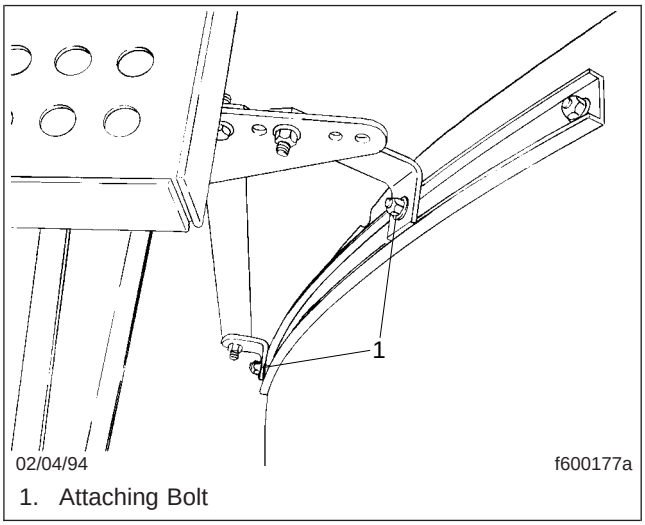
Fig. 7), lift the fairing panel off the bracket after removing the attaching bolts. The mudflaps are independently attached to the frame and are not connected to the fairing.

Panel Installation

1. On 120 Conventionals, install the bolts to connect the upper and lower fairing panels together, if panels are separated.
2. On COEs and 120 Conventionals, place the panel in position on the mounting brackets.

NOTE: On FLDs equipped with side fairings, the fuel tank filler neck does not have to be cen-

Panel Removal and Installation



1. Attaching Bolt

Fig. 2, Rear Mudflap Connection (120 Conventional Setback Axle)

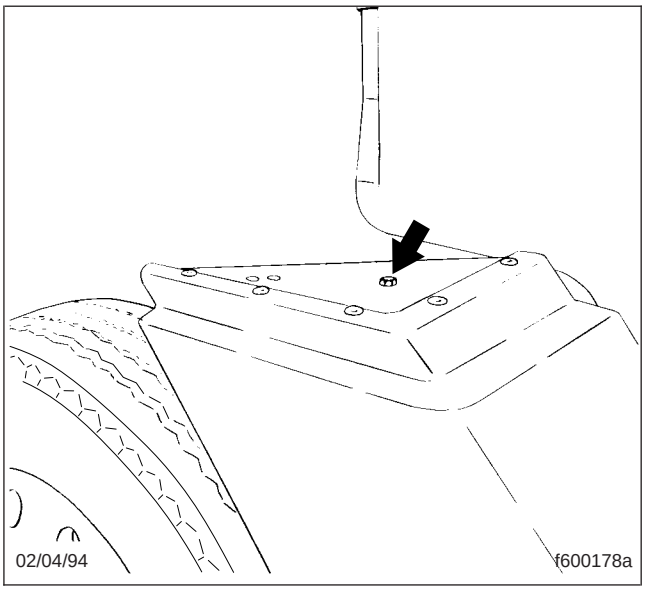


Fig. 3, Front Mudflap Connection (120 Conventional Setback Axle)

tered in the fill door opening of the side fairing. The centerline of the fuel tank cap is to be within 1 inch (25 mm) of either side of the centerline of the fill door opening. **See Fig. 8**. Don't move the fuel tanks to center the fuel tank filler neck in the fill door opening.

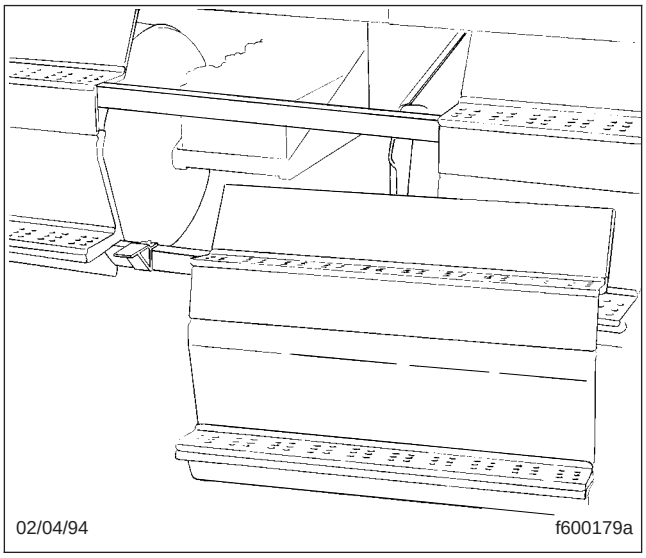


Fig. 4, Fairing Removed from the Vehicle

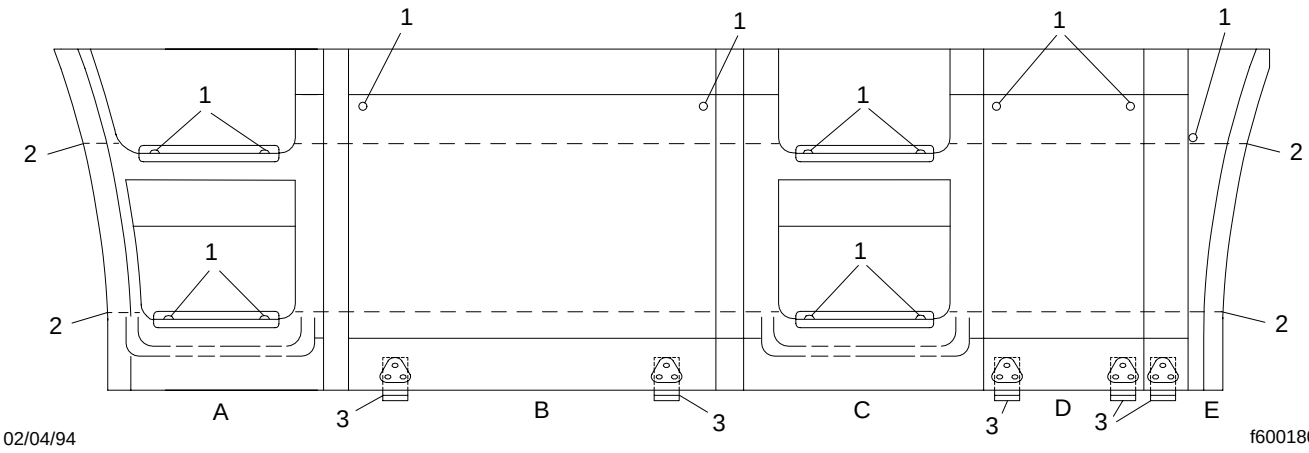
If you do need to move the fuel tank, refer to the fuel group in the vehicle service manual for instructions.

3. If applicable, install the attaching bolts to secure the mudflaps to the support bracket.
4. Install the attaching bolts and the load-bearing washers (if equipped), and tighten the screws 15 lbf·ft (20 N·m).

⚠ CAUTION

CAUTION: Do not overtighten the attaching bolts. This could cause the fairing to crack.

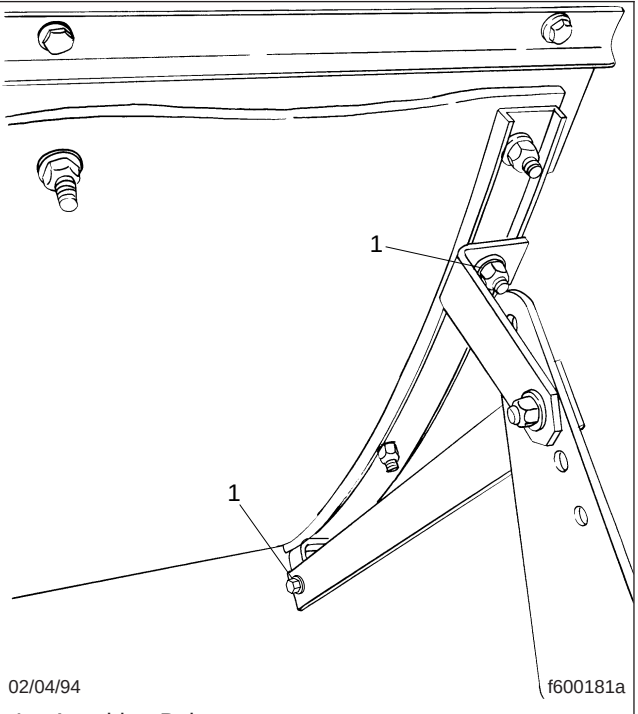
5. Remove the chocks from the tires, and release the parking brakes.



NOTE: Forward center panel size is determined by the cab size. Aft center panel size is determined by the vehicle's wheelbase.

A. Front Panel
B. Forward Center Panel
C. Side Step Panel
D. Aft Center Panel
E. Rear Panel
1. Attaching Bolts
2. Fairing Bracket
3. Riveted Retaining Clip and Backing Plate

Fig. 5, Axle Forward COE Chassis Side Fairing Assembly



1. Attaching Bolt

Fig. 6, Standard Mounted Mudflap Connection (rear shown)

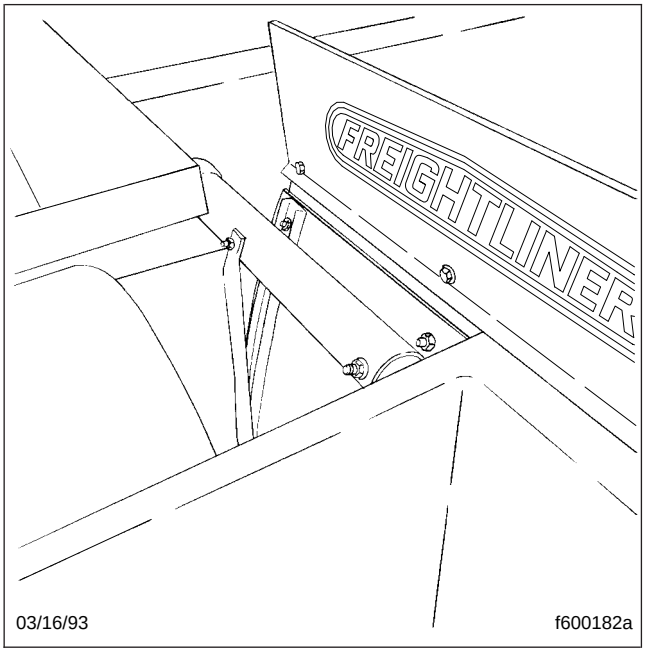
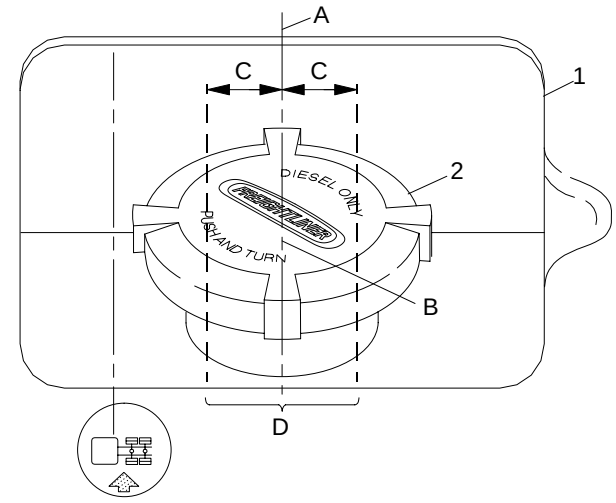


Fig. 7, Tube-Style Mounted Mudflap Connection (rear shown)

Panel Removal and Installation



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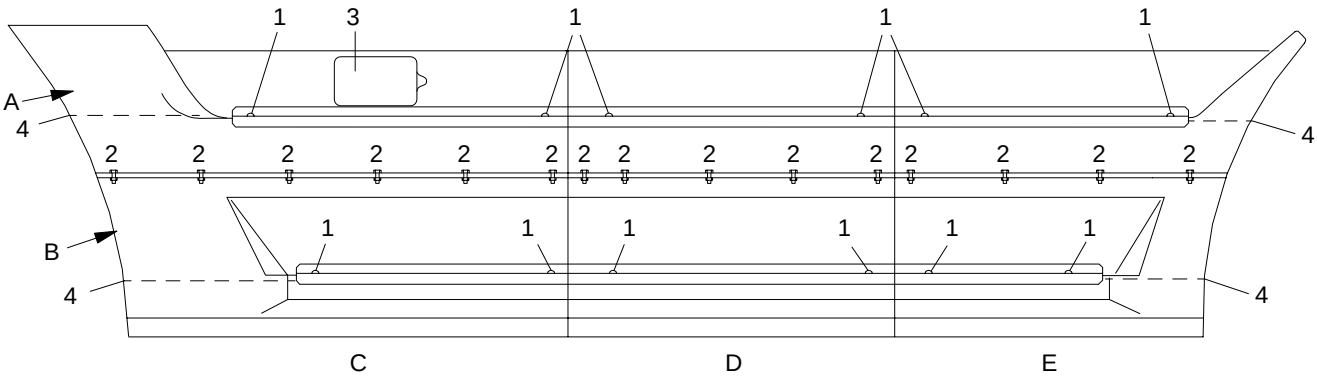
A. Centerline of fill door opening
B. Centerline of fuel cap
C. 1 inch (25 mm)
D. Fuel cap centerline to be within this area.
1. Fill Door Opening
2. Fuel Cap

Fig. 8

Chassis Side Fairing Adjustment, FLD Conventional

IMPORTANT: Chassis side fairings installed on FLD Conventional vehicles are adjustable within certain limits using specific adjustment procedures. Enhancement of fairing design has been an ongoing process since introduction in 1987. Current fairing design and fairing hardware offers the best possible fit. See **Fig. 1**.



NOTE: Center panel size is determined by the vehicle's wheelbase.

A. Upper Panels
B. Lower Panels
C. Front Panel
D. Center Panel
E. Rear Panel
1. Attaching Bolts
2. Panel Assembly Fasteners
3. Fuel Fill Door
4. Fairing Bracket

Fig. 1, 120 Conventional Chassis Side Fairing Assembly (left side shown)

Side Fairing Adjustment Requirements

Freightliner chassis side fairings are designed to enhance vehicle appearance in addition to providing a durable installation that requires few if any adjustments over the life of the vehicle. Following are recommended adjustment procedures for FLD vehicles manufactured from March 1993.

Adjustment of the chassis side fairings is not typically required unless the vehicle has been damaged in a collision. Check the position of the fairings carefully, as described below, before adjusting. Most vehicles will have fairings adjusted within specifications and will not require adjustment.

The fairing panels vary in alignment due to material variations. The step treads are aligned parallel to the support rails. The outboard edge of the step treads should be parallel to the support rails within 1/2 inch (13 mm). Misalignment of the tread beyond this range is not possible unless the panel has been damaged. Do not attempt to align the upper and lower fairing panels. Their location is fixed by the step tread alignment. The gap between panels will vary from no gap to 1/2 inch (13 mm) at the tread surfaces. Gaps in the panels beyond the treads are dependent on material variations and are not adjustable.

When adjusting, use only the original number of specified fasteners. Any additional fasteners will reduce service life and void any warranty.

Position Checks

Before checking or adjusting wheel-to-wheel side fairings, make sure the cab air suspension is properly adjusted. Then, check that the hood is properly

Chassis Side Fairing Adjustment, FLD Conventional

adjusted. See the vehicle service manual, **Section 60.02** for cab air suspension ride height, and **Section 88.00** for hood adjustment.

To check the position of the side fairings, use the following steps:

1. On FLD day cabs with cab air suspension, the vertical distance from the top step tread to the bottom of the cab side skirt measured below the cab entry door should be between 8 and 8-1/2 inches (203 mm to 216 mm). On FLD day cabs without air suspension and on all vehicles with SleeperCabs, this vertical distance is between 7-3/4 and 8-1/4 inches (197 mm to 210 mm). See **Fig. 2**, **Fig. 3**, and **Fig. 4**.

   Check this measurement at the cab skirt where the underturned flange of the skirt begins and ends. The range listed above gives 1/2-inch (13-mm) maximum between the two measurements, with the lower numbers being nominal. The tolerance range allows the side fairing to be non-parallel with the bottom edge of the cab and still not require adjustment.

   At the leading outboard edge of the front fairing panel, the gap between the hood and the fairing on FLD 120 vehicles and the quarter fender and fairing on FLD 112 vehicles will be 1-1/8 to 1-5/8 inches (29 mm to 41 mm) on day cabs with air suspension. The measurement will be 3/4 inch to 1-1/4 inch (19 mm to 32 mm) on day cabs without air suspension and on all vehicles with SleeperCabs.

IMPORTANT: Measurements taken on the upper step tread must be taken between the tread risers, which is the lowest portion of the tread component.

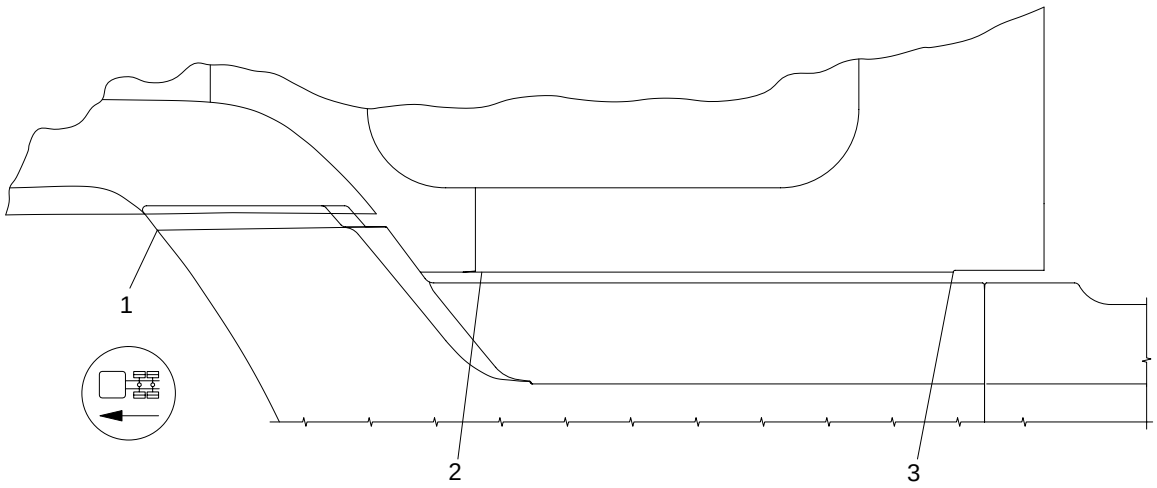
2. The horizontal location of the fairing is checked by measuring the distance from the forward underturned edge of the cab skirt to the forward edge of the upper step tread. On FLD 112 vehicles, the forward edge of the cab skirt mates with the quarter fender. On FLD 120 vehicles, the forward edge of the skirt mates with the cowl side panel. This horizontal distance measured parallel to the skirt edge should be 3-3/4 to 4-1/4 inches (95 mm to 108 mm) for all the FLD 112 vehicles. The horizontal distance will be 8-1/2 to 9 inches (216 mm to 229 mm) for all FLD 120 vehicles. If the measured distance is outside the ranges specified, inspect the forward mudflap-fairing mounting bracket for damage. The steel tube strut of this bracket should be perpendicular to the frame rail web.
3. The width of the side fairings is for all practical purposes fixed by the mounting brackets. Minor adjustments may be made to align the fairing support rails when making height and fore-and-aft adjustments.
4. If the inspections listed above are within the ranges specified, no further adjustment of the fairing support system is necessary.

Fairing Height Adjustment

1. Determine the height change required at the top step tread by using the height ranges specified in the first step under "Position Checks." Maintain a written record of these changes.
2. Open the hood.
3. Remove the side fairing panels.
4. Loosen the fairing support rail fasteners. Leave the rails in place, taking care not to shift the rails forward or backward. A mark on the aluminum support rails with a permanent marker will locate the rails at the supports. Avoid scribing the aluminum if possible.
5. Measure the distance from the ground to the forward rail mounting surface (which is the upper mounting surface for the upper support rail). Add (to raise) or subtract (to lower) the number from the first step above to determine the finish height measurement. Note this number.
6. Repeat the previous step at the rear support bracket. As before, write down the finished height measurement.
7. Loosen the mounting brackets and adjust the front and rear brackets to the required finish heights. Adjust the intermediate support to touch the support rails after the front and rear supports are changed.

NOTE: The fuel tank support bracket has a lower adjusting nut that is torqued 94 lbf·in (1062 N·cm) after the upper slots are adjusted. The other brackets are slotted in the upper fastener locations where the support bracket is fastened to the angle mounting bracket. Tighten

Chassis Side Fairing Adjustment, FLD Conventional



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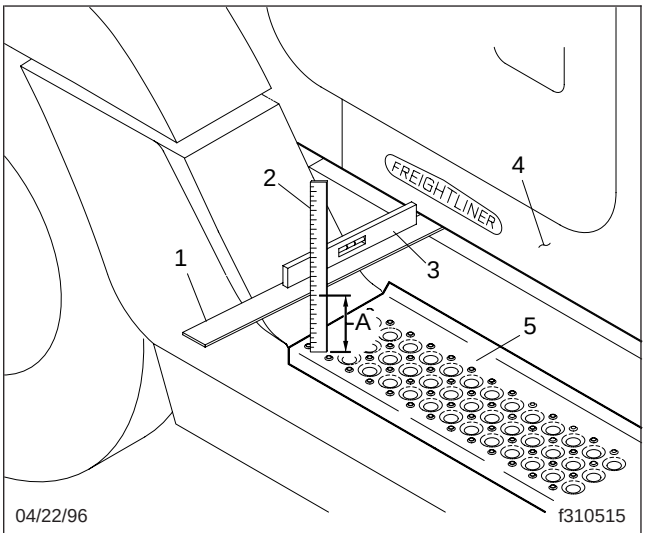
1. Forward End of Fairing
2. Forward End of the Underturned Flange of the Skirt
3. Aft End of the Underturned Flange of the Skirt

Fig. 2, Panel Alignment Measuring



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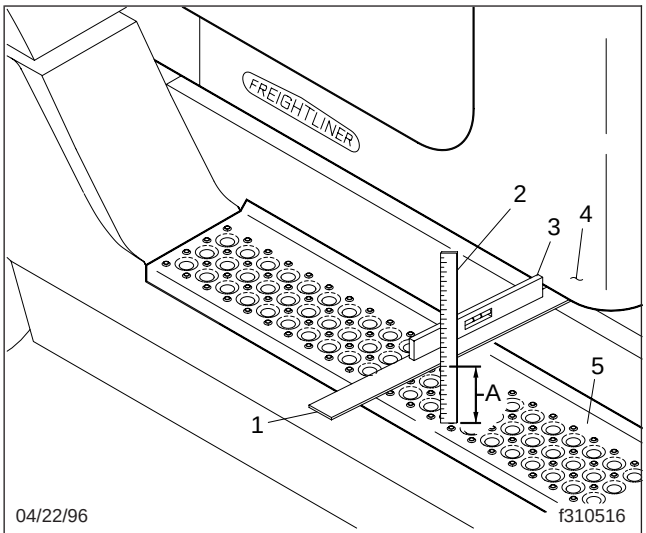
NOTE: Measure between tread risers.

A. Measure Here
1. Straight Edge
2. Ruler
3. Level
4. Cab Side Skirt
5. Top Step Tread

Fig. 3, Checking Gap at Forward Underturned Flange



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NOTE: Measure between tread risers.

A. Measure Here
1. Straight Edge
2. Ruler
3. Level
4. Cab Side Skirt
5. Top Step Tread

Fig. 4, Checking Gap at Aft Underturned Flange

these fasteners to the torque specified in **Section 00.06** of the vehicle service manual.

8. Retighten the support rail fasteners 180 lbf·ft (244 N·cm).

Chassis Side Fairing Adjustment, FLD Conventional

9. At the front mudflap support bracket, move the upper fairing support, and then measure the distance from the ground to the horizontal bracket. Add or subtract the change required and record the finish height measurement. Loosen the fasteners and move the support. Torque the fasteners.
10. Install the fairing side panels by starting at the front of the vehicle and working aft. The outboard edge of the step treads is to be parallel to the support rails within 1/2 inch (13 mm). The gap between panels is to be from no gap to a 1/2 inch (13 mm) gap.

Fore-and-Aft Adjustment

1. Determine the fore-and-aft change required at the top step tread using the length ranges previously specified. Maintain a written record of the changes.
2. Open the hood.
3. Remove the side fairing panels.
4. Mark the original location of the side rails with a permanent marker.
5. Loosen the rails, and move them to the required position.
6. Retighten the rail mounting fasteners using the torque values listed in the service manual.
7. Install the fairing side panels by starting at the front of the vehicle and working aft. The outboard edge of the step treads is to be parallel to the support rails within 1/2 inch (13 mm). The gap between the panels is to be from no gap to 1/2 inch (13 mm).

General Information

NOTE: The Holland 3500 series XA–3501 model fifth wheel top plate has been replaced by the XA–351 model. All 3500 series fifth wheel top plates which are marked with a manufactured date after June 1, 1996 are XA–351 models.

NOTE: Service operations for the Holland 3500 series slide mounts (FW2535/FW35) are covered in **Section 31.06** in this group.

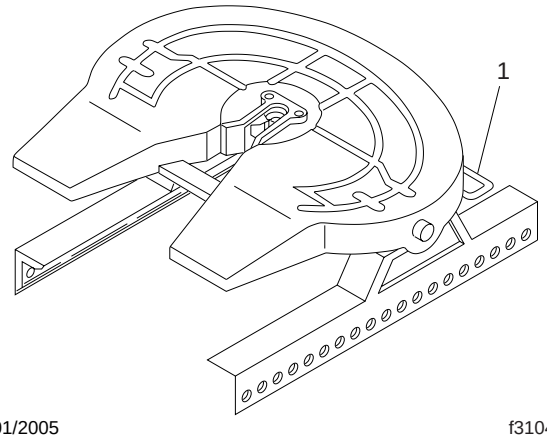
MODEL XA–3501 TOP PLATE

NOTE: The part number prefix for the stationary fifth wheel is FW3500 and the part number prefix for the sliding fifth wheel is FW2535.

Holland 3500 series XA–3501 fifth wheels are used for pulling trailers having the standard SAE kingpin. When installed as stationary fifth wheels, they are bracket-mounted to the trailer frame in a position that best distributes the trailer load over the tractor axles. When installed as sliding fifth wheels, they are mounted on the Holland 3500 series sliding mount. These fifth wheels have a capacity of 150,000 lbf (667 000 N) maximum drawbar pull and 40,000 to 50,000 lbf (178 000 to 222 000 N) maximum vertical load. The fifth wheel (**Fig. 1**) has a cast steel top plate, and is equipped with a split type "B" mechanical spring lock. This steel kingpin lock system requires a 300 lbf (1330 N) push (force) to couple, and also includes a slack adjustment and the Holland lockguard (which prevents high kingpin coupling).

The two spring-loaded lock halves separate as the kingpin enters the lock mechanism. See **Fig. 2**. The final forward motion of the kingpin forces the lock to close in a 360 degree grip around the shoulder and neck of the kingpin, and moves the yoke between the lock halves and the tapered rib members of the fifth wheel understructure. The kingpin can be released only by manually operating the kingpin lock control handle. See **Fig. 1**. An adjustment nut compensates for wear on the lock or kingpin, if necessary.

See Chapter 10 (FLD) or Chapter 10 (FLB) in the vehicle driver's manual for complete operating instructions.



1. Kingpin Lock Control Handle

Fig. 1, XA-3501 Fifth Wheel

MODEL XA–351 TOP PLATE

NOTE: The part number prefix for the stationary fifth wheel and the sliding fifth wheel is FW35.

The Holland 3500 series XA–351 fifth wheels are applicable for general over-the-road use. They are designed to pull trailers having a 2 inch (5 cm) SAE J700b kingpin. They have a capacity of 150,000 lbf (667 000 N) maximum drawbar pull and 55,000 lbf (244 652 N) maximum vertical load. These fifth wheels are available in three different mounting assemblies: the Kompensator®; the slide mount; and the stationary mount.

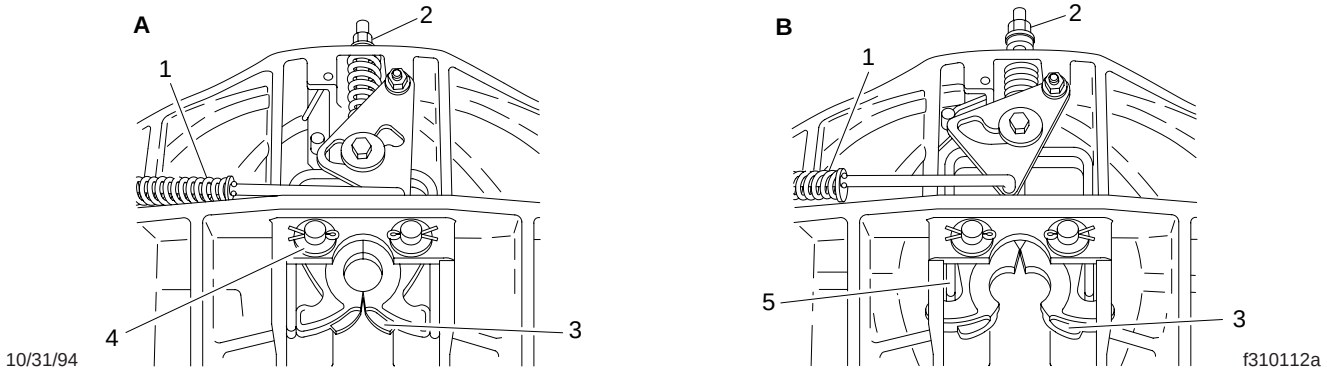
The stationary mount fifth wheels are available with four different mounting bracket styles, which include:

- a bracket with a mounting base for over-the-frame mounting;
- a bracket with a mounting angle for over-the-frame mounting;
- a bracket for angle mounting (designed to be welded to the angle) for over-the-frame mounting;
- and, a bracket for outboard angle mounting.

The mounting brackets use nylon-lined "up-shock" bushings. These fifth wheels come in a variety of heights to accommodate many applications.

The sliding fifth wheels are available with either an over-the-frame mounting bracket or an outboard angle mounting bracket. These mounting brackets

General Information



A. Closed Position—Locked
B. Open Position—Unlocked
1. Release Handle and Spring
2. Adjusting Nut
3. Lock (2 used)
4. Lock Pivot (2 used)
5. Sliding Yoke

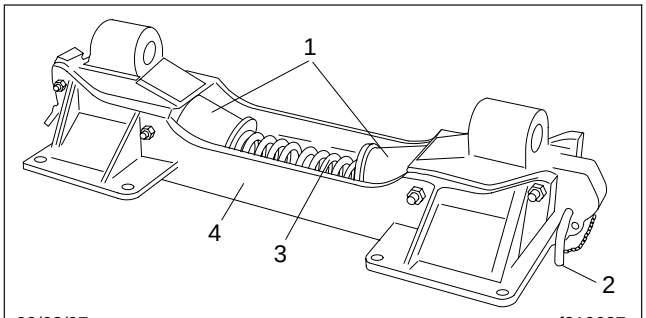
Fig. 2, Type B Kingpin Lock Mechanism (bottom view)

are either equipped with a manual slide release or an air slide release mechanism. These sliding mounts have a position adjustment that gives the fifth wheel top plate the ability to be released, incrementally moved (by 1.5 inch [3.8 cm] displacements) and locked in alternate positions. The position adjustment feature allows the fifth wheel position to vary combination length and tractor axle load distribution for maximum equipment utilization. The mounting brackets use nylon-lined "up-shock" bushings. The sliding fifth wheels are available in a variety of heights and slide travel lengths.

The Kompensator® fifth wheel is equipped with either a stationary or sliding mounting bracket. This fifth wheel is designed for rigid trailers that don't flex during torsional loading. It provides torsional stress relief and promotes vehicle stability with trailers that have an unusually high center of gravity (where the center of gravity is up to 44 inches [111 cm] above the top plate surface). This fifth wheels unique cradle design provides side-to-side movement to help relieve the torque and twist of the trailer. Spring cushions act as a restoring force to provide stability after absorbing the strain and pressure of the load. Additionally, it keeps the center of compensation above the fifth wheel bearing surface and centered between the frame rails. All models are available with an optional "lock-out" feature to restrict compensation for applications that do not require compensation. See **Fig. 3**.

The 3500 series top plate consists of:

- the cast steel top plate;
- the bracket pin mount;



1. Urethane Cushions
2. Optional Lockout
3. Compression Springs
4. Kompensator® Cradle Design Mounting Bracket

Fig. 3, The Kompensator®Cradle

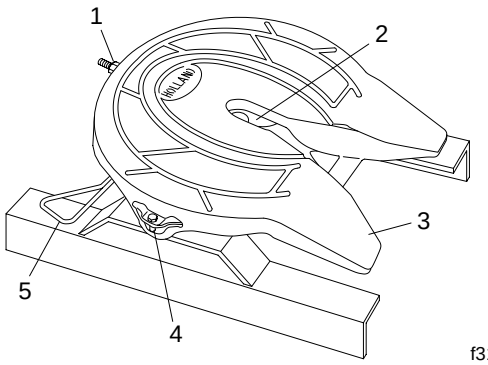
- the release handle;
- the infinite lock adjustment nut;
- and the kingpin lock mechanism.

See **Fig. 4**.

The kingpin lock mechanism consists of:

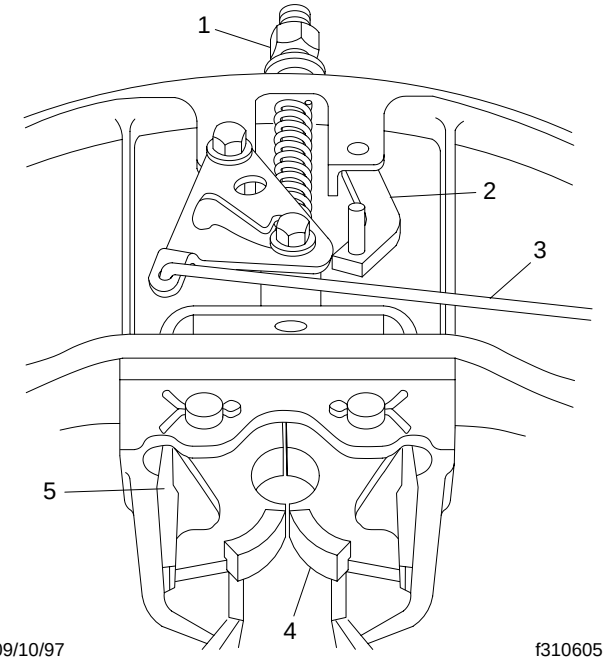
- the infinite lock adjustment nut;
- the secondary lock;
- the release handle;
- the type "B" forged steel split lock;
- and, the yoke.

See **Fig. 5**.



1. Infinite Lock Adjustment Nut
2. Kingpin Lock
3. Cast Steel Top Plate
4. Bracket Pin Mount
5. Release Handle

Fig. 4, XA-351 Fifth Wheel



1. Infinite Lock Adjustment Nut
2. Secondary Lock (Automatic Shown)
3. Release Handle
4. Kingpin Guide
5. Yoke

Fig. 5, Kingpin Lock Mechanism (bottom view)

When the yoke is retracted, the two spring-loaded lock halves separate as the kingpin enters the lock mechanism. When the yoke engages, the final forward motion of the kingpin forces the lock to close in a 360 degree grip around the shoulder and neck of the kingpin. After the yoke is engaged (positioned between the lock halves and the tapered rib members of the top plate casting), the secondary lock moves behind the yoke. For fifth wheels with an automatic secondary lock, the kingpin is released by manually operating the release handle. For fifth wheels with a manual secondary lock, the fifth wheel is released by pulling the secondary release handle, then hooking the secondary release handle to the top plate casting, and finally manually operating the primary release handle. For high coupling protection, a one step rear lock is incorporated into the split lock. For increased durability of the kingpin lock mechanism, the infinite lock adjustment positions are available to compensate for wear in both the kingpin and the lock jaws.

See Chapter 10 (FLD) or Chapter 10 (FLB) in the vehicle driver's manual for complete operating instructions.

Model XA–3501 Top Plate Removal and Disassembly

Removal and Disassembly

(See Fig. 1)

WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

A fifth wheel rebuild kit is available for servicing the 3500 series XA–3501 fifth wheel (part number RK–63501 [left release] and RK–63500 [right release]). The kit contains all replacement parts for the fifth wheel, except the fifth wheel plate, slide mount assembly, rubber bushings, bushing pins, and roll pins.

Review the troubleshooting section before rebuilding the fifth wheel. Rebuilding may be unnecessary.

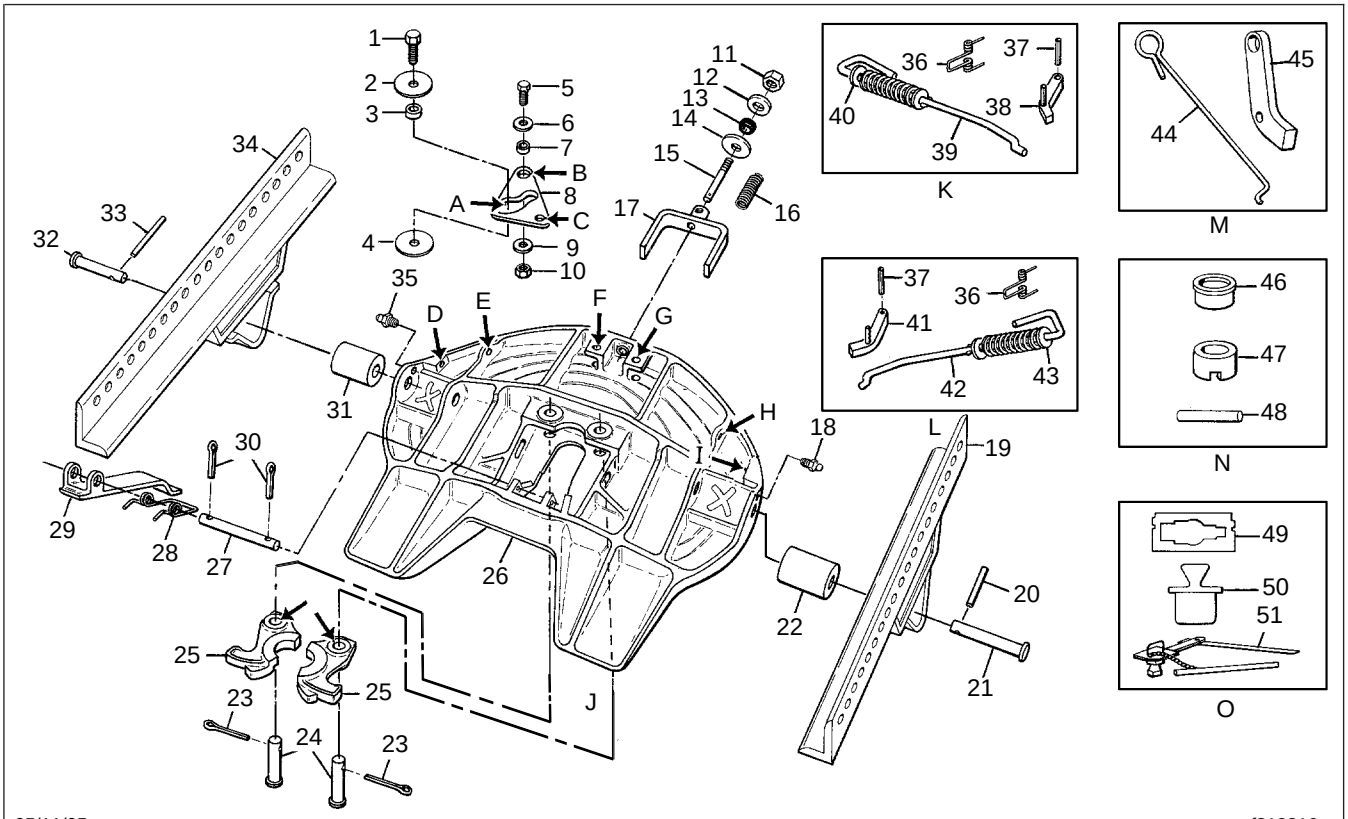
1. Steam clean the top plate. Remove it from the slide mounts (Fig. 1) by removing the roll pins from the bushing pins; then, remove the bushing pins from the slide mounts. Use an overhead hoist to lift the fifth wheel from the slide mount assembly and tractor frame.
2. Turn the fifth wheel upside down with the locks open.
3. While disassembling the fifth wheel, check it for cracks and for missing or damaged parts, as follows:
   - 3.1 Remove the lockguard, the lockguard torsion spring, the lockguard pin, and the lockguard cotter pins.
   - 3.2 On fifth wheels with a right-hand release, remove the secondary lock roll pin from hole F. Then, remove the right-hand secondary lock from under hole F.

     On fifth wheels with a left-hand release, remove the secondary lock roll pin from hole G. Then, remove the left-hand secondary lock with the secondary lock spring from under hole G.
   - 3.3 Remove the attaching release arm capscrew, capscrew washer, and roller from hole A of the release arm and yoke subassembly.
   - 3.4 Remove the release arm capscrew, release arm capscrew washer, and release arm roller from hole G for models with right-hand release or from hole F for models with left-hand release.
   - 3.5 Remove the release handle from the fifth wheel top plate. Remove the washer, release handle spring, and release handle washer from the release handle.
   - 3.6 Remove the yoke shaft locknut, yoke shaft washer, and rubber block from the yoke shank. Then, remove the yoke shank and the yoke shank spring from the yoke subassembly.
   - 3.7 Remove the yoke from the fifth wheel top plate.
   - 3.8 Remove the lock cotter pins, lockpins, and the lock jaws from the fifth wheel top plate.
   - 3.9 If the top plate is cracked, discard it. If the lockpin hole is worn, the top plate can be returned for a factory rebuild.

WARNING

Do not attempt to repair or rebuild the top plate if it is cracked or if the lockpin does not fit tightly. The top plate could fail or the locks could malfunction. This could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

Model XA–3501 Top Plate Removal and Disassembly



A. Release Arm Cam Profile
B. Release Arm Pivot Hole
C. Hole for Attachment of Release Handle
D. Guide Hole for Right-Hand Release
E. Hole for Left-Hand Manual Secondary Lock Handle
F. Right-Hand Secondary Lock Anchor Hole
G. Left-Hand Secondary Lock Anchor Hole
H. Hole for Right-Hand Manual Secondary Lock Handle
I. Guide Hole for Left-Hand Release
J. Lockpin Holes
K. For Right-Hand Release
L. For Left-Hand Release
M. For Models With Secondary Lock
N. For Models With Lockpin Bushings
O. Accessories

1. Capscrew, 5/8–18 x 1-3/4
2. Flatwasher, 5/8" i.d.
3. Roller
4. Washer, 5/8" i.d.
5. Capscrew, 1/2–20
6. Washer, 1-3/4" o.d. x 9/16" i.d.
7. Roller
8. Release Arm (Cam Plate)
9. Washer, 1-3/4" o.d. x 13/16" i.d.
10. Locknut, 1/2–20
11. Locknut, 3/4–16
12. Washer, 1-1/2" o.d. x 13/16" i.d.
13. Rubber Block
14. Lock Adjustment Tag
15. Yoke Shank
16. Yoke Shank Spring
17. Yoke Subassembly
18. Grease Fitting
19. Mounting Bracket
20. Roll Pin
21. Bracket Pin
22. Rubber Bushing
23. Cotter Pins, 1/4" x 2"
24. Lockpins
25. Lock Jaws
26. Fifth Wheel Top Plate
27. Lockguard Pin
28. Lockguard Torsion Spring
29. Lockguard
30. Cotter Pins, 1/8" x 1"
31. Rubber Bushing
32. Bracket Pin
33. Roll Pin
34. Mounting Bracket
35. Grease Fitting
36. Secondary Lock Torsion Spring
37. Roll Pin
38. Right-Hand Secondary Lock
39. Right-Hand Release Handle
40. Washer, 1-3/4" o.d. x 9/16" i.d.
41. Left-Hand Secondary Lock
42. Left-Hand Release Handle
43. Washer, 1-3/4" o.d. x 9/16" i.d.
44. Manual Secondary Lock Handle
45. Manual Secondary Lock
46. Lockpin Bushings, 2
47. Lockpin Bushing, 2
48. Roll Pin, 2
49. Kingpin Gauge
50. Plug, 2"
51. Kingpin Lock Tester

Fig. 1, Holland 3500 Series XA-3501 Fifth Wheel and Accessories (bottom view)

Model XA–3501 Top Plate Assembly and Installation

Assembly and Installation

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

A fifth wheel rebuild kit is available for servicing the 3500 series XA–3501 fifth wheel (part numbers RK–63501 [left release] and RK–63500 [right release]). The kit contains all replacement parts for the fifth wheel, except the fifth wheel plate, slide mount assembly, rubber bushings, bushing pins, and roll pins.

Review the troubleshooting section before rebuilding the fifth wheel. Rebuilding may be unnecessary.

IMPORTANT: Use only Holland rebuilding kits. Replace all roll pins, cotter pins, springs, capscrews, nuts, and washers.

1. Clean all moving parts with no. 2 diesel fuel before assembly.
2. Before installing the lock jaws (**Fig. 1**), lubricate the lockpin holes (Ref. J) with Never-Seez®.

⚠ CAUTION

Use only Never-Seez®. Other lubricants can damage the lockpin holes.

3. Place the lock jaws in the top plate with the 2-7/8 inch bore toward the face of the top plate. See **Fig. 2**.
4. Drive the lockpins (**Fig. 1**) through the top plate and lockpin holes (Ref. J) in the lock jaws until the head of the pins are flush with the top plate.
5. If the top plate is equipped with lockpin bushings, use roll pins instead of cotter pins. See **Fig. 3**.
6. Check that the lock jaws move freely.

⚠ WARNING

Use only Holland part number TF–0237 or a precision plug machined to 2.000 ± 0.005 inch (5.08 ± 0.0127 cm) to adjust the locking mechanism. Failure to do so may cause locking mechanism malfunction. This could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

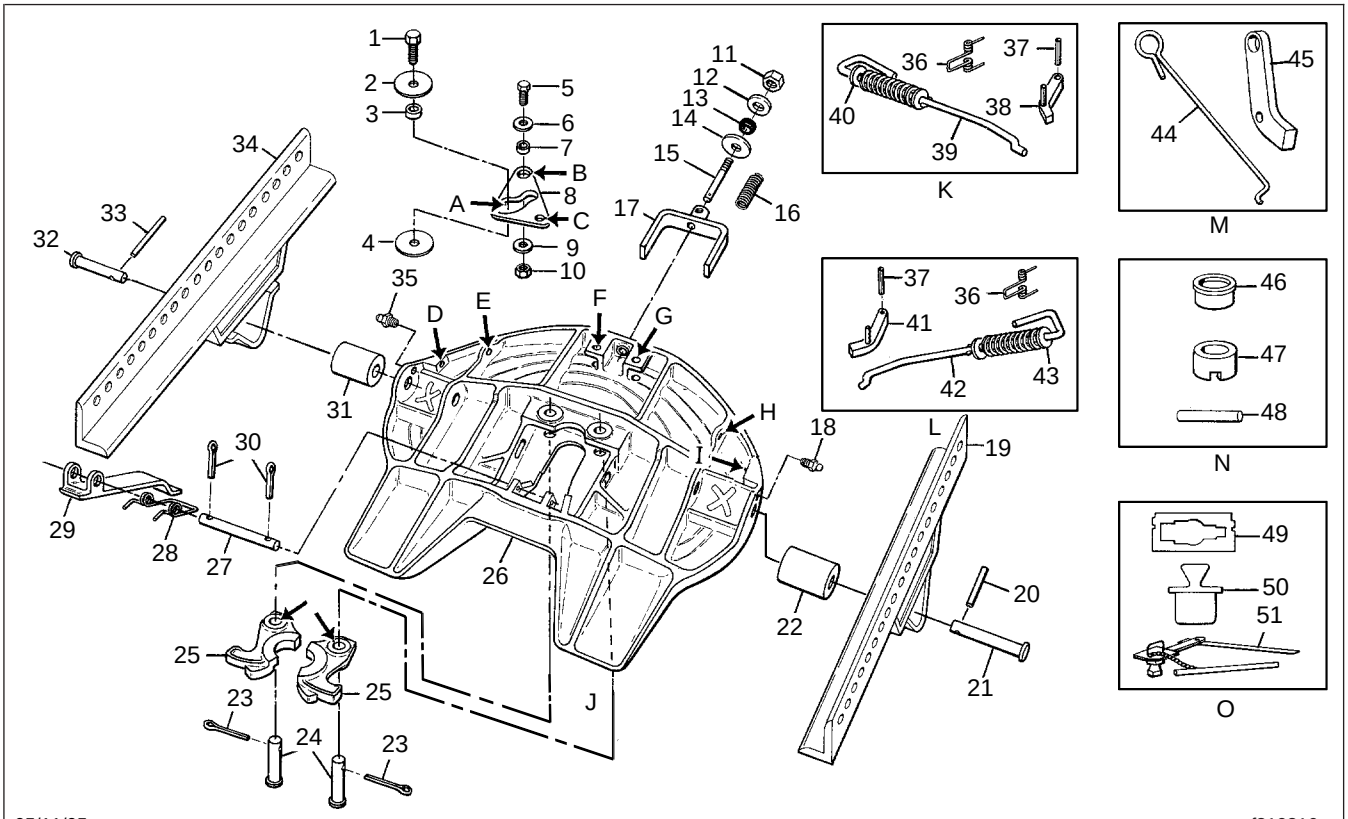
7. Install a 2-inch (5.08 cm) diameter plug (Holland part number TF–0237) in the lock jaws. See **Fig. 4**.
8. Strike the yoke with a mallet to bend the yoke tips outward slightly. See **Fig. 5**.
9. Slide the yoke into the top plate with the threaded hole facing up, and tap the yoke into position.

⚠ WARNING

Never grind on the inside of the yoke or on the locks. This can weaken the yoke structure, possibly causing the kingpin to fit loosely. This could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

10. Inspect the yoke tips. The tips must be flush with the ends of the locks, or extend no more than 1/32 inch (0.8 mm) beyond. See **Fig. 6**.
    - 10.1 If the yoke tips fall short (**Fig. 7**), use a belt sander or disk grinder to grind the outside surfaces of the yoke until it fits precisely into place. See **Fig. 8**.
    - 10.2 If the yoke tips extend beyond the ends of the locks, build up the outer surfaces of the yoke using a low hydrogen E70XX welding rod. See **Fig. 9**. After welding, grind the beads smooth.
11. The outside of each yoke tip has two contact areas. Check that all four surfaces have full area contact with the top plate ribs (**Fig. 10**) after welding and grinding.
12. Continue welding, grinding, and fitting until the yoke has full contact and the yoke tips are flush with the ends of the locks.
13. Apply a coat of light grease to both the inside and outside friction surfaces of the yoke, then slide the yoke into the top plate with the threaded hole facing up.
14. Install the spring (**Fig. 1**) between the yoke and the top plate. Insert the yoke shank through the top plate and spring, then into the yoke. Make

Model XA–3501 Top Plate Assembly and Installation



05/11/95 f310316a

A. Release Arm Cam Profile
B. Release Arm Pivot Hole
C. Hole for Attachment of Release Handle
D. Guide Hole for Right-Hand Release
E. Hole for Left-Hand Manual Secondary Lock Handle
F. Right-Hand Secondary Lock Anchor Hole
G. Left-Hand Secondary Lock Anchor Hole
H. Hole for Right-Hand Manual Secondary Lock Handle
I. Guide Hole for Left-Hand Release
J. Lockpin Holes
K. For Right-Hand Release
L. For Left-Hand Release
M. For Models With Secondary Lock
N. For Models With Lockpin Bushings
O. Accessories

1. Capscrew, 5/8–18 x 1-3/4
2. Flatwasher, 5/8" i.d.
3. Roller
4. Washer, 5/8" i.d.
5. Capscrew, 1/2–20
6. Washer, 1-3/4" o.d. x 9/16" i.d.
7. Roller
8. Release Arm (Cam Plate)
9. Washer, 1-3/4" o.d. x 13/16" i.d.
10. Locknut, 1/2–20
11. Locknut, 3/4–16
12. Washer, 1-1/2" o.d. x 13/16" i.d.
13. Rubber Block
14. Lock Adjustment Tag
15. Yoke Shank
16. Yoke Shank Spring
17. Yoke Subassembly
18. Grease Fitting
19. Mounting Bracket
20. Roll Pin
21. Bracket Pin
22. Rubber Bushing
23. Cotter Pins, 1/4" x 2"
24. Lockpins
25. Lock Jaws
26. Fifth Wheel Top Plate
27. Lockguard Pin
28. Lockguard Torsion Spring
29. Lockguard
30. Cotter Pins, 1/8" x 1"
31. Rubber Bushing
32. Bracket Pin
33. Roll Pin
34. Mounting Bracket
35. Grease Fitting
36. Secondary Lock Torsion Spring
37. Roll Pin
38. Right-Hand Secondary Lock
39. Right-Hand Release Handle
40. Washer, 1-3/4" o.d. x 9/16" i.d.
41. Left-Hand Secondary Lock
42. Left-Hand Release Handle
43. Washer, 1-3/4" o.d. x 9/16" i.d.
44. Manual Secondary Lock Handle
45. Manual Secondary Lock
46. Lockpin Bushings, 2
47. Lockpin Bushing, 2
48. Roll Pin, 2
49. Kingpin Gauge
50. Plug, 2"
51. Kingpin Lock Tester

Fig. 1, Holland 3500 Series XA-3501 Fifth Wheel and Accessories (bottom view)

Model XA–3501 Top Plate Assembly and Installation

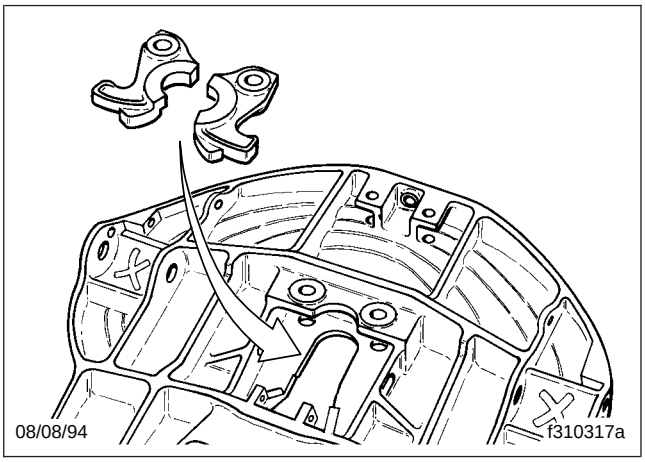


Fig. 2, Place the Lock Jaws

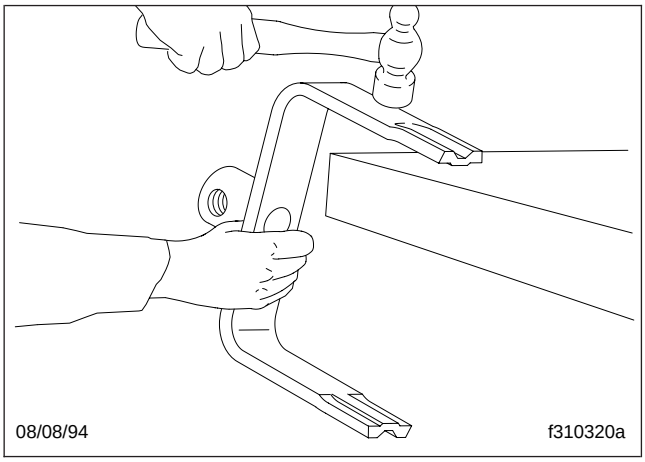


Fig. 5, Strike the Yoke

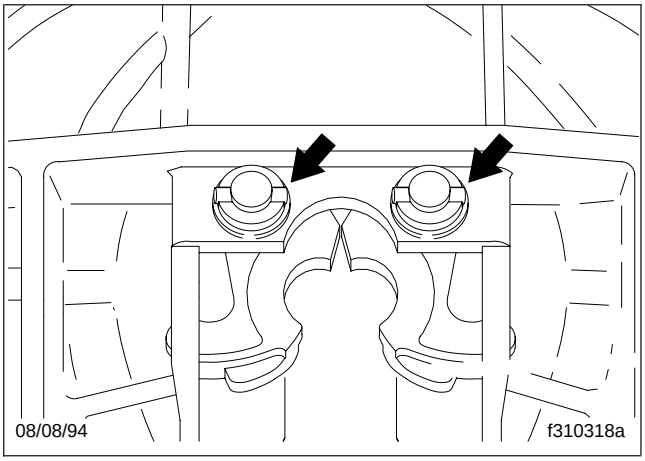


Fig. 3, Roll Pins Used

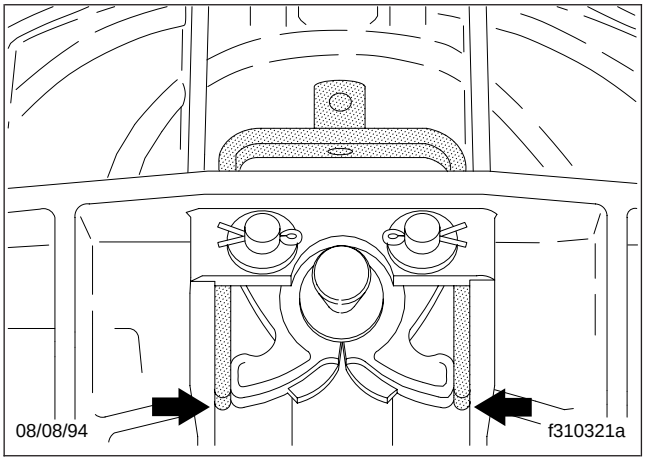


Fig. 6, Inspect the Tips

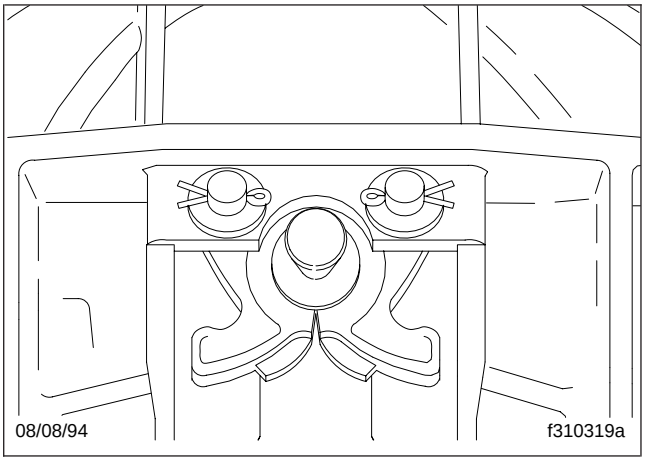


Fig. 4, Plug in the Lock Jaws

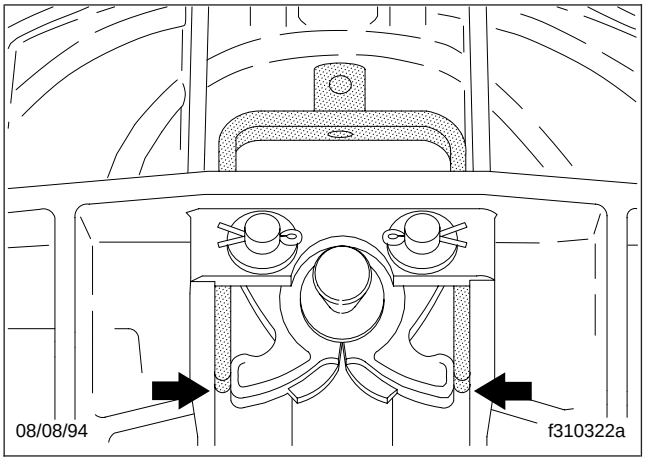
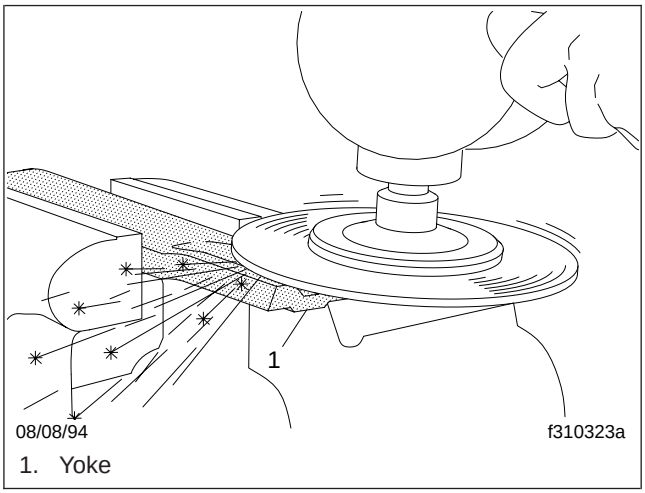


Fig. 7, Yoke Tips Fall Short

Model XA–3501 Top Plate Assembly and Installation



1. Yoke

Fig. 8, Grind the Yoke

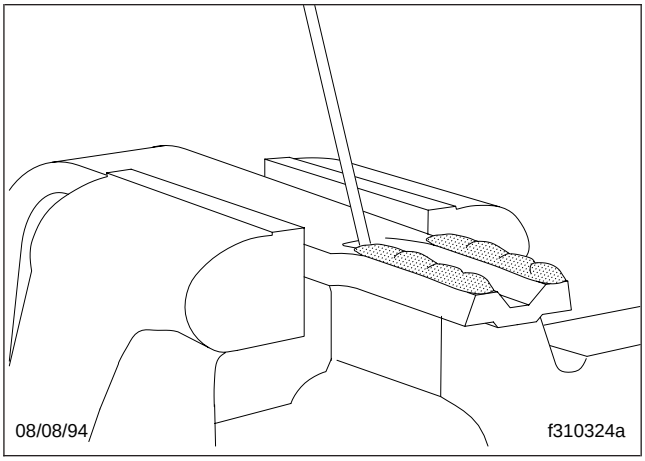


Fig. 9, Build Up the Yoke

sure that the predrilled recess in the yoke shank aligns with the threaded hole in the yoke.

15. Install the lock adjustment tag, the rubber block, a 13/16-inch i.d. steel washer, and the 3/4-inch locknut in the order stated.
16. Install the 9/16-inch i.d. washer on the release handle as shown in **Fig. 1**.
17. Pass the open end of the release handle through the guide hole (Ref. D for models with right-hand release, Ref. I for models with left-hand release) toward the outside of the top plate.
18. Inspect the release arm (cam plate) for burrs or rough edges in the cam profile (Ref. A). Remove any burrs or rough edges.

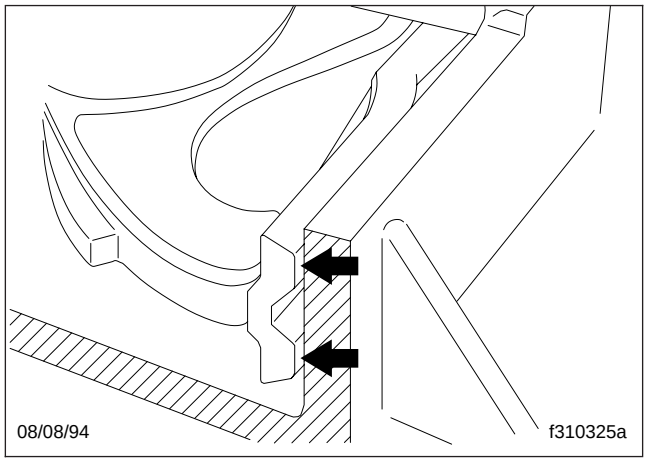


Fig. 10, Contact with Top Plate

19. Apply a light coat of grease to the cam profile and pivot holes.
20. Insert the "S" end of the release handle through the small hole in the release arm (cam plate).
21. Place the release arm (cam plate) on the top plate so that the cam profile (**Fig. 11**, Ref. A) is over the hole in the yoke and the large hole (Ref. B) is over the lug in the top plate opposite the release handle.

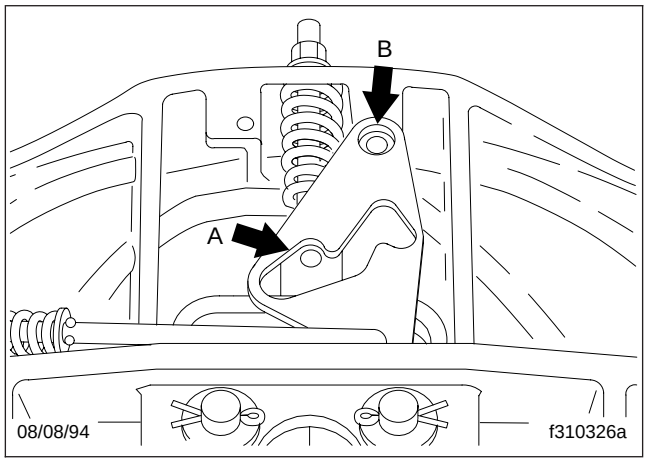


Fig. 11, Place the Release Arm

22. Slide a 9/16-inch i.d. flatwasher between the plate lug and the release arm with the rounded edge towards the cam. See **Fig. 12**.
23. Install the 1/2-inch i.d. roller (**Fig. 1**) in the large hole of the release arm.

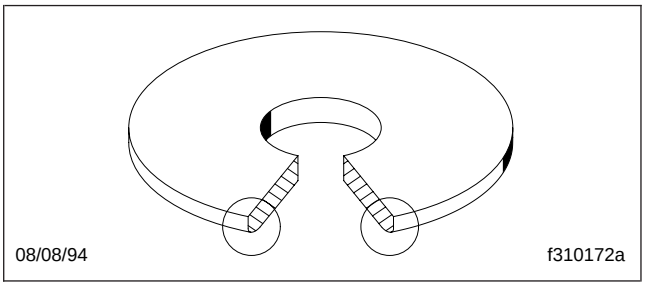


Fig. 12, Rounded Edge

24. Place a second 9/16-inch i.d. flatwasher over the release arm. Make sure the rounded edge of the washer faces the cam.
25. Install the 1/2-inch diameter capscrew through the washers, roller, and hole in the top plate lug (Ref. G for right-hand release models, Ref. F for left-hand release models).
26. Secure the capscrew with a 1/2-inch locknut. Tighten the locknut; then, check that the release arm moves freely.
27. Place a 5/8-inch i.d. washer between the yoke and the release arm. Make sure that the rounded edge of the washer faces the release arm.
28. Insert the 5/8-inch i.d. roller in the release arm opening.
29. Install the second 5/8-inch i.d. washer on top of the release arm.
30. Pass the 5/8-inch diameter capscrew through the assembly. Be certain that the bolt passes through the yoke and into the recess in the yoke shank.
31. Tighten the capscrew securely, but make sure the top washer turns freely.
32. Turn the nut on the yoke shank clockwise until the yoke just begins to move.
33. Check the plug (Holland part number TF–0237). It should fit snugly in the locks, but you should be able to turn it with some force.
34. On models with an automatic secondary lock assembly, proceed as follows:
    - 34.1 Start the roll pin into the hole in the top plate lug opposite the release arm anchor capscrew.
    - 34.2 Install the torsion spring on the secondary lock, and position them on the lug. Be sure the open end of the spring faces toward the rib of the lug. See **Fig. 13**.

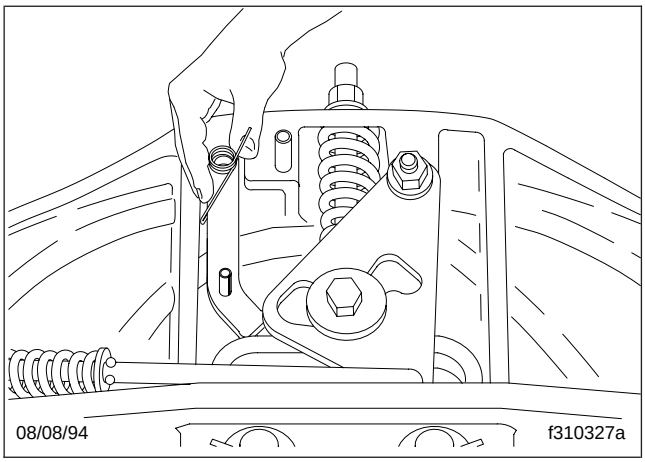


Fig. 13, Torsion Spring Installation

    - 34.3 While holding the parts in place, drive the roll pin until it is flush with the lug.
    - 34.4 Check the spring tension on the secondary lock. Check that the lock moves freely.
35. On models with a manual secondary lock assembly, proceed as follows:
    - 35.1 Pass the end of the manual secondary lock handle (**Fig. 1**) through the hole (Ref. E for right-hand release, Ref. H for left-hand release).
    - 35.2 Attach the handle to the secondary lock.
    - 35.3 Start the roll pin into the hole in the top plate lug opposite the release arm anchor capscrew.
    - 35.4 Install the torsion spring on the secondary lock, and place them in position on the lug. Be sure the open end of the spring faces toward the rib of the lug. See **Fig. 13**.
    - 35.5 While holding the parts in place, drive the roll pin until it is flush with the lug.
    - 35.6 Check the spring tension on the secondary lock. Check that the lock moves freely.

Model XA–3501 Top Plate Assembly and Installation

36. Pull the release handle, remove the plug, and pry open the lock jaws.
37. Assemble the lockguard and the torsion spring.
38. Mount the lockguard using the lockguard pin and cotter pins. See **Fig. 14**.

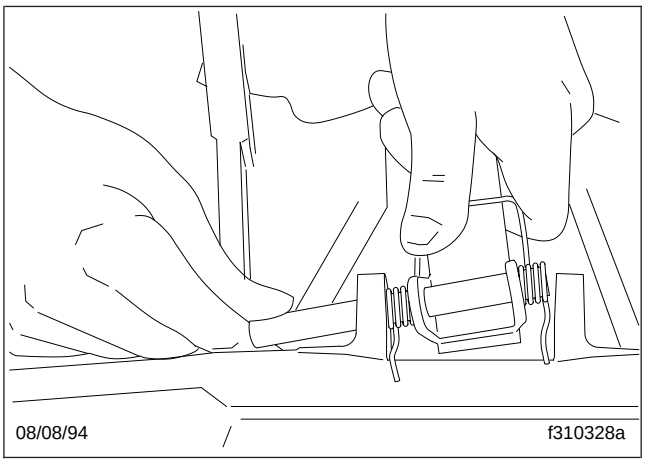


Fig. 14, Mount the Lockguard

39. Check the spring tension on the lockguard. Check that the lockguard moves freely.
40. Check the adjustment. The tip of the guard should be even with the edge of the 2-inch bore in the lock jaw. See **Fig. 15**.

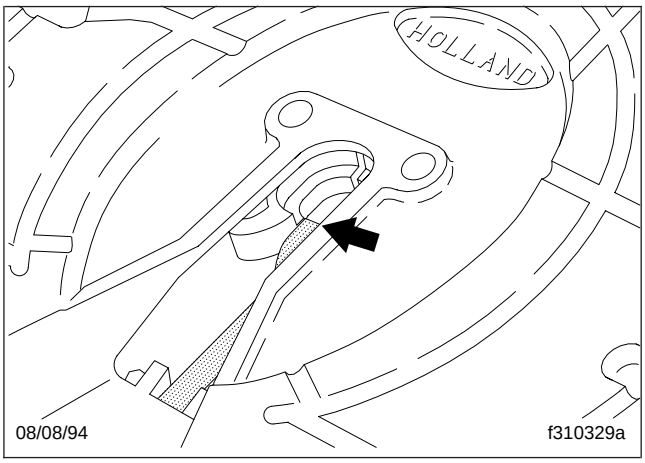


Fig. 15, Check the Guard

41. Adjust the lockguard position by supporting the end of the guard with a short piece of steel placed between the locks and the lock-guard. Tap the center of the guard to adjust it. See **Fig. 16**.

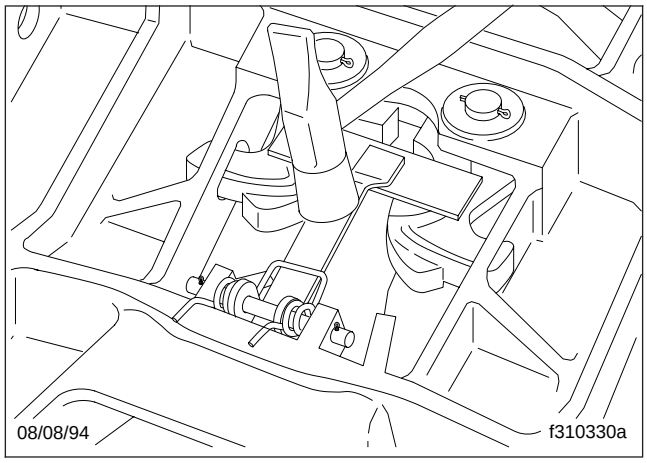


Fig. 16, Adjust the Guard

42. Using a Holland Lock Tester, close the locks. For instructions, refer to Holland Publication FW 130. Make sure that the locking mechanism functions properly. See **Fig. 17**. If the fifth wheel does not operate properly, repeat the above procedures or contact your local Holland representative for assistance.

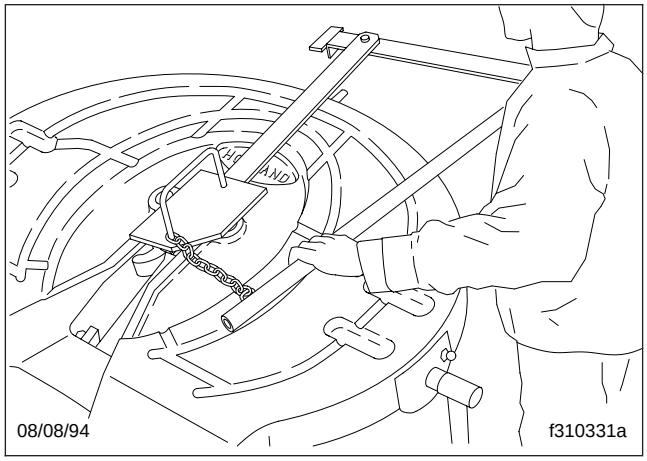


Fig. 17, Using the Lock Tester

IMPORTANT: The fifth wheel must be well lubricated to operate correctly. See Group 31 of the *Heavy-Duty Trucks Maintenance Manual*, for complete maintenance and lubrication instructions of the fifth wheel assembly.

⚠ WARNING

If the fifth wheel does not operate properly, do not use it. The fifth wheel could malfunction, resulting in bodily injury or property damage due to possible separation of the trailer from the tractor.

43. Using an overhead hoist, position the fifth wheel on the sliding mount assembly. Insert the bushing pins. Then install the roll pins.

Model XA–351 Top Plate Removal and Disassembly

WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

Fifth wheel rebuild kits are available for servicing the 3500 series XA–351 fifth wheels. For the rebuild kits, the part numbers include:

- RK–351AL (left release with automatic secondary lock);
- RK–351A02L (left release with manual secondary lock);
- RK–351A (right release with automatic secondary lock);
- RK–351A02 (right release with manual secondary lock).

These fifth wheel rebuild kits contain all the replacement parts, except: the fifth wheel top plate; the bracket assembly rubber bushings; the bracket assembly bushing pins; and the bracket assembly bushing pin capscrews and locknuts.

Rebuilding the fifth wheel may be unnecessary. Review the troubleshooting section before rebuilding the fifth wheel. If the troubleshooting section does not correct the problem, then the fifth wheel may need rebuilding.

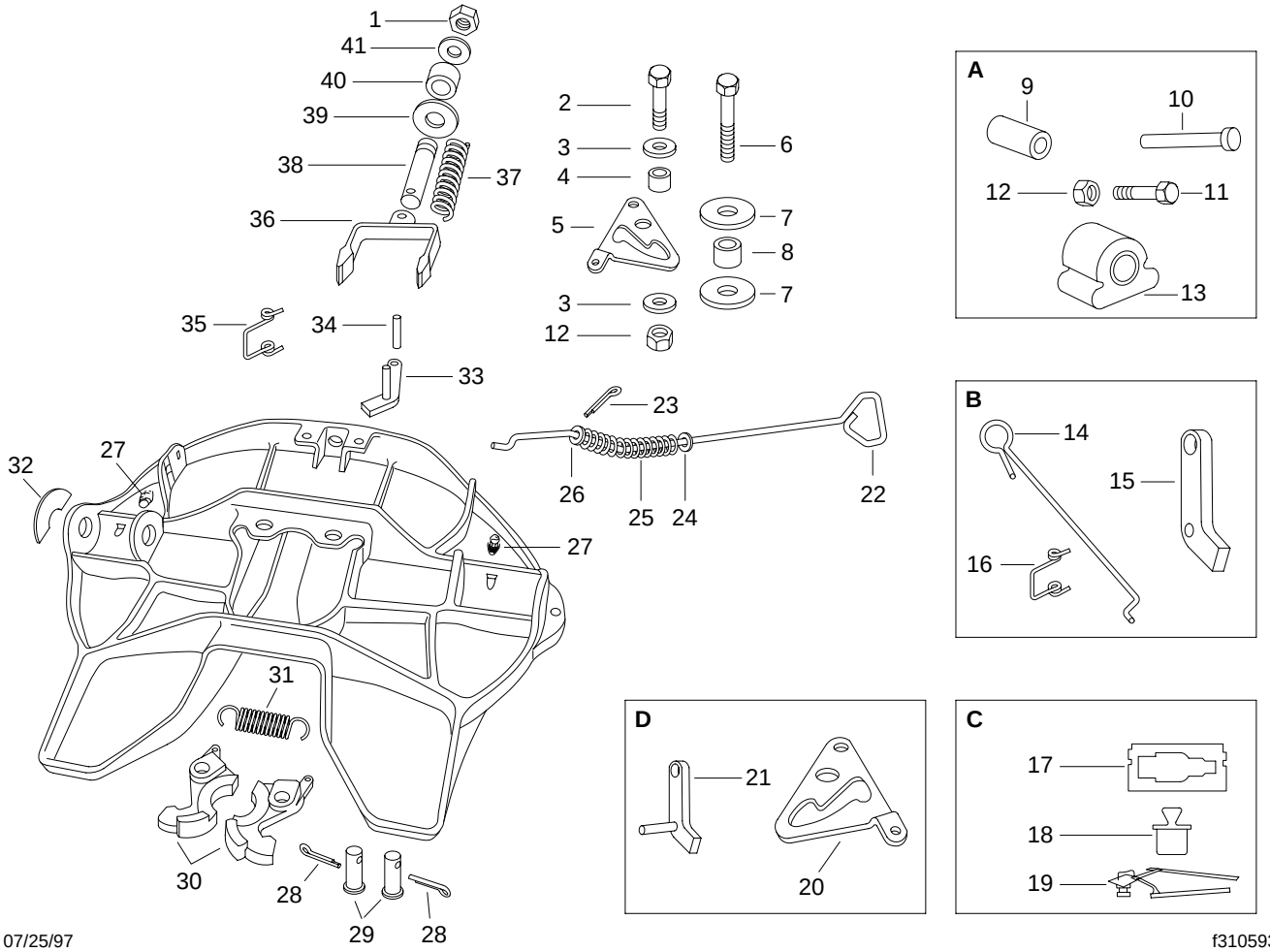
While disassembling the fifth wheel, Check it for cracks and for missing or damaged parts. Discard all used components.

Removal and Disassembly

(See Fig. 1)

1. Steam clean the top plate.
2. Remove the top plate from the bracket assembly.
   - 2.1 Loosen and remove the 1/2–20 bushing pin capscrews and locknuts from the top plate.
   - 2.2 Remove the bushing pins from the bracket assembly. See **Fig. 2**.
   - 2.3 Using an overhead hoist, lift the fifth wheel from the bracket assembly and tractor frame.
3. Disassemble the secondary lock.
   - 3.1 Turn the fifth wheel upside down with the locks open.
   - 3.2 Using a suitable driver and hammer, drive the 1/2-inch by 2-3/4 inch roll pin from the top plate and the secondary lock. See **Fig. 3**.
   - 3.3 If the fifth wheel has an automatic secondary lock, proceed to the next substep, otherwise, remove the manual secondary release handle by passing the "S" bend of the release handle through the large hole in the secondary lock and then through the guide hole. See **Fig. 4**.
   - 3.4 Remove the secondary lock.
4. Disassemble the cam plate.
   - 4.1 Loosen and remove the 5/8-inch capscrew from the threaded hole in the yoke. Remove the washers, and the roller from the cam plate. See **Fig. 5**.
   - 4.2 Loosen and remove the 1/2-inch capscrew and nut from the top plate lug. Remove the washers, and the roller from the cam plate. See **Fig. 6**.
   - 4.3 Remove the release handle by passing the "S" bend of the release handle through the large hole in the raised tab of the cam plate and through the top plate casting hole. See **Fig. 6**.
5. Disassemble the yoke.
   - 5.1 Slide the yoke shaft assembly away from the yoke, through the compression spring, and out of the top plate casting. See **Fig. 7**.
   - 5.2 Remove the compression spring and remove the yoke.
6. Disassemble the lock.
   - 6.1 Remove the cotter pins from the lockpins.
   - 6.2 Using a suitable driver and hammer, drive the lockpins out of the casting. See

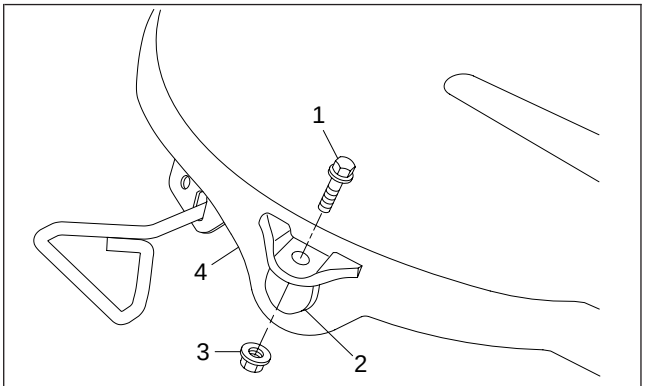
Model XA–351 Top Plate Removal and Disassembly



A. Bushing Pin Assembly
B. Manual Secondary Lock Assembly
C. Fifth Wheel Accessories
D. Right Hand Secondary Lock Assembly

1. Locknut, 3/4–16
2. Capscrew, 1/2–20 x 1–3/4)
3. Washer, 1–3/4" o.d. x 9/16" i.d.
4. Roller, 1/2" i.d.
5. Cam Plate (left-hand)
6. Capscrew, 5/8–18 x 3/4
7. Washer, 2–5/8 x 21/32
8. Roller, 5/8" i.d.
9. Rubber Bushing (brackets manufactured prior to 5/82)
10. Bracket Bushing Pin
11. Capscrew, 1/2–20 x 1–1/4
12. Locknut, 1/2–20
13. Rubber Bushing (brackets manufactured after 5/82)
14. Manual Secondary Lock Release Handle
15. Manual Secondary Lock
16. Torsion Spring
17. Kingpin Gauge
18. 2" Lock Gauge (Plug)
19. Kingpin Lock Tester
20. Cam Plate (right-hand)
21. Secondary Lock (right-hand)
22. Release Handle
23. Cotter Pin, 1/8 x 1–1/4
24. Washer, 1–3/8" o.d. x 9/16" i.d.
25. Compression Spring
26. Washer, 1–1/16" o.d. x 5/8" i.d.
27. Grease Zerk
28. Cotter Pin, 1/4 x 2
29. Lockpin
30. Lock Jaw Set
31. Extension Spring
32. Operation Tag
33. Secondary Lock (left-hand)
34. Roll Pin, 1/2 x 2–3/4
35. Torsion Spring
36. Yoke
37. Compression Spring
38. Yoke Shaft
39. Lock Adjustment Tag
40. Rubber Washer
41. Washer 1–1/2" o.d. x 13/16" i.d.

Fig. 1, Holland 3500 Series XA-351 Fifth Wheel and Accessories (bottom view)



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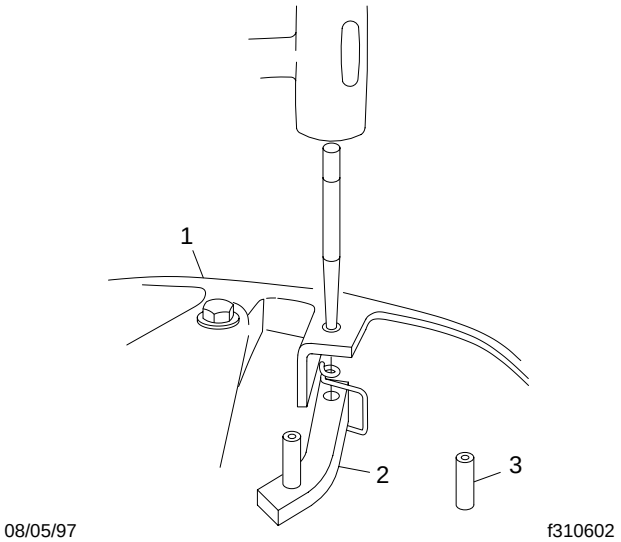
1. Capscrew
2. Bushing Pin
3. Locknut
4. Top Plate

Fig. 2, Remove the Bushing Pin



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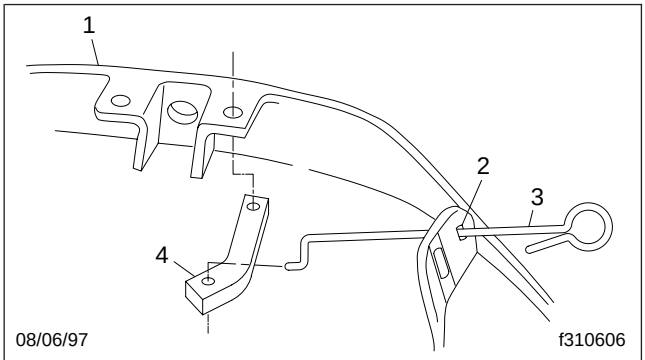
1. Top Plate
2. Secondary Lock
3. Roll Pin

Fig. 3, Disassemble the Secondary Lock

Fig. 8. This will free the lock jaws assembly. Remove the lock jaws and lock spring.



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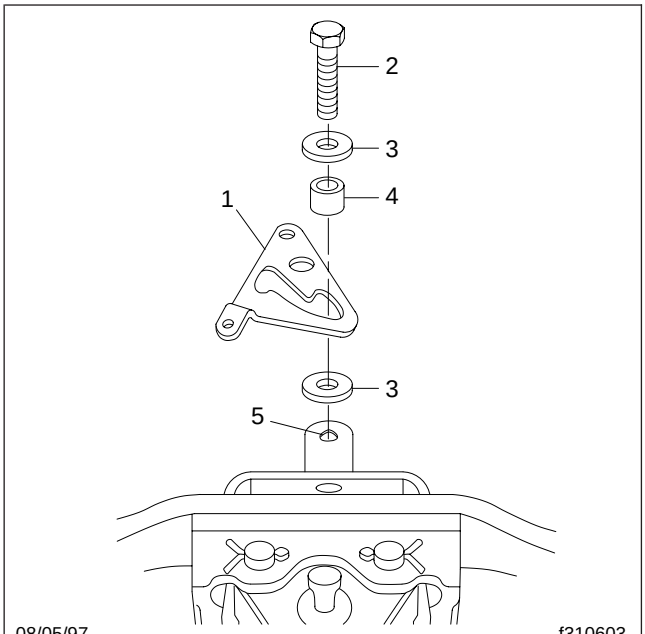
1. Top Plate
2. Guide Hole
3. Release Handle
4. Secondary Lock

Fig. 4, Remove the Release Handle



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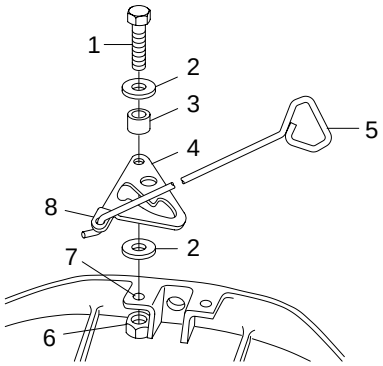
1. Cam Plate
2. Capscrew, 5/8–20
3. Washer
4. Roller
5. Threaded Hole In Yoke

Fig. 5, Remove the Capscrew From the Yoke

Model XA–351 Top Plate Removal and Disassembly



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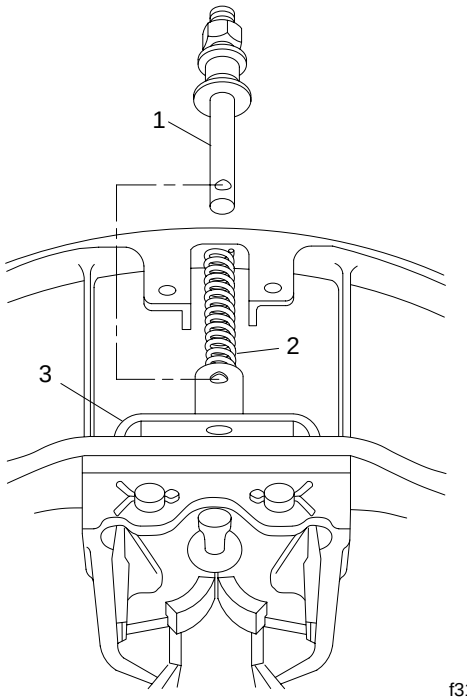
1. Capscrew, 1/2–20
2. Washer
3. Roller
4. Cam Plate
5. Release Handle
6. Nut, 1/2–20
7. Top Plate Lug
8. Raised Tab

Fig. 6, Disassemble the Cam Plate

⚠ WARNING

Do not attempt to repair or rebuild the top plate if it is cracked or if the lockpin does not fit tightly. The top plate could fail or the locks could malfunction. This could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.



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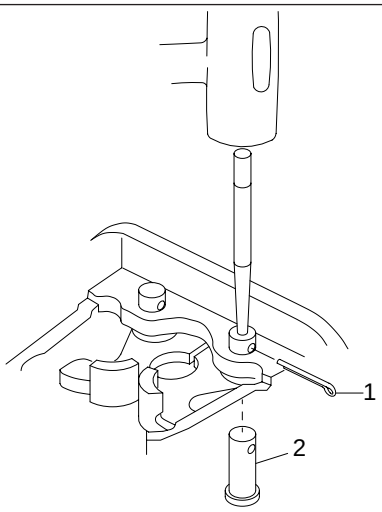
1. Yoke Shaft Assembly
2. Compression Spring
3. Yoke

Fig. 7, Remove the Yoke Shaft Assembly



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1. Cotter Pin
2. Lockpin

Fig. 8, Remove the Lockpins

Model XA–351 Top Plate Assembly and Installation

WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

Fifth wheel rebuild kits are available for servicing the 3500 series XA–351 fifth wheels. For the rebuild kits, the part numbers include:

- RK–351AL (left release with automatic secondary lock);
- RK–351A (right release with automatic secondary lock);
- RK–351A02L (left release with manual secondary lock);
- RK–351A02 (right release with manual secondary lock).

These fifth wheel rebuild kits contain all the replacement parts, except: the fifth wheel top plate; the bracket assembly rubber bushings; the bracket assembly bushing pins; and the bracket assembly bushing pin capscrews and locknuts.

Review the troubleshooting section before rebuilding the fifth wheel. Rebuilding may be unnecessary.

IMPORTANT: Use only Holland rebuilding kits. Replace all roll pins, springs, capscrews, nuts, and washers that are included in the kit. Do not reuse all parts.

WARNING

Use only genuine Holland parts and do not modify, change or add to the product. Any alterations to the fifth wheel assembly could compromise its performance. This could result in the loss of the trailer connection during vehicle travel, possibly causing bodily injury and property damage.

Assembly and Installation

(See Fig. 1)

WARNING

Do not attempt to repair or rebuild the top plate if it is cracked or distorted or if the lockpin does not fit tightly. The top plate could fail or the locks could malfunction. This could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

1. Inspect the top plate.
   - 1.1 If necessary, turn the fifth wheel upside down.
   - 1.2 Inspect the front lock surface for burrs or cracks. See **Fig. 2**. The front lock surface must be free of any burrs or cracks.
2. Install the lock.
   - 2.1 Lubricate the lockpin holes of the lock jaws with Never-Seez (provided in the kit). See **Fig. 3**.

CAUTION

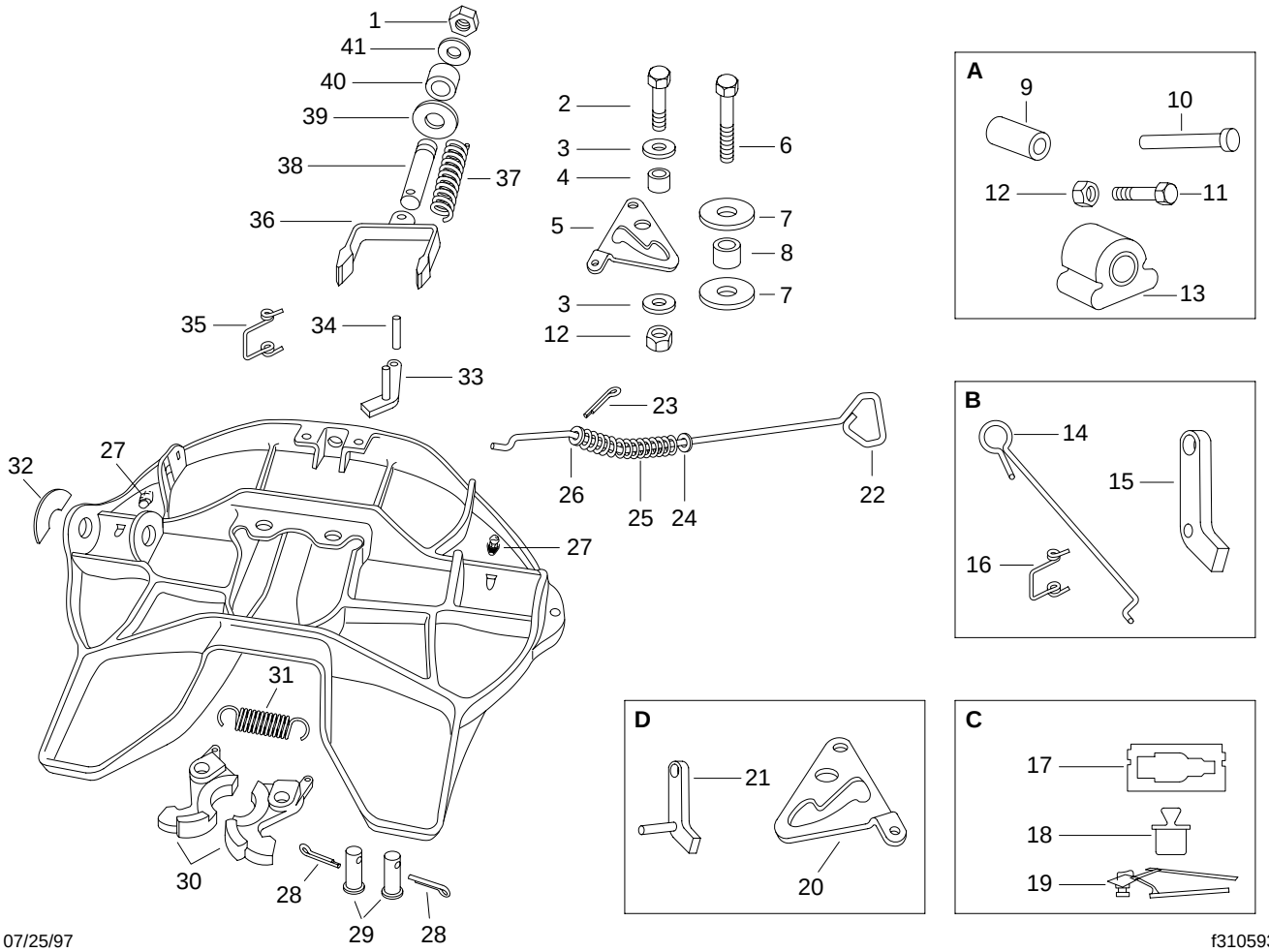
Use only Never-Seez. Other lubricants can damage the lockpin holes.

   - 2.2 Align the lock jaws in the casting and position the lock jaws so that the raised edge of the kingpin guides are facing up. See **Fig. 4**.
   - 2.3 Align the holes in the lockpins so that the cotter pins can be inserted. Insert the lockpins into the casting and through the lock jaws. Using a suitable hammer, drive the lockpins into the casting until the heads are flush with the casting. See **Fig. 5**.
   - 2.4 Insert the cotter pins and spread.
   - 2.5 Check that the lock jaws move freely.

WARNING

You must use a Holland lock gauge (TF–0237) or a precision plug that is 2.000 ± 0.005 inch (5.08 ± 0.0127 cm) for proper installation of the locking

Model XA–351 Top Plate Assembly and Installation



A. Bushing Pin Assembly
B. Manual Secondary Lock Assembly
C. Fifth Wheel Accessories
D. Right Hand Secondary Lock Assembly

1. Locknut, 3/4–16
2. Capscrew, 1/2–20 x 1–3/4
3. Washer, 1–3/4" o.d. x 9/16" i.d.
4. Roller, 1/2" i.d.
5. Cam Plate (left-hand)
6. Capscrew, 5/8–18 x 3/4
7. Washer, 2–5/8 x 21/32
8. Roller, 5/8" i.d.
9. Rubber Bushing (brackets manufactured prior to 5/82)
10. Bracket Bushing Pin
11. Capscrew, 1/2–20 x 1–1/4
12. Locknut, 1/2–20
13. Rubber Bushing (brackets manufactured after 5/82)
14. Manual Secondary Lock Release Handle
15. Manual Secondary Lock
16. Torsion Spring
17. Kingpin Gauge
18. 2" Lock Gauge (Plug)
19. Kingpin Lock Tester
20. Cam Plate (right-hand)
21. Secondary Lock (right-hand)
22. Release Handle
23. Cotter Pin, 1/8 x 1–1/4
24. Washer, 1–3/8" o.d. x 9/16" i.d.
25. Compression Spring
26. Washer, 1–1/16" o.d. x 5/8" i.d.
27. Grease Zerk
28. Cotter Pin, 1/4 x 2
29. Lockpin
30. Lock Jaw Set
31. Extension Spring
32. Operation Tag
33. Secondary Lock (left-hand)
34. Roll Pin, 1/2 x 2–3/4
35. Torsion Spring
36. Yoke
37. Compression Spring
38. Yoke Shaft
39. Lock Adjustment Tag
40. Rubber Washer
41. Washer, 1–1/2" o.d. x 13/16" i.d.

Fig. 1, Holland 3500 Series XA-351 Fifth Wheel and Accessories (bottom view)

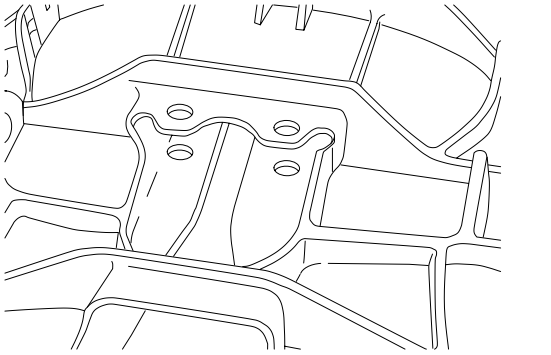


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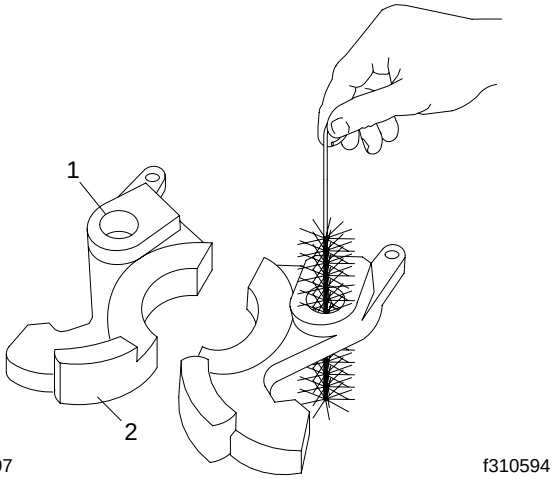
Fig. 2, Front Lock Surface Inspection



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1. Lockpin Hole
2. Lock Jaw

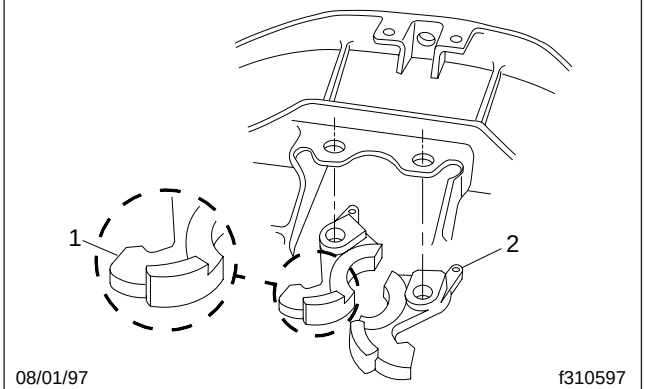
Fig. 3, Lubricate the Lockpin Holes

mechanism. If the proper plug is not used, the lock could malfunction or fail. This could result in the loss of the trailer connection during vehicle travel, possibly causing personal injury and property damage.

2.6 Position a 2-inch (5.08 cm) diameter "plug" into the lock jaws. See **Fig. 6**. A lock gauge, Holland part number TF–0237 is available at a Holland distributor.

3. Install the yoke.

3.1 Lubricate the surface area of the yoke tips with light grease. With the threaded



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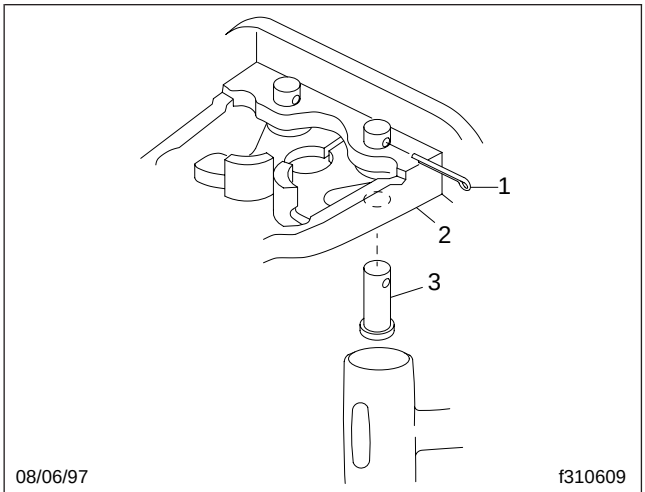
1. Kingpin Guide
2. Lock Jaw

Fig. 4, Align the Lock Jaws



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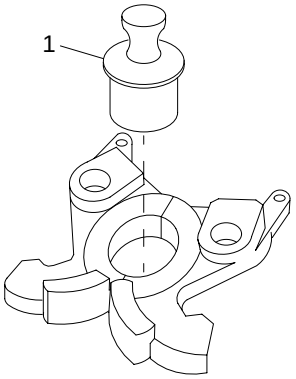
1. Cotter Pin, 1/4 x 2
2. Top Plate Casting
3. Lockpin

Fig. 5, Install the Lockpins

hole facing up, slide the yoke into the casting and seat it around the locks. See **Fig. 7**.

3.2 Inspect the amount of yoke tip engagement. Yoke tips must extend flush with the end of the locks and no more then 1/2 inch (12.7 mm) past the locks. See **Fig. 8**. If the new yoke extends more than 1/2 inch (12.7 mm) past the locks, *do not use it*. Discard it and order part number

Model XA–351 Top Plate Assembly and Installation



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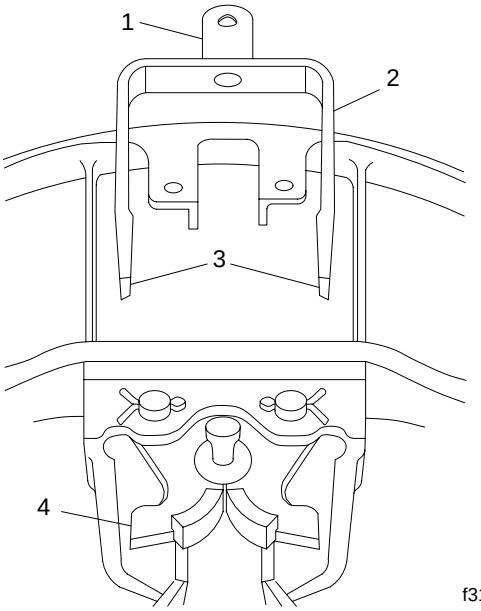
1. Lock Gauge (Plug)

Fig. 6, Install the Lock Gauge



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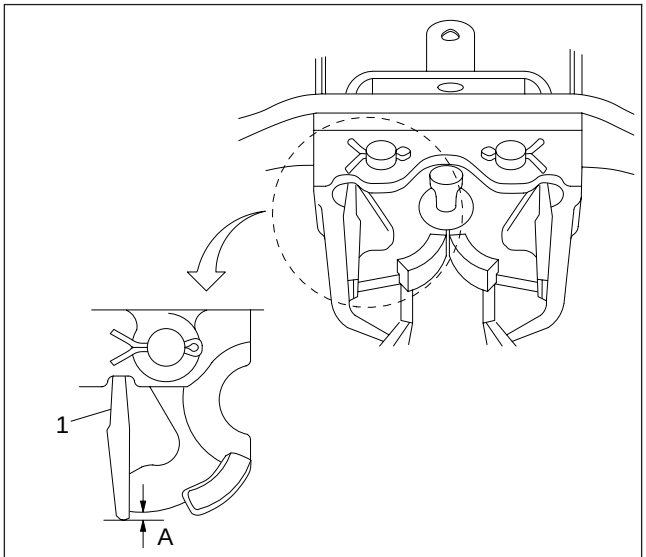
1. Threaded hole
2. Yoke
3. Yoke Tips
4. Lock

Fig. 7, Install the Yoke

XA–07295–THK from your nearest Holland distributor.

3.3 Install the lock spring. See **Fig. 9**.

3.4 Install the yoke spring. Slide the yoke shaft into the casting, through the yoke spring and into the yoke. Align the recessed hole in the yoke shaft with the threaded hole in the yoke. See **Fig. 10**.



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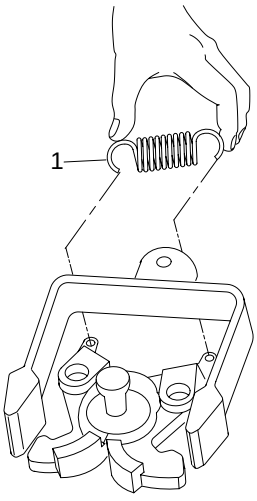
A. Measurement: 1/2" (12.7 mm) Maximum
1. Yoke Tip

Fig. 8, Measure the Yoke Tip Engagement



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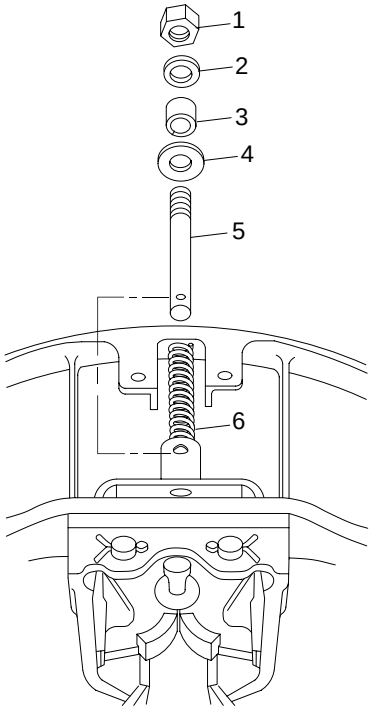
1. Lock Spring

Fig. 9, Install the Lock Spring

3.5 In this order, slide the lock adjustment tag, rubber washer, and 1-1/2 inch



1. Locknut, 3/4–16
2. Washer, 1–1/2" o.d. x 13/16" i.d.
3. Rubber Washer
4. Lock Adjustment Tag
5. Yoke Shaft
6. Yoke Spring

Fig. 10, Install and Assemble the Yoke Shaft

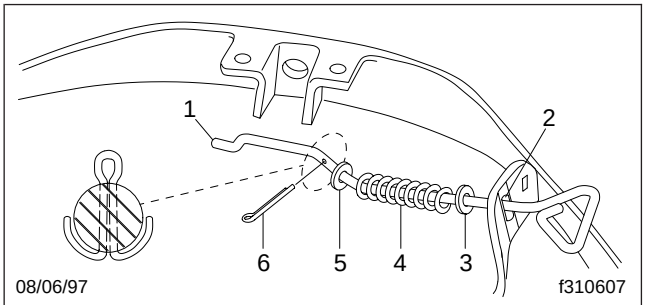
washer onto the yoke shaft. Then, start the locknut and turn it finger tight. See **Fig. 10**

4. Install the release handle.

   4.1 Slide the release handle through the hole in the casting (on the left side for left release or on the right side for right release). See **Fig. 11**.

   4.2 In this order, slide the 1-3/4 inch washer, compression spring, and 1-1/16 inch washer over the "S" bend of the release handle.

   4.3 Compress the spring using the 1-1/16 inch washer until the cotter pin hole is exposed.



1. Release Handle
2. Casting Hole
3. Washer, 1–3/8" o.d. x 9/16" i.d.
4. Compression Spring
5. Washer, 1–1/16" o.d. x 5/8" i.d.
6. Cotter Pin, 1/8 x 1–1/4

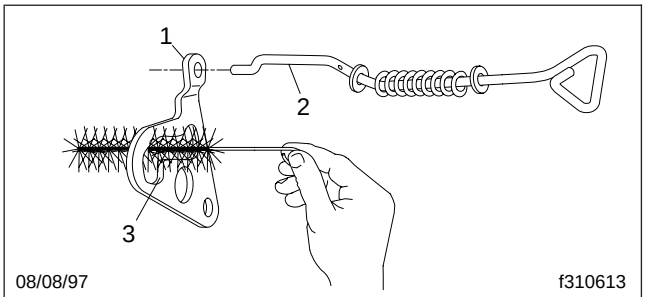
Fig. 11, Install the Release Handle

   4.4 Insert the cotter pin; spread it and wrap it completely around the release handle. See **Fig. 11**.

5. Install the cam plate.

   5.1 Inspect the cam plate for burrs and remove as required.

   5.2 Lubricate the cam plate track and pivot hole with light grease. Then connect the raised tab in the cam plate to the "S" bend in the release handle. See **Fig. 12**.



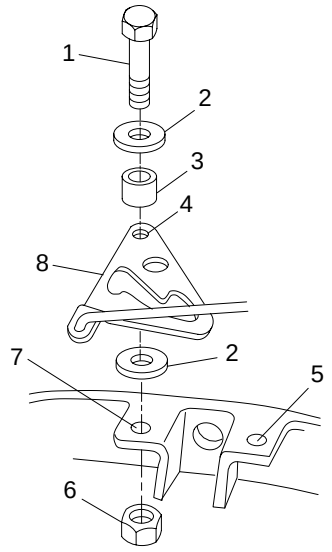
1. Cam Plate Raised Tab
2. Release Handle
3. Cam Plate Track

Fig. 12, Lubricate the Cam Plate

   5.3 Position the cam plate attachment hole over the proper casting lug hole. Then, slide the 1-3/4 inch washer between the cam plate and casting lug hole with the rounded side of the washer facing the cam plate. Then install the 1/2-inch roller

Model XA–351 Top Plate Assembly and Installation

into the cam plate and place the second 1-3/4 inch washer on top of the roller with the rounded side facing the cam plate. See **Fig. 13**.



1. Capscrew, 1/2–20 x 1–3/4
2. Washer, 1–3/4" o.d. x 9/16" i.d.
3. Roller, 1/2" i.d.
4. Cam Plate Attachment Pivot Hole
5. Hole for Right Release
6. Locknut, 1/2–20
7. Hole for Left Release
8. Cam Plate

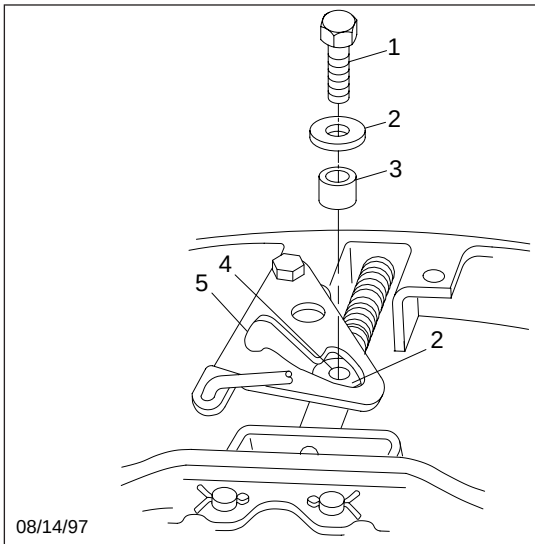
Fig. 13, Install the Cam Plate

5.4 Install the 1/2-inch capscrew through the washers, roller, and top plate lug. Then, secure the capscrew with the 1/2-inch locknut and tighten securely. See **Fig. 13**.

5.5 Check for free movement of the cam plate.

NOTE: When installing the washers, the rounded edge of the washers *must* always face the cam plate.

5.6 Align the cam plate track over the threaded hole in the yoke. Then slide a 2-5/8 inch o.d. washer between the yoke and the cam plate with the rounded side of the washer facing the cam plate. Then place the 5/8-inch roller into the cam plate track and place the second 2-5/8 inch o.d. washer over the roller with the rounded side of the washer facing the cam plate. See **Fig. 14**.



1. Capscrew (5/8–18 x 1–3/4")
2. Washer (2-5/8 x 21/32")
3. Roller (5/8" i.d.)
4. Threaded Hole in Yoke
5. Cam Plate Track

Fig. 14, Install the Capscrew Into the Yoke

5.7 Check the alignment of the recessed hole in the yoke shaft. Then, install the 5/8-inch capscrew through the washers, roller, and cam plate and into the threaded hole in the yoke. Make sure the capscrew enters the recessed hole in the yoke shaft. Then, tighten the capscrew securely. See **Fig. 14**.

5.8 Check for free movement of the cam plate.

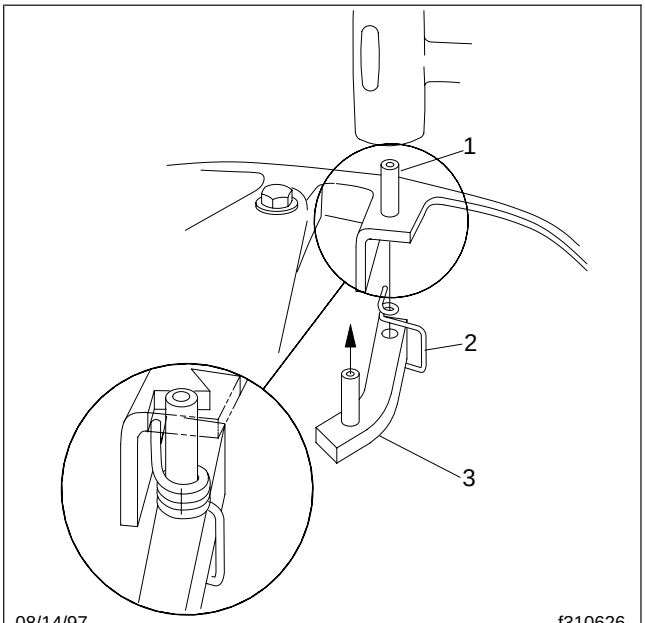
6. Install the secondary lock.

6.1 If equipped with the automatic version, start the roll pin into the hole in the top plate opposite the cam attachment capscrew. Then, assemble and install the secondary lock and torsion spring. Make sure the flats of the torsion spring are resting against the casting. See **Fig. 15**.

With a suitable hammer, drive the roll pin through the torsion spring and secondary

lock until the roll pin is flush with the casting. See **Fig. 15**.

Check the lock spring for tension and lock for free movement.



1. Roll Pin, 1/2 x 2-3/4
2. Torsion Spring
3. Secondary Lock

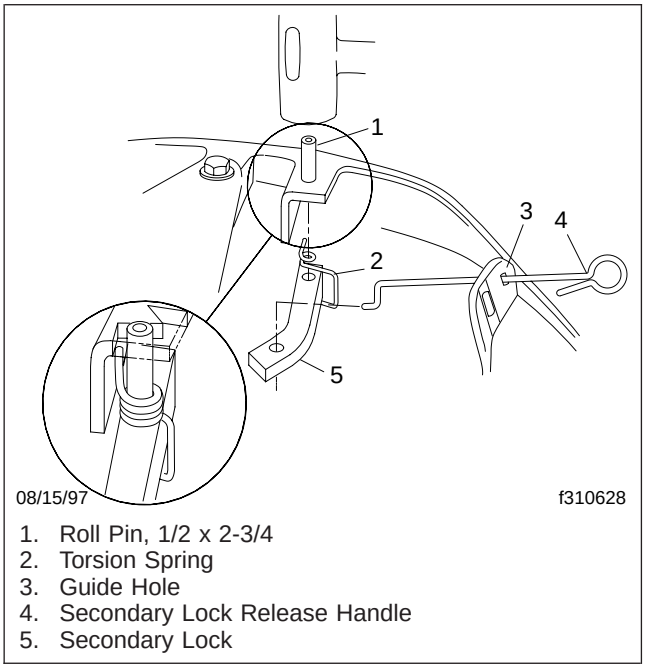
Fig. 15, Install the Secondary Lock

6.2 Pass the "S" bend of the manual secondary release handle through the casting guide hole (If equipped with the manual version). Then, pass the "S" bend of the release handle through the large hole in the secondary lock. See **Fig. 16**.

6.3 Start the roll pin into the hole in the top plate opposite the cam attachment capscrew (If equipped with the manual version). Then, assemble and install the secondary lock and torsion spring. Make sure the flats of the torsion spring are resting against the casting. See **Fig. 16**.

6.4 With a suitable hammer, drive the roll pin through the torsion spring and secondary lock until the roll pin is flush with the casting (If equipped with the manual version). See **Fig. 16**.

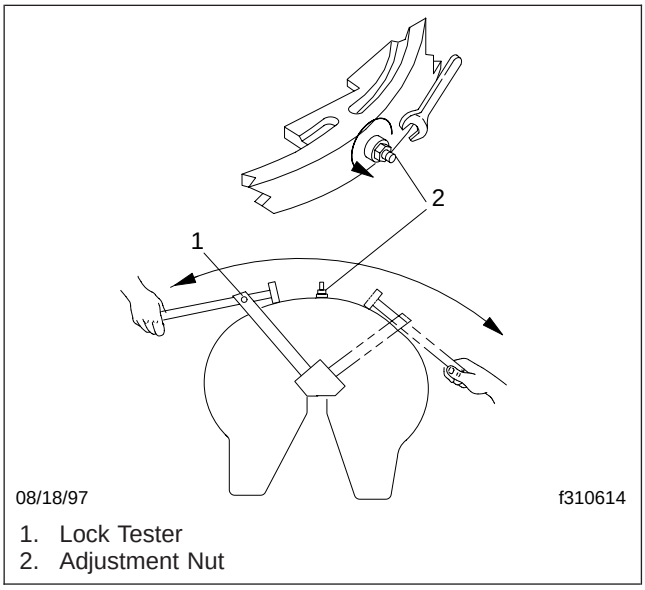
6.5 Check the lock spring for tension and lock for free movement.



1. Roll Pin, 1/2 x 2-3/4
2. Torsion Spring
3. Guide Hole
4. Secondary Lock Release Handle
5. Secondary Lock

Fig. 16, Install the Secondary Lock

7. Adjust the lock. See **Fig. 17**.



1. Lock Tester
2. Adjustment Nut

Fig. 17, Adjusting the Lock

Model XA–351 Top Plate Assembly and Installation

7.1 If equipped, pull the secondary release handle and hook it on the casting. Next, pull the primary release handle to open the locks. Now, remove the 2-inch plug.

7.2 Turn the fifth wheel right side up and close the locks using a Holland Lock tester (see Holland publication FW130 for operating instructions for the lock tester).

7.3 Verify that the locks are completely closed around the kingpin. The lock halves should be seated against each other.

7.4 Alternate tightening the adjustment nut and attempting to turn the lock tester back and forth. Continue tightening the adjustment nut until there is some resistance felt in the lock tester (as it is turned back and forth).

The fifth wheel is properly adjusted when there is resistance between locks and the lock tester, but the lock tester can still be turned by hand.

7.5 Pull the release handle and remove the lock tester.

8. Check the fifth wheel for proper operation.

8.1 Using the Holland lock tester, open and close the fifth wheel at least three times.

Each time you close the locks, verify that the locks have closed completely around the kingpin and that the adjustment nut and rubber bushing are seated snug against the casting.

8.2 Check for resistance between the locks and the lock tester one final time, and adjust as needed.

⚠ WARNING

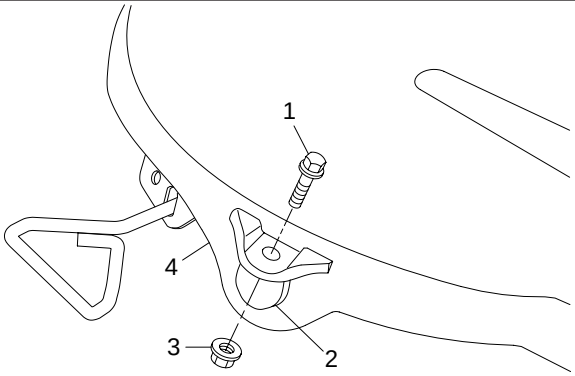
If the fifth wheel does not operate properly, do not use it. Either disassemble it and repeat the rebuilding procedure or contact your nearest Holland representative for assistance. Never use a fifth wheel that does not operate properly. The fifth wheel could malfunction, resulting in bodily injury or property damage due to a possible separation of the trailer from the tractor.

8.3 The fifth wheel is now ready for operation.

9. Install the top plate.

9.1 Using an overhead hoist, lift and position the fifth wheel over the bracket assembly.

9.2 Install the bushing pins through the fifth wheel and into the bracket assembly. Then, install and tighten securely the 1/2–20 bushing pin capscrews and locknuts. See **Fig. 18**. Remove the overhead hoist.



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1. Capscrew
2. Bushing Pin
3. Locknut
4. Top Plate

Fig. 18, Install the Bushing Pin

9.3 Lubricate the fifth wheel. For instructions, see Group 31 of the *Heavy-Duty Trucks Maintenance Manual*.

Troubleshooting Chart

Problem—The Fifth Wheel Is Hard to Hook Up to the Trailer

Problem—The Fifth Wheel Is Hard to Hook Up to the Trailer	
Possible Cause	**Remedy**
The trailer may be too high; the kingpin is not entering the locks properly.	Lower the trailer landing gear until the bolster plate contacts the fifth wheel.
The locks are closed.	Pull the release handle and pry open the locks.
Rust or grime is interfering with the lock operation.	Spray a light lubricant or diesel fuel on all moving parts including the release handle. Operate the release mechanism several times.
The fifth wheel locks are too tight.	Check the lock adjustment. Correct as needed.
A bent release handle, bent kingpin, or damaged bolster plate is interfering with the lock movement.	Check the release handle, kingpin, and bolster plate. Replace parts as required.
The locks are damaged.	Inspect the locks and replace parts as required.
The fifth wheel needs rebuilding.	Rebuild the fifth wheel, using the parts in the appropriate rebuilding kit.

Problem—The Fifth Wheel Is Hard to Unhook from the Trailer

Problem—The Fifth Wheel Is Hard to Unhook from the Trailer	
Possible Cause	**Remedy**
The secondary lock is not released.	If equipped with a manual secondary lock, pull the release handle and lock it open by resting it against the top plate. If equipped with an automatic secondary lock, inspect the lock for missing or broken parts, and repair or replace as required.
The tractor is putting pressure against the locks.	Set trailer brakes. Back the tractor into the trailer to relieve pressure and lock the tractor brakes before pulling the release handle.
There is rust or grime on the locking mechanism.	Spray a light lubricant or diesel fuel on all moving parts including the release handle. Operate the release mechanism several times.
The kingpin is bent or the bolster plate is damaged.	Check the kingpin, using a Holland TF–0110 Kingpin Gauge. Check the bolster plate, using a 48-inch (122 cm) straight edge. Repair or replace parts as required.
The fifth wheel locks are too tight.	Check the lock adjustment. Correct as needed.
The release handle will not stay out or must be held out when unlocking.	Replace the cam or release arm and the release handle spring.

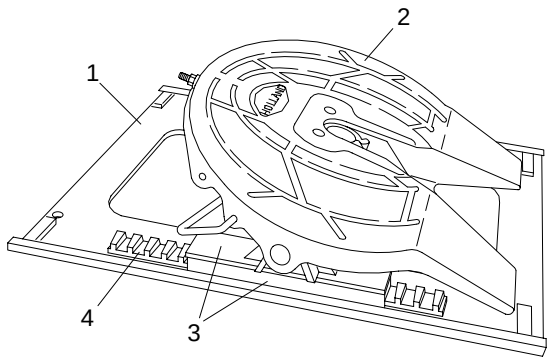
General Information

NOTE: For Holland 3500 series fifth wheel service operations, see **Section 31.05** in this group.

NOTE: Prior to June 1, 1996, the Holland sliding fifth wheel mount carried a part number prefix FW2535. Since June 1,1996, the Holland sliding fifth wheel mount part number prefix has been replaced by FW35.

The Holland sliding fifth wheel mount is designed to provide maximum tractor use for different lengths and types of trailers. The FW2535/FW35 sliding fifth wheel mount is used with the Holland 3500 series fifth wheel, and is equipped with either a manually operated or an air-operated release slider.

Sliding fifth wheel assemblies are mounted on a baseplate with notched rails. See **Fig. 1**. Plungers are meshed into teeth on the baseplate to lock the fifth wheel. This assembly allows forward or rearward movement of the fifth wheel along the notched rails for optimum weight distribution over the tractor axles. The mounting baseplate is bolted to the tractor frame.



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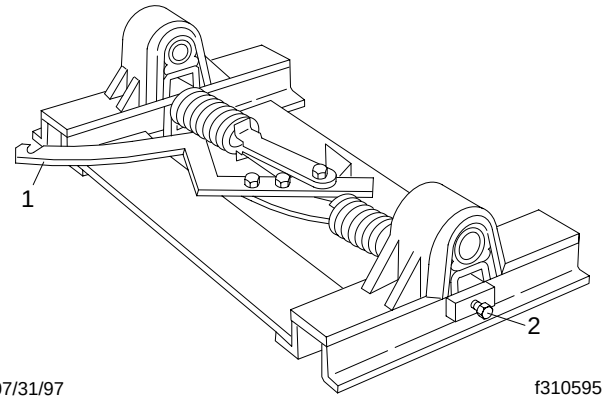
1. Baseplate
2. Fifth Wheel Top Plate (XA–3500)
3. Slide Mount
4. Baseplate Rail

Fig. 1, XA-3500 Sliding Fifth Wheel

When the fifth wheel is in the desired position, it is locked in place by wedge-shaped plungers that engage in the notched rails under the sliding mount. To release the fifth wheel, the plungers are withdrawn.

The manually operated release slider contains a release lever (**Fig. 2**), which when manually pulled or released, unlocks or locks both sides of the sliding mount at the same time.



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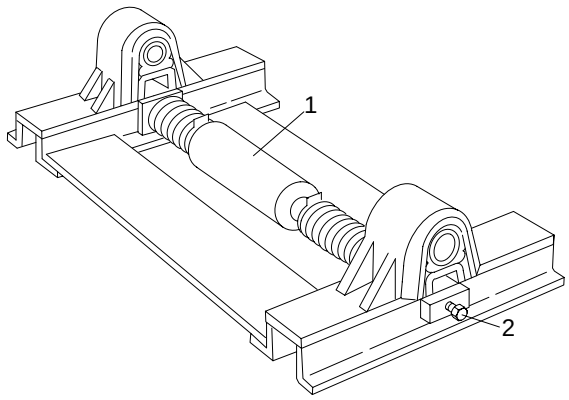
NOTE: Baseplate rails not shown.

1. Release Lever
2. Slider Plunger Release

Fig. 2, Manual Release Slider Assembly

The air-operated release slider contains a double-ended air cylinder (**Fig. 3**), which locks and unlocks both sides of the sliding mount at the same time. The air cylinder is activated by a two-position air-control valve in the tractor cab. See **Fig. 4**.



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NOTE: Baseplate rails not shown.

1. Double-Ended Air Cylinder
2. Slider Plunger Release

Fig. 3, Air Valve Release Slider Assembly

General Information

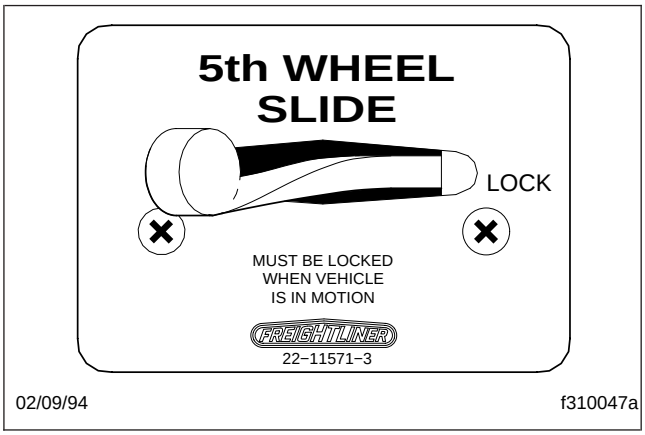


Fig. 4, Control Valve

See Chapter 10 (FLD) or Chapter 10 (FLB) in the vehicle driver's manual for complete operating instructions.

Disassembly

⚠ WARNING

Fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Incorrect or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

1. Remove the top plate.
   - 1.1 If equipped with model XA–3501 top plate, remove the roll pins (**Fig. 1**) from both the right and left side of the top plate. Then, remove the bushing pins.

     Using an overhead hoist, lift the fifth wheel off the slide mount assembly.
   - 1.2 If equipped with model XA–351 top plate, loosen and remove the 1/2–20 bushing pin capscrews and locknuts from both the left and right sides of the top plate. Then, remove the bushing pins (**Fig. 1**) from the bracket assembly.

     Using an overhead hoist, lift the fifth wheel off the slide mount assembly.

⚠ WARNING

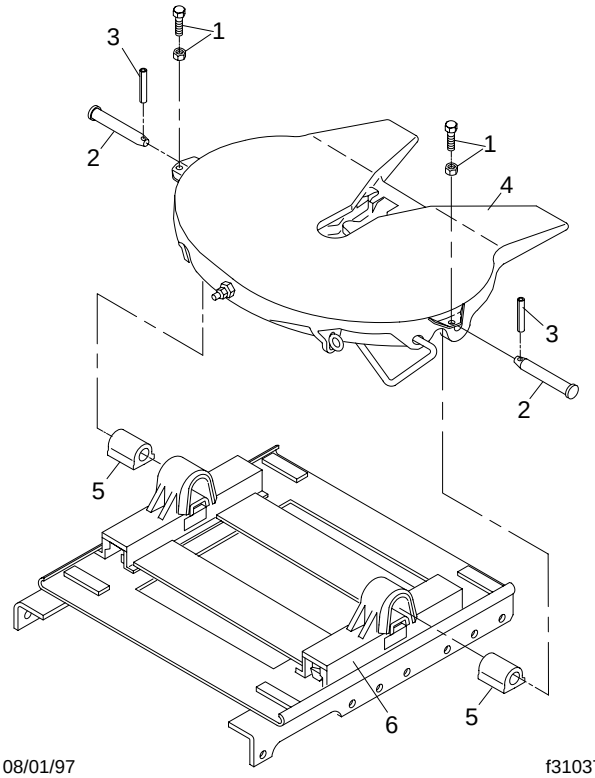
When draining the air reservoir, do not look into the air jets, or direct them toward anyone. Dirt or sludge particles may be in the airstream, and could cause injury if ejected.

2. If the fifth wheel has a manual release sliding mount, then go to the next step. Otherwise, drain the air reservoir; then disconnect and plug the air line from the air cylinder.

⚠ WARNING

Parts are under spring compression. Wear safety goggles during disassembly and assembly, and keep fingers away from possible pinch points at the ends of springs. Failure to do so can result in bodily injury, due to parts ejecting with force.

3. Using a Holland TF–TN 2500 spring compressor (**Fig. 2**), compress one of the plunger return springs (**Fig. 3**).



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1. Capscrew and Locknut (XA–351 only)
2. Bushing Pin
3. Roll Pin (XA–3501 only)
4. Fifth Wheel Top Plate
5. Rubber Bushing
6. Slide Mount Assembly

Fig. 1, Sliding Mount Components

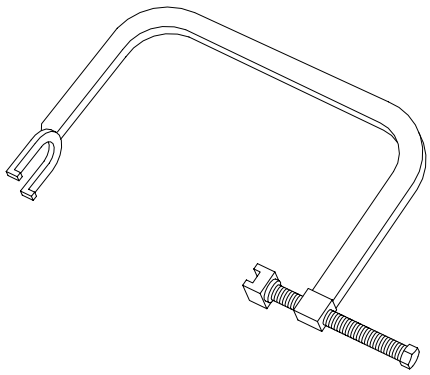

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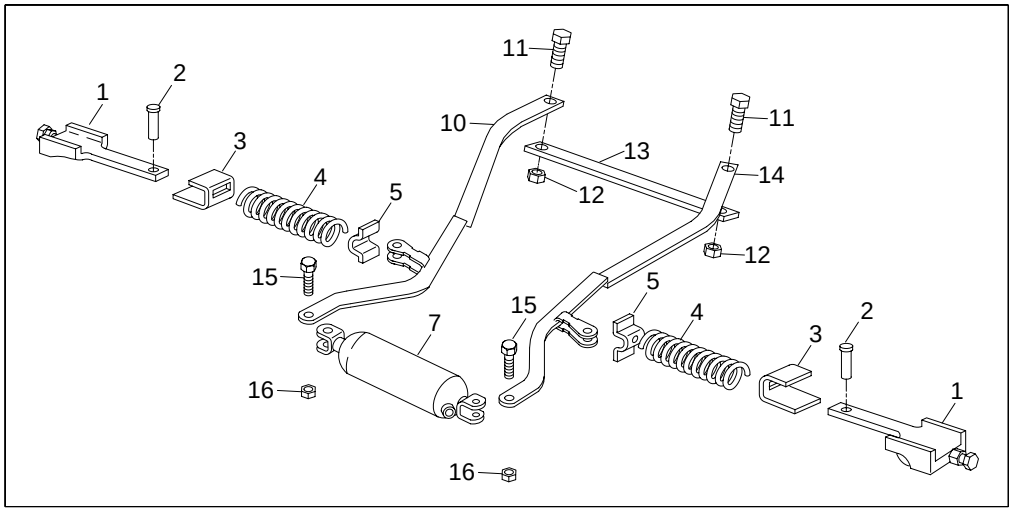
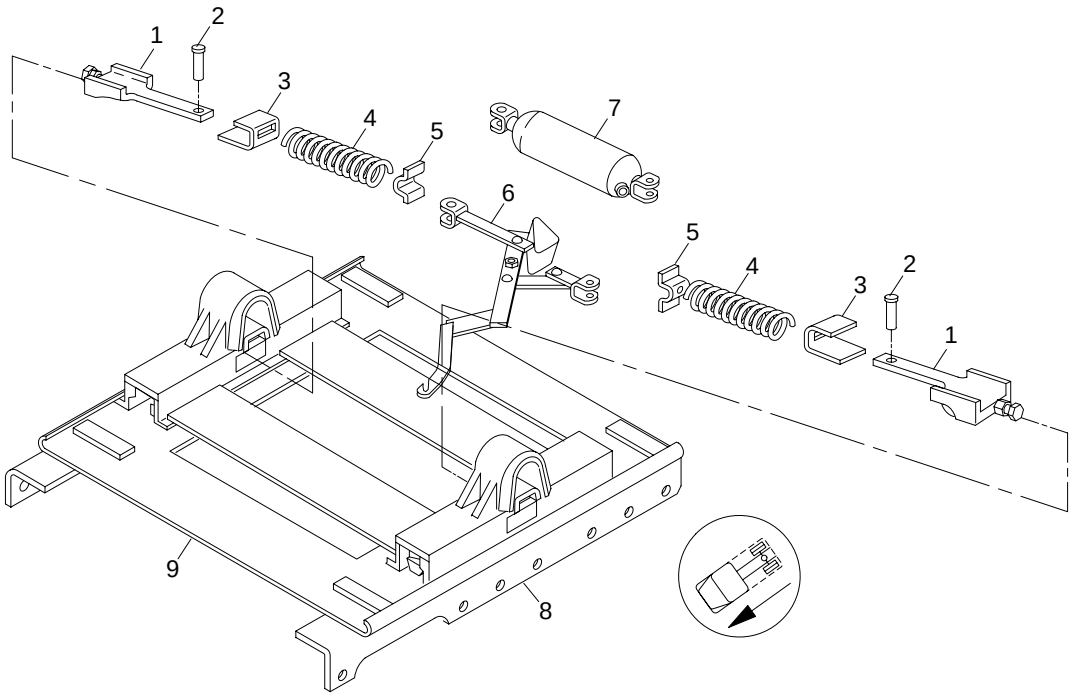
Fig. 2, Spring Compressor

Sliding Mount Disassembly and Assembly



A



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A. Spring assembly for 6.62 and 8.12 inch (16.8 and 20.6 cm) fifth wheel heights

1. Plunger
2. Retaining Pin
3. Spring Compression Stop
4. Plunger Return Spring
5. Spring Retainer
6. Manual Release Lever
7. Air-Release Cylinder
8. Slide Mount Assembly
9. Baseplate
10. Right Release Lever
11. Capscrew, 3/8–16
12. Locknut, 3/8–16
13. Tie Bar
14. Left Release Lever
15. Capscrew, 1/2–20
16. Locknut, 1/2–20

Fig. 3, Spring Assemblies

4. Remove the plunger retaining pin (**Fig. 3**) from the plunger end, and either the air-release cylinder or manual release lever clevis. Then remove the plunger.

   If equipped with a fifth wheel height of 6.62 or 8.12 inches (16.8 or 20.6 cm), remove the plunger retaining pin from the release lever, then remove the plunger.

5. Carefully remove the spring compressor; then remove the plunger return spring, the spring compression stop, and the spring retainer (**Fig. 3**).

   Repeat the procedure for the other plunger.

6. Remove the air-release cylinder or the manual release lever.

   If equipped with a fifth wheel height of 6.62 or 8.12 inches (16.8 or 20.6 cm), remove the air-release cylinder or the manual release lever along with the right and left release levers (**Fig. 3**). Disconnect the release levers from the air-release cylinder or manual release lever.

⚠ WARNING

Wear protective eye and facial gear when grinding to remove the rear stops. Failure to do so could result in personal injury due to flying metal debris from the grinding.

7. If the slide mount assembly (**Fig. 3**) is damaged, dismantle it from the baseplate (Ref. 9).

   7.1 Grind down the welded area to remove the rear stops.

   7.2 Remove the slide mount assembly from the baseplate by sliding it off the rear of the tracks.

8. Remove all dirt and grease from the parts. Replace any parts that show signs of wear or damage.

NOTE: If the rubber bushings (**Fig. 1**) are damaged, or if they allow movement of more than 1/8 inch (3 mm), replace them.

Assembly

⚠ WARNING

Fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Incorrect or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

1. Using a rubber lubricant or a waterless hand cleaner, lubricate the outer surfaces of the new rubber bushings.

2. Install the rubber bushings (**Fig. 1**) into the slide mount assembly until they are flush with the outboard ends of the assembly.

3. Using a multipurpose chassis grease, lubricate the flanges on the slide mount assembly. Then slide the assembly onto the tracks of the baseplate.

4. Move the slide mount assembly to the rearmost position. Install the plungers into the outboard ends of the slide mount. Engage the plungers in the rail teeth.

5. Install the rear stops under the curled edge of the baseplate. Allow a clearance of about 1/8 inch (3 mm) from the rear stops to the slide mount (when it's in the full rear position. The stops should be about 1/4 to 1/2 inch (6 to 13 mm) from the rear edge of the baseplate). See **Fig. 4**.

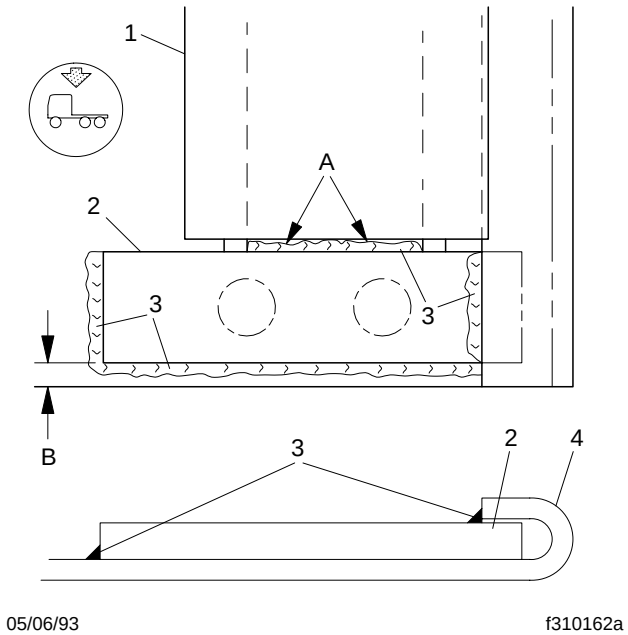
6. Clamp the rear stops in place, then move the slide mount assembly forward and out of the way.

7. Weld the stops in place. The welds should be 1/4-inch (6 mm) fillet. On the forward edge, weld only the center area; not the area where the slide mount assembly contacts the stop. See **Fig. 4**.

8. Move the slide mount assembly to the rearmost position and check for clearance. Make sure the plungers seat into the rail with all teeth engaged.

9. If equipped with a fifth wheel height of 6.62 or 8.12 inches (16.8 or 20.6 cm), and if new release levers are being installed, attach the right and left release levers to the tie bar (**Fig. 3**). Install

Sliding Mount Disassembly and Assembly



A. Weld carefully to avoid slide mount.
B. 1/4 to 1/2 inch (6 to 13 mm)

1. Slide Mount
2. Rear Stop
3. Weld
4. Baseplate

Fig. 4, Slide Stop Installation

3/8–16 capscrews and locknuts and tighten them firmly, but make sure the parts are not binding.

Using the 1/2–20 capscrews and locknuts, attach the air-release cylinder or the manual release lever to the ends of the release levers, tighten the nuts firmly, but make sure the parts are not binding.

10. Install the spring compression stops and the plunger return springs on the inboard ends of the plungers. Then install the spring retainers.

⚠ WARNING

Parts are under spring compression. Wear safety goggles during disassembly and assembly, and keep fingers away from possible pinch points at the ends of springs. Failure to do so can result in bodily injury, due to parts ejecting with force.

11. Using a Holland TF–TN 2500 spring compressor, compress one of the plunger return springs and its spring retainer enough to access the hole through the end of the plunger shaft.

12. If equipped with a standard fifth wheel, position the air-release cylinder or the manual release lever so that the holes in its clevis line up with the hole through the end of the plunger shaft. Install the retaining pin.

    If equipped with a fifth wheel height of 6.62 or 8.12 inches (16.8 or 20.6 cm), line up the holes in the clevis of one of the release levers (**Fig. 3**) with the hole in the end of the plunger shaft. Install the retaining pin.

13. Carefully remove the spring compressor.

14. Repeat the procedure on the other side of the vehicle.

15. If the fifth wheel has a manual release sliding mount, then go to the next step, otherwise connect the air lines.

    15.1 Remove the plugs from the air line.

    15.2 Connect the air line to the inlet on the air-release cylinder.

    15.3 Start the engine to build air pressure, then check the operation of the slide mechanism.

16. Adjust the plungers, following the procedure in **Subject 110**.

17. Install the top plate.

    17.1 If equipped with model XA–3501 top plate, using an overhead hoist, lift the fifth wheel onto the slide mount assembly.

    From both the right and left side of the top plate, install the bushing pins and the roll pins (**Fig. 1**).

    17.2 If equipped with model XA–351 top plate, using an overhead hoist, lift the fifth wheel onto the slide mount assembly.

    From both the right and left side of the top plate, Install the bushing pins. Then, install and tighten snugly the 1/2–20 bushing pin capscrews and locknuts (**Fig. 1**).

Sliding Mount Assembly Plunger Adjustment

Adjustment

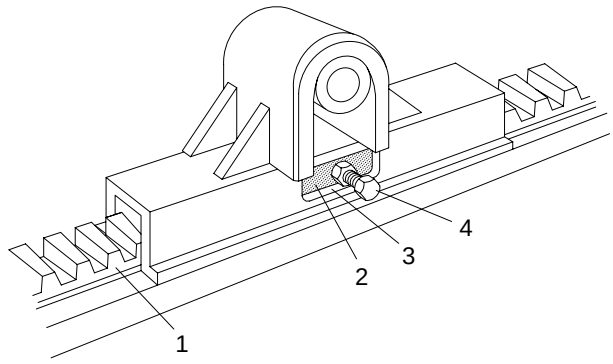
⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Incorrect or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

NOTE: The locking plungers are adjusted at installation and again after one month of operation. Make additional adjustments as needed.

1. The plungers should seat in the pocket with a small amount of play when locked (engaged). See **Fig. 1**. If they wedge or bind, turn the adjusting bolt clockwise or counterclockwise as needed.

   Turning the adjusting bolt clockwise moves the plunger out of the pocket; turning it counterclockwise moves the plunger further into the pocket.



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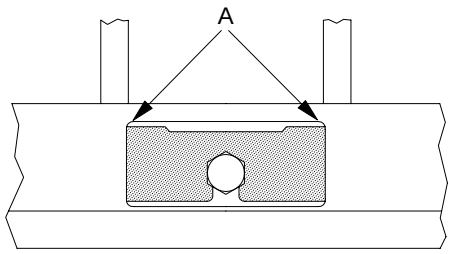
1. Plunger Adjusting Bolt
2. Pocket
3. Plunger
4. Rack

Fig. 1, Plunger Position

2. If the plungers don't unlock (release), check the air-release cylinder or the manual release lever for correct operation. Replace it if needed. See **Subject 100** for removal and installation instructions.

3. If the adjusted plunger binds on the bottom of the pocket, remove it; then grind the plunger top edges 1/16 inch (2 mm). See **Fig. 2**. Install the plunger. See **Subject 100** for plunger removal and installation instructions.

   Adjust the plunger, following the instructions above.



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A. Check for interference here.

Fig. 2, Plunger Checking

4. If the plungers are too loose, check the tension of the plunger return springs. If the springs are damaged or worn, replace them, following the instructions in **Subject 100**.

   If the plungers are still too loose, replace the plungers, following the instructions in **Subject 100**.

General Description

Fontaine 5000 series fifth wheels are used for pulling trailers having the standard kingpin. When installed as a stationary fifth wheel, it is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. When used as a sliding fifth wheel (**Fig. 1**), it is mounted on the Fontaine 5AWS or 5MWS model sliding mount.

The Fontaine fifth wheel lock mechanism for the trailer kingpin consists of a spring-loaded jaw and a sliding wedge. Kingpin release is accomplished by activating a manual lock control handle located on either the right side (curbside) or left side (roadside) of the fifth wheel. Kingpin lockup occurs when the kingpin is forced into the jaws and the lock control handle moves to the locked position.

Principles of Operation

As the kingpin enters the lock mechanism, the jaw is moved first with the spring-loaded wedge sliding in place against the jaw. **See Fig. 2**. The jaw will move behind the kingpin, followed by the wedge. The wedge reinforces the jaw and takes up slack around the kingpin.

Placing the lock control handle in the unlocked position moves the wedge and jaw out from behind the kingpin. This action unlocks the fifth wheel, allowing freedom of movement underneath the trailer when the tractor is moved.

Refer to the vehicle driver's manual for complete operating instructions.

General Description and Principles of Operation

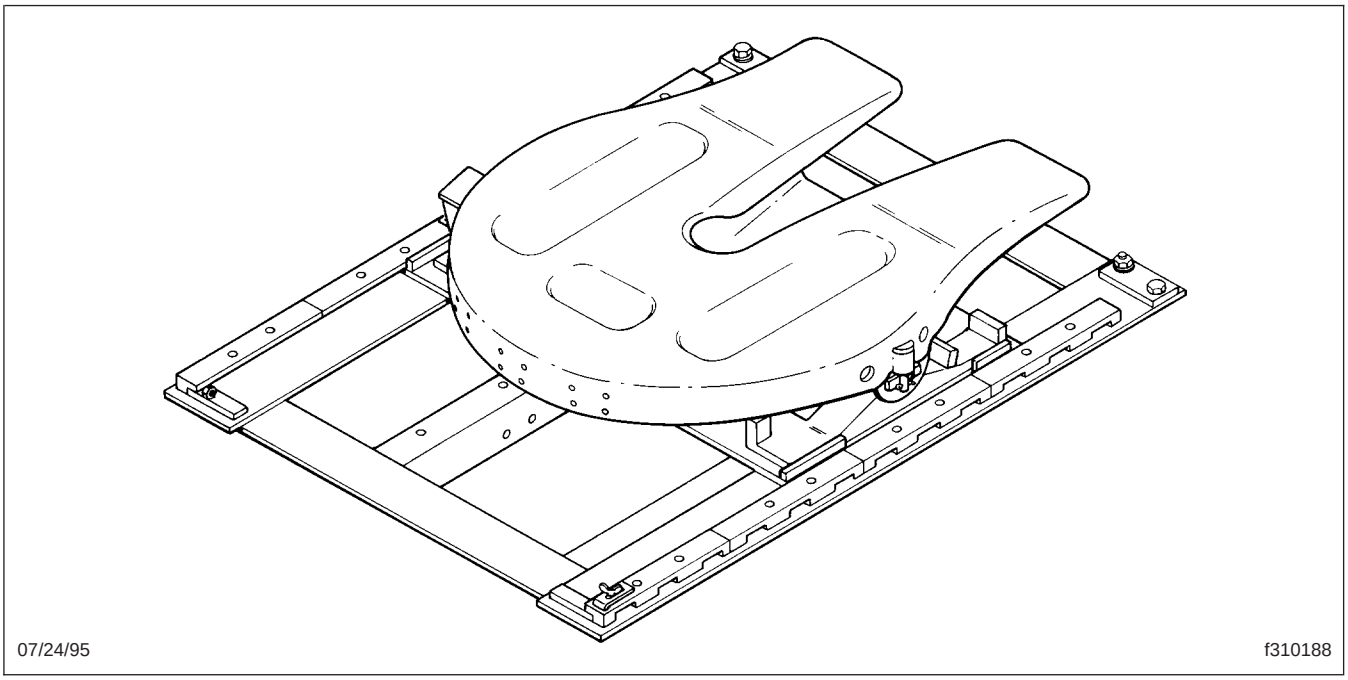


Fig. 1, Fontaine 5000 Series Fifth Wheel and Sliding Mount

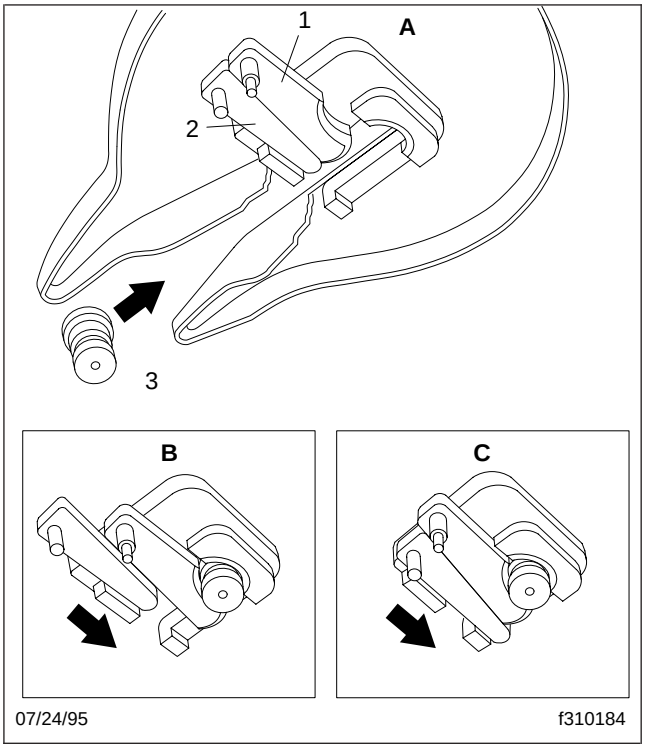


Fig. 2, Fontaine Kingpin Lock Mechanism

Removal and Disassembly

(See Fig. 1)

⚠ WARNING

WARNING: All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in a hazardous operating condition due to a possible disengagement of the trailer from the tractor.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

1. Steam clean the top plate. Remove it from the sliding mount by removing the cotter pins (Ref. 6) from the retaining pins (Ref. 7). Remove the retaining pins and bushing pins (Ref. 9) from both sides of the top plate.
2. Using an overhead hoist, lift the fifth wheel off the sliding mount and tractor frame.
3. Turn the fifth wheel upside down.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

⚠ WARNING

WARNING: Do not attempt to repair or rebuild the top plate if it is cracked or if parts are damaged. The top plate or parts could malfunction. This could result in disengagement of the trailer during vehicle travel, possibly causing personal injury and property damage.

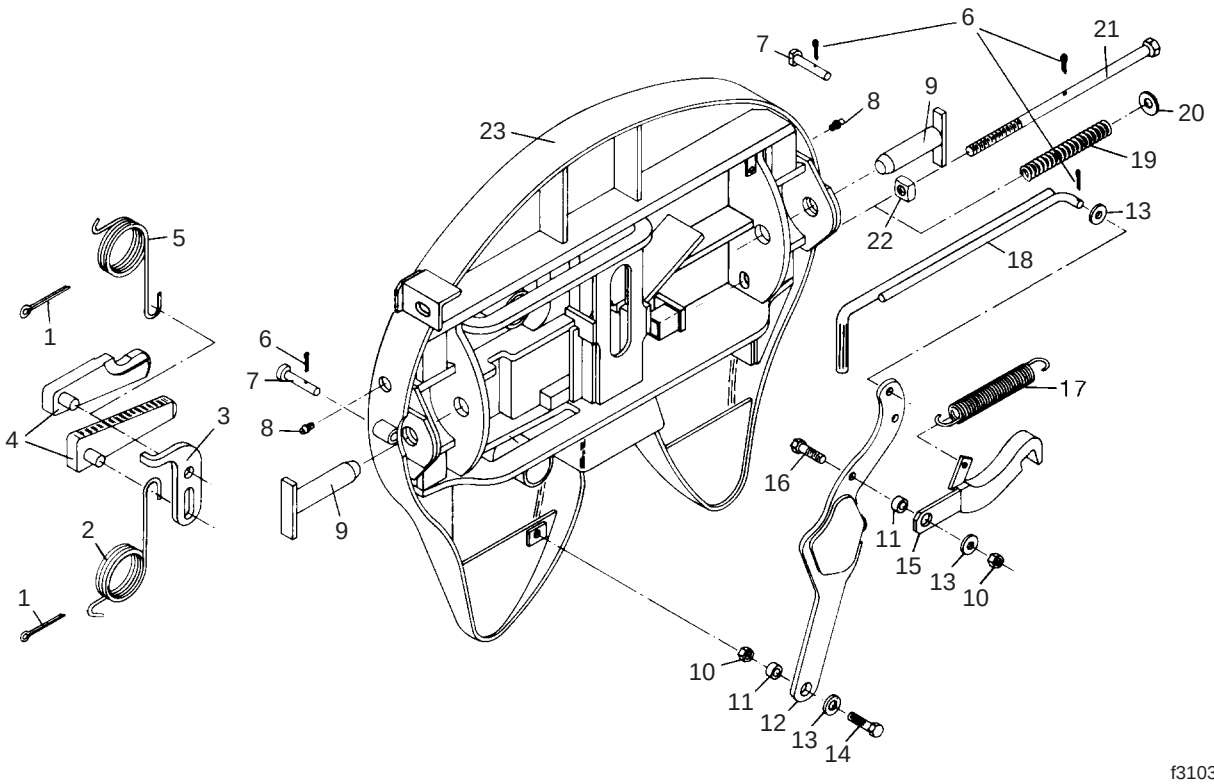
4. Unhook the bumper spring (Ref. 17) from its clasp. **See Fig. 2** .
5. Remove the two hexhead capscrews (Refs. 14 and 16) from the operating handle (Ref. 12). **See Fig. 3**.
6. Remove the bumper (Ref. 15). **See Fig. 4**.
7. Remove the cotter pin (Ref. 6) and flatwasher (Ref. 13) that attach the release handle (Ref. 18) to the operating handle.

   Slide the release handle out through the side of the fifth wheel. **See Fig. 5**.
8. Slide the operating handle over to the side of the fifth wheel. **See Fig. 6**.

NOTE: Slide the bottom part of the operating handle first. This will allow the handle to clear the studs under the handle.

9. Lift the timer (Ref.3) off the studs. **See Fig. 7**.
10. Slide the operating handle out through the slot at the top or bottom of the fifth wheel. **See Fig. 8**.
11. Using pliers or a screwdriver, pry the wedge and jaw springs (Refs. 2 and 5) over the studs. **See Fig. 9**.
12. Remove the jaw and wedge (Ref. 4). **See Fig. 10**.
13. Remove the jaw and wedge springs as follows:
    - 13.1 Remove the cotter pin (**Fig. 11**).
    - 13.2 Using a screwdriver, pry up on the spring to relieve tension and remove it. **See Fig. 12**.

Removal and Disassembly



1. 3-inch Cotter Pin
2. Wedge Spring
3. Timer
4. Jaw and Wedge
5. Jaw Spring
6. 1-Inch Cotter Pin
7. Retaining Pin
8. Grease Fitting
9. Bushing Pin
10. 1/2–13 Locknut
11. Pivot Bushing
12. Operating Handle
13. 1/2-Inch Flatwasher
14. 1/2–13 x 2-Inch Hexhead Capscrew
15. Bumper
16. 1/2–13 x 1-1/2 Inch Hexhead Capscrew
17. Bumper Spring
18. Release Handle
19. Wedge Stoprod Spring
20. 5/8-Inch Flatwasher
21. Wedge Stoprod
22. 5/8–11 Square Nut
23. Fifth Wheel Top Plate

Fig. 1, Fontaine 5000 Series Fifth Wheel (right-side release shown)

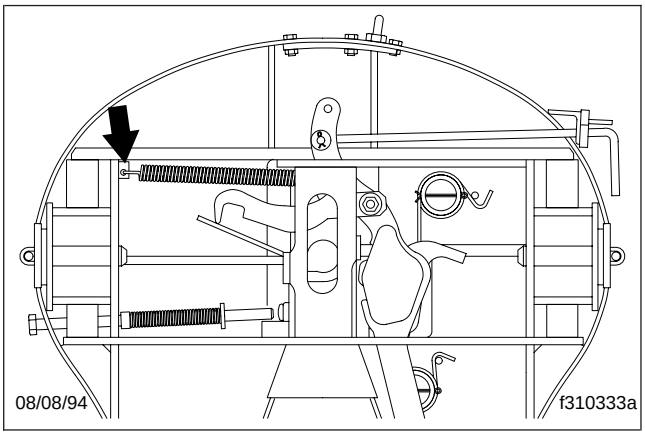


Fig. 2, Bumper Spring Removal

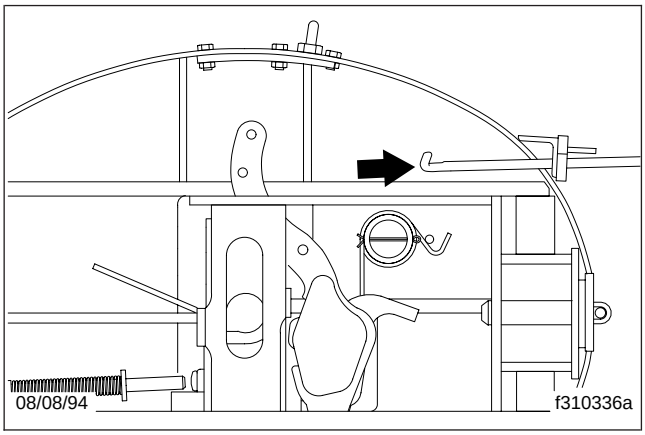


Fig. 5, Pull Handle Removal

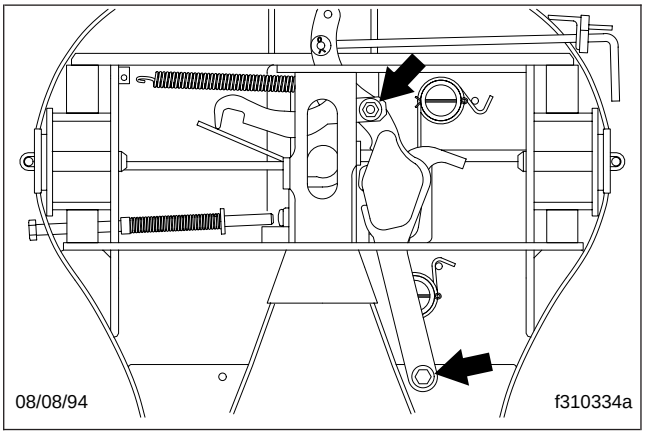


Fig. 3, Bolt Removal

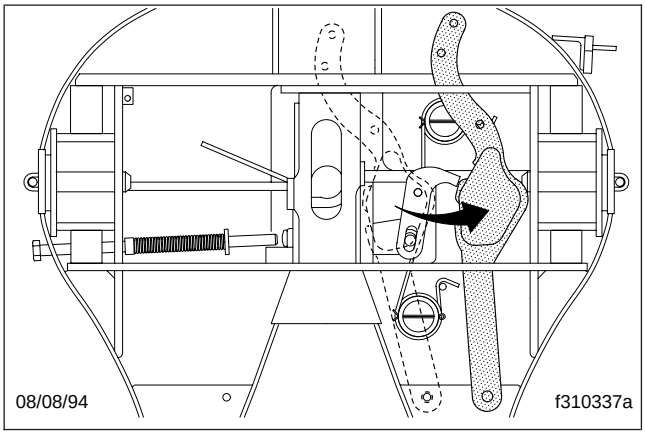


Fig. 6, Operating Handle Positioning

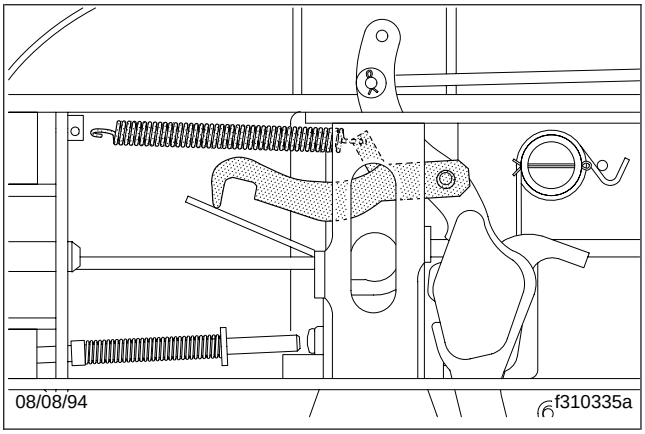


Fig. 4, Bumper Removal

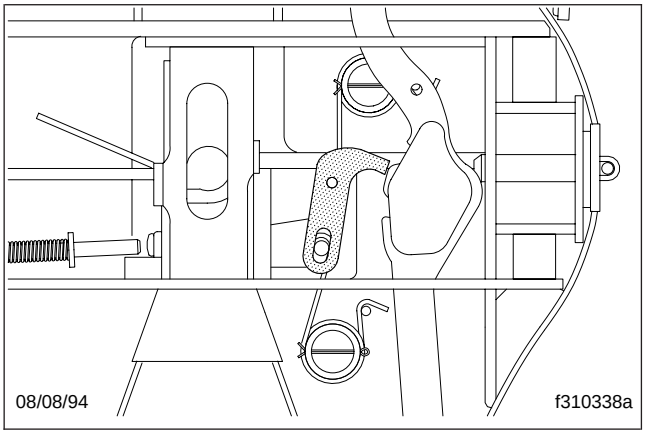


Fig. 7, Timer Removal

Removal and Disassembly

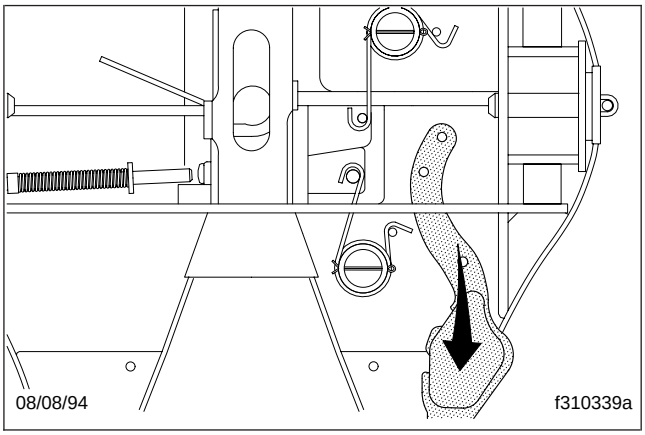


Fig. 8, Operating Handle Removal

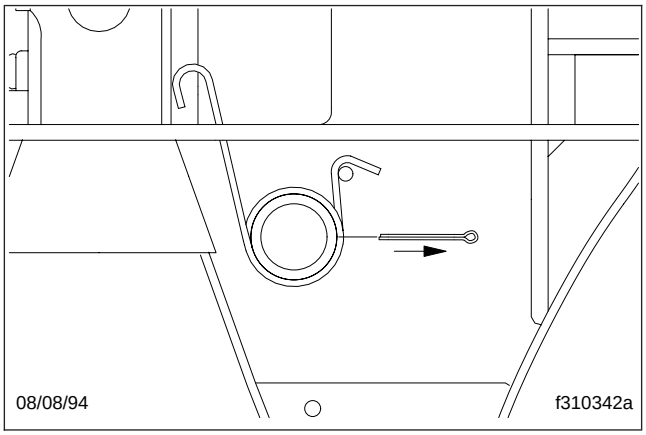


Fig. 11, Cotter Pin Removal

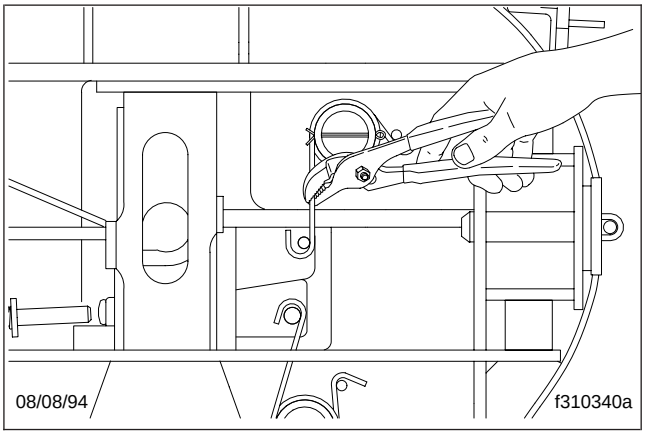


Fig. 9, Wedge and Jaw Springs Removal

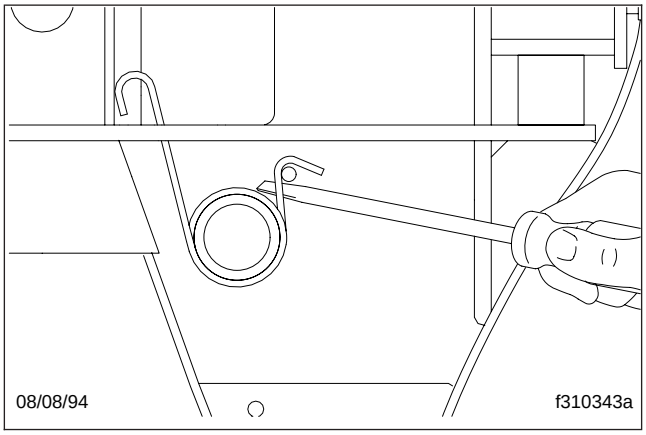


Fig. 12, Spring Removal

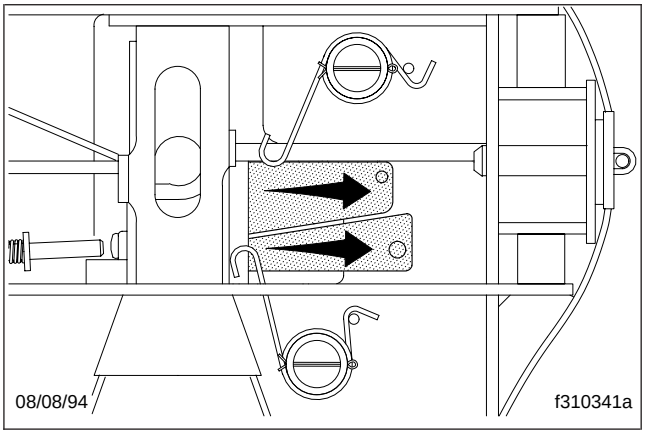
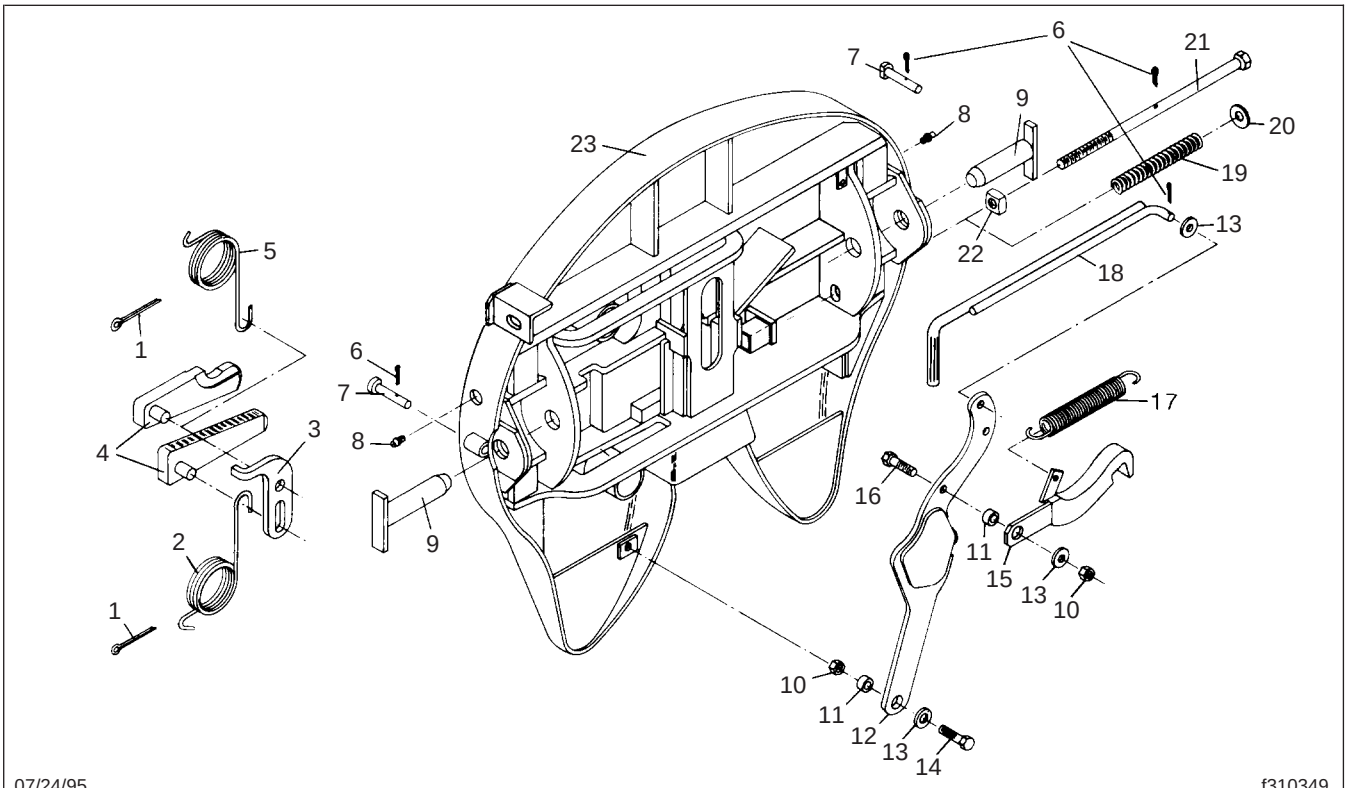


Fig. 10, Jaw and Wedge Removal

Assembly and Installation

(See Fig. 1)



1. 3-inch Cotter Pin
2. Wedge Spring
3. Timer
4. Jaw and Wedge
5. Jaw Spring
6. 1-Inch Cotter Pin
7. Retaining Pin
8. Grease Fitting
9. Bushing Pin
10. 1/2–13 Locknut
11. Pivot Bushing
12. Operating Handle
13. 1/2-Inch Flatwasher
14. 1/2–13 x 2-Inch Hexhead Capscrew
15. Bumper
16. 1/2–13 x 1-1/2 Inch Hexhead Capscrew
17. Bumper Spring
18. Release Handle
19. Wedge Stoprod Spring
20. 5/8-Inch Flatwasher
21. Wedge Stoprod
22. 5/8–11 Square Nut
23. Fifth Wheel Top Plate

Fig. 1, Fontaine 5000 Series Fifth Wheel (right-side release shown)

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in a hazardous operating condition due to a possible disengagement of the trailer from the tractor.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

IMPORTANT: Replace any parts that show signs of wear, damage, or deterioration.

Assembly and Installation

⚠ WARNING

When cleaning parts with no. 2 diesel fuel, do not smoke or use an open flame near the area. To do so could result in a possible fire.

1. Clean all moving parts with no. 2 diesel fuel before assembly.
2. Insert the wedge spring through the slot and lay the spring coil over the spring bracket. See **Fig. 2**.

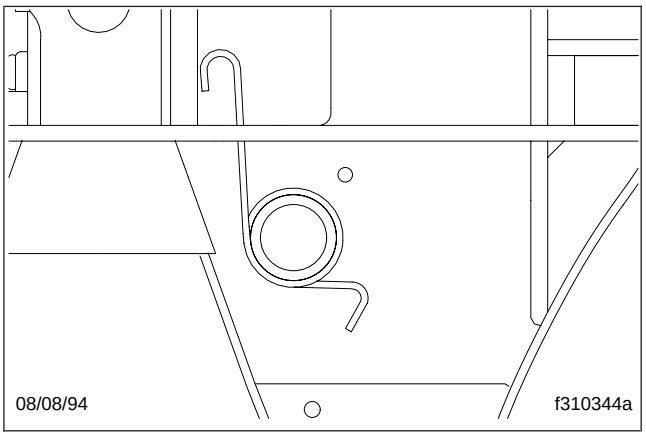


Fig. 2, Wedge Spring Installation

3. Insert the spring tool part number 710 into the spring bracket (**Fig. 3**). Engage the small hooked tail and wind it around until it is directly over the small stud at the back of the bracket.

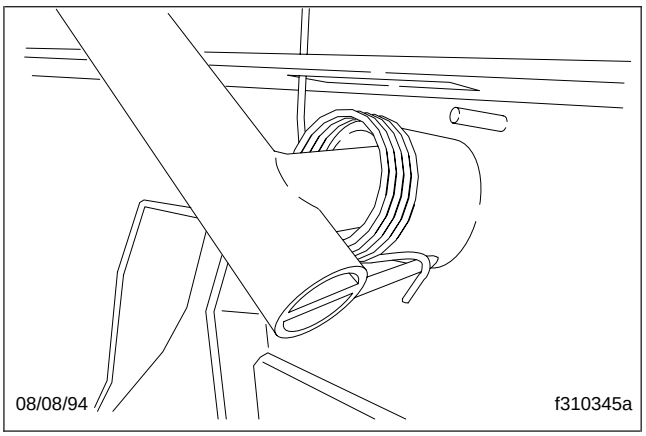


Fig. 3, Spring Winding

NOTE: Order the spring tool part number 710 from: Fontaine Fifth Wheel Company, 125 Cleage Drive, Birmingham, Alabama 35217

Using a hammer, tap down on the spring until it catches on the stud. Install the cotter pin (**Fig. 4**).

4. The jaw spring has very little tension; install it by hand.

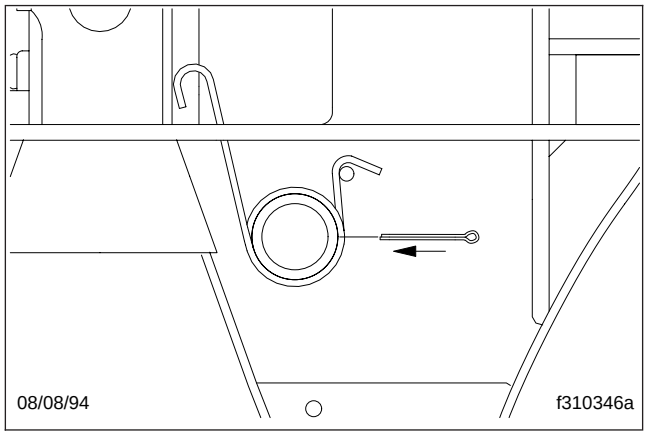


Fig. 4, Cotter Pin Installation

5. Install a 2-inch diameter shaft where the kingpin will engage in the fifth wheel.
6. Apply a moderate amount of a multipurpose chassis grease to the sides and serrated edges of the jaw and wedge (**Fig. 1**, Ref. 4), and also the stationary jaw in the throat of the fifth wheel.
7. Install the wedge and jaw.
8. Using pliers or a screwdriver, pry the jaw and wedge springs over the studs. See **Fig. 5**.
9. Insert the operating handle (Ref. 12) and move it over to the side of the wheel. Apply a moderate amount of multipurpose chassis grease to the grooved middle section of the operating handle.
10. Install the timer (Ref. 3) over the studs.

NOTE: The small hole on the timer fits over the top stud. Make sure the small bent arm of the timer is facing down.

11. Slide the operating handle (top part first) over to the side. Make sure that the handle is in a vertical position once it goes over the studs. See **Fig. 6**.

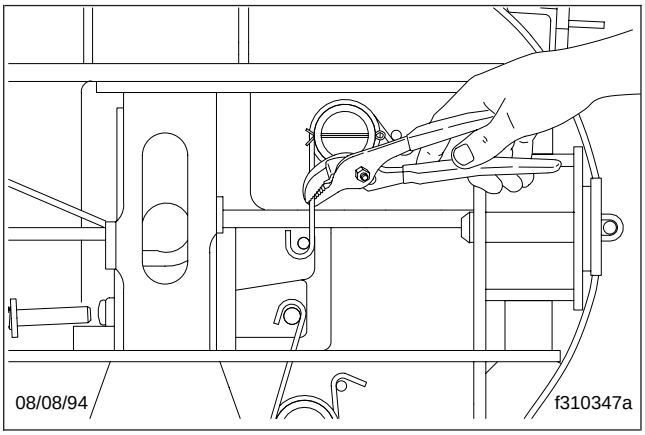


Fig. 5, Jaw and Wedge Spring Installation

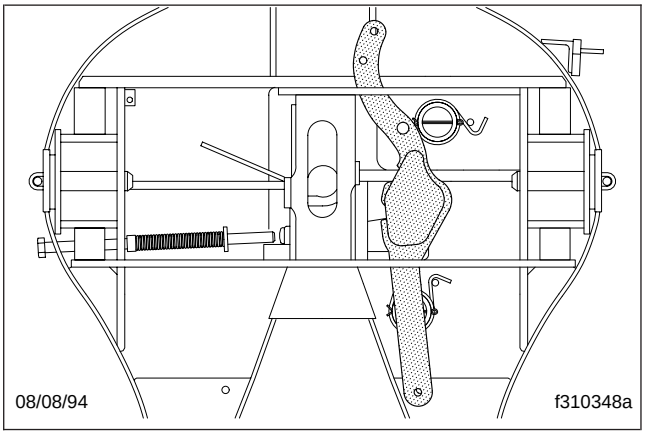


Fig. 6, Operating Handle Positioning

12. Slide the release handle (Ref. 18) in through the safety lock. Using a flatwasher (Ref. 13) and cotter pin (Ref. 6), attach the release handle to the second hole from the top on the operating handle.
13. Position the bumper (Ref. 15), then attach it to the operating handle with a new 1/2–13 x 1-1/2 inch capscrew (Ref. 16), bushing, washer, and locknut.
14. On the other end of the operating handle, install a new 1/2–13 x 2 inch capscrew (Ref. 14), washer, bushing, and locknut.
15. Apply multipurpose chassis grease to the operating handle, and to other fifth wheel parts that may come into contact with the handle during operation.
16. Connect the bumper spring.
17. Using multipurpose chassis grease, grease the top plate and the zerk fittings on the side of the fifth wheel.

    On heavy-duty oscillating fifth wheels, grease the top of the rocker bearing bushing.
18. Measure the distance from the wedge to the end of the wedge stoprod (see **Fig. 7**). The correct measurement should be 3/8 inch (10 mm). Turn the wedge stoprod clockwise if the measurement is more than 3/8 inch (10 mm), or turn it counterclockwise if the measurement is less than 3/8 inch (10 mm).

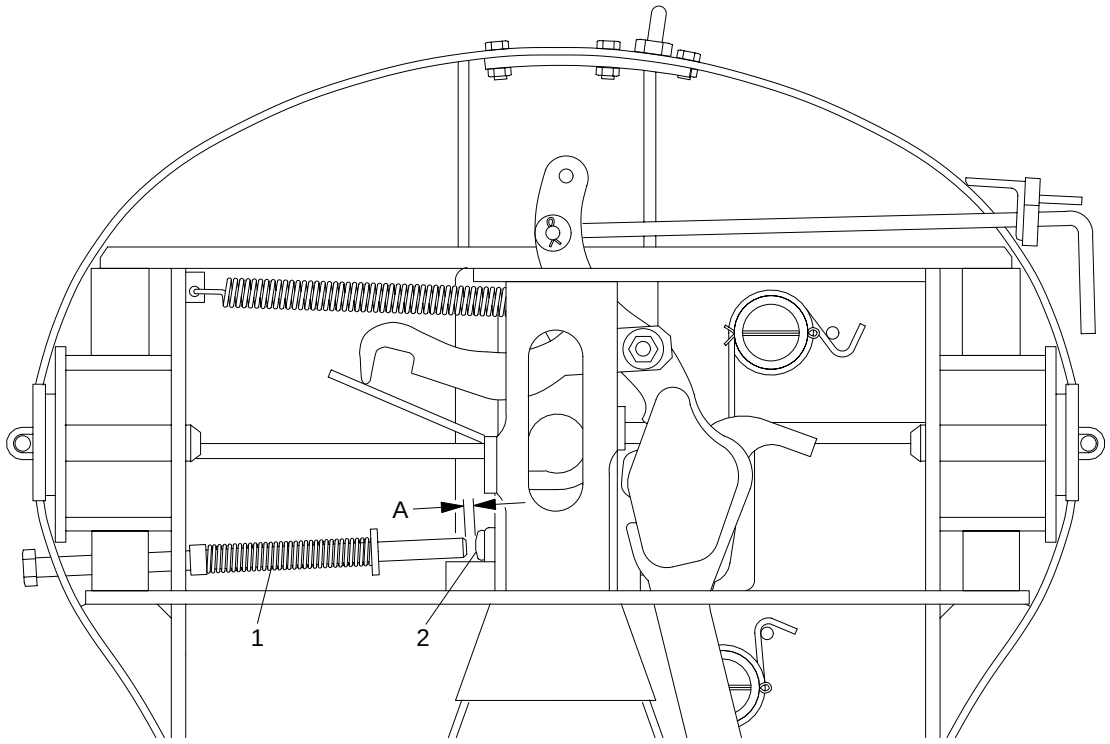
IMPORTANT: The fifth wheel must be well lubricated to operate correctly. Refer to the fifth wheel section in the vehicle maintenance manual, for complete maintenance and lubrication instructions of the fifth wheel assembly.

⚠ WARNING

If the fifth wheel does not operate properly, do not use it. The fifth wheel could malfunction, resulting in personal injury or property damage due to possible disengagement of the trailer from the tractor.

19. Using an overhead hoist, position the fifth wheel on the sliding mount assembly. Insert the bushing pins. Install the retaining pins and the 1-inch long cotter pins.

Assembly and Installation



A. 3/8" (10 mm)
1. Stoprod
2. Wedge

Fig. 7, Correct Measurement

Troubleshooting

Problem—The Fifth Wheel Is Hard to Hook Up to the Trailer

Possible Cause	Remedy
The trailer may be too high; the kingpin is not entering the locks correctly.	Lower the trailer landing gear until the trailer plate contacts the fifth wheel.
Bent kingpin, or damaged trailer plate is interfering with the lock movement.	Check the kingpin and trailer plate. Replace parts as needed.

Problem—The Fifth Wheel Is Hard to Unhook from the Trailer

Possible Cause	Remedy
The tractor is putting pressure against the locks.	Back the tractor into the trailer; set the tractor brakes. Strike the wedge stoprod to release pressure.
Too much slack in the fifth wheel locks.	Check that the wedge stoprod is 3/8 inch (10 mm) from the end of the wedge. Adjust as needed.
	Check the kingpin diameter; it should not be worn more than 3/8 inch (10 mm). Replace if needed.
	Check the jaw and wedge for excessive wear. Replace if needed.

General Description

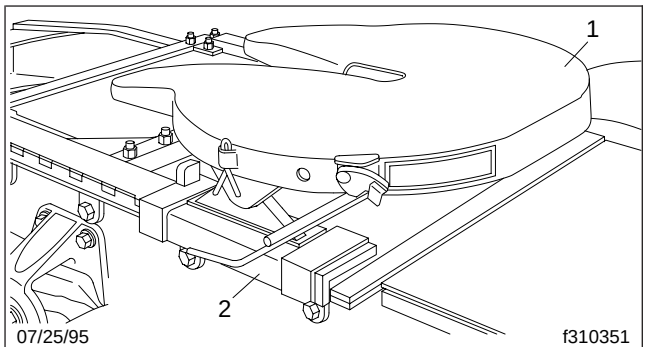
The Fontaine sliding fifth-wheel mount is designed to provide optimum axle loading for maximum tractor use with different lengths and types of trailers. The sliding fifth-wheel mount is used with the Fontaine 5000 series fifth wheel and is equipped with either an air-operated release slider (5AWB model),or a manual release slider (5MWS model).

Sliding fifth wheel assemblies are mounted on slide rails that are attached to the vehicle frame. **See Fig. 1**. Tapered holes are evenly spaced along the slider rails, and retractable tapered wedges are positioned through the holes to hold the fifth wheel in the desired position. This assembly allows forward or rearward movement of the fifth wheel along the slide rails for optimum weight distribution over the tractor axles. The slide rails are bolted to the tractor frame.

Principles of Operation

When the fifth wheel is in the desired position, it is locked in place by tapered wedges that engage in the tapered holes under the sliding mount. To release the fifth wheel, the wedges are withdrawn (manually or air-operated).

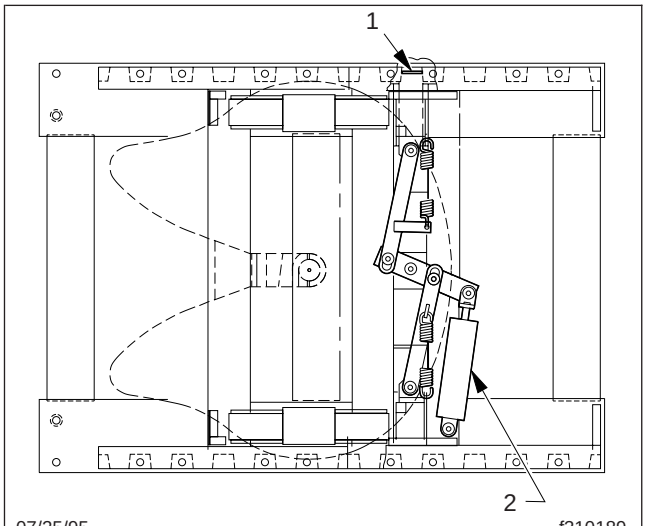
The air-operated release slider contains an air cylinder (**Fig. 2**) which locks and unlocks both sides of the sliding mount at the same time. The air cylinder is activated by a two-position air-control valve in the tractor cab.



1. Fifth-Wheel Mount 2. Sliding Rails

Fig. 1, Sliding Fifth-Wheel Assembly

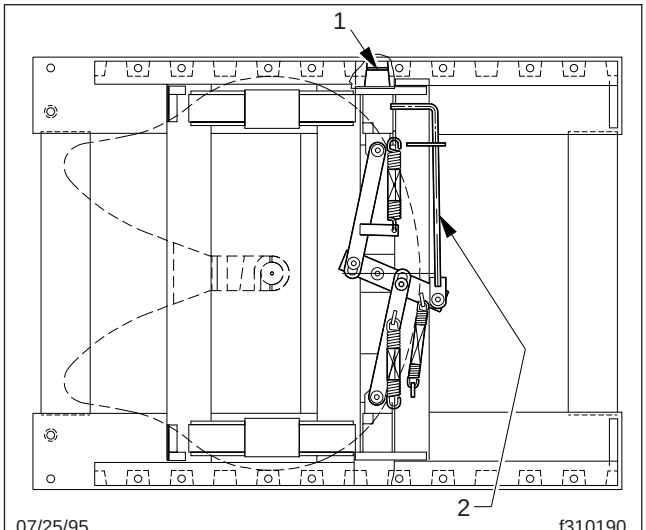
The manual release slider assembly (**Fig. 3**) contains a slider locking control handle, located on the left side (roadside) of the fifth wheel, which locks or unlocks both sides of the sliding mount.



1. Release Slider 2. Air Cylinder

Fig. 2, Air-Operated Sliding Fifth Wheel Mount, 5AWB Model

Refer to the vehicle driver's manual for complete operating instructions.



1. Release Slider 2. Air Cylinder

Fig. 3, Manual Release Sliding Fifth Wheel Mount, 5MWS Model

General Description and Principles of Operation

Disassembly

(See Fig. 1 or Fig. 2)

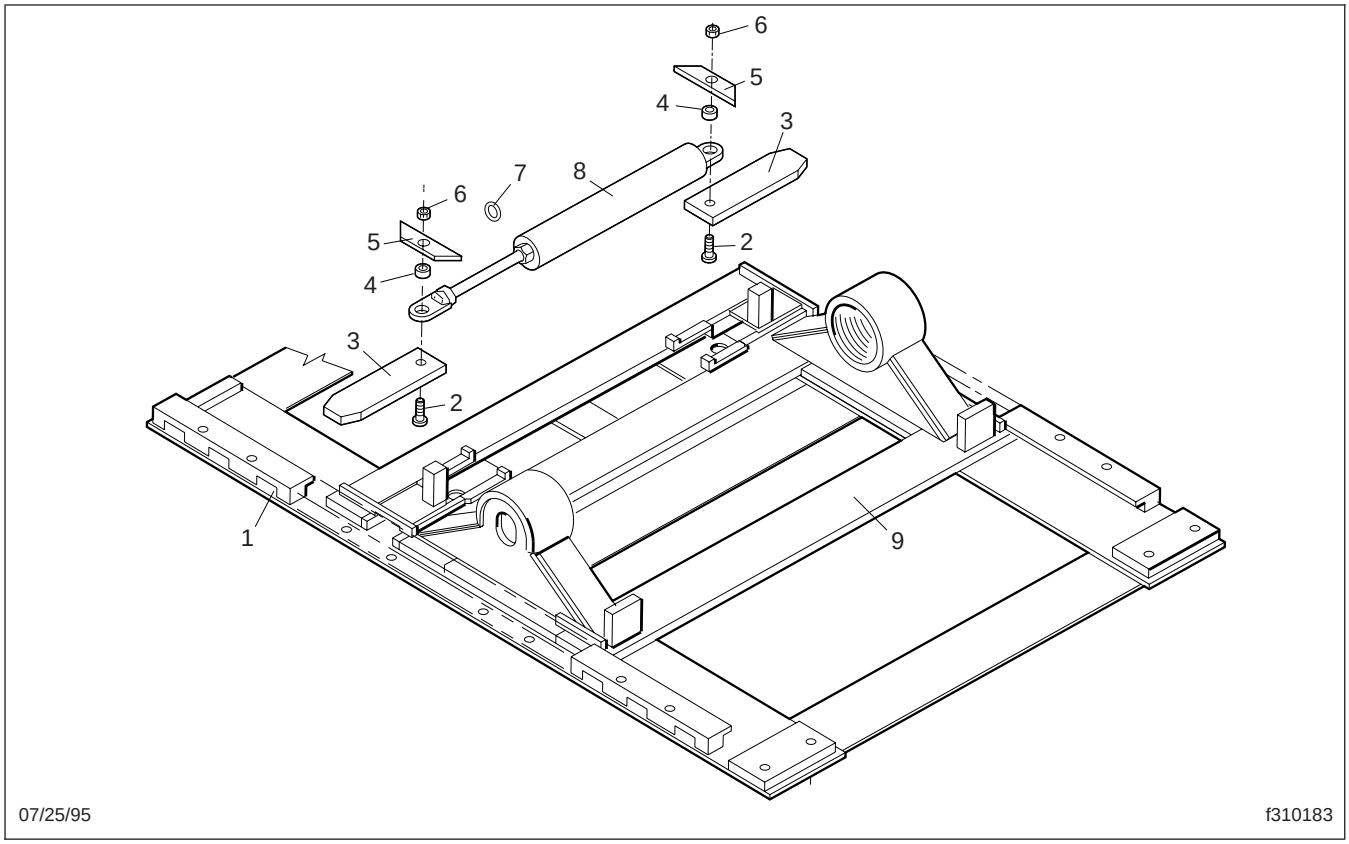


Fig. 1, Fontaine Sliding Fifth Wheel Mount, Model 5AWB (Air-Operated)

WARNING

WARNING: All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in a hazardous operating condition due to a possible disengagement of the trailer from the tractor.

1. Remove the top plate by removing the cotter pins from the retaining pins). Then remove the retaining pins and bushing pins from both sides of the top plate.
2. Using an overhead hoist, lift the fifth wheel off the sliding mount and tractor frame.
3. If equipped with a release air cylinder, remove it as follows (See **Fig. 1**):
   - 3.1 Drain the air from the air reservoirs. Disconnect the air line from the air cylinder (Ref. 8). Remove the O-ring (Ref. 7) if it shows signs of wear. Install plugs in the air line and the air cylinder to prevent dirt or other matter from entering.
   - 3.2 Remove the locknuts (Ref. 6) from the tapered wedges (Ref. 3) and the air cylinder.
   - 3.3 Remove the support bars (Ref. 5), spacer bushings (Ref. 4), and the sockethead capscrews (Ref. 2).

   Remove the air cylinder and the wedges.
4. If equipped with a manual release, do the following (See **Fig. 2**):

Sliding Mount Disassembly and Assembly

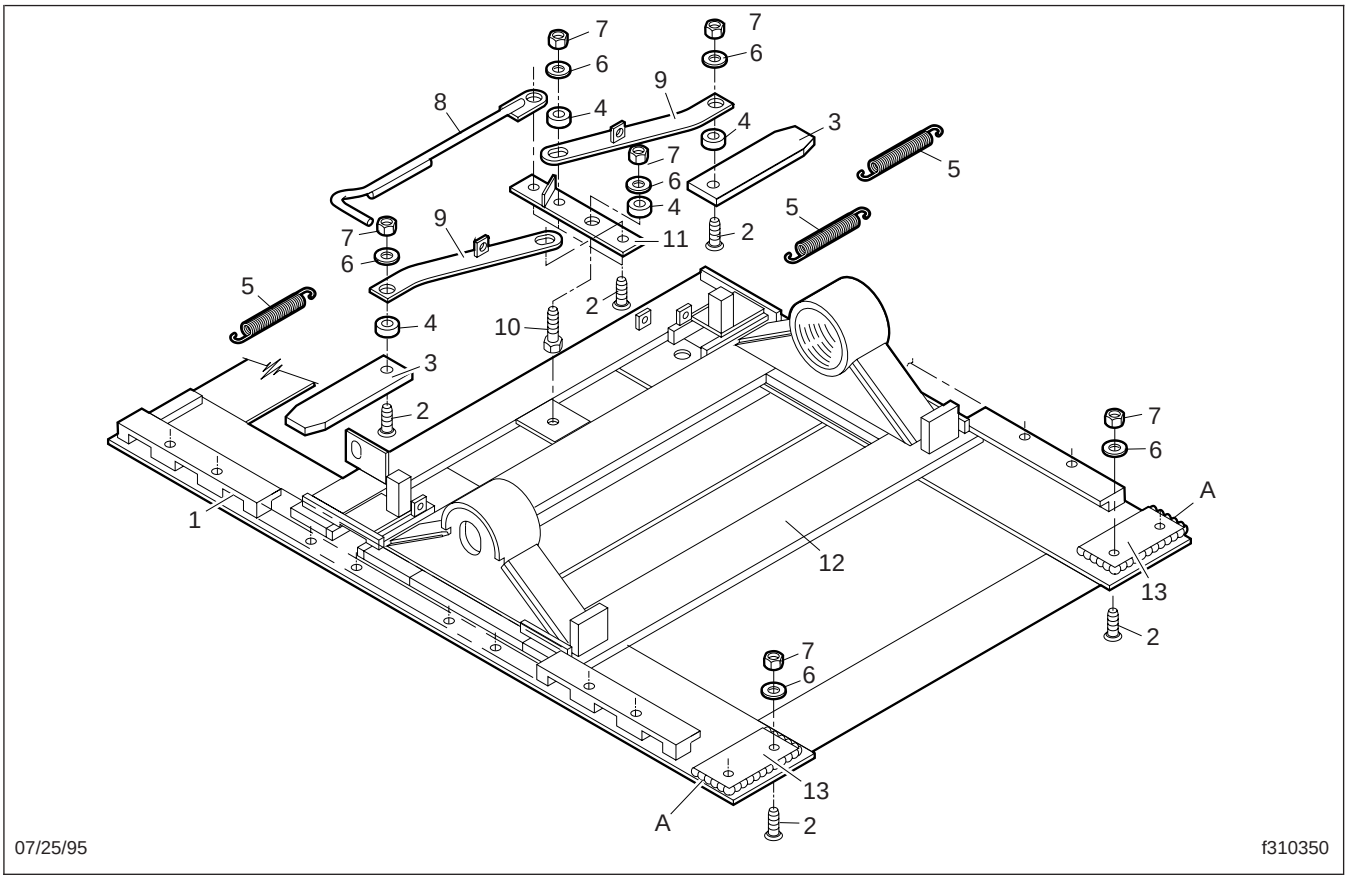


Fig. 2, Fontaine Sliding Fifth Wheel Mount, Model 5MWS (Manual Release)

4.1 Remove the three springs (Ref. 5) from the sliding mount assembly (Ref.12).

4.2 Remove the locknuts (Ref. 7) from the tapered wedges (Ref. 3).

Remove the washers (Ref. 6), spacer bushings (Ref. 4), and sockethead capscrews (Ref. 2).

Remove the wedges.

4.3 Remove the locknuts from the release handle (Ref. 8), and the lock-release bars (Ref. 9).

Remove the spacer bushings (Ref. 4), washers (Ref. 6), and sockethead capscrews (Ref. 2).

Remove the lock-release bars and the release handle from the latching lever.

4.4 Remove the locknut, washer, spacer bushing, and hexhead capscrew (Ref. 10) from the latching lever (Ref. 11).

Remove the latching lever.

5. If the sliding mount assembly is damaged, remove it as follows:

5.1 Remove the nuts, washers, and sockethead capscrews that secure the rear slide stops (Ref. 13) to the rear of the baseplate.

⚠ WARNING

WARNING: Wear protective eye and facial gear when grinding to remove the rear stops. Failure to wear this protective gear can result in personal injury due to flying metal debris from the grinding process.

5.2 Grind down the welded area to remove the rear stops.

5.3 Remove the sliding mount assembly from the baseplate by sliding it off the rear of the tracks.

6. Remove all dirt and grease from the parts. Replace any parts that show signs of wear, damage, or deterioration.

Assembly

(See Fig. 1 or Fig. 2)

WARNING

WARNING: All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in a hazardous operating condition due to a possible disengagement of the trailer from the tractor.

1. Using a multipurpose chassis lube, grease the flanges on the sliding mount. Then, slide the assembly onto the tracks of the baseplate.
2. Slide the mounting assembly to the rearmost position. Position the wedges in the rail.

   Install the sockethead capscrews, washers, and nuts that secure the rear stops to the baseplate.

WARNING

WARNING: Wear a protective welding mask and gloves when welding. Failure to do so could result in personal injury due to the intensity of heat, sparks, and flying debris.

3. Slide the mounting assembly out of the way, then weld the stops in place. The welds should be 1/4-inch (6 mm) fillet.
4. Slide the mounting assembly to the rearmost position and check for clearance. Make sure that the wedges seat in the rail.
5. If equipped with a manual release, do the following:

   5.1 Using a hexhead capscrew, spacer bushing, washer, and locknut, install the latching lever.

   5.2 Using sockethead capscrews, spacer bushings, washers, and locknuts, attach the lock-release bars and release handle to the latching lever.

   5.3 Using sockethead capscrews, spacer bushings, washers, and locknuts, attach the sliding mount wedges to the lock-release bars.

   5.4 Install the three springs on the bracket assembly.

6. If equipped with the release air cylinder, do the following:

   6.1 Position the wedges in the holes on the slide rails. Position the release air cylinder so that the ends line up with the holes in the wedges.

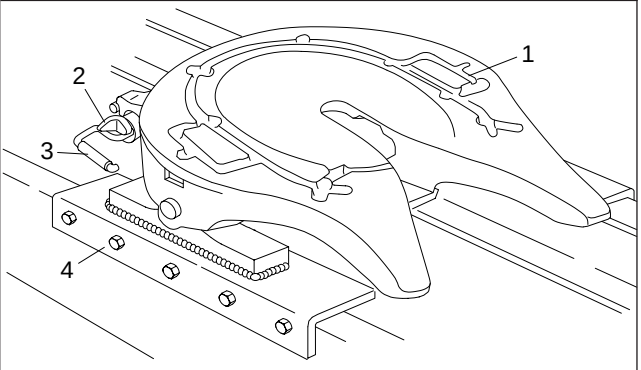
   6.2 Install sockethead capscrews, spacer bushings, support bars, and locknuts.

   6.3 Remove the plugs from the air line and the air cylinder. Install a new O-ring (if needed), then connect the air line to the inlet on the air cylinder.

7. Using an overhead hoist, position the fifth wheel on the sliding mount assembly. Insert the bushing pins. Then install the retaining pins and cotter pins.

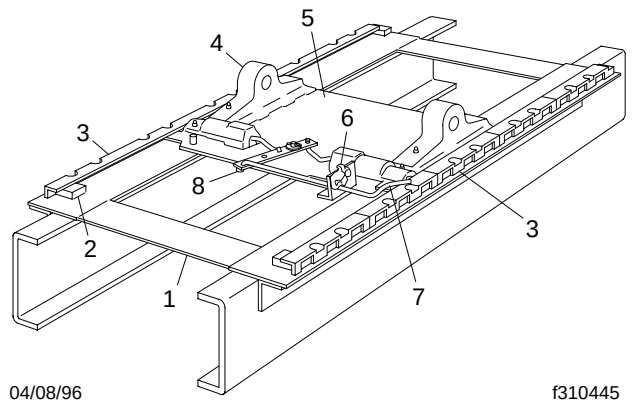
General Information

The ASF Castloc II™ and Simplex series fifth wheels are used for pulling trailers having the standard 2-inch diameter kingpin. When installed as a stationary fifth wheel (**Fig. 1**), they are bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. When used as a sliding fifth wheel (**Fig. 2**), they are mounted on the Taperloc® sliding mount (air-operated or manual release).



1. Lubricant Grooves
2. Safety Latch
3. Lock Control Handle
4. Mount

Fig. 1, Simplex II Stationary Fifth Wheel



1. Baseplate
2. Baseplate Rail
3. Fifth Wheel Bracket
4. Slider Saddle Plate
5. Safety Latch
6. Slider Handle and Rod Assembly

Fig. 2, Taperloc Slider, Manually-Operated Release

The fifth wheel lock mechanism for the trailer kingpin consists of a rotating jaw that grips the trailer kingpin, and a spring-actuated lock. The jaw rotates on a jaw pin during coupling and uncoupling operations. Kingpin release is accomplished by activating a manual lock control handle located on either the right side (curbside) or left side (roadside) of the fifth wheel. Kingpin lockup occurs when the kingpin is forced into the jaw and the operating rod handle moves to the locked position.

On air-operated sliding mounts, release or lockup of the slider saddle plate occurs when the air cylinder is activated by a two-position air-control valve in the tractor cab (**Fig. 3**). The manually-operated slider saddle plate has an operating rod that moves the operating lever to lock or unlock both sides of the saddle plate at the same time.

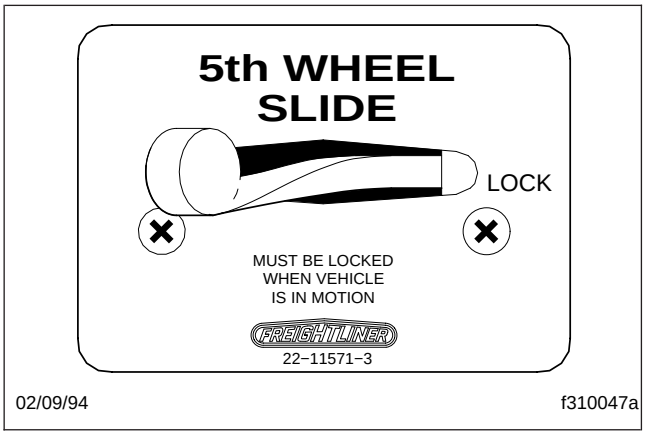


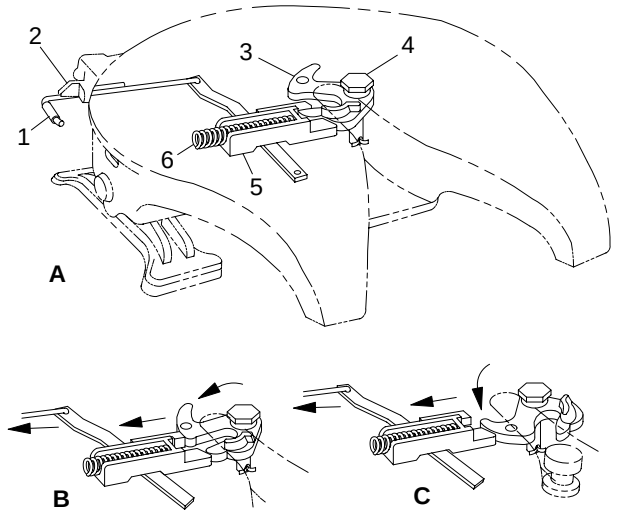
Fig. 3, Air Control Valve

Principles of Operation

When the tractor is moved out from under the trailer after unlocking the fifth wheel, the kingpin rotates the jaw until the jaw is in a position that allows the kingpin to disconnect. During coupling, the motion of the kingpin entering the jaw rotates the jaw into the locked position, locking the jaw around the kingpin. **See Fig. 4** .

Refer to the vehicle driver's manual for complete operating instructions.

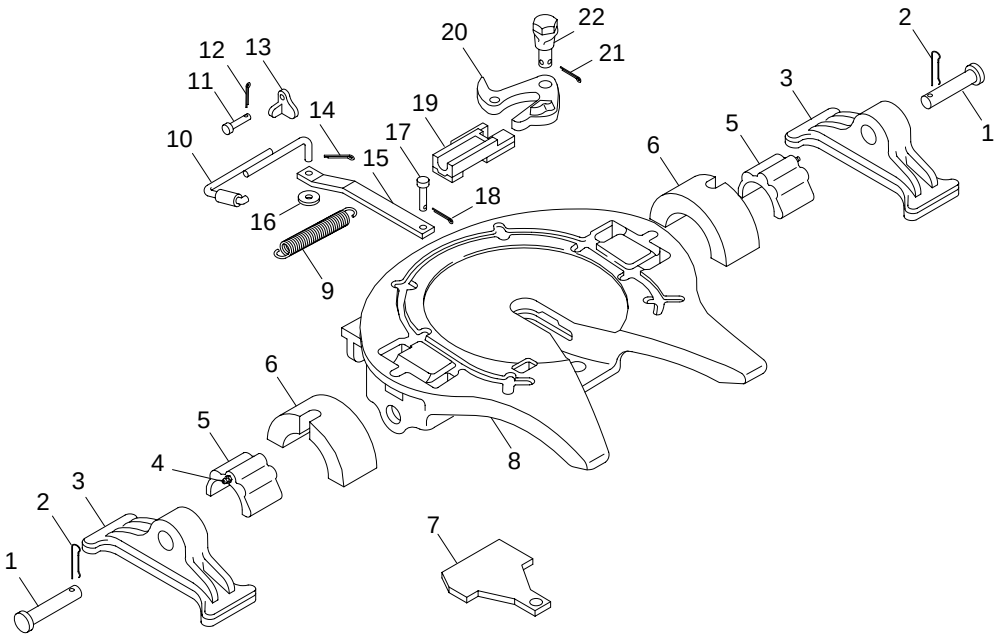
General Information and Principles of Operation



A. Locked Position
B. Jaw Movement Compresses Spring
C. Fully Open
1. Lock Control Handle
2. Safety Latch
3. Jaw
4. Jaw Pin

Fig. 4, ASF Castloc II and Simplex Series Kingpin Locking Mechanism Operation

Disassembly (See Fig. 1)



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1. Bracket pin
2. Clinch Pin
3. Mounting Bracket (for stationary mounts)
4. Grease Fitting
5. Bracket Shoe
6. Bracket Rubber
7. Cover Plate
8. Top Plate
9. Lock Spring
10. Lock Control Handle
11. Latch Pin
12. Cotter Pin
13. Safety Latch
14. Cotter Pin
15. Lever Bar
16. Washer
17. Lever Bar Pin
18. Cotter Pin
19. Lock
20. Jaw
21. Clinch Pin
22. Jaw Pin

Fig. 1, Fifth Wheel Assembly, Simplex II Shown

⚠ WARNING

Fifth wheel maintenance, adjustment, and rebuilding procedures must be done only by a qualified mechanic. Incorrect or incomplete procedures could cause the trailer to disconnect from the tractor, which could result in an accident causing death or serious injury, and property damage.

Wear safety goggles during disassembly and assembly. Parts are under spring compression, and failure to wear goggles can result in personal injury, due to parts ejecting with force.

NOTE: Although some of the parts are shaped differently, disassembly and assembly procedures are the same for ASF Castloc II and Simplex series fifth wheels.

1. Lock the fifth wheel, using a bar.
2. Steam clean the top plate. Remove it from the sliding or stationary mount by removing the clinch pins and the bracket pins. If cotter pins are present instead of clinch pins, discard them. Clinch pins may be reused. If needed, use a clamp, and compress the top plate and brackets to relieve the pressure on the bracket pins.
3. Using an overhead hoist, lift the fifth wheel off the mount and tractor frame.

Fifth Wheel Disassembly and Assembly

4. Turn the fifth wheel upside down.

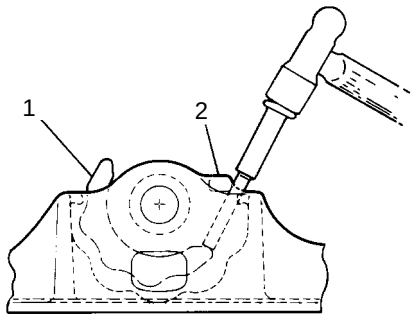
NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

⚠ WARNING

Do not attempt to repair or rebuild the top plate if it is cracked or if parts are damaged. The top plate or parts could malfunction. This could cause the trailer to disconnect from the tractor, which could result in an accident causing death or serious injury, and property damage.

5. Slide the jaw away from the lock, then remove the jaw from the top plate.
6. Remove the cotter pin and the lever bar pin. Discard the cotter pin. Remove the cover plate, lever bar, lock, and lock spring.
7. Remove the cotter pin holding the lock control rod to the lever bar; then remove the lock control rod and the washer. Discard the cotter pin.
8. Check the bracket shoes and bracket rubbers for wear. For instructions, see the *Heavy-Duty Trucks Maintenance Manual*. If needed, remove the bracket rubbers and bracket shoes as follows:

   8.1 Remove the grease fitting and drive out the bracket shoe. See **Fig. 2**.



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1. Bracket Shoe
2. Stop

Fig. 2, Bracket Shoe Removal

   8.2 Remove the bracket rubbers.

9. With the fifth wheel in the locked position, remove the clinch pin and the jaw pin.

Assembly (See Fig. 1)

⚠ WARNING

Fifth wheel maintenance, adjustment, and rebuilding procedures must be done only by a qualified mechanic. Incorrect or incomplete procedures could cause the trailer to disconnect from the tractor, which could result in an accident causing death or serious injury, and property damage.

Wear safety goggles during disassembly and assembly. Parts are under spring compression, and failure to wear goggles can result in personal injury, due to parts ejecting with force.

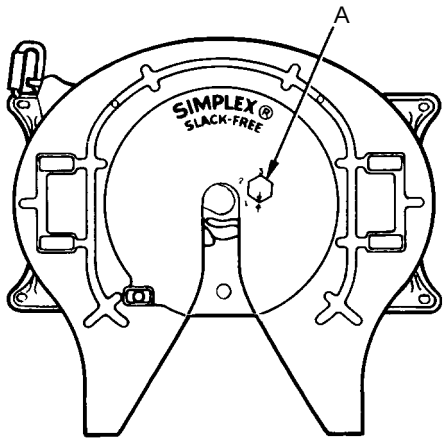
IMPORTANT: Replace any parts that show signs of wear, damage, or deterioration. Brackets, bracket shoes, bracket rubbers, and bracket pins should be replaced in pairs.

1. Clean all moving parts with no. 2 diesel fuel before assembly.
2. Apply liquid soap to the bracket rubbers, then install them, making sure the cutout on them is facing outboard.
3. Grease the bracket shoe surfaces that contact the mounting brackets. Drive the bracket shoes in place against the stop and replace the bracket shoe grease fittings.

IMPORTANT: Do not grease the bracket rubbers or pockets.

4. Apply a thin film of a multipurpose chassis grease to the cover plate, lever bar pin, lever bar, jaw, jaw pin, the lock, and the casting lock area. The casting lock area is underneath the top plate, where the lock sets.
5. Install the lock spring into the lock; then install them as a unit.
6. Install the lever bar, then the lever bar pin.
7. Install the cover plate; then install a new cotter pin in the lever bar pin.
8. Install the lock control handle onto the lever bar, using a new cotter pin and the existing washer.

9. Slide the jaw into the lock and install the jaw pin. Make sure the arrow on the jaw pin lines up with the arrow on the top plate. See **Fig. 3**. Install the clinch pin.



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A. Jaw pin positioned arrow-to-arrow.

Fig. 3, Jaw Pin Location

10. Using an overhead hoist, position the fifth wheel on the sliding or stationary mount brackets. Clamp the fifth wheel in place to compress the bracket rubbers. Insert the bracket pins and clinch pins.

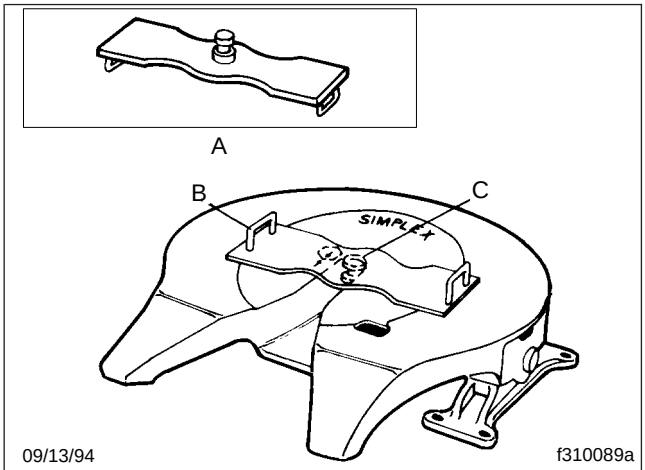
11. Check for clearance between the jaw and kingpin as follows:

    11.1 With the jaw open, insert an ASF gauge part number 40–2–00171 (**Fig. 4**) or a new kingpin into the fifth wheel. Make sure the safety latch swings freely over the lock control handle (**Fig. 5**). This will place the fifth wheel in the coupled and locked position.

    11.2 Measure the distance between the kingpin (or gauge) and the front edge of the top plate slot. If using the gauge, make sure it is flat on the fifth wheel, and pulled as far to the rear as possible.

    11.3 Remove the gauge or kingpin.

    11.4 If the measurement was 1/8 inch (3.2 mm) or less, skip the next two steps and continue this procedure. If the measurement was more than 1/8 inch (3.2 mm), go to the next step.



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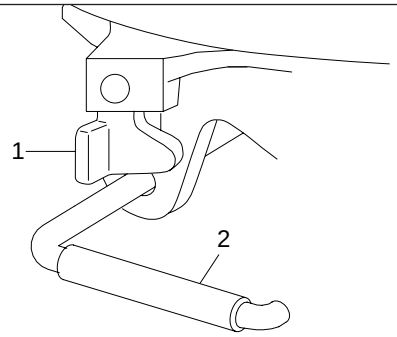
A. Bottom View of Gauge 40–2–00171
B. Gauge Installed
C. Feeler Shim Opening

Fig. 4, Jaw Gauge



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1. Safety Latch
2. Lock Control Handle

Fig. 5, Left-Side View

12. Adjust the clearance between the jaw and kingpin as follows:

    12.1 Using a bar, move the jaw to the locked position. This will relieve the pressure on the jaw pin.

    12.2 Remove the clinch pin from the jaw pin. Lift the jaw pin just enough to clear the indexing head. Turn the jaw pin to the next higher numbered position.

Fifth Wheel Disassembly and Assembly

NOTE: Starting from the original position, with the arrow pointing to the rear, each turn of the jaw pin (**Fig. 6**) to one of the three positions (position numbers are indented on the casting) reduces the distance between the kingpin and jaw. See **Table 1**.

12.3 Repeat the first two substeps in the last step above.

Position	Distance	
	Each Turn	Total
1	1/16" (1.6 mm)	1/16" (1.6 mm)
2	3/32" (2.4 mm)	5/32" (4.0 mm)
3	1/16" (1.6 mm)	7/32" (5.6 mm)

Table 1, Jaw Positions

12.4 If the distance is 1/8 inch (3.2 mm) or less, the clearance between the jaw and kingpin is correct. Go to the next step.

12.5 If the distance is still more than 1/8 inch (3.2 mm), remove the gauge or kingpin.

12.6 Repeat the substeps above.

IMPORTANT: Don't turn the jaw past position 3. If more than 1/8 inch (3.2 mm) clearance remains at position 3, replace the jaw, jaw pin, and lock.

13. After the final adjustment, install the clinch pin in the jaw pin.

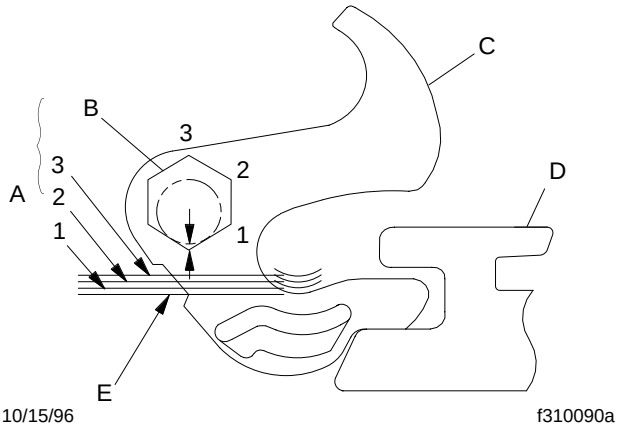
14. Using a multipurpose chassis grease, grease the top plate and the grease fittings.

IMPORTANT: The fifth wheel must be well lubricated to operate correctly. See Group 31 of the *Heavy-Duty Trucks Maintenance Manual* for complete maintenance and lubrication instructions of the fifth wheel assembly.

15. Check the fifth wheel operation. For instructions, see the vehicle driver's manual.

⚠ WARNING

Don't use the fifth wheel if it doesn't work correctly. The fifth wheel could malfunction, causing the trailer to disconnect from the tractor. This could result in an accident causing death or serious injury, and property damage.



A. Jaw Pin Positions
B. Jaw Pin
C. Jaw
D. Lock
E. Original Position

Fig. 6, Jaw Pin Positions

Troubleshooting

Problem—The Fifth Wheel Is Hard to Hook Up to the Trailer

Problem—The Fifth Wheel Is Hard to Hook Up to the Trailer	
Possible Cause	**Remedy**
The trailer may be too high; the kingpin is not entering the jaws correctly	Lower the trailer landing gear until the trailer plate contacts the fifth wheel.
Bent kingpin or damaged trailer plate is interfering with the jaw movement.	Check the kingpin and trailer plate. Replace parts as needed.
The jaw pin has not been adjusted correctly.	Check the clearance between the jaw and kingpin. Adjust as needed.
The lever bar is bent.	Check the lever bar. Replace it if needed.
The lock control handle is bent.	Check the lock control handle. Replace it if needed.
The safety latch is jammed.	Check the lock control handle. Replace it if it is bent.
The cover plate is bent	Check the cover plate. Replace it if needed.
Dirt has accumulated on the moving parts.	Clean all the parts and lubricate them lightly.

Problem—Too Much Slack at the Kingpin

Problem—Too Much Slack at the Kingpin	
Possible Cause	**Remedy**
The jaw pin has not been adjusted correctly.	Check the clearance between the jaw and kingpin. Adjust as needed.
The kingpin is worn.	Check the kingpin diameter; it should not be worn more than 1/8 inch (3.2 mm). Replace if needed.

Problem—The Fifth Wheel Is Hard to Unhook from the Trailer

Problem—The Fifth Wheel Is Hard to Unhook from the Trailer	
Possible Cause	**Remedy**
The operating rod is hard to pull out.	Back the tractor a little to relieve any kingpin load against the fifth wheel jaw.
There is pressure on the jaw from the kingpin.	Back the tractor into the trailer to reduce the pressure.
The jaw is adjusted too tightly.	Back the tractor inot the trailer to relieve the pressure on the jaw. Unlock the fifth wheel. Adjust the jaw as needed.
The lever bar or the lock control handle is bent.	Check both parts. Replace if needed.
The cover plate is bent.	Check the cover plate. Replace it if it is bent.

Aerodynamic Bumper Assembly Removal and Installation

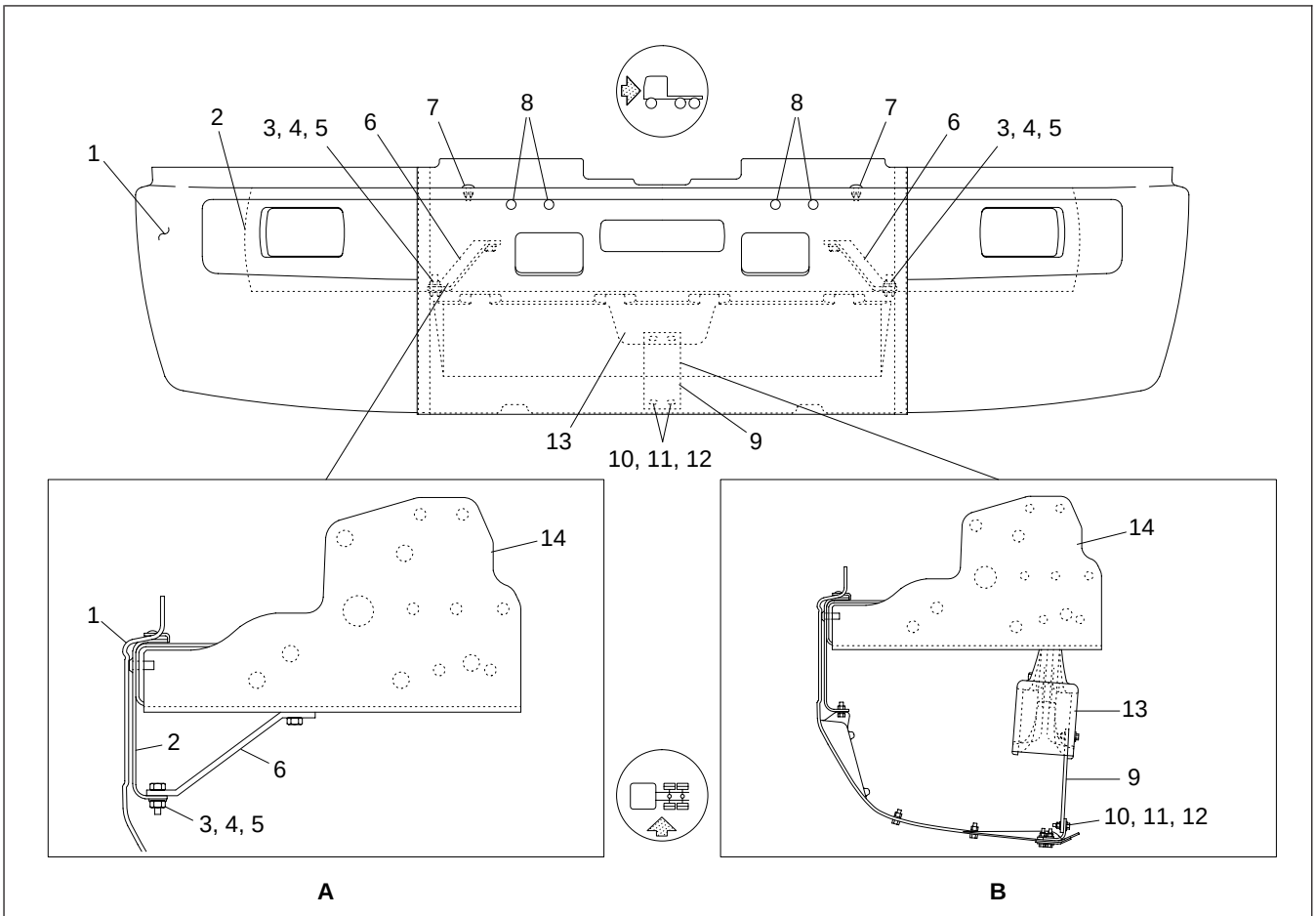
Removal (See Fig. 1)

NOTE: Use these instructions when you need to remove the bumper and air dam as a unit, in order to access the front axle or the engine crossmember. To remove only the bumper air dam (or sections of it), refer elsewhere in this group.

1. *For COEs,* remove the four Phillips-head screws holding the lower grille in place, then remove the lower grille.

   Tilt the cab, following the instructions in the vehicle driver's manual.

   For Conventionals, tilt the hood, following the instructions in the vehicle driver's manual.



A. Side View, Left and Right of Center

B. Side View, Center

1. Air Dam Assembly
2. Bumper
3. 1/2–13 Hexnut (2 qty.)
4. 1/2–13 Hexbolt (2 qty.)
5. 1/2-inch Washer
6. Bumper Strut Support
7. Phillips-Head Screw (2 qty.)
8. 1/2–13 Allen- or Torx®-Head Screw (4 qty.)
9. Air Dam Hanger
10. 5/16–18 Hexbolt (2 qty.)
11. 5/16-inch Flatwasher (2 qty.)
12. 5/16–18 Locknut (2 qty.)
13. Engine Crossmember
14. Frame Rail Extension

Fig. 1, Aerodynamic Bumper Installation

Aerodynamic Bumper Assembly Removal and Installation

2. Underneath the cab, remove the two lower fasteners holding the air dam hanger (Ref. 9) to the air dam (Ref. 1).
3. Disconnect the wires from the fog/road lights.
4. Remove the fasteners from the bumper side of each strut support (Ref. 6) attaching the bumper to the frame rail extension (Ref. 14).
5. Lower the cab or hood.
6. At the front of the cab, remove the two Phillips-head screws (Ref. 7) that attach the upper part of the air dam to the upper flange of the bumper.
7. Pry out the air dam to access the four Allen- or Torx®-head screws (Ref. 8) that hold the bumper to the front crossmember.
8. While supporting the bumper and air dam assembly, remove the four screws; then remove the assembly.

Installation (See Fig. 1)

1. Position the bumper and air dam assembly so that the four holes in the bumper line up with the those of the front crossmember, then install the four Allen- or Torx-head screws (Ref. 8). Tighten them 100 lbf·ft (135 N·m).
2. Install the two Phillips-head screws (Ref. 7) that fasten the upper part of the air dam to the upper flange of the bumper. Tighten them firmly.
3. Tilt the cab or hood, as applicable, following the instructions in the vehicle driver's manual.
4. Install the lower center of the air dam to the air dam hanger (Ref. 9). Tighten the fasteners 15 lbf·ft (20 N·m).
5. Install the ends of the air dam onto the strut supports (Ref. 6). Tighten the fasteners 64 lbf·ft (87 N·m).
6. Lower the cab or hood, as applicable, following the instructions in the vehicle driver's manual.
7. On COEs, install the lower grille. Tighten the fasteners firmly.

Non-Aerodynamic Bumper Removal and Installation

Removal

NOTE: Refer to **Table 1** for the applicable figure.

Vehicle Model	Figure Reference
COE with 8.5-inch or 16-inch Bumper	**Fig. 1**
FLD Conventional, Axle Forward	**Fig. 2**
FLD Conventional; Setback Axle, with Tow Eyes	**Fig. 3**
FLD Conventional, Extended Straight Rail, Setback Axle	**Fig. 4**
FLD 120 Conventional; Severe Duty, Setback Axle	**Fig. 5**
FLD 112 Conventional; Setback Axle	**Fig. 6**

Table 1

1. Remove the fasteners attaching the bumper to the front crossmember and, if present, the bumper brackets.
2. Remove the bumper.

Installation

1. Position the bumper so the holes in the bumper align with those in the front crossmember.

⚠ CAUTION

Don't use standard torque values when tightening the fasteners on 8-1/2-inch and 16-inch bumpers for FLA and FLB COEs. To do so may damage the spacers. Tighten the fasteners 35 lbf·ft (47 N·m). See Fig. 1.

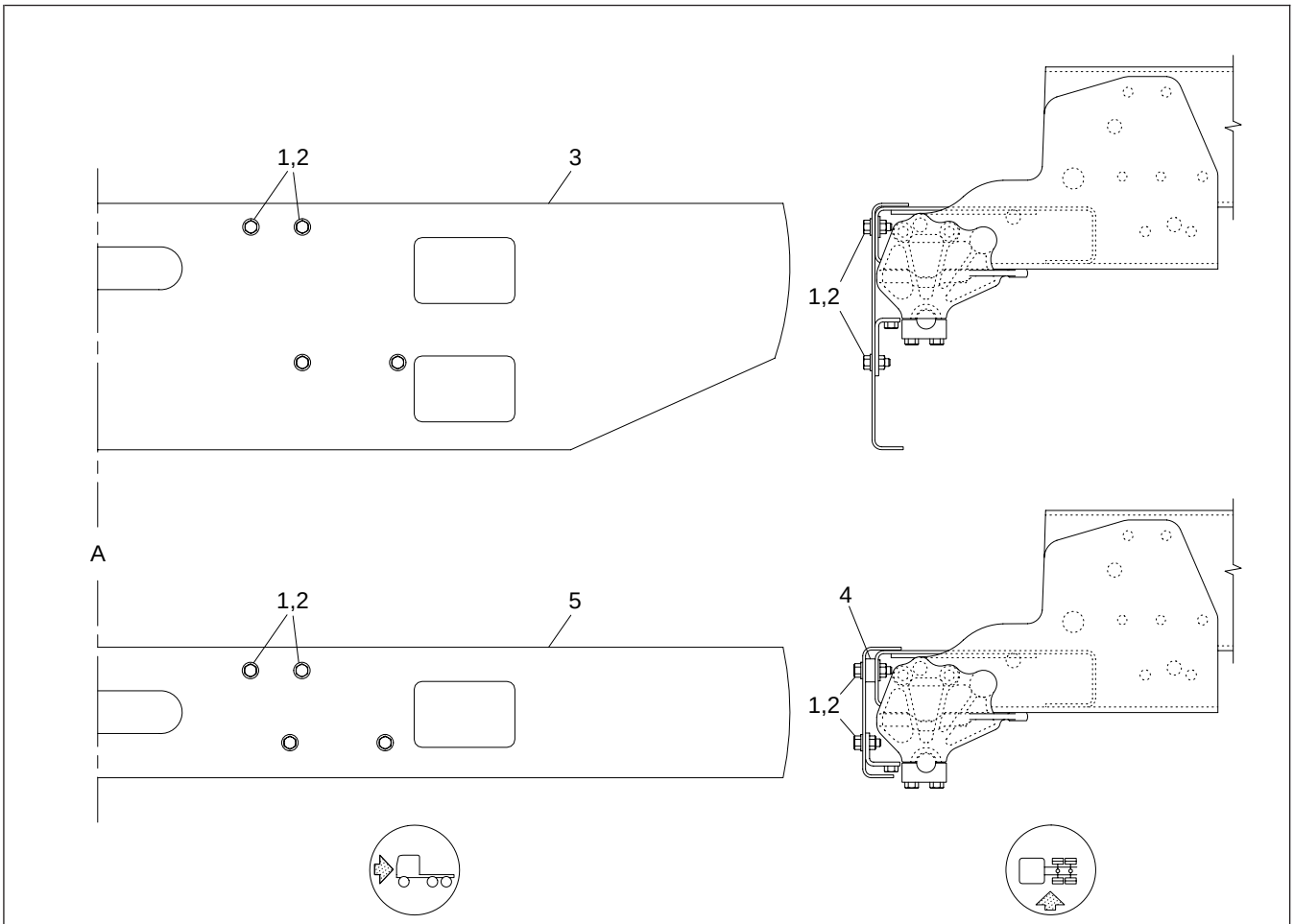
2. Refer to the applicable figure. Install the fasteners that attach the bumper to the front crossmember. Don't tighten them completely.
3. If applicable, attach the bumper to the bumper brackets.
4. With the bumper correctly aligned, tighten all the fasteners to the torque values in **Table 2**.

Fastener Size	Grade	Torque lbf·ft (N·m)
1/2–13 *	5	64 (87)
5/8–11	5	128 (173)
5/8–11	8	180 (244)

* See the "Caution" for torque values for COEs equipped with 8.5-inch or 16-inch bumpers.

Table 2

Non-Aerodynamic Bumper Removal and Installation



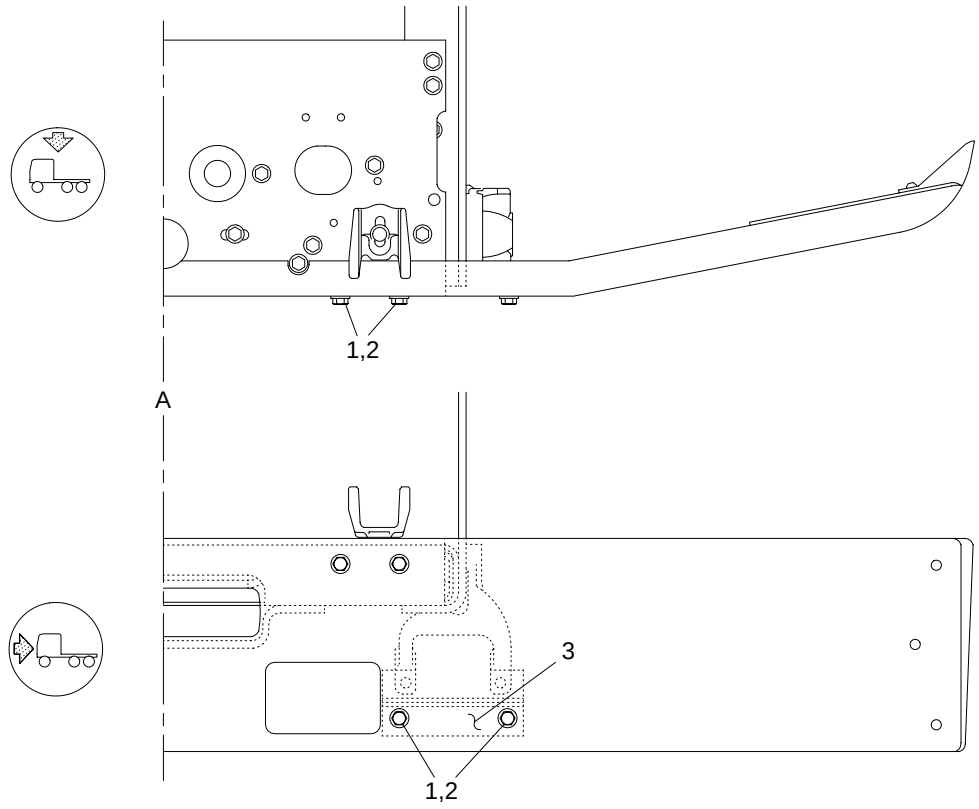
IMPORTANT: Tighten hexbolts 35 lbf·ft (47 N·m).

A. Centerline

1. 1/2–13 Hexbolt (8 qty.)
2. 1/2-Inch Washer (8 qty.)
3. 16-Inch Bumper
4. Spacer (2 qty.)
5. 8.5-Inch Bumper

Fig. 1, COE 8.5-Inch and 16-Inch Bumper Installations

Non-Aerodynamic Bumper Removal and Installation



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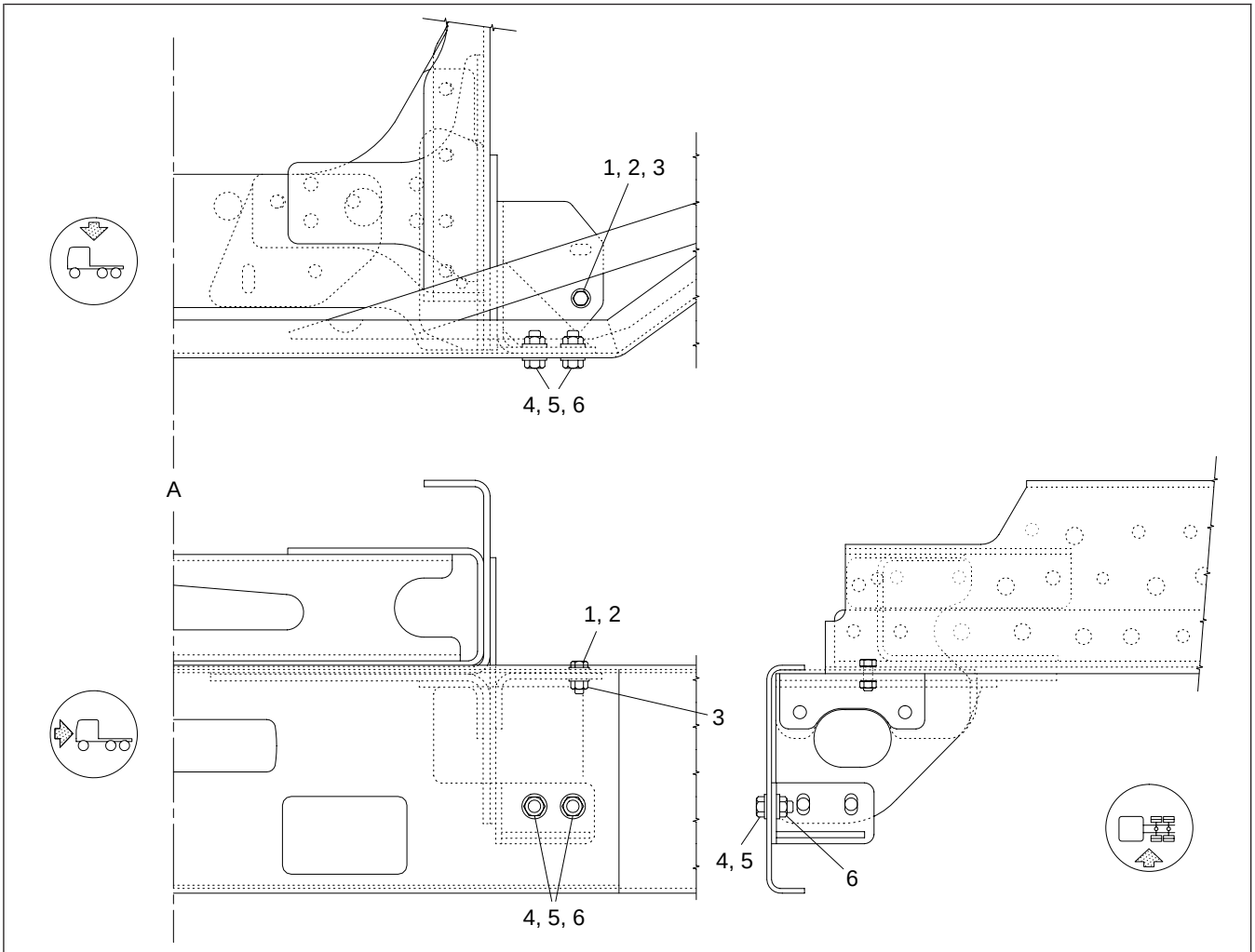
NOTE: Driver's side shown; bumper is symmetrical

A. Centerline

1. 1/2–13 Hexbolts, Grade 5 (8 qty.)
2. 1/2-Inch Washers
3. Bumper Bracket

Fig. 2, FLD Conventional, Axle Forward

Non-Aerodynamic Bumper Removal and Installation



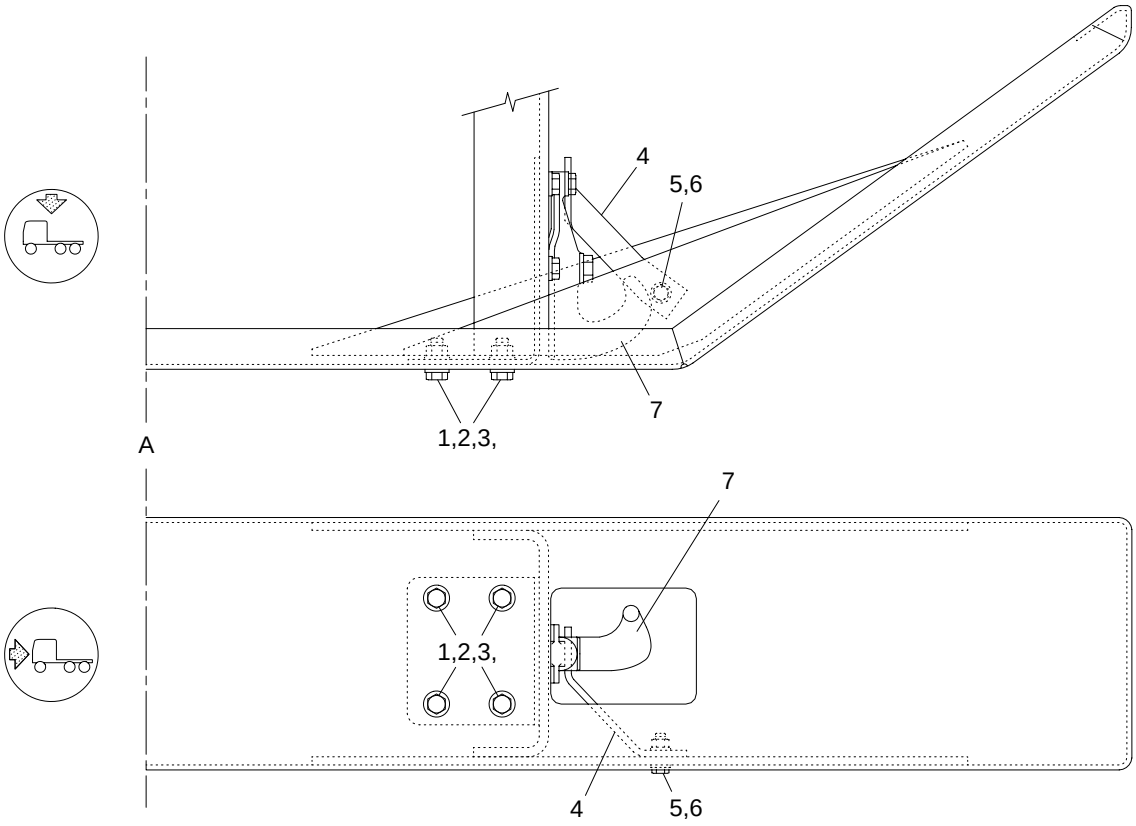
NOTE: Driver's side shown; bumper is symmetrical.

A. Centerline

1. 1/2–13 Hexbolt, Grade 5 (2 qty.)
2. 1/2-Inch Washer (2 qty.)
3. 1/2–13 Hexnut, Grade 5 (2 qty.)
4. 5/8–11 Hexbolt, Grade 5 (4 qty.)
5. 5/8-Inch Washer (4 qty.)
6. 5/8–11 Hexnut, Grade 5 (4 qty.)

Fig. 3, FLD Conventional, Setback Axle; with Tow Eyes

Non-Aerodynamic Bumper Removal and Installation



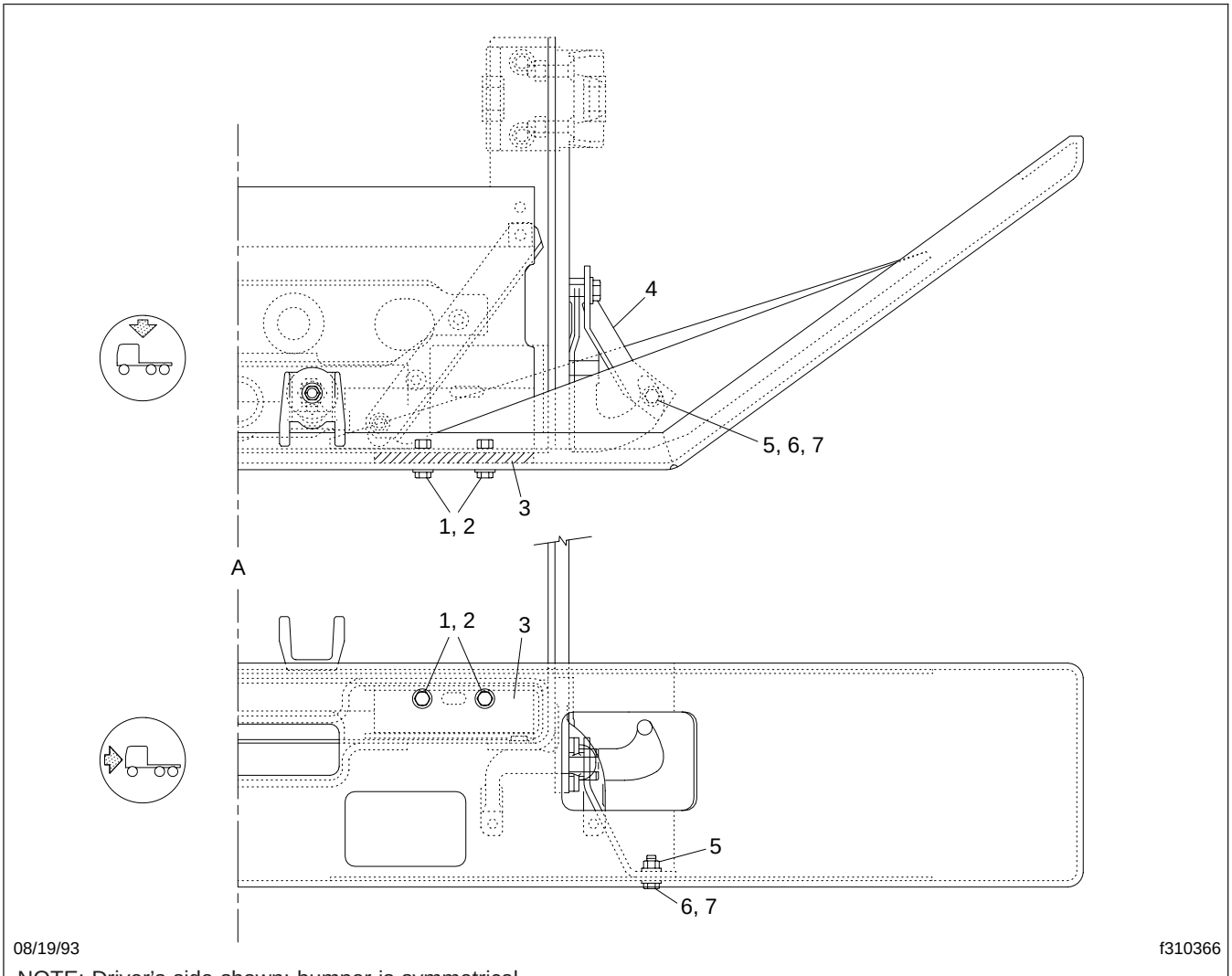
NOTE: Driver's side shown; bumper is symmetrical.

A. Centerline

1. 5/8–11 Hexbolt, Grade 5 (8 qty.)
2. 5/8-Inch Washer (8 qty.)
3. 5/8–11 Hexnut, Grade 5 (8 qty.)
4. Bumper Bracket (2 qty.)
5. 1/2–13 Hexnut, Grade 5 (2 qty.)
6. 1/2–13 Hexbolt, Grade 5 (2 qty.)
7. Tow Hook

Fig. 4, FLD Conventional, Extended Straight Rail; Setback Axle

Non-Aerodynamic Bumper Removal and Installation



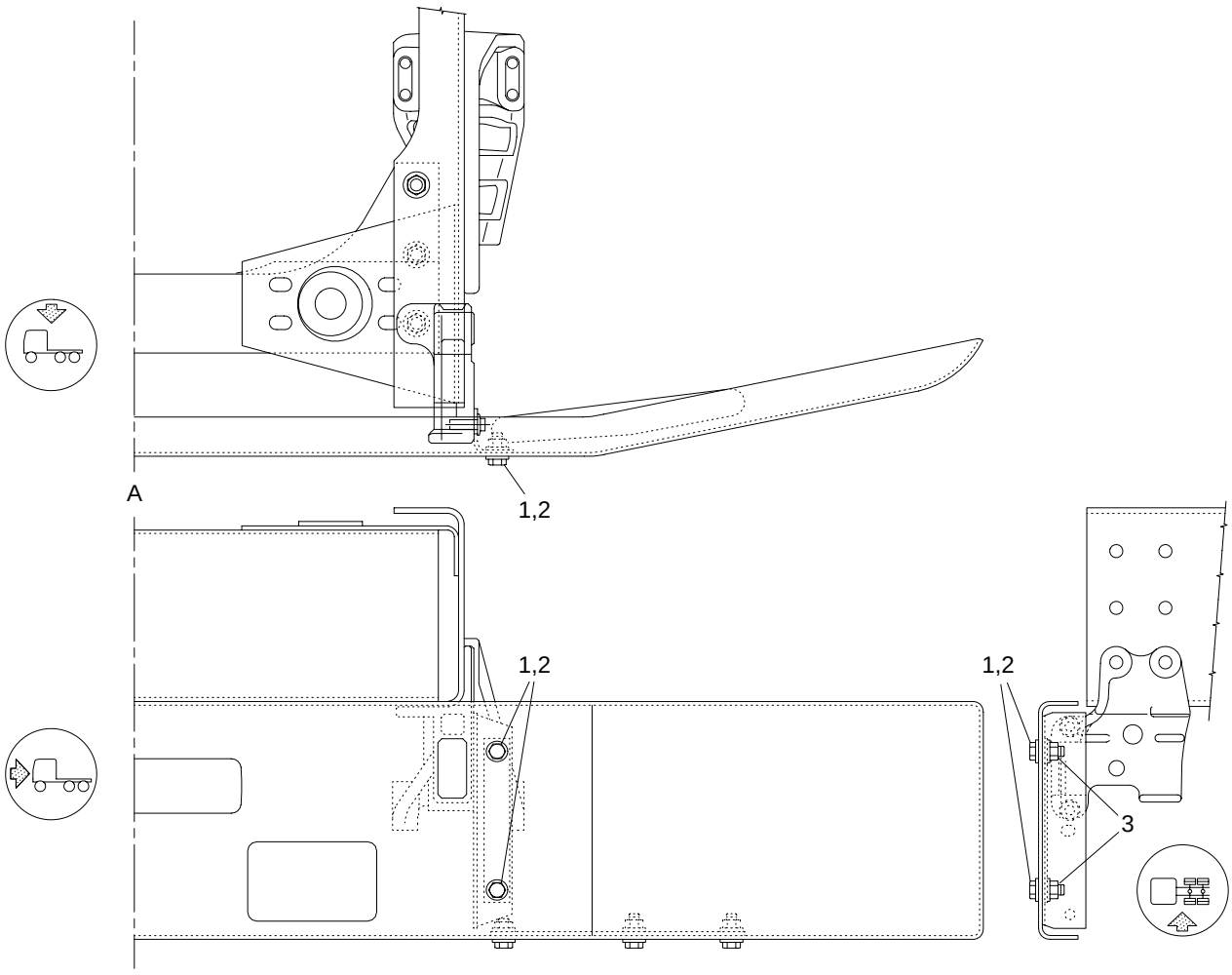
NOTE: Driver's side shown; bumper is symmetrical.

A. Centerline

1. 1/2–13 Hexbolt, 2" Long; Grade 5 (4 qty.)
2. 1/2-Inch Washer (4 qty.)
3. Spacer (2 qty.)
4. Bumper Bracket
5. 1/2–13 Hexnut, Grade 5 (2 qty.)
6. 1/2–13 Hexbolt, 1-1/2 " Long; Grade 5 (2 qty.)
7. 1/2-Inch Washer (2 qty.)

Fig. 5, FLD 120 Conventional, Severe Duty; Setback Axle

Non-Aerodynamic Bumper Removal and Installation



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NOTE: Driver's side shown; bumper is symmetrical.

A. Centerline

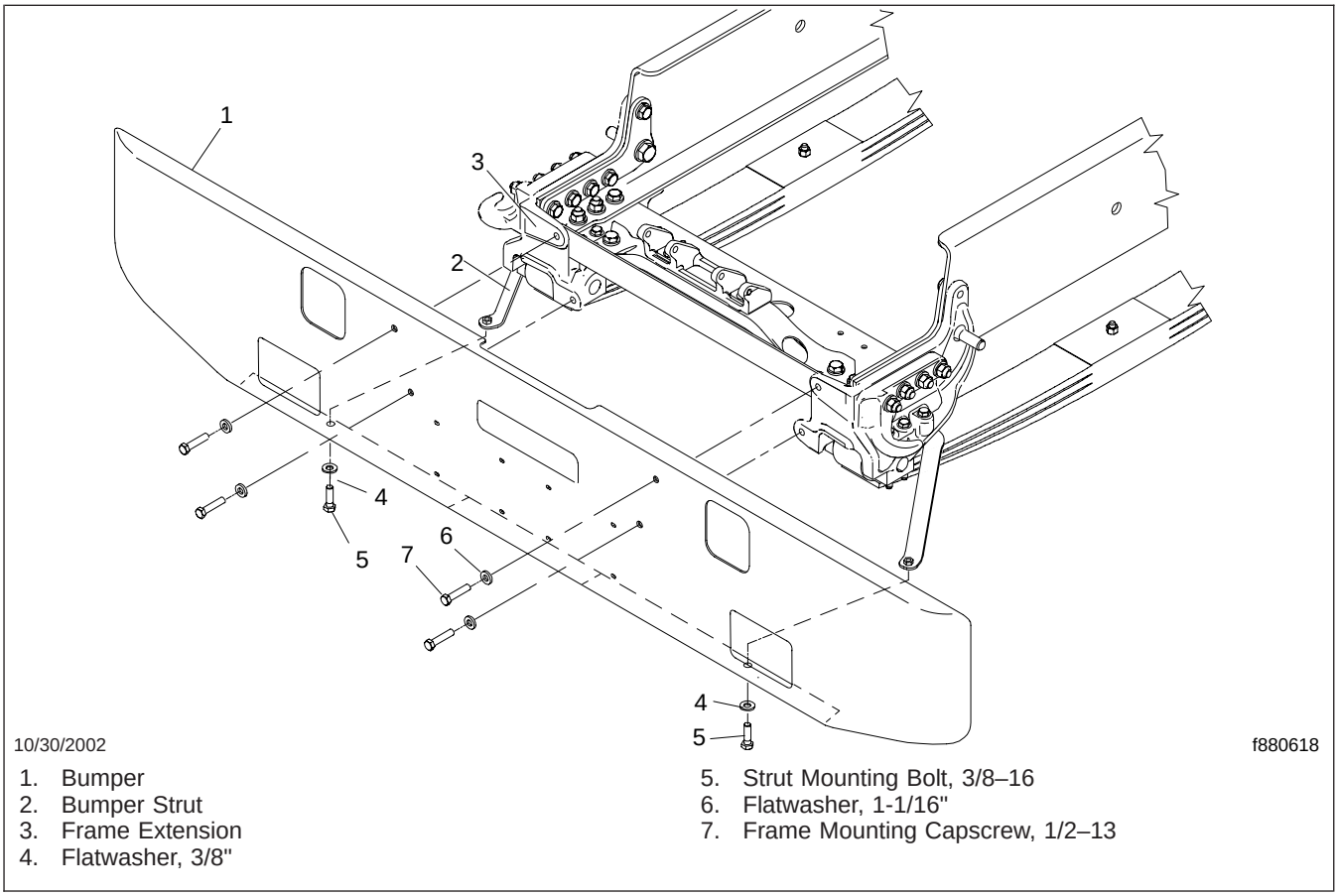
1. 1/2–13 Hexbolt, Grade 5 (4 qty.)
2. 1/2-Inch Washer (4 qty.)
3. Weldnuts (4 qty.)

Fig. 6, FLD 112 Conventional, Setback Axle

Non-Aerodynamic Bumper Removal and Installation, FLD Classic and Classic XL

Removal

1. Park the vehicle, apply the parking brakes and chock the front tires.
2. Remove the fasteners (strut mounting bolt and 3/8-inch flatwasher) attaching the bumper to the lower end of each bumper strut. See **Fig. 1**.
3. Remove the fasteners (frame mounting capscrew and 1-1/16 inch flatwasher) attaching the bumper to the frame extension.
4. Remove the bumper from the vehicle.



1. Bumper
2. Bumper Strut
3. Frame Extension
4. Flatwasher, 3/8"
5. Strut Mounting Bolt, 3/8–16
6. Flatwasher, 1-1/16"
7. Frame Mounting Capscrew, 1/2–13

Fig. 1, FLD Classic and Classic XL Bumper

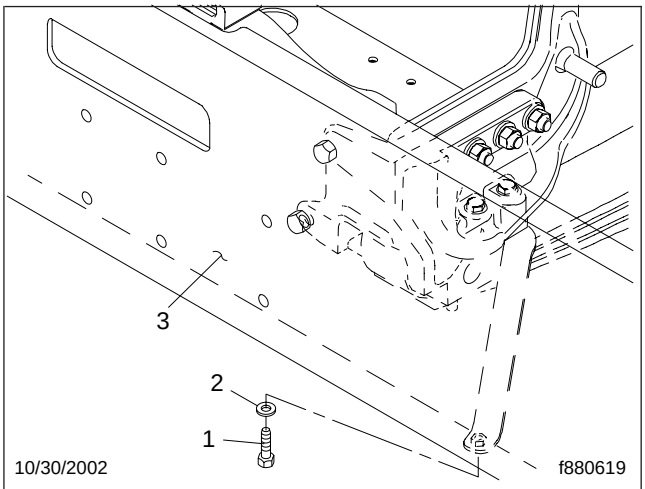
Installation

1. Position the bumper on the frame extension so that the holes in the bumper line up with those in the struts.
2. Install the fasteners attaching the two bumper struts to the lower edge of the bumper. See **Fig. 2**. Don't tighten the strut mounting bolts completely.

NOTE: Installing the strut fasteners first allows the bumper to set up better and makes the alignment of the frame mounting capscrews easier.

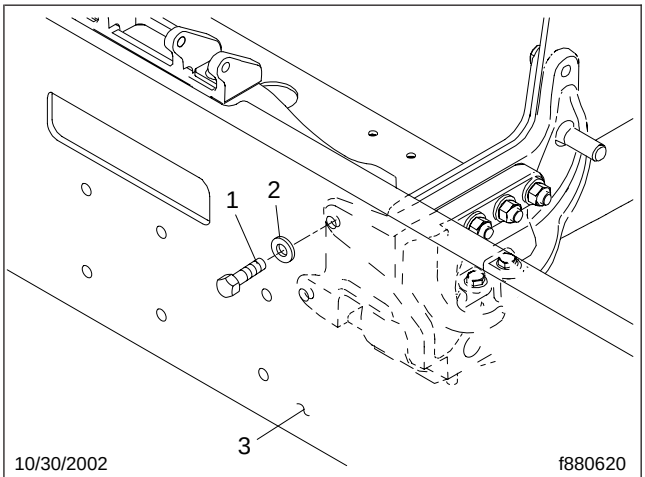
3. Using a frame mounting capscrew as a guide, align the mounting fastener holes in the bumper with those in the frame extension. See **Fig. 3**.
4. Install the fasteners that attach the bumper to the frame extension. Don't tighten the frame mounting capscrews completely.

Non-Aerodynamic Bumper Removal and Installation, FLD Classic and Classic XL



1. Strut Mounting Bolt
2. Flatwasher, 3/8"
3. Bumper

Fig. 2, Installing the Strut Mounting Bolts



1. Frame Mounting Capscrew
2. Flatwasher, 1-1/16"
3. Bumper

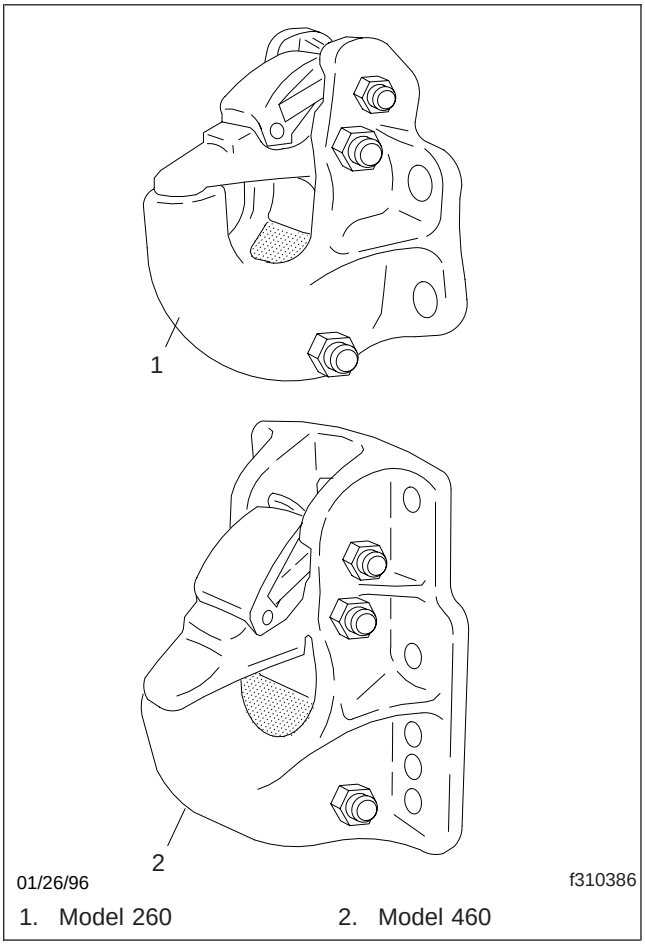
Fig. 3, Installing the Frame Mounting Capscrews

5. With the bumper correctly aligned, tighten the 1/2–13 frame mounting capscrews 64 lbf·ft (87 N·m) and the 3/8–16 strut mounting bolts 26 lbf·ft (36 N·m).
6. Remove the chocks from the front tires.

General Information

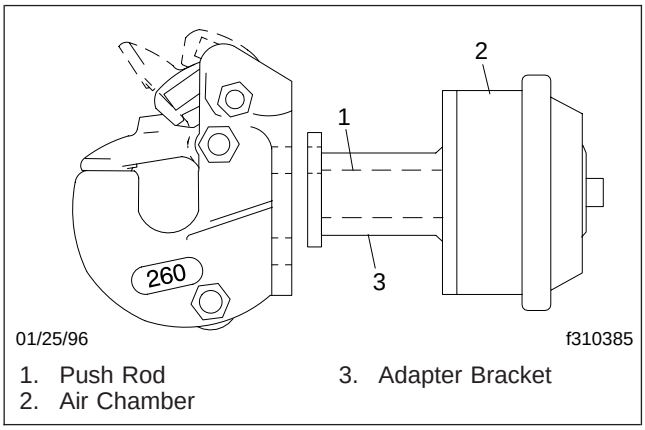
The Premier models 260 and 460 trailer couplings (**Fig. 1**) are air adjusted. When they are in use, an air chamber and push rod at the rear of the coupling (**see Fig. 2**) reduce any slack between the coupling and the drawbar eye of the trailer. This provides smoother towing and reduces wear on the parts.

The design of the 260 and 460 models is the same; the 460 is a heavy-duty version of the 260.



1. Model 260
2. Model 460

Fig. 1

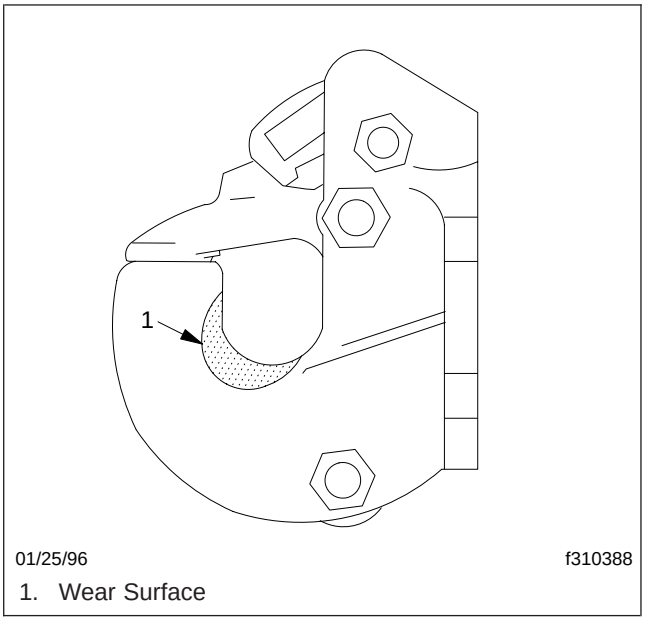


1. Push Rod
2. Air Chamber
3. Adapter Bracket

Fig. 2

Check the pintle hook for damage or stress cracks, then check it for wear on its lower inside surface. **See Fig. 1**. Use Premier wear gauge 14011 (**see Fig. 2**) to check the percentage of wear on the pintle hook.

If the pintle hook is damaged, or if it's worn beyond 20% of its original diameter, replace the entire coupling; it is not repairable.



1. Wear Surface

Fig. 1

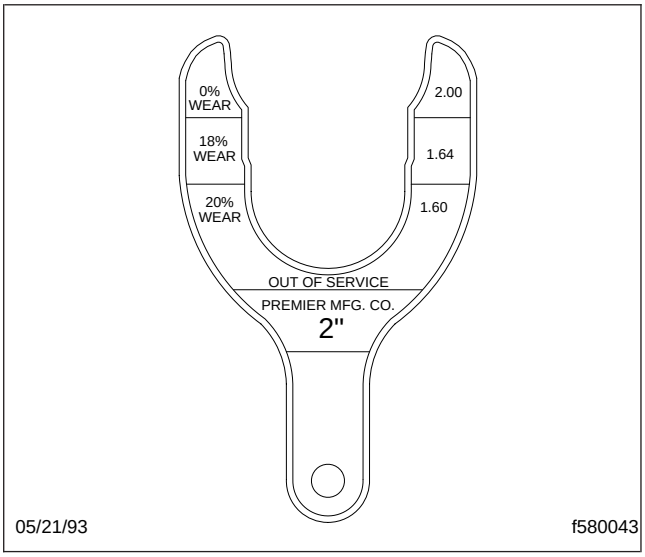


Fig. 2

Check the pintle hook for wear on its lower inside surface. See **Subject 100** for wear checking instructions.

Disassembly

CAUTION

CAUTION: If the pintle hook is damaged, has stress cracks, or if it's worn beyond 20% of its original diameter, replace the entire coupling; don't repair it.

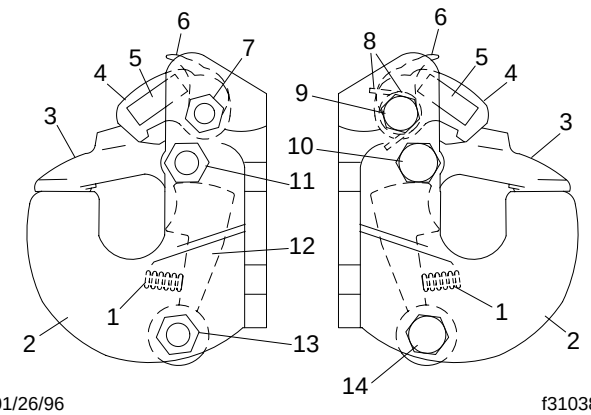
WARNING

WARNING: When disassembling the trailer coupling, wear safety glasses. Some of the parts are under tension (such as springs), and could fly out, possibly causing eye injury.

1. Remove the coupling from the vehicle; then put it on its side, with the pawl-, latch-, and shoe-bolt nuts facing up.
2. Remove the pawl-bolt nut and pawl bolt (**see Fig. 1**, Refs. 7 and 9, and **Fig. 2**, Refs. 12 and 4); then remove the pawl assembly from the coupling body.
3. Disassemble the pawl. **See Fig. 3**.
   - 3.1 Remove the pawl lock and spring (Refs. 2 and 1).
   - 3.2 Remove the two nylon bushings (Ref. 6), then the pawl wedges and compression spring (Refs. 4 and 5).
4. Remove the latch nut and bolt (**Fig. 1,** Refs. 11 and 10); then remove the latch (Ref. 3).
5. Remove the shoe nut and bolt (Refs. 13 and 14).
6. From the bottom of the coupling body, compress the shoe spring (Ref. 1), then remove the shoe (Ref. 12) from the coupling body.

Assembly

1. Check for wear on all the parts that aren't included in the new parts kit. Replace them if needed.

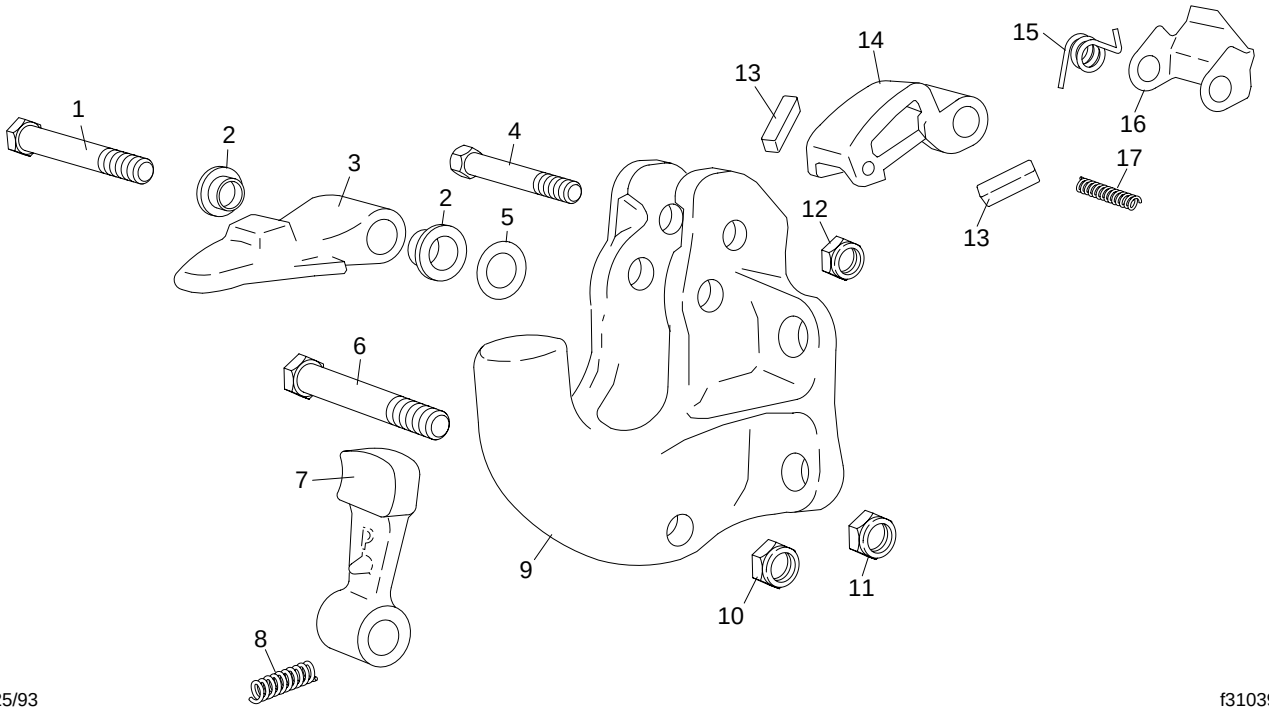


1. Shoe Spring
2. Pintle Hook/Coupling Body
3. Latch
4. Pawl
5. Pawl Wedge
6. Pawl Lock
7. Pawl-Bolt Nut
8. Pawl Spring
9. Pawl Bolt
10. Latch Bolt
11. Latch-Bolt Nut
12. Shoe
13. Shoe Nut
14. Shoe Bolt

Fig. 1, Model 260 Shown

2. Put the coupling body on the workbench with the mounting surface down, and the bottom of the body facing you.
3. Install the shoe, then the shoe bolt and nut (**Fig. 1**, Refs. 12, 14, and 13) in the bottom of the coupling body.
4. Install the shoe spring (Ref. 1) in the recess inside the coupling body.
5. Install the pawl bolt (Ref. 9) part way into the left side of the coupling body; then put the pawl spring over the end of the bolt. Make sure the tang on the spring is pointing inboard.
6. Install the pawl lock (**Fig. 2**, Ref. 16) in the body so the spring tang hooks onto the lip of the pawl lock. **See Fig. 3**.
7. Install new nylon bushings in the pawl, then install the compression spring and wedges in the pawl.
8. While compressing the pawl wedges, install the pawl assembly in the pawl lock and the coupling body, aligning the holes of the pawl and pawl lock with the pawl bolt.

Disassembly and Assembly



1. Pawl Bolt
2. Nylon Bushing
3. Latch
4. Pawl Bolt
5. Spacer
6. Shoe Bolt
7. Shoe
8. Shoe Spring
9. Pintle Hook/Coupling Body
10. Shoe-Bolt Nut
11. Latch-Bolt Nut
12. Pawl Bolt Nut
13. Pawl Wedge
14. Pawl
15. Pawl Spring
16. Pawl Lock
17. Compression Spring

Fig. 2

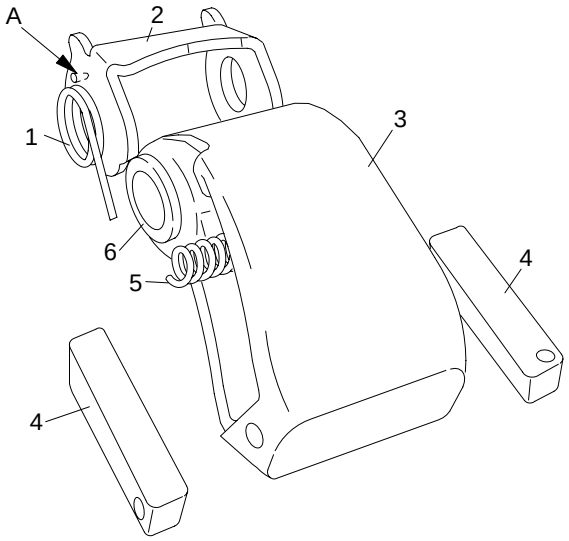
9. Push the pawl bolt through the holes of the pawl lock and the pawl just far enough to hold them in place, then install the spacer (**Fig. 2**, Ref. 5) onto the end of the pawl bolt.
10. Push the pawl bolt all the way through the right side of the coupling body.
11. Raise the pawl assembly (push it away from you), then slide the latch (**Fig. 1**, Ref. 3) into the body, below the pawl assembly.

    Install the latch bolt.

⚠ CAUTION

CAUTION: Don't overtighten the pawl-, latch-, and shoe-bolt nuts. To do so may cause the parts to bind, which could result in unnecessary wear on the latch assembly.

12. Install the nuts on the pawl bolt, latch bolt, and shoe bolt. Tighten them snugly.
13. Lubricate all the moving parts—but not the pintle hook—with a light penetrating oil. Open and close the latch several times to distribute the oil.
14. Install the coupling on the vehicle. Tighten the fasteners 320 lbf·ft (434 N·m).



A. Spring tang hooks here.

1. Pawl Spring
2. Pawl Lock
3. Pawl
4. Pawl Wedge
5. Compression Spring
6. Nylon Bushing

Fig. 3

General Information

The Premier model 690 trailer coupling (**see Fig. 1**) is a non-air adjusted, heavy-duty coupling. It is used for load capacities up to 90,000 lbs, and is available with either right- or left-hand operation.

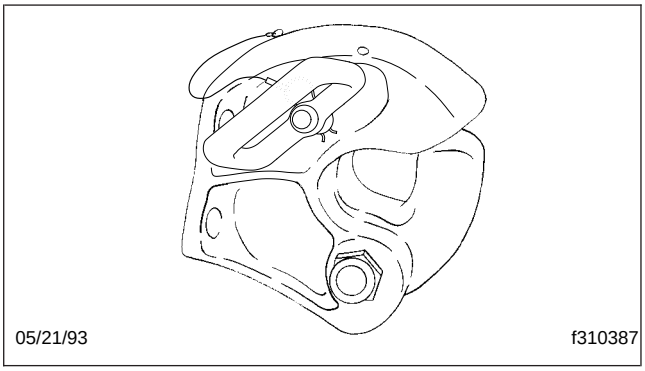
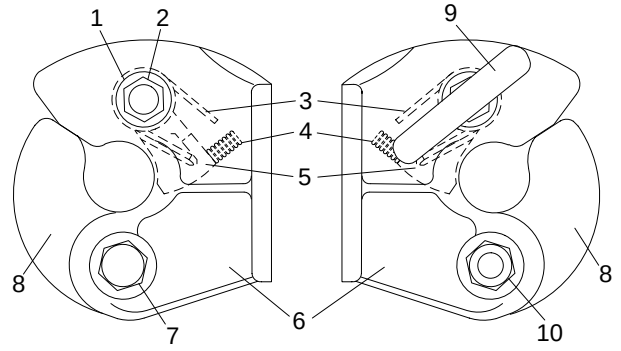


Fig. 1

Disassembly (See Fig. 1)

1. Remove the coupling from the vehicle.
2. Remove the pintle-hook nut and bolt (Refs. 10 and 7), then remove the pintle hook (Ref. 8) from the coupling body (Ref. 6).
3. With the handle pushed in, remove the nut (Ref. 2) from the end of the handle.
4. Remove the bushing (Ref. 1), then the handle (Ref. 9) from the body.
5. From the bottom of the coupling body, remove the small pawl spring (Ref. 4), then the pawl and the large pawl spring (Refs. 3 and 5). Discard the two springs.
6. Remove and discard the locking pin assembly (**Fig. 2**, Ref. 2) from the coupling body.



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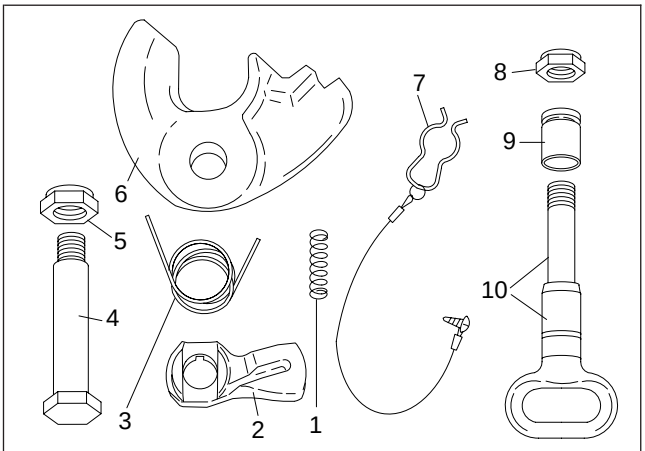
1. Bushing
2. Nut
3. Large Pawl Spring
4. Small Pawl Spring
5. Pawl
6. Coupling Body
7. Pintle-Hook Bolt
8. Pintle Hook
9. Handle
10. Pintle-Hook Nut

Fig. 1

Assembly (See Fig. 2)

1. Check for wear on any parts that aren't included in the new parts kit. Replace them if needed.
2. Put the coupling body on its face, with the mounting surface up and the bottom of the coupling body toward you. See **Fig. 3**



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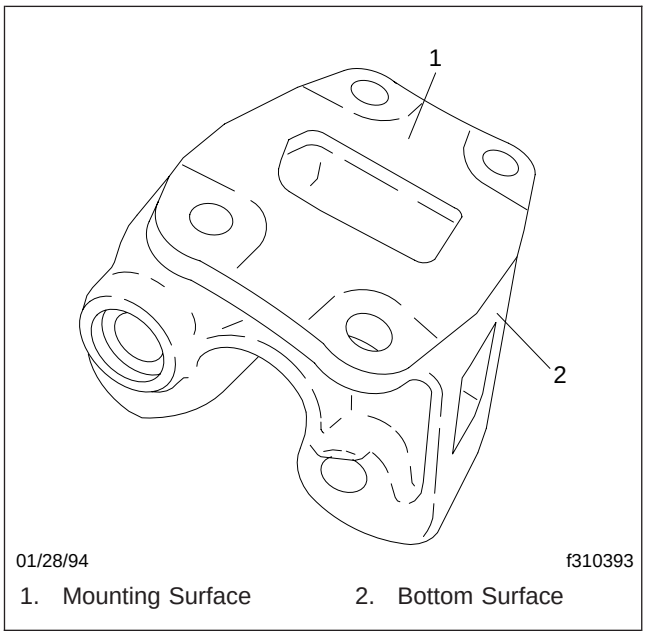
1. Pintle Hook
2. Locking Pin Assembly
3. Nut
4. Bushing
5. Handle
6. Small Pawl Spring
7. Pawl
8. Large Pawl Spring
9. Pintle-Hook Bolt
10. Pintle-Hook Nut

Fig. 2

3. Place a new large spring on the pawl, so that one leg of the spring fits into the groove in the pawl. See **Fig. 4**



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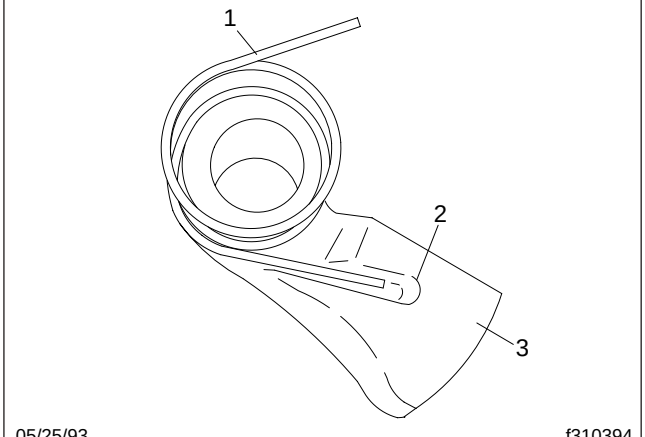
1. Mounting Surface
2. Bottom Surface

Fig. 3

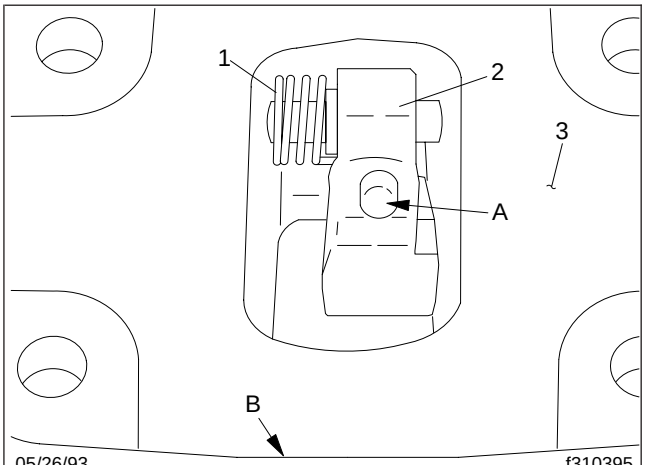
Disassembly and Assembly



1. Large Pawl Spring
2. Groove
3. Pawl

Fig. 4

4. Install the pawl and spring in the bottom of the coupling body, with the spring to your left. See **Fig. 5**. Make sure the other leg of the spring sits in the slot inside the body.



A. Install small pawl spring in here.
B. Bottom of Coupling Body

1. Large Pawl Spring
2. Pawl
3. Mounting Surface

Fig. 5

5. Install the handle (**Fig. 2**, Ref. 5) into the coupling body and the pawl (Ref. 7). Make sure the taper of the handle matches the taper of the hole in the pawl, and that the handle locks into place.
6. Install the bushing over the threaded end of the handle, then install the nut.
7. Turn the handle toward yourself, then—from the bottom of the coupling body—install the small pawl spring (**Fig. 2**, Ref. 6) in the depression on the pawl. See **Fig. 5**. Make sure the other end of the spring fits into the depression inside the coupling body.
8. Rotate the pawl up and lock it into position by turning the handle away from you, then pushing it in.

⚠ CAUTION

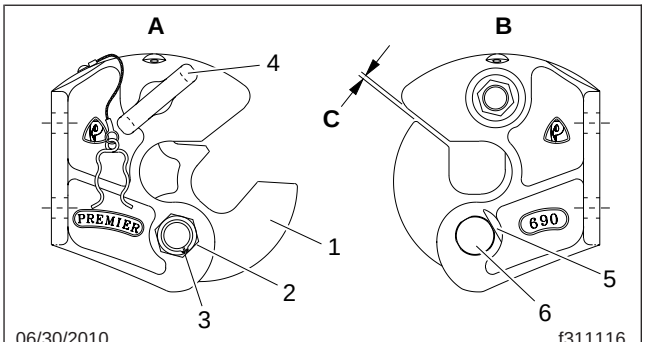
CAUTION: Don't overtighten the nuts for the pintle hook and the handle. To do so may cause the parts to bind, which could result in unnecessary wear on the coupling.

9. Set the coupling body on its mounting surface, then install the new pintle hook, bolt, and nut. Tighten the nuts on the pintle hook bolt and the handle snugly.
10. Install the new locking pin assembly (**Fig. 2**, Ref. 2). on the top of the coupling body.
11. Lubricate all the moving parts with light penetrating oil. Don't lubricate the wear surface of the pintle hook. Open and close the pintle hook several times to distribute the oil.
12. Install the coupling on the vehicle. Tighten the mounting bolts 320 lbf·ft (434 N·m).

Inspection

With the 690 coupling in the closed position, pull outward on the 692 pintle:

- The measured gap between the top of the 692 pintle and the adjacent face of the 690 coupling body must be less than 3/8 inch (9.52 mm). See **Fig. 1**.
- A 3/8 inch (9.52 mm) or greater gap indicates that the coupling is no longer suitable for service. A repair kit will be necessary to return the coupling to service, or a new 690 coupling may be installed.



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A. Left Side, Open Position
B. Right Side, Closed Position
C. 3/8 inch (9.52 mm) or less

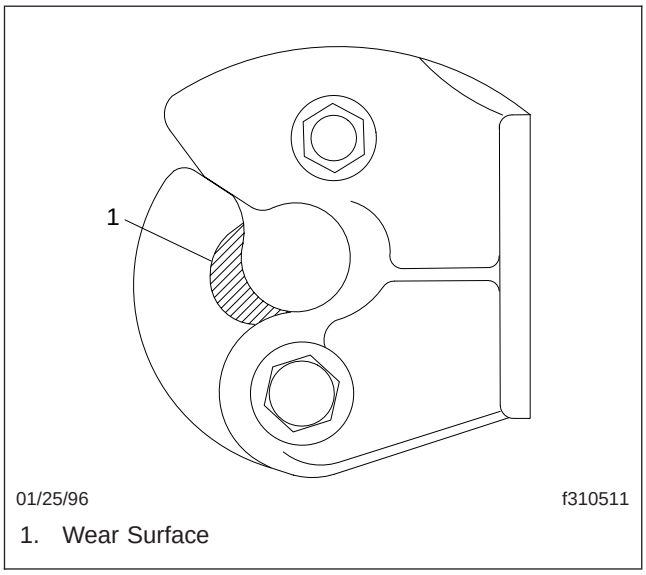
1. 692 Pintle
2. 297 Locknut
3. 295Z-87 Snap Ring
4. 691 Release Handle
5. Bolt Stop
6. 294 Bolt

Fig. 1, 690 Coupling

Using Premier wear gauge, part number 14014, check the percentage of wear on the pintle hook. See **Fig. 2** and **Fig. 3**.

⚠ WARNING

WARNING: If the pintle hook is damaged, has stress cracks, or if it's worn beyond 20% of its original diameter, replace the entire coupling; don't repair it. Using a worn or damaged trailer coulpling could cause the trailer to disconnect from the vehicle, which could result in an accident causing serious personal injury and property damage.



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1. Wear Surface

Fig. 2, Wear Checking

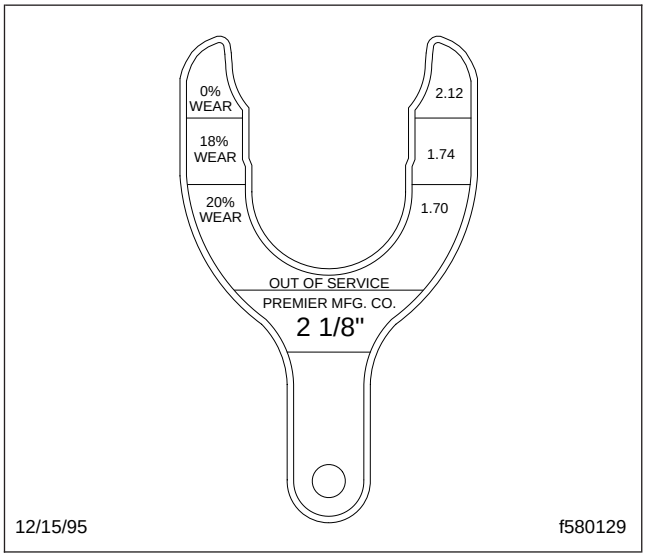

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Fig. 3, Wear Gauge

NOTE: Before performing the 294 bolt replacement procedure, first verify that the 690 coupling is not in need of a complete repair kit. Perform the inspection procedure in **Subject 100**.

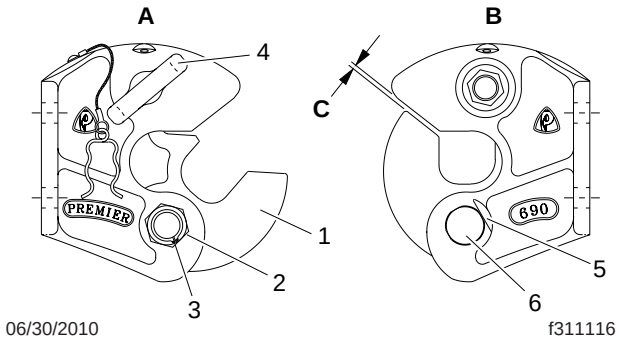
Bolt Replacement

See **Table 1** for new parts required. Parts can be ordered from Premier Manufacturing Company at: (800) 255-5387 or (503) 234-9202.

Description	Part Number	Qty.
Bolt	294	1
Locknut	297	1

Table 1, Parts Required

1. Place the 690 coupling into the OPEN position as shown in **Fig. 1**.



A. Left Side, Open Position
B. Right Side, Closed Position
C. 3/8 inch (9.52 mm) or less

1. 692 Pintle
2. 297 Locknut
3. 295Z-87 Snap Ring
4. 691 Release Handle
5. Bolt Stop
6. 294 Bolt

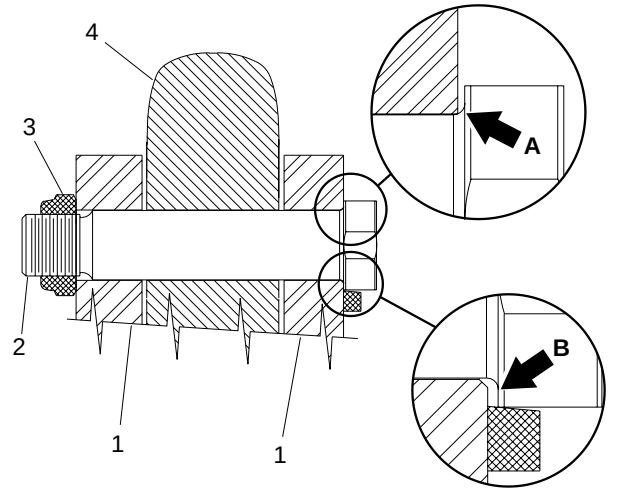
Fig. 1, 690 Coupling

2. If the bolt is an old style with a snap ring, remove the 295Z-87 snap ring from the end of the 294 bolt, then discard it.
3. Remove the 297 locknut and discard it.
4. Firmly gripping the 692 pintle, slide the 294 bolt out of the 690 coupling body.
5. Using a hammer or file, destroy the threaded end of the 294 bolt and discard it.
6. Thoroughly clean the 690 coupling body holes where the 294 bolt was inserted, as well as the interior surfaces of the 690 coupling body. Clean the hole and all surfaces of the 692 pintle.
7. On each side of the coupling body, measure the hole diameters where the 294 bolt was inserted. If a hole diameter exceeds 1.156 inches (29.36 mm) the coupling body is considered out-of-service and must be replaced.
8. Inspect the holes around the 691 release handle for wear. If there is a gap of 1/32-inch (0.79 mm) or greater between the 691 handle shaft and hole circumference, remove the handle assembly, then measure the hole diameters. If a hole diameter exceeds 1.30 inches (33.02 mm), the coupling is to be considered out-of-service and must be replaced.
9. Test fit the 294 bolt by inserting it from the right side through the holes of the 690 coupling body, without the 692 pintle in place. Make certain that the new 294 bolt head is flush with the outer 690 coupling body side wall.

   If the new 294 bolt head and the 690 coupling body are not flush, two possible causes are shown in **Fig. 2**.

   - Arrow A indicates a gap between the new 294 bolt head and the 690 coupling body caused by the hole in the 690 coupling body not being chamfered. This can be resolved by grinding a 45 degree chamfer, no larger than 1/16 inch (1.59 mm), around the entire circumference of the 690 coupling body hole.
   - Arrow B indicates a gap because the bolt stop is preventing the bolt from sitting flush to the coupling body. This can be corrected by grinding or filing the bolt stop until the bolt head clears it.
10. For final assembly, remove the 294 bolt and apply heavy grease to the the 692 pintle hole, the 690 coupling body holes, and the shank of the new 294 bolt (do not lubricate the threads).
11. Place the 692 pintle into the 690 coupling body, aligning the pintle hole with the body holes. From the right side, insert the new 294 bolt through the aligned holes. Clean all signs of lubrication from the threads of the 294 bolt. Align one of the four flatheads adjacent to the bolt stop as shown in **Fig. 1**.

294 Bolt Replacement



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A. Gap caused by 690 body hole not chamfered. Correct by chamfering hole.
B. Gap caused by bolt stop preventing the bolt head from seating flush to the coupling body. Correct by grinding or filing the bolt stop until the bolt head clears it.

1. 690 Body
2. 294 Bolt
3. 297 Locknut
4. 692 Pintle

Fig. 2, Bottom Section View

12. Securing the 294 bolt head with a wrench, thread a new 297 locknut onto the bolt. Ensure that no lubricant is present on the bolt threads, then torque to 50 lbf·ft (68 N·m).
13. Open and close the 690 coupling several times, making sure it operates smoothly and correctly.

General Information

The Holland model PH–60–AL–60 trailer coupling (**see Fig. 1**) has a rigid-type pintle hook. It is designed for trailers with a maximum gross weight of 10,000 lbs. It is mounted to the vehicle by 1/2–13 fasteners.

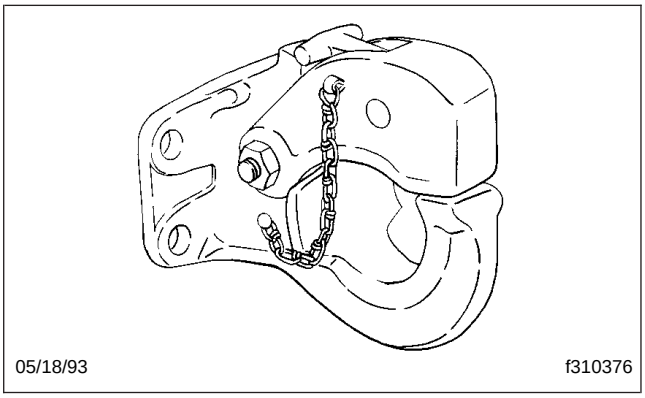
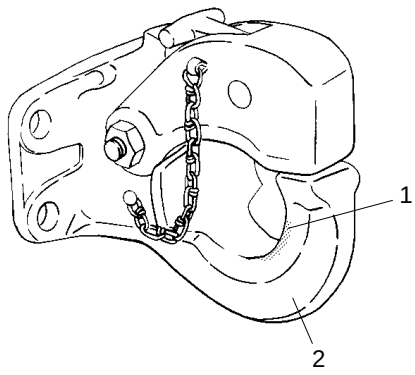


Fig. 1

Pintle Hook Inspection

Check the pintle hook for damage or stress cracks, then check it for wear on its lower inside surface. **See Fig. 1**.

If the pintle hook is damaged, or if the wear surface is worn deeper than 1/8 inch (3 mm), replace the entire coupling; it is not repairable.



1. Wear Surface
2. Pintle Hook

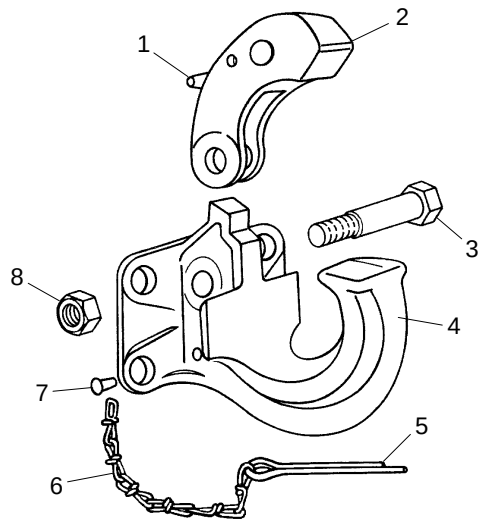
Fig. 1

Disassembly

WARNING

WARNING: If the pintle hook is damaged, has stress cracks, or if it's worn beyond 1/8 inch of its original diameter, replace the entire coupling; don't repair it. See Subject 100 for wear checking information.

1. Remove the coupling from the vehicle.
2. Remove the latch-bolt nut and the latch bolt (**Fig. 1**, Refs. 8 and 3).
3. Remove the latch and lock assembly (Ref. 2).
4. If the cotter pin and chain (Refs. 6 and 5) need replacing, remove the drive pin (Ref. 7) attaching them to the coupling.



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1. Lock
2. Latch and Lock Assembly
3. Latch Bolt
4. Pintle Hook
5. Cotter Pin
6. Chain
7. Drive Pin
8. Latch-Bolt Nut

Fig. 1

Assembly

1. Install a new latch and lock assembly, aligning its holes with the holes in the coupling body. **See Fig. 1**.

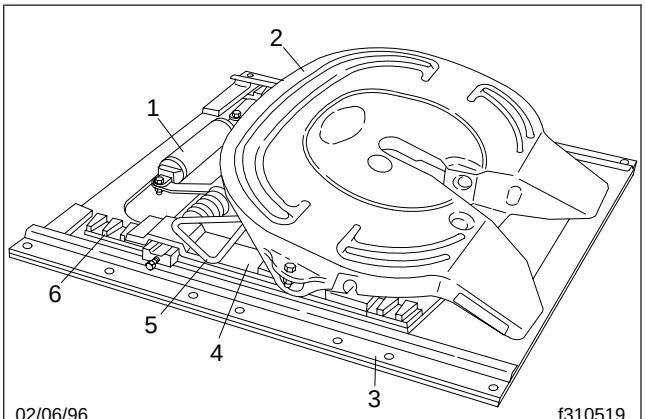
CAUTION

CAUTION: Don't overtighten the latch-bolt nut. To do so may cause the parts to bind, which result in unnecessary wear on the coupling.

2. Install the latch bolt, then the latch bolt nut (Refs. 3 and 8). Tighten the nut snugly.
3. If replacing the cotter pin and chain, install them using a new drive pin (Ref. 7).
4. Lubricate all the moving parts—but not the pintle hook—with a light penetrating oil. Open and close the latch several times to distribute the oil.
5. Install the coupling on the vehicle. Tighten the fasteners 68 lbf·ft (92 N·m).

General Description (See Fig. 1)

The Holland Fleetmaster fifth wheel is used for pulling trailers having the standard 2-inch diameter kingpin. When installed as a stationary fifth wheel, it is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. When used as a sliding fifth wheel, it is mounted to a slide bracket and plate assembly (air-operated or manual release).



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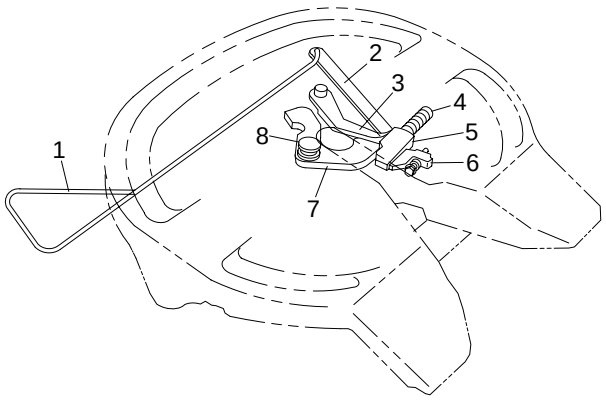
1. Air Cylinder
2. Top Plate
3. Outboard Mounting Plate
4. Slide Plate
5. Release Handle
6. Track

Fig. 1, Holland Fleetmaster Fifth Wheel Assembly

Principles of Operation

The fifth wheel lock mechanism for the trailer kingpin consists of a hinged lock, locking plunger, plunger spring, cam arm, release arm, and operating rod. The lock rotates on a lock pin during coupling and uncoupling operations. During coupling the hinged lock and cam arm pivot against the kingpin and are secured by the locking plunger (See **Fig. 2**).

Uncoupling is accomplished by pulling the release handle using 60–70 lbs. (27–32 kg) of force. The release arm pivots and forces the locking plunger against the plunger spring. The hinged lock is released and the trailer kingpin can be removed (See **Fig. 3**).



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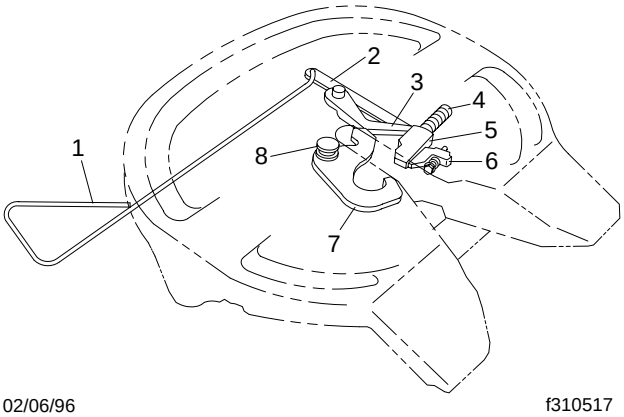
1. Release Handle
2. Release Arm
3. Cam Arm
4. Plunger Spring
5. Locking Plunger
6. Adjusting Wedge
7. Hinged Lock
8. Lock Pin

Fig. 2, Fifth Wheel in Locked Position



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1. Release Handle
2. Release Arm
3. Cam Arm
4. Plunger Spring
5. Locking Plunger
6. Adjusting Wedge
7. Hinged Lock
8. Lock Pin

Fig. 3, Fifth Wheel in Unlocked Position

Removal (See Fig. 1)

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in a hazardous operating condition due to possible disengagement of the trailer from the tractor.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

1. Steam clean the top plate. Remove the cotter pins from the bracket pins. Remove the bracket pins. Discard the cotter pins and remove the top plate.
2. Using an overhead hoist, lift the fifth wheel off the mount and tractor frame.

Disassembly (See Fig. 1)

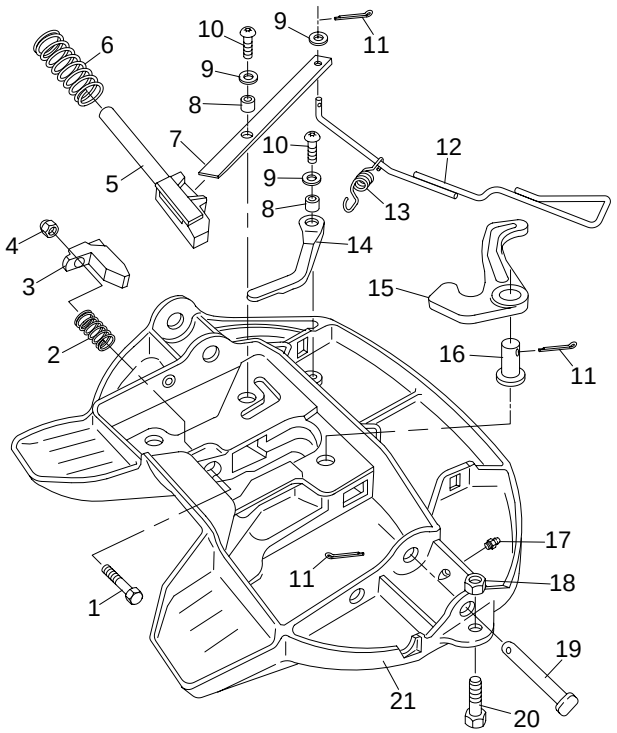
1. Turn the fifth wheel upside down.

⚠ WARNING

Do not attempt repair or rebuilding if the top plate is cracked or distorted or if the lock pin is sloppy in the top plate. These conditions could result in top plate failure or malfunction of the locks.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

2. Pull the release handle out, slide it forward and hook the handle to the unlock notch of the casting.
3. With the plunger in the unlocked position, remove and discard the cotter pin. Remove the lock pin.
4. Slide the hinged lock away from the locking plunger and remove it from the top plate.



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NOTE: Bottom view shown.

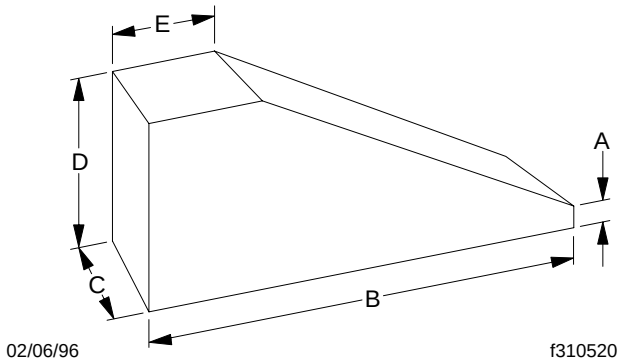
1. Hex Head Capscrew
2. Spring
3. Adjusting Wedge
4. Locking Nut
5. Locking Plunger
6. Plunger Spring
7. Release Arm
8. Roller
9. Washer
10. Torx Screw
11. Cotter Pin
12. Release Handle
13. Extension Spring
14. Cam Arm
15. Hinged Lock
16. Lock Pin
17. Grease Fitting
18. Locknut
19. Bracket Pin
20. Hex Head Capscrew
21. Top Plate

Fig. 1, Fifth Wheel Assembly Components (with left-hand release)

NOTE: It may be necessary to fabricate a wedge to hold the plunger in the unlocked position during the disassembly and assembly procedure.

5. Insert the fabricated wedge, see **Fig. 2**.
6. Pull the release handle and slide it rearward to unhook it from the notch in the casting.

Removal and Disassembly

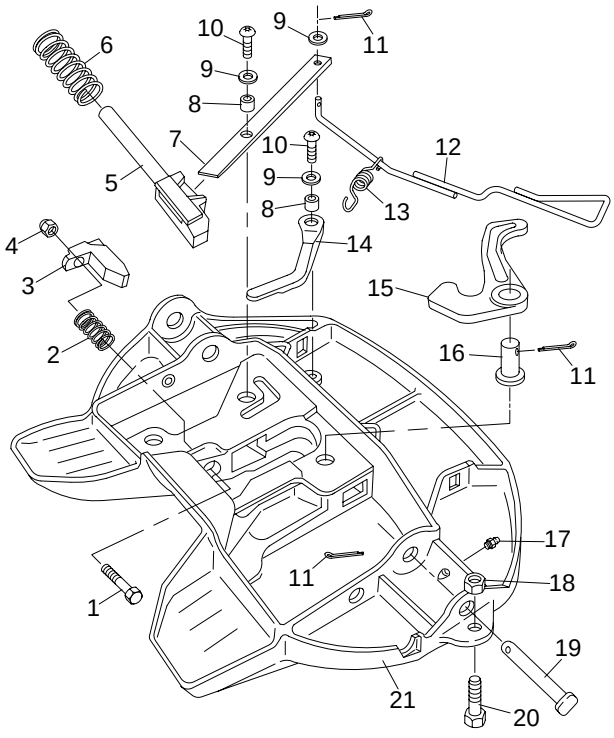


A. 0.3 inch (7.6 mm)
B. 8 inches (203.2 mm)
C. 1.5 inches (38.1 mm)
D. 3 inches (76.2 mm)
E. 2.5 inches (63.5 mm)

Fig. 2, Fabricated Wedge Dimensions

7. Remove the cotter pin and washer. Discard the cotter pin. Disconnect and pull the release handle away from the release arm.
8. Remove the release arm Torx screw, washer, and roller. Remove the release arm.
9. Slowly remove the fabricated wedge. Guide the locking plunger from the left throat of the fifth wheel to the right throat. Pull the plunger out of the right throat of the fifth wheel. Remove the plunger spring and adjusting wedge.
10. Remove the Torx screw, washer, and roller. Remove the cam arm.
11. Remove the extension spring and the release handle.
12. Remove the grease fittings.

Assembly (See Fig. 1)



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NOTE: Bottom view shown.

1. Capscrew
2. Spring
3. Adjusting Wedge
4. Locking Nut
5. Locking Plunger
6. Plunger Spring
7. Release Arm
8. Roller
9. Washer
10. Torx Screw
11. Cotter Pin
12. Release Handle
13. Extension Spring
14. Cam Arm
15. Hinged Lock
16. Lock Pin
17. Grease Fitting
18. Locknut
19. Bracket Pin
20. Capscrew
21. Top Plate

Fig. 1, Fifth Wheel Assembly Components (with left-hand release)

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in a hazardous operating condition due to possible disengagement of the trailer from the tractor.

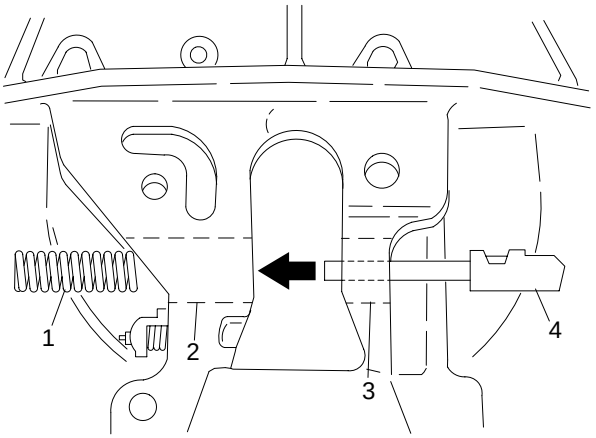
Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

IMPORTANT: When rebuilding use only Holland rebuilding kits. Replace all roll pins, cotter pins, springs, bolts, nuts, and washers. Inspect the rebuild kit to verify that all parts are present.

IMPORTANT: Check the lock pin holes. If the holes are elongated the top plate must be replaced. Replace any parts that show signs of wear, damage, or deterioration. Brackets, bracket bushings, bracket pins, and bracket shoes should be replaced in pairs.

1. Clean all moving parts with no. 2 diesel fuel before assembly.
2. Replace the grease fittings.
3. Apply a thin film of multipurpose chassis grease to the release arm, release arm roller, hinged lock, lock pin, cam arm and roller, adjusting wedge, and locking plunger.
4. Install a 5/8-inch capscrew through the hole in the right side of the throat of the fifth wheel.
5. Slide the wedge spring, and wedge over the capscrew. Thread a 5/8-inch locknut onto the capscrew. Hand tighten the locknut.
6. Install the plunger through the opening in the right throat of the fifth wheel, through the left throat, into the plunger spring, and through the hole in the rib of the casting. See **Fig. 2**.
7. Compress the plunger spring by inserting the fabricated block into the throat until the plunger is flush with the throat of the casting. See **Fig. 3**.
8. Insert the cam arm tail into the pocket in the plunger. Align the cam arm hole with the bolt hole in the casting. See **Fig. 4**.
9. Install the roller, washer (rounded edge towards the roller), and torx bolt. Tighten the torx bolt 85 to 120 lbf·ft (115 to 163 N·m).
10. Insert the tapered end of the release arm through the main rib of the casting into the

Assembly and Installation



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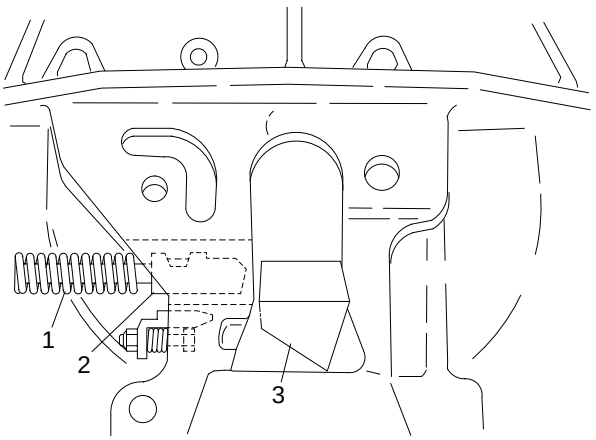
1. Plunger Spring
2. Left Throat
3. Right Throat
4. Locking Plunger

Fig. 2, Plunger Installation



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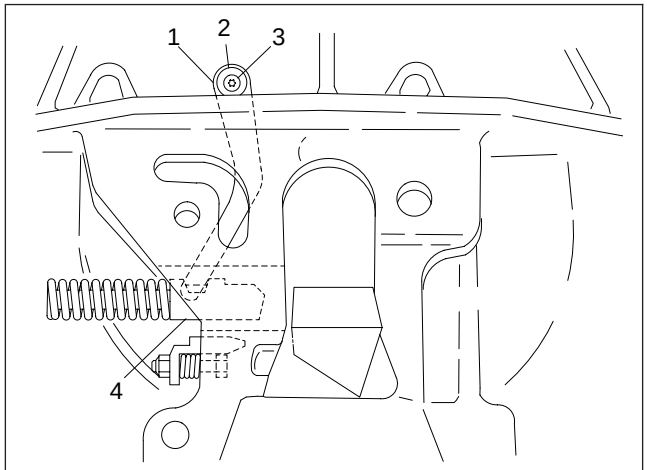
1. Plunger Spring
2. Locking Plunger
3. Fabricated Wedge

Fig. 3, Inserting Fabricated Wedge

plunger. The tapered end of the release arm must face down next to the cam arm. Align the release arm hole with the bolt hole in the casting.

The following step applies only to fifth wheels equipped with a left-hand (road side) release. Fifth wheels equipped with a right-hand (curb-



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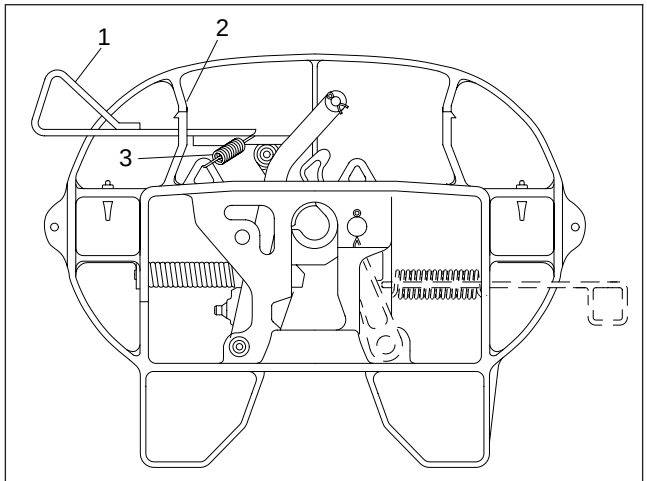
1. Cam Arm
2. Washer
3. Torx Screw
4. Locking Plunger

Fig. 4, Cam Arm Installation

side) release (see **Fig. 5**) do not require a roller, washer, and torx bolt to install the release arm.

11. Install the roller, washer (rounded edge towards the roller), and torx bolt. Tighten the torx bolt 85 to 120 lbf·ft (115 to 163 N·m).



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1. Release Handle
2. Main Rib
3. Release Handle Spring

Fig. 5, Right-Hand (curb-side) Release

12. Feed the release handle through the hole in the casting, through the closed end of the release

handle spring, and up through the bottom of the release arm.

13. Install the washer and cotter pin.
14. Lubricate the release handle spring contact areas with a light grease. Attach the release handle spring to the casting ear.
15. Pull the release handle and hook it on the unlock notch of the casting.
16. Remove the fabricated block. Keep hands and fingers clear.
17. Grease the lock pin hole and the lock contact areas. Slide the hinged lock through the opening in the right-hand side of the throat of the fifth wheel. Align the lock pin hole with the hole in the casting.
18. Slide the lock pin through the casting from the face of the top plate through the lock, then through the bottom of the casting. Install a cotter pin.
19. Unhook the release handle from the notch in the casting.

Installation

NOTE: Before remounting the top plate, inspect the rubber bushings and bracket pins for wear. Replace as necessary. If bushing replacement is required, be sure to use the correct diameter bushing.

1. Using an overhead hoist, position the fifth wheel on the sliding or stationary mount brackets. Clamp the fifth wheel in place to compress the bracket rubbers.
2. Insert the bracket pins and new cotter pins. Lock the cotter pins.

Lock Adjustment

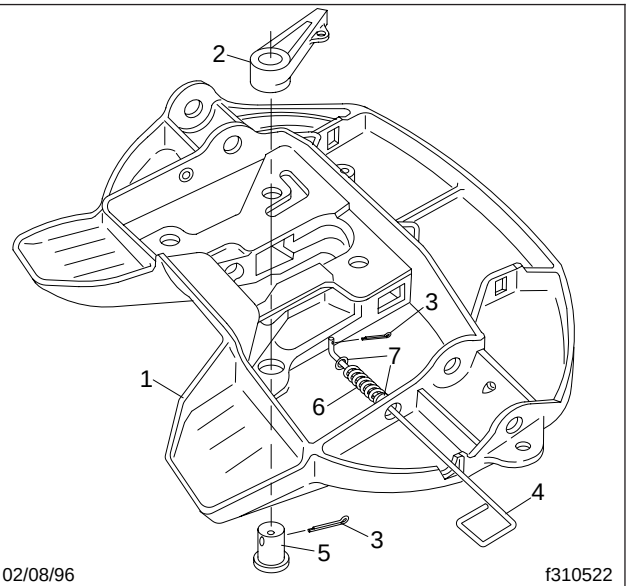
1. Open the hinged lock by pulling the release handle and putting pressure against the hinged lock, moving it towards the open position.
2. Close the fifth wheel using a Holland lock tester. Tighten the adjustment bolt while attempting to rotate the lock tester back and forth.
3. Slowly tighten the bolt until the lock tester just stops rotating. Loosen the adjustment bolt two full turns.
4. Verify proper operation by locking and unlocking the fifth wheel several times using the tester.

⚠ WARNING

If the fifth wheel top plate does not operate properly, do not use it. An improperly functioning fifth wheel could cause loss of vehicle or trailer control, resulting in personal injury. Repeat the above procedure or call your local Holland representative for assistance.

Secondary Lock Installation

1. Using the Holland lock tester, close the fifth wheel lock. (See **Fig. 1**).



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NOTE: Bottom view shown.

1. Top Plate
2. Secondary Lock Arm
3. Cotter Pin
4. Secondary Lock Release Handle
5. Secondary Lock Pin
6. Spring
7. 7/16-inch Washer

Fig. 1, Optional Secondary Lock Assembly

2. Lubricate the secondary lock arm pin hole with Never Seez grease.
3. Slide the lock arm into the right side of the casting with the lock arm ear facing the outside of the casting.
4. Align the pin holes of the secondary lock arm and the casting. Drive the lock pin through the casting from the top plate, through the secondary lock. Install the cotter pin through the secondary lock.
5. Install a 45-degree lube fitting into the secondary lock pin.
6. Grasp the secondary lock handle handhold, and slide the other end of the handle through the rib of the casting, through the 7/16-inch washer, through the handle spring, through another 7/16-inch washer, and up through the bottom of the loop on the secondary lock arm.
7. Compress the release handle spring and secure the release handle using a cotter pin. Lock the cotter pin.
8. Check the secondary release handle for proper operation.

Troubleshooting

Problem—Hard to Hook Up the Fifth Wheel to the Trailer

Problem—Hard to Hook Up the Fifth Wheel to the Trailer	
Possible Cause	**Remedy**
The trailer may be too high; the kingpin is not entering the lock correctly.	Lower the trailer landing gear until the trailer plate contacts the fifth wheel.
A bent kingpin or damaged trailer plate is interfering with the hinged lock movement.	Check the kingpin and trailer plate. Replace parts as needed.
The hinged lock has not been adjusted correctly.	Check the clearance between the lock and the kingpin. Adjust as described in this section.
Attempting to couple too quickly.	Pick up the trailer with the fifth wheel. Stop. Continue backing up until the fifth wheel locks firmly to the kingpin. Stopping helps prevent hitting the kingpin too hard.
The locks are closed.	Pull the release handle. Hook the handle on the notch in the casting and pry the hinged lock open.
Accumulated rust or grime is interfering with lock operation.	Spray a light lubricant or diesel fuel on all moving parts, including the release handle. Operate the unit several times.
The locks are damaged.	Inspect and replace components as described in this section.
The fifth wheel requires rebuilding.	Follow the procedures contained in this section using the appropriate rebuilding kit.
Using a lube plate with the wrong kingpin length.	See Holland Service Bulletins 4 and 4A.

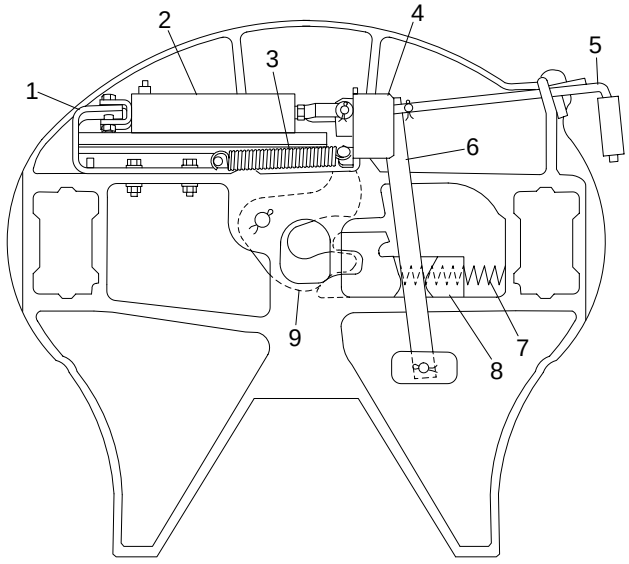
Problem—Hard to Unhook the Fifth Wheel from the Trailer

Problem—Hard to Unhook the Fifth Wheel from the Trailer	
Possible Cause	**Remedy**
The tractor is putting pressure against the locks.	Back the tractor up a little to relieve kingpin load against the fifth wheel lock. Lock the tractor brakes before pulling the release handle and hooking it on the notch in the top of the plate casting.
The optional secondary lock (if equipped) is not released.	Pull out the secondary release handle and move it forward to secure it on the top plate casting.
The release handle will not stay out or must be held out when unlocking.	Follow the procedures contained in this section using the appropriate rebuilding kit.
The primary release handle is not pulled out completely and locked on the notch in the casting.	Slide the primary release handle out and pull it forward. Slide the handle forward, hooking it on the notch on the top plate casting.
Rust or grime is on the locking mechanism.	Spray a light lubricant or diesel fuel on all moving parts including the release handle. Operate the unit several times.
Bent kingpin or damaged bolster plate.	Check the kingpin with a Holland TF–0110 Kingpin Gage and bolster plate with a 48 inch straightedge. Repair or replace as required.
Fifth wheel locks are adjusted too tight.	Check the clearance between the lock and the kingpin. Adjust as described in this section.

Troubleshooting

NOTE: After the fifth wheel is unlocked and moves freely from the kingpin, it is normal for the release handle to disengage from the notch in the casting to return to a position between locked and unlocked.

General Description (See Fig. 1)



1. Housing Weldment
2. Air Cylinder
3. Extension Spring
4. Slide Cam
5. Operating Rod
6. Lever Bar
7. Lock Spring
8. Lock
9. Locking Mechanism Jaw

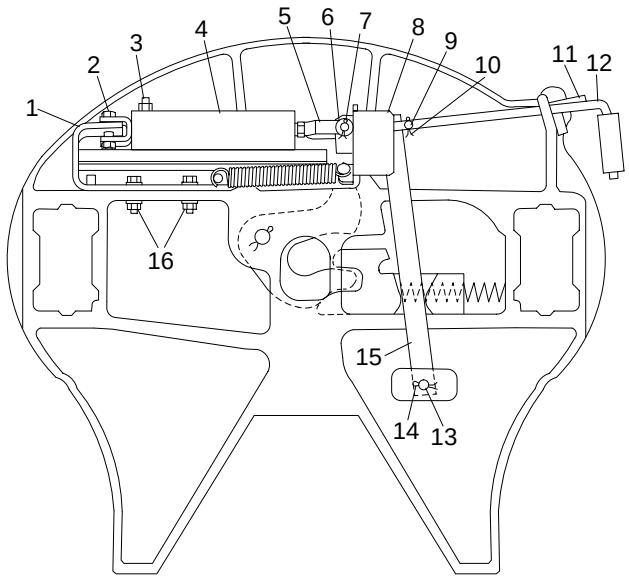
Fig. 1, Touchloc Control Mechanism

The Touchloc™ air-operated latch consists of an air cylinder, an extension spring, a housing weldment, a slide cam, an operating rod, and a safety latch. An inversion valve and an air control valve direct air (pneumatic) pressure through air lines to the air-operated latch.

Principles of Operation (See Fig. 1)

The fifth wheel lock can be operated manually using the operating rod, or by using an air cylinder remotely controlled from the cab. For remote operation, tractor air pressure must be between 90 and 120 psi (620 and 827 kPa). With the parking brake set, the cab air control valve knob is pulled (the parking brake must be set to activate the air-operated latch). An inversion valve forces air through the air lines to the air cylinder. The air cylinder extends, pushing the slide cam against the lever bar. The lever bar is forced back, pushing the lock against the lock spring, releasing the locking mechanism jaw. As the tractor moves away from the trailer, the trailer kingpin automatically opens the locking mechanism jaw.

Removal (See Fig. 1)



1. Housing Weldment
2. Grade 8 Bolt and Nut
3. NPT Inlet
4. Air Cylinder
5. Yoke
6. Yoke Pin Cotter
7. Yoke Pin
8. Slide Cam
9. Operating Rod Pin
10. Operating Rod Pin Cotter
11. Safety Indicator
12. Operating Rod
13. Lever Bar Pin
14. Lever Bar Pin Cotter
15. Lever Bar
16. Grade 8 Bolt, Washers and Locknut

Fig. 1, Touchloc™ Control Mechanism

1. Put the fifth wheel in the locked position using the bar or block.

⚠ WARNING

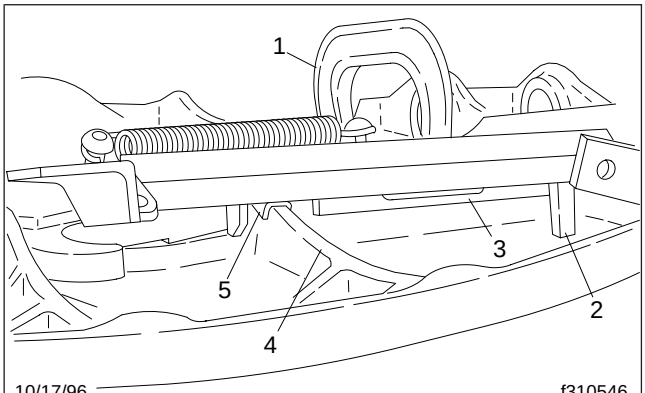
WARNING: The lock is spring loaded. Keep hands away to avoid injury. Stand clear, as the operating rod retracts rapidly during lockup.

2. Remove the safety latch cotter pin, and the pin. Remove the safety latch. Discard the cotter pin.
3. Remove the lever cotter pin from the lever bar pin and remove the lever bar pin. Discard the cotter pin.
4. Slide the cover plate back, lift and remove it.
5. Remove the operating rod cotter. Slide the lever bar forward, lift and disconnect it from the operating rod. Remove the operating rod.
6. Disconnect the air line from the air cylinder supply port.
7. Remove the air cylinder yoke cotter pin and the pin. Discard the cotter pin.
8. Unbolt the rear of the air cylinder from the rear housing weldment. Remove the air cylinder.

Installation (See Fig. 1)

IMPORTANT: Before installation, steam clean the fifth wheel in the area where the air mechanism is to be mounted.

1. Insert the new operating rod through the slot into the lever bar and install a new cotter pin in the operating rod.
2. Slide the lever bar back into the lock assembly. Install the cover plate, the lever bar pin and a new lever bar cotter pin.
3. Install the safety latch and the safety latch pin. Secure the safety latch with a new cotter pin.
4. Place the Touchloc unit in position with the predrilled flat mounting plate (see **Fig. 2**) flat against the plate casting transverse rib. Seat the locator saddle on the longitudinal rib and the support/mounting stud on the plate casting.



1. C-Clamp
2. Support/Mounting Stud
3. Flat Mounting Plate
4. Longitudinal Rib
5. Locator Saddle

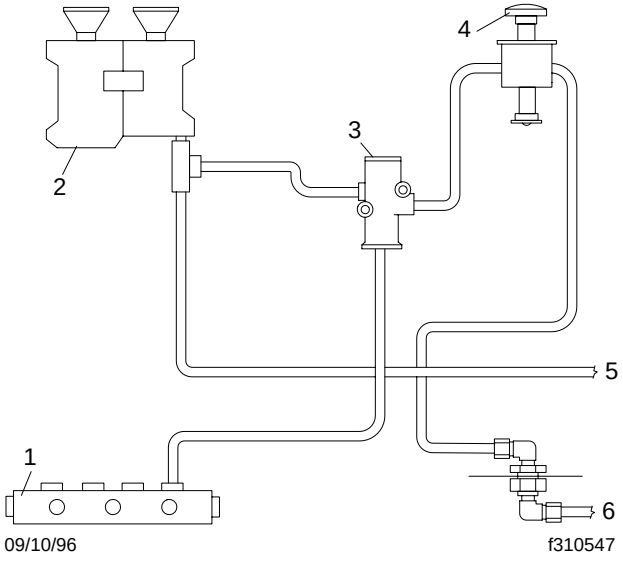
Fig. 2, Touchloc Mounting

Air Control Mechanism Removal and Installation

IMPORTANT: Make sure the pre-drilled flat mounting plate seats flat against the transverse rib. There must not be an air gap between the mounting plate and the rib.

5. Insert two 3/8-inch Grade 8 bolts, with washers, through the Touchloc side of the fifth wheel. Install washers and locknuts on the bolt ends and tighten.
6. Mount the air cylinder. Fully retract the yoke and thread the jam nut to the end of the piston threads. Secure the rear of the air cylinder to the housing weldment rear support with a 1/2-inch Grade 8 bolt and self-locking nut. Move the slide cam to align the holes in the yoke and the slide cam. Insert the pin and a new cotter pin.
7. Check the clearance between the slide cam mating surface and the air cylinder yoke. Slide cam movement should not be restricted.
8. Inspect the Touchloc air mechanism for proper installation. Connect the air line to the air cylinder fitting and test the unit using the instructions in **Section 110**.

Air System Operational Checks (See Fig. 1)



1. Cab Auxiliary Air Junction Block
2. Dash-Mounted Parking Brake Valve
3. Inversion Valve
4. Air Control Valve
5. To #12 Port of Air Junction Box
6. To Touchloc Air Cylinder on Fifth Wheel

Fig. 1, Touchloc Plumbing Schematic

IMPORTANT: Before performing the inversion valve and air control valve checks, visually inspect the system air lines, connections, and fittings. If evidence of damage, cracking, or kinks exists, repair as necessary before continuing with the operational check.

IMPORTANT: The following operational checks should be performed using two gauges known to be accurate. Depending on installation, it may be necessary to completely remove the valve to be tested.

Inversion Valve

1. Install one test gauge in a common control and supply line. Install the second gauge in the delivery port.
2. Gradually apply pressure to the common control and supply line.
3. Observe the common control and supply line gauge. Exhaust should occur at 60 psi (414 kPa). If it does not, rebuild or replace as necessary.
4. With the valve pressurized, apply a soap solution to the exterior of the valve, and observe for air leakage (bubbling). Slight bubbling is permitted. However, excessive leakage indicates a faulty O-ring, or inlet valve, or a crack.
5. Observe the delivery port gauge while slowly decreasing pressure in the control cavity. Delivery should occur at 45 psi (310 kPa). If it does not, rebuild or replace as necessary.

Air Control Valve

1. Install a test gauge in the delivery port. Gradually apply air pressure to the supply port. Pull the valve knob and observe the gauge. The gauge should indicate air pressure equivalent to the pressure applied at the supply port. If it does not, rebuild or replace as necessary.
2. With the valve pressurized, apply a soap solution to the exterior of the valve and observe for air leakage (bubbling). Slight bubbling is permitted. However, excessive leakage indicates a faulty O-ring, or a crack.
3. With the valve pressurized, depress the knob, and observe the gauge at the delivery port. Air pressure should rapidly exit the exhaust port and the gauge reading should decrease to zero. If it does not, rebuild or replace as necessary.

Troubleshooting

NOTE: Visually inspect all air mechanism components for damage, cracks, warpage, or binding which may cause the unit to malfunction.

Problem—Air Mechanism Does Not Release the Locking Jaw

Problem—Air Mechanism Does Not Release the Locking Jaw	
Possible Cause	**Remedy**
The slide cam is damaged or warped.	Replace the slide cam as needed.
The slide cam track lacks lubrication.	Spray the slide cam, track, and inside of the rectangular slide cam housing with light oil, silicone, or equivalent.
The air cylinder has failed.	Check for proper air pressure at the air cylinder. If air pressure is 90 to 120 psi (620 to 827 kPa), replace the air cylinder as necessary. If air pressure is below 90 psi (620 kPa), refer to **Subject 110**.

Problem—Air Mechanism Does Not Lock The Hinged Lock

Problem—Air Mechanism Does Not Lock The Hinged Lock	
Possible Cause	**Remedy**
The extension spring has failed.	Inspect the extension spring for rust deterioration, over extension, and proper installation. Repair or replace as necessary.
Air cylinder is binding.	Remove the air cylinder and manually extend and retract the cylinder. Any binding of the piston requires reconditioning or replacement.
Cylinder air pressure will not exhaust.	Check for foreign material or debris in the air cylinder and the air cylinder connecting port. Clean as necessary. If the air cylinder retracts when the air delivery line is disconnected, refer to **Subject 110**.

General Information

Fontaine H5092 series fifth wheels couple to trailers having the standard 2-inch kingpin. When installed as a stationary mount, the fifth wheel is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. Sliding fifth wheels (**Fig. 1**), are mounted on the Fontaine HAWB or HMWS (previously called 5AWB and 5MWS) model slide mounts.

The Fontaine fifth wheel lock mechanism for the trailer kingpin consists of a spring-loaded jaw and sliding wedge. Kingpin release is accomplished by pulling a manual lock control handle located on either the right side (curbside) or left side (roadside) of the fifth wheel. Kingpin coupling occurs when the kingpin enters the throat of the fifth wheel, triggers the jaw and wedge to slide into place behind the kingpin, and moves the lock control handle into the locked position.

As the kingpin enters the lock mechanism, the jaw is moved first with the spring-loaded wedge sliding in place against the jaw. The jaw will move behind the kingpin, followed by the wedge. The wedge reinforces the jaw and automatically adjusts for slack around the kingpin. See **Fig. 2** for an illustration of the jaw and wedge in the locked position.

Placing the lock control handle in the unlocked position moves the wedge and jaw out from behind the kingpin and unlocks the fifth wheel. See **Fig. 3** for an illustration of the jaw and wedge in the unlocked postition.

General Information

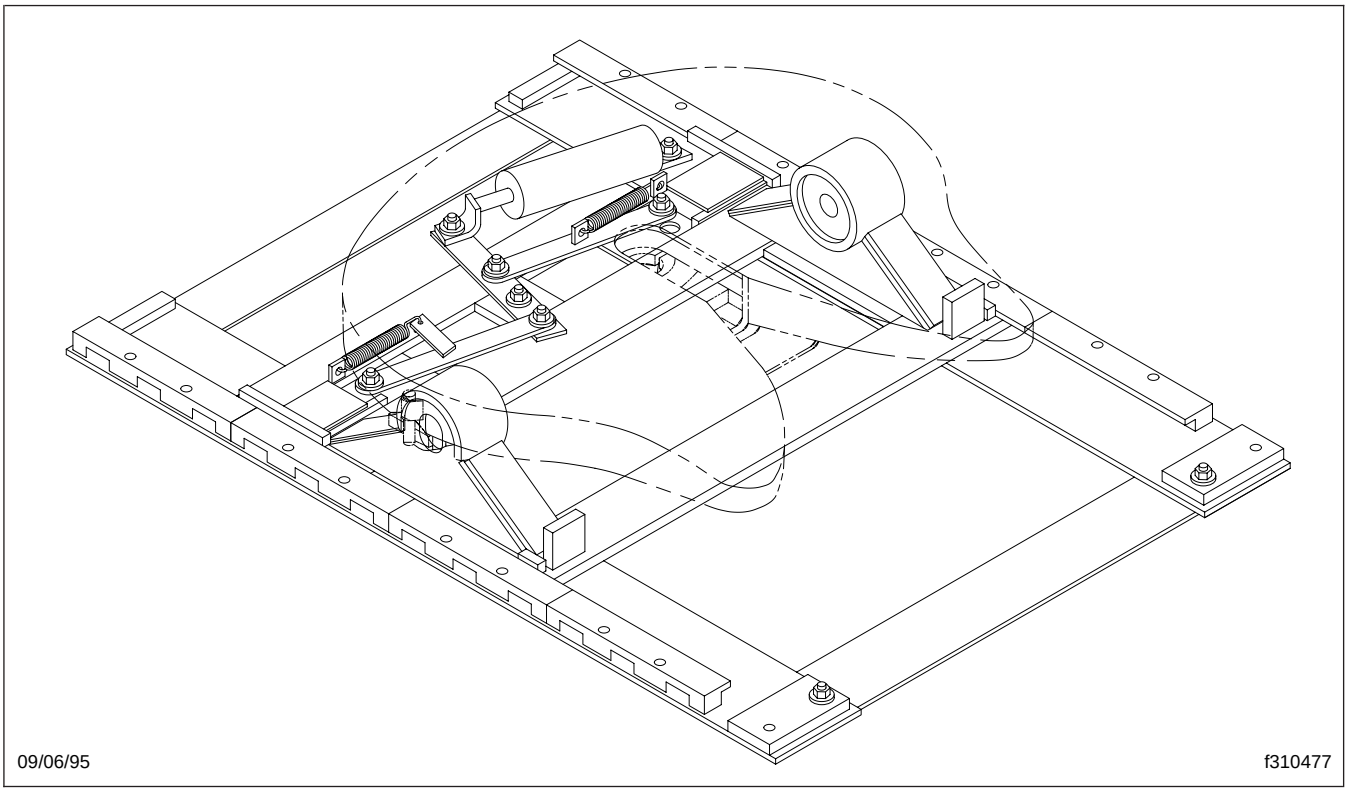


Fig. 1, Fontaine H5092 Series Air Slide Fifth Wheel

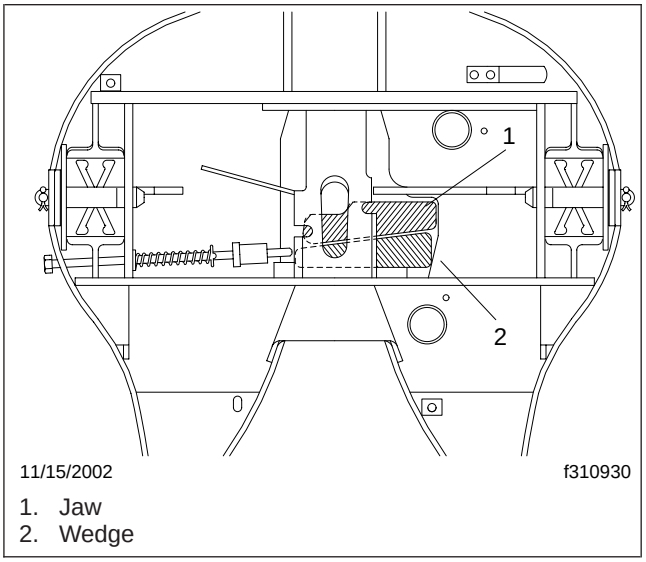


Fig. 2, Locked Position

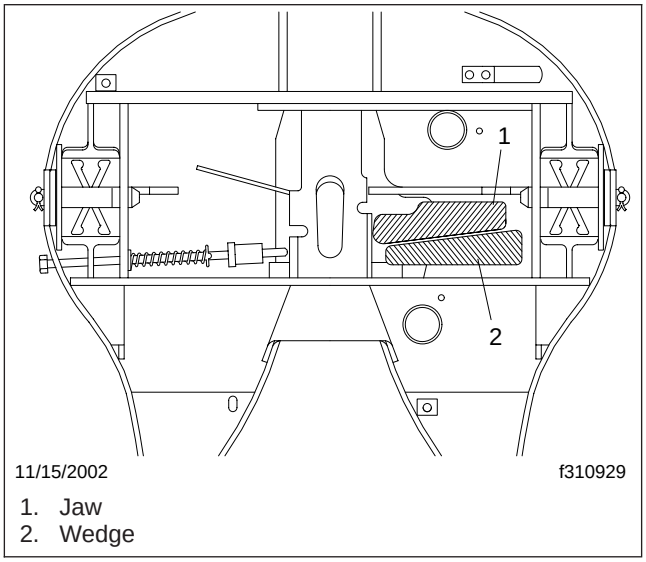


Fig. 3, Unlocked Position

Fifth Wheel Removal and Disassembly

See **Fig. 1** for an exploded view of a Fontaine H5092 fifth wheel.

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in disengagement of the trailer from the tractor, leading to personal injury or property damage.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

1. Steam clean the top plate. Remove it from the sliding mount by removing the cotter pins from the retaining pins. Remove the retaining pins and bushing pins from both sides of the top plate.
2. Using an overhead hoist, lift the fifth wheel off the sliding mount and tractor frame.
3. Turn the fifth wheel upside down.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

⚠ WARNING

Do not attempt to repair or rebuild the top plate if it is cracked or if parts are damaged. The top plate or parts could malfunction. This could result in disengagement of the trailer during vehicle travel, possibly causing personal injury and property damage.

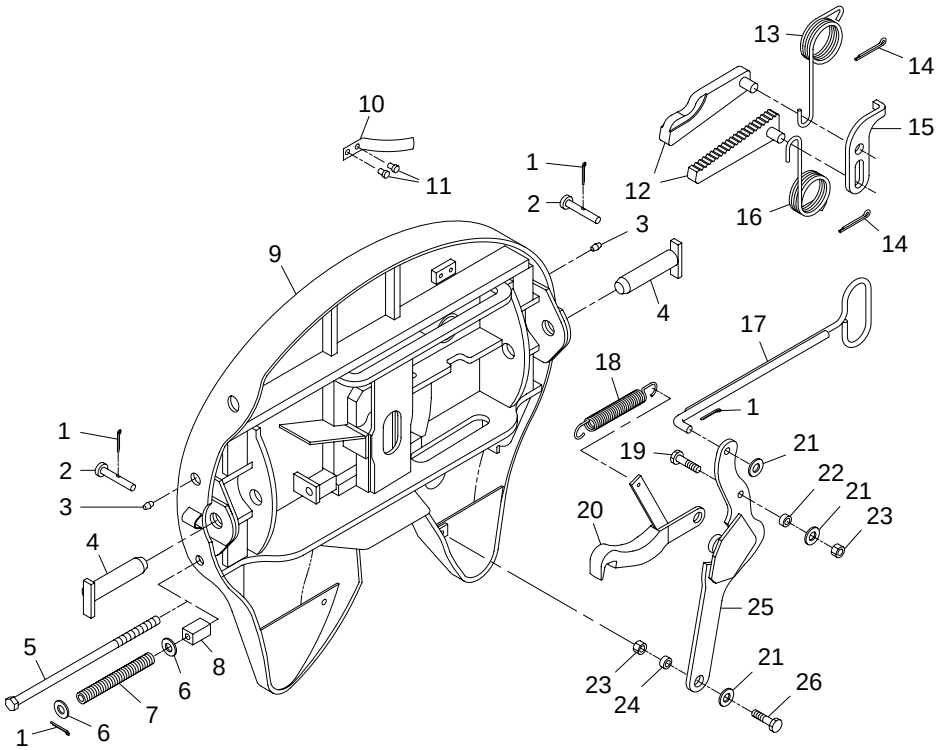
4. Set the fifth wheel in a locked position, then unhook the bumper spring from the bumper tang and the tab on the side of the fifth wheel substructure. See **Fig. 2**. Remove the bumper spring.
5. Remove the two bolts on the operating handle. See **Fig. 3**. Each bolt has a nut, washer, and bushing. Discard the bushings.
6. Remove the cotter pin and washer that holds the pull handle to the operating handle. Slide the pull handle out through the side of the fifth wheel. See **Fig. 4**.
7. Slide the operating handle over to the side of the fifth wheel. Slide the bottom part first. This will allow the handle to clear the jaw and wedge studs on the underside and clear the timer. See **Fig. 5**.
8. Remove the timer by lifting upward. See **Fig. 6**.
9. Slide the operating handle out through the slot in the rear crossmember of the fifth wheel. See **Fig. 7**.
10. Slide the bumper toward the operating handle slot and to the rear of the fifth wheel until the bumper tang clears the operating handle slot. Lift upward and remove. See **Fig. 8**.

⚠ WARNING

The wedge spring is under extreme tension. Always wear safety glasses. Do not stand directly over the springs. A flying spring could cause personal injury.

11. Remove the cotter pins from the jaw and wedge springs. Discard the cotter pins, and pry the small hooked tail of the jaw and wedge spring up over the jaw and wedge studs. Remove and discard both springs. See **Fig. 9**.
12. Remove the wedge first, and then the jaw. Discard the jaw and wedge. See **Fig. 10**.

Removal and Disassembly



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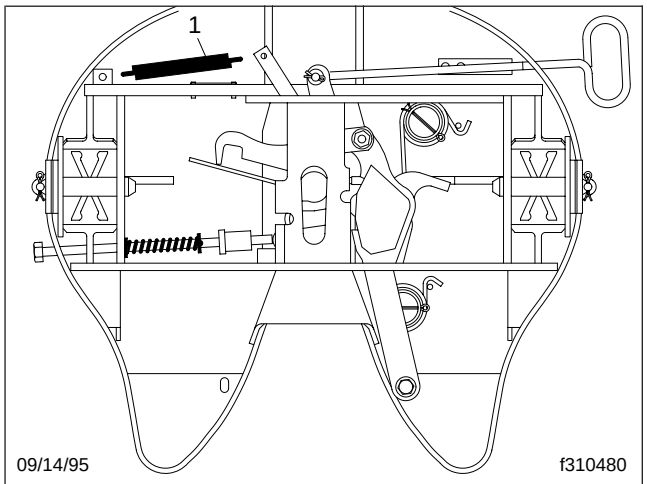
1. Cotter Pin, 3/16" x 1"
2. Lower Bracket Retainer Pin
3. Grease Fitting
4. Lower Bracket Pin
5. Wedge Stop Rod
6. Flatwasher
7. Wedge Stop Rod Spring
8. Nut, Wedge Stop Rod
9. Upper Assembly, Side Release
10. Leaf Spring
11. Thread-Cutting Screw, 1/4–20 x 3/8"
12. Step Jaw and Wedge
13. Jaw Spring
14. Cotter Pin, 1/4" x 3"
15. Timer
16. Wedge Spring
17. Pull Handle
18. Bumper Handle Spring
19. Hexhead Bolt, 1/2–13 x 2", Bumper Pivot
20. Bumper
21. Flatwasher
22. Bushing, 5/16", Bumper Pivot
23. Hex Locknut, 1/2–13
24. Bushing, 7/16", Handle Pivot
25. Operating Handle, Side Release Only
26. Hexhead Bolt, 1/2–13 x 2", Handle Pivot

Fig. 1, Fontaine H5092 Series Fifth Wheel (left-side release shown)



1. Bumper Spring

Fig. 2, Bumper Spring Removal

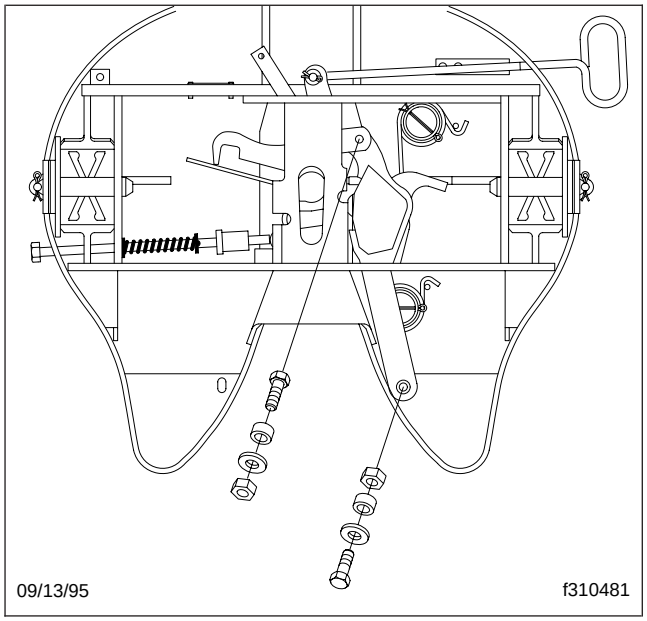


Fig. 3, Bolt Removal

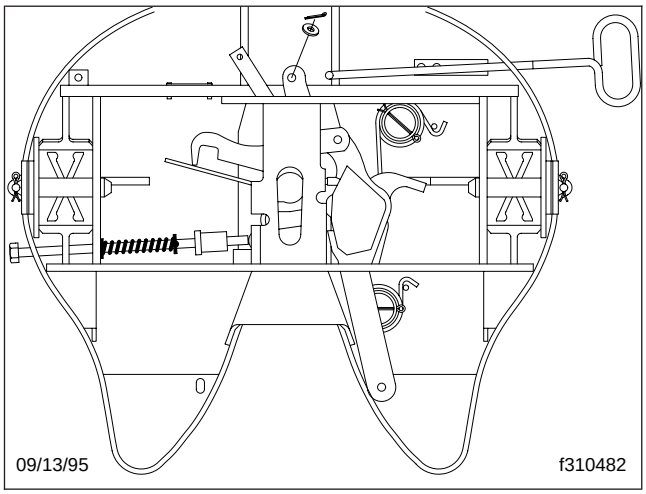
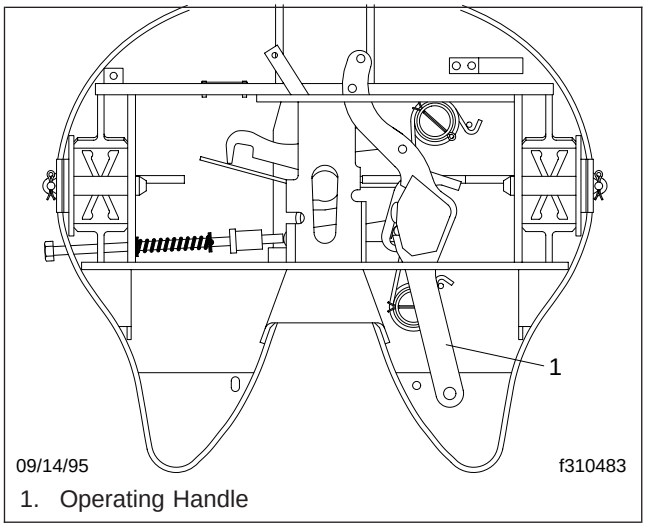


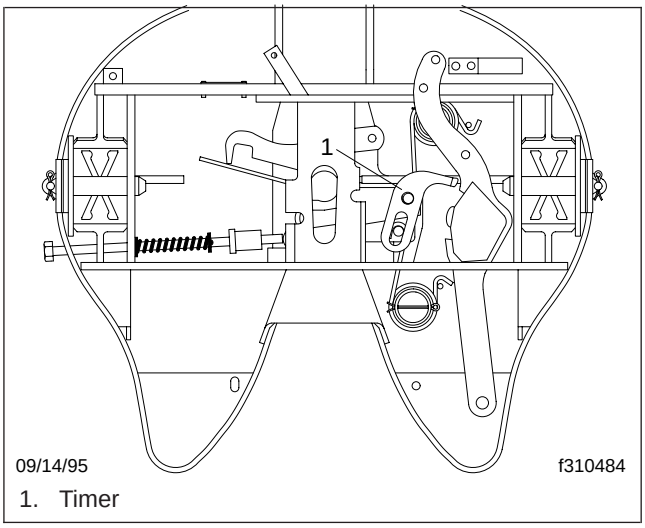
Fig. 4, Pull Handle Removal



1. Operating Handle

Fig. 5, Operating Handle Positioning

Removal and Disassembly



1. Timer

Fig. 6, Timer Removal

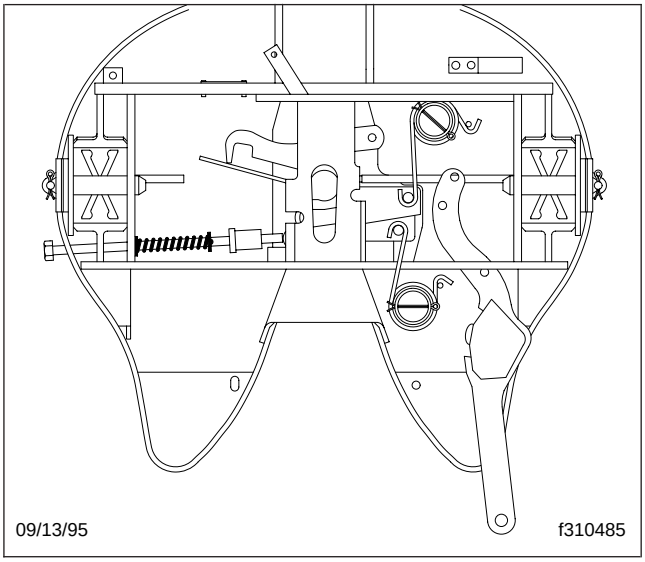
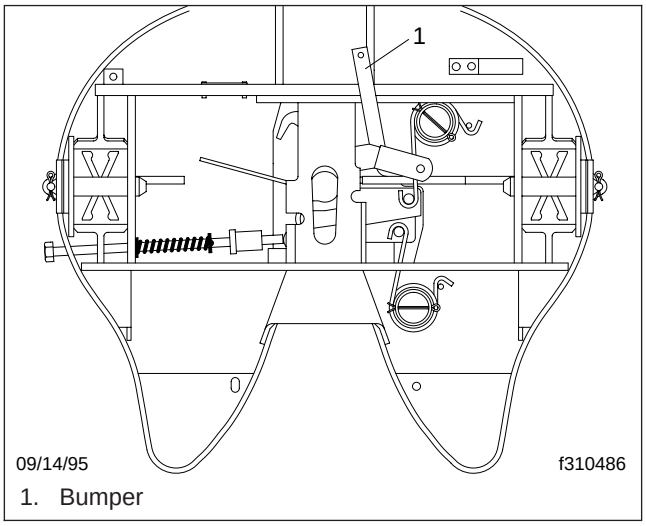


Fig. 7, Operating Handle Removal



1. Bumper

Fig. 8, Bumper Removal

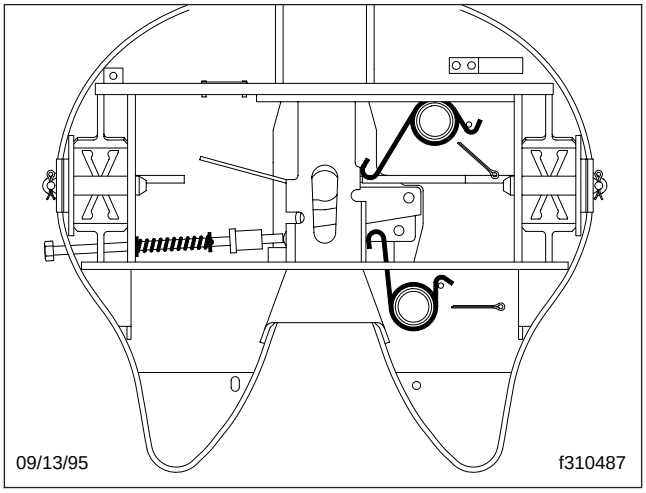


Fig. 9, Spring Removal

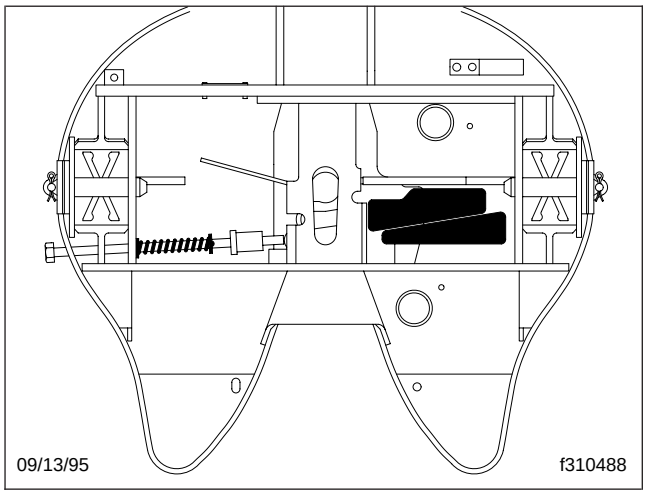


Fig. 10, Jaw and Wedge Removal

Assembly and Installation

See **Fig. 1** for an exploded view of a Fontaine H5092 fifth wheel.

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in possible disengagement of the trailer from the tractor, leading to personal injury and property damage.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

IMPORTANT: Replace any parts that show signs of wear, damage, or deterioration.

1. Clean all moving parts with no. 2 diesel fuel before assembly.
2. Always assemble the parts around a 2-inch kingpin or a shaft with a 2-inch diameter. Insert the jaw first and then the new wedge below it. Apply a moderate amount of grease having EP (extra pressure) additives to the sides and serrated edges of the jaw and wedge. Also apply grease to the stationary jaw in the throat of the fifth wheel. See **Fig. 2**.
3. Insert the new wedge spring through the slot in the rear crossmember and lay the coil over the spring boss. Using a spring tool, engage the small hooked tail of the wedge spring and wind it around until it is directly over the small stud at the back of the bracket. Using a hammer, nudge the spring downward allowing it to catch on the stud. Insert a new cotter pin. See **Fig. 3**.

   Repeat these steps to replace the jaw spring.

NOTE: The jaw spring has minimal tension and can be replaced by hand.

4. Place the bumper back in position, sliding the bumper tang through the operating handle guide slot and toward the tab on the side of the fifth wheel substructure. See **Fig. 4**.
5. Apply a liberal amount of grease to the grooved middle section of the operating handle, then insert the operating handle and move it over to the side of the wheel. See **Fig. 5**.
6. Insert the timer over the jaw and wedge studs. the small hole on the timer fits over the jaw stud and the slotted hole fits over the wedge stud. Be certain the small bent arm of the timer is facing downward. See **Fig. 6**.
7. Slide the operating handle toward the center of the wheel to engage the handle with the studs on the jaw and wedge. Slide the top part first. This will ensure that the grooves on the operating handle are aligned with the studs. A correctly aligned operating handle should be in a vertical position once it goes over the studs. See **Fig. 7**.
8. Slide the pull handle in through the safety lock and using the cotter pin and washer, fasten it in the top hole of the operating handle. See **Fig. 8**.
9. Align the bumper hole with the hole in the operating handle. Replace the bolts on the operating handle. The bolt which fastens the operating handle to the bumper must be inserted with the threads facing toward you to prevent interference with the jaw springs. The other bolt should be positioned with the threads facing downward. Each bolt has a nut, washer, and new bushings. Apply grease to the bolt parts and where there is metal to metal contact with the operating handle. See **Fig. 9**. Do not overtighten the bolts. Lubricate all pivot points.

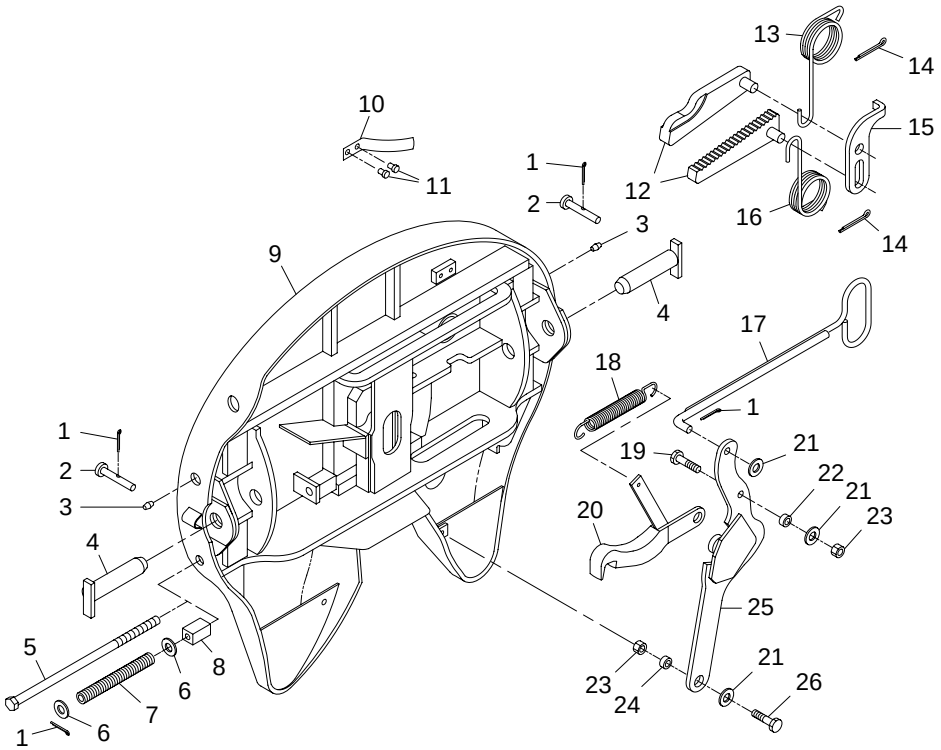
IMPORTANT: The fifth wheel must be well lubricated to operate correctly. Refer to Group 31 of the *Heavy-Duty Trucks Maintenance Manual* for complete maintenance and lubrication instructions for the fifth wheel assembly.

10. Connect the bumper spring to its clasp. See **Fig. 10**. Apply grease to the bracket pockets and to the grease fittings on the side of the fifth wheel until grease flows into the upper brackets. Also apply a liberal amount of grease to the top plate.

⚠ WARNING

If the fifth wheel does not operate properly, do not use it. The fifth wheel could malfunction, resulting in personal injury or property damage due to possible disengagement of the trailer from the tractor.

Fifth Wheel Assembly and Installation



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1. Cotter Pin, 3/16" x 1"
2. Lower Bracket Retainer Pin
3. Grease Fitting
4. Lower Bracket Pin
5. Wedge Stop Rod
6. Flatwasher
7. Wedge Stop Rod Spring
8. Nut, Wedge Stop Rod
9. Upper Assembly, Side Release
10. Leaf Spring
11. Thread-Cutting Screw, 1/4–20 x 3/8"
12. Step Jaw and Wedge
13. Jaw Spring
14. Cotter Pin, 1/4" x 3"
15. Timer
16. Wedge Spring
17. Pull Handle
18. Bumper Handle Spring
19. Hexhead Bolt, 1/2–13 x 2", Bumper Pivot
20. Bumper
21. Flatwasher
22. Bushing, 5/16", Bumper Pivot
23. Hex Locknut, 1/2–13
24. Bushing, 7/16", Handle Pivot
25. Operating Handle, Side Release Only
26. Hexhead Bolt, 1/2–13 x 2", Handle Pivot

Fig. 1, Fontaine H5092 Series Fifth Wheel (left-side release shown)

11. Using an overhead hoist, position the fifth wheel on the sliding mount assembly. Insert the bushing pins. Install the retaining pins and the 1-inch-long cotter pins.

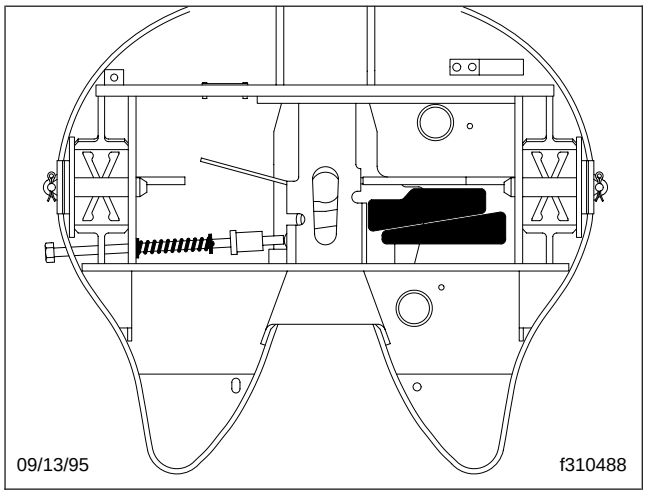


Fig. 2, Wedge and Jaw Installation

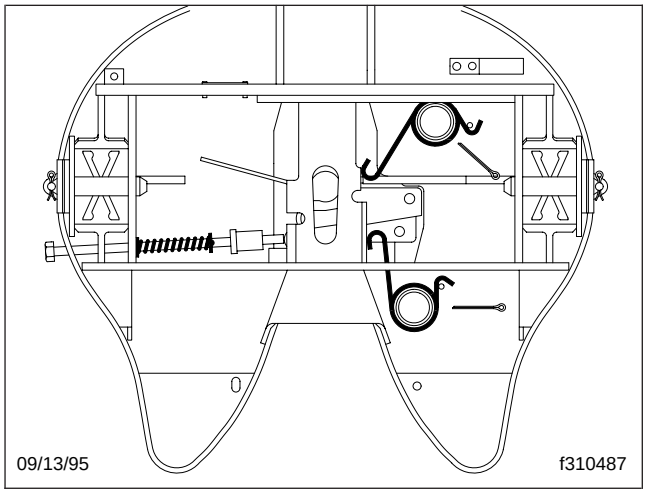


Fig. 3, Spring Installation

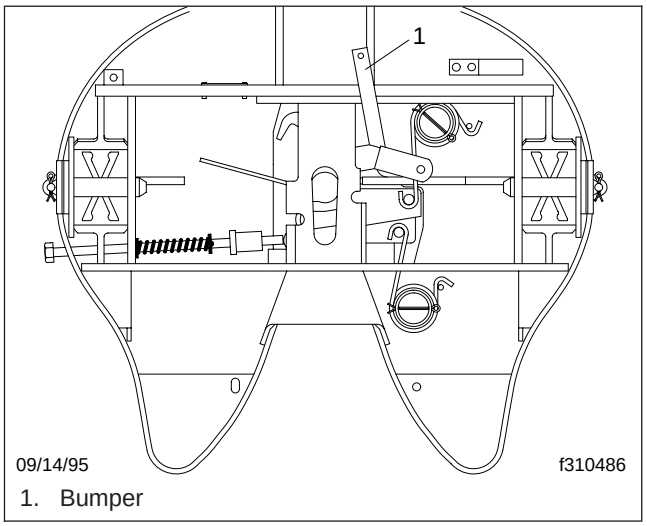


Fig. 4, Bumper Installation

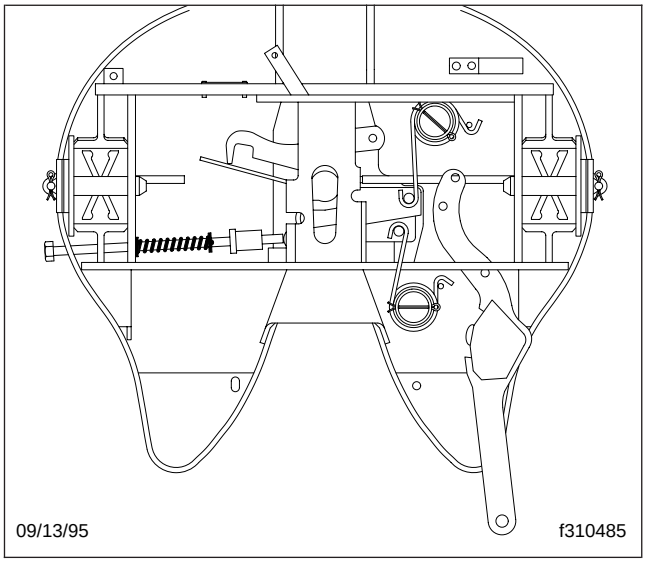
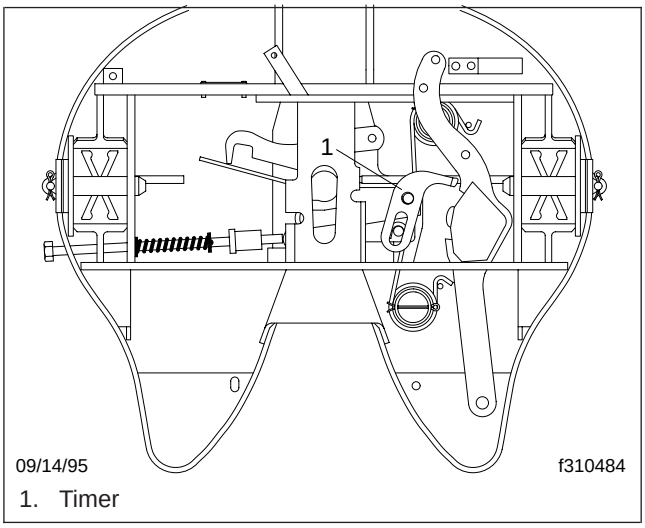


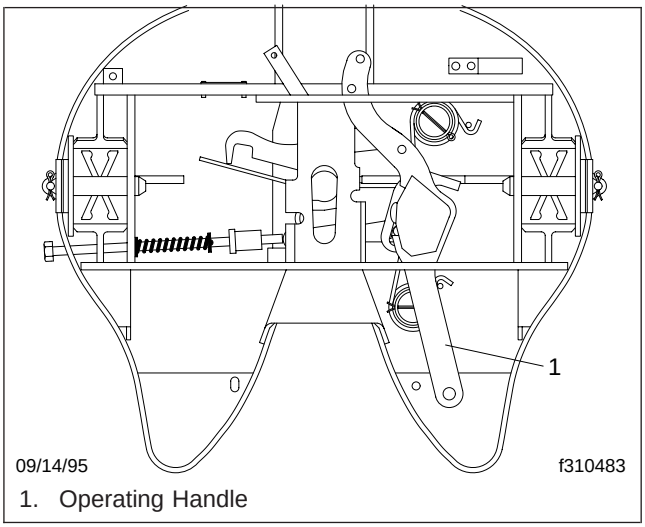
Fig. 5, Operating Handle Installation

Fifth Wheel Assembly and Installation



1. Timer

Fig. 6, Timer Installation



1. Operating Handle

Fig. 7, Operating Handle Positioning

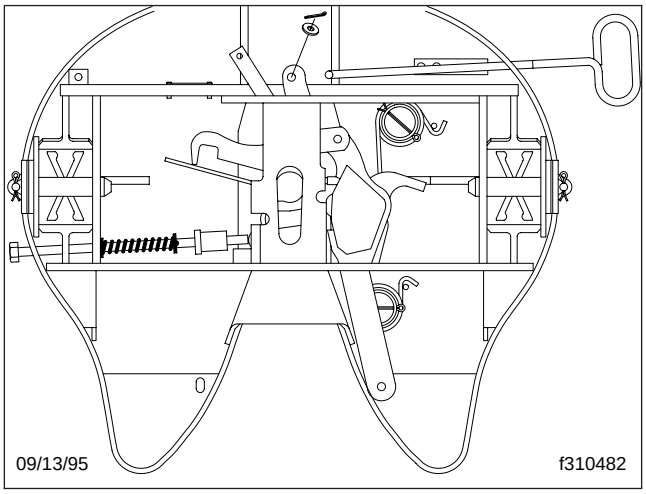


Fig. 8, Pull Handle Installation

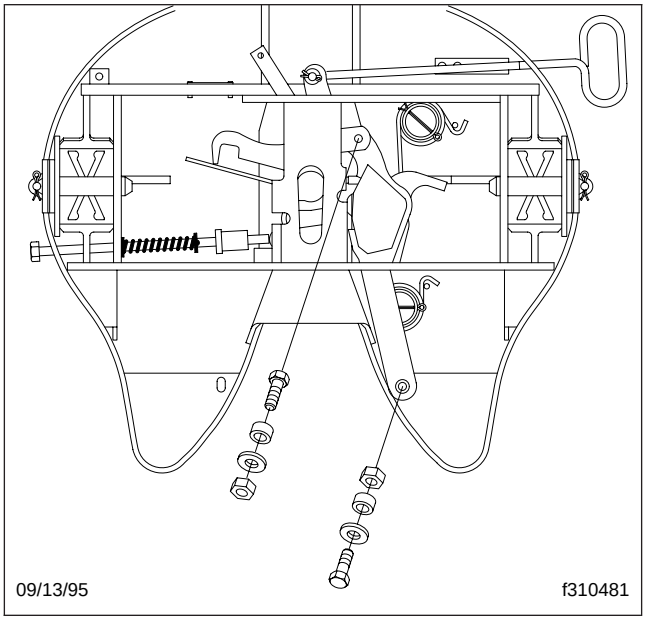
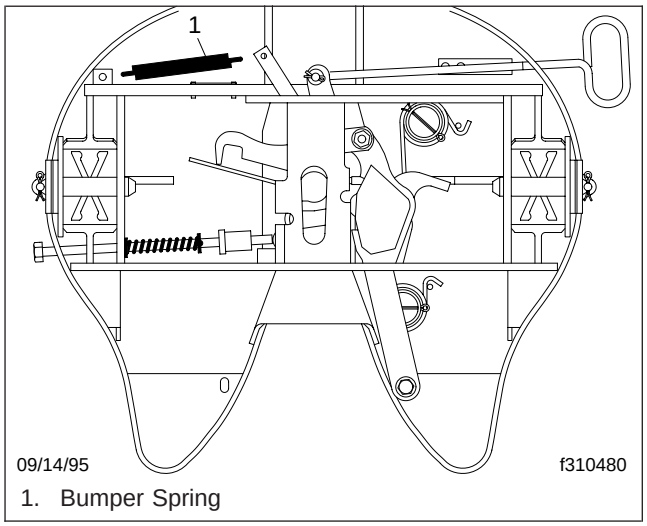


Fig. 9, Bolt Installation



1. Bumper Spring

Fig. 10, Spring Installation

Troubleshooting Tables

Problem—Difficulty Coupling

Possible Cause	Remedy
The kingpin is too high to trip the latch	Lower the landing gear.
The trailer plate or kingpin is damaged	Check the trailer plate for flatness. Check the kingpin for squareness with the trailer plate.

Problem—Excessive Wear on the Fifth Wheel Top Plate

Possible Cause	Remedy
Damaged trailer plate	If the trailer plate is not flat, replace it.

Problem—Difficulty Uncoupling

Possible Cause	Remedy
Pressure on the locking mechanism caused by the truck drifting apart from the trailer putting excess pressure on the lock	Back up the trailer and set the brakes. Strike the wedge stop rod which protrudes through the side of the fifth wheel. This spring-loaded rod will release the pressure on the locking mechanism.
Oval-shaped kingpin	Lower the landing gear.
Debris build-up in the grease	

Problem—Slack

Possible Cause	Remedy
Undersized kingpin	Replace the kingpin if worn greater than 1/8 inch (3 mm) at the 2-inch (5-cm) diameter.
Worn jaw and wedge	Jaw and wedge could have excessive wear. Replace them.

General Information

Fontaine 6000 and 7000 series fifth wheels couple to trailers having a standard 2-inch kingpin. When installed as a stationary mount, the fifth wheel is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. Sliding fifth wheels are mounted on the Fontaine AWB or MWS model slide mounts.

The Fontaine fifth wheel lock mechanism for the trailer kingpin consists of a spring-loaded jaw and sliding wedge. Kingpin release is accomplished by pulling a manual lock control handle located on either the right side (curbside) or left side (roadside) of the fifth wheel. Kingpin coupling occurs when the kingpin enters the throat of the fifth wheel, triggers the jaw and wedge to slide into place behind the kingpin, and moves the lock control handle into the locked position.

As the kingpin enters the lock mechanism, the jaw is moved first with the spring-loaded wedge sliding in place against the jaw. The jaw will move behind the kingpin, followed by the wedge. The wedge reinforces the jaw and automatically adjusts for slack around the kingpin. See **Fig. 1** for an illustration of the jaw and wedge in the locked position.

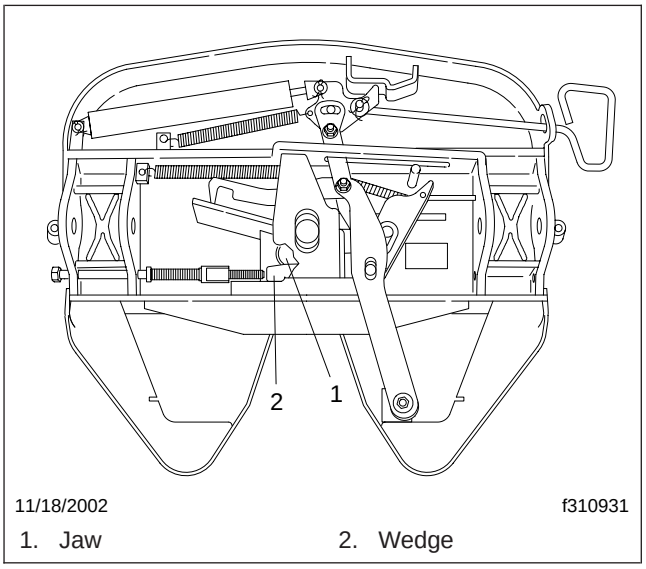


Fig. 1, Locked Position

Placing the lock control handle in the unlocked position moves the wedge and jaw out from behind the kingpin and unlocks the fifth wheel. See **Fig. 2** for an illustration of the jaw and wedge in the unlocked position.

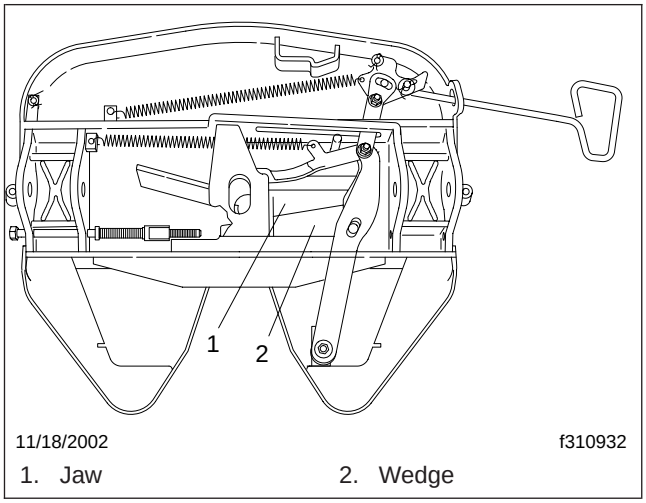


Fig. 2, Unlocked Position

Fifth Wheel Removal and Disassembly

See **Fig. 1** for an exploded view of a Fontaine® 6000 or 7000 No-Slack II series fifth wheel.

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in disengagement of the trailer from the tractor, leading to personal injury or property damage.

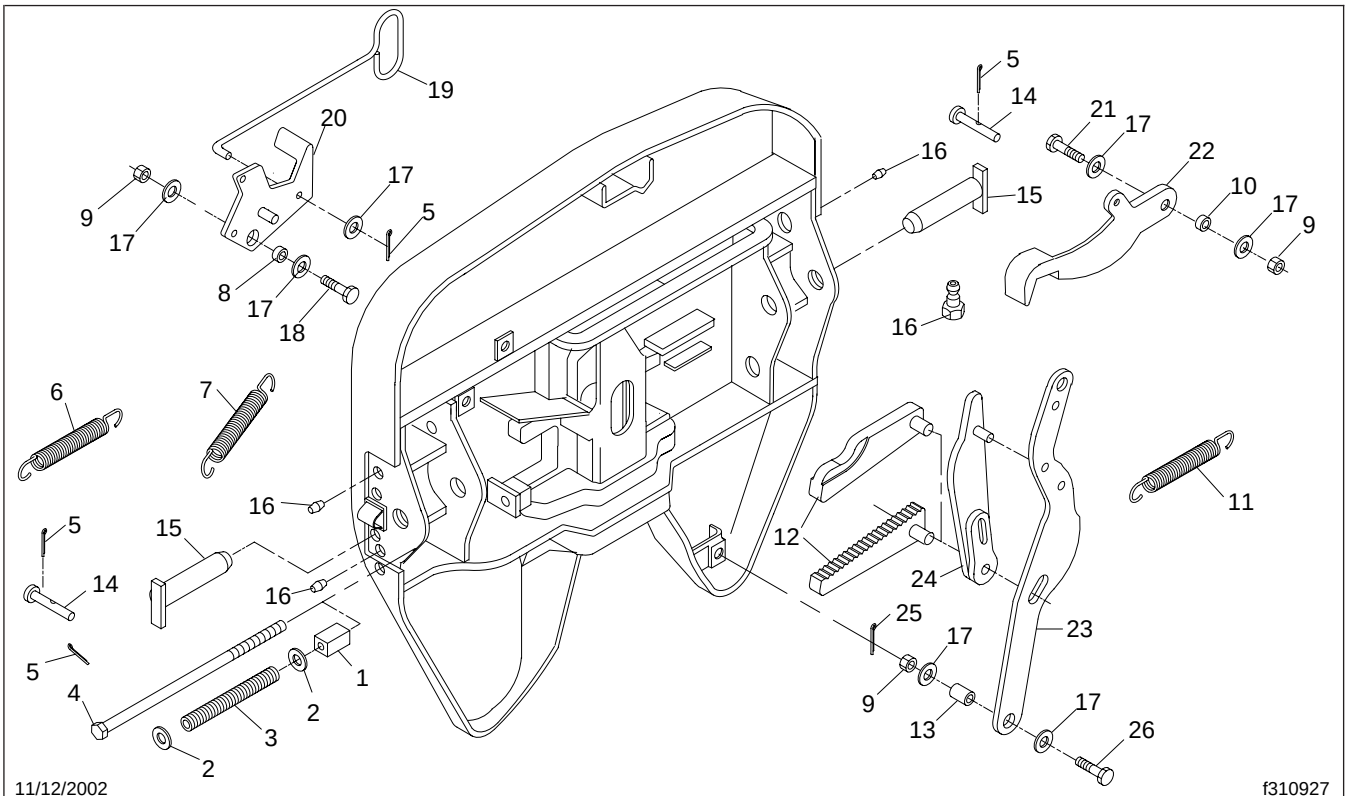
Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

1. Steam clean the top plate. Remove it from the sliding mount by removing the cotter pins from the retaining pins. Remove the retaining pins and bushing pins from both sides of the top plate.
2. Using an overhead hoist, lift the fifth wheel off the sliding mount and tractor frame.
3. Turn the fifth wheel upside down.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

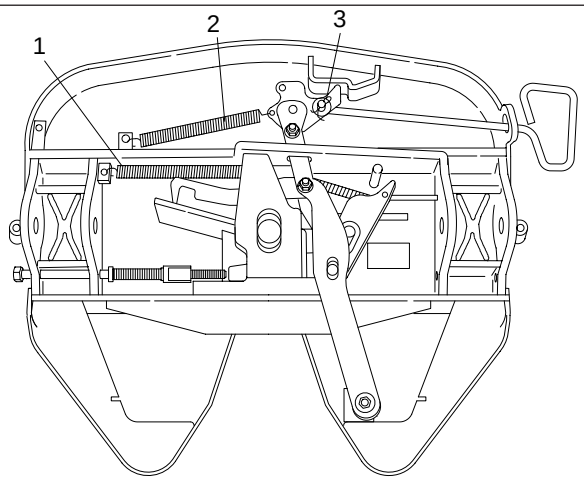
4. Remove the secondary lock spring and bumper spring. See **Fig. 2**. Remove the pull-handle cotter pin and washer, then slide out the pull handle.
5. Unbolt and remove the secondary lock from the operating handle. Discard the locknut and bushing. See **Fig. 3**.
6. Unbolt and remove the bumper from the operating handle. Discard the locknut and bushing. See **Fig. 4**.
7. Unbolt the operating handle from the pivot mount and remove. Discard the locknut. See **Fig. 5**.
8. Remove the timer spring and timer. See **Fig. 6**.
9. Remove the jaw and wedge. See **Fig. 7**.

Removal and Disassembly



1. Wedge Stop Rod Nut
2. Flatwasher, 5/8", Plain
3. Wedge Stop Rod Spring
4. Wedge Stop Rod
5. Cotter Pin, 3/16 x 1"
6. Bumper Spring
7. Handle Spring
8. Bushing, 7/16"
9. Hex Locknut, 1/2–13
10. Bushing, 5/16"
11. Timer Spring
12. Step Jaw and Wedge Set
13. Bushing
14. Bracket Retainer Pin
15. Bracket Pin
16. Grease Fitting
17. Flatwasher, 1/2" I.D. x 1-3/4" O.D., Plain
18. Hexhead Bolt, 1/2–13 x 1-1/2", Grade 5
19. Pull Handle
20. Secondary Lock
21. Hexhead Bolt, 1/2–13 x 1-3/4", Grade 5
22. Bumper
23. Operating Handle
24. Timer
25. Hairpin Cotter Pin
26. Hexhead Bolt, 1/2–13 x 2-3/4", Grade 5

Fig. 1, Fontaine 6000 and 7000 No-slack II Series Fifth Wheel (left-side release shown)



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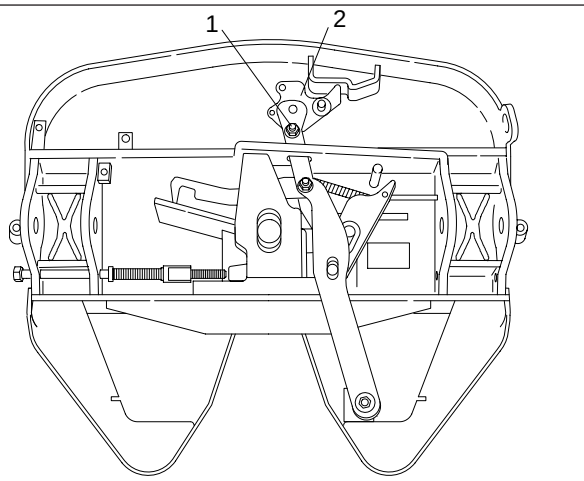
1. Bumper Spring
2. Secondary Lock Spring
3. Pull-Handle Cotter Pin

Fig. 2, Pull Handle



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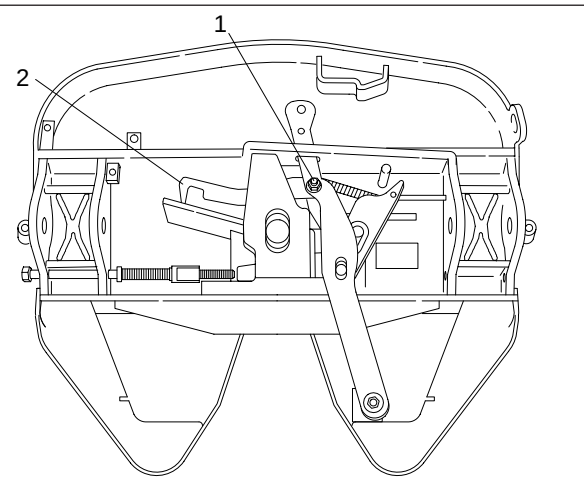
1. Bolt
2. Secondary Lock

Fig. 3, Secondary Lock



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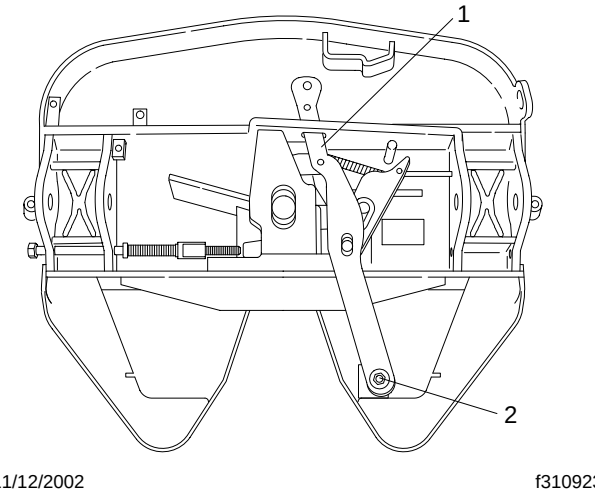
1. Bolt
2. Bumper

Fig. 4, Bumper



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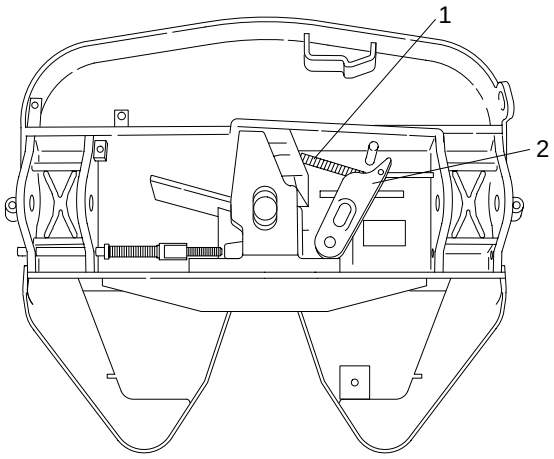
1. Operating Handle
2. Bolt

Fig. 5, Operating Handle

Removal and Disassembly



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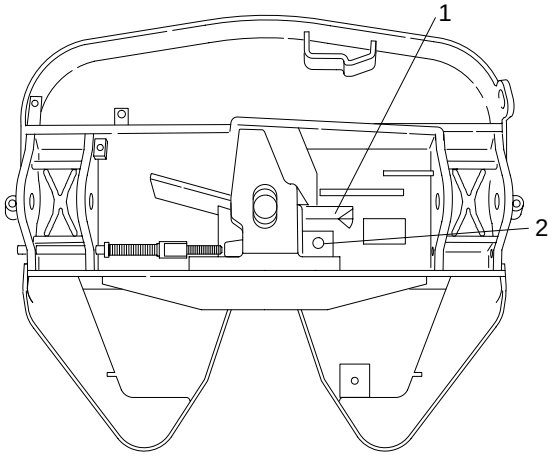
1. Timer Spring
2. Timer

Fig. 6, Timer Spring and Timer



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1. Jaw
2. Wedge

Fig. 7, Jaw and Wedge

Assembly and Installation

⚠ WARNING

Before rebuilding the fifth wheel assembly, make sure that there are no cracks in the frame crossmembers or other frame components and fifth wheel mounting components. Also check the fifth wheel bracket pin holes to ensure they are not worn oversize (pins should fit snugly). Under no circumstances should a fifth wheel be repaired or used if any component (crossmember, saddle bearing, etc.) is cracked. Operating a fifth wheel with damaged components could result in disengagement of the trailer from the tractor, leading to personal injury or property damage.

Use a Moly-based lubricant such as Mobil grease Moly 50 or equivalent when applying lubricant to the locking jaw and wedge. Lightly oil other moving parts in the fifth wheel.

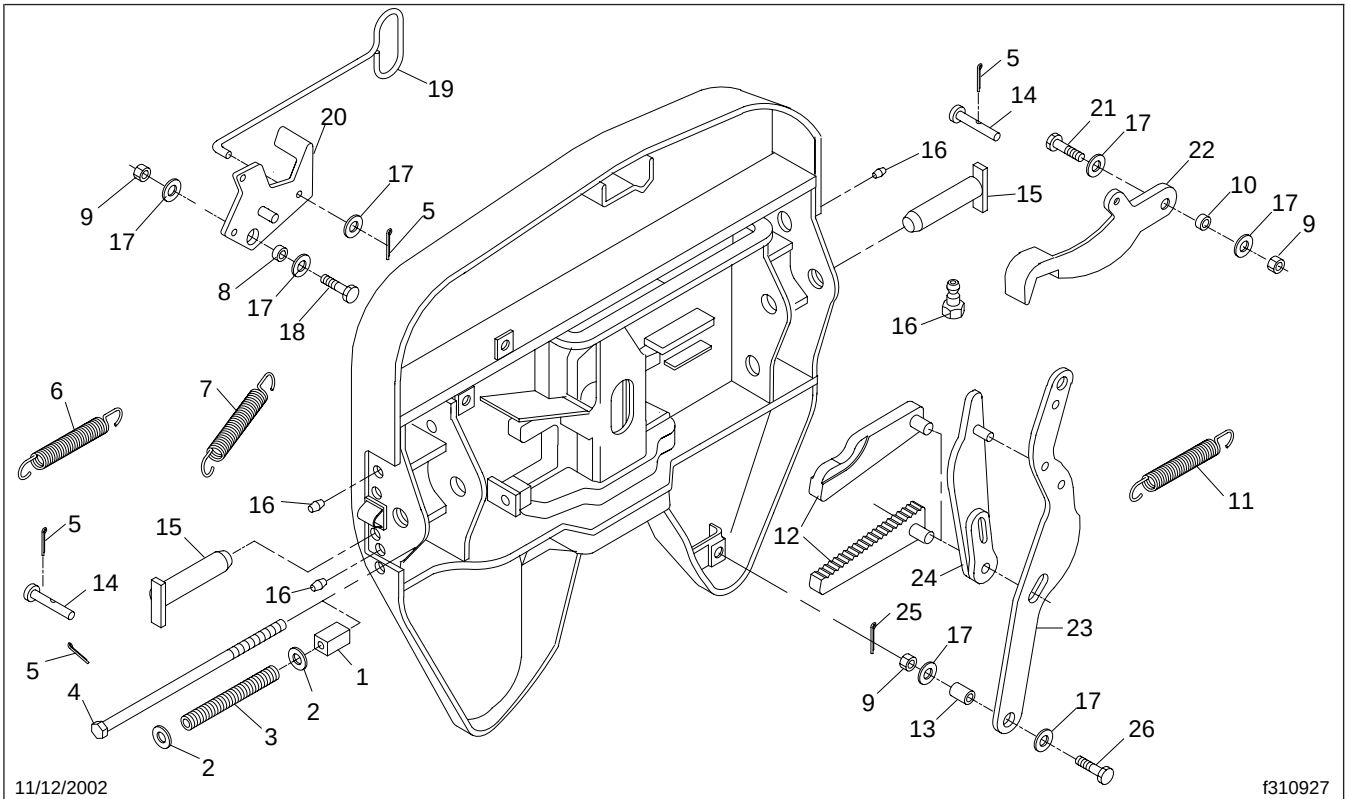
See **Fig. 1** for an exploded view of a Fontaine® 6000 or 7000 No-Slack II series fifth wheel.

1. Always assemble parts around a 2-inch kingpin or a 2-inch diameter shaft. Insert the jaw first, then the wedge below it. See **Fig. 2**. Grease the jaw and wedge on the top and bottom.
2. Install the timer and the timer spring. See **Fig. 3**.
3. Install the operating handle, and bolt it to the pivot mount. See **Fig. 4**. Use the existing bolt, washer, hairpin cotter pin and bushing. Inspect the bushing for wear before using it and replace it if necessary. Use the new locknut that is supplied in the repair kit. Note the orientation of the bolt (**Fig. 1**).
4. Install the bumper, and bolt it to the operating handle. See **Fig. 5**. Use the existing bolt and washers (inspect for wear before using and replace if necessary). Use the new locknut and bushing that is supplied in the repair kit. Note the orientation of the bolt (**Fig. 1**). After installing the bumper, check to make sure that it can pivot freely.
5. Insert the secondary lock and bolt it to the operating handle. See **Fig. 6**. Use the existing bolt and washers (inspect for wear before using and replace if necessary). Use the new locknut and bushing that is supplied in the repair kit. Note the orientation of the bolt (**Fig. 1**).
6. Install the pull handle. See **Fig. 7**. Use the existing washer and cotter pin (inspect for wear before using and replace if necessary). Attach the new secondary lock/bumper spring that is supplied in the repair kit. Open and close the fifth wheel to ensure that it works properly. The fifth wheel must be properly lubricated before opening and closing the wheel.

Use a Moly-based lubricant such as Mobil grease Moly 50 or equivalent when applying lubricant to the locking jaw and wedge. Lightly oil other moving parts in the fifth wheel.

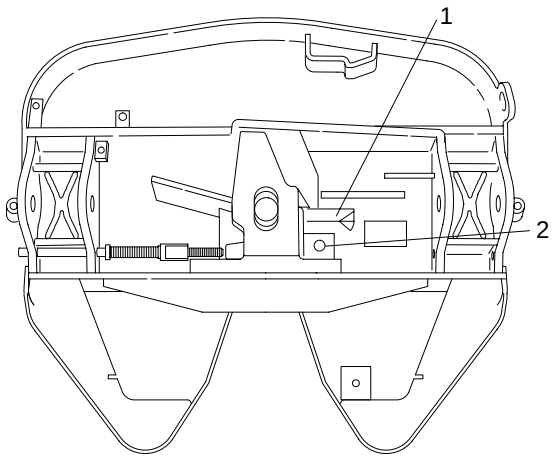
7. Close the fifth wheel several times with a standard 2-inch kingpin tool. With the lock closed, adjust the wedge stop rod so that the end is 1/4 inch (6 mm) from the wedge. See **Fig. 8**.
8. Using an overhead hoist, position the fifth wheel on the sliding mount assembly. Insert the bushing pins. Install the retaining pins and the 1-inch-long cotter pins.

Assembly and Installation



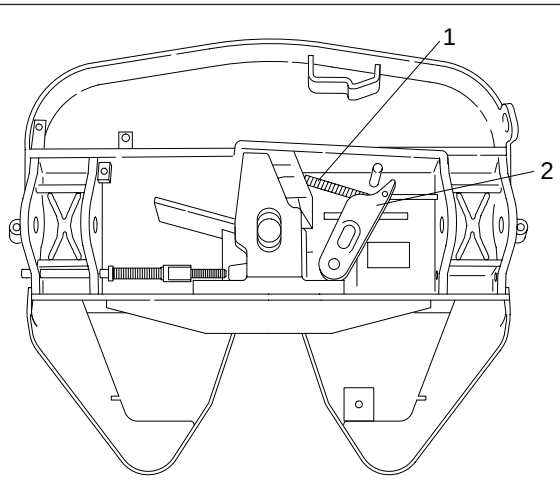
1. Wedge Stop Rod Nut
2. Flatwasher, 5/8", Plain
3. Wedge Stop Rod Spring
4. Wedge Stop Rod
5. Cotter Pin, 3/16 x 1"
6. Bumper Spring
7. Handle Spring
8. Bushing, 7/16"
9. Hex Locknut, 1/2–13
10. Bushing, 5/16"
11. Timer Spring
12. Step Jaw and Wedge Set
13. Bushing
14. Bracket Retainer Pin
15. Bracket Pin
16. Grease Fitting
17. Flatwasher, 1/2" I.D. x 1-3/4" O.D., Plain
18. Hexhead Bolt, 1/2–13 x 1-1/2", Grade 5
19. Pull Handle
20. Secondary Lock
21. Hexhead Bolt, 1/2–13 x 1-3/4", Grade 5
22. Bumper
23. Operating Handle
24. Timer
25. Hairpin Cotter Pin
26. Hexhead Bolt, 1/2–13 x 2-3/4", Grade 5

Fig. 1, Fontaine 6000 and 7000 No-slack II Series (left side release shown)



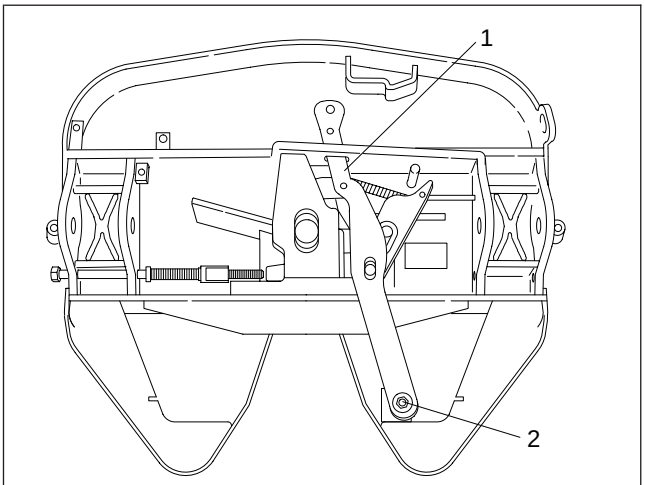
1. Jaw
2. Wedge

Fig. 2, Jaw and Wedge



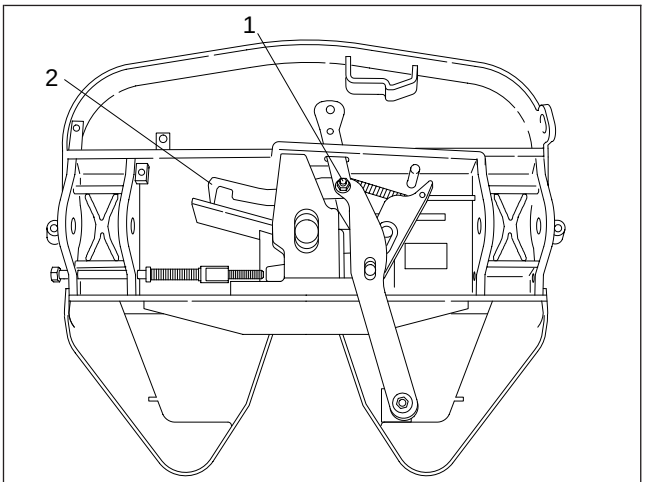
1. Timer Spring
2. Timer

Fig. 3, Timer Spring and Timer



1. Operating Handle
2. Bolt

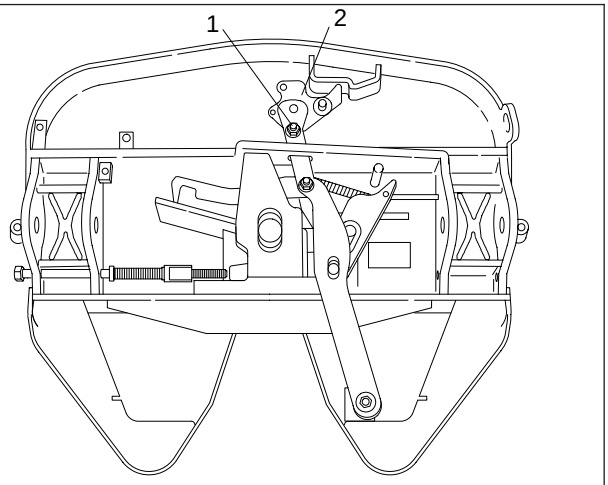
Fig. 4, Operating Handle



1. Bolt
2. Bumper

Fig. 5, Bumper

Assembly and Installation



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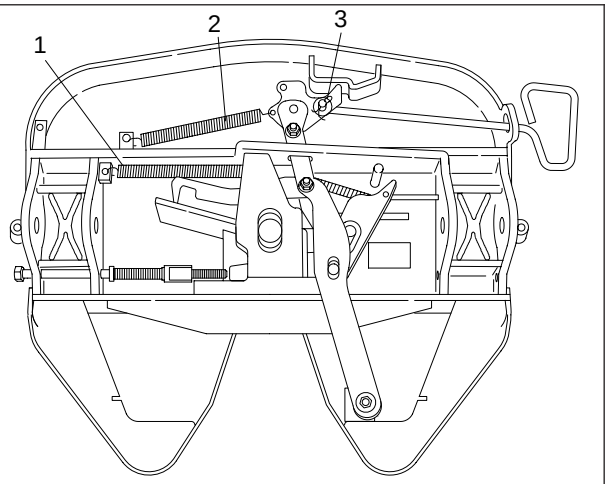
1. Bolt
2. Secondary Lock

Fig. 6, Secondary Lock



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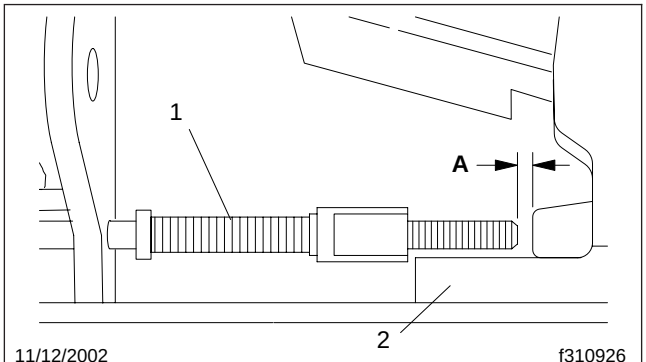
1. Bumper Spring
2. Secondary Lock Spring
3. Pull-Handle Cotter Pin

Fig. 7, Pull Handle



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A. 1/4 inch (6 mm)
1. Stop Rod
2. Wedge

Fig. 8, Wedge Stop Rod Adjustment

Troubleshooting Tables

Problem—Difficulty Coupling

Possible Cause	Remedy
The kingpin is too high to trip the latch	Lower the landing gear.
The trailer plate or kingpin is damaged	Check the trailer plate for flatness. Check the kingpin for squareness with the trailer plate.

Problem—Excessive Wear on the Fifth Wheel Top Plate

Possible Cause	Remedy
Damaged trailer plate	If the trailer plate is not flat, replace it.

Problem—Difficulty Uncoupling

Possible Cause	Remedy
Pressure on the locking mechanism caused by the truck drifting apart from the trailer, putting excess pressure on the lock	Back up the trailer and set the brakes. Strike the wedge stop rod which protrudes through the side of the fifth wheel. This spring-loaded rod will release the pressure on the locking mechanism.
Oval-shaped kingpin	Lower the landing gear.
Debris build-up in the grease	

Problem—Slack

Problem—Slack	
Possible Cause	**Remedy**
Undersized Kingpin.	Replace the Kingpin if it is worn greater than 1/8 inch (3.2 mm) at the 2-inch (5-cm) diameter.
Worn jaw and wedge.	The jaw and wedge could have excessive wear. Replace them.

General Information

Standard Freightliner front suspensions (see **Fig. 1** or **Fig. 2**) use either tapered leaf spring assemblies or flat leaf spring assemblies.

Shock absorbers are standard with tapered leaf spring assemblies, and are optional with flat leaf spring assemblies.

The spring assemblies are attached to the axle with U-bolts, hardened washers, and high nuts. The forward end of each spring contains a bushing and a spring pin, that mount to a stationary front suspension bracket. The rear of each spring mounts to a pair of spring shackles that are suspended from a frame-mounted bracket. The rear spring eye and shackle bracket each contain a bushing and a spring pin to allow the spring shackles to pivot. The spring shackles allow for variations in spring length during spring flexing.

The leaf spring assembly absorbs and stores energy, then releases it. The individual leaves are held together by a center bolt, with the center bolt head used as a locating dowel during installation on the vehicle. On the front end of the leaf spring assembly is an alignment clip. Alignment clips limit lateral spread and vertical separation of the individual leaves.

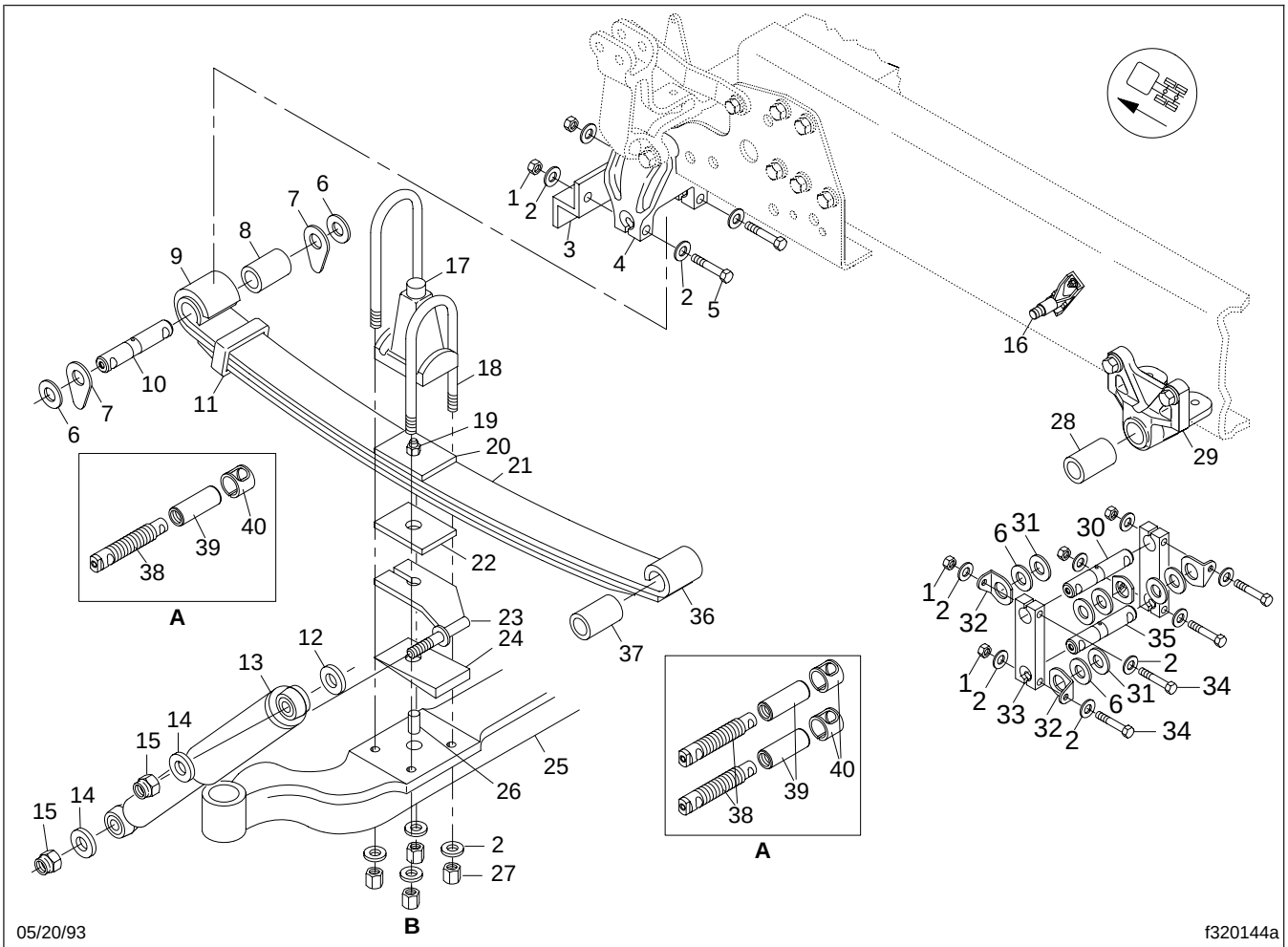
Nonthreaded, steel spring pins with an annular lubrication groove are available for all vehicle models. Bronze bushings are used with these pins. The bronze bushings used with 12,000-pound front tapered leaf springs are graphite impregnated and have a grease seal at each end.

NOTE: The spring pins used on some older vehicles do not have the annular groove.

Threaded spring pins with threaded steel bushings are available with 12,000-pound or 14,000-pound front tapered or flat leaf suspensions.

NOTE: FLD 120 Conventionals with a setback axle may have the same frame configuration and front suspension bracket as the FLD 112 Conventionals, or they may have a drop-style frame extension with a different type of front suspension bracket. D2 Classic vehicles have a front suspension bracket that also serves as a frame rail extension. See **Fig. 3**.

General Information

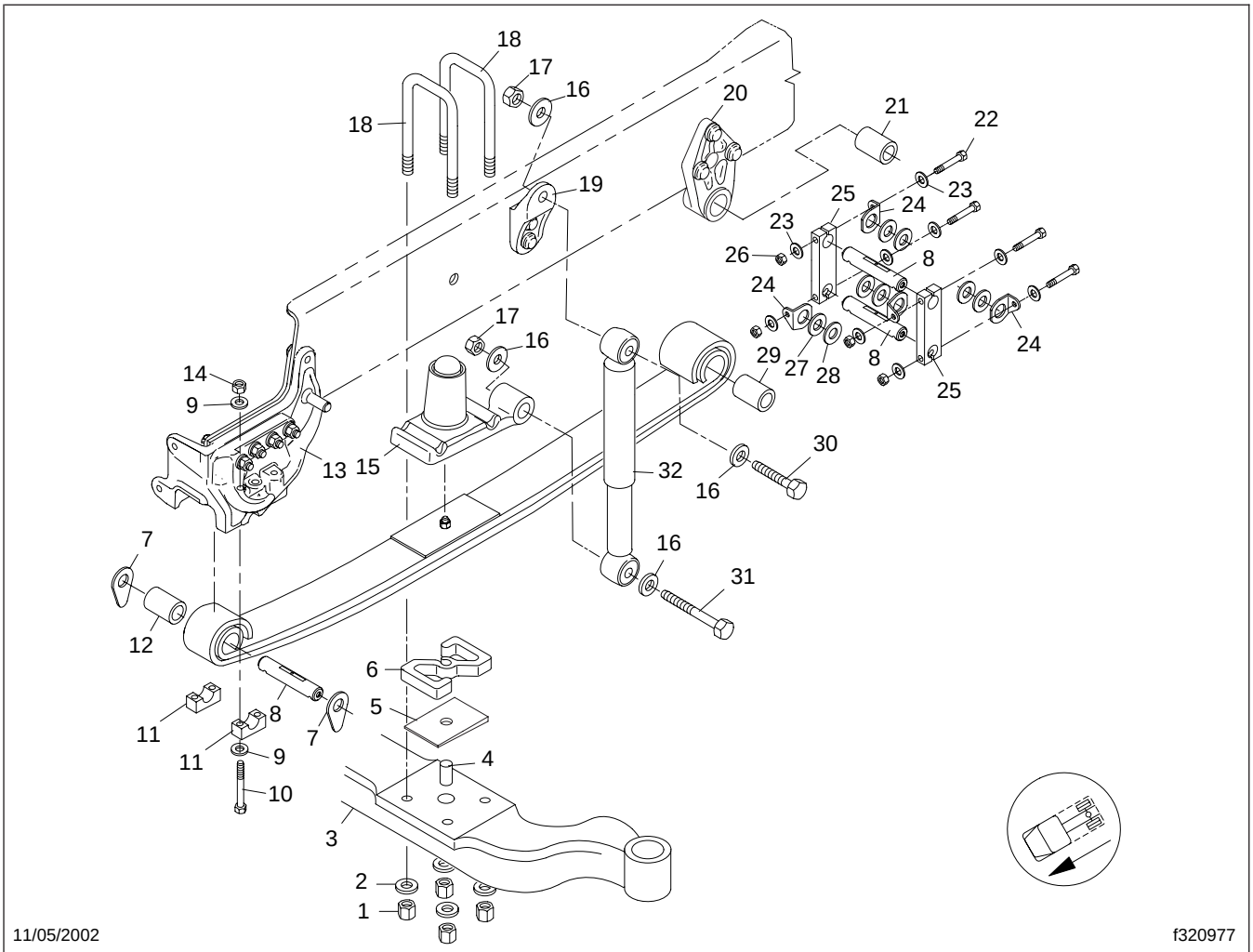


A. Optional Threaded Pins and Bushings

B. FLA COE With Set-Forward Axle Shown

1. Self-Locking Nut, 1/2–13
2. Hardened Washer
3. Bumper Mounting Z-Bracket
4. Front Suspension Bracket
5. Pinch-Bolt, 1/2–13 x 4"
6. Spacing Washer(s)
7. Spring Spacer
8. Spring Bushing, Forward Spring Eye
9. Forward Spring Eye
10. Spring Pin, Forward Spring Eye
11. Spring Leaf Alignment Clip
12. Washer, 1" i.d., 2" o.d.
13. Shock Absorber
14. Washer, 3/4" i.d., 2" o.d.
15. Self-Locking Nut, 3/4–16
16. Shock Absorber Upper Bracket
17. Axle Stop
18. U-Bolt
19. Spring Center-Bolt and Center-Bolt Nut
20. Spring Spacer Plate
21. Tapered Leaf Spring Assembly
22. Axle Spacer
23. Shock Absorber Lower Bracket
24. Caster Shim
25. Front Axle
26. Dowel Pin
27. U-Bolt High Nut
28. Bushing, Shackle Bracket
29. Shackle Bracket
30. Spring Pin, Shackle Bracket
31. Hardened Washer, 2-1/4" o.d.
32. Wear Plate
33. Shackle
34. Pinch-Bolt, 1/2–13 x 3"
35. Spring Pin, Rear Spring Eye
36. Rear Spring Eye
37. Spring Bushing, Rear Spring Eye
38. Threaded Spring Pin
39. Threaded Bushing
40. Split Ring

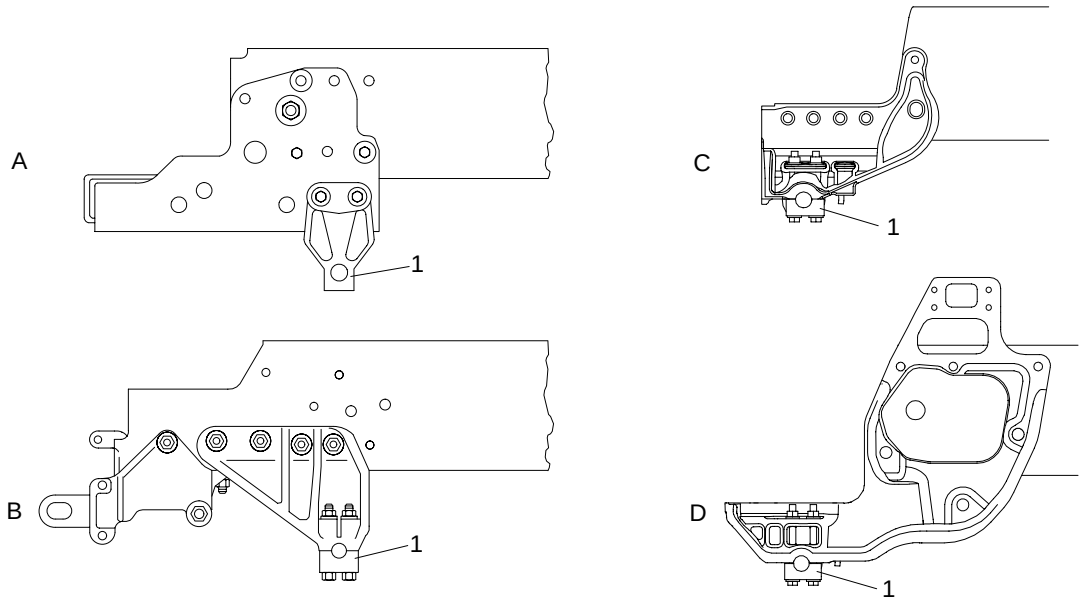
Fig. 1, Front Suspension Components (FLD Conventional and FLB COE)



1. U-Bolt High Nut
2. Hardened Washer
3. Front Axle Beam
4. Dowel Pin
5. Caster Shim
6. Axle Spacer
7. Spring Spacer
8. Spring-Eye Pin
9. Hardened Washer
10. Hexbolt, 1/2–13 (4 qty.)
11. Front Suspension Bracket Cap
12. Spring Bushing, Forward Spring Eye
13. Front Suspension Bracket
14. Locknut, 1/2–13
15. Axle Stop
16. Hardened Washer
17. Hexnut, 3/4–16
18. U-Bolt
19. Shock Absorber Upper Bracket
20. Shackle Bracket
21. Bushing, Shackle Bracket
22. Pinch-Bolt, 1/2–13 x 3"
23. Flatwasher
24. Wear Plate
25. Shackle
26. Hexnut, 1/2–13
27. Spacing Washer
28. Hardened Washer, 2-1/4"
29. Bushing, Rear Spring Eye
30. Hexbolt, 3/4–16 x 3"
31. Hexbolt, 3/4–16 x 5"
32. Shock Absorber

Fig. 2, Front Suspension Components (D2 Classic vehicle)

General Information



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A. With Drop-Style Frame Extension (FLD 120 Conventional only)
B. Without Drop-Style Frame Extension (FLD 120 and FLD 112 Conventionals)
C. D2 Classic Vehicles (with 1200 sq. in. radiator)
D. D2 Classic Vehicles (with 1400 sq. in. radiator)

1. Front Suspension Bracket

Fig. 3, Front Suspension Brackets

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

Removal

NOTE: See **Fig. 1** or **Fig. 2** for this procedure.

1. For a set-forward axle vehicle with an 8-1/2 inch bumper, the front suspension bracket pinch bolts are installed from the front, and the front bumper will interfere with their removal. Remove the fog lights from the bumper; secure the lights out of the way so they aren't dangling from their wires. Remove the front bumper.

Make sure the frame rails are level and an equal distance off the ground.

2. Apply the parking brakes, and chock the rear tires. Raise the front of the vehicle until both wheels are off the ground and the frame is supported with safety stands. The axle and leaf springs can then be manipulated with the floor jack.

⚠ WARNING

Safety stands must securely support all axle and frame weight during suspension repairs. Unsecured components may drop when fasteners are loosened or removed, possibly causing serious personal injury and component damage.

3. For a COE, tilt the cab, following the instructions in the cab group of this manual. This will allow access to the spring shackle.
4. Remove the U-bolts and axle stop from the leaf spring assembly.
5. For an FLB COE or an FLD 120 Conventional with a drop-style frame extension, remove the self-locking nuts, pinch bolts, and hardened washers from the front suspension bracket. If so equipped, remove the bumper mounting Z-bracket, noting its position for later installation.

   For an FLD 112 Conventional, an FLD 120 Conventional without a drop-style frame extension, or a D2 Classic vehicle, remove the locknuts, hardened washers, hexbolts, and both bracket caps from the front suspension bracket. See **Fig. 3**. For vehicles with non-threaded spring pins, remove the spacing washers from the spring pin, and keep them for later installation.
6. If the spring pin is threaded, unscrew it from the bushing.

   If the spring pin is nonthreaded, drive it outboard with a suitable drift, then remove it.

   For an FLB COE, an FLD 120 Conventional with a drop-style frame extension, remove all spacing washers (used only with non-threaded pins) and spring spacers from both sides of the spring eye, and keep them with the pin for later installation.
7. Remove the pinch bolts, hardened washers, and locknuts securing the rear spring eye spring pin in the shackles.
8. If the spring pin is threaded, unscrew it from the bushing.

   If the spring pin is nonthreaded, drive it outboard with a suitable drift, then remove it from the shackles and the rear spring eye.

   Remove all the spacing washers, hardened washers, and wear plates (used only with non-threaded pins), and keep them with the pin for later installation.
9. Lift the spring assembly slightly and move it toward the front of the truck. If needed, remove the axle spacer, shock absorber lower bracket, and the caster shim. Note the taper direction of the caster shim so that it will not inadvertently be reversed during installation.
10. If the shackle bracket spring pin or shackle bracket bushing is to be checked for condition or replaced, remove the spring pin:

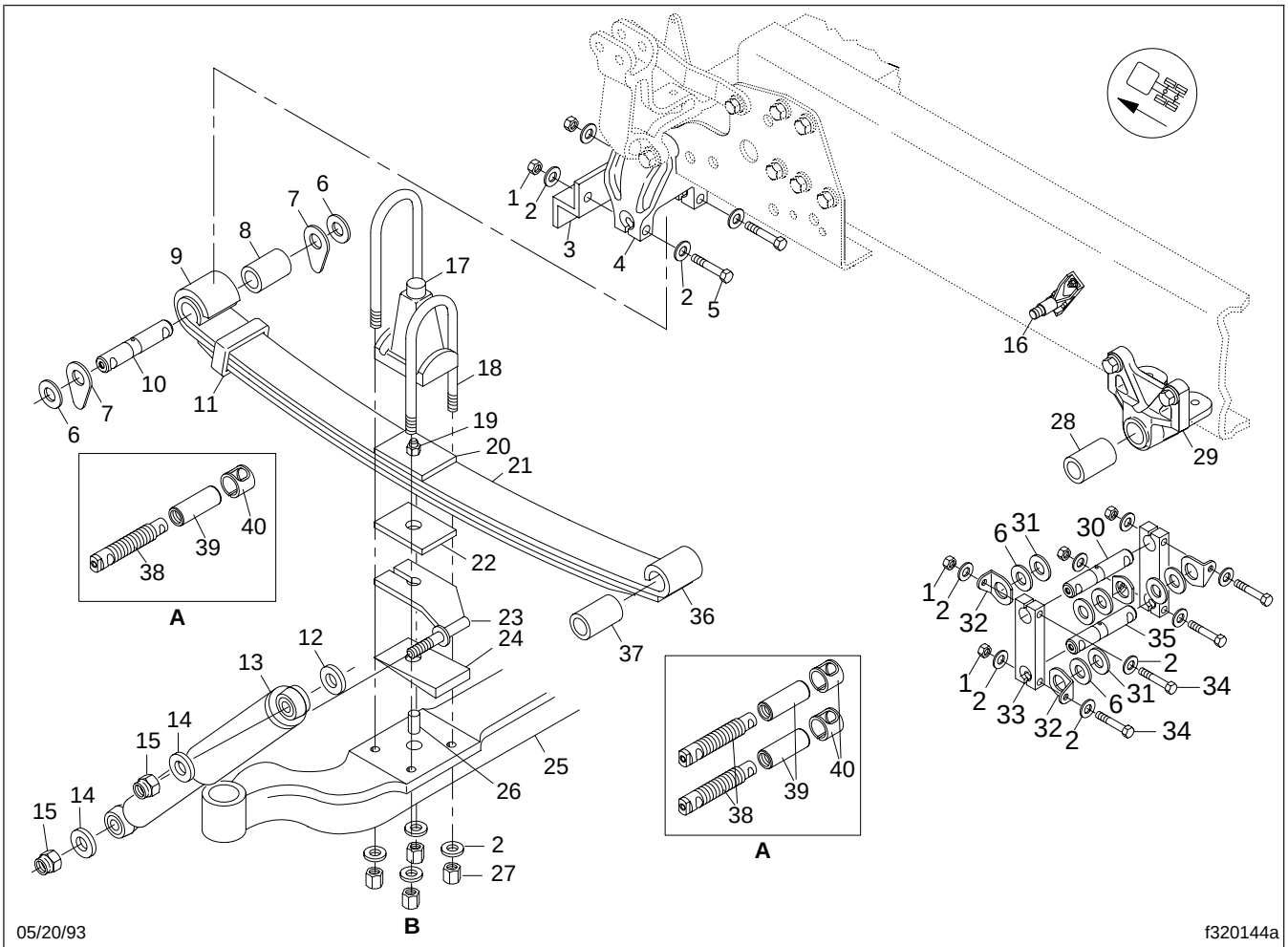
    10.1 Remove the pinch bolts, hardened washers, and locknuts.

    10.2 Pull the shackle, wear plate, hardened washers, and spacing washer(s) from each end of the pin.

    10.3 If the spring pin is threaded, unscrew it from the bushing.

    If the spring pin is nonthreaded, drive it outboard with a suitable drift, then remove it.
11. If inspection shows the shackle bracket bushing needs to be replaced (see "Cleaning and Inspection"); or if the shackle bracket is to be inspected thoroughly, remove the fasteners that secure the shackle bracket to the frame, and remove the bracket.

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation



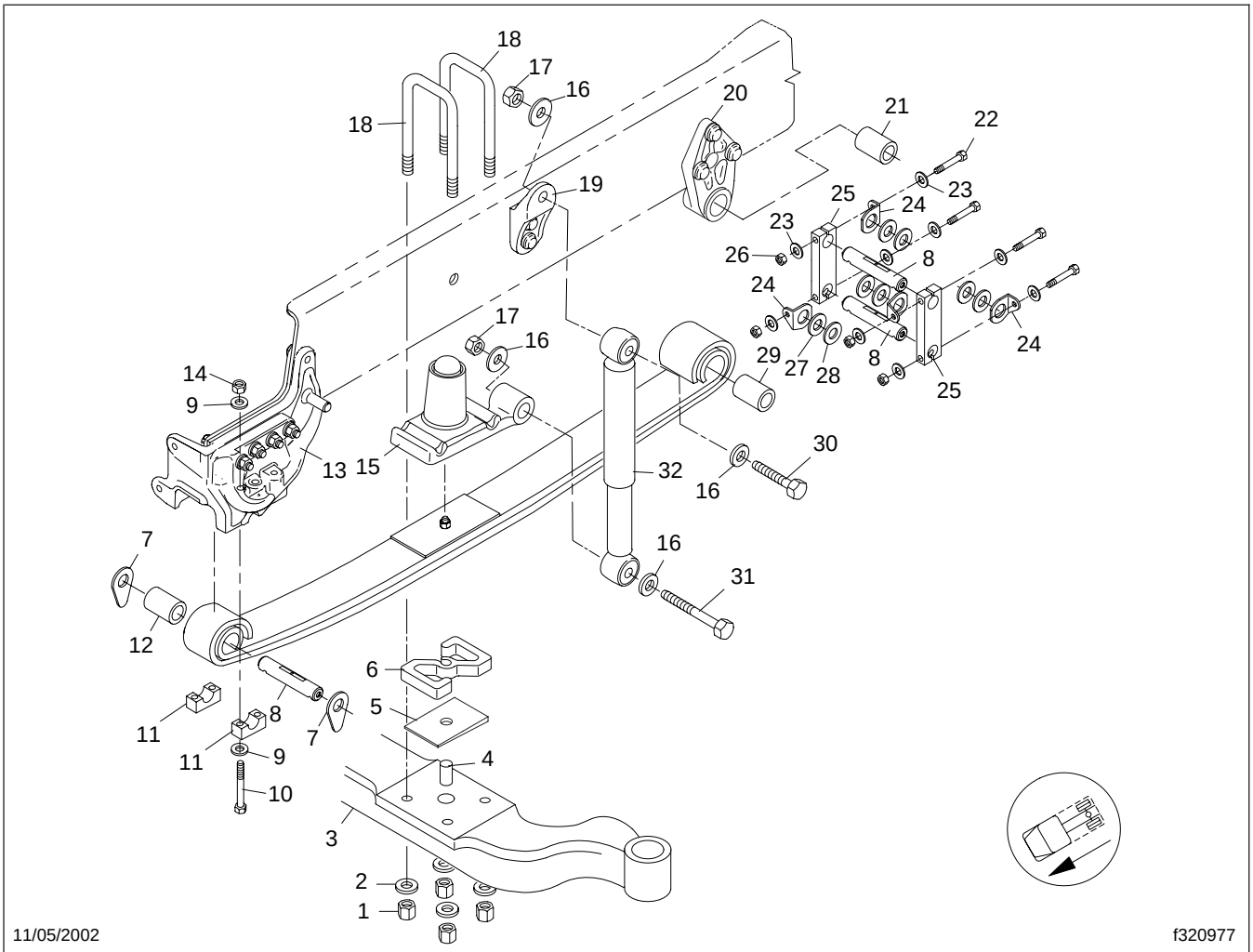
A. Optional Threaded Pins and Bushings

B. FLB COE With Set-Forward Axle Shown

1. Self-Locking Nut, 1/2–13
2. Hardened Washer
3. Bumper Mounting Z-Bracket
4. Front Suspension Bracket
5. Pinch-Bolt, 1/2–13 x 4"
6. Spacing Washer(s)
7. Spring Spacer
8. Spring Bushing, Forward Spring Eye
9. Forward Spring Eye
10. Spring Pin, Forward Spring Eye
11. Spring Leaf Alignment Clip
12. Washer, 1" i.d., 2" o.d.
13. Shock Absorber
14. Washer, 3/4" i.d., 2" o.d.
15. Self-Locking Nut, 3/4–16
16. Shock Absorber Upper Bracket
17. Axle Stop
18. U-Bolt
19. Spring Center-Bolt and Center-Bolt Nut
20. Spring Spacer Plate
21. Tapered Leaf Spring Assembly
22. Axle Spacer
23. Shock Absorber Lower Bracket
24. Caster Shim
25. Front Axle
26. Dowel Pin
27. U-Bolt High Nut
28. Bushing, Shackle Bracket
29. Shackle Bracket
30. Spring Pin, Shackle Bracket
31. Hardened Washer, 2-1/4" o.d.
32. Wear Plate
33. Shackle
34. Pinch-Bolt, 1/2–13 x 3"
35. Spring Pin, Rear Spring Eye
36. Rear Spring Eye
37. Spring Bushing, Rear Spring Eye
38. Threaded Spring Pin
39. Threaded Bushing
40. Split Ring

Fig. 1, Leaf Spring Removal (FLD Conventional and FLB COE)

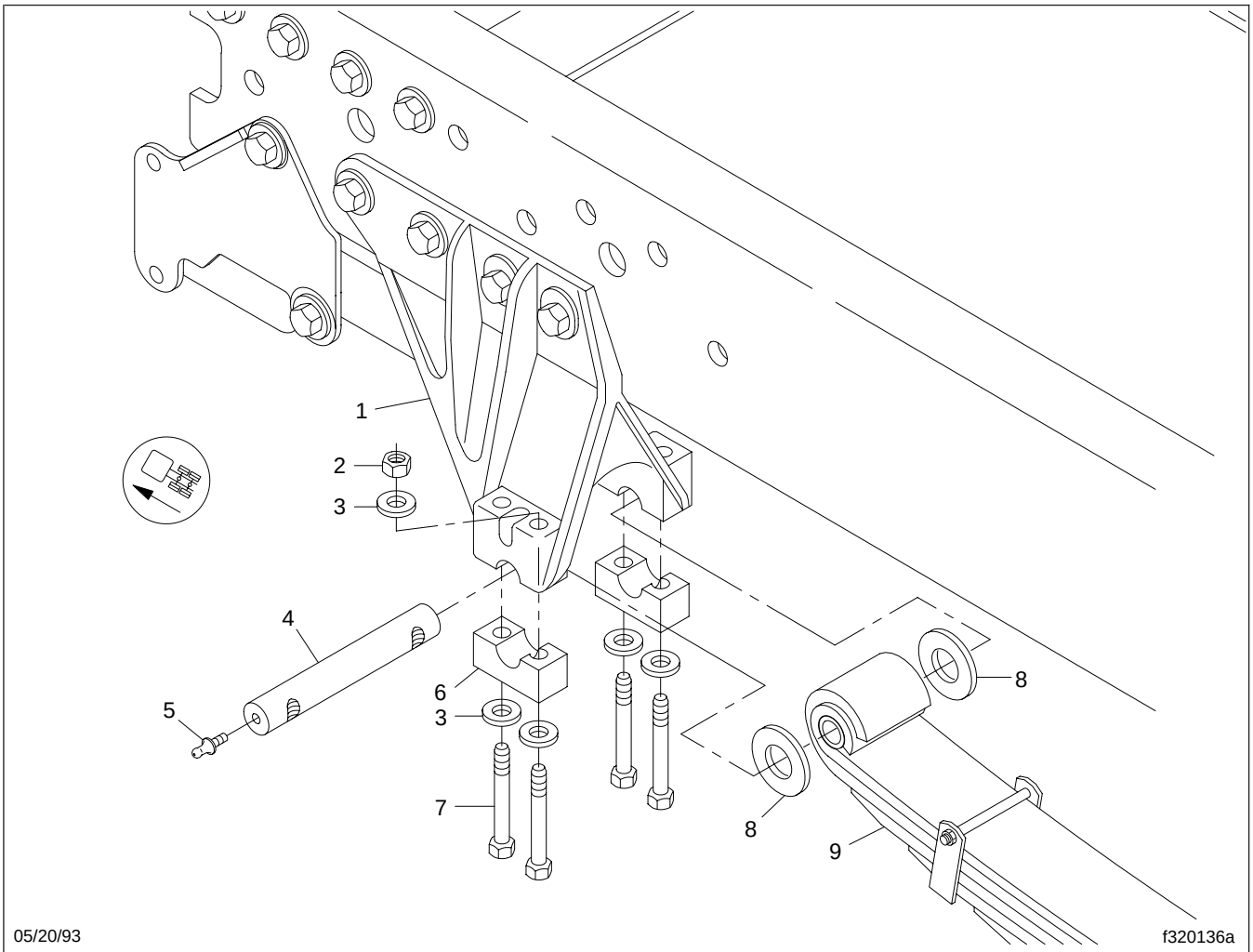
Leaf Spring and Components Removal, Cleaning and Inspection, and Installation



1. U-Bolt High Nut
2. Hardened Washer
3. Front Axle Beam
4. Dowel Pin
5. Caster Shim
6. Axle Spacer
7. Spring Spacer
8. Spring-Eye Pin
9. Hardened Washer
10. Hexbolt, 1/2–13 (4 qty.)
11. Front Suspension Bracket Cap
12. Spring Bushing, Forward Spring Eye
13. Front Suspension Bracket
14. Locknut, 1/2–13
15. Axle Stop
16. Hardened Washer
17. Hexnut, 3/4–16
18. U-Bolt
19. Shock Absorber Upper Bracket
20. Shackle Bracket
21. Bushing, Shackle Bracket
22. Pinch-Bolt, 1/2–13 x 3"
23. Flatwasher
24. Wear Plate
25. Shackle
26. Hexnut, 1/2–13
27. Spacing Washer
28. Hardened Washer, 2-1/4"
29. Bushing, Rear Spring Eye
30. Hexbolt, 3/4–16 x 3"
31. Hexbolt, 3/4–16 x 5"
32. Shock Absorber

Fig. 2, Leaf Spring Removal (D2 Classic vehicle)

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation



1. Front Suspension Bracket
2. Locknut, 1/2–13
3. Hardened Washer
4. Spring Pin
5. Grease Fitting
6. Front Suspension Bracket Cap
7. Hexbolt, 1/2–13 x 5"
8. Spacing Washer(s)
9. Flat Leaf Spring Assembly

Fig. 3, Spring Installation for FLD 112 and FLD 120 Conventionals Without a Drop-Style Frame Extension

Cleaning and Inspection

1. Using a wire brush and solvent or steam cleaning equipment, wash all parts to remove dirt, grease, and scale.
2. Inspect the shackle bracket, wear plates, and spring shackles for cracks, wear, and other damage. Replace any damaged parts.
3. Inspect the leaf spring assembly for cracks and corrosion. If any cracked or broken leaves are discovered, *replace the entire spring assembly*.

⚠ WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring

is safe. On front spring assemblies, if cracks or breaks exist in the two top leaves, a loss of vehicle control could occur. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

4. If the protective coating is gone from some areas of the spring, paint the cleaned areas with a rust-inhibiting paint. If rusting or corrosion is severe, replace the spring assembly.
5. Using a micrometer, check non-threaded spring pins and the shackle bracket spring pin for wear. Replace a pin if its diameter at any point is less than 1.242 inches (31.55 mm).

   Inspect threaded spring and shackle pins for cracked or broken threads. Replace any pin that has damaged threads.
6. Inspect the spring and bracket bushings. Replace the bushings if gouged, cracked, or otherwise damaged.

   If the non-threaded bushings are not damaged, inspect them for wear. Using an inside micrometer or bore gauge, check the inside diameter of each bushing. The inside diameter of any bushing should not exceed the diameter of its spring pin by more than 0.020 inch (0.51 mm). Replace any bushing which exceeds this limit. For instructions, refer to the applicable subheading in **Subject 110**.

Installation

IMPORTANT: For normal highway operation do not install two different spring designs or load capacities on the front axle. In order to maintain a balanced front suspension system, and to prevent difficult handling after the vehicle is placed in service, install identical spring assemblies.

NOTE: See **Fig. 1** or **Fig. 2** for this procedure.

1. If the shackle bracket was removed from the vehicle, proceed as follows:

   1.1 Apply Alumilastic® or a similar compound to all areas of the shackle bracket that contact metal other than aluminum. Also, apply it to all capscrews, washers, and locknuts that contact aluminum parts. *Do not apply the compound to the inner (bearing) surface of the bushing or on fastener threads.*

CAUTION

Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the shackle bracket or other parts.

   1.2 Install the shackle bracket and fasteners. Tighten the 1/2-inch locknuts 80 lbf·ft (108 N·m) and the 5/8-inch locknuts 160 lbf·ft (217 N·m).

   NOTE: All suspension bracket (frame) fasteners require periodic retorquing. Refer to the vehicle maintenance manual for recommended intervals.
2. Using multipurpose chassis grease, lubricate all spring pins and the inside surfaces of all bushings.
3. For vehicles equipped with threaded shackle bracket spring pins, if the shackles were disconnected from the shackle bracket, install the threaded spring pin and attach the shackles to the bracket, as follows:

   NOTE: For vehicles equipped with non-threaded shackle bracket spring pins, go to the next step for installing nonthreaded shackle bracket spring pins.

   3.1 Screw the pin into the bushing until it is centered. Make sure that the grease fitting is outboard.

   3.2 Install the shackle and align the groove of the pin with the shackle pinch-bolt bore.

   3.3 Install the pinch bolt and the self-locking nut to secure the shackle, wear plate, and spring pin in place. Tighten the locknut 45 lbf·ft (61 N·m).

   3.4 Repeat the procedure for the other shackle. Go to the step for installing the dowel pin, caster shim, etc. onto the front axle.

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

CAUTION

Do not over-tighten the shackle pinch-bolt nuts. Over-tightening these nuts could cause distortion and weakening of the aluminum shackles.

4. If the shackles were disconnected from the shackle bracket, install the nonthreaded spring pin and attach the shackles to the bracket.
   - 4.1 Insert the pin into the bracket making sure that the grease fitting is outboard.
   - 4.2 Install the applicable wear plate, spacing washer(s), and hardened washer on one end of the pin.
   - 4.3 Install the shackle. Be sure the wear plate is in direct contact with the shackle. Align the groove of the pin with the shackle pinch-bolt bore.
   - 4.4 Install the pinch bolt, hardened washers, and self-locking nut to secure the shackle, wear plate, and spring pin in place. Tighten the locknut 45 lbf·ft (61 N·m).

CAUTION

Do not over-tighten the shackle pinch-bolt nuts. Over-tightening these nuts could cause distortion and weakening of the aluminum shackles.

   - 4.5 Repeat the procedure for the other shackle. Go to the next step.

5. Install the dowel pin, caster shim, shock absorber lower bracket (if so equipped), and axle spacer (if so equipped) on the front axle. First, apply Alumilastic or similar compound to all aluminum surfaces which will contact metal other than aluminum.

CAUTION

Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the parts.

6. Be sure the caster shim is installed with the taper pointing in the original direction.

IMPORTANT: For FLB COEs, and FLD 120 Conventionals (with a drop-style frame extension) equipped with both a shock absorber and an axle spacer, install the shock absorber lower bracket first, with the axle spacer on top. See **Fig. 4**.

For an FLD 112 Conventional (or an FLD 120 Conventional without a drop-style frame extension) equipped with both a shock absorber and an axle spacer, install the axle spacer first, with the shock absorber lower bracket on top. See **Fig. 4**.

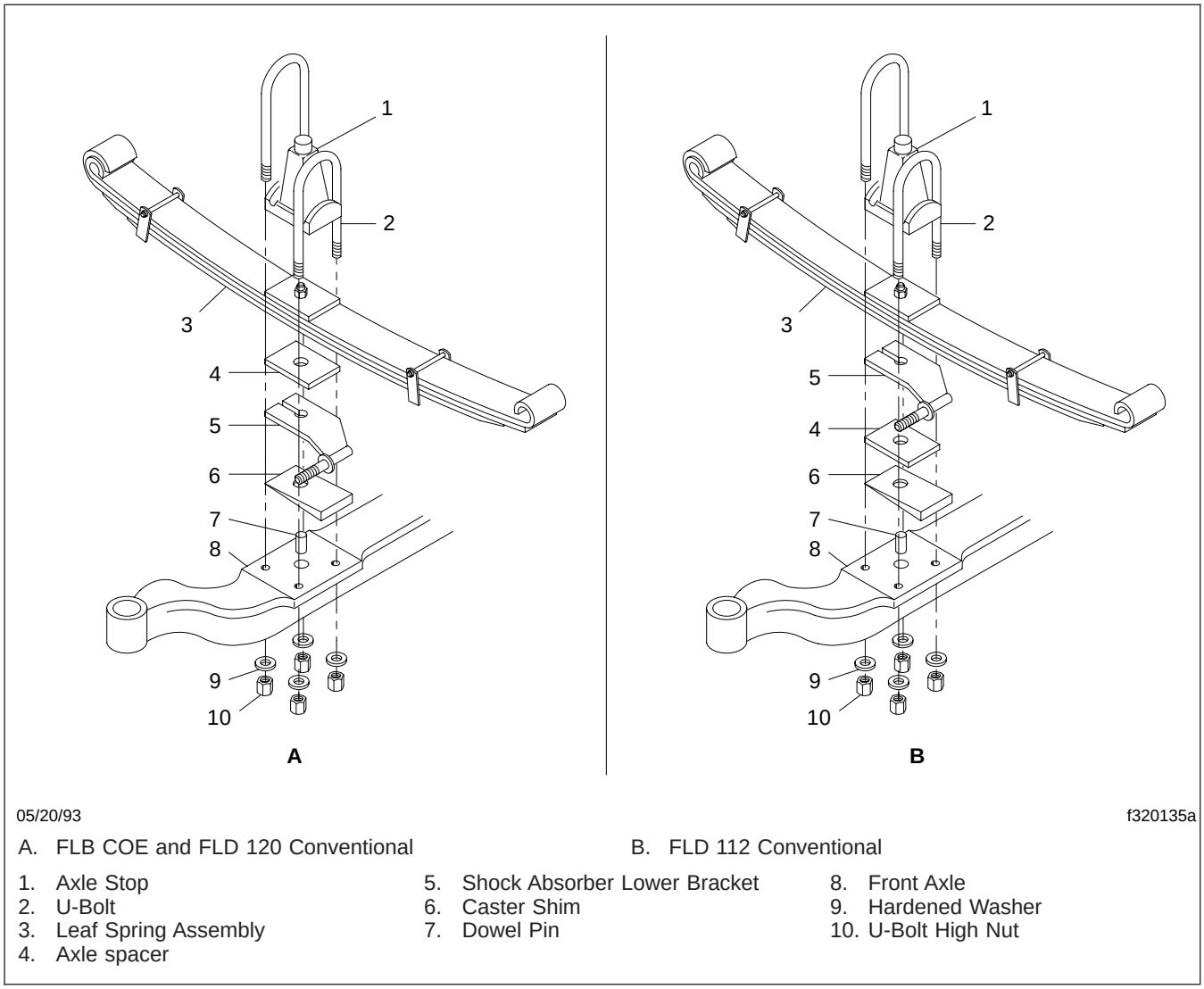
On D2 Classic vehicles, the shock absorber lower mounting bracket and the axle stop are one component.

7. Install the spring assembly on the axle so the spring center bolt head fits into the bore in the axle spacer, shock absorber lower bracket, or caster shim, as applicable. See **Fig. 4**.
8. Place the axle stop on top of the spring assembly.
9. Install the U-bolts over the axle stop and spring assembly and through the holes in the axle. It may be necessary to compress the sides of the U-bolts slightly in order to get the U-bolt ends to align with the axle holes. A C-clamp attached above the U-bolt threads can be used for this purpose.
10. Install the hardened washers and the high nuts finger-tight.
11. For an FLD 112 Conventional, an FLD 120 Conventional without a drop-style frame extension, or a D2 Classic vehicle, go to the next step.

    For an FLB COE or an FLD 120 Conventional with a drop-style frame extension, attach the spring assembly to the front suspension bracket:

    - 11.1 With non-threaded spring pins, hold one spring spacer and half the total number of spacing washers between the outboard end of the bracket and the spring, and insert the end of the pin without a grease fitting far enough into the bushing to hold the spacer and washers in place. Hold the remaining spring spacer and washers in place, and push the spring pin the rest of the way until the grooves in the pin align with the front suspension bracket pinch-bolt bores.

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation



A. FLB COE and FLD 120 Conventional

B. FLD 112 Conventional

1. Axle Stop
2. U-Bolt
3. Leaf Spring Assembly
4. Axle spacer
5. Shock Absorber Lower Bracket
6. Caster Shim
7. Dowel Pin
8. Front Axle
9. Hardened Washer
10. U-Bolt High Nut

Fig. 4, Leaf Spring Installation

11.2 With threaded pins, screw the pin all the way into the bushing until the spring pin grooves align with the suspension bracket's pinch-bolt bores.

With non-threaded spring pins, check for play between the spring eye and the bracket ends. If needed, install additional 1/32-inch (0.8-mm) spacing washers (1-1/4 inch [32 mm] i.d., 1-7/8 inch [48 mm] o.d.) so there is less than one washer thickness of end play. It is preferable to have an equal number of washers on each side of the spring. However, if the amount of play requires an uneven number of washers, the additional washer should be installed on the outboard side of the spring eye.

11.3 With both threaded and non-threaded spring pins, install the pinch bolts, with a hardened washer on each, in the front suspension bracket from the rear. For a vehicle with a set-forward axle, install the bumper mounting Z-bracket, in the same position noted during removal. Install the

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

hardened washers and self-locking nuts. Tighten the locknuts 80 lbf·ft (108 N·m).

NOTE: If a set-forward axle vehicle is equipped with an 8-1/2 inch bumper, install the pinch bolts through the *front* of the front suspension bracket, to allow clearance between the fasteners and the bottom flange of the bumper.

11.4 Go to the step for attaching the spring assembly to the shackles.

12. For an FLD 112 Conventional, an FLD 120 Conventional without a drop-style frame extension, or a D2 Classic vehicle, attach the spring assembly to the front suspension bracket:

12.1 Insert the spring pin into the forward spring eye, with its grease fitting outboard. See **Fig. 2**.

With threaded pins, screw the pin all the way into the bushing until the spring pin grooves align with the suspension bracket's pinch-bolt bores.

12.2 With non-threaded spring pins, install the appropriate number of spacing washers on each end of the spring pin, then move the spring eye and pin into place in the front suspension bracket. Align the grooves of the pin with the bracket's rear bolt holes.

12.3 With both threaded and non-threaded spring pins, install the suspension bracket caps, hexbolts, hardened washers, and *new* locknuts. Tighten the locknuts until the bracket caps are against the bracket.

12.4 With non-threaded spring pins, check for play between the spring eye and the sides of the bracket. If needed, install additional 1/32-inch (0.8-mm) thick spacing washers (1-1/4 inch [32 mm] i.d., 1-7/8 inch [48 mm] o.d.) so there is less than one washer thickness of end play. It is preferable to have an equal number of washers on each side of the spring. However, if the amount of play requires an uneven number of washers, the additional washer should be installed on the outboard side.

12.5 With both threaded and non-threaded spring pins, tighten the locknuts 70 lbf·ft (95 N·m).

Go to the next step.

13. Attach the spring assembly to the shackles:

13.1 With non-threaded spring pins, hold a wear plate, half the total number of spacing washers, and a hardened washer between the outboard shackle and the spring eye. With the grease fitting outboard, insert the spring pin far enough into the bushing to hold the wear plate and washers in place. Hold the remaining wear plate and washers in place, and push the pin the rest of the way until the grooves in the pin align with the shackle pinch-bolt bores.

13.2 With threaded pins, screw the pin all the way into the bushing until the spring pin grooves align with the shackle pinch-bolt bores.

With non-threaded spring pins, check for play between the spring and the shackles. If needed, install additional 1/32-inch (0.8-mm) spacing washers (1-1/4 inch [32 mm] i.d., 1-7/8 inch [48 mm] o.d.) so there is less than one washer thickness of end play. It is preferable to have an equal number of washers on each side of the spring. However, if the amount of play requires an uneven number of washers, the additional washer should be installed on the outboard side of the spring eye.

13.3 Install the pinch bolts, hardened washers, and locknuts. Torque the nuts 45 lbf·ft (61 N·m).

⚠ CAUTION

Do not over-tighten the shackle pinch-bolt nuts. Overtightening these nuts could lead to distortion and weakening of the aluminum shackles.

14. Wipe all dirt from the grease fittings on the spring pins and the shackle bracket spring pin. Apply multipurpose chassis grease with a pressure gun until grease appears at the opposite end of the pin.

15. For a COE, if the cab was tilted, clear the area of tools, etc., and lower the cab to its operating position.
16. Remove the jack stands from the chassis and lower the truck.
17. Install the bumper and the fog lights, if previously removed.
18. Tighten the U-bolt high nuts in stages in a diagonal pattern as described in Section 32.00, **Specifications 400**.

CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component fastener torque checking intervals and instructions, refer to the suspension section in the vehicle maintenance manual.

19. Remove the chocks from the tires.

Shackle Bracket Bushing Replacement

1. With the shackle bracket removed from the vehicle, press out the worn or damaged bushing.
2. With an inside micrometer or bore gauge, check for an out-of-round condition in the bracket bore. Replace the bracket if the bushing bore is out-of-round.
3. Before installing the new bushing, check the shackle bracket spring pin for ease of fit in the bushing. Threaded pins should screw in easily by hand without binding. Non-threaded pins should have an easy slip fit without wobble between the pin and the bushing.
4. Using a press, press the new bushing into the bracket until the bushing is centered in the bracket. The bushing ends must be flush or inside the vertical edges of the bracket bore, and the split in the bushing must be within 1/4 inch (6 mm) of the bottom of the bracket bore.
5. Check the shackle bracket spring pin for ease of fit in the bushing. Threaded pins should still turn easily by hand without binding. Non-threaded pins should still have an easy slip fit without wobble between the pin and the bushing. If binding occurs, the bushing may have been distorted during installation. Replace the bushing and check again for proper fit.

Spring Bushing Replacement (nonthreaded bushings only)

1. Press out the worn or damaged bushing.
2. Press the new bushing into the spring eye until the bushing and the spring edges are flush. The split in the bushing must be within 3/16 inch (5 mm) of the top of the spring eye.
3. Ream the newly installed bushing 1.252 to 1.254 inches (31.80 to 31.85 mm) i.d., if needed; do not ream graphite-impregnated bronze bushings.

Shock Absorber Removal and Installation

NOTE: See **Fig. 1** and **Fig. 2** for these procedures.

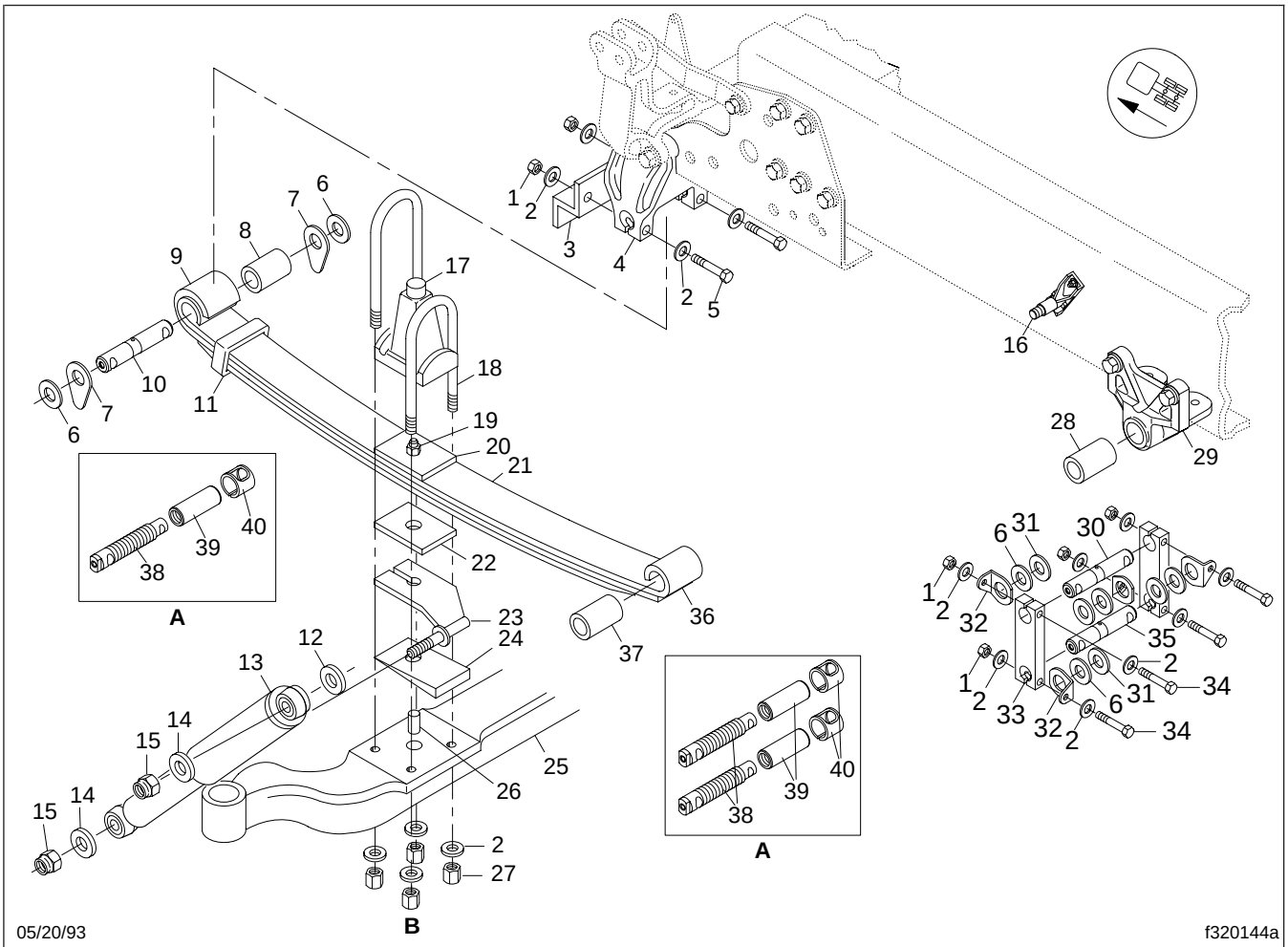
Removal

Remove the locknuts and hardened washers from the shock absorber upper and lower bracket studs. Pull straight out on the shock absorber to remove it.

Installation

1. Check the shock absorber bushings (two bushings in each eye) for wear or damage, and replace them if needed.
2. Make sure the 2-inch o.d. by 1-inch i.d. washer is installed on the stud of the shock absorber upper bracket.
3. Install the eyes of the shock absorber on the upper and lower bracket studs.
4. Install the washer and a new self-locking nut on each of the bracket studs. Tighten the locknuts 150 lbf·ft (203 N·m).

Shock Absorber Removal and Installation



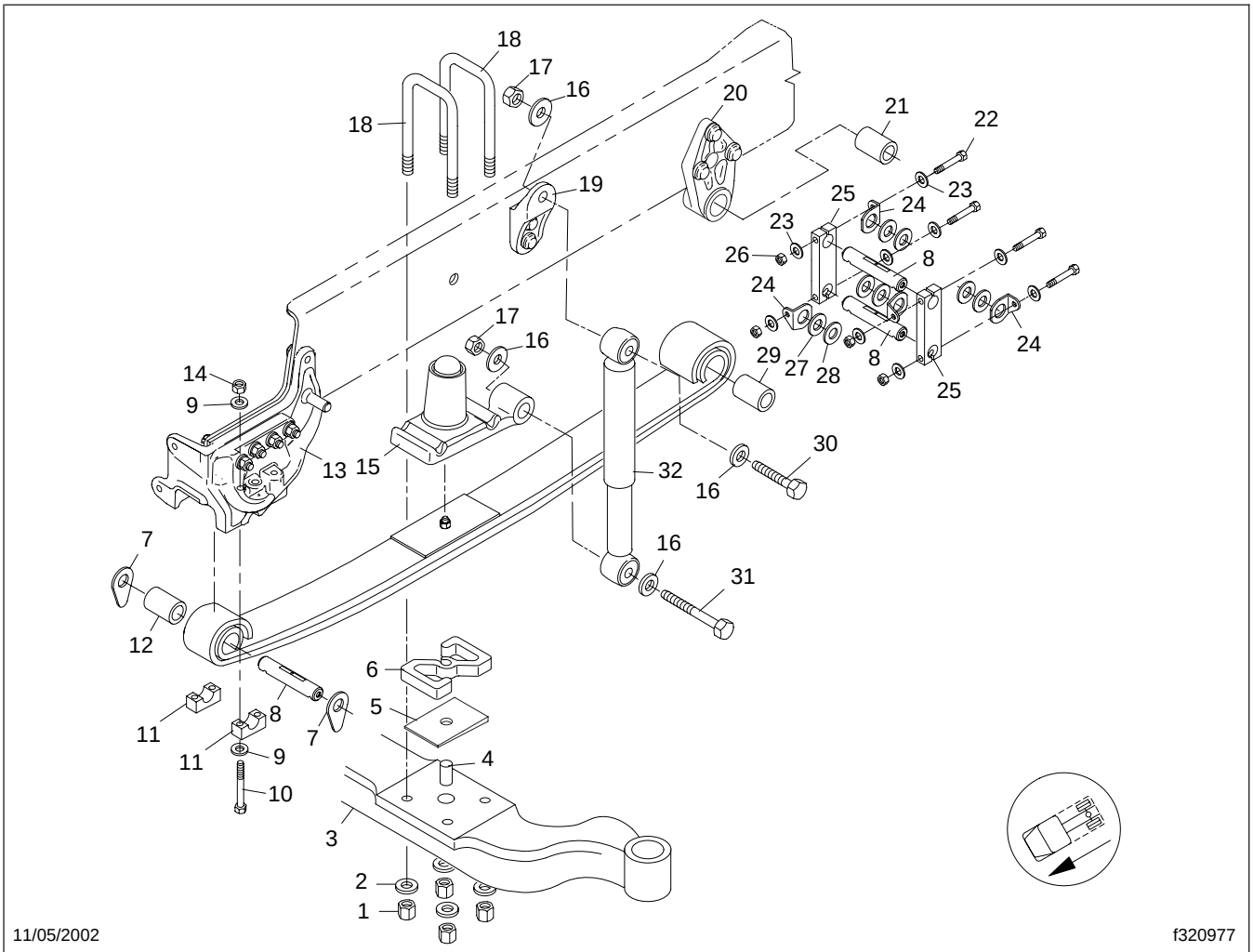
A. Optional Threaded Pins and Bushings

B. FLB COE With Set-Forward Axle Shown

1. Self-Locking Nut, 1/2–13
2. Hardened Washer
3. Bumper Mounting Z-Bracket
4. Front Suspension Bracket
5. Pinch-Bolt, 1/2–13 x 4"
6. Spacing Washer(s)
7. Spring Spacer
8. Spring Bushing, Forward Spring Eye
9. Forward Spring Eye
10. Spring Pin, Forward Spring Eye
11. Spring Leaf Alignment Clip
12. Washer, 1" i.d., 2" o.d.
13. Shock Absorber
14. Washer, 3/4" i.d., 2" o.d.
15. Self-Locking Nut, 3/4–16
16. Shock Absorber Upper Bracket
17. Axle Stop
18. U-Bolt
19. Spring Center-Bolt and Center-Bolt Nut
20. Spring Spacer Plate
21. Tapered Leaf Spring Assembly
22. Axle Spacer
23. Shock Absorber Lower Bracket
24. Caster Shim
25. Front Axle
26. Dowel Pin
27. U-Bolt High Nut
28. Bushing, Shackle Bracket
29. Shackle Bracket
30. Spring Pin, Shackle Bracket
31. Hardened Washer, 2-1/4" o.d.
32. Wear Plate
33. Shackle
34. Pinch-Bolt, 1/2–13 x 3"
35. Spring Pin, Rear Spring Eye
36. Rear Spring Eye
37. Spring Bushing, Rear Spring Eye
38. Threaded Spring Pin
39. Threaded Bushing
40. Split Ring

Fig. 1, Front Suspension (FLD Conventional and FLB COE)

Shock Absorber Removal and Installation



1. U-Bolt High Nut
2. Hardened Washer
3. Front Axle Beam
4. Dowel Pin
5. Caster Shim
6. Axle Spacer
7. Spring Spacer
8. Spring-Eye Pin
9. Hardened Washer
10. Hexbolt, 1/2–13 (4 qty.)
11. Front Suspension Bracket Cap
12. Spring Bushing, Forward Spring Eye
13. Front Suspension Bracket
14. Locknut, 1/2–13
15. Axle Stop
16. Hardened Washer
17. Hexnut, 3/4–16
18. U-Bolt
19. Shock Absorber Upper Bracket
20. Shackle Bracket
21. Bushing, Shackle Bracket
22. Pinch-Bolt, 1/2–13 x 3"
23. Flatwasher
24. Wear Plate
25. Shackle
26. Hexnut, 1/2–13
27. Spacing Washer
28. Hardened Washer, 2-1/4"
29. Bushing, Rear Spring Eye
30. Hexbolt, 3/4–16 x 3"
31. Hexbolt, 3/4–16 x 5"
32. Shock Absorber

Fig. 2, Front Suspension (D2 Classic vehicle)

Troubleshooting Chart

Problem—Vehicle Leans to One Side

Possible Cause	Remedy
One or more spring leaves are broken.	Replace the spring assembly.
The spring assembly is weak or fatigued.	Replace the spring assembly.
Unmatched spring-design/load-capacity spring assemblies are installed.	Install the correct spring assemblies as originally specified for the vehicle.
A frame rail is bent or twisted.	Check the frame rails for bends and twists. Correct as needed.

Problem—Vehicle Wanders

Possible Cause	Remedy
One or more spring leaves are broken.	Replace the spring assembly.
The wheels are out of alignment.	Adjust the wheel alignment using the instructions in the front axle section in this manual.
Caster is incorrect.	Install correct caster shims. Refer to the front axle section in this manual for specifications.
Steering gear is not centered.	Adjust steering using the instructions in the steering section in this manual.
Drive axles are out of alignment.	Align the drive axles using the instructions in the rear axle section in this manual.

Problem—Vehicle Bottoms Out

Possible Cause	Remedy
Excessive weight on the vehicle is causing an overload.	Reduce the loaded vehicle weight to the maximum spring capacities.
One or more spring leaves are broken.	Replace the spring assembly.
The spring assembly is weak or fatigued.	Replace the spring assembly.

Problem—Frequent Spring Breakage

Possible Cause	Remedy
The vehicle is overloaded or operated under severe conditions.	Reduce the loaded vehicle weight to the maximum spring capacities. Caution the driver on improper vehicle handling.
There is insufficient torque on the U-bolt high nuts.	Torque the U-bolt high nuts to the value listed in the torque table in **Specifications, 400.**
A loose center bolt is allowing the spring leaves to slip.	Check the spring leaves for damage. If damaged, replace the spring assembly. If not, tighten the center-bolt nut to the value listed in the torque table in **Specifications, 400.**
Worn or damaged spring pin bushings are allowing spring end-play.	Replace the spring pin and bushing.

Troubleshooting

Problem—Noisy Spring

Possible Cause	Remedy
A loose U-bolt nut or center bolt is allowing spring leaf slippage.	Inspect the components for damage. Replace damaged components as necessary. Torque the fasteners to the values listed in the torque table in **Specifications, 400**.
A loose, bent, or broken spring shackle or front suspension bracket is impairing the spring flex.	Inspect the shackles and brackets for damage. Replace damaged components as necessary. Torque the fasteners to the values listed in the torque table under **Specifications, 400**.
Worn or damaged spring pins are allowing spring end-play.	Replace any worn or damaged spring pins.

Problem—Rough Ride

Possible Cause	Remedy
Refer to the suspension section in this manual.	

Specifications

Front Suspension Fastener Torque Values		
Description	**Size**	**Torque: lbf·ft (N·m)**
Shackle Bracket-to-Frame Locknut	3/4–10	240 (325)
Forward Spring-Eye Bolt	3/4–10	240 (325)
Upper and Lower Shackle Bolt	3/4–10	240 (325)
Axle U-bolt High Nuts (Tighten in a diagonal pattern as shown in **Fig. 1**.)	5/8–18	Stage 1: Hand-tighten Stage 2: 60 (81) Stage 3: 180–230 (245–313)
	3/4–16	Stage 1: Hand-tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 270–330 (367–449)
	7/8–14	Stage 1: Hand-tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 420–500 (571–680)
	1–14	Stage 1: Hand-tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 520–600 (707–816)
Spring Assembly Center-Bolt Nut	1/2–20	65 (88)
Shock Absorber Upper and Lower Mounting Locknut	3/4–10	140 (190)

Table 1, Front Suspension Fastener Torque Values

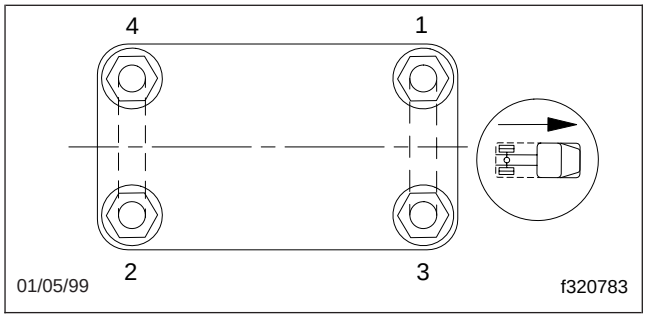


Fig. 1, Tightening Pattern for U-bolt High Nuts

General Description

There are two terms used to describe rough ride conditions: harmonic and harsh. Harmonic ride problems are those in which the once-per-revolution energy input from such things as bent or imbalanced wheels match the natural frequency of the frame flexing. This produces a fore-and-aft motion in the cab, which continues as long as the critical road speed is maintained. Harmonic ride problems can occur on smooth roads.

Harsh ride problems are those in which the suspension transfers, rather than absorbs, the momentary energy inputs produced when the tires hit bumps or holes in the road. Wavy asphalt, or a series of bumps, may cause repetition of the harsh, jarring motion in the cab, but the motion stops after the tires pass over the bumps. Harsh ride problems occur on rough roads.

This section is designed for use as an aid in locating and correcting rough ride problems. It is not intended for use as a replacement for the detailed service information located in the applicable subjects in this manual, or in the component manufacturer's service manuals.

Harmonic Ride Checks

1. Visually check the vehicle for signs of damaged or missing suspension components. Repair or replace the components using the instructions in the applicable sections in this manual.
2. Test drive the vehicle.

NOTE: When test driving the vehicle, duplicate as closely as possible the conditions under which the problem occurs. Note the area of the vehicle where the problem seems to be coming from. Pay special attention to this area during the service operations.

3. Raise the vehicle until the tires are off the ground, and all of the weight is removed from the leaf springs. Block the axle and frame with safety stands. Perform the corrections under "Harmonic Ride, Tires Off the Ground" in **Troubleshooting, 300**.

⚠ WARNING

WARNING: Safety stands must securely support all of the wheel and frame weight during suspension repairs. Unsecured components may drop when the fasteners are loosened or removed, causing component damage and serious personal injury.

4. Remove the safety stands from under the frame and axle, then lower the vehicle. Perform the corrections under "Harmonic Ride, Tires On the Ground" in **Troubleshooting, 300**.

Harsh Ride Checks

1. Visually check the vehicle for signs of damaged or missing suspension components. Repair or replace the components using the instructions in the applicable sections in this manual.
2. Test drive the vehicle.

NOTE: When test driving the vehicle, duplicate as closely as possible the conditions under which the problem occurs. Note the area of the vehicle where the problem seems to be coming from. Pay special attention to this area during the service operations.

3. Raise the vehicle until the tires are off the ground, and all of the weight is removed from the leaf springs. Block the axle and frame with safety stands. Perform the corrections under "Harsh Ride, Tires Off the Ground" in **Troubleshooting, 300**.

⚠ WARNING

WARNING: Safety stands must securely support all of the wheel and frame weight during suspension repairs. Unsecured components may drop when the fasteners are loosened or removed, causing component damage and serious personal injury.

4. Remove the safety stands from under the frame and axle, then lower the vehicle. Perform the corrections under "Harsh Ride, Tires On the Ground" in **Troubleshooting, 300**.
5. If the problem persists, perform the harmonic ride checks in this subject. Occasionally, ride problems associated with rough roads are harmonic ride problems masked by the road conditions.

Problem—Harmonic Ride, Tires Off the Ground

Possible Cause	Remedy
Bent, distorted, or out-of-round wheels or rims are causing a rough ride.	Inspect and repair the assemblies using the instructions in the wheels and tires section in this manual.
Bent, distorted, or out-of-round brake drums or hubs are causing a rough ride.	Replace damaged components using the instructions in the front or rear axle section in this manual.
An improperly seated tire-to-rim bead is causing an out-of-round assembly.	Inspect the tires and rims for proper bead seating. Correct the problem using the instructions in the wheels and tires section in this manual.
A tire and rim assembly on spoke wheels is improperly installed, causing an out-of-round assembly.	Remove and install the tire and rim assembly using the instructions in the wheels and tires section in this manual.
Worn or distorted rim spacers are causing an out-of-round assembly.	Replace damaged spacers using the instructions in the wheels and tires section in this manual.
The wheels, brake drums, or hub assemblies are out of balance.	Inspect the components for missing balance weights. Balance, as necessary.
Radial force variations in the tires are causing a rough ride.	Exchange the tires and wheels with a set that is known to cause no ride problems. If this corrects the problem, discard the old tires. For instructions, refer to the wheels and tires section in this manual.

Problem—Harmonic Ride, Tires On the Ground

Possible Cause	Remedy
On Conventionals, worn or loose cab mounts allow the cab to bounce.	With a long bar, lever the cab legs up and down. If there is looseness, replace or tighten the mounts, as necessary.
On COEs, the rear cab latches are out of adjustment.	Adjust the latches using the instructions in the cab section in this manual.
Forces from the trailer suspension are pushing on the tractor fifth wheel.	Review the ride problems in this subject that apply to the trailer suspension. Perform the corrections, as necessary.

Problem—Harsh Ride, Tires Off the Ground

Possible Cause	Remedy
Seized front spring shackle pins are not allowing the springs to flex.	Replace seized shackle pins. For instructions, refer to the suspension section in this manual.

Problem—Harsh Ride, Tires On the Ground

Possible Cause	Remedy
The tires are improperly inflated.	Adjust the tire pressure using the instructions in the wheels and tires section in the vehicle maintenance manual.

Troubleshooting

Possible Cause	Remedy
The frame is bottoming out against the suspension.	Check the suspension for weak or damaged springs or components. Inspect the springs for "gull-winging" when the vehicle is loaded. Replace the spring assembly, as necessary, using the instructions in the suspension section in this manual.
	Reduce the overall loaded weight on each axle to conform with the maximum spring load capacities on the vehicle specification sheet. Do not exceed the maximum spring load capacities.
	Adjust the air spring height using the instructions in the suspension section in this manual.
The vehicle normal loaded weight is markedly below the spring load capacity.	Contact the Freightliner Service Operations Regional Office for the correct application of a lower rated spring. Replace the spring assembly using the instructions in the suspension section in this manual.
When the vehicle is loaded, the front axle spring shackle angle is not within the rearward 3 to 18 degree angle.	Contact the Freightliner Service Operations Regional Office for shackle angle corrective measures. Refer to the suspension section in this manual for service instructions.
The weight on the tractor fifth wheel is causing overloading on the front axle springs.	If possible, move the fifth wheel toward the rear of the vehicle; otherwise, change the loading pattern on the trailer.
There is a loaded weight differential between the rear axles greater than 800 pounds (363 kg).	Contact the Freightliner Service Operations Regional Office for corrective measures.
Forces from the trailer suspension are pushing on the tractor fifth wheel causing a rough ride condition.	Review the ride problems in this subject that apply to the trailer suspension. Perform the corrections, as necessary.

General Description

The Freightliner Air Suspension (FAS) is equipped with a tapered leaf spring assembly, secured to the axle housing by U-bolts. The rear end of the spring attaches to a suspension crossmember, and the forward end to a spring hanger. Air springs mounted between the frame rail and suspension crossmember are used to adjust vehicle height, compensating for changes in road conditions and vehicle load. The air springs also absorb road shock.

A leveling valve regulates the flow of air into or out of the air springs. **See Fig. 1.** Changes in the clearance between the vehicle frame and the suspension crossmember activate the leveling valve.

A pressure holding valve (**see Fig. 2**, Ref. 2) located in the air line to the leveling valve, is preset to maintain a minimum pressure of about 65 psi (448 kPa) in the vehicle secondary air system, if a leak were to occur in the air suspension system. In that case, solid rubber bumpers in the air springs would support the vehicle load until a repair could be made.

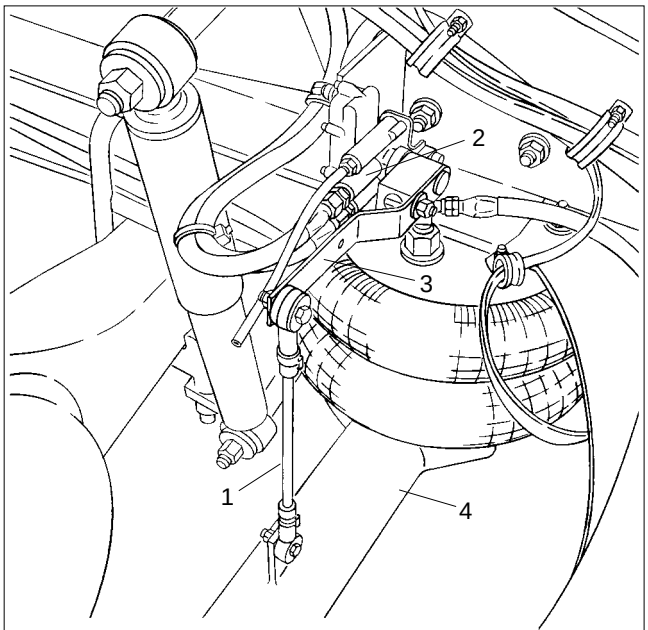


Fig. 1, Leveling Valve System

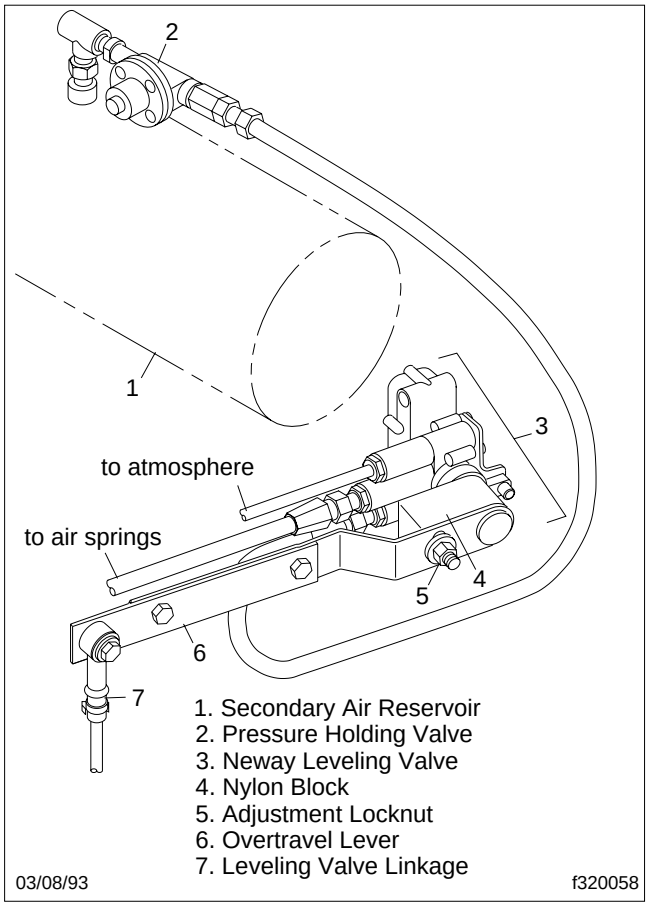


Fig. 2, Leveling Valve Linkage Installation

Principles of Operation

The leveling valve controls the air suspension system. All of the air in the system is admitted through or exhausted from this valve.

The leveling valve is mounted on the inside web of the frame rail. An overtravel lever extends horizontally from the end of the leveling valve control shaft to a linkage arm that connects to the suspension crossmember. **See Fig. 1.** When the load changes, the overtravel lever turns the leveling valve control shaft, activating either the intake or exhaust valve core inside the leveling valve. This adjusts the air pressure in the air springs, until the frame returns to the normal ride height, and the overtravel lever returns to the neutral (horizontal) position.

General Description and Principles of Operation

With the vehicle in motion, and the overtravel lever in the neutral position, small movements of the overtravel lever occur without activating the leveling valve. This is due to a free-travel range: a gap between the leveling valve control shaft and the internal valve cores of the leveling valve. In addition, the leveling valve is filled with a silicone fluid, which delays (from two to six seconds) the closing of one valve core after the opening of the other. This prevents activation of the leveling valve during abrupt movements of the axle.

General Guidelines and Precautions

1. Because air suspension systems are controlled by contaminant-sensitive air valves, the air system must be kept free of any oil, moisture, or foreign material. Air system components should be inspected and maintained regularly. Refer to the brake section in the vehicle maintenance manual for maintenance operations.

⚠ CAUTION

CAUTION: Failure to prevent the entry of moisture, oil, or other foreign material into the air suspension system could eventually lead to sludge forming in the air system. Sludge could adversely affect the operation of the air suspension system as well as other air system components.

2. Attach spring hangers and brackets to the frame using SAE grade 8 bolts with phosphate-and oil-coated threads, and grade C prevailing torque locknuts that are cadmium plated and wax coated. Install flatwashers with a hardness rating of 38 to 45 HRC under both the bolt and the nut.
3. All suspension fasteners require periodic retorquing. For suspension component inspecting, lubricating, and fastener torque checking intervals and instructions, refer to the maintenance schedule and the suspension section in the vehicle maintenance manual.

⚠ CAUTION

CAUTION: Failure to periodically torque suspension fasteners can result in abnormal tire wear and damage to springs, spring hangers, brackets, and frame rails.

4. At all points where aluminum parts are fastened to steel parts, use Alumilastic® compound, or equivalent, on the mating surfaces. This includes nuts, bolts, and washers.

⚠ CAUTION

CAUTION: Failure to apply Alumilastic compound, or equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in suspension system and frame damage.

Adjustment

Adjust the leveling valve with the vehicle on a level surface.

⚠ CAUTION

CAUTION: Failure to adjust the leveling valve could adversely affect driveline angles. Also, if the air springs are set too high, the driver may have difficulty (or be prevented from) backing the vehicle under a trailer. If the air springs are set too low, too much wear of suspension parts will result.

1. Chock the tires. Run the engine to build up and maintain a vehicle air pressure of 70 psi (482 kPa).
2. Disconnect the leveling valve linkage from the overtravel lever. **See Fig. 1.** Exhaust all air from the air springs by moving the overtravel lever down.
3. Loosen the adjustment locknut (**See Fig. 1**, Ref. 5), and move the overtravel lever until the stud in the nylon block or overtravel control body is centered in the overtravel lever adjustment slot. Then, tighten the leveling valve adjustment locknut 60 lbf·in (680 N·cm).

NOTE: Insert a 3/16-inch diameter locating pin (or a 3/16-inch drill bit) in the hole at the back of the nylon block and through the hole in the mounting bracket. **See Fig. 2.** This will aid in centering the nylon block stud in the overtravel lever adjustment slot. After tightening the adjustment locknut, remove the locating pin (drill bit).

4. Connect the overtravel lever to its linkage, and allow the air springs to fill until the valve shuts off.
5. Measure the distance from the bottom of the frame rail flange to the bottom of the air springs. **See Fig. 3.** This distance should be 6-3/4 ±1/8 inches (170 ±3 mm).

IMPORTANT: Because of a built-in delay in the leveling valve, two to six seconds are required after making adjustments before the spring height changes.

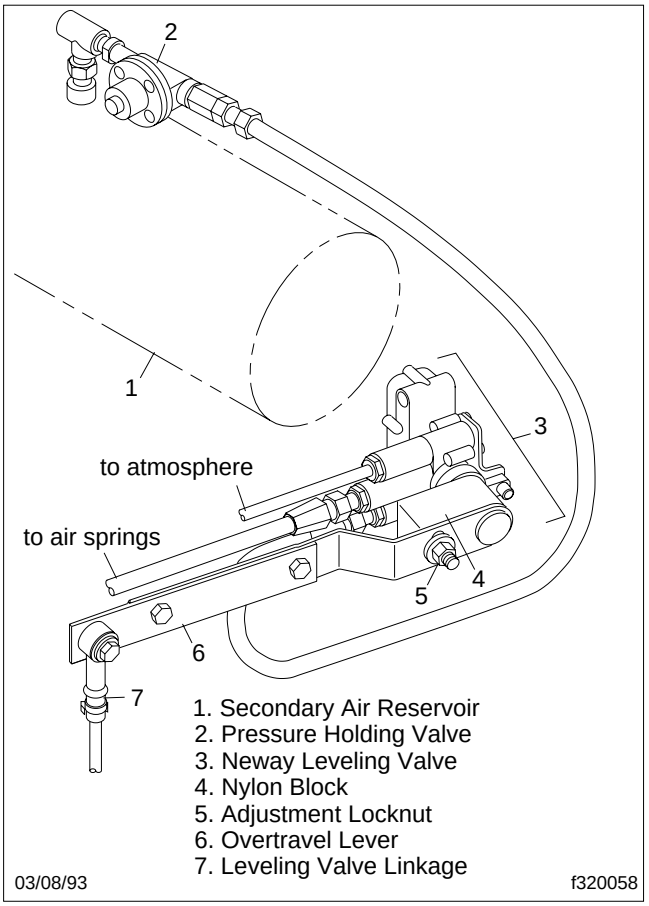


Fig. 1, Leveling Valve Linkage Installation

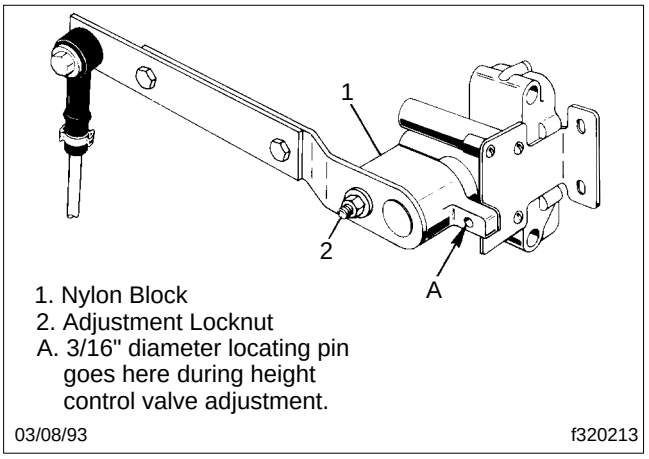


Fig. 2, Neway Leveling Valve

Leveling Valve Adjustment

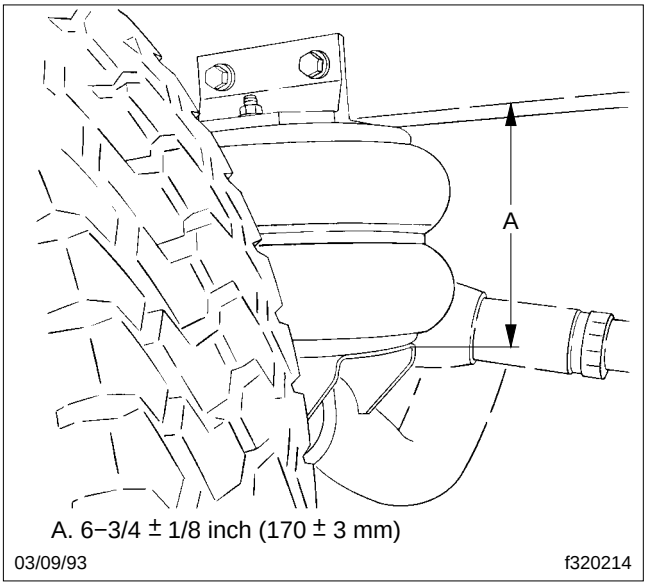


Fig. 3, Air Spring Height Measurement

NOTE: Perform this measurement on the forward axle of tandem axle installations.

If the distance is not 6-3/4 ±1/8 inches (170 ±3 mm), loosen the leveling valve mounting bolt nuts, and rotate the entire valve slightly until the height is correct. Tighten the leveling valve mounting bolt nuts 14 lbf·ft (19 N·m).

6. Disconnect the leveling valve linkage, and allow the air springs to deflate about halfway.

   Connect the linkage to inflate the air springs, and check the air spring height again. Repeat the last two steps above, until the height measures 6-3/4 ±1/8 inches (170 ±3 mm).

   When the height is within 1/8 inch (3 mm) of the required 6-3/4 inches (170 mm), final adjustment is made by loosening the adjustment locknut and slightly moving the overtravel lever relative to the nylon block or overtravel control body. Tighten the leveling valve adjustment locknut 60 lbf·in (680 N·cm).

7. Connect the leveling valve linkage to the overtravel lever. Tighten the lever nut 12 lbf·ft (16 N·m).

8. Remove the chocks from the tires.

Checking

The leveling valve is the control center of any air suspension system and is sensitive to changes in height; when correctly adjusted, it maintains the correct suspension ride height.

Carefully check the valve before replacing it. Do the following steps to see if a valve is damaged or out of adjustment.

1. Disconnect the valve linkage from the overtravel lever. **See Fig. 1** .
2. Pull the overtravel lever up about 45 degrees for 6 to 8 seconds. **See Fig. 2**, Ref. A. If air passes through the valve, that section of the valve is okay.
3. Return the valve to the neutral position. **See Fig. 2**, Ref. B. Air should stop flowing. If so, that section of the valve is okay.
4. Push the overtravel lever down about 45 degrees for 6 to 8 seconds. **See Fig. 2**, Ref. C. If air exhausts from the valve, that section of the valve is okay.
5. Return the valve to the neutral position. If the air stops again in the neutral position, the valve is working correctly.
6. If you do all of the above steps and the valve works as stated, the valve is operative.

   If adjustment of the leveling valve is needed, refer to **Subject 110**.

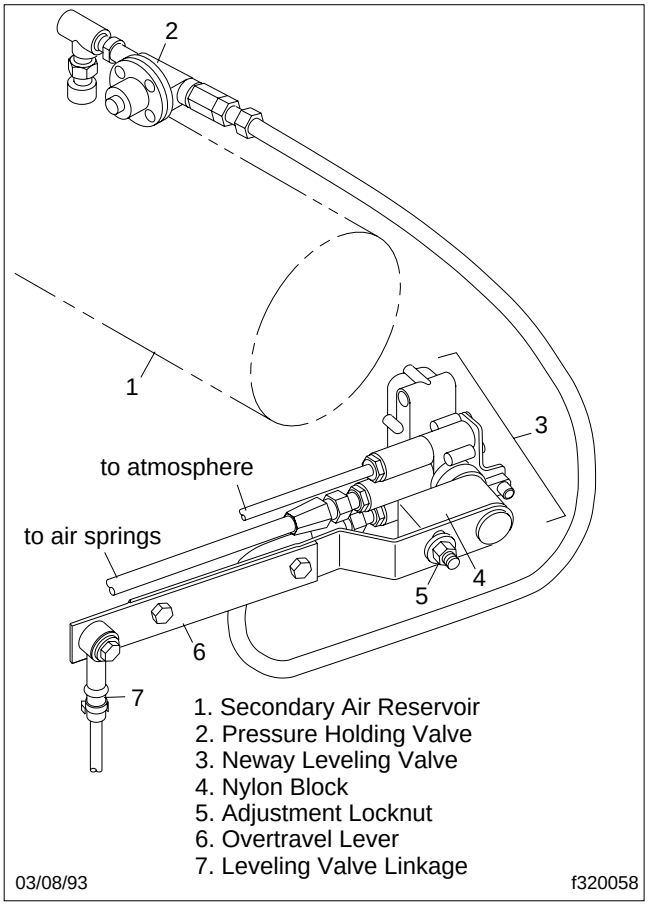


Fig. 1

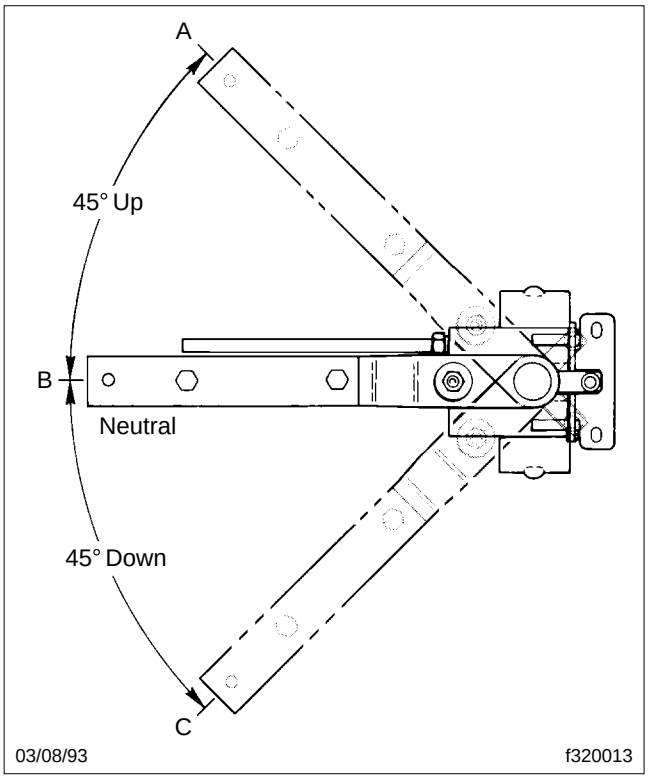


Fig. 2

Removal

1. Chock the tires.
2. Drain the air system. For instructions, refer to the brake section in the vehicle maintenance manual.
3. Disconnect the linkage from the overtravel lever. **See Fig. 1.** Exhaust all air from the air springs by moving the overtravel lever down.

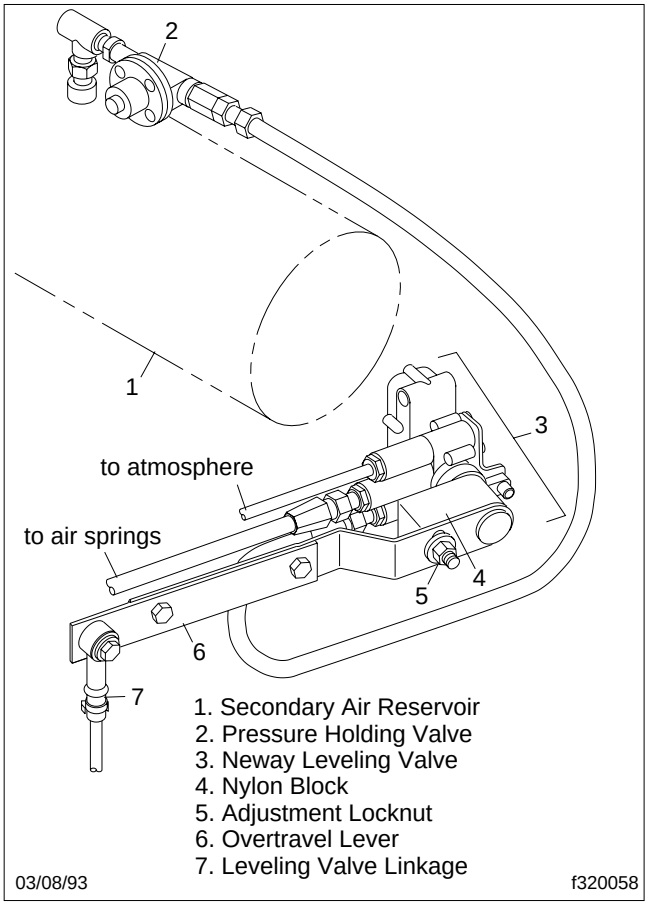


Fig. 1

4. Disconnect the air lines at the leveling valve, and mark the lines for later assembly reference (do not disconnect the exhaust tube). Using tape, cover the open ends of the air lines and fittings to prevent dirt or foreign material from entering.
5. Remove the leveling valve mounting bolts and nuts, and remove the leveling valve from the frame rail.

Installation

1. Attach the leveling valve to the frame rail. Tighten the valve mounting bolt nuts 14 lbf·ft (19 N·m).
2. Remove the tape from the air lines and fittings, and connect the air lines to the leveling valve, as referenced earlier or **as shown in Fig. 2.** Tighten the lines to the values in the brake section in the vehicle maintenance manual.
3. Connect the leveling valve linkage to the overtravel lever. Tighten the lever nut 12 lbf·ft (16 N·m).
4. Close the drain cocks on all reservoirs.
5. Build up normal operating pressure in the air system. Check all air lines and connections for leaks. Eliminate all leaks.
6. Adjust the leveling valve. For instructions, **refer to Subject 110.**

Leveling Valve Removal and Installation

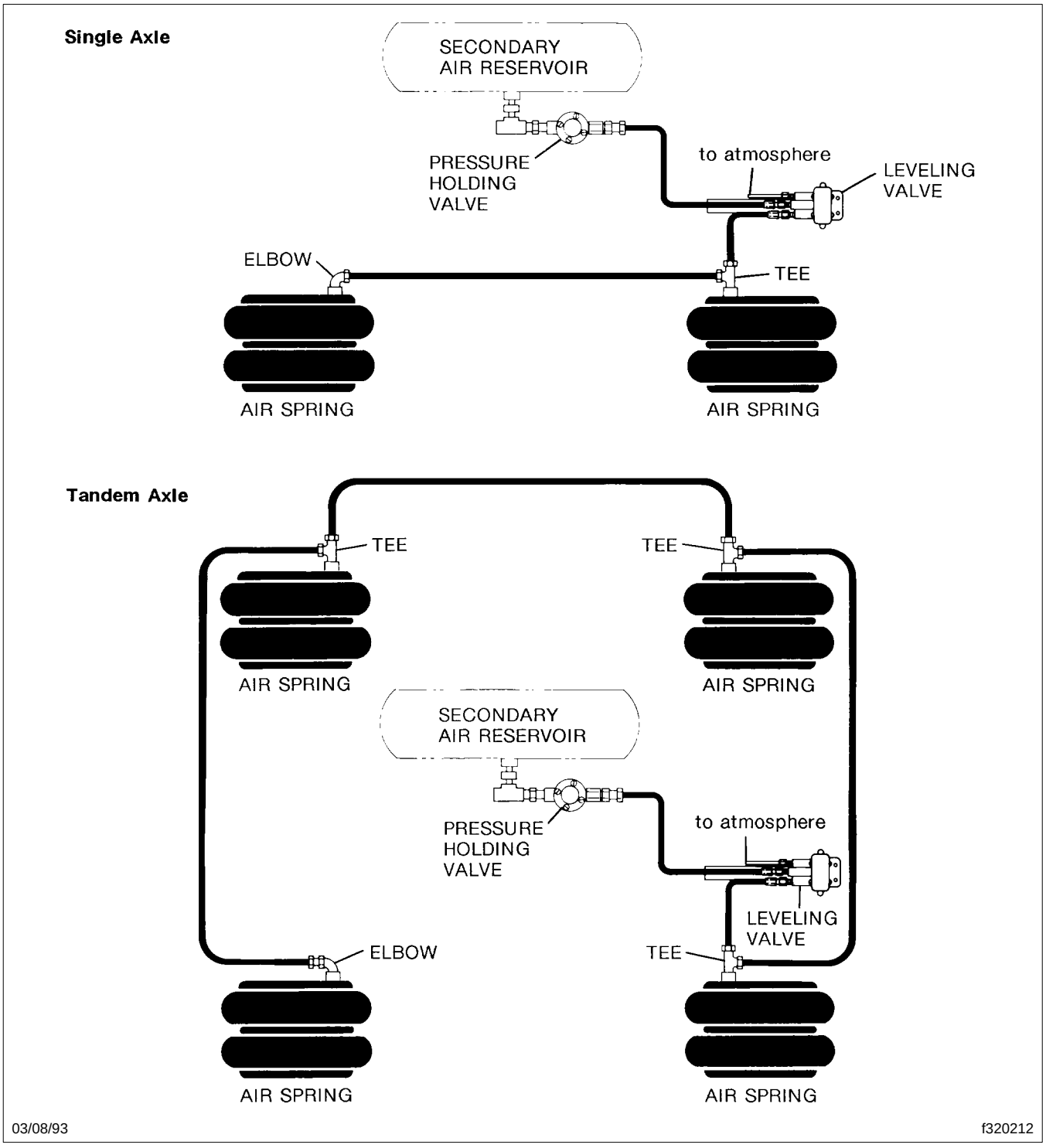
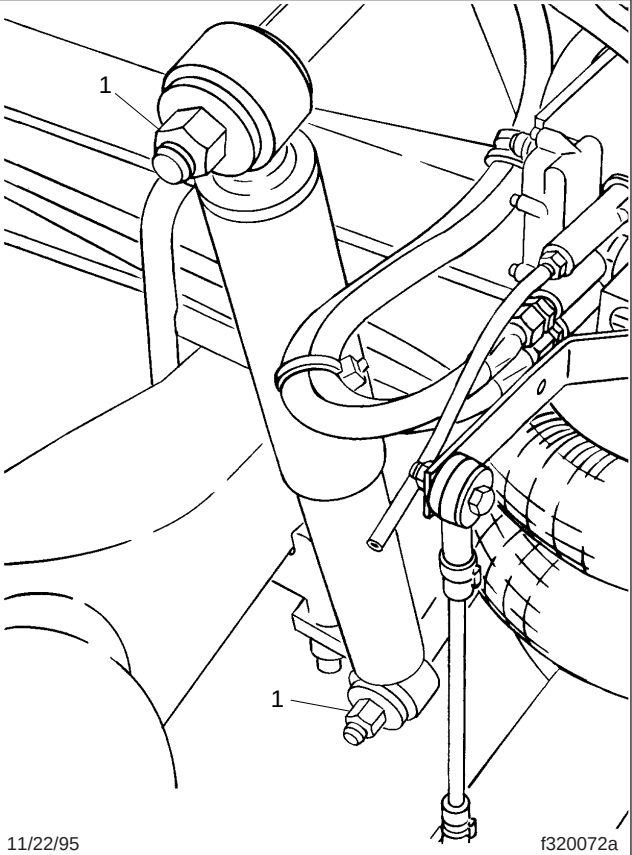


Fig. 2, Plumbing Diagram

Replacement

1. Chock the tires.
2. Remove the locknuts and washers from the shock absorber upper and lower mounting pins. **See Fig. 1.**
3. Pull the shock absorber off the mounting pins to remove it from the vehicle. If the inner metal sleeve has become attached to the mounting pin, use a small, sharp chisel to force the sleeve from the pin.
4. Install the replacement shock absorber on the mounting pins, and secure it with the locknuts and washers.Tighten the shock absorber mounting locknuts 150 lbf·ft (203 N·m).
5. Remove the chocks from the tires.

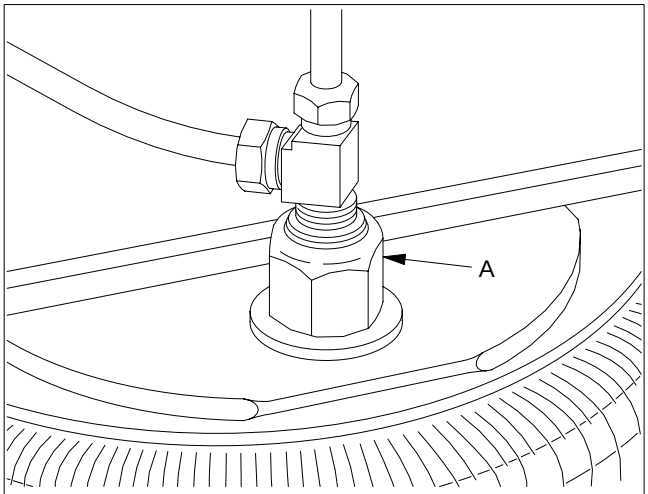


1. Locknut

Fig. 1, Shock Absorber Fasteners

Replacement

1. Chock the front tires. Raise and support the vehicle frame with safety stands to remove all weight from the air springs. The leveling valve automatically releases air from the air springs when all weight is removed from the suspension.
2. Disconnect the air supply line from the air spring. Using tape, cover the ends of the air supply line and the fitting to prevent dirt or foreign material from entering.
3. Remove the locknuts and washers that connect the air spring to the upper mounting bracket. See **Fig. 1**.



A. Remove/install locknut here and on outside of frame rail.

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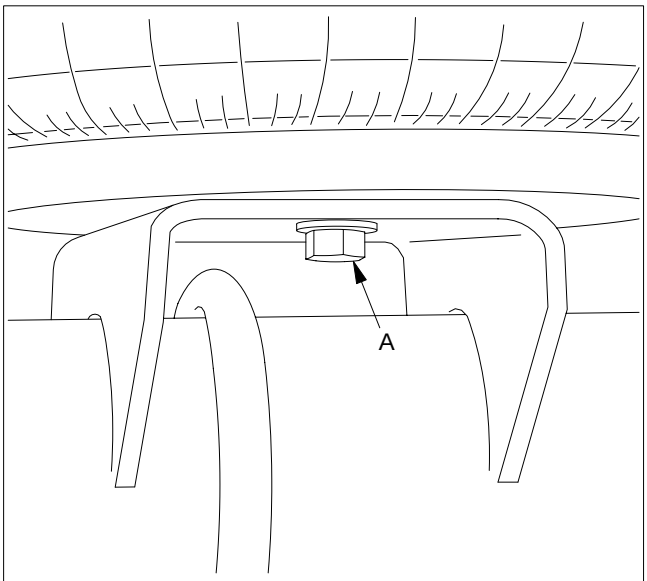
Fig. 1, Air Spring Upper Mounting Bracket

4. Remove the serrated-flange capscrews that connect the air spring to the lower bag support. See **Fig. 2**. Remove the air spring.
5. Place the new air spring on the lower bag support, and install the capscrews securing the air spring in place. See **Fig. 2**. Use only serrated-flange 3/8–16 by 3/4-inch cadmium-plated capscrews. Tighten the capscrews 34 lbf·ft (46 N·m).



A. Remove/install capscrew here and on opposite end.

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Fig. 2, Air Spring Lower Support

CAUTION

Make sure the capscrews are not longer than 3/4 inch. Longer capscrews can damage the air bag base plate.

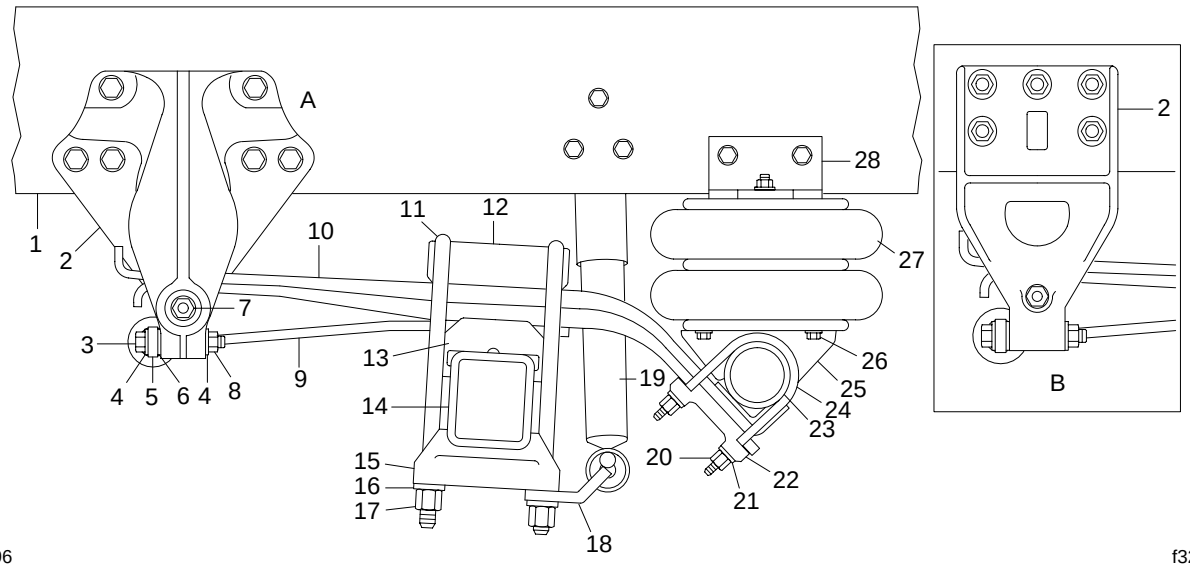
6. Attach the washers and locknuts connecting the air spring to the upper mounting bracket. See **Fig. 1**. Tighten air spring upper mounting 3/4–16 locknuts 45 lbf·ft (61 N·m); tighten 1/2–13 locknuts 20 lbf·ft (27 N·m).
7. Remove the tape from the end of the air supply line and the fitting. Connect the air supply line to the air spring. Tighten the line to the value in Group 42 of the *Heavy-Duty Trucks Maintenance Manual*.
8. Remove the safety stands, and lower the vehicle. Remove the chocks from the tires.

Removal (See Fig. 1)

WARNING

WARNING: Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

1. Chock the front tires.
2. Raise the rear of the vehicle, and support the rear axle(s) with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then securely support the frame with safety stands. Remove the wheel/tire assembly to gain easy access to the suspension. Refer to **Group 40** for instructions.
3. Remove the locknut (Ref. 7), bearing washer, bolt, and neoprene sleeve from the spring hanger.
4. Note the number and position of alignment washers on the spring mounting eye bolts (Ref. 3). Remove the locknuts, bolts, and washers. Disconnect the spring torque leaf (Ref. 9) from the spring hanger.



A. Aluminum Spring Hanger
B. Iron Spring Hanger

1. Frame Rail
2. Spring Hanger
3. Spring Mounting Eye Bolt
4. Bearing Washer
5. Spring Mounting Eye Pin
6. Alignment Washer
7. Neoprene Sleeve Locknut
8. Locknut
9. Spring Torque Leaf
10. Tapered Leaf Spring Assembly
11. Axle U-Bolt
12. Axle U-Bolt Pad
13. Spring Seat
14. Axle (sectional view)
15. Axle Clamp
16. Flatwasher
17. High Nut
18. Shock Absorber Mounting Bracket
19. Shock Absorber
20. High Nut
21. Flatwasher
22. Pressure Plate
23. Suspension Crossmember
24. Suspension Crossmember U-Bolt
25. Air Spring Lower Support
26. Serrated-Flange Capscrew
27. Air Spring
28. Air Spring Upper Mounting Bracket

Fig. 1, Leaf Spring Mounting, FAS 20 and FAS 40

Leaf Spring Removal and Installation

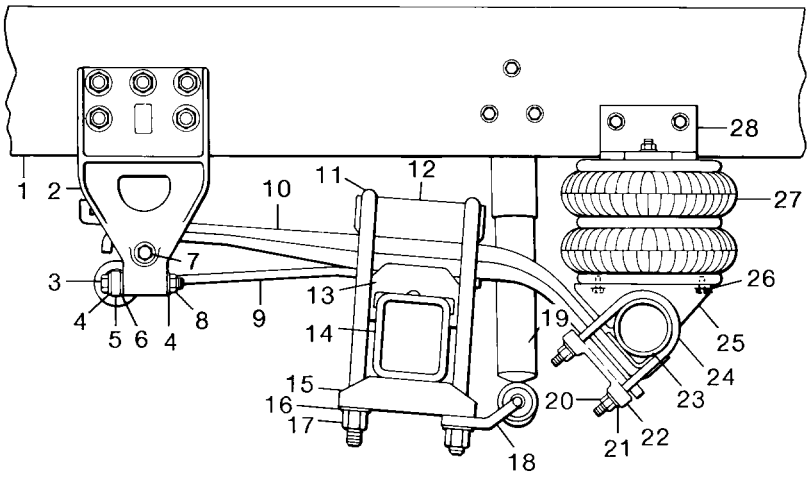
5. Remove the high nuts and flatwashers (Refs. 20 and 21) from the suspension crossmember U-bolts. Remove the pressure plate (Ref. 22) and the U-bolts.
6. Remove the high nuts and flatwashers (Refs. 16 and 17) from the axle U-bolts. Remove the shock absorber mounting bracket (Ref. 18), the axle clamp (Ref. 15), the axle U-bolts and the U-bolt pad (Ref. 12).
7. Slide the leaf spring off the spring seat (Ref. 13).

Installation

1. Place the leaf spring assembly on the spring seat (Ref. 13), and set the axle U-bolt pad (Ref. 12) in place on top of the leaf spring assembly. Then, slide the axle U-bolts into place, and apply antiseize compound to the U-bolt threads. Install the axle clamp (Ref. 15), and the shock absorber mounting bracket (Ref. 18). Hold them in place with the flatwashers and high nuts. Tighten the nuts finger-tight.
2. Position the leaf spring assembly on the suspension crossmember; then, install the crossmember U-bolts (Ref. 24) and the pressure plate (Ref. 22). Install the flatwashers and high nuts on the crossmember U-bolts. Tighten the high nuts 65 lbf·ft (88 N·m).
3. Install the spring mounting eye bolts (Ref. 3) with the appropriate alignment washers (noted during removal), and locknuts. Tighten the locknuts 190 lbf·ft (258 N·m).
4. In a diagonal pattern, tighten the axle U-bolt high nuts 60 lbf·ft (80 N·m). Then, in the same pattern, tighten them 200 lbf·ft (270 N·m); then to the final torque of 460 lbf·ft (624 N·m).
5. Install the neoprene sleeve in the spring hanger, then install the bolt from the inboard side of the spring hanger. Install the flatwasher and locknut on the bolt. Tighten the locknut 30 lbf·ft (41 N·m).
6. Install the wheel/tire assembly. For instructions, refer to the applicable subject in **Group 40**. Remove the safety stands, and lower the vehicle.
7. Check the rear axle alignment. Refer to **Section 35.03** for instructions. If necessary, adjust the rear axle alignment using the instructions in **Subject 170** of this section.

Alignment (See Fig. 1)

1. Disconnect the forward end of the spring torque leaf from the spring hanger by removing the spring eye-to-hanger bolts, nuts, and washers.
2. Move the axle forward or backward until it is aligned within the tolerances in the rear axle alignment checking section in this manual.
3. When the axle is in alignment, install axle alignment washers as needed between the mounting eyes and the spring hanger. Install the bearing washers, bolts, and locknuts. See **Fig. 1**. Tighten the locknuts 190 lbf·ft (258 N·m).



1. Frame Rail
2. Spring Hanger
3. Spring Mounting Eye Bolt
4. Bearing Washer
5. Spring Mounting Eye
6. Alignment Washer
7. Neoprene Sleeve Locknut
8. Locknut
9. Spring Torque Leaf
10. Tapered Leaf Spring Assembly
11. Axle U-Bolt
12. Axle U-Bolt Pad
13. Spring Seat
14. Axle (sectional view)
15. Axle Clamp
16. Flatwasher
17. High Nut
18. Shock Absorber Mounting Bracket
19. Shock Absorber
20. High Nut
21. Flatwasher
22. Pressure Plate
23. Suspension Crossmember
24. Suspension Crossmember U-Bolt
25. Lower Air Spring Support
26. Serrated-Flange Capscrew
27. Air Spring
28. Air Spring Upper Mounting Bracket

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Fig. 1

4. Check the axle alignment again. Repeat the above procedure until alignment is within tolerances.

Problem—All Air Springs Are Flat

Possible Cause	Remedy
Low air pressure in the secondary air system.	Check the air pressure gauge on the instrument panel. If secondary air pressure is low, run the engine until at least 70 psi (482 kPa) is indicated.
Air is leaking from the air suspension system.	Check for leakage from fittings, air lines, air springs, and the leveling valve. Tighten loose fittings and clamps to stop leakage; replace worn or damaged parts.
The leveling valve is out of adjustment.	Adjust the leveling valve.
The leveling valve is inoperative.	If upward movement of the overtravel lever on a properly adjusted valve fails to inflate the air springs, replace the leveling valve.
The leveling valve linkage is damaged.	Check for damage to the leveling valve linkage and overtravel lever. Repair or replace damaged linkage parts.

Problem—Air Springs Deflate Rapidly When the Vehicle is Parked

Possible Cause	Remedy
Air is leaking from the air suspension system.	Check for leakage from fittings, air lines, air springs, and the leveling valve. Tighten loose fittings and clamps to stop leakage; replace worn or damaged parts.

Problem—Vehicle Rides Too High or Too Low

Possible Cause	Remedy
The leveling valve is out of adjustment.	Adjust the leveling valve.

Problem—Collapsed Air Spring

Possible Cause	Remedy
An air spring is punctured.	Locate leaks by listening for escaping air, or by applying a soap and water solution to the air spring and watching for bubbles. Repair punctures and cuts that are less than 1/8 inch (3 mm). Replace the air spring if damage is greater.
	Check the area around the damaged air spring for air spring contact with such things as frame-mounted accessories, new tires and rims, tire chains, and other components. Correct the problem areas as needed.
The air spring is continually or repeatedly over-extended.	Check the height of the air spring. Make sure the 6-3/4 ±1/8 inch (170 ±3 mm) air spring height is maintained. Adjust, if needed. Check for a broken shock absorber. Replace, if broken.

Problem—Air Springs Do Not Fully Deflate When All Weight is Removed from the Suspension

Possible Cause	Remedy
The leveling valve is out of adjustment.	Adjust the leveling valve.
The air line between the leveling valve and the air spring is restricted.	Disconnect the leveling valve linkage, and move the overtravel lever down. If the air spring remains inflated, check for a pinched or blocked line. Clean out plugged lines; replace damaged lines.
The leveling valve is inoperative.	If downward movement of the overtravel lever on a properly adjusted valve fails to deflate the air springs, replace the leveling valve.

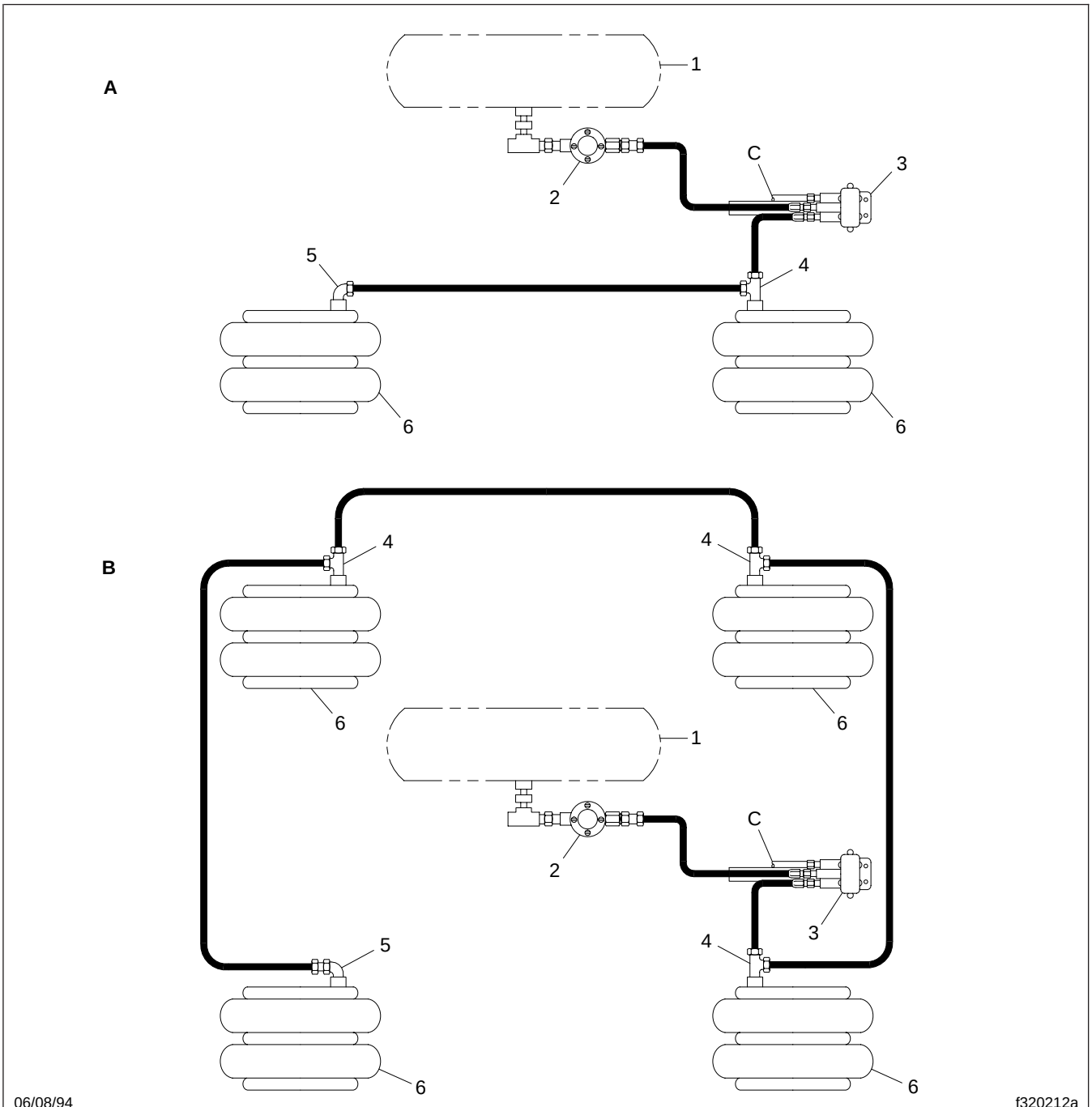
For a plumbing diagram of the FAS 20 and FAS 40 air suspension system, see **Fig. 1**.

Torque Values		
Description	**Size**	**Torque**
Height Control Valve Adjustment Locknut	1/4–20	62 lbf·in (700 N·cm)
Height Control Valve Mounting Bolt Nuts	5/8–16	14 lbf·ft (19 N·m)
Height Control Valve Linkage-to-Overall Lever Nut	1/4–20	12 lbf·ft (16 N·m)
Adjustment Block U-Bolt Stop Nuts	3/4–16	340 lbf·ft (461 N·m)
Adjustment Block-to-Spring Hexnut and Self-Locking Nut	1/2–20	100 lbf·ft (136 N·m)
Shock Absorber Locknuts	3/4–16	150 lbf·ft (203 N·m)
Air Spring Lower Mounting Capscrews	3/8–16	34 lbf·ft (46 N·m)
Air Spring Upper Mounting Locknuts	3/4–16	45 lbf·ft (61 N·m)
	1/2–13	20 lbf·ft (27 N·m)
Crossmember U-Bolt High Nuts	1/2–20	75 lbf·ft (102 N·m)
Spring Mounting Nut Eye Bolt Locknuts	5/8–11	190 lbf·ft (258 N·m)
Axle U-Bolt High Nuts	7/8–14	Stage 1: Hand Tighten Stage 2: 60 lbf·ft (81 N·m) * Stage 3: 200 lbf·ft (271 N·m) * Stage 4: 420 to 500 lbf·ft (571 to 680 N·m)) *
	1–14	Stage 1: Hand tighten Stage 2: 60 lbf·ft (81 N·m) * Stage 3: 200 lbf·ft (271 N·m) * Stage 4: 520 to 600 lbf·ft (707 to 816 N·m) *
Neoprene Sleeve Locknut	3/4–16	30 lbf·ft (41 N·m)
Spring Hanger Mounting Locknuts	3/4–10	370 lbf·ft (502 N·m)
Shock Absorber Upper Bracket Mounting Locknuts	1/2–13	95 lbf·ft (129 N·m)
Air Spring Upper Mounting Bracket Nuts	5/8–11	190 lbf·ft (258 N·m)
Spring Hanger Mounting Bolts	3/4–10	269 lbf·ft (365 N·m)
	3/4–16	241 lbf·ft (327 N·m)
	5/8–11	128 lbf·ft (173 N·m)

* Tighten in a diagonal pattern as shown in **Fig. 2**.

Table 1, Torque Values

Specifications



A. Single Axle
B. Tandem Axle
C. to atmosphere
1. Secondary Air Reservoir
2. Pressure Holding Valve
3. Height Control Valve
4. Tee
5. Elbow
6. Air Spring

Fig. 1, Plumbing Diagram

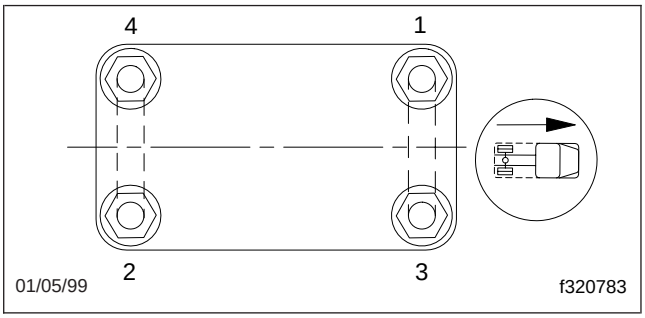


Fig. 2, Tightening Pattern for U-bolt High Nuts

General Description

The single-axle rear spring suspension (**Fig. 1**) uses a full-floating spring design. Semi-elliptical spring assemblies are attached to the axles with U-bolt assemblies.The spring ends ride in aluminum brackets that are mounted on the frame rails. Steel wear shoes are cast into each bracket. Radius rods attached to the axle seats and the forward spring brackets hold the axle in alignment.

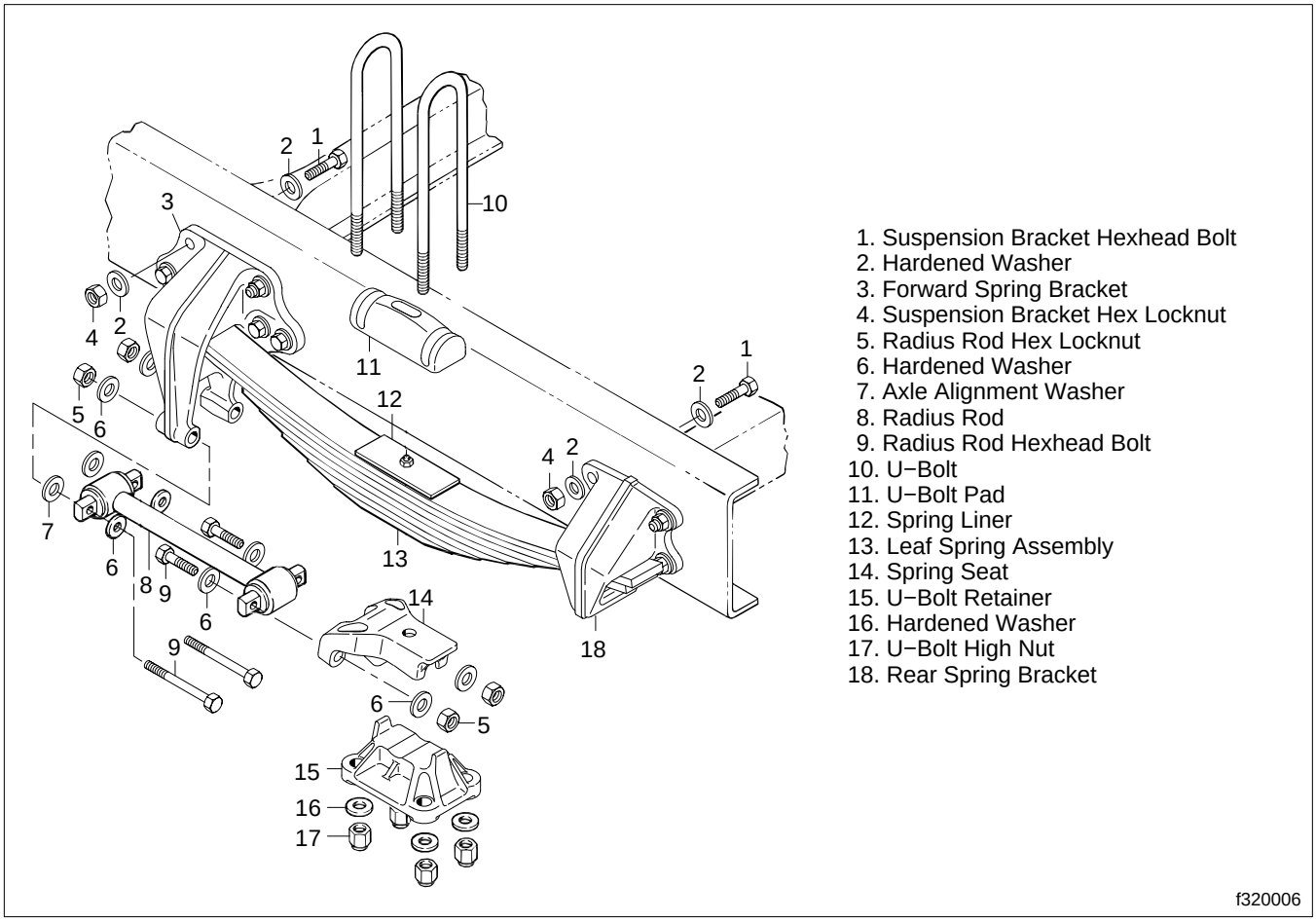


Fig. 1, Single-Axle Spring Suspension

Radius Rod Removal and Installation

Removal (See Fig. 1)

1. Apply the parking brakes, and chock the tires.
2. Note the number of axle alignment washers (Ref. 4) at the forward end of the radius rod that is being removed.
3. Remove the fasteners that attach the radius rod to the forward spring bracket and to the axle seat.
4. Remove the radius rod and any axle alignment washers.

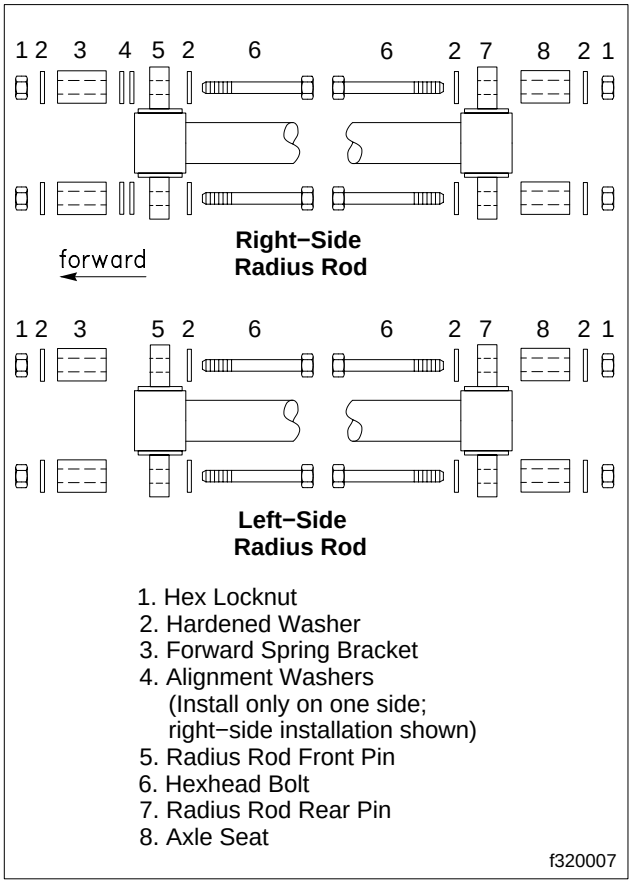


Fig. 1, Radius Rod Attachment (top view)

Installation (See Fig. 1)

IMPORTANT: At all points where steel parts (including bolts, washers, and nuts) contact the aluminum forward spring bracket, apply Alumilastic® compound, or an equivalent, on the mating surfaces.

CAUTION

Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.

1. Place the radius rod pins between the rear side of the forward spring bracket, and the front side of the axle seat.
2. Install the hexhead bolts, hardened washers, and locknuts in the axle seat and the radius rod rear pin.
3. Install any previously removed axle alignment washers between the radius rod front pin and the forward spring bracket. Install the hexhead bolts, hardened washers, and locknuts in the radius rod front pin and the forward spring bracket.
4. Tighten the radius rod locknuts to the torque value in **Specifications, 400**.
5. Check the axle alignment. For instructions, refer to the rear axle section in this manual. If necessary, adjust the rear axle alignment, using the instructions in **Subject 130**.

Replacement (See Fig. 1)

WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

1. Chock the front tires.
2. Raise the frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Raise the rear axle until the spring no longer contacts the spring bracket wear shoes, then block the axle. Make sure the stands will securely support the weight of the axles and frame. To gain easy access to the suspension system, remove the wheel assembly; refer to the wheels and tires section in this manual for instructions.
3. Remove the U-bolt high nuts, hardened washers, U-bolt retainer, U-bolts, and upper U-bolt pad.
4. Lift the spring assembly off the axle seat, then move it to the rear, out of the forward spring bracket. Lift the front of the spring, then move it forward, out of the rear spring bracket.
5. Using chassis grease, lubricate the ends of the new spring where they contact the stationary wear shoes in the spring brackets.
6. Work the new spring assembly into the spring brackets, and place it on the axle seat. Make sure the spring center-bolt head seats in the axle seat hole.
7. Place the upper U-bolt pad on the spring assembly. Place the U-bolts over the upper U-bolt pad and the spring assembly.
8. Install the U-bolt retainer, hardened washers, and U-bolt high nuts.
9. Tighten the U-bolt high nuts in stages in a diagonal pattern as described in Section 32.03, **Specifications 400**.

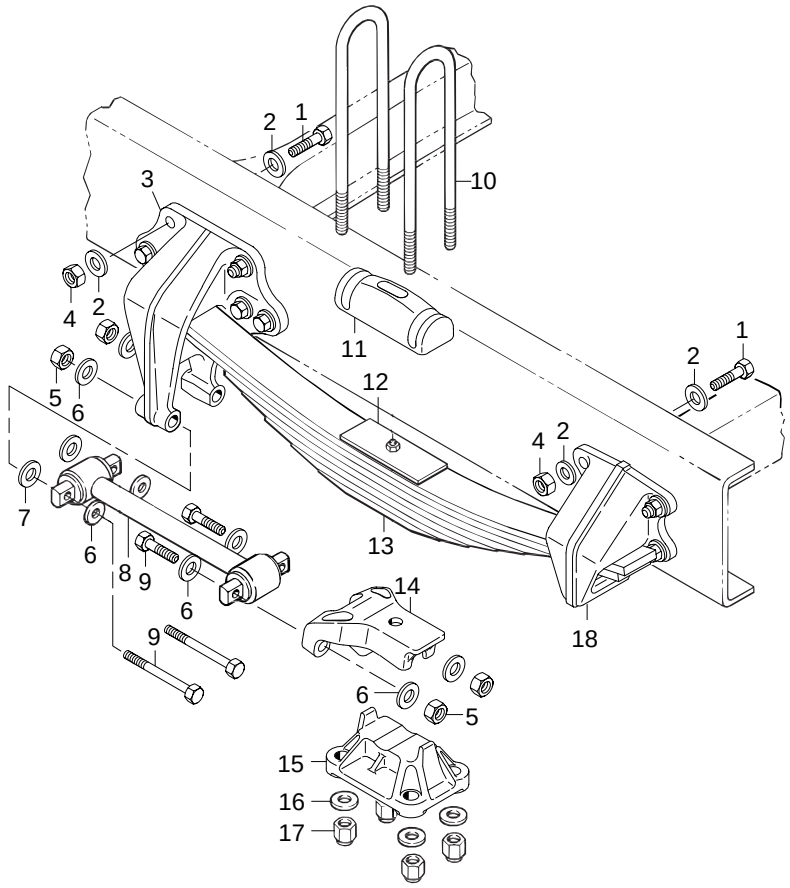
CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 of the *Heavy-Duty Trucks Maintenance Manual*.

10. Install the wheel assembly, using the instructions in **Group 40**. Remove the safety stands from under the frame and axle, and lower the vehicle.
11. Check the axle alignment. For instructions, see **Group 35**. If necessary, adjust the rear axle alignment, using the instructions in **Subject 130**.

Spring Assembly Replacement



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1. Suspension Bracket Hexhead Bolt
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Torque Arm Hexhead Bolt
6. Hardened Washer
7. Axle Alignment Washer
8. Torque Arm
9. Torque Arm Hexhead Bolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Rear Spring Bracket

Fig. 1, Single-Axle Spring Suspension

Replacement

WARNING

WARNING: Failure to replace worn, cracked, or damaged spring brackets could result in breakage of the bracket, which could cause a loss of vehicle control, resulting in personal injury or property damage.

IMPORTANT: At all points where steel parts (including bolts, washers, and nuts) contact the aluminum spring brackets, apply Alumilastic® compound, or an equivalent, on the mating surfaces.

CAUTION

CAUTION: Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.

1. Chock the front tires.
2. Raise the rear of the vehicle, and block the rear axle with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will securely support the weight of the axle and frame.
3. If removing the forward spring bracket, note the number of axle alignment washers, if any, between the bracket and the radius rod front pin. Remove the fasteners that attach the radius rod to the bracket, and remove any axle alignment washers.
4. Remove the fasteners that attach the spring bracket to the frame rail, and remove the spring bracket.
5. Place the new spring bracket on the frame rail. Align the mounting holes, and install the spring bracket bolts, hardened washers, and locknuts.

NOTE: If installing the forward spring bracket, install the nuts for the top two bolts on the outboard side of the frame rail, and install the nuts for the bottom four bolts on the inboard side of the frame rail. **See Fig. 1.**

If installing the rear spring bracket, install the nuts for the top two bolts on the outboard side of the frame rail, and install the nuts for the bottom two bolts on the inboard side of the frame rail. **See Fig. 1.**

6. Tighten the locknuts to the applicable torque value in **Specifications, 400**.

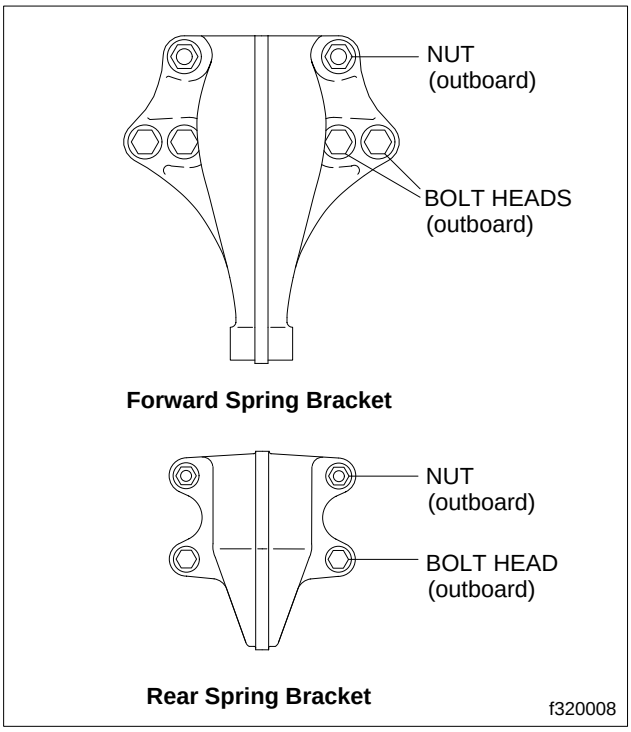


Fig. 1, Frame Brackets

CAUTION

CAUTION: Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, refer to the suspension section in the vehicle maintenance manual.

7. If replacing the forward spring bracket, position any previously removed axle alignment washers between the bracket and the radius rod front pin.

Spring Bracket Replacement

Install the bolts, hardened washers, and locknuts in the radius rod front pin and the forward spring bracket. Tighten the locknuts to the torque value in **Specifications, 400**.

8. Remove the safety stands from under the frame and axle, and lower the vehicle.
9. Check the axle alignment. For instructions, refer to the rear axle section in this manual. If necessary, adjust the rear axle alignment, using the instructions in **Subject 130**.

Adjustment

1. Using a straightedge and a tape measure, determine the amount of adjustment needed to align the axle at a right angle to the frame. For instructions, refer to the rear axle section in this manual. The difference in measurements between the sides of the vehicle is the approximate amount that the trailing end of the axle will have to be brought forward, or the leading end will have to be moved back to align it at a right angle to the frame. **See Fig. 1.**

NOTE: To adjust the axle alignment, add washers between the radius rod front pin and the forward spring bracket on the leading end, to adjust the leading end backward. Or, remove washers from the trailing end, to bring the trailing end forward. When possible, alignment washers should be removed instead of added.

2. On both sides of the axle, loosen the axle U-bolts enough to allow the springs to shift on the axle seats.
3. On the side of the vehicle that is to be adjusted, remove the fasteners that attach the radius rod to the forward spring bracket. Remove any axle alignment washers.

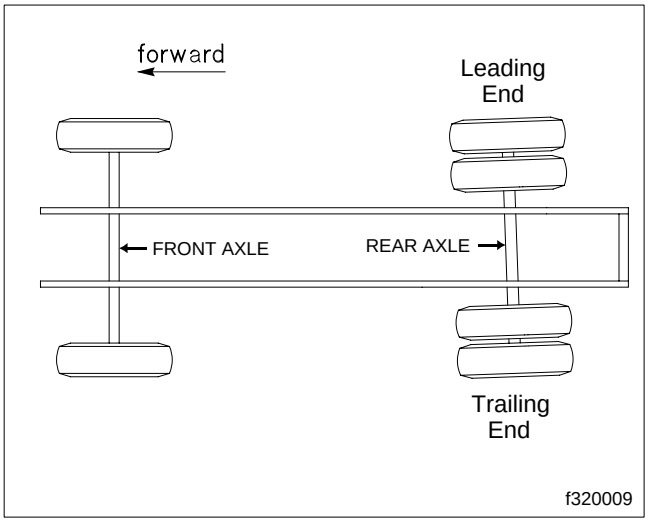


Fig. 1, Single Axle, Shown Out of Alignment

4. Raise the frame just enough to relieve the weight from the springs. Place safety stands under the frame. Make sure the stands will support the weight of the frame.
5. Move the loosened end of the axle forward or backward as needed, by rolling the wheels.
6. Insert the correct thickness of axle alignment washers between the radius rod front pin and the forward spring bracket.
7. Install the hexhead bolt, hardened washers, and locknut in the radius rod pin and forward spring bracket. Place an equal thickness of washers on the other end of the radius rod pin, and install the fasteners.
8. Tighten the locknuts to the applicable torque value in **Specifications, 400**.
9. Remove the safety stands, and lower the vehicle. Remove the chocks from the front tires.
10. Check the axle alignment with the straightedge and the tape measure. If alignment is within specifications, center the spring in the forward spring bracket, if needed, then tighten the axle U-bolt nuts to the torque value in **Specifications, 400**.

    If not in alignment, repeat the procedure above.

CAUTION

CAUTION: Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, refer to the suspension section in the vehicle maintenance manual.

Specifications

Torque Values			
Description	**Size**	**IFI Grade**	**Torque: lbf·ft (N·m)**
Forward Spring Bracket-to-Frame Rail Locknut *	3/4–10	C	240 (325)
Rear Spring Bracket-to-Frame Rail Locknut *	5/8–11	C	135 (184)
Axle U-Bolt High Nuts (Tighten in a diagonal pattern as shown in **Fig. 1**)	7/8–14	C	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 420–500 (571–680)
	1–14	C	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 520–600 (707–816)
Radius Rod Locknut	5/8–18	C	135 (184)

* Cadmium-plated, wax-coated nuts, and grade 8 hexbolts with phosphate- and oil-coated threads; both used with hardened washers.

Table 1, Torque Values

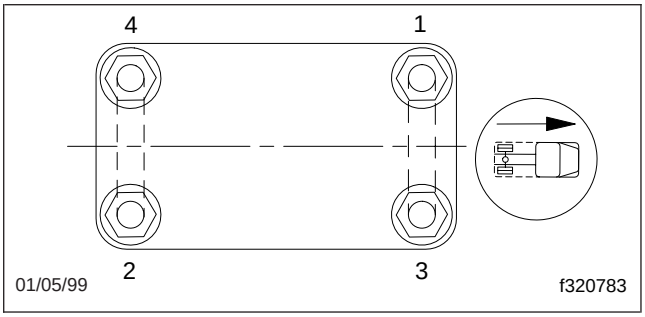


Fig. 1, Tightening Pattern for U-bolt High Nuts

General Description (See Fig. 1)

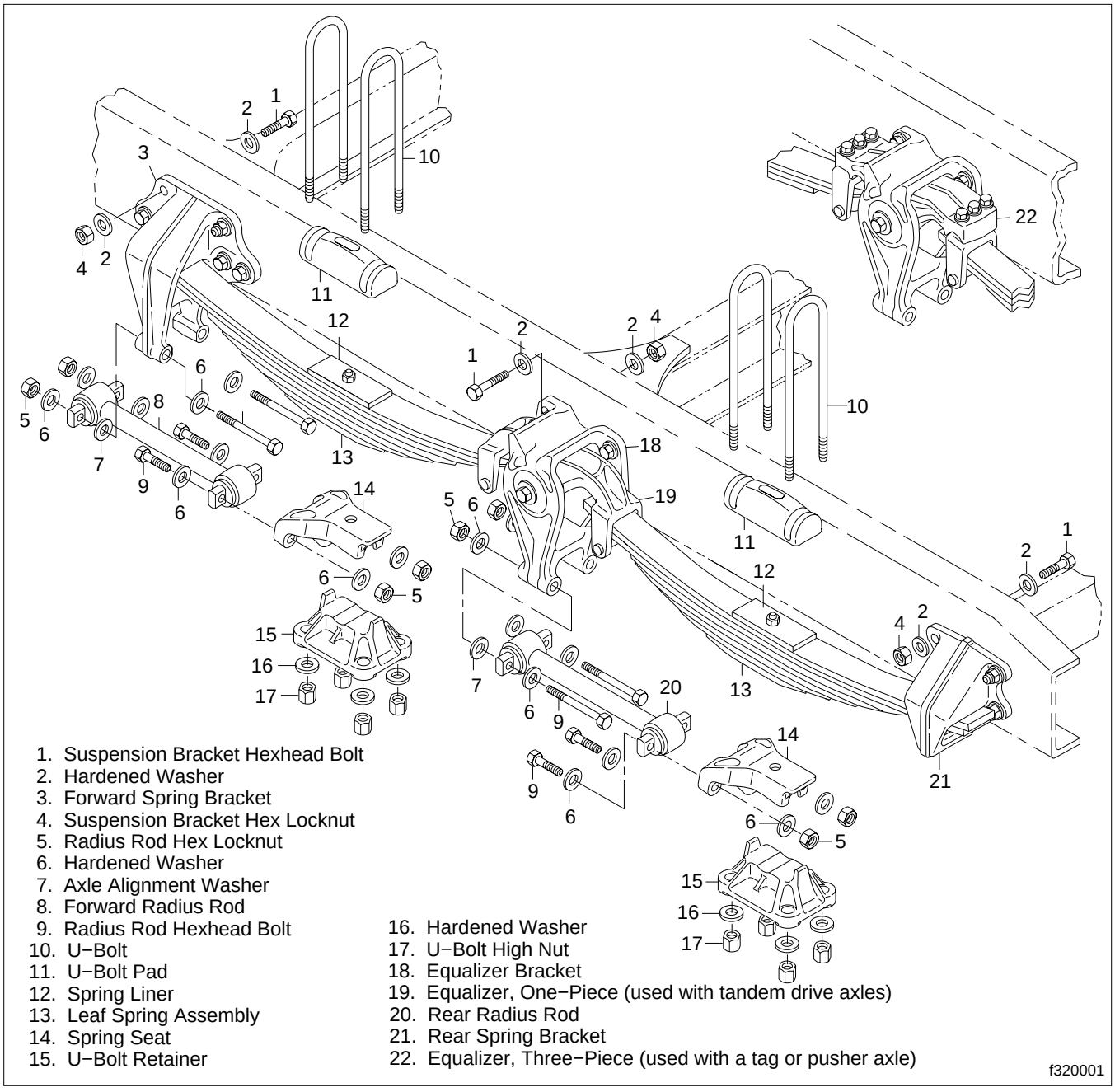


Fig. 1, Tandem-Axle Spring Suspension

The tandem-axle rear spring suspension uses a six-point equalizing leaf spring design, which compensates for axle articulation, from side to side, and front to rear. Four semi-elliptical spring assemblies are

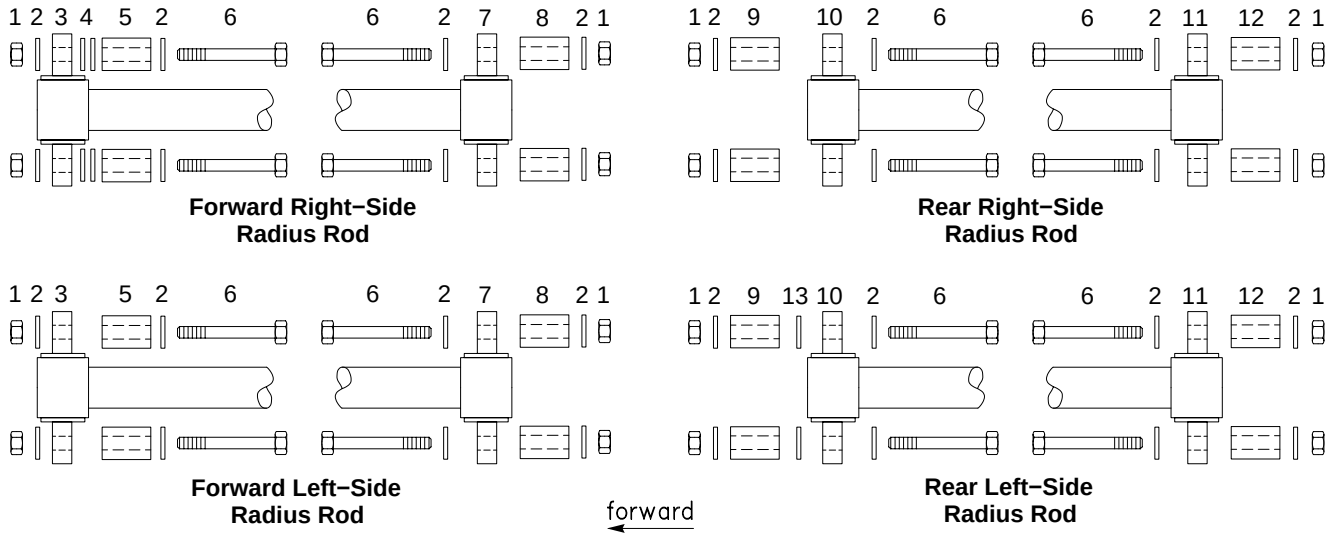
General Description

attached to the axles with U-bolts. On both sides of the vehicle, the forward end of the forward spring and the rear end of the rear spring ride in aluminum brackets that are mounted on the frame rails. Steel wear shoes are cast into each bracket.

At the center, between the forward and rear springs, the springs ride on an equalizer, which pivots on a sleeve in the equalizer bracket. Equalizer travel is stopped when the top of the equalizer and equalizer bracket make contact. Each axle is held in alignment by a pair of radius rods that extend forward from the axle seats to the forward spring brackets for the forward-rear axle, and to the equalizer brackets for the rearmost axle.

Radius Rod Removal and Installation

Removal (See Fig. 1)



1. Hex Locknut
2. Hardened Washer
3. Forward Radius Rod Front Pin
4. Alignment Washers (Install only on one side of front axle; right−side installation shown)
5. Forward Spring Bracket
6. Hexhead Bolt
7. Forward Radius Rod Rear Pin
8. Forward Axle Seat
9. Equalizer Bracket
10. Rear Radius Rod Front Pin
11. Rear Radius Rod Rear Pin
12. Rear Axle Seat
13. Alignment Washer (Install only on one side of rear axle; left−side installation shown)

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Fig. 1, Radius Rod Attachment (top view)

1. Apply the parking brakes, and chock the tires.
2. Note the number of axle alignment washers (Ref. 4) at the forward end of each radius rod that is being removed.
3. Remove the fasteners that attach the radius rod to the forward spring bracket or equalizer bracket, and to the axle seat.
4. Remove the radius rod and any axle alignment washers.

Installation

(See Fig. 1)

IMPORTANT: At all points where steel parts (including bolts, washers, and nuts) contact aluminum brackets, apply Alumilastic compound, or an equivalent, on the mating surfaces.

⚠ CAUTION

CAUTION: Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.

If installing forward and rear radius rods, install the forward radius rod before installing the rear radius rod.

1. If installing a forward radius rod, place the radius rod front pin on the front side of the forward spring bracket, and place the radius rod rear pin in front of the axle seat.

   If installing a rear radius rod, place the radius rod pins between the rear side of the equalizer bracket and the front side of the axle seat.

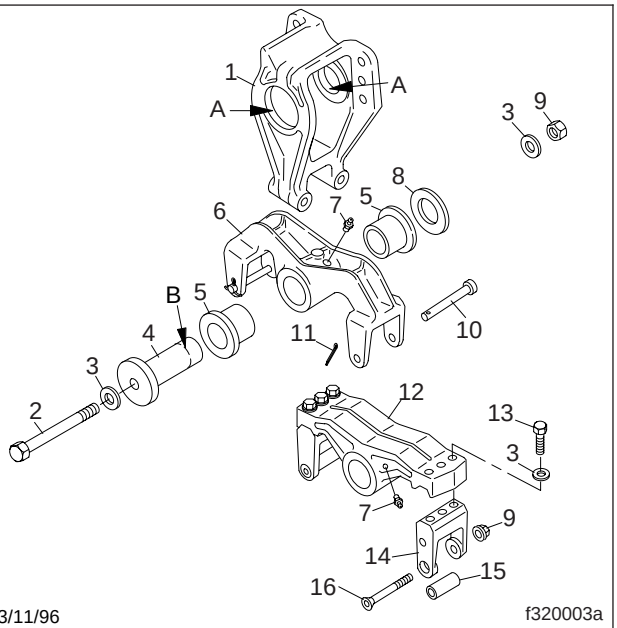
Radius Rod Removal and Installation

2. Install a hexhead bolt with a hardened washer through each end of the radius rod rear pin and the axle seat ears. Install the hardened washers and locknuts.
3. If installing a forward radius rod, install any previously removed axle alignment washers between the radius rod front pin and the forward spring bracket. Install the hexhead bolts, hardened washers, and locknuts.

   If installing a rear radius rod, install any previously removed axle alignment washers between the radius rod front pin and the equalizer bracket. Install the hexhead bolts, hardened washers, and locknuts.
4. Tighten the radius rod locknuts to the torque value in **Specifications, 400**.
5. After all of the radius rods are installed, check the rear axle alignment. For instructions, refer to the rear axle section in this manual. If necessary, adjust the axle alignment, using the instructions in **Subject 140**.

Equalizer Removal, Inspection, and Installation

Removal (See Fig. 1)



A. Apply Loctite here.
B. No grease here.
1. Equalizer Bracket
2. Hexbolt
3. Bearing Washer
4. Cap and Tube Assembly
5. Equalizer Assembly Bushing
6. Equalizer, One-Piece (tandem drive axles)
7. Grease Fitting
8. Wear Washer(s)
9. Locknut
10. Spring Retainer Pin
11. Cotter Pin
12. Equalizer, Three-Piece (tag or pusher axle)
13. Capscrew
14. Wear-Shoe Side-Restraint
15. Side-Restraint Sleeve
16. Flathead Bolt

Fig. 1, Equalizer Assembly

1. Chock the front tires.
2. Raise the rear of the vehicle, and block the axles with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will securely support the weight of the axles and frame. To allow access to the equalizer, remove the wheel assemblies on that side, using the instructions found in **Group 40**.
3. If removing an equalizer from a vehicle with two drive axles, remove the cotter pin from the outboard end of each spring retainer pin, then remove the retainer pins.

   If removing an equalizer from a vehicle with a pusher or tag axle, remove the nuts from the flathead bolts in the wear-shoe side-restraints, on each end of the equalizer. Remove the flathead bolts and side-restraint sleeves. Remove the six capscrews and washers, and remove both wear-shoe side-restraints from the equalizer.
4. Remove the cap and tube assembly locknut, inboard bearing washer, bolt, and outboard bearing washer.
5. Insert a bar between the bottom of the equalizer and the equalizer bracket. Gently lever the weight of the equalizer off the cap and tube assembly. Insert a piece of barstock through the inboard cap and tube assembly bolt hole, and lightly tap the cap and tube assembly out of the equalizer.
6. Remove the equalizer from the equalizer bracket. Remove the wear washer(s) and equalizer bushings from the equalizer.

Inspection

1. Thoroughly clean the equalizer with steam or a hot soap solution. Inspect it for wear, cracks, or other damage. Replace the equalizer if any of these conditions are present.

⚠ WARNING

WARNING: Replace a worn or damaged equalizer. A broken equalizer could cause a loss of vehicle control, resulting in personal injury or property damage.

2. Inspect the equalizer bushings, cap and tube assembly, and the equalizer bracket. If wear, cracks, or other damage are present, replace the bushings, cap and tube assembly, or bracket.

Installation (See Fig. 1)

1. Apply a thin film of multipurpose chassis grease to the outside of the equalizer bushings, then install the bushings in the equalizer.

NOTE: The equalizer is *not* symmetrical. To ensure that the equalizer is installed in the proper direction, an arrow is cast into its top surface.

Equalizer Removal, Inspection, and Installation

2. Install the equalizer in the equalizer bracket. Make sure that the arrow cast into the top of the equalizer is pointing toward the frame rail. **See Fig. 2.**

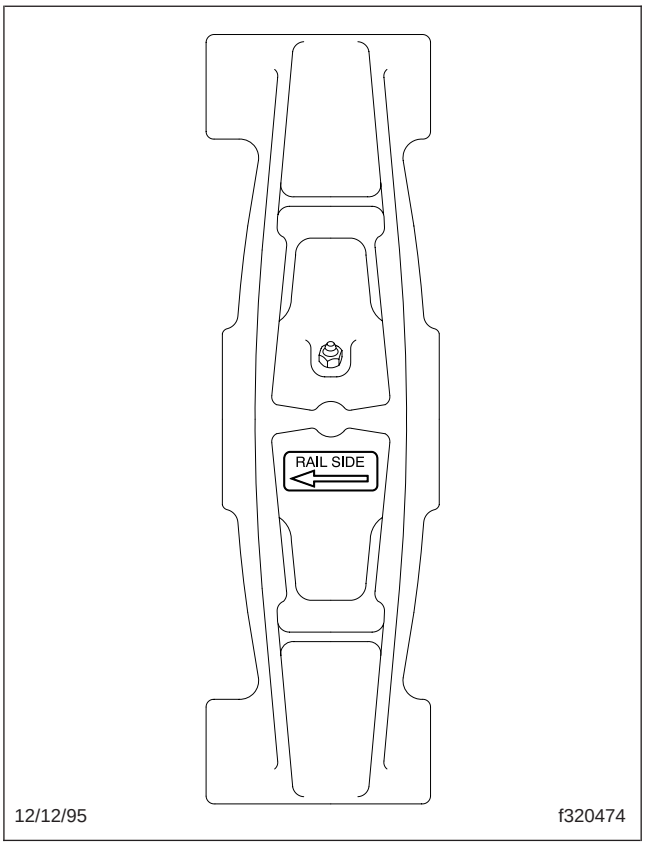


Fig. 2, Equalizer Marking

NOTE: The next four steps must be completed before the Loctite begins to cure (approximately 5 to 10 minutes).

IMPORTANT: Be careful to prevent grease from contacting the inboard surface of the cap and tube assembly, where the Loctite is applied.

3. Apply Loctite 680 to both interior surfaces of the equalizer bracket, where the cap and tube assembly is inserted. Apply multipurpose chassis grease to the cap and tube assembly, except the last inch which connects to the equalizer bracket. **See Fig. 1,** Ref. B. Start the cap and tube assembly into the equalizer, through the equalizer bracket.
4. Push the cap and tube assembly part way through the equalizer, then place the wear washer(s) between the inboard equalizer bushing and the equalizer bracket. Push the cap and tube assembly the rest of the way into the equalizer bracket.
5. Place the outboard bearing washer on the equalizer cap and tube assembly bolt, and install the bolt in the cap and tube assembly.
6. Install the inboard bearing washer and locknut on the cap and tube assembly bolt. Tighten the locknut to the torque value in **Specifications, 400**.
7. Lubricate the equalizer assembly by applying multipurpose chassis grease at the grease fitting. Lubricate with a hand gun or pressure gun until grease is forced past the bushing seals, or if equipped with a pressure-relief grease fitting, until grease is forced out from the base of the pressure relief fitting.
8. If installing an equalizer on a vehicle with two drive axles, apply Alumilastic compound, or an equivalent, to the spring retainer pins; then install them from the inboard side. Be sure the hooked ends of the spring leaves are above the retainer pins. Install a cotter pin in the outboard end of each retainer pin, and lock it in place.

   If installing an equalizer on a vehicle with a pusher or tag axle, apply Alumilastic compound, or an equivalent, to the surfaces where the wear-shoe side-restraints contact the equalizer. Attach the side-restraints to the equalizer, offsetting them toward the inboard side of the equalizer. Tighten the equalizer wear-shoe capscrews to the torque value in **Specifications, 400**. Install the side-restraint sleeves and flathead bolts in the wear-shoe side-restraints. Be sure the hooked ends of the spring leaves are above the side-restraint sleeves. Install the nuts, and tighten them to the applicable torque value in **Specifications, 400**.

⚠ CAUTION

CAUTION: Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel contact each other, could lead to corrosion of the metals, resulting in suspension damage.

9. Install the wheel assemblies, using the instructions found in **Group 40**. Remove the safety stands from under the frame and axle, and lower the vehicle.
10. If the radius rods have been loosened, or the equalizer bracket has been removed, check the rear axle alignment. For instructions, refer to **Group 35**. If necessary, adjust the axle alignment using the instructions in **Subject 140**.

Replacement (See Fig. 1)

⚠ WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

1. Chock the front tires.
2. Raise the frame so that all weight is removed from the leaf springs; then block the frame with safety stands. Raise the rear axle until the spring no longer contacts the spring bracket wear shoes and the spring retainer pin (or side-restraint sleeve); then block the axle. Make sure the stands will securely support the weight of the axles and frame. To access the spring assembly, remove the wheel assembly. See **Group 40** for instructions.
3. If equipped with two drive axles, remove the cotter pin from the spring retainer pin on the end of the equalizer where the spring is being replaced. Drive the spring retainer pin out of the equalizer.

   If equipped with a pusher or tag axle, remove the nut from the flathead bolt on the end of the equalizer where the spring is being replaced. Remove the bolt and the side-restraint sleeve from the wear-shoe side-restraint.
4. Remove the U-bolt high nuts, hardened washers, U-bolt retainer, U-bolts, and upper U-bolt pad.
5. Remove the spring assembly by lifting it off the axle seat, then moving it toward the equalizer, out of the forward or rear spring bracket.
6. Using chassis grease, lubricate the new spring assembly where the ends will contact the stationary wear shoes in the spring bracket and equalizer.
7. Place the new spring assembly in the spring bracket and on the axle seat. Make sure the spring center-bolt head seats in the axle seat hole.
8. If the upper U-bolt pad is aluminum, apply Alumilastic compound, or an equivalent, to those areas of the pad that will come in contact with the U-bolts and with the upper spring leaf.

⚠ CAUTION

Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel contact each other, could lead to corrosion of the metals, resulting in suspension damage.

9. Place the upper U-bolt pad on the spring assembly. Place the U-bolts over the upper U-bolt pad and the spring assembly.
10. Install the U-bolt retainer, hardened washers, and U-bolt high nuts.
11. If installing a spring assembly on a vehicle with two drive axles, apply Alumilastic compound, or an equivalent, to the spring retainer pins, then install them from the inboard side. Be sure the hooked ends of the spring leaves are above the retainer pins. Install a cotter pin in the outboard end of each retainer pin, and lock it in place.

    If installing a spring assembly on a vehicle with a pusher or tag axle, install the side-restraint sleeves and flathead bolts in the wear-shoe side-restraints. Be sure the hooked ends of the spring leaves are above the side-restraint sleeves. Install the nuts, and tighten them to the applicable torque value in **Specifications 400**.
12. Tighten the U-bolt high nuts in stages in a diagonal pattern as described in **Specifications 400**.

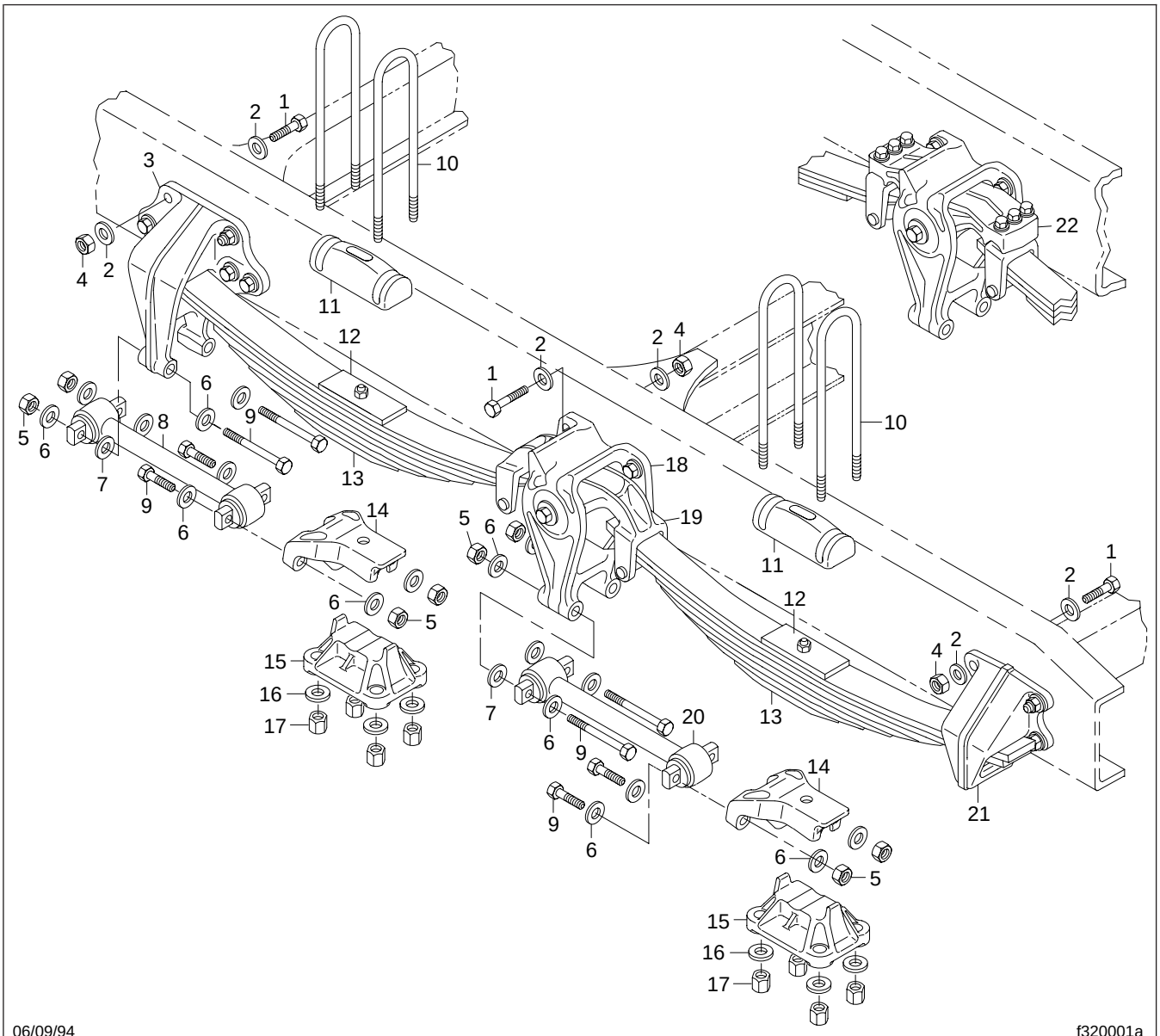
⚠ CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, Group 32 of the *Heavy-Duty Trucks Maintenance Manual*.

13. Install the wheel assembly, using the instructions in **Group 40**. Remove the safety stands from under the frame and axle, and lower the vehicle.

Spring Assembly Replacement



1. Suspension Bracket Hexbolt
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Torque Arm Hex Locknut
6. Hardened Washer
7. Axle Alignment Washer
8. Forward Torque Arm
9. Torque Arm Hexbolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Equalizer Bracket
19. Equalizer, One-Piece (tandem drive axles)
20. Rear Torque Arm
21. Rear spring Bracket
22. Equalizer, Three-Piece (tag or pusher axle)

Fig. 1, Tandem-Axle Spring Suspension

14. Check the rear axle alignment. For instructions, see **Group 35**. If necessary, adjust the axle alignment, using the instructions in **Subject 140**.

Replacement (See Fig. 1)

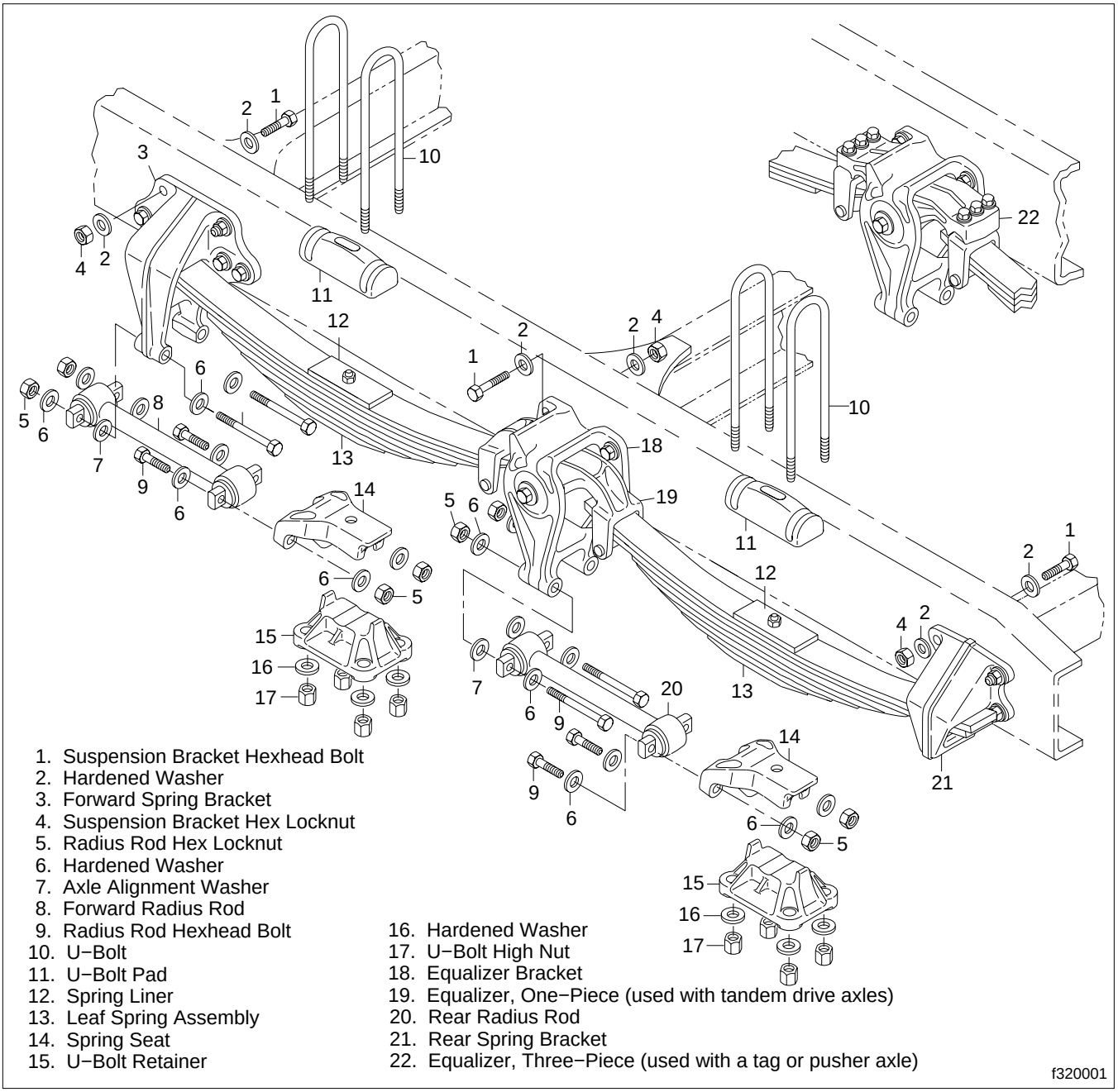


Fig. 1, Tandem-Axle Spring Suspension

Spring Bracket and Equalizer Bracket Replacement

⚠ WARNING

Failure to replace worn, cracked, or damaged spring brackets or equalizer brackets could result in breakage of the bracket, which could cause a loss of vehicle control, resulting in personal injury or property damage.

IMPORTANT: At all points where steel parts (including bolts, washers, and nuts) contact the aluminum spring brackets, apply Alumilastic compound, or an equivalent, on the mating surfaces.

⚠ CAUTION

Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.

1. Chock the front tires.
2. Raise the rear of the vehicle, and block the axles with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will securely support the weight of the axles and frame.
3. If removing the forward spring bracket or the equalizer bracket, note the number of any axle alignment washers, then remove the fasteners that attach the radius rod to the forward spring bracket or equalizer bracket. Remove any axle alignment washers.
4. If removing an equalizer bracket, remove the equalizer. For instructions, see **Subject 110**.
5. Remove the fasteners that attach the forward or rear spring bracket, or equalizer bracket, to the frame rail. Remove the bracket.
6. Place the new spring bracket or equalizer bracket on the frame rail. Align the mounting holes, and install the bracket bolts, hardened washers, and locknuts.

NOTE: If installing the forward spring bracket, install the nuts for the top two bolts on the outboard side of the frame rail, and install the nuts for the bottom four bolts on the inboard side of the frame rail. See **Fig. 2**.

If installing the equalizer bracket, for clearance, install all of the nuts on the inboard side of the frame rail. See **Fig. 2**.

If installing the rear spring bracket, install the nuts for the top two bolts on the outboard side of the frame rail, and install the nuts for the bottom two bolts on the inboard side of the frame rail. See **Fig. 2**.

7. Tighten the bracket mounting locknuts to the applicable torque value in **Specifications, 400**.

⚠ CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 of the *Heavy-Duty Trucks Maintenance Manual*.

8. When replacing the forward spring bracket or equalizer bracket, install any previously removed axle alignment washers between the forward radius rod front pin and the forward spring bracket, or between the rear radius rod front pin and the equalizer bracket, as applicable. See **Fig. 3**.

   Install bolts with hardened washers in the radius rod front pin, and the forward spring bracket or equalizer bracket. Install the hardened washers and locknuts, and tighten the locknuts to the torque value in **Specifications 400**.
9. If replacing an equalizer bracket, install the equalizer. For instructions, see **Subject 110**.
10. Remove the safety stands from under the frame and axle, and lower the vehicle.
11. Check the rear axle alignment. For instructions, see **Group 35** of this manual. If necessary,adjust the axle alignment, using the instructions in **Subject 140**.

Spring Bracket and Equalizer Bracket Replacement

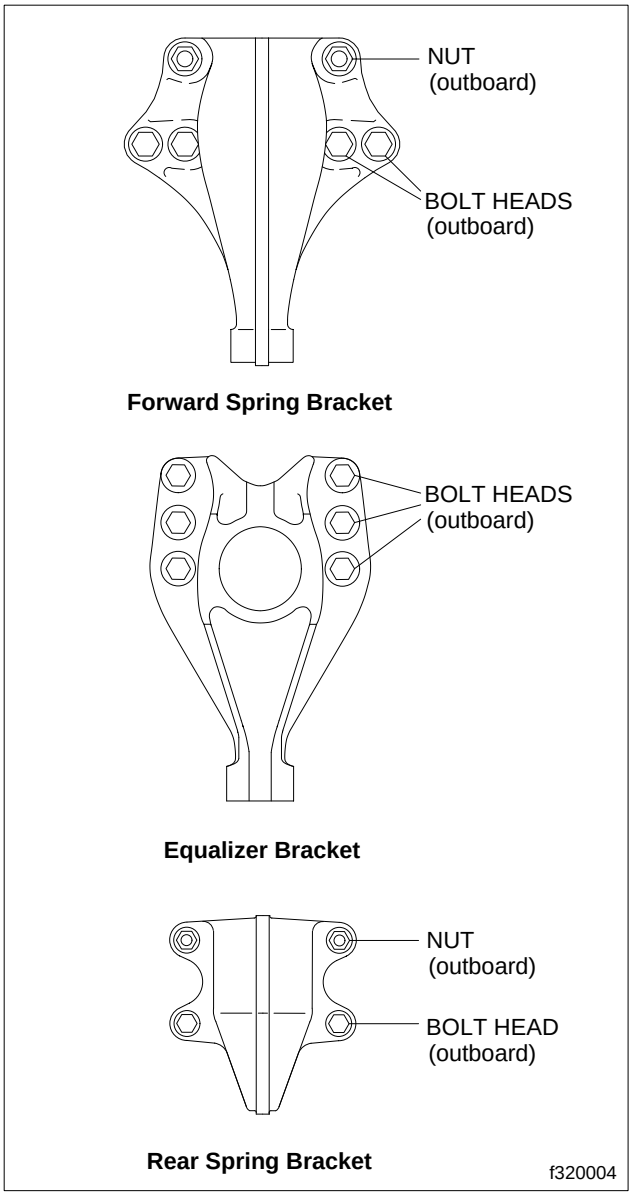
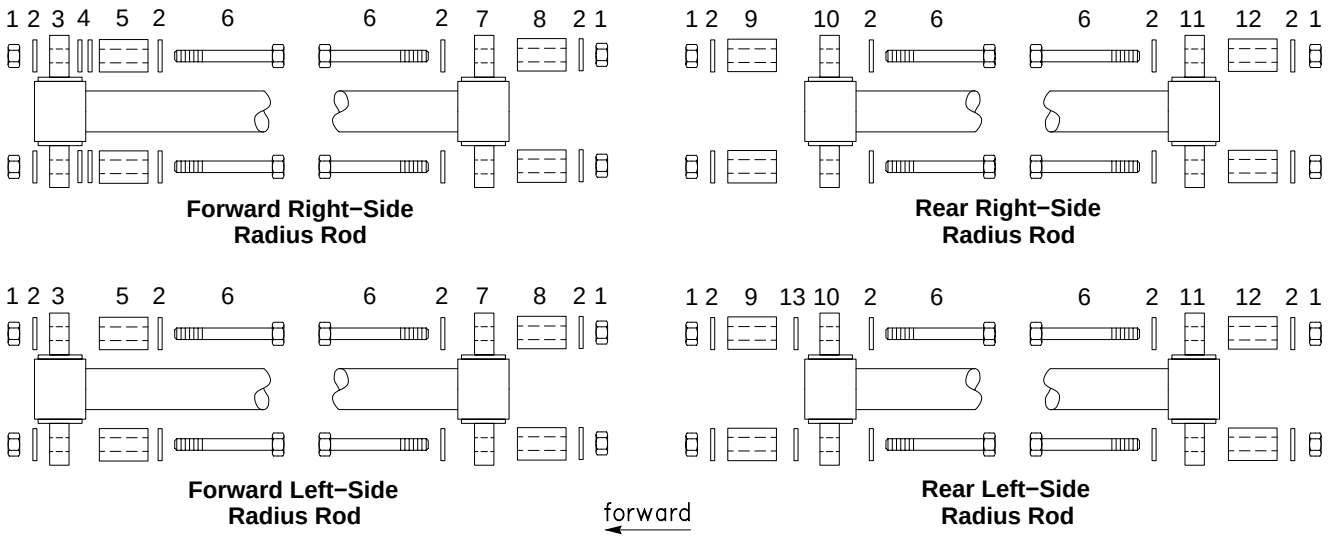


Fig. 2, Frame Brackets

Spring Bracket and Equalizer Bracket Replacement



1. Hex Locknut
2. Hardened Washer
3. Forward Radius Rod Front Pin
4. Alignment Washers (Install only on one side of front axle; right−side installation shown)
5. Forward Spring Bracket
6. Hexhead Bolt
7. Forward Radius Rod Rear Pin
8. Forward Axle Seat
9. Equalizer Bracket
10. Rear Radius Rod Front Pin
11. Rear Radius Rod Rear Pin
12. Rear Axle Seat
13. Alignment Washer (Install only on one side of rear axle; left−side installation shown)

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Fig. 3, Radius Rod Attachment (top view)

Rear Axle Alignment Adjustment

Adjustment

1. Using a straightedge and a tape measure, determine the amount of adjustment needed to align the forward-rear axle at a right angle to the frame. For instructions, refer to the rear axle section in this manual. The difference in measurements between the sides of the vehicle is the approximate amount that the trailing end of the forward-rear axle will have to be brought forward, or the leading end will have to be moved back to align it at a right angle to the frame. **See Fig. 1.**

   If the forward-rear axle alignment is within specifications, go to the step that begins "Using a center-point bar, determine...".

2. Chock the front tires. On both sides of the forward-rear axle, loosen the axle U-bolts enough to allow the springs to shift on the axle seats.

3. On the side of the vehicle that is to be adjusted, remove the fasteners that attach the forward radius rod to the forward spring bracket. Remove any axle alignment washers.

NOTE: To adjust the forward-rear axle alignment, add alignment washers between the radius rod and the forward spring bracket on the leading end, to adjust the leading end backward. Or, remove alignment washers from the trailing end, to bring the trailing end forward. When possible, alignment washers should be removed instead of added.

4. Raise the frame just enough to relieve the weight from the springs. Place safety stands under the frame. Make sure the stands will securely support the weight of the frame.

5. Move the loosened end of the axle forward or backward as needed, by rolling the wheels.

6. Between one end of the radius rod front pin and the forward spring bracket, insert the correct thickness of axle alignment washers needed to bring the forward-rear axle into alignment. Install the hexhead bolt, hardened washers, and locknut in the radius rod pin and forward spring bracket.

7. Place an equal thickness of washers on the other end of the radius rod pin, and install the fasteners.

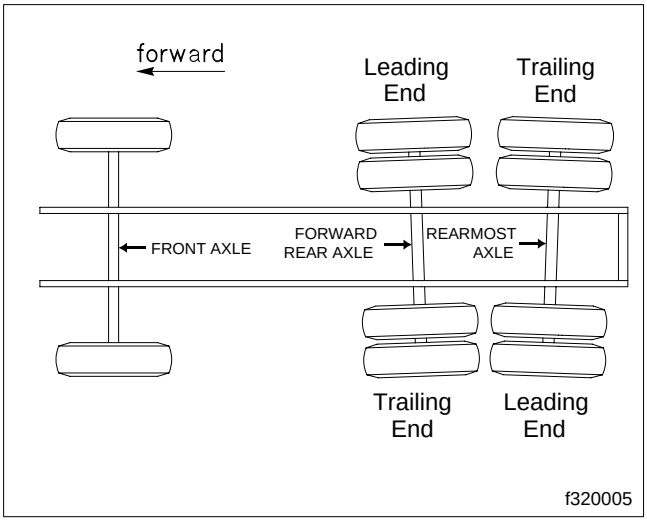


Fig. 1, Tandem Axle, Shown Out of Alignment

8. Tighten the radius rod locknuts to the torque value in **Specifications, 400**.

9. Remove the safety stands, and lower the vehicle.

10. Check the forward-rear axle alignment with the straightedge and the tape measure. If alignment is within specifications, center the spring in the forward spring bracket, if needed, then tighten the axle U-bolt nuts to the torque value in **Specifications, 400**.

    If not in alignment, repeat all of the steps above.

⚠ CAUTION

CAUTION: Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, refer to the suspension section in the vehicle maintenance manual.

11. Using a center-point bar, determine the difference between the forward-rear and the rearmost axles' center-to-center measurements on each side of the vehicle. For instructions, refer to the rear axle section in this manual. This difference is the approximate distance that the leading end of the rearmost axle will have to be adjusted

Rear Axle Alignment Adjustment

rearward, or that the trailing end will have to be adjusted forward, to align it at a right angle to the frame, and to align it parallel to the forward-rear axle. **See Fig. 1.**

12. On both sides of the rearmost axle, loosen the axle U-bolts enough to allow the springs to shift on the axle seats.
13. On the side of the vehicle that is to be adjusted, remove the fasteners that attach the rear radius rod to the equalizer bracket. Remove any axle alignment washers.
14. Raise the frame just enough to relieve the weight from the springs. Place safety stands under the frame. Make sure the stands will securely support the weight of the frame.
15. Move the loosened end of the axle forward or backward, by rolling the wheels. Move the axle just enough to provide space to allow installation of alignment washers between the equalizer bracket and the radius rod pin.
16. Between one end of the radius rod pin and the equalizer bracket, insert the additional thickness of alignment washers needed to make up for the difference in center-point bar measurements.

    For example, if one end of the axle was equipped with a 3/16-inch (4.5-mm) thickness of washers, and the difference in the center-point bar measurements is 1/4 inch (6 mm) less on that side, add an additional 1/4 inch (6 mm) of washers (for a total of 7/16 inch [10.5 mm]) to correct the alignment.

    Or, if one end of the axle was equipped with a 1/4-inch thickness of washers, and the difference in center-point bar measurements is 3/16 inch (4.5 mm) more on that side, install a 1/16-inch (1.6-mm) thickness of washers in place of the 1/4-inch (6-mm) thickness.
17. Install the bolt, hardened washers, and locknut in the equalizer bracket and the radius rod pin. Place an equal thickness of alignment washers on the other end of the radius rod pin, and install the fasteners at that end.
18. Tighten the radius rod locknuts to the torque value in **Specifications, 400**.
19. Remove the safety stands, and lower the vehicle. Remove the chocks from the front tires.
20. Using the center-point bar, check the rearmost axle alignment. If alignment is within specifications, center the spring in the rear spring bracket, if needed, then tighten the axle U-bolt nuts to the applicable torque value in **Specifications, 400**.

    If not in alignment, repeat the applicable steps above.

⚠ CAUTION

CAUTION: Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, refer to the suspension section in the vehicle maintenance manual.

Specifications

Torque Values			
Description	**Size**	**IFI Grade**	**Torque lbf·ft (N·m)**
Equalizer Bracket-to-Frame Rail Locknut *	3/4–10	C	240 (325)
Forward Spring Bracket-to-Frame Rail Locknut *	3/4–10	C	240 (325)
Rear Spring Bracket-to-Frame Rail Locknut *	5/8–11	C	135 (184)
U-bolt High Nuts	7/8–14	C	Stage 1: Hand tighten Stage 2: 60 (81) † Stage 3: 200 (271) † Stage 4: 420 to 500 (571 to 680) †
	1–14	C	Stage 1: Hand tighten Stage 2: 60 (81) † Stage 3: 200 (271) † Stage 4: 520 to 600 (707 to 816) †
Radius Rod Locknut *	5/8–18	C	135 (184)
Equalizer Cap and Tube Assembly Locknut *	3/4– 16	C	270 (365)
Equalizer Wear Shoe Capscrew	5/8–11	8	135 (184)
Side-Restraint Sleeve Locknut	1/2–13	C	68 (93)

* Cadmium-plated, wax-coated nuts, and grade 8 hexbolts with phosphate- and oil-coated threads; both used with hardened washers.
† Tighten in a diagonal pattern as shown in **Fig. 1**.

Table 1, Torque Values

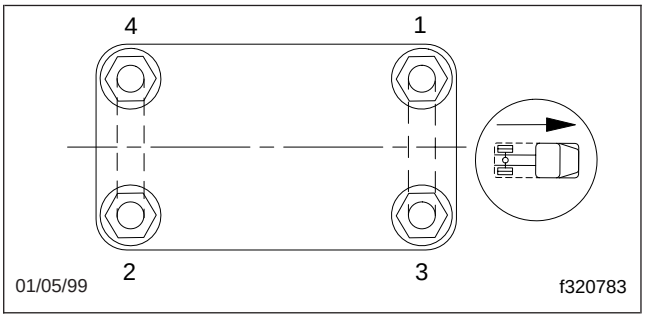


Fig. 1, Tightening Pattern for U-bolt High Nuts

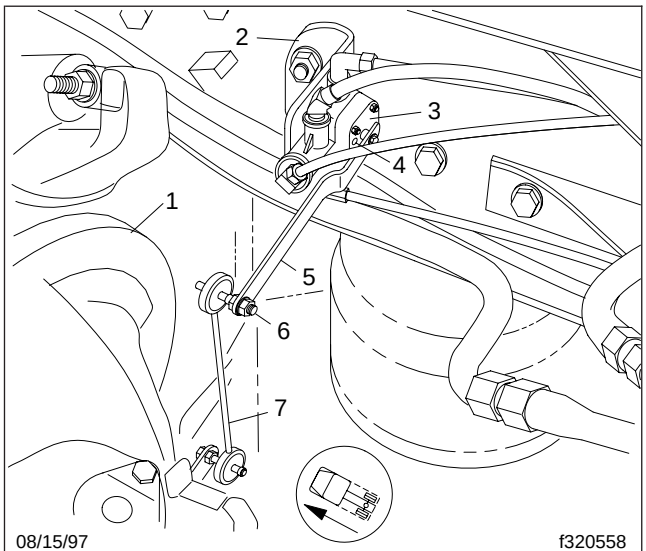
General Information

The Freightliner AirLiner Suspension is a single axle or tandem axle suspension that uses a combination of air and leaf springs. The suspension is manufactured at numerous weight ratings up to 46,000 pounds (20 865 kg). The top of the air spring is bolted to a bracket on the frame rail, or through the bottom flange of the frame rail; the bottom is bolted to the rear end of the tapered leaf spring assembly or, for the 23,000-pound (10 433 kg) and 46,000-pound suspensions, to a cross bar. The axle housing is fastened to the leaf spring assembly by U-bolts. A control rod, mounted between the axle housing and the frame rail, can be used to help locate the assembly laterally.

The air springs compensate for changes in road conditions and vehicle load, maintaining vehicle height. The air springs also absorb road shock.

A height-control valve (**Fig. 1**) regulates the air flow into or out of all the air springs. As the air spring compresses or expands, changes in the clearance between the vehicle frame and the axle housing activate the height-control valve.

A pressure holding valve, located in the air line to the height-control valve, is preset to maintain a minimum pressure of 65 psi (448 kPa) in the vehicle secondary air system if a leak should occur in the air suspension system.



1. Forward Drive Axle
2. Valve Mounting Bracket
3. Height-Control Valve
4. Neutral-Position Hole
5. Horizontal Control Lever
6. Stud Bolt
7. Vertical Linkage

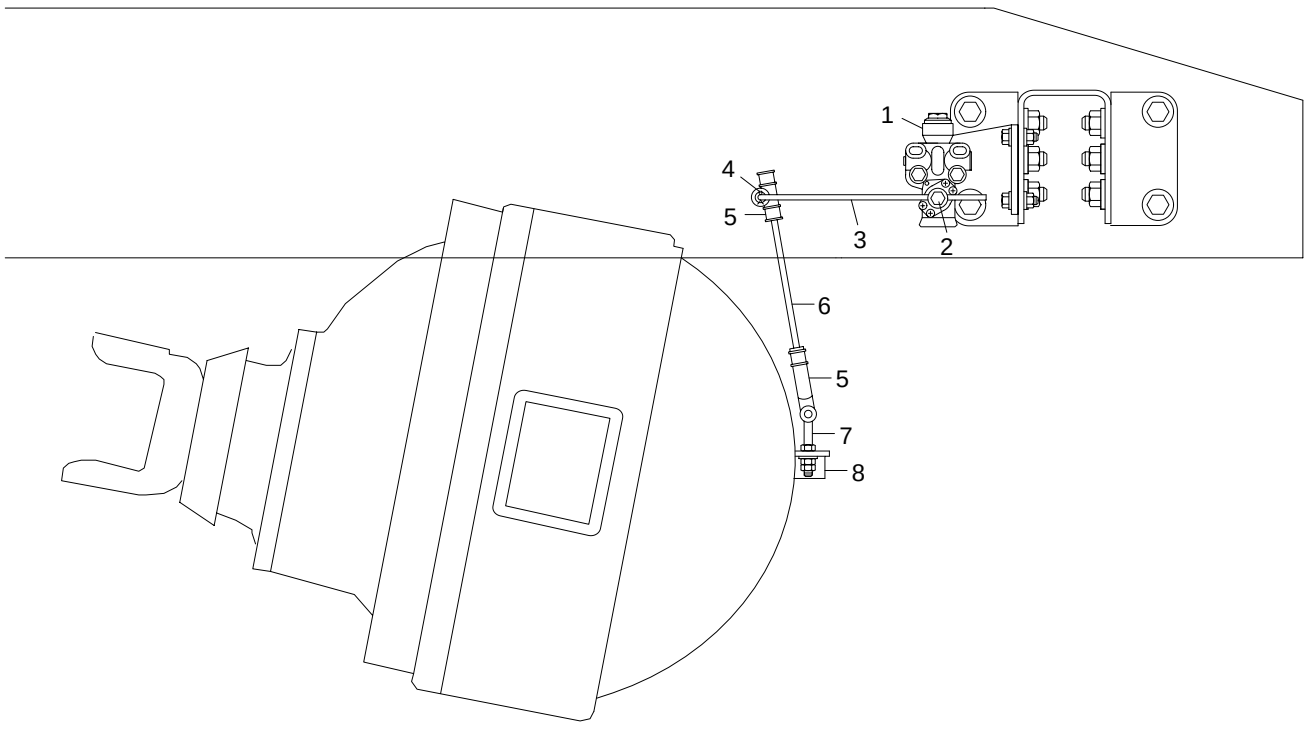
Fig. 1, Barksdale Height-Control Valve Assembly

Principles of Operation

The height-control valve controls the air suspension system. All of the air in the system is admitted through or exhausted from this valve.

The height-control valve is mounted on the frame rail or the rear frame crossmember. A horizontal control lever extends from the end of the height-control valve control shaft to a vertical linkage that connects to a bracket welded to the differential housing; see **Fig. 1**.

When the load changes, the horizontal control lever turns the height-control valve control shaft, activating either the intake or exhaust function of the valve. This adjusts the volume of air in the air springs, until the frame returns to the normal ride height, and the horizontal control lever returns to the (horizontal) neutral position.



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1. Height-Control Valve
2. Adjustment Locknut
3. Horizontal Control Lever
4. Cotter Pin
5. Linkage Adjustment Clamp
6. Vertical Linkage Rod
7. L-Rod
8. Height-Control Valve Linkage Bracket

Fig. 1, Height-Control Valve Linkage (WABCO shown)

General Guidelines

To keep the air suspension system operating reliably, the air system must be kept free of any oil, moisture, or foreign material. Inspect and maintain the air system components regularly. Refer to the vehicle maintenance manual for maintenance operations.

⚠ CAUTION

CAUTION: Failure to take precautions against the entry of moisture, oil, or other foreign material into the air suspension system could eventually lead to sludge forming in the air system. Sludge could adversely affect the operation of the air suspension system and other air system components.

Use only SAE grade 8 flanged bolts and grade G prevailing torque flanged locknuts to attach spring hangers and brackets to the frame.

For suspension component inspecting, lubricating, and fastener torque checking intervals and instructions, refer to the maintenance schedule and the suspension section in the vehicle maintenance manual.

Ride Height Adjustment

NOTICE

Failure to adjust the suspension ride height could adversely affect driveline angles. Also, if the air springs are set too high, the driver may have difficulty (or be prevented from) backing the vehicle under a trailer. If the air springs are set too low, rapid wear of suspension parts will result.

The height-control valve make and installation may vary. Use the applicable procedure to adjust the suspension height.

- Vehicle with a Barksdale Valve
- Vehicle with a Meritor WABCO Valve Adjustable Installation
- Vehicle with a Meritor WABCO Valve Fixed Installation

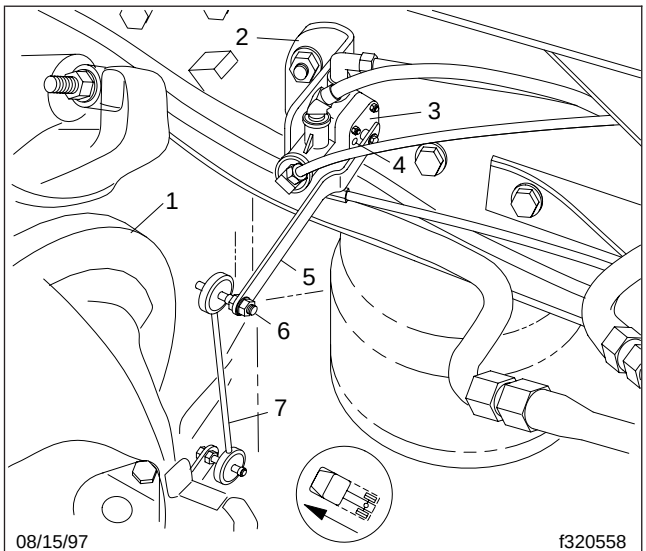
The Barksdale height-control valve replaced the Meritor WABCO valve after July 25, 1997. On vehicles with tandem-axle AirLiner rear suspensions, the Barksdale vertical linkage rod is attached to the forward drive axle instead of the rearmost drive axle, and the valve is mounted on the frame rail; see **Fig. 1**.

There are two types of WABCO height-control valve installations: adjustable and fixed. See **Fig. 2**. On adjustable installations, the suspension height is changed by tilting the height-control valve up or down. On fixed installations, the suspension height is changed by adjusting the length of the vertical linkage rod.

Vehicle with a Barksdale Valve

IMPORTANT: Before checking the suspension height, make sure there is no load on the chassis. For tractors, unhitch the trailer. Trucks must be empty.

1. Park the vehicle on a level surface, using a light application of the brakes. Do not apply the parking brakes. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.
2. Mark the location of the front and rear tires on the floor, then chock the tires on one axle only.



1. Forward Drive Axle
2. Valve Mounting Bracket
3. Height-Control Valve
4. Neutral-Position Hole
5. Horizontal Control Lever
6. Stud Bolt
7. Vertical Linkage Rod

Fig. 1, Barksdale Height-Control Valve Installation

NOTE: The stud bolt that fastens the horizontal control lever to the vertical is oriented correctly when the linkage rod is vertical as viewed from the side of the vehicle; see **Fig. 3**.

3. Measure the distance between the left forward most axle stop and the suspension as indicated. See *Suspension Ride Height Measurement*, **Table 1**, **Table 2**, **Table 3**, **Table 4**, and **Table 5** for an acceptable range of heights for each suspension.

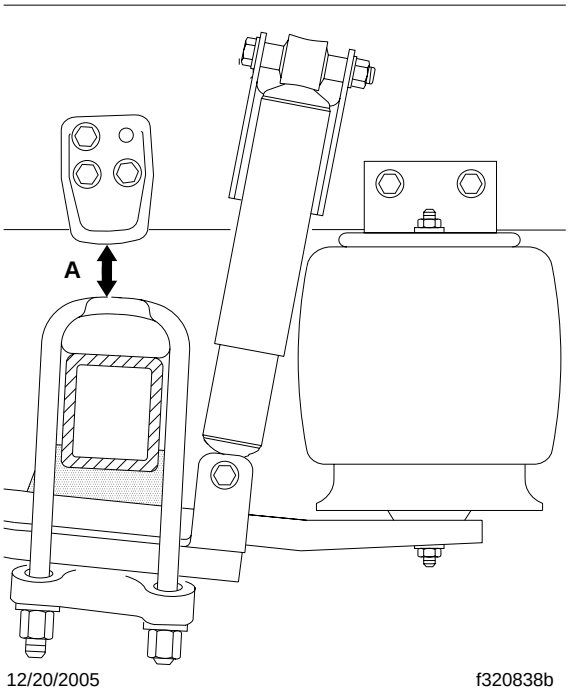
IMPORTANT: **Suspensions with Dual-Leaf Springs, and all Vehicles built before August 24, 2001:** Measure between the top of the U-bolt and the bottom of the axle stop (distance A).

Suspensions with Single-Leaf Springs, built after August 24, 2001: Measure between the top of the U-bolt **pad** and the bottom of the axle stop (distance B).

4. If the distance is within the acceptable range, the ride height is adjusted correctly. Apply the parking brakes.

Suspension Ride Height Adjustment

If the measurement is not within the acceptable range, go to the next step.



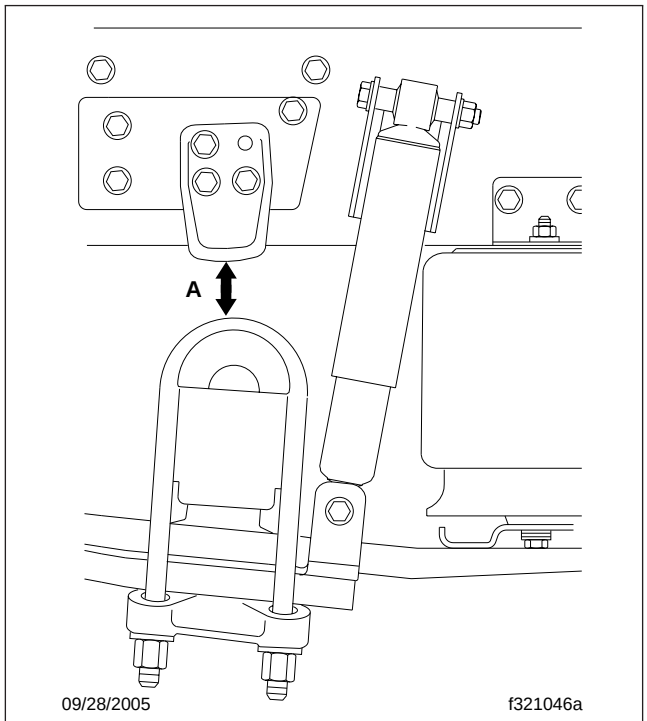
Measure Point	Suspension Height Measurement (A)		
	Min	Target	Max
A = Measure Here	2-3/8 inch (60 mm)	2-5/8 inch (67 mm)	2-7/8 inch (73 mm)

Table 1, Suspension Ride Height Measurement, Dual-Leaf Spring, 20k/40k High Ride

NOTICE

When loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

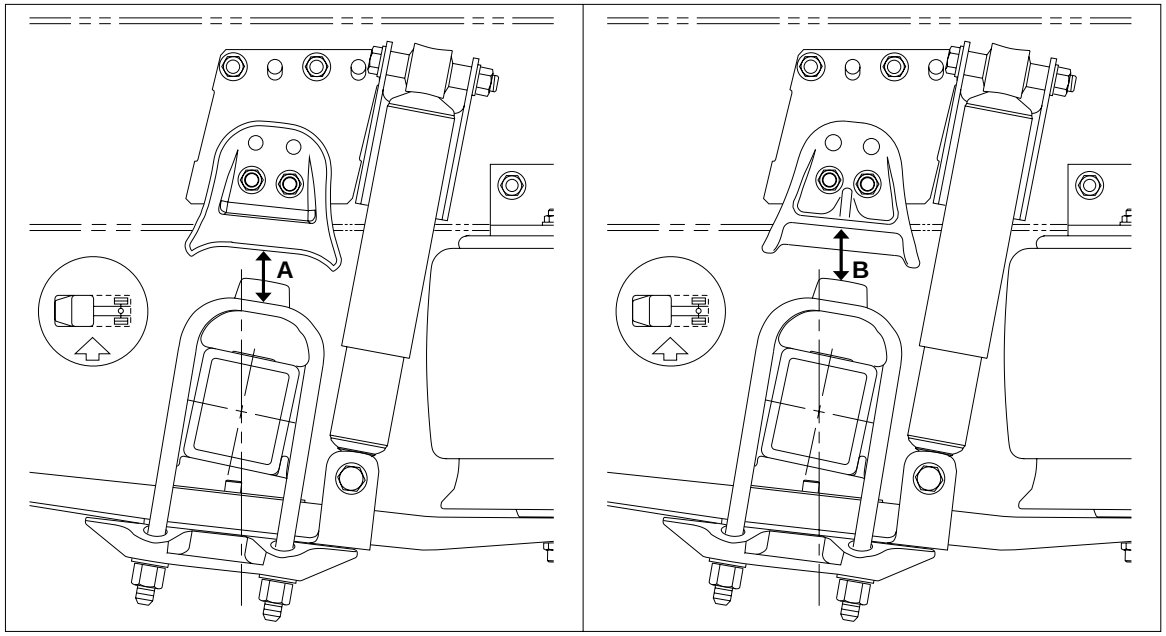
5. While holding the height-control valve mounting studs in place with an Allen wrench, loosen the nuts that attach the valve to the mounting bracket.



Measure Point	Suspension Height Measurement (A)		
	Min	Target	Max
A = Measure Here	2-3/4 inch (70 mm)	3 inch (76 mm)	3-1/4 inch (83 mm)

Table 2, Suspension Ride Height Measurement, Dual-Leaf Spring, 23k/46k/69k High Ride

6. Adjust the position of the valve body, until the distance from the bottom of the left axle stop to the top of the U-bolt or U-bolt pad is the target measurement from the applicable *Suspension Ride Height Measurement* table.
7. Center the horizontal control lever on the valve by inserting a 5/32-inch (4-mm) pin or drill bit into the neutral-position hole in the height-control valve and the horizontal control lever.



Measure Point	Suspension Height Measurement (A or B)		
	Min	Target	Max
A = Measure Here if Built Before August 24, 2001 B = Measure Here if Built After August 24, 2001	2-3/8 inch (60 mm)	2-5/8 inch (67 mm)	2-7/8 inch (73 mm)

Table 3, Suspension Ride Height Measurement, Single-Leaf Spring, 20k/40k, High Ride Height

8. While holding the height-control valve mounting studs in place with an Allen wrench, tighten the nuts 95 lbf·in (1100 N·cm). Do not overtighten.
9. Remove the pin or drill bit previously inserted in the height-control valve.
10. Drive the vehicle unloaded for about 1/4 mile (1/2 km), then stop the vehicle in the exact location (as previously marked) of the original measurement.

    Park the vehicle using a light brake application. Chock the tires on one axle only, and put the transmission in neutral. Do not apply the parking brakes.
11. Check the distance between the bottom of the left axle stop and the top of the axle U-bolt or U-bolt pad.

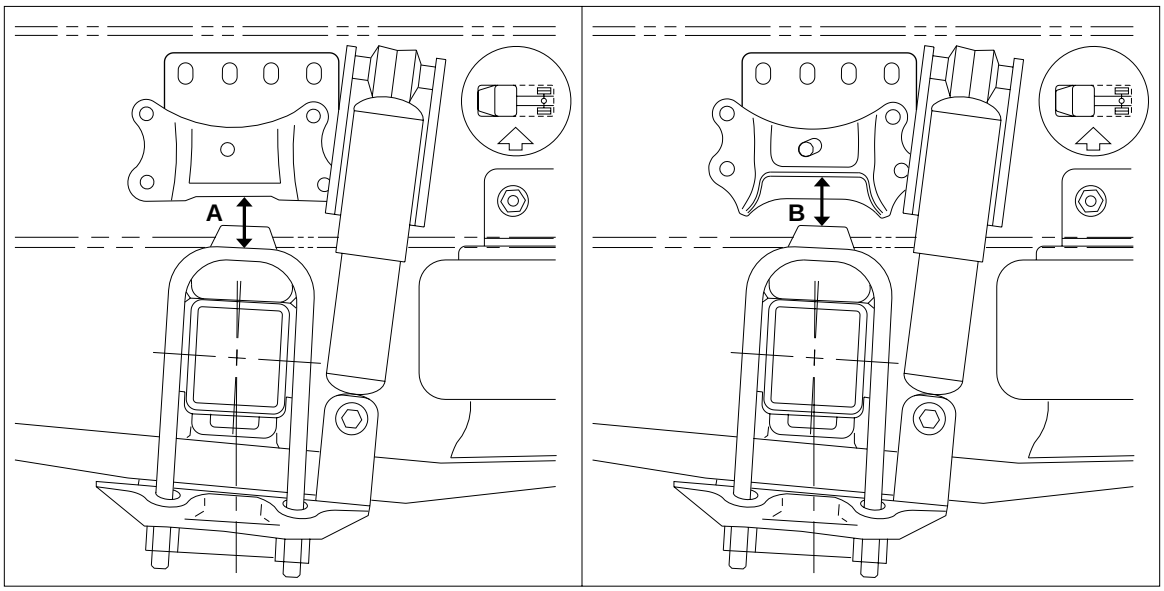
IMPORTANT: **Suspensions with Dual-Leaf Springs, and all Vehicles built before August 24, 2001:** Measure between the top of the U-bolt and the bottom of the axle stop (distance A).

Suspensions with Single-Leaf Springs, built after August 24, 2001: Measure between the top of the U-bolt *pad* and the bottom of the axle stop (distance B).

12. If the distance is within the acceptable range, ride height is adjusted correctly. Apply the parking brakes.

    If the distance is not within the acceptable range, repeat the adjustment procedure.

Suspension Ride Height Adjustment



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Measure Point	Suspension Height Measurement (A or B)		
	Min	Target	Max
A = Measure Here if Built Before August 24, 2001 B = Measure Here if Built After August 24, 2001	2-3/8 inch (60 mm)	2-1/2 inch (64 mm)	2-7/8 inch (73 mm)

Table 4, Suspension Ride Height Measurement, Single-Leaf Spring, 10k/12k/15k/18k Mid Ride Height and 40k Low and Mid Ride Height

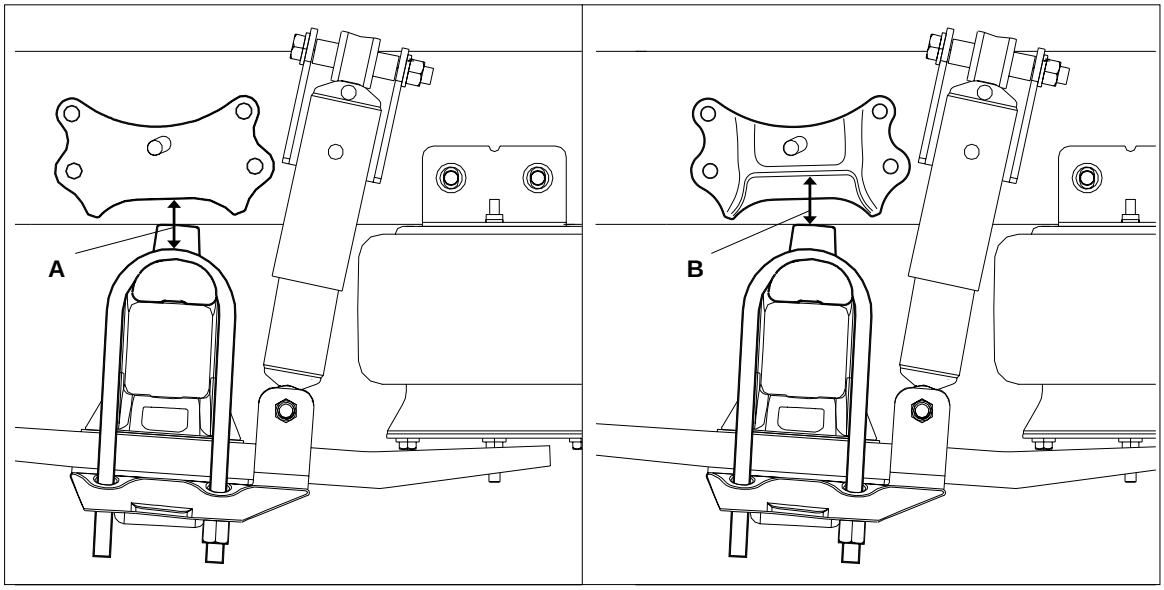
Vehicle with a Meritor WABCO Valve Adjustable Installation

IMPORTANT: Before checking the AirLiner suspension height, make sure there is no load on the chassis. For tractors, unhitch the trailer. Trucks must be empty.

1. Park the vehicle on a level surface, using a light application of the brakes. Do not apply the parking brakes. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.
2. Mark the location of the front and rear tires on the floor, then chock the tires on one axle only.
3. Check the length of the horizontal control lever between its pivot points. See **Fig. 4**. The length should be 8 inches (203 mm). If needed, adjust the length of the horizontal control lever.
   - 3.1 Loosen the adjustment locknut on the control shaft.
   - 3.2 Move the horizontal control lever fore or aft until the length between the pivot points is 8 inches (203 mm).
   - 3.3 Tighten the adjustment locknut 62 lbf·in (700 N·cm).
4. AirLiner suspensions may have one of three types of axle seats; see **Fig. 5**.

   The three styles are:

   - a one-piece, cast axle seat, that is *not* welded to the axle housing;
   - a one-piece, cast axle seat, that *is* welded to the axle housing;
   - a two-piece, fabricated axle seat that is welded to the axle housing.



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Measure Point	Suspension Height Measurement (A or B)		
	Min	Target	Max
A = Measure Here if Built Before August 24, 2001 B = Measure Here if Built After August 24, 2001	2-1/8 inch (54 mm)	2-9/32 inch (58 mm)	2-5/8 inch (67 mm)

Table 5, Suspension Ride Height Measurement, Single-Leaf Spring, 10k/12k/15k Low or Extra Low Ride Height

IMPORTANT If the axle seat is a two-piece welded type, subtract 1/4 inch (6 mm) from the minimum, target, and maximum heights when adjusting the suspension height.

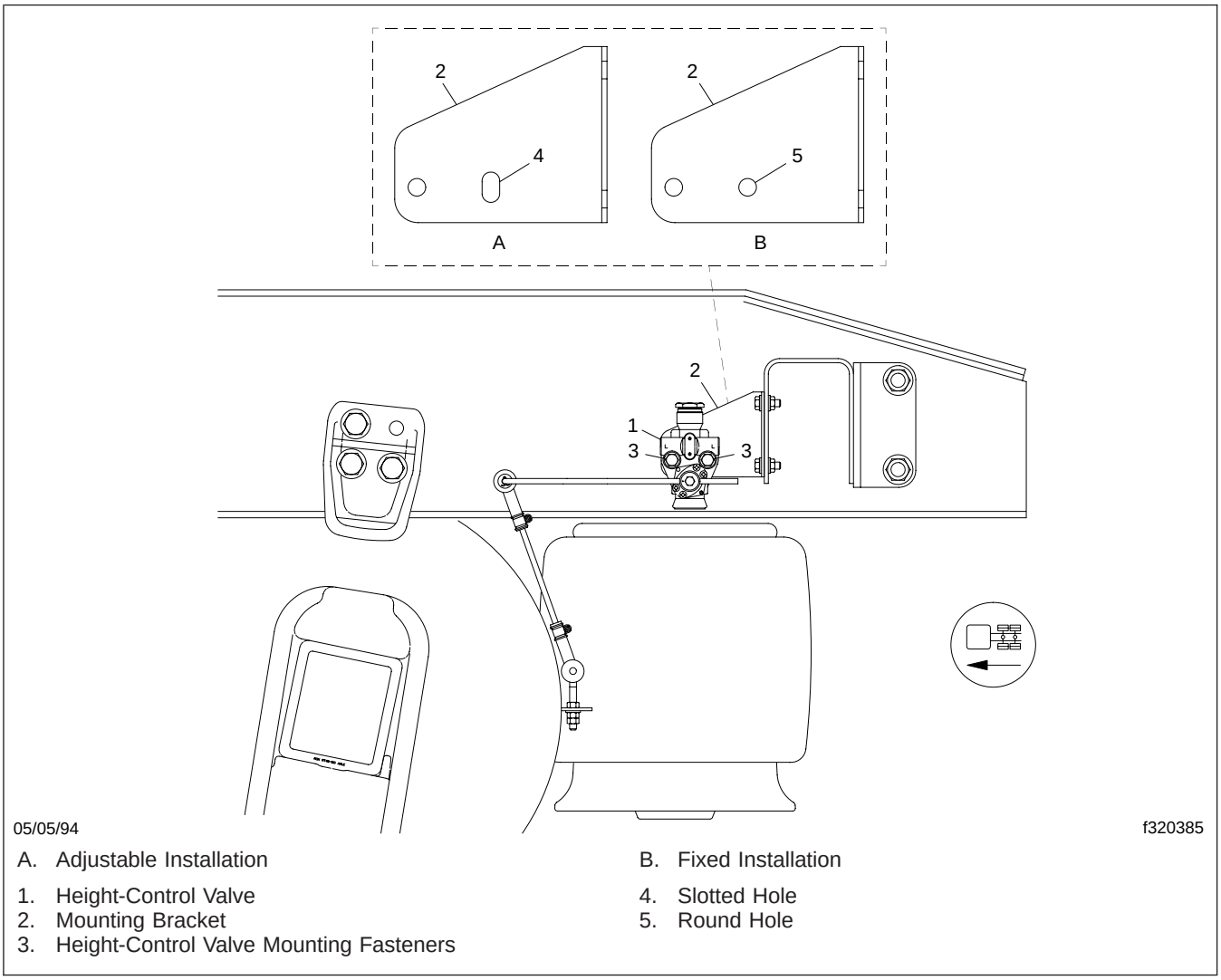
5. Measure the distance from the bottom of the left forwardmost axle stop to the top of the axle U-bolt; see **Table 1**, **Table 2**, **Table 3**, **Table 4**, and **Table 5** for an acceptable range of heights for each suspension.
6. If the distance is within the acceptable range, ride height is adjusted correctly. Apply the parking brakes.

   If the distance is not within the acceptable range, go to the next step.
7. Loosen the two fasteners that attach the height-control valve to the mounting bracket.
8. Rotate the height-control valve clockwise (as you are facing it from the driver's side of the vehicle). Let the air exhaust from the valve until the distance from the bottom of the left forwardmost axle stop to the top of the axle U-bolt is 2 inches (51 mm) or less.
9. Rotate the height-control valve counterclockwise, and raise the suspension height to the target height (previously noted from the appropriate table). Stop the air flow to the air bag by rotating the height-control valve clockwise.
10. Center the height-control valve.

    10.1 Rotate the valve very slightly clockwise and counterclockwise until you can insert a 5/32-inch (4-mm) pin or drill bit into the valve centering hole. Don't rotate the valve too much, or you will change the suspension height.

    10.2 Tighten the height-control valve mounting fasteners firmly.
11. Drive the vehicle unloaded for about 1/4 mile (1/2 km), then stop the vehicle in the exact loca-

Suspension Ride Height Adjustment



A. Adjustable Installation
B. Fixed Installation

1. Height-Control Valve
2. Mounting Bracket
3. Height-Control Valve Mounting Fasteners
4. Slotted Hole
5. Round Hole

Fig. 2, Meritor WABCO Height-Control Valve Installation

tion (as previously marked) of the original measurement.

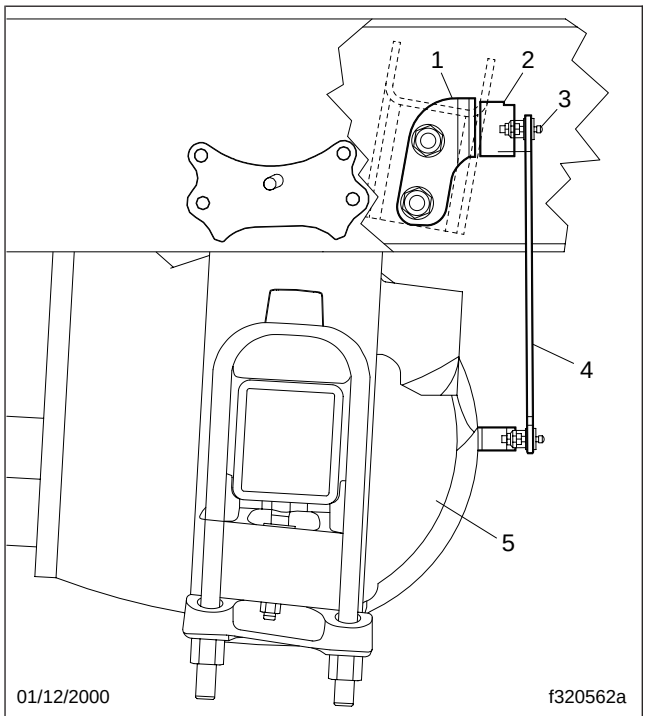
Park the vehicle using a light brake application. Chock the tires on one axle only, and put the transmission in neutral. Do not apply the parking brakes.

12. Check the adjusted distance between the bottom of the left forwardmost axle stop and the top of the axle U-bolt. It should be within the acceptable range for the applicable suspension previously noted.
13. If the distance is not within the acceptable range, repeat the adjustment procedure.

    If the distance is within the acceptable range, ride height is adjusted correctly. Apply the parking brakes.

Vehicle With a Meritor WABCO Valve Fixed Installation

IMPORTANT: Before checking the AirLiner suspension height, make sure there is no load on the chassis. For tractors, unhitch the trailer.



1. Valve Mounting Bracket
2. Height-Control Valve
3. Stud Bolt
4. Linkage Rod
5. Axle

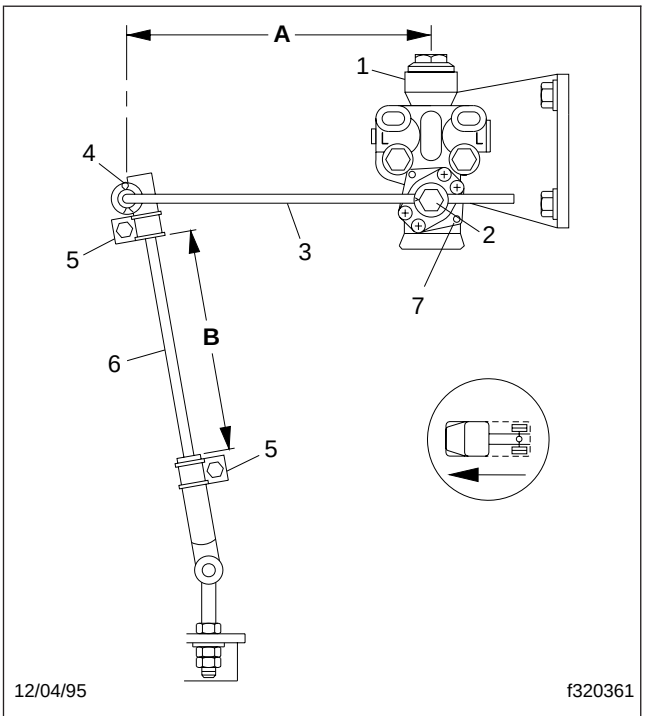
Fig. 3, Barksdale Height-Control Valve Installation (side view)

Trucks must be empty. In order to adjust the suspension height, you must change the length of the vertical linkage rod using the following procedure.

1. Park the vehicle on a level surface, using a light application of the brakes. Do not apply the parking brakes. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.
2. Mark the location of the front and rear tires on the floor, then chock the tires on one axle only.
3. Check the length of the height-control valve horizontal control lever; see **Fig. 4**. See **Table 6** for the correct length.

   If the length is acceptable, go to the next step.

   If the length is not acceptable, adjust the length of the horizontal control lever as follows.



A. Measure the length of the horizontal control lever between these two points.
B. Measure the length of the vertical linkage rod between these two points.

1. Height-Control Valve
2. Adjustment Locknut
3. Horizontal Control Lever
4. Cotter Pin
5. Adjustment Clamp
6. Vertical Linkage
7. Valve Centering Hole

Fig. 4, Meritor WABCO Height-Control Valve Horizontal Control Lever and Vertical Linkage Rod Measurement

   3.1 Loosen the adjustment locknut on the control shaft.

   3.2 Move the horizontal control lever fore or aft until it is the correct length.

   3.3 Tighten the adjustment locknut 62 lbf·in (700 N·cm).

4. Measure the distance from the bottom of the left forwardmost axle stop to the top of the axle U-bolt. See *Suspension Ride Height Measurement*, **Table 1**, **Table 2**, **Table 3**, **Table 4**, and **Table 5** for an acceptable range of heights for each suspension.

Suspension Ride Height Adjustment

If the distance is within the acceptable range, ride height is adjusted corrcetly. Apply the parking brakes.

If the distance is not within the acceptable range, go to the next step.

5. Determine how much the suspension height needs to be adjusted so the distance matches the target height in the applicable table. Then, using **Table 7**, find the amount that the length of the vertical linkage rod needs to be changed; see **Fig. 4**.
6. Adjust the length of the vertical linkage rod as needed, adding or subtracting the amount shown in **Table 7**.

   NOTE: If the vertical linkage rod is too short, replace it with a new rod, part number 16–13485–000. The vertical linkage rod should be long enough so that at least 1/2 inch (13 mm) of it fits into both flexible end-sections of the linkage.

   6.1 Mark the existing length of the vertical linkage rod between the upper and lower flexible end-sections of the linkage; see **Fig. 4**.

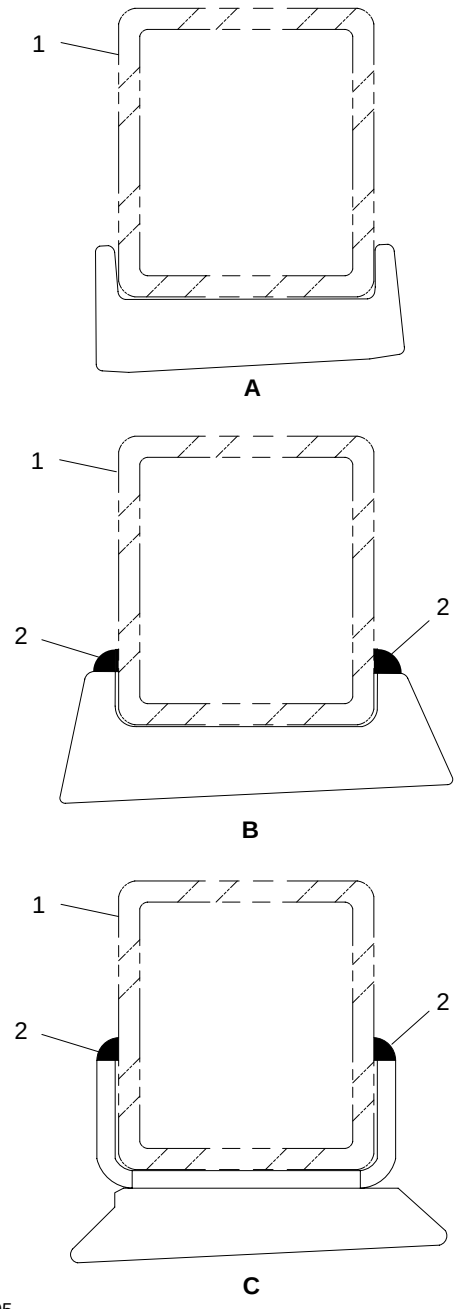
   6.2 Loosen both linkage adjustment clamps.

   6.3 Slide the flexible end-sections of the linkage over the linkage rod until the rod is the correct length.

   To increase the suspension height, lengthen the vertical linkage rod; to decrease the suspension height, shorten the rod.

   6.4 Tighten the adjustment clamps.
7. Drive the vehicle unloaded for about 1/4 mile (1/2 km), then stop the vehicle in the exact location (as previously marked) of the original measurement.

   Park the vehicle using a light brake application. Chock the tires on one axle only, and put the transmission in neutral. Don't apply the parking brakes.
8. Check the distance between the bottom of the left forwardmost axle stop and the top of the axle U-bolt.



A. One-Piece Cast Axle Seat, Not Welded
B. One-Piece Cast Axle Seat, Welded
C. Two-Piece Fabricated Axle Seat, Welded

1. Axle Housing 2. Welds

Fig. 5, Axle Seats

9. If the distance is within the acceptable range, ride height is adjusted correctly. Apply the parking brakes.

   If the distance is not within the acceptable range, repeat the adjustment procedure.

Horizontal Lever Length	
Axle Designation	**Horizontal Control Lever Length: inches (mm)**
Meritor RS23–161	8 (203)
Meritor 23–180	7-3/8 (187)
Meritor SQ100	9-1/4 (235)
Meritor SSHD	9 (229)
Meritor RT40–145	9-3/4 (248)
Meritor RT44–145	9-3/4 (248)
Meritor RT46–160	8-1/8 (206)
Eaton 23105 SC	7-1/4 (184)
Eaton 402	8-3/8 (213)
Eaton 404	8-3/8 (213)
Eaton 461	8-3/8 (213)

Table 6, Horizontal Control Lever Length

Vertical Linkage Length Changes	
Suspension Height Correction: inches (mm)	**Vertical Linkage Length Correction: inches (mm)**
1/16 (2)	1/16 (2)
1/8 (3)	3/16 (5)
3/16 (5)	1/4 (6)
1/4 (6)	5/16 (8)
5/16 (8)	3/8 (10)
3/8 (10)	1/2 (13)
7/16 (11)	9/16 (14)
1/2 (13)	5/8 (16)
9/16 (14)	3/4 (19)
5/8 (16)	13/16 (21)
11/16 (17)	7/8 (22)
3/4 (19)	1 (25)
13/16 (21)	1-1/16 (27)
7/8 (22)	1-3/16 (30)
15/16 (24)	1-1/4 (32)

Vertical Linkage Length Changes	
Suspension Height Correction: inches (mm)	**Vertical Linkage Length Correction: inches (mm)**
1 (25)	1-5/16 (33)

Table 7, Vertical Linkage Lengths

Height-Control Valve Checking

It is normal to hear air escaping from the height-control valve for as much as 10 minutes after getting out of the vehicle when it is in an unladen condition. This air "leaking" is just the height-control valve exhausting air from the suspension air springs in order to return to the neutral mode.

The height-control valves used on the Heavy-Duty Trucks are Barksdale or Meritor WABCO valves. Two methods are available to check the operation of the Barksdale height-control valves. A leak in the valve may be discovered without using a test kit, but a test kit is necessary to determine if the valve has an unacceptable rate of leakage. WABCO valves can only be checked without a test kit.

Some Barksdale height-control valves have been returned for warranty because the four bolts in the valve housing were overtightened, often, enough to crack the valve housing. These bolts should not be loose, and should not normally require tightening, as there are no serviceable parts in the valve.

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing if you detect leaks in the housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

NOTICE

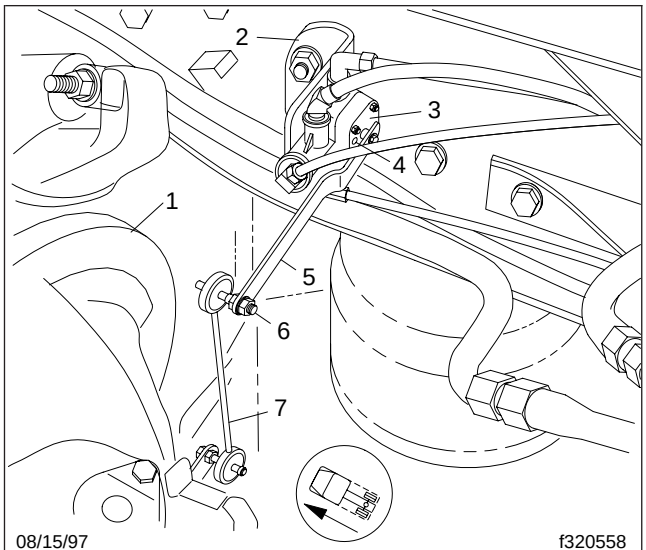
When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

Checking the Height-Control Valve Without Using a Test Kit

1. Apply the parking brakes and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

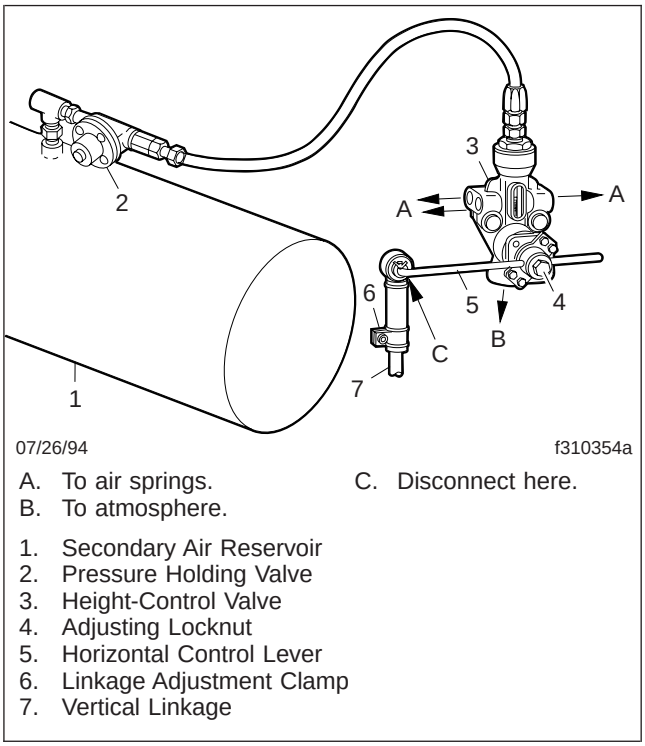
4. Disconnect the vertical linkage from the control lever; see **Fig. 1** or **Fig. 2**.



1. Forward Drive Axle
2. Valve Mounting Bracket
3. Height-Control Valve
4. Neutral-Position Hole
5. Horizontal Control Lever
6. Stud Bolt
7. Vertical Linkage

Fig. 1, Barksdale Height-Control Valve Installation

Height-Control Valve Checking



A. To air springs.
B. To atmosphere.
C. Disconnect here.

1. Secondary Air Reservoir
2. Pressure Holding Valve
3. Height-Control Valve
4. Adjusting Locknut
5. Horizontal Control Lever
6. Linkage Adjustment Clamp
7. Vertical Linkage

Fig. 2, Meritor WABCO Height-Control Valve Installation

5. Pull the control lever up about 45 degrees for 6 to 8 seconds. If air passes through the valve, that section of the valve is working.
6. Return the control lever to the neutral position. Air should stop flowing. If so, that section of the valve is working.
7. Push the control lever down about 45 degrees for 6 to 8 seconds. If air exhausts from the valve, that section of the valve is working.
8. Return the control lever to the neutral position. If the air stops again in the neutral position, the valve is working correctly.
9. If the valve works as stated in all of the above steps, then no further checking is necessary. Connect the vertical linkage to the control lever, then tighten the linkage nut (Barksdale valves), or secure the linkage with a cotter pin (Meritor WABCO valves).

   If needed, adjust the ride height or replace the height-control valve. For adjustment of the ride height, see **Subject 110**. For replacement of the height-control valve, see **Subject 130**.

NOTE: If a leak is detected on a Barksdale height-control valve, go to "Checking the Height-Control Valve Using a Test Kit". Barksdale valves have an acceptable leak rate of 3 cubic inches (50 cc) per minute. You can determine if a leak is acceptable only by using the Barksdale test kit.

If a leak is detected at the exhaust port on a WABCO height-control valve, the valve is defective. Replace it, following the procedure in **Subject 130**.

Checking the Height-Control Valve Using a Test Kit

IMPORTANT: The procedure described below is for use on Barksdale height-control valves only.

NOTE: The Barksdale field test kit is designed to be used with the height-control valve installed on the vehicle. Refer to **Specifications 400** for information on ordering the Barksdale height-control valve test kit KD2264.

1. If not already done, park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. For valves without an integral dump port, go to the next step.

   For valves with an integral dump port, check the rubber exhaust flapper at the back of the valve housing for leaks; see **Fig. 3**. Use a soapy solution.

   If a leak is found, there may be contaminants blocking the piston. Cycle the height-control valve switch inside the cab for two-second bursts, four or five times, to clear away any contaminants.

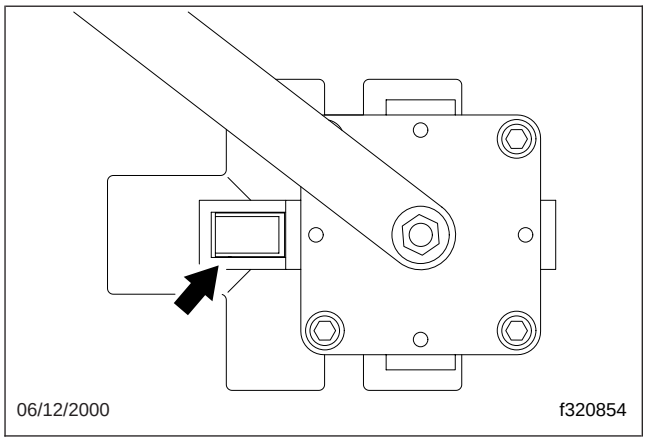


Fig. 3, Exhaust Flap Location (height-control valve with integral dump port)

5. Disconnect the vertical linkage from the horizontal control lever.
6. Rotate and hold the horizontal control lever down at about 45 degrees to exhaust air from the air springs.
7. *If equipped with an integral dump port,* turn on the quick dump switch on the dash. Leave the switch on until testing is complete.

   If not equipped with an integral dump port, disconnect the air lines from the air spring ports on the height-control valve. Leave the elbow fittings (if equipped) in place. Install a Parker plug into each air spring port (or elbow fitting); see **Fig. 4**.
8. If a flapper is present on the exhaust port of the height-control valve, remove it using needlenose pliers.
9. Clean the surface around the exhaust port, then install the test fitting into the exhaust port. The centering pin on the fitting must align with the slot on the exhaust port. Rotate the test fitting 45 degrees clockwise to lock it in place; see **Fig. 4**.

NOTE: It may be necessary to cut the tie straps that hold the chassis wiring running below the height-control valve, in order to access the exhaust port.

10. Connect one end of the air hose from the kit to the test connector on the exhaust port, and the other end to the test gauge.
11. Check the height-control valve in the fill mode, as follows.

    11.1 Rotate the valve control lever up 45 degrees from the horizontal to the fill position.

    11.2 Press the reset button on the test gauge.

    11.3 Observe the test gauge for 30 seconds. Refer to **Fig. 5** for the maximum allowable exhaust pressure change versus inlet pressure.

    The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

    If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

12. Check the height-control valve in the exhaust mode, as follows.

    12.1 Rotate the valve control lever down 45 degrees from the horizontal to the exhaust position.

    12.2 Press the reset button on the test gauge.

    12.3 Observe the test gauge for 30 seconds. Refer to **Fig. 5** for the maximum allowable exhaust pressure change versus inlet pressure.

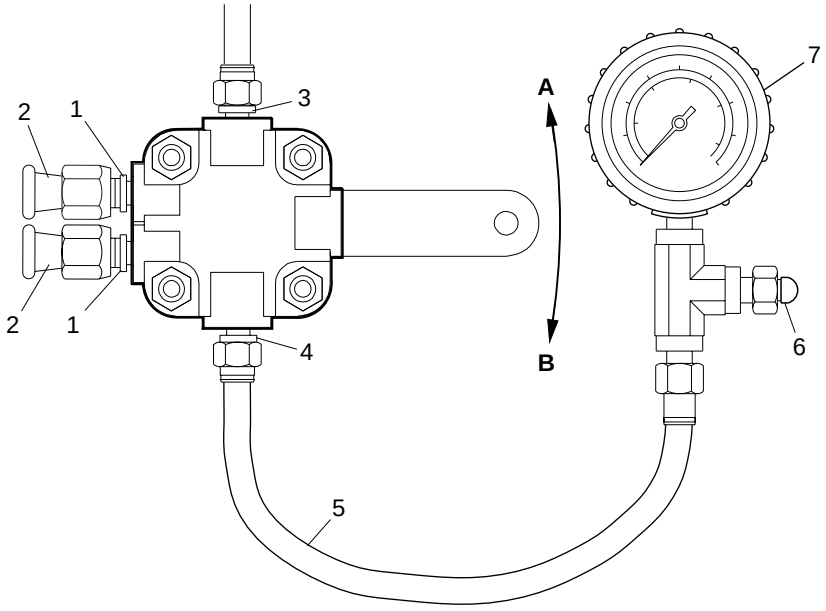
    The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

    If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

13. Disconnect the test gauge and connector from the valve exhaust port.
14. If the height-control valve is defective, replace it; see **Subject 130**.
15. Install the flapper on the exhaust port by pressing it into place.
16. *For height-control valves with an integral dump port,* connect the vertical linkage to the height-control valve control lever. Turn off the quick

Height-Control Valve Checking



A. Fill
B. Exhaust

1. Air Spring Port
2. Parker Plug
3. Air Intake Port
4. Exhaust Port Test Fitting
5. Air Line
6. Reset Button
7. Test Gauge Assembly

Fig. 4, Test Connections

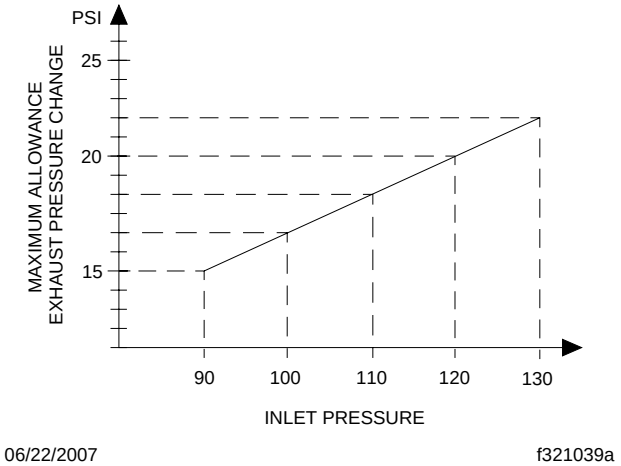


Fig. 5, Inlet Pressure vs. Exhaust Pressure Change in 30 Seconds

dump switch on the dash. The ride height will automatically return to the correct position.

For height-control valves without an integral dump port, remove the two Parker plugs from the air spring ports, and connect the air lines to the air spring ports (or elbow fittings). Connect the vertical linkage to the height-control valve control lever. The ride height will automatically return to the correct position.

Replacement

NOTE: The Barksdale height-control valve replaced the Meritor WABCO valve after September 19, 1997. On vehicles with tandem-axle AirLiner rear suspensions, the Barksdale vertical linkage rod is attached to the forward drive axle instead of the rearmost drive axle, and the valve is mounted on the frame rail.

Barksdale

The Barksdale valve does not use an adjustable linkage rod. To adjust the Barksdale valve, see **Subject 110**.

1. Apply the parking brakes and chock the tires.

⚠ WARNING

Keep your hands and all objects away from the area under and around the slack adjusters and suspension components when removing the pressure from the air system. These parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.

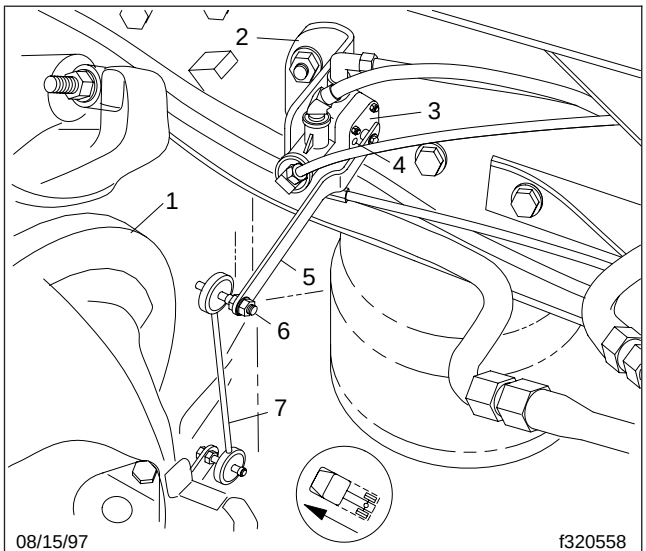
2. Drain all air from the air tanks.

⚠ WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

3. Remove the nut and washer that attaches the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1**.
4. Rotate and hold the horizontal control lever down until all air is exhausted from the air springs.
5. Disconnect the air lines at the height-control valve, and mark the lines for later reference. Using tape, cover the open ends of the air lines and fittings to prevent dirt or foreign material from entering.

IMPORTANT: For quick-connect tube fittings, do not remove the tube by cutting it close to the fitting. If the remaining part of the tube cannot be pulled from the fitting, the fitting will not be reusable and the warranty on that unit will be void.



1. Forward Drive Axle
2. Valve Mounting Bracket
3. Height-Control Valve
4. Neutral-Position Hole
5. Horizontal Control Lever
6. Stud Bolt
7. Vertical Linkage

Fig. 1, Barksdale Height-Control Valve

NOTICE

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

6. While holding the height-control valve mounting studs in place with an Allen wrench, remove the nuts and washers that attach the valve to the mounting bracket. Remove the height-control valve.

Height-Control Valve Replacement

7. Position the new height-control valve on the height-control bracket. While holding the height-control valve mounting studs in place with an Allen wrench, install the nuts and washers, and tighten the nuts 95 lbf·in (1100 N·cm). Do not overtighten.
8. Remove the tape from the air lines and fittings, and connect the air lines to the height-control valve as marked earlier. Tighten nylon tube air fittings until only two threads show on the fitting. On wire-braid hose fittings, tighten the nut with a wrench until there is firm resistance, then tighten one-sixth turn more.
9. Close the drain cocks on all reservoirs.
10. Build up normal operating pressure in the air system. Check all air lines and connections for leaks. Eliminate all leaks.
11. Adjust the height-control valve; see **Subject 110**.

Meritor WABCO

1. Park the vehicle on a level surface. Apply the parking brakes and chock the tires.

⚠ WARNING

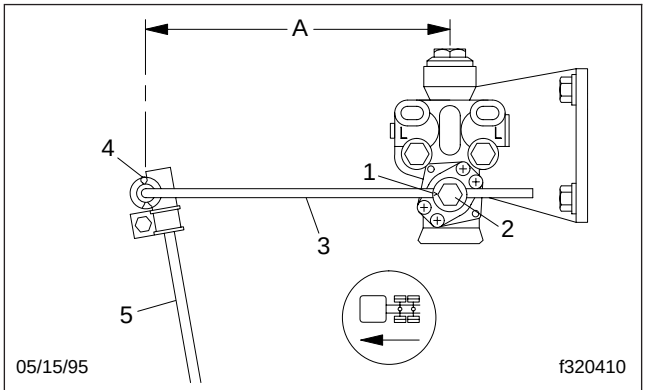
Keep your hands and all objects away from the area under and around the slack adjusters and suspension components when removing the pressure from the air system. These parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.

2. Drain all air from the air tanks.

⚠ WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

3. Disconnect the vertical linkage from the horizontal control lever; see **Fig. 2**.
4. Rotate and hold the horizontal control lever down until all air is exhausted from the air springs.
5. Disconnect the air lines at the height-control valve, and mark the lines for later reference. Using tape, cover the open ends of the air lines and fittings to prevent dirt or foreign material from entering.
6. Remove the height-control valve mounting bolts and nuts, then remove the height-control valve from the bracket.
7. Remove the horizontal control lever from the height-control valve.
8. Attach the new height-control valve to the bracket. Tighten the valve mounting bolt nuts 14 lbf·ft (19 N·m).
9. Remove the tape from the air lines and fittings, and connect the air lines to the height-control valve as marked earlier. Tighten nylon tube air fittings until only two threads show on the fitting. On wire-braid hose fittings, tighten the nut with a wrench until there is firm resistance, then tighten one-sixth turn more.
10. Connect the vertical linkage to the horizontal control lever. Secure the linkage with a cotter pin.
11. Connect the horizontal control lever to the height-control valve. Insert the horizontal control lever into the valve at the hole with the V-shaped mark; see **Fig. 2**. Be sure the length between pivot points is 8 inches (20.3 cm); see **Fig. 2**, Ref. A.



A. Measure the length of the horizontal control level between these two points.

1. V-Shaped Mark
2. Adjustment Locknut
3. Horizontal Control Lever
4. Cotter Pin
5. Vertical Linkage

Fig. 2, Meritor Height-Control Valve Linkage Measurement

12. Close the drain cocks on all reservoirs.
13. Build up normal operating pressure in the air system. Check all air lines and connections for leaks. Eliminate all leaks.
14. Adjust the height-control valve; see **Subject 110**.

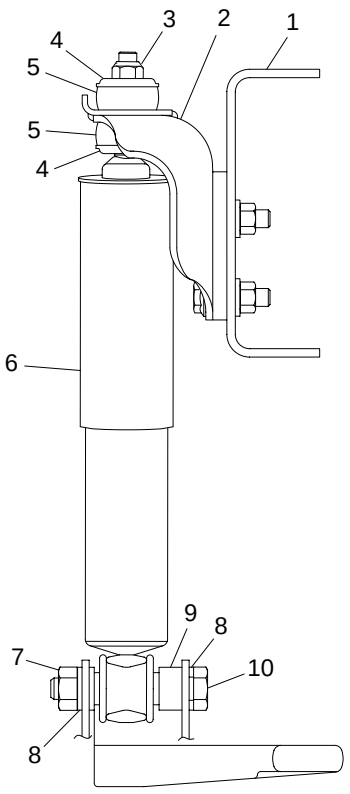
Replacement

1. Chock the tires.
2. Disconnect the top of the shock absorber from the frame bracket.
   - 2.1 On vehicles built before September 1994—remove the nut, upper retainer, and upper bushing from the top of the shock absorber. See **Fig. 1.**
   - 2.2 On vehicles built from September 1994—remove the locknut, bolt, and washers from the top of the shock absorber. See **Fig. 2.**
3. Compress the shock absorber until the top mounting stud or bushing clears the upper mounting bracket.
4. Remove the locknut, bolt, and spacer from the shock absorber lower mounting bracket.
5. Remove the shock absorber.
6. Position the replacement shock absorber in the lower bracket and install the shock absorber lower mounting bolt, washers, and locknut.

WARNING

WARNING: Use only the retainers included with the replacement shock absorber. Do not use washers. They can be extruded over the nut and be ejected violently, possibly causing personal injury and property damage.

7. Connect the top of the shock absorber to the frame bracket.
   - 7.1 On vehicles built before September 1994—install a retainer and bushing on the shock absorber top stud. Then, extend the shock absorber until the stud enters the upper bracket and install the upper bushing and retainer on the shock absorber. Make sure that the new bushings and retainers are positioned properly. See **Fig. 3.**
   - 7.2 On vehicles built from September 1994—extend the shock absorber until the bushing eye enters the upper mounting bracket and install the bolt, washers, and locknut.



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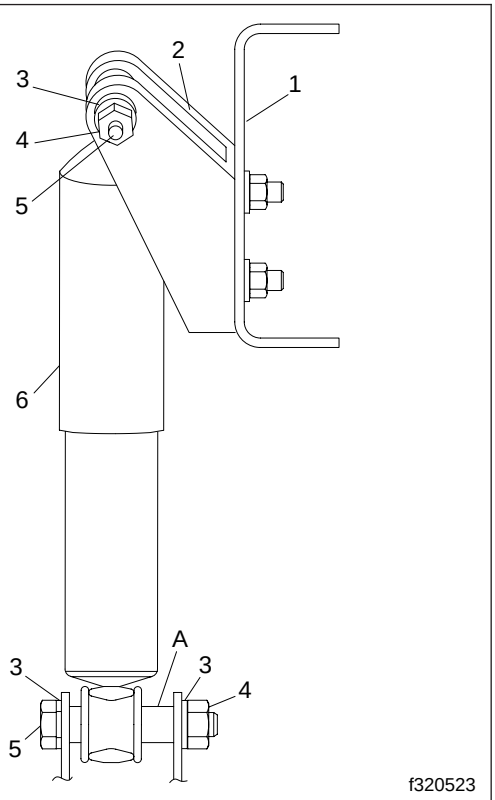
1. Frame Rail
2. Upper Bracket
3. Nut
4. Retainer
5. Bushing
6. Shock Absorber
7. Locknut
8. Washer
9. Spacer
10. Bolt

Fig. 1, Shock Absorber Mounting, Before September 1994

8. Tighten the shock absorber lower mounting locknut 170 lbf·ft (230 N·m).
9. Tighten the shock absorber upper mounting fasteners.
   - 9.1 On vehicles built before September 1994—tighten the shock absorber upper mounting nut to compress the bushings to the dimension shown in **Fig. 3**.
   - 9.2 On vehicles built from September 1994—tighten the shock absorber upper mounting locknut 170 lbf·ft (230 N·m).

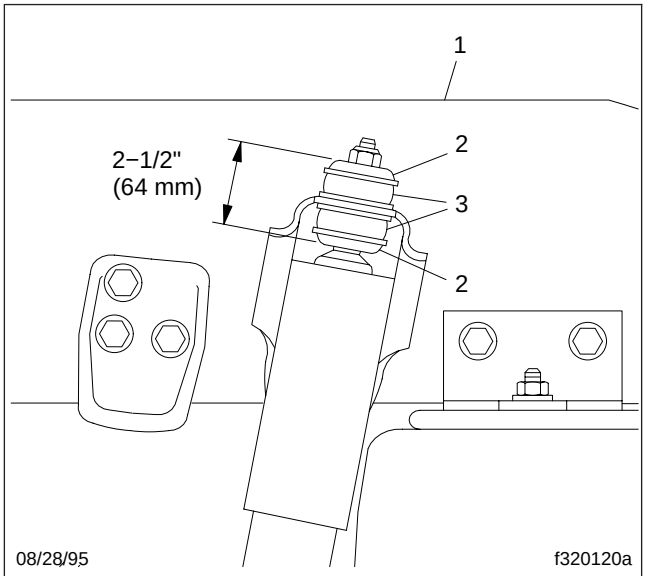
Shock Absorber Replacement



A. Shock absorber is installed with long end of sleeve toward frame rail.

1. Frame Rail
2. Upper Bracket
3. Washer
4. Locknut
5. Bolt
6. Shock Absorber

Fig. 2, Shock Absorber Mounting, From September 1994



1. Frame Rail
2. Retainer
3. Bushings

Fig. 3, Shock Absorber Bushing Compression

Air Spring Replacement

IMPORTANT: Effective March 2011, the steel bead on the inside of the air bag where it attaches to the piston, changed to a square bead to increase the pull-off force between the air bag and piston. The new air bag is stamped “BD8” and “Do Not Re-Assemble Rubber Bellow to Piston.” See **Fig. 1**. With this design change it is not possible to reseat the air bag to the piston. In the event of an air bag failure, or separation from the piston, the complete air-spring assembly must be replaced. For service it is acceptable to have a replacement air-spring assembly on one side of the vehicle, and an older style on the other side.

NOTE: The air-spring-to-frame-rail mounting bracket is not supplied with the air-spring assembly. If it needs to be replaced it must be ordered separately.

Follow these steps to replace the air-spring and piston assembly.

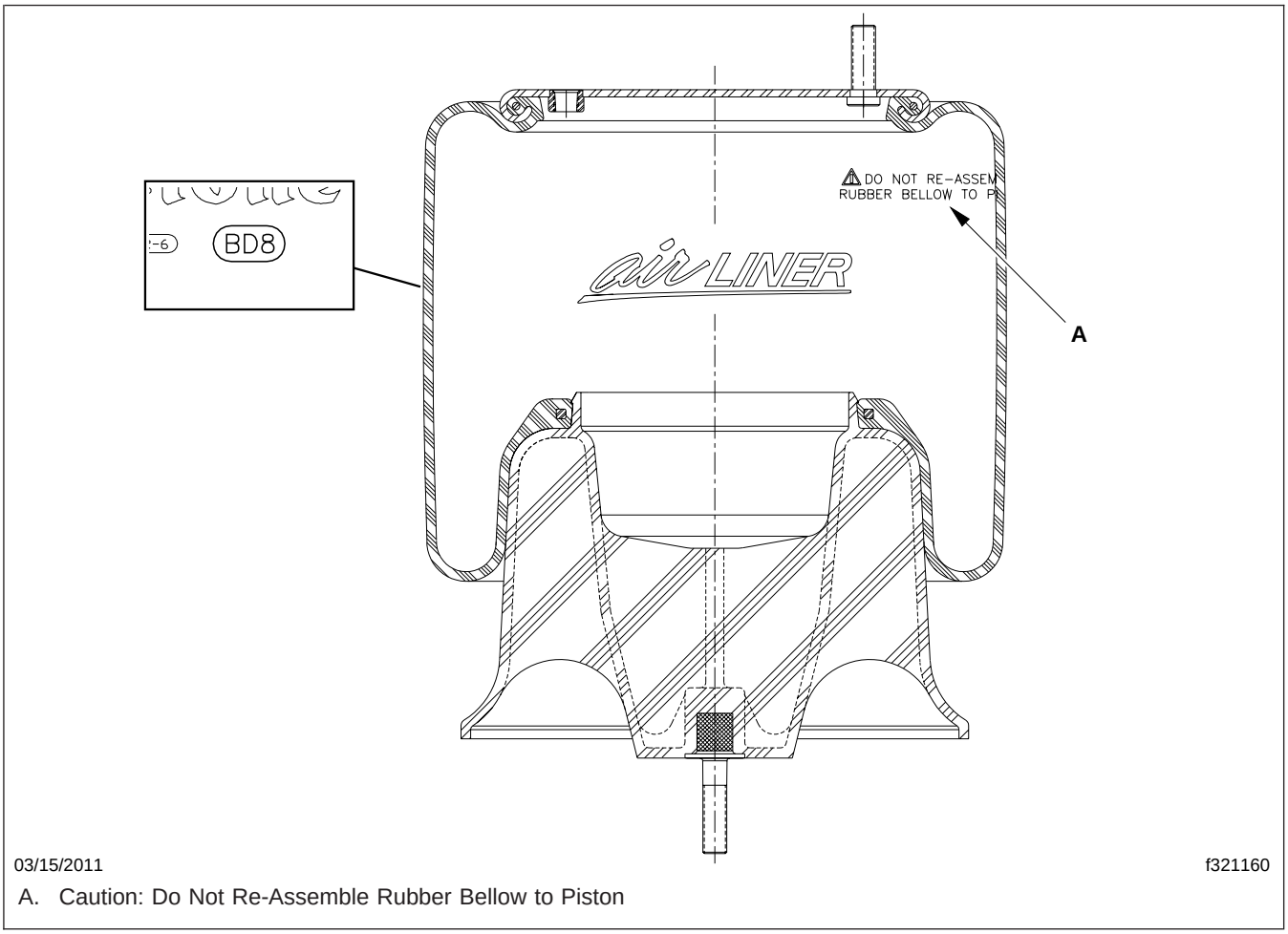
1. Chock the front tires. Raise the vehicle frame and support it with safety stands to remove all weight from the air springs. The leveling valve automatically releases air from the air springs when all weight is removed from the suspension.
2. Disconnect the air supply line,including the brass tee, from the air spring. Using tape, cover the ends of the air supply line and the fitting to prevent dirt or foreign material from entering.
3. Remove the locknuts and washers that connect the air spring to the upper mounting bracket, or to the frame rail flange. See **Fig. 2** and **Fig. 3.**
4. Remove the capscrews and lockwashers that connect the air spring to the rear of the leaf spring. Remove the air spring. **See Fig. 4.**

NOTE: Suspensions manufactured to a 46,000-pound (20 865 kg) or 23,000-pound (10 433 kg) weight rating have a different leaf spring, and an additional cross bar attached between the air spring and rear of the leaf spring. **See Fig. 5.**

5. Place the new air spring on the rear of the leaf spring (or the cross bar on the 23,000- and 46,000-pound suspensions), and install the washer and locknut that hold the air spring (and cross bar) in place. **See Fig. 4.** Tighten the locknut 55 lbf·ft (75 N·m).
6. *For bracket-mounted air springs:* Attach the air spring to the upper mounting bracket, using the 1/2–13 locknut on the outside of the frame rail and the 3/4–16 locknut on the inside. **See Fig. 2.** Tighten the 3/4–16 locknut 45 lbf·ft (61 N·m); tighten the 1/2–13 locknut 23 lbf·ft (31 N·m).

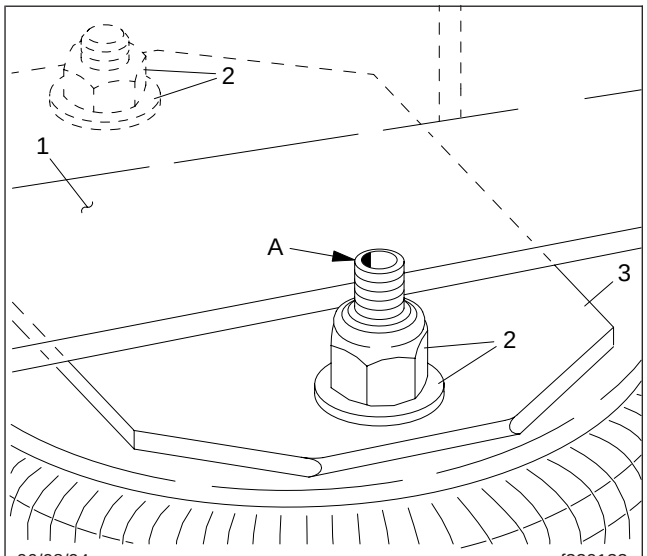
   For flange-mounted air springs: Attach the air spring to the frame rail flange, using the 3/4–16 locknut on the forward stud of the air spring, and the 1/2–13 locknut on the rear stud. **See Fig. 3.** Tighten the 3/4–16 locknut 45 lbf·ft (61 N·m); tighten the 1/2–13 locknut 23 lbf·ft (31 N·m).
7. Remove the tape from the ends of the air supply line, the fitting, and the brass tee. Connect the air supply line to the air spring. Tighten nylon tube air fittings until only two threads show on the fitting. On wire-braid hose fittings, tighten the nut with a wrench until there is firm resistance, then tighten one-sixth turn more.
8. Remove the safety stands, and lower the vehicle. Remove the chocks from the tires.

Air Spring Replacement



A. Caution: Do Not Re-Assemble Rubber Bellow to Piston

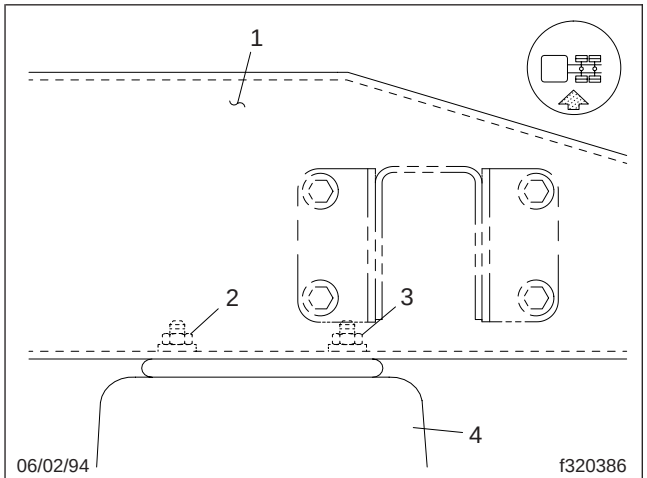
Fig. 1, Air-Spring and Piston Assembly



A. Air line connects here.

1. Right Frame Rail Flange
2. Locknut and Washer
3. Upper Mounting Bracket

Fig. 2, Bracket-Mounted Air Spring



1. Frame Rail (left)
2. 3/4–16 Locknut and Washer
3. 1/2–13 Locknut and Washer
4. Air Spring

Fig. 3, Flange-Mounted Air Spring

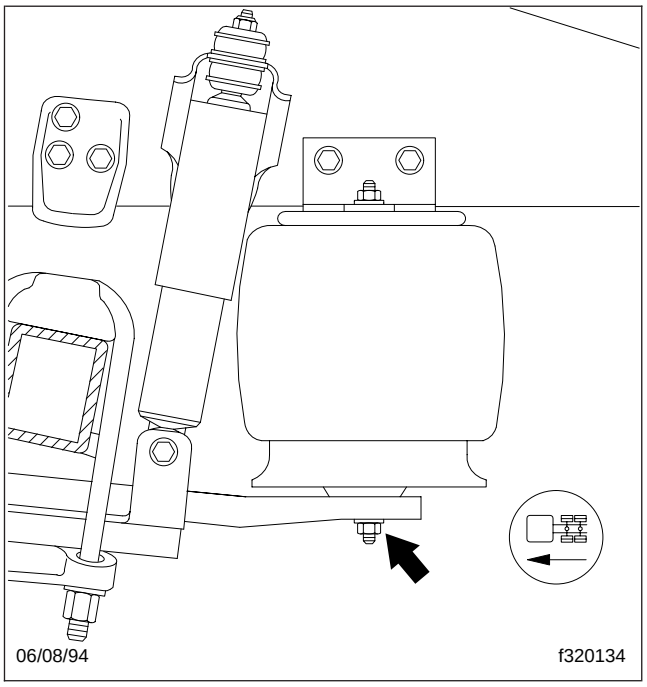
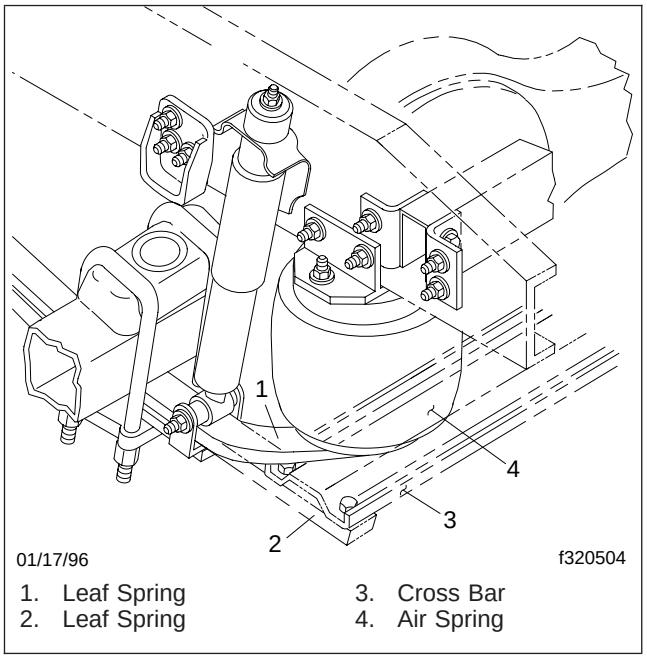


Fig. 4, Capscrew Connecting Leaf Spring and Air Spring



1. Leaf Spring
2. Leaf Spring
3. Cross Bar
4. Air Spring

Fig. 5, Leaf Spring and Air Spring Assembly, (23,000- and 46,000-pound suspensions)

Leaf Spring Replacement

(See Fig. 1)

WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

1. Chock the front tires.
2. Raise the rear of the vehicle, and support the rear axle(s) with safety stands. Raise the vehicle so that all weight is removed from the leaf springs, then securely support the frame with safety stands. Remove the wheel and tire assembly to easily access the suspension. Refer to the wheels and tires section in this manual for instructions.
3. Remove the nut, bolt, and washers from the shock absorber lower mounting bracket. Remove the high nuts, flatwashers, and axle clamp from each U-bolt. Support the leaf spring assembly with a jack.
4. If the air spring mounts to the leaf spring, disconnect the bottom of the air spring from the leaf spring.

   If the air spring mounts to a cross bar, disconnect the cross bar from the leaf spring by removing the capscrews, nuts, and washers. See **Fig. 2.**
5. Note the number and position of the alignment shims (see **Fig. 1**) on the spring mounting bolt.
6. Remove the hexnut, washers, alignment shim(s), spring mounting bolt, and wear shoe clip from the spring hanger. See **Fig. 1.**

WARNING

The leaf spring assembly is heavy. Use care when handling it to prevent injury.

7. Remove and discard the leaf spring assembly.
8. While supporting a new leaf spring assembly with a jack, position the assembly on the spring hanger. Install the bolts, wear shoe clips, washers, alignment shims, and hexnuts. Tighten the bolts just enough to hold the leaf spring assembly in place.
9. If the air spring mounts to the leaf spring, attach the air spring to the leaf spring assembly. Install the washer and locknut. Tighten the locknut 55 lbf·ft (75 N·m).

   If the air spring mounts to a cross bar, attach the cross bar to the leaf spring assembly. The longer capscrews attach in the forwardmost holes; the shorter capscrews attach in the aft holes.
10. Making sure that the U-bolt pads are in place on the top of the axle, fasten the leaf spring assembly to the axle using the U-bolts, axle clamp, washers, and high nuts making sure the U-bolt pads and axle clamps are positioned correctly.

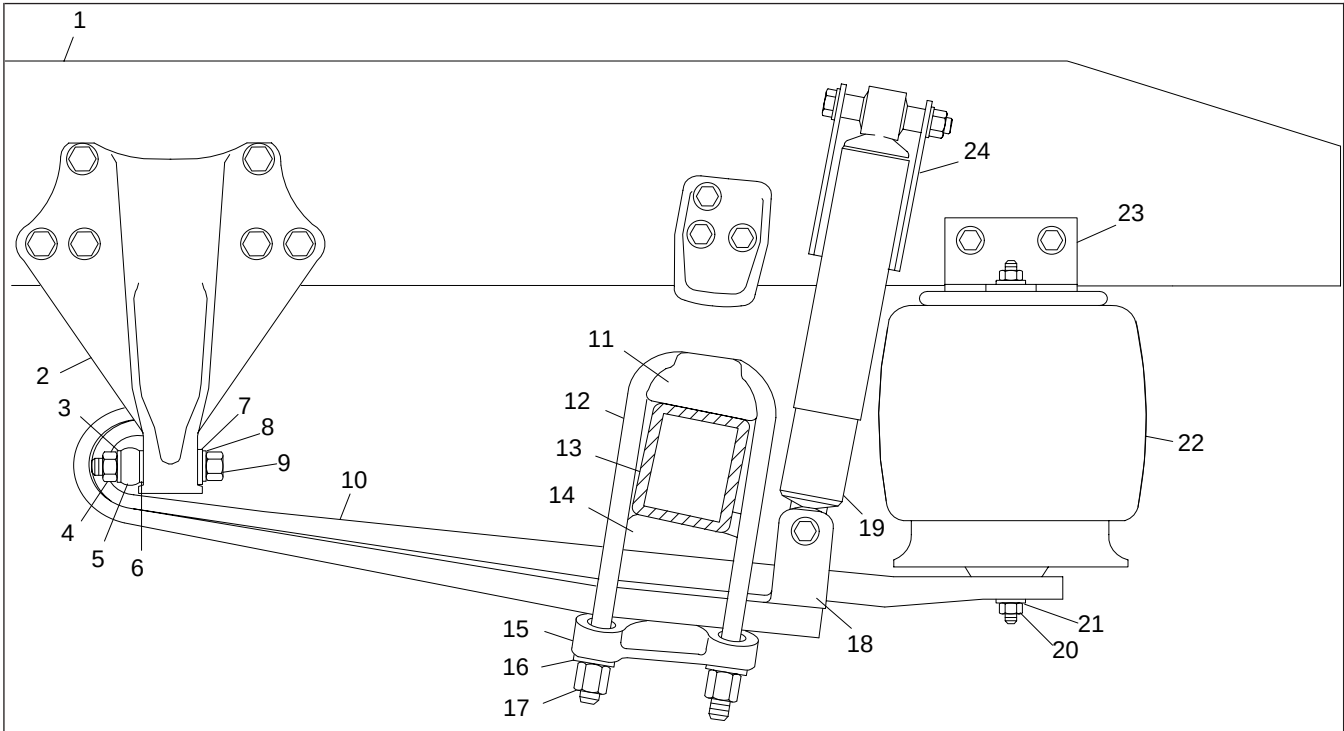
NOTE: On single-drive axles angled 5 degrees, the arrow on the U-bolt pads must point to the front of the axle housing. See **Fig. 3**. On single-drive axles angled 3 degrees, there is no arrow. Make sure that the axle bump stop on the U-bolt pad is positioned toward the vehicle centerline. See **Fig. 4 .**

With both 5- and 3-degree single-drive axle angles, the arrow on the bottom of the axle clamp (see **Fig. 1**) must point toward the rear of the vehicle.

On tandem axle suspensions, refer to **Table 1** for U-bolt pad orientation. The arrow on the bottom of the axle clamp must point toward the rear of the vehicle on the forward rear axle and toward the front of the vehicle on the rearmost axle.

11. Tighten the U-bolt high nuts in stages in a diagonal pattern as described in **Specifications 400**.
12. Install the bolt, washers, and hexnut to connect the shock absorber to its lower mounting bracket. Tighten the hexnut 170 lbf·ft (230 N·m).
13. Tighten the locknut on the bottom of the air spring 55 lbf·ft (75 N·m).

Leaf Spring Replacement



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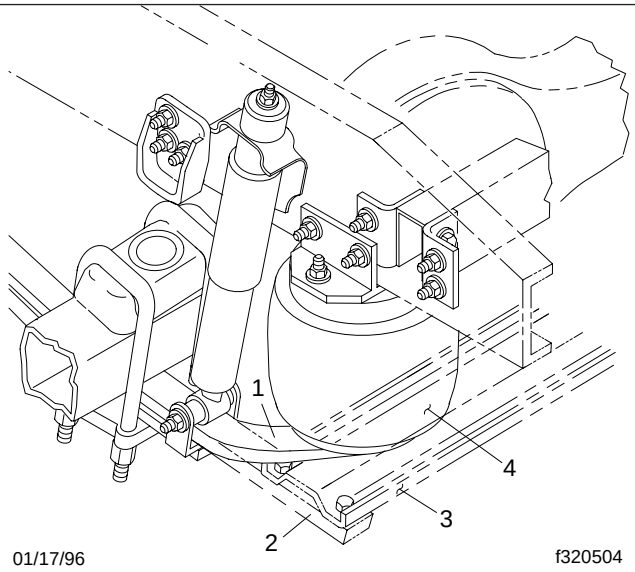
1. Frame Rail
2. Spring Hanger
3. Washer
4. Hexnut
5. Spring Mounting Eye Pin
6. Alignment Shim
7. Wear Shoe Clip
8. Washer
9. Spring Mounting Bolt
10. Leaf Spring Assembly
11. U-Bolt Pad
12. U-Bolt
13. Axle
14. Axle Seat
15. Axle Clamp
16. Flatwasher
17. High Nut
18. Shock Absorber Lower Mounting Bracket
19. Shock Absorber
20. Nylon Locknut
21. Washer
22. Air Spring
23. Air Spring Mounting Bracket
24. Shock Absorber Upper Mounting Bracket

Fig. 1, AirLiner Leaf Spring Assembly

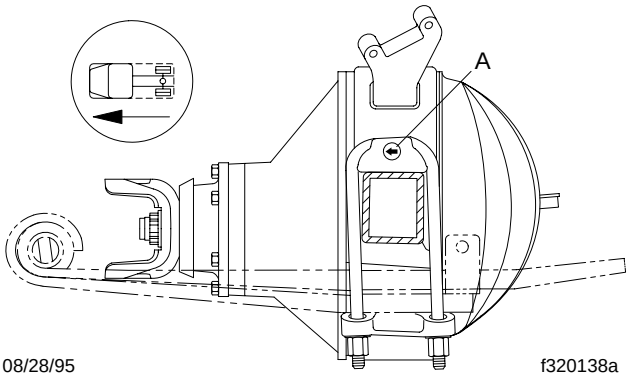
On 23,000-pound and 46,000-pound suspensions, tighten the locknuts on the bottom of the cross bar 241 lbf·ft (327 N·m).

14. Tighten the hexnuts at the front of the leaf spring 170 lbf·ft (230 N·m).
15. Install the wheel and tire assembly. For instructions, refer to **Group 40**. Remove the safety stands, and lower the vehicle.
16. Check the rear axle alignment. For instructions, refer to the rear axle section in this manual. If necessary, adjust the rear axle alignment using the instructions in **Subject 170**.



1. Leaf Spring
2. Leaf Spring
3. Cross Bar
4. Air Spring

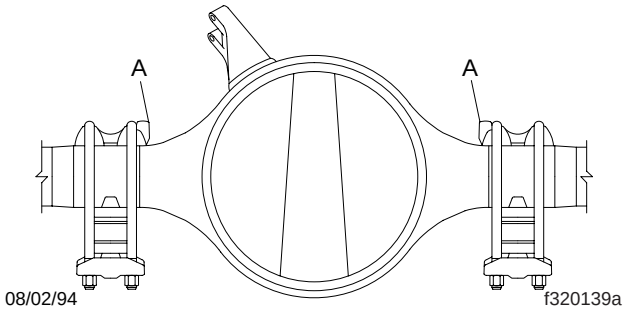
Fig. 2, Leaf Spring and Air Spring Assembly (23,000- and 46,000-pound suspensions)



A. Arrow on U-Bolt Pad

Fig. 3, U-bolt Pad Arrow Positioning

Leaf Spring Replacement



A. Axle Bump Stop

Fig. 4, Axle Bump Stop Positioning

U-Bolt Pad Orientation for Axles		
Axle Designation	**U-Bolt Pad Orientation**	
Rockwell SQ 100, SSHD	Forward Rear Axle	No arrow; axle bump stop toward vehicle centerline.
	Rearmost Axle	No arrow; axle bump stop toward vehicle centerline.
Rockwell RT40-145, RT44-145, RT46-160	Forward Rear Axle	No arrow; axle bump stop toward vehicle centerline.
	Rearmost Axle	Arrow toward front of vehicle.
Eaton 402, 461	Forward Rear Axle	No arrow; axle bump stop toward vehicle centerline.
	Rearmost Axle	No arrow; axle bump stop toward vehicle centerline.

Table 1, U-Bolt Pad Orientation for Axles

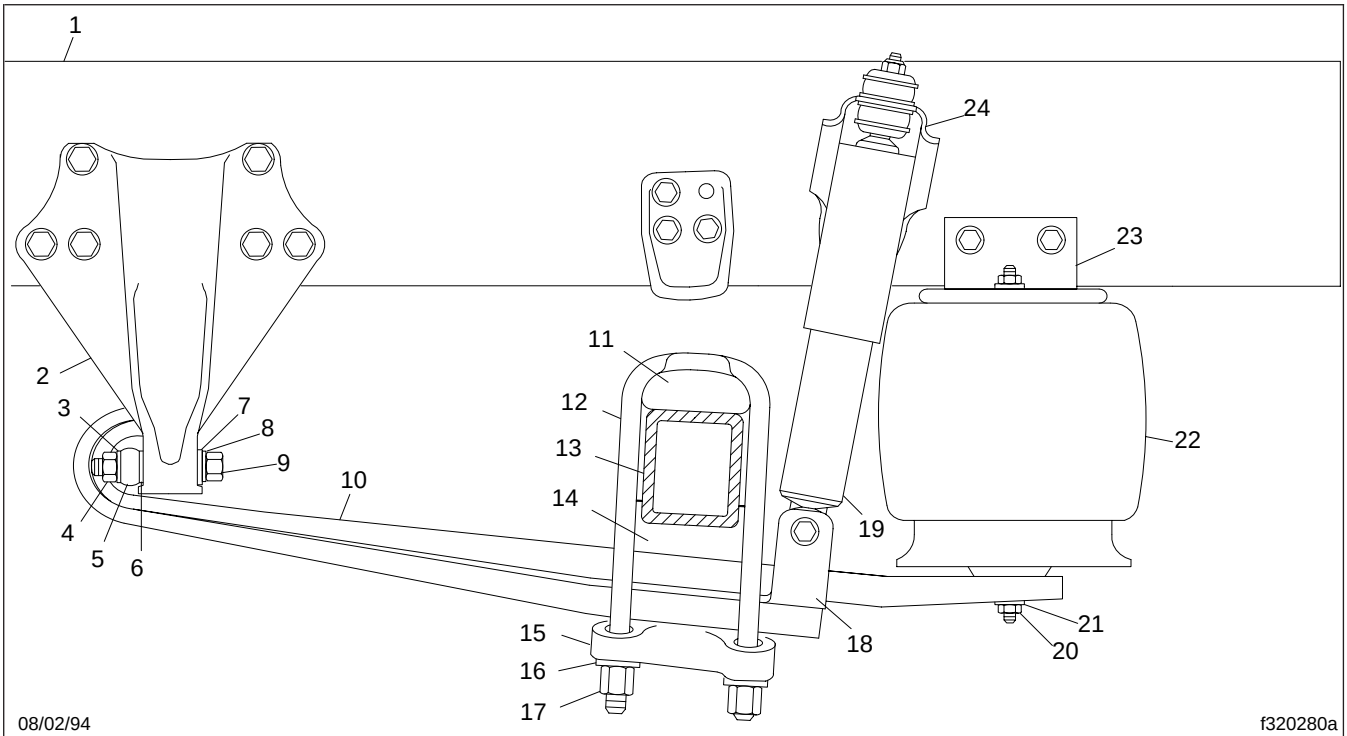
Rear Axle Alignment Adjusting

See **Fig. 1**.

Follow the instructions in **Group 35** to see if rear axle alignment adjustment is needed. If adjustment is needed, proceed as follows:

3. When the axle is in alignment, install alignment shim(s) to take up the slack between the spring hanger and the spring mounting eye pin.

IMPORTANT: Make sure the same number of shims is installed on both ends of the spring mounting eye pin.



1. Frame Rail
2. Spring Hanger
3. Washer
4. Hexnut
5. Spring Mounting Eye Pin
6. Alignment Shim
7. Wear Shoe Clip
8. Washer
9. Spring Mounting Bolt
10. Leaf Spring Assembly
11. U-Bolt Pad
12. U-Bolt
13. Axle
14. Axle Seat
15. Axle Clamp
16. Flatwasher
17. High Nut
18. Shock Absorber Lower Mounting Bracket
19. Shock Absorber
20. Nylon Locknut
21. Washer
22. Air Spring
23. Air Spring Mounting Bracket
24. Shock Absorber Upper Mounting Bracket

Fig. 1, Airliner Leaf Spring Assembly

1. Loosen the spring mounting eye bolts so that the forward end of the leaf spring can slide fore and aft in the spring hanger.
2. Move the axle forward or backward until it is aligned within the tolerances in the rear axle alignment checking section.
4. Tighten the spring mounting eye bolts 170 lbf·ft (230 N·m).
5. Check the axle alignment again. If necessary, repeat the above procedure until the alignment is within tolerances.

Rear Axle Alignment

Rear Axle Tracking Adjustment

Single Axle

1. At the forward edge of the right rear tire, measure the distance from the inner side of the tire to the outer side of the right frame rail. See **Fig. 2**.

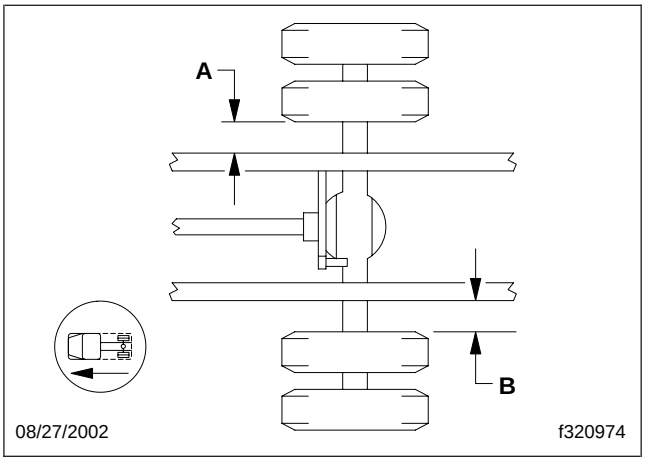


Fig. 2, Rear Axle Tracking Measurements (single axle)

2. At the rear edge of the left rear tire, measure the distance from the inner side of the tire to the outer side of the left frame rail. See **Fig. 2**.

IMPORTANT: Measurement "A" should not vary by more than 1/4-inch (6 mm) from measurement "B."

3. If measurements "A" and "B" vary by more than 1/4-inch (6 mm), loosen the fasteners holding the lateral torque rod to the frame rail. Add or remove torque-rod shims as needed.
4. For bar-pin style torque rods, tighten the fasteners 136 lbf·ft (184 N·m).

   For taper-pin style torque rods, tighten the fasteners 165 lbf·ft (224 N·m). See **Fig. 3**.

Tandem Axles

1. Check the tracking of the forward-rear axle. For instructions, see "Single Axle" in this subject. Adjust the tracking if needed.
2. At the forward-rear drive axle, measure the distance from the inner side of the right rear tire to the outer side of the right frame rail. Measure at the forward edge of the tire. See **Fig. 4**.

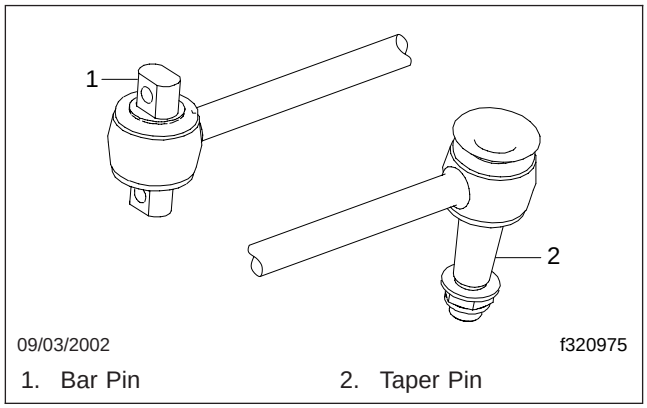


Fig. 3, Torque Rod Types

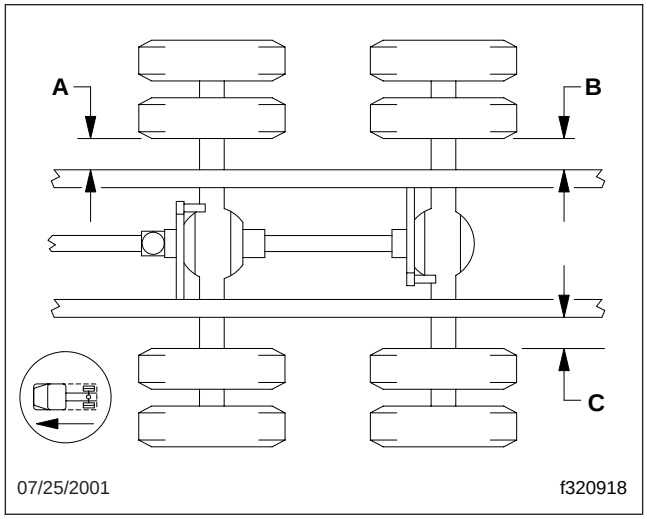


Fig. 4, Rear Axle Tracking Measurements (tandem axles)

3. At both sides of the rear-rear drive axle, measure the distance from the inner side of the rear tires to the outer side of each frame rail. Measure at the rear edge of each tire. See **Fig. 4**.

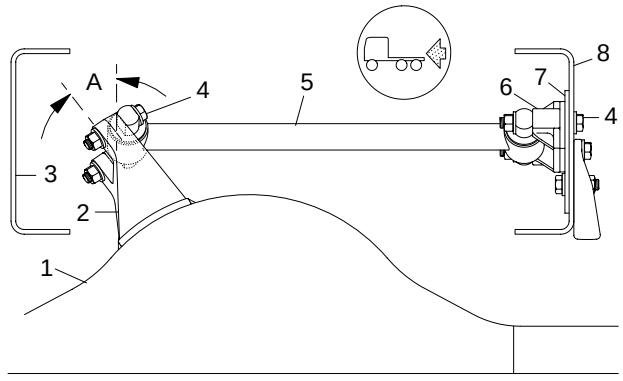
IMPORTANT: Measurements "B" and "C" should not vary by more than 1/4-inch (6 mm) from measurement "A."

4. If measurements "B" and "C" vary by more than 1/4-inch (6 mm) from measurement "A," loosen the fasteners holding the axle lateral torque rod at the rear-rear drive axle to the frame rail. Add or remove torque-rod shims as needed.

5. For bar-pin style torque rods, tighten the fasteners 136 lbf·ft (184 N·m). For taper-pin style torque rods, tighten the fasteners 165 lbf·ft (224 N·m). See **Fig. 3**.

Replacement

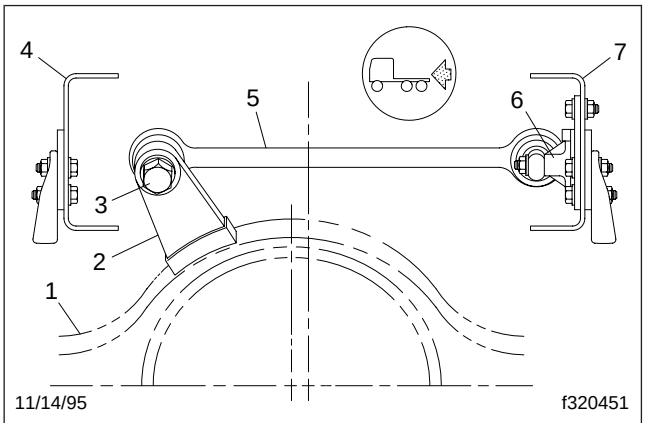
1. Park the vehicle. Shut down the engine, and apply the brakes.
2. Chock the tires. Raise the vehicle. Support the frame rails with jack stands.
3. Remove the fasteners holding the control rod to the frame rail bracket. Remove the shims, and set the shims aside.
4. Remove the control rod.
5. Position the new control rod so that the end with the fasteners angled up at 35 degrees is installed in the axle housing bracket. **See Fig. 1.**



A. Angle: 35 degrees
1. Axle Housing
2. Control Rod Axle Bracket
3. Left Frame Rail
4. Bolt
5. Control Rod
6. Control Rod Frame Bracket
7. Shim
8. Right Frame Rail

Fig. 1, AirLiner Control Rod Installation

6. Install the fasteners with the bolt heads facing up. Tighten the fasteners enough to hold the control rod in place.
7. Install the shims that were previously removed.
8. Install the other end of the control rod in the frame rail bracket; then, install the fasteners. Tighten the fasteners enough to hold the control rod in place.
9. Tighten all the fasteners 136 lbf·ft (184 N·m).
10. Remove the jack stands. Lower the vehicle. Remove chocks.



1. Axle Housing
2. Control Rod Axle Bracket
3. Bolt
4. Left Frame Rail
5. Control Rod
6. Control Rod Frame Bracket
7. Right Frame Rail

Fig. 2, Control Rod Installation on 23,000- and 46,000-pound AirLiner Suspensions

NOTE: Control rods on suspensions manufactured to a 23,000-pound (10 433 kg) or 46,000-pound (20 865 kg) weight rating are larger and are attached to the axle bracket with a single bolt. Tighten the fasteners attaching the control rod frame bracket to the frame rail 160 to 170 lbf·ft (217 to 230 N·m), and the bolt connecting the control rod to the axle housing 175 to 225 lbf·ft (237 to 305 N·m). **See Fig. 2.**

Replacement

WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.
2. Raise the rear of the vehicle, and support the rear axle(s) with safety stands. Raise the vehicle so that all weight is removed from the leaf springs, then securely support the frame with safety stands.
3. Remove the wheel and tire assembly to easily access the suspension. For instructions, see the information in **Group 40**.
4. Remove the leaf spring assembly. See removal information in **Subject 160**.

WARNING

The leaf spring assembly is heavy. Use care when handling it to prevent injury.

5. Remove the bushing from the leaf spring eye.

WARNING

Do not use a cutting torch to remove the outer metal of the bushing from the spring eye. Welding, torching or cutting the leaf spring assembly can damage the leaf spring material, which may result in the failure of the components and cause serious personal injury, death, or property damage.

   5.1 Using a shop press with a capacity of at least 10 tons (9 072 kg), place the spring assembly in the shop press with the spring assembly squarely supported on the press bed for safety and to avoid bending the spring assembly.

   5.2 Center the bushing tool on the outer metal of the bushing and push the bushing from the spring eye.

   5.3 Remove any burrs or material left behind by the old bushing.

6. Install the new bushing in the leaf spring eye.

   6.1 Position the bushing on the shop press.

   6.2 Apply a bonding agent, either Permabond HM–160 or Loctite RC–609 or 680, liberally around the outside surface of the bushing.

   6.3 Press the bushing into place.

   6.4 Allow the bonding agent to cure for 24 hours.

   NOTE: After the curing time, the bushing must resist a minimum 7,700 lb (3 490 kg) pushout force.

7. Install the leaf spring assembly. See the information in **Subject 160**.
8. Install the wheel and tire assembly. For instructions, see **Group 40**. Remove the safety stands, and lower the vehicle.
9. Check the rear axle alignment. For instructions, refer to **Group 35** in this manual. If necessary, adjust the rear axle alignment using the instructions in **Group 35**.
10. Remove the chocks from the tires.

Torque Specifications

For fastener torque values, see **Table 1**.

Torque Values for AirLiner Suspension			
Description	**Size**	**Torque**	
		lbf·ft (N·m)	**lbf·in (N·cm)**
Height-Control Valve Housing Bolts, Barksdale*	1/4–20	—	45 (500)
Height-Control Valve Mounting Locknuts, Barksdale*	1/4–20	—	95 (1100)
Height-Control Valve Adjustment Nut, Meritor WABCO	1/4–20	—	62 (700)
Height-Control Valve Mounting Bolt Nuts, Meritor WABCO	5/16–18	14 (19)	—
Shock Absorber Mounting Locknuts	3/4–10	165 (220)	—
Air Spring Upper Mounting Locknuts	3/4–16	45 (61)	—
	1/2–13	23 (31)	—
Air Spring Lower Mounting Locknuts	1/2–13	55 (75)	—
Leaf Spring Mounting Eye Bolt Locknuts	3/4–10	241 (327)	—
Control Rod Mounting Bolt Locknuts	5/8–11	136 (184)	—
Axle U-Bolt High Nuts Tighten in a diagonal pattern as shown in **Fig. 1**.	3/4–16	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 270 to 330 (367 to 449)	—
	7/8–14	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 420 to 500 (571 to 680)	—
	1–14	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 520 to 600 (707 to 816)	—
Air Spring Upper Mounting Bracket	5/8–11	136 (184)	—
Spring Hanger Mounting Locknuts	3/4–10	240 (325)	—

* See the cautionary statements below.

Table 1, Torque Values for AirLiner Suspension

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing. The bolts should not be loose, and should not

require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.

- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

NOTICE

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

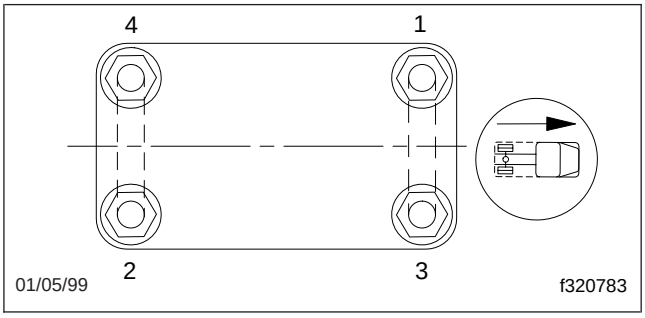
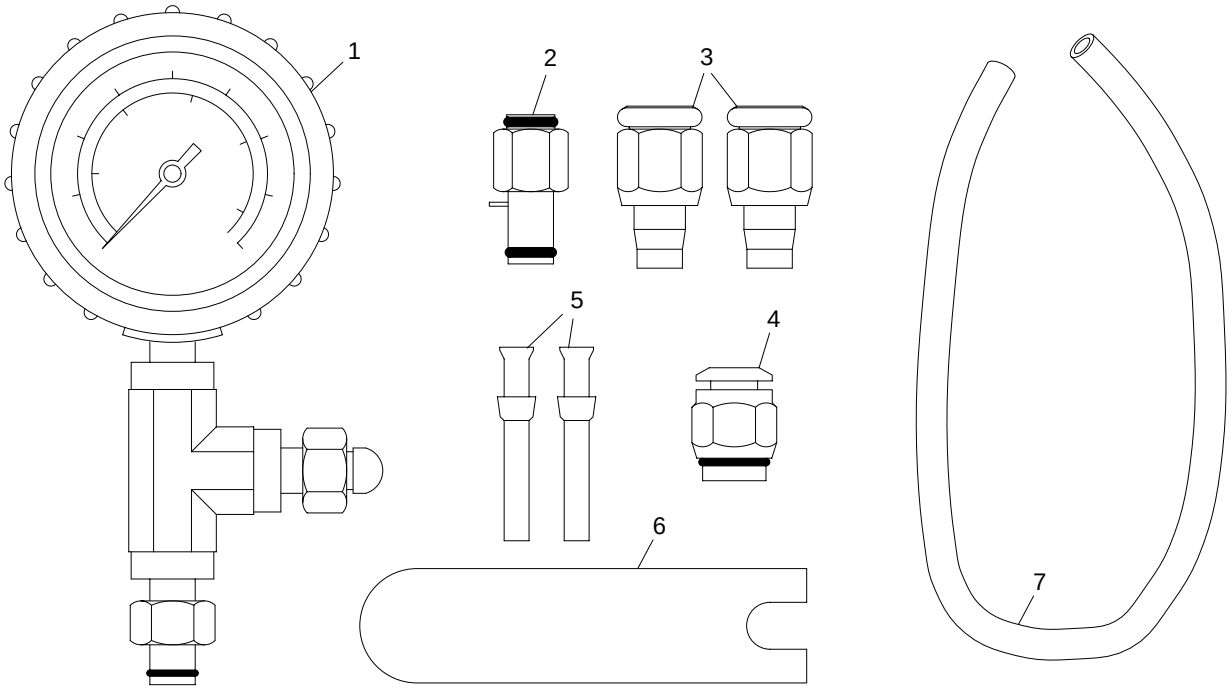


Fig. 1, Tightening Pattern for U-Bolt High Nuts

Special Tools

Use the kit shown in **Fig. 2** to test a Barksdale height-control valve. Test kit BKS KD2264 is available via the Direct Ship program in Paragon.



NOTE: Parts for cab suspension valve testing included.

1. Test Gauge Assembly with Reset Button
2. Exhaust Port Test Connector for Cab Suspension Valve (used for cab suspension valve testing)
3. Parker Plugs
4. Exhaust Port Test Connector for Chassis Suspension Valve
5. Test Plugs for Cab Suspension Valve (used for cab suspension valve testing)
6. Special Tool for Disconnecting Air Line
7. Air Line

Fig. 2, Barksdale Height-Control Valve Test Kit BKS KD2264

General Description

The Neway Air Ride Suspension is a single axle (Model ARD 125-8; see **Fig. 1**) or tandem axle (Model ARD 244-8; see **Fig. 2**) suspension that uses air springs. The top of each air spring is bolted to a frame-rail bracket, and the bottom of each spring is attached to a suspension crossmember. The suspension crossmember is attached to the rear ends of two equalizing beams which carry the axle. The forward ends of the equalizing beams are journaled to brackets bolted on the frame rail.

Both models of the suspension allow for 8 inches (20 cm) of vertical travel. The maximum loading capacity of the single axle model is 22,500 lbs (10,000 kg); and the maximum loading capacity for the tandem axle model is 44,000 lbs (20,000 kg).

The Neway suspension maintains a stable, level ride by adjusting the air spring height according to vehicle load and road conditions. A height control valve mounted inside the frame rail is linked to the suspension crossmembers and monitors ride height in relation to the crossmember. If the load is riding too high, the suspension crossmember pulls the valve's control lever (**Fig. 4**) down, and the valve lowers the load by venting air from the springs (**Fig. 3**, Ref. 41). If the load rides too low, the suspension crossmember pushes the valve's control lever up, and the valve raises the load by delivering air to the springs. The air springs and the shocks mounted between the axle and the frame rails absorb road shock.

The design of the height control valve allows a several second delay between delivering air to and venting air from the air springs. This prevents the valve from reacting to abrupt axle movements caused by the condition of the road surface.

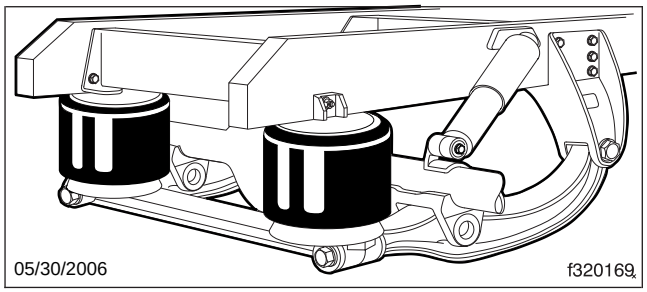


Fig. 1, Single Axle Suspension, Model ARD 125-8

A torque rod (**Fig. 3**, Ref. 5) connects each axle housing to a frame crossmember to prevent torque-induced rotation of the axle. A similar lateral rod (**Fig. 3**, Ref. 18) connects each axle housing to a frame rail to prevent the axle from moving laterally.

If the air springs lose pressure, a solid rubber bumper inside the spring will support the vehicle until it can be repaired. Do not drive the vehicle over 30 mph (50 km/h) with the air springs deflated, and drive it only as far as the nearest service facility. To deflate the air springs, disconnect the control lever arm from the linkage rod, and press the valve's control lever down to simulate overinflated air springs. The valve will vent the air from the springs.

General Description

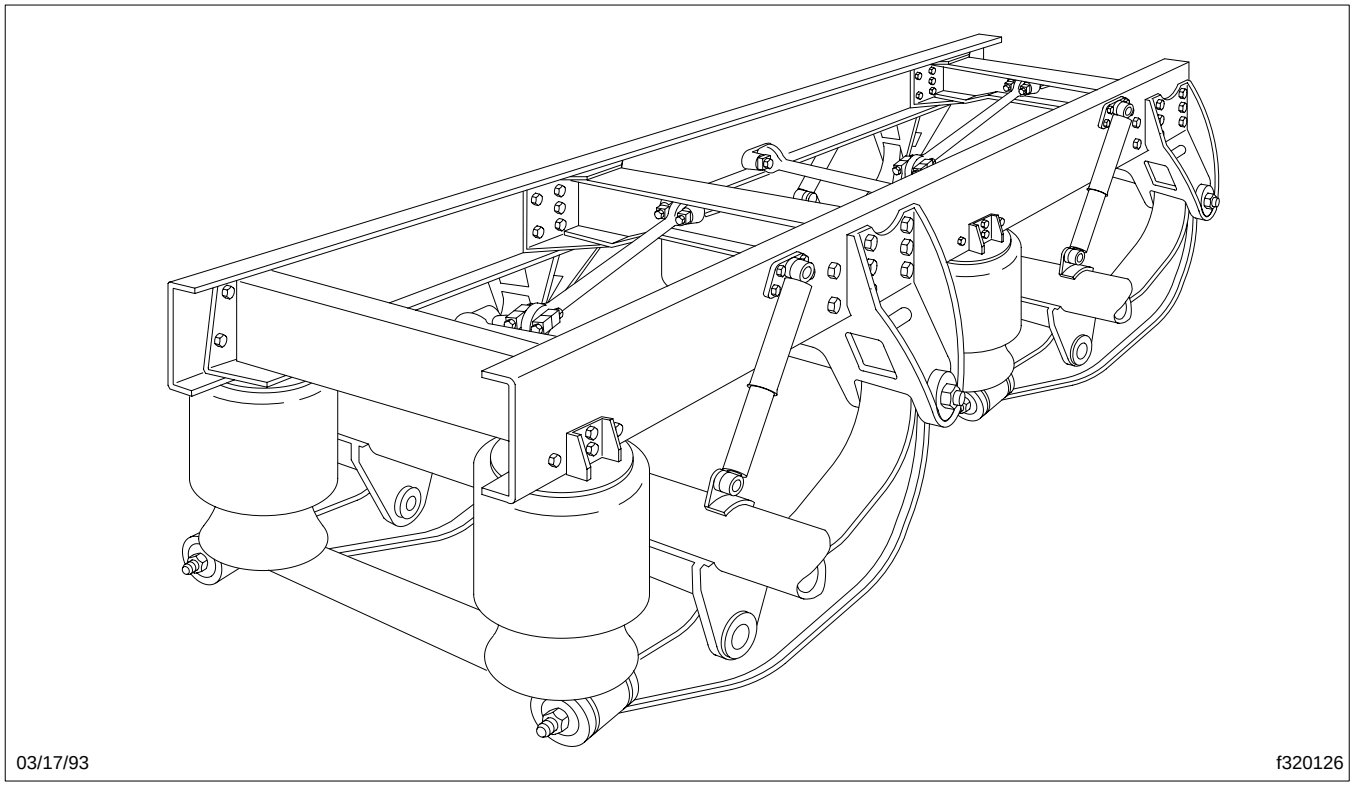


Fig. 2, Tandem Axle Suspension, Model ARD 244-8

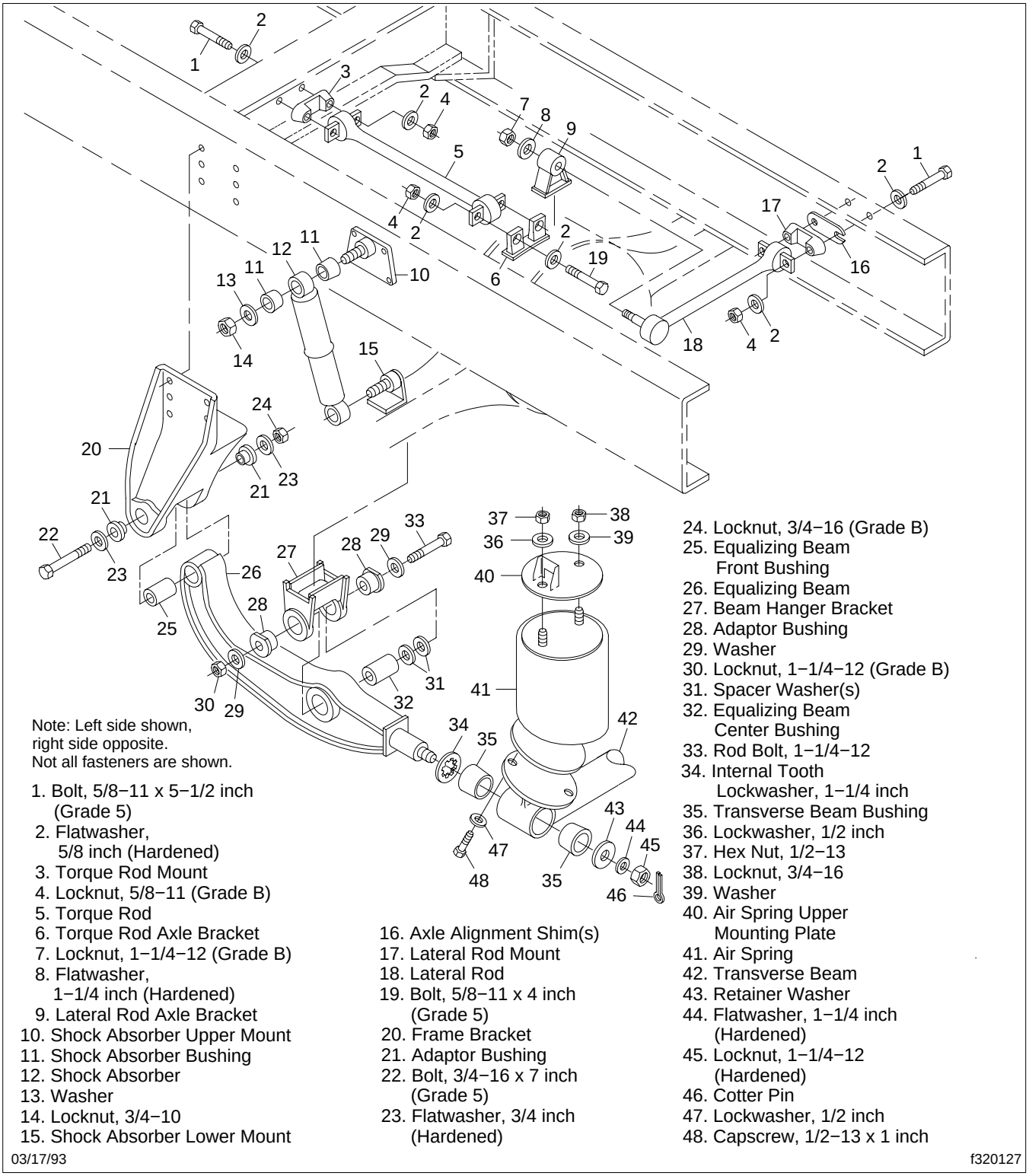


Fig. 3, Neway Suspension Components

General Description

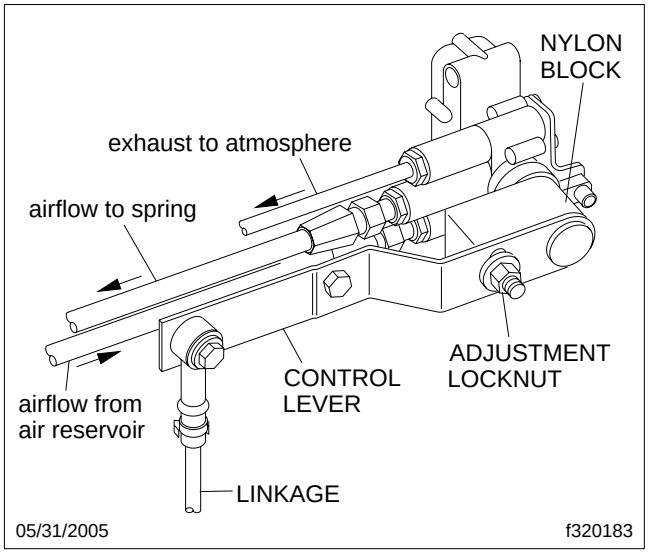


Fig. 4, Height Control Valve

Adjustment

1. Park the unloaded or evenly loaded vehicle on a level surface. Run the engine until the air brake system is fully charged. Chock the tires.
2. Remove the bolt that secures the height control valve linkage to the control lever of each valve. See **Fig. 1**. Disconnect the linkages from the control levers.
3. Exhaust all air from the air springs by pushing the control levers down to the vertical position.
4. Connect one of the control levers to its respective linkage, and allow the air spring(s) controlled by the lever to fill until the valve shuts off.
5. Measure the distance from the underside of the frame rail to the centerline of the axle nearest the inflated spring. This dimension should be 10 inches (25 cm). Adjust the height control valve by loosening the adjustment locknut (**Fig. 1**) and moving the control lever slightly, relative to the nylon block. When the 10-inch (25-cm) height dimension is achieved, retighten the adjustment locknut.

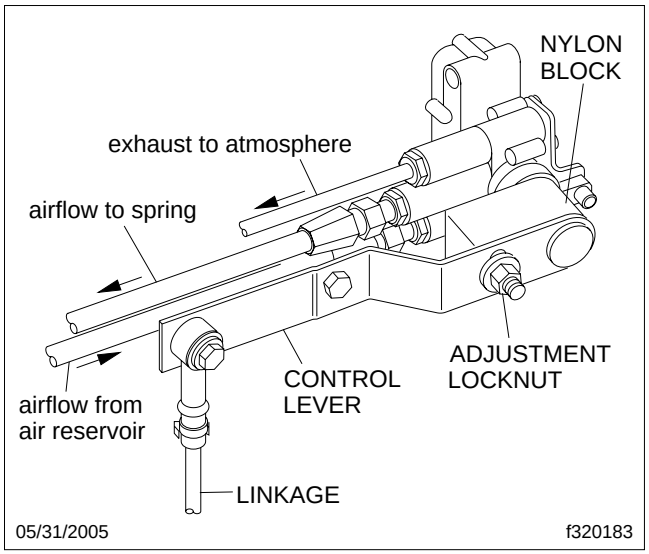


Fig. 1, Height Control Valve

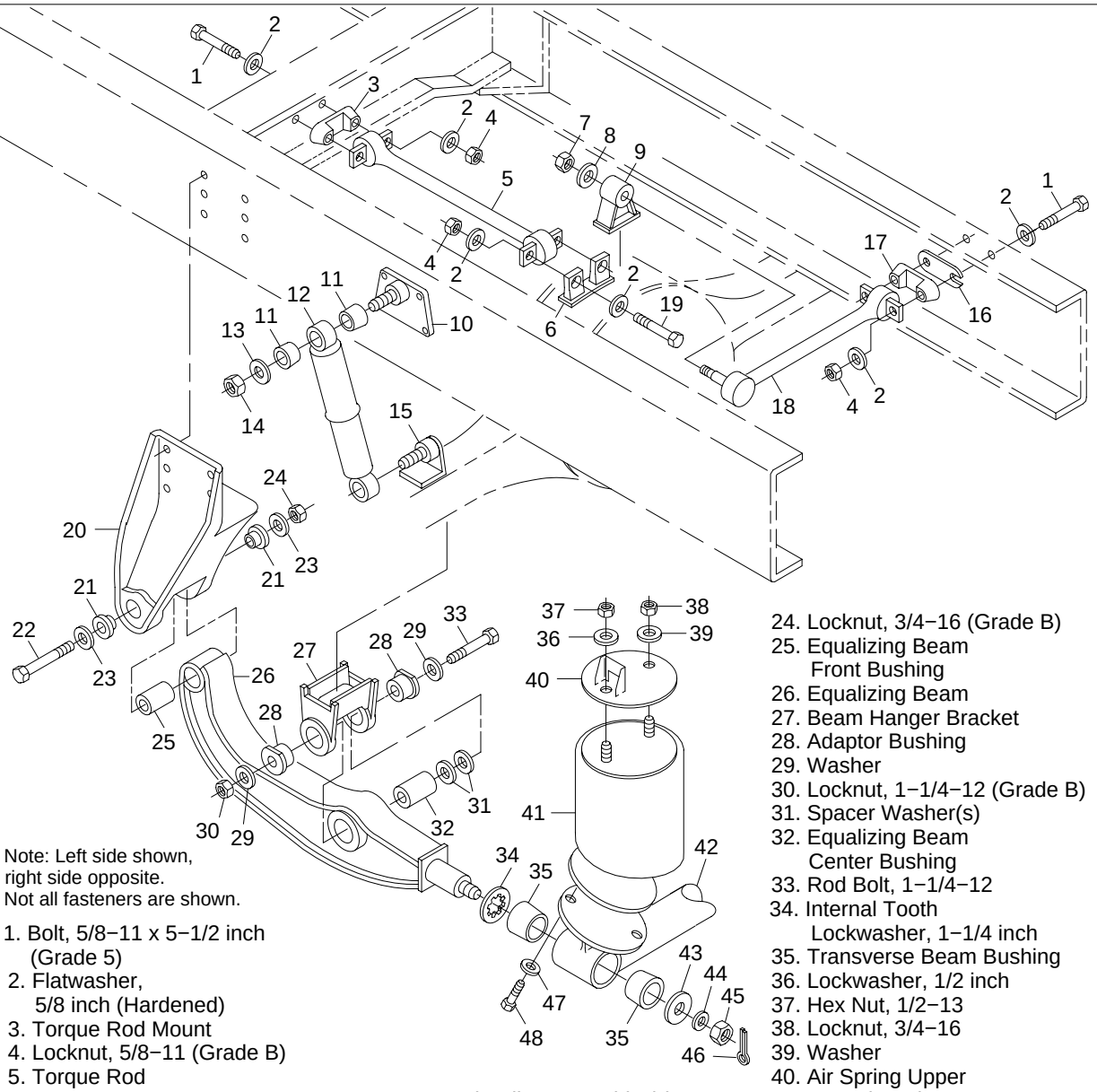
6. Disconnect the control lever from the linkage, and press it down to deflate the air springs about halfway. Reconnect the linkage to inflate the air springs, then check the height dimension. Repeat the step above and this step until the height dimension measures 10 inches (25 cm).
7. When the height control valve is adjusted, disconnect the control lever from the height control valve linkage, and push it down to the vertical position to fully deflate the air spring.
8. Repeat the previous four steps on the other height control valve(s).
9. Connect all linkage assemblies to the control levers. All height dimensions should now be equal. If they aren't, check for loose mounting bolt nuts on the height control valves. Tighten any loose nuts or capscrews. Repeat the adjustment procedures until all height dimensions are 10 inches (25 cm).

Replacing

(See Fig. 1)

1. Chock the front tires to prevent vehicle movement. Open the stopcocks on the air tanks to drain the air system.
2. Raise the rear of the vehicle to remove all weight from the rear axles, and place safety stands to secure the vehicle in its raised position. When raised, the height control valves will vent all air from the air springs.
3. Taking care to prevent foreign substances from entering the line or fitting, disconnect the air supply line from the air spring.
4. Remove the locknut (**Fig. 1**, Ref. 38), hexnut (Ref. 37), and washers that secure the air spring to the air spring upper mounting plate (Ref. 40).
5. Remove the capscrews (Ref. 48) and lockwashers that connect the air spring to the air spring lower mounting plate on the transverse beam (Ref. 42). Remove the air spring.
6. Position the new air spring on the air spring lower mounting plate, then install the capscrews and lockwashers to secure the air spring to the lower mounting plate. Tighten the capscrews to the torque under **Specifications, 400.**
7. Install the locknut, hexnut, and washers previously removed, to connect the air spring to the air spring upper mounting plate. Tighten the nuts to the torque under **Specifications, 400**.
8. Connect the air supply line to the air spring.
9. Remove the safety stands from under the vehicle, then lower the vehicle.
10. There must be 10 inches (25 cm) between the bottom of the frame rail and the centerline of the axle. Adjust the height control valve adjustment; for instructions, refer to **Subject 100**.

Air Spring Replacement



Note: Left side shown, right side opposite.
Not all fasteners are shown.

1. Bolt, 5/8−11 x 5−1/2 inch (Grade 5)
2. Flatwasher, 5/8 inch (Hardened)
3. Torque Rod Mount
4. Locknut, 5/8−11 (Grade B)
5. Torque Rod
6. Torque Rod Axle Bracket
7. Locknut, 1−1/4−12 (Grade B)
8. Flatwasher, 1−1/4 inch (Hardened)
9. Lateral Rod Axle Bracket
10. Shock Absorber Upper Mount
11. Shock Absorber Bushing
12. Shock Absorber
13. Washer
14. Locknut, 3/4−10
15. Shock Absorber Lower Mount
16. Axle Alignment Shim(s)
17. Lateral Rod Mount
18. Lateral Rod
19. Bolt, 5/8−11 x 4 inch (Grade 5)
20. Frame Bracket
21. Adaptor Bushing
22. Bolt, 3/4−16 x 7 inch (Grade 5)
23. Flatwasher, 3/4 inch (Hardened)
24. Locknut, 3/4−16 (Grade B)
25. Equalizing Beam Front Bushing
26. Equalizing Beam
27. Beam Hanger Bracket
28. Adaptor Bushing
29. Washer
30. Locknut, 1−1/4−12 (Grade B)
31. Spacer Washer(s)
32. Equalizing Beam Center Bushing
33. Rod Bolt, 1−1/4−12
34. Internal Tooth Lockwasher, 1−1/4 inch
35. Transverse Beam Bushing
36. Lockwasher, 1/2 inch
37. Hex Nut, 1/2−13
38. Locknut, 3/4−16
39. Washer
40. Air Spring Upper Mounting Plate
41. Air Spring
42. Transverse Beam
43. Retainer Washer
44. Flatwasher, 1−1/4 inch (Hardened)
45. Locknut, 1−1/4−12 (Hardened)
46. Cotter Pin
47. Lockwasher, 1/2 inch
48. Capscrew, 1/2−13 x 1 inch

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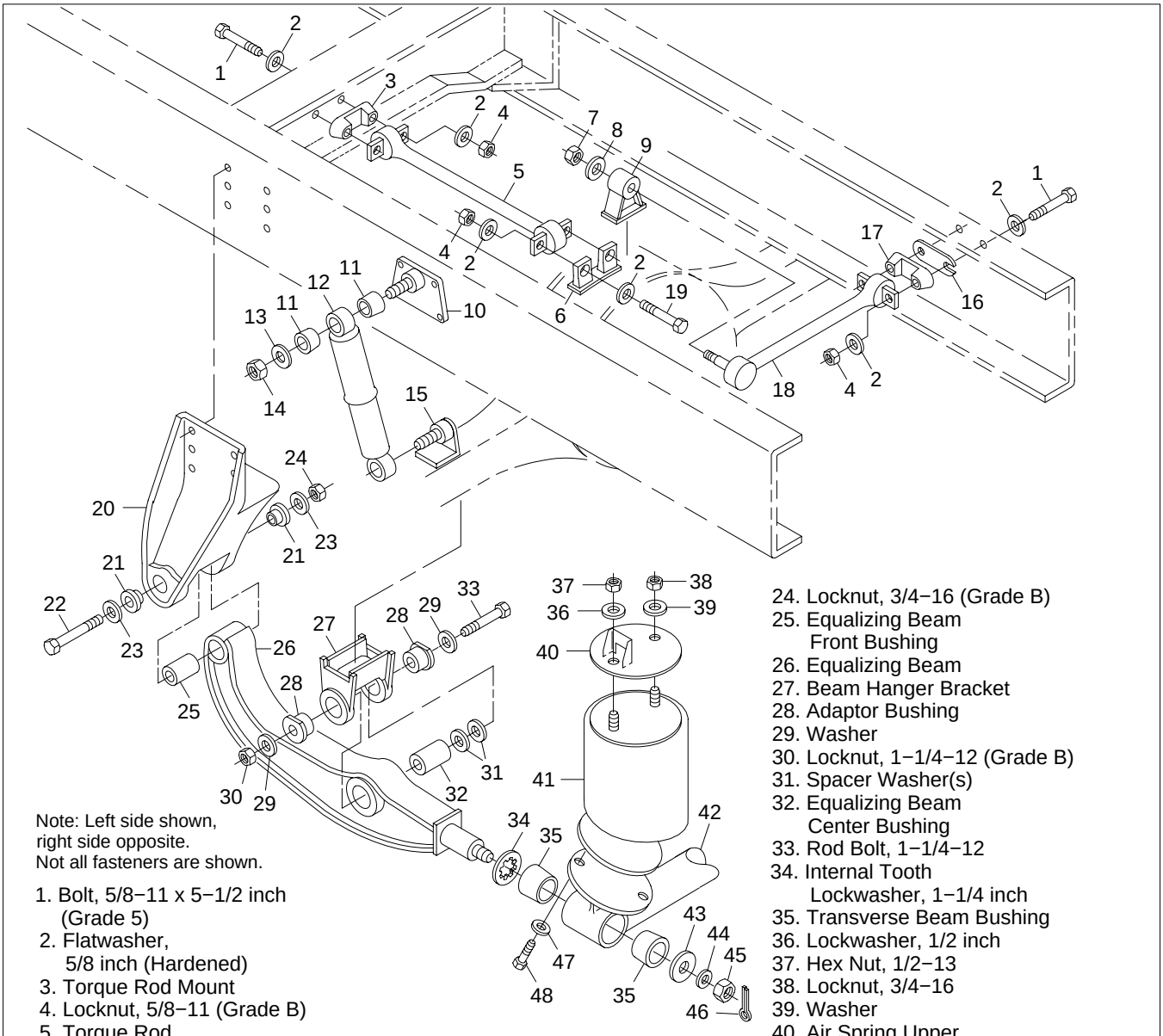
Fig. 1

Replacement (See Fig. 1)

1. Remove the locknuts (Ref. 14) from the shock absorber upper and lower mounting brackets.
2. If the shock absorber is fully extended, chock the vehicle wheels and jack up the axle to relieve tension from the shock. Remove the shock absorber. If the inner metal sleeve is rusted to the mounting pin, use a small, sharp chisel to force the sleeve from the pin.
3. Install the new shock absorber on the mounting pins and secure it with the locknuts and washers previously removed. Tighten the locknuts to the torque under **Specifications, 400**.

Shock Absorber Replacement



Note: Left side shown, right side opposite.
Not all fasteners are shown.

1. Bolt, 5/8−11 x 5−1/2 inch (Grade 5)
2. Flatwasher, 5/8 inch (Hardened)
3. Torque Rod Mount
4. Locknut, 5/8−11 (Grade B)
5. Torque Rod
6. Torque Rod Axle Bracket
7. Locknut, 1−1/4−12 (Grade B)
8. Flatwasher, 1−1/4 inch (Hardened)
9. Lateral Rod Axle Bracket
10. Shock Absorber Upper Mount
11. Shock Absorber Bushing
12. Shock Absorber
13. Washer
14. Locknut, 3/4−10
15. Shock Absorber Lower Mount
16. Axle Alignment Shim(s)
17. Lateral Rod Mount
18. Lateral Rod
19. Bolt, 5/8−11 x 4 inch (Grade 5)
20. Frame Bracket
21. Adaptor Bushing
22. Bolt, 3/4−16 x 7 inch (Grade 5)
23. Flatwasher, 3/4 inch (Hardened)
24. Locknut, 3/4−16 (Grade B)
25. Equalizing Beam Front Bushing
26. Equalizing Beam
27. Beam Hanger Bracket
28. Adaptor Bushing
29. Washer
30. Locknut, 1−1/4−12 (Grade B)
31. Spacer Washer(s)
32. Equalizing Beam Center Bushing
33. Rod Bolt, 1−1/4−12
34. Internal Tooth Lockwasher, 1−1/4 inch
35. Transverse Beam Bushing
36. Lockwasher, 1/2 inch
37. Hex Nut, 1/2−13
38. Locknut, 3/4−16
39. Washer
40. Air Spring Upper Mounting Plate
41. Air Spring
42. Transverse Beam
43. Retainer Washer
44. Flatwasher, 1−1/4 inch (Hardened)
45. Locknut, 1−1/4−12 (Hardened)
46. Cotter Pin
47. Lockwasher, 1/2 inch
48. Capscrew, 1/2−13 x 1 inch

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Fig. 1

Equalizing Beam Removal and Installation

Removal

1. Chock the front tires.
2. Raise the rear of the vehicle to remove all weight from the rear suspension, and place safety stands to secure the vehicle in its raised position.
3. Remove the rear wheels and tires for access to the suspension. Block the axle securely to prevent it from dropping away from the vehicle as the equalizing beam is removed.
4. With the weight removed from the suspension, the air springs should be fully deflated. If they aren't, disconnect the height control valve linkage from the height control valve control lever. Push the lever down to the vertical position to deflate the air springs.
5. Remove the capscrews and lockwashers (see **Fig. 1**, Refs. 48 and 47) that secure the air springs to the air spring lower mounting plates on both ends of the transverse beam (Ref. 42).
6. Remove the cotter pins, locknuts, flatwashers, and retainer washers (Refs. 46, 45, 44, and 43) from the studs in the ends of the equalizing beams (Ref. 26). Tap the transverse beam (Ref. 42) back from the ends of the equalizing beams.

NOTE: In some cases, the transverse beam bushings (Ref. 35) will stick, making it difficult to remove the transverse beam from the equalizing beams. Use a Porta-Power, or equivalent tool, between the axle housing and the transverse beam at a point as near to the end of the transverse beam as possible to remove the beam.

7. Remove the locknut and washer (Refs. 30 and 29) from the outboard end of the rod bolt (Ref. 33). Support the equalizing beam on a floor jack, then extract the equalizing beam center bushing bolt from the beam hanger bracket (Ref. 27).
8. Use a drift to tap the adaptor bushings (Ref. 28) from the beam hanger bracket. Lower the equalizing beam to the floor.
9. Remove the locknut (Ref. 24) from the inboard end of the bolt (Ref. 22). Note the positions of the spacer washers at either side of the equalizing beam so they can be reassembled in their original positions. Use a drift to drive the rod bolt out of the frame bracket. Remove the equalizing beam from the vehicle.

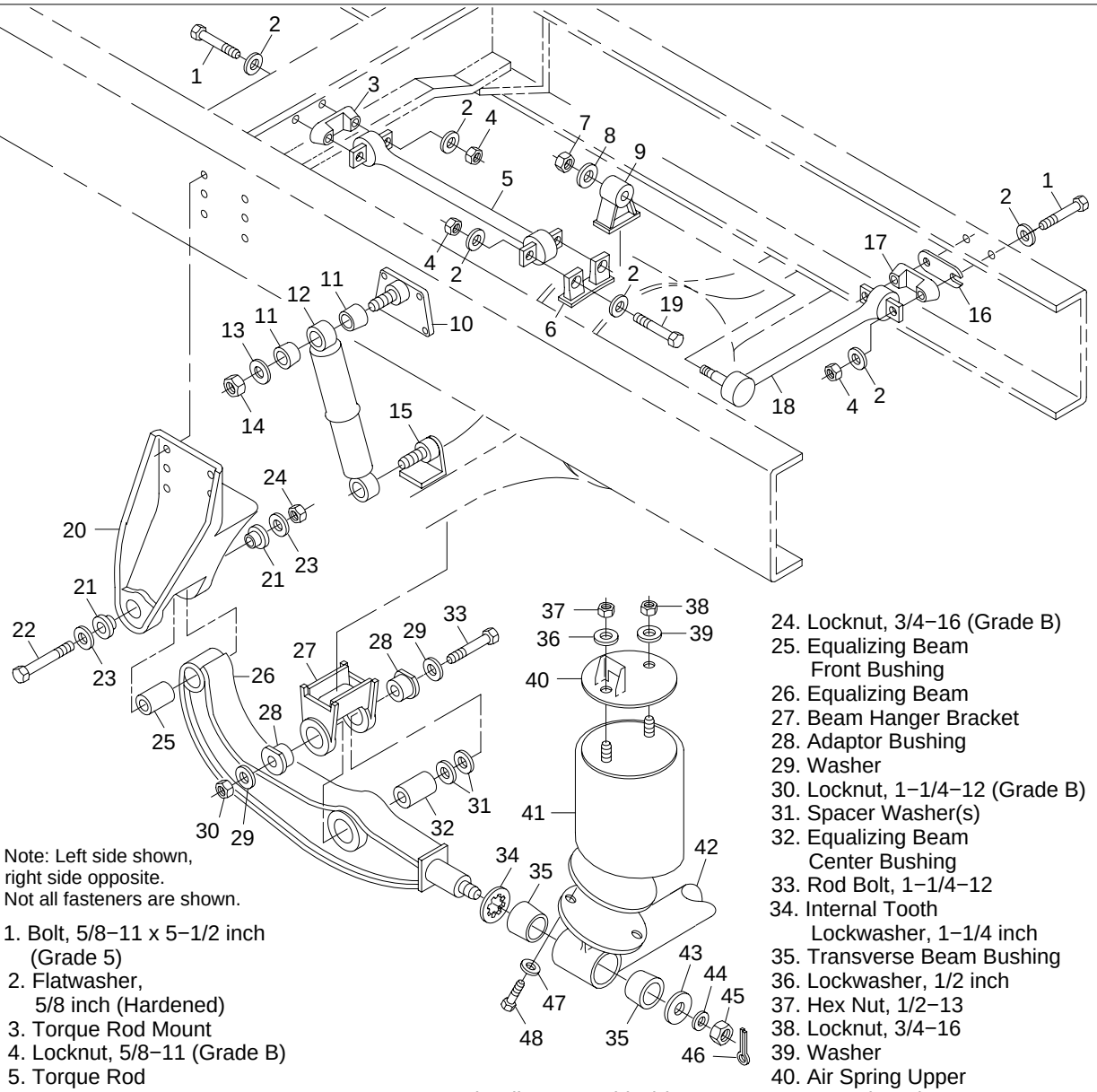
Installation

1. Make sure the adaptor bushings (Ref. 21) are installed in the frame bracket.
2. Position the equalizing beam with its front bushing centered in the frame bracket. Push the rod bolt into the frame bracket while inserting the spacer washers into their original positions between the equalizing beam and the frame bracket.

NOTE: Refer to **Subject 190** for placement of the spacer washers if their positions were not recorded during removal of the equalizer beam.

3. Lubricate the threads of the rod bolt with SAE-20 oil, then install the locknut. Tighten the locknut to the torque under **Specifications, 400.**
4. Raise the equalizing beam so the center bushing is centered in the beam hanger bracket. Insert the beam hanger adaptor bushings (Ref. 28) through the beam hanger bracket and into the equalizing beam center bushing.
5. With a flatwasher under the head,insert the rod bolt (Ref. 33) through the beam hanger adaptor bushings with the threaded end on the outboard side of the suspension.
6. Lubricate the center bushing bolt threads with SAE-20 oil, then install the flatwasher and locknut on the bolt. Tighten the locknut to the torque under **Specifications, 400**.
7. Lubricate the transverse beam bushings (Ref. 35) with rubber lubricant, soap and water solution, or a waterless hand cleaner. Install the inner halves of the bushings with their thicker ends toward the front of the vehicle.
8. Install the transverse beam on the equalizing beams, with the air spring lower mounting plates tilted toward the rear of the vehicle. Install the outer halves of the transverse beam bushings on the equalizer beam journals.
9. Apply SAE-20 oil to the threads on the studs at the rear of the equalizing beams. Install the retainer washers, flatwashers and locknuts on the studs (Refs. 43, 44, and 45). Tighten the locknuts to the low end of the torque ranges under

Equalizing Beam Removal and Installation



Note: Left side shown, right side opposite.
Not all fasteners are shown.

1. Bolt, 5/8−11 x 5−1/2 inch (Grade 5)
2. Flatwasher, 5/8 inch (Hardened)
3. Torque Rod Mount
4. Locknut, 5/8−11 (Grade B)
5. Torque Rod
6. Torque Rod Axle Bracket
7. Locknut, 1−1/4−12 (Grade B)
8. Flatwasher, 1−1/4 inch (Hardened)
9. Lateral Rod Axle Bracket
10. Shock Absorber Upper Mount
11. Shock Absorber Bushing
12. Shock Absorber
13. Washer
14. Locknut, 3/4−10
15. Shock Absorber Lower Mount
16. Axle Alignment Shim(s)
17. Lateral Rod Mount
18. Lateral Rod
19. Bolt, 5/8−11 x 4 inch (Grade 5)
20. Frame Bracket
21. Adaptor Bushing
22. Bolt, 3/4−16 x 7 inch (Grade 5)
23. Flatwasher, 3/4 inch (Hardened)
24. Locknut, 3/4−16 (Grade B)
25. Equalizing Beam Front Bushing
26. Equalizing Beam
27. Beam Hanger Bracket
28. Adaptor Bushing
29. Washer
30. Locknut, 1−1/4−12 (Grade B)
31. Spacer Washer(s)
32. Equalizing Beam Center Bushing
33. Rod Bolt, 1−1/4−12
34. Internal Tooth Lockwasher, 1−1/4 inch
35. Transverse Beam Bushing
36. Lockwasher, 1/2 inch
37. Hex Nut, 1/2−13
38. Locknut, 3/4−16
39. Washer
40. Air Spring Upper Mounting Plate
41. Air Spring
42. Transverse Beam
43. Retainer Washer
44. Flatwasher, 1−1/4 inch (Hardened)
45. Locknut, 1−1/4−12 (Hardened)
46. Cotter Pin
47. Lockwasher, 1/2 inch
48. Capscrew, 1/2−13 x 1 inch

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Fig. 1

Specifications, 400. Install the cotter pins and lock them in place. Tighten the locknuts further if it's necessary in order to install the cotter pins.

10. Apply SAE-20 oil to the threads of the capscrews that secure the air springs to the air spring lower mounting plates. Position the air springs on the plates and install the capscrews and lockwashers. Tighten the capscrews to the torque under **Specifications, 400**

Replacement

1. Remove the equalizing beam. Refer to **Subject 130**.

⚠ WARNING

WARNING: Do not use a torch to cut the bushing sleeve out of the equalizing beam. To do so could alter the molecular structure of the beam, seriously weakening the casting and resulting in an unsafe operating condition.

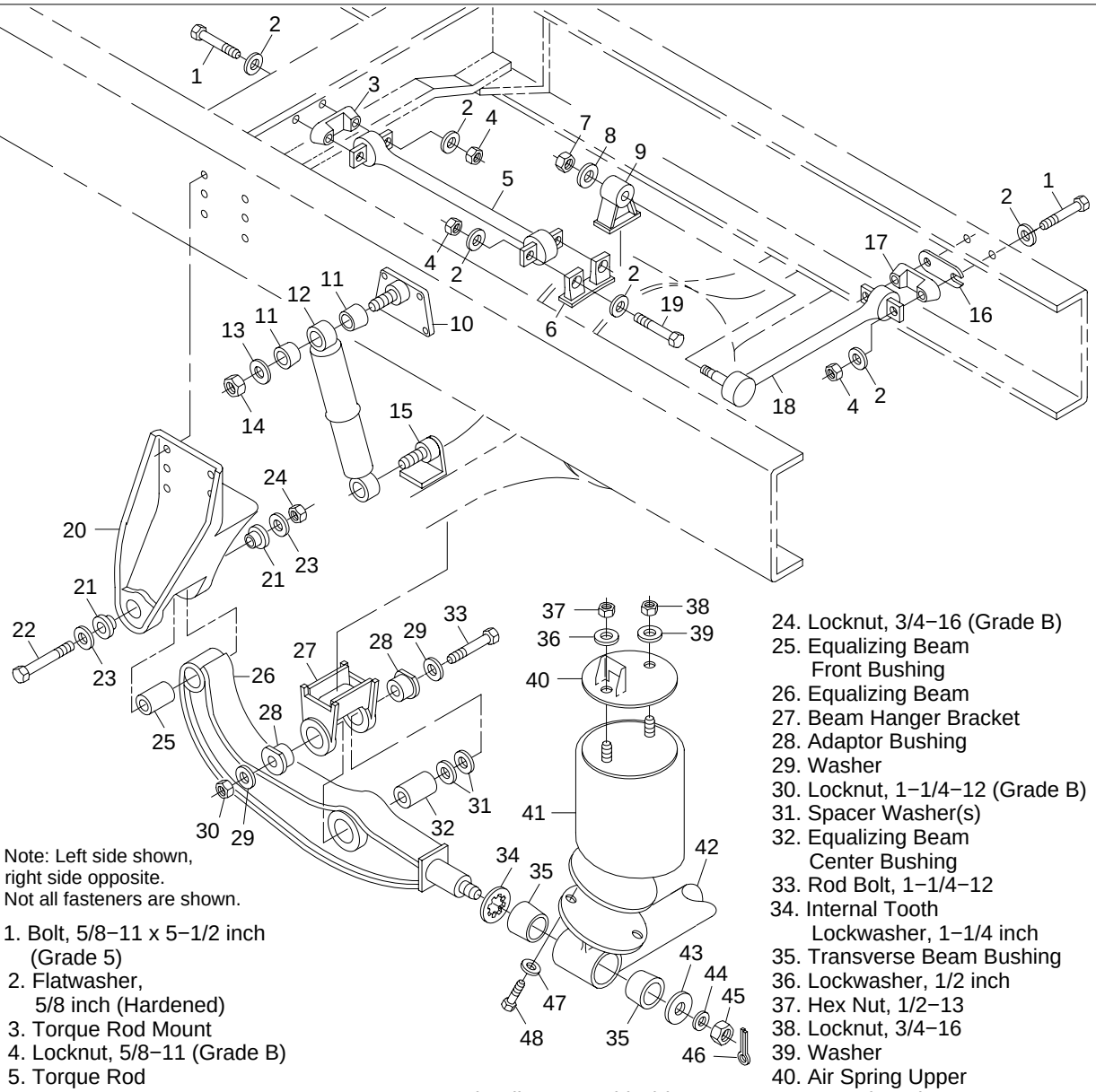
2. Using a hydraulic press, apply 2000 to 3000 pounds (metric) pressure to remove the equalizing beam front and center bushings. See **Fig. 1**, Refs. 25 and 32.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

3. Using a wire brush and solvent, clean out the equalizing beam bushing receptacles. Inspect the entire beam for cracks or bends. Replace any damaged equalizing beam with a new one.
4. Lubricate the replacement bushings and the bushing receptacles with a non-mineral lubricant. If standard rubber lubricant is not available, use a soap and water solution or a waterless hand cleaner.
5. Press the replacement bushings into the bushing receptacles with a hydraulic press. Press the bushings slightly past center, then turn the equalizing beam over and press the bushings back to a centered position.
6. Install the equalizing beam. Refer to **Subject 130**.

Equalizing Beam Bushing Replacement



Note: Left side shown, right side opposite.
Not all fasteners are shown.

1. Bolt, 5/8−11 x 5−1/2 inch (Grade 5)
2. Flatwasher, 5/8 inch (Hardened)
3. Torque Rod Mount
4. Locknut, 5/8−11 (Grade B)
5. Torque Rod
6. Torque Rod Axle Bracket
7. Locknut, 1−1/4−12 (Grade B)
8. Flatwasher, 1−1/4 inch (Hardened)
9. Lateral Rod Axle Bracket
10. Shock Absorber Upper Mount
11. Shock Absorber Bushing
12. Shock Absorber
13. Washer
14. Locknut, 3/4−10
15. Shock Absorber Lower Mount
16. Axle Alignment Shim(s)
17. Lateral Rod Mount
18. Lateral Rod
19. Bolt, 5/8−11 x 4 inch (Grade 5)
20. Frame Bracket
21. Adaptor Bushing
22. Bolt, 3/4−16 x 7 inch (Grade 5)
23. Flatwasher, 3/4 inch (Hardened)
24. Locknut, 3/4−16 (Grade B)
25. Equalizing Beam Front Bushing
26. Equalizing Beam
27. Beam Hanger Bracket
28. Adaptor Bushing
29. Washer
30. Locknut, 1−1/4−12 (Grade B)
31. Spacer Washer(s)
32. Equalizing Beam Center Bushing
33. Rod Bolt, 1−1/4−12
34. Internal Tooth Lockwasher, 1−1/4 inch
35. Transverse Beam Bushing
36. Lockwasher, 1/2 inch
37. Hex Nut, 1/2−13
38. Locknut, 3/4−16
39. Washer
40. Air Spring Upper Mounting Plate
41. Air Spring
42. Transverse Beam
43. Retainer Washer
44. Flatwasher, 1−1/4 inch (Hardened)
45. Locknut, 1−1/4−12 (Hardened)
46. Cotter Pin
47. Lockwasher, 1/2 inch
48. Capscrew, 1/2−13 x 1 inch

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Fig. 1

Lateral Rod Removal, Inspection, and Installation

Removal

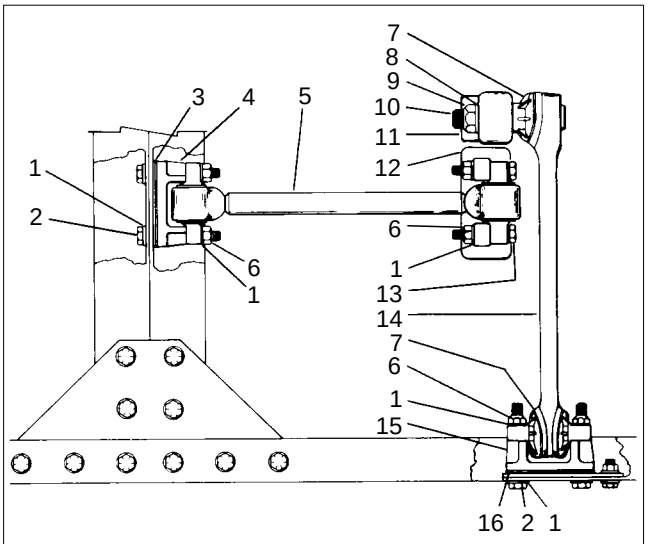
1. Apply the parking brakes.
2. Remove the locknuts and flatwashers (**Fig. 1**, Refs. 6 and 1) from the bolts that secure the lateral rod mount to the frame rail. To ease reassembly, note the order of the axle alignment shims (Ref. 16) between the lateral rod mount and the backing plate.
3. Remove the lateral rod mount bolts. Swing the lateral rod clear of its mount, and remove the axle alignment shims and the mount (Refs. 16 and 15).
4. Remove the locknut (Ref. 9) and flatwasher (Ref. 8) from the ball stud on the inboard end of the lateral rod. Rap the ball stud eye on the lateral rod axle mount (Ref. 11) with a hammer to loosen the ball stud. If this fails to break it loose, use a tie-rod separator tool to remove the ball stud from the lateral rod axle mount. Remove the lateral rod.
5. Remove the seals (Ref. 7) from both ends of the lateral rod. Clean the seals and rod to remove all dirt and grease.

Inspection

Inspect the seals for dryness, cracks, or other signs of deterioration and wear. Replace damaged seals with new ones. Visually inspect the lateral rod for cracks or bends. Work the ball joint and lateral rod pin to check for looseness in the bushings. If the lateral rod is bent, cracked, or otherwise damaged, or if there is any slack in either of the bushings, replace the lateral rod with a new one.

Installation

1. Lubricate all lateral rod and fastener threads with SAE-20 oil, and install the seals (**Fig. 1**, Ref. 7) removed from the rod ends.
2. Insert the lateral rod ball stud (Ref. 10) through the lateral rod axle mount (Ref. 11), then install the flatwasher and locknut (Refs.8and 9) on the stud. Tighten the locknut to the torque under **Specifications, 400**, then rap the lateral rod axle mount with a hammer. Tighten the locknut again to the torque under **Specifications, 400**.



1. Flatwasher, 5/8−Inch
2. Bolt, 5/8−11 x 5−1/2 Inch
3. Axle Plane Shim(s)
4. Torque Rod Mount
5. Torque Rod
6. Locknut, 5/8−18
7. Seal
8. Flatwasher, 1−1/4 Inch
9. Locknut, 1−1/4−12
10. Ball Stud
11. Lateral Rod Axle Mount
12. Torque Rod Axle Mount
13. Bolt, 5/8−11 x 4−Inch
14. Lateral Rod
15. Lateral Rod Mount
16. Axle Alignment Shim(s)

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Fig. 1, Lateral Rod Mounting

3. Position the lateral rod mount (Ref. 15) and the axle alignment shims against the backing plate on the inside of the frame rail. Move the lateral rod into position on the lateral rod mount.
4. Install flatwashers on the lateral rod mount bolts (Ref. 2), then install the bolts through the frame rail, the shims, the lateral rod mount, and the lateral rod. Install the flatwashers and locknuts (Refs.1and 6) on the bolts,and tighten the locknuts to the torque under **Specifications, 400**.
5. Check the alignment of the axle. Refer to **Subject 180** for instructions.

Torque Rod Removal, Inspection, and Installation

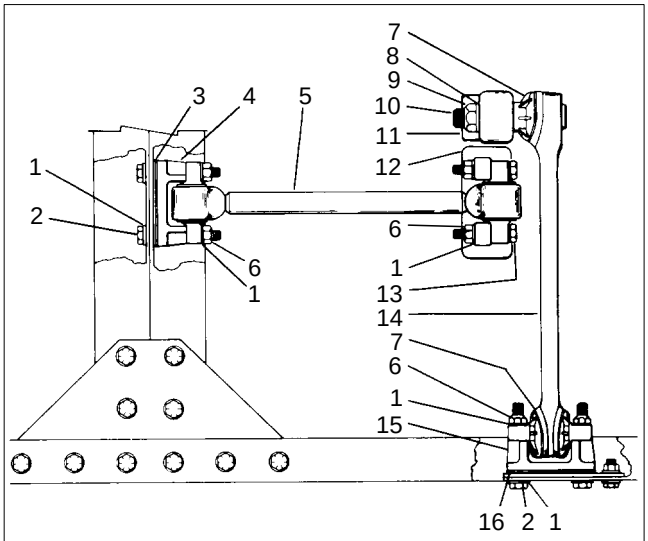
Removal

1. Apply the parking brakes.

⚠ WARNING

WARNING: When the torque rods are disconnected from the axle brackets, the axles become free to pivot on the equalizer beam end bushings. Keep clear of the beam hangers and beam ends to avoid possible injury.

2. Remove the locknuts and the flatwashers (**Fig. 1**, Refs. 6 and 1) from the bolts (Ref. 2) that secure the torque rod mount (Ref. 4) to the vehicle frame crossmember. For ease of installation, note the order of the axle plane shims (Ref.3) between the torque rod mount and the frame crossmember.



1. Flatwasher, 5/8−Inch
2. Bolt, 5/8−11 x 5−1/2 Inch
3. Axle Plane Shim(s)
4. Torque Rod Mount
5. Torque Rod
6. Locknut, 5/8−18
7. Seal
8. Flatwasher, 1−1/4 Inch
9. Locknut, 1−1/4−12
10. Ball Stud
11. Lateral Rod Axle Mount
12. Torque Rod Axle Mount
13. Bolt, 5/8−11 x 4−Inch
14. Lateral Rod
15. Lateral Rod Mount
16. Axle Alignment Shim(s)

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Fig. 1, Torque Rod Mounting

3. Remove the torque rod mount bolts. Swing the torque rod clear of the torque rod mount, and remove the axle plane shims together with the torque rod mount.
4. Remove the locknuts and flatwashers (Refs. 6 and 1) from the bolts (Ref. 13) that secure the torque rod to the torque rod axle mount (Ref. 12). Remove the bolts. Remove the torque rod from the vehicle.

Inspection

Inspect the torque rod for bends or cracks. Work the torque rod pins to check for looseness in the polyurethane bushings. If the torque rod is bent, cracked, or otherwise damaged, replace it with a new one. If either of the polyurethane bushings is loose, replace the bushing with a new one. For instructions, refer to **Subject 170**.

Installation

1. Lubricate all torque rod and fastener threads with SAE-20 oil.
2. Position the torque rod against the torque rod axle mount (**Fig. 1**, Ref. 12). Slip a flatwasher over each of the two bolts (Ref. 13), then insert the bolts through the torque rod axle mount and the torque rod.
3. Install the flatwashers and locknuts (Refs. 1 and 6) on the torque rod mount bolts. Tighten the locknuts to the torque under **Specifications, 400**.
4. Position the torque rod mount (Ref. 4) and the axle plane shims (Ref. 3) against the frame crossmember, and move the torque rod into place on the torque rod mount.
5. Install flatwashers on the bolts (Ref. 2), and install the bolts through the frame crossmember, the shims, the torque rod mount, and the torque rod. Install flatwashers and locknuts (Refs. 1 and 6) on the bolts, and tighten the locknuts to the torque under **Specifications, 400**.

Replacement

NOTE: In order to replace the torque rod polyurethane bushings,you need special installation tool kit P-097-009. This tool kit can be purchased from Freightliner, or it can be machined, using the dimensions given in **Specifications, 400.**

1. Remove the snap ring and washer from each side of the bushing to be removed. **See Fig. 1.** Note that the torque rod eye has a smaller shoulder on one side than on the other, and the larger shoulder has a rounded edge around the inside of the eye. The polyurethane bushing must be pressed in and out through the larger side.

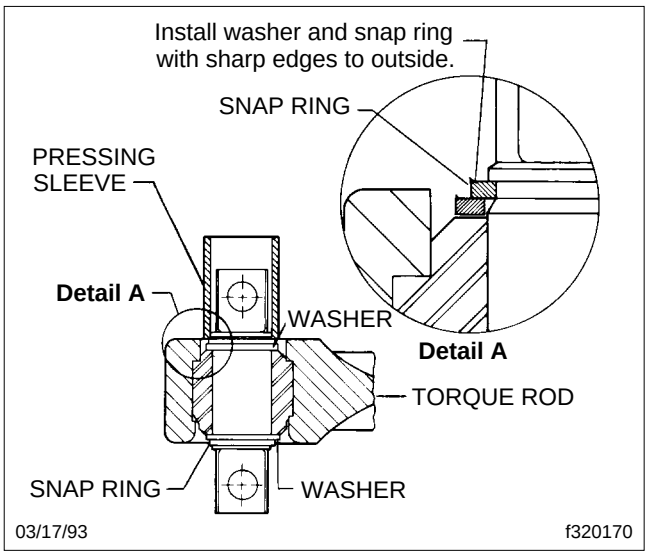


Fig. 1, Bushing Snap Ring Installation

2. Using the plunger from the special tool kit on a hydraulic press, press the old bushing out of the torque rod eye. Clean all dirt, grease, or foreign matter from the torque rod.
3. Coat the replacement bushing with a non-mineral lubricant, such as rubber lubricant or waterless hand cleaner. Position the bushing in the larger end of the insertion sleeve from the tool kit, then fit the beveled (smaller) end of the sleeve into the larger side of the torque rod eye.
4. Center the torque rod eye on the tool base, and insert the plunger tool into the polyurethane bushing. **See Fig. 2.** Press the bushing into the torque rod eye.

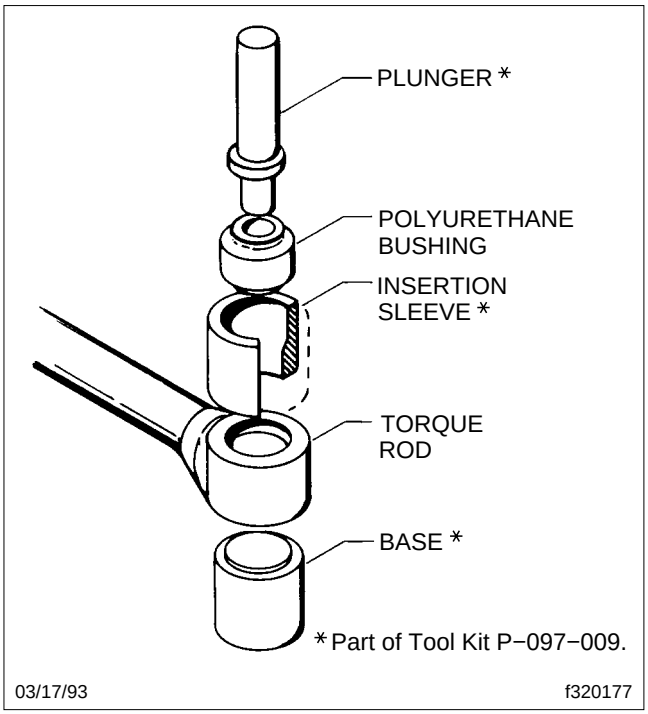


Fig. 2, Torque Rod Bushing Installation

5. Install the snap ring and flatwasher on one end of the torque rod pin, with the sharp edges of the washer and the snap ring facing the outward end of the pin. **See Fig. 1.**
6. Press the torque rod pin into the torque rod bushing from the same side as the bushing was pressed into the torque rod eye. Make sure the snap ring seats. Do not lubricate the torque rod pin.
7. Turn the torque rod over and install a flatwasher, with the sharp edge facing away from the bushing; then install the other snap ring onto the outer shoulder of the pin, with the sharp edge facing outward.
8. Place a pressing sleeve over the end of the torque rod pin, then seat the snap ring. **See Fig. 1.**
9. After assembly, press the torque rod pin slightly to center it in the torque rod eye.

Torque Rod Bushing Replacement

There should be no slack on either side of the polyurethane bushing, and the bushing should be compressed by about half the thickness of the snap ring. If necessary, install a second washer under one of the snap rings to compress the bushing.

Lateral Alignment

NOTE: See **Fig. 1** for an over-all view of the Neway Air Ride Suspension.

1. Park the vehicle on a level surface; then position the front tires straight ahead and chock them. Release the parking brakes, and place the transmission in neutral.
2. Raise the rear of the vehicle until the tires clear the ground, then place safety stands under the rear of the vehicle to hold it in this position.
3. Check the wheel bearing adjustment. Refer to the rear axle section in this manual for instructions. Adjust or replace the wheel bearings as needed.
4. Measure the lateral runout of the rear wheels. If the runout on any wheel exceeds 0.18 inch (4.6 mm), replace the wheel before proceeding with the axle alignment check.
5. Remove the safety stands and lower the rear of the vehicle. Relieve any internal stresses in the suspension by jacking the axles up and letting them down; or, remove the tire chocks, then move the vehicle back and forth (with the inter-axle differential disengaged).
6. On either rear axle, measure the distance between the left frame rail and the nearest point on the inside wheel rim. **See Fig. 2**, Dimension A.
7. On the same axle, measure the distance between the right frame rail and the nearest point on the inside wheel rim (**Fig. 2**, Dimension B).
8. Compare Dimension A with Dimension B. If they're within 1/8 inch (3.25 mm) of being equal, alignment is not necessary. However, if they're different by more than 1/8 inch (3.25 mm), adjust the lateral alignment.

   8.1 Loosen the locknuts on the bolts that secure the lateral rod mount to the frame rail.

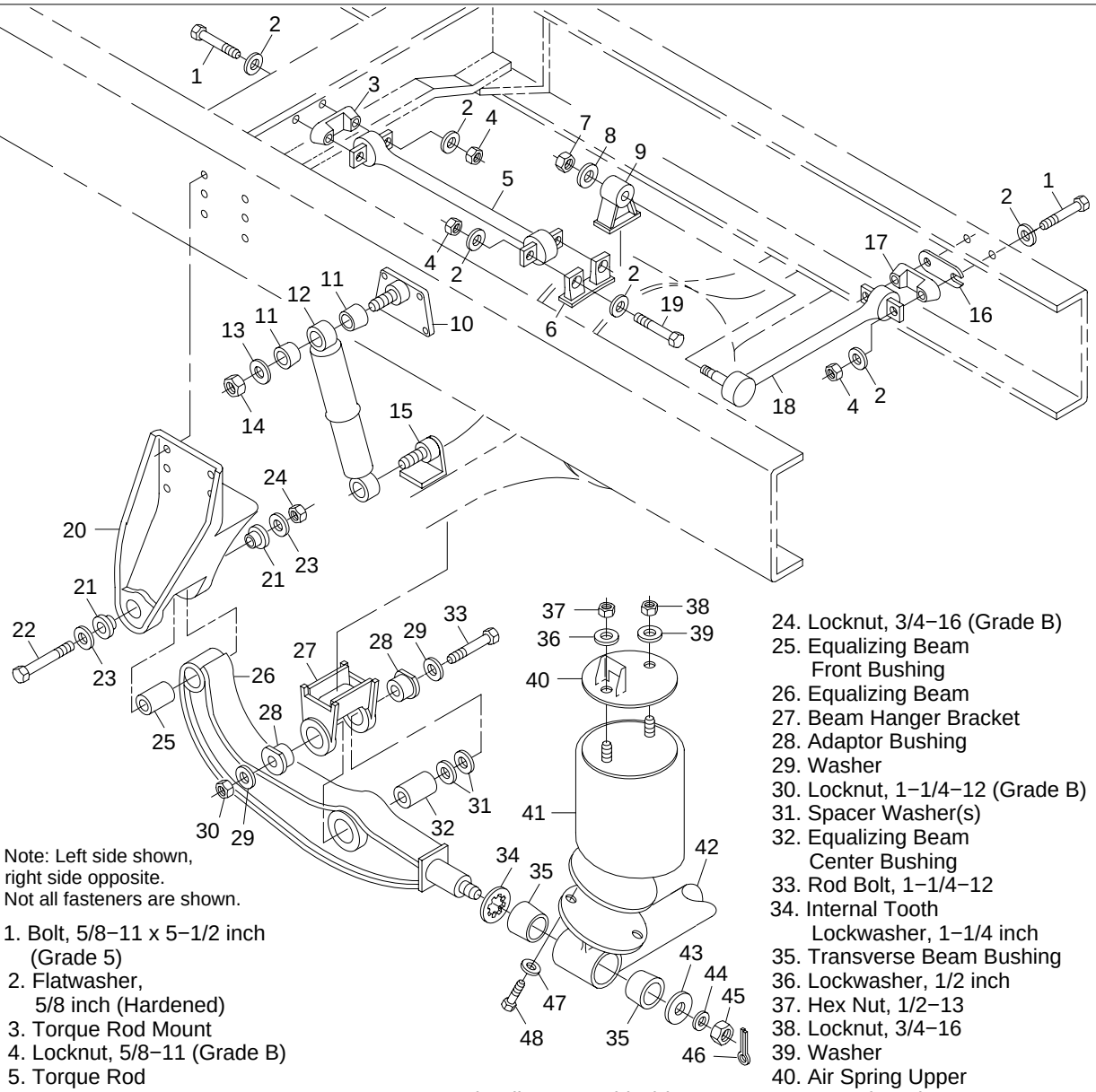
   8.2 Add or remove one axle alignment shim for each 1/8 inch (3.25 mm) difference between Dimensions A and B. Adding shims will decrease the measurement on the side of the vehicle to which the lateral rod is attached, and removing shims will increase the measurement.

   8.3 After installing the shims, lubricate the threads on the lateral rod mount bolts with engine oil; tighten the locknuts to the torque under **Specifications, 400**.

9. On tandem axle installations, do the previous three steps on the other axle.
10. On suspensions equipped with an axle alignment feature (alignment bushings welded to slotted frame brackets), proceed to **Subject 190**.

    On suspensions not equipped with an axle alignment feature, no further checking is required. Apply the parking brakes; then remove the chocks from the tires.

Rear Axle Lateral Alignment



Note: Left side shown, right side opposite.
Not all fasteners are shown.

1. Bolt, 5/8−11 x 5−1/2 inch (Grade 5)
2. Flatwasher, 5/8 inch (Hardened)
3. Torque Rod Mount
4. Locknut, 5/8−11 (Grade B)
5. Torque Rod
6. Torque Rod Axle Bracket
7. Locknut, 1−1/4−12 (Grade B)
8. Flatwasher, 1−1/4 inch (Hardened)
9. Lateral Rod Axle Bracket
10. Shock Absorber Upper Mount
11. Shock Absorber Bushing
12. Shock Absorber
13. Washer
14. Locknut, 3/4−10
15. Shock Absorber Lower Mount
16. Axle Alignment Shim(s)
17. Lateral Rod Mount
18. Lateral Rod
19. Bolt, 5/8−11 x 4 inch (Grade 5)
20. Frame Bracket
21. Adaptor Bushing
22. Bolt, 3/4−16 x 7 inch (Grade 5)
23. Flatwasher, 3/4 inch (Hardened)
24. Locknut, 3/4−16 (Grade B)
25. Equalizing Beam Front Bushing
26. Equalizing Beam
27. Beam Hanger Bracket
28. Adaptor Bushing
29. Washer
30. Locknut, 1−1/4−12 (Grade B)
31. Spacer Washer(s)
32. Equalizing Beam Center Bushing
33. Rod Bolt, 1−1/4−12
34. Internal Tooth Lockwasher, 1−1/4 inch
35. Transverse Beam Bushing
36. Lockwasher, 1/2 inch
37. Hex Nut, 1/2−13
38. Locknut, 3/4−16
39. Washer
40. Air Spring Upper Mounting Plate
41. Air Spring
42. Transverse Beam
43. Retainer Washer
44. Flatwasher, 1−1/4 inch (Hardened)
45. Locknut, 1−1/4−12 (Hardened)
46. Cotter Pin
47. Lockwasher, 1/2 inch
48. Capscrew, 1/2−13 x 1 inch

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Fig. 1

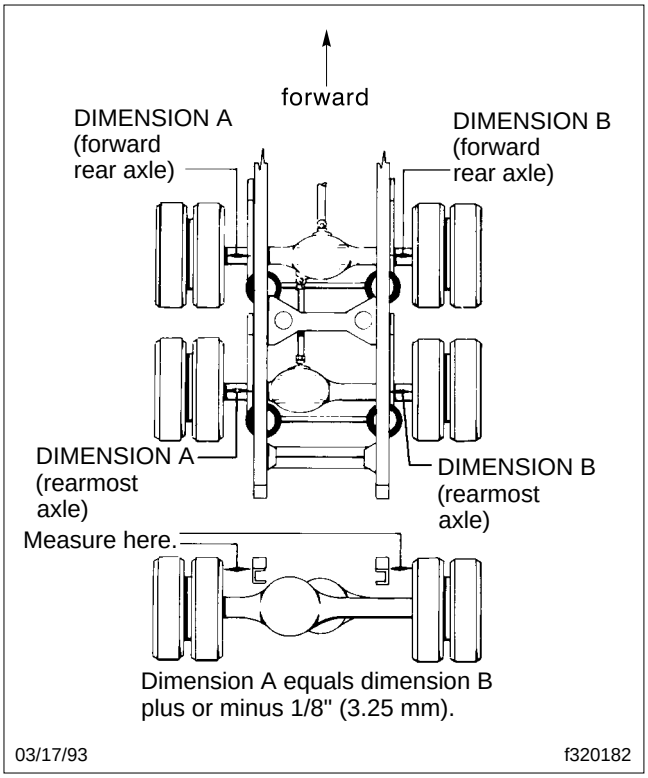


Fig. 2, Rear Axle Lateral Alignment

Parallel Alignment

1. Check and, if needed, adjust the lateral alignment of the rear axle(s) before checking parallel alignment. **Refer to Subject 180** for instructions.
2. Check the axles for parallel alignment. Refer to the rear axle section in this manual for instructions.
3. Adjust the rear axle, if necessary.

   3.1 Using jack stands, support the vehicle frame at normal ride height. Disconnect both height control valve linkages from their respective control levers. **See Fig. 1.** Then exhaust all air from all air springs by pushing the valve control levers down.

   3.2 Remove the equalizing beam pivot connection locknut and bolt, and both spacer washers. **See Fig. 2.** Lower the equalizing beam from the frame bracket.

⚠ WARNING

WARNING: Wear protective goggles and gloves while grinding. Failure to do so could cause personal injury resulting from sparks and metal debris from the grinding process.

   3.3 Cut the welds off of the alignment bushings on both sides of the frame bracket. Remove the alignment bushings; then grind any remaining weld material off of the frame bracket and alignment bushings.

   3.4 Position the alignment bushings in the frame bracket; then raise the equalizing beam until the front eye is aligned with the frame bracket. Install the spacer washers and pivot connection bolt and locknut. Position the spacer washers as shown in **Fig. 2**. Suspension installations which have a 1/4-inch (6-mm) frame-rail spacer between the forward frame-rail bracket and the frame rail will require one spacer washer on each side of the equalizing beam. Installations without a frame-rail spacer require two spacer washers on the inboard side of the equalizing beam.

   3.5 Move the axle forward or backward by rolling the wheels on that side of the vehicle (only that side), until the correct axle alignment is obtained.

   3.6 With the axle aligned and the vehicle frame supported at normal ride height, torque the equalizing beam front bushing locknut to the torque under **Specifications, 400**.

   3.7 Weld both of the alignment bushings to the frame bracket, using AWS spec E7018 welding rod or Linde 3/32 FC 72 wire weld, or an equivalent. Weld (1/4-inch fillet) each bushing with three, 3/4-inch (19-mm) long welds. **See Fig. 2.**

4. Connect the linkages to their respective control levers.
5. Apply the parking brakes; then remove the jack stands from the frame and the chocks from the tires.

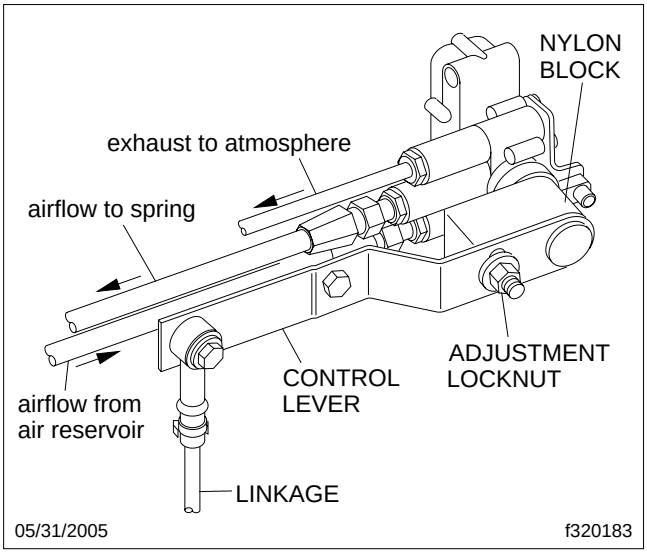


Fig. 1, Height Control Valve

Rear Axle Parallel Alignment

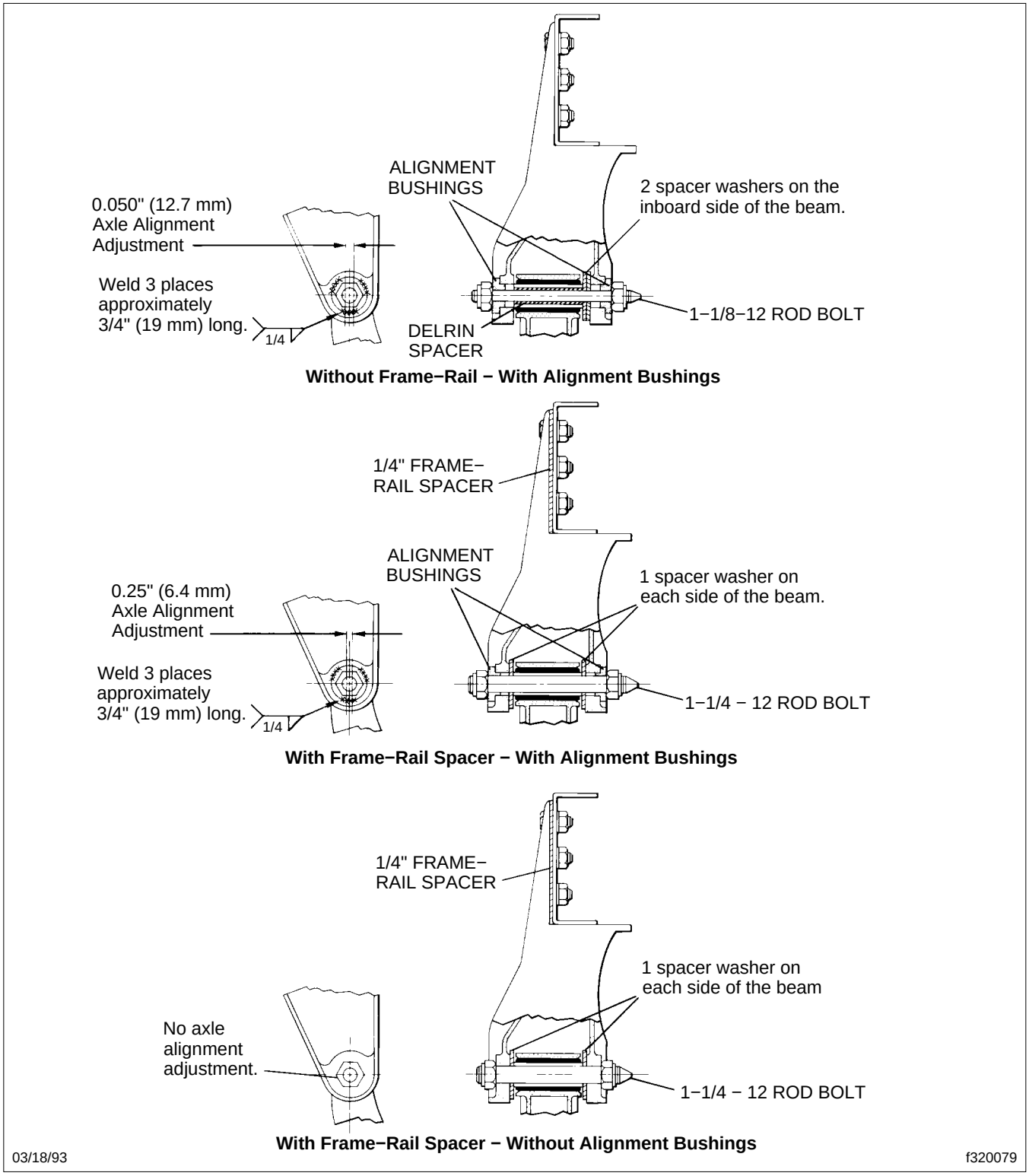


Fig. 2, Spacer Washer Installation and Alignment Bushing Welding

Troubleshooting

Problem—All Air Springs Are Flat

Possible Cause	Remedy
Low air pressure in the vehicle brake system.	Check the air pressure gauge on the instrument panel. If air pressure is low, run the engine until a minimum pressure of 70 psi (483 kPa) is shown on the gauge.
Air leaking from the suspension air system or the air brake system.	Listen for leakage due to loose fittings or damaged air lines, air springs, brake actuators or control valves. Tighten loose fittings or replace worn or damaged air lines with new ones.

Problem—Air Spring(s) Flat on One Side of the Vehicle

Possible Cause	Remedy
Air leakage between the pressure holding valve and the air spring(s).	Listen for leakage due to loose fittings or damaged air lines. Tighten loose fittings or replace damaged lines with new ones.
Air spring leaking.	Inspect the air spring for leaks caused by damage, wear, or deterioration. If any air spring is leaking, install a new one.
Bent, broken, or disconnected height control valve linkage.	Inspect the linkage for damaged or loose parts. Reconnect loose linkage parts or replace damaged parts with new ones.
Height control valve out of adjustment.	Disconnect the height control valve linkage from the height control valve control lever. Move the lever upward. If the air spring then inflates, adjust the height control valve.
Inoperative height control valve.	If movement of the control lever in the previous step fails to inflate the air spring, the height control valve is damaged. Replace the valve.

Problem—Tractor Leans Due to Unequal Inflation of the Air Springs

Possible Cause	Remedy
Damaged height control valve linkage.	Inspect the height control valves and linkages for damage. Repair or replace damaged parts.
Loose or missing height control valve bolts or adjustment locknut.	Inspect for damage to the height control valve mounting bolts or adjustment locknut. Replace any missing bolts or nuts, then adjust the height control valve.
Height control valve out of adjustment.	Adjust the height control valve.

Problem—Air Springs Deflate Rapidly When the Vehicle Is Parked

Possible Cause	Remedy
Air leakage from the suspension air system.	Listen for leakage due to loose fittings or damaged air lines, air springs, or height control valves. Tighten loose fittings and replace worn or damaged parts with new ones.

Troubleshooting

Problem—Tractor Rides Too High or Too Low

Possible Cause	Remedy
Height control valve out of adjustment.	Disconnect the height control valve linkage from the height control valve control lever. Move the lever upward. If the air spring then inflates, adjust the height control valve.

Problem—Air Spring Blown Out

Possible Cause	Remedy
Air spring cut or punctured.	Locate large leaks by listening for escaping air, and locate small leaks by applying a soap and water solution to the suspected air spring and watching for bubbles. Temporarily repair punctures or cuts less than 1/8-inch (3-mm) long by applying hot patches on both sides of the hole. If the cut is more than 1/8-inch (3-mm) long, install a new air spring.
Tires, rims, or chains rubbing the air spring.	Check the clearance between the air spring and the tire. If the tire, rim, or chains contact the inflated air spring, change to narrower tires and rims to provide clearance for tires with chains.
Air brake actuator rubbing against the air spring.	Relocate the brake actuator with factory approved parts to provide adequate clearance.

Problem—Air Spring Deflated Due to Fatigue

Possible Cause	Remedy
Driving the vehicle too long or too fast with the air springs deflated.	If the vehicle must be driven with the air springs deflated, maintain a speed of less than 30 mph (48 km/h), and drive only as far as the nearest repair facility.
Continual or repeated overextension of the air springs.	Inspect for broken or loose shock absorbers or shock absorber mounting brackets. Reconnect loose parts and replace any damaged parts. Check the adjustment on the height control valve.

Problem—Air Spring Doesn't Fully Deflate When All Weight Is Removed from the Suspension

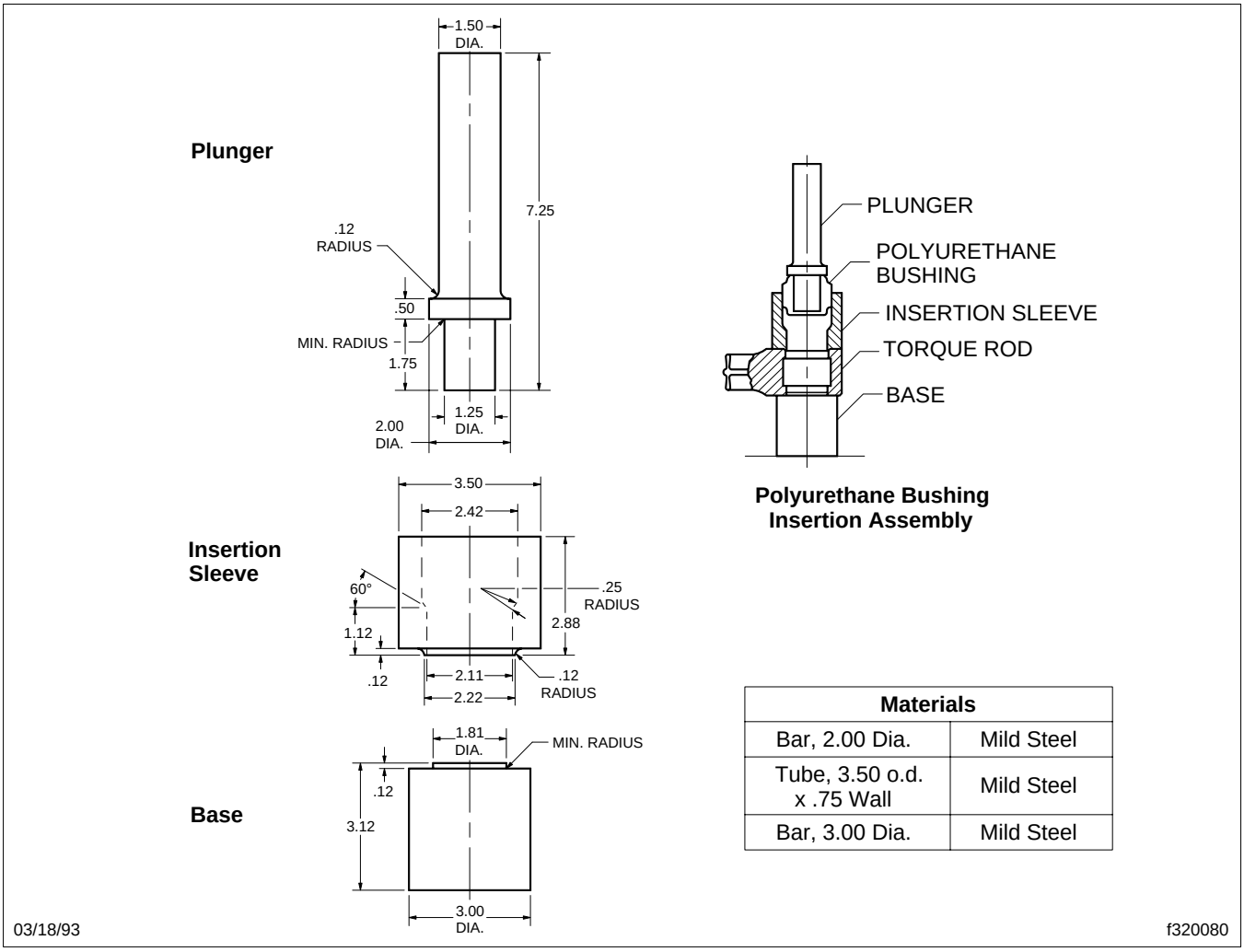
Possible Cause	Remedy
Restricted air line between the height control valve and the air spring.	Disconnect the height control valve linkage, and push the control lever down. If the air spring remains inflated, check for a pinched or blocked line. Clean out any plugged line and replace any damaged line.

Suspension Torque Specifications (lubricated threads)		
Description	**Size**	**Torque lbf·ft (N·m)**
Shock Absorber Mount Locknut	3/4-16	110–150 (149–203)
Air Spring Upper Mounting Plate Locknut	3/4-16	31–42 (42–57)
Air Spring Upper Mounting Plate Capscrew	1/2-13	31–42 (42–57)
Air Spring Lower Mounting Plate Capscrew	1/2-13	31–42 (42–57)
Transverse Beam Bushing Locknuts	1-1/4–12	600–700 (814–950)
Equalizing Beam Center Bushing Locknut	3/4-16	150–200 (203–271)
Equalizing Beam Front Bushing Locknut	1-1/8–12	600–700 (814–950)
	1-1/4–12	
Lateral Rod Ball Stud Locknut	1-1/8–12	550–650 (746–880)
Lateral and Torque Rod Mounting Locknuts	5/8-18	110–150 (149–203)

Table 1, Suspension Torque Specifications (lubricated threads)

See Fig. 1 for the bushing installation tool.

Specifications



Materials	
Bar, 2.00 Dia.	Mild Steel
Tube, 3.50 o.d. x .75 Wall	Mild Steel
Bar, 3.00 Dia.	Mild Steel

Fig. 1, Bushing Installation Tool

General Description

The Hendrickson RS series suspensions use rubber load cushions in place of leaf springs to lessen road shocks. These cushions are mounted under each frame rail, between frame-mounted brackets (frame hangers) and a saddle. **See Fig. 1.** For added stability, two smaller cushions (making a total of three cushions per frame rail) are optional on suspension model RS–400, but standard on models RS–460, RS–480, and RS–520. **See Fig. 2.** The RS–650 has three large load cushions per frame rail. **See Fig. 3.**

The frame hangers at the top of each cushion have vertical pins that extend down through rubber cushions and anchor in rubber bushings in the saddle. **See Fig. 4.** The pins allow the saddles to move up and down as the rubber load cushions deflect, but maintain lateral and fore-and-aft alignment of the saddles. On turns, the rubber bushings allow the axles a certain amount of in-and-out movement that permits each axle to follow its own natural course more closely. **See Fig. 5.** Once a straight track is resumed, the action of the bushings squares off the tandem so the leading tire sets the tracking pattern for the rear tires.

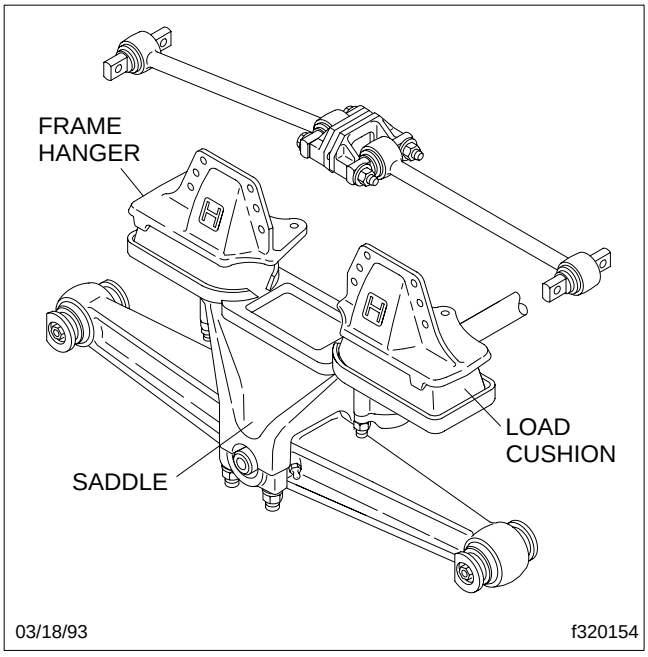


Fig. 1, Hendrickson Suspension Model RS–400

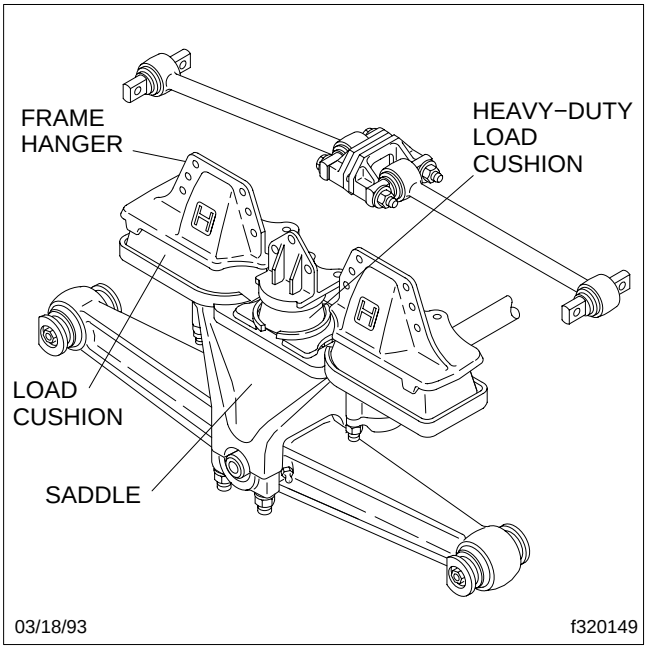


Fig. 2, Hendrickson Suspension Models RS–460, RS–480, and RS–520

The saddle at the bottom of each cushion holds equalizer beams, and beam hangers at the ends of the equalizer beams hod the axles. Torque rods, mounted between the axles and the frame rails and frame crossmembers, stabilize axle movement caused by accelerating and braking.

All suspension fasteners require periodic tightening. For suspension inspecting, lubricating, and fastener torque checking instructions, refer to the suspension section in the vehicle maintenance manual.

⚠ WARNING

WARNING: Failure to periodically torque the suspension fasteners could result in damage to the frame hangers or separation of components. This could cause a loss of vehicle control, resulting in injury or property damage.

⚠ CAUTION

CAUTION: Failure to apply Alumilastic® compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the components or parts.

General Description

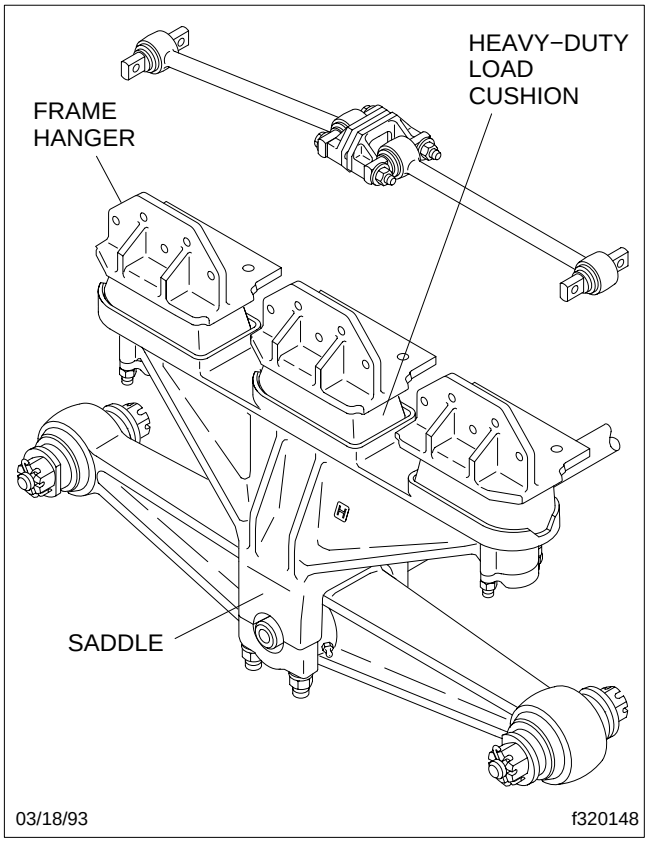


Fig. 3, Hendrickson Suspension Model RS–650

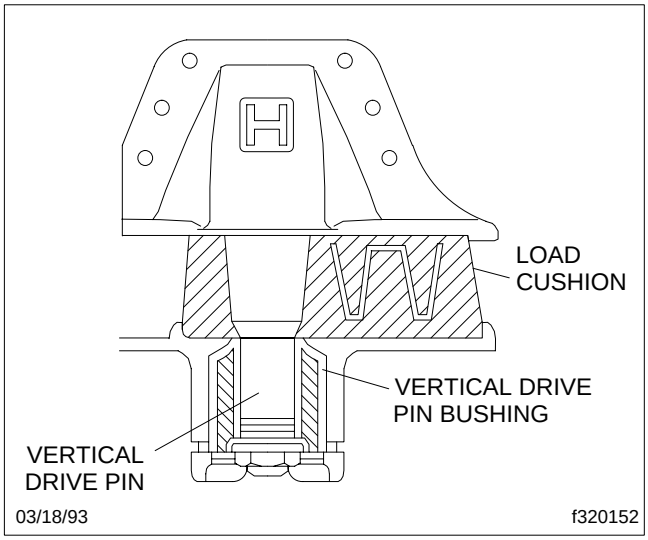


Fig. 4, Load Cushion Assembly

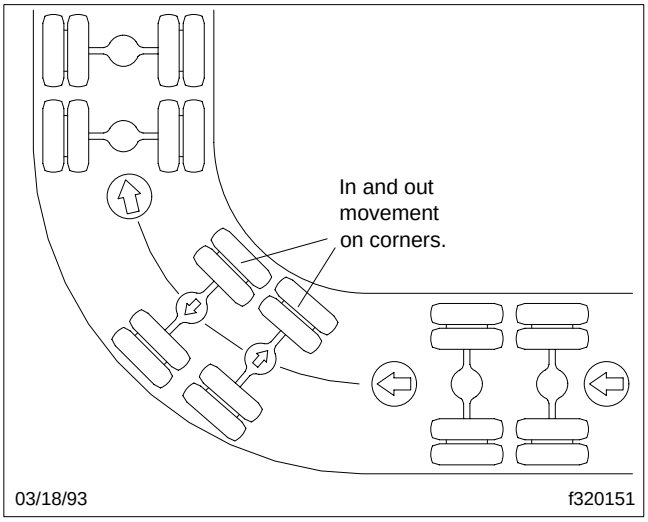


Fig. 5, Axle Movement Allowed With Rubber Bushings

Removal (See Fig. 1)

1. Chock the front tires.
2. Drain the vehicle air system.
3. Disconnect all air lines leading to the rear axles, marking the lines for later assembly reference. Plug or cap all lines and fittings to prevent dirt from entering the system.
4. Disconnect the driveline rear universal joint from the forward-rear axle. Then, remove the interaxle driveline. For instructions, refer to the driveline section in this manual.
5. Manually release the spring brake chambers. For instructions, refer to the brake section in this manual.

⚠ WARNING

When the torque rods are disconnected from the axle brackets, the axles become free to pivot on the equalizer beam end bushings. Keep clear of the beam hangers and beam ends to avoid possible injury.

6. Remove the torque rods. For instructions, refer to **Subject 170**.
7. Raise the rear of the vehicle so that all weight is removed from the suspension. Then, block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

8. Remove the saddle cap nuts and washers from each side of the vehicle, and remove the saddle caps.
9. Raise the rear of the vehicle frame until there is enough clearance to roll the axles out from under the vehicle. Install safety stands under the frame, then roll the axles—with the equalizer beams attached—out from under the vehicle.

Installation (See Fig. 1)

1. Roll the axles under the vehicle frame. Align the center bushing of each equalizer beam with the center of the saddle legs.
2. Raise the vehicle frame off the safety stands, then remove the safety stands.
3. Lower the frame, centering the saddles on the beam center bushings.
4. Install the saddle caps, washers and new self-locking nuts. Do not tighten.
5. Install the torque rods. For instructions, refer to **Subject 170**.
6. Tighten the saddle cap locknuts 225 to 275 lbf·ft (305 to 375 N·m).

NOTE: Maintain an even gap between the saddle cap and the saddle when tightening the self-locking nuts.

7. Remove the safety stands from under the frame and axle, and lower the vehicle.
8. Manually reset the spring brake chambers. For instructions, refer to the brake section in this manual.
9. Connect the driveline rear universal joint to the forward-rear axle. Connect the interaxle driveline. For instructions, refer to the driveline section in this manual.
10. Uncap all air lines and fittings, then connect the lines leading to the rear axles.
11. Check the axle pinion angle. For instructions, refer to the driveline section.

Suspension Removal and Installation

1. Split−Ring Adapter Assembly
2. Nut
3. Washer
4. Adapter
5. Intermediate Tube
6. Adapter Plug
7. Split−Ring
8. Adapter Bolt and Washer
9. Adapter−Type End Support
10. Nut
11. Washer
12. Adapter
13. Intermediate Tube
14. End Bushing
15. Adapter
16. Adapter Bolt and Washer
17. Thrustwashers
18. Bushing Seal
19. Bronze Center Bushing
20. Bushing Seal
21. Thrustwashers
22. Rubber Center Bushing
23. Equalizer Beam
24. Crosstube
25. Saddle Cap
26. Washer
27. Nut
28. Saddle Cap Stud
29. Bronze Bushing Grease Fitting
30. Retainer Cap Stud
31. Nut
32. Vertical Drive Pin Nut
33. Vertical Drive Pin Washer
34. Retainer Cap
35. Vertical Drive Pin Bushing
36. Saddle Assembly
37. Load Cushion
38. Frame Hanger and Vertical Drive Pin
39. Saddle Plate
40. Heavy−Duty Load Cushion
41. Frame Hanger

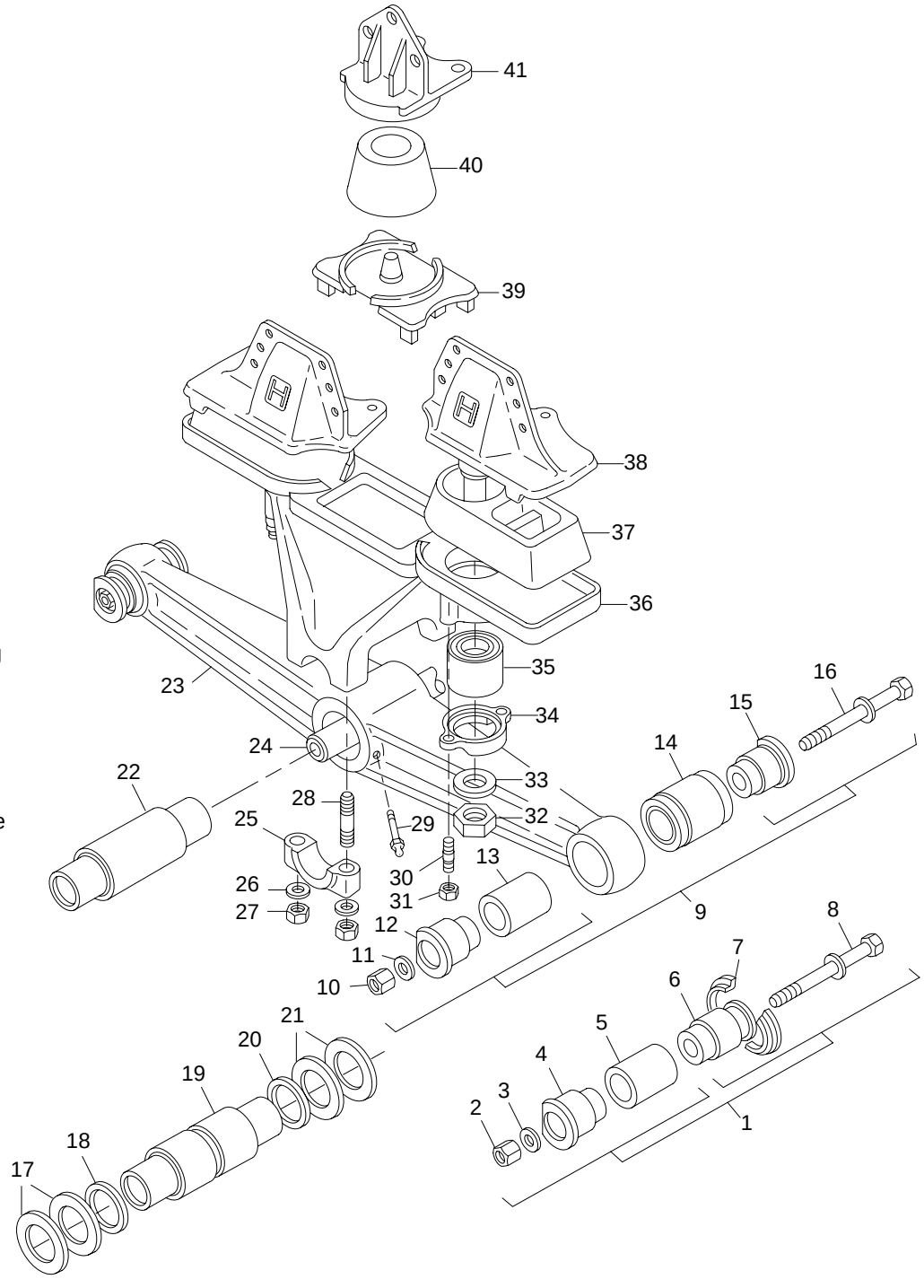


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Fig. 1, Hendrickson RS Series Heavy-Duty Suspension

Removal

1. Remove the suspension. For instructions, refer to **Subject 100.**
2. Support the saddle assembly with a floor jack.
3. Remove the vertical drive pin locknuts and the concave washers (see **Fig. 1**).

   On rebound control kit installations, use a 3/4-inch drive socket to remove the stop nuts. Then remove the bumper and the concave washers. See **Fig. 2** .

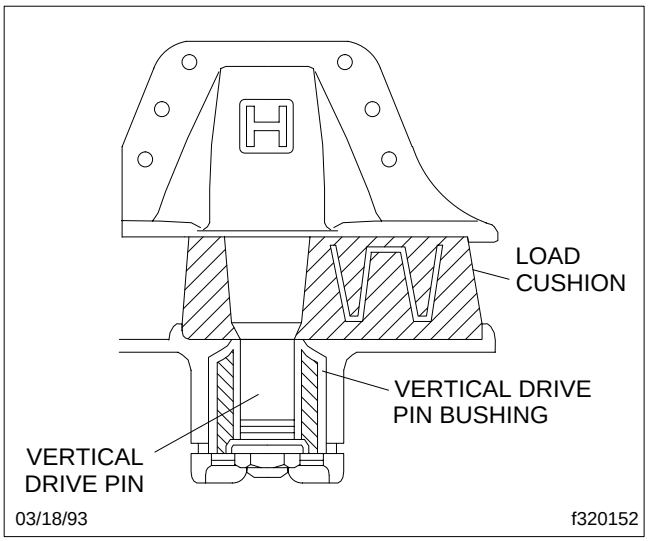


Fig. 1, Load Cushion Assembly

WARNING

The leaf spring assembly is heavy. Use care when handling it to prevent injury.

4. Lower the saddle and load cushions from the frame hanger and the vertical drive pins.

Installation

1. Apply Texaco Compound L, or an equivalent rust preventive lubricant, on the vertical drive pins and the vertical drive pin bushings.
2. Position the rubber load cushions on the saddle. Raise the saddle assembly, guiding the vertical drive pin bushings over the vertical drive pins.

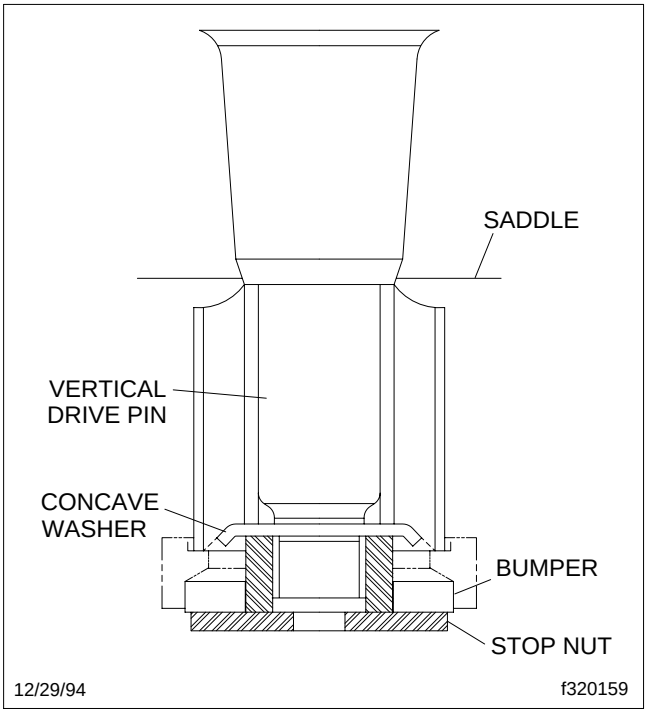


Fig. 2, Rebound Control Kit

3. Install the drive pin washers (with the concave end pointing down) over the threaded ends of the drive pins.
4. Install the vertical drive pin locknuts and tighten 175 to 225 lbf·ft (235 to 305 N·m).

   On rebound control kit installations, install the stop nuts, bumpers,and the concave washers. Tighten the stop nuts 175 to 225 lbf·ft (235 to 305 N·m).
5. Install the suspension. For instructions, refer to **Subject 100**.

Load Cushion and Vertical Drive Pin Bushing Replacement

Replacement

1. Remove the saddle assembly. For instructions, refer to **Subject 110**.

NOTE: If replacing only the heavy-duty load cushions, removal of the saddle assembly is not needed. These cushions can be forced out after raising the frame to open the area between the saddle and the frame hanger brackets.

2. Inspect all of the rubber load cushions for cuts or other damage. Replace a load cushion if these conditions exist.
3. Measure each load cushion. If the height of a load cushion is less than 3-11/16 inches (94 mm), replace it.
4. Remove the retainer locknuts from the drive pin bushing retainer cap, and remove the retainer cap.
5. Using a hydraulic press, press the vertical drive pin bushings out of the saddle from the top.

   If the outer sleeve of the bushing is frozen in the saddle bore, press out the inner sleeve and rubber insert, then work the outer sleeve out of the saddle bore.

⚠ WARNING

WARNING: Do not use a cutting torch to remove the vertical drive pin bushings. High heat will weaken the saddle, which could cause a loss of vehicle control, resulting in injury or property damage.

6. Using emery cloth, remove small nicks or scratches from the vertical drive pin and the vertical drive pin bushing. Clean the saddle bores with a solvent.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

7. Apply Texaco Compound L, or an equivalent rust preventive lubricant, on the drive pin bushings and the saddle bores.
8. Fit the bushings into the saddle bores. Position the drive pin bushing retainer cap and install the retainer cap locknuts. Tighten the locknuts 100 to 125 lbf·ft (135 to 170 N·m).
9. Install the rubber load cushions.
10. Install the saddle assembly. For instructions, refer to **Subject 110**.

Equalizer Beam Adapter- and Tube-Type End Support Removal and Installation

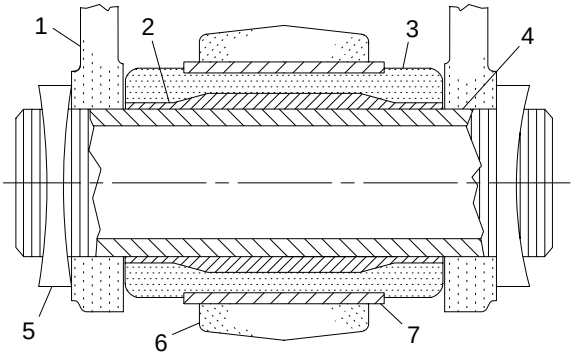
Removal

IMPORTANT: To ensure that the required tools are available, see the table under **Specifications, 400** before beginning these procedures. Special tools are available from the Owatonna Tool Company, Owatonna, Minnesota, or an affiliated dealer. Although these tools are recommended, shop-made adapters can be used if a vertical hydraulic press with a 50-ton capacity is available. Dimensions for the shop-made adapters are provided in the table under **Specifications, 400**.

1. Chock the front tires.
2. Remove the saddle cap nuts and washers, then remove the saddle cap. Support the equalizer beam with safety stands.
3. Raise the rear of the vehicle until the saddle studs clear the equalizer beam. Block the axles and frame with safety stands.
4. Remove the wheels and tires. For instructions, refer to the wheels and tires section in this manual.
5. Remove the brake shoes, brake spider, and brake backing plate (dust shield). Refer to the brake section in this manual for instructions.
6. Apply a penetrating oil to all beam end connections.
7. On a tube-type end support (**see Fig. 1**), remove the tube nuts from both sides of the beam end tube.

   On an adapter-type end support (**see Fig. 2**), remove the nut, washers, and the adapter bolt.
8. If using Owatonna tools, remove the tube-type end supports by positioning the receiving tube over the outboard end of the beam end tube. Position the hydraulic ram, pulling screw, speed nut, and the removing adapter (**see Fig. 3**). Connect a hydraulic pumping unit to the ram, and apply pressure to remove the beam end tube.
9. If using Owatonna tools, remove the adapter-type end supports as follows:

   9.1 Using either a 7/8- or 15/16-inch hand-tap (**see Fig. 4**), tap the adapter bolt hole (outboard side) to a depth of about 1-1/2 inches (38 mm).



1. Axle Beam Hanger
2. Bushing Inner Sleeve
3. Rubber End Bushing
4. Beam End Tube
5. End Tube Nut
6. Equalizer Beam
7. Bushing Outer Sleeve

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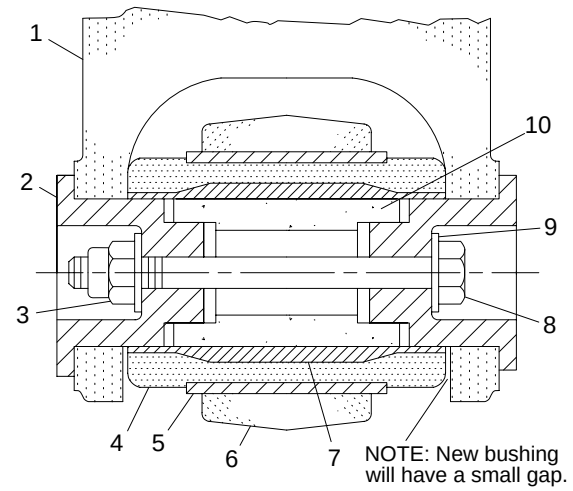
Fig. 1, Equalizer Beam Tube-Type End Support



1. Axle Beam Hanger
2. Adapter
3. Adapter Bolt Nut
4. Rubber End Bushing
5. Bushing Outer Sleeve
6. Equalizer Beam
7. Bushing Inner Sleeve
8. Adapter Bolt
9. Washer (both ends)
10. Intermediate Tube

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Fig. 2, Equalizer Beam Adapter-Type End Support

Equalizer Beam Adapter- and Tube-Type End Support Removal and Installation

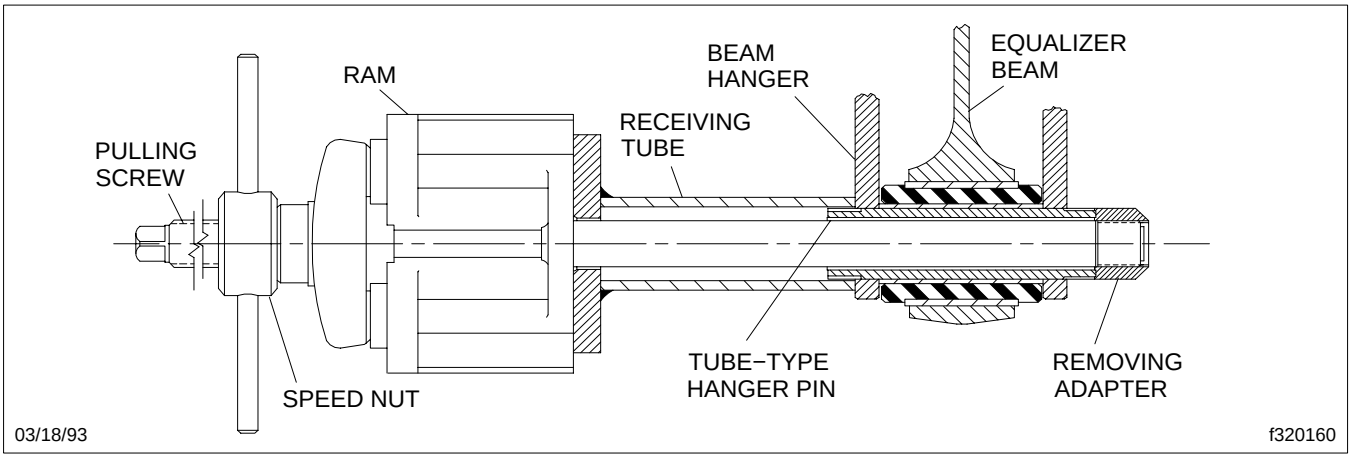


Fig. 3, Tube-Type Beam End Removal

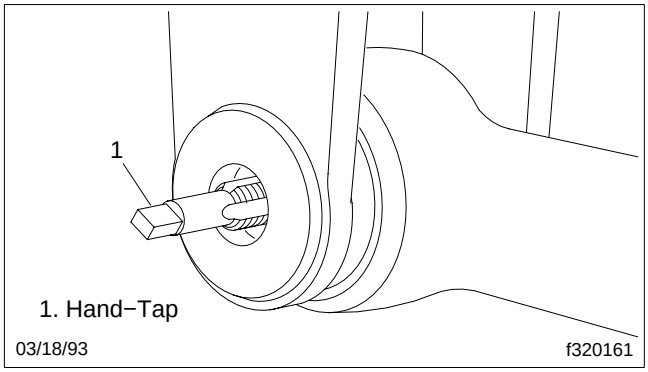


Fig. 4

NOTE: Determine the correct size of hand-tap by using the plug gauge. If the gauge passes through the adapter bolt hole, use a 15/16-inch tap; if it doesn't, use a 7/8-inch tap.

9.2 On the outboard side of the axle, thread the removing screw into the tapped hole. Position the receiving cup and hexnut on the removing screw (**see Fig. 5**). Turn the hexnut until the adapter plug breaks loose and bottoms on the inside of the receiving cup. **See Fig. 6.** If needed, add spacers to complete removal of the adapter plug. **See Fig. 7.**

9.3 On the inboard side of the axle, position the receiving cup over the adapter plug. On the outboard side of the axle, insert the removing screw through the receiving cup and secure it with the hexnut. A regular bolt may be used to remove the inboard adaptor. **See Fig. 8.**

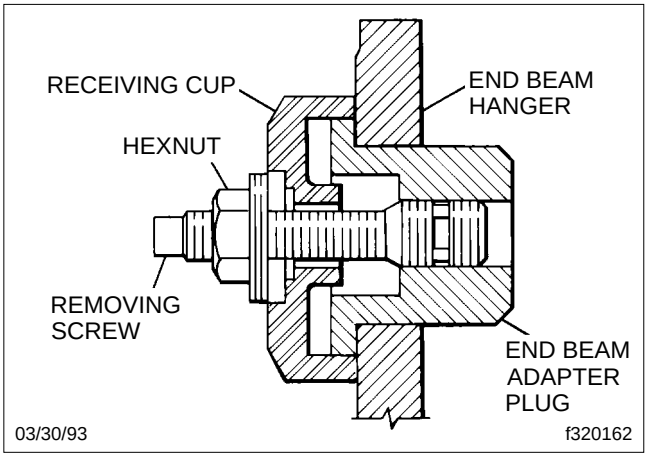


Fig. 5

9.4 Hold the removing screw and turn the nut with a 1-1/2 inch open- or box-end wrench. Turn the nut until the adapter plug bottoms on the inside of the receiving cup.

10. If not using Owatonna tools, remove the end supports.

10.1 For tube-type end supports, install a spacer bushing between one end-tube nut and the beam hanger. Tighten the nut to pull the end tube out of the beam end bushing. If the tube doesn't come loose,

Equalizer Beam Adapter- and Tube-Type End Support Removal and Installation

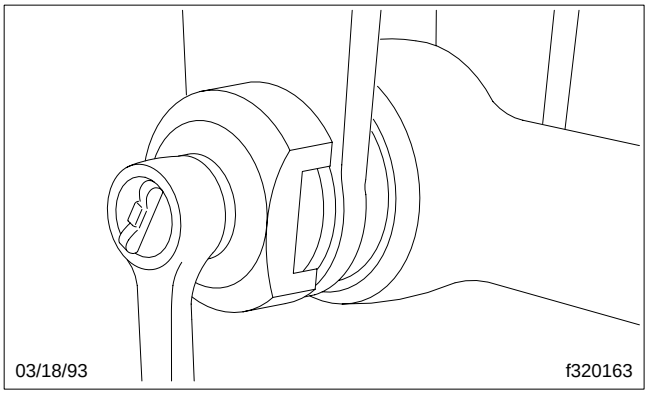


Fig. 6

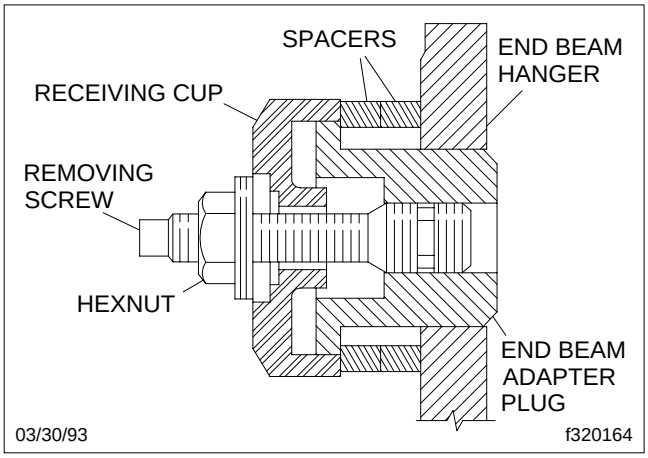


Fig. 7

use a hack-saw and saw the tube along the inside surface of both axle beam hanger legs.

⚠ WARNING

WARNING: Don't use a cutting torch to remove the equalizer beams from the beam hangers. The equalizer beams are heat-treated, and using a cutting torch could weaken them. This could result in a loss of vehicle control and possible personal injury or property damage.

10.2 For adapter-type end supports, a relief is located on each side of the adapter (**see Fig. 9**). Turn the adapter with an air chisel, then insert a chisel into the relief on the inboard adapter. Drive the chisel in and wedge the adapter out of the beam hanger. Do the same on the outboard adapter.

If a split-ring adapter is used, drive a chisel between the two halves to remove the end support plug. Drive the plug into the equalizer beam end bushing until it is clear of the beam hanger. After the equalizer beam is removed, drive the adapter plug out of the bushing.

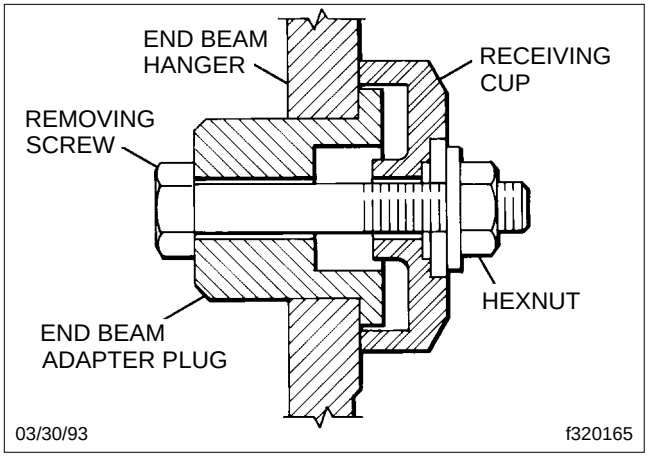


Fig. 8

11. Remove the ends of the equalizer beams from the axle beam hangers.
12. Lower the equalizer beams and the crosstube to the ground. Remove the thrustwashers and pull the beams from the crosstube.

Installation

1. On adapter-type end supports, apply Texaco Compound L, or an equivalent rust preventive lubricant, to the axle beam hanger eyes, beam end bushing inner sleeve, end support adapters, outside surface of the bushing intermediate tubes, and the ends of the crosstube.

   Install the crosstube and thrustwashers in both equalizer beam center bushings.

   On tube-type end supports, apply Texaco Compound L, or an equivalent rust preventive lubricant,to the axle beam hanger eyes, beam end bushing inner sleeve, outer surface of the beam

Equalizer Beam Adapter- and Tube-Type End Support Removal and Installation

end tubes, beam center bushing inner sleeves, and the ends of the crosstube.

Using SAE 20 oil, lubricate the threads of the beam end tube, then install the crosstube and thrustwashers in both equalizer beam center bushings.

2. Position the equalizer beam assembly under the axles, then raise the assembly and place the forward ends of each beam in the forward-rear axle beam hangers. Align the beam end bushings with the beam hangers.

   On adapter-type end supports, install the intermediate tubes, the adapters, the adapter bolt, washers, and nut in each beam end to hold the beam in the axle beam hangers. Do not tighten.

   On tube-type end supports, install the beam end tubes through the beam hangers and the beam end bushings. Hand-tighten both nuts on the beam end tubes.

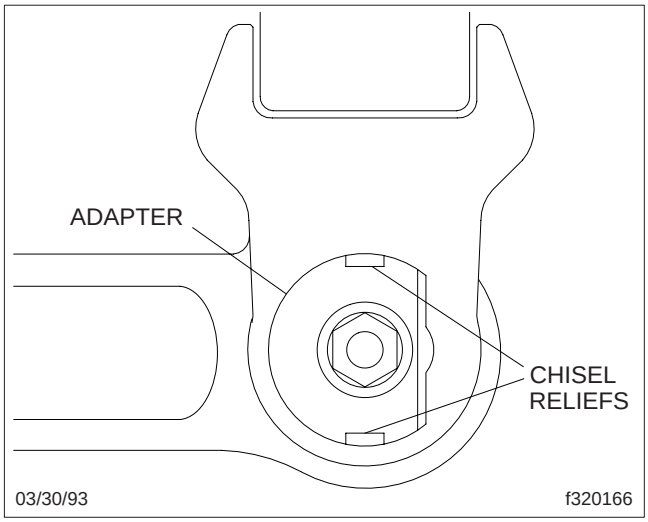


Fig. 9

3. Place the rear ends of each beam in the rearmost-axle beam hangers. Align the beam end bushings with the beam hangers.

   On adapter-type end supports, install the intermediate tubes, the adapters, the adapter bolt, washers, and nut in each beam end to hold the beam in the axle beam hangers. Do not tighten.

   On tube-type end supports, install the beam end tubes through the beam hangers and the beam end bushings. Hand-tighten both nuts on the beam end tubes.

4. Position the saddle caps on the saddle cap studs, then install the washers and new self-locking nuts. Tighten the nuts 225 to 275 lbf·ft (305 to 375 N·m).

5. Tighten the adapter bolt nuts 210 to 240 lbf·ft (285 to 325 N·m). Make sure the flat section of the adapter flange is in the vertical position. **See Fig. 10.**

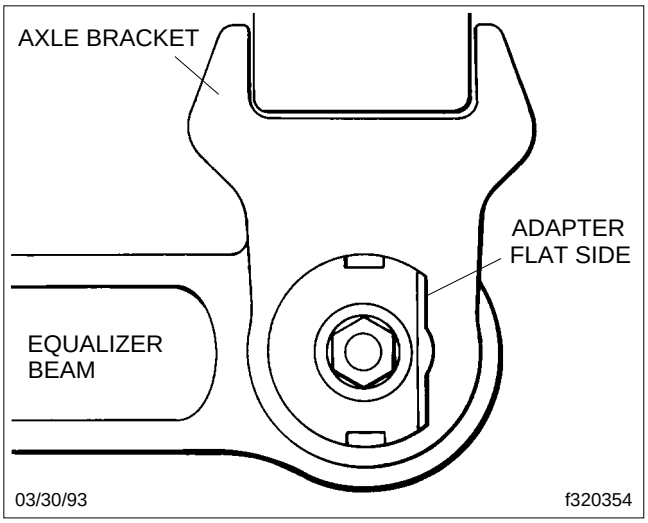


Fig. 10

6. Tighten the end tube nuts 375 to 425 lbf·ft (510 to 575 N·m).

⚠ WARNING

WARNING: The adapter bolt nuts and end tube nuts must be tightened to the values in the steps above. If not, the metal surfaces of the end support assembly will rub, and excessive wear to the beam hanger legs and end bushing inner sleeves will occur. This could result in separation of suspension components, loss of vehicle control, and possible injury or property damage.

7. Install the brake backing plate (dust shield), brake spider, and brake shoes. Refer to the brake section in this manual for instructions.

8. Install the wheels and tires. For instructions, refer to the wheels and tires section in this manual.

Equalizer Beam End Bushing Removal and Installation

Removal

⚠ WARNING

WARNING: Don't use a cutting torch to remove the beam end bushing. Equalizer beams are heat-treated by the manufacturer. Using a cutting torch could weaken the beams, which could cause a loss of vehicle control, resulting in injury or property damage.

1. Remove the equalizer beam ends from the axle beam hangers. For instructions, refer to **Subject 130.**
2. Cut off the protruding rubber from one side of each beam end bushing (**see Fig. 1**).
3. If using Owatonna tools, remove the beam end bushings as follows (**see Fig. 2**):

   3.1 Install the receiving adapter on the receiving tube.

   3.2 Position the hydraulic ram and slide the pulling screw through the end bushing.

   3.3 Install the end bushing removing adapter on the inboard side of the beam end bushing. Check that the cone-shaped surface of the adapter is facing the equalizer beam.

   IMPORTANT: Align the receiving tube so that the bushing will clear the edges of the tube when force is exerted against the beam. Align the removing adapter so that force is exerted only on the bushing to ensure a clean pull through the beam.

   3.4 Install the hexnut on the pulling screw. Full thread engagement is needed.

   3.5 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

   3.6 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely remove the end bushing.

   NOTE: If the pressure gauge on the hydraulic pumping unit reads 10,000 psi (68 950 kPa) and the bushing has not broken loose, stop and check the alignment of the receiving tool and removal adapter. If both tools are aligned correctly, attach a sledging adapter on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adapter with a heavy hammer. A loud noise followed by a sudden drop of the pressure gauge reading indicate the bushing has broken loose.

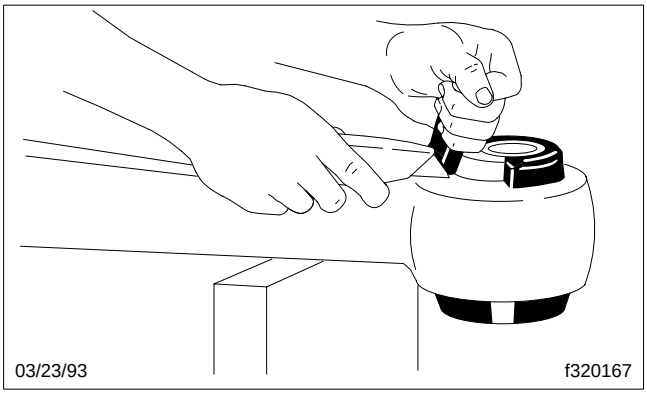


Fig. 1

4. If using shop-made adapters, remove the beam end bushings as follows:

   4.1 Remove the equalizer beams. For instructions, refer to **Subject 130**.

   4.2 Position the equalizer beam on a 50-ton vertical hydraulic press.

   4.3 Center the shop-made adapter (refer to the table under **Specifications, 400**) on the trimmed end of the equalizer beam bushing. Press the end bushing from the beam eye.

Installation

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.
2. Using emery cloth, clean the outer sleeves of the new equalizer beam end bushings. Apply a thin coating of Texaco Compound L, or an equivalent rust preventive lubricant, to the surface of the outer sleeves on the new bushing.

Equalizer Beam End Bushing Removal and Installation

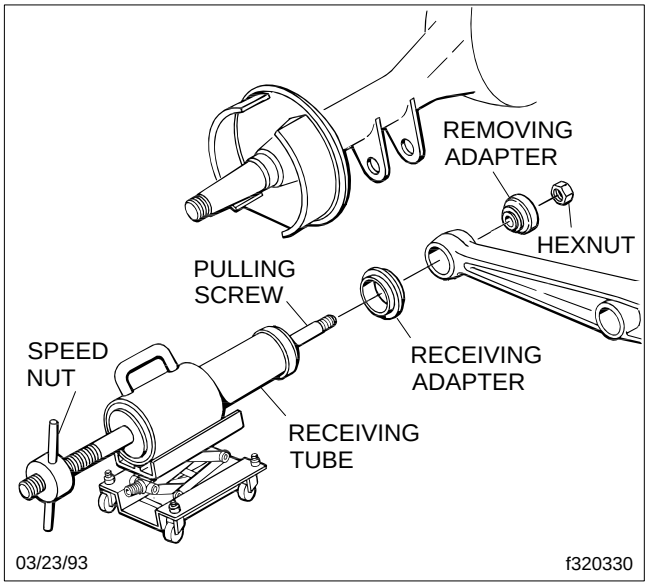


Fig. 2

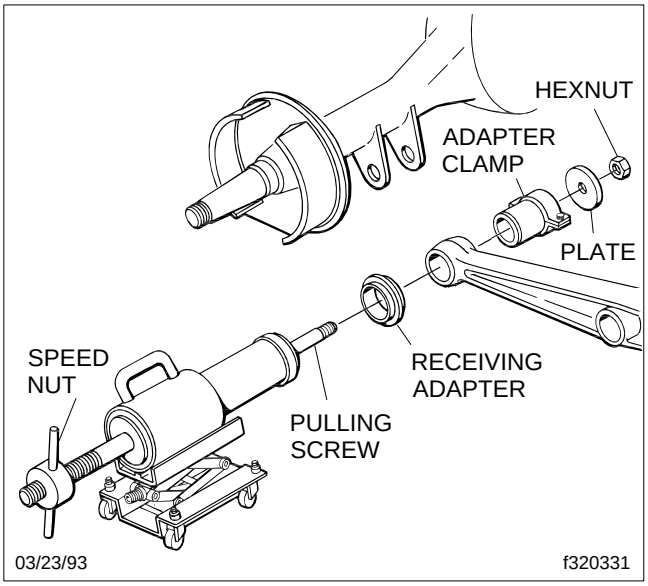


Fig. 3

3. If using Owatonna tools, install the beam end bushings as follows **(see Fig. 3)**:

   3.1 Fit the adapter clamp over the exposed rubber on the new bushing. Tighten the clamp nuts until the clamp is flush against the bushing outer sleeve.

   3.2 Install the receiving adapter on the receiving tube.

   3.3 Position the hydraulic ram and slide the pulling screw through the end bushing.

   3.4 Center the adapter clamp and bushing on the inboard side of the beam end.

   3.5 Install the adapter plate and secure it with the hexnut.

   IMPORTANT: Check that the new bushing and the installation tools are centered so that the bushing will clear the receiving tube when force is exerted against the beam.

   3.6 Tighten the speed nut and remove any slack in the assembly.

   3.7 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

   3.8 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely install the end bushing.

   NOTE: The pressure gauge on the pumping unit should read 4000 to 5500 psi (27 580 to 37 920 kPa) during installation. If the reading reaches the operating limit of 10,000 psi (68 950 kPa) and the bushing is not going into the beam end, check the alignment of the bushing, tooling, and hydraulic equipment. Installation is complete when the adapter clamp is flush against the beam.

   3.9 Install the equalizer beam ends on the axle beam hangers. For instructions, refer to **Subject 130**.

4. If using shop-made adapters, install the beam end bushings as follows **(see Fig. 4)**:

   4.1 Position the equalizer beam on a 50-ton hydraulic press.

   4.2 Using a sheave puller, compress the exposed rubber of the bushing until the puller jaws are flush against the end of the bushing outer sleeve.

   4.3 Position the shop-made adapter (refer to the table under **Specifications, 400**)

against the jaws of the sheave puller. Press the new bushing into the beam eye.

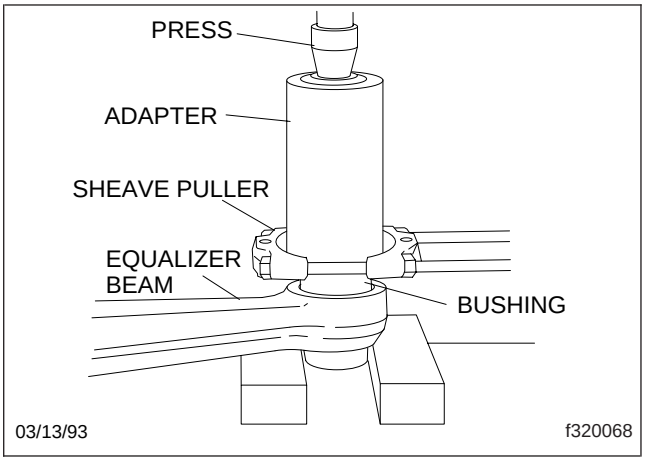


Fig. 4

4.4 Install the equalizer beam. For instructions, refer to **Subject 130**.

Equalizer Beam Bar Pin/Bushing Assembly Removal, Installation, and Alignment

Removal

NOTE: From July 1995, most Hendrickson suspensions are manufactured with a bar pin-type bushing assembly that connects the equalizer beam to the axle. The bar pin/bushing assembly can be serviced without removing the brake assembly.

⚠ WARNING

Do not use a cutting torch to remove the equalizer beams from the beam hangers. The equalizer beams are heat-treated, and using a cutting torch could weaken them. This could result in a loss of vehicle control, possible personal injury, or property damage.

1. Shut down the engine and set the parking brake.
2. Chock the front tires.
3. Support the equalizer beams with jack stands.
4. Remove the four bolts attaching the equalizer beam to the saddle.
5. Apply a penetrating oil to the threads of the two 1-inch (25 mm) bolts and locknuts attaching each bar pin/bushing assembly to the axle brackets.
6. Remove the bolts. If the fasteners are rusted in place, an air hammer chisel may be used to loosen the bolts attaching the bar pin/bushing assembly to the axle brackets.

NOTE: The upper torque rods may have to be disconnected at the top of the axle, and the axle rotated to a more vertical position to assist in the removal of the equalizer beam from the axle bracket.

7. Remove the equalizer beam from the axle beam hangers.
8. The bar pin/bushing assemblies can be removed from the equalizer beams with Owatonna tools. To do so, follow Owatonna recommendations.
9. If shop-made tools are used, remove the bar pin/bushing assemblies from the beam ends as follows:
   - 9.1 Position the equalizer beam on a 50-ton vertical hydraulic press.
   - 9.2 Center the shop-made tool, and press the bar pin/bushing assembly from the beam end eye.

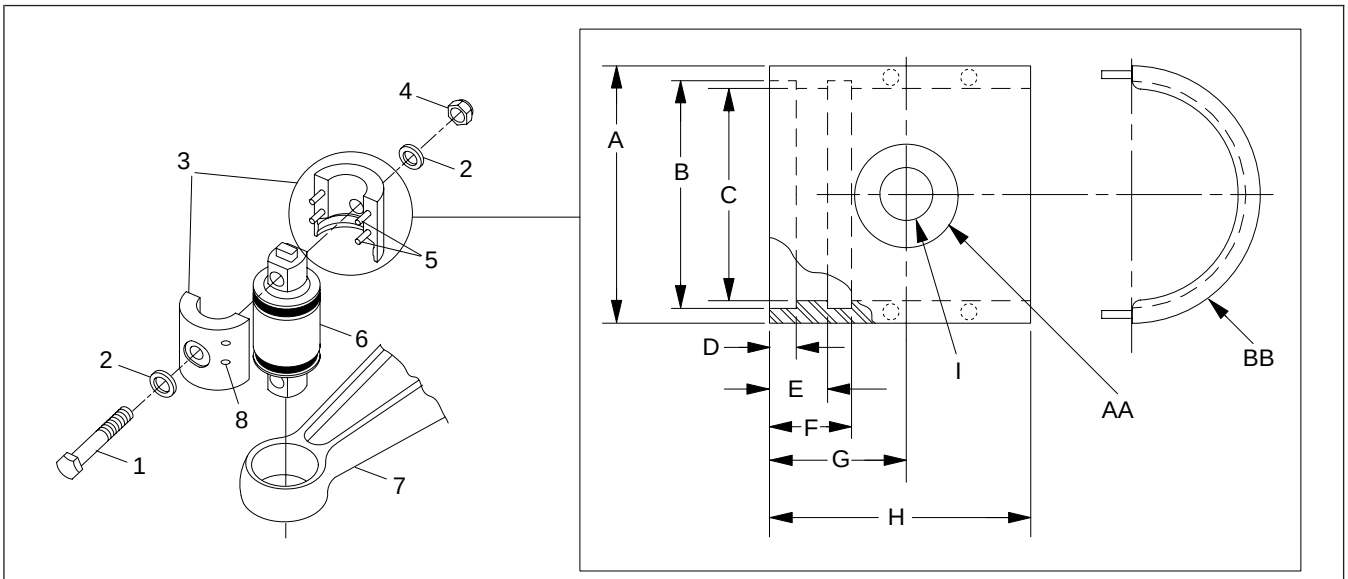
Installation

IMPORTANT: Do not reuse the old fasteners. Replace them during installation.

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.
2. The outer metals of some Hendrickson rubber bushings are covered with a phosphate coating that acts as a rust preventive. This coating must be removed with emery cloth before installation. Also apply a coating of grease to the cleaned outer metals of the bar pin/bushing assembly, and to the beam end eyes to help when pressing the bar pin/bushing assembly into the beam end eye.
3. If using Owatonna tools, install the bar pin/bushing assemblies using Owatonna recommendations.
4. If using shop-made tools, create the needed assembly tool from a 5-inch (127 mm) length of 5-inch (127 mm) O.D. steel tubing with 1/2-inch (13 mm) wall thickness. See **Fig. 1**. The assembly tool must be split in half, then clamped or bolted together to compress the rubber to allow contact with the bushing outer metal.
   - 4.1 Position the equalizer beam on a 50-ton hydraulic press with the beam end bore squarely supported on the bed for safety and to avoid bending the equalizer beam.
   - 4.2 Before pressing the bar pin/bushing assembly, align the holes in the end of the bar pin/bushing assembly with the center line of the equalizer beam. This will help assembly into the axle brackets. Care should be taken during the assembly process to ensure the orientation of the bar pin/bushing assembly in the beam eye.

   NOTE: After installation, verify that the bar pin/bushing assembly is centered in the end of the beam.

Equalizer Beam Bar Pin/Bushing Assembly Removal, Installation, and Alignment



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1. Bolt, 1" (25 mm)
2. Washer, 1" (25 mm) o.d.
3. Assembly Tool
4. Locknut
5. Alignment Pins
6. Bar Pin/Bushing Assembly
7. Equalizer Beam
8. Alignment Pin Hole

A. 5.0" (127 mm)
B. 4.43" (113 mm)
C. 4.12" (105 mm)
D. 0.50" (13 mm)
E. 1.07" (27 mm)
F. 1.54" (39 mm)
G. 2.62" (67 mm)
H. 5.0" (127 mm)
I. 1.0" (25 mm)

AA. Recess flat counter bore, 2.0" (51 mm) x 0.25" (6 mm) deep.
BB. Tool wall, 0.50" (13 mm), top view.
NOTE: Tool material used to make tool is 0.50" (13 mm) wall x 5.0" (127 mm) o.d. x 5.0" (127 mm) long steel tubing.

Fig. 1, Assembly Tool (exploded view, with manufacturing information)

5. Install the equalizer beam on the axle hangers.
6. Attach the bar pin/bushing assembly to the axle brackets. Tighten the 1-inch (25 mm) bolts 450 to 600 lbf·ft (610 to 813 N·m).

NOTE: Bar pin/bushing assembly kits are available with or without alignment shims.

7. Install the four bolts attaching the equalizer beam to the saddle. Tighten 225 to 275 lbf·ft (305 to 375 N·m).
8. Remove the jack stands.
9. Remove the chocks from the tires.

Alignment

For a detailed adjustment procedure, refer to Hendrickson's service literature, **Bar Pin Alignment Instructions, Technical Publication No. 17730-213**.

The instruction publication may be obtained from:

Hendrickson Truck Suspension Systems
1-630-910-2800
1-800-973-0360
(fax) 1-630-378-4849
800 South Frontage Road
Woodridge, IL 60517-4904

Equalizer Beam Rubber Center Bushing Removal and Installation

Removal

NOTE: If using Owatonna tools, removal of the equalizer beam is not required for removal or installation of the rubber center bushing.

1. Chock the front tires.
2. Raise the rear of the vehicle so that all weight is removed from the suspension. Block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

3. Remove the saddle cap nuts and washers from each side of the vehicle, and remove the saddle caps.
4. Raise the rear of the truck frame until the saddle studs clear the equalizer beam. Install safety stands under the frame.
5. Using a 2-1/2 inch diameter hole saw (**see Fig. 1**), cut out the end plug from the center bushing on each side of the suspension, and remove the crosstube.

⚠ CAUTION

CAUTION: Do not use a cutting torch to burn out the end plugs. The equalizer beams are heat-treated, and the use of a cutting torch could weaken the beam.

6. On the inboard side of the equalizer beam, inspect the exposed edge of the bushing's outer sleeve.
7. Chisel or grind off any portion of the outer sleeve that has flared over the surface of the equalizer beam.
8. If using Owatonna tools, remove the rubber center bushings as follows (**see Fig. 2**):

   8.1 Position the hydraulic ram and slide the pulling screw through the center bushing.

   8.2 Install the center bushing removing adapter on the inboard side of the beam eye.

   IMPORTANT: Align the receiving tube so that the bushing will clear the edges of the tube when force is exerted against the beam. Align the removing adapter so that force is exerted only on the bushing to ensure a clean pull through the beam.

   8.3 Install the hexnut on the pulling screw. Full thread engagement is needed.

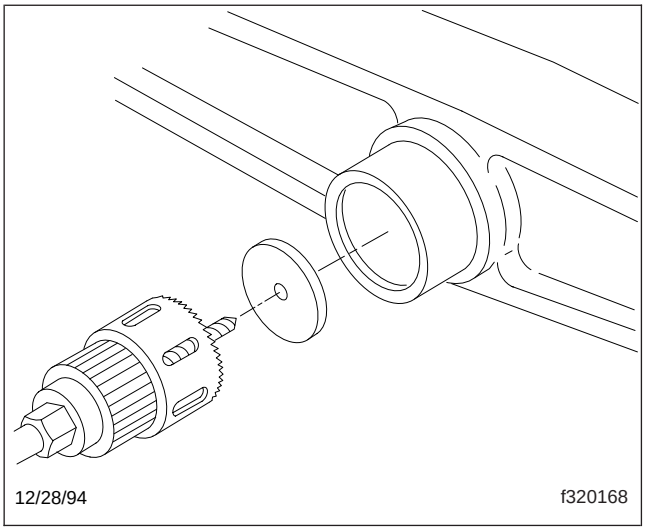


Fig. 1

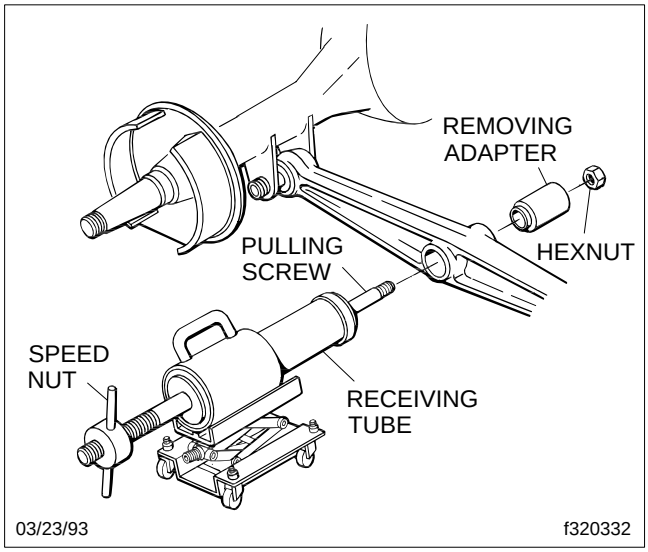


Fig. 2

Equalizer Beam Rubber Center Bushing Removal and Installation

8.4 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

8.5 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

8.6 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely remove the bushing.

NOTE: If the pressure gauge on the hydraulic pumping unit reads 10,000 psi (68 950 kPa) and the bushing has not broken loose, stop and check the alignment of the receiving tool and removal adapter. If both tools are aligned correctly, attach a sledging adapter on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adapter with a heavy hammer. Aloud noise followed by a sudden drop of the pressure gauge reading indicate that the bushing has broken loose.

9. If using shop-made adapters, remove the equalizer beams. For instructions, refer to **Subject 130**.

9.1 Position the equalizer beam on a 50-ton vertical hydraulic press.

9.2 Position the shop-made adapter (refer to the table under **Specifications, 400**) on the outer metal edge of the equalizer beam bushing. Press the center bushing from the beam eye.

Installation

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.

2. Using emery cloth, clean the outer sleeves of the new equalizer beam center bushings. Apply a thin coating of Texaco Compound L, or an equivalent rust preventive lubricant, to the surface of the outer sleeves on the new bushing.

3. If using Owatonna tools, install the rubber center bushings **(see Fig. 3)**.

3.1 Center the hydraulic ram and slide the pulling screw through the beam eye.

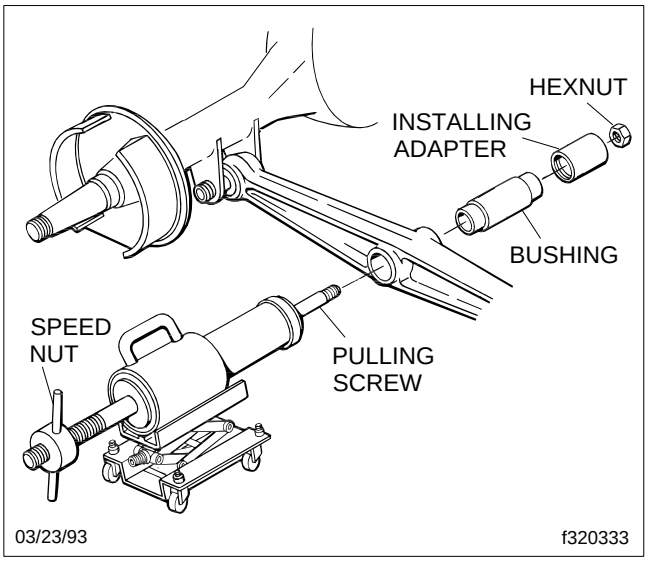


Fig. 3

3.2 Position the bushing on the inboard side of the beam eye.

IMPORTANT: Center the new bushing to ensure a clean pull through the beam eye.

3.3 Fit the installing adapter over the inner sleeve and against the outer sleeve of the bushing.

3.4 Install the hexnut on the pulling screw. Full thread engagement is needed.

3.5 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

3.6 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

3.7 Release the pressure, add spacers, and tighten the speed nut. About

three adjustments are needed to completely install the center bushing.

NOTE: The pressure gauge on the pumping unit should read 4000 to 5500 psi (27 580 to

37 920 kPa) during installation. If the reading reaches the operating limit of 10,000 psi (68 950 kPa) and the bushing is not going into the beam, check the alignment of the bushing, tooling, and hydraulic equipment. Installation is complete when the installing adapter is flush against the beam.

3.8 Position the crosstube in the center bushings.

⚠ WARNING

WARNING: Wear protective welding masks and gloves when welding. Failure to do so could result in personal injury due to the intensity of heat, sparks, and flying debris from the welding process.

3.9 Arc weld new end plugs to the tire side of each center bushing inner sleeve.

NOTE: Heat from welding the end plugs will not affect the beam or the new rubber bushings because of their distance from the point of welding.

4. Position the saddle caps on the saddle cap studs, then install the washers and new self-locking nuts. Tighten the nuts 225 to 275 lbf·ft (305 to 375 N·m).

5. If using shop-made adapters, position the equalizer beam on a 50-ton hydraulic press.

5.1 Using standard center bushings with the end plugs welded in place, position the shop-made adapter (refer to the table under **Specifications, 400**,) over the inner sleeve of the bushing. Check that the adapter bottoms against the bushing outer sleeve, then press the new bushing into the beam eye.

5.2 Install the equalizer beams. For instructions, refer to **Subject 130**.

Equalizer Beam Bronze Center Bushing Removal and Installation

Removal

NOTE: If using Owatonna tools, you can remove or install the bronze center bushing without removing the equalizer beam.

1. Chock the front tires.
2. Raise the rear of the vehicle so that all weight is removed from the suspension. Block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

3. Remove the saddle cap nuts and washers from each side of the suspension, and remove the saddle caps.
4. Raise the rear of the truck frame until the saddle studs clear the equalizer beam. Install safety stands under the frame.
5. Using a 2-1/2 inch diameter hole saw, cut out the retaining disk from the center bushing on each side of the suspension, and remove the cross-tube.

⚠ CAUTION

CAUTION: Do not use a cutting torch to burn out the retaining disk. The equalizer beams are heat treated, and the use of a cutting torch could weaken the beam.

6. If using Owatonna tools, remove the bronze center bushing (see **Fig. 1**).
   - 6.1 Position the hydraulic ram and slide the pulling screw through the center bushing.
   - 6.2 Install the center bushing removing adapter on the inboard side of the beam eye.

   IMPORTANT: Align the receiving tube so that the bushing will clear the edges of the tube when force is exerted against the beam. Align the removing adapter so that force is exerted only on the bushing to ensure a clean pull through the beam.
   - 6.3 Install the hexnut on the pulling screw. Full thread engagement is needed.

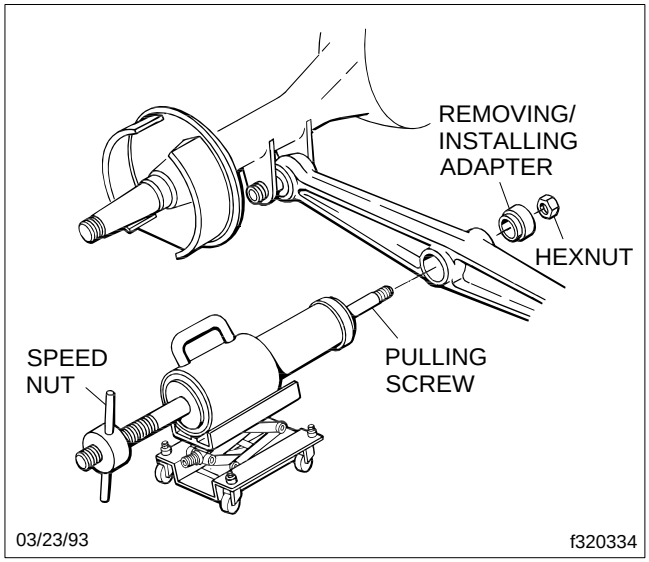


Fig. 1

   - 6.4 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.
   - 6.5 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.
   - 6.6 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely remove the center bushing.

   NOTE: If the pressure gauge on the hydraulic pumping unit reads 10,000 psi (68 950 kPa) and the bushing has not broken loose, stop and check the alignment of the receiving tool and removal adapter. If both tools are aligned correctly, attach a sledging adapter on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adapter with a heavy hammer. A loud noise followed by a sudden drop of the pressure gauge reading indicate that the bushing has broken loose.
7. If using shop-made adapters, remove the equalizer beams. For instructions, refer to **Subject 130**.

Equalizer Beam Bronze Center Bushing Removal and Installation

7.1 Position the equalizer beam on a 50-ton vertical hydraulic press.

7.2 Center the shop-made adapter (refer to the table in **Specifications, 400**) on the center bushing. Press the bushing from the beam eye.

Installation

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.
2. Using emery cloth, clean the outer sleeves of the new equalizer beam center bushings. Apply a thin coating of Texaco Compound L, or an equivalent rust preventive lubricant, to the surface of the outer sleeves on the new bushing, and to the inside surface of the beam eye.
3. Position the bushing on the equalizer beam eye.
4. If using Owatonna tools, install the bronze center bushings (see **Fig. 2**).

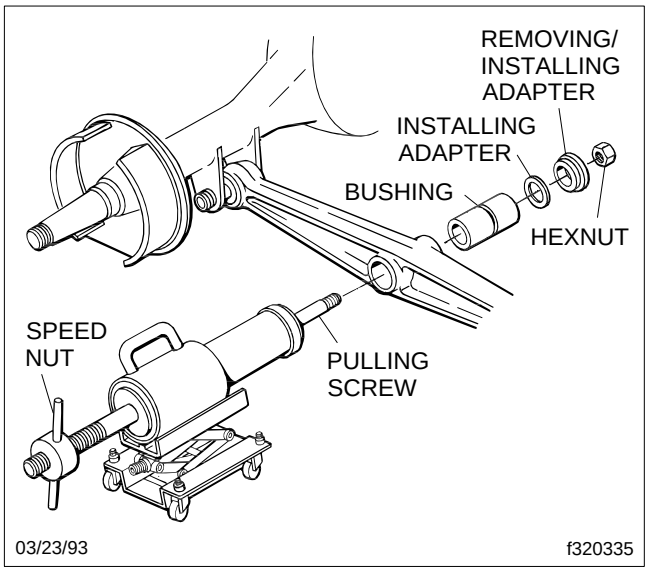


Fig. 2

4.1 Center the hydraulic ram and slide the pulling screw through the beam eye.

4.2 Position the bushing on the inboard side of the beam eye. Check that the grooves of the bushing are aligned with the vertical centerline of the equalizer beam (see **Fig. 3**).

4.3 Fit the installing adapter and the removing/installing adapter against the outer sleeve of the bushing. Make sure the deep ridge on the installing adapter is positioned against the bronze bushing (see **Fig. 4**).

4.4 Install the hexnut on the pulling screw. Full thread engagement is needed.

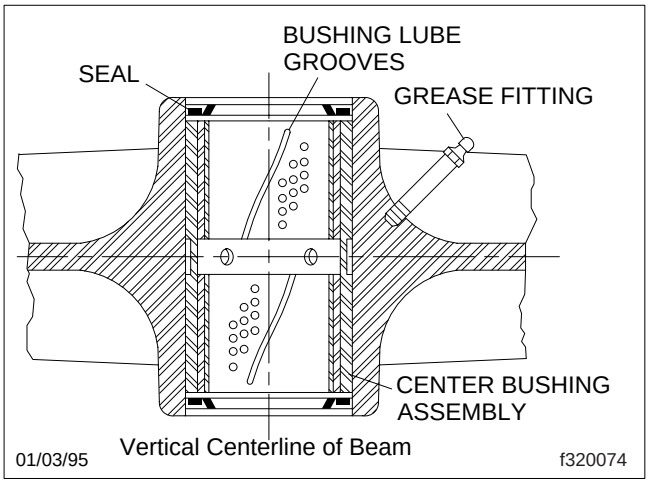


Fig. 3

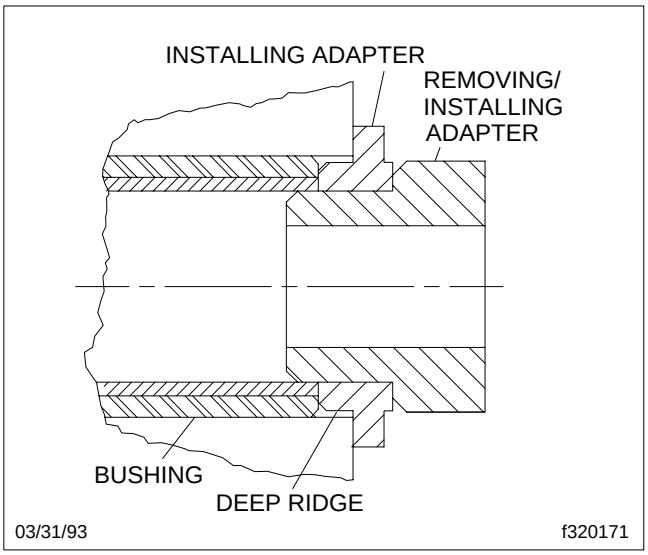


Fig. 4

Equalizer Beam Bronze Center Bushing Removal and Installation

4.5 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

4.6 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

4.7 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely install the center bushing.

NOTE: The pressure gauge on the pumping unit should read 4000 to 5500 psi (27 580 to 37 920 kPa) during installation. If the reading reaches the operating limit of 10,000 psi (68 950 kPa) and the bushing is not going into the beam, check the alignment of the bushing, tooling, and hydraulic equipment. Installation is complete when the installing adapter is flush against the beam.

4.8 On the inboard side of the beam, position a grease seal and installing adapter against the center bushing. Make sure the shallow end of the adapter is against the grease seal (see **Fig. 5**). Using a hammer, tap the installing adapter until it is flat against the beam. Using the same procedure, install a grease seal on the outboard side of the beam.

5. If using shop-made adapters, position the equalizer beam on a 50-ton hydraulic press.

5.1 Center the new bushing in the beam eye. Using a standard bushing driver, press the bushing in until there is equal spacing between both bushing ends and the sides of the beam eye.

5.2 Install the new grease seals (with the seal lips facing out).

NOTE: Check that the new seals are 1/6 inch (4 mm) inside the beam hub surface to ensure clearance and protection of the seals when the saddle cap is installed.

6. Apply a thin coating of multipurpose chassis grease to the inside surface of the center bushing. Slide the bushing center sleeve into the bushing.

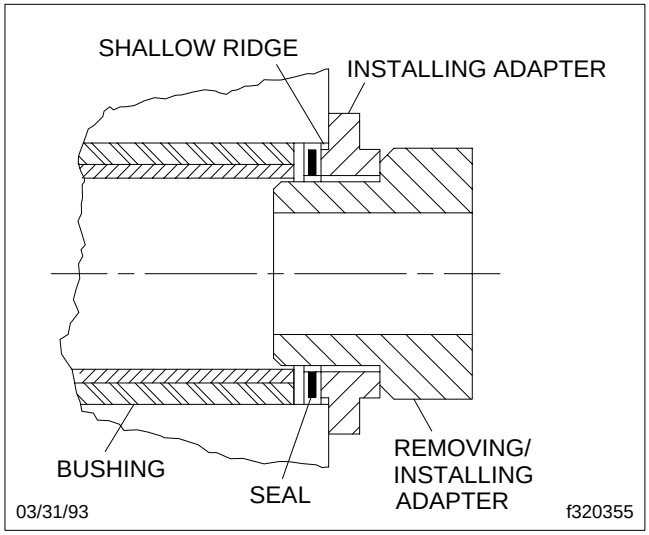


Fig. 5

7. Install the grease fitting into the beam hub. Rotate the center sleeve and apply multipurpose chassis grease in the grease fitting. Lubricate until clean grease appears at both ends of the grease seals.
8. Install the crosstube.
9. Install the saddle caps or the equalizer beam (if removed) on the axle beam hangers. For instructions, refer to **Subject 130**.

Torque Rod and Bushing Removal and Installation

Removal (See Fig. 1)

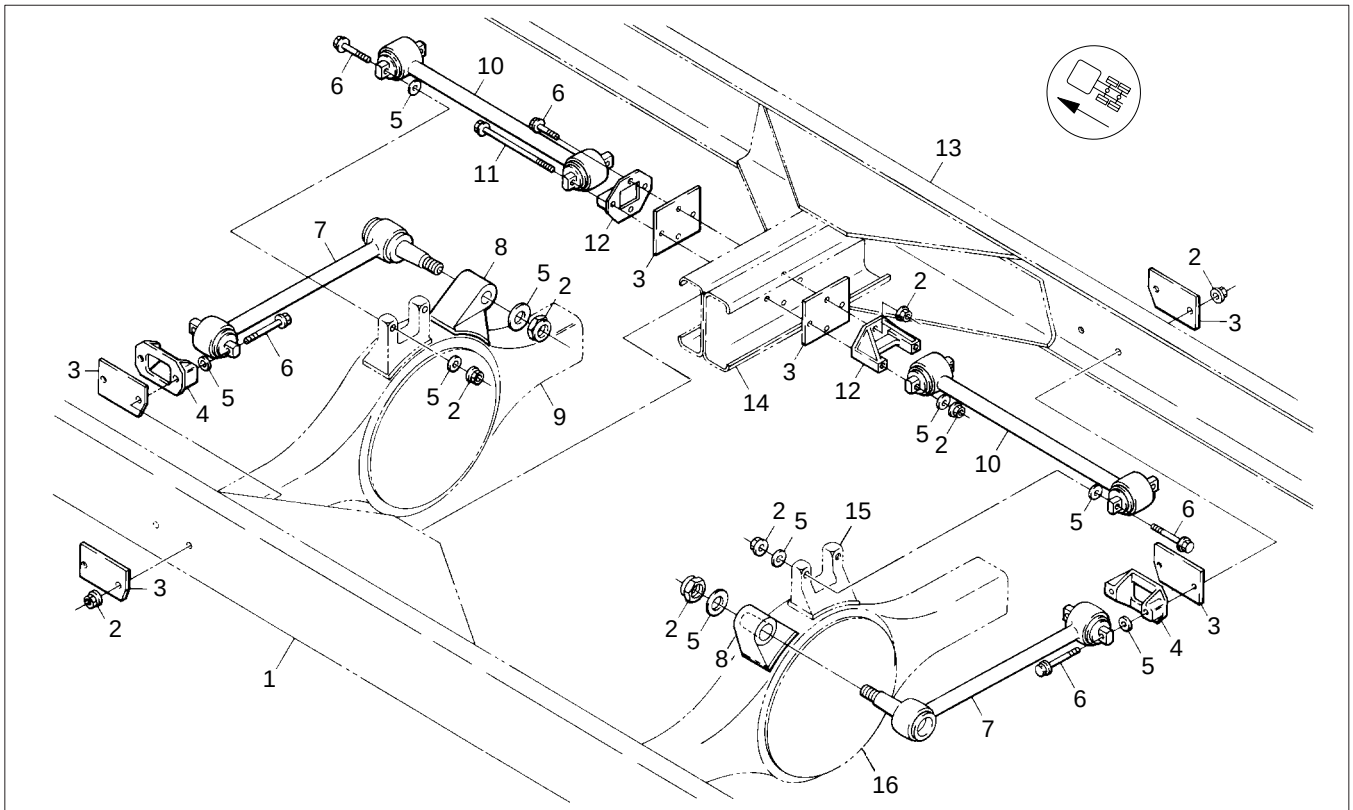


Fig. 1, Torque Rod Mounting Assembly

IMPORTANT: To ensure that the required tools are available, see **Specifications, 400** before beginning these procedures. Special tools are available from the Owatonna Tool Company, Owatonna, Minnesota, or an affiliated dealer.

⚠ WARNING

WARNING: When the torque rods are disconnected from the axle brackets, the axles become free to pivot on the equalizer beam end bushings. Keep clear of the beam hangers and beam ends to avoid possible injury.

Torque Rod and Bushing Removal and Installation

1. On fore and aft torque rods, remove the flanged bolts and nuts from the torque rod axle brackets, and the crossmember mounting brackets. Remove the torque rods.

   On transverse torque rods, remove the nuts and washers from the axle brackets, and remove the flanged bolts and nuts from the frame-rail mounting brackets (see **Fig. 1**). Remove the torque rods.

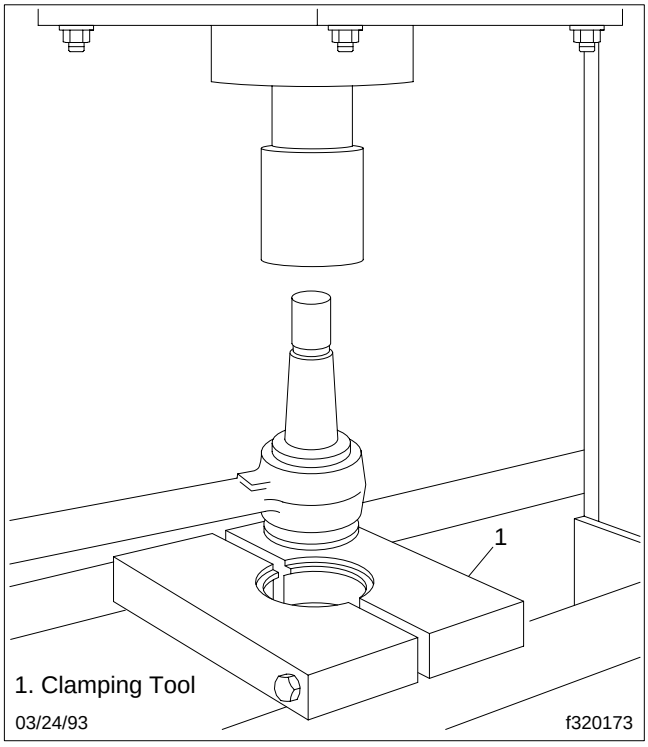


Fig. 2

NOTE: If necessary, use an impact hammer and tap the top of the axle bracket to disengage the rod stud from the axle bracket.

2. Inspect the torque rods. If bent or cracked, replace. Check the torque rod bushings. If one of the bushings is loose or damaged, replace both of the bushings.
3. Position the press plate on the hydraulic press. Check that the small counterbore of the plate hole is facing up.

NOTE: Some tapered stud torque rod bushings have a large non-removable washer on the stud that will not fit though the press plate hole.

Loosen the press plate capscrews and separate the halves (see **Fig. 2**) until the washer clears the counterbore, and the torque rod sets on the press plate. Tighten the capscrews until the press plate halves are closed.

4. Position the tapered stud removal tool (using the end with the larger inside diameter) on the torque rod stud. Apply lubricating oil (see **Fig. 3**), then press the stud out of the bushing.

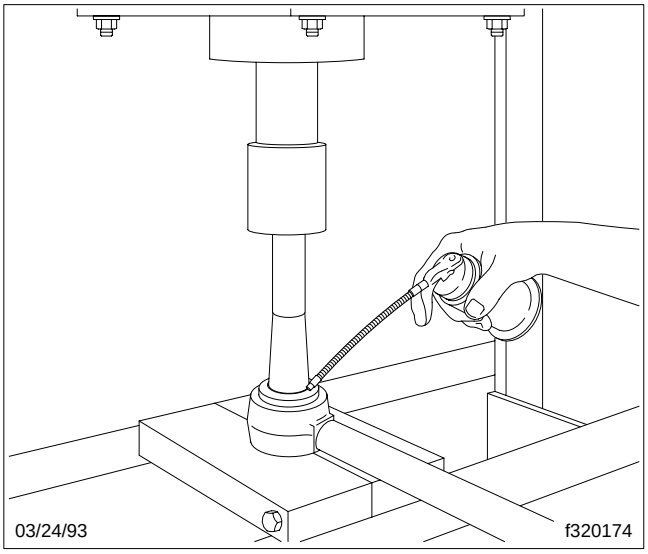


Fig. 3

5. Position the bushing remover/replacer tool (using the end with the larger outside diameter) on the bushing. Install the cap, then apply lubricating oil to the torque rod bushing.
6. Press the rubber bushing out of the torque rod eye.
7. Position the straddle mount end of the torque rod into the hole of the press plate. Tighten the press plate capscrews.
8. Position the straddle mount pin remover on the straddle mount pin (see **Fig. 4**).
9. Apply lubricating oil to the straddle mount pin. Press the straddle mount pin out of the bushing.
10. Position the end of the rubber bushing remover/replacer tool (using the end that has the larger outside diameter) on the bushing. Install the cap, then apply lubricating oil to the torque rod bushing.

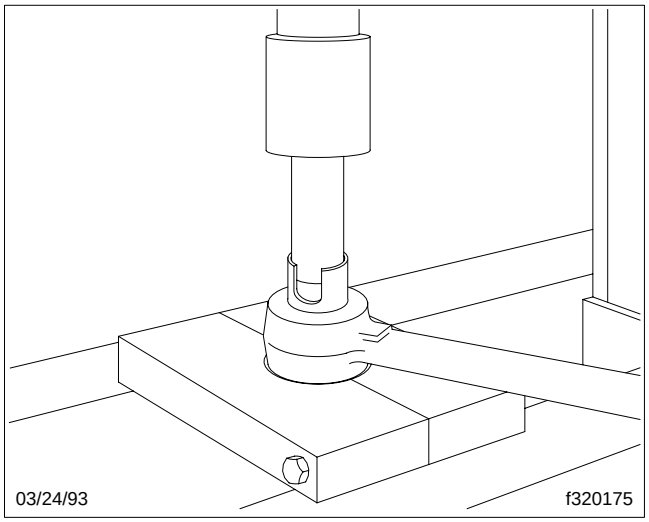


Fig. 4

11. Press the rubber bushing out of the torque rod eye.

Installation

1. Remove all dirt and grease from the torque rod ends. Apply lubricant on the new bushings and in the torque rod eyes.
2. Position the press plate on the hydraulic press. Check that the small counterbore of the plate hole is facing up.
3. Position the new bushing on the tapered stud of the transverse torque rod. Position the clamp and tighten it to compress the rubber (see **Fig. 5**).
4. Place the torque rod end, the bushing, and the clamp on the press plate.
5. Place the remover/replacer tool (see **Fig. 6**) and cap on top of the clamping tool and press the bushing in the torque rod end. Check that the bushing sleeve protrudes equally on each side of the torque rod end.
6. On straddle mount end assemblies, align the clamping tool on the bushing as shown in **Fig. 7**. Tighten the clamp to compress the rubber of the new straddle mount bushing.

NOTE: When tightening the clamp, make sure that the position of the bushing pin is at a right angle to the centerline of the torque rod shank (see **Fig. 8**).

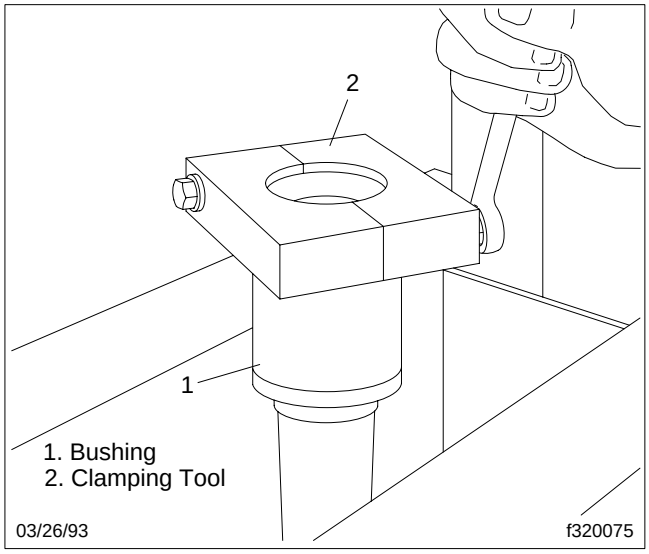


Fig. 5

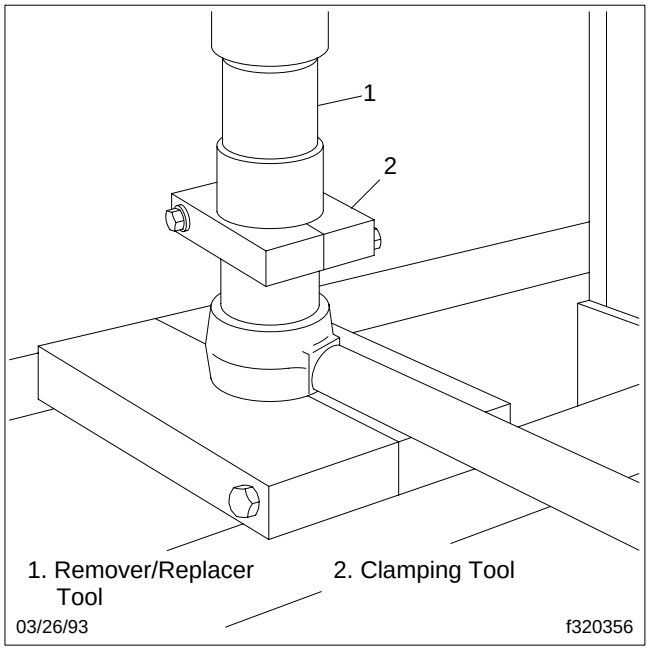


Fig. 6

7. Place the torque rod end, the bushing, and the clamp on the press plate.

Torque Rod and Bushing Removal and Installation

8. Using the larger end of the remover/replacer tool, position the tool and cap on top of the clamp assembly.
9. Press the bushing in the torque rod end. Check that the bushing's outer sleeve protrudes equally on each side of the torque rod end.

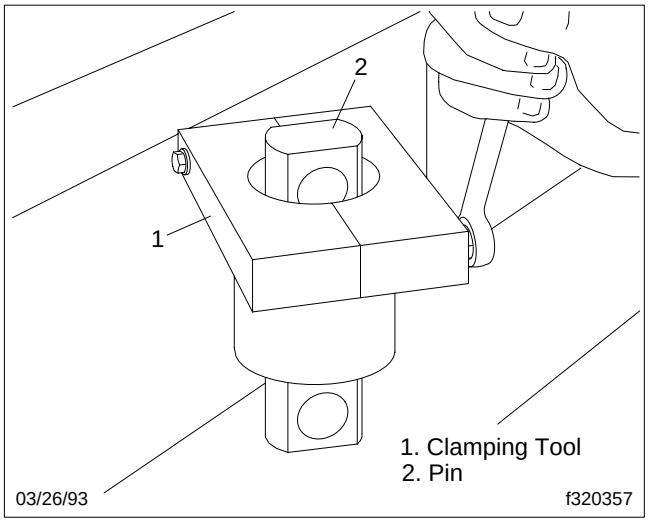


Fig. 7

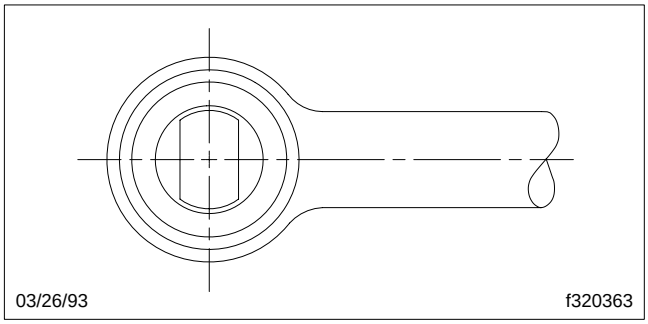


Fig. 8

10. Install the fore and aft torque rods (see **Fig. 1**).
    - 10.1 Position a torque rod straddle mount pin in the forward-rear axle bracket. Install the flanged bolts through the axle bracket and the straddle mount pin. Install a spacer and nut on each bolt, and tighten 190 lbf·ft (260 N·m).
    - 10.2 Position a torque rod straddle mount pin in the rearmost axle bracket. Install the flanged bolts through the axle bracket and the straddle mount pin. Install a spacer and nut on each bolt, and tighten 190 lbf·ft (260 N·m).
    - 10.3 Position a torque rod spacer and straddle mount bracket on each side of the crossmember. Insert bolts through the upper and lower holes of the forward mounting bracket. Install nuts and tighten 95 lbf·ft (130 N·m).
    - 10.4 Position the straddle mount pin of the forward torque rod in the mounting bracket. Insert bolts through the forward pin, both bracket assemblies, and the straddle mount pin of the rear torque rod. Install the nuts and bearing washers. Tighten the nuts 190 lbf·ft (260 N·m).
11. Install the transverse torque rods (see **Fig. 1**).
    - 11.1 Check that the tapered stud end and the tapered stud bracket hole are clean. Lubricate the tapered stud ends with SAE 20 oil.
    - 11.2 Install the tapered stud in the axle bracket. Install a washer and nut. Tighten the nut 175 to 225 lbf·ft (235 to 305 N·m).
    - 11.3 Align the straddle mount end, the mounting bracket, and the spacer against the inside frame rail.
    - 11.4 On the inboard side of the frame rail, install the bolts through the mounting assembly and the frame rail.
    - 11.5 On the outboard side of the frame rail, install a spacer over the mounting bolt studs. Install the nuts and tighten them 190 lbf·ft (260 N·m).
12. Check the axle pinion angle. For instructions, refer to the driveline section in this manual.

Specifications

Part Number	Tool	Usage
1745	Adapter Puller Set	Adapter-Type End Support Removal
1761	Torque Rod Set	Torque Rod Bushing Removal and Installation
28536	Installing Adapter (5-3/4" o.d.)	Bronze Center Bushing and Seal Removal and Installation
44119	Receiving Tube	Center and End Bushing Removal and Installation
45052	Adapter Clamp	End Bushing Installation
51678	80-Ton Hydraulic Ram	All Operations
51695	Jack	All Operations
206459	Plate	End Bushing Installation
302018	Spacer (3 qty.)	Center and End Bushing Removal and Installation
302019	Receiving Adapter	End Bushing Removal and Installation
302023	Pulling Screw	All Operations
302024	Removing and Installing Adapter	Bronze Center Bushing Removal and Installation
302026	Installing Adapter	Rubber Center Bushing Removal and Installation
302027	Removing Adapter	Rubber Center Bushing Removal and Installation
302028	Hexnut	All Operations
302029	Speed Nut	All Operations
302030	Removing Adapter	End Bushing Removal and Installation

Table 1, Special Tools (Owatonna Tool Company)

Tool Number	Dimensions	Usage
1	4-1/4 inch o.d. by 4 inch	Beam End Bushing Removal
2	4-1/2 inch i.d. by 4 inch	Beam End Bushing Installation
3	4-5/8 inch o.d. by 7 inch	Beam Center Bushing Removal and Installation

Table 2, Shop-Made Adapters

Description	Size	Torque lbf·ft (N·m)
Vertical Drive Pin Bushing Retainer Cap Locknut	5/8-18	100-125 (135-170)
Vertical Drive Pin Bushing Retainer Cap Stud	5/8-11	55-65 (75-90)
Vertical Drive Pin Locknut	1-1/2-12	175-225 (235-305)
Torque Rod Straddle Mount Nut	5/8-11	190 (260)
Torque Rod Stud Locknut	1-1/4-12	175-225 (235-305)
Saddle Cap Stud	7/8-14	55-65 (75-90)
Saddle Cap Locknut	7/8-14	225-275 (305-375)
Adapter-Type Beam End Locknut	3/4-16	210-240 (285-325)
Tube-Type Beam End Nut	2-1/2-12	375-425 (510-575)

Specifications

Description	Size	Torque lbf·ft (N·m)
Fore-and-Aft Torque Rod Mount Nut	—	95 (130)

Table 3, Torque Values

General Description

The Hendrickson RT series suspension (**see Fig. 1**) uses leaf springs to lessen road shocks. The forward and rear ends of the spring assembly ride in hangers. At the forward end, the springs are attached to the hanger with pins. At the rear end, the springs have no rigid attachment to the hangers, and are free to move forward and backward to compensate for spring deflection.

The RTE series suspension (**see Fig. 2**) is basically the same as the RT suspension. However, the RTE series uses a different spring assembly and a third spring hanger. This design provides a two-stage spring rate, depending on vehicle load condition. When the vehicle is unloaded, a gap exists between the top spring leaf and the no. 2 spring hanger. The weight of the vehicle is then carried through the no. 3 spring hanger, and most of the spring deflection through the top extended leaves (**see Fig. 3**). When the vehicle is loaded, the top extended leaf contacts the no. 2 spring hanger and the spring weight is carried through the nos. 1 and 2 spring hangers (**see Fig. 4**).

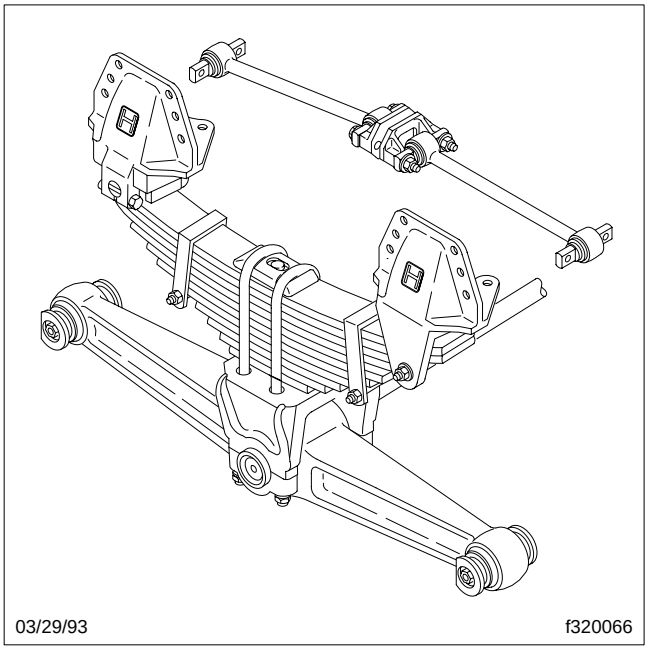


Fig. 1, RT Series Suspension

The RTEA series suspension is similar to the RTE suspension, but the RTEA series uses aluminum equalizer beams instead of steel.

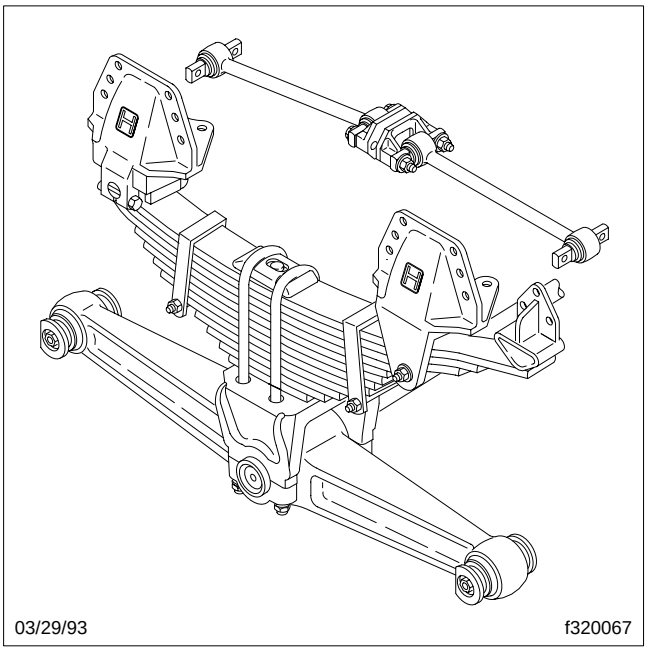


Fig. 2, RTE Series Suspension

CAUTION

CAUTION: Failure to apply Alumilastic® compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the components or parts.

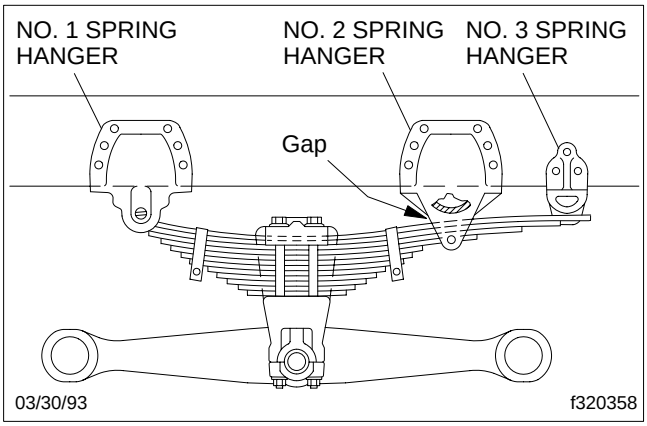


Fig. 3, Unloaded RTE Spring

The axles are attached to beam hangers at the ends of the equalizer beams, allowing an articulating action between the axles to lessen road shock. Torque

General Description

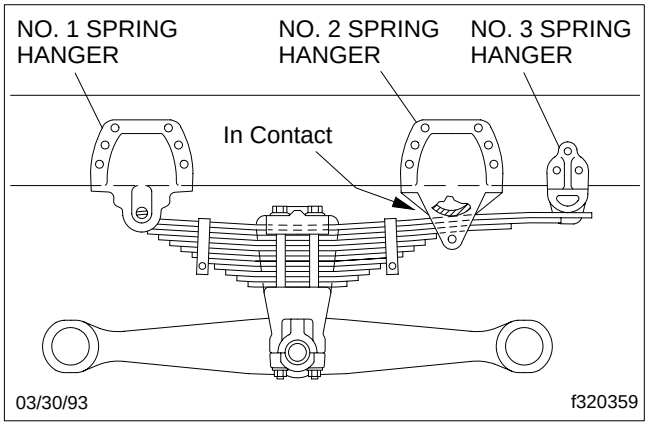


Fig. 4, Loaded RTE Spring

rods, mounted between the axles and frame rails, stabilize axle and vehicle movement caused by accelerating and braking.

All suspension fasteners require periodic tightening. For suspension inspecting, lubricating, and fastener torque checking instructions, refer to the suspension section in the vehicle maintenance manual.

⚠ WARNING

WARNING: Failure to periodically torque the suspension fasteners could result in damage to the frame hangers or separation of components. This could cause a loss of vehicle control, resulting in injury or property damage.

Removal (See Fig. 1)

1. Chock the front tires.
2. Drain the vehicle air system.
3. Disconnect all air lines leading to the rear axles, marking the lines for later assembly

   reference. Plug or cap all lines and fittings to prevent dirt from entering the system.
4. Disconnect the driveline rear universal joint from the forward-rear axle. Then, remove the interaxle driveline. For instructions, refer to the driveline section in this manual.
5. Manually release the spring brake chambers. For instructions, refer to the brake section in this manual.

⚠ WARNING

WARNING: When the torque rods are disconnected from the axle brackets, the axles become free to pivot on the equalizer beam end bushings. Keep clear of the beam hangers and beam ends to avoid possible injury.

6. Remove the torque rods. For instructions, **refer to Subject 170**.
7. Raise the rear of the vehicle so that all weight is removed from the suspension. Then, block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

8. Remove the saddle cap nuts and washers from each side of the vehicle, and remove the saddle caps.

NOTE: If the saddle cap studs are damaged, replace them.

9. Raise the rear of the vehicle frame until there is enough clearance to roll the axles out from under the vehicle. Install safety stands under the frame, then roll the axles—with the equalizer beams attached—out from under the vehicle.

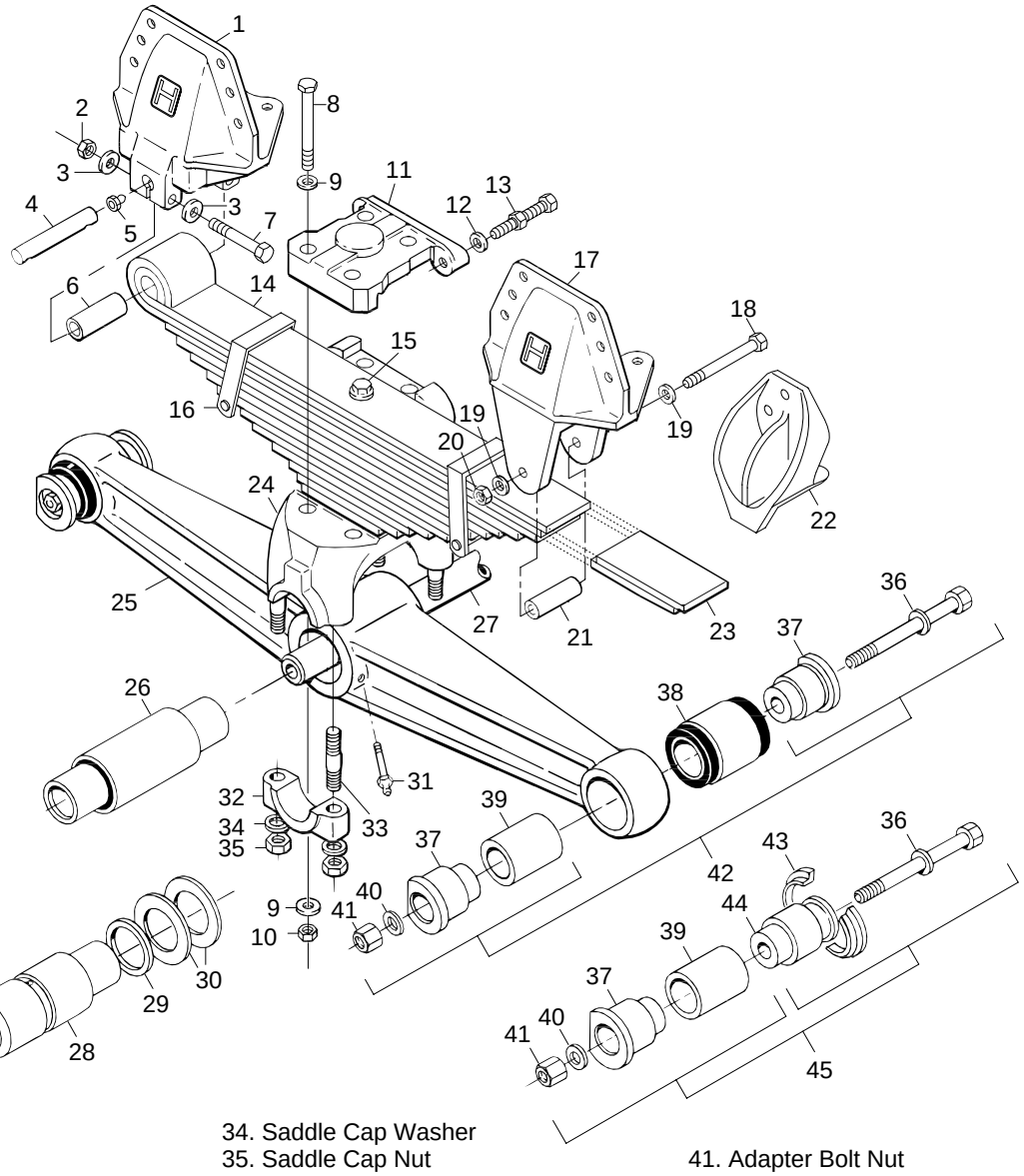
Installation ((See Fig. 1)

1. Roll the axles under the vehicle frame. Align the center bushing of each equalizer beam with the center of the saddle legs.
2. Raise the vehicle frame off the safety stands, then remove the safety stands.
3. Lower the frame, centering the saddles on the beam center bushings.
4. Lubricate the saddle cap studs with SAE 20 oil. Install the saddle caps, washers and new self-locking nuts. Do not tighten.
5. Install the torque rods. For instructions, **refer to Subject 170**.
6. Tighten the saddle cap locknuts 225 to 275 lbf·ft (305 to 373 N·m).

NOTE: Maintain an even gap between the saddle cap and the saddle when tightening the self-locking nuts (**see Fig. 2**).

7. Remove the safety stands from under the frame and axle, and lower the vehicle.
8. Manually reset the spring brake chambers. For instructions, refer to the brake section in this manual.
9. Connect the driveline rear universal joint to the forward-rear axle. Connect the interaxle driveline. For instructions, refer to the driveline section in this manual.
10. Uncap all air lines and fittings, then connect the lines leading to the rear axles.
11. Check the axle pinion angle. For instructions, refer to the driveline section in this manual.

Suspension Removal and Installation



1. Forward (no. 1) Spring Hanger
2. Locknut
3. Washer
4. Spring Pin
5. Grease Fitting
6. Spring Eye Bushing
7. Lock Bolt
8. Top Pad Bolt
9. Top Pad Washer
10. Top Pad Locknut
11. Top Pad
12. Setscrew Washer
13. Setscrew and Locknut
14. Spring Assembly
15. Spring Center Bolt and Nut
16. Spring Alignment Clip
17. Rear (no. 2) Spring Hanger
18. Rebound Spacer Bolt
19. Spacer Bolt Washer
20. Spacer Bolt Locknut
21. Rebound Spacer
22. RTE Rear (no. 3) Spring Hanger
23. RTE Spring Extension
24. Saddle Assembly
25. Equalizer Beam Assembly
26. Rubber Center Bushing
27. Crosstube
28. Bronze Center Bushing
29. Bushing Grease Seal
30. Thrustwashers
31. Grease Fitting (Bronze Bushing)
32. Saddle Cap
33. Saddle Cap Stud
34. Saddle Cap Washer
35. Saddle Cap Nut
36. Adapter Bolt and Washer
37. Adapter
38. End Bushing
39. Intermediate Tube
40. Adapter Bolt Washer
41. Adapter Bolt Nut
42. Adapter−Type End Support Assembly
43. Split−Ring
44. Adapter Plug
45. Split−Ring Adapter Assembly

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Fig. 1, RT and RTE Series (exploded view)

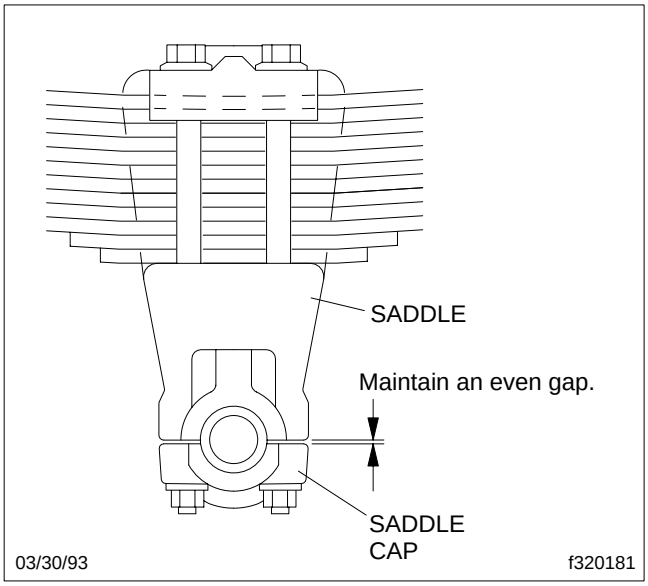


Fig. 2

Removal

1. Remove the suspension. For instructions, **refer to Subject 100**.
2. Support the spring and saddle assembly with a floor jack.
3. Remove the locknuts from the spring pin lockbolts; then remove the lockbolts and washers from the number one spring hanger.
4. Using a suitable drift, drive the spring pin through the no. 1 spring hanger and out the inboard side of the spring hanger (see **Fig. 1**).

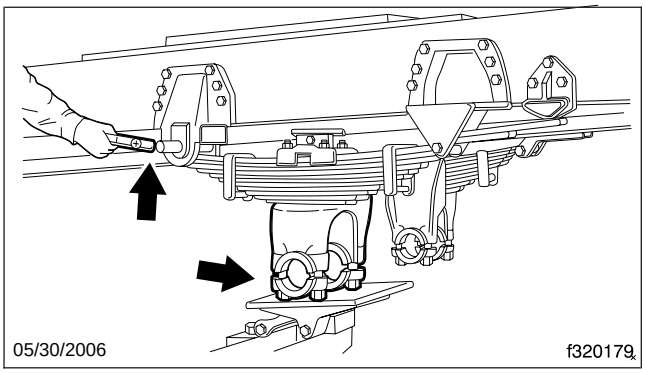


Fig. 1

5. Remove the locknut and lockwasher from the rebound spacer bolt in the no. 2 spring hanger. Remove the rebound spacer bolt and the spacer.

⚠ WARNING

WARNING: The leaf spring assembly is heavy. Use care when handling it to prevent injury.

6. Lower the spring and saddle assembly from the spring hangers.
7. Loosen the spring alignment setscrews on the top pad. Remove the top pad nuts, washers, and bolts.
8. Remove the top pad from the spring assembly, then remove the spring from the saddle.

Installation

1. Seat the leaf spring assembly on the saddle.
2. Position the top pad on the spring assembly. Check that the top pad is properly seated.

NOTE: The main leaf has a cup that is forged upward at the center bolt. This cup serves as a pilot when installing the top pad, and ensures correct alignment of the spring assembly.

3. Lubricate the threads on the top pad bolts with SAE 20 oil, then install the washers and bolts through the top pad and saddle. Install new nuts and washers finger-tight. Do not tighten at this time.
4. Lubricate the threads on the spring setscrews with SAE 20 oil. Hand-tighten the spring setscrews against the leaf springs. Tighten the setscrews 100 to 150 lbf·ft (135 to 203 N·m), then tighten the setscrew locknuts until the lockwasher is locked.
5. Tighten the top pad nuts 275 to 400 lbf·ft (373 to 542 N·m). Use the tightening sequence shown in **Fig. 2**.
6. Position the spring and saddle assembly into the no. 1 and no. 2 spring hangers.

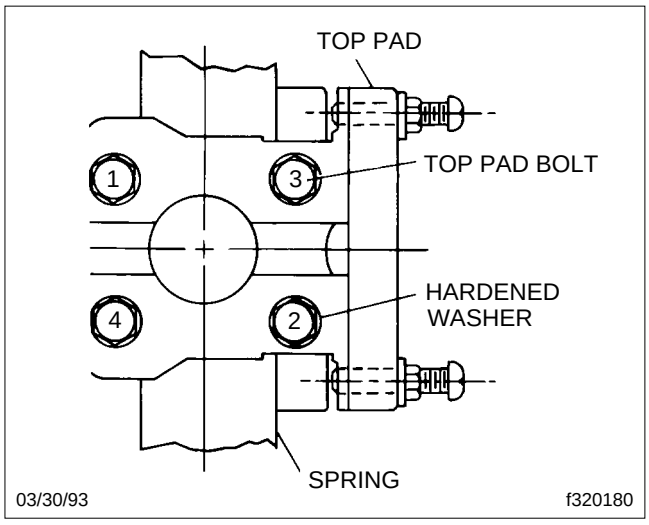


Fig. 2, Top Pad Bolt Tightening Sequence

7. Coat the spring pin and the inside diameter of the spring eye bushing with multipurpose chassis grease.
8. Align the spring pin with the spring eye bushing in the forward spring hanger.
9. From the outboard side of the spring hanger, tap the spring pin into the bushing with a soft hammer. If necessary, adjust the spring to assist spring pin entry.

Spring and Saddle Removal and Installation

10. Place washers on the spring pin lockbolts, and insert the lockbolts through the spring hanger. If necessary, use a screwdriver to turn the spring pin until the lockbolts can slide past it.
11. Lubricate the lockbolt threads with SAE 20 oil. Install the lockwashers and locknuts. Tighten the locknuts 45 to 63 lbf·ft (61 to 85 N·m).
12. Position the rebound spacer in the no. 2 spring hanger leg, then install the rebound spacer bolt, lockwasher, and locknut. Tighten the locknut 38 to 45 lbf·ft (51 to 61 N·m).
13. Install the grease fittings in both spring eye pins. Apply multipurpose chassis grease to the grease fittings until grease appears on both sides of the spring eye bushings.
14. Install the suspension. Refer to **Subject 100** for instructions.

Spring Leaf, Spring Pin, and Spring Eye Bushing Replacement

Replacement

1. Remove the spring and saddle assembly. For instructions, **refer to Subject 110**.
2. Using a C-clamp to hold the spring leaves together, remove the center bolt and nut, and the spring alignment clips. Remove the C-clamp and separate the leaves.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

3. Using a wire brush and solvent, clean all grease, dirt, and rust from the spring leaves. Inspect the spring leaves for cracks, gouges, wear, or abnormal bends. The no. 1 main and no. 2 wrapper spring leaves (the top two spring leaves) may each be replaced; if equipped with the RTE series suspension, the nos. 1, 2, and 3 spring leaves (the top three spring leaves) may each be replaced. If a spring leaf is damaged below these numbers in a pack, replace the spring assembly. Replace both spring assemblies to ensure even spring deflection.
4. Inspect the spring pin and spring eye bushing for wear or damage. If the pin diameter is less than 1.367 inch, replace it. If the inside diameter of the spring eye bushing is more than 1.395 inch, replace it.

NOTE: If necessary, press out the bushing with a hydraulic press. Install the new bushing with the split of the bushing positioned at the top (30 degrees) of the spring eye (**see Fig. 1**).

5. Position the spring leaves in order, then insert a drift through the center bolt hole to align the leaves.
6. Compress the leaves with a C-clamp, then install the spring alignment clips on the spring leaves. Install the spring alignment clip nuts and bolts. Tighten the nuts 15 lbf·ft (20 N·m).
7. Remove the drift punch. At the bottom of the spring, insert a new center bolt. Install a new center bolt nut and tighten to the value in the table under **Specifications, 400**.
8. Install the spring and saddle assembly. For instructions, refer to **Subject 110**.

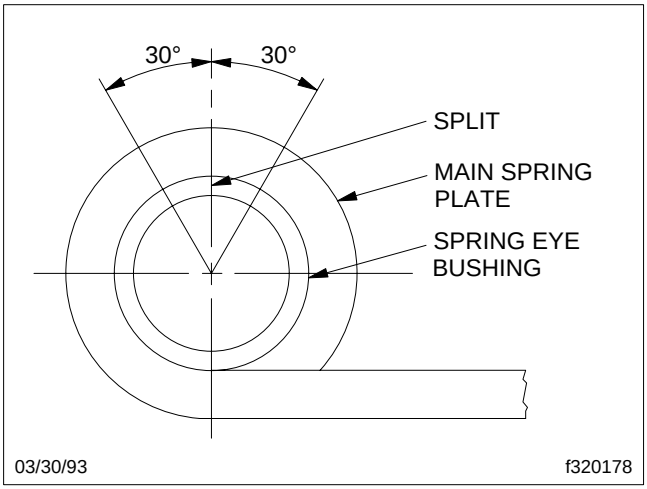


Fig. 1

Equalizer Beam Adapter- and Tube-Type End Support Removal and Installation

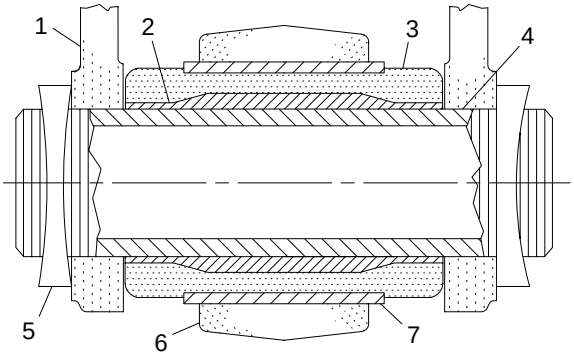
Removal

IMPORTANT: To ensure that the required tools are available, see the table under **Specifications, 400** before beginning these procedures. Special tools are available from the Owatonna Tool Company, Owatonna, Minnesota, or an affiliated dealer. Although these tools are recommended, shop-made adapters can be used if a vertical hydraulic press with a 50-ton capacity is available. Dimensions for the shop-made adapters are provided in the table under **Specifications, 400**.

1. Chock the front tires.
2. Remove the saddle cap nuts and washers, then remove the saddle cap. Support the equalizer beam with safety stands.
3. Raise the rear of the vehicle until the saddle studs clear the equalizer beam. Block the axles and frame with safety stands.
4. Remove the wheels and tires. For instructions, refer to the wheels and tires section in this manual.
5. Remove the brake shoes, brake spider, and brake backing plate (dust shield). Refer to the brake section in this manual for instructions.
6. Apply a penetrating oil to all beam end connections.
7. On a tube-type end support (**see Fig. 1**), remove the tube nuts from both sides of the beam end tube.

   On an adapter-type end support (**see Fig. 2**), remove the nut, washers, and the adapter bolt.
8. If using Owatonna tools, remove the tube-type end supports by positioning the receiving tube over the outboard end of the beam end tube. Position the hydraulic ram, pulling screw, speed nut, and the removing adapter (**see Fig. 3**). Connect a hydraulic pumping unit to the ram, and apply pressure to remove the beam end tube.
9. If using Owatonna tools, remove the adapter-type end supports as follows:

   9.1 Using either a 7/8- or 15/16-inch hand-tap (**see Fig. 4**), tap the adapter bolt hole (outboard side) to a depth of about 1-1/2 inches (38 mm).



1. Axle Beam Hanger
2. Bushing Inner Sleeve
3. Rubber End Bushing
4. Beam End Tube
5. End Tube Nut
6. Equalizer Beam
7. Bushing Outer Sleeve

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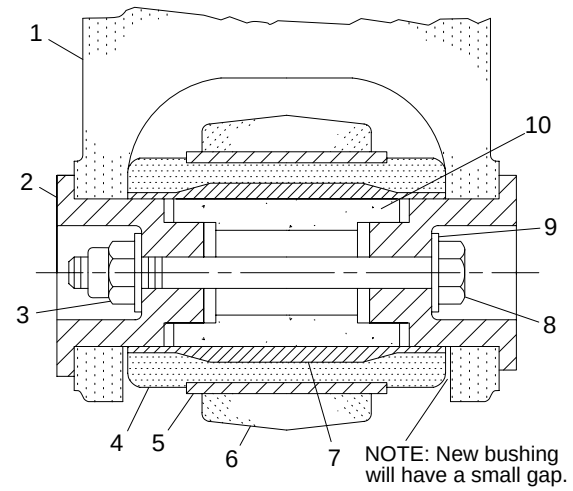
Fig. 1, Equalizer Beam Tube-Type End Support



1. Axle Beam Hanger
2. Adapter
3. Adapter Bolt Nut
4. Rubber End Bushing
5. Bushing Outer Sleeve
6. Equalizer Beam
7. Bushing Inner Sleeve
8. Adapter Bolt
9. Washer (both ends)
10. Intermediate Tube

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Fig. 2, Equalizer Beam Adapter-Type End Support

Equalizer Beam Adapter- and Tube-Type End Support Removal and Installation

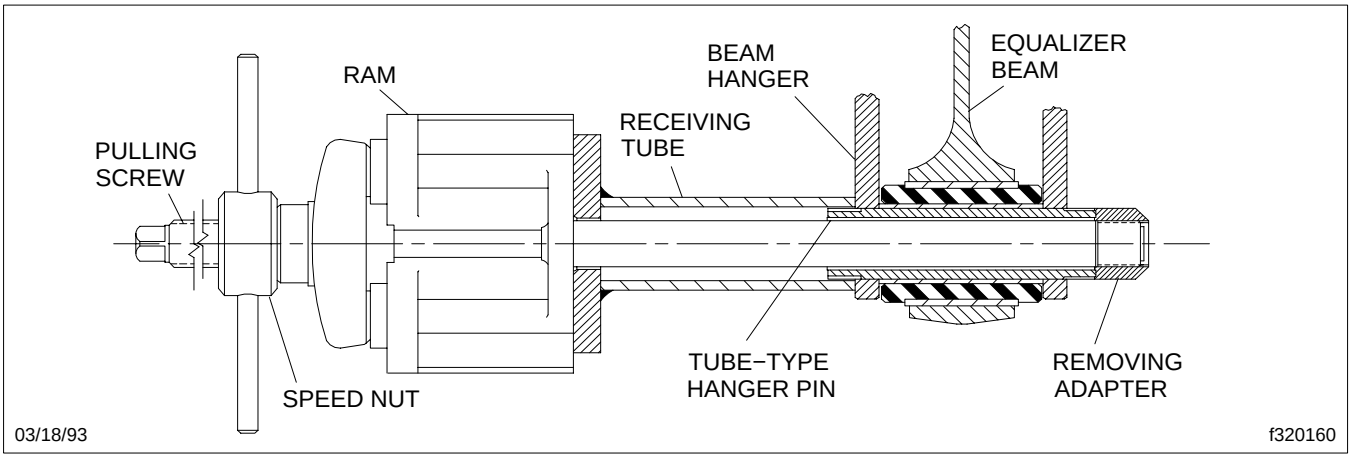


Fig. 3, Tube-Type Beam End Removal

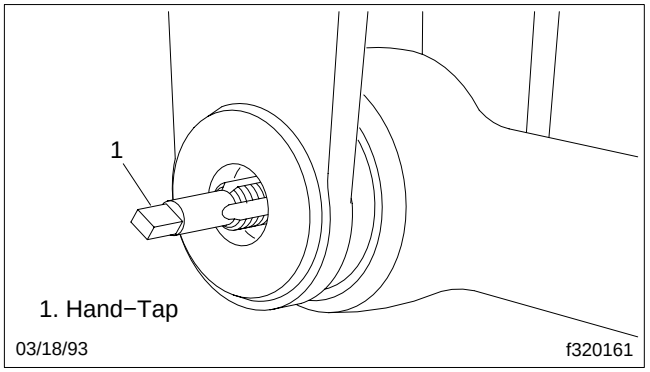


Fig. 4

NOTE: Determine the correct size of hand-tap by using the plug gauge. If the gauge passes through the adapter bolt hole, use a 15/16-inch tap; if it doesn't, use a 7/8-inch tap.

9.2 On the outboard side of the axle, thread the removing screw into the tapped hole. Position the receiving cup and hexnut on the removing screw (**see Fig. 5**). Turn the hexnut until the adapter plug breaks loose and bottoms on the inside of the receiving cup. If needed, add spacers to complete removal of the adapter plug. **See Fig. 6.**

9.3 On the inboard side of the axle, position the receiving cup over the adapter plug. On the outboard side of the axle, insert the removing screw through the receiving cup and secure it with the hexnut. **See Fig. 7.**

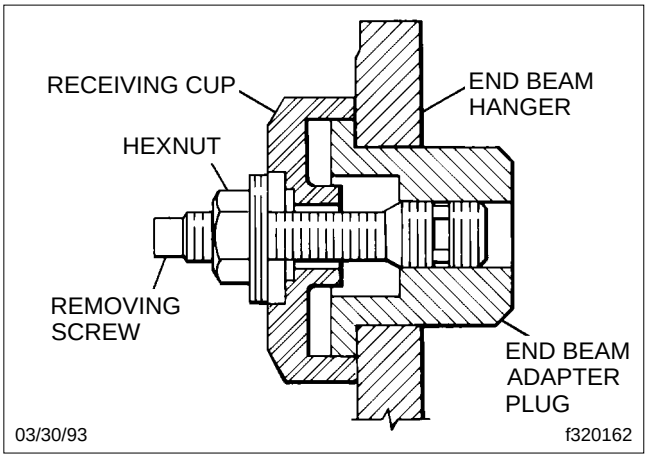


Fig. 5

9.4 Hold the removing screw and turn the nut with a 1-1/2 inch open-or box-end wrench. Turn the nut until the adapter plug bottoms on the inside of the receiving cup.

10. If not using Owatonna tools, remove the end supports as follows:

10.1 For tube-type end supports, install a spacer bushing between one end-tube nut and the beam hanger. Tighten the nut to pull the end tube out of the beam end bushing. If the tube doesn't come loose, use a hacksaw and saw the tube along

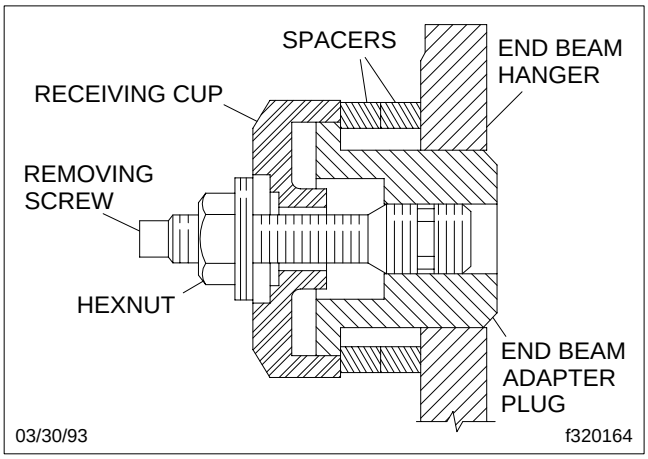


Fig. 6

the inside surface of both axle beam hanger legs.

⚠ WARNING

WARNING: Don't use a cutting torch to remove the equalizer beams from the beam hangers. The equalizer beams are heat-treated, and using a cutting torch could weaken them. This could result in a loss of vehicle control and possible personal injury.

10.2 For adapter-type end supports, a relief is located on each side of the adapter (**see Fig. 8**). Turn the adapter with an air chisel, then insert a chisel into the relief on the inboard adapter. Drive the chisel in and wedge the adapter out of the beam hanger. Do the same on the outboard adapter.

If a split-ring adapter is used, drive a chisel between the two halves to remove the end support plug. Drive the plug into the equalizer beam end bushing until it is clear of the beam hanger. After the equalizer beam is removed, drive the adapter plug out of the bushing.

11. Remove the ends of the equalizer beams from the axle beam hangers.

12. Lower the equalizer beams and the crosstube to the ground. Remove the thrustwashers and pull the beams from the crosstube.

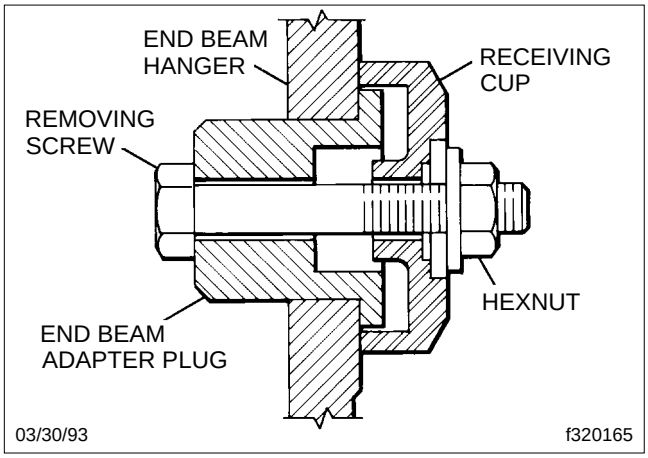


Fig. 7

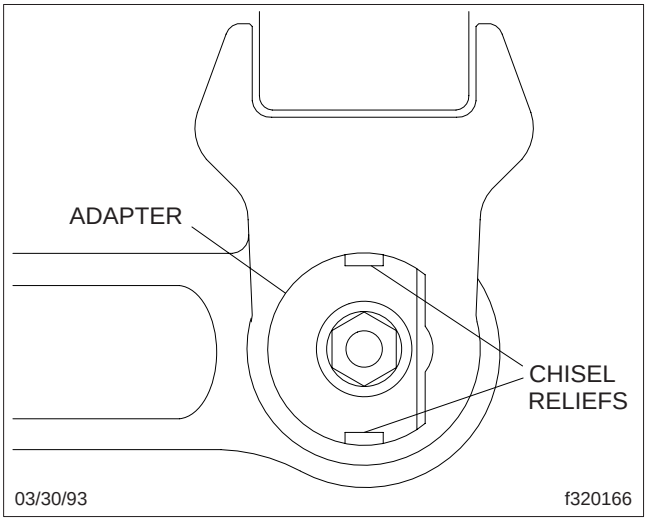


Fig. 8

Installation

1. On adapter-type end supports, apply Texaco Compound L, or an equivalent rust preventive lubricant, to the axle beam hanger eyes, beam end bushing inner sleeve, end support adapters, outside surface of the bushing intermediate tubes, and the ends of the crosstube.

   Install the crosstube and thrustwashers in both equalizer beam center bushings.

   On tube-type end supports, apply Texaco Compound L, or an equivalent rust preventive lubricant, to the axle beam hanger eyes, beam end

Equalizer Beam Adapter- and Tube-Type End Support Removal and Installation

bushing inner sleeve, outer surface of the beam end tubes, beam center bushing inner sleeves, and the ends of the crosstube.

Using SAE 20 oil, lubricate the threads of the beam end tube, then install the crosstube and thrustwashers in both equalizer beam center bushings.

2. Position the equalizer beam assembly under the axles, then raise the assembly and place the forward ends of each beam in the forward-rear axle beam hangers. Align the beam end bushings with the beam hangers.

   On adapter-type end supports, install the intermediate tubes, the adapters, the adapter bolt, washers, and nut in each beam end to hold the beam in the axle beam hangers. Do not tighten.

   On tube-type end supports, install the beam end tubes through the beam hangers and the beam end bushings. Hand-tighten both nuts on the beam end tubes.

3. Place the rear ends of each beam in the rearmost axle beam hangers. Align the beam end bushings with the beam hangers.

   On adapter-type end supports, install the intermediate tubes, the adapters, the adapter bolt, washers, and nut in each beam end to hold the beam in the axle beam hangers. Do not tighten.

   On tube-type end supports, install the beam end tubes through the beam hangers and the beam end bushings. Hand-tighten both nuts on the beam end tubes.

4. Position the saddle caps on the saddle cap studs, then install the washers and new self-locking nuts. Tighten the nuts 225 to 275 lbf·ft (305 to 373 N·m).

5. Tighten the adapter bolt nuts 210 to 240 lbf·ft (285 to 325 N·m). Make sure the flat section of the adapter flange is in the vertical position. **See Fig. 9.**

6. Tighten the end tube nuts 375 to 425 lbf·ft (508 to 576 N·m).

⚠ WARNING

WARNING: The adapter bolt nuts and end tube nuts must be tightened to the values in the previous two steps. If not, the metal surfaces of the end support assembly will rub, and excessive wear to the beam hanger legs and end bushing inner sleeves will occur. This could result in separation of suspension components, loss of vehicle control, and possible injury or property damage.

7. Install the brake backing plate (dust shield), brake spider, and brake shoes. Refer to the brake section in this manual for instructions.

8. Install the wheels and tires. For instructions, refer to the wheels and tires section in this manual.

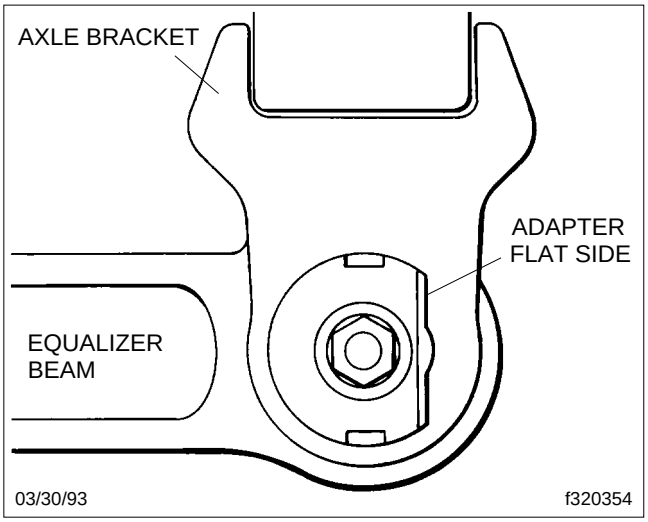


Fig. 9

Equalizer Beam End Bushing Removal and Installation

Removal

⚠ WARNING

WARNING: Don't use a cutting torch to remove the beam end bushing. Equalizer beams are heat-treated by the manufacturer. Using a cutting torch could weaken the beams, and may result in a loss of vehicle control. This could cause personal injury or property damage.

1. Remove the equalizer beam ends from the axle beam hangers. For instructions, **refer to Subject 130**.
2. Cut off the protruding rubber from one side of each beam end bushing (**see Fig. 1**).
3. If using Owatonna tools, remove the beam end bushings as follows (**see Fig. 2**):

   3.1 Install the receiving adapter on the receiving tube.

   3.2 Position the hydraulic ram and slide the pulling screw through the end bushing.

   3.3 Install the end bushing removing adapter on the inboard side of the beam end bushing. Check that the cone-shaped surface of the adapter is facing the equalizer beam.

   IMPORTANT: Align the receiving tube so that the bushing will clear the edges of the tube when force is exerted against the beam. Align the removing adapter so that force is exerted only on the bushing to ensure a clean pull through the beam.

   3.4 Install the hexnut on the pulling screw. Full thread engagement is needed.

   3.5 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

   3.6 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely remove the end bushing.

   NOTE: If the pressure gauge on the hydraulic pumping unit reads 10,000 psi (68 950 kPa) and the bushing has not broken loose, stop and check the alignment of the receiving tool and removal adapter. If both tools are aligned correctly, attach a sledging adapter on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adapter with a heavy hammer. A loud noise followed by a sudden drop of the pressure gauge reading indicate the bushing has broken loose.

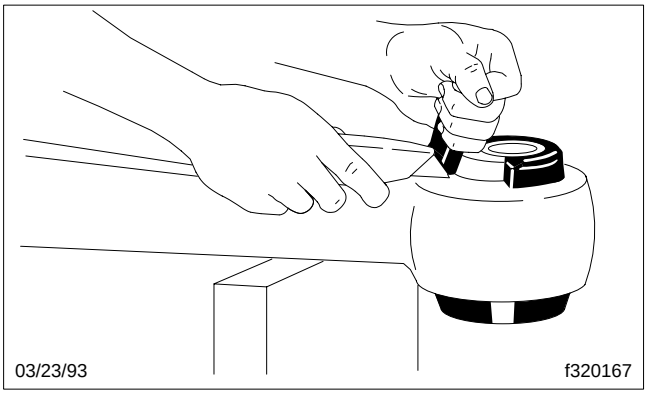


Fig. 1

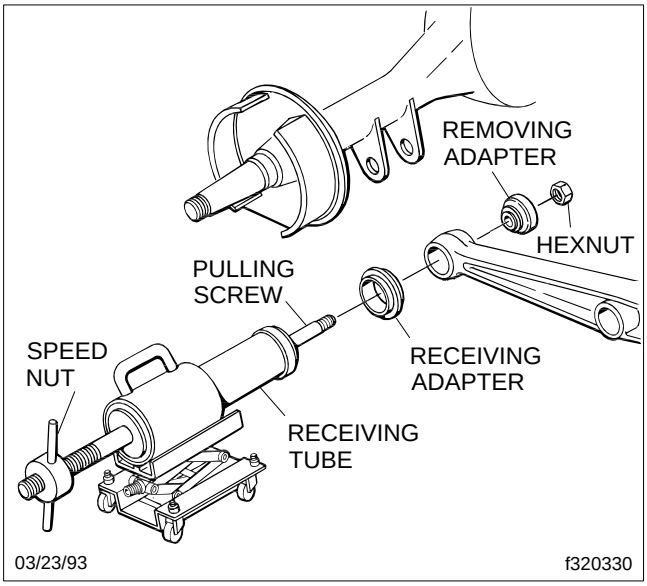


Fig. 2

4. If using shop-made adapters, remove the beam end bushings as follows:

   4.1 Remove the equalizer beams. For instructions, **refer to Subject 130**.

Equalizer Beam End Bushing Removal and Installation

4.2 Position the equalizer beam on a 50-ton vertical hydraulic press.

4.3 Center the shop-made adapter (refer to the table under **Specifications, 400**) on the trimmed end of the equalizer beam bushing. Press the end bushing from the beam eye.

Installation

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.
2. Using emery cloth, clean the outer sleeves of the new equalizer beam end bushings. Apply a thin coating of Texaco Compound L, or an equivalent rust preventive lubricant, to the surface of the outer sleeves on the new bushing.
3. If using Owatonna tools, install the beam end bushings as follows (**see Fig. 3**):

   3.1 Fit the adapter clamp over the exposed rubber on the new bushing. Tighten the clamp nuts until the clamp is flush against the bushing outer sleeve.

   3.2 Install the receiving adapter on the receiving tube.

   3.3 Position the hydraulic ram and slide the pulling screw through the end bushing.

   3.4 Center the adapter clamp and bushing on the inboard side of the beam end.

   3.5 Install the adapter plate and secure it with the hexnut.

   IMPORTANT: Check that the new bushing and the installation tools are centered so that the bushing will clear the receiving tube when force is exerted against the beam.

   3.6 Tighten the speed nut and remove any slack in the assembly.

   3.7 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

   3.8 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely install the end bushing.

   NOTE: The pressure gauge on the pumping unit should read 4000 to 5500 psi (27 580 to 37 920 kPa) during installation. If the reading reaches the operating limit of 10,000 psi (68 950 kPa) and the bushing is not going into the beam end, check the alignment of the bushing, tooling, and hydraulic equipment. Installation is complete when the adapter clamp is flush against the beam.

   3.9 Install the equalizer beam ends on the axle beam hangers. For instructions, **refer to Subject 130**.

4. If using shop-made adapters, install the beam end bushings as follows (**see Fig. 4**):

   4.1 Position the equalizer beam on a 50-ton hydraulic press.

   4.2 Using a sheave puller, compress the exposed rubber of the bushing until the puller jaws are flush against the end of the bushing outer sleeve.

   4.3 Position the shop-made adapter (refer to the table under **Specifications, 400**)

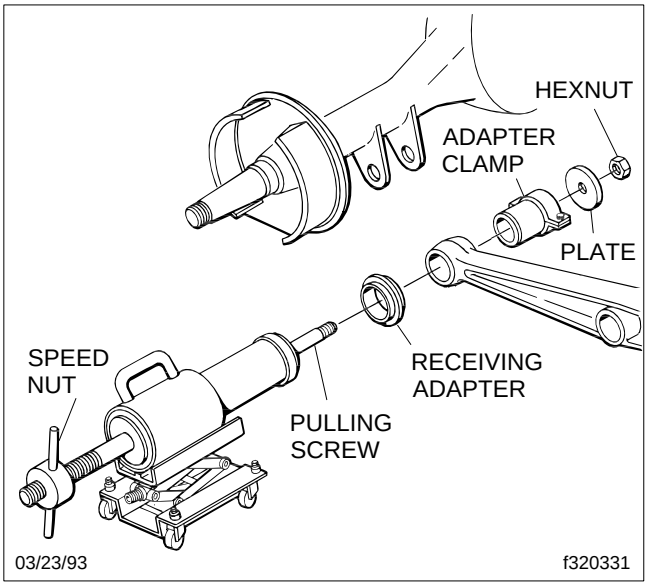


Fig. 3

against the jaws of the sheave puller. Press the new bushing into the beam eye.

4.4 Install the equalizer beam. For instructions, refer to **Subject 130**.

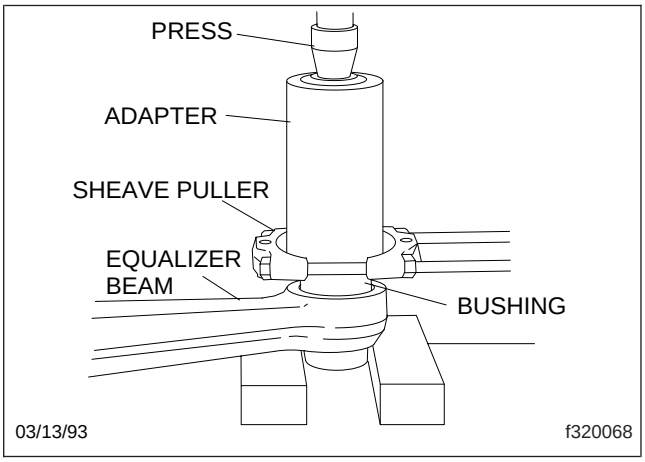


Fig. 4

Equalizer Beam Bar Pin/Bushing Assembly Removal, Installation, and Alignment

Removal

NOTE: From July 1995, most Hendrickson suspensions are manufactured with a bar pin-type bushing assembly that connects the equalizer beam to the axle. The bar pin/bushing assembly can be serviced without removing the brake assembly.

⚠ WARNING

Do not use a cutting torch to remove the equalizer beams from the beam hangers. The equalizer beams are heat-treated, and using a cutting torch could weaken them. This could result in a loss of vehicle control, possible personal injury, or property damage.

1. Shut down the engine and set the parking brake.
2. Chock the front tires.
3. Support the equalizer beams with jack stands.
4. Remove the four bolts attaching the equalizer beam to the saddle.
5. Apply a penetrating oil to the threads of the two 1-inch (25 mm) bolts and locknuts attaching each bar pin/bushing assembly to the axle brackets.
6. Remove the bolts. If the fasteners are rusted in place, an air hammer chisel may be used to loosen the bolts attaching the bar pin/bushing assembly to the axle brackets.

NOTE: The upper torque rods may have to be disconnected at the top of the axle, and the axle rotated to a more vertical position to assist in the removal of the equalizer beam from the axle bracket.

7. Remove the equalizer beam from the axle beam hangers.
8. The bar pin/bushing assemblies can be removed from the equalizer beams with Owatonna tools. To do so, follow Owatonna recommendations.
9. If shop-made tools are used, remove the bar pin/bushing assemblies from the beam ends as follows:
   - 9.1 Position the equalizer beam on a 50-ton vertical hydraulic press.
   - 9.2 Center the shop-made tool, and press the bar pin/bushing assembly from the beam end eye.

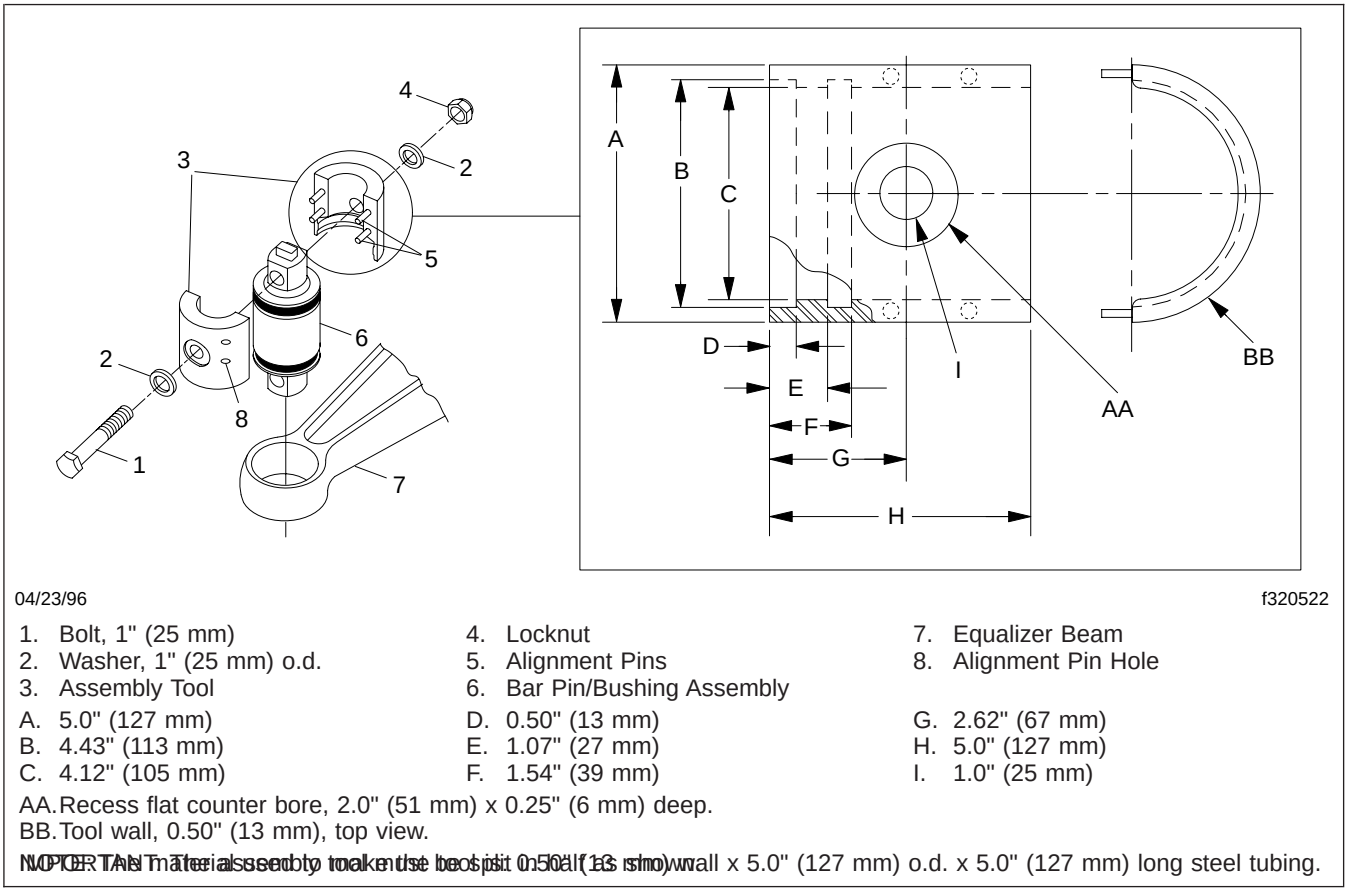
Installation

IMPORTANT: Do not reuse the old fasteners. Replace them during installation.

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.
2. The outer metals of some Hendrickson rubber bushings are covered with a phosphate coating that acts as a rust preventive. This coating must be removed with emery cloth before installation. Also apply a coating of grease to the cleaned outer metals of the bar pin/bushing assembly, and to the beam end eyes to help when pressing the bar pin/bushing assembly into the beam end eye.
3. If using Owatonna tools, install the bar pin/bushing assemblies using Owatonna recommendations.
4. If using shop-made tools, create the needed assembly tool from a 5-inch (127 mm) length of 5-inch (127 mm) O.D. steel tubing with 1/2-inch (13 mm) wall thickness. See **Fig. 1**. The assembly tool must be split in half, then clamped or bolted together to compress the rubber to allow contact with the bushing outer metal.
   - 4.1 Position the equalizer beam on a 50-ton hydraulic press with the beam end bore squarely supported on the bed for safety and to avoid bending the equalizer beam.
   - 4.2 Before pressing the bar pin/bushing assembly, align the holes in the end of the bar pin/bushing assembly with the center line of the equalizer beam. This will help assembly into the axle brackets. Care should be taken during the assembly process to ensure the orientation of the bar pin/bushing assembly in the beam eye.

   NOTE: After installation, verify that the bar pin/bushing assembly is centered in the end of the beam.

Equalizer Beam Bar Pin/Bushing Assembly Removal, Installation, and Alignment



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1. Bolt, 1" (25 mm)
2. Washer, 1" (25 mm) o.d.
3. Assembly Tool
4. Locknut
5. Alignment Pins
6. Bar Pin/Bushing Assembly
7. Equalizer Beam
8. Alignment Pin Hole

A. 5.0" (127 mm)
B. 4.43" (113 mm)
C. 4.12" (105 mm)
D. 0.50" (13 mm)
E. 1.07" (27 mm)
F. 1.54" (39 mm)
G. 2.62" (67 mm)
H. 5.0" (127 mm)
I. 1.0" (25 mm)

AA. Recess flat counter bore, 2.0" (51 mm) x 0.25" (6 mm) deep.
BB. Tool wall, 0.50" (13 mm), top view.
NOTE: Tool material used to make tool is 0.50" (13 mm) wall x 5.0" (127 mm) o.d. x 5.0" (127 mm) long steel tubing.

Fig. 1, Assembly Tool (exploded view, with manufacturing information)

5. Install the equalizer beam on the axle hangers.
6. Attach the bar pin/bushing assembly to the axle brackets. Tighten the 1-inch (25 mm) bolts 450 to 600 lbf·ft (610 to 813 N·m).

NOTE: Bar pin/bushing assembly kits are available with or without alignment shims.

7. Install the four bolts attaching the equalizer beam to the saddle. Tighten 225 to 275 lbf·ft (305 to 375 N·m).
8. Remove the jack stands.
9. Remove the chocks from the tires.

Alignment

For a detailed adjustment procedure, refer to Hendrickson's service literature, **Bar Pin Alignment Instructions, Technical Publication No. 17730-213**.

The instruction publication may be obtained from:

Hendrickson Truck Suspension Systems
1-630-910-2800
1-800-973-0360
(fax) 1-630-378-4849
800 South Frontage Road
Woodridge, IL 60517-4904

Equalizer Beam Rubber Center Bushing Removal and Installation

Removal

NOTE: If using Owatonna tools, removal of the equalizer beam is not required for removal or installation of the rubber center bushing.

1. Chock the front tires.
2. Raise the rear of the vehicle so that all weight is removed from the suspension. Block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

3. Remove the saddle cap nuts and washers from each side of the vehicle, and remove the saddle caps.
4. Raise the rear of the truck frame until the saddle studs clear the equalizer beam. Install safety stands under the frame.
5. Using a 2-1/2 inch diameter hole saw (**see Fig. 1**), cut out the end plug from the center bushing on each side of the suspension, and remove the crosstube.

⚠ CAUTION

CAUTION: Do not use a cutting torch to burn out the end plugs. The equalizer beams are heat-treated, and the use of a cutting torch could weaken the beam.

6. On the inboard side of the equalizer beam, inspect the exposed edge of the bushing's outer sleeve.
7. Chisel or grind off any portion of the outer sleeve that has flared over the surface of the equalizer beam.
8. If using Owatonna tools, remove the rubber center bushings as follows (**see Fig. 2**):

    8.1 Position the hydraulic ram and slide the pulling screw through the center bushing.

    8.2 Install the center bushing removing adapter on the inboard side of the beam eye.

    IMPORTANT: Align the receiving tube so that the bushing will clear the edges of the tube when force is exerted against the beam. Align the removing adapter so that force is exerted only on the bushing to ensure a clean pull through the beam.

    8.3 Install the hexnut on the pulling screw. Full thread engagement is needed.

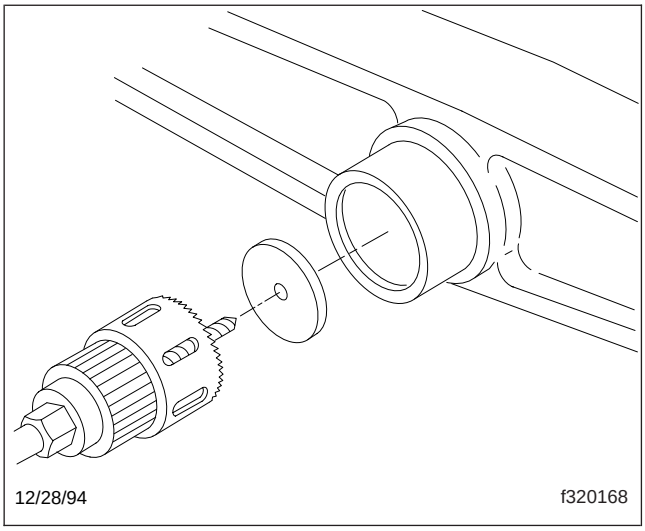


Fig. 1

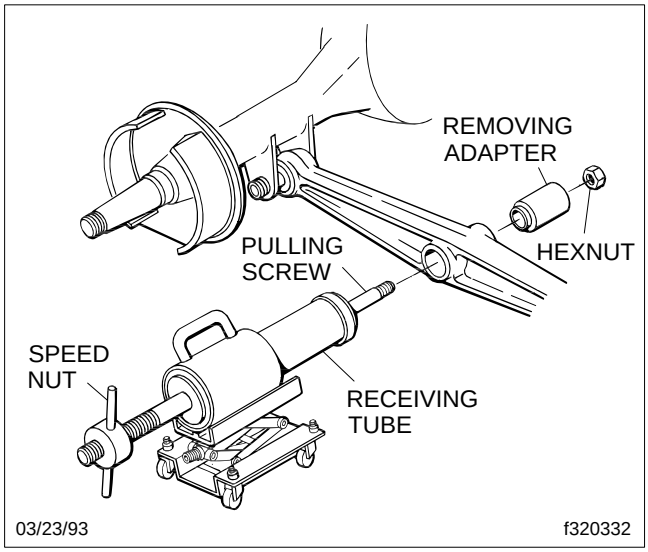


Fig. 2

Equalizer Beam Rubber Center Bushing Removal and Installation

8.4 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

8.5 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

8.6 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely remove the bushing.

NOTE: If the pressure gauge on the hydraulic pumping unit reads 10,000 psi (68 950 kPa) and the bushing has not broken loose, stop and check the alignment of the receiving tool and removal adapter. If both tools are aligned correctly, attach a sledging adapter on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adapter with a heavy hammer. A loud noise followed by a sudden drop of the pressure gauge reading indicate that the bushing has broken loose.

9. If using shop-made adapters, remove the equalizer beams. For instructions, refer to **Subject 130**.

9.1 Position the equalizer beam on a 50-ton vertical hydraulic press.

9.2 Center the shop-made adapter (refer to the table under **Specifications, 400**) on the trimmed end of the equalizer beam bushing. Press the center bushing from the beam eye.

Installation

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.

2. Using emery cloth, clean the outer sleeves of the new equalizer beam center bushings. Apply a thin coating of Texaco Compound L, or an equivalent rust preventive lubricant, to the surface of the outer sleeves on the new bushing.

3. If using Owatonna tools, install the rubber center bushings as follows (**see Fig. 3**):

3.1 Center the hydraulic ram and slide the pulling screw through the beam eye.

3.2 Position the bushing on the inboard side of the beam eye.

IMPORTANT: Center the new bushing to ensure a clean pull through the beam eye.

3.3 Fit the installing adapter over the inner sleeve and against the outer sleeve of the bushing.

3.4 Install the hexnut on the pulling screw. Full thread engagement is needed.

3.5 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

3.6 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

3.7 Release the pressure, add spacers, and tighten the speed nut. About

three adjustments are needed to completely install the center bushing.

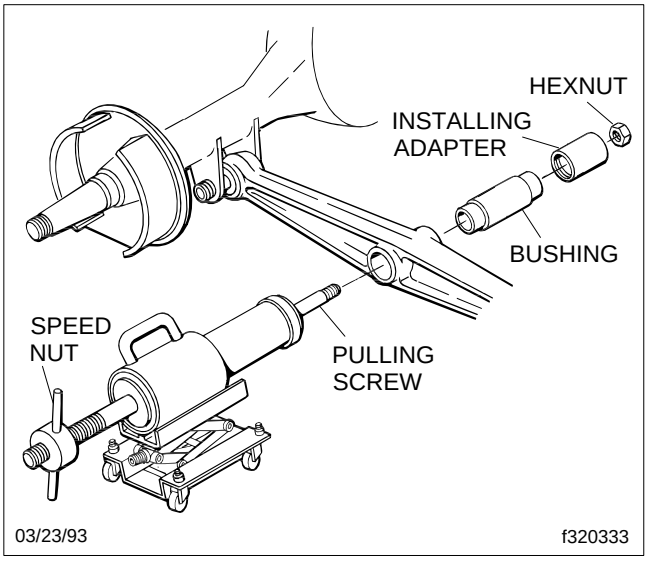


Fig. 3

NOTE: The pressure gauge on the pumping unit should read 4000 to 5500 psi (27 580 to

37 920 kPa) during installation. If the reading reaches the operating limit of 10,000 psi (68 950 kPa) and the bushing is not going into the beam, check the alignment of the bushing, tooling, and hydraulic equipment. Installation is complete when the installing adapter is flush against the beam.

3.8 Position the crosstube in the center bushings.

⚠ WARNING

WARNING: Wear protective welding masks and gloves when welding. Failure to do so could result in personal injury due to the intensity of heat, sparks, and flying debris from the welding process.

3.9 Arc weld new end plugs to the tire side of each center bushing inner sleeve.

NOTE: Heat from welding the end plugs will not affect the beam or the new rubber bushings because of their distance from the point of welding.

4. Position the saddle caps on the saddle cap studs, then install the washers and new self-locking nuts. Tighten the nuts 225 to 275 lbf·ft (305 to 373 N·m).

5. If using shop-made adapters, position the equalizer beam on a 50-ton hydraulic press.

   5.1 Using standard center bushings with the end plugs welded in place, position the shop-made adapter (refer to the table under **Specifications, 400"**) over the inner sleeve of the bushing. Check that the adapter bottoms against the bushing outer sleeve, then press the new bushing into the beam eye.

   5.2 Install the equalizer beams. For instructions, **refer to Subject 130**.

Equalizer Beam Bronze Center Bushing Removal and Installation

Removal

NOTE: If using Owatonna tools, you can remove or install the bronze center bushing without removing the equalizer beam.

1. Chock the front tires.
2. Raise the rear of the vehicle so that all weight is removed from the suspension. Block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

3. Remove the saddle cap nut and washers from each side of the suspension, and remove the saddle caps.
4. Raise the rear of the truck frame until the saddle studs clear the equalizer beam. Install safety stands under the frame.
5. Using a 2-1/2 inch diameter hole saw, cut out the retaining disk from the center bushing on each side of the suspension, and remove the cross-tube.

⚠ CAUTION

CAUTION: Do not use a cutting torch to burn out the retaining disk. The equalizer beams are heat treated, and the use of a cutting torch could weaken the beam.

6. If using Owatonna tools, remove the bronze center bushing as follows (**see Fig. 1**):
   - 6.1 Position the hydraulic ram and slide the pulling screw through the center bushing.
   - 6.2 Install the center bushing removing adapter on the inboard side of the beam eye.

   IMPORTANT: Align the receiving tube so that the bushing will clear the edges of the tube when force is exerted against the beam. Align the removing adapter so that force is exerted only on the bushing to ensure a clean pull through the beam.
   - 6.3 Install the hexnut on the pulling screw. Full thread engagement is needed.

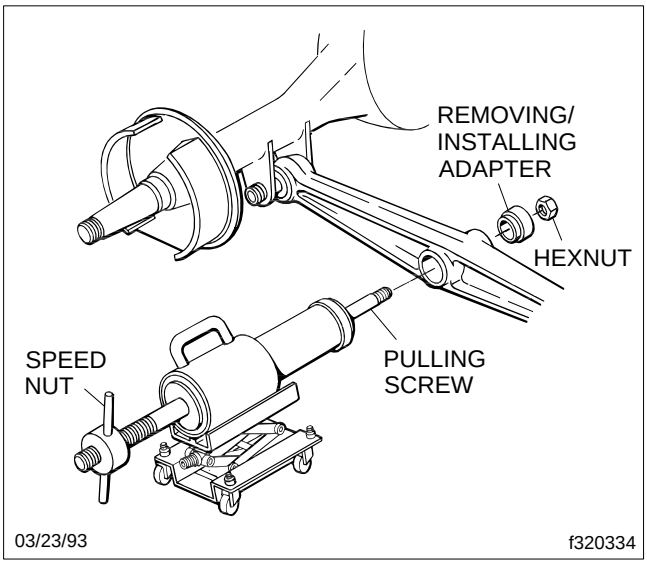


Fig. 1

   - 6.4 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.
   - 6.5 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.
   - 6.6 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely remove the center bushing.

   NOTE: If the pressure gauge on the hydraulic pumping unit reads 10,000 psi (68 950 kPa) and the bushing has not broken loose, stop and check the alignment of the receiving tool and removal adapter. If both tools are aligned correctly, attach a sledging adapter on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adapter with a heavy hammer. A loud noise followed by a sudden drop of the pressure gauge reading indicate that the bushing has broken loose.
7. If using shop-made adapters, remove the equalizer beams. For instructions, refer to **Subject 130**.

Equalizer Beam Bronze Center Bushing Removal and Installation

7.1 Position the equalizer beam on a 50-ton vertical hydraulic press.

7.2 Center the shop-made adapter (refer to the table under **Specifications, 400**) on the center bushing. Press the bushing from the beam eye.

Installation

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.
2. Using emery cloth, clean the outer sleeves of the new equalizer beam center bushings. Apply a thin coating of Texaco Compound L, or an equivalent rust preventive lubricant, to the surface of the outer sleeves on the new bushing, and to the inside surface of the beam eye.
3. Position the bushing on the equalizer beam eye.
4. If using Owatonna tools, install the bronze center bushings as follows (**see Fig. 2**):

4.1 Center the hydraulic ram and slide the pulling screw through the beam eye.

4.2 Position the bushing on the inboard side of the beam eye. Check that the grooves of the bushing are aligned with the vertical centerline of the equalizer beam (**see Fig. 3**).

4.3 Fit the installing adapter and the removing/installing adapter against the outer sleeve of the bushing. Make sure the deep ridge on the installing adapter is positioned against the bronze bushing (**see Fig. 4**).

4.4 Install the hexnut on the pulling screw. Full thread engagement is needed.

4.5 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

4.6 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

4.7 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely install the center bushing.

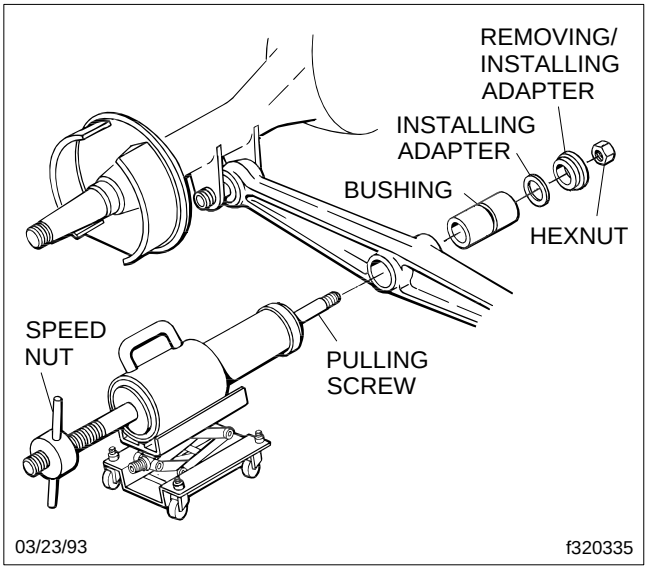


Fig. 2

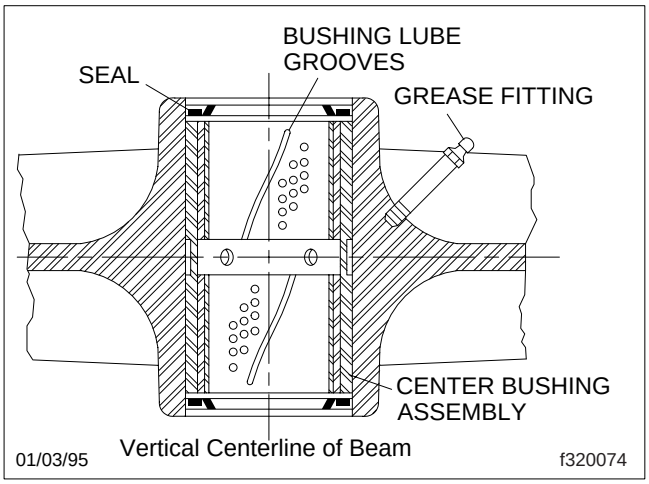


Fig. 3

NOTE: The pressure gauge on the pumping unit should read 4000 to 5500 psi (27 580 to 37 920 kPa) during installation. If the reading reaches the operating limit of 10,000 psi (68 950 kPa) and the bushing is not going into the beam, check the alignment of the bushing, tooling, and hydraulic equipment. Installation is complete when the installing adapter is flush against the beam.

Equalizer Beam Bronze Center Bushing Removal and Installation

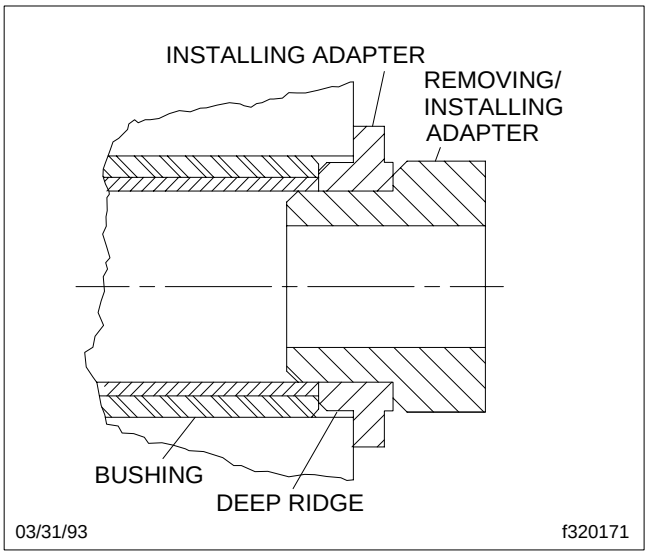


Fig. 4

4.8 On the inboard side of the beam, position a grease seal and installing adapter against the center bushing. Make sure the shallow end of the adapter is against the grease seal (**see Fig. 5**). Using a hammer, tap the installing adapter until it is flat against the beam. Using the same procedure, install a grease seal on the outboard side of the beam.

5. If using shop-made adapters, position the equalizer beam on a 50-ton hydraulic press.

   5.1 Center the new bushing in the beam eye. Using a standard bushing driver, press the bushing in until there is equal spacing between both bushing ends and the sides of the beam eye.

   5.2 Install the new grease seals (with the seal lips facing out).

   NOTE: Check that the new seals are 1/6 inch (4 mm) inside the beam hub surface to ensure clearance and protection of the seals when the saddle cap is installed.

6. Apply a thin coating of multipurpose chassis grease to the inside surface of the center bushing. Slide the bushing center sleeve into the bushing.

7. Install the grease fitting into the beam hub. Rotate the center sleeve and apply multipurpose chassis grease in the grease fitting. Lubricate until clean grease appears at both ends of the grease seals.

8. Install the crosstube.

9. Install the saddle caps or the equalizer beam (if removed) on the axle beam hangers. For instructions, **refer to Subject 130**.

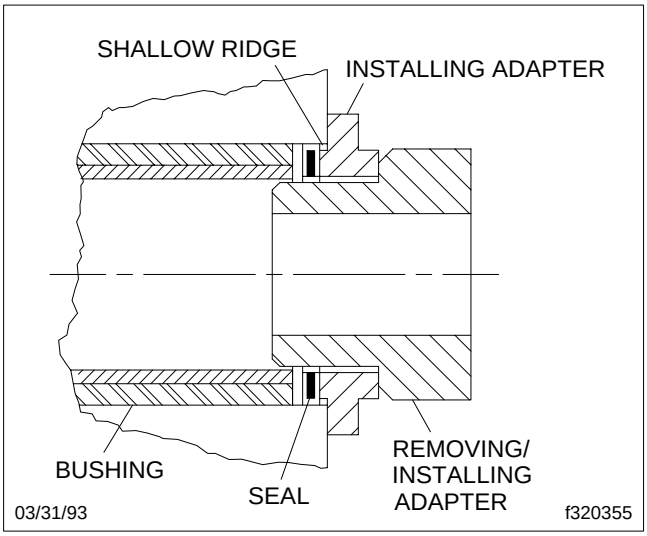


Fig. 5

Torque Rod and Bushing Removal and Installation

Removal

IMPORTANT: To ensure that the required tools are available, see the table under **Specifications, 400**, before beginning these procedures. Special tools are available from the Owatonna Tool Company, Owatonna, Minnesota, or an affiliated dealer.

⚠ WARNING

WARNING: When the torque rods are disconnected from the axle brackets, the axles become free to pivot on the equalizer beam end bushings. Keep clear of the beam hangers and beam ends to avoid possible injury.

1. On fore and aft torque rods, remove the flanged bolts and nuts from the torque rod axle brackets, and the crossmember mounting brackets (**see Fig. 1**). Remove the torque rods.

   On transverse torque rods, remove the nuts and washers from the axle brackets, and remove the flanged bolts and nuts from the frame rail mounting brackets (**see Fig. 1**). Remove the torque rods.

NOTE: If necessary, use an impact hammer and tap the top of the axle bracket to disengage the rod stud from the axle bracket.

2. Inspect the torque rods. If bent or cracked, replace. Check the torque rod bushings. If one of the bushings is loose or damaged, replace both of the bushings.
3. Position the press plate on the hydraulic press. Check that the small counterbore of the plate hole is facing up.

NOTE: Some tapered stud torque rod bushings have a large non-removable washer on the stud that will not fit though the press plate hole. Loosen the press plate capscrews and separate the halves (**see Fig. 2**) until the washer clears the counterbore, and the torque rod sets on the press plate. Tighten the capscrews until the press plate halves are closed.

4. Position the tapered stud removal tool (using the end with the larger inside diameter) on the torque rod stud. Apply lubricating oil (**see Fig. 3**), then press the stud out of the bushing.
5. Position the bushing remover/replacer tool (using the end with the larger outside diameter) on the bushing. Install the cap, then apply lubricating oil to the torque rod bushing.
6. Press the rubber bushing out of the torque rod eye.
7. Position the straddle mount end of the torque rod into the hole of the press plate. Tighten the press plate capscrews.
8. Position the straddle mount pin remover on the straddle mount pin (**see Fig. 4**).
9. Apply lubricating oil to the straddle mount pin. Press the straddle mount pin out of the bushing.
10. Position the end of the rubber bushing remover/replacer tool (using the end that has the larger outside diameter) on the bushing. Install the cap, then apply lubricating oil to the torque rod bushing.
11. Press the rubber bushing out of the torque rod eye.

Installation

1. Remove all dirt and grease from the torque rod ends. Apply lubricant on the new bushings and in the torque rod eyes.
2. Position the press plate on the hydraulic press. Check that the small counterbore of the plate hole is facing up.
3. Position the new bushing on the tapered stud of transverse torque rods. Position the clamp and tighten it to compress the rubber (**see Fig. 5**).
4. Place the torque rod end, the bushing, and the clamp on the press plate.
5. Place the remover/replacer tool (**see Fig. 6**) and cap on top of the clamping tool and press the bushing in the torque rod end. Check that the bushing sleeve protrudes equally on each side of the torque rod end.
6. On straddle mount end assemblies, align the clamping tool on the bushing **as shown in Fig. 7**

Torque Rod and Bushing Removal and Installation

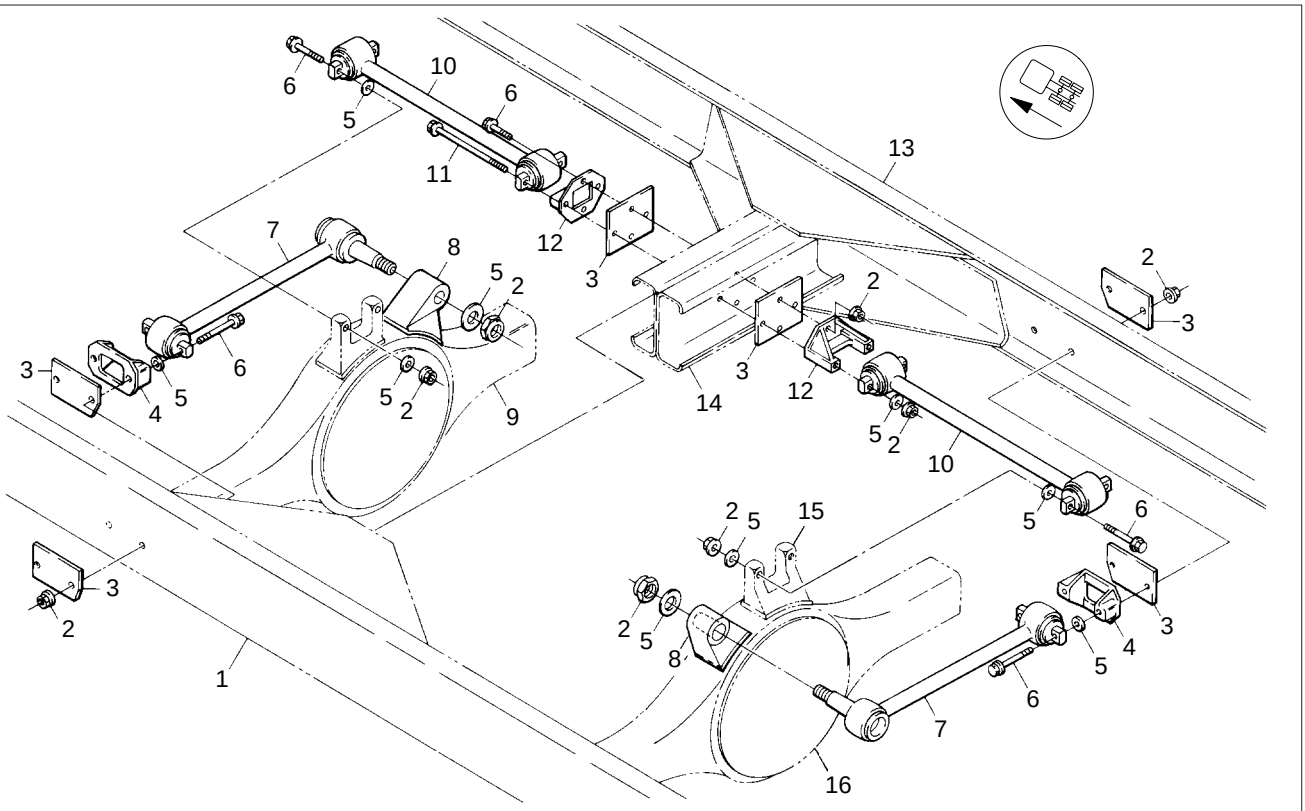


Fig. 1, Torque Rod Mounting Assembly

. Tighten the clamp to compress the rubber of the new straddle mount bushing.

NOTE: When tightening the clamp, make sure that the position of the bushing pin is at a right angle to the center line of the torque rod shank (**see Fig. 8**).

7. Place the torque rod end, the bushing, and the clamp on the press plate.
8. Using the larger end of the remover/ replacer tool, position the tool and cap on top of the clamp assembly.
9. Press the bushing in the torque rod end. Check that the bushing's outer sleeve protrudes equally on each side of the torque rod end.
10. Install the fore and aft torque rods as follows (**see Fig. 1**):

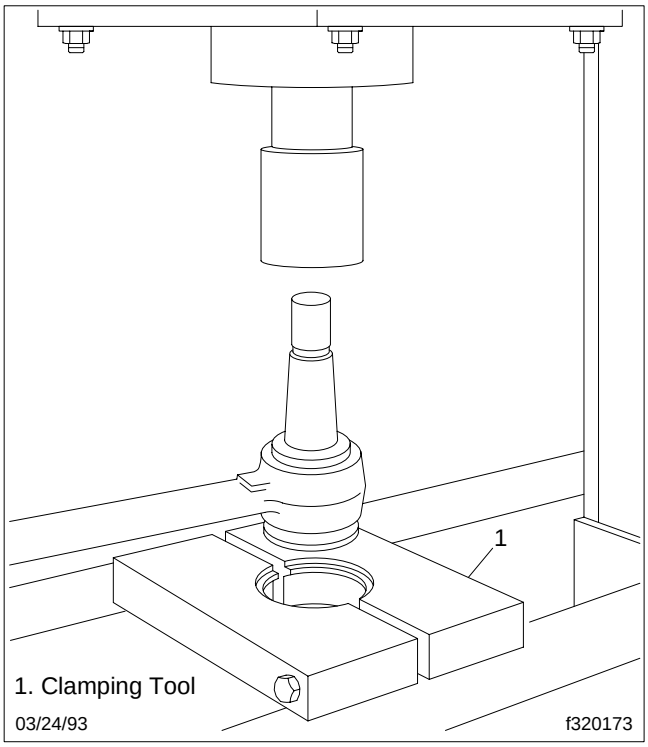


Fig. 2

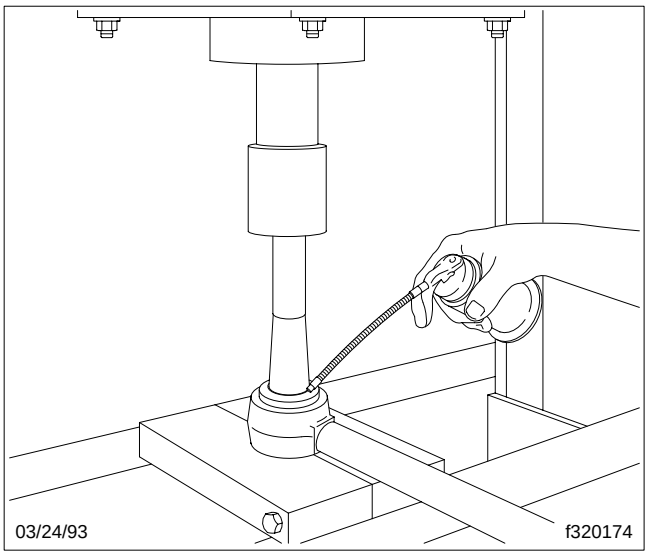


Fig. 3

10.1 Position a torque rod straddle mount pin in the forward-rear axle bracket. Install the flanged bolts through the axle bracket and the straddle mount pin. Install a spacer and nut on each bolt, and tighten 190 lbf·ft (260 N·m).

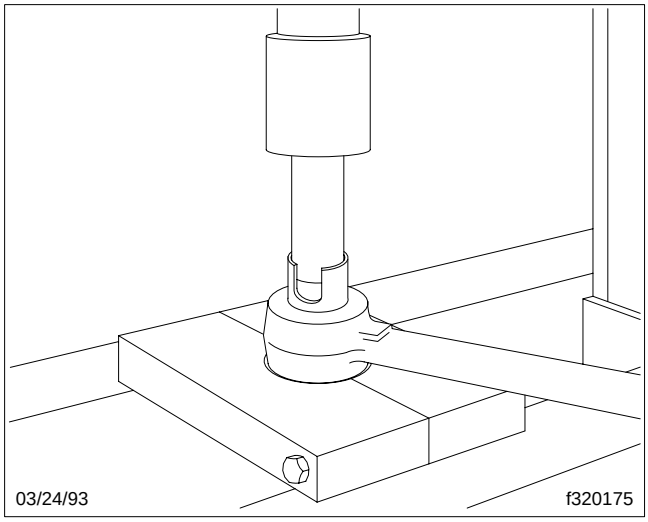


Fig. 4

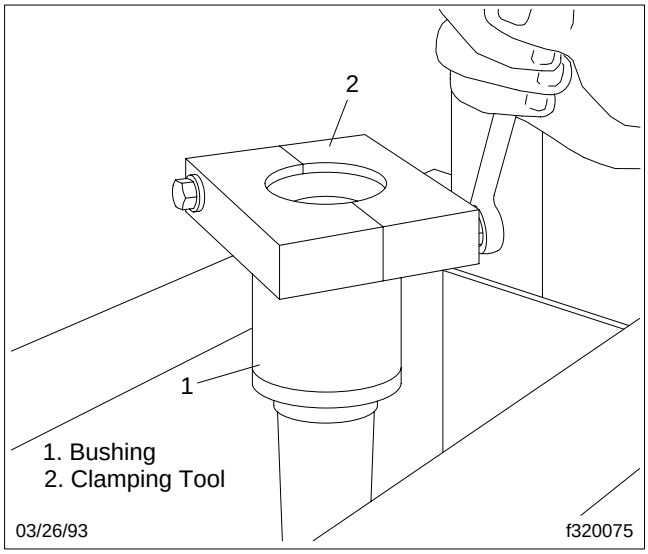


Fig. 5

10.2 Position a torque rod straddle mount pin in the rearmost axle bracket. Install the flanged bolts through the axle bracket and the straddle mount pin. Install a spacer and nut on each bolt, and tighten 190 lbf·ft (260 N·m).

10.3 Position a torque rod spacer and straddle mount bracket on each side of the cross-

Torque Rod and Bushing Removal and Installation

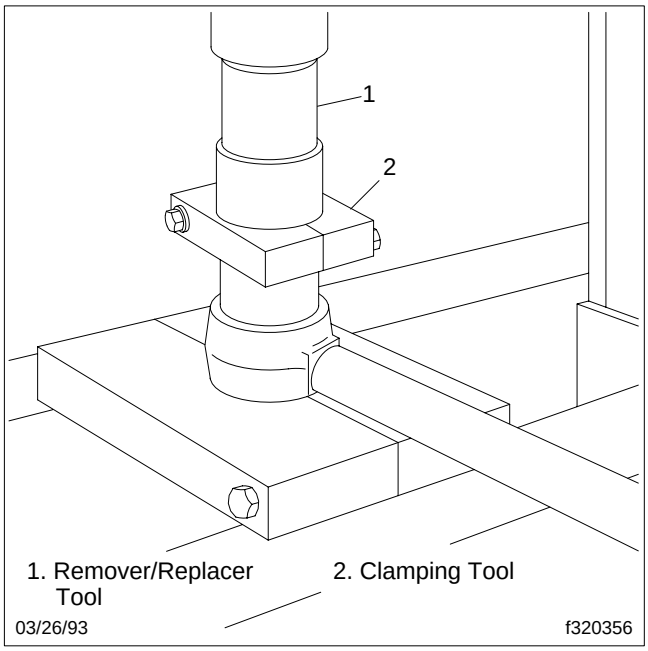


Fig. 6

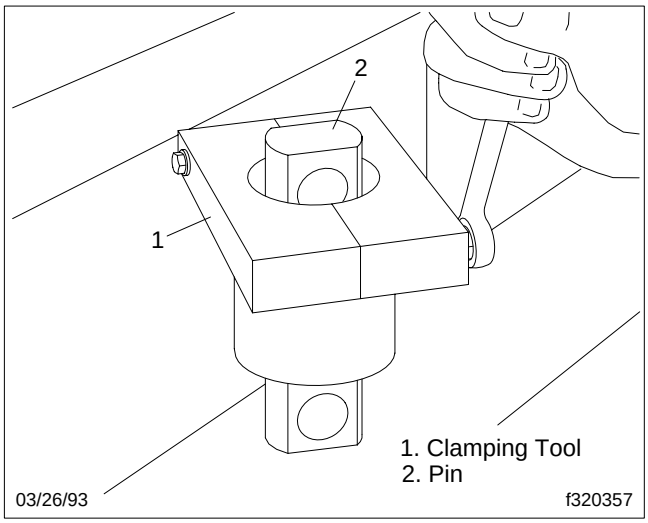


Fig. 7

member. Insert bolts through the upper and lower holes of the forward mounting bracket. Install nuts and tighten 95 lbf·ft (130 N·m).

10.4 Position the straddle mount pin of the forward torque rod in the mounting bracket. Insert bolts through the forward pin, both bracket assemblies, and the straddle

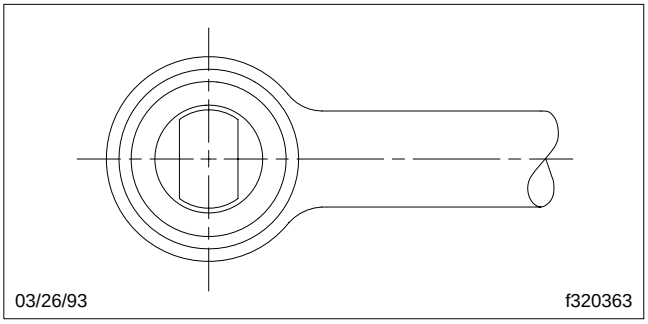


Fig. 8

mount pin of the rear torque rod. Install the nuts and bearing washers. Tighten the nuts 190 lbf·ft (260 N·m).

11. Install the transverse torque rods as follows (**see Fig. 1**):

    11.1 Check that the tapered stud end and the tapered stud bracket hole are clean. Lubricate the tapered stud ends with SAE 20 oil.

    11.2 Install the tapered stud in the axle bracket. Install a washer and nut. Tighten the nut 175 to 225 lbf·ft (235 to 305 N·m).

    11.3 Align the straddle mount end, the mounting bracket, and the spacer against the inside frame rail.

    11.4 On the inboard side of the frame rail, install the bolts through the mounting assembly and the frame rail.

    11.5 On the outboard side of the frame rail, install a spacer over the mounting bolt studs. Install the nuts and tighten them 190 lbf·ft (260 N·m).

12. Check the axle pinion angle. For instructions, refer to the driveline section in this manual.

Part Number	Tool	Usage
1745	Adapter Puller Set	Adapter-Type End Support Removal
1761	Torque Rod Set	Torque Rod Bushing Removal and Installation
28536	Installing Adapter (5-3/4" o.d.)	Bronze Center Bushing and Seal Removal and Installation
44119	Receiving Tube	Center and End Bushing Removal and Installation
45052	Adapter Clamp	End Bushing Installation
51678	80-Ton Hydraulic Ram	All Operations
51695	Jack	All Operations
206459	Plate	End Bushing Installation
302018	Spacer (3 qty.)	Center and End Bushing Removal and Installation
302019	Receiving Adapter	End Bushing Removal and Installation
302023	Pulling Screw	All Operations
302024	Removing and Installing Adapter	Bronze Center Bushing Removal and Installation
302026	Installing Adapter	Rubber Center Bushing Removal and Installation
302027	Removing Adapter	Rubber Center Bushing Removal and Installation
302028	Hexnut	All Operations
302029	Speed Nut	All Operations
302030	Removing Adapter	End Bushing Removal and Installation

Table 1, Special Tools (Owatonna Tool Company)

Tool Number	Dimensions	Usage
1	4-1/4 inch o.d. by 4 inch	Beam End Bushing Removal
2	4-1/2 inch i.d. by 4 inch	Beam End Bushing Installation
3	4-5/8 inch o.d. by 7 inch	Beam Center Bushing Removal and Installation

Table 2, Shop-Made Adapters

Description	Size	Torque lbf·ft (N·m)
Top Pad to Spring Aligning Setscrew	—	100-150 (135-200)
Top Pad Nut	—	275-400 (375-542)
Spring Pin Locknut	1/2-13	45-63 (61-85)
Torque Rod Straddle Mount Nut	5/8-11	190 (260)
Torque Rod Stud Locknut	1-1/4-12	175-225 (235-305)
Saddle Cap Stud	7/8-14	55-65 (75-90)
Saddle Cap Locknut	7/8-14	225-275 (305-373)
Adapter-Type Beam End Locknut	3/4-16	210-240 (285-325)
Tube-Type Beam End Nut	2-1/2-12	375-425 (508-576)

Specifications

Description	Size	Torque lbf·ft (N·m)
Spring Center Bolt	7/16-20	50-60 (70-80)
	1/2-20	65-75 (90-100)
Rebound Spacer Locknut	1/2-13	38-45 (51-61)
Spring Alignment Clip	—	15 (20)
Fore and Aft Torque Rod Mount Nut	—	95 (130)

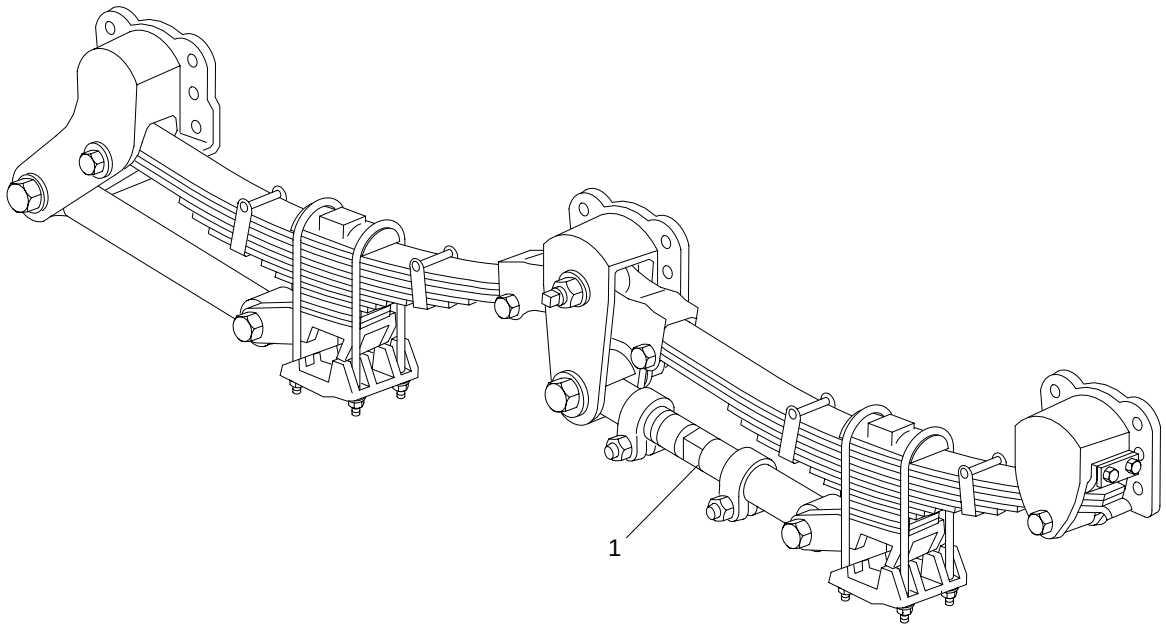
Table 3, Torque Values

General Information

The Reyco suspension has two springs at each side of the vehicle frame. See **Fig. 1**. These springs are supported and held in place by three frame-mounted brackets. The two forward brackets also serve as mounts for the axle radius rod eyes. The middle bracket is a two-piece assembly that supports one end of each tandem spring. The two pieces are fastened together in a pivoting manner, permitting movement of the individual leaf springs as they adjust to varying load and changing road contours. The distribution of the vehicle load is equalized between the axles by the leveling action of this pivoting assembly.

each spring assembly is formed into a hook which catches on a spring roller and rebound bolt to prevent excessive forward movement of the axle if a radius rod breaks.

NOTE: Effective April 1, 1995, Reyco redesigned the adjustable torque end track rod with a lighter weight rod. See **Fig. 2**. Changes in torque values are listed in **Specifications, 400**. Reyco also redesigned the torque arm bushing assembly used on the hanger end of the 102 Series and all spring suspensions.



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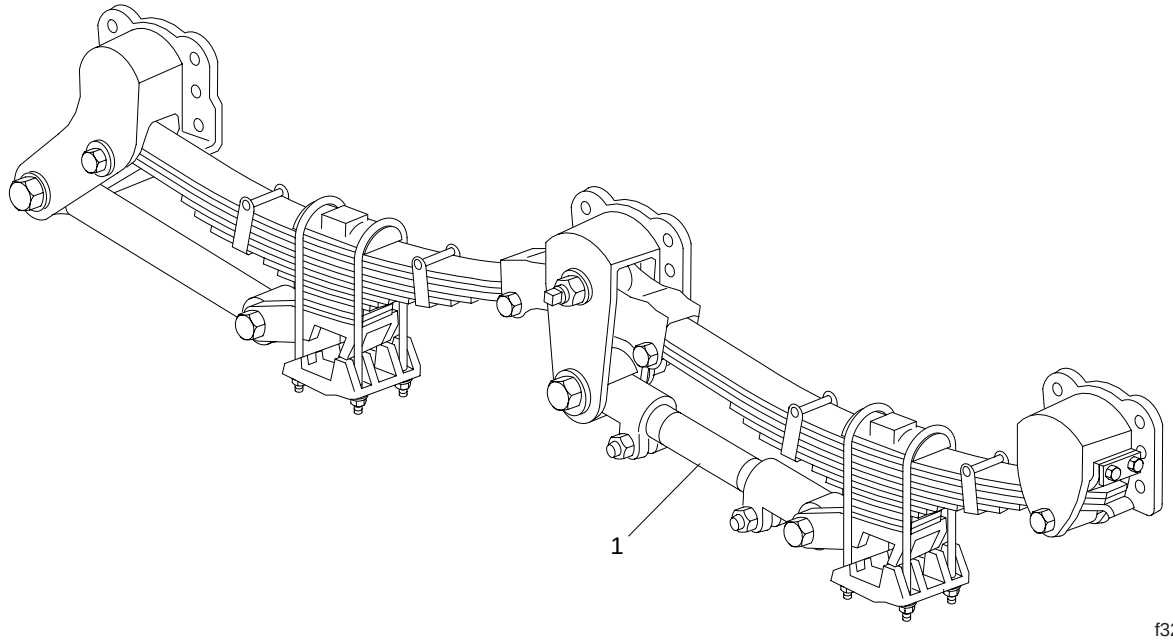
1. Adjustable Torque Tracking Rod

Fig. 1, Reyco Suspension (typical, before April 1, 1995)

Driving and braking forces are transmitted to the vehicle frame through radius rods or torque leaves. Eccentric bushings at the forward end (or eye) of each radius rod permit alignment of each axle independently of the other. A total adjustment of 7/16 inch (11 mm) can be made on each side of the vehicle.

Road shock is cushioned by rubber bushings and cushions at most points of movement. Lubrication of suspension parts is not necessary. The rear end of

General Information



1. Adjustable Torque Tracking Rod

Fig. 2, Reyco Suspension (typical, from April 1, 1995)

Removal

If the suspension system is being overhauled, remove the suspension using the following procedure:

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the front tires.
2. Drain the vehicle air system. Disconnect all air lines leading to the rear axles, marking the lines for later assembly reference. Plug all lines and fittings to prevent dirt or foreign material from entering the lines.
3. Disconnect the driveline rear universal joint from the forward-rear axle. For instructions see **Group 41**.
4. Manually cage the parking brake chambers. For instructions, see **Group 42**.
5. Using an overhead hoist, raise the rear of the vehicle enough to relieve the weight from the suspension. Support the frame and axle with safety stands.

⚠ WARNING

Securely support all axle and frame weight with safety stands during suspension repairs. Unsecured components may drop when fasteners are loosened or removed, causing serious personal injury and component damage.

NOTE: Do not raise the vehicle to the point where the suspension and axles hang from the vehicle.

6. On both sides of the vehicle, remove the forward-rear spring bracket rebound bolt, spring roller, radius rod eye bolt, large flatwashers, and eccentric rubber bushings. See **Fig. 1**.

NOTE: The radius rod eye bushing is a two-piece unit. Insert a punch into the inside of the bushing and drive out one side of the bushing. Insert the punch from the opposite side to remove the remaining half of the bushing.

7. On both sides of the vehicle, remove the rebound bolts and the spring rollers from the equalizer arm.

NOTE: For clarity, only one of each of the rebound components is shown in **Fig. 1** even though two are used on the equalizer arm.

8. Secure all radius rods to the spring assemblies.
9. On both sides of the vehicle, remove the rear spring bracket rebound bolt, spring roller, and bushing.
10. Using the hoist, raise the frame high enough to remove the tandem assembly out from under the frame.

Inspection

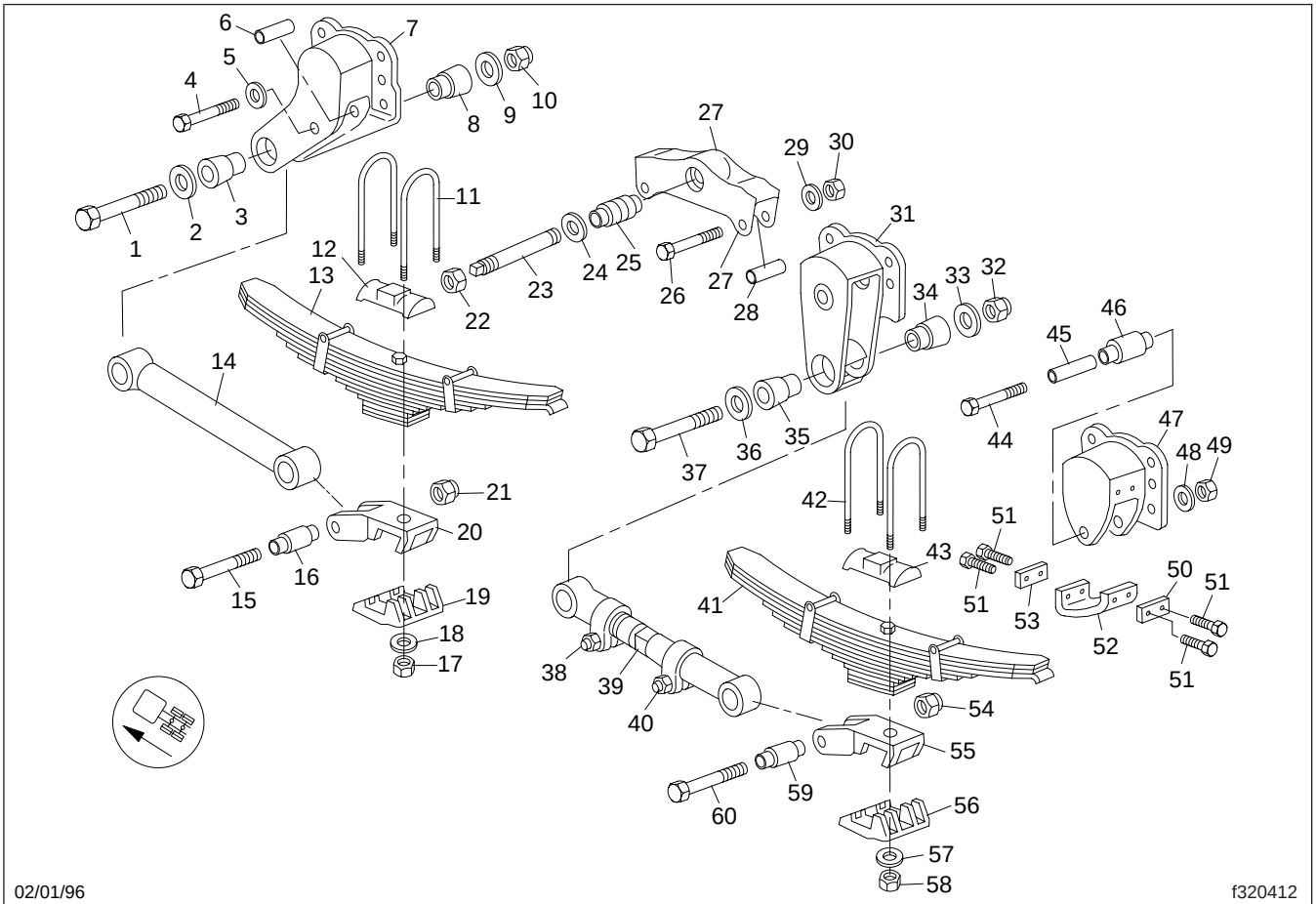
1. Clean the suspension parts and inspect all parts carefully for cracks, excessive wear, or damage.
2. Inspect the rubber bushings for damage or wear.
3. Replace components as required, following the instructions in this subject.

Installation

NOTE: When repairs are made on the removed tandem suspension that involve removal and installation of the spring U-bolts or radius rods, the mounting nuts should be tightened only partially before installation. When the tandem suspension is installed, do a preliminary alignment of the axles to the frame as described below. Then tighten the rear axle U-bolt nuts to the final torque. Tighten the radius rod bolts to the final torque only after the final alignment of the axles. See **Specifications, 400** for the torque settings.

1. With the frame raised on a hoist and a hydraulic floor jack under the forward-rear axle differential carrier, roll the axles and suspension assembly into position under the frame. Lower the frame.
2. On both sides of the vehicle install the rear spring bracket bushing, spring roller, and rebound bolt, washer, and nut. Tighten the nut 75 lbf·ft (102 N·m).
3. On both sides of the vehicle install the spring rollers, rebound bolts, washers, and nuts in the center spring equalizer arm. Tighten the nuts 75 lbf·ft (102 N·m).

Suspension Removal, Inspection, and Installation



1. Radius Rod Eye Bolt
2. Flatwasher
3. Rubber Bushing (half)
4. Rebound Bolt
5. Rebound Bolt Washer
6. Spring Roller
7. Forward Spring Bracket
8. Rubber Bushing (half)
9. Flatwasher
10. Radius Rod Eye Bolt Nut
11. U-Bolts
12. Upper U-Bolt Spacer Pad
13. Forward-Rear Spring Assembly
14. Radius Rod (rigid type)
15. Radius Rod Bolt
16. Bushing
17. U-Bolt Nut
18. U-Bolt Washer
19. U-Bolt Anchor Plate
20. Forward-Rear Axle Seat
21. Locknut
22. Pivot Shaft Nut
23. Pivot Shaft
24. Lockwasher
25. Pivot Shaft Bushing
26. Rebound Bolt
27. Equalizer Arm
28. Spring Roller
29. Rebound Bolt Washer
30. Rebound Bolt Nut
31. Equalizer Bracket
32. Radius Rod Eye Bolt Nut
33. Flatwasher
34. Rubber Bushing (half)
35. Rubber Bushing (half)
36. Flatwasher
37. Radius Rod Eye Bolt
38. Capscrew, Washer, and Nut
39. Radius Rod (adjustable type)
40. Capscrew, Washer, and Nut
41. Rearmost Spring Assembly
42. U-Bolts
43. U-Bolt Spacer Pad
44. Rebound Bolt
45. Spring Roller
46. Bushing
47. Rear Spring Bracket
48. Rebound Washer
49. Rebound Bolt Nut
50. Clamp Plate
51. Capscrew
52. Plastic Pad
53. Clamp Plate
54. Lock Nut
55. Rearmost Axle Seat
56. U-Bolt Anchor Plate
57. U-Bolt Washer
58. U-Bolt Nut
59. Bushing
60. Radius Rod Bolt

Fig. 1, Reyco Suspension (exploded view)

4. On both sides of the vehicle install the forward spring bracket rebound bolt, washer, and spring roller. There is no nut on the forward spring bracket rebound bolt. Tighten the bolt 75 lbf·ft (102 N·m).
5. Connect the driveline rear universal joint to the forward-rear axle. See **Group 41**. Remove the hydraulic floor jack.
6. Lower each radius rod and align the radius rod eye with the spring bracket. Install both halves of the rubber eccentric bushing into the spring bracket from the outside with the flat of the bushing insert in the down position, or with the arrow pointing up. Install the large flatwasher onto the bolt and insert the bolt into the bushing with the arrow on the bolt head also pointing up. Install the large flatwasher and nut on the bolt. Tighten the nut, but not to its final torque.

NOTE: With all four radius rod eccentric bushings and bolts installed with the arrows pointing up, the suspension is in its base alignment to the frame.

7. Tighten the rear axle U-bolt nuts to the final torque listed in **Specifications, 400** in the sequence shown in **Fig. 2**.

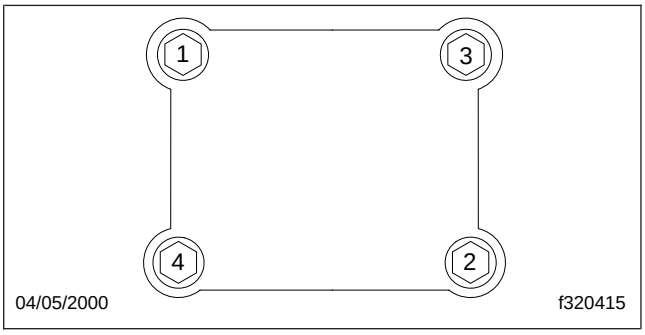


Fig. 2, U-Bolt Tightening Sequence

8. Taking care to prevent dirt and other foreign material from entering the lines or fittings, connect the air brake lines leading to the axles. Close the air system drain valve.
9. Check the axle pinion angle. For instructions, see **Group 41**. Adjust the angle if it is not according to specifications.
10. Check the axle alignment and adjust it if needed. For instructions, see **Subject 140**.
11. Make sure the radius rod eye bolt nuts are tightened to the torque value in **Specifications, 400**.
12. Remove the chocks from the tires.

Forward-Rear Spring Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Raise the vehicle and block the axles with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will support the weight of the axles and frame securely. Remove the wheel assembly to gain easy access to the suspension system.
3. Remove the U-bolts and the U-bolt anchor plate. Remove the front rebound bolt, washer, and spring roller from the front spring bracket. See **Fig. 1**.
4. Remove the rebound bolt, nut, washer, and spring roller from the front of the equalizer arm in the equalizer bracket.

NOTE: Some references in **Fig. 1** are shown at the rear of the equalizer arm. For clarity, they have been omitted at the front of the equalizer arm.

5. Slide the spring forward until it clears the equalizer arm. Lift the spring assembly at the rear to clear the equalizer arm. Slide the spring to the rear and remove it.

Forward-Rear Spring Installation

1. Locate the spring in the front spring bracket and slide it forward until the rear of the spring is in position to clear the equalizer arm.
2. Slide the spring rearward into position in the equalizer arm.
3. Install the rebound bolts, washers, spring rollers, and nuts in the front spring bracket and in the equalizer arm. There is no nut on the rebound bolt in the front spring bracket. Tighten the fasteners 75 lbf·ft (102 N·m).
4. Place the spring assembly on the axle spring seat with the center bolt head in the locating hole of the lower spring seat.
5. Place the upper U-bolt spacer pad on top of the spring. Install the U-bolts and the U-bolt anchor plate. Install the U-bolt washers and nuts. Partially tighten the nuts until preliminary adjustment of the suspension has been made; then, tighten them in the sequence shown in **Fig. 2**.
6. Install the wheels. Remove all safety stands. Remove the chocks from the tires.

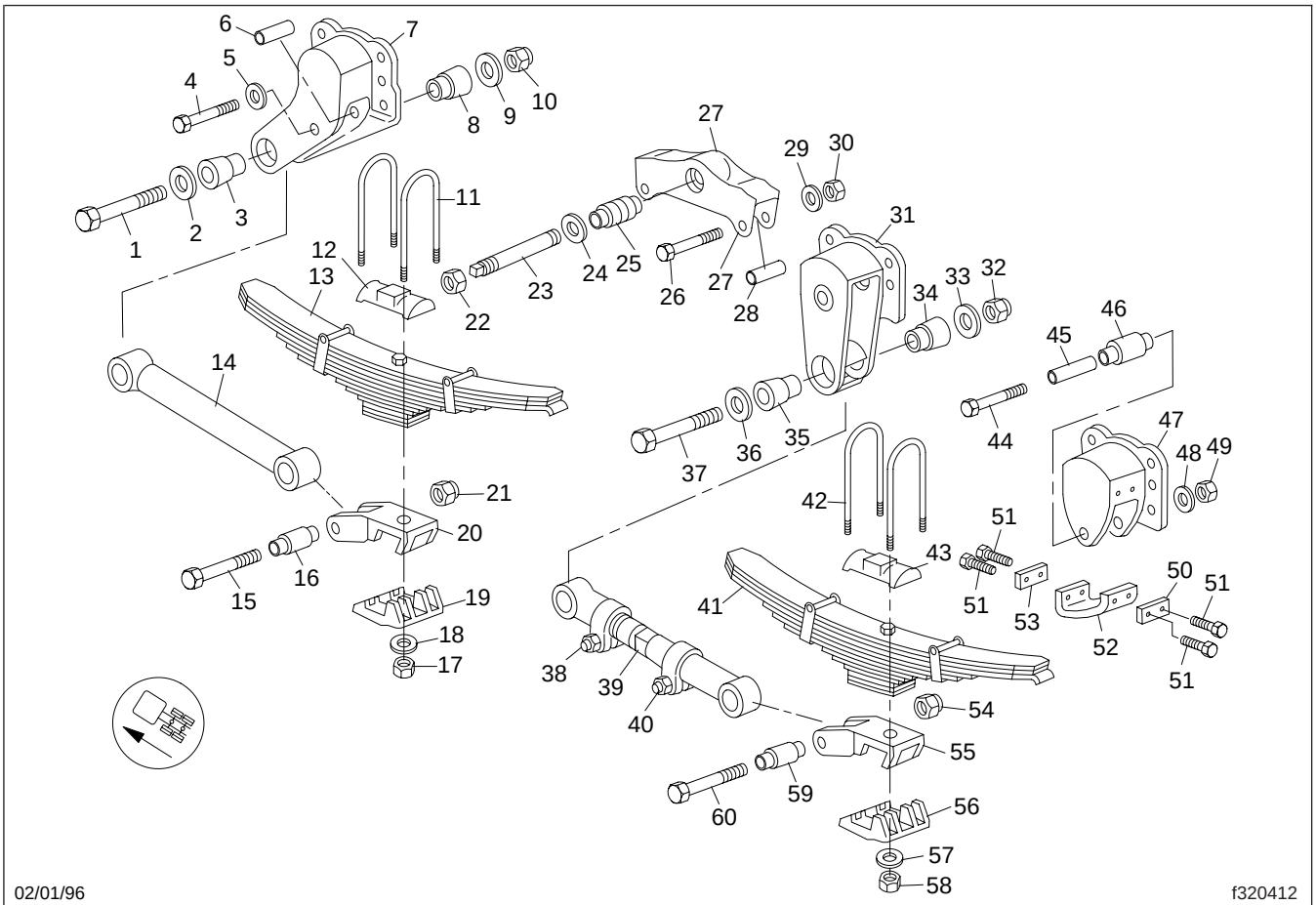
Rearmost Spring Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Raise the vehicle and block the axles with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will support the weight of the axles and frame securely. Remove the wheel assembly to gain easy access to the suspension system.
3. Remove the U-bolt nuts and washers, the U-bolt anchor plate, the U-bolts, and the upper U-bolt spacer pad.
4. Remove the rear rebound bolt, nut, washer, spring roller, and bushing from the rear spring bracket.
5. Remove the rear rebound bolt, nut, washer, and spring roller from the equalizer arm in the equalizer bracket.
6. Slide the spring rearward until it clears the equalizer arm. Lift the spring assembly at the front to clear the equalizer arm and remove the spring.

Rearmost Spring Installation

1. Locate the spring in the front spring bracket and slide it to the rear until the front of the spring is in position to clear the equalizer arm.
2. Slide the spring forward into position in the equalizer arm.
3. Install the rebound bolts, washers, and spring rollers in the rear spring bracket and in the equalizer arm. Tighten the nuts 75 lbf·ft (102 N·m).

Spring Removal and Installation



1. Radius Rod Eye Bolt
2. Flatwasher
3. Rubber Bushing (half)
4. Rebound Bolt
5. Rebound Bolt Washer
6. Spring Roller
7. Forward Spring Bracket
8. Rubber Bushing (half)
9. Flatwasher
10. Radius Rod Eye Bolt Nut
11. U-Bolts
12. Upper U-Bolt Spacer Pad
13. Forward-Rear Spring Assembly
14. Radius Rod (rigid type)
15. Radius Rod Bolt
16. Bushing
17. U-Bolt Nut
18. U-Bolt Washer
19. U-Bolt Anchor Plate
20. Forward-Rear Axle Seat
21. Locknut
22. Pivot Shaft Nut
23. Pivot Shaft
24. Lockwasher
25. Pivot Shaft Bushing
26. Rebound Bolt
27. Equalizer Arm
28. Spring Roller
29. Rebound Bolt Washer
30. Rebound Bolt Nut
31. Equalizer Bracket
32. Radius Rod Eye Bolt Nut
33. Flatwasher
34. Rubber Bushing (half)
35. Rubber Bushing (half)
36. Flatwasher
37. Radius Rod Eye Bolt
38. Capscrew, Washer, and Nut
39. Radius Rod (adjustable type)
40. Capscrew, Washer, and Nut
41. Rearmost Spring Assembly
42. U-Bolts
43. U-Bolt Spacer Pad
44. Rebound Bolt
45. Spring Roller
46. Bushing
47. Rear Spring Bracket
48. Rebound Washer
49. Rebound Bolt Nut
50. Clamp Plate
51. Capscrew
52. Plastic Pad
53. Clamp Plate
54. Lock Nut
55. Rearmost Axle Seat
56. U-Bolt Anchor Plate
57. U-Bolt Washer
58. U-Bolt Nut
59. Bushing
60. Radius Rod Bolt

Fig. 1, Reyco Suspension (exploded view)

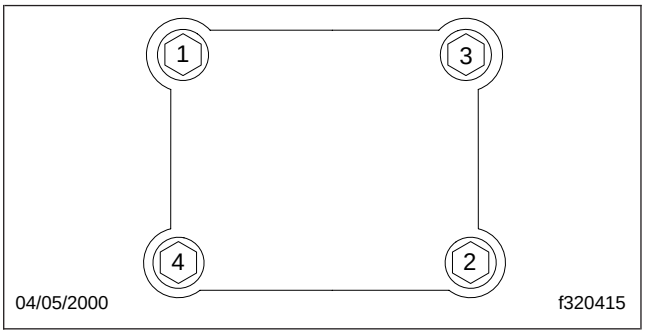


Fig. 2, U-Bolt Tightening Sequence

4. Place the spring assembly on the axle spring seat with the center bolt head in the locating hole of the lower spring seat.
5. Place the upper U-bolt spacer plate on top of the spring. Install the U-bolts and the U-bolt anchor plate. Install the U-bolt washers and nuts. Partially tighten the nuts until preliminary adjustment of the suspension has been made; then, tighten them in the sequence shown in **Fig. 2**.
6. Install the wheels. Remove all safety stands. Remove the chocks from the tires.

Disassembly, Inspection, and Assembly

1. Before disassembly, use chalk or a grease pencil to make a mark down the side of the spring pile so the spring leaves can be assembled in the same relative position.
2. Anchor the spring at a point near the center bolt in a vise or arbor press. Tighten the vise or arbor press firmly.
3. Remove the bolts, nuts, and sleeve from the spring clips. Observe the spring leaves. Pay special attention to the top three leaves, since the spring can easily be incorrectly assembled, even though reference marks are used.
4. Prior to inspection, wash all parts in a suitable solvent. Remove any scale, rust, or deposits from the spring leaves.
5. Inspect all the leaves for breaks and small cracks. If any are found, replace the entire spring assembly.

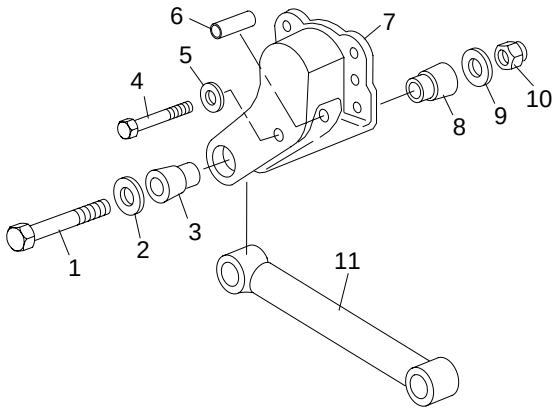
⚠ WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

6. Inspect the spring assembly for loose or broken rebound clips. Rebound clips should be tight enough to hold the spring leaves in alignment, but not tight enough to restrict the free movement of the leaves.
7. Inspect the center bolt for distortion and wear. Replace the bolt if it is not in good condition.
8. Inspect the U-bolts and spring spacer plates. Replace them if they are damaged or cracked.
9. Inspect the spring brackets at the reinforcing webs and in the corners. Do not weld or braze cracks. If the bracket is cracked, replace it.
10. For assembly, stack the spring leaves using care to position them in the proper sequence.
11. Using a long punch or other suitable tool, align the center bolt holes. Anchor the spring at a point near the center bolt hole in a vise or arbor press. Tighten the vise or arbor press firmly. Remove the alignment tool.
12. Install the center bolt and nut. Tighten the nut 70 lbf·ft (95 N·m) and peen the end of the bolt.
13. Install the bolts, nuts, and spacer sleeves to the spring clips. Tighten the nuts firmly. Peen the ends of the bolts.
14. Remove the assembly from the vise or arbor press.

Bracket Removal and Installation

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. To remove the forward spring bracket, raise the frame until all weight is off the spring, and safely block it in position.
3. Remove the rebound bolt, washer, and spring roller from the front spring bracket. See **Fig. 1**.



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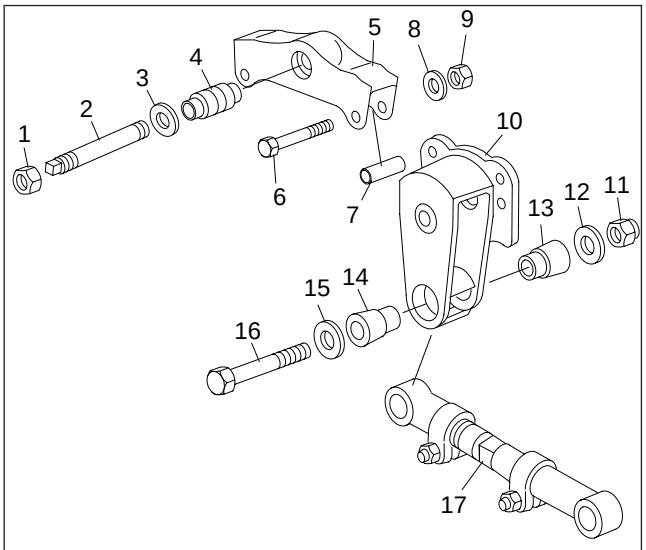
1. Radius Rod Eye Bolt
2. Flatwasher
3. Rubber Bushing (half)
4. Rebound Bolt
5. Rebound Bolt Washer
6. Spring Roller
7. Forward Spring Bracket
8. Rubber Bushing (half)
9. Flatwasher
10. Radius Rod Eye Bolt Nut
11. Radius Rod

Fig. 1, Forward Spring Bracket Assembly

4. Remove the radius rod eye bolt nut and large flatwasher from the eye bolt.
5. Using a brass drift, drive the eye bolt with the remaining flatwasher from the spring bracket. Secure the radius rod to the spring.
6. Using a brass drift inside the rubber bushing, drive out one half of the bushing. Reverse the position of the drift and drive out the other half of the bushing from the opposite side of the bracket.
7. Remove all the bolts, nuts, and washers securing the spring bracket to the frame.
8. Remove the spring bracket and spacer plate, moving it away from the spring end and lifting it straight up from the frame.
9. To remove the rear spring bracket, raise the frame until all weight is off the spring, then safely block it in position.
10. Remove the bolts, nuts, and washers that secure the rear spring bracket to the frame.
11. Remove the spring bracket and spacer plate.
12. To remove the equalizer bracket (center spring bracket), raise the frame until all weight is off the spring, then safely block it in position.
13. Remove the rebound nuts, washers, bolts, and spring rollers from the ends of the equalizer arm. See **Fig. 2**.



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1. Pivot Shaft Nut
2. Pivot Shaft
3. Lockwasher
4. Pivot Shaft Bushing
5. Equalizer Arm
6. Rebound Bolt
7. Spring Roller
8. Rebound Bolt Washer
9. Rebound Bolt Nut
10. Equalizer Bracket
11. Radius Rod Eye Bolt Nut
12. Flatwasher
13. Rubber Bushing (half)
14. Rubber Bushing (half)
15. Flatwasher
16. Radius Rod Eye Bolt
17. Radius Rod

Fig. 2, Equalizer Arm and Bracket Assembly

Spring Bracket Removal and Installation

14. Remove the radius rod eye bolt nut and large flatwasher from the eye bolt.
15. Using a brass drift, drive the eye bolt with the remaining flatwasher from the equalizer bracket.
16. Secure the radius rod to the spring.
17. Using a brass drift inside the rubber bushing, drive out one half of the bushing. Reverse the position of the drift and drive out the other half of the bushing from the opposite side of the bracket.
18. Remove the equalizer pivot nut, lockwasher, and shaft.
19. Slide the equalizer back and forth as necessary to gain access to the mounting bracket bolts.
20. Remove all the bolts, nuts, and washers that secure the equalizer bracket to the frame.
21. Remove the equalizer bracket and the spacer plate.
22. To install spring or equalizer brackets, reverse the removal procedure. Make sure the spacer plates are installed between the frame and bracket. Check the axle alignment, and correct it if necessary, before tightening the radius rod eye bolt nuts to the final torque. For instructions, see **Subject 140**.
23. Remove the chocks from the tires.

Radius Rod and Radius Rod Bushing Replacement

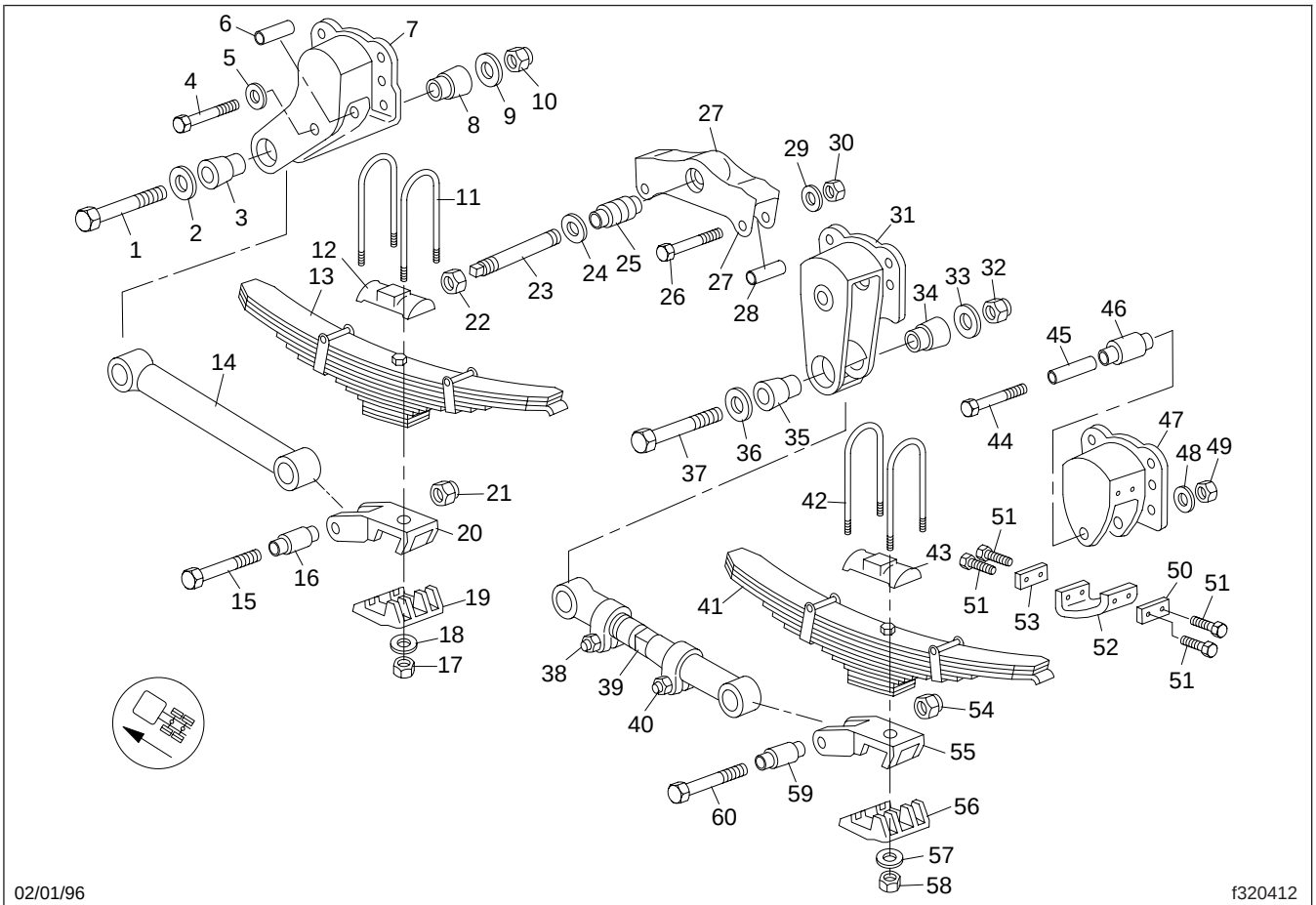
Radius Rod Replacement

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Raise the frame until all weight is off the spring, then safely block the frame in position.
3. Remove the locknut, washer (if so equipped), and bolt from the radius rod at the axle seat. Lower the rod. See **Fig. 1**.
4. Remove the nut and large flatwasher from the radius rod eye bolt. Using a brass drift tool, drive the eye bolt with the remaining flatwasher from the forward spring bracket or equalizer bracket.
5. Using a brass drift inside the rubber bushing, drive out one half of the bushing. Reverse the position of the drift and drive out the other half of the bushing from the opposite side of the bracket.
6. Remove the radius rod.
7. Place the eye of the new radius rod into the front spring or equalizer bracket.
8. Install both halves of the rubber eccentric bushing into the bracket from the outside with the flat of the bushing insert pointing down or the arrow pointing up.
9. Install the large flatwasher onto the radius rod eye bolt and insert the bolt into the bushing with the arrow on the bolt head pointing up.
10. Install the large flatwasher and the nut on the radius rod eye bolt. Tighten the nut, but not to its final torque.
11. Check the axle alignment and adjust it if necessary. For instructions, see **Subject 140**.
12. After the adjustment has been made, lower the vehicle and tighten the radius rod eye bolt nut to the torque value in **Specifications, 400**.
13. Remove the chocks from the tires.

Radius Rod Bushing Replacement

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Raise the frame until all weight is off the spring, then safely block the frame in position.
3. Remove the radius rod as follows:
   - 3.1 Remove the locknut, washer (if so equipped), and bolt from the radius rod at the axle seat. Lower the rod. See **Fig. 1**.
   - 3.2 Remove the nut and large flatwasher from the radius rod eye bolt. Using a brass drift tool, drive the eye bolt with the remaining flat washer from the front spring or equalizer bracket.
   - 3.3 Using a brass drift inside the rubber bushing, drive out one half of the bushing. Reverse the position of the drift and drive out the other half of the bushing from the opposite side of the bracket.
   - 3.4 Remove the radius rod.
4. Press the old bushing out of the radius rod.
5. Coat the new bushing with a rubber lubricant and press it in so the bushing is equal on both sides of the rod.
6. Install the radius rod as follows:
   - 6.1 Place the eye of the radius rod into the front spring or equalizer bracket.
   - 6.2 Install both halves of the rubber eccentric bushing into the bracket from the outside with the flat of the bushing insert pointing down or the arrow pointing up.
   - 6.3 Install the large flatwasher onto the radius rod eye bolt and insert the bolt into the bushing with the arrow on the bolt head pointing up.
   - 6.4 Install the large flatwasher and the nut on the radius rod eye bolt. Tighten the nut, but not to its final torque.
7. Check the axle alignment and adjust it if necessary. For instructions, see **Subject 140**.

Radius Rod and Radius Rod Bushing Replacement



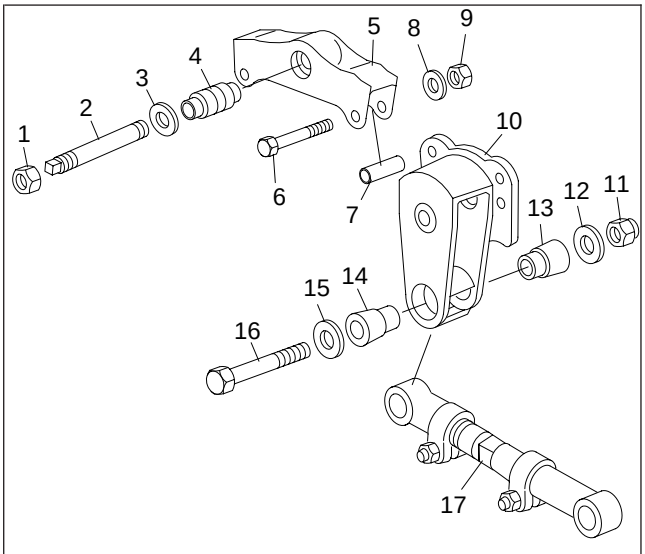
1. Radius Rod Eye Bolt
2. Flatwasher
3. Rubber Bushing (half)
4. Rebound Bolt
5. Rebound Bolt Washer
6. Spring Roller
7. Forward Spring Bracket
8. Rubber Bushing (half)
9. Flatwasher
10. Radius Rod Eye Bolt Nut
11. U-Bolts
12. Upper U-Bolt Spacer Pad
13. Forward-Rear Spring Assembly
14. Radius Rod (rigid type)
15. Radius Rod Bolt
16. Bushing
17. U-Bolt Nut
18. U-Bolt Washer
19. U-Bolt Anchor Plate
20. Forward-Rear Axle Seat
21. Locknut
22. Pivot Shaft Nut
23. Pivot Shaft
24. Lockwasher
25. Pivot Shaft Bushing
26. Rebound Bolt
27. Equalizer Arm
28. Spring Roller
29. Rebound Bolt Washer
30. Rebound Bolt Nut
31. Equalizer Bracket
32. Radius Rod Eye Bolt Nut
33. Flatwasher
34. Rubber Bushing (half)
35. Rubber Bushing (half)
36. Flatwasher
37. Radius Rod Eye Bolt
38. Capscrew, Washer, and Nut
39. Radius Rod (adjustable type)
40. Capscrew, Washer, and Nut
41. Rearmost Spring Assembly
42. U-Bolts
43. U-Bolt Spacer Pad
44. Rebound Bolt
45. Spring Roller
46. Bushing
47. Rear Spring Bracket
48. Rebound Washer
49. Rebound Bolt Nut
50. Clamp Plate
51. Capscrew
52. Plastic Pad
53. Clamp Plate
54. Lock Nut
55. Rearmost Axle Seat
56. U-Bolt Anchor Plate
57. U-Bolt Washer
58. U-Bolt Nut
59. Bushing
60. Radius Rod Bolt

Fig. 1, Reyco Suspension (exploded view)

8. After the adjustment has been made, lower the vehicle and tighten the radius rod eye bolt nut to the torque value in **Specifications, 400**.
9. Remove the chocks from the tires.

Replacement

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Raise the frame until all the weight is off the springs, then safely block the frame into position.
3. Remove the rebound nuts, washers, bolts, and spring rollers from the ends of the equalizer arm. See **Fig. 1**.



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1. Pivot Shaft Nut
2. Pivot Shaft
3. Lockwasher
4. Pivot Shaft Bushing
5. Equalizer Arm
6. Rebound Bolt
7. Spring Roller
8. Rebound Bolt Washer
9. Rebound Bolt Nut
10. Equalizer Bracket
11. Radius Rod Eye Bolt Nut
12. Flatwasher
13. Rubber Bushing (half)
14. Rubber Bushing (half)
15. Flatwasher
16. Radius Rod Eye Bolt
17. Radius Rod

Fig. 1, Equalizer Arm and Bracket Assembly

NOTE: For clarity, only one of each of the rebound components is shown, even though two are used on the equalizer arm.

4. Remove the nut and large flatwasher from the radius rod eye bolt. Using a brass drift, drive the eye bolt with the remaining flatwasher from the equalizer bracket.
5. Secure the radius rod to the spring.
6. Remove the equalizer pivot nut, washer, and shaft.
7. Move the equalizer arm forward over the forward rear spring. Raise the frame. Slide the equalizer arm rearward through the bracket, then up and out.
8. Using a suitable press, press out the equalizer bushing.
9. Coat the new bushing with a rubber lubricant.
10. Press the bushing into the equalizer arm.
11. With the frame raised and the equalizer arm properly positioned, slide the equalizer arm into the equalizer bracket and forward over the front spring assembly.
12. Lower the frame and slide the equalizer arm over the rear spring until the center hole aligns with the hole in the equalizer bracket.
13. Install the pivot shaft.
    - 13.1 Apply anti-seize compound to the pivot shaft threads.
    - 13.2 Install the pivot shaft by hand in the bracket.
    - 13.3 With steel crossmembers, install the bolt with the nut inside the frame.
    - 13.4 With aluminum crossmembers, install the bolt with the nut outside the frame.
    - 13.5 When the shaft reaches the frame rail, back it out one-half turn.
    - 13.6 Install the lockwasher and nut. Tighten the nut 975 lbf·ft (1330 N·m).
14. Install the radius rod as follows (see **Fig. 1**):
    - 14.1 Place the radius rod eye into the equalizer bracket. Install both halves of the rubber eccentric bushing into the bracket from the outside, with the flat of the bushing insert pointing down or the arrow pointing up.
    - 14.2 Install the large flatwasher onto the radius rod eye bolt and insert the bolt into the bushing with the arrow on the bolt head pointing up.

Equalizer Arm Bushing Replacement

14.3 Install the large flatwasher and the nut on the bolt. Tighten the nut, but not to its final torque.

14.4 Check the axle alignment and adjust it if necessary. For instructions, see **Subject 140**. After the adjustment has been made, lower the vehicle and tighten the radius rod eye bolt nut to the torque value shown in **Specifications, 400**.

15. Install the spring rollers and rebound bolts in the equalizer arm and tighten the nuts 45 lbf·ft (61 N·m).
16. Remove the chocks from the tires.

Checking

Manufacturers of axle alignment equipment offer a variety of systems to precisely measure and correct rear axle alignment. If access to this type of equipment is not available, check the axle alignment using the following procedure:

1. Position the vehicle on a level surface. Using the engine, rock the vehicle back and forth several times with the brakes applied lightly. This will release any "set" of the suspension joint.
2. Obtain a piece of bar stock, angle iron, or other suitable material about 96 inches (2.5 m) long. Inspect the material for straightness. The bar should be long enough to extend past the outside edge of one outside dual tire to a similar point on the opposite dual tire.
3. Measure from the center point of the equalizer bracket to any open part of the frame in front of the wheels where the bar stock can be placed across the frame. This point must be accessible for the use of C-clamps. A point in front of the forward-rear axle is recommended; however, a point behind the rearmost axle will work if none is available in front of the axle.
4. Using a square, mark a chalk line across the top of the frame rail.
5. Repeat the previous steps for the opposite side of the vehicle.
6. Position the bar stock across the frame rails so it extends an equal distance beyond the frame rail on each side. Line up the bar stock with the chalk lines and secure it with C-clamps.
7. Measure the distance from the outside edge of the secured bar stock to the center of the rearmost axle shaft.
8. Repeat the previous steps on the opposite side of the vehicle. Compare the measurements taken on both sides. If they are equal or vary no more than 1/8-inch (3-mm), the axle alignment is correct. If the measurements differ by more than 1/8-inch (3-mm), adjust the axle alignment.
9. If the rearmost axle alignment is correct, check the forward-rear axle alignment as follows:
   - 9.1 Measure the distance from the rearmost axle shaft center to the center of the forward-rear axle or the bar stock.
   - 9.2 Repeat the measurement for the opposite side and compare the measurements. If they are equal or vary no more than 1/8-inch (3-mm), the axle alignment is correct. If the measurements differ by more than 1/8-inch (3-mm), adjust the axle alignment as described above.

Adjustment (Models 101 and 101A)

1. Loosen the nut on the radius rod eye bolt three full turns.
2. Using a soft brass or lead hammer to avoid damage to the eye bolt threads, tap the end of the eye bolt and the end of the rod between the front spring bracket casting. This should loosen the components so the adjustment can be made.

NOTE: The maximum adjustment on each side of the vehicle is 7/16 inch (11 mm). In most cases, the axle alignment can be corrected by adjusting one side only; however, additional adjustment can be made from the other side of the axle if necessary.

3. On the side to be corrected, jack up the frame to remove the weight from the springs.
4. To adjust the axle forward, rotate the radius rod eye bolt forward. To adjust the axle rearward, rotate the radius rod eye bolt to the rear.
5. Lower the vehicle and check the axle alignment as described above. Repeat the adjustment as needed.
6. After the final adjustment has been made, lower the vehicle and tighten the radius rod eye bolt nut to the torque value in **Specifications, 400**.

Adjustment (Models 102 and 102W)

1. On the side to be corrected, jack up the frame to remove the weight from the springs.

Axle Alignment Checking and Adjusting

2. Loosen the clamp nuts on the radius rod being adjusted.
3. Using a wrench on the radius rod flats, turn the adjustable section to move the axle forward or rearward.
4. Lower the vehicle and check the axle alignment. Repeat the adjustment as needed.
5. After the adjustment has been made, lower the vehicle and tighten the radius rod clamp nuts 190 lbf·ft (258 N·m).
6. Tighten the radius rod eye bolt nuts to the torque value in **Specifications, 400**.

Problem—Spring is Noisy

Problem—Spring is Noisy	
Possible Cause	**Remedy**
Loose U-bolts	Tighten the U-bolts to the recommended torque
Worn radius rod eye bushings	Replace the radius rod eye bushings.
Worn or damaged shock absorbers	Replace the shock absorbers.

Problem—Spring Sags or Bottoms Out

Problem—Spring Sags or Bottoms Out	
Possible Cause	**Remedy**
Shock absorbers not working properly	Replace the shock absorbers.
Broken spring leaf	Replace the spring leaf assembly.
Overloaded vehicle	Check the load capacity rating and correct if needed.

Problem—Springs Break

Problem—Springs Break	
Possible Cause	**Remedy**
Loose U-bolts	Tighten the U-bolts to the recommended torque.
Springs experiencing normal fatigue	Replace the springs.
Overloaded vehicle	Check the load capacity rating and correct if needed.

Specifications

Torque Values	
Description	**Torque lbf·ft (N·m)**
Equalizer Pivot Shaft: 101A, 102	600 (814)
Equalizer Pivot Shaft: 102W	975 (1330)
Equalizer Arm Rebound Bolt (text)	45 (61)
Rebound Bolt (spec. chart)	60-80 (80-110)
Spring Center Bolt Nut	70 (95)
Spring-Bracket-to-Frame Bolt	180 (244)
Radius Rod Clamp Nut: 101A	125-150 (170-205)
Radius Rod Clamp Nut: 102	125-150 (170-205)
Radius Rod Clamp Nut: 102W	125-150 (170-205)
Radius Rod Eye Bolt: 101A	160 (217)
Radius Rod Eye Bolt: 102	500-525 (670-704)
Radius Rod Eye Bolt: 102W	500-525 (670-704)
Radius Rod Bolt: 101A	250 (339)
Radius Rod Bolt: 102	200 (271)
Radius Rod Bolt: 102W	250 (339)
U-Bolt Nuts: 3/4", First Stage	Hand tighten
Second Stage	60 (81) *
Third Stage	200 (271) *
Final Stage	270 to 330 (367 to 449) *
U-Bolt Nuts: 7/8", First Stage	Hand tighten
Second Stage	60 (81) *
Third Stage	200 (271) *
Final Stage	420 to 500 (571 to 680) *

* Tighten in a diagonal pattern as shown in the Figure.

Table 1, Torque Settings

Tighten U-bolt high nuts in a diagonal pattern as shown in **Fig. 1**.

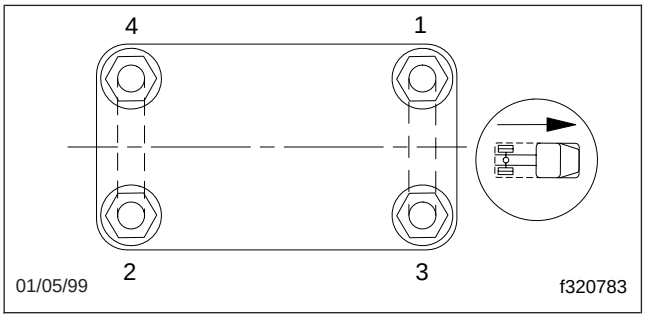


Fig. 1, Tightening Pattern for U-bolt High Nuts

General Description

The Chalmers 800 Series Rear Suspension is a walking beam-type tandem axle suspension that uses hollow rubber springs instead of leaf springs or air bags. Each hollow rubber spring is mounted between a frame-rail plate and the center (front-to-rear) of the steel walking beam. A sawhorse bracket assembly is attached to the frame and provides mounting points for the lower torque rods that tie the axles to the frame. The upper torque rods are fastened to brackets that bolt to the frame side rails and to tower assemblies that are welded to the top of the differential housings. **See Fig. 1.**

The 800 Series Rear Suspension allows a high degree of both parallel and diagonal articulation, while maintaining wheel load equalization to within 3%.

The Chalmers suspension design separates the rear suspension's responsibility for supporting/cushioning the load from that of locating/guiding the axles. The suspension is very light, relative to its load carrying capacity, but requires very little maintenance. In fact, there are no lubrication fittings since grease and oil are never needed.

The 800 Series Rear Suspension is available in three different maximum load capacities: 40,000 lb (18,000 kg), 46,000 lb (21,000 kg), and 50,000 lb (23,000 kg). The 40,000 lb version is easily distinguished from the other two versions since the upper torque rods do not cross over one another on the 40,000 lb version.

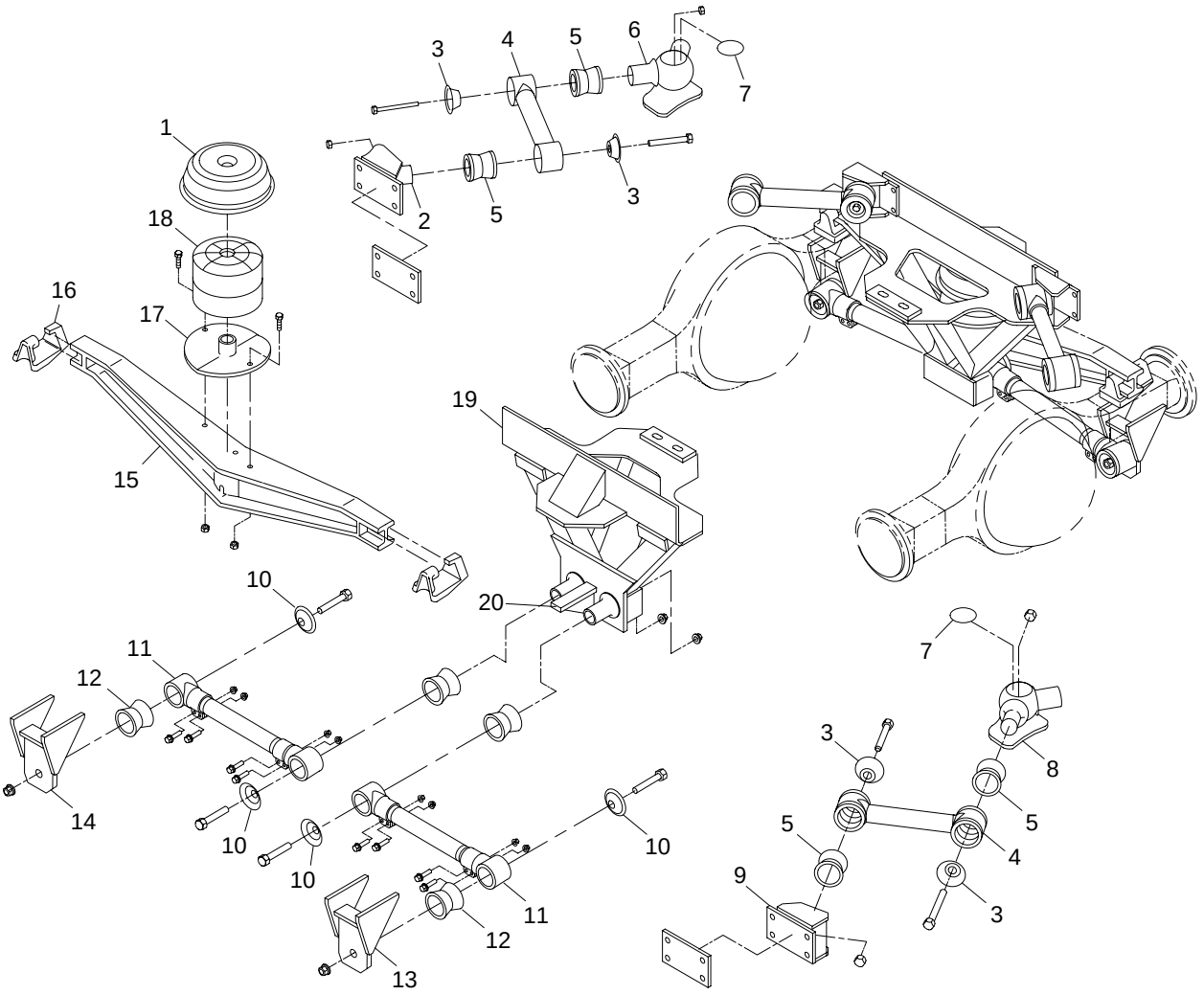
The 800 Series is also available in three different axle spacings: 54-inch, 60-inch, and 72-inch axle-to-axle. The axle-to-axle spacing dimension is often included as part of the suspension name, e.g. "Chalmers 854 Rear Suspension" or "Chalmers 860 Suspension."

Shock absorbers are optional on all versions of the suspension, and available in two styles—beam mounted and axle housing mounted.

Other variations depend on whether the suspension is installed on a truck (high-mount) or a tractor (low-mount) and whether high center-of-gravity or low center-of-gravity is desired.

The rear suspension may be precision-aligned by adjusting the length of the lower torque rods. These rods have both left and right hand threads cut on the same tube so rotating the tube changes the effective length of the tube.

General Description



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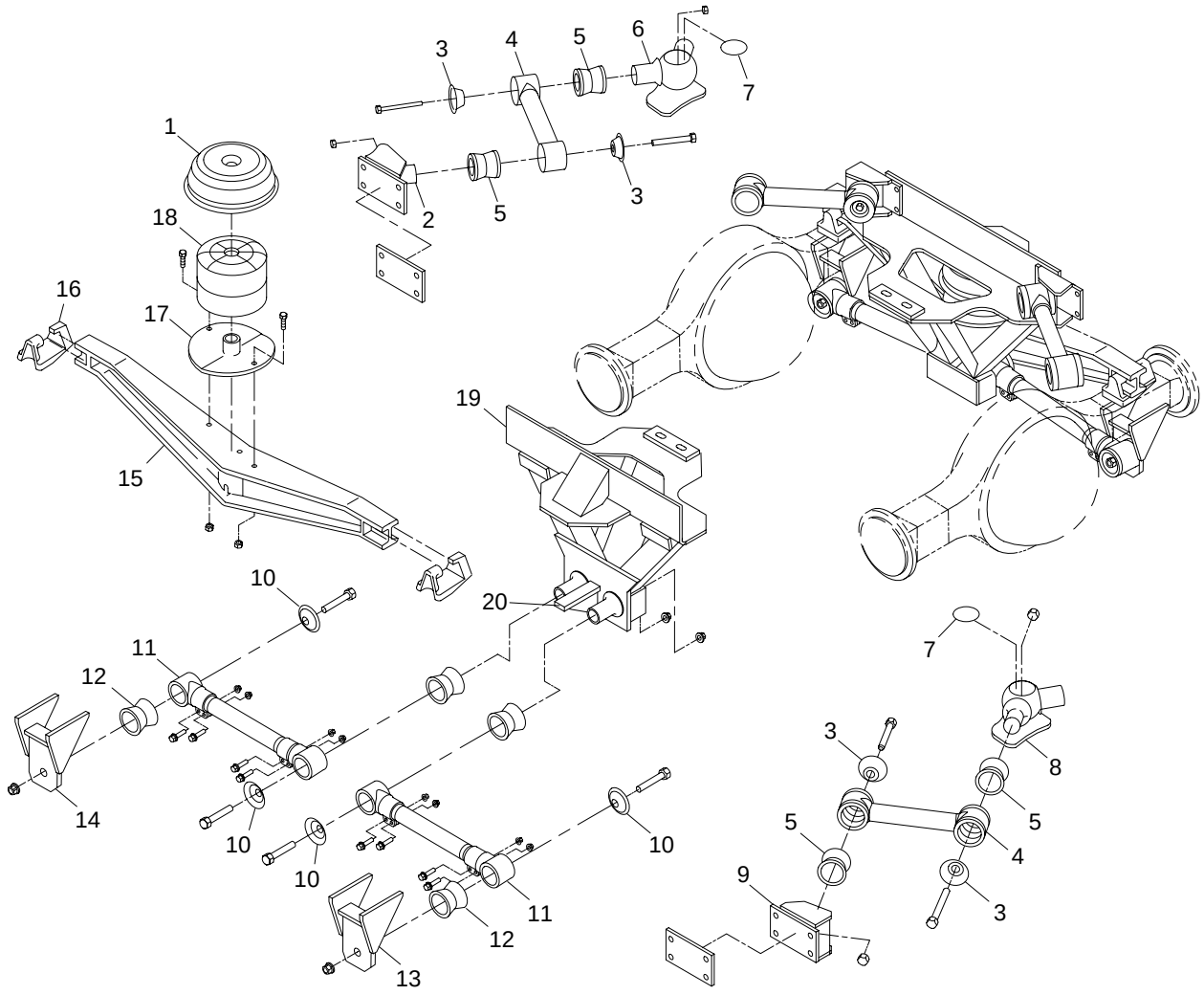
1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
14. Lower Torque Rod Axle Housing Bracket (LH forward)
15. Beam
16. Axle Housing Beam Saddle Bracket
17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

Fig. 1, Chalmers 800 Series Tandem Axle Suspension (40k capacity shown without shock absorbers)

Removal (See Fig. 1)



1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
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17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

Fig. 1, Chalmers 800 Series Tandem Axle Suspension (40k capacity shown without shock absorbers)

Restrictor Can Removal, Inspection, and Installation

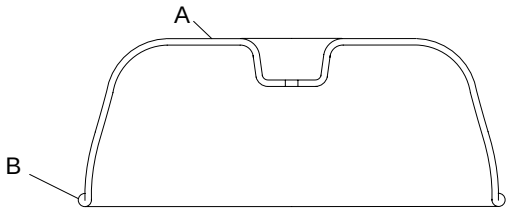
1. If necessary, power wash the spring restrictor can area to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Raise the rear of the vehicle just enough to remove all weight from the rear axles, and place safety stands under the frame to support the vehicle in its raised position.
4. Remove the two bolts and nuts that secure the walking beam spring plate (**see Fig. 1**, Ref. 17) to the walking beam assembly. Discard the fasteners.

NOTE: On 54-inch spread suspensions, it may be necessary to remove either the front or rear tires to allow spring assembly removal.

5. Pull the lower spring plate, rubber spring, and restrictor can as one assembly outward, off the beam assembly. **See Fig. 1**, Refs. 1, 17, 18.
6. Separate the restrictor can, spring, and spring plate.

Inspection

1. Carefully inspect the restrictor can for cracks or severe corrosion. Pay special attention to the top surface of the can and the can rim. **See Fig. 2 .**



A. Inspect top surface for cracks or severe corrosion.
B. Carefully inspect can rim for cracks.

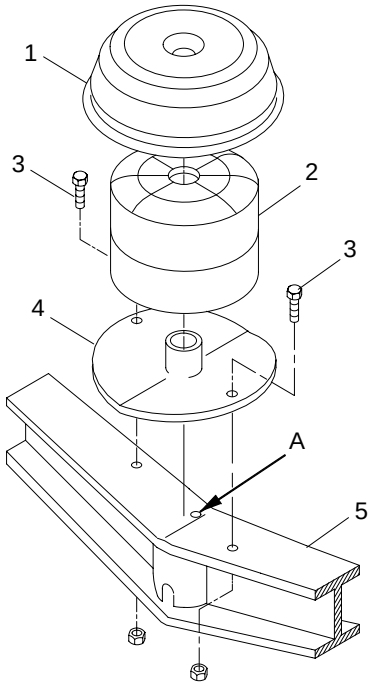
Fig. 2, Restrictor Can Inspection Areas

NOTE: It is recommended that both restrictor cans be replaced at the same time to insure evenness of ride and handling characteristics.

2. Replace a cracked or severely corroded restrictor can.

Installation

1. Using a stiff wire brush or gasket scraper, clean rust and road dirt from the spring plate. Also, make sure that the center vent holes in the plate and in the walking beam are free of rust and debris. **See Fig. 3.**



A. Make sure that the vent hole in the walking beam is free of rust and debris.

1. Spring Restrictor Can
2. Hollow Rubber Spring
3. Spring Plate Bolt
4. Spring Plate
5. Walking Beam

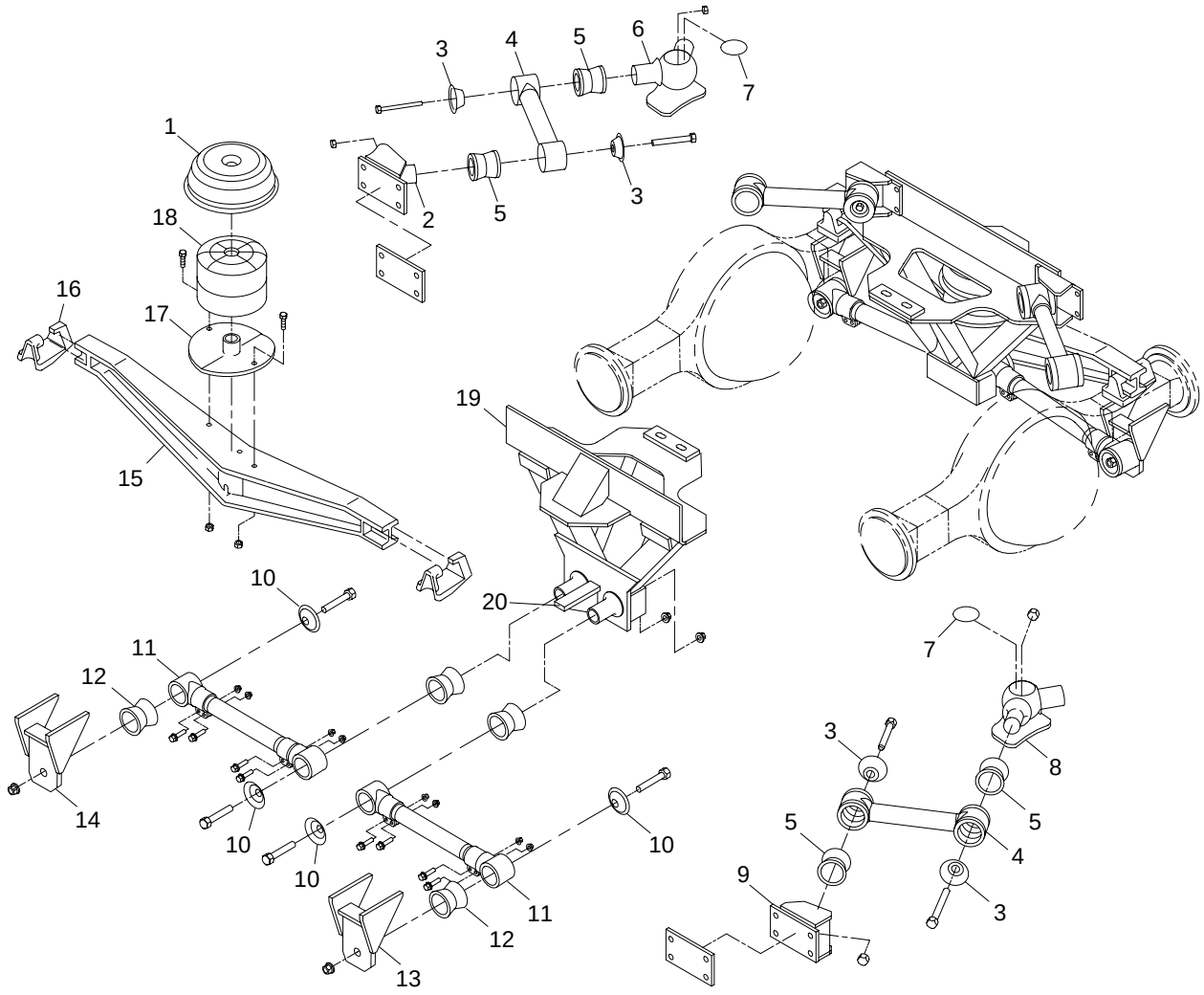
Fig. 3, Spring Assembly Components

2. Inspect the spring plate for cracks; replace it if any are present.

IMPORTANT: Never use any mineral based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only lubricants specifically designed for use with rubber compounds.

3. Position the rubber spring on the spring plate so it is upside down, relative to its original orientation. Make sure that the spring vent hole is centered on the spring plate tube. Place the new restrictor can over the spring; make sure the can is centered on the spring.
4. Slide, as one assembly, the spring plate, spring, and restrictor cap, into position on the walking beam.
5. Install and tighten the spring plate fasteners 35 lbf·ft (47 N·m).
6. Check the gap between the spring and the restrictor can to make sure it is even, all the way around the can. Rotate the spring and/or can as necessary to make the gap even.
7. Remove the safety stands from under the vehicle, then lower the vehicle.
8. Remove the chocks from the tires.

Replacement (See Fig. 1)



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1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
14. Lower Torque Rod Axle Housing Bracket (LH forward)
15. Beam
16. Axle Housing Beam Saddle Bracket
17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

Fig. 1, Chalmers 800 Series Tandem Axle Suspension (40k capacity shown without shock absorbers)

Rubber Spring Replacement

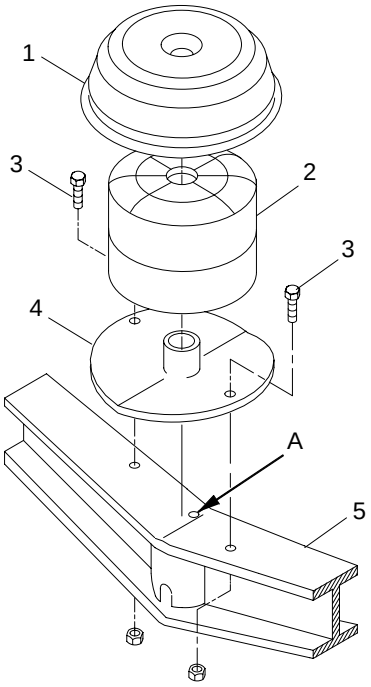
1. If necessary, power wash the spring restrictor can area to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Raise the rear of the vehicle just enough to remove all weight from the rear axles, and place safety stands under the frame to support the vehicle in its raised position.
4. Remove the two bolts and nuts that secure the walking beam spring plate (**see Fig. 1**, Ref. 17) to the walking beam assembly. Discard the fasteners.

NOTE: On 54-inch spread suspensions, it may be necessary to remove either the front or rear tires to allow spring assembly removal.

5. Pull the lower spring plate, rubber spring, and restrictor can as one assembly outward, off the beam assembly. **See Fig. 1**, Refs. 1, 17, 18.
6. Separate the restrictor can, spring, and spring plate; discard the spring.
7. Using a stiff wire brush or gasket scraper, clean rust and road dirt from the spring plate. Also, make sure that the center vent holes in the plate and in the walking beam are free of rust and debris. **See Fig. 2.**
8. Inspect the spring plate for cracks; replace it if any are present.

IMPORTANT: Never use any mineral based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only lubricants specifically designed for use with rubber compounds.

9. Position the new rubber spring on the spring plate, making sure that the vent hole is centered on the spring plate tube. Place the restrictor can over the spring; make sure the can is centered on the spring.
10. Slide, as one assembly, the spring plate, spring, and restrictor cap, into position on the walking beam.
11. Install and tighten the spring plate fasteners 35 lbf·ft (47 N·m).



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A. Make sure that the vent hole in the walking beam is free of rust and debris.

1. Spring Restrictor Can
2. Hollow Rubber Spring
3. Spring Plate Bolt
4. Spring Plate
5. Walking Beam

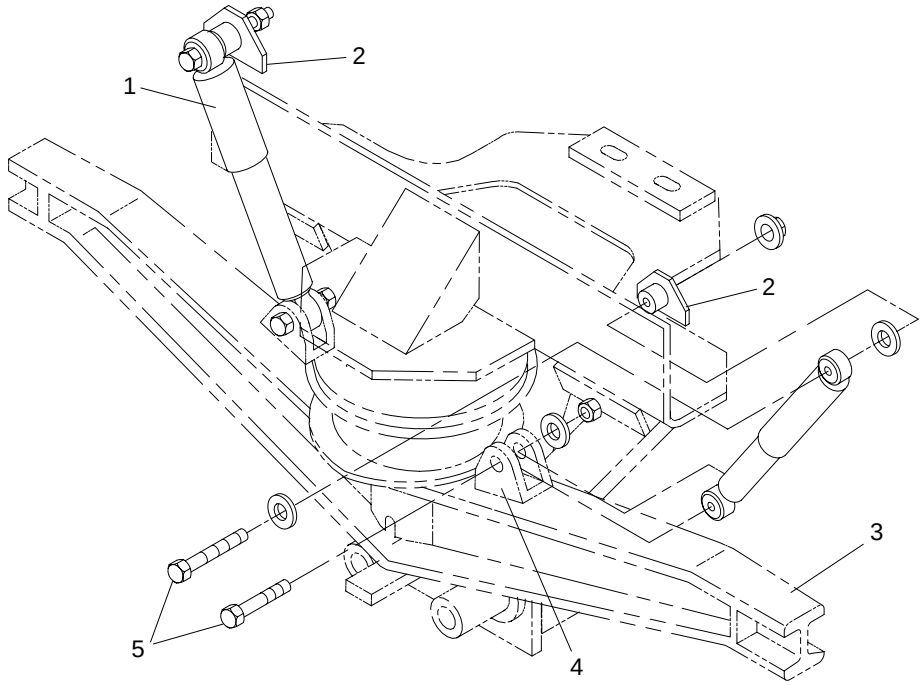
Fig. 2, Spring Assembly Components

12. Remove the safety stands from under the vehicle, then lower the vehicle.
13. Remove the chocks from the tires.

Replacement

The Chalmers 800 Series Suspension may be fitted with either beam-mounted or axle-mounted shock absorbers. **See Fig. 1** and **Fig. 2.** The replacement procedure is essentially the same for both types of shock absorber.

4. Remove and discard the shock absorber.
5. On axle-mounted shock absorber installations, the compression sleeve (**see Fig. 2**, Ref. 3) may be rusted to the shock mounting pin and remain on the pin when the shock is removed. If this occurs, drive the sleeve off of the pin using a small, sharp chisel.



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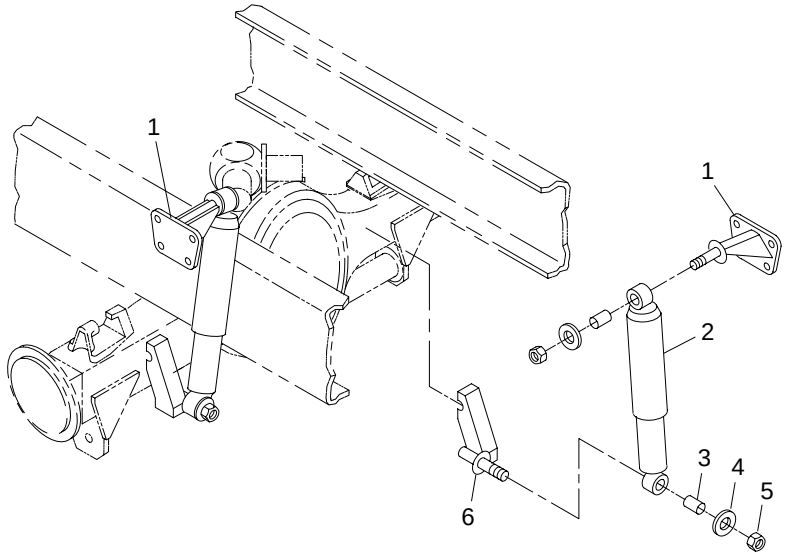
1. Shock Absorber
2. Frame-Mounted Bracket
3. Walking Beam
4. Beam-Mounted Bracket
5. 3/4" Mounting Bolts

Fig. 1, Shock Absorbers, Beam-Mounted

1. If necessary, power wash the rear suspension to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Remove the shock absorber mounting fasteners.
   - 3.1 On beam-mounted shocks, remove the upper and lower bolts. **See Fig. 1**, Ref. 5. Discard the fasteners.
   - 3.2 On axle-mounted shocks, remove the upper and lower locknuts and hardened washers. **See Fig. 2**, Refs. 4 and 5. Discard the fasteners.
6. On axle-mounted shock absorber installations, clean the shock mounting pin threads using a stiff wire brush or, if necessary, a thread-chaser die.

   Lubricate the threads with a small amount of engine oil.
7. Install the new shock absorbers.
   - 7.1 On beam-mounted shock absorber installations, extend or compress the shock absorber as necessary to install the

Shock Absorber Replacement



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1. Frame-Mounted Bracket
2. Shock Absorber
3. Compression Sleeve
4. Hardened Washer
5. 7/8" Mounting Locknut
6. Axle-Mounted Bracket

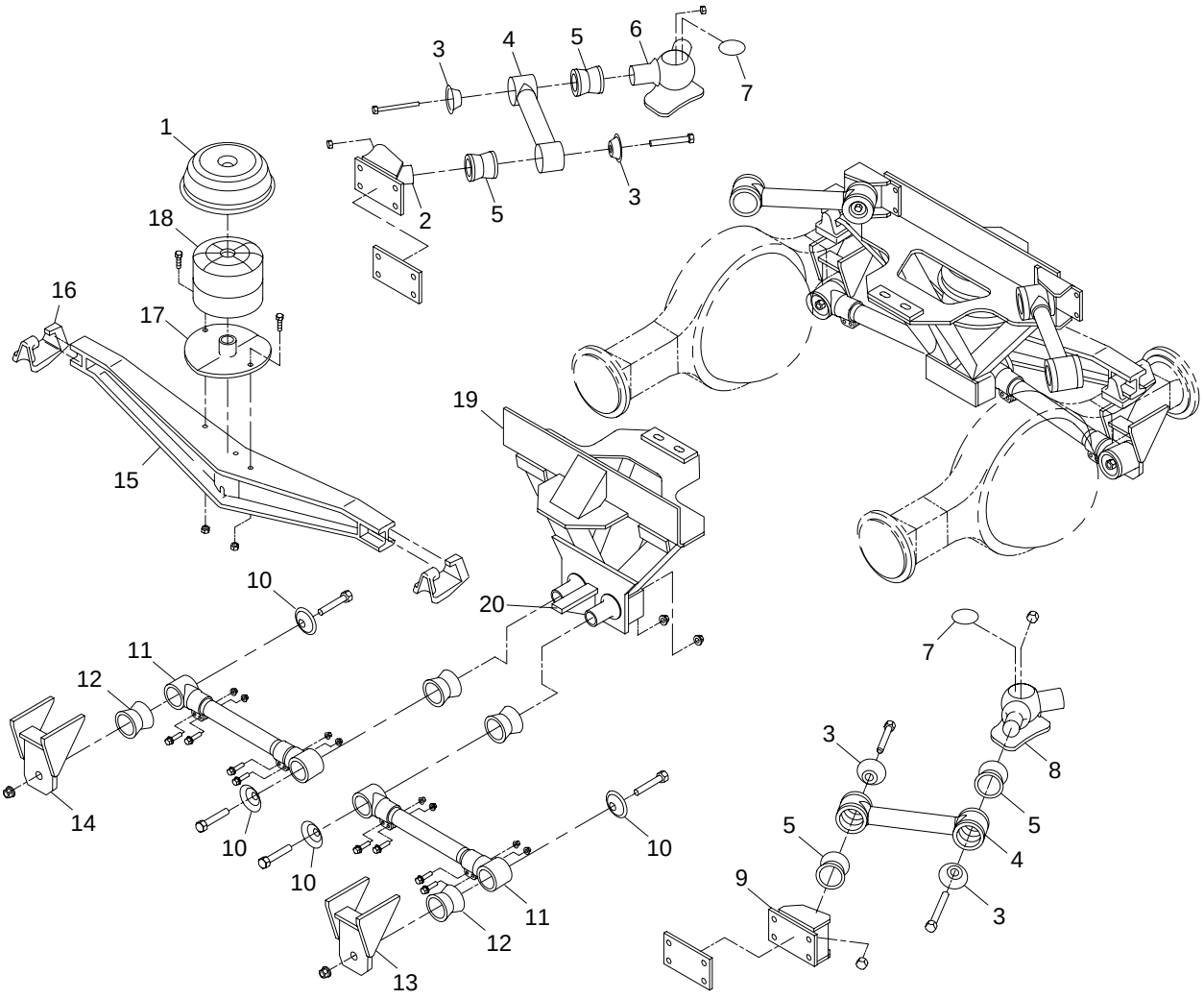
Fig. 2, Shock Absorbers, Axle-Mounted

mounting bolts. Install the locknuts and tighten the fasteners 170 lbf·ft (230 N·m).

7.2 On axle-mounted shock absorber installations, extend or compress the shock absorber as necessary to fit it on the mounting pins. Install the locknuts and tighten them 270 lbf·ft (366 N·m).

8. Remove the chocks from the tires.

Removal (See Fig. 1)



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1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
14. Lower Torque Rod Axle Housing Bracket (LH forward)
15. Beam
16. Axle Housing Beam Saddle Bracket
17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

Fig. 1, Chalmers 800 Series Tandem Axle Suspension (40k capacity shown without shock absorbers)

Walking Beam Removal, Inspection, and Installation

1. If necessary, power wash the walking beams and axle housing ends to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Relieve all drive axle brake or wind-up loads by placing the transmission in neutral and releasing the spring or driveline brakes.
4. Raise the rear of the vehicle to remove all weight from the rear axles, and place safety stands under the frame to secure the vehicle in its raised position.
5. If equipped, disconnect beam-mounted shock absorbers from the walking beam being replaced. Refer to **Subject 120**, if necessary.
6. Remove the two bolts and nuts that secure the walking beam spring plate (**see Fig. 1**, Ref. 17) to the walking beam assembly. Discard the fasteners.

NOTE: On 54-inch spread suspensions, it may be necessary to remove the front or rear tires to allow spring assembly removal.

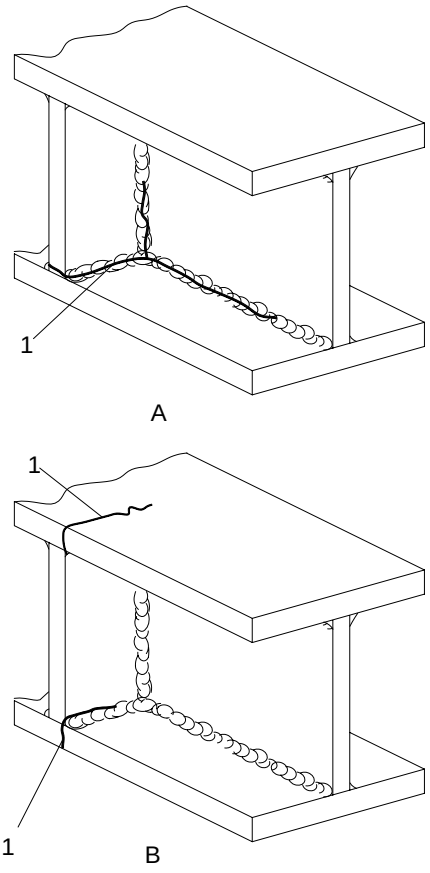
7. Pull the lower spring plate, rubber spring, and restrictor can as one assembly outward, off the beam assembly. **See Fig. 1**, Refs. 1, 17, 18.

NOTE: Tag or otherwise mark each torque rod to ensure that it can be re-installed in the same position and orientation.

8. Disconnect the rearmost axle's upper torque rods from the rear axle tower and the lower torque rods from the rear axle housing brackets. **See Fig. 1**, Refs. 4, 8, 11, 13.
9. Roll the rear axle rearward just enough to disengage the axle saddles (Ref. 16) from the walking beam ends.
10. Lift up the free end of the walking beam and slide the beam rearward to disengage it from the front axle saddle; remove the walking beam.

Inspection

1. Inspect the beam ends carefully, looking for cracks. Cracks along weld lines may be repairable, while cracks in or across the beam flanges require walking beam replacement. **See Fig. 2.**



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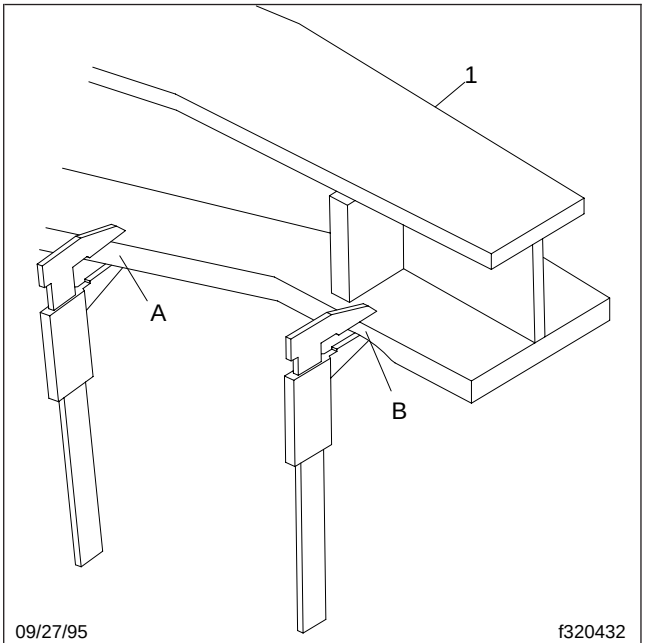
A. Repairable Walking Beam
B. Non-repairable Walking Beam
1. Cracks

Fig. 2, Repairable/Non-repairable Beam Cracks

NOTE: Take flange thickness measurements at least 1/2 inch (12 mm) from the flange edges. Measurements taken at the flange edges are not an accurate indication of beam wear and may lead to unnecessary beam repair/replacement.

2. Check for excessive wear on the beam flanges, where they contact the axle housing saddle brackets.

If flange wear is significant, use a micrometer or vernier calipers to take measurements at both unworn and worn areas. The maximum allowable difference between unworn and worn areas is 0.062 inch (1.5 mm). **See Fig. 3.**



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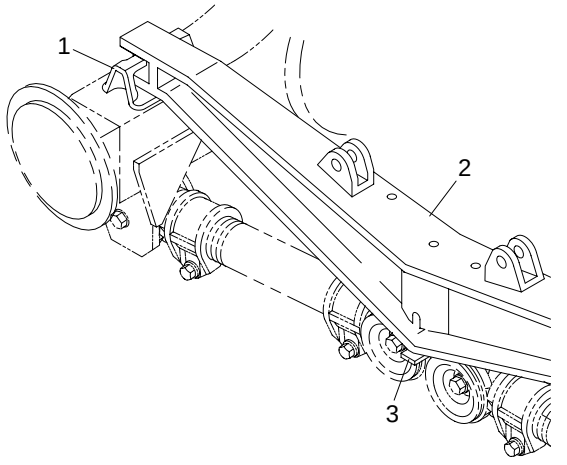
A. Flange thickness measurement taken at unworn area for reference.
B. Flange thickness measurement taken at wear area to assess beam condition.
1. Walking Beam

Fig. 3, Beam Wear Measurement

3. Beams showing excessive wear must be repaired or replaced. Refer to **Subject 140** for beam repair information.

Installation

1. Position the new or repaired walking beam over the rearmost rear axle, with the front end of the beam tilted downward.
2. Slide the beam forward and downward so the front end of the beam enters the axle housing saddle bracket. **See Fig. 4.** Let the middle of the beam rest on the sawhorse bracket beam stop.



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1. Front Axle Housing, Beam Saddle Bracket
2. Walking Beam
3. Beam Stop

Fig. 4, Beam/Saddle Bracket Alignment

NOTE: On 54-inch spread suspensions, it may be necessary to install the spring assembly before the rearmost axle is rolled into place.

3. Carefully roll the rearmost rear axle forward, while lifting the rear end of the walking beam enough so the beam end enters the axle housing saddle bracket.
4. Connect the rearmost axle's upper and lower torque rods to the axle housing brackets. Install and tighten the torque rod bushing through-bolts 135 lbf·ft (183 N·m).
5. Slide, as one assembly, the spring plate, rubber spring, and restrictor cap, into position on the walking beam.
6. Install and tighten the spring plate fasteners 35 lbf·ft (47 N·m).
7. If so equipped, connect the beam-mounted shock absorbers to the beam brackets and tighten the fasteners 170 lbf·ft (230 N·m).
8. Remove the safety stands from under the vehicle, then lower the vehicle.
9. Remove the chocks from the tires.

Repair

NOTE: This subject addresses only instances where excessive beam flange wear occurs, but cracks in the web or flange are not present.

Cracked webs and/or flanges require walking beam replacement.

Walking beams with excessive flange wear, however, can be repaired by welding a Chalmers Wear Plate over the worn areas as described below.

1. Remove the walking beam assembly. Refer to **Subject 130** for information.

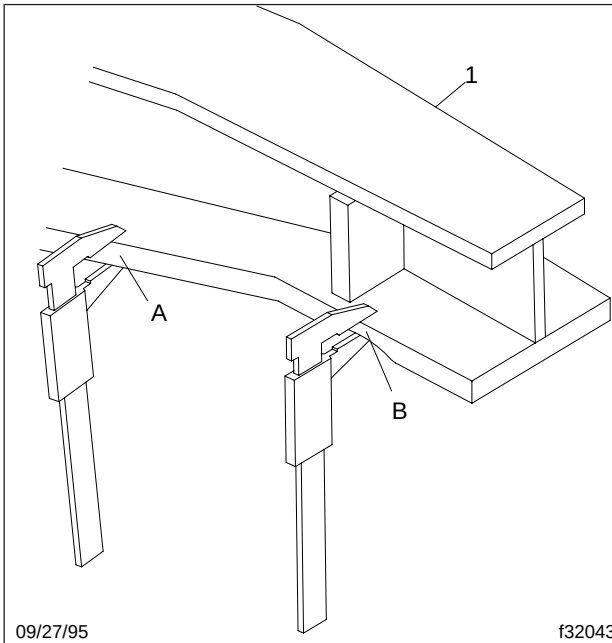
NOTE: Take flange thickness measurements at least 1/2 inch (12 mm) from the flange edges. Measurements taken at the flange edges are not an accurate indication of beam wear and may lead to unnecessary beam repair/ replacement.

2. Confirm that flange wear is severe enough to warrant repairs. Use a micrometer or vernier calipers to take flange thickness measurements at both unworn and worn areas. The maximum allowable difference between unworn and worn areas is 0.062 inch (1.5 mm). **See Fig. 1.**
3. If repair is required, clean the worn area of the beam thoroughly. Make sure that any oil or grease is removed, as well as rust or road dirt accumulation. If necessary, slight grinding of the beam is allowed to smooth raised areas.
4. Clamp Chalmers Wear Plate #700313 to the bottom flange of the beam. Make sure the plate is centered and has good surface-to-surface contact with the beam. Slight grinding is allowable to obtain good plate-to-beam contact.
5. Tack weld the plate to the beam, welding on the sides of the plate only.

⚠ CAUTION

CAUTION: Weld at sides of wear plate and beam only. Never weld at the ends of the wear plate.

6. Remove the clamps and weld the plate to the beam, welding on the sides of the plate only. **See Fig. 2.**



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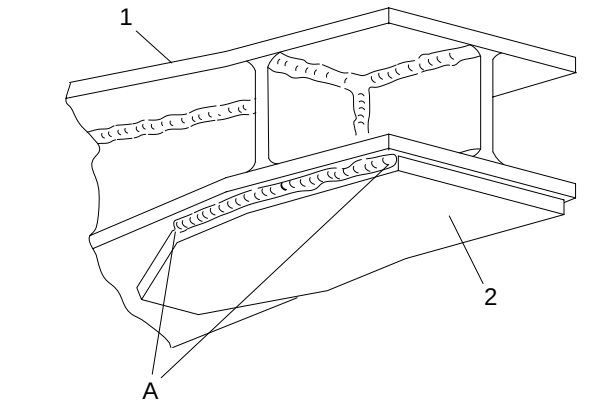
A. Flange thickness measurement taken at unworn area for reference.
B. Flange thickness measurement taken at wear area to assess beam condition.
1. Walking Beam

Fig. 1, Beam Wear Measurement



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A. Limit weld to this area only.
1. Walking Beam 2. Wear Plate

Fig. 2, Chalmers Wear Plate Welding

7. Prime and paint the repaired area.

Walking Beam Repair

8. Install the repaired walking beam assembly. Refer to **Subject 130** for information.

Torque Rod Removal and Installation

The torque rods hold the rear axles in place, maintaining both axle alignment and pinion nose angle. When servicing the torque rods, it is good practice to remove and install them one at a time to avoid the possibility of mixing them up and affecting the alignment or pinion nose angle.

Several different styles of torque rods and bushing spigots exist. On the 40,000 lb version of the 800 Series suspension, the torque rods have tubular steel bodies and the upper rods do not cross over one another. On the 46,000 and 50,000 lb versions, the lower torque rods have tubular steel bodies, but the upper torque rods are made of "I-beam" shaped ductile iron. These upper torque rods do cross over one another. See **Fig. 1** and **Fig. 2**.

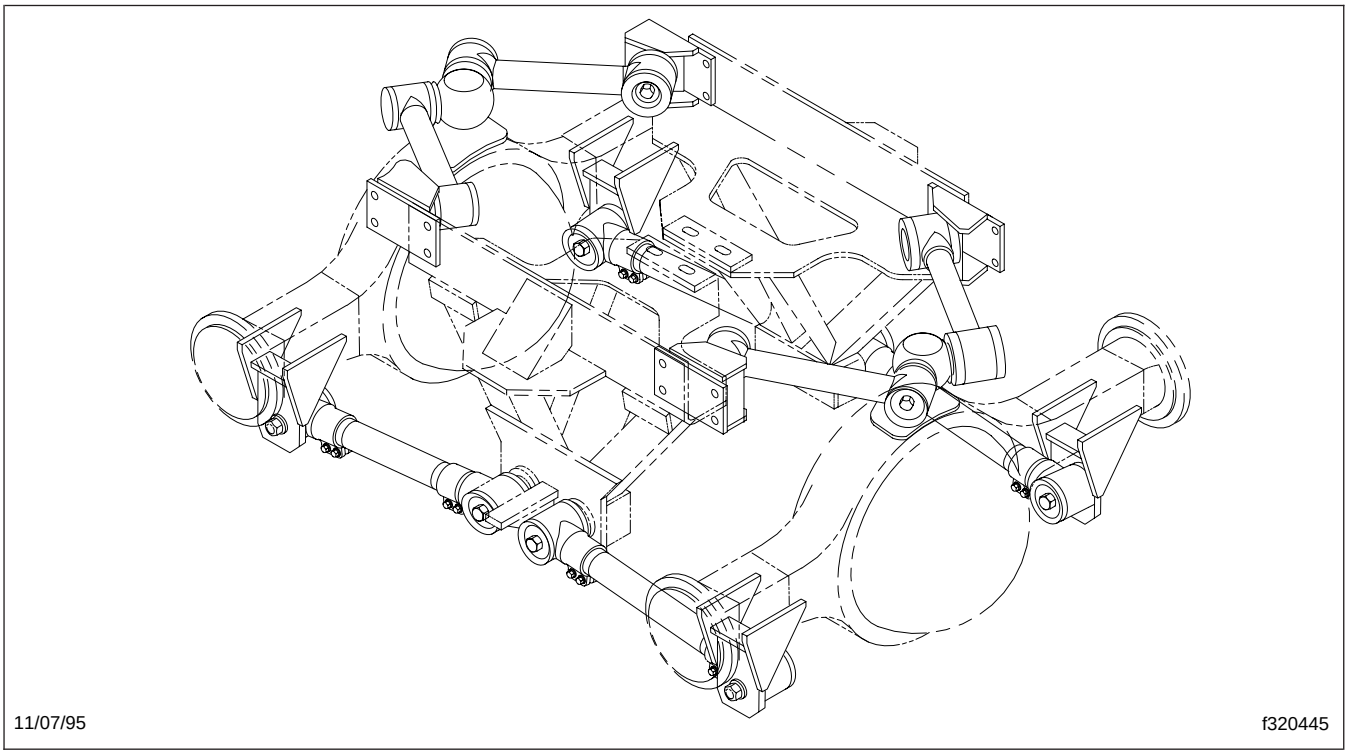


Fig. 1, Torque Rod Arrangement, 40,000 lb Capacity Suspension

Removal

NOTE: Inspect torque rod bushings for free play before removing the torque rods. Refer to **Subject 160** for torque rod bushing inspection information.

1. If necessary, power wash the rear suspension to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Relieve all drive axle brake or wind-up loads by placing the transmission in neutral and releasing the spring or driveline brakes.
4. Raise the rear of the vehicle to remove all weight from the rear axles, and place safety stands under the frame to secure the vehicle in its raised position.
5. Working on one torque rod at a time, remove the torque rod bolts and spigot caps. Discard the bolts. Set the spigot caps aside for cleaning and inspection.

   Remove the torque rods by prying between the torque rod eye and the spigot base or frame bracket.

NOTE: At the axle housing towers, pry off the tower cap to access the torque rod fasteners.

Torque Rod Removal and Installation

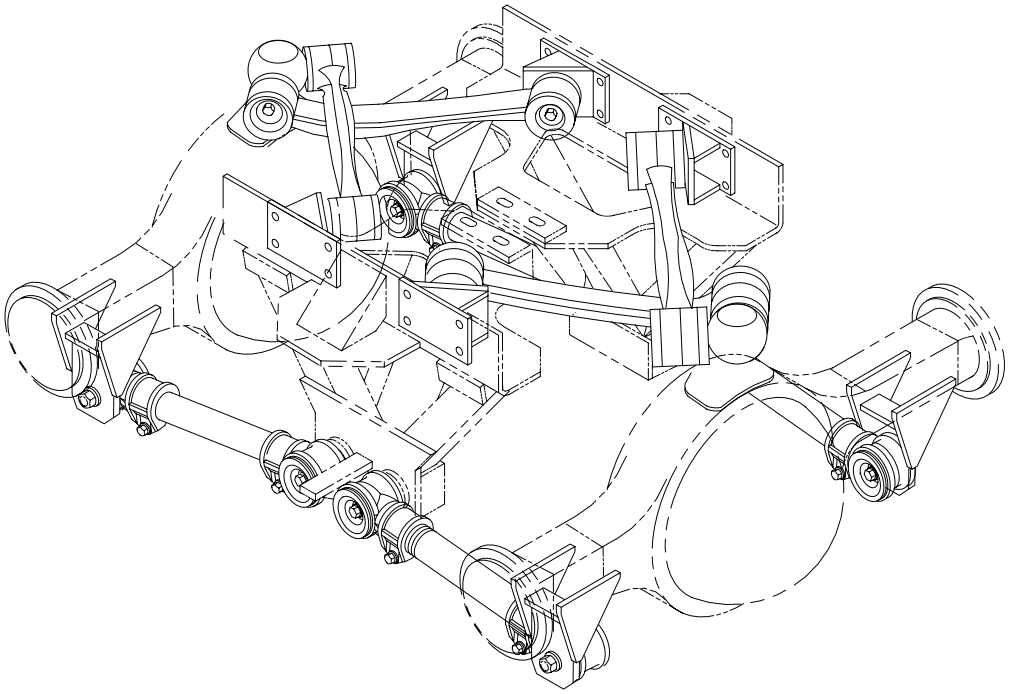
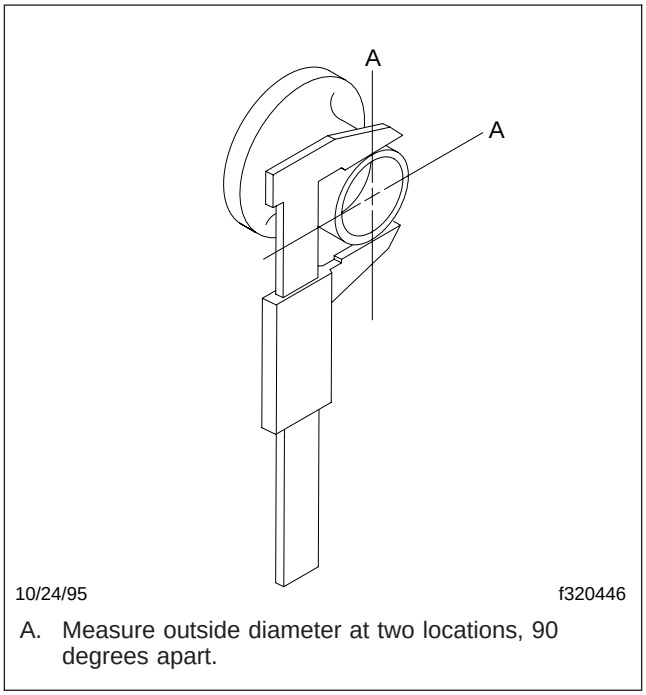


Fig. 2, Torque Rod Arrangement, 46,000 and 50,000 lb Capacity Suspensions

6. Replace worn or damaged bushings following the instructions in **Subject 160**.
7. Inspect the spigots for damage, severe corrosion, or extensive wear. Replace damaged or severely corroded spigots. To determine whether or not a spigot is worn enough to warrant replacement, refer to **Fig. 3** and **Table 1**.

   The smaller of the two measurements should be used as the spigot diameter.
8. On vehicles equipped with Size #0 spigots, carefully inspect the spigot cap bolt head contact area for wear. A worn cap must be replaced to avoid fastener loosening. See **Fig. 4**.



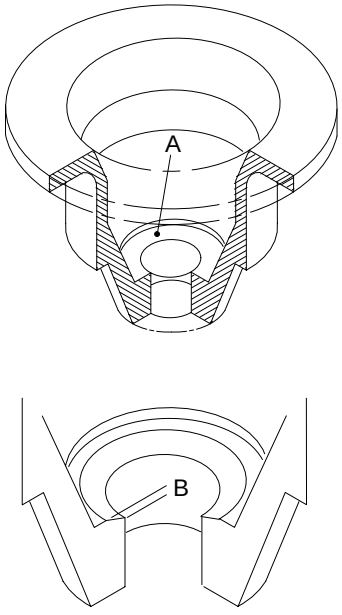
A. Measure outside diameter at two locations, 90 degrees apart.

Fig. 3, Spigot Measurement Points

Installation

1. Check the torque rod bushings to make sure they are properly installed. They must be centered within the torque rod eye. See **Fig. 5**.

IMPORTANT: Never use any mineral based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only



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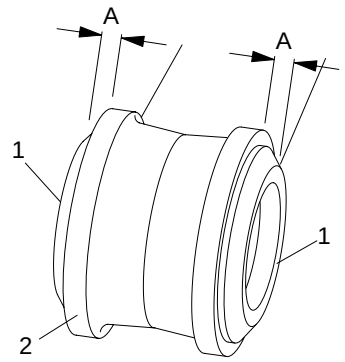
A. The bolt head contact area is the critical wear area.
B. Wear from the bolt head must not exceed 0.005" in depth

Fig. 4, Size #0 Spigot Cap Inspection Areas

lubricants specifically designed for use with rubber compounds.

2. Lubricate the outside of the spigots and the inside of the rubber bushings with a generous amount of rubber lubricant such as Rimslip® or equivalent.
3. Push the torque rod into position on its spigots. After the torque rod is partially installed, use a heavy soft-faced mallet to drive the torque rod into position until the bushing contacts the spigot bottom face.



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A. The amount of rubber protruding from each side of the torque rod eye must be equal.
1. Torque Rod Bushing 2. Torque Rod Eye

Fig. 5, Torque Rod Bushing Protrusion

NOTE: For easier installation, alternate mallet blows between ends of the torque rod to drive it onto the spigots evenly.

4. Install the spigot caps.
5. Install and tighten the torque rod bushing through-bolts 135 lbf·ft (183 N·m).
6. Remove the safety stands from under the vehicle, then lower the vehicle.
7. Remove the chocks from the tires.

Spigot Size	Spigot Part No.	Useage	Minimum Spigot Diameter With Standard Bushing	Minimum Spigot Diameter With Oversize Bushing
#0	700096	40,000 lb capacity—vehicles built before 1/93	2.350 in (59.69 mm)	2.320 in (58.93 mm)
#1	800200	40,000 lb capacity—vehicles built from 1/93	2.350 in (59.69 mm)	2.320 in (58.93 mm)
#2	800021	46,000 & 50,000 lb capacity—all	2.530 in (64.26 mm)	2.500 in (63.50 mm)

Table 1, Spigot Wear Limits

Torque Rod Bushing Inspection and Replacement

Inspection

1. If necessary, power wash the upper and lower torque rods to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Relieve all drive axle brake or wind-up loads by placing the transmission in neutral and releasing the spring or driveline brakes.
4. Using your hands only, attempt to move the torque rod ends, checking for free play. Some movement as the bushings "give" is normal, but only free play is cause for bushing replacement.

NOTE: Never use a lever or pry bar to check for torque rod bushing free play. To do so may result in unnecessary bushing replacement.

5. If free play is detected, replace the bushing as described below.

Replacement

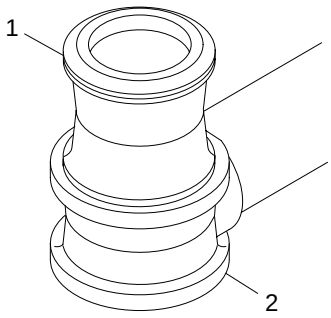
1. Remove the torque rod containing the worn out bushing. Refer to **Subject 150**, if necessary.

NOTE: Remove only one torque rod at a time to avoid mixing-up torque rod positions.

2. Place the torque rod on the floor or a workbench with a bushing open end facing upward. Push the tip of a large screwdriver down between the torque rod eye and the bushing and pry out the bushing. Discard removed bushings.
3. Use a wire brush and/or scraper to clean the torque rod eyes, removing all rust, scale, and rubber accumulations.
4. Inspect the torque rod eyes looking for cracks, distortion, or severe corrosion. Replace torque rods with damaged bushing eyes.

IMPORTANT: Never use any mineral based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only lubricants specifically designed for use with rubber compounds.

5. Lubricate both the inside of the torque rod eye and the outside of the new bushing with a generous amount of rubber lubricant, such as Rimslip® or equivalent.
6. Place the torque rod on a solid level floor with an open end of the eye facing upward. Position a lubricated bushing on the eye, making sure that the tapered shoulder of the bushing is centered on the eye. **See Fig. 1.**



1. Torque Rod Bushing 2. Torque Rod Eye

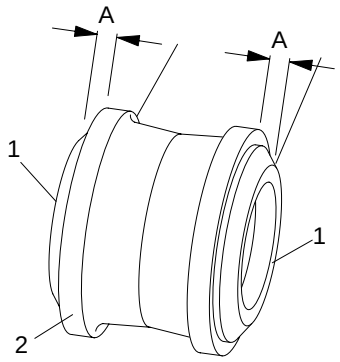
Fig. 1, Torque Rod Bushing Installation

7. Using a heavy, soft-faced mallet, strike the bushing squarely to drive it into the torque rod eye. Then, flip the torque rod over 180 degrees and tap on the torque rod shaft with the mallet while the bushing rests on the floor.

NOTE: If available, a small press may be used instead of a mallet for bushing installation.

8. The bushing is completely installed when it is centered within the torque rod eye. **See Fig. 2.**
9. Install the re-bushed torque rod. Refer to **Subject 150**, if necessary.

Torque Rod Bushing Inspection and Replacement



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A. The amount of rubber protruding from each side of the torque rod eye must be equal .
1. Torque Rod Bushing 2. Torque Rod Eye

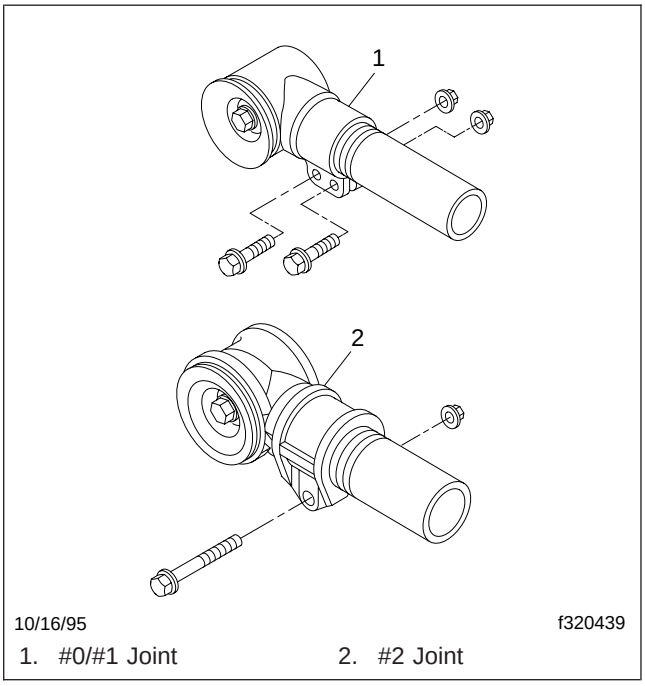
Fig. 2, Torque Rod Bushing Protrusion

Rear Axle Alignment Adjustment

On the Chalmers 800 Series Rear Suspension, the lower torque rods provide the only means for adjusting rear axle alignment. The upper torque rods play no part in the axle alignment process.

The lower torque rod bodies consist of steel tubes, with fine threads cut into the ends of the tube. Left-hand threads are cut into one end of the tube, right-hand threads into the other end. Therefore, by simply twisting the tube body while restraining the ends, the effective length of the tube is changed.

Two different types of torque rod ends are used. On #0 and #1 sizes, two 1/2-inch clamp bolts secure the rod ends to the tube. On the #2 size, a single 5/8-inch bolt is used. See **Fig. 1**.



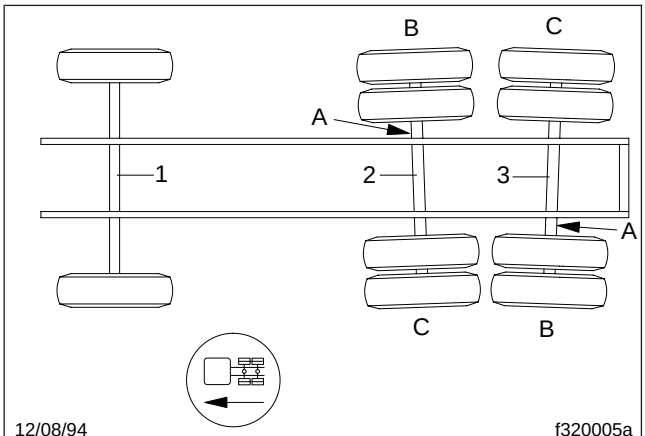
1. #0/#1 Joint
2. #2 Joint

Fig. 1, Adjustable Torque Rod Ends

Adjustment

1. Ensure that the torque rod bushings are in a fully relaxed, neutral state by slowly moving the vehicle back and forth a few times. Apply the service brakes, *not the parking brakes*.
2. Chock the front tires to prevent vehicle movement.
3. Relieve drive axle brake or wind-up loads by placing the transmission in neutral and releasing the brakes.
4. Using a straightedge and a tape measure, determine the amount of adjustment needed to align the forward-rear axle at right angles to the frame. For instructions, see **Group 35**. The difference in measurements between the sides of the vehicle is the approximate amount that the trailing end of the forward-rear axle will have to be brought forward, or the leading end will have to be moved back to align it at a right angle to the frame. See **Fig. 2**.

   If the forward-rear axle alignment is within specifications, go to the step that begins "Using a center-point bar, determine...".



A. Adjust here.
B. Leading End
C. Trailing End
1. Front Axle
2. Forward Rear Axle
3. Rearmost Axle

Fig. 2, Tandem Axle, Shown Out of Alignment

5. On the side of the vehicle that is to be adjusted forward or rearward, loosen the torque rod end pinch bolts at both ends of the torque rod.

NOTE: If the pinch bolts are badly corroded or otherwise damaged, remove and discard them. Install new Chalmers fasteners.

6. Attach a pipe wrench to the tube body (chain type preferred) and rotate the tube to shorten or

Rear Axle Alignment Adjustment

lengthen the torque rod. Continue to rotate the tube until the forward-rear axle is square to the frame.

NOTE: If the torque rod tube is difficult to rotate, apply penetrating oil to the tube threads. If this does not help, remove the pinch bolts and drive wedges between the eye lugs to relieve the clamping effect.

7. When the forward-rear axle is square with the frame, tighten the pinch bolts.
   - 7.1 Tighten 1/2-inch UNC bolts on #0 and #1 joints 65 lbf·ft (88 N·m).
   - 7.2 Tighten 5/8-inch UNC bolts on #2 joints 135 lbf·ft (183 N·m).
8. Using a center-point bar, determine the difference between the forward-rear and the rearmost axles' center-to-center measurements on each side of the vehicle. For instructions, see **Group 35**. This difference is the approximate distance that the leading end of the rearmost axle will have to be adjusted rearward, or that the trailing end will have to be adjusted forward, to align it at a right angle to the frame, and to align it parallel to the forward-rear axle. See **Fig. 2**.
9. On the side of the vehicle that is to be adjusted forward or rearward, loosen the torque rod end pinch bolts at both ends of the torque rod.

NOTE: If the pinch bolts are badly corroded or otherwise damaged, remove and discard them. Install new Chalmers fasteners.

10. Attach a pipe wrench to the tube body (chain type preferred) and rotate the tube to shorten or lengthen the torque rod. Continue to rotate the tube until the rearmost axle is square to the frame.

NOTE: If the torque rod tube is difficult to rotate, apply penetrating oil to the tube threads. If this does not help, remove the pinch bolts and drive wedges between the eye lugs to relieve the clamping effect.

11. When the rearmost axle is square with the frame, tighten the pinch bolts.
    - 11.1 Tighten 1/2-inch UNC bolts on #0 and #1 joints 65 lbf·ft (88 N·m).
    - 11.2 Tighten 5/8-inch UNC bolts on #2 joints 135 lbf·ft (183 N·m).
12. Remove the safety stands, and lower the vehicle. Remove the chocks from the front tires.
13. Using the center-point bar, check the rearmost axle alignment. If alignment is not within specifications, repeat the applicable steps above.

⚠ CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the suspension.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 of the *Heavy-Duty Trucks Maintenance Manual*.

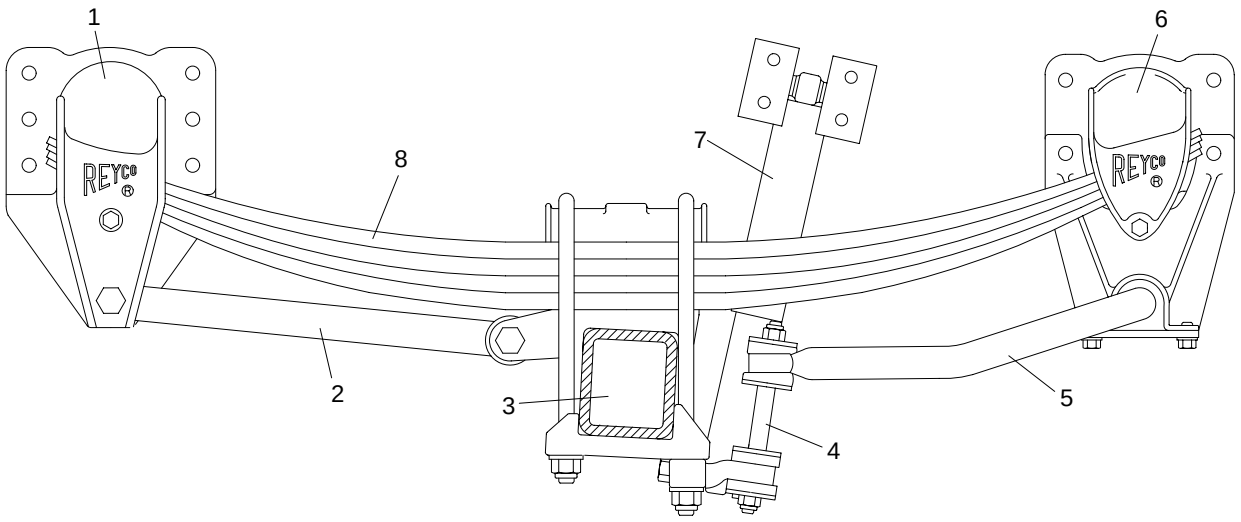
Specifications

Description	Bolt Size	IFI Grade	Torque lbf·ft (N·m)
Beam Spring Plate Bolt	3/8 UNC	8	35 (47)
Torque Rod End Through Bolts	5/8 UNC	8	135 (183)
Shock Absorber (Beam-Mounted) Bolt	3/4	8	170 (230)
Shock Absorber (Axle-Mounted) Nut	7/8	G	270 (366)
#0/#1 Torque Rod End Pinch Bolts	1/2 UNC	8	65 (88)
#2 Torque Rod End Pinch Bolts	5/8 UNC	8	135 (183)

Table 1, Fastener Torques, 800 Series Suspension

General Description (See Fig. 1)

The Reyco 79KB suspension uses a full–floating spring design. Semi-elliptical spring assemblies, or optional parabolic springs, are attached to the axles with U–bolt assemblies. The spring ends ride in hangers that are mounted on the frame rails. Adjustable torque rods are attached to the front frame hanger and axle seat to hold the axle in alignment.



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1. Forward Spring Hanger
2. Torque Rod
3. Axle
4. Anti-Sway Bar End–Link (optional)
5. Anti–Sway Bar (optional)
6. Rear Spring Hanger
7. Shock Absorber
8. Leaf Spring

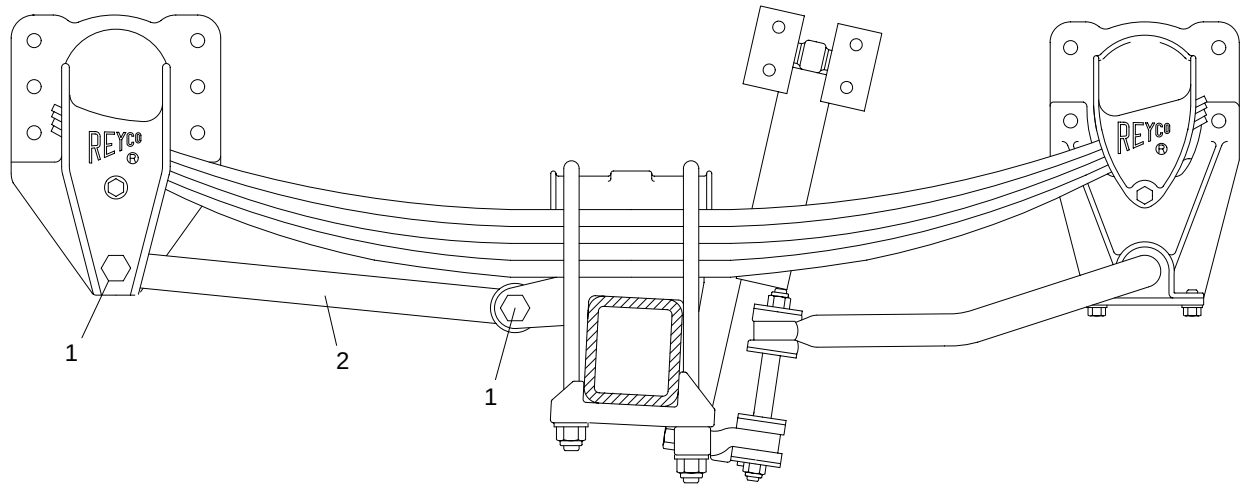
Fig. 1, Reyco 79KB Suspension

Torque Rod Removal and Installation

Removal (See Fig. 1)

There are two torque rods installed on the Reyco 79KB suspension. The curb (right) side torque rod is not adjustable (rigid). The left (driver's) side torque rod is adjustable to allow proper axle alignment.

1. Apply the parking brakes, and chock the front tires.
2. Use a lifting device and raise the rear of the tractor until the rear tires are elevated above the ground. Place jack stands under the frame rails to unload the suspension, and lower the lifting device until only the jack stands are supporting the vehicle weight.
3. Place the lifting device under the axle and raise the axle to unload the torque rod. Place jack stands under the axle.
4. Remove the two torque rod bolts and nuts, and remove the torque rod. See **Fig. 1**.



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1. Torque Rod Bolt
2. Torque Rod

Fig. 1, Reyco 79KB Torque Rod

Installation (See Fig. 1)

1. Place the torque rod on the forward frame hangar and install a torque rod bolt to hold it in place.
2. Raise the opposite end of the torque rod on the lower axle mounting plate.
3. Install a bolt on the torque rod
4. Tighten the torque rod locknuts 400 to 450 lbf·ft (540 to 610 N·m).
5. Raise the axle and remove the jack stands. Lower the axle to the ground.
6. Raise the rear of the vehicle and remove the jack stands. Lower the vehicle to the ground.
7. Check the axle alignment. For instructions, see **Group 35**. If necessary, adjust the rear axle alignment, using the instructions in **Subject 130**.

Removal (See Fig. 1)

⚠ WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

⚠ WARNING

Leaf spring assemblies weigh approximately 100 to 190 lbs (45 to 86 kg). Do not attempt to remove a leaf spring assembly without assistance. Personal injury and property damage may result.

1. Park the vehicle on a level surface. Apply the parking brakes and chock the front tires.
2. Raise the frame so that all weight is removed from the leaf springs, then support the frame with safety stands. Raise the rear axle until the spring no longer contacts the spring retainer rollers, then support the axle with safety stands. Make sure the stands will securely support the weight of the axles and frame. To gain easy access to the suspension system, remove the wheel assembly; see **Group 40** for instructions.
3. Remove the U-bolt locknuts and washers (see **Fig. 1**. Remove the U-bolt mounting plate. Remove the U-bolts , and the upper axle mounting plate.
4. Remove the spring retaining bolts, spring rollers, and nuts.
5. Use a pry tool to lift the leaf spring assembly off of the lower mounting plate.

NOTE: There is a projection at the center of the leaf spring assembly to locate the spring.

6. With assistance, carefully move the leaf spring assembly forward to clear the rear hanger. Raise the rear of the leaf spring assembly and move it rearward to clear the front hanger. Remove the leaf spring from the vehicle.

Installation

⚠ WARNING

Leaf spring assemblies weigh approximately 100 to 190 lbs (45 to 86 kg). Do not attempt to install a leaf spring assembly without assistance. Personal injury and property damage may result.

1. With assistance, position the leaf spring assembly on the axle.
2. Place the front of the leaf spring assembly through the hanger, then place the rear of the leaf spring assembly through the rear hanger.
3. Install the projection on the center of the leaf spring assembly on the spring seat.
4. Install the U-bolt pad on the leaf spring assembly.
5. Install the U-bolts over the U-bolt pad and axle tube. Insert the U-bolts through the axle clamp, then install the U-bolt washers and locknuts. Tighten the U-bolt nuts in stages in a diagonal pattern as described in **Specifications 400**.
6. Install the spring retainer bolts, rollers, and locknuts. Tighten the spring retaining bolt locknuts 60 to 80 lbf·ft (85 to 110 N·m).
7. Move the torque rod into position with the lower axle mounting plate.
8. Install the torque rod mounting bolt and locknut. Tighten the locknut 350 to 400 lbf·ft (475 to 545 N·m).
9. Install the wheel assembly. See **Group 40** for instructions.
10. Raise the axle assembly, remove the safety stands and lower the axle to the ground.
11. Raise the vehicle frame, remove the safety stands from under the frame and lower the vehicle.

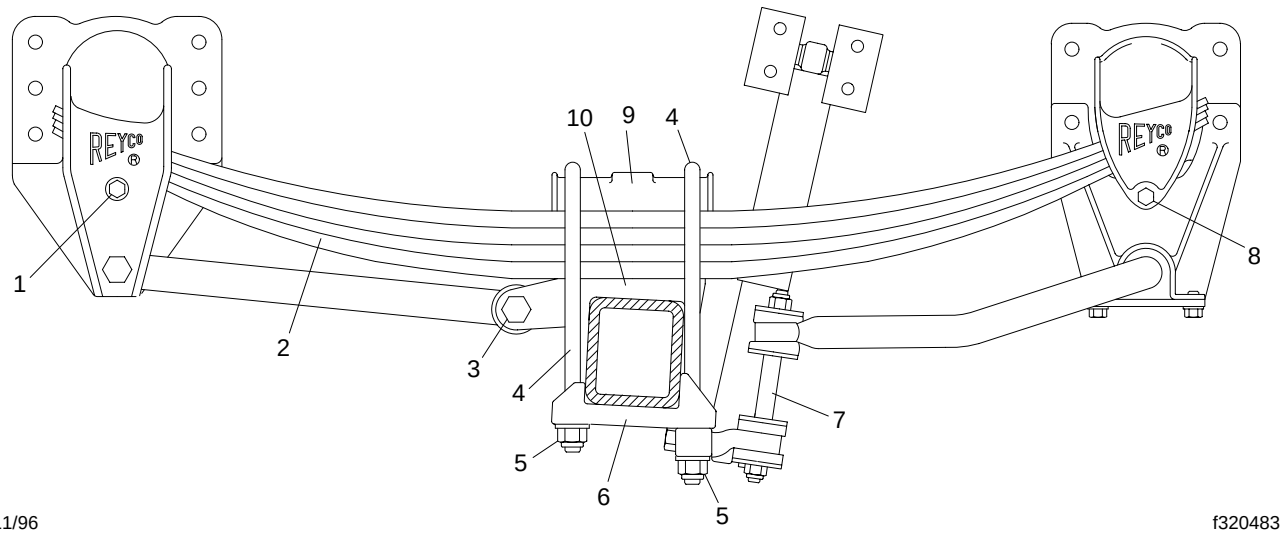
⚠ CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear and damage to the springs, spring brackets, and frame rail.

Spring Assembly Replacement

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 of the *Heavy-Duty Trucks Maintenance Manual*.

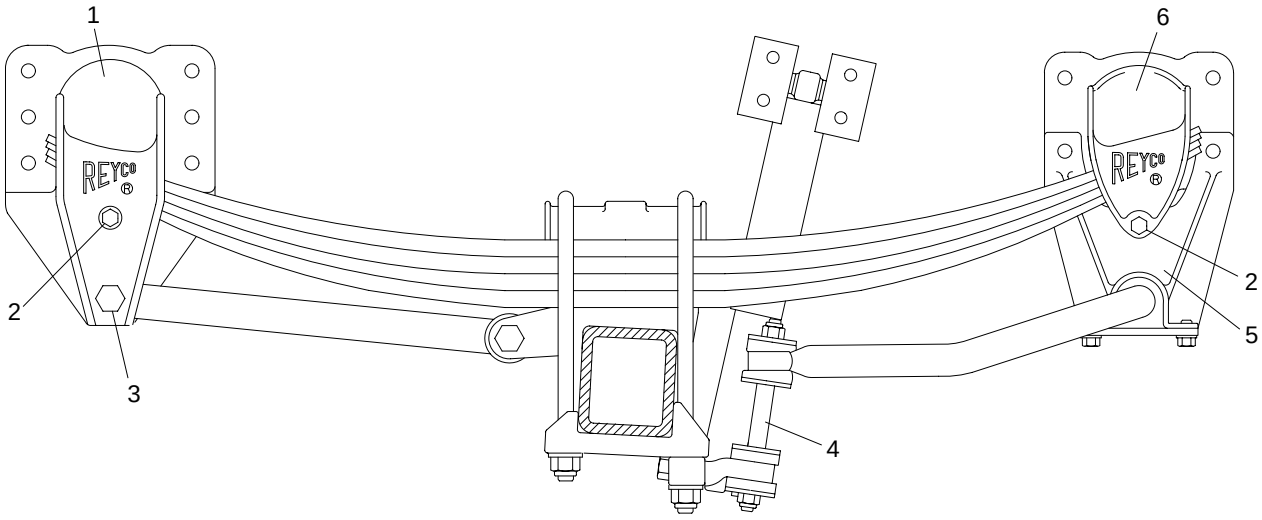
12. Check the axle alignment. For instructions, see **Group 35** in this manual. If necessary, adjust the rear axle alignment, using the instructions in **Subject 130**.



1. Forward Hanger Spring Retainer Bolt
2. Leaf Spring
3. Torque Rod Bolt
4. U–Bolt
5. U–Bolt Locknut
6. Axle Clamp
7. Anti–Sway Bar End Link (optional)
8. Rear Hanger Spring Retainer Bolt
9. U-Bolt Pad
10. Spring Seat

Fig. 1, Reyco 79KB Leaf Spring Replacement

Removal (See Fig. 1)



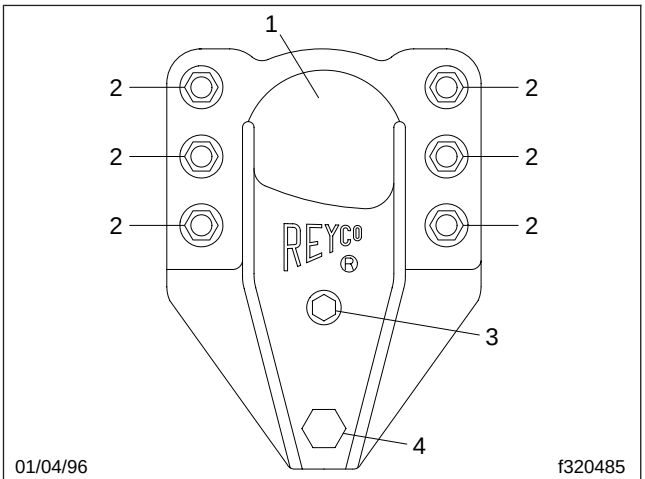
1. Forward Spring Hanger
2. Spring Retainer Bolt
3. Torque Rod Mounting Bolt
4. Anti-Sway Bar End Link (optional)
5. Anti-Sway Bar Mounting Bracket (optional)
6. Rear Spring Hanger

Fig. 1, Reyco 79KB Frame Hanger Components for Removal

⚠ WARNING

Replace worn, cracked, or damaged spring hangers. Failure to do so could result in bracket breakage, possibly leading to loss of vehicle control and resulting in personal injury or property damage.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the front tires.
2. Place a lifting device under the vehicle frame. Lift the frame until the leaf spring assemblies are no longer in contact with the hangers, and support the frame with safety stands.
3. Remove the torque rod mounting bolt located on the forward hanger. See **Fig. 2**, Ref. 4.
4. Remove the spring retainer bolt from the forward hanger. See **Fig. 2**, Ref. 3.
5. Remove the six hanger mounting bolts and nuts. See **Fig. 2**, Ref. 2.
6. Remove the forward hanger from the frame rail.



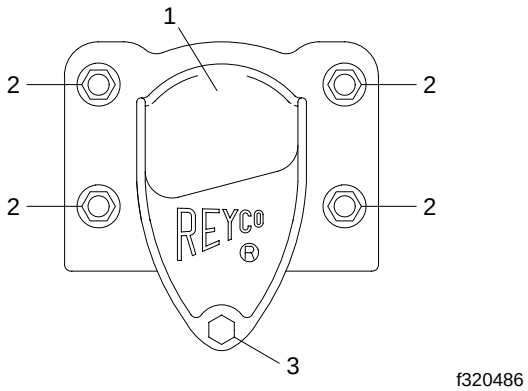
1. Forward Spring Hanger
2. Forward Spring Hanger Mounting Bolt
3. Spring Retainer Bolt
4. Torque Rod Mounting Bolt

Fig. 2, Reyco 79KB Forward Spring Hanger

7. Remove the spring retainer bolt from the rear hanger. See **Fig. 3**, Ref. 3.

Spring Hanger Replacement

8. Remove the anti-sway bar end links, if equipped. See **Fig. 1**, Ref. 4.
9. Remove the lower spring hanger mounting bolts (see **Fig. 3**, Ref. 2) and remove the anti-sway bar mounting bracket, if equipped. See **Fig. 1**, Ref. 5.
10. Remove the upper spring hanger mounting bolts (see **Fig. 3**, Ref. 2) and remove the rear hanger.



1. Rear Spring Hanger
2. Spring Hanger Mounting Bolt
3. Spring Retainer Bolt

Fig. 3, Reyco 79KB Rear Spring Hanger

⚠ CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 of the *Heavy-Duty Trucks Maintenance Manual*.

Installation

1. Install the rear spring hanger on the frame rail, then install the two upper mounting bolts.
2. If equipped, position the anti-sway bar mounting bracket over the lower bolt holes on the rear spring hanger, then install the two lower mounting bolts.
3. Tighten the rear spring hanger mounting bolts 190 lbf·ft (258 N·m).
4. Install the anti-sway bar end link and bushings, if equipped. Tighten the end link capscrew. See **Group 00** of this manual for proper torque specifications.
5. Install the spring retainer bolt, roller, and nut. Tighten the spring retainer bolt 60 to 80 lbf·ft (85 to 110 N·m).
6. Install the forward spring hanger on the frame rail, then install the mounting bolts. Tighten the mounting bolts 190 lbf·ft (258 N·m).
7. Install the torque rod mounting bolt. Tighten the torque rod mounting bolt 350 to 400 lbf·ft (475 to 545 N·m).
8. Install the spring retainer bolt, roller, and nut. Tighten the spring retainer bolt 60 to 80 lbf·ft (85 to 110 N·m).
9. Raise the vehicle frame with a lifting device, and remove the safety stands. Lower the vehicle to the ground.
10. Remove the wheel chocks.

Adjustment

CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 of the *Heavy-Duty Trucks Maintenance Manual*.

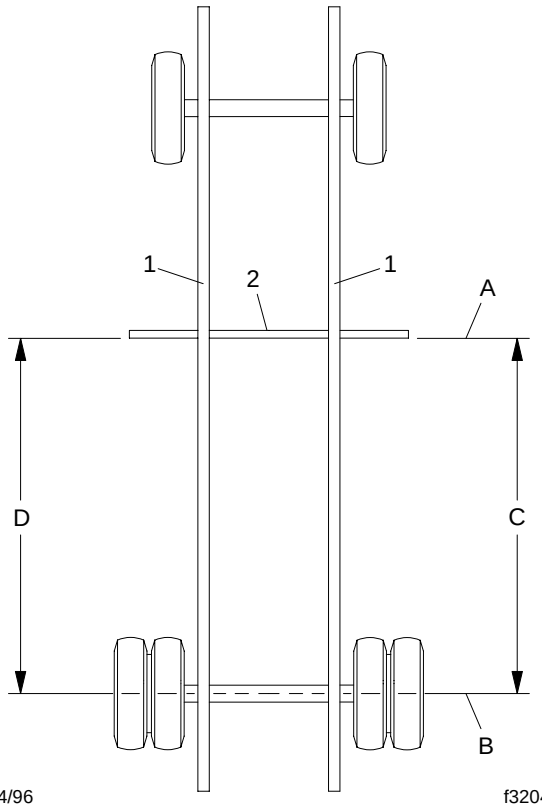
1. Park the vehicle on a level surface. Move the vehicle slowly back and forth several times without using the brakes to free all of the suspension joints. Shut down the engine. Do not apply the parking brakes.
2. Chock the front tires.

NOTE: Check that the leaf springs are not binding in the frame hangars. Make sure that the U-bolts and torque rod bolts are torqued to specification, and all of the bushings are in good condition.

3. Position an 8 ft (2-1/2 m) length of bar stock, or angle iron across the frame. Square the bar across the frame using a carpenter's square, and clamp it in place on the frame rail. See **Fig. 1**, Ref. 2.

NOTE: Position the bar as far forward of the drive axle as possible.

4. Start on the fixed (right) torque rod side. Measure the distance from the bar stock to the centerline of the drive axle. Repeat the same procedure on the adjustable (left) torque rod side. See **Fig. 1**, Ref. C and D.
5. If the distance varies more than 1/8-inch, alignment is necessary.
6. Loosen the torque rod clamp bolts. See **Fig. 2**, Ref. 1.
7. Use a pipe wrench or other suitable tool and slowly turn the torque rod.

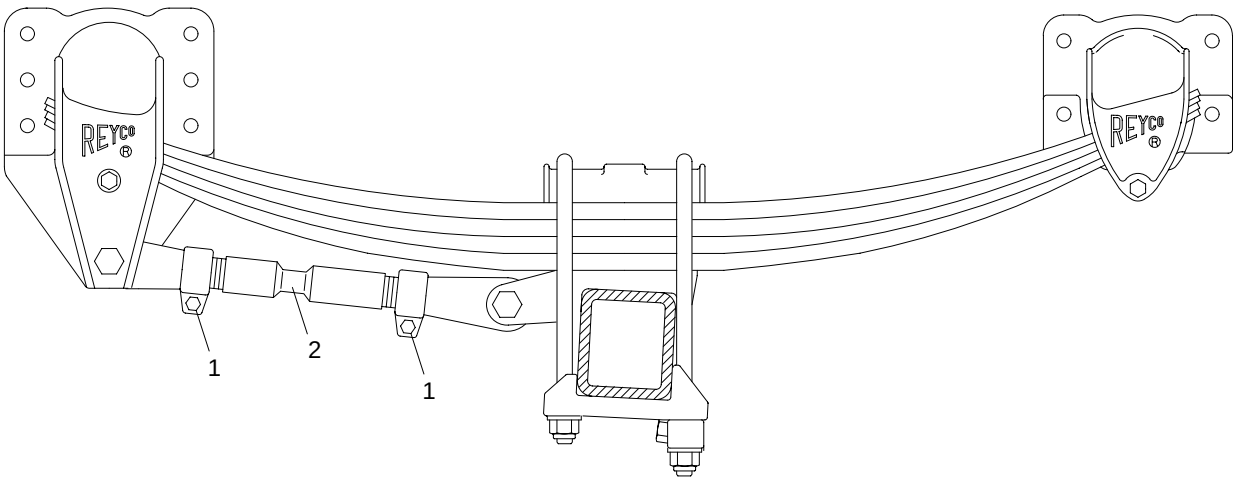


A. Trailing Edge
B. Drive Axle Centerline
C. Fixed Torque Rod Side
D. Adjustable Torque Rod Side
1. Frame Rail
2. Bar Stock

Fig. 1, Measuring Axle Alignment

8. Turn until the measurement on both sides of the axle are within 1/8-inch, then tighten the torque rod clamp bolts 125 to 150 lbf·ft (170 to 203 N·m).
9. Remove the wheel chocks and drive the vehicle through a short series of turns.
10. Recheck the alignment.

Rear Axle Alignment Adjustment



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1. Torque Rod Clamp Bolt
2. Torque Rod Adjustment Location

Fig. 2, Adjustable Torque Rod

Specifications

Reyco 79KB Torque Values		
Description	**Size in.**	**Torque lbf·ft (N·m)**
Forward Spring Hanger	5/8	190 (258)
Rear Spring Hanger	5/8	190 (258)
Axle U-Bolt High Nuts	7/8–14	Stage 1: Hand Tighten Stage 2: 60 (81) * Stage 3: 200 (271) * Stage 4: 420 to 500 (571 to 680) *
Torque Rod Mounting Bolts	7/8	400 to 450 (545 to 615)
Torque Rod Clamp Nuts	5/8	125 to 150 (170 to 203)
Spring Retainer Bolts	1/2	60 to 80 (85 to 110)

* Tighten in a diagonal pattern as shown in **Fig. 1**.

Table 1, Reyco 79KB Torque Values

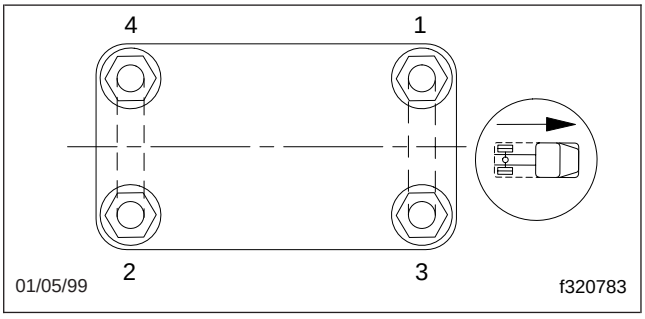
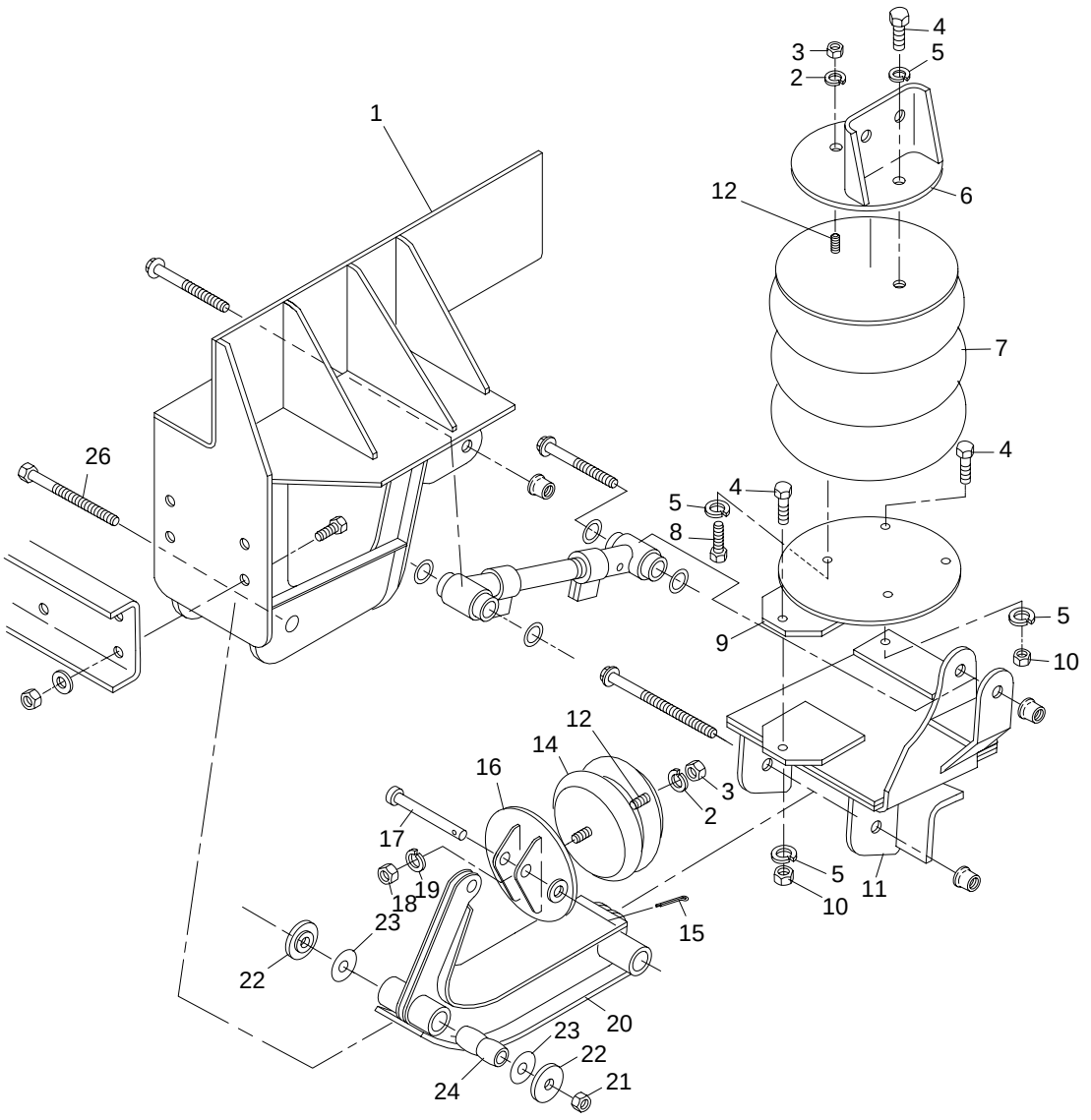


Fig. 1, Tightening Pattern for U-bolt High Nuts

General Description

The Watson and Chalin SL series steerable axle lift suspension (**Fig. 1**) uses a full-floating air spring design. Two air springs are attached to a trailing arm assembly. One air spring controls the suspension riding height, depending on load requirements, and the other air spring is used to lift the axle assembly when not in use. The trailing arm and air springs are attached to the frame rail with an upper torque rod, and a fastener that rides on a rubber bushing. Weld collars locate the suspension on the frame and hold the axle in alignment.

General Description



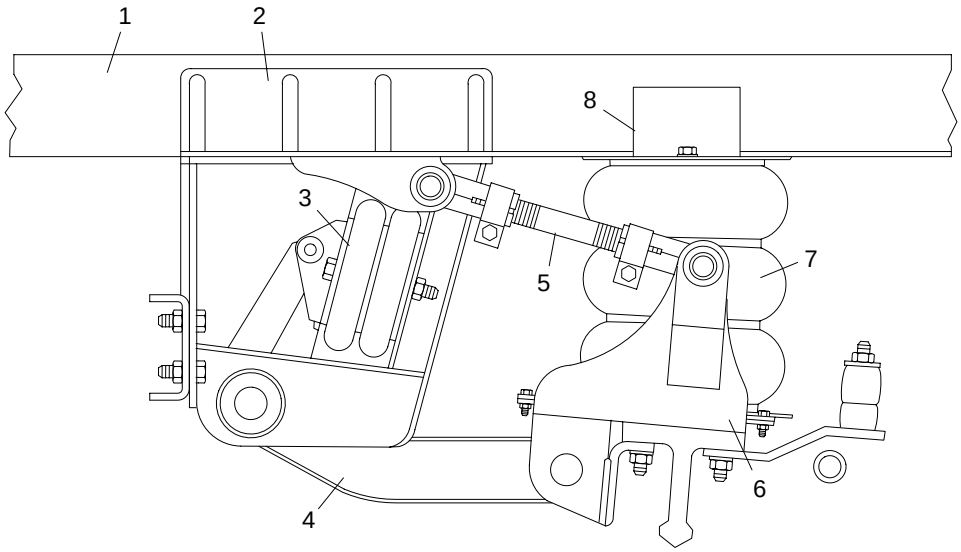
1. Side Rail Assembly
2. 3/4-Inch Lockwasher
3. 3/4-Inch UNF Hexnut
4. 3/8 x 1-1/8 Inch Capscrew
5. 3/8-Inch Lockwasher
6. Upper Air-Spring Plate
7. Load-Bearing Air Spring
8. 3/8-Inch UNC x 1 Inch Capscrew
9. Lower Air-Spring Plate
10. 3/8-Inch UNF Hexnut
11. Axle Pad Assembly
12. Air Fitting
13. Flatwasher
14. Axle Lift-Air Spring
15. Cotter Pin
16. Lift Plate
17. 3/4-Inch Clevis Pin
18. 1/2-Inch UNC Hexnut
19. 1/2-Inch Lockwasher
20. Trailing Arm
21. 1-1/8-Inch Locknut
22. Weld Collar
23. Washer
24. Bushing

Fig. 1, Air Spring Replacement, Exploded View

Upper Torque Rod Removal and Installation

Removal (See Fig. 1)

Installation (See Fig. 1)



1. Frame Rail
2. Side Rail Assembly
3. Axle-Lift Air Spring
4. Trailing Arm
5. Torque Rod
6. Axle Pad Assembly
7. Load-Bearing Air Spring
8. Upper Air-Spring Mounting Plate

Fig. 1, Watson and Chalin SL Series Steerable Axle Lift Suspension

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Completely drain all of the air from the air system. The air pressure gauge should read 0 psi (0 kPa).

⚠ WARNING

WARNING: Failure to drain the air system could result in personal injury, or property damage.

NOTE: If the upper torque rod has been previously serviced, remove the two mounting capscrews, two nuts, and four washers that attach the upper torque rod to the frame rail and axle assembly.

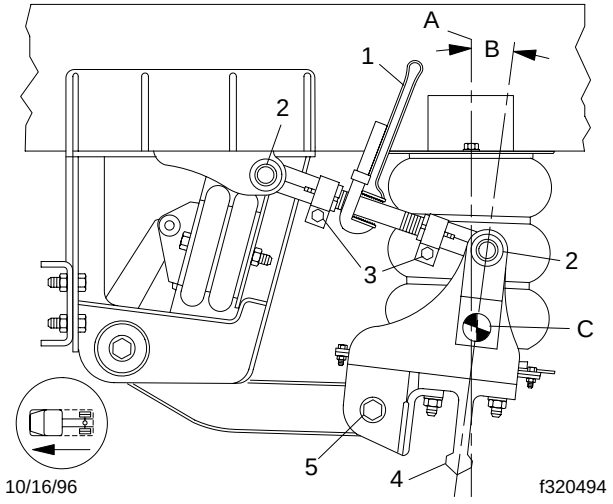
3. Remove the two huck bolts, two huck collars, and four washers that attach the upper torque rod to the frame rail and axle assembly.
4. Remove the upper torque rod from the vehicle.

1. If you are replacing the upper torque rod, measure the length of the old upper torque rod.
2. Duplicate the measurement, as closely as possible, on the new upper torque rod.
3. Install the upper torque rod onto the frame rail and axle assembly using the two capscrews, four washers, and two locknuts. Do not tighten the upper torque rod clamps.

   Use a pipe wrench to align the upper torque rod to the frame hanger and the axle pad assembly.
4. Tighten the capscrew at the frame rail 600 lbf·ft (814 N·m).
5. Tighten the capscrew at the axle assembly 1000 lbf·ft (1356 N·m).
6. Connect a magnetic protractor to the steerable axle.
7. Position the protractor on the axle pad assembly, so it is even with the centerline of the axle and the axle spindle center. See **Fig. 2**, Ref. 2.

Upper Torque Rod Removal and Installation

8. Move the protractor to position the centerline of the axle with the centerline of the upper torque rod capscrew. See **Fig. 2**, Ref. 6.
9. Record the caster setting. See **Fig. 2**, Ref. A.



A. Centerline of Axle
B. Caster Setting
C. Axle Spindle Center
1. Pipe Wrench
2. Huck Collar
3. Upper Torque Rod Clamp
4. Steerable Axle
5. Axle Seat Capscrew

Fig. 2, Watson & Chalin SL Series Suspension, Adjusting Caster

NOTE: Check both wheels for proper caster settings.

Caster should be set at 5° to 6° positive. Caster cannot be less than 5° positive.

10. If the caster setting is incorrect, adjust by turning the upper torque rod clockwise, or counterclockwise to achieve the proper caster setting. See **Fig. 2**, Ref. 1.
11. Tighten the upper torque rod clamps 600 lbf·ft (814 N·m).
12. Check the toe-in of the axle, using instructions found in **Group 33**.

Air Spring Inspection and Replacement

Inspection (See Fig. 1)

Check the air springs periodically to ensure that there is no dry-rot, cracking, deformities, or other damage that could impede the performance of the vehicle. Refer to the driver's manual for additional information regarding daily, pre-trip inspections of the air springs.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Check the air bags for cracks, deformities, dry-rotting, or other damage. Replace the air bags as needed.
3. Check for obstructions that could cause a breach of the air bag integrity. Reposition any component that is making contact with the air spring.
4. Check that the air system is fully charged, then check the operation of the axle lift air spring. If the axle lift air springs do not operate properly, refer to **Subject 300** for troubleshooting information.
5. Check the air lines for cracks, deformities, or leaking. Replace the air lines as needed.

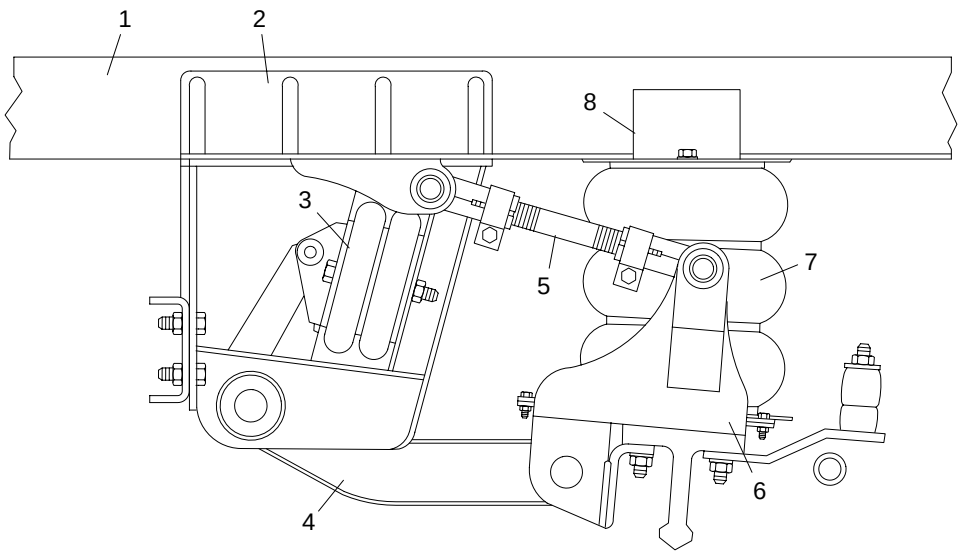
Replacement (See Fig. 2)

⚠ WARNING

WARNING: Before attempting to remove the air springs, be sure that all of the air has been drained from the air system. The air spring will expand, suddenly, when removed from its mount if the air system is not fully drained and could result in personal injury, or property damage.

Axle Lift Air Spring

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the wheels.
2. Completely drain all of the air from the air system. The air pressure gauges should read 0 psi (0 kPa).
3. Use a lifting device and elevate the steerable axle.
4. Place jack stands under the axle beam.
5. Remove the cotter pin, washer, and clevis pin from the lift plate.



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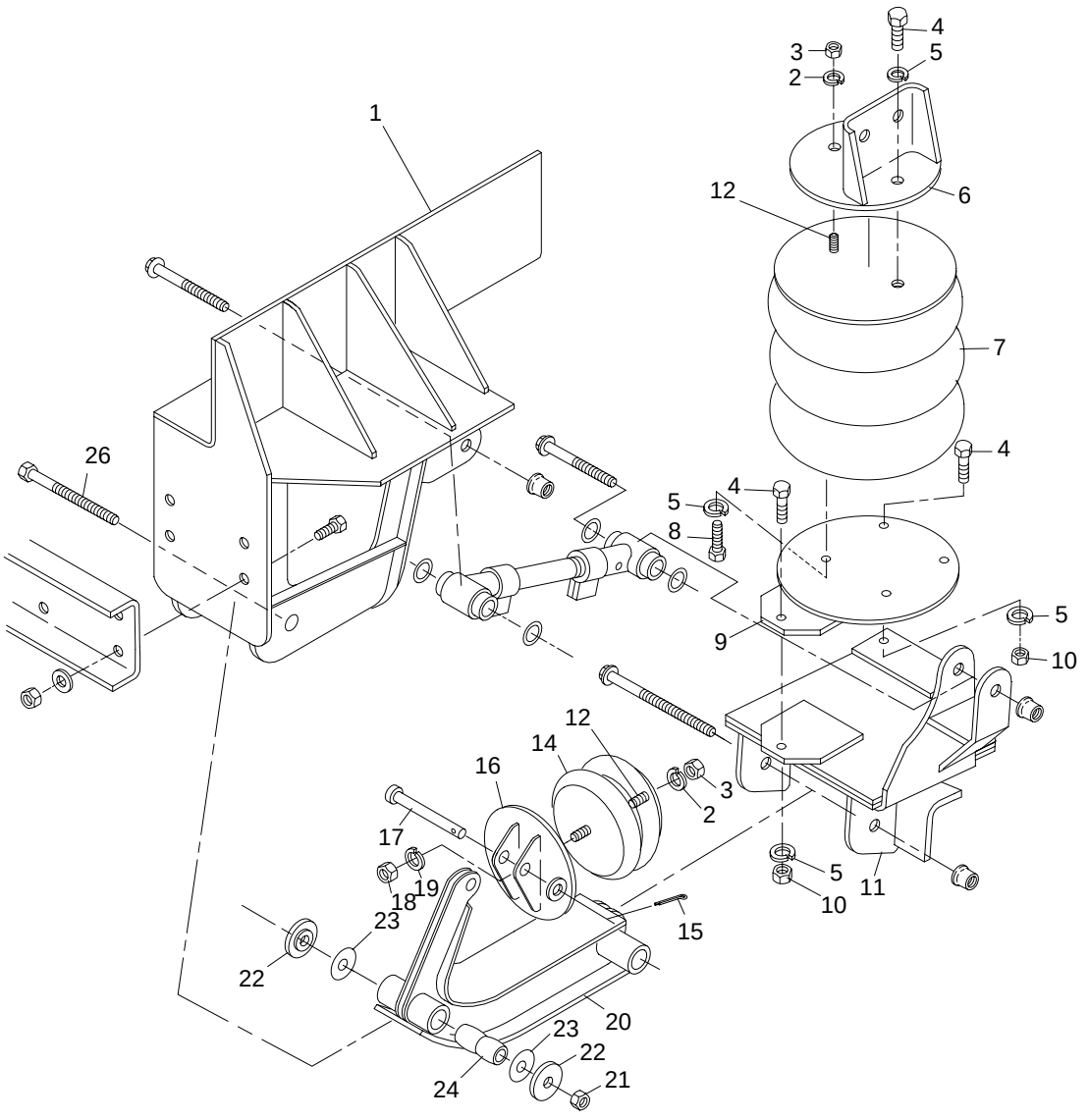
1. Frame Rail
2. Side Rail Assembly
3. Axle-Lift Air Spring
4. Trailing Arm
5. Torque Rod
6. Axle Pad Assembly
7. Load-Bearing Air Spring
8. Upper Air-Spring Mounting Plate

Fig. 1, Watson & Chalin SL Series Steerable Axle Lift Suspension

Air Spring Inspection and Replacement



1. Side Rail Assembly
2. 3/4-Inch Lockwasher
3. 3/4-Inch UNF Hexnut
4. 3/8 x 1-1/8 Inch Capscrew
5. 3/8-Inch Lockwasher
6. Upper Air-Spring Plate
7. Load-Bearing Air Spring
8. 3/8-Inch UNC x 1 Inch Capscrew
9. Lower Air-Spring Plate
10. 3/8-Inch UNF Hexnut
11. Axle Pad Assembly
12. Air Fitting
13. Flatwasher
14. Axle Lift-Air Spring
15. Cotter Pin
16. Lift Plate
17. 3/4-Inch Clevis Pin
18. 1/2-Inch UNC Hexnut
19. 1/2-Inch Lockwasher
20. Trailing Arm
21. 1-1/8-Inch Locknut
22. Weld Collar
23. Washer
24. Bushing

Fig. 2, Air Spring Replacement, Exploded View

6. Remove the air line and fitting from the axle lift air spring.
7. Remove the capscrew, two washers, two washers, and one locknut then lower the trailing arm.

8. Remove the 3/4-inch hexnut and washer; then remove the axle lift air spring.
9. Remove the 1/2-inch hexnut and lockwasher from the lift plate; then separate the axle-lift air spring (Ref. 14).
10. Install the axle-lift air spring on the lift plate. Install the 1/2-inch hexnut and lockwasher on the lift plate. Tighten the hexnut 25 lbf·ft (34 N·m).
11. Install the new axle-lift air spring, lockwasher, and 3/4-inch hexnut on the frame hanger. Tighten the hexnut 200 lbf·ft (271 N·m).
12. Raise the trailing arm and insert the clevis pin through the lift plate; then insert and lock a new cotter pin into the clevis pin.
13. Start the capscrew (Ref. 26) through the frame hanger (Ref 1). Position the washers between the frame hanger and the lower trailing arm and the trailing arm. Install the capscrew through the frame hanger and the trailing arm. Install the locknut and tighten it 1000 lbf·ft (1356 N·m).
14. Install the air fittings and the air lines.
15. Remove the jack stands.
16. Start the engine and build up air pressure.
17. Check for air leaks, and check axle lift operation.
18. Remove the chocks from the tires.

Load Bearing Air Spring

⚠ WARNING

WARNING: Before attempting to remove the air springs, be sure that all of the air has been drained from the air system. The air spring will expand suddenly when removed from its mount if the air system is not fully drained. This could result in personal injury or property damage.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Completely drain all of the air from the air system. The air pressure gauges should read 0 psi (0 kPa).
3. Remove the air line and fitting.
4. Remove the 3/4-Inch hexnut and lockwasher (Refs. 2 and 3) from the upper air-spring plate.
5. Remove the 3/8-inch capscrew and lockwasher (Refs. 4 and 5) from the upper air-spring plate.
6. Remove three 3/8-inch capscrews, hexnuts, and three lockwashers (Refs. 4, 5 and 10) from the rear of the axle pad assembly.
7. Place a pry tool between the upper air-spring plate and the load bearing air spring.
8. Pull down on the pry tool to separate the air spring from the mounting plate, and remove the air spring from the vehicle.
9. Remove two 3/8-inch capscrews and two lockwashers that secure the lower air-spring plate to the air spring. Separate the lower air-spring plate from the air spring.
10. Check the upper and lower air-spring plates for signs of corrosion, cracks, or other damage. Replace any air-spring plate that appears damaged, or excessively corroded.
11. Install the lower air-spring plate on the air spring.
12. Apply a light coating of Loctite® 242 to the threads of the capscrews. Install the capscrews on the air spring and tighten 15 lbf·ft (20 N·m).
13. Install the air spring on the upper air-spring plate and center the lower air-spring plate capscrew holes on the axle pad assembly.
14. Install the three 3/8-inch capscrews, three lockwashers, and three hexnuts on the lower air spring plate. Tighten the capscrews 15 lbf·ft (20 N·m).
15. Install the 3/8-inch x 1-1/8 inch capscrew and lockwasher on the upper air-spring plate. Tighten the capscrew 15 lbf·ft (20 N·m).
16. Install the 3/4-inch hexnut and lockwasher on the upper air-spring plate. Tighten the hexnut 200 lbf·ft (271 N·m).
17. Install the air fitting, then connect the air line to the air springs.
18. Start the engine and build up air pressure. Check for air leaks and repair as needed. See **Subject 300** for troubleshooting information.
19. Shut down the engine and remove the chocks from the tires.

Ride Height Measurement and Load Capacity Adjustment

IMPORTANT: It is the responsibility of the vehicle operator to weigh the vehicle to get accurate axle load capacity for the vehicle for legal operation. The amount of air pressure supplied to the lift axle load air spring will vary depending on vehicle load.

Ride Height Measurement

Suspension ride height is defined as the distance between the suspension mounting surface and the spindle center of the auxiliary liftable axle.Suspension ride height must be calculated with the vehicle in its loaded condition.

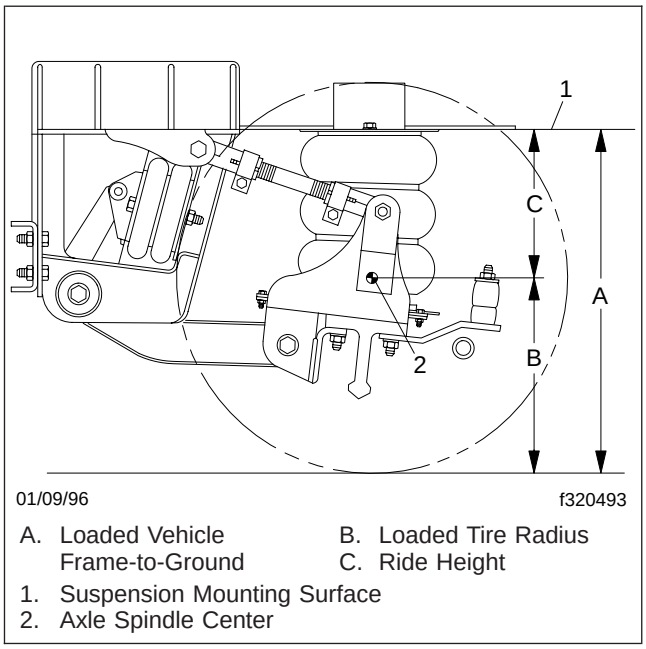
To check the ride height of the Watson & Chalin SL series suspension, use the following formula: A (loaded vehicle frame-to-ground) – B (loaded tire radius) = C (Ride Height). See **Fig. 1**.

1. Park the vehicle on a level surface. Apply the parking brakes and chock the front tires.
2. Run the engine until pressure in the air brake system exceeds 115 psi (792 kPa). Shut down the engine.
3. Measure the loaded frame-to-ground measurement; the distance from the bottom of the frame rail to the ground, with the vehicle in a loaded condition.
4. Measure the loaded tire radius; the distance from the axle spindle center to the ground, with the vehicle in a loaded condition.
5. Subtract the loaded tire radius from the loaded frame-to-ground measurement to determine ride height.

Load Capacity Adjustment

Load capacity can be adjusted by increasing or decreasing the air pressure to the lift air springs. The amount of air pressure varies depending on vehicle load. See **Specifications 400**, for load-to-pressure specifications.

The air pressure to the lift air springs, which is indicated on the gauge located on the frame rail or in the cab, is set by the pressure regulator. See **Fig. 2**. Pressure is increased by turning the knob clockwise, and it is reduced by turning the knob counterclockwise.



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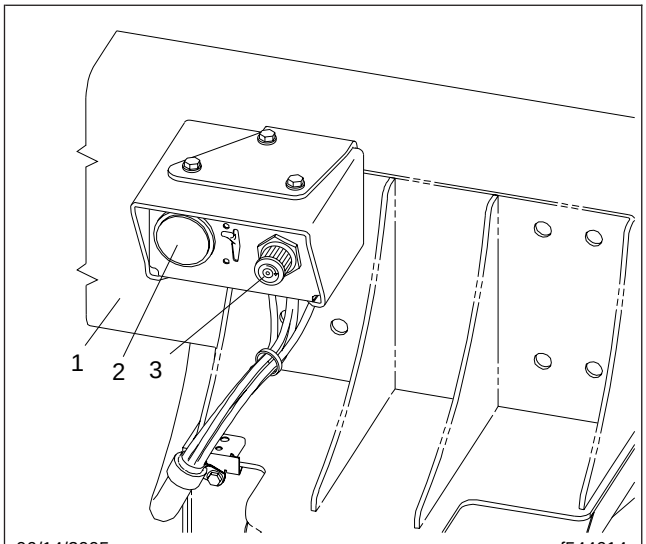
A. Loaded Vehicle Frame-to-Ground
B. Loaded Tire Radius
C. Ride Height
1. Suspension Mounting Surface
2. Axle Spindle Center

Fig. 1, Watson & Chalin SL Series Suspension, Calculating Ride Height



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1. Frame Rail
2. Gauge
3. Regulator

Fig. 2, Pressure Regulator and Gauge

Inspection

The Watson & Chalin SL series steerable-axle lift suspension is operated from a control panel consisting of an air pressure gauge, pressure regulator, and a double-pull, double-throw air valve. See **Fig. 1**.

The control panel is designed so the driver can regulate the load pressure in the air springs for the proper, or desired load on the auxiliary axle. It is also designed to lift the auxiliary axle to the UP position when the vehicle load is empty, or the auxiliary axle is not required.

Optionally, an automatic reverse lift can be installed to automatically lift the suspension when the vehicle is shifted into reverse. An automatic reverse lockout will automatically lock the steerable axle to prevent it from turning when the vehicle is shifted to reverse. See **Fig. 2**.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the front tires.
2. Start the engine and build up air pressure in excess of 80 psi (552 kPa).

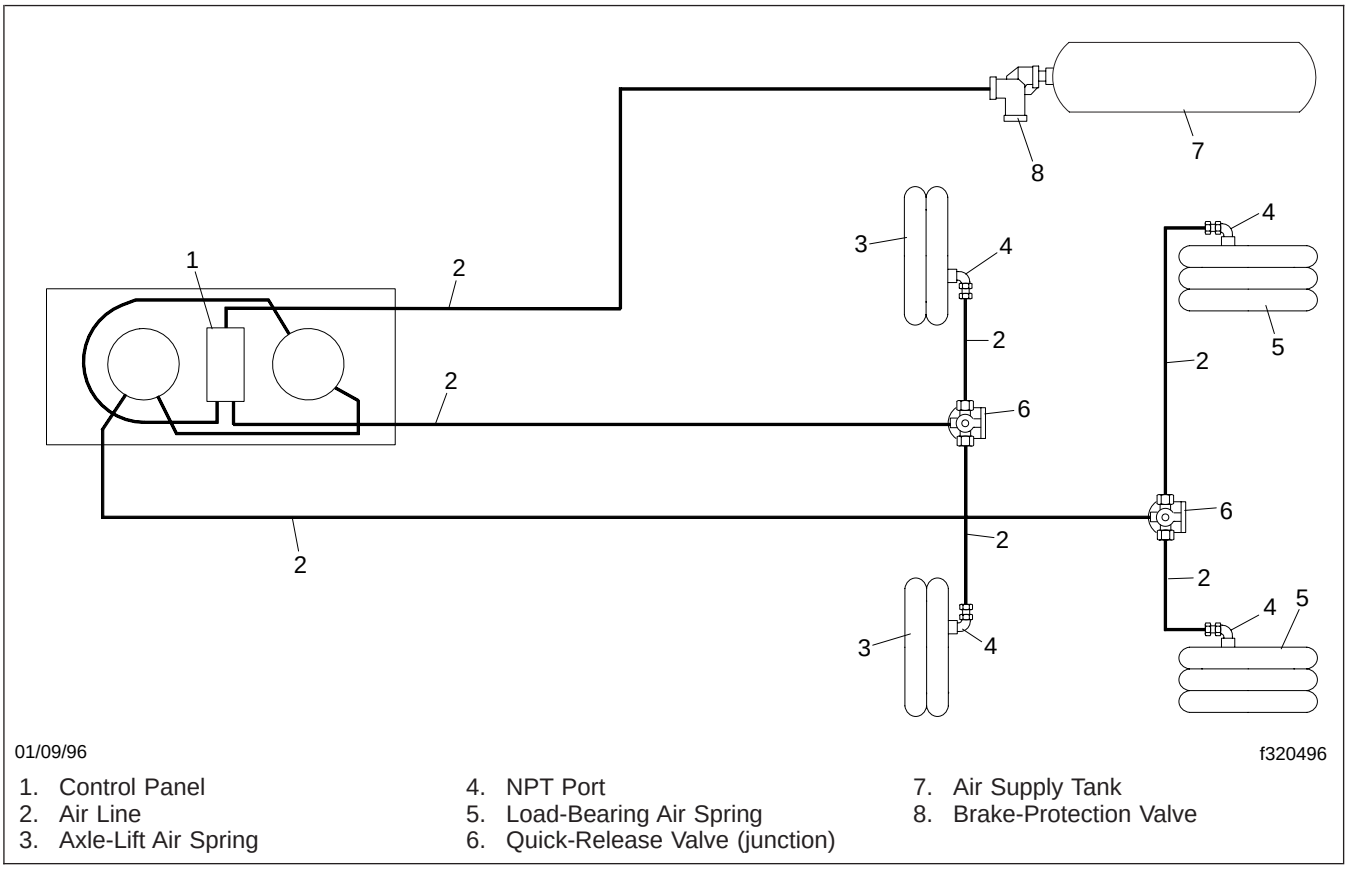
⚠ WARNING

Maintain air pressure of 80 psi (552 kPa). Failure to do so could result in brake failure if the suspension system suffered an air loss. This could result in personal injury or property damage.

3. Shut down the engine.
4. With a mixture of soap and water, coat the air fitting on the load bearing air springs, axle lift air springs, and at each air line junction.
5. If an air leak exists, air bubbles will form around the area where the leak originated. Repair or replace any leaking air line, fitting, or junction as needed.
6. Inspect the air supply tank for excessive corrosion, dents, or other damage that could weaken the tank. Replace any air supply tank that's damaged.
7. On vehicles equipped with an automatic reverse lift, check the solenoids for proper operation.
   - 7.1 Start the engine and lower the auxiliary axle suspension.
   - 7.2 Shift the transmission to reverse and check the position of the auxiliary axle.

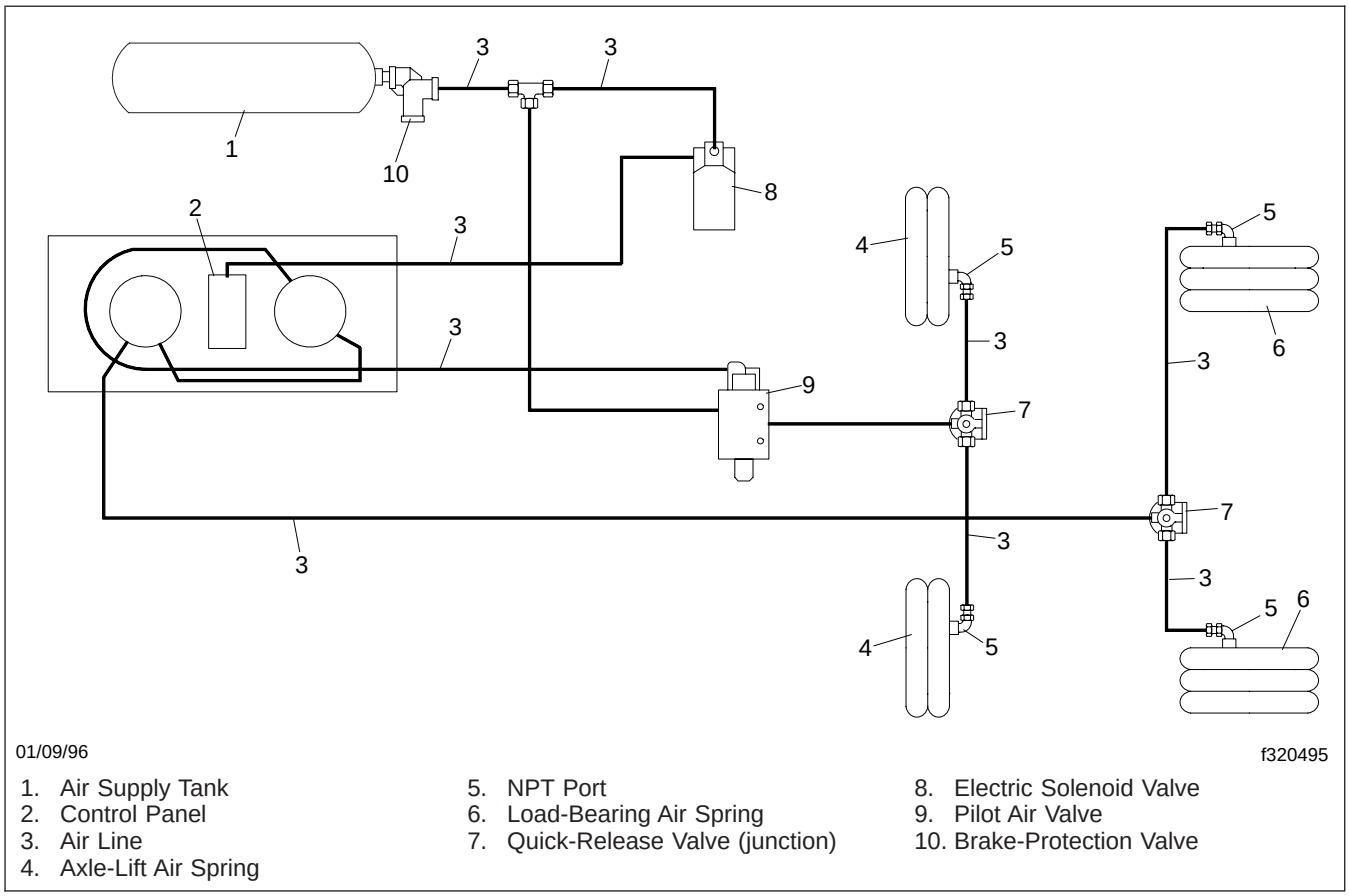
   NOTE: When the shifter is placed in reverse, the steering will lock in a straight-ahead position, and the axle will lift off the ground.
8. If the axle does not lift, shut down the engine and use the following instructions.
   - 8.1 Turn the ignition key ON, but do not start the engine.
   - 8.2 Disconnect the harness connector from the reverse lock-out solenoids.
   - 8.3 With a voltmeter, probe the harness side of the connector. There should be no voltage with the shifter in neutral or any forward gear.
   - 8.4 Do not start the engine. Move the shifter into reverse, and recheck for voltage. When the shifter is in reverse gear there should be 11 to 13 volts at the solenoid. If no voltage is found, trace and correct a short to ground in circuit 120B.
9. Check the air springs for cuts, dry-rotting, deformities, or other damage. Replace the air springs as needed. Refer to **Subject 110**, for replacement instructions.

Air System Inspection



1. Control Panel
2. Air Line
3. Axle-Lift Air Spring
4. NPT Port
5. Load-Bearing Air Spring
6. Quick-Release Valve (junction)
7. Air Supply Tank
8. Brake-Protection Valve

Fig. 1, Watson and Chalin Suspension with Standard Air Control



1. Air Supply Tank
2. Control Panel
3. Air Line
4. Axle-Lift Air Spring
5. NPT Port
6. Load-Bearing Air Spring
7. Quick-Release Valve (junction)
8. Electric Solenoid Valve
9. Pilot Air Valve
10. Brake-Protection Valve

Fig. 2, Watson and Chalin Suspension with Automatic Reverse Lockout

Problem–Not Getting the Desired Load on Steerable Axle

Problem–Not Getting the Desired Load on Steerable Axle	
Possible Cause	**Remedy**
Incorrect air pressure to load the air springs.	Increase or decrease air pressure at regulator valve.
Air control system not properly installed.	Check piping of air system.
Mounted too high.	Shim axle area. May require lower trailing arm replacement.

Problem–Insufficient Air Pressure to Steerable Axle System

Problem–Insufficient Air Pressure to Steerable Axle System	
Possible Cause	**Remedy**
Damaged brake protection valve or air compressor.	Replace brake protection valve and check air compressor.

Problem–Steerable Axle Not Getting the Correct Lift

Problem–Steerable Axle Not Getting the Correct Lift	
Possible Cause	**Remedy**
Axle lift air springs not getting proper air pressure.	Check system pressure, and check air system piping.
Interference with chassis, driveline, or other chassis components.	Check for interference, and correct as needed.
Unit not properly installed.	Check installation.
Lower trailing arm being restricted from full retraction.	Contact Watson & Chalin.

Problem–Steerable Axle is Steering in Opposite Direction from Truck

Problem–Steerable Axle is Steering in Opposite Direction from Truck	
Possible Cause	**Remedy**
Improper caster setting.	Adjust caster.

Problem–Steerable Axle has Vertical Hop

Problem–Steerable Axle has Vertical Hop	
Possible Cause	**Remedy**
Insufficient air pressure.	Increase air pressure.
Excessive road vibration.	Install vertical shock kit.

Specifications

Load-to-Pressure Ratings for SL–1100–SR Suspension			
Load at Ground lb (kg)	**Run Height 10 Inches psi (kPa)**	**Run Height 11 Inches psi (kPa)**	**Run Height 12 Inches psi (kPa)**
5000 (2268)	29 (200)	31 (214)	34 (234)
6000 (2722)	37 (255)	39 (269)	43 (297)
7000 (3175)	44 (303)	47 (324)	52 (360)
8000 (3629)	52 (360)	56 (386)	60 (414)
9000 (4082)	60 (414)	64 (441)	69 (476)
10,000 (4536)	67 (462)	72 (496)	78 (538)
11,000 (4990)	75 (517)	80 (552)	87 (600)
12,000 (5443)	82 (565)	88 (607)	96 (662)
13,000 (5897)	90 (621)	97 (669)	105 (724)
14,000 (6350)	98 (676)	105 (724)	114 (786)

Table 1, Load-to-Pressure Ratings for Watson & Chalin SL-1100-SR Suspension

Torque Specifications for Watson & Chalin SL–1100–SR Suspension	
Size in.	**Torque Rating lbf·ft (N·m)**
1/4	5 (7)
3/8	15 (20)
1/2	25 (35)
5/8	150 (205)
3/4	200 (270)
7/8	550 (745)
1	600 (815)
1-1/8	1000 (1355)

Table 2, Bolt Torque Specifications for Watson & Chalin SL-1100-SR suspension

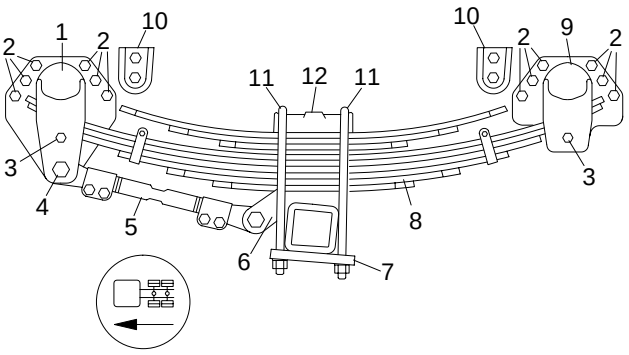
Wheel Caster and Toe-In Specifications		
Item	**Minimum Setting**	**Variable**
Caster	+5°	+1°

Wheel Caster and Toe-In Specifications		
Item	**Minimum Setting**	**Variable**
Toe-In	+1/32-Inch (+0.8 mm)	±1/32-Inch (±0.8 mm)

Table 3, Wheel Caster and Toe-In Specifications

General Description (See Fig. 1)

The Reyco 179 suspension uses a four-point attachment, two-spring suspension with variable rate spring cams. It also incorporates torque rods. Semi-elliptical spring assemblies are attached to the axles with U–bolt assemblies. The spring ends ride in spring hangers that are mounted on the frame rails. Adjustable torque rods are attached to the forward spring hanger and the axle seat to hold the axle in alignment.



1. Forward Spring Hanger
2. Spring Hanger Mounting Bolts
3. Spring Retainer Bolt
4. Torque Rod Mounting Bolt
5. Torque Rod
6. Spring Seat
7. U–Bolt Mounting Plate
8. Leaf Spring
9. Rear Spring Hanger
10. Spring Wear Pad
11. U-Bolt
12. U-Bolt Pad

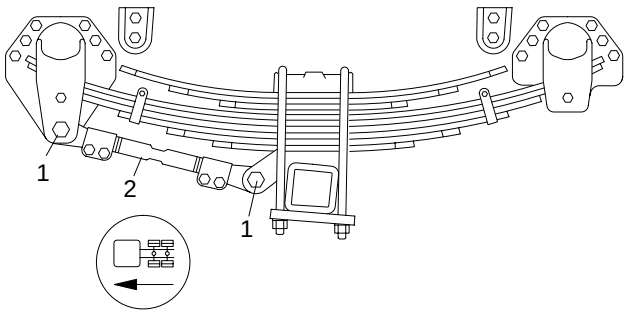
Fig. 1, Reyco 179 Suspension

Torque Rod Removal and Installation

Removal (See Fig. 1)

There are two torque rods installed on the Reyco 179 suspension. The right side torque rod is rigid. The left side torque rod is adjustable to allow proper axle alignment.

1. Apply the parking brakes, and chock the front tires.
2. Use a lifting device and raise the rear of the tractor until the rear tires are elevated above the ground. Place jack stands under the frame rails to unload the suspension, and lower the lifting device until only the jack stands are supporting the vehicle weight.
3. Place the lifting device under the axle and raise the axle to unload the torque rod. Place jack stands under the axle.
4. Remove the two torque rod bolts and nuts (Ref. 1), and remove the torque rod.



1. Torque Rod Bolt
2. Torque Rod

Fig. 1, Reyco 179 Torque Rod

Installation (See Fig. 1)

1. Place the torque rod on the forward frame hanger and install a torque rod bolt to hold it in place. On adjustable torque rods, match the length of the right side (rigid) torque rod before installing.

NOTE: Matching the length of the adjustable torque rod to the rigid torque rod will reduce the amount of adjustment necessary to align the rear axle.

2. Raise the opposite end of the torque rod, then install it on the spring seat.
3. Tighten the torque-rod-end locknuts 600 to 625 lbf·ft (814 to 847 N·m).
4. Raise the axle and remove the jack stands. Lower the axle to the ground.
5. Raise the rear of the vehicle and remove the jack stands. Lower the vehicle to the ground.
6. Check the axle alignment. For instructions, see **Group 35**. If necessary, adjust the rear axle alignment, using the instructions in **Subject 130**.
7. Tighten the torque rod clamp nuts 125 to 150 lbf·ft (170 to 203 N·m).
8. Apply the parking brakes and remove the wheel chocks.

Removal (See Fig. 1)

WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

WARNING

Leaf spring assemblies weigh approximately 290 to 350 lbs (132 to 159 kg). Do not attempt to remove a leaf spring assembly without assistance. Personal injury and property damage may result.

1. Park the vehicle on a level surface. Apply the parking brakes and chock the front tires.
2. Raise the frame so that all weight is removed from the leaf springs, then support the frame with safety stands. Raise the rear axle until the spring no longer contacts the spring retainer rollers, then support the axle with safety stands. Make sure the stands will securely support the weight of the axles and frame. To gain easy access to the suspension system, remove the wheel assembly; see **Group 40** for instructions.
3. Remove the U-bolt locknuts and washers, and remove the bottom plate.
4. Remove the U-bolts, and the U-bolt pad.
5. Remove the spring retaining bolts, spring rollers, and nuts.
6. Use a pry tool to lift the leaf spring assembly off of the spring seat.

NOTE: There is a projection at the center of the leaf spring assembly to locate the spring on the U-bolt pad and the spring seat.

7. With assistance, carefully move the leaf spring assembly forward to clear the rear frame hanger. Raise the rear of the leaf spring assembly and move it rearward to clear the front frame hanger. Remove the leaf spring from the vehicle.

Installation (See Fig. 1)

WARNING

Leaf spring assemblies weigh approximately 290 to 350 lbs (132 to 159 kg). Do not attempt to install a leaf spring assembly without assistance. Personal injury and property damage may result.

1. With assistance, position the leaf spring assembly on the axle.
2. Place the front of the leaf spring assembly through the frame hanger, then place the rear of the leaf spring assembly through the rear frame hanger.
3. Locate the projection on the center of the leaf spring assembly into the bore on the lower axle mounting plate.
4. Install the U-bolt pad on the leaf spring assembly.
5. Install the U-bolts; then install the U-bolt washers and high nuts. Tighten the U-bolt nuts in stages in a diagonal pattern as described in **Specifications 400**.
6. Install the spring retainer bolts, rollers, and locknuts. Tighten the spring retaining bolt locknuts 60 to 80 lbf·ft (85 to 110 N·m).
7. Move the torque rod in position with the spring seat.
8. Install the torque rod mounting bolt and locknut. Tighten the locknut 600 to 625 lbf·ft (814 to 847 N·m).
9. Install the wheel assembly. See **Group 40** for instructions.
10. Raise the axle assembly, remove the safety stands and lower the axle to the ground.
11. Raise the vehicle frame, remove the safety stands from under the frame and lower the vehicle.

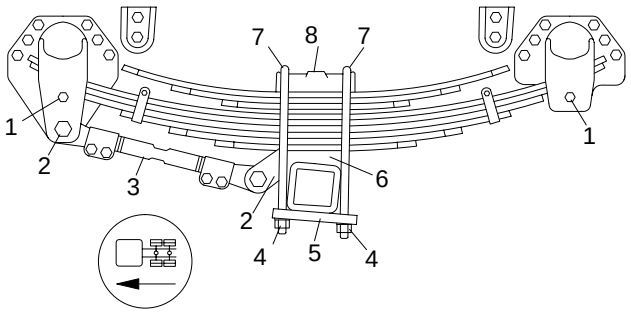
CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

Spring Assembly Replacement

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 of the *Heavy-Duty Trucks Maintenance Manual*.

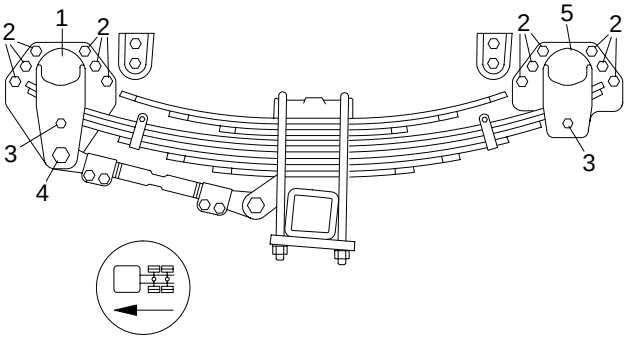
12. Check the axle alignment. For instructions, see **Group 35** of this manual. If necessary, adjust the rear axle alignment, using the instructions in **Subject 130**.



1. Spring Retainer Bolt
2. Torque Rod Mounting Bolt
3. Torque Rod
4. U-Bolt Locknut
5. Bottom Plate
6. Spring Seat
7. U-Bolt
8. U-Bolt Pad

Fig. 1, Reyco 179 Leaf Spring Replacement

Removal (See Fig. 1)



1. Forward Spring Hanger
2. Spring Hanger Mounting Bolts
3. Spring Retainer Bolt
4. Torque Rod Mounting Bolt
5. Rear Spring Hanger

Fig. 1, Reyco 179 Spring Hanger Components for Removal

⚠ WARNING

Replace worn, cracked, or damaged spring brackets. Failure to do so could result in breakage of the bracket, which could cause a loss of vehicle control, resulting in personal injury or property damage.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the front tires.
2. Place a lifting device under the vehicle frame. Lift the frame until the leaf spring assemblies are no longer in contact with the spring hangers, and support the frame with safety stands.
3. Remove the torque rod mounting bolt located on the forward spring hanger.
4. Remove the spring retainer bolt from the front spring hanger.
5. Remove the six spring hanger mounting bolts and nuts.
6. Remove the forward spring hanger from the frame rail.
7. Remove the spring retainer bolt from the rear spring hanger.
8. Remove the spring hanger mounting bolts (Ref. 2), and remove the rear spring hanger.

⚠ CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 of the *Heavy-Duty Trucks Maintenance Manual*.

Installation

1. Install the rear spring hanger on the frame rail, and install the two upper mounting bolts.
2. Tighten the spring hanger mounting bolts 190 lbf·ft (258 N·m).
3. Install the spring retainer bolt, roller, and nut. Tighten the spring retainer bolt 60 to 80 lbf·ft (85 to 110 N·m).
4. Install the front spring hanger on the frame rail, then install the mounting bolts. Tighten the rear spring hanger mounting bolts 190 lbf·ft (258 N·m).
5. Install the torque rod mounting bolt. Tighten the torque rod mounting bolt 600 to 625 lbf·ft (814 to 847 N·m).
6. Install the spring retainer bolt, roller, and nut. Tighten the spring retainer bolt 60 to 80 lbf·ft (85 to 110 N·m).
7. Raise the vehicle frame with a lifting device, and remove the safety stands. Lower the vehicle to the ground.
8. Remove the wheel chocks.

Adjustment (See Fig. 1)

CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear and damage to the springs, spring hangers, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 of the *Heavy-Duty Trucks Maintenance Manual*.

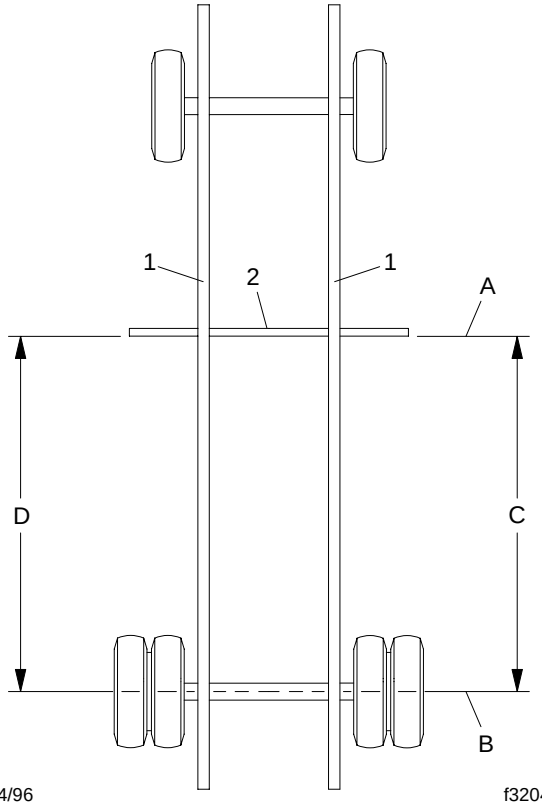
1. Park the vehicle on a level surface, move the vehicle back and forth several times, and shut down the engine. Move the vehicle slowly, without using the brakes, to free all of the suspension joints. Do not apply the parking brakes.

NOTE: Check that the leaf springs are not binding in the spring hangers. Make sure that the U-bolts and torque rod bolts are torqued to specification, and all of the bushings are in good condition.

2. Chock the front tires.
3. Position an 8 ft (2-1/2 m) length of bar stock, or angle iron across the frame. Square the bar across the frame using a carpenter's square, and clamp it in place on the frame rail (Ref. 2).

NOTE: Position the bar as far forward of the drive axle as possible.

4. Start on the fixed (right) torque rod side. Measure the distance from the bar stock to the centerline of the drive axle. Repeat the same procedure on the adjustable (left) torque rod side.
5. If the distance varies more than 1/8-inch, alignment is necessary.
6. Loosen the torque rod clamp bolts. See **Fig. 2**, Ref. 1.
7. Use a pipe wrench or other suitable tool and slowly turn the torque rod.
8. Turn until the measurement on both sides of the axle are within 1/8-inch, and tighten the torque rod clamp bolts 125 to 150 lbf·ft (170 to 203 N·m).

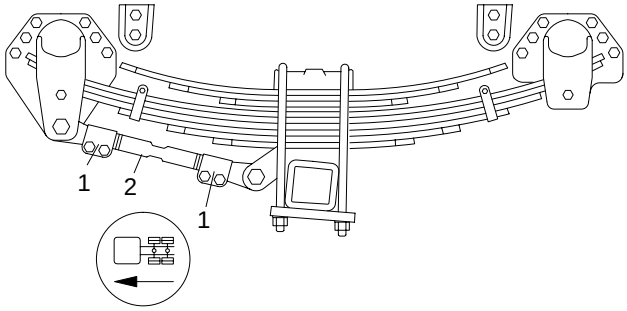


A. Trailing Edge
B. Drive Axle Centerline
C. Fixed Torque Rod Side
D. Adjustable Torque Rod Side
1. Frame Rail
2. Bar Stock

Fig. 1, Measuring Axle Alignment

9. Remove the wheel chocks and drive the vehicle through a short series of turns.
10. Recheck the alignment.

Rear Axle Alignment Adjustment



1. Torque Rod Clamp
2. Torque Rod

Fig. 2, Adjustable Torque Rod

Reyco 179 Torque Values		
Description	**Size in.**	**Torque lbf·ft (N·m)**
Forward Spring Hanger	5/8	190 (258)
Rear Spring Hanger	5/8	190 (258)
U-bolt High Nuts	7/8–14	Stage 1: Hand Tighten Stage 2: 60 (81) * Stage 3: 200 (271) * Stage 4: 420 to 500 (571 to 680) *
Torque Rod Mounting Bolts	1	600 to 625 (814 to 847)
Torque Rod Clamp Nuts	5/8	125 to 150 (170 to 203)
Spring Retainer Bolts	1/2	60 to 80 (85 to 110)

* Tighten in a diagonal pattern as shown in **Fig. 1**.

Table 1, Reyco 179 Torque Values

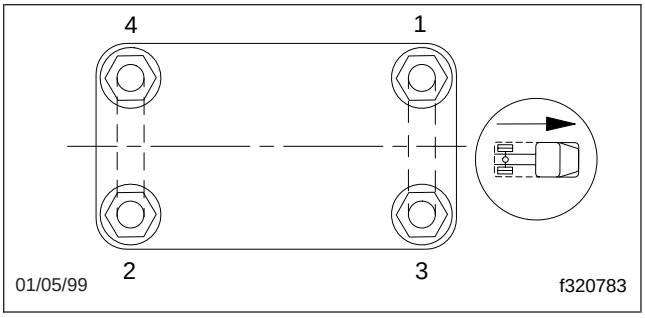


Fig. 1, Tightening Pattern for U-bolt High Nuts

General Information

The AirLiner Plus suspension is used on vehicles with pusher or tag axles to improve traction performance.

The system maintains an accurate leveling of frame height through the use of the Rockwell WABCO ECAS (Electronically Controlled Air Suspension) system with sensors and an electronic control unit. A height sensor mounted between the frame and the drive axle housing provides the ECAS control unit with frame height information. Other sensors provide additional information, which the control unit uses to quickly lower or raise the frame height as necessary. The operation occurs while the vehicle is in motion or while parked.

The vehicle must be equipped with a rear axle air suspenion, and requires ABS with Automatic Traction Control to trigger the optional load transfer function automatically.

AirLiner Plus components include:

- A cab-mounted electronic control unit that uses information about the vehicle's rear frame height to adjust the air pressure of the air spring bags;
- A frame rail-mounted solenoid valve that adjusts the air pressure;
- An axle- and frame-mounted height sensor that provides the control unit with frame-height information;
- A brake light switch that informs the control unit when the brakes are applied;
- A dash-mounted warning light that indicates a system fault;
- A load transfer light that displays automatic load transfer status;
- A three-position dash switch that allows automatic load transfer, driver-activated load transfer, or no load transfer.
- An optional hand-held remote control unit that is used to alter the chassis height for loading and unloading.

System Operation

Indicator Lights

ECAS FAIL: Lights for approximately two seconds when the ignition key is turned on, then the light goes out and remains out during vehicle operation. If the ECAS FAIL light does not go out after two seconds, or if it comes on during vehicle operation, there is a failure in the ECAS system.

LOAD X-FER: Lights for approximately two seconds when the igition key is turned on, then the light goes out. Lights whenever there is a manual or an automatic load transfer.

Frame Height Control

ECAS will maintain the vehicle frame to a pre-set height within a 3/16-inch (5 mm) range. The optional remote control unit allows frame height adjustment within operating limits if the vehicle is parked or moving less than 7 mph.

Load Transfer Activation

If the load weight is transferred from the tag axle to the drive axle, it will remain shifted for 20 seconds and is then slowly transferred back to a normal condition. The complete load cycle takes approximately 45 seconds.

Slippage of the driving wheels (usually when starting out on a slick surface) will activate the automatic load transfer. The load transfer will activate after the Automatic Traction Control activates.

Pressing the MOM ON (momentary on) side of the LOAD X-FER dash switch will activate the load transfer system. Manual activation works, however, only at vehicle speeds less than 30 mph.

Load Transfer Termination

The load transfer cycle will immediately terminate if the service brakes are applied when the vehicle speed is more than 30 mph, when the STOP button on the remote control (if equipped) is pressed, or when the vehicle speed exceeds 75 mph.

The STOP button on the remote control will terminate the load transfer at any speed.

ECU Removal and Installation

Removal

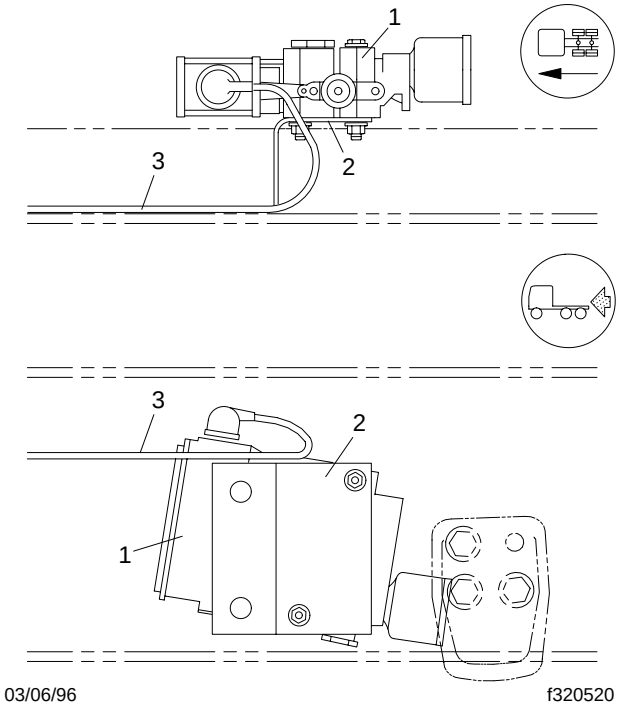
1. Shut down the engine and set the parking brake.
2. Chock the front tires.
3. Remove the lower cover at the base of the left B-pillar.
4. Disconnect the electrical connections at the base of the B-pillar.
5. Remove the grab handle.
6. Remove the shoulder harness adjustable D-loop mechanism mounted to the B-pillar.
7. Detach the plastic channel that attaches the upholstery to the door frame. This will provide slack in the upholstery to allow access to the ECU mounted inside the B-pillar.
8. Remove the fasteners that attach the B-pillar upholstery to the cab wall.
9. Reach inside the B-pillar and remove the fasteners that attach the ECU.
10. Disconnect the electrical connections on the unit, and remove the ECU from the B-pillar.

Installation

1. Install the ECU inside the B-pillar. Connect the electrical connections.
2. Install the B-pillar upholstery.
3. Attach the plastic channel around the door frame and upholstery.
4. Install the shoulder harness adjustable D-loop mechanism.
5. Install the grab handle.
6. Connect the electrical connections at the base of the B-pillar.
7. Install the lower panel at the base of the B-pillar.
8. Remove the chocks from the tires.

Replacement

1. Shut down the engine and set the parking brake.
2. Chock the front tires.
3. Drain air from the suspension system.
4. At the ECAS solenoid valve (see **Fig. 1**), which is mounted to the frame rail, disconnect the electrical connector.



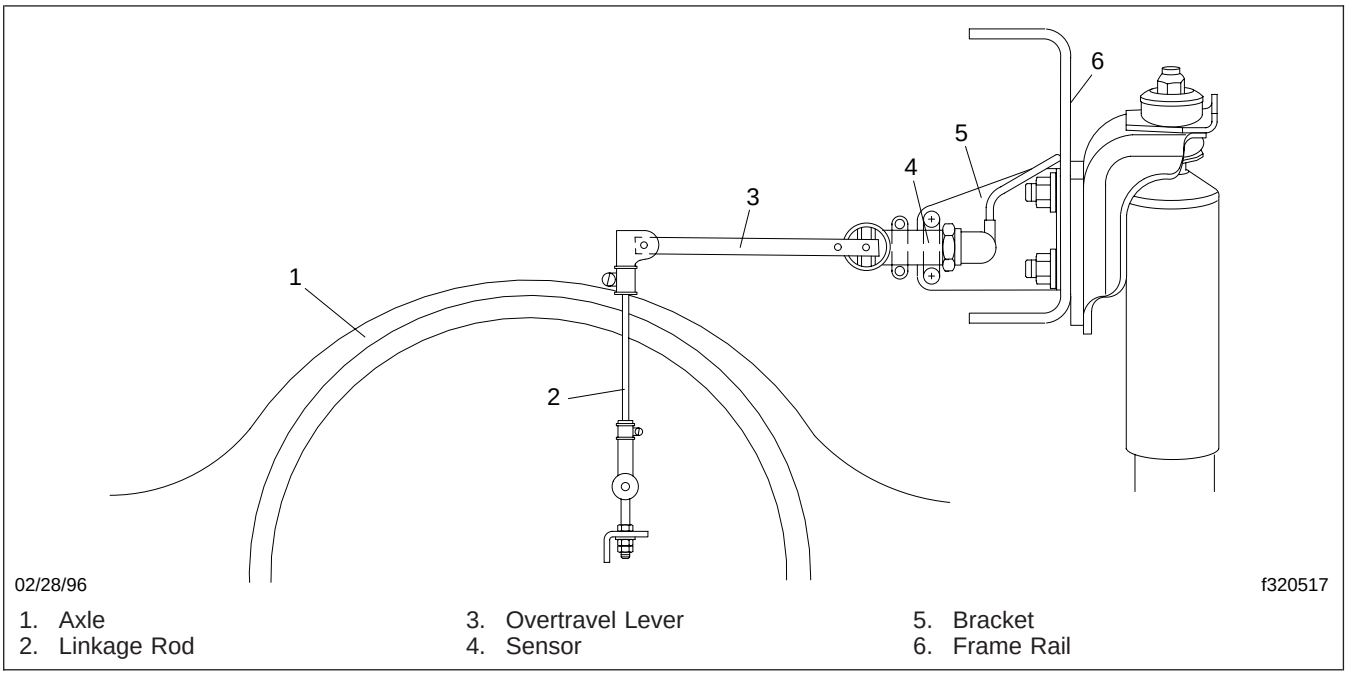
1. Solenoid Valve
2. Bracket
3. Wire

Fig. 1, Solenoid Valve Assembly

5. Mark the air lines for later reference.
6. Disconnect the air lines from the solenoid valve.
7. Remove the two bolts attaching the solenoid valve to the valve bracket.
8. Remove the valve from the bracket.
9. Attach the new valve to the bracket. Install the bolts.
10. Connect the air lines to the valve as marked earlier.
11. Connect the electrical connector to the valve.
12. Remove chocks from tires.

Replacement

1. Shut down the engine and set the parking brake.
2. Chock the front tires.
3. At the ECAS height sensor (see **Fig. 1**), which is mounted between the frame rail and the drive axle housing, disconnect the electrical plug on the back of the sensor.



1. Axle
2. Linkage Rod
3. Overtravel Lever
4. Sensor
5. Bracket
6. Frame Rail

Fig. 1, Height Sensor Assembly

4. Remove the bolts attaching the sensor to the frame rail bracket.
5. Disconnect the linkage rod from the axle housing.
6. Remove the overtravel lever from the height sensor.
7. Remove the sensor.
8. To install the sensor, attach the overtravel lever to the height sensor.
9. Attach the linkage rod to the axle housing.
10. Fasten the sensor to the frame rail bracket.
11. Connect the electrical plug to the back of the height sensor.
12. Remove the chocks from the tires.

Troubleshooting Information

1. Indicator Lights:
    - ECAS FAIL lights up if there is a failure in the ECAS system.
    - Load XFER lights up whenever there is a manual or automatic load transfer.
2. Frame Height Control: ECAS will maintain the vehicle frame height to a preset value within 3/16-inch (4.7 mm) by adjusting the pressure in the rear suspension air bags. With the remote-control unit, the operator can adjust the frame height within the operating limits if the vehicle is parked or traveling less than 7 mph (15 km/h).
3. Load Transfer Activation: The weight is transferred from the tag axle to the drive axle by adjusting the pressure in the air bags. The load is shifted for 20 seconds, then is slowly equalized back to the normal condition. The complete load transfer cycle takes approximately 45 seconds. The load transfer occurs under the following conditions.
    - Automatic activation: The drive wheels slipping (usually when staring out on a slick surface) will activate the load transfer. If the vehicle is equipped with Automatic Traction Control, the load transfer will activate just after the ATC.
    - Manual activation: Pressing the MOM ON (Momentary On) side of the ECAS XFER dash switch will activate the load transfer. Manual activation works only at vehicle speeds less than 30 mph (50 km/h).
4. Load Transfer Termination: The load transfer cycle will terminate under the following conditions.
    - Applying the service brakes with a vehicle speed of more than 30 mph (50 km/h).
    - Vehicle speed exceeds 75 mph (120 km/h).
    - Pressing the STOP button on the remote control or disconnecting the remote control. This will terminate the load transfer at any speed.

Troubleshooting Tables

Before performing any diagnostics, make sure there are no ABS faults. Because of the interaction of the ABS and the ECAS systems, a fault in one system may cause a malfunction in the other system.

The following types of failures cause the "ECAS FAIL" indicator light to remain on:

- Grounded "ECAS FAIL" light wire;
- No power at ECAS electronic control unit (ECU) pin 1;
- Electrical fault in ECAS height sensor;
- Electrical fault in ECAS valve;
- Failure of J1587 data bus;
- Internal ECU fault;
- Faulty calibration of ECAS height control;
- Frame height cannot be adjusted within five minutes after ignition or within 30 seconds during normal service.

See **Table 1** for troubleshooting problems when the "ECAS FAIL" light remains on. This would include problems where the wrong action occurs, such as the air bags inflating rather than deflating, or the drive axle air bags deflating rather than the tag axle air bags. The causes may be crossed electrical wiring or air supply plumbing.

See **Table 2** for frame height problems.

See **Table 3** for incorrect ECAS functionality.

See **Table 4** for indicator lamp problems.

See **Table 5** for manual load transfer problems.

NOTE: All lamps are activated by the ECU for approximately two seconds after the ignition is switched on. The ignition must be switched off for at least 6.4 seconds before restarting to determine lamp condition.

Troubleshooting

Electrical Systems Testing

Electrical Systems Testing				
System Tested	**Ignition**	**Test these pins on ECAS ECU harness 35-pin connector (disconnected unless otherwise noted)**	**Acceptable Value**	**Remedy (if not within specification)**
ECAS FAIL light	On	—	Light is out	Find short to ground in wire between ECAS FAIL light and ECU.
Ground	Off	27 and Battery Ground	0 ohms	Trace wire between pin 27 and ground to find cause of high resistance.
Ground	Off	1 and 27	System voltage	Find open circuit or cause of high resistance in wiring.
Ignition and constant power	On	1 and 27 9 and 27	System voltage	Find open circuit or cause of high resistance in wiring.
Height sensor	Off	25 and 27	100 to 140 ohms	If resistance is infinite (open circuit), find open circuit in wires to height sensor and repair. If there is continuity but resistance is out of specification, check resistance at height sensor. If sensor is not within specification, replace sensor.
ECAS valve electrical checks	Off	13 and 27 15 and 27 30 and 27	15 to 25 ohms	If resistance is infinite (open circuit), find open circuit in wires to ECAS valve and repair. If there is continuity but resistance is out of specification, check resistance at ECAS valve. If valve is not within specification, replace valve.
Data bus connectivity (ECAS reads vehicle speed and other data from J1587 data bus)	On	Connect harness to ECU, and run Service Link to see if ECU is connected to data bus.	—	If other ECUs are identified with Service Link, check data bus wires to ECU for open, grounded, or crossed wires (pins 4 and 2). If no other ECUs are identified with Service Link, there is a main data bus problem, not a specific ECAS problem.
Internal ECU fault	—	There is no test for ECU. If all other tests are within specifications, ECU is probably bad.	—	Replace ECU.

Table 1, Electrical Systems Testing

Frame Height Systems Testing

Frame Height Systems Testing		
System Tested	**Test Procedure**	**Remedy (if not within specification)**
ECAS height calibration	Using the remote control unit, raise or lower the vehicle frame. Press the Normal key, and the frame should return to normal height.	Install the height sensor arm in the correct position relative to the height sensor rotating spool.

Frame Height Systems Testing		
System Tested	**Test Procedure**	**Remedy (if not within specification)**
Frame height adjust time	Check air suspension system for leaks or restrictions in lines or valve ports. Check air supply system for proper charge time.	Repair as required.

Table 2, Frame Height Systems Testing

ECAS Functionality Testing

<table>
<tr><th colspan="5">ECAS Functionality Testing</th></tr>
<tr><th>System Tested</th><th>Ignition</th><th>Test these pins on ECAS ECU harness 35-pin connector (disconnected)</th><th>Acceptable Value</th><th>Remedy (if not within specification)</th></tr>
<tr><td>Inflate function</td><td>On</td><td>Connect 9 to 15. Alternately connect 13 to 9 and to 15.</td><td>All rear suspension air bags inflate when (and only when) 13 is connected</td><td rowspan="2">Make sure there is adequate air in the supply tanks to inflate the air bags. Check for crossed wiring to the ECAS valve. Check for correct air plumbing between the ECAS valve and the air bags.</td></tr>
<tr><td colspan="4">CAUTION
Do not over-inflate air bags. This may extend the shock absorbers to their limits and cause damage.</td></tr>
<tr><td>Deflate function</td><td>On</td><td>Connect 9 to 13</td><td>All rear suspension air bags deflate</td><td>Make sure there is adequate air in the supply tanks to inflate the air bags. Check for crossed wiring to the ECAS valve. Check for correct air plumbing between the ECAS valve and the air bags.</td></tr>
<tr><td rowspan="2">Load transfer function</td><td rowspan="2">On</td><td>Connect 9 to 30</td><td>Tag axle air bags deflate</td><td>Make sure there is adequate air in the supply tanks to inflate the air bags. Check for crossed wiring to the ECAS valve. Check for correct air plumbing between the ECAS valve and the air bags.</td></tr>
<tr><td>Disconnect 9 from 30
Connect 9 to 15</td><td>Pressure will equalize between drive and tag axle air bags.</td><td>Check for crossed wiring to the ECAS valve. Check for correct air plumbing between the ECAS valve and the air bags.</td></tr>
</table>

Table 3, ECAS Functionality Testing

Troubleshooting

Indicator Light Testing

Indicator Light Testing				
System Tested	**Ignition**	**Test these pins on ECU harness 35-pin connector (disconnected)**	**Acceptable Value**	**Remedy (if not within specification)**
ECAS FAIL light	On	Connect 33 and 27	Light on	Replace bulb. If bulb still does not light, check the wiring between the bulb and the 35-pin connector.
ECAS XFER light	On	Connect 18 and 27	Light on	Replace bulb. If bulb still does not light, check the wiring between the bulb and the 35-pin connector.

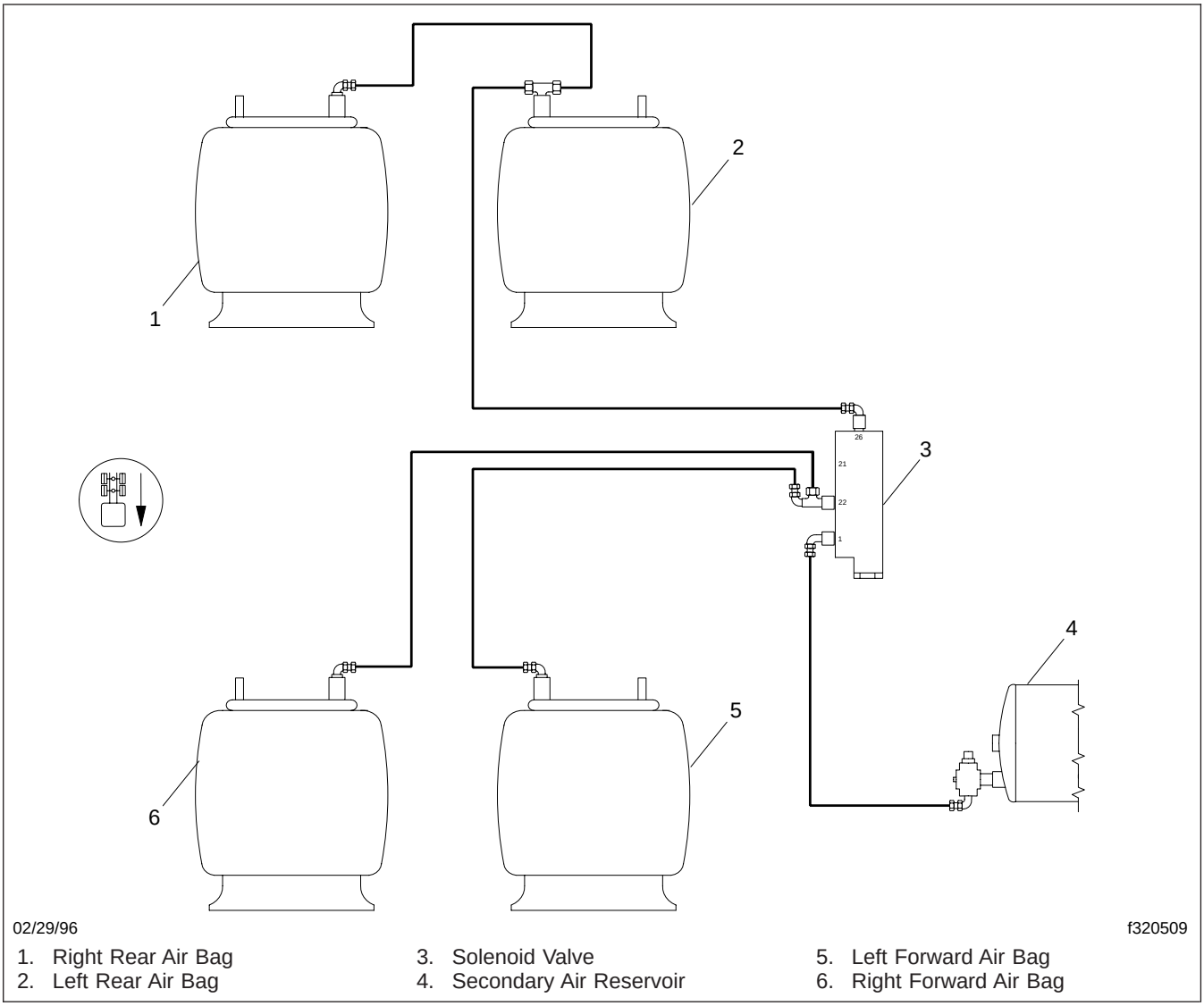
Table 4, Indicator Light Testing

Manual Load Transfer Testing

Manual Load Transfer Testing				
System Tested	**Ignition**	**Test These Pins On ECAS ECU harness 35-pin connector**	**Acceptable Value**	**Remedy (if not within specification)**
Manual load transfer switch	Off	17 and 27, MOM ON switch released (with harness disconnected)	>30k ohms	Locate and repair ground (wire pin to pin 17).
		17 and 27, MOM ON switch pressed (with harness disconnected)	0 to 2 ohms	Locate and repair high resistance in switch circuit.
	On	ECAS ECU harness; Jump pin 17 to ground (with harness connected to ECU	Load transfer cycle will occur	Perform air bag functionality tests. If air bags function correctly as described, manual load transfer function of ECU is malfunctioning. Replacement of ECU is probably necessary.

Table 5, Manual Load Transfer Testing

See **Fig. 1** for the AirLiner Plus air system plumbing diagram, and see **Fig. 2**, **Fig. 3** and **Fig. 4** for diagrams of the AirLiner Plus electrical system.



1. Right Rear Air Bag
2. Left Rear Air Bag
3. Solenoid Valve
4. Secondary Air Reservoir
5. Left Forward Air Bag
6. Right Forward Air Bag

Fig. 1, AirLiner Plus ECAS Air System Plumbing Diagram

Specifications

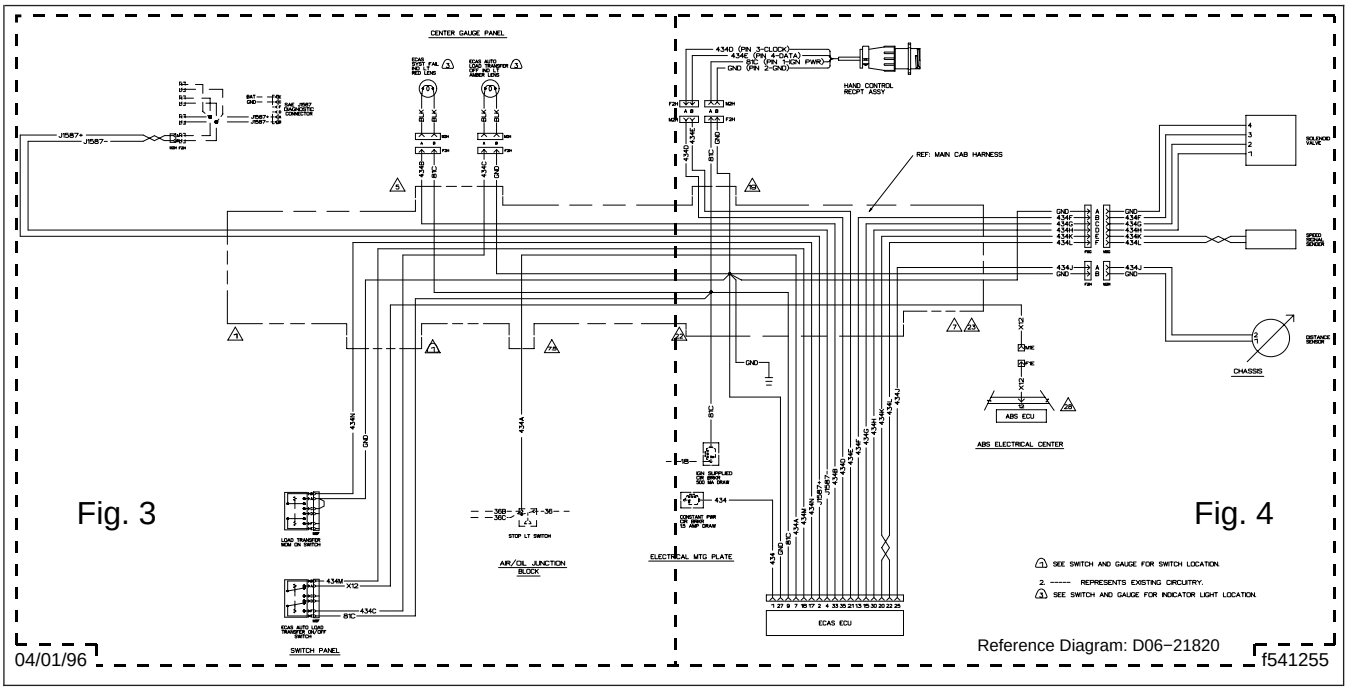


Fig. 2, AirLiner Plus ECAS Electrical Diagram (complete view)

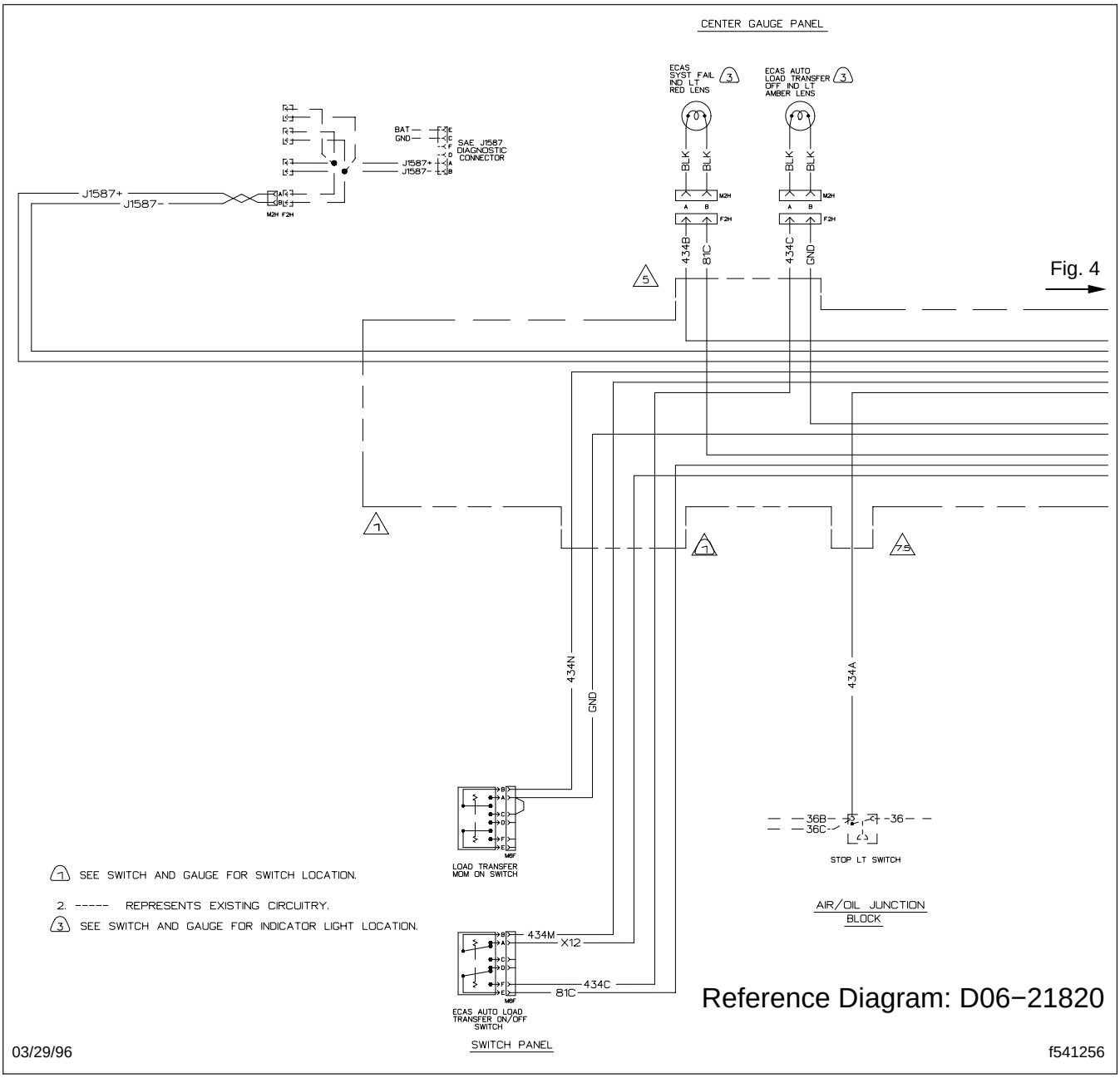


Fig. 3, AirLiner Plus ECAS Electrical Diagram (partial view)

Specifications

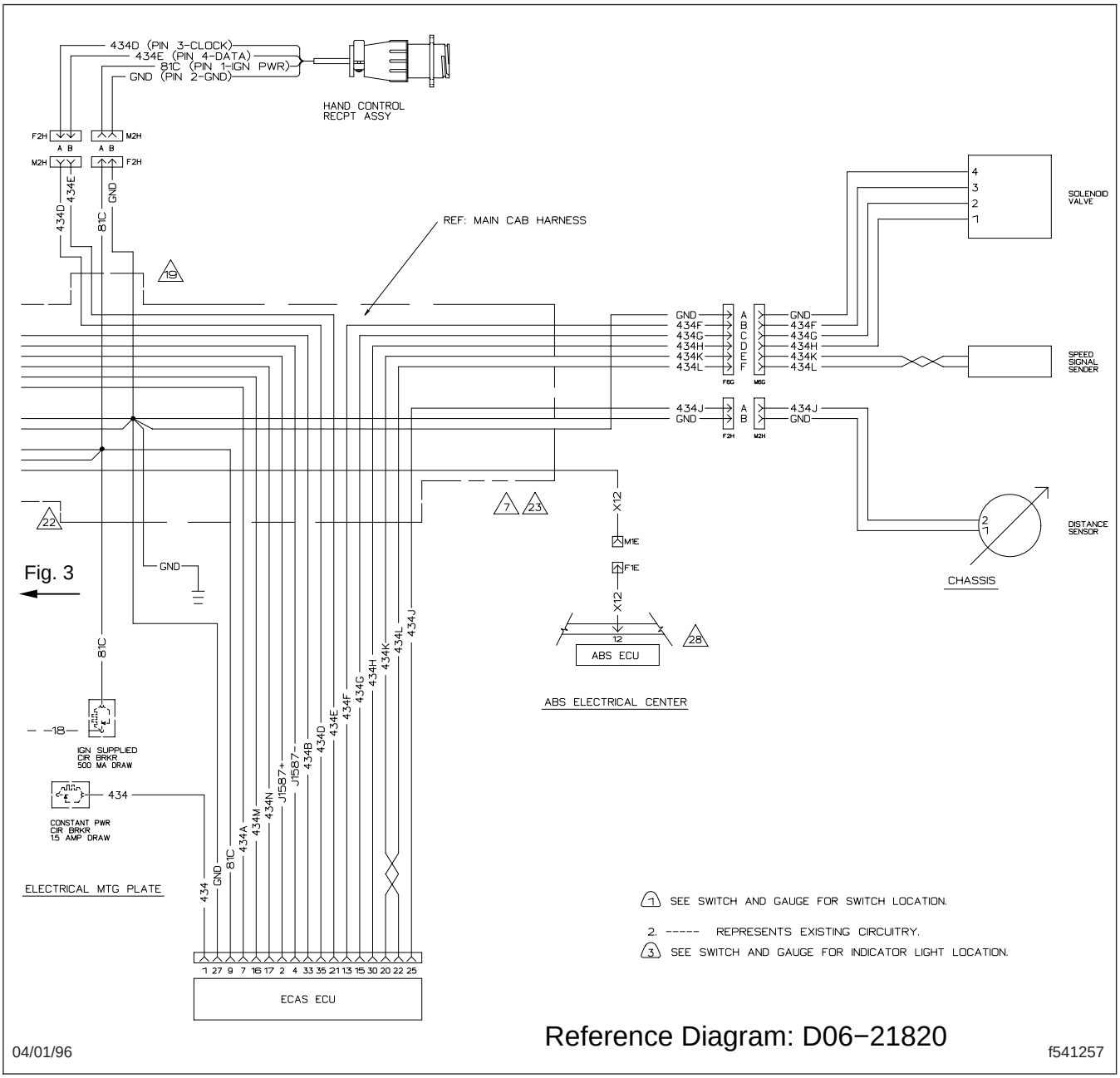


Fig. 4, AirLiner Plus ECAS Electrical Diagram (partial view)

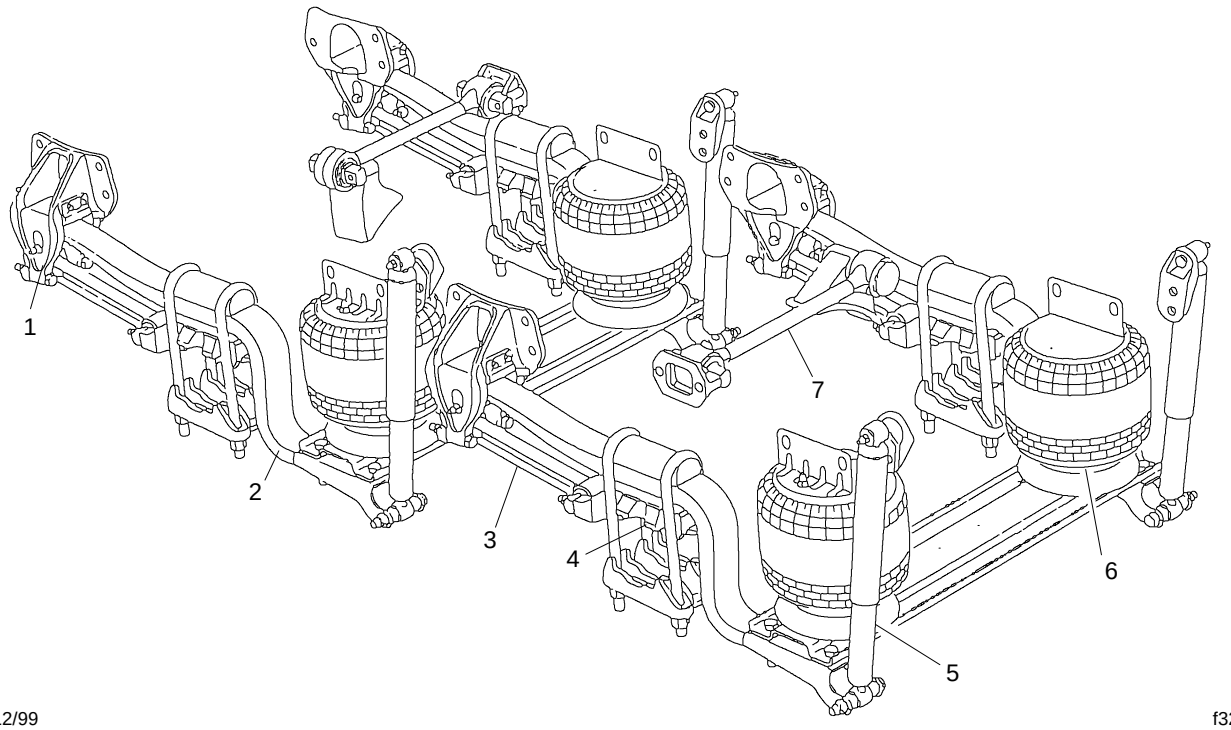
General Description

The Hendrickson HAS suspension (see **Fig. 1**) uses air bags to support the sprung weight on vehicles with both single and tandem axles. The air bags (air springs) mount on a crossmember between the two main support beams that are fastened to the axle housing and pivot on forward-mounted hanger brackets on the frame. Torque rods, running from the hanger brackets to the axle seats, transfer vehicle motion to the frame. Lateral stability is provided by transverse torque rods from the inside of the frame rails to brackets on the axle housings. The shock absorbers help to dampen the oscillations of the air springs and control the torque reaction of the axle housings on acceleration.

Air Control System

The Hendrickson HAS air suspension system allows for a smooth ride while maintaining a constant ride height, even with varying loads. Although most vehicles with the HAS system use only one height control valve for the rear suspension, some vehicles with uneven loading may have a height control valve for each side of the vehicle. An optional suspension dump system permits the driver to temporarily lower the frame for trailer coupling or uncoupling without having to leave the cab. See **Subject 400** for a schematic of the air control system.

The suspension air control system uses air supplied from the secondary air brake system. The air supply line is connected to a secondary air manifold located behind the instrument panel. If a loss of air pressure occurs forward (upstream) of the protection valve,



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1. Hanger Bracket
2. Main Support Beam
3. Torque Rod
4. Axle Seat
5. Shock Absorber
6. Air Spring
7. Transverse Rod

Fig. 1, Rear Suspension, Hendrickson HAS-Series

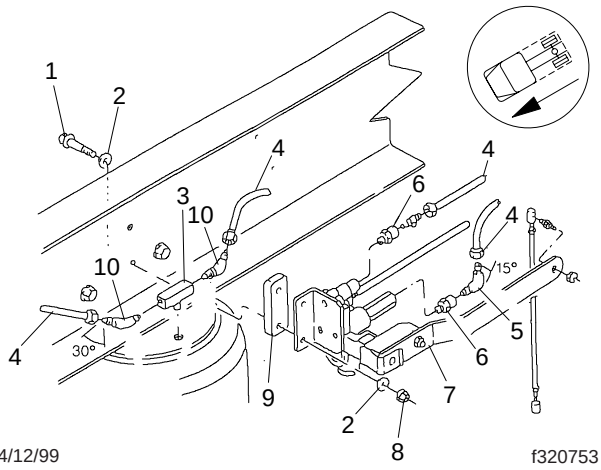
General Information

the air spring system will be isolated and maintain the air pressure within the suspension system until repairs can be made. However, if a loss of air occurs rearward (downstream) of the protection valve, the air in the brake system will be protected, but the air pressure in the air springs will be lost.

The vehicle ride height is maintained by a height control valve mounted on the frame and linkage that connects the valve to the suspension crossmember. (See **Fig. 2**). As the frame-to-axle housing clearance changes due to a change in the vehicle load, the linkage moves the lever on the height control valve, causing air to move in or out of the air bags. A slight delay in the operation of the height control valve prevents the system from trying to adjust the ride height for each suspension movement.

The optional air suspension dump system is used to deflate the rear suspension air springs during trailer coupling and uncoupling operations. The dump control valve is located on the dash in the cab. When the dump control valve is toggled, supply air flows through the dump control valve delivery port and pressurizes the signal line to the relay valve. The pressurization of the signal line closes the relay valve supply port while opening the ports from the air bags to the atmosphere. Air from the air bags exhausts through the relay valve until the dump control valve is released or until the frame rests on the stops inside the air bags. A pressure switch in the signal line to the relay valve senses the signal pressure and switches on an optional red status light on the dash. To allow the air springs to inflate after being dumped, the dump control valve must be first toggled downward to exhaust the pressure in the signal line.

The pilot-operated relay valve is used for rapid deflation of the air bags for trailer coupling and uncoupling. When pilot pressure from the dump control valve is applied to the relay valve, the supply air from the height control valve is stopped from flowing through the relay valve and, simultaneously, the air spring pressure is exhausted directly to the atmosphere through passages in the relay valve.



1. Bolt
2. Washer
3. Tee
4. Tube Assembly
5. Elbow
6. Adapter
7. Height Control Valve
8. Nut
9. Bracket
10. Elbow

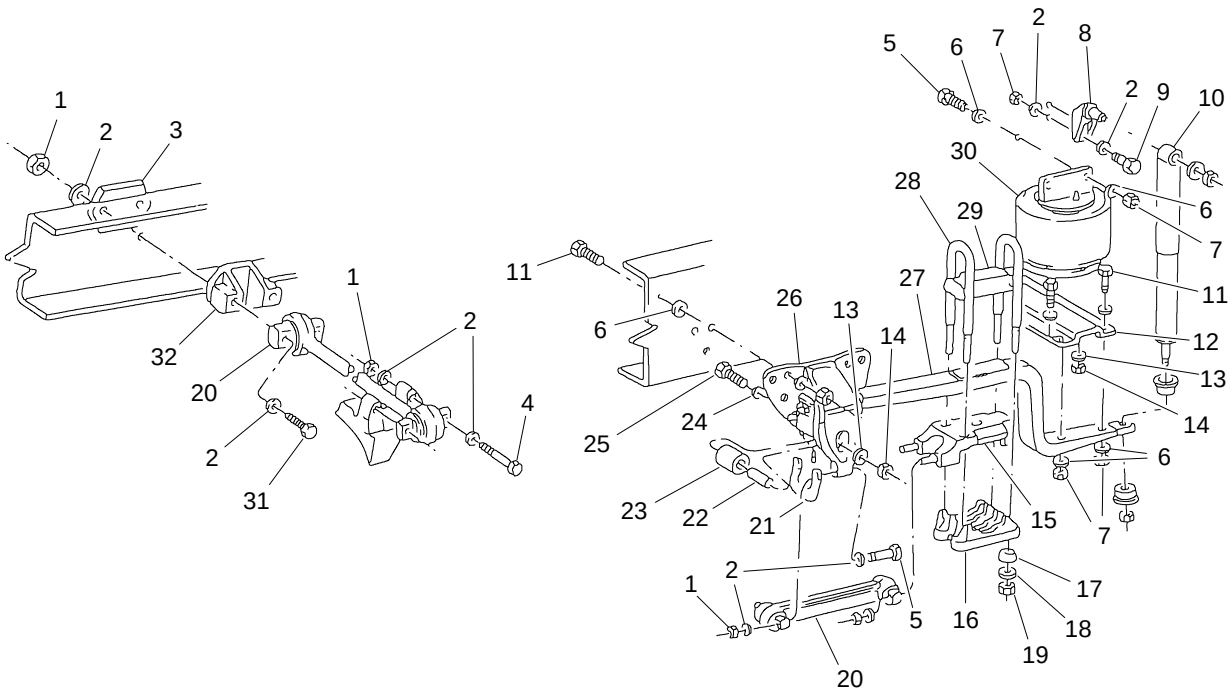
Fig. 2, Height Control Valve Assembly (typical)

Rear Suspension Components

The axle housing, the lower shock mounts and the lower air bag mounts are all solidly attached to the HAS main support arms. See **Fig. 3** and **Fig. 4**. The main support arm hanger brackets, the upper shock mounts and the upper air bag mounts are all solidly mounted to the frame rails. The torque rods, with flexible bushings in each end, connect the hangers to the axle seats. When the vehicle travels over a bump, the axle housing suddenly rises and compresses the air bags. The pressure in the air bags increases immediately, which absorbs most of the energy of the upward-moving axle housing without transferring that movement to the frame. The shock absorbers then help absorb the release of that higher pressure by slowing the downward movement of the axle housing after the bump.

The front of each main support arm is allowed to pivot and slide on replaceable slipper pads in the hanger brackets. A torque rod is attached to each hanger bracket and to each axle seat bracket by rubber bushings with internal pins, installed in the torque rods at specified angles. Shims are used for adjustment at the front of each torque rod to make sure that the wheels run parallel to the frame rails.

The torque rods control the forward and aft movement of the unsprung pieces during suspension travel. The flexible rubber bushings in the torque rods allow vertical movement of the axle housing while limiting its forward and aft movement. The driveline angles are kept within the specified limits by the torque rods' control of the rotational forces on the axle housings during acceleration and deceleration. The torque rods transfer the forward motion of the



1. Nut
2. Washer
3. Reinforcement
4. Bolt
5. Bolt
6. Washer
7. Nut
8. Shock Absorber Mounting Bracket
9. Bolt
10. Shock Absorber
11. Bolt
12. Suspension Support
13. Washer
14. Nut
15. Axle Seat
16. Bottom Cap Assembly
17. Spherical Washer
18. Washer
19. Nut
20. Transverse Rod Assembly
21. Alignment Shims
22. Spacer
23. Rebound Roller
24. Washer
25. Bolt
26. Hanger
27. Main Support Beam
28. U-Bolt
29. Top Pad
30. Air Spring Assembly
31. Bolt
32. Bracket

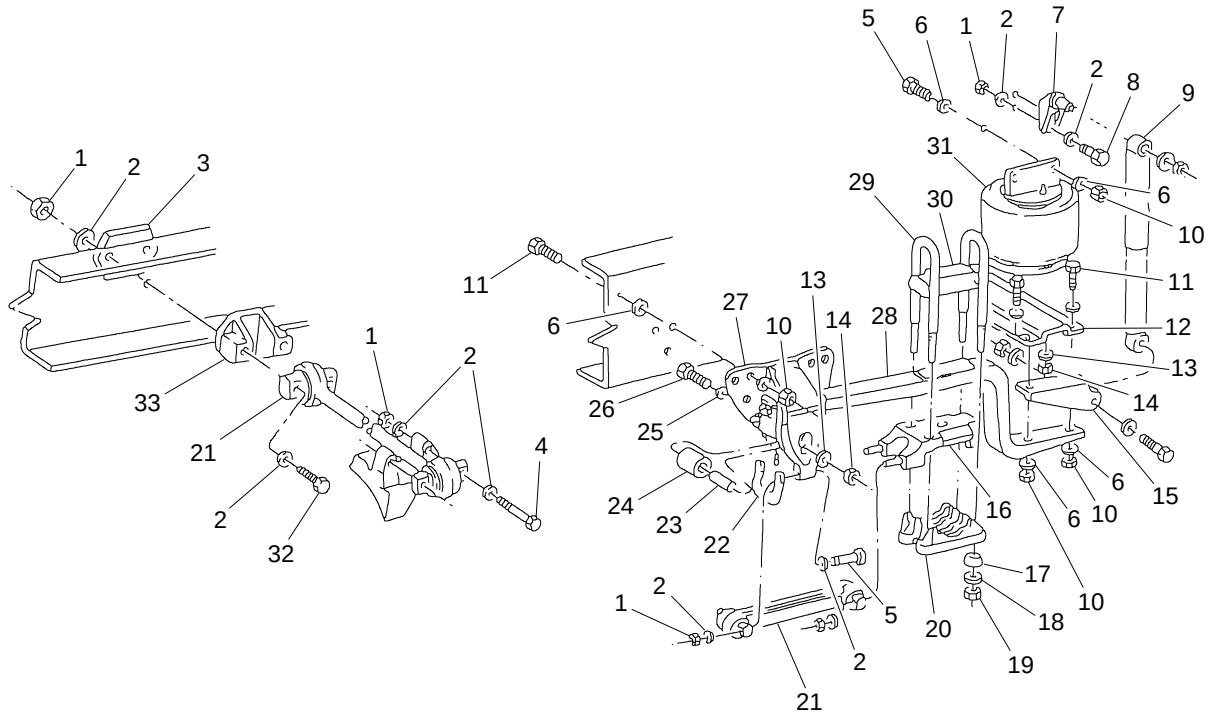
Fig. 3, Rear Suspension Components, Hendrickson HAS-40LH Series

axle housing to the frame rails on acceleration and pull back on the frame during braking.

The transverse rods, also with rubber bushings in each end, connect the brackets on the axle housings to the brackets on the frame rails. The transverse rods keep a constant lateral relationship of the frame to the axle housing, while still allowing vertical movement of the axle housings.

The Hendrickson HAS suspension is available in varying capacities and for limited off-highway use. The heavy-duty or off-highway suspensions have thicker main support arms, heavier crossmembers and torque rods, and heavy-duty air bags and shock absorbers. There are two HAS ride height specifications (measured from the bottom of the frame rail to the bottom of the main support arm at the axle seat) depending on which suspension is used. The HAS suspensions are available for single or tandem axle vehicles and can be ordered with or without the suspension dump feature.

General Information



1. Nut
2. Washer
3. Reinforcement
4. Bolt
5. Bolt
6. Washer
7. Shock Absorber Mounting Bracket
8. Bolt
9. Shock Absorber
10. Nut
11. Bolt
12. Suspension Support
13. Washer
14. Nut
15. Shock Absorber Mounting Bracket
16. Axle Seat
17. Spherical Washer
18. Washer
19. Nut
20. Bottom Cap Assembly
21. Transverse Rod Assembly
22. Alignment Shims
23. Spacer
24. Rebound Roller
25. Washer
26. Bolt
27. Hanger
28. Main Support Beam
29. U-Bolt
30. Top Pad
31. Air Spring Assembly
32. Bolt
33. Bracket

Fig. 4, Rear Suspension Components, Hendrickson HAS-400, HAS-402, and HAS-460 Series

Rear Suspension Service Notes

⚠ WARNING

A main support member that has been subjected to heat, nicks or gouges can fail, causing loss of vehicle control and possible personal injury or property damage.

⚠ CAUTION

Do not use an arc welder on the suspension parts or use a cutting torch to remove any fasteners. The use of heat on suspension components will adversely affect the strength of these parts. Never reinstall used suspension fasteners. Always use the same part number or an exact equivalent part number when replacing any suspension fastener. All fasteners must be tightened

to their specified torque and the U-bolts must be tightened in stages as described in Specifications 400.

Check the axle alignment after replacing components that affect alignment, such as a main support beam, a torque rod or a hanger.

NOTE: During installation, apply Pipe Sealant with Teflon D8AZ–19554–A or equivalent meeting specification WSK–M2G350–A2 or ESR–M18P7–A to the air fitting threads.

NOTE: When replacing the torque rod bushings, lubricate the new bushings with a vegetable-based oil only. Make sure the new bushings are centered in the torque rod bores.

NOTE: A shim pack of three 0.11 inch (2.8 mm) thick spacers are used to adjust axle lateral tracking offset. Install the spacers as required to adjust tracking.

Main Support Member Removal and Installation

Removal

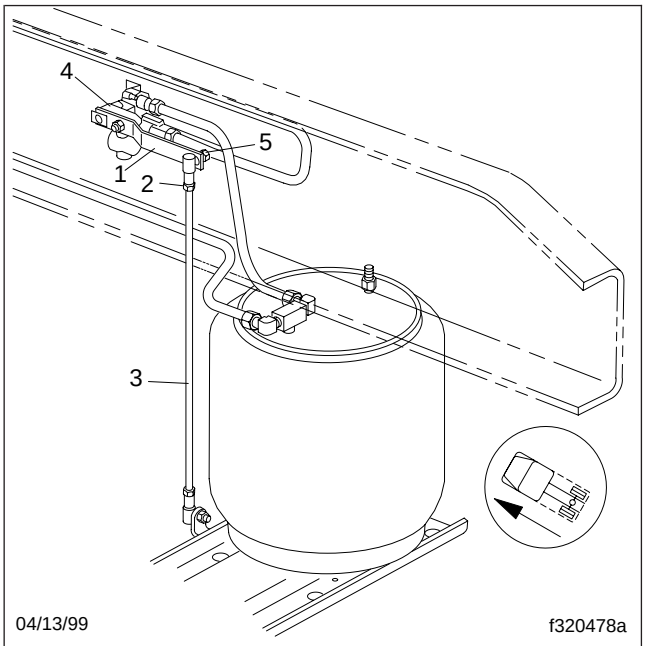
NOTE: Operation of the HAS suspension will result in wear between the main support member and the spring hanger slipper pad. In normal use, these components will function satisfactorily even though they show some wear. Premature wear may occur, however, and requires the replacement of one or both parts. A main support member should be replaced if it has 3/8 inch (9.5 mm) or more wear at the hanger cam contact area.

1. Stop the vehicle on a level surface, shut down the engine and apply the park brakes. Chock the front and rear tires.
2. Support the axle housing with a jack stand under the pinion nose to prevent the axle housing from rotating when the U-bolts are removed.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

3. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the frame about 3 inches (75 mm). Support the frame at that position with jack stands.
4. Remove the locknuts, washers and bolts that connect the cross channel and shock absorber brackets to both main support members. See **Fig. 2**. Remove the lower shock mount fasteners on the HAS–40LH models.
5. Use a floor jack to raise the cross channel about 3 inches (75 mm). Support the cross channel assembly with jack stands.
6. Remove the locknut, washers and bolt from the rebound roller assembly at the front hanger. See **Fig. 3**. Remove the rebound roller and spacer.
7. Remove the U-bolt high nuts and washers, then remove the bottom cap, U-bolts and the top pad and Delrin liner.

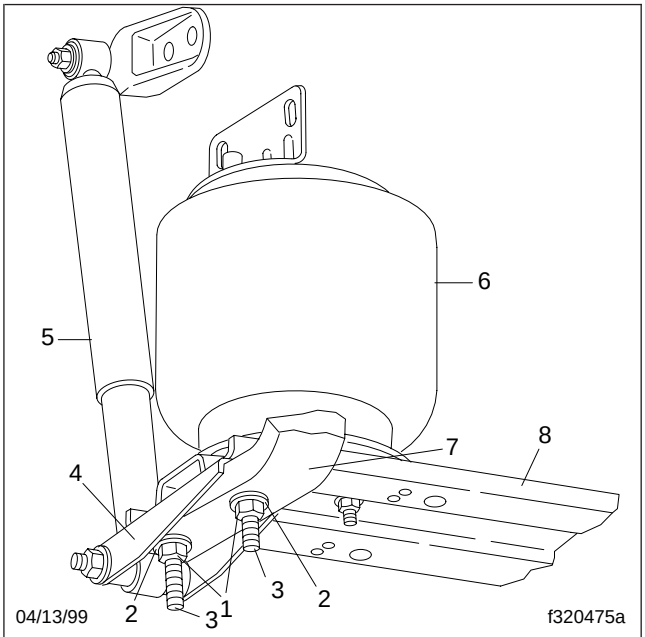


1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Ride Height Control Linkage

8. Slide the main support member out of the hanger and remove the main support assembly from the vehicle.
9. Inspect the main support member for wear. Replace the main support member if worn more than 3/8 inch (9.5 mm) at the hanger end where it contacts the slipper pad or if it has cracks, nicks or signs of the application of heat from a torch or welder.
10. Inspect the slipper pad for wear. Replace the slipper pad if worn. Remove the four bolts and washers that hold the slipper pad to the hanger. If rivets were installed instead of bolts to hold the slipper pad, use a grinder to remove the rivet heads.

Main Support Member Removal and Installation



1. Locknut
2. Washer
3. Bolt
4. Lower Shock Bracket
5. Shock Absorber
6. Air Spring
7. Main Support Member
8. Cross Channel

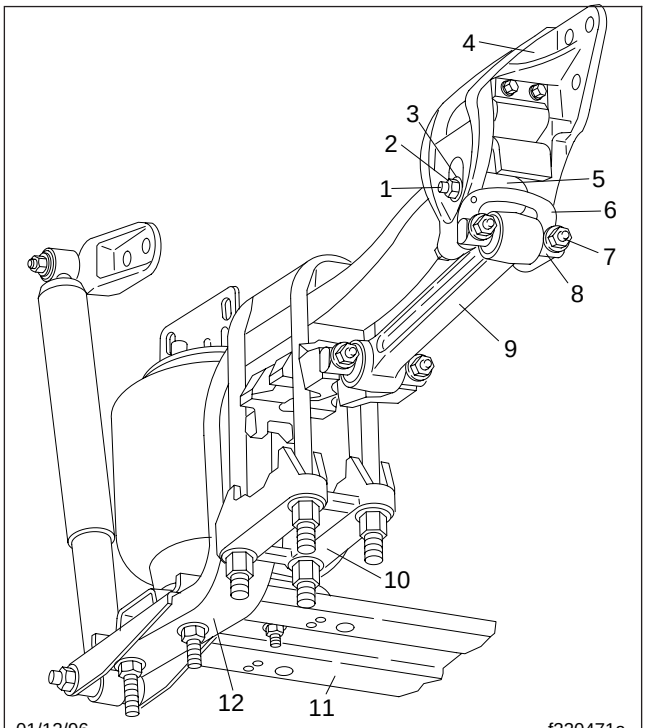
Fig. 2, Main Support Member

Installation

⚠ WARNING

Always use new fasteners when installing suspension components. Reuse of fasteners can lead to component damage and loss of vehicle control, possibly resulting in personal injury or property damage.

1. Install the slipper pad, bolts and washers into the hanger. Tighten the bolts 25 lbf·ft (34 N·m). Install new rivets if so equipped.
2. Slide the main support member into the hanger assembly.
3. Position the main support member on the axle seat, or on the spacer plate if the vehicle is so equipped, with the main support member center dowel sliding into the hole in the axle seat or spacer plate.



1. Rebound Bolt
2. Locknut
3. Washer
4. Hanger
5. Rebound Roller
6. Alignment Shim(s)
7. Bolt
8. Bar Pin
9. Torque Rod
10. Bottom Cap
11. Cross Channel
12. Main Support Member

Fig. 3, Removing the Rebound Roller

4. The Delrin liner must be positioned on the top of the main support member. Install the U-bolt top pad on the Delrin liner. Install the U-bolts over the top pad and liner and around the main support member, the spacer (if so equipped), the axle seat assembly, the axle housing, and the bottom cap. Install the washers and high nuts and tighten with your fingers, but do not fully tighten the U-bolt high nuts at this time.
5. Lower the floor jack under the cross channel until the cross channel is against the main support members. Install the shock absorber bracket (if so equipped) and bolts into the cross channel and main support members. See **Fig. 2**. Install the washers and tighten the locknuts 280 lbf·ft (380 N·m). On the HAS–40LH models, install the

lower shock absorber mount bolts, washers and nuts. Tighten the shock absorber nut 60 lbf·ft (82 N·m).

6. Install the rebound roller into the hanger. Install the bolt, washer and locknut. Tighten the locknut 60 lbf·ft (82 N·m).
7. Center the main support member between the hanger legs. Move the lever for the height control valve up to lift the frame from its jack stands. Remove the jack stands from the frame.
8. Tighten the U-bolt locknuts in stages as described in **Specifications 400**. Rap the top of the U-bolts with a hammer and then retighten the high nuts 500 lbf·ft (680 N·m).

IMPORTANT: Do not exceed the specified torque on the U-bolt high nuts. Retighten the U-bolt high nuts after 1000 miles (1600 km).

9. Move the lever for the height control valve down to lower the frame until the upper ball joint stud in the vertical linkage exactly aligns with the hole in the lever when the lever is in the horizontal position. Install the height control valve ball joint stud, washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
10. Remove the jack stand from under the nose of the axle housing.
11. Check and adjust the ride height as described in **Subject 180**.
12. Check the alignment after new main support members are installed.

Axle Seat Removal and Installation

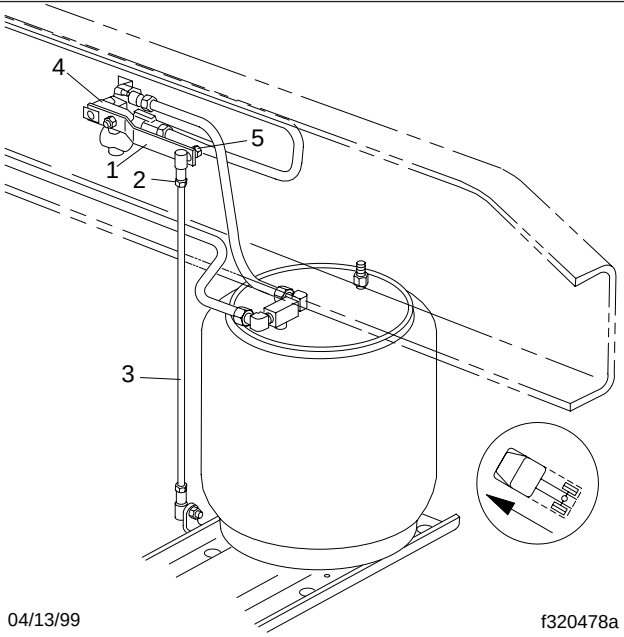
Removal

1. Stop the vehicle on a level surface, shut down the engine and apply the park brakes. Chock the front and rear tires.
2. Support the axle housing with a jack stand under the pinion nose to prevent the axle housing from rotating when the U-bolts are removed.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

3. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the rear of the frame about 3 inches (75 mm). Support the frame at that position with jack stands.
4. Remove the nuts, washers and bolts that hold the torque rod to the hanger legs.
5. Remove the nuts and washers that hold the torque rod to the axle seat. Remove the torque rod.
6. Remove the high nuts from the U-bolts and remove the bottom cap and top pad and Delrin liner.
7. Use a floor jack to raise the cross channel and main support member just enough to remove the axle seat.
8. Remove the axle seat. See **Fig. 2**.
9. If the axle seat studs need replacement, remove them with a hammer and brass drift.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Ride Height Control Linkage

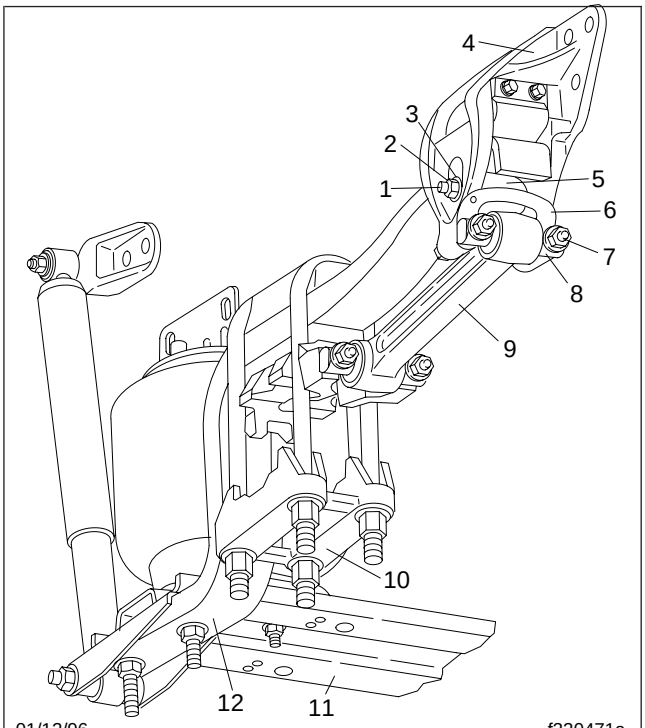
Installation

⚠ WARNING

Always use new fasteners when installing suspension components. Reuse of fasteners can lead to component damage and loss of vehicle control, possibly resulting in personal injury or property damage.

1. Install the new studs with a stud driver. Insert the stud in the hole of the axle seat and tap into position with a hammer and brass drift.
2. Lift the main support member with a floor jack and install the axle seat on the top of the axle housing. Install the spacer (if so equipped) above the axle seat.
3. Position the main support member on the axle seat, or on the spacer plate if the vehicle is so equipped, with the main support member center dowel sliding into the hole in the axle seat or spacer plate.
4. The Delrin liner must be positioned on the top of the main support member. Install the U-bolt top pad on the Delrin liner. Install the U-bolts over the top pad and liner and around the main support member, the spacer (if so equipped), the axle seat assembly, the axle housing, and the bottom cap. Install the washers and high nuts

Axle Seat Removal and Installation



1. Rebound Bolt
2. Locknut
3. Washer
4. Hanger
5. Rebound Roller
6. Alignment Shim(s)
7. Bolt
8. Bar Pin
9. Torque Rod
10. Bottom Cap
11. Cross Channel
12. Main Support Member

Fig. 2, Removing the Axle Seat

and tighten with your fingers, but do not fully tighten the U-bolt high nuts at this time.

5. Install the torque rod on the axle seat so that the holes in the bushing pin align with the axle seat studs. Install the washers and nuts, but do not tighten at this time.
6. Install the front end of the torque rod onto the hanger legs and install any shims that were removed. Install the bolts through the hanger legs, shims, and the front bushing pin.
7. Tighten the nuts on the front of the torque rod 175 lbf·ft (237 N·m).
8. Tighten the nuts for the torque rod pin at the axle seat 175 lbf·ft (237 N·m).
9. Move the lever for the height control valve up to lift the frame from its jack stands, Remove the jack stands from the frame.
10. Tighten the U-bolt locknuts in stages as described in **Specifications 400**. Rap the top of the U-bolts with a hammer and then retighten the high nuts 500 lbf·ft (680 N·m).

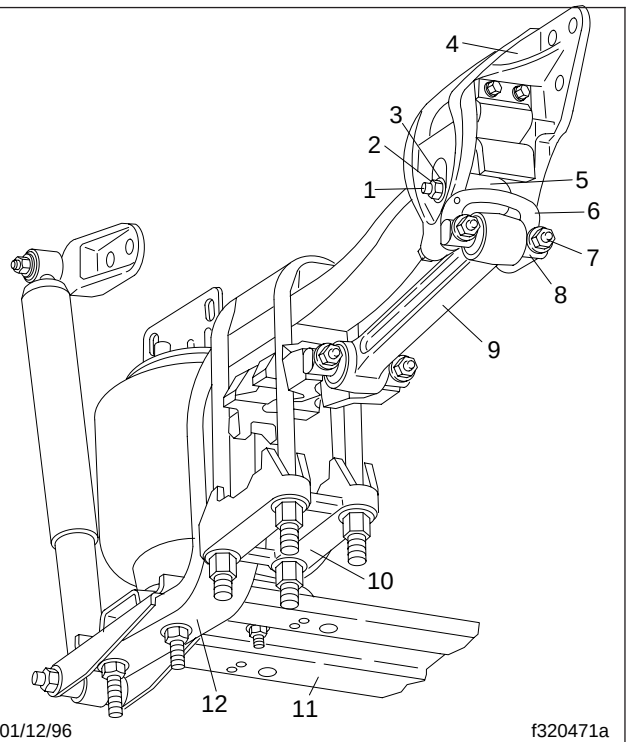
IMPORTANT: Do not exceed the specified torque on the U-bolt high nuts. Retighten the U-bolt high nuts after 1000 miles (1600 km).

11. Move the lever for the height control valve down to lower the frame until the upper ball joint stud in the vertical linkage exactly aligns with the hole in the lever when the lever is in the horizontal position. Install the height control valve ball joint stud, washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
12. Remove the jack stand from under the nose of the axle housing.
13. Check and adjust the ride height as described in **Subject 180**.
14. Check the alignment after new axle seats are installed.

Replacement (See Fig. 1)

Use the following procedure to replace the torque rod bushing.

1. Chock the front tires, and the tires of the drive axles.
2. Remove the bushing pin locknuts and washers at the axle end of the torque rod. See **Fig. 1**.



1. Rebound Bolt
2. Locknut
3. Washer
4. Hanger
5. Rebound Roller
6. Alignment Shim(s)
7. Bolt
8. Bar Pin
9. Torque Rod
10. Bottom Cap
11. Cross Channel
12. Main Support Member

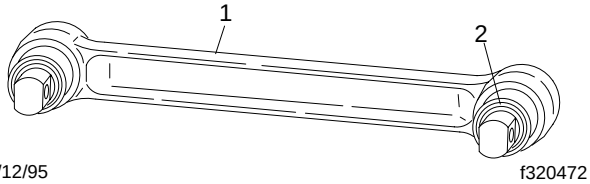
Fig. 1, Torque Rod Installation

3. Loosen the rebound bolt locknut in the hanger.
4. Remove the bushing pin locknuts, bolts and washers, and any alignment shims at the hanger end of the torque rod. Note the number of shims, as the same thickness shim pack must be reinstalled to avoid affecting the vehicle's alignment.
5. Push out the old bushings. Use a vertical shop press with a capacity of at least 10 tons. A 5-inch (127 mm) piece of 2-inch by 1/4-inch (50-mm by 6-mm) wall, steel-tubing receiving tool is required. The bushings are not cartridge-type bushings and do not have a metal outer sleeve.
6. Support the torque rod end on the receiving tool with the end tube of the torque rod centered on the tool.

⚠ WARNING

Do not use heat or a cutting torch to remove the bushings from the torque rod. The use of heat will weaken the torque rod, which could cause the rod to break. This could result in a loss of vehicle control, personal injury, or property damage.

7. Push directly on the bushing pin until the bushing is pushed out of the torque rod end tube.
8. Clean and inspect the torque rod ends. Remove any nicks with emery cloth.
9. Lubricate the torque rod ends and the new rubber bushings with a vegetable-based oil. Do not use a petroleum-based or soap-based lubricant.
10. Press in the new bushings while supporting the torque rod end on the receiving tool with the end tube of the torque rod centered on the receiving tool. The bushings must be installed with the mounting flats on the bar pin positioned 90 degrees to the shank of the torque rod. See **Fig. 2**.



1. Torque Rod
2. Bushing Bar Pin

Fig. 2, Positioning the Bar Pin Mounting Flats

11. Press directly on the bar pin of the bushings, which must be centered within the torque rod end tubes. When pressing in the new bushings, overshoot the final position by approximately 3/16 inch (5 mm).
12. Press the bushing again from the opposite side to center the bushing within the torque rod end.

Torque Rod Bushing Replacement

13. Position the torque rod into the axle seat and attach it with the washers and locknuts. Handtighten the locknuts.
14. Position the torque rod onto the forward face of the hanger legs. Assemble the bolts, washers and locknuts, and any alignment shims. Tighten locknut 175 lbf·ft (237 N·m). See **Fig. 1**.
15. Tighten locknuts at the axle end of the torque rods 175 lbf·ft (237 N·m).
16. Tighten rebound bolt locknut 60 lbf·ft (81 N·m).

Height Control Valve Removal and Installation

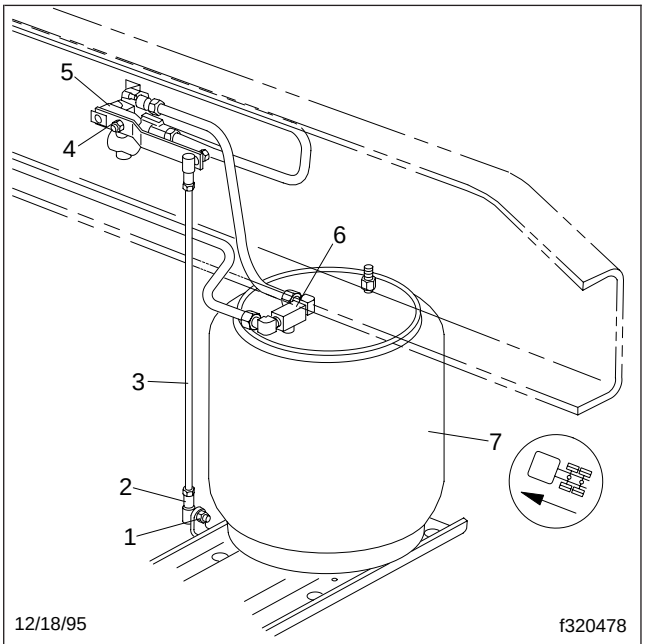
Removal

1. Chock the front tires.
2. Drain the vehicle's air system.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

3. Remove the height control valve vertical rod from the valve lever by removing the nut and lock washer. Push down on the lever of the height control valve to exhaust the air from the rear suspension air bags.
4. Remove the air lines attached to the height control valve. See **Fig. 1**.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Height Control Valve System

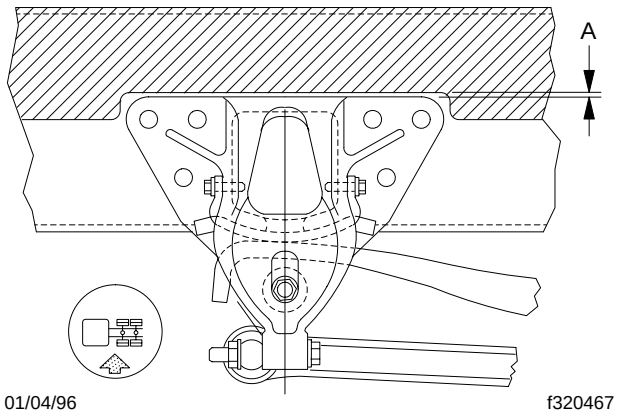
5. Remove the locknuts, washers, and bolts that attach the height control valve to the frame.
6. Remove the brass air fittings from the height control valve.

Installation

1. Install the brass air fittings into the height control valve ports.
2. Install the bolts, washers, and locknuts that attach the valve to the frame rail.
3. Attach the air lines to the height control valve.
4. Attach the height control valve vertical linkage rod to the height control valve lever, and install the lock washer and nut. See **Fig. 1**.
5. Return air to the system.
6. Adjust the height control valve for proper ride height as described in **Subject 180**.

Information

The HAS front hangers must have at least 1/4-inch (6 mm) clearance between the top of the hanger and the bottom of the fifth wheel mounting bracket on the sides of the frame rails. In some cases, the fifth wheel mounting bracket may have to be cut out to provide the correct clearance. See **Fig. 1** for an example of a fifth wheel mounting bracket that has been modified.

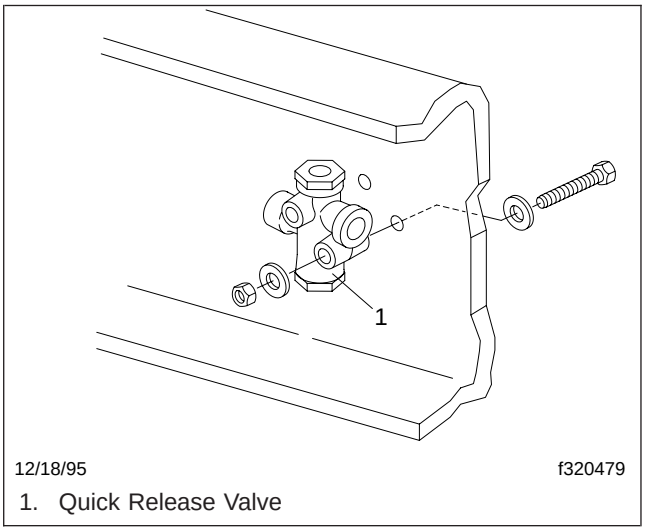


A. Clearance: 1/4 inch (6 mm)

Fig. 1, Fifth Wheel Mounting Angle Clearance

Replacement (See Fig. 1)

1. Chock the front tires.
2. Drain the vehicle's air system.
3. Disconnect the air lines from the quick release valve. Identify the air line at the top of the valve.
4. Remove the quick release valve from the frame or cross member.
5. Remove the brass air fittings from the valve.
6. Attach the brass air fittings to the replacement quick release valve.
7. Attach the valve to the frame or cross member.



1. Quick Release Valve

Fig. 1, Quick Release Valve Installation

8. Connect the air lines to the valve, making sure to attach the identified line to the top of the valve.
9. Build up pressure in the air system.
10. Remove the chocks from the front tires.

Slipper Pad Removal and Installation

Removal

NOTE: Operation of the HAS suspension will result in wear between the main support member and the hanger slipper pad. In normal use, these components will function satisfactorily even though the components indicate some wear.

1. Chock the front tires.

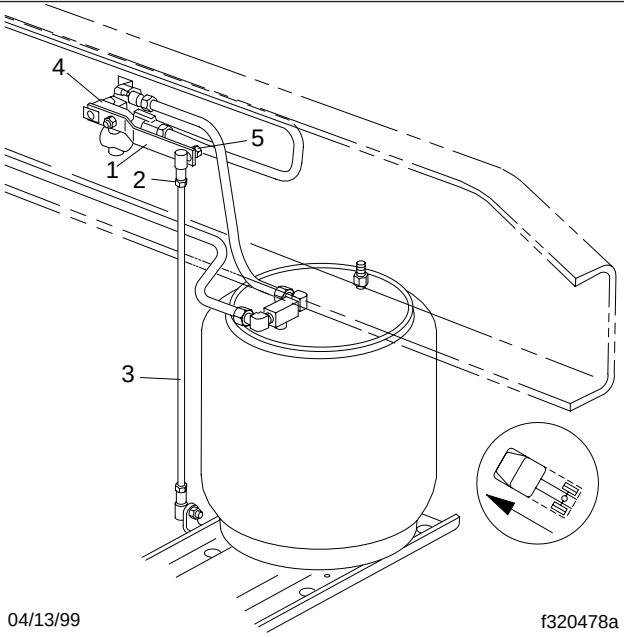
⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

2. Disconnect the vertical linkage from the lever of the height control valve and lift the lever to raise the rear of the frame about 3 inches (75 mm). See **Fig. 1**.
3. Support the frame with jack stands.
4. Apply an upward force on the cross channel with a jack or, on single axles, by pushing down on the height control lever to lift the cross channel. This will cause the tips of the main support members to drop away from the slipper pad. See **Fig. 2**.

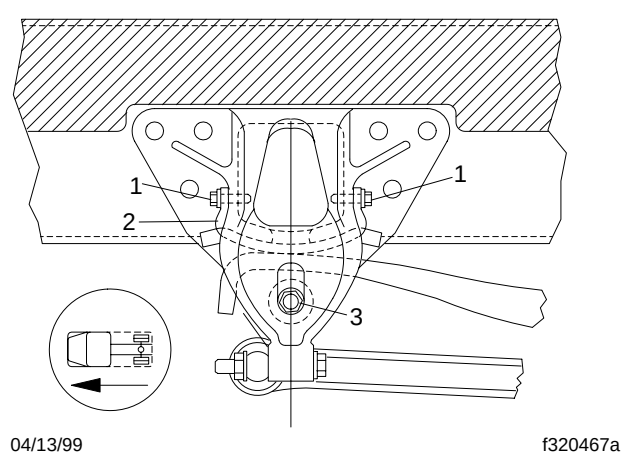
IMPORTANT: Do not nick or gouge the cross channel.

5. Remove the fasteners and the slipper pad. In some instances, the screws may have to be drilled out. See **Fig. 3**.
6. In some instances, remove the rebound roller to gain enough clearance to remove the slipper pad. Loosen the rebound bolt locknut, remove the washer, the bolt, and the rebound roller assembly.
7. For rivets, remove the four 1/4-inch (6-mm) rivets by grinding away the rivet heads. With a drift pin, punch the rivets through the holes and remove the slipper pad.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

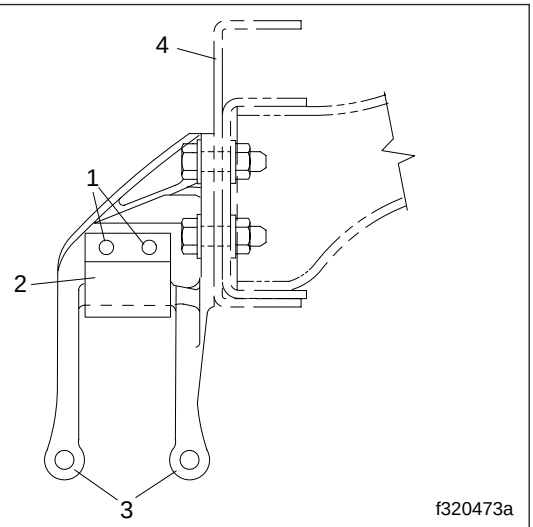
Fig. 1, Ride Height Control Linkage



1. Slipper Pad
2. Bolts or Rivets
3. Rebound Roller Bolt and Nut

Fig. 2, Slipper Pad Installation

Slipper Pad Removal and Installation



1. Bolts or Rivets
2. Slipper Pad
3. Hanger Legs
4. Frame Rail

Fig. 3, Hanger Assembly

Installation

1. Position the slipper pad and retainer plate on the frame hanger.
2. Tighten the hexhead self-tapping screws 25 lbf·ft (34 N·m).
3. Or, install the rivets using a rivet gun.
4. Raise the frame off the jack stands by pulling up on the height control valve lever. Remove the jack stands.
5. Push down on the height control valve lever to lower the frame until the upper ball stud on the vertical linkage rod exactly aligns with the hole in the lever when the lever is horizontal.
6. Install the ball stud into the hole in the lever and install the washer and nut. Tighten the nut 10 lbf·ft (14 N·m).
7. Remove the chocks from the tires.

Cross Channel Removal and Installation

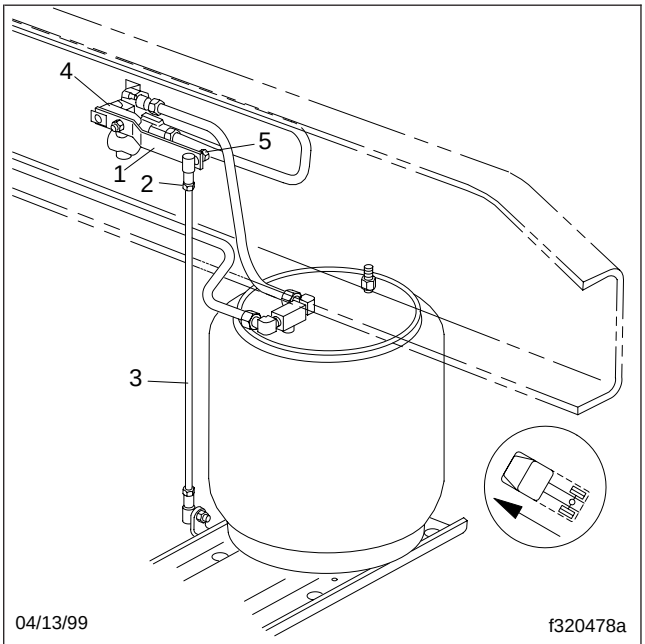
Removal

1. Stop the vehicle on a level surface and shutdown the engine. Chock the front and rear tires.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

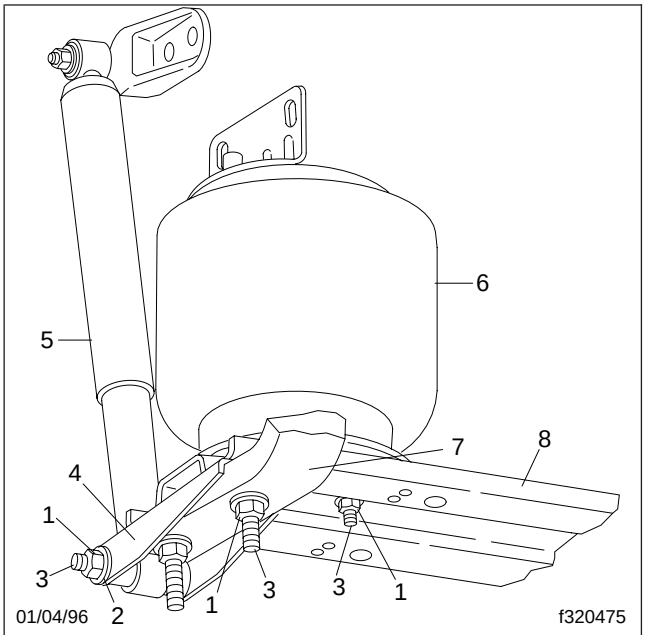
2. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the rear of the frame about 3 inches (75 mm). Support the frame at that position with jack stands.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Height Control Linkage

3. Remove the locknuts and washers that attach both the air springs to the cross channel. See **Fig. 2**.



1. Locknut
2. Washer
3. Bolt
4. Lower Shock Bracket
5. Shock Absorber
6. Air Spring
7. Main Support Member
8. Cross Channel

Fig. 2, Main Support Member

4. Remove the locknuts, washers, and bolts that attach the cross channel to the main support members and to the shock absorber lower mounting brackets.
5. Raise the cross channel by pushing down on the height control lever to compress the air springs just enough to clear the studs on the bottom of the air springs. Remove the cross channel.

Installation

1. Position the cross channel so that the holes in the cross channel are aligned under the studs of the air springs. Install the washers and nuts. Tighten the nuts on the air spring studs 25 lbf·ft (34 N·m).

Cross Channel Removal and Installation

2. Lower the cross channel assembly onto the main support members by pushing down on the height control valve lever.
3. Install the bolts, washers and locknuts that connect the cross channel to the main support member and lower shock absorber mounts. Tighten the locknuts 290 lbf·ft (393 N·m).
4. Raise the frame by lifting the height control valve lever and remove the jack stands.
5. Attach the ball joint stud of the vertical linkage rod to the height control valve link, and tighten the locknut on the ball joint stud 10 lbf·ft (14 N·m).
6. Remove the chocks from the tires.

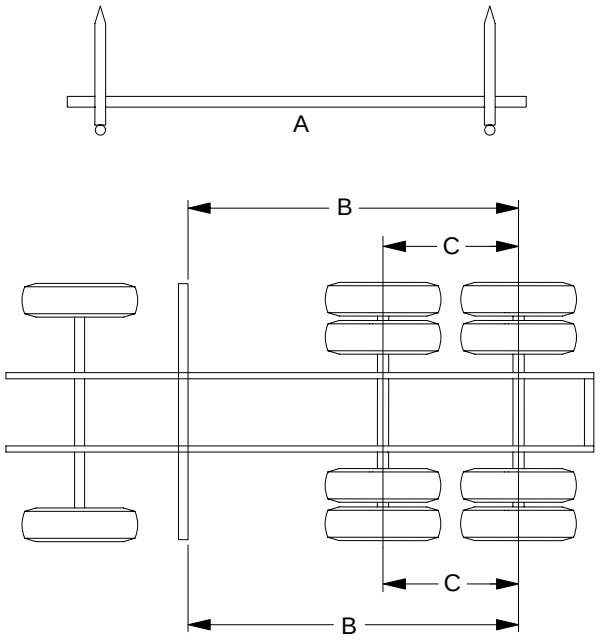
Checking and Adjustment

Use the following procedure after all repairs to the suspension:

1. Park vehicle on a level surface. Free and center all suspension joints by slowly moving the vehicle back and forth several times without applying the brakes.
2. Chock the front tires and the tires of drive axles.
3. C-clamp a nine-foot (2.74-m) piece of straight bar stock or angle iron across the frame. Select a location as far forward of the forward drive axle as possible where components will not interfere. The lower frame flange may be preferred on some vehicles, otherwise use the upper frame flange.
4. Align the straight bar stock or angle iron on the frame using a carpenter's square.
5. Check the rear drive axle first. See **Fig. 1** . Use a trammel bar or its equivalent to measure from the straight edge to the center line of the rear axle on both sides of the vehicle. If both sides measure within 3/16 inch (5 mm) of being the same, the alignment of the rear drive axle is acceptable. If the sides differ by more than 3/16-inch (5 mm), first loosen the rebound locknut, and then adjust the rear drive axle by loosening up the torque rod bar pin locknuts on the hangers. Add or remove drop-in shims as needed.

NOTE: The torque rod bar pin must be mounted to the forward face of the hanger legs. No more than four shims may be used (for a maximum thickness of 1/4 inch (6 mm).

6. Snug the torque rod bar pin locknuts but do not torque to specification.
7. With the rear drive axle properly aligned, the front drive axle alignment can be checked by measuring forward from the center of the axle shafts on the rear drive axle using a trammel bar. If the forward drive axle spacing measurements differ by more than 1/8 inch (3 mm), add or subtract shims at the forward hangers.
8. Following the adjustment of both axles, move the vehicle back and forth several times prior to removing the straight edge from the frame. Recheck the alignment.



A. Trammel Bar
B. Each side must be within 3/16 inch (5 mm) of each other.
C. Distances between axles must be within 1/8 inch (3 mm) of each other.

Fig. 1, Drive Axle Tracking Alignment

9. Tighten the torque rod bar pin locknuts 180 lbf·ft (244 N·m).
10. Remove the chocks from the tires.

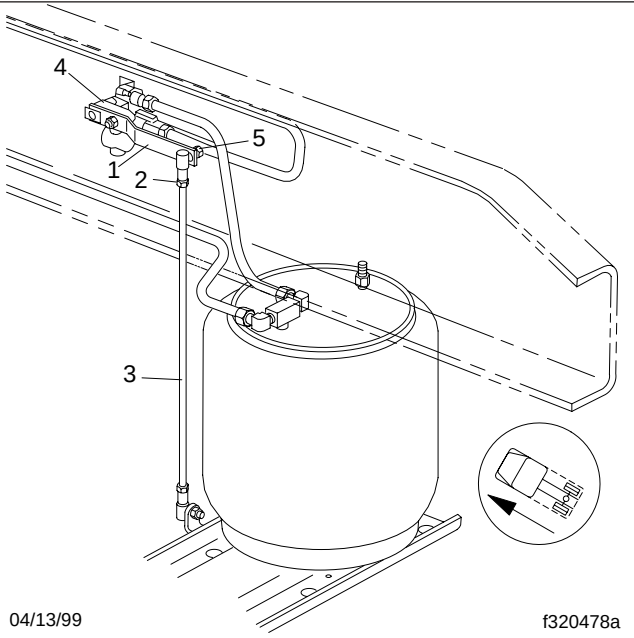
Replacement

1. Chock the front tires.
2. Support the frame with jack stands.
3. Drain the vehicle's air system.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

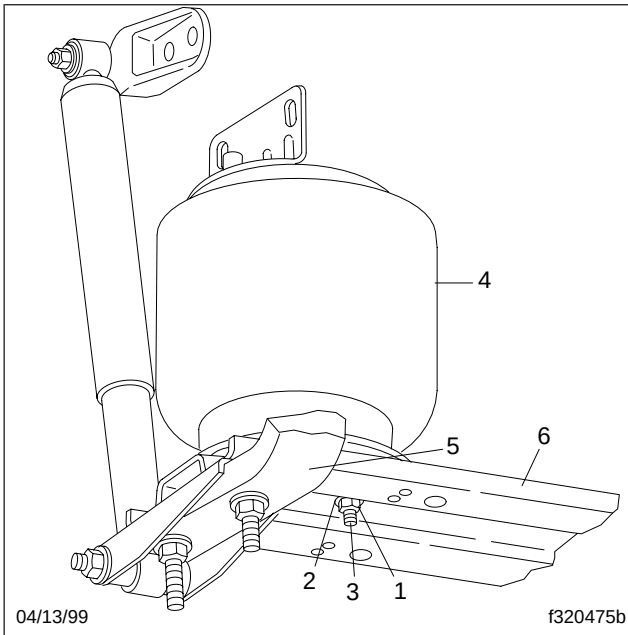
4. Remove the upper ball joint nut and stud from the lever on the height control valve. See **Fig. 1**. Move the height control valve lever down to exhaust all the air from the air bags.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Ride Height Control Linkage

5. Remove the locknuts and washers that attach the air spring to the cross channel. See **Fig. 2**.
6. Disconnect the air lines to the air spring.
7. Remove the brass air fittings from the air spring.
8. Remove the locknuts and washers that attach the air spring to the upper air spring frame hanger.
9. Remove the air spring.
10. Attach the new air spring to the air spring frame hanger by inserting the studs into the appropriate holes.
11. Attach the air spring to the cross channel. Tighten the nuts 25 lbf·ft (34 N·m).
12. Tighten the outboard locknut that attaches the air spring to the air spring frame hanger 25 lbf·ft (34 N·m).



1. Locknut
2. Washer
3. Bolt
4. Air Spring
5. Main Support Member
6. Cross Channel

Fig. 2, Air Spring Mounting

13. Attach the brass fittings to the air spring using a Teflon thread seal.
14. Connect the air lines to the air spring.

Air Spring Replacement

15. Connect the ball stud on the vertical linkage rod to the lever for the height control valve. Install the washer and tighten the nut 10 lbf·ft (14 N·m).
16. Remove the jack stands.
17. Build up pressure in the air system and check the ride height as described in **Subject 180**.
18. Remove the chocks from the tires.

Air Spring Frame Hanger Removal and Installation

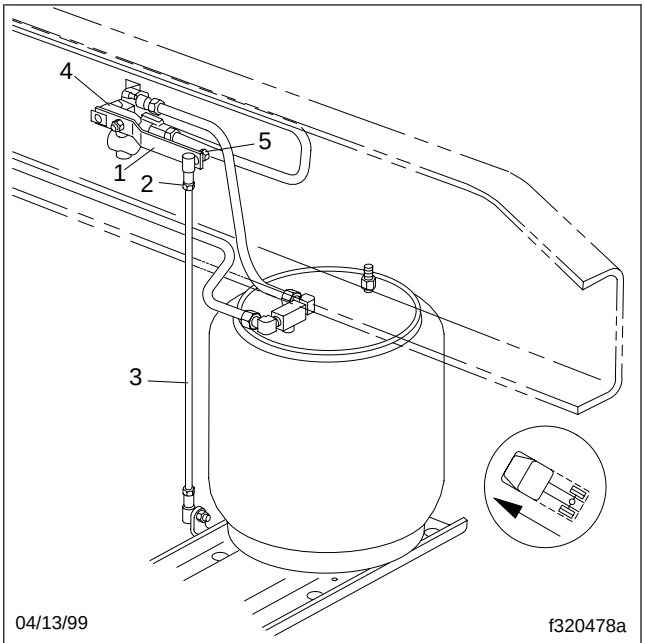
Removal

1. Chock the front tires.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

2. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the rear of the frame about 3 inches (75 mm). Support the frame at that position with jack stands.



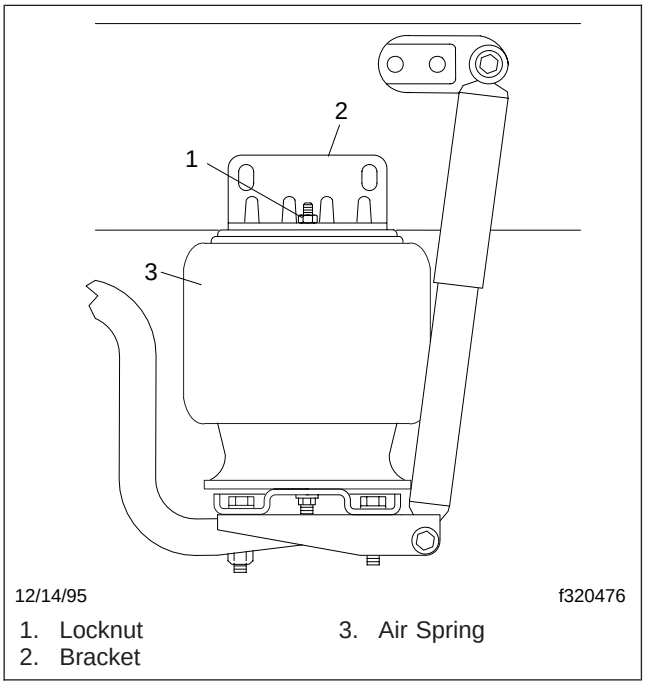
1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Height Control Valve Linkage

3. Drain the air from the vehicle's air system then lower the lever on the height control valve to exhaust the air from the air springs.
4. Disconnect the air lines from the air spring fittings.
5. Remove the brass air fittings from the air spring.
6. Remove the locknuts and washers that attach the air springs studs to the upper bracket on the frame rail. See **Fig. 2**.
7. Remove the nuts, washers and bolts that hold the upper air spring bracket to the frame rail. Remove the air spring bracket.

Installation

1. Position the air spring upper bracket on the frame rails. Install the bolts through the frame rail and upper bracket and install the washers, and locknuts. Tighten the locknuts 340 lbf·ft (461 N·m).
2. Attach the air spring to the air spring frame bracket. Tighten the outboard locknut 25 lbf·ft (34 N·m).



1. Locknut
2. Bracket
3. Air Spring

Fig. 2, Air Spring Installation

3. Attach the brass air fittings to the air spring port using Teflon thread sealant.
4. Connect the air lines to the air spring fittings.

Air Spring Frame Hanger Removal and Installation

5. Build up pressure in the air system and raise the height control lever to lift the frame off the jack stands. Remove the jack stands and lower the vehicle.
6. Align the ball joint stud in the vertical linkage rod with the hole in the height control lever. Install the ball joint stud, the washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
7. Remove the chocks from the tires.

Shock Absorber Bracket Removal and Installation

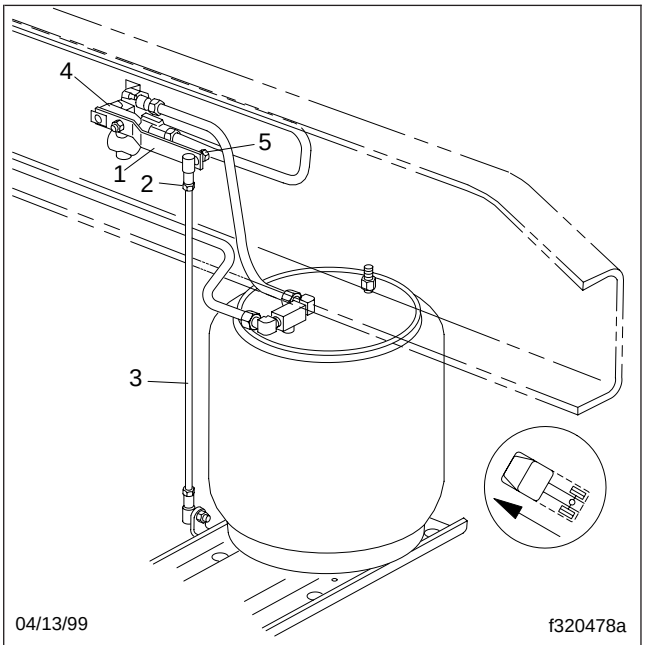
Removal

1. Chock the front tires.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

2. Remove the locknut and washer and disconnect the ball joint stud on the top of the vertical linkage rod from the height control valve lever. See **Fig. 1**.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

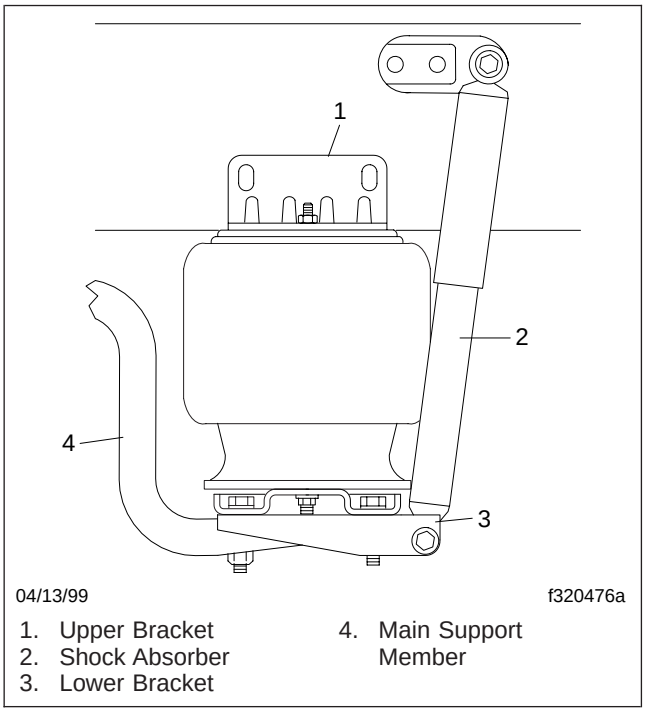
Fig. 1, Height Control Valve Linkage

3. Lift the height control lever to raise the rear of the frame enough to remove the load from the suspension.

   NOTE: The front of the main support member will move downward as the load is removed. Support the frame in this position with jack stands.

4. Remove the shock absorber. Refer to **Subject 170**.

5. Remove nuts, washers and bolts from the shock absorber frame hanger bracket. See **Fig. 2**. Remove the top shock absorber bracket from the frame.



1. Upper Bracket
2. Shock Absorber
3. Lower Bracket
4. Main Support Member

Fig. 2, Shock Absorber Mounts (typical)

6. Remove the nuts, washers and bolts that attach the cross channel and lower shock absorber bracket to the rear of the main support member.

7. Remove the lower bracket by sliding the bracket to the rear.

Installation

1. Install the bolts and washers that attach the frame hanger bracket from the inboard side of the frame. Install the brackets, washers and locknuts. Tighten the nuts 340 lbf·ft (461 N·m).

2. Position the lower bracket between the cross channel and the main support member.

Shock Absorber Bracket Removal and Installation

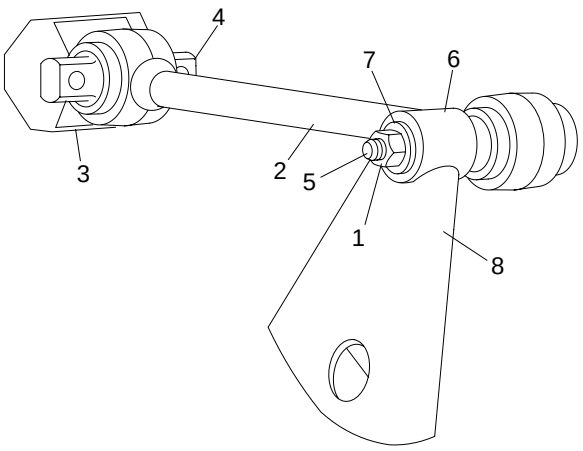
3. Install the bolts and washers from the top of the cross channel, through the shock bracket and main support member. Install the washers and locknuts and tighten the locknuts attaching the cross channel to the main support member 290 lbf·ft (393 N·m).
4. Install the shock absorber. Install the washers at both sides of each shock bushing for a total of four washers per shock absorber.
5. Tighten shock absorber locknuts 60 lbf·ft (81 N·m).
6. Lift the lever of the height control valve to raise the rear of the frame off the jack stands. Remove the jack stands and lower the frame by pushing down on the height control valve lever.
7. Align the ball joint stud in the vertical linkage rod with the hole in the height control valve lever. Install the washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
8. Remove the chocks from the tires.

Transverse Rod Removal and Installation

Removal (See Fig. 1)

NOTE: This procedure is for replacement of a transverse rod with a tapered stud at the axle connection and a straddle mount pin at the frame bracket end. Some installations have straddle mounts at both ends of the transverse rod.

1. Chock the front and rear tires.
2. Remove the nuts and washers from the bolts that fasten the pin in the transverse rod bushing to the frame bracket. Disconnect the transverse rod where it is attached to the frame bracket bracket.
3. Remove the nut from the tapered stud in the tube bracket on the axle housing. Hit the top of the axle bracket tube hard with a large hammer to momentarily distort the tube and loosen the tapered stud. Remove the stud and transverse rod from the bracket on the axle housing.



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1. Locknut
2. Transverse Rod
3. Frame Bracket
4. Straddle Mount Pin
5. Tapered Stud End
6. Axle Bracket Tube
7. Washer
8. Axle Bracket

Fig. 1, Transverse Rod Assembly

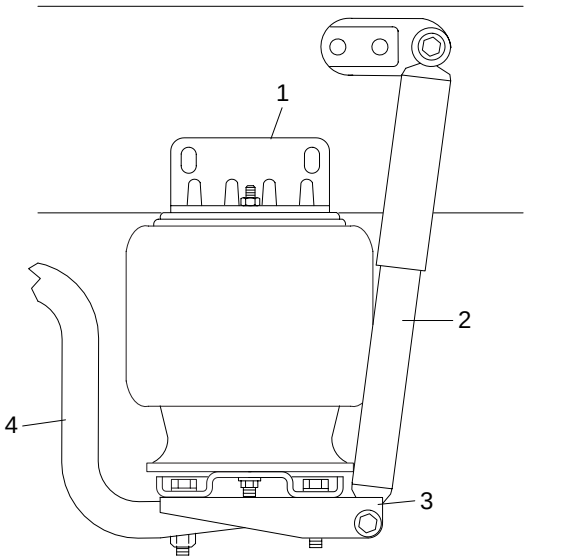
Installation

1. Clear the tapered hole in the axle bracket of all foreign matter.
2. Insert the tapered stud and torque rod bushing into the bracket.
3. Attach the washer and locknut to the stud. Tighten 200 lbf·ft (271 N·m).
4. After tightening, hit the top of the axle bracket tube with a hammer to seat the tapered stud. Retighten.
5. Position the straddle mount end of the transverse rod at the frame bracket, and tighten 200 lbf·ft (271 N·m).
6. Remove the chocks from the tires.

Replacement

NOTE: Shock absorbers are 1 3/8 inches (35 mm) in diameter with a compressed length of 18 1/3 inches (466 mm) and an extended length of 30 inches (762 mm).

1. Chock the front tires.
2. Remove the nut, washer and bolts that attach the shock absorber to the frame hanger bracket. See **Fig. 1**.



1. Upper Bracket
2. Shock Absorber
3. Lower Bracket
4. Main Support Member

Fig. 1, Shock Absorber Mounts (typical)

3. Remove the fasteners that attach the shock absorber to the lower bracket.
4. Remove the shock absorber.
5. Install the new shock absorber with the rod and shield tube at the top. Install the bolts, washers and nuts in the lower bracket and the frame hanger bracket. Install washers at both sides of each shock bushing, that is four washers per shock absorber.
6. Tighten the fasteners 60 lbf·ft (81 N·m).

General Information

NOTE: This subject applies only to Hendrickson series HAS 190/210/230/40LH/400/402/460 suspensions.

Adjust the vehicle ride height with the unloaded vehicle on a level surface. The frame slope, driveline angles, and axle mounting alignment should be checked after the ride height has been changed.

⚠ CAUTION

Failure to adjust the vehicle ride height could adversely affect driveline angles. Also, if the air springs are set too high, the driver may have difficulty (or be prevented from) backing the vehicle under a trailer. If the air springs are set too low, rapid wear of driveline parts will result.

Ride Height Adjustment

The vehicle ride height for Hendrickson HAS air suspension systems is changed by adjusting the length of the vertical linkage at the ride height control valve. Use the following procedure to adjust the ride height of the frame rails.

IMPORTANT: Before checking the ride height, make sure there is no load on the chassis. For tractors, unhitch the trailer. Trucks must be empty when checking the ride height.

1. Stop the vehicle on a level surface, using a light application of the brakes. Slowly move the vehicle forward and back several times without using the brakes to center the suspension joints. Do not apply the parking brakes.
2. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.

   NOTE: Allow several minutes for the air pressure to equalize in the system before checking the ride height.
3. Mark the location of the front and rear tires on the floor so that the vehicle can be checked in the same location after a test drive. Chock the front tires.

IMPORTANT: Any difference in height between the two sides of the vehicle must be corrected using spacers between the main support arm and the rear axle housing before setting the vehicle ride height. See the appropriate section in Group 32 in the vehicle's service manual for the alignment procedure.

4. Measure the distance from the bottom of the frame rail to the bottom of the main support arm at the rear axle U-bolts. See **Fig. 1**. The correct measurement for Hendrickson HAS suspension systems is 4-1/4±1/8 inches (108±3 mm) for vehicles with a specified ride height of 8-1/2 inches (215 mm) or greater. For vehicles with less than an 8-1/2-inch (215 mm) ride height, the distance between the bottom of the frame rail and the bottom of the main support arm must be 2-3/8 inches (60 mm).

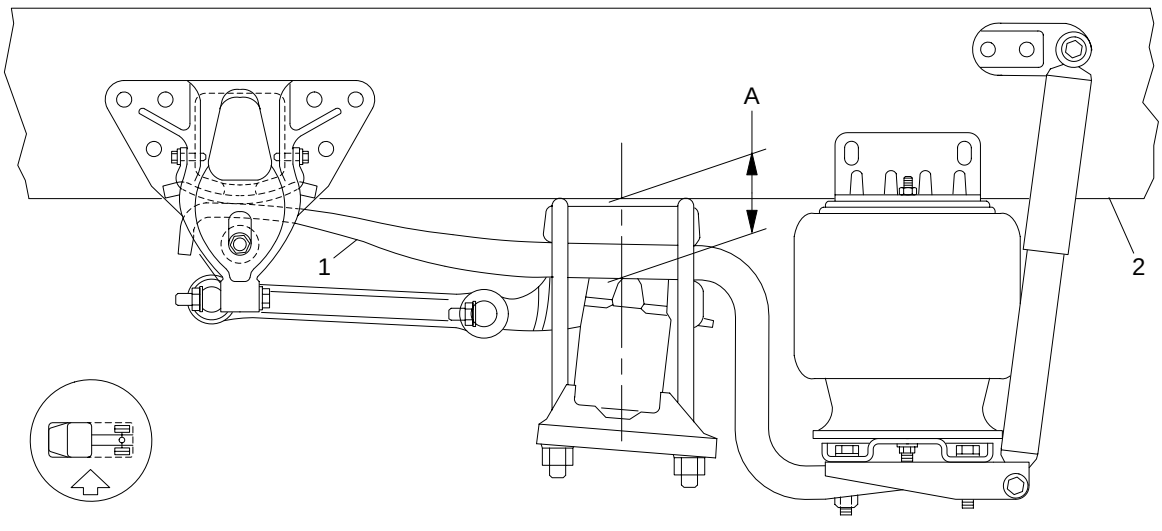
   If the measurement is the same as the specification at each support arm, the ride height is correctly adjusted. If the distance measured is not the same at each rear axle mount on the vehicle, correct this alignment problem before attempting to adjust the ride height.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

5. Remove the nut and lockwasher from the ball joint stud at the end of the lever on the ride height control valve. See **Fig. 2**. Separate the vertical rod assembly from the lever, being careful to avoid moving the lever while disconnecting the ball joint.
6. Push the lever down to lower the frame by removing the air in the suspension air bags.
7. Slowly pull the lever up to raise the frame until the ride height measurement is exactly correct for the specified ride height.
8. Make sure that the centering hole in the lever near its pivot aligns with the centering hole in the height control valve body. Check the height control valve to make sure that no air flows through

Ride Height Adjustment

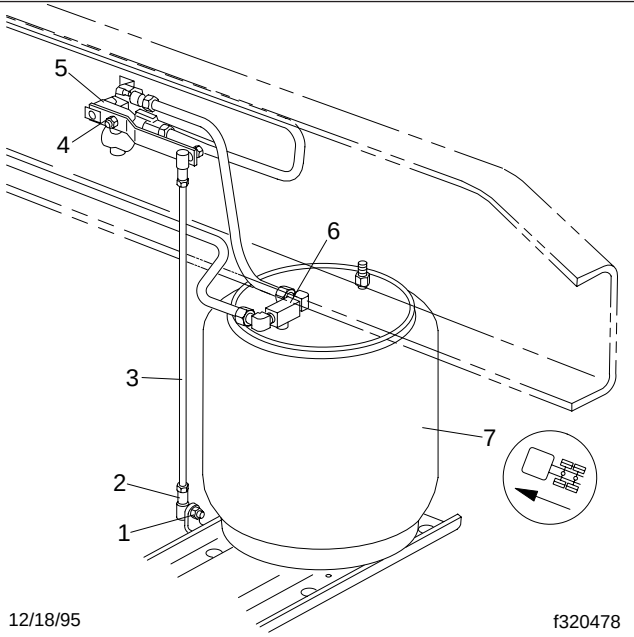


A. Measure ride height here.
1. Bottom of Main Support Arm
2. Bottom of Frame Rail

Fig. 1, Measuring the Ride Height

the ride height control valve when the lever is in the centered position.

9. Loosen the jam nuts a few turns at the top and bottom ball joints on the vertical rod that attaches to the height control lever. Note that one of the ball joints and jam nuts has left-hand threads. Hold the top ball joint with your hand and turn the vertical rod with a wrench until the top ball joint stud exactly aligns with the hole in the end of the lever when the lever is centered horizontally on the control valve.
10. Install the ball joint stud in the lever and install the lockwasher and nut on the stud. Tighten the nut on the stud to 125 lbf·inch (11 N·cm).
11. Tighten the jam nut on each ball joint without changing the length of the vertical rod.
12. Apply the parking brakes; then remove the chocks from the tires. Drive the vehicle unloaded for about 1/4 mile (1/2 km); then stop the vehicle in the exact location (as previously marked) of the original measurement.
13. Park the vehicle using only a light brake application. Chock the tires on one axle only and put the transmission in neutral. Do not apply the parking brakes.
14. Check the adjusted distance between the bottom of the frame and the bottom of the main support arm at the U-bolts. See **Fig. 1**.
15. If the distance is still not correct, loosen the ball joint jam nuts on the vertical rod and turn the rod to adjust the ride height. Lengthen the vertical rod to raise the frame or shorten the rod to lower the frame to the correct ride height. Drive the vehicle and again check the ride height.
16. Apply the parking brakes; then remove the chocks from the tires.



1. Lockwasher and Nut
2. Ball Joint and Jam Nut
3. Vertical Rod
4. Leveling Arm Locknut
5. Ride Height Control Valve
6. Brass Air Fitting
7. Air Spring

Fig. 2, Ride Height Control System

Problem—All Air Bags Are Deflated

Problem—All Air Bags Are Deflated	
Possible Cause	**Remedy**
The vehicle air system pressure is too low.	Run the engine until the air gauge indicates 100 psi (690 kPa).
Air is leaking from the vehicle air system.	Listen for air leakage at the air fittings, tanks, and brake componenets. Repair or replace fittings as needed.
The linkage for the height control valve is disconnected or maladjusted.	Connect the linkage and adjust as described in **Subject 180**.
The suspension dump valve is activated.	Toggle the dump control valve to the normal position.
The relay valve is stuck open.	Check and repair the relay valve.
The air bags have a leak.	Listen for leaks at the air bags, tubes, and fittings.
The height control valve is not operating correctly.	Disconnect the linkage and raise and lower the lever to check the operation of the height control valve. Make sure that no air flows through the valve when the lever is in the center position. Replace the valve if it is bad.
There is a obstruction in the lines to the height control valve.	Check the air pressure at theheight control valve supply port. Remove any obstruction or restriction to air flow to the valve.
The pressure protection valve is not allowing air to flow to the height control valve.	Check the operation of the pressure protection valve between the secondary air tank and the height control valve. Replace the valve if it is not operating correctly.

Problem—One Side of the Vehicle Is Higher Than the Other

Problem—One Side of the Vehicle Is Higher Than the Other	
Possible Cause	**Remedy**
The axle seat spacer thickness is not the same on each side.	Adjust the spacers so that the frame is level before adjusting the ride height.
The load on the vehicle is not distributed evenly.	Change the position of the load to ensure equal weight on each side.
There is an obstruction to air flow to the air bags on one side of the vehicle.	Disconnect the fittings and test the flow to the air bags on the lower side of the vehicle.
The height control valve or relay valve has an internal restriction.	Check for the same pressure at the ports on each side of the valve. Replace the valve if the pressure is not the same.
The air bags or fittings have a leak.	Listen for leaks at the air bags, tubes, and fittings. Tighten the fittings, if loose, or replace any bad parts.

Problem—The Ride Height Is Not Constant

Problem—The Ride Height Is Not Constant	
Possible Cause	**Remedy**
Air is leaking from the air bags or lines.	Listen or use soap bubbles to find air leaks. Tighten or replace leaking fittings or air bags.
The height control valve is not working correctly.	Make sure that no air is exhausted from the height control valve when the lever is in the horizontal position and that the air bags inflate when the lever is raised. The bags must deflate when the lever is pushed down. There must be a slight delay between the lever movement and the valve operation. Check for fluid leaks from the height control valve. Replace the valve if damaged.

Troubleshooting

Problem—The Ride Height Is Not Constant	
Possible Cause	**Remedy**
There is an obstruction to air flow to the air bags.	Disconnect the fittings and test the flow to the air bags.
The height control valve has a restriction at the exhaust port.	Check for air exhausting from the valve when the height control lever is pushed down.
The height control linkage is loose.	Make sure that all the jam nuts are tight and that the ball sockets are not worn.

Problem—The Ride Height Measurement Is Not Correct

Problem—The Ride Height Measurement Is Not Correct	
Possible Cause	**Remedy**
The vehicle is loaded.	The ride height of a loaded vehicle will be slightly lower than that of an unloaded vehicle. Adjust the ride only when the vehicle is unloaded.
The ride height adjustment is not correct.	Adjust the ride height as described in **Subject 180**.
Air is leaking from the air bags or lines.	Listen or use soap bubbles to find air leaks. Tighten or replace leaking fittings or air bags.
The height control valve is not working correctly.	Make sure that no air is exhausted from the height control valve when the lever is in the horizontal position and that the air bags inflate when the lever is raised. The bags must deflate when the lever is pushed down. There must be a slight delay between the lever movement and the valve operation. Check for fluid leaks from the height control valve. Replace the valve if damaged.
There is an obstruction to air flow to the air bags.	Disconnect the fittings and test the flow to the air bags.
The height control valve has a restriction at the exhaust port.	Check for air exhausting from the valve when the height control lever is pushed down.
The height control linkage is loose.	Make sure that all the jam nuts are tight and that the ball sockets are not worn.

Problem—The Air Springs Have Cuts

Problem—The Air Springs Have Cuts	
Possible Cause	**Remedy**
The ride height is adjusted too high.	Adjust the ride height so that the air bags are not continually overinflated.
The tires are too wide and are rubbing the air bags.	Install the correct tires.
A shock absorber or mount is broken.	Replace any broken components.

Problem—The Vehicle Does Not Track Straight

Problem—The Vehicle Does Not Track Straight	
Possible Cause	**Remedy**
The axle alignment is not correct.	Adjust the alignment with shims at the front of the torque rods.
The bushings in the torque rods are worn.	Replace the worn bushings.

Problem—The Vehicle Does Not Track Straight	
Possible Cause	**Remedy**
The bushings in the transverse rods are worn.	Replace the worn bushings.
A shock absorber or mount is broken.	Replace any broken components.
The U-bolt high nuts are loose.	Periodically tighten the nuts as described in **Specifications 400**.
The suspension fasteners are loose or damaged.	Tighten or replace the fasteners.

Problem—The Vehicle Vibrates When Driven

Problem—The Vehicle Vibrates When Driven	
Possible Cause	**Remedy**
The ride height is not correct.	Adjust the ride height as described in **Subject 180**.
The axle housing rotational alignment is not correct.	Adjust the rotational alignment of the axle housing with wedge-shaped shims at the axle seats. The driveline U-joint angles must be with 1% of each other.
The shock absorbers are worn or disconnected.	Replace the shock absorbers, if worn, or tighten the mounting fasteners.
The bushings in the torque rods are worn.	Replace the worn bushings.
The U-bolt high nuts are loose.	Periodically tighten the nuts as described in **Specifications 400**.
The suspension fasteners are loose or damaged.	Tighten or replace the fasteners.
The frame is not level from front to rear.	Check and adjust the ride height at the front suspension and each rear axle. The frame should not slope more than 1/2 inch (13 mm). Correct the ride height if not at specifications.

Specifications

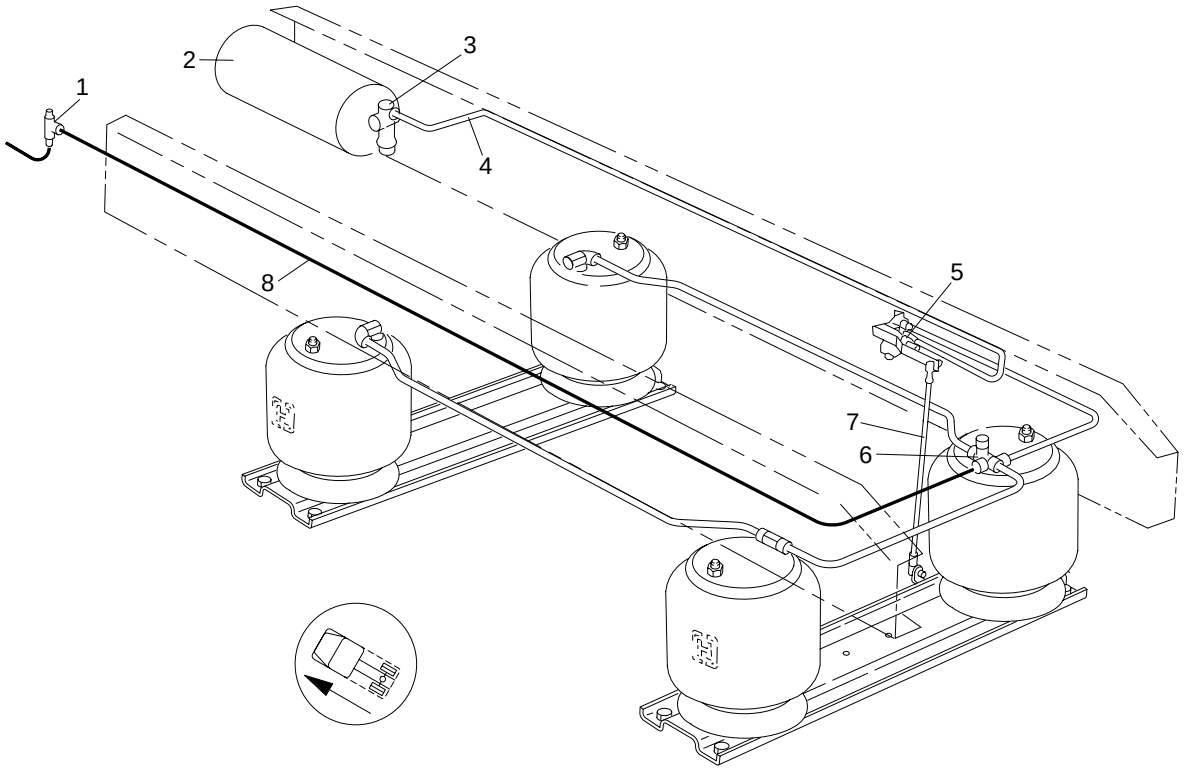
For an overview of the Hendrickson HAS air system plumbing, see **Fig. 1** and **Fig. 2**.

Torque Values		
Description	**Size**	**Torque: lbf·ft (N·m)**
U-bolt High Nuts	7/8–14	Stage 1: Hand tighten Stage 2: 60 (81) * Stage 3: 200 (271) * Stage 4: 420 to 500 (571 to 680) *
	1–14	Stage 1: Hand tighten Stage 2: 60 (81) * Stage 3: 200 (271) * Stage 4: 520 to 600 (707 to 816) *
Torque Rod Bar Pin Locknut	5/8–11	180 (244)
Axle Seat Stud	5/8–11	65 (88)
Rebound Bolt Locknut	1/2–13	60 (81)
Shock Absorber Locknut, Upper	1/2–13	60 (81)
Shock Absorber Locknut, Lower	3/4–10	60 (81)
Cross Channel to Main Support Member Locknut	3/4–10	290 (393)
Air Spring to Frame Hanger Locknut	1/2–13	25 (34)
Air Spring to Cross Channel Locknut	1/2–13	25 (34)
Transverse Rod Locknut	1-1/4–12	200 (271)
Extension Arm Jam Nut	5/16–24	125 (169)
Extension Arm Locknut	5/16–24	125 (169)

* Tighten in a diagonal pattern as shown in **Fig. 3**.

Table 1, Torque Values

Specifications



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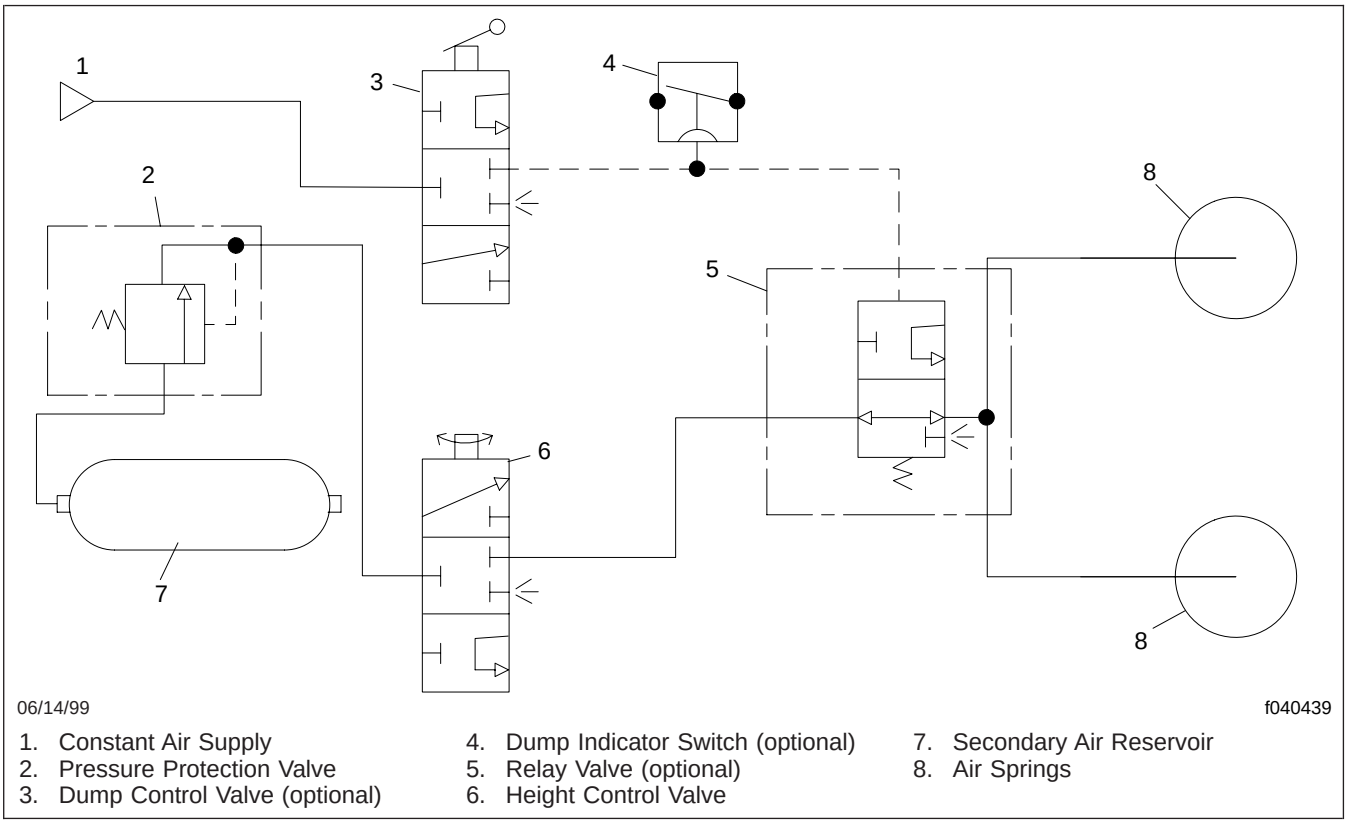
NOTE: The height control valve was moved to the forward axle on later HAS systems.

1. Switch Control Valve
2. Air Tank
3. Pressure Protection Valve
4. Air Supply Line
5. Height Control Valve
6. Quick Release Valve
7. Leveling Valve Extension Arm
8. Air Signal Line

Fig. 1, Suspension Air Plumbing



1. Constant Air Supply
2. Pressure Protection Valve
3. Dump Control Valve (optional)
4. Dump Indicator Switch (optional)
5. Relay Valve (optional)
6. Height Control Valve
7. Secondary Air Reservoir
8. Air Springs

Fig. 2, Air Suspension Dump System Schematic (typical)

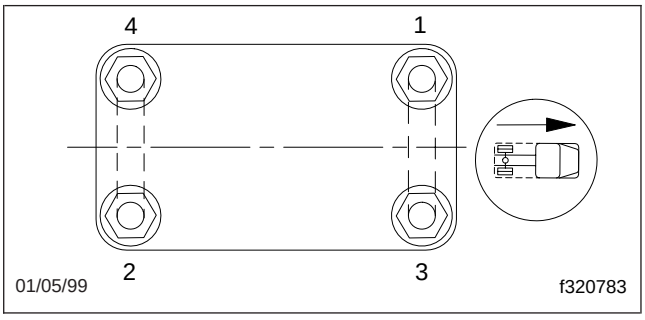


Fig. 3, Tightening Pattern for U-bolt High Nuts

General Description

The Neway Air Ride Suspension is a single axle (Model AD–123; see **Fig. 1**) or tandem axle (Model AD–246; see **Fig. 2**) suspension that uses air springs. The top of each air spring is bolted to a frame-rail bracket, and the bottom of each spring is attached to a suspension crossmember. The suspension crossmember is attached to the rear ends of two equalizing beams which carry the axle. The forward ends of the equalizing beams are journaled to brackets bolted on the frame rail.

Both models of the suspension allow for vertical travel. The maximum loading capacity of the single axle model is 22,500 pounds (10 000 kg); and the maximum loading capacity for the tandem axle model is 44,000 pounds (20 000 kg).

The Neway suspension maintains a stable, level ride by adjusting the air spring height according to vehicle load and road conditions. A height control valve mounted inside the frame rail is linked to the suspension crossmembers and monitors ride height in relation to the crossmember. See **Fig. 3**. If the load is riding too high, the suspension crossmember pulls the valve's control lever down, and the valve lowers the load by venting air from the springs. See **Fig. 4**. If the load rides too low, the suspension crossmember pushes the valve's control lever up, and the valve raises the load by delivering air to the springs. The air springs and the shocks mounted between the axle and the frame rails absorb road shock.

The design of the height control valve allows a several second delay between delivering air to and venting air from the air springs. This prevents the valve from reacting to abrupt axle movements caused by the condition of the road surface.

A torque rod (**Fig. 3**) connects each axle housing to a frame crossmember to prevent torque-induced rotation of the axle. A similar control rod (**Fig. 3**) connects each axle housing to a frame rail to prevent the axle from moving laterally.

If the air springs lose pressure, a solid rubber bumper inside the spring will support the vehicle until it can be repaired. Do not drive the vehicle over 30 mph (50 km/h) with the air springs deflated, and drive it only as far as the nearest service facility. To deflate the air springs, disconnect the control lever arm from the linkage rod, and press the valve's control lever down to simulate overinflated air springs. The valve will vent the air from the springs.

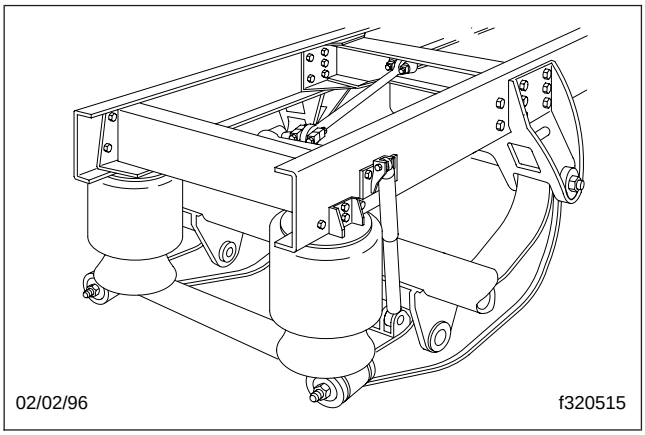


Fig. 1, Single Axle Suspension, Model AD-123

General Information

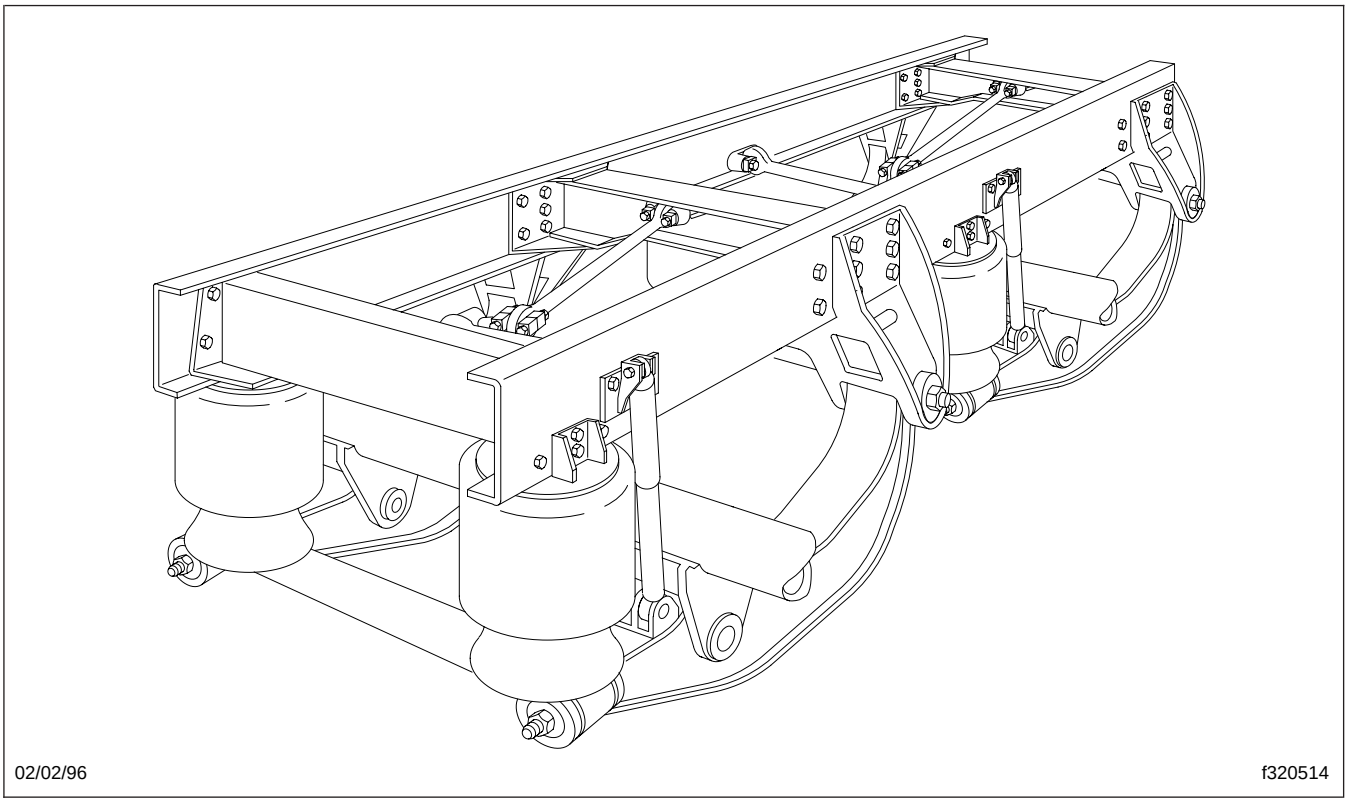
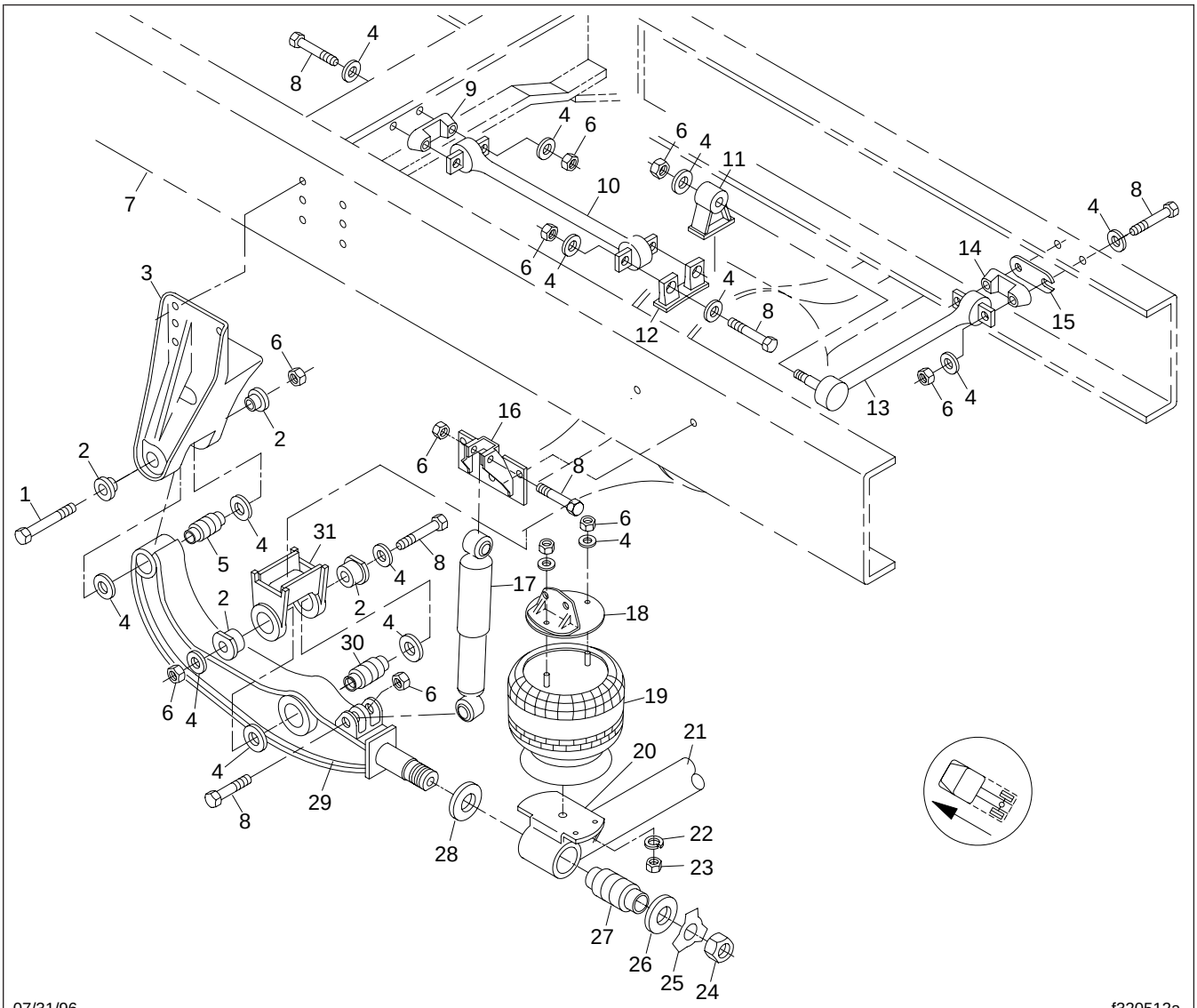


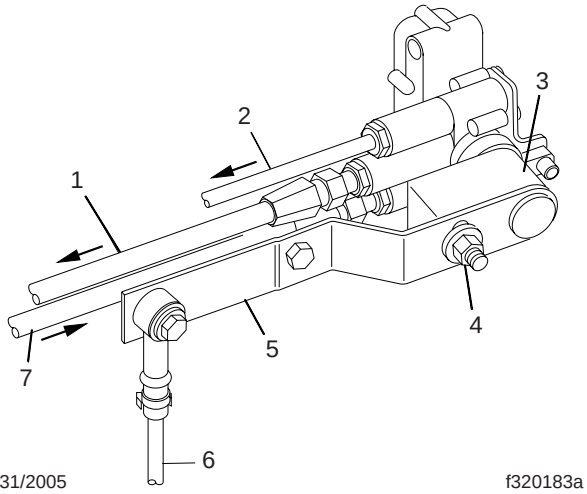
Fig. 2, Tandem Axle Suspension, Model AD-246



1. Rod Bolt, 1-1/8–7 x 9-1/4
2. Adaptor Bushing
3. Frame Bracket
4. Spacer Washer
5. Equalizing Beam Front Bushing
6. Locknut
7. Frame Rail
8. Rod Bolt, 3/4–10 x 7-1/2
9. Torque Rod Crossmember Bracket
10. Torque Rod
11. Control Rod Axle Bracket
12. Torque Rod Axle Bracket
13. Control Rod
14. Control Rod Frame Bracket
15. Axle Alignment Shim(s)
16. Shock Absorber Frame Bracket
17. Shock Absorber
18. Air Spring Upper Mounting Plate
19. Air Spring
20. Air Spring Lower Mounting Plate
21. Transverse Beam
22. Lock Washer
23. Hexnut, 1/2–13
24. Hexnut, 2-1/4–8
25. Tab Washer
26. Spacer Washer
27. Transverse Beam Bushing
28. Spacer Washer
29. Equalizing Beam
30. Equalizing Beam Center Bushing
31. Beam Hanger Bracket

Fig. 3, Neway Suspension Components

General Information

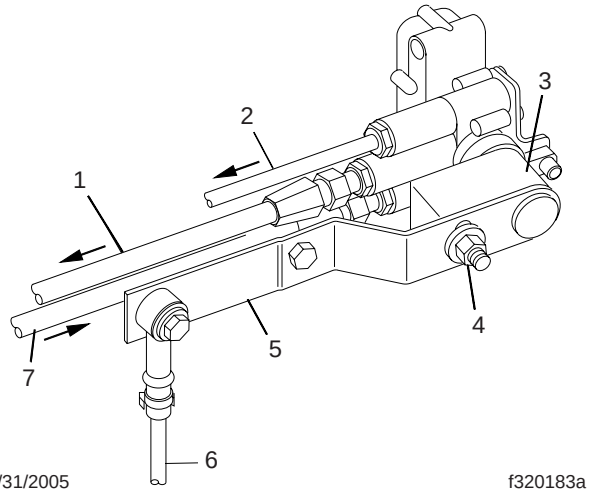


1. Airflow to Spring
2. Exhaust to Atmosphere
3. Nylon Block
4. Adjustment Locknut
5. Control Lever
6. Linkage
7. Airflow from Air Reservoir

Fig. 4, Height Control Valve

Adjustment

1. Park the unloaded or evenly loaded vehicle on a level surface. Run the engine until the air brake system is fully charged. Chock the tires.
2. Remove the bolt that secures the height control valve linkage to the control lever of each valve. See **Fig. 1**. Disconnect the linkages from the control levers.
3. Exhaust all air from the air springs by pushing the control levers down to the vertical position.
4. Connect one of the control levers to its respective linkage, and allow the air spring(s) controlled by the lever to fill until the valve shuts off.
5. Measure the distance from the underside of the frame rail to the centerline of the axle nearest the inflated spring. This dimension should be 10 inches (25 cm). Adjust the height control valve by loosening the adjustment locknut (see **Fig. 1**) and moving the control lever slightly, relative to the nylon block. When the 10-inch (25-cm) height dimension is achieved, retighten the adjustment locknut.



1. Airflow to Spring
2. Exhaust to Atmosphere
3. Nylon Block
4. Adjustment Locknut
5. Control Lever
6. Linkage
7. Airflow from Air Reservoir

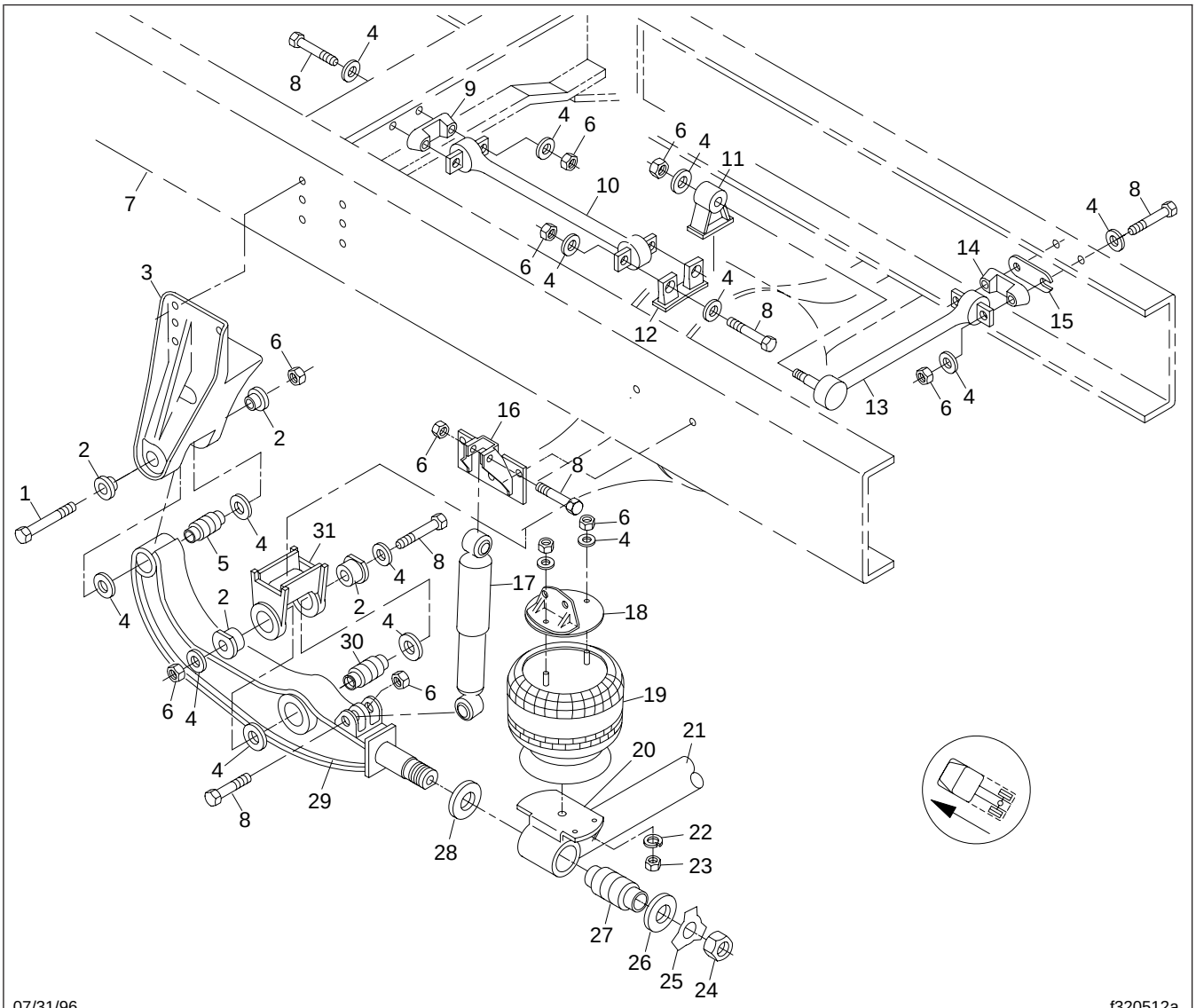
Fig. 1, Height Control Valve

6. Disconnect the control lever from the linkage, and press it down to deflate the air springs about halfway. Reconnect the linkage to inflate the air springs, then check the height dimension. Repeat the step above and this step until the height dimension measures 10 inches (25 cm).
7. When the height control valve is adjusted, disconnect the control lever from the height control valve linkage, and push it down to the vertical position to fully deflate the air spring.
8. Repeat the previous four steps on the other height control valve(s).
9. Connect all linkage assemblies to the control levers. All height dimensions should now be equal. If they aren't, check for loose mounting bolt nuts on the height control valves. Tighten any loose nuts or capscrews. Repeat the adjustment procedures until all height dimensions are 10 inches (25 cm).

Replacement (See Fig. 1)

1. Chock the front tires to prevent vehicle movement. Open the stopcocks on the air tanks to drain the air system.
2. Raise the rear of the vehicle to remove all weight from the rear axles, and place safety stands to secure the vehicle in its raised position. When raised, the height control valves will vent all air from the air springs.
3. Taking care to prevent foreign substances from entering the line or fitting, disconnect the air supply line from the air spring.
4. Remove the locknut, hexnut, and washers that secure the air spring to the air spring upper mounting plate. See **Fig. 1**
5. Remove the capscrews and lockwashers that connect the air spring to the air spring lower mounting plate on the transverse beam. Remove the air spring.
6. Position the new air spring on the air spring lower mounting plate, then install the capscrews and lockwashers to secure the air spring to the lower mounting plate. Tighten the capscrews to the torque under **Specifications 400**.
7. Install the locknut, hexnut, and washers previously removed, to connect the air spring to the air spring upper mounting plate. Tighten the nuts to the torque under **Specifications 400**.
8. Connect the air supply line to the air spring.
9. Remove the safety stands from under the vehicle, then lower the vehicle.
10. There must be 10 inches (25 cm) between the bottom of the frame rail and the centerline of the axle. Adjust the height control valve adjustment; for instructions, see **Subject 100**.

Air Spring Replacement



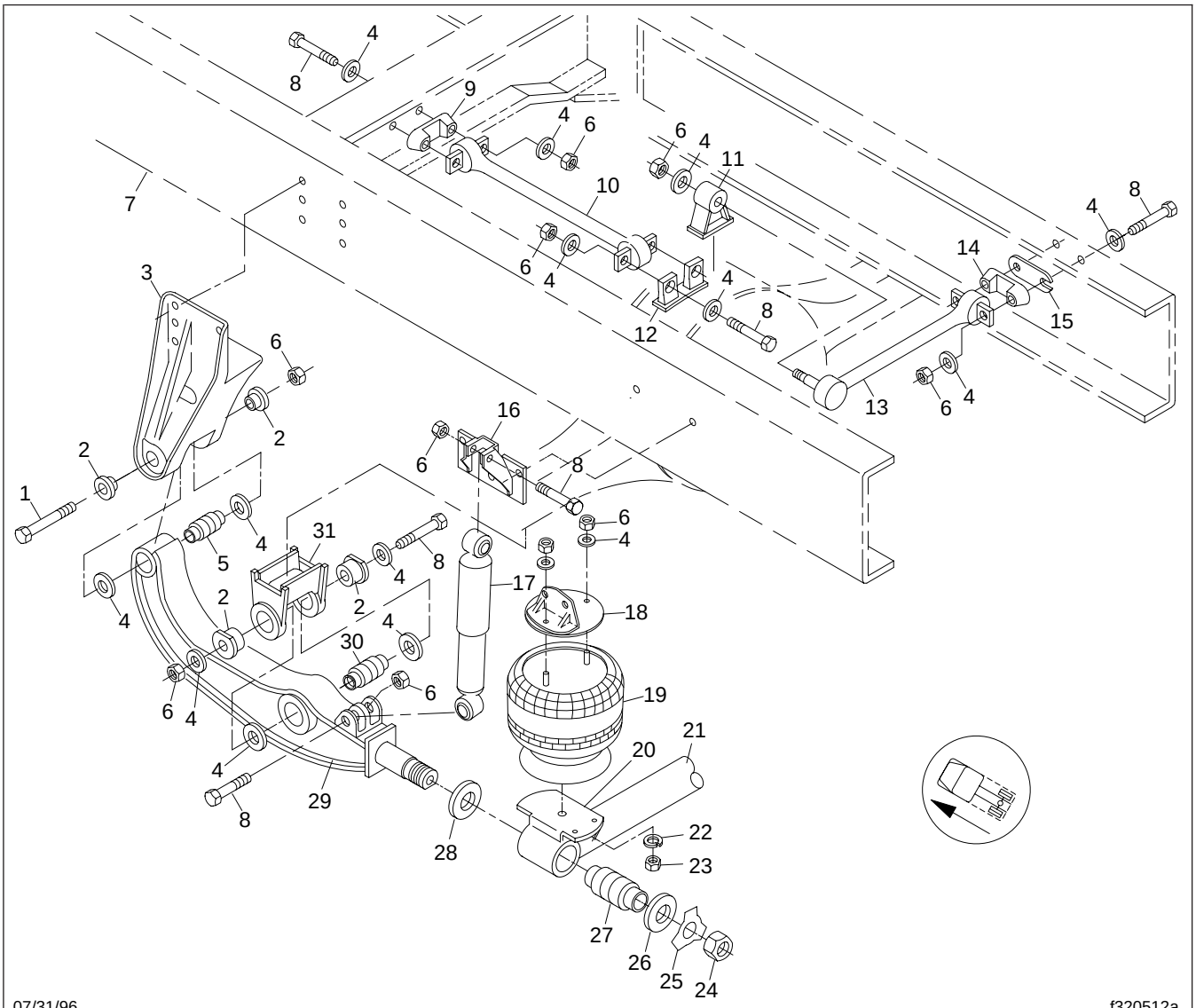
1. Rod Bolt, 1-1/8–7 x 9-1/4
2. Adaptor Bushing
3. Frame Bracket
4. Spacer Washer
5. Equalizing Beam Front Bushing
6. Locknut
7. Frame Rail
8. Rod Bolt, 3/4–10 x 7-1/2
9. Torque Rod Crossmember Bracket
10. Torque Rod
11. Control Rod Axle Bracket
12. Torque Rod Axle Bracket
13. Control Rod
14. Control Rod Frame Bracket
15. Axle Alignment Shim(s)
16. Shock Absorber Frame Bracket
17. Shock Absorber
18. Air Spring Upper Mounting Plate
19. Air Spring
20. Air Spring Lower Mounting Plate
21. Transverse Beam
22. Lock Washer
23. Hexnut, 1/2–13
24. Hexnut, 2-1/4–8
25. Tab Washer
26. Spacer Washer
27. Transverse Beam Bushing
28. Spacer Washer
29. Equalizing Beam
30. Equalizing Beam Center Bushing
31. Beam Hanger Bracket

Fig. 1, Neway Suspension Components

Replacement (See Fig. 1)

1. Remove the locknuts from the shock absorber upper and lower mounting brackets.
2. If the shock absorber is fully extended, chock the vehicle wheels and jack up the axle to relieve tension from the shock. Remove the shock absorber. If the inner metal sleeve is rusted to the mounting pin, use a small, sharp chisel to force the sleeve from the pin.
3. Install the new shock absorber on the mounting pins and secure it with the locknuts and washers previously removed. Tighten the locknuts to the torque under **Specifications 400**.

Shock Absorber Replacement



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12. Torque Rod Axle Bracket
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14. Control Rod Frame Bracket
15. Axle Alignment Shim(s)
16. Shock Absorber Frame Bracket
17. Shock Absorber
18. Air Spring Upper Mounting Plate
19. Air Spring
20. Air Spring Lower Mounting Plate
21. Transverse Beam
22. Lock Washer
23. Hexnut, 1/2–13
24. Hexnut, 2-1/4–8
25. Tab Washer
26. Spacer Washer
27. Transverse Beam Bushing
28. Spacer Washer
29. Equalizing Beam
30. Equalizing Beam Center Bushing
31. Beam Hanger Bracket

Fig. 1, Neway Suspension Components

Equalizing Beam Removal and Installation

Removal (See Fig. 1)

1. Chock the front tires.
2. Raise the rear of the vehicle to remove all weight from the rear suspension, and place safety stands to secure the vehicle in its raised position.
3. Remove the rear wheels and tires for access to the suspension. Block the axle securely to prevent it from dropping away from the vehicle as the equalizing beam is removed.
4. With the weight removed from the suspension, the air springs should be fully deflated. If they aren't, disconnect the height control valve linkage from the height control valve control lever. Push the lever down to the vertical position to deflate the air springs.
5. Remove the capscrews and lockwashers that secure the air springs to the air spring lower mounting plates on both ends of the transverse beam. See **Fig. 1**.
6. Remove the cotter pins, locknuts, flatwashers, and retainer washers from the studs in the ends of the equalizing beams. Tap the transverse beam back from the ends of the equalizing beams.

NOTE: In some cases, the transverse beam bushings will stick, making it difficult to remove the transverse beam from the equalizing beams. Use a Porta-Power, or equivalent tool, between the axle housing and the transverse beam at a point as near to the end of the transverse beam as possible to remove the beam.

7. Remove the locknut and washer from the outboard end of the rod bolt. Support the equalizing beam on a floor jack, then extract the equalizing beam center bushing bolt from the beam hanger bracket.
8. Use a drift to tap the adaptor bushings from the beam hanger bracket. Lower the equalizing beam to the floor.
9. Remove the locknut from the inboard end of the bolt. Note the positions of the spacer washers at either side of the equalizing beam so they can be reassembled in their original positions. Use a drift to drive the rod bolt out of the frame bracket. Remove the equalizing beam from the vehicle.

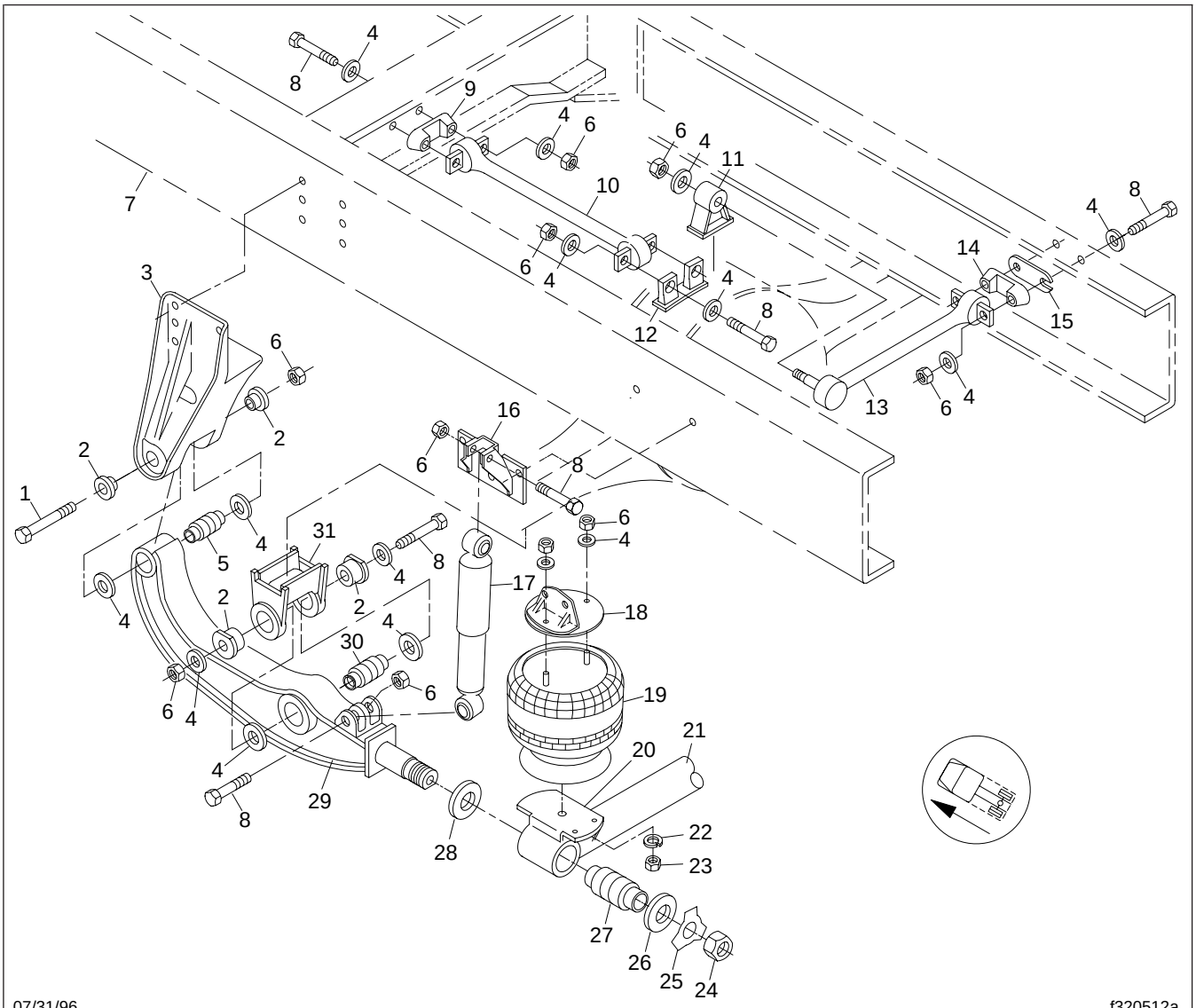
Installation

1. Make sure the adaptor bushings are installed in the frame bracket.
2. Position the equalizing beam with its front bushing centered in the frame bracket. Push the rod bolt into the frame bracket while inserting the spacer washers into their original positions between the equalizing beam and the frame bracket.

NOTE: See **Subject 190** for placement of the spacer washers if their positions were not recorded during removal of the equalizer beam.

3. Lubricate the threads of the rod bolt with SAE–20 oil, then install the locknut. Tighten the locknut to the torque under **Specifications 400**.
4. Raise the equalizing beam so the center bushing is centered in the beam hanger bracket. Insert the beam hanger adaptor bushings through the beam hanger bracket and into the equalizing beam center bushing.
5. With a flatwasher under the head,insert the rod bolt through the beam hanger adaptor bushings with the threaded end on the outboard side of the suspension.
6. Lubricate the center bushing bolt threads with SAE–20 oil, then install the flatwasher and locknut on the bolt. Tighten the locknut to the torque under **Specifications 400**.
7. Lubricate the transverse beam bushings with rubber lubricant, soap and water solution, or a waterless hand cleaner. Install the inner halves of the bushings with their thicker ends toward the front of the vehicle.
8. Install the transverse beam on the equalizing beams, with the air spring lower mounting plates tilted toward the rear of the vehicle. Install the outer halves of the transverse beam bushings on the equalizer beam journals.
9. Apply SAE–20 oil to the threads on the studs at the rear of the equalizing beams. Install the retainer washers, flatwashers and locknuts on the studs. Tighten the locknuts to the low end of the torque ranges under **Specifications 400**. Install the cotter pins and lock them in place. Tighten the locknuts further if it's necessary in order to install the cotter pins.

Equalizing Beam Removal and Installation



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19. Air Spring
20. Air Spring Lower Mounting Plate
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22. Lock Washer
23. Hexnut, 1/2–13
24. Hexnut, 2-1/4–8
25. Tab Washer
26. Spacer Washer
27. Transverse Beam Bushing
28. Spacer Washer
29. Equalizing Beam
30. Equalizing Beam Center Bushing
31. Beam Hanger Bracket

Fig. 1, Neway Suspension Components

10. Apply SAE–20 oil to the threads of the capscrews that secure the air springs to the air spring lower mounting plates. Position the air springs on the plates and install the capscrews and lockwashers. Tighten the capscrews to the torque under **Specifications 400**.

Replacement (See Fig. 1)

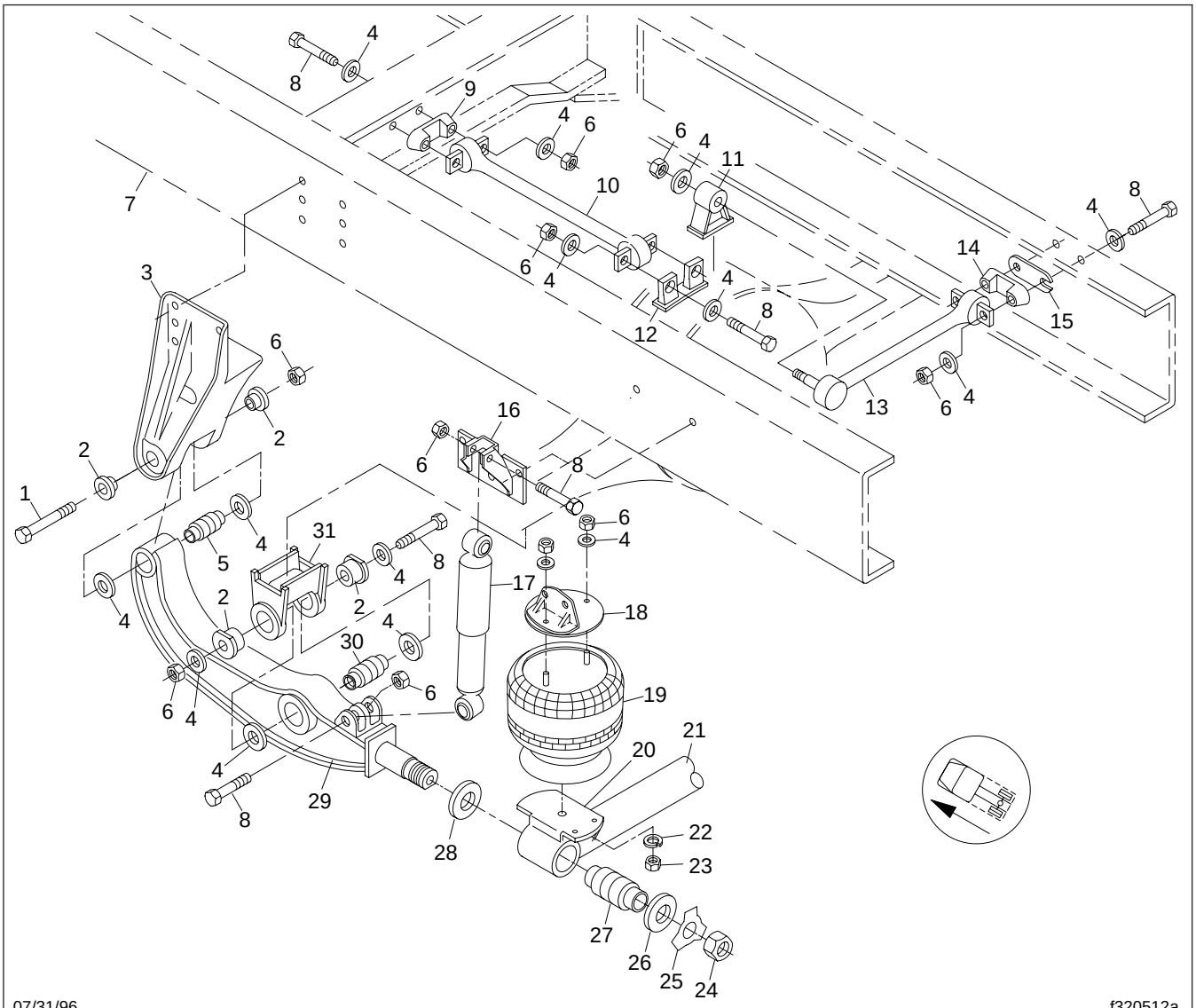
1. Remove the equalizing beam. See **Subject 130**.

⚠ WARNING

Do not use a torch to cut the bushing sleeve out of the equalizing beam. To do so could weaken the casting, possibly resulting in loss of vehicle control and personal injury.

2. Using a hydraulic press, apply 2000 to 3000 pounds (907 to 1 361 kg) pressure to remove the equalizing beam front and center bushings. See **Fig. 1**.
3. Using a wire brush and solvent, clean out the equalizing beam bushing receptacles. Inspect the entire beam for cracks or bends. Replace any damaged equalizing beam with a new one.
4. Lubricate the replacement bushings and the bushing receptacles with a non-mineral lubricant. If standard rubber lubricant is not available, use a soap and water solution or a waterless hand cleaner.
5. Press the replacement bushings into the bushing receptacles with a hydraulic press. Press the bushings slightly past center, then turn the equalizing beam over and press the bushings back to a centered position.
6. Install the equalizing beam. See **Subject 130**.

Equalizing Beam Bushing Replacement



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12. Torque Rod Axle Bracket
13. Control Rod
14. Control Rod Frame Bracket
15. Axle Alignment Shim(s)
16. Shock Absorber Frame Bracket
17. Shock Absorber
18. Air Spring Upper Mounting Plate
19. Air Spring
20. Air Spring Lower Mounting Plate
21. Transverse Beam
22. Lock Washer
23. Hexnut, 1/2–13
24. Hexnut, 2-1/4–8
25. Tab Washer
26. Spacer Washer
27. Transverse Beam Bushing
28. Spacer Washer
29. Equalizing Beam
30. Equalizing Beam Center Bushing
31. Beam Hanger Bracket

Fig. 1, Neway Suspension Components

Control Rod Removal, Inspection, and Installation

Removal

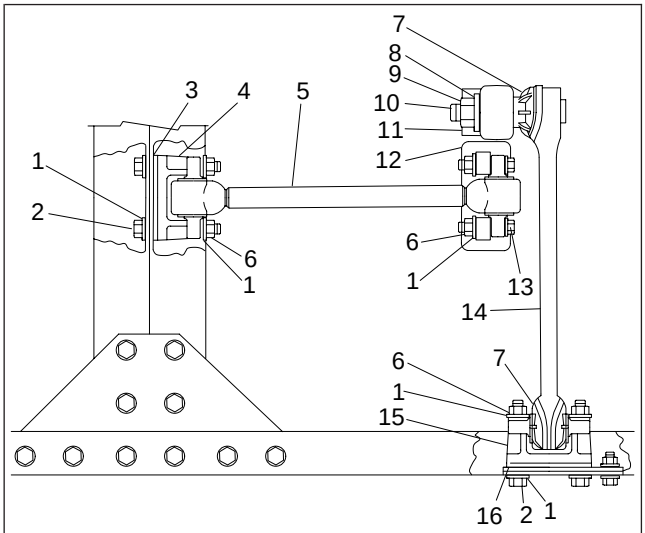
1. Apply the parking brakes.
2. Remove the locknuts and flatwashers (see **Fig. 1**) from the bolts that secure the control rod frame bracket to the frame rail. To ease reassembly, note the order of the axle alignment shims between the control rod frame bracket and the backing plate.
3. Remove the control rod frame bracket bolts. Swing the control rod clear, and remove the axle alignment shims and the bracket.
4. Remove the locknut and flatwasher from the ball stud on the inboard end of the control rod. Rap the ball stud eye on the control rod axle bracket with a hammer to loosen the ball stud. If this fails to break it loose, use a tie-rod separator tool to remove the ball stud from the control rod axle bracket. Remove the control rod.
5. Remove the seals from both ends of the control rod. Clean the seals and rod to remove all dirt and grease.

Inspection

Inspect the seals for dryness, cracks, or other signs of deterioration and wear. Replace damaged seals with new ones. Visually inspect the control rod for cracks or bends. Work the ball joint and control rod pin to check for looseness in the bushings. If the control rod is bent, cracked, or otherwise damaged, or if there is any slack in either of the bushings, replace the control rod with a new one.

Installation

1. Lubricate all control rod and fastener threads with SAE–20 oil, and install the seals (**see Fig. 1**) removed from the rod ends.
2. Insert the control rod ball stud through the control rod axle bracket, then install the flatwasher and locknut on the stud. Tighten the locknut to the torque under **Specifications, 400**, then rap the control rod axle mount with a hammer. Tighten the locknut again to the torque under **Specifications, 400**.



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1. Flatwasher, 5/8-inch
2. Bolt, 5/8-11 x 5–1/2 Inch
3. Axle Plane Shim(s)
4. Torque Rod Crossmember Bracket
5. Torque Rod
6. Locknut, 5/8–18
7. Seal
8. Flatwasher, 1-1/4 Inch
9. Locknut, 1-1/4–12
10. Ball Stud
11. Control Rod Axle Bracket
12. Torque Rod Axle Bracket
13. Bolt, 5/8–11 x 4 Inch
14. Control Rod
15. Control Rod Frame Bracket
16. Axle Alignment Shim(s)

Fig. 1, Control Rod Mounting

3. Position the control rod frame bracket and the axle alignment shims against the backing plate on the inside of the frame rail. Move the control rod into position on the control rod frame bracket.
4. Install flatwashers on the control rod frame bracket bolts, then install the bolts through the frame rail, the shims, the control rod frame bracket, and the control rod. Install the flatwashers and locknuts on the bolts, and tighten the locknuts to the torque under **Specifications, 400**.
5. Check the alignment of the axle. See **Subject 180** for instructions.

Torque Rod Removal, Inspection, and Installation

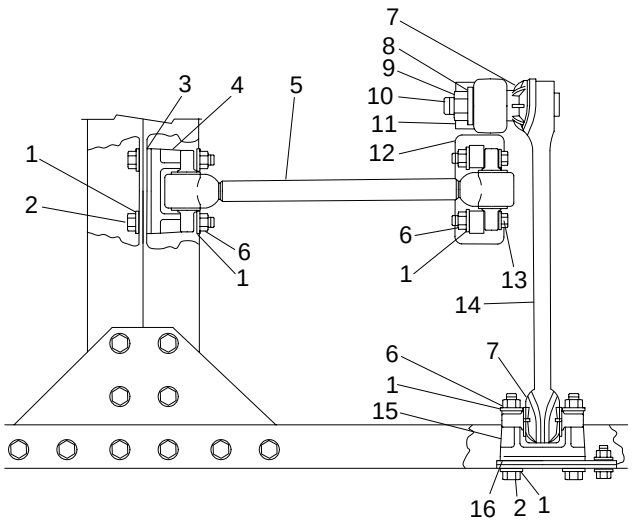
Removal

1. Apply the parking brakes.

⚠ WARNING

WARNING: When the torque rods are disconnected from the axle brackets, the axles become free to pivot on the equalizer beam end bushings. Keep clear of the beam hangers and beam ends to avoid possible injury.

2. Remove the locknuts and the flatwashers (see **Fig. 1**) from the bolts that secure the torque rod crossmember bracket to the vehicle frame crossmember. For ease of installation, note the order of the axle plane shims between the torque rod crossmember bracket and the frame crossmember.



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1. Flatwasher, 5/8-inch
2. Bolt, 5/8–11 x 5-1/2 Inch
3. Axle Plane Shim(s)
4. Torque Rod Crossmember Bracket
5. Torque Rod
6. Locknut, 5/8–18
7. Seal
8. Flatwasher, 1-1/4 Inch
9. Locknut, 1-1/4–12
10. Ball Stud
11. Control Rod Axle Bracket
12. Torque Rod Axle Bracket
13. Bolt, 5/8–11 x 4 Inch
14. Control Rod
15. Control Rod Frame Bracket
16. Axle Alignment Shim(s)

Fig. 1, Torque Rod Mounting

3. Remove the torque rod crossmember bracket bolts. Swing the torque rod clear of the torque rod crossmember bracket, and remove the axle plane shims together with the torque rod crossmember bracket.
4. Remove the locknuts and flatwashers from the bolts that secure the torque rod to the torque rod axle bracket . Remove the bolts. Remove the torque rod from the vehicle.

Inspection

Inspect the torque rod for bends or cracks. Work the torque rod pins to check for looseness in the polyurethane bushings. If the torque rod is bent, cracked, or otherwise damaged, replace it with a new one. If either of the polyurethane bushings is loose, replace the bushing with a new one. For instructions, see **Subject 170**.

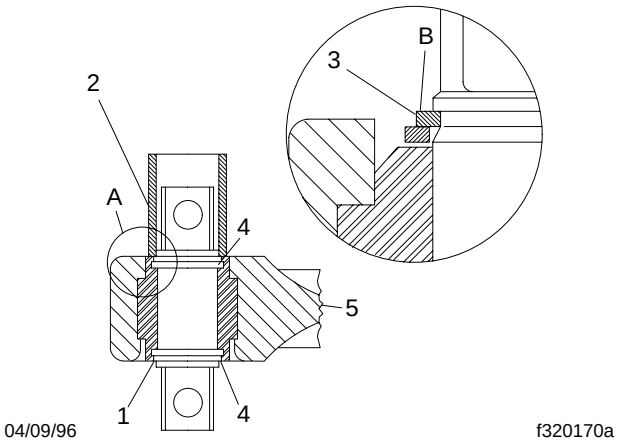
Installation

1. Lubricate all torque rod and fastener threads with SAE–20 oil.
2. Position the torque rod against the torque rod axle bracket (see **Fig. 1**). Slip a flatwasher over each of the two bolts, then insert the bolts through the torque rod axle bracket and the torque rod.
3. Install the flatwashers and locknuts on the torque rod axle bracket bolts. Tighten the locknuts to the torque under **Specifications, 400**.
4. Position the torque rod crossmember bracket and the axle plane shims against the frame crossmember, and move the torque rod into place on the torque rod crossmember bracket.
5. Install flatwashers on the bolts, and install the bolts through the frame crossmember, the shims, the torque rod crossmember bracket, and the torque rod. Install flatwashers and locknuts on the bolts, and tighten the locknuts to the torque under **Specifications, 400**.

Replacement

NOTE: In order to replace the torque rod polyurethane bushings, you need special installation tool kit P–097–009. This tool kit can be purchased from Freightliner, or it can be machined, using the dimensions given in **Specifications, 400.**

1. Remove the snap ring and washer from each side of the bushing to be removed. See **Fig. 1**. Note that the torque rod eye has a smaller shoulder on one side than on the other, and the larger shoulder has a rounded edge around the inside of the eye. The polyurethane bushing must be pressed in and out through the larger side.

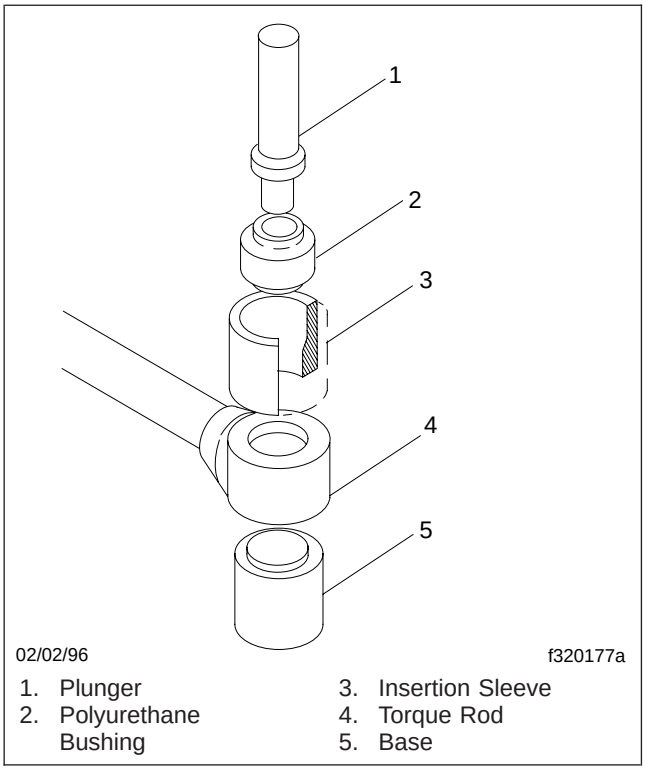


A. Detail
B. Install washer and snap ring with sharp edges to outside.

1. Snap Ring
2. Pressing Sleeve
3. Snap Ring
4. Washer
5. Torque Rod

Fig. 1, Bushing Snap Ring Installation

2. Using the plunger from the special tool kit on a hydraulic press, press the old bushing out of the torque rod eye. Clean all dirt, grease, or foreign matter from the torque rod.
3. Coat the replacement bushing with a non-mineral lubricant, such as rubber lubricant or waterless hand cleaner. Position the bushing in the larger end of the insertion sleeve from the tool kit, then fit the beveled (smaller) end of the sleeve into the larger side of the torque rod eye.
4. Center the torque rod eye on the tool base, and insert the plunger tool into the polyurethane bushing. See **Fig. 2**. Press the bushing into the torque rod eye.



1. Plunger
2. Polyurethane Bushing
3. Insertion Sleeve
4. Torque Rod
5. Base

Fig. 2, Torque Rod Bushing Installation

5. Install the snap ring and flatwasher on one end of the torque rod pin, with the sharp edges of the washer and the snap ring facing the outward end of the pin. See **Fig. 1**.
6. Press the torque rod pin into the torque rod bushing from the same side as the bushing was pressed into the torque rod eye. Make sure the snap ring seats. Do not lubricate the torque rod pin.
7. Turn the torque rod over and install a flatwasher, with the sharp edge facing away from the bushing; then install the other snap ring onto the outer shoulder of the pin, with the sharp edge facing outward.
8. Place a pressing sleeve over the end of the torque rod pin, then seat the snap ring. See **Fig. 1**.

Torque Rod Bushing Replacement

9. After assembly, press the torque rod pin slightly to center it in the torque rod eye.

   There should be no slack on either side of the polyurethane bushing, and the bushing should be compressed by about half the thickness of the snap ring. If necessary, install a second washer under one of the snap rings to compress the bushing.

Lateral Alignment (See Fig. 1)

1. Park the vehicle on a level surface; then position the front tires straight ahead and chock them. Release the parking brakes, and place the transmission in neutral.
2. Raise the rear of the vehicle until the tires clear the ground, then place safety stands under the rear of the vehicle to hold it in this position.
3. Check the wheel bearing adjustment. See **Group 35** for instructions. Adjust or replace the wheel bearings as needed.
4. Measure the lateral runout of the rear wheels. If the runout on any wheel exceeds 0.18 inch (4.6 mm), replace the wheel before proceeding with the axle alignment check.
5. Remove the safety stands and lower the rear of the vehicle. Relieve any internal stresses in the suspension by jacking the axles up and letting them down; or, remove the tire chocks, then move the vehicle back and forth (with the interaxle differential disengaged).
6. On either rear axle, measure the distance between the left frame rail and the nearest point on the inside wheel rim. See **Fig. 2**, Dimension A.
7. On the same axle, measure the distance between the right frame rail and the nearest point on the inside wheel rim (see **Fig. 2**, Dimension B).
8. Compare Dimension A with Dimension B. If they're within 1/8 inch (3.25 mm) of being equal, alignment is not necessary. However, if they're different by more than 1/8 inch (3.25 mm), adjust the lateral alignment.

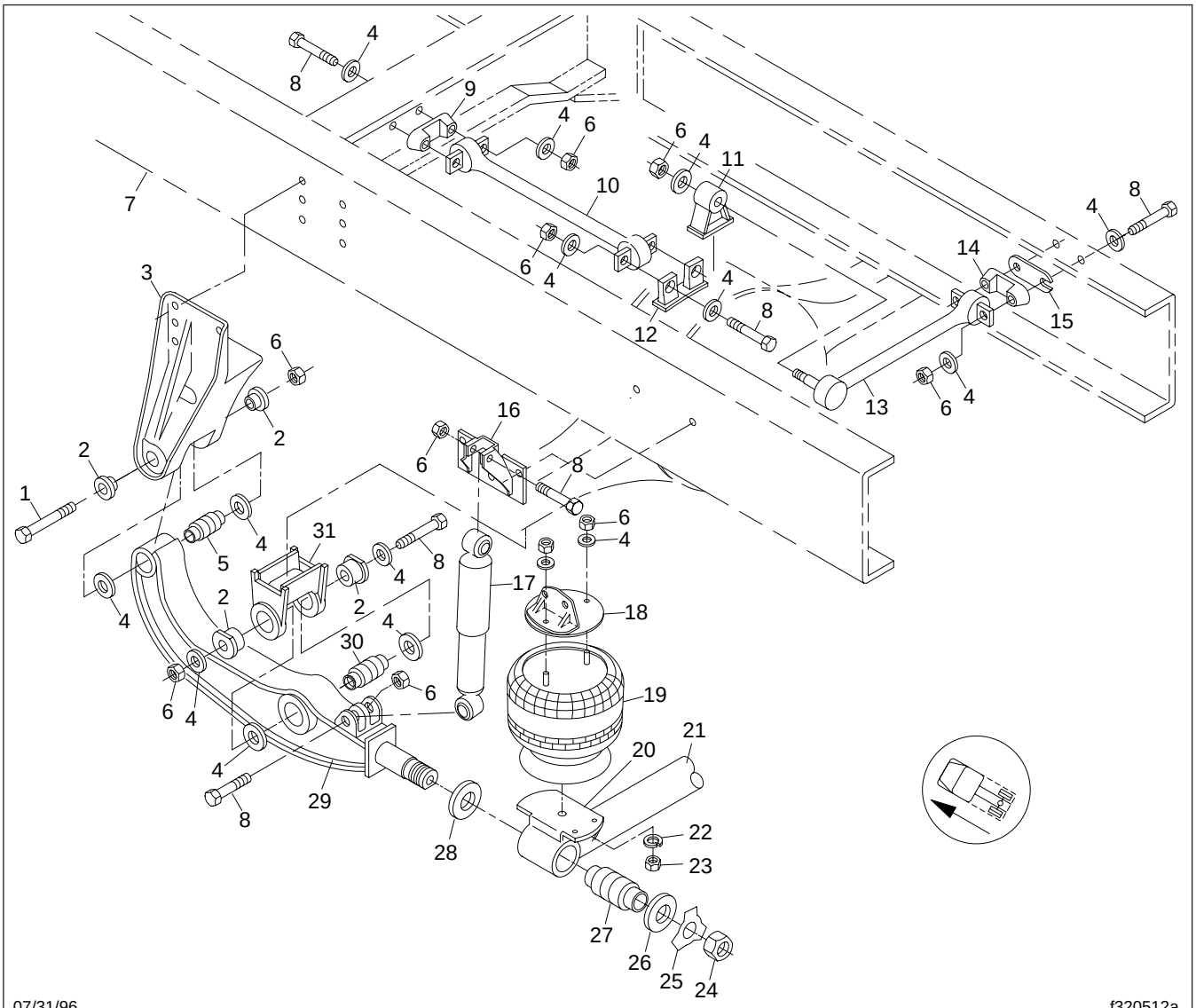
   8.1 Loosen the locknuts on the bolts that secure the lateral rod mount to the frame rail.

   8.2 Add or remove one axle alignment shim for each 1/8 inch (3.25 mm) difference between Dimensions A and B. Adding shims will decrease the measurement on the side of the vehicle to which the lateral rod is attached, and removing shims will increase the measurement.

   8.3 After installing the shims, lubricate the threads on the lateral rod mount bolts with engine oil; tighten the locknuts to the torque under **Specifications 400**.
9. On tandem axle installations, do the previous three steps on the other axle.
10. On suspensions equipped with an axle alignment feature (alignment bushings welded to slotted frame brackets), proceed to **Subject 190**.

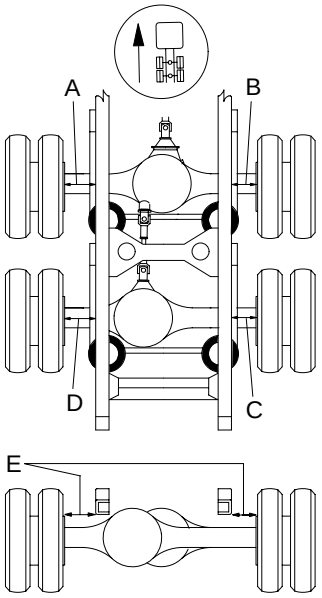
    On suspensions not equipped with an axle alignment feature, no further checking is required. Apply the parking brakes; then remove the chocks from the tires.

Rear Axle Lateral Alignment



1. Rod Bolt, 1-1/8–7 x 9-1/4
2. Adaptor Bushing
3. Frame Bracket
4. Spacer Washer
5. Equalizing Beam Front Bushing
6. Locknut
7. Frame Rail
8. Rod Bolt, 3/4–10 x 7-1/2
9. Torque Rod Crossmember Bracket
10. Torque Rod
11. Control Rod Axle Bracket
12. Torque Rod Axle Bracket
13. Control Rod
14. Control Rod Frame Bracket
15. Axle Alignment Shim(s)
16. Shock Absorber Frame Bracket
17. Shock Absorber
18. Air Spring Upper Mounting Plate
19. Air Spring
20. Air Spring Lower Mounting Plate
21. Transverse Beam
22. Lock Washer
23. Hexnut, 1/2–13
24. Hexnut, 2-1/4–8
25. Tab Washer
26. Spacer Washer
27. Transverse Beam Bushing
28. Spacer Washer
29. Equalizing Beam
30. Equalizing Beam Center Bushing
31. Beam Hanger Bracket

Fig. 1, Neway Suspension Components



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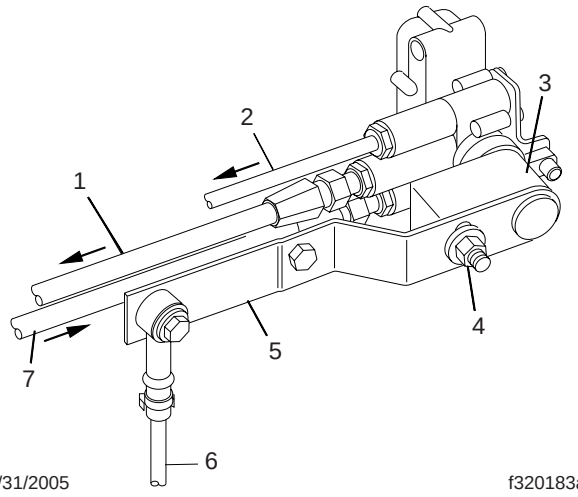
NOTE: Dimension A equals Dimension B plus or minus 1/8-inch (3.25 mm)

A. Dimension A (forward rear axle)
B. Dimension B (forward rear axle)
C. Dimension C (rearmost axle)
D. Dimension D (rearmost axle)
E. Measure Here

Fig. 2, Rear Axle Lateral Alignment

Parallel Alignment

1. Check and, if needed, adjust the lateral alignment of the rear axle(s) before checking parallel alignment. See **Subject 180** for instructions.
2. Check the axles for parallel alignment. See **Group 35** for instructions.
3. Adjust the rear axle, if necessary.
   - 3.1 Using jack stands, support the vehicle frame at normal ride height. Disconnect both height control valve linkages from their respective control levers. See **Fig. 1**. Then exhaust all air from all air springs by pushing the valve control levers down.
   - 3.2 Remove the equalizing beam pivot connection locknut and bolt, and both spacer washers. See **Fig. 2**. Lower the equalizing beam from the frame bracket.
   - 3.3 Cut the welds off of the alignment bushings on both sides of the frame bracket. Remove the alignment bushings; then grind any remaining weld material off of the frame bracket and alignment bushings.

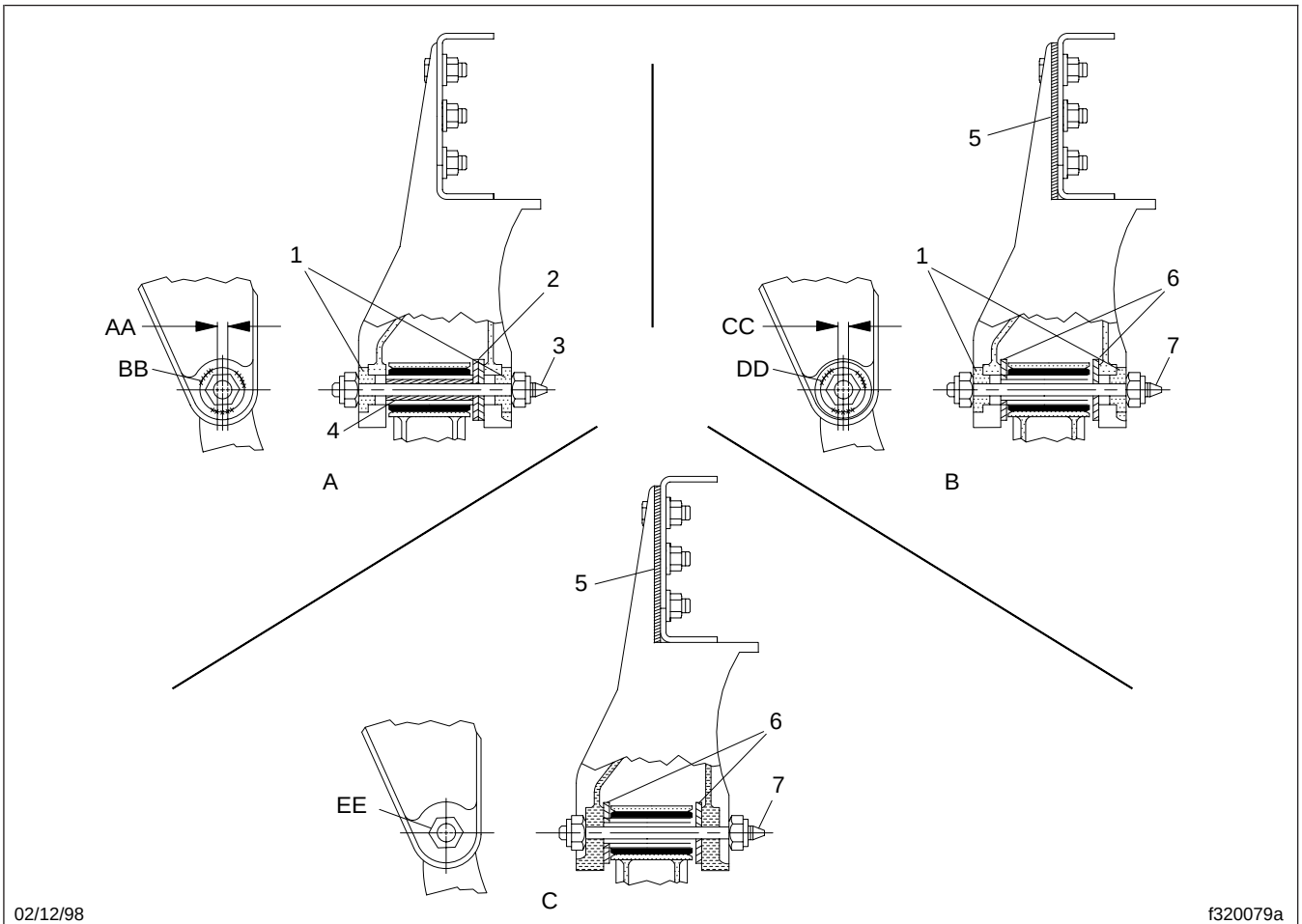


1. Airflow to Spring
2. Exhaust to Atmosphere
3. Nylon Block
4. Adjustment Locknut
5. Control Lever
6. Linkage
7. Airflow from Air Reservoir

Fig. 1, Height Control Valve

   - 3.4 Position the alignment bushings in the frame bracket; then raise the equalizing beam until the front eye is aligned with the frame bracket. Install the spacer washers and pivot connection bolt and locknut. Position the spacer washers. See **Fig. 2**. Suspension installations which have a 1/4-inch (6-mm) frame-rail spacer between the forward frame-rail bracket and the frame rail will require one spacer washer on each side of the equalizing beam. Installations without a frame-rail spacer require two spacer washers on the inboard side of the equalizing beam.
   - 3.5 Move the axle forward or backward by rolling the wheels on that side of the vehicle (only that side), until the correct axle alignment is obtained.
   - 3.6 With the axle aligned and the vehicle frame supported at normal ride height, torque the equalizing beam front bushing locknut to the torque under **Specifications, 400**.
   - 3.7 Weld both of the alignment bushings to the frame bracket, using AWS spec E7018 welding rod or Linde 3/32 FC 72 wire weld, or an equivalent. Weld (1/4-inch fillet) each bushing with three, 3/4-inch (19-mm) long welds. See **Fig. 2**.
4. Connect the linkages to their respective control levers.
5. Apply the parking brakes; then remove the jack stands from the frame and the chocks from the tires.

Rear Axle Parallel Alignment



A. Without Frame Rail Spacer, With Alignment Bushings
B. With Frame Rail Spacer, With Alignment Bushings
C. With Frame Rail Spacer, Without Alignment Bushings

1. Alignment Bushings
2. Two Spacer Washers on the Inboard Side of the Beam
3. Rod Bolt, 1-1/8–12
4. Delrin Spacer
5. 1/4-inch Frame Rail Spacer
6. One Spacer Washer on Each Side of the Beam
7. Rod Bolt, 1-1/4–12

AA. Measurement: 0.50" (12.7 mm) Axle Alignment Adjustment
BB. Weld: Three places approximately 3/4" (19 mm) long
CC. Measurement: 0.25" (6.4 mm) Axle Alignment Adjustment
DD. Weld: Three places approximately 3/4" (19 mm) long
EE. No Axle Alignment Adjustment

Fig. 2, Spacer Washer Installation and Alignment Bushing Welding

Troubleshooting

Problem—Air Springs Are Flat

Problem—Air Springs Are Flat	
Possible Cause	**Remedy**
Low air pressure in the vehicle brake system.	Check the air pressure gauge on the instrument panel. If the air pressure is low, run the engine until a minimum pressure of 70 psi (483 kPa) is shown on the gauge.
Air leaking from the suspension air system or the air brake system.	Listen for leakage due to loose fittings or damaged air lines, air springs, brake actuators or control valves. Tighten loose fittings or replace worn or damaged air lines with new ones.

Problem—Air Spring(s) Flat on One Side of the Vehicle

Problem—Air Spring(s) Flat on One Side of the Vehicle	
Possible Cause	**Remedy**
Air leakage between the pressure holding valve and the air spring(s).	Listen for leakage due to loose fittings or damaged air lines. Tighten loose fittings or replace damaged lines with new ones.
Air spring leaking.	Inspect the air spring for leaks caused by damage, wear, or deterioration. If any air spring is leaking, install a new one.
Bent, broken, or disconnected height control valve linkage.	Inspect the linkage for damaged or loose parts. Reconnect loose linkage parts or replace damaged parts with new ones.
Height control valve out of adjustment.	Disconnect the height control valve linkage from the height control valve control lever. Move the lever upward. If the air spring then inflates, adjust the height control valve.
Inoperative height control valve.	If movement of the control lever in the previous step fails to inflate the air spring, the height control valve is damaged. Replace the valve.

Problem—Tractor Leans Due to Unequal Inflation of the Air Springs

Problem—Tractor Leans Due to Unequal Inflation of the Air Springs	
Possible Cause	**Remedy**
Damaged height control valve linkage.	Inspect the height control valves and linkages for damage. Repair or replace damaged parts.
Loose or missing height control valve bolts or adjustment locknut.	Inspect for damage to the height control valve mounting bolts or adjustment locknut. Replace any missing bolts or nuts, then adjust the height control valve.
Height control valve out of adjustment.	Adjust the height control valve.

Troubleshooting

Problem—Air Springs Deflate Rapidly When the Vehicle Is Parked

Problem—Air Springs Deflate Rapidly When the Vehicle Is Parked	
Possible Cause	**Remedy**
Air leakage from the suspension air system.	Listen for leakage due to loose fittings or damaged air lines, air springs, or height control valves. Tighten loose fittings and replace worn or damaged parts with new ones.

Problem—Tractor Rides Too High or Too Low

Problem—Tractor Rides Too High or Too Low	
Possible Cause	**Remedy**
Height control valve out of adjustment.	Disconnect the height control valve linkage from the height control valve control lever. Move the lever upward. If the air spring then inflates, adjust the height control valve.

Problem—Air Spring Blown Out

Problem—Air Spring Blown Out	
Possible Cause	**Remedy**
Air spring cut or punctured.	Locate large leaks by listening for escaping air, and locate small leaks by applying a soap and water solution to the suspected air spring and watching for bubbles. Temporarily repair punctures or cuts less than 1/8-inch (3-mm) long by applying hot patches on both sides of the hole. If the cut is more than 1/8-inch (3-mm) long, install a new air spring.
Tires, rims, or chains rubbing the air spring.	Check the clearance between the air spring and the tire. If the tire, rim, or chains contact the inflated air spring, change to narrower tires and rims to provide clearance for tires with chains.
Air brake actuator rubbing against the air spring.	Relocate the brake actuator with factory approved parts to provide adequate clearance.

Problem—Air Spring Deflated Due to Fatigue

Problem—Air Spring Deflated Due to Fatigue	
Possible Cause	**Remedy**
Driving the vehicle too long or too fast with the air springs deflated.	If the vehicle must be driven with the air springs deflated, maintain a speed of less than 30 mph (48 km/h), and drive only as far as the nearest repair facility.
Continual or repeated overextension of the air springs.	Inspect for broken or loose shock absorbers or shock absorber mounting brackets. Reconnect loose parts and replace any damaged parts. Check the adjustment on the height control valve.

Problem—Air Spring Doesn't Fully Deflate When All Weight Is Removed from the Suspension

Problem—Air Spring Doesn't Fully Deflate When All Weight Is Removed from the Suspension	
Possible Cause	**Remedy**
Restricted air line between the height control valve and the air spring.	Disconnect the height control valve linkage, and push the control lever down. If the air spring remains inflated, check for a pinched or blocked line. Clean out any plugged line and replace any damaged line.

Specifications

Description	Size	Torque: lbf·ft (N·m)
Shock Absorber Mount Locknut	3/4–16	110–150 (149–203)
Air Spring Upper Mounting Plate Locknut	3/4–16	31–42 (42–57)
Air Spring Upper Mounting Plate Capscrew	1/2–13	31–42 (42–57)
Air Spring Lower Mounting Plate Capscrew	1/2–13	31–42 (42–57)
Transverse Beam Bushing Locknuts	1-1/4–12	600–700 (814–950)
Equalizing Beam Center Bushing Locknut	3/4–16	150–200 (203–271)
Equalizing Beam Front Bushing Locknut	1-1/8–12	600–700 (814–950)
	1-1/4–12	
Control Rod Ball Stud Locknut	1-1/8–12	550–650 (746–880)
Control and Torque Rod Mounting Locknuts	5/8–18	110–150 (149–203)

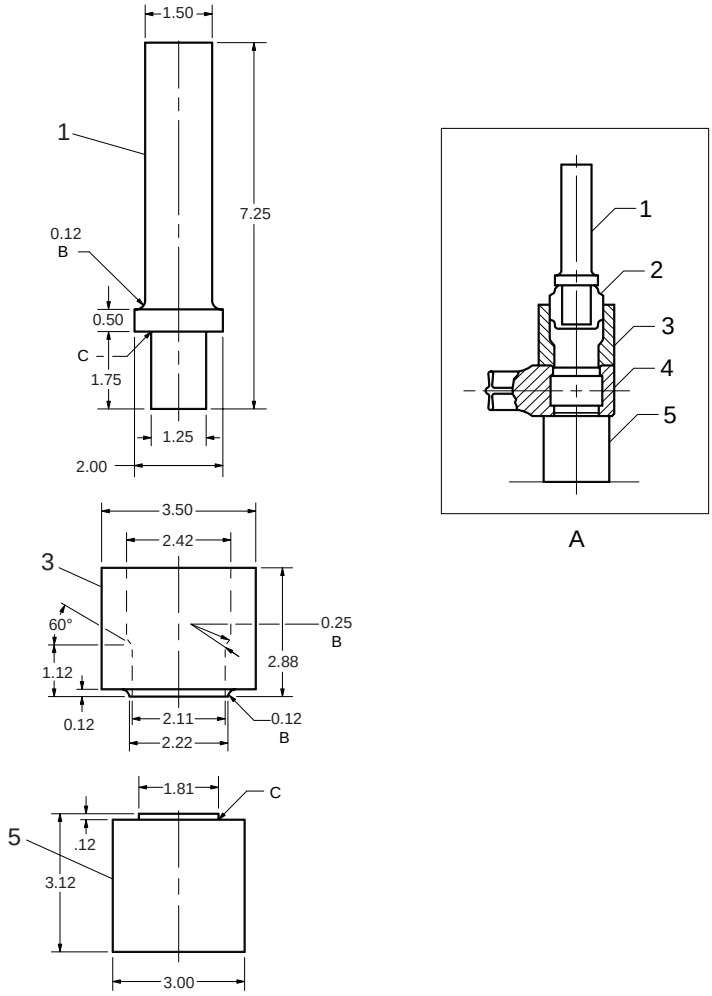
Table 1, Suspension Torque Specifications (lubricated threads)

See **Fig. 1** and **Table 2** for the bushing installation tool.

Tool	Dimensions	Material
A	Bar, 2.00" Diameter (51 mm)	Mild Steel
B	Tube, 3.50" (89 mm) o.d. x 0.75" (19 mm) wall	Mild Steel
C	Bar, 3.00" Diameter (76 mm)	Mild Steel

Table 2, Bushing Installation Tool Materials

Specifications



1. Plunger
2. Bushing
3. Insertion Sleeve
4. Torque Rod
5. Base

A. Detail
B. Radius
C. Minimum Radius

Fig. 1, Bushing Installation Tool

General Description

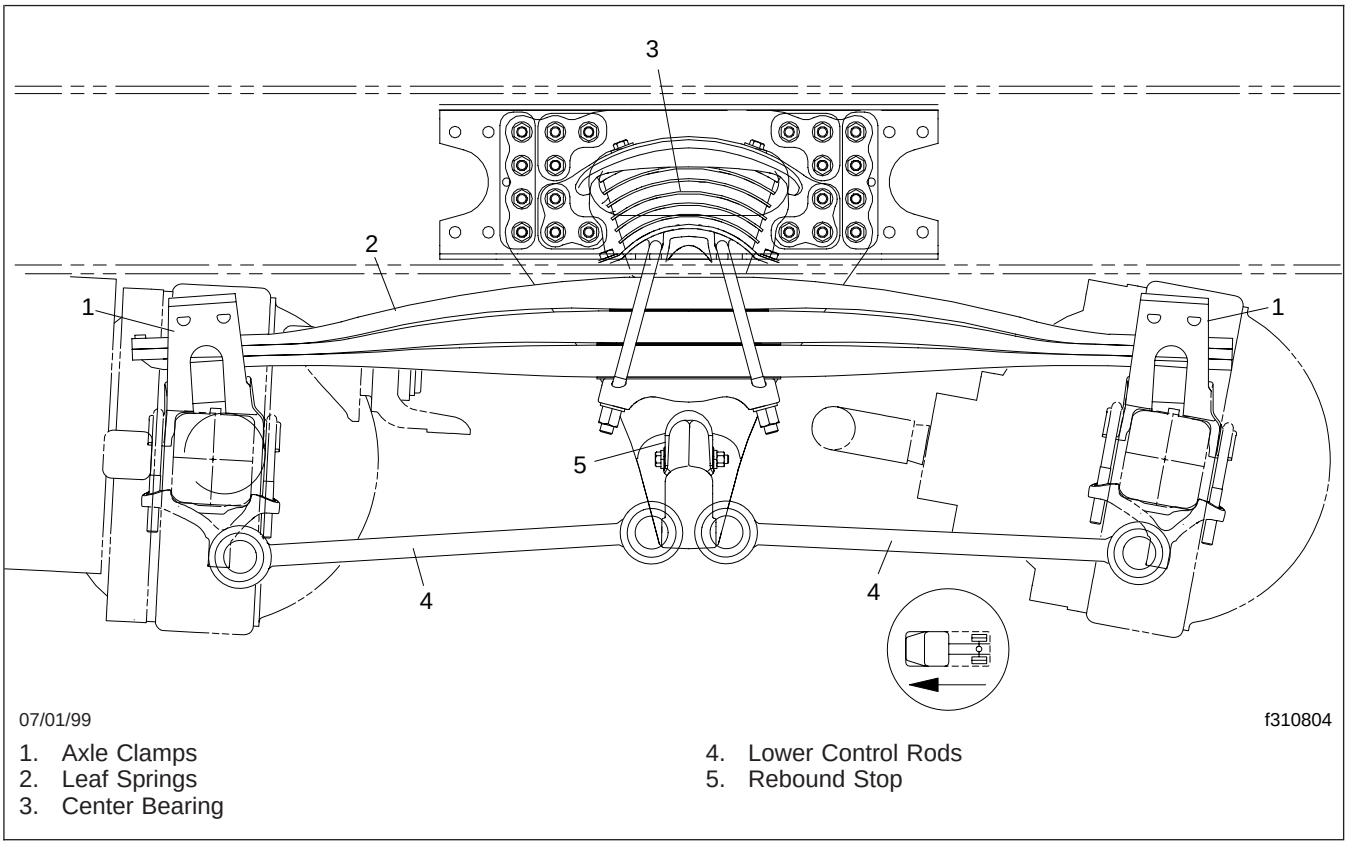
The TufTrac Suspension (**Fig. 1**) is heavy-duty "six rod" tandem-axle suspension option for trucks built for severe on/off highway work. The TufTrac design allows a truck to maneuver over bumps, ridges and washboard roads that typically generate high rates of axle articulation, without bottoming out the suspension or losing traction.

The TufTrac suspension is available in three weight ratings — 40,000-, 46,000- and 52,000-pound (18 144-, 20 865-, 23 586-kilogram) capacities. The 40,000-pound (18 144-kilogram) capacity suspension uses two taper leaf springs and has an axle spacing of 54 inches. The 46,000-pound (20 865-kilogram) capacity suspension has three leaf springs (shown in this section), while the 52,000-pound (23 586-kilogram) suspension features four leaf springs. Both the 46,000-pound (20 865-kilogram) and the 52,000-pound (23 586-kilogram) suspensions have a standard axle spacing of 56 inches.

Principles of Operation

Six functional links in the TufTrac suspension maintain the positions of the axles. Side-to-side axle movement is controlled by two v-rods from the frame to the axles at the top of the suspension. Four bar links from the frame to the axles at the bottom control the forces of driving and braking as well as fore-and-aft road shocks. Vertical loads are carried by the rubber-isolated parabolic taper leaf spring packs.

General Information

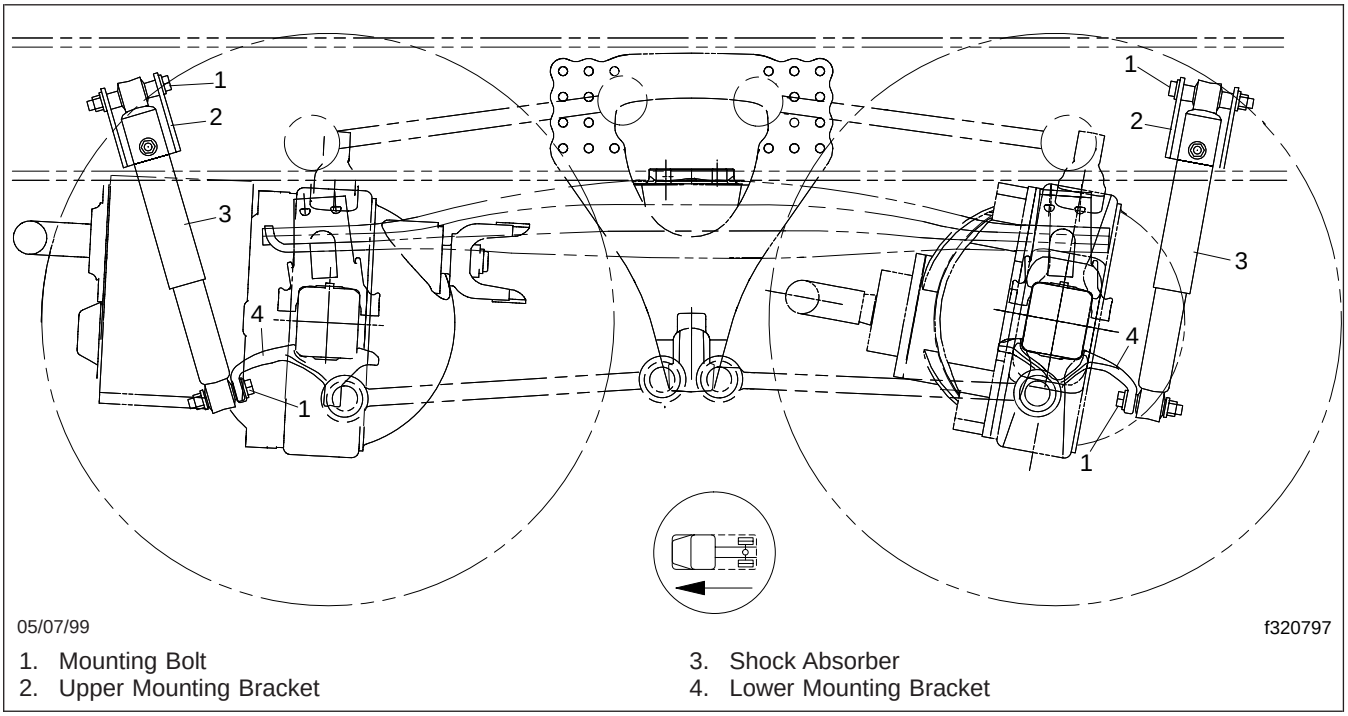


1. Axle Clamps
2. Leaf Springs
3. Center Bearing
4. Lower Control Rods
5. Rebound Stop

Fig. 1, TufTrac Suspension (46,000-pound [20 865-kilogram] version shown)

Replacement

1. Park the vehicle on a level surface, shut down the engine and apply the parking brakes. Chock the tires.
2. Remove the lower shock mounting nut and washer. **See Fig. 1.**
3. Remove the upper shock mounting nut and washer.
4. Remove the upper and lower mounting bolts and remove the shock absorber.
5. Position the new shock absorber in place and install the mounting bolts.
6. Loosely fasten the bolts with the nuts and washers removed from the old shock absorber.
7. Torque each mounting nut 241 lbf·ft (327 N·m).
8. Remove the chocks from the tires.

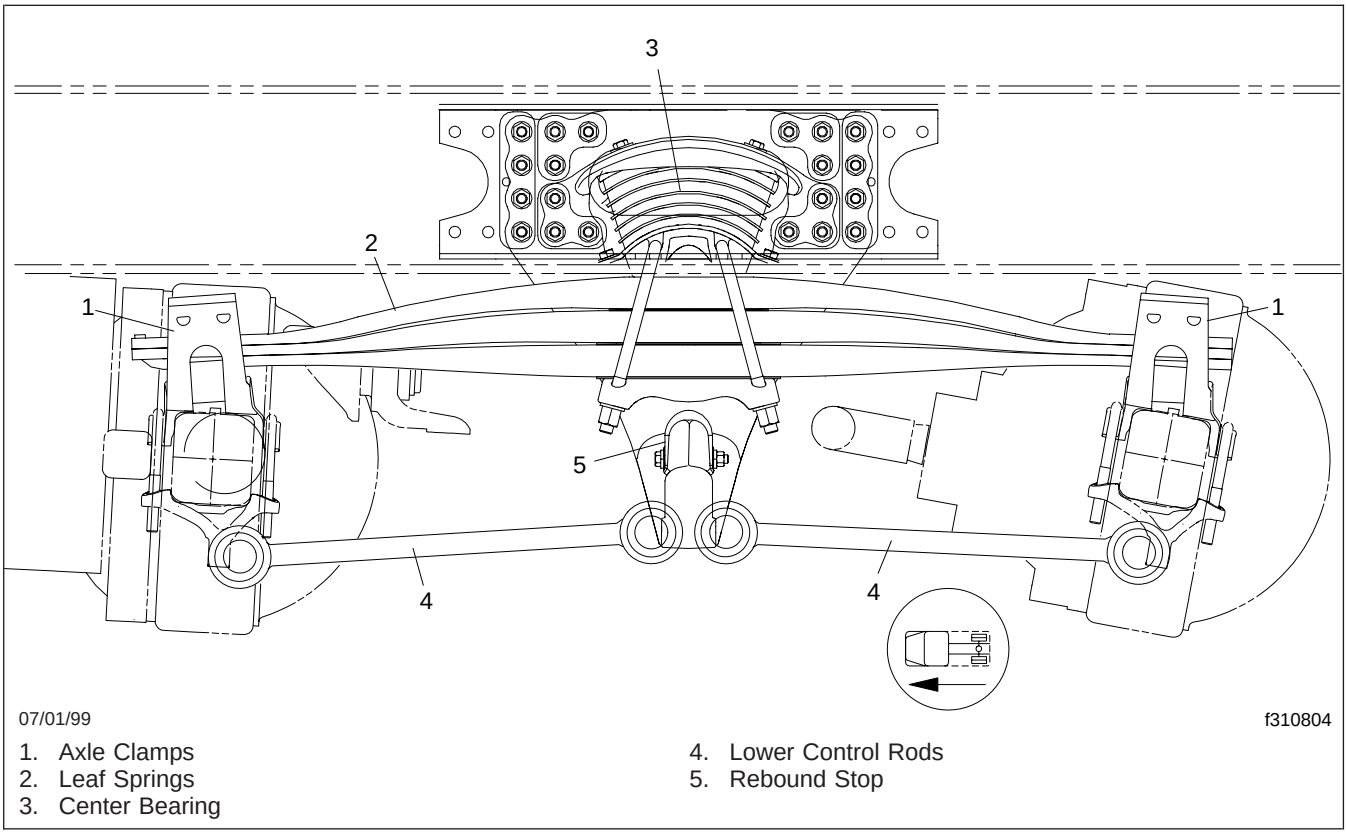


1. Mounting Bolt
2. Upper Mounting Bracket
3. Shock Absorber
4. Lower Mounting Bracket

Fig. 1, Shock Absorber Replacement

Replacement

1. Park the vehicle on a level surface, shut down the engine and apply the parking brakes. Chock the tires.
2. Remove the rebound stop from the suspension. See **Fig. 1**.



1. Axle Clamps
2. Leaf Springs
3. Center Bearing
4. Lower Control Rods
5. Rebound Stop

Fig. 1, TufTrac Suspension (46,000-pound [20 865-kilogram] version shown)

   2.1 Remove the nut and bolt securing the rebound stop to the mounting bracket.

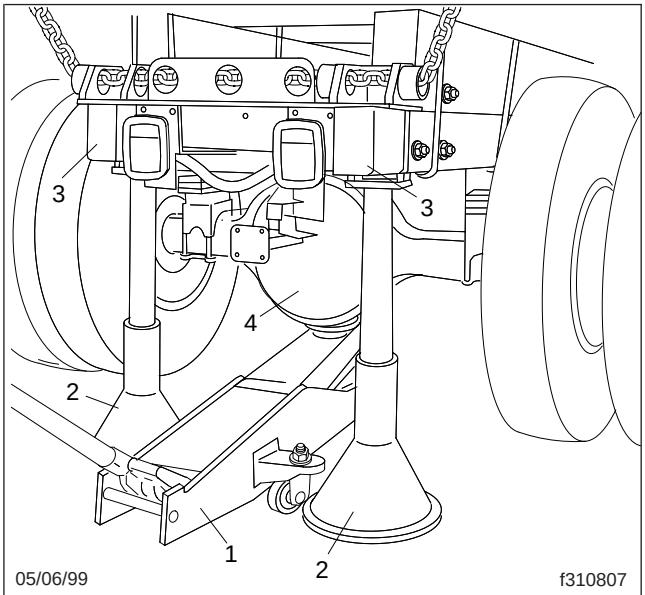
   2.2 Slide the rebound stop from the mounting bracket.

3. Remove the upper two fasteners on the center bearing.
4. Jack up the vehicle under the rear axle.
5. Support the rear frame rails with jack stands, then lower the jack. This will clear the center bearing from the top of the mounting bracket. See **Fig. 2**.
6. Remove the lower center bearing bolts attached to the spring assembly casting. Discard the bolts.
7. Remove the center bearing. See **Fig. 3**.
8. Position the new center bearing in the mounting bracket.
9. Install the upper mounting bolts and tighten 68 lbf·ft (92 N·m).
10. With the jack, raise the rear axle until bottom of the center bearing meets the mounting bracket on the leaf springs.

IMPORTANT: Be sure to use new bolts with loctite (p/n 23–12576–125) when attaching the center bearing to the leaf spring casting.

11. Install new lower mounting bracket bolts (p/n 23–12576–125). Tighten the bolts 155 lbf·ft (210 N·m).

Center Bearing Replacement



1. Jack
2. Jack Stand
3. Frame Rail
4. Rear Axle

Fig. 2, Jack and Jack Stand Placement

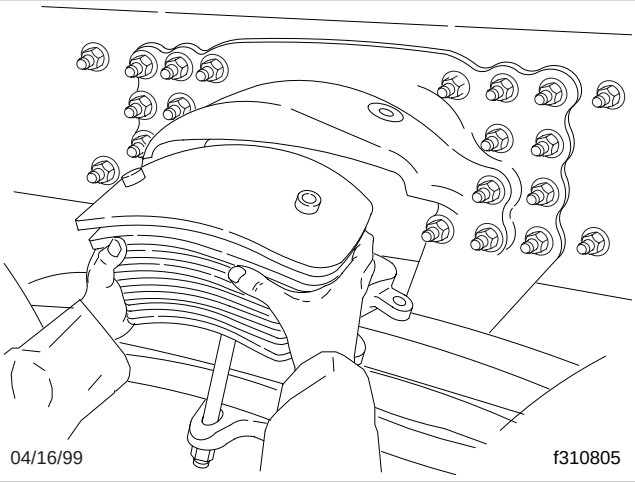
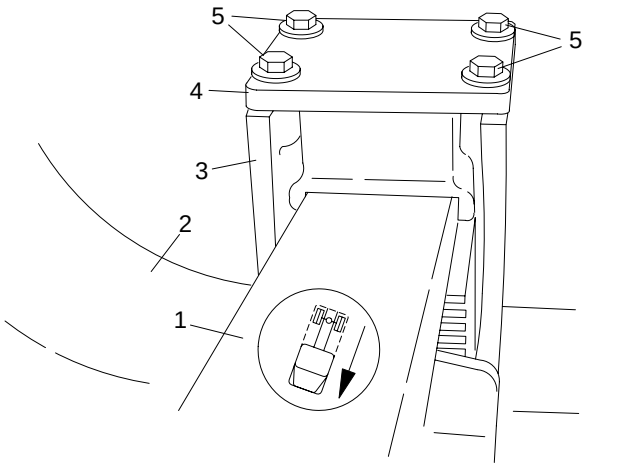


Fig. 3, Center Bearing Removal

12. Return the vehicle to its normal operating position.
13. Install the rebound stop.
14. Remove the chocks from the tires.

Replacement

1. Park the vehicle on a level surface, shut down the engine and apply the parking brakes. Chock the tires.
2. Remove the tip pad bolts above each axle on the axle clamp. There are four bolts on each pad. See **Fig. 1**.



1. Leaf Springs
2. Axle
3. Axle Pad
4. Tip Pad
5. Tip Pad Bolts

Fig. 1, Tip Pad Installation

3. Remove the center bearing. See **Subject 110**.
4. With the vehicle still raised, remove the wheels on both rear axles on the side the spring assembly will be replaced. For instructions, see **Group 40**.

⚠ WARNING

Do not attempt to remove the spring assembly by hand. The assembly is very heavy and attempting to remove it could result in bodily injury.

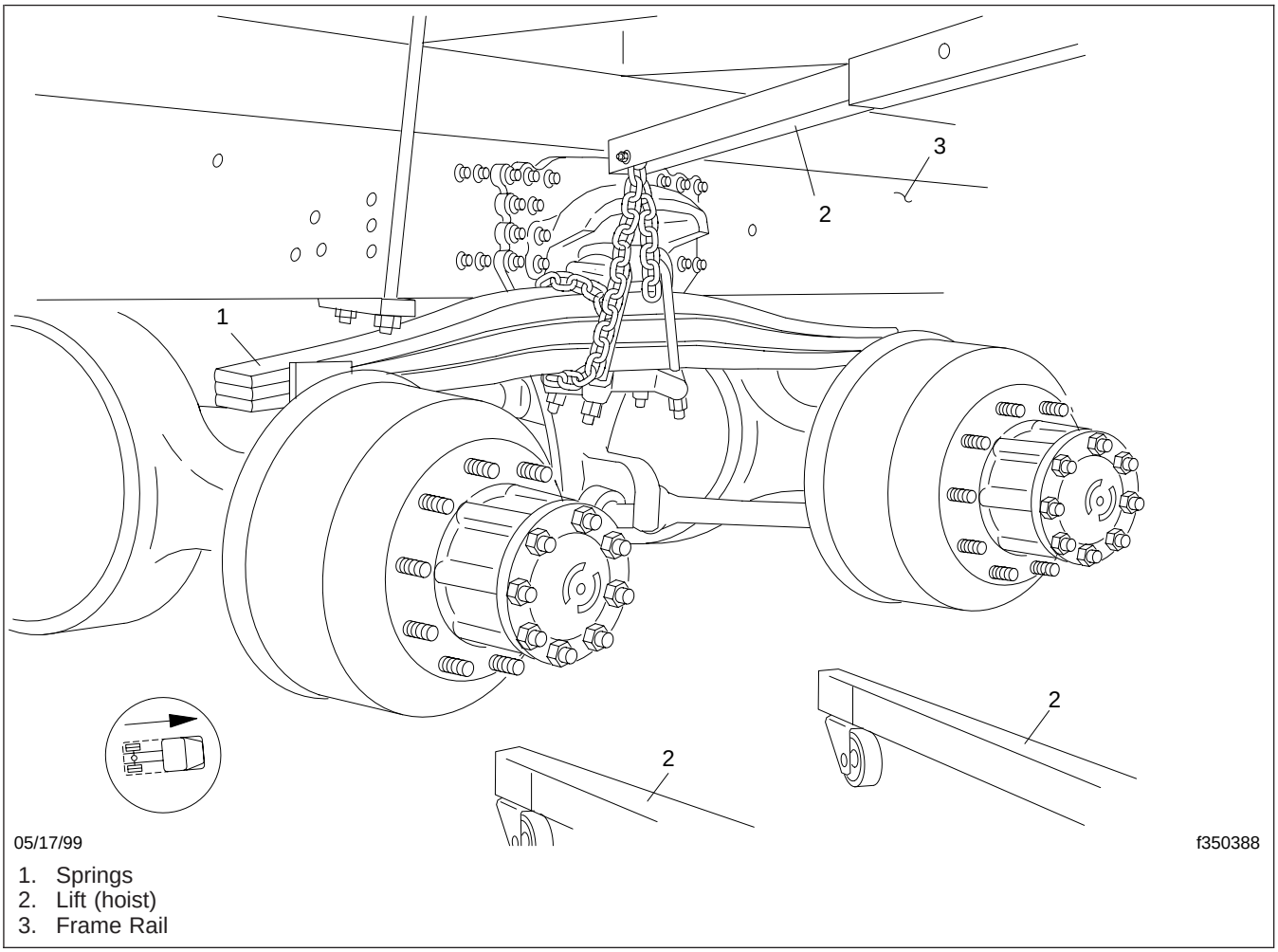
5. Using a lift (i.e. engine hoist), remove the leaf spring assembly from the vehicle. See **Fig. 2**.

⚠ WARNING

Do not attempt to install the spring assembly by hand. The assembly is very heavy and attempting to remove it could result in bodily injury.

6. Place the new spring assembly on the vehicle.
   - 6.1 Attach the new assembly to the lift.
   - 6.2 Using the lift (hoist), lift the assembly into place on the axle clamps.
7. Install the center bearing. For instructions, see **Subject 110**.
8. Install the tip pad and bolts on each axle clamp. Tighten the bolts 37 lbf·ft (50 N·m). See **Fig. 1**.
9. If not already installed, install the rebound stop and mounting bolt. Tighten the nut 68 lbf·ft (92 N·m).
10. Install the wheels. For instructions, see **Group 40**.
11. Return the vehicle to its normal operating position.
12. Remove the chocks from the tires.

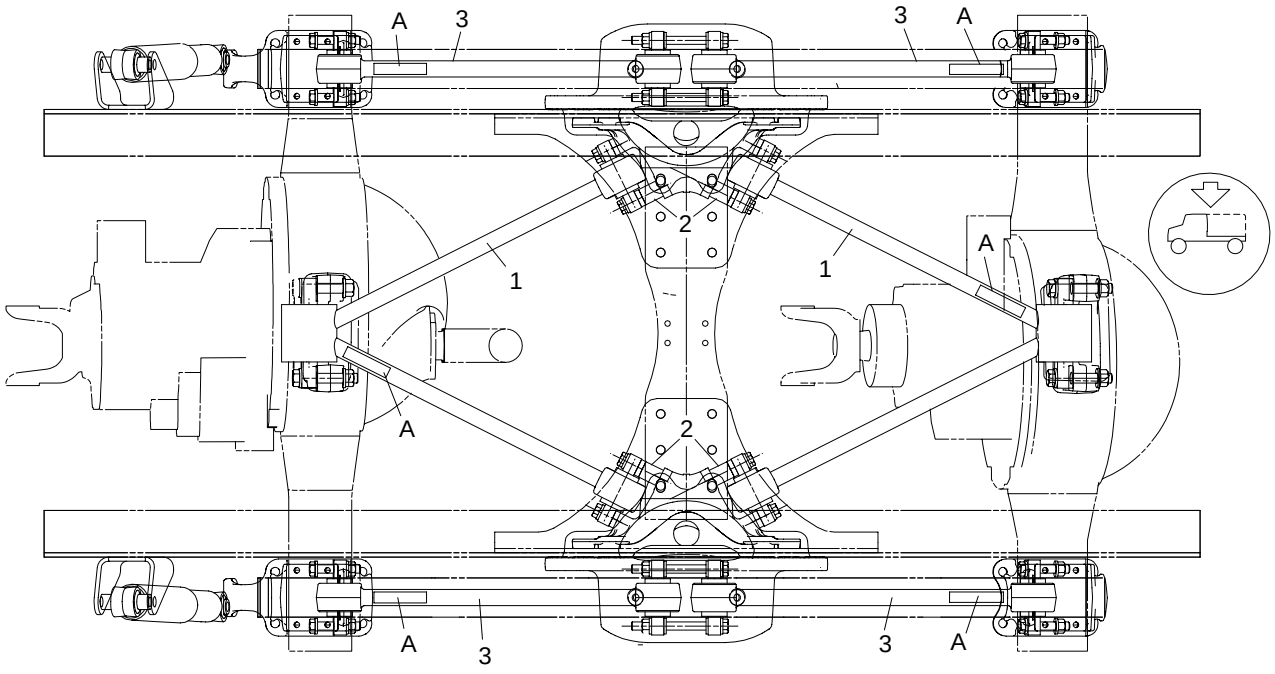
Spring Assembly Replacement



1. Springs
2. Lift (hoist)
3. Frame Rail

Fig. 2, Leaf Spring Replacement

Lower Control Rod Replacement (See Fig. 1)



A. Label
1. V-Rod
2. Spacer
3. Lower Control Rod

Fig. 1, Control and V-Rod Replacement

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the front tires.
2. Raise the rear axle and support the frame rails with jack stands.
3. Lower the jack under the axle. See **Fig. 2**.
4. Remove the bolts holding both rods between the rear axles, below the rebound stop. See **Fig. 3**.
5. Remove the nut and bolt from the axle clamp.
6. Remove the control rod from the vehicle.

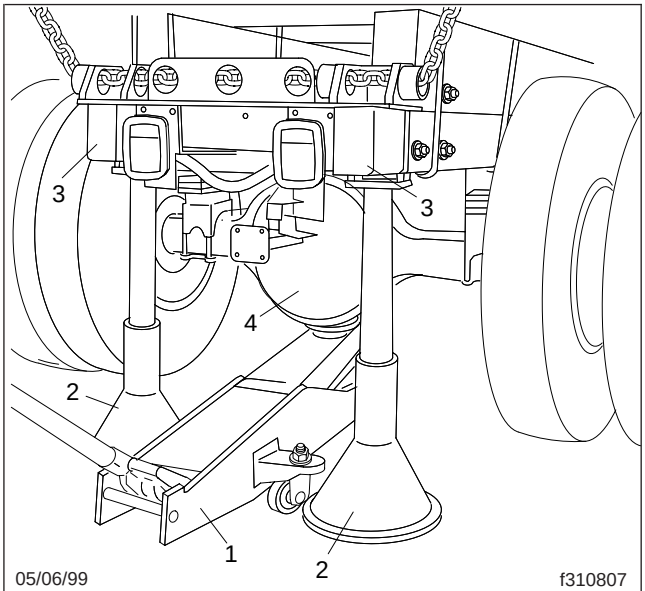
IMPORTANT: When installing the rods make sure the labels on the rods are facing upward. Forward axle rods are marked "FDA" and rear axle rods "RDA."

7. Fasten the new control rod to the axle clamp. Tighten the nut 136 lbf·ft (184 N·m).
8. Fasten the other end of the rod to the bracket below the rebound stop. Tighten the nut 136 lbf·ft (184 N·m).
9. Return the vehicle to the normal operating position.

V-Rod Replacement

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the tires.
2. Raise the rear axle and support the frame rails with jack stands.
3. Lower the jack under the axle. See **Fig. 2**.

Lower Control Rod and V-Rod Replacement



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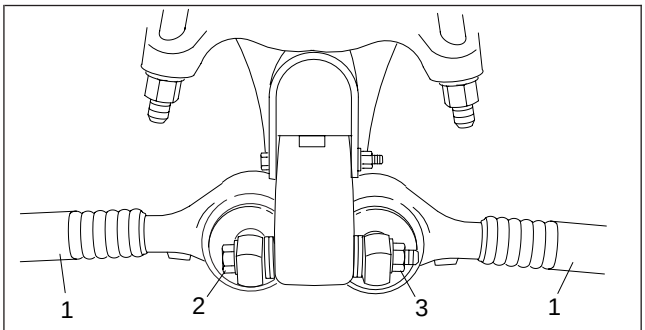
1. Jack
2. Jack Stand
3. Frame Rail
4. Rear Axle

Fig. 2, Jack and Jack Stand Placement



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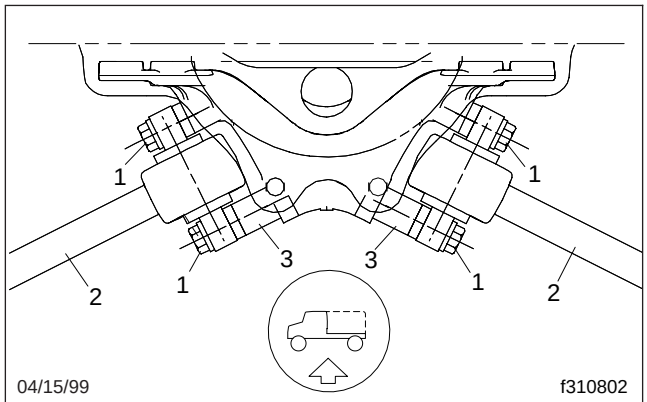
1. Lower Control Rod
2. Mounting Bolt
3. Mounting Nut

Fig. 3, Lower Control Rods

4. Remove all six mounting bolts securing the v-rod to the chassis and axle.
5. Remove the v-rod from the chassis.

IMPORTANT: When installing the rods make sure the labels on the rods are facing upward. Forward axle rods are marked "FDA" and rear axle "RDA."

6. Install the v-rod. See **Fig. 4**.



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1. Mounting Bolt
2. V-Rod
3. Spacer

Fig. 4, V-Rod Replacement

6.1 Place the new rod in position between the frame rails.

6.2 Install the bolts and spacers and loosely tighten all connections.

6.3 After all fasteners and spacers are installed, torque as follows:

- Tighten the bolts at the frame bracket 136 lbf·ft (184 N·m).
- Tighten the bolts at the axle bracket 427 lbf·ft (579 N·m).

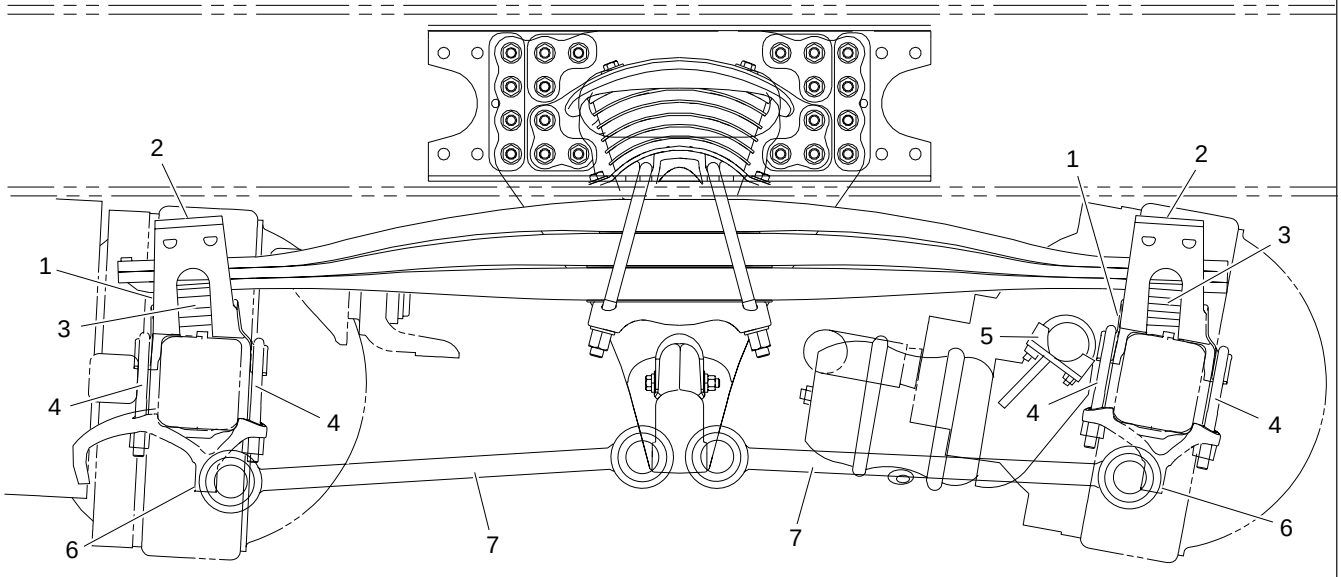
7. Return the vehicle to normal operating position.
8. Remove the chocks from the tires.

Replacement

1. With the vehicle parked on a level surface, shut down the engine, and chock the tires.

NOTE: All of the following steps should be performed on the left side of the vehicle, first; then the right side of the vehicle.

2. Remove the two upper spring-tip pads and bolts from the suspension spring. See **Fig. 1**.
9. Jack up the center of the suspension spring (at the center bearing, between the tandem) and support with jack stands at the frame. See **Fig. 2**. Make sure that all weight has been relieved from the axle clamp group and that there is sufficient clearance to remove the upper axle clamp.
10. Remove the lower spring-tip pads from both rear axles.



1. Upper Axle Clamp
2. Upper Spring-Tip Pad
3. Lower Spring-Tip Pad
4. U-Bolt
5. Brake Cam Tube-Support Bracket
6. Lower Axle Retainer
7. Lower Torque-Control Rods

Fig. 1, TufTrac Suspension (left-side view)

3. Disconnect the shock absorbers from the lower axle retainer on the suspension spring.
4. Disconnect the two lower torque-control rods from the lower axle retainers.
5. Remove and discard the U-bolt nuts and washers.
6. Remove the brake cam tube-support bracket.
7. Remove and discard the lower axle retainers.
8. Remove and discard the axle U-bolts from both rear axles.
11. Remove and discard the upper axle clamps from both rear axles.
12. On both rear axles, install new upper axle clamps. Locate the dowel pin through the hole in the bottom of each axle clamp to confirm proper alignment.

NOTE: Confirm that you are installing the correct upper axle clamps before continuing. You can visually identify the new upper axle clamp

Axle Clamp and Retainer Replacement

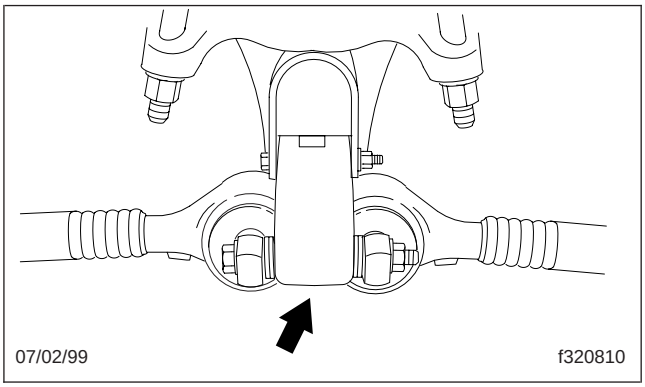
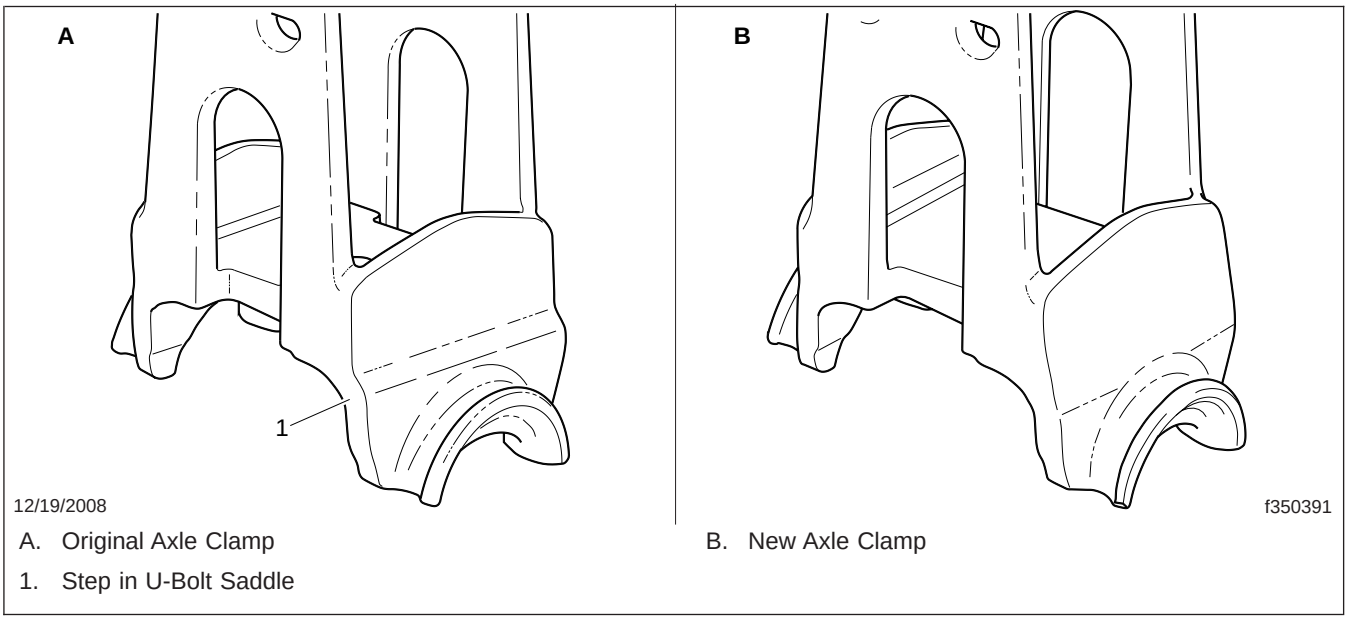


Fig. 2, Vehicle Jacking Point

because the step has been removed from the area directly above the U-bolt saddles. See **Fig. 3**.

13. Install the lower spring-tip pads into the front and rear axle clamps.



A. Original Axle Clamp

1. Step in U-Bolt Saddle

B. New Axle Clamp

Fig. 3, Upper Axle Clamps

14. Jack up the left-side suspension spring, remove the jack stands, and lower the spring. While the spring is being lowered, ensure that it is seated correctly onto the lower spring-tip pads.
15. Install new lower axle retainers onto both rear axles.
16. Install the brake cam tube-support bracket onto the rear axle.
17. Install new U-bolts as follows.

    IMPORTANT: Install two new washers for each U-bolt nut.

    17.1 Install each U-bolt over the U-bolt saddle in the upper axle clamp and through the holes in the lower axle retainer.

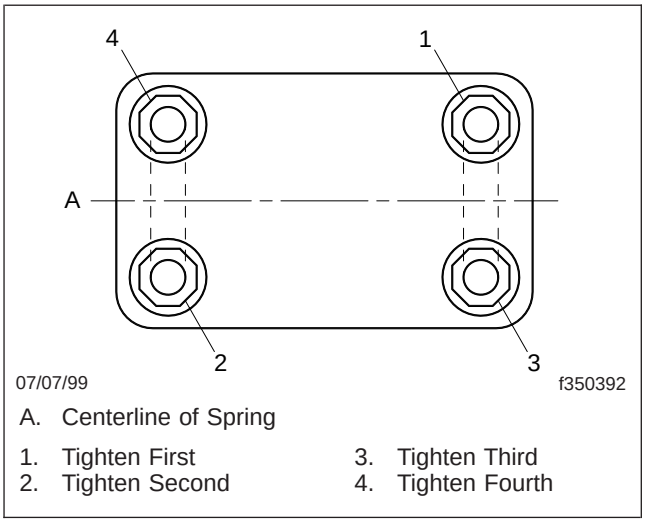
    17.2 Install the washers and finger-tighten the nuts in the order shown in **Fig. 4**.

    Make sure all brackets are snug against the axle housing before proceeding.

    IMPORTANT: U-bolt nuts must be tightened in the order shown in **Fig. 4**.

    17.3 Tighten the nuts 60 lbf·ft (81 N·m), then 200 lbf·ft (271 N·m), in two separate rotations, following the order shown in **Fig. 4**.
18. Attach the lower torque-control rods to the lower axle retainers, then tighten 136 lbf·ft (184 N·m).
19. Install the shock absorbers as follows.

    19.1 Install the lower shock mounting bolts.



A. Centerline of Spring

1. Tighten First
2. Tighten Second
3. Tighten Third
4. Tighten Fourth

Fig. 4, U-Bolt Nut Tightening Sequence

19.2 Install the lower shock absorber mounting washers and nuts, then hand-tighten the nuts.

19.3 Tighten the nuts to 241 lbf·ft (327 N·m).

20. Install the spring-tip pads on the suspension spring, then install the bolts, and tighten 37 lbf·ft (50 N·m).
21. Repeat the steps for the right-side spring.

Adjustments

Rear axle positioning and alignment on a vehicle equipped with the TufTrac suspension is determined by the length of the lower control rods and the V-rods. See **Fig. 1**. The length of the control rods and V-rods can be controlled by the addition or removal of shims at the mounting points of the control rods and/or V-rods. The addition of shim(s) between the control rod or V-rod and its mounting will effectively lengthen the rod moving the axle relative to the frame. Conversely, the removal of shim(s) will shorten the length of the rod, moving the axle in the opposite direction.

The lower control rods use a horse-shoe style of shim (**Fig. 2**) while the V-rods use hardened washers for shims.

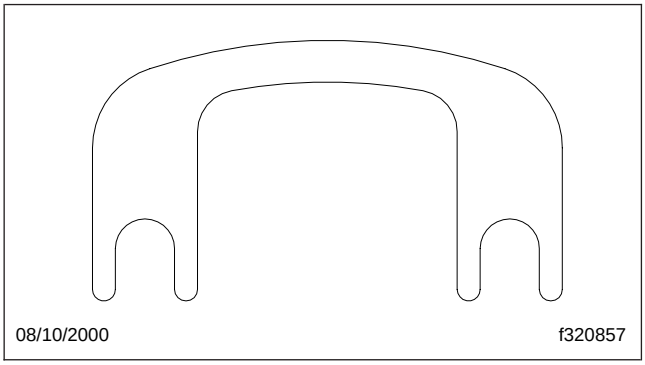
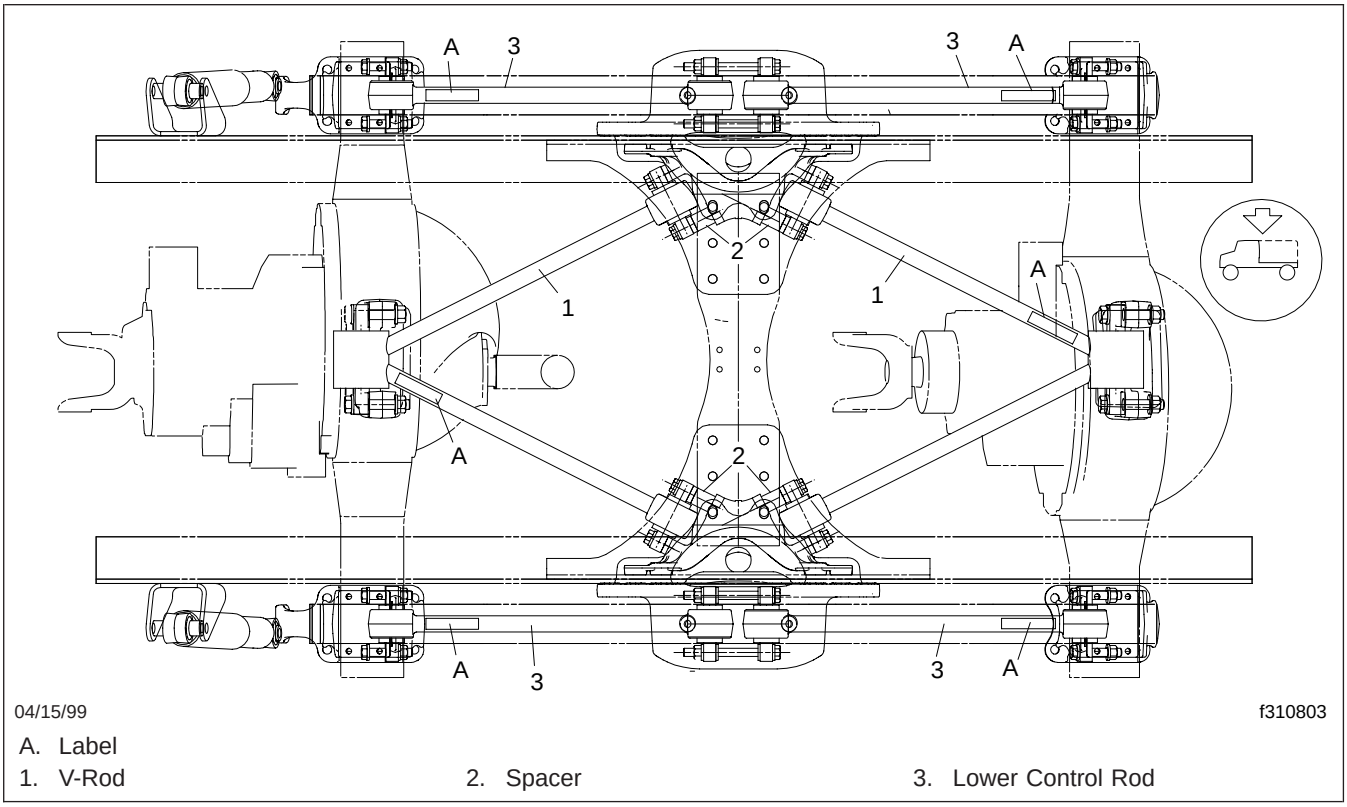


Fig. 2, Lower Control Rod Shim

ment is to provide axle alignment and planing adjustment (angle of the axle from vertical in the side view).



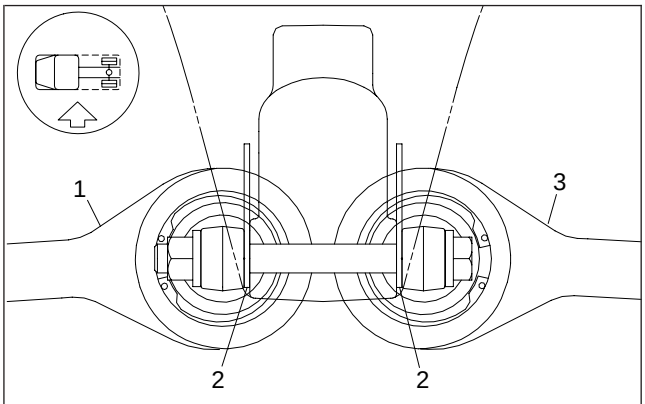
A. Label
1. V-Rod
2. Spacer
3. Lower Control Rod

Fig. 1, Control Rod and V-Rod Installation

Control rod shimming is performed at the center bracket. See **Fig. 3**. The purpose of this shim adjustment is to provide axle alignment and planing adjustment (angle of the axle from vertical in the side view).

Axle tracking (lateral axle positioning) is performed by inserting or removing hardened washers at the V-rod mounting at the frame end. See **Fig. 4**.

Rear Axle Alignment Adjustments



1. Forward Lower Control Rod
2. Shims
3. Rear Lower Control Rod

Fig. 3, Lower Control Rod Shim Installation

Lower Control Rods

Alignment Adjustments

NOTE: Alignment refers to the squareness of the axles to each other and the frame rails viewed from the top of the vehicle.

Add or remove shims at the center bracket to achieve proper alignment. See **Fig. 3**. To minimize the effect on planing angles, if possible, add or remove shims from both sides of the vehicle.

When one 3mm thick shim is added and one removed (from the opposite side) the axle position is affected as follows:

- Angle of the axle in the plan view: 0.33 degrees
- Fore-aft movement of the wheel at the outside (assuming 97.6 in. (2480 mm) wheel to wheel distance): 0.283 in. (7.2 mm)

Planing Adjustments

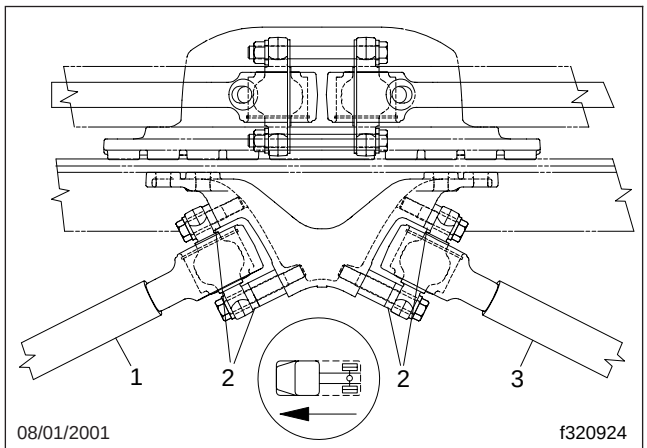
NOTE: planing refers to the angle of the axle from vertical in the side view.

Add or remove shims at the center bracket to change the planing angle. See **Fig. 3**. Unless alignment is required, an equal number of shims should be used left and right for a given axle; example, when adding one shim to the left forward rod add one shim to right forward rod. A shim 0.12 inch thick changes the planing angle 0.3 degrees.

V-Rods

Axle Tracking Adjustments

The tracking adjustment of the forward and rear axles is done by adding and/or removing hardened washers between the V-rod bar pin and the frame-mounted bracket. See **Fig. 4**.

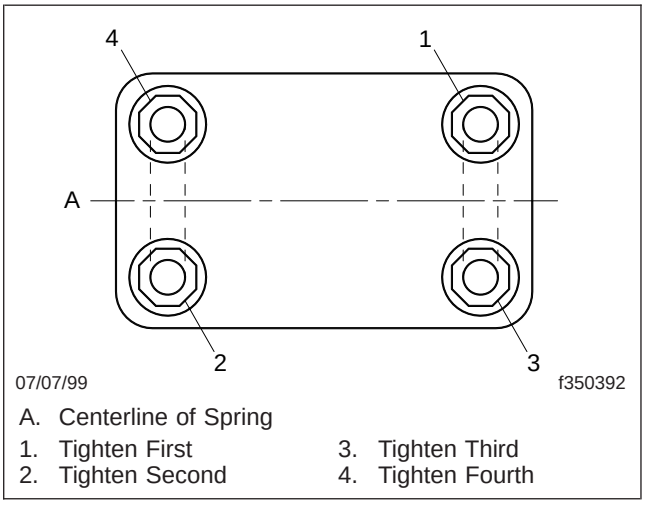


1. Forward Rear Axle V-Rod
2. Hardened Washers
3. Rear Rear Axle V-Rod

Fig. 4, V-Rod Hardened Washer Installation

Torque Specifications	
Description	**Torque: lbf·ft (N·m)**
Shock Absorber Mounting Bolt	241 (327)
Center Bearing Upper Mounting Bolts	68 (92)
Center Bearing Lower Mounting Bolts	155 (210)
Tip Pad Bolts	37 (50)
Rebound Stop Mounting Bolt	68 (92)
Lower Control Rod Mounting Bolts	136 (184)
V-Rod Frame Bracket Mounting Bolts	136 (184)
V-Rod Axle Bracket Mounting Bolts	427 (579)
5/8—18 Axle Clamp U-bolt Nuts (tighten as shown in **Fig. 1**)	Stage 1: Hand-Tighten Stage 2: 60 (81) Stage 3: 200 (271)
3/4-Inch Spring Pack U-bolt Nuts	Stage 1: 60 (81) Stage 2: 200 (271) Stage 3: 300 (406)

Table 1, Torque Specifications



A. Centerline of Spring
1. Tighten First
2. Tighten Second
3. Tighten Third
4. Tighten Fourth

Fig. 1, Tightening Pattern for U-bolt Nuts

General Description

The Scotseal oil seal acts as a barrier between the inside bore of the wheel hub and the axle spindle. **See Fig. 1.** This stops the entry of dirt, moisture, or other contaminants into the inner cavity of the wheel hub, and keeps oil in the hub to lubricate the wheel bearings.

Each seal is installed in the wheel hub like a conventional oil seal. When the wheel hub is installed over the spindle, the inside diameter of the seal will press-fit onto the spindle shoulder. As the wheel rotates, the seal wears within itself and does not wear on the inside of the hub or on the spindle shoulder.

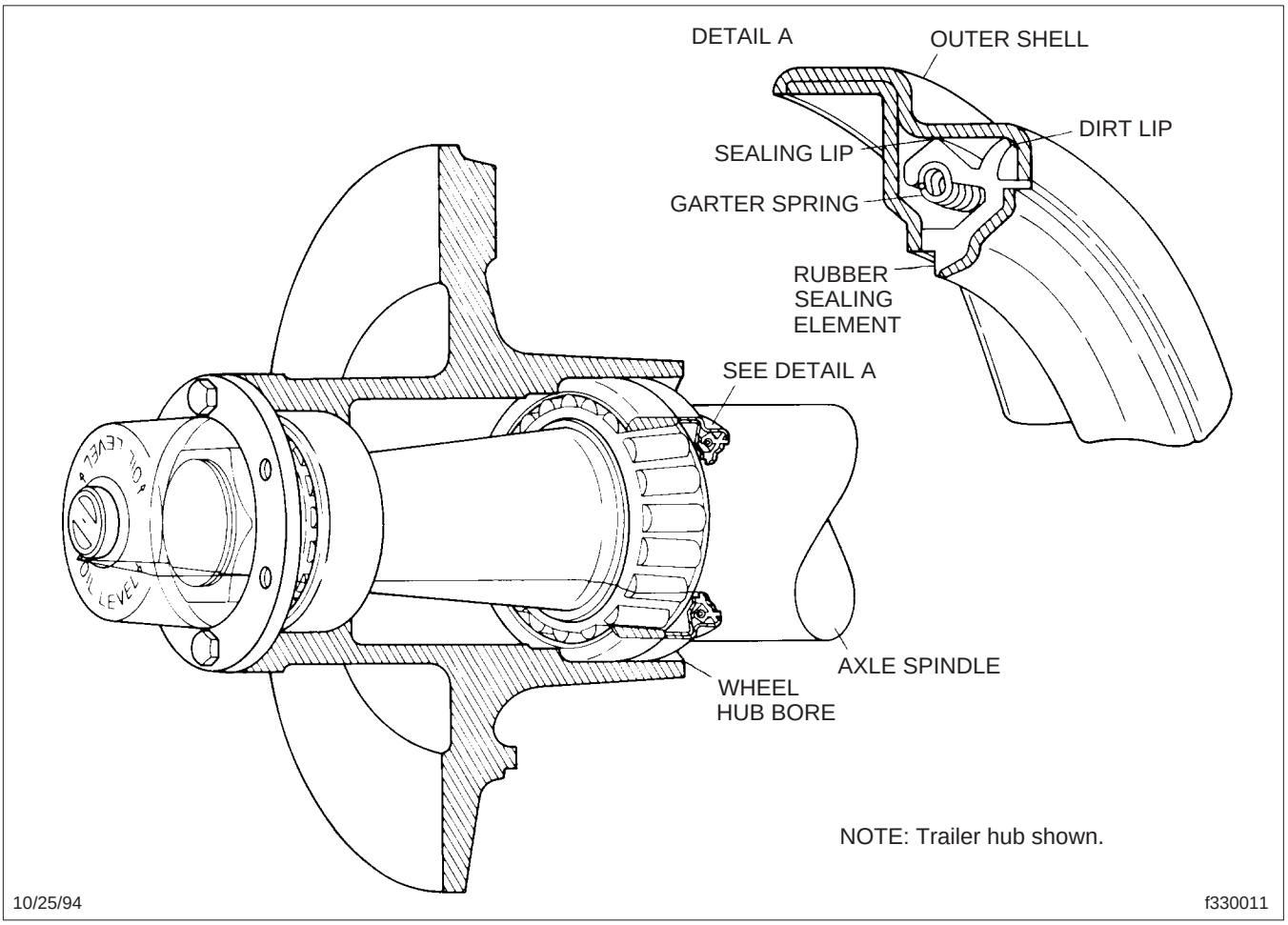


Fig. 1, Wheel Hub and Seal Assembly

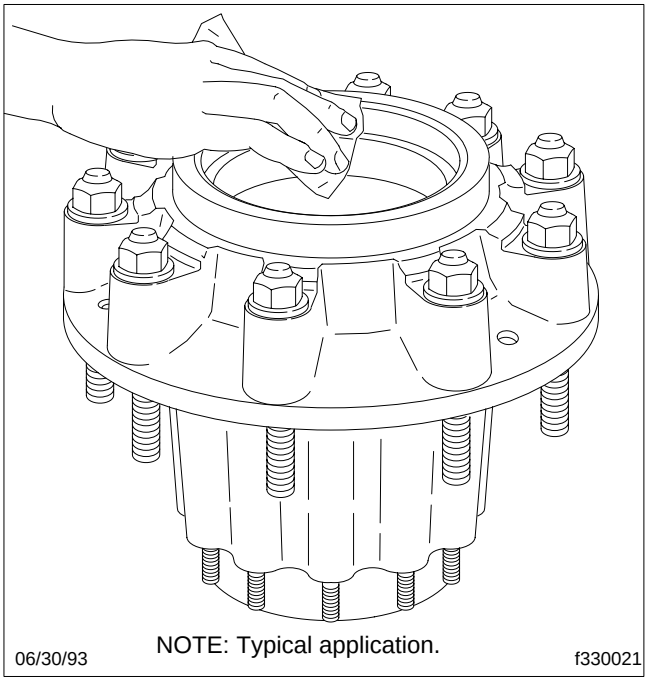
Replacement

Review the front axle section in the vehicle maintenance manual before starting the service operations below. It provides additional instructions and lubricant requirements for oil seal replacement.

1. Remove the wheel, drum, and hub from the axle. Refer to the front axle section in this manual for instructions.
2. Remove the inner wheel bearing assembly from the axle. Handling the bearings with clean dry hands,wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone assembly will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion to catch the bearing assembly. Using a hardwood drift and a light hammer, gently tap the bearing and seal out of the inner wheel bearing cup.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity.
4. Remove all burrs from the shoulder and the seal bore with an emery cloth or a file. See **Fig. 1** and **Fig. 2**. Clean any metal filings from the components.

IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

5. Inspect the bearings and hub components for wear or damage. Replace any worn or damaged components as necessary.
6. Coat the wheel bearing cones with oil.
7. Install the inner wheel bearing cone in the inner wheel bearing cup.
8. Seat the small o.d. of the seal in the recess of the tool adaptor. See **Fig. 3.** The correct adaptor is identified on the box.
9. Insert the centering plug of the tool in the bore of the inner bearing cone. See **Fig. 4.** The plug prevents cocking of the seal in the bore.
10. Hold the tool handle firmly, and strike it until the sound of the impact changes as the seal bottoms out. See **Fig. 5.** Hold the tool firmly to avoid bounce or unseating of the seal from the adaptor.



06/30/93 NOTE: Typical application. f330021

Fig. 1

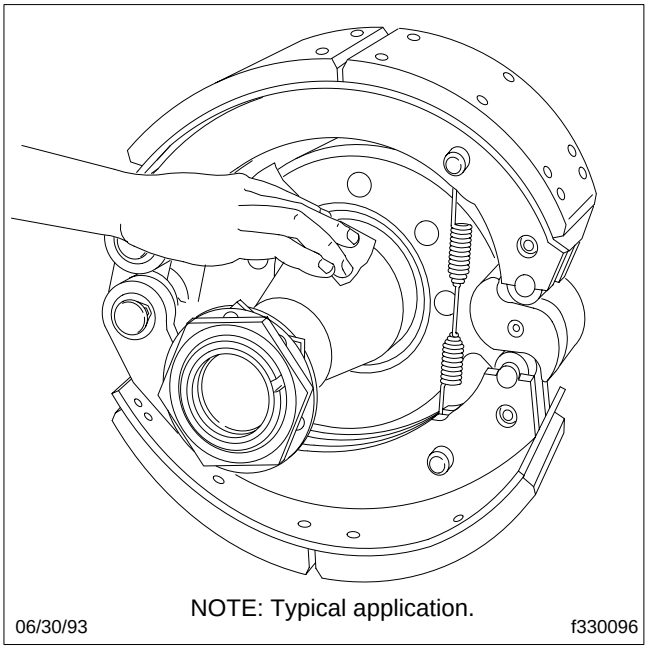


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Fig. 2

Seal Replacement

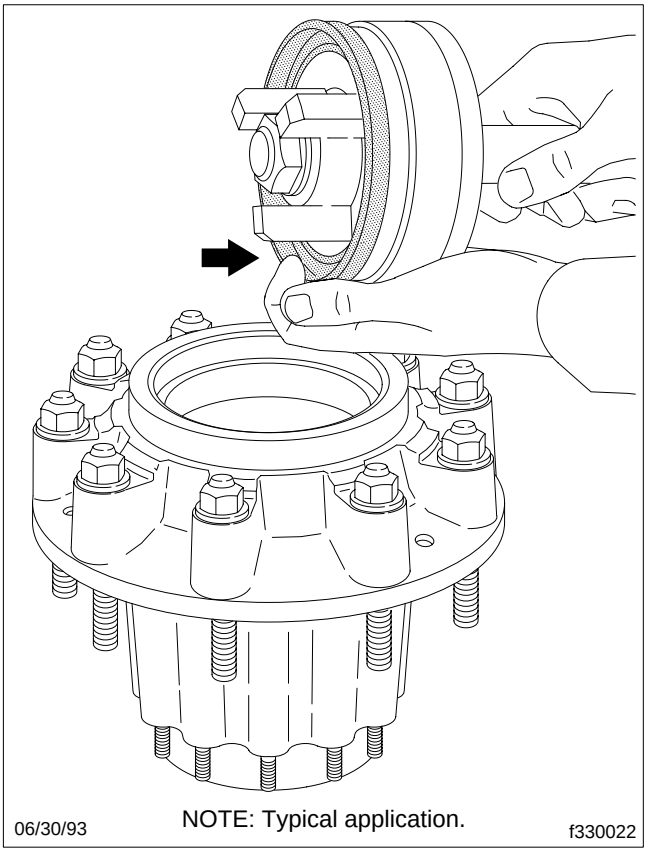


Fig. 3

11. After the seal is bottomed in the bore, check for freedom of movement by manually moving the interior rubber part of the seal backwards and forward. A slight movement indicates a damage-free installation.
12. Fill the wheel cavity between the bearings with oil.
13. Install the wheel hub on the axle. Adjust the wheel bearings. For instructions, refer to the front axle section in this manual.

IMPORTANT: When starting the wheel on the spindle, center the hub carefully to avoid seal damage from the leading edge of the spindle.

14. Place the hubcap and a new gasket in position, then install the capscrews. Tighten the capscrews 15 lbf·in (20 N·m).
15. Fill the hub with oil to the level shown on the hubcap. See **Fig. 6.** Do not overfill.

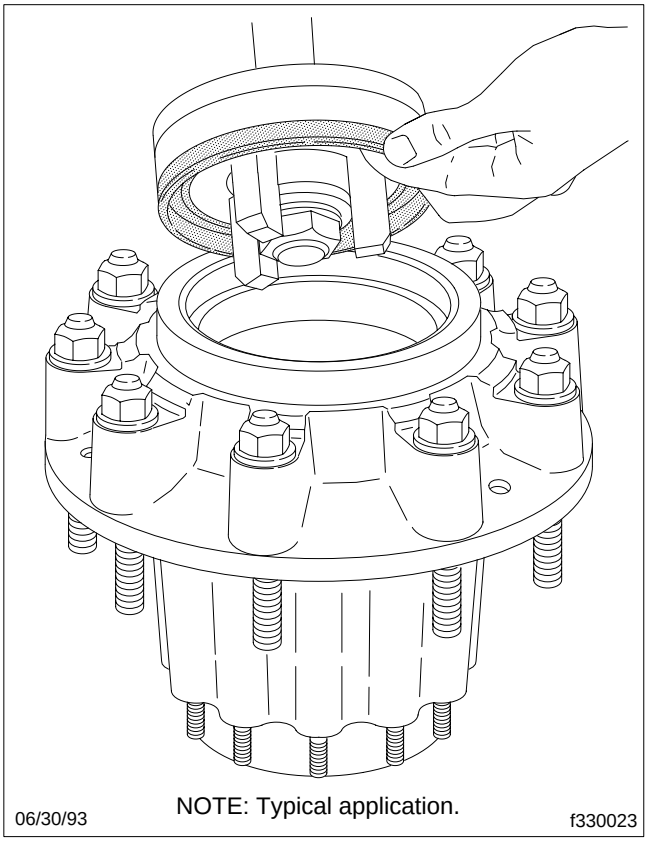
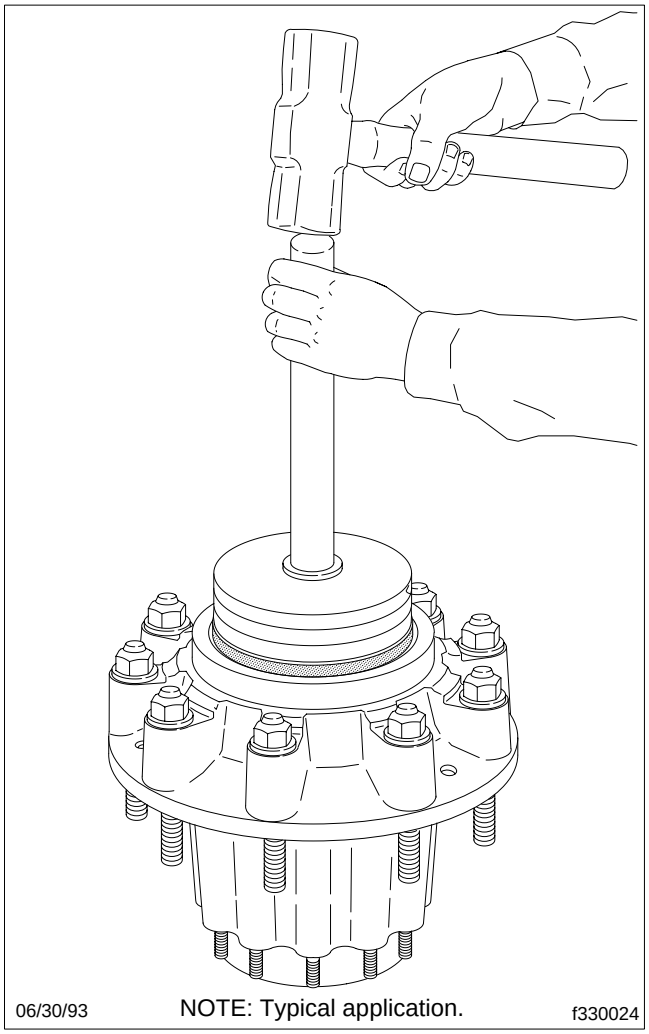


Fig. 4

16. Spin the wheel and check the oil level.
17. Adjust the brake shoe-to-drum clearance. For instructions, refer to the brake section in the vehicle maintenance manual.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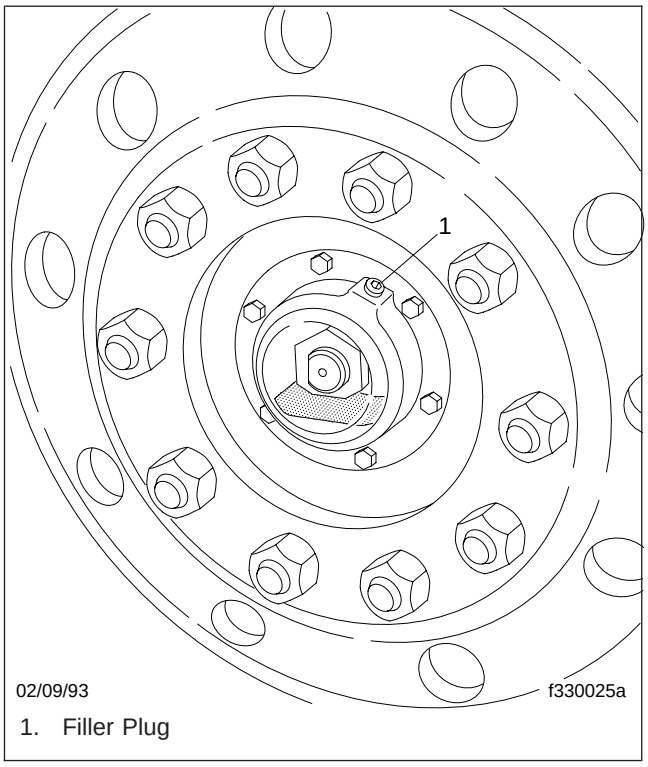
NOTE: Typical application.
f330024

Fig. 5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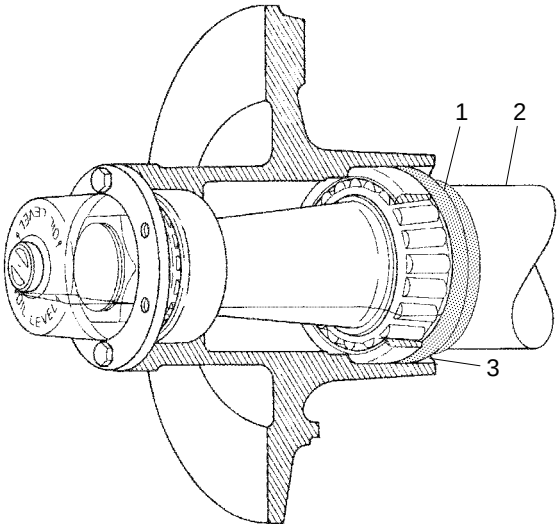
1. Filler Plug

Fig. 6

General Description

Oil seals keep oil in the hub to lubricate the wheel bearings. They also protect the wheel bearings from dirt, dust, and water. The oil seal fits between the hub bore and the axle spindle. **See Fig. 1** .



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1. Oil Seal
2. Axle Spindle
3. Wheel Hub Bore

Fig. 1

Replacement

Review the front axle section in the vehicle maintenance manual before beginning the service operations below. It provides additional instructions and the lubricant requirements for oil seal replacement.

1. Remove the wheel, drum, and hub from the axle. For instructions, refer to the front axle section in this manual.
2. Remove the old oil seal from the hub or spindle.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity.

⚠ CAUTION

CAUTION: Never use a sharp chisel to cut through an axle ring. A sharp chisel could damage the spindle or shoulder.

4. Remove the steel axle ring by striking the ring surface several times with a ball-peen hammer (**see Fig. 1**). The stretched axle ring can then be removed from the spindle.

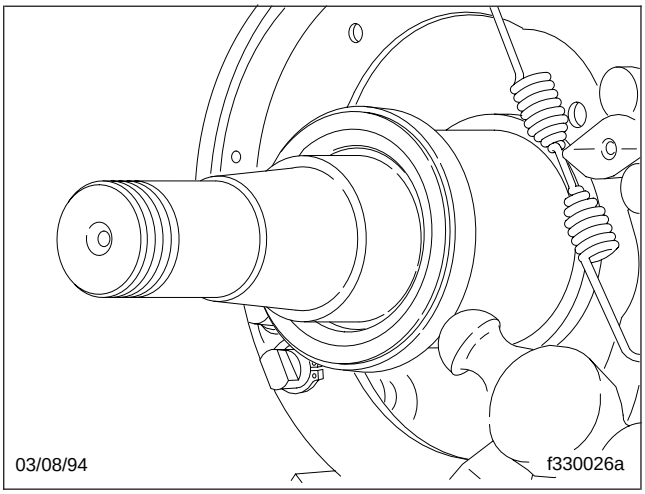


Fig. 1

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

5. Using a wire brush, remove any old sealant and corrosion from the axle spindle and shoulder. Remove any burrs with an emery cloth (**see Fig. 2**). Wipe the spindle and shoulder clean with safety solvent.

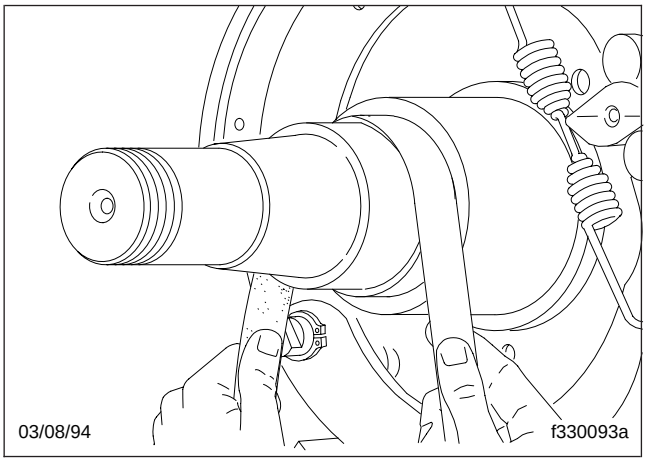
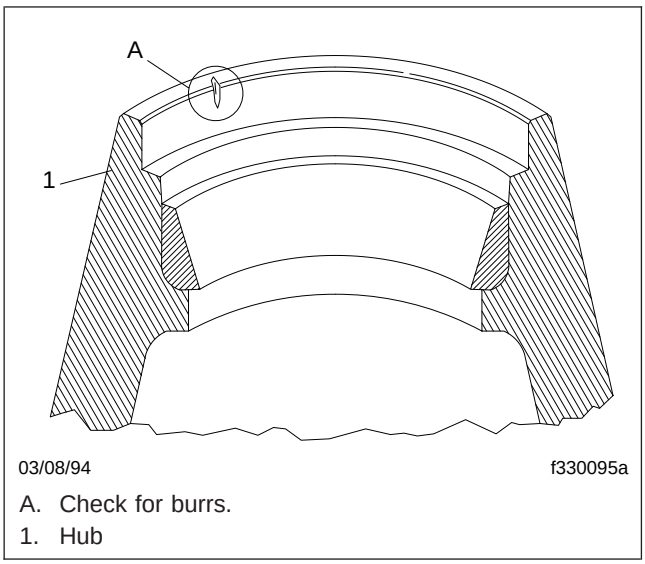


Fig. 2

6. Remove any burrs from the inside of the hub bore (**see Fig. 3**). The hub bore must be free of burrs that will scratch the outer surface of the seal and allow oil to escape from the hub. Remove any spacer rings or washers, if so equipped.



A. Check for burrs.
1. Hub

Fig. 3

Seal Replacement

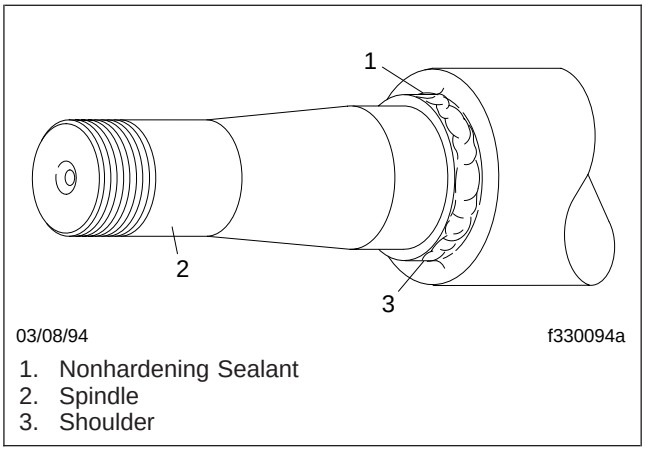
IMPORTANT: Clean the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause rapid wear of the bearing assembly.

7. Inspect the bearings and hub components for wear or damage. Replace any worn or damaged parts as necessary.

⚠ CAUTION

CAUTION: Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

8. If burrs were removed from the spindle shoulder, apply a thin layer of nonhardening sealant to the spindle shoulder. **See Fig. 4.**



1. Nonhardening Sealant
2. Spindle
3. Shoulder

Fig. 4

NOTE: Use a nonhardening sealant such as Permatex® Number-2 or Loctite® 515.

9. Place the oil seal on the spindle so the words "oil-bearing side" are exposed to the oil. A slight step on the inside circumference of the seal ring will allow it to be placed by hand about 1/8 inch (3 mm) onto the shoulder. **See Fig. 5**.

⚠ CAUTION

CAUTION: Do not install the oil seal in the hub bore. Incorrect seal installation will damage the seal and lead to possible spindle, hub, and bearing damage.

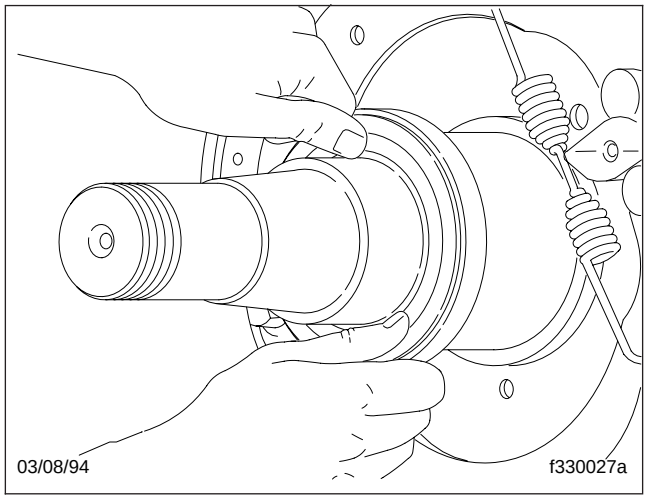


Fig. 5

10. Position the Stemco installation tool over the spindle (**see Fig. 6**). Using a 3 to 5 lb (1 to 2 kg) hammer, drive the seal on the spindle until the tool bottoms against the shoulder. After the tool bottoms, turn it while applying several light taps with the hammer to ensure the seal ring is flush with the face of the shoulder. Wipe off all excess sealant.

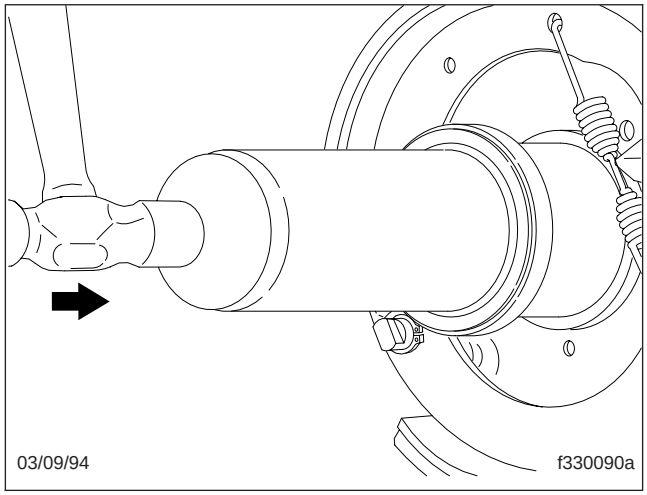


Fig. 6

IMPORTANT: Use only the tool specified by Stemco for the vehicle's front axle. In order for the Stemco warranty to apply, the product must be correctly installed using the correct tool made by Stemco or a tool approved by Stemco.

11. Make sure there aren't any gaps between the ring and shoulder. **See Fig. 7**.

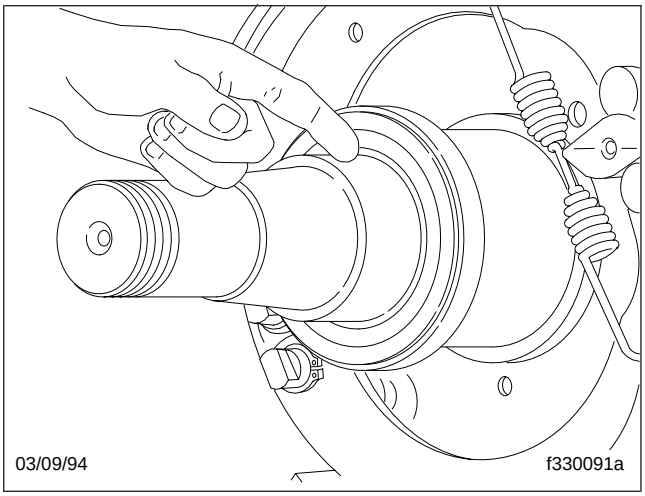


Fig. 7

12. Coat the inner wheel bearing with oil and install it on the spindle (**see Fig. 8**). No additional oil is needed on the outside of the seal. The seals are lubed at the factory.

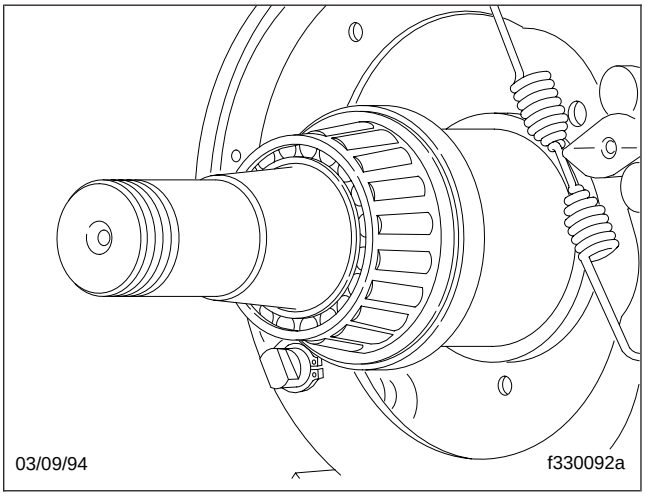


Fig. 8

13. With the wheel mounted on a wheel dolly, align the hub bore with the spindle, then push the wheel onto the spindle until it just contacts the seal (**see Fig. 9**). Coat the outer bearing with oil and place it on the spindle and into the bearing cup.

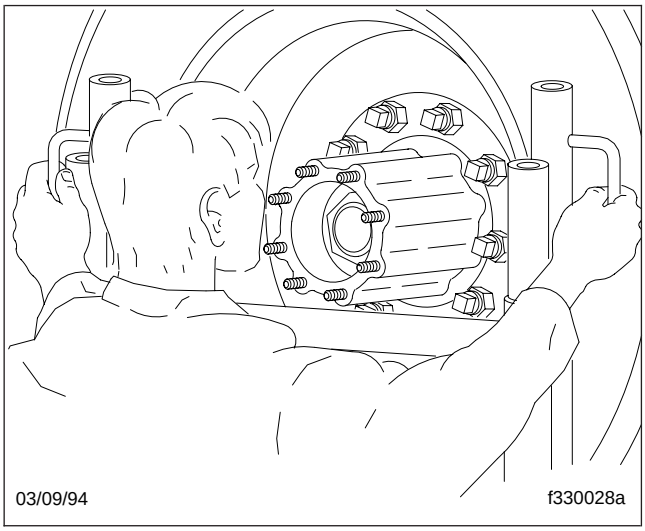


Fig. 9

IMPORTANT: Do not force the wheel onto the seal. The wheel will seat on the seal when the adjustment nut is tightened.

14. Adjust the wheel bearings. For instructions, refer to the front axle section in this manual.

15. Install the hub cap with a new gasket. Tighten the hub cap nuts 15 lbf·ft (20 N·m) (**see Fig. 10**). Add oil to the level shown on the window (**see Fig. 11**), about 1 to 1-1/2 pints (0.5 to 0.7 L). Turn the hub and allow the oil to settle. Recheck the hub and fill to a level from the oil line to about 1/4 inch (6 mm) above the oil line. Do not overfill the hub. Install the vent plug or threaded filler plug.

16. Spin the wheel and check the oil level.

17. Adjust the brake shoe-to-drum clearance. For instructions, refer to the brake section in the vehicle maintenance manual.

Seal Replacement

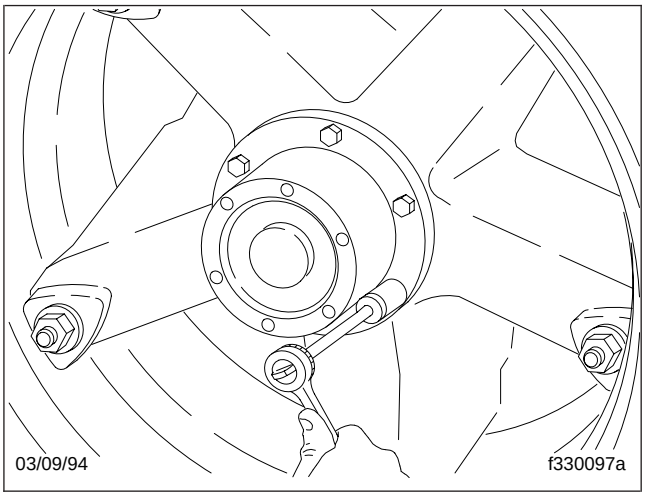


Fig. 10

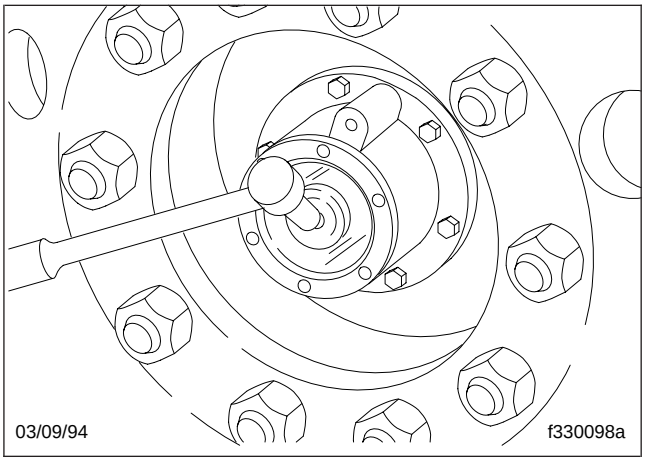


Fig. 11

General Information

The front axle full-floating wheel hub assembly is made up of four major components: tapered wheel bearings, the wheel hub, wheel studs, and the brake drum. **See Fig. 1.**

TAPERED WHEEL BEARINGS

A typical tapered wheel bearing assembly consists of a cone, tapered rollers, a roller cage, and a separate cup that is press-fit in the hub. **See Fig. 2.** All components carry the load, with the exception of the cage, which spaces the rollers around the cone.

Each hub has a set of inner and outer tapered wheel bearing assemblies. The bearing setting is locked in place on the axle spindle (steering knuckle) by an adjusting nut and jam nut, or a Pro-Torq® nut and lockring. **See Fig. 3.**

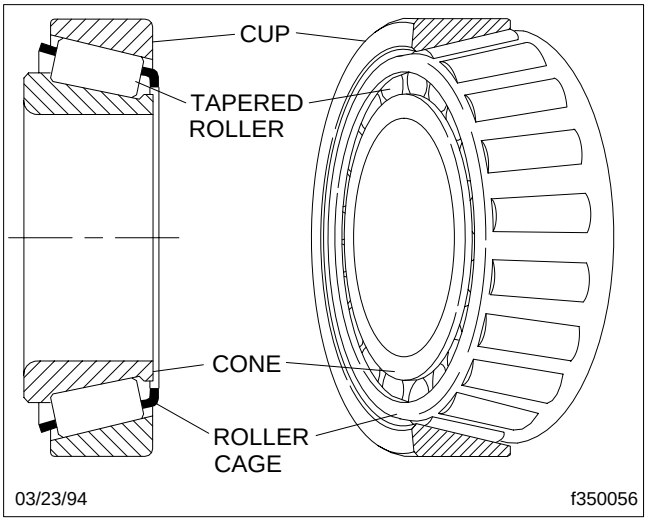


Fig. 2, Tapered Wheel Bearing Assembly

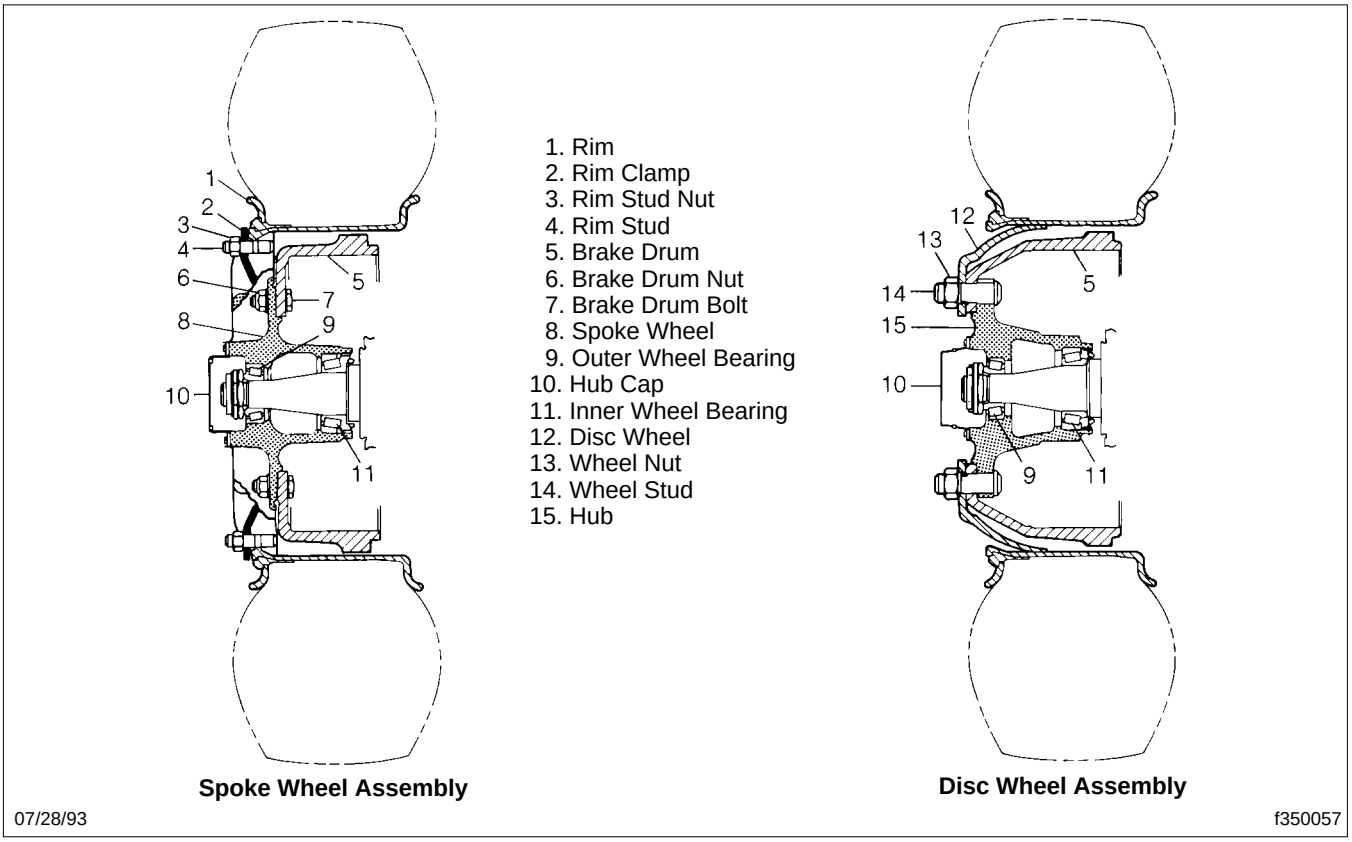
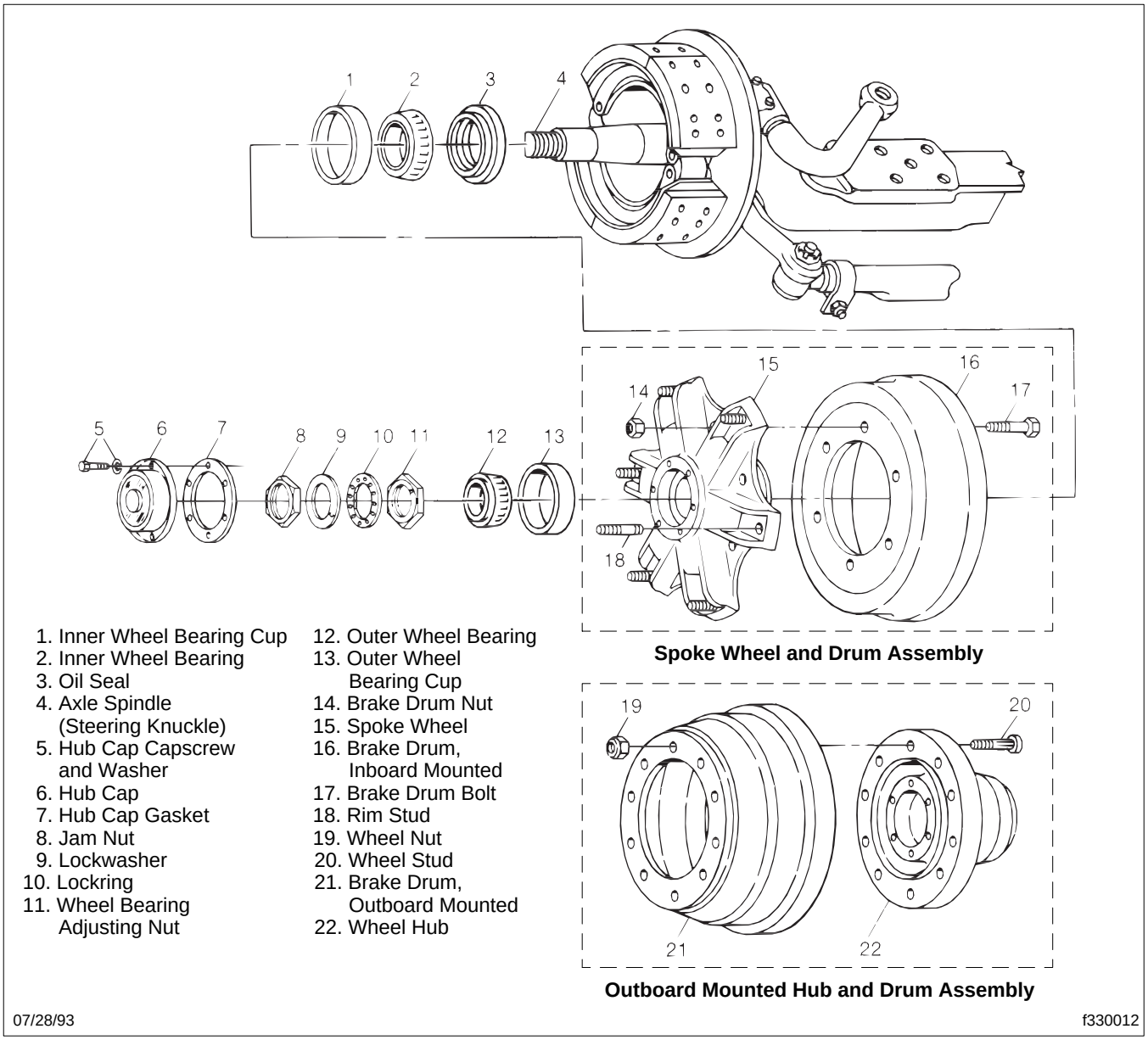


Fig. 1, Sectional View of Spoke and Disc Wheel Assemblies

General Information



1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle (Steering Knuckle)
5. Hub Cap Capscrew and Washer
6. Hub Cap
7. Hub Cap Gasket
8. Jam Nut
9. Lockwasher
10. Lockring
11. Wheel Bearing Adjusting Nut
12. Outer Wheel Bearing
13. Outer Wheel Bearing Cup
14. Brake Drum Nut
15. Spoke Wheel
16. Brake Drum, Inboard Mounted
17. Brake Drum Bolt
18. Rim Stud
19. Wheel Nut
20. Wheel Stud
21. Brake Drum, Outboard Mounted
22. Wheel Hub

Fig. 3, Typical Front Axle

WHEEL HUB

The wheel and the brake drum are mounted on an aluminum or iron wheel hub (**Fig. 4**).

Both the inner and outer wheel bearing cups and the wheel studs are press-fit in the hub.

Spoke wheels combine the wheel and hub into a single unit.

WHEEL STUDS

A headed wheel stud (**Fig. 5**) is used on front axle disc wheel hub assemblies and has either serrations on the stud body or a flat area on the stud's head to prevent the stud from turning in the wheel hub.

The end of the stud that faces away from the vehicle is stamped with an "L" or "R," depending on which

side of the vehicle the stud is installed. Studs stamped with an "L" are left-hand threaded and are installed on the driver's side of the vehicle. Studs stamped with an "R" are right-hand threaded and are installed on the passenger's side of the vehicle.

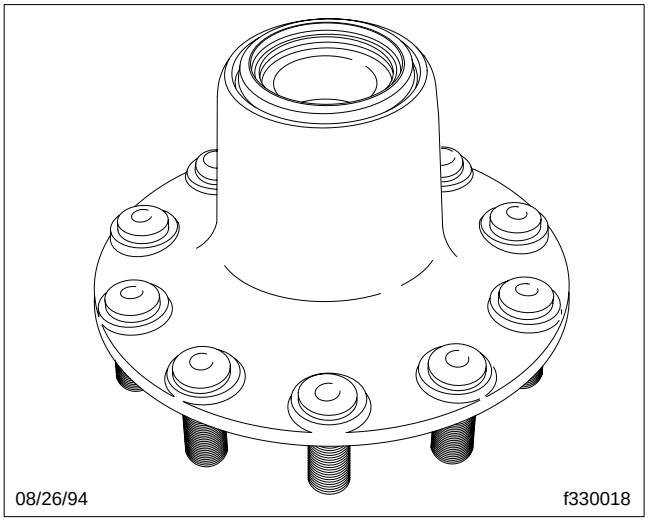


Fig. 4, Front Axle Wheel Hub

Spoke wheels have rim studs. Rim studs are threaded on both ends, with a nonthreaded section midway along the shaft of the stud. The studs are coated with an anaerobic locking compound.

BRAKE DRUM

The brake drum and lining work together as a mated friction pair, with the drum responsible for both heat absorption and dissipation. Lining performance and life largely depend on the condition of the drum and whether it can adequately absorb and dissipate heat generated by braking action.

On spoke wheel assemblies, the brake drum is mounted inboard, and is held in place with bolts. On all other hub and drum assemblies, the brake drum is mounted on the outboard face of the hub and fits over the wheel studs. **See Fig. 3.**

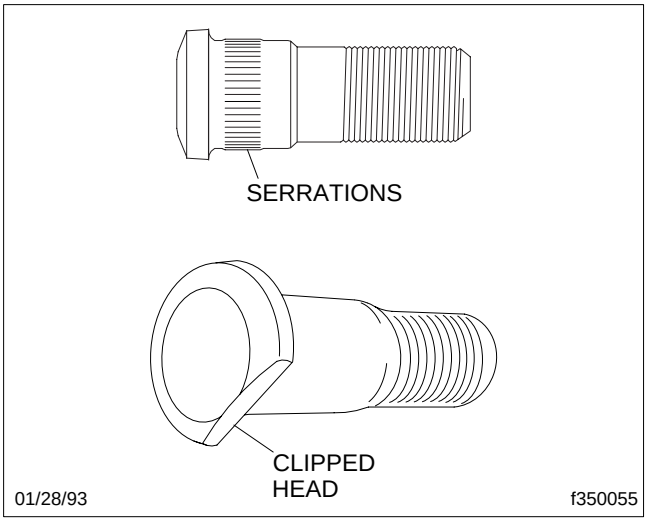


Fig. 5, Typical Wheel Studs

Outboard-Mounted Drum Removal and Installation

WARNING

When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.

For an exploded view of a typical wheel and axle assembly, including the brake drum, see **Fig. 1**.

Removal

1. Chock the rear tires to prevent vehicle movement. Apply the parking brakes.
2. Raise the front of the vehicle until the tires clear the ground. Then place safety stands under the axle.
3. Back off the slack adjuster to release the front axle brake shoes.

WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

4. Remove the wheel and tire assembly. See **Group 40** for instructions.

   To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.
5. Remove the brake drum.
6. Inspect the drum. See **Subject 110** for instructions.

Installation

1. On brake drum assemblies with an aluminum hub, coat the hub and drum contact surfaces with Alumilastic® compound or an equivalent.
2. Install the brake drum on the wheel hub.

   2.1 On hub-piloted drums, position the brake drum on the top step of the pilot pad. One of the hub's pilot pads should be at the twelve o'clock (top center) position. See **Fig. 2**.

   IMPORTANT: If the drum is not positioned correctly, the pilot pad could be damaged when the wheel nuts are torqued.

   2.2 Make sure that the pilot pads securely center the drum (space between drum and hub is equal all around the hub).

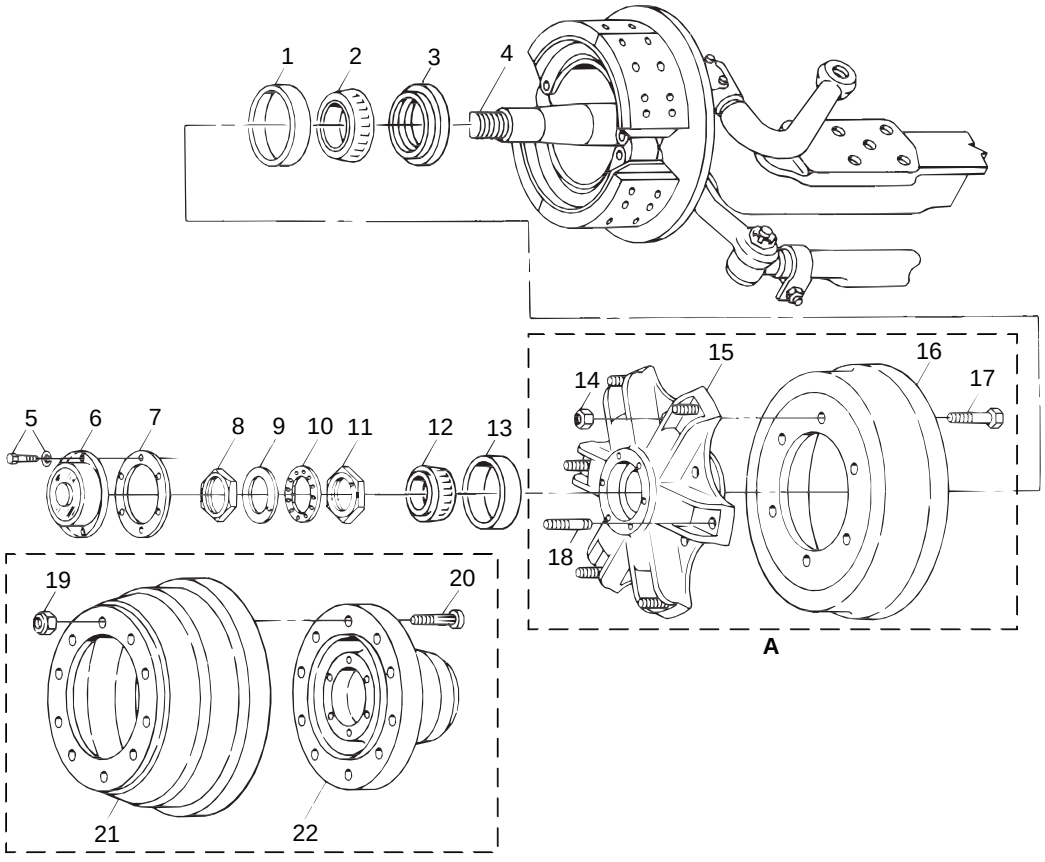
   IMPORTANT: If damage to the pads prevents the drum from centering, replace the hub. If necessary, to hold the drum in position, adjust the brakes before installing the wheels.
3. Install the wheel and tire assembly. To ensure that the drum does not slip off the pilot pad, follow the proper nut tightening sequence. For instructions, see **Group 40**.

WARNING

If the wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking ability, and the hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist, could result in the loss of a wheel or loss of vehicle control, and possible personal injury.

Outboard-Mounted Drum Removal and Installation

4. Adjust the front axle brakes. See Group 42 of the *Heavy-Duty Trucks Maintenance Manual*.
5. Remove the safety stands from under the axle; lower the vehicle.
6. Remove the chocks from the rear tires.

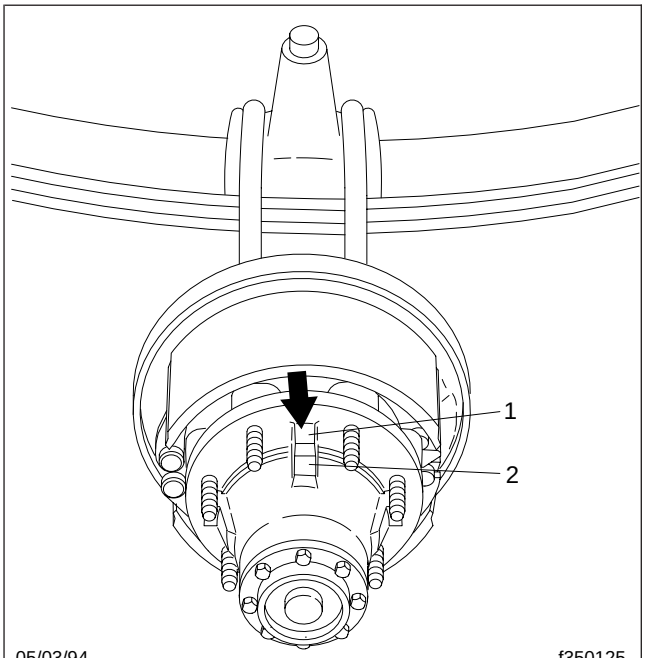


A. Spoke Wheel and Inboard-Mounted Drum Assembly
B. Disc Wheel, Hub, and Outboard-Mounted Drum Assembly

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle (Steering Knuckle)
5. Hub Cap Capscrew and Washer
6. Hub Cap
7. Hub Cap Gasket
8. Jam Nut
9. Lockwasher
10. Lockring
11. Wheel Bearing Adjusting Nut
12. Outer Wheel Bearing
13. Outer Wheel Bearing Cup
14. Brake Drum Nut
15. Spoke Wheel
16. Brake Drum, Inboard-Mounted
17. Brake Drum Bolt
18. Rim Stud
19. Wheel Nut
20. Wheel Stud
21. Brake Drum, Outboard-Mounted
22. Wheel Hub

Fig. 1, Typical Front Axle (exploded view)

Outboard-Mounted Drum Removal and Installation



NOTE: Pilot pad at 12 o'clock position

1. Drum Pilot
2. Wheel Pilot

Fig. 2

Hub Assembly Removal and Installation, Disc Wheels

Removal

1. Chock the rear tires to prevent vehicle movement. Apply the parking brakes.
2. Raise the front of the vehicle until the tires clear the ground. Then place safety stands under the axle.
3. Back off the slack adjuster to release the front axle brake shoes.
4. Remove the wheel and tire assembly. See **Group 40** for instructions.

WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

5. To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.
6. Remove the brake drum. See **Fig. 1**.

NOTE: Oil will spill as the hub cap and wheel hub are removed. Place a suitable container under the axle spindle to catch any spilled oil. Dispose of the oil properly.

7. Remove the capscrews, washers, and hub cap. Remove and discard the hub cap gasket.
8. Remove the axle spindle (steering knuckle) jam nut, lockwasher, and lockring or nut-lock. See **Fig. 2** or **Fig. 3**. If equipped with a Pro-Torq® nut, remove the lockring. See **Fig. 4**.
9. Back off the wheel bearing adjusting nut or Pro-Torq nut about two turns, or enough to allow the weight of the hub to be lifted from the wheel bearings.
10. Lift the hub until all weight is removed from the wheel bearings; remove the adjusting nut or Pro-Torq nut.

CAUTION

Be careful not to let the outer wheel bearing drop from the axle spindle. Dropping the bearing can warp the cage or damage the rollers, ruining the bearing. On vehicles equipped with WABCO ABS, use care when working with the hubs. To prevent damage to the tone wheel, do not drop the hub, or lay it down in a way that would damage the tone wheel.

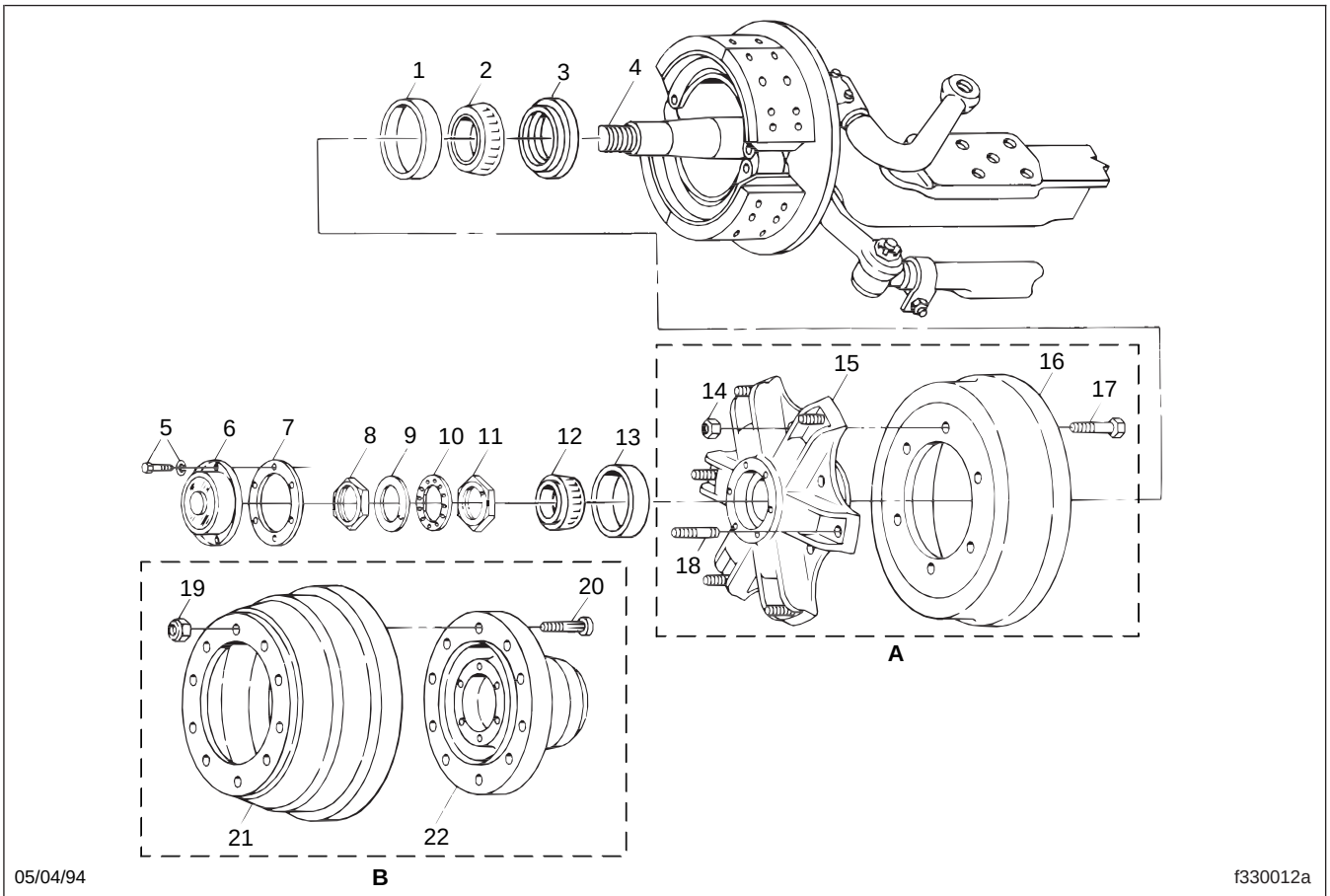
11. Move the hub about 1/2 inch (13 mm) to jar loose the outer wheel bearing (allow the hub-only assembly to rest on the axle spindle; be careful not to damage the axle spindle threads).
12. Carefully remove the outer wheel bearing; handle the bearings with clean, dry hands. Wrap the bearings in either clean oil-proof paper or lint-free rags.

CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

13. Remove the hub from the axle spindle. Be careful not to damage the axle spindle threads as the assembly is removed.
14. Remove the inner wheel bearing from the axle; handle the bearings with clean, dry hands. Wrap the bearings in clean, oil-proof paper or lint-free rags. Occasionally, the inner wheel bearing will remain in the hub after the hub is removed. In those cases, place a protective cushion where it will catch the bearings. Use a hardwood drift and a light hammer to gently tap the bearing (and seal, if necessary) out of the cup.
15. Remove the oil seal from the axle spindle, if not already removed. See the applicable front axle oil seal section in this manual for additional information.
16. Clean any metal filings from the parts. For instructions, see **Subject 110**.

Hub Assembly Removal and Installation, Disc Wheels



A. Spoke Wheel and Drum Assembly

B. Outboard Mounted Hub and Drum Assembly

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle (Steering Knuckle)
5. Hub Cap Capscrew and Washer
6. Hub Cap
7. Hub Cap Gasket
8. Jam Nut
9. Lockwasher
10. Lockring
11. Wheel Bearing Adjusting Nut
12. Outer Wheel Bearing
13. Outer Wheel Bearing Cup
14. Brake Drum Nut
15. Spoke Wheel
16. Brake Drum, Inboard Mounted
17. Brake Drum Bolt
18. Rim Stud
19. Wheel Nut
20. Wheel Stud
21. Brake Drum, Outboard Mounted
22. Wheel Hub

Fig. 1, Typical Front Axle

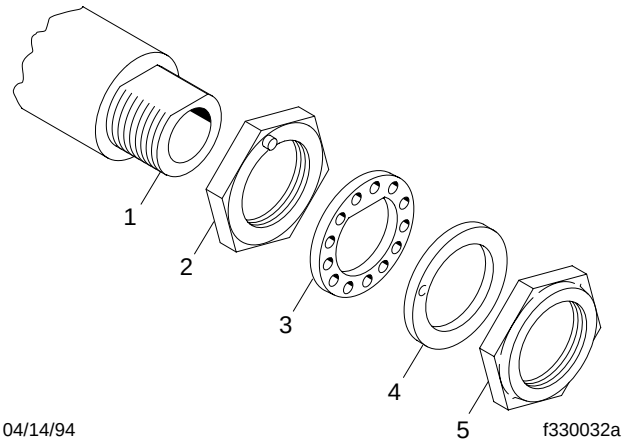
Installation

⚠ WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

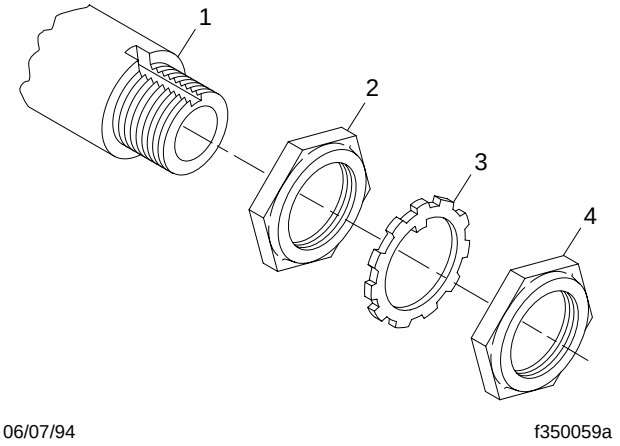
1. Using cleaning solvent, remove the old oil from the axle spindle (steering knuckle) and the disassembled parts. Allow the parts to dry, or dry them with a clean, absorbent, and lint-free cloth or paper. Wrap a protective layer of friction tape on the axle spindle threads.

Hub Assembly Removal and Installation, Disc Wheels



1. Axle Spindle
2. Adjusting Nut
3. Lockring
4. Lockwasher
5. Jam Nut

Fig. 2, Axle With Jam Nut and Lockring



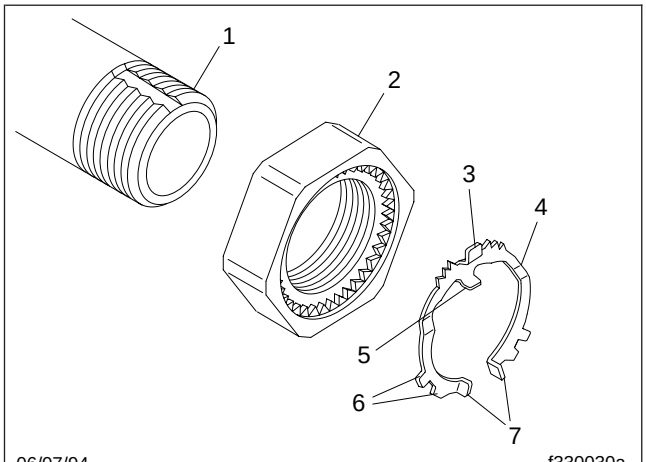
1. Axle Spindle
2. Adjusting Nut
3. Nut-Lock
4. Jam Nut

Fig. 3, Axle With Jam Nut and Nut-Lock

2. On brake drum assemblies with an aluminum hub, coat the hub and drum contact surfaces with Alumilastic® compound or an equivalent.

CAUTION

Make sure that both bearing assemblies are coated with fresh oil. Use only fresh oil on the bearing assemblies; old oil could be contaminated with dirt or water (both are corrosives) and could cause damage to both wheel bearing assemblies and the wheel hub.



1. Axle Spindle
2. Pro-Torque Nut
3. Keeper Tab
4. Lockring
5. Keyway Tab
6. Keeper Arms
7. Keeper Projections

Fig. 4, Axle With Pro-Torq Nut

3. Coat both bearing assemblies with fresh oil. Install the inner wheel bearings and oil seal. Handle the bearings with clean, dry hands. Refer to the applicable section for oil seal installation instructions. For lubricant specifications, see **Specifications, 400**.
4. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing.

CAUTION

On vehicles equipped with WABCO ABS, use care when installing the hubs. To prevent damage to the tone wheel, do not drop the hub or lay it down in a way that would damage the tone wheel.

5. Carefully mount the hub and inner wheel bearing assembly on the axle spindle. Be careful not to unseat the inner wheel bearing or seal.
6. Fill the hub cavity with oil, then install the outer wheel bearing; handle the bearings with clean, dry hands. Use care not to damage the bearings as they are seated in the bearing cups. Remove the friction tape from the axle spindle threads.

Hub Assembly Removal and Installation, Disc Wheels

NOTE: If the axle is equipped with Pro-Torq nuts (see **Fig. 4**), skip the next four steps, and go to the step for installing the Pro-Torq nuts.

7. If the axle is equipped with adjusting nuts and jam nuts (see **Fig. 2** or **Fig. 3**), install the wheel bearing adjusting nut.

   7.1 After the wheel hub and bearings are assembled on the spindle, tighten the inner adjusting nut finger-tight.

   IMPORTANT: Be sure there is sufficient clearance between the brake shoe and the brake drum, so brake shoe drag will not interfere with bearing adjustment.

   7.2 While rotating the wheel hub assembly, tighten the inner adjusting nut 100 lbf·ft (136 N·m).

   7.3 Back off the adjusting nut completely.

   7.4 Tighten the adjusting nut 20 lbf·ft (27 N·m) while rotating the wheel hub assembly.

   7.5 Back off the adjusting nut one-third turn.

   NOTE: If you're securing the wheel bearings with a pierced lockring and no hole in the lockring aligns with the dowel on the adjusting nut, remove the lockring, turn it over and install it, again. If a hole still doesn't align with the dowel, loosen the adjusting nut, but only enough to align the dowel with a hole in the lockring.

8. Install the locking device and jam nut.

   8.1 Install the locking device.

   NOTE: The locking device can be any one of the following types:

   - Tanged nut-lock
   - Lockring
   - Lockwasher *and* lockring
   - Nut-lock *and* lockring

   8.2 Install the jam nut, and tighten it to the applicable torque in **Table 1**.

9. With the jam nut installed and tightened, adjust the bearings.

   IMPORTANT: Do not adjust the wheel bearings with the wheel mounted on the hub. You cannot accurately adjust or measure bearing end play with the wheel mounted on the hub.

   9.1 Attach a dial indicator to the hub and set the point of the indicator in line with the end of the axle spindle.

   If using aluminum hubs, you may have to install the brake drum on the hub to provide a steel base for the magnet of the dial indicator. Mount the drum on the hub's drum pilot, then adjust the brake or have someone apply the brakes to hold the drum securely while you secure the drum using the stud at the 12 o'clock position, then the studs at about the 4 o'clock and 8 o'clock positions.

Dual-Nut Wheel Bearing Lock Torque Values		
Application	**Size**	**Torque: lbf·ft (N·m)**
Adjusting Nut	—	Stage 1: Tighten to 100 (135)
		Stage 2: Back Off Completely
		Stage 3: Tighten to 20 (25) While Rotating Hub
		Stage 4: Back Off 1/3 Turn

Hub Assembly Removal and Installation, Disc Wheels

Dual-Nut Wheel Bearing Lock Torque Values		
Application	**Size**	**Torque: lbf·ft (N·m)**
Jam Nut (with Wheel Bearing Nut, Pierced Lockwasher, and Bendable Lockwasher)	1-1/8	Target: 175 (235) Permissible Range: 150–225 (205–305)
	1-1/2 to 2-1/2	Target: 250 (340) Permissible Range: 200–300 (270–405)
	2-5/8 or Larger	Target: 325 (440) Permissible Range: 250–400 (340–540)

Table 1, Dual-Nut Wheel Bearing Lock Torque Values

NOTE: If using a stud-piloted hub and a steel drum, install 1–1/4 inch washers between the nuts and the drum.

9.2 Release the brakes if you used them to hold the drum while installing it.

9.3 Grip the sides of the hub at the three o'clock and nine o'clock positions. Push in on the hub (and drum, if applicable), to seat the inboard bearing set. Zero the dial indicator.

9.4 Once more, grip the sides of the hub at the three o'clock and nine o'clock positions. This time, pull out on the hub (and drum, if applicable). Read the dial indicator, and note the end play.

9.5 Push the hub back in to confirm that the needle of the dial indicator returns to zero.

10. The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm). If the end play is not within this range, adjust the end play.

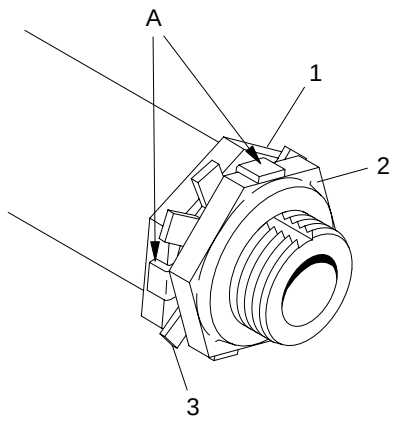
10.1 Remove the jam nut and locking device, and back off or tighten the inner adjusting nut.

IMPORTANT: *If you're using a nut-lock,* turning the adjusting nut 1/4 turn will change the end play about 0.014 inch (0.36 mm).

If you're using a lockring, turning the adjusting nut one lockring hole will change the end play about 0.005 inch (0.13 mm). If you take the lockring off and reverse it, then turn the adjusting nut to the next hole, this will change the end play about 0.0025 inch (0.064 mm).

10.2 Install the locking device and jam nut as described earlier, and measure the end play. If the end play is not between 0.001 and 0.005 inch (0.03 and 0.13 mm), turn the inner adjusting nut again.

10.3 Once the end play is correct, bend the nut-lock (see **Fig. 5**) or lockwasher, as applicable, to lock the jam nut and/or adjusting nut in place.



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A. Bend only each tang that is at a right angle to a flat.

1. Wheel Bearing Adjusting Nut
2. Wheel Bearing Jam Nut
3. Wheel Bearing Adjusting Nut-Lock

Fig. 5, Wheel Bearing Adjusting Nut-Lock Installation

11. If equipped with Pro-Torq nuts, adjust the wheel bearings as follows (see **Fig. 4**).

Hub Assembly Removal and Installation, Disc Wheels

11.1 Install the Pro-Torq nut, and turn it against the bearing while spinning the wheel.

IMPORTANT: Be sure there is enough clearance between the brake shoes and the brake drum, so brake shoe drag won't interfere with the bearing adjustment.

11.2 Tighten the adjusting nut 90 to 110 lbf·ft (122 to 149 N·m) while spinning the wheel in both directions.

11.3 Loosen the nut to zero torque and spin the wheel a few turns.

11.4 Tighten the nut 50 lbf·ft (68 N·m) while spinning the wheel in both directions.

Back off the nut one-eighth to one-sixth turn.

11.5 Hold the lockring with the keeper projections facing outboard. See **Fig. 6**.

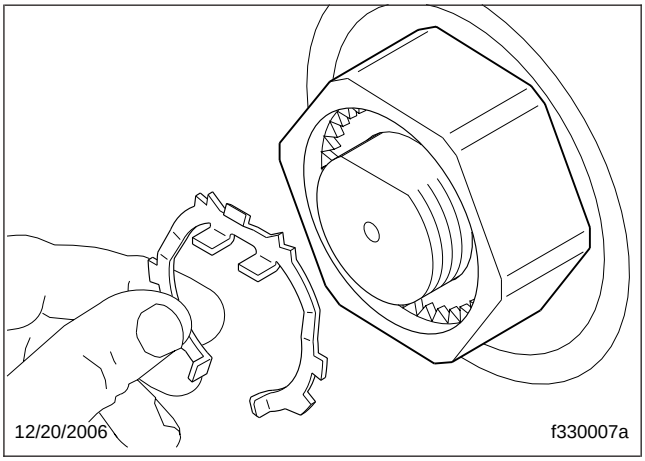


Fig. 6, Lockring Position

11.6 Insert the keeper tab in the undercut groove of the Pro-Torq nut, while pressing the keyway tabs on the flat surface of the axle spindle, engaging the mating teeth.

11.7 Insert a screwdriver, or similar tool, in the undercut groove of the nut, between the keeper arms. Compress the lockring with the tool to lock in place. See **Fig. 7**.

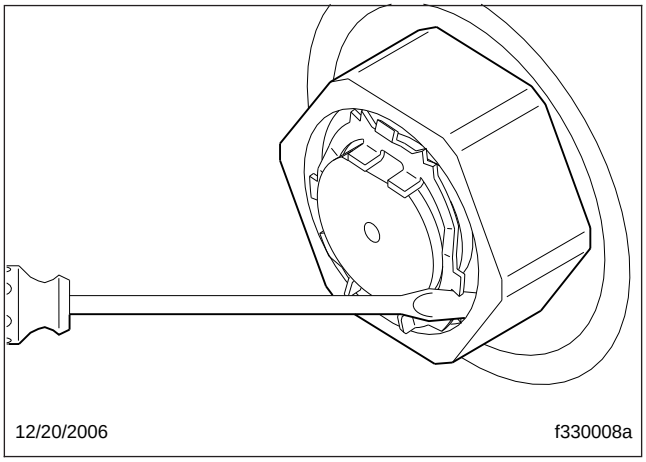


Fig. 7, Compress the Lockring

CAUTION

Do not use pliers or similar devices on the keeper projections to compress the lockring. This could result in damage to or breakage of the lockring.

11.8 Using the screwdriver, press around the edges of the lockring to be sure it is locked in place. See **Fig. 8**.

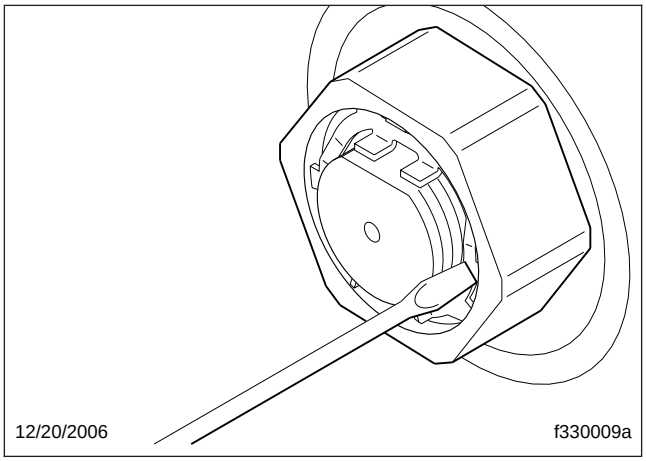


Fig. 8, Make Sure the Lockring is Locked

12. Place the hub cap and a new gasket in position, then install the washers and capscrews. Tighten the capscrews to the torque values in the torque table in **Specifications, 400**.

13. Add fresh oil to the wheel hub to the level indicated on the hub cap. See **Specifications, 400** for the recommended axle lubricants.

⚠ WARNING

Failure to add oil to the wheel hub after the hub has been serviced will cause the wheel bearings to overheat and seize during vehicle operation. See Fig. 9. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

14. Install the brake drum on the wheel hub.

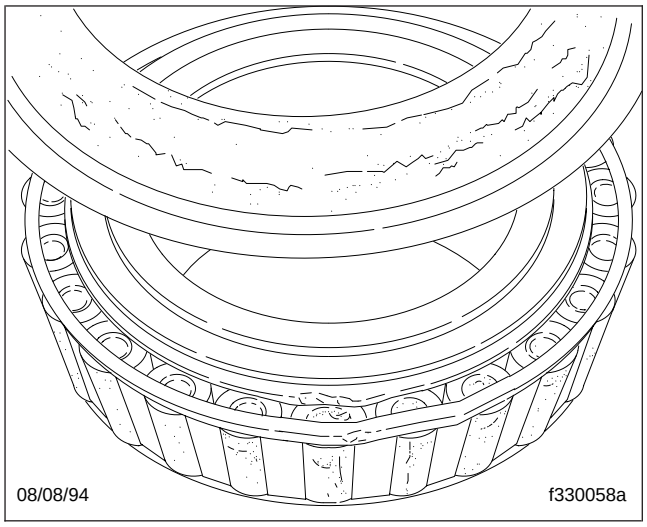


Fig. 9, Bearing Damage Resulting from Inadequate Lubrication

⚠ WARNING

If the wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking action, and the wheel hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist could result in the loss of a wheel or loss of vehicle control, and possible personal injury.

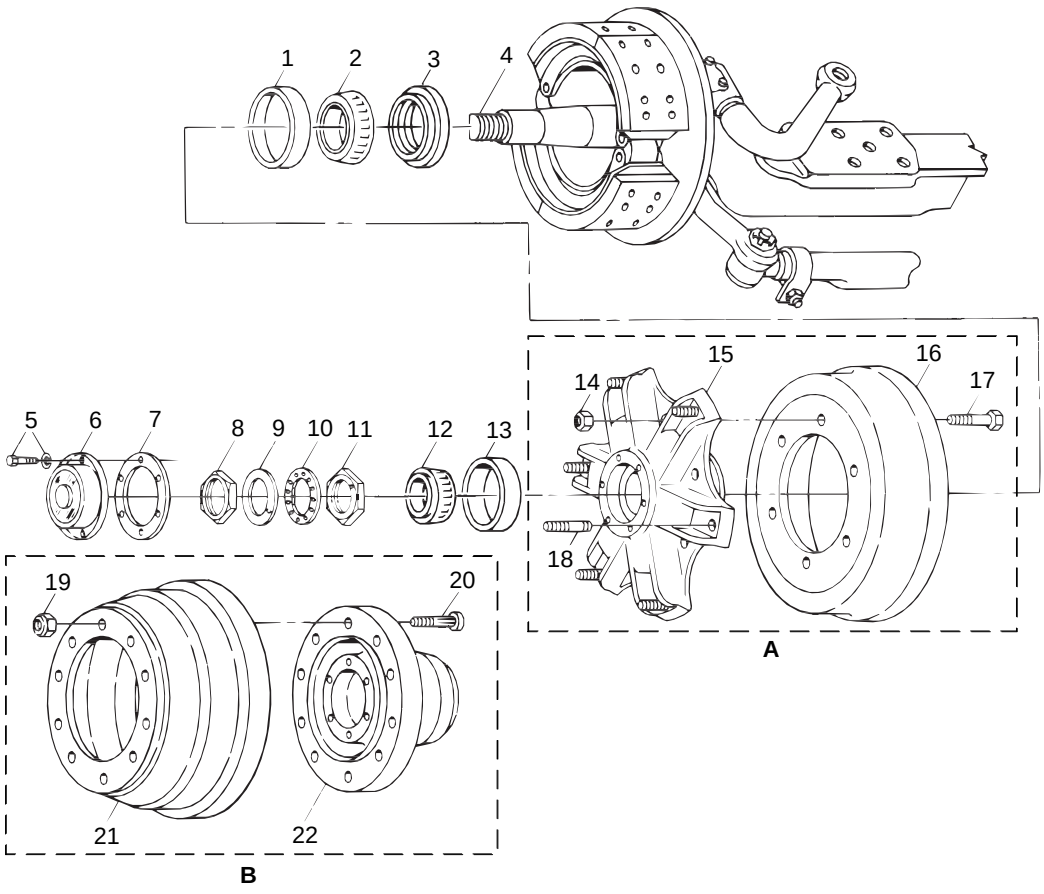
15. Install the wheel and tire assembly. See **Group 40** for instructions.
16. Adjust the front axle brakes. For instructions, see **Group 42** in the *Heavy-Duty Trucks Maintenance Manual*.
17. Remove the safety stands from under the axle and lower the vehicle.
18. Remove the chocks from the rear tires.

Hub Assembly Removal and Installation, Spoke Wheels

Removal (See Fig. 1)

Spoke wheel assemblies do not need to be completely disassembled for brake component maintenance. The tires and rims can remain attached to the wheel, and the wheel to the brake drum. The assembly is then removed from the axle as a single unit to expose brake components. Refer to the brake group of this manual for brake assembly service information.

1. Chock the rear tires to prevent vehicle movement. Apply the parking brakes.
2. Raise the front of the vehicle until the tires clear the ground. Place safety stands under the axle. Position a jack or wheel-and-tire dolly under the tire.
3. Back off the slack adjuster to release the front axle brake shoes.



A. Spoke Wheel and Drum Assembly

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle (Steering Knuckle)
5. Hub Cap Capscrew and Washer
6. Hub Cap
7. Hub Cap Gasket
8. Jam Nut
9. Lockwasher
10. Lockring
11. Wheel Bearing Adjusting Nut
12. Outer Wheel Bearing
13. Outer Wheel Bearing Cup
14. Brake Drum Nut
15. Spoke Wheel

B. Outboard Mounted Hub and Drum Assembly

16. Brake Drum, Inboard Mounted
17. Brake Drum Bolt
18. Rim Stud
19. Wheel Nut
20. Wheel Stud
21. Brake Drum, Outboard Mounted
22. Wheel Hub

Fig. 1, Typical Front Axle

Hub Assembly Removal and Installation, Spoke Wheels

4. Remove the rim and tire assembly. Refer to the wheels and tires section in this manual for instructions.

NOTE: Oil will spill as the hub cap is removed. Place a suitable container under the wheel to catch any spilled oil.

5. Remove the capscrews, washers, and hub cap. Discard the hub cap gasket and oil.
6. Remove the axle spindle (steering knuckle) jam nut, lockwasher, and lockring or nut-lock. If equipped with a Pro-Torq® nut, remove the lockring.
7. Back off the wheel bearing adjusting nut or Pro-Torque nut about two turns, or just enough to allow the weight of the wheel and drum assembly to be lifted from the wheel bearings.
8. Using an adjustable wheeled support, raise the wheel and drum assembly until all weight is removed from the bearings. Remove the adjusting nut, or the Pro-Torq nut.
9. Carefully remove the outer wheel bearing; handle the bearings with clean, dry hands. If the wheel bearings have not loosened from the cup, move the wheel assembly about 1/2 inch (13 mm) to jar loose the outer wheel bearing. Be careful to not drop the bearings. Wrap the bearings in clean oil-proof paper or lint-free rags.

CAUTION

Do not spin the bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

10. Using the wheeled support, pull the wheel assembly away from the vehicle. Be careful not to damage the axle spindle threads as the assembly is removed.

    To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.

WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

11. Remove the brake drum nuts (**Fig. 1**) and detach the brake drum from the wheel.
12. Remove the inner wheel bearing from the axle. Handle the bearings with clean, dry hands. Wrap the bearings in clean oil-proof paper or lint-free rags. Occasionally, the inner wheel bearing will remain in the wheel after the wheel is removed from the axle. In this case, place a protective cushion where it will catch the bearings. Use a hardwood drift and a light hammer to gently tap the bearing (and seal, if necessary) out of the cup.
13. Remove the oil seal from the axle spindle, if not already removed. Refer to the appropriate oil seal section in this group.
14. Go to **Subject 110**.

Installation (See Fig. 1)

WARNING

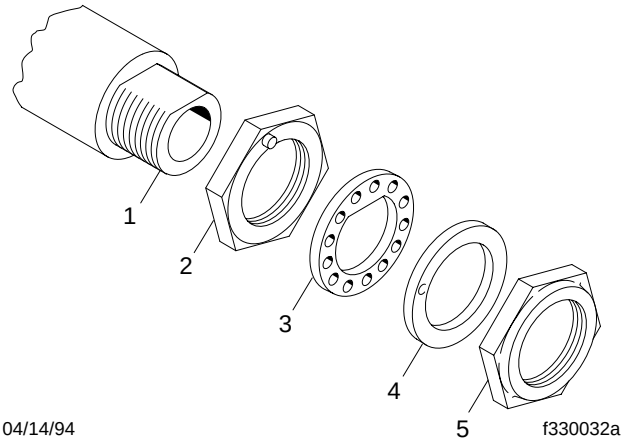
Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

1. Remove the old oil from the axle spindle and also the disassembled axle parts. Inspect and clean the wheel hub cavity and the wheel bearings as instructed in **Subject 110**.
2. Wrap a protective layer of friction tape on the axle spindle threads.

Hub Assembly Removal and Installation, Spoke Wheels

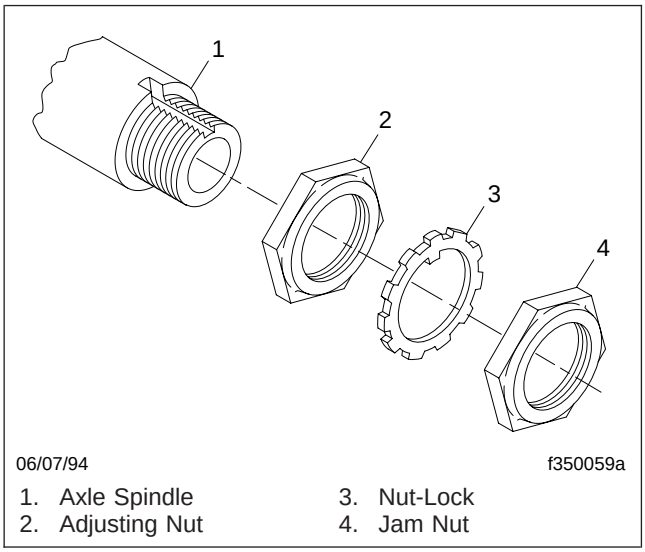
3. If it was removed, attach the wheel to the brake drum. Install the brake drum bolts and nuts, then tighten the nuts to the torque values in the torque table in **Specifications, 400**.
4. Coat both bearing assemblies with fresh oil. Install the inner wheel bearing and oil seal. Handle the bearings with clean, dry hands. For oil seal installation instructions, refer to the applicable section in this group.
5. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing.
6. Using a wheeled support, mount the wheel and drum assembly on the axle spindle; be careful not to unseat the bearings or seal.
7. Fill the hub cavity with oil, and install the outer wheel bearing; handle the bearings with clean, dry hands. Remove the friction tape from the axle spindle threads.
8. If the axle is equipped with Pro-Torq nuts, skip the next three steps, and go to the step for installing the Pro-Torq nuts.

   If the axle is equipped with adjusting nuts and jam nuts (**Fig. 2** or **Fig. 3**), install the wheel bearing adjusting nut. Tighten the nut finger-tight. Adjust the bearings.



1. Axle Spindle
2. Adjusting Nut
3. Lockring
4. Lockwasher
5. Jam Nut

Fig. 2, Axle With Jam Nut and Lockring



1. Axle Spindle
2. Adjusting Nut
3. Nut-Lock
4. Jam Nut

Fig. 3, Axle With Jam Nut and Nut-Lock

IMPORTANT: Be sure there is sufficient clearance between the brake shoe and the brake drum, so brake shoe drag will not interfere with bearing adjustment.

8.1 After the wheel hub and bearings are assembled on the spindle, tighten the inner (adjusting) nut 200 lbf·ft (271 N·m) while rotating the wheel hub assembly.

8.2 Back off the inner nut one full turn.

8.3 Tighten the inner nut 50 lbf·ft (68 N·m) while rotating the wheel hub assembly

8.4 Back off the inner nut one quarter turn.

NOTE: If you're securing the wheel bearings with a pierced lockring and no hole in the lockring aligns with the dowel on the adjusting nut, remove the lockring, turn it over and install it, again. If a hole still doesn't align with the dowel, loosen the adjusting nut, but only enough to align the dowel with a hole in the lockring.

8.5 Install the locking device:

- Tanged nut-lock
- Lockring
- Lockwasher *and* a lockring
- Nut-lock *and* a lockring

Hub Assembly Removal and Installation, Spoke Wheels

Then install the jam nut, and tighten it to the applicable torque in **Table 1**.

Locking Device	Torque: lbf·ft (N·m)	
	1-1/8 to 2-1/2 Inch Jam Nuts	2-5/8 Inch or Larger Jam Nuts
Tanged Nut-Lock	200 to 300 (271 to 407)	
Lockring		
Tanged Nut-Lock and Lockring	200 to 300 (271 to 407)	250 to 400 (339 to 542)
Lockwasher and Lockring		

Table 1, Jam Nut Torques

IMPORTANT: Do not adjust the wheel bearings with the wheel mounted on the hub. You cannot accurately adjust or measure bearing end play with the wheel mounted on the hub.

8.6 With the jam nut installed and tightened, attach a dial indicator to the hub and set the point of the indicator in line with the end of the axle spindle.

If using aluminum hubs, you may have to install the brake drum on the hub to provide a steel base for the magnet of the dial indicator. Mount the drum on the hub's drum pilot, then adjust the brake or have someone apply the brakes to hold the drum securely while you secure the drum using the stud at the 12 o'clock position, then the studs at about the 4 o'clock and 8 o'clock positions.

NOTE: If using a stud-piloted hub and a steel drum, install 1–1/4 inch washers between the nuts and the drum.

8.7 Release the brakes if you used them to hold the drum while installing it.

Grip the sides of the hub at the three o'clock and nine o'clock positions, then push the hub (and drum, if applicable), to seat the inboard bearing set. Zero the dial indicator.

Grip the sides of the hub at the three o'clock and nine o'clock positions, then pull the hub (and drum, if applicable). Read the dial indicator, and note the end play.

Push the hub back in to confirm that the needle of the dial indicator returns to zero.

The end play must be between 0.001 and 0.005 inch (0.025 and 0.127 mm).

9. If the end play is not within this range, remove the jam nut and locking device, and back off or tighten the inner (adjusting) nut to adjust the end play. Keep the following in mind:

If you're using a nut-lock: turning the inner nut 1/4 turn will change the end play about 0.014 inch (0.355 mm).

If you're using a lockring: turning the inner nut one lockring hole will change the end play about 0.005 inch (0.127 mm). If you take the lockring off and reverse it, then turn the inner nut to the next hole, this will change the end play about 0.0025 inch (0.0635 mm).

Install the locking device and jam nut as described earlier, and measure the end play. If the end play is not between 0.001 and 0.005 inch (0.025 and 0.127 mm), adjust the inner (adjusting) nut, again.

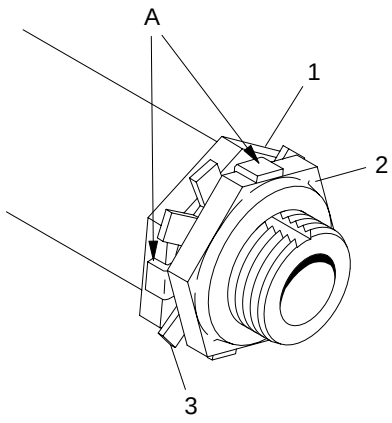
10. Once the end play is correct, bend the nut-lock (see **Fig. 4**) or lockwasher as applicable to lock the jam nut and/or adjusting nut in place.

11. If equipped with Pro-Torq nuts, adjust the wheel bearings (see **Fig. 5**).

11.1 Install the Pro-Torq nut, and turn it against the bearing while spinning the wheel.

IMPORTANT: Be sure there is enough clearance between the brake shoes and the

Hub Assembly Removal and Installation, Spoke Wheels



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A. Bend only each tang that is at a right angle to a flat.
1. Wheel Bearing Adjusting Nut
2. Wheel Bearing Jam Nut
3. Wheel Bearing Adjusting Nut-Lock

Fig. 4, Wheel Bearing Adjusting Nut-Lock Installation

brake drum, so brake shoe drag won't interfere with the bearing adjustment.

11.2 Tighten the adjusting nut 90 to 110 lbf·ft (122 to 149 N·m) while spinning the wheel in both directions.

11.3 Loosen the nut to zero torque and spin the wheel a few turns.

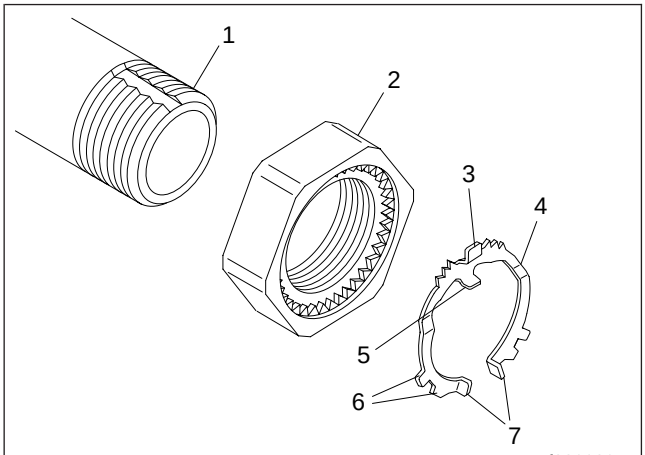
11.4 Tighten the nut 50 lbf·ft (68 N·m) while spinning the wheel in both directions. Back off the nut one-eighth to one-sixth turn.

11.5 Hold the lockring with the keeper projections facing outboard. See **Fig. 6**.

11.6 Insert the keeper tab in the undercut groove of the Pro-Torq nut, while pressing the keyway tabs on the flat surface of the axle spindle, engaging the mating teeth.

11.7 Insert a screwdriver, or similar tool, in the undercut groove of the nut, between the keeper arms. Compress the lockring with the tool to lock in place. See **Fig. 7**.

Using the screwdriver, press around the edges of the lockring to be sure it is locked in place. See **Fig. 8**.



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1. Axle Spindle
2. Pro-Torque Nut
3. Keeper Tab
4. Lockring
5. Keyway Tabs
6. Keeper Arms
7. Keeper Projections

Fig. 5, Axle With Pro-Torq Nut

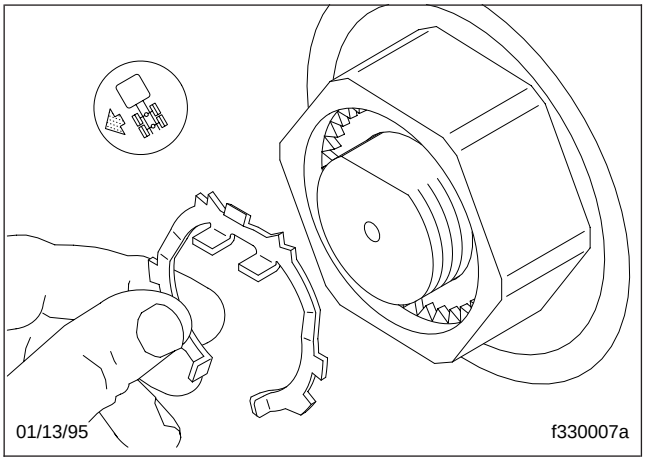

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Fig. 6, Lockring Position, Disc Wheel Shown

CAUTION

Do not use pliers or similar devices on the keeper projections to compress the lockring. This could result in damage or breakage of the lockring.

12. Place the hub cap, with a new gasket, in position. Install the washers and capscrews. Tighten the capscrews to the torque values in the torque table in **Specifications, 400**.

Hub Assembly Removal and Installation, Spoke Wheels

13. Install the rim and tire assembly. Refer to the wheels and tires section in this manual for instructions.

⚠ WARNING

If the rim nuts cannot be tightened to minimum torque values, the rim studs have lost their locking ability, and the wheel hub flange is probably damaged. In this case, replace it with a new wheel. Failure to replace the wheel when the conditions described above exist could result in loss of a wheel or loss of vehicle control, and possible personal injury.

14. Lower and remove the jack or wheel-and-tire dolly from under the tires.

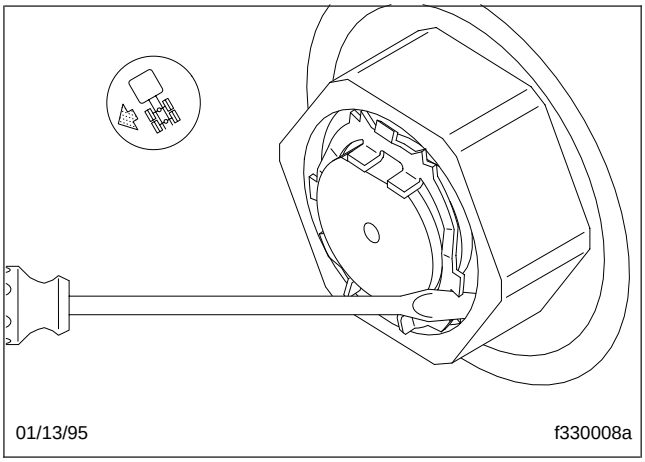


Fig. 7, Compress the Lockring, Disc Wheel Shown

15. Add fresh oil to the wheel hub cavity to the level shown on the hub cap. Refer to **Specifications, 400** for lubricant specifications.

⚠ WARNING

Failure to add oil to the wheel hub cavity after the wheel has been serviced can cause the wheel bearings to overheat and seize during vehicle operation. See Fig. 9. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

16. Adjust the front axle brakes. For instructions, refer to the brake section in the vehicle maintenance manual.

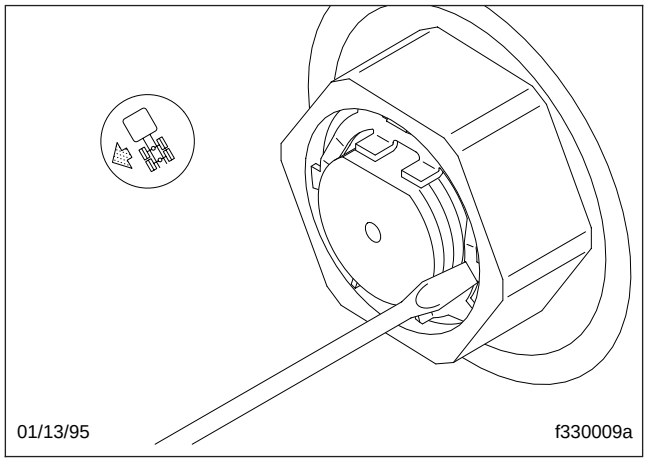


Fig. 8, Make Sure the Lockring is Locked, Disc Wheel Shown

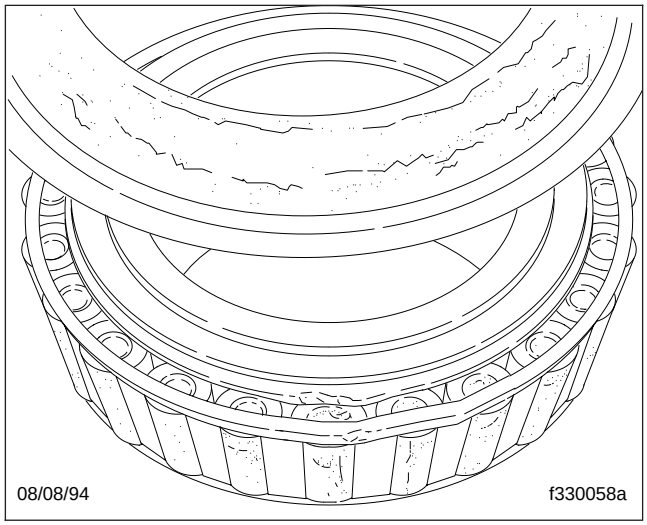


Fig. 9, Bearing Damage Resulting from Inadequate Lubrication

17. Remove the safety stands from under the axle. Then lower the vehicle.

18. Remove the chocks from the rear tires.

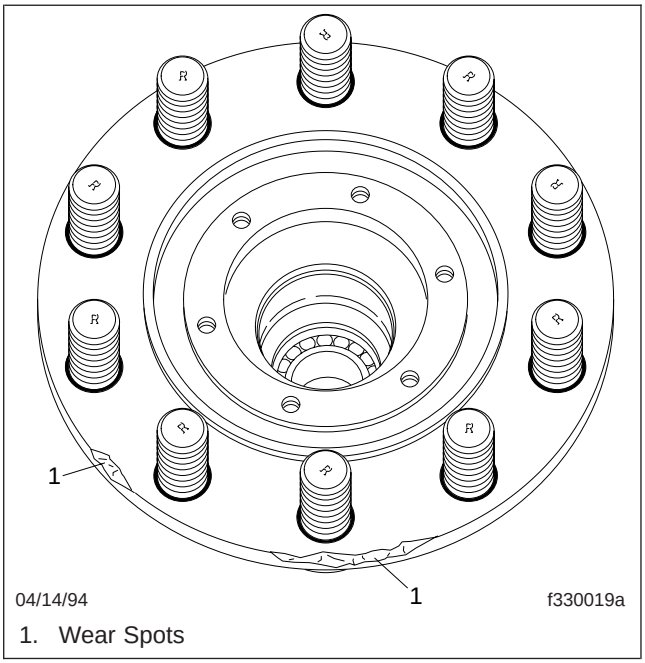
Wheel Hub Assembly Inspection

1. Inspect the wheel hub mounting flange. A loose wheel assembly will cause the flange to be worn, jagged, or warped. **See Fig. 1.** Replace the wheel hub if any of these conditions exist.

   Inspect the flange surface around the wheel studs. Improperly torqued wheel nuts will cause worn or cracked stud grooves on the hub. **See Fig. 2.** If wear spots or cracks appear anywhere on the hub, or if the hub is otherwise damaged, replace it with a new one.

2. Remove all the old oil from the spoke wheel or hub cavity. Inspect the inner surface of the wheel or hub for cracks, dents, wear, or other damage. Replace the wheel or hub if damaged.

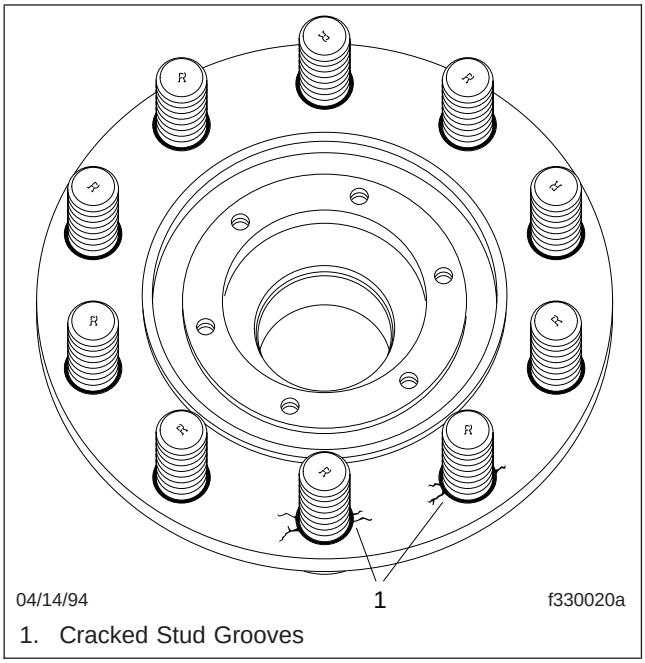
3. Remove all the old grease or oil from the surfaces of the wheel bearing cups. Inspect the cups for cracks, wear, spalling, or flaking. **See Fig. 3.** Replace the cups if damaged in any way. Refer to **Subject 120**.



1. Wear Spots

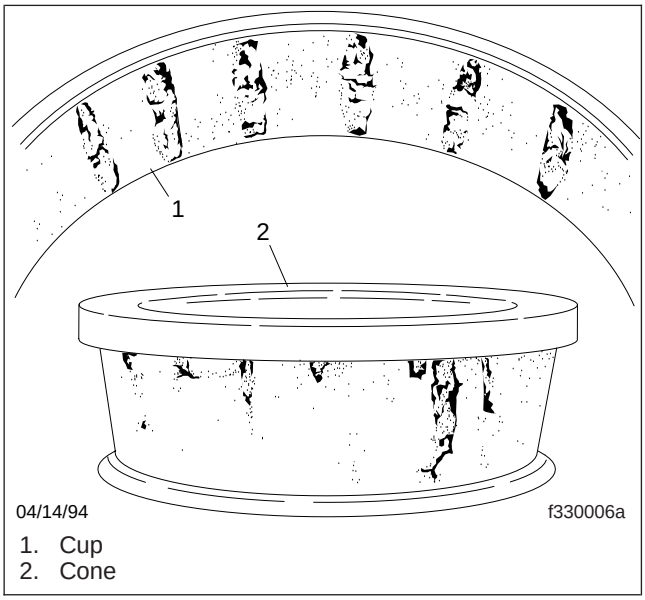
Fig. 1, Damaged Front Axle Wheel Hub

4. Inspect the wheel nuts on disc wheel installations, or the rim nuts on spoke-wheel installations. Damaged nuts (**Fig. 4**), usually caused by inadequate tightening, must be replaced with new ones.



1. Cracked Stud Grooves

Fig. 2, Damaged Front Axle Wheel Hub



1. Cup
2. Cone

Fig. 3, Spalling (Flaking) of Wheel Bearing Assembly

Axle Components Cleaning and Inspection

5. Inspect the wheel studs or rim studs. Replace studs that are stripped, broken, bent, or otherwise damaged. Refer to **Subject 130** or **Subject 140**.

Wheel Bearing Cleaning and Inspection

CLEANING

⚠ WARNING

WARNING: Do not expose kerosene or diesel fuel oil to flames or intense heat. Both fluids are flammable and, if ignited, could cause personal injury.

Don't spin the bearing rollers at any time. Dirt or grit can scratch the roller surface and cause premature wear of the bearing assembly. Treat a used bearing as carefully as a new one.

Wheel bearings should be very closely inspected at the time of disassembly. The best inspection conditions are possible only after the bearings have been thoroughly cleaned using kerosene or diesel fuel oil, and a stiff brush (**Fig. 5**). Before inspecting, clean the bearings.

1. Clean all old oil from the bearings and hub cavities, with kerosene or diesel fuel and a stiff brush. **See Fig. 5.** Don't use gasoline or heated solvent.
2. Allow the cleaned parts to dry, or dry them with a clean absorbent cloth or paper. Clean and dry your hands and all tools used in the maintenance operation. Oil will not stick to a surface that is wet with kerosene or diesel fuel, and the kerosene or diesel fuel may dilute the lubricant.

INSPECTION

After the bearings are cleaned, inspect the assemblies, which include the rollers, cones, cups, and cages. If any of the following conditions exist, replace the bearing assemblies:

1. Large ends of the rollers worn flush to the recess; the radii at the large ends of the rollers are worn sharp. These are signs of advanced wear. **See Fig. 6.**

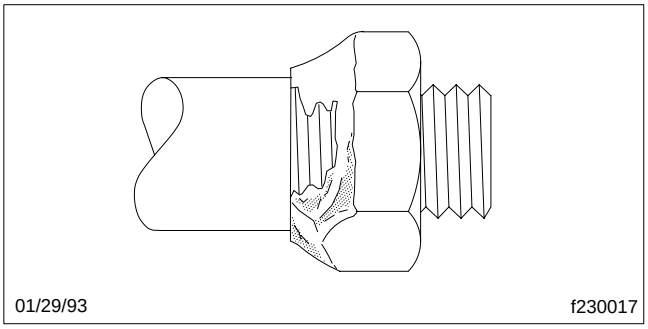


Fig. 4, Damaged Wheel Stud Nut

2. Visible step wear, especially at the small end of the roller track, or deep indentations, cracks, or breaks in the cone surfaces. **See Fig. 7** .
3. Bright rubbing marks on the dark phosphate surfaces of the bearing cage. **See Fig. 8.**

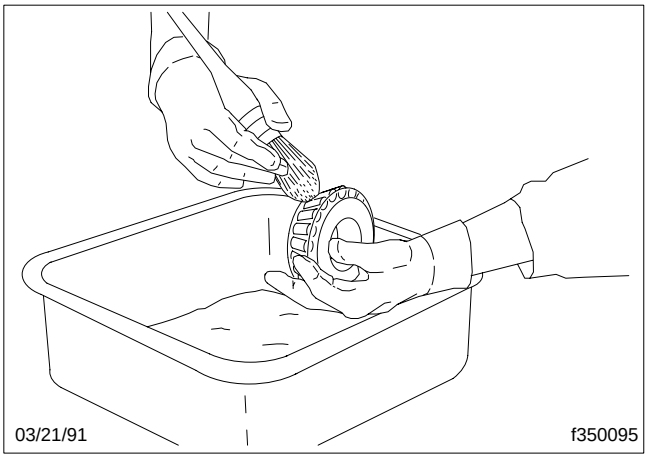
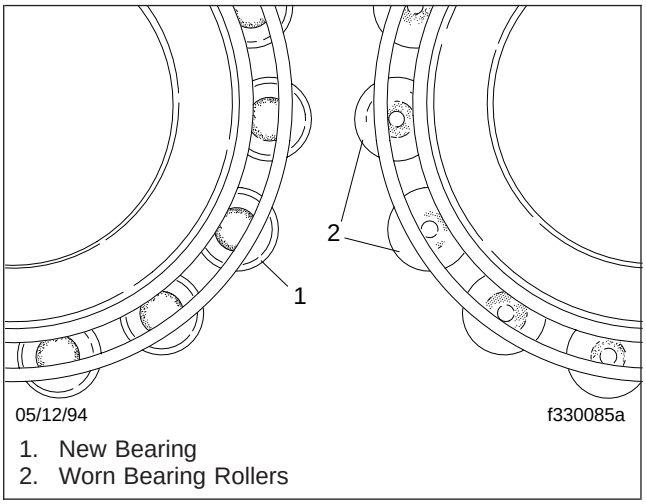


Fig. 5, Wheel Bearing Cleaning

4. Water etch on any bearing surface. Water etch appears as gray or black stains on the steel surface, and it greatly weakens the affected area. If water etch is present, check the bearing seal sealing surfaces.
5. Etching or pitting on functioning surfaces. **See Fig. 9.**
6. Spalling (flaking) of the bearing cup, roller, or cone surfaces. **See Fig. 3.**

   After inspection, brush the bearings with fresh axle lubricant.



1. New Bearing
2. Worn Bearing Rollers

Fig. 6, Wheel Bearing Roller Wear

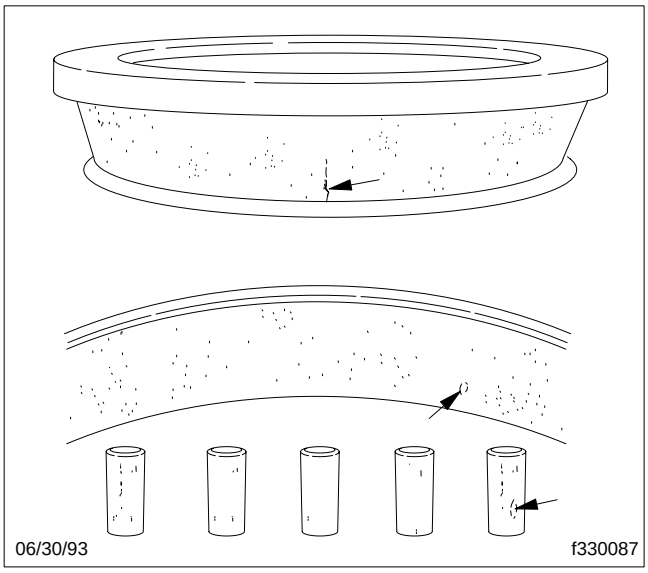


Fig. 7, Indentions, Cracks, or Breaks in Bearing Surfaces

Brake Drum Inspection

New brake drums are purposely undersized to allow for turning, which may be needed if the drum is off-center when mounted on the hub. If a new drum is installed, the protective coating on the inner friction surface must first be removed with a solvent, and then rinsed with a hot water wash. Use a clean rag to remove any oily residue or metal chips from the friction surface.

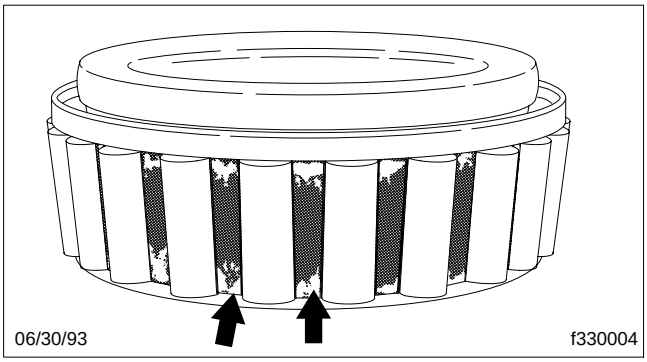


Fig. 8, Rubbing Marks on Bearing Cage

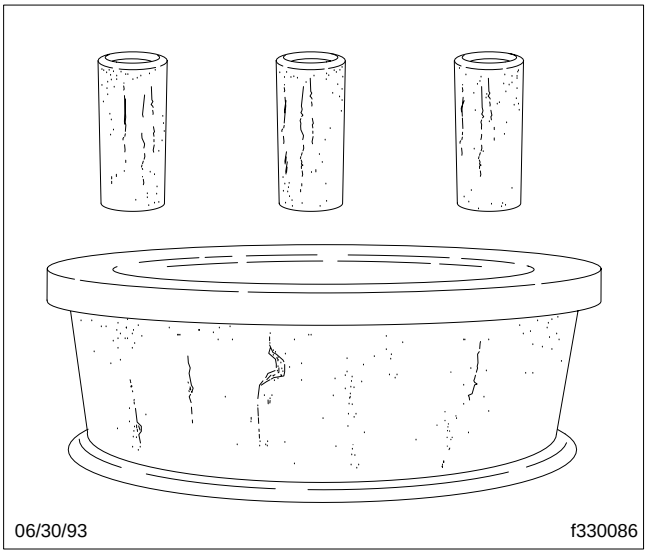


Fig. 9, Etching (Pitting) on Bearing Surfaces

If a drum must be turned or replaced, the other same-axle drum must be similarly turned or replaced to provide the same braking power on both wheels. Turned drums should not exceed the maximum allowable diameter, which is stamped on the outside surface of the drum. **See Fig. 10** for a typical location of this stamp.

NOTE: Drums that have been turned should then be cleaned by using fine emery cloth followed with a hot water wash. Drums that have been renewed using emery cloth should also be cleaned with a hot water wash.

Axle Components Cleaning and Inspection

⚠ CAUTION

CAUTION: Failure to replace drums when worn or turned to limits exceeding the maximum allowable diameter will cause drum weakness and reduced braking capacity, which can lead to distortion, higher drum temperatures, and ultimate drum breakage.

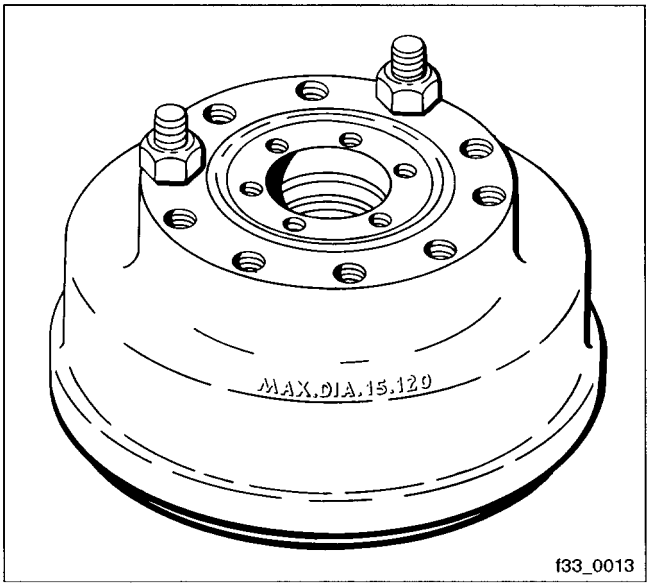


Fig. 10, Outboard-Mounted Hub and Drum Assembly

If the drums are turned or replaced, replace the brake linings. Refer to the applicable section in this group for instructions.

1. Inspect the inner friction surface. If a veneered (highly glossed) or glazed surface exists, renew the drum by using 80-grit emery cloth or by turning the drums.
2. Inspect for heat checking, which is a form of buckling (cracking) resulting from a temperature differential in the drum wall between a relatively cool exterior and a hot friction surface. Heat checking is normal on all drums and may not reduce performance and lining life if the network of fine hairline cracks remains small. Examine heat checks of drums often to be sure the checks have not widened into drum weakening cracks (substantial cracks extending to the open edge of the drum).

   Replace the same-axle drums if substantial cracks are present, or if widening of the fine hairline cracks occurs.

NOTE: If there is normal heat checking as described above, inspect the drums at least every 12,000 miles (19 300 km) thereafter. Inspect the drums (using a flashlight from the inboard side of the wheels) every 6000 miles (9700 km). Inspect more often under adverse operating conditions.

3. Check for a contaminated inner friction surface. If fluids are present, such as oil or grease, remove the contaminants. Locate and correct the source of the contamination.

⚠ WARNING

WARNING: If the brake drums are contaminated with fluids, the brake linings will also be affected. Since oil- or grease-saturated linings cannot be salvaged, they must be replaced. For brake lining replacement procedures, refer to the applicable section in this group. Failure to replace fluid-contaminated brake linings could result in a partial loss of braking capacity.

4. Measure the inside diameter of the drum. If the measured diameter is greater than the maximum allowable diameter, replace the same-axle drums and linings.
5. Check for a variation in gauge readings at different points on the radius of the drum's working surface. If the variation is more than 0.010 inch (0.25 mm) at any point, the drum is out-of-round to unacceptable limits. Remachine or replace the same-axle drums.
6. Inspect the outside surface of the drum. Remove any accumulation of mud, dirt, or rust; foreign matter acts as an insulator, trapping heat within the drum.
7. Check for hard, slightly raised dark-colored spots on the inner friction surface or for a bluish cast on the brake parts, both of which are caused by high temperatures. If the drums' maximum allowable diameters have not been exceeded, remachine both same-axle drums. If the spots or discoloration cannot be removed, or if remachining is not possible, replace the drums. Also replace the brake shoe return springs.

Wheel Bearing Cup Removal and Installation, Aluminum Hubs

Removal

(See Fig. 1)

To ensure a tight fit, wheel bearing cups are purposely larger than the wheel hub bores they occupy. To remove the bearing cups, aluminum hub bores must be temporarily expanded by heating the hub in an oven (the bearing cups will also expand, but to a considerably lesser extent). If adequate heating facilities are not available, replace the hub, wheel stud, and bearing cup assembly.

To install the bearing cups, aluminum hubs must again be temporarily expanded using oven heating. When the hub is properly heated, the bearing cup and hub can be press-fit together, using a suitable press.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.

⚠ WARNING

WARNING: Do not use oxyacetylene equipment or similar equipment to heat the hub. The heat emitted from these instruments is not suitable for uniform heating of the wheel hub. If any local surface of an aluminum hub is heated to 350°F (177°C) or higher, artificial aging through metallurgical change will occur. Cracks or weakness in the hub can result, which could ultimately result in the loss of a wheel and loss of vehicle control.

2. Oven-heat the hub to a temperature range of 240° to 280°F (116° to 138°C). Make sure the oven thermostat is accurately set; if unsure, use an oven thermometer to check the temperature of the oven before placing the hub inside.

   If adequate heating facilities are not available, replace the hub, wheel stud, and bearing cup assembly.

3. Wearing heavy protective gloves, remove the hub from the oven. Place the hub on a suitable press so that the base is fully supported. Quickly press out the bearing cups.

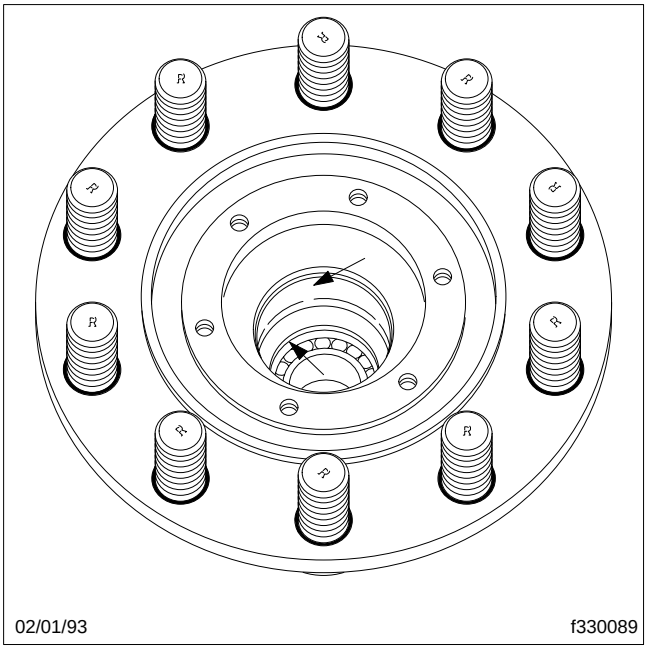


Fig. 1, Wheel Bearing Cup Locations

Installation

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.

Wheel Bearing Cup Removal and Installation, Aluminum Hubs

WARNING

WARNING: Do not use oxyacetylene equipment or similar equipment to heat the hub. The heat emitted from these instruments is not suitable for uniform heating of the wheel hub. If any local surface of an aluminum hub is heated to 350°F (177°C) or higher, artificial aging through metallurgical change will occur. Cracks or weakness in the hub can result, which could ultimately result in the loss of a wheel and loss of vehicle control.

3. Oven-heat the hub to a temperature range of 240° to 280°F (116° to 138°C). Make sure the oven thermostat is accurately set; if unsure, use an oven thermometer to check the temperature of the oven before placing the hub inside.
4. Coat the hub-contact surface of the replacement bearing cup with a film of grease.
5. Wearing heavy protective gloves, remove the hub from the oven.
6. Place the hub on a suitable press so that the base is fully supported. Quickly press-fit the bearing cup into the wheel hub until it is completely and evenly seated. Be careful not to shave the sides of the bearing cup bore as the bearing cup is seated. The accumulation of debris will prevent the cup from being seated and will also cause permanent damage to the wheel hub. If the sides of the bearing cup bore are damaged during installation, replace the wheel hub assembly.
7. Allow the wheel hub to cool before handling. Then, using a 0.0015-inch feeler gauge, check at several places for the seating of the bearing cup in the bearing cup bore. The gauge should not enter beneath the cup. If it does, there is probably dirt or debris preventing the cup from seating. Using the instructions above, remove the cup, then remove the foreign matter. Reinstall the cup.

WARNING

WARNING: Do not expose kerosene or diesel fuel oil to flames or intense heat. Both fluids are flammable and, if ignited, could cause personal injury.

8. Wipe off the accumulation of grease left after the bearing cup has been seated. Then, using a clean, lint-free cloth dampened with kerosene or diesel fuel oil, clean the inner surface of the bearing cup. Wipe the surface dry using a clean, absorbent, and lint-free cloth or paper.

Wheel Bearing Cup Removal and Installation, Ferrous Hubs

Wheel bearing cups on ferrous hubs are removed and installed by driving them out and pressing them in without heating the hub.

REMOVAL

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Using a mild-steel rod through the opposite end of the hub, drive against the inner edge of the bearing cup. Alternately drive on opposite sides of the cup to avoid cocking the cup and damaging the inside of the hub.

INSTALLATION

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.
3. Coat the hub-contact surface of the replacement bearing cup with a film of grease.
4. Position the cup in the hub and press it into place, using a suitable driving tool. Cups must seat against the shoulder in the hub.

⚠ WARNING

WARNING: Do not expose kerosene or diesel fuel oil to flames or intense heat. Both fluids are flammable and, if ignited, could cause personal injury.

5. Wipe off the accumulation of grease left after the bearing cup has been seated. Then, using a clean lint-free cloth dampened with kerosene or diesel fuel oil, clean the inner surface of the bearing cup. Wipe the surface dry using a clean, absorbent, and lint-free cloth or paper.

Replacement

WARNING

WARNING: If a wheel stud breaks, the remaining studs are subjected to undue strain and could fail due to fatigue. When a broken stud is replaced, replace the stud on each side of it. See Fig. 1. If more than one stud is broken, replace all of the studs. Failure to replace the studs could result in the loss of a wheel or loss of vehicle control, possibly resulting in personal injury.

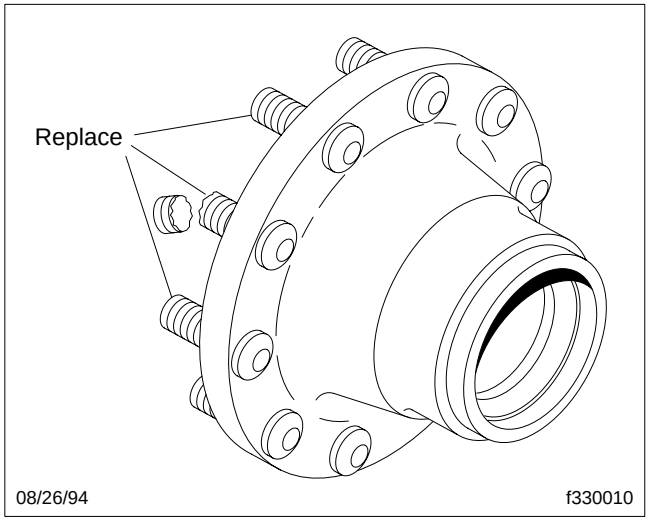


Fig. 1, Wheel Stud Replacement

1. Remove the wheel hub from the axle. For instructions, refer to **Subject 100**.
2. If a bent portion of a wheel stud will have to pass through the wheel stud bore, cut off the bent portion before removing the wheel stud.
3. Place the wheel hub on a suitable press; make sure the hub flange is evenly supported around and next to the stud being removed. With steady movement, press the damaged stud out of the hub.

CAUTION

CAUTION: Do not use a drift and hammer or concentrated heat for removing and installing the wheel studs. Constant, smooth movement of the wheel stud is necessary to ensure the least amount of metal removal from the wheel stud bore. Concentrated heat will damage the hub. If the hub is damaged during wheel stud removal or installation, replace it.

4. Apply a coating of clean axle grease to the entire shaft on headed studs.
5. With the hub on a suitable press, make sure the hub flange is evenly supported around and next to the stud being installed.
6. Position the stud in its hole. *Be sure the flat edge of the head flange on clipped studs is in line with the shoulder on the hub.*

CAUTION

CAUTION: If headed studs with serrations are being installed, position the teeth of the serrated portion in the notches carved by the original wheel studs during factory installation. If additional metal is scraped from the wheel stud bores, the locking action provided by the serrations will be greatly weakened. Loss of locking action will prevent achieving final torque of the wheel nuts during wheel installation. If final wheel nut torques during wheel installation cannot be achieved, replace the wheel hub assembly.

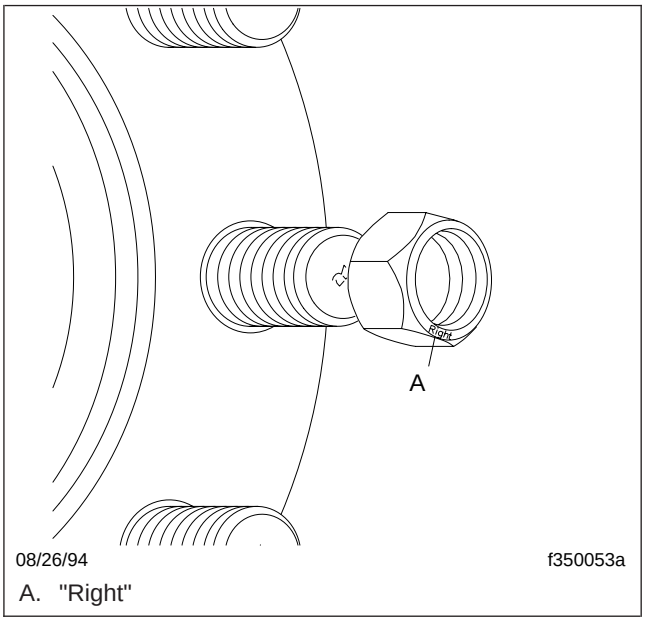
IMPORTANT: If the driver's side of the vehicle is being serviced, the replacement wheel stud must be stamped with an "L" (left-hand threaded), and the nut's face must be stamped "Left." If the passenger's side of the vehicle is being serviced, the replacement stud must be stamped with an "R" (right-hand threaded), and the nut's face must be stamped "Right" (**Fig. 2**).

7. With steady movement, press the new stud all the way into the hub.
8. Make sure the stud is fully seated and that its head (flange) is not embedded in the hub. If the head of the stud is embedded in the hub, replace the hub.

WARNING

WARNING: Wheel studs with heads embedded in the wheel hub will weaken the wheel hub flange. Weakness in the wheel hub can result in the loss

Wheel Stud Replacement, Disc Wheels



A. "Right"

Fig. 2, Thread Stamp Location

of a wheel or loss of steering control, possibly resulting in personal injury.

9. Wipe off any grease on the wheel studs and wheel hub. Install wheel nuts on dry wheel studs only.
10. Install the wheel hub on the axle. For instructions, refer to **Subject 100**.

Replacement

1. Remove the rim and tire assembly from the spoked wheel. For instructions, refer to the wheels and tires section in this manual.
2. If enough threads remain on the damaged stud, remove it by double-nutting the stud. Turn the inner nut with a wrench in order to remove the stud. Then, proceed to the next step.

   If the rim stud is broken near the surface of the wheel, the stud should be center-drilled using a high-speed drill, and then removed with an easy-out tool. If needed, grind off a flat surface on the damaged stud, then centerpunch the surface as a starting point for drilling. Follow these recommendations:

   2.1 Determine the correct drill diameter by referring to the easy-out tool manufacturer's guidelines. At no time should it be large enough to penetrate the threads of the stud; if the stud threads in the wheel are damaged, replace the wheel.

   2.2 Do not drill more than 1.25 inches (32 mm) into the broken stud, as measured at the stud's entrance into the wheel. Drilling through the bottom of the rim stud could damage the wheel. If the wheel is drilled into, replace it.

   2.3 While drilling, keep the cutting surfaces of the drill well lubricated with oil, which acts as a coolant. Allow the drill and drill bit to cool frequently.
3. After the damaged stud is removed, tap out the rim stud hole in the wheel to rid the threads of old stud-locking compound. Use an appropriate sized tap, depending on the original rim stud installation size.
4. Be sure the threads of the new stud are clean and dry. Then, coat the insertion end of the rim stud with an anaerobic thread- lock compound.
5. Using double nuts on the fine thread portion of the stud, install the new stud. Seat the rim stud using the torque values in the torque table in **Specifications, 400**.
6. Allow enough time for the thread-lock compound to set, as suggested by the manufacturer.
7. Install the rim and tire assembly. For instructions, refer to the wheels and tires section in this manual.

Troubleshooting Tables

Problem—Noisy Bearings or Excessive Bearing Replacement Intervals

Possible Cause	Remedy
Not enough oil was used on the bearings, or the wrong type of oil was used.	Clean, then inspect the bearings for wear. Replace worn seals. Coat the bearing assemblies with fresh oil. For lubricant specifications, refer to **Specifications, 400**.
Foreign matter or corrosive agents entered the bearing assembly. Dirt or metallic debris from the bearings was not removed.	Clean, then inspect the bearings for wear. Replace worn seals. Also clean the wheel hub, the axle spindle, and any other component in contact with the bearing lubricant.
An incorrect adjustment of the wheel bearings is causing noise and wear.	Adjust the wheel bearings following the instructions in **Subject 100** and **Subject 102** in this section.
Flat spots or dents on the roller surface were caused by skidding of the roller or improper handling of the wheel bearing during installation.	Clean, then inspect the bearing rollers. Replace the bearing if damaged. Coat the replacement bearings with fresh oil. For lubricant specifications, refer to **Specifications, 400**.

Problem—Broken Wheel or Rim Studs

Possible Cause	Remedy
The wheel or rim nuts were overtightened.	Replace the wheel or rim studs. Refer to **Group 40** for the wheel or rim nut tightening sequence.
An incorrect nut tightening sequence was used.	
The wrong brake drums were installed.	Install new brake drums.
Wheels are mismatched (hub-piloted wheels are mixed with stud-piloted wheels).	Install properly matched wheels.
The vehicle is being overloaded.	Do not exceed the maximum load-carrying capacity of the vehicle.

Problem—Damaged Hub

Possible Cause	Remedy
(Cracked hub) Local surface of an aluminum hub was heated higher than 350°F (177°C) during bearing cup removal.	Replace the hub assembly. When removing the bearing cup, oven-heat the hub.
(Bent flange) Incorrect installation of the wheel studs, such as using a hammer and drift, or the hub flange was not fully supported on the press during wheel stud replacement.	Replace the hub assembly. Replace the wheel studs as instructed in **Subject 130**.
The wrong brake drums were installed.	Install new brake drums.
Insufficient tightening of the wheel nuts to the wheel hub.	Replace the hub assembly and tighten the wheel nuts to the values in the torque table in **Specifications, 400**.

Troubleshooting

Problem—Loss of Lubricant from the Wheel Hubs

Possible Cause	Remedy
The seals or gaskets are worn or damaged.	Replace worn or damaged parts.

Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied

Possible Cause	Remedy
Dirt or grease has built up on the brake linings (glazing), or the brake linings have worn excessively.	Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The brake drums are worn, heat-checked or cracked.	Install new brake drums.

Problem—Service Brakes Grab or Pull

Possible Cause	Remedy
For detailed information, refer to the **air brake system troubleshooting** section of this manual.	

Problem—Poor Lining-to-Drum Contact

Possible Cause	Remedy
The inside surface of the brake drum is scored or grooved.	Install new brake linings on both sets of axle brake shoes. Install new brake drums or turn the drums.
The brake shoes are stretched or bent.	Replace the brake shoes.
Undersized linings were installed.	Install new brake linings on both sets of axle brake shoes.
An incorrect grind was used on the brake linings.	
The wrong brake drums were installed.	Install new brake drums.
An incorrect adjustment of the wheel bearings is causing wheel instability.	Adjust the wheel bearings following the instructions in **Subject 100** and **Subject 102** in this section.

Problem—Brake Linings Are Tapered Across the Width

Possible Cause	Remedy
The inside surface of the brake drum is scored or grooved.	Install new brake linings on both sets of axle brake shoes. Turn or replace the drums.
The brake shoes are bent.	Replace the brake shoes.
An incorrect adjustment of the wheel bearings is causing wheel instability.	Adjust the wheel bearings following the instructions in **Subject 100** and **Subject 102** in this section

Problem—Brake Shoes on the Same Brake Are Wearing Unequally

Possible Cause	Remedy
The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed.	Install a new matched set of brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.

Possible Cause	Remedy
The brake shoes are stretched.	Replace the brake shoes.

Problem—Shoes on Each Side of the Axle (Side-to-Side Brakes) Are Wearing Unequally

Possible Cause	Remedy
The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed.	Install a new matched set of brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The inside surface of the brake drum is in poor condition.	Turn or replace the drums.
The wheel bearings are out of adjustment.	Adjust the wheel bearings following the instructions in **Subject 100** and **Subject 102** in this section.

Problem—Edge of the Lining Is Showing Wear

Possible Cause	Remedy
The brake lining is too wide.	Install new brake linings on both sets of axle brake shoes.
The brake linings are misaligned because of incorrectly drilled brake lining holes.	
Undersized brake drums were installed.	Install new brake drums.
The wheel bearings are out of adjustment.	Adjust the wheel bearings following the instructions in **Subject 100** and **Subject 102** in this section.
There is an incorrect fit of the wheel onto the spindle due to the wrong wheel bearings.	Install new wheel bearings and adjust them following the instructions in **Subject 100** and **Subject 102** in this section.
The brake shoes are bent.	Replace the brake shoes.

Problem—Brake Linings Are Scored or Grooved

Possible Cause	Remedy
Worn or scored brake drums have been causing poor contact with the brake linings.	Install new brake linings on both sets of axle brake shoes. Turn or replace the brake drums.
There is abrasive material between the lining and the drum.	

Problem—Brake Linings Are Loose

Possible Cause	Remedy
The rivet holes in the brake shoes are to large.	Replace the brake shoes.
Incorrectly crimped rivets are working loose and allowing the linings to move.	Replace the rivets.
Rust has built up on the shoe table.	Clean the brake shoe table of all rust, dirt, scale, and paint.

Troubleshooting

Problem—Brake Lining Is Cracked at the Rivet Holes or Bolt Holes

Possible Cause	Remedy
Overtightening of the lining bolts is causing cracks.	Install new brake linings. Replace the rivets or bolts with the correct size.
The wrong size counter bore for the rivet holes was made.	
The wrong rivets or bolts were used.	Replace the rivets or bolts with the correct size.
Incorrectly crimped rivets are working loose and allowing the linings to move.	Replace the rivets.
Rust has built up on the shoe table.	Clean the brake shoe table of all rust, dirt, scale, and paint.

Problem—Out-of-Round Rivet Holes or Bolt Holes

Possible Cause	Remedy
The rivets or bolts are loose.	Replace the brake shoes or linings.

Problem—Brake Drums Are Heat-Checked

Possible Cause	Remedy
The brake drums are out-of-round.	Turn or replace the brake drums.
The wrong brake drums were installed.	Install new brake drums.
The wheel bearings are out of adjustment.	Adjust the wheel bearings following the instructions in **Subject 100** and **Subject 102** in this section.
The brake linings are glazed (dirt or grease build-up) or are worn unevenly.	Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The lining friction material for the operation of the vehicle is incorrect.	
There is a brake imbalance between the tractor and the trailer.	Do a brake balance test (tractor versus trailer). Contact the District Service Manager if help is needed.

Problem—Brake Drums Are Heavily Scored

Possible Cause	Remedy
The brake linings are damaged.	Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
There is excessive wear on the linings.	
On the last brake reline, the drums were not turned.	Turn the brake drums.

Problem—Excessive Brake Lining Wear

Possible Cause	Remedy
There is a brake imbalance between the tractor and the trailer.	Do a brake balance test (tractor versus trailer). Contact the District Service Manager if help is needed.

Specifications

Torque Values		
Application	**Size (grade 8)**	**Torque: lbf·ft (N·m)**
Hub Cap Capscrews	5/16–18	15 (20)
Spoke-Wheel Brake Drum Nuts	3/4–10	240 (325)
Spoke-Wheel Rim Studs	3/4–10	240 (325)
Wheel-Bearing Adjusting Nuts, 4-Piece System, Standard Hub	—	Stage 1: Tighten to 100 (136)
		Stage 2: Back Off Completely
		Stage 3: Tighten to 20 (27) While Rotating Hub
		Stage 4: Back Off 1/3 Turn
Pro-Torq® Nuts	—	Stage 1: Tighten to 100 (136) While Spinning Wheel In both Directions
		Stage 2: Back Off Completely and Spin the Wheel a Few Times
		Stage 3: Tighten to 50 (68) While Spinning Wheel In both Directions
		Stage 4: Back Off 1/8 to 1/6 Turn

Table 1, Torque Values

Dana Spicer® Axle Recommended Lubricant		
Lubricant Type	**Condition**	**SAE Viscosity Grade**
Eaton Roadranger® Synthetic Axle Lubricants, or Equivalent with Military Specification MIL–L–2105D	Over-the-Road Service	75W–90
	Off-Highway Equipment, or Under Extra Heavy Loads	80W–140

Table 2, Dana Spicer Axle Recommended Lubricant

Meritor Axle Recommended Lubricant			
Lubricant Type	**Ambient Temperature**	**SAE Viscosity Grade**	**Meritor Specification**
Hypoid Gear Oil API Service Classification GL–5	+10°F (–12.2°C) and up*	85W–140	0–76–A
	–15°F (–26.1°C) and up*	80W–140	0–76–B
	–15°F (–26.1°C) and up*	80W–90	0–76–D
	–40°F (–40°C) and up*	75W–90	0–76–E
	–40°F (–40°C) to +35°F (+2°C)	75W	0–76–J
	–40°F (–40°C) and up*	75W–140	0–76–L
Synthetic Gear Oil	–40°F (–40°C) and up*	75W–90	0–76–N
	–40°F (–40°C) and up*	75W–140	0–76–M

* There is no upper limit on these ambient temperatures, but axle sump temperature must never exceed 250°F (121°C).

Table 3, Meritor Axle Recommended Lubricant

Specifications

Dual-Nut Wheel Bearing Lock Torque Values		
Application	**Size**	**Torque: lbf·ft (N·m)**
Adjusting Nut	—	Stage 1: Tighten to 100 (135)
		Stage 2: Back Off Completely
		Stage 3: Tighten to 20 (25) While Rotating Hub
		Stage 4: Back Off 1/3 Turn
Jam Nut (with Wheel Bearing Nut, Pierced Lockwasher, and Bendable Lockwasher)	1-1/8	Target: 175 (235) Permissible Range: 150–225 (205–305)
	1-1/2 to 2-1/2	Target: 250 (340) Permissible Range: 200–300 (270–405)
	2-5/8 or Larger	Target: 325 (440) Permissible Range: 250–400 (340–540)

Table 4, Dual-Nut Wheel Bearing Lock Torque Values

General Description

Correct front axle wheel alignment is needed to ensure long tire life, ease of handling, and steering stability.

Three factors are involved in wheel alignment: camber angle, caster angle, and wheel toe-in.

Camber angle (**Fig. 1**) is the vertical tilt of the wheel as viewed from the front of the vehicle. Camber angle is measured in degrees, and is not adjustable. Positive camber is the outward tilt of the wheel at the top. Excessive positive camber in one wheel causes the vehicle to pull in the opposite direction, rapidly wearing the outboard side of the tire tread. Negative camber is the inward tilt of the wheel at the top. Excessive negative camber in one wheel causes the vehicle to pull in the same direction that the negative-camber wheel is on, wearing the inboard side of the tire tread. If camber angles are not correct, the tires will wear smooth around the edge on one side. **See Fig. 2.**

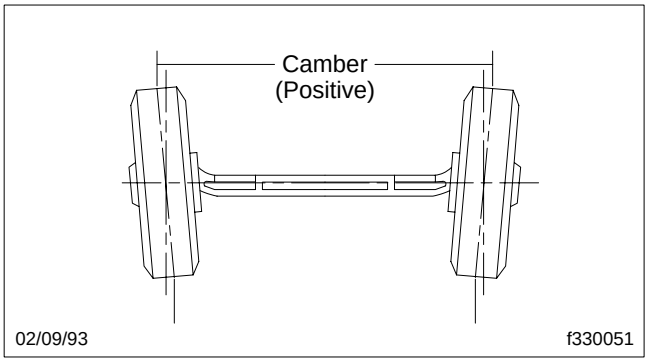


Fig. 1, Camber Angle

Caster angle (**Fig. 3**) is the tilt of the knuckle pin (or kingpin) as viewed from the side. Caster angle is measured in degrees and it is adjustable. A positive caster angle is the tilt of the top of the knuckle pin toward the rear of the vehicle. A negative caster angle is the tilt of the top of the knuckle pin toward the front of the vehicle. Caster angles are based on the design load of the vehicle. An incorrect caster angle does not cause tire wear. However, a positive caster angle that exceeds specifications could cause vehicle shimmy, road shock, and an increased steering effort. A negative caster angle that does not meet specifications could cause unstable steering. The vehicle may wander and weave, and extra steering effort may be necessary. After leaving a turn, the tendency to return to and maintain a straight-ahead position is reduced. Too much or too little caster in one wheel can cause erratic steering when the service brakes are applied to stop the vehicle.

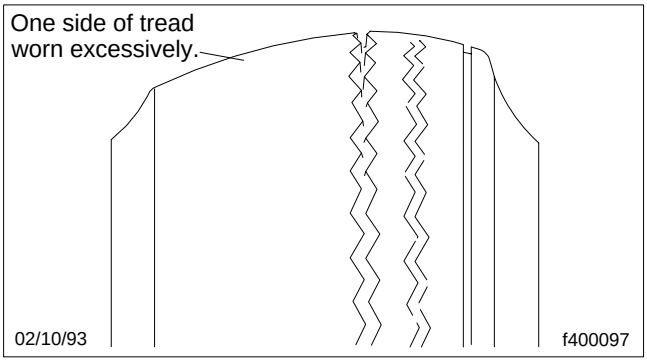


Fig. 2, Tire Damage Due to Excessive Camber

Wheel toe-in (**Fig. 4**) is the distance in inches that the front of the wheels are closer together than the rear of the wheels, as viewed from the top. Wheel toe-in is adjustable. If it is not adjusted correctly, the vehicle could pull to one side while driving. Wheel shimmy and cupped tire treads (indentations on the road contact surface of the treads) could occur. Also, rapid or severe tire wear on the steering axle could occur, usually in a feather-edged pattern. **See Fig. 5.**

Advanced wear patterns can be seen, but less severe wear patterns are detected only by rubbing the palm of your hand flat across the tire tread.

Feather-edging more often affects the front tire on the passenger's side of the vehicle, and is usually more apparent on the outside grooves of the tire.

If any of the conditions listed above occur, the vehicle could need a front end wheel alignment, and possibly, drive axle alignment. However, in some cases these conditions are not wheel alignment related; refer to **Troubleshooting, 300** for other possible causes.

If excessive tire tread wear has resulted from incorrect wheel alignment, replace the damaged tires. For minimum tread wear specifications, refer to the wheels and tires section in the vehicle maintenance manual.

General Description

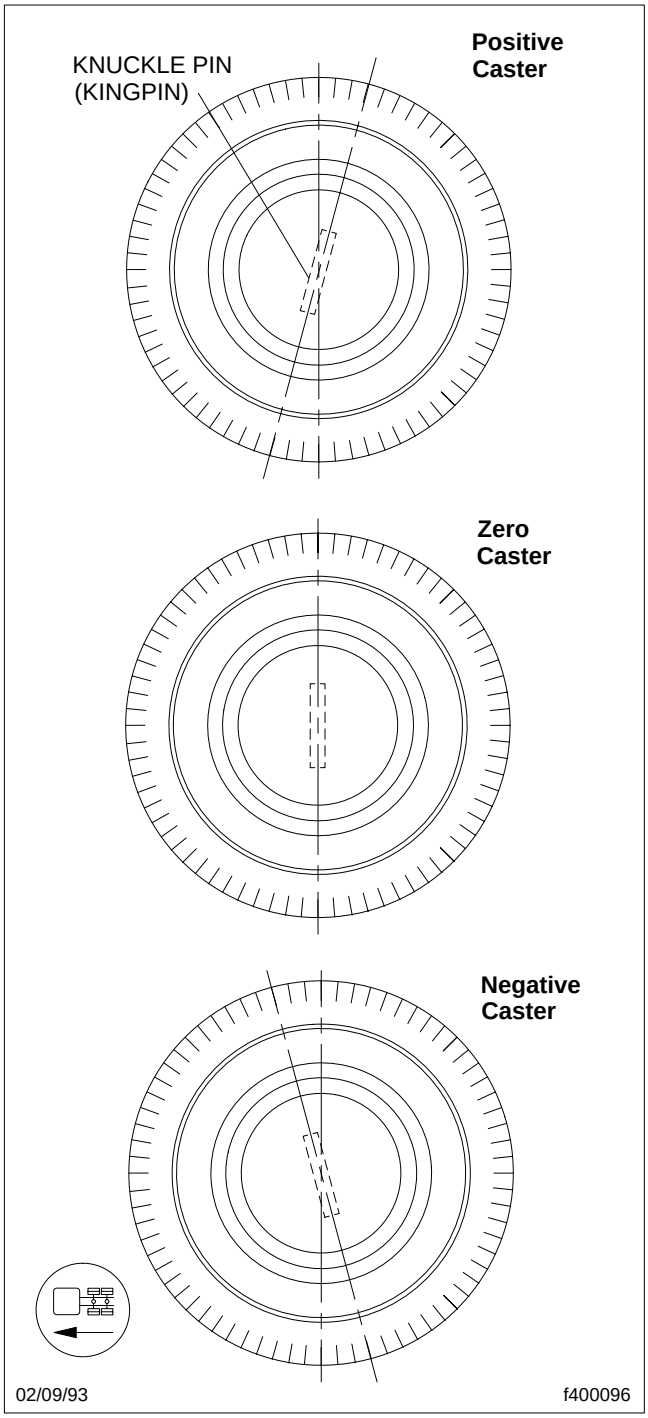


Fig. 3, Caster Angle

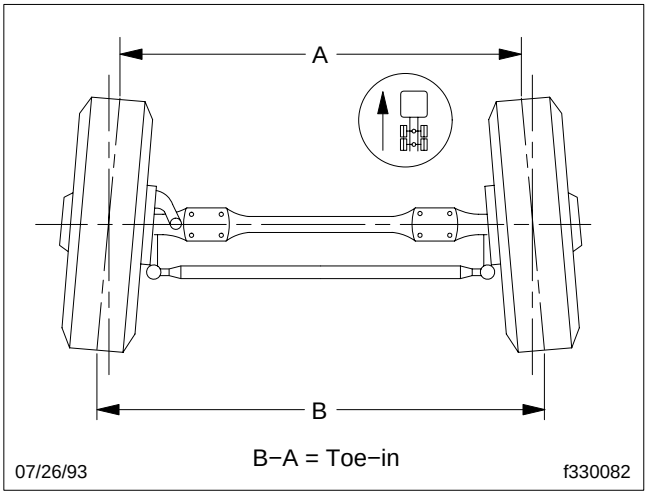


Fig. 4, Wheel Toe-In (Overhead View)

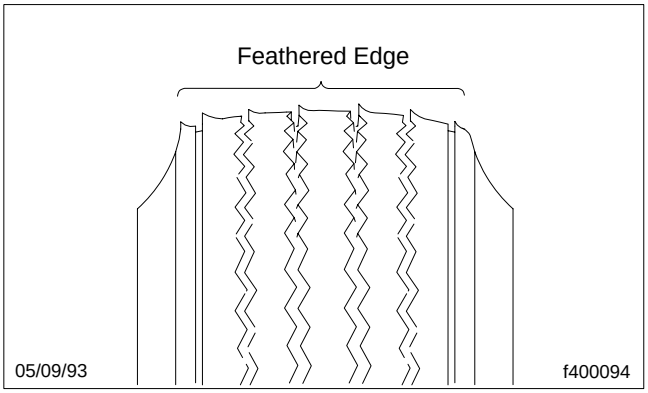


Fig. 5, Tire Damage Due to Excessive Toe-In or Incorrect Drive Axle Alignment

Preliminary Checks

1. Steering axle wheel assemblies should be balanced, especially for vehicles that travel at sustained speeds of more than 50 mph (80 km/h). Off-balance wheel assemblies cause vibrations that result in severely shortened life for tires, and steering suspension parts.
2. Do not mix tires of different size, type, or weight. Tire wear should be even and not worn to limits exceeding government specifications. Refer to the wheels and tires section in this manual and the vehicle maintenance manual for more information. Replace any tire that is excessively worn.
3. Check the inflation pressure of the tires. Refer to the wheels and tires section in this manual for recommended pressures. An underinflated tire causes tread wear completely around both tire shoulders. An overinflated tire causes tread wear in the center of the tire. **See Fig. 1.**
4. Check for out-of-round wheels, rims, or wheel stud holes. Replace the wheel if any of these conditions exist.
5. On each side of the vehicle, check the height of the chassis above the ground. Sagging, fatigued, or broken suspension springs create a lopsided vehicle appearance. This causes an unbalanced weight distribution. Anything that changes the ratio of weight on the springs affects the alignment angles and also the tire tread contact area. Replace damaged springs as instructed in the suspension section in this manual.
6. Inspect the front axle beam (also called the axle center) for bends or twists. If the axle beam is bent or twisted over 1/2 degree, replace it before aligning the front axle wheels.
7. Check for damaged, worn, or bent steering gear or linkage parts. Make sure the steering gear is centered. Replace damaged components, and adjust the steering gear, using the instructions in the steering section in this manual.
8. Check the steering angle, and adjust the axle steering stops, as needed. Refer to **Subject 110**.

Preliminary Checks

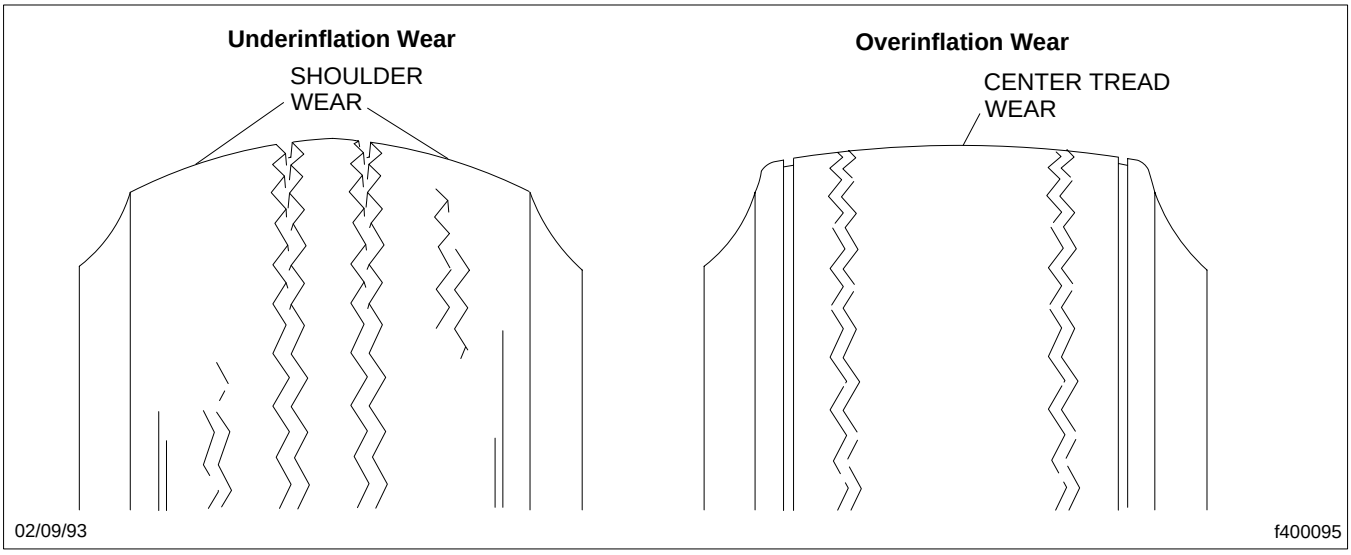


Fig. 1, Tire Damage Due to Underinflated or Overinflated Tires

Checking and Adjusting

Steering (or turning) angle is the degree of front wheel movement from a straight-ahead position to either an extreme right or left position. Although front wheel movement can be limited by the amount of internal travel in the steering gear, it generally depends on how much clearance there is between chassis components and the tire and wheel assemblies. All axles have adjustable stopscrew-and locknut-type axle stops (**Fig. 1**), which are located on the rear side of each front axle spindle.

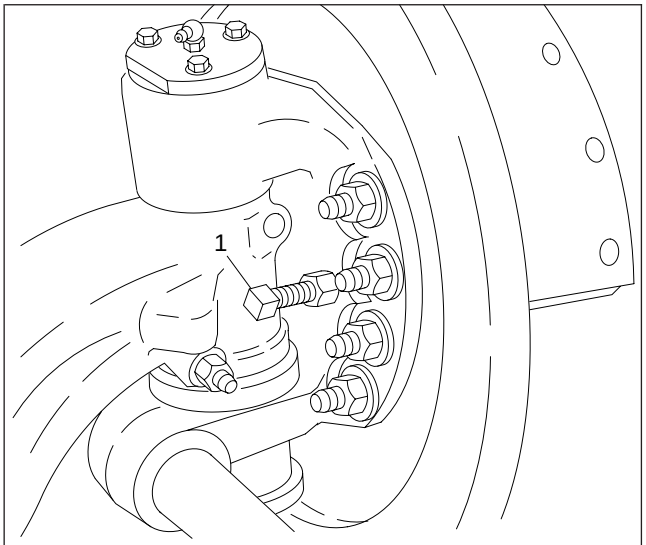
IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

1. Make sure the steering gear is in the center of travel when the wheels are in a straight-ahead position. Center the gear, using the instructions in the steering section in this manual. Bottoming of the steering gear must not occur when making an extreme right or left turn.
2. If using stationary turn-plates or turntables (**Fig. 2**), drive the vehicle on the plates; the tires must be exactly straight ahead. Apply the parking brakes.

   If using portable gauges, apply the parking brakes, chock the rear tires, and raise the front of the vehicle. Place a turn-plate or turntable under each tire. With the tires exactly straight ahead,lower the vehicle so that the tires rest on the center of the gauges.
3. Remove the lockpins from the gauges, and adjust the dials so that the pointers on both gauges read zero.
4. With the brakes fully applied, turn the steering wheel clockwise to the end of travel. Have someone check both sides of the vehicle for interference at the tires and wheels. There must be at least 0.50 inch (13 mm) clearance from any fixed object, and 0.75 inch (19 mm) from any moving object.

   If necessary, loosen the stopscrew locknut; adjust the stopscrew to contact the axle when the maximum turning angle of the wheels is determined.

   Tighten the locknut to the value in the torque table under **Specifications, 400**.



1. Stopscrew and Locknut

Fig. 1, Axle Stop

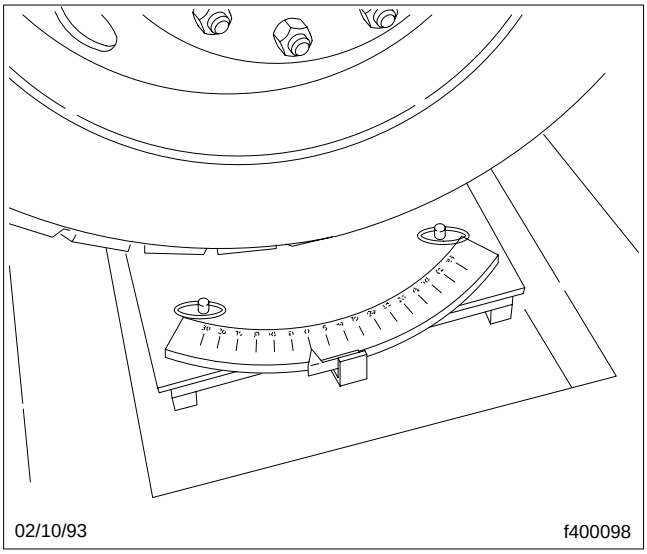


Fig. 2, Turn-Plate (Turntable), Stationary Type

Steering Angle Checking and Adjusting

5. Repeat the step above with the steering wheel turned counterclockwise. Adjust the axle stop, as needed.
6. If equipped with power steering, adjust the steering gear so that pressure is released ahead of the axle stop. This will prevent possible damage to the steering or axle components. For poppet valve adjustment instructions, refer to the steering section in this manual.
7. Drive the vehicle off the turn-plates or turntables, or remove them from under the tires and lower the vehicle.

Measuring and Adjusting Front Axle Wheel Alignment Angles

Measuring and Adjusting

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

Precision instruments and equipment are needed for accurately measuring and adjusting wheel alignment. Refer to the operating instructions provided by the wheel alignment equipment manufacturer.

Before checking or correcting wheel alignment, make sure the vehicle is at curb weight. Curb weight is the weight of the unloaded vehicle complete with accessories and full fuel tanks.

If a road test is necessary, the route should be one that allows full left and right turns and full stops. It should also include a length of straight, level road to check the steering wheel position during straight-ahead driving.

During the road test, note any steering effort and possible roughness. Check for looseness, too much wheel play, any tendency for the vehicle to lead in one direction, and for pull during stopping.

Note the position of the steering wheel while driving on a straight, level road. When the steering gear is centered, the steering wheel spokes should be at the 4 and 8 o'clock positions, or within 10 degrees of that position. **See Fig. 1.**

If there are any problems, refer to **Subject 300**.

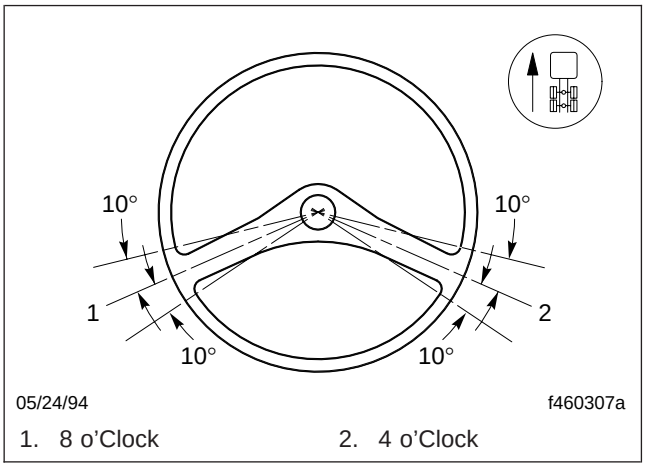


Fig. 1, Steering Wheel Position

Checking (See Fig. 1)

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

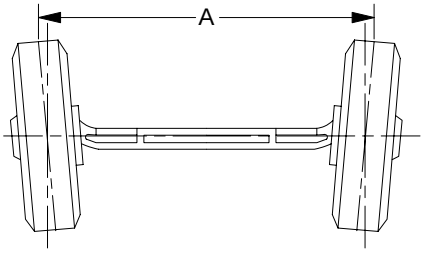
1. Apply the parking brakes, and chock the rear tires.
2. Raise the front of the vehicle until the tires clear the ground. Place safety stands under the axle; make sure the stands will support the weight of the cab, frame, and front axle.
3. Before measuring camber, check the front wheel bearings for wear and incorrect adjustment. Try moving the wheel on the axle spindle (steering knuckle) either by grasping the front tire on the top and bottom, or by using a bar for leverage. If movement between the brake drum and the backing plate or other axle-mounted reference point is 0.05 inch (1 mm) or more, the bearings may be worn or incorrectly adjusted. Inspect the wheel bearings for damage using the instructions elsewhere in this section. If needed, replace or adjust the bearings.
4. Remove the safety stands, and lower the vehicle to the ground.
5. Using the alignment equipment manufacturer's instructions, measure the front wheel camber.
6. Compare the camber angles with those shown in the appropriate table in **Specifications, 400**. Differences between the measurements taken in the step above and the angles in the table are caused by damaged (bent) axle components.

   Incorrect camber angles could be caused by damage in one or more of the following front axle components: the knuckle pin, the knuckle pin bushings, the axle spindle, or the axle beam. Replace twisted or otherwise damaged components. Don't try to straighten twisted or bent components; replace them with new components. If a bent or twisted front axle knuckle pin, axle spindle, or axle beam has been straightened, the axle warranty will be voided.

WARNING

WARNING: Trying to straighten a twisted or bent front axle component can crack or weaken it. A cracked or weakened axle component could result in a collapsed front axle or the loss of a wheel, which could cause serious personal injury.

7. Remove the chocks from the tires.

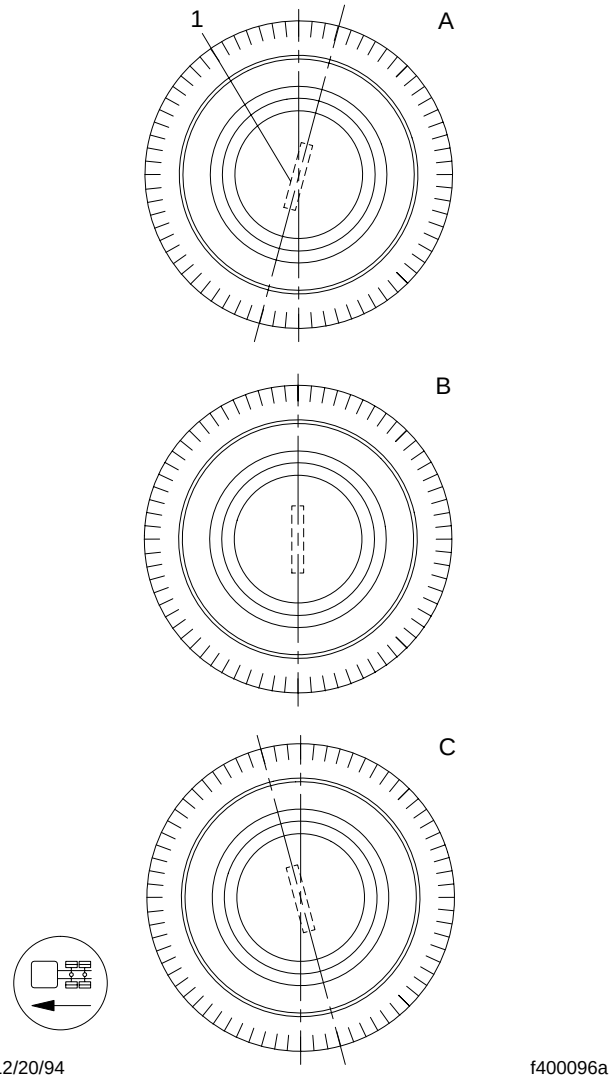


A. Camber (Positive)

Fig. 1, Camber Angle

Checking and Adjusting

(See Fig. 1)



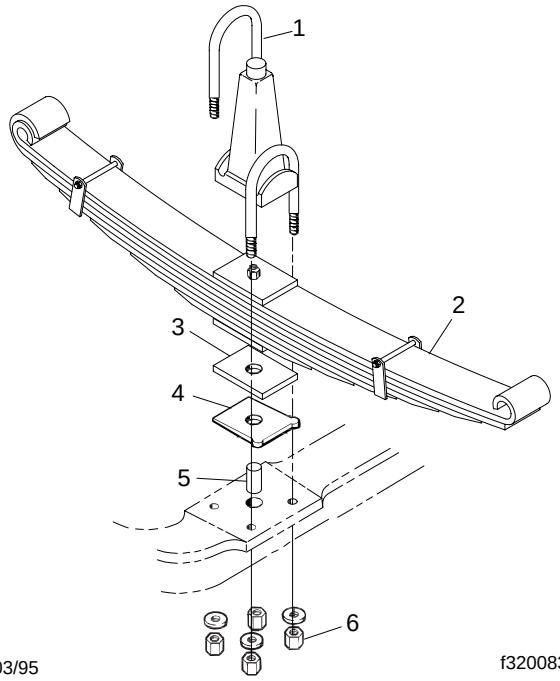
A. Positive Caster
B. Zero Caster
C. Negative Caster
1. Knuckle Pin (Kingpin)

Fig. 1, Caster Angle

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

Using the alignment equipment manufacturer's operating instructions, measure the front wheel caster.

Compare the caster angles with those shown the appropriate table in **Specifications, 400**. If needed, adjust the caster angle by placing wedge-shaped shims between the axle spacer and the axle beam, as follows (**see Fig. 2**):



1. Axle Spring U-Bolt
2. Leaf Spring Assembly
3. Spacer
4. Front Caster Shim
5. Dowel Pin
6. U-Bolt High Nut

Fig. 2

IMPORTANT: Extreme angle shims cannot be used to correct caster angles that vary by more than 2 degrees from the values in the table. Weak or broken leaf springs, or worn shackle bushings, can cause extreme deviations to caster angles. Replace damaged parts before doing caster adjustments.

Caster Angle Checking and Adjusting

1. Apply the parking brakes, and chock the front and rear tires.
2. Back off the U-bolt nuts from the U-bolts on one side of the front axle. **See Fig. 2**.
3. Raise the spring away from the axle enough to allow removal of the front caster shim.
4. Remove the shim, and install one that will provide the correct caster angle, as specified in the table in **Specifications, 400**. Install the dowel pin and check penetration.

IMPORTANT: Place front caster shims between the axle beam and the axle spacer, or between the axle beam and the shock absorber bracket. **See Fig. 2.**

5. Lower the vehicle onto the axle.
6. Coat the threaded ends of the U-bolts with chassis lube or an antiseize compound, such as Loctite® 242. Tighten the U-bolt nuts to the value in the appropriate table in **Specifications, 400**.

   U-bolt nuts need periodic retightening. Refer to the suspension section in the vehicle maintenance manual for recommended intervals.

⚠ CAUTION

CAUTION: Failure to periodically retighten the U-bolt nuts could result in spring breakage and abnormal tire wear.

7. Using the steps above, replace the shim on the other side of the axle.
8. Remove the chocks from the tires. Do a final caster angle check.

Checking and Adjusting

(See Fig. 1)

Using the alignment equipment manufacturer's operating instructions, measure the wheel toe-in. Compare the measurement with that shown in the appropriate table in **Specifications, 400**. If corrections are needed, go to the applicable (tie rod adjustment) step below.

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

1. Apply the parking brakes, and chock the rear tires.
2. Raise the front of the vehicle until the tires clear the ground. Place safety stands under the axle. Make sure the stands will support the weight of the cab, axle, and frame.
3. Using spray paint or a piece of chalk, mark the entire center rib of each front tire.
4. Place a scribe or pointed instrument against the marked center rib of each tire, and turn the tires. The scribes must be held firmly in place so that a single straight line is scribed all the way around each tire.
5. Place a turn-plate or turntable under each tire. Remove the safety stands from under the axle, then lower the vehicle. Remove the lockpins from the gauges; make sure the tires are exactly straight ahead.

NOTE: If turn-plates or turntables are not available, lower the vehicle. Remove the chocks from the rear tires and release the parking brakes. Move the vehicle backward and then forward about six feet (2 meters).

6. Place the trammel bar at the rear of the front tires; locate the trammel pointers at spindle height, and adjust the pointers to line up with the scribe lines. Lock in place. Make sure that the scale is set on zero.

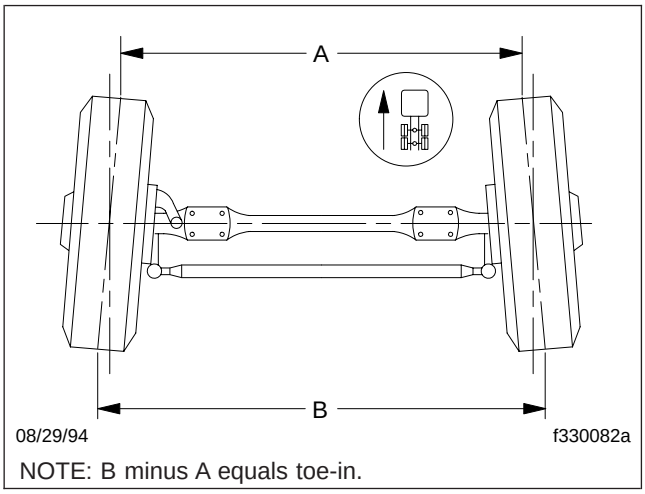


Fig. 1, Wheel Toe-In (Overhead View)

7. Place the trammel bar at the front of the tires as shown in **Fig. 2**. Adjust the scale end so that the pointers line up with the scribe lines. **See Fig. 3.**
8. Read the toe-in from the scale. Compare the toe-in with the value in the appropriate table in **Specifications, 400**. If corrections are needed, go to the next step.
9. Loosen the tie rod (cross tube) clamp nuts, and turn the tie rod as needed.

   If the vehicle is not on turn-plates or turntables, move the vehicle backward and then forward about six feet (two meters). This is important when setting the toe-in on vehicles equipped with radial tires.

   Do a final wheel toe-in check to make sure that it is correct.

   Tighten the clamp nuts to the values in the appropriate table in **Specifications, 400**.
10. If not already done, remove the chocks from the rear tires. Road test the vehicle.

Wheel Toe-In Checking and Adjusting

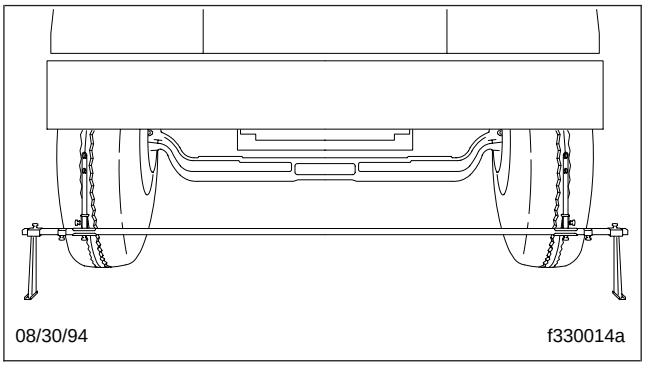


Fig. 2, Trammel Bar Positioning

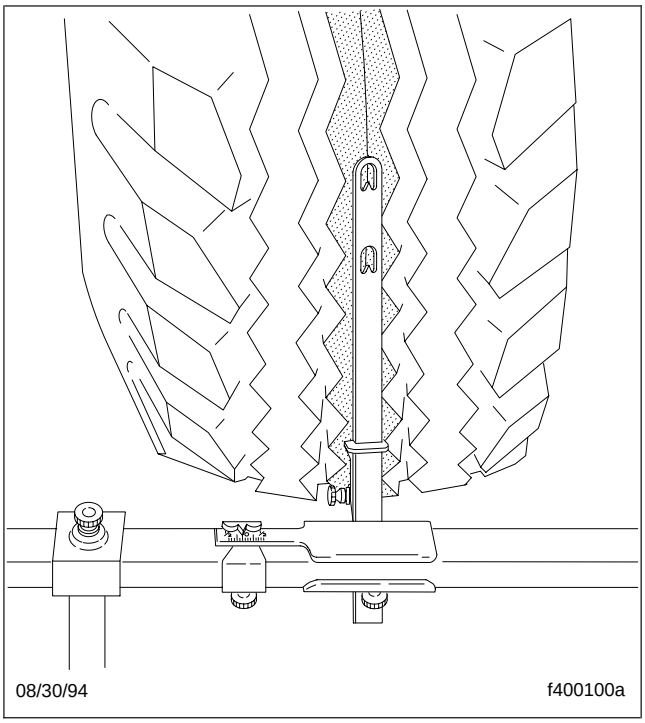


Fig. 3, Calculating Wheel Toe-In

Troubleshooting

Service instructions for most of the remedies below are found by referring to the index in the back of this manual. For axles, refer to the service literature provided by either Rockwell or Eaton Corporation. For tire inflation pressures, refer to the wheels and tires section in this manual. For more steering system troubleshooting information, refer to the steering section in this manual.

Problem - Hard Steering

Problem - Hard Steering	
Possible Cause	**Remedy**
Tire pressure is low in one or both front tires.	Inflate tires to the correct pressure.
Binding in the steering gear due to a lack of lubrication.	Lubricate the steering gear. For instructions, refer to the vehicle maintenance manual.
Too much caster angle in the front wheels.	Check the caster angle and adjust as needed
The front suspension is sagging due to a damaged spring.	Repair or replace the spring as needed. For instructions, refer to the suspension section in this manual.
The axle spindle is bent.	Replace the spindle.
The frame is misaligned.	Check the frame alignment; correct, as needed.
Low pressure in the power steering system.	Repair the power steering system.
Steering gear is not assembled correctly.	Assemble the steering gear correctly.
King pins are binding.	Replace the king pins.
Steering arm geometry is incorrect.	Service the steering system as necessary.
Tie rod ends are hard to move.	Replace the tie rod ends.
Thrust bearing is worn.	Replace the thrust bearing.

Problem - Erratic Steering When the Brakes are Applied

Problem - Erratic Steering When the Brakes are Applied	
Possible Cause	**Remedy**
Tire pressure is low in one or both front tires.	Inflate the tires to the correct pressure.
One or more front axle spring U-bolt nuts are loose.	Check the U-bolt nuts for looseness. If loose, check the U-bolt for damage. Replace damaged parts; tighten loose nuts.
The brakes are not adjusted evenly.	Adjust the brakes on all axles. Also, check the operation of the slack adjusters.
Grease or oil contamination of the brake linings is reducing brake effectiveness.	Replace the brake linings and clean the drums. Find and correct the cause of grease or oil contamination.
The caster angle is wrong.	Check, and adjust as needed.
An axle spindle is bent.	Replace the axle spindle.
The front axle wheel bearings are worn or were incorrectly adjusted.	Check the bearings for wear or damage; replace as needed.

Troubleshooting

Problem - Vehicle Pulls to One Side During Operation

Problem - Vehicle Pulls to One Side During Operation	
Possible Cause	**Remedy**
Tire pressure is low in one or both front tires.	Inflate the tires to the correct pressure.
One or more of the alignment measurements are incorrect.	Check all the alignment measurements. Correct as needed.
The wheels or tires are out-of-round.	Inspect the wheels and tires. Replace out-of-round parts.
The front axle wheel bearings are too tightly adjusted.	Check the bearings for wear or other damage. Replace the bearings if needed.
The front suspension is sagging due to a damaged spring.	Repair or replace the spring as needed. For instructions, refer to the suspension section in this manual.
The axle spindle is bent.	Replace the spindle.
The frame is misaligned.	Check the frame alignment; correct as needed.
The rear axle(s) is out of alignment.	Check, and if needed, adjust the rear axle alignment.

Problem - Front Wheel Wander

Problem - Front Wheel Wander	
Possible Cause	**Remedy**
One or more wheels or brake drums are out-of-balance.	Balance the wheels. Check for out-of-round brake drums; correct as needed.
One of the front springs is weak or broken.	Repair or replace the spring as needed. For instructions, refer to the suspension section in this manual.

Problem - Front Wheel Shimmy

Problem - Front Wheel Shimmy	
Possible Cause	**Remedy**
Tire pressure is low in one or both front tires.	Inflate the tires to the correct pressure.
One or more wheels or brake drums are out-of-balance.	Balance the wheels. Check for out-of-round brake drums, correct or replace as needed.
One or more tires are out-of-round or bulged.	Replace the tire.
The front axle wheel bearings are worn or were incorrectly adjusted.	Check the bearings for wear or other damage. Replace the bearings if needed.
Parts of the steering gear or linkage are worn.	Test for play in the steering gear and linkage with the front tires off the ground. Replace parts as needed.
The axle spindle is bent.	Replace the spindle.
One or more of the alignment measurements are incorrect.	Check all alignment measurements and correct as needed.
The knuckle pin is loose due to worn bushings.	Inspect the knuckle pin and bushings for damage. Replace worn or damaged parts as needed.

Problem - Front Wheel Shimmy	
Possible Cause	**Remedy**
Shock absorbers are worn or damaged.	Check the shock absorbers and replace if needed.
Caster is out of adjustment.	Adjust the caster.

Problem - Vehicle Wanders

Problem - Vehicle Wanders	
Possible Cause	**Remedy**
Tire pressure is low in one or both front tires.	Inflate the tires to the correct pressure.
One or more of the alignment measurements are incorrect.	Check all of the alignment measurements; correct as needed.
The rear axle(s) is out of alignment.	Check the rear axle alignment and adjust as needed.
Parts of the steering gear or linkage are worn.	Test for play in the steering gear and linkage with the front tires off the ground. Replace parts as needed.
A knuckle pin is loose due to worn bushings.	Inspect the knuckle pin and bushings for damage. Replace worn or damaged parts.
The axle spindle is bent.	Replace the spindle.

Problem - Cupped Tires

Problem - Cupped Tires	
Possible Cause	**Remedy**
Tire pressure is too low or too high in one or both front tires.	Inflate or deflate the tires to the correct pressure.
One or more wheels or brake drums are out-of-balance.	Balance the wheels. Check for eccentric brake drums; correct or replace as needed.
The wheel toe-in is not correct.	Adjust the wheel toe-in.
The brakes are not adjusted evenly.	Adjust the brakes on all axles. Also, check the operation of the slack adjusters.
The front axle wheel bearings are worn or were not adjusted correctly.	Check the bearings for wear or other damage; replace them if needed.
The camber angle is not within specifications.	Check the front wheel camber angle. If not correct, find and replace the damaged axle component.

Problem - Steering Wheel Spokes Do Not Point at the 4 and 8 O'clock Positions

Problem - Steering Wheel Spokes Do Not Point at the 4 and 8 O'clock Positions	
Possible Cause	**Remedy**
The steering gear is not centered.	Center the steering gear.
If adjustable, the drag link is out of adjustment.	Adjust the drag link.

Troubleshooting

Problem - Steering Wheel Spokes Do Not Point at the 4 and 8 O'clock Positions	
Possible Cause	**Remedy**
The steering wheel was not installed (positioned) correctly on the steering column.	Reposition the steering wheel on the steering column.
The pitman arm is not correctly aligned with the timing mark on the steering gear output shaft.	Reposition the pitman arm on the steering gear output shaft. For instructions, refer to the steering section in this manual.

Problem - Tires Wear Out Quickly or Have Uneven Tire Tread Wear

Problem - Tires Wear Out Quickly or Have Uneven Tire Tread Wear	
Possible Cause	**Remedy**
Tires have incorrect air pressure.	Inflate or deflate the tires to the correct pressure.
Tires are out of balance.	Balance or replace the tires.
Tandem axle alignment is incorrect.	Align the tandem axles.
Toe-in setting is incorrect.	Adjust toe-in to the specified setting.
Steering arm geometry is incorrect.	Service the steering arm as necessary.

Problem - Ends of the Cross Tube are Worn

Problem - Ends of the Cross Tube are Worn	
Possible Cause	**Remedy**
Ends of the cross tube need lubrication.	Lubricate the ends of the cross tube. Make sure lubrication schedule is followed.
Vehicle is operated in severe conditions.	Operate the vehicle correctly.
Boot on end of cross tube is damaged.	Replace the boot.
Add-on type of power steering cylinders are not installed correctly.	Install the power steering cylinders correctly.

Problem - Bent or Broken Cross Tube, Ball Stud, Steering Arm or Cross Tube Arm

Problem - Bent or Broken Cross Tube, Ball Stud, Steering Arm or Cross Tube Arm	
Possible Cause	**Remedy**
Too much pressure in the power steering system.	Adjust the power steering system to the specified pressure.
Cut-off pressure in the power steering system is out of adjustment.	Adjust the power steering system to the specified pressure.
Vehicle is not operated correctly.	Make sure vehicle is operated correctly.

Problem - Bent or Broken Cross Tube, Ball Stud, Steering Arm or Cross Tube Arm	
Possible Cause	**Remedy**
Add-on type power steering system is not installed correctly.	Install the add-on power steering system correctly.

Problem - Worn or Broken Steering Ball Stud

Problem - Worn or Broken Steering Ball Stud	
Possible Cause	**Remedy**
Drag link fasteners are tightened past specified torque.	Tighten the drag link fasteners to the specified torque.
Lack of lubrication, or lubricant is incorrect.	Lubricate the linkage with specified lubricant.
Power steering stops are out of adjustment.	Adjust the stops to specified dimension.

Problem - Worn King Pins and Knuckle Bushings

Problem - Worn King Pins and Knuckle Bushings	
Possible Cause	**Remedy**
Seals and gaskets are worn or missing.	Replace the seals and gaskets.
Lubricant is incorrect.	Lubricate the axle with specified lubricant.
Axle is not lubricated at scheduled frequency.	Lubricate the axle at scheduled frequency.
Lubrication procedures are incorrect.	Use the correct lubrication procedures.
Lubrication schedule does not match the operating conditions.	Change the lubrication schedule to match the operating conditions.

Specifications

IMPORTANT: When aligning the front axle, it is essential that the rear axle(s) be checked for proper alignment at the same time. Alignment of the rear axle(s) has a direct impact on how the vehicle tracks. See **Section 35.03**, Specifications 400.

Left-Hand-Drive Camber and Toe-In					
Axle Manufacturer	**Axle Model**	**Left Camber * Degrees**	**Right Camber * Degrees**	**Toe-In Limits inch (mm)**	**Toe-In Target inch (mm)**
Meritor	FF-943 FF-961 FG-941 FL-941 FG-943 FF-965 FF-981	Axles built before September 1992: † +1/4 ± 7/16 Axles built from September 1, 1992: † –1/4 ± 7/16	–1/4 ± 7/16	0 to +1/8 ‡ (0 to +3.2)	+1/16 (+1.6)
Freightliner	FK-120	+1/2 ± 1/4	+1/2 ± 1/4		
Dana Spicer	EFA-12F4 E1200 I E1320I	+7/16 ± 7/16	+7/16 ± 7/16		

* Camber angle under axle rated load with axle installed in vehicle.
† A manufacturer's code tag is riveted to the front of the axle beam for identification. Tags with no date code, or with a date code followed by the letter "P" (for example "24592P"), were manufactured before September 1, 1992.
‡ If adjustment is required, set the toe-in as close as possible to +1/16 inch.

Table 1, Left-Hand-Drive Camber and Toe-In

Left-Hand-Drive Caster					
Axle Manufacturer	**Beissbarth Degrees**	**Bee Line**		**Hunter Degrees**	**Target, All Models Degrees**
		Except LC 4000 Degrees	**LC 4000 Degrees**		
Meritor, Freightliner, and Dana Spicer	+3 to +6-1/2	+3 to +6-1/2	+2-1/4 to +4-3/4	+1-1/2 to +5	Left +3-1/2; Right +4
IMPORTANT: Caster settings for the left and right sides *must* be within 1/2 degree of each other. It is necessary for only one side to be within the specifications given in this table.					

Table 2, Left-Hand-Drive Caster

Tie Rod Clamp Nut Torque Values				
Axle Manufacturer	**Axle Model**	**Tie Rod Clamp Nut Size**	**Plain Nut Torque * lbf·ft (N·m)**	**Locknut Torque * lbf·ft (N·m)**
Meritor	FF–943, FF–961, FG–941, FL–941, FG–943	5/8–11	40–60 (54–81)	40–60 (54–81)
Meritor	FF–943, FF–961, FG–941, FL–941, FG–943	5/8–18	40–60 (54–81)	40–55 (54–75)

Specifications

Tie Rod Clamp Nut Torque Values				
Axle Manufacturer	**Axle Model**	**Tie Rod Clamp Nut Size**	**Plain Nut Torque * lbf·ft (N·m)**	**Locknut Torque * lbf·ft (N·m)**
Freightliner	FK–120	7/16–14	—	46–50 (62–68)
Dana Spicer	EFA–12F4	1/2–13	—	45–60 (61–81)

* All torque values in this table apply to parts lightly coated with rust-preventive type oil.

Table 3, Tie Rod Clamp Nut Torque Values

Miscellaneous Torque Values	
Description	**Torque lbf·ft (N·m)**
U-Bolt Nuts 7/8–14	400 (542)
Meritor Stopscrew Locknut	50–65 (68–88)
Freightliner Stopscrew Locknut	80–85 (108–115)

Miscellaneous Torque Values	
Description	**Torque lbf·ft (N·m)**
Dana Spicer Stopscrew Locknut	90–120 (122–163)

Table 4, Miscellaneous Torque Values

Right-Hand-Drive Bias Camber and Toe-In					
Axle Manufacturer	**Axle Model**	**Curb Side Camber * Degrees**	**Driver Side Camber * Degrees**	**Toe-In Limits inch (mm)**	**Toe-In Target inch (mm)**
Meritor	FG–941	–1/2 ± 7/16	3/4 ± 7/16	0 to +1/8 † (0 to +3.2)	+1/16 (+1.6)

* Camber angle under axle rated load with axle installed in vehicle.
† If adjustment is required, set the toe-in as close as possible to +1/16 inch.

Table 5, Right-Hand-Drive Bias Camber and Toe-In

Right-Hand-Drive Caster					
Axle Manufacturer	**Beissbarth Degrees**	**Bee Line**		**Hunter Degrees**	**Target, All Models Degrees**
		Except LC 4000 Degrees	**LC 4000 Degrees**		
Meritor	+3 to +6-1/2	+3 to +6-1/2	+2-1/4 to +4-3/4	+1-1/2 to +5	Left +4; Right +3-1/2
IMPORTANT: Caster settings for the left and right sides *must* be within 1/2 degree of each other. It is necessary for only one side to be within the specifications given in this table.					

Table 6, Right-Hand-Drive Caster

Replacement

1. Remove the wheel, drum, and hub from the axle. For instructions, refer to **section 33.02** in this service manual group for instructions.
2. Remove the inner wheel bearing assembly from the axle. Handling the bearings with clean dry hands, wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone assembly will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion to catch the bearing assembly. Using a hardwood drift and a light hammer, gently tap the bearing and seal out of the inner wheel bearing cup.

⚠ CAUTION

CAUTION: Never use a sharp chisel to cut through an axle ring (wear sleeve). A sharp chisel could damage the spindle or shoulder.

3. Remove the steel axle ring (wear sleeve) by striking the ring surface several times with a ball-peen hammer (**see Fig. 1**). Then, remove the stretched axle ring from the spindle.

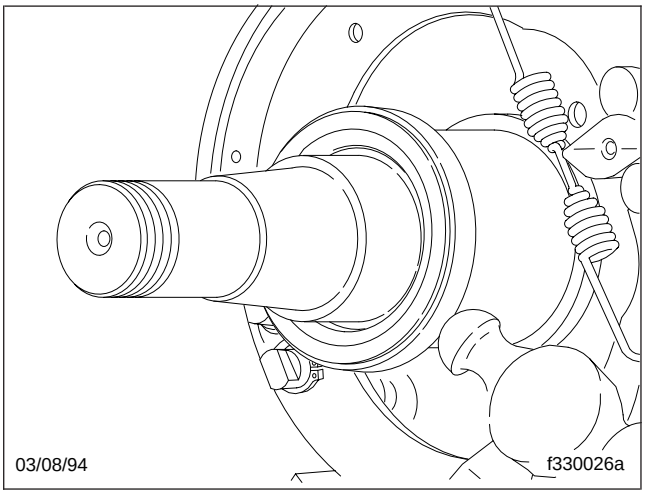


Fig. 1, Removing the Axle Ring

4. Clean and inspect the bearings, the spindle, spindle threads, seal bore, and the hub cavity.

   IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

   4.1 Inspect the inner hub bore. Remove dirt and contaminants from all recesses and corners. Smooth any sharp edges with emery cloth, and fill in any grooves with filler. **See Fig. 2.**

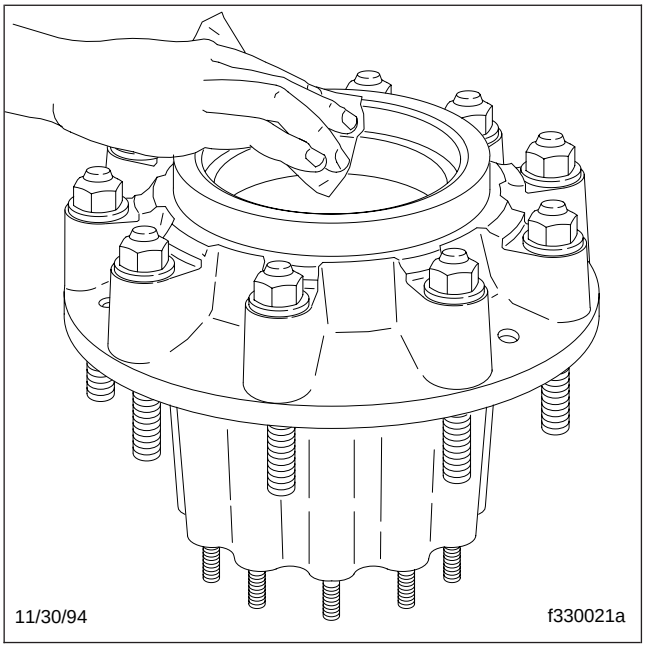


Fig. 2, Clean and Inspect the Hub Bore

   4.2 Wipe the hub area with a clean shop cloth.

   4.3 After removing the wear sleeve, inspect the spindle. Remove any sharp edges and burrs from the leading edges and the shoulder area. Repair deep gouges with filler and smooth with an emery cloth. **See Fig. 3.**

   4.4 Wipe the seal and shoulder area with a clean shop cloth.

⚠ CAUTION

CAUTION: Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

Seal Replacement, Outrunner™

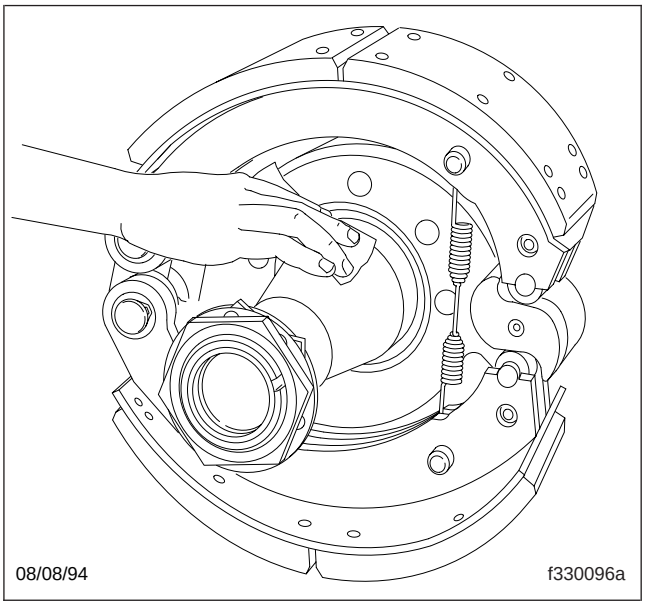


Fig. 3, Clean and Inspect the Axle Spindle

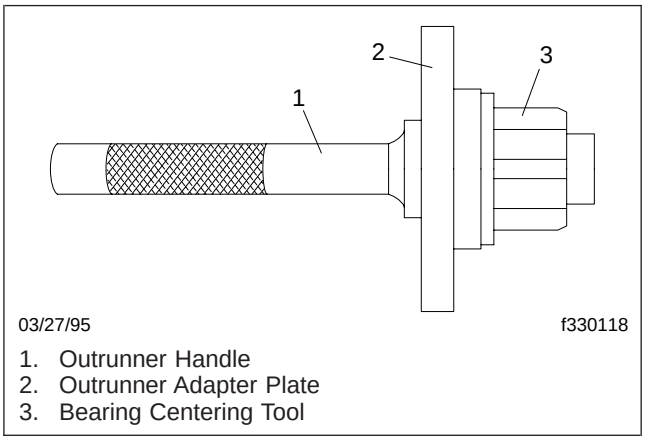
4.5 Inspect the bearings and hub components for wear or damage. Replace any worn or damaged components as necessary.

4.6 Coat the wheel bearing cones with oil.

5. Install the inner wheel bearing cone in the inner wheel bearing cup.

IMPORTANT: Use the Eaton Outrunner installation tool *with the centering tool* when installing the seal. **See Fig. 4.**

6. Install the oil seal in the hub bore.



1. Outrunner Handle
2. Outrunner Adapter Plate
3. Bearing Centering Tool

Fig. 4, Eaton Outrunner Installation Tool

⚠ CAUTION

CAUTION: Do not use any silicone or permatex type bore sealant with this seal. The Eaton Corporation recommends a light coating of bearing oil on the outer circumference of the seal.

Do not mix lubricants of different grades. No not mix mineral and synthetic lubricants. Do not pack the bearings with grease when using an oil bath system. Failure to follow these installation guidlines will result in less than desired performance of the Outrunner seal, and installation-related failures are not covered under warranty.

6.1 Place the outrunner seal tool with the words "air side" facing the adaptor plate of the installation tool. **See Fig. 5.** Lubricate the seal outer circumference with wheel bearing oil.

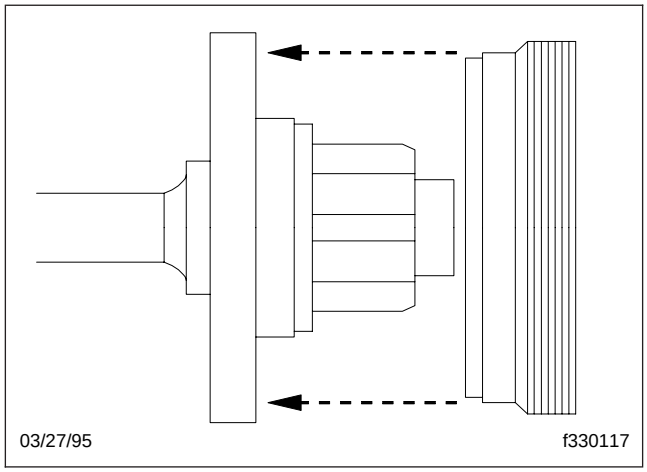


Fig. 5, Seal Placement on Tool

IMPORTANT: Install the seal in the hub bore with the hub layed flat. Do not install the seal with the hub in the vertical (upright) position.

6.2 With the hub and the wheel assembly layed flat on the floor, place the inner bearing cone in the cup.

6.3 Position the oil seal in the hub bore. Before striking the handle of the installation tool, tap the adaptor plate around the outer edge to position the seal. **See Fig. 6.**

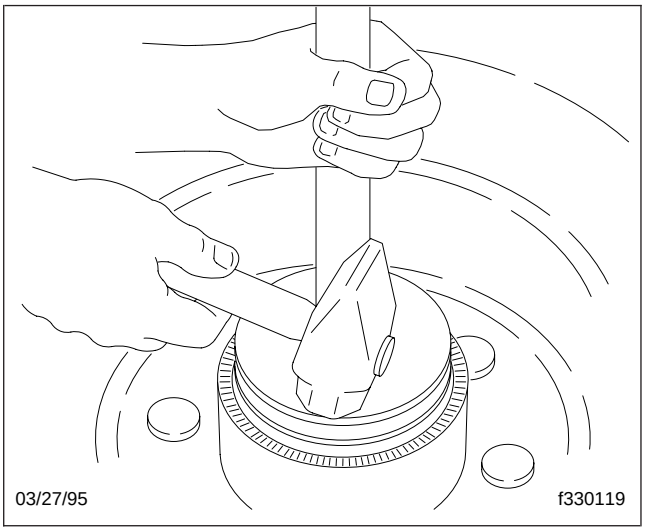


Fig. 6, Position the Seal

6.4 Hit the handle of the installation tool *gently*. **See Fig. 7 .**

Because of the rubber outer circumference, the Outrunner seal is easier to install than seals with metal outer circumferences. When the adaptor plate bottoms out on the hub surface, the seal is installed correctly. You will hear a metal-to-metal sound.

6.5 Check that the seal is not cocked, and that the unitized seal inner circumference and inner bearing turn freely.

6.6 Lubricate the inner circumference of the seal with a light film of clean bearing oil.

7. Install the wheel hub on the axle. Adjust the wheel bearings. For instructions, refer to **section 33.02** in this service manual group.

IMPORTANT: When starting the wheel on the spindle, center the hub carefully to avoid seal damage from the leading edge of the spindle.

8. Place the hubcap and a new gasket in position, then install the capscrews. Tighten the capscrews 15 lbf·ft (20 N·m).

9. Fill the hub with oil to the level shown on the hubcap. **See Fig. 8.** Do not overfill.

10. Spin the wheel and check the oil level.

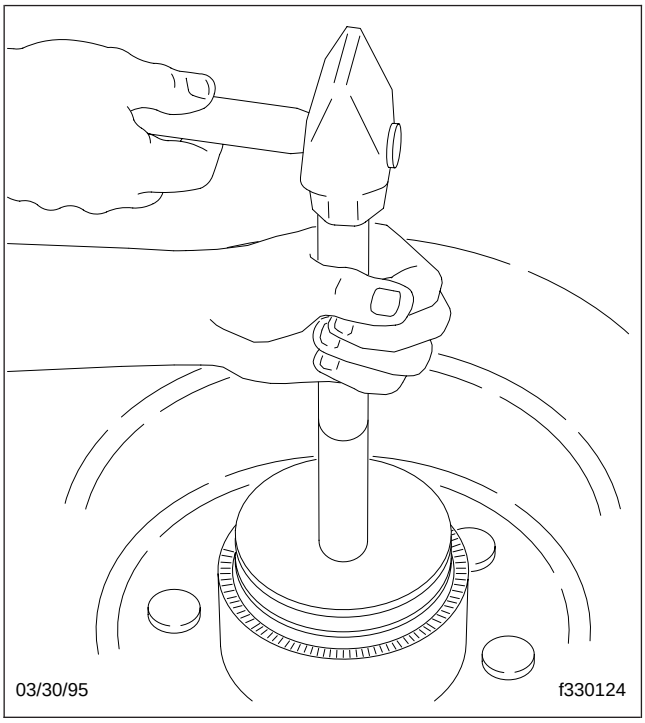
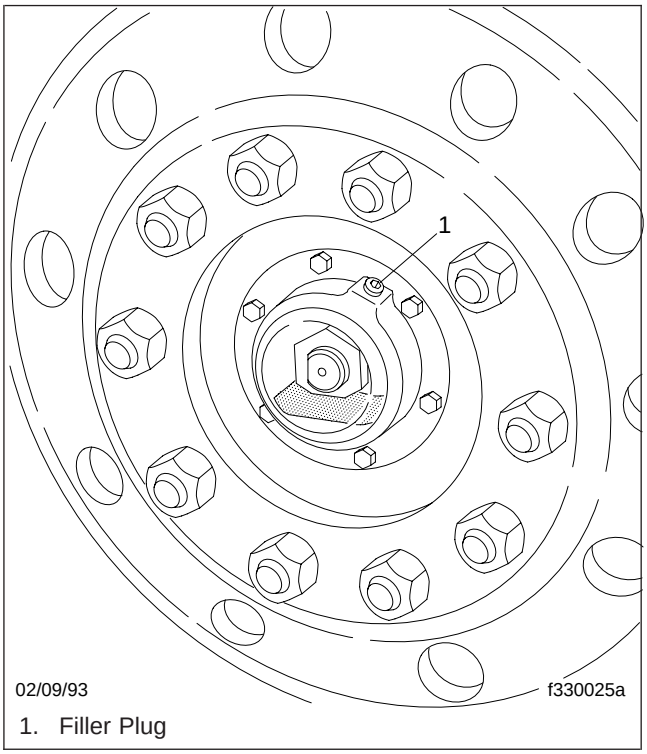


Fig. 7, Install the Seal

11. Adjust the brake shoe-to-drum clearance. For instructions, refer to the brake section in the vehicle maintenance manual.

Seal Replacement, Outrunner™



1. Filler Plug

Fig. 8, Fill the Hub with Oil

General Information

Detroit front axles have a unique steering knuckle design that reduces vibration and wear. Low-friction, high-strength needle bearings roll on a large-diameter kingpin, replacing the conventional bushings. They are compatible with industry-standard brakes, hubs, and wheel bearings.

The following explains a typical model code found on a Detroit front axle identification tag. See **Fig. 1**.

Typical Model Code: AF-12-3.

- *AF* = front axle
- *12* = Weight Rating (times 1000 lb)
- *3* = Model Number

Fig. 1, Front Axle ID Tag

NOTE: Detroit axles are a proprietary product, though in some applications they may be referred to as "Freightliner" or "Axle Alliance" axles or "MB components."

Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the rear tires. Put the transmission in neutral.
2. At both ends of the front axle, loosen all the wheel nuts.

⚠ WARNING

Never work around or under a vehicle that is supported only by a jack. Always support the vehicle with safety stands. Jacks can slip, causing the vehicle to fall, which could result in serious injury or death.

3. Raise the front of the vehicle and support it with safety stands.
4. Drain the air system.
5. Remove the front wheel and tire assemblies. For instructions, see **Group 40**.
6. Remove the front hubs from the axle. See **Section 33.02** for instructions.
7. For drum brakes, remove the brake shoes; see the applicable service brake section in **Group 42** for instructions.
8. Remove the ABS sensors and wiring from the brake spiders (anchor plates) and secure them and their wiring out of the way.
9. Remove the brake air chambers and the slack adjusters. For instructions, see the applicable sections in **Group 42**.
10. Remove the brake spiders from the axle flanges. For instructions, see the applicable service brake section in **Group 42**.
11. Disconnect the drag link from the axle steering arm.
12. If so equipped, disconnect the sway bar from the axle brackets.
13. Using a suitable jack, support the front axle.
14. Remove the U-bolt nuts or remove the nuts holding the axle beam to the leaf springs and the air bag brackets, as applicable.
15. Remove the U-bolts, if applicable.
16. Remove the axle from the vehicle.
17. If you are replacing the steering knuckles, put the axle on a suitable stand and secure it to prevent it from moving.

Installation

1. With the axle on a suitable jack, position it under the vehicle.
2. For vehicles with front air suspension, raise the axle so that the holes in the axle beam line up with the bolts holding the air bags to the leaf springs. Install the nuts and washers and tighten the nuts 220 lbf·ft (298 N·m).

   For vehicles with a leaf-spring front suspension, install the U-bolts and nuts. For instructions on tightening U-bolt nuts, see the applicable section in **Group 32**.
3. If so equipped, connect the sway bar to the axle brackets. Tighten the sway bar fasteners 100 lbf·ft (136 N·m).
4. Connect the drag link to the steering arm. For instructions, see the applicable section in **Group 46**.
5. Install the brake spiders on the axle flanges. For instructions, see the applicable service brake section in **Group 42**.
6. Install the brake air chambers and slack adjusters onto the axle. For instructions, see the applicable sections in **Group 42**.
7. Install the ABS sensors.
8. For drum brakes, install the brake shoes; see the applicable service brake section in **Group 42** for instructions.
9. Install the hubs. For instructions, see **Section 33.02**.
10. Install the brake drums.
11. Adjust the slack adjusters. For instructions, see the applicable section in **Group 42**.
12. Install the tire and wheel assemblies. For instructions, see **Group 40**.
13. Raise the vehicle, remove the safety stands, and lower the vehicle.
14. Start the engine and build the air pressure.
15. If equipped with a front air suspension, ensure that the suspension air bags inflate correctly.

Steering Knuckle Disassembly and Assembly

Disassembly

NOTE: The following procedures can be done with the axle installed on the vehicle or with the axle removed from the vehicle.

1. If the axle has been removed, make sure it is securely mounted on a suitable stand. Go to the step for removing the tie rod from the tie-rod arm.

   If the axle is on the vehicle, park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the rear tires. Drain the air system.

2. If the axle is on the vehicle, do the following substeps to gain access to the steering knuckle.

   2.1 Remove the wheel and tire assembly from the applicable side of the vehicle.

   2.2 Remove the hub. For instructions, see **Section 33.02**.

   2.3 Remove the brake shoes. For instructions, see the applicable service brake section in **Group 42**.

   2.4 Remove the ABS sensor and wiring from the brake spider (anchor plate), and secure the sensor and the wiring out of the way.

   2.5 Disconnect the air line from the brake air chamber, then remove the air chamber and the slack adjusters. For instructions, see the applicable sections in **Group 42**.

   2.6 Remove the brake spider from the axle flange. For instructions, see the applicable service brake section in **Group 42**.

   2.7 Disconnect the drag link from the steering arm, if present.

   NOTE: On the driver side of the vehicle, the steering arm connects to the steering knuckle; on the passenger side, no steering arm is present.

3. If not already done, disconnect the tie rod from the tie-rod arm.

4. Remove the tie-rod arm from the steering knuckle. See **Fig. 1**.

5. Remove the steering arm. See **Fig. 1**.

6. Remove the steering knuckle and spindle assembly from the axle beam. See **Fig. 1**.

   6.1 Remove the upper and lower snap rings that hold the cover plates in place.

   6.2 Remove the upper and lower cover plates from the steering knuckle.

   6.3 Remove and discard the O-ring from the edges of each cover plate.

   6.4 Note the orientation of the draw keys and the kingpin, then remove the draw keys and nuts that hold the kingpin in place.

   6.5 Using a brass drift, remove the kingpin by driving it downward. Note where the needle bearings were installed.

   6.6 Remove the spacer(s) and shim(s) from the upper surface of the axle beam bore.

   6.7 Push down on the steering knuckle and spindle assembly to clear the lip on the thrust friction bearing and remove the assembly from the axle beam bore.

NOTE: The steering knuckle on the passenger side (side without a steering arm) has a thrust roller bearing instead of a thrust friction bearing. Unlike the thrust friction bearing, the thrust roller bearing has no protruding lip at the top. When removing the thrust roller bearing from the axle beam bore, it is not necessary to push down on the steering knuckle.

7. Remove the grease seal from the upper steering-knuckle bore.

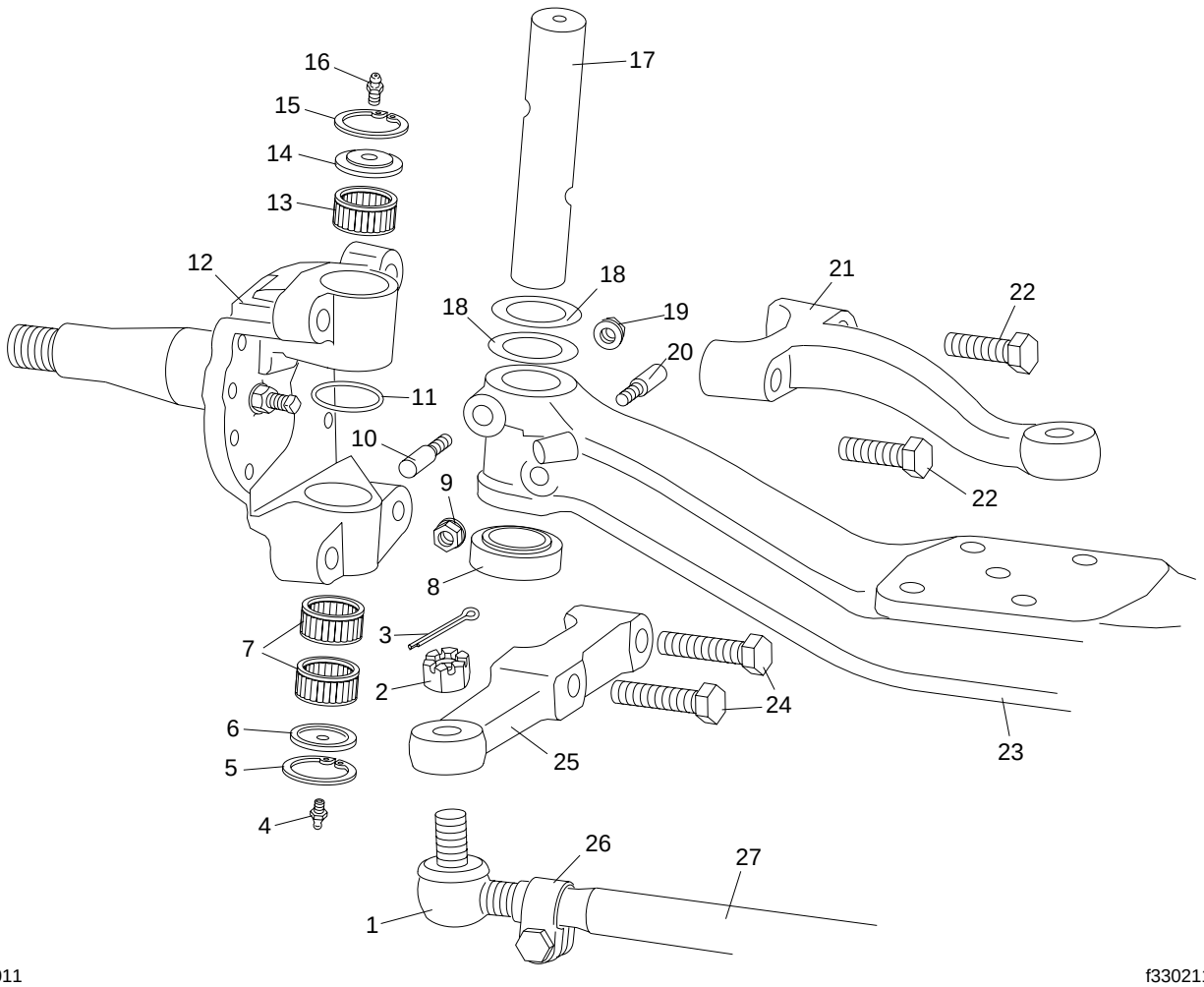
8. Remove the thrust friction bearing (driver side) or the thrust roller bearing (passenger side) from the top of the lower steering knuckle bore.

NOTE: If removing the thrust friction bearing (driver side), note the orientation of the bearing for future reference.

9. Using a suitable bushing driver, drive out the needle bearings from the steering knuckle bores.

10. If needed, repeat the entire procedure for the other side of the axle assembly.

Steering Knuckle Disassembly and Assembly



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NOTE: The number of upper and lower needle bearing sets may vary, depending on the axle model.

1. Tie-Rod Ball Joint
2. Castle Nut
3. Cotter Pin
4. Lower Grease Fitting
5. Lower Snap Ring
6. Lower Cover Plate
7. Lower Needle Bearings (may be one or two sets)
8. Thrust Friction Bearing (thrust roller bearing on the passenger side)
9. Lower Draw Key Nut
10. Upper Draw Key
11. Grease Seal
12. Steering Knuckle
13. Upper Needle Bearing (may be one or two sets)
14. Upper Cover Plate
15. Upper Snap Ring
16. Upper Grease Fitting
17. Kingpin
18. Shim
19. Upper Draw Key Nut
20. Lower Draw Key
21. Steering Arm
22. Steering Arm Capscrew
23. Axle Beam
24. Tie-Rod Arm Capscrews
25. Tie-Rod Arm
26. Tie-Rod Clamp
27. Tie-Rod Tube

Fig. 1, Front Axle Components (driver side shown)

Assembly

IMPORTANT: If replacing the kingpin, use a complete rebuild kit with all new components.

1. Clean the steering knuckle bores and the axle beam bores. Check for damage such as grooves, scratches, and pitting.

   If any bores show significant damage, replace the component.

2. Install the grease seal — with the grooved side down (toward the road) — into the top of the upper steering knuckle bore. Carefully drive the seal down into the bore until the outer edge of the seal is flush with the bottom edge of the bore. Make sure the seal is not cocked.

3. Install new needle bearings into the bores of one of the steering knuckles. Install the same number of bearings as was removed.

NOTE: Install the needle bearings just far enough into the bores so that the cover plates can be installed.

4. Install a new thrust friction bearing (driver side) or thrust roller bearing (passenger side) into the top of the lower steering knuckle bore. Install the thrust friction bearing (or thrust roller bearing) with the sealed side up.

NOTE: The thrust friction bearing has a protruding lip at the top; the thrust roller bearing has no such protruding lip.

5. Partially install the steering knuckle onto the axle beam.

   5.1 Making sure the flats on the kingpin are aligned with the draw-key holes in the axle beam, put the new kingpin into the top bore of the steering knuckle. Note that the top of the new kingpin is clearly marked. Push the kingpin through the axle beam bore until the upper end of the kingpin is flush with the upper surface of the axle beam bore.

   IMPORTANT: To correctly check the clearance, the thrust friction or thrust roller bearing must be installed correctly, and upward pressure must be applied to the steering knuckle.

   5.2 Align the steering knuckle with the axle beam, then check the clearance between the axle beam bore and the upper steering knuckle bore. Clearance is to be a maximum of 0.007 inch (0.18 mm).

   5.3 If needed, install sufficient spacers to reduce the clearance to a maximum of 0.007 inch (0.18 mm).

6. Install the kingpin fully into the steering knuckle bores, ensuring that the flats on the kingpin are still aligned with the draw-key holes in the axle beam, and that the top of the kingpin (marked "Top") is properly positioned.

IMPORTANT: Make sure the new draw keys are the same length as those removed. On some axle models the lower draw key is longer than the upper one.

7. Install new upper and lower draw keys and nuts. See **Fig. 1**.

   IMPORTANT: Incorrect installation of the draw keys could cause interference with the steering stop bolt.

   7.1 Install the upper draw key from the back of the axle, and the lower one from the front of the axle.

   7.2 Tighten the draw-key nuts 30 to 55 lbf·ft (40 to 75 N·m).

8. Install new grease fittings and cover plates.

   8.1 Install the new upper cover plate (with a new O-ring) and the snap ring. Install the new grease fitting into the cover plate.

   8.2 Install the new lower cover plate (with a new O-ring) and the snap ring. Install the new grease fitting into the cover plate.

9. Install the steering arm. Apply Loctite® 277 to the threads and tighten the steering arm capscrews: if M20 capscrews are used, tighten them 425 lbf·ft (575 N·m); if M24 capscrews are used, tighten them 664 lbf·ft (900 N·m).

10. Attach the tie-rod arm to the steering knuckle. Apply Loctite® 277 to the threads and tighten the tie-rod arm capscrews: if M20 capscrews are used, tighten them 425 lbf·ft (575 N·m); if M24 capscrews are used, tighten them 664 lbf·ft (900 N·m).

Steering Knuckle Disassembly and Assembly

11. Attach the tie-rod arm to the tie rod. Tighten the castle nut 120 to 170 lbf·ft (163 to 230 N·m) plus a maximum of one-sixth of a turn to align a slot in the castle nut with the cotter pin hole in the tie rod stud. Insert the cotter pin and bend the tangs to secure it.
12. If removed, install the axle.
13. If removed, connect the drag link to the steering arm.
14. Install the brake spider on the axle flange. For instructions, see the applicable service brake section in **Group 42**.
15. Install the brake air chambers and slack adjusters on the axle. For instructions, see the applicable sections in **Group 42**.
16. Install the ABS sensor.
17. Install the brake shoes. For instructions, see the applicable service brake section in **Group 42**.
18. Install the hub. For instructions, see **Section 33.02**.
19. If so equipped, install the brake drum.
20. Install the tire and wheel assembly. For instructions, see **Group 40**.
21. If necessary, repeat the entire procedure for the other side of the vehicle.
22. Raise the vehicle, remove the safety stands, then lower the vehicle.

Specifications

Torque Values			
Application	**Size**	**Class**	**Torque: lbf·ft (N·m)**
Draw-Key Nuts	—	—	30–55 (40–75)
Steering Arm Capscrews	M20 x 1.5	10.9	425 (575)*
	M24 x 1.5	10.9	664 (900)*
Sway Bar Fasteners	—	—	100 (136)
Tie-Rod Arm Capscrews	M20 x 1.5	10.9	425 (575)*
	M24 x 1.5	10.9	664 (900)*

* Apply Loctite® 277.

Table 1, Torque Values

General Description

Oil seals keep oil in the hub to lubricate the wheel bearings. They also protect the wheel bearings from dirt, dust, and water. The oil seal fits between the hub bore and the axle spindle. **See Fig. 1.**

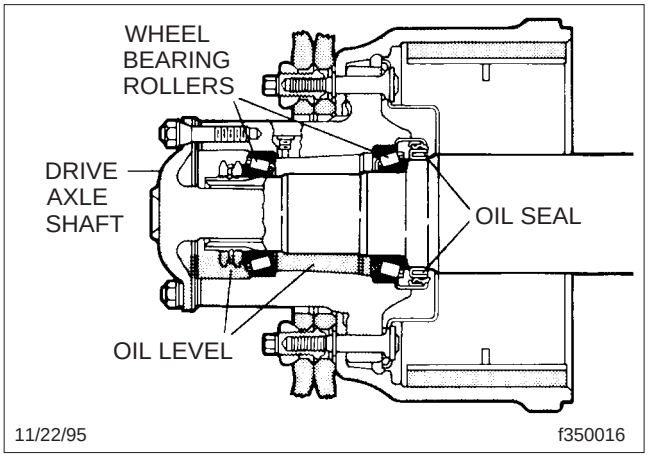


Fig. 1

Replacement

Review the rear axle section of the vehicle maintenance manual before beginning the service operations below. It provides lubrication requirements and additional instructions for oil seal replacement.

1. Chock the front tires to prevent vehicle movement. Release the parking brakes.
2. Raise the rear of the vehicle until the tires clear the ground. Then, place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.
4. Remove the wheel, drum, and hub from the axle. Refer to the rear axle section in this manual for instructions.
5. Remove the old oil seal from the hub or spindle.
6. Clean the spindle, spindle threads, seal bore, and the hub cavity.

⚠ CAUTION

CAUTION: Never use a sharp chisel to cut through an axle ring. A sharp chisel could damage the spindle or shoulder.

7. Remove the steel axle ring by striking the ring surface several times with a ball-peen hammer (**Fig. 1**). The stretched axle ring can then be removed from the spindle.
8. Using a wire brush, remove any old sealant and corrosion from the spindle and shoulder. Remove any burrs with an emery cloth (**Fig. 2**).

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

9. Wipe the spindle and shoulder clean with safety solvent.
10. Remove any burrs from the inside of the hub bore (**Fig. 3**). The hub bore must be free of burrs that will scratch the outside diameter of the seal and allow oil to escape from the hub. Remove any spacer rings or washers, if so equipped.

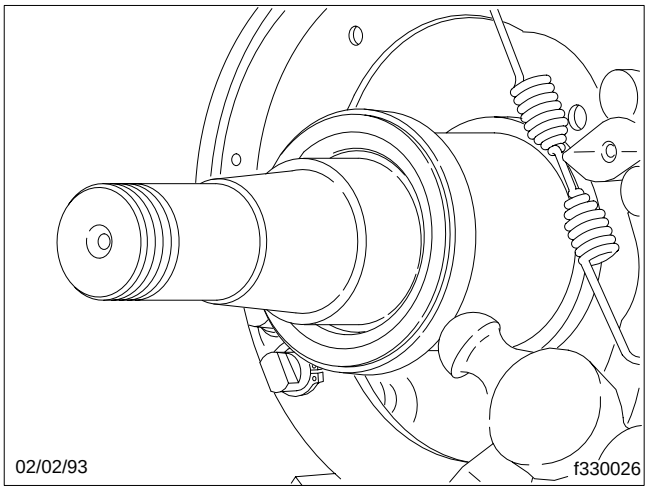


Fig. 1

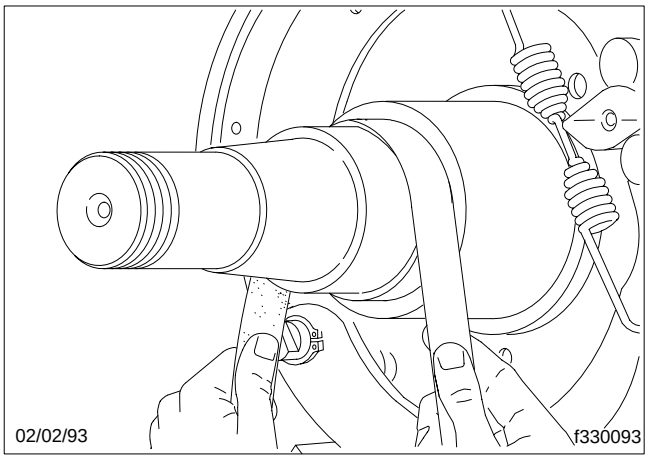
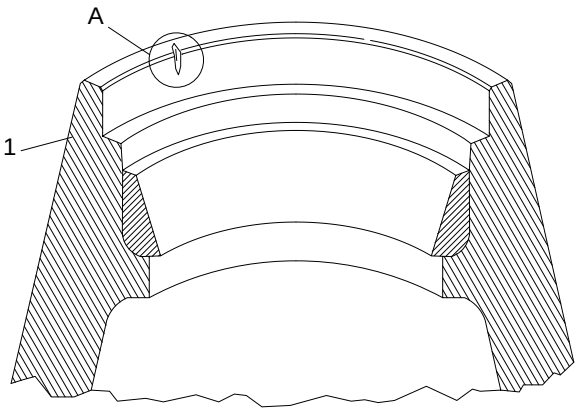


Fig. 2

IMPORTANT: Clean the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause rapid wear of the bearing assembly.

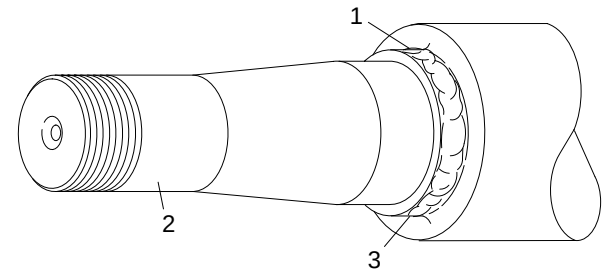
11. Inspect the bearings and hub parts for wear or damage. Replace any worn or damaged parts as necessary.

Seal Replacement



1. Hub
A. Check for burrs.

Fig. 3



1. Nonhardening Sealant
2. Spindle
3. Shoulder

Fig. 4

⚠ CAUTION

CAUTION: Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

12. If burrs were removed from the spindle shoulder, apply a thin layer of a nonhardening sealant to the spindle shoulder, as shown in **Fig. 4**.

NOTE: Use a nonhardening sealant such as Permatex® Number-2 or Loctite® 515.

13. Place the oil seal on the spindle so the words "oil-bearing side" are exposed to the oil. A slight step on the inside diameter of the seal ring will allow it to be placed by hand about 1/8 inch (3 mm) onto the shoulder. **See Fig. 5.**

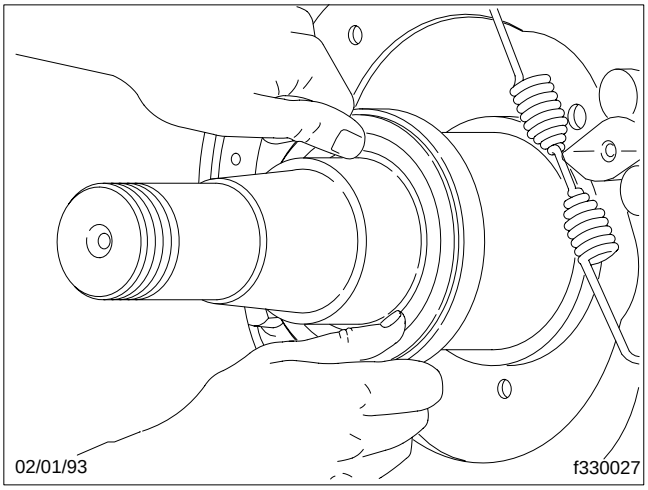


Fig. 5

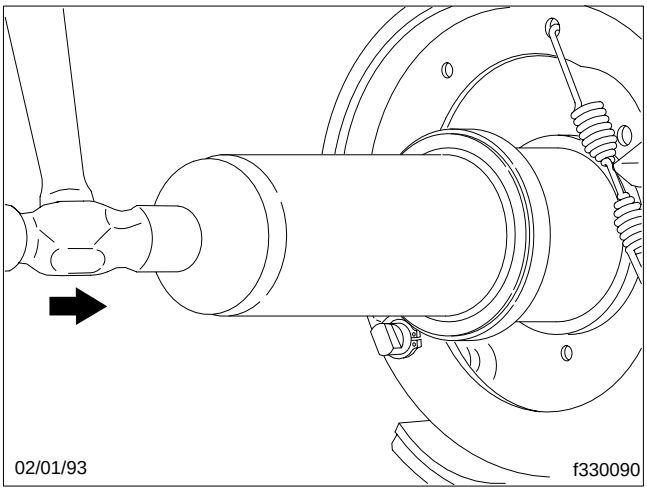


Fig. 6

⚠ CAUTION

CAUTION: Do not install the oil seal in the hub bore. Incorrect seal installation will damage the seal and lead to possible spindle, hub, and bearing damage.

14. Position the installation tool, specified by Stemco for the axle on the vehicle, over the spindle (

Fig. 6). Using a 3 to 5 lb (1 to 2 kg) hammer, drive the seal on the spindle until the tool bottoms against the shoulder. After it bottoms, turn the tool while applying several light taps with the hammer to ensure the seal ring is flush with the face of the shoulder. Wipe off all excess sealant.

IMPORTANT: Always use the tool specified for the axle. In order for the Stemco warranty to apply, the product must be correctly installed using the correct tool made by Stemco or a tool approved by Stemco.

15. Make sure there aren't any gaps between the ring and shoulder. **See Fig. 7.**
16. Coat the inner wheel bearing with oil and install it on the spindle (**Fig. 8**). No additional lubrication is needed on the outside of the seal. The seals are lubed at the factory.
17. With the wheel mounted on a wheel dolly, align the hub bore with the spindle (**Fig. 9**), then push the wheel onto the spindle until it just contacts the seal. Add oil until the level is even with the inner bearing cup. Do not overfill; the seal is not yet seated in the bore. **See Fig. 10.**

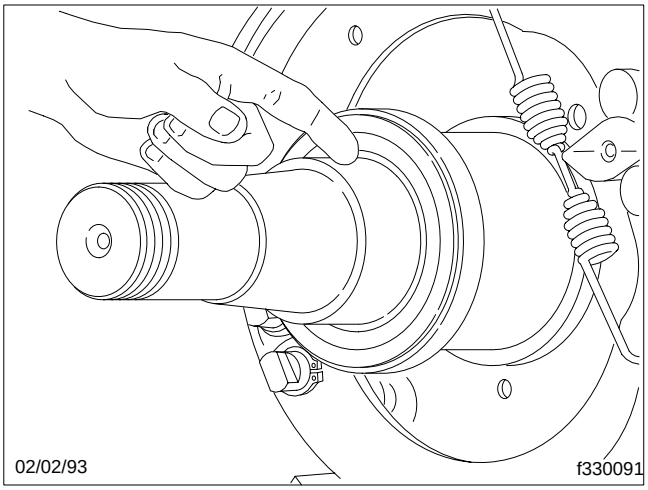


Fig. 7

IMPORTANT: Do not force the wheel hub onto the seal. The wheel hub will seat on the seal when the adjustment nut is tightened.

18. Coat the outer bearing in oil and place it on the spindle and into the bearing cup.

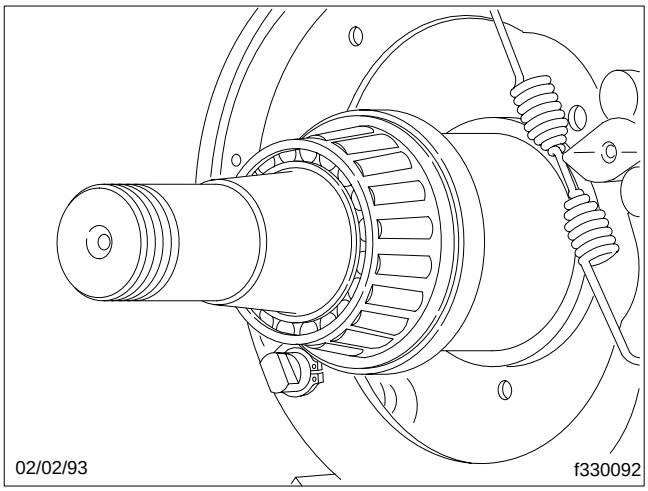


Fig. 8

19. Adjust the wheel bearings. For instructions, refer to the rear axle section in this manual.
20. Install a new gasket on the drive axle studs.

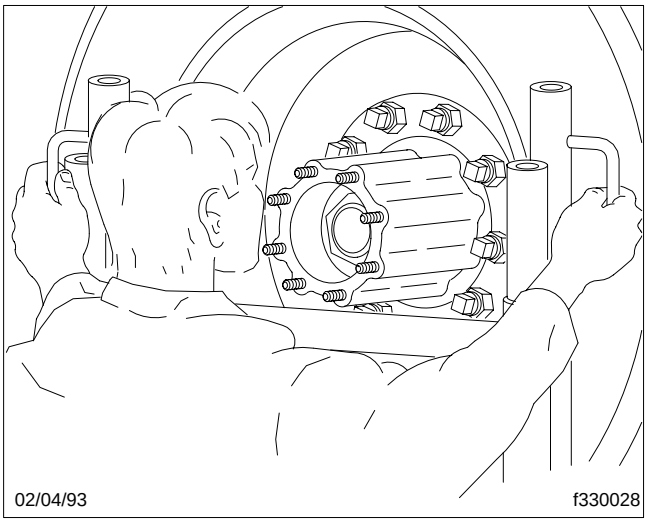


Fig. 9, Rear Axle

21. Install the drive axle shaft or, on non-drive axles, the hub cap. The splined end of the axle shaft must seat before the drive axle flange will fit over the studs.
22. If equipped, install the dowels and washers on the drive axle studs. Install the drive axle nuts. Tighten the nuts to the torque values in the torque table in **Specifications, 400**.

Seal Replacement

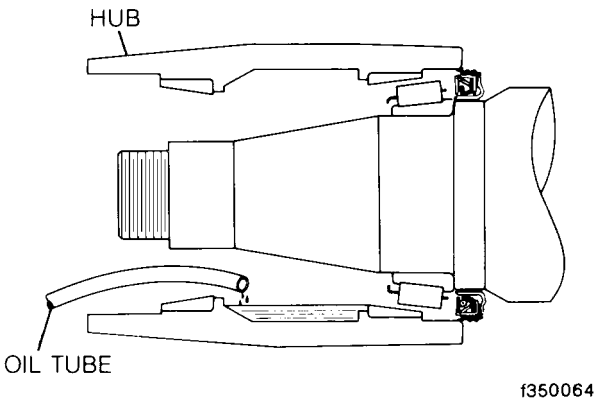


Fig. 10

23. Install the brake drum on the wheel hub.

⚠ WARNING

WARNING: If the inner wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking action, and the hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist, could result in loss of a wheel or loss of vehicle control, and possible personal injury.

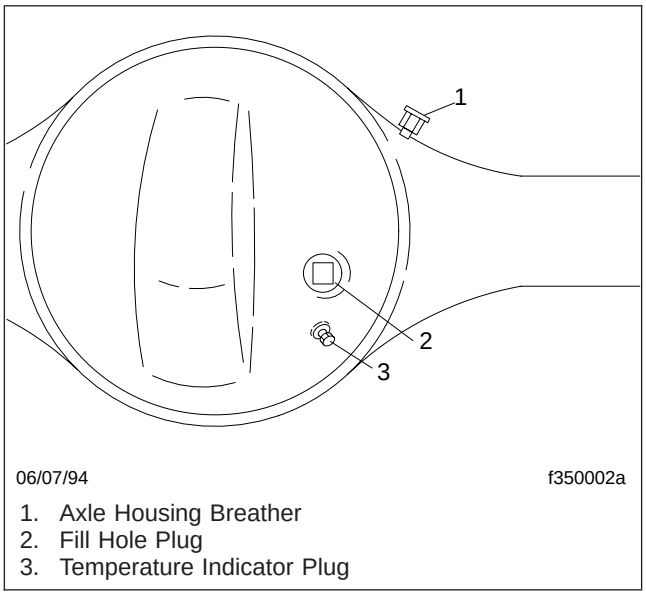
24. Install the inner and outer wheel and tire assemblies. For instructions, refer to the wheels and tires section in this manual.

⚠ WARNING

WARNING: Failure to add oil to the axle housing bowl or the wheel hub after the drive axle shaft and wheel hub have been serviced will damage the wheel bearings and cause them to seize during vehicle operation. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

25. For drive axles, pour the recommended drive axle lubricant through the axle housing filler hole (**Fig. 11** or **Fig. 12**) until the lubricant is level with the bottom of the hole. **See Fig. 13.** Refer to **Specifications, 400** for the recommended axle lubricants. On Eaton axles, tighten the oil filler plug 40 to 60 lbf·ft (54 to 81 N·m); on Rockwell axles, tighten the plug 35 lbf·ft (47 N·m).

    Tilt the axle to the left and right, by jacking the opposite side. Hold the tilted position for one minute on each side, to allow oil to run into the wheel end. Return the axle to a level position, and add oil through the axle housing filler hole. About two extra pints (1 L) of lubricant will be needed, to bring the oil level even with the base of the filler hole.



1. Axle Housing Breather
2. Fill Hole Plug
3. Temperature Indicator Plug

Fig. 11, Eaton Axle

NOTE: Drive axle wheel bearings are lubricated by oil drawn from the axle housing bowl section. This method ensures good exchange of heat, prevents stagnation, and minimizes the maintenance required on bearings, and hub assemblies.

26. For non-drive axles, add about 1 to 1-1/2 pints (0.5 to 0.7 L) of oil to the level shown on the hub cap. Do not overfill. Install the vent plug or threaded filler plug.

27. Turn the wheels, and check the lubricant level.

28. Adjust the rear axle brakes. For instructions, refer to the rear axle section in the vehicle maintenance manual.

29. Remove the safety stands from under the axle, then lower the vehicle.

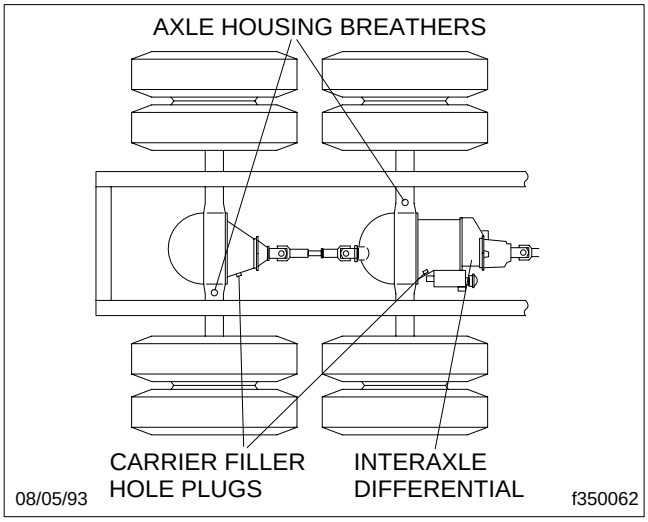


Fig. 12, Filler Hole Plug and Axle Housing Breather Locations, Rockwell Axle

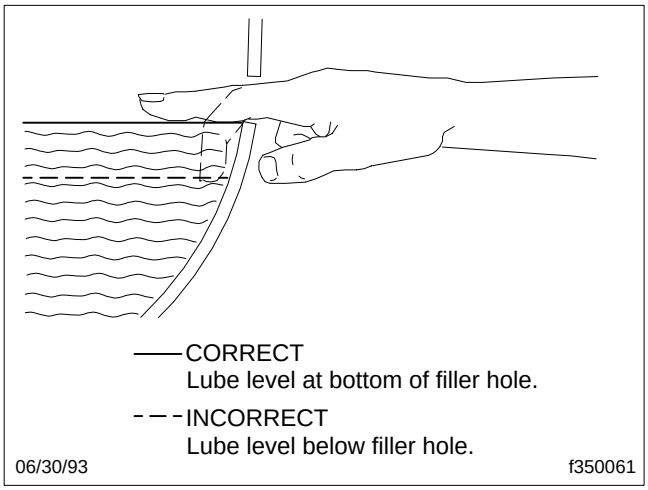


Fig. 13

30. Apply the parking brakes, then remove the chocks from the front tires.

Specifications

Lubricant Type	Condition	Lubricant SAE Viscosity Grade
Eaton® Roadranger® Synthetic Drive Axle Lubricants, or Equivalent with Military Specification MIL–L–2105D	Over-the-Road Service	75W–90
	Off-Highway Equipment, or Under Extra Heavy Loads	80W–140

Table 1, Eaton Drive Axle Recommended Lubricant

Axle Type	Axle Model	Capacity * pints (liters)
Single Reduction	23085S, 23085D	40 (18.9)
	23105S, 23105D	48 (22.7)
	23121	41 (19.4)
	30105S	46 (21.8)
Double Reduction	35055P	36 (17.0)

* Quantities listed are approximate. Fill axle until lubricant is level with bottom of fill hole with vehicle on level ground.

Table 2, Eaton Drive Axle Lubricant Capacities, Single-Drive Axles

Specifications

Axle Type	Axle Model	Capacity * pints (liters)	Axle Type	Axle Model	Capacity * pints (liters)
Single Reduction	DS341	39 (18.5) †	Dual Range (2-Speed)	DT401, 401–P	39 (18.5) †
	RS341	36 (17)		RT401	36 (17)
	DS381, 381–P	39 (18.5) †		DT402, 402–P	34 (16.1) †
	RS381	36 (17)		RT–402	34 (16.1)
	DS401, 401–P	39 (18.5) †		DT451, DT451–P	39 (18.5) †
	RS401	36 (17)		RT451	34 (16.1)
	DS402, 402–P	39 (18.5) †		DT461–P	43 (20.3) †
	RS402	36 (17)		RT461	40 (18.9)
	DS404	39 (18.5) †	Double Reduction	DP451–P	34 (16.1) †
	RS404	36 (17)		RP451	34 (16.1)
	DS451, 451–P	39 (18.5) †		DP461–P	43 (20.3) †
	RS451	36 (17)		RP461	40 (18.9)
	DS460–P	44 (20.8) †		DP521–P	42 (19.9) †
	RS460	40 (18.9)		RP521	39 (18.5)
	DS461–P	43 (20.3) †		DP601–P	42 (19.9) †
	RS461	40 (18.9)		RP601	39 (18.5)
	DS581–P	42 (19.9) †		DP651–P	41 (19.4) †
	RS581	39 (18.5)		RP651	37 (17.5)

* Quantities listed are approximate. Fill axle until lubricant is level with bottom of fill hole with vehicle on level ground.
† Add 2 pints (1 L) of additional lubricant to the power divider.

Table 3, Eaton Drive Axle Lubricant Capacities, Tandem-Drive Axles

Recommended Lubricant Type	Ambient Temperature	Lubricant SAE Viscosity Grade	Rockwell Specification
Hypoid Gear Oil API Service Classification GL–5	+10°F (–12.2°C) and up *	85W–140	0–76–A
	–15°F (–26.1°C) and up *	80W–140	0–76–B
	–15°F (–26.1°C) and up *	80W–90	0–76–D
	–40°F (–40°C) and up *	75W–90	0–76–E
	–40°F (–40°C) to +35°F (+2°C)	75W	0–76–J
	–40°F (–40°C) and up *	75W–140	0–76–L
Synthetic Gear Oil	–40°F (–40°C) and up *	75W–90	0–76–N
	–40°F (–40°C) and up *	75W–140	0–76–M

* There is no upper limit on these ambient temperatures, but axle sump temperature must never exceed 250°F (121°C).

Table 4, Rockwell Drive Axle Recommended Lubricant

Axle Type	Axle Model	Capacity * pints (liters)
Single Reduction	RS–23–160	39.5 (18.7)
	RS–23–161	37.2 (17.6)
	RS–23–180	47.3 (22.4)
	RS–26–180	46.6 (22.0)
	RS–30–180	46.6 (22.0)
Double Reduction	RS–26–380	58.2 (27.5)
	RS–30–380	46.6 (22.0)
	RS–38–380	58.2 (27.5)

* Quantities listed are approximate. Fill axle until lubricant is level with bottom of fill hole with vehicle on level ground.

Table 5, Rockwell Drive Axle Lubricant Capacities, Single-Drive Axles

Axle Type	Axle Model	Capacity * pints (liters)	Axle Type	Axle Model	Capacity * pints (liters)
Single Reduction	Q–100	Forward 40.0 (18.9) Rear 37.0 (17.5)	Single Reduction	SQ–100P	Forward 42.0 (19.9) Rear 37.0 (17.5)
	RT–40–140	Forward 30.2 (14.3) Rear 22.8 (10.8)		SQR–100	Forward 36.0 (17.0) Rear 33.0 (15.6)
	RT–40–145 and –145P	Forward 30.2 (14.3) Rear 25.8 (12.2)		SQR–100P	Forward 38.0 (18.0) Rear 33.0 (15.6)
	RT–44–145 and –145P	Forward 29.3 (13.9) Rear 25.1 (11.9)		SR–170	Forward 55.0 (26.0) Rear 43.0 (23.3)
	RT–46–160 and –160P	Forward 39.1 (18.5) Rear 34.4 (16.3)		SSHD	Forward 34.0 (16.0) Rear 28.0 (13.0)
	RT–48–180	Forward 61.1 (28.9) Rear 38.8 (17.4)	Double Reduction	RT–48–380	Forward 61.1 (28.9) Rear 63.6 (30.1)
	RT–52–160 and –160P	Forward 44.1 (20.9) Rear 41.2 (19.5)		RT–52–380	Forward 56.1 (26.5) Rear 58.2 (27.5)
	RT–52–180	Forward 56.1 (26.5) Rear 41.2 (19.5)		RT–58–380	Forward 56.1 (26.5) Rear 58.2 (27.5)
	RT–58–180	Forward 56.1 (26.5) Rear 36.1 (17.1)		RT–70–380	Forward 54.4 (25.7) Rear 53.1 (25.1)
	SQ–100A	Forward 40.0 (18.9) Rear 37.0 (17.5)			

* Quantities listed are approximate. Fill axle until lubricant is level with bottom of fill hole with vehicle on level ground.

Table 6, Rockwell Drive Axle Lubricant Capacities, Tandem-Drive Axles

Specifications

Description		Size (grade 8)	Torque: lbf·ft (N·m)
Spoke Wheel Brake Drum Nuts		3/4–10	240 (325)
Hub Cap Capscrews		5/16–18	15 (20)
Drive Axle Studs (to hub)		1/2–13	70 (95)
		5/8–11	135 (185)
Drive Axle Stud Nuts	With Dowels	5/8–11	135 (185)
	Without Dowels	5/8–18	130–140 (175–190)
Spoke Wheel Rim Studs		3/4–10	185–200 (250–325)

Table 7, Torque Values

General Description

The Scotseal oil seal acts as a barrier between the inside bore of the wheel hub and the axle spindle. **See Fig. 1.** This stops dirt, moisture, or other contaminants from entering the inner cavity of the wheel hub, and keeps oil in the hub to lubricate the wheel bearings.

Each seal is installed in the wheel hub. When the hub is installed onto the axle spindle, the inside diameter of the seal will press-fit onto the spindle shoulder. As the wheel turns, the seal wears within itself and does not wear on the inside of the hub or on the spindle shoulder.

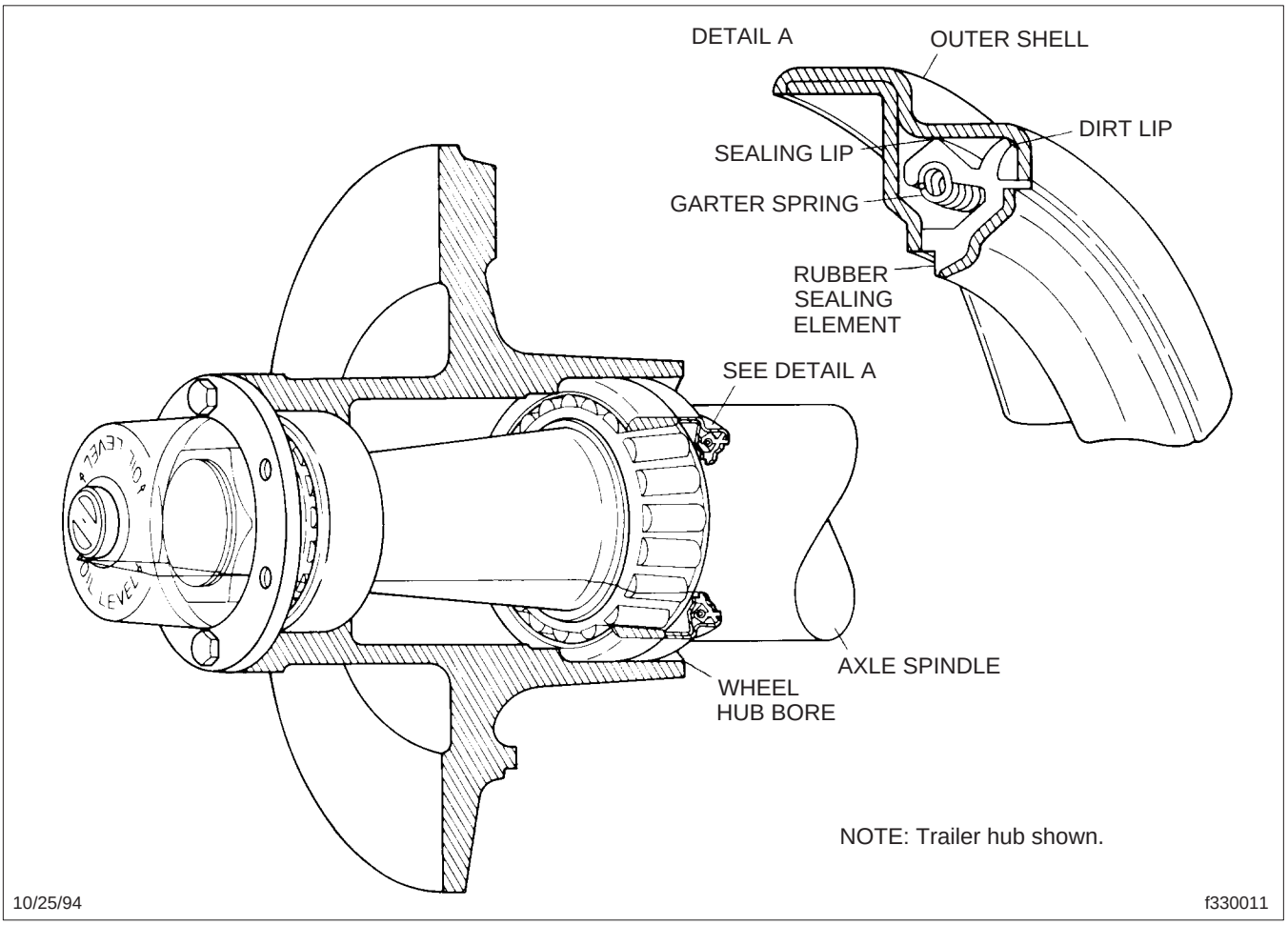


Fig. 1, Wheel Hub and Seal Assembly

Replacement

1. Chock the front tires to prevent vehicle movement.
2. Raise the rear of the vehicle until the tires clear the ground. Then, place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.
4. Remove the wheel, drum, and hub from the axle. For instructions, refer to the rear axle section in this manual.
5. Remove the old oil seal from the hub or spindle.
6. Clean the spindle, spindle threads, seal bore, and the hub cavity.
7. Remove all burrs from the shoulder and the seal bore with an emery cloth or a file. See **Fig. 1** and **Fig. 2**.
8. Clean any metal filings from the components.

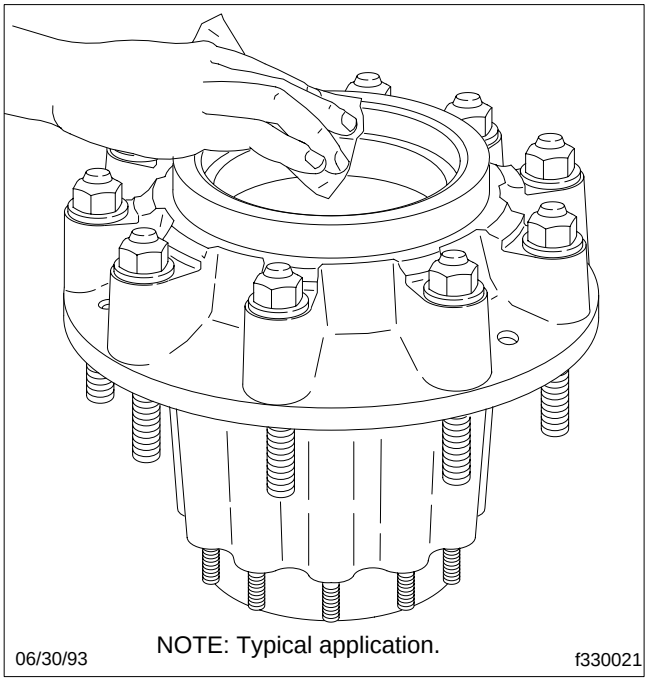


Fig. 1

IMPORTANT: Clean the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause rapid wear of the bearing assembly.

9. Inspect the bearings and hub parts for wear or damage. Replace any worn or damaged parts as needed.

⚠ CAUTION

CAUTION: Don't spin bearing rollers at any time. Dirt or grit can scratch the roller and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

10. Coat the inner wheel bearing with oil and install it on the spindle.
11. Seat the small o.d. of the seal in the recess of the tool adaptor. **See Fig. 3.** The correct adaptor is identified on the box.
12. Insert the centering plug of the tool in the bore of the inner bearing. **See Fig. 4.** The plug prevents cocking of the seal in the bore.
13. Hold the tool handle firmly, and strike until the sound of the impact changes as the seal bottoms out. **See Fig. 5.** Hold the tool firmly to avoid bounce or unseating of the seal from the adaptor.

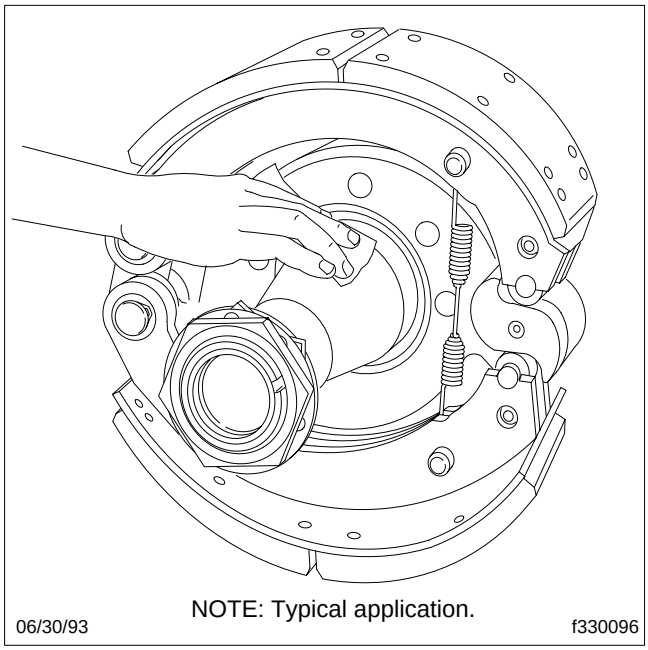


Fig. 2, Front Axle

Seal Replacement

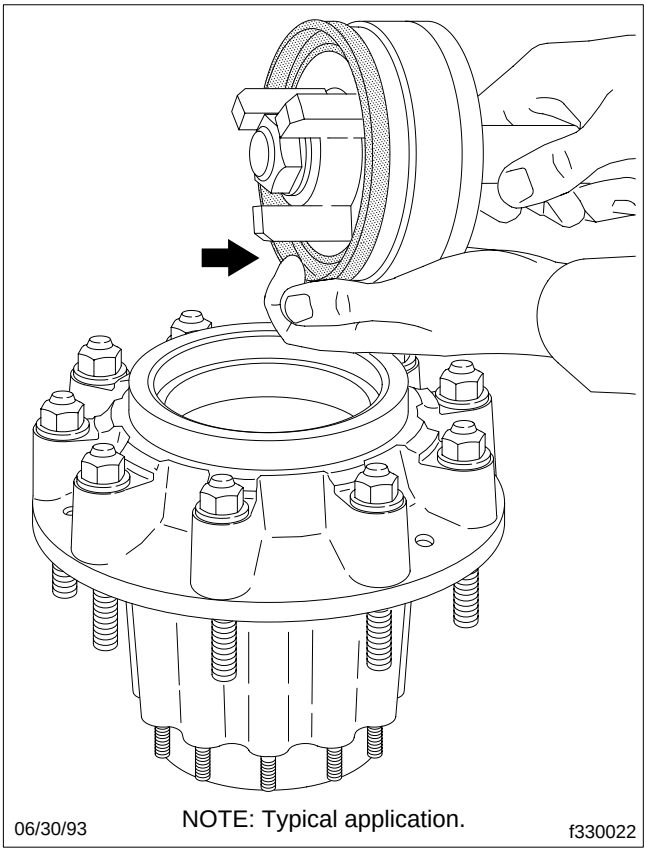


Fig. 3

14. After the seal is bottomed in the bore, check for freedom of movement by manually moving the interior rubber part of the seal in and out. A slight movement indicates a damage-free installation.
15. With the wheel mounted on a wheel dolly, align the hub bore with the spindle. Fill the wheel hub cavity with oil until the level is even with the inner bearing cup.
16. Center the hub on the spindle, then install the wheel hub.
17. Coat the outer bearing in oil and place it on the spindle and into the bearing cup.
18. Adjust the wheel bearings. For instructions, refer to the rear axle section in this manual.
19. Install a new gasket on the drive axle studs.
20. Install the drive axle shaft or, on non-drive axles, the hub cap. The splined end of the axle shaft must seat before the drive axle flange will fit over the studs.

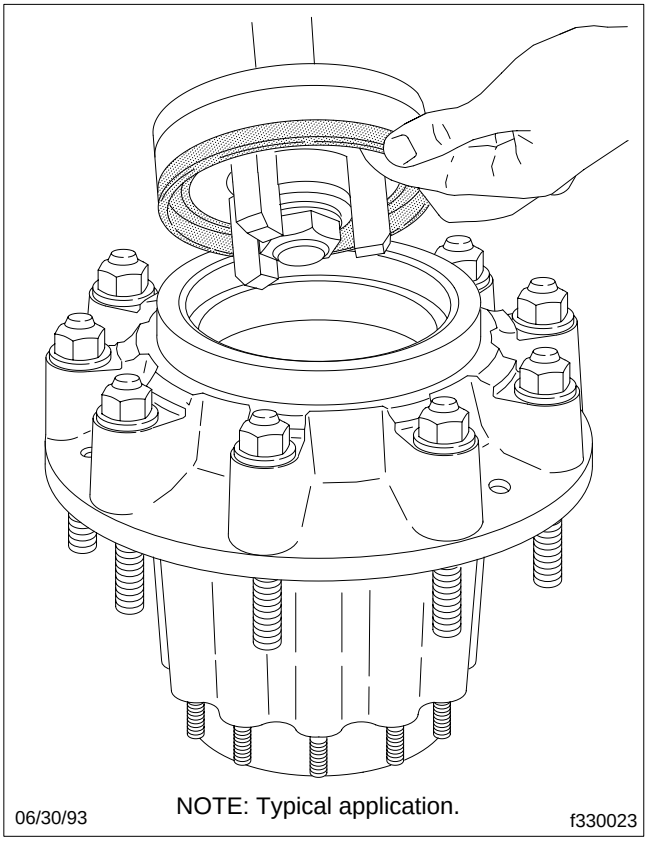


Fig. 4

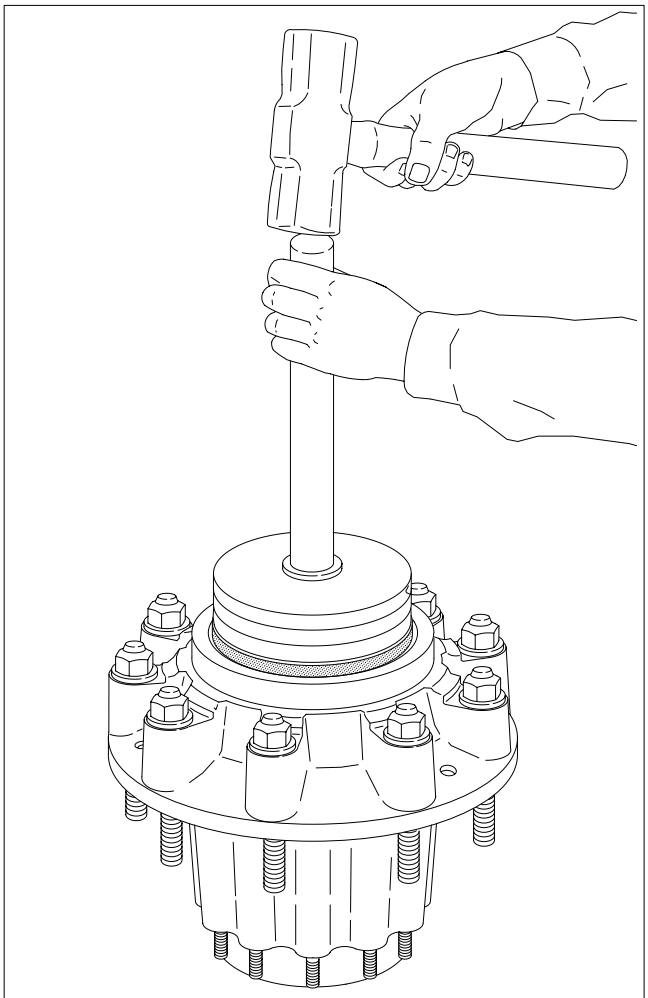
21. If equipped, install the dowels and washers on the drive axle studs. Install the drive axle nuts. Tighten the nuts to the torque values in the torque table in **Specifications, 400**.
22. Install the brake drum on the wheel hub.

⚠ WARNING

WARNING: If the inner wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking action, and the hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist, could result in loss

of a wheel or loss of vehicle control, and possible personal injury.

23. Install the inner and outer wheel and tire assemblies. For instructions, refer to the wheels and tires section in this manual.



06/30/93 NOTE: Typical application. f330024

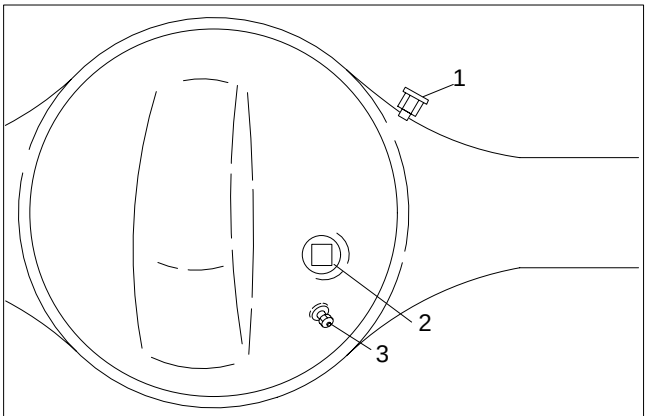
Fig. 5

⚠ WARNING

WARNING: Failure to add oil to the axle housing bowl or the wheel hub after the drive axle shaft and wheel hub have been serviced will damage the wheel bearings and cause them to seize during vehicle operation. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

24. For drive axles, pour the recommended drive axle lubricant through the axle housing filler hole (**Fig. 6** or **Fig. 7**) until the lubricant is level with the bottom of the hole. **See Fig. 8.** Refer to **Specifications, 400** for the recommended axle lubricants. On Eaton axles, tighten the oil filler plug 40 to 60 lbf·ft (54 to 81 N·m); on Rockwell axles, tighten the plug 35 lbf·ft (47 N·m).

    Tilt the axle to the left and right, by jacking the opposite side. Hold the tilted position for one minute on each side, to allow oil to run into the wheel end. Return the axle to a level position, and add oil through the axle housing filler hole. About two extra pints (1 L) of lubricant will be needed to bring the oil level even with the base of the filler hole.



1. Axle Housing Breather
2. Fill Hole Plug
3. Temperature Indicator Plug

01/26/93 f350002

Fig. 6, Eaton Axle

NOTE: Drive axle wheel bearings are lubricated by oil drawn from the axle housing bowl section. This method ensures good exchange of heat, prevents stagnation, and minimizes the maintenance required on bearings and hub assemblies.

25. For non-drive axles, add about 1 to 1-1/2 pints (0.5 to 0.7 L) of oil to the level shown on the hub cap. Do not overfill. Install the vent plug or threaded filler plug.

26. Turn the wheels, and check the lubricant level.

Seal Replacement

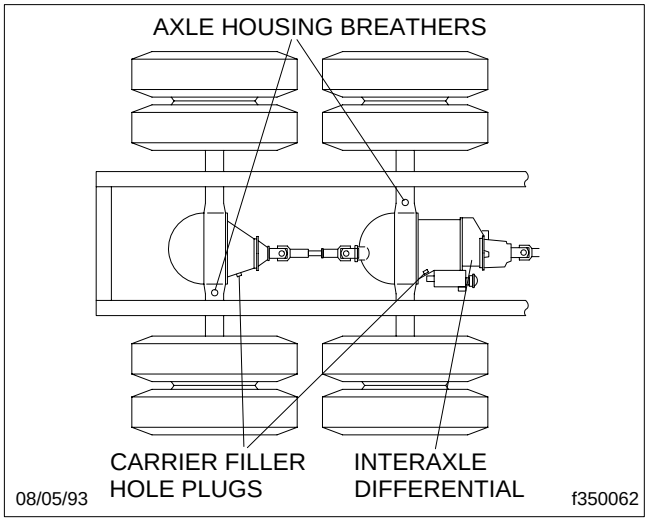


Fig. 7, Filler Hole Plug and Axle Housing Breather Locations, Rockwell Axle

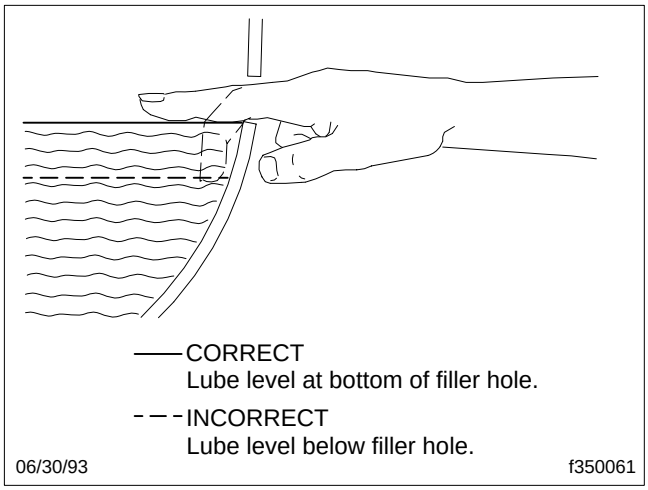


Fig. 8

27. Adjust the rear axle brakes. For instructions, refer to the brake section in the vehicle maintenance manual.
28. Remove the safety stands from under the axle, then lower the vehicle.
29. Apply the parking brakes, then remove the chocks from the front tires.

Lubricant Type	Condition	Lubricant SAE Viscosity Grade
Eaton® Roadranger® Synthetic Drive Axle Lubricants, or Equivalent with Military Specification MIL–L–2105D	Over-the-Road Service	75W–90
	Off-Highway Equipment, or Under Extra Heavy Loads	80W–140

Table 1, Eaton Drive Axle Recommended Lubricant

Axle Type	Axle Model	Capacity * pints (liters)
Single Reduction	23085S, 23085D	40 (18.9)
	23105S, 23105D	48 (22.7)
	23121	41 (19.4)
	30105S	46 (21.8)
Double Reduction	35055P	36 (17.0)

* Quantities listed are approximate. Fill axle until lubricant is level with bottom of fill hole with vehicle on level ground.

Table 2, Eaton Drive Axle Lubricant Capacities, Single-Drive Axles

Specifications

Axle Type	Axle Model	Capacity * pints (liters)	Axle Type	Axle Model	Capacity * pints (liters)
Single Reduction	DS341	39 (18.5) †	Dual Range (2-Speed)	DT401, 401–P	39 (18.5) †
	RS341	36 (17)		RT401	36 (17)
	DS381, 381–P	39 (18.5) †		DT402, 402–P	34 (16.1) †
	RS381	36 (17)		RT–402	34 (16.1)
	DS401, 401–P	39 (18.5) †		DT451, DT451–P	39 (18.5) †
	RS401	36 (17)		RT451	34 (16.1)
	DS402, 402–P	39 (18.5) †		DT461–P	43 (20.3) †
	RS402	36 (17)		RT461	40 (18.9)
	DS404	39 (18.5) †	Double Reduction	DP451–P	34 (16.1) †
	RS404	36 (17)		RP451	34 (16.1)
	DS451, 451–P	39 (18.5) †		DP461–P	43 (20.3) †
	RS451	36 (17)		RP461	40 (18.9)
	DS460–P	44 (20.8) †		DP521–P	42 (19.9) †
	RS460	40 (18.9)		RP521	39 (18.5)
	DS461–P	43 (20.3) †		DP601–P	42 (19.9) †
	RS461	40 (18.9)		RP601	39 (18.5)
	DS581–P	42 (19.9) †		DP651–P	41 (19.4) †
	RS581	39 (18.5)		RP651	37 (17.5)

* Quantities listed are approximate. Fill axle until lubricant is level with bottom of fill hole with vehicle on level ground.
† Add 2 pints (1 L) of additional lubricant to the power divider.

Table 3, Eaton Drive Axle Lubricant Capacities, Tandem-Drive Axles

Recommended Lubricant Type	Ambient Temperature	Lubricant SAE Viscosity Grade	Rockwell Specification
Hypoid Gear Oil API Service Classification GL–5	+10°F (–12.2°C) and up *	85W–140	0–76–A
	–15°F (–26.1°C) and up *	80W–140	0–76–B
	–15°F (–26.1°C) and up *	80W–90	0–76–D
	–40°F (–40°C) and up *	75W–90	0–76–E
	–40°F (–40°C) to +35°F (+2°C)	75W	0–76–J
	–40°F (–40°C) and up *	75W–140	0–76–L
Synthetic Gear Oil	–40°F (–40°C) and up *	75W–90	0–76–N
	–40°F (–40°C) and up *	75W–140	0–76–M

* There is no upper limit on these ambient temperatures, but axle sump temperature must never exceed 250°F (121°C).

Table 4, Rockwell Drive Axle Recommended Lubricant

Axle Type	Axle Model	Capacity * pints (liters)
Single Reduction	RS–23–160	39.5 (18.7)
	RS–23–161	37.2 (17.6)
	RS–23–180	47.3 (22.4)
	RS–26–180	46.6 (22.0)
	RS–30–180	46.6 (22.0)
Double Reduction	RS–26–380	58.2 (27.5)
	RS–30–380	46.6 (22.0)
	RS–38–380	58.2 (27.5)

* Quantities listed are approximate. Fill axle until lubricant is level with bottom of fill hole with vehicle on level ground.

Table 5, Rockwell Drive Axle Lubricant Capacities, Single-Drive Axles

Axle Type	Axle Model	Capacity * pints (liters)	Axle Type	Axle Model	Capacity * pints (liters)
Single Reduction	Q–100	Forward 40.0 (18.9) Rear 37.0 (17.5)	Single Reduction	SQ–100P	Forward 42.0 (19.9) Rear 37.0 (17.5)
	RT–40–140	Forward 30.2 (14.3) Rear 22.8 (10.8)		SQR–100	Forward 36.0 (17.0) Rear 33.0 (15.6)
	RT–40–145 and –145P	Forward 30.2 (14.3) Rear 25.8 (12.2)		SQR–100P	Forward 38.0 (18.0) Rear 33.0 (15.6)
	RT–44–145 and –145P	Forward 29.3 (13.9) Rear 25.1 (11.9)		SR–170	Forward 55.0 (26.0) Rear 43.0 (23.3)
	RT–46–160 and –160P	Forward 39.1 (18.5) Rear 34.4 (16.3)		SSHD	Forward 34.0 (16.0) Rear 28.0 (13.0)
	RT–48–180	Forward 61.1 (28.9) Rear 38.8 (17.4)	Double Reduction	RT–48–380	Forward 61.1 (28.9) Rear 63.6 (30.1)
	RT–52–160 and –160P	Forward 44.1 (20.9) Rear 41.2 (19.5)		RT–52–380	Forward 56.1 (26.5) Rear 58.2 (27.5)
	RT–52–180	Forward 56.1 (26.5) Rear 41.2 (19.5)		RT–58–380	Forward 56.1 (26.5) Rear 58.2 (27.5)
	RT–58–180	Forward 56.1 (26.5) Rear 36.1 (17.1)		RT–70–380	Forward 54.4 (25.7) Rear 53.1 (25.1)
	SQ–100A	Forward 40.0 (18.9) Rear 37.0 (17.5)			

* Quantities listed are approximate. Fill axle until lubricant is level with bottom of fill hole with vehicle on level ground.

Table 6, Rockwell Drive Axle Lubricant Capacities, Tandem-Drive Axles

Specifications

Description		Size (grade 8)	Torque: lbf·ft (N·m)
Spoke Wheel Brake Drum Nuts		3/4–10	240 (325)
Hub Cap Capscrews		5/16–18	15 (20)
Drive Axle Studs (to hub)		1/2–13	70 (95)
		5/8–11	135 (185)
Drive Axle Stud Nuts	With Dowels	5/8–11	135 (185)
	Without Dowels	5/8–18	130–140 (175–190)
Spoke Wheel Rim Studs		3/4–10	185–200 (250–325)

Table 7, Torque Values

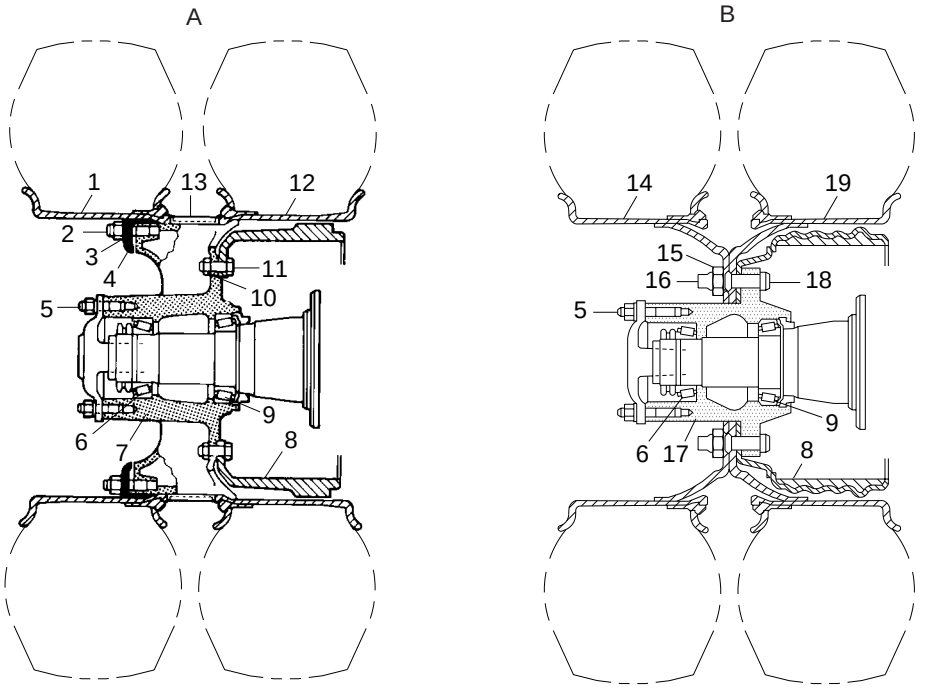
General Information

The rear axle full-floating wheel hub assembly is made up of five major components: inner and outer tapered wheel bearings, the drive axle spindle assembly, the wheel hub, the brake drum, and the wheel studs. **See Fig. 1.**

place on the axle spindle by an adjusting nut, lockring, and jam nut, or a Pro-Torq® nut and lockring. **See Fig. 3.**

DRIVE AXLE SPINDLE ASSEMBLY

The drive axle spindle assembly is made up of a



A. Spoke Wheel and Brake Drum Assembly

1. Outer Rim
2. Rim Stud
3. Rim Stud Nut
4. Rim Clamp
5. Drive Axle Stud
6. Outer Wheel Bearing
7. Spoke Wheel
8. Brake Drum
9. Inner Wheel Bearing
10. Brake Drum Nut
11. Brake Drum Bolt
12. Inner Rim
13. Rim Spacer

B. Disc Wheel, Wheel Hub, and Brake Drum Assembly

14. Outer Wheel
15. Outer Wheel Nut
16. Inner Wheel Nut
17. Wheel Hub
18. Wheel Stud
19. Inner Wheel

Fig. 1

TAPERED WHEEL BEARINGS

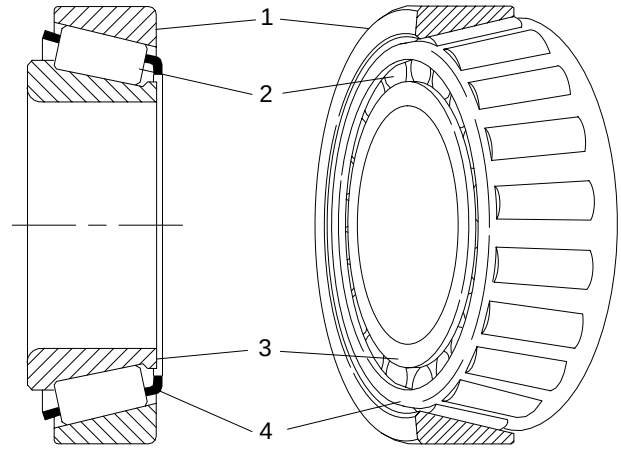
A typical tapered wheel bearing assembly consists of a cone, tapered rollers, a roller cage, and a separate cup that is press-fit in the hub. **See Fig. 2.** All components carry the load, with the exception of the cage, which spaces the rollers around the cone.

Each hub has a set of inner and outer tapered wheel bearing assemblies. The bearing setting is locked in

drive axle flange and shaft, drive axle studs and stud nuts, a flange gasket, an axle spindle, an oil seal, and the locking assembly described above (**see Fig. 4**, Refs. 3 through 10, 13).

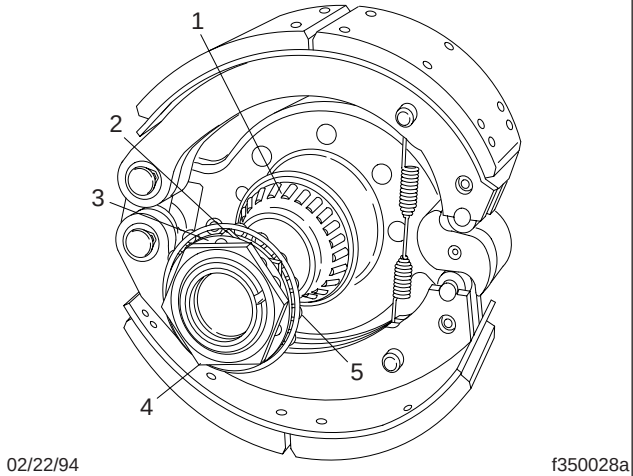
The surfaces of the spindle and the nut threads are machined. When these surfaces become damaged, repairs are necessary. There are standard methods for performing those repairs that preserve the proper

General Information



1. Cup
2. Tapered Roller
3. Cone
4. Roller Cage

Fig. 2, Tapered Wheel Bearing Assembly



1. Inner Wheel Bearing
2. Wheel Bearing Inner Adjusting Nut
3. Lockring
4. Axle Spindle Jam Nut
5. Outer Wheel Bearing

Fig. 3, Drive Axle Bearings and Spindle Assembly

alignment of the axle spindle assembly. Refer to the axle manufacturer for instructions.

CAUTION

CAUTION: The National Highway Traffic Safety Administration (NHTSA) has warned against repairs that involve cutting off a portion of a damaged spindle and welding on a replacement part. The heat of welding can reduce the strength of spindles made with heat-treated materials and lead to spindle failure. After the cutting and welding operations, the replacement part may not be correctly aligned on the spindle. This can cause damage to the spindle nut.

WHEEL HUB

The inner disc wheel and/or brake drum is mounted on an aluminum or iron wheel hub (**Fig. 4**, Ref. 20). Both the inner and outer bearing cups and certain types of wheel studs are press-fit in the hub. The hub is also the interconnecting point for the drive axle shaft and wheels.

Each spoke wheel (**Fig. 4**, Ref. 16) combines both wheel and hub into a single unit.

BRAKE DRUM

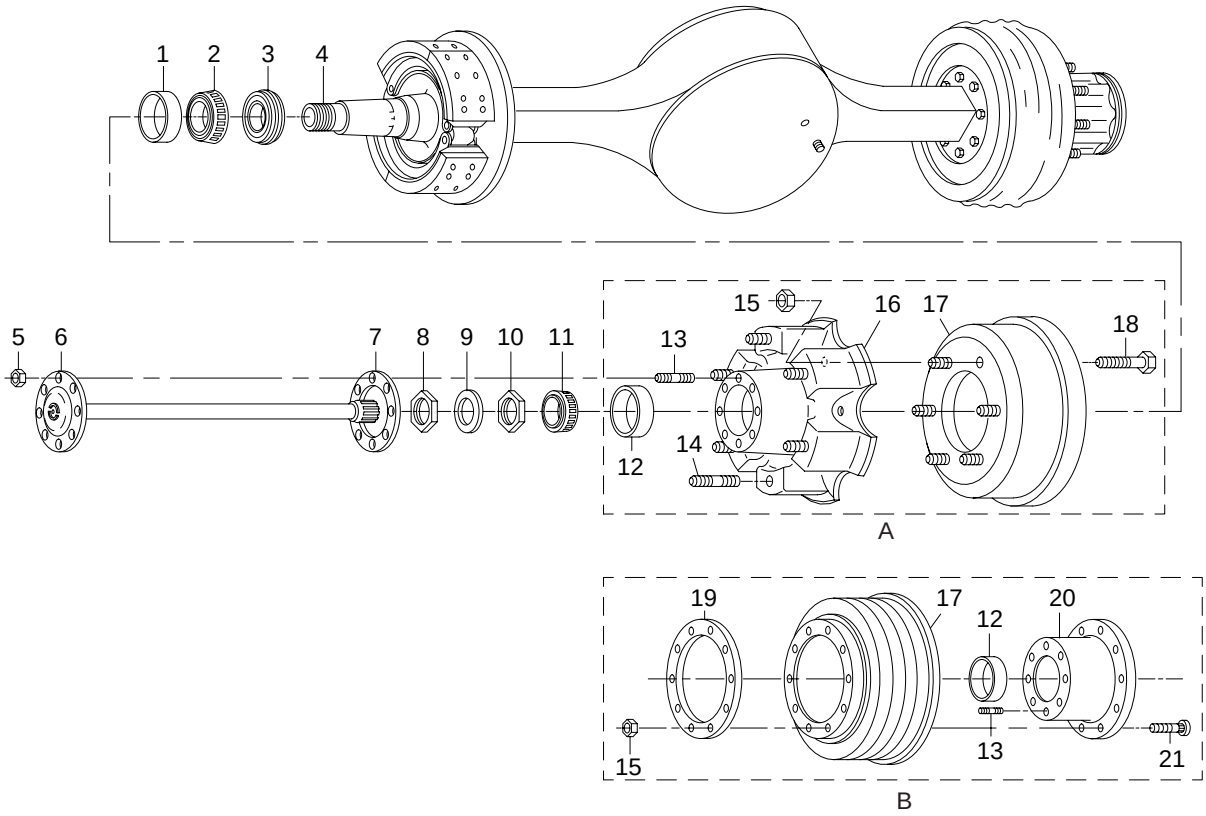
The brake drum and lining work together as a mated friction pair, with the drum responsible for both heat absorption and dissipation. Lining performance and life largely depend on the condition of the drum and whether it can adequately absorb and dissipate heat generated by braking action.

On spoke wheel assemblies, the brake drum is mounted inboard, behind the hub flange, and is held in place with bolts. On all other hub and drum assemblies, the brake drum is mounted on the outboard face of the hub and fits over the wheel studs. **See Fig. 4.**

WHEEL STUDS

A headed wheel stud (**Fig. 5**) is used on rear axle disc wheel hub assemblies and has either serrations on the stud body or a flat area on the stud's head to prevent the stud from turning in the wheel hub.

The end of the stud that faces away from the vehicle is stamped with an "L" or "R," depending on which side of the vehicle the stud is installed. Studs stamped with an "L" are left-hand threaded and are installed on the driver's side of the vehicle. Studs



A. Spoke Wheel and Drum Assembly

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Drive Axle Stud Nut
6. Drive Axle Flange and Shaft
7. Gasket
8. Jam Nut
9. Lockring
10. Wheel Bearing Inner Adjusting Nut
11. Outer Wheel Bearing
12. Outer Wheel Bearing Cup
13. Drive Axle Stud
14. Rim Stud
15. Brake Drum Nut
16. Spoke Wheel
17. Brake Drum
18. Brake Drum Bolt

B. Disc Wheel, Hub, and Drum Assembly

19. Hub Spacer
20. Wheel Hub
21. Wheel Stud

Fig. 4, Typical Drive Axle (exploded view)

stamped with an "R" are right-hand threaded and are installed on the passenger's side of the vehicle.

Spoke wheels have rim studs. Rim studs are threaded on both ends, with a nonthreaded section midway along the shaft of the stud. The studs are coated with an anaerobic locking compound.

General Information

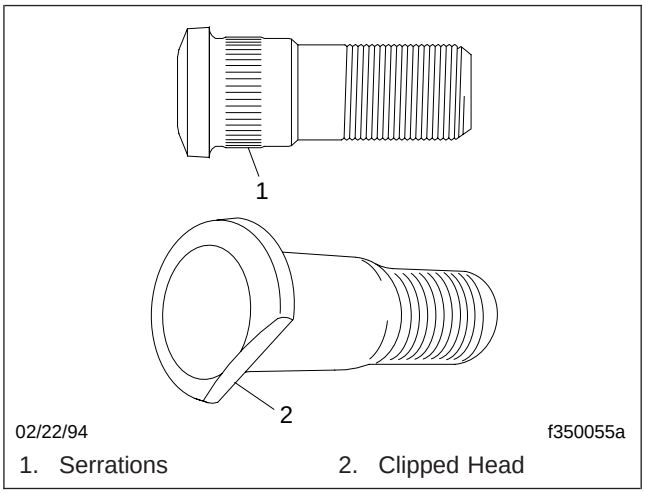


Fig. 5, Typical Headed Wheel Studs

Outboard-Mounted Drum Removal and Installation

WARNING

When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.

For an exploded view of a typical wheel and axle assembly, including the brake drum, see **Fig. 1**.

Removal

1. Chock the front tires to prevent vehicle movement. Release the parking brakes.
2. Raise the rear of the vehicle until the tires clear the ground. Then place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.
4. Remove both wheel and tire assemblies. Refer to the wheels and tires section in this manual for instructions.
5. Remove the brake drum.

WARNING

WARNING: Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

6. To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.
7. Inspect the drum. Refer to **Subject 110** for instructions.

Installation

1. On brake drum assemblies with an aluminum hub, coat the hub and drum contact surfaces with Alumilastic® compound or an equivalent.

CAUTION

CAUTION: With hub-piloted drums, make sure the brake drum is positioned on the raised step of the pilot pad. One of the hub's pilot pads should be at the twelve o'clock position. If the drum is not positioned correctly when the wheel nuts are torqued, the pilot pad could be damaged. See Fig. 2. If necessary, adjust the brakes before installing the wheels to hold the drum in position.

With the drum in position, be sure the pilot pads securely center the drum. If the pads have been damaged so they won't center the drum, replace the hub.

2. Install the brake drum on the wheel hub.
3. Install the inner and outer wheel and tire assemblies. Refer to the wheels and tires section in this manual for instructions.

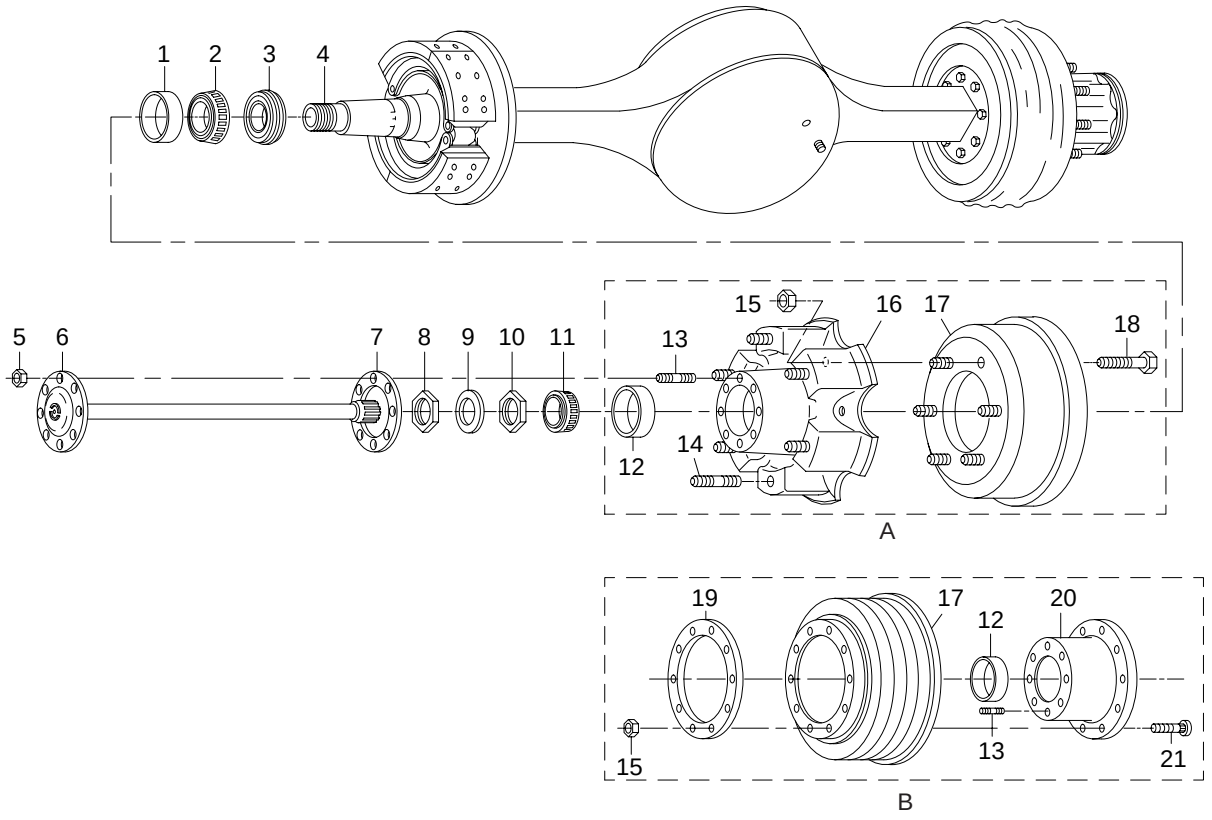
WARNING

WARNING: If the inner wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking action, and the hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist, could result in the loss of a wheel or loss of vehicle control, and possible personal injury or property damage.

4. Adjust the rear axle brakes; refer to the brake section in the vehicle maintenance manual.
5. Remove the safety stands from under the axle; lower the vehicle.

Outboard-Mounted Drum Removal and Installation

6. Apply the parking brakes; then remove the chocks from the front tires.



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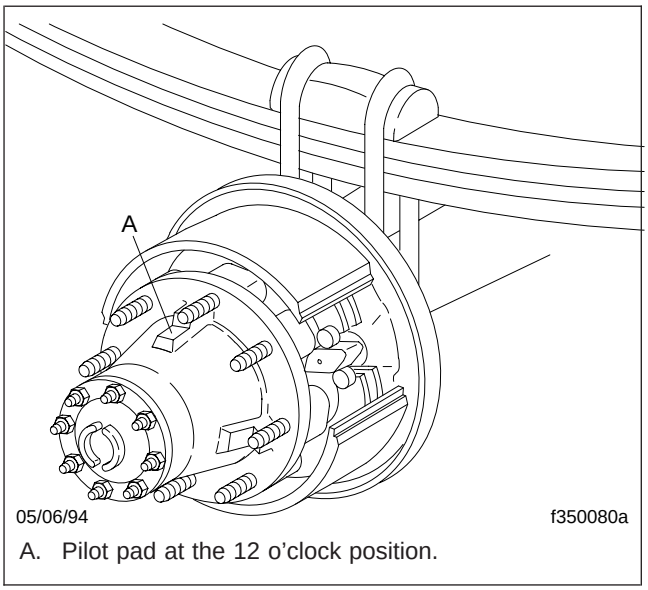
A. Spoke Wheel and Drum Assembly

B. Disc Wheel Hub and Drum Assembly

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Drive Axle Stud Nut
6. Drive Axle Flange and Shaft
7. Gasket
8. Jam Nut
9. Lockring
10. Wheel Bearing Inner Adjusting Nut
11. Outer Wheel Bearing
12. Outer Wheel Bearing Cup
13. Drive Axle Stud
14. Rim Stud
15. Brake Drum Nut
16. Spoke Wheel
17. Brake Drum
18. Brake Drum Bolt
19. Hub Spacer
20. Wheel Hub
21. Wheel Stud

Fig. 1, Typical Drive Axle (exploded view)

Outboard-Mounted Drum Removal and Installation



A. Pilot pad at the 12 o'clock position.

Fig. 2, Hub Pilot Pads

Hub Assembly Removal and Installation, Disc Wheels

Removal

See **Fig. 1** for this procedure.

1. Chock the front tires to prevent vehicle movement. Release the parking brakes.
2. Raise the rear of the vehicle until the tires clear the ground. Place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes. For instructions, see the applicable slack adjuster section in **Group 42**.
4. Remove both wheel and tire assemblies. For instructions, see **Group 40**.

⚠ WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

5. To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.
6. Remove the brake drum.

NOTE: Oil will spill as the drive axle shaft (or hub cap) and the wheel hub are removed. Place a suitable container under the drive axle flange or hub cap to catch any spilled oil. Dispose of the oil properly.

7. Remove the drive axle stud nuts and washers. See **Fig. 2**.
8. Using a hammer and a soft drift, such as one made of brass, sharply tap the center portion of the drive axle flange. See **Fig. 2**. The shaft will usually spring slightly outward after the seal has broken. Remove the drive axle shaft.

⚠ CAUTION

When tapping the drive axle flange, avoid striking the drive axle studs. If struck, the studs may bend or break, or the stud threads can be damaged. Replace damaged studs.

NOTE: Even if the drive axle shaft doesn't spring outward, the seal may have loosened enough to allow the shaft to be pulled from the axle housing. If the seal has not broken, repeat the step above.

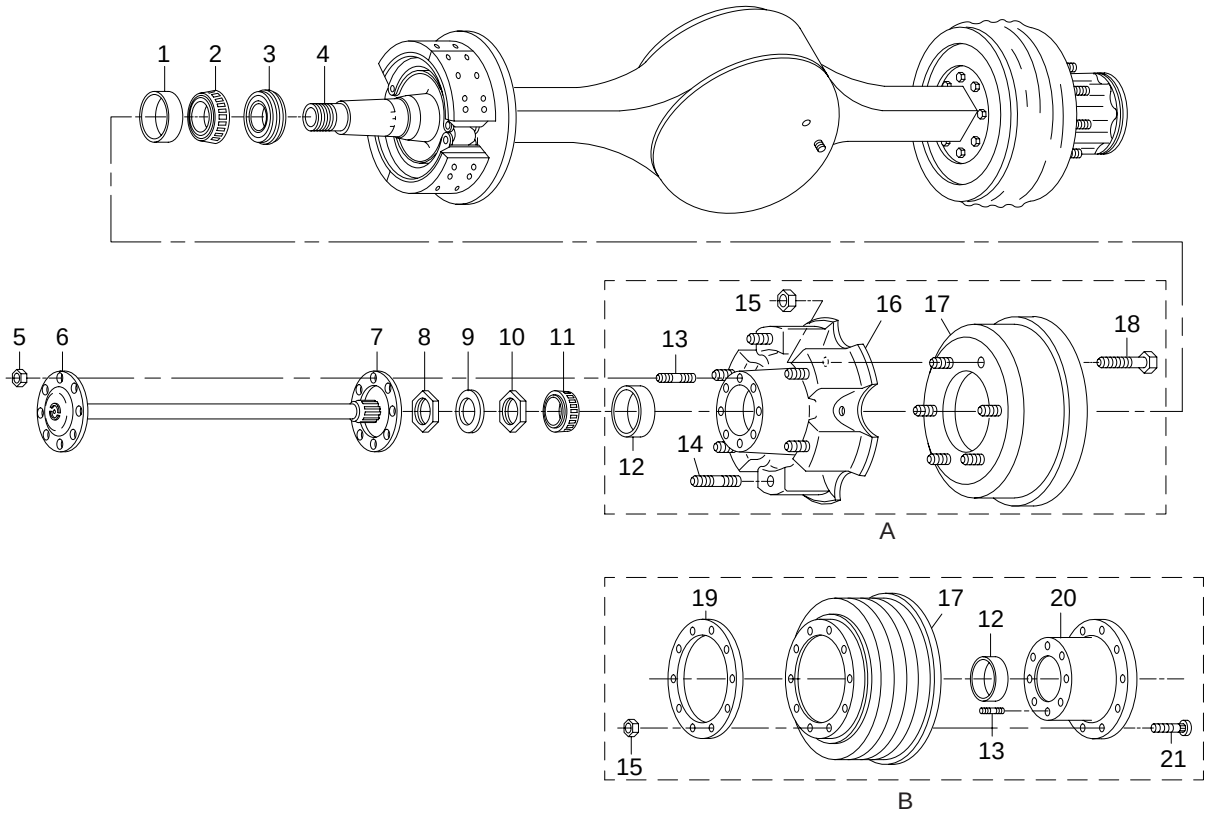
9. If so equipped, remove the tapered dowels and washers from the drive axle flange.
10. Remove and discard the gasket.
11. Remove the axle spindle jam nut and the lockring or tanged nut-lock, as equipped. See **Fig. 3** or **Fig. 4**. If the axle is equipped with a lockring and a tanged nut-lock, remove both. See **Fig. 5**. If the axle is equipped with a Pro-Torq® nut, remove the lockring. See **Fig. 6**.
12. Back off the wheel bearing inner adjusting nut or Pro-Torq nut about two turns, or enough to allow the weight of the hub to be lifted from the wheel bearings.
13. Lift the hub until all weight is removed from the wheel bearings; remove the wheel bearing inner adjusting nut, or Pro-Torq nut.

⚠ CAUTION

Be careful not to let the outer wheel bearing drop from the axle spindle. Dropping the bearing can warp the cage or damage the rollers, ruining the bearing. On vehicles equipped with WABCO ABS, use care when working with the hubs. To prevent damage to the tone wheel, do not drop the hub, or lay it down in a way that would damage the tone wheel.

14. Move the hub about 1/2 inch (13 mm) to jar loose the outer wheel bearing (allow the hub-only assembly to rest on the axle spindle; be careful not to damage the axle spindle threads).
15. Carefully remove the outer wheel bearing; handle the bearings with clean, dry hands. Wrap the bearings in either clean oil-proof paper or lint-free rags.

Hub Assembly Removal and Installation, Disc Wheels



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A. Spoke Wheel and Drum Assembly

B. Disc Wheel Hub and Drum Assembly

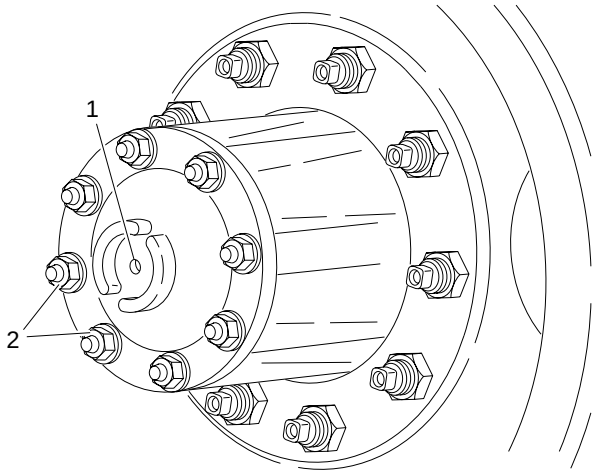
1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Drive Axle Stud Nut
6. Drive Axle Flange and Shaft
7. Gasket
8. Jam Nut
9. Lockring
10. Wheel Bearing Inner Adjusting Nut
11. Outer Wheel Bearing
12. Outer Wheel Bearing Cup
13. Drive Axle Stud
14. Rim Stud
15. Brake Drum Nut
16. Spoke Wheel
17. Brake Drum
18. Brake Drum Bolt
19. Hub Spacer
20. Wheel Hub
21. Wheel Stud

Fig. 1, Typical Drive Axle (exploded view)

⚠ CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

16. Remove the hub. Be careful not to damage the axle spindle threads as the assembly is removed.
17. Remove the inner wheel bearing from the axle. Handle the bearings with clean, dry hands, then wrap the bearings in either clean oil-proof paper or lint-free rags. Occasionally, the inner wheel bearing will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion where it will catch the bearings. Then use a hardwood drift and a light hammer to gently tap the bearing (and seal, if necessary) out of the cup.



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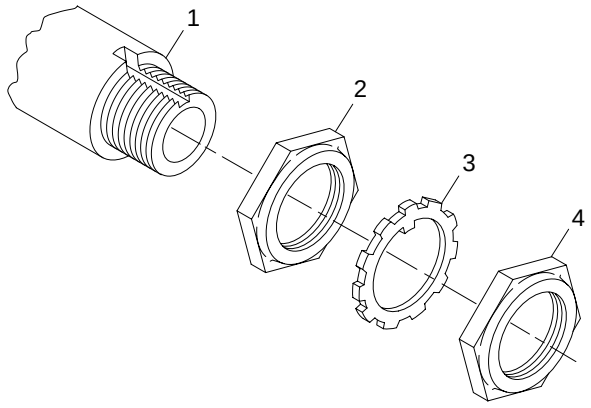
1. Center Portion of Drive Axle Flange
2. Drive Axle Studs and Nuts
3. Inner Wheel Nut
4. Outer Wheel Nut

Fig. 2, Wheel Assembly and Hub



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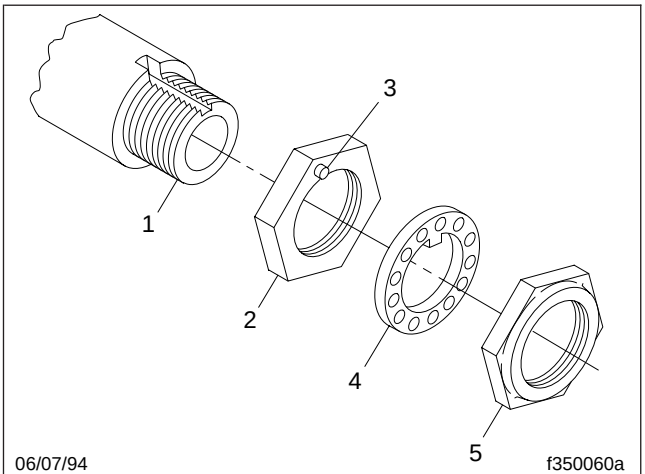
1. Axle Spindle
2. Adjusting Nut
3. Nut-Lock
4. Jam Nut

Fig. 3, Axle Secured With a Nut-Lock

18. Remove the oil seal from the axle spindle, if not already removed. See the applicable oil seal section in this group for additional information.



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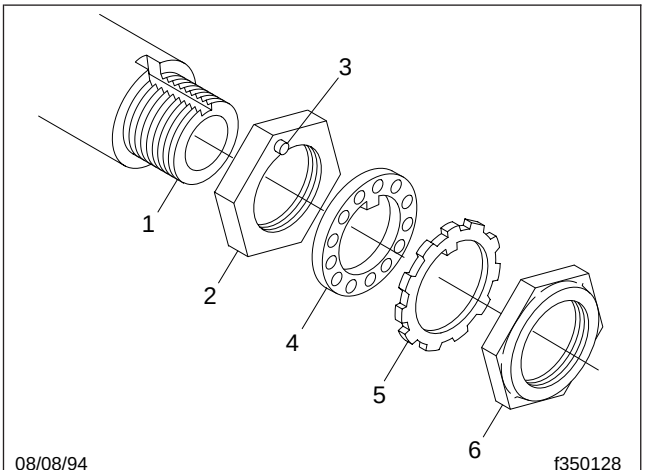
1. Axle Spindle
2. Adjusting Nut
3. Dowel
4. Pierced Lockring
5. Jam Nut

Fig. 4, Axle Secured With a Lockring



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1. Axle Spindle
2. Adjusting Nut
3. Dowel
4. Pierced Lockring
5. Nut-Lock
6. Jam Nut

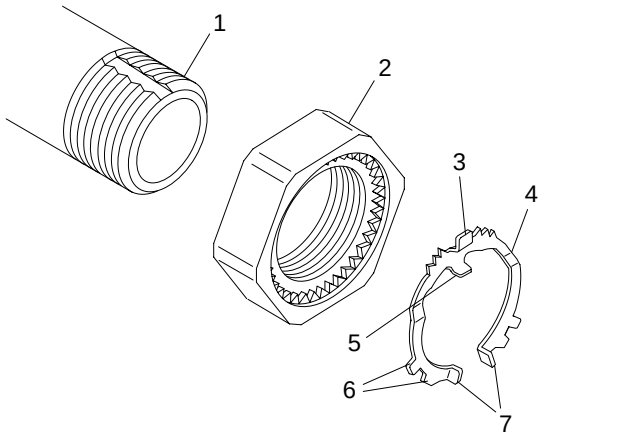
Fig. 5, Axle Secured With a Lockring and a Nut-Lock

Installation

⚠ WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying res-

Hub Assembly Removal and Installation, Disc Wheels



1. Axle Spindle
2. Pro-Torq Nut
3. Keeper Tab
4. Lockring
5. Keyway Tabs
6. Keeper Arms
7. Keeper Projections

Fig. 6, Axle With Pro-Torq Nut and Lockring

pirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

1. Using cleaning solvent, remove the old oil from the axle spindle and the disassembled parts. Allow the parts to dry, or dry them with a clean, absorbent, and lint-free cloth or paper. Wrap a protective layer of friction tape on the axle spindle threads.

⚠ WARNING

Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

2. On brake drum assemblies with an aluminum hub, coat the hub and drum contact surfaces with Alumilastic compound or an equivalent.
3. Coat both bearing assemblies with fresh oil. Install the inner wheel bearing and oil seal. Handle the bearings with clean, dry hands. Refer to the applicable section for oil seal installation instructions. For lubricant specifications, see **Specifications, 400**.

⚠ CAUTION

Use only fresh oil on the bearing assemblies; old oil could be contaminated with dirt or water (both are corrosives) and could cause damage to both wheel bearing assemblies and the wheel hub.

4. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing.

⚠ CAUTION

On vehicles equipped with WABCO ABS, use care when installing the hubs. To prevent damage to the tone wheel, do not drop the hub or lay it down in a way that would damage the tone wheel.

5. Carefully mount the hub and inner wheel bearing assembly on the axle spindle. Be careful not to unseat the inner wheel bearing or seal.
6. Fill the hub cavity with oil, and install the outer wheel bearing; handle the bearings with clean, dry hands. Use care not to damage the bearings as they are seated in the bearing cups. Then remove the friction tape from the axle spindle threads.

NOTE: If the axle is equipped with Pro-Torq nuts (see **Fig. 6**), skip the next four steps, and go to the step for installing the Pro-Torq nuts.

7. If the axle is equipped with adjusting nuts and jam nuts (see **Fig. 3** for axles secured with a nut-lock, **Fig. 4** for axles secured with a lockring, or **Fig. 5** for axles secured with both a nut-lock and a lockring), install the wheel bearing adjusting nut.

   7.1 After the wheel hub and bearings are assembled on the spindle, tighten the inner adjusting nut finger-tight.

   IMPORTANT: Be sure there is sufficient clearance between the brake shoe and the brake drum, so brake shoe drag will not interfere with bearing adjustment.

   7.2 While rotating the wheel hub assembly, tighten the inner adjusting nut 100 lbf·ft (136 N·m).

   7.3 Back off the adjusting nut completely.

7.4 Tighten the adjusting nut 20 lbf·ft (27 N·m) while rotating the wheel hub assembly.

7.5 Back off the adjusting nut one-third turn.

NOTE: If you're securing the wheel bearings with a pierced lockring and no hole in the lockring aligns with the dowel on the adjusting nut, remove the lockring, turn it over and install it again. If a hole still doesn't align with the dowel, loosen the adjusting nut, but only enough to align the dowel with a hole in the lockring.

8. Install the locking device and jam nut.

8.1 Install the locking device.

NOTE: The locking device can be any one of the following types:

- Tanged nut-lock
- Lockring
- Lockwasher *and* lockring
- Nut-lock *and* lockring

8.2 Install the jam nut, and tighten it to the applicable torque in **Table 1**.

9. With the jam nut installed and tightened, adjust the bearings.

IMPORTANT: Do not adjust the wheel bearings with the wheel mounted on the hub.

You cannot accurately adjust or measure bearing end play with the wheel mounted on the hub.

9.1 Attach a dial indicator to the hub and set the point of the indicator in line with the end of the axle spindle.

If using aluminum hubs, you may have to install the brake drum on the hub to provide a steel base for the magnet of the dial indicator. Mount the drum on the hub's drum pilot, then adjust the brake or have someone apply the brakes to hold the drum securely while you secure the drum using the stud at the 12 o'clock position, then the studs at about the 4 o'clock and 8 o'clock positions.

NOTE: If using a stud-piloted hub and a steel drum, install 1–1/4 inch washers between the nuts and the drum.

9.2 Release the brakes if you used them to hold the drum while installing it.

9.3 Grip the sides of the hub at the three o'clock and nine o'clock positions. Push in on the hub (and drum, if applicable), to seat the inboard bearing set. Zero the dial indicator.

Dual-Nut Wheel Bearing Lock Torque Values		
Application	**Size**	**Torque: lbf·ft (N·m)**
Adjusting Nut	—	Stage 1: Tighten to 100 (135)
		Stage 2: Back Off Completely
		Stage 3: Tighten to 20 (25) While Rotating Hub
		Stage 4: Back Off 1/3 Turn
Jam Nut (with Wheel Bearing Nut, Pierced Lockwasher, and Bendable Lockwasher)	1-1/8	Target: 175 (235) Permissible Range: 150–225 (205–305)
	1-1/2 to 2-1/2	Target: 250 (340) Permissible Range: 200–300 (270–405)
	2-5/8 or Larger	Target: 325 (440) Permissible Range: 250–400 (340–540)

Table 1, Dual-Nut Wheel Bearing Lock Torque Values

Hub Assembly Removal and Installation, Disc Wheels

9.4 Once more, grip the sides of the hub at the three o'clock and nine o'clock positions. This time, pull out on the hub (and drum, if applicable). Read the dial indicator, and note the end play.

9.5 Push the hub back in to confirm that the needle of the dial indicator returns to zero.

10. The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm). If the end play is not within this range, adjust the end play.

10.1 Remove the jam nut and locking device, and back off or tighten the inner adjusting nut.

IMPORTANT: *If you're using a nut-lock,* turning the adjusting nut 1/4 turn will change the end play about 0.014 inch (0.36 mm).

If you're using a lockring, turning the adjusting nut one lockring hole will change the end play about 0.005 inch (0.13 mm). If you take the lockring off and reverse it, then turn the adjusting nut to the next hole, this will change the end play about 0.0025 inch (0.064 mm).

10.2 Install the locking device and jam nut as described earlier, and measure the end play. If the end play is not between 0.001 and 0.005 inch (0.03 and 0.13 mm), turn the inner adjusting nut again.

10.3 Once the end play is correct, bend the nut-lock (see **Fig. 7**) or lockwasher, as applicable, to lock the jam nut and/or adjusting nut in place.

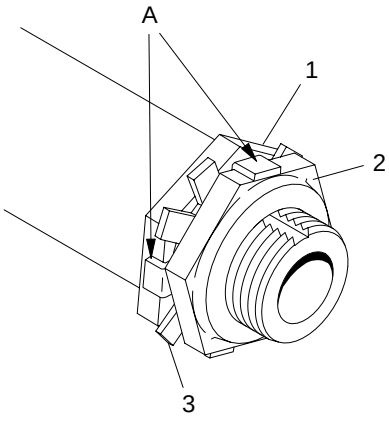
11. If equipped with Pro-Torq nuts, adjust the axle wheel bearings as follows (**Fig. 6**):

11.1 Install the Pro-Torq nut, and turn it against the bearing while spinning the wheel.

IMPORTANT: Be sure there is enough clearance between the brake shoes and the brake drum, so brake shoe drag won't interfere with the bearing adjustment.

11.2 Tighten the adjusting nut 90 to 110 lbf·ft (122 to 149 N·m) while spinning the wheel in both directions.

11.3 Loosen the nut to zero torque and spin the wheel a few turns.



A. Bend only each tang that is at a right angle to a flat.

1. Wheel Bearing Adjusting Nut
2. Wheel Bearing Jam Nut
3. Wheel Bearing Adjusting Nut-Lock

Fig. 7, Wheel Bearing Adjusting Nut-Lock Installation

11.4 Tighten the nut 50 lbf·ft (68 N·m) while spinning the wheel in both directions. Back off the nut one-eighth to one-sixth turn.

11.5 Hold the lockring with the keeper projections facing outboard. See **Fig. 8**.

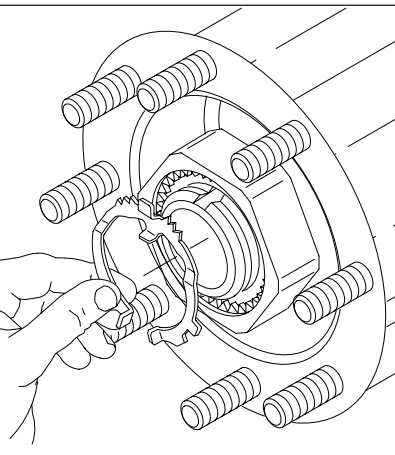


Fig. 8, Lockring Position

11.6 Insert the keeper tab in the undercut groove of the Pro-Torq nut, while pressing the keyway tabs on the flat surface of the axle spindle, engaging the mating teeth.

11.7 Insert a screwdriver, or similar tool, in the undercut groove of the nut, between the keeper arms. Compress the lockring with the tool to lock in place. See **Fig. 9**.

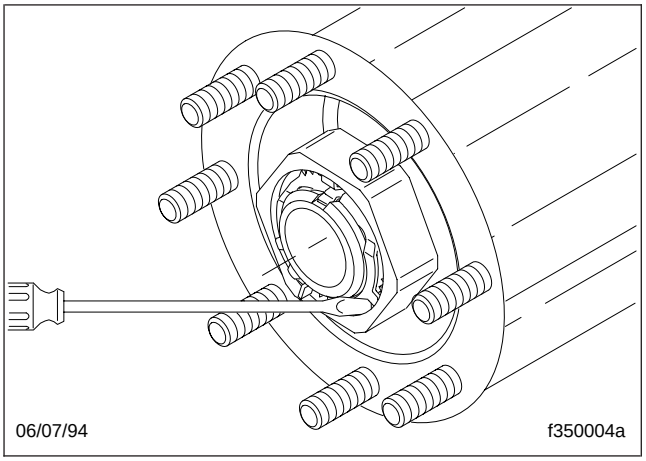


Fig. 9, Compress the Lockring

CAUTION

Do not use pliers or similar devices on the keeper projections to compress the lockring. This could result in damage to or breakage of the lockring.

11.8 Using the screwdriver, press around the edges of the lockring to be sure it is locked in place. See **Fig. 10**.

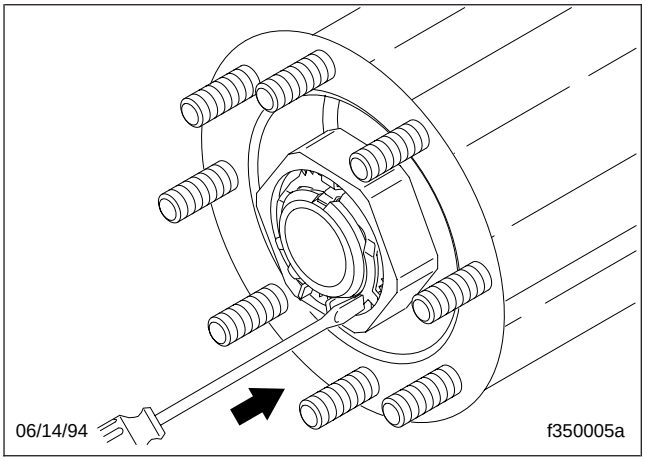


Fig. 10, Make Sure the Lockring is Locked

12. Install a new gasket on the drive axle studs.

13. Install the drive axle shaft or, on non-drive axles, the hub cap. The splined end of the axle shaft must seat before the drive axle flange will fit over the studs.

14. If equipped, install the dowels and washers on the drive axle studs. Install the drive axle stud nuts. Using the sequence shown in **Fig. 11**, tighten the nuts to the torque values given in the table in **Specifications, 400**.

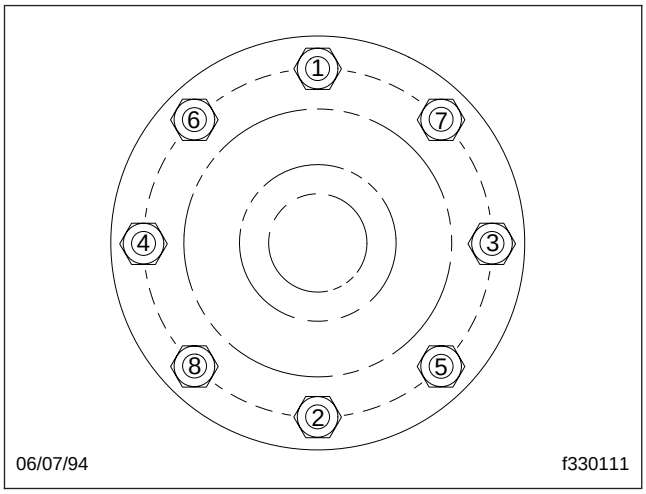


Fig. 11, Tightening Sequence, Drive Axle Stud Nuts

15. Install the brake drum on the wheel hub. For instructions, see **Subject 075**.

WARNING

If the inner wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking action, and the hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist, could result in loss of a wheel or loss of vehicle control, and possible personal injury.

16. Install the inner and outer wheel and tire assemblies. For instructions, see **Group 40**.

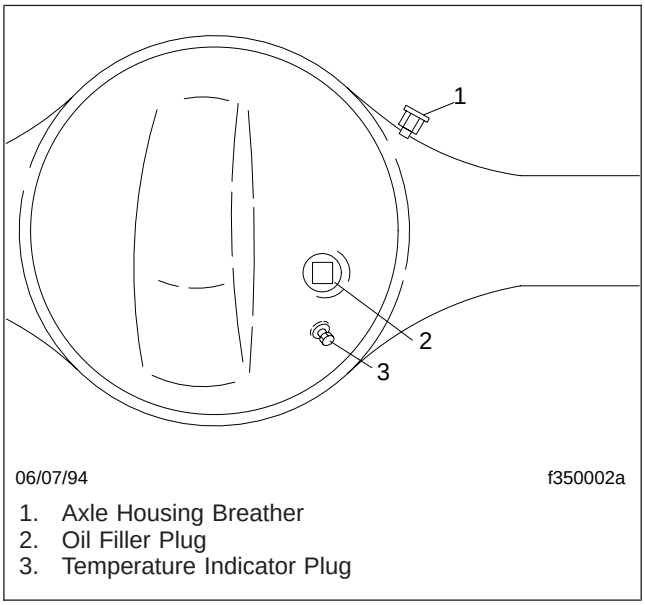
WARNING

Failure to add oil to the axle housing bowl or the wheel hub after the drive axle shaft and wheel hub have been serviced will damage the wheel bearings and cause them to seize during vehicle

Hub Assembly Removal and Installation, Disc Wheels

operation. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

17. For drive axles, pour the recommended drive axle lubricant through the axle housing filler hole (see **Fig. 12** or **Fig. 13**) until the lubricant is level with the bottom of the hole. See **Fig. 14**. See **Specifications, 400** for the recommended axle lubricants. On Eaton axles, tighten the oil filler plug 40 to 60 lbf·ft (54 to 81 N·m); on Meritor axles, tighten the plug 35 lbf·ft (47 N·m).



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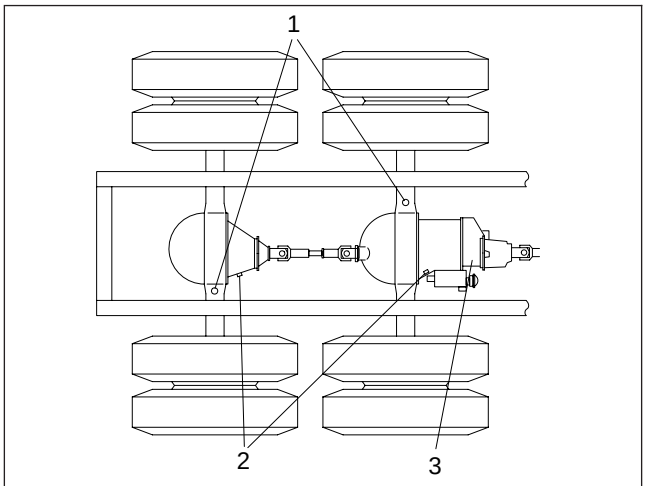
1. Axle Housing Breather
2. Oil Filler Plug
3. Temperature Indicator Plug

Fig. 12, Eaton Axle Fill Plug

18. Tilt the axle to the left and right, by jacking the opposite side. Hold the tilted position for one minute on each side, to allow oil to run into the wheel end. Return the axle to a level position, and add oil through the axle housing filler hole. About two extra pints (1 liter) of lubricant will be needed, to bring the oil level even with the base of the filler hole.

NOTE: Drive axle wheel bearings are lubricated by oil drawn from the axle housing bowl section. This method ensures good exchange of heat, prevents stagnation, and minimizes the maintenance required on bearings and hub assemblies.

19. For non-drive axles, add about 1 to 1-1/2 pints (0.5 to 0.7 liters) of oil to the level shown on the hub cap. Do not overfill. Install the vent plug or threaded filler plug.



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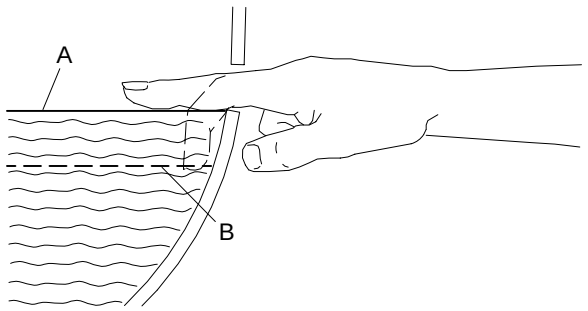
1. Axle Housing Breathers
2. Carrier Filler Plugs
3. Interaxle Differential

Fig. 13, Carrier Filler Holes, Meritor Axle



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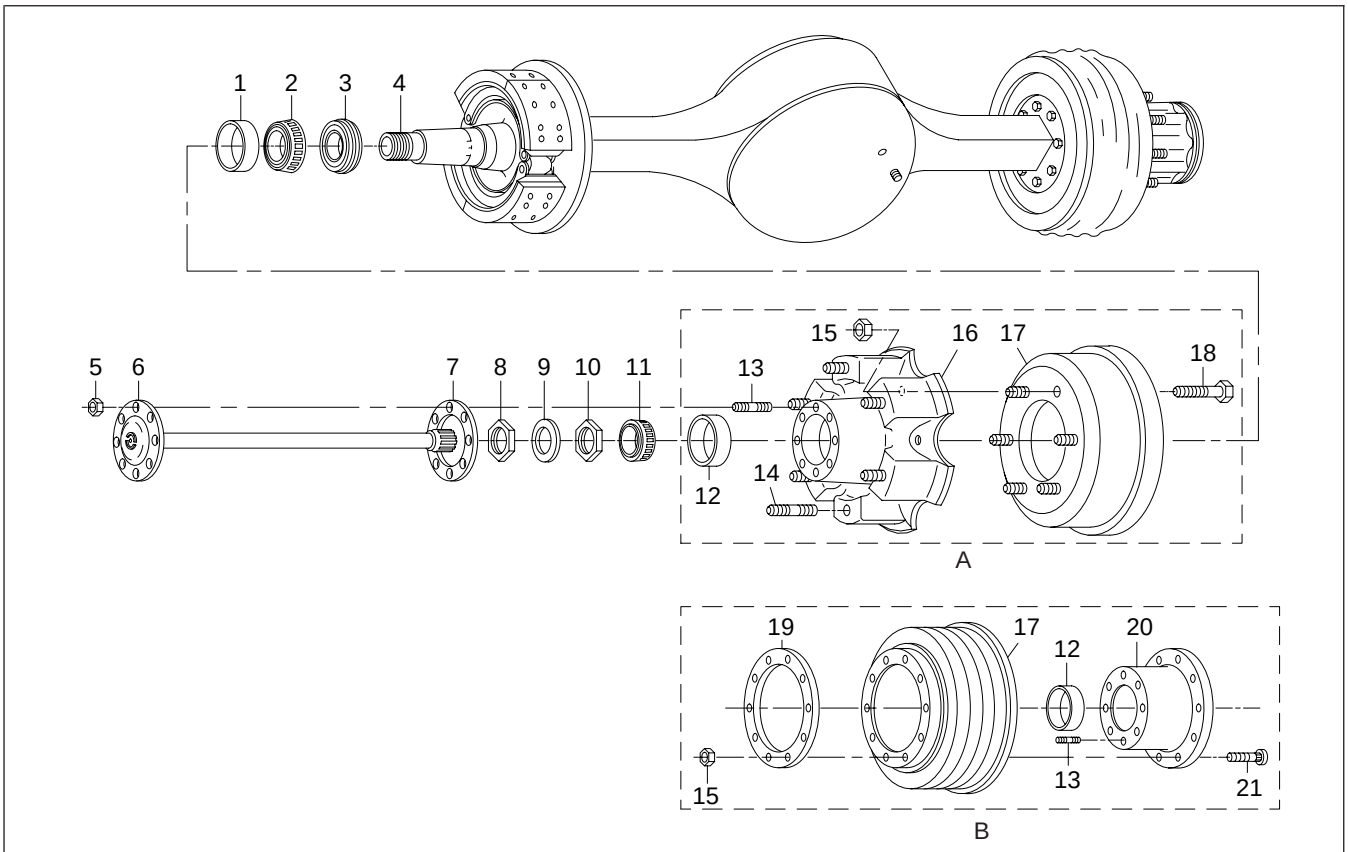
A. Correct: Lube level at the bottom of the fill hole.
B. Incorrect: Lube level is below the fill hole.

Fig. 14, Lubricant Level Checking

20. Turn the wheels and check the lubricant level.
21. Adjust the rear axle brakes. For instructions, see **Group 42** in the *Heavy-Duty Trucks Maintenance Manual*.
22. Remove the safety stands from under the axle, and lower the vehicle.
23. Apply the parking brakes and remove the chocks from the front tires.

Hub Assembly Removal and Installation, Spoke Wheels

Removal (See Fig. 1)



A. Spoke Wheel and Drum Assembly

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Drive Axle Stud Nut
6. Drive Axle Flange and Shaft
7. Gasket
8. Jam Nut
9. Lockring
10. Wheel Bearing Inner Adjusting Nut
11. Outer Wheel Bearing
12. Outer Wheel Bearing Cup
13. Drive Axle Stud
14. Rim Stud

B. Disc Wheel Hub and Drum Assembly

15. Brake Drum Nut
16. Spoke Wheel
17. Brake Drum
18. Brake Drum Bolt
19. Hub Spacer
20. Wheel Hub
21. Wheel Stud

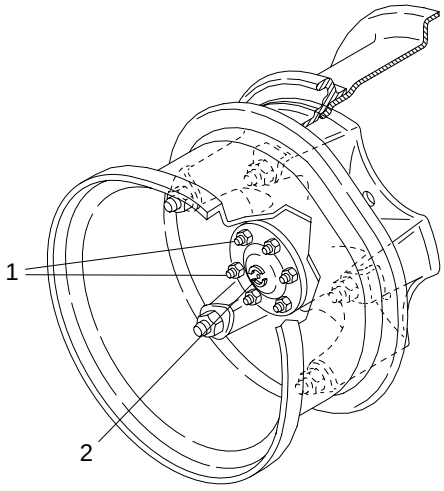
Fig. 1, Typical Drive Axle (exploded view)

Spoke wheel assemblies do not need to be completely disassembled for brake component maintenance. The tires and rims can remain attached to the wheel, and the wheel to the brake drum. The assembly is then removed from the axle as a single unit to expose brake components. Refer to **Group 42** for brake assembly service information.

1. Chock the front tires to prevent vehicle movement. Release the parking brakes.
2. Raise the rear of the vehicle until the tires clear the ground. Then place safety stands under the axle to be serviced. Position a jack or wheel-and-tire dolly under the tires.

Hub Assembly Removal and Installation, Spoke Wheels

3. Back off the slack adjuster to release the rear axle brake shoes.
4. Remove both rim and tire assemblies. Refer to the wheels and tires section in this manual for instructions.
5. Remove the drive axle flange nuts (**Fig. 2**) and washers.



1. Drive Axle Studs and Nuts
2. Center Portion of Drive Axle Flange

Fig. 2

NOTE: Oil will spill as the drive axle shaft and wheel are removed. Place a suitable container under the wheel to catch any spilled oil. Discard the oil.

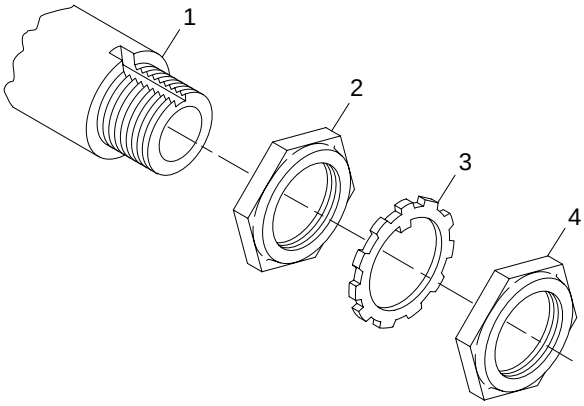
6. Using a hammer and a soft drift, such as one made of brass, sharply tap the center portion of the drive axle flange. **See Fig. 2.** The shaft will usually spring slightly outward after the seal has broken. Then remove the drive axle shaft.

CAUTION

When tapping the drive axle flange, avoid striking the drive axle studs. If struck, the studs may bend or break, or the stud threads can be damaged. Replace damaged studs.

NOTE: Even if the drive axle shaft doesn't spring outward, the seal may have loosened enough to allow the shaft to be pulled from the axle housing. If the seal has not broken, repeat the above step.

7. If so equipped, remove the tapered dowels and washers from the drive axle flange.
8. Remove and discard the gasket.
9. Remove both the axle spindle jam nut and the lockring or nut-lock. See **Fig. 3** or **Fig. 4**. If equipped with a lockring and a nut-lock, remove both. **See Fig. 5.** If equipped with a Pro-Torq® nut, remove the lockring. **See Fig. 6.** Then, back off the wheel bearing inner adjusting nut or Pro-Torq nut about two turns, or enough to allow the weight of the wheel and drum assembly to be lifted from the wheel bearings.

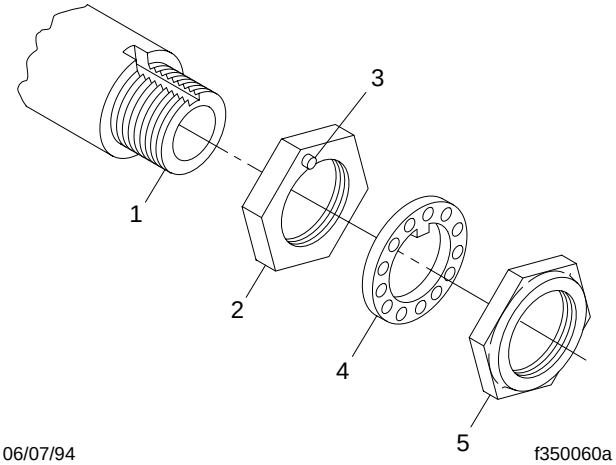


1. Axle Spindle
2. Adjusting Nut
3. Nut-Lock
4. Jam Nut

Fig. 3, Axle Secured With a Nut-Lock

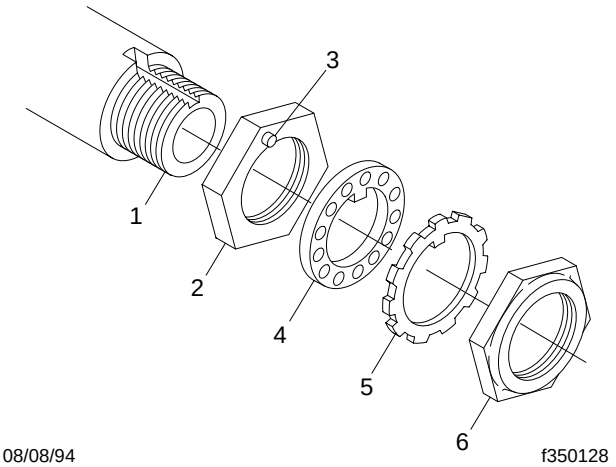
10. Using the wheel dolly or jack, raise the wheel and drum assembly until all weight is removed from the bearings. Then remove the wheel bearing inner adjusting nut, or Pro-Torq nut.
11. Carefully remove the outer wheel bearing; handle the bearings with clean, dry hands. If the wheel bearings have not loosened from the cup, move the wheel assembly about 1/2 inch (13 mm) to jar loose the outer wheel bearing. Be careful to not drop the bearings. Wrap the bearings in clean oil-proof paper or lint-free rags.

Hub Assembly Removal and Installation, Spoke Wheels



1. Axle Spindle
2. Adjusting Nut
3. Pin
4. Pierced Lockring
5. Jam Nut

Fig. 4, Axle Secured With a Lockring



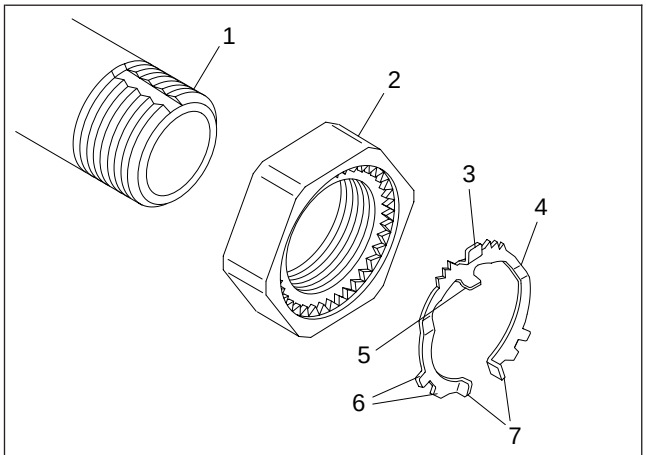
1. Axle Spindle
2. Adjusting Nut
3. Pin
4. Pierced Lockring
5. Nut-Lock
6. Jam Nut

Fig. 5, Axle Secured With a Lockring and a Nut-Lock

CAUTION

CAUTION: Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

12. Using the wheeled support, pull the wheel assembly away from the vehicle. Be careful not to damage the axle spindle threads as the assembly is removed.



1. Axle Spindle
2. Pro-Torque Nut
3. Keeper Tab
4. Lockring
5. Keyway Tabs
6. Keeper Arms
7. Keeper Projections

Fig. 6, Axle With Pro-Torq Nut and Lockring

13. Remove the brake drum nuts (see **Fig. 1**) and detach the brake drum from the wheel.

WARNING

WARNING: Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.

14. Remove the inner wheel bearing from the axle. Handle the bearings with clean, dry hands, then wrap the bearings in clean oil-proof paper or lint-free rags. Occasionally, the inner wheel bearing

Hub Assembly Removal and Installation, Spoke Wheels

will remain in the wheel after the wheel is removed from the axle. In those cases, place a protective cushion where it will catch the bearing. Then use a hardwood drift and a light hammer to gently tap the bearing (and seal, if necessary) out of the cup.

15. Remove the oil seal, if not already removed. Refer to the applicable oil seal section in this group.

Installation (See Fig. 1)

⚠ WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

1. Remove the old oil from the axle spindle and also the disassembled parts. Inspect and clean the wheel hub cavity and the wheel bearings, as instructed in **Subject 110**.
2. Wrap a protective layer of friction tape on the axle spindle threads.
3. If it was removed, attach the brake drum to the wheel. Install the brake drum bolts and nuts, then tighten the nuts to the torque values in the torque table in **Specifications, 400**.
4. Coat both bearing assemblies with fresh oil. Install the inner wheel bearing and oil seal. Handle the bearings with clean, dry hands. For oil seal installation instructions, refer to the applicable section in this group.
5. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing.
6. Using a wheeled support, mount the wheel and drum assembly on the axle spindle; be careful not to unseat the bearings or seal.
7. Fill the hub cavity with oil, and install the outer wheel bearing; handle the bearings with clean, dry hands. Then remove the friction tape from the axle spindle threads.
8. If the axle is equipped with Pro-Torq nuts (**Fig. 6**), skip the next three steps, and go to the step for installing the Pro-Torq nuts.

   If the axle is equipped with adjusting nuts and jam nuts, adjust the wheel bearings as follows (**see Fig. 3**, **Fig. 4** or **Fig. 5**):

   IMPORTANT: Be sure there is enough clearance between the brake shoes and the brake drum, so brake shoe drag will not interfere with bearing adjustment.

   8.1 After the wheel hub and bearings are assembled on the spindle, tighten the inner (adjusting) nut 200 lbf·ft (271 N·m) while rotating the wheel hub assembly.

   8.2 Back off the inner nut one full turn.

   8.3 Tighten the inner nut 50 lbf·ft (68 N·m) while rotating the wheel hub assembly

   8.4 Back off the inner nut one quarter turn.

   NOTE: If you're securing the wheel bearings with a pierced lockring, and no hole in the lockring aligns with the dowel on the adjusting nut, remove the lockring, turn it over and install it, again. If a hole still doesn't align with the dowel, loosen the adjusting nut, but only enough to align the dowel with a hole in the lockring.

   8.5 Install the locking device:

   - Tanged nut-lock
   - Lockring
   - Lockwasher *and* a lockring
   - Nut-lock *and* a lockring

   Then install the jam nut, and tighten it to the applicable torque in **Table 1**.

Locking Device	Torque lbf·ft (N·m)	
	1-1/8 to 2-1/2 Inch Jam Nuts	2-5/8 Inch or Larger Jam Nuts
Tanged Nut-Lock	200 to 300 (271 to 407)	
Lockring		

Hub Assembly Removal and Installation, Spoke Wheels

Locking Device	Torque lbf·ft (N·m)	
	1-1/8 to 2-1/2 Inch Jam Nuts	2-5/8 Inch or Larger Jam Nuts
Tanged Nut-Lock and Lockring	200 to 300 (271 to 407)	250 to 400 (339 to 542)
Lockwasher and Lockring		

Table 1, Jam Nut Torques

8.6 With the jam nut installed and tightened, attach a dial indicator to the hub and set the point of the indicator in line with the end of the axle spindle.

If using aluminum hubs, you may have to install the brake drum on the hub to provide a steel base for the magnet of the dial indicator. Mount the drum on the hub's drum pilot, then adjust the brake or have someone apply the brakes to hold the drum securely while you secure the drum using the stud at the 12 o'clock position, then the studs at about the 4 o'clock and 8 o'clock positions.

NOTE: If using a stud-piloted hub and a steel drum, install 1–1/4 inch washers between the nuts and the drum.

8.7 Release the brakes if you used them to hold the drum while installing it.

Grip the sides of the hub at the three o'clock and nine o'clock positions, then push the hub (and drum, if applicable), to seat the inboard bearing set. Zero the dial indicator.

Grip the sides of the hub at the three o'clock and nine o'clock positions, then pull the hub (and drum, if applicable). Read the dial indicator, and note the end play.

Push the hub back in to confirm that the needle of the dial indicator returns to zero.

The end play must be between 0.001 and 0.005 inch (0.025 and 0.127 mm).

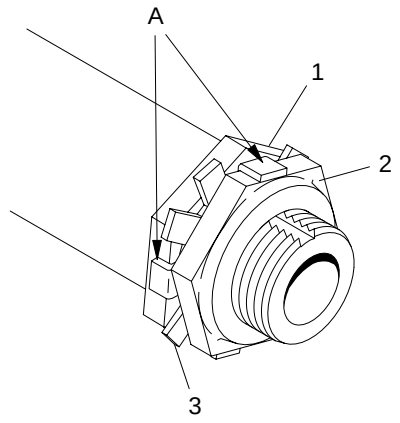
9. If the end play is not within this range, remove the jam nut and locking device, and back off or tighten the inner (adjusting) nut to adjust the end play. Keep the following in mind:

If you're using a nut-lock: turning the inner nut 1/4 turn will change the end play about 0.020 inch (0.508 mm).

If you're using a lockring: turning the inner nut one lockring hole will change the end play about 0.005 inch (0.127 mm). If you take the lockring off and reverse it, then turn the inner nut to the next hole, this will change the end play about 0.0025 inch (0.0635 mm).

Install the locking device and jam nut as described earlier, and measure the end play. If the end play is not between 0.001 and 0.005 inch (0.025 and 0.127 mm), adjust the inner (adjusting) nut, again.

10. Once the end play is correct, bend the nut-lock (**see Fig. 7**) or lockwasher as applicable to lock the jam nut and/or adjusting nut in place.



A. Bend only each tang that is at a right angle to a flat.
1. Wheel Bearing Adjusting Nut
2. Wheel Bearing Jam Nut
3. Wheel Bearing Adjusting Nut-Lock

Fig. 7, Wheel Bearing Adjusting Nut-Lock Installation

11. If equipped with Pro-Torq nuts, adjust Eaton and Rockwell axle wheel bearings as follows (see **Fig. 6**):

11.1 Install the Pro-Torq nut, and turn it against the bearing while spinning the wheel.

Hub Assembly Removal and Installation, Spoke Wheels

IMPORTANT: Be sure there is enough clearance between the brake shoes and the brake drum, so brake shoe drag won't interfere with the bearing adjustment.

11.2 Tighten the adjusting nut 90 to 110 lbf·ft (122 to 149 N·m) while spinning the wheel in both directions.

11.3 Loosen the nut to zero torque and spin the wheel a few turns.

11.4 Tighten the nut 50 lbf·ft (68 N·m) while spinning the wheel in both directions. Back off the nut one-eighth to one-sixth turn.

11.5 Hold the lockring with the keeper projections facing outboard. **See Fig. 8.**

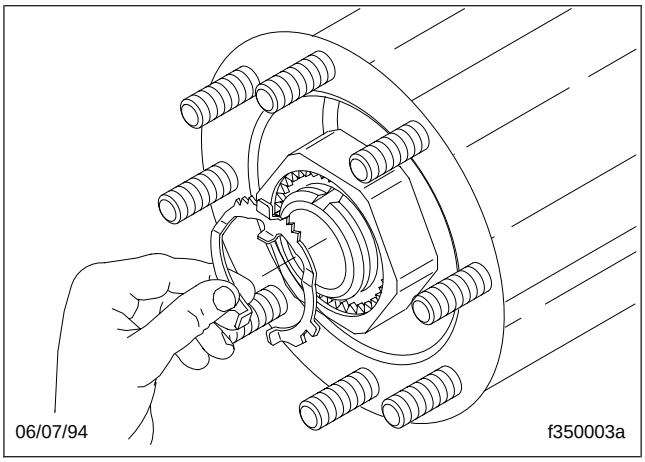


Fig. 8, Lockring Position, Disc Wheel Shown

11.6 Insert the keeper tab in the undercut groove of the Pro-Torq nut, while pressing the keyway tabs on the flat surface of the axle spindle, engaging the mating teeth.

11.7 Insert a screwdriver, or similar tool, in the undercut groove of the nut, between the keeper arms. Compress the lockring with the tool to lock in place. **See Fig. 9.**

CAUTION

CAUTION: Do not use pliers or similar devices on the keeper projections to compress the lockring. This could result in damage or breakage of the lockring.

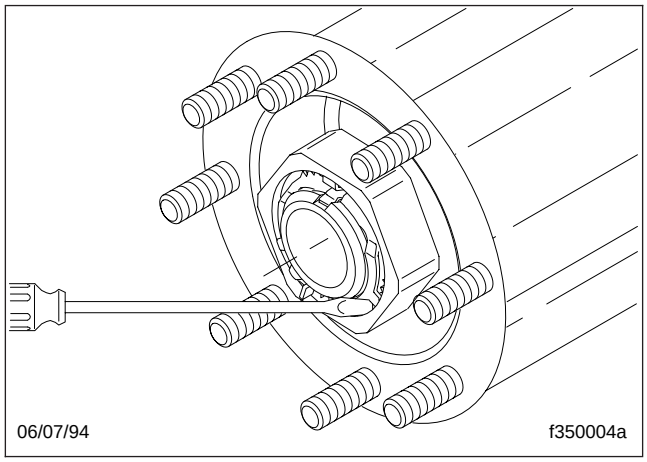


Fig. 9, Compress the Lockring, Disc Wheel Shown

11.8 Using the screwdriver, press around the edges of the lockring to be sure it is locked in place. **See Fig. 10.**

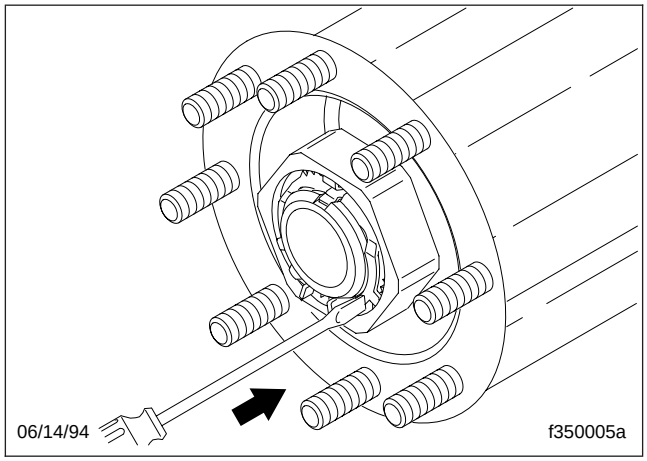


Fig. 10, Make Sure the Lockring is Locked, Disc Wheel Shown

12. Install a new gasket on the drive axle studs.

13. Install the drive axle shaft or, on non-drive axles, the hub cap. The splined end of the axle shaft must seat before the drive axle flange will fit over the studs.

14. If equipped, install the dowels and washers on the drive axle studs. Install the drive axle nuts. Using the sequence shown in **Fig. 11**, tighten the nuts to the torque values in the torque table in **Specifications, 400**.

Hub Assembly Removal and Installation, Spoke Wheels

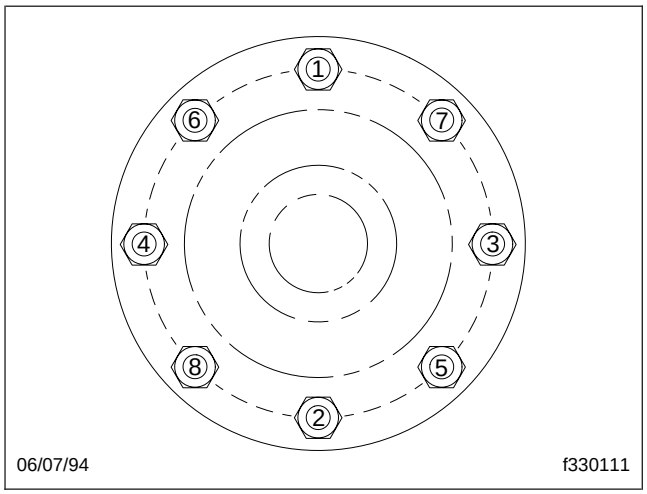


Fig. 11, Axle Shaft Flange Nut-Tightening Sequence

15. Install the brake drum on the wheel hub. For instructions, refer to **Subject 075**.

WARNING

WARNING: If the inner rim nuts cannot be tightened to minimum torque values, the rim studs have lost their locking action, and the wheel is probably damaged. In this case, replace it with a new wheel. Failure to replace the wheel when the conditions described above exist, could result in loss of a wheel or loss of vehicle control, and possible personal injury.

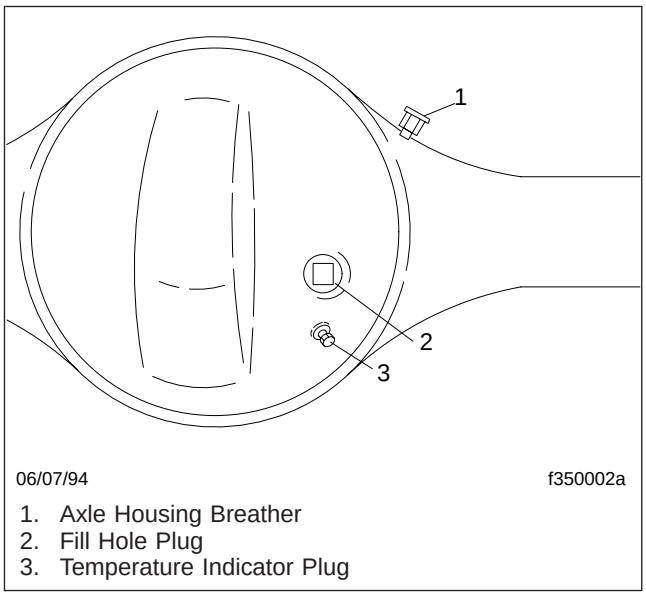
16. Install the rim and tire assemblies. For instructions, refer to **Group 40**.

WARNING

WARNING: Failure to add oil to the axle housing bowl or the wheel hub after the drive axle shaft and wheel have been serviced will damage the wheel bearings and cause them to seize during vehicle operation. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

17. Pour the recommended drive axle lubricant through the axle housing filler hole (**Fig. 12** or **Fig. 13**) until the lubricant is level with the bottom of the hole. **See Fig. 14.** Refer to **Specifications, 400** for the recommended axle lubricants. On Eaton axles, tighten the oil filler plug 40 to 60 lbf·ft (54 to 81 N·m); on Rockwell axles, tighten the plug 35 lbf·ft (47 N·m).

    Tilt the axle to the left and right, by jacking the opposite side. Hold the tilted position for one minute on each side, to allow oil to run into the wheel end. Return the axle to a level position, and add oil through the axle housing filler hole. About two extra pints (1 L) of lubricant will be needed, to bring the oil level even with the base of the filler hole.



1. Axle Housing Breather
2. Fill Hole Plug
3. Temperature Indicator Plug

Fig. 12, Eaton Axle

NOTE: Drive axle wheel bearings are lubricated by oil drawn from the axle housing bowl section. This method ensures good exchange of heat, prevents stagnation, and minimizes the maintenance required on bearings and hub assemblies.

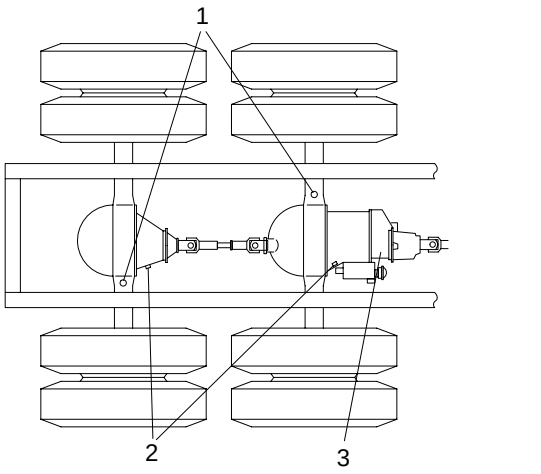
18. For non-drive axles, add about 1 to 1-1/2 pints (0.5 to 0.7 L) of oil to the level shown on the hub cap. Do not overfill. Install the vent plug or threaded filler plug.

19. Turn the wheels, and check the lubricant level.

20. Adjust the rear axle brakes. For instructions, refer to the brake section in the vehicle maintenance manual.

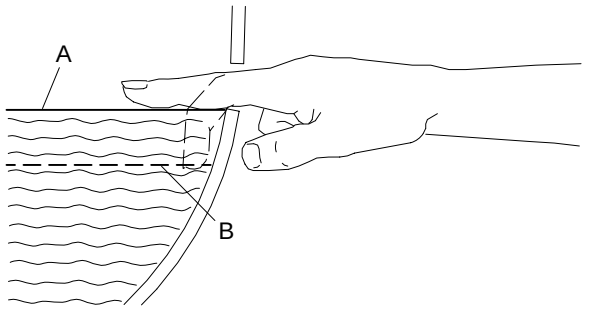
21. Remove the safety stands from under the axle, then lower the vehicle.

Hub Assembly Removal and Installation, Spoke Wheels



1. Axle Housing Breathers
2. Carrier Filler Hole Plugs
3. Interaxle Differential

Fig. 13, Filler Hole Plug and Axle Housing Breather Locations, Rockwell Axle



A. Correct: Lube level at the bottom of the fill hole.
B. Incorrect: Lube level is below the fill hole.

Fig. 14, Lubricant Level Checking

22. Apply the parking brakes, then remove the chocks from the front tires.

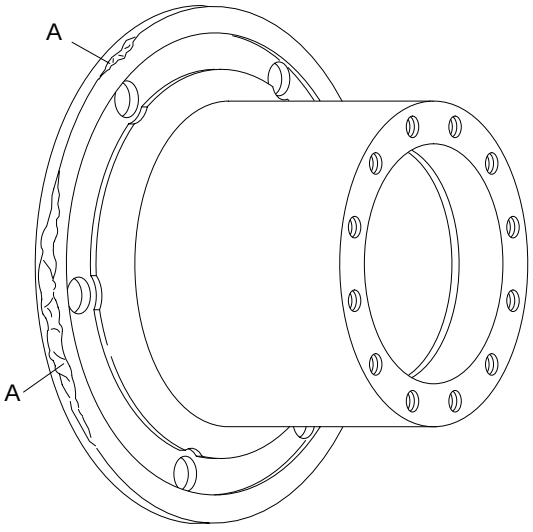
Wheel Hub Assembly and Drive Axle Inspection

1. Inspect the wheel hub flange. A loose wheel assembly will cause the flange to be worn, jagged, or warped. **See Fig. 1 .** Replace the wheel hub if any of these conditions exist.

   Inspect the flange surface around the wheel studs. Improperly torqued wheel nuts will cause worn or cracked stud grooves on the hub. **See Fig. 2.** If wear spots or cracks appear anywhere on the hub, or if the hub is otherwise damaged, replace it with a new one.

2. Remove all the old oil from the spoke wheel or hub cavity. Inspect the inner surface of the wheel or hub for cracks, dents, wear, or other damage. Replace the wheel or hub if damaged.

3. Remove all the old grease or oil from the surfaces of the wheel bearing cups. Inspect the cups for cracks, wear, spalling, or flaking. **See Fig. 3.** Replace the cups if damaged in any way; for instructions, refer to **Subject 120**.



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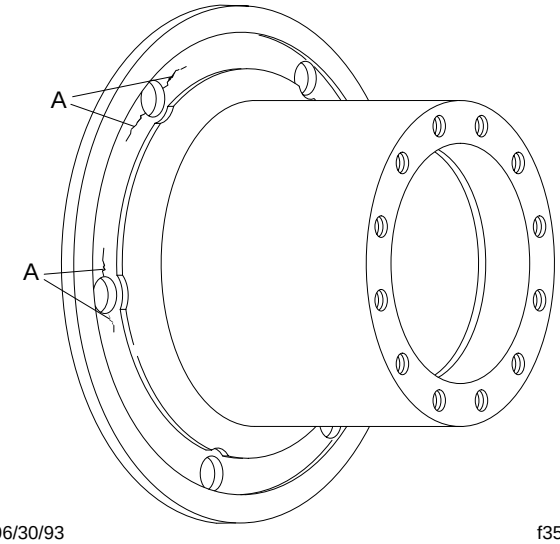
A. Wear spots.

Fig. 1, Typical Wheel Hub, Damaged

4. Inspect the wheel nuts on disc wheel installations, or the rim nuts on spoke-wheel installations. Damaged nuts (**Fig. 4**), usually caused by inadequate tightening, must be replaced with new ones.

   Inspect the wheel studs or rim studs. Replace studs that are stripped, broken, bent, or otherwise damaged (**Fig. 5**); for instructions, refer to **Subject 130** or **Subject 140**.



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A. Cracked stud grooves.

Fig. 2, Typical Wheel Hub, Damaged

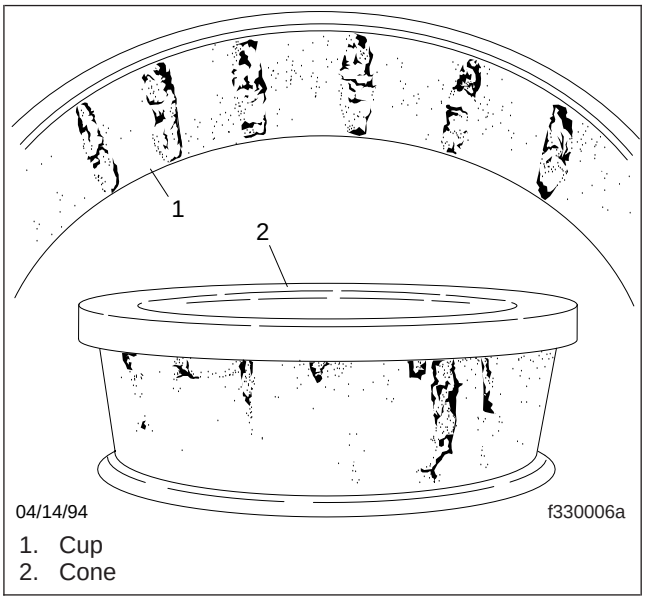
5. Inspect the drive axle studs. Replace the studs that have stripped threads or are broken. Also, replace bent or otherwise damaged studs; for instructions, refer to **Subject 120**.

6. Inspect the drive axle shaft. If the vehicle has been overloaded, or used under severe or improper operations, the drive axle shaft may be twisted, bent, or otherwise damaged. **See Fig. 6.** Replace the drive axle shaft and flange assembly if damaged.

CAUTION

CAUTION: If the drive axle shaft and flange assembly is not replaced once the shaft is twisted or otherwise damaged, it will continue to twist until fracture occurs. With complete fracture of the shaft, other axle parts may be damaged which will increase the cost of repairs. Whenever a drive axle assembly is damaged, the drive axle

Axle Components Cleaning and Inspection



1. Cup
2. Cone

Fig. 3, Spalling (Flaking) of Wheel Bearing Assembly

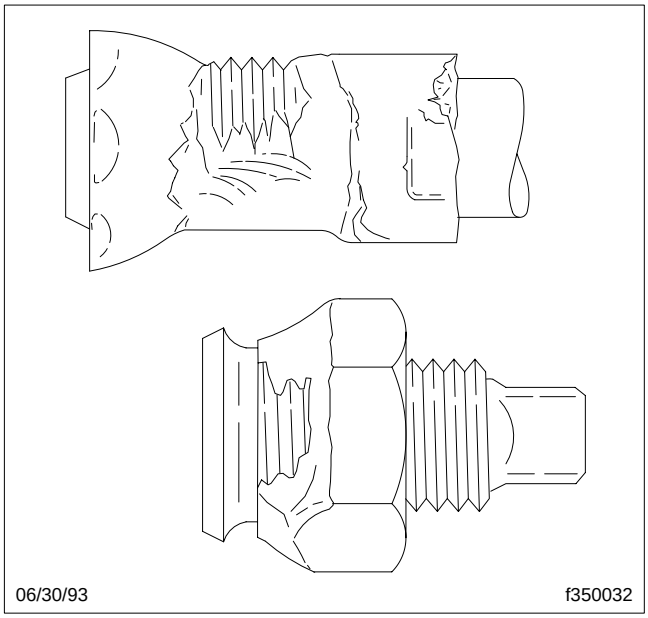


Fig. 4, Damaged Wheel Stud Nuts

shaft and flange on the opposite side of the axle should also be carefully examined, and replaced if damaged.

7. Inspect the drive axle shaft-to-flange surface. Loose wheel bearings can lead to progressive fatigue fractures where the shaft and flange meet. **See Fig. 7.** Replace the drive axle assembly if damaged.

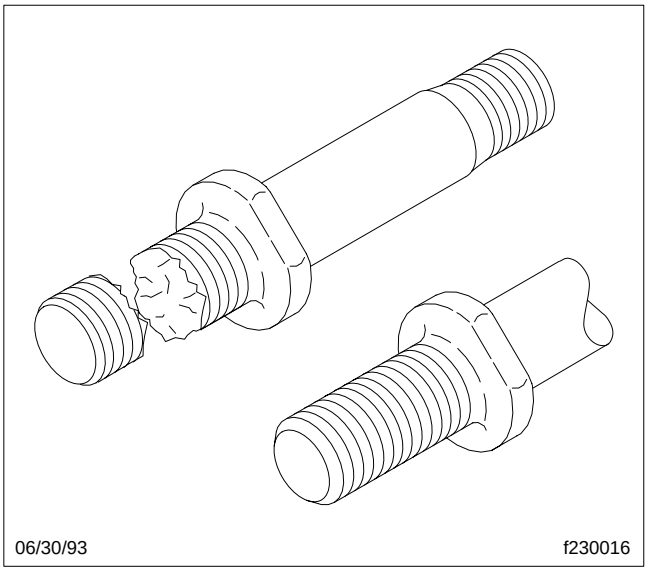
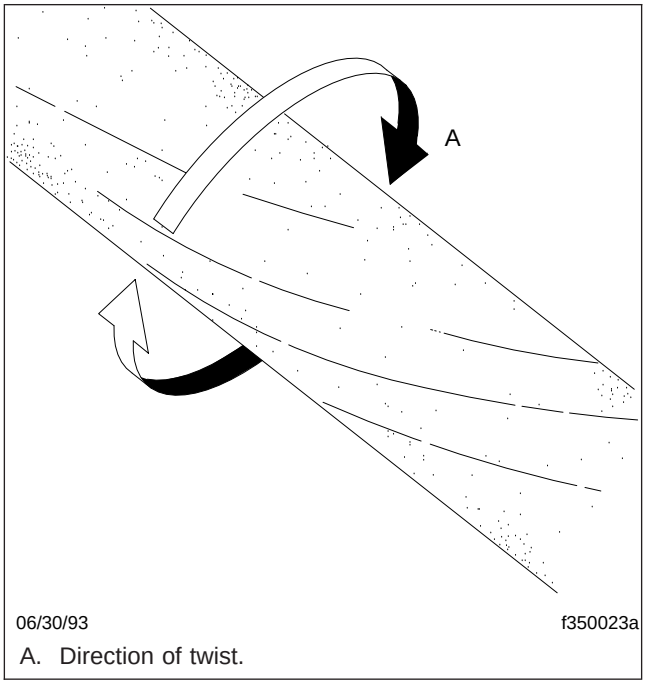


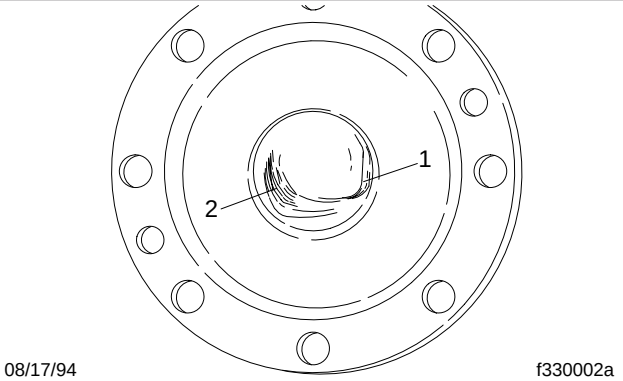
Fig. 5, Damaged Wheel Stud Nuts (Shouldered Type)



A. Direction of twist.

Fig. 6, Damaged Drive Axle Shaft

8. Inspect the inboard portion of the drive axle flange. Minor burrs or rough spots can adversely affect the sealing action of the oil or grease



1. Sudden Fracture Surface (dark area)
2. Area of Progressive Fracture

Fig. 7, Inboard View of Damaged Drive Axle

seals. Remove the burrs or rough spots using fine-grit emery cloth. If they cannot be removed, replace the drive axle shaft.

9. Inspect the drive axle flange around the stud holes. Replace the drive axle shaft and flange assembly if any of the following conditions exist:

   9.1 Cracks on the flange surface.

   9.2 Metal build-up around the stud holes (a result of wear).

   9.3 Out-of-round stud holes.

Wheel Bearing Cleaning and Inspection

CLEANING

Wheel bearings should be very closely inspected at the time of disassembly. The best inspection conditions are possible only after the bearings have been thoroughly cleaned using kerosene or diesel fuel oil, and a stiff brush (**Fig. 8**). Before inspecting, clean the bearings as follows:

⚠ WARNING

WARNING: Do not expose kerosene or diesel fuel oil to flames or intense heat. Both fluids are flammable and, if ignited, could cause personal injury.

Don't spin the bearing rollers at any time. Dirt or grit can scratch the roller surface and cause premature wear of the bearing assembly. Treat a used bearing as carefully as a new one.

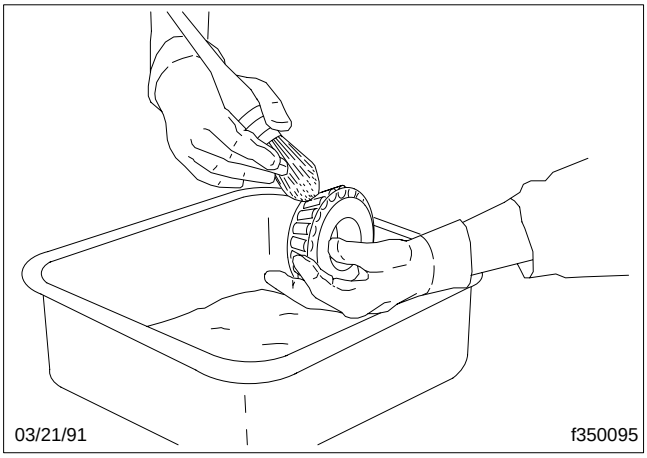


Fig. 8, Wheel Bearing Cleaning

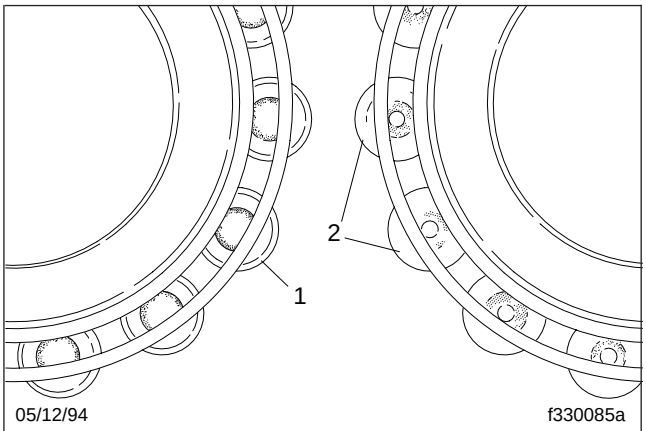
1. Clean all old oil from the bearings and hub cavities, with kerosene or diesel fuel and a stiff brush. **See Fig. 8.** Don't use gasoline or heated solvent.
2. Allow the cleaned parts to dry, or dry them with a clean absorbent cloth or paper. Clean and dry your hands and all tools used in the maintenance operation. Oil will not stick to a surface that is wet with kerosene or diesel fuel, and the kerosene or diesel fuel may dilute the lubricant.

INSPECTION

After the bearings are cleaned, inspect the assemblies, which include the rollers, cones, cups, and cages. If any of the following conditions exist, replace the bearing assemblies:

1. Large ends of the rollers are worn flush to the recess; the radii at the large ends of the rollers are worn sharp. These are signs of advanced wear. **See Fig. 9.**
2. Visible step wear, especially at the small end of the roller track, or deep indentations, cracks, or breaks in the cone surfaces. **See Fig. 10.**
3. Bright rubbing marks on the dark phosphate surfaces of the bearing cage. **See Fig. 11.**
4. Water etch on any bearing surface. Water etch appears as gray or black stains on the steel sur-

Axle Components Cleaning and Inspection



1. New Bearing
2. Worn Bearing Rollers

Fig. 9, Wheel Bearing Roller Wear

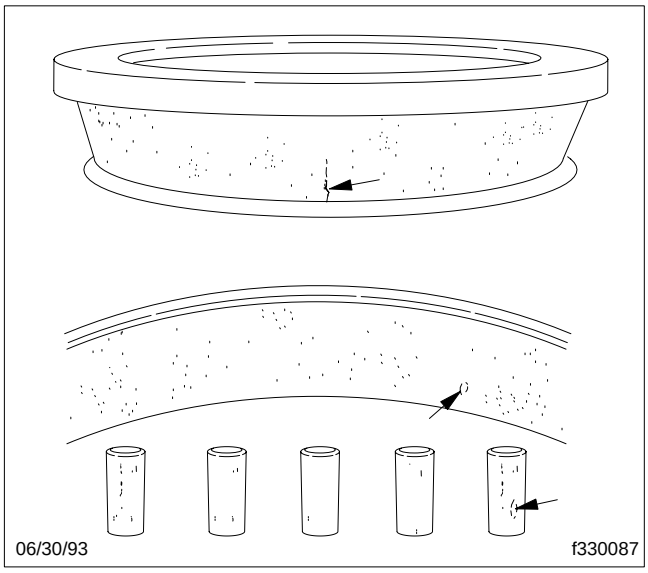


Fig. 10, Indentations, Cracks, or Breaks in Bearing Surfaces

face, and it greatly weakens the affected area. If water etch is present, check the oil seal sealing surfaces.

5. Etching or pitting on functioning surfaces. **See Fig. 12.**
6. Spalling (flaking) of the bearing cup, roller, or cone surfaces. **See Fig. 3.**

   After inspection, brush the bearings with fresh axle lubricant.

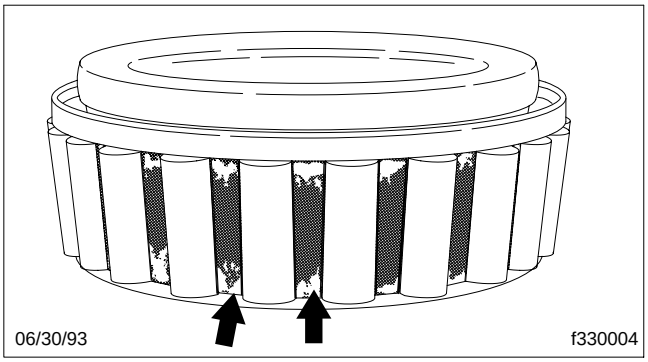


Fig. 11, Rubbing Marks on Bearing Cage

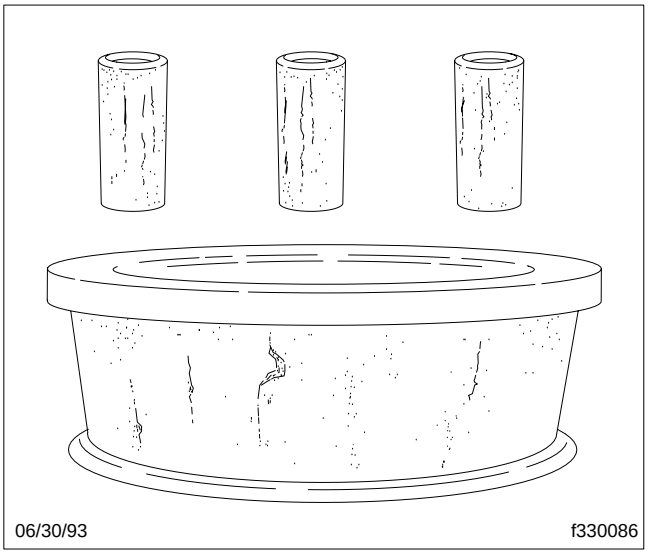


Fig. 12, Etching (Pitting) on Bearing Surfaces

Brake Drum Inspection

New brake drums are purposely undersized to allow for turning, which may be needed if the drum is non-concentric when mounted on the hub. If a new drum is installed, the protective coating on the inner friction surface must first be removed with a solvent, and then rinsed with a hot water wash. Use a clean rag to remove any oily residue or metal chips from the friction surface.

If a drum must be turned or replaced, the other same-axle drum must be similarly turned or replaced to provide the same braking power on both wheels. Turned drums should not exceed the maximum allowable diameter, which is stamped on the outside

surface of the drum. **See Fig. 13** for a typical location of this stamp.

NOTE: Drums that have been turned should then be cleaned by using fine emery cloth followed with a hot water wash. Drums that have been renewed using emery cloth should also be cleaned with a hot water wash.

CAUTION

CAUTION: Failure to replace drums when worn or turned to limits exceeding the maximum allowable diameter will cause drum weakness and reduced braking capacity, which can lead to distortion, higher drum temperatures, and ultimate drum breakage.

WARNING

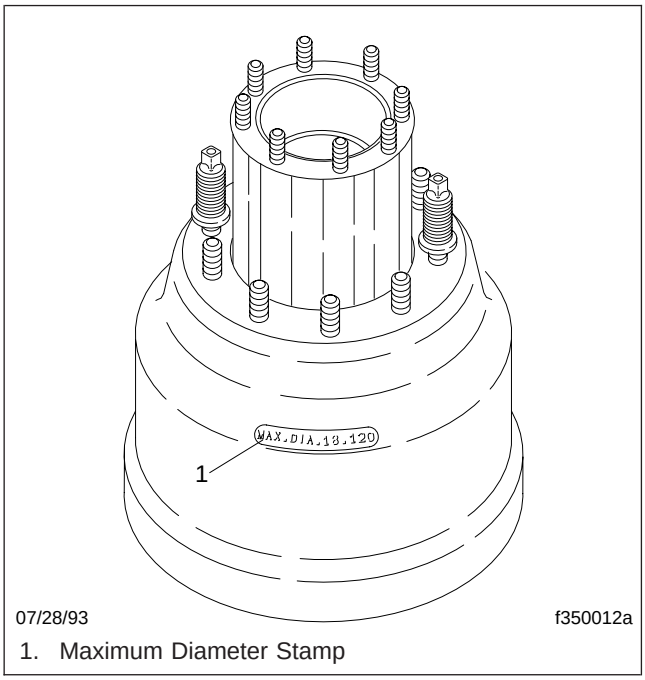
WARNING: Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes,starting with removal of the wheels and continuing through assembly.

To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.

If the drums are turned or replaced, replace the brake linings. Refer to the brake section in this manual for instructions.

1. Inspect the inner friction surface. If a veneered (highly glossed) or glazed surface exists, renew the drum by using 80-grit emery cloth or by turning the drums.
2. Inspect for heat checking, which is a form of buckling (cracking) resulting from a temperature differential in the drum wall between a relatively cool exterior and a hot friction surface. Heat checking is normal on all drums and may not reduce performance and lining life if the network of fine hairline cracks remains small. Examine heat checks of drums often to be sure the checks have not widened into drum weakening cracks (substantial cracks extending to the open edge of the drum).

   Replace the same-axle drums if substantial cracks are present, or if widening of the fine hairline cracks occurs.



1. Maximum Diameter Stamp

Fig. 13, Outboard Mounted Hub and Drum Assembly

NOTE: If there is normal heat checking as described above, inspect the drums at least every 12,000 miles (19 300 km) thereafter. If the vehicle is not equipped with brake dust shields, inspect the drums (using a flashlight from the inboard side of the wheels) every 6000 miles (9700 km). Inspect more often under adverse operating conditions.

3. Check for a contaminated inner friction surface. If fluids are present, such as oil or grease, remove the contaminants. Locate and correct the source of the contamination.

Axle Components Cleaning and Inspection

⚠ WARNING

WARNING: If the brake drums are contaminated with fluids, the brake linings will also be affected. Since oil- or grease-saturated linings cannot be salvaged, they must be replaced. For brake lining replacement procedures, refer to the brake section in this manual. Failure to replace fluid-contaminated brake linings could result in a partial loss of braking capacity.

4. Measure the inside diameter of the drum. If the measured diameter is greater than the maximum allowable diameter, replace the same-axle drums and linings.
5. Check for a variation in gauge readings at different points on the radius of the drum's working surface. If the variation is more than 0.010 inch (0.25 mm) at any point, the drum is out-of-round to unacceptable limits. Remachine or replace the same-axle drums.
6. Inspect the outside surface of the drum. Remove any accumulation of mud, dirt, or rust; foreign matter acts as an insulator, trapping heat within the drum.
7. Check for hard, slightly raised, dark-colored spots on the inner friction surface or for a bluish cast on the brake parts, both of which are caused by high temperatures. If the drums' maximum allowable diameters have not been exceeded, remachine both same-axle drums. If the spots or discoloration cannot be removed, or if remachining is not possible, replace the drums. Also replace the brake shoe return springs. Refer to the brake section in this manual for instructions.

Wheel Bearing Cup Removal and Installation, Aluminum Hubs

Removal (See Fig. 1)

To ensure a tight fit, wheel bearing cups are purposely larger than the wheel hub bores they occupy. To remove the bearing cups, aluminum hub bores must be temporarily expanded by heating the hub in an oven (the bearing cups will also expand, but to a considerably lesser extent). If adequate heating facilities are not available, replace the hub, wheel stud, and bearing cup assembly.

To install the bearing cups, aluminum hubs must again be temporarily expanded using oven heating. When the hub is properly heated, the bearing cup and hub can be press-fit together, using a suitable press.

⚠ WARNING

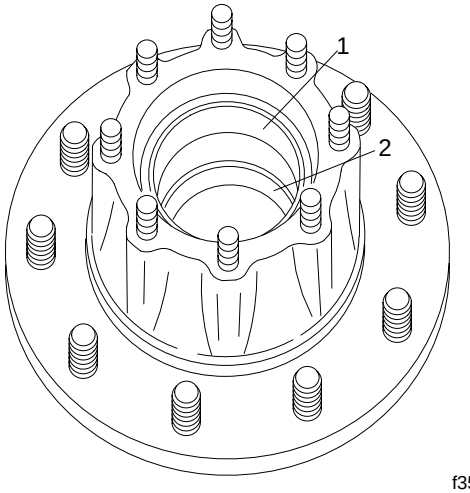
WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Oven-heat the hub to a temperature range of 240° to 280°F (116° to 138°C). Make sure the oven thermostat is accurately set; if unsure, use an oven thermometer to check the temperature of the oven before placing the hub inside. If adequate heating facilities are not available, replace the hub, wheel stud, and bearing cup assembly.

⚠ WARNING

WARNING: Do not use oxyacetylene equipment or similar equipment to heat the hub. The heat emitted from these instruments is not suitable for uniform heating of the wheel hub. If any local surface of an aluminum hub is heated to 350°F (177°C) or higher, artificial aging through metallurgical change will occur. Cracks or weakness in the hub can result, which could ultimately result in the loss of a wheel and loss of vehicle control.

3. Wearing heavy protective gloves, remove the hub from the oven. Place the hub on a suitable press so that the base is fully supported. Quickly press out the bearing cups.



1. Outer Bearing Cup
2. Inner Bearing Cup

Fig. 1

Installation

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.
3. Oven-heat the hub to a temperature range of 240° to 280°F (116° to 138°C). Make sure the oven thermostat is accurately set; if unsure, use an oven thermometer to check the temperature of the oven before placing the hub inside.

Wheel Bearing Cup Removal and Installation, Aluminum Hubs

⚠ WARNING

WARNING: Do not use oxyacetylene equipment or similar equipment to heat the hub. The heat emitted from these instruments is not suitable for uniform heating of the wheel hub. If any local surface of an aluminum hub is heated to 350°F (177°C) or higher, artificial aging through metallurgical change will occur. Cracks or weakness in the hub can result, which could ultimately result in the loss of a wheel and loss of vehicle control.

4. Coat the hub-contact surface of the replacement bearing cup with a film of grease.
5. Wearing heavy protective gloves, remove the hub from the oven.
6. Place the hub on a suitable press so that the base is fully supported. Quickly press-fit the bearing cup into the wheel hub until it is completely and evenly seated. Be careful not to shave the sides of the bearing cup bore as the bearing cup is seated. The accumulation of debris will prevent the cup from being seated and will also cause permanent damage to the wheel hub. If the sides of the bearing cup bore are damaged during installation, replace the wheel hub assembly.
7. Allow the wheel hub to cool before handling. Then, using a 0.0015-inch feeler gauge, check at several places for the seating of the bearing cup in the bearing cup bore. The gauge should not enter beneath the cup. If it does, there is probably dirt or debris preventing the cup from seating. Using the instructions above, remove the cup, then remove the foreign matter. Reinstall the cup.

⚠ WARNING

WARNING: Do not expose kerosene or diesel fuel oil to flames or intense heat. Both fluids are flammable and, if ignited, could cause personal injury.

8. Wipe off the accumulation of grease left after the bearing cup has been seated. Then, using a clean, lint-free cloth dampened with kerosene or diesel fuel oil, clean the inner surface of the bearing cup. Wipe the surface dry using a clean, absorbent, and lint-free cloth or paper.

Wheel Bearing Cup Removal and Installation, Ferrous Hubs

Removal

Wheel bearing cups on ferrous hubs are removed and installed by pressing them in and driving them out without heating the hub.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Using a mild steel rod through the opposite end of the hub, drive against the inner edge of the bearing cup. Alternately drive on opposite sides of the cup to avoid cocking the cup and damaging the inside of the hub.

Installation

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.
3. Coat the hub-contact surface of the replacement bearing cup with a film of grease.
4. Position the cup in the hub and press it into place, using a suitable tool against the outer edge of the cup. Cups must seat against the shoulder in the hub.

⚠ WARNING

WARNING: Do not expose kerosene or diesel fuel oil to flames or intense heat. Both fluids are flammable and, if ignited, could cause personal injury.

5. Wipe off the accumulation of grease left after the bearing cup has been seated. Then, using a clean lint-free cloth dampened with kerosene or diesel fuel oil, clean the inner surface of the bearing cup. Wipe the surface dry using a clean, absorbent, and lint-free cloth or paper.

Replacement

WARNING

WARNING: If a wheel stud breaks, the remaining studs are subjected to undue strain and could fail due to fatigue. When a broken stud is replaced, replace the stud on each side of it (Fig. 1). If more than one stud is broken, replace all of the studs. Failure to replace the studs could result in the loss of a wheel or loss of vehicle control, possibly resulting in personal injury.

1. Remove the wheel hub from the axle. For instructions, refer to **Subject 100**.
2. If a bent portion of a wheel stud will have to pass through the wheel stud bore, cut off the bent portion before removing the wheel stud.
3. Place the wheel hub on a suitable press; make sure the hub flange is evenly supported around and next to the stud being removed. With steady movement, press the damaged stud out of the hub.

CAUTION

CAUTION: Don't use a hammer or concentrated heat to remove or install the wheel studs. Constant, smooth movement of the wheel stud is necessary to ensure the least amount of metal removal from the wheel stud bore. Concentrated heat will damage the hub. If the hub is damaged during wheel stud removal or installation, replace it.

4. Apply a coating of clean axle grease to the entire shaft on headed studs.
5. With the hub on a suitable press, make sure the hub flange is evenly supported around and next to the stud being installed.
6. Position the stud in its hole. Be sure the flat edge of the head flange on clipped studs is in line with the shoulder on the hub.

CAUTION

CAUTION: If headed studs with serrations are being installed, position the teeth of the serrated portion in the notches carved by the original wheel studs during factory installation. If additional metal is scraped from the wheel stud bores, the locking action provided by the serrations will be greatly weakened. Loss of locking action will prevent achieving final torque of the wheel nuts during wheel installation. If final wheel nut torques during wheel installation cannot be achieved, replace the wheel hub assembly.

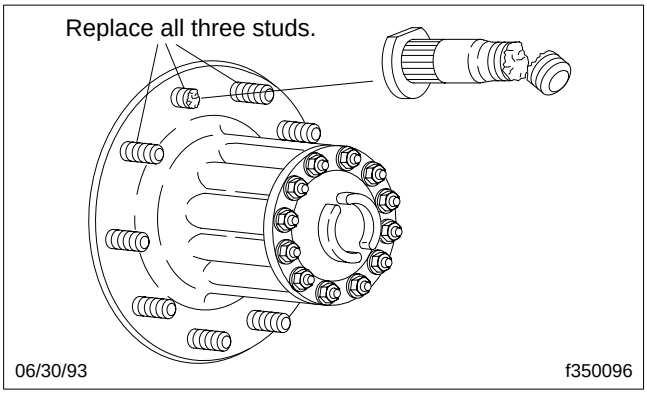


Fig. 1, Wheel Stud Replacement

IMPORTANT: If the driver's side of the vehicle is being serviced, the replacement wheel stud and inner wheel nut must be stamped with an "L" (left-hand threaded), and the nut's face must be stamped "Left." **See Fig. 2.** If the passenger's side of the vehicle is being serviced, the replacement stud and inner wheel nut must be stamped with an "R" (right-hand threaded), and the nut's face must be stamped "Right."

7. With steady movement, press the new stud all the way into the hub.
8. Make sure the stud is fully seated and that its head (flange) is not embedded in the hub. If the head of the stud is embedded in the hub, replace the hub.

WARNING

WARNING: Wheel studs with heads embedded in the wheel hub will weaken the wheel hub flange. Weakness in the wheel hub can result in the loss of a wheel or loss of steering control, possibly resulting in personal injury.

Wheel Stud Replacement, Disc Wheels

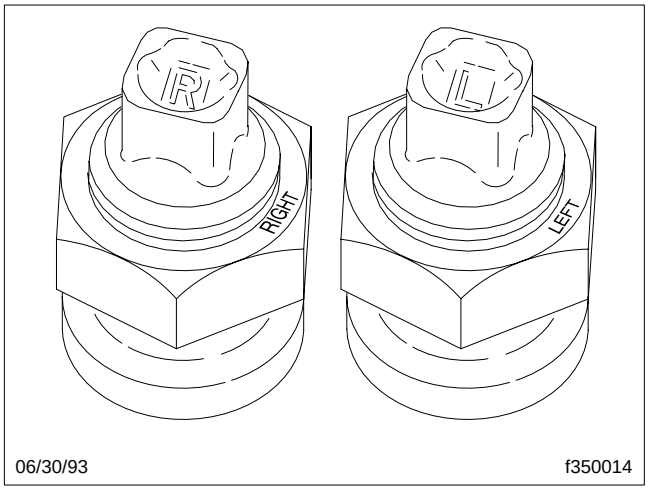


Fig. 2, Wheel Nuts

9. Wipe off any grease on the wheel studs and wheel hub. Install wheel nuts on dry wheel studs only.
10. Install the wheel hub on the axle. For instructions, refer to **Subject 100**.

Replacement

1. Remove the rim and tire assemblies from the spoke wheel. For instructions, refer to the wheels and tires section in this manual.
2. If enough threads remain on the damaged stud, remove it by double-nutting the stud. Turn the inner nut with a wrench in order to remove the stud. Then, proceed to the next step.

   If the rim stud is broken near the surface of the wheel, the stud should be center-drilled using a high-speed drill, and then removed with an easy-out tool. If needed, grind off a flat surface on the damaged stud, then centerpunch the surface as a starting point for drilling. Follow these recommendations:

   2.1 Determine the correct drill diameter by referring to the easy-out tool manufacturer's guidelines. At no time should it be large enough to penetrate the threads of the stud; if the stud threads in the wheel are damaged, replace the wheel.

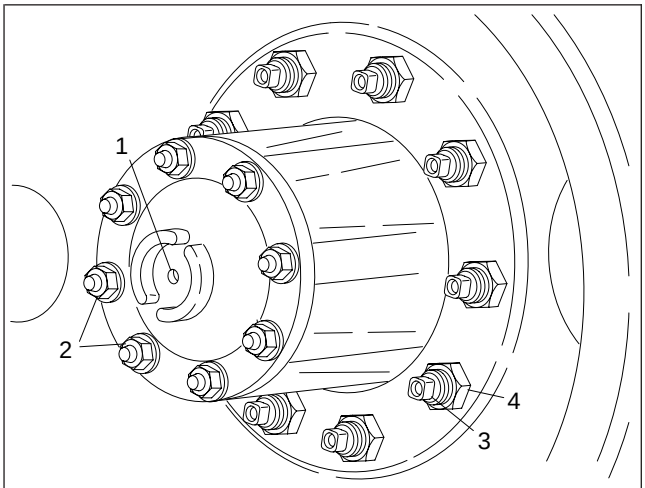
   2.2 Do not drill more than 1.25 inches (32 mm) into the broken stud, as measured at the stud's entrance into the wheel. Drilling through the bottom of the rim stud could damage the wheel. If the wheel is drilled into, replace it.

   2.3 While drilling, keep the cutting surfaces of the drill well lubricated with oil, which acts as a coolant. Allow the drill and drill bit to cool frequently.
3. After the damaged stud is removed, tap out the rim stud hole in the wheel to rid the threads of old stud-locking compound. Use an appropriate sized tap, depending on the original rim stud installation size.
4. Be sure the threads of the new stud are clean and dry. Then, coat the insertion end of the rim stud with an anaerobic thread-lock compound.
5. Using double nuts on the fine thread portion of the stud, install the new stud. Seat the rim stud using the torque values in the torque table in **Specifications, 400**.
6. Allow enough time for the thread-lock compound to set, as suggested by the manufacturer.
7. Install the rim and tire assemblies. For instructions, refer to the wheels and tires section in this manual.

Replacement

NOTE: If the hub has been removed from the axle, proceed to the step which begins, "If enough threads remain..."

1. Apply the parking brakes.
2. Oil will spill as the drive axle shaft is removed. Place a suitable container inside the wheel and under the drive axle flange. Discard the lubricant after removal.
3. Remove the drive axle stud nuts (**see Fig. 1**), and the washers. Remove the drive axle shaft as follows:



1. Center Portion of Drive Axle Flange
2. Drive Axle Studs and Nuts
3. Inner Wheel Nut
4. Outer Wheel Nut

Fig. 1, Wheel Assembly and Hub

3.1 Using a hammer and a soft drift, such as one made of brass, sharply tap the center portion of the drive axle flange (**see Fig. 1**). The shaft will usually spring slightly outward after the seal has broken.

CAUTION

When tapping the drive axle flange, avoid striking the drive axle studs. If struck, the studs may bend or break, or the stud threads can be damaged. Replace damaged studs.

3.2 If the drive axle shaft does not spring outward, the seal may have loosened enough to allow the shaft to be manually pulled from the axle housing. Try to manually remove the drive axle shaft from the housing. If the seal has not broken, repeat the substep above.

4. If equipped, remove the tapered dowels and washers from the drive axle flange.
5. Remove and discard the gasket.
6. If enough threads remain on the damaged stud, remove it by double-nutting the stud. Turn the inner nut with a wrench in order to remove the stud. Then, proceed to the next step.

   If the drive axle stud is broken near the surface of the hub, the stud should be center-drilled using a high-speed drill, and then removed with an easy-out tool. If needed, grind off a flat surface on the damaged stud, then center-punch the surface as a starting point for drilling. Follow these recommendations:

   6.1 Determine the correct drill diameter by referring to the easy-out tool manufacturer's guidelines. At no time should it be large enough to penetrate the threads of the stud; if the stud threads in the wheel hub are damaged, replace the hub.

   6.2 Do not drill more than 1.25 inches (32 mm) into the broken stud, as measured at the stud's entrance into the wheel hub. Drilling through the bottom of the drive axle stud could damage the hub. If the wheel hub is drilled into, replace it.

   6.3 While drilling, keep the cutting surfaces of the drill well lubricated with oil, which acts as a coolant. Allow the drill and drill bit to cool frequently.
7. After the damaged stud is removed, tap out the drive axle stud hole in the wheel to rid the threads of old stud-locking compound. Use an appropriate sized tap, depending on the original drive axle stud installation size.
8. Be sure the threads of the new stud are clean and dry. Then, coat the insertion end of the drive axle stud (the coarse threads) with an anaerobic thread-lock compound.

Drive Axle Stud Replacement

9. Using double nuts on the fine-thread portion of the stud, install the new stud. Seat the drive axle stud using the torque values in the torque table in **Specifications, 400**.
10. Allow sufficient time for the thread-lock compound to set, as suggested by the manufacturer.
11. If the hub was removed from the axle, proceed to **Subject 100** or **Subject 102** for installation instructions. If the hub was not removed from the axle, proceed as follows:

    11.1 Install a new axle flange gasket over the drive axle studs.

    11.2 Install the drive axle shaft in the axle housing. The splined end of the shaft must seat before the drive axle flange will fit over the drive axle studs.

    11.3 If equipped, install the dowels and washers on the drive axle studs. Install the drive axle nuts. Using the sequence shown in **Fig. 2**, tighten the nuts to the torque values in the torque table in **Specifications, 400**.

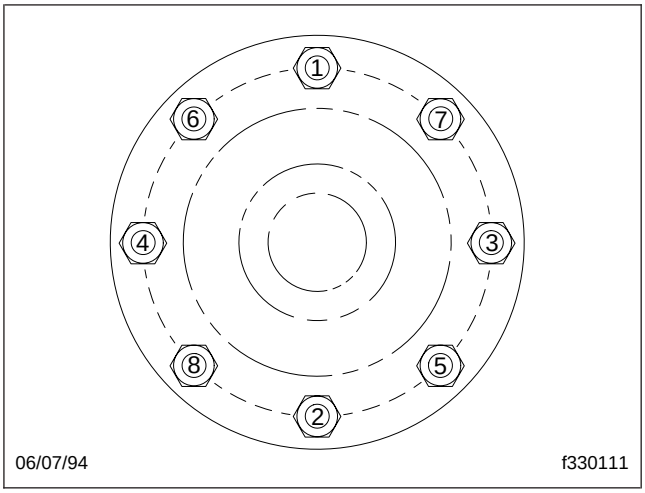


Fig. 2, Axle Shaft Flange Nut-Tightening Sequence

    11.4 Add fresh oil to the wheel hub. For instructions, refer to **Subject 100** or **Subject 102**.

WARNING

WARNING: Failure to add oil to the wheel hub after the drive axle shaft has been serviced will damage the wheel bearings and cause them to seize during vehicle operation. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

Troubleshooting Tables

Problem—Noisy Bearings or Excessive Bearing Replacement Intervals

Possible Cause	Remedy
Not enough oil was used on the bearings, or the wrong type of oil was used.	Clean, then inspect the bearings for wear. Replace worn seals. Coat the bearing assemblies with fresh oil. For lubricant specifications, refer to **Specifications, 400**.
Foreign matter or corrosive agents entered the bearing assembly. Dirt or metallic debris from the bearings was not removed.	Clean, then inspect the bearings for wear. Replace worn seals. Also clean the wheel hub, the axle spindle, and any other component in contact with the bearing lubricant.
An incorrect adjustment of the wheel bearings is causing noise and wear.	Adjust the wheel bearings following the instructions in **Subject 100** and **Subject 102** in this section.
Flat spots or dents on the roller surface were caused by skidding of the roller or improper handling of the wheel bearing during installation.	Clean, then inspect the bearing rollers. Replace the bearing if damaged. Coat the replacement bearings with fresh oil. For lubricant specifications, refer to **Specifications, 400**.

Problem—Broken Wheel or Rim Studs

Possible Cause	Remedy
The wheel or rim nuts were overtightened.	Replace the wheel or rim studs. Refer to **Group 40** for the wheel or rim nut tightening sequence.
An incorrect nut tightening sequence was used.	
The wrong brake drums were installed.	Install new brake drums.
Wheels are mismatched (hub-piloted wheels are mixed with stud-piloted wheels).	Install properly matched wheels.
The vehicle is being overloaded.	Do not exceed the maximum load-carrying capacity of the vehicle.

Problem—Damaged Hub

Possible Cause	Remedy
(Cracked hub) Local surface of an aluminum hub was heated higher than 350°F (177°C) during bearing cup removal.	Replace the hub assembly. When removing the bearing cup, oven-heat the hub.
(Bent flange) Incorrect installation of the wheel studs, such as using a hammer and drift, or the hub flange was not fully supported on the press during wheel stud replacement.	Replace the hub assembly. Replace the wheel studs as instructed under **Subject 130**.
The wrong brake drums were installed.	Install new brake drums.
Insufficient tightening of the wheel nuts to the wheel hub.	Replace the hub assembly and tighten the wheel nuts to the values in the torque table in **Specifications, 400**.

Troubleshooting

Problem—Loss of Lubricant From the Wheel Hub

Possible Cause	Remedy
The drive axle studs are loose.	Tighten the nuts to the torque values in the torque table in **Specifications, 400**. Add lubricant to the axle housing or to the wheel hub.
The seals or gaskets are worn or damaged.	Replace worn or damaged parts.
Minor burrs or rough spots are on the inboard portion of the drive axle flange.	Use fine-grit emery cloth to remove the burrs or rough spots. If they cannot be removed, replace the drive axle shaft.

Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied

Possible Cause	Remedy
Dirt or grease has built up on the brake linings (glazing), or the brake linings have worn excessively.	Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The brake drums are worn, heat-checked, or cracked.	Install new brake drums.

Problem—Service Brakes Grab or Pull

Possible Cause	Remedy
For detailed information, refer to the **air brake system troubleshooting** section of this manual.	

Problem—Poor Lining-to-Drum Contact

Possible Cause	Remedy
The inside surface of the brake drum is scored or grooved.	Install new brake linings on both sets of axle brake shoes. Turn or replace the brake drums.
The brake shoes are stretched or bent.	Replace the brake shoes.
Undersized linings were installed.	Install new brake linings on both sets of axle brake shoes.
An incorrect grind was used on the brake linings.	
An incorrect adjustment of the wheel bearings is causing wheel instability.	Adjust the wheel bearings following the instructions in **Subject 100** and **Subject 102**.

Problem—Brake Linings Are Tapered Across the Width

Possible Cause	Remedy
The inside surface of the brake drum is scored or grooved.	Install new brake linings on both sets of axle brake shoes. Turn or replace the brake drums.
The brake shoes are bent.	Replace the brake shoes.
An incorrect adjustment of the wheel bearings is causing wheel instability.	Adjust the wheel bearings following the instructions in **Subject 100** and **Subject 102**.

Problem—Brake Shoes on the Same Brake Are Wearing Unequally

Possible Cause	Remedy
The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed.	Install a new, matched set of brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The brake shoes are stretched.	Replace the brake shoes.

Problem—Shoes on Each Side of the Axle (Side-to-Side Brakes) Are Wearing Unequally

Possible Cause	Remedy
The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed.	Install a new matched set of brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The inside surface of the brake drum is in poor condition.	Turn or replace the drums.
The wheel bearings are out of adjustment.	Adjust the wheel bearings following the instructions in **Subject 100** and **Subject 102** in this section.

Problem—Edge of the Lining Is Showing Wear

Possible Cause	Remedy
The brake lining is too wide.	Install new brake linings on both sets of axle brake shoes.
The brake linings are misaligned because of incorrectly drilled brake lining holes.	
Undersized brake drums were installed.	Install new brake drums.
The wheel bearings are out of adjustment.	Adjust the wheel bearings following the instructions in **Subject 100** and **Subject 102**.
incorrect fit of the wheel onto the spindle due to the wrong wheel bearings or cone.	Install new wheel bearings and adjust them following the instructions in **Subject 100** and **Subject 102**
The brake shoes are bent.	Replace the brake shoes.

Problem—Brake Linings Are Scored or Grooved

Possible Cause	Remedy
Worn or scored brake drums have been causing poor contact with the brake linings.	Install new brake linings on both sets of axle brake shoes. Turn or replace the brake drums.
There is abrasive material between the lining and the drum.	

Problem—Brake Linings Are Loose

Possible Cause	Remedy
The rivet holes in the brake shoes are too large.	Replace the brake shoes.
Incorrectly crimped rivets are working loose and allowing the linings to move.	Replace the rivets.

Troubleshooting

Possible Cause	Remedy
Rust has built up on the shoe table.	Clean the brake shoe table of all rust, dirt, scale, and paint.

Problem—Brake Lining is Cracked at the Rivet Holes or Bolt Holes

Possible Cause	Remedy
Overtightening of the lining bolts is causing cracks.	Replace the brake linings. Replace the rivets or bolts with the correct size.
The wrong size counter bore for the rivet holes was made.	
The wrong rivets or bolts were used.	Replace the rivets or bolts with the correct size.
Incorrectly crimped rivets are working loose and allowing the linings to move.	Replace the rivets.
Rust has built up on the shoe table.	Clean the brake shoe table of all rust, dirt, scale, and paint.

Problem—Out-of-Round Rivet Holes or Bolt Holes

Possible Cause	Remedy
The rivets or bolts are loose.	Replace the brake shoes or linings.

Problem—Brake Drums Are Heat-Checked

Possible Cause	Remedy
The brake drums are out-of-round.	Turn or replace the brake drums.
The wrong brake drums were installed.	Install new brake drums.
The wheel bearings are out of adjustment.	Adjust the wheel bearings following the instructions in **Subject 100** and **Subject 102**.
The brake linings are glazed (dirt or grease build-up) or are worn unevenly.	Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
The lining friction material for the operation of the vehicle is incorrect.	
There is a brake imbalance between the tractor and the trailer.	Do a brake balance test (tractor versus trailer). Contact the District Service Manager if help is needed.

Problem—Brake Drums Are Heavily Scored

Possible Cause	Remedy
The brake linings are damaged.	Install new brake linings on both sets of axle brake shoes. Clean, turn or replace the drums.
There is excessive wear on the linings.	
On the last brake reline, the drums were not turned.	Turn the brake drums.

Problem—Excessive Brake Lining Wear

Possible Cause	Remedy
There is a brake imbalance between the tractor and the trailer.	Do a brake balance test (tractor versus trailer). Contact the District Service Manager if help is needed.

Specifications

Torque Values		
Description	**Size (grade 8)**	**Torque: lbf·ft (N·m)**
Drive Axle Studs-to-Hub	1/2–13	70 (95)
	5/8–11	135 (185)
Drive Axle Stud Nuts	1/2–20	75–115 (102–156)
	5/8–18	150–170 (203–230)
Hub Cap Capscrews	5/16–18	15 (20)
Oil Filler Plug (Dana® Spicer® axles)	—	40–60 (54–81)
Oil Filler Plug (Meritor axles)	—	35 (47)
Pro-Torq® Nuts	—	Stage 1: Tighten to 100 (136) While Spinning Wheel In both Directions
		Stage 2: Back Off Completely and Spin the Wheel a Few Times
		Stage 3: Tighten to 50 (68) While Spinning Wheel In both Directions
		Stage 4: Back Off 1/8 to 1/6 Turn
Spoke Wheel Brake Drum Nuts	3/4–10	240 (325)
Spoke Wheel Rim Studs	3/4–10	185–200 (250–325)
Wheel-Bearing Adjusting Nuts, 4-Piece System, Standard Hub	—	Stage 1: Tighten to 100 (136)
		Stage 2: Back Off Completely
		Stage 3: Tighten to 20 (27) While Rotating Hub
		Stage 4: Back Off 1/3 Turn
Wheel-Bearing Jam Nut with Tanged Nut-Lock or Lockring	All Sizes	200–300 (271–407)
Wheel-Bearing Jam Nut with Nut-Lock and Lockring or Lockwasher and Lockring	1–1/8 to 2–1/2	200–300 (271–407)
	2–5/8 or larger	250–400 (339–542)

Table 1, Torque Values

Eaton Drive Axle Recommended Lubricant		
Lubricant Type	**Condition**	**Lubricant SAE Viscosity Grade**
Eaton® Roadranger® Synthetic Drive Axle Lubricants, or Equivalent with Military Specification MIL-L-2105D	Over-the-Road Service	75W–90
	Off-Highway Equipment, or Under Extra Heavy Loads	80W–140

Table 2, Eaton Drive Axle Recommended Lubricant

Specifications

Eaton Drive Axle Lubricant Capacities, Single-Drive Axles		
Axle Type	**Axle Model**	**Capacity* pints (liters)**
Single Reduction	23085S, 23085D	40 (18.9)
	23105S, 23105D	48 (22.7)
	23121	41 (19.4)
	30105S	46 (21.8)
Double Reduction	35055P	36 (17.0)

* Quantities listed are approximate. Fill axle until lubricant is level with bottom of fill hole with vehicle on level ground.

Table 3, Eaton Drive Axle Lubricant Capacities, Single-Drive Axles

Eaton Drive Axle Lubricant Capacities, Tandem-Drive Axles					
Axle Type	**Axle Model**	**Capacity* pints (liters)**	**Axle Type**	**Axle Model**	**Capacity* pints (liters)**
Single Reduction	DS341	39 (18.5)†	Dual Range (2-Speed)	DT401, 401-P	39 (18.5)†
	RS341	36 (17)		RT401	36 (17)
	DS381, 381-P	39 (18.5)†		DT402, 402-P	34 (16.1)†
	RS381	36 (17)		RT-402	34 (16.1)
	DS401, 401-P	39 (18.5)†		DT451, DT451-P	39 (18.5)†
	RS401	36 (17)		RT451	34 (16.1)
	DS402, 402-P	39 (18.5)†		DT461-P	43 (20.3)†
	RS402	36 (17)		RT461	40 (18.9)
	DS404	39 (18.5)†	Double Reduction	DP451-P	34 (16.1)†
	RS404	36 (17)		RP451	34 (16.1)
	DS451, 451-P	39 (18.5)†		DP461-P	43 (20.3)†
	RS451	36 (17)		RP461	40 (18.9)
	DS460-P	44 (20.8)†		DP521-P	42 (19.9)†
	RS460	40 (18.9)		RP521	39 (18.5)
	DS461-P	43 (20.3)†		DP601-P	42 (19.9)†
	RS461	40 (18.9)		RP601	39 (18.5)
	DS581-P	42 (19.9)†		DP651-P	41 (19.4)†
	RS581	39 (18.5)		RP651	37 (17.5)

* Quantities listed are approximate. Fill axle until lubricant is level with bottom of fill hole with vehicle on level ground.

† Add 2 pints (1 L) of additional lubricant to the power divider.

Table 4, Eaton Drive Axle Lubricant Capacities, Tandem-Drive Axles

Specifications

Meritor Drive Axle Recommended Lubricant			
Recommended Lubricant Type	**Ambient Temperature**	**Lubricant SAE Viscosity Grade**	**Meritor Specification**
Hypoid Gear Oil API Service Classification GL-5	+10°F (–12.2°C) and up*	85W–140	0-76-A
	–15°F (–26.1°C) and up*	80W–140	0-76-B
	–15°F (–26.1°C) and up*	80W–90	0-76-D
	–40°F (–40°C) and up*	75W–90	0-76-E
	–40°F (–40°C) to +35°F (+2°C)	75W	0-76-J
	–40°F (–40°C) and up*	75W–140	0-76-L
Synthetic Gear Oil	–40°F (–40°C) and up*	75W–90	0-76-N
	–40°F (–40°C) and up*	75W–140	0-76-M

* There is no upper limit on these ambient temperatures, but axle sump temperature must never exceed 250°F (121°C).

Table 5, Meritor Drive Axle Recommended Lubricant

Meritor Drive Axle Lubricant Capacities, Single-Drive Axles		
Axle Type	**Axle Model**	**Capacity* pints (liters)**
Single Reduction	RS-23-160	39.5 (18.7)
	RS-23-161	37.2 (17.6)
	RS-23-180	47.3 (22.4)
	RS-26-180	46.6 (22.0)
	RS-30-180	46.6 (22.0)
Double Reduction	RS-26-380	58.2 (27.5)
	RS-30-380	46.6 (22.0)
	RS-38-380	58.2 (27.5)

* Quantities listed are approximate. Fill axle until lubricant is level with bottom of fill hole with vehicle on level ground.

Table 6, Meritor Drive Axle Lubricant Capacities, Single-Drive Axles

Specifications

Meritor Drive Axle Lubricant Capacities, Tandem-Drive Axles					
Axle Type	**Axle Model**	**Capacity* pints (liters)**	**Axle Type**	**Axle Model**	**Capacity* pints (liters)**
Single Reduction	Q-100	Forward 40.0 (18.9) Rear 37.0 (17.5)	Single Reduction	SQ-100P	Forward 42.0 (19.9) Rear 37.0 (17.5)
	RT-40-140	Forward 30.2 (14.3) Rear 22.8 (10.8)		SQR-100	Forward 36.0 (17.0) Rear 33.0 (15.6)
	RT-40-145 and -145P	Forward 30.2 (14.3) Rear 25.8 (12.2)		SQR-100P	Forward 38.0 (18.0) Rear 33.0 (15.6)
	RT-44-145 and -145P	Forward 29.3 (13.9) Rear 25.1 (11.9)		SR-170	Forward 55.0 (26.0) Rear 43.0 (23.3)
	RT-46-160 and -160P	Forward 39.1 (18.5) Rear 34.4 (16.3)		SSHD	Forward 34.0 (16.0) Rear 28.0 (13.0)
	RT-48-180	Forward 61.1 (28.9) Rear 38.8 (17.4)	Double Reduction	RT-48-380	Forward 61.1 (28.9) Rear 63.6 (30.1)
	RT-52-160 and -160P	Forward 44.1 (20.9) Rear 41.2 (19.5)		RT-52-380	Forward 56.1 (26.5) Rear 58.2 (27.5)
	RT-52-180	Forward 56.1 (26.5) Rear 41.2 (19.5)		RT-58-380	Forward 56.1 (26.5) Rear 58.2 (27.5)
	RT-58-180	Forward 56.1 (26.5) Rear 36.1 (17.1)		RT-70-380	Forward 54.4 (25.7) Rear 53.1 (25.1)
	SQ-100A	Forward 40.0 (18.9) Rear 37.0 (17.5)			

* Quantities listed are approximate. Fill axle until lubricant is level with bottom of fill hole with vehicle on level ground.

Table 7, Meritor Drive Axle Lubricant Capacities, Tandem-Drive Axles

General Information

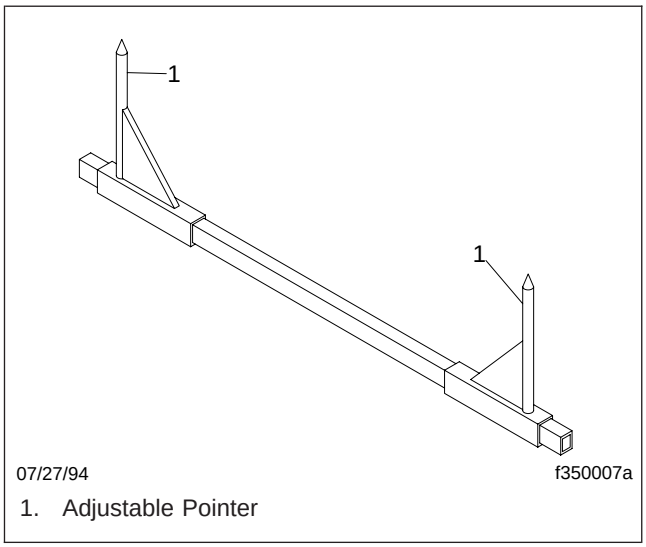
Rear axle alignment should be checked whenever rear axle or suspension components are replaced. It should also be checked when there is excessive front and rear tire wear, or hard or erratic steering.

Manufacturers of axle alignment equipment offer a variety of systems to precisely measure and correct rear axle alignment. If this type of equipment is not available, the basic tools needed for checking rear axle alignment on tandem or single axles are a straightedge (that is nonflexible and at least as long as the axle), steel tape rule, and trammel bar or center point bar.

The straightedge is used to see if a single axle, or a forward-rear axle of a tandem axle installation, is in alignment with the frame. The distance from the straightedge to the center of the wheel hub is measured on each side of the vehicle; any difference in the measurements means that the axle is out of alignment.

A center point bar (**Fig. 1**) is used to see if the forward-rear axle and rearmost axle of a tandem installation are aligned with each other (parallel). It has adjustable pointers at each end, which are inserted into the axle cap holes of each axle. By comparing the distance between the two axles on one side to the distance on the other side, it can be determined if the axles are parallel.

Instructions and a list of materials for making a center point bar are in **Subject 130**.



1. Adjustable Pointer

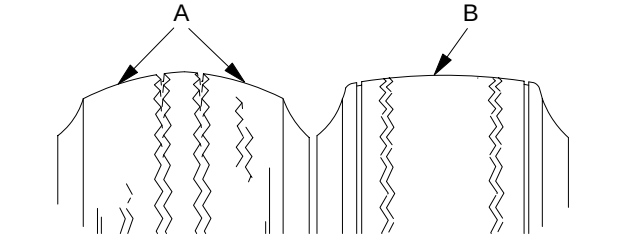
Fig. 1, Center Point Bar

The following preliminary checks should be completed before checking any alignment measurements.

Preliminary Checks

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. Relieve internal stresses in the suspension by driving the vehicle back and forth in a straight line.

1. Wheel assemblies should be balanced, especially for vehicles that travel at sustained speeds of more than 50 mph (80 km/h). Off-balance wheel assemblies cause vibrations that result in severely shortened life for tires and suspension parts.
2. Do not mix tires of different size, type, or weight. Tire wear should be even and not worn to limits exceeding government specifications. Refer to **Group 40** in this manual and **Group 40** in the *Heavy-Duty Trucks Maintenance Manual* for more information. Replace any tire that is excessively worn.
3. Check the inflation pressure of the tires. Refer to **Group 40** in this manual for recommended pressures. An underinflated tire causes tread wear completely around both tire shoulders. An overinflated tire causes tread wear in the center of the tire. See **Fig. 1.**



A. Underinflation Wear B. Overinflation Wear

Fig. 1, Tire Damage Due to Underinflated or Overinflated Tires

4. Check for out-of-round wheels and wheel stud holes. Replace the wheel if any of these conditions exist.
5. On each side of the vehicle, check the height of the chassis above the ground; for instructions, see **Group 32** in this manual or the suspension manufacturer's service literature. Sagging, fatigued, or broken suspension springs create a lopsided vehicle appearance and an unbalanced weight distribution. Anything that changes the ratio of weight on the springs affects the alignment angles and also the tire tread contact area. Replace damaged springs as instructed in the applicable suspension section.
6. Check and, if necessary, correct frame rail alignment as instructed in **Group 31** in this manual.
7. Check and, if necessary, adjust rear axle tracking. For instructions, see **Group 32** in this manual or the suspension manufacturer's service literature.
8. Check the rear axle wheel bearings for wear and incorrect adjustment. Refer to **Section 35.02** for instructions.

Checking Using Computerized Alignment Systems

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

Follow the manufacturer's instructions for use of the alignment equipment, and use the alignment measurements given in **Fig. 1** and the applicable tables in **Specifications 400**.

Checking Using the Manual Method

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction.

1. Park the vehicle on a level surface. Relieve internal stresses in the suspension by driving the vehicle back and forth in a straight line, or by jacking the axle up and letting it down.
2. Chock the front tires and place the transmission in neutral. Release the parking brakes.

NOTICE

Do not use scribe lines for marking on frame rails. Scribe lines, which cut or scratch the metal, can develop into starting points for structural damage to the frame.

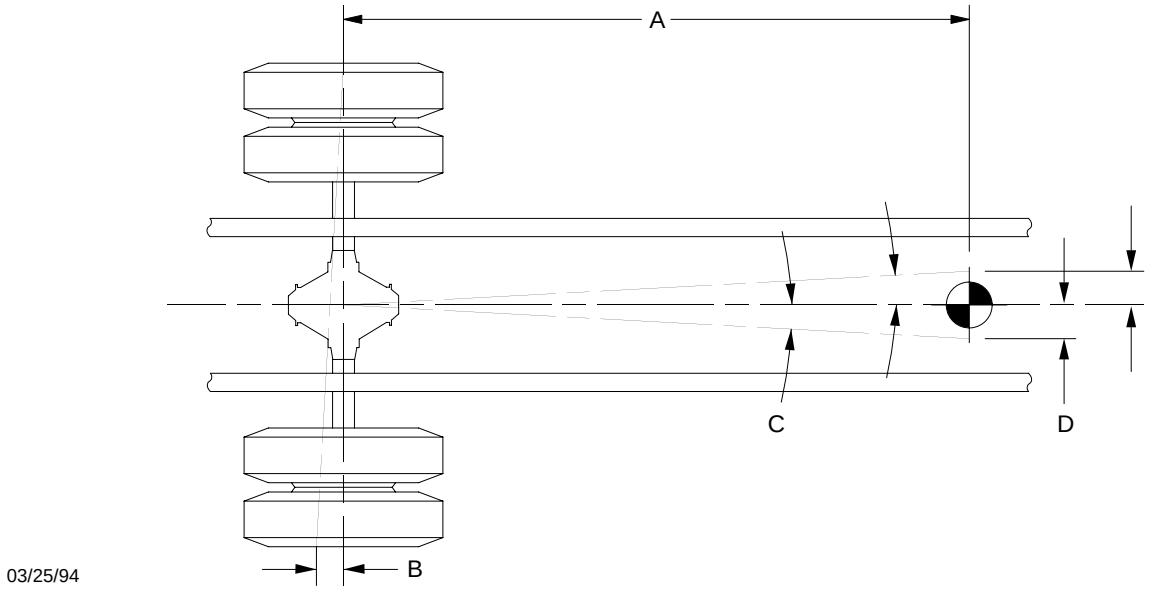
3. Select a point on the frame rail forward of the rear axle, and mark it using a pencil or soapstone. Then mark two other points, exactly 4 inches (102 mm) forward and to the rear of the original point. Make sure that all three marks are aligned and of equal distance from the outside edge of the frame rail. Using a center point or trammel bar, place one pointer on the forwardmost point, and make an arc with a pencil or soapstone on the opposite frame rail. Then place the pointer on the rearmost point and make an arc on the opposite frame rail intersecting the first arc. See **Fig. 2**. The point where the two arcs intersect and the original (or middle) point on the opposite frame rail have matching locations.
4. Line up the straightedge with the two matching points. Check that the straightedge extends out about the same distance on each side of the frame rail. Using C-clamps, clamp the straightedge to the frame; see **Fig. 3**. The straightedge must line up exactly with the points.
5. Measuring from the outside edge of each frame rail, mark the straightedge on both sides of the frame. The marks (**Fig. 3**, Ref. A) must be of equal distance from the frame and as far from the frame rail as the tires are at their farthest point from the frame.

IMPORTANT: The distance between the mark on the straightedge and the frame rail must be equal on both sides of the vehicle.

6. On each side of the vehicle, measure the distance from the mark on the straightedge to the center of the wheel hub. See **Fig. 3**.

   The difference between these measurements should be 1/4 inch (6 mm) or less. See **Fig. 1**. If the difference is more than 1/4 inch (6 mm), adjust the axle alignment. For instructions, see **Group 32** in this manual, or the suspension manufacturer's service literature.

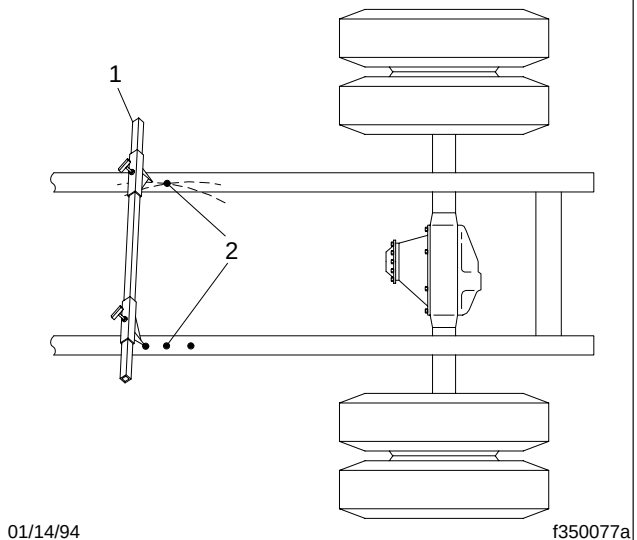
Alignment Checking, Single Axle



For items A and D, see **Specifications 400**.

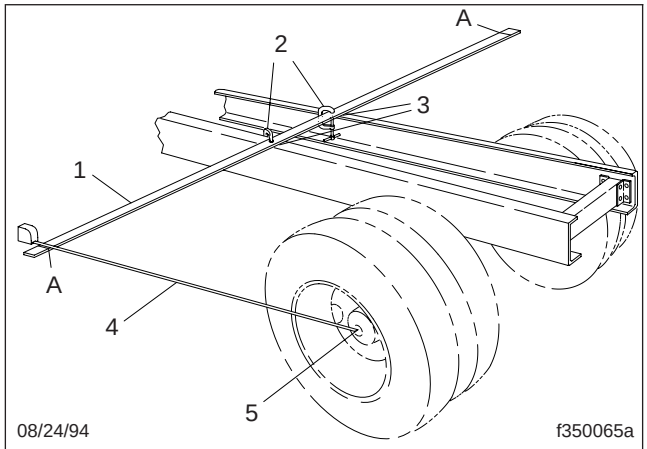
A. Distance from Rear Axle to Target (using Bee Line Alignment Tools)
B. Maximum Allowable Difference if Aligned Manually = ±1/4 inch (6 mm)
C. Maximum Allowable Tolerance if Aligned with Hunter Tools = ±0.18 degree
D. Maximum Allowable Tolerance if Aligned with Bee Line Tools

Fig. 1, Alignment Measurements



1. Center Point/Trammel Bar
2. Matching Points

Fig. 2, Marking an Arc



A. Marks

1. Straightedge
2. C-Clamps
3. Matching Points
4. Tape Measure
5. Wheel Hub

Fig. 3, Straightedge to Wheel Hub Measurement

To align a tandem axle, first, check and (if needed) align the rearmost axle; then, check and (if needed) align the forward-rear axle.

Checking Using Computerized Alignment Systems

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

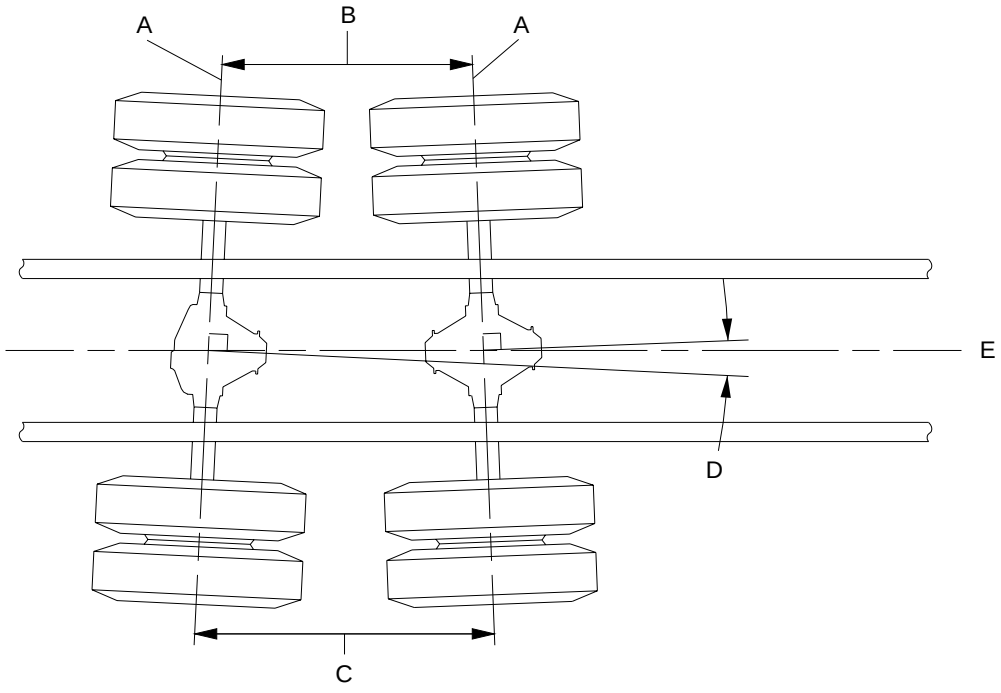
Follow the manufacturer's instructions for use of the alignment equipment, and use the alignment measurements given in **Fig. 1** and the applicable tables in **Specifications 400**.

Checking Using the Manual Method

A straightedge and a center point bar are needed to manually align a tandem axle. For instructions for making a center point bar, see **Subject 130**.

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction.

1. Using the instructions in **Subject 110**, check and align the rearmost axle.
2. Using a center point bar, set the two points into the axle cap holes as shown in **Fig. 2**. Lock them in place by tightening the setscrews.
3. With the points still locked in place, move the center point bar to the other side of the vehicle, set the two points into the axle cap holes, and compare the axle spacing. If there is a difference



A. Axle Centerline
B. Left-Hand Axle End Spacing, Measured Manually or with Bee Line Alignment Tools
C. Right-Hand Axle End Spacing, Measured Manually or with Bee Line Alignment Tools
D. Maximum Tolerance as Measured with Hunter Alignment Tools = ±0.08 degree
E. Vehicle Centerline

Fig. 1, Tandem Axle Measurements

Alignment Checking, Tandem Axle

of 1/8 inch (3 mm) or less between the spacing on one side of the vehicle compared to the other, no further action is necessary. If the difference is more than 1/8 inch (3 mm), adjust the forward-rear axle alignment. See **Fig. 1**. For instructions, see **Group 32** in this manual, or the suspension manufacturer's service literature.

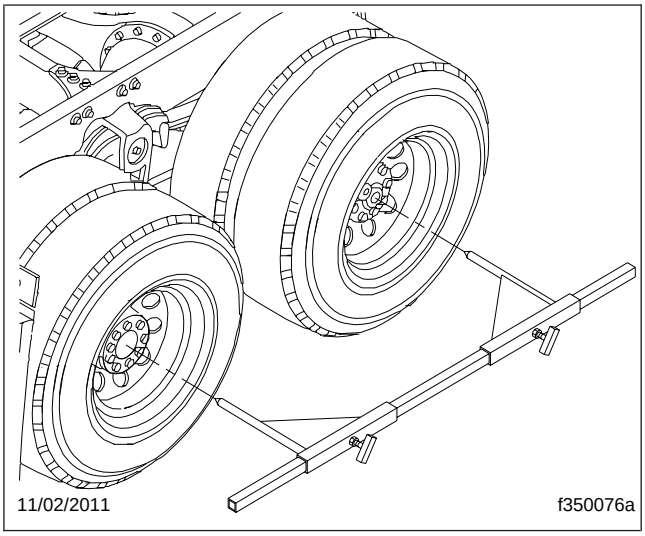


Fig. 2, Center Point Bar Placement

Center Point Bar Construction

Materials Required

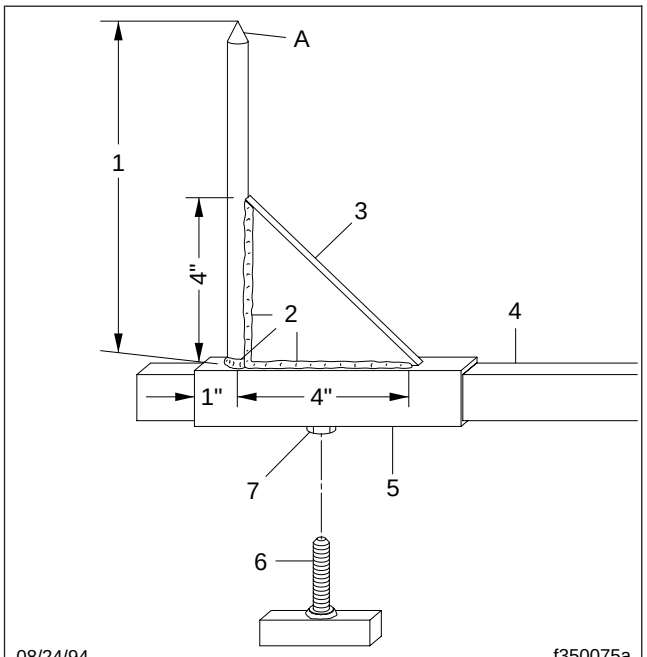
NOTE: To obtain metric conversions (millimeters), multiply the number of inches by 25.4.

The following materials are required:

- 62" of square steel tube (1" x 1", measured outside)
- 12" of square steel tube (1-1/8" x 1-1/8", measured inside)
- 20" of 3/8" steel rod
- two 1/2" x 3" pieces of steel square-bar stock
- one 4" x 4" steel plate, 1/8" thick
- two 3/8–16 capscrews (grade 5), 2" long
- two 3/8–16 hexnuts (equivalent to grade 5)

Construction

1. Cut the 1-1/8 x 1-1/8 inch (inside measurement) square steel tube in half to obtain two pieces 6 inches long. These will be the sliding members (slides) of the center point bar.
2. Cut the 4-inch by 4-inch steel plate diagonally into two pieces (gussets). Weld one gusset to each slide, as shown in **Fig. 1**.
3. Cut the steel rod in half to obtain two 10-inch rods. Grind one end of each to form a point.
4. Weld the pointed steel rods to the slides and gussets, as shown in **Fig. 1**.
5. Drill a 1/2-inch hole in the center of each slide, on the side opposite where the pointer was welded. Drill through only one side of the tube.
6. Directly over each hole drilled in the step above, weld a 3/8–16 nut (equivalent to grade 5).
7. Weld a piece of steel stock, about 1/2-inch wide by 3-inches long, over the head of each of two 3/8–16 by 2-inch long capscrews.
8. Place a slide over each end of the 60-inch piece of steel tube, with the pointed rods to the outside. Screw the handscrews (made in the step above) into the slides until they are clamped tightly to the cross tube.



A. Grind to a point.

1. 3/8-Inch Diameter Rod
2. Weld
3. Gusset
4. 1-Inch Square Steel Tube
5. 1–1/8 Inch Square Steel Tube
6. 3/8–16 Bolt
7. 3/8–16 Nut

Fig. 1, Center Point Bar Construction

Specifications

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Dealers must have proof of this calibration history.

Maximum Tolerance from Perpendicular, Manual Method	
Method	**Maximum Tolerance ± from Perpendicular**
Manual	1/4-inch (6 mm)

Table 1, Maximum Tolerance from Perpendicular, Manual Method

Maximum Tolerance from Perpendicular, Hunter Equipment	
Method	**Maximum Tolerance ± from Perpendicular**
Hunter *	0.18 degree

* To use Hunter alignment equipment, refer to the applicable Hunter service literature.

Table 2, Maximum Tolerance from Perpendicular, Hunter Equipment

Maximum Tolerance from Perpendicular at Target, Bee Line Equipment	
Distance from the Forward or Rear Drive Axle to Target inches (mm)	**Maximum Tolerance± from Perpendicular inches (mm)**
100 (2540)	5/16 (8)
120 (3048)	3/8 (10)
140 (3556)	7/16 (11)
160 (4064)	1/2 (13)
180 (4572)	9/16 (14)
200 (5080)	5/8 (16)
220 (5588)	11/16 (17)
240 (6096)	3/4 (19)
260 (6604)	13/16 (21)

Table 3, Maximum Tolerance from Perpendicular at Target, Bee Line Equipment

Rear Axle Parallelism Specifications	
Method	**Maximum Tolerance**
Hunter	±0.08 degree maximum axle-to-axle difference; reference "C" in **Fig. 1**.
Bee Line or Manual	±1/8-inch max. difference in axle end-spacing; reference "B" minus "A" in **Fig. 1**.

Table 4, Rear Axle Parallelism Specifications

Specifications

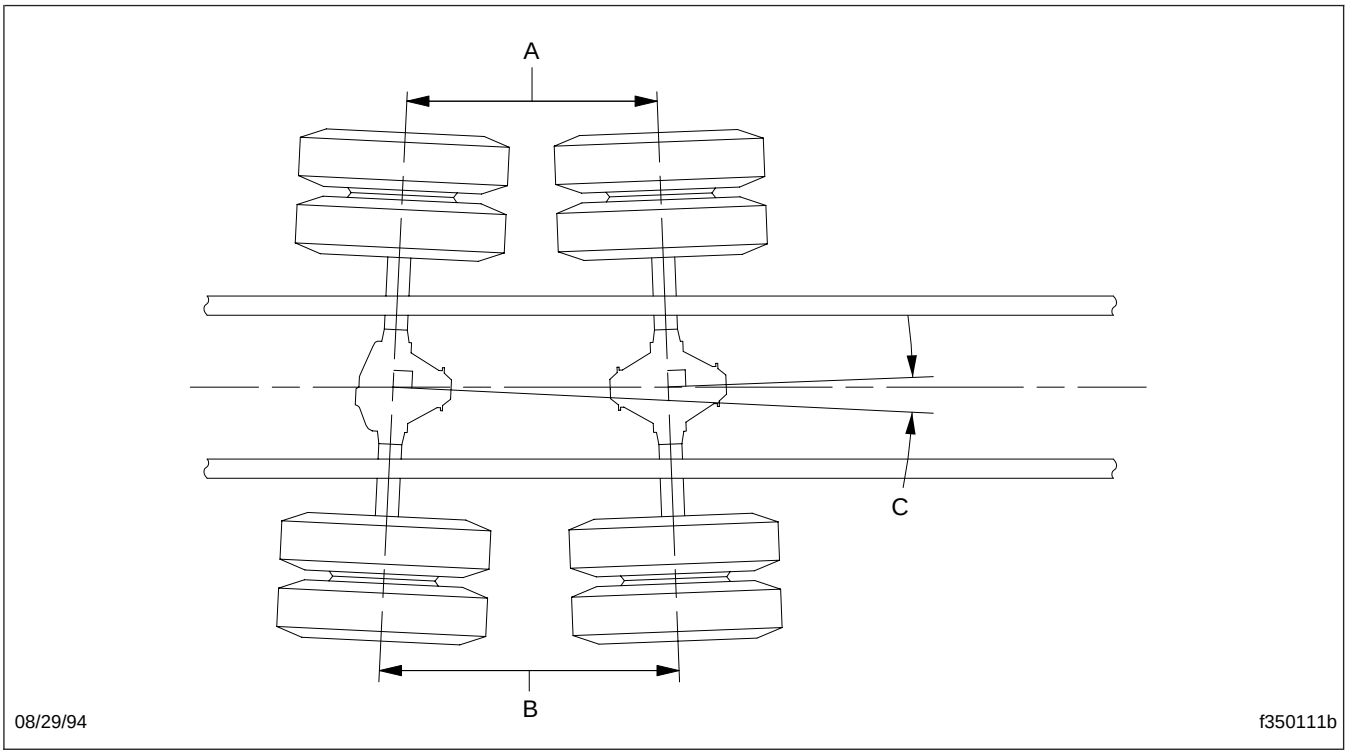


Fig. 1, Tandem Axle Measurements

Replacement

1. Remove the wheel, drum, and hub from the axle. For instructions, refer to **section 35.02** in this service manual group for instructions.
2. Remove the inner wheel bearing assembly from the axle. Handling the bearings with clean dry hands, wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone assembly will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion to catch the bearing assembly. Using a hardwood drift and a light hammer, gently tap the bearing and seal out of the inner wheel bearing cup.

⚠ CAUTION

CAUTION: Never use a sharp chisel to cut through an axle ring (wear sleeve). A sharp chisel could damage the spindle or shoulder.

3. Remove the steel axle ring (wear sleeve) by striking the ring surface several times with a ball-peen hammer (**see Fig. 1**). Then, remove the stretched axle ring from the spindle.

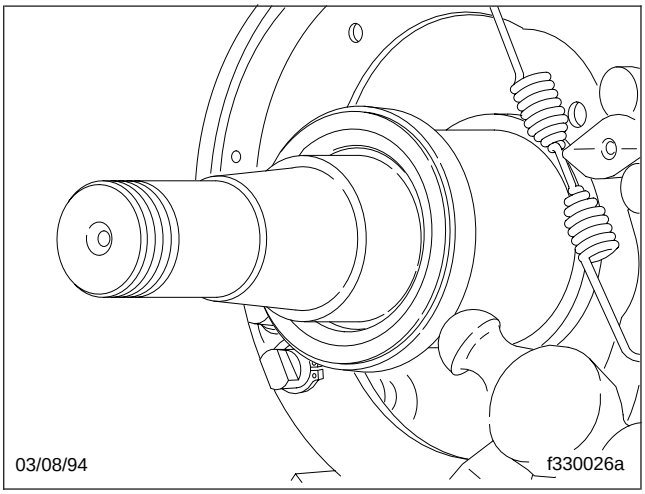


Fig. 1, Removing the Axle Ring

4. Clean and inspect the bearings, the spindle, spindle threads, seal bore, and the hub cavity.

   IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

   4.1 Inspect the inner hub bore. Remove dirt and contaminants from all recesses and corners. Smooth any sharp edges with emery cloth, and fill in any grooves with filler. **See Fig. 2.**

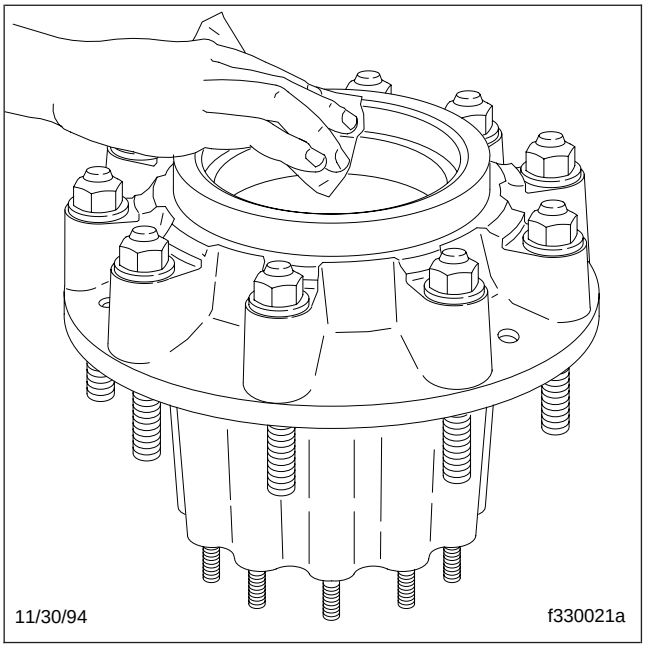


Fig. 2, Clean and Inspect the Hub Bore

   4.2 Wipe the hub area with a clean shop cloth.

   4.3 After removing the wear sleeve, inspect the spindle. Remove any sharp edges and burrs from the leading edges and the shoulder area. Repair deep gouges with filler and smooth with an emery cloth. **See Fig. 3.**

   4.4 Wipe the seal and shoulder area with a clean shop cloth.

⚠ CAUTION

CAUTION: Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

Seal Replacement, Outrunner™

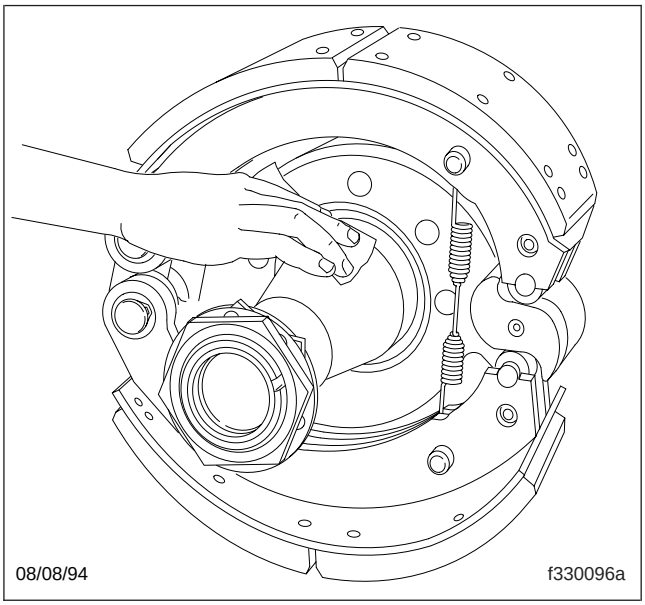


Fig. 3, Clean and Inspect the Axle Spindle

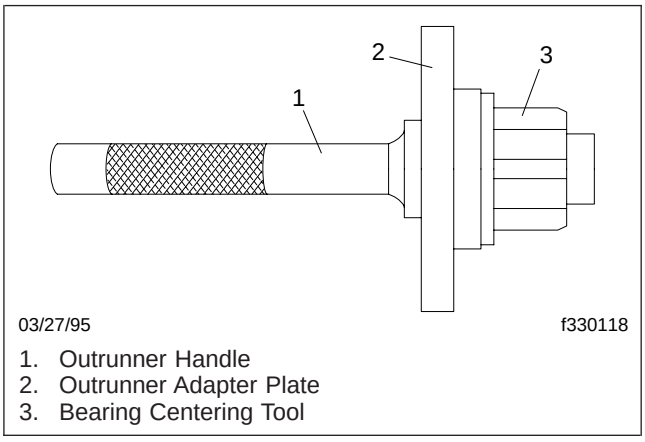
4.5 Inspect the bearings and hub components for wear or damage. Replace any worn or damaged components as necessary.

4.6 Coat the wheel bearing cones with oil.

5. Install the inner wheel bearing cone in the inner wheel bearing cup.

IMPORTANT: Use the Eaton Outrunner installation tool *with the centering tool* when installing the seal. **See Fig. 4.**

6. Install the oil seal in the hub bore.



1. Outrunner Handle
2. Outrunner Adapter Plate
3. Bearing Centering Tool

Fig. 4, Eaton Outrunner Installation Tool

⚠ CAUTION

CAUTION: Do not use any silicone or permatex type bore sealant with this seal. The Eaton Corporation recommends a light coating of bearing oil on the outer circumference of the seal.

Do not mix lubricants of different grades. No not mix mineral and synthetic lubricants. Do not pack the bearings with grease when using an oil bath system. Failure to follow these installation guidlines will result in less than desired performance of the Outrunner seal, and installation-related failures are not covered under warranty.

6.1 Place the outrunner seal tool with the words "air side" facing the adaptor plate of the installation tool. **See Fig. 5.** Lubricate the seal outer circumference with wheel bearing oil.

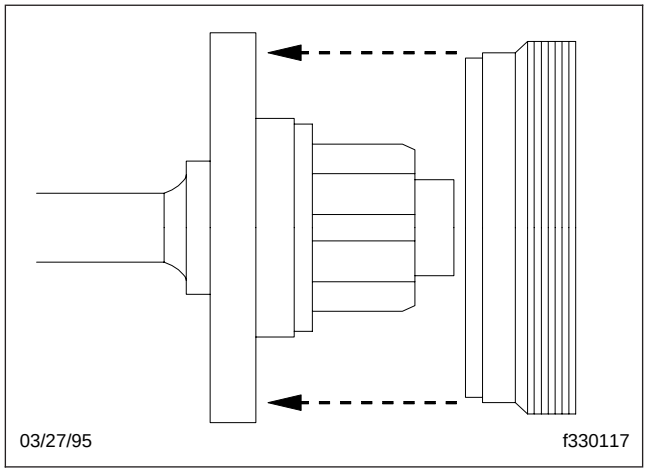


Fig. 5, Seal Placement on Tool

IMPORTANT: Install the seal in the hub bore with the hub layed flat. Do not install the seal with the hub in the vertical (upright) position.

6.2 With the hub and the wheel assembly layed flat on the floor, place the inner bearing cone in the cup.

6.3 Position the oil seal in the hub bore. Before striking the handle of the installation tool, tap the adaptor plate around the outer edge to position the seal. **See Fig. 6.**

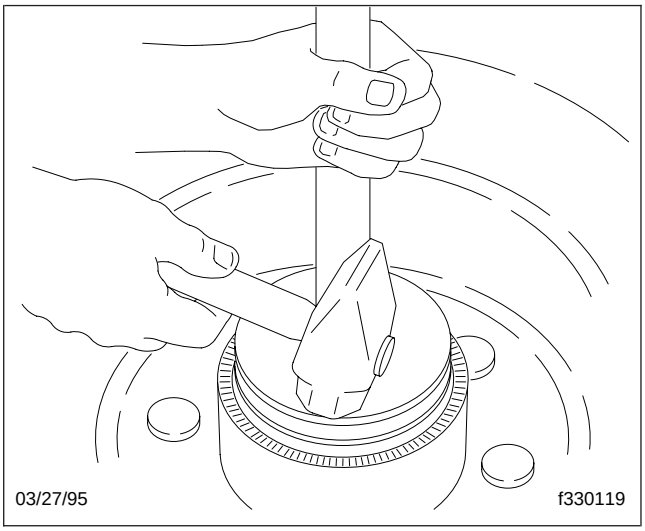


Fig. 6, Position the Seal

6.4 Hit the handle of the installation tool *gently*. **See Fig. 7 .**

Because of the rubber outer circumference, the Outrunner seal is easier to install than seals with metal outer circumferences. When the adaptor plate bottoms out on the hub surface, the seal is installed correctly. You will hear a metal-to-metal sound.

6.5 Check that the seal is not cocked, and that the unitized seal inner circumference and inner bearing turn freely.

6.6 Lubricate the inner circumference of the seal with a light film of clean bearing oil.

7. Install the wheel hub on the axle. Adjust the wheel bearings. For instructions, refer to **section 35.02** in this service manual group.

IMPORTANT: When starting the wheel on the spindle, center the hub carefully to avoid seal damage from the leading edge of the spindle.

8. Place the hubcap and a new gasket in position, then install the capscrews. Tighten the capscrews 15 lbf·ft (20 N·m).

9. Fill the hub with oil to the level shown on the hubcap. **See Fig. 8.** Do not overfill.

10. Spin the wheel and check the oil level.

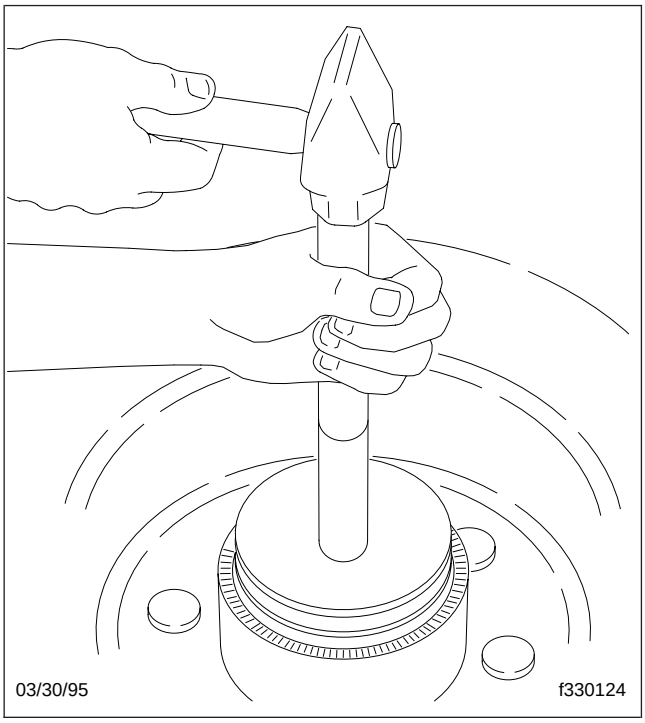
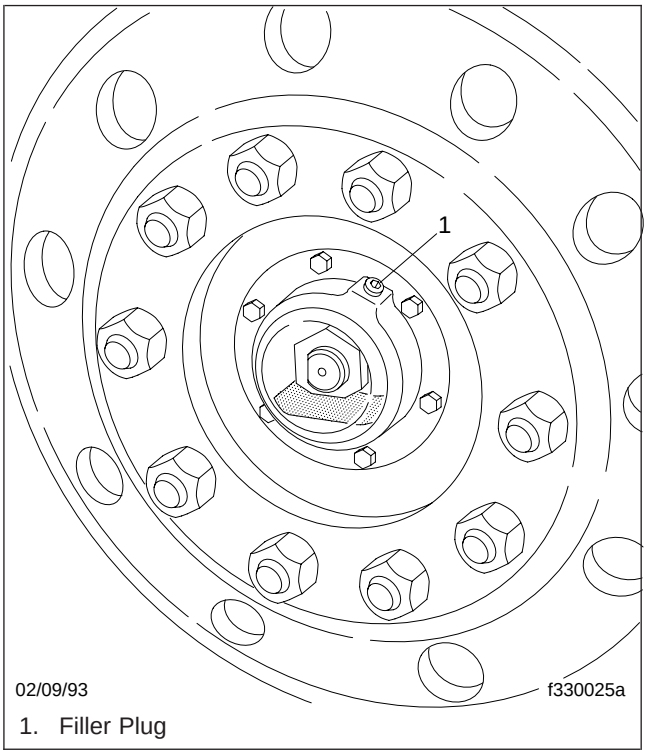


Fig. 7, Install the Seal

11. Adjust the brake shoe-to-drum clearance. For instructions, refer to the brake section in the vehicle maintenance manual.

Seal Replacement, Outrunner™



1. Filler Plug

Fig. 8, Fill the Hub with Oil

General Information

Detroit rear axles are compatible with industry-standard brakes, hubs, and wheel bearings.

The following explains an example of the number found on a Detroit rear axle identification tag, which is located on the carrier. See **Fig. 1**.

Typical Model Number: ART-40.0-4

- *ART* = tandem rear axle
- *40.0* = weight rating (times 1000 lb)
- *4* = basic model number

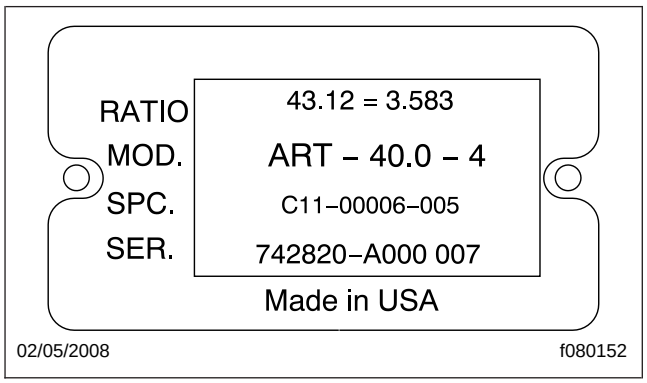


Fig. 1, Rear Axle ID Tag

Detroit rear axles may have a main differential lock, which is commonly known as the "DCDL" (Driver-Controlled Differential Lock). The DCDL is an optional feature that can lock the differential assembly to improve traction on icy road conditions. When the differential lock is engaged, the clutch collar completely locks the differential case, gearing, and axle shafts together to maximize traction of both wheels and protect against spinout. Each part of the DCDL is replaceable; see **Subject 180**.

On tandem axles there are three possible differential lock options: forward-rear carrier only, rearmost carrier only, or both rear carriers.

NOTE: Detroit axles are a proprietary product, though in some applications they may be referred to as "Freightliner" or "Axle Alliance" axles or "MB components."

Warranty

To assist in the determination of warrantable and non-warrantable failures for these axles, warranty evaluation guides are available through WarrantyLit on **www.accessfreightliner.com**. These guides help determine whether or not pre-approval is needed for a repair. The following evaluation guides are available:

- **Warranty Evaluation Guide**
- **Submission Guidelines - Differential Cross Failure**
- **Submission Guidelines - Pinion Bearing Cage Damage**
- **Submission Guidelines - Pinion Nut Failure**
- **Submission Guidelines - Thrust Bearing Failure**
- **Submission Guidelines - Yoke (Pinion) End Play**

Single or Rearmost Axle Removal and Installation

Removal

For rear axle components, see **Fig. 1**.

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires. Put the transmission in neutral.
2. Using a suitable jack, raise the vehicle enough to take the weight off the axles, but not enough to raise the tires off the ground.
3. At both ends of the axle, loosen all the wheel nuts.
4. Continue to raise the vehicle evenly until there is room to fit a stand underneath the axle housing.

⚠ WARNING

Never work around or under a vehicle that is supported only by a jack. Always support the vehicle with safety stands. Jacks can slip, allowing the vehicle to fall, which could result in serious injury or death.

5. Support the vehicle with safety stands.
6. Remove the tire and wheel assemblies.
7. Drain the oil from the differential housing. Install the drain plug.
8. Disconnect the driveshaft from the differential carrier; see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
9. Release the parking brakes.
10. Cage the parking brake springs to prevent the parking brakes from engaging. For instructions, see **Group 42**.
11. If DCDL is installed on the vehicle, use the DCDL switch in the cab to engage the lock. An indicator light comes on when the differential lock is engaged. Turn the appropriate wheels to ensure the lock is fully engaged.
12. Place a basin under the axle shaft flanges to catch any oil, then remove the axle shafts; see **Subject 120**.
13. Drain the air system.
14. Disconnect the DCDL air line from the carrier housing, if installed.
15. If necessary, back off the slack adjusters, then remove the brake drums.
16. Remove the hubs from the axle spindles; see **Section 35.02**.
17. Remove the brake shoes. For instructions, see the applicable service brake section in **Group 42**.
18. If applicable, disconnect the leveling valve rod(s) from the suspension.
19. At the frame rail or crossmember, disconnect the wiring for the ABS sensors. Remove any tie straps that hold the wires to the frame rails.
20. Disconnect the air lines from the rear brake chambers.
21. Remove the brake air chambers and the slack adjusters from the axle housing. For instructions, see **Group 42**.
22. Remove the ABS sensors and wiring, and the fasteners that hold the brake spiders to the axle flanges. Remove the spiders from the axle.
23. Using a suitable jack, support the axle housing.
24. If applicable, remove the hexnuts that hold the bottom of each suspension air bag to its suspension bracket.
25. Remove the suspension components that attach the axle to the vehicle. If applicable, remove the U-bolt nuts from the U-bolts. Discard the U-bolt nuts and U-bolts.
26. Lower the axle enough to clear the suspension components.
27. Remove the axle from the vehicle.
28. If you are going to replace the differential carrier, place the axle on a secure axle stand.

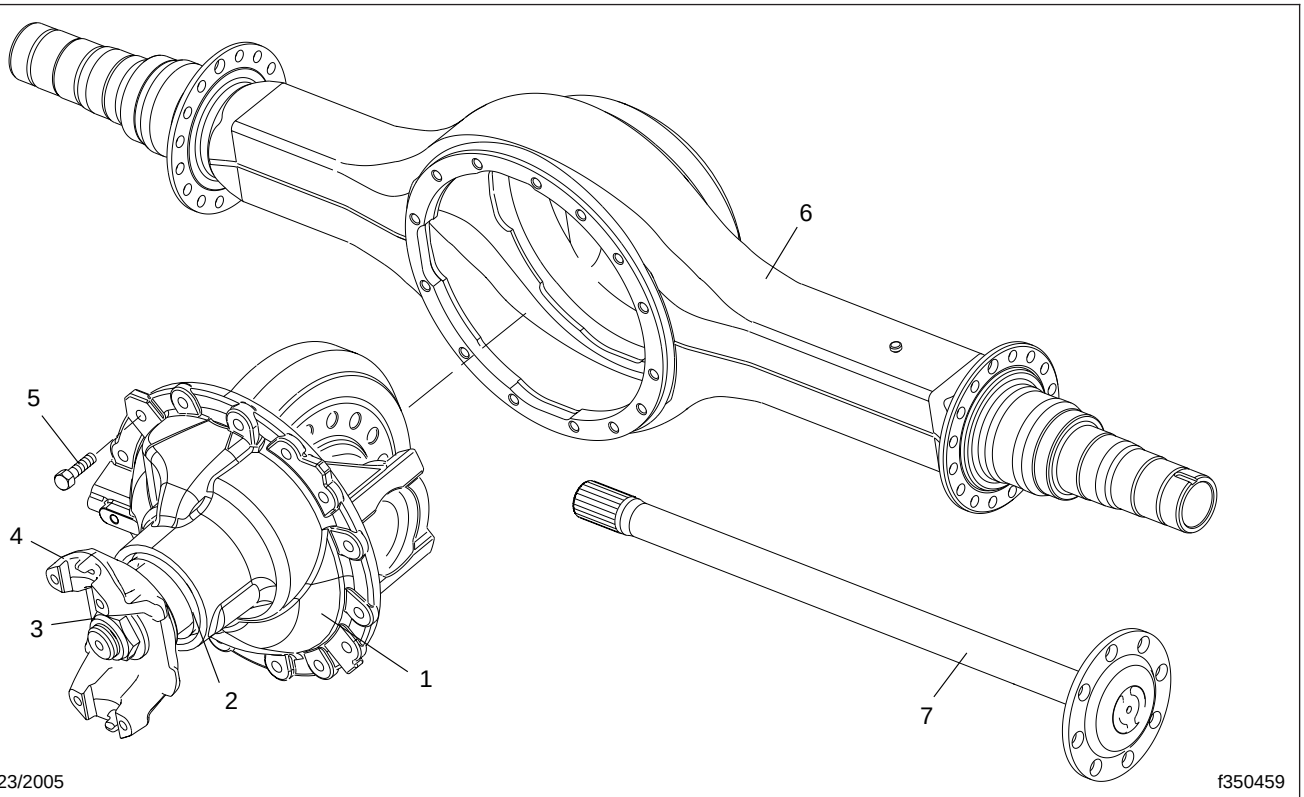
Installation

1. Position the axle underneath the vehicle.
2. Install the suspension components that attach the axle to the vehicle, as follows.

   NOTE: U-bolts and U-bolt nuts cannot be reused.

   2.1 On vehicles with conventional suspensions, install the upper U-bolt brackets,

Single or Rearmost Axle Removal and Installation



1. Differential Carrier
2. Radial Shaft Seal
3. Yoke Nut
4. Carrier Yoke
5. Carrier Capscrew
6. Rear Axle Housing
7. Axle Shaft

Fig. 1, Single or Rearmost Axle Components

new U-bolts, lower U-bolt brackets, and new U-bolt nuts.

On vehicles with air suspensions, in addition to the U-bolts, install the hexnuts that attach the air springs to the suspension brackets. For torque values, see **Group 32**.

On vehicles without U-bolts, install the walking beams.

2.2 If applicable, tighten the new U-bolt nuts in a diagonal pattern. For torque values, see **Group 32**.

3. Connect the driveshaft to the differential carrier yoke; see **Section 41.00, Subject 120**.
4. Install the brake spiders on the axle flanges. For instructions, see the applicable service brake section in **Group 42**.
5. Install the ABS sensors and connect the wiring at the frame rail. Secure the wiring with tie straps as needed.
6. Install the brake air chambers and slack adjusters on the axle housing brackets. For instructions, see **Group 42**.
7. Connect the air lines to the brake air chambers.
8. Install the brake shoes, as removed. For instructions, see the applicable service brake section in **Group 42**.
9. Fill each hub with approved axle oil until you can see a little amount of oil trickling out of the back of the hub (use about 0.8 quart, or 0.75 liter). Install the hubs on the axle spindles. For instructions, see **Section 35.02**.

NOTE: See **Table 1** for approved axle oils.

10. If DCDL is installed on the vehicle, connect the DCDL air line, fill the air system, and use the DCDL switch in the cab to engage the lock. An indicator light comes on when the differential lock is engaged.
11. Using new gaskets, install the axle shafts; see **Subject 120**.
12. Install the brake drums on the hubs.
13. Install the wheels and tires. For instructions, see **Group 40**.
14. Adjust the brakes. For instructions, see the applicable service brake section in **Group 42**.
15. Uncage the parking brake springs.
16. Using approved axle oil, fill the axle housing to the bottom of the fill hole, or until filled to capacity as shown in **Table 1**.
17. If the hubs are dry, raise one side of the vehicle about 4 inches (10 cm) to let the oil flow into the hub on the opposite side, then raise the other side in the same manner. On each side, hold the tilted position for three minutes to allow oil to run into the wheel end.

NOTICE

Make sure the hubs are filled. Driving with the hubs dry will cause bearing damage.

18. Turn the wheels, wait one minute, and check the lubricant level.
19. Raise the vehicle, remove the safety stands, then lower the vehicle.
20. If applicable, connect the suspension leveling valve(s). Start the engine, build the air pressure, and make sure the suspension air bags inflate correctly. Make sure the ride height is correct. For instructions, see **Group 32**.
21. Check the oil level in the axle housing. The level should be up to the bottom of the fill hole. Add approved axle oil, if needed.
22. Set the parking brake.

Single Rear Axle Oil Type and Capacity		
Approved Oil Type	Capacity: quarts (liters)	
	Hubs Full	Hubs Dry
80W-90 Gear Oil	10.6 (10.0)	12.2 (11.5)
75W-90 Synthetic Gear Oil		

Table 1, Single Rear Axle Oil Type and Capacity

Single or Rearmost Axle Differential Carrier Removal and Installation

When the wheel lock is removed, inspect the carrier for damage and replace it if damage is found. If no damage is found, install the carrier again.

Removal

NOTE: The differential carrier can be removed either with the rear axle installed on the vehicle, or with the rear axle removed from the vehicle.

Axle Installed on Vehicle

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires. Put the transmission in neutral.
2. If applicable, release the suspension air pressure.
3. Using suitable jacks, raise the vehicle evenly until there is room to fit a jack underneath the axle housing.
4. Remove the tires and wheels. For instructions, see **Group 40**.
5. Drain the oil from the axle housing.
6. Disconnect the driveshaft from the carrier yoke; see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
7. If DCDL is installed on the vehicle, use the DCDL switch in the cab to engage the lock. An indicator light comes on when the differential lock is engaged. Turn the appropriate wheels to ensure the lock is fully engaged.
8. Place a basin under the axle shaft flanges, then remove the axle shafts; see **Subject 120**.
9. Do the steps under the heading, "Axle Removed from Vehicle."

Axle Removed from Vehicle

1. Using a suitable jack, support the differential carrier. Chain the differential carrier to the jack.
2. If DCDL is installed on the vehicle, ensure the lock is engaged. Turn the appropriate wheels to verify it is fully engaged.

⚠ WARNING

The differential carrier is heavy. Do not try to move it without a suitable support. To do so could result in the carrier falling, which could cause serious personal injury and component damage. Support the carrier with a suitable jack and chain it to the jack, or use a hoist if the axle has been removed from the vehicle.

3. Remove the carrier capscrews that hold the differential carrier to the axle housing. See **Fig. 1**.
4. With the differential carrier securely supported, remove it from the axle housing.

Installation

IMPORTANT: If you replace the yoke on the differential carrier, use a **new** nut when installing the new yoke.

NOTE: Use a cleaning solvent and clean rags to remove dirt. Blow dry the cleaned areas with air.

1. Remove any old sealant material from the mating surfaces of the axle housing. Clean the inside of the rear axle housing and the forward carrier mating surface.
2. Inspect the axle housing for damage. Repair or replace the axle housing as necessary.
3. Apply a thin bead of Loctite® 5900 sealant all the way around the mating surface of the axle housing, and around each bolt hole.

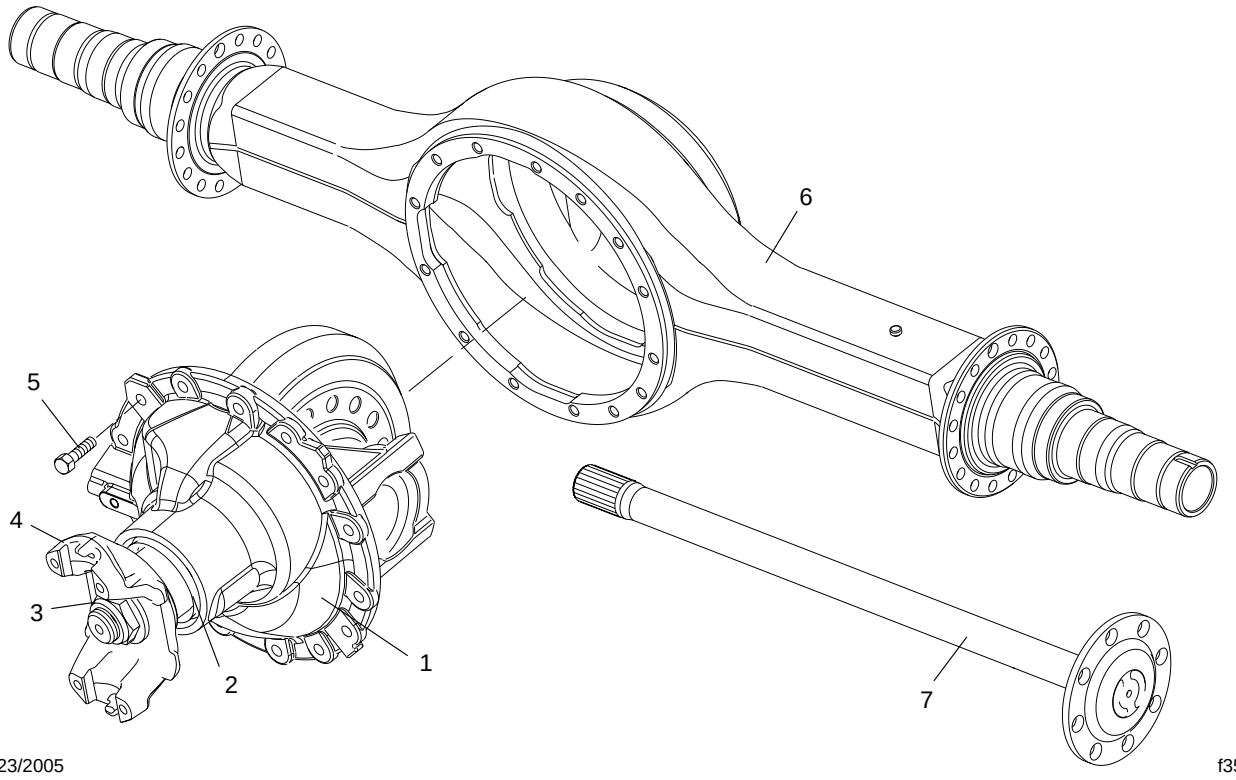
NOTE: Alignment dowels for installing the differential carrier can be made by sawing off the heads of two M16 x 1.5 x 100 mm bolts.

4. Install alignment dowels 180 degrees apart at the 3 o'clock and 9 o'clock positions on the axle housing flange.
5. If DCDL is installed on the vehicle, ensure it is engaged.

NOTICE

Make sure the differential carrier is centered and straight on the axle housing before you install the mounting capscrews. Attempting to install the carrier when it is not centered or straight may cause damage to the carrier.

Single or Rearmost Axle Differential Carrier Removal and Installation



1. Differential Carrier
2. Radial Shaft Seal
3. Yoke Nut
4. Carrier Yoke
5. Carrier Capscrew
6. Rear Axle Housing
7. Axle Shaft

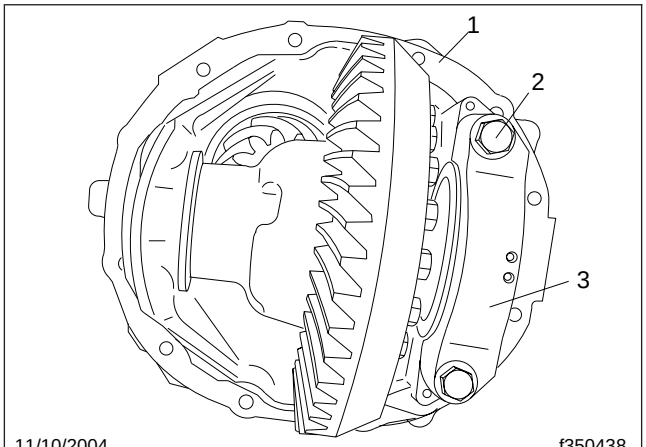
Fig. 1, Single or Rearmost Axle Components

6. Using a hoist (if the axle is removed from the vehicle) or a suitable transmission jack, install the differential carrier into the axle housing. Use the alignment dowels to center the carrier on the axle housing.
7. Install the end caps at the sides of the carrier into the corresponding slots in the axle housing. See **Fig. 2**.

   7.1 For the last 3/4 inch (19 mm) or so of travel, walk the carrier slowly into the housing.

   IMPORTANT: The end caps fit tightly into the axle housing. Be very careful not to cock the carrier.

   7.2 Install the carrier capscrews finger-tight. Make sure the carrier capscrews turn easily in the axle housing.



1. Differential Carrier
2. End Cap Bolt
3. End Cap

Fig. 2, Carrier End Caps

7.3 In a star pattern, gradually tighten the M16 carrier capscrews 200 lbf·ft (270 N·m).

8. If removed, install the axle on the vehicle; see **Subject 100**.

   If the axle is already on the vehicle, go to the next step.

9. Connect the driveshaft to the carrier yoke; see **Section 41.00, Subject 120**.
10. Using new gaskets, install the axle shafts; see **Subject 120**.
11. Install the wheels and tires; see **Group 40**.
12. Using approved axle oil, fill the axle housing to the bottom of the fill hole, or until filled to capacity as shown in **Table 1**.

Single Rear Axle Oil Type and Capacity		
Approved Oil Type	Capacity: quarts (liters)	
	Hubs Full	Hubs Dry
80W-90 Gear Oil	10.6 (10.0)	12.2 (11.5)
75W-90 Synthetic Gear Oil		

Table 1, Single Rear Axle Oil Type and Capacity

13. If the hubs are dry, raise one side of the vehicle about 4 inches (10 cm) to let the oil flow into the hub on the opposite side, then raise the other side in the same manner. On each side, hold the tilted position for three minutes to allow oil to run into the wheel end.

NOTICE

Make sure the hubs are filled. Driving with the hubs dry will cause bearing damage.

14. Turn the wheels, wait one minute, and check the lubricant level.
15. Raise the vehicle, remove the safety stands, then lower the vehicle.
16. Start the engine, build the air pressure, and check that the suspension air bags inflate evenly and correctly. Make sure the ride height is correct.
17. Check the oil level in the axle housing. The level should be up to the bottom of the fill hole. Add approved axle oil, if needed.

Removal

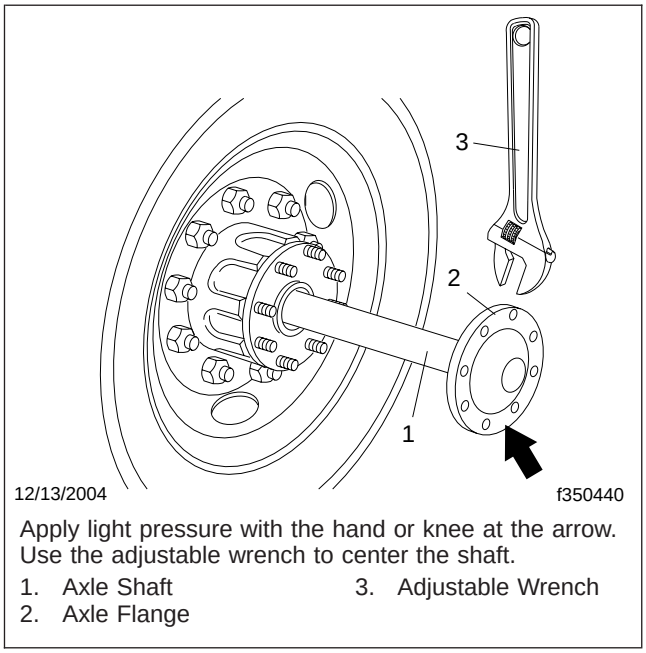
1. Chock the front tires.
2. If DCDL is installed on the vehicle, use the DCDL switch in the cab to engage the lock. An indicator light comes on when the differential lock is engaged. Turn the appropriate wheels to ensure the lock is fully engaged.
3. Raise the rear of the vehicle with a suitable jack high enough to clear the axle. Support the axle with jack stands.
4. Place a basin under the axle shaft flanges to catch any oil. Dispose of used oil properly.
5. If necessary, remove the tires. For procedures, see **Group 40**.

NOTE: This procedure can be done with the wheels and tires installed or with the wheels and tires removed.

6. Remove the drive axle stud nuts that attach the axle shaft to the wheel hub.
7. Tap the axle shaft flange if necessary to loosen it, and slide the axle shaft out of the axle. Remove and discard the gasket.

Installation

1. Position a new gasket on the axle shaft flange.
2. If DCDL is installed on the vehicle, ensure it is engaged.
3. Install the axle shaft, as follows. See **Fig. 1**.
   - 3.1 Carefully raise the axle with a floor jack, and support the axle with jack stands. Slide the axle shaft into the axle.
   - 3.2 Apply light pressure with the hand or knee to the axle flange.
   - 3.3 Use an adjustable wrench to center the shaft. Turn the shaft with a slight rotating motion.
   - 3.4 Install the drive axle stud nuts and tighten them to the values given.
     - 1/2–20 nuts: 75 to 115 lbf·ft (102 to 156 N·m)
     - 5/8–18 nuts: 150 to 170 lbf·ft (203 to 230 N·m)



Apply light pressure with the hand or knee at the arrow. Use the adjustable wrench to center the shaft.

1. Axle Shaft
2. Axle Flange
3. Adjustable Wrench

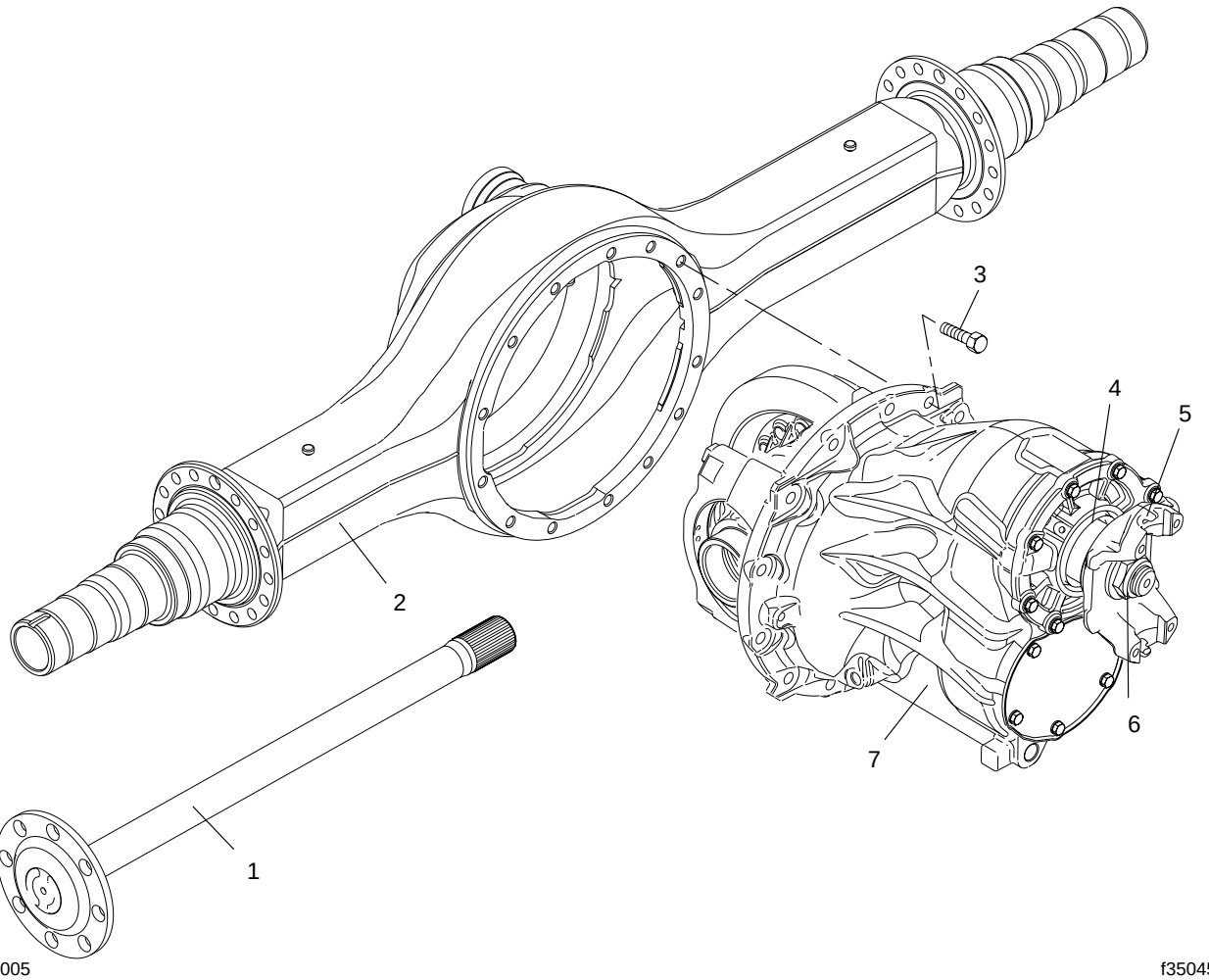
Fig. 1, Installing the Axle Shaft

4. If removed, install the tires and tighten the wheel nuts according to the procedures in **Group 40**.
5. Remove the supports and lower the vehicle.
6. As needed, replace any oil that was drained from the hub when the axle shaft was removed.

Removal

For forward-rear axle components of a tandem installation, see **Fig. 1**.

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the front tires. Put the transmission in neutral.
2. Using a suitable jack, raise the vehicle enough to take the weight off the axles, but not enough to raise the tires off the ground.
3. At both ends of the axle, loosen all the wheel nuts.



1. Axle Shaft
2. Forward-Rear Axle Housing
3. Carrier Capscrew
4. Input Seal
5. Carrier Yoke
6. Input Yoke Nut
7. Forward Differential Carrier

Fig. 1, Forward-Rear Axle Components

Forward-Rear Axle Removal and Installation

4. Using a suitable jack, continue to raise the vehicle evenly until there is room to fit a stand underneath the axle housing.

⚠ WARNING

Never work around or under a vehicle that is supported only by a jack. Always support the vehicle with safety stands. Jacks can slip, allowing the vehicle to fall, which could result in serious injury or death.

5. Support the vehicle with safety stands.
6. Remove the oil drain plug from the bottom of the axle housing and drain the oil from the axle housing. Install the drain plug after emptying.
7. Remove the wheels and tires. For instructions, see **Group 40**.
8. Release the parking brakes.
9. If necessary, back off the slack adjusters, then remove the brake drums.
10. If installed, make sure the optional DCDL (main differential lock) has been shifted into the engaged (locked) position.
11. If not done previously, disconnect the air lines at the interaxle lock and (if installed) the wheel lock.
12. Disconnect the main driveshaft from the forward differential carrier. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
13. Disconnect the interaxle driveshaft from the output yoke of the forward-rear axle and the input yoke of the rearmost axle. For instructions, see **Section 41.00, Subject 120**.
14. Cage the parking brake springs to prevent the parking brakes from engaging. For instructions, see **Group 42**.
15. Drain the air system.
16. Place a basin under the axle shaft flanges to catch any oil; then remove the axle shafts. For instructions, see **Subject 120**.
17. Remove the hubs from the axle spindles; see **Section 35.02**.
18. Remove the brake shoes. For instructions, see the applicable service brake section in **Group 42**.
19. Remove the ABS sensors and wiring, and the fasteners that hold the brake spiders to the axle flanges. Remove the spiders from the axle.
20. If applicable, disconnect the leveling valve rod(s) from the suspension.
21. At the frame rail or crossmember, disconnect the wiring for the ABS sensors. Remove any tie straps that hold the wires to the frame rails.
22. Disconnect the air lines from the rear brake chambers.
23. Remove the brake air chambers and the slack adjusters from the axle housing. For instructions, see **Group 42**.
24. Using a suitable jack, support the axle housing.
25. If applicable, remove the hexnuts that hold the bottom of each suspension air bag to its suspension bracket.
26. Remove the suspension components that attach the axle to the vehicle. If applicable, remove the U-bolt nuts from the U-bolts. Discard the U-bolt nuts and U-bolts.
27. Lower the axle enough to clear the suspension components.
28. Remove the axle from the vehicle.
29. If you are going to replace the differential carrier, place the axle on a secure axle stand.

Installation

1. Position the axle underneath the vehicle.
2. Install the suspension components that attach the axle to the vehicle, as follows.

   NOTE: U-bolts and U-bolt nuts cannot be reused.

   2.1 On vehicles with conventional suspensions, install the upper U-bolt brackets, new U-bolts, lower U-bolt brackets, and new U-bolt nuts.

   On vehicles with air suspensions, in addition to the U-bolts, install the hexnuts that attach the air springs to the suspension brackets. For torque values, see **Group 32**.

On vehicles without U-bolts, install the walking beams.

2.2 If applicable, tighten the new U-bolt nuts in a diagonal pattern. For torque values, see **Group 32**.

3. Connect the interaxle driveshaft to the output yoke of the forward carrier and the input yoke of the rear carrier. For instructions, see **Section 41.00, Subject 120**.
4. Install the brake spiders on the axle flanges. For instructions, see the applicable service brake section in **Group 42**.
5. Install the ABS sensors and connect the wiring at the frame rail. Secure the wiring with tie straps as needed.
6. Install the brake air chambers and slack adjusters on the axle housing brackets. For instructions, see **Group 42**.
7. Connect the air lines to the brake air chambers.
8. Install the brake shoes, as removed. For instructions, see the applicable service brake section in **Group 42**.
9. Using new gaskets, install the axle shafts; see **Subject 120**.
10. Connect the main driveshaft to the forward input yoke. For instructions, see **Section 41.00, Subject 120**.
11. Connect the air hoses to the air cylinder for the interaxle lock and (if installed) the wheel lock.
12. Connect the electrical connector of the sensor unit for axles equipped with a wheel lock.
13. Fill each hub with approved axle oil until you can see a little amount of oil trickling out of the back of the hub (use about 0.8 quart, or 0.75 liter). Install the hubs on the axle spindles, and adjust the wheel bearings. For instructions, see the applicable subject in **Section 35.02**. See **Table 1** for approved axle oils.
14. Install the brake drums on the hubs.
15. Install the wheels and tires. For instructions, see **Group 40**.
16. Adjust the brakes. For instructions, see the applicable service brake section in **Group 42**.
17. Uncage the parking brake springs.
18. Using approved axle oil, fill the forward-rear axle housing to the bottom of the fill hole, or until filled to capacity as shown in **Table 1**.

Forward-Rear Axle Oil Type and Capacity		
Approved Oil Type	**Capacity: quarts (liters)**	
	Hubs Full	**Hubs Dry**
80W-90 Gear Oil	14.3 (13.5)	15.9 (15.0)
75W-90 Synthetic Gear Oil		

Table 1, Forward-Rear Axle Oil Type and Capacity

19. Raise one side of the vehicle about 8 inches (20 cm) to let the oil flow into the hub on the opposite side, then raise the other side in the same manner. On each side, hold the tilted position for three minutes to allow oil to run into the wheel end.

NOTICE

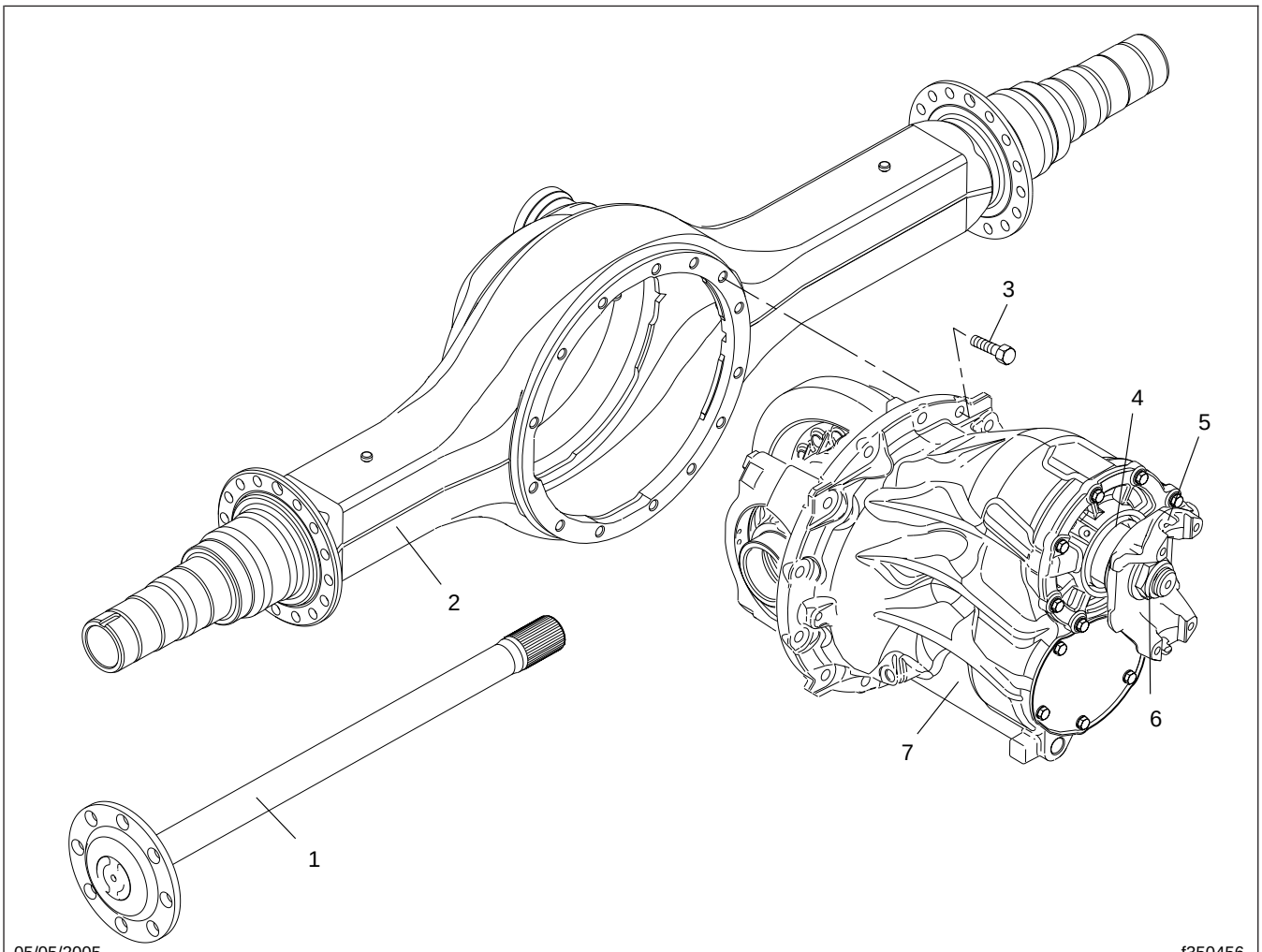
Make sure the hubs are filled. Driving with the hubs dry will cause bearing damage.

20. Turn the wheels, wait one minute, and check the lubricant level.
21. Raise the vehicle, remove the safety stands, then lower the vehicle.
22. If applicable, connect the suspension leveling valve(s). Start the engine, build the air pressure, and make sure the suspension air bags inflate correctly. Make sure the ride height is correct. For instructions, see **Group 32**.
23. Check the operation of the wheel lock, if installed.
24. Check the oil level in the axle housing. The level should be up to the bottom of the fill hole. Add approved axle oil, if needed.
25. Set the parking brake.

Forward-Rear Axle Differential Carrier Removal and Installation

For forward-rear axle components of a tandem installation, see **Fig. 1**.

Forward-Rear Axle Differential Carrier



1. Axle Shaft
2. Forward-Rear Axle Housing
3. Carrier Capscrew
4. Input Seal
5. Carrier Yoke
6. Input Yoke Nut
7. Forward Differential Carrier

Fig. 1, Forward-Rear Axle Components

Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the front tires. Put the transmission in neutral.
2. If applicable, release the suspension air pressure.

Forward-Rear Axle Differential Carrier Removal and Installation

3. Using suitable jacks, raise the vehicle evenly until there is room to fit a jack underneath the axle housing.
4. Remove the tires and wheels. For instructions, see **Group 40**.
5. Remove the oil drain plug from the bottom of the axle housing and drain the oil from the axle housing. Install the drain plug after emptying.
6. Disconnect the driveshaft from the carrier yoke; see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
7. Place a basin under the axle shaft flanges to catch any oil; then remove the axle shafts. For instructions, see **Subject 120**.
8. Using a suitable jack, support the differential carrier. Chain the differential carrier to the jack.

NOTICE

When using a pry bar, be careful not to damage the carrier or housing flange. Damage to these surfaces will cause oil leaks.

9. Remove the differential carrier from the axle housing, as follows.
   - 9.1 Remove all but the top two carrier capscrews.
   - 9.2 Loosen and back off, but do not remove, the top two carrier capscrews. The capscrews will hold the carrier in the housing.
   - 9.3 Using a pry bar, separate the mating surfaces of the differential carrier and axle housing.

   NOTE: Use a pry bar that has a round end to help separate the carrier from the housing.

   - 9.4 When the surfaces are separated, remove the top two capscrews.
   - 9.5 With the carrier on the jack, slide the carrier away from the axle housing.

WARNING

The differential carrier is heavy. Do not try to move it without a suitable support. To do so could result in the carrier falling, which could cause serious personal injury and component damage. Support the carrier with a suitable jack and chain it to the jack, or use a hoist if the axle has been removed from the vehicle.

   - 9.6 Lift the carrier assembly onto a suitable stand.

Installation

NOTE: Use a cleaning solvent and clean rags to remove dirt. Blow dry the cleaned areas with air.

1. Remove any old sealant material from the mating surfaces of the axle housing. Clean the inside of the axle housing and the carrier mating surface.
2. Inspect the axle housing for damage. Repair or replace the axle housing as necessary.
3. Apply a thin bead of Loctite® 5900 sealant all the way around the mating surface of the axle housing, and around each bolt hole.

NOTE: Alignment dowels for installing the differential carrier can be made by sawing off the heads of two M16 x 1.5 x 100 mm bolts.

4. Install alignment dowels 180 degrees apart at the 3 o'clock and 9 o'clock positions on the axle housing flange.
5. Position the forward differential carrier in front of the axle housing, using an axle jack or other suitable lifting tool.

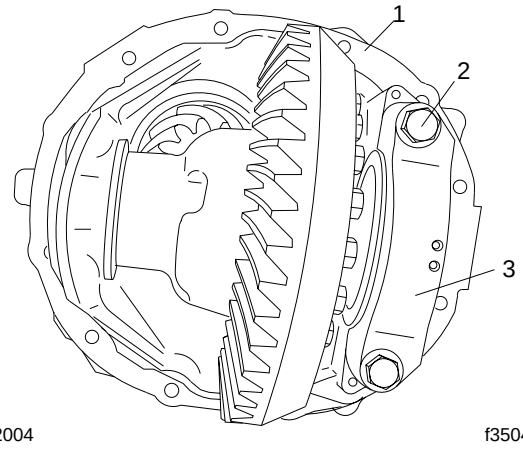
NOTICE

Do not use a hammer or a mallet to install the differential carrier. A hammer or a mallet will damage the mounting flange of the carrier and cause oil leaks.

6. Install the end caps at the sides of the forward differential carrier into the corresponding slots in the axle housing. See **Fig. 2**.
   - 6.1 For the last 3/4 inch (19 mm) or so of travel, walk the carrier slowly into the housing.

   IMPORTANT: The end caps fit tightly into the axle housing. Be very careful not to cock the carrier.

Forward-Rear Axle Differential Carrier Removal and Installation



1. Differential Carrier
2. End Cap Bolt
3. End Cap

Fig. 2, Carrier End Caps

6.2 Install the forward carrier capscrews finger-tight. Make sure the carrier capscrews turn easily in the axle housing.

6.3 In a star pattern, gradually tighten the M16 forward carrier capscrews 200 lbf·ft (270 N·m).

7. Connect the driveshaft to the carrier yoke; for instructions, see **Section 41.00, Subject 120**.
8. Using new gaskets, install the axle shafts; for instructions, see **Subject 120**.
9. Install the wheels and tires; for instructions, see **Group 40**.
10. Using approved axle oil, fill the axle housing to the bottom of the fill hole, or until filled to capacity as shown in **Table 1**.

Forward-Rear Axle Oil Type and Capacity		
Approved Oil Type	Capacity: quarts (liters)	
	Hubs Full	Hubs Dry
80W-90 Gear Oil	14.3 (13.5)	15.9 (15.0)
75W-90 Synthetic Gear Oil		

Table 1, Forward-Rear Axle Oil Type and Capacity

11. If the hubs are dry, raise one side of the vehicle about 4 inches (10 cm) to let the oil flow into the hub on the opposite side, then raise the other side in the same manner. On each side, hold the tilted position for three minutes to allow oil to run into the wheel end.

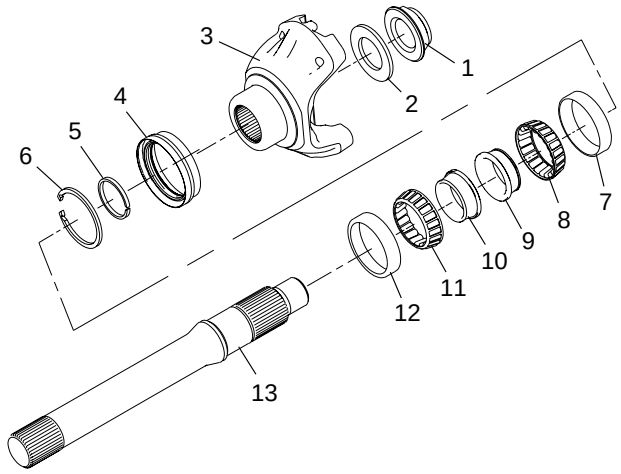
NOTICE

Make sure the hubs are filled. Driving with the hubs dry will cause bearing damage.

12. Turn the wheels, wait one minute, and check the lubricant level.
13. Raise the vehicle, remove the safety stands, then lower the vehicle.
14. Start the engine, build the air pressure, and check that the suspension air bags inflate evenly and correctly. Make sure the ride height is correct.
15. Check the oil level in the axle housing. The level should be up to the bottom of the fill hole. Add approved axle oil, if needed.

Repair

1. Remove the output yoke nut, washer, and output yoke; see **Subject 170**.
2. Remove the output oil seal from the thru-shaft bore; see **Subject 170**.
3. Remove the snap ring and spacer from the thru-shaft. See **Fig. 1**.



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1. Output Yoke Nut
2. Washer
3. Output Yoke
4. Output Oil Seal
5. Spacer
6. Snap Ring
7. Outer Bearing Race
8. Outer Bearing
9. Outer Bearing Cup
10. Inner Bearing Cup
11. Inner Bearing
12. Inner Bearing Race
13. Thru-Shaft

Fig. 1, Thru-Shaft Components

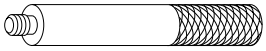
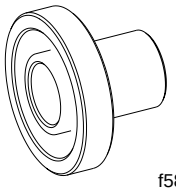
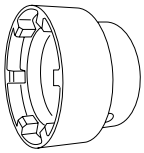
4. Using a suitable shaft puller, draw the thru-shaft out of the bore.
5. Using a suitable bearing puller on the outer races, remove both the inner and outer bearings from the thru-shaft.
6. Inspect the bearings for wear and damage. Replace both bearings if any damage is found.
7. Install the inner bearing race in the thru-shaft bore.
8. Using an arbor press or other suitable pressing tool, press the bearings and bearing cups onto the thru-shaft.
9. Insert the thru-shaft into its bore.
10. Install the outer bearing race onto the thru-shaft and bore.
11. Install the snap ring and spacer. Use the next thicker snap ring from the snap ring pack supplied with the bearings.
12. Install the output oil seal; see **Subject 170**.
13. Install the output yoke, nut, and washer; see **Subject 170**. Make sure the output yoke nut is firmly tightened, but do not tighten the nut to specifications at this time.
14. Attach a dial indicator to the flat surface of the output yoke.
15. Using a pry bar or other lever, apply force to the base of the output yoke. If the dial indicator shows a deflection of 0.0012 to 0.0024 inches (0.03 to 0.06 mm), the end play is correct.

    If the deflection is too large, use a thicker snap ring. If the deflection is too small, use a thinner snap ring.
16. Coat the threads of the nut with Loctite® 577. Tighten the output yoke nut 516 lbf·ft (700 N·m).

Single or Rearmost Axle Yoke and Seal Replacement

Special Tools

Special tools are required for this procedure. See **Table 1**.

Special Tools			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580400	Universal Handle*	Kent-Moore	J-8092
 f580406	Rear Pinion Seal Installer*	Kent-Moore	J-47354
 f580450	Yoke Nut Socket†	Daimler	MBA 742589020700

* To order Kent-Moore tools call 1-800-328-6657.

† The yoke nut socket is needed to remove the round, slotted yoke nut installed on some vehicles. It can be ordered through Paragon.

Table 1, Special Tools

Replacement

1. Disconnect the driveshaft from the differential carrier. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
2. Remove the yoke nut from the center of the carrier yoke. If the yoke nut is round and slotted, use the yoke nut socket shown in **Table 1**. See **Fig. 1**. Be careful not to damage the seal bore.
3. Remove the carrier yoke from the input shaft.
4. Pry up the seal, using a prybar or large screwdriver. Clean any old sealant from the axle housing. Do not allow dirt or grease to contaminate the seal bore or shaft bearings. See **Fig. 2**.
5. Install the rear pinion seal on the rear input shaft, as follows. See **Fig. 3**.
   - 5.1 Inspect the area around the seal for damage. Use emery paper to remove scratches, nicks, or burrs on the seal bore.
   - 5.2 Assemble the rear pinion seal installer onto the threaded end of the universal handle. See **Table 1**.

   IMPORTANT: Be careful not to cock the seal during installation.

   - 5.3 Using the rear pinion seal installer assembly, press the seal into the bore until the seal surface is flush with the bottom surface of the counterbore.

Single or Rearmost Axle Yoke and Seal Replacement

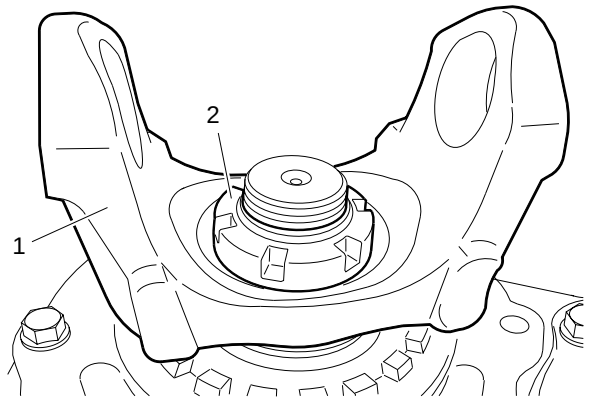
6. Install the carrier yoke on the input shaft. If the yoke is damaged or worn, install a new yoke.

NOTE: It is not necessary to replace the yoke when replacing the seal.

7. Install a new M45 x 1.5 yoke nut on the carrier yoke and tighten 627 lbf·ft (850 N·m).
8. Punch in the cylindrical area at the pinion groove to lock the nut in place.

IMPORTANT: The bent area has to reach the bottom of the pinion groove.

9. Connect the driveshaft. For instructions, see **Section 41.00, Subject 120**.



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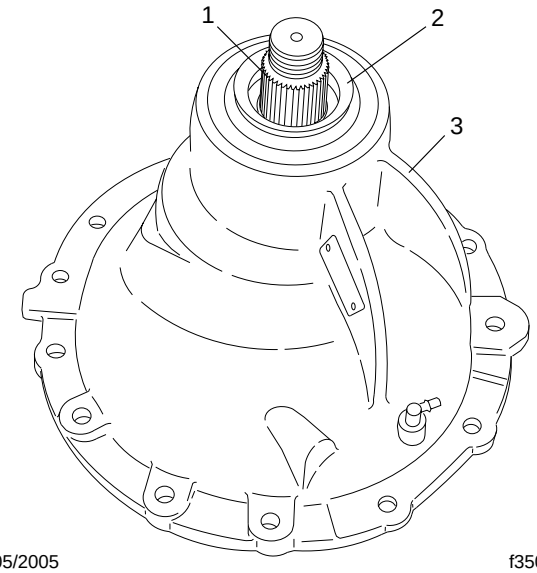
NOTE: The yoke nut may be a hexnut rather than the round, slotted nut shown here.

1. Yoke
2. Yoke Nut

Fig. 1, Yoke Nut on the Carrier



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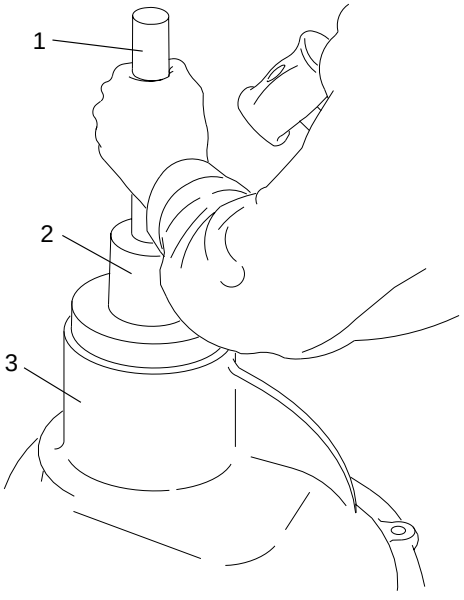
1. Input Shaft
2. Rear Pinion Seal
3. Carrier Housing

Fig. 2, Rear Pinion Seal



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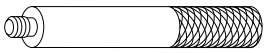
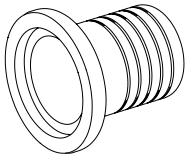
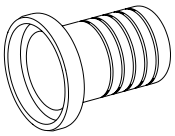
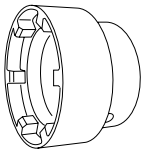
1. Universal Handle
2. Rear Pinion Seal Installer
3. Carrier Housing

Fig. 3, Installing the Rear Pinion Seal

Special Tools

Special tools are required for this procedure. See **Table 1**.

Special Tools for Forward-Rear Axle Yoke and Seal Replacement			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580400	Universal Handle*	Kent-Moore	J-8092
 f580410	Input Seal Installer*	Kent-Moore	J-47369
 f580408	Output Seal Installer*	Kent-Moore	J-47368
 f580450	Yoke Nut Socket†	Daimler	MBA 742589020700

* To order Kent-Moore tools call 1-800-328-6657.

† The yoke nut socket is needed to remove the round, slotted yoke nut installed on some vehicles. It can be ordered through Paragon.

Table 1, Special Tools for Forward-Rear Axle Yoke and Seal Replacement

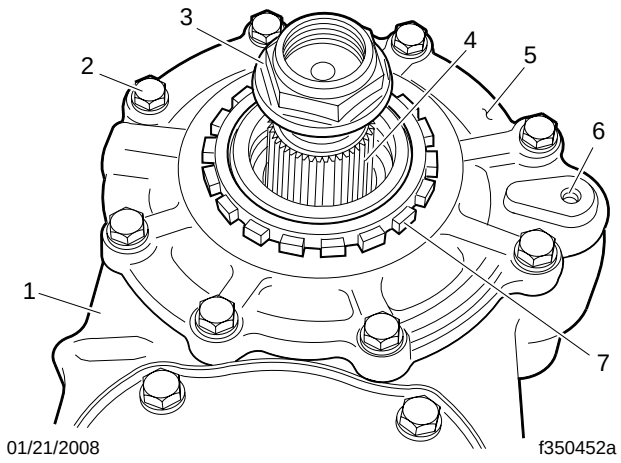
Replacement

Forward Carrier Input Yoke and Seal

1. Disconnect the main driveshaft from the forward carrier input yoke. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
2. Remove the input yoke nut and washer from the center of the forward carrier input yoke.
3. Remove the old forward carrier input yoke from the forward input shaft.
4. If there is an oil leak at the threaded ring, repair it; for instructions, see **Subject 200**.

Forward-Rear Axle Yoke and Seal Replacement

5. If there is a leak between the bearing cage and the carrier housing, remove the bearing cage, as follows. See **Fig. 1**.



1. Forward Carrier Housing
2. Bearing Cage Mounting Capscrew
3. Input Yoke Nut
4. Input Shaft
5. Bearing Cage
6. Interaxle Lock Bore
7. Threaded Ring

Fig. 1, Bearing Cage

5.1 Remove the bearing cage capscrews from the bearing cage.

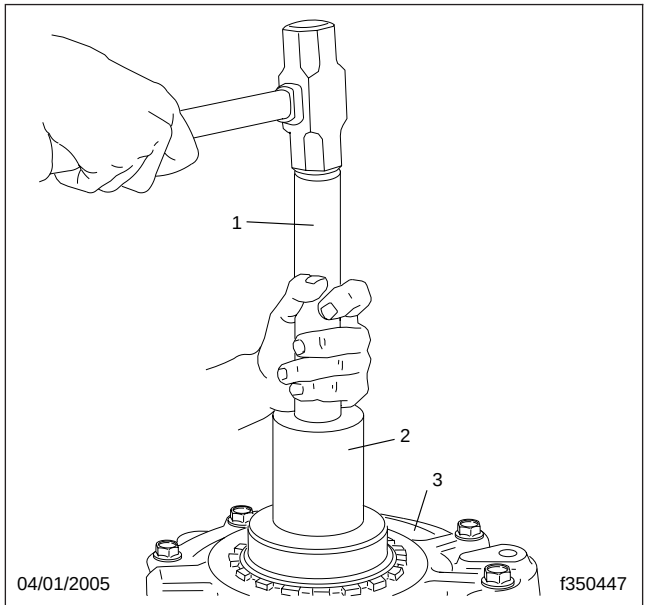
5.2 Pry the bearing cage from the forward carrier housing. Clean any remnants of sealant clinging to the mating surfaces of the carrier housing and the bearing cage.

6. Pry up the input seal, using a prybar or large screwdriver. Clean any old sealant from the axle housing. Do not allow dirt or grease to contaminate the seal bore or shaft bearings.

7. Install the seal in the input shaft bore, as follows. See **Fig. 2**.

7.1 Inspect the area around the seal for damage. Use emery paper to remove scratches, nicks, or burrs on the seal bore.

7.2 Assemble the input seal installer onto the threaded end of the universal handle. See **Table 1**.



1. Universal Handle
2. Input Seal Installer
3. Carrier Housing

Fig. 2, Installing the Forward Carrier Input Seal

7.3 Using the input seal installer assembly, press the seal into the bore until the seal surface is flush with the threaded ring.

8. On the mating surface of the bearing cage, lay down a bead of Loctite® 5900 sealant, or equivalent. Go around all of the bolt holes and other openings in the inside cover of the bearing cage. See **Fig. 3**.

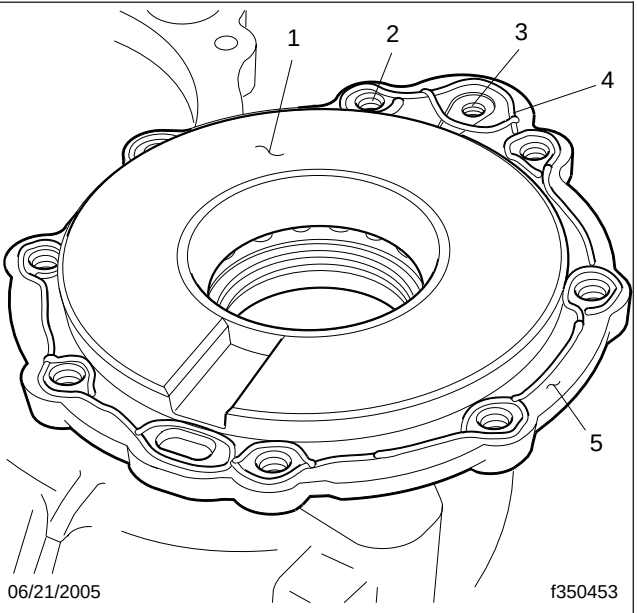
IMPORTANT: Do not allow sealant to get into the interaxle lock bore. See **Fig. 4**. Do not attempt to repair the interaxle differential lock (IAD). No repairs to this component are possible.

9. Install the bearing cage onto the forward carrier housing. Tighten the M12 bearing cage capscrews 107 lbf·ft (145 N·m).

10. Install the forward carrier input yoke on the forward input shaft. If the yoke is damaged or worn, install a new yoke.

NOTE: It is not necessary to replace the yoke when replacing the seal.

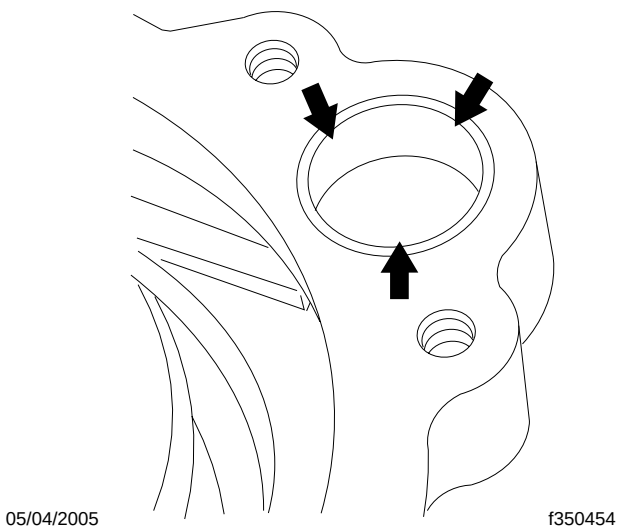
11. Coat the threads of a new M45 x 1.5 input yoke nut with Loctite® 277. Install the new washer and



Apply a bead of sealant to the inner mating surface as shown.

1. Inside Cover
2. Mounting Capscrew Hole
3. Interaxle Lock Bore
4. Sealant
5. Mating Surface

Fig. 3, Sealant Application



Keep sealant away from this bore.

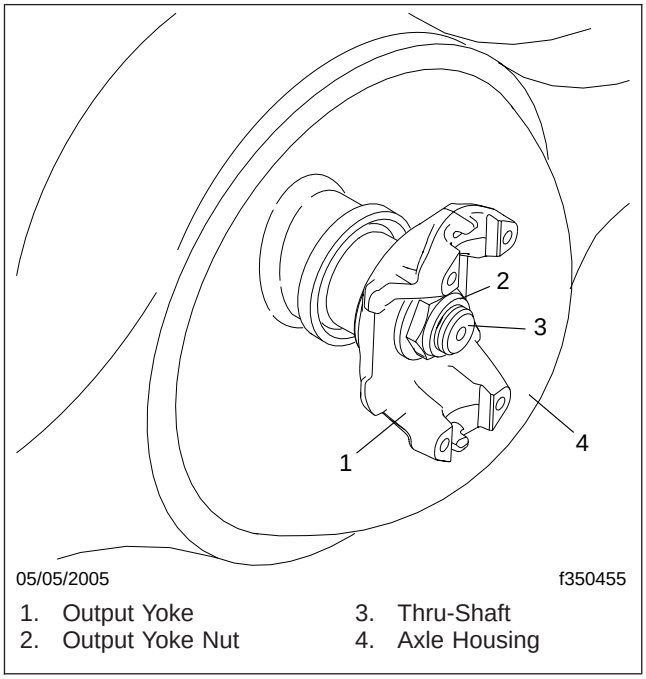
Fig. 4, Interaxle Lock Bore

input yoke nut on the forward carrier input yoke. Tighten the nut 627 lbf·ft (850 N·m).

12. Connect the main driveshaft; see **Section 41.00, Subject 120**.

Output Yoke and Seal

1. Disconnect the interaxle driveshaft from the output yoke; see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
2. Remove the output yoke nut and washer from the center of the output yoke.
3. Remove the output yoke from the thru-shaft. See **Fig. 5**.



1. Output Yoke
2. Output Yoke Nut
3. Thru-Shaft
4. Axle Housing

Fig. 5, Output Yoke

4. Pry up the output oil seal, using a prybar or large screwdriver. Clean any old sealant from the axle housing. Do not allow dirt or grease to contaminate the seal bore or thru-shaft bearings.
5. Install the seal on the thru-shaft, as follows.

   5.1 Inspect the area around the output oil seal for damage. Use emery paper to remove scratches, nicks, or burrs on the seal bore.

Forward-Rear Axle Yoke and Seal Replacement

5.2 Assemble the output seal installer onto the threaded end of the universal handle. See **Table 1**.

5.3 Using the output seal installer assembly, press the seal into the bore until the seal surface is flush with the thru-shaft receptacle.

6. Install the output yoke on the thru-shaft. If the yoke is damaged or worn, install a new yoke.

NOTE: It is not necessary to replace the yoke when replacing the seal.

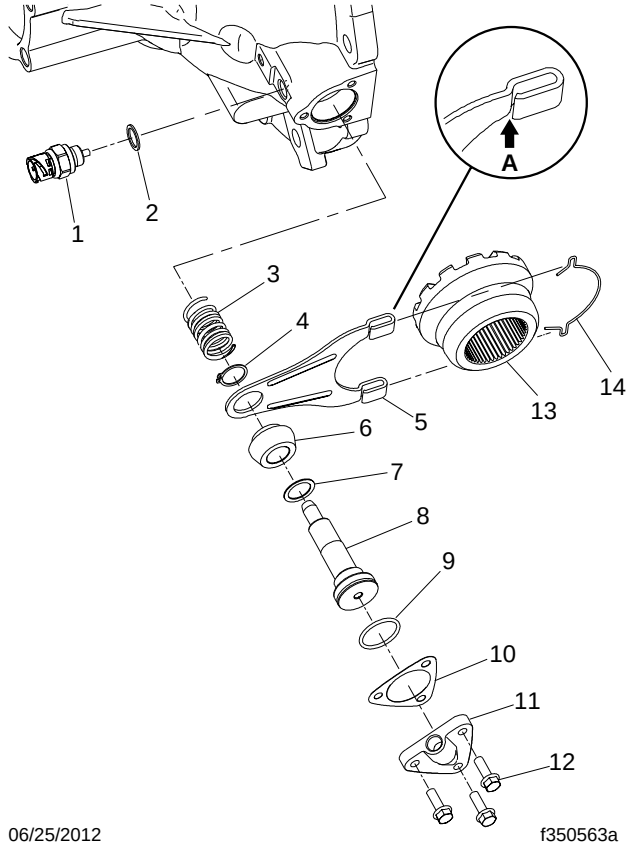
7. Coat the threads of a new M39 x 1.5 output yoke nut with Loctite® 577. Install the new washer and output yoke nut on the forward carrier output yoke. Tighten the nut 516 lbf·ft (700 N·m).
8. Connect the interaxle driveshaft; see **Section 41.00, Subject 120**.

Main Differential Lock Disassembly and Assembly

General Information

Commonly known as DCDL (Driver-Controlled Differential Lock), a main differential lock is available on single and tandem rear axles. On tandem rear axles DCDL is available for the forward, rear, or both axles. The following procedures only apply to Model 4 rear axles with optional DCDL.

Each part of the main differential lock is replaceable. See **Fig. 1**.



A. Opening in fork loop faces away from the clutch collar as shown.

1. Sending Unit
2. Sending Unit Seal
3. Spring
4. Snap Ring
5. Shift Fork
6. Alignment Boss
7. Shim(s)
8. Shift Shaft Piston
9. O-Ring
10. Air Interface Gasket
11. Air Interface
12. Capscrew
13. Clutch Collar
14. Retaining Clip

Fig. 1, DCDL Components

Disassembly

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the front tires.
2. Remove the differential carrier, and place it on a work stand.

   To remove a single or rearmost axle differential carrier, see **Subject 110**.

   To remove a forward-rear differential carrier, see **Subject 140**.
3. Unlatch the retaining clip, and remove it. See **Fig. 1**.
4. Remove the clutch collar.
5. Remove the DCDL sending unit from the carrier housing.
6. Remove the three bolts that attach the air interface to the carrier housing.
7. Remove the air interface and gasket.
8. Remove the shift shaft piston from the bore in the carrier housing, and note the number of shims found on the piston. There should be at least one shim, and a maximum of three.
9. Compress the spring and pull the shift fork from the carrier housing.
10. Remove the spring from the carrier housing.

Assembly

1. Install the spring in the carrier housing, and compress it to install the shift fork in the housing. Ensure that the spring is centered in the bore.
2. Ensure the O-ring on the shift shaft piston is properly installed and lubricated. Then install the piston, being careful to properly align it in the bore. Do not force the piston into the bore.
3. Place the air interface and gasket over the air interface bore, and insert the three capscrews that attach the air interface to the carrier housing. Tighten the capscrews in a regular sequence that ensures it seats evenly. Tighten the capscrews 19 lbf·ft (25 N·m).
4. Install the clutch collar.
5. Install the retaining clip on the shift fork.

Main Differential Lock Disassembly and Assembly

6. Install the DCDL sending unit in the carrier housing, as removed.
7. Connect the DCDL air line, and engage the DCDL. Ensure the teeth of the lock fully engage the teeth of the gear inside the carrier housing.
8. The clearance between the clutch collar and ring gear must be between 0.4 and 1.4 mm. Engage the DCDL, and use a feeler gauge to measure the gap.

   If the gap between the clutch collar and ring gear measured between 0.4 and 1.4 mm, ensure the same number of shims are on the shift shaft piston (as when it was removed).

   If the gap between the clutch collar and ring gear was not between 0.4 and 1.4 mm, add or remove shims to vary the gap until it measures within the acceptable range. The acceptable maximum number of shims is three, and the minimum is one.
9. Install the differential carrier.

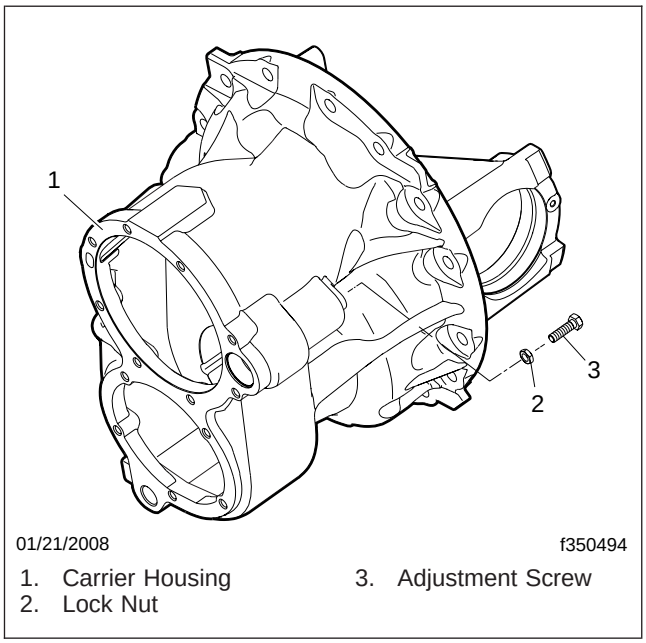
   For instructions on installing a single or rearmost axle differential carrier, see **Subject 110**.

   For instructions on installing a forward-rear axle differential carrier, see **Subject 140**.

Adjustment

The Interaxle Differential (IAD) has an adjustment screw that can become loose or even fall out, causing an oil leak, and malfunction of the IAD. To ensure the adjustment screw is properly tightened and secured, follow the steps below. The IAD is sometimes called the power divider. See **Fig. 1**.

1. Chock the front tires.
2. Use the IAD switch in the cab to engage the lock.
3. At the forward-rear axle, rotate one of the wheels to ensure the teeth of the lock fully engage the teeth of the gear inside the carrier housing.
4. Remove the adjustment screw, and using a suitable solvent (such as brake cleaner), clean the threads of the screw and bore. Dry the surfaces completely, making sure no cleaning solvent remains.
5. Coat the threads of the adjustment screw with Loctite® 577, install it, and hand-tighten it until it hits the shaft.
6. Disengage the IAD to relieve the air pressure exerted on the adjustment screw.
7. Hand-tighten the adjustment screw one quarter turn, then tighten the locknut 30 lbf·ft (41 N·m).

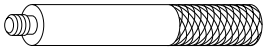
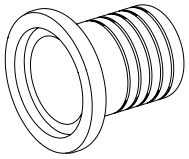


1. Carrier Housing
2. Lock Nut
3. Adjustment Screw

Fig. 1, Interaxle Differential and Adjustment Screw

Special Tools

Special tools are required for this procedure. See **Table 1**.

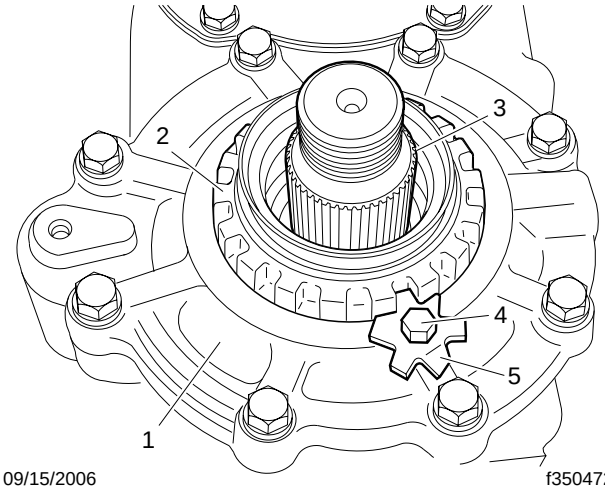
Special Tools for Threaded Ring Repair			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580400	Universal Handle*	Kent-Moore	J-8092
 f580410	Input Seal Installer*	Kent-Moore	J-47369

* To order Kent-Moore tools call 1-800-328-6657.

Table 1, Special Tools for Threaded Ring Repair

Repair

1. Apply the parking brakes, shut down the engine, and chock the tires.
2. Disconnect the main driveshaft from the forward carrier input yoke. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
3. Remove the yoke nut and washer from the input shaft of the forward differential carrier, then remove the yoke.
4. Remove the capscrew and the locking plate from the bearing cage on the front of the differential carrier. See **Fig. 1**.
5. Using a spanner wrench, remove the threaded ring to expose the bearing cavity. See **Fig. 2**.
6. Using a suitable solvent, such as brake cleaner, clean the surface of the bearing cavity. See **Fig. 2**. Dry the surface, making sure no cleaning solvent remains.
7. Coat the threads of the threaded ring with Loctite® 577 sealant. Apply a 1/8-inch (3-mm) diameter bead all the way around the bottom thread, then spread the sealant evenly over the threads, so that all threads are thoroughly covered with the sealant.



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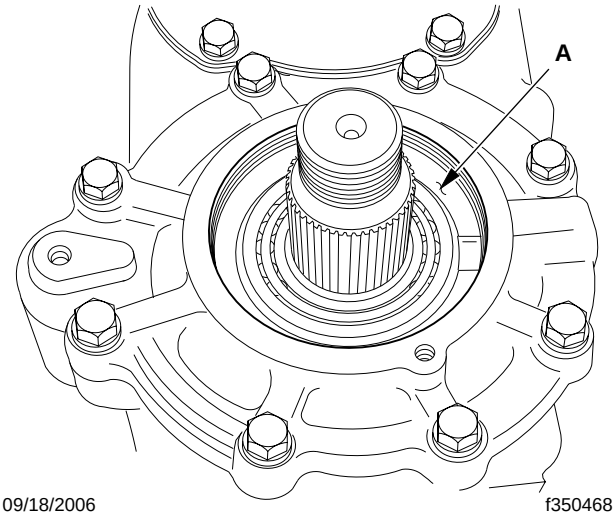
1. Bearing Cage
2. Threaded Ring
3. Input Shaft (yoke removed)
4. Capscrew
5. Locking Plate

Fig. 1, Forward-Rear Axle Differential Housing

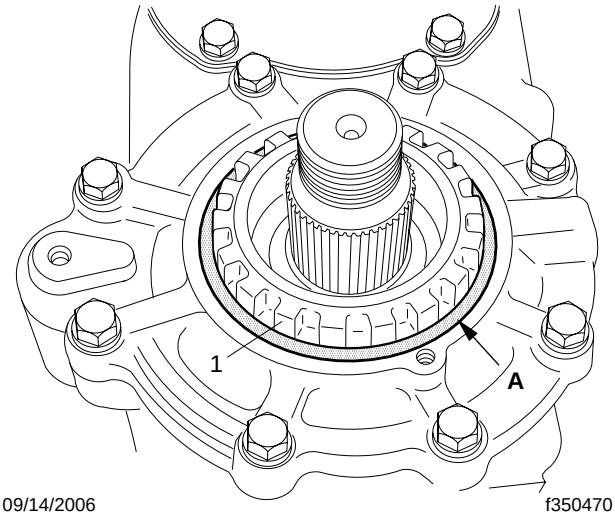
Threaded Ring Repair



A. Clean and dry this entire surface.

Fig. 2, Bearing Cavity Exposed

8. Install the threaded ring (without the new input-shaft seal) and turn it clockwise (tighten it) enough to form a uniform bead of sealant all the way around the threaded ring. See **Fig. 3**.

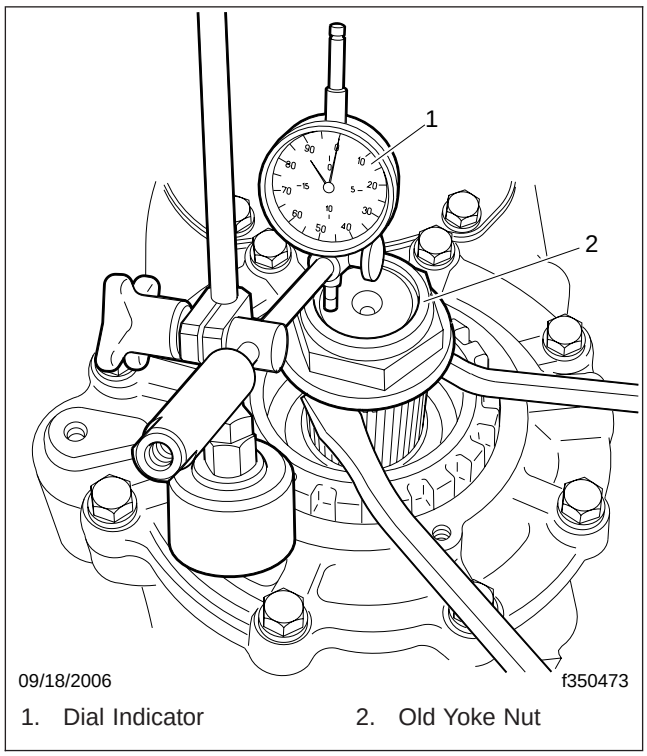


A. Loctite Bead from the Threads

1. Threaded Ring

Fig. 3, Preliminary Installation of the New Threaded Ring

9. Install the old yoke nut on the input shaft to protect the threads, then strike the nut sharply with a brass mallet to unseat the bearing.
10. Adjust the initial bearing preload to 0.002 inch (0.05 mm), as follows:
    10.1 Install a dial indicator on the bearing cage, and using two pry bars, pry up evenly on the yoke nut (and the input shaft) to determine the bearing preload. See **Fig. 4**.



1. Dial Indicator
2. Old Yoke Nut

Fig. 4, Measuring Bearing Preload

    10.2 Tighten the threaded ring until the dial indicator reads 0.002 inch (0.05 mm).
11. Using a suitable marker or paint, mark the center of one of the teeth on the threaded ring and the surface of the bearing cage. See **Fig. 5**.

IMPORTANT: The next step is critical. Tightening the threaded ring by advancing it one tooth will set the bearing preload to 0.00 to 0.0012 inch (0.00 to 0.03 mm). If you tighten the threaded ring beyond this tolerance, you cannot back it off; you will need to remove the threaded ring and repeat the entire installation procedure.

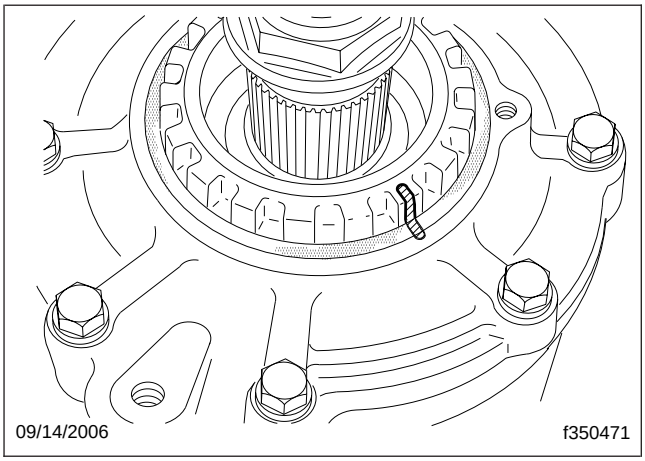


Fig. 5, Marking the Tooth and Bearing Cage

12. Very carefully advance the threaded ring one tooth while checking the paint mark. Stay close to a one-tooth advancement when making the final adjustment. Bear in mind that the new locking plate must fit into place once the correct tightness is achieved. The locking tab should fit in place either slightly before or slightly past a one-tooth advancement of the threaded ring. *You cannot back off the threaded ring once it is tightened.*

    Try fitting the new locking plate in place by turning and flipping it over as you slowly tighten the threaded ring. Tighten the threaded ring so the bearing preload is 0.00 to 0.0012 inch (0.00 to 0.03 mm). When the correct tolerance is reached, the mark on the surface of the bearing cage should line up with the center of the next tooth. See **Fig. 6**. Do not tighten the threaded ring any further.

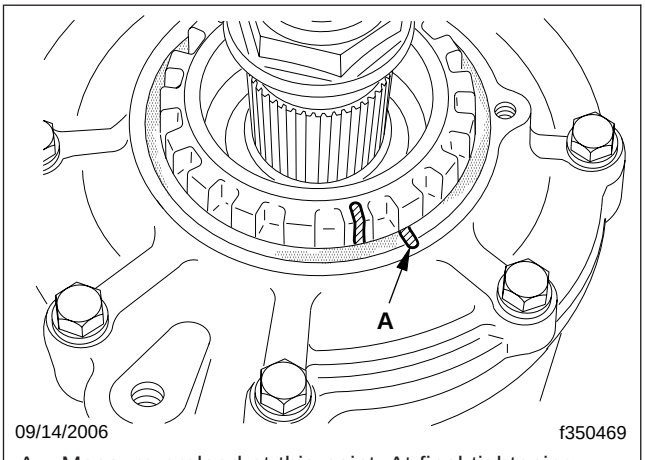
13. When the bearing preload is correct, install the new locking plate and capscrew. Tighten the capscrew 18 lbf·ft (24 N·m).

14. Install the new input-shaft seal as follows (see **Fig. 7**):

    14.1 Inspect the area around the seal for damage. Use emery paper to remove scratches, nicks, or burrs on the seal bore.

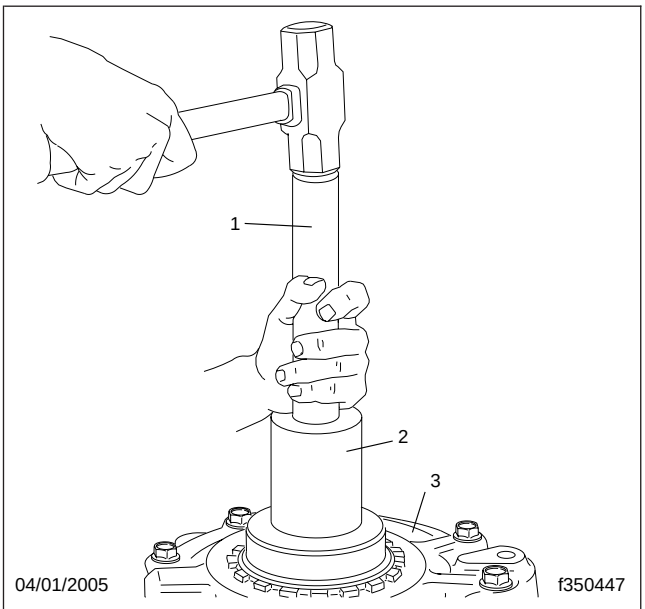
    14.2 Apply a light coating of axle oil to the seal bore.

    14.3 Coat the mating surfaces of the new seal with Loctite® 5900 sealant, or equivalent.



A. Measure preload at this point. At final tightening, this mark should be opposite the center of the next tooth, but no further.

Fig. 6, Advancing the Threaded Ring



1. Universal Handle (Kent-Moore tool, J-8092)
2. Input Seal Installer (Kent-Moore tool, J-47369)
3. Carrier Housing

Fig. 7, Installing the Forward Carrier Input Seal

14.4 Assemble the input shaft seal installer onto the threaded end of the universal handle. See **Fig. 7**.

Threaded Ring Repair

14.5 Using the input shaft seal installer assembly, press the seal into the bore until the seal surface is flush with the threaded ring.

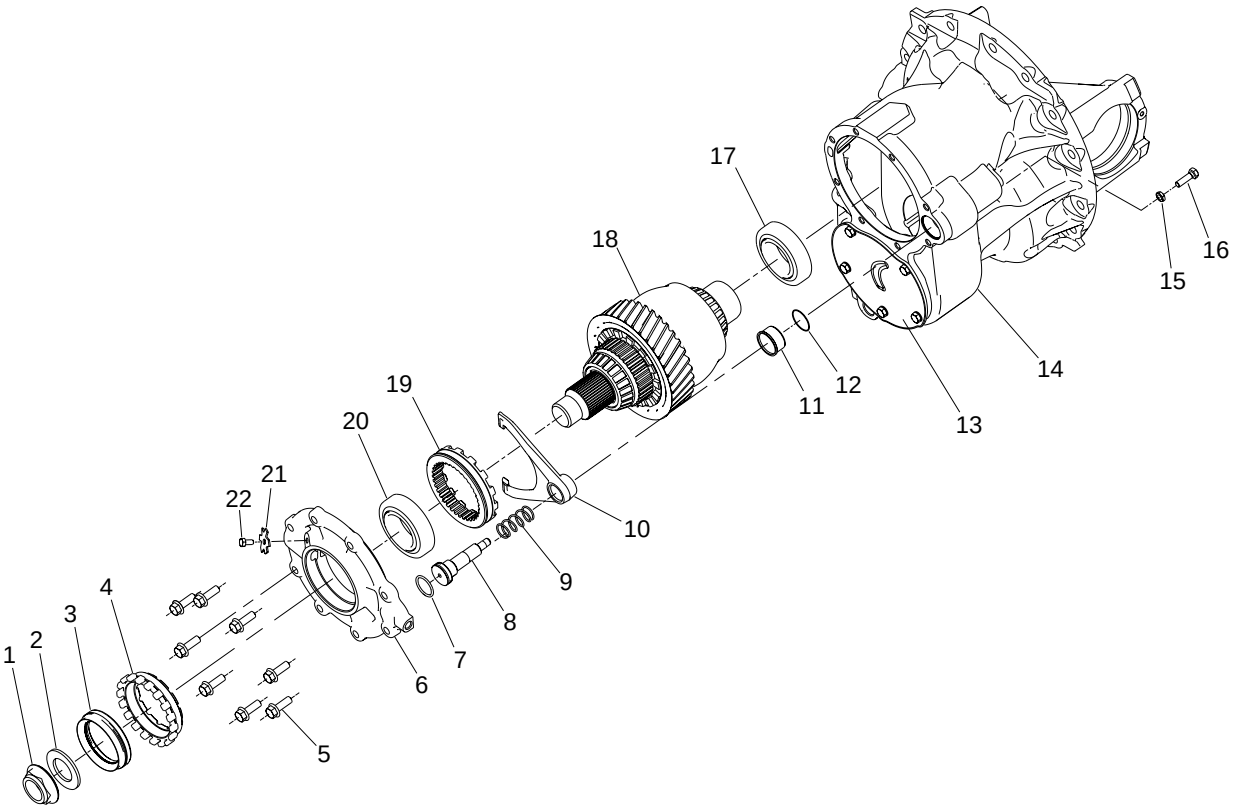
15. Apply Loctite 242 to the threads of the new yoke nut, then using it and a new washer, install the existing yoke on the input shaft. Tighten the yoke nut 628 lbf·ft (850 N·m).
16. Connect the main driveshaft to the input shaft. For instructions, see **Section 41.00, Subject 120**.

Interaxle Differential Replacement

The following on-vehicle procedure replaces the interaxle differential (IAD) assembly and accomplishes a minor carrier rebuild by replacing the bearing races and, as needed, the shift shaft bushing. The front cover is resealed and the input shaft seal is replaced. See **Fig 1**.

Special Tools

Special tools are required for this procedure. See **Table 1**.



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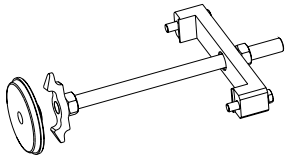
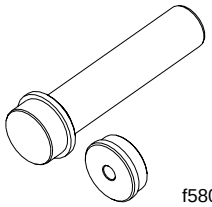
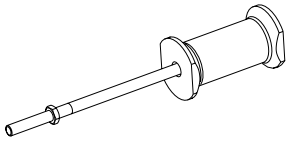
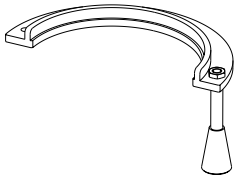
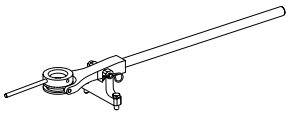
1. Yoke Nut
2. Washer
3. Input Shaft Seal
4. Threaded Ring
5. Bearing Cage Capscrews
6. Bearing Cage
7. Shift Shaft Piston O-ring
8. Shift Shaft Piston
9. Piston Spring
10. Shift Fork
11. Shift Shaft Bushing
12. Shift Shaft Bushing O-ring
13. Cover Plate
14. Carrier Housing
15. Locknut
16. IAD Adjustment Screw
17. Output Bearing Race
18. IAD Assembly
19. Clutch Collar
20. Input Bearing Race
21. Locking Plate
22. Locking Plate Capscrew

Fig. 1, The Interaxle Differential and Carrier Housing Components

Interaxle Differential Replacement

Special Tools for Interaxle Differential Replacement			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580478	Output Bearing Remover and Installer	Daimler	MBA 420589003300
 f580480	Shift Shaft Bushing Remover and Installer	Daimler	MBA 420589013300
 f580476	Slide Hammer	Daimler	MBA 060589003300
 f580479	Half-Moon Device	Daimler	MBA 420589006300
 f580477	Push-Pull Device	Daimler	MBA 420589001600

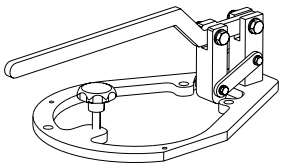
Special Tools for Interaxle Differential Replacement			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580481	Shift Shaft Piston Installer	Daimler	MBA 420589023300

Table 1, Special Tools for Interaxle Differential Replacement

Replacement

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the front tires.
2. Ensure the interaxle differential is disengaged and the system is charged with air. The rear wheels will need to turn near the end of this procedure.
3. Place a suitable strap around the driveshaft and frame to hold the driveshaft out of the way after it is disconnected.
4. Disconnect the main driveshaft from the forward carrier input yoke (for instructions, see **Section 41.00, Subject 120**), and support it with the strap.
5. Clean the carrier housing and surrounding area as needed to remove any debris that could enter the housing.
6. Drain the oil from the carrier housing.
7. Disconnect the air line connected to the bearing cage.
8. Remove the yoke nut and washer from the input shaft of the forward differential carrier, then remove the yoke.
9. Remove the capscrew and the locking plate. See **Fig 1**.
10. Using a spanner wrench, remove the threaded ring by turning it counterclockwise.
11. Remove the bearing cage capscrews from the bearing cage, and pry the bearing cage from the carrier housing. It may help to tap the bearing cage loose with a chisel; see **Fig. 2**.

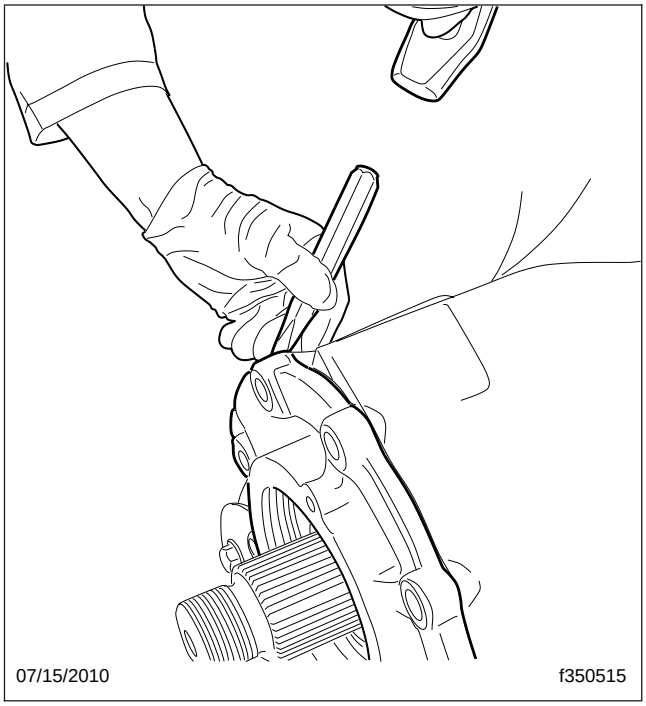


Fig. 2, Tapping the Bearing Cage Loose

12. Remove the IAD adjustment screw and locknut.

NOTICE

When unseating the shift shaft piston, multiple taps may be needed, but use moderate force only and be careful to hit the piston only (not the housing). Stop tapping it once it protrudes from the housing. The use of excessive force, or tapping it while it protrudes from the housing can damage the piston and the housing.

Interaxle Differential Replacement

13. Using a brass or plastic mallet, squarely tap the shift shaft piston to unseat it, and then remove it from the carrier housing.
14. Remove the piston spring, clutch collar, and shift fork.

NOTICE

The IAD assembly is heavy. Use appropriate support while removing and transporting it to prevent dropping and damaging it. Do not allow it to rest on the oil slinger; see Fig. 3. Resting the IAD assembly on the oil slinger could damage the oil slinger.

15. Remove the IAD assembly.

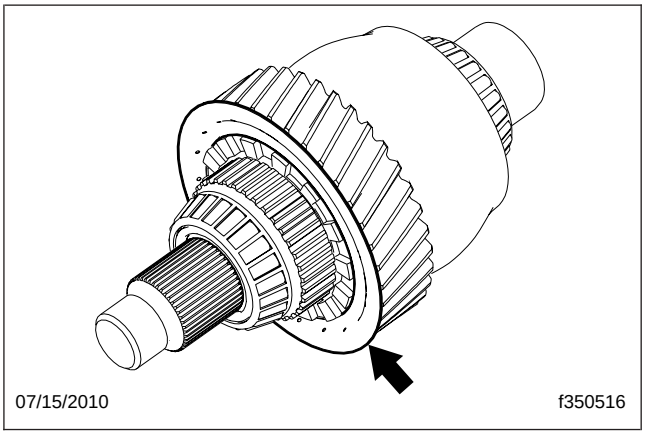


Fig. 3, Oil Slinger

16. Align the output bearing remover (see Table 1) with the notches in the rear of the carrier housing, then attach it to the housing with bearing cage capscrews, and use it to remove the output bearing race. See Fig. 4.
17. If the brass shift shaft bushing is damaged or worn, assemble the slide hammer and shift shaft bushing remover (see Table 1), and slide the hammer handle to remove the bushing. See Fig. 5.
18. Using a suitable solvent (such as brake cleaner), clean any remaining sealant from the threaded ring and mating surfaces of the carrier housing and the bearing cage. Dry the surfaces with compressed air, ensuring no cleaning solvent remains.

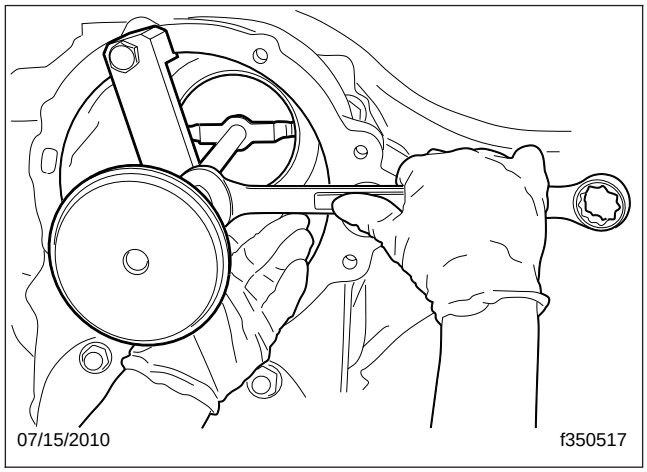
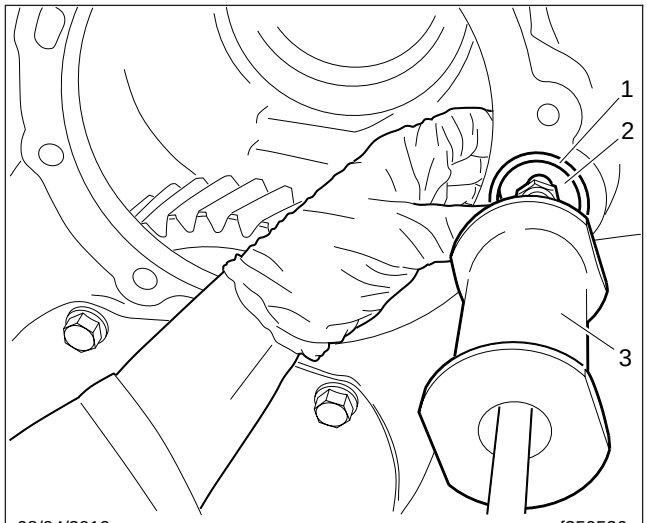


Fig. 4, Removing the Output Bearing Race



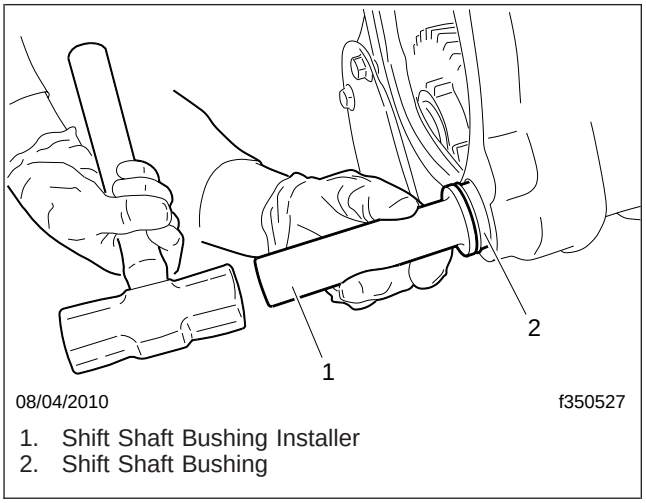
1. Shift Shaft Bushing
2. Shift Shaft Bushing Remover
3. Slide Hammer

Fig. 5, Installing the Bushing Remover

19. As in the previous step, clean the groove at the piston bushing bore.
20. If the brass shift shaft bushing was removed, install a new one using a mallet and the Shift Shaft Bushing Installer. See Fig. 6.
21. A new output bearing race is included with the new IAD. Install it as follows.

    21.1 To get it started, lightly tap the race into place with a hammer handle or wood

block. The race must be square in the housing or damage will occur when it is pressed. See **Fig. 7**.



1. Shift Shaft Bushing Installer
2. Shift Shaft Bushing

Fig. 6, Installing the Bushing

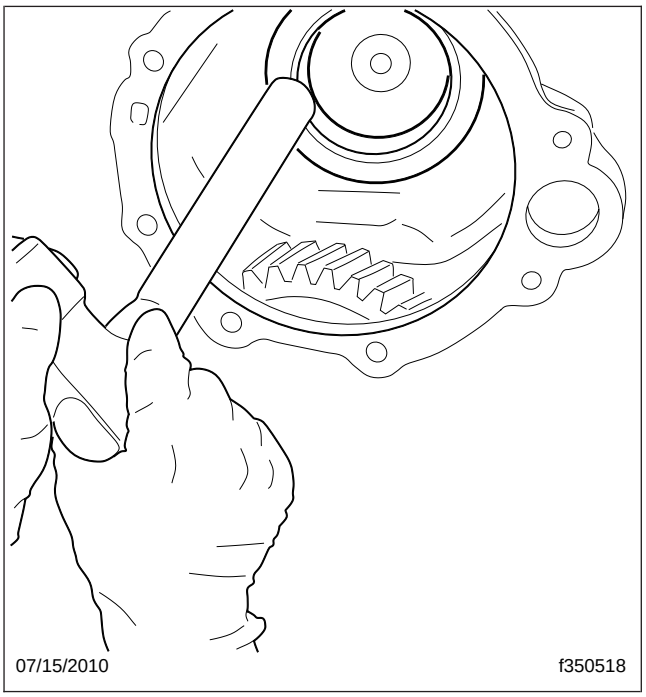


Fig. 7, Setting the Race

21.2 Fasten the output bearing installer to the carrier housing, and use it to press the race into the housing. As the race is installed, slight jerks can be felt and heard. See **Fig. 8**.

22. Lubricate the output gear and bearing of the new IAD assembly with white grease.

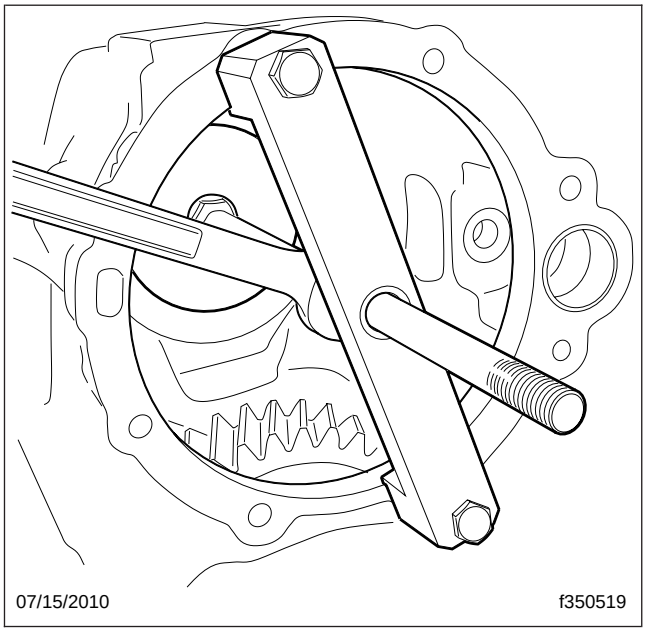


Fig. 8, Pressing a New Race into the Housing

23. Install the IAD assembly and output gear. Do not allow the assembly to rest on the oil slinger.
24. Install the clutch collar and shift fork.
25. Apply a thin film of white grease to the shift shaft piston, and insert it with the piston spring into the housing until about 1 inch (2.5 cm) of the piston protrudes from the bore.
26. The half-moon device (see **Table 1**) helps align the shift fork and shift shaft piston. To install it, slide it between the oil slinger and the shift fork. See **Fig. 9**.
27. Install the shift shaft piston as follows.

    27.1 The shift shaft piston installer (see **Table 1**) is designed to install the piston without damaging it or the carrier housing. Use two bearing cage capscrews to mount it to the carrier housing. See **Fig. 10**.

    27.2 Adjust the hex screw until the shift fork is snug but not bound.

Interaxle Differential Replacement

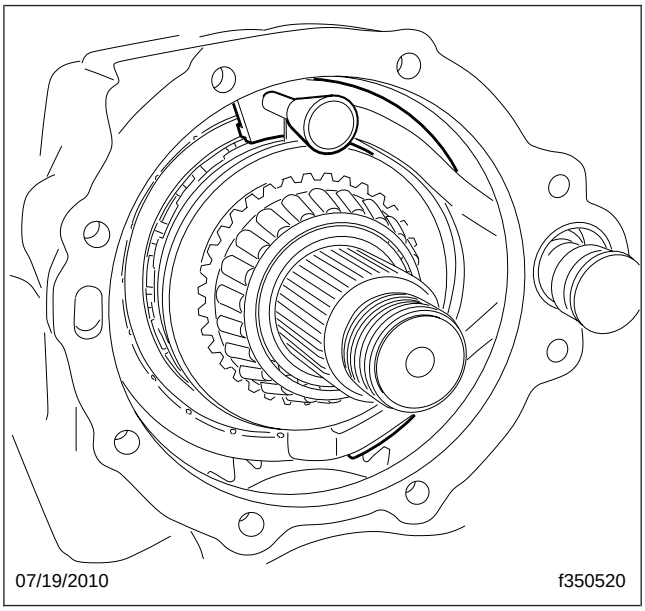
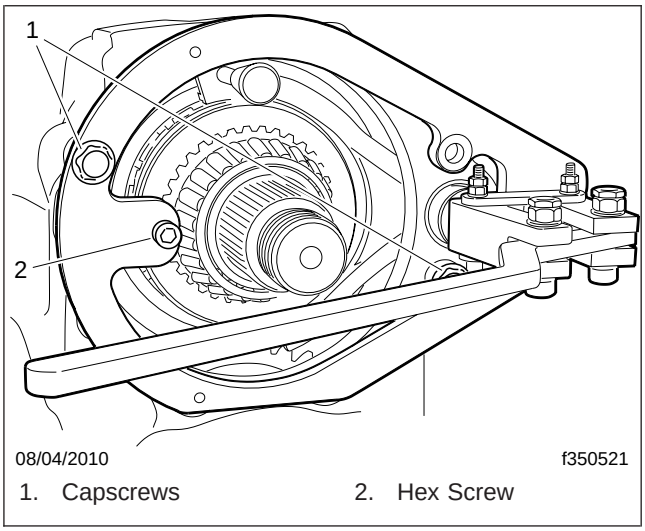


Fig. 9, The Half-Moon Device, Installed



1. Capscrews 2. Hex Screw

Fig. 10, Shift Shaft Piston Installer, Mounted

27.3 In a single movement of moderate force, use the lever of the installer to press the piston into the bore until only about 1/8 to 1/16 inch (2 to 3 mm) of the piston protrudes from the carrier housing. When the piston seats, a "click" sound may be audible. If the piston does not seat readily, adjust the hex screw, and try again.

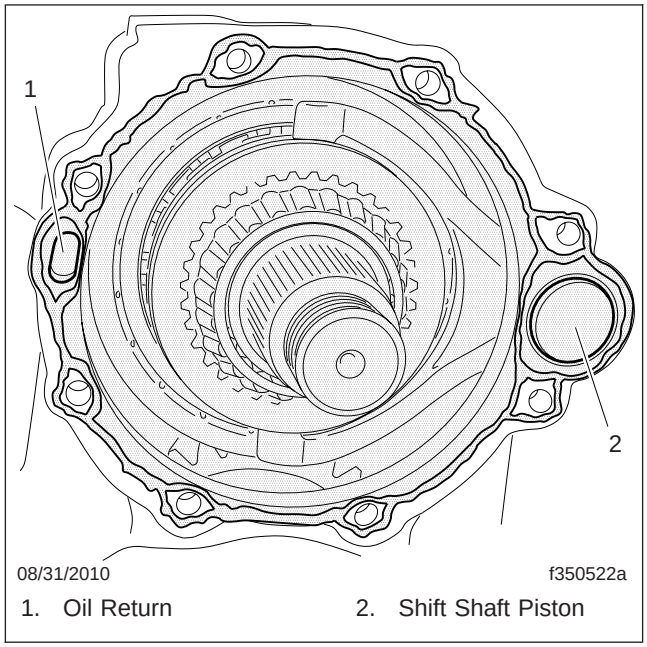
27.4 Once the piston is seated, remove the shift shaft piston installer and the half-moon device.

28. Remove the input bearing race from the bearing cage. Place the new race into the cage so that it is more forward than in the final position. As the preload is adjusted, the race will seat to its final position.

29. Apply Loctite® 577 sealant to the threads of the threaded ring and tighten it until it is snug against the race.

IMPORTANT: Do not overapply sealant. Do not allow sealant to enter the oil return or touch the shift shaft piston.

30. Apply a small bead of Loctite 5900 to the carrier housing. See **Fig. 11**. To help ensure a good seal, spread it uniformly over the surface area.



1. Oil Return 2. Shift Shaft Piston

Fig. 11, Sealant Applied to Carrier Housing

31. Install the bearing cage, and using a star pattern tighten the capscrews to 103 lbf·ft (140 N·m).

32. The push-pull device (see **Table 1**) is used to set pre-load on the input bearing. Remove the two upper capscrews from the cover plate and install the device as shown in **Fig. 12**.

33. Set the correct end play as follows.

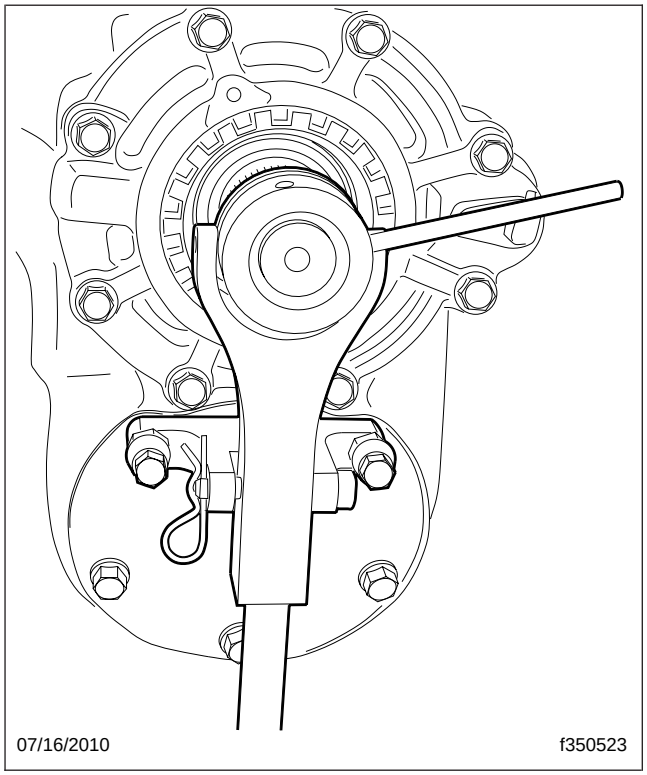


Fig. 12, Push-Pull Device, Installed

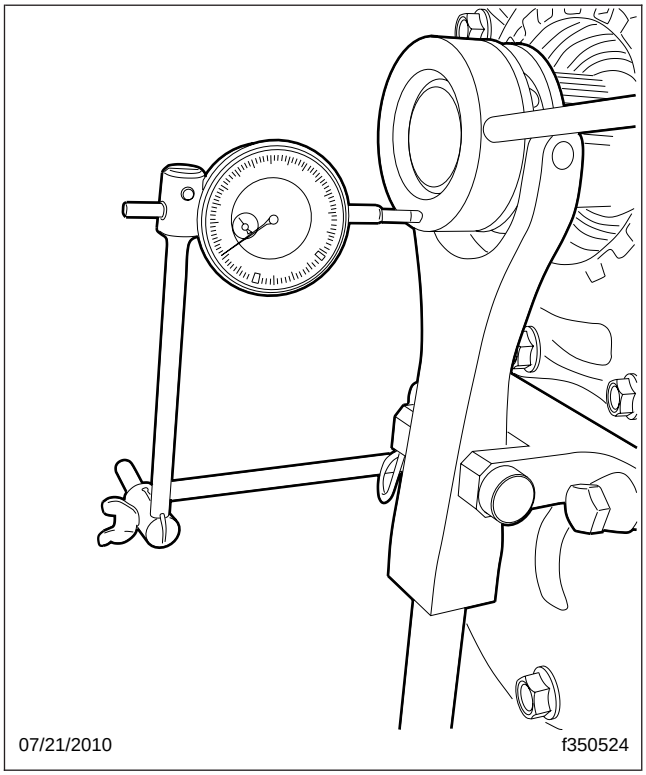


Fig. 13, Dial Indicator and Push-Pull Device

33.1 Set up a dial indicator as shown in **Fig. 13**.

33.2 Turn the input shaft three revolutions and tighten the threaded ring until there is between 0.002 and 0.003 inch (0.05 and 0.08 mm) of end play. Turn the input shaft three more revolutions and verify the measurement.

33.3 When there is between 0.002 and 0.003 inch (0.05 and 0.08 mm) of end play, align a mark on the threaded ring with one on the bearing cage. See **Fig. 14**.

33.4 Tighten the threaded ring almost one notch.

IMPORTANT: Do not loosen the threaded ring. If the threaded ring is loosened, the bearing cage must be removed and the race re-installed.

33.5 The locking plate has six positions that can lock the threaded ring. Find the position that fits best, install it, and tighten the capscrew 18 lbf·ft (24 N·m).

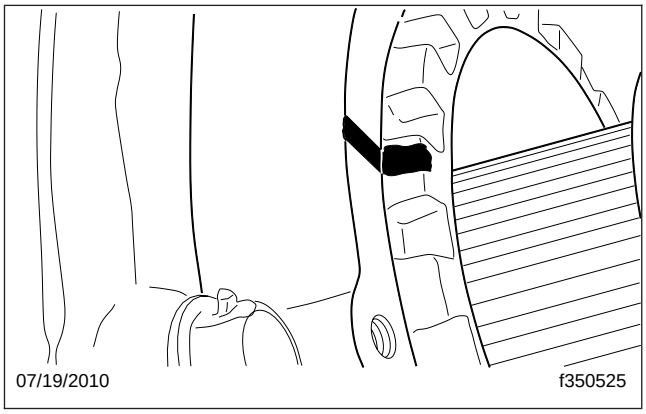


Fig. 14, Threaded Ring and Bearing Cage, Marked

33.6 Remove the push-pull device and dial indicator, and install the the two upper capscrews on the cover plate. Tighten the capscrews 63 lbf·ft (85 N·m).

Interaxle Differential Replacement

34. Install a new input shaft seal and the yoke, nut, and washer; see **Subject 170** for instructions.
35. Clean, install, and adjust the IAD adjustment screw and locknut as follows.
    - 35.1 Clean the IAD adjustment screw and locknut with a suitable solvent (such as brake cleaner). Dry the cleaned surfaces, ensuring no solvent remains.
    - 35.2 Connect an air line at the interaxle lock.
    - 35.3 Apply air, and by hand, turn the input shaft to ensure the gear cogs fully engage.
    - 35.4 Coat the threads of the adjustment screw with Loctite® 577.
    - 35.5 Install the adjustment screw, with the locknut, into the carrier housing, and handtighten the screw until it touches the engaged shift shaft piston.
    - 35.6 Disengage the IAD to relieve the air pressure exerted on the adjustment screw.
    - 35.7 Hand-tighten the adjustment screw one quarter turn, then tighten the locknut 30 lbf·ft (41 N·m).
36. Connect the main driveshaft; for instructions, see **Section 41.00, Subject 120**.
37. Using approved axle oil, fill the axle housing to the bottom of the fill hole, or until filled to capacity as shown in **Table 2**.

Forward-Rear Axle Oil Type and Capacity		
Approved Oil Type	**Capacity: quarts (liters)**	
	Hubs Full	**Hubs Dry**
80W-90 Gear Oil	14.3 (13.5)	15.9 (15.0)
75W-90 Synthetic Gear Oil		

Table 2, Forward-Rear Axle Oil Type and Capacity

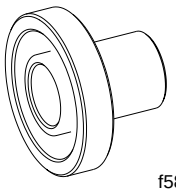
38. To lubricate the wheel ends, tilt the axle to the left and right by jacking the opposite side 8 inches (20 cm). Hold the tilted position for two minutes on each side to allow oil to run into the wheel end. Return the axle to a level position, and add oil through the axle housing filler hole. About two more pints (1 liter) of lubricant will be needed to bring the oil level even with the base of the filler hole.

Torque Values		
Application	**Size**	**Torque: lbf·ft (N·m)**
All Model 4 Axles		
Carrier Capscrews	M16	200 (270)
Drive Axle Stud Nuts	1/2–20	75–115 (102–156)
	5/8–18	150–170 (203–230)
Yoke Nut (model 4 axles)	M45 x 1.5	627 (850)
Forward-Rear Axles		
Bearing Cage Capscrews	M12	107 (145)
Input Yoke Nut	M45 x 1.5	627 (850)
Output Yoke Nut	M39 x 1.5	516 (700)

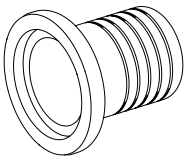
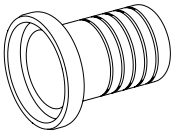
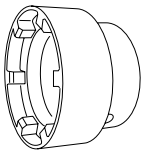
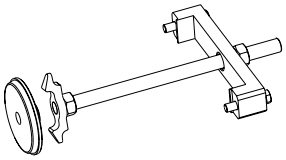
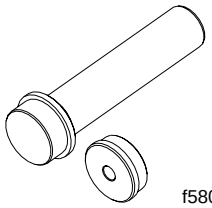
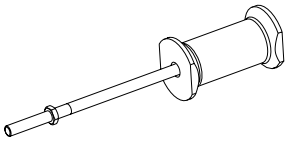
Table 1, Torque Values

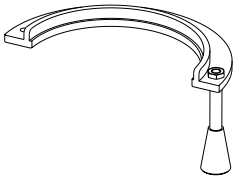
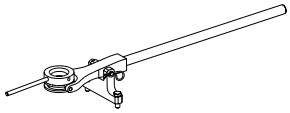
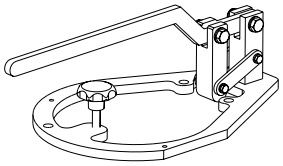
Rear Axle Lubricant Type and Capacity			
Approved Lubricant Type	**Axle**	**Oil Capacity: quarts (liters)**	
		Hubs Full	**Hubs Dry**
80W/90 Gear Oil	Forward-Rear	14.3 (13.5)	15.9 (15.0)
75W/90 Synthetic Gear Oil			
80W/90 Gear Oil	Single and Rearmost Tandem	10.6 (10.0)	12.2 (11.5)
75W/90 Synthetic Gear Oil			

Table 2, Rear Axle Lubricant Type and Capacity

Special Tools for Detroit Rear Axles			
Tool	**Description**	**Manufacturer**	**Part Number**
f580400	Universal Handle*	Kent-Moore	J-8092
 f580406	Rear Pinion Seal Installer*	Kent-Moore	J-47354

Specifications

Special Tools for Detroit Rear Axles			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580410	Input Seal Installer*	Kent-Moore	J-47369
 f580408	Output Seal Installer*	Kent-Moore	J-47368
 f580450	Yoke Nut Socket†	Daimler	MBA 742589020700
 f580478	Output Bearing Remover and Installer	Daimler	MBA 420589003300
 f580480	Shift Shaft Bushing Remover and Installer	Daimler	MBA 420589013300
 f580476	Slide Hammer	Daimler	MBA 060589003300

Special Tools for Detroit Rear Axles			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580479	Half-Moon Device	Daimler	MBA 420589006300
 f580477	Push-Pull Device	Daimler	MBA 420589001600
 f580481	Shift Shaft Piston Installer	Daimler	MBA 420589023300

* To order Kent-Moore tools call 1-800-328-6657.

† The yoke nut socket is needed to remove the round, slotted yoke nut installed on some vehicles. It can be ordered through Paragon.

Table 3, Special Tools for Detroit Rear Axles

General Information

Wheels and Tires

The tires support the weight of the vehicle, and are integral parts of the transmission and braking systems. The wheels serve as load carrying members between the tires and the axle.

There are two types of wheels: spoke and disc.

Spoke wheels consist of a wheel and brake drum assembly installed on the axle and a tire and rim assembly that mounts on the wheel. Rim clamps and rim nuts hold the tire and rim assembly in place.

Disc wheels consist of a rim and disc. The rim, the portion of the wheel on which the tire is mounted and supported, is welded to the disc. See **Fig. 1**. After the tire is mounted on the wheel, the assembly is held in place on the hub with wheel studs and nuts.

Standard ten-hole dual disc wheels are held in place on the hub by self-centering inner and outer wheel nuts. Eight-hole and optional ten-hole (single and dual) disc wheels are centered by pilot pads and are held in place on the hub with two-piece flange nuts.

Tires are constructed of either radial or bias plies:

- Radial tires have ply cords that run from bead to bead, and at a right angle to the belt plies and tire tread. See **Fig. 2**. The belt plies constrict the radial ply cords and give rigidity to the tread.
- Bias ply tires have body ply cords that run diagonally from bead to bead. See **Fig. 3**. The tires may also have narrow plies under the tread, called breakers, with cords that lie in about the same direction as the body ply cords.

Tire body plies, breakers, and belts are made of polyester, rayon, nylon, fiberglass, steel, or aramids (fibrous reinforcements). In radial ply tires, these materials are used in various combinations, including steel body/steel belt, polyester body/fiberglass belt, or nylon body/steel belt.

Wheels and tires operate either with or without tubes. Tube-type tires require a tube and flap for correct assembly on a two-or three-piece rim. Tubeless tires require only the tire, and a one-piece drop-center wheel or rim. See **Fig. 1**.

Tire Matching and Mixing

IMPORTANT: Review and follow these requirements for matching and mixing tires, before installing any tire and wheel or rim assembly on a vehicle.

Before changing wheels and tires, consider the effect that the change may have on the Gross Vehicle Weight Rating (GVWR) of the vehicle. At the time of vehicle certification, the GVWR is calculated by adding the vehicle's Gross Axle Weight Ratings (GAWR). The GVWR and each of the GAWRs are shown on a certification label (U.S.-purchased tractors) or "Statement of Compliance" label (Canadian-purchased tractors) attached to the left rear door post. See **Fig. 4**.

Tire and rim labels (**Fig. 4** and **Fig. 5**) certify the minimum tire and rim combinations that can be installed on the vehicle for the given GAWRs. Each GAWR is determined by considering each component of the axle system, including suspension, axle, wheels, and tires. The lowest component's capacity is the value used for the system. Therefore, the tires and rims installed on the vehicle at the time of vehicle manufacture may have a higher load capacity than that certified by the tire and rim label. Tires and rims of the minimum capacity can be installed without changing the load limitations. If tires and rims are installed that have a lower load capacity than that shown on the tire and rim label, then the tires and rims determine the load limitations (the GAWRs and GVWR will be lower).

When pairing tires in a dual assembly, the tire diameters must not differ by more than 1/4 inch (6.4 mm), or the tire circumference by more than 3/4 inch (19 mm). The total tire circumference of one driving rear axle must match, as nearly as possible, the total tire circumference of the other driving rear axle.

⚠ CAUTION

Mismatching dual tires overloads the larger diameter tire, causing it to overdeflect and overheat. The smaller diameter tire, lacking proper road contact, wears faster and unevenly. Tread or ply separation, tire body breaks, and blowouts can occur from mismatched duals.

With an endless pi tape (**Fig. 6**) or square (**Fig. 7**), measure the diameter of the tires 24 hours after inflation. A matching stick (**Fig. 8**), string gauge (

Fig. 9), or tire straight edge (Fig. 10) can also be used to determine the difference in tire radius, which is then doubled to calculate the diameter difference.

When pairing tires of unequal diameters (but within the above limits), mount the larger tire on the outside.

CAUTION

Driving a vehicle on one tire of a dual assembly dangerously exceeds the carrying capacity of the single tire and wheel. Operating in this manner can cause damage to the wheel and tire.

Inflate all tires on an axle, or on both axles of a tandem unit, to within 5 psi (35 kPa) of one another. For tire inflation specifications, see **Specifications, 400**.

There must be sufficient space between dual tires for air to flow and cool the tires, and to prevent them from rubbing against one another. Rims and wheels of the same size, but of different makes and types, can have different offsets, which would affect dual spacing. If there is sidewall contact between tires, or between the inside tire and the chassis, see the tire manufacturer's catalog to determine the minimum dual spacing. See the rim or wheel manufacturer's catalog to determine the correct offset.

Federal Motor Carrier Safety regulations require the removal of all tires with less than 4/32-inch (3 mm) remaining groove depth on a front axle, and tires with less than 2/32-inch (1.5 mm) remaining groove depth on a rear axle. However, tires with the word "Regroovable" on the sidewall, may be regrooved.

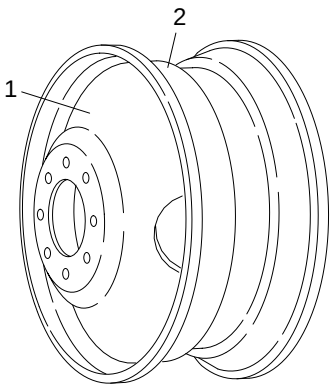
Better tire and vehicle performance is usually obtained by using tires of the same size and construction. Using tires of different construction is permitted if the following rules are observed:

- Do not mix radial and bias ply tires on the same axle.
- If both radial and bias ply tires are used, better handling is usually obtained by using the bias ply tires on the front axle.
- Use either all radial or all bias ply tires on the non-driving rear axles of a vehicle. However, all radial or all bias ply tires must be used on vehicles with tandem drive-axles.

CAUTION

Mixing radial and bias ply tires should be done as an emergency measure only. Some loss of steering control and premature tire wear could occur when driving under such conditions.

If installing radial tires on a vehicle formerly equipped with bias ply tires, see **Specifications, 400** concerning the inflation needs and load limits of the bias ply tires being removed, and of the radial ply tires being installed. Radial ply tires permit greater loads per tire, but also require higher inflation. They can also cause higher stresses on rims and wheels than bias ply tires. Contact the rim or wheel manufacturer about the compatibility of the rim or wheel with radial ply tires. Also, see the front axle section in this manual for information on the possible differences in toe-in setting between radial and bias ply tires.



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1. Disc
2. Rim

Fig. 1, Disc Wheel

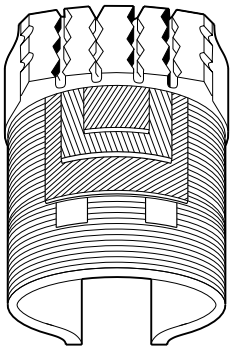

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Fig. 2, Radial Ply Tire Construction

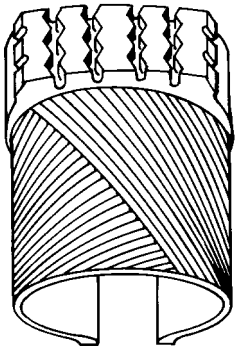

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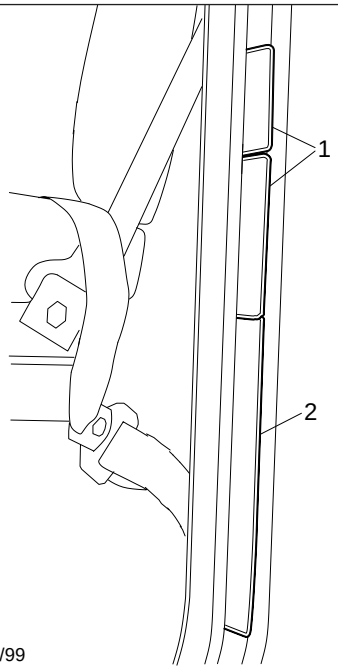
Fig. 3, Bias Ply Tire Construction



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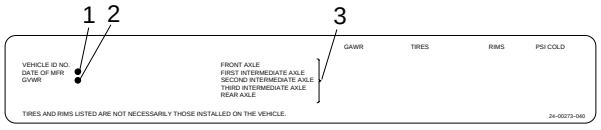
1. Tire and Rim Labels
2. Certification Label

Fig. 4, Labels Location



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NOTE: Example only. Actual specifications may vary from vehicle to vehicle.

1. Date of manufacture by month and year.
2. Gross vehicle weight rating; developed by taking the sum of all the vehicle's gross axle ratings.
3. Gross axle weight ratings; developed by considering each component in an axle system, including suspension, axle, wheels, and tires. The lowest component capacity is the value for the system.

Fig. 5, Tire and Rim Label

General Information

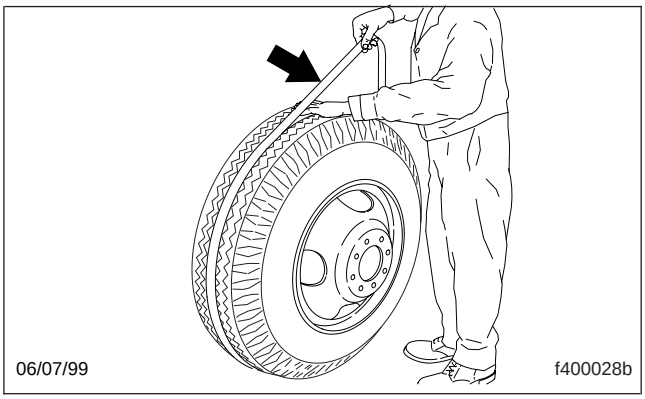


Fig. 6, Endless Pi Tape

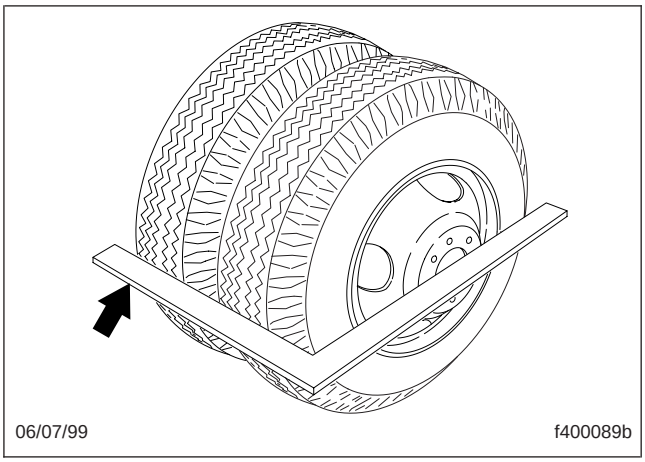


Fig. 7, Square

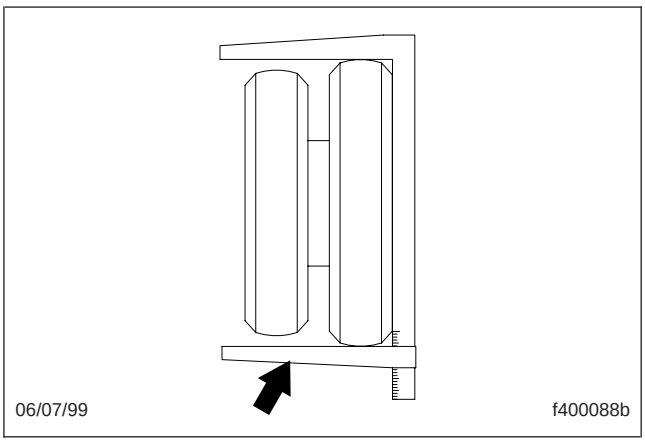


Fig. 8, Matching Stick

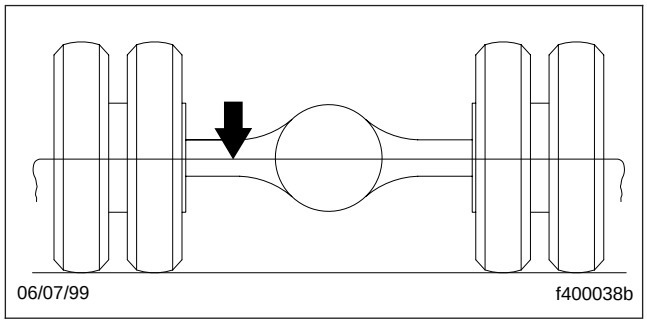


Fig. 9, String Gauge

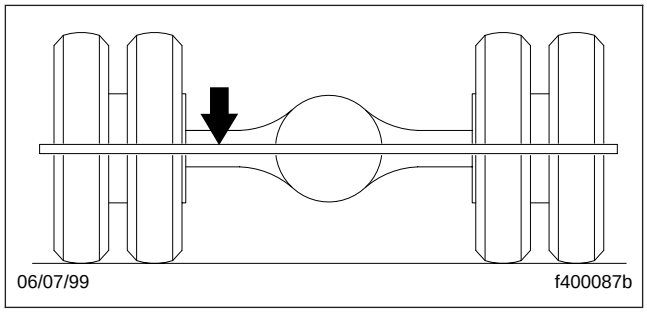


Fig. 10, Tire Straight Edge

8-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock all tires that will not be serviced, to prevent vehicle movement.
2. If removing the wheels and tires from the front axle:
   - 2.1 Raise the front of the vehicle until the tires clear the floor. Place safety stands under the front axle.
   - 2.2 If the tire or wheel is damaged (or if there is suspected damage), deflate the tire being serviced by removing the valve core.
   - 2.3 Place a jack or wheel-and-tire dolly under the front wheel assembly being serviced. Turn the wheel until one hub-pilot pad is in the top-center position.
   - 2.4 Leaving the top nut until last, remove all eight two-piece flange nuts.

CAUTION

The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during removal and damage the stud threads or hub-pilot pads. Keep the wheel square to the hub during removal.

IMPORTANT: On both sides of the vehicle, the two-piece flange nuts have right-hand threads.

   - 2.5 Remove the wheel. Do not let it drop on or drag across the stud threads.

3. If removing wheels and tires from a rear axle:
   - 3.1 Raise the rear of the vehicle until the tires clear the floor. Place safety stands under the axle being serviced.
   - 3.2 If the tire or wheel is damaged (or if there is suspected damage), deflate both tires of the dual assembly being serviced by removing the valve cores.
   - 3.3 Place a jack or wheel-and-tire dolly under the dual wheel assembly being serviced. Turn the wheel until one hub pilot pad is in the top-center position.
   - 3.4 Leaving the top nut until last, remove all eight two-piece flange nuts.

CAUTION

The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during removal and damage the stud threads or hub-pilot pads. Keep the wheel square to the hub during removal.

IMPORTANT: On both sides of the vehicle, the two-piece flange nuts have right-hand threads.

   - 3.5 Remove the wheel. Do not let it drop on or drag across the stud threads.

Installation

NOTE: Before installing a wheel and tire assembly, inspect it using the instructions in **Subject 190**. Also, follow the tire matching and mixing requirements in **Subject 050**.

1. Clean the hub and wheel mounting surfaces. Clean between the rims of dual wheels. Make sure the tire is correctly inflated. For instructions, see **Subject 210**.
2. Apply a few drops of light engine oil to the wheel studs and the area between the body and the flange of each two-piece flange nut. Wipe off any excess oil.

CAUTION

The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during installation and damage the stud threads or hub-pilot pads. Keep the wheel square to the hub during installation.

IMPORTANT: Before installing the wheels, make sure the drum is positioned on the raised step of the pilot pad. One of the hub's pilot pads must be at the top location. To help keep the drum in place, it may be necessary to adjust the brakes before installing the wheels.

8-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

3. If installing a front wheel assembly:
   - 3.1 Locate one hub-pilot pad in the top-center position. Using a jack or wheel-and-tire dolly, position the wheel assembly on the hub. Make sure the wheel is square to the hub and that the threads or hub-pilot pads are not damaged by contact with the wheel during installation.
   - 3.2 Make sure the hub-pilot pad is still centered at the top.

IMPORTANT: Install the wheel assembly so that the balance weight(s) on the wheels are 180 degrees opposite the balance weight(s) on the brake drum.

4. If installing a rear wheel assembly:
   - 4.1 Locate one hub-pilot pad in the topcenter position. Using a jack or wheel-and-tire dolly, position the inner wheel assembly on the hub. Make sure the wheel is square to the hub and that the threads or hub-pilot pads are not damaged by contact with the wheel during installation.
   - 4.2 Using the same procedure, mount the outer wheel against the inner wheel. Make sure the hub-pilot pad is still centered at the top.

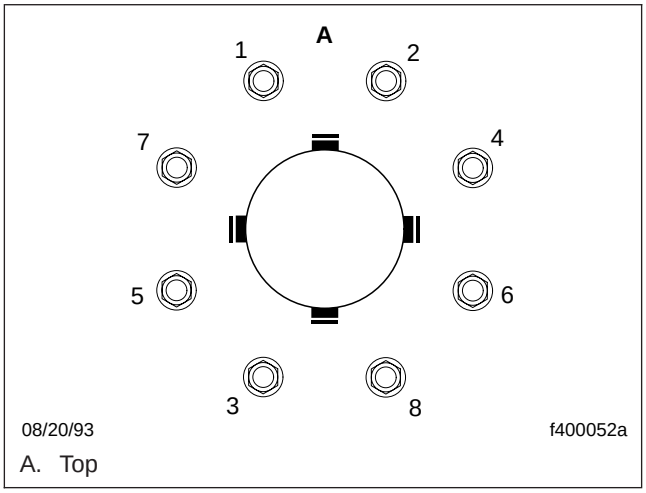
IMPORTANT: Install the wheel assembly so that the balance weight(s) on the wheels are 180 degrees opposite the balance weight(s) on the brake drum. If this causes the valve stems to be in the same wheel hole, mount the outer wheel so that the outer wheel balance weight(s) are on the same side as the brake drum balance weight(s).

5. Install and hand-tighten a two-piece flange nut on the top and bottom studs.

CAUTION

The two-piece flange nuts have right-hand metric threads. Do not try to install a similar size SAE nut on a stud, or the stud and nut will be damaged.

6. Install and hand-tighten the remaining two-piece flange nuts. Tighten the two-piece flange nuts 50 to 100 lbf·ft (68 to 135 N·m) following the sequence in **Fig. 1**.



A. Top

Fig. 1, 8-Stud Disc Wheel Tightening Sequence

7. Check that the wheel is correctly seated against the hub and on the hub-pilot pads.
8. Following the sequence in **Fig. 1**, tighten the two-piece flange nuts 450 to 500 lbf·ft (610 to 678 N·m).

WARNING

If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly.

Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts. Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing property damage or personal injury.

NOTE: Replace damaged parts following the instructions in the front or rear axle section in this manual.

9. Remove the safety stands, lower the vehicle, and remove the chocks.

10. After operating the vehicle for 50 to 100 miles (80 to 160 km), retighten the wheel nuts 450 to 500 lbf·ft (610 to 678 N·m). Follow the sequence in **Fig. 1**.

CAUTION

Too little wheel nut torque can cause wheel shimmy, wheel damage, stud breakage, and extreme tire tread wear. Too much wheel nut torque can break studs, damage threads, and crack discs in the stud hole area. Use the specified torque values, and follow the tightening sequence in Fig. 1.

IMPORTANT: The two-piece flange nuts seat during vehicle operation. It is necessary to periodically tighten the wheel nuts to the specified torque. Tighten the two-piece flange nuts to the specified torque 50 to 100 miles (80 to 160 km) after service work, and check the torque every 50,000 miles (80 000 km) thereafter.

10-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock all tires that will not be serviced, to prevent vehicle movement.
2. If working on the front axle wheels, raise the front of the vehicle until the tires clear the floor. Place safety stands under the front axle.

   If working on the rear axle wheels, raise the rear of the vehicle until the tires clear the floor. Place safety stands under the axle being serviced.
3. If the tire or wheel is damaged or if there is suspected damage, deflate the tire (or tires, on a dual assembly) being serviced by removing the valve core.
4. Turn the wheel until one hub-pilot pad is in the top-center position.
5. Leaving the top and bottom nuts until last and remove the other eight two-piece flange nuts.
6. Place a jack or wheel-and-tire dolly under the wheel assembly being serviced. Remove the top and bottom nuts.

⚠ CAUTION

The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during removal and damage the stud threads or hub-pilot pads. Keep the wheel square to the hub during removal.

IMPORTANT: On both sides of the vehicle, the two-piece flange nuts have right-hand metric threads.

7. Remove the wheel. Do not let it drop on or drag across the stud threads.

Installation

IMPORTANT: Before installing the wheels, it is recommended that an anti-seize compound be applied on the 360 degree wheel pilot hubs of Meritor FF-981 "Easy Steer Plus" front axles. After time in service, a small amount of rust or corrosion may make the wheel difficult to remove because of the extended wheel-to-hub contact. Applying an anti-seize compound on the wheel pilot of the hub will ensure easy wheel removal at a later date. Compounds such as the following may be used:

- Armite Led-Plate No. 250
- Loctite Anti-Seize No. 767
- Never-Seez
- Permabond Anti-Seize No. 82-9839.

Compounds are available for purchase locally.

IMPORTANT: Freightliner "Turbo" wheel assemblies require directional mounting, as shown in **Fig. 1**.

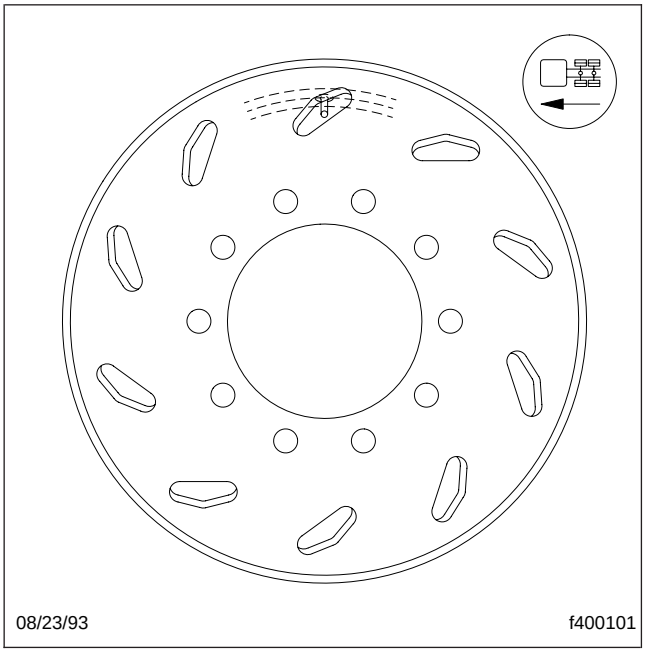


Fig. 1, Side View

NOTE: Before installing a wheel and tire assembly, inspect it using the instructions in **Subject 190**. Also, follow the tire matching and mixing requirements in **Subject 050**.

1. Clean the hub and wheel mounting surfaces, and all disc faces of dual wheels. Make sure the tire is correctly inflated. For instructions, see **Subject 210**.
2. Apply a few drops of light engine oil to the wheel studs and the area between the body and the

10-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

flange of each two-piece flange nut. Wipe off any excess oil.

CAUTION

The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during installation and damage the stud threads or hub-pilot pads. Keep the wheel square to the hub during installation.

IMPORTANT: Before installing the wheels, make sure the drum is positioned on the raised step of the pilot pad. One of the hub's pilot pads must be at the top location. To help keep the drum in place, it may be necessary to adjust the brakes before installing the wheels.

3. If installing a rear wheel assembly, go to the next step. Install the front wheel assembly.
   - 3.1 Locate one hub-pilot pad in the top-center position. Using a jack or wheel-and-tire dolly, position the wheel assembly on the hub. Make sure the wheel is square to the hub so that the stud threads or hub-pilot pads are not damaged by contact with the wheel during installation.
   - 3.2 Make sure the hub-pilot pad is still centered at the top.

IMPORTANT: Install the wheel assembly so that the balance weight(s) on the wheels are 180 degrees opposite the balance weight(s) on the brake drum.

4. Install the rear wheel assembly:
   - 4.1 Locate one hub-pilot pad in the top-center position. Using a jack or wheel-and-tire dolly, position the inner wheel assembly on the hub. Make sure the wheel is square to the hub so that the stud threads or hub-pilot pads are not damaged by contact with the wheel during installation.
   - 4.2 Using the same procedure, mount the outer wheel against the inner wheel. Make sure the hub-pilot pad is still centered at the top.

IMPORTANT: Install the wheel assembly so that the balance weight(s) on the wheels are 180 degrees opposite the balance weight(s) on the brake drum. If this causes the valve stems to be in the same wheel hole on rear wheel assemblies, mount the outer wheel so that the outer wheel balance weight(s) is on the same side as the brake drum balance weight(s).

5. Install and hand-tighten a two-piece flange nut on the top and bottom studs.

CAUTION

The two-piece flange nuts have right-hand metric threads. Do not try to install a similar size SAE nut on a stud, or the stud and nut will be damaged.

6. Install and hand-tighten the remaining two-piece flange nuts. Tighten the nuts 50 lbf·ft (68 N·m) following the sequence in **Fig. 2**.

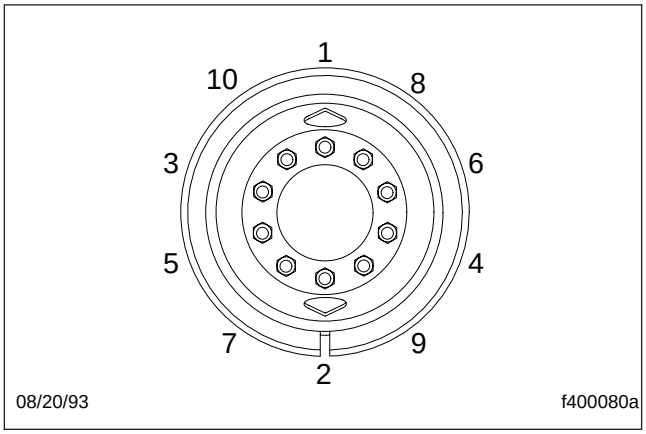


Fig. 2, 10-Stud Disc Wheel Tightening Sequence

7. Check that the wheel is correctly seated against the hub and on the hub-pilot pads.
8. Following the sequence in **Fig. 2**, tighten the two-piece flange nuts 450 to 500 lbf·ft (610 to 678 N·m).

WARNING

Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.

IMPORTANT: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly. Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts.

9. Remove the safety stands, lower the vehicle, and remove the chocks.

CAUTION

Too little wheel nut torque can cause wheel shimmy, wheel damage, stud breakage, and extreme tire tread wear. Too much wheel nut torque can break studs, damage threads, and crack discs in the stud hole area. Use the specified torque values, and follow the tightening sequence in Fig. 2.

IMPORTANT: The two-piece flange nuts seat during vehicle operation. It is necessary to periodically tighten the wheel nuts to the specified torque. Tighten the two-piece flange nuts to the specified torque 50 to 100 miles (80 to 160 km) after service work, and check the torque every 10,000 miles (16 000 km) thereafter.

10. After operating the vehicle for 50 to 100 miles (80 to 160 km), retighten the wheel nuts 450 to 500 lbf·ft (610 to 678 N·m). Follow the sequence in **Fig. 2**.

10-Hole Disc Wheel With Inner and Outer Nuts Removal and Installation

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock all tires that will not be serviced, to prevent vehicle movement.
2. Remove the wheels and tires from the front axle.
   - 2.1 Raise the front of the vehicle until the tires clear the floor. Place safety stands under the front axle.
   - 2.2 Deflate the tire being serviced by removing the valve core.
   - 2.3 Place a jack or wheel-and-tire dolly under the front wheel assembly being serviced. Remove the wheel nuts, then raise and remove the wheel assembly. Be careful not to damage the threads of the wheel studs as the wheel is pulled away.
3. Remove the wheels and tires from a rear axle:
   - 3.1 Raise the rear of the vehicle until the tires clear the floor. Place safety stands under the axle being serviced.
   - 3.2 Deflate both tires of the dual assembly being serviced by removing the valve cores.
   - 3.3 Place a jack or wheel-and-tire dolly under the outer wheel assembly. Remove the outer wheel nuts, then raise and remove the outer wheel. Be careful not to damage the threads of the inner wheel nuts as the outer wheel is pulled away.
   - 3.4 Place a jack or wheel-and-tire dolly under the inner wheel assembly. Remove the inner wheel nuts, then raise and remove the inner wheel. Be careful not to damage the threads of the wheel studs as the inner wheel is pulled away.

Installation

IMPORTANT: Before installing the wheels, it is recommended that an anti-seize compound be applied on the 360 degree wheel pilot hubs of Meritor FF-981 "Easy Steer Plus" front axles. After time in service, a small amount of rust or corrosion may make the wheel difficult to remove because of the extended wheel-to-hub contact. Applying an anti-seize compound on the wheel pilot of the hub will ensure easy wheel removal at a later date. Compounds such as the following may be used:

- Armite Led-Plate No. 250
- Loctite Anti-Seize No. 767
- Never-Seez
- Permabond Anti-Seize No. 82-9839.

Compounds are available for purchase locally.

IMPORTANT: Freightliner "Turbo" wheel assemblies require directional mounting, as shown in **Fig. 1**.

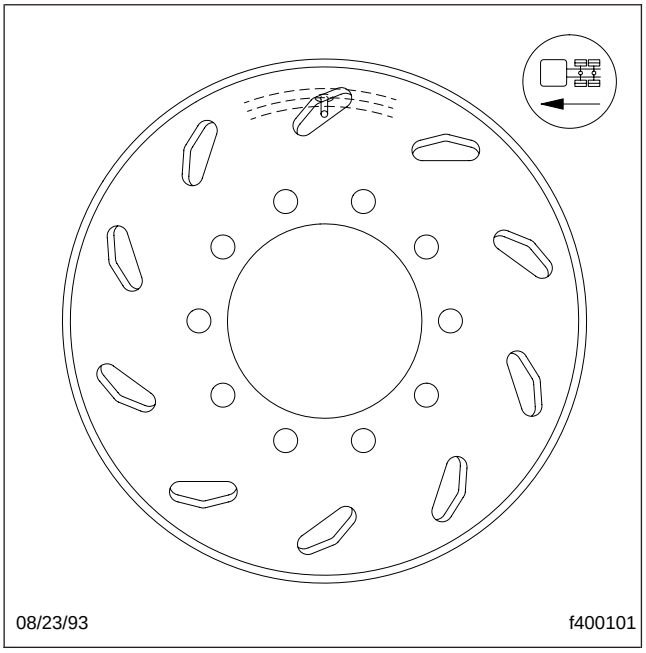


Fig. 1, Side View

NOTE: Before installing a wheel and tire assembly, inspect it using the instructions in **Subject 190**. Also, follow the tire matching and mixing requirements in **Subject 050**.

1. Clean the hub and wheel mounting surfaces, and between the rims of dual wheels. Make sure the tire is inflated using the procedures in **Subject 210**.

10-Hole Disc Wheel With Inner and Outer Nuts Removal and Installation

WARNING

Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.

IMPORTANT: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly. Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts.

2. If installing a rear wheel assembly, go to the next step. Install the front wheel assembly.
   - 2.1 Use a jack or wheel-and-tire dolly to mount the wheel assembly on the wheel studs. Be careful not to damage the threads of the wheel studs when installing the wheel assembly.
   - 2.2 Install a wheel nut on each wheel stud, and run them up until each nut is flush with the face or the chamfer of the wheel. Rotate the wheel a half turn to seat the parts.
   - 2.3 Tighten the wheel nuts 50 lbf·ft (68 N·m), following the sequence in **Fig. 2**.

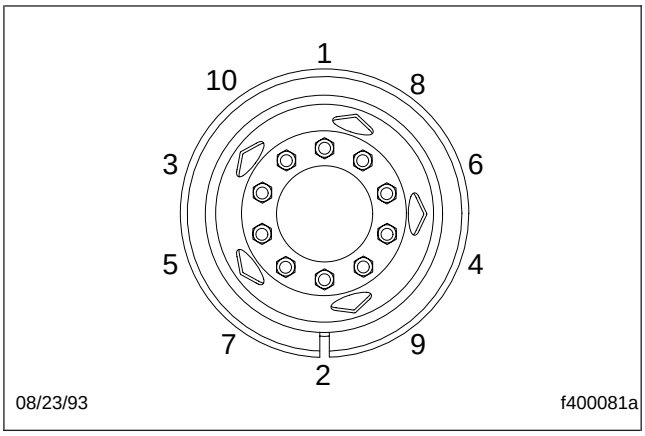


Fig. 2, 10-Stud Disc Wheel Tightening Sequence

   - 2.4 Using the same sequence, tighten the wheel nuts again, to the torque in the disc-type wheel fastener torque table in **Specifications, 400**.

WARNING

Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.

IMPORTANT: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly. Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts.

3. Install a rear wheel assembly:
   - 3.1 Use a jack or wheel-and-tire dolly to mount the inner wheel assembly on the wheel studs. Be careful not to damage the threads of the wheel studs when installing the wheel assembly.

   IMPORTANT: Mount the wheel assembly so that the balance weight(s) on the wheels are 180 degrees opposite the balance weight(s) on the brake drum. See **Fig. 3**.

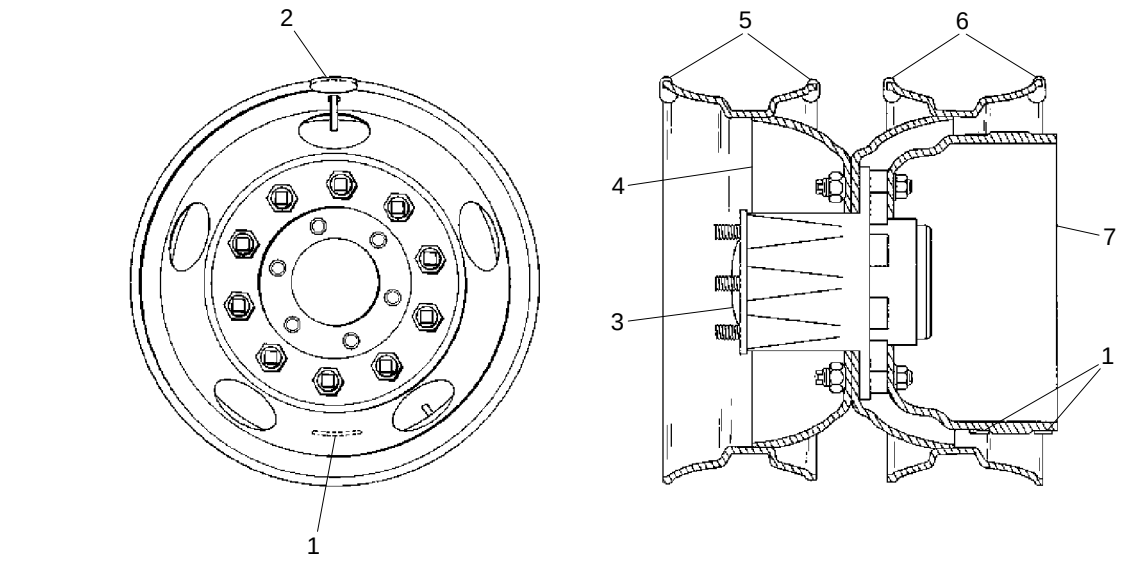
   If, on two-handhole wheels, this causes the valve stems to be in the same wheel hole, mount the outer wheel so that the outer wheel balance weight(s) are on the same side of the assembly as the brake drum balance weight(s). See **Fig. 4**.

   If, on five-handhole or aluminum wheels, the valve stems are in the same handhole, separate the valve stems by one hole. If balancing the wheels, install the wheel weights evenly and as close to 180 degrees opposite the brake drum balance weight(s) as possible. See **Fig. 5**.
   - 3.2 Install the inner wheel nuts on each wheel stud, and run them up until each

10-Hole Disc Wheel With Inner and Outer Nuts Removal and Installation

nut is flush with the face or the chamfer of the wheel. Rotate the wheel a half turn to seat the parts.

CAUTION



1. Brake Drum Balance Weight(s)
2. Inner and Outer Balance Weight(s)
3. Hub
4. Disc Wheel
5. Outer Wheel Balance Weight(s)
6. Inner Wheel Balance Weight(s)
7. Brake Drum

Fig. 3, Recommended Location of Wheel and Brake Drum Balance Weights

3.3 Tighten the inner wheel nuts 50 lbf·ft (68 N·m), following the sequence in **Fig. 2**.

3.4 Using the same sequence, tighten the inner wheel nuts again, to the torque in the disc-type wheel fastener torque table in **Specifications, 400**.

3.5 Use a jack or wheel-and-tire dolly to mount the outer dual wheel on the inner wheel nuts. Be careful not to damage the threads of the inner wheel nuts when installing the wheel assembly.

3.6 Install the outer wheel nuts following the procedures above.

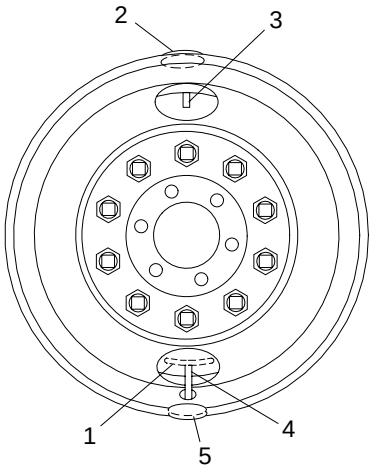
4. Remove the safety stands, lower the vehicle, and remove the chocks.

Locknuts seat during vehicle operation. It is necessary to periodically tighten the wheel nuts to the specified torque. Not enough wheel nut torque can cause wheel shimmy, wheel damage, stud breakage, and extreme tire tread wear. Too much wheel nut torque can break studs, damage threads, and crack discs in the stud hole area. Use the specified torque values, and follow the tightening sequence in Fig. 2.

5. After operating the vehicle for 50 to 100 miles (80 to 160 km), retighten the wheel nuts to the torque in the disc-type wheel fastener torque table in **Specifications, 400**. Follow the sequence in **Fig. 2**.

NOTE: When retightening the inner wheel nuts, loosen the outer wheel nuts several turns, retighten the inner wheel nuts, then the outer wheel nuts.

10-Hole Disc Wheel With Inner and Outer Nuts Removal and Installation



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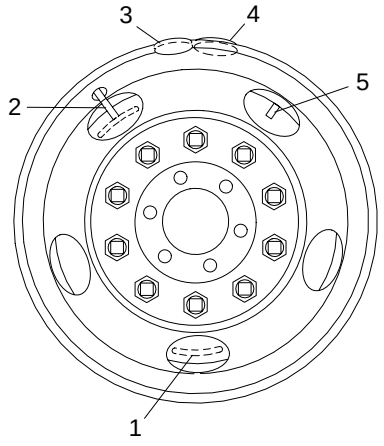
1. Brake Drum Balance Weight(s)
2. Inner Wheel Balance Weight(s)
3. Inner Wheel Valve Stem
4. Outer Wheel Valve Stem
5. Outer Wheel Balance Weight(s)

Fig. 4, Alternate Location of Wheel and Brake Drum Balance Weights, Two-Handhole Wheels



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1. Brake Drum Balance Weight(s)
2. Outer Wheel Valve Stem
3. Outer Wheel Balance Weight(s)
4. Inner Wheel Balance Weight(s)
5. Inner Wheel Valve Stem

Fig. 5, Alternate Location of Wheel and Brake Drum Balance Weights, Five-Handhole or Aluminum Wheels

Spoke Wheel, Tire and Rim Assembly; Removal and Installation

Removal

1. Chock all tires that will not be serviced, to prevent vehicle movement.
2. If removing tire and rim assemblies from the front axle:
   - 2.1 Apply the parking brakes.
   - 2.2 Raise the front of the vehicle until the tires clear the floor. Place safety stands under the front axle.
   - 2.3 Deflate the tire being serviced by removing the valve core.
   - 2.4 Place a jack or wheel-and-tire dolly under the front tire and rim assembly being serviced. Remove the rim nuts and rim clamps, then slide the tire and rim assembly off the wheel.
3. If removing tire and rim assemblies from a rear axle:
   - 3.1 Raise the rear of the vehicle until the tires clear the floor. Place safety stands under the axle being serviced.
   - 3.2 Deflate the tire(s) being serviced by removing the valve core(s).
   - 3.3 Place a jack or wheel-and-tire dolly under the outer tire and rim assembly being serviced. Remove the rim nuts and clamps; then slide the outer tire and rim off.
   - 3.4 Remove the rim spacer. Place a jack or wheel-and-tire dolly under the inner tire and rim assembly, and slide it off.

Installation

NOTE: Before installing a wheel and tire assembly, inspect it using the instructions in **Subject 190**. Also, follow the tire matching and mixing requirements in **Subject 050**.

1. Clean the wheel, rim spacer, and rim mounting surfaces. The mounting surface of the wheel is the 28-degree taper on the inboard side of each spoke. **See Fig. 1.**
2. Make sure the tire and rim assembly is inflated using the procedures in **Subject 210**.

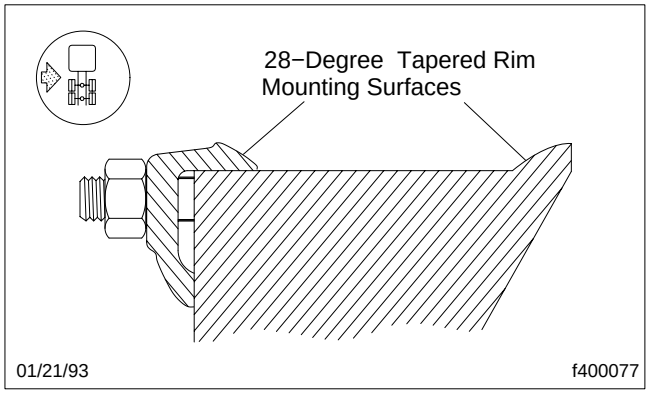


Fig. 1, Spoke Wheel Tapered Mounting Surface

3. If installing a front tire and rim assembly:
   - 3.1 Slide the assembly over the wheel and push it into place against the tapered mounting surface. It should fit snugly against all the tapers. Be sure that the valve stem faces out and is centered between two spokes.
   - 3.2 Install the rim clamps and nuts. Run the nuts up until the end of each wheel stud is flush with the face of its nut. Rotate the wheel a half turn to seat the parts.
   - 3.3 Tighten the rim nuts a quarter turn at a time, following the star pattern shown in **Fig. 2**. Continue until all the rim nuts are tightened to the torque in the applicable torque table in **Specifications, 400**.

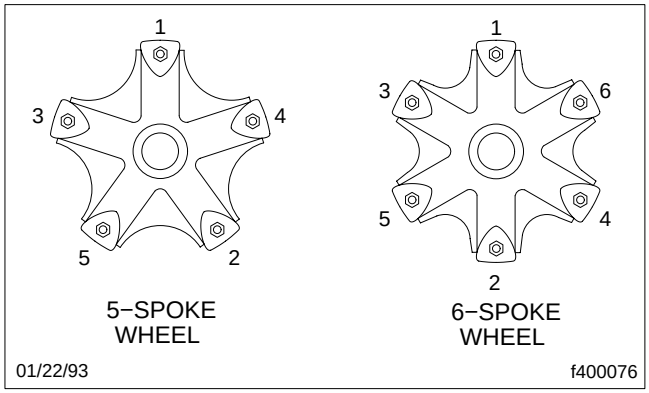


Fig. 2, Spoke Wheel Tightening Sequence

Spoke Wheel, Tire and Rim Assembly; Removal and Installation

CAUTION

CAUTION: Failure to tighten the nuts in the sequence shown, and to the correct torque, could cause misalignment of the tire and chording of the rim (Fig. 3). This would result in excessive vehicle vibration and permanent damage to the rim and wheel.

WARNING

WARNING: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly.

Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts, as described in the front or rear axle section in this manual. Failure to replace damaged parts could result in the loss of a wheel and loss of vehicle control, causing property damage or personal injury.

NOTE: When replacing a spoke wheel, contact the wheel manufacturer for the correct torque value for the brake drum nuts attaching the spoke wheel to the brake drum.

4. If installing a rear tire and rim assembly:
   - 4.1 Slide the inner tire and rim over the wheel hub. Push it into position against the tapered mounting surface. Make sure the valve stem faces out and is centered between two spokes.
   - 4.2 Slide the rim spacer over the wheel hub.
   - 4.3 Slide the outer tire and rim over the wheel hub. Make sure the valve stem faces inward, and is in the same position as the inner valve stem.
   - 4.4 Push the whole assembly in place, so that the inner rim fits snugly against the tapers all around, the spacer is seated against the inner rim, and the outer rim is seated against the spacer.
   - 4.5 Install the rim clamps and nuts. Run the nuts up until the end of each stud is flush with the face of its nut. Rotate the wheel a half turn to allow the parts to seat.
   - 4.6 Tighten the rim nuts a quarter turn at a time, following the star pattern shown in **Fig. 2**. Continue until all the rim nuts are tightened to the torque in the applicable torque table in **Specifications, 400**.
   - 4.7 The clamps must not bottom out until at least 80 percent of the recommended torque is reached. If the clamps do bottom out, make sure the correct clamps and rim spacers are being used. Make sure the rim edges contact the spacer edges.

CAUTION

CAUTION: Failure to tighten the nuts in the sequence shown, and to the correct torque, could cause misalignment of the tire and chording of the rim (Fig. 3). This would result in excessive vehicle vibration and permanent damage to the rim and wheel.

WARNING

WARNING: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly.

Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts, as described in the front or rear axle section in this manual. Failure to replace damaged parts could result in the loss of a wheel and loss of vehicle control, causing property damage or personal injury.

NOTE: When replacing a spoke wheel, contact the wheel manufacturer for the correct torque value for the brake drum nuts attaching the spoke wheel to the brake drum.

5. Check the wheel alignment by placing a block of wood or any other point of reference on the floor next to the tire. Rotate the tire and note any variations in the space between the tire and the block. If the variation exceeds 1/16-inch (1.5

mm) for front rims, or 1/8-inch (3 mm) for rear duals, the rim is not correctly mounted.

To correct any misalignment, loosen the rim nuts where the largest gap occurs, and tighten the nuts on the opposite side. Recheck and correct until the variation is corrected. Make sure the rim nuts are tightened to the correct torque in the applicable torque table in **Specifications, 400**.

6. Remove the safety stands, lower the vehicle, and remove the chocks.
7. After driving the vehicle for 50 to 100 miles (80 to 160 km), retighten the rim nuts to the torque specified in the applicable torque table in **Specifications, 400**. Follow the sequence shown in **Fig. 2**.

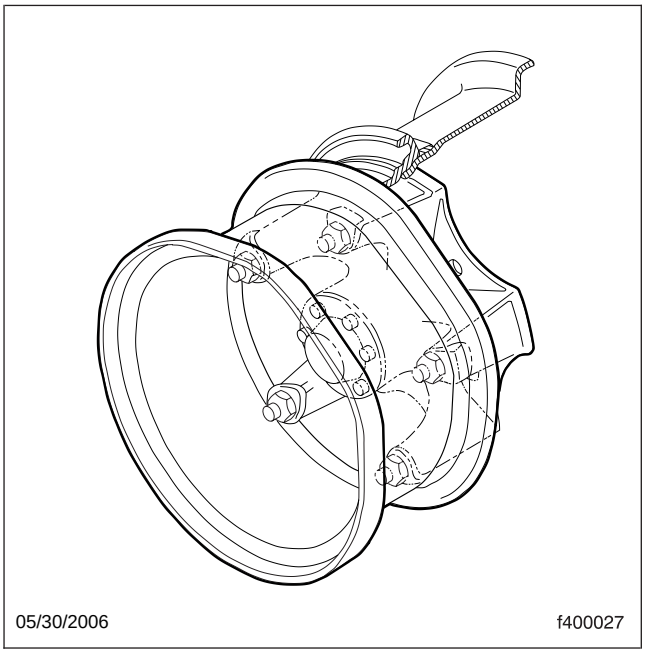


Fig. 3, Out-of-Round Rim (Rim Cording)

Tire Demounting and Mounting Service Precautions

Service Precautions

IMPORTANT: Don't mount or demount tires without proper training as required in Occupational Safety and Health Administration (OSHA) Rules and Regulations 1910.177, *Servicing Multi-Piece and Single Piece Rim Wheels*. Service information containing mounting and demounting instructions are available through your rim supplier. Charts detailing service procedures are available through OSHA area offices. The address and telephone number of the nearest OSHA area office can be obtained by looking in the local telephone directory under U.S. Government, Labor Department of Occupational Safety and Health Administration.

Use the information from the above sources with the following precautions before and during the demounting and mounting of tires:

- Examine all wheel and tire parts as explained in **Subject 190** and **Subject 200** . Replace damaged, rusted, or worn parts.
- Since wheels and rims are under stress, and are dangerous if improperly assembled, be sure all parts of an assembly match in size, manufacturer, and classification within a manufacturer's line. Before assembling the wheel or rim, check the catalog issued by the wheel or rim manufacturer for the correct part numbers and sizes of approved parts. Never use a part that does not bear clear, legible, and correct numbers and manufacturer's identification, even if that part appears to fit.
- Make sure that tires are stored indoors, or outdoors under cover, to prevent water collecting inside the tire.
- Use special tools, as recommended by tire suppliers, for mounting and demounting tires. These tools must be smooth, and used with care, to avoid gouging the rim.
- Loosening tire beads may be difficult, since considerable force may be needed. The use of a machine designed for loosening tire beads is recommended.
- Handle the wheels and rims on a wooden floor or rubber mat to prevent nicking or gouging the wheel or rim.
- Do not use a duck-bill hammer, or any steel hammer on wheel or rim parts. Use rubber, leather-faced, or plastic mallets to tap parts together, if necessary.
- Lubricate the tire with an approved tire-mounting lubricant. Never use antifreeze, silicones, petroleum-based lubricants, or any flammable material (ether/starting aid).
- When lubricating a tire prior to mounting, make sure excess lubricant does not run into the tire.
- Michelin Tire Corporation recommends applying lubricant to the valley of the tire, formed by the tire and rim, before using tools to break the bead.
- Michelin also recommends applying a sufficient but sparing amount of lubricant to the entire rim face when mounting a tire on a rim, to ensure correct bead seating and ease of mounting.
- Don't reinflate a tire that has been run flat or has been run at 80 per cent or less of its recommended operating pressure. Use your spare. Before removing the low tire from the vehicle, make sure it is completely deflated. Later, have the assembly taken apart and all the parts checked for damage, including the side or lockrings.
- The air pressure contained in a tire is dangerous. When servicing a tire, stay out of any potential path or route that a rim wheel component may travel during an explosive separation.

Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims

Five Degree Full Drop Center

WARNING

WARNING: Read the information in Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing equipment damage and personal injury.

To demount or mount tubeless tires on 5 degree full drop center rims, regular or safety type, follow the same procedures used to demount or mount tubeless automobile tires.

Fifteen Degree Tapered Drop Center

WARNING

WARNING: Read the information in Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing equipment damage and personal injury.

DEMOUNTING

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Loosen both beads from the rim by driving the flat end of the tire tool between the tire bead and the rim flange. Holding the tool upright, hammer on the neck to free the tire bead from the rim (**Fig. 1**). Repeat at 8-inch (20 cm) intervals around the flanges, until both beads are free from the rim.
3. Place the wide side of the rim down. Lubricate the tire bead and the rim. Insert the curved end of two tire tools between the bead and the rim, and just to one side of the tire valve. Step on the side of the tire, opposite from the valve, to force the first bead into the rim well (**Fig. 2**). Hold one of the tools in place with your foot and pry with the second tool, forcing the bead over the rim flange. Continue to work the first bead off of the rim.

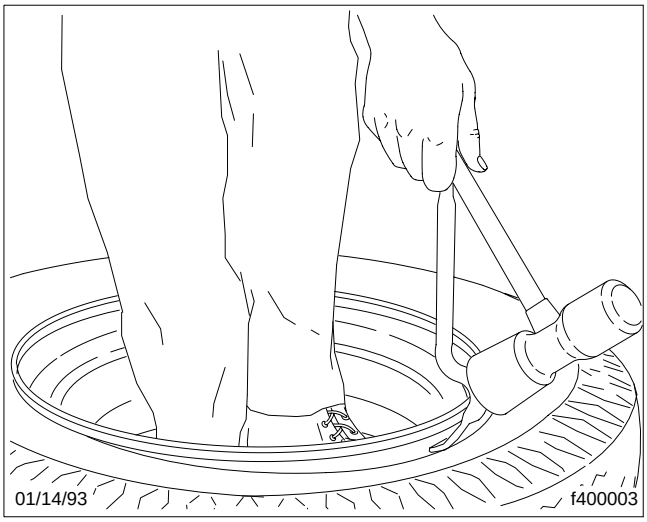


Fig. 1

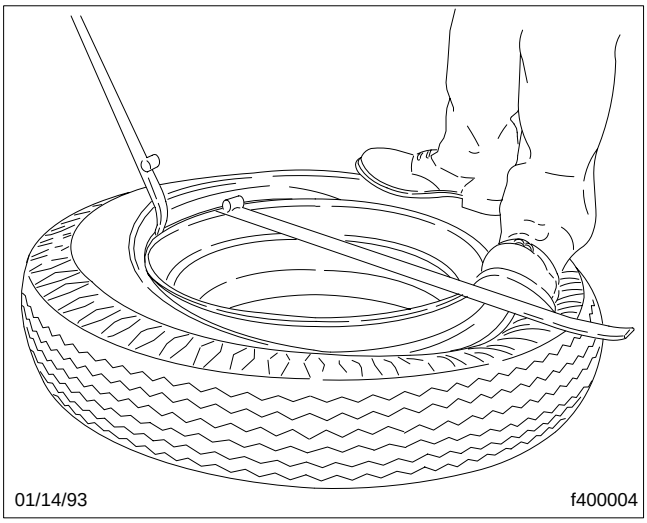


Fig. 2

4. When the first bead is off the rim, and the second bead is in the rim well, stand the assembly upright with the valve stem near the top. Lubricate the second bead and rim. Insert the straight end of the tool between the tire bead and the back rim flange, hooking the tool over the second flange. Lean the tire assembly toward the tool and use a rocking or bouncing action to pry the rim out of the tire. **See Fig. 3.**

Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims

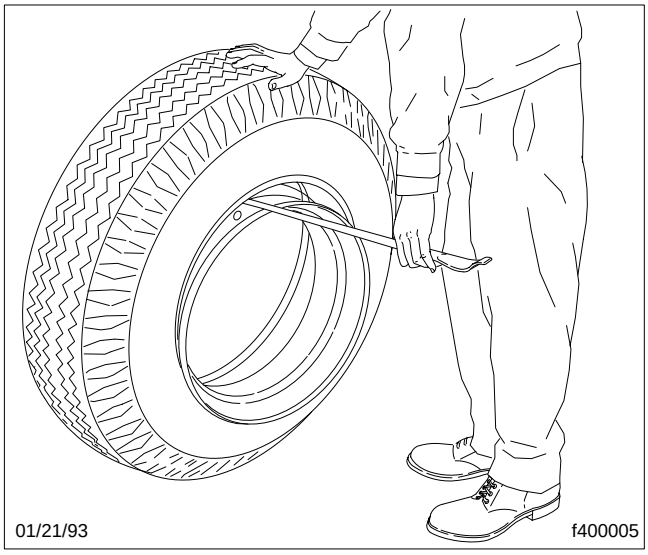


Fig. 3

5. Clean and inspect all parts. Refer to **Subject 190** and **Subject 200** for procedures.

MOUNTING

1. Place the valve stem, with a rubber washer, through the valve hole from the tire side of the rim. Screw on the valve nut from the opposite side. Make sure the rubber bushing and metal collar or nut are centered and fit snugly in the valve hole (**Fig. 4**). Tighten the nut securely.

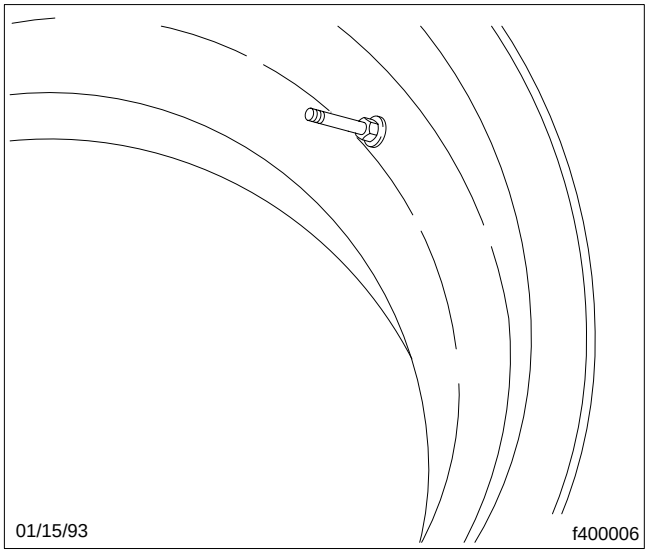


Fig. 4

2. Place the rim on the floor with the wide side down. Using a brush or swab, lubricate both bead seats (flanges) of the rim, and both tire beads, with an approved lubricant. Apply enough lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.
3. Lay the tire on the rim. If there is a balance mark on the tire, line up this mark with the valve stem. Push the lower bead over the flange and into the rim well. Using the straight end of the tire tool (with the stop resting on the rim flange), take small bites to work the remaining section of the bead into the rim. **See Fig. 5**.

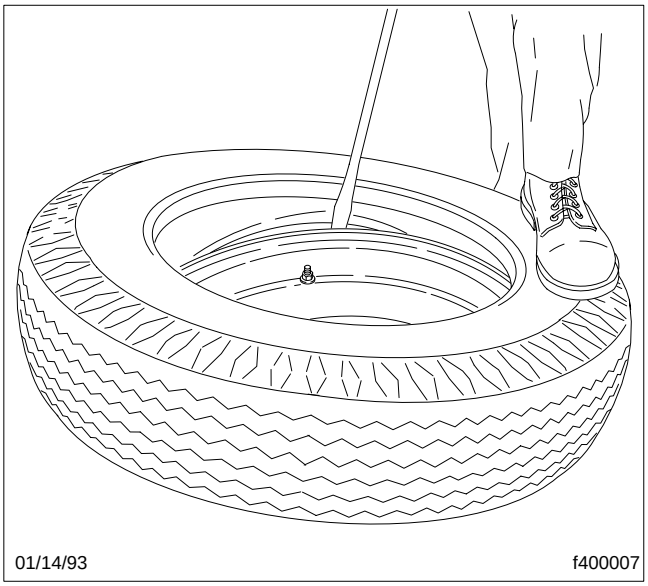


Fig. 5

4. Start the upper bead over the rim flange and into the rim well by standing on the tire. If necessary, push a section of the bead into the rim well, and anchor it by attaching Vise-Grip® pliers to the rim flange (snub side toward the tire). Using the spoon end of the tire iron, with the stop toward the rim, work around the bead (**Fig. 6**). Use small bites until the bead slips over the flange and into the rim well. If necessary, insert a second tire iron and relubricate the last 8 inches (20 cm) of bead.
5. Inflate the tire. Refer to **Subject 210** for procedures.

Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims

Fig. 6

Demounting and Mounting Tube-Type Tires on Two-Piece Flat Base Wheels or Rims

Continuous Base, Split Side Ring

WARNING

WARNING: Read the information in Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing equipment damage and personal injury.

DEMOUNTING

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Place the assembly on the floor, side ring up. Insert the hooked ends of the tire tools between the side ring and the sidewall of the tire. Pry the bead loose from the side ring using downward pressure on the tools (**Fig. 1**). Continue prying around the rim until the bead is loose.

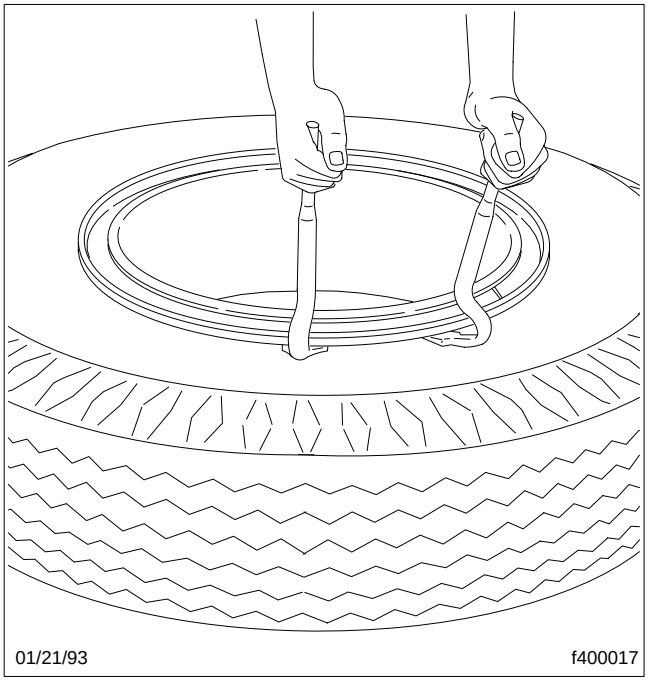


Fig. 1

3. Insert the tapered end of the tool into the prying notch on the side ring (**Fig. 2**) Pry the side ring from its groove in the rim by prying around the tire until the ring is free.

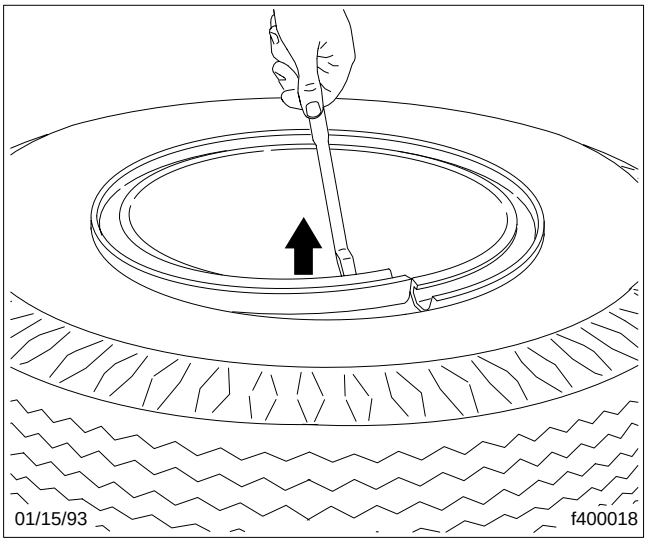


Fig. 2

4. Turn the assembly over, and unseat the second tire bead from the rim. Lift the rim from the tire, and remove the tube and flap from the tire.
5. Clean and inspect all parts. Refer to **Subject 190** and **Subject 200** for procedures.

MOUNTING

1. Place the tube in the tire, then partially inflate it to round it out. Apply an approved tire lubricant to the inside and outside surfaces of both beads and to the portion of the tube that appears between the beads. Insert the flap, and lubricate the portion of the flap that faces the rim. Apply enough lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.
2. Lay the rim flat on the floor with the valve slot up. Align the valve with the rim valve-slot. Place the tire on the rim, and insert the valve through the valve slot.
3. Place the side ring on the rim base so that the ring split is opposite the valve stem. Snap the leading end of the side ring into the rim groove (

Demounting and Mounting Tube-Type Tires on Two-Piece Flat Base Wheels or Rims

Fig. 3). Progressively "walk" the side ring into place. Check that the side ring is seated in the groove.

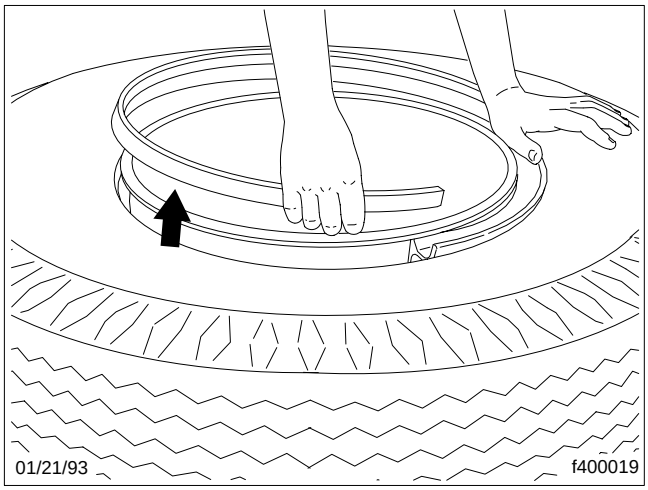


Fig. 3

4. Inflate the tire. Refer to **Subject 210** for procedures.

Split Base, Continuous Side Ring

WARNING

WARNING: Read the information in Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing equipment damage and personal injury.

DEMOUNTING

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Place the assembly on the floor, side ring up. Insert the hooked ends of the tools between the side ring and the sidewall of the tire. Pry the bead loose from the side ring using downward pressure on the tools (**Fig. 1**). Continue prying around the tire until the bead is loose.
3. Insert the tapered end of the tool into the breaking notch near the rim split, and push downward, partially offsetting the rim ends.
4. Insert the tapered end of the tool in the second rim notch, and push downward, prying the continuous side ring from the rim. **See Fig. 4.**

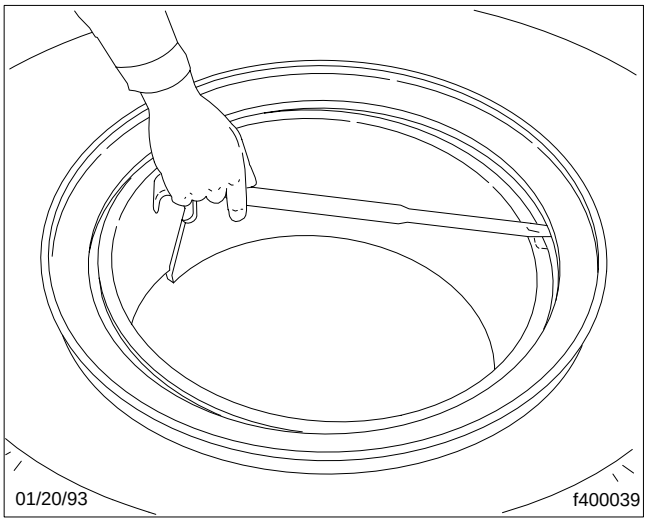


Fig. 4

5. Turn the assembly over, and unseat the second tire bead from the rim. Lift the rim from the tire, and remove the tube and flap from the tire.
6. Clean and inspect all parts. Refer to **Subject 190** and **Subject 200**.

MOUNTING

1. Place the tube in the tire, then partially inflate it to round it out. Apply an approved tire lubricant to the inside and outside surfaces of both beads and to the portion of the tube that appears between the beads. Insert the flap, and lubricate the portion of the flap that faces the rim. Apply enough lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.
2. Spread the rim base by placing a wooden block under the left side of the rim split (as shown in **Fig. 5**). Place the tire, tube, and flap, over the rim base. Lay the rim flat on the floor with the valve slot up. Align the valve with the rim's valve slot. Place the tire on the rim, and insert the valve through the valve slot.

Demounting and Mounting Tube-Type Tires on Two-Piece Flat Base Wheels or Rims

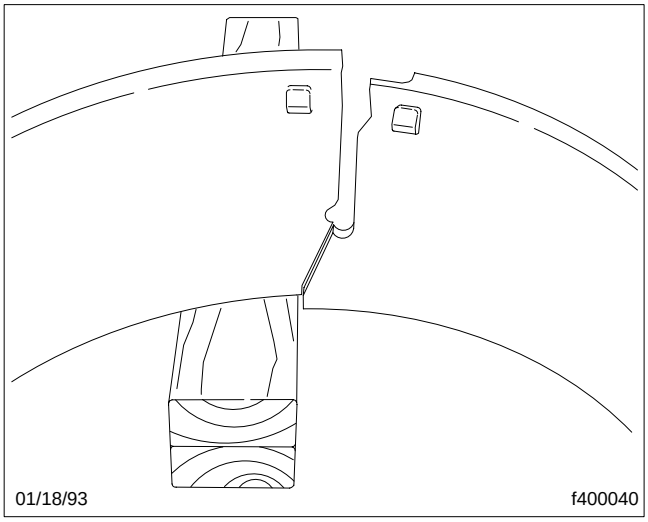


Fig. 5

3. Install the side ring by starting at the left side of the split and "walking" the ring into place.
4. Turn the assembly over. With the fixed flange side up, place a wooden block under the right side of the split. Tap the rim base, as shown in **Fig. 6**, until the split is correctly aligned.

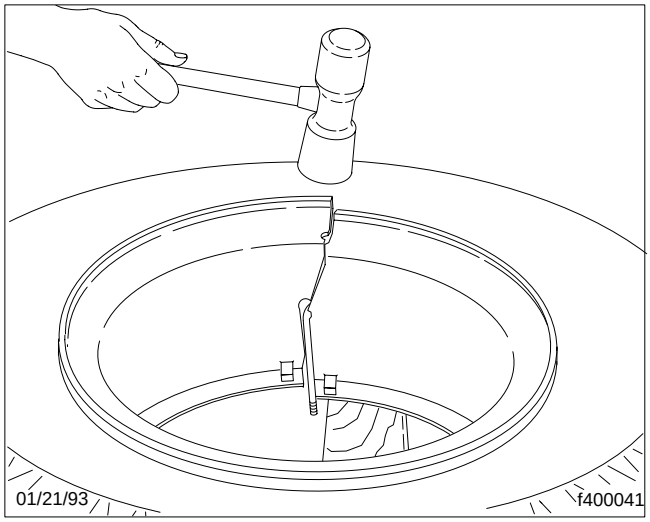


Fig. 6

5. Inflate the tire. Refer to **Subject 210** for procedures.

Continuous Base, Continuous Side Ring

WARNING

WARNING: Read the information in Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing equipment damage and personal injury.

DEMOUNTING

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Loosen the tire bead from the side ring by driving the curved end of a rim tool between the side ring and the bead (**Fig. 7**). Pry the bead loose from the side ring, using downward pressure on the tool. Continue prying around the tire until the bead is loose.

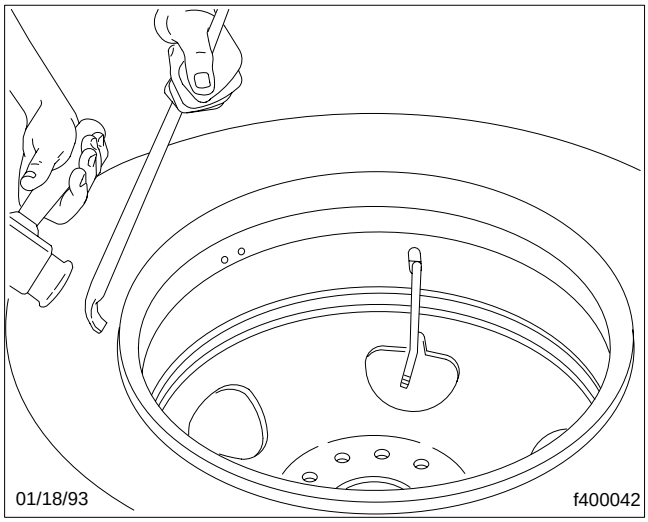


Fig. 7

3. Insert the straight end of a rim tool into the notch (located between embossings) in the side ring, as shown in **Fig. 8**. Push the ring downward at the point opposite the notch. At the same time, force the tool handle downward to disengage the

Demounting and Mounting Tube-Type Tires on Two-Piece Flat Base Wheels or Rims

ring from the rim gutter. Continue prying the side ring away from the rim gutter until it is loose.

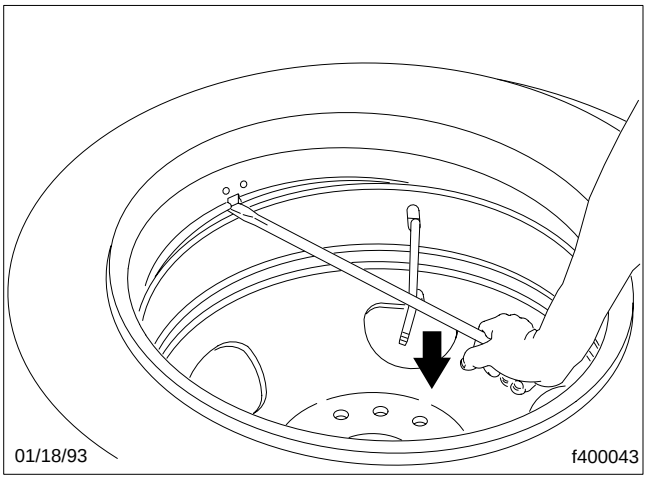


Fig. 8

4. Turn the assembly over, and unseat the second tire bead the same way the first bead was loosened from the side ring in the step above. Stand the tire up, then remove the rim base. Remove the tube and flap from the tire.
5. Clean and inspect all parts. Refer to **Subject 190** and **Subject 200** for procedures.

MOUNTING

1. Place the tube in the tire, then partially inflate it to round it out. Apply an approved tire lubricant to the inside and outside surfaces of both beads and to the portion of the tube that appears between the beads. Insert the flap, and lubricate the portion of the flap that faces the rim. Apply enough lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.
2. Place the disc portion of the wheel on the floor, with the rim gutter up. Position the tire, with the valve pointing in the desired direction, then insert the valve through the valve slot. Position the side ring by locating the operating notch between the two embossings, about 3 inches (8 cm) from the valve.
3. The two cutaway portions opposite each other in the inner diameter of the ring are placed so as to span the rim gutter. Opposite the valve, work half of the side ring into the gutter, as far as possible, using a mallet.
4. Insert the straight end of the rim tool into the notch, then pull on the rim tool. **See Fig. 9.** Maintaining pressure with the tool, strike the side ring downward with a mallet at the point between the tool slot and the cutaway portion, forcing the side ring over the rim gutter. Remove the tool, then strike additional blows, moving toward the other cutaway portion, until the entire toe of the side ring passes over the rim gutter. Be sure the side ring has cleared the gutter of the rim base and that the side ring can be depressed by hand.

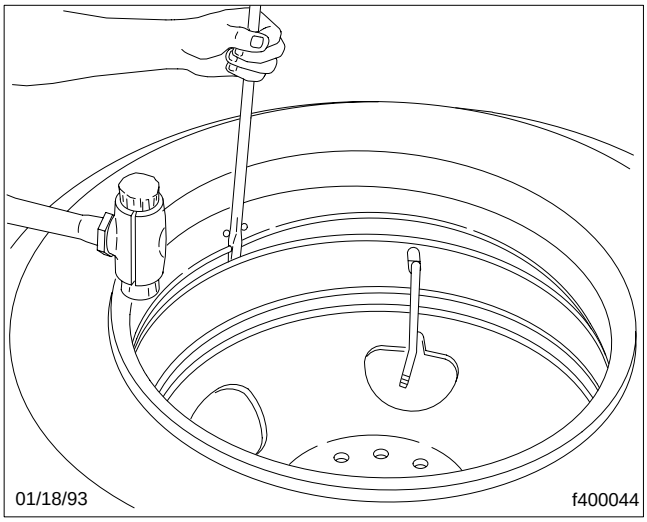


Fig. 9

5. Inflate the tire. Refer to **Subject 210** for procedures.

Demounting and Mounting Tube-Type Tires on Three-Piece Flat Base Wheels or Rims

Continuous Side Ring, Split Lockring

DEMOUNTING

⚠ WARNING

WARNING: Read the information in Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing equipment damage and personal injury.

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Place the tire on the floor, side ring up. Insert the hooked ends of the tire tools between the side ring and the sidewall of the tire. Pry the bead loose from the side ring, using downward pressure on the tools (**Fig. 1**). Continue prying around the tire until the bead is loose.
3. With the side ring and tire bead pushed down, insert the tapered end of the tool into the notch near the split in the lockring.
4. Push downward to pry the lockring from the gutter groove of the rim base. **See Fig. 2.**
5. Using the hooked end of the tool, complete the removal of the lockring by working around the tire (**Fig. 3**). Lift off the side ring. Turn the assembly over and unseat the second tire bead from the rim. Lift the rim from the tire and remove the tube and flap from the tire.
6. Clean and inspect all parts. Refer to **Subject 190** and **Subject 200** for procedures.

MOUNTING

1. Place the tube in the tire, then partially inflate it to round it out. Apply an approved tire lubricant to the inside and outside surfaces of both beads, and to the portion of the tube that appears between the beads. Insert the flap, and lubricate the portion of the flap that faces the rim. Apply enough lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.

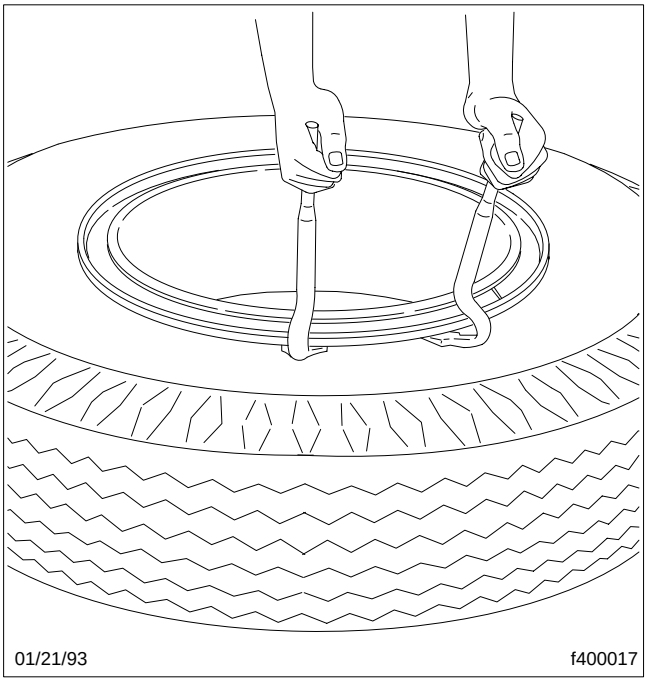


Fig. 1

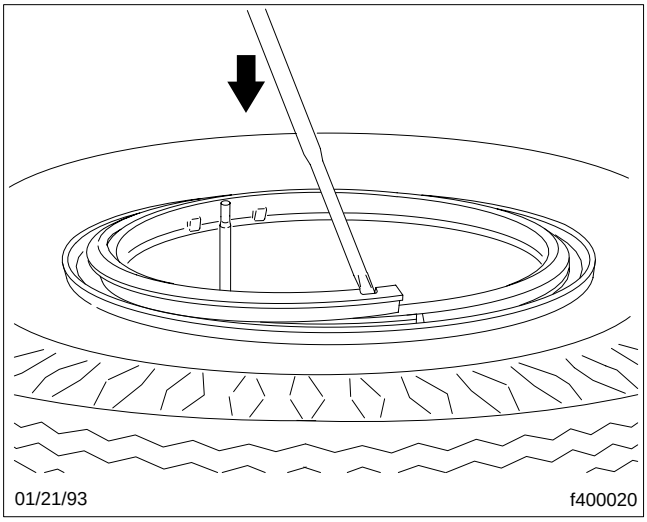


Fig. 2

2. Lay the rim flat on the floor, with the valve slot up. Align the valve with the rim valve slot. Place the tire on the rim and insert the valve through the slot.
3. Place the side ring on the rim base and stand on the ring to position it below the gutter grooves in the rim base.

Demounting and Mounting Tube-Type Tires on Three-Piece Flat Base Wheels or Rims

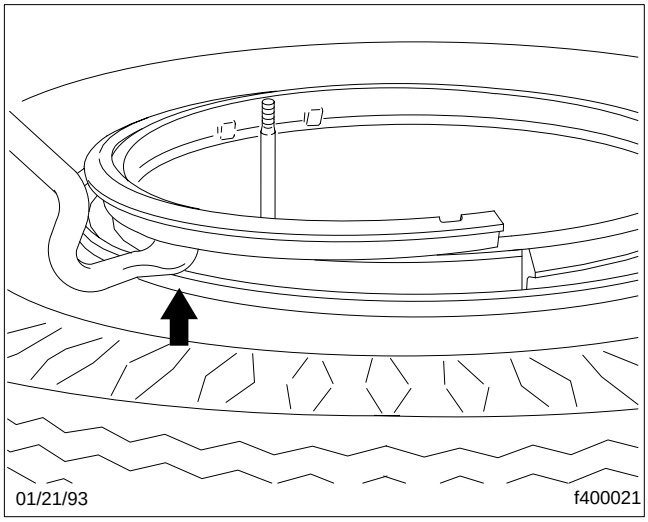


Fig. 3

4. Snap the leading end of the lockring into the gutter groove of the rim base, and "walk" the lockring into place (**Fig. 4**). Check that the lockring is seated in the gutter groove.
5. Inflate the tire. Refer to **Subject 210** for procedures.

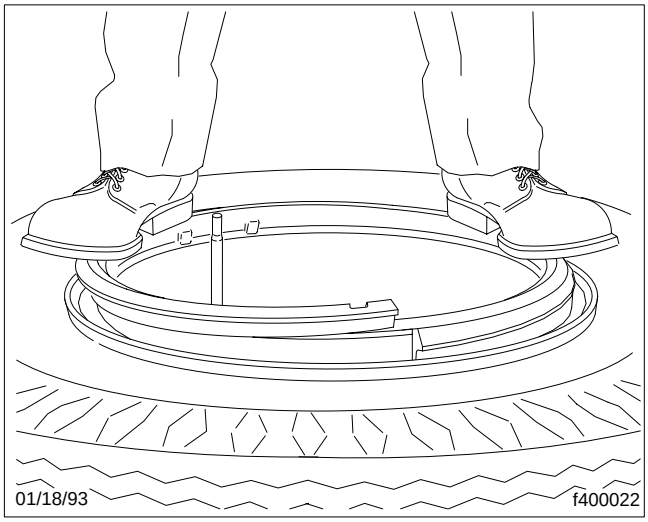


Fig. 4

Demounting and Mounting Tube-Type Tires on Semi Drop-Center Wheels or Rims

Continuous Base, Split Side Ring

Refer to **Subject 160**, "Continuous Base, Split Side Ring," for tire demounting and mounting on a rim with a continuous base and a split side ring.

Continuous Base, Continuous Side Ring

DEMOUNTING

⚠ WARNING

WARNING: Read the information in Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing equipment damage and personal injury.

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Place the tire and wheel on the floor with the side ring up. Loosen the first bead by driving the hooked end of the rim tool between the tire and rim flange, then press downward on the bead. Do this around the rim, using two tools, as shown in **Fig. 1**.
3. Insert the tool into the notch; then using foot pressure, force the side ring opposite the notch into the gutter (**Fig. 2**). Then, prying up and out on the side ring, carefully pry off the side ring. Don't bend the side ring.
4. Force the upper tire bead into the well opposite the valve slot. With the tire tool, pry the opposite portion of the bead over the edge of the rim.
5. Turn the tire over. Using the tools, loosen the bead on the opposite bead seat. This can be done using foot pressure. Make sure one portion of the second bead is still in the rim well, then pry the opposite portion of the bead over the edge of the rim. This will free the tire from the rim (**Fig. 3**). Remove the tube and flap from the tire.
6. Clean and inspect all parts. Refer to **Subject 190** and **Subject 200** for procedures.

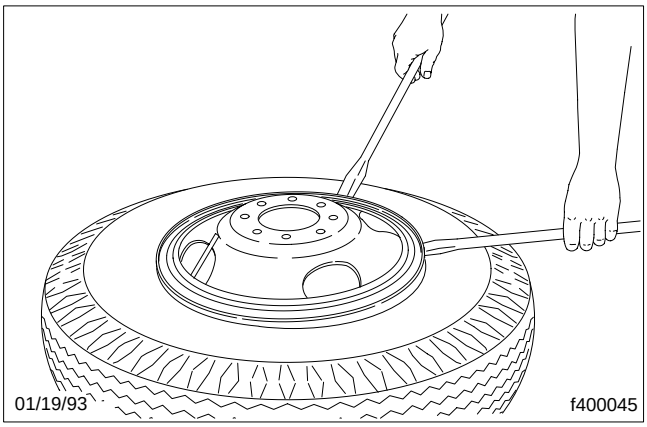


Fig. 1

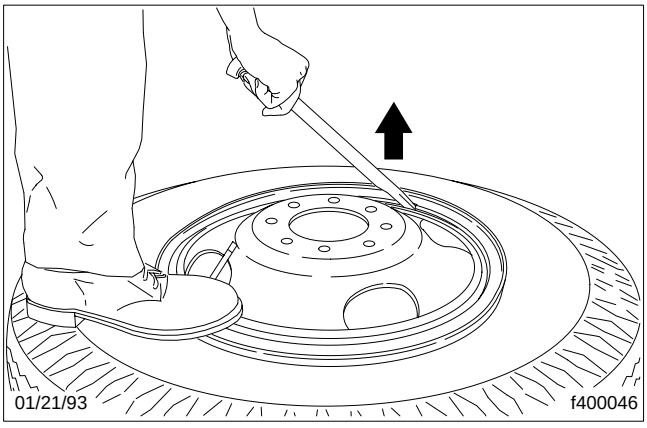


Fig. 2

MOUNTING

1. Place the tube in the tire and partially inflate it to round it out. Apply an approved tire lubricant to the inside and outside surfaces of both beads and to the portion of the tube that appears between the beads. Insert the flap, and lubricate the portion of the flap that faces the rim. Apply enough lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.
2. Place the tire on the rim so that the valve lines up with the valve hole. Insert the valve through the valve hole. Using foot pressure, work the first bead into the rim well just to the side of the valve. Pry the first bead over the rim gutter with

Demounting and Mounting Tube-Type Tires on Semi Drop-Center Wheels or Rims

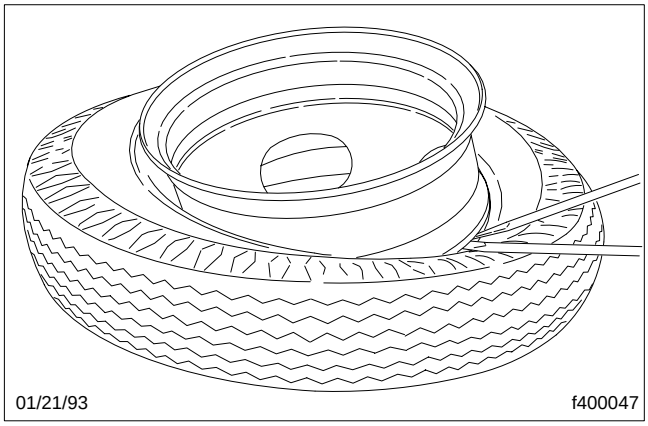


Fig. 3

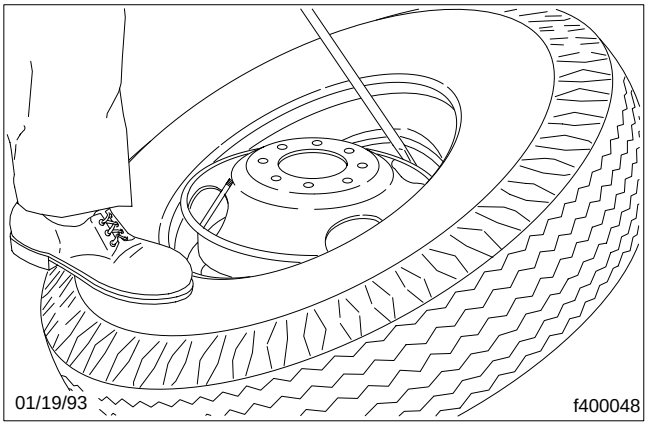


Fig. 4

the rim tool, moving from each side of your foot, alternately, to a point just opposite your foot (**Fig. 4**). Then pry the last section over the rim gutter.

3. To mount the second bead, start at a point opposite the valve, and using foot pressure, press the bead toe over the rim gutter and into the rim well. Mount the remainder of the bead over the rim gutter, using a thin tire tool, and following the procedure in the step above. Be careful not to pinch the tube.
4. Place half of the side ring in the rim gutter with the cutaway portions in place, as shown in **Fig. 5**. Insert the thin end of a rim tool or heavy screwdriver, then pull the side ring outward toward the centered position. Work the side ring into the gutter by striking it with a mallet.
5. Inflate the tire. Refer to **Subject 210** for procedures.

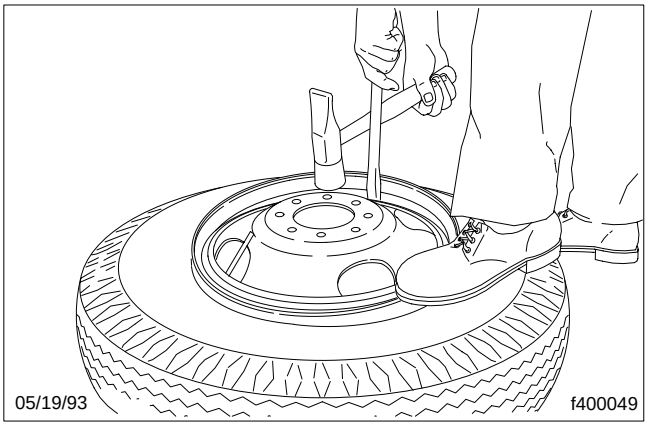


Fig. 5

Inspection

⚠ WARNING

WARNING: Failure to inspect the tires and wheels and correct any problems, could cause tire or rim damage while servicing or while in use. An incorrectly mounted tire can burst causing equipment damage and personal injury.

Examine the wheel or rim, and all parts. Remove any grease, dirt, or rust. Using a wire brush, remove any rubber from the bead seat. Use special care when cleaning the rim gutter. Rust or other foreign matter can prevent the correct fitting of side rings. Replace corroded parts. Paint the rim to prevent corrosion.

NOTE: Don't paint Alcoa aluminum disc wheels. If the wheels are corroded, contact the manufacturer for instructions.

Sprung or broken rings (**Fig. 1**), a cracked rim, wheel (**Fig. 2**), or brake drum, damaged inner or outer wheel nuts (**Fig. 3**), or an out-of-round wheel or rim, requires the replacement of the damaged part. Replace the wheel if it has out-of-round stud holes.

NOTE: Refer to the front and rear axle sections in this manual for inspection and service procedures for the hub, wheel studs, wheel, and brake drum assemblies. When replacing the spoke wheel or the brake drum, contact the wheel manufacturer for the correct torque value for the brake drum nut that attaches the spoke wheel to the brake drum.

Inspect valve cores for cracks, bends, and air retention. Replace damaged or leaky cores.

The most critical area of a spoke wheel is the 28-degree tapered rim mounting surface (**Fig. 4**). Clean the surface and examine it for damage or excessive wear. Replace the wheel if the mounting surface is damaged or worn below the 28-degree taper.

Check the clamps, rim spacer, rim studs, and spoke-wheel nuts for damage or wear. The clamps must not be excessively worn. The end of the wedge portion must be at least 1/16-inch thick (1.5 mm) (**Fig. 5**). The rim spacer must not be bent, distorted, or crushed. Replace all damaged or broken parts.

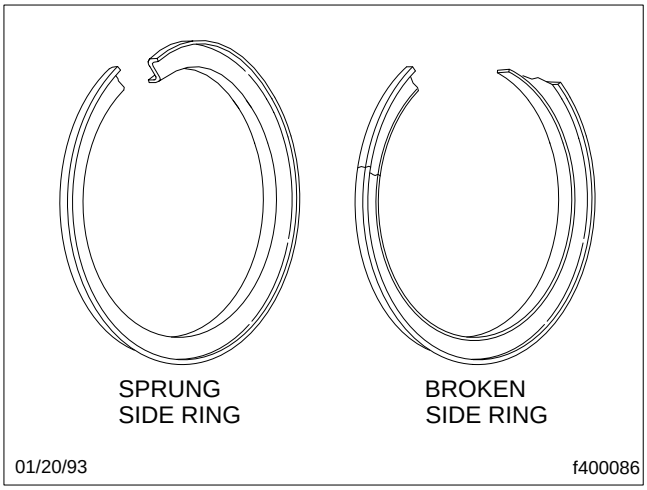


Fig. 1, Sprung and Broke Side Rings

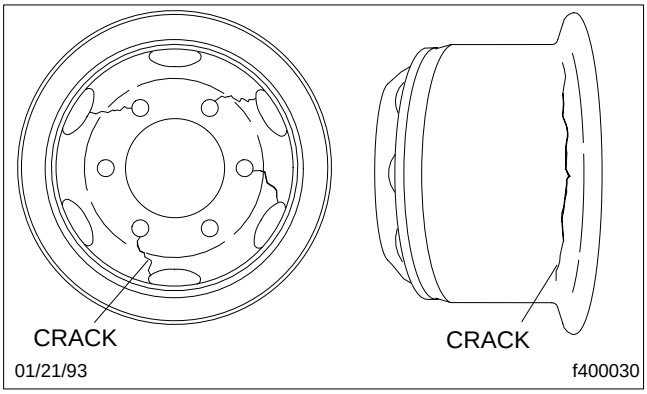


Fig. 2, Cracked Wheel and Rim

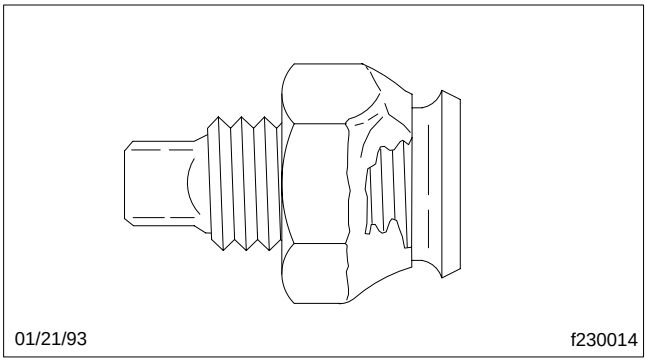


Fig. 3, Damaged Outer Wheel Nut

Do not attempt to rework, weld, heat, or braze any rim or wheel parts that are cracked, broken, or damaged. Use new parts or parts that are not cracked,

Wheel and Components Inspection

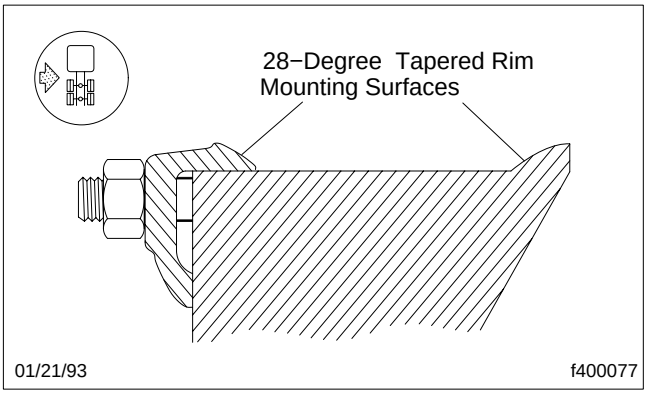


Fig. 4, Spoke Wheel Tapered Mounting Surface

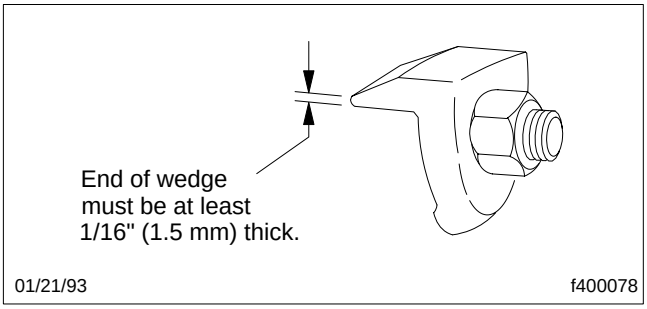


Fig. 5, Rim Clamp

broken, or otherwise damaged, and that are of the same size and type.

Remove all foreign matter, such as grease and dirt, from the wheel mounting surface. Smooth any projections on the mounting surface to ensure even pressure when tightening the wheel nuts.

Inspection

WARNING

WARNING: Failure to inspect the tires and wheels and correct any problems, could cause tire or rim damage while servicing or while in use. An incorrectly mounted tire can burst causing equipment damage and personal injury.

Inspect the inside and outside of the tire for out-of-roundness, loose cords, cuts, foreign objects, and other damage. Repair as needed. Contact the tire manufacturer for repair procedures.

Do not repair tires with the following problems:

- Cuts in the tread that are wire or breaker fiber deep.
- Tread worn to the wire or breaker fibers.
- Tread that is scalloped or otherwise worn unevenly.
- Visible, broken, deformed, or otherwise damaged bead wires.
- Deteriorated rubber.
- Rubber cracked to the wire or cord.
- Separations in the casing.
- Exposed cord (for example, due to weather checking or sidewall scuffing).

Inspect the tread for abnormal or excessive wear. Refer to **Troubleshooting, 300** for possible causes of abnormal wear. If the tires are wearing irregularly, they should be rotated. If the front axle tires become irregularly worn, they should be moved to the drive axle(s) or trailer axles. The front-end alignment should be checked. In a dual assembly, if one tire wears faster than its mate, the position of the two tires should be reversed. Refer to the vehicle maintenance manual for tire rotation procedures.

Government regulations require the removal of any tire with less than 2/32-inch (1.5 mm) tread remaining. Retread the tire (if possible), regroove it (only if marked "Regroovable" on the sidewall), or discard it.

Clean and inspect the tube and flap of tube-type tires. Discard tubes or flaps that are buckled or creased. Do not use an old tube in a new tire, and always mount a used flap in the same size tire and on the same size rim as the one from which it was removed. Michelin Tire Corporation recommends using only new tubes, flaps, valve cores, caps, and O-rings in a new mounting.

Tire Inflation

1. Check all parts to make sure they are correctly seated prior to inflation.

NOTE: Inflate tires in a safety cage (**Fig. 1**) or an approved portable restraining device. Always use a clip-on chuck with an inline valve and gauge. Make sure the inflation hose is long enough to permit standing to the side of the tire during inflation. Never sit on or stand in front of an assembly that is being inflated.

⚠ WARNING

WARNING: During initial tire inflation, there is the possibility of an explosion of the assembly. Observe the following safety rules to reduce the possibility of serious physical injury in the event of an explosion.

IMPORTANT: Inflate tires immediately after mounting, before the tire lubricant dries. Once the lubricant dries, bead positioning is not possible, even with increased inflation pressure.

Water in the tire can cause ply separation. During tire inflation, air tank reservoirs and lines must be dry. Use well-maintained air line moisture traps, and service them regularly.

2. After placing the tire in a safety cage, or an approved portable restraining device, inflate the tire to 10 psi (69 kPa). Check the parts for correct seating. If the seating is not correct, completely deflate the tire and correct the problem. Never attempt to seat rings or other parts by hammering on an inflated or partially inflated tire.

3. If there are no problems with the assembly at 10 psi (69 kPa), continue to inflate the tire to the recommended pressure. Refer to **Specifications, 400** for correct cold inflation pressures. Michelin Tire Corporation recommends an initial inflation pressure of 90 to 100 psi (620 to 690 kPa) to correctly seat the tire beads.

   IMPORTANT: Due to the different flex characteristics of radial sidewalls, it may be necessary to use an inflation aid to help seat tubeless tire beads:

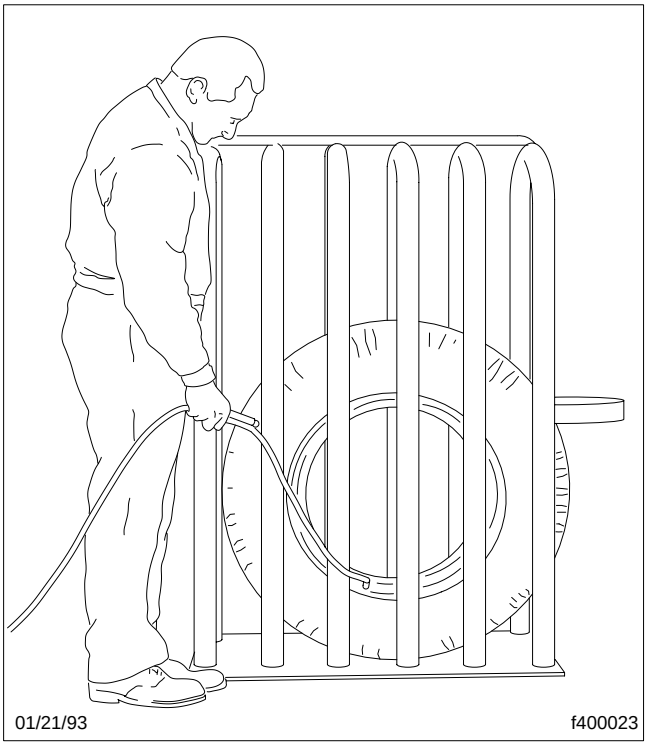


Fig. 1, Safety Cage

   NOTE: The position of the beads, flap, and tube with 4 to 5 psi (28 to 35 kPa) pressure is shown in **Fig. 2**. The tube is fully rounded-out within the tire, but there isn't enough pressure to move the beads on wide-base rims. Depending on the tire size and rim condition, from 20 to 40 psi (140 to 275 kPa) pressure is needed to push the beads onto the bead seat. **See Fig. 3.**

   3.1 Metal rings, which use a blast of compressed air to seat the beads.

   3.2 Rubber rings, which seal between the tire bead and rim, allowing the bead to move out and seat correctly. A well-lubricated, heavy-duty bicycle tube can be used to help seal between the tire bead and rim.

4. After the initial inflation, completely deflate the tire by removing the valve core. This ensures correct bead seating, and prevents buckling or overstretching the tube in tube-type tires. Then inflate the tire to the recommended cold inflation

Tire Inflation

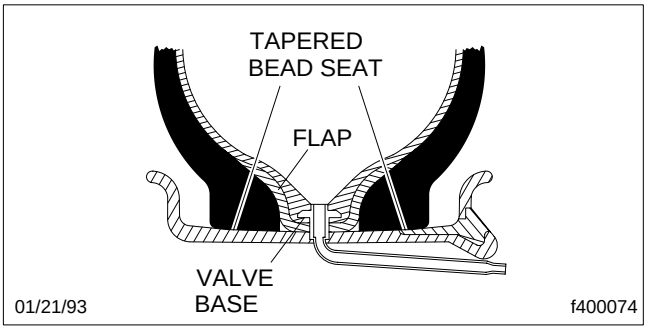


Fig. 2

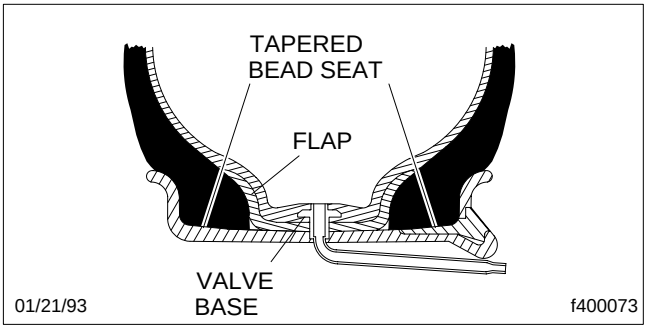


Fig. 3

pressure listed in **Specifications, 400**. Install valve caps and tighten them finger-tight.

CAUTION

CAUTION: Improperly inflating tube-type tires can crack or tear the edge or inside of the valve base. Once seated, the tube can stretch only in the rim area. Because resistance to stretch is greatest at the valve base, there is often enough tension to break the tube at the edge of the valve base or in the valve base.

NOTE: Inflate the tires to the recommended pressure. Driving on overinflated tires will weaken the cords by reducing their ability to absorb road shocks, and will increase the danger of cuts, snags, and punctures. Overinflation will overstress and damage the rims. Driving on underinflated tires will generate excessive heat. This weakens the tire body, and reduces tire strength.

WARNING

WARNING: Tire underinflation or overinflation will damage wheels and tires, and could result in a blowout causing possible property damage and personal injury.

Use tires of the same size, type, and capacity to carry the load at the recommended cold pressure. Attempting to increase the load capacity of a tire by overinflation will damage the tire assembly.

5. Check the inflation pressure 24 hours after mounting new tires.

NOTE: When testing a vehicle on a dynamometer, severe tire damage can occur. Because the manufacturers differ in their recommendations for preventing tire damage, refer to the manufacturer's instructions for testing a vehicle on a dynamometer.

General Information

Runout is side-to-side (lateral) or up-and-down (radial) movement when the tire/wheel assembly is rotated. Runout can be measured with a dial indicator, a tire runout gauge, or another instrument capable of measuring small movements of the tire/wheel assembly.

Lateral runout, shown in **Fig. 1**, is side-to-side movement of the rotating tire/wheel assembly. This may cause a perceived "shimmy" or "wobble".

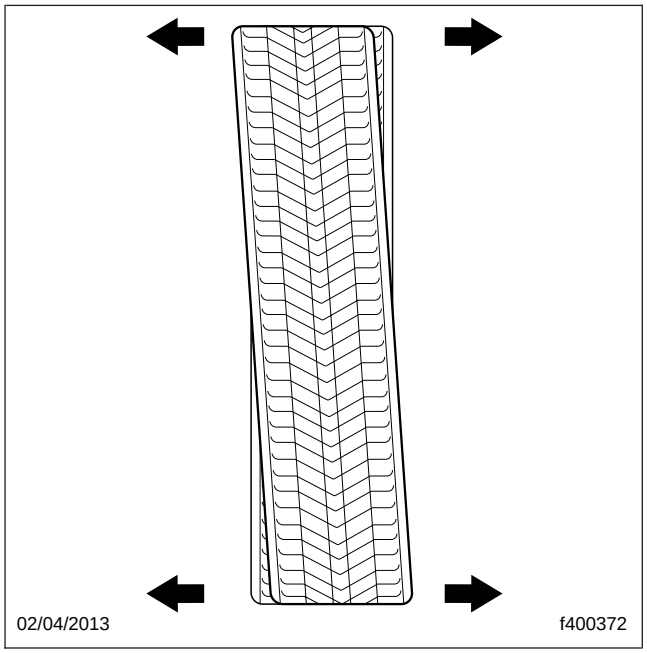


Fig. 1, Lateral Runout

Radial runout, shown in **Fig. 2**, is a changing radius of the rotating tire/wheel assembly. For a tire or wheel, its effect is to raise and lower the vehicle as it rolls along, giving the perception of a vertical "hop" or "bounce".

If a tire and wheel assembly shows visible up-and-down or side-to-side movement, it may have excessive runout. Use the inspection procedure that follows to measure runout.

Inspection

IMPORTANT: Before checking wheel runout, check the tires for proper:

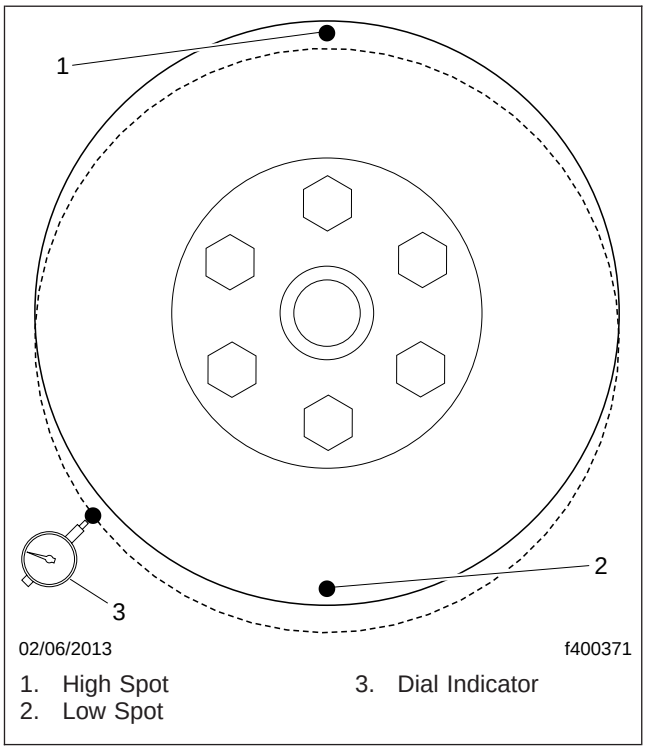


Fig. 2, Radial Runout

- inflation;
- wheel nut torque;
- bead seating on the rim.

Use a tire runout gauge, as shown in **Fig. 3**, to check lateral and radial runouts of the entire wheel end assembly.

Check radial runout on a smooth rib in the center of the tread. Check lateral runout on a smooth surface along the tire's mid-sidewall. If the wheel end assembly radial runout exceeds 0.060 inch (0.2 cm), or the lateral runout exceeds 0.150 inch (0.4 cm), the tire/wheel assembly should be removed to check the brake drum and hub runouts. Brake drum and hub runout tolerances are as follows:

- brake drum lateral runout—0.045 inch (0.11 cm)
- brake drum radial runout measured inside of the drum—0.020 inch (0.050 cm)
- hub lateral runout measured at the face of the hub—0.015 inch (0.38 cm)

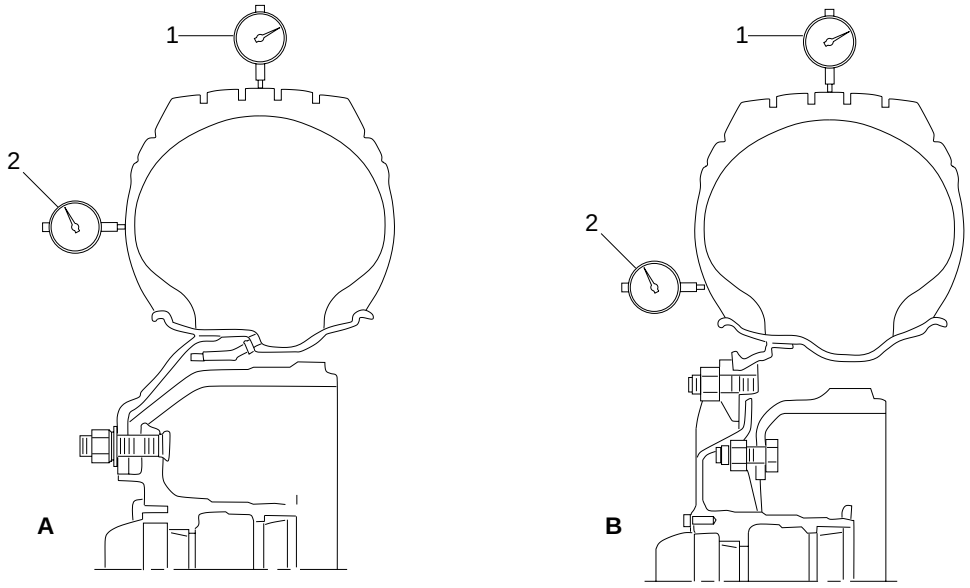
Wheel and Tire Runout Measurements

- hub radial runout measured near the hub pilots—0.015 inch (0.38 cm)

If hub and brake drum runouts are within specification, then the wheel runout will need to be checked. Demount the tire from the wheel and check lateral and radial runouts for the wheel as shown in **Fig. 4**. For tire demounting instructions, see **Section 40.00**. Make certain the wheel is properly fixed in a wheel balancer or remounted on the hub. See **Table 1** for wheel runout specifications.

Wheel Runout Specifications		
Wheel Type	**Lateral Runout: inches (cm)**	**Radial Runout: inches (cm)**
Aluminum	0.030 (0.08)	0.030 (0.08)
Steel	0.060 (0.15)	0.060 (0.15)

Table 1, Wheel Runout Specifications



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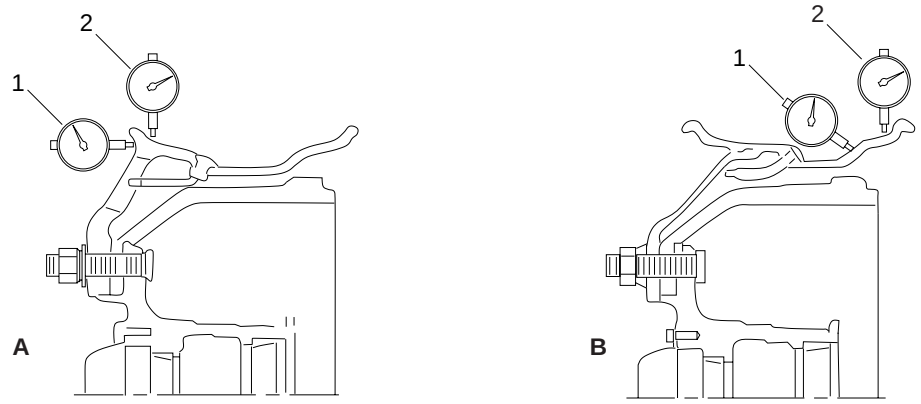
A. Tubeless Steel Disc Wheel
1. Radial Runout
B. Tubeless Demountable Wheel
2. Lateral Runout

Fig. 3, Runout Check for Tires

Wheel and Tire Runout Measurements



A. Tubeless Aluminum Disc Wheel
B. Tubeless Steel Disc Wheel
1. Lateral Runout
2. Radial Runout

Fig. 4, Runout Check for Wheels

Troubleshooting Chart

Problem—Abnormal Tire Wear

Problem—Abnormal Tire Wear	
Possible Cause	**Remedy**
Tires are not inflated to the correct pressure	Operate the tires at the recommended inflation pressure and use the proper size tires, wheels, and rims for the load to be carried. Refer to **Specifications, 400**.
Inflation pressures in a dual assembly are unequal.	Inflate all tires to a uniform pressure, within 5 psi (35 kPa). Refer to **Specifications, 400** for the proper cold inflation pressures.
Dual tires are mismatched.	Examine all tires and match them according to the specifications in this section.
Vehicle is vibrating severely.	Follow the recommendations under "Vehicle Vibration" in this chart.
Brakes are grabbing.	Examine and adjust the brakes according to the instructions in the brake section in this manual.
Axles are improperly aligned.	Align the axles. Refer to the front and rear axle sections in this manual for instructions.
Wheel bearings are loose or damaged, or bushings are excessively worn.	Examine, and repair or replace according to the instructions in the front and rear axle sections in this manual.
Wear is uneven among tire sets.	Rotate the tires according to the instructions in the vehicle maintenance manual.
Driver is abusing equipment.	Caution the driver.

Problem—Vehicle Vibration

Problem—Vehicle Vibration	
Possible Cause	**Remedy**
Axles are improperly aligned.	Align the axles. Refer to the front and rear axle sections in this manual for instructions.
Wheels, rims, or tires are out-of-round, bent, or distorted.	Replace damaged components.
Tires, wheels, rims, or brake drums are out-of-balance.	Determine the out of balance component and balance.
Tire beads are not properly seated.	Demount and mount the tire. Make certain adequate lubrication is used and, if necessary, use an inflation aid to help seat tubeless tire beads.
Tire and rim assembly is improperly installed on a spoke wheel.	Remove the tire and rim assembly and inspect it for out-of-round or rim chording. Replace the rim if it is damaged. Follow closely the tightening sequence and torque values listed.
Rim spacers are worn or distorted.	Replace the rim spacers.
Driveline, suspensions, or steering components are loose or worn.	Determine the location of the vibration, then repair or replace the loose or worn components.

Troubleshooting

Problem—Excessive On-the-Road Tire Failures

Problem—Excessive On-the-Road Tire Failures	
Possible Cause	**Remedy**
Tires are not inflated to the correct pressure.	Operate the tires at the recommended inflation pressure and use the proper size tires, wheels, and rims for the load to be carried. Refer to **Specifications, 400**.
Dual tires are mismatched.	Examine all tires and match them according to the specifications in this section.
Water or foreign material is inside the casing.	Clean and dry the tires and tubes prior to mounting. Make sure excess lubricant does not flow down into the tire. Store unmounted tires indoors, or under cover, to prevent moisture from collecting inside.
Tires are contaminated with oil.	Clean the tires and inspect the engine seals, transmission seals, axle-end and drive axle seals, oil filters and oil lines for leakage. Make sure the lubricant used in mounting does not contain a petroleum derivative.
Vehicle is vibrating severely.	Follow the recommendations under "Vehicle Vibration" in this chart.
Wheel or rim components are mismatched.	Check the catalog issued by the applicable wheel or rim manufacturer for the proper part numbers and sizes of approved components. Make sure that all parts of an assembly match in size, manufacturer, and classifications within a manufacturer's line. Never use a component which does not bear clear, legible, and proper numbers and manufacturer's identification, even if it appears to fit.
Parts are corroded, worn, or otherwise damaged.	Clean or replace parts as necessary.

Tire Pressure

Do not reduce the pressure of a hot tire if it exceeds the specified pressure. In normal driving, tire temperature and inflation pressure increase. Increases of 10 to 15 psi (70 to 105 kPa) are common. Higher pressures may be signs of overloading, underinflation, excessive speed, improper tire size, or any combination of these factors, and must be checked when the tire is cool.

IMPORTANT: The load and cold inflation pressure must not exceed the rim or wheel manufacturer's recommendations, even though the tire may be approved for a higher load or inflation. Some rims and wheels are stamped with a maximum load and maximum cold inflation rating. If they are not stamped, consult the rim or wheel manufacturer for the correct tire inflation pressure for the vehicle load. If the load exceeds the maximum rim or wheel capacity, the load must be adjusted or reduced.

For further information on rims and tires (other than Michelin), and for inflation and load limits, see the "Tire and Rim Association Yearbook." Contact the Michelin Tire Corporation for further data on their tires.

Wheel Fastener Torque Values

For torque values for disc wheel fasteners, see **Table 1**.

For torque values for spoke wheel rim clamp nuts, see **Table 2**.

Disc Wheel Fastener Torque			
Description	**Nut Size**	**Wheel Manufacturer**	**Torque (dry threads): lbf·ft (N·m)**
8-Hole Disc Wheel With Two-Piece Flange Nuts			
Front and Rear Wheel Nut	M22 x 1.5	All	450–500 (610–678)*
10-Hole Disc Wheel With Two-Piece Flange Nuts			
Front and Rear Wheel Nut	M22 x 1.5	All	450–500 (610–678)*
10-Hole Disc Wheel With Inner and Outer Nuts			
Front Wheel Nut	1-1/8–16	Alcoa	400–500 (540–678)†
		Budd	450–500 (610–678)‡
		Firestone and Motor Wheel	450–500 (610–678)
Rear Wheel Inner Nut	3/4–16	Alcoa	400–500 (540–678)†
		Budd, Firestone, and Motor Wheel	450–500 (610–678)
Rear Wheel Outer Nut	1-1/8–16	Alcoa	400–500 (540–678)†
		Budd, Firestone, and Motor Wheel	450–500 (610–678)
Wheel Stud Retainer Nut	3/4–16	All	175–200 (235–270)

* Torque values are given for lubricated threads.

† Torque values given are for dry threads. Lubricated threads should be tightened 300 to 375 lbf·ft (405 to 510 N·m). Lubricate threads with a mixture of 25 percent colloidal graphite in cup grease or equivalent. Do not apply thread lubricant to ball seats of the nuts and wheels. Wipe it off if it is applied accidentally.

‡ On 1–1/8-16 wheel studs with a head (**Fig. 1**), tighten the wheel nuts 650 to 750 lbf·ft (990 to 1020 N·m).

Table 1, Disc Wheel Fastener Torque

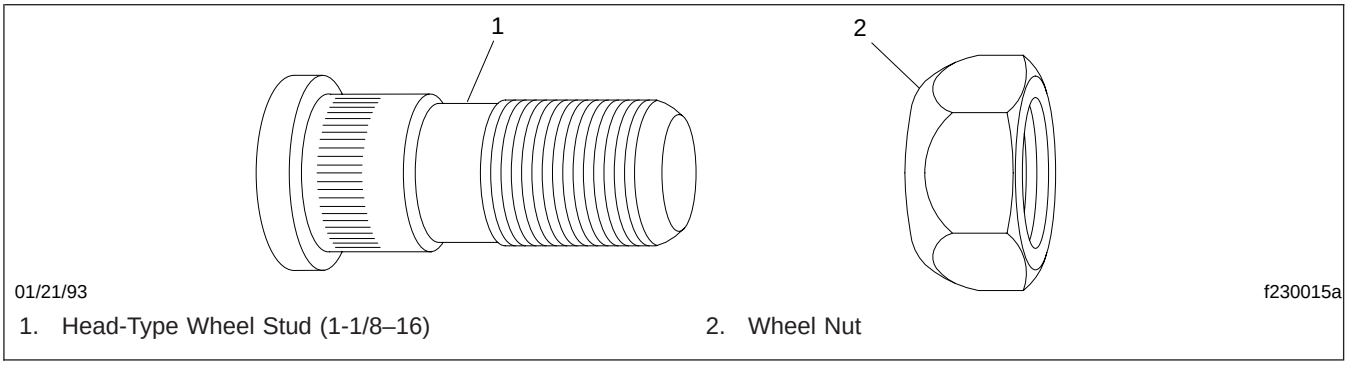
Specifications

Spoke Wheel Rim Clamp Nut Torque			
Description	**Nut Size**	**Manufacturer**	**Dry Threads: lbf·ft (N·m)**
Front Wheel Nut, 5 and 6 Spoke	5/8–11	Dayton and Gunite	160–175 (215–235)
		Webb	150–175 (205–235)
	3/4–10	Dayton	240–260 (325–355)
		Gunite	200–225 (270–305)*
		Webb	200–250 (270–340)
Rear Wheel Nut, 5 and 6 Spoke	5/8–11	Dayton and Gunite	160–175 (215–235)
		Webb	150–175 (205–235)
	3/4–10	Dayton	190–210 (260–285)†
		Gunite	200–225 (270–305)
		Webb	200–250 (270–340)

* On front axles with over 12,000 lb (5448 kg) capacity, tighten nuts 240 to 265 lbf·ft (325 to 360 N·m). Gunite part number W-854 nut, with a phosphate and oil coating, must be used.

† When using channel spacers (see **Fig. 2**), recommended torque for rim clamp nuts is 190 to 210 lbf·ft (260 to 285 N·m); when using corrugated or corrugated-channel spacers (see **Fig. 3**), permitted torque is 240 to 260 lbf·ft (325 to 355 N·m).

Table 2, Spoke Wheel Rim Clamp Nut Torque



1. Head-Type Wheel Stud (1-1/8–16)
2. Wheel Nut

Fig. 1, Head-Type Wheel Stud

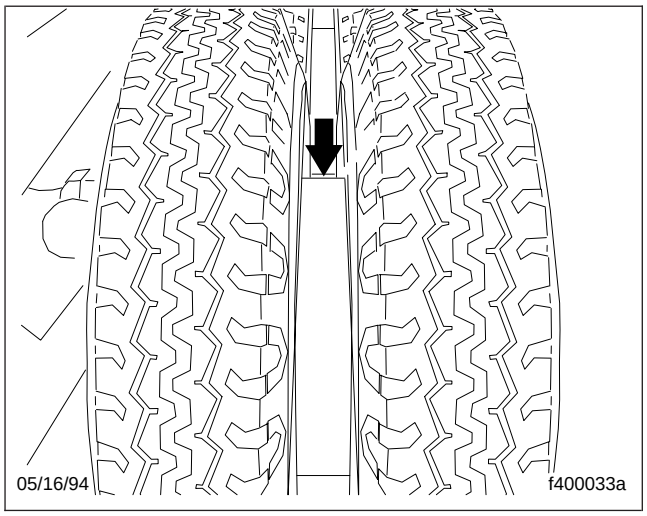


Fig. 2, Channel Spacer

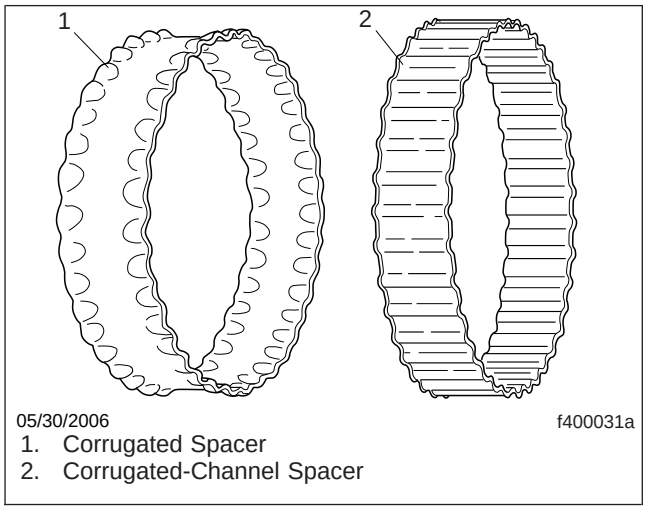


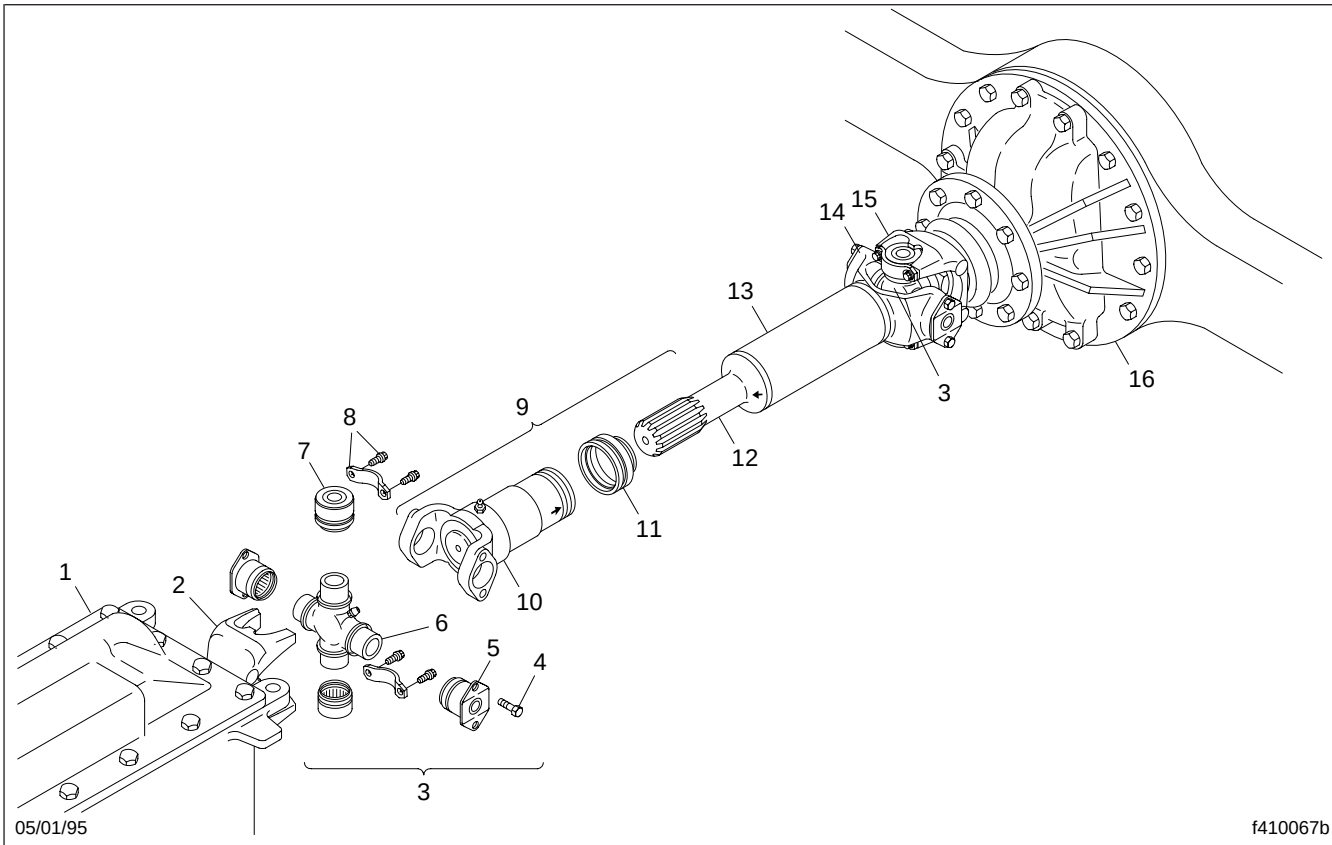
Fig. 3, Corrugated Spacers

General Information

The simplest driveline consists of a transmission output-shaft end-yoke, an axle input-shaft end-yoke, and a single slip-jointed driveshaft connecting the two end-yokes. See **Fig. 1**. The driveshaft is made up of a universal joint (U-joint), a sleeve-yoke, a splined stub shaft, a driveshaft tube, a tube-yoke, and a second U-joint.

Driveline Configuration

The specific type and number of drivelines used on each vehicle depends on its number of transmissions, its number of drive axles, and its wheelbase. See **Fig. 2**. A driveline is used between each driving and driven component. A driveline connecting a main transmission (or an auxiliary transmission) to a single drive axle or forward-rear axle of a dual-drive vehicle is always referred to as a No. 2 driveline. See **Fig. 2**, examples A, B, C, D, and E. An interaxle driveline of a dual-drive vehicle is always called a No. 3 drive-



NOTE: Not all fasteners are shown.

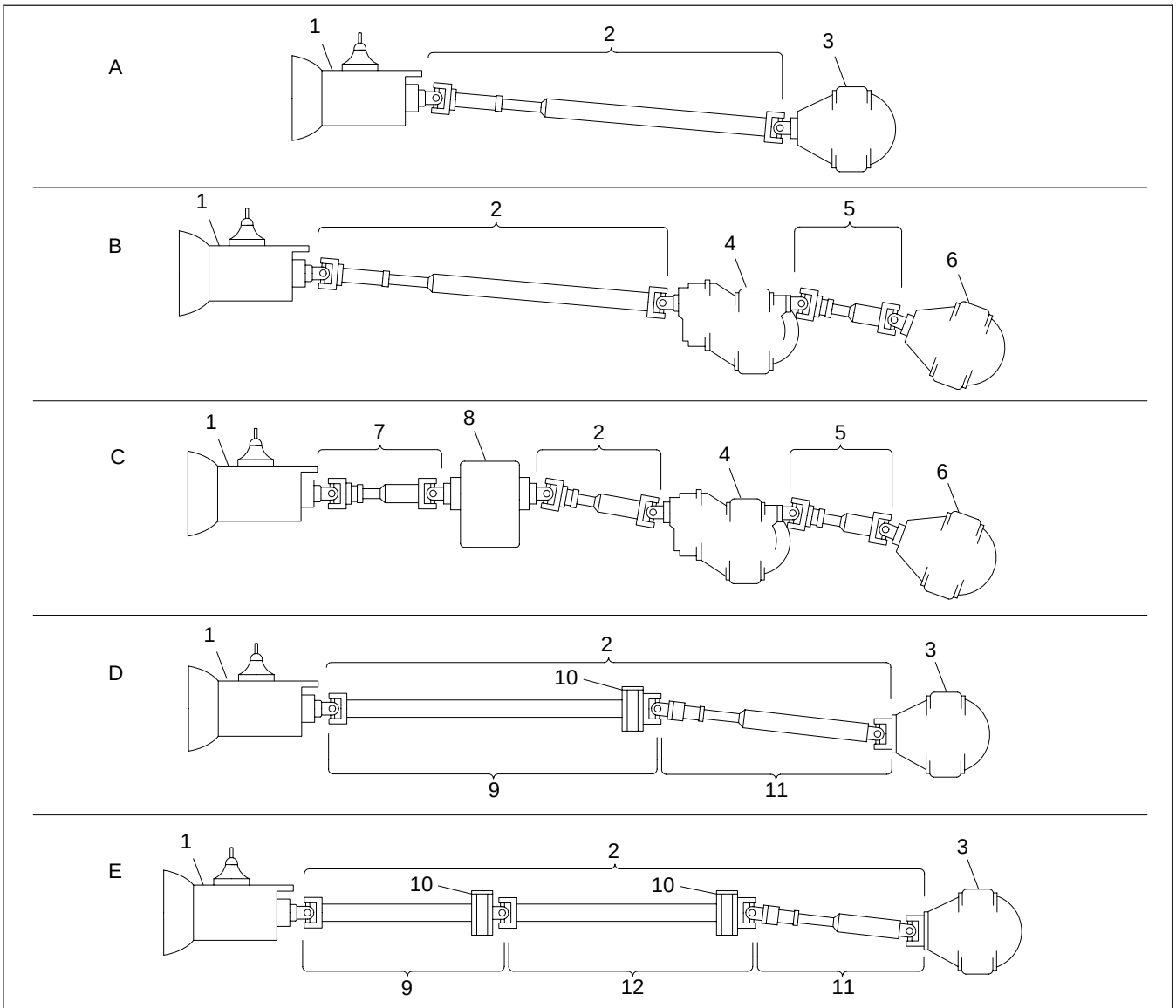
1. Transmission
2. Transmission Output-Shaft End-Yoke (half-round)
3. U-Joint Assembly
4. Bearing Plate Self-Locking Capscrew
5. Bearing Cup (for full-round yoke)
6. U-Joint Cross
7. Bearing Cup (for half-round yoke)
8. Bearing Strap and Bearing-Strap Capscrew
9. Slip-Joint Assembly
10. Sleeve-Yoke (full-round)
11. Dust Cap
12. Splined Stub Shaft
13. Driveshaft Tube
14. Tube-Yoke (full-round)
15. Axle Input-Shaft End-Yoke (half-round)
16. Rear Axle

Fig. 1, Components of a Basic Driveline

General Information

line. See **Fig. 2**, examples B and C. A driveline connecting a main transmission to an auxiliary transmission is always referred to as a No. 1 driveline. See **Fig. 2**, example C.

A long driveshaft, supported only at its ends, will sag in the middle from its own weight. When turning at high rpm, it will flex, causing an out-of-balance vibration. Therefore, vehicles having a long wheelbase



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1. Main Transmission
2. No. 2 Driveline
3. Rear Axle
4. Forward-Rear Axle
5. No. 3 Driveline
6. Rearmost Axle
7. No. 1 Driveline
8. Auxiliary Transmission
9. Primary Coupling Shaft
10. Midship Bearing
11. No. 2 Driveshaft
12. Intermediate Coupling Shaft

Fig. 2, Driveline Configurations

use a midship bearing, mounted on a frame crossmember, for additional support. See **Fig. 2**, example D. This allows the No. 2 driveline to be separated into two, shorter shafts (a coupling shaft and a No. 2 driveshaft), thus improving balance and stability.

Vehicles having an even longer wheelbase use two crossmember-mounted midship bearings, allowing the No. 2 driveline to be separated into three short shafts, joined by four U-joints. See **Fig. 2**, example E. The first shaft is the primary coupling shaft, the second is the intermediate coupling shaft, and the third is the No. 2 driveshaft.

Slip-Joints, U-Joints, and Yokes

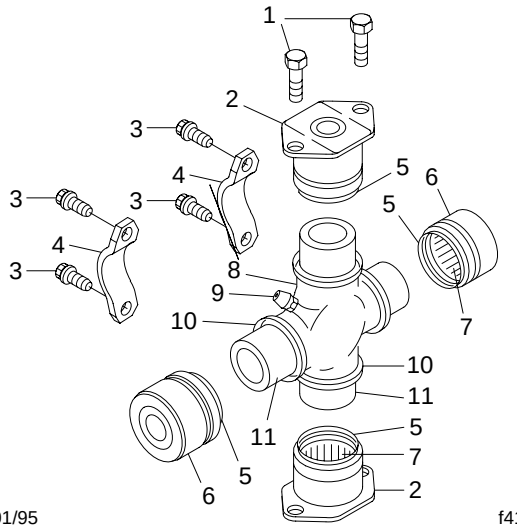
The basic function of the driveline is to send torque from the transmission to the axle in a smooth and continuous action. Because the vehicle axles are not attached directly to the frame, but are suspended by springs, they ride in an irregular, floating motion (when going over bumps or depressions), thus changing the distance between the transmission (or coupling shaft) and the rear axle, and the distance between the rear axles. The slip-joints of the No. 2 and No. 3 driveshafts, by expanding and contracting, allow for length changes between drivetrain components. Coupling shafts do not require a slip-joint.

Motion of the rear axle(s) also causes changes to the relative angles between drivetrain components. U-joints allow transfer of torque from an output shaft (or coupling shaft) to the driveshaft, and from the driveshaft to an input shaft, even though the angles between the shafts may be constantly changing.

Each U-joint consists of a cross with a close-tolerance ground cylindrical surface (trunnion) at the end of each of the four arms. Installed on each trunnion is a bearing cup lined with bearing needles. All bearing cups are sealed to retain lubricants, and to prevent entry of foreign material. See **Fig. 3**. In operation, the four bearing cups are held stationary in a pair of yokes, while the U-joint cross pivots on its trunnions.

Full-round yokes are installed at the front of coupling shafts and at both ends of the No. 2 and No. 3 driveshafts. All tube-yokes (yokes that are welded into driveshaft tubes) and all sleeve-yokes (yokes that are part of the internally splined half of slip-joints) are full-round yokes. See **Fig. 4**, items 4 and 9.

An end-yoke is an internally splined yoke, held on an externally splined shaft by a locknut. As standard



1. Bearing-Plate Capscrews
2. Bearing Cup (for full-round yoke)
3. Bearing-Strap Capscrew
4. Bearing Strap
5. Bearing-Cup Seal
6. Bearing Cup (for half-round yoke)
7. Bearing Needles
8. U-Joint Cross
9. Grease Fitting
10. U-Joint Cross Slinger
11. Trunnion

Fig. 3, Typical U-Joint

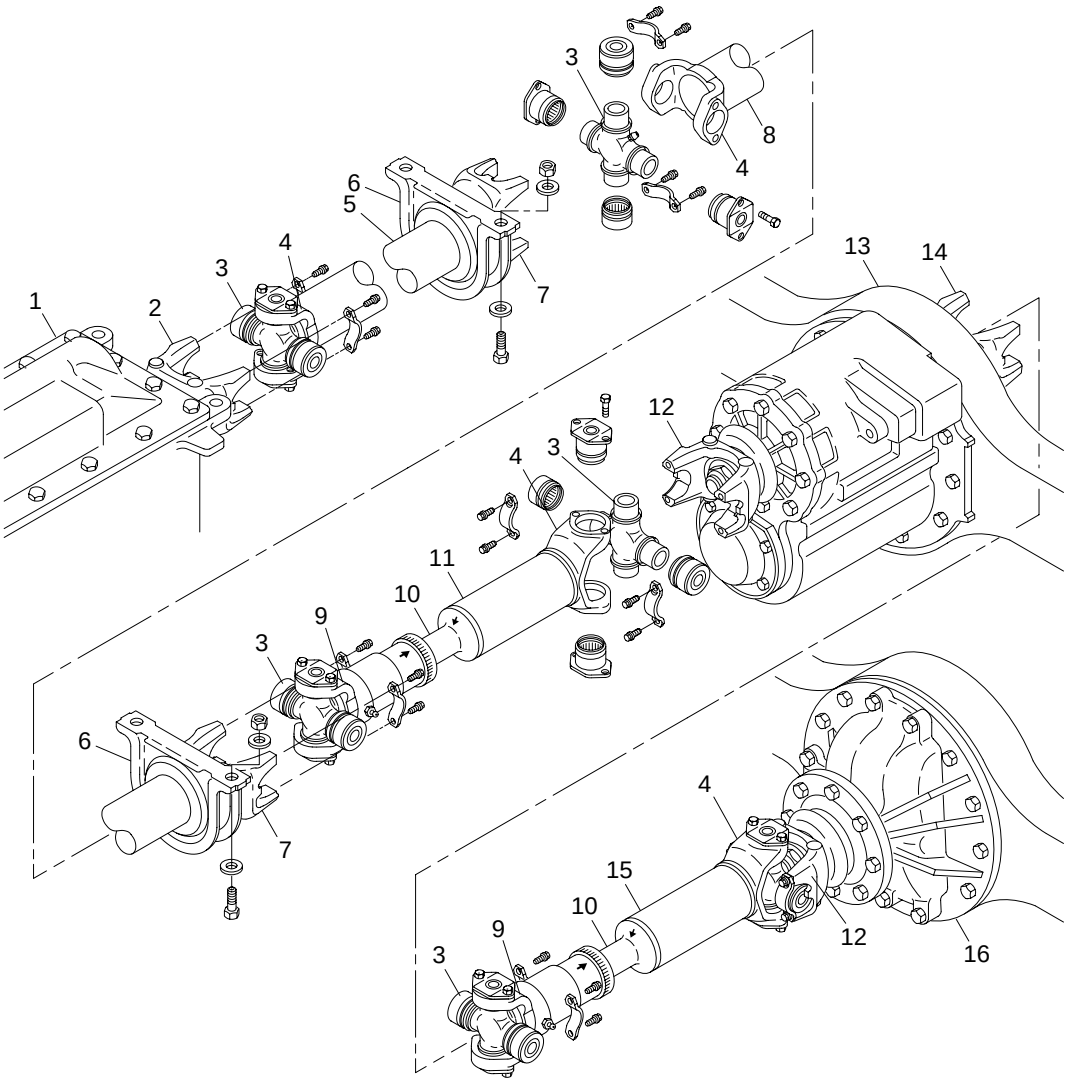
equipment, all No. 2 driveline end-yokes are half-round, with full-round optional. And, as standard equipment, all No. 3 driveline end-yokes are full-round, with half-round optional. End-yokes are installed on the transmission output shaft, on each axle input and output shaft, and behind the midship bearing of most coupling shafts. See **Fig. 4**, items 2, 7, 12, and 14.

Meritor 17T and 18T U-joints are coupled to half-round end-yokes by capscrews inserted through semicircular bearing straps that hold the bearing cups in place under tabs in the yoke cross-holes. See **Fig. 5**.

Meritor RPL Series U-joints are coupled to half-round end-yokes by capscrews inserted through the bearing cups. See **Fig. 6**.

U-joints are installed in full-round tube-yokes, sleeve-yokes, and end-yokes, by inserting the cross through from the inside of both yoke cross-holes, then install-

General Information



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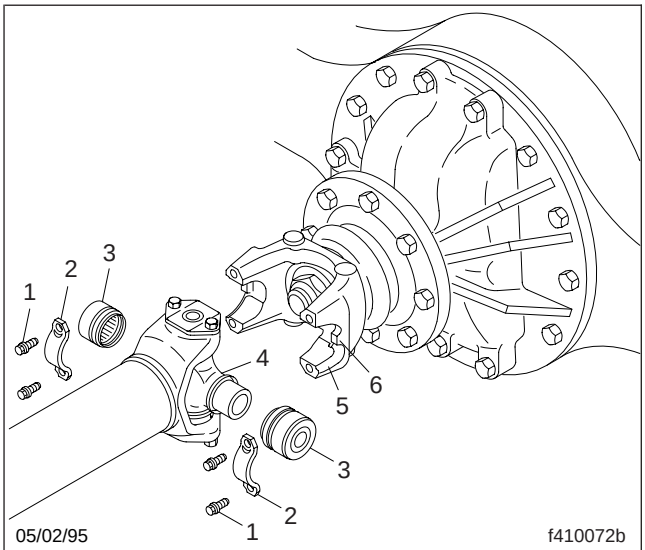
NOTE: Not all fasteners are shown.

1. Transmission
2. Transmission Output-Shaft End-Yoke (half-round)
3. U-Joint Assembly
4. Full-Round Tube-Yoke
5. Primary Coupling Shaft Tube
6. Midship Bearing Assembly
7. Coupling Shaft End-Yoke (half-round)
8. Intermediate Coupling Shaft Tube
9. Sleeve-Yoke (full-round)
10. Slip-Joint Assembly
11. No. 2 Driveshaft Tube
12. Axle Input-Shaft End-Yoke (half-round)
13. Forward-Rear Axle
14. Axle Output-Shaft End-Yoke (half-round)
15. No. 3 Driveshaft Tube
16. Rearmost Axle

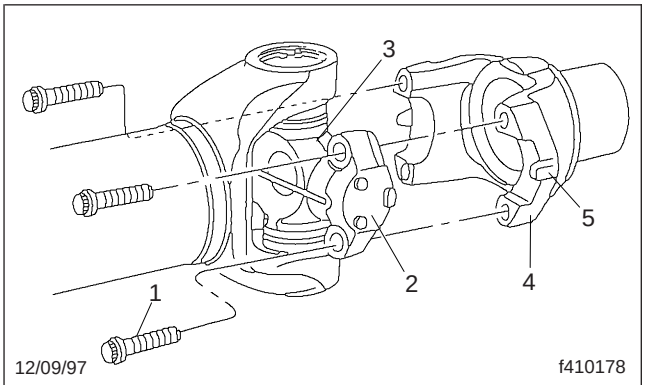
Fig. 4, Dual-Drive Installation With Primary and Intermediate Coupling Shafts

ing the bearing cups into the outsides of the yoke and over the ends of the trunnions. Snap rings or self-locking capscrews are installed into the yoke to secure the cups. See **Fig. 7**.



1. Bearing-Strap Capscrew
2. Bearing Strap
3. Bearing Cup
4. U-Joint Cross
5. Half-Round Yoke
6. Yoke Cross-Hole Tab

Fig. 5, Coupling of a U-Joint With a Half-Round End-Yoke

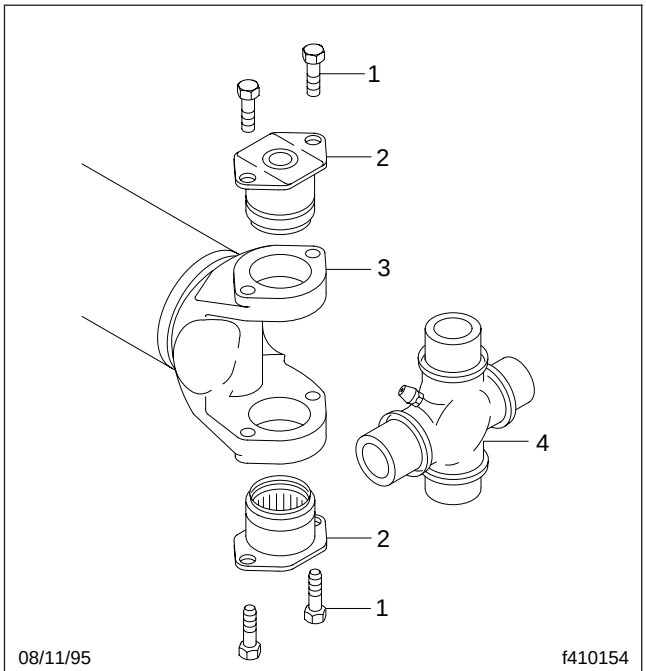


1. Capscrew
2. Bearing Cup
3. U-Joint Cross
4. Half-Round Yoke
5. Yoke Cross-Hole Tab

Fig. 6, Coupling of a RPL Series U-Joint

U-Joint Angles, Phasing, and Driveline Balance

Correct U-joint working angles, U-joint phasing, and driveline balance are vital to maintaining a quiet-running drivetrain and long life of drivetrain components (including driveline components).



1. Bearing-Plate Self-Locking Capscrew
2. Bearing Cup (bearing-plate-type)
3. Full-Round Yoke
4. U-Joint Cross

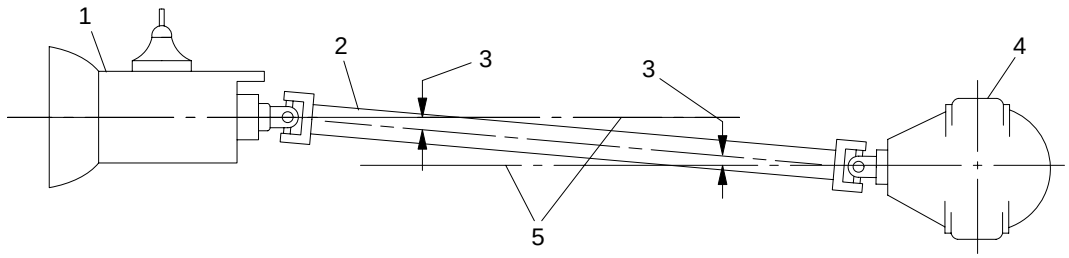
Fig. 7, Installation of a U-Joint in a Full-Round Yoke

The U-joint working angle is the angle formed by the intersection of the driveshaft centerline and the extended centerline of the shaft of any component (or other driveshaft) to which the U-joint connects. See **Fig. 8**. Because the double oscillating motion of a U-joint that connects angled shafts causes a fluctuating speed difference between the shafts, the effect created by the U-joint at one end of the shaft must cancel the effect created by the U-joint at the other end. This is done by making U-joint working angles at both ends of the driveshaft approximately equal, with the U-joints in phase. If the yoke lugs at both ends of the shaft are lying in the same plane (a plane that bisects the shaft lengthwise) the U-joints will be in phase. See **Fig. 9**.

NOTE: Some driveshafts are designed and phased with their end yokes clocked 90 degrees from each other. This is referred to as cross phasing.

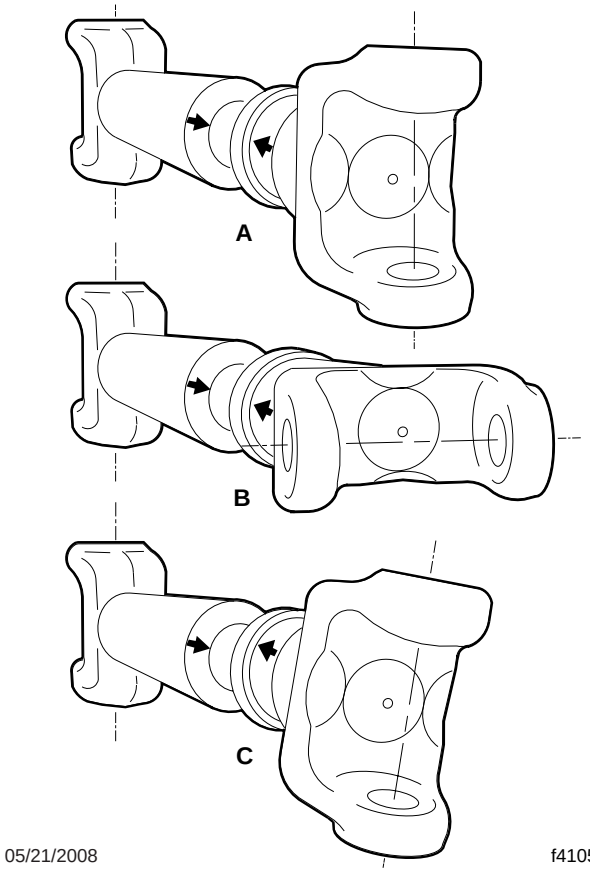
After manufacture, each driveline yoke is statically balanced. After assembly, each driveshaft and cou-

General Information



1. Transmission
2. No. 2 Driveshaft
3. U-Joint Working Angles
4. Rear Axle
5. Extended Centerlines

Fig. 8, U-Joint Working Angles



A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

Fig. 9, U-Joint Phasing

pling shaft is checked for out-of-roundness, straightened as necessary, then dynamically balanced.

Avoiding Driveline Problems

To ensure that U-joints turn in phase, sleeve-yokes, splined shafts, coupling shaft end-yokes, and coupling shafts, should be marked for assembly reference before disassembly. A misaligned slip-joint will seriously affect driveline balance (and U-joint phasing). Even if a slip-joint is assembled 180 degrees from its original position (which will keep the U-joints in phase), the dynamic balance of the driveshaft will be negatively affected.

A driveline can become unbalanced or greatly weakened if a driveshaft has been dented, bent, twisted, or otherwise damaged. Operating a vehicle at speeds that exceed the speed of the driveshaft's design specifications will cause an out-of-balance vibration. Any condition that allows excessive movement of a driveshaft will cause driveline imbalance: loose end-yoke nuts, loose midship bearing mounts, loose U-joint bearing cup retaining capscrews, worn U-joint trunnions and bearings, and worn slip-joint splines.

Among the most common causes of U-joint and slip-joint damage is lack of lubrication.

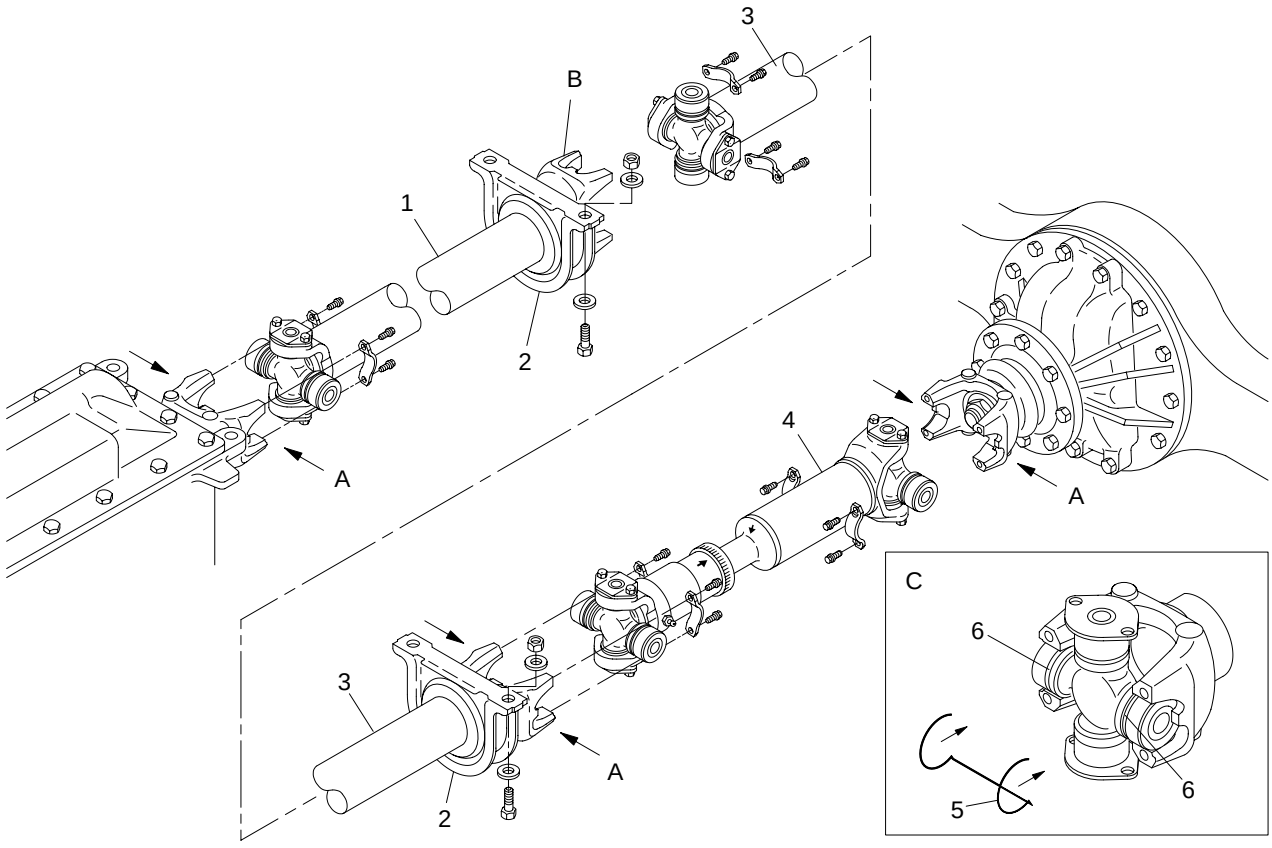
To keep a vehicle operating smoothly and economically, the driveline must be carefully checked and lubricated at regular intervals. For inspection and lubrication intervals and procedures, see **Group 41** of the *Heavy-Duty Trucks Maintenance Manual*.

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke

U-Joint Uncoupling

Refer to **Fig. 1** and **Fig. 2** for this procedure.

or a tube-yoke. To remove the driveshaft, see **Subject 120**.



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NOTE: Not all fasteners are shown.

A. End-yoke cross-hole centerline is horizontal.
B. Before uncoupling/coupling the U-joint, turn the end-yoke until its cross-hole centerline is horizontal.
C. Install a half-round bearing-cup retaining wire (or safety wire) before removing the bearing straps.

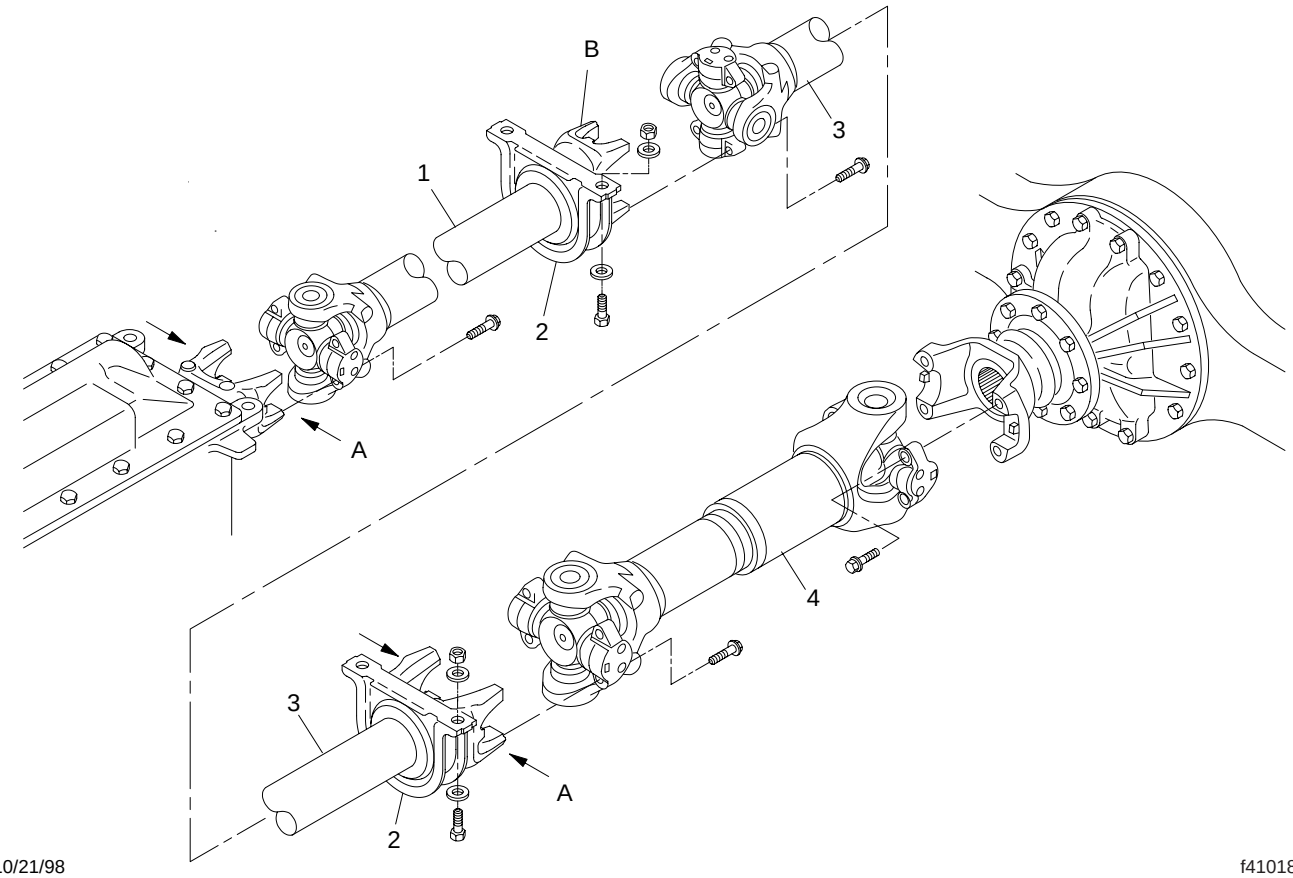
1. Primary Coupling Shaft
2. Midship Bearing
3. Intermediate Coupling Shaft
4. No. 2 Driveshaft
5. Half-Round Bearing-Cup Retaining Wire
6. Retaining-Wire Groove

Fig. 1, U-Joint Uncoupling/Coupling for Drivelines With Half-Round End-Yokes, Except RPL U-Joints

NOTE: It is easier to check driveline parts, and to replace a U-joint or midship bearing assembly if the driveshaft is removed from the vehicle. If a driveshaft requires straightening or balancing, it must be removed, and installed on a lathe or a balance machine. Removal is required for replacement of slip-joint parts, a driveshaft tube,

Many service operations do not require driveshaft removal from the vehicle: end-yoke nut tightening; drive component shaft seal or end-yoke replacement; changing U-joint phasing at the slip-yoke; and transmission or axle removal (for overhaul, repair, or replacement). To per-

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke



NOTE: Not all fasteners are shown.

A. End-yoke cross-hole centerline is horizontal.
B. Before uncoupling/coupling the U-joint, turn the end-yoke until its cross-hole centerline is horizontal.

1. Primary Coupling Shaft
2. Midship Bearing
3. Intermediate Coupling Shaft
4. No. 2 Driveshaft

Fig. 2, U-Joint Uncoupling/Coupling for Drivelines With Half-Round End-Yokes, RPL U-Joints

form these operations, uncouple the U-joint at the applicable end of the appropriate driveshaft.

1. Roll the vehicle forward or backward as needed to turn the rearmost end-yoke (of the driveline that is being uncoupled) until the centerline through its cross-holes is horizontal. See **Fig. 1**, Ref. A and Ref. B.
2. Apply the parking brakes, and chock the tires.
3. If the half-round bearing cups do not already have a retaining wire installed, install a bearing-cup retaining wire. See **Fig. 1**, Ref. C. Or, install safety wire from the retaining-wire groove of one half-round bearing cup to the other.
4. Support the driveshaft with a nylon support strap.

   When uncoupling a coupling shaft, install two or three support straps, as needed. Remove the fasteners that attach the midship bearing(s) to its bracket(s). See **Fig. 1** and **Fig. 2**.
5. Remove the capscrews that secure the bearing cups or straps to the half-round yoke. Remove the bearing straps, if equipped.

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke

6. Compress the slip-joint to remove the U-joint from the yoke.

CAUTION

Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.

U-Joint Coupling

Refer to **Fig. 1** and **Fig. 2** for this procedure.

1. Check and clean the end-yoke.
   - 1.1 Check the torque on the end-yoke nut. See **Specifications 400**.
   - 1.2 Check the end-yoke cross-holes for burrs or raised metal. Using a half-round file, remove burrs or raised metal. See **Fig. 3**.

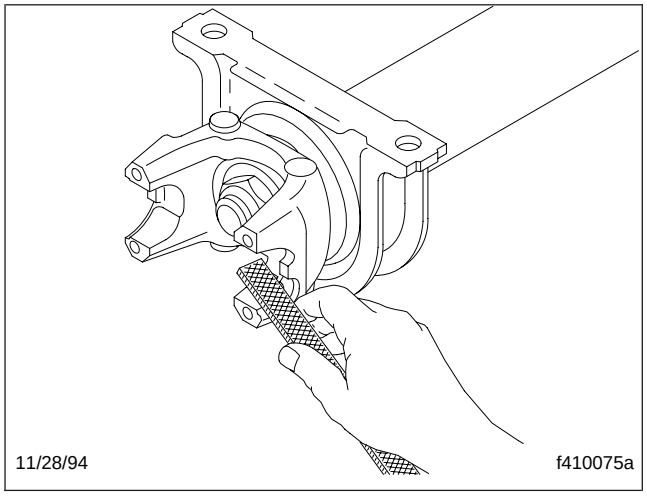
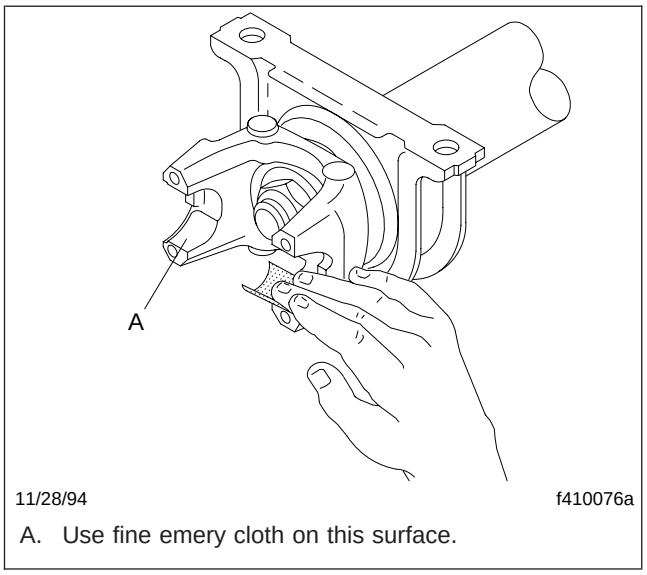


Fig. 3, Removing Burrs from a Half-Round End-Yoke Cross-Hole

   - 1.3 Using fine emery cloth, smooth and clean the entire surface of the yoke cross-holes and bearing straps. See **Fig. 4**.
   - 1.4 Turn the end-yoke until its cross-holes are horizontal. See **Fig. 1** and **Fig. 2**.
2. Check, clean, and lubricate the U-joint.
   - 2.1 Remove the bearing-cup retaining wire or safety wire. See **Fig. 1**, Ref. C.



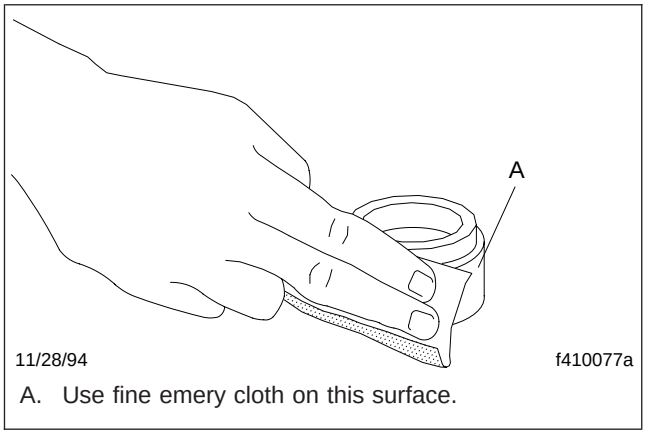
A. Use fine emery cloth on this surface.

Fig. 4, Smoothing a Half-Round End-Yoke Cross-Hole

CAUTION

Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.

   - 2.2 Using fine emery cloth, smooth and clean the outside surfaces of both bearing cups. See **Fig. 5**.



A. Use fine emery cloth on this surface.

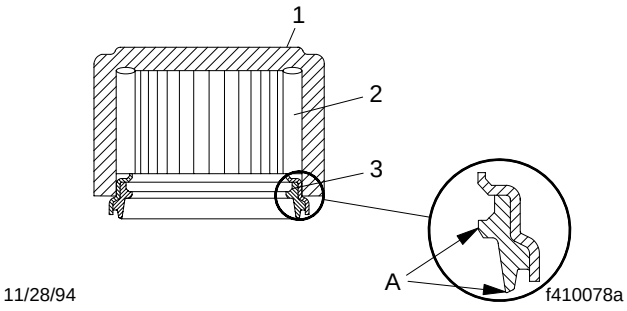
Fig. 5, Smoothing a Half-Round End-Yoke U-Joint Bearing Cup

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke

2.3 Check the U-joint trunnions and bearing cups for minute particles of dirt or grit. Clean if necessary. See **Subject 140**.

2.4 Using NLGI grade 2 grease with EP additives, wipe a small amount of grease on the needles in the bearing cups.

2.5 Using a light-weight oil, lubricate the lips of the bearing-cup seals. See **Fig. 6**.



A. Lubricate seal lips here.

1. Bearing Cup
2. Bearing Needle
3. Bearing-Cup Seal

Fig. 6, Sectional View of a Half-Round End-Yoke U-Joint Bearing Cup

2.6 Install the bearing cups on the cross.

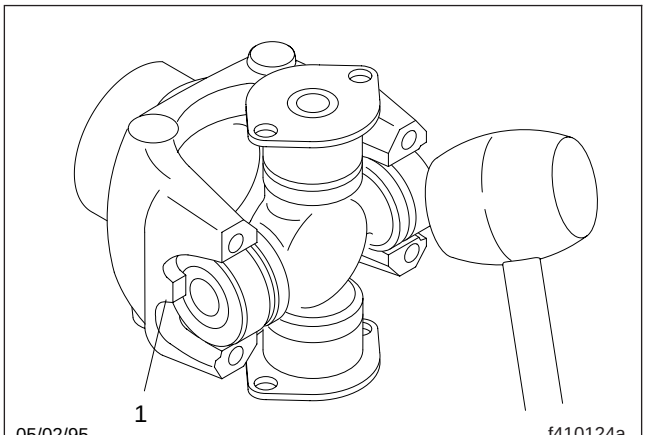
2.7 Install a bearing-cup retaining wire. See **Fig. 1**, Ref. C. Or, install safety wire from the retaining-wire groove of one half-round bearing cup to the other.

3. Extend the slip-joint, while pressing the cross and bearing cups into place in the yoke cross-holes. Using a rubber or plastic mallet, gently tap the bearing cups to seat them in the yoke. See **Fig. 7**.

CAUTION

Do not use the capscrews and bearing straps (if equipped) to seat the bearing cups in the yoke. Seating the cross by tightening the bearing straps can deform the bearing straps, allowing the bearing cups to spin, which will cause rapid wear and serious damage to the U-joint.

4. Place the bearing straps (if equipped) over the cups. Install the capscrews, finger-tight.



1. Retaining Tab

Fig. 7, Seating a U-Joint in a Half-Round End-Yoke

WARNING

The self-locking capscrews must not be reused. Replace the capscrews with new ones. Also, do not undertighten or overtighten the capscrews. A loose or broken fastener at any point in the driveline weakens the driveline connection, which could cause serious vehicle damage, or could result in a driveshaft separating from the vehicle. Driveline separation can cause loss of vehicle control that could result in serious personal injury or death.

Separation of the driveline can also cause damage to the driveline, driveline components, or other areas of the vehicle.

5. Alternately tighten the capscrews in increments of 20 lbf·ft (27 N·m) to the applicable torque value in **Specifications 400**.

6. If they were removed, install the fasteners that attach each midship bearing to its bracket; tighten the flanged locknuts 68 lbf·ft (92 N·m).

7. Lubricate the U-joint, following the procedure in **Group 41** of the *Heavy-Duty Trucks Maintenance Manual*.

8. Remove the nylon support straps, then remove the chocks.

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke

U-Joint Uncoupling

Refer to **Fig. 1** for this procedure.

NOTE: It is easier to check driveline parts, and to replace a U-joint or midship bearing assembly if the driveshaft is removed from the vehicle. If a driveshaft requires straightening or balancing, it must be removed, and installed on a lathe or a balance machine. Removal is required for replacement of slip-joint parts, a driveshaft tube, or a tube-yoke. To remove the driveshaft, see **Subject 120**.

Many service operations do not require driveshaft removal from the vehicle: end-yoke nut tightening; drive component shaft seal or end-yoke replacement; changing U-joint phasing at the slip-yoke; and transmission or axle removal (for overhaul, repair, or replacement). To perform these operations, uncouple the U-joint at the applicable end of the appropriate driveshaft.

1. Roll the vehicle forward or backward as needed to turn the end-yoke (of the driveline that is being uncoupled) until the centerline through its cross-holes is vertical. See **Fig. 1**.
2. Apply the parking brakes, and chock the tires.
3. Support the driveshaft with a nylon support strap.

   When uncoupling a coupling shaft, install two or three support straps, as needed. Remove the fasteners that attach the midship bearing(s) to its bracket(s).
4. Remove and discard all four bearing-cup-plate self-locking capscrews.
5. Using one of the U-joint pullers listed in **Specifications, 400**, remove both bearing assemblies from the end-yoke cross-holes. See **Fig. 2**.
6. Compress the slip-joint and pivot the end of the U-joint cross to remove it from the yoke. Install the bearing cups on the U-joint cross, and secure them with tape.

CAUTION

Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.

U-Joint Coupling

Refer to **Fig. 1** for this procedure.

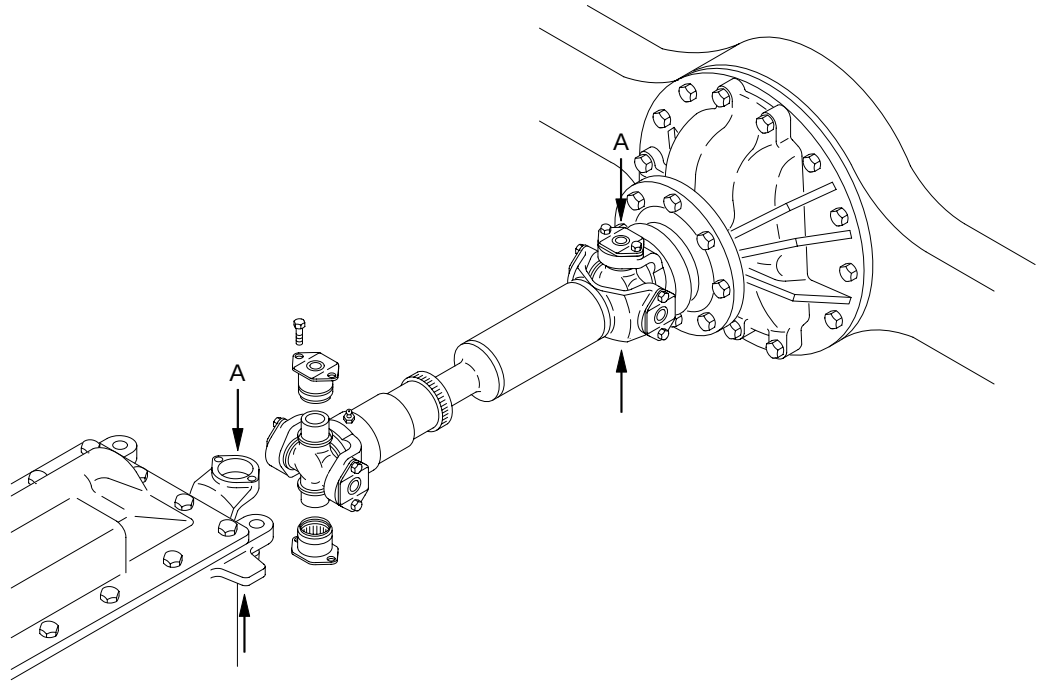
1. Check and clean the end-yoke.
   - 1.1 Check the torque on the end-yoke nut. See **Specifications, 400**.
   - 1.2 Check the end-yoke cross-holes for burrs or raised metal. Using a rat-tail or half-round file, remove burrs or raised metal. See **Fig. 3**.
   - 1.3 Using a mill file, and holding it flat against the machined surface of the yoke lug, remove any burrs or raised metal. See **Fig. 4**.
   - 1.4 Using fine emery cloth, smooth and clean the entire surface of the yoke cross-holes. See **Fig. 5**.
   - 1.5 Turn the end-yoke until the centerline through its cross-holes is vertical. See **Fig. 1**.
2. Check, clean, and lubricate the U-joint.
   - 2.1 Using fine emery cloth, smooth and clean the outside surfaces of both bearing cups. See **Fig. 6**.
   - 2.2 Check the U-joint trunnions and bearing cups for minute particles of dirt or grit. Clean if necessary; see **Subject 140**.

CAUTION

Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.

   - 2.3 Using NLGI grade 2 grease with EP additives, wipe a small amount of grease on the needles in the bearing cups.
   - 2.4 Using a light-weight oil, lubricate the lips of the bearing-cup seals. See **Fig. 7**.
3. Couple the U-joint cross to the end-yoke.
   - 3.1 Extend the slip-joint, while pivoting the U-joint cross into place in the yoke cross-holes.

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke



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NOTE: Not all fasteners are shown.
A. End-yoke cross-hole centerline is vertical.

Fig. 1, U-Joint Uncoupling/Coupling of a Driveline With Full-Round End-Yokes

3.2 Move one end of the cross until a trunnion projects through the cross-hole, beyond the outer machined face of the yoke lug. Using a Spicer trunnion (journal) locator (see **Specifications, 400**), hold the trunnions in alignment with the cross-holes, while placing a bearing assembly over the projected trunnion, and aligning it with the cross-hole. See **Fig. 8**.

IMPORTANT: A Spicer trunnion (journal) locator should be used, to prevent damage to the U-joint trunnions and slingers.

3.3 By hand, press the bearing assembly flush with the face of the yoke. If the bearing assembly binds in the cross-hole, tap the *center* of the bearing plate with a rubber or rawhide mallet; do not tap the outer edges of the bearing plate. See **Fig. 9**.

3.4 Install *new* bearing-cup-plate self-locking capscrews (see **Fig. 10**). Tighten the capscrews until all the parts are drawn down tight, with no gaps; do not tighten the capscrews to their final torque value.

⚠ WARNING

Self-locking bearing-cup-plate capscrews must not be reused; replace the capscrews with new ones. Also, do not undertighten or overtighten any bearing-cup-plate capscrews. A loose or broken fastener at any point in the driveline weakens the driveline connection, which could cause serious vehicle damage, or could result in a driveshaft separating from the vehicle, possibly causing loss of vehicle control that could result in serious personal injury or death.

3.5 Move the cross until it projects beyond the machined surface of the opposite yoke lug. Repeat applicable substeps to install the opposite bearing.

3.6 Alternately tighten the bearing-cup-plate capscrews in increments of 5 lbf·ft (7

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke

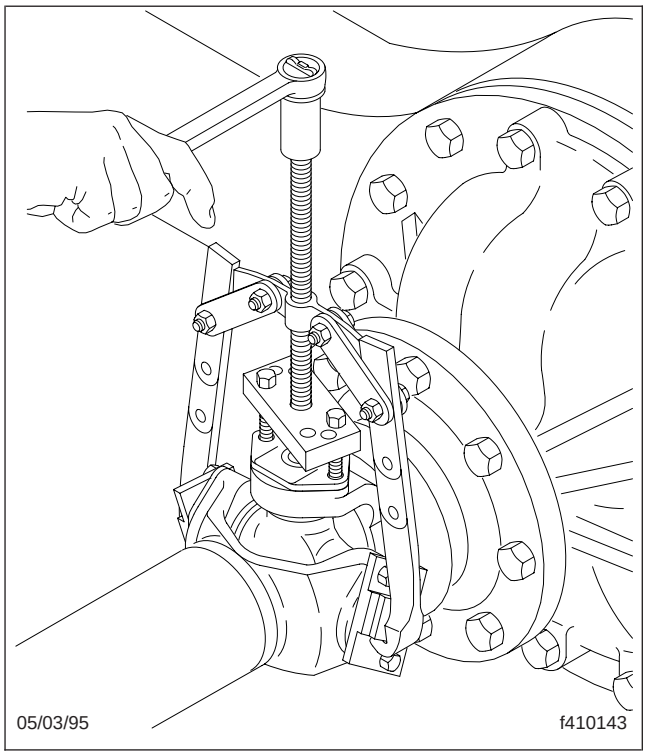


Fig. 2, Removing a Bearing Cup from a Full-Round End-Yoke

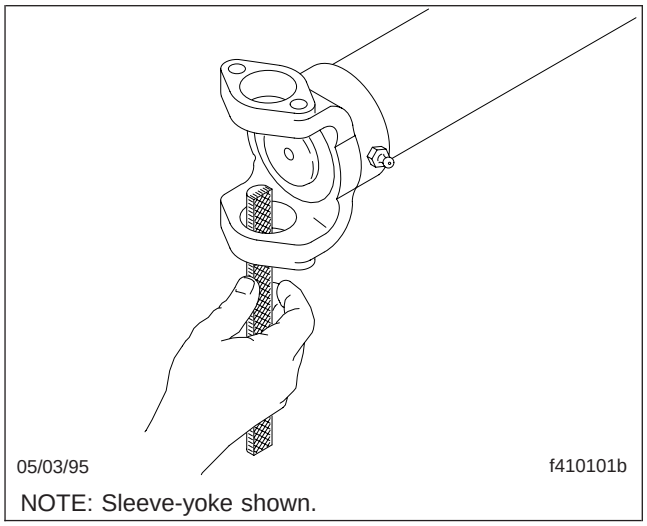


Fig. 3, Removing Burrs from a Full-Round Yoke Cross-Hole

N·m), to the torque value in **Specifications, 400**.

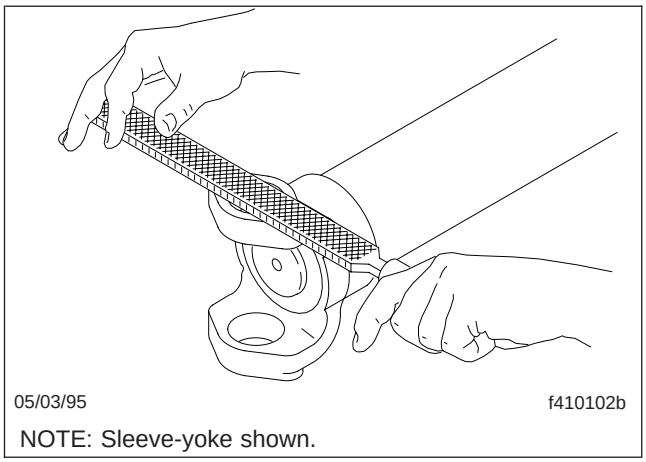


Fig. 4, Removing Burrs from the Machined Surface of a Full-Round Yoke Lug

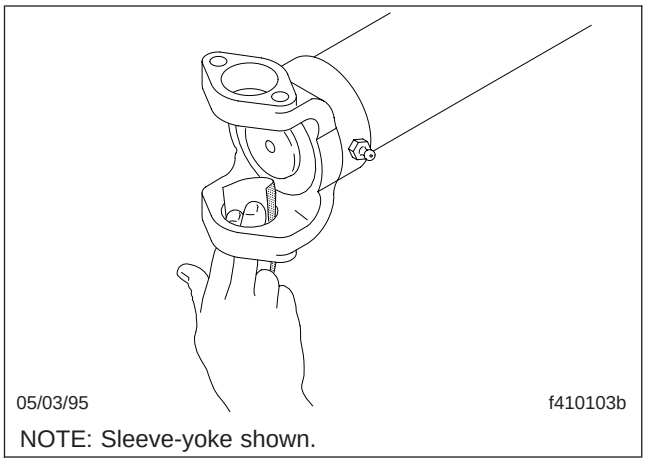
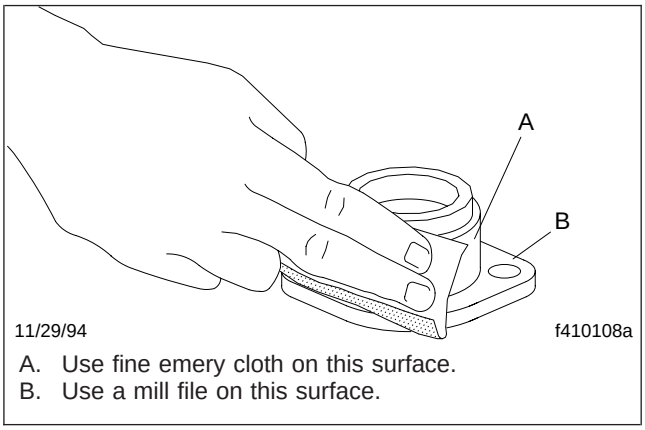


Fig. 5, Smoothing a Full-Round Yoke Cross-Hole

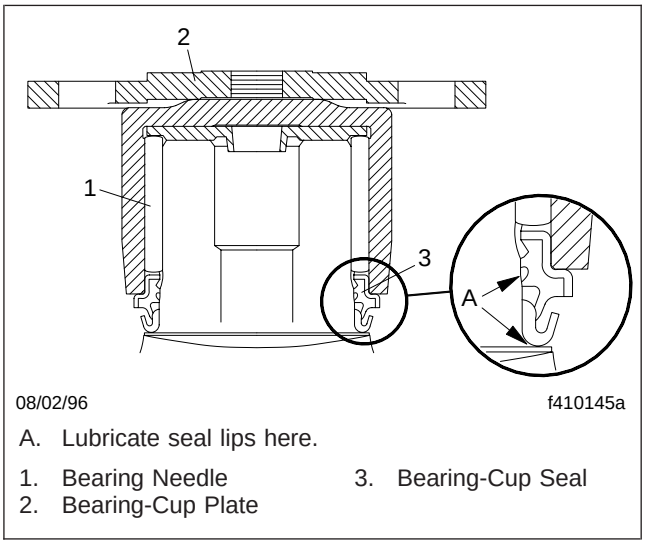
4. If they were removed, install the fasteners that attach each midship bearing to its bracket; tighten the flanged locknuts 68 lbf·ft (92 N·m).
5. Lubricate the U-joint, following the procedure in **Group 41** of the *Heavy-Duty Trucks Maintenance Manual*.
6. Remove the nylon support straps, then remove the chocks.

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke



A. Use fine emery cloth on this surface.
B. Use a mill file on this surface.

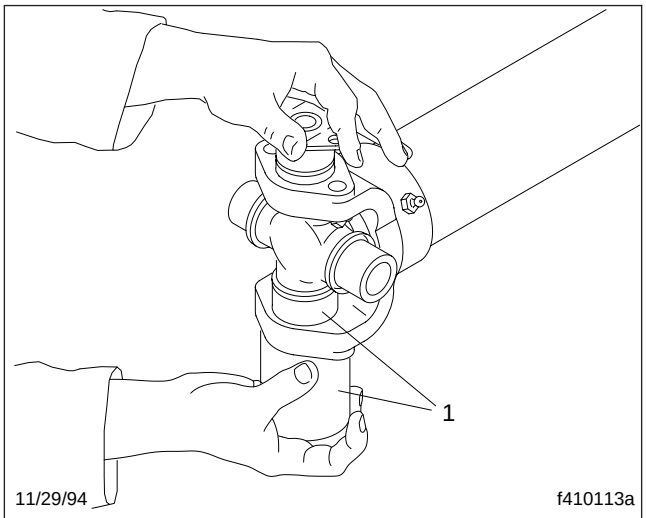
Fig. 6, Smoothing a Full-Round Yoke U-Joint Bearing Cup



A. Lubricate seal lips here.

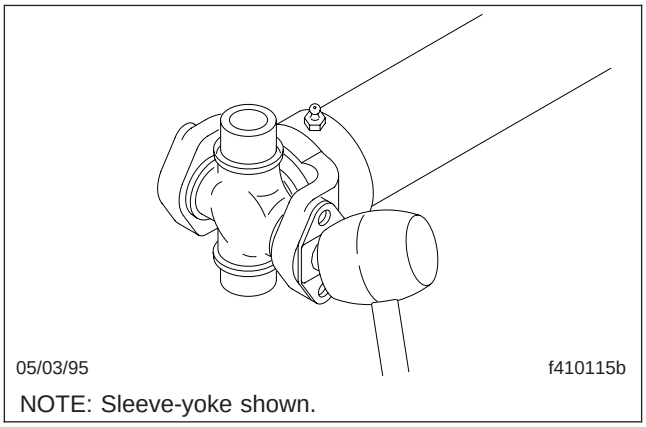
1. Bearing Needle
2. Bearing-Cup Plate
3. Bearing-Cup Seal

Fig. 7, Sectional View of a Full-Round Yoke U-Joint Bearing Cup



NOTE: Sleeve-yoke shown.
1. Trunnion Locator

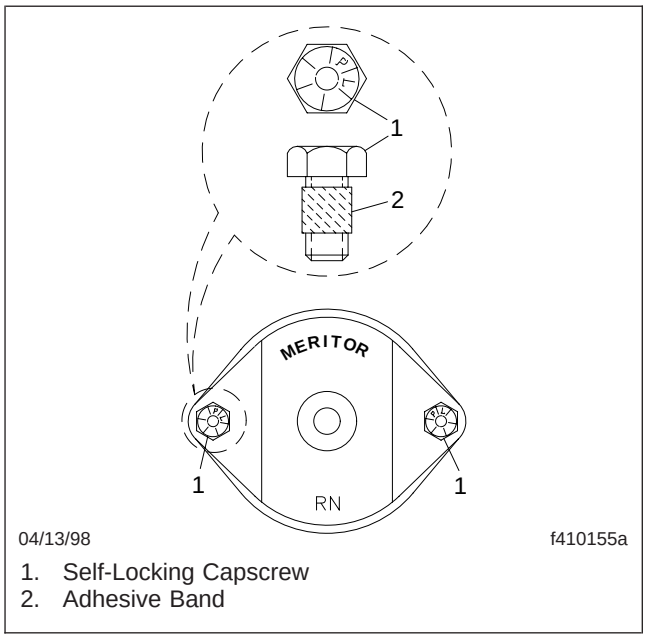
Fig. 8, Using a U-Joint Trunnion Locator



NOTE: Sleeve-yoke shown.

Fig. 9, Seating a U-Joint Bearing Cup in a Full-Round Yoke

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke



1. Self-Locking Capscrew
2. Adhesive Band

Fig. 10, Meritor U-Joint Fasteners for Full-Round Yokes

NOTE: Many service operations do not require driveshaft removal from the vehicle: end-yoke nut tightening; drive component shaft seal or end-yoke replacement; changing U-joint phasing at the slip-yoke; and transmission or axle removal (for overhaul, repair, or replacement). To perform these operations, uncouple the U-joint at the applicable end of the appropriate driveshaft. See **Subject 100** for uncoupling from a *half-round* end-yoke, or see **Subject 110** for uncoupling from a *full-round* end-yoke.

It is easier to check driveline parts, and to replace a U-joint or midship bearing assembly if the driveshaft is removed from the vehicle. If a driveshaft requires straightening or balancing, it must be removed, and installed on a lathe or balance machine. Removal is required for replacement of slip-joint parts, a driveshaft tube, or a tube-yoke.

No. 3 Driveshaft Removal

Refer to **Fig. 1** and **Fig. 2** for this procedure.

1. Uncouple the No. 3 driveshaft from the rearmost axle. If the No. 3 driveshaft is coupled to *half-round* end-yokes, follow the uncoupling procedure in **Subject 100**. If the No. 3 driveshaft is coupled to *full-round* end-yokes, follow the uncoupling procedure in **Subject 110**.
2. Uncouple the No. 3 driveshaft from the forward-rear axle. If the No. 3 driveshaft is coupled to half-round end-yokes, follow the uncoupling procedure in **Subject 100**. If the No. 3 driveshaft is coupled to full-round end-yokes, follow the uncoupling procedure in **Subject 110**.
3. Lift the No. 3 driveshaft out of the chassis.

No. 2 Driveshaft Removal

Refer to **Fig. 3** and **Fig. 4** for this procedure.

1. Uncouple the No. 2 driveshaft from the single or forward-rear axle. If the No. 2 driveshaft is coupled to *half-round* end-yokes, follow the uncoupling procedure in **Subject 100**. If the No. 2 driveshaft is coupled to *full-round* end-yokes, follow the uncoupling procedure in **Subject 110**.
2. Uncouple the No. 2 driveshaft from the transmission or coupling shaft. If the No. 2 driveshaft is coupled to half-round end-yokes, follow the uncoupling procedure in **Subject 100**. If the No. 2 driveshaft is coupled to full-round end-yokes, follow the uncoupling procedure in **Subject 110**.
3. Lift the No. 2 driveshaft out of the chassis.

Intermediate Coupling Shaft Removal

Refer to **Fig. 5** and **Fig. 6** for this procedure.

1. If the No. 2 driveshaft is also being removed, remove it first.

   If the No. 2 driveshaft is not being removed, use a nylon support strap to support its forward end.
2. Uncouple the intermediate coupling shaft from the No. 2 driveshaft. If the intermediate coupling shaft has a *half-round* end-yoke, follow the uncoupling procedure in **Subject 100**. If the intermediate coupling shaft has a *full-round* end-yoke, follow the uncoupling procedure in **Subject 110**.
3. Uncouple the intermediate coupling shaft from the primary coupling shaft. See **Fig. 7** and **Fig. 8**. If the primary coupling shaft has a half-round end-yoke, follow the uncoupling procedure in **Subject 100**. If the primary coupling shaft has a full-round end-yoke, follow the uncoupling procedure in **Subject 110**.
4. Lift the intermediate coupling shaft out of the chassis.

Primary Coupling Shaft Removal

Refer to **Fig. 7** and **Fig. 8** for this procedure.

1. *For a vehicle with one coupling shaft:*

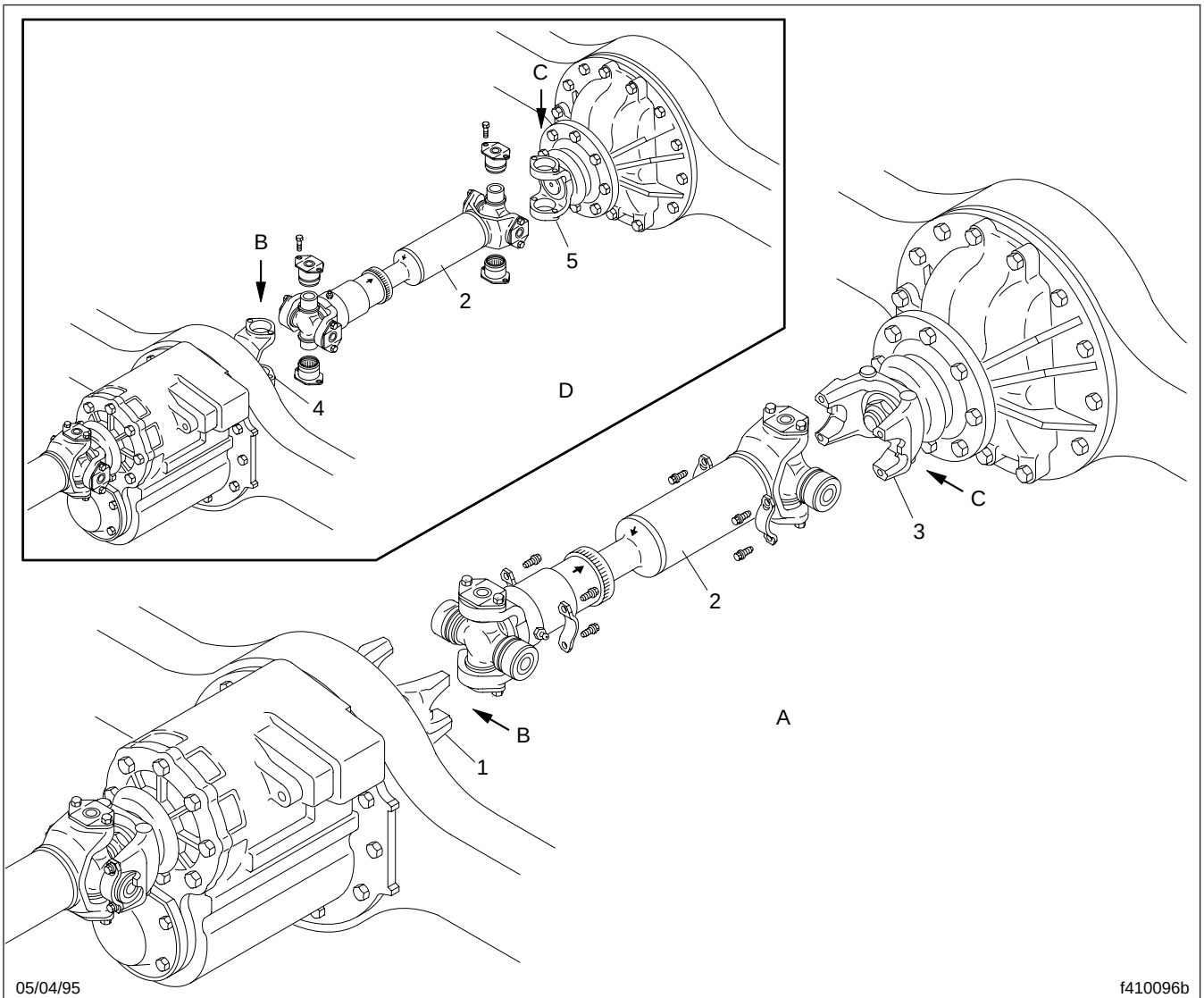
   If the No. 2 driveshaft is also being removed, remove it first.

   If the No. 2 driveshaft is not being removed, use a nylon support strap to support its forward end.

   For a vehicle with two coupling shafts:

   If the No. 2 driveshaft is also being removed, remove it first; then, remove the intermediate coupling shaft.

Driveshaft Removal and Installation



NOTE: Not all fasteners are shown.

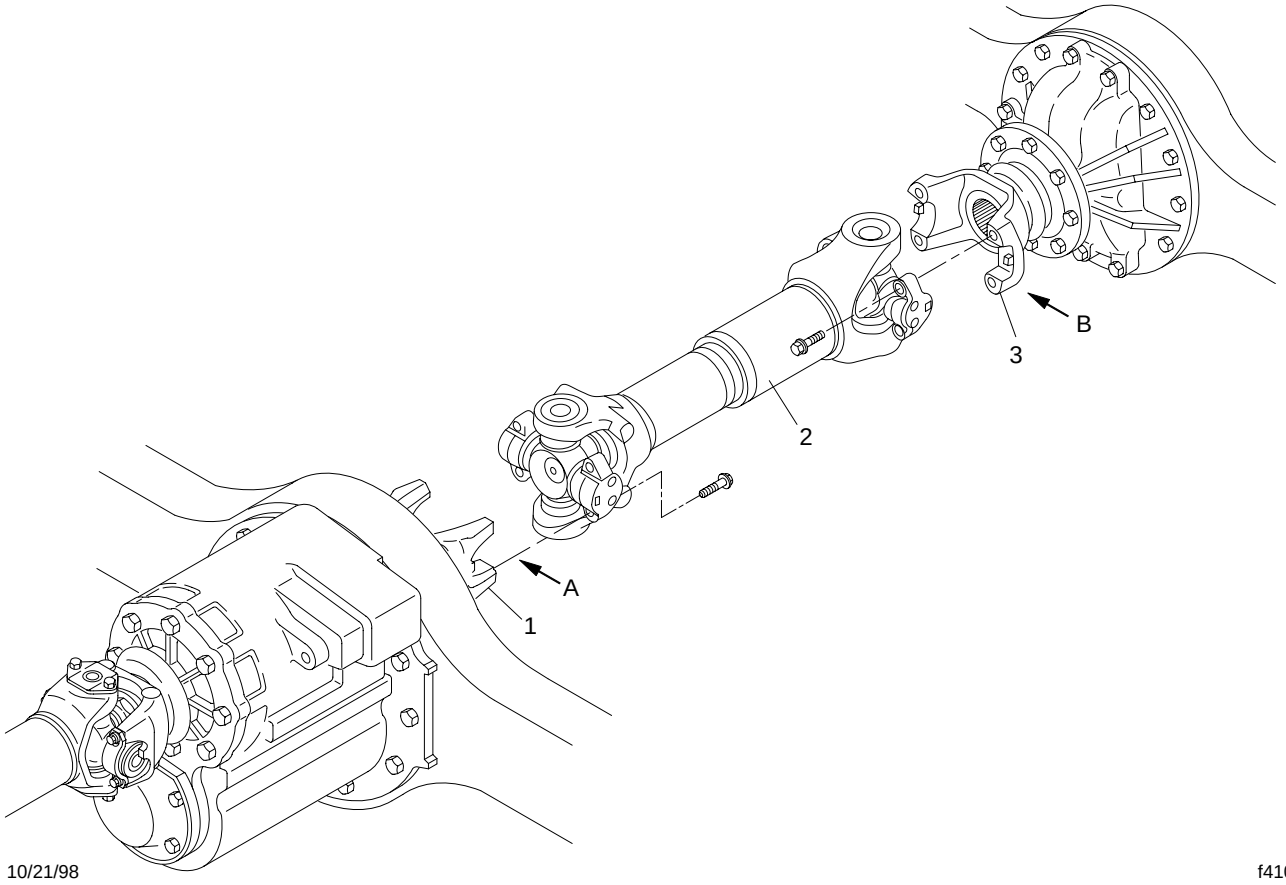
A. No. 3 Driveshaft Coupled to Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 3 Driveshaft Coupled to Full-Round End-Yokes

1. Forward-Rear Axle Output-Shaft Half-Round End-Yoke
2. No. 3 Driveshaft
3. Rearmost Axle Input-Shaft Half-Round End-yoke
4. Forward-Rear Axle Output-Shaft Full-Round End-Yoke
5. Rearmost Axle Input-Shaft Full-Round End-yoke

Fig. 1, Removal/Installation of a No. 3 Driveshaft Without RPL U-Joints

If the intermediate coupling shaft is also being removed (but not the No. 2 driveshaft), remove the intermediate coupling shaft first.

If only the primary coupling shaft is being removed, use nylon support straps to support the forward end of the No. 2 driveshaft and both ends of the intermediate coupling shaft. Then,



NOTE: Not all fasteners are shown.

A. Uncouple this end last; couple this end first.

B. Uncouple this end first; couple this end last.

1. Forward-Rear Axle Output-Shaft Half-Round End-Yoke

2. No. 3 Driveshaft

3. Rearmost Axle Input-Shaft Half-Round End-Yoke

Fig. 2, Removal/Installation of a No. 3 Driveshaft With RPL U-Joints

remove the fasteners that attach the intermediate coupling shaft midship bearing to its bracket. See **Fig. 7** and **Fig. 8**.

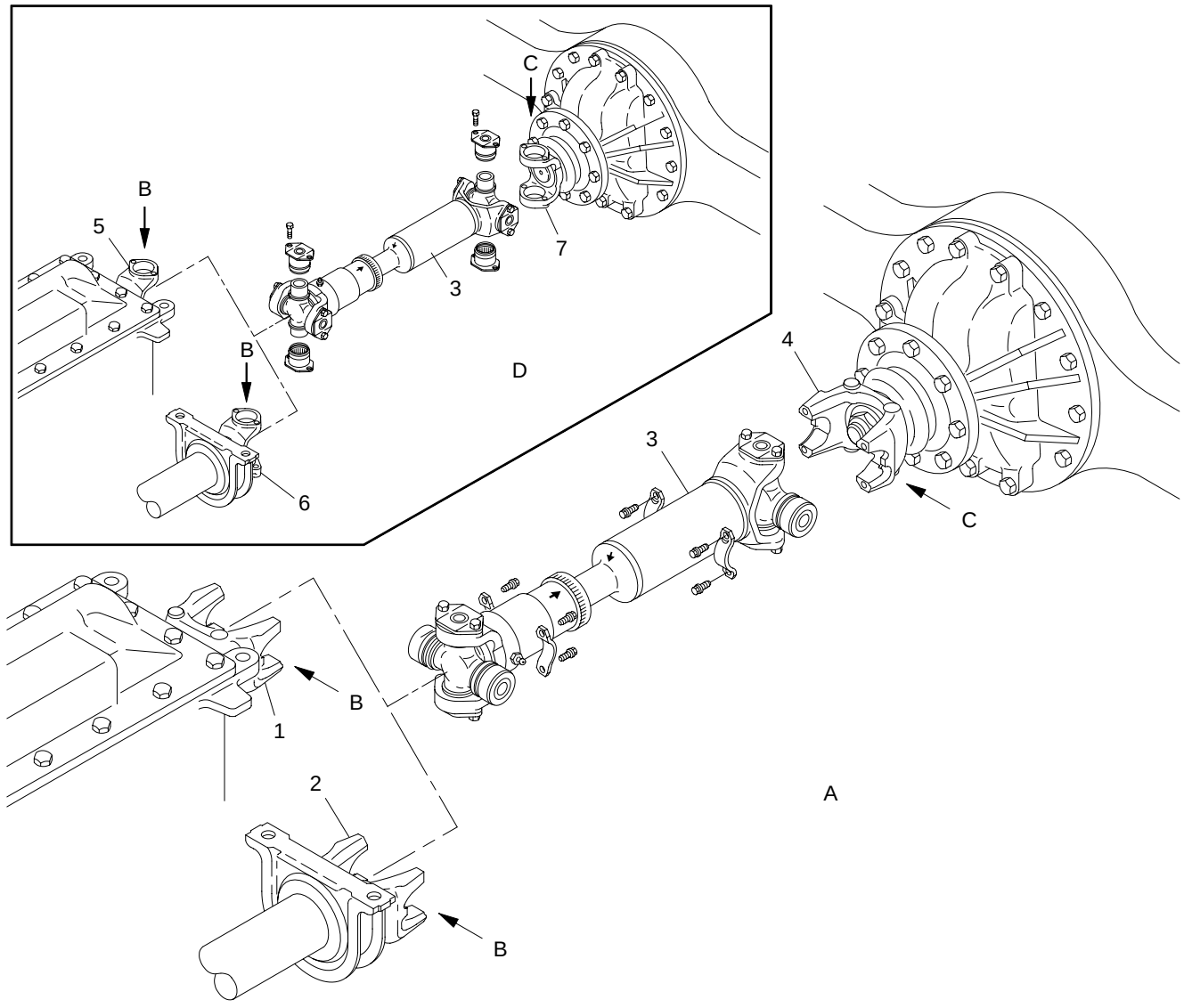
2. If not already done, uncouple the primary coupling shaft from the No. 2 driveshaft or intermediate coupling shaft. If the primary coupling shaft has a *half-round* end-yoke, follow the uncoupling procedure in **Subject 100**. If the primary coupling shaft has a *full-round* end-yoke, follow the uncoupling procedure in **Subject 110**.

3. Using two nylon support straps, support the primary coupling shaft. Then remove the fasteners that attach the primary coupling shaft midship bearing to its bracket. See **Fig. 7** and **Fig. 8**.

4. Uncouple the primary coupling shaft from the transmission. If the primary coupling shaft is coupled to a half-round end-yoke, follow the uncoupling procedure in **Subject 100**. If the primary coupling shaft is coupled to a full-round end-yoke, follow the uncoupling procedure in **Subject 110**.

5. Lift the primary coupling shaft out of the chassis.

Driveshaft Removal and Installation



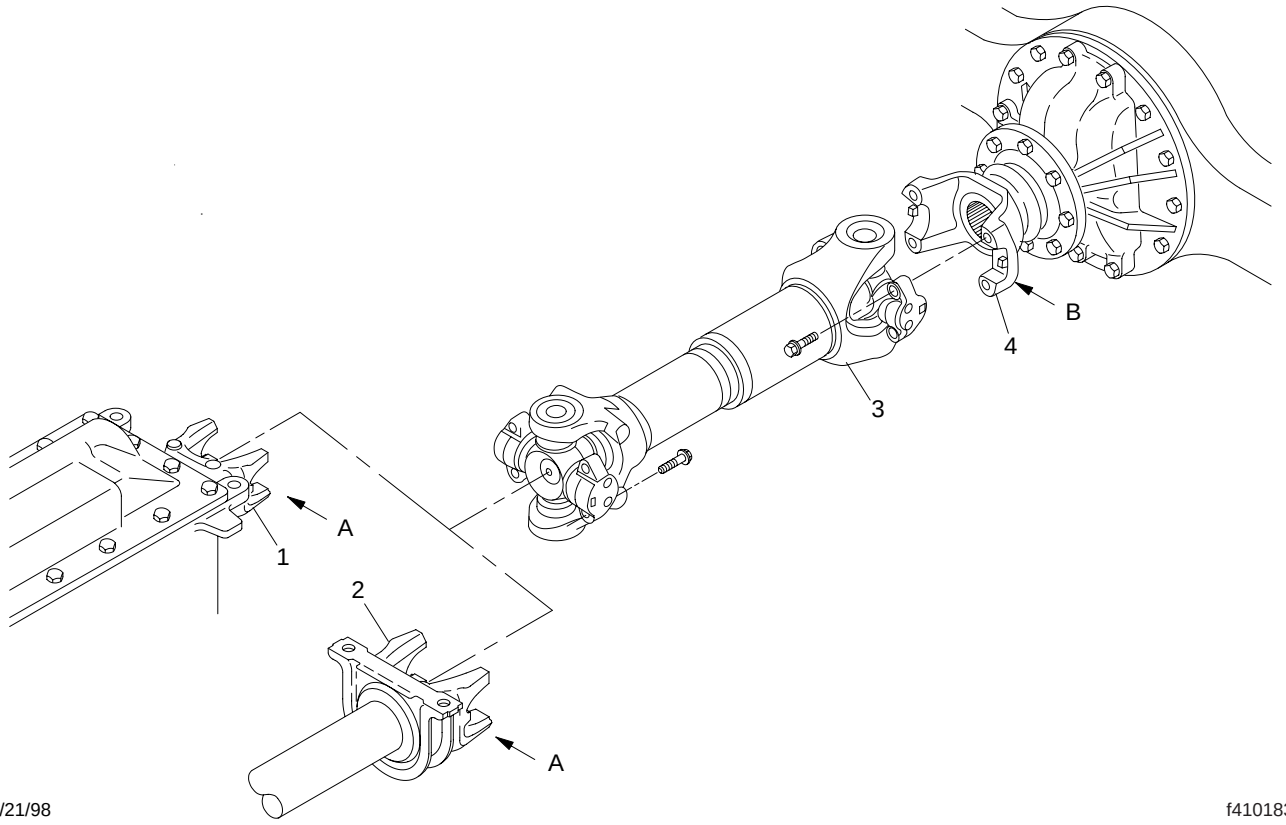
05/05/95 f410080b

NOTE: Not all fasteners are shown.

A. No. 2 Driveshaft Coupled to Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 2 Driveshaft Coupled to Full-Round End-Yokes

1. Transmission Output-Shaft Half-Round End-Yoke
2. Coupling Shaft Half-Round End-Yoke
3. No. 2 Driveshaft
4. Single Axle or Forward-Rear Axle Input-Shaft Half-Round End-Yoke
5. Transmission Output-Shaft Full-Round End-Yoke
6. Coupling Shaft Full-Round End-Yoke
7. Single Axle or Forward-Rear Axle Input-Shaft Full-Round End-Yoke

Fig. 3, Removal/Installation of a No. 2 Driveshaft Without RPL U-Joints



NOTE: Not all fasteners are shown.

A. Uncouple this end last; couple this end first.
B. Uncouple this end first; couple this end last.

1. Transmission Output-Shaft Half-Round End-Yoke
2. Coupling Shaft Half-Round End-Yoke
3. No. 2 Driveshaft
4. Single Axle or Forward-Rear Axle Input-Shaft Half-Round End-Yoke

Fig. 4, Removal/Installation of a No. 2 Driveshaft With RPL U-Joints

Primary Coupling Shaft Installation

Refer to **Fig. 7** and **Fig. 8** for this procedure.

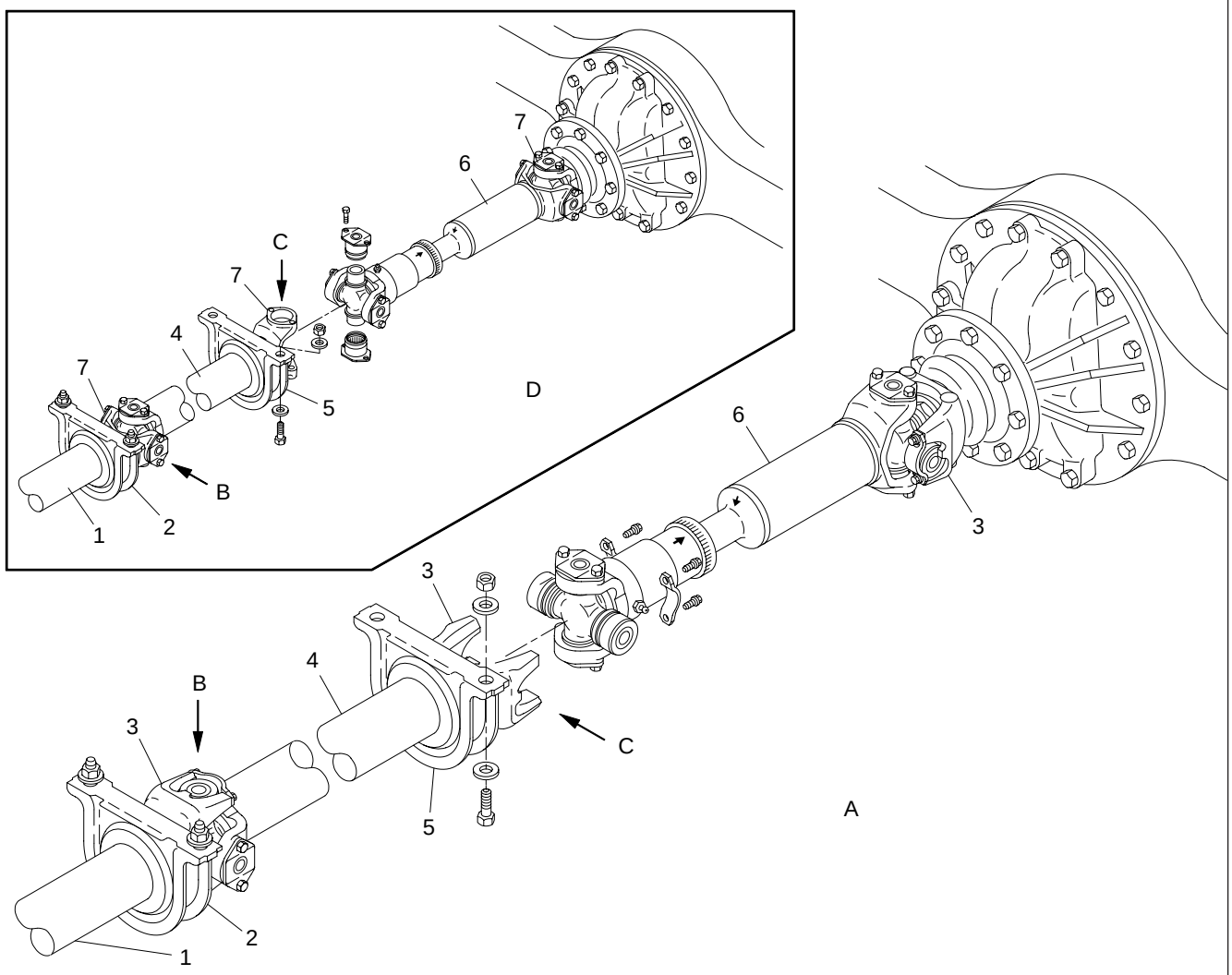
IMPORTANT: Before installing a coupling shaft, make sure the yokes are aligned to keep the U-joints in phase. See **Fig. 9**.

1. Place the primary coupling shaft under the vehicle and support it with nylon support straps so it can be coupled to the transmission end-yoke.
2. Couple the shaft to the transmission end-yoke. If the primary coupling shaft was coupled to a *half-round* end-yoke, follow the coupling procedure in **Subject 100**. If the primary coupling shaft was coupled to a *full-round* end-yoke, follow the coupling procedure in **Subject 110**.
3. *For a vehicle with one coupling shaft:*

   If the No. 2 driveshaft was also removed, install it, as instructed in this subject.

   If the No. 2 driveshaft was not removed, couple it to the primary coupling shaft end-yoke. If the primary coupling shaft has a half-round end-yoke, follow the coupling procedure in **Subject 100**. If

Driveshaft Removal and Installation



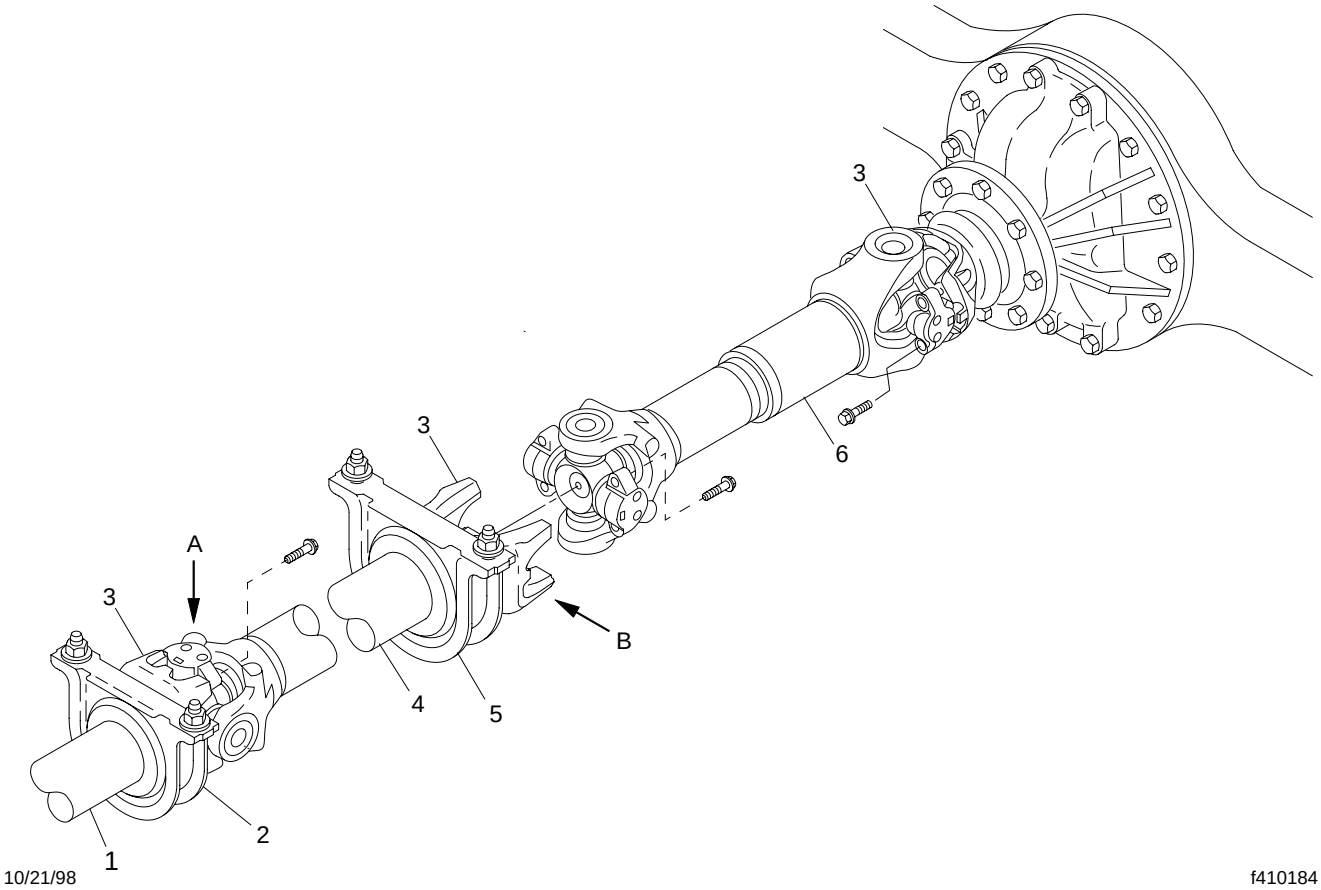
05/04/95 f410084b

NOTE: Not all fasteners are shown.

A. No. 2 Driveline With Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 2 Driveline With Full-Round End-Yokes

1. Primary Coupling Shaft
2. Primary Coupling Shaft Midship Bearing
3. Half-Round End-Yoke
4. Intermediate Coupling Shaft
5. Intermediate Coupling Shaft Midship Bearing
6. No. 2 Driveshaft
7. Full-Round End-Yoke

Fig. 5, Removal/Installation of an Intermediate Coupling Shaft Without RPL U-Joints



NOTE: Not all fasteners are shown.

A. Uncouple this end last; couple this end first.
B. Uncouple this end first; couple this end last.
1. Primary Coupling Shaft
2. Primary Coupling Shaft Midship Bearing
3. Half-Round End-Yoke
4. Intermediate Coupling Shaft
5. Intermediate Coupling Shaft Midship Bearing
6. No. 2 Driveshaft

Fig. 6, Removal/Installation of an Intermediate Coupling Shaft With RPL U-Joints

the primary coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.

For a vehicle with two coupling shafts:

If the intermediate coupling shaft was also removed, install it, as instructed in this subject.

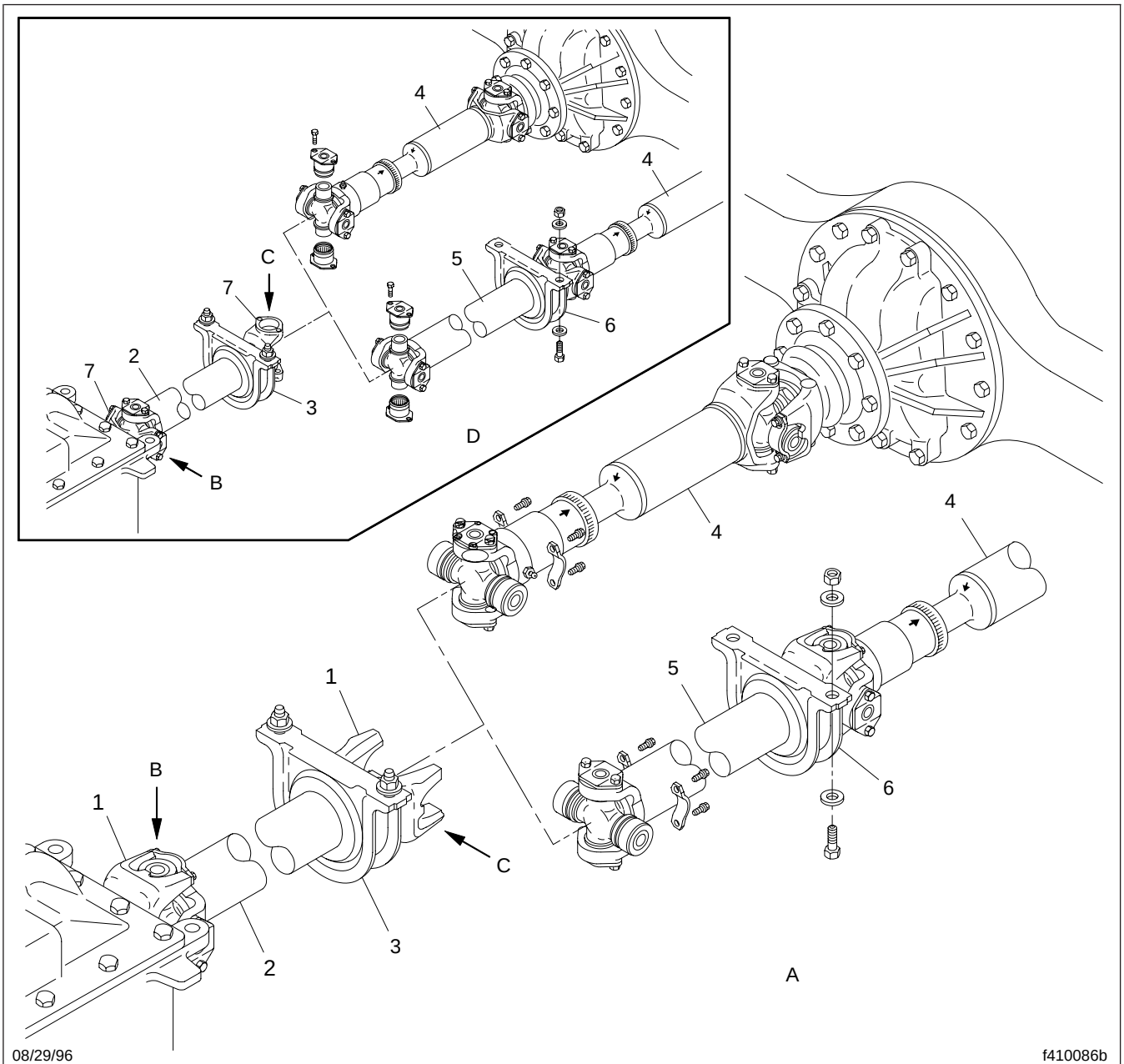
If only the primary coupling shaft was removed, couple the intermediate coupling shaft to the primary coupling shaft end-yoke. If the primary coupling shaft has a half-round end-yoke, follow the coupling procedure in **Subject 100**. If the primary coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.

Intermediate Coupling Shaft Installation

Refer to **Fig. 5** and **Fig. 6** for this procedure.

IMPORTANT: Before installing a coupling shaft, make sure the yokes are aligned to keep the U-joints in phase. See **Fig. 9**.

Driveshaft Removal and Installation

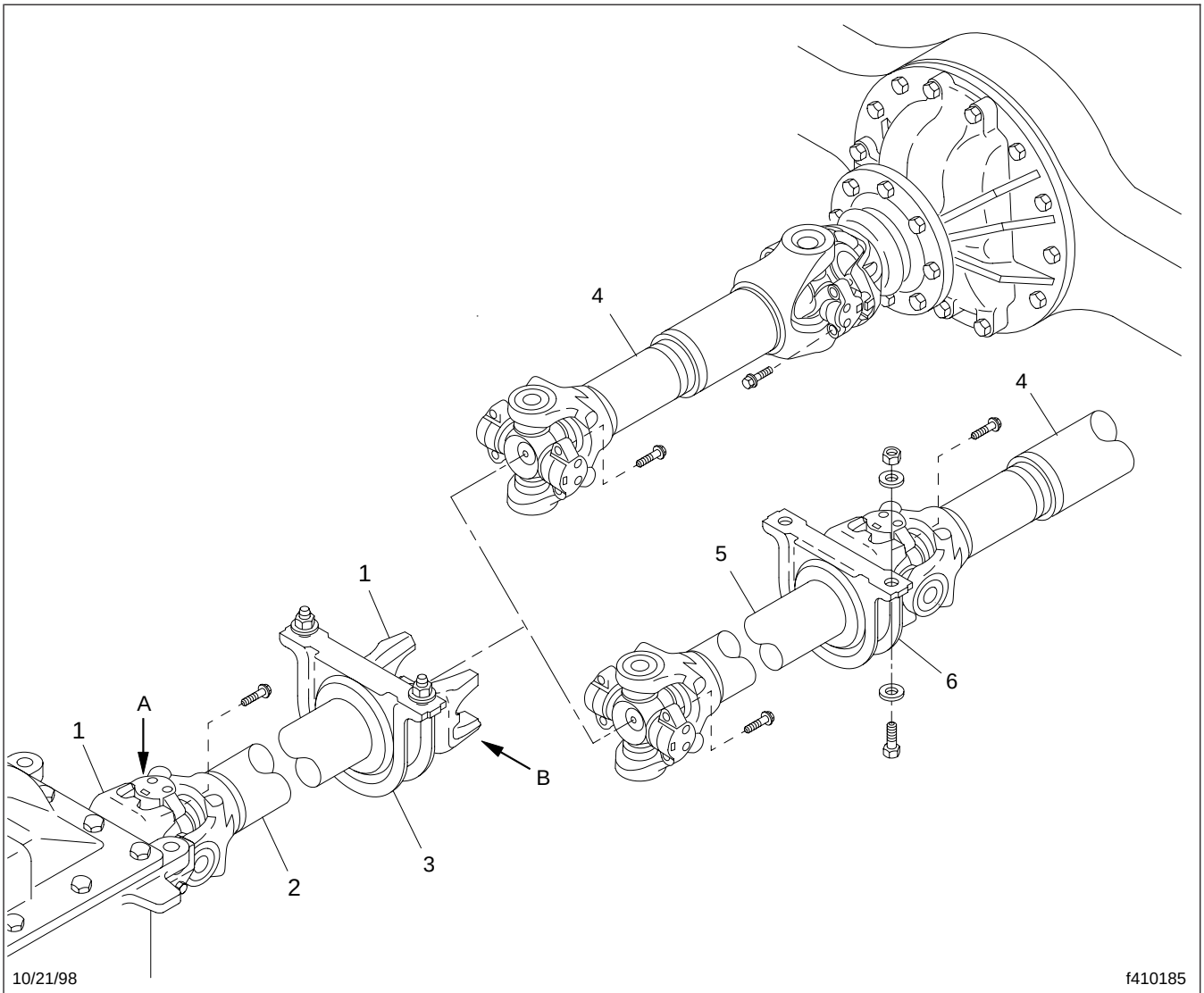


NOTE: Not all fasteners are shown.

A. No. 2 Driveline With Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 2 Driveline With Full-Round End-Yokes

1. Half-Round End-Yoke
2. Primary Coupling Shaft
3. Primary Coupling Shaft Midship Bearing
4. No. 2 Driveshaft
5. Intermediate Coupling Shaft
6. Intermediate Coupling Shaft Midship Bearing
7. Full-Round End-Yoke

Fig. 7, Removal/Installation of a Primary Coupling Shaft Without RPL U-Joints



NOTE: Not all fasteners are shown.

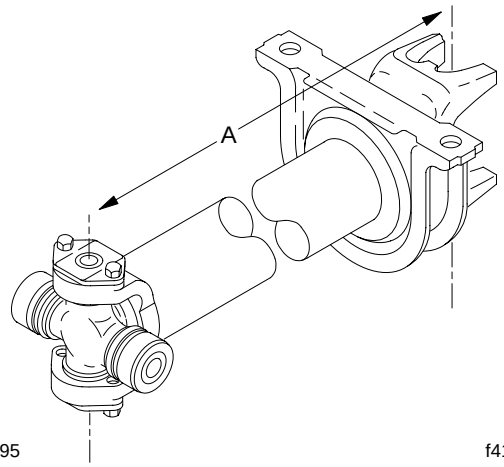
A. Uncouple this end last; couple this end first.
B. Uncouple this end first; couple this end last.

1. Half-Round End-Yoke
2. Primary Coupling Shaft
3. Primary Coupling Shaft Midship Bearing
4. No. 2 Driveshaft
5. Intermediate Coupling Shaft
6. Intermediate Coupling Shaft Midship Bearing

Fig. 8, Removal/Installation of a Primary Coupling Shaft With RPL U-Joints

1. If the primary coupling shaft was also removed, install it first, as instructed in this subject.
2. Place the intermediate coupling shaft under the vehicle and support it with nylon support straps so it can be coupled to the primary coupling shaft end-yoke.
3. Couple the intermediate coupling shaft to the primary coupling shaft end-yoke. If the intermediate coupling shaft was coupled to a *half-round* end-yoke, follow the coupling procedure in **Subject 100**. If the intermediate coupling shaft was

Driveshaft Removal and Installation



A. Cross-hole centerlines of both yokes must be in alignment.

Fig. 9, U-Joint Phasing of a Coupling Shaft

coupled to a *full-round* end-yoke, follow the coupling procedure in **Subject 110**.

4. If the No. 2 driveshaft was also removed, install it, as instructed in this subject.

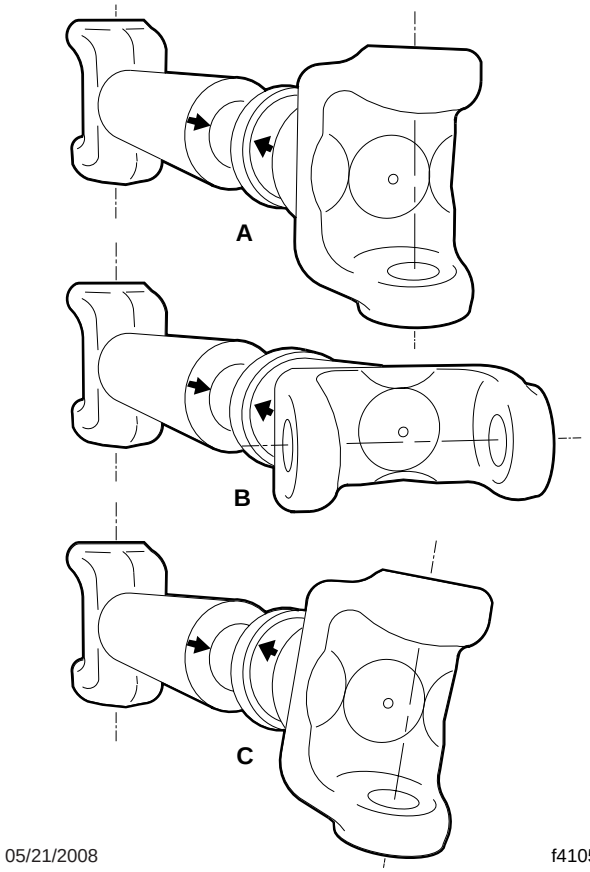
   If the No. 2 driveshaft was not removed, couple it to the intermediate coupling shaft end-yoke. If the intermediate coupling shaft has a half-round end-yoke, follow the coupling procedure in **Subject 100**. If the intermediate coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.

No. 2 Driveshaft Installation

Refer to **Fig. 3** and **Fig. 4** for this procedure.

IMPORTANT: Before installing a No. 2 driveshaft, make sure the alignment marks on the slip-joint assembly are aligned, to keep the U-joints in phase; see **Fig. 10**.

1. If a primary coupling shaft was also removed, install it first, as instructed in this subject.
2. If an intermediate coupling shaft was also removed, install it before installing the No. 2 driveshaft.
3. Place the No. 2 driveshaft under the vehicle with its sleeve-yoke at the forward end, and support its rear end with a nylon support strap.



A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

Fig. 10, U-Joint Phasing

4. Couple the sleeve-yoke to the coupling shaft end-yoke or transmission output-shaft end-yoke, as applicable. If the No. 2 driveshaft was coupled to *half-round* end-yokes, follow the coupling procedure in **Subject 100**. If the No. 2 driveshaft was coupled to *full-round* end-yokes, follow the coupling procedure in **Subject 110**.
5. Couple the No. 2 driveshaft to the axle input-shaft end-yoke. If the No. 2 driveshaft was coupled to half-round end-yokes, follow the coupling procedure in **Subject 100**. If the No. 2 driveshaft was coupled to full-round end-yokes, follow the coupling procedure in **Subject 110**.

No. 3 Driveshaft Installation

Refer to **Fig. 1** and **Fig. 2** for this procedure.

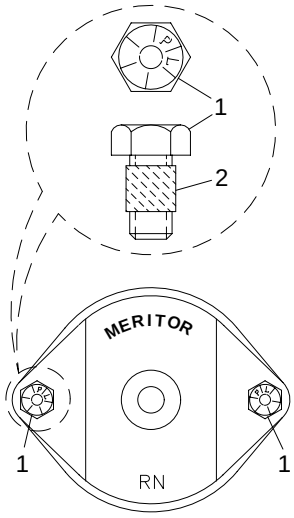
IMPORTANT: Before installing a No. 3 driveshaft, make sure the alignment marks on the slip-joint assembly are aligned, to keep the U-joints in phase; see **Fig. 10**.

1. Place the No. 3 driveshaft under the vehicle with its sleeve-yoke at the forward end, and support its rear end with a nylon support strap.
2. Couple the sleeve-yoke to the forward-rear axle output-shaft end-yoke. If the No. 3 driveshaft was coupled to *half-round* end-yokes, follow the coupling procedure in **Subject 100**. If the No. 3 driveshaft was coupled to *full-round* end-yokes, follow the coupling procedure in **Subject 110**.
3. Couple the No. 3 driveshaft to the axle input-shaft end-yoke. If the No. 3 driveshaft was coupled to half-round end-yokes, follow the coupling procedure in **Subject 100**. If the No. 3 driveshaft was coupled to full-round end-yokes, follow the coupling procedure in **Subject 110**.

U-Joint Removal

Full-Round Yokes

1. Remove the driveshaft from the vehicle. See **Subject 120**.
2. Place the driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
3. Remove and discard all four bearing-plate self-locking capscrews. See **Fig. 1**.



04/13/94 f410155a

1. Self-Locking Capscrew
2. Adhesive Band

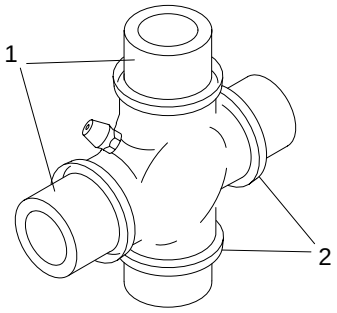
Fig. 1, Meritor U-Joint Fasteners for Full-Round Yokes

IMPORTANT: If the U-joint will be reinstalled, use care not to nick the cross trunnions or damage the slingers. See **Fig. 2**.

4. Using one of the U-joint pullers listed in **Specifications, 400**, remove both bearing cups from the yoke cross-holes. See **Fig. 3**. Remove the cross from the yoke.

RPL Series U-Joints

NOTE: Do not reuse RPL U-joints. Always replace an RPL U-joint with a new one after they have been disassembled and removed from a driveshaft.



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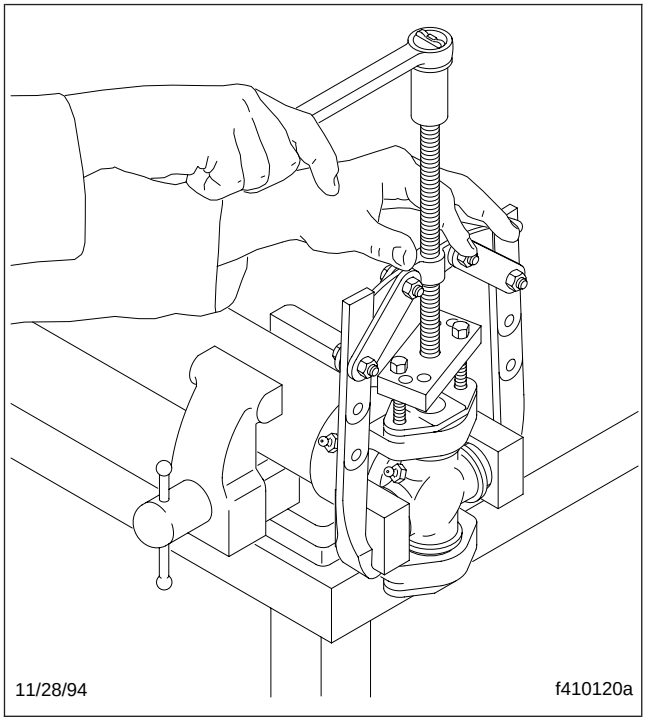
1. Trunnions 2. Slingers

Fig. 2, U-Joint Cross

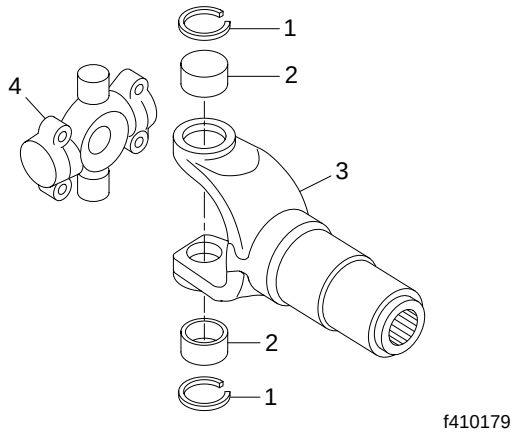


11/28/94 f410120a

Fig. 3, Removing a Bearing Cup from a Full-Round Yoke

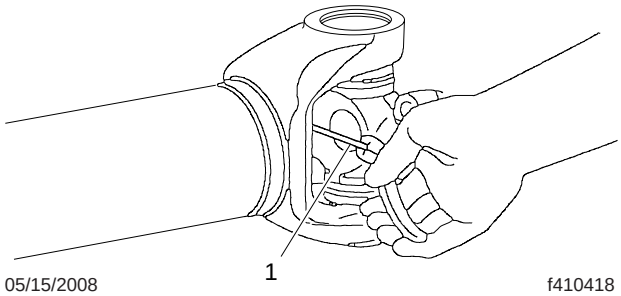
1. Remove the driveshaft from the vehicle. See **Subject 120**.
2. Place the driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
3. Remove and discard snap rings. See **Fig. 4**.
4. Cut the weld strap (**Fig. 5**) that retains the bearing cups; remove both bearing cups. See **Fig. 6**.

Driveline Component Removal/Disassembly



1. Snap Ring
2. Bearing Cup
3. Full Round Yoke
4. Bearing Cup (RPL Joint)

Fig. 4, RPL U-Joint Components



1. Weld-Strap

Fig. 5, Cutting the Weld-Strap

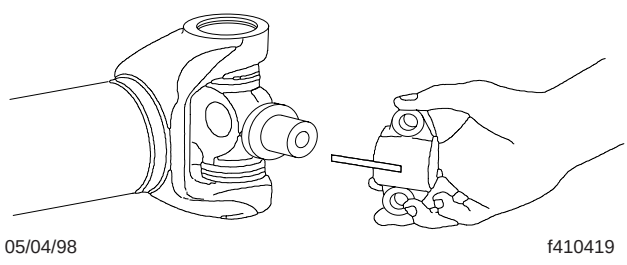
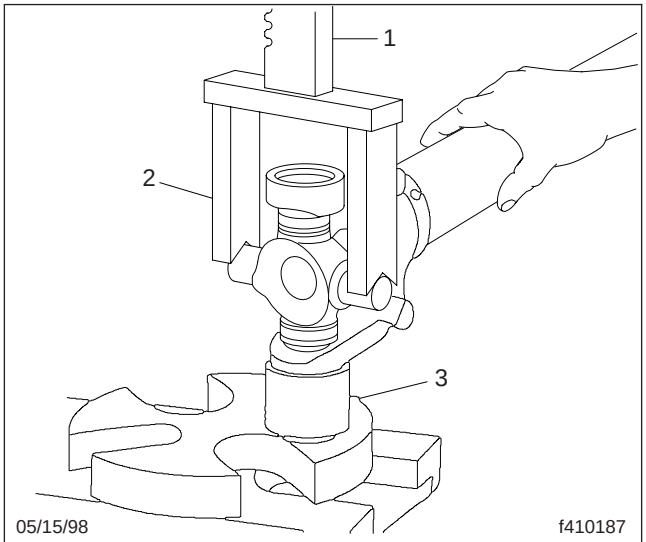


Fig. 6, Removing the Bearing Cups

5. Remove both bearing cups from the yoke cross-holes. See **Fig. 7**. Remove the cross from the yoke.



1. Press
2. Bridge
3. Bearing Cup Receiver

Fig. 7, Removing Bearing Cups from an RPL U-Joint

Slip-Joint Disassembly

Except RPL Drivelines

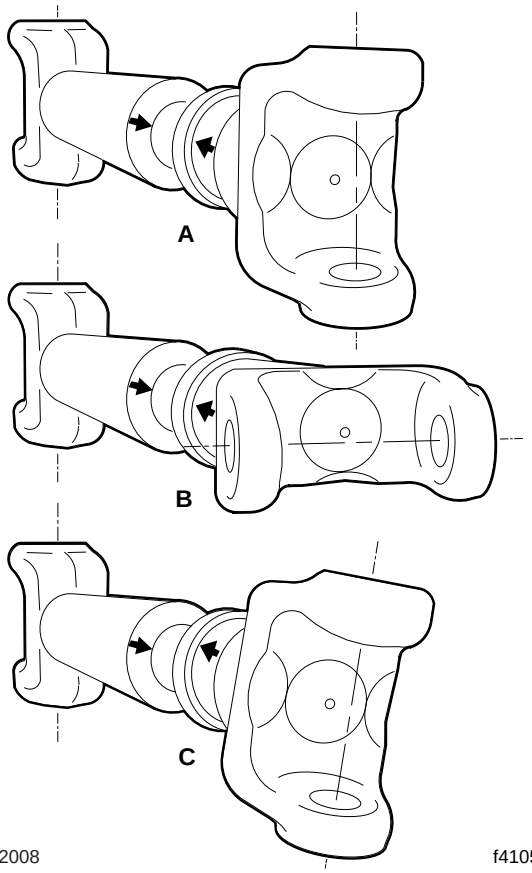
1. Check that the driveshaft yokes are aligned to hold the U-joints at either end in phase, as shown in **Fig. 8**. Using a marking stick or paint, mark the sleeve-yoke and splined shaft with alignment marks, as shown in **Fig. 9**. This will ensure proper alignment of the slip-joint components when the driveshaft is assembled.

IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

2. With the driveshaft uncoupled at one end, *or* removed from the vehicle, use a strap wrench to unscrew the slip-joint dust cap from the sleeve-yoke, then pull the sleeve-yoke off of the splined shaft. Remove the dust cap, and (if so equipped) the steel washer and cork seal. See **Fig. 10**.

RPL Drivelines

1. Check that the driveshaft yokes are aligned to hold the U-joints at either end in phase, as shown in **Fig. 8**. Using a marking stick or paint, mark the sleeve-yoke and splined shaft with alignment marks, as shown in **Fig. 9**. This will



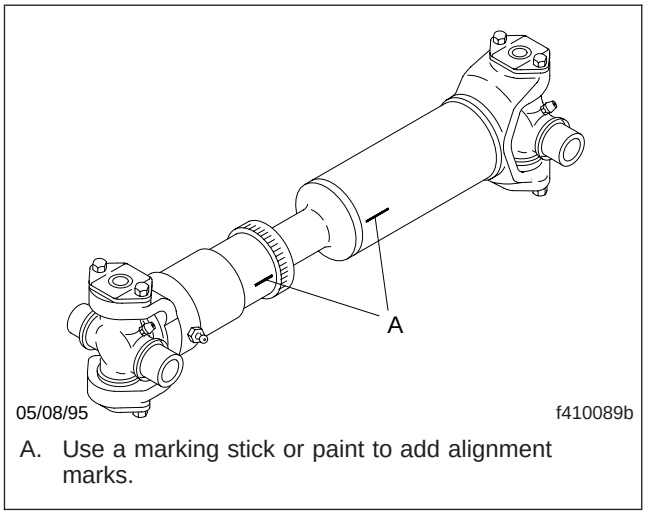
A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

Fig. 8, U-Joint Phasing

ensure proper alignment of the slip-joint components when the driveshaft is assembled.

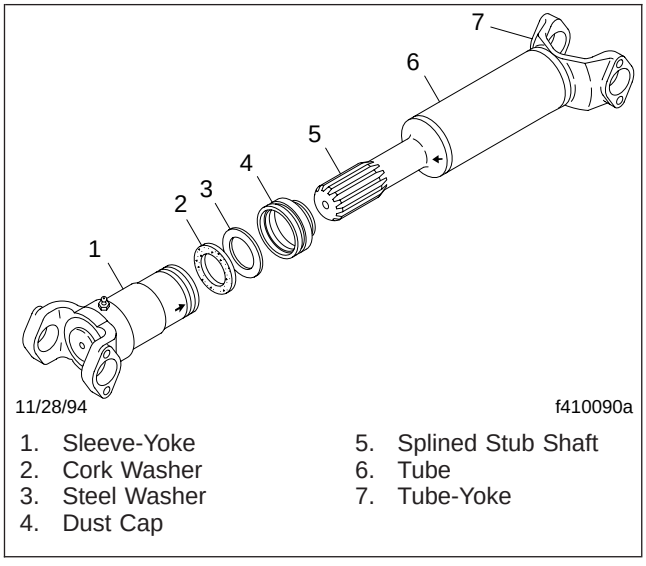
IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

2. With the driveshaft uncoupled at one end, *or* removed from the vehicle, use a brass hammer and punch to tap the shroud off the slip seal. See **Fig. 11**.
3. Use a screwdriver to pry the seal out of the groove in the slip yoke, then pull the sleeve-yoke off of the splined shaft. Remove the shroud and seal.



A. Use a marking stick or paint to add alignment marks.

Fig. 9, Slip-Joint Alignment Marks



1. Sleeve-Yoke
2. Cork Washer
3. Steel Washer
4. Dust Cap
5. Splined Stub Shaft
6. Tube
7. Tube-Yoke

Fig. 10, Slip-Joint Components

Transmission/Axle End-Yoke Removal

IMPORTANT: Before removing a transmission output-shaft end-yoke or an axle shaft end-yoke, do the steps under "End-Yoke Cleaning and Inspection," in **Subject 140**.

1. Uncouple the driveshaft from the end-yoke **(Subject 100** for a half-round yoke or **Sub-**

Driveline Component Removal/Disassembly

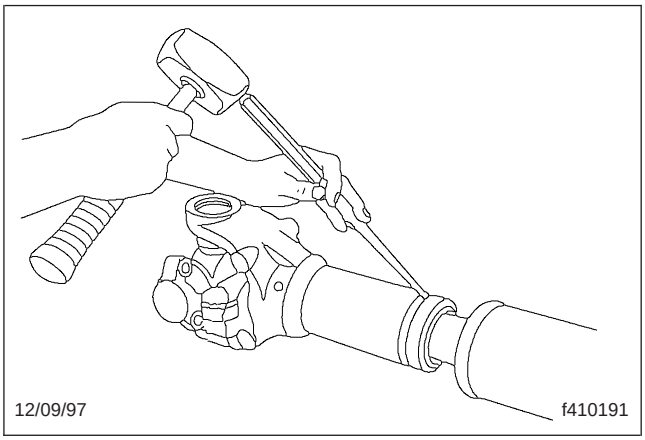


Fig. 11, Shroud Removal

ject 110 for a full-round yoke), or remove the driveshaft from the vehicle (Subject 120).

2. Remove the end-yoke locknut. See Fig. 12.

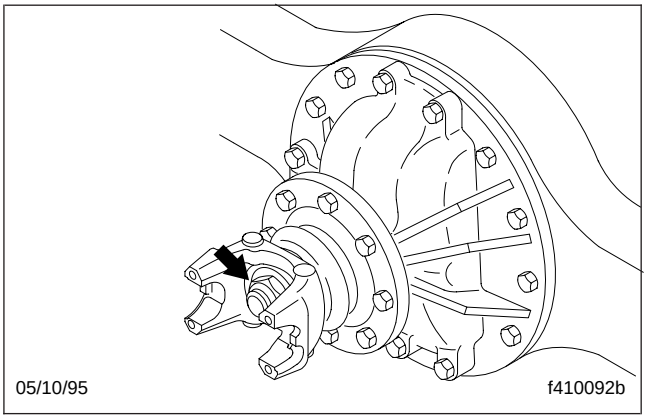
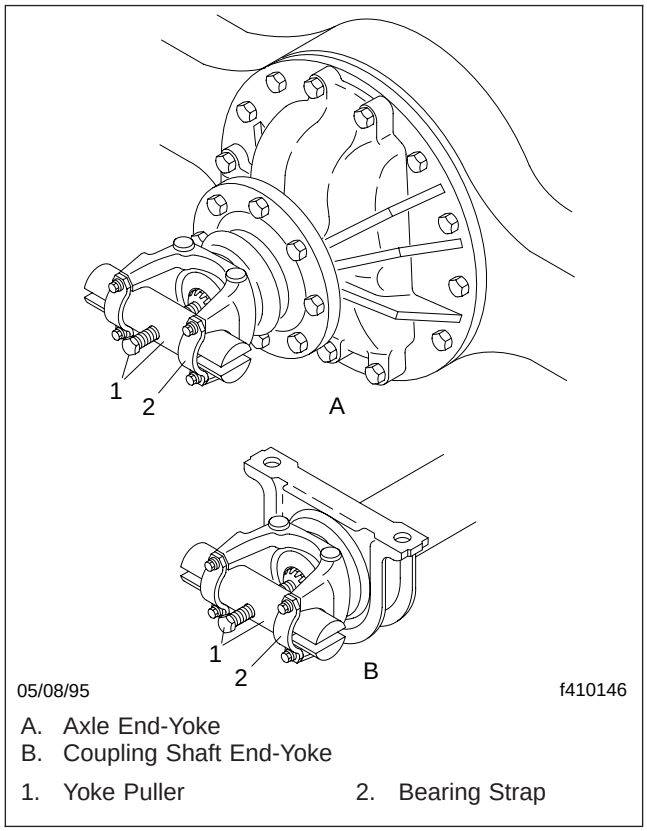


Fig. 12, Axle End-Yoke Locknut

3. Using a yoke puller, remove the end-yoke. See Fig. 13 for a half-round end-yoke, or see Fig. 14 for a full-round end-yoke.

Coupling Shaft End-Yoke and Midship Bearing Removal

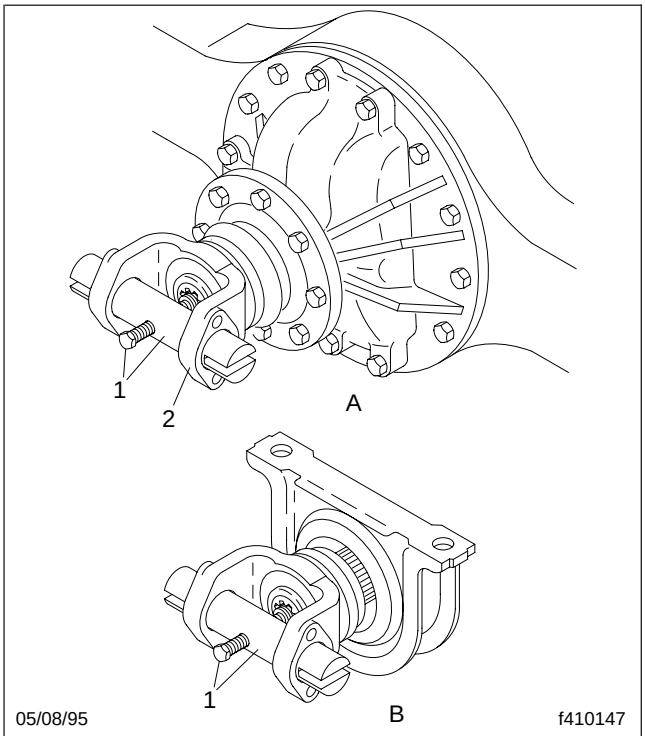
NOTE: Vehicles manufactured after January 18, 2002, were built with a newly designed Meritor midship hanger bearing assembly. Separate dust shields, or "slingers," common to the previous design, are no longer required.



A. Axle End-Yoke
B. Coupling Shaft End-Yoke
1. Yoke Puller
2. Bearing Strap

Fig. 13, Removing a Half-Round End-Yoke

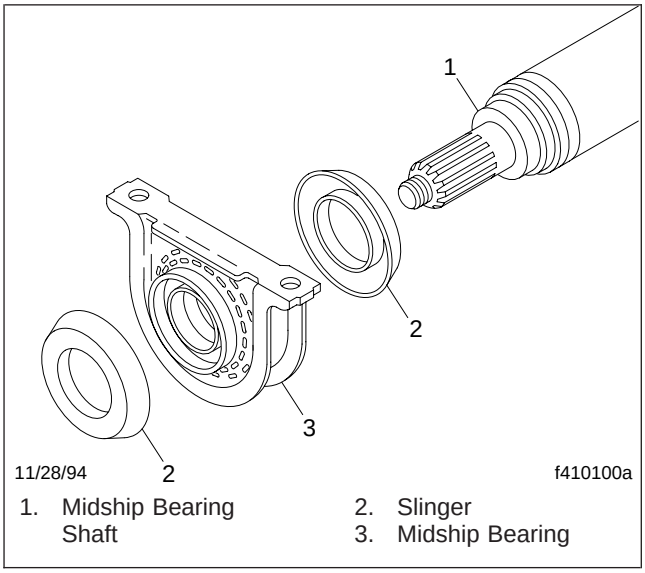
1. Remove the coupling shaft from the vehicle. See Subject 120.
2. Clamp the coupling shaft in a soft-jawed vise; do not distort the tube with excessive grip.
3. Remove the end-yoke, then the midship bearing and (if equipped) slingers, as follows.
   - 3.1 Use a marking stick or paint to mark the end-yoke and coupling shaft with alignment marks. See Fig. 16.
   - 3.2 Remove the coupling shaft end-yoke locknut.
   - 3.3 Using a yoke puller, remove the end-yoke. See Fig. 13 for a half-round end-yoke, or see Fig. 14 for a full-round end-yoke.
   - 3.4 Use a hammer and a brass drift to remove the midship bearing. See Fig. 15.



A. Axle End-Yoke
B. Coupling Shaft End-Yoke

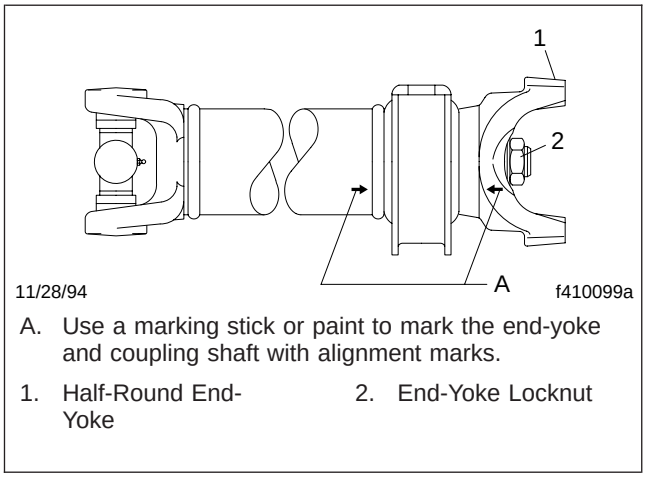
1. Yoke Puller
2. Full-Round End-Yoke

Fig. 14, Removing a Full-Round End-Yoke



1. Midship Bearing Shaft
2. Slinger
3. Midship Bearing

Fig. 15, Midship Bearing and Slingers



A. Use a marking stick or paint to mark the end-yoke and coupling shaft with alignment marks.

1. Half-Round End-Yoke
2. End-Yoke Locknut

Fig. 16, Alignment Marks on a Coupling Shaft With an End-Yoke

Driveshaft Tube, Slip-Joint, Sleeve-Yoke, and Tube-Yoke Cleaning and Inspection

1. With the driveshaft removed, scrape or soak away any foreign material.
2. Examine the driveshaft tube for dents, bends, twists, splitting weld-seams, and signs of missing balance weights.

   Replace the driveshaft tube if damaged; see "Driveshaft Tube, Stub Shaft (Slip-Joint), or Tube-Yoke Replacement," in **Subject 150**. If balance weights appear to be missing, have the driveshaft balanced to a maximum tolerance of one inch-ounce per ten pounds weight per end, at 3000 rpm.
3. Clean the slip-joint (male and female) splines, then check them for twisting and galling. See **Fig. 1**. Replace both the sleeve-yoke and the splined shaft if the slip-joint is damaged; see "Driveshaft Tube, Stub Shaft (Slip-Joint), or Tube-Yoke Replacement," in **Subject 150**. Remove any burrs or rough spots using fine emery cloth.

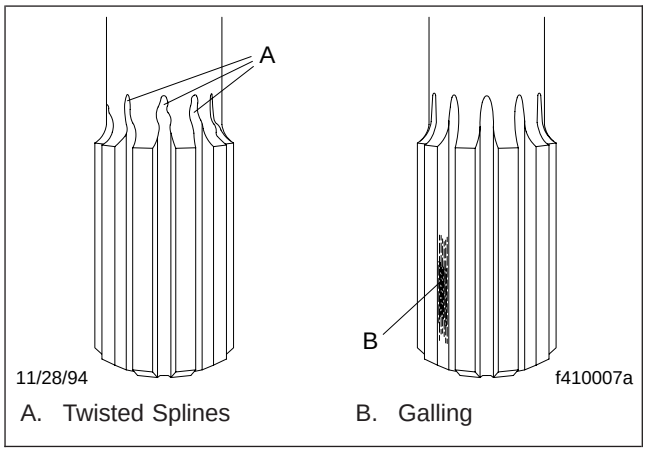


Fig. 1, Damaged Slip-Joint Splines

4. Check for a loose or missing sleeve-yoke plug. See **Fig. 2**. Repair or replace the plug as needed.
5. With the U-joint assemblies removed, check all driveshaft yoke cross-holes for raised metal. Using a rat-tail or half-round file, remove burrs or raised metal. See **Fig. 3**.

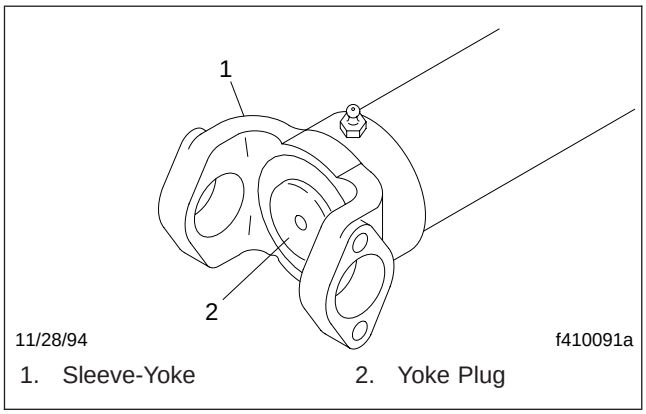


Fig. 2, Sleeve-Yoke Plug

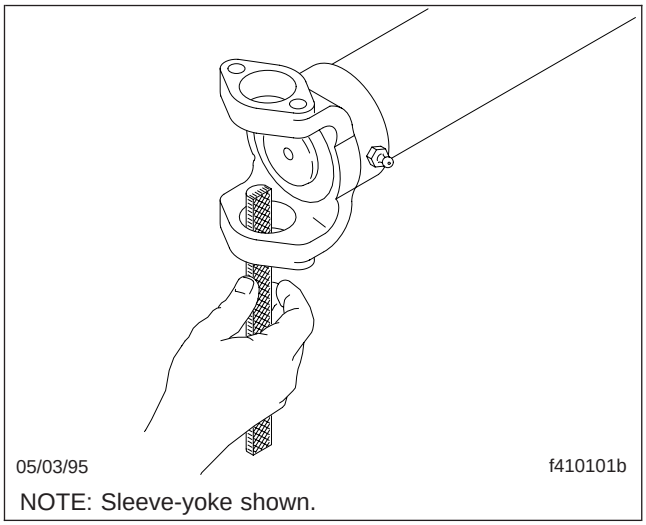


Fig. 3, Removing Burrs From a Full-Round Yoke Cross-Hole

6. Using a mill file, and holding it flat against the machined surface of the driveshaft yoke lug, file each yoke lug, to remove any burrs or raised metal. See **Fig. 4**.
7. Using fine emery cloth, smooth and clean the entire surface of all driveshaft yoke cross-holes. See **Fig. 5**.

Midship Bearing Cleaning and Inspection

1. With the midship bearing removed from the coupling shaft, use clean rags or paper towels to

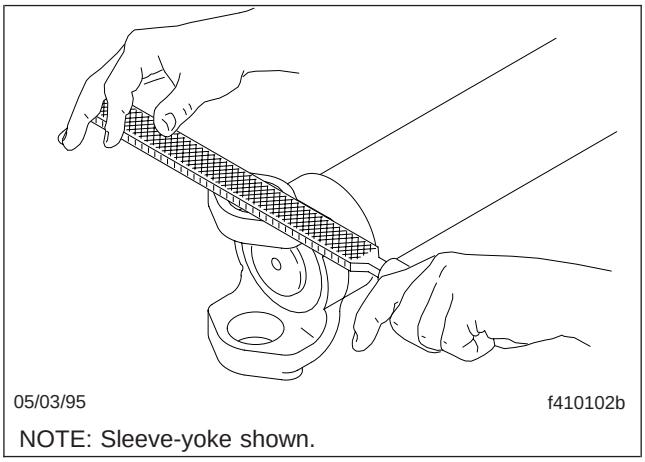


Fig. 4, Removing Burrs From the Machined Surface of a Full-Round Yoke Lug

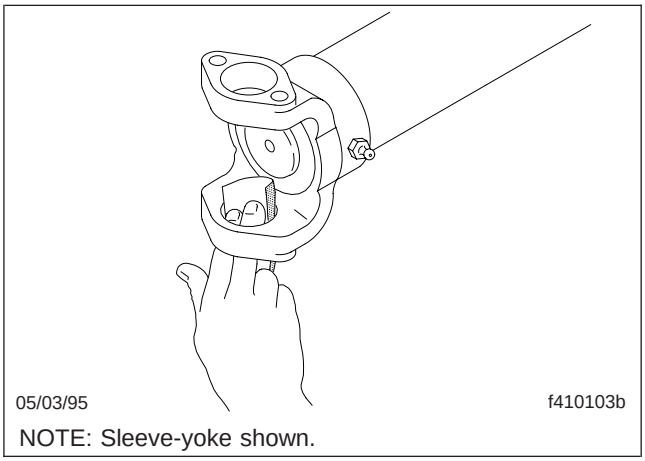


Fig. 5, Smoothing a Full-Round Yoke Cross-Hole

wipe off the outside of the midship bearing, rubber cushion, and slingers (if equipped).

IMPORTANT: Do not immerse the midship bearing in cleaning solvent. The solvent will wash out the lubricant, requiring bearing-assembly replacement.

2. Check the midship bearing for roughness or rattles by holding the outside of the bearing while manually turning the inner bearing race. Replace the bearing assembly if there are any rough spots or rattles.
3. Check the rubber cushion for deterioration or oil-soaking, and replace the midship bearing assembly if needed.

End-Yoke Cleaning and Inspection

1. With the transmission output-shaft and axle shaft end-yokes installed, check them for cracks and looseness.

   Replace cracked yokes. If the end-yoke can be moved in or out on its shaft, or can be rocked on its shaft, uncouple the driveshaft from the end-yoke. Check the drive component's shaft seal for leakage or other visible damage that may have been caused by the loose yoke. Replace the shaft seal if needed. Tighten the end-yoke nut to the torque value given in **Specifications 400**. If the end-yoke is still loose after tightening the yoke nut, install a new yoke and yoke nut.

NOTE: If the end-yoke locknut is removed for any reason, install a new one.

2. With the U-joints uncoupled from the end-yokes, check all driveshaft and input/output shaft end-yoke cross-holes for raised metal. Using a rat-tail or half-round file, remove burrs or raised metal. See **Fig. 3** for full-round yokes, or see **Fig. 6** for half-round yokes.

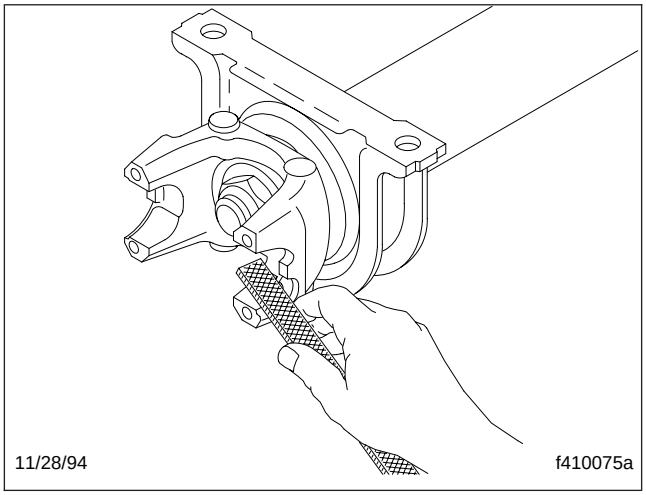
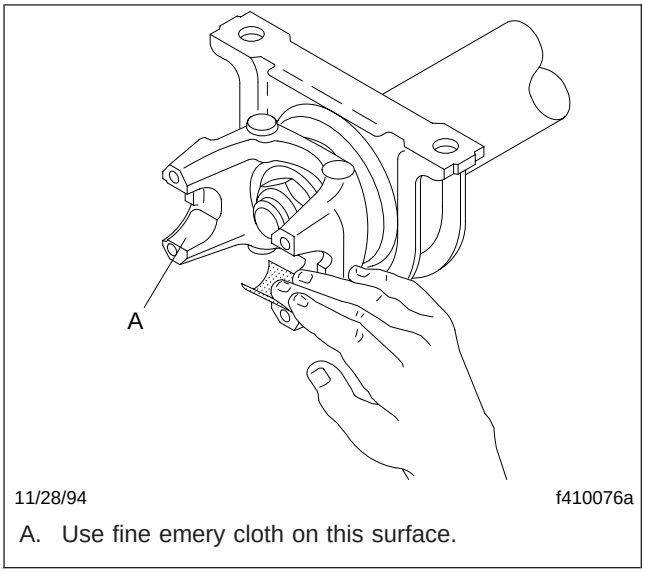


Fig. 6, Removing Burrs From a Half-Round End-Yoke Cross-Hole

3. Using a mill file, and holding it flat against the machined surface of the *full-round* end-yoke lug, file each yoke lug, to remove any burrs or raised metal. See **Fig. 4**.

4. Smooth and clean the entire surface of all end-yoke cross-holes, using fine emery cloth. See **Fig. 5** for full-round yokes, or see **Fig. 7** for half-round yokes.



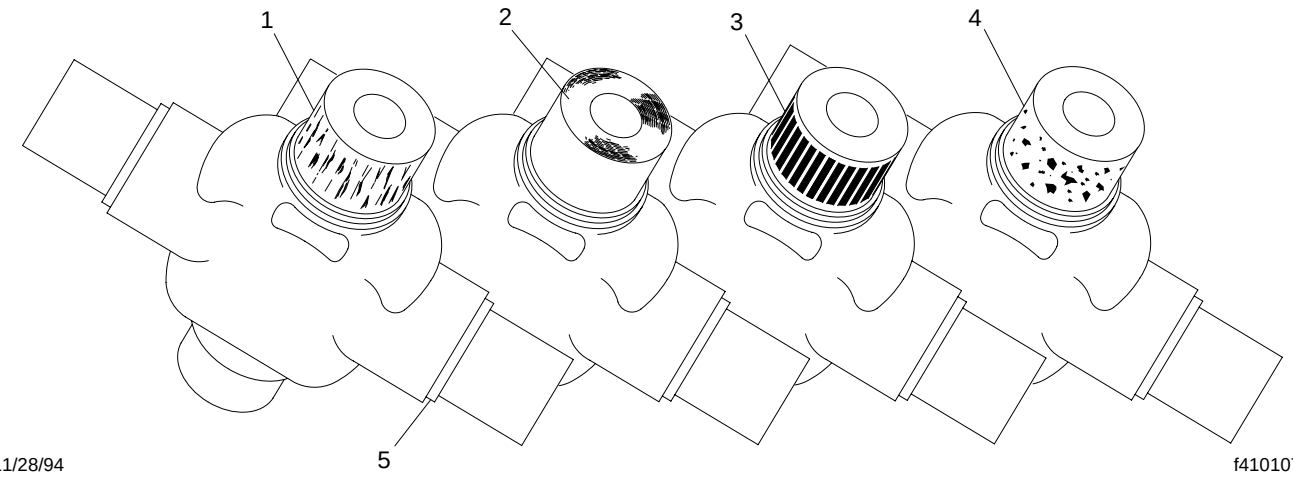
A. Use fine emery cloth on this surface.

Fig. 7, Smoothing a Half-Round End-Yoke Cross-Hole

U-Joint Cleaning and Inspection (not RPL Series)

1. With the U-joints removed from the yokes, and the bearing cups removed from the crosses, inspect the U-joint cross slingers for damage, then inspect the U-joint trunnions for spalling (flaking metal), end galling (displacement of metal), brinelling (grooves caused by bearing needles), and pitting (small craters caused by corrosion). See **Fig. 8**. If damaged, replace the U-joint assembly.
2. Using a hand-type grease gun, apply multipurpose chassis grease to the fitting on each U-joint cross until all old lubricant is forced out. See **Fig. 9**. Examine the old lubricant. If it appears rusty, gritty, or burnt, replace the U-joint assembly.
3. Soak the bearing cups in a non-flammable cleaner until particles of grease and foreign matter are loosened or dissolved. Do not disassemble the bearing cups; clean the bearing needles with a short, stiff brush, then blow them dry with compressed air. Check for minute particles of dirt or grit, and clean again if necessary.
4. Check each bearing cup for missing bearing needles. Check the bearing-cup seals for nicks. See **Fig. 10** for a half-round-yoke U-joint bearing cup, or see **Fig. 11** for a full-round-yoke U-joint bearing cup. Replace the U-joint assembly if any bearing needles are missing or any seals are damaged.
5. Apply a small quantity of multipurpose chassis grease to the bearing needles in each cup, then apply a small amount of light-weight oil to the lips of the bearing-cup seals. Rotate each bearing cup on the cross to check for wear. Replace the U-joint assembly if any bearing surfaces are worn.
6. Check the underside of each bearing-cup plate for burrs or raised metal. Use a mill file to remove any burrs or raised metal. See **Fig. 12**.
7. Using fine emery cloth, smooth and clean the outside surfaces of all bearing cups. See **Fig. 12** and **Fig. 13**.

Driveline Component Cleaning and Inspection



1. Spalling
2. End Galling
3. Brinelling
4. Pitting
5. Slinger

Fig. 8, Damaged U-Joint Crosses

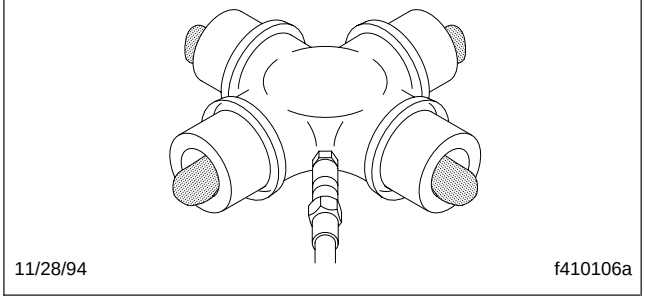
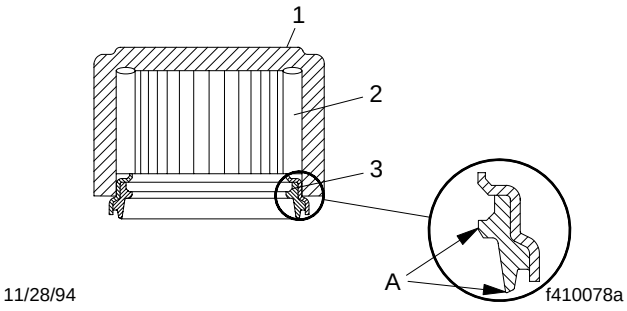


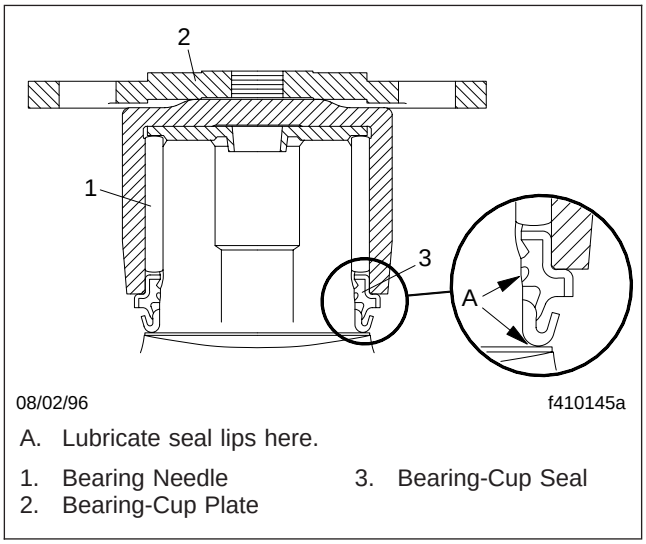
Fig. 9, Forcing Out Old Lubricant From a U-Joint Cross



A. Lubricate seal lips here.

1. Bearing Cup
2. Bearing Needle
3. Bearing-Cup Seal

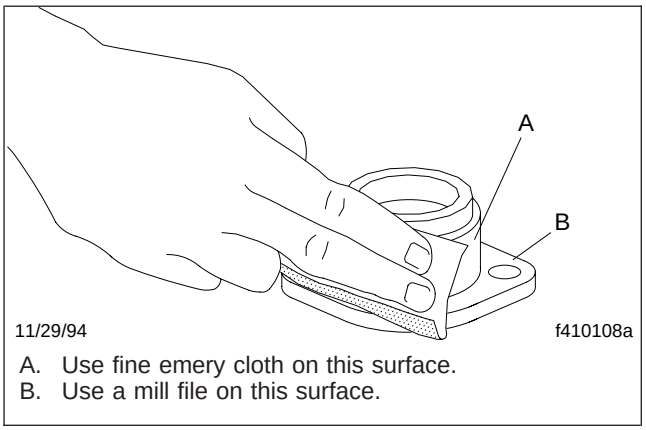
Fig. 10, Sectional View of a Half-Round End-Yoke U-Joint Bearing Cup



A. Lubricate seal lips here.

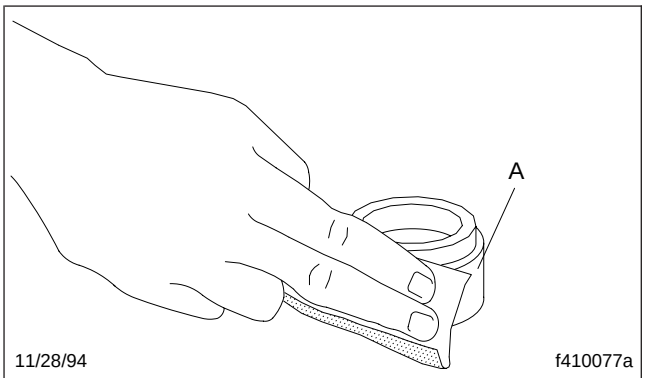
1. Bearing Needle
2. Bearing-Cup Plate
3. Bearing-Cup Seal

Fig. 11, Sectional View of a Full-Round Yoke U-Joint Bearing Cup



A. Use fine emery cloth on this surface.
B. Use a mill file on this surface.

Fig. 12, Smoothing a Full-Round Yoke U-Joint Bearing Cup



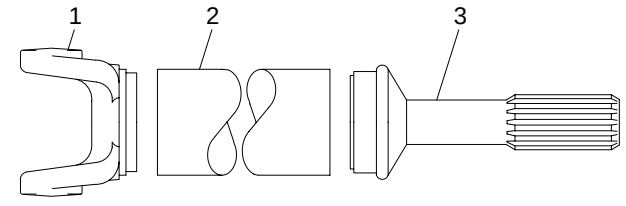
A. Use fine emery cloth on this surface.

Fig. 13, Smoothing a Half-Round Yoke U-Joint Bearing Cup

Driveshaft Tube, Stub Shaft (Slip-Joint), and Tube-Yoke Replacement

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

To replace a driveshaft tube, a tube-yoke, or a stub shaft (**Fig. 1**), the driveshaft must be chucked in a lathe, so the welds can be removed. Driveshaft rebuilding should be done by a machine shop that specializes in driveline repair.



1. Tube-Yoke
2. Driveshaft Tube
3. Stub Shaft

Fig. 1, Driveshaft Tube, Stub Shaft, and Tube-Yoke

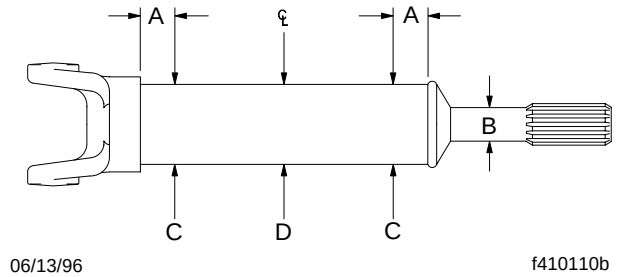
Runout limits for a new (rebuilt) driveshaft (**Fig. 2**) are:

- 0.005 inch (0.127 mm) T.I.R. (Total Indicator Reading) on the smooth portion of the stub shaft neck;
- 0.010 inch (0.254 mm) T.I.R. on the tube 3 inches (76 mm) from the front and rear welds;
- 0.015 inch (0.381 mm) T.I.R. at the center of the tube.

Balance the rebuilt driveshaft to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

Slip-Joint Replacement or Assembly

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled



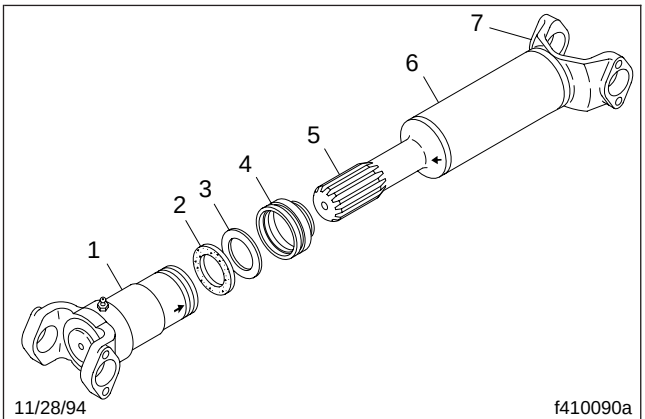
A. Measurement: 3 inches (76 mm)
B. Measurement: 0.005 inch (0.127 mm)
C. Measurement: 0.010 inch (0.2540 mm)
D. Measurement: 0.015 inch (0.381 mm)

Fig. 2, Runout Specifications for a Rebuilt (or New) Driveshaft

or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

Except RPL Drivelines

1. Place the slip-joint dust cap, and (if so equipped) steel washer and cork seal, over the splined shaft. See **Fig. 3**.



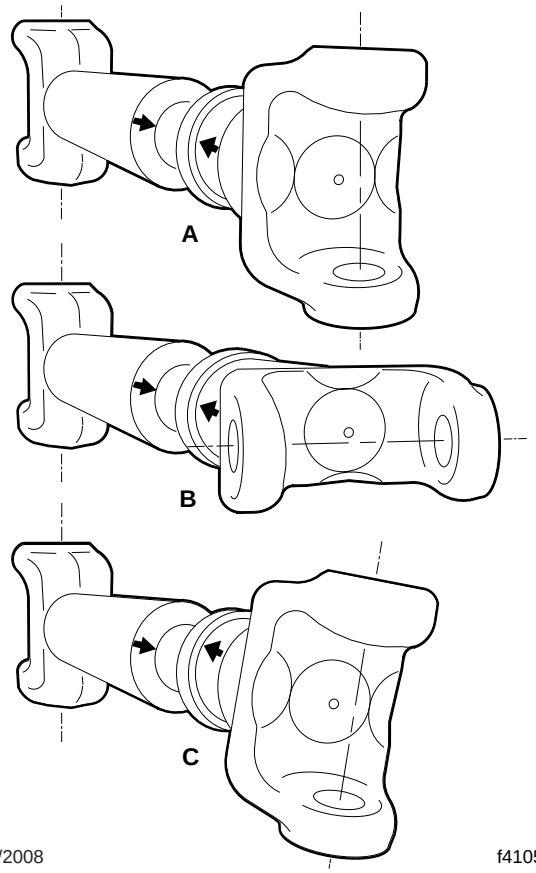
1. Sleeve-Yoke
2. Cork Washer
3. Steel Washer
4. Dust Cap
5. Splined Stub Shaft
6. Tube
7. Tube-Yoke

Fig. 3, Slip-Joint Components

2. Coat the splines of the shaft with multipurpose chassis grease.

Driveline Component Replacement or Installation/ Assembly

3. Insert the splined shaft in the sleeve-yoke, so that the alignment marks are aligned, and the U-joints at each end of the driveshaft will be in phase. See **Fig. 4** and **Fig. 5**.

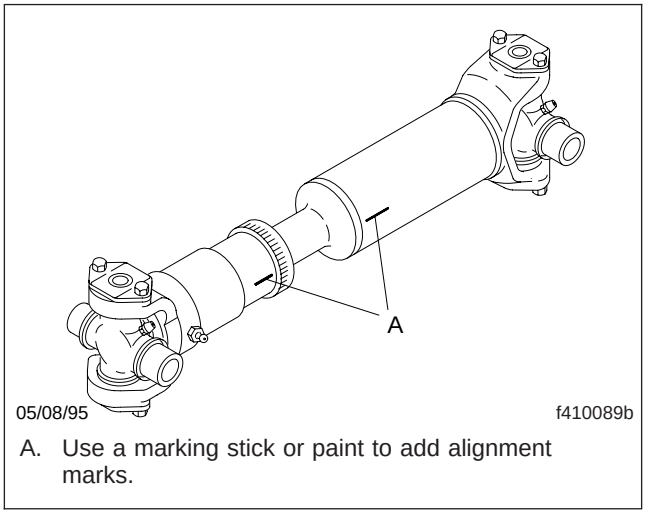


1. In Phase (parallel phased)
2. In Phase (cross phased)
3. Out of Phase

Fig. 4, U-Joint Phasing

IMPORTANT: If no alignment marks are visible, or new slip-joint components have been installed, align the yokes, assemble the slip-joint, then have the driveline balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

4. Install the slip-joint dust cap. Use only enough torque to seat the steel washer and cork seal (if so equipped) snug against the end of the sleeve-yoke; do not overtighten.



A. Use a marking stick or paint to add alignment marks.

Fig. 5, Slip-Joint Alignment Marks

NOTE: The splines should slide freely, with only a slight drag from the slip-joint dust cap.

RPL Drivelines

1. Remove the grease plug from the sleeve-yoke.
2. Coat the splines of the sleeve-yoke with multipurpose chassis grease.
3. Install the shroud on the splined shaft.
4. Install the seal onto the shroud.
5. Insert the splined shaft in the sleeve-yoke so that the alignment marks are aligned, and the U-joints at each end of the driveshaft will be in phase. See **Fig. 4** and **Fig. 5**.

IMPORTANT: If no alignment marks are visible, or new slip-joint components have been installed, align the yokes, assemble the slip-joint, then have the driveline balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

6. Install the seal into the shaft groove.
7. Install the shroud. Use a brass hammer to tap the shroud over the seal.
8. Install the grease plug in the sleeve-yoke.

NOTE: The splines should slide freely, with only a slight drag from the slip-joint dust cap.

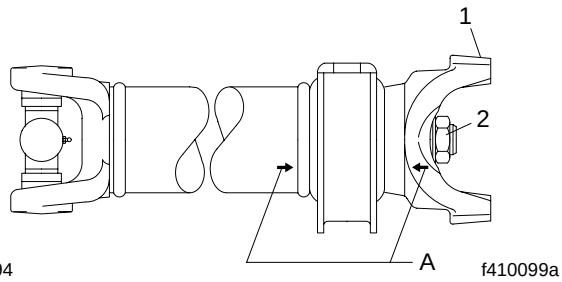
Midship Bearing and Coupling Shaft End-Yoke Replacement or Assembly

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

1. Place the coupling shaft in a soft-jawed vise; do not distort the tube with excessive grip.

NOTE: Midship bearings are permanently lubricated when manufactured; it is not necessary to pack the bearing with grease.

2. Install the midship bearing on the coupling shaft. Press the bearing on by hand as far as it will go.
3. Install the end-yoke. See **Fig. 6**.
   - 3.1 Apply Loctite® 242 to the shaft threads where the end-yoke locknut will be installed.
   - 3.2 Align the marks added to the coupling shaft and end-yoke during removal, then place the end-yoke on the shaft so the yoke bores are aligned at both ends of the shaft. See **Fig. 6**.



A. Use a marking stick or paint to mark the end-yoke and coupling shaft with alignment marks.

1. Half-Round End-Yoke
2. End-Yoke Locknut

Fig. 6, Alignment Marks on a Coupling Shaft With an End-Yoke

   - 3.3 Install the end-yoke nut, and tighten it 475 to 525 lbf·ft (645 to 710 N·m). Then back the nut off slightly, and tighten it to the same torque.

U-Joint Replacement or Installation

IMPORTANT: Parts for different series drivelines must not be intermixed. Also, components of the various makes of U-joints may not be interchangeable, and must be assembled only with compatible products. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

Worn bearing assemblies used with a new cross, or new bearing assemblies used with a worn cross will wear rapidly, making another replacement necessary in a short time. Always replace the cross and all four bearing assemblies at the same time.

If the slip-joint of a No. 2 or No. 3 driveshaft has been disassembled, assemble the slip-joint before installing the U-joints.

Full Round Yokes

1. Place the assembled driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
2. For a No. 2 or No. 3 driveshaft, check that the slip-joint alignment marks are aligned, so that the U-joints at each end of the driveshaft will be in phase. See **Fig. 4** and **Fig. 5**.

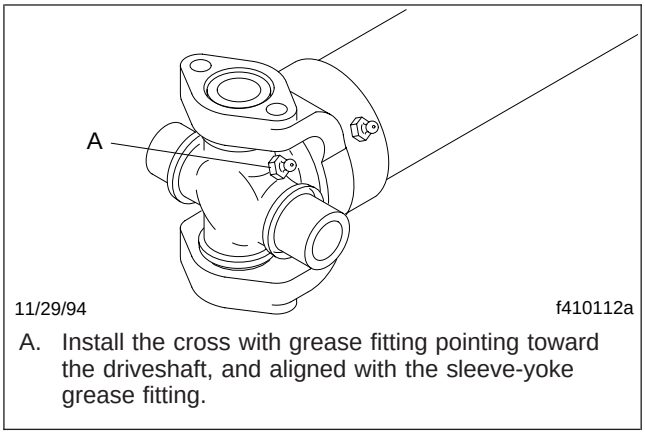
   For a coupling shaft, check that the end-yoke and tube-yoke are aligned, so that the U-joints at each end of the coupling shaft will be in phase. See **Fig. 6**.

IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

3. Inspect and lubricate the U-joint; see **Subject 140**.
4. Install the U-joint cross and bearing assemblies in the yoke.
   - 4.1 Position the U-joint cross in the driveshaft yoke so one grease fitting points toward

Driveline Component Replacement or Installation/ Assembly

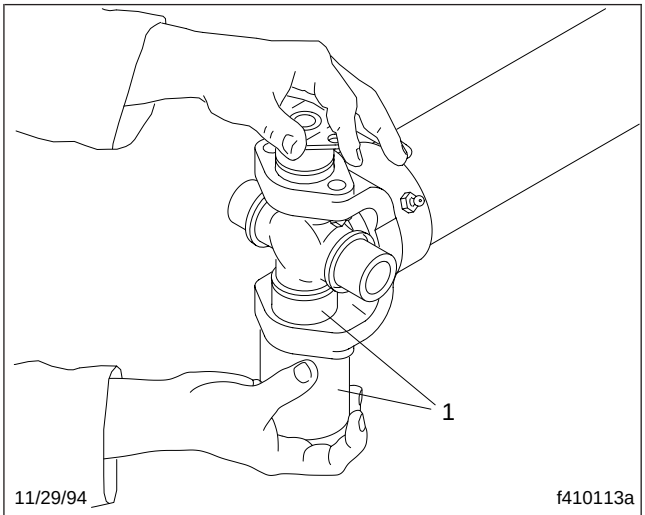
the driveshaft, and aligns with the grease fitting on the sleeve-yoke (if so equipped). See **Fig. 7**.



A. Install the cross with grease fitting pointing toward the driveshaft, and aligned with the sleeve-yoke grease fitting.

Fig. 7, U-Joint Grease Fitting Positioning

4.2 Move one end of the cross until a trunnion projects through the cross-hole, beyond the outer machined face of the yoke lug. Using a Spicer trunnion (journal) locator (**Specifications 400**), hold the trunnions in alignment with the cross-holes, while placing a bearing cup (plate-type) over the projected trunnion, and aligning it with the cross-hole. See **Fig. 8**.



NOTE: Sleeve-yoke shown.
1. Trunnion Locator

Fig. 8, Use of a U-Joint Trunnion Locator

IMPORTANT: A Spicer trunnion (journal) locator should be used to prevent damage to the U-joint trunnions and slingers.

4.3 By hand, press the bearing-cup-plate flush with the face of the yoke. If the bearing cup binds in the cross-hole, tap the *center* of the bearing-cup plate with a leather or rubber mallet; do not tap the outer edges of the plate. See **Fig. 9**.

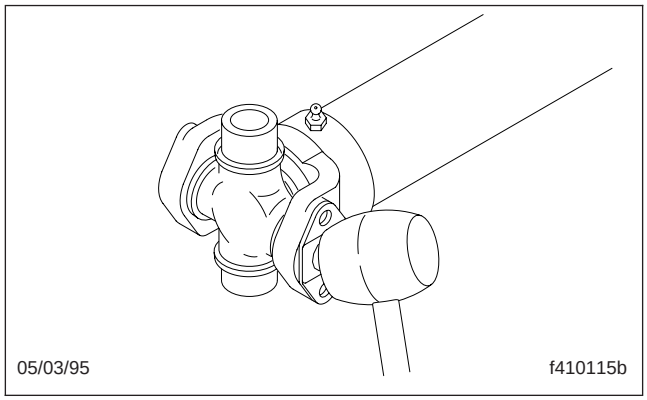


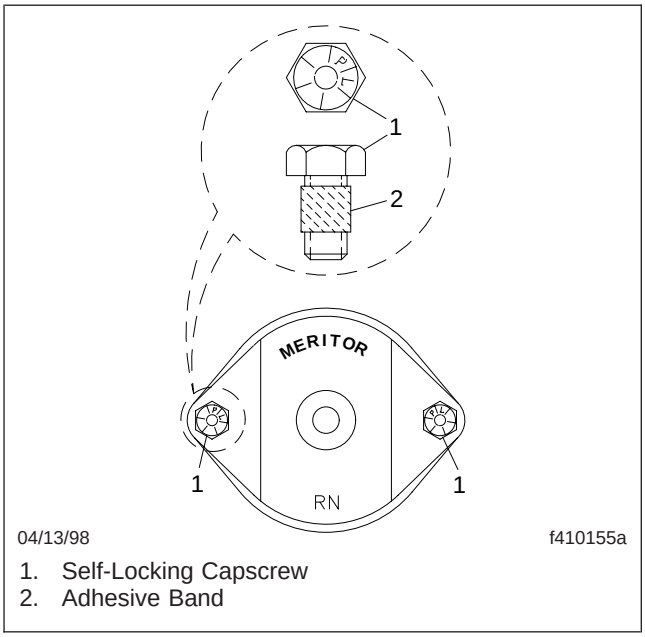
Fig. 9, Seating a U-Joint Bearing Cup In a Full-Round Yoke

4.4 Install *new* bearing-cup-plate self-locking capscrews. See **Fig. 10**. Tighten the capscrews until all the parts are drawn down tight, with no gaps; do not tighten the capscrews to their final torque value.

⚠ WARNING

Self-locking bearing-cup-plate capscrews must not be reused; replace the capscrews with new ones. Also, do not undertighten or overtighten any bearing-cup-plate capscrews. A loose or broken fastener at any point in the driveline weakens the driveline connection, which could cause serious vehicle damage, or could result in a driveshaft separating from the vehicle, possibly causing loss of vehicle control that could result in serious personal injury or death.

4.5 Move the cross until it projects beyond the machined surface of the opposite yoke lug. Using the above procedure, install the opposite bearing assembly and its fasteners.



1. Self-Locking Capscrew
2. Adhesive Band

Fig. 10, Meritor U-Joint Fasteners for Full-Round Yokes

4.6 Slightly back off all four capscrews, then alternately tighten them in increments of 5 lbf·ft (7 N·m), to the applicable torque value in **Specifications 400**.

NOTE: The U-joint should flex, and be free of excessive bind. A slight drag is the most desirable condition for new U-joints. Excessive looseness is not desirable, and may result in an unbalanced driveshaft.

RPL Series U-Joints

NOTE: Do not reuse RPL U-joints. Always replace an RPL U-joint with a new one after they have been disassembled and removed from a driveshaft.

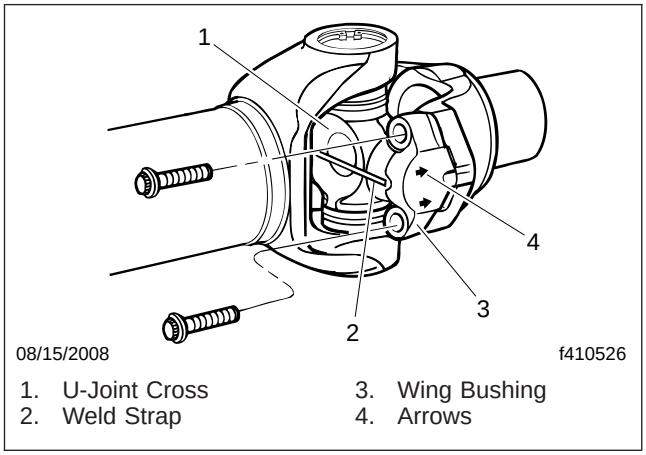
1. Place the assembled driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
2. For a No. 2 or No. 3 driveshaft, check that the slip-joint alignment marks are aligned, so that the U-joints at each end of the driveshaft will be in phase. See **Fig. 4** and **Fig. 5**.

   For a coupling shaft, check that the end-yoke and tube-yoke are aligned, so that the U-joints at each end of the coupling shaft will be in phase. See **Fig. 6**.

IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

3. Install the U-joint cross and bearing assemblies in the yoke.

   3.1 Position the U-joint cross in the driveshaft yoke so that the wing bearing weld strap faces inboard, and the arrows point toward the end of the coupling yoke. See **Fig. 11**.



1. U-Joint Cross
2. Weld Strap
3. Wing Bushing
4. Arrows

Fig. 11, Fitting the U-Joint

   3.2 Move one end of the cross until a trunnion projects through the cross-hole, beyond the outer machined face of the yoke lug. Place a bearing cup over the projected trunnion, and align it with the cross-hole.

   3.3 Press the bearing cup into the yoke slightly past the snap ring groove. See **Fig. 12**. Check that the bearing cup is aligned with the universal joint trunnion.

   3.4 Install the snap ring into the snap ring groove. See **Fig. 13**.

   3.5 Use a snap ring installation gauge to check that the snap ring is fully seated in the snap ring groove. See **Fig. 14**.

   3.6 Move the cross until it projects beyond the machined surface of the opposite yoke lug. Using the above procedure, install the opposite bearing cup assembly.

Driveline Component Replacement or Installation/ Assembly

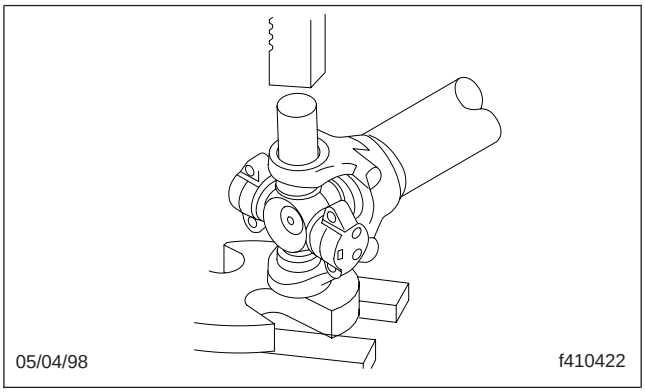
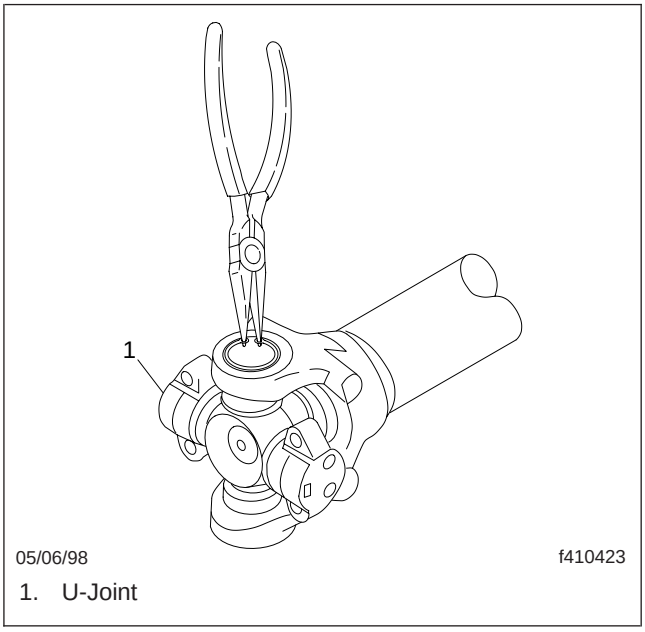


Fig. 12, Installing Bearing Cups, RPL Series U-Joint



1. U-Joint

Fig. 13, Installing the Snap Rings

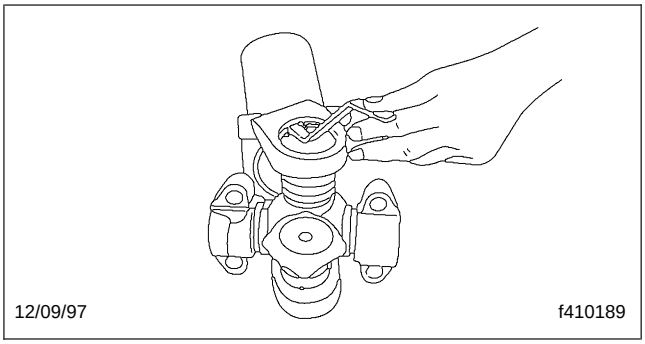
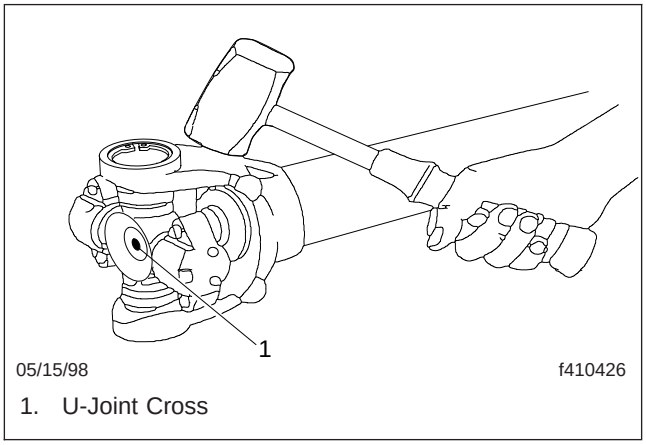


Fig. 14, Checking Snap Ring Installation

NOTE: The U-joint should flex, and be free of excessive bind. A slight drag is the most desirable condition for new U-joints. Excessive looseness is not desirable, and may result in an unbalanced driveshaft.

3.7 If the universal joint does not move freely, strike the yoke ear with a brass or copper hammer. See **Fig. 15**.



1. U-Joint Cross

Fig. 15, Striking the Yoke Ear

Transmission/Axle End-Yoke Replacement or Installation

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

1. Apply Loctite® 242 to the input- or output-shaft threads where the end-yoke locknut will be installed. See **Fig. 16**.
2. By hand, install the end-yoke on the input or output shaft as far as it will go.
3. Install a new end-yoke locknut, and tighten it to the applicable torque value in **Specifications 400**.

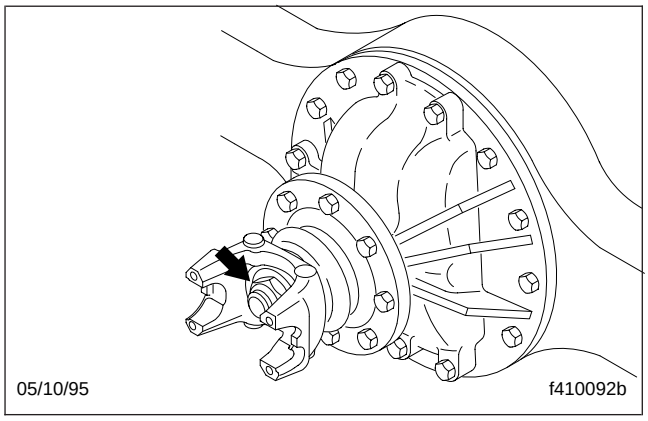


Fig. 16, Axle End-Yoke Locknut

Troubleshooting

Noise or vibration associated with the driveline can be caused by non-driveline parts. To find the cause of noise or vibration, first road test the loaded vehicle. Drive in all gears and at all speed ranges for which the vehicle was designed, including those at which problems are reported.

NOTE: Operating a vehicle at speeds that exceed its drivetrain design specifications may cause an out-of-balance vibration.

The following is a troubleshooting elimination process; checks should be made in the order listed. At each step where a problem is found, correct the problem before proceeding to the next step, then test drive the vehicle to see if other problems still exist. If no other problems exist, the elimination process may be ended at that step.

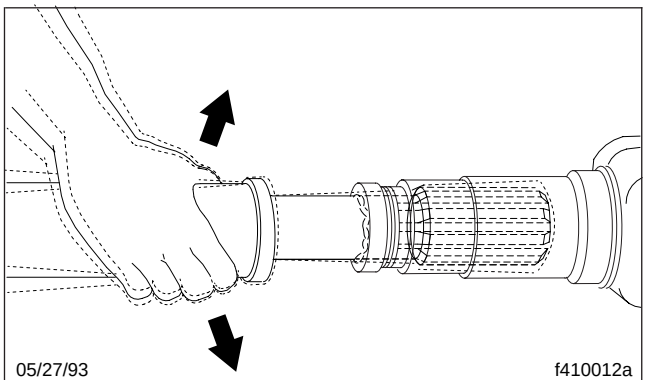
1. Check all tires for uneven wear and for out-of-roundness. Check for mismatched tires. Look for wheels and rims that are out of alignment. For instructions, see **Group 40**.
2. Check the rear suspension for loose or broken U-bolts; broken, shifted, or mismatched rear springs; or broken spring seats. If so equipped, check the air suspension for incorrect air spring height. Look for anything that could cause angular misalignment of the rear axle pinion(s). For instructions, see **Group 32**.
3. Check the frame rails and crossmembers for bends, twists, or breaks; for frame-alignment-checking and crossmember-replacement instructions, see **Group 31**.
4. Check the engine and transmission mounts; see **Group 01** (Engine) and **Group 26** (Transmission). Check the coupling shaft's midship bearing mounts. Replace mountings that are deteriorated or oil-soaked; tighten loose mounting bolts. Oil-soaked or deteriorated mountings, or loose mounting bolts, can cause driveline angular misalignment.
5. Check for loose U-joint bearing-cup-plate and bearing-strap capscrews. Tighten any loose fastener to the applicable torque value in **Specifications 400**.

⚠ CAUTION

Do not overtighten the bearing-cup-plate or bearing-strap capscrews. A loose or broken fastener at any point in the driveline weakens the driveline connection, which could result in serious vehicle damage.

6. Check all U-joint assemblies, slip-joint splines, and midship bearings for wear.
   - 6.1 Try to move each driveshaft up and down, and from side to side. If movement is greater than 0.006 in (0.15 mm) of a U-joint cross in its bearings, replace the U-joint assembly.
   - 6.2 If the midship bearing rattles or is loose on its shaft, replace it.
   - 6.3 Try to bend the sleeve-yoke and splined shaft up and down, and from side to side. See **Fig. 1**. If looseness is greater than 0.007 in (0.18 mm), replace the sleeve-yoke and splined shaft.

     If driveline components must be replaced, see **Subject 150**.



Try to bend the sleeve-yoke and splined shaft up and down, and from side to side.

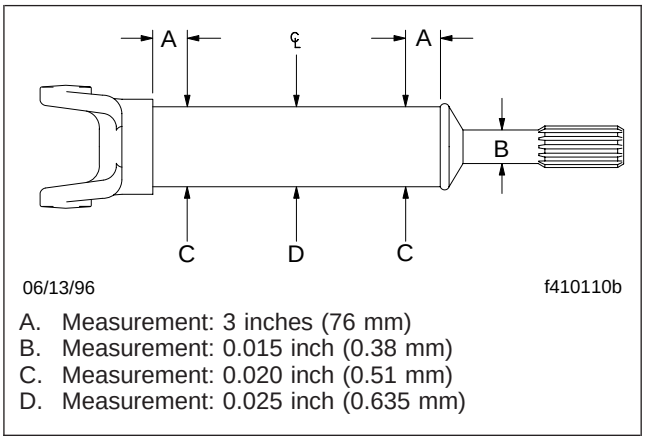
Fig. 1, Checking for Slip-Joint Spline Wear

7. Check each driveshaft for an indication of missing balance weights. If any weights appear to be missing, have the driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.
8. Check each driveshaft for dents, bends, twists, or other damage.

If damaged, jack up the rear axle, support it on jackstands, place the transmission in neutral, and turn the driveshaft by hand to check runout.

The driveshaft must be straight within 0.015 inch (0.38 mm) on the slip-joint seal surface of the splined shaft, 0.020 inch (0.51 mm) on the tube 3 inches (76 mm) from the front and the rear welds, and 0.025 inch (0.635 mm) at the center of the tube. See **Fig. 2**.

If the driveshaft is not straight within specifications, replace the tube. See **Subject 150** for runout specifications for a *new* (or rebuilt) driveshaft.



A. Measurement: 3 inches (76 mm)
B. Measurement: 0.015 inch (0.38 mm)
C. Measurement: 0.020 inch (0.51 mm)
D. Measurement: 0.025 inch (0.635 mm)

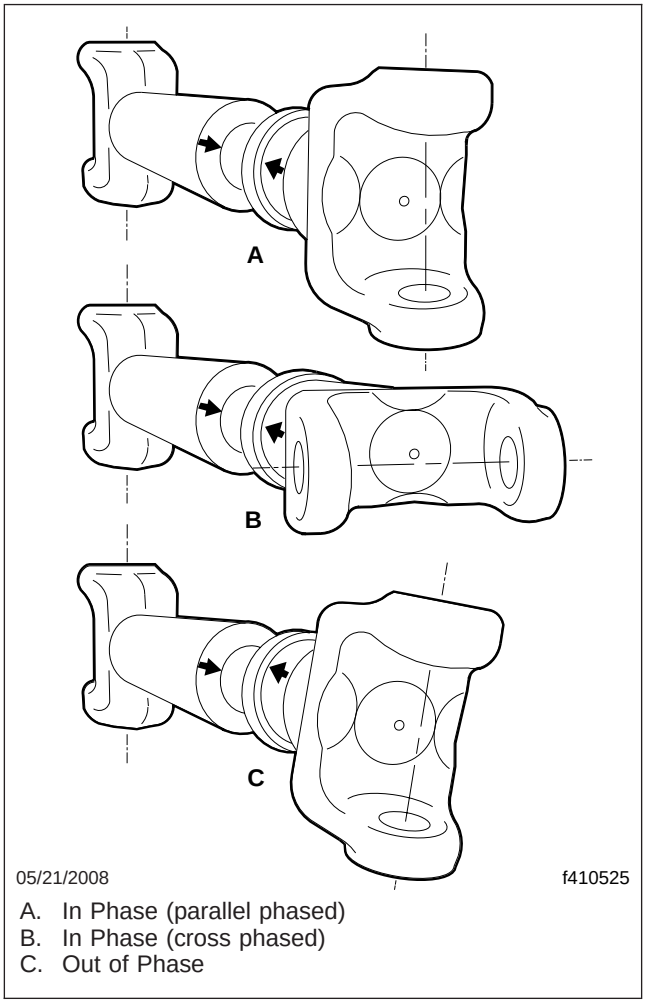
Fig. 2, Runout Specifications for a Used Driveshaft

9. Check each driveline for proper U-joint phasing. See **Fig. 3**.

   9.1 On No. 2 and No. 3 driveshafts, if the U-joints are out of phase, check the slip-joint for alignment marks. If necessary, disassemble the slip-joint, and align the marks.

   NOTE: To disassemble the slip-joint, uncouple the U-joint at one end of the driveshaft, unscrew the slip-joint seal from the sleeve-yoke, then pull the sleeve-yoke and splined shaft apart. Reverse the procedure to assemble the slip-joint.

   9.2 If no alignment marks are present, disassemble the slip-joint, and reassemble it with the U-joints in one of the two in-phase positions (180 degrees apart).



A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

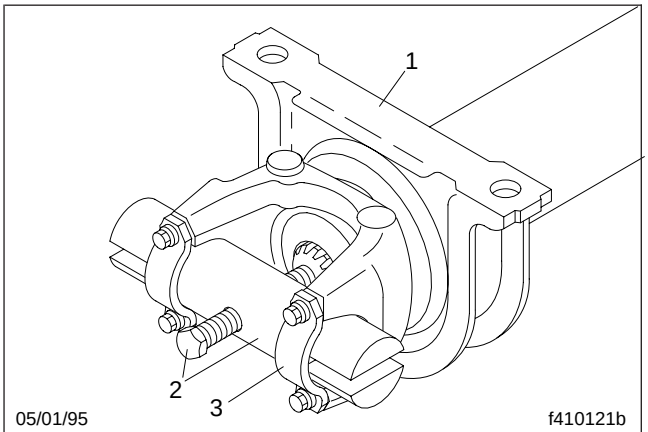
Fig. 3, U-Joint Phasing

Test drive the vehicle, then assemble the slip-joint in the other in-phase position. Test drive the vehicle again.

Determine which in-phase position provides vibration-free operation. Assemble the slip-joint in the correct in-phase position, and mark the slip-joint with alignment marks.

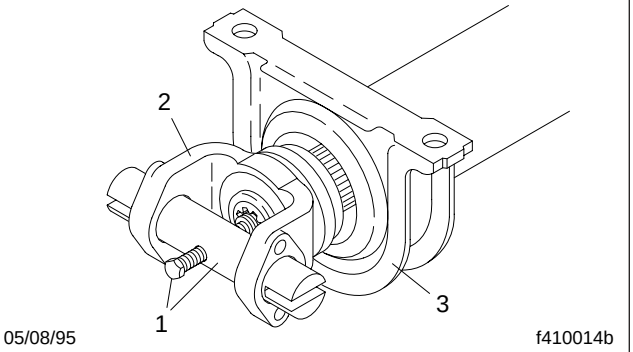
9.3 If the U-joints are out of phase on a coupling shaft, uncouple the U-joint from the coupling shaft end-yoke, then remove the end-yoke nut. Remove the end-yoke, using a yoke puller. See **Fig. 4** for a half-round end-yoke, or see **Fig. 5** for a full-round end-yoke. Align the end-yoke, then

install it by hand. Install the end-yoke nut, and tighten it 475 to 525 lbf·ft (645 to 710 N·m). Slightly back off the nut, and again tighten it to the same torque. Couple the coupling shaft to the driveshaft U-joint.



1. Midship Bearing
2. Yoke Puller
3. Bearing Strap

Fig. 4, Removing a Half-Round End-Yoke from a Coupling Shaft



1. Yoke Puller
2. Full-Round Yoke
3. Midship Bearing

Fig. 5, Removing a Full-Round End-Yoke from a Coupling Shaft

10. Check the torque on all of the end-yoke nuts in the drivetrain; see the applicable torque values in **Specifications 400**.

    If any yoke nut was not at its specified torque, check the yoke for wear by trying to move it up and down, and back and forth. If the yoke can be rocked on its shaft, or moved in or out on its shaft, replace the yoke and yoke nut. See **Subject 150**.

    If the yoke is not worn, tighten the yoke nut to its torque value.

11. *On single-drive vehicles:*

    Have the No. 2 driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

    On dual-drive vehicles:

    11.1 Remove the No. 3 driveline; then, with the interaxle differential locked, test drive the vehicle.

    11.2 If vibration still exists, install the No. 3 driveline, then have the No. 2 driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

    If *no* vibration exists, check that both rear axle gear ratios are matched. If the gear ratios do not match, replace one of the gear sets with a gear set having the correct ratio, then install the No. 3 driveline.

    11.3 Have the No. 3 driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

    11.4 Have the No. 2 driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

12. If so equipped, balance the coupling shaft(s) to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

Transmission Output-Shaft End-Yoke Nut Fastener Torques			
Description		**Size**	**Torque: lbf·ft (N·m)**
Fuller	RT 8609	1-1/2–18	400–450 (542–610)
	T/X 14607 RT 8608 /7608LL RTO 11909MLL /14909MLL /11908LL RTX 16709 /15710 /16710 RT/X 11609 /11709 /12609 /12709 /13609 /13709 /14609 /14709 /11710 /12710 /13710 /14710 RTO/X 11708LL /14708LL RT/O/X 14715 /15715 RTLO 12610 /13610 /14610 /15610 /16610 /12713 /14713 /16713 /14718 /16718 /18718	2–16	450–500 (610–678)
Meritor	RM/O/X 9–115, –125, –135, –145, –155 RM/X 10–115, –125, –135, –145, –155, –165 RMO 13–145	2–16	450–500 (610–678)
Allison	HD Series	2–16	600–800 (813–1085)

Table 1, Transmission Output-Shaft End-Yoke Nut Fastener Torques

Midship Bearing Fastener Torques		
Location	**Size**	**Torque: lbf·ft (N·m)**
Coupling Shaft	1-1/4–18	475–525 (645–710)
Bracket to Crossmember Locknut	1/2–13	68 (92)
Bearing Mount to Bracket Locknut	1/2–13	68 (92)

Table 2, Midship Bearing Fastener Torques

Spicer U-Joint Capscrew Torque			
Series	**Thread Size**	**Style**	**Torque lbf·ft (N·m)**
1710 HD 1760 HD 1810 HD	1/2–20	Half Round	130–135 (176–183)
	3/8–24	Full Round	38–48 (52–65)
SPL100	3/8–24	Half Round	45–60 (61–81)
SPL140/HD/XL SPL170/XL SPL250/HD/XL	M12–1.25	Half Round	115–135 (156–183)

Table 3, Spicer U-Joint Capscrew Torque

Specifications

Meritor U-Joint Capscrew Torque			
Series	**Thread Size**	**Style**	**Torque lbf·ft (N·m)**
16T	3/8–24	Half Round	45–60 (61–81)
16N	5/16–24	Full Round	26–35 (35–47)
17T	1/2–20	Half Round	115–135 (156–183)
17N	3/8–24	Full Round	38–48 (52–65)
176T	1/2–20	Half Round	115–135 (156–183)
176N	3/8–24	Full Round	38–48 (52–65)
18T	1/2–20	Half Round	115–135 (156–183)
18N	3/8–24	Full Round	38–48 (52–65)
RPL20 G2 RPL250HD G2	1/2–20	Wing Yoke	115–135 (156–183)

Table 4, Meritor U-Joint Capscrew Torque

Axle End-Yoke Fastener Torques				
Position	**Brand**	**Model Number**	**Input Size**	**Torque: lbf·ft (N·m)**
Single Axle Input Shaft	Meritor	MS-21-14X	M39- 1.5	920-1130 (1250-1530)
		RS-23-160, RS-23-161, RS-23-186, RS-25-160, RS-26-185, RS-30-185,	M45-1.5	1000-1230 (1355-1670)
		RS-30-380, RS-38-380	1-1/2 -12 UNF	800-1100 (1085-1490)
	Detroit	DA-RS-17.5-4, DA-RS-19.0-4, DA-RS-21.0-4, DA-RS-23.0-4	M45-1.5	627-850 (850-1150)
First Carrier Input Shaft	Meritor	MT-40-143/4M, MT-40-14X, MT-40-14XGP, MT-40-14XP, MT-44-14X, MT-44-14XP	M 45-1.5	750-850 (1015-1150)
		RT-40-145, RT-40-145A, RT-40-145GP, RT-40-145P, RT-44-145, RT-44-145P, RT-40-160, RT-40-160P, RT-46-160, RT-46-160GP, RT-46-160P, RT-46-164, RT-46-164P		
		RT-50-160, RT-50-160GP, RT-50-160P, RZ-166, RZ-166 R-SERIES		
		RT-52-185, RT-52-185G, RT-58-185, RT-52-380G, RT-70-380, RT-70-380P, RZ-186, RZ-188, RZ-188G	1-3/4x12 UN	
	Detroit	DA-RT-40.0-4, DA-RT-40.0-4 HT, DA-RT-44.0-4, DA-RT-44.0-4 HT, DA-RT-46.0-4 HH	M45-1.5	627-850 (850-1150)
	Dana Spicer	DT463P, DD404, DD405, DD405P, DDH40, DDH40P, DS404, DS404P, DS405, DS405P, DSH40, DSH40P, DST40, DST41, DDH44P, DSH44P	M42 X 1.5	840-1020 (1140-1385)
		S23-190, D46-170, D50-170P, D52-190P, D40-170, D40-170P, D46-170P	M48 X 1.5	800-1000 (1085-1355)

Axle End-Yoke Fastener Torques				
Position	**Brand**	**Model Number**	**Input Size**	**Torque: lbf·ft (N·m)**
First Carrier Output Shaft	Meritor	MT-40-143/4M, MT-40-14X, MT-40-14XGP, MT-40-14XP, MT-44-14X, MT-44-14XP	M 39 x 1.5	600-800 (815-1085)
		RT-40-145, RT-40-145A, RT-40-145GP, RT-40-145P, RT-44-145, RT-44-145P, RT-40-160, RT-40-160P, RT-46-160, RT-46-160GP, RT-46-160P, RT-46-164, RT-46-164P		
		RT-50-160, RT-50-160GP, RT-50-160P, RZ-166, RZ-166 R-SERIES		
		RT-52-185, RT-52-185G, RT-58-185, RT-52-380G, RT-70-380, RT-70-380P, RZ-186, RZ-188, RZ-188G	1-1/2x12 UNF	450-650 (610-880)
	Detroit	DA-RT-40.0-4, DA-RT-40.0-4 HT, DA-RT-44.0-4, DA-RT-44.0-4 HT, DA-RT-46.0-4 HH	M39 x 1.5	520 - 700 (705-950)
	Dana Spicer	DT463P, DD404, DD405, DD405P, DDH40, DDH40P, DS404, DS404P, DS405, DS405P, DSH40, DSH40P, DST40, DST41, DDH44P, DSH44P	M39 X 1.5	680 - 832 (920-1130)
		S23-190, D46-170, D50-170P, D52-190P, D40-170, D40-170P, D46-170P	M42 x 1.5	800-1000 (1085-1355)
Second Carrier Input Shaft	Meritor	MT-40-143/4M, MT-40-14X, MT-40-14XGP, MT-40-14XP, MT-44-14X, MT-44-14XP	M 39 x 1.5	920-1130 (1250-1530)
		RT-40-145, RT-40-145A, RT-40-145GP, RT-40-145P, RT-44-145, RT-44-145P		
		RT-40-160, RT-40-160P, RT-46-160, RT-46-160GP, RT-46-160P, RT-46-164, RT-46-164P, RT-50-160, RT-50-160GP, RT-50-160P, RT-52-185, RT-52-185G, RT-58-185	M45 x 1.5	1000-1230 (1355-1670)
		RT-52-380G, RT-70-380, RT-70-380P	1-1/2 - 12 UNF	800-1100 (1085-1490)
		RZ-166, RZ-166 R-SERIES, RZ-186	M45 x 1.5	600-800 (815-1085)
		RZ-188, RZ-188G	1-3/4 - 12 UN	600-800 (815-1085)
Second Carrier Output Shaft	Meritor	RZ-166, RZ-166 R-SERIES, RZ-186	M39 x 1.5	450-650 (610-880)
		RZ-188, RZ-188G	1-1/2 -12 UNF	450-650 (610-880)
Third Carrier Input Shaft	Meritor	RZ-166, RZ-166 R-SERIES, RZ-186, RZ-188, RZ-188G	M45 x 1.5	1000-1230 (1355-1670)

Table 5, Axle End-Yoke Fastener Torques

Specifications

Special Tools

Journal Locator (for installing U-joints in full-round yokes)

To order, contact your Dana Corporation Spicer Service Representative.

U-Joint Removal Tool Kit (for removing U-joints from full-round yokes)

To order Owatonna Tool Kit No. 7057, contact:

Owatonna Tool Company
Owatonna, Minnesota 55060

End-Yoke Puller (for removing end-yokes from transmission output shafts, coupling shafts, and rear-axle input and output shafts)

To order End-Yoke Puller J 7804–01, contact:

Kent-Moore Tool Division
29784 Little Mack
Roseville, MI 48066–2298
Telephone: 1–800–328–6657 Telex: 244040 KMTR
UR FAX: (313) 774–9870

To order Yoke and Flange Remover SP–450, contact:

G & W Tool Company
907 South Dewey
Wagoner, OK 74467

General Information

Driveline Angularity

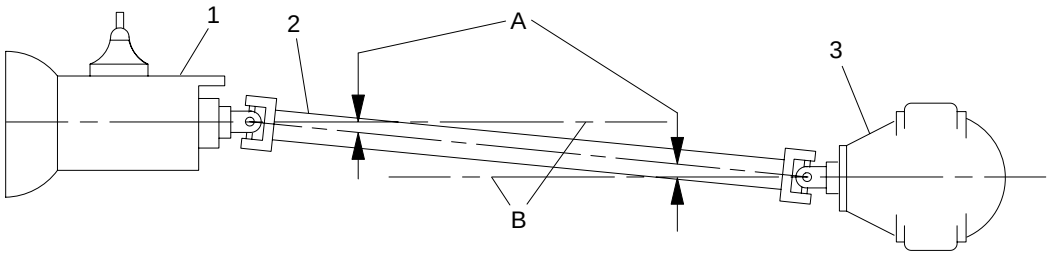
The most important consideration of driveline angularity is the U-joint working angle. The U-joint working angle is the angle formed by the intersection of the driveshaft centerline and the extended centerline of the shaft of any component to which the U-joint connects. See **Fig. 1.** Because the action of a U-joint causes a fluctuating speed difference between the shafts it connects, the effect created by the U-joint at the input yoke must cancel the effect created by the U-joint at the output yoke. This is done by making the U-joint working angles at both ends of the driveshaft approximately equal, with the U-joints in phase.

The U-joint working angles may be made approximately equal by either of two basic arrangements: a parallel arrangement (**Fig. 1**), or an intersecting arrangement (**Fig. 2**).

Driveline angularity may be adversely affected if rear suspension U-bolts are loose or broken; rear springs are broken, shifted, or mismatched; spring seats are broken; frame rails are bent, twisted, or broken; or transmission or engine mounts are loose or deteriorated.

U-Joint Phasing

The fluctuating speed difference caused by the action of a U-joint connecting angled shafts can be cancelled only if the U-joint at the other end of the driveshaft is in phase with that U-joint (and the U-joint working angles are approximately equal). If the yoke lugs at both ends of the driveshaft are lying in the same plane (a plane that bisects the shaft lengthwise) the U-joints will be in phase. See **Fig. 3.**



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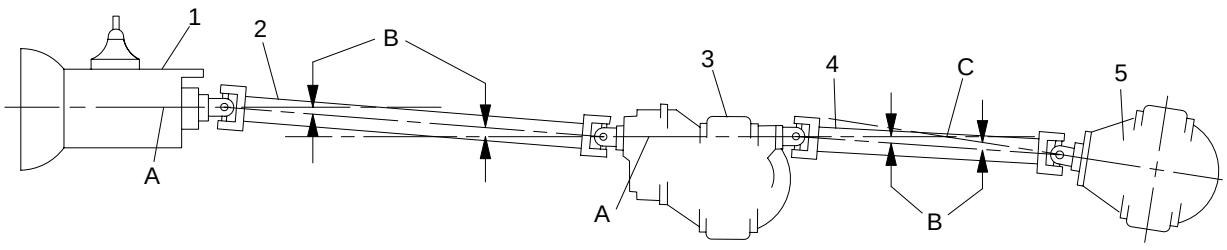
A. Equal U-Joint Working Angles
B. Parallel Centerlines
1. Transmission
2. No. 2 Driveshaft
3. Rear Axle

Fig. 1, Parallel Arrangement for Single-Drive Vehicles



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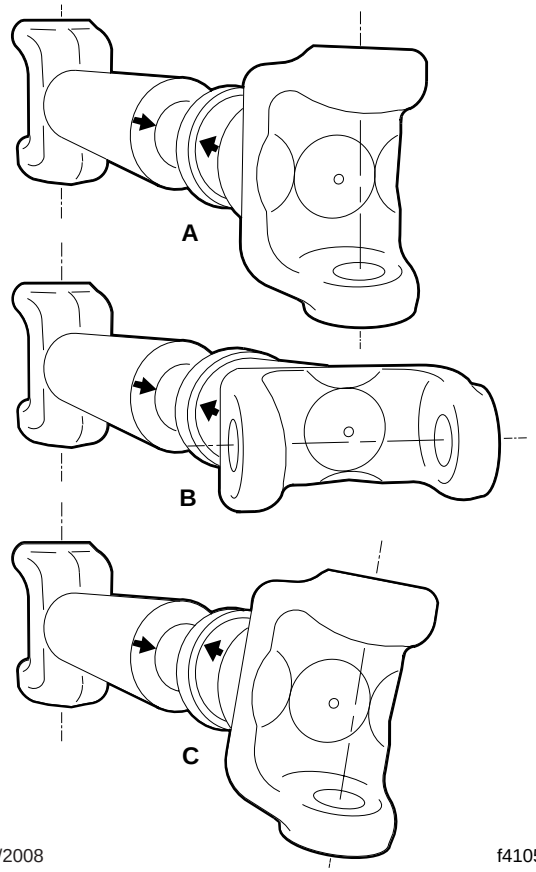
A. Parallel Centerlines
B. Equal U-Joint Working Angles
C. Intersecting Centerlines
1. Transmission
2. No. 2 Driveshaft
3. Forward-Rear Axle
4. No. 3 Driveshaft
5. Rearmost Axle

Fig. 2, Intersecting Planing Arrangements for Dual-Drive Vehicles

General Information

NOTE: Some driveshafts are designed and phased with their end yokes clocked 90 degrees from each other. This is referred to as cross phasing.



A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

Fig. 3, Driveline U-Joint Phasing

To ensure that the U-joints turn in phase, the sleeve yoke and splined shaft of driveshaft slip joints, and the tube shaft and midship bearing end yoke or midship bearing shafts, should be marked for assembly reference before disassembly.

Driveline Balance

After manufacture, each driveline yoke is statically balanced. After assembly of the slip joint, each driveshaft is checked for out-of-roundness, and straightened as necessary; then each shaft is dynamically balanced.

If the driveshaft slip joint is disassembled for any reason, the sleeve yoke and splined shaft should be marked for assembly alignment. Misaligned slip joints will seriously affect the U-joint phasing and balance of the driveline. Even if the slip joint is assembled 180 degrees from its original position (which will keep the U-joints in phase), the dynamic balance of the driveshaft will be negatively affected.

A driveline can become unbalanced or greatly weakened if a driveshaft has been dented, bent, twisted, or otherwise damaged. Operating a vehicle at speeds that exceed the speed of the driveshaft's design specifications will cause an out-of-balance vibration. Loose end yoke nuts, loose midship bearing or auxiliary transmission mounts, loose bearing retainer capscrews, worn U-joint trunnions or bearings, and worn slip joint splines can lead to excessive movement of the driveshaft and cause driveline imbalance.

Midship Bearings

A long driveshaft, supported only at its ends, will sag in the middle from its own weight. When turning at high rpm, it will flex, causing an out-of-balance vibration. Therefore, most vehicles having a long wheelbase use a midship bearing, mounted on a crossmember in the frame, for additional driveline support (**Fig. 4**). This allows the driveshaft to be separated into two shorter shafts, thus improving balance and stability.

Angularity Standards and Driveline Configuration

The U-joints require a minimum working angle of 1/2 degree to ensure needle-roller movement in the U-joint bearings. Without this movement, brinelling of the trunnion bearing contact surfaces would occur. Suspension movement causes driveshaft angles to change (and therefore, needle-roller movement) in both U-joints attached to driveshafts that connect to the axles. However, no angle change occurs in the U-joints attached to a driveshaft that connects the main transmission to a midship bearing or auxiliary transmission. Their working angles must be established during installation.

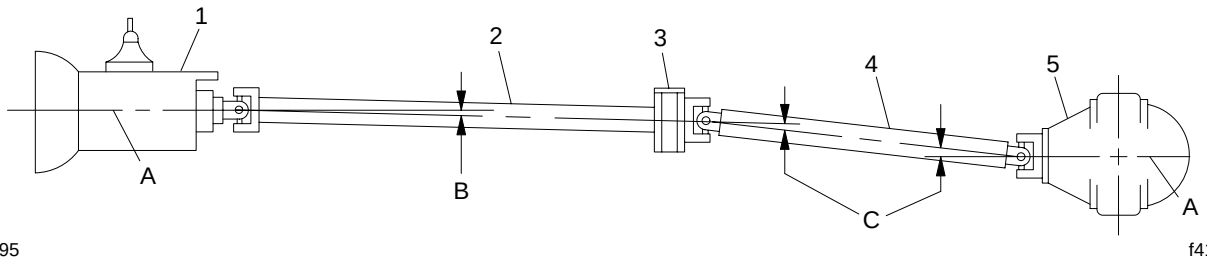
When a midship bearing is included in the drivetrain, it must be installed so that the centerline of the mid-

ship bearing shaft is in horizontal alignment within 1/2 degree and within 1/2 to 1 degree of vertical alignment with the centerline of the main transmission output shaft. See **Fig. 4.**

When an auxiliary transmission is included in the drivetrain, it must be installed so that the centerline of the intertransmission (no. 1) driveline is in exact horizontal alignment within 1/2 degree and down 1/2 to 1 degree vertically from the centerline of the main transmission output shaft. Further, the auxiliary transmission thru-shaft centerline must be parallel to the centerline of the main transmission output shaft, in order to achieve equal working angles. See **Fig. 5.**

struction of the U-joint. For smooth operation and long drivetrain component life, the U-joint working angles of each shaft must be kept small and approximately equal.

The U-joint working angles may be made approximately equal by either of two basic arrangements: a parallel arrangement (**Fig. 1**) or an intersecting arrangement (**Fig. 2**). The parallel arrangement consists of installing the drivetrain components so that all of the input, output, and thru-shaft centerlines are approximately parallel. The intersecting arrangement (used only for some interaxle drivelines) consists of installing the drive components so that the rearmost



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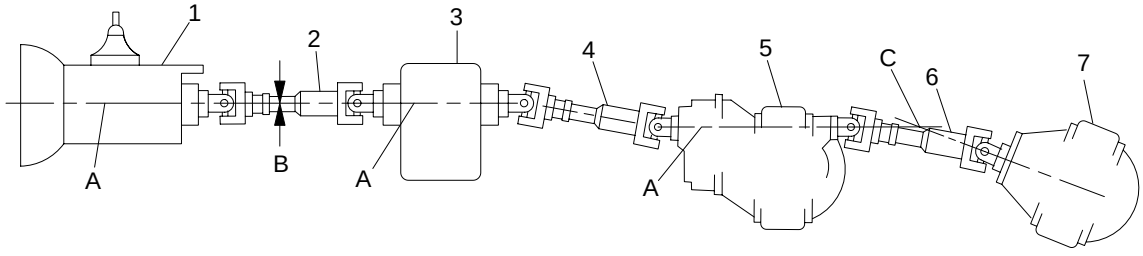
A. Parallel Centerlines
B. 1/2 to 1 Degree
C. Working Angles Unequal by 1/2 to 1 Degree
1. Main Transmission
2. Coupling Shaft
3. Midship Bearing
4. No. 2 Driveshaft
5. Rear Axle

Fig. 4, Midship Bearing in a Single-Drive Vehicle



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A. Parallel Centerlines
B. 1/2 to 1 Degree
C. Intersecting Centerlines
1. Main Transmission
2. No. 1 Driveline
3. Auxiliary Transmission
4. No. 2 Driveshaft
5. Forward-Rear Axle
6. No. 3 Driveshaft
7. Rearmost Axle

Fig. 5, Auxiliary Transmission in a Dual-Drive Vehicle

Every U-joint has a maximum working angle, determined by the design and size of its cross assembly and yokes. Exceeding the maximum working angle can cause rapid U-joint wear, or in severe cases, de-

axle pinion shaft's extended centerline intersects the forward-rear axle thru-shaft's extended centerline approximately midway between the U-joints, when all of

General Information

the other shafts (including the forward-rear axle thru-shaft) are approximately parallel.

All single-drive vehicles, and the forward-rear axles of dual-drive vehicles, use the parallel arrangement. Rearmost axles of dual-drive vehicles may use the parallel arrangement or the intersecting arrangement, depending on the drivetrain configuration.

The specific drivetrain configuration of each Freightliner vehicle consists of its wheelbase, number and type of axles, axle spacing, type of suspension, and number of transmissions. The specific drivetrain configuration determines the driveline arrangement and required installation angles of all the vehicle's drivetrain components.

The simplest drivetrain configuration consists of a single short driveline connecting a main transmission to a single-drive axle, in a parallel arrangement. This driveshaft is always referred to as the no. 2 driveshaft. The parallel arrangement always used on single-drive vehicles is shown in **Fig. 1**.

On dual-drive vehicles that have both axle input shafts of approximately the same height, a parallel arrangement is used. The driveshaft connecting the main (or auxiliary) transmission to the forward-rear axle is always referred to as the no. 2 driveshaft; and the interaxle driveshaft is always referred to as the no. 3 driveshaft. See **Fig. 6**, which shows a parallel arrangement when used on dual-drive vehicles.

Most dual-drive vehicles have a high thru-shaft on the forward-rear axle, and a low pinion on the rearmost axle. When the vehicle is on level ground, the interaxle (no. 3) driveshaft may create very sharp U-joint working angles with the input and output shafts when they are parallel. In normal driving, the U-joints could momentarily exceed their maximum working angle, and driveline or drivetrain damage could result. By using an intersecting arrangement at the no. 3 driveshaft, smaller U-joint working angles are created, promoting longer U-joint life and reduced driveline vibration. An intersecting arrangement used on dual-drive vehicles is shown in **Fig. 2**.

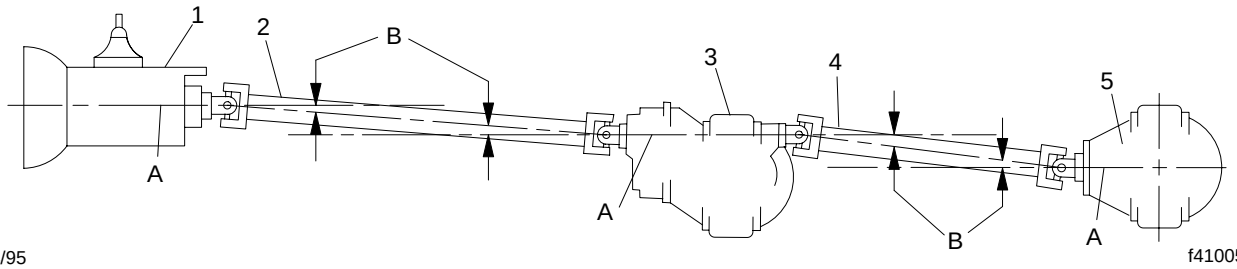
However, some axle spacings, axle models, and suspension designs allow additional axle movement or axle windup, require additional clearances between the driveshaft and the frame or suspension components, or create other conditions that make the intersecting arrangement of the no. 3 driveshaft unsatisfactory. For those drivetrain configurations, it is necessary to use a modified parallel or modified-intersecting arrangement for the no. 3 driveshaft.

On drivetrain configurations that require a modified parallel arrangement, the rearmost axle pinion shaft centerline is placed at an angle that is 2 degrees higher above horizontal than are the other input and output shafts. See **Fig. 7.**

On drivetrain configurations that require a modified-intersecting arrangement, the "proper" intersecting angle is determined, then the rearmost axle pinion shaft centerline is placed at an angle that is 2 degrees closer to horizontal than the "proper" intersecting angle. See **Fig. 8.**

The axle pinion angles for all suspensions are factory-set for correct driveline angularity. On Hendrickson and Neway suspensions, spacers or washers at the torque rods are used to maintain the correct axle pinion angles. On the suspensions listed in **Specifications, 400**, tapered axle planing shims at the springs help maintain the correct axle pinion angle.

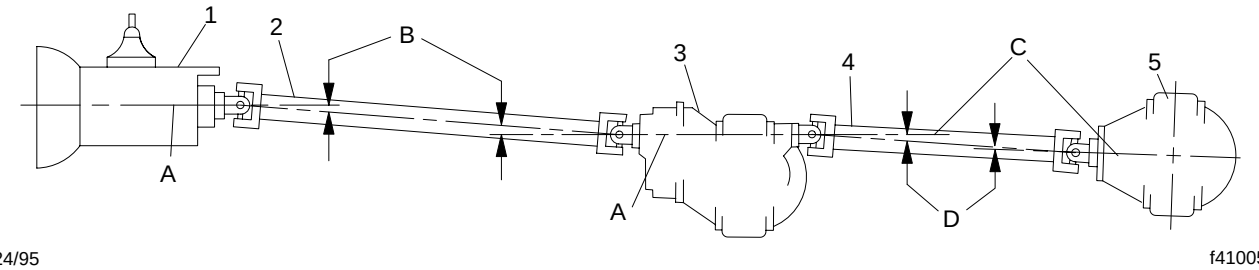
In the field, whenever axle or suspension components are changed, the axle pinion angles may also change. If this occurs, contact your district service manager for the correct axle pinion angle adjustment procedure.



A. Parallel Centerlines
B. Equal U-Joint Working Angles

1. Transmission
2. No. 2 Driveshaft
3. Forward-Rear Axle
4. No. 3 Driveshaft
5. Rearmost Axle

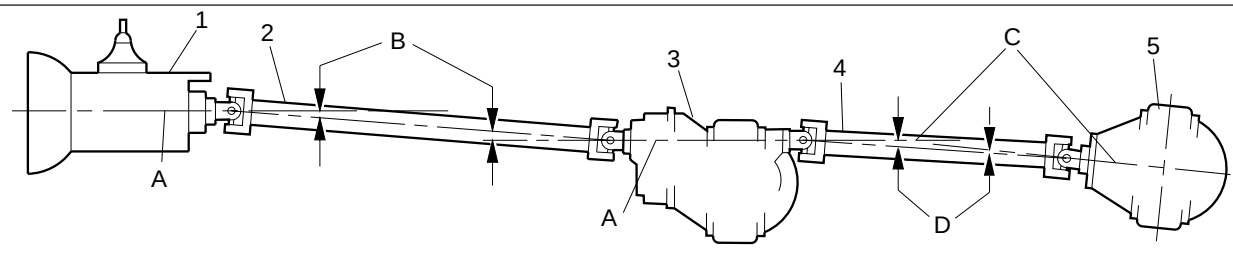
Fig. 6, Parallel Arrangement for Dual-Drive Vehicles



A. Parallel Centerlines
B. Equal U-Joint Working Angles
C. Modified-Parallel Centerlines
D. U-Joint Working Angles Not Equal by 2 Degrees

1. Transmission
2. No. 2 Driveshaft
3. Forward-Rear Axle
4. No. 3 Driveshaft
5. Rearmost Axle

Fig. 7, Modified-Parallel Arrangement for Dual-Drive Vehicles



A. Parallel Centerlines
B. Equal U-Joint Working Angles
C. Modified-Intersecting Centerlines
D. U-Joint Working Angles Not Equal by 2 Degrees

1. Transmission
2. No. 2 Driveshaft
3. Forward-Rear Axle
4. No. 3 Driveshaft
5. Rearmost Axle

Fig. 8, Modified-Intersecting Arrangement for Dual-Drive Vehicles

Use the procedure below for the type of tool being used. The Digital Angle Analyzer is the recommended tool.

Digital Angle Analyzer

Before checking the pinion angles or engine angle, check that the engine and transmission mounts are tight and in good condition. Loose or deteriorated mounts will cause inaccurate readings.

IMPORTANT: When using a digital angle analyzer (DAA) or digital level, be sure to always take readings from the same side of the vehicle. Also, keep the same end of the DAA pointed toward the front of the truck.

Using a DAA (**Fig. 1**), measure the engine angle, driveshaft angles, and pinion angles. Read all angles to the nearest one-tenth of a degree.

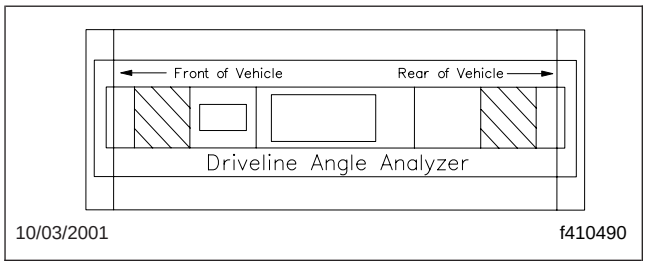
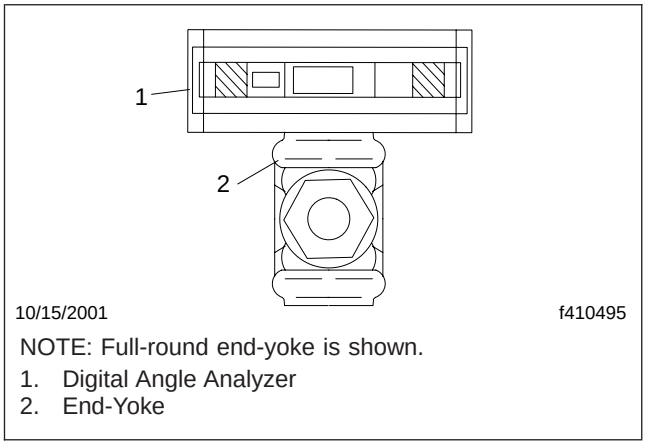


Fig. 1, Digital Angle Analyzer

After adjustment of any driveline angle, check the angle again. Also, verify ride height if the vehicle has an air suspension.

To measure the engine angle (transmission output-shaft angle) or axle pinion angles, do the following:

1. Inflate the vehicle tires to their normal operating pressure.
2. Park the unloaded vehicle on a level surface. Do not try to level the vehicle frame by jacking the front or rear axles. If the frame cannot be leveled from front to rear, determine and record the off-level inclination of the frame, and add or subtract that value from the measured values.
3. Chock the tires and place the transmission in neutral. Release the parking brakes.
4. The transmission output-shaft, coupling-shaft, and axle input- and output-yoke angles can be measured at either the top or bottom lug of the end-yoke being checked. For a full-round end-yoke, remove the bearing cup from the yoke lug. See **Section 41.00** for full-round end-yoke bearing cup removal.
5. Turn the end-yoke until the machined surface of the yoke lug is horizontal. See **Fig. 2**.

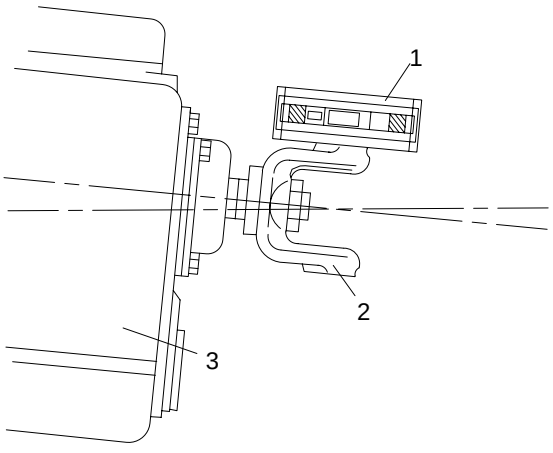


NOTE: Full-round end-yoke is shown.
1. Digital Angle Analyzer
2. End-Yoke

Fig. 2, Horizontal Positioning of Yoke Lug Machined Surface

6. To turn the driveshaft, raise one side of the rear (single-drive) or rearmost (dual-drive) axle until the tires are off the ground. Place a safety stand under the axle. With the transmission in neutral, and the interaxle differential (if equipped) unlocked, turn the tire to move the driveshaft.
7. Calibrate the digital level by placing it on the surface where the vehicle is parked at a 90-degree angle to the frame centerline. Zero the digital level.
8. Position the DAA alongside the U-joint trunnion, on the machined surface of the end-yoke, and at a 90-degree angle to the frame centerline. See **Fig. 2**. Then turn the end-yoke until the DAA reads 0 degrees. Remove the jack stand and lower the rear axle to the ground.
9. Calibrate the digital level by placing it on the surface where the vehicle is parked parallel to the frame centerline. Zero the digital level.
10. Without changing the position of the end-yoke, turn the DAA until it is parallel to the frame centerline. See **Fig. 3**. Record the measured angle of the pinion.

Engine and Pinion Angle Measurement



NOTE: Full-round end-yoke is shown.

1. Digital Angle Analyzer
2. End-Yoke
3. Transmission

Fig. 3, Measuring Pinion Angles

11. For a full-round end-yoke, install the bearing cup. See **Section 41.00** for full-round end-yoke bearing cup installation.

Spirit Level Protractor

Before checking the pinion angles or engine angle, check that the engine and transmission mounts are tight and in good condition. Loose or deteriorated mounts will cause inaccurate readings.

Using a digital angle meter, spirit level protractor (see **Fig. 4**), or the head of a machinists's protractor, measure the engine angle, driveshaft angles, and pinion angles. Read all angles to the nearest one-tenth of a degree (6 minutes).

After adjustment of any driveline angle, check the angle again.

To measure the engine angle (transmission output-shaft angle) or axle pinion angles, do the following:

1. Inflate the vehicle tires to their normal operating pressure.
2. Park the unloaded vehicle on a level surface. Do not try to level the vehicle frame by jacking the front or rear axles. If the frame cannot be leveled from front to rear, determine and record the off-level inclination of the frame, and add or subtract that value from the measured values.

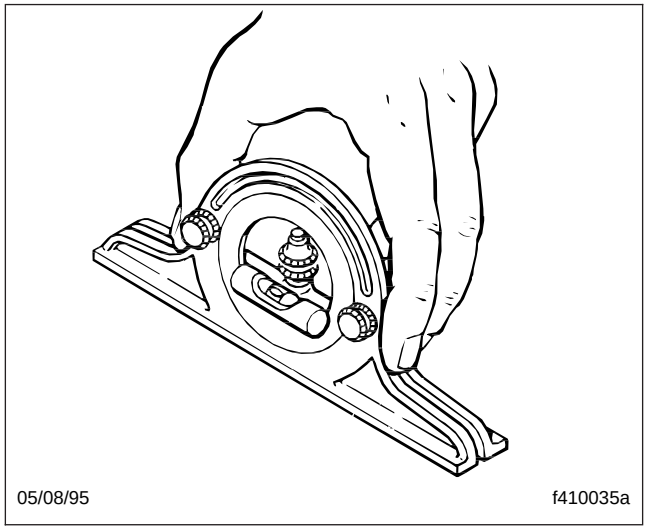
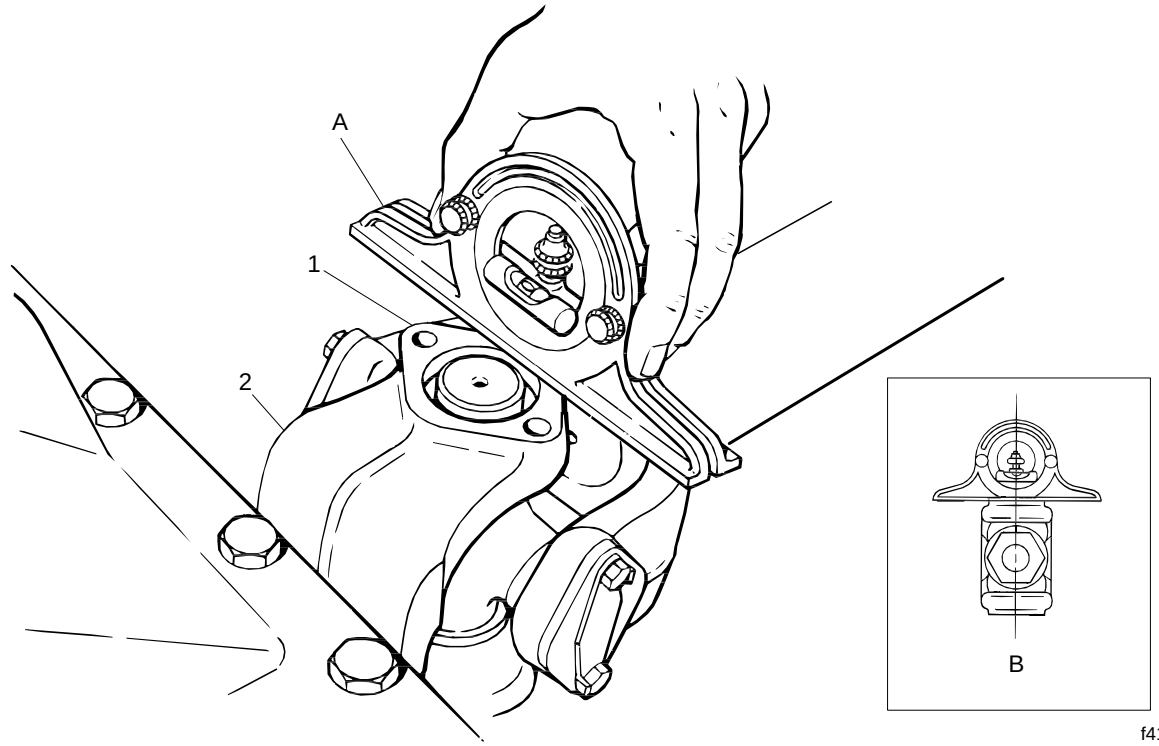


Fig. 4, Spirit Level Protractor

3. Chock the tires and place the transmission in neutral. Release the parking brakes.
4. The transmission output-shaft, coupling-shaft, and axle input- and output-yoke angles can be measured at either the top or bottom lug of the end-yoke being checked. For a full-round end-yoke, remove the bearing cup from the yoke lug. See **Section 41.00** for full-round end-yoke bearing cup removal.
5. Turn the end-yoke until the machined surface of the yoke lug is horizontal. See **Fig. 5**.

NOTE: To turn the driveshaft, raise one side of the rear (single-drive) or rearmost (dual-drive) axle until the tires are off the ground. Place a safety stand under the axle. With the transmission in neutral, and the interaxle differential (if equipped) unlocked, turn the tire to move the driveshaft.

6. Adjust the protractor scale to read 0 degrees. Position the protractor alongside the U-joint trunnion, on the machined surface of the end-yoke, and at a 90-degree angle to the frame centerline. See **Fig. 2**. Then turn the end-yoke until the bubble in the level vial is exactly between the two marks on the vial. Remove the jack stand and lower the rear axle to the ground.



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NOTE: Full-round end-yoke is shown.

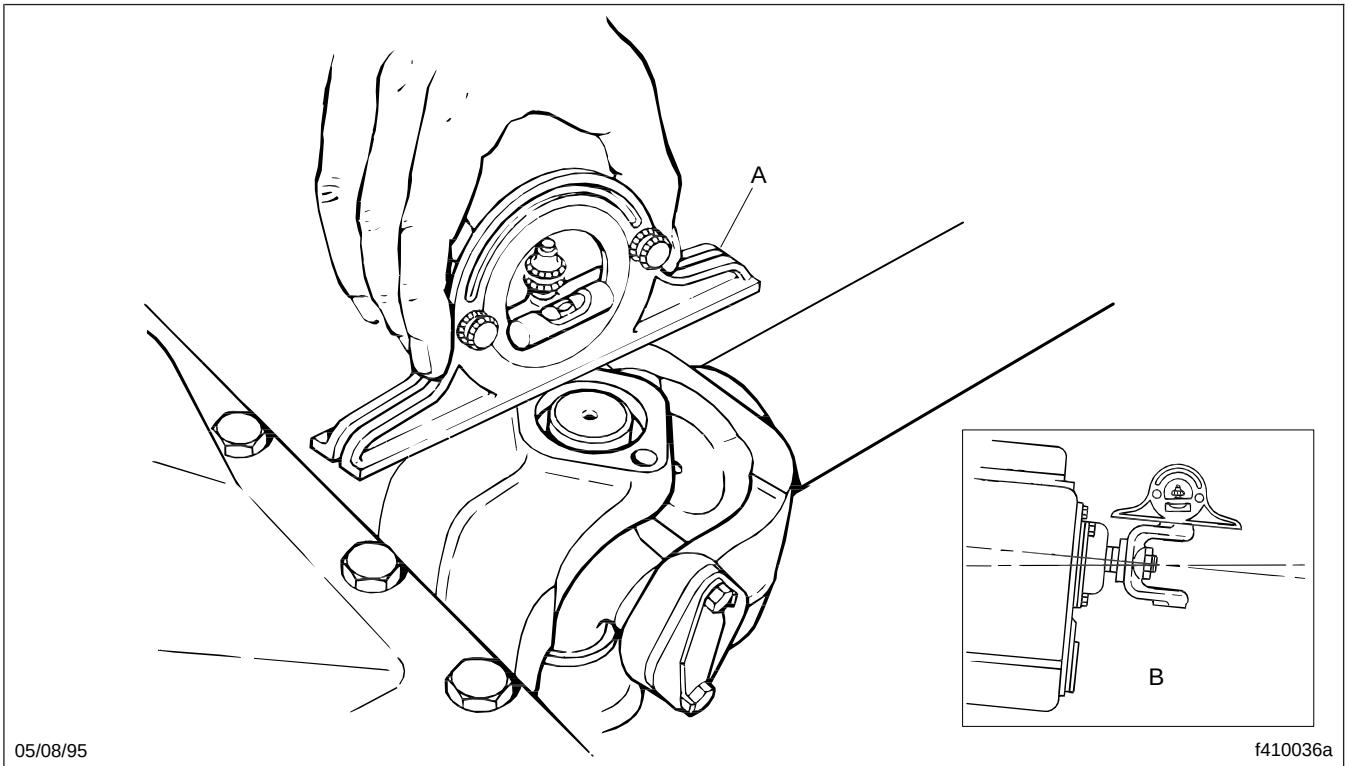
A. Protractor held at right angle to vehicle frame centerline.
B. End view of end-yoke.

1. Machined Surface of Yoke Lug
2. End-Yoke

Fig. 5, Horizontal Positioning of Yoke Lug Machined Surface

7. Without changing the position of the end-yoke, turn the protractor until it is parallel to the frame centerline. See **Fig. 6**. Adjust the calibrated scale so the bubble is exactly between the two marks on the level vial. Record the calibrated scale reading opposite the "0" mark. Correct this value for any previously recorded off-level inclination.
8. For a full-round end-yoke, install the bearing cup. See **Section 41.00** for full-round end-yoke bearing cup installation.

Engine and Pinion Angle Measurement



NOTE: Full-round end-yoke is shown.

A. Protractor held parallel to vehicle frame centerline.
B. Side view of end-yoke.

Fig. 6, Measuring Pinion Angles

Checking

If the vehicle is equipped with a Freightliner four-spring suspension, Freightliner Air Suspension (FAS), or Reyco 102AR suspension, the axle pinion angles are factory-set using alignment shims at the rear springs. Starting in September 1990, these shims have notches on the thick end of the shim. Count the number of notches in the thick end of each shim to make sure that the correct shim is used. Also, make sure the thick end of the shim is positioned correctly. Refer to the applicable table in **Specifications, 400** for shim identification and use. The pinion angles listed for these suspensions are for vehicles built before September 1990. If the axle pinion angles on these suspensions are incorrect, contact your district service manager for the adjustment procedure.

On Hendrickson and Neway 244-6 suspensions, spacers or washers at the torque rods are used to maintain the correct axle pinion angles. If the measured axle pinion angles on these suspensions are not the same as the angles listed in the applicable table in **Specifications, 400**, contact your district service manager for the adjustment procedure.

NOTE: In any of the following steps, if an off-level inclination was added to or subtracted from the engine angle, the same figure must be added to or subtracted from the midship shaft or axle pinion reading before comparing the angles.

1. Check the engine angle at the transmission output yoke. The engine angle must be 3 degrees ± 1/2 degree. For instructions, refer to **Subject 100**.
2. If the driveline includes a midship bearing, place a protractor on top of the midship shaft. Align the protractor with the driveshaft centerline. **See Fig. 1.** Read the scale. The centerline of the midship shaft must be 1/2 degree out of vertical alignment with the transmission output shaft. **See Fig. 2.** Compare this reading with the measured engine angle.

   If needed, adjust the midship bearing mounting to meet the above specification. Contact your district service manager for midship bearing mount adjusting procedures.
3. On single-drive installations, measure the rear axle pinion angle at the back of the no. 2 driveline. For instructions, refer to **Subject 100**.

   The measured rear axle pinion angle must be equal ±1 degree to the measured engine angle. If the rear axle pinion angle doesn't meet the above specification, contact your district service manager.
4. On dual-drive installations, measure the forward rear-axle pinion angle (at the rear of the no. 2 driveline). For instructions, refer to **Subject 100**.

   The measured forward-rear axle pinion angle must be equal ±1 degree to the measured engine angle. If the forward rear-axle pinion angle doesn't meet the above specification, contact your district service manager.

   Measure the rearmost axle pinion angle (at the rear of the no. 3 driveline). For instructions, refer to **Subject 100**.

   Compare the measured angle with that shown in the applicable table in **Specifications, 400**. The measured rearmost axle pinion angle must be equal ±1 degree to the angle shown in the table. If the measured angle is incorrect, contact your district service manager.

Driveline Angle Checking

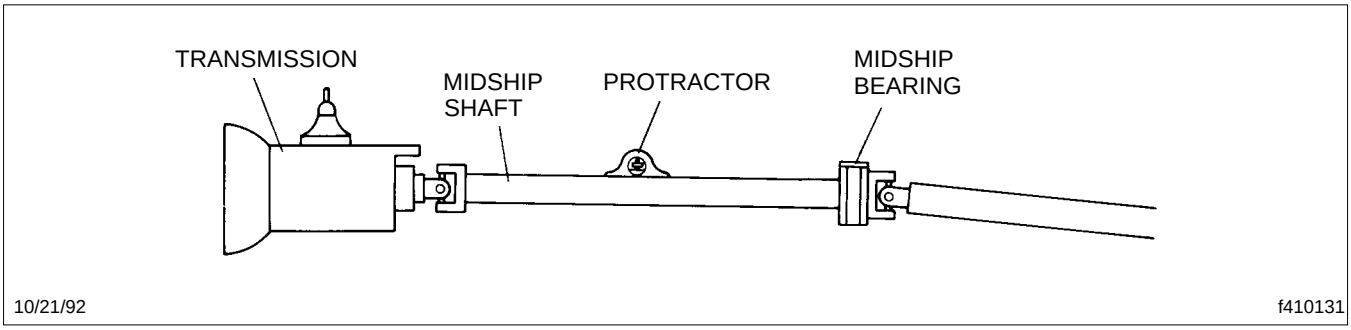


Fig. 1, Midship Shaft Angularity

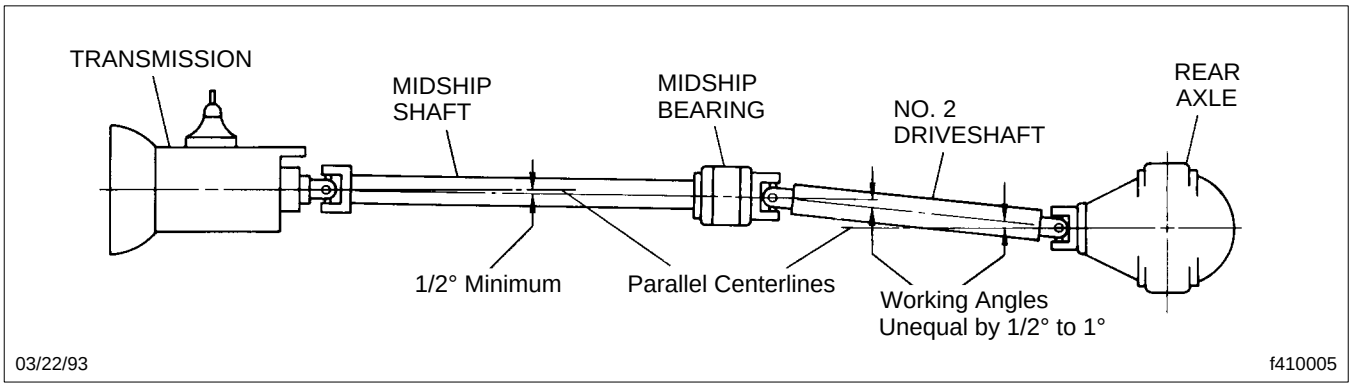


Fig. 2, Midship Bearing in a Single-Drive Vehicle

Troubleshooting

Not all noise or vibration is caused by driveline components. Never change the angularity or balance of the driveline until a thorough check has been completed.

Road test the vehicle to determine the cause of noise or vibration. Drive the vehicle in all gears and all speed ranges for which the vehicle was designed.

NOTE: Operating a vehicle at speeds that exceed its driveshaft design specifications may cause an out-of-balance vibration.

The following is a troubleshooting elimination process; the checks should be made in the order listed. At each step where a possible cause is found and corrective action is taken, road test the vehicle to see if other problems still exist, before going to the next step. If no more problems exist, stop the process at that step.

1. Check tires for uneven wear and out-of-roundness. Check for mismatched tires. Look for wheels and rims that are out of alignment or are missing balance weights.
2. Check the rear suspension for loose or broken U-bolts; broken, shifted, or mismatched rear springs; or broken spring seats. Look for anything that could cause angular misalignment of the rear axle pinion(s).
3. Check the frame rails for bends, twists, or breaks.
4. Check the engine and main transmission mounts (and auxiliary transmission mounts and midship bearing, if equipped). Tighten any loose mounting bolts and replace any mounts that are deteriorated or oil-soaked. Loose mounting bolts, or oil-soaked or deteriorated mounts, can cause angular misalignment of through-shafts and pinion shafts.
5. Check the U-joint bearing caps for loose capscrews. Tighten any loose bearing-cap capscrews to the torque values in **Table 1**, then bend the tabs of the lockstrap firmly against a flat side of each capscrew.

⚠ CAUTION

Don't overtighten the bearing-cap capscrews. A broken fastener at any point in the driveline will weaken the driveline connection, which could result in serious damage to the vehicle.

6. Check all of the U-joint assemblies, slip joint splines, and midship bearings (if so equipped) for wear, as follows:
   - 6.1 Try to move the driveshaft up and down, and from side to side. If there is movement of the U-joint trunnion in the bearings, replace the complete U-joint cross assembly. If the midship bearing is loose on its shaft, or rattles, replace it.
   - 6.2 Try to bend the sleeve yoke and splined shaft back and forth. If radial looseness can be seen or felt, replace both the sleeve yoke and the splined shaft.
7. Check the driveshaft for missing balance weights. If any weights are missing, have the driveshaft balanced to a tolerance of one inch-ounce per ten pounds weight per end (maximum) at 3000 rpm.
8. Check the driveshaft tubes for dents, bends, twists, or other damage. If damaged, remove the driveshaft and check the runout. If the tube is not straight (and cannot be straightened) to within 0.001 inch (0.03 mm) on the slip-joint-seal surface of the spline shaft, 0.005 inch (0.13 mm) on the tube, 2 inches (51 mm) from the rear weld, and 0.010 inch (0.25 mm) at the center of the tube, replace the tube. See **Fig. 1**.

   If the driveshaft tube needs to be straightened or replaced, balance the repaired driveshaft before installing it.
9. Check each driveline for proper U-joint phasing as follows. See **Fig. 2**.

   On slip-jointed driveshafts, if the U-joints are out of phase, check the slip joint for alignment marks, disassemble the slip joint, and align the marks.

   NOTE: To disassemble the slip joint, uncouple the U-joint at one end of the driveshaft, unscrew the slip joint seal from the sleeve yoke, then pull the sleeve yoke and splined shaft apart. Reverse the procedure to assemble the slip joint. Refer to

Troubleshooting

Section 41.00 for instructions covering U-joint uncoupling and coupling.

If no alignment marks are present, disassemble the slip joint, and reassemble with the U-joints in one of the two in-phase positions (180 degrees apart). Test drive the vehicle, then assemble the slip joint in the other in-phase position.

Determine which in-phase position provides vibration-free operation. Assemble the slip joint in the correct in-phase position and mark the slip joint with alignment marks.

On midship shafts, if the U-joints are out of phase remove, align, and install the midship shaft end-yoke.

NOTE: To remove the midship shaft end-yoke, uncouple the U-joint cross assembly from the midship shaft end-yoke, leaving the U-joint attached to the no. 2 driveshaft sleeve yoke. Remove the midship-shaft cotter pin and end-yoke nut. Remove the end yoke, using a yoke puller. See **Fig. 3**. Align the end yoke, then install it by hand. Install the end-yoke nut and tighten it 700 to 750 lbf·ft (949 to 1017 N·m). Back off the nut slightly, and again tighten it to the same torque. Install and lock a new cotter pin. If necessary, turn the nut in a direction that is closest to aligning a nut slot with the shaft hole. Couple the midship shaft to the no. 2 driveshaft. Refer to **Section 41.00** for instructions covering U-joint uncoupling and coupling.

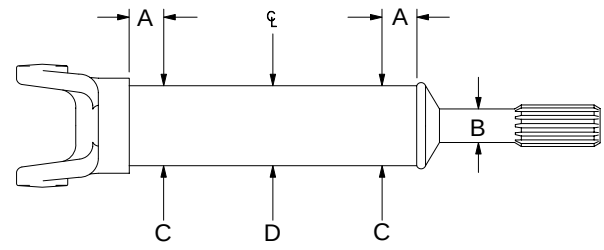
Bearing-Cap Capscrew Torque Values	
Capscrew Size	**Torque lbf·ft (N·m)**
5/16–24	20 (27)
3/8–24	37 (50)
7/16–20	60 (81)

Table 1, Bearing-Cap Capscrew Torque Values

10. On dual-drive vehicles, do the following:

    10.1 With the interaxle differential locked, remove the no. 3 (interaxle) driveshaft, then test drive the vehicle. Refer to **Section 41.00** for instructions covering driveshaft removal and installation.

    If vibration still exists, continue with the next substep.



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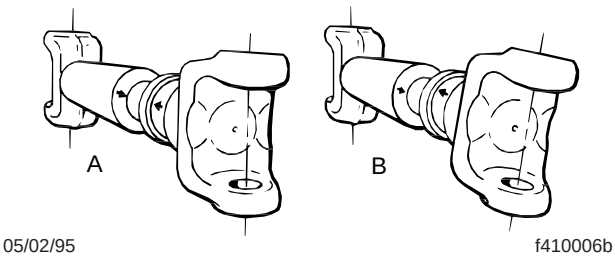
A. Measurement: 3" (76 mm)
B. Measurement: 0.005" (0.127 mm)
C. Measurement: 0.010" (0.254 mm)
D. Measurement: 0.015" (0.381 mm)

Fig. 1, New (rebuilt) Driveshaft Runout Specifications



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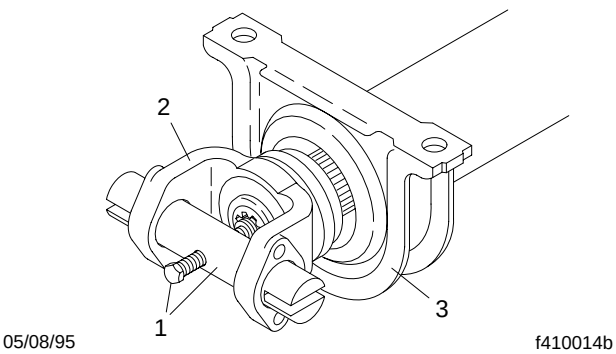
1. In Phase
2. Out of Phase

Fig. 2, U-Joint Phasing



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1. Yoke Puller
2. Midship Bearing Shaft End-Yoke

1. Midship Bearing Assembly

Fig. 3, Midship Shaft End-Yoke Removal

If no vibration exists, install the no. 3 driveshaft, then go to the next step.

10.2 Check the torque on the yoke nuts in the drivetrain. Refer to the applicable table in **Specifications, 400** for yoke-nut torque values. If any of the yoke nuts are not tightened correctly, check the yoke for worn splines by trying to move it up and down, and back and forth. If there is any movement of the yoke, replace the yoke and yoke nut. If it doesn't move, tighten the yoke nut to the correct torque value.

10.3 If the vehicle is equipped with alignment shims at the rear springs, count the number of notches in the thick end of each shim to make sure that the correct shim is used. Also, make sure the thick end of the shim is orientated correctly. Refer to the applicable table in **Specifications, 400** for shim identification and use.

10.4 Balance the no. 2 driveshaft to a tolerance of one inch-ounce per ten pounds weight per end (maximum) at 3000 rpm. Also, balance the midship shaft (if equipped). Or, if an auxiliary transmission is included in the drivetrain, the no. 1 driveshaft should also be balanced.

10.5 If vibration still exists after installing the no. 3 (interaxle) driveshaft, balance the driveshaft.

11. Check the torque on the yoke nuts at the forward rear-axle output shaft and the rearmost axle input shaft. Refer to the applicable table in **Specifications, 400** for yoke-nut torque values. If any of the yoke nuts are not tightened to their torque value, check the yoke for worn splines by trying to move it up and down, and back and forth. If there is any movement of the yoke, replace the yoke and yoke nut. If it doesn't move, tighten the yoke nut to the correct torque value.

    Check that both rear axle gear ratios are matched. If necessary, replace one of the gear sets with a gear set of the proper ratio.

    Balance the no. 3 (interaxle) driveshaft to a tolerance of one inch-ounce per ten pounds weight per end (maximum) at 3000 rpm.

12. On single-drive vehicles, do the following:

    12.1 Check the torque on all of the yoke nuts in the drivetrain. Refer to the applicable table in **Specifications, 400** for yoke-nut torque values. If any of the yoke nuts are not tightened to their torque value, check the yoke for worn splines by trying to move it up and down, and back and forth. If it moves, replace the yoke and yoke nut. If it doesn't move, tighten the yoke nut to its torque value.

    12.2 Have the no. 2 driveshaft balanced to a tolerance of one inch-ounce per ten pounds weight per end (maximum) at 3000 rpm.

    12.3 If the no. 2 driveline is equipped with a midship bearing, balance the midship shaft to a tolerance of one inch-ounce per ten pounds weight per end (maximum) at 3000 rpm. Or, if an auxiliary transmission is included in the drivetrain, the no. 1 driveshaft should also be balanced.

Specifications

1. Engine Angle—All Suspensions: Adjust to 3 degrees ±1/2 degree.
2. Single-Drive—All Suspensions: Adjust rear axle pinion angle to 3 degrees ±1 degree.
3. Dual-Drive—Adjust axle pinion angles to the values in **Table 2**, ±1 degree.

End-Yoke-Nut Torque		
Application	**Size**	**Torque lbf·ft (N·m)**
Transmissions		
Fuller	—	450-500 (610-678)
Spicer	—	550-600 (746-813)
Eaton Axles		
Single-Drive Rear Axle and Dual-Drive Rearmost Axle Drive Pinions	1–20	360-440 (488-597)
	1-1/8–18	360-440 (488-597)
	1-1/4–12	480-600 (651-813)
	1-1/2–18	560-700 (759-949)
	1-3/4–12	840-1020 (1139-1383)
	1-7/8–12	840-1020 (1139-1383)
Dual-Drive Forward Rear-Axle Input Shafts	1-1/2–18	560-700 (759-949)
	1-5/8–18	780-960 (1058-1302)
	1-7/8–12	840-1020 (1139-1383)
Dual-Drive Forward Rear-Axle Output Shafts	1-1/4–12	480-600 (651-813)
	1-3/4–12	840-1020 (1139-1383)
Rockwell Axles		
Single-Drive Rear Axle and Dual-Drive Rearmost Axle Drive Pinions	7/8–20	200-275 (271-373)
	1–20	300-400 (407-542)
	1-1/4–12	700-900 (949-1220)
	1-1/4–18	700-900 (949-1220)
	1-1/2–12	800-1100 (1085-1491)
	1-1/2–18	800-1100 (1085-1491)
	1-3/4–12	900-1200 (1220-1627)
	2–12	1200-1500 (1627-2034)
Dual-Drive Forward Rear-Axle Input Shafts	1-1/4–18	450-600 (610-813)
	1-1/2–12	450-600 (610-813)
	1-1/2–18	450-600 (610-813)
	1-3/4–12	450-600 (610-813)

Specifications

End-Yoke-Nut Torque		
Application	**Size**	**Torque lbf·ft (N·m)**
Dual-Drive Forward Rear-Axle Output Shafts	1–20	450-600 (610-813)
	1-1/4–12	450-600 (610-813)
	1-1/4–18	450-600 (610-813)
	1-1/2–12	450-600 (610-813)
Rockwell Midship Bearings		
Midship Bearing End Yoke	1-1/4–18	700-750 (949-1017)

Table 1, End-Yoke-Nut Torque

Suspension Model	Axle Model	Axle Spacing	Forward Rear-Axle Pinion Angle/ Planing Shims			Rearmost Axle Pinion Angles/ Planing Shims		
			Pinion Angle	Orientation of the Shim's Thick End	Number of Shim Notches	Pinion Angle	Orientation of the Shim's Thick End	Number of Shim Notches
Reyco Suspensions With Eaton Axles (Vehicle Unloaded)								
102AR	401, 402	52"	2° 0'	Forward	2	8° 00'	Forward	4
Reyco Suspensions With Rockwell Axles (Vehicle Unloaded)								
102AR	SQ-100	52"	2° 00'	Forward	2	8° 00'	Forward	4
	RT 40 145 RT 44 145	52"	2° 00'	Forward	2	9° 45'	Forward	1
Reyco Suspensions With Eaton Axles (Vehicle Loaded)								
102AR	401, 402	52"	3° 00'	Forward	2	10° 00'	Forward	4
Reyco Suspensions With Rockwell Axles (Vehicle Loaded)								
102AR	SQ-100	52"	3° 00'	Forward	2	10° 00'	Forward	4
	RT 40 145 RT 44 145	52"	3° 00'	Forward	2	11° 45'	Forward	1
Neway Suspensions With Eaton Axles (Vehicle Loaded or Unloaded)								
244-6	401, 402	52"	3° 00'	—	—	9° 30'	—	—
		54"	3° 00'	—	—	3° 00'	—	—
		60"	3° 00'	—	—	3° 00'	—	—
	461	52"	3° 00'	—	—	10° 45'	—	—
		54"	3° 00'	—	—	10° 30'	—	—
		60"	3° 00'	—	—	3° 00'	—	—
Neway Suspensions With Rockwell Axles (Vehicle Loaded or Unloaded)								

Specifications

Suspension Model	Axle Model	Axle Spacing	Forward Rear-Axle Pinion Angle/ Planing Shims			Rearmost Axle Pinion Angles/ Planing Shims		
			Pinion Angle	Orientation of the Shim's Thick End	Number of Shim Notches	Pinion Angle	Orientation of the Shim's Thick End	Number of Shim Notches
244-6	SQ-100	52"	3° 00'	—	—	9° 45'	—	—
		54"	3° 00'	—	—	9° 30'	—	—
		60"	3° 00'	—	—	3° 00'	—	—
	SSHD	52"	3° 00'	—	—	9° 30'	—	—
		54"	3° 00'	—	—	9° 00'	—	—
		60"	3° 00'	—	—	3° 00'	—	—
	RT 40 145 RT 44 145	52"	3° 00'	—	—	11° 30'	—	—
		54"	3° 00'	—	—	11° 15'	—	—
		60"	3° 00'	—	—	3° 00'	—	—
	RT 46 160	52"	3° 00'	—	—	11° 30'	—	—
		54"	3° 00'	—	—	11° 00'	—	—
		60"	3° 00'	—	—	3° 00'	—	—
Hendrickson Suspension With Eaton Axles (Vehicle Loaded or Unloaded)								
RS/RT/RTE	401, 402	52"	3° 00'	—	—	9° 30'	—	—
		54"	3° 00'	—	—	9° 00'	—	—
		60"	3° 00'	—	—	8° 00'	—	—
	461	52"	3° 00'	—	—	10° 45'	—	—
		54"	3° 00'	—	—	10° 30'	—	—
		60"	3° 00'	—	—	9° 00'	—	—
Hendrickson Suspensions With Rockwell Axles (Vehicle Loaded or Unloaded)								

Specifications

Suspension Model	Axle Model	Axle Spacing	Forward Rear-Axle Pinion Angle/ Planing Shims			Rearmost Axle Pinion Angles/ Planing Shims		
			Pinion Angle	Orientation of the Shim's Thick End	Number of Shim Notches	Pinion Angle	Orientation of the Shim's Thick End	Number of Shim Notches
RS/RT/RTE	SQ-100	52"	3° 00'	—	—	9° 45'	—	—
		54"	3° 00'	—	—	9° 30'	—	—
		60"	3° 00'	—	—	8° 30'	—	—
	SSHD	52"	3° 00'	—	—	9° 30'	—	—
		54"	3° 00'	—	—	9° 00'	—	—
		60"	3° 00'	—	—	7° 45'	—	—
	STHD	52"	3° 00'	—	—	9° 30'	—	—
		54"	3° 00'	—	—	9° 00'	—	—
		60"	3° 00'	—	—	8° 00'	—	—
	RT 40 145 RT 46 160	52"	3° 00'	—	—	11° 35'	—	—
		54"	3° 00'	—	—	11° 10'	—	—
		60"	3° 00'	—	—	10° 00'	—	—
	RT 48 180	52"	3° 00'	—	—	12° 00'	—	—
		54"	3° 00'	—	—	11° 30'	—	—
		60"	3° 00'	—	—	10° 00'	—	—
	RT 52 180	52"	3° 00'	—	—	12° 00'		—
		54"	3° 00'	—	—	11° 30'	—	—
		60"	3° 00'	—	—	10° 00'	—	—
Freightliner Air Suspensions (FAS) With Eaton Axles (Vehicle Unloaded)								
FAS I	401, 402	52"	2° 00'	—	—	0° 30'	Forward	1
		54"	2° 15'	Rearward	1	1° 30'	—	—
		60"	2° 15'	Rearward	1	0° 30'	Forward	2
	461	52"	2° 00'	—	—	2° 15'	Rearward	2
		54"	2° 15'	Rearward	1	2° 00'	Rearward	2
		60"	2° 15'	Rearward	1	0° 30'	Forward	2
Freightliner Air Suspensions (FAS) With Rockwell Axles (Vehicle Unloaded)								

Specifications

Suspension Model	Axle Model	Axle Spacing	Forward Rear-Axle Pinion Angle/ Planing Shims			Rearmost Axle Pinion Angles/ Planing Shims		
			Pinion Angle	Orientation of the Shim's Thick End	Number of Shim Notches	Pinion Angle	Orientation of the Shim's Thick End	Number of Shim Notches
FAS I	SQ-100	52"	2° 00'	—	—	1° 45'	—	—
		54"	2° 15'	Rearward	1	1° 40'	—	—
		60"	2° 15'	Rearward	1	0° 00'	Forward	2
	SSHD	52"	2° 00'	—	—	2° 15'	Rearward	2
		54"	2° 15'	Rearward	1	0° 30'	Forward	1
		60"	2° 15'	Rearward	1	0° 00'	Forward	2
	RT 40 145 RT 44 145	52"	2° 00'	—	—	9° 15'	—	—
		54"	2° 15'	Rearward	1	8° 30'	Forward	1
		60"	2° 15'	Rearward	1	7° 15'	Forward	3
	RT 46 160	52"	2° 00'	—	—	9° 15'	—	—
		54"	2° 15'	Rearward	1	8° 00'	Forward	1
		60"	2° 15'	Rearward	1	7° 15'	Forward	3
Freightliner Spring Suspensions With Eaton Axles (Vehicle Loaded)								
4-Spring	401, 402	52"	1° 15'	Forward	1	8° 45'	—	—
		54"	1° 30'	Rearward	1	8° 15'	Forward	3
		60"	1° 45'	—	—	1° 45'	—	—
	461	52"	1° 30'	Forward	1	10° 00'	Rearward	2
		54"	1° 15'	Rearward	1	9° 30'	—	—
		60"	1° 45'	—	—	1° 45'	—	—
Freightliner Spring Suspensions With Rockwell Axles (Vehicle Loaded)								
4-Spring	SQ-100	52"	1° 30'	Forward	1	8° 45'	—	—
		54"	1° 45'	Rearward	1	8° 15'	Forward	3
		60"	1° 45'	—	—	1° 45'	—	—
	SSHD	52"	1° 15'	Forward	1	8° 45'	—	—
		54"	1° 30'	Rearward	1	7° 45'	Forward	4
		60"	1° 45'	—	—	1° 45'	—	—
	RT 40 145 RT 44 145	52"	1° 30'	Forward	1	10° 30'	Rearward	3
		54"	1° 30'	Rearward	1	10° 15'	Rearward	1
		60"	1° 45'	—	—	1° 45'	—	—
	RT 46 160	52"	1° 30'	Forward	1	10° 00'	Rearward	2
		54"	1° 30'	Rearward	1	10° 00'	Rearward	1
		60"	1° 45'	—	—	1° 45'	—	—

Table 2, Axle Pinion Angle Data

Installing Air Lines

Nylon Tubes

(See **Fig. 1** and **Fig. 2**)

When installing a nylon tube, be careful not to bend it past its minimum bend radius. For minimum bend radius values, refer to the appropriate table in **Specifications, 400**.

CAUTION

CAUTION: If the tubing is bent to a radius smaller than the specified minimum bend radius, it may kink, and shut off normal airflow to the component.

1. Cut the end of the tubing smooth and square.

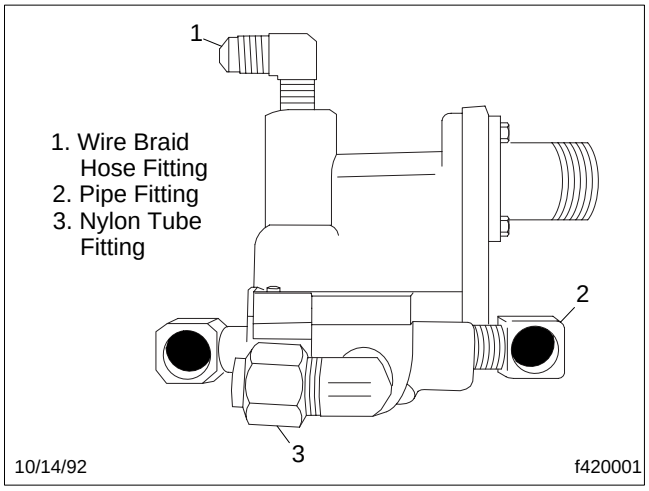


Fig. 1, Tube and Hose Fittings (for reference only)

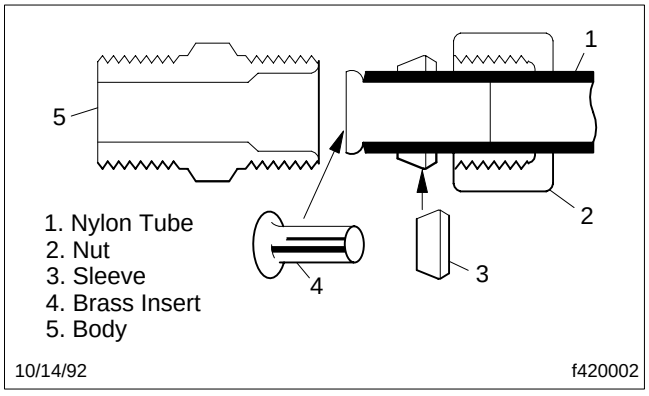


Fig. 2, Nylon Tube Fitting

2. Make sure the nylon tubing ends and fittings are free of grease and debris. If the tubing is crimped or otherwise damaged, replace it with new tubing.
3. Install a new sleeve in the nut.
4. Insert the squared end of the tubing in the fitting, until it bottoms in the body of the fitting. See **Fig. 3.**
5. Tighten the nut finger-tight. Then, using two wrenches to prevent twisting of the tube, tighten the nut a minimum of 2 turns (refer to the appropriate table in **Specifications, 400**) or until one thread shows on the fitting body.

Wire Braid Hoses

(See **Fig. 1**)

When installing a wire braid hose, be careful not to bend it past its minimum bend radius. For minimum bend radius values, refer to the appropriate tables in **Specifications, 400**.

CAUTION

CAUTION: If the hose is bent to a radius smaller than the specified minimum bend radius, it may kink, and shut off normal airflow to the component.

Make sure the wire braid hose assembly is free of grease and dirt. Replace the assembly if the hose or fitting is crimped or otherwise damaged.

Install the hose and tighten the nut finger-tight. Then, using two wrenches to prevent twisting of the hose, tighten the nut until it seats solidly. Tighten the nut one-sixth turn more.

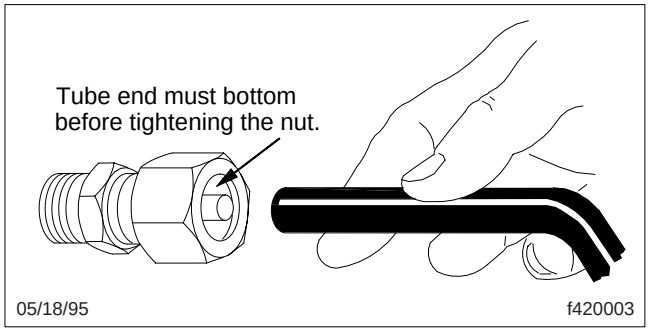


Fig. 3, Installing Nylon Tubing

Installing Air Lines and Fittings

Installing Fittings

Brass and Steel Pipe Fittings

(See **Fig. 1**)

For brass pipe fittings, both male and female parts, tighten as follows:

1. Make sure the fittings are free of grease, dirt, and old sealant. Apply liquid Loctite® Hydraulic Sealant (brown), or an equivalent, to the threads, then tighten securely, finger-tight.

NOTE: Always apply the sealant to the external thread, so that any excess will be scraped off externally rather than internally to the joint.

2. For fittings that must be positioned, tighten one additional turn from finger-tight using a wrench.

   Then, continue tightening until the fitting is correctly positioned.

   For fittings that do not require positioning, tighten 1-1/2 additional turns from finger-tight.

Copper Tube Fittings

For copper tube fittings, tighten the nut finger-tight. Then, using two wrenches to prevent twisting of the tube, tighten the nut the number of turns shown in the table in **Specifications, 400**.

Tube and Pipe Fittings on Plastic Components

For tightening specifications, refer to the table in **Specifications, 400**.

Nylon Tube			
Number	Inside Diameter: inch	Outside Diameter: inch	Minimum Bend Radius: inch (mm)
4	0.170	1/4	1.00 (25)
6	0.251	3/8	1.50 (38)
8	0.376	1/2	2.00 (51)
10	0.439	5/8	2.50 (64)
12	0.566	3/4	3.00 (76)

Table 1, Nylon Tube

Additional Turns from Hand-Tight (nylon tube)	
Tube Size: inch	Additional Turns from Hand-Tight
1/4	3
3/8 or 1/2	4
5/8 or 3/4	3-1/2

Table 2, Additional Turns from Hand-Tight (Nylon Tube)

211 Wire Braid (medium pressure) Hose *			
Number	Inside Diameter: inch	Outside Diameter: inch	Minimum Bend Radius: inch (mm)
4	3/16	0.52	3.00 (76)
5	1/4	0.58	3.38 (86)
6	5/16	0.67	4.00 (102)
8	13/32	0.77	4.63 (118)
10	1/2	0.92	5.50 (140)
12	5/8	1.08	6.50 (165)
16	7/8	1.23	7.38 (187)
20	1-1/8	1.50	9.00 (229)

* 211 hose is identified by part number and size (for example, part numbers 211-4, 211-5, and so on).

Table 3, 211 Wire Braid (Medium Pressure) Hose

213 Wire Braid (diesel) Hose *			
Number	Inside Diameter: inch	Outside Diameter: inch	Minimum Bend Radius: inch (mm)
4	3/16	0.49	0.75 (19)
5	1/4	0.55	1.00 (25)
6	5/16	0.62	1.25 (32)
8	13/32	0.74	1.75 (44)
10	1/2	0.83	2.25 (57)
12	5/8	0.96	2.75 (70)
16	7/8	1.21	3.50 (89)
20	1-1/8	1.49	4.50 (114)

* 213 hose is identified by two green stripes 180 degrees apart, part numbers, and size (for example, part numbers 213-4, 213-5, and so on).

Table 4, 213 Wire Braid (Diesel) Hose

Copper Tube Fittings			
Number	Outside Diameter: inch	Additional Turns from Hand-Tight	
		Compression Fitting	Threaded Sleeve
2	1/8	1-1/4	1-1/2
3	3/16		
4	1/4		
5	5/16	1-3/4	
6	3/8	2-1/4	
8	1/2		
10	5/8		
12	3/4		
16	1		
20	1-1/4		

Table 5, Copper Tube Fittings

Specifications

Tube and Pipe Fittings on Plastic Components			
Description	**Port Size: inch**	**Torque:**	
		lbf·in (N·cm)	**lbf·ft (N·m)**
Midland Quick Release Valve	3/8	60–90 (680–1020) *	—
	1/2	—	13–17 (18–23) *
Bendix MV-2/MV-3 Valve	1/4	—	10 (14)

* Tighten to the lower torque value; then, if needed, turn the fittings to allow for proper routing of air lines.

Table 6, Tube and Pipe Fittings on Plastic Components

General Description and Principles of Operation (See Fig. 1)

The dual circuit brake valve (foot valve) controls the air supply and delivery of the dual circuit brake system. The brake valve is mounted either on the firewall (120 Conventionals), or under the floor (COEs).

APPLYING

The primary circuit of the brake valve is controlled by the brake pedal and a push rod. When the brake pedal is depressed, the push rod applies pressure on the spring seat, rubber spring, and the primary (upper) piston (Ref. 9). The downward movement of the primary piston closes the upper exhaust valve (Ref. 13), and then opens the upper inlet valve (Ref. 13), allowing high-pressure air from port 11 to flow to low-pressure port 21.

The secondary circuit is pneumatically operated by the pressure from the primary circuit. Primary circuit pressure on top of the relay piston (Ref. 18) first closes the lower exhaust valve (Ref. 20), and then opens the lower inlet valve (Ref. 20), allowing high-pressure from port 12 to flow to low-pressure port 22.

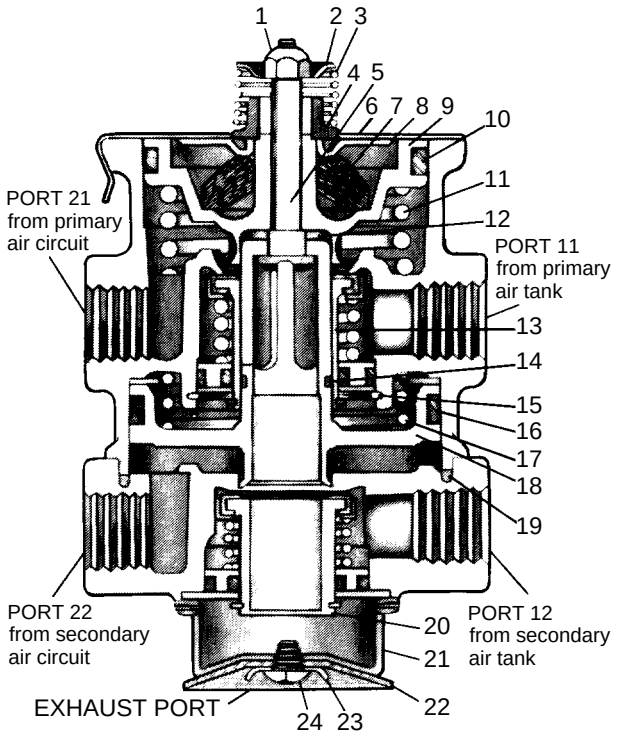
HOLDING

As air pressure builds in the primary circuit, the pressure under the primary piston will match the pressure of the rubber spring. This allows the piston to move up enough to close the upper inlet valve (Ref. 13), and prevent the flow of air from the primary air tank into the brake valve. The exhaust port remains closed.

RELEASING

When the pedal is released, the push rod releases pressure from the spring seat, rubber spring, and the primary (upper) piston. Air pressure builds to push the piston up, opening the upper exhaust valve and allowing air from the primary circuit to escape through the exhaust port.

In the secondary circuit, the release of primary air pressure allows air under the relay piston, pushing the piston up and opening the lower exhaust valve. All remaining air pressure is vented through the exhaust port.



1. Locknut
2. Spring Seat
3. Stem Spring
4. Spring Seat Nut
5. Primary Piston Stem
6. Primary Piston Retainer
7. Rubber Spring
8. Spring Seat
9. Primary Piston
10. Primary Piston O−Ring
11. Primary Piston Return Spring
12. Small Washer
13. Upper Inlet and Exhaust Valve Assembly
14. Small O−Ring
15. Retaining Ring
16. Large O−Ring
17. Relay Piston Spring (if equipped)
18. Relay Piston
19. Rubber Seal Ring
20. Lower Inlet and Exhaust Valve Assembly
21. Exhaust Cover
22. Exhaust Diaphragm
23. Washer
24. Phillips Head Screw

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Fig. 1, Bendix E-6 Dual Circuit Foot Valve (sectional view)

Operating Checks

IMPORTANT: If there is a change in the way a vehicle brakes, or if low pressure warnings occur, check the operation of the brakes' air system. Although the brake system may continue to work, do not operate the vehicle until the braking circuits, including the pneumatic and mechanical devices, have been repaired and are operating normally. Always check the brake system for proper operation after doing brake work, and before returning the vehicle to service.

Check for the proper brake valve operation as follows:

1. Apply the parking brakes, and chock the tires.
2. Connect test gauges to the primary and secondary delivery ports on the brake valve. **See Fig. 1** .

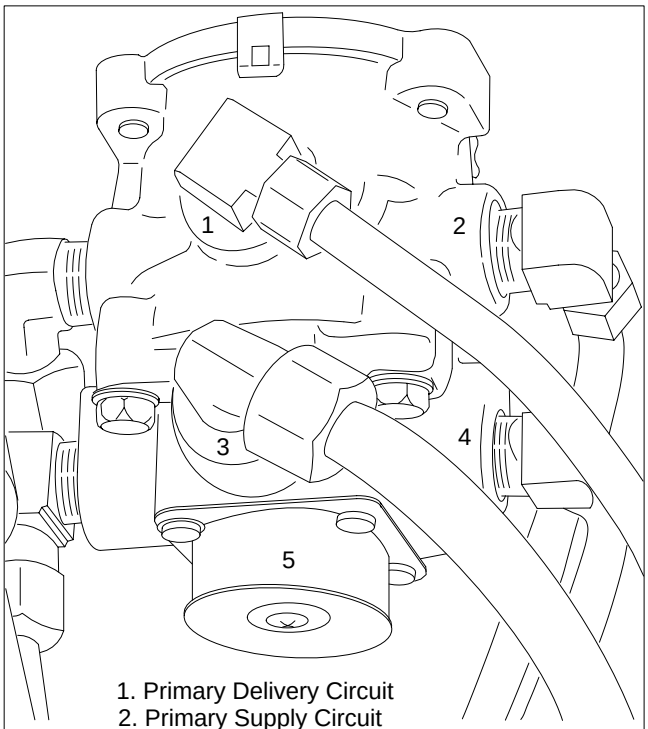


Fig. 1

NOTE: When checking the delivery pressure of the primary and secondary circuits, use test gauges that are accurate.

3. Start the engine and build air pressure to 120 psi (827 kPa).
4. Depress the pedal to several different positions; check the pressure on the test gauges to ensure that it varies equally and proportionately with the movement of the brake pedal.
5. Fully depress the brake pedal, then release it. After a full application is released, the reading on the test gauges should promptly fall to zero.

NOTE: Pressure in the primary delivery circuit will be about 2 psi (14 kPa) greater than pressure in the secondary delivery circuit (if both supply reservoirs are at the same pressure). This is normal for this valve.

6. Proceed to "Leakage Check."

Leakage Check

1. Make and hold a pressure application of 80 psi (552 kPa).
2. Check the air line fittings for leaks: tighten or replace fittings as needed.
3. Coat the exhaust port and body of the valve with a soap solution, and check for leakage. The leakage permitted is a one-inch bubble in 3 seconds.

   If the brake valve does not function as described above, or if leakage is excessive, replace it with a new or remanufactured unit.

   Repeat the leakage test before placing the brake valve in service.
4. Remove the chocks from the tires.

Removal

1. Chock the tires, then tilt the cab or hood. For instructions, refer to the vehicle driver's manual.

⚠ WARNING

WARNING: When draining the air system, don't look into the air jets or direct them toward another person, because dirt or sludge particles may be in the airstream. Don't disconnect pressurized hoses because they may whip as air escapes from the line. Failure to take all necessary precautions during service operations of the air brake system can result in personal injury.

2. Drain all of the air reservoirs.
3. Mark the brake valve air supply and delivery lines for assembly reference. Disconnect the air lines from the brake valve, and plug them to keep out contaminants.
4. On COEs, fold back the carpet around the brake pedal mounting bracket (**Fig. 1**, Ref. 9). Remove the retaining clips (Ref. 7) from each end of the pedal shaft (Ref. 8), then remove the shaft and the pedal from the mounting bracket. Remove the nylon bearings from the mounting bracket flanges.

   Remove the three 5/16-18 capscrews and flatwashers (Ref. 2) from the mounting bracket. Remove the brake valve (Ref. 11), spacer (if equipped), and mounting bracket from the vehicle. Discard the spacer.

   Clean the area surrounding the wedge-shaped gap at the forward edge of the mounting surface between the cab deck and the E-6 valve body.
5. On Conventionals, remove both 3/8-16 capscrews and flatwashers (**Fig. 2**, Ref. 4) that attach the brake valve (Ref. 1) and mounting adaptor (Ref. 3) to the front cab mount plate (Ref. 6).

   Remove the three 5/16-18 capscrews and lockwashers (Ref. 2) that attach the brake valve to the mounting adaptor.

   Remove the plunger (Ref. 8) from the mounting adaptor. Wipe off the old grease from the plunger and adaptor.
6. Note the locations and positions of the double check valves and elbows, then remove them from the brake valve. Clean off the dirt and old sealant from the threads of the valves and elbows.

Installation

⚠ WARNING

WARNING: When applying sealant, make sure that excess sealant doesn't get inside either the male or the female fittings. Loose foreign material inside the air plumbing may clog a valve, causing a loss of brake control, which could result in personal injury.

1. Apply a small quantity of Loctite® Pipe Sealant (with Teflon® 59241), or an equivalent sealant, to the male threads of each of the double check valves and the elbows.
2. Install the double check valves and elbows in the ports of the brake valve. Tighten them finger-tight, then tighten them one additional turn with a wrench. As needed, further tighten them until they are properly positioned.
3. On COEs **(see Fig. 1):**

   3.1 Attach the brake valve and mounting bracket to the cab deck. Using three 5/16-18 capscrews and flatwashers, tighten the capscrews 15 lbf·ft (20 N·m).

   3.2 Clean any dirt, gravel, and other foreign material from the base of the brake pedal, the plunger boot (Ref. 3), and the mounting bracket.

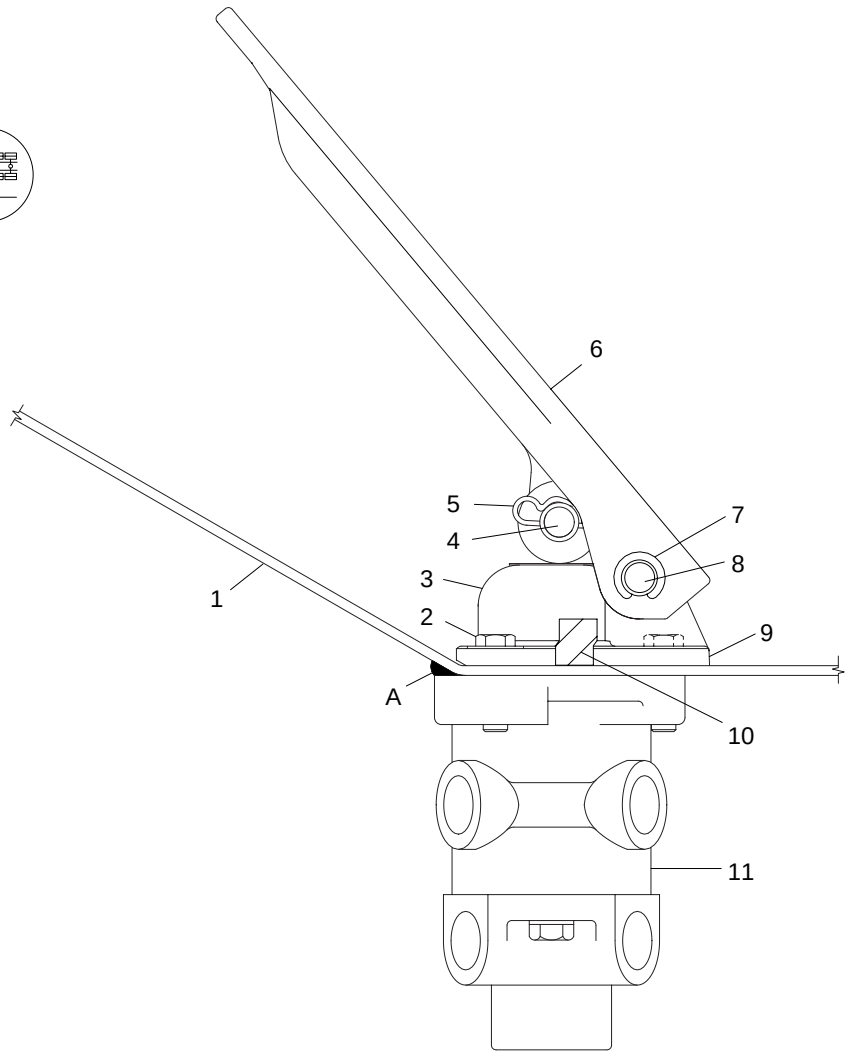
   3.3 Using a light oil, lubricate the brake pedal roller and roller pin (Ref. 4).

   3.4 Remove the brake plunger boot. Lubricate the plunger (Ref. 10) and inside surface of the boot with barium grease, part number BW 246671 or Pennzoil Adhezoplex EP 2. Install the plunger and boot.

   IMPORTANT: If there was a spacer on the brake valve, replace the existing plunger with plunger BW 237074.

   3.5 Install the nylon bearings in the mounting bracket flanges. Place the brake pedal in position on the mounting bracket. Move

Removal and Installation



A. Apply silicone sealant here.

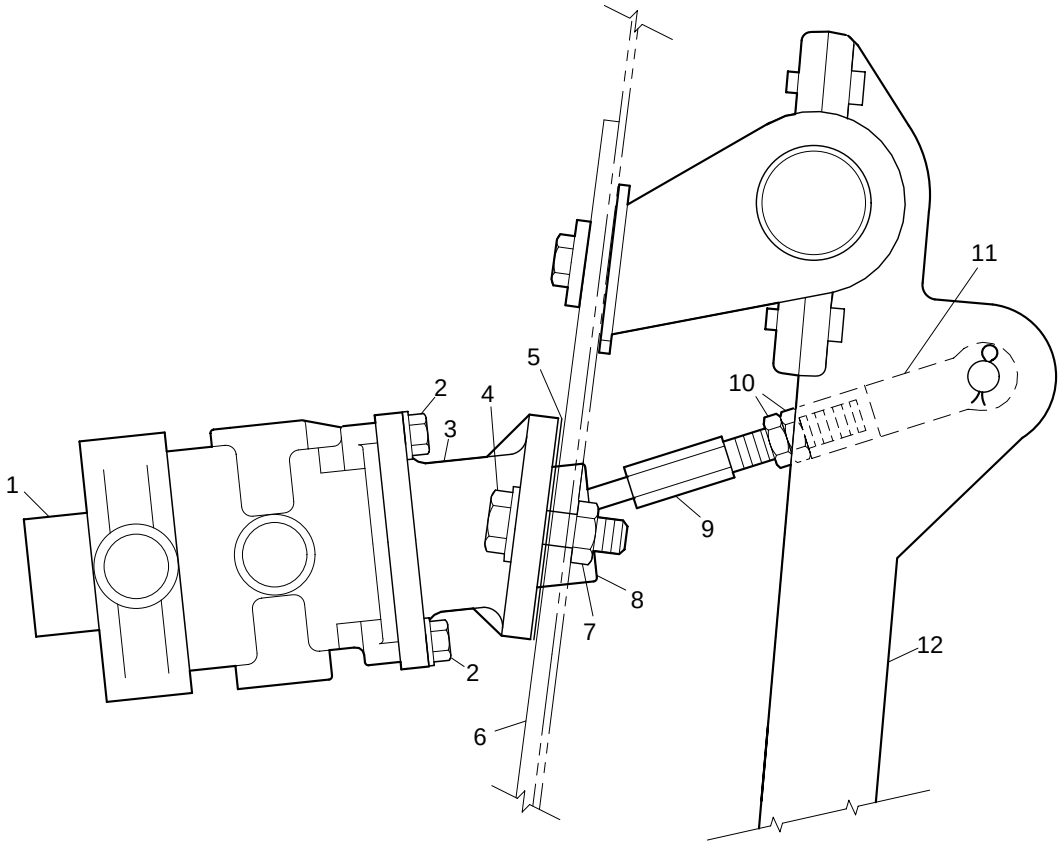
1. Cab Deck
2. 5/16–18 Capscrew and Flatwasher (3 qty. each)
3. Brake Plunger Boot
4. Roller Pin
5. Hitch Pin
6. Brake Pedal
7. Retaining Clip (2 qty.)
8. Pedal Shaft
9. Brake Pedal Mounting Bracket
10. Brake Plunger
11. Brake Valve

Fig. 1, Brake Valve Mounting, COE Installation

the pedal as needed to align the hole in the brake pedal and the mounting bracket, then carefully insert the pedal shaft through the pedal and mounting bracket flanges.

Install the retaining clips on each end of the pedal shaft. Place the carpet around the mounting bracket.

3.6 Using Permatex 81157 or an equivalent silicone sealant, fill the gap at the forward



1. Brake Valve
2. 5/16–18 Capscrew and Lockwasher
3. Mounting Adaptor
4. 3/8–16 Capscrew and Flatwasher
5. Adaptor Gasket
6. Front Cab Mount Plate
7. Weldnut
8. Plunger
9. Brake Pedal Push Rod
10. Push Rod Jam Nuts
11. Push Rod Clevis
12. Brake Pedal Assembly

Fig. 2, Brake Valve Mounting, FLD Conventional Installation

edge of the mounting surface between the cab deck and the E-6 valve body **(Fig. 1).**

3.7 Connect the air lines, as previously marked. Tighten the nuts finger-tight. Using a wrench, further tighten the nuts until there is resistance, then tighten one-sixth additional turn.

4. On Conventionals **(see Fig. 2):**

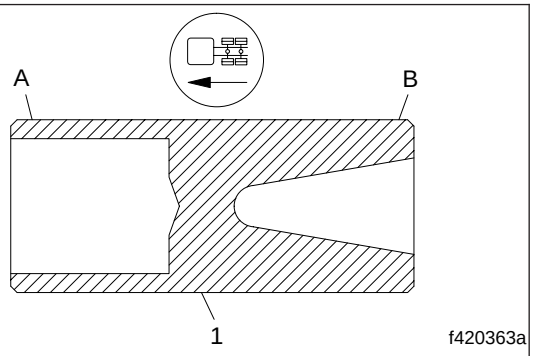
4.1 Lubricate the sliding surface of the brake plunger (Ref. 8) with barium grease, part number BW 246671 or Pennzoil Adhezoplex EP 2. Install the plunger in the mounting adaptor. Make sure the plunger is positioned correctly **(see Fig. 3).**

4.2 Using the three 5/16–18 capscrews and lockwashers (**Fig. 2**, Ref. 2), attach the mounting adaptor to the brake valve. Tighten the capscrews 15 lbf·ft (20 N·m).

4.3 Remove the lower steering column cover panel to gain access to the brake pedal assembly. **See Fig. 4.**

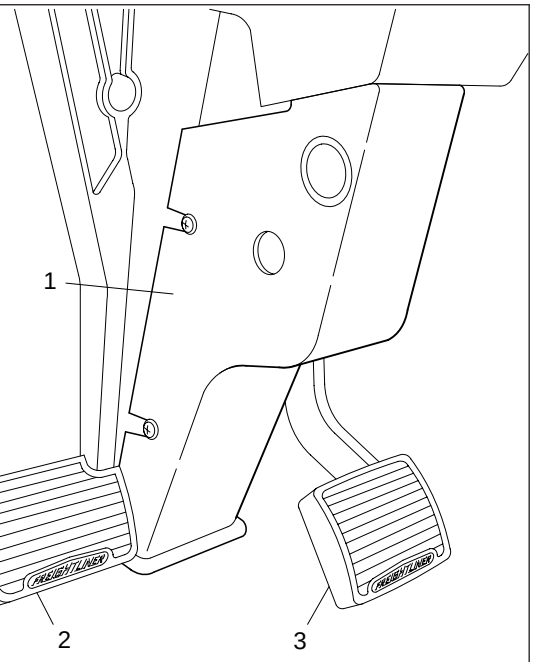
4.4 Loosen the jam nuts (**Fig. 2**, Ref. 10) on the brake pedal push rod (Ref. 9), then turn the push rod into the clevis (Ref. 11) at least three full turns.

Removal and Installation



A. This end toward brake valve.
B. This end toward brake pedal push rod.
1. Plunger

Fig. 3



1. Lower Steering Column Cover Panel
2. Clutch Pedal
3. Brake Pedal

Fig. 4

CAUTION

CAUTION: In the following substep, if you loosen the pedal stop bracket capscrews or remove the pedal stop bracket, don't lift the brake pedal past where the stop bracket was located. To do so could bend the push rod.

4.5 Check that the front face of the brake pedal pad is flush with the front face of the throttle pedal. **See Fig. 5.** If it isn't, adjust the brake pedal height as follows:

Loosen the pedal stop bracket capscrews (**Fig. 5**, Ref. 5).

Adjust the position of the pedal stop bracket (Ref. 4), until the front face of the brake pedal pad is flush with the front face of the throttle pedal.

Tighten the pedal stop bracket capscrews 13 lbf·ft (18 N·m).

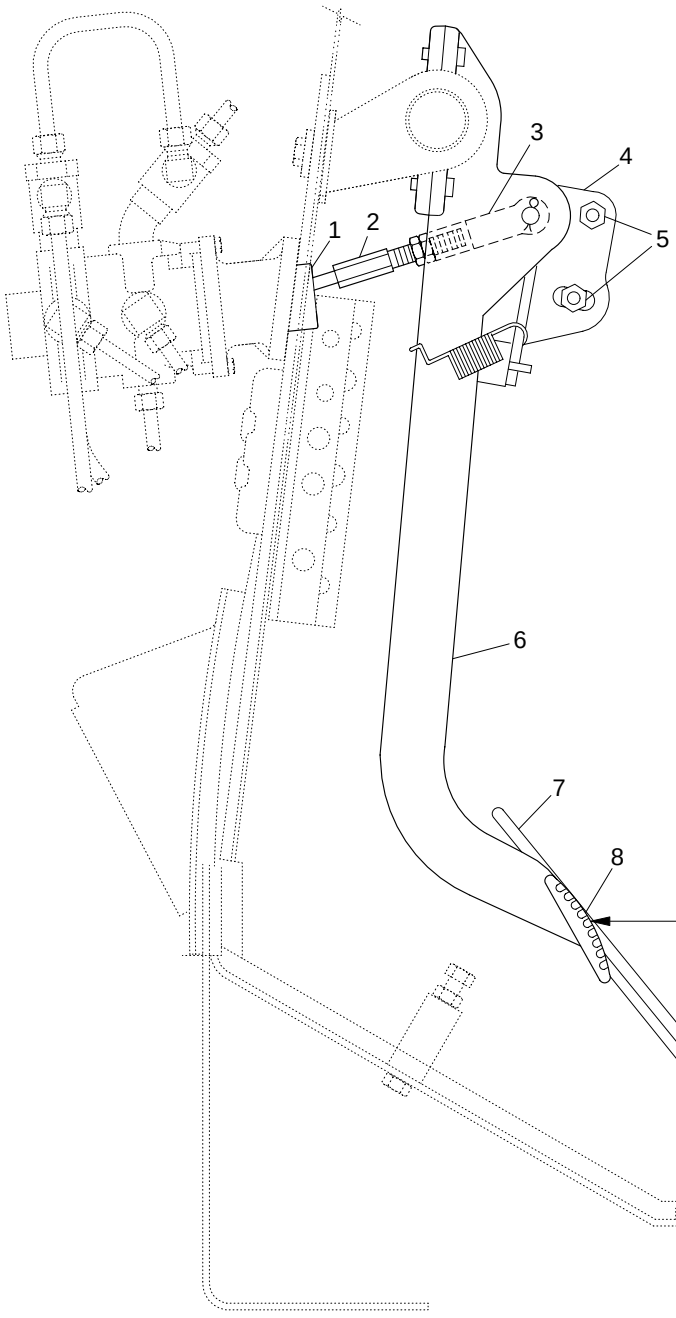
4.6 Check the adaptor gasket (**Fig. 2**, Ref. 5), and replace it if damaged. Install the brake valve and mounting adaptor on the outside of the front cab mount plate (Ref. 6), while mak-ing sure the forward end of the brake pedal push rod (Ref. 9) enters the plunger (Ref. 8). Install both 3/8–16 adaptor mounting capscrews and flat-washers (Ref. 4), and tighten the cap-screws 23 lbf·ft (31 N·m).

4.7 Connect the air lines, as previously marked. Tighten the nuts finger-tight. Us-ing a wrench, further tighten the nuts until there is resistance, then tighten one-sixth additional turn.

IMPORTANT: In the following substep, be sure the push rod and plunger aren't "pre-loading" the brake valve, which could keep the brake valve from exhausting.

4.8 Inside the cab, push the plunger into the mounting adaptor until increased resis-tance is felt. Using your fingers, turn the push rod out of the clevis (**Fig. 2**, Ref. 11) until it bottoms in the plunger without pushing the plunger further.

Check the pedal for freeplay. There should be no pedal freeplay and no brake valve preloading. Use a wrench to hold the push rod to keep it from turning, then tighten the double jam nuts (Ref. 10) against the clevis 15 lbf·ft (20 N·m).



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A. Front face of brake pedal pad must be flush with or slightly higher (1/4 inch [3.2 mm]) than the front face of throttle pedal.

1. Plunger
2. Brake Pedal Push Rod
3. Push Rod Clevis
4. Pedal Stop Bracket
5. Stop Bracket Fasteners
6. Brake Pedal Assembly
7. Throttle Pedal
8. Brake Pedal Pad

Fig. 5

Removal and Installation

4.9 Check and secure the air lines and electrical wires so they can't interfere with the movement of the brake pedal or push rod.

4.10 Install the lower steering column cover panel. **See Fig. 4.**

5. Return the cab or hood to the operating position. For instructions, refer to the vehicle driver's manual.
6. Perform the operating and leakage checks. For instructions, refer to **Subject 100.**
7. Remove the chocks from the tires.
8. Test drive the vehicle in a safe area at low speed. Make several brake applications to be sure the vehicle comes to a safe stop.

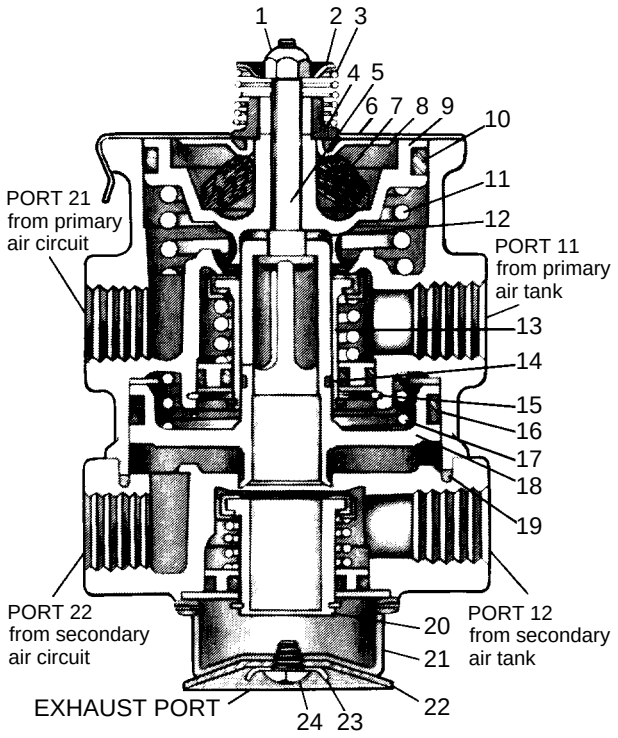
Disassembly (See Fig. 1)

1. Remove the screw (Ref. 24) that attaches the exhaust diaphragm (Ref. 22) and washer (Ref. 23) to the exhaust cover (Ref. 21).
2. Remove the four screws that attach the exhaust cover to the lower valve body.
3. Remove the lower inlet and exhaust valve assembly (Ref. 20).
4. Remove the four hexhead capscrews and washers that attach the lower and upper valve bodies. Separate the valve bodies.
5. Remove the rubber seal ring (Ref. 19) from the lower valve body.
6. Apply thumb pressure to the primary piston, then lift out and up on the three lock tabs of the primary piston retainer (Ref. 6).

⚠ WARNING

WARNING: The locknut and spring seat are used to restrain the primary piston return spring, stem spring, and the relay piston spring. The combined force of these springs is about 50 pounds (220 N). When removing these springs, use care to prevent them from flying out and possibly causing personal injury. Manually or mechanically hold down these springs when removing the locknut.

7. Using a 3/8-inch wrench, hold the locknut (Ref. 1) on the threaded end of the primary piston stem (Ref. 5). Insert a screwdriver in the exhaust passage through the center of the valve, and engage the slotted head of the stem.
8. Using the screwdriver to keep the stem from turning, remove the locknut, spring seat (Ref. 2), and the stem spring (Ref. 3).
9. Being careful to avoid damaging the valve seats, remove the relay piston (Ref. 18), relay piston spring (Ref. 17), and the primary piston and primary piston return spring (Refs. 9 and 11).
10. Remove the small washer (Ref. 12) from the cavity in the lower side of the primary piston.
11. Turn the spring seat nut (Ref. 4) counterclockwise, and separate the spring seat nut, spring



1. Locknut
2. Spring Seat
3. Stem Spring
4. Spring Seat Nut
5. Primary Piston Stem
6. Primary Piston Retainer
7. Rubber Spring
8. Spring Seat
9. Primary Piston
10. Primary Piston O−Ring
11. Primary Piston Return Spring
12. Small Washer
13. Upper Inlet and Exhaust Valve Assembly
14. Small O−Ring
15. Retaining Ring
16. Large O−Ring
17. Relay Piston Spring (if equipped)
18. Relay Piston
19. Rubber Seal Ring
20. Lower Inlet and Exhaust Valve Assembly
21. Exhaust Cover
22. Exhaust Diaphragm
23. Washer
24. Phillips Head Screw

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Fig. 1, Bendix E-6 Dual Circuit Foot Valve (sectional view)

Disassembly, Cleaning and Inspecting, and Assembly

seat (Ref. 8), and the rubber spring (Ref. 7). Remove the primary piston O-ring (Ref. 10).

12. Remove the small and large O-rings (Refs. 14 and 16) from the relay piston (Ref. 18).
13. Remove the retaining ring (Ref. 15). Remove the upper inlet and exhaust valve assembly (Ref. 13).

Cleaning and Inspecting

Wash all metal parts in mineral spirits and dry them thoroughly with compressed air. Inspect the valve seat surfaces of the pistons and the valve housings for conditions that could cause leakage. Inspect air line fittings for corrosion, and replace corroded fittings.

Assembly (See Fig. 1)

NOTE: Keep the work area, tools, and brake valve parts clean during assembly.

1. Using Dow Corning 55-M pneumatic grease, or equivalent, lightly grease all the new O-rings, O-ring grooves, piston bores, and all sliding surfaces.
2. Place the upper inlet and exhaust assembly (Ref. 13) in the upper body, and secure the assembly with the retaining ring (Ref. 15). Make sure that the retaining ring is seated in its groove.
3. Install the large and small O-rings (Refs. 16 and 14) on the relay piston (Ref. 18).
4. Install the primary piston O-ring (Ref. 10) in the piston O-ring groove.
5. Install the rubber spring (Ref. 7), concave side down, in the primary piston (Ref. 9). Place the spring seat (Ref. 8), flat side up, over the rubber spring.
6. Install the spring seat nut (Ref. 4) and turn the nut clockwise until the top surface of the spring seat is even with the top surface of the piston. Set this assembly aside.
7. Place the relay piston spring (Ref. 17), if equipped, in the concave portion of the relay piston. Install the relay piston through the upper inlet and exhaust assembly (Ref. 13), and into the underside of the upper valve body.
8. Place a screwdriver (blade up) in a vise. Place the primary piston stem (Ref. 5) in the relay piston. Position the upper valve body over the screwdriver blade, with the blade engaged in the slotted head of the piston stem.
9. Place the small washer (Ref. 12) over the stem.
10. Install the primary piston return spring (Ref. 11) in the upper valve body piston bore.
11. Install the primary piston and rubber spring assembly (assembled in steps 5 and 6) over the stem, and into the upper valve body piston bore.

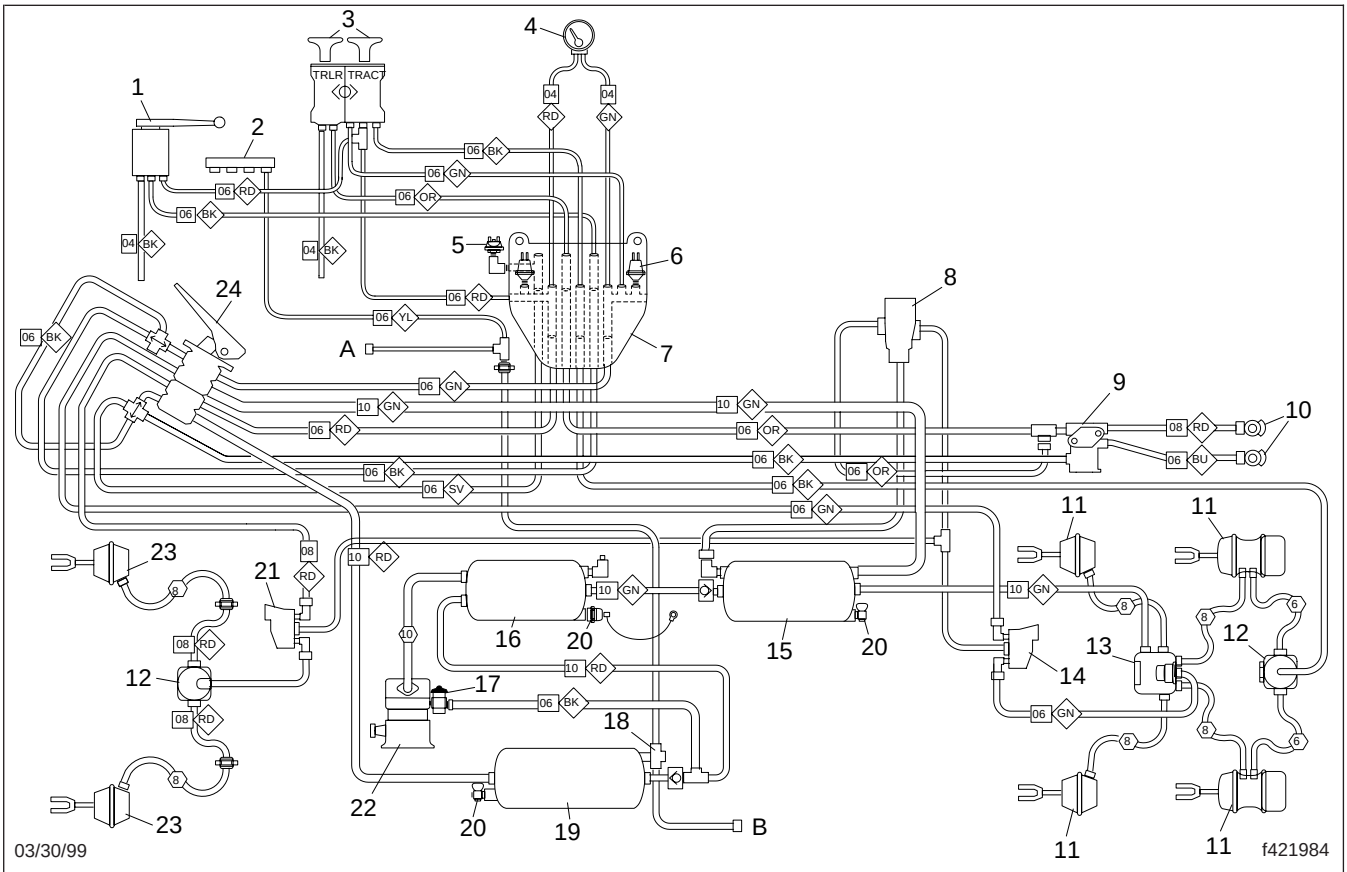
⚠ WARNING

WARNING: The locknut and spring seat are used to restrain the primary piston return spring, stem spring, and the relay piston spring. The combined force of these springs is about 50 pounds (222 N). When installing these springs, use care to prevent them from flying out and possibly causing personal injury. Manually or mechanically hold down these springs when installing the locknut.

12. Push down and hold the primary and relay pistons in the upper valve body.
13. Place the stem spring (Ref. 3) over the spring seat nut (Ref. 4). Place the spring seat over the stem.
14. Install the locknut (Ref. 1) on the stem. Tighten the locknut 20 to 30 lbf·in (220 to 340 N·cm).
15. Install the primary piston retainer (Ref. 6) over the piston. Make sure that all three lock tabs have engaged the outer lip of the valve body.
16. Install the rubber seal ring (Ref. 19) in the lower valve body.
17. Attach the lower and upper valve bodies. Install the four hexhead capscrews and washers. Tighten the capscrews 11 lbf·ft (15 N·m).
18. Install the lower inlet and exhaust valve assembly (Ref. 20).
19. Install the four screws that attach the exhaust cover to the lower valve body.
20. Install the screw that attaches the exhaust diaphragm and washer to the exhaust cover.

21. Install the brake valve. For instructions, refer to **Subject 110**.

General Description and Principles of Operation (See Fig. 1)



A. To the air horn and air seat
B. To the transmission

1. Trailer Hand Valve
2. Dash Junction
3. Dash Valve
4. Air Gauge
5. Stop Lamp Switch
6. Low Air Switch
7. Cab Junction Block
8. TR–3 Inversion Valve
9. Tractor Protection
10. Trailer Air Connectors
11. Rear Brake Chambers
12. Quick-Release Valve
13. Relay valve
14. Rear Proportioning Valve
15. Primary Air Tank
16. Supply Air Tank
17. Governor
18. Pressure Protection
19. Secondary Air Tank
20. Drain Valve
21. Front Proportioning Valve
22. Air Compressor
23. Front Brake Chambers
24. Foot Valve

Fig. 1, Air Brake Proportioning System

The automatic brake proportioning system improves vehicle control during braking, and reduces the stopping distance of bobtail tractors. Braking improvement depends on vehicle type, brake sizing, and road conditions.

The BP-1 front and BP-1 rear proportioning valves react to pressure, and the lack of pressure, in the trailer supply line. When the trailer line is charged (trailer connected) the braking pressure is limited at the front axle and full at the rear. When the trailer line is not charged (no trailer) the braking pressure at the rear axle(s) is reduced while the braking effort on the front axle of tractors operating in the bobtail mode is 100 percent.

The front and rear valves are mounted inside the left-hand frame rail. The front BP-1 valve replaces the

front axle limiting valve, and is located between the foot valve and the front axle. The rear valve is located between the foot valve and the rear axle.

The TR-3 inversion valve senses pressure from the trailer emergency line and sends the appropriate signal to the proportioning valves. It has four ports: a delivery, control, supply, and exhaust. The exhaust port is protected by a diaphragm.

The inversion valve is mounted inside the left-hand frame rail between the foot valve and the relay valve.

A control line from the inversion valve is connected by a tee to the inlet supply port of the tractor protection valve. This control line is charged with full line pressure when a trailer is connected and its spring brakes are released; or is completely exhausted when the tractor is bobtailed and the dash valve trailer charge knob is not applied.

The rear brake proportioning system is standard on the COE setback axle. The front and rear brake proportioning system is optional on all other vehicles. However, the system is not compatible on vehicles with wedge brakes or a WABCO antilock brake system.

TRAILER SUPPLY VALVE APPLIED (TRACTOR/TRAILER MODE)

The control port of the inversion valve senses air pressure and shuts off the constant supply air to the delivery port.

On vehicles equipped with a rear proportioning system, the lack of air pressure at the rear proportioning valve allows full service air pressure from the foot valve to pass through the proportioning valve to the relay valve. This gives full braking effort to the rear axle(s) when a trailer is connected.

On vehicles equipped with a front proportioning system, the front axle will receive 50 percent of the service brake application pressure up to 40 psi (276 kPa). The application pressures will become equal on the front and rear axle(s) as service brake application approaches 60 psi (414 kPa). The delivery port of the front valve provides full service air pressure 60 psi (414 kPa) and above, whether a trailer is connected or not.

TRAILER SUPPLY VALVE PULLED OUT (BOBTAIL MODE)

The control port of the inversion valve senses no air pressure and allows full supply pressure to the delivery port.

On vehicles equipped with a rear proportioning system, this full pressure at the control port of the proportioning valve signals the valve to reduce service air pressure from the foot valve to the relay valve by about 25 percent. This reduces braking effort on the rear axle(s) when a trailer is not used, which allows increased braking effort on the front axle.

On vehicles equipped with a front proportioning system, the control port of the front valve senses full air pressure and allows full service air pressure to pass to the brake valves.

IMPORTANT: Air pressure to the control port of a BP-1 front valve allows full air pressure to pass through the valve. Air pressure to the control port of a BP-1 rear valve restricts air pressure passing through the valve. Front and rear BP-1 proportioning valves are not interchangeable.

Safety Precautions

⚠ WARNING

WARNING: When draining the air system, don't look into the air jets or direct them toward another person, as dirt or sludge particles may be in the airstream. Don't disconnect pressurized hoses because they may whip as air escapes from the line. Failure to take all necessary precautions during service operations of the air brake system can cause personal injury.

When working on or around air brake systems and components, observe the following precautions.

1. Apply the parking brakes, chock the tires, and stop the engine when working under the vehicle. Draining the air system may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters, which may apply as air system pressure drops.
2. Wear safety goggles.
3. Never connect or disconnect a hose or line containing air under pressure; it may whip as air escapes. Never remove a component or pipe plug unless you are sure all system pressure has been depleted.
4. Don't disassemble a component before reading and understanding recommended procedures. Use only the correct tools and follow basic tool safety.
5. Replacement hardware, tubing, hose, fittings, etc. should be the same size, type, length, and strength as the original equipment. When replacing tubing or hose, be sure that all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace any components that have stripped threads or damaged parts. Don't attempt to repair parts by machining.
7. Never exceed recommended air pressure.

BP-1 Front or Rear Proportioning Valve

1. Park the vehicle on a level surface and chock the tires.
2. With the trailer supply valve pulled out (bobtail running position), install two air gauges in the service brake system: one at a front axle brake chamber and one at a rear axle brake chamber.
3. Build up the air system pressure until it reaches the air compressor governor cut-out setting.
4. Have a co-worker apply the service brake foot valve, while you watch the gauges. When the front axle gauge reaches 40 psi (276 kPa), the rear gauge should read 10 to 20 psi (70 to 138 kPa), depending on the rear axle relay valve differential. The difference in pressures between the front and rear axle(s) should decrease as the brake application pressure is increased.

   Connect the trailer and push in the trailer supply valve (applied position). Then have a co-worker apply the service brake foot valve, while you watch the gauges. When the front axle gauge reads 20 psi (138 kPa), the rear axle gauge should read about 40 psi (276 kPa) for a system with both front and rear BP-1 valves, otherwise the rear axle gauge should read 20 to 25 psi (138 to 172 kPa). The difference in pressures between the front and rear axle(s) should decrease as the brake application pressure is increased.

   If the pressures on the gauges don't match the pressures specified above, find the cause of the problem. **Refer to "Troubleshooting, 300"** for more information.
5. Remove the test gauges from the service brake system.
6. Remove the chocks from the tires. Test drive the vehicle in a safe area at slow speed with the trailer supply valve pulled out (bobtail position). Make several brake applications to become familiar with the feel of the system before placing the vehicle back in service.

TR-3 Inversion Valve Operating and Leakage Tests

1. Park the vehicle on a level surface and chock the tires.
2. Tee two pressure gauges in the brake system: one in a common control and supply line and one in the delivery port.
3. With the red dash knob pushed in and pressure coming to the control port from the trailer supply line, the valve should close. There should be 0 psi (0 kPa) at the delivery port.
4. With air pressure in the supply and control ports, apply a soap-water solution around the supply port capnut. If leakage exceeds a 1-inch (25-mm) soap bubble within three seconds, replace the O-ring.

   Check for leakage. If leakage continues to exceed the 1-inch bubble limit, replace the valve.
5. Exhaust the line coming into the control port by pulling out the red dash knob in the cab. The pressure gauge at the delivery port should be the same pressure as is being fed the valve at the supply port.
6. Replace the valve if pressures are not at the rates specified above.
7. Remove the test gauges from the brake system.
8. Remove the chocks from the tires. Test drive the vehicle in a safe area at slow speed with the trailer supply valve pulled out (bobtail position). Make several brake applications to become familiar with the feel of the system before placing the vehicle back in service.

BP-1 Brake Proportioning Valve Removal and Installation

Removal (See Fig. 1)

1. Park the vehicle on a level surface, apply the parking brakes, chock the tires, and drain all air tanks to 0 psi (0 kPa).

⚠ WARNING

WARNING: When draining the system, don't look into the air jets or direct them toward another person, as dirt or sludge particles may be in the airstream. Don't disconnect pressurized hoses because they may whip as air escapes from the line. Failure to take all necessary precautions during service operations of the air brake system can cause personal injury.

2. Identify (mark) and disconnect the three air lines from the valve.
3. Remove the two bolts attaching the valve to the vehicle. Remove the valve.

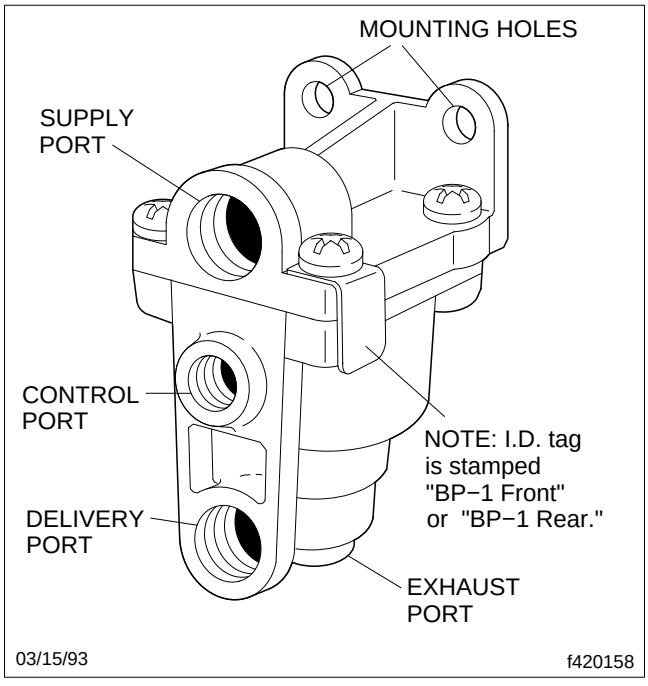


Fig. 1, BP-1 (Front/Rear) Proportioning Valve

Installation

IMPORTANT: The front and rear BP-1 valves are not interchangeable. They are identified with a metal tag stamped "BP-1 Front" or "BP-1 Rear." The tag is attached to one of the cap-screws on the cover.

1. Install the valve on the vehicle using the mounting bolts previously removed. Tighten the bolts 15 lbf·ft (20 N·m).
2. Connect the three air lines to the proper ports as marked during removal.
3. Check the proportioning valve operation using the instructions in **Subject 110**.

TR-3 Inversion Valve Removal and Installation

Removal (See Fig. 1)

1. Park the vehicle on a level surface, apply the parking brakes, chock the tires, and drain all air tanks to 0 psi (0 kPa).

⚠ WARNING

WARNING: When draining the system, don't look into the air jets or direct them toward another person, as dirt or sludge particles may be in the airstream. Don't disconnect pressurized hoses because they may whip as air escapes from the line. Failure to take all necessary precautions during service operations of the air brake system can cause personal injury.

2. Identify (mark) and disconnect the three air lines from the inversion valve.
3. Remove the two bolts attaching the valve to the vehicle. Remove the valve.

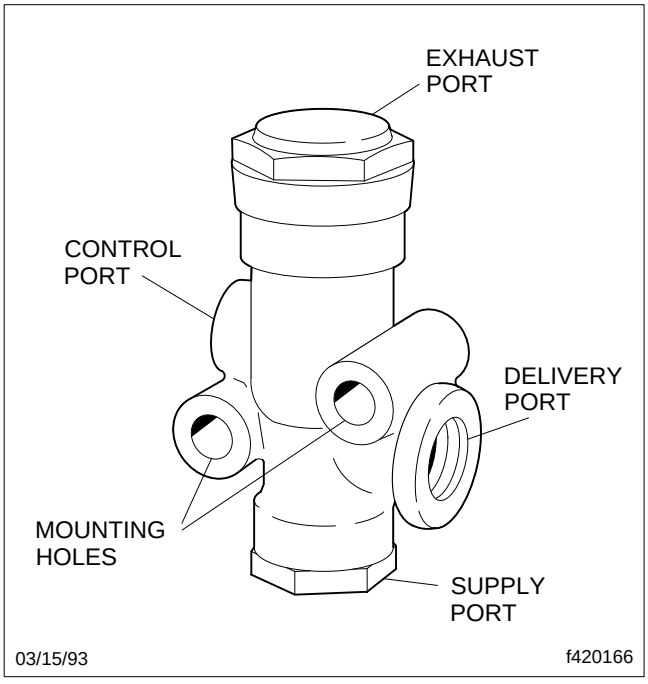


Fig. 1, TR-3 Inversion Valve

Installation

1. Install the valve on the vehicle using the mounting bolts previously removed. Tighten the bolts 15 lbf·ft (20 N·m).
2. Connect the three air lines to the proper ports as marked during removal.
3. Check the inversion valve operation using the instructions in **Subject 120**.

BP-1 Brake Proportioning Valve Disassembly and Cleaning, Inspecting, and Assembly

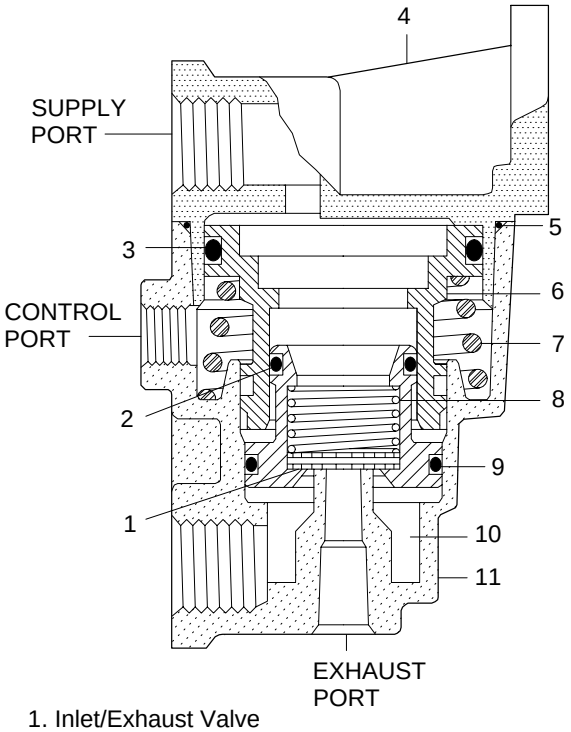
Disassembly

BP-1 FRONT PROPORTIONING VALVE (See Fig. 1)

1. Holding the cover down against the spring, remove the four Sems screws from the cover. Slowly release it after the screws are removed.

   Keep the screws and the metal tag with "BP-1 Front" stamped on it.

2. Separate the cover (Ref. 4) from the body (Ref. 11). Remove and discard the cover O-ring (Ref. 5).



1. Inlet/Exhaust Valve
2. Valve O−Ring
3. Upper Piston O−Ring
4. Cover
5. Cover O−Ring
6. Upper Piston
7. Piston Spring
8. Valve Spring
9. Lower Piston O−Ring
10. Lower Piston
11. Body

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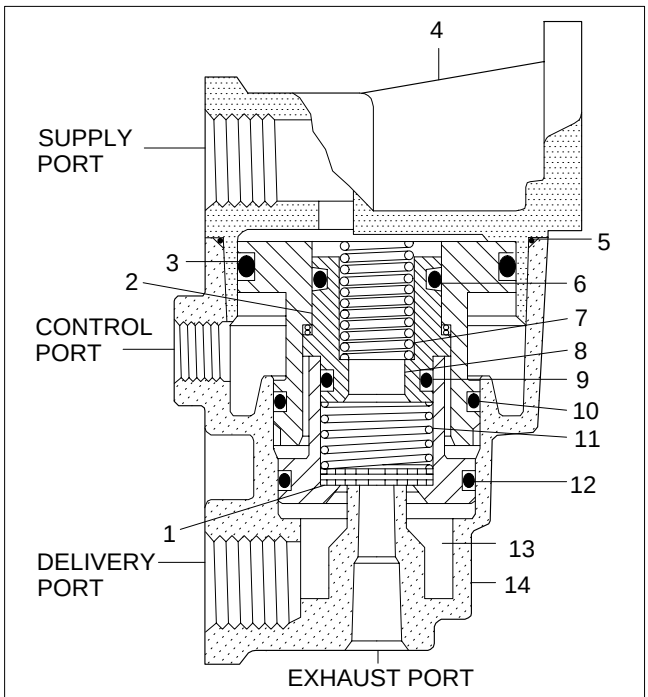
Fig. 1, BP-1Front Proportioning Valve (sectional view)

3. Remove the upper piston (Ref. 6) from the cover. Remove the piston spring (Ref. 7) and the lower piston (Ref. 10) from the body.
4. With a pair of needle nose pliers, grasp the end of the valve spring (Ref. 8) inside the lower piston. To remove, pull and turn the spring clockwise.
5. Remove the inlet/exhaust valve (Ref. 1) from the lower piston.
6. Remove the O-rings from the pistons.

BP-1 REAR PROPORTIONING VALVE (See Fig. 2)

1. Holding the cover down against the spring, remove the four Sems screws from the cover. Slowly release it after the screws are removed.

   Keep the screws and the metal tag with "BP-1 Rear" stamped on it.



1. Inlet/Exhaust Valve
2. Upper Piston
3. Upper Piston O−Ring
4. Cover
5. Cover O−Ring
6. Inner Piston O−Ring
7. Piston Spring
8. Inner Piston
9. O−Ring
10. O−Ring
11. Valve Spring
12. Lower Piston O−Ring
13. Lower Piston
14. Body

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Fig. 2, BP-1 Rear Proportioning Valve (sectional view)

BP-1 Brake Proportioning Valve Disassembly and Cleaning, Inspecting, and Assembly

2. Separate the cover (Ref. 4) from the body (Ref. 14). Remove and discard the cover O-ring (Ref. 5).
3. Remove the inner piston spring (Ref. 7). Remove the upper piston (Ref. 2) from the body. Push the inner piston (Ref. 8) out of the center of the upper piston.
4. Remove the lower piston (Ref. 13) from the body of the valve. Tip the piston over to remove the valve spring (Ref. 11) and the inlet/exhaust valve (Ref. 1).
5. Remove the O-rings from the pistons.

Cleaning, Inspecting, and Assembly

BP-1 FRONT PROPORTIONING VALVE (See Fig. 1)

WARNING

WARNING: Mineral spirits are toxic, can cause severe skin irritation, and may be a fire hazard. When using mineral spirits, follow the safety precautions recommended by the mineral spirits manufacturer.

1. Clean the exterior of the valve with mineral spirits, taking care to prevent contaminants from entering the open ports of the valve.
2. Wipe the interior of the cover, body, and pistons with a clean dry cloth to remove any contaminants.
3. Replace all rubber parts.
4. Inspect all components for cracks, scoring, or damage of any kind. If any of these conditions exist, replace the valve.
5. Lightly coat the bore surfaces of the cover, body, and upper piston with silicone lubricant.
6. Lubricate the four O-rings with silicone lubricant. Install the O-rings.
7. Install the large end of the upper piston into the bore of the cover of the valve.
8. Place the inlet/exhaust valve (Ref. 1) inside the lower piston (Ref. 10) and hold in place with the valve spring. Use needle nose pliers to install the spring (Ref. 8). Grasp the spring on the bar that intersects the end of the spring, and twist it clockwise while pressing down.

IMPORTANT: Be sure the inlet/exhaust valve is seated flat against the bottom of the piston, and the spring is fully seated below the step on the inside of the piston wall.

9. Install the lower piston assembly into the body of the valve (large end to enter the bore first).
10. Install the piston spring into the body of the valve (large diameter of the spring to enter first).
11. Place the cover and upper piston onto the body so that the supply port is directly above the control port. Place the valve on a hard surface and compress the spring by pushing down on the cover. Hold it in this position and install two of the four 1/4-inch capscrews.
12. Place the metal tag stamped "BP-1 Front" onto one of the remaining 1/4-inch capscrews. Install the remaining screws and tighten all of the screws 50 to 80 lbf·ft (68 to 108 N·m).

BP-1 REAR PROPORTIONING VALVE (See Fig. 2)

WARNING

WARNING: Mineral spirits are toxic, can cause severe skin irritation, and may be a fire hazard. When using mineral spirits, follow the safety precautions recommended by the mineral spirits manufacturer.

1. Clean the exterior of the valve with mineral spirits, taking care to prevent contaminants from entering the open ports of the valve.
2. Wipe the interior of the cover, body, and pistons with a clean dry cloth to remove any contaminants.
3. Replace all rubber parts.
4. Inspect all components for cracks, scoring, or damage of any kind. If any of these conditions exist, replace the valve.
5. Lightly coat the bore surfaces of the cover, body, and upper piston with silicone lubricant.

BP-1 Brake Proportioning Valve Disassembly and Cleaning, Inspecting, and Assembly

6. Lubricate the six O-rings with silicone lubricant. Install the O-rings.
7. Install the inlet/exhaust valve into the bore of the lower piston. Place the spring (Ref. 11) on top of the inlet/exhaust valve.
8. Install the inner piston into the bore of the upper piston. Place the lower piston into the bottom of the upper piston.
9. Place the piston assemblies into the body of the valve. Install the spring (Ref. 7) in the inner piston.
10. Install the cover, with the O-ring in place, on the body, with the supply port directly above the control port.
11. Place the metal tag stamped "BP-1 Rear" onto one of the capscrews. Install and tighten the screws 50 to 80 lbf·ft (68 to 108 N·m).

TR-3 Inversion Valve Disassembly and Cleaning, Inspecting, and Assembly

Disassembly (See Fig. 1)

1. Remove the exhaust port capnut (Ref. 2) and the O-ring (Ref. 3).
2. Remove the diaphragm (Ref. 1) and the diaphragm retainer (Ref. 4).

⚠ WARNING

WARNING: The piston is retained by a spring that is under compression. When removing the spring, use care to prevent it from flying out and possibly causing personal injury.

3. Remove the piston spring (Ref. 5) and the shim(s) (Ref. 7).
4. Remove the piston (Ref. 15) from the body (Ref. 14).
5. Remove the piston O-ring (Ref. 6) and the exhaust stem O-ring (Ref. 8).
6. Remove the supply port cap (Ref. 9) and the O-ring (Ref. 10).
7. Remove the valve stop (Ref. 11) and the valve spring (Ref. 12).
8. Remove the inlet/exhaust valve (Ref. 13).

Cleaning, Inspecting, and Assembly

⚠ WARNING

WARNING: Mineral spirits are toxic, can cause severe skin irritation, and may be a fire hazard. When using mineral spirits, follow the safety precautions recommended by the mineral spirits manufacturer.

1. Clean the exterior of the valve with mineral spirits, taking care to prevent contaminants from entering the open ports of the valve.
2. Wipe the interior of the cover, body, and pistons with a clean dry cloth to remove any contaminants.
3. Replace all rubber parts.
4. Inspect all components for cracks, scoring, or damage of any kind. Replace the valve if damaged.

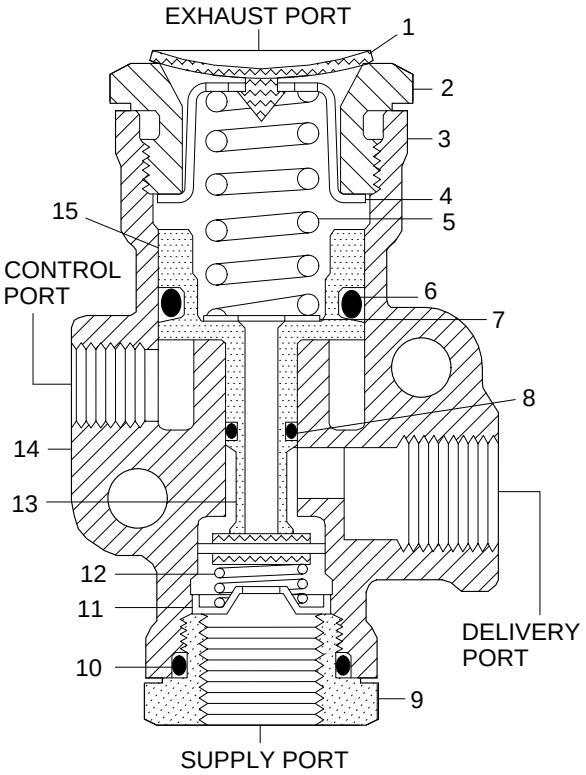


Fig. 1, TR-3 Inversion Valve (sectional view)

5. Lightly coat the bore surfaces of the body, piston, and O-rings with silicone lubricant.
6. Install the inlet/exhaust valve in the body.
7. Install the inlet valve spring and center the valve stop on the spring.
8. Install the O-ring on the supply capnut. Install and tighten the capnut 100 lbf·in (1120 N·cm).
9. Install the exhaust stem O-ring on the piston. Install the piston in the body.

TR-3 Inversion Valve Disassembly and Cleaning, Inspecting, and Assembly

10. Install the shim washer(s).
11. Install the piston spring.
12. Install the diaphragm retainer and the exhaust diaphragm.
13. Install the O-ring on the exhaust capnut. Install and tighten the capnut 275 lbf·in (3100 N·cm).

Troubleshooting

This troubleshooting guide will help if the problem exists in the proportioning or inversion valves. Before testing the air brake proportioning system, do the following:

1. Check the operation of the air compressor. Refer to the engine manufacturer's service manual.

   Check the pressure levels of the air reservoirs, following the instructions in the brake system chapter in the vehicle driver's manual.

2. Be sure that all relay valves are operating. Refer elsewhere in this section for instructions.
3. Check the operation of the brake chambers following the instructions in the brake section in the vehicle maintenance manual.
4. Inspect all tubing for kinks, dents, and other damage. Replace damaged tubing.
5. Inspect all hoses for cracks, drying out, overheating, and other damage. Replace damaged hoses.
6. Inspect all air line fittings. Tighten loose connections; replace fittings that are damaged.

BP-1 FRONT OR REAR PROPORTIONING VALVE

Install a tee and a pressure gauge in each delivery and each control port. Air pressure will enter the proportioning valve at the control port when the inversion valve is open, allowing pressure through.

Starting at 4 psi (28 kPa), note the pressure at which the valve begins to operate. Check readings at the delivery port every 2 or 3 psi (14 or 21 kPa). Zero to 20 psi (0 to 138 kPa) is the average braking range for the vehicle. Continue to check readings between 20 and 40 psi (138 and 276 kPa). The delivery port should read about half the pressure being applied through the control port, on the front BP-1 valve and about one-quarter on the rear BP-1 valve.

Replace the valve if pressures do not match the pressures specified above.

TR-3 INVERSION VALVE

Install a tee and a pressure gauge into the delivery port. With pressure coming to the control port from the trailer supply line, the valve should close if it's functioning properly. There should be a 0 psi (0 kPa) reading at the delivery port.

Exhaust the line coming into the control port by releasing the red dash knob in the cab. The pressure gauge at the delivery port should now register the same pressure as is being fed to the valve at the supply port.

Replace the valve if pressures do not match the pressures specified above.

General Information

This troubleshooting guide is designed to help locate causes of problems originating in the air brake system. The corrective measures given are not intended to replace the detailed service information found in other sections of this manual or in the component manufacturer's service manuals. If the vehicle is equipped with ABS (antilock brake system), refer to the brake section in this manual for troubleshooting the ABS system.

Before attempting to isolate the causes of an air brake system problem, do the following:

1. Check the operation of the air compressor. Refer to the engine manufacturer's service manual.

   Check the pressure levels of the air reservoirs. Refer to the brake system chapter in the vehicle driver's manual.
2. Be sure that all relay valves are operating. Refer to the brake section in the vehicle maintenance manual.
3. Check the operation of the brake chambers as instructed in the brake section in the vehicle maintenance manual.
4. Examine all tubing for kinks, dents, and other damage. Replace damaged tubing.
5. Examine all hoses for cracks, drying out, overheating, and other damage. Replace damaged hoses.
6. Examine all air line fittings. Tighten loose connections; replace fittings that are damaged. For instructions, refer elsewhere in this group.
7. Examine leaking pipe connections for cracks or thread damage; replace as needed. If there is no damage, retighten the fitting. For instructions, refer elsewhere in this group.

Safety Precautions

Compression and storage of air in the air brake system is comparable to the energy in a coiled spring: when released, it may present a hazard. Because of this, certain precautions are required:

1. Chock the tires. This will prevent accidental rolling of the vehicle when air is released from the brake system.
2. Don't disconnect pressurized hoses because they will whip as air escapes from the line. Drain the air system before disconnecting the air hoses.
3. When draining the air system, do not look into the air jets or direct them toward another person: dirt particles or sludge may be carried in the air stream.
4. As air pressure is drained and the parking/ emergency brakes apply, keep your hands away from the brake chamber push rods and parking brake chambers, which will activate automatically with the loss of pressure. This also applies to the service brake system.

⚠ WARNING

WARNING: Follow the manufacturer's procedures while working on any air device so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion. Failure to take all necessary precautions during servicing of the air brake system can result in personal injury.

Troubleshooting Tables

Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied

Possible Cause	Remedy
The vehicle is overloaded.	Observe the recommended maximum load limits.
There is low air pressure in the brake system, about 60 psi (413 kPa) or lower.	The drain cock on the air reservoir was left open; close the drain cock.
	Check the compressor output pressure; correct as necessary.
	Check the setting of the air governor with an accurate test gauge. Adjust the air governor to the recommended specification.
The application air lines are leaking excessively.	Check the application air line, brake valve, and the service and parking brake chambers for air leaks. Repair or replace the damaged component(s).
Brake valve delivery pressure is below normal.	Lubricate the brake valve parts; overhaul the unit, if necessary.
Wear or glazing of the brake linings is present.	Install new brake linings on the brake shoes on both sides of the axle.
Adjustment or lubrication of the brakes is needed.	Adjust or lubricate the brakes.
The automatic slack adjusters (if so equipped) are not operating.	Lubricate the automatic slack adjusters and check for binding,damaged, or inoperative slack adjuster parts. Replace damaged or inoperative parts, or eliminate the cause of the binding.
The cam has flipped over.	Replace the linings and the cam on each end of the axle.
Flat spots or dents on the roller surface were caused by skidding of the roller or improper handling of the wheel bearing during installation.	Clean, then inspect the bearing rollers. Replace the bearing if damaged. Ensure that the bearings to be installed are sufficiently lubricated as outlined in the front and rear axle sections in the vehicle maintenance manual.
One or more of the brake drums is broken or cracked.	Replace the brake drum(s).
Wrong size brake linings were installed.	Replace the brake linings with the recommended size.
Wrong size brake chambers were installed.	Replace the brake chambers with the recommended size.
A camshaft bracket or chamber mounting bracket is bent or broken.	Replace the camshaft bracket or chamber mounting bracket.
The brake chamber mounting stud nuts or brake chamber mounting bracket is loose.	Tighten the brake chamber to its mounting bracket or the mounting bracket to the foundation brake housing.
There is a ruptured diaphragm in the service brake.	Replace the diaphragm.

Problem—Service Brakes Release Too Slowly

Possible Cause	Remedy
The brake shoe anchor pins are frozen.	Inspect the anchor pins. If damaged, replace them; if not damaged, lubricate them.
Lubrication of the brake system components is inadequate.	Lubricate those components requiring periodic lubrication.

Troubleshooting

Possible Cause	Remedy
The brake foot valve push rod may be improperly adjusted.	Readjust the push rod and/or pedal stop bracket.
The brake foot valve is not returning to the fully released position.	Check for obstructions which might prevent the brake foot valve from returning to the fully released position. Remove any obstructions.
The exhaust port of the brake foot valve or quick-release valve is plugged.	Clear the exhaust port of obstructions.
The brake foot valve or quick-release valve is inoperative.	Overhaul or replace the inoperative valve, as needed.
The camshaft and bushings are binding.	Clean and lubricate the camshaft bushings.
The brake shoe return spring is weak or broken.	Replace the spring.
Flat spots or dents on the roller surface were caused by skidding of the roller or improper handling of the wheel bearing during installation.	Clean, then inspect the bearing rollers. Replace the bearing if damaged. Ensure that the bearings to be installed are sufficiently lubricated as outlined in the front and rear axle sections in the vehicle maintenance manual.

Problem—Service Brakes Do Not Apply or Apply Too Slowly

Possible Cause	Remedy
Lubrication of the foundation brake assembly is needed.	Lubricate those components requiring periodic lubrication.
There is insufficient air pressure in the brake system.	Check all parts of the air pressure system for leaks or inoperative components.
The brake foot valve or relay valve is inoperative.	Repair or replace the brake foot valve or relay valve.
The camshaft bushings are binding.	Clean and lubricate the camshaft bushings.

Problem—Service Brakes Apply When the Parking Brakes Are Released With Air Pressure

Possible Cause	Remedy
The air delivery lines to the brake chamber have been reversed.	Reverse the connections of the brake chamber air lines.
There is a leaking push rod seal between the parking brake and the service brake.	Replace the push rod seal.
The braking mechanism is binding.	Lubricate the brake mechanism and make sure all parts are aligned with each other and are securely fastened.
	Check for obstructions; remove any obstructions.

Problem—Service Brakes Do Not Release

Possible Cause	Remedy
The brake shoes are incorrectly adjusted.	Adjust the brakes. Also, make sure the slack adjuster is operating correctly. If not, overhaul or replace the slack adjuster.
The brake foot valve may not be in the fully released position.	Lubricate the brake foot valve if needed. Check the adjustment of the brake foot valve push rod (FLD only).

Possible Cause	Remedy
The brake foot valve is inoperative.	Overhaul or replace the brake foot valve.
There is restriction in the tubing, hose, or exhaust port of the brake foot valve or quick-release valve.	Check for bends or obstructions on the exhaust side of the service brakes. Remove any obstructions; plumb the air lines so that bends are minimal.
A broken power spring may be blocking the parking brake piston movement.	Replace the power spring or replace the parking brake assembly, whichever is recommended by the parking brake manufacturer.

Problem—Service Brakes Grab or Pull

Possible Cause	Remedy
There is not enough weight on the vehicle (underloaded).	Add weight to the vehicle, reducing brake sensitivity.
Adjustment of the brakes on one axle is uneven.	Adjust the brakes.
Lubrication of the brake system components is inadequate.	Lubricate those components requiring periodic lubrication.
The brake mechanism is binding.	Lubricate the brake mechanism and make sure all parts are aligned with each other and are securely fastened.
The clevis pin or camshaft is binding at one or more wheels.	Clean and lubricate the camshaft bushings.
A brake spider is loose.	Tighten the mounting bolts or replace the brake spider.
A slack adjuster is damaged.	Replace the damaged component.
The air chamber push rods or slack adjusters are a different length.	Replace the components with the correct size and material.
The brake foot valve is inoperative.	Overhaul or replace the brake foot valve, as needed.
If equipped with cam brakes, there is a flat or dent on the S-head camshaft or on the cam roller(s).	Replace the damaged component(s).
Grease has saturated the brake linings or the linings are glazed.	Install a matched set of linings on both sets of brake shoes on that axle. Clean, turn, or replace both brake drums. For instructions on turning drums, refer to the brake manufacturer's service manual.
The brake linings are loose or broken.	Install a matched set of linings on both sets of brake shoes on that axle.
The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed.	Install a new, matched set of brake linings. Clean, turn, or replace both brake drums on that axle. For instructions on turning drums, refer to the brake manufacturer's service manual.
A brake shoe is distorted or broken.	Replace the brake shoe. Install a new, matched set of linings on both sets of brake shoes on that axle.
The pilot pads are damaged, allowing the brake drum to be installed out-of-round.	Replace the wheel hub.
A brake drum is out-of-round to unacceptable limits.	Turn both the brake drums on that axle. If the maximum allowable diameter of either drum has been exceeded, replace that drum. For instructions on turning drums, refer to the brake manufacturer's service manual.
One or more brake drums is scored or broken.	Replace both of the drums on that axle.

Troubleshooting

Problem—Uneven Service Brakes

Possible Cause	Remedy
The wrong brake linings were installed, or the linings were not replaced in pairs.	Replace the brake linings with the recommended size. Install new linings on both sets of axle brake shoes.
Grease has saturated the brake linings or the linings are glazed.	Install new linings on both axle brake shoes. Clean the brake drums.
The return spring for the brake shoe release or the service brake has broken.	Replace all broken springs.
The brake drum is out-of-round to unacceptable limits.	Turn both the brake drums on that axle. If the maximum allowable diameter of either drum has been exceeded, replace that drum. For instructions on turning drums, refer to the brake manufacturer's service manual.
A service brake chamber diaphragm is leaking.	Tighten the clamp ring. If leaks persist, replace the service brake diaphragm.
The wheel bearings are out of adjustment.	Adjust the wheel bearings, or replace them if damaged. For instructions, refer to the front and rear axle sections in this manual.
A brake spider is damaged.	Replace the brake spider.
The brake shoes are bent or stretched.	Replace the axle brake shoes on each wheel.
Grease, oil, or dirt is on the linings.	Replace the linings on each set of axle brake shoes. Clean the brake drums.

Problem—Dragging Service Brake

Possible Cause	Remedy
The service brake return spring is broken.	Replace the service brake return spring.
The service-application air is not exhausting or not exhausting fast enough, due to blockage in the control valve, the quick-release valve, or the limiting and quick-release valve.	Test the air system valves for leakage and operation.
A brake shoe retracting spring is broken.	Replace the brake shoe retracting spring.
Binding is occurring in the camshaft linkage.	Lubricate the camshaft linkage. Replace bent or broken parts.

Problem—Insufficient Parking Brake Application When Dash Control Valve Is Activated

Possible Cause	Remedy
The parking brake is not set for full stroke.	Adjust the brakes.
There is a ruptured parking brake diaphragm or ineffective piston seal.	Replace the diaphragm or parking brake piston seal.
A power spring is broken.	Replace the power spring or replace the parking brake assembly, whichever is recommended by the parking brake manufacturer.
A power spring in a parking brake is manually caged.	Release the power spring by screwing in the release bolt.

Problem—Dragging Brakes Due to Parking Brake Mechanism

Possible Cause	Remedy
The system air pressure is insufficient to fully release the parking brake.	Be sure that all air lines are clear. Check that the air governor cutout settings meet recommended specifications.
A parking brake diaphragm is ruptured or a piston seal is ineffective.	Replace the diaphragm or parking brake piston seal.
There is a broken return spring in the parking brake (double-diaphragm type brake chambers only).	Replace the parking brake return spring.

Problem—Air Pressure Will Not Rise to Normal

Possible Cause	Remedy
The air pressure gauge(s) on the dash is (are) registering inaccurately.	Check the dash gauge with an accurate test gauge. Replace the dash gauge(s) as needed.
There is excessive leakage (not including the air compressor).	Check all valves, air lines, and connections for leakage. Repair or replace valves and lines until leakage is eliminated.
The compressor is inoperative (including excessive leakage of the compressor).	Rebuild or replace the compressor.
The air reservoir drain cock has been left open.	Close the drain cock.
The air governor cutout setting is not adjusted correctly.	Check the setting with an accurate test gauge, then adjust the air governor to the recommended specification.
There is inadequate clearance at the compressor unloading valve.	Repair or adjust the compressor at the unloading valve.
If so equipped, the compressor drive belt is slipping.	Adjust or replace the compressor drive belt.
Carbon is building up in the compressor cylinder head or discharge line.	Remove the carbon. If disassembly is not recommended by the compressor manufacturer, replace the air compressor with a factory rebuilt or a new unit.

Problem—Air Pressure Rises Above Normal

Possible Cause	Remedy
The air reservoir pressure dash gauge is inaccurate.	Check the dash gauge with an accurate test gauge. Replace the dash gauge, as needed.
The compressor air governor is out of adjustment.	Check the setting with an accurate test gauge, then adjust the air governor to the recommended specification.
The air governor is not operating.	Repair or replace the air governor.
There is too much clearance at the air compressor unloading valve.	Repair or adjust the compressor at the unloading valve.
The air compressor unloading valve is stuck closed.	
The air compressor unloading valve cavities or the unloading valve passage is blocked with carbon.	

Troubleshooting

Problem— Air Pressure Drops Quickly With the Engine Stopped and the Brakes Released

Possible Cause	Remedy
The brake foot valve is leaking.	Repair or replace the brake foot valve.
The air compressor discharge valve is leaking.	Repair or replace the discharge valve. If disassembly is not recommended by the compressor manufacturer, replace the air compressor with a factory-rebuilt or a new unit.
The air governor is leaking.	Repair or replace the air governor.

Problem—Air Pressure Drops Quickly With the Engine Stopped and the Brakes Fully Applied

Possible Cause	Remedy
A service or parking brake chamber is leaking.	Tighten the clamp ring(s). If leaks persist, replace the diaphragm(s) or assembly.
The brake foot valve or relay valve is leaking.	Repair or replace the component(s) or assembly.

Problem—Compressor Knocks (Continuously or Intermittently)

Possible Cause	Remedy
There is a loose drive pulley, belt, coupling, or gear (as indicated).	Tighten or replace the component. If applicable, inspect the pulley shaft for damage. Replace the shaft, if damaged.
Backlash is in the compressor drive gears on the drive coupling.	Repair or replace the compressor drive gears or drive coupling.
The air compressor bearings are damaged or worn.	Replace the bearings.
There are carbon deposits in the compressor cylinder head.	Remove the carbon deposits or replace the compressor.

Problem—Safety Valve Activates

Possible Cause	Remedy
The safety valve is out of adjustment.	Adjust the safety valve, or install a new one.
There is excessive air pressure in the brake system.	Refer to the problem "Air Pressure Rises Above Normal."
Draining of the air reservoirs needs to be performed more often.	Drain the air reservoirs daily.

Problem—Oil or Water in the Brake System

Possible Cause	Remedy
Excessive oil is passing through the air compressor.	Rebuild or replace the compressor.
If so equipped, the air compressor air strainer is dirty.	Clean the strainer or install a new one.

General Information

The DV-2 automatic reservoir drain valve (**Fig. 1**) automatically removes contaminants and water from the wet-air tank each time the brakes are applied. The drain valve is attached to a drain cock located on the bottom of either end of the wet-air tank. Since the brake application valve is protected by a check valve between the wet- and dry-air tanks, any leak or failure will not reduce the supply of air that is in the dry part of the system. If the leak is severe, it could prevent the continued resupply of air as it is used up when applying the brakes. A failed drain valve will allow moisture to build up in the wet tank which in turn could reach the dry tank, and then travel into the air brake system where it could cause brake failure. A leaking drain valve allows wet tank leakdown which in turn can cause premature wear on the air compressor during vehicle operation as the air compressor continues to run to maintain wet tank air pressure.

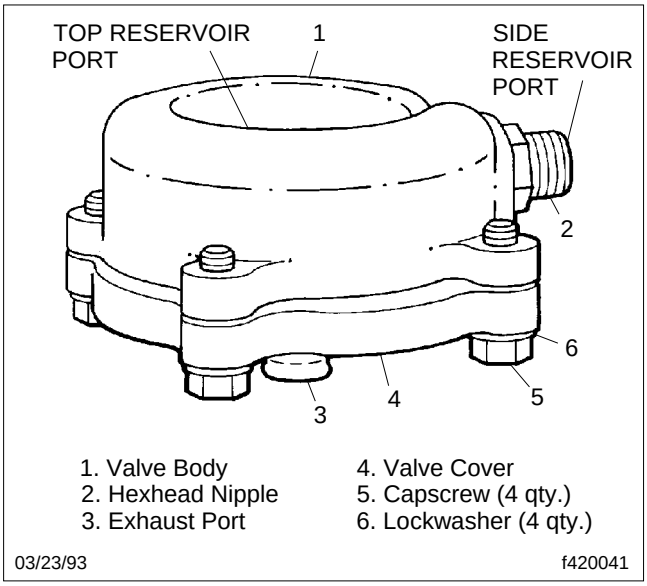


Fig. 1, DV-2 Valve

Principles of Operation

With no pressure in the system, the drain valve's inlet and exhaust valves are closed. **See Fig. 2.** Upon charging the system, a slight pressure opens the inlet valve which permits air and contaminants to collect in the sump. **See Fig. 3.** The inlet valve remains open when pressure is rising in the system until the air compressor cuts off, allowing the spring action of the valve guide in the sump cavity to close the inlet valve. The inlet valve and the exhaust valve are now both closed. **See Fig. 4.** When the wet tank pressure drops approximately 2 psi (14 kPa), the air pressure in the sump cavity opens the exhaust valve and allows moisture and contaminants to be ejected from the sump cavity until pressure in the sump cavity drops sufficiently to close the exhaust valve. **See Fig. 5.**

The length of time the exhaust valve remains open and the amount of moisture and contaminants ejected depends upon the sump pressure and the wet tank pressure drop that occurs each time air is used from the system.

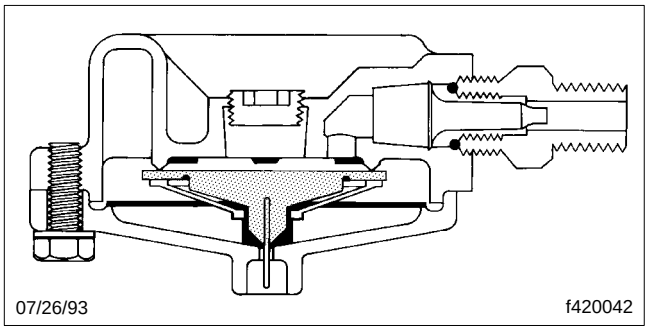


Fig. 2

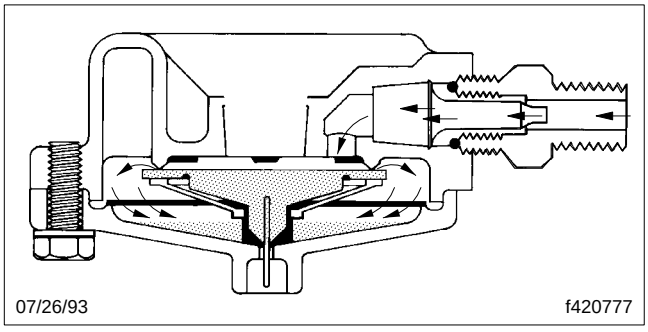


Fig. 3

General Information and Principles of Operation

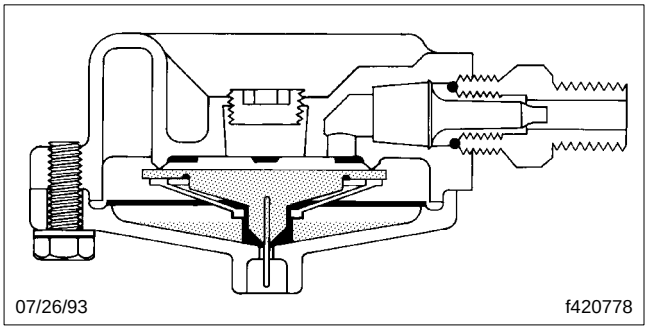


Fig. 4

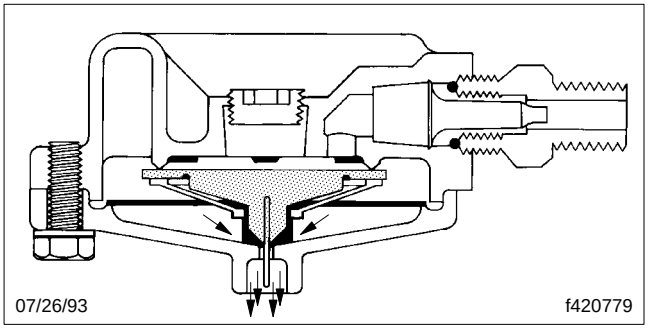


Fig. 5

Safety Precautions

When working on or around air brake systems and components, the following precautions should be observed:

1. Always chock the vehicle's wheels and stop the engine when working under a vehicle. Depleting vehicle air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing air pressure. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been depleted.
3. Never exceed recommended air pressure and always wear safety glasses when working with air pressure. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood the recommended procedures. Some components contain powerful springs and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

Operating Test

IMPORTANT: Before working on or around air brake systems and components, **review "Safety Precautions, 100."**

Perform the following test after repairing or replacing the DV-2 valve to ensure that the valve is functioning properly.

With the system charged, apply the brakes several times. Each time the brakes are applied, an exhaust of air should occur from the exhaust port of the drain valve. If no air comes out, push the wire stem located inside the exhaust port. If no air comes out after pushing the wire stem, there may be a plugged filter in the adapter which should be replaced.

If the drain valve does not function properly, repair or replace it following instructions in this section.

Leakage Test

Perform the following test after repairing or replacing the DV-2 valve to ensure that the valve is functioning properly.

With the system charged and pressure stabilized in the system, there should be no leaks at the drain valve exhaust port. A constant slight exhaust of air at the drain valve exhaust port could be caused by excessive leakage in the air brake system.

If the drain valve is leaking excessively, repair or replace it following instructions in this section.

Removal

IMPORTANT: Before working on or around air brake systems and components, **review "Safety Precautions, 100."**

1. Chock the tires, and open the drain cocks to bleed the air from the wet and dry compressed air reservoirs.
2. Remove the drain valve assembly from the end of the wet tank compressed air reservoir.

Installation

IMPORTANT: Before working on or around air brake systems and components, **review "Safety Precautions, 100."**

1. Using an approved cleaning solvent, thoroughly flush and clean the wet tank reservoir to avoid early fouling at the drain valve. Aerate the wet tank thoroughly if solvents were used during cleaning.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

2. Install the drain valve assembly on the wet tank by tightening the hexagonal nipple until the drain valve is positioned so that the valve body is parallel to the bottom of the wet tank with the exhaust port facing straight down. Make sure that the exhaust port is clear of any air, electric, or fuel lines. Make sure the drain valve is attached tight enough to prevent leakage.
3. Close the drain cocks to the wet and dry air reservoirs. Start the vehicle engine to pressurize the air system.
4. Leak test the drain valve **following the instructions in Subject 110.**

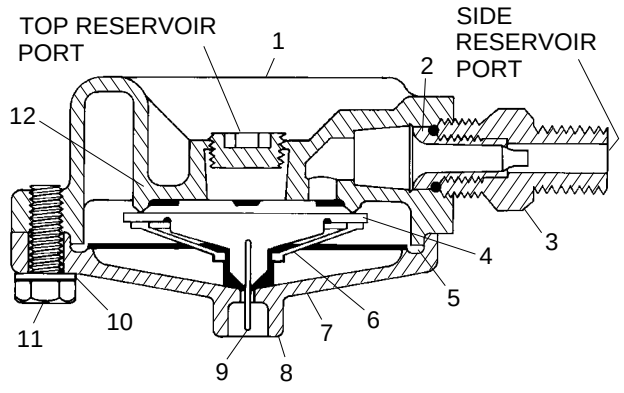
Disassembly (See Fig. 1)

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Remove the drain valve following the instructions in **Subject 120**.
2. Remove the four capscrews (Ref. 11) that hold the valve cover (Ref. 7) to the valve body (Ref. 1).
3. Remove the valve cover and sealing ring (Ref. 5).
4. Remove the valve guide (Ref. 6), and the inlet and exhaust valve (Ref. 4) from the valve body.
5. Remove the hexhead nipple (Ref. 3) from the valve body.

Cleaning and Inspection

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.



1. Valve Body
2. Filter Retainer
3. Hexhead Nipple
4. Inlet and Exhaust Valve
5. Valve Seating Ring
6. Valve Guide
7. Valve Cover
8. Exhaust Port
9. Wire Stem
10. Lockwasher (4 qty.)
11. Capscrew (4 qty.)
12. Insle Valve Seat

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Fig. 1, DV-2 Valve, Cutaway View

1. Wash all metal parts of the drain valve in an approved cleaning solvent. Dry the metal parts of the disassembled moisture ejection valve with compressed air.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

Use eye protection when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

2. Wipe all rubber parts clean with a clean cloth. Examine all rubber parts for wear cracks, tears, or other deterioration. If any rubber parts are worn, cracked, torn or otherwise deteriorated, replace them with new parts.
3. Examine all metal parts for wear, cracks, or other damage. If any metal parts are worn, cracked, or otherwise damaged, replace them with new parts.
4. Clean and examine the filter. If it will not clean completely, or is torn or damaged, replace it with a new filter.

⚠ CAUTION

CAUTION: Do not reassemble the drain valve with a dirty filter; to do so could result in failure of the drain valve in service.

Assembly (See Fig. 1)

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

Before assembling the drain valve, apply a light film of grease on the inlet valve seat. See Ref. 12.

⚠ CAUTION

CAUTION: Do not apply oil to the inlet and exhaust valve.

1. Install the valve sealing ring (Ref. 5) into its groove in the valve cover.

Disassembly, Cleaning and Inspection, and Assembly

2. Install the valve guide (Ref. 6) over the inlet and exhaust valve (Ref. 4).
3. Install the valve guide, and the inlet and exhaust valve as an assembly into the valve cover. The wire stem (Ref. 9) will project through the exhaust port (Ref. 8).
4. Install the valve body on the valve cover and install the lockwashers and capscrews. Tighten the capscrews 72 to 96 lbf·in (820 to 1080 N·cm).
5. Install the hexhead nipple onto the valve body, and tighten it 48 to 72 lbf·in (540 to 820 N·cm).
6. Install the drain valve on the wet tank following the instructions in **Subject 120**.

Specifications

Description	Torque: lbf·in (N·cm)
Valve Cover Capscrews	72–96 (820–1080)
Hexhead Nipple (to valve body)	48–72 (540–820)

Table 1, Torque Values

General Description

The CR Brakemaster air dryer (**Fig. 1**) is a heat exchanger air dryer, mounted vertically between the air compressor and the supply reservoir. The air dryer receives hot compressed air, which it cools and filters before sending it to the supply reservoir, reducing the build-up of dirt and moisture in the vehicle air system.

The air dryer consists of a one-piece aluminum body with external fins designed to increase the surface area available for heat transfer. The top cap of the air dryer houses a pressure release safety valve and an outlet port. A check valve is built into the outlet port.

The bottom cap houses three ports. The inlet port, located in the side of the bottom cap, receives air from the compressor. The unloader port, located near the bottom of the cap, houses a valve assembly and is connected to the air governor unloader port. The exhaust port, located in the bottom of the end cap, is where collected moisture and contaminants are expelled from the unit.

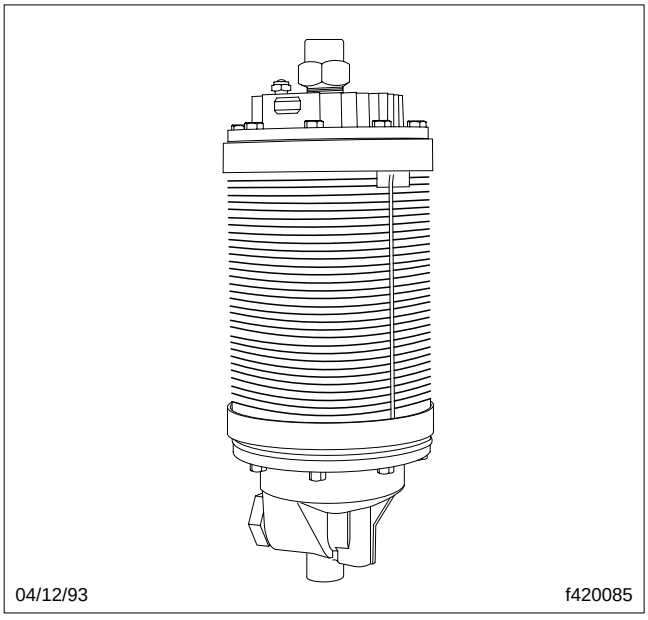


Fig. 1, CR Brakemaster Air Dryer

Principles of Operation

Hot, compressed air enters the air dryer through the inlet port located near the bottom of the air dryer. As the hot air is forced upward into the narrow channel between the deflector and the finned air dryer walls, the temperature of the compressed air falls to nearly ambient. Oil and water vapor condense and settle into the sump. At the top of the unit, the air is filtered through a mass of fine, stainless steel wires, which remove microscopic carbon and other particles from the air. The air then passes through the air dryer outlet port to the supply reservoir.

When the compressor reaches 120 psi (827 kPa), the air dryer unloader valve opens automatically, due to air pressure from the governor valve. This rapid change causes a backrush of air through the air filter, which forces accumulated contaminants out through the exhaust port. The air dryer is then ready for the next cycle.

After each operation of the unloader valve, the pressure in the line between the air compressor and air dryer drops to atmospheric pressure. Thus, the air compressor starts each cycle pumping against atmospheric pressure.

Preparation for Servicing

IMPORTANT: If the air compressor is rebuilt or replaced, or if the air dryer is moved from one vehicle to another, completely disassemble and clean it.

1. Apply the parking brakes, and chock the tires.
2. Drain the air from the air reservoirs.
3. Release the air pressure in the line leading from the unloader port of the air dryer by securing the unloader nut (**Fig. 1**, Ref. 17) with a wrench, and slowly loosening the fitting. Make sure the unloader nut does not turn. Disconnect the air line from the unloader port.

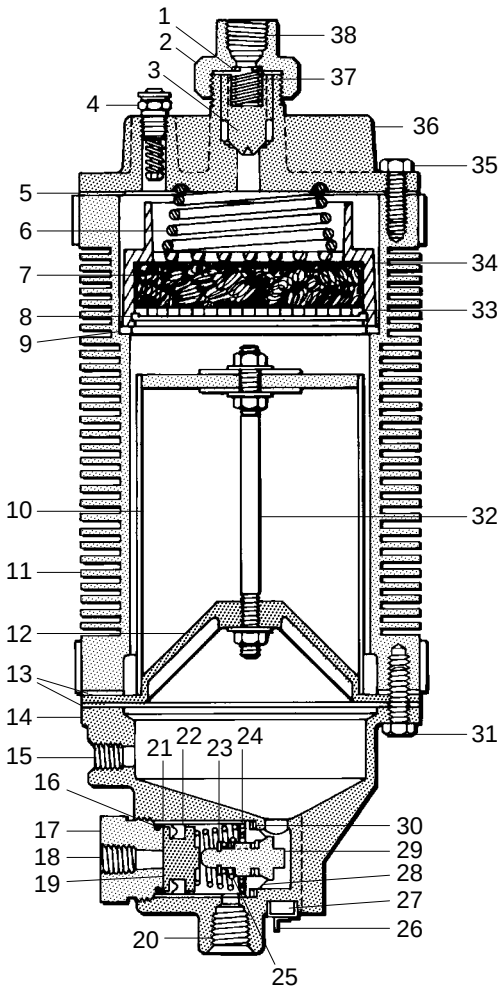
⚠ WARNING

Use caution when loosening this fitting, or the line could whip, resulting in possible personal injury or causing the air stream to direct dirt and sludge particles toward persons in the area.

Don't turn the unloader nut. Turning the unloader nut will change the alignment of the holes in the exhaust port and unloader valve sleeve; the air dryer will not work.

4. Clean the air dryer and surrounding area to prevent dirt, oil, or other road grime from getting into the air brake system.

Preparation for Servicing



1. Gasket
2. Nut
3. Spindle
4. Safety Valve
5. Gasket
6. Spring
7. Filter
8. V−Spring
9. Packing Ring
10. Deflector
11. Body
12. Mounting Plate
13. Gasket
14. Bottom Cap
15. Inlet Port
16. O−Ring
17. Unloader Nut
18. Unloader Port
19. Unloader Piston
20. Exhaust Port
21. Unloader Valve Sleeve
22. U−Cup
23. Retaining Ring
24. Large Spring
25. Small Spring
26. Thermostat
27. Heater
28. Seat Ring
29. Unloader Spindle
30. Gasket
31. Capscrew
32. Support Rod Assembly
33. Strainer
34. Filter Cup
35. Capscrew
36. Top Cap
37. Spring
38. Outlet Port

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Fig. 1, CR Brakemaster Air Dryer, Sectional View

Removal

NOTE: If the air dryer is located in a position where service operations may be safely and easily performed, removal is not necessary unless the unit is to be replaced.

1. Do the procedures in **Subject 100**.
2. Disconnect the electrical wires from the air dryer heater.
3. Mark the air lines for later reference; then, disconnect them from the air dryer.
4. Remove the nuts and bolts on the bracket that mounts the air dryer to the vehicle.
5. Remove the air dryer.

Installation

1. Position the air dryer on the vehicle; then, install the fasteners that mount the unit to the vehicle. If SAE grade 5 fasteners are used, tighten them 55 to 65 lbf·ft (75 to 88 N·m). If SAE grade 8 fasteners are used, tighten them 80 to 90 lbf·ft (108 to 122 N·m). **See Fig. 1** to determine which grade of fastener is used.
2. Make sure the air lines are clean. Replace any line or fitting that is crimped or damaged.

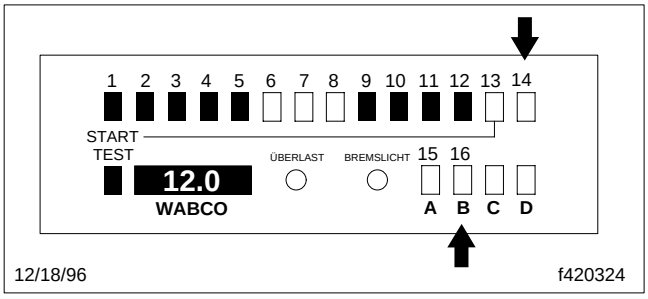


Fig. 1, Bolt Grade Identification

CAUTION

CAUTION: Turning the unloader nut will change the alignment of the holes in the exhaust port and unloader sleeve, and the air dryer will not work.

3. Secure the unloader nut with a wrench, and connect the air line to the air dryer unloader port. Using a second wrench, tighten the nut on the air line fitting until there is firm resistance. Make sure the unloader nut does not turn.
4. Connect the remaining air lines to the air dryer as previously marked, or as shown in the plumbing diagram in **Specifications, 400**. Tighten the nut on each fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance.
5. Connect the electrical line to the air dryer heater.
6. Do the operating tests in **Subject 260** after installing the air dryer on the vehicle and before placing the vehicle in service.

Unloader Valve Mechanism Servicing (See Fig. 1)

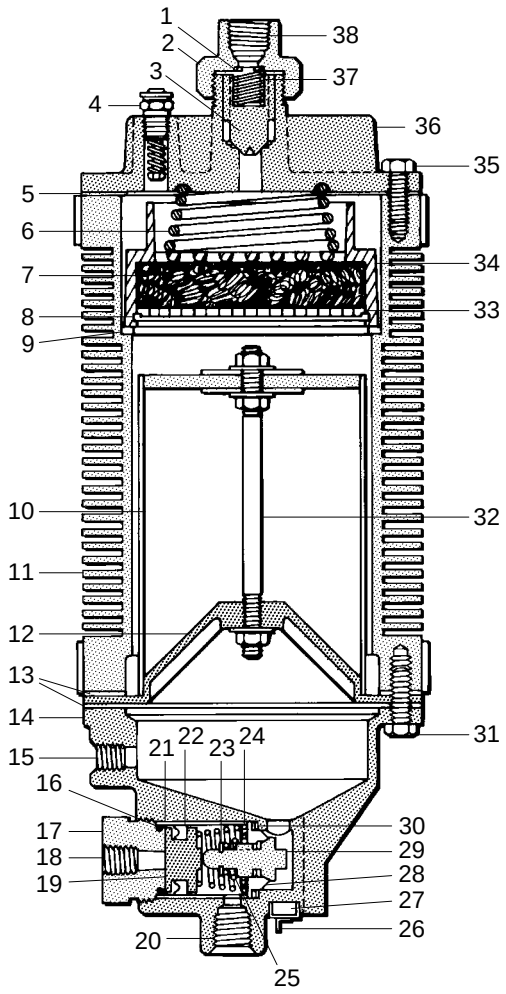
1. Do the procedures in **Subject 100**.
2. If the air dryer is still mounted on the vehicle, disconnect the electrical line from the heater. Disconnect the air lines from the inlet and unloader ports, marking the lines for later assembly.
3. Remove the unloader nut. While removing it from the unloader port, apply moderate pressure by hand to prevent the nut from ejecting as the large spring inside the unloader port uncoils.

WARNING

WARNING: Failure to apply moderate pressure may cause the nut to eject rapidly, possibly causing personal injury.

4. Remove the unloader mechanism (**Fig. 2**) from the unloader port.

NOTE: If there is too much oil in the unloader mechanism, check and service the air compressor following the instructions in the air compressor section in this manual and the vehicle main-



1. Gasket
2. Nut
3. Spindle
4. Safety Valve
5. Gasket
6. Spring
7. Filter
8. V−Spring
9. Packing Ring
10. Deflector
11. Body
12. Mounting Plate
13. Gasket
14. Bottom Cap
15. Inlet Port
16. O−Ring
17. Unloader Nut
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19. Unloader Piston
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25. Small Spring
26. Thermostat
27. Heater
28. Seat Ring
29. Unloader Spindle
30. Gasket
31. Capscrew
32. Support Rod Assembly
33. Strainer
34. Filter Cup
35. Capscrew
36. Top Cap
37. Spring
38. Outlet Port

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Fig. 1, CR Brakemaster Air Dryer, Sectional View

Unloader Valve Mechanism Servicing

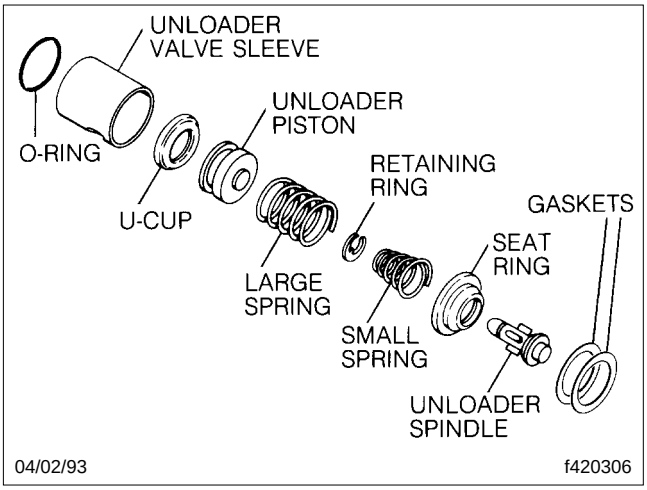


Fig. 2, Unloader Mechanism

tenance manual, or by referring to the air compressor manufacturer's maintenance manual.

5. Clean the unloader mechanism with a commercial solvent. Inspect the assembly for nicks, wrinkles, or scratches. If the sleeve or any other part of the unloader mechanism is nicked, wrinkled, or scratched, replace the unloader mechanism.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

NOTE: Do not disassemble the unloader spindle, seat ring, small spring, and retaining ring. They are a mated assembly.

6. Place the two copper gaskets together and lightly coat the exposed surfaces with grease. Use a multipurpose, high-temperature grease that resists water, steam, and alkali.
7. Place the gaskets on the side of the seat ring opposite the small spring. Place the gaskets and seat ring into the unloader port, gasket end first.
8. Install the unloader valve sleeve into the unloader port, with the 1/2-inch diameter cross hole near the seat ring. Insert the large spring into the unloader valve sleeve, with the larger diameter coil resting against the seat ring.
9. Install the U-cup in the groove of the unloader piston with the lips of the U-cup facing away from the spring seat. When installing the U-cup, do not use sharp tools that may mar or score the parts. Insert the unloader piston and U-cup into the unloader sleeve, with the unloader piston resting against the large spring.
10. Install the O-ring on the end of the unloader nut; then, lightly grease the O-ring. Apply a nonhardening sealing compound to the threads of the unloader nut.
11. Insert a 1/2-inch diameter rod into the exhaust port through the cross hole of the unloader valve sleeve to align the holes while tightening the unloader nut.

⚠ CAUTION

CAUTION: If the exhaust port and the cross hole of the unloader valve sleeve are not aligned, the air dryer will not operate.

12. Install the unloader nut. With the rod in place in the exhaust port, tighten the nut 60 lbf·ft (81 N·m). Remove the rod from the exhaust port.

⚠ CAUTION

CAUTION: Do not overtighten the unloader nut. To do so will damage the unloader mechanism.

13. Install the air dryer if it was removed from the vehicle. Refer to **Subject 120**, "Installation." If the unit is still mounted on the vehicle, connect the air lines to the air dryer as previously marked, or as shown in the plumbing diagram in **Specifications, 400**. Tighten the nut on each fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance. Tighten the nut one-sixth turn more.

⚠ CAUTION

CAUTION: When attaching the air line to the air dryer unloader port, secure the unloader nut with a wrench to prevent turning the unloader nut. Turning the unloader nut will change the alignment of the holes in the exhaust port and unloader valve sleeve, and the dryer will not work.

14. Connect the electrical wires to the heater.
15. Do the operating tests in **Subject 260** after servicing the air dryer and before placing the vehicle in service.

Deflector Assembly Replacement (See Fig. 1)

1. Follow the procedures listed in **Subject 100**.
2. If the air dryer is still mounted on the vehicle, disconnect the electrical line from the heater. Mark the air lines for later reference; then, disconnect them from the inlet and unloader ports.
3. Remove the eight capscrews holding the bottom cap to the body of the air dryer. Remove the bottom cap and the deflector. Discard the deflector.

NOTE: On some models, the deflector is attached to the bottom cap. Remove the deflector from the bottom cap by removing and discarding the four screws that hold the deflector to the bottom cap. Also remove and discard the feet of the bottom cap (to which the deflector was attached).

4. Carefully remove all traces of gasket material from the gasket surfaces of the bottom cap and of the air dryer body. Do not scratch or mar the gasket surfaces. Discard the old gaskets.

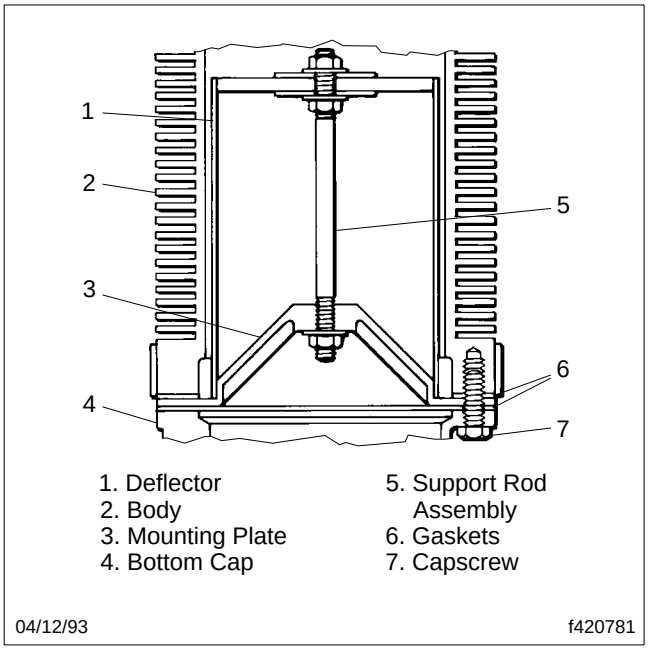


Fig. 1, Deflector Assembly

5. Using a commercial solvent, clean the bottom cap and the inside of the air dryer body.

WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

6. Place a new gasket on the top surface of the new deflector mounting plate, and place another new gasket on the gasket surface of the bottom cap.
7. Align the bolt holes; then, insert the deflector assembly into the air dryer body. Position the bottom cap against the bottom gasket surface of the deflector mounting plate.

NOTE: Do not use gasket sealant.

8. Insert the eight capscrews that attach the bottom cap to the body and the deflector assembly. Tighten the capscrews alternately and evenly 15 lbf·ft (20 N·m).

NOTE: If the unit was previously equipped with the old style deflector that was attached to the bottom cap, use the eight longer capscrews that are available in the replacement kit to attach the bottom cap to the air dryer body and the deflector assembly.

9. If the air dryer was removed from the vehicle, install it following the procedures in **Subject 120**, "Installation."

   If the unit is still mounted on the vehicle, connect the air lines to the air dryer as previously marked or as shown in the plumbing diagram in **Specifications, 400**. Tighten the nut on each fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance. Tighten the nut one-sixth turn more.

CAUTION

CAUTION: When connecting the air line to the unloader port, secure the unloader nut with a wrench to prevent turning the unloader nut. Turning the unloader nut will change the alignment of

Deflector Assembly Replacement

the holes in the exhaust port and unloader valve sleeve, and the air dryer will not work.

10. Connect the electrical wires to the heater.
11. Do the operating tests in **Subject 260** after servicing the air dryer and before placing the vehicle in service.

Check Valve Assembly Replacement (See Fig. 1)

1. Do the procedures in **Subject 100**.
2. If the air dryer is still mounted on the vehicle, mark the air line for later reference; then, disconnect the line from the outlet port.
3. Remove the nut from the outlet port. While removing the nut, apply moderate pressure by hand to prevent the top cap from ejecting as the spring inside the outlet port uncoils.

⚠ WARNING

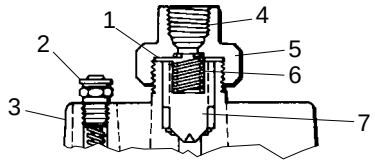
WARNING: Failure to apply moderate pressure may result in personal injury from the top cap ejecting.

4. Remove the copper gaskets, spring, and spindle.
5. Using a commercial solvent, clean the inside and the outside of the outlet port area of the air dryer. Also clean the nut removed from the outlet port. Let the area dry before installing new parts.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

6. Place a new spindle in the outlet port, tapered end down. Then, install a new spring in the spindle.



1. Gasket
2. Safety Valve
3. Top Cap
4. Outlet Port
5. Nut
6. Spring
7. Spindle

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Fig. 1, Check Valve Assembly

7. Install new copper gaskets in the nut removed from the outlet port. Rub a small amount of grease on the gaskets to help keep them in place in the nut. Use a multipurpose, high-temperature grease that resists water, steam, and alkali. Install the nut onto the outlet port; tighten it 60 lbf·ft (81 N·m).
8. If the air dryer was removed from the vehicle, install it following the procedures in **Subject 120**, "Installation."

   If the unit is still mounted on the vehicle, connect the air line to the outlet port, as previously marked or as shown in the plumbing diagram in **Specifications, 400**. Tighten the nut on the fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance. Tighten the nut one-sixth turn more. Using the same procedures, also tighten the fitting at the unloader port that was loosened during the procedures in **Subject 100**.

Safety Valve Replacement

Do not remove the safety valve from the top cap. If the safety valve has been removed, replace the valve with a new safety valve. Apply a nonhardening sealant to the threads of the top cap before installing the new safety valve.

Filter Assembly Servicing

(See Fig. 1)

1. Do the procedures **in Subject 100**.
2. If the air dryer is still mounted on the vehicle, mark the air line for later reference; then, disconnect it from the outlet port.
3. Remove the eight capscrews holding the top cap to the body of the air dryer. Remove the top cap from the body of the air dryer. The top cap is spring loaded to approximately 40 lbs (18 kg). While removing the top cap from the body of the air dryer, apply pressure by hand to prevent the top cap from ejecting as the spring beneath the top cap uncoils.

⚠ WARNING

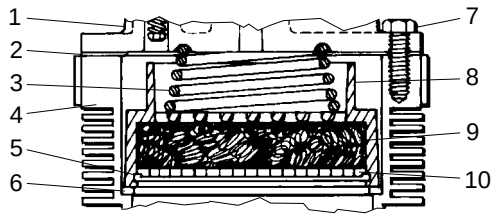
WARNING: Failure to apply pressure to the air dryer top cap may result in personal injury if the top cap ejects.

4. Carefully remove all traces of gasket material from the gasket surfaces of the top cap and of the air dryer body. Do not scratch or score the gasket surfaces. Discard the gasket.
5. Using a commercial solvent, clean the top cap.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

6. Remove the complete filter assembly from the body of the air dryer.
7. Discard the packing ring and the filter. If the filter assembly is not to be replaced, proceed to the next step. If the filter assembly is to be replaced, also discard the filter cup, strainer, and V-spring.
8. Using a commercial solvent, wash the strainer and filter cup, stretching the filter slightly to fill the space in the filter cup.
9. Install the strainer on the filter, with the flat face of the strainer towards the filter. Install the V-spring to hold the assembly together.



1. Top Cap
2. Gasket
3. Spring
4. Body
5. V−Spring
6. Packing Ring
7. Capscrew
8. Filter Cup
9. Filter
10. Strainer

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Fig. 1, Filter Assembly

10. Install the packing ring on the ledge of the body of the air dryer. Install the filter assembly, V-spring down, into the body. The filter assembly must rest on the packing ring.
11. Install the spring with the larger coil against the top of the filter assembly. Position the new gasket on the body.

NOTE: Do not use gasket cement on the gasket.

12. Install the top cap on the body of the air dryer, making sure the small coil on the spring fits into the groove in the top cap.
13. Compress the spring, then install four of the capscrews evenly around the top cap of the air dryer. The capscrews should be engaged at least three full turns before releasing pressure on the spring. Install the remaining four capscrews by hand.
14. Alternately tighten all eight capscrews 15 lbf·ft (20 N·m).
15. If the air dryer was removed from the vehicle, install it following the instructions **in Subject 120, "Installation."**

    If the unit is still mounted on the vehicle, connect the air line to the outlet port, as previously marked or as shown in the plumbing diagram in **Specifications, 400**. Tighten the nut on the fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut

Filter Assembly Servicing

until there is firm resistance. Tighten the nut one-sixth turn more. Using the same procedures, also tighten the fitting at the unloader port that was loosened during the procedures in **Subject 100**.

CAUTION

CAUTION: When connecting the air line to the unloader port, secure the unloader nut with a wrench to prevent turning the unloader nut. Turning the unloader nut will change the alignment of the holes in the exhaust port and unloader valve sleeve, and the air dryer will not work.

16. Do the operating tests in **Subject 260** after servicing the air dryer and before placing the vehicle in service.

Heater Replacement

1. Do the procedures **in Subject 100**.
2. If the air dryer is still mounted on the vehicle, disconnect the electrical wires from the heater.
3. On the bottom cap, loosen the screw that holds the heater. Remove the two small screws that hold the thermostat. Remove and discard the heater and the thermostat.
4. Install the new heater into the hole from which the old heater was removed. Tighten the screw that holds it in place.
5. Install the new thermostat into the hole from which the old thermostat was removed. Install and tighten the two screws that hold it in place.
6. If the unit was removed from the vehicle, install it following the instructions **in Subject 120, "Installation."**

   If the air dryer is still mounted on the vehicle, connect the electrical line to the heater.
7. Do the operating tests **in Subject 260** after servicing the air dryer and before placing the vehicle in service.

Operating Tests

1. Start the engine and build the air pressure to 120 psi (827 kPa). Using a soap and water solution, check all fittings and gasketed surfaces for air leaks, and correct as necessary.
2. Force the air compressor to cycle several times. Check the temperature at the inlet and outlet ports of the air dryer by placing your hand near each of the port areas. The inlet port should be warmer than the outlet port, and the outlet port should be at or slightly above ambient temperature. If both ports are at the same temperature, the deflector assembly of the air dryer may need servicing.

⚠ WARNING

WARNING: Since the vehicle is stationary, the air dryer will become hotter than it would during normal operation. Be careful not to burn your skin when checking the air dryer temperature.

3. Hold a clean shop towel under the exhaust port. When the air compressor stops cycling, air and water should be exhausted into the shop towel. If the air dryer does not unload when the air compressor stops cycling, or if oily or dirty water is exhausted when the unit unloads, **refer to "Troubleshooting, 300."**
4. After the air dryer has exhausted, and before the air compressor starts cycling again, hold your hand under the exhaust port. If air is flowing out the exhaust port, the check valve located in the unloader port of the air dryer may be stuck open and need servicing. If air is flowing out the exhaust port after the air compressor starts pumping, the unloader mechanism of the air dryer is stuck open and needs servicing.

NOTE: When the air compressor is building pressure, the check valve at the air dryer outlet port should open and close rapidly. This rapid opening and closing may produce a rattling sound, which is normal.

Troubleshooting Chart

Problem—Air Continually Exhausts from the Exhaust Port When the Air Compressor Is in the Standby Mode

Possible Cause	Remedy
The air dryer outlet port check valve is stuck open.	Clean or replace the check valve assembly.

Problem—System Air Pressure Drops Rapidly

Possible Cause	Remedy
Fittings are loose or damaged.	Tighten or replace loose or damaged fittings.
Air reservoir, tubing, or hoses are damaged.	Repair or replace damaged items.
The air dryer outlet port check valve is stuck open.	Clean or replace the check valve assembly.

Problem—The Air Compressor Goes Into Standby Mode But Cycles Rapidly

Possible Cause	Remedy
Fittings are loose or damaged.	Tighten or replace loose or damaged fittings.
Air reservoir, tubing, or hoses are damaged.	Repair or replace damaged items.
The air dryer outlet port check valve is stuck open.	Clean or replace the check valve assembly.
The seal or sleeve in the unloader mechanism is damaged.	Replace the unloader mechanism.

Problem—Air Flows from the Exhaust Port When the Air Compressor Is Trying to Build Up Pressure

Possible Cause	Remedy
The unloader mechanism is stuck open or damaged.	Replace the unloader mechanism.
Dirt or foreign material is stuck in the unloader mechanism.	Clean or replace the unloader mechanism.

Problem—The Air Compressor Runs Continuously (System Pressure Will Not Build Up)

Possible Cause	Remedy
Fittings are loose or damaged.	Tighten or replace loose or damaged fittings.
Air reservoir, tubing, or hoses are damaged.	Repair or replace damaged items.
The air compressor needs to be serviced or replaced.	Rebuild or replace the air compressor.
The unloader mechanism is stuck open.	Clean or replace the unloader mechanism.
The air compressor capacity is too low for the vehicle.	Install a larger air compressor.

Troubleshooting

Possible Cause	Remedy
The line between the air compressor and the air dryer is blocked.	Replace the line or remove the blockage.

Problem—The Air Dryer Does Not Unload When the Air Compressor Goes Into Standby Mode

Possible Cause	Remedy
The line between the air governor and the air dryer unloader port is missing, loose, or damaged.	Install or replace the air line, or tighten the fittings.
The unloader mechanism parts are worn.	Replace the unloader mechanism.
Ice has formed in the unloader mechanism.	Shorten the line between the air governor and the air dryer unloader port, or install a heater.
The heater is not working.	Replace the heater or check the electrical connections.

Problem—The Safety Valve Opens

Possible Cause	Remedy
The air dryer outlet port check valve is stuck closed.	Replace the check valve assembly.
The air brake system is blocked downstream from the air dryer.	Remove the blockage or replace the necessary components.
The air compressor governor valve is not working.	Replace the air compressor governor valve.
The safety valve is not working.	Replace the safety valve.

See Fig. 1 for the air dryer plumbing diagram.

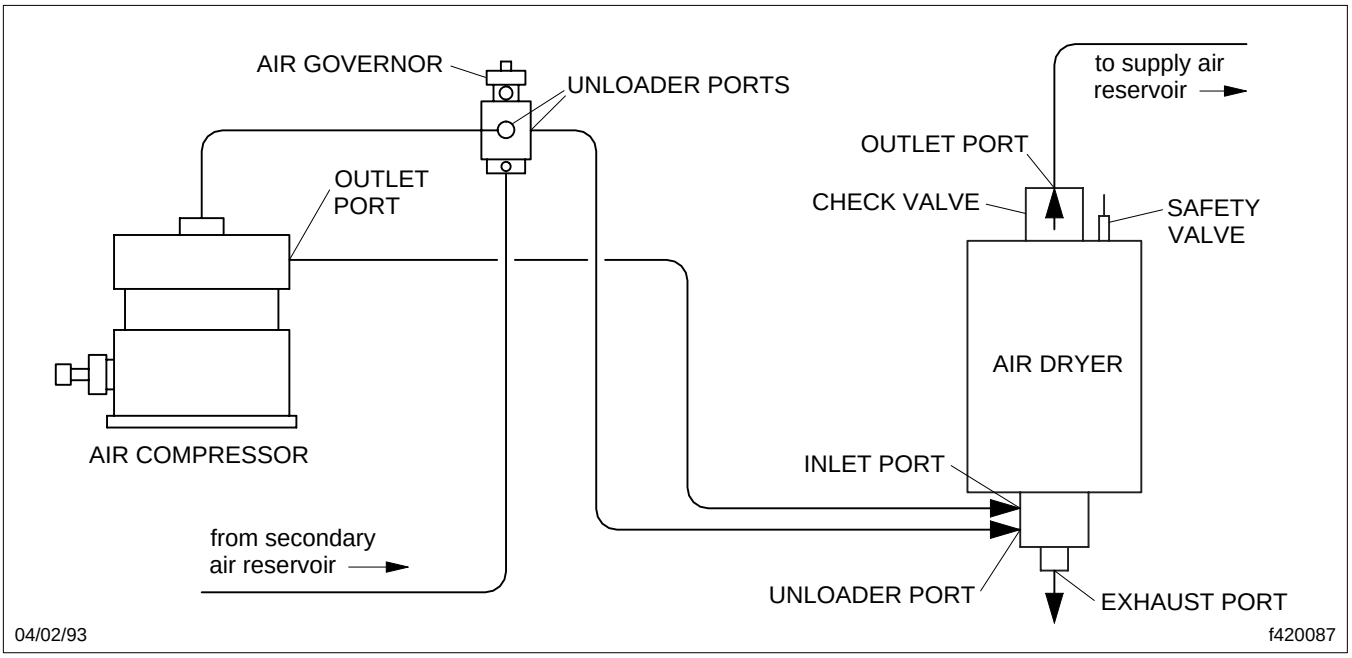
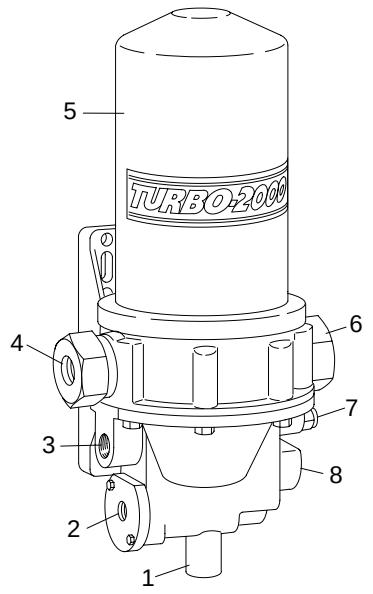


Fig. 1, Air Dryer Plumbing Diagram

General Information

The Turbo-2000 air dryer **(Fig. 1)** is a desiccant air dryer, mounted vertically between the air compressor and the supply reservoir. The air dryer receives hot compressed air, which it cools and filters before sending it to the supply reservoir, reducing the build-up of dirt and moisture in the vehicle air system.



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1. Exhaust Port
2. Unloader Port (to air governor)
3. Inlet Port (from air compressor)
4. Outlet Port (to air supply reservoir)
5. Desiccant Canister
6. Purge Port (to purge tank)
7. Safety Valve
8. Heater/Thermostat Assembly

Fig. 1

The air dryer consists of a light weight aluminum and steel body. The desiccant cartridge is contained in a spinoff canister at the top of the air dryer.

The bottom half of the air dryer houses six ports, including the pressure release safety valve. The inlet port receives air from the compressor. The outlet port sends clean/dry air to the air supply reservoir. The unloader port contains a valve assembly and is connected to the air governor unloader port. The purge port contains a bleed valve and is connected to the purge tank. The exhaust port is where collected moisture and contaminants are expelled from the unit.

Principles of Operation

Hot, compressed air enters the air dryer through the inlet port. As the hot air is forced upward into the desiccant cartridge, the temperature of the compressed air falls to nearly ambient. Oil and water vapor condense and settle into the sump. At the top of the unit, the air is filtered through a mass of fine, stainless steel wires, which remove microscopic carbon and other particles from the air. The clean air then passes through the air dryer outlet port to the supply reservoir.

When the compressor reaches 120 psi (827 kPa), the air dryer unloader valve opens automatically, due to air pressure from the governor valve. This rapid change causes a backrush of air through the air filter, which forces accumulated contaminants out through the exhaust port. The air dryer is then ready for the next cycle.

The purge cycle begins by allowing air to slowly backflush the clean dry air from the purge tank, forcing accumulated contaminants out through the exhaust port.

Safety Precautions

⚠ WARNING

WARNING: When draining the air system, don't look into the air jets or direct them toward another person, as dirt or sludge particles may be in the airstream. Don't disconnect pressurized hoses because they may whip as air escapes from the line. Failure to take all necessary precautions during service operations of the air brake system can cause personal injury.

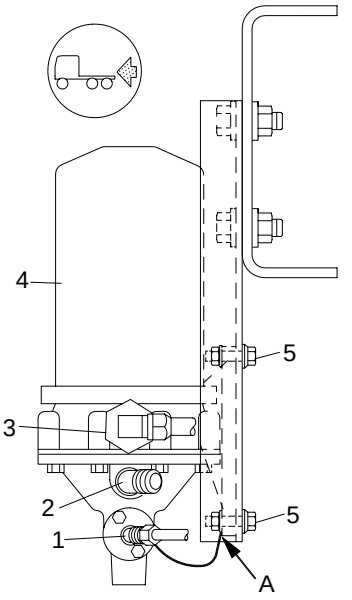
When working on or around air brake systems and components, observe the following precautions.

1. Apply the parking brake, chock the tires, and stop the engine when working under the vehicle. Draining the air system may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters, which may apply as air system pressure drops.
2. Wear safety goggles.
3. Never connect or disconnect a hose or line containing air under pressure; it may whip as air escapes. Never remove a component or pipe plug unless you are sure all system pressure has been depleted.
4. Don't disassemble a component before reading and understanding recommended procedures. Use only the correct tools and follow basic tool safety.
5. Replacement hardware, tubing, hose, fittings, etc. should be the same size, type, length, and strength as the original equipment. When replacing tubing or hose, be sure that all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace any components that have stripped threads or damaged parts. Don't attempt to repair parts by machining.
7. Never exceed recommended air pressure.

⚠ WARNING

WARNING: Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

Removal (See Fig. 1)



A. Ground Wire Location
1. Unloader Port
2. Inlet Port
3. Outlet Port
4. Desiccant Cartridge
5. 3/8" Locknut, Washer, and Capscrew

Fig. 1, Air Dryer Installation (outboard rail mounting shown)

1. Drain the air system.
2. Disconnect the wiring harness from the air dryer.
3. Mark the air lines for later reference; then, disconnect them from the air dryer.

IMPORTANT: The air dryer ground wire is attached to the mounting bracket with one of the mounting capscrews. Note the location for installation.

4. Remove the locknuts, washers, and capscrews that attach the air dryer to the mounting bracket.
5. Remove the air dryer.

Installation (See Fig. 1)

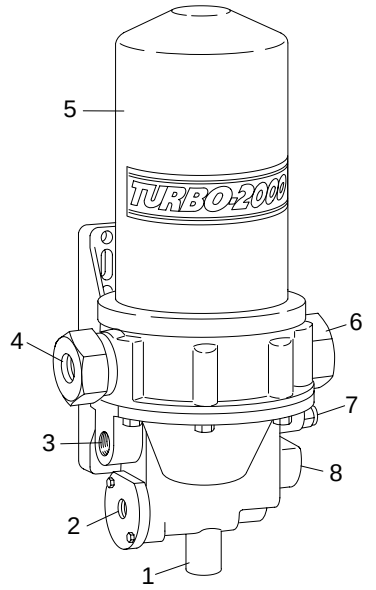
1. Position the air dryer on the mounting bracket. Install the capscrews, washers, and locknuts. Tighten them 37 lbf·ft (50 N·m).
2. Make sure the air lines are clean. Replace any line or fitting that is crimped or damaged.
3. Connect the air line to the air dryer unloader port. Using a second wrench, tighten the nut on the air line fitting until there is firm resistance.
4. Connect the remaining air lines to the air dryer as previously marked. Tighten the nut on each fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance.
5. Connect the air dryer wiring harness.

Replacement

⚠ WARNING

WARNING: Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Disconnect the air line from the unloader port. **See Fig. 1.**



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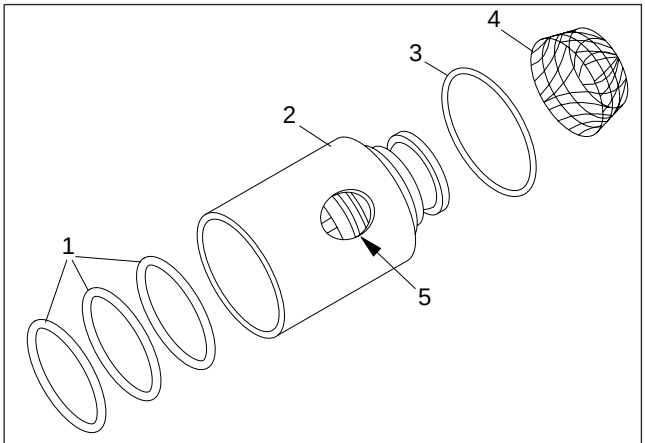
1. Exhaust Port
2. Unloader Port
3. Inlet Port
4. Outlet Port
5. Desiccant Canister
6. Purge Port
7. Safety Valve
8. Heater

Fig. 1

3. Remove the two fasteners that attach the unloader valve retainer. Remove the retainer.
4. Remove the unloader assembly **(Fig. 2)** from the unloader port.



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1. O-Rings (thick)
2. O-Ring Seat
3. O-Ring (thin)
4. Filter Screen
5. Valve Assembly Exhaust Port

Fig. 2

NOTE: If there is too much oil in the unloader assembly, check and service the air compressor following the instructions in the air compressor section in this manual and the vehicle maintenance manual, or by referring to the air compressor manufacturer's maintenance manual.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

5. Clean the unloader valve cavity with a commercial cleaning solvent.
6. Remove the three thick O-rings from the center portion of the retainer.
7. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the three new O-rings.
8. Install the two thickest O-rings on the retainer; then, install the third (thinner) O-ring.
9. Install the new filter screen in the unloader cavity (closed end first).

Unloader Valve Replacement

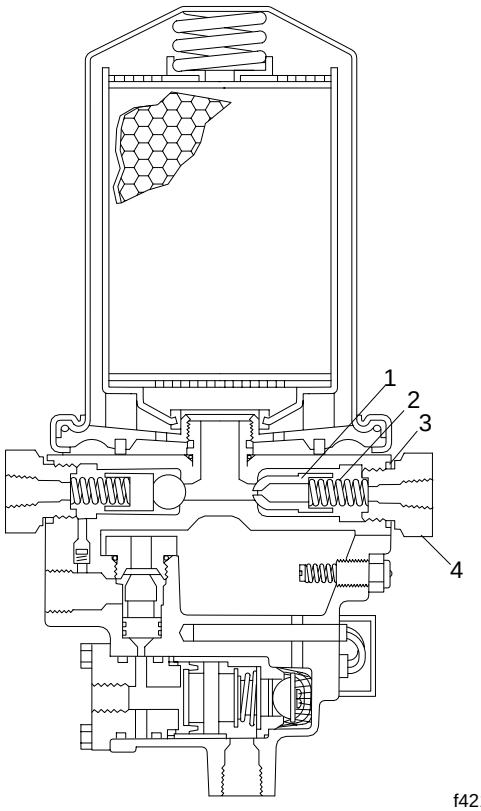
10. Apply a light coating of grease around the O-ring seat. Install the thin O-ring.
11. Aligning the valve assembly exhaust port with the air dryer exhaust port, install the valve assembly. Use care not to dislodge the thin O-ring from its seat.
12. Insert the 1/2-inch diameter rod (supplied in the replacement kit) into the air dryer exhaust port and through the exhaust port of the unloader valve assembly to align the holes while tightening the retainer bolts.

⚠ CAUTION

CAUTION: If the air dryer exhaust port and the exhaust port of the unloader valve assembly are not aligned, the air dryer will not operate.

13. Apply a light coating of grease on the threads of the two retainer bolts.
14. Install the two retainer bolts and tighten them 10 to 15 lbf·ft (14 to 20 N·m).
15. Connect the air line to the unloader port. Tighten the nut finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance. Tighten the nut one-sixth turn more.

Replacement (See Fig. 1)



1. Bleed Valve Spindle
2. Spring
3. O-Ring
4. Nut

Fig. 1, Bleed Valve Assembly

⚠ WARNING

WARNING: Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

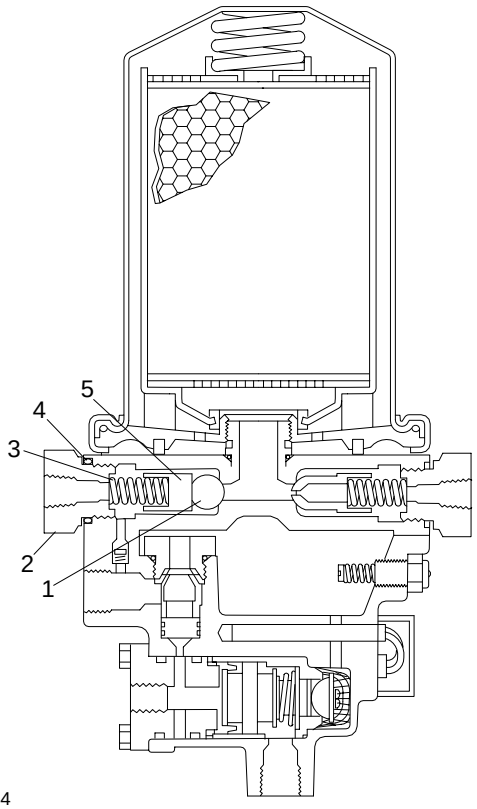
1. Drain the air system.
2. Disconnect the air line from the purge port.
3. Remove the bleed valve nut.
4. Remove and discard the O-ring, spring, and the bleed valve spindle.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

5. Clean the bleed valve nut and the cavity area with a commercial cleaning solvent.
6. Position the new spindle in the cavity area with the spring pocket facing out. Install the spring.
7. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring. Install the O-ring on the bleed valve nut.
8. Apply a light coating of grease to the threads of the nut. Install the nut and tighten it 60 lbf·ft (81 N·m).
9. Connect the air line to the purge port. Tighten the nut on the fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance. Tighten the nut one-sixth turn more.

Replacement (See Fig. 1)



1. Ball
2. Nut
3. Spring
4. O-Ring
5. Check Valve Spindle

Fig. 1, Check Valve Assembly

⚠ WARNING

WARNING: Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Disconnect the air line from the outlet port.
3. Remove the check valve nut.
4. Remove and discard the O-ring, spring, check valve spindle, and the ball.

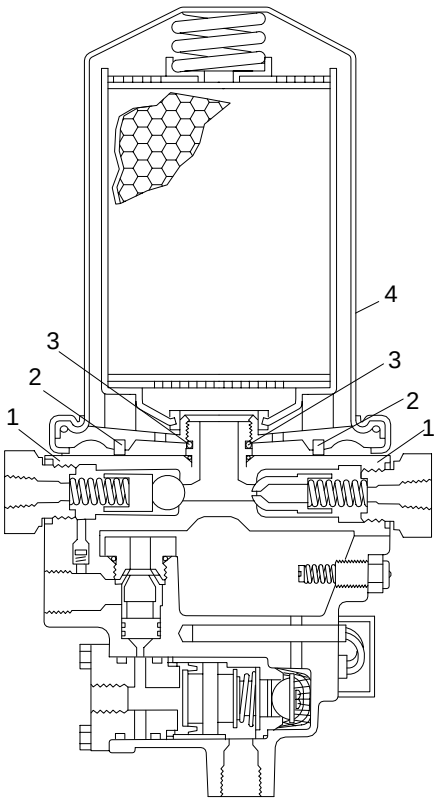
NOTE: If there is too much oil in the check valve assembly, check and service the air compressor following the instructions in the air compressor section in this manual and the vehicle maintenance manual, or by referring to the air compressor manufacturer's maintenance manual.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

5. Clean the check valve nut and the cavity area with a commercial cleaning solvent.
6. Position the new ball in the cavity area. Position the spindle on top of the ball with the spring pocket facing out. Install the spring.
7. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring. Install the O-ring on the check valve nut.
8. Apply a light coating of grease to the threads of the nut. Install the nut and tighten it 60 lbf·ft (81 N·m).
9. Connect the air line to the outlet port. Tighten the nut on the fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance. Tighten the nut one-sixth turn more.

Replacement (See Fig. 1)



1. Adaptor Plate
2. Gasket
3. O-Ring
4. Desiccant Cartridge

Fig. 1, Desiccant Cartridge Assembly

⚠ WARNING

WARNING: Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Using a strap wrench, turn the desiccant cartridge counterclockwise and remove it.
3. Remove and discard the adaptor plate O-ring.

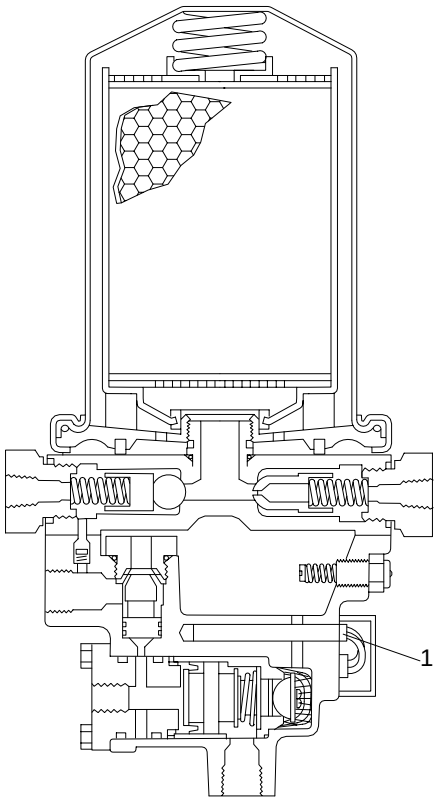
NOTE: If there is too much oil in the desiccant cartridge assembly, check and service the air compressor following the instructions in the air compressor section in this manual and the vehicle maintenance manual, or by referring to the air compressor manufacturer's maintenance manual.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

4. Clean the top surface of the adaptor plate and the threaded adaptor with a commercial cleaning solvent.
5. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring. Install the O-ring on the threaded adaptor.
6. Apply a light coating of the lubricant supplied in the replacement kit on the new desiccant cartridge gasket.
7. Thread the new cartridge onto the adaptor (turn clockwise). When the gasket contacts the adaptor plate, tighten the cartridge 1/2 turn more. Do not over tighten.

Replacement (See Fig. 1)



1. Heater/Thermostat Assembly

Fig. 1

WARNING

WARNING: Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Disconnect the wiring harness and remove the ground wire from the air dryer mounting bracket.
3. Remove the two screws that attach the heater/thermostat cover. Remove the cover.
4. Remove the setscrew that holds the heater element in place. Remove and discard the heater/thermostat assembly.

WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

5. Clean the heater/thermostat assembly area with a commercial cleaning solvent.
6. Apply a light coating of antiseize compound in the thermostat cavity, and to the heater element.
7. Position the new heater in the heater cavity. Slightly twist the heater to evenly spread the antiseize compound. Install the setscrew.

NOTE: The setscrew should protrude about 1/8 inch (3.2 mm) from the bottom cap. Do not over tighten the setscrew.

8. Insert the thermostat into the thermostat cavity.
9. Coil the wires around the heater cover posts allowing them to protrude through the slots.
10. To prevent corrosion, fill the cover with a silicone sealant.
11. Using the two screws removed previously, install the cover. Tighten the screws securely.
12. Attach the blue ground wire to the air dryer mounting bracket. Connect the wiring harness.

Operating Tests

WARNING

WARNING: Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

Air Dryer Pressure Check

1. Drain the air system.
2. Start the engine and build the air pressure to as close to cutout pressure as possible (about 100 psi [689 kPa]). Don't allow the air dryer to exhaust.
3. Stop the engine.
4. Using a soap and water solution, check for air leaks around the desiccant cartridge and the adaptor plate. If there is leakage at the adaptor plate, replace the desiccant cartridge. For instructions, refer to **Subject 150.**

Bleed Valve

1. Inspect the purge tank, hose connections, and the hose assembly for any damage or loose connections. Repair as needed.
2. Start the engine and build the air pressure to 120 psi (827 kPa). Allow the air dryer to exhaust.
3. Stop the engine.

NOTE: After the initial exhaust, the air dryer will continue to bleed air for about 45 to 60 seconds.

4. If the air dryer does not exhaust, replace the bleed valve. For instructions, refer to **Subject 130.**

Check Valve

1. Start the engine and build the air pressure to 120 psi (827 kPa). Allow the air dryer to exhaust.
2. Stop the engine.
3. Listen for air leaking from the exhaust port.

NOTE: After the initial exhaust, the air dryer will continue to bleed air for about 45 to 60 seconds.

4. If air continues to leak after the 45 to 60 seconds, replace the check valve. For instructions, refer to **Subject 140.**

Unloader Valve

1. Check the unloader valve with the compressor off.
   - 1.1 Start the engine and build the air pressure to 120 psi (827 kPa). Allow the air dryer to exhaust.
   - 1.2 Allow the air dryer to cycle several times.
   - 1.3 If the air dryer doesn't exhaust, or the unloader valve sticks, replace the valve. For instructions, refer to **Subject 120.**
2. Check the unloader valve with the compressor on.
   - 2.1 Start the engine and build the air pressure to as close to cutout pressure as possible (about 100 psi [689 kPa]). Don't allow the air dryer to exhaust.
   - 2.2 Stop the engine.
   - 2.3 Listen for air leaking from the exhaust port. If it is, drain the air system and remove the air line from the unloader port.

     If the air leak stops, replace the air compressor governor. For instructions, refer to the applicable section in this group.

     If the air leak continues, replace the unloader valve. For instructions, refer to **Subject 120.**

Heater/Thermostat Assembly

IMPORTANT: The thermostat must be cooled to at least 35°F (2°C) for this test.

1. Connect an ohmmeter across the heater electrical terminals.

   The reading should show a closed circuit.
2. If the reading shows an open circuit, replace the heater/thermostat assembly. For instructions, refer to **Subject 160.**

Troubleshooting Tables

Problem—Air Continually Exhausts from the Exhaust Port When the Air Compressor Is in the Standby Mode

Possible Cause	Remedy
The air dryer outlet port check valve is stuck open.	Clean or replace the check valve assembly.

Problem—System Air Pressure Drops Rapidly

Possible Cause	Remedy
Fittings are loose or damaged.	Tighten or replace loose or damaged fittings.
Air reservoir, tubing, or hoses are damaged.	Repair or replace damaged items.
The air dryer outlet port check valve is stuck open.	Clean or replace the check valve assembly.

Problem—The Air Compressor Goes Into Standby Mode But Cycles Rapidly

Possible Cause	Remedy
Fittings are loose or damaged.	Tighten or replace loose or damaged fittings.
Air reservoir, tubing, or hoses are damaged.	Repair or replace damaged items.
The air dryer outlet port check valve is stuck open.	Clean or replace the check valve assembly.
The seal or sleeve in the unloader valve is damaged.	Replace the unloader valve.
The governor is not working properly.	Replace the air governor.

Problem—Air Flows from the Exhaust Port When the Air Compressor Is Trying to Build Up Pressure

Possible Cause	Remedy
The unloader valve is stuck open or damaged.	Replace the unloader valve.
Dirt or foreign material is stuck in the unloader valve.	Clean or replace the unloader valve.
The governor is not working properly.	Replace the air governor.
The heater/thermostat assembly is not working properly.	Replace the heater/thermostat assembly.

Problem—The Air Compressor Runs Continuously (System Pressure Will Not Build Up)

Possible Cause	Remedy
Fittings are loose or damaged.	Tighten or replace loose or damaged fittings.
Air reservoir, tubing, or hoses are damaged.	Repair or replace damaged items.

Troubleshooting

Possible Cause	Remedy
The air compressor needs to be serviced or replaced.	Rebuild or replace the air compressor.
The unloader valve is stuck open.	Clean or replace the unloader valve.
The air compressor capacity is too low for the vehicle.	Install a larger air compressor.
The line between the air compressor and the air dryer is blocked.	Replace the line or remove the blockage.
The governor is not working properly.	Replace the air governor.

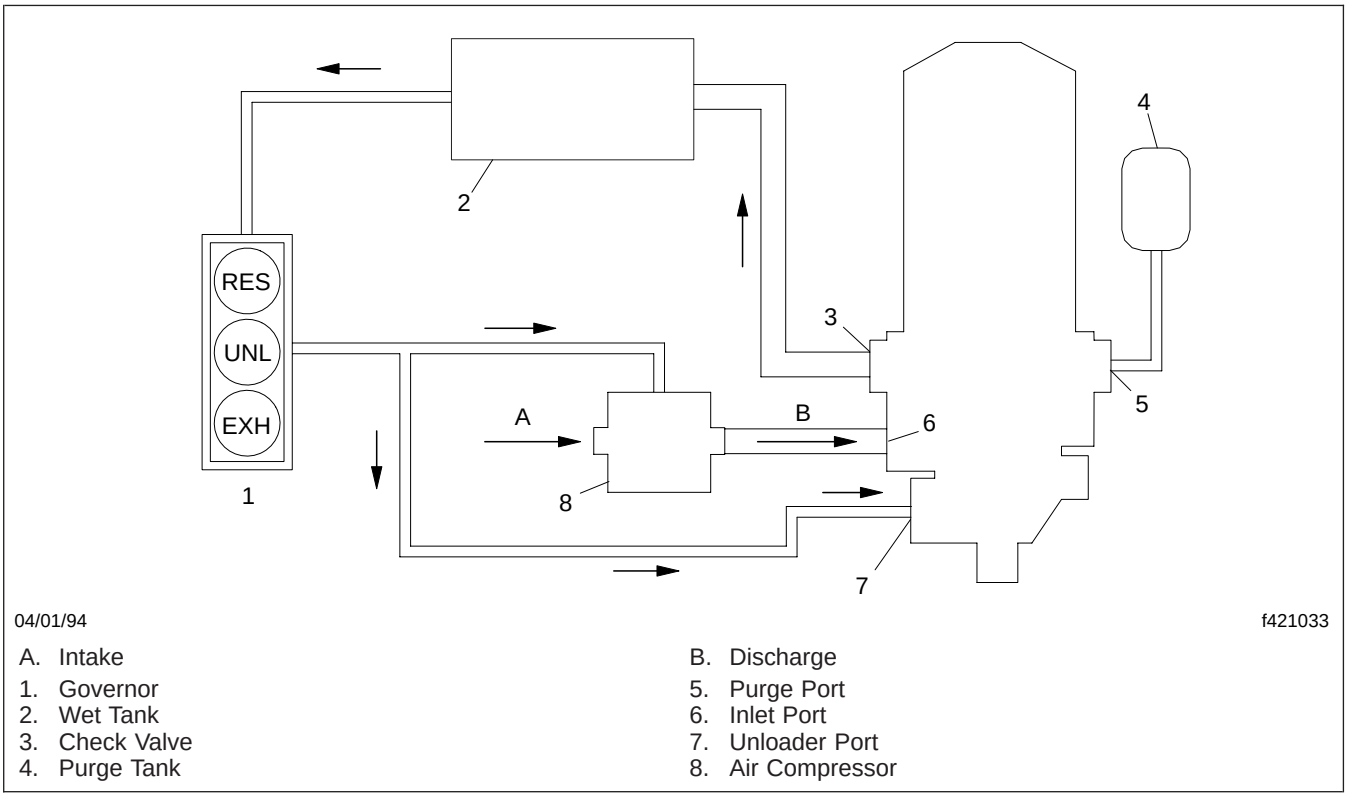
Problem—The Air Dryer Does Not Unload When the Air Compressor Goes Into Standby Mode

Possible Cause	Remedy
The line between the air governor and the air dryer unloader port is missing, loose, or damaged.	Install or replace the air line, or tighten the fittings.
The unloader valve parts are worn.	Replace the unloader valve.
Ice has formed in the unloader valve.	Shorten the line between the air governor and the air dryer unloader port, or install a heater.
The heater is not working.	Replace the heater or check the electrical connections.

Problem—The Safety Valve Opens

Possible Cause	Remedy
The air dryer outlet port check valve is stuck closed.	Replace the check valve assembly.
The air brake system is blocked downstream from the air dryer.	Remove the blockage or replace the necessary components.
The air compressor governor valve is not working.	Replace the air compressor governor valve.
The safety valve is not working.	Replace the safety valve.

See **Fig. 1** for the air dryer plumbing diagram.



A. Intake
B. Discharge
1. Governor
2. Wet Tank
3. Check Valve
4. Purge Tank
5. Purge Port
6. Inlet Port
7. Unloader Port
8. Air Compressor

Fig. 1, Air Dryer Plumbing Diagram

General Information

Air reservoirs serve two main purposes:

1. They store compressed air used to apply the brakes and operate other air-powered devices, such as window lifts, windshield wipers, and seats.
2. They provide a place where air, heated during compression, can cool and water vapor can condense into a liquid. Also, air reservoirs collect small amounts of oil passed by the compressor.

   Each vehicle is equipped with three or four air reservoirs, depending on the number of rear axles. On all vehicles, each reservoir is identified as one of three types: supply, primary, and secondary.

   A supply reservoir receives compressed air directly from the compressor. Also referred to as the wet tank, its functions are to collect most of the water and oil condensate from the air, and to feed air to the other reservoirs. At the outlet port of the supply reservoir (the port leading to the primary reservoir) is a safety valve, which protects the air system against excessive air pressure build-up. The supply reservoir is usually mounted on the right-hand frame rail.

   Primary reservoirs are air sources for the brakes on the rear axles. One or two primary reservoirs are installed on a vehicle, depending on the number of rear axles and the air system configuration. At the inlet port of the primary reservoir is an inline check valve. The check valve allows air flow in one direction only, and prevents air flow in the reverse direction in case there is a drop in upstream air pressure. Each primary reservoir is usually mounted behind the supply reservoir on the right-hand frame rail.

   A secondary reservoir is the air source for the front axle brakes. It is usually mounted on the left-hand frame rail, and, like the primary reservoir, is equipped with an inline check valve.

   The secondary reservoir supplies air to a pressure protection valve. This valve prevents complete loss of secondary air pressure if there is an air leak in any non-brake accessory.

All air reservoirs are equipped with drain valves to eject the water and oil emulsion from the tanks.

Tests

NOTE: If equipped with an automatic moisture-ejection valve, refer elsewhere in this group for leak testing.

Be sure the air system is fully charged. Using a soap solution or leak detector, check for leaks on the outside surfaces of the reservoirs and drain valves. No leakage is permitted.

If leaks exist at the drain valve, note if they occur at the joint of the valve and coupler, or through the valve body. **Proceed to Subject 110**.

If leaks occur on the surfaces of the air reservoir, replace the tank; **refer to Subject 120**.

Drain Valve Replacement and Leak Elimination

NOTE: If equipped with an automatic moisture-ejection valve, refer elsewhere in this group for instructions.

1. Apply the parking brakes, and chock the tires.
2. Drain the air system, using the instructions in the appropriate driver's manual.
3. Using two wrenches (hold the coupler in place with one of them), unscrew the drain valve from the coupler. Clean off the threads inside the coupler on the reservoir, removing all sludge and sealant build-up.

   Obtain a new drain valve if leaks occurred through the body of the valve.

   If leaks occurred at the joint of the drain valve and coupler, clean off the sludge and sealant from the threads of the valve. Check for damaged threads on the valve and inside the coupler. Replace damaged parts. If no damage exists, leakage was probably due to inadequate tightening of the drain valve in the coupler.
4. Apply Loctite®, or an equivalent sealant, to the end threads of the drain valve or coupler, as applicable, and install finger-tight. Tighten one and one-half additional turns (use two wrenches if installing the drain valve).
5. Perform a leak test after completing the installation. If leaks occur at the joint of the drain valve and coupler, tighten the valve up to one additional turn to stop the leaks.
6. Remove the chocks from the tires.

Replacement

1. Apply the parking brakes, and chock the tires.
2. Drain the air system, using the instructions in the appropriate driver's manual.
3. Reference all reservoir air lines, couplers, and valves for later assembly; disconnect the components. Cap the exposed ports tightly to keep out contaminants. If access is limited, remove the components after removing the reservoir from its mount (step 4).
4. Remove the reservoir strap fasteners. Remove the reservoir.
5. If access is limited, perform step 6 first. If not, place a new reservoir in the mount, and install the strap fasteners. On two-piece straps (**Fig. 1**), tighten the nuts 20 to 25 lbf·ft (27 to 34 N·m). On one-piece straps (**Fig. 2**), tighten the weld nut bolt 30 to 40 lbf·ft (41 to 54 N·m).
6. As referenced earlier, connect all air lines, couplers, and valves to the new reservoir, removing the caps as each component is installed. Tighten the connections as instructed elsewhere in this section.
7. Remove the chocks from the tires.

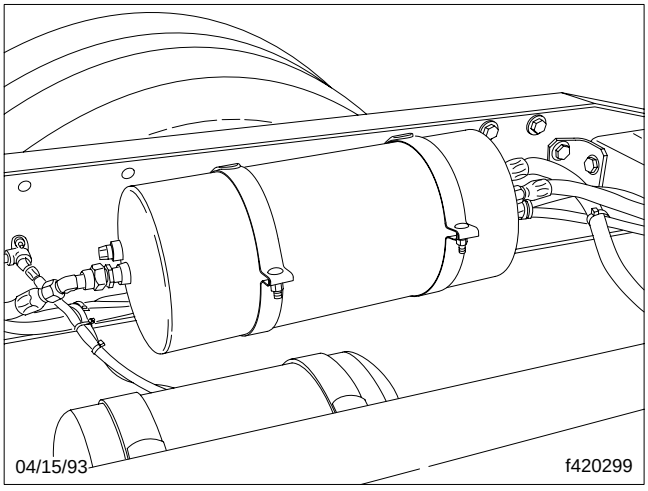


Fig. 1, Air Reservoir, Two-Piece Strap (in Frame Rail) Mounting

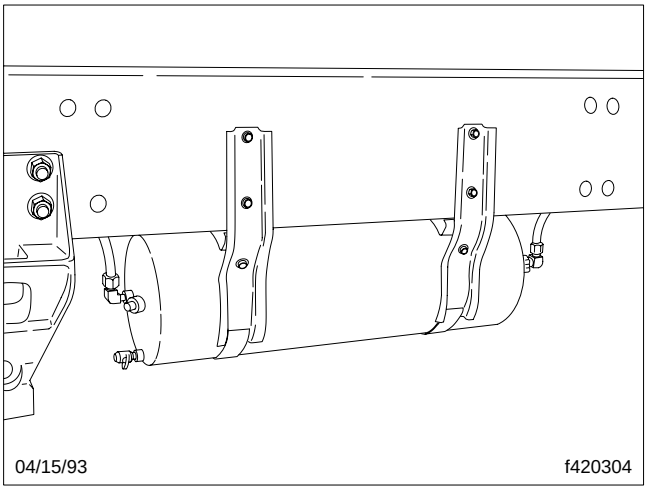


Fig. 2, Air Reservoir, One-Piece Strap (Under Frame Rail) Mounting

Internal Check Valve Replacement, Two-Chamber Air Reservoir

General Information

Contamination in two-chamber, wet/secondary, reservoirs may cause the internal check valve to become clogged or stuck closed. This can result in insufficient air buildup. If insufficient air buildup is noted, replace the check valve. If the check valve can not be removed (due to corrosion), it is acceptable to install a bypass line.

There are two styles of check valves that may have been installed in the tank. An internal check valve is threaded into the internal wall that separates the wet side and secondary side of the reservoir. Or a check valve is mounted in a port on the top surface of the reservoir.

Internal Check Valve Replacement (located in the separator wall of the reservoir)

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Drain the air reservoir.
3. Disconnect the air lines and remove the reservoir from the vehicle.
4. On the supply (wet) side of the reservoir, disconnect the pressure-protection valve, and the 90-degree elbow located on the end of the reservoir.

⚠ CAUTION

Take care not to drop the check valve into the reservoir when removing or installing it. The reservoir can not be used if the check valve is lost in it. A loose check valve could scratch the teflon coating of the interior of the reservoir, causing it to corrode. If the check valve is not recoverable, replace the reservoir.

5. The check valve is located on the interior wall that separates the sides of the reservoir. To reach it, use a 1/4-inch drive, 1/2-inch deep-well socket with a 1/4- to 3/8-inch drive adapter, and necessary 3/8-inch extensions to reach the valve. Tape the socket and extensions, to ensure the valve will stay in the socket, and that the wrench assembly will stay together inside the tank. Insert the socket assembly through the end port of the reservoir, and remove the valve. See **Fig. 1** and **Fig. 2**.

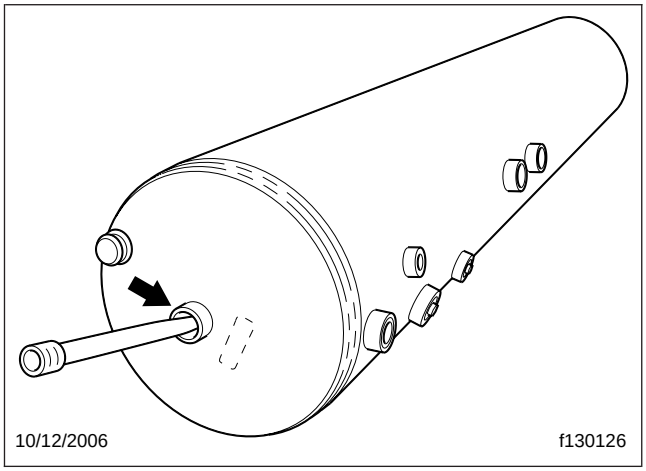
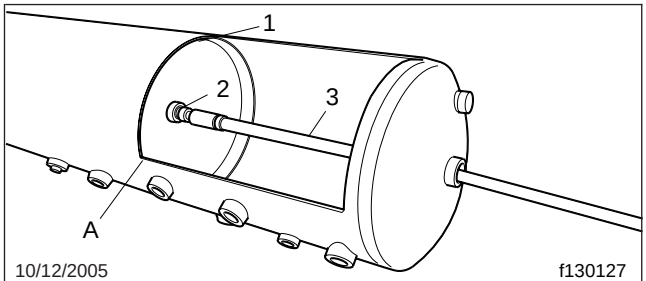


Fig. 1, Accessing the Internal Check Valve



A. Tank cut away for clarity.
1. Interior Wall
2. Check Valve
3. Socket with Extension

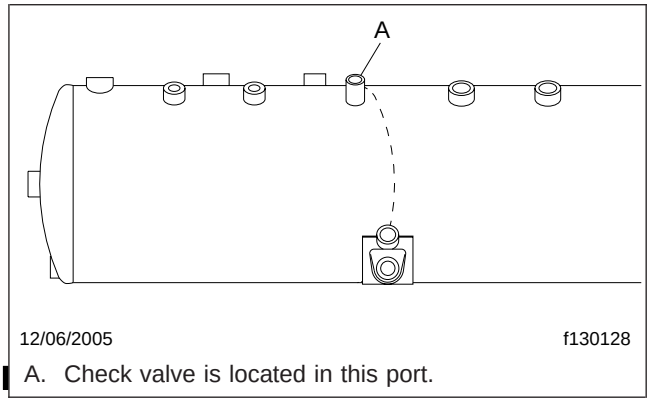
Fig. 2, Cutaway View of Split Air Reservoir

6. Install a new check valve.
7. Attach the pressure-protection valve and the 90-degree elbow.
8. Install the reservoir on the vehicle and attach the air lines.
9. Charge the air system and inspect for leaks.
10. Remove the chocks from the tires.

Internal Check Valve Replacement

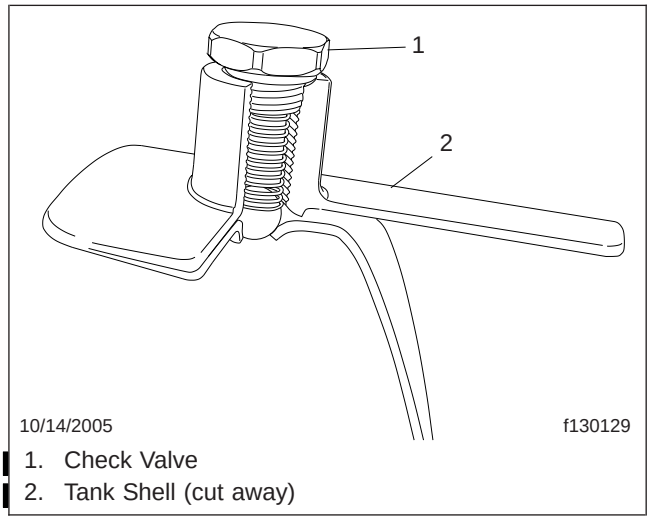
Internal Check Valve Replacement (located in the side port of the reservoir)

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Drain the air reservoir.
3. Remove the check valve assembly from the top port on the reservoir. See **Fig. 3** and **Fig. 4**.



A. Check valve is located in this port.

Fig. 3, Check Valve Location



1. Check Valve
2. Tank Shell (cut away)

Fig. 4, Cutaway View of the Check Valve Installation

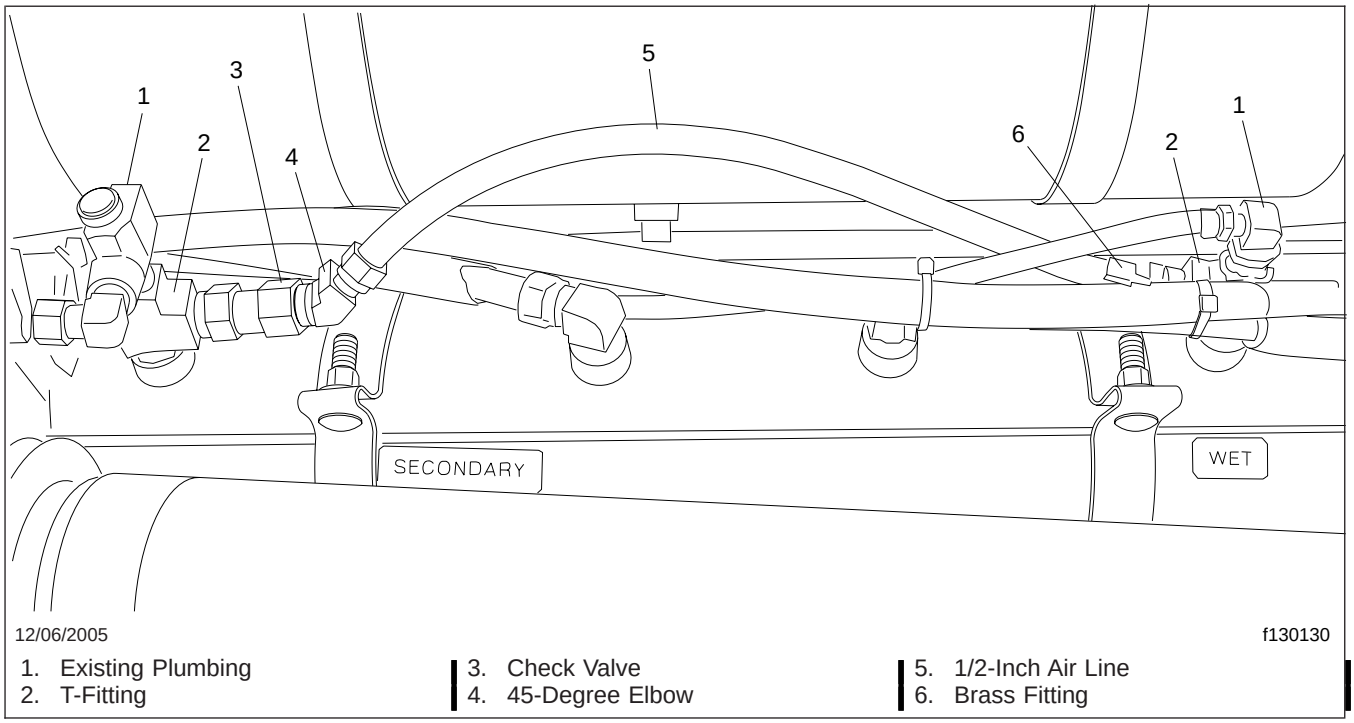
4. Install a new check valve.
5. Charge the air system and inspect for leaks.
6. Remove the chocks from the tires.

Internal Check Valve Bypass Line Installation

Check with the PDC for the appropriate bypass line kit for your vehicle.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Drain the air reservoir.
3. On the top port on both sides of the reservoir, disconnect the existing plumbing from the tank. Install a T-fitting, and connect the existing plumbing to the top port of the T-fitting. See **Fig. 5**.
4. On the secondary (dry) side of the reservoir, on the side port of the T-fitting, install a check valve, then a 45-degree elbow.
5. On the supply (wet) side of the reservoir, on the side port of the T-fitting, install the straight brass fitting.
6. Install a 1/2-inch air line between the 45-degree elbow on the secondary (dry) side, and the brass fitting on the supply (wet) side.
7. Charge the air system and inspect for leaks.
8. Remove the chocks from the tires.

Internal Check Valve Replacement



1. Existing Plumbing
2. T-Fitting
3. Check Valve
4. 45-Degree Elbow
5. 1/2-Inch Air Line
6. Brass Fitting

Fig. 5, Internal Check Valve Bypass

See Fig. 1 for a full view of the plumbing diagram wire braid hose in chassis, with hand valve, date of use 4/88 to 4/91. **See Fig. 2**, or **Fig. 3** for partial (detailed) views plumbing diagram wire braid hose in chassis, with hand valve, date of use 4/88 to 4/91.

See Fig. 4 for a full view of the plumbing diagram nylon tube in chassis, with hand valve, date of use 4/88 to 4/91. **See Fig. 5**, or **Fig. 6**, for partial (detailed) views of plumbing diagram nylon tube in chassis, with hand valve, date of use 4/88 to 4/91.

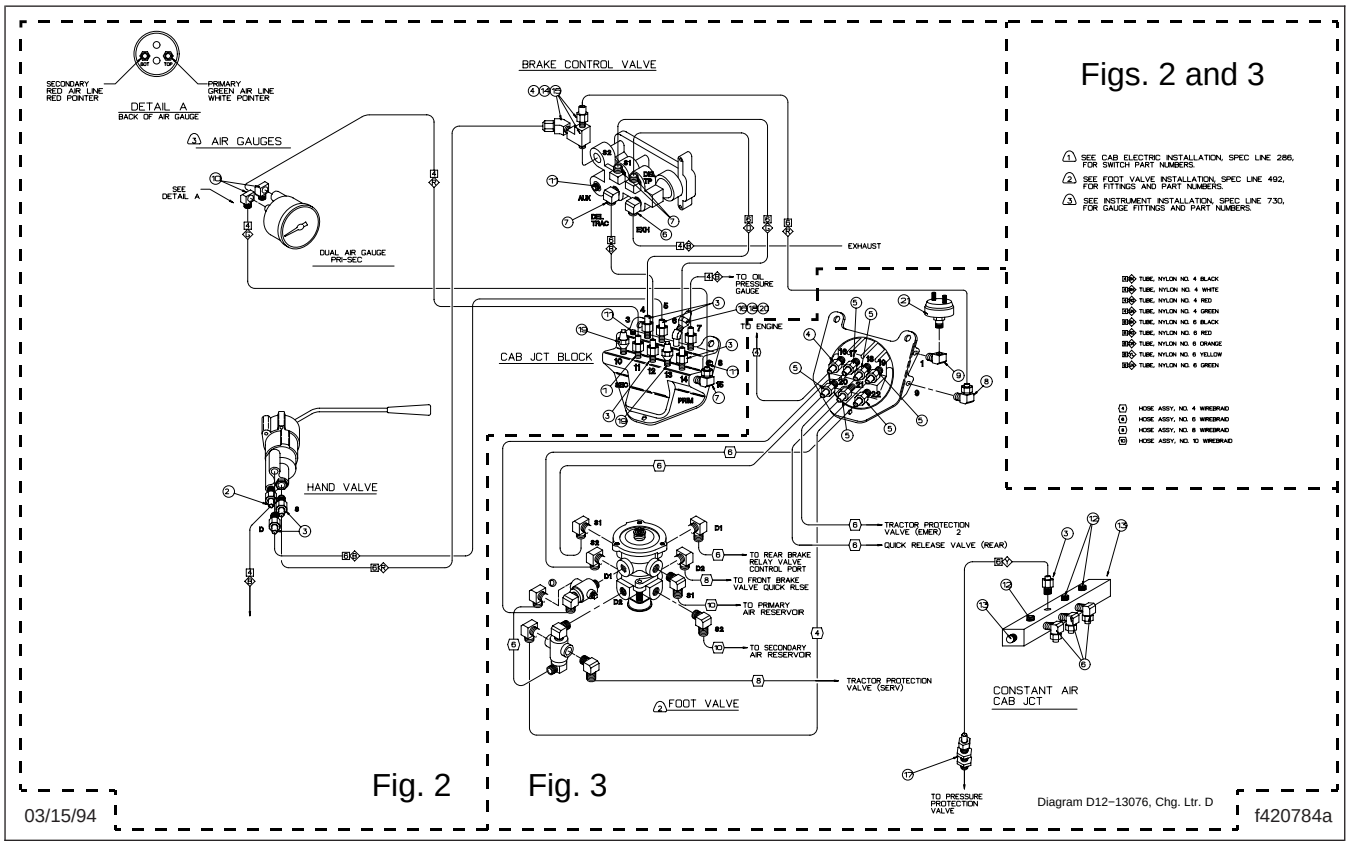


Fig. 1, Wire Braid Hose in Chassis, With Hand Valve, Date of Use 4/88 to 4/91

See Fig. 7 for a full view of the plumbing diagram wire braid hose in chassis, without hand valve, date of use 4/88 to 4/91. **See Fig. 8**, or **Fig. 9** for partial (detailed) views of plumbing diagram wire braid hose in chassis, without hand valve, date of use 4/88 to 4/91.

See Fig. 10 for a full view of the plumbing diagram nylon tube in chassis, without hand valve, date of use 4/88 to 4/91. **See Fig. 11**, or **Fig. 12** for partial (detailed) views of plumbing diagram nylon tube in chassis, without hand valve, date of use 4/88 to 4/91.

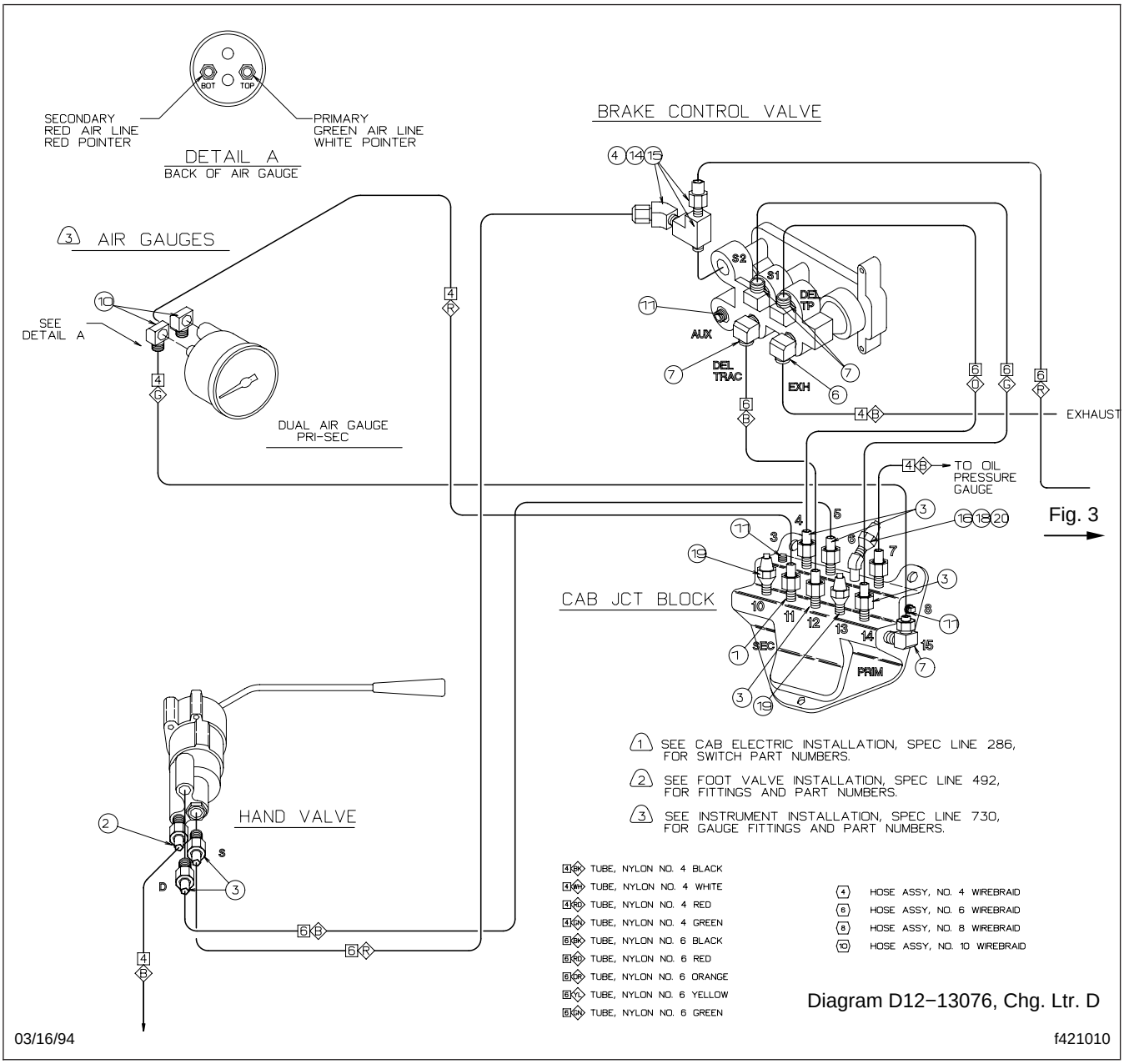

BOT
TOP
SECONDARY
RED AIR LINE
RED POINTER
PRIMARY
GREEN AIR LINE
WHITE POINTER
DETAIL A
BACK OF AIR GAUGE
BRAKE CONTROL VALVE
AIR GAUGES
SEE
DETAIL A
DUAL AIR GAUGE
PRI-SEC
S2
S1
DEL
TP
AUX
DEL
TRAC
EXH
EXHAUST
TO OIL
PRESSURE
GAUGE
Fig. 3
CAB JCT BLOCK
SEC
PRIM
HAND VALVE
1 SEE CAB ELECTRIC INSTALLATION, SPEC LINE 286, FOR SWITCH PART NUMBERS.
2 SEE FOOT VALVE INSTALLATION, SPEC LINE 492, FOR FITTINGS AND PART NUMBERS.
3 SEE INSTRUMENT INSTALLATION, SPEC LINE 730, FOR GAUGE FITTINGS AND PART NUMBERS.
4BK TUBE, NYLON NO. 4 BLACK
4WH TUBE, NYLON NO. 4 WHITE
4RD TUBE, NYLON NO. 4 RED
4GN TUBE, NYLON NO. 4 GREEN
6BK TUBE, NYLON NO. 6 BLACK
6RD TUBE, NYLON NO. 6 RED
6OR TUBE, NYLON NO. 6 ORANGE
6YL TUBE, NYLON NO. 6 YELLOW
6GN TUBE, NYLON NO. 6 GREEN
4 HOSE ASSY, NO. 4 WIREBRAID
6 HOSE ASSY, NO. 6 WIREBRAID
8 HOSE ASSY, NO. 8 WIREBRAID
10 HOSE ASSY, NO. 10 WIREBRAID
Diagram D12−13076, Chg. Ltr. D
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Fig. 2

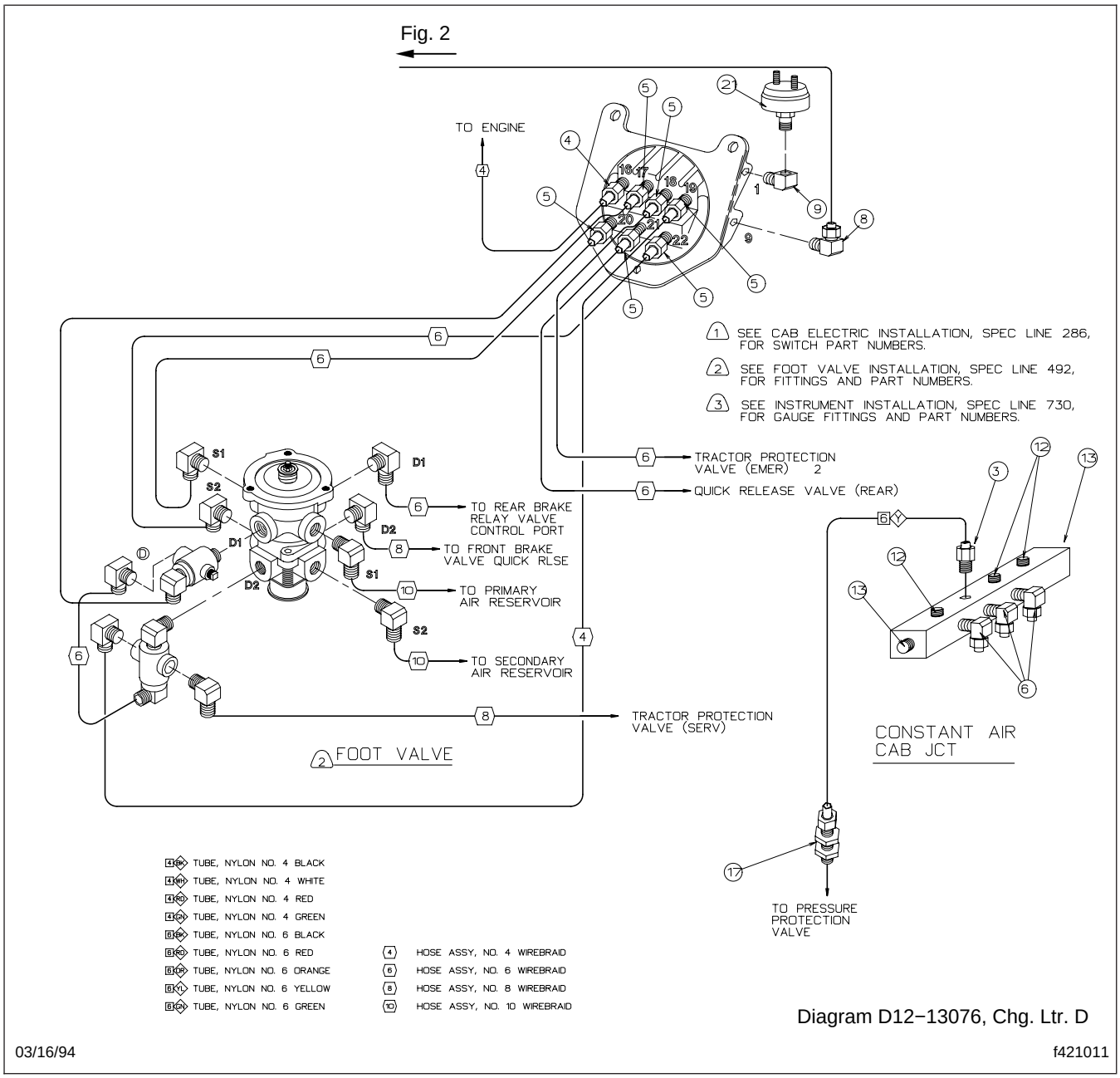
Fig. 2
TO ENGINE
1 SEE CAB ELECTRIC INSTALLATION, SPEC LINE 286, FOR SWITCH PART NUMBERS.
2 SEE FOOT VALVE INSTALLATION, SPEC LINE 492, FOR FITTINGS AND PART NUMBERS.
3 SEE INSTRUMENT INSTALLATION, SPEC LINE 730, FOR GAUGE FITTINGS AND PART NUMBERS.
TRACTOR PROTECTION VALVE (EMER) 2
QUICK RELEASE VALVE (REAR)
TO REAR BRAKE RELAY VALVE CONTROL PORT
TO FRONT BRAKE VALVE QUICK RLSE
TO PRIMARY AIR RESERVOIR
TO SECONDARY AIR RESERVOIR
TRACTOR PROTECTION VALVE (SERV)
FOOT VALVE
CONSTANT AIR CAB JCT
TO PRESSURE PROTECTION VALVE
TUBE, NYLON NO. 4 BLACK
TUBE, NYLON NO. 4 WHITE
TUBE, NYLON NO. 4 RED
TUBE, NYLON NO. 4 GREEN
TUBE, NYLON NO. 6 BLACK
TUBE, NYLON NO. 6 RED
TUBE, NYLON NO. 6 ORANGE
TUBE, NYLON NO. 6 YELLOW
TUBE, NYLON NO. 6 GREEN
HOSE ASSY, NO. 4 WIREBRAID
HOSE ASSY, NO. 6 WIREBRAID
HOSE ASSY, NO. 8 WIREBRAID
HOSE ASSY, NO. 10 WIREBRAID
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Fig. 3

COE

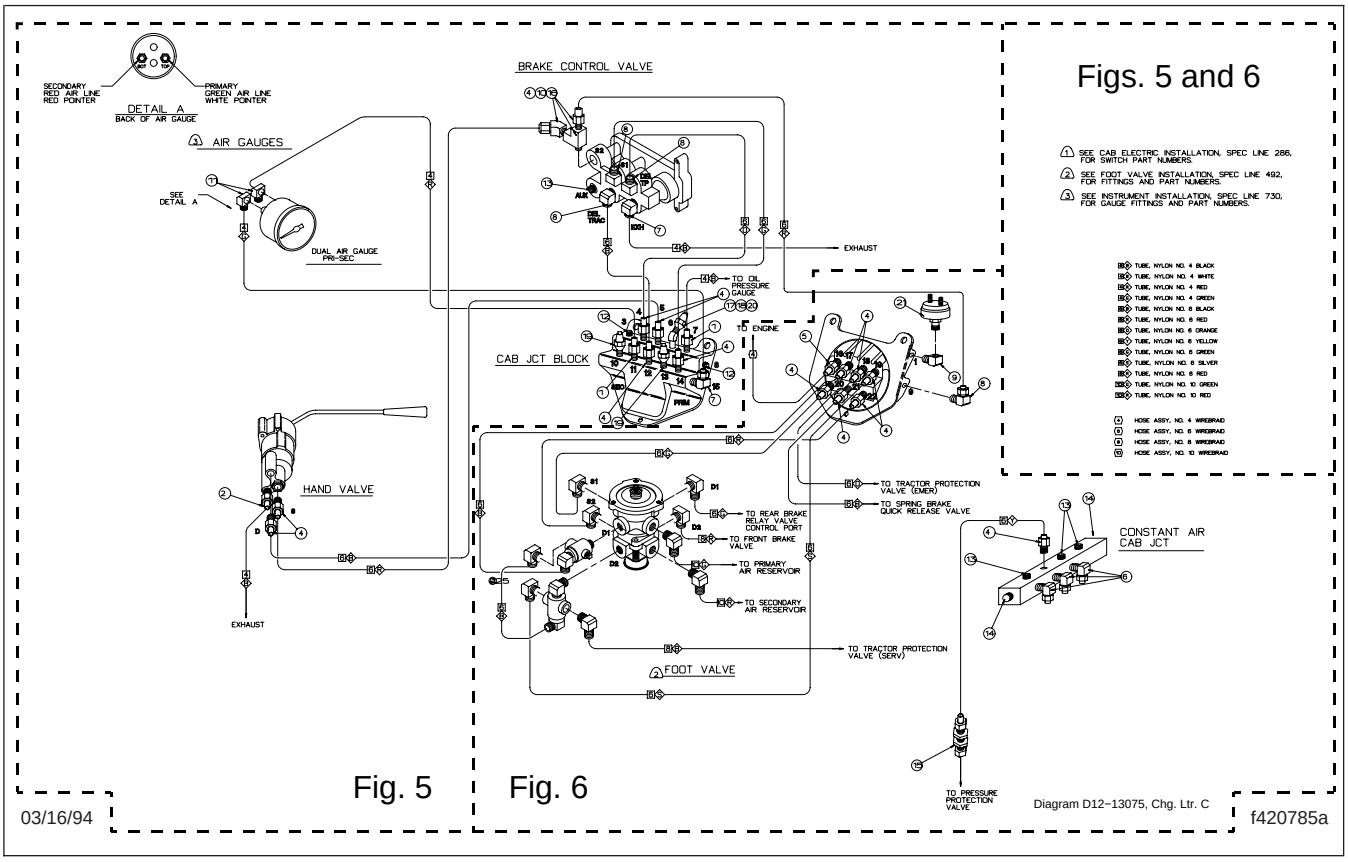

Fig. 4, Nylon Tube in Chassis, With Hand Valve, Date of Use 4/88 to 4/91

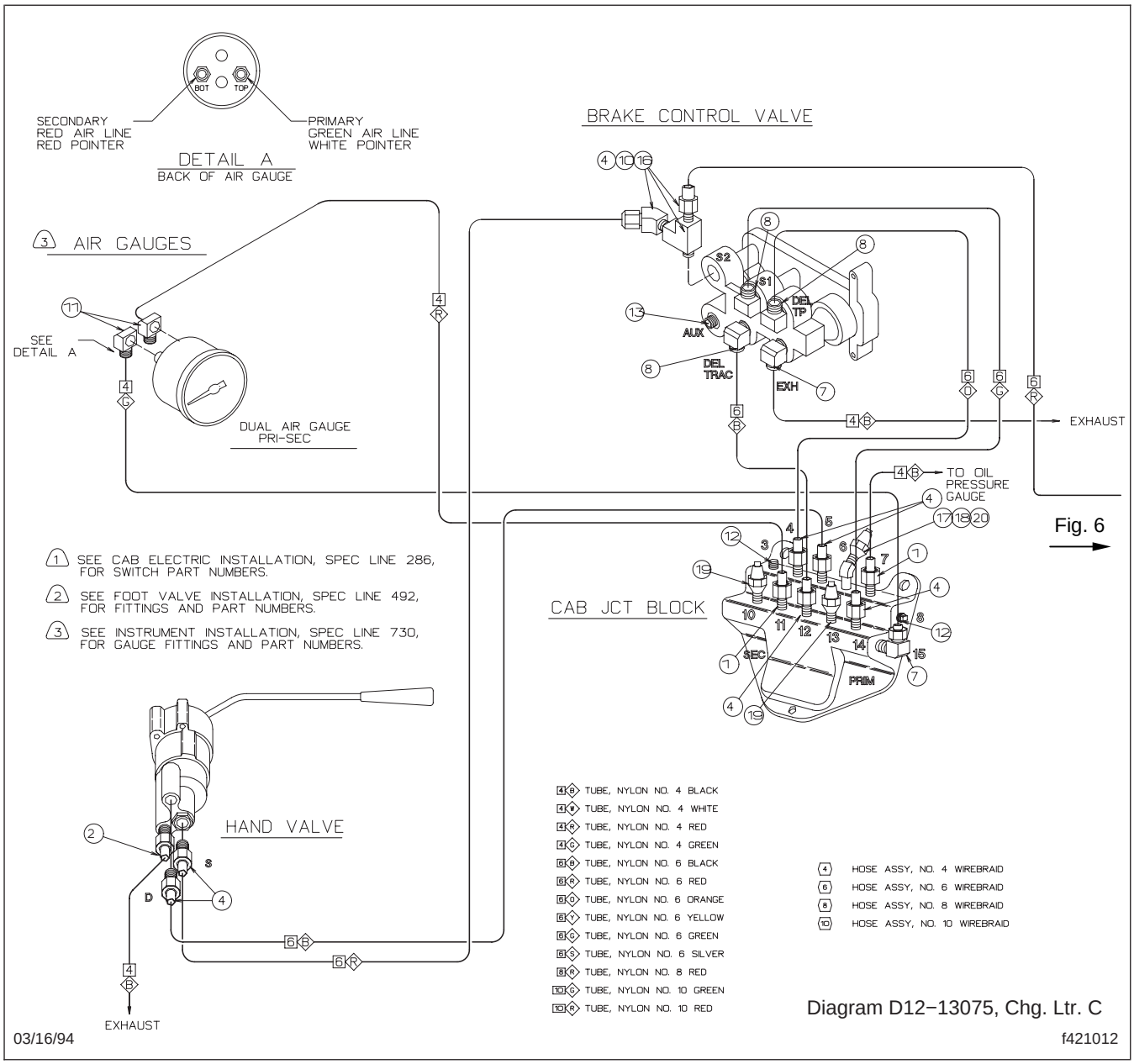
BOT
TOP
SECONDARY
RED AIR LINE
RED POINTER
PRIMARY
GREEN AIR LINE
WHITE POINTER
DETAIL A
BACK OF AIR GAUGE
BRAKE CONTROL VALVE
AIR GAUGES
SEE
DETAIL A
DUAL AIR GAUGE
PRI-SEC
S2
S1
DEL
TP
AUX
DEL
TRAC
EXH
EXHAUST
TO OIL
PRESSURE
GAUGE
CAB JCT BLOCK
SEC
PRIM
HAND VALVE
EXHAUST
1 SEE CAB ELECTRIC INSTALLATION, SPEC LINE 286, FOR SWITCH PART NUMBERS.
2 SEE FOOT VALVE INSTALLATION, SPEC LINE 492, FOR FITTINGS AND PART NUMBERS.
3 SEE INSTRUMENT INSTALLATION, SPEC LINE 730, FOR GAUGE FITTINGS AND PART NUMBERS.
TUBE, NYLON NO. 4 BLACK
TUBE, NYLON NO. 4 WHITE
TUBE, NYLON NO. 4 RED
TUBE, NYLON NO. 4 GREEN
TUBE, NYLON NO. 6 BLACK
TUBE, NYLON NO. 6 RED
TUBE, NYLON NO. 6 ORANGE
TUBE, NYLON NO. 6 YELLOW
TUBE, NYLON NO. 6 GREEN
TUBE, NYLON NO. 6 SILVER
TUBE, NYLON NO. 8 RED
TUBE, NYLON NO. 10 GREEN
TUBE, NYLON NO. 10 RED
HOSE ASSY, NO. 4 WIREBRAID
HOSE ASSY, NO. 6 WIREBRAID
HOSE ASSY, NO. 8 WIREBRAID
HOSE ASSY, NO. 10 WIREBRAID
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Fig. 6

Fig. 5

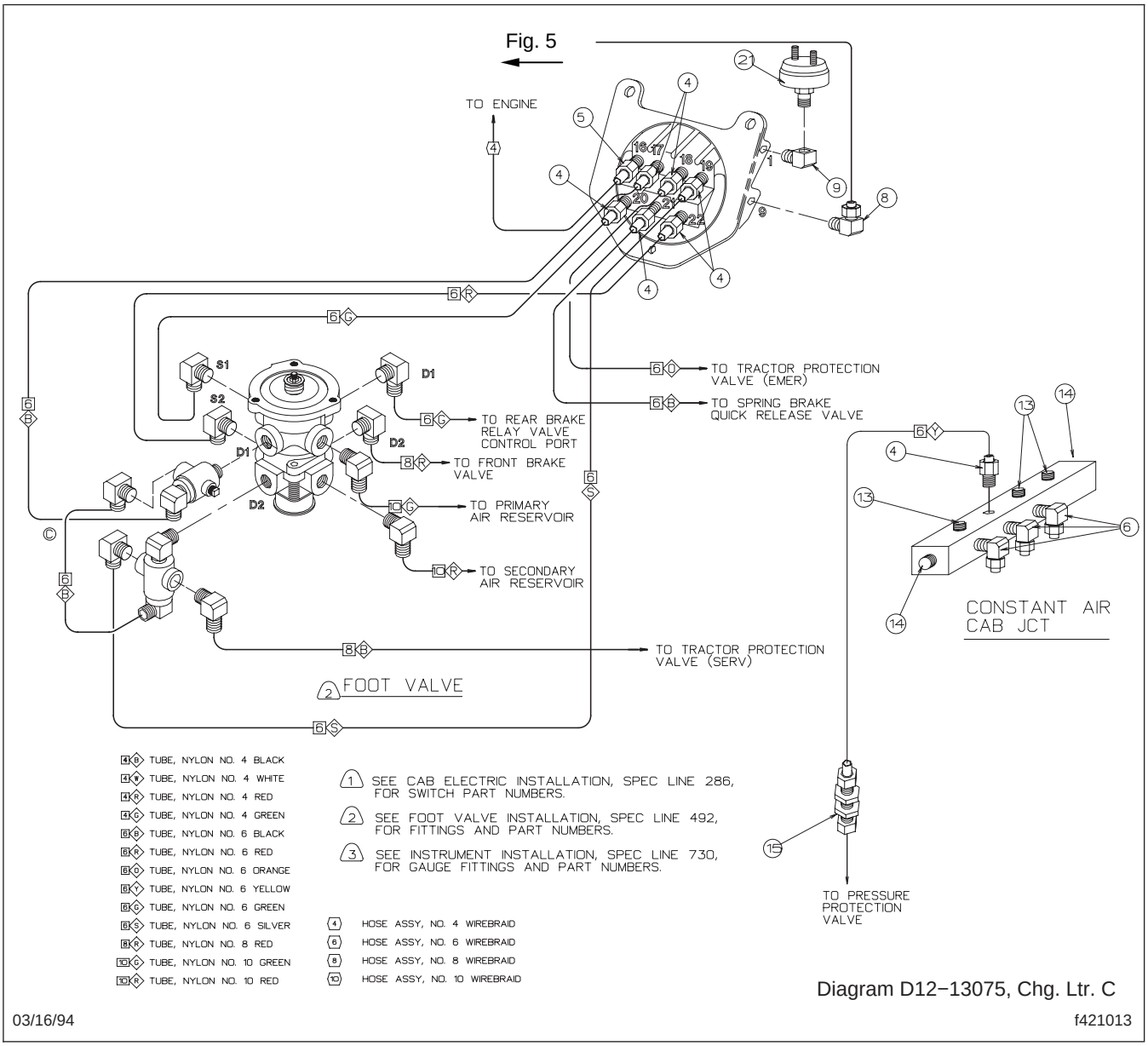
Fig. 5
TO ENGINE
TO TRACTOR PROTECTION VALVE (EMER)
TO SPRING BRAKE QUICK RELEASE VALVE
TO REAR BRAKE RELAY VALVE CONTROL PORT
TO FRONT BRAKE VALVE
TO PRIMARY AIR RESERVOIR
TO SECONDARY AIR RESERVOIR
TO TRACTOR PROTECTION VALVE (SERV)
2 FOOT VALVE
CONSTANT AIR CAB JCT
TO PRESSURE PROTECTION VALVE
S1
S2
D1
D2
TUBE, NYLON NO. 4 BLACK
TUBE, NYLON NO. 4 WHITE
TUBE, NYLON NO. 4 RED
TUBE, NYLON NO. 4 GREEN
TUBE, NYLON NO. 6 BLACK
TUBE, NYLON NO. 6 RED
TUBE, NYLON NO. 6 ORANGE
TUBE, NYLON NO. 6 YELLOW
TUBE, NYLON NO. 6 GREEN
TUBE, NYLON NO. 6 SILVER
TUBE, NYLON NO. 8 RED
TUBE, NYLON NO. 10 GREEN
TUBE, NYLON NO. 10 RED
1 SEE CAB ELECTRIC INSTALLATION, SPEC LINE 286, FOR SWITCH PART NUMBERS.
2 SEE FOOT VALVE INSTALLATION, SPEC LINE 492, FOR FITTINGS AND PART NUMBERS.
3 SEE INSTRUMENT INSTALLATION, SPEC LINE 730, FOR GAUGE FITTINGS AND PART NUMBERS.
4 HOSE ASSY, NO. 4 WIREBRAID
6 HOSE ASSY, NO. 6 WIREBRAID
8 HOSE ASSY, NO. 8 WIREBRAID
10 HOSE ASSY, NO. 10 WIREBRAID
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Fig. 6

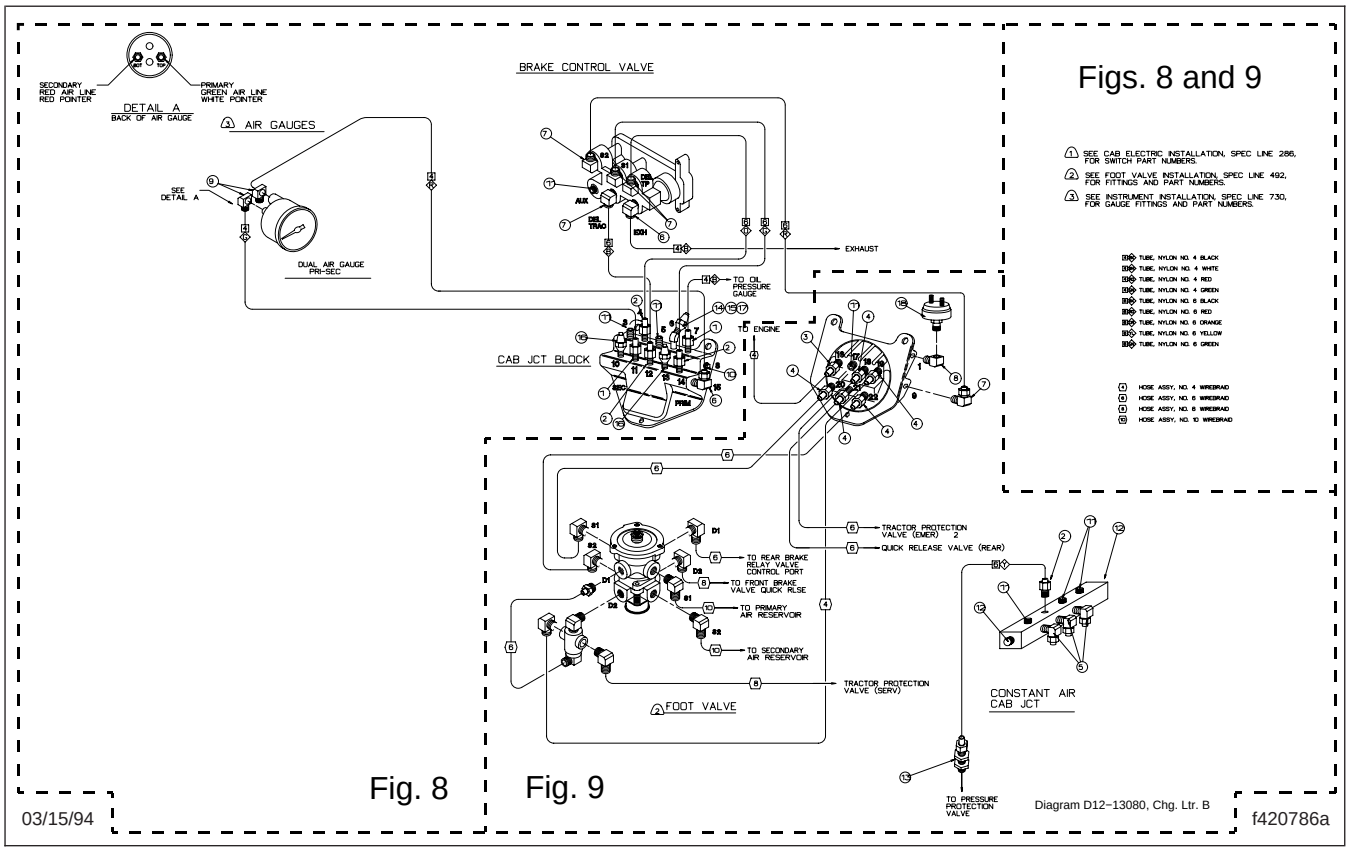


Fig. 7, Wire Braid Hose in Chassis, Without Hand Valve, Date of Use 4/88 to 4/91

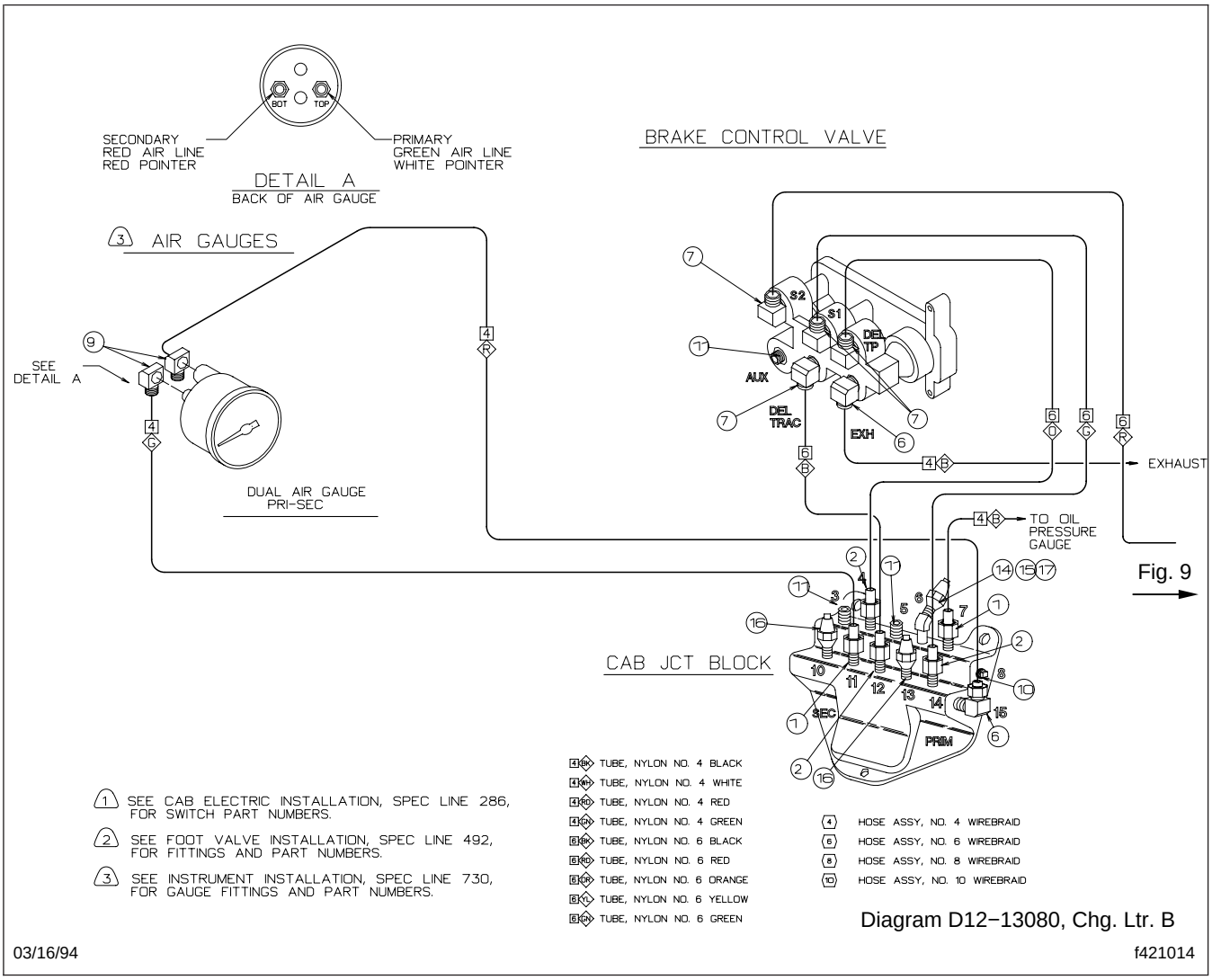

BOT
TOP
SECONDARY
RED AIR LINE
RED POINTER
PRIMARY
GREEN AIR LINE
WHITE POINTER
DETAIL A
BACK OF AIR GAUGE
BRAKE CONTROL VALVE
3 AIR GAUGES
SEE
DETAIL A
DUAL AIR GAUGE
PRI-SEC
S2
S1
DEL
TP
AUX
DEL
TRAC
EXH
EXHAUST
TO OIL
PRESSURE
GAUGE
CAB JCT BLOCK
SEC
PRIM
Fig. 9
1 SEE CAB ELECTRIC INSTALLATION, SPEC LINE 286, FOR SWITCH PART NUMBERS.
2 SEE FOOT VALVE INSTALLATION, SPEC LINE 492, FOR FITTINGS AND PART NUMBERS.
3 SEE INSTRUMENT INSTALLATION, SPEC LINE 730, FOR GAUGE FITTINGS AND PART NUMBERS.
4BK TUBE, NYLON NO. 4 BLACK
4WH TUBE, NYLON NO. 4 WHITE
4RD TUBE, NYLON NO. 4 RED
4GN TUBE, NYLON NO. 4 GREEN
6BK TUBE, NYLON NO. 6 BLACK
6RD TUBE, NYLON NO. 6 RED
6OR TUBE, NYLON NO. 6 ORANGE
6YL TUBE, NYLON NO. 6 YELLOW
6GN TUBE, NYLON NO. 6 GREEN
4 HOSE ASSY, NO. 4 WIREBRAID
6 HOSE ASSY, NO. 6 WIREBRAID
8 HOSE ASSY, NO. 8 WIREBRAID
10 HOSE ASSY, NO. 10 WIREBRAID
Diagram D12−13080, Chg. Ltr. B
03/16/94
f421014

Fig. 8

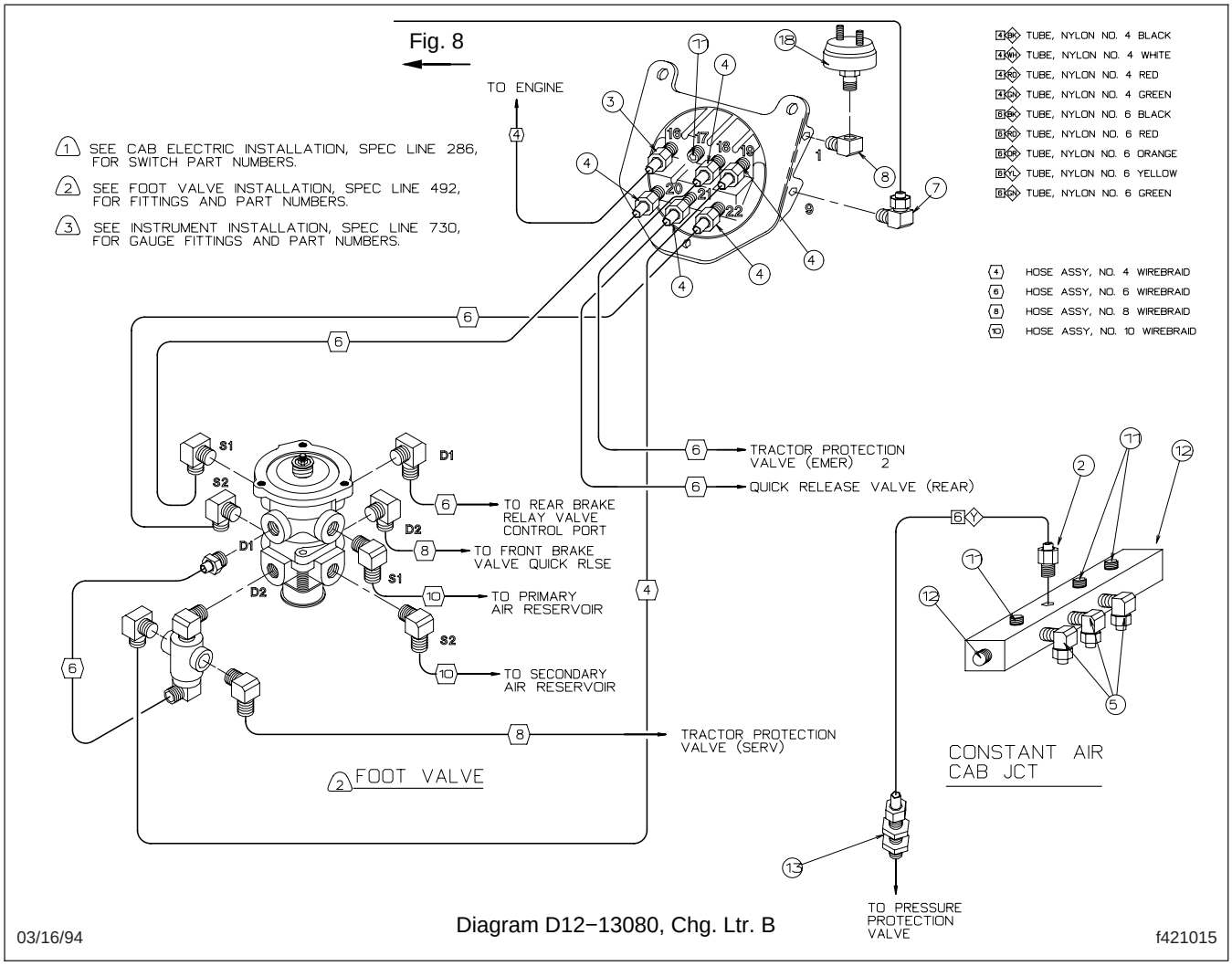


Fig. 8
TO ENGINE
1 SEE CAB ELECTRIC INSTALLATION, SPEC LINE 286, FOR SWITCH PART NUMBERS.
2 SEE FOOT VALVE INSTALLATION, SPEC LINE 492, FOR FITTINGS AND PART NUMBERS.
3 SEE INSTRUMENT INSTALLATION, SPEC LINE 730, FOR GAUGE FITTINGS AND PART NUMBERS.
4 TUBE, NYLON NO. 4 BLACK
4 TUBE, NYLON NO. 4 WHITE
4 TUBE, NYLON NO. 4 RED
4 TUBE, NYLON NO. 4 GREEN
6 TUBE, NYLON NO. 6 BLACK
6 TUBE, NYLON NO. 6 RED
6 TUBE, NYLON NO. 6 ORANGE
6 TUBE, NYLON NO. 6 YELLOW
6 TUBE, NYLON NO. 6 GREEN
4 HOSE ASSY, NO. 4 WIREBRAID
6 HOSE ASSY, NO. 6 WIREBRAID
8 HOSE ASSY, NO. 8 WIREBRAID
10 HOSE ASSY, NO. 10 WIREBRAID
TRACTOR PROTECTION VALVE (EMER) 2
QUICK RELEASE VALVE (REAR)
TO REAR BRAKE RELAY VALVE CONTROL PORT
TO FRONT BRAKE VALVE QUICK RLSE
TO PRIMARY AIR RESERVOIR
TO SECONDARY AIR RESERVOIR
TRACTOR PROTECTION VALVE (SERV)
2 FOOT VALVE
CONSTANT AIR CAB JCT
TO PRESSURE PROTECTION VALVE
S1
S2
D1
D2
03/16/94
Diagram D12−13080, Chg. Ltr. B
f421015

Fig. 9

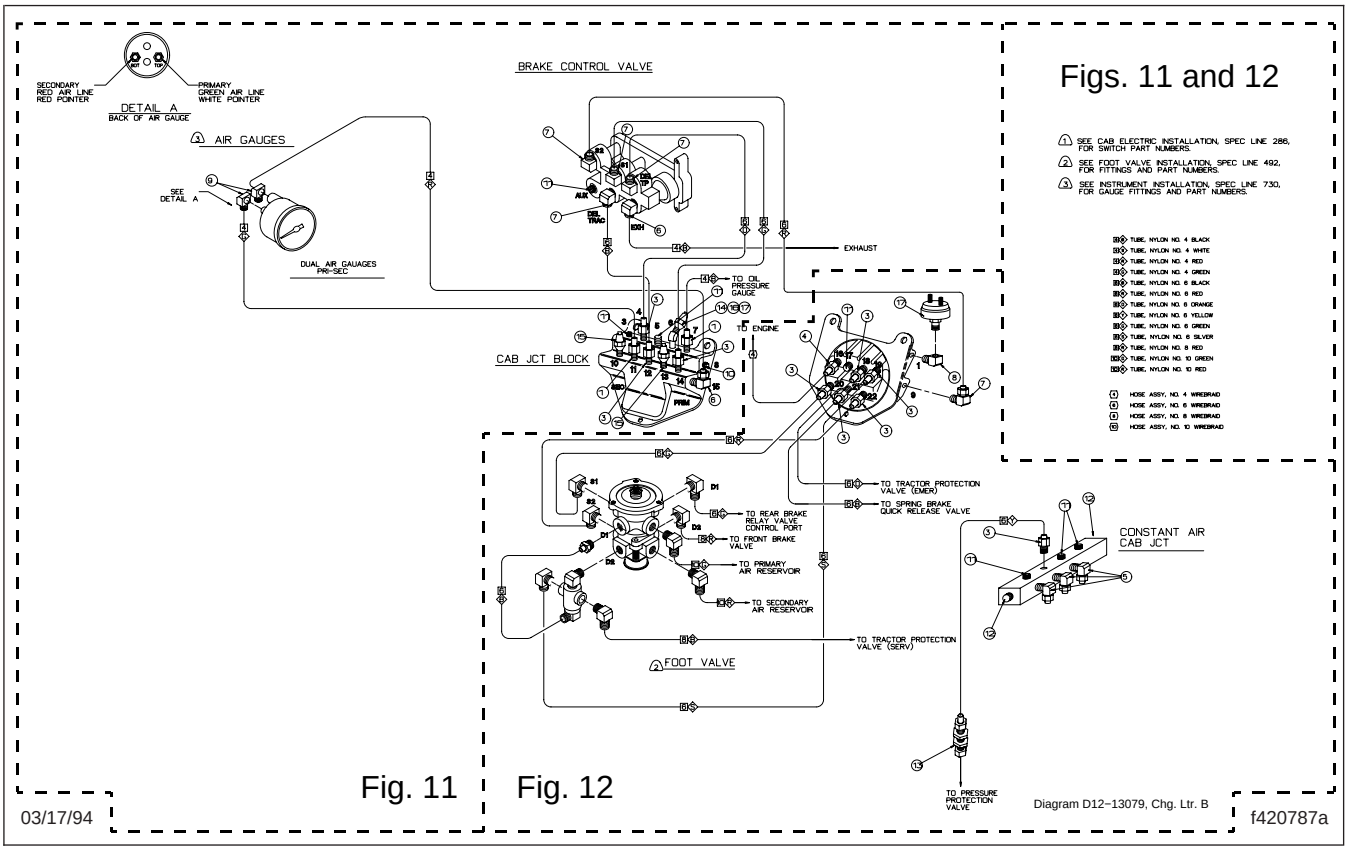


Fig. 10, Nylon Tube in Chassis, Without Hand Valve, Date of Use 4/88 to 4/91

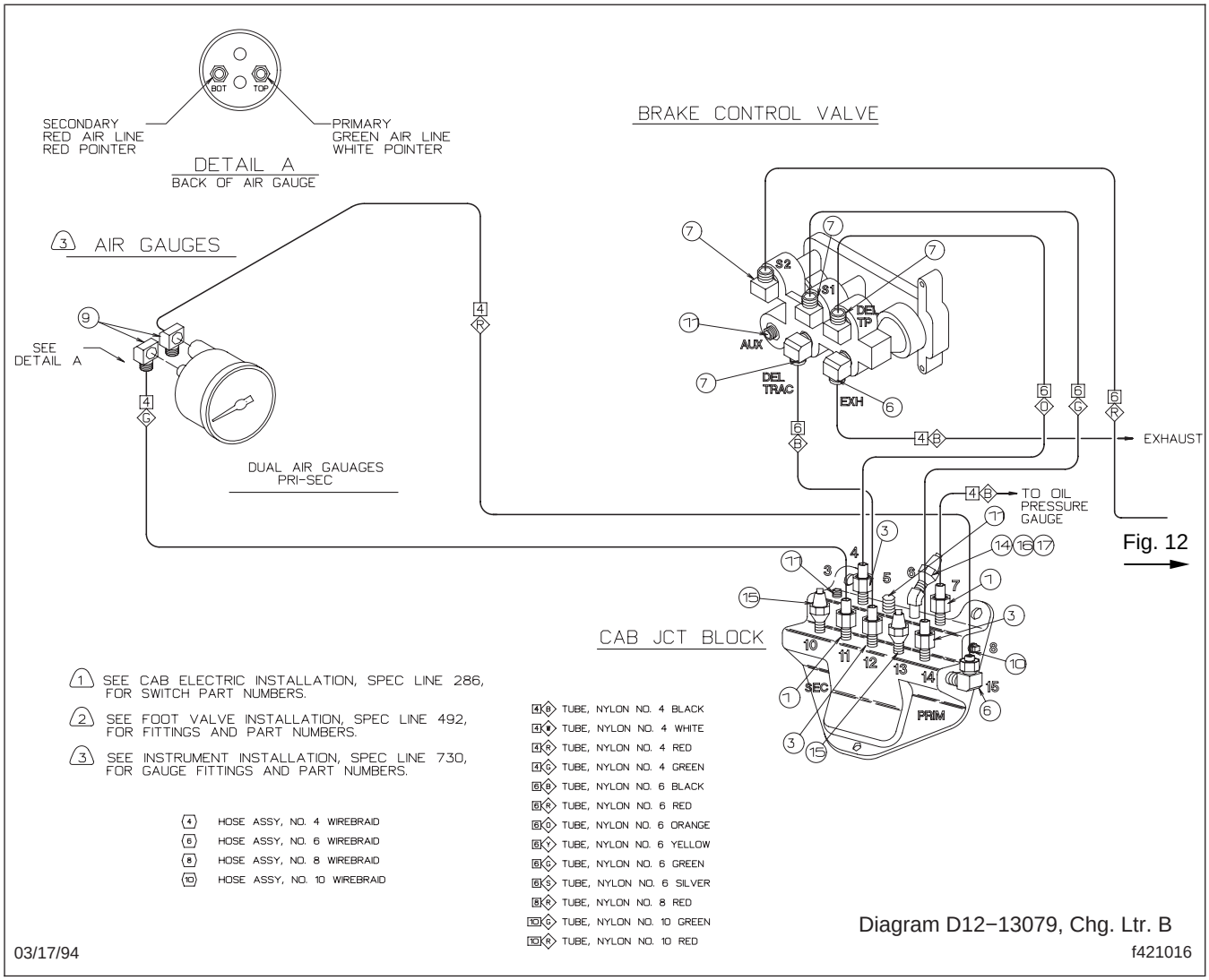

BOT
TOP
SECONDARY
RED AIR LINE
RED POINTER
PRIMARY
GREEN AIR LINE
WHITE POINTER
DETAIL A
BACK OF AIR GAUGE
BRAKE CONTROL VALVE
3 AIR GAUGES
SEE
DETAIL A
DUAL AIR GAUAGES
PRI-SEC
S2
S1
DEL
TP
AUX
DEL
TRAC
EXH
EXHAUST
TO OIL
PRESSURE
GAUGE
CAB JCT BLOCK
SEC
PRIM
Fig. 12
1 SEE CAB ELECTRIC INSTALLATION, SPEC LINE 286, FOR SWITCH PART NUMBERS.
2 SEE FOOT VALVE INSTALLATION, SPEC LINE 492, FOR FITTINGS AND PART NUMBERS.
3 SEE INSTRUMENT INSTALLATION, SPEC LINE 730, FOR GAUGE FITTINGS AND PART NUMBERS.
4 HOSE ASSY, NO. 4 WIREBRAID
6 HOSE ASSY, NO. 6 WIREBRAID
8 HOSE ASSY, NO. 8 WIREBRAID
10 HOSE ASSY, NO. 10 WIREBRAID
4B TUBE, NYLON NO. 4 BLACK
4W TUBE, NYLON NO. 4 WHITE
4R TUBE, NYLON NO. 4 RED
4G TUBE, NYLON NO. 4 GREEN
6B TUBE, NYLON NO. 6 BLACK
6R TUBE, NYLON NO. 6 RED
6O TUBE, NYLON NO. 6 ORANGE
6Y TUBE, NYLON NO. 6 YELLOW
6G TUBE, NYLON NO. 6 GREEN
6S TUBE, NYLON NO. 6 SILVER
8R TUBE, NYLON NO. 8 RED
10G TUBE, NYLON NO. 10 GREEN
10R TUBE, NYLON NO. 10 RED
Diagram D12−13079, Chg. Ltr. B
03/17/94
f421016

Fig. 11

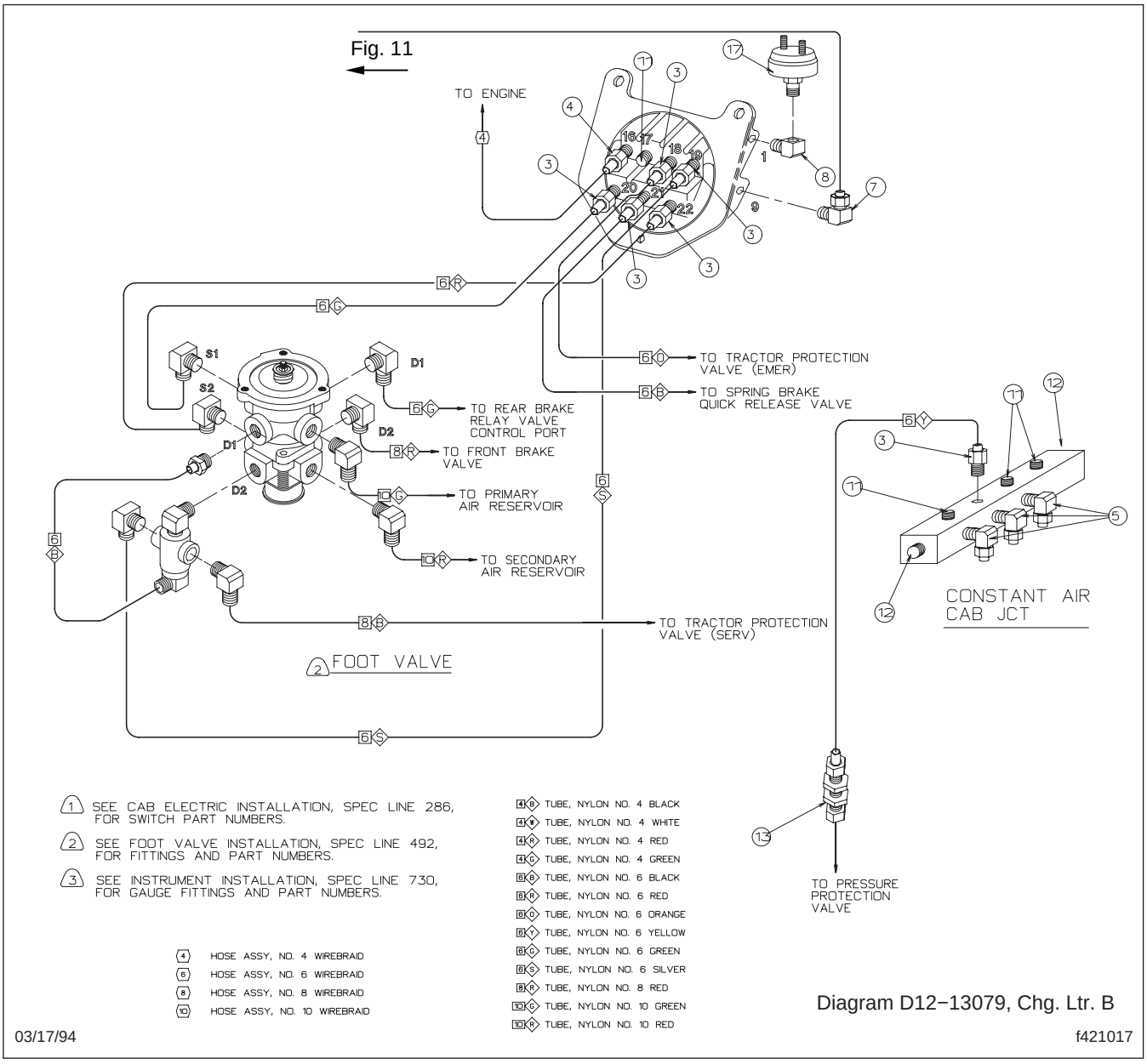


Fig. 11
TO ENGINE
TO TRACTOR PROTECTION VALVE (EMER)
TO SPRING BRAKE QUICK RELEASE VALVE
TO REAR BRAKE RELAY VALVE CONTROL PORT
TO FRONT BRAKE VALVE
TO PRIMARY AIR RESERVOIR
TO SECONDARY AIR RESERVOIR
TO TRACTOR PROTECTION VALVE (SERV)
FOOT VALVE
CONSTANT AIR CAB JCT
TO PRESSURE PROTECTION VALVE
S1
S2
D1
D2
1 SEE CAB ELECTRIC INSTALLATION, SPEC LINE 286, FOR SWITCH PART NUMBERS.
2 SEE FOOT VALVE INSTALLATION, SPEC LINE 492, FOR FITTINGS AND PART NUMBERS.
3 SEE INSTRUMENT INSTALLATION, SPEC LINE 730, FOR GAUGE FITTINGS AND PART NUMBERS.
4 HOSE ASSY, NO. 4 WIREBRAID
6 HOSE ASSY, NO. 6 WIREBRAID
8 HOSE ASSY, NO. 8 WIREBRAID
10 HOSE ASSY, NO. 10 WIREBRAID
4B TUBE, NYLON NO. 4 BLACK
4W TUBE, NYLON NO. 4 WHITE
4R TUBE, NYLON NO. 4 RED
4G TUBE, NYLON NO. 4 GREEN
6B TUBE, NYLON NO. 6 BLACK
6R TUBE, NYLON NO. 6 RED
6O TUBE, NYLON NO. 6 ORANGE
6Y TUBE, NYLON NO. 6 YELLOW
6G TUBE, NYLON NO. 6 GREEN
6S TUBE, NYLON NO. 6 SILVER
8R TUBE, NYLON NO. 8 RED
10G TUBE, NYLON NO. 10 GREEN
10R TUBE, NYLON NO. 10 RED
Diagram D12−13079, Chg. Ltr. B
03/17/94
f421017

Fig. 12

See Fig. 1 for a full view of the plumbing diagram wire braid hose in chassis, with hand valve, date of use 4/88 to 4/91. **See Fig. 2**, or **Fig. 3** for partial (detailed) views plumbing diagram wire braid hose in chassis, with hand valve, date of use 4/88 to 4/91.

See Fig. 4 for a full view of the plumbing diagram nylon tube in chassis, with hand valve, date of use 4/88 to 4/91. **See Fig. 5**, or **Fig. 6** for partial (detailed) views of plumbing diagram nylon tube in chassis, with hand valve, date of use 4/88 to 4/91.

See Fig. 7 for a full view of the plumbing diagram wire braid hose in chassis, without hand valve, date of use 4/88 to 4/91. **See Fig. 8**, or **Fig. 9** for partial (detailed) views of plumbing diagram wire braid hose in chassis, without hand valve, date of use 4/88 to 4/91.

(detailed) views of plumbing diagram nylon tube in chassis, without hand valve, date of use 4/88 to 4/91.

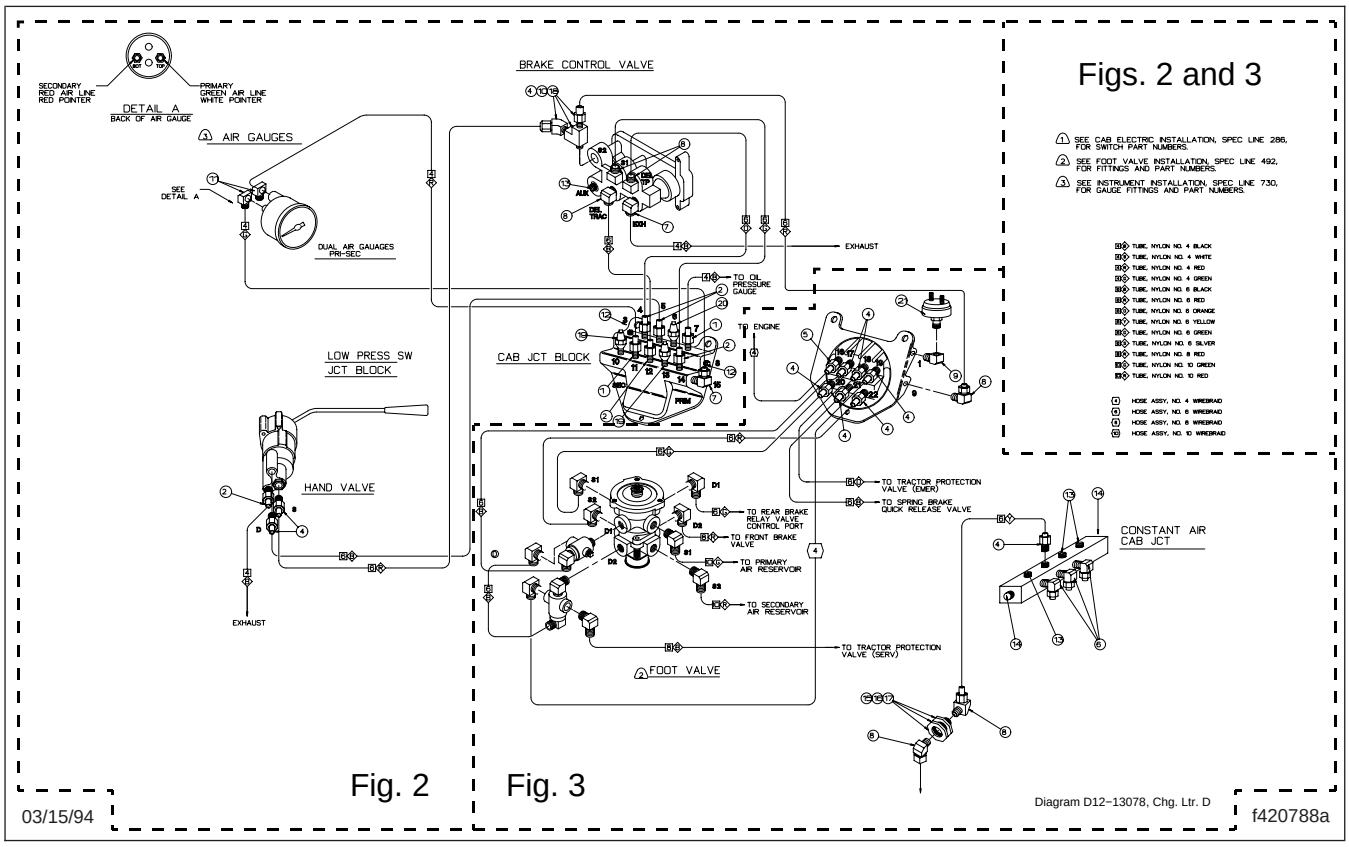


Fig. 1, Wire Braid Hose in Chassis, With Hand Valve, Date of Use 4/88 to 4/91

See Fig. 10 for a full view of the plumbing diagram nylon tube in chassis, without hand valve, date of use 4/88 to 4/91. **See Fig. 11**, or **Fig. 12** for partial

Conventional

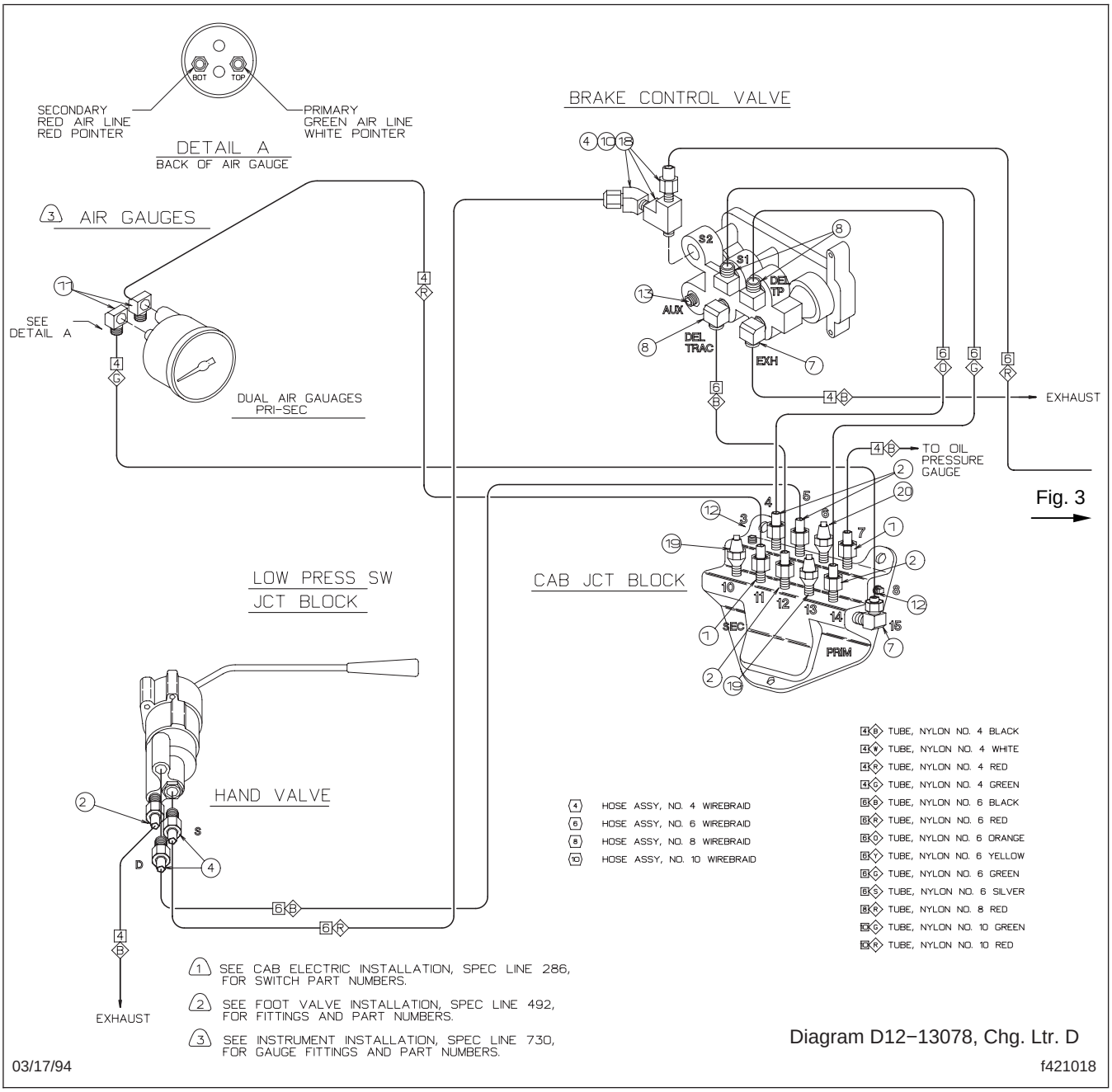


Fig. 2

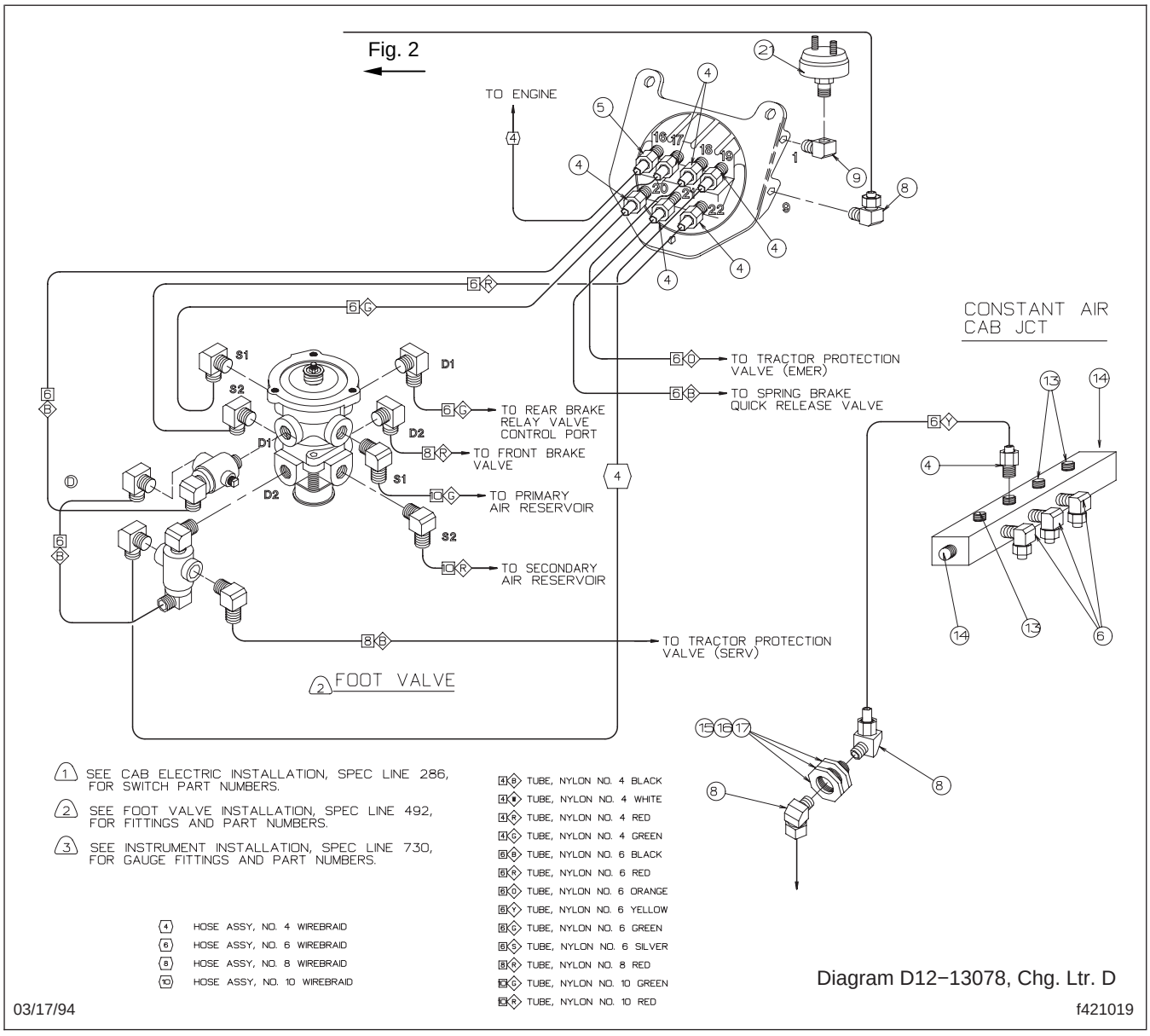


Fig. 2
TO ENGINE
CONSTANT AIR CAB JCT
TO TRACTOR PROTECTION VALVE (EMER)
TO SPRING BRAKE QUICK RELEASE VALVE
TO REAR BRAKE RELAY VALVE CONTROL PORT
TO FRONT BRAKE VALVE
TO PRIMARY AIR RESERVOIR
TO SECONDARY AIR RESERVOIR
TO TRACTOR PROTECTION VALVE (SERV)
2 FOOT VALVE
S1
S2
D1
D2
1 SEE CAB ELECTRIC INSTALLATION, SPEC LINE 286, FOR SWITCH PART NUMBERS.
2 SEE FOOT VALVE INSTALLATION, SPEC LINE 492, FOR FITTINGS AND PART NUMBERS.
3 SEE INSTRUMENT INSTALLATION, SPEC LINE 730, FOR GAUGE FITTINGS AND PART NUMBERS.
4 HOSE ASSY, NO. 4 WIREBRAID
6 HOSE ASSY, NO. 6 WIREBRAID
8 HOSE ASSY, NO. 8 WIREBRAID
10 HOSE ASSY, NO. 10 WIREBRAID
4B TUBE, NYLON NO. 4 BLACK
4W TUBE, NYLON NO. 4 WHITE
4R TUBE, NYLON NO. 4 RED
4G TUBE, NYLON NO. 4 GREEN
6B TUBE, NYLON NO. 6 BLACK
6R TUBE, NYLON NO. 6 RED
6O TUBE, NYLON NO. 6 ORANGE
6Y TUBE, NYLON NO. 6 YELLOW
6G TUBE, NYLON NO. 6 GREEN
6S TUBE, NYLON NO. 6 SILVER
8R TUBE, NYLON NO. 8 RED
10G TUBE, NYLON NO. 10 GREEN
10R TUBE, NYLON NO. 10 RED
Diagram D12−13078, Chg. Ltr. D
03/17/94
f421019

Fig. 3

Conventional

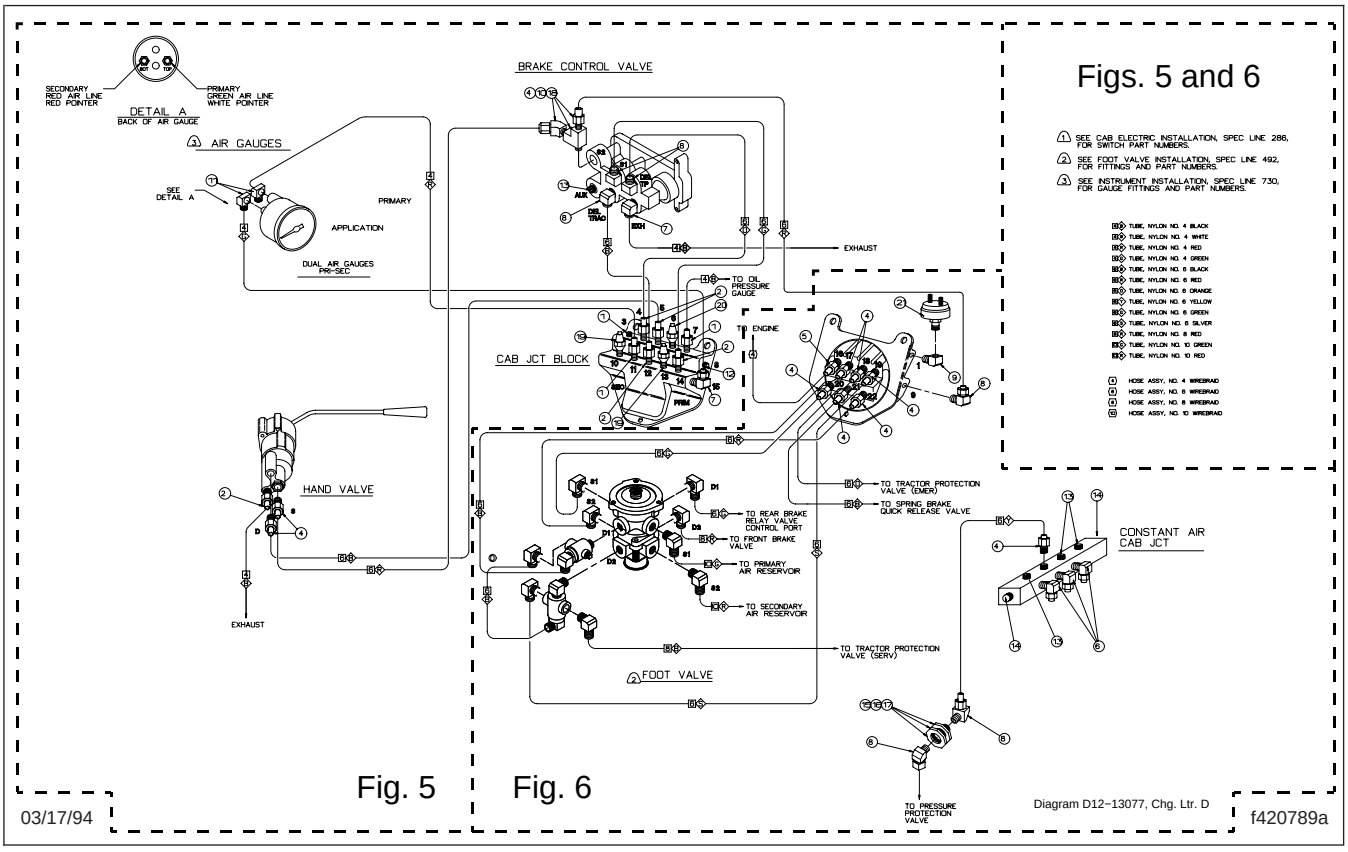


Fig. 4, Nylon Tube in Chassis, With Hand Valve, Date of Use 4/88 to 4/91

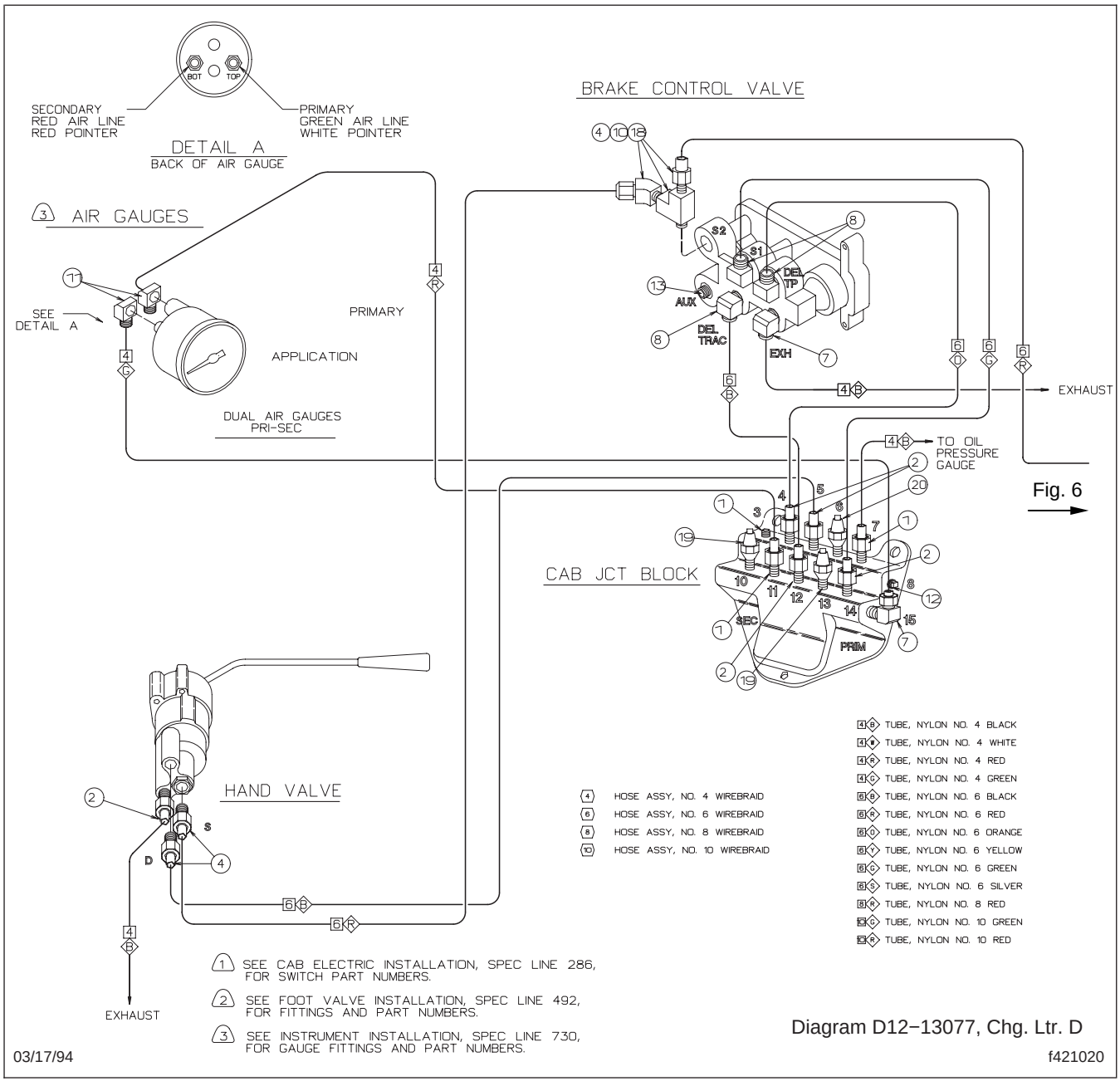

BOT
TOP
SECONDARY
RED AIR LINE
RED POINTER
PRIMARY
GREEN AIR LINE
WHITE POINTER
DETAIL A
BACK OF AIR GAUGE
3 AIR GAUGES
SEE
DETAIL A
PRIMARY
APPLICATION
DUAL AIR GAUGES
PRI-SEC
BRAKE CONTROL VALVE
S2
S1
DEL
TP
AUX
DEL
TRAC
EXH
EXHAUST
TO OIL
PRESSURE
GAUGE
Fig. 6
CAB JCT BLOCK
SEC
PRIM
HAND VALVE
EXHAUST
4 HOSE ASSY, NO. 4 WIREBRAID
6 HOSE ASSY, NO. 6 WIREBRAID
8 HOSE ASSY, NO. 8 WIREBRAID
10 HOSE ASSY, NO. 10 WIREBRAID
4B TUBE, NYLON NO. 4 BLACK
4W TUBE, NYLON NO. 4 WHITE
4R TUBE, NYLON NO. 4 RED
4G TUBE, NYLON NO. 4 GREEN
6B TUBE, NYLON NO. 6 BLACK
6R TUBE, NYLON NO. 6 RED
6O TUBE, NYLON NO. 6 ORANGE
6Y TUBE, NYLON NO. 6 YELLOW
6G TUBE, NYLON NO. 6 GREEN
6S TUBE, NYLON NO. 6 SILVER
8R TUBE, NYLON NO. 8 RED
10G TUBE, NYLON NO. 10 GREEN
10R TUBE, NYLON NO. 10 RED
1 SEE CAB ELECTRIC INSTALLATION, SPEC LINE 286, FOR SWITCH PART NUMBERS.
2 SEE FOOT VALVE INSTALLATION, SPEC LINE 492, FOR FITTINGS AND PART NUMBERS.
3 SEE INSTRUMENT INSTALLATION, SPEC LINE 730, FOR GAUGE FITTINGS AND PART NUMBERS.
Diagram D12−13077, Chg. Ltr. D
03/17/94
f421020

Fig. 5

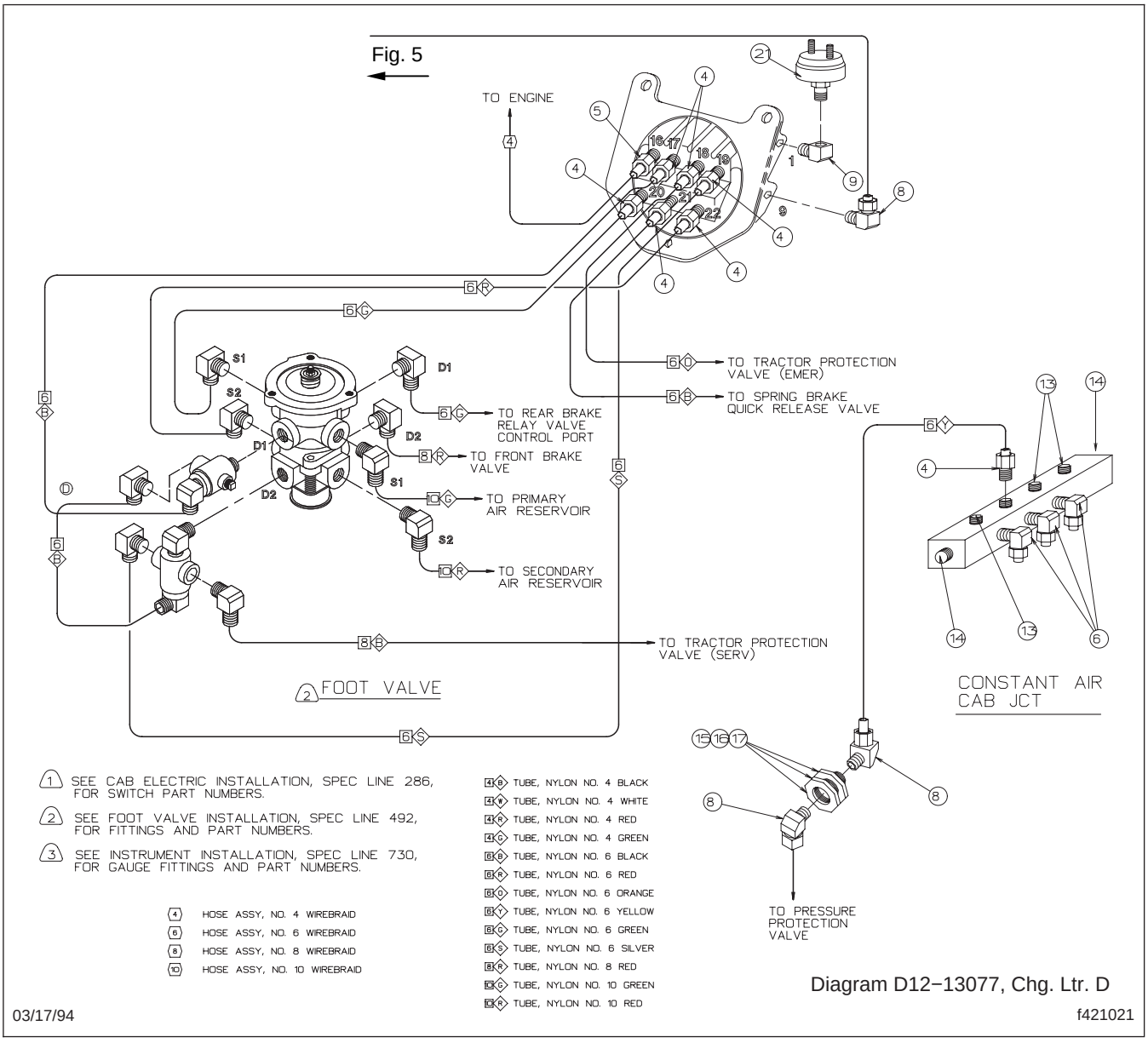


Fig. 5
TO ENGINE
TO TRACTOR PROTECTION VALVE (EMER)
TO SPRING BRAKE QUICK RELEASE VALVE
TO REAR BRAKE RELAY VALVE CONTROL PORT
TO FRONT BRAKE VALVE
TO PRIMARY AIR RESERVOIR
TO SECONDARY AIR RESERVOIR
TO TRACTOR PROTECTION VALVE (SERV)
2 FOOT VALVE
CONSTANT AIR CAB JCT
TO PRESSURE PROTECTION VALVE
1 SEE CAB ELECTRIC INSTALLATION, SPEC LINE 286, FOR SWITCH PART NUMBERS.
2 SEE FOOT VALVE INSTALLATION, SPEC LINE 492, FOR FITTINGS AND PART NUMBERS.
3 SEE INSTRUMENT INSTALLATION, SPEC LINE 730, FOR GAUGE FITTINGS AND PART NUMBERS.
4 HOSE ASSY, NO. 4 WIREBRAID
6 HOSE ASSY, NO. 6 WIREBRAID
8 HOSE ASSY, NO. 8 WIREBRAID
10 HOSE ASSY, NO. 10 WIREBRAID
4B TUBE, NYLON NO. 4 BLACK
4W TUBE, NYLON NO. 4 WHITE
4R TUBE, NYLON NO. 4 RED
4G TUBE, NYLON NO. 4 GREEN
6B TUBE, NYLON NO. 6 BLACK
6R TUBE, NYLON NO. 6 RED
6O TUBE, NYLON NO. 6 ORANGE
6Y TUBE, NYLON NO. 6 YELLOW
6G TUBE, NYLON NO. 6 GREEN
6S TUBE, NYLON NO. 6 SILVER
8R TUBE, NYLON NO. 8 RED
10G TUBE, NYLON NO. 10 GREEN
10R TUBE, NYLON NO. 10 RED
Diagram D12−13077, Chg. Ltr. D
03/17/94
f421021

Fig. 6

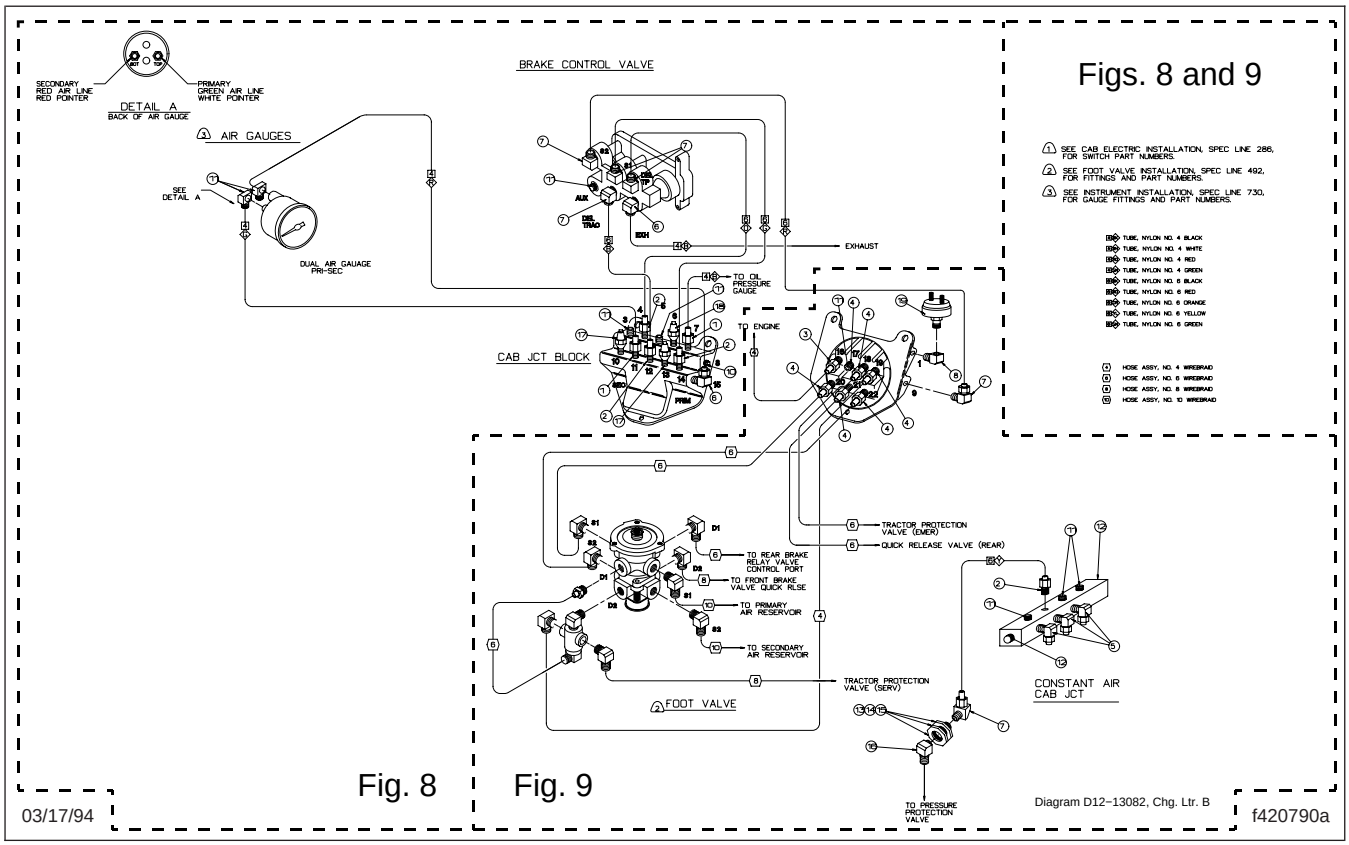


Fig. 7, Wire Braid Hose in Chassis, Without Hand Valve, Date of Use 4/88 to 4/91

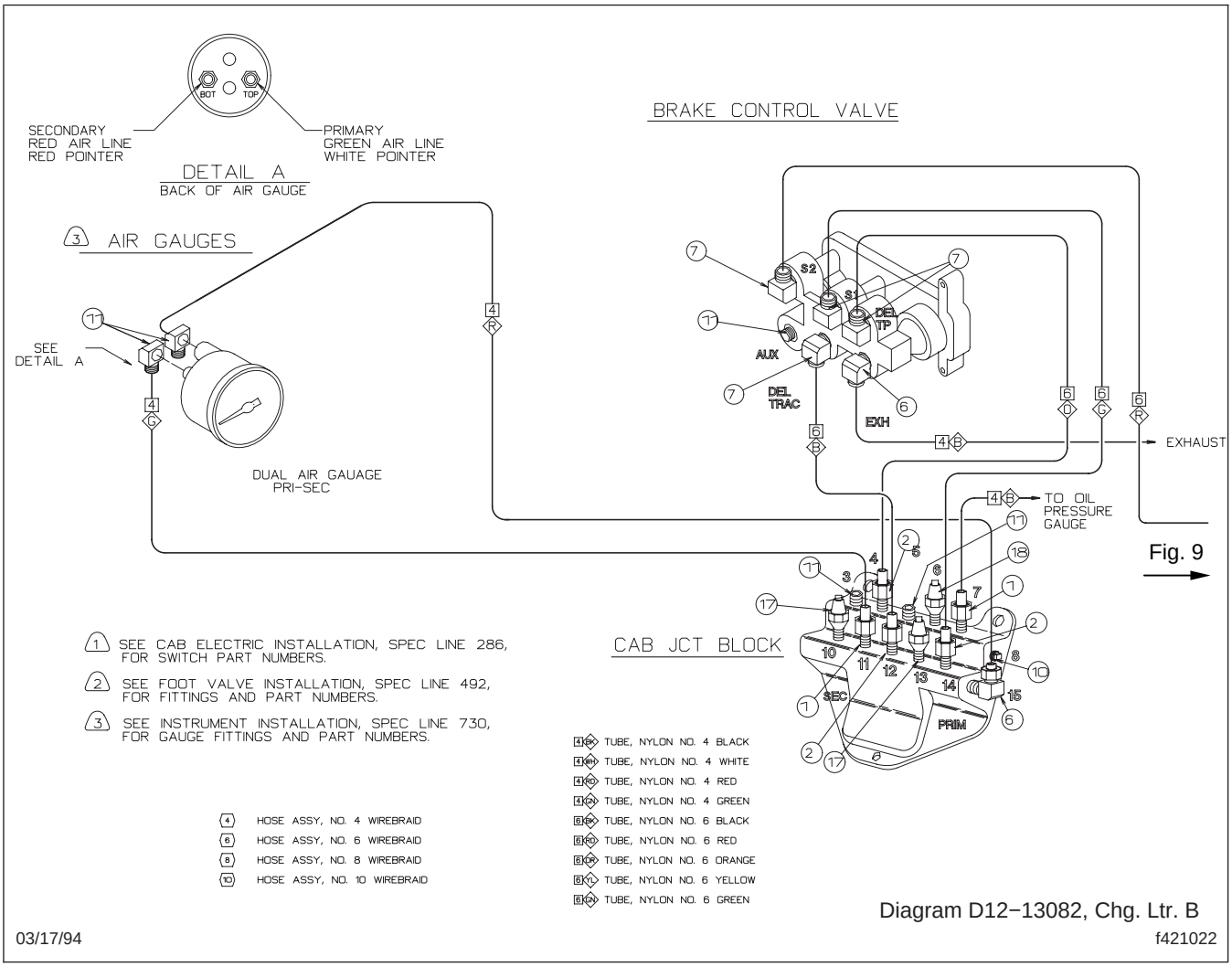

BOT
TOP
SECONDARY
RED AIR LINE
RED POINTER
PRIMARY
GREEN AIR LINE
WHITE POINTER
DETAIL A
BACK OF AIR GAUGE
BRAKE CONTROL VALVE
3 AIR GAUGES
SEE
DETAIL A
DUAL AIR GAUAGE
PRI-SEC
S2
S1
DEL
TP
AUX
DEL
TRAC
EXH
EXHAUST
TO OIL
PRESSURE
GAUGE
CAB JCT BLOCK
SEC
PRIM
Fig. 9
1 SEE CAB ELECTRIC INSTALLATION, SPEC LINE 286, FOR SWITCH PART NUMBERS.
2 SEE FOOT VALVE INSTALLATION, SPEC LINE 492, FOR FITTINGS AND PART NUMBERS.
3 SEE INSTRUMENT INSTALLATION, SPEC LINE 730, FOR GAUGE FITTINGS AND PART NUMBERS.
4 HOSE ASSY, NO. 4 WIREBRAID
6 HOSE ASSY, NO. 6 WIREBRAID
8 HOSE ASSY, NO. 8 WIREBRAID
10 HOSE ASSY, NO. 10 WIREBRAID
4B TUBE, NYLON NO. 4 BLACK
4W TUBE, NYLON NO. 4 WHITE
4R TUBE, NYLON NO. 4 RED
4G TUBE, NYLON NO. 4 GREEN
6B TUBE, NYLON NO. 6 BLACK
6R TUBE, NYLON NO. 6 RED
6O TUBE, NYLON NO. 6 ORANGE
6Y TUBE, NYLON NO. 6 YELLOW
6G TUBE, NYLON NO. 6 GREEN
Diagram D12−13082, Chg. Ltr. B
03/17/94
f421022

Fig. 8

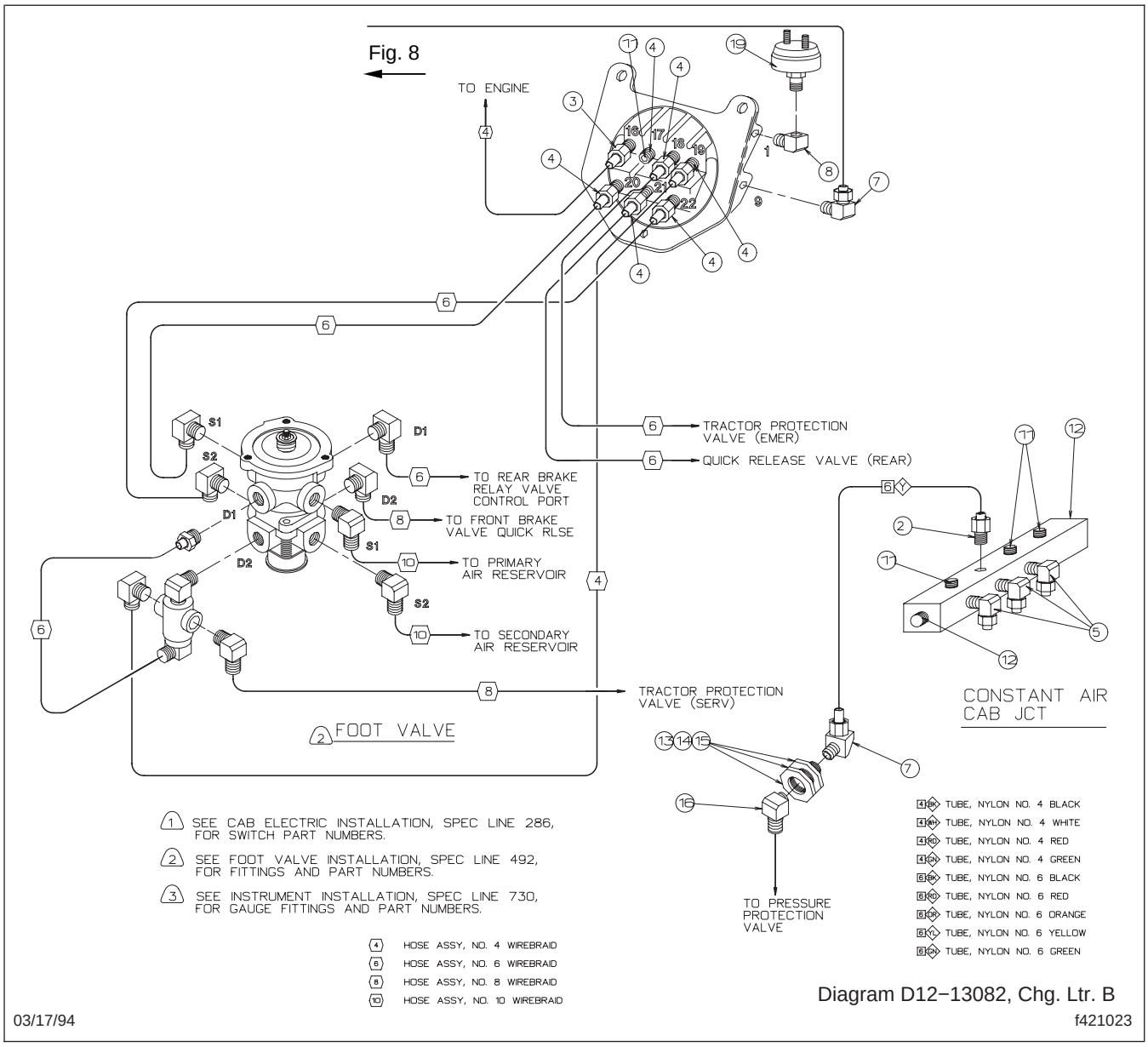


Fig. 8
TO ENGINE
TRACTOR PROTECTION VALVE (EMER)
QUICK RELEASE VALVE (REAR)
TO REAR BRAKE RELAY VALVE CONTROL PORT
TO FRONT BRAKE VALVE QUICK RLSE
TO PRIMARY AIR RESERVOIR
TO SECONDARY AIR RESERVOIR
TRACTOR PROTECTION VALVE (SERV)
2 FOOT VALVE
CONSTANT AIR CAB JCT
TO PRESSURE PROTECTION VALVE
1 SEE CAB ELECTRIC INSTALLATION, SPEC LINE 286, FOR SWITCH PART NUMBERS.
2 SEE FOOT VALVE INSTALLATION, SPEC LINE 492, FOR FITTINGS AND PART NUMBERS.
3 SEE INSTRUMENT INSTALLATION, SPEC LINE 730, FOR GAUGE FITTINGS AND PART NUMBERS.
4 HOSE ASSY, NO. 4 WIREBRAID
6 HOSE ASSY, NO. 6 WIREBRAID
8 HOSE ASSY, NO. 8 WIREBRAID
10 HOSE ASSY, NO. 10 WIREBRAID
4BK TUBE, NYLON NO. 4 BLACK
4WH TUBE, NYLON NO. 4 WHITE
4RD TUBE, NYLON NO. 4 RED
4GN TUBE, NYLON NO. 4 GREEN
6BK TUBE, NYLON NO. 6 BLACK
6RD TUBE, NYLON NO. 6 RED
6OR TUBE, NYLON NO. 6 ORANGE
6YL TUBE, NYLON NO. 6 YELLOW
6GN TUBE, NYLON NO. 6 GREEN
Diagram D12−13082, Chg. Ltr. B
03/17/94
f421023

Fig. 9

Conventional

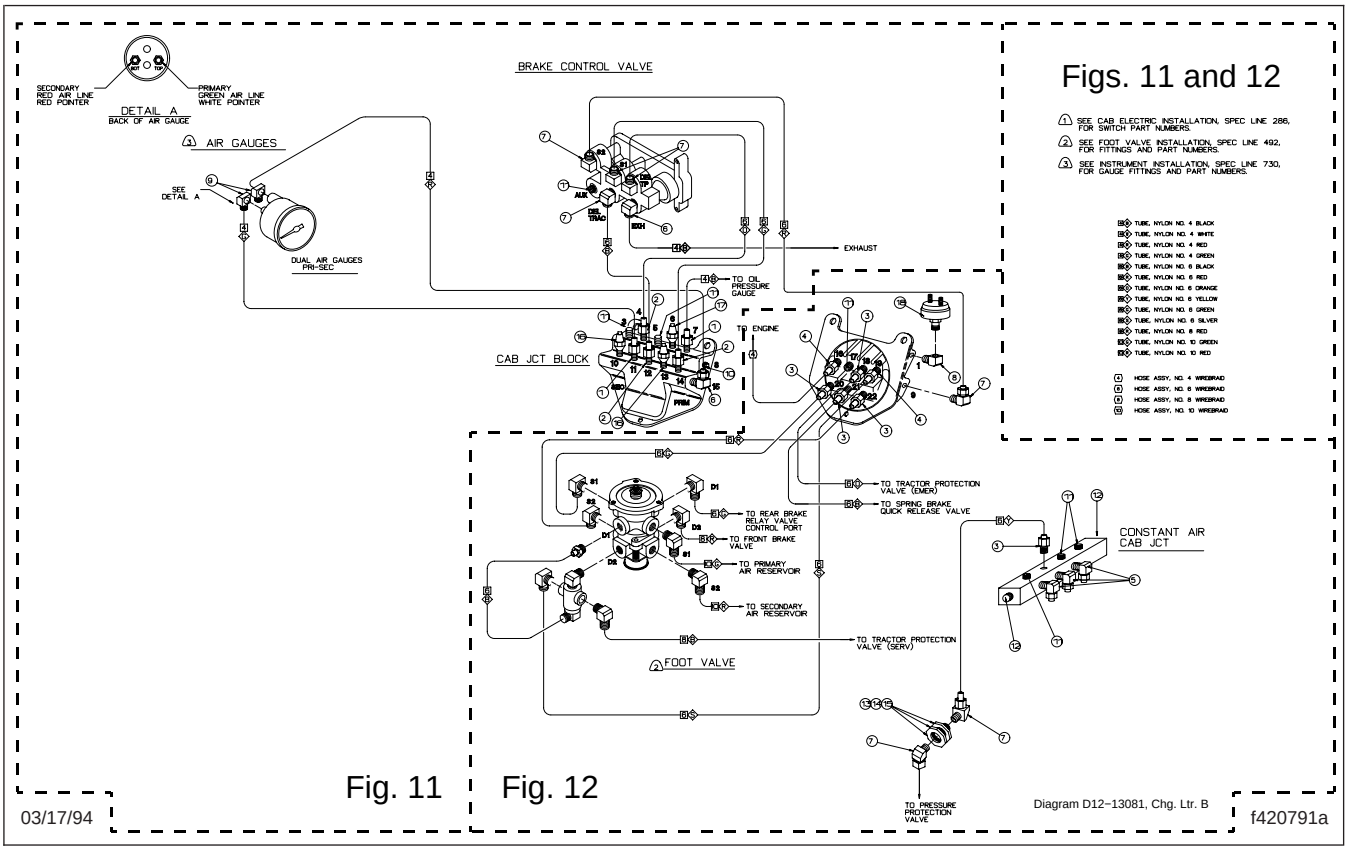


Fig. 10, Nylon Tube in Chassis, Without Hand Valve, Date of Use 4/88 to 4/91

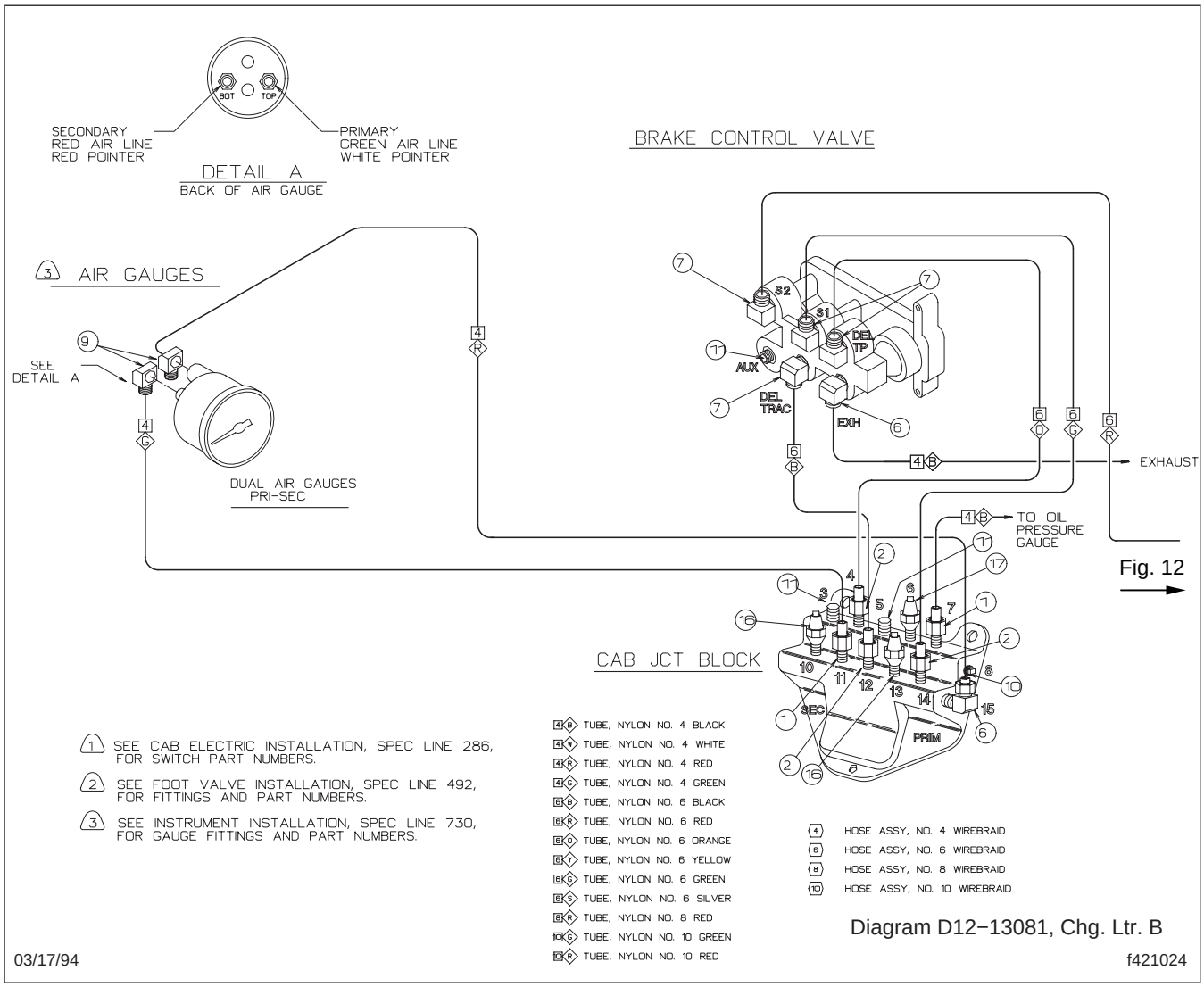

BOT
TOP
SECONDARY
RED AIR LINE
RED POINTER
PRIMARY
GREEN AIR LINE
WHITE POINTER
DETAIL A
BACK OF AIR GAUGE
BRAKE CONTROL VALVE
3 AIR GAUGES
SEE
DETAIL A
DUAL AIR GAUGES
PRI-SEC
S2
S1
DEL
TP
AUX
DEL
TRAC
EXH
EXHAUST
TO OIL
PRESSURE
GAUGE
CAB JCT BLOCK
SEC
PRIM
1 SEE CAB ELECTRIC INSTALLATION, SPEC LINE 286, FOR SWITCH PART NUMBERS.
2 SEE FOOT VALVE INSTALLATION, SPEC LINE 492, FOR FITTINGS AND PART NUMBERS.
3 SEE INSTRUMENT INSTALLATION, SPEC LINE 730, FOR GAUGE FITTINGS AND PART NUMBERS.
TUBE, NYLON NO. 4 BLACK
TUBE, NYLON NO. 4 WHITE
TUBE, NYLON NO. 4 RED
TUBE, NYLON NO. 4 GREEN
TUBE, NYLON NO. 6 BLACK
TUBE, NYLON NO. 6 RED
TUBE, NYLON NO. 6 ORANGE
TUBE, NYLON NO. 6 YELLOW
TUBE, NYLON NO. 6 GREEN
TUBE, NYLON NO. 6 SILVER
TUBE, NYLON NO. 8 RED
TUBE, NYLON NO. 10 GREEN
TUBE, NYLON NO. 10 RED
HOSE ASSY, NO. 4 WIREBRAID
HOSE ASSY, NO. 6 WIREBRAID
HOSE ASSY, NO. 8 WIREBRAID
HOSE ASSY, NO. 10 WIREBRAID
Diagram D12−13081, Chg. Ltr. B
03/17/94
f421024

Fig. 12

Fig. 11

Conventional

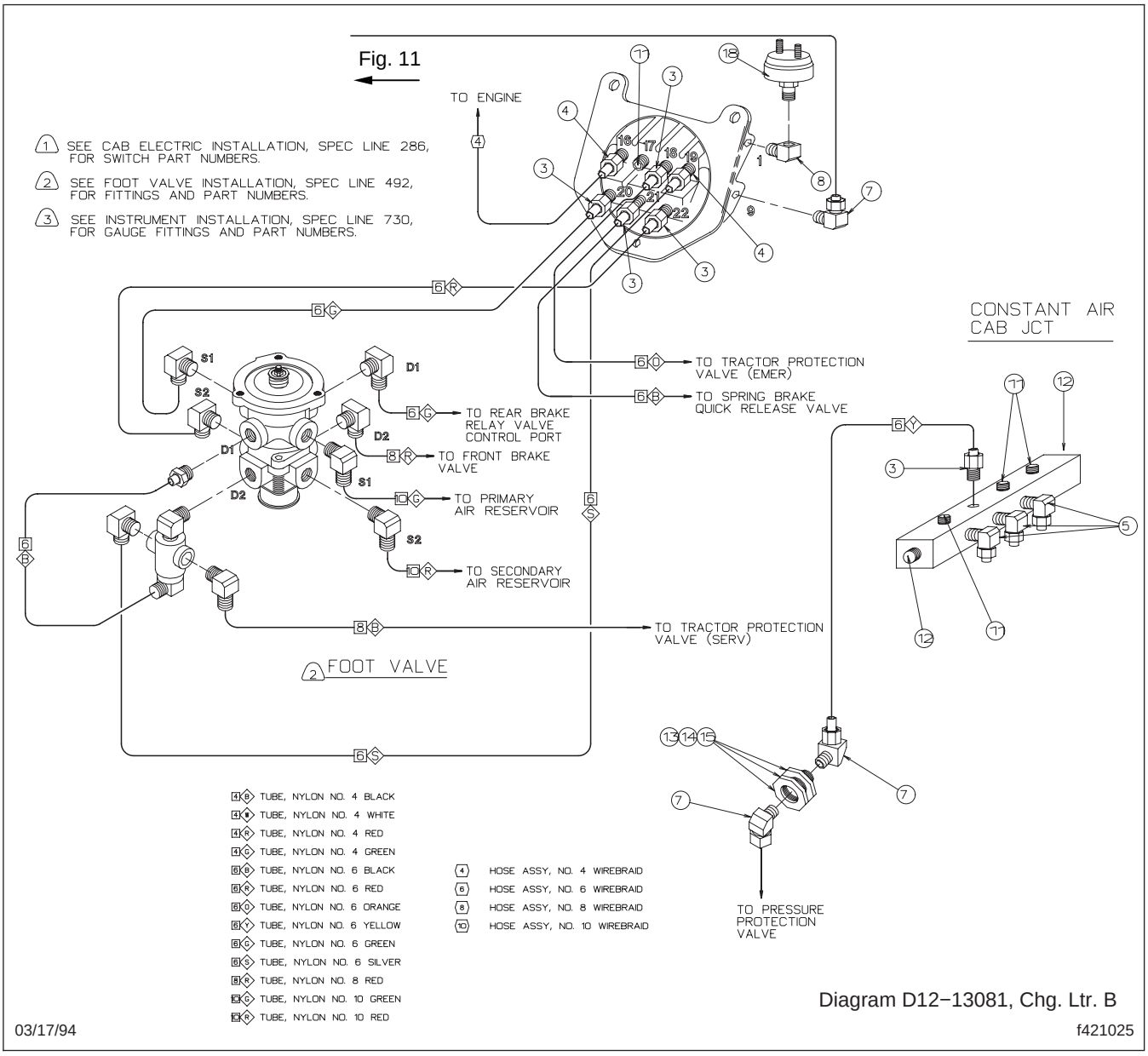
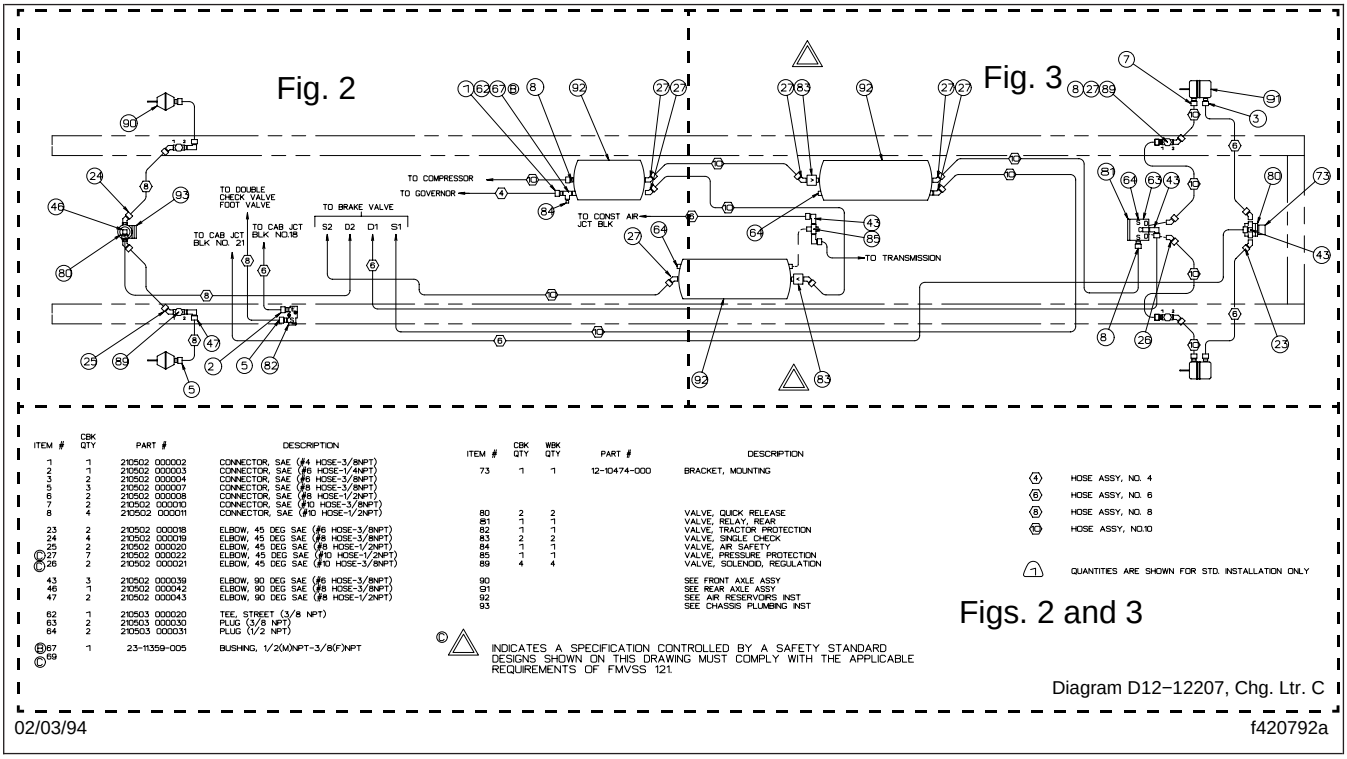


Fig. 12

Single Rear Axle Tractor, With Antilock, Without Brake Proportioning

See Fig. 1 for a full view of the plumbing diagram wire braid hose, with single rear axle, with antilock, and without brake proportioning, date of use 4/88 to 4/91. **See Fig. 2**, or **Fig. 3** for partial (detailed) views plumbing diagram wire braid hose, with single rear axle, with antilock, and without brake proportioning, date of use 4/88 to 4/91.

See Fig. 4 for a full view the plumbing diagram nylon tubing, with single rear axle, with antilock, and without brake proportioning, date of use 4/88 to 4/91. **See Fig. 5**, or **Fig. 6** for partial (detailed) views plumbing diagram nylon tubing, with single rear axle, with antilock, and without brake proportioning, date of use 4/88 to 4/91.



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	2	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	4	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	4	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
©27	7	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
©26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	2	210503 000031	PLUG (1/2 NPT)
ⒷⒸ67 ©69	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
73	1	1	12-10474-000	BRACKET, MOUNTING
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
89	4	4		VALVE, SOLENOID, REGULATION
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

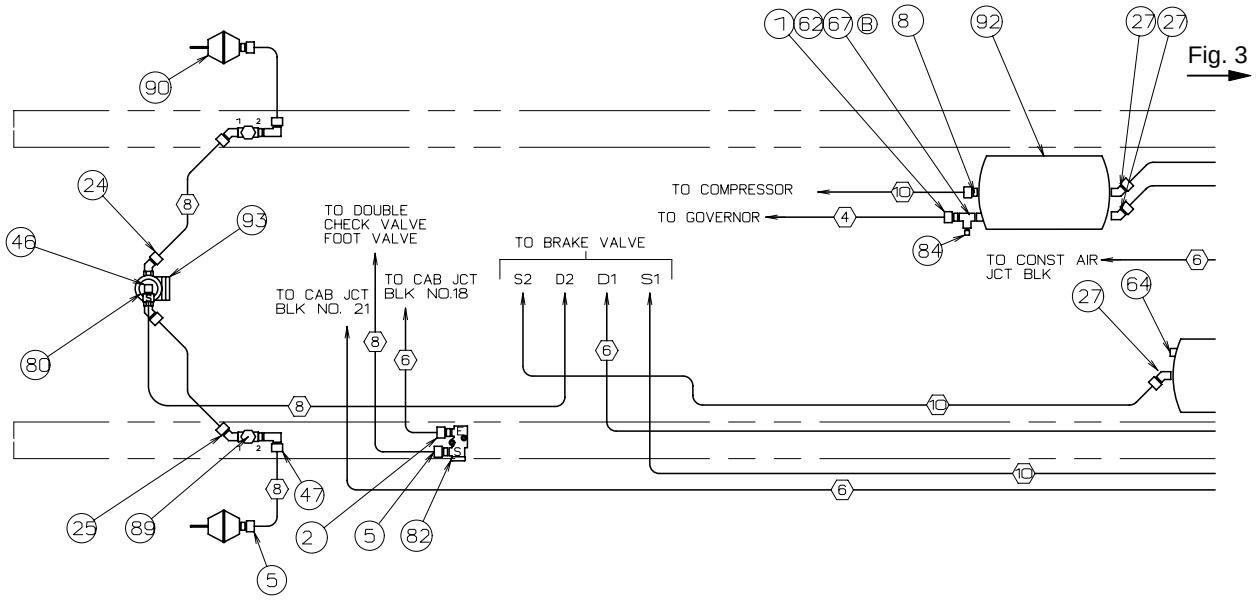
© △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

① QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Fig. 1, Wire Braid Hose With Single Rear Axle Tractor, With Antilock, and Without Brake Proportioning, Date of Use 4/88 to 4/91

Single Rear Axle Tractor, With Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	2	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	4	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	4	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
©27	7	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
©26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	2	210503 000031	PLUG (1/2 NPT)
Ⓑ67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
©69			

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
73	1	1	12-10474-000	BRACKET, MOUNTING
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
89	4	4		VALVE, SOLENOID, REGULATION
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST
	④		HOSE ASSY, NO. 4	
	⑥		HOSE ASSY, NO. 6	
	⑧		HOSE ASSY, NO. 8	
	⑩		HOSE ASSY, NO.10	

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

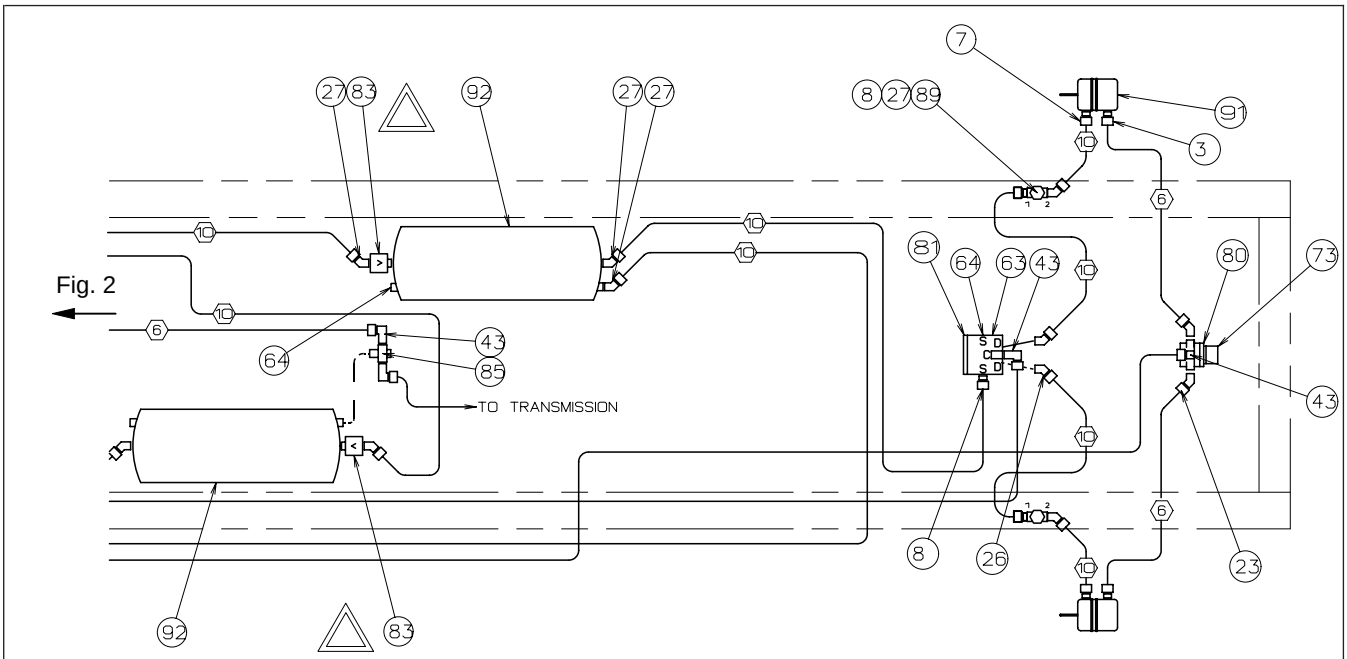
© △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12207, Chg. Ltr. C

02/03/94 f421090

Fig. 2

Single Rear Axle Tractor, With Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	2	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	4	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	4	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
©27	7	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
©26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	2	210503 000031	PLUG (1/2 NPT)
Ⓑ67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
©69			

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
73	1	1	12-10474-000	BRACKET, MOUNTING
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
89	4	4		VALVE, SOLENOID, REGULATION
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

④	HOSE ASSY, NO. 4
⑥	HOSE ASSY, NO. 6
⑧	HOSE ASSY, NO. 8
⑩	HOSE ASSY, NO.10

△1 QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

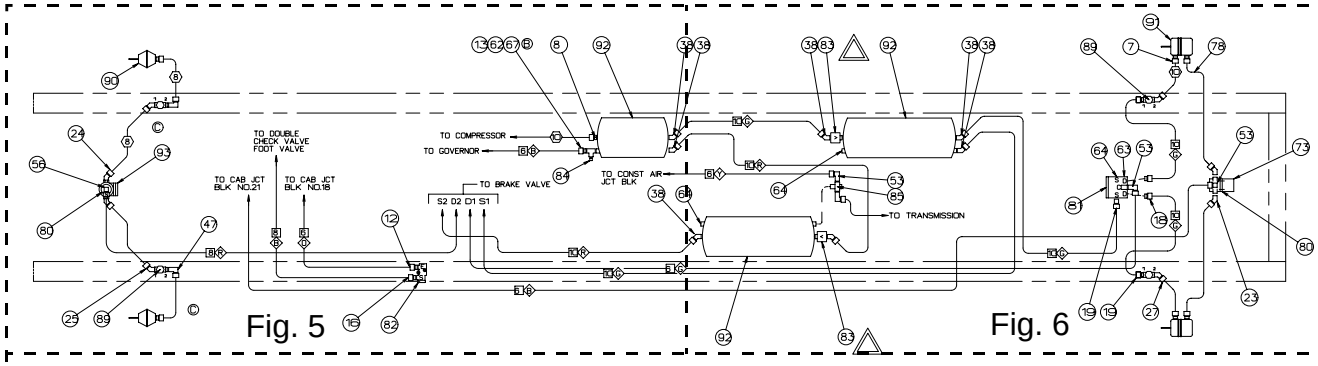
© △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12207, Chg. Ltr. C

02/03/94 f421091

Fig. 3

Single Rear Axle Tractor, With Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	3	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
38	7	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
(B) 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(B) HOSE ASSY, #6 WIREBRAID
(B) HOSE ASSY, #8 WIREBRAID
(C) HOSE ASSY, #10 WIREBRAID
(6) TUBE, NYLON NO.6 BLACK
(6) TUBE, NYLON NO.6 YELLOW
(6) TUBE, NYLON NO.6 GREEN
(6) TUBE, NYLON NO.6 ORANGE
(6) TUBE, NYLON NO.6 RED
(8) TUBE, NYLON NO.8 BLACK
(8) TUBE, NYLON NO.8 RED
(10) TUBE, NYLON NO.10 GREEN
(10) TUBE, NYLON NO.10 RED

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Figs. 5 and 6

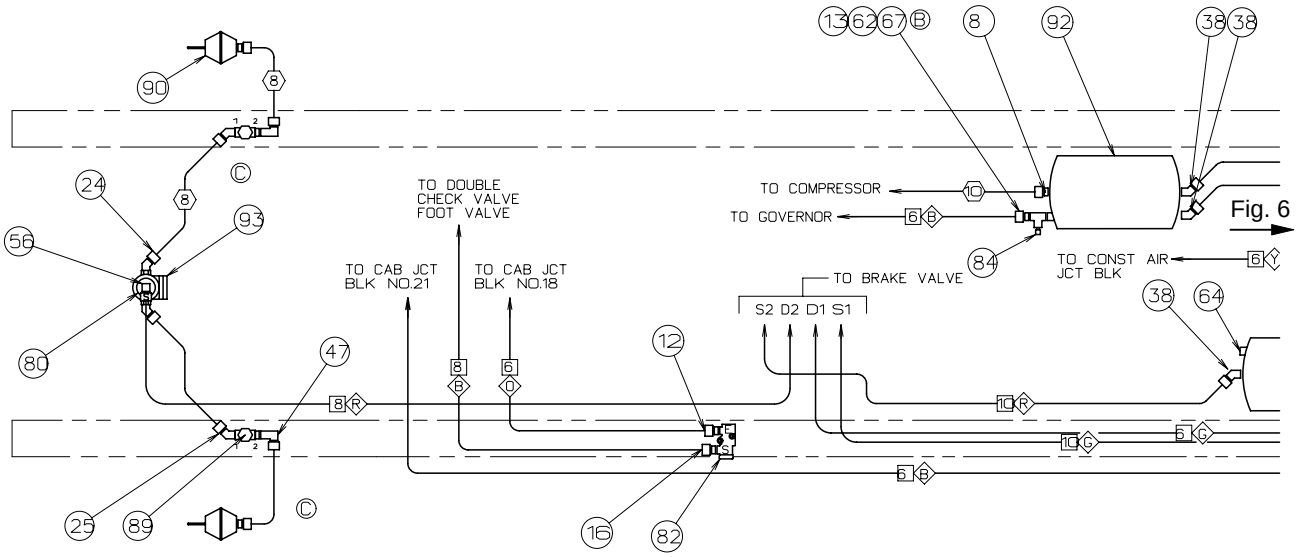
© INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12201, Chg. Ltr. D

02/03/94 f420793a

Fig. 4, Nylon Tubing With Single Rear Axle Tractor, With Antilock, and Without Brake Proportioning, Date of Use 4/88 to 4/91

Single Rear Axle Tractor, With Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	3	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
38	7	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID	6 R	TUBE, NYLON NO.6 RED
8	HOSE ASSY, #8 WIREBRAID	8 B	TUBE, NYLON NO.8 BLACK
10	HOSE ASSY, #10 WIREBRAID	8 R	TUBE, NYLON NO.8 RED
6 B	TUBE, NYLON NO.6 BLACK	10 G	TUBE, NYLON NO.10 GREEN
6 Y	TUBE, NYLON NO.6 YELLOW	10 R	TUBE, NYLON NO.10 RED
6 G	TUBE, NYLON NO.6 GREEN		
6 O	TUBE, NYLON NO.6 ORANGE		

Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

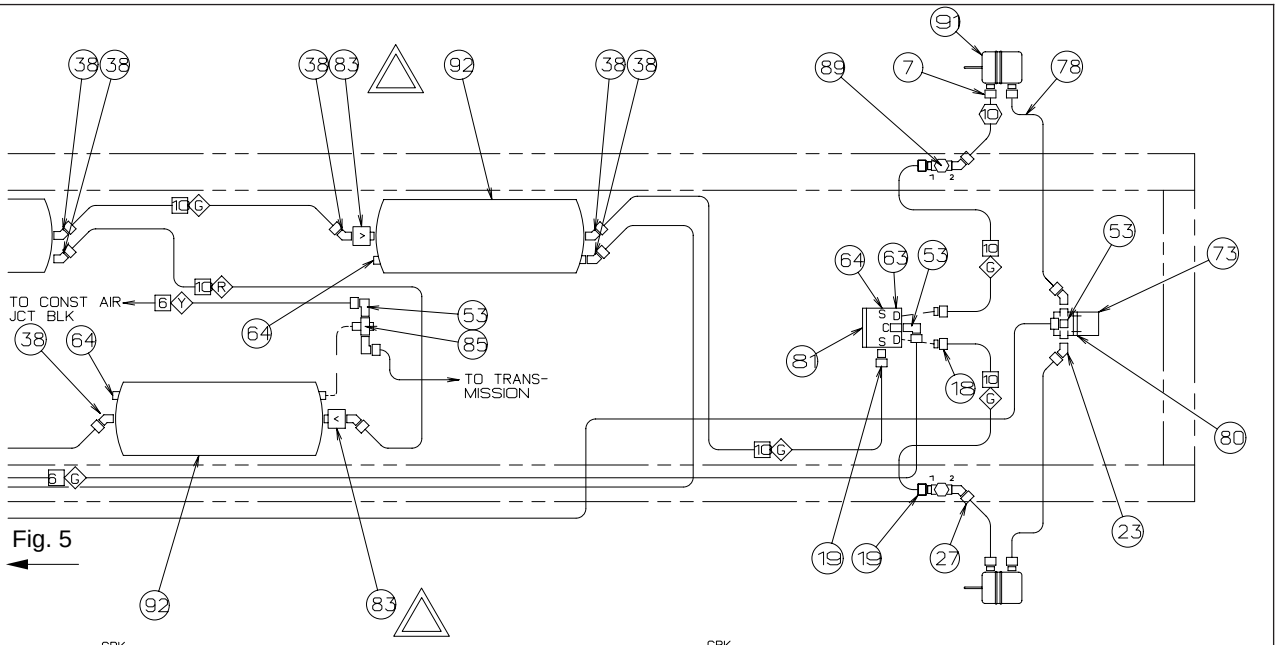
Diagram D12−12201, Chg. Ltr. D

02/07/94

f421092

Fig. 5

Single Rear Axle Tractor, With Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	3	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
38	7	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
(B) 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID	6 R	TUBE, NYLON NO.6 RED
8	HOSE ASSY, #8 WIREBRAID	8 B	TUBE, NYLON NO.8 BLACK
10	HOSE ASSY, #10 WIREBRAID	8 R	TUBE, NYLON NO.8 RED
6 B	TUBE, NYLON NO.6 BLACK	10 G	TUBE, NYLON NO.10 GREEN
6 Y	TUBE, NYLON NO.6 YELLOW	10 R	TUBE, NYLON NO.10 RED
6 G	TUBE, NYLON NO.6 GREEN		
6 O	TUBE, NYLON NO.6 ORANGE		

(D) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Diagram D12-12201, Chg. Ltr. D

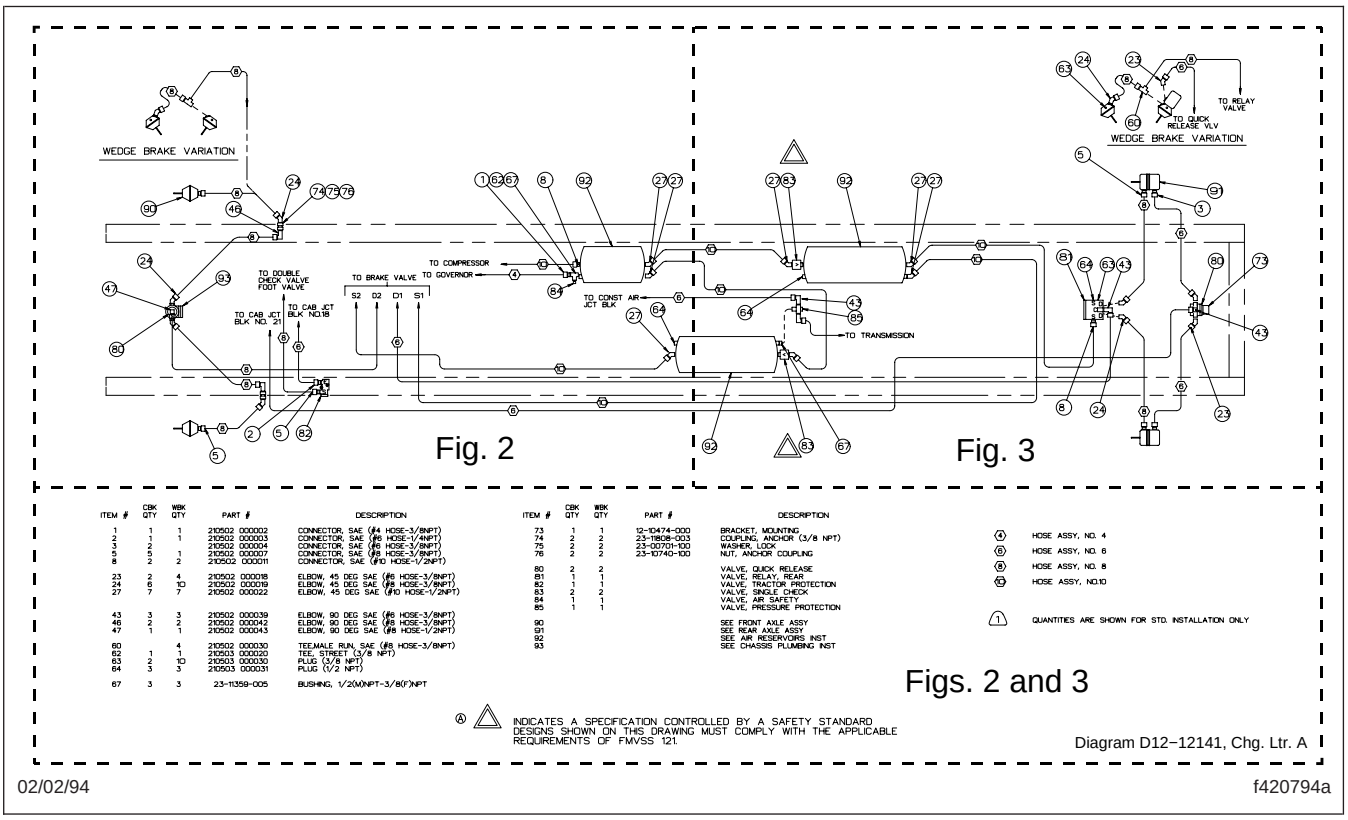
08/08/95 f421093

Fig. 6

Single Rear Axle Tractor, Without Antilock, Without Brake Proportioning

See **Fig. 1** for a full view of the plumbing diagram with wire braid hose, with single rear axle, without antilock, and without brake proportioning, date of use 4/88 to 4/91. See **Fig. 2**, or **Fig. 3** for partial (detailed) views of **Fig. 1**.

See **Fig. 4** for a full view of the plumbing diagram with nylon tubing, with single rear axle, without antilock, and without brake proportioning, date of use 4/88 to 4/91. See **Fig. 5**, or **Fig. 6** for partial (detailed) views of **Fig. 4**.



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
1	1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	5	1	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	2	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	6	10	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	7	7	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60		4	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	10	210503 000030	PLUG (3/8 NPT)
64	3	3	210503 000031	PLUG (1/2 NPT)
67	3	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

① QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Figs. 2 and 3

Ⓐ △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12141, Chg. Ltr. A

02/02/94 f420794a

Fig. 1, Wire Braid Hose With Single Rear Axle Tractor, Without Antilock, and Without Brake Proportioning, Date of Use 4/88 to 4/91

Single Rear Axle Tractor, Without Antilock, Without Brake Proportioning

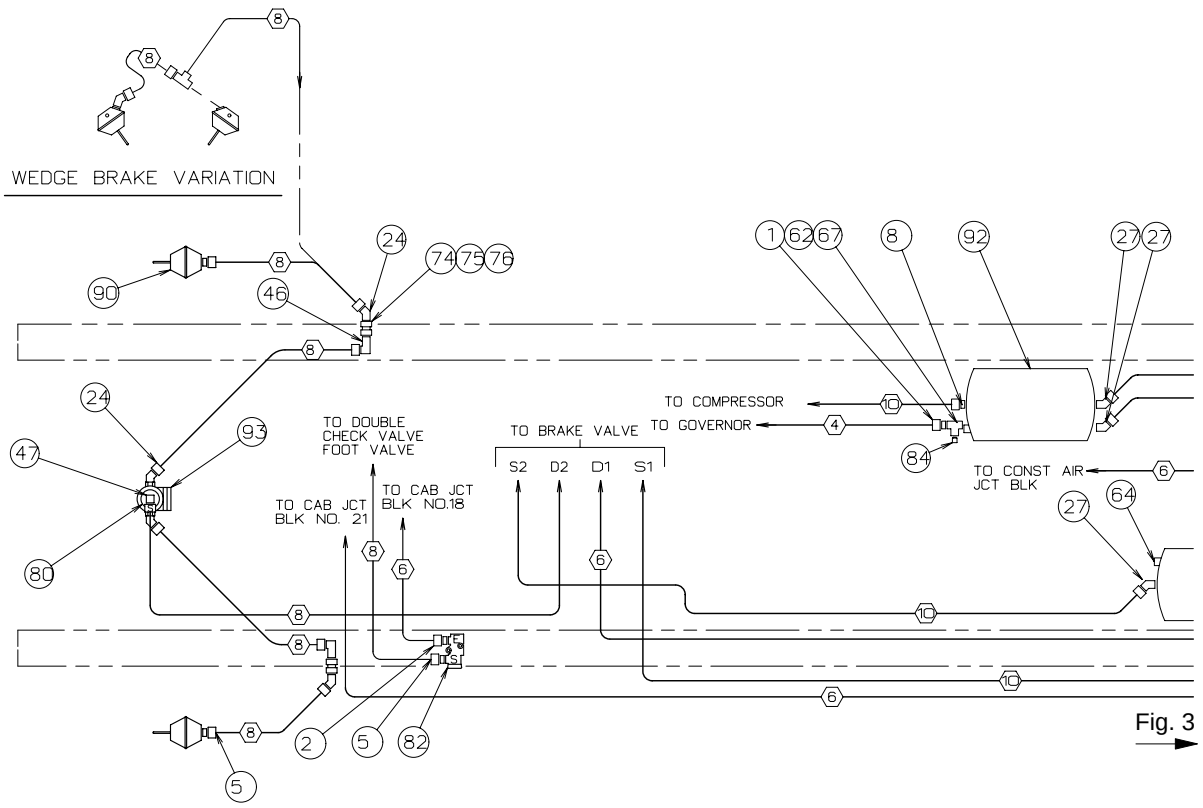


Fig. 3

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
1	1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2		210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	5	1	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	2	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	6	10	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	7	7	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60		4	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	10	210503 000030	PLUG (3/8 NPT)
64	3	3	210503 000031	PLUG (1/2 NPT)
67	3	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

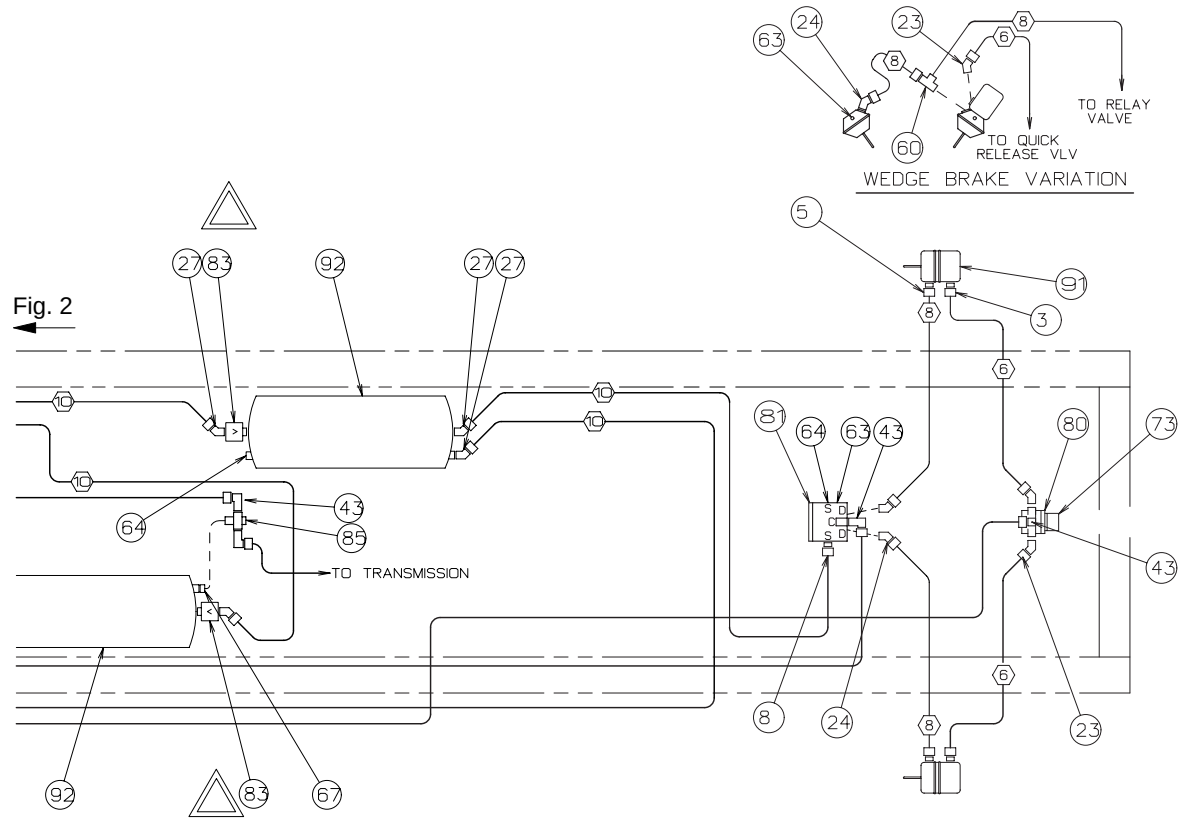
Ⓐ △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12141, Chg. Ltr. A

02/07/94 f421096

Fig. 2

Single Rear Axle Tractor, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
1	1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2		210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	5	1	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	2	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	6	10	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	7	7	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60		4	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	10	210503 000030	PLUG (3/8 NPT)
64	3	3	210503 000031	PLUG (1/2 NPT)
67	3	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

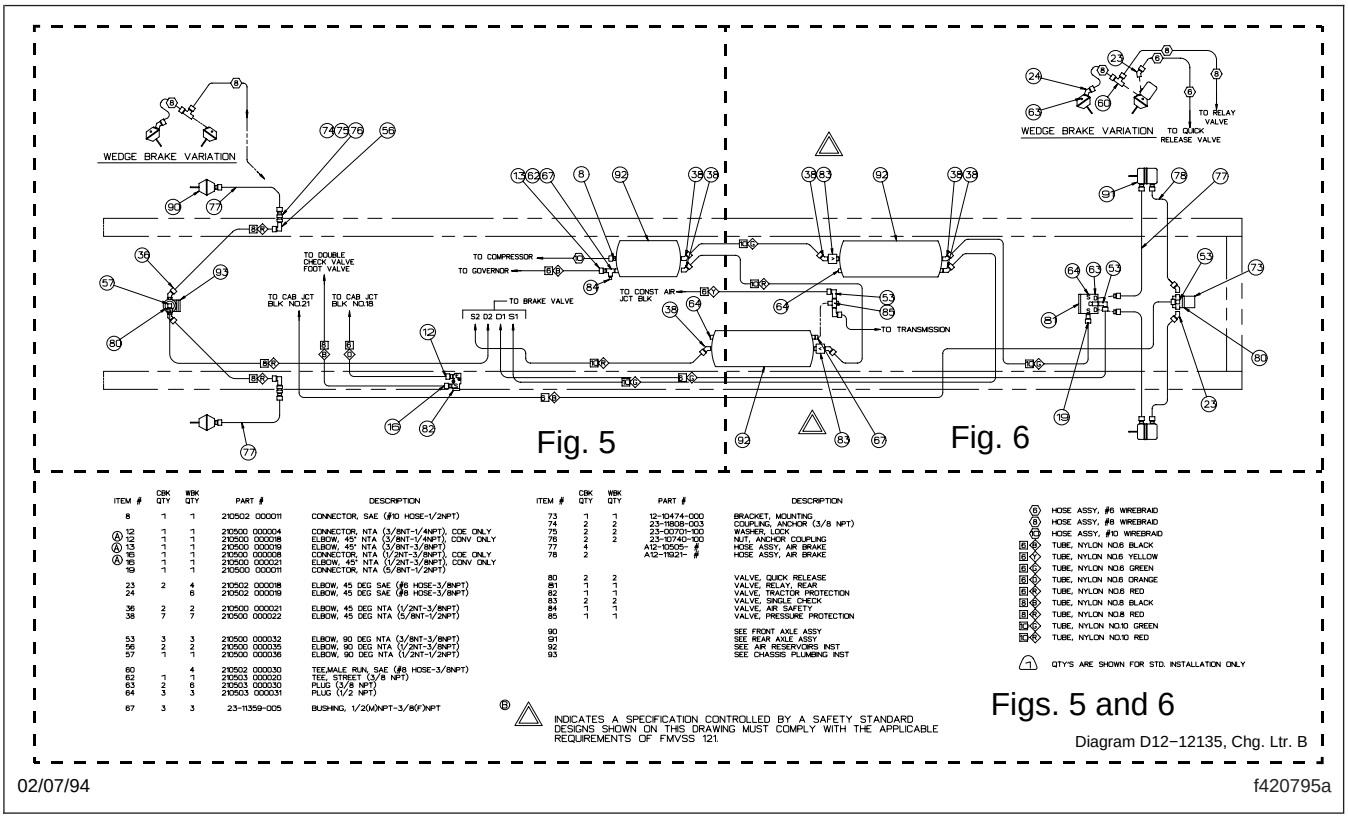
Ⓐ △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12141, Chg. Ltr. A

02/07/94 f421097

Fig. 3

Single Rear Axle Tractor, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
8	1	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
Ⓐ 12	1	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT), COE ONLY
Ⓐ 12	1	1	210500 000018	ELBOW, 45° NTA (3/8NT-1/4NPT), CONV ONLY
Ⓐ 13	1	1	210500 000019	ELBOW, 45° NTA (3/8NT-3/8NPT)
Ⓐ 15	1	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT), COE ONLY
Ⓐ 16	1	1	210500 000021	ELBOW, 45° NTA (1/2NT-3/8NPT), CONV ONLY
19	1	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24		6	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
36	2	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	7	7	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
53	3	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
60		4	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	6	210503 000030	PLUG (3/8 NPT)
64	3	3	210503 000031	PLUG (1/2 NPT)
67	3	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
77	4		A12-10505- #	HOSE ASSY, AIR BRAKE
78	2		A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVORS INST
93				SEE CHASSIS PLUMBING INST

Ⓑ △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Ⓐ	HOSE ASSY, #6 WIREBRAID
Ⓑ	HOSE ASSY, #8 WIREBRAID
Ⓒ	HOSE ASSY, #10 WIREBRAID
6	TUBE, NYLON NO.6 BLACK
6	TUBE, NYLON NO.6 YELLOW
6	TUBE, NYLON NO.6 GREEN
6	TUBE, NYLON NO.6 ORANGE
8	TUBE, NYLON NO.8 RED
8	TUBE, NYLON NO.8 BLACK
8	TUBE, NYLON NO.8 RED
10	TUBE, NYLON NO.10 GREEN
10	TUBE, NYLON NO.10 RED

△1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Figs. 5 and 6

Diagram D12−12135, Chg. Ltr. B

02/07/94 f420795a

Fig. 4, Nylon Tubing With Single Rear Axle Tractor, Without Antilock, and Without Brake Proportioning, Date of Use 4/88 to 4/91

Single Rear Axle Tractor, Without Antilock, Without Brake Proportioning

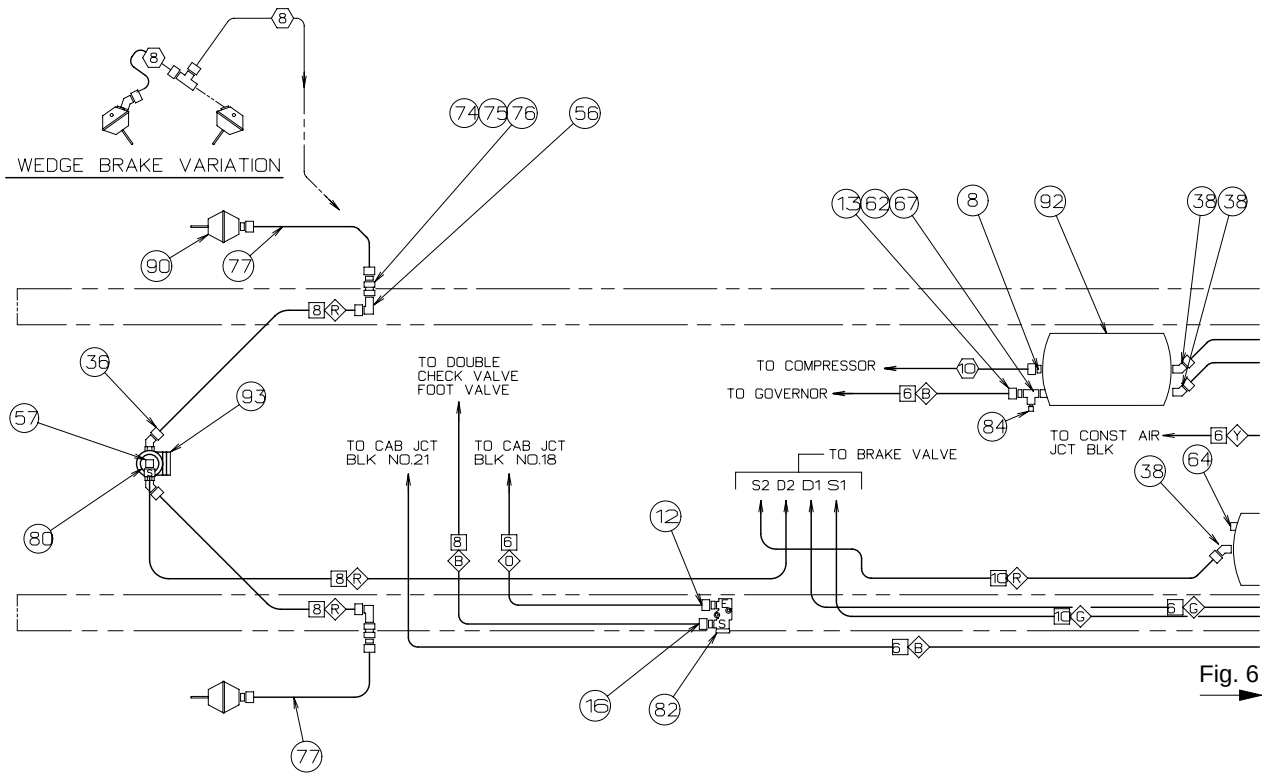


Fig. 6

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
8	1	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
Ⓐ 12	1	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT), COE ONLY
Ⓐ 12	1	1	210500 000018	ELBOW, 45° NTA (3/8NT-1/4NPT), CONV ONLY
Ⓐ 13	1	1	210500 000019	ELBOW, 45° NTA (3/8NT-3/8NPT)
Ⓐ 16	1	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT), COE ONLY
Ⓐ 16	1	1	210500 000021	ELBOW, 45° NTA (1/2NT-3/8NPT), CONV ONLY
19	1	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24		6	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
36	2	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	7	7	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
53	3	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
60		4	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	6	210503 000030	PLUG (3/8 NPT)
64	3	3	210503 000031	PLUG (1/2 NPT)
67	3	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
77	4		A12-10505- #	HOSE ASSY, AIR BRAKE
78	2		A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

⑥ HOSE ASSY, #6 WIREBRAID
⑧ HOSE ASSY, #8 WIREBRAID
⑩ HOSE ASSY, #10 WIREBRAID
6 B TUBE, NYLON NO.6 BLACK
6 Y TUBE, NYLON NO.6 YELLOW
6 G TUBE, NYLON NO.6 GREEN
6 O TUBE, NYLON NO.6 ORANGE
6 R TUBE, NYLON NO.6 RED
8 B TUBE, NYLON NO.8 BLACK
8 R TUBE, NYLON NO.8 RED
10 G TUBE, NYLON NO.10 GREEN
10 R TUBE, NYLON NO.10 RED

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

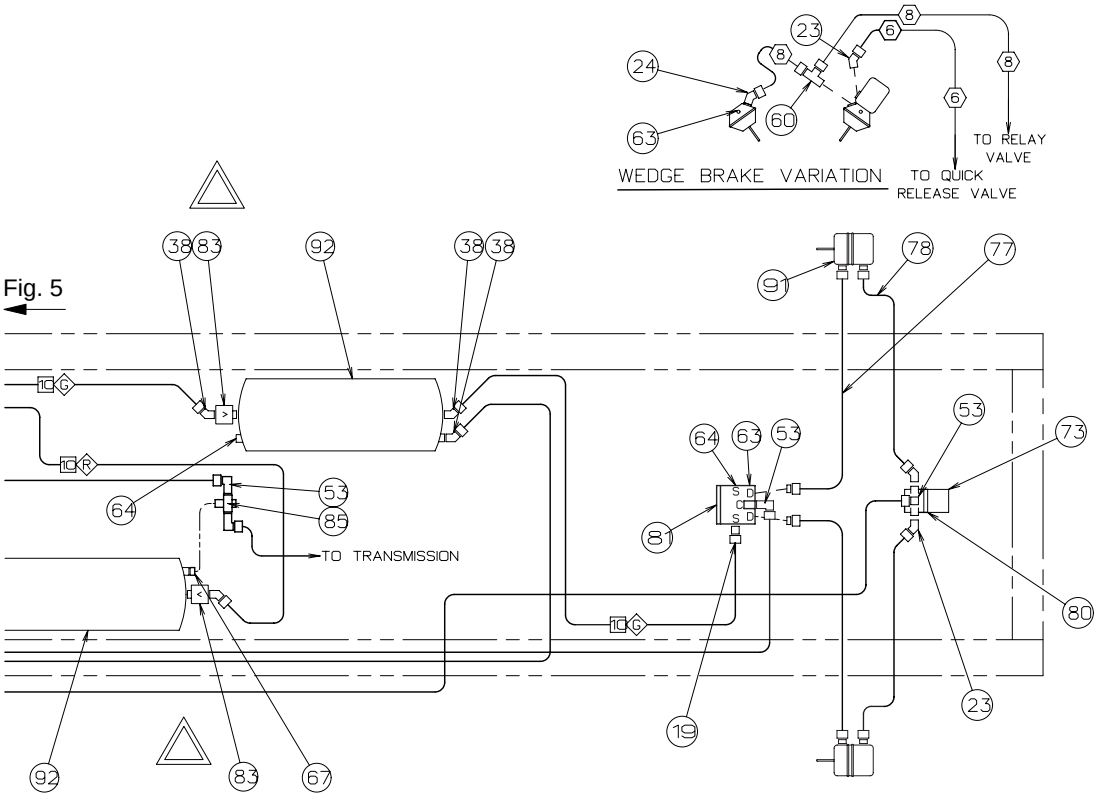
Ⓑ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12135, Chg. Ltr. B

02/07/94 f421098

Fig. 5

Single Rear Axle Tractor, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
8	1	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT), COE ONLY
Ⓐ 12	1	1	210500 000018	ELBOW, 45° NTA (3/8NT-1/4NPT), CONV ONLY
Ⓐ 13	1	1	210500 000019	ELBOW, 45° NTA (3/8NT-3/8NPT)
16	1	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT), COE ONLY
Ⓐ 16	1	1	210500 000021	ELBOW, 45° NTA (1/2NT-3/8NPT), CONV ONLY
19	1	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24		6	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
36	2	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	7	7	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
53	3	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
60		4	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	6	210503 000030	PLUG (3/8 NPT)
64	3	3	210503 000031	PLUG (1/2 NPT)
67	3	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
77	4		A12-10505- #	HOSE ASSY, AIR BRAKE
78	2		A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
90				SEE FRONT AXLE ASSY
91		1		SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓑ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID
6 B TUBE, NYLON NO.6 BLACK
6 Y TUBE, NYLON NO.6 YELLOW
6 G TUBE, NYLON NO.6 GREEN
6 O TUBE, NYLON NO.6 ORANGE
6 R TUBE, NYLON NO.6 RED
8 B TUBE, NYLON NO.8 BLACK
8 R TUBE, NYLON NO.8 RED
10 G TUBE, NYLON NO.10 GREEN
10 R TUBE, NYLON NO.10 RED

Diagram D12−12135, Chg. Ltr. B

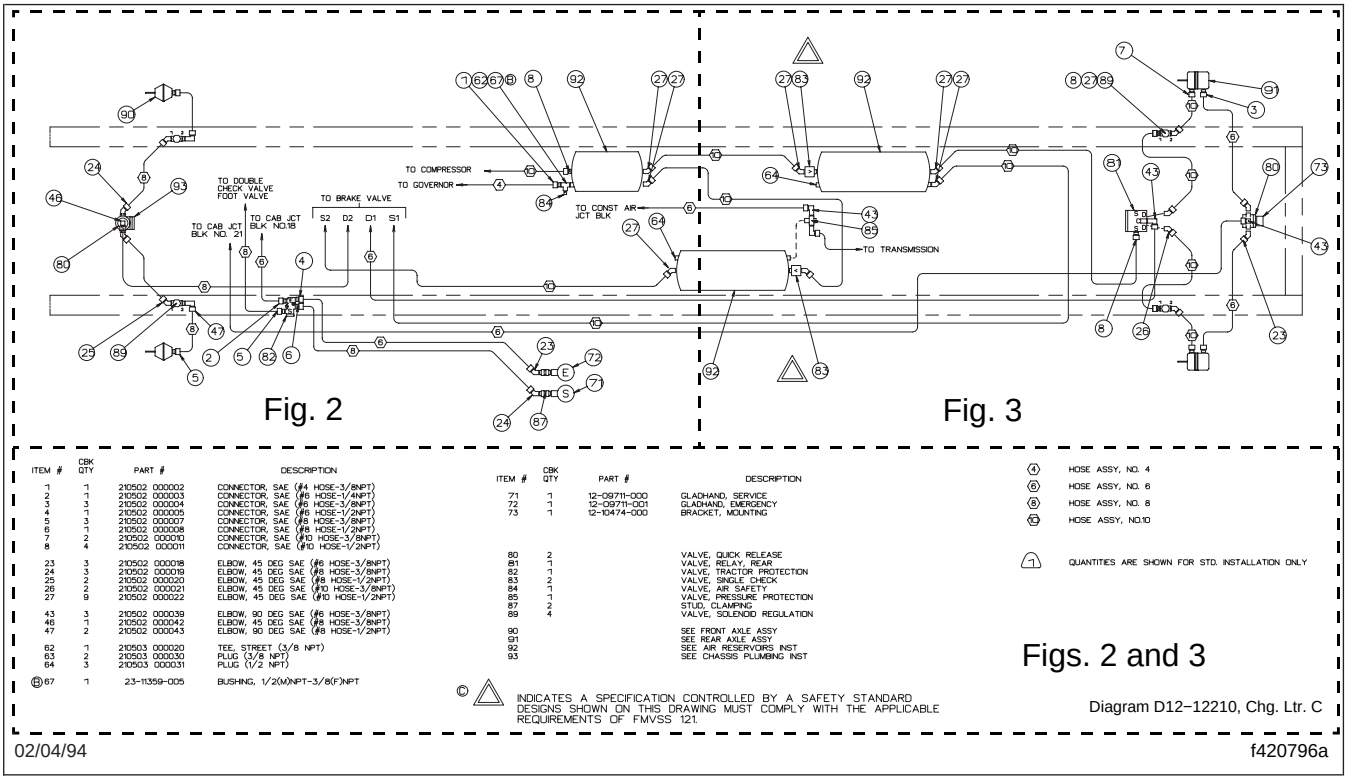
02/07/94 f421099

Fig. 6

Single Rear Axle Truck, With Antilock, Without Brake Proportioning

See Fig. 1 for a full view of the plumbing diagram wire braid hose, with single rear axle, with antilock, and without brake proportioning, date of use 4/88 to 4/91. **See Fig. 2**, or **Fig. 3** for partial (detailed) views plumbing diagram wire braid hose, with single rear axle, with antilock, and without brake proportioning, date of use 4/88 to 4/91.

See Fig. 4 for a full view of the plumbing diagram nylon tubing, with single rear axle, with antilock, and without brake proportioning, date of use 4/88 to 4/91. **See Fig. 5**, or **Fig. 6** for partial (detailed) views plumbing diagram nylon tubing, with single rear axle, with antilock, and without brake proportioning, date of use 4/88 to 4/91.



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	3	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
4	1	210502 000005	CONNECTOR, SAE (#6 HOSE-1/2NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	1	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	4	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	3	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	3	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	9	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
(B)67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
71	1	12-09711-000	GLADHAND, SERVICE
72	1	12-09711-001	GLADHAND, EMERGENCY
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
87	2		STUD, CLAMPING
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

© INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

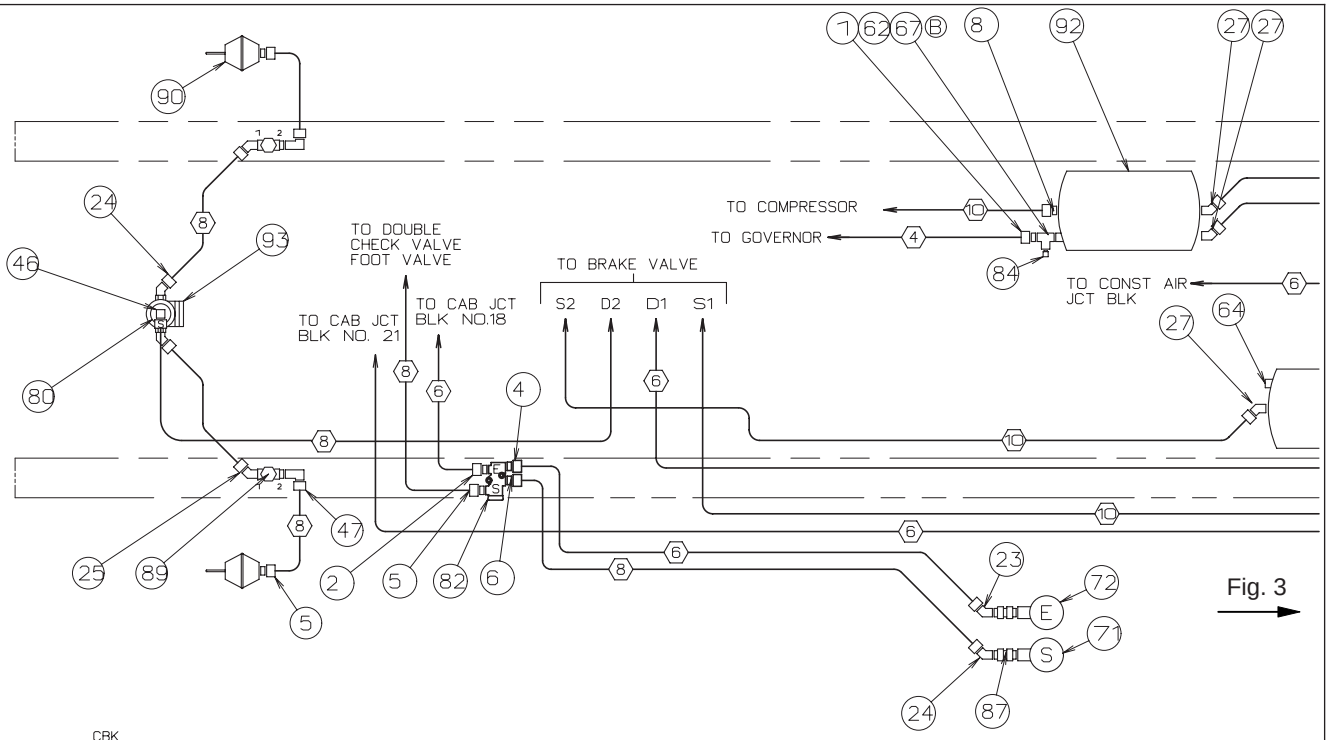
Figs. 2 and 3

Diagram D12−12210, Chg. Ltr. C

02/04/94 f420796a

Fig. 1, Wire Braid Hose With Single Rear Axle Truck, With Antilock, and Without Brake Proportioning, Date of Use 4/88 to 4/91

Single Rear Axle Truck, With Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	3	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
4	1	210502 000005	CONNECTOR, SAE (#6 HOSE-1/2NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	1	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	4	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	3	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	3	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	9	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
Ⓑ67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
71	1	12-09711-000	GLADHAND, SERVICE
72	1	12-09711-001	GLADHAND, EMERGENCY
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
87	2		STUD, CLAMPING
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

⟨4⟩ HOSE ASSY, NO. 4
⟨6⟩ HOSE ASSY, NO. 6
⟨8⟩ HOSE ASSY, NO. 8
⟨10⟩ HOSE ASSY, NO.10

⟨1⟩ QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

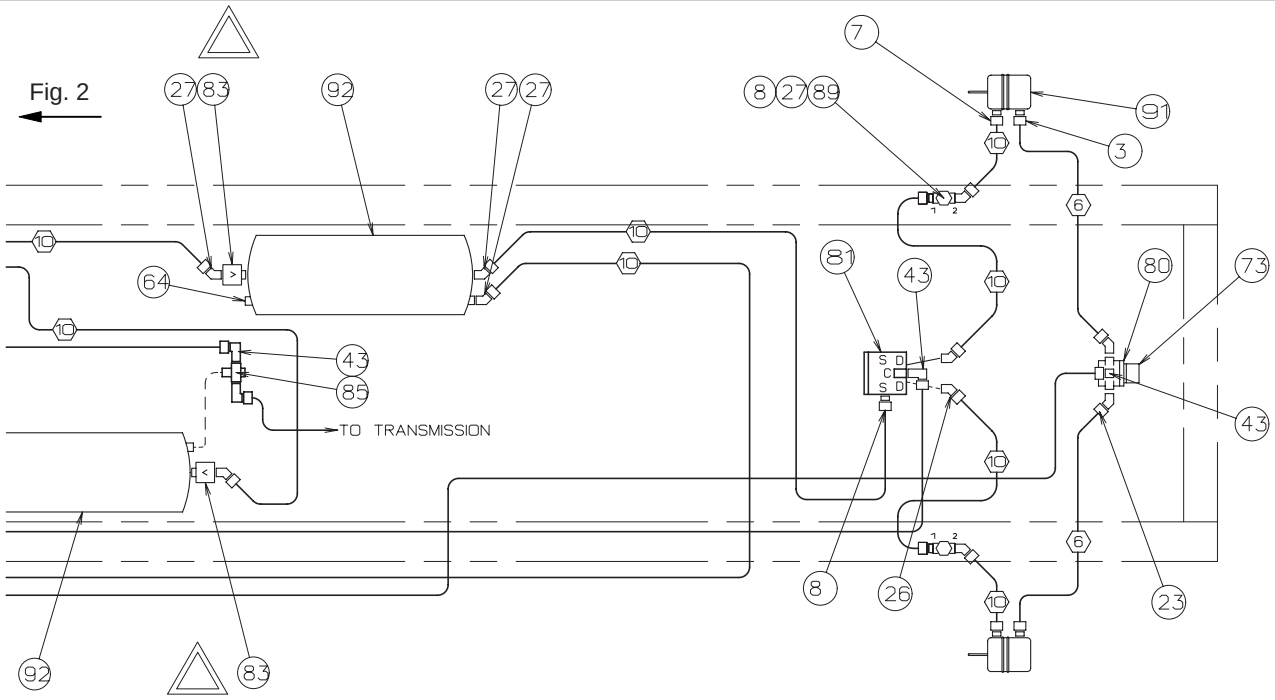
© △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12210, Chg. Ltr. C

02/03/94 f422000

Fig. 2

Single Rear Axle Truck, With Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	3	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
4	1	210502 000005	CONNECTOR, SAE (#6 HOSE-1/2NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	1	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	4	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	3	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	3	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	9	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
Ⓑ67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
71	1	12-09711-000	GLADHAND, SERVICE
72	1	12-09711-001	GLADHAND, EMERGENCY
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
87	2		STUD, CLAMPING
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

⟨4⟩ HOSE ASSY, NO. 4
⟨6⟩ HOSE ASSY, NO. 6
⟨8⟩ HOSE ASSY, NO. 8
⟨10⟩ HOSE ASSY, NO.10

⟨1⟩ QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

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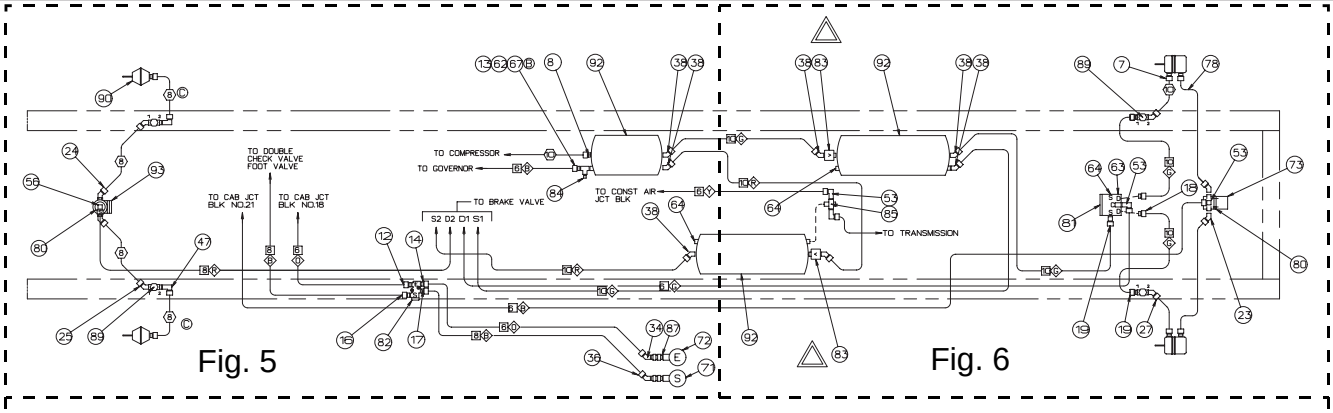
Diagram D12−12210, Chg. Ltr. C

02/03/94

f422001

Fig. 3

Single Rear Axle Truck, With Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
14	1	210500 000006	CONNECTOR, NTA (3/8NT-1/2NPT)
16	3	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
17	3	210500 000009	CONNECTOR, NTA (1/2NT-1/2NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	3	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
34	1	210500 000020	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210503 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	7	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
B 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
71	1	12-09711-000	GLADHAND, SERVICE
72	1	12-09711-001	GLADHAND, EMERGENCY
73	1	12-10474-000	BRACKET, MOUNTING
© 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
87	2		STUD, CLAMPING
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(E)	HOSE ASSY, #6 WIREBRAID
(S)	HOSE ASSY, #8 WIREBRAID
(X)	HOSE ASSY, #10 WIREBRAID
B	TUBE, NYLON NO.6 BLACK
E	TUBE, NYLON NO.6 YELLOW
G	TUBE, NYLON NO.6 GREEN
O	TUBE, NYLON NO.6 ORANGE
R	TUBE, NYLON NO.6 RED
B	TUBE, NYLON NO.8 BLACK
R	TUBE, NYLON NO.8 RED
N	TUBE, NYLON NO.10 GREEN
R	TUBE, NYLON NO.10 RED

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

© INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

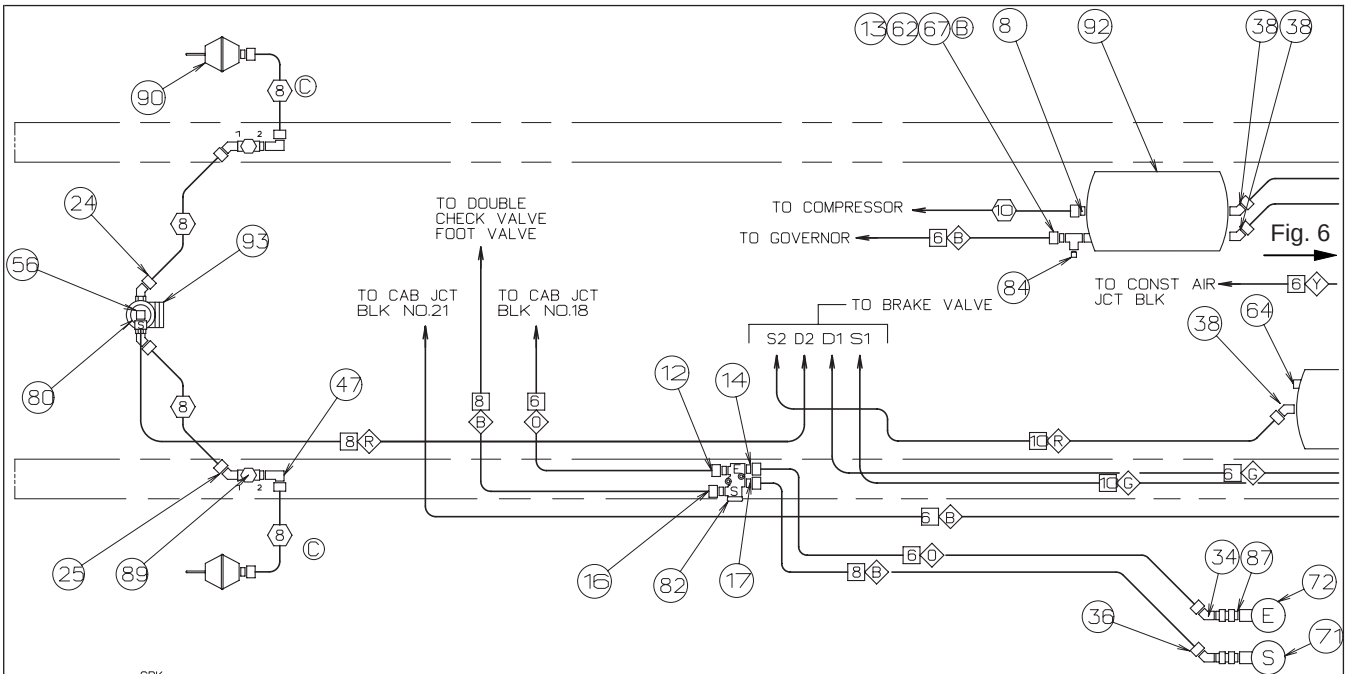
Figs. 5 and 6

Diagram D12−12204, Chg. Ltr. D

02/04/94 f420797a

Fig. 4, Nylon Tubing With Single Rear Axle Truck, With Antilock, and Without Brake Proportioning, Date of Use 4/88 to 4/91

Single Rear Axle Truck, With Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
14	1	210500 000006	CONNECTOR, NTA (3/8NT-1/2NPT)
16	3	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
17	3	210500 000009	CONNECTOR, NTA (1/2NT-1/2NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	3	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
34	1	210500 000020	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	7	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
(B)67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
71	1	12-09711-000	GLADHAND, SERVICE
72	1	12-09711-001	GLADHAND, EMERGENCY
73	1	12-10474-000	BRACKET, MOUNTING
(D) 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
87	2		STUD, CLAMPING
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

(D) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

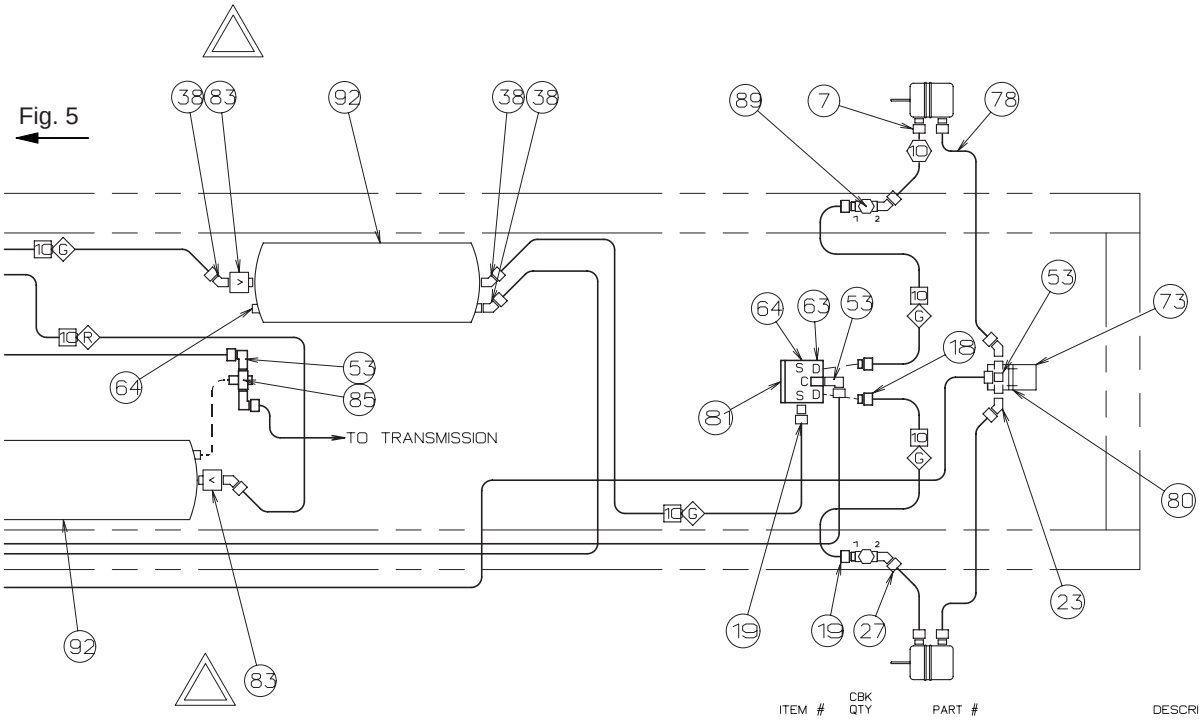
(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID
6 (B) TUBE, NYLON NO.6 BLACK
6 (Y) TUBE, NYLON NO.6 YELLOW
6 (G) TUBE, NYLON NO.6 GREEN
6 (O) TUBE, NYLON NO.6 ORANGE
6 (R) TUBE, NYLON NO.6 RED
8 (B) TUBE, NYLON NO.8 BLACK
8 (R) TUBE, NYLON NO.8 RED
10 (G) TUBE, NYLON NO.10 GREEN
10 (R) TUBE, NYLON NO.10 RED

Diagram D12−12204, Chg. Ltr. D

02/04/94 f422004

Fig. 5

Single Rear Axle Truck, With Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
14	1	210500 000006	CONNECTOR, NTA (3/8NT-1/2NPT)
16	3	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
17	3	210500 000009	CONNECTOR, NTA (1/2NT-1/2NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	3	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
34	1	210500 000020	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	7	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
Ⓑ67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
71	1	12-09711-000	GLADHAND, SERVICE
72	1	12-09711-001	GLADHAND, EMERGENCY
73	1	12-10474-000	BRACKET, MOUNTING
Ⓓ78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
87	2		STUD, CLAMPING
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID
6B TUBE, NYLON NO.6 BLACK
6Y TUBE, NYLON NO.6 YELLOW
6G TUBE, NYLON NO.6 GREEN
6O TUBE, NYLON NO.6 ORANGE
6R TUBE, NYLON NO.6 RED
8B TUBE, NYLON NO.8 BLACK
8R TUBE, NYLON NO.8 RED
10G TUBE, NYLON NO.10 GREEN
10R TUBE, NYLON NO.10 RED

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/04/94

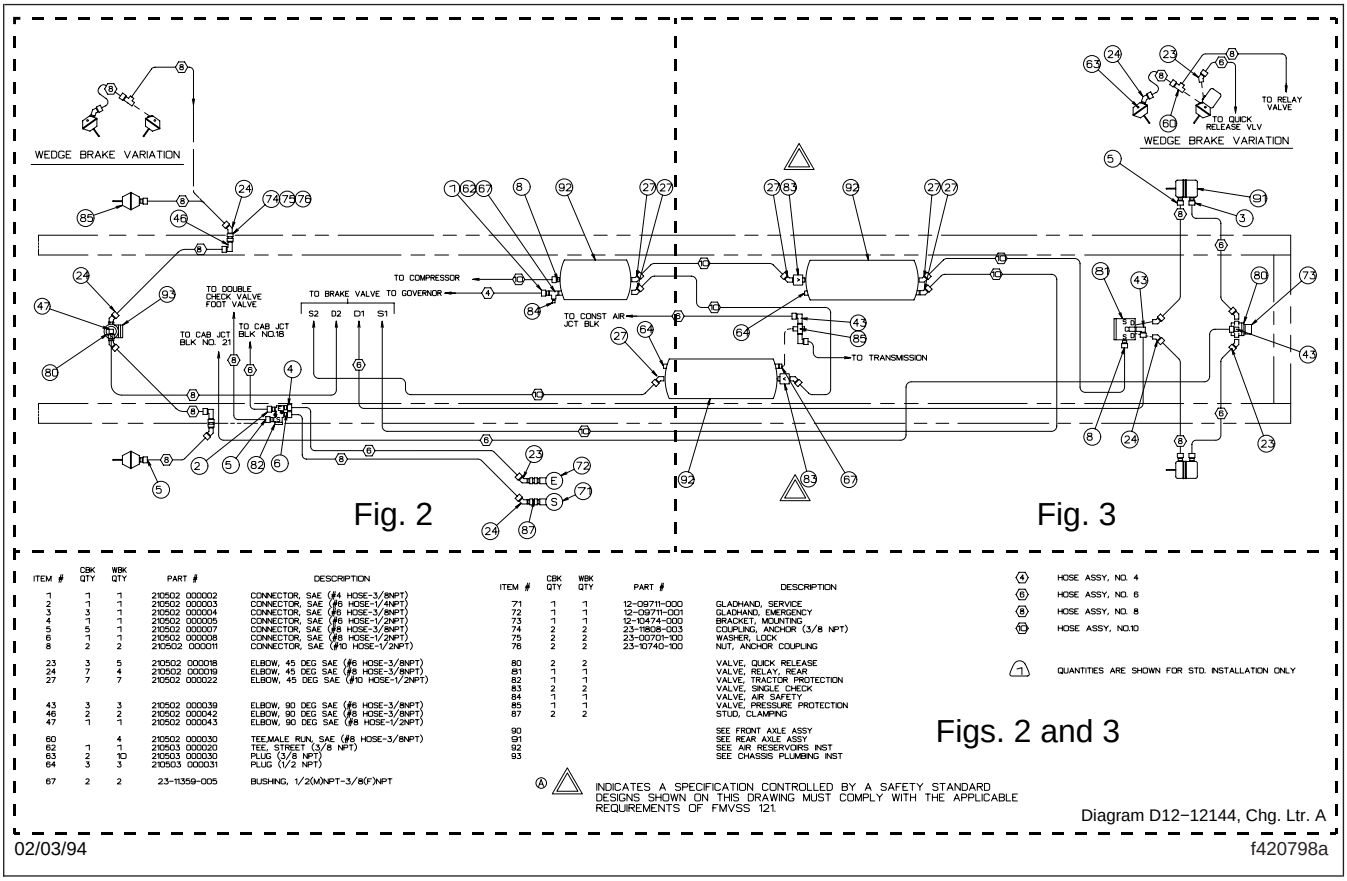
Diagram D12−12204, Chg. Ltr. D
f422005

Fig. 6

Single Rear Axle Truck, Without Antilock, Without Brake Proportioning

See Fig. 1 for a full view of the plumbing diagram wire braid hose, with single rear axle, without antilock, and without brake proportioning, date of use 4/88 to 4/91. **See Fig. 2**, or **Fig. 3** for partial (detailed) views plumbing diagram wire braid hose, with single rear axle, without antilock, and without brake proportioning, date of use 4/88 to 4/91.

See Fig. 4 for a full view of the plumbing diagram nylon tubing, with single rear axle, without antilock, and without brake proportioning, date of use 4/88 to 4/91. **See Fig. 5**, or **Fig. 6** for partial (detailed) views plumbing diagram nylon tubing, with single rear axle, without antilock, and without brake proportioning, date of use 4/88 to 4/91.



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
1	1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	1	1	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
4	1	1	210502 000005	CONNECTOR, SAE (#6 HOSE-1/2NPT)
5	5	1	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	1	1	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
8	2	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	3	5	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	7	4	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	7	7	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60		4	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	10	210503 000030	PLUG (3/8 NPT)
64	3	3	210503 000031	PLUG (1/2 NPT)
67	2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
71	1	1	12-09711-000	GLADHAND, SERVICE
72	1	1	12-09711-001	GLADHAND, EMERGENCY
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
87	2	2		STUD, CLAMPING
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

① QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

④ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

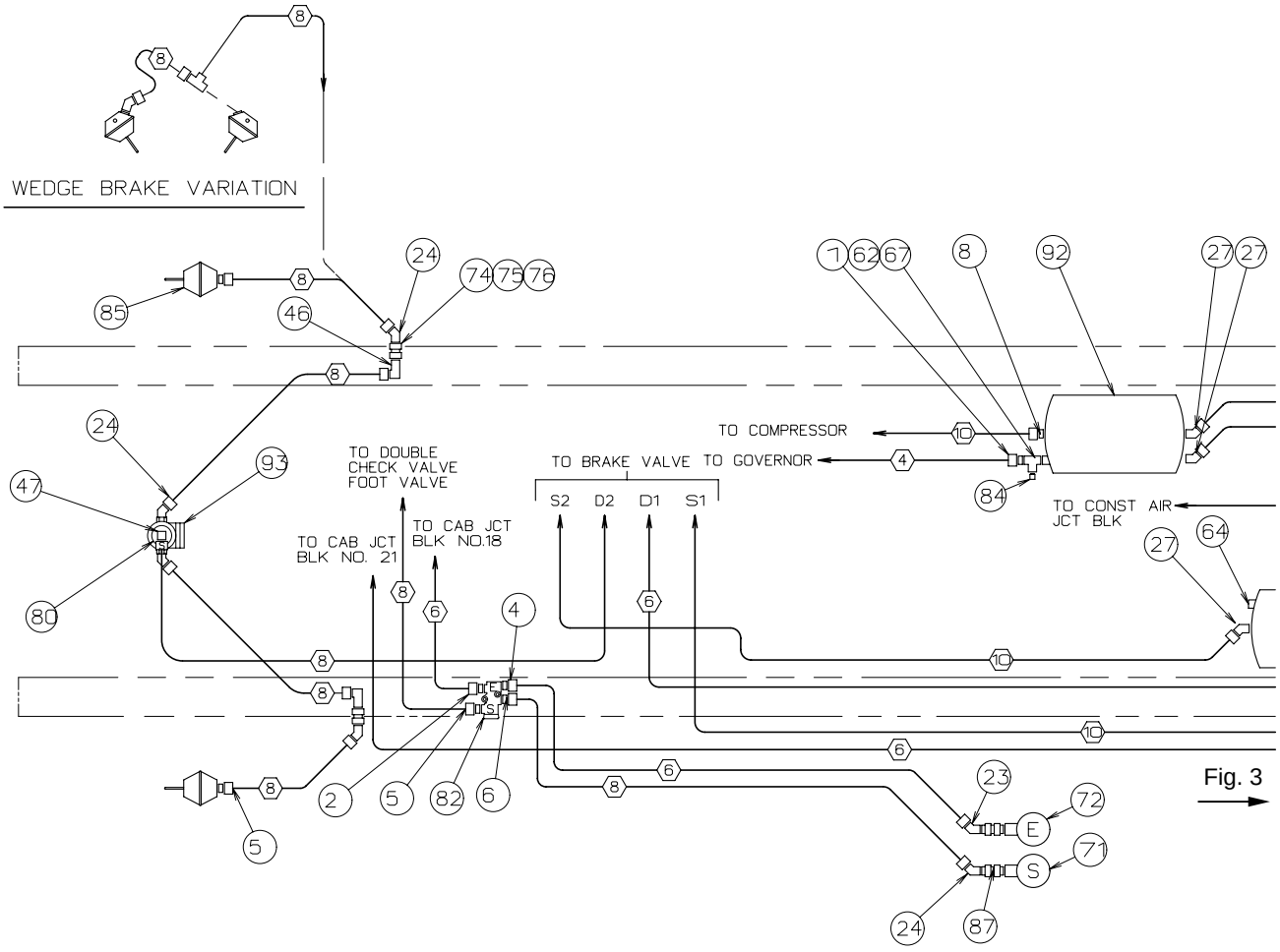
Figs. 2 and 3

Diagram D12−12144, Chg. Ltr. A

02/03/94 f420798a

Fig. 1, Wire Braid Hose With Single Rear Axle Truck, Without Antilock, and Without Brake Proportioning, Date of Use 4/88 to 4/91

Single Rear Axle Truck, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
1	1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	3	1	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
4	1	1	210502 000005	CONNECTOR, SAE (#6 HOSE-1/2NPT)
5	5	1	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	1	1	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
8	2	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	3	5	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	7	4	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	7	7	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60		4	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	10	210503 000030	PLUG (3/8 NPT)
64	3	3	210503 000031	PLUG (1/2 NPT)
67	2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
71	1	1	12-09711-000	GLADHAND, SERVICE
72	1	1	12-09711-001	GLADHAND, EMERGENCY
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
87	2	2		STUD, CLAMPING
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

Ⓐ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

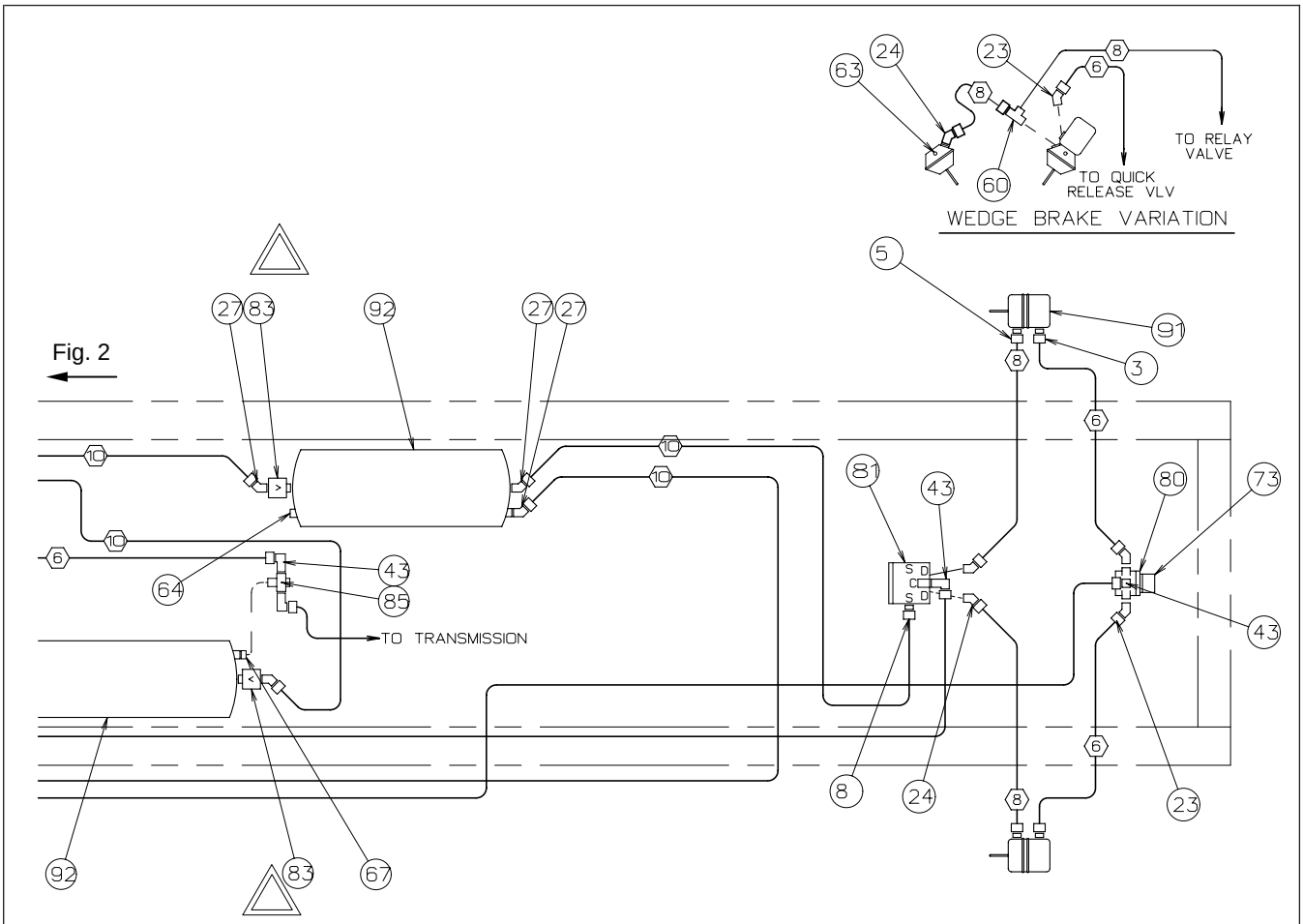
(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Diagram D12−12144, Chg. Ltr. A

02/03/94 f422002

Fig. 2

Single Rear Axle Truck, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
1	1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	3	1	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
4	1	1	210502 000005	CONNECTOR, SAE (#6 HOSE-1/2NPT)
5	5	1	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	1	1	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
8	2	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	3	5	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	7	4	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	7	7	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60		4	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	10	210503 000030	PLUG (3/8 NPT)
64	3	3	210503 000031	PLUG (1/2 NPT)
67	2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
71	1	1	12-09711-000	GLADHAND, SERVICE
72	1	1	12-09711-001	GLADHAND, EMERGENCY
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
87	2	2		STUD, CLAMPING
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(A) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

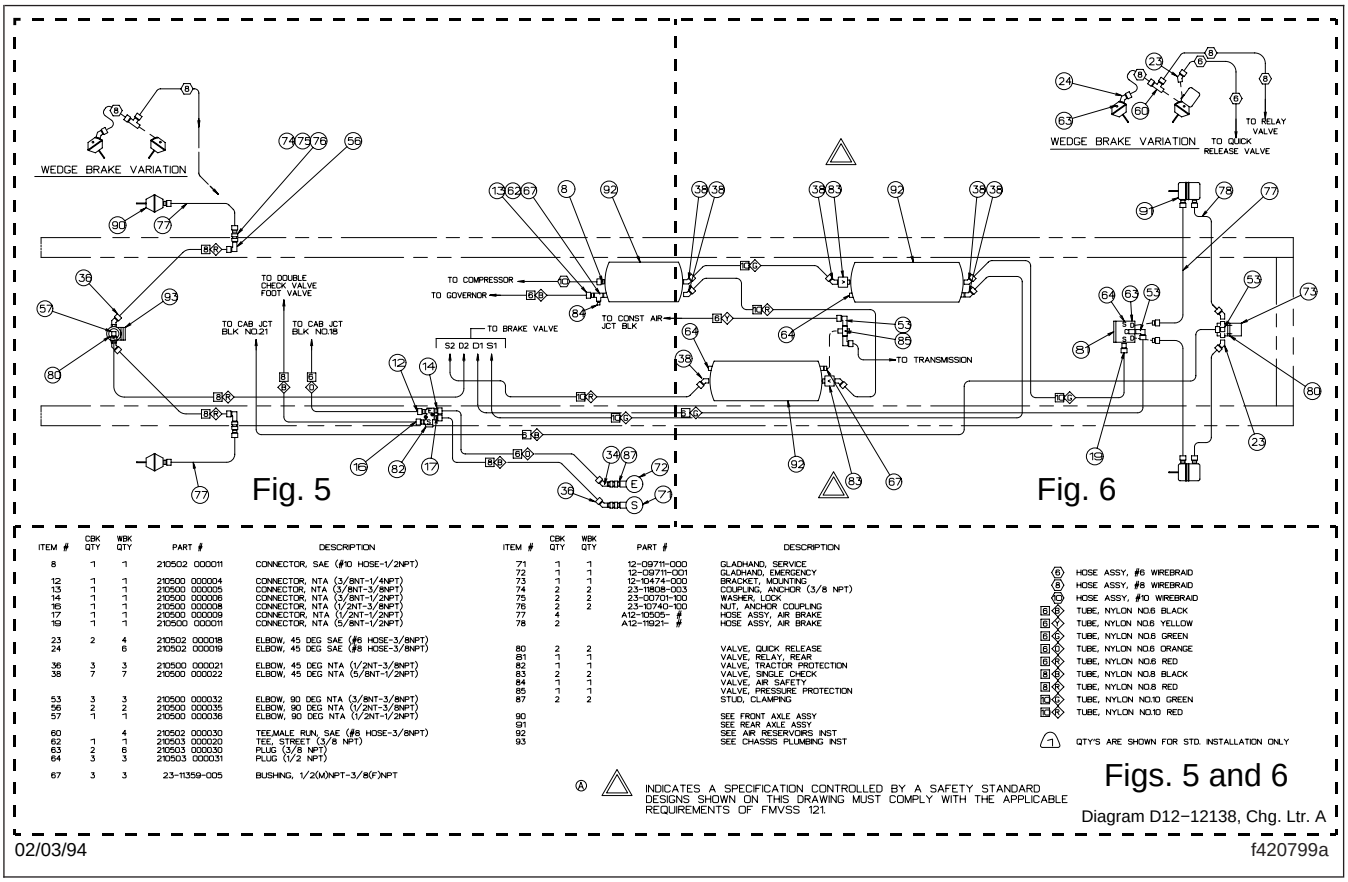
Diagram D12−12144, Chg. Ltr. A

02/03/94

f422003

Fig. 3

Single Rear Axle Truck, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
8	1	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
14	1	1	210500 000006	CONNECTOR, NTA (3/8NT-1/2NPT)
16	1	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
17	1	1	210500 000009	CONNECTOR, NTA (1/2NT-1/2NPT)
19	1	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24		6	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
36	3	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	7	7	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
53	3	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
60		4	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	6	210503 000030	PLUG (3/8 NPT)
64	3	3	210503 000031	PLUG (1/2 NPT)
67	3	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
71	1	1	12-09711-000	GLADHAND, SERVICE
72	1	1	12-09711-001	GLADHAND, EMERGENCY
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
77	4		A12-10525- #	HOSE ASSY, AIR BRAKE
78	2		A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
87	2	2		STUD, CLAMPING
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

- (6) HOSE ASSY, #6 WIREBRAID
- (8) HOSE ASSY, #8 WIREBRAID
- (10) HOSE ASSY, #10 WIREBRAID
- [6] TUBE, NYLON NO.6 BLACK
- [6] TUBE, NYLON NO.6 YELLOW
- [6] TUBE, NYLON NO.6 GREEN
- [6] TUBE, NYLON NO.6 ORANGE
- [8] TUBE, NYLON NO.8 RED
- [8] TUBE, NYLON NO.8 BLACK
- [8] TUBE, NYLON NO.8 RED
- [10] TUBE, NYLON NO.10 GREEN
- [10] TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

(A) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

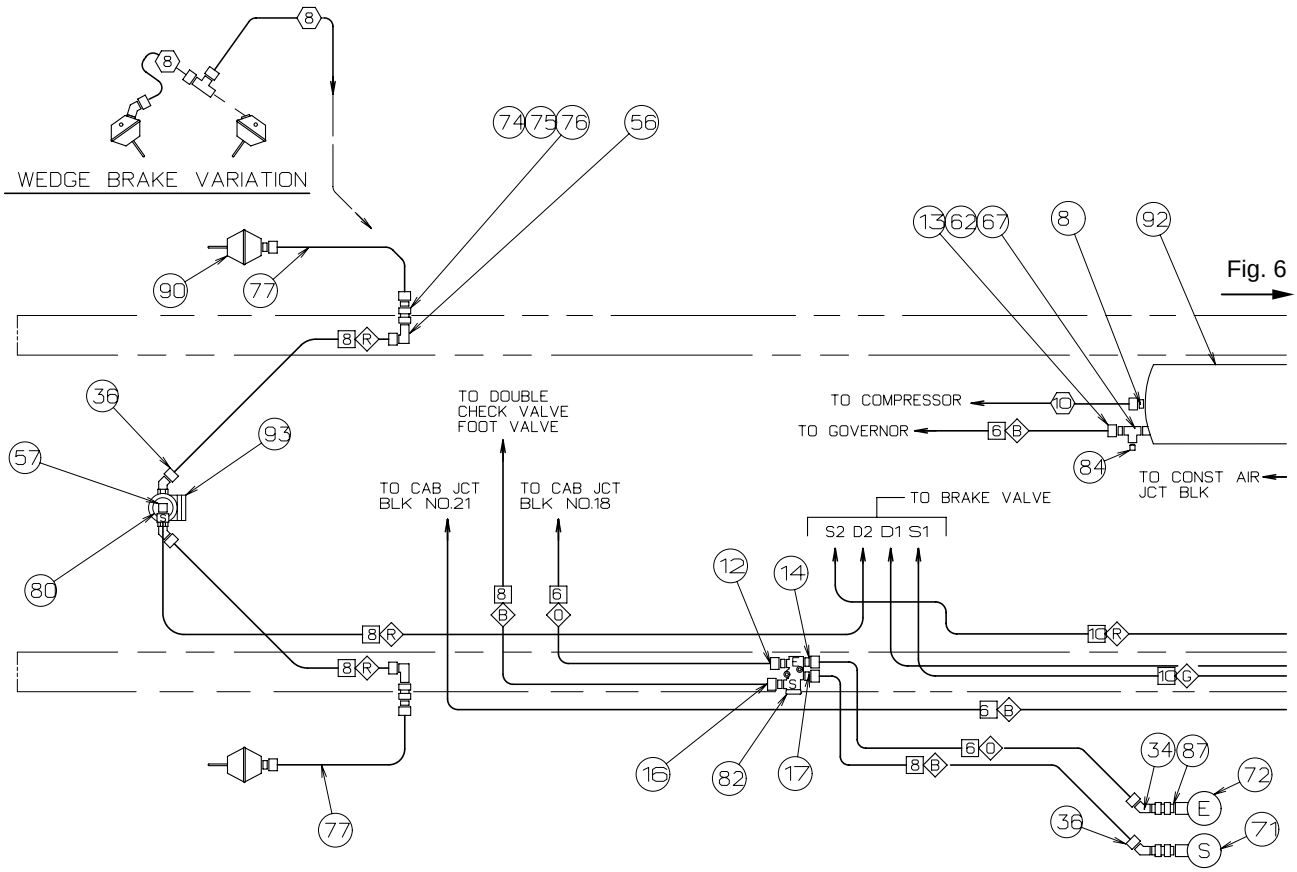
Figs. 5 and 6

Diagram D12−12138, Chg. Ltr. A

02/03/94 f420799a

Fig. 4, Nylon Tubing With Single Rear Axle Truck, Without Antilock, and Without Brake Proportioning, Date of Use 4/88 to 4/91

Single Rear Axle Truck, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
8	1	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
14	1	1	210500 000006	CONNECTOR, NTA (3/8NT-1/2NPT)
16	1	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
17	1	1	210500 000009	CONNECTOR, NTA (1/2NT-1/2NPT)
19	1	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24		6	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
36	3	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	7	7	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
53	3	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
60		4	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	6	210503 000030	PLUG (3/8 NPT)
64	3	3	210503 000031	PLUG (1/2 NPT)
67	3	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
71	1	1	12-09711-000	GLADHAND, SERVICE
72	1	1	12-09711-001	GLADHAND, EMERGENCY
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
77	4		A12-10505- #	HOSE ASSY, AIR BRAKE
78	2		A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
87	2	2		STUD, CLAMPING
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID
6B TUBE, NYLON NO.6 BLACK
6Y TUBE, NYLON NO.6 YELLOW
6G TUBE, NYLON NO.6 GREEN
6O TUBE, NYLON NO.6 ORANGE
6R TUBE, NYLON NO.6 RED
8B TUBE, NYLON NO.8 BLACK
8R TUBE, NYLON NO.8 RED
10G TUBE, NYLON NO.10 GREEN
10R TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

(A) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/03/94

Diagram D12−12138, Chg. Ltr. A

f422006

Fig. 5

Single Rear Axle Truck, Without Antilock, Without Brake Proportioning

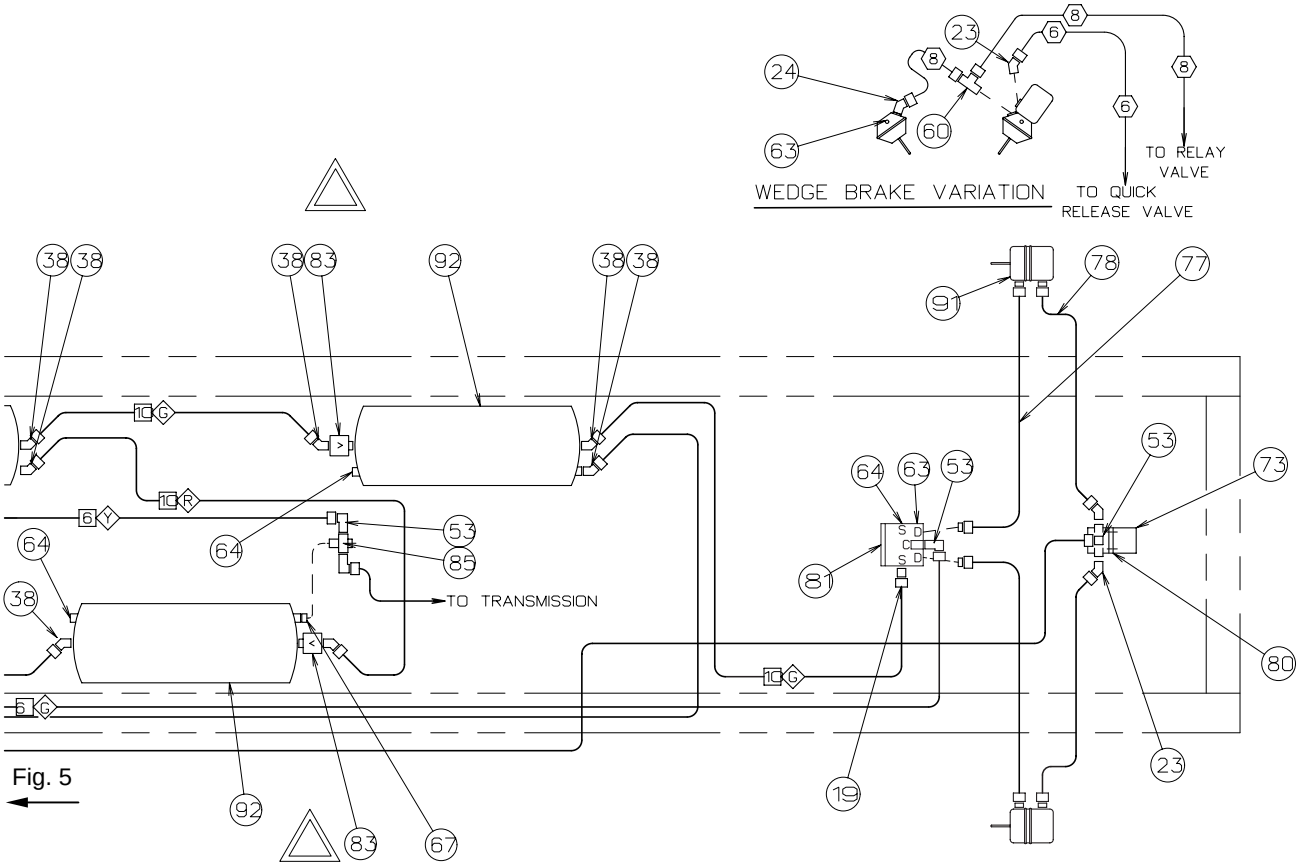


Fig. 5

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
8	1	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
14	1	1	210500 000006	CONNECTOR, NTA (3/8NT-1/2NPT)
16	1	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
17	1	1	210500 000009	CONNECTOR, NTA (1/2NT-1/2NPT)
19	1	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24		6	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
36	3	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	7	7	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
53	3	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
60		4	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	6	210503 000030	PLUG (3/8 NPT)
64	3	3	210503 000031	PLUG (1/2 NPT)
67	3	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
71	1	1	12-09711-000	GLADHAND, SERVICE
72	1	1	12-09711-001	GLADHAND, EMERGENCY
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
77	4		A12-10505- #	HOSE ASSY, AIR BRAKE
78	2		A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
87	2	2		STUD, CLAMPING
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID
6 B TUBE, NYLON NO.6 BLACK
6 Y TUBE, NYLON NO.6 YELLOW
6 G TUBE, NYLON NO.6 GREEN
6 O TUBE, NYLON NO.6 ORANGE
6 R TUBE, NYLON NO.6 RED
8 B TUBE, NYLON NO.8 BLACK
8 R TUBE, NYLON NO.8 RED
10 G TUBE, NYLON NO.10 GREEN
10 R TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

(A) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/03/94

Diagram D12−12138, Chg. Ltr. A

f422007

Fig. 6

Tandem Rear Axle Tractor, With Six-Channel Antilock, Without Brake Proportioning

See Fig. 1 for a full view of the plumbing diagram wire braid hose, with front quick release valve, date of use 4/88 to 4/91. **See Fig. 2**, or **Fig. 3** for partial (detailed) views plumbing diagram wire braid hose, with front quick release valve, date of use 4/88 to 4/91.

See Fig. 4 for a full view of the plumbing diagram wire braid hose, with front relay valve, date of use 4/88 to 4/91. **See Fig. 5**, or **Fig. 6** for partial (detailed) views plumbing diagram wire braid hose, with front relay valve, date of use 4/88 to 4/91.

See Fig. 7 for a full view of the plumbing diagram nylon tubing, with front quick release valve, date of use 4/88 to 4/91. **See Fig. 8**, or **Fig. 9** for partial (detailed) views plumbing diagram with nylon tubing, with front quick release valve, date of use 4/88 to 4/91.

See Fig. 10 for a full view of the plumbing diagram nylon tubing, with front relay valve, date of use 4/88 to 4/91. **See Fig. 11**, or **Fig. 12** for partial (detailed) views plumbing diagram with nylon tubing, with front relay valve, date of use 4/88 to 4/91.

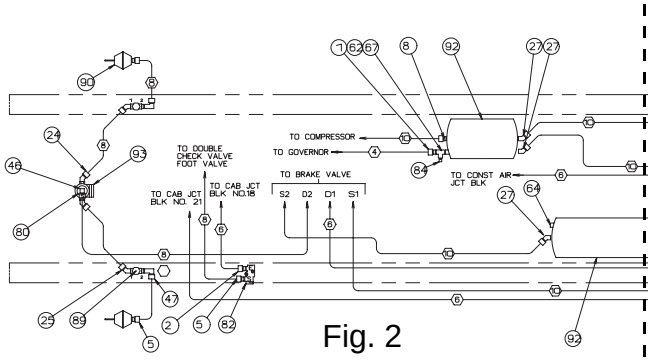


Fig. 2

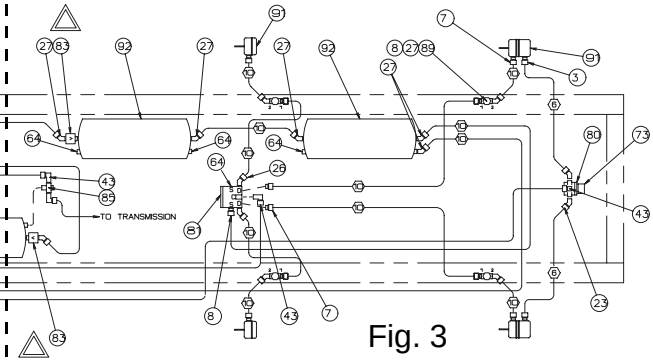


Fig. 3

ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#5 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	2	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	11	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
28	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOE, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69			

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

△1 QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

△2 INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

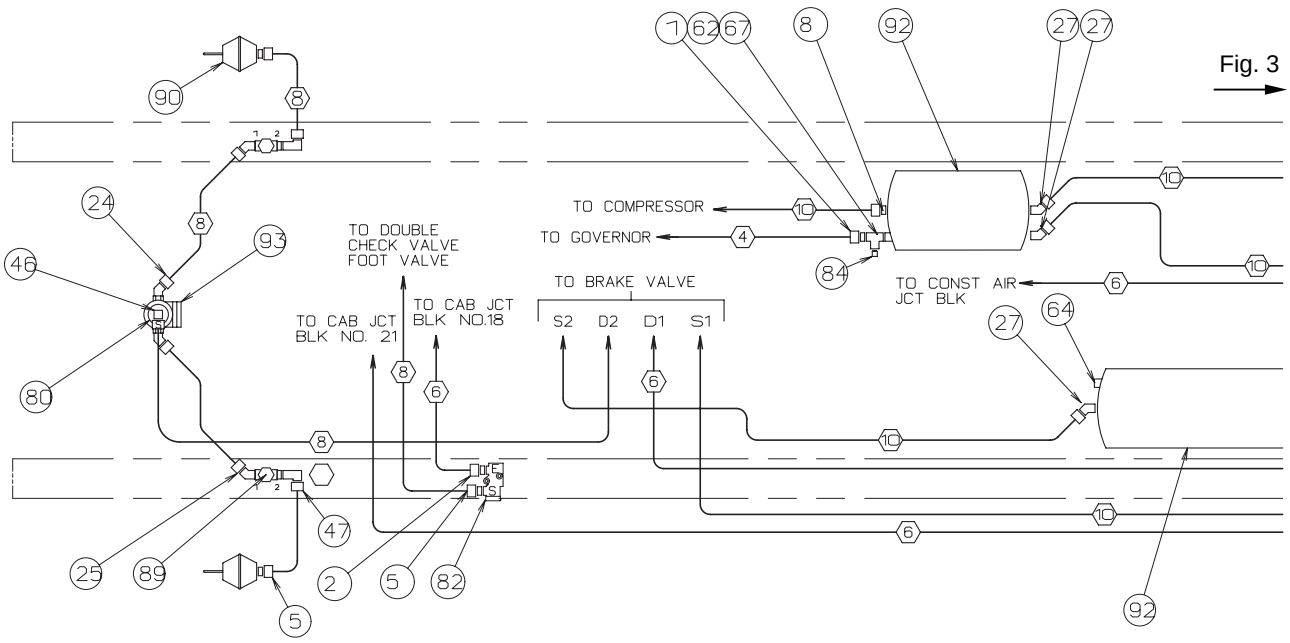
Figs. 2 and 3

Diagram D12−12208, Chg. Ltr. C

02/02/94 f420800a

Fig. 1, Wire Braid Hose, With Front Quick Release Valve, Date of Use 4/88 to 4/91

Tandem Rear Axle Tractor, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	2	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	11	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOE, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)

ITEM #	CBK QTY	PART #	DESCRIPTION
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69			
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

△ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12208, Chg. Ltr. C

02/02/94

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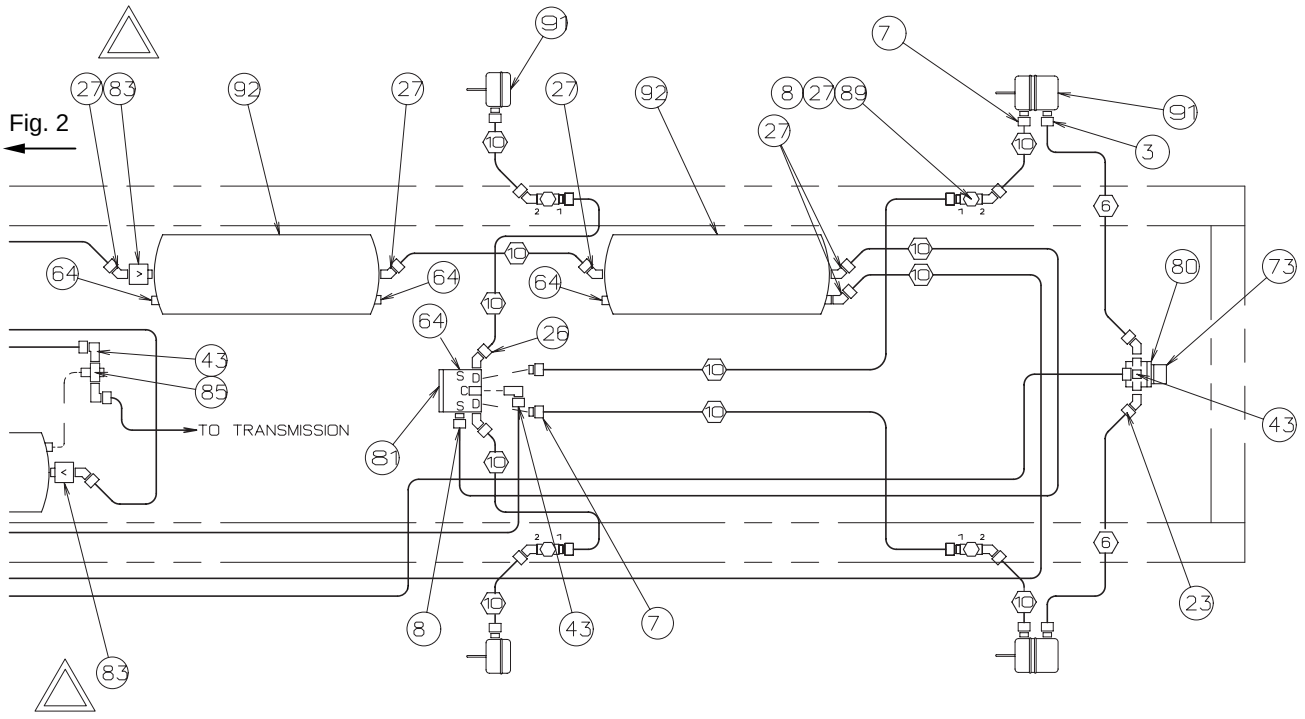
Fig. 2

Tandem Rear Axle Tractor, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	2	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	11	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOE, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)

ITEM #	CBK QTY	PART #	DESCRIPTION
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69			
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12208, Chg. Ltr. C

02/01/94

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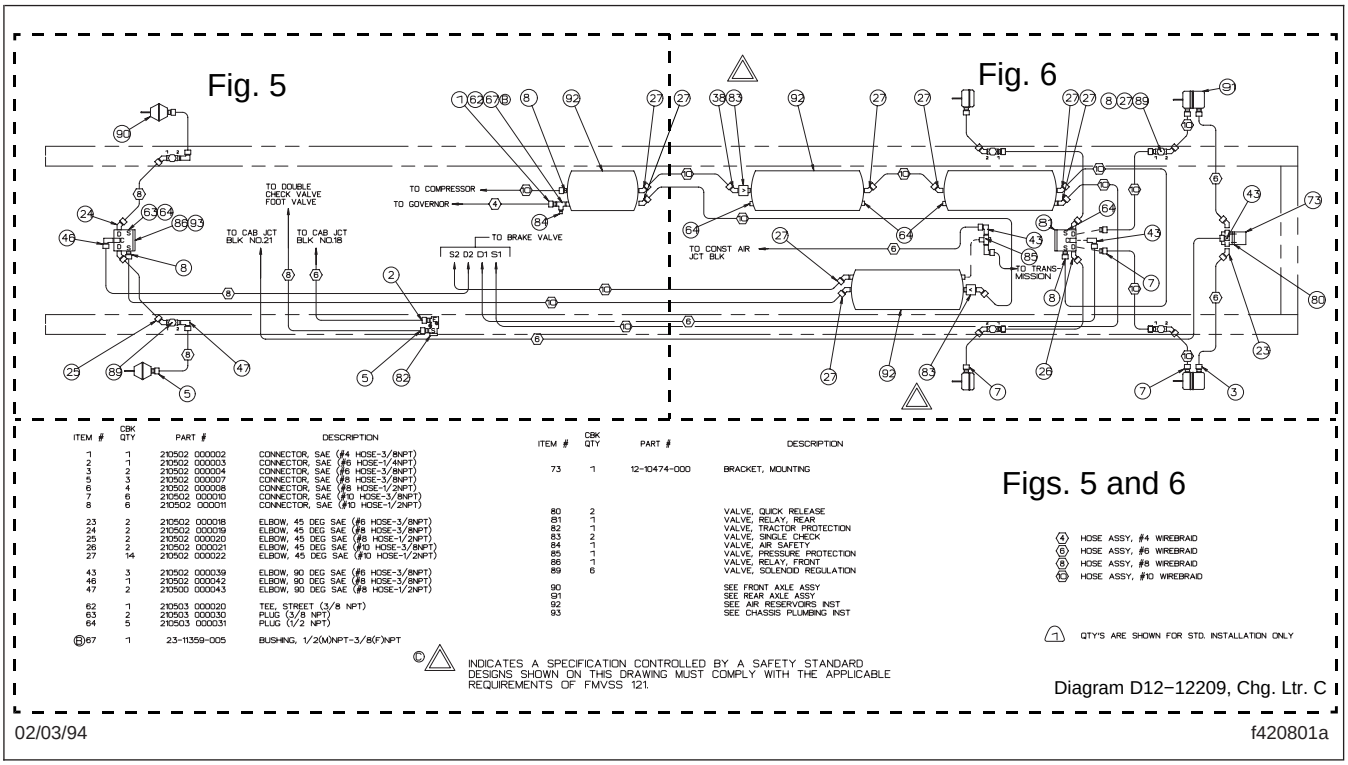
Fig. 3

Tandem Rear Axle Tractor, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	4	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	14	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
(B)67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

Figs. 5 and 6

(4) HOSE ASSY, #4 WIREBRAID
(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

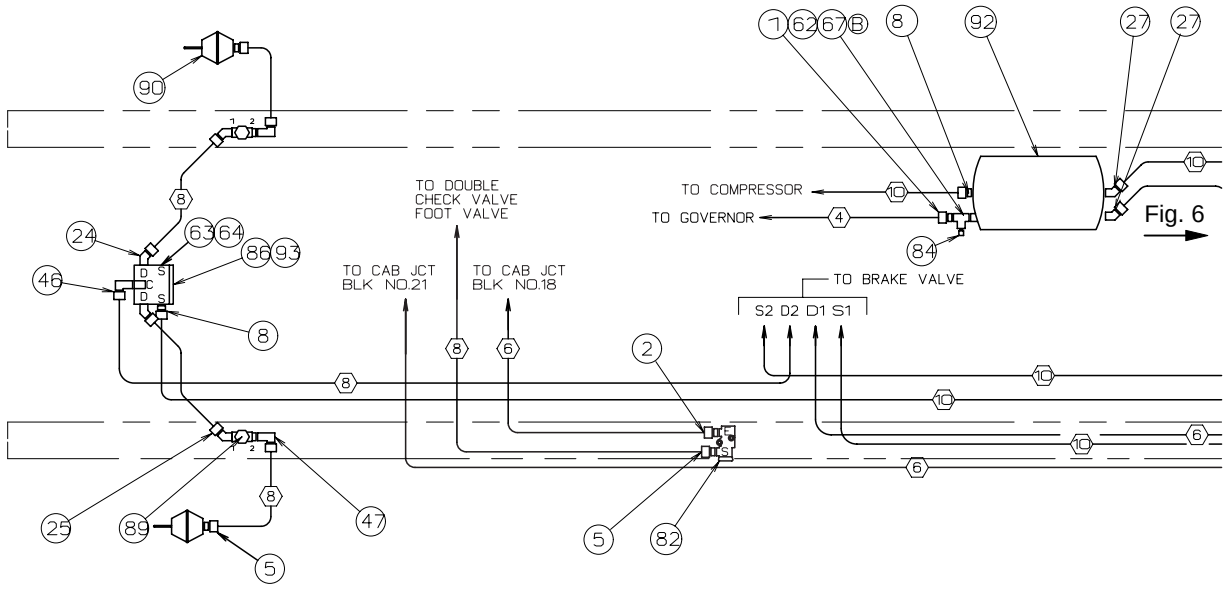
© INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12209, Chg. Ltr. C

02/03/94 f420801a

Fig. 4, Wire Braid Hose, With Front Relay Valve, Date of Use 4/88 to 4/91

Tandem Rear Axle Tractor, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	4	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	14	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210500 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓑ67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

④	HOSE ASSY, #4 WIREBRAID
⑥	HOSE ASSY, #6 WIREBRAID
⑧	HOSE ASSY, #8 WIREBRAID
⑩	HOSE ASSY, #10 WIREBRAID

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

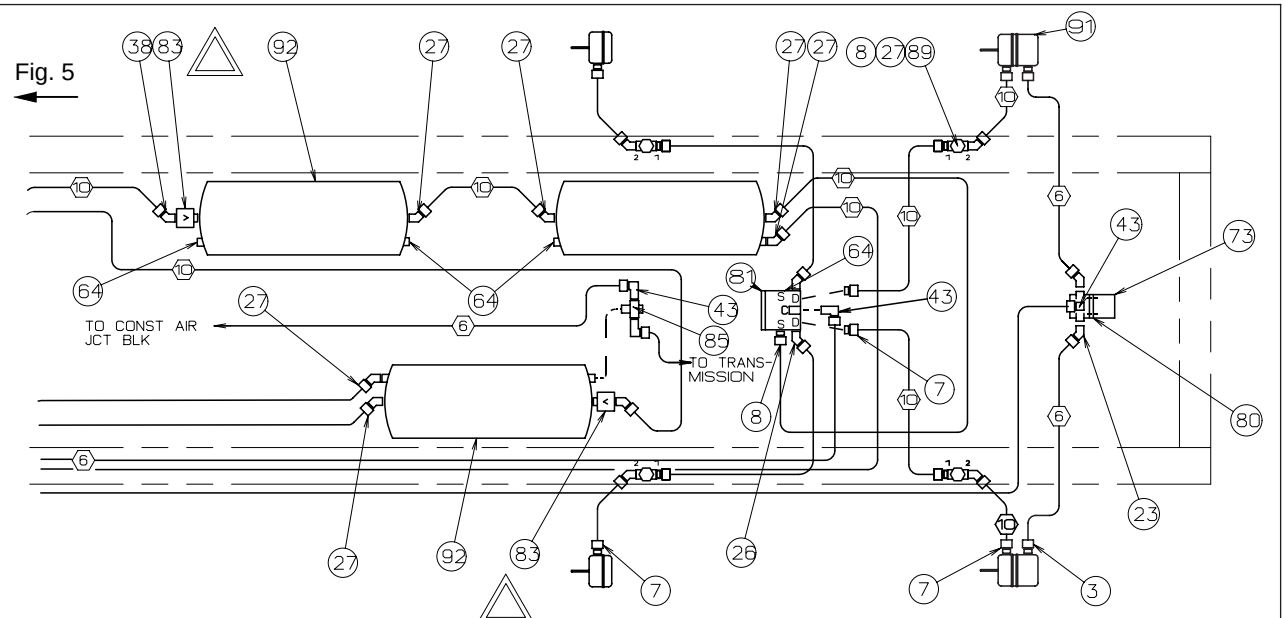
© △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12209, Chg. Ltr. C

02/03/94 f421094

Fig. 5

Tandem Rear Axle Tractor, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	4	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	14	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210500 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓑ67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, #4 WIREBRAID
(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

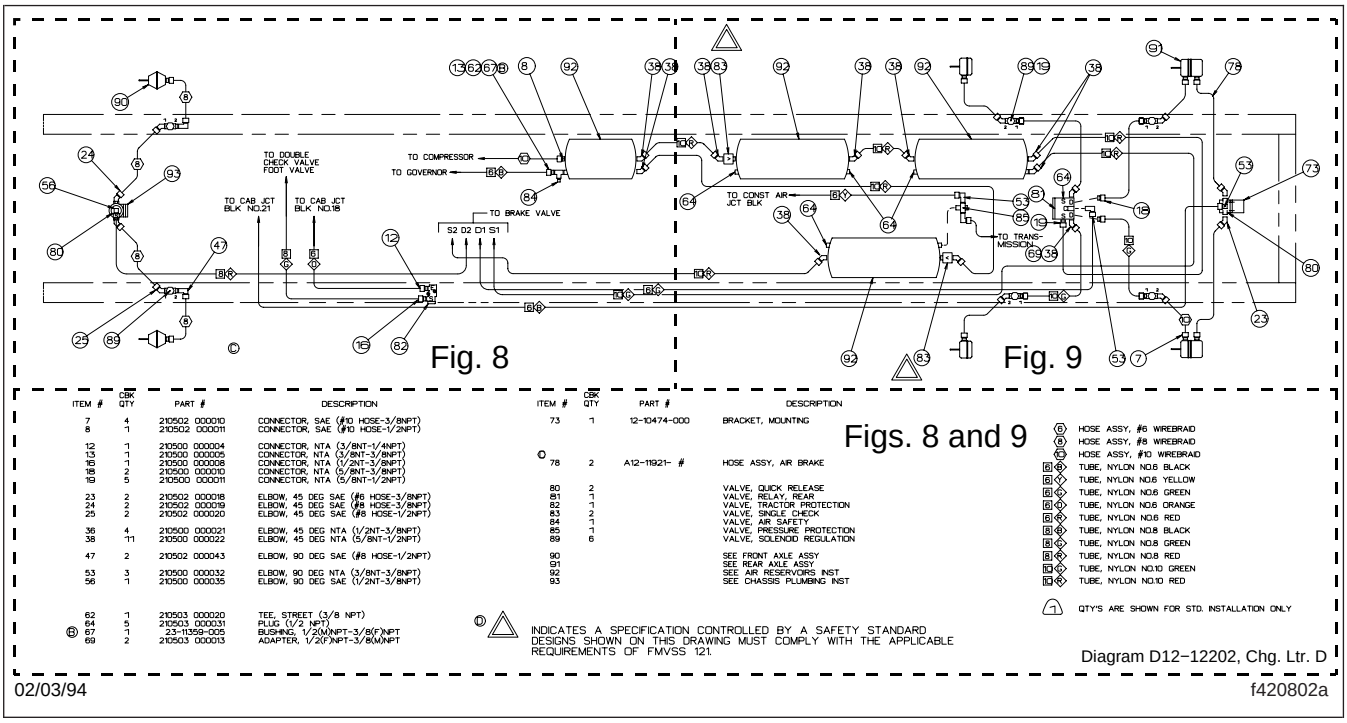
© △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12209, Chg. Ltr. C

02/09/94 f421095

Fig. 6

Tandem Rear Axle Tractor, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CSK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	5	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
36	4	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	11	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG SAE (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
(B) 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CSK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
© 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

Figs. 8 and 9

(6)	HOSE ASSY, #6 WIREBRAID
(8)	HOSE ASSY, #8 WIREBRAID
(10)	HOSE ASSY, #10 WIREBRAID
[6]	TUBE, NYLON NO.6 BLACK
[6]	TUBE, NYLON NO.6 YELLOW
[6]	TUBE, NYLON NO.6 GREEN
[6]	TUBE, NYLON NO.6 ORANGE
[6]	TUBE, NYLON NO.6 RED
[8]	TUBE, NYLON NO.8 BLACK
[8]	TUBE, NYLON NO.8 GREEN
[8]	TUBE, NYLON NO.8 RED
[10]	TUBE, NYLON NO.10 GREEN
[10]	TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

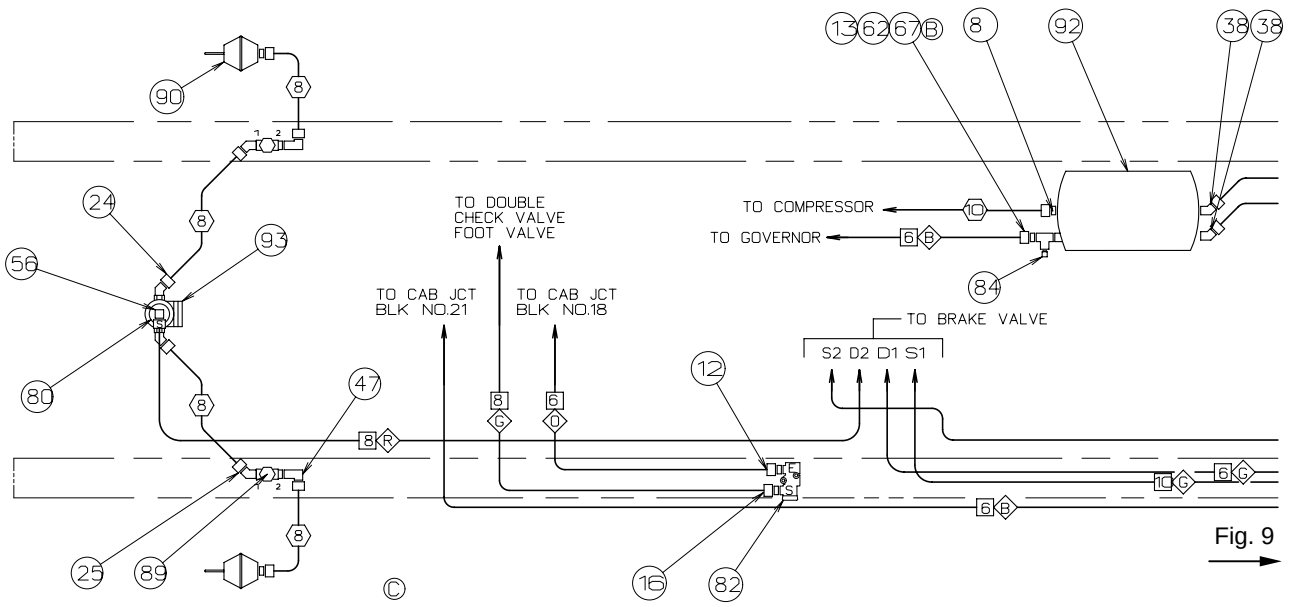
© INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12202, Chg. Ltr. D

02/03/94 f420802a

Fig. 7, Nylon Tubing, With Front Quick Release Valve, Date of Use 4/88 to 4/91

Tandem Rear Axle Tractor, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	7	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	5	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
36	4	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	11	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG SAE (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
(B) 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
(D) 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID
6 B TUBE, NYLON NO.6 BLACK
6 Y TUBE, NYLON NO.6 YELLOW
6 G TUBE, NYLON NO.6 GREEN
6 O TUBE, NYLON NO.6 ORANGE
6 R TUBE, NYLON NO.6 RED
8 B TUBE, NYLON NO.8 BLACK
8 G TUBE, NYLON NO.8 GREEN
8 R TUBE, NYLON NO.8 RED
10 G TUBE, NYLON NO.10 GREEN
10 R TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

(D) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

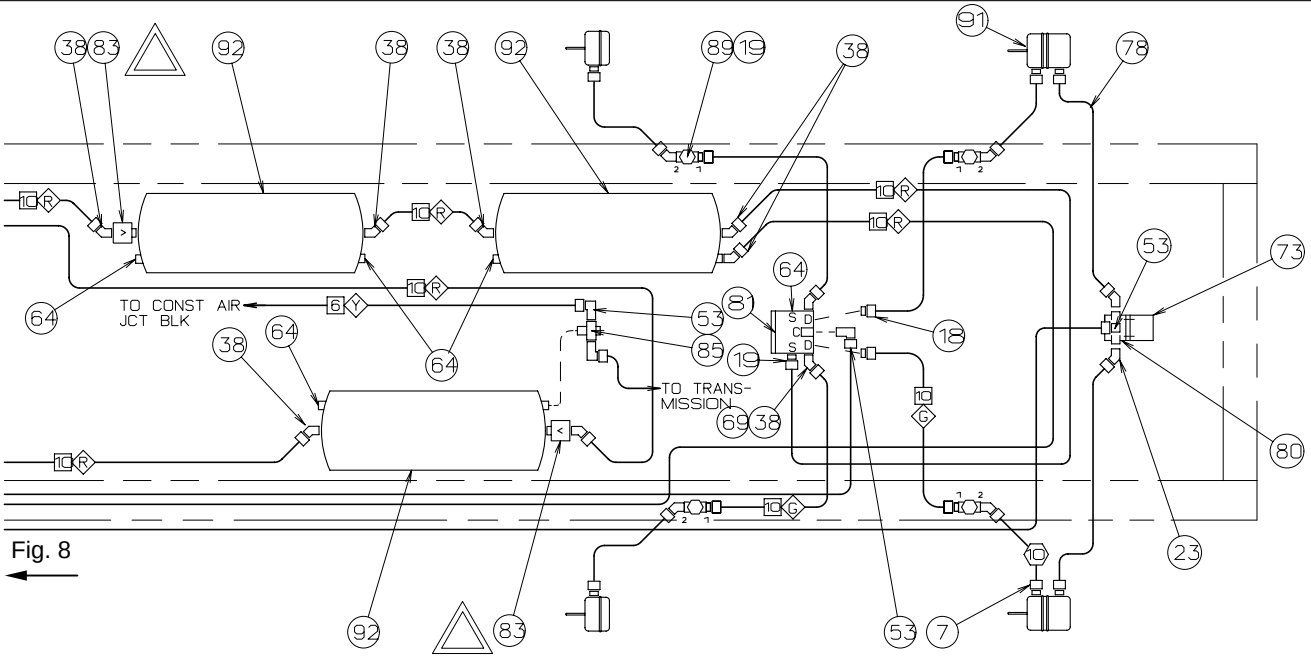
02/03/94

Diagram D12−12202, Chg. Ltr. D

f422008

Fig. 8

Tandem Rear Axle Tractor, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	5	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
36	4	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	11	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG SAE (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
Ⓓ 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

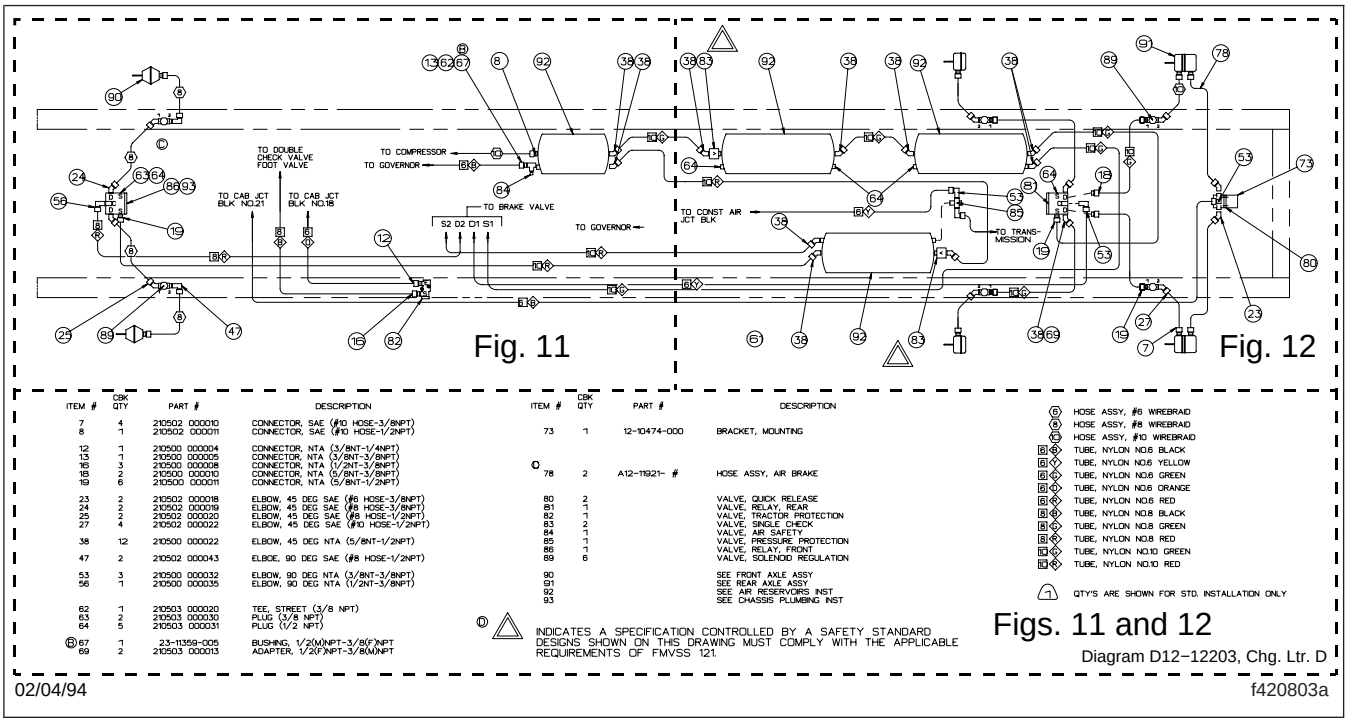
Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6B	TUBE, NYLON NO.6 BLACK
6Y	TUBE, NYLON NO.6 YELLOW
6G	TUBE, NYLON NO.6 GREEN
6O	TUBE, NYLON NO.6 ORANGE
6R	TUBE, NYLON NO.6 RED
8B	TUBE, NYLON NO.8 BLACK
8G	TUBE, NYLON NO.8 GREEN
8R	TUBE, NYLON NO.8 RED
10G	TUBE, NYLON NO.10 GREEN
10R	TUBE, NYLON NO.10 RED

02/03/94 Diagram D12−12202, Chg. Ltr. D f422009

Fig. 9

Tandem Rear Axle Tractor, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	3	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	6	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	4	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
38	12	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOE, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓡ67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
© 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

© INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Ⓑ HOSE ASSY, #6 WIREBRAID
Ⓒ HOSE ASSY, #8 WIREBRAID
Ⓓ HOSE ASSY, #10 WIREBRAID
TUBE, NYLON NO.6 BLACK
TUBE, NYLON NO.6 YELLOW
TUBE, NYLON NO.6 GREEN
TUBE, NYLON NO.6 ORANGE
TUBE, NYLON NO.6 RED
TUBE, NYLON NO.8 BLACK
TUBE, NYLON NO.8 GREEN
TUBE, NYLON NO.8 RED
TUBE, NYLON NO.10 GREEN
TUBE, NYLON NO.10 RED

△1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

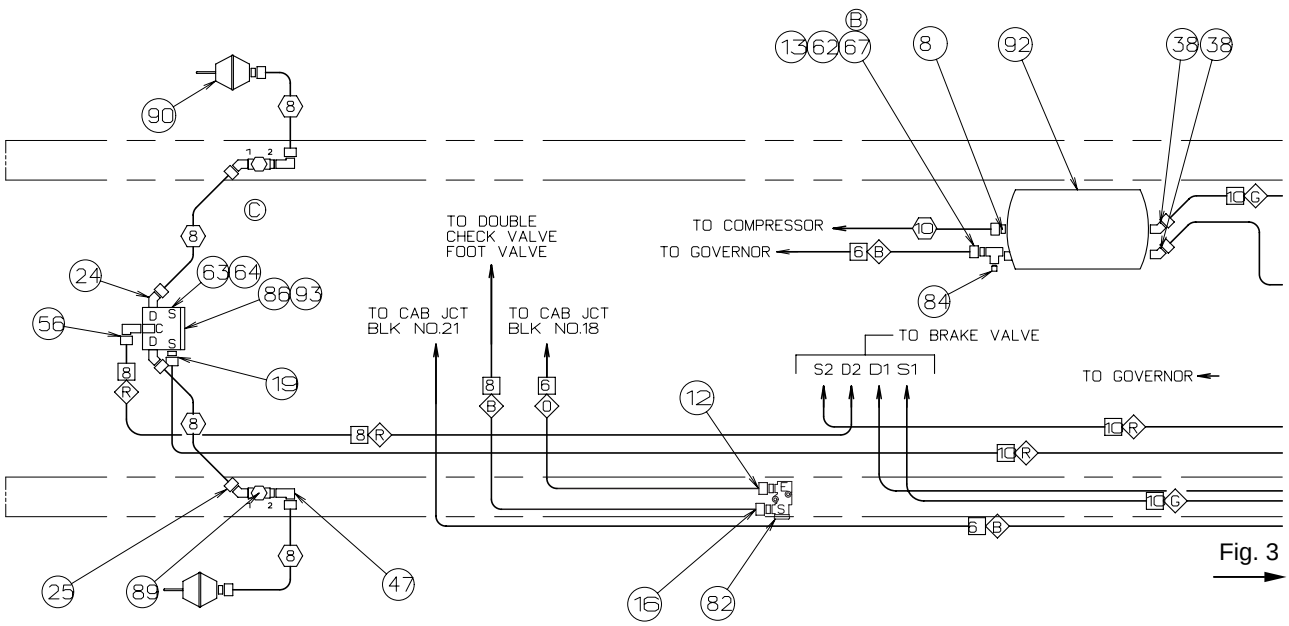
Figs. 11 and 12

Diagram D12−12203, Chg. Ltr. D

02/04/94 f420803a

Fig. 10, Nylon Tubing, With Front Relay Valve, Date of Use 4/88 to 4/91

Tandem Rear Axle Tractor, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	3	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	6	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	4	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
38	12	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOE, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
© 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

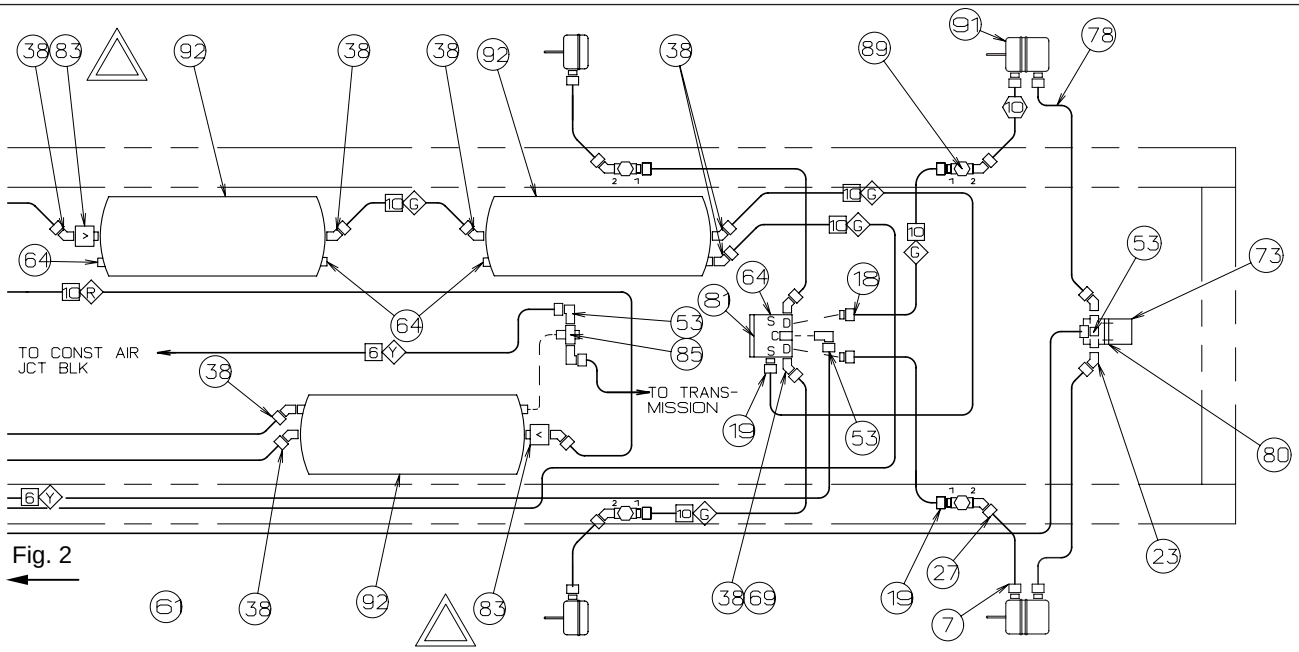
02/04/94

Diagram D12−12203, Chg. Ltr. D

f422010

Fig. 11

Tandem Rear Axle Tractor, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	3	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	6	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	4	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
38	12	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOE, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
Ⓒ 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/04/94

Diagram D12−12203, Chg. Ltr. D

f422011

Fig. 12

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning

See Fig. 1 for a full view of the plumbing diagram COE with rear proportioning, wire braid hose, front quick release valve, tractor protection valve on frame, date of use 4/88 to 4/91. **See Fig. 2**, or **Fig. 3** for partial (detailed) views plumbing diagram COE with rear proportioning, wire braid hose, front quick release valve, tractor protection valve on frame, date of use 4/88 to 4/91.

See Fig. 4 for a full view of the plumbing diagram COE with rear proportioning only, wire braid hose, front quick release valve, tractor protection valve on tunnel, date of use 3/89 to 4/91. **See Fig. 5**, or **Fig. 6** for partial (detailed) views plumbing COE with rear proportioning only, wire braid hose, front quick release valve, tractor protection valve on tunnel, date of use 3/89 to 4/91.

See Fig. 7 for a full view of the plumbing diagram COE with rear proportioning only, wire braid hose, front relay valve, tractor protection valve on frame, date of use 4/88 to 4/91. **See Fig. 8**, or **Fig. 9** for partial (detailed) views plumbing diagram COE with rear proportioning only, wire braid hose, front relay valve, tractor protection valve on frame, date of use 4/88 to 4/91.

See Fig. 10 for a full view of the plumbing diagram COE with rear proportioning only, wire braid hose, front relay valve, tractor protection valve on tunnel, date of use 3/89 to 4/91. **See Fig. 11**, or **Fig. 12** for partial (detailed) views plumbing diagram COE with rear proportioning only, wire braid hose, front relay valve, tractor protection valve on tunnel, date of use 3/89 to 4/91.

See Fig. 13 for a full view of the plumbing diagram COE with rear proportioning only, nylon tubing, front quick release valve, tractor protection valve on frame, date of use 4/88 to 4/91. **See Fig. 14**, or **Fig. 15** for partial (detailed) views plumbing diagram COE with rear proportioning only, nylon tubing, front quick release valve, tractor protection valve on frame, date of use 4/88 to 4/91.

See Fig. 16 for a full view of the plumbing diagram COE with rear proportioning only, nylon tubing, front quick release valve, tractor protection valve on tunnel, date of use 3/89 to 4/91. **See Fig. 17**, or **Fig. 18** for partial (detailed) views plumbing diagram COE with rear proportioning only, nylon tubing, front quick release valve, tractor protection valve on tunnel, date of use 3/89 to 4/91.

See Fig. 19 for a full view of the plumbing diagram COE with rear proportioning only, nylon tubing, front relay valve, tractor protection valve on frame, date of use 4/88 to 4/91. **See Fig. 20**, or **Fig. 21** for partial (detailed) views plumbing diagram COE with rear proportioning only, nylon tubing, front relay valve, tractor protection valve on frame, date of use 4/88 to 4/91.

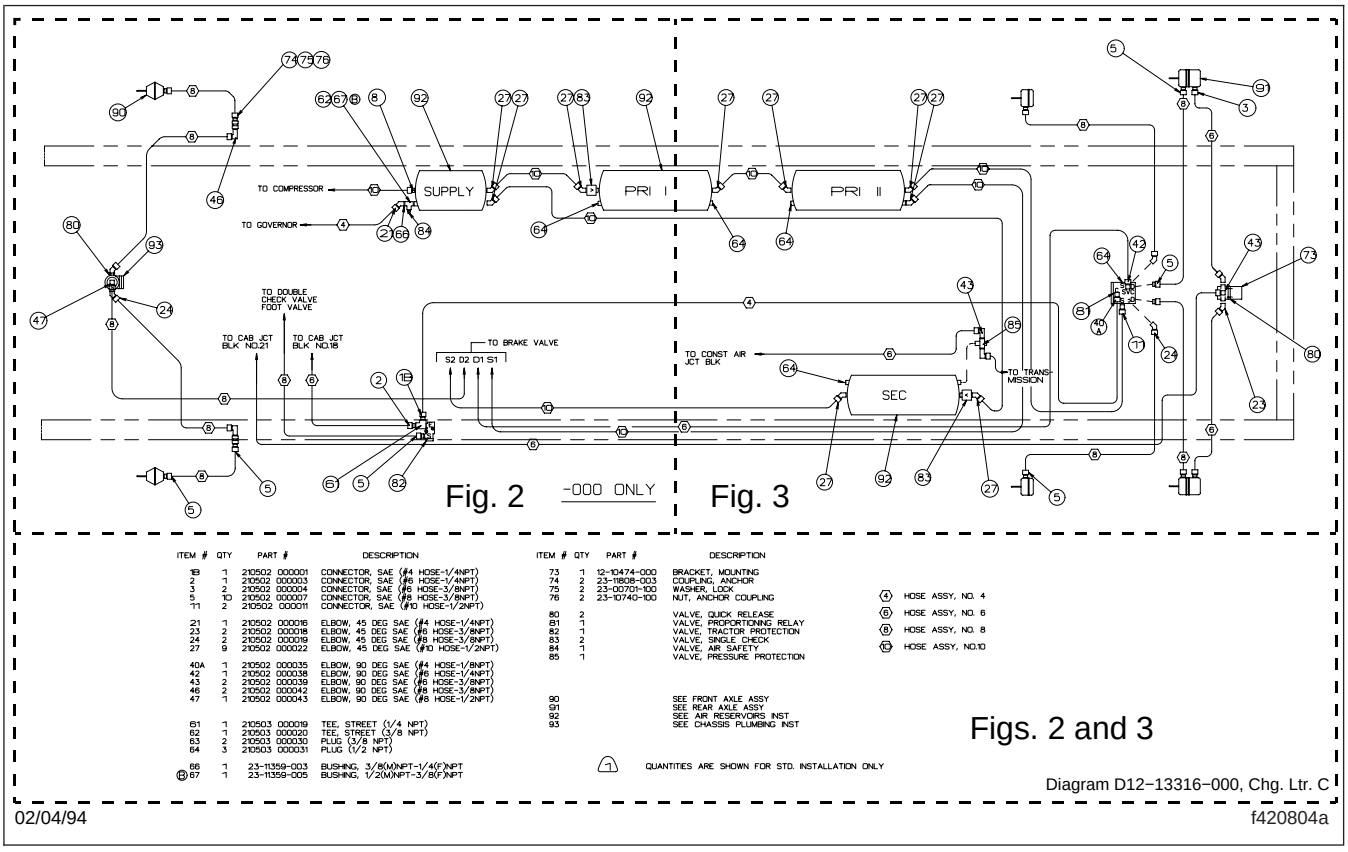
See Fig. 22 for a full view of the plumbing diagram COE with rear proportioning only, nylon tubing, front relay valve, tractor protection valve on tunnel, date of use 3/89 to 4/91. **See Fig. 23**, or **Fig. 24** for partial (detailed) views plumbing diagram COE with rear proportioning only, nylon tubing, front relay valve, tractor protection valve on tunnel, date of use 3/89 to 4/91.

See Fig. 25 for a full view of the plumbing diagram COE or Conventional, front and rear proportioning, nylon tubing, with inversion valve, date of use 4/88 to 4/91. **See Fig. 26**, or **Fig. 27** for partial (detailed) views plumbing diagram COE or Conventional, front and rear proportioning, nylon tubing, with inversion valve, date of use 4/88 to 4/91.

See Fig. 28 for a full view of the plumbing diagram COE or Conventional, rear proportioning only, nylon tubing, with inversion valve, date of use 4/88 to 4/91. **See Fig. 29**, or **Fig. 30** for partial (detailed) views plumbing diagram COE or Conventional, rear proportioning only, nylon tubing, with inversion valve, date of use 4/88 to 4/91.

See Fig. 31 for a full view of the plumbing diagram COE or Conventional, front and rear proportioning, nylon tubing, with inversion valve, date of use 4/88 to 4/91. **See Fig. 32**, or **Fig. 33** for partial (detailed) views plumbing diagram COE or Conventional, front and rear proportioning, nylon tubing, with inversion valve, date of use 4/88 to 4/91.

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	10	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	9	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
(B)67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

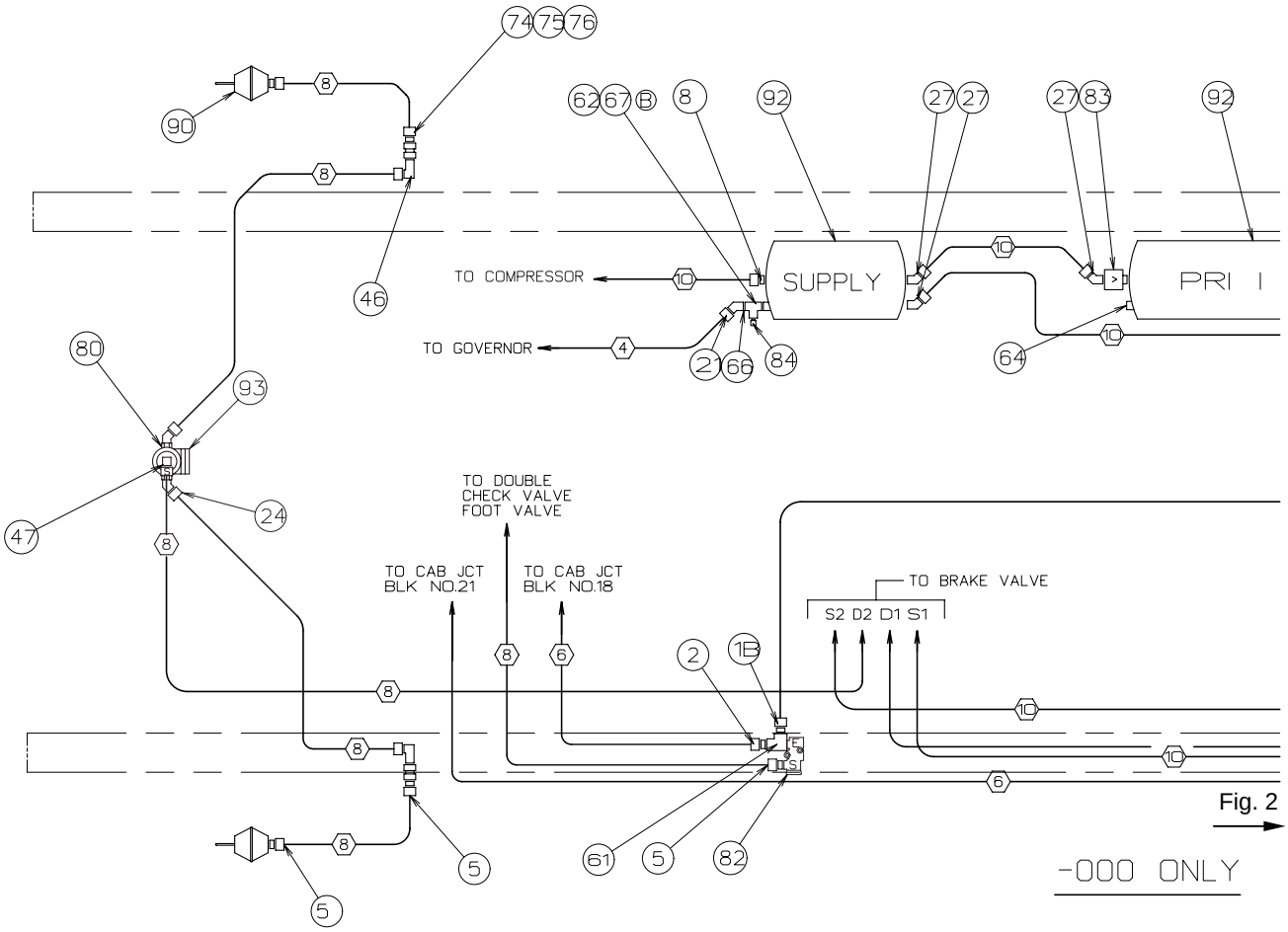
Figs. 2 and 3

Diagram D12−13316−000, Chg. Ltr. C

02/04/94 f420804a

Fig. 1, COE With Rear Proportioning, Wire Braid Hose, Front Quick Release Valve, Tractor Protection Valve on Frame, Date of Use 4/88 to 4/91

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	10	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	9	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
B 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

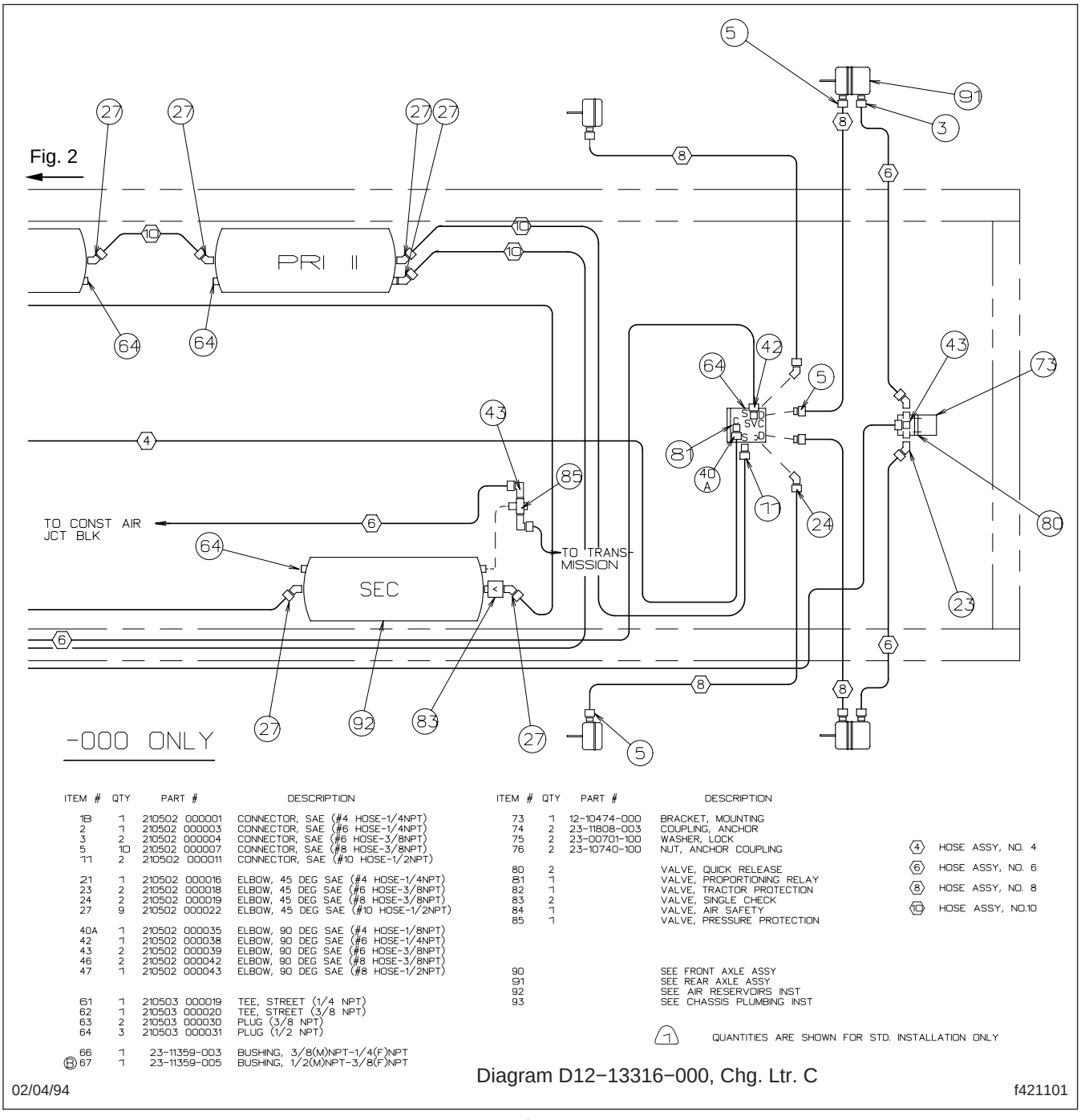
02/04/94

Diagram D12−13316−000, Chg. Ltr. C

f421100

Fig. 2

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	10	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	9	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
(B) 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

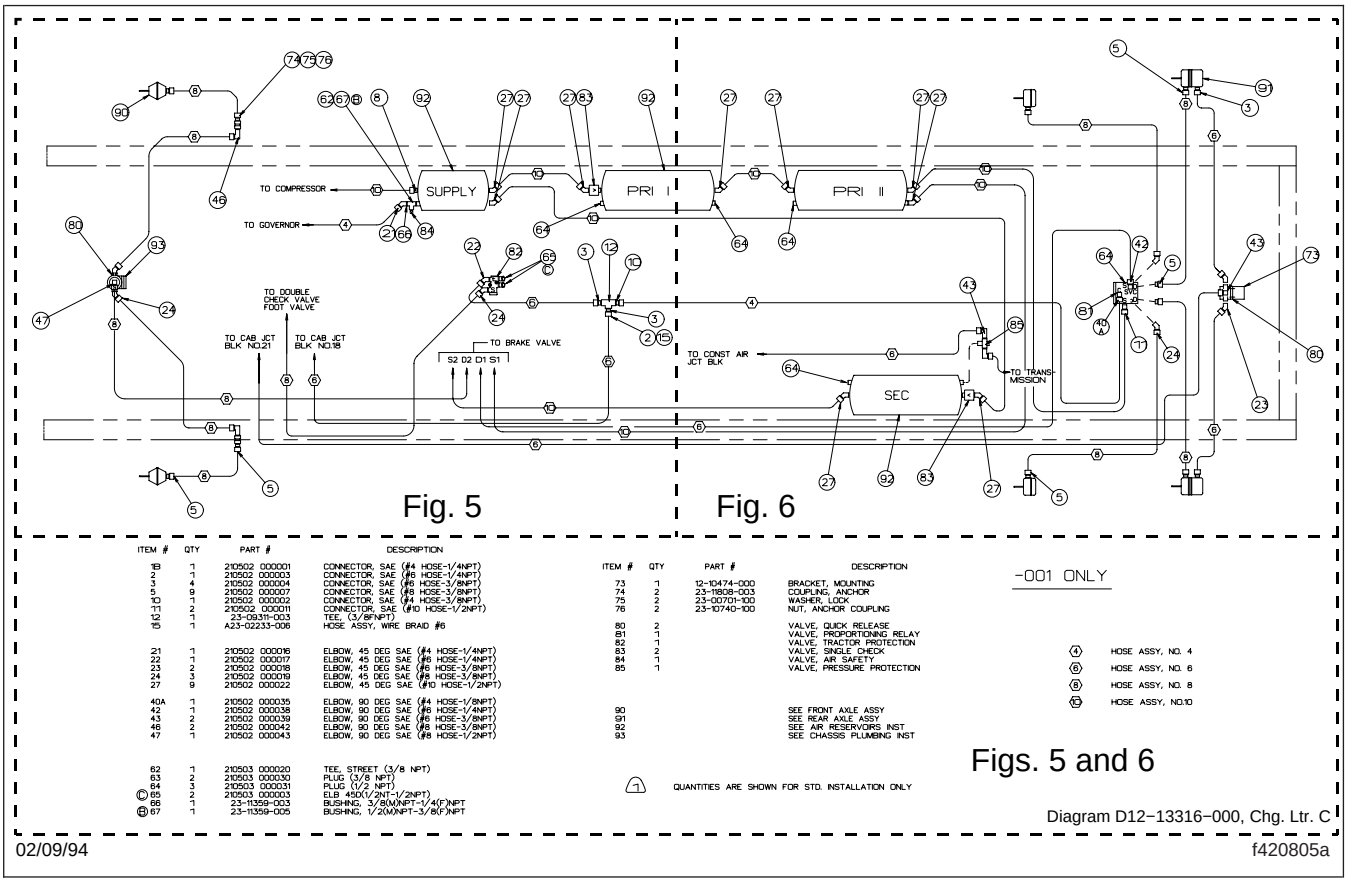
(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Diagram D12−13316−000, Chg. Ltr. C

02/04/94 f421101

Fig. 3

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	4	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	9	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
10	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	23-09311-003	TEE, (3/8FNPT)
15	1	A23-02233-006	HOSE ASSY, WIRE BRAID #6
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	3	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	8	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
© 65	2	210503 000003	ELB 450(1/2NPT-1/2NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
⊟ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11838-003	COUPLING, ANCHOR
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-001 ONLY

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

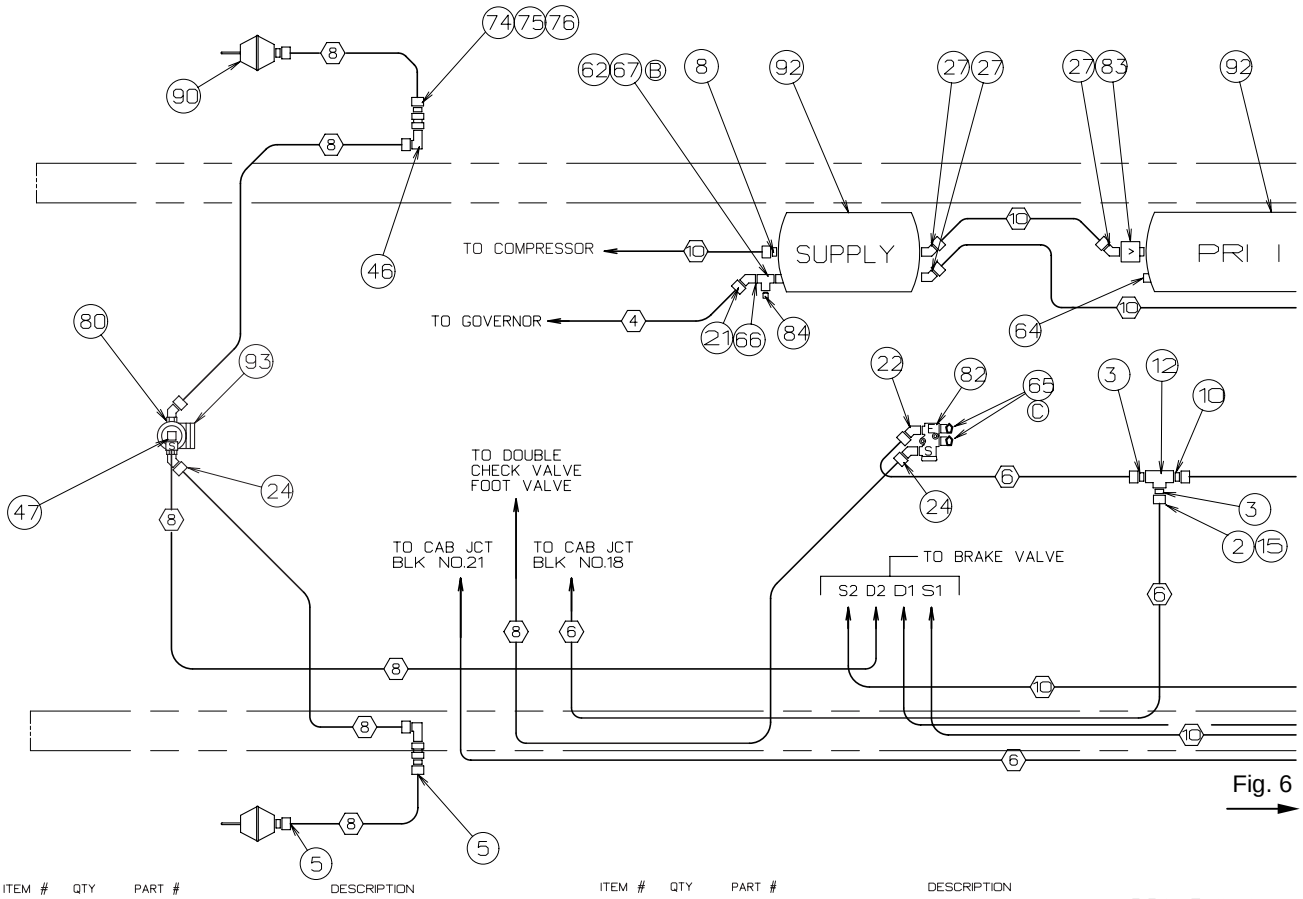
Figs. 5 and 6

Diagram D12−13316−000, Chg. Ltr. C

02/09/94 f420805a

Fig. 4, COE With Rear Proportioning Only, Wire Braid Hose, Front Quick Release Valve, Tractor Protection Valve on Tunnel, Date of Use 3/89 to 4/91

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	4	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	9	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
10	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	23-09311-003	TEE, (3/8FNPT)
15	1	A23-02233-006	HOSE ASSY, WIRE BRAID #6
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	3	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	9	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
Ⓒ 65	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-001 ONLY

⟨4⟩ HOSE ASSY, NO. 4
⟨6⟩ HOSE ASSY, NO. 6
⟨8⟩ HOSE ASSY, NO. 8
⟨10⟩ HOSE ASSY, NO.10

⟨1⟩ QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

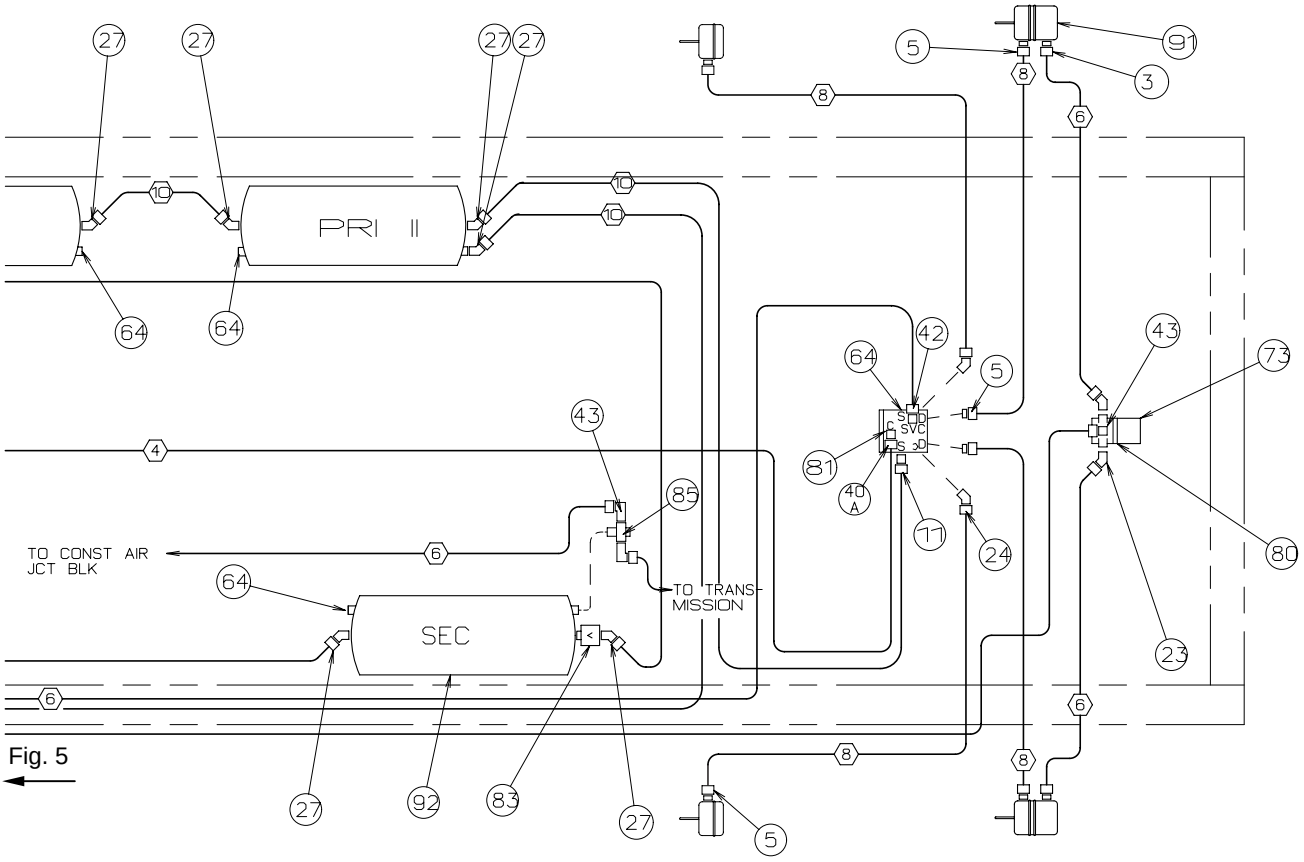
02/09/94

Diagram D12−13316−000, Chg. Ltr. C

f421102

Fig. 5

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	4	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	9	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
10	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	23-09311-003	TEE, (3/8FNPT)
15	1	A23-02233-006	HOSE ASSY, WIRE BRAID #6
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	3	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	9	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
Ⓒ 65	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-001 ONLY

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

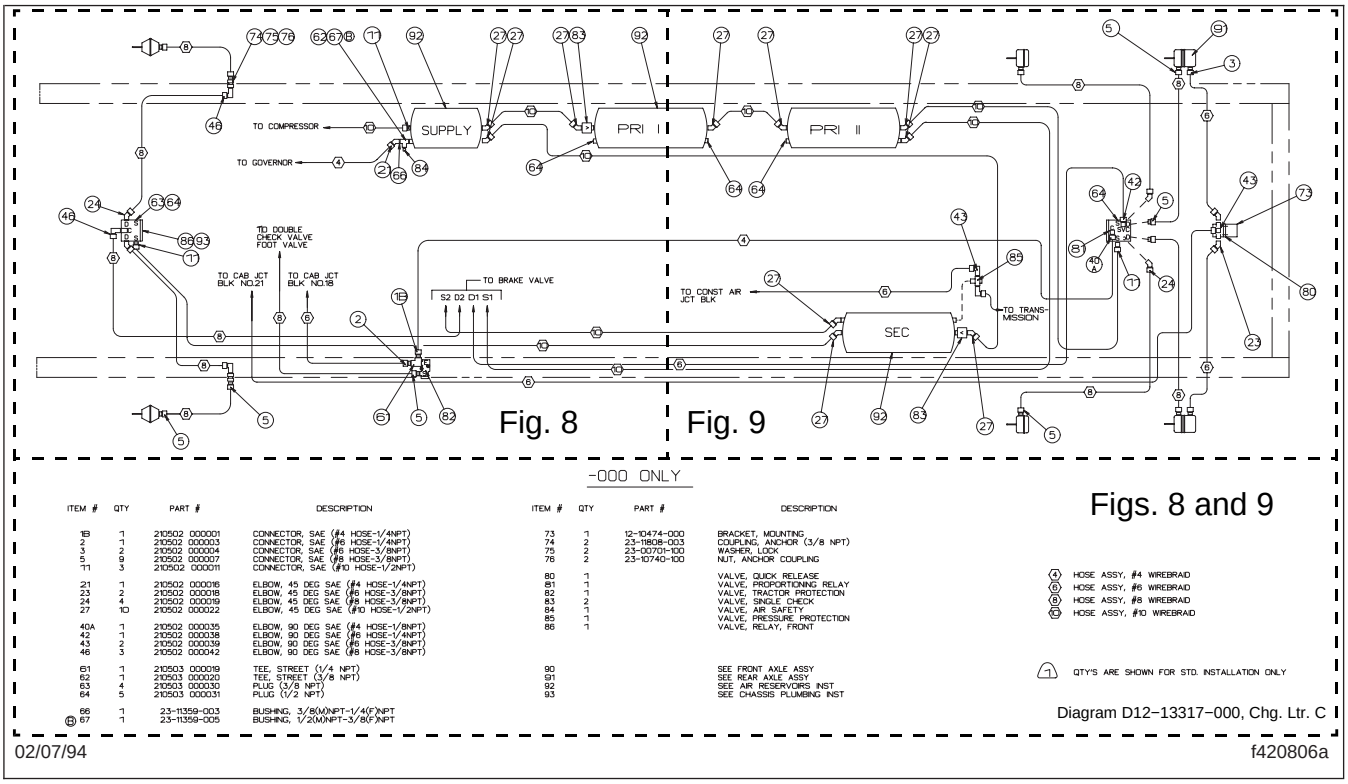
02/09/94

Diagram D12−13316−000, Chg. Ltr. C

f421103

Fig. 6

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



-000 ONLY

Figs. 8 and 9

ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	9	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
11	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000018	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	4	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	10	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	3	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	4	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
80	1		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, #4 WIREBRAID
(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Diagram D12−13317−000, Chg. Ltr. C

02/07/94 f420806a

Fig. 7, COE With Rear Proportioning Only, Wire Braid Hose, Front Relay Valve, Tractor Protection Valve on Frame, Date of Use 4/88 to 4/91

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning

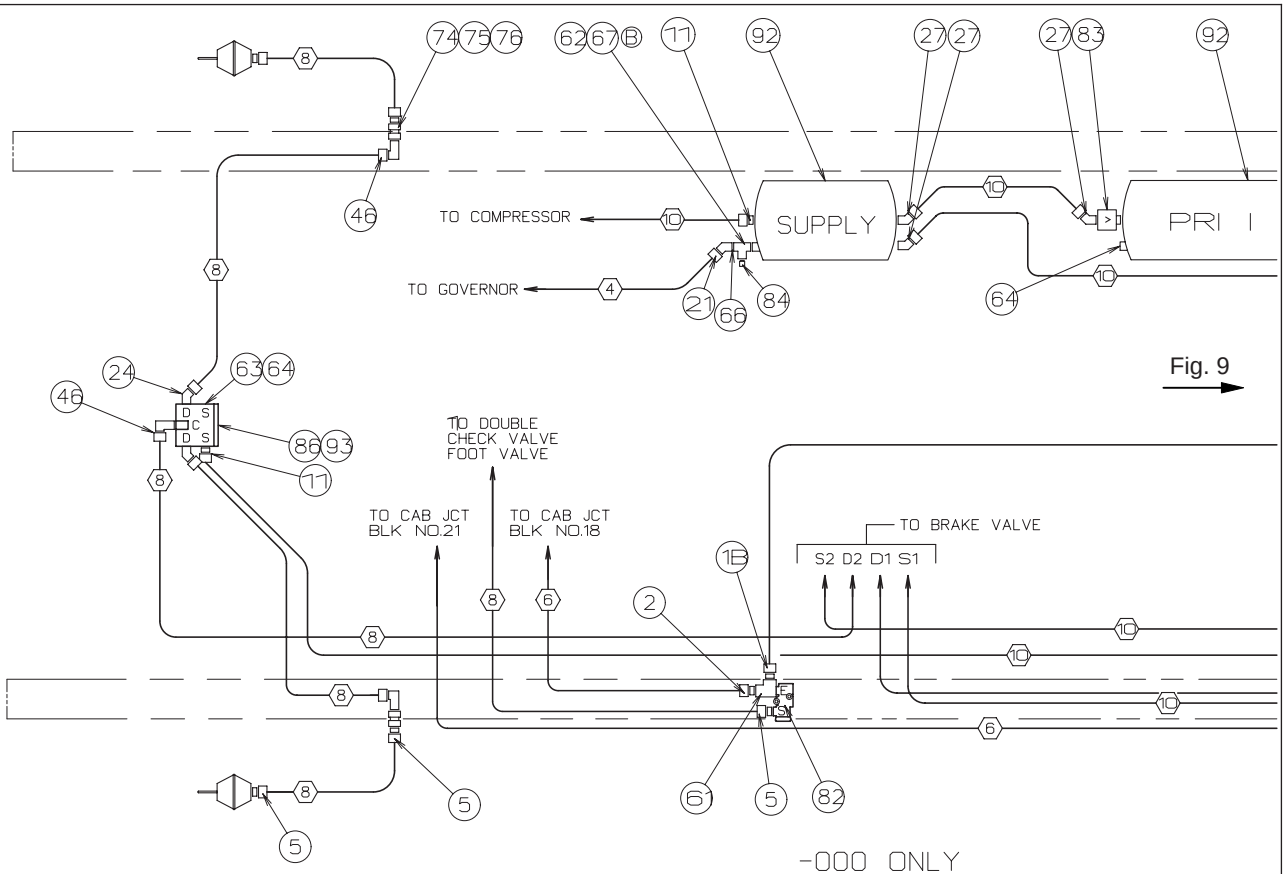


Fig. 9

ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	9	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
11	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	4	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	10	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	3	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	4	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
(B) 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
80	1		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

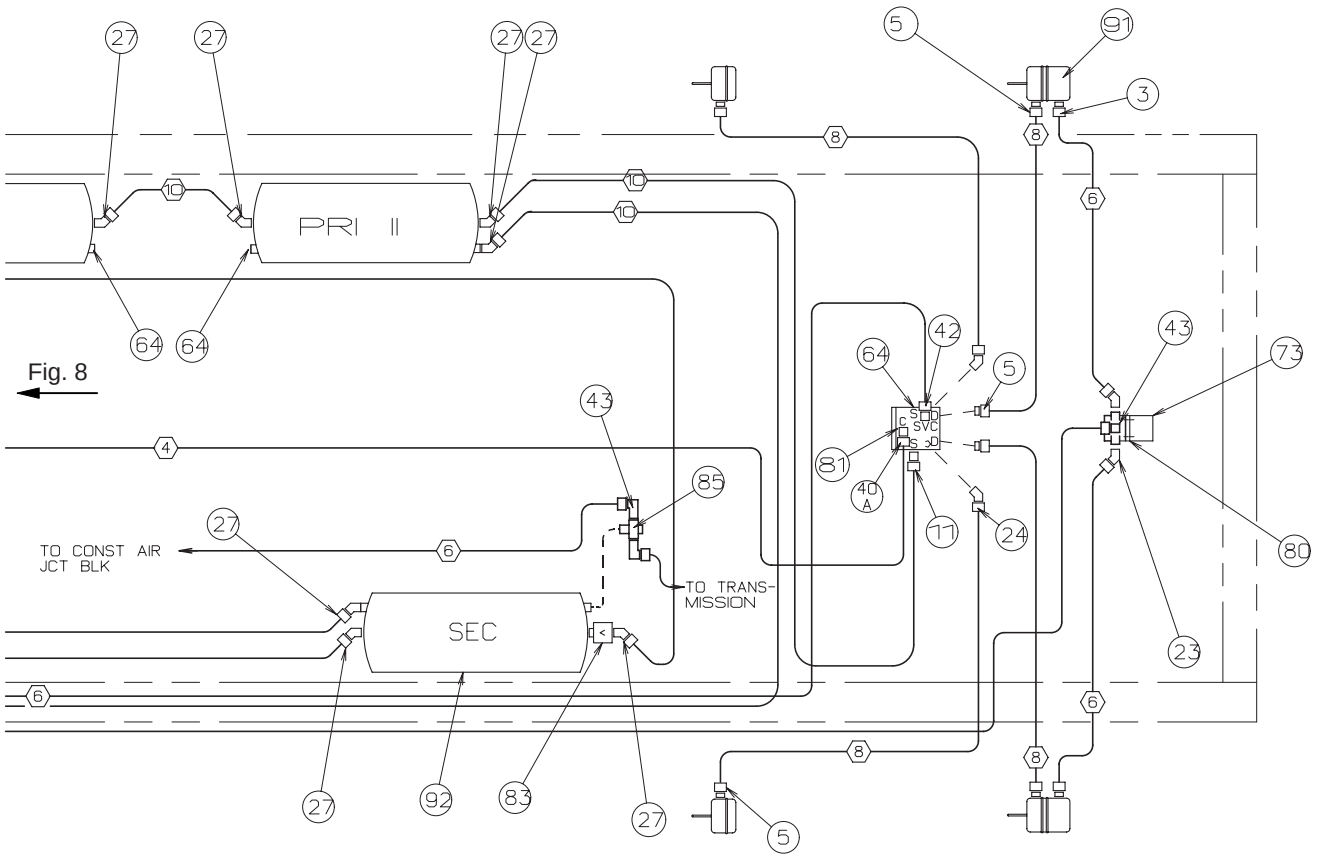
(4) HOSE ASSY, #4 WIREBRAID
(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID

Diagram D12−13317−000, Chg. Ltr. C

02/07/94 f421108

Fig. 8

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



-000 ONLY

ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	9	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
11	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	4	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	10	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	3	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	4	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
(B) 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
80	1		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

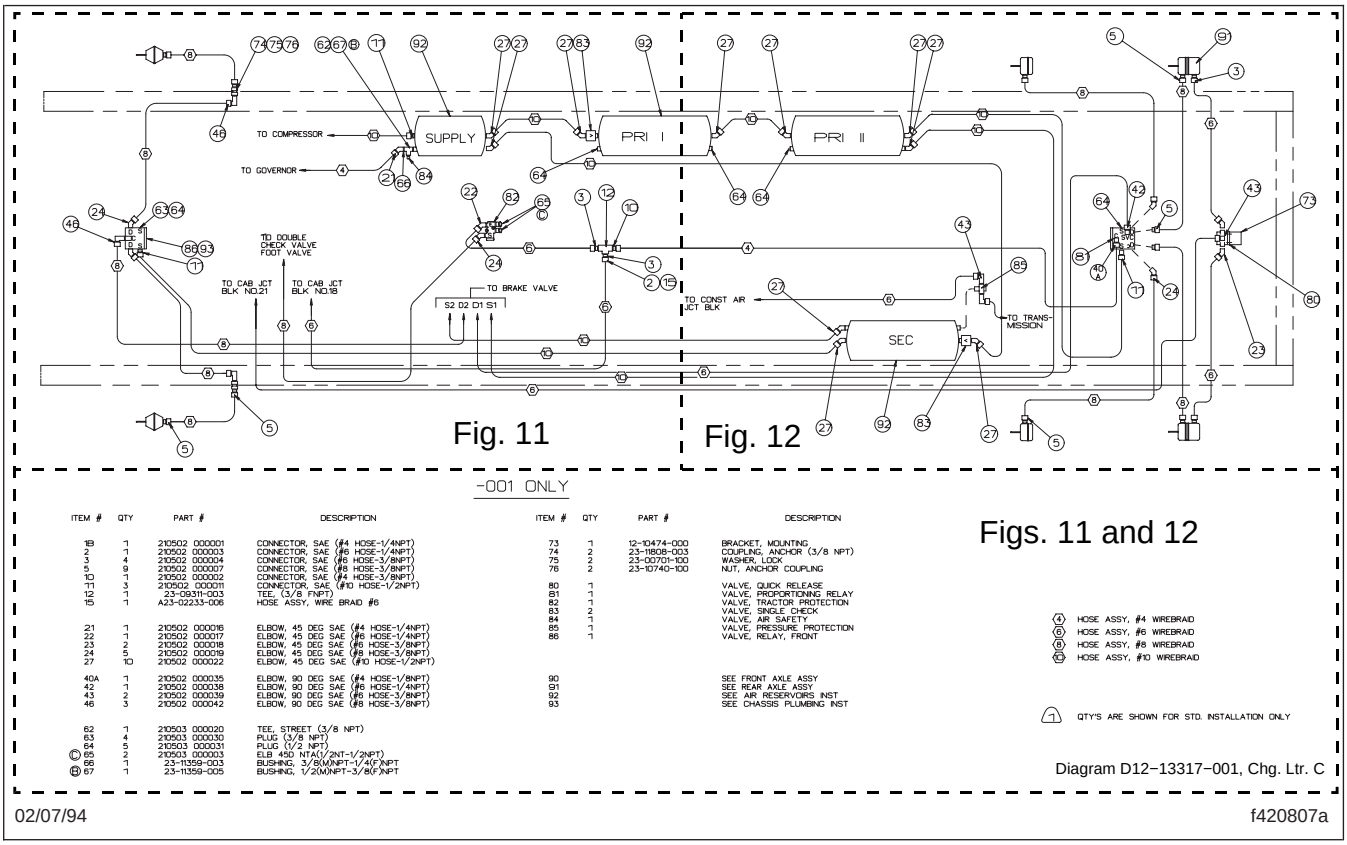
(4) HOSE ASSY, #4 WIREBRAID
(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID

Diagram D12−13317−000, Chg. Ltr. C

02/07/94 f421109

Fig. 9

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



-001 ONLY

ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	4	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	9	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
10	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
11	3	210502 000011	CONNECTOR, SAE, (#10 HOSE-1/2NPT)
12	1	23-09311-003	TEE, (3/8 FNPT)
15	1	A23-02233-006	HOSE ASSY, WIRE BRAID #6
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	5	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	10	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	3	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	4	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
(C) 65	2	210503 000033	ELB 45D NTA(1/2NT-1/2NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
(B) 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
80	1		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

Figs. 11 and 12

(4) HOSE ASSY, #4 WIREBRAID
(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID

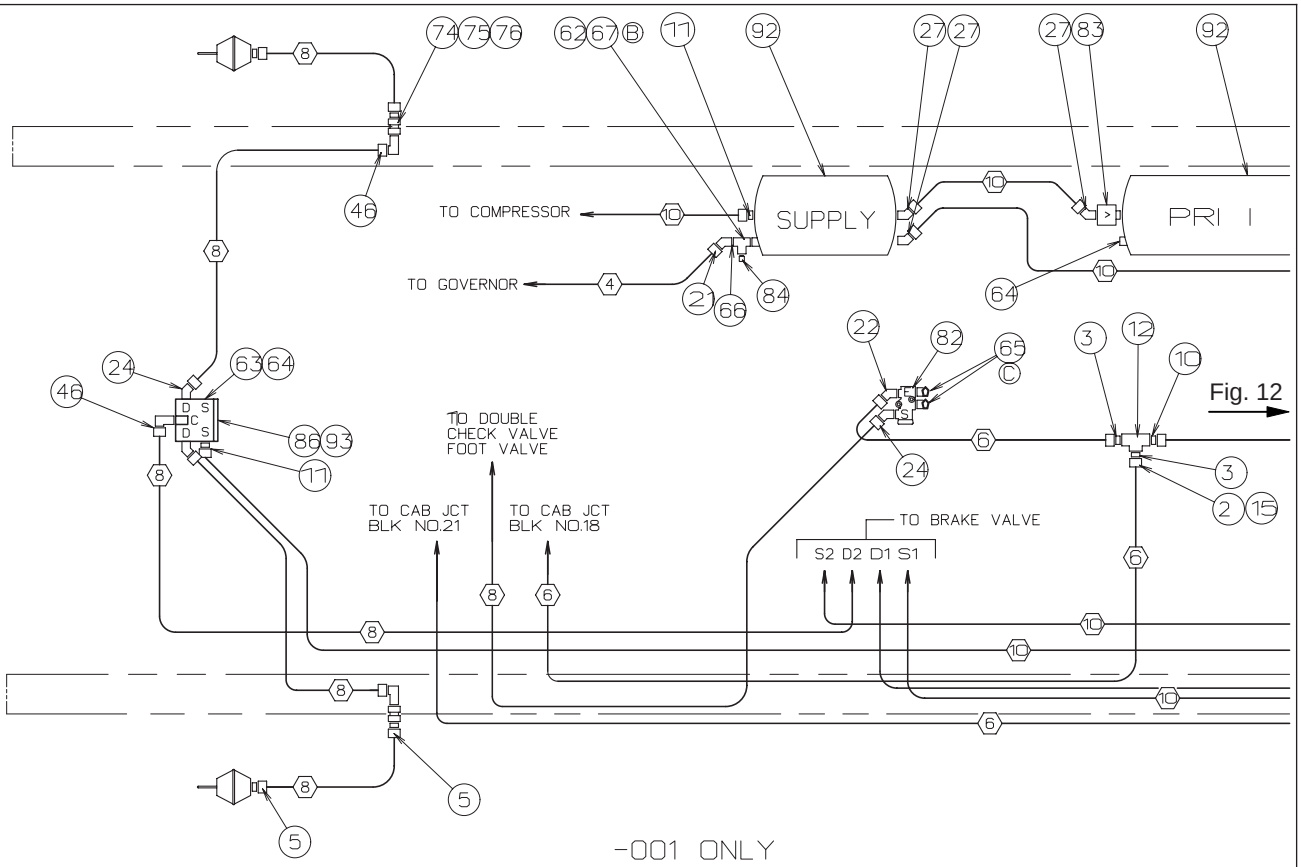
(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Diagram D12−13317−001, Chg. Ltr. C

02/07/94 f420807a

Fig. 10, COE With Rear Proportioning Only, Wire Braid Hose, Front Relay Valve, Tractor Protection Valve on Tunnel, Date of Use 3/89 to 4/91

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	4	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	9	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
10	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
11	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	23-09311-003	TEE, (3/8 FNPT)
15	1	A23-02233-006	HOSE ASSY, WIRE BRAID #6
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	5	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	10	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	3	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	4	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓒ 65	2	210503 000003	ELB 45D NTA(1/2NT-1/2NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
80	1		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, #4 WIREBRAID
(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Diagram D12−13317−001, Chg. Ltr. C

02/08/94 f421110

Fig. 11

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning

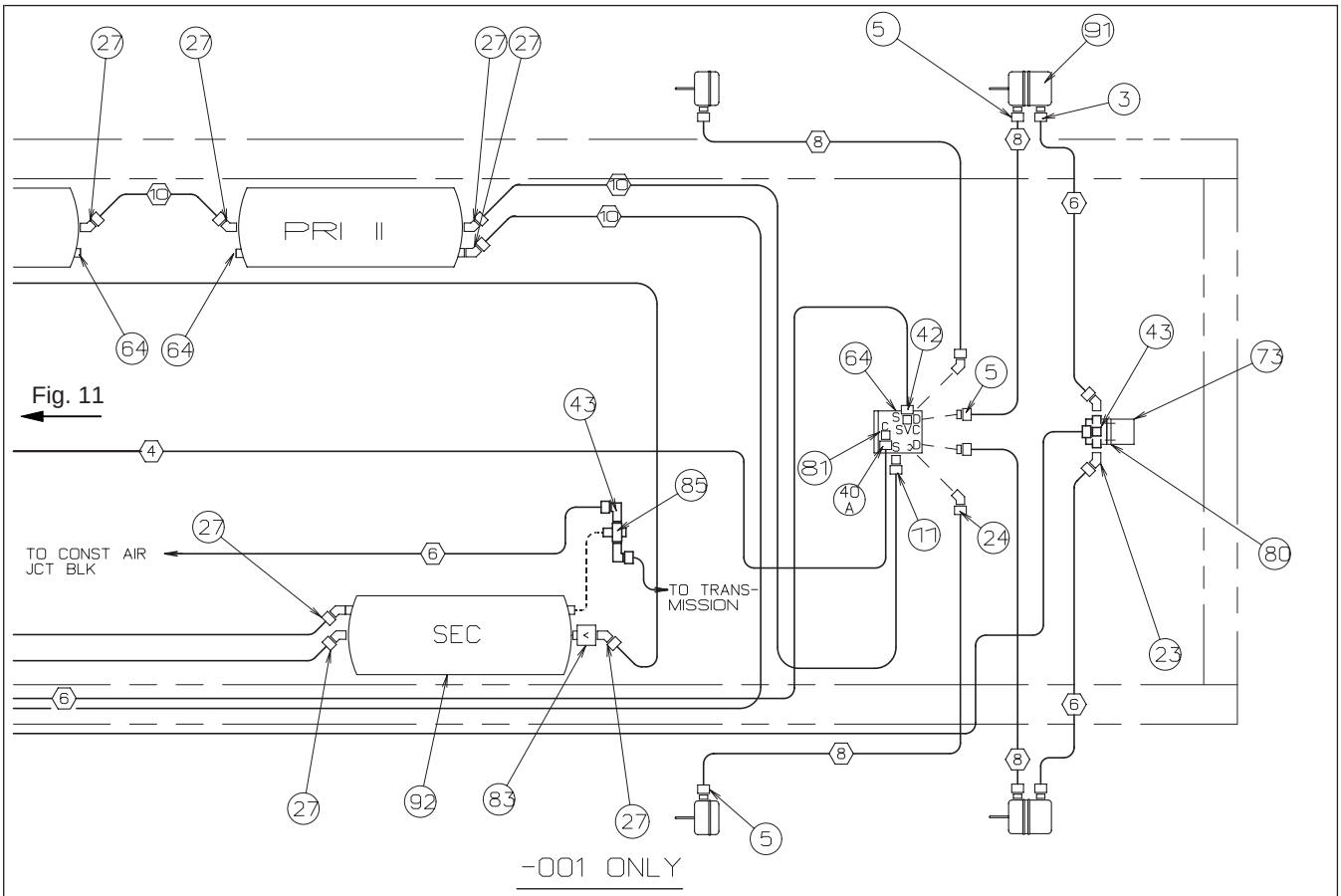


Fig. 11

ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	4	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	9	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
10	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
11	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	23-09311-003	TEE, (3/8 FNPT)
15	1	A23-02233-006	HOSE ASSY, WIRE BRAID #6
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	5	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	10	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	3	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	4	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓒ 65	2	210503 000003	ELB 45D NTA(1/2NT-1/2NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
80	1		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

④ HOSE ASSY, #4 WIREBRAID
⑥ HOSE ASSY, #6 WIREBRAID
⑧ HOSE ASSY, #8 WIREBRAID
⑩ HOSE ASSY, #10 WIREBRAID

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Diagram D12−13317−001, Chg. Ltr. C

02/08/94

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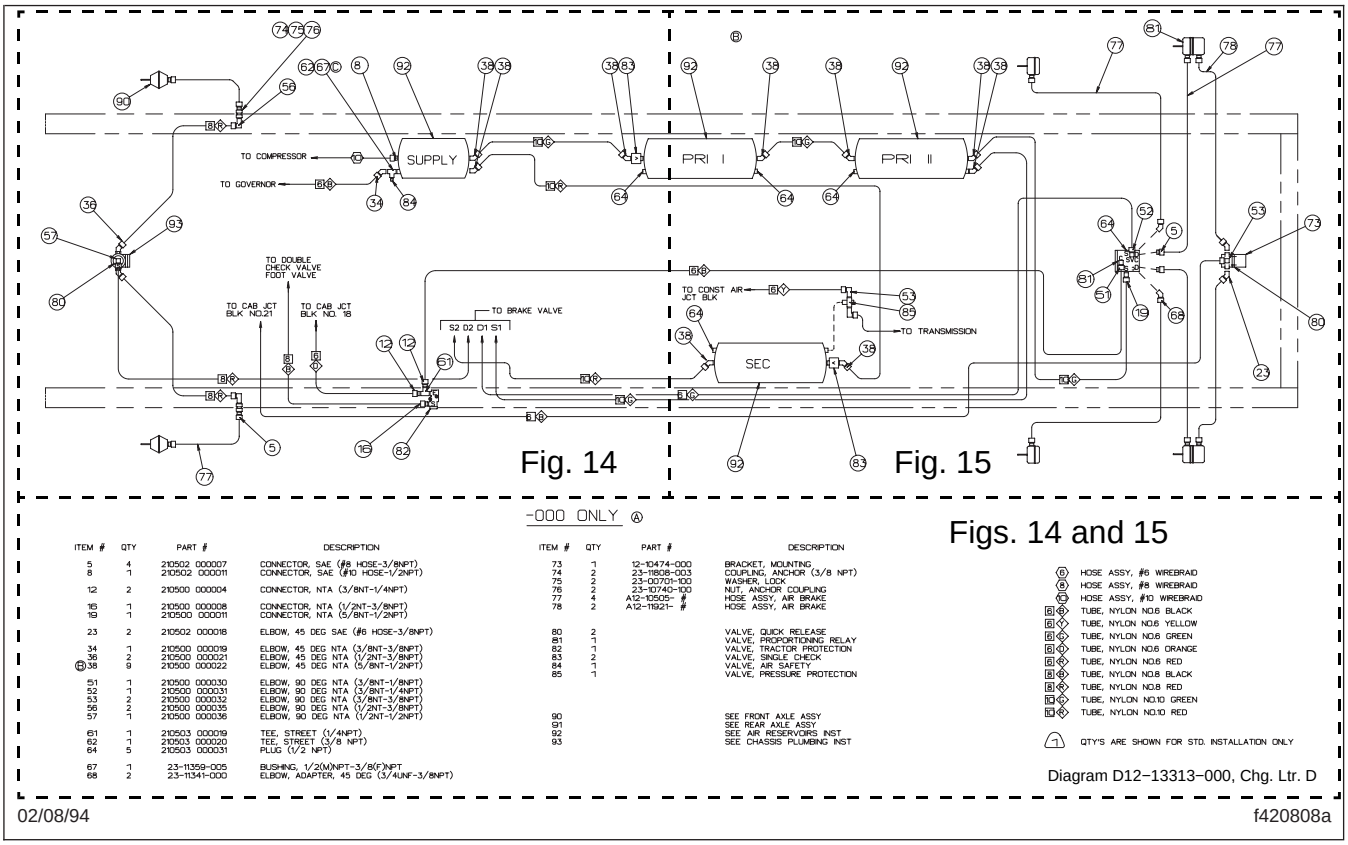
Fig. 12

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



-000 ONLY Ⓐ

ITEM #	QTY	PART #	DESCRIPTION
5	4	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
15	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
Ⓔ 38	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

Figs. 14 and 15

Ⓑ	HOSE ASSY, #6 WIREBRAID
Ⓑ	HOSE ASSY, #8 WIREBRAID
Ⓒ	HOSE ASSY, #10 WIREBRAID
6	TUBE, NYLON NO.6 BLACK
6	TUBE, NYLON NO.6 YELLOW
6	TUBE, NYLON NO.6 GREEN
6	TUBE, NYLON NO.6 ORANGE
6	TUBE, NYLON NO.6 RED
8	TUBE, NYLON NO.8 BLACK
8	TUBE, NYLON NO.8 RED
10	TUBE, NYLON NO.10 GREEN
10	TUBE, NYLON NO.10 RED
1	QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Diagram D12−13313−000, Chg. Ltr. D

02/08/94 f420808a

Fig. 13, COE With Rear Proportioning Only, Nylon Tubing, Front Quick Release Valve, Tractor Protection Valve on Frame, Date of Use 4/88 to 4/91

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning

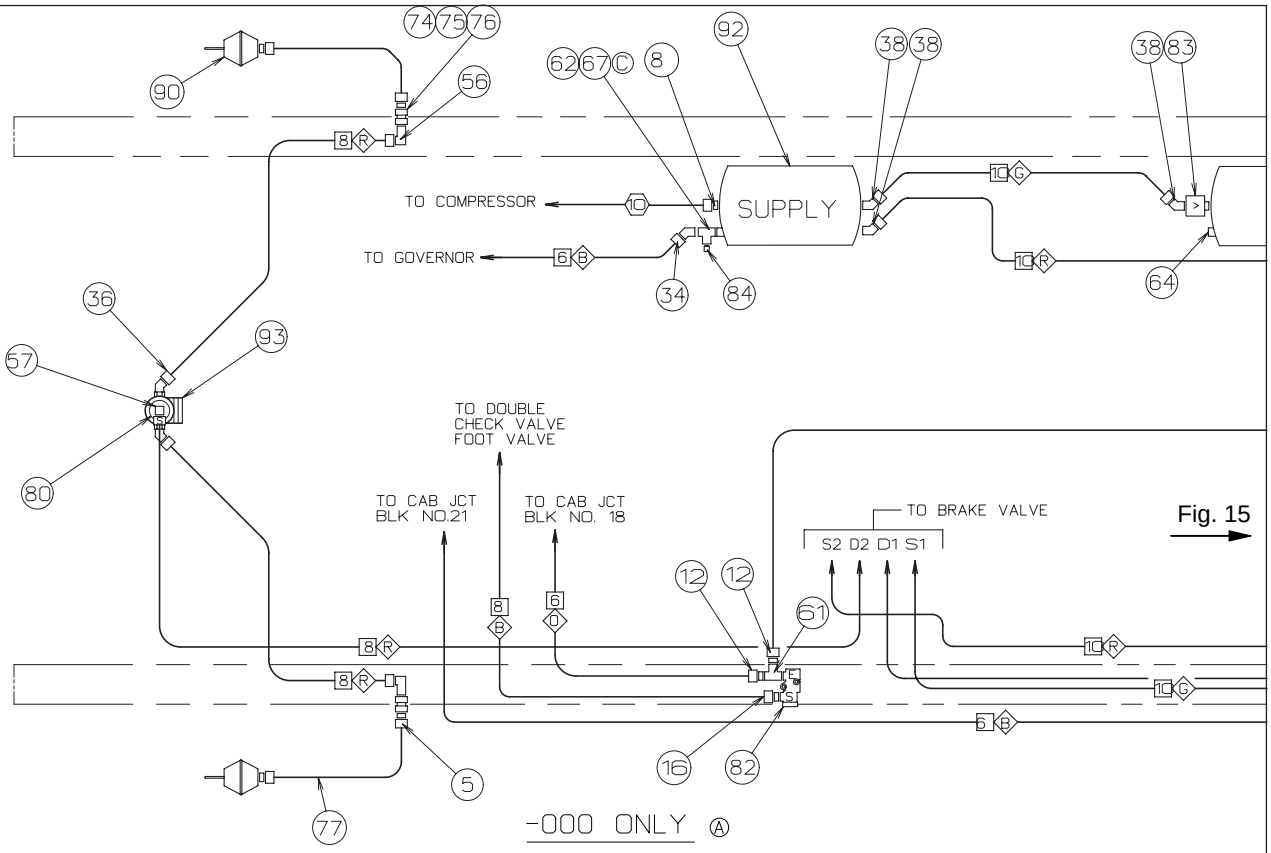


Fig. 15

ITEM #	QTY	PART #	DESCRIPTION
5	4	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
B 38	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

Diagram D12−13313−000, Chg. Ltr. D

02/09/94 f421116

Fig. 14

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning

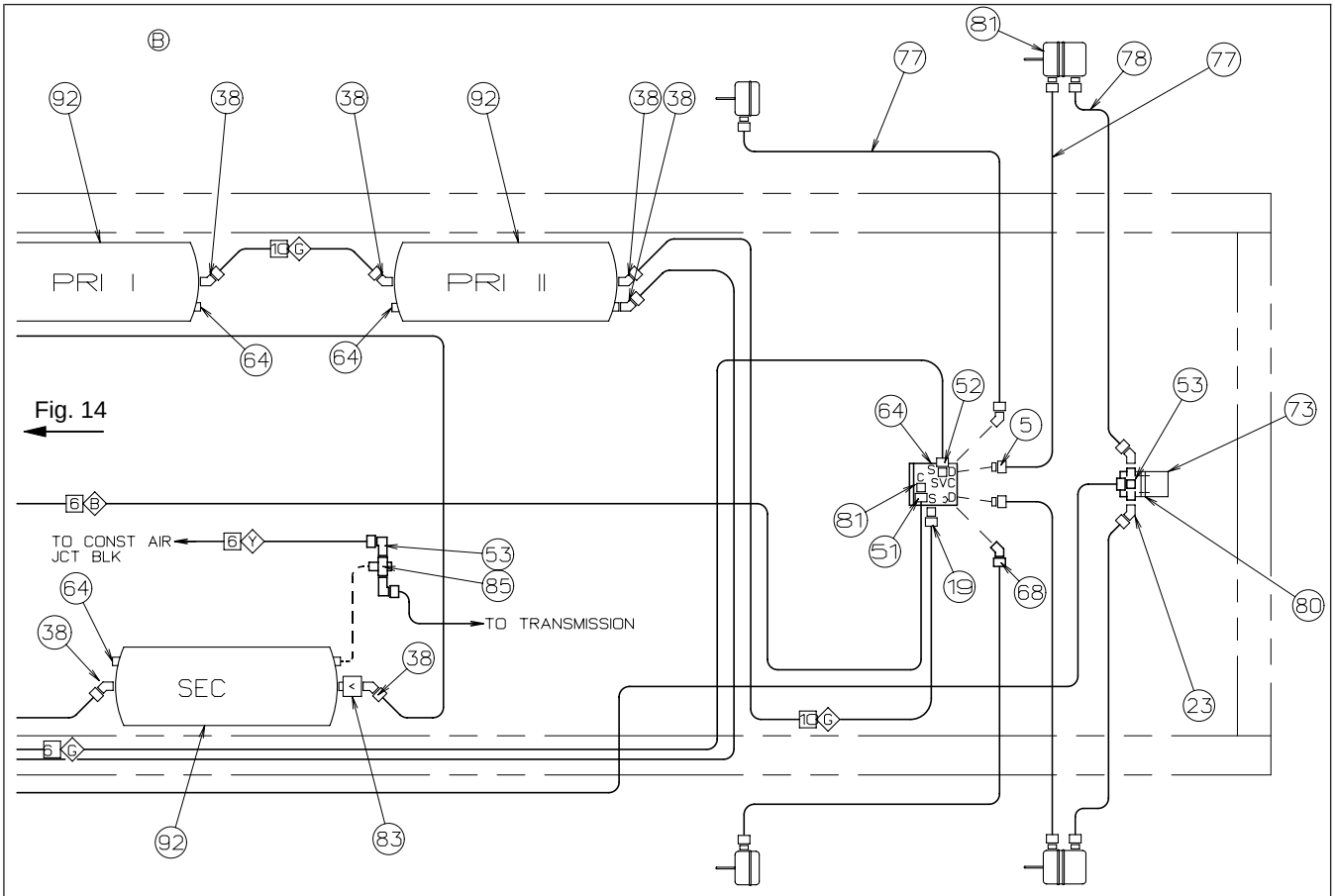


Fig. 14

ITEM #	QTY	PART #	DESCRIPTION
5	4	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
Ⓑ38	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID	6 D	TUBE, NYLON NO.6 ORANGE
8	HOSE ASSY, #8 WIREBRAID	6 R	TUBE, NYLON NO.6 RED
10	HOSE ASSY, #10 WIREBRAID	8 B	TUBE, NYLON NO.8 BLACK
6 B	TUBE, NYLON NO.6 BLACK	8 R	TUBE, NYLON NO.8 RED
6 Y	TUBE, NYLON NO.6 YELLOW	10 G	TUBE, NYLON NO.10 GREEN
6 G	TUBE, NYLON NO.6 GREEN	10 R	TUBE, NYLON NO.10 RED

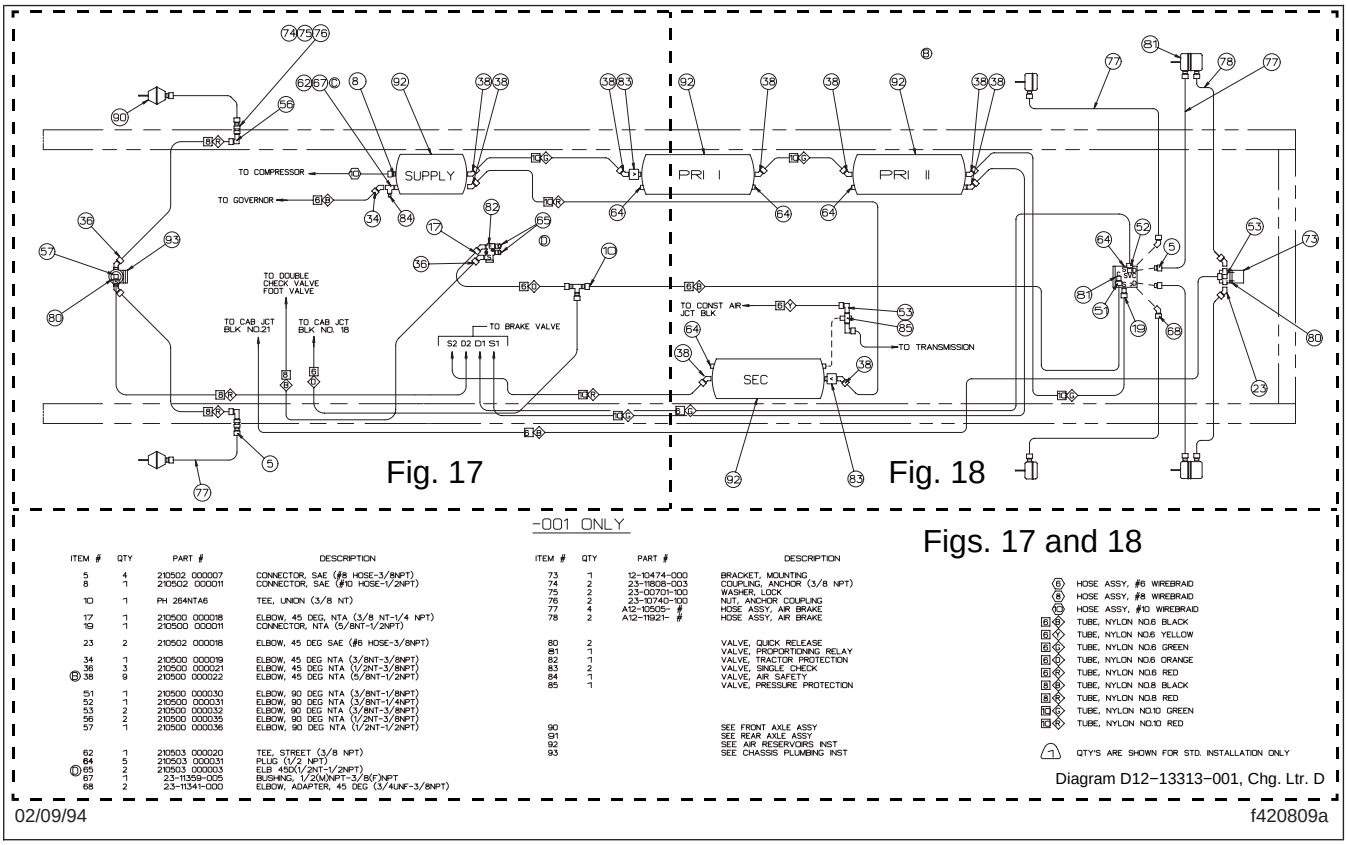
1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Diagram D12−13313−000, Chg. Ltr. D

02/09/94 f421117

Fig. 15

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



-001 ONLY

ITEM #	QTY	PART #	DESCRIPTION
5	4	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
10	1	PH 264NTA6	TEE, UNION (3/8 NT)
17	1	210500 000018	ELBOW, 45 DEG, NTA (3/8 NT-1/4 NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
Ⓑ 38	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓓ 65	2	210503 000033	ELB 45DEG(2NT-1/2NPT)
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-09701-103	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

Ⓒ HOSE ASSY, #6 WIREBRAID
Ⓐ HOSE ASSY, #8 WIREBRAID
Ⓑ HOSE ASSY, #10 WIREBRAID
[6] TUBE, NYLON NO.6 BLACK
[6] TUBE, NYLON NO.6 YELLOW
[6] TUBE, NYLON NO.6 GREEN
[6] TUBE, NYLON NO.6 ORANGE
[6] TUBE, NYLON NO.6 RED
[8] TUBE, NYLON NO.8 BLACK
[8] TUBE, NYLON NO.8 RED
[10] TUBE, NYLON NO.10 GREEN
[10] TUBE, NYLON NO.10 RED

△1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

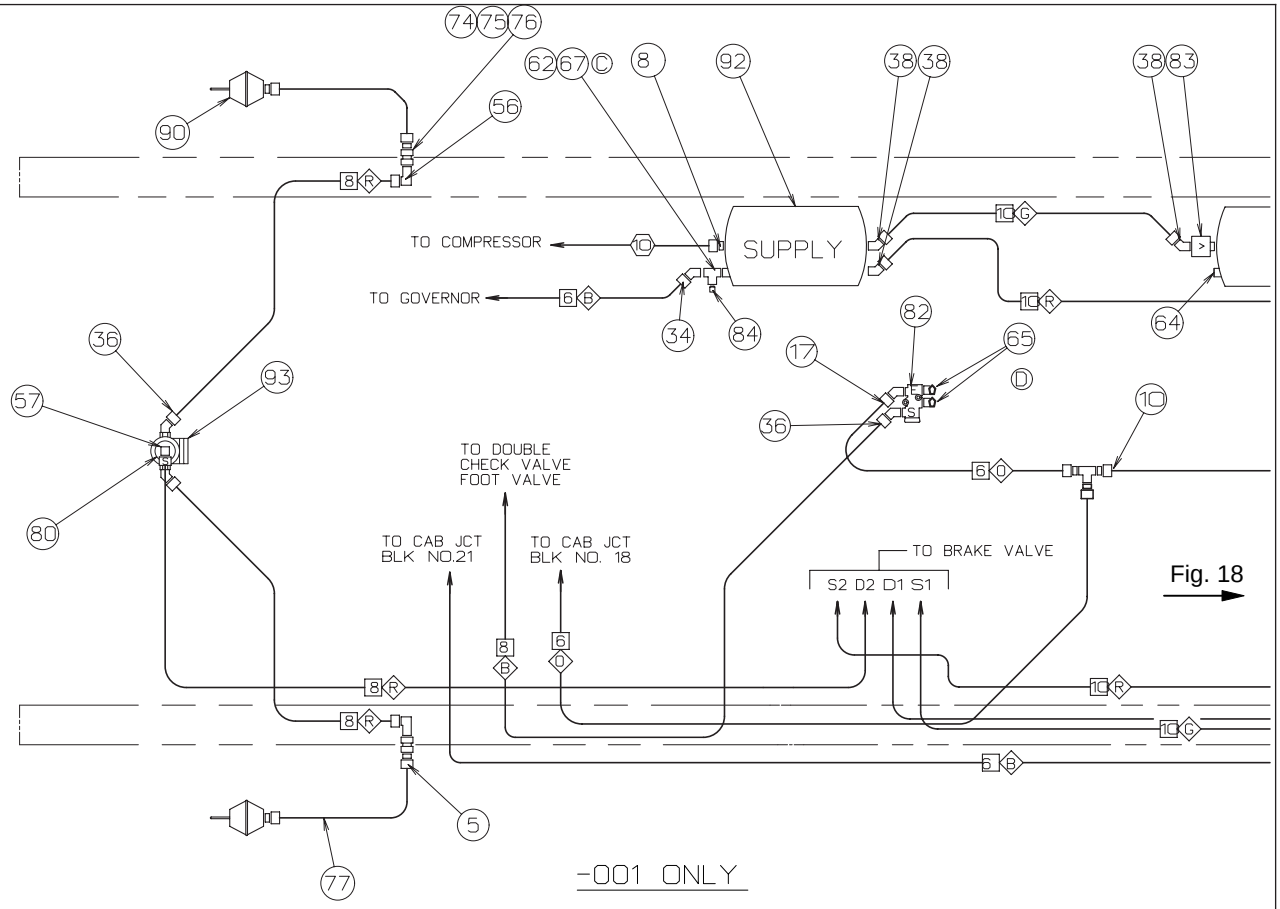
Figs. 17 and 18

Diagram D12−13313−001, Chg. Ltr. D

02/09/94 f420809a

Fig. 16, COE With Rear Proportioning Only, Nylon Tubing, Front Quick Release Valve, Tractor Protection Valve on Tunnel, Date of Use 3/89 to 4/91

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
5	4	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
10	1	PH 264NTA6	TEE, UNION (3/8 NT)
17	1	210500 000018	ELBOW, 45 DEG, NTA (3/8 NT-1/4 NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
Ⓑ 38	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓓ 65	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID	6D	TUBE, NYLON NO.6 ORANGE
8	HOSE ASSY, #8 WIREBRAID	6R	TUBE, NYLON NO.6 RED
10	HOSE ASSY, #10 WIREBRAID	8B	TUBE, NYLON NO.8 BLACK
6B	TUBE, NYLON NO.6 BLACK	8R	TUBE, NYLON NO.8 RED
6Y	TUBE, NYLON NO.6 YELLOW	10G	TUBE, NYLON NO.10 GREEN
6G	TUBE, NYLON NO.6 GREEN	10R	TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Diagram D12−13313−001, Chg. Ltr. D

02/09/94 f421118

Fig. 17

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning

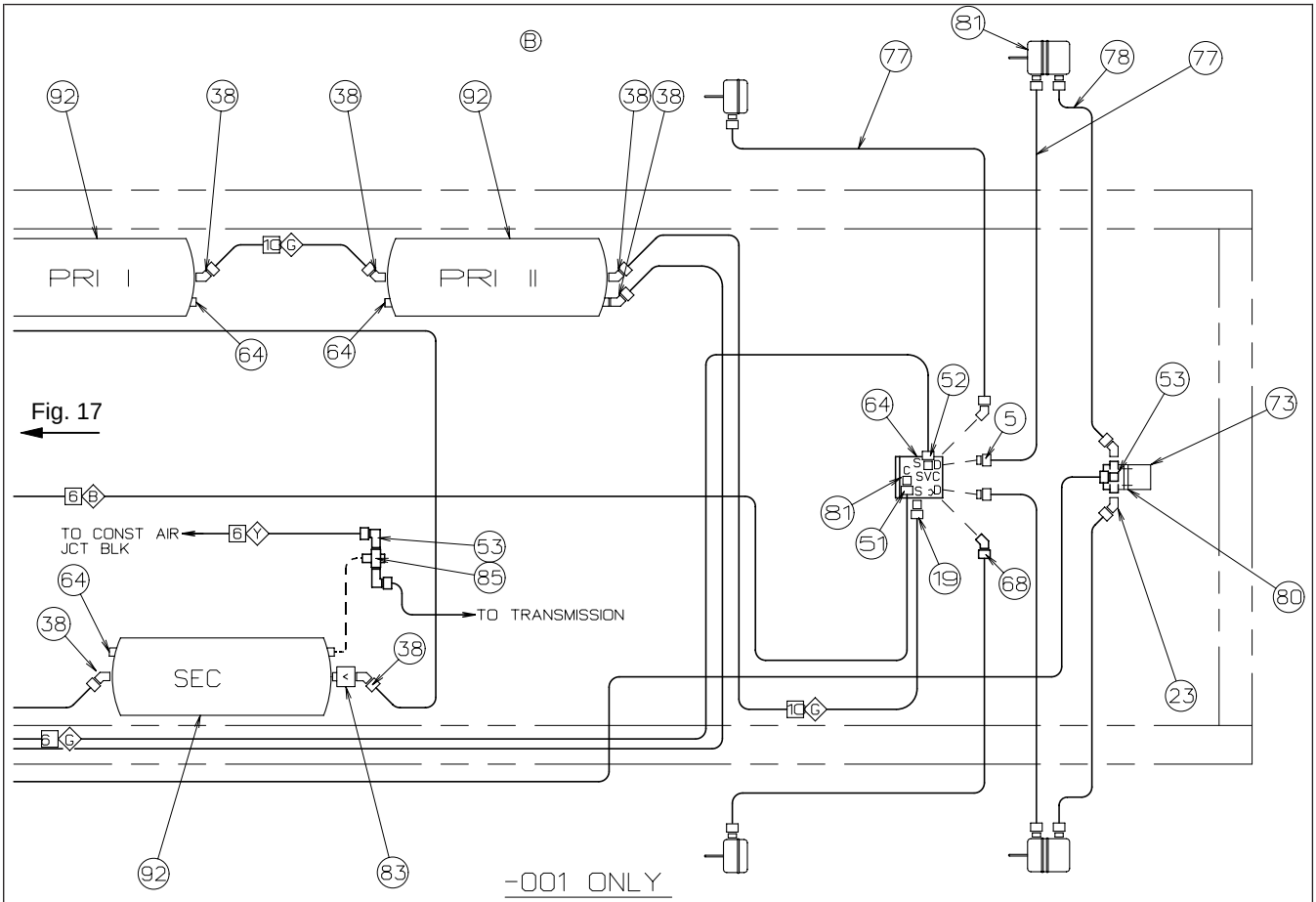


Fig. 17

ITEM #	QTY	PART #	DESCRIPTION
5	4	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
10	1	PH 264NTA6	TEE, UNION (3/8 NT)
17	1	210500 000018	ELBOW, 45 DEG, NTA (3/8 NT-1/4 NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
Ⓑ 38	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓓ 65	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID	6 O	TUBE, NYLON NO.6 ORANGE
8	HOSE ASSY, #8 WIREBRAID	6 R	TUBE, NYLON NO.6 RED
10	HOSE ASSY, #10 WIREBRAID	8 B	TUBE, NYLON NO.8 BLACK
6 B	TUBE, NYLON NO.6 BLACK	8 R	TUBE, NYLON NO.8 RED
6 Y	TUBE, NYLON NO.6 YELLOW	10 G	TUBE, NYLON NO.10 GREEN
6 G	TUBE, NYLON NO.6 GREEN	10 R	TUBE, NYLON NO.10 RED

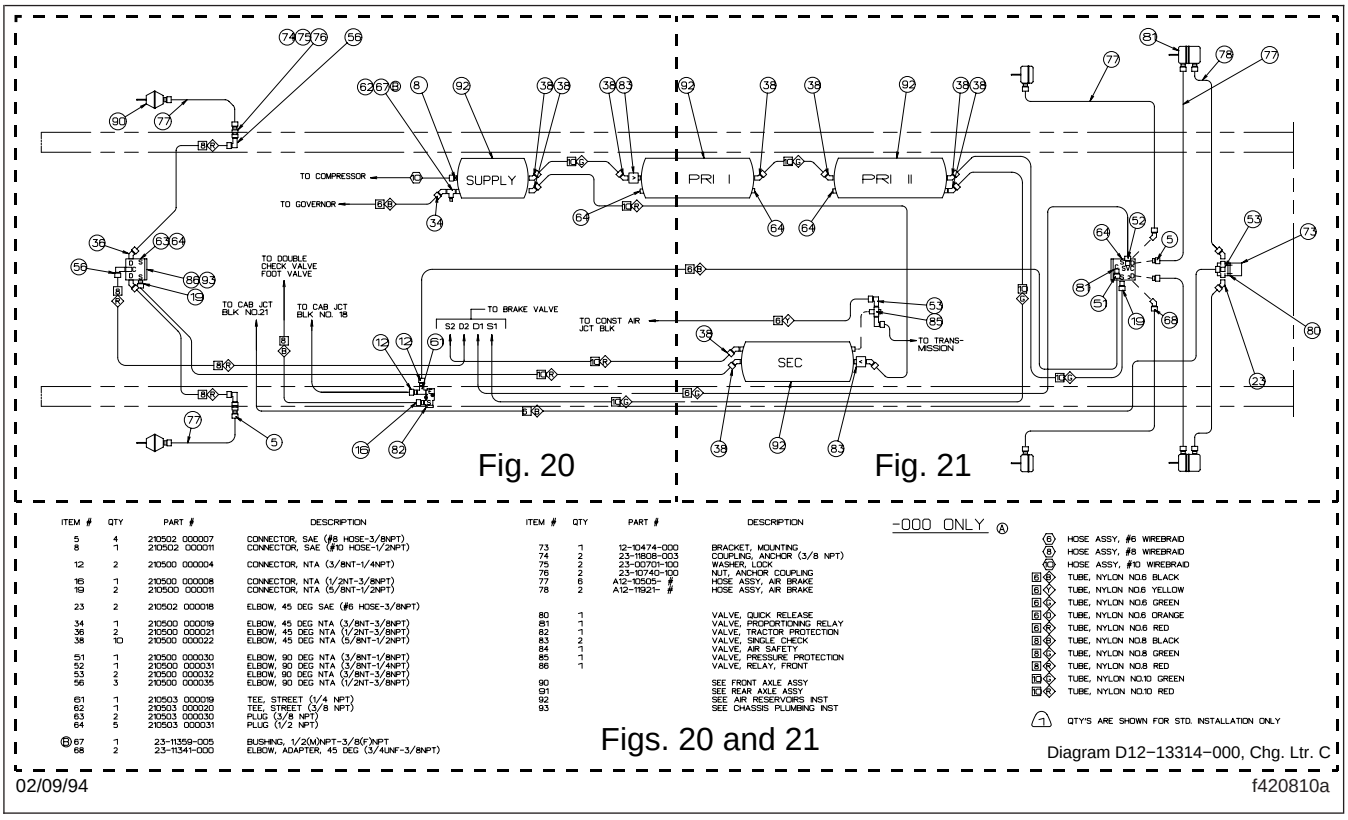
(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Diagram D12−13313−001, Chg. Ltr. D

02/09/94 f421119

Fig. 18

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
5	4	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
18	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	2	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	10	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	3	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	6	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11821- #	HOSE ASSY, AIR BRAKE
80	1		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-000 ONLY Ⓐ

Ⓑ	HOSE ASSY, #6 WIREBRAID
Ⓒ	HOSE ASSY, #8 WIREBRAID
Ⓓ	HOSE ASSY, #10 WIREBRAID
6	TUBE, NYLON NO.6 BLACK
6	TUBE, NYLON NO.6 YELLOW
6	TUBE, NYLON NO.6 GREEN
6	TUBE, NYLON NO.6 ORANGE
6	TUBE, NYLON NO.6 RED
8	TUBE, NYLON NO.8 BLACK
8	TUBE, NYLON NO.8 GREEN
8	TUBE, NYLON NO.8 RED
10	TUBE, NYLON NO.10 GREEN
10	TUBE, NYLON NO.10 RED

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Figs. 20 and 21

Diagram D12−13314−000, Chg. Ltr. C

02/09/94 f420810a

Fig. 19, COE With Rear Proportioning Only, Nylon Tubing, Front Relay Valve, Tractor Protection Valve on Frame, Date of Use 4/88 to 4/91

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning

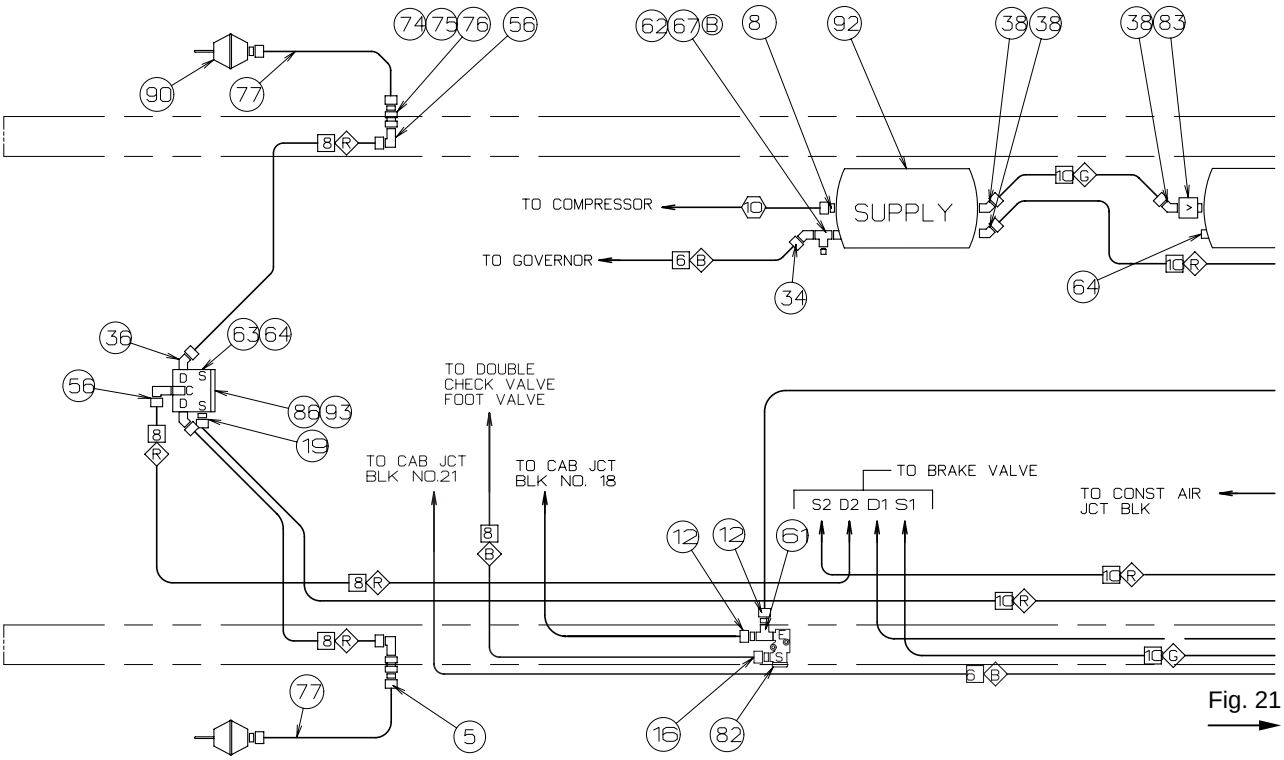


Fig. 21

ITEM #	QTY	PART #	DESCRIPTION
5	4	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	2	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	10	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	3	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	6	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	1		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-000 ONLY Ⓐ

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

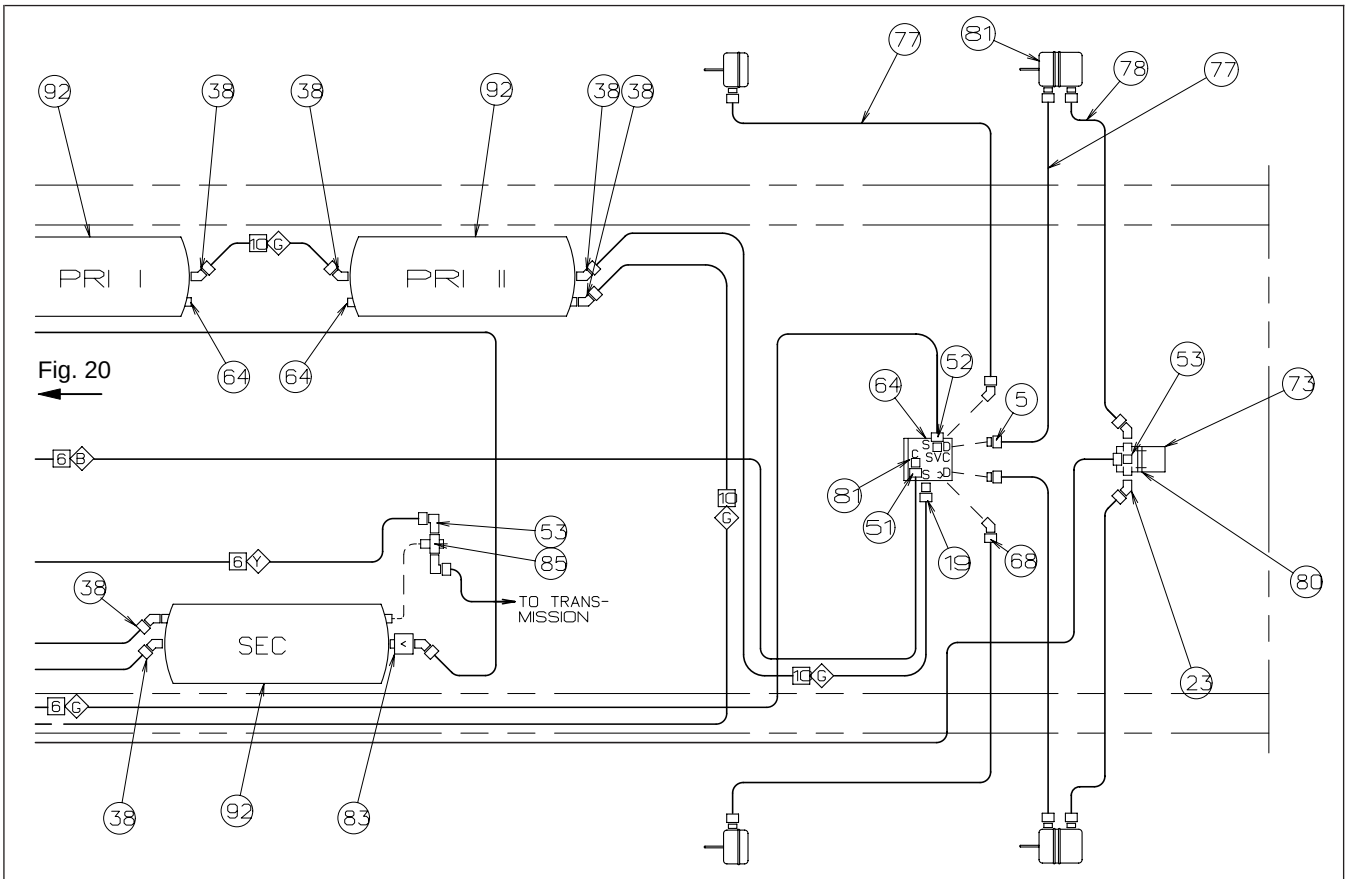
02/09/94

Diagram D12−13314−000, Chg. Ltr. C

f421120

Fig. 20

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
5	4	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	2	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	10	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	3	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	6	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	1		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-000 ONLY Ⓐ

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

02/11/94

Diagram D12−13314−000, Chg. Ltr. C

f421121

Fig. 21

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning

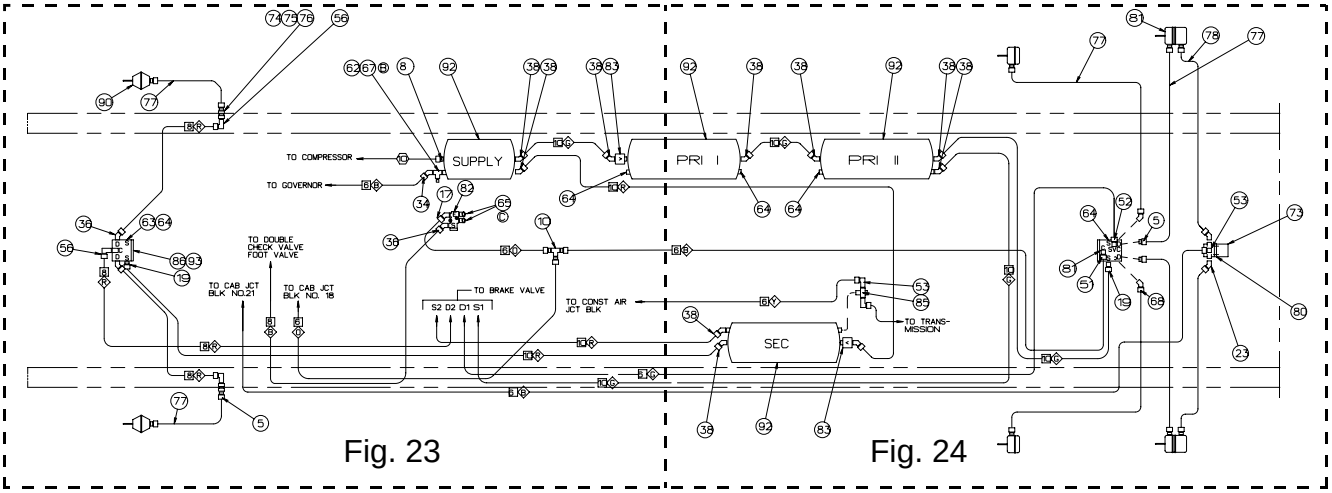


Fig. 23

Fig. 24

ITEM #	QTY	PART #	DESCRIPTION
5	4	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
10	1	PH 264NTA6	TEE, UNION (3/8 NT)
17	1	210500 000018	ELBOW, 45 DEG, NTA (3/8 NT-1/4 NPT)
19	2	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	10	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	3	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
ⓒ 65	2	210503 000003	ELB 45DEG(1/2NT-1/2NPT)
ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	6	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	1		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-001 ONLY

⑥	HOSE ASSY, #6 WIREBRAID
⑧	HOSE ASSY, #8 WIREBRAID
⑩	HOSE ASSY, #10 WIREBRAID
⑥◇	TUBE, NYLON NO.6 BLACK
⑥◇	TUBE, NYLON NO.6 YELLOW
⑥◇	TUBE, NYLON NO.6 GREEN
⑥◇	TUBE, NYLON NO.6 ORANGE
⑥◇	TUBE, NYLON NO.6 RED
⑧◇	TUBE, NYLON NO.8 BLACK
⑧◇	TUBE, NYLON NO.8 GREEN
⑧◇	TUBE, NYLON NO.8 RED
⑩◇	TUBE, NYLON NO.10 GREEN
⑩◇	TUBE, NYLON NO.10 RED

△1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Figs. 23 and 24

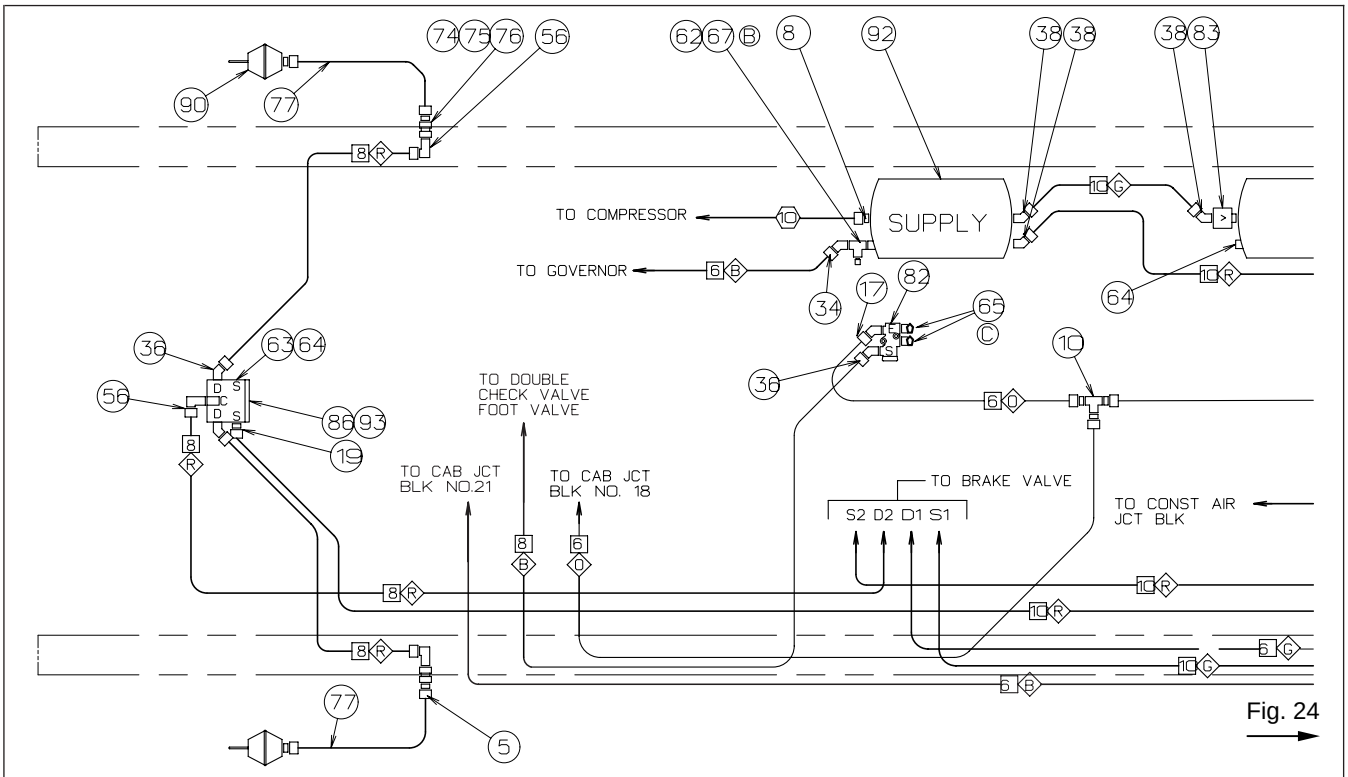
Diagram D12−13314−001, Chg. Ltr. C

02/10/94

f420811a

Fig. 22, COE With Rear Proportioning Only, Nylon Tubing, Front Relay Valve, Tractor Protection Valve on Tunnel, Date of Use 3/89 to 4/91

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
5	4	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
10	1	PH 264NTA6	TEE, UNION (3/8 NT)
17	1	210500 000018	ELBOW, 45 DEG, NTA (3/8 NT-1/4 NPT)
19	2	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	10	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	3	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓒ 65	2	210503 000003	ELB 450(1/2NT-1/2NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	6	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	1		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-001 ONLY

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

△1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

02/10/94

Diagram D12−13314−001, Chg. Ltr. C

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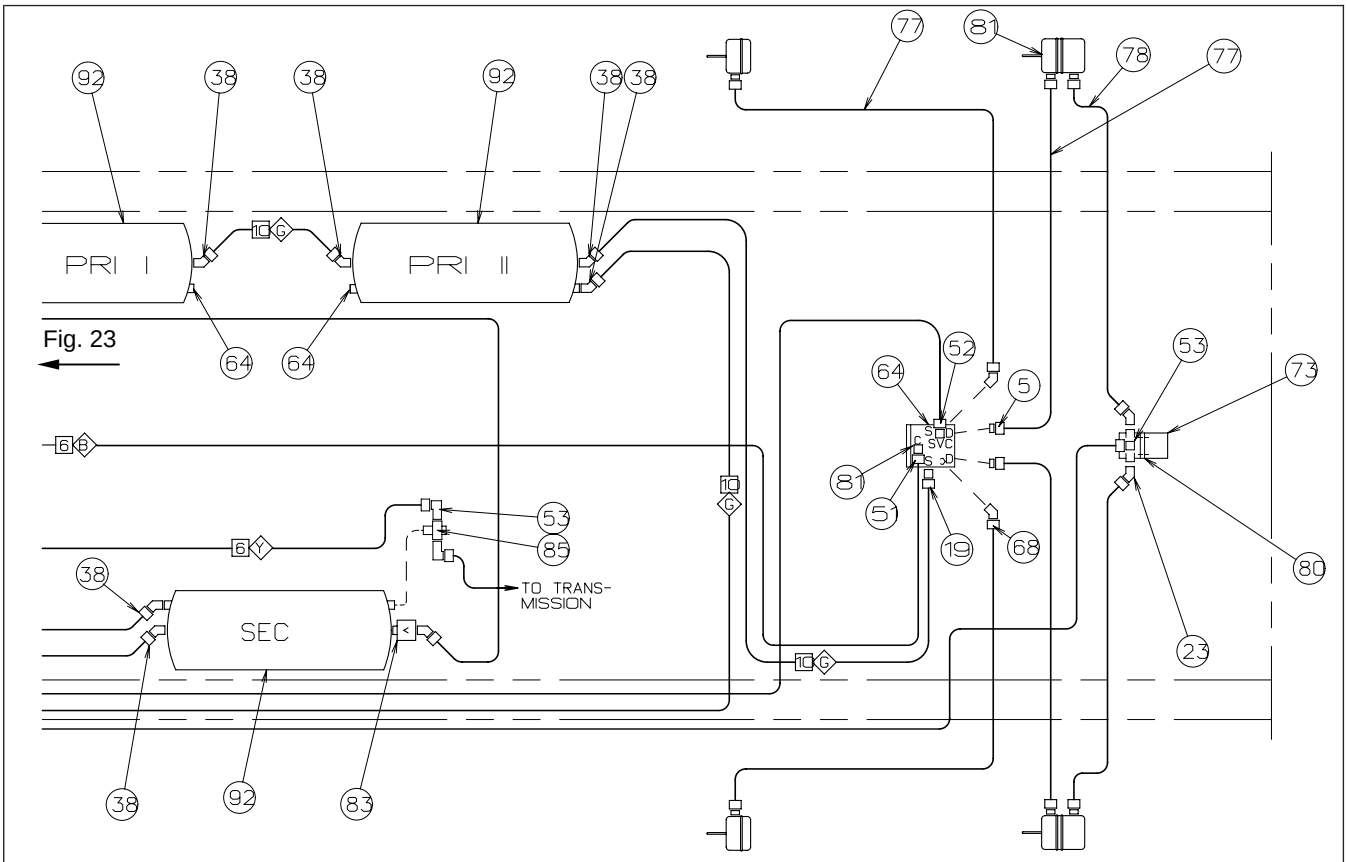
Fig. 23

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
5	4	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
10	1	PH 264NTA6	TEE, UNION (3/8 NT)
17	1	210500 000018	ELBOW, 45 DEG, NTA (3/8 NT-1/4 NPT)
19	2	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	10	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	3	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓒ 65	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	6	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	1		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-001 ONLY

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

⚠1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

02/10/94

Diagram D12−13314−001, Chg. Ltr. C

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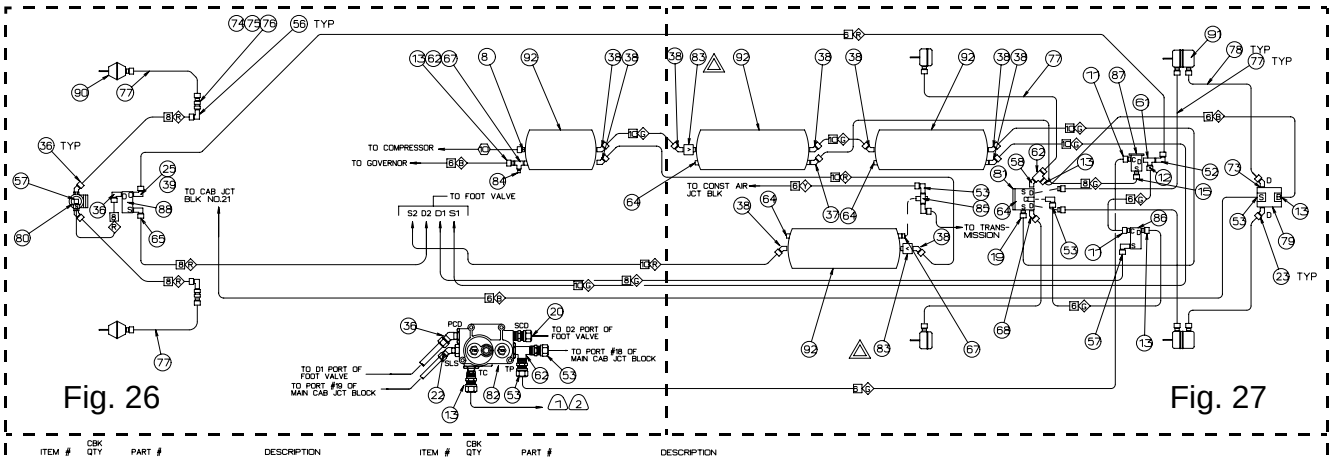
Fig. 24

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
11	2	210500 000003	CONNECTOR, NTA (3/8NT-1/8NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	5	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
15	1	210500 000007	CONNECTOR, NTA (1/2NT-1/4NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
20	1	210500 000008	CONNECTOR,NTA (1/2 NT-3/8 NPT)
22	1	210500 000018	ELBOW, 45 DEG SAE (3/8 NT-1/4 NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
25	1	210503 000005	ADAPTER (1/8 MPT-1/4 FPT)
36	4	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
37	1	210500 000024	ELBOW, 45 DEG NTA (1/2NT-1/2NPT)
38	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
39	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-3/8 NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	5	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	2	210500 000036	ELBOW, 90 DEG SAE (1/2NT-1/2NPT)
58	1	210503 000002	ELBOW, STREET (3/8 NPT-3/8 NTA)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	3	210503 000020	TEE, STREET (3/8 NPT)
64	4	210503 000031	PLUG (1/2 NPT)
65	1	210502 000042	ELBOW, 90 DEG SAE(#8 HOSE-3/8 NPT)
67	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	23-11341-000	ELBOW, ADPTER 45 DEG (3/4UNF-3/8NPT)
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
79	1	BW 289714	VALVE, QUICK RELEASE,REAR QR-1C
80	1	BW 229859	VALVE, QUICK RELEASE,FRONT
81	1	BW 103125	VALVE, RELAY, REAR
82	1	681 429 00 44	VALVE, TRACTOR PROTECTION
83	2	BW 228194	VALVE, SINGLE CHECK
84	1	12-11767-000	VALVE, AIR SAFETY
85	1	681 429 08 44	VALVE, PRESSURE PROTECTION
86	1	BW 106284	VALVE, BRAKE PROPORTIONING REAR
87	1	BW 281459	VALVE, INVERSION
88	1	BW 104598	VALVE, BRAKE PROPORTIONING FRONT
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

1. W/O HAND VALVE (SPEC LN 492) VENT TC PORT TO ATMOSPHERE. OMIT ITEMS 6. DEPENDING ON TP VALVE ORIENTATION ADDITIONAL CALLOUTS MAY APPEAR ON SPEC LN 460 FOR VENTING TC PORT.
2. W/HAND VALVE (SPEC LN 492) ROUTE TO PORT #17 OF MAIN CAB JCT BLOCK.

X	HOSE ASSY, #10 WIREBRAID
B	TUBE, NYLON NO.6 BLACK
Y	TUBE, NYLON NO.6 YELLOW
G	TUBE, NYLON NO.6 GREEN
O	TUBE, NYLON NO.6 ORANGE
R	TUBE, NYLON NO.6 RED
B	TUBE, NYLON NO.8 BLACK
G	TUBE, NYLON NO.8 GREEN
R	TUBE, NYLON NO.8 RED
G	TUBE, NYLON NO.10 GREEN
R	TUBE, NYLON NO.10 RED

⚠ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Figs. 26 and 27

Diagram D12−13045

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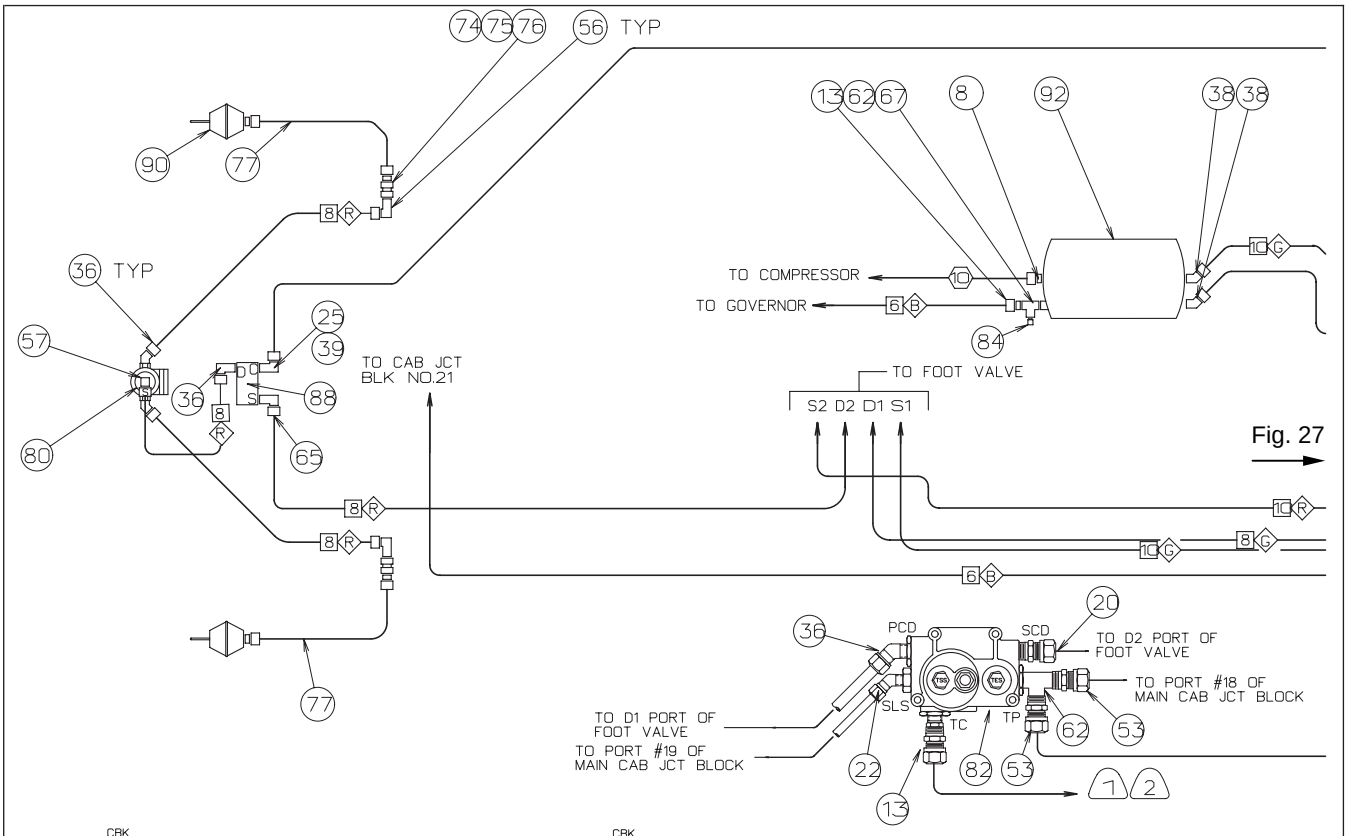
Fig. 25, COE or Conventional, Front and Rear Proportioning, Nylon Tubing, With Inversion Valve, Date of Use 4/88 to 4/91

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
11	2	210500 000003	CONNECTOR, NTA (3/8NT-1/8NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	5	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
15	1	210500 000007	CONNECTOR, NTA (1/2NT-1/4NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
20	1	210500 000008	CONNECTOR,NTA (1/2 NT-3/8 NPT)
22	1	210500 000018	ELBOW, 45 DEG SAE (3/8 NT-1/4 NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
25	1	210503 000005	ADAPTER (1/8 MPT-1/4 FPT)
36	4	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
37	1	210500 000024	ELBOW, 45 DEG NTA (1/2NT-1/2NPT)
38	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
39	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-3/8 NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	5	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	2	210500 000036	ELBOW, 90 DEG SAE (1/2NT-1/2NPT)
58	1	210503 000002	ELBOW, STREET (3/8 NPT-3/8 NTA)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	3	210503 000020	TEE, STREET (3/8 NPT)
64	4	210503 000031	PLUG (1/2 NPT)
65	1	210502 000042	ELBOW, 90 DEG SAE(#8 HOSE-3/8 NPT)
67	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	23-11341-000	ELBOW, ADPTER 45 DEG (3/4UNF-3/8NPT)

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
79	1	BW 289714	VALVE, QUICK RELEASE,REAR QR-1C
80	1	BW 229859	VALVE, QUICK RELEASE,FRONT
81	1	BW 103125	VALVE, RELAY, REAR
82	1	681 429 00 44	VALVE, TRACTOR PROTECTION
83	2	BW 228194	VALVE, SINGLE CHECK
84	1	12-11767-000	VALVE, AIR SAFETY
85	1	681 429 08 44	VALVE, PRESSURE PROTECTION
86	1	BW 106284	VALVE, BRAKE PROPORTIONING REAR
87	1	BW 281459	VALVE, INVERSION
88	1	BW 104598	VALVE, BRAKE PROPORTIONING FRONT
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

△ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/11/94

1 W/O HAND VALVE (SPEC LN 492) VENT TC PORT TO ATMOSPHERE: OMIT ITEMS 6. DEPENDING ON TP VALVE ORIENTATION ADDITIONAL CALLOUTS MAY APPEAR ON SPEC LN 460 FOR VENTING TC PORT.

2 W/HAND VALVE (SPEC LN 492) ROUTE TO PORT #17 OF MAIN CAB JCT BLOCK.

Diagram D12−13045

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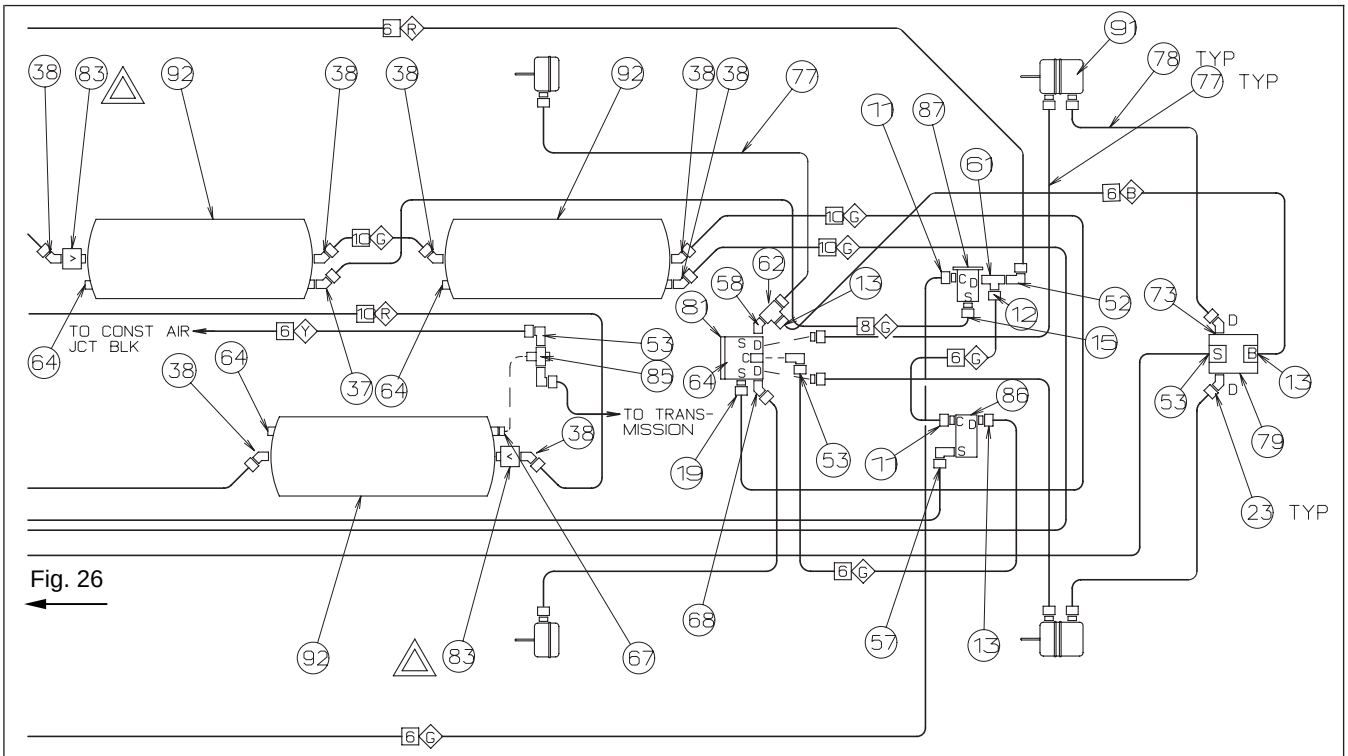
Fig. 26

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
11	2	210500 000003	CONNECTOR, NTA (3/8NT-1/8NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	5	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
15	1	210500 000007	CONNECTOR, NTA (1/2NT-1/4NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
20	1	210500 000008	CONNECTOR,NTA (1/2 NT-3/8 NPT)
22	1	210500 000018	ELBOW, 45 DEG SAE (3/8 NT-1/4 NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
25	1	210503 000005	ADAPTER (1/8 MPT-1/4 FPT)
36	4	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
37	1	210500 000024	ELBOW, 45 DEG NTA (1/2NT-1/2NPT)
38	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
39	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-3/8 NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	5	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	2	210500 000036	ELBOW, 90 DEG SAE (1/2NT-1/2NPT)
58	1	210503 000002	ELBOW, STREET (3/8 NPT-3/8 NTA)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	3	210503 000020	TEE, STREET (3/8 NPT)
64	4	210503 000031	PLUG (1/2 NPT)
65	1	210502 000042	ELBOW, 90 DEG SAE(#8 HOSE-3/8 NPT)
67	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	23-11341-000	ELBOW, ADPTER 45 DEG (3/4UNF-3/8NPT)

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
79	1	BW 289714	VALVE, QUICK RELEASE,REAR QR-1C
80	1	BW 229859	VALVE, QUICK RELEASE,FRONT
81	1	BW 103125	VALVE, RELAY, REAR
82	1	681 429 00 44	VALVE, TRACTOR PROTECTION
83	2	BW 228194	VALVE, SINGLE CHECK
84	1	12-11767-000	VALVE, AIR SAFETY
85	1	681 429 08 44	VALVE, PRESSURE PROTECTION
86	1	BW 106284	VALVE, BRAKE PROPORTIONING REAR
87	1	BW 281459	VALVE, INVERSION
88	1	BW 104598	VALVE, BRAKE PROPORTIONING FRONT
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

10 G	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

1 W/O HAND VALVE (SPEC LN 492) VENT TC PORT TO ATMOSPHERE: OMIT ITEMS 6. DEPENDING ON TP VALVE ORIENTATION ADDITIONAL CALLOUTS MAY APPEAR ON SPEC LN 460 FOR VENTING TC PORT.

2 W/HAND VALVE (SPEC LN 492) ROUTE TO PORT #17 OF MAIN CAB JCT BLOCK.

△ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

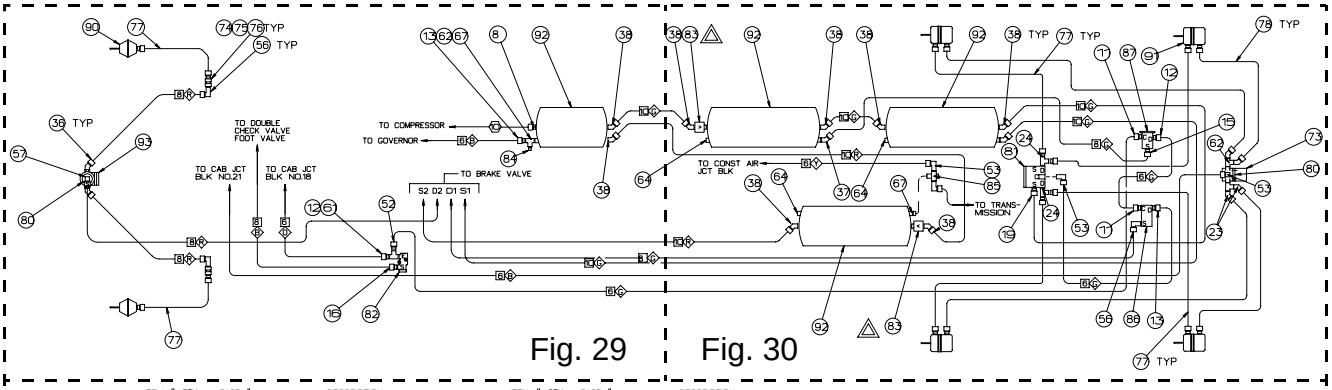
02/10/94

Diagram D12−13045

f421125

Fig. 27

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
11	2	210500 000003	CONNECTOR, NTA (3/8NT-1/8NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	2	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
15	1	210500 000007	CONNECTOR, NTA (1/2NT-1/4NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210503 000021	TEE,STREET
36	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
37	1	210500 000024	ELBOW, 45 DEG NTA (1/2NT-1/2NPT)
38	6	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	3	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG SAE (1/2NT-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	3	210503 000020	TEE, STREET (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10525- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	BW 229859	VALVE, QUICK RELEASE
81	1	BW 103125	VALVE, RELAY, REAR
82	1	BW 279000	VALVE, TRACTOR PROTECTION
83	2	BW 228194	VALVE, SINGLE CHECK
84	1	12-11767-000	VALVE, AIR SAFETY
85	1	681 429 08 44	VALVE, PRESSURE PROTECTION
86	1	BW 108264	VALVE, BRAKE PROPORTIONING
87	1	BW 281459	VALVE, INVERSION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

HOSE ASSY, #10 WIREBRAID
TUBE, NYLON NO.6 BLACK
TUBE, NYLON NO.6 YELLOW
TUBE, NYLON NO.6 GREEN
TUBE, NYLON NO.6 ORANGE
TUBE, NYLON NO.8 BLACK
TUBE, NYLON NO.8 GREEN
TUBE, NYLON NO.8 RED
TUBE, NYLON NO.10 GREEN
TUBE, NYLON NO.10 RED

INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Figs. 29 and 30

Diagram D12−13062

02/10/94

f420813a

Fig. 28, COE or Conventional, Rear Proportioning Only, Nylon Tubing, With Inversion Valve, Date of Use 4/88 to 4/91

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning

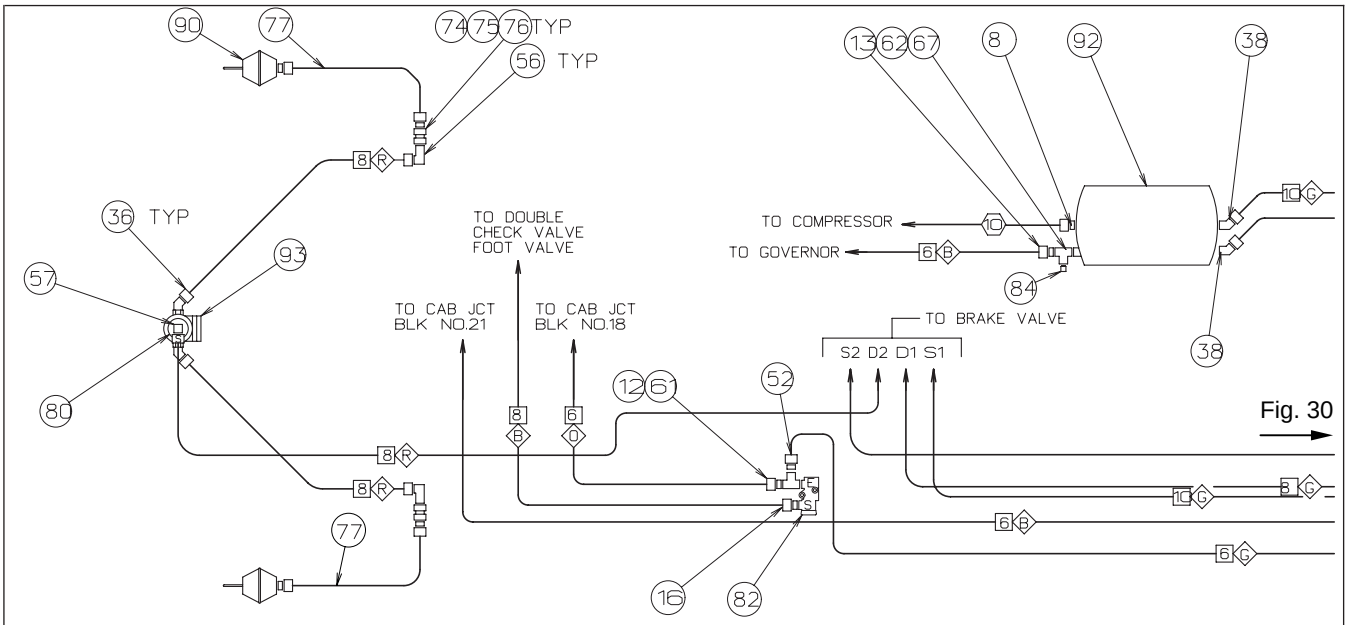


Fig. 30

ITEM #	QTY	PART #	DESCRIPTION
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
11	2	210500 000003	CONNECTOR, NTA (3/8NT-1/8NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	2	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
15	1	210500 000007	CONNECTOR, NTA (1/2NT-1/4NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210503 000021	TEE,STREET
36	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
37	1	210500 000024	ELBOW, 45 DEG NTA (1/2NT-1/2NPT)
38	6	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	3	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG SAE (1/2NT-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	3	210503 000020	TEE, STREET (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	BW 229859	VALVE, QUICK RELEASE
81	1	BW 103125	VALVE, RELAY, REAR
82	1	BW 279000	VALVE, TRACTOR PROTECTION
83	2	BW 228194	VALVE, SINGLE CHECK
84	1	12-11767-000	VALVE, AIR SAFETY
85	1	681 429 08 44	VALVE, PRESSURE PROTECTION
86	1	BW 106284	VALVE, BRAKE PROPORTIONING
87	1	BW 281459	VALVE, INVERSION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

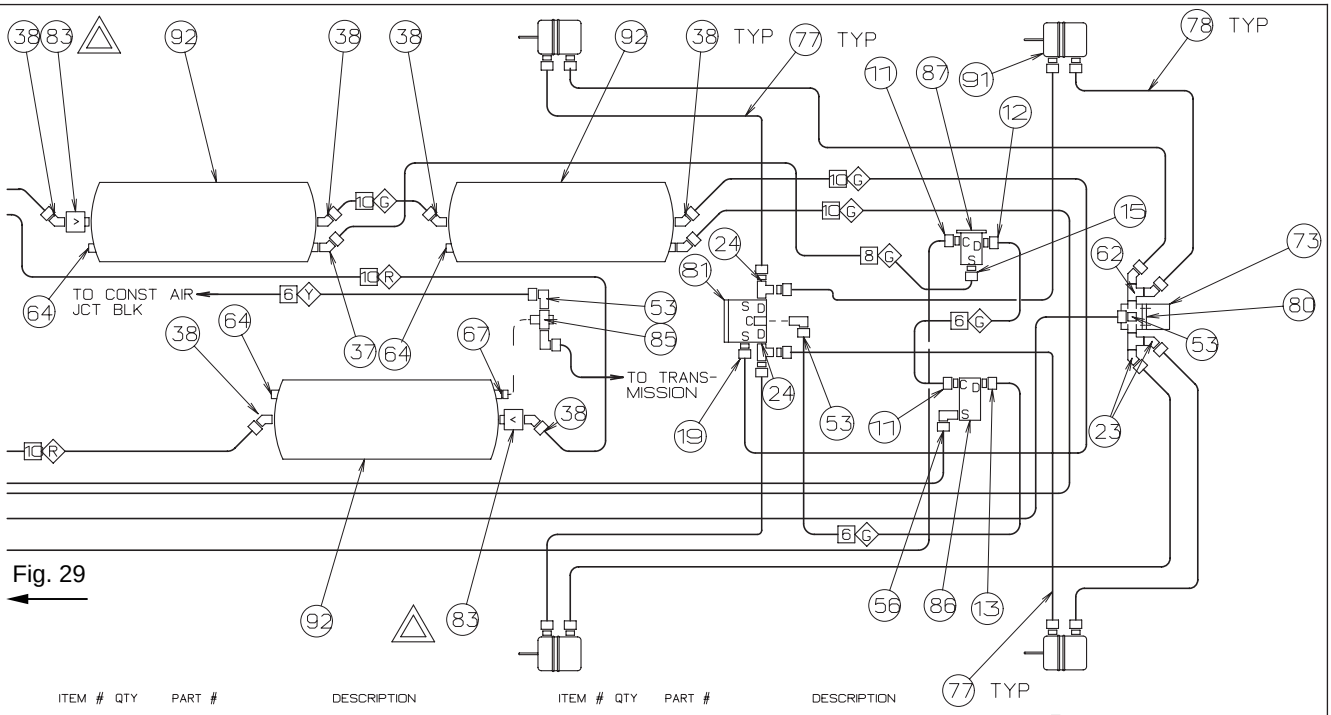
Diagram D12−13062

△ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/10/94 f421126

Fig. 29

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
11	2	210500 000003	CONNECTOR, NTA (3/8NT-1/8NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	2	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
15	1	210500 000007	CONNECTOR, NTA (1/2NT-1/4NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210503 000021	TEE,STREET
36	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
37	1	210500 000024	ELBOW, 45 DEG NTA (1/2NT-1/2NPT)
38	6	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	3	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG SAE (1/2NT-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	3	210503 000020	TEE, STREET (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	BW 229859	VALVE, QUICK RELEASE
81	1	BW 103125	VALVE, RELAY, REAR
82	1	BW 279000	VALVE, TRACTOR PROTECTION
83	2	BW 228194	VALVE, SINGLE CHECK
84	1	12-11767-000	VALVE, AIR SAFETY
85	1	681 429 08 44	VALVE, PRESSURE PROTECTION
86	1	BW 106284	VALVE, BRAKE PROPORTIONING
87	1	BW 281459	VALVE, INVERSION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

10	HOSE ASSY, #10 WIREBRAID
6B	TUBE, NYLON NO.6 BLACK
6Y	TUBE, NYLON NO.6 YELLOW
6G	TUBE, NYLON NO.6 GREEN
6O	TUBE, NYLON NO.6 ORANGE
8B	TUBE, NYLON NO.8 BLACK
8G	TUBE, NYLON NO.8 GREEN
8R	TUBE, NYLON NO.8 RED
10G	TUBE, NYLON NO.10 GREEN
10R	TUBE, NYLON NO.10 RED

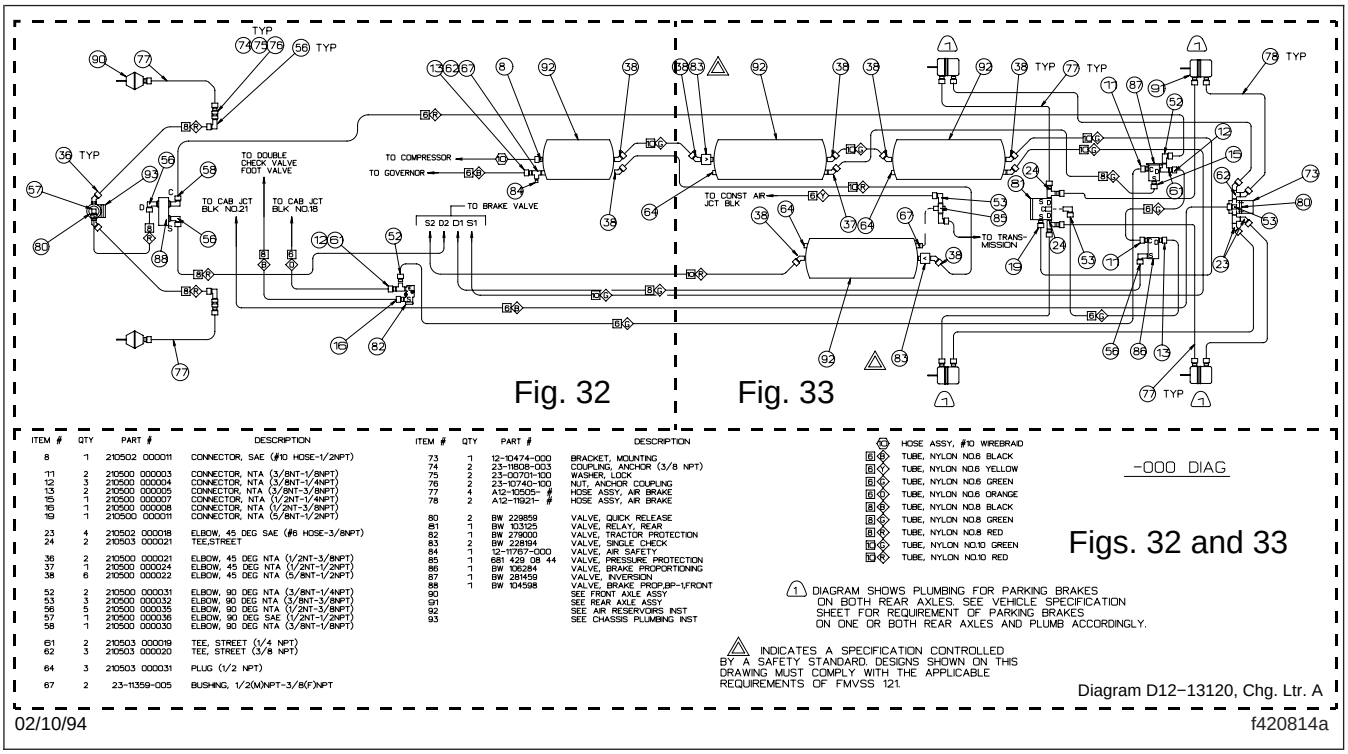
Diagram D12−13062

△ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/10/94 f421127

Fig. 30

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
11	2	210500 000003	CONNECTOR, NTA (3/8NT-1/8NPT)
12	3	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	2	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
15	1	210500 000007	CONNECTOR, NTA (1/2NT-1/4NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	4	210502 000018	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
24	2	210503 000021	TEE,STREET
36	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
37	1	210500 000024	ELBOW, 45 DEG NTA (1/2NT-1/2NPT)
38	6	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
52	2	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	5	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG SAE (1/2NT-1/2NPT)
58	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
61	2	210503 000019	TEE, STREET (1/4 NPT)
62	3	210503 000020	TEE, STREET (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-11505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	BW 229859	VALVE, QUICK RELEASE
81	1	BW 103125	VALVE, RELAY, REAR
82	1	BW 279000	VALVE, TRACTOR PROTECTION
83	2	BW 228194	VALVE, SINGLE CHECK
84	1	12-11767-000	VALVE, AIR SAFETY
85	1	681 429 08 44	VALVE, PRESSURE PROTECTION
86	1	BW 106284	VALVE, BRAKE PROPORTIONING
87	1	BW 281459	VALVE, INVERSION
88	1	BW 104598	VALVE, BRAKE PROP,BP-1/FRONT
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

HOSE ASSY, #10 WIREBRAID
TUBE, NYLON NO.6 BLACK
TUBE, NYLON NO.6 YELLOW
TUBE, NYLON NO.6 GREEN
TUBE, NYLON NO.6 ORANGE
TUBE, NYLON NO.8 BLACK
TUBE, NYLON NO.8 GREEN
TUBE, NYLON NO.8 RED
TUBE, NYLON NO.10 GREEN
TUBE, NYLON NO.10 RED

-000 DIAG

Figs. 32 and 33

(1) DIAGRAM SHOWS PLUMBING FOR PARKING BRAKES ON BOTH REAR AXLES. SEE VEHICLE SPECIFICATION SHEET FOR REQUIREMENT OF PARKING BRAKES ON ONE OR BOTH REAR AXLES AND PLUMB ACCORDINGLY.

⚠ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−13120, Chg. Ltr. A

02/10/94 f420814a

Fig. 31, COE or Conventional, Front and Rear Proportioning, Nylon Tubing, With Inversion Valve, Date of Use 4/88 to 4/91

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning

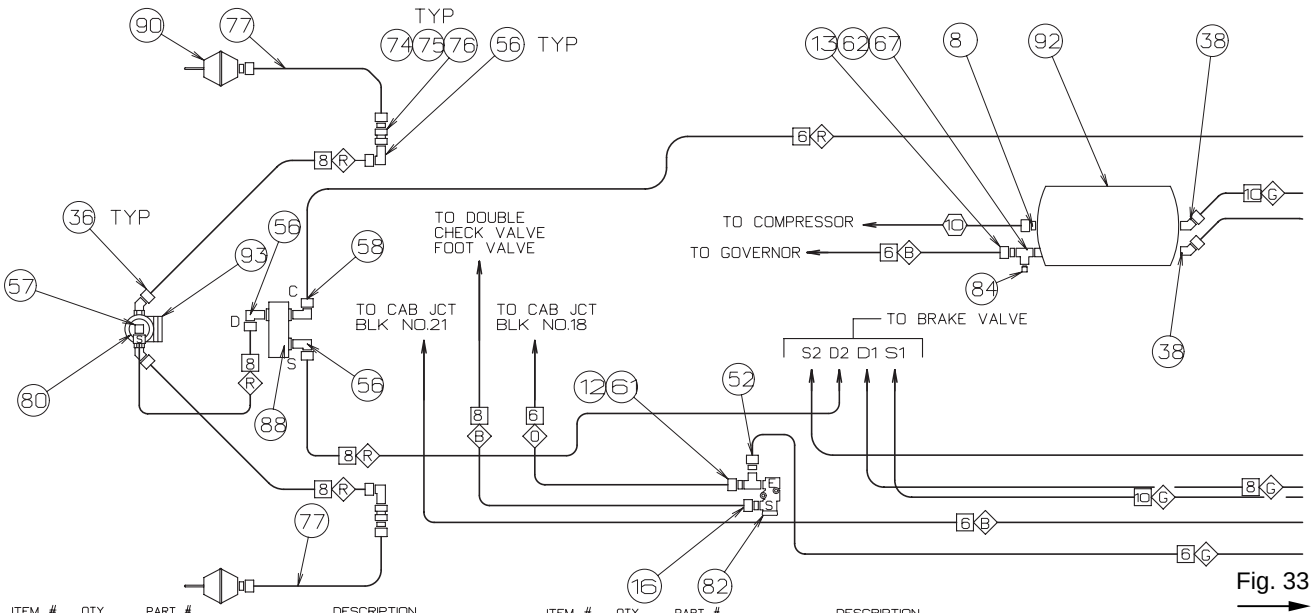


Fig. 33

ITEM #	QTY	PART #	DESCRIPTION
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
11	2	210500 000003	CONNECTOR, NTA (3/8NT-1/8NPT)
12	3	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	2	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
15	1	210500 000007	CONNECTOR, NTA (1/2NT-1/4NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210503 000021	TEE,STREET
36	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
37	1	210500 000024	ELBOW, 45 DEG NTA (1/2NT-1/2NPT)
38	6	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
52	2	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	5	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG SAE (1/2NT-1/2NPT)
58	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
61	2	210503 000019	TEE, STREET (1/4 NPT)
62	3	210503 000020	TEE, STREET (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	BW 229859	VALVE, QUICK RELEASE
81	1	BW 103125	VALVE, RELAY, REAR
82	1	BW 279000	VALVE, TRACTOR PROTECTION
83	2	BW 228194	VALVE, SINGLE CHECK
84	1	12-11767-000	VALVE, AIR SAFETY
85	1	681 429 08 44	VALVE, PRESSURE PROTECTION
86	1	BW 106284	VALVE, BRAKE PROPORTIONING
87	1	BW 281459	VALVE, INVERSION
88	1	BW 104598	VALVE, BRAKE PROP,BP-1,FRONT
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-000 DIAG

10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

△ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

(1) DIAGRAM SHOWS PLUMBING FOR PARKING BRAKES ON BOTH REAR AXLES. SEE VEHICLE SPECIFICATION SHEET FOR REQUIREMENT OF PARKING BRAKES ON ONE OR BOTH REAR AXLES AND PLUMB ACCORDINGLY.

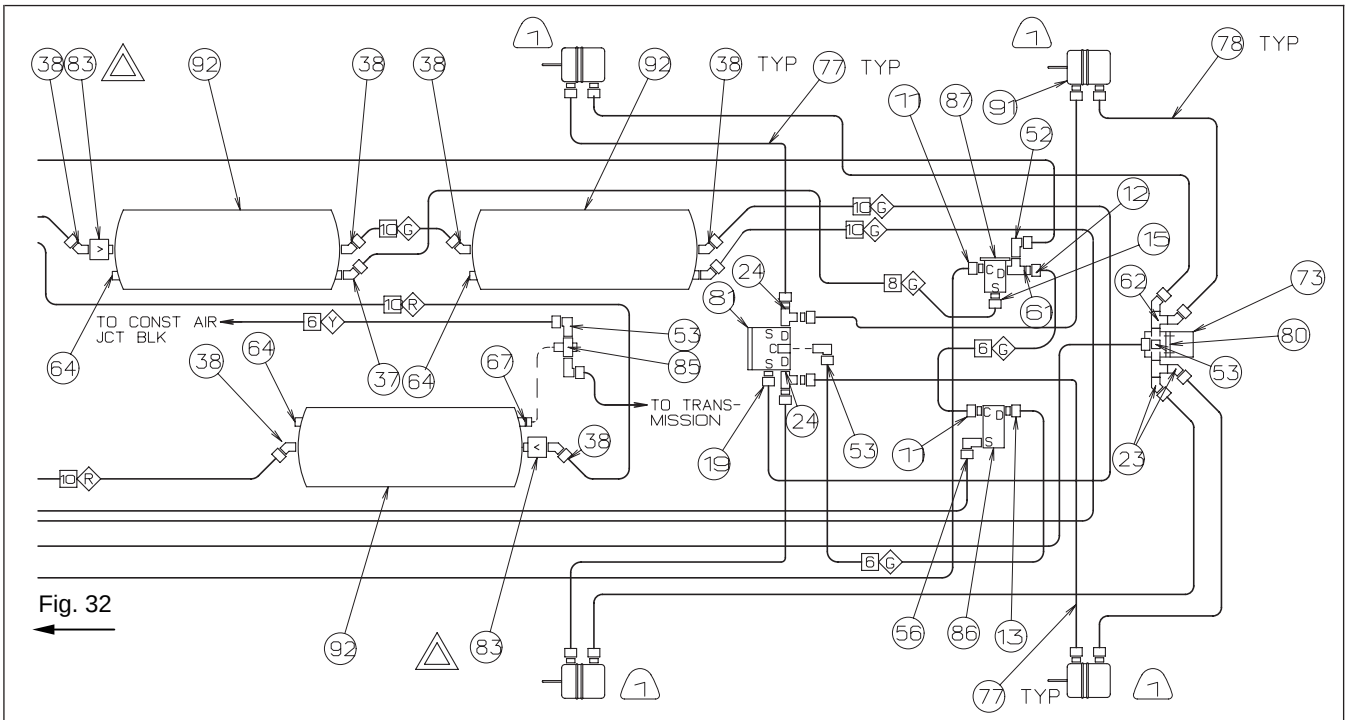
02/10/94

Diagram D12−13120, Chg. Ltr. A

f421128

Fig. 32

Tandem Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
11	2	210500 000003	CONNECTOR, NTA (3/8NT-1/8NPT)
12	3	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	2	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
15	1	210500 000007	CONNECTOR, NTA (1/2NT-1/4NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210503 000021	TEE,STREET
36	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
37	1	210500 000024	ELBOW, 45 DEG NTA (1/2NT-1/2NPT)
38	6	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
52	2	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	5	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG SAE (1/2NT-1/2NPT)
58	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
61	2	210503 000019	TEE, STREET (1/4 NPT)
62	3	210503 000020	TEE, STREET (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	BW 229859	VALVE, QUICK RELEASE
81	1	BW 103125	VALVE, RELAY, REAR
82	1	BW 279000	VALVE, TRACTOR PROTECTION
83	2	BW 228194	VALVE, SINGLE CHECK
84	1	12-11767-000	VALVE, AIR SAFETY
85	1	681 429 08 44	VALVE, PRESSURE PROTECTION
86	1	BW 106284	VALVE, BRAKE PROPORTIONING
87	1	BW 281459	VALVE, INVERSION
88	1	BW 104598	VALVE, BRAKE PROP,BP-1,FRONT
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-000 DIAG

10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

1 DIAGRAM SHOWS PLUMBING FOR PARKING BRAKES ON BOTH REAR AXLES. SEE VEHICLE SPECIFICATION SHEET FOR REQUIREMENT OF PARKING BRAKES ON ONE OR BOTH REAR AXLES AND PLUMB ACCORDINGLY.

△ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/10/94

Diagram D12−13120, Chg. Ltr. A

f421129

Fig. 33

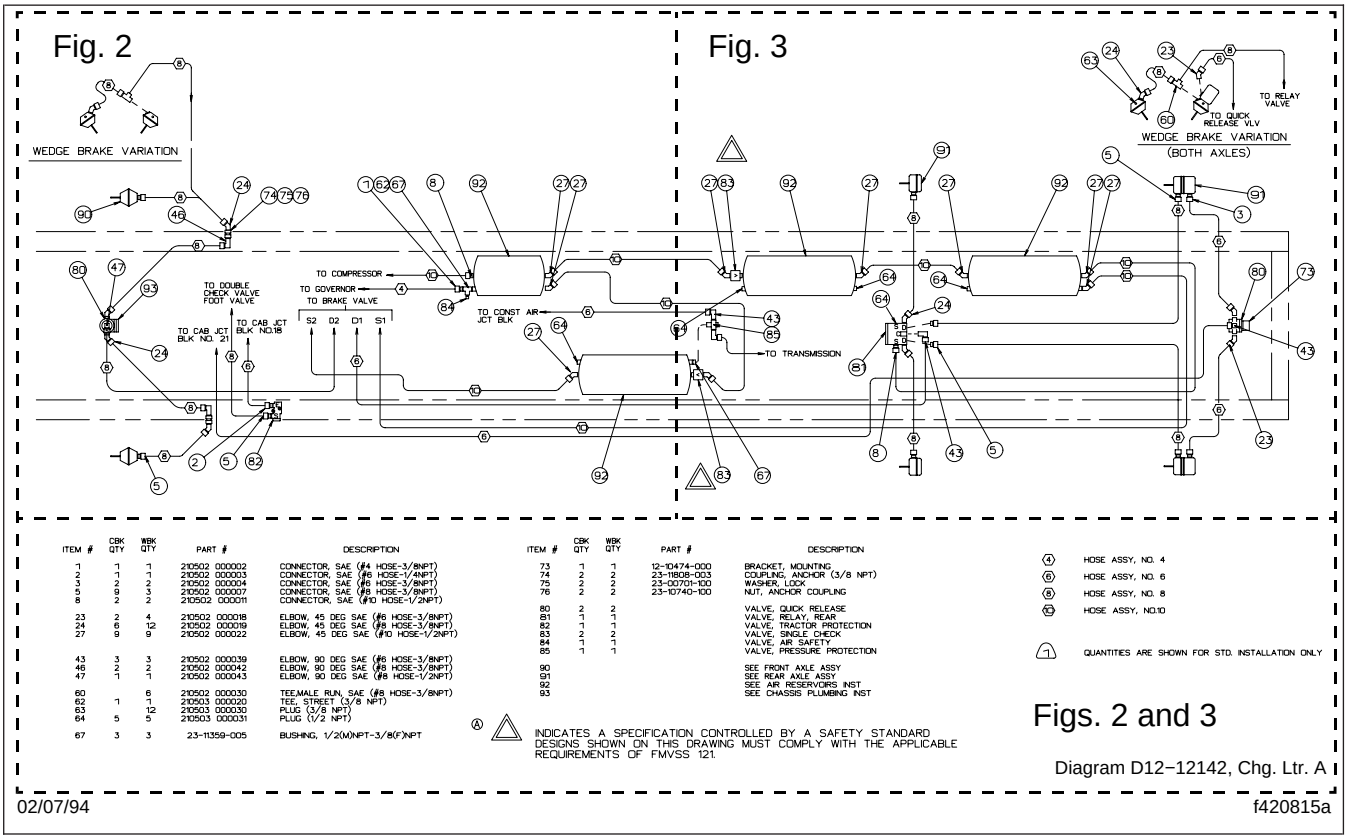
Tandem Rear Axle Tractor, Without Antilock, Without Brake Proportioning

See Fig. 1 for a full view of the plumbing diagram wire braid hose, front quick release valve, date of use 4/88 to 4/91. **See Fig. 2**, or **Fig. 3** for partial (detailed) views plumbing diagram wire braid hose, front quick release valve, date of use 4/88 to 4/91.

See Fig. 4 for a full view of the plumbing diagram wire braid hose, front relay valve. **See Fig. 5**, or **Fig. 6** for partial (detailed) views plumbing diagram wire braid hose, front relay valve.

See Fig. 7 for a full view of the plumbing diagram nylon tubing, front quick release valve, date of use 4/88 to 4/91. **See Fig. 8**, or **Fig. 9** for partial (detailed) views plumbing diagram nylon tubing, front quick release valve, date of use 4/88 to 4/91.

See Fig. 10 for a full view of the plumbing diagram nylon tubing, front relay valve, date of use 4/88 to 4/91. **See Fig. 11**, or **Fig. 12** for partial (detailed) views plumbing diagram nylon tubing, front relay valve, date of use 4/88 to 4/91.



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
1	1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	9	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	2	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	6	12	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	9	9	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63		12	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	3	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

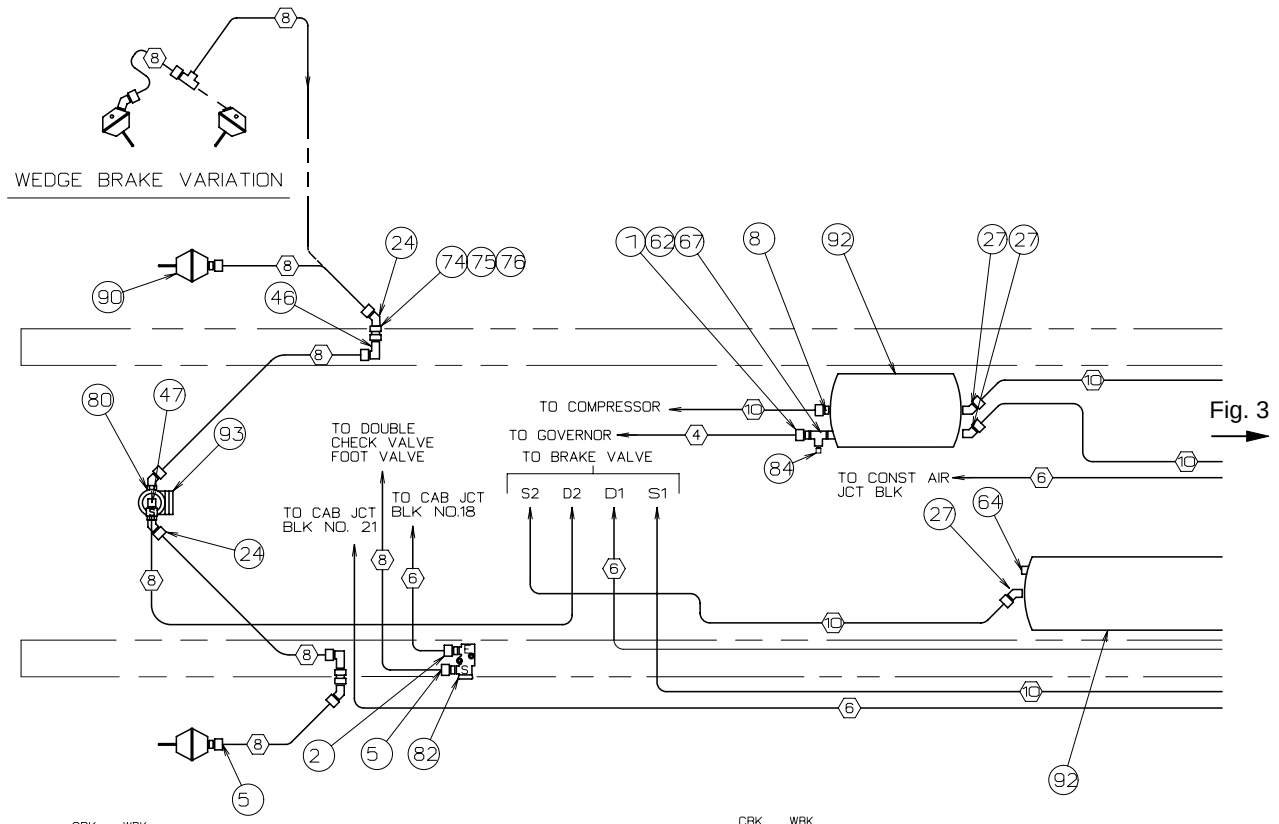
Ⓐ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

1 QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Fig. 1, Wire Braid Hose, Front Quick Release Valve, Date of Use 4/88 to 4/91

Tandem Rear Axle Tractor, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
1	1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	9	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	2	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	6	12	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	9	9	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63		12	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	3	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

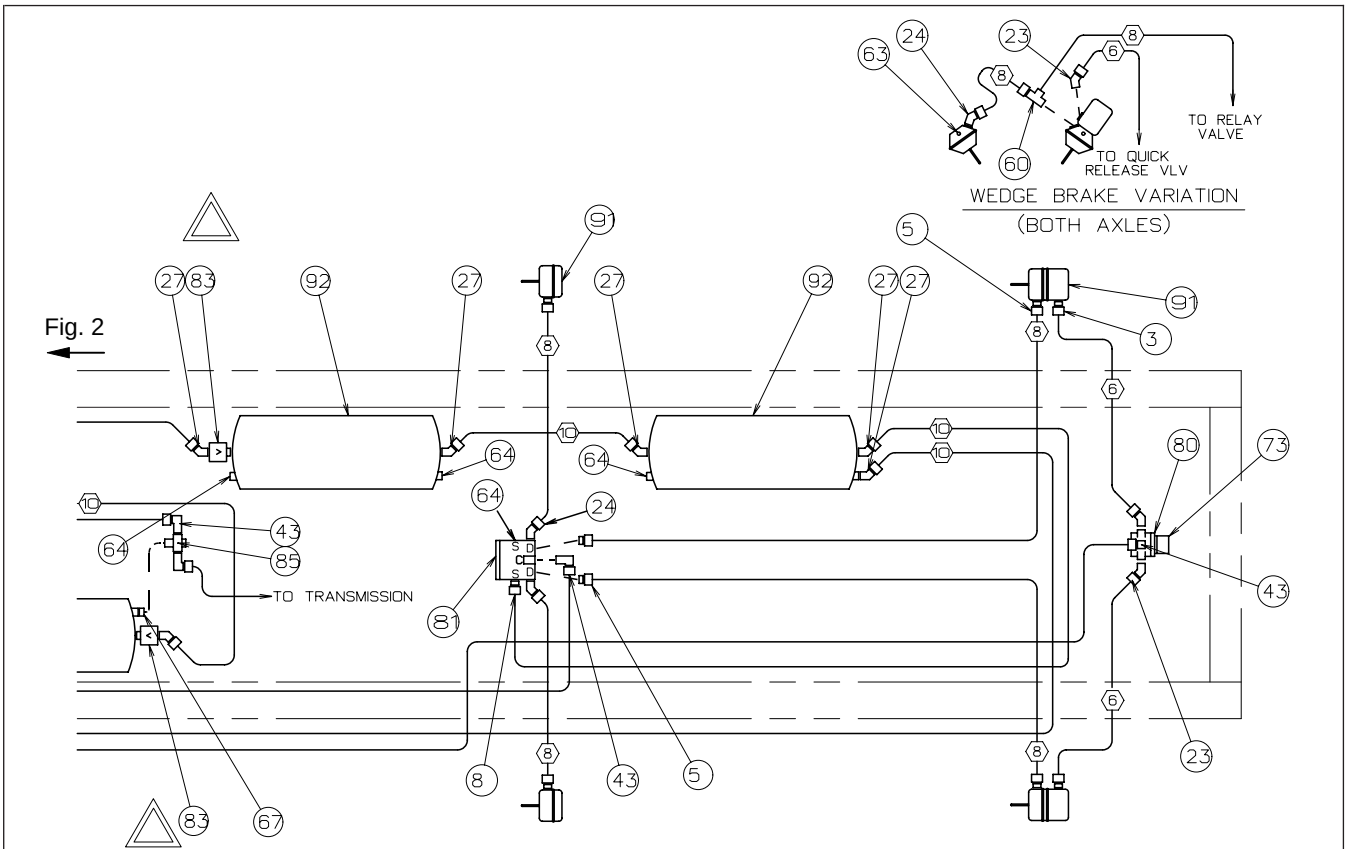
(A) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12142, Chg. Ltr. A

02/07/94 f421104

Fig. 2

Tandem Rear Axle Tractor, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
1	1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	9	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	2	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	6	12	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	9	9	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63		12	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	3	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

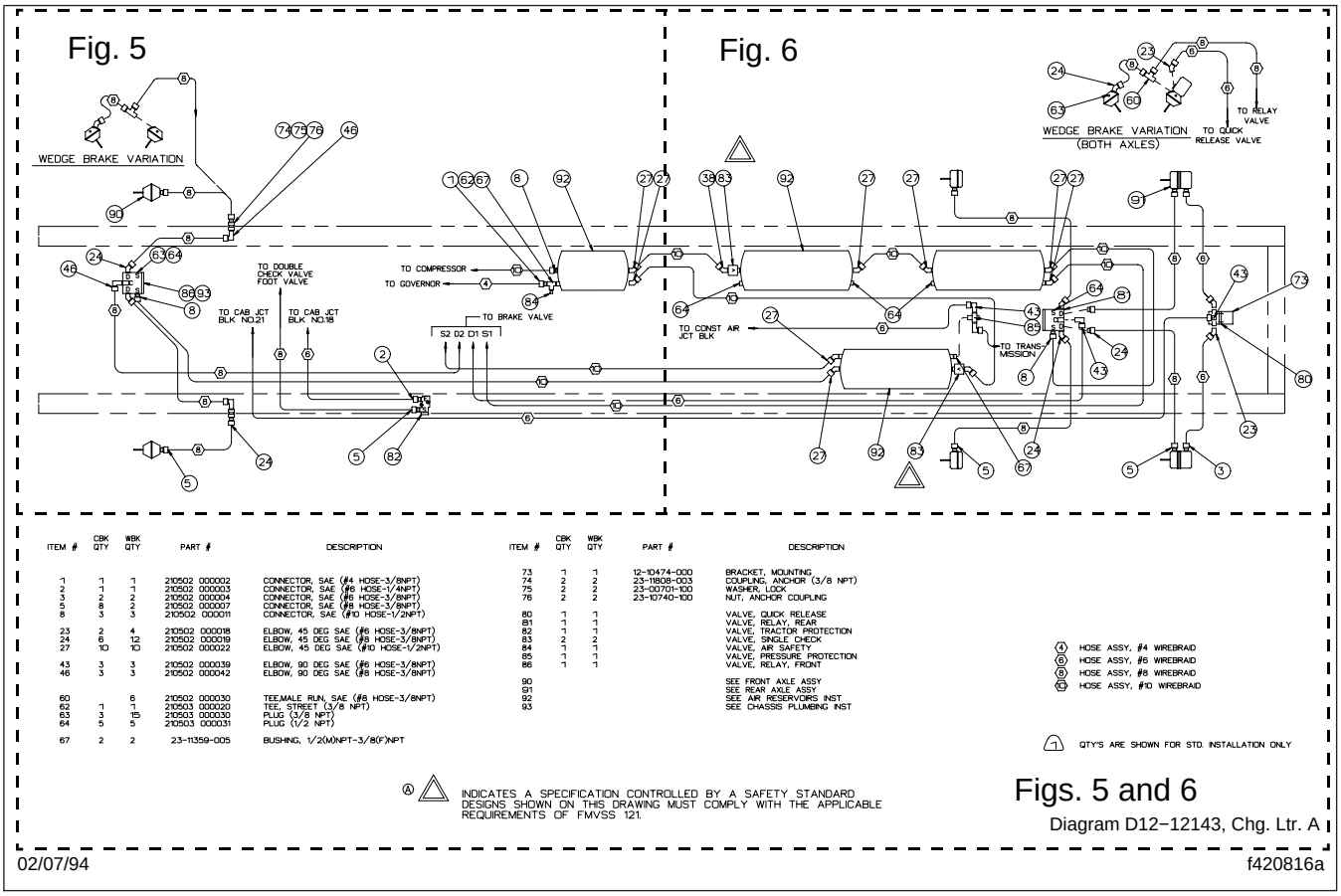
(A) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12142, Chg. Ltr. A

02/07/94 f421105

Fig. 3

Tandem Rear Axle Tractor, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
1	1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	8	2	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	3	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	6	12	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	10	10	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	3	3	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	115	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
80	1	1		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
86	1	1		VALVE, RELAY, FRONT
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

④ HOSE ASSY, #4 WIREBRAID
⑥ HOSE ASSY, #6 WIREBRAID
⑧ HOSE ASSY, #8 WIREBRAID
⑩ HOSE ASSY, #10 WIREBRAID

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓐ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

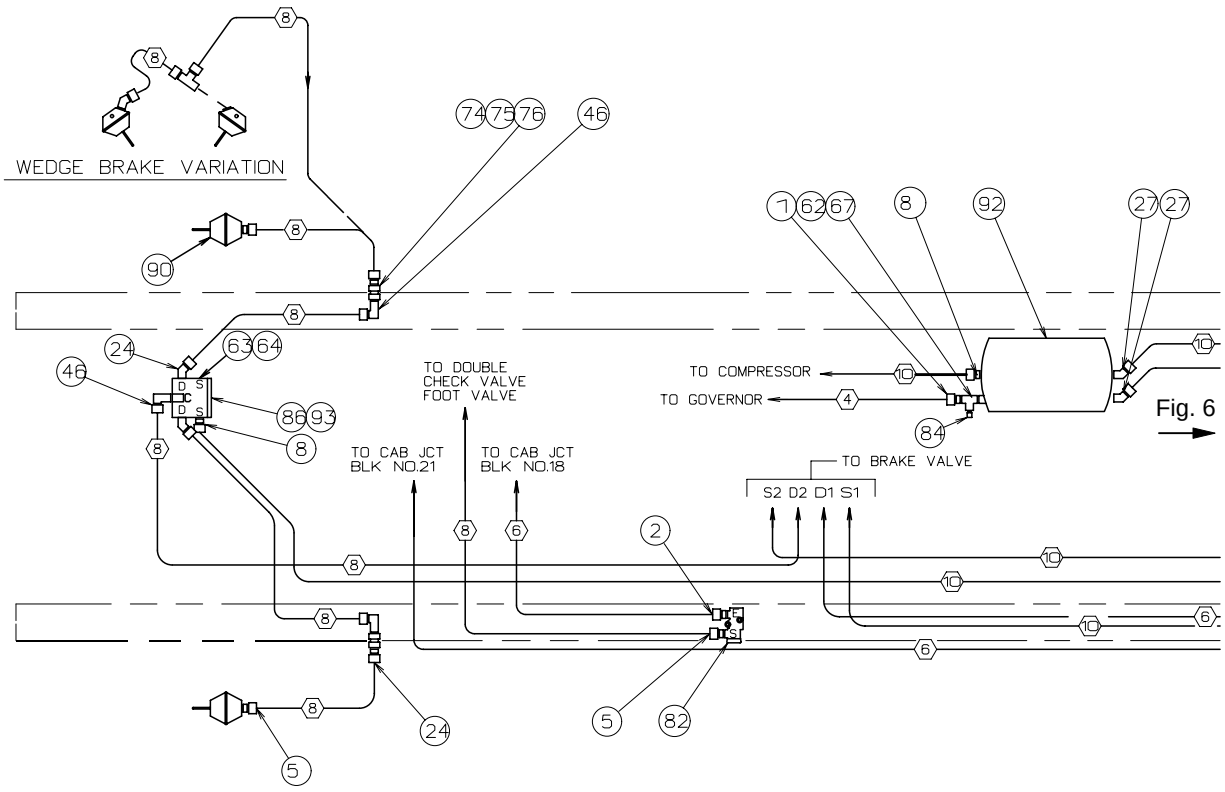
Figs. 5 and 6

Diagram D12−12143, Chg. Ltr. A

02/07/94 f420816a

Fig. 4, Wire Braid Hose, Front Relay Valve

Tandem Rear Axle Tractor, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
1	1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	8	2	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	3	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	6	12	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	10	10	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	3	3	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	3	15	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
80	1	1		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
86	1	1		VALVE, RELAY, FRONT
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, #4 WIREBRAID
(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓐ △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12143, Chg. Ltr. A

02/08/94 f421106

Fig. 5

Tandem Rear Axle Tractor, Without Antilock, Without Brake Proportioning

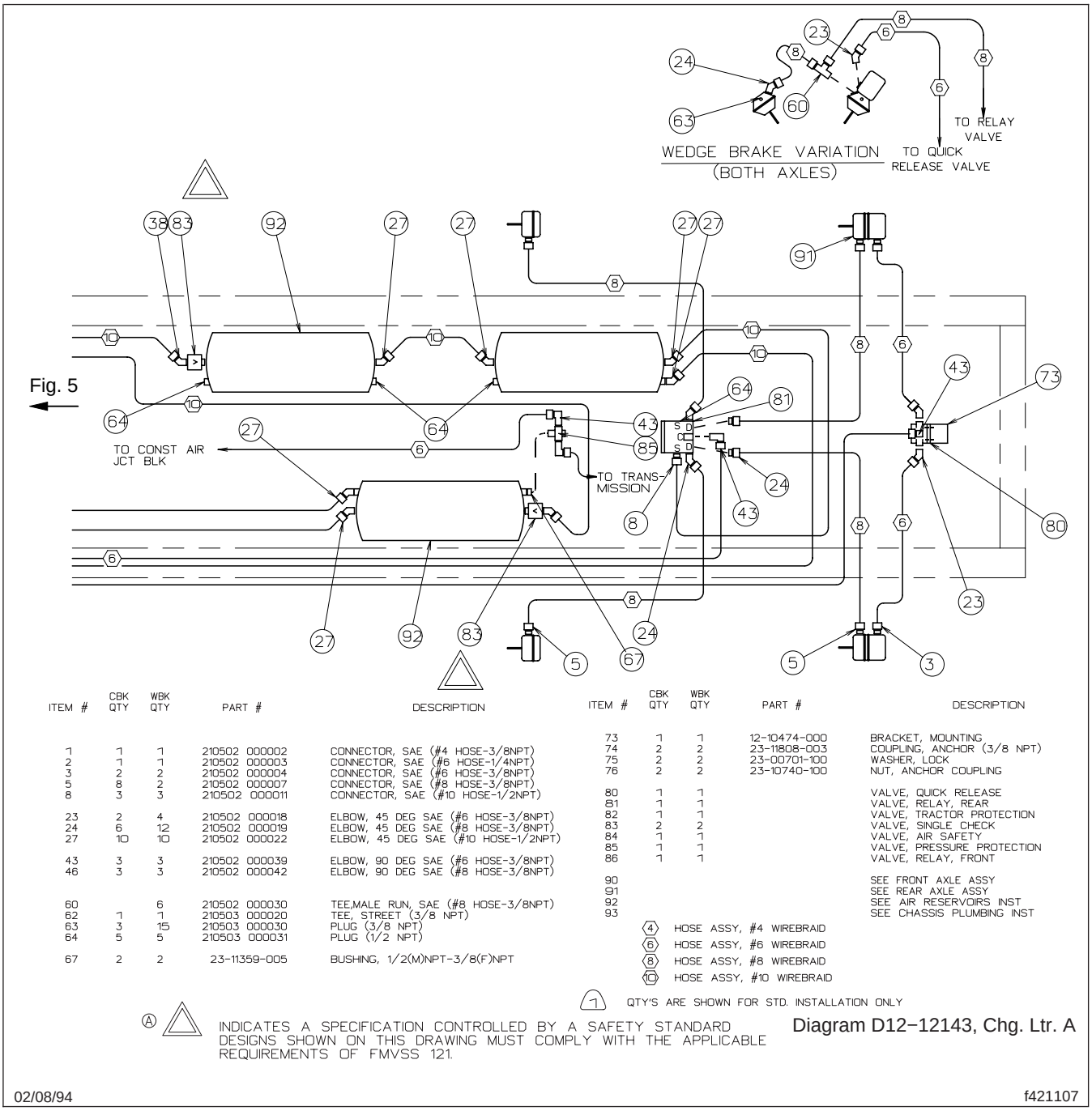


Fig. 5

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
1	1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	8	2	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	3	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	6	12	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	10	10	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	3	3	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	3	15	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
80	1	1		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
86	1	1		VALVE, RELAY, FRONT
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, #4 WIREBRAID
(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

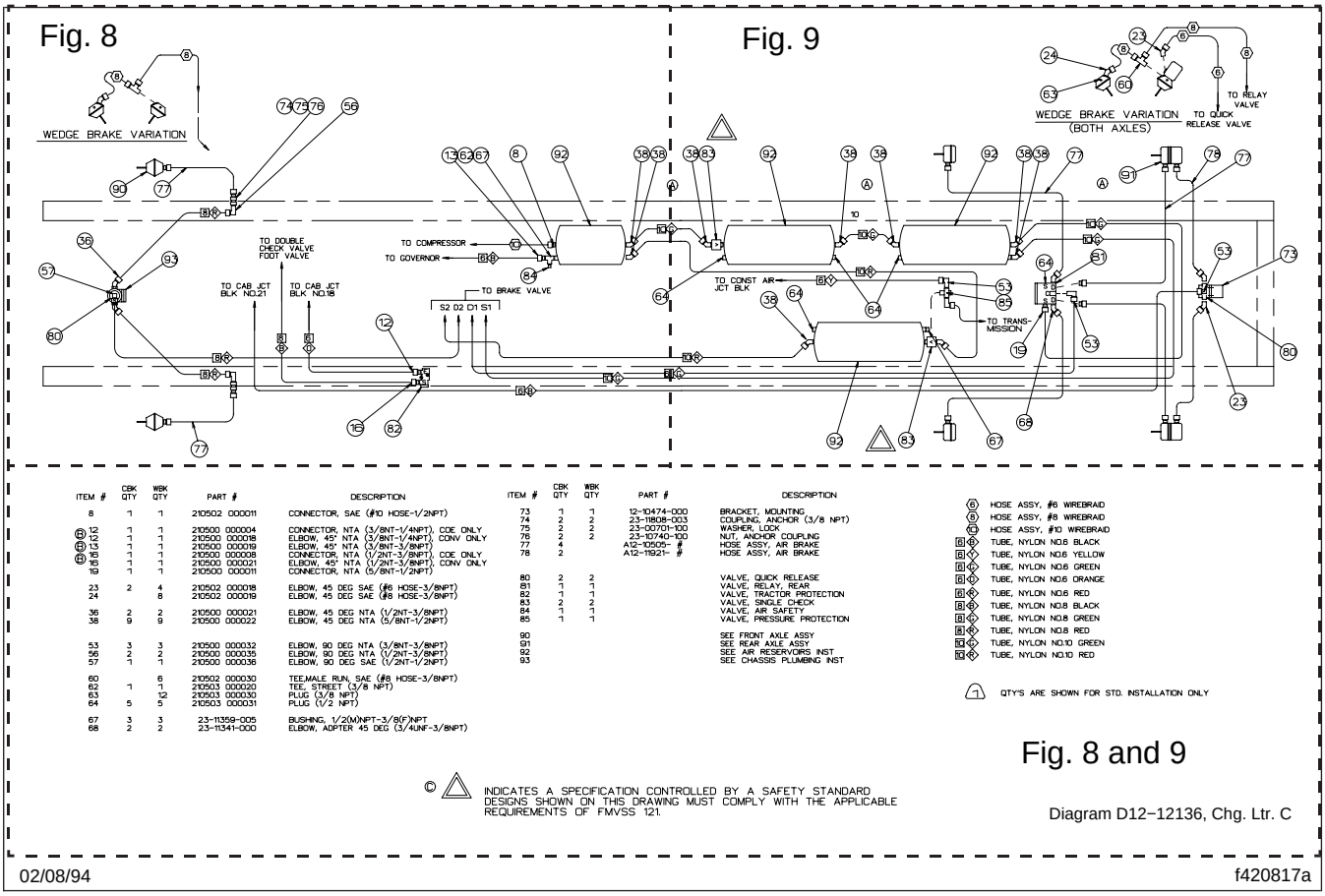
(A) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12143, Chg. Ltr. A

02/08/94 f421107

Fig. 6

Tandem Rear Axle Tractor, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
8	1	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT), CDE ONLY
12	1	1	210500 000018	ELBOW, 45° NTA (3/8NT-1/4NPT), CONV ONLY
13	1	1	210500 000019	ELBOW, 45° NTA (3/8NT-3/8NPT)
15	1	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT), CDE ONLY
16	1	1	210500 000021	ELBOW, 45° NTA (1/2NT-3/8NPT), CONV ONLY
19	1	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24		8	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
36	2	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	9	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
53	3	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	1	210500 000036	ELBOW, 90 DEG SAE (1/2NT-1/2NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63		12	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	3	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	2	23-11341-000	ELBOW, ADPTER 45 DEG (3/4UNF-3/8NPT)
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
77	4		A12-10505- #	HOSE ASSY, AIR BRAKE
78	2		A12-11321- #	HOSE ASSY, AIR BRAKE
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

- (6) HOSE ASSY, #6 WIREBRAID
- (8) HOSE ASSY, #8 WIREBRAID
- (10) HOSE ASSY, #10 WIREBRAID
- TUBE, NYLON NO.6 BLACK
- TUBE, NYLON NO.6 YELLOW
- TUBE, NYLON NO.6 GREEN
- TUBE, NYLON NO.6 ORANGE
- TUBE, NYLON NO.8 RED
- TUBE, NYLON NO.8 BLACK
- TUBE, NYLON NO.8 GREEN
- TUBE, NYLON NO.8 RED
- TUBE, NYLON NO.10 GREEN
- TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Fig. 8 and 9

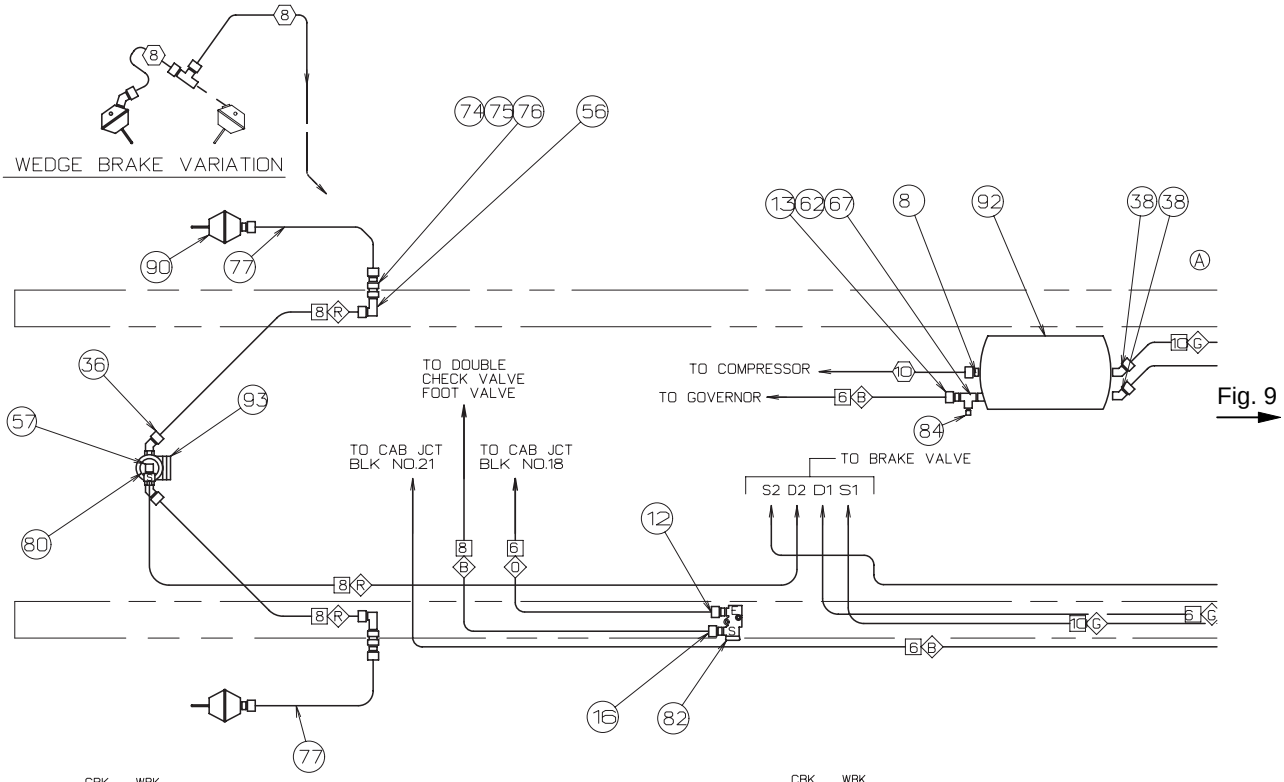
© △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12136, Chg. Ltr. C

02/08/94 f420817a

Fig. 7, Nylon Tubing, Front Quick Release Valve, Date of Use 4/88 to 4/91

Tandem Rear Axle Tractor, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
8	1	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
(B) 12	1	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT), COE ONLY
12	1	1	210500 000018	ELBOW, 45° NTA (3/8NT-1/4NPT), CONV ONLY
(B) 13	1	1	210500 000019	ELBOW, 45° NTA (3/8NT-3/8NPT)
(B) 16	1	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT), COE ONLY
16	1	1	210500 000021	ELBOW, 45° NTA (1/2NT-3/8NPT), CONV ONLY
19	1	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24		8	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
36	2	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	9	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
53	3	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	1	210500 000036	ELBOW, 90 DEG SAE (1/2NT-1/2NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63		12	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	3	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	2	23-11341-000	ELBOW, ADPTER 45 DEG (3/4UNF-3/8NPT)

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
77	4		A12-10505- #	HOSE ASSY, AIR BRAKE
78	2		A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID	6 R	TUBE, NYLON NO.6 RED
8	HOSE ASSY, #8 WIREBRAID	8 B	TUBE, NYLON NO.8 BLACK
10	HOSE ASSY, #10 WIREBRAID	8 G	TUBE, NYLON NO.8 GREEN
6 B	TUBE, NYLON NO.6 BLACK	8 R	TUBE, NYLON NO.8 RED
6 Y	TUBE, NYLON NO.6 YELLOW	10 G	TUBE, NYLON NO.10 GREEN
6 G	TUBE, NYLON NO.6 GREEN	10 R	TUBE, NYLON NO.10 RED
6 O	TUBE, NYLON NO.6 ORANGE		

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

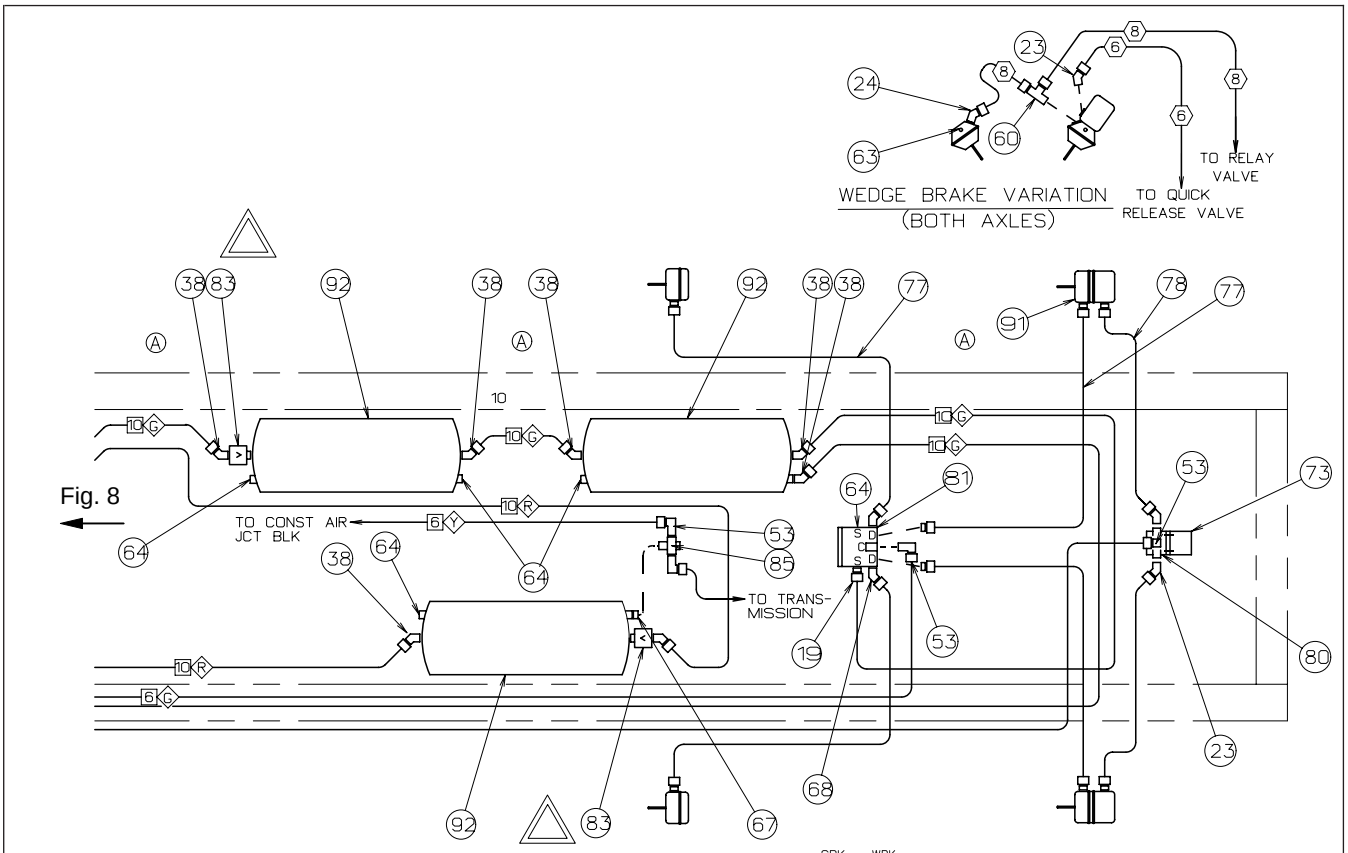
© △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12136, Chg. Ltr. C

02/08/94 f420956

Fig. 8

Tandem Rear Axle Tractor, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
8	1	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
(B) 12	1	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT), COE ONLY
(B) 12	1	1	210500 000018	ELBOW, 45° NTA (3/8NT-1/4NPT), CONV ONLY
(B) 13	1	1	210500 000019	ELBOW, 45° NTA (3/8NT-3/8NPT)
(B) 16	1	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT), COE ONLY
(B) 16	1	1	210500 000021	ELBOW, 45° NTA (1/2NT-3/8NPT), CONV ONLY
19	1	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24		8	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
36	2	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	9	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
53	3	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	1	210500 000036	ELBOW, 90 DEG SAE (1/2NT-1/2NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63		12	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	3	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	2	23-11341-000	ELBOW, ADPTER 45 DEG (3/4UNF-3/8NPT)

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
77	4		A12-10505- #	HOSE ASSY, AIR BRAKE
78	2		A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

(6)	HOSE ASSY, #6 WIREBRAID	[6 R]	TUBE, NYLON NO.6 RED
(8)	HOSE ASSY, #8 WIREBRAID	[8 B]	TUBE, NYLON NO.8 BLACK
(10)	HOSE ASSY, #10 WIREBRAID	[8 G]	TUBE, NYLON NO.8 GREEN
[6 B]	TUBE, NYLON NO.6 BLACK	[8 R]	TUBE, NYLON NO.8 RED
[6 Y]	TUBE, NYLON NO.6 YELLOW	[10 G]	TUBE, NYLON NO.10 GREEN
[6 G]	TUBE, NYLON NO.6 GREEN	[10 R]	TUBE, NYLON NO.10 RED
[6 O]	TUBE, NYLON NO.6 ORANGE		

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

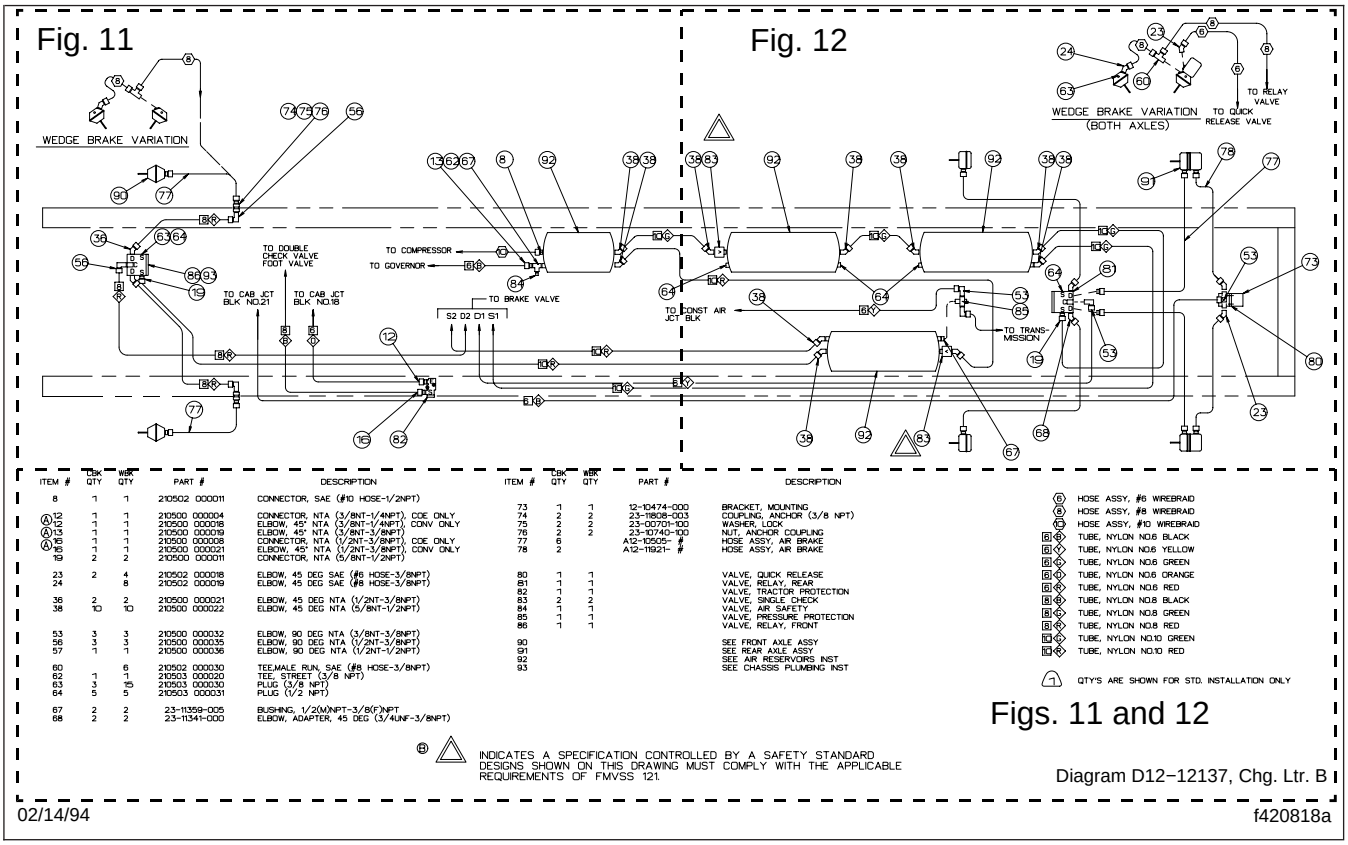
© INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12136, Chg. Ltr. C

02/08/94 f420957

Fig. 9

Tandem Rear Axle Tractor, Without Antilock, Without Brake Proportioning



ITEM #	BBK QTY	WBK QTY	PART #	DESCRIPTION
8	1	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
(A)12	1	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT), CDE ONLY
12	1	1	210500 000018	ELBOW, 45° NTA (3/8NT-1/4NPT), CONV ONLY
(A)13	1	1	210500 000019	ELBOW, 45° NTA (3/8NT-3/8NPT)
(A)15	1	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT), CDE ONLY
16	1	1	210500 000021	ELBOW, 45° NTA (1/2NT-3/8NPT), CONV ONLY
19	2	2	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24		8	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
36	2	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	10	10	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
53	3	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	3	3	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	3	15	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
77	6		A12-10505- #	HOSE ASSY, AIR BRAKE
78	2		A12-11921- #	HOSE ASSY, AIR BRAKE
80	1	1		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
86	1	1		VALVE, RELAY, FRONT
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID
(R) TUBE, NYLON NO.6 BLACK
(R) TUBE, NYLON NO.6 YELLOW
(R) TUBE, NYLON NO.6 GREEN
(R) TUBE, NYLON NO.6 ORANGE
(R) TUBE, NYLON NO.6 RED
(R) TUBE, NYLON NO.8 BLACK
(R) TUBE, NYLON NO.8 GREEN
(R) TUBE, NYLON NO.8 RED
(R) TUBE, NYLON NO.10 GREEN
(R) TUBE, NYLON NO.10 RED

(A) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Figs. 11 and 12

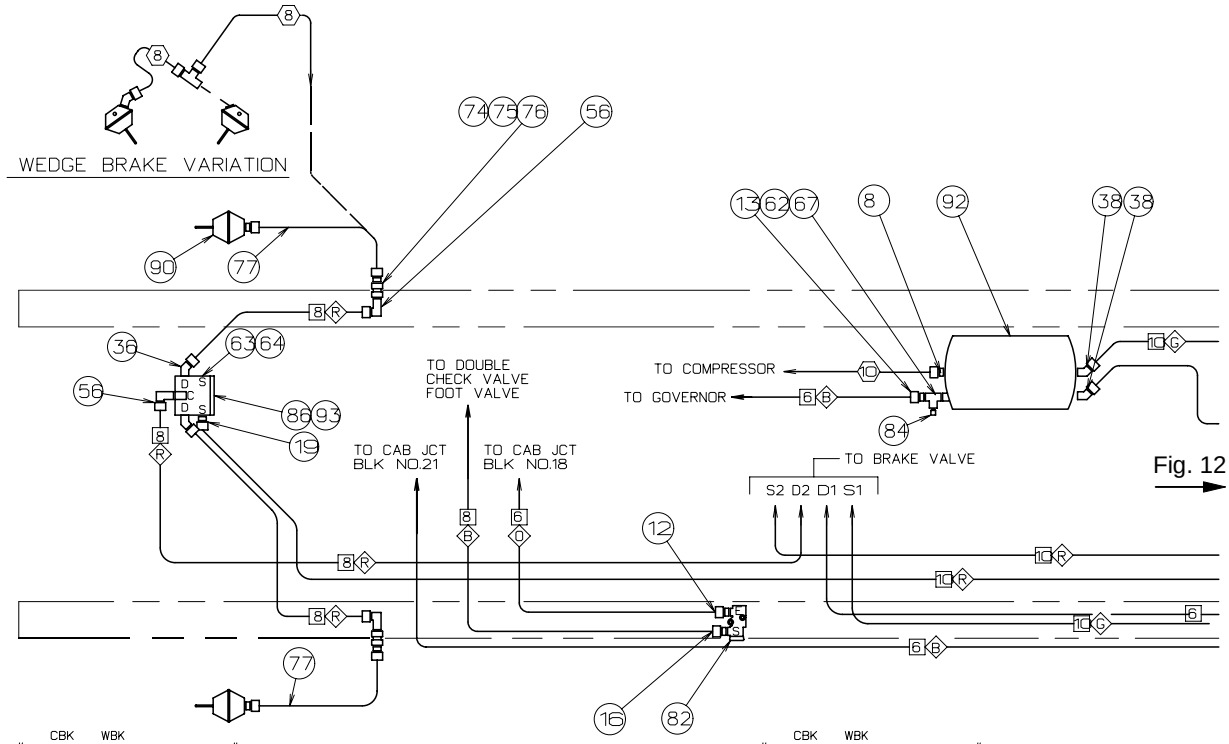
(B) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12137, Chg. Ltr. B

02/14/94 f420818a

Fig. 10, Nylon Tubing, Front Relay Valve, Date of Use 4/88 to 4/91

Tandem Rear Axle Tractor, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
8	1	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
Ⓐ12	1	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT), COE ONLY
Ⓐ12	1	1	210500 000018	ELBOW, 45° NTA (3/8NT-1/4NPT), CONV ONLY
Ⓐ13	1	1	210500 000019	ELBOW, 45° NTA (3/8NT-3/8NPT)
Ⓐ16	1	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT), COE ONLY
Ⓐ16	1	1	210500 000021	ELBOW, 45° NTA (1/2NT-3/8NPT), CONV ONLY
19	2	2	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24		8	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
36	2	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	10	10	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
53	3	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	3	3	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	3	15	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
77	6		A12-10505- #	HOSE ASSY, AIR BRAKE
78	2		A12-11921- #	HOSE ASSY, AIR BRAKE
80	1	1		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
86	1	1		VALVE, RELAY, FRONT
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID	6R	TUBE, NYLON NO.6 RED
8	HOSE ASSY, #8 WIREBRAID	8B	TUBE, NYLON NO.8 BLACK
10	HOSE ASSY, #10 WIREBRAID	8G	TUBE, NYLON NO.8 GREEN
6B	TUBE, NYLON NO.6 BLACK	8R	TUBE, NYLON NO.8 RED
6Y	TUBE, NYLON NO.6 YELLOW	10G	TUBE, NYLON NO.10 GREEN
6G	TUBE, NYLON NO.6 GREEN	10R	TUBE, NYLON NO.10 RED
6O	TUBE, NYLON NO.6 ORANGE		

Ⓑ △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12137, Chg. Ltr. B

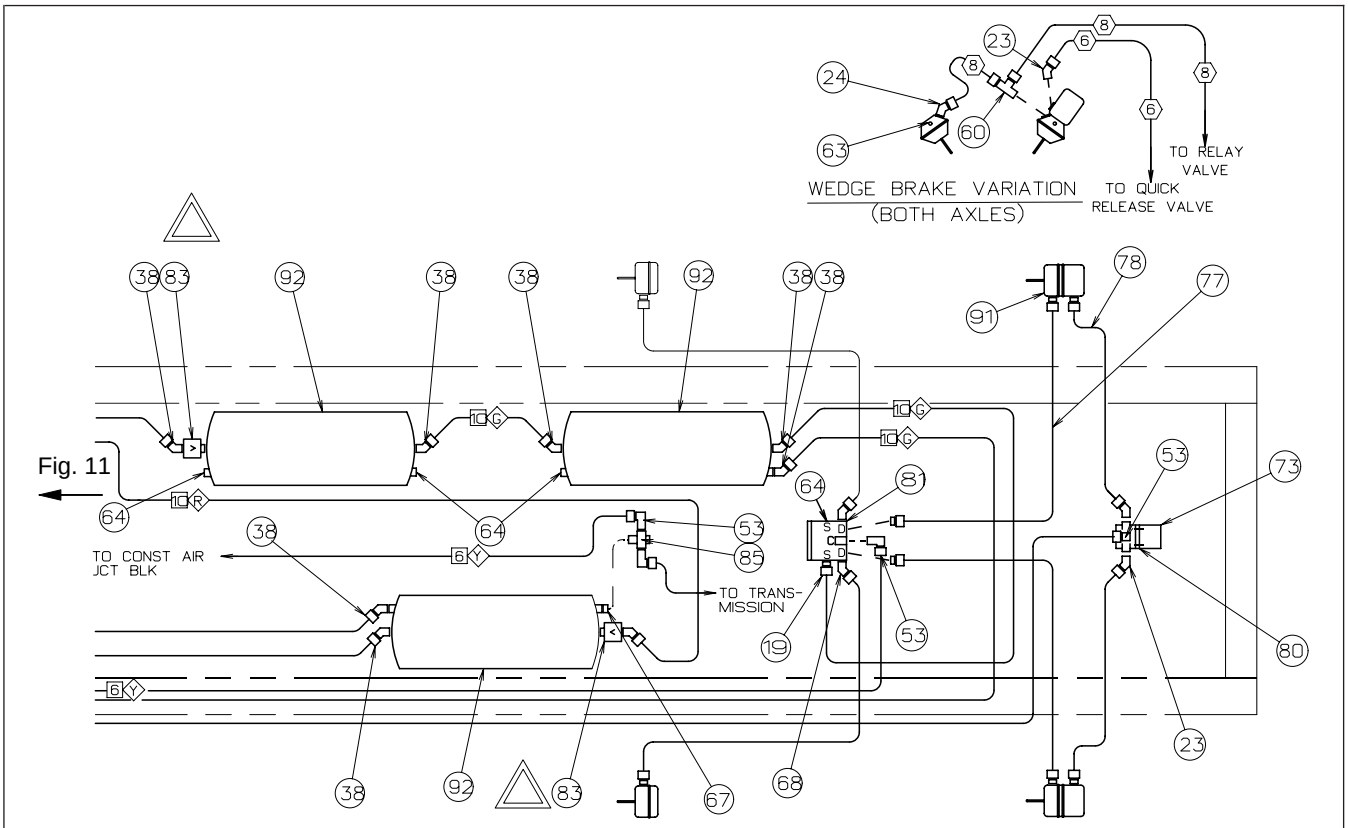
02/14/94

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

f421112

Fig. 11

Tandem Rear Axle Tractor, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
8	1	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
(A)12	1	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT), COE ONLY
12	1	1	210500 000018	ELBOW, 45° NTA (3/8NT-1/4NPT), CONV ONLY
(A)13	1	1	210500 000019	ELBOW, 45° NTA (3/8NT-3/8NPT)
(A)16	1	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT), COE ONLY
16	1	1	210500 000021	ELBOW, 45° NTA (1/2NT-3/8NPT), CONV ONLY
19	2	2	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24		8	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
36	2	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	10	10	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
53	3	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	3	3	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	3	15	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
77	6		A12-10505- #	HOSE ASSY, AIR BRAKE
78	2		A12-11921- #	HOSE ASSY, AIR BRAKE
80	1	1		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
86	1	1		VALVE, RELAY, FRONT
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID	6 R	TUBE, NYLON NO.6 RED
8	HOSE ASSY, #8 WIREBRAID	8 B	TUBE, NYLON NO.8 BLACK
10	HOSE ASSY, #10 WIREBRAID	8 G	TUBE, NYLON NO.8 GREEN
6 B	TUBE, NYLON NO.6 BLACK	8 R	TUBE, NYLON NO.8 RED
6 Y	TUBE, NYLON NO.6 YELLOW	10 G	TUBE, NYLON NO.10 GREEN
6 G	TUBE, NYLON NO.6 GREEN	10 R	TUBE, NYLON NO.10 RED
6 O	TUBE, NYLON NO.6 ORANGE		

(B) △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12137, Chg. Ltr. B

02/15/94

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

f421113

Fig. 12

Tandem Rear Axle Truck, With Six-Channel Antilock, Without Brake Proportioning

See Fig. 1 for a full view of the plumbing diagram wire braid hose, front quick release valve, date of use 4/88 to 4/91. **See Fig. 2**, or **Fig. 3** for partial (detailed) views plumbing diagram wire braid hose, front quick release valve, date of use 4/88 to 4/91.

See Fig. 4 for a full view of the plumbing diagram wire braid hose, front relay valve, date of use 4/88 to 4/91. **See Fig. 5**, or **Fig. 6** for partial (detailed) views plumbing diagram wire braid hose, front relay valve, date of use 4/88 to 4/91.

See Fig. 7 for a full view of the plumbing diagram nylon tubing, front quick release valve, date of use 4/88 to 4/91. **See Fig. 8**, or **Fig. 9** for partial (detailed) views plumbing diagram nylon tubing, front quick release valve, date of use 4/88 to 4/91.

See Fig. 10 for a full view of the plumbing diagram nylon tubing, front relay valve, date of use 4/88 to 4/91. **See Fig. 11**, or **Fig. 12** for partial (detailed) views plumbing diagram nylon tubing, front relay valve, date of use 4/88 to 4/91.

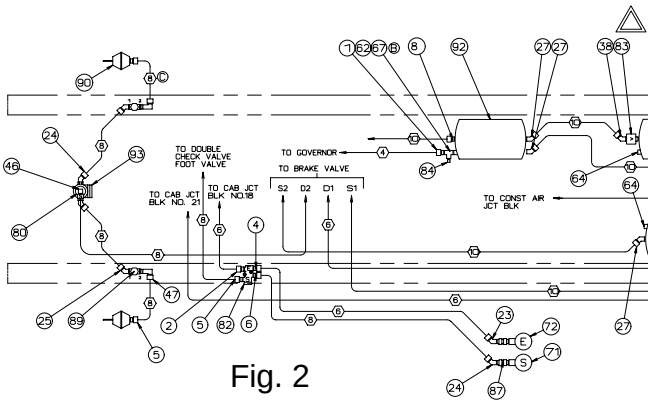


Fig. 2

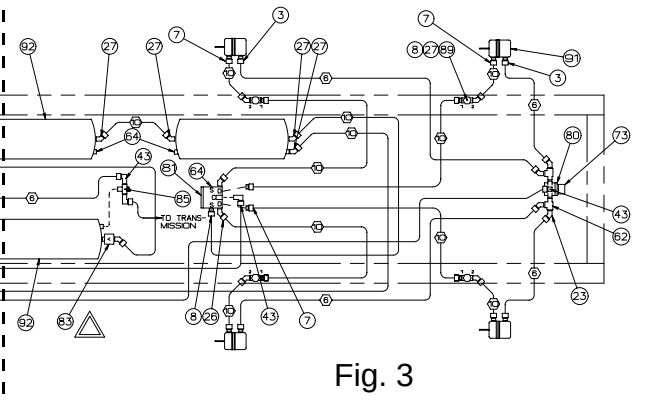


Fig. 3

ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	4	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
4	1	210502 000005	CONNECTOR, SAE (#6 HOSE-1/2NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	1	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	5	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	13	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	3	210503 000020	TEE, STREET 3/8NPT
64	5	210503 000031	PLUG (1/2 NPT)
Ⓑ67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
71	1	12-09711-000	GLADHAND, SERVICE
72	1	12-09711-001	GLADHAND, EMERGENCY
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
Ⓐ81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
87	2		STUD, CLAMPING
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

△1 QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓐ △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

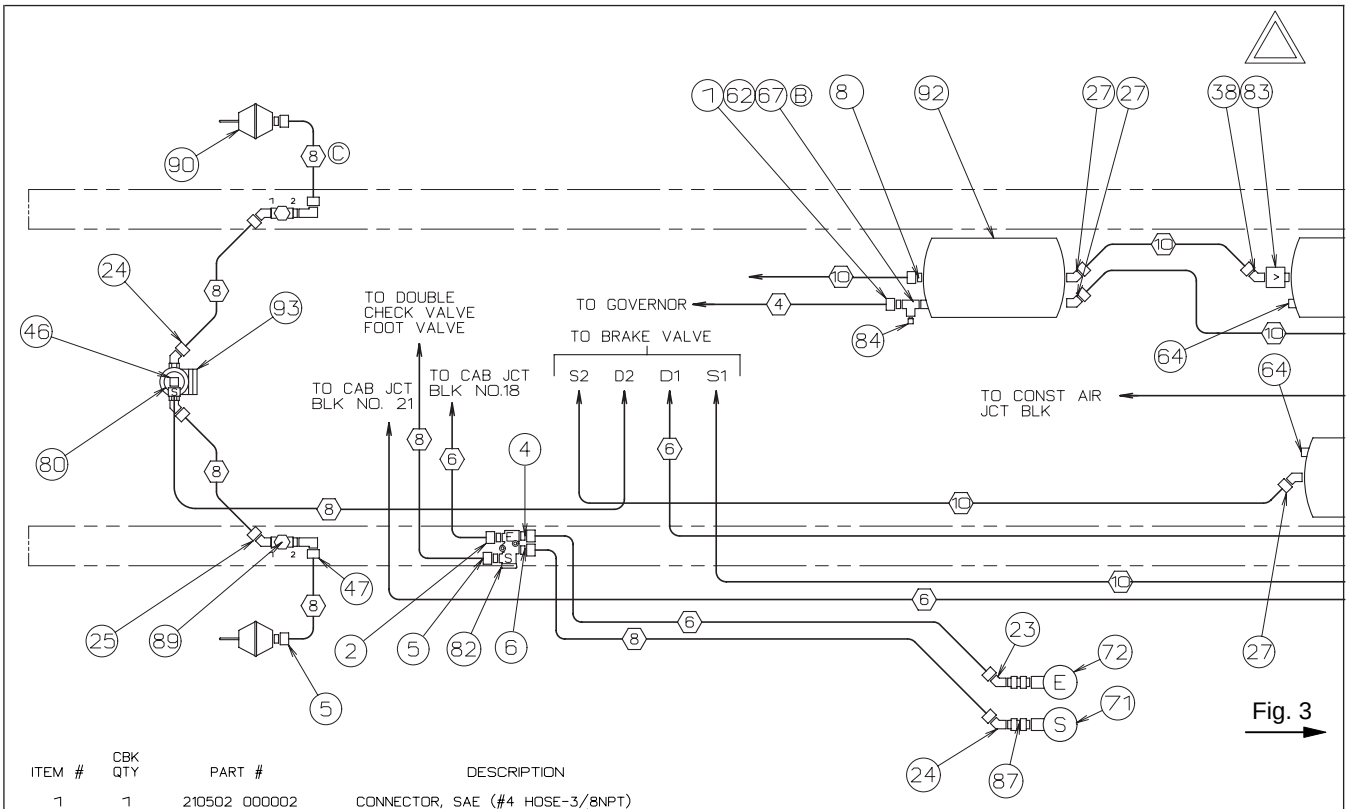
Figs. 2 and 3

Diagram D12−12211, Chg. Ltr. D

02/10/94 f420819a

Fig. 1, Wire Braid Hose, Front Quick Release Valve, Date of Use 4/88 to 4/91

Tandem Rear Axle Truck, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	4	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
4	1	210502 000005	CONNECTOR, SAE (#6 HOSE-1/2NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	1	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	5	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	13	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	3	210503 000020	TEE, STREET 3/8NPT
64	5	210503 000031	PLUG (1/2 NPT)
Ⓑ67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
71	1	12-09711-000	GLADHAND, SERVICE
72	1	12-09711-001	GLADHAND, EMERGENCY
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
87	2		STUD, CLAMPING
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

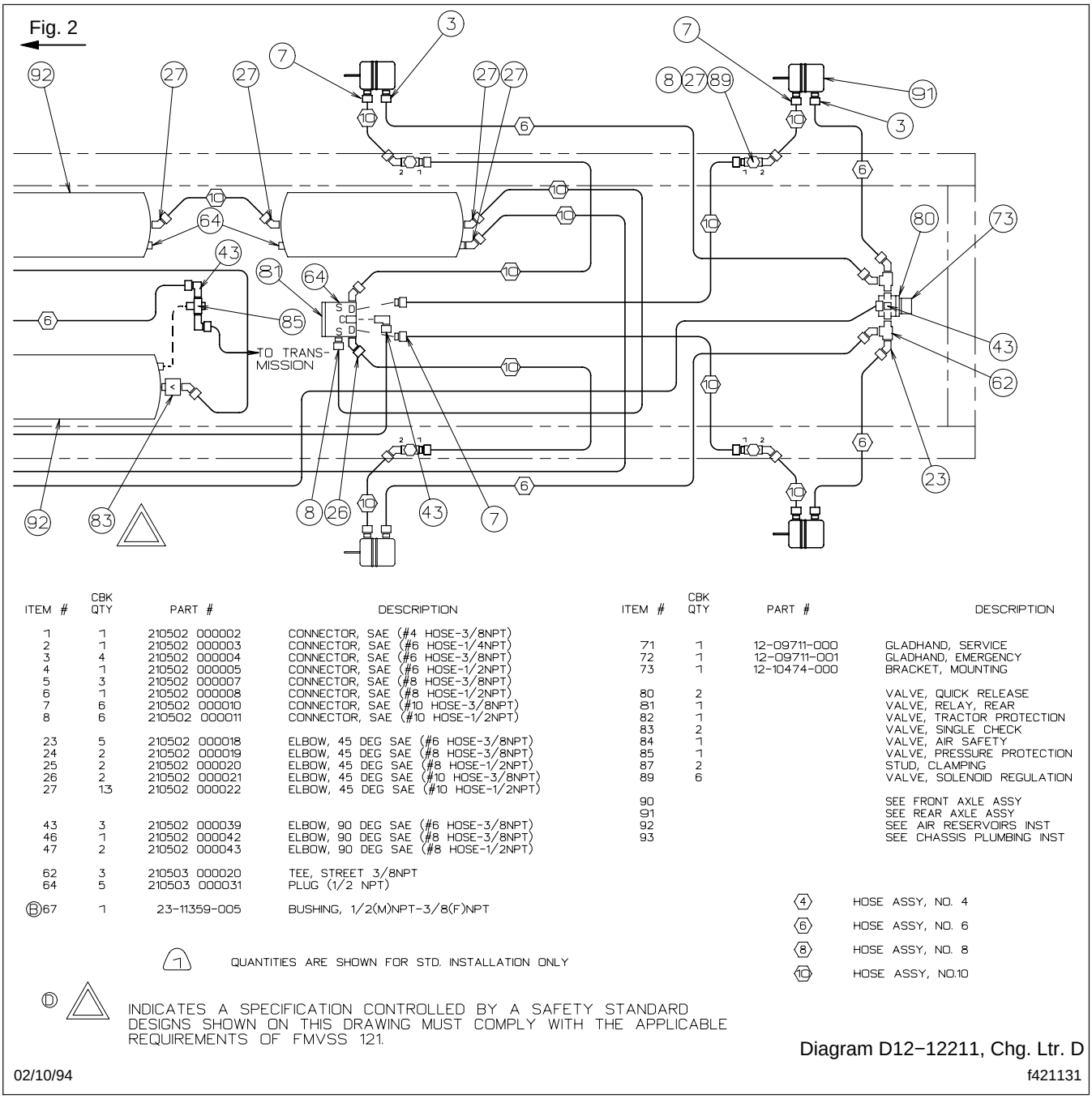
Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12211, Chg. Ltr. D

02/10/94 f421130

Fig. 2

Tandem Rear Axle Truck, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	4	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
4	1	210502 000005	CONNECTOR, SAE (#6 HOSE-1/2NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	1	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	5	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	13	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	3	210503 000020	TEE, STREET 3/8NPT
64	5	210503 000031	PLUG (1/2 NPT)
Ⓑ67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
71	1	12-09711-000	GLADHAND, SERVICE
72	1	12-09711-001	GLADHAND, EMERGENCY
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
87	2		STUD, CLAMPING
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

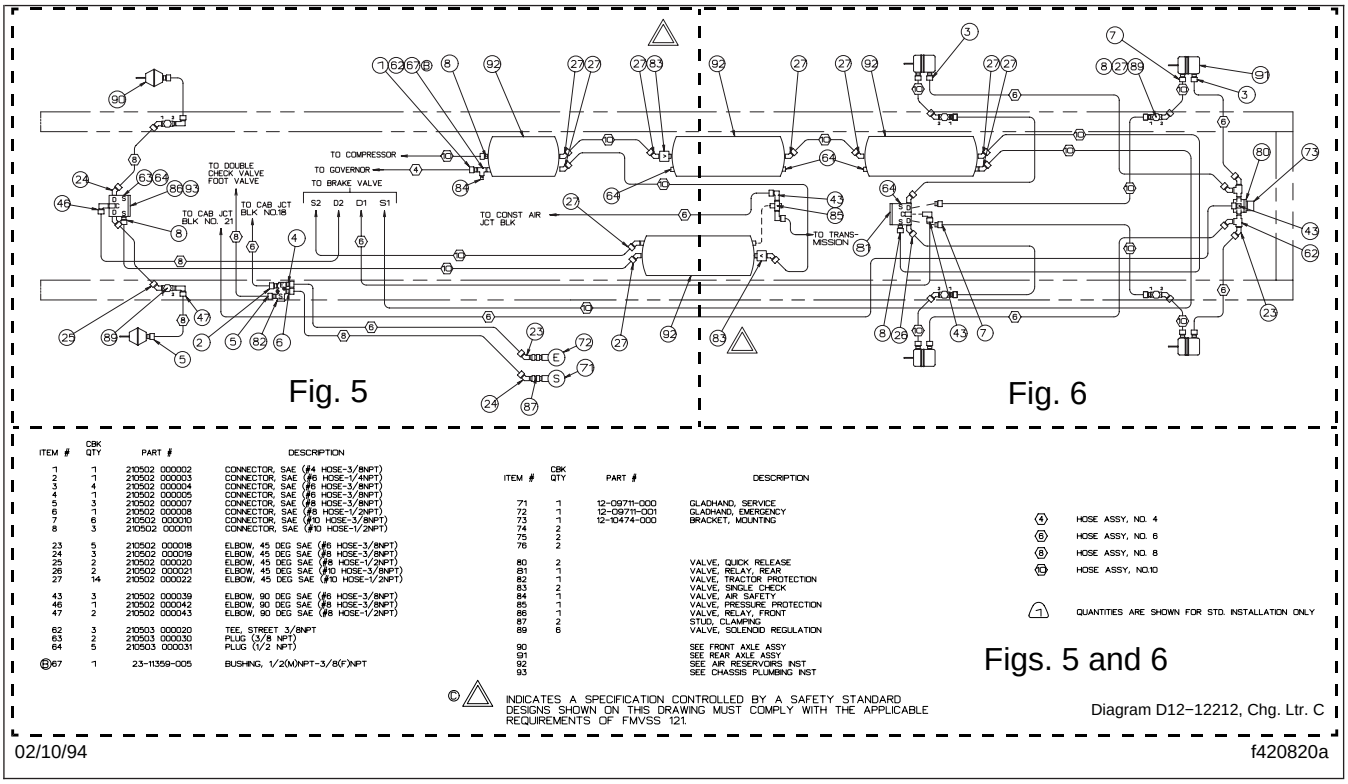
Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12211, Chg. Ltr. D

02/10/94 f421131

Fig. 3

Tandem Rear Axle Truck, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	4	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
4	1	210502 000005	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	1	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	5	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	3	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	14	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	3	210503 000020	TEE, STREET 3/8NPT
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
⊕67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
71	1	12-09711-000	GLADHAND, SERVICE
72	1	12-09711-001	GLADHAND, EMERGENCY
73	1	12-10474-000	BRACKET, MOUNTING
74	2		
75	2		
76	2		
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
87	2		STUD, CLAMPING
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

① QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Figs. 5 and 6

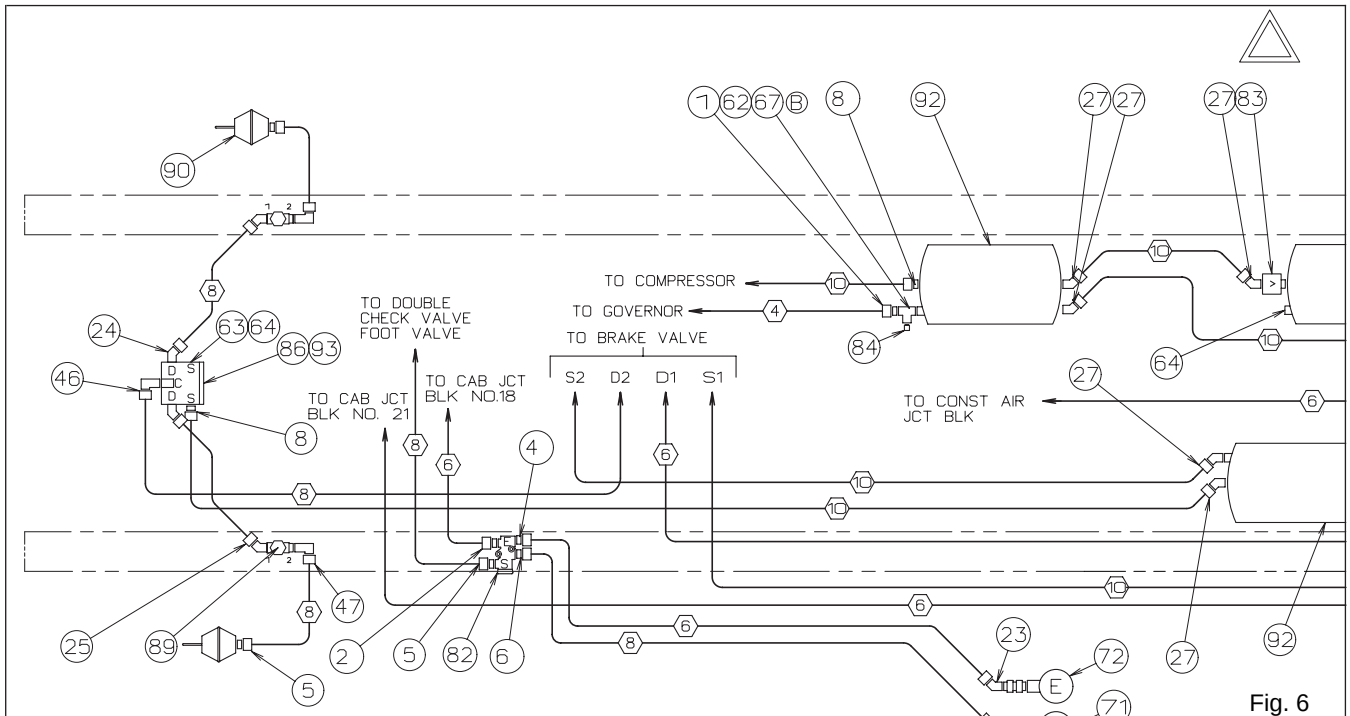
© △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12212, Chg. Ltr. C

02/10/94 f420820a

Fig. 4, Wire Braid Hose, Front Relay Valve, Date of Use 4/88 to 4/91

Tandem Rear Axle Truck, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	4	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
4	1	210502 000005	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	1	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	5	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	3	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	14	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	3	210503 000020	TEE, STREET 3/8NPT
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓑ67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
71	1	12-09711-000	GLADHAND, SERVICE
72	1	12-09711-001	GLADHAND, EMERGENCY
73	1	12-10474-000	BRACKET, MOUNTING
74	2		
75	2		
76	2		
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
87	2		STUD, CLAMPING
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

△1 QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

© △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12212, Chg. Ltr. C

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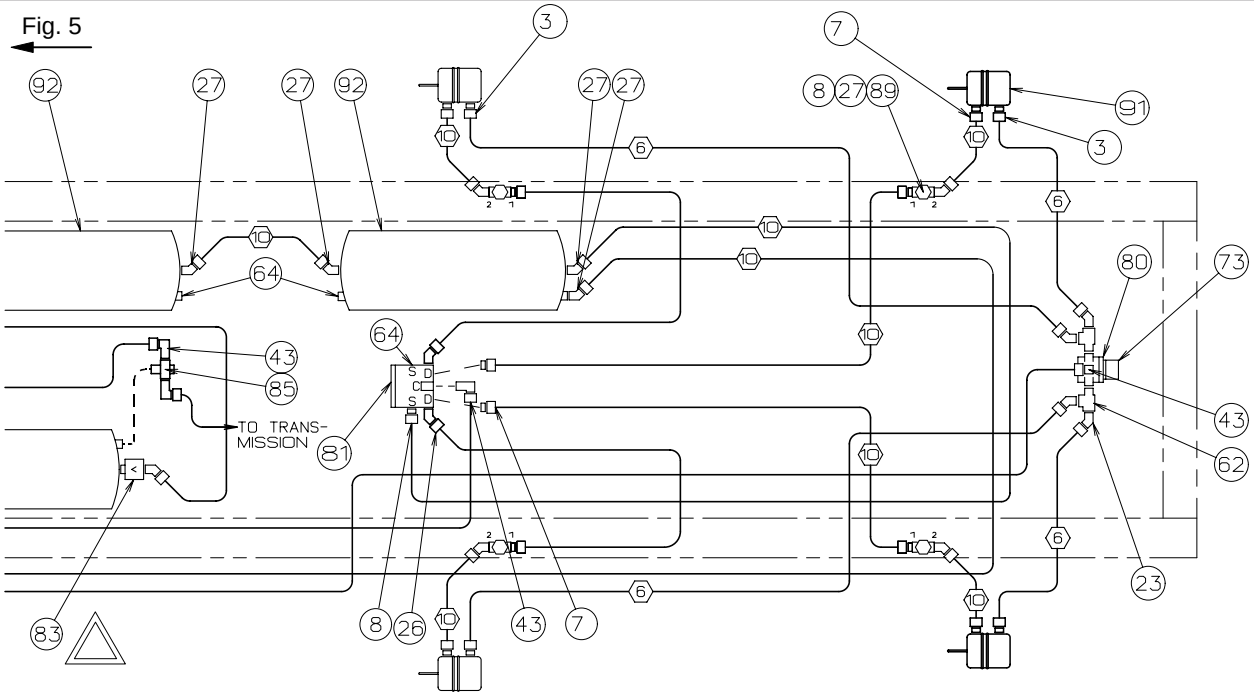
Fig. 5

Tandem Rear Axle Truck, With Six-Channel Antilock, Without Brake Proportioning

Fig. 5



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	4	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
4	1	210502 000005	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	1	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	5	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	3	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	14	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	3	210503 000020	TEE, STREET 3/8NPT
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓑ67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
71	1	12-09711-000	GLADHAND, SERVICE
72	1	12-09711-001	GLADHAND, EMERGENCY
73	1	12-10474-000	BRACKET, MOUNTING
74	2		
75	2		
76	2		
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
87	2		STUD, CLAMPING
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

© △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12212, Chg. Ltr. C

02/10/94

f421133

Fig. 6

Tandem Rear Axle Truck, With Six-Channel Antilock, Without Brake Proportioning

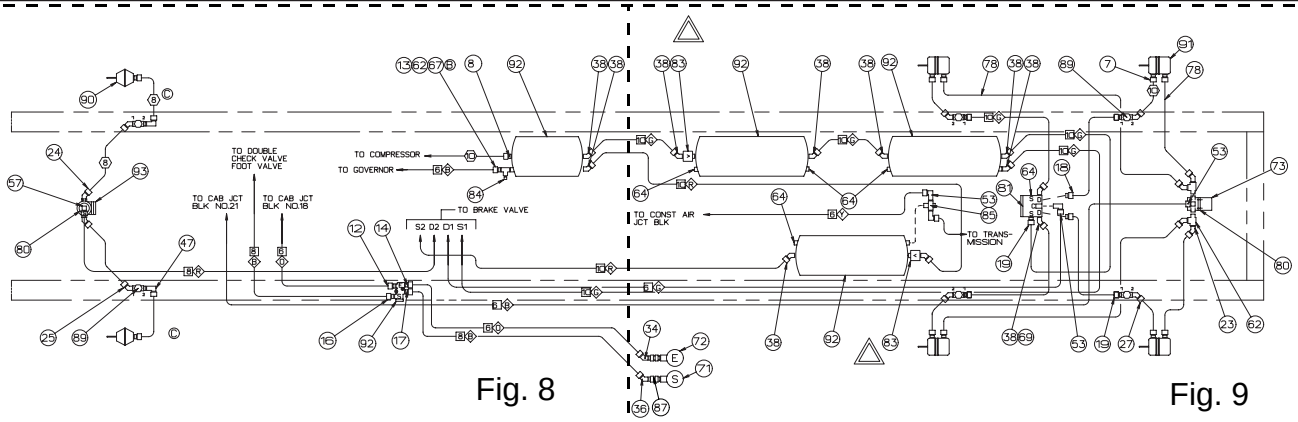


Fig. 8

Fig. 9

ITEM #	CBK QTY	PART #	DESCRIPTION
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
14	1	210500 000006	CONNECTOR, NTA (3/8NT-1/2NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
17	1	210500 000009	CONNECTOR, NTA (1/2NT-1/2NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	5	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	4	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	11	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	3	210503 000020	TEE, STREET 3/8NPT
64	5	210503 000031	PLUG (1/2 NPT)
Ⓑ67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
71	1	12-09711-000	GLADHAND, SERVICE
72	1	12-09711-001	GLADHAND, EMERGENCY
73	1	12-10474-000	BRACKET, MOUNTING
Ⓒ 78	4	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
87	2		STUD, CLAMPING
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

Ⓒ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID
(B) TUBE, NYLON NO.6 BLACK
(E) TUBE, NYLON NO.6 YELLOW
(G) TUBE, NYLON NO.6 GREEN
(O) TUBE, NYLON NO.6 ORANGE
(R) TUBE, NYLON NO.6 RED
(B) TUBE, NYLON NO.8 BLACK
(G) TUBE, NYLON NO.8 GREEN
(R) TUBE, NYLON NO.8 RED
(G) TUBE, NYLON NO.10 GREEN
(R) TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

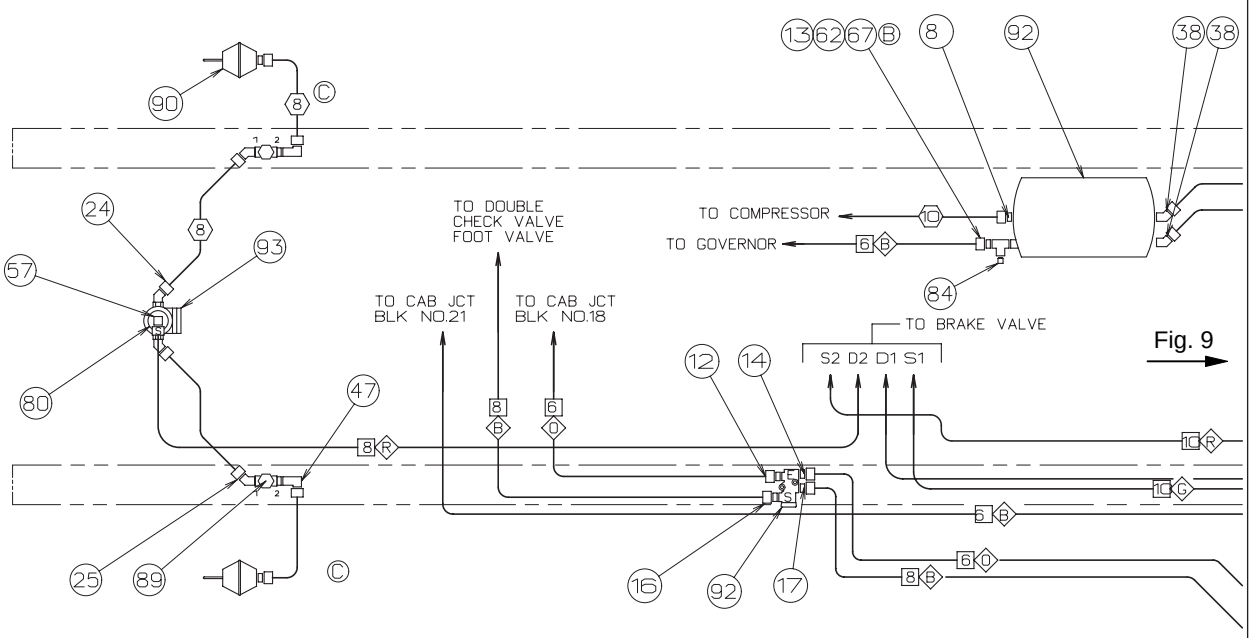
Figs. 8 and 9

Diagram D12−12205, Chg. Ltr. D

02/10/94 f420821a

Fig. 7, Nylon Tubing, Front Quick Release Valve, Date of Use 4/88 to 4/91

Tandem Rear Axle Truck, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
14	1	210500 000006	CONNECTOR, NTA (3/8NT-1/2NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
17	1	210500 000009	CONNECTOR, NTA (1/2NT-1/2NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	5	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	4	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	11	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	3	210503 000020	TEE, STREET 3/8NPT
64	5	210503 000031	PLUG (1/2 NPT)
Ⓑ67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
71	1	12-09711-000	GLADHAND, SERVICE
72	1	12-09711-001	GLADHAND, EMERGENCY
73	1	12-10474-000	BRACKET, MOUNTING
Ⓒ 78	4	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
87	2		STUD, CLAMPING
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID	6 R	TUBE, NYLON NO.6 RED
8	HOSE ASSY, #8 WIREBRAID	8 B	TUBE, NYLON NO.8 BLACK
10	HOSE ASSY, #10 WIREBRAID	8 G	TUBE, NYLON NO.8 GREEN
6 B	TUBE, NYLON NO.6 BLACK	8 R	TUBE, NYLON NO.8 RED
6 Y	TUBE, NYLON NO.6 YELLOW	10 G	TUBE, NYLON NO.10 GREEN
6 G	TUBE, NYLON NO.6 GREEN	10 R	TUBE, NYLON NO.10 RED
6 O	TUBE, NYLON NO.6 ORANGE		

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

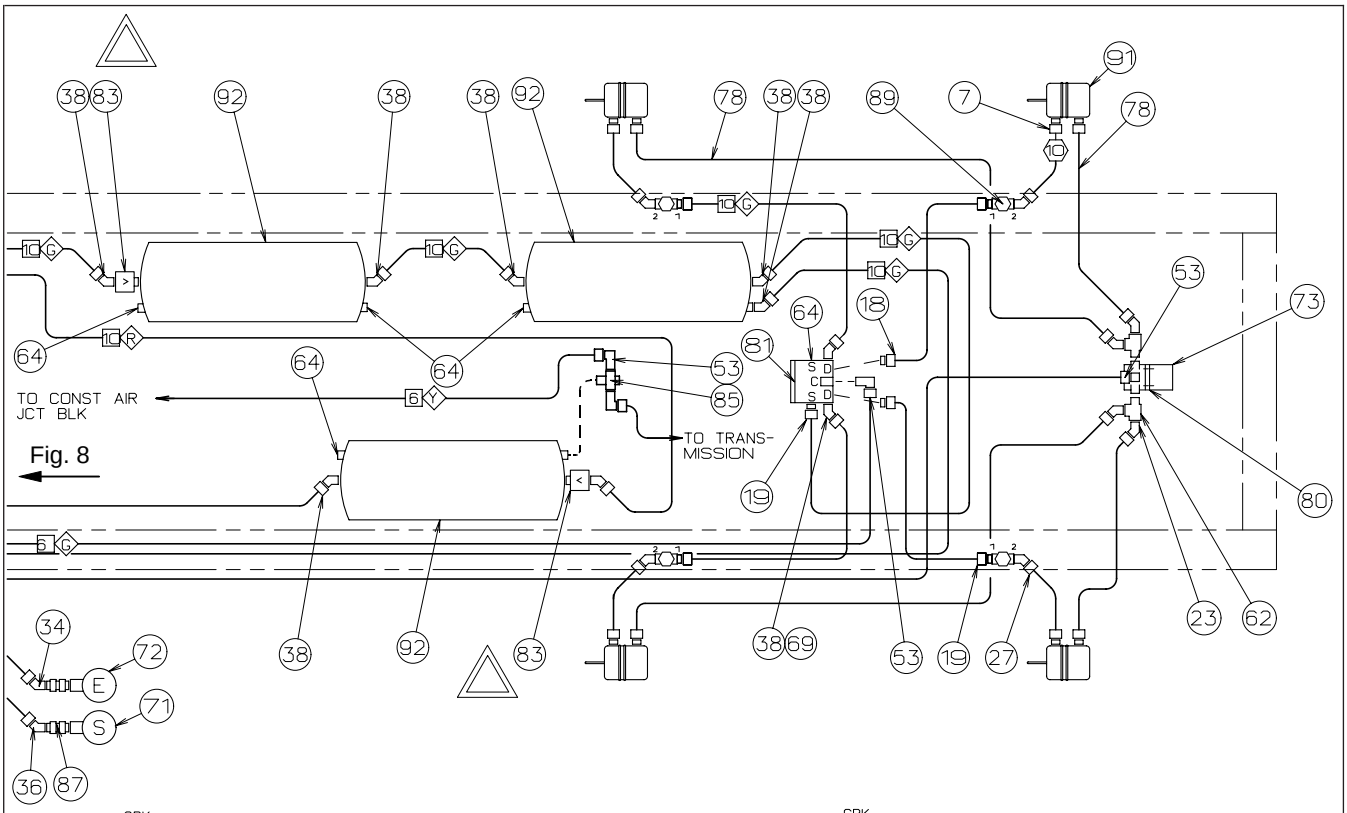
Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−12205, Chg. Ltr. D

02/14/94 f421134

Fig. 8

Tandem Rear Axle Truck, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
14	1	210500 000006	CONNECTOR, NTA (3/8NT-1/2NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
17	1	210500 000009	CONNECTOR, NTA (1/2NT-1/2NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	5	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	4	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	11	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	3	210503 000020	TEE, STREET 3/8NPT
64	5	210503 000031	PLUG (1/2 NPT)
Ⓑ67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
71	1	12-09711-000	GLADHAND, SERVICE
72	1	12-09711-001	GLADHAND, EMERGENCY
73	1	12-10474-000	BRACKET, MOUNTING
Ⓒ 78	4	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
87	2		STUD, CLAMPING
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

△1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓓ △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

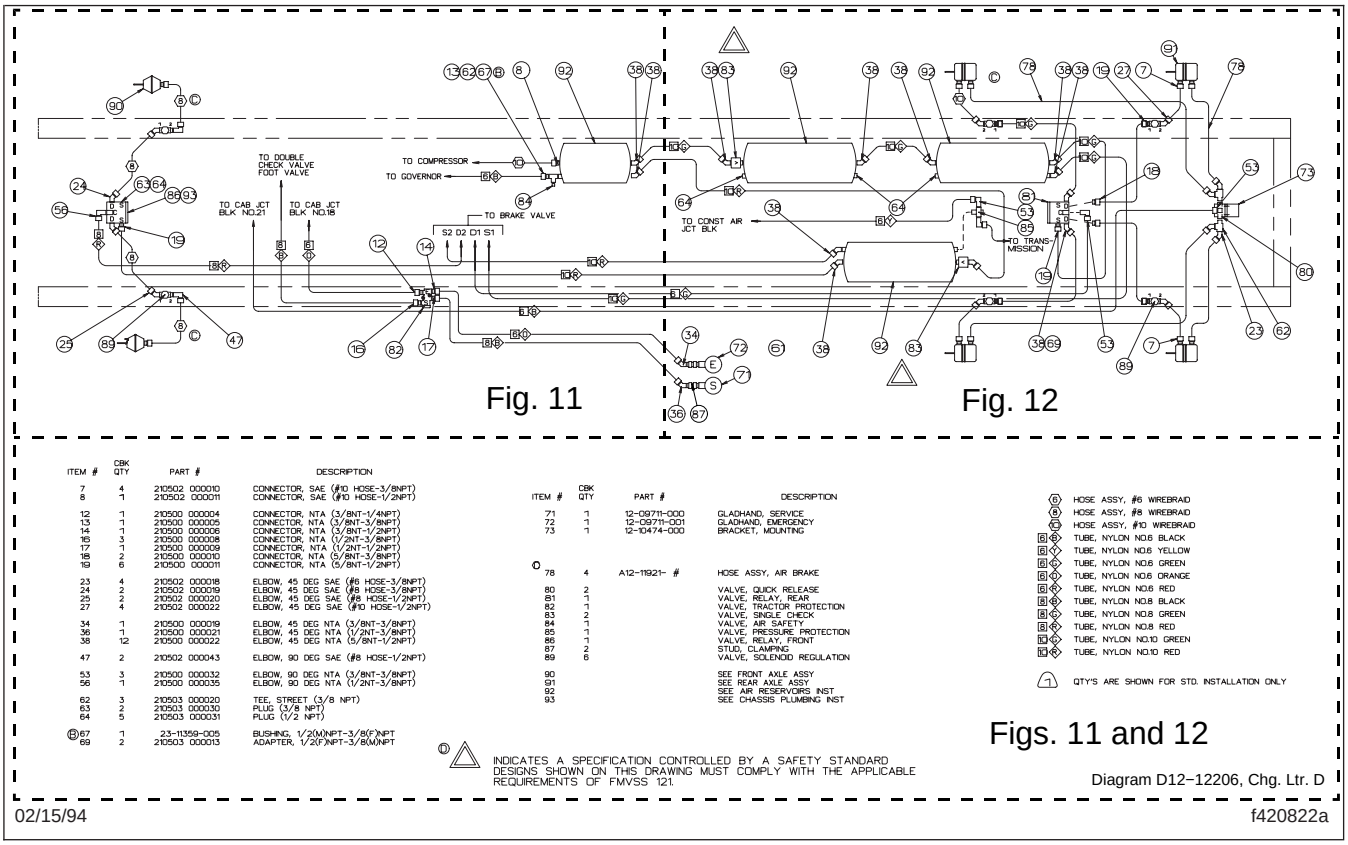
⑥	HOSE ASSY, #6 WIREBRAID	6 R	TUBE, NYLON NO.6 RED
⑧	HOSE ASSY, #8 WIREBRAID	8 B	TUBE, NYLON NO.8 BLACK
⑩	HOSE ASSY, #10 WIREBRAID	8 G	TUBE, NYLON NO.8 GREEN
6 B	TUBE, NYLON NO.6 BLACK	8 R	TUBE, NYLON NO.8 RED
6 Y	TUBE, NYLON NO.6 YELLOW	10 G	TUBE, NYLON NO.10 GREEN
6 G	TUBE, NYLON NO.6 GREEN	10 R	TUBE, NYLON NO.10 RED
6 O	TUBE, NYLON NO.6 ORANGE		

Diagram D12−12205, Chg. Ltr. D

02/14/94 f421135

Fig. 9

Tandem Rear Axle Truck, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
14	1	210500 000006	CONNECTOR, NTA (3/8NT-1/2NPT)
16	3	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
17	1	210500 000009	CONNECTOR, NTA (1/2NT-1/2NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	6	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	4	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	12	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	3	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
©67	1	23-11359-005	BUSHNG, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
71	1	12-09711-000	GLADHAND, SERVICE
72	1	12-09711-001	GLADHAND, EMERGENCY
73	1	12-10474-000	BRACKET, MOUNTING
© 78	4	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
87	2		STUD, CLAMPING
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

- (B) HOSE ASSY, #6 WIREBRAID
- (B) HOSE ASSY, #8 WIREBRAID
- (C) HOSE ASSY, #10 WIREBRAID
- (6) TUBE, NYLON NO.6 BLACK
- (6) TUBE, NYLON NO.6 YELLOW
- (6) TUBE, NYLON NO.6 GREEN
- (6) TUBE, NYLON NO.6 ORANGE
- (6) TUBE, NYLON NO.6 RED
- (8) TUBE, NYLON NO.8 BLACK
- (8) TUBE, NYLON NO.8 GREEN
- (8) TUBE, NYLON NO.8 RED
- (10) TUBE, NYLON NO.10 GREEN
- (10) TUBE, NYLON NO.10 RED

△1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

© △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

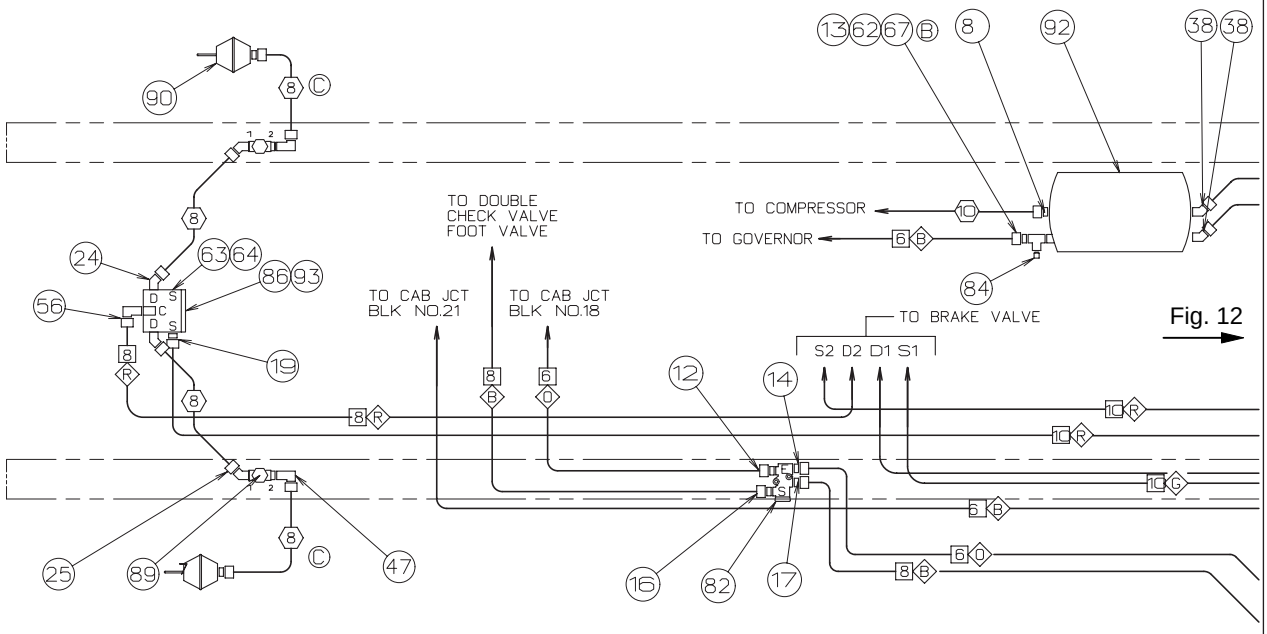
Figs. 11 and 12

Diagram D12−12206, Chg. Ltr. D

02/15/94 f420822a

Fig. 10, Nylon Tubing, Front Relay Valve, Date of Use 4/88 to 4/91

Tandem Rear Axle Truck, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
14	1	210500 000006	CONNECTOR, NTA (3/8NT-1/2NPT)
16	3	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
17	1	210500 000009	CONNECTOR, NTA (1/2NT-1/2NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	6	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	4	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	12	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	3	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓑ67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

ITEM #	CBK QTY	PART #	DESCRIPTION
71	1	12-09711-000	GLADHAND, SERVICE
72	1	12-09711-001	GLADHAND, EMERGENCY
73	1	12-10474-000	BRACKET, MOUNTING
Ⓒ 78	4	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
87	2		STUD, CLAMPING
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

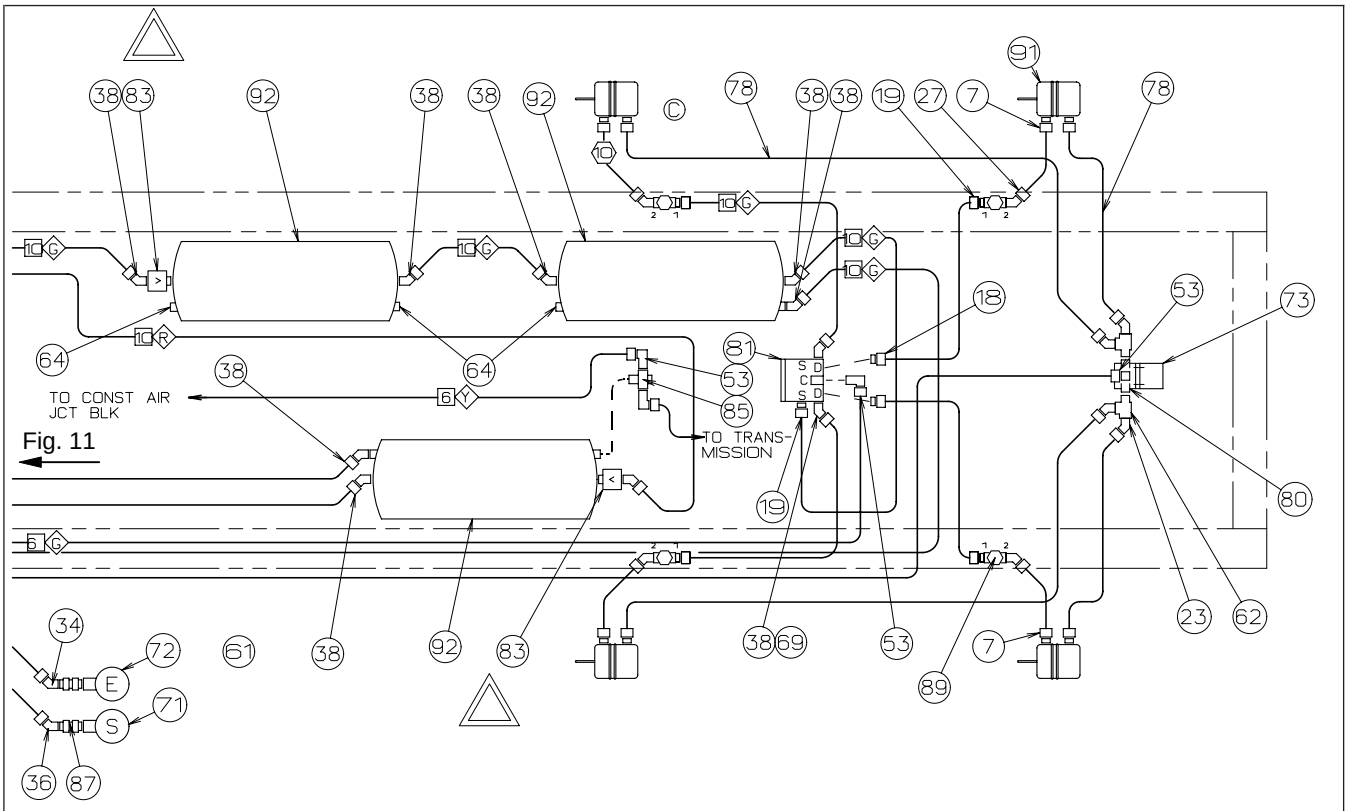
6	HOSE ASSY, #6 WIREBRAID	6R	TUBE, NYLON NO.6 RED
8	HOSE ASSY, #8 WIREBRAID	8B	TUBE, NYLON NO.8 BLACK
10	HOSE ASSY, #10 WIREBRAID	8G	TUBE, NYLON NO.8 GREEN
6B	TUBE, NYLON NO.6 BLACK	8R	TUBE, NYLON NO.8 RED
6Y	TUBE, NYLON NO.6 YELLOW	10G	TUBE, NYLON NO.10 GREEN
6G	TUBE, NYLON NO.6 GREEN	10R	TUBE, NYLON NO.10 RED
6O	TUBE, NYLON NO.6 ORANGE		

Diagram D12−12206, Chg. Ltr. D

02/15/94 f421144

Fig. 11

Tandem Rear Axle Truck, With Six-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
14	1	210500 000006	CONNECTOR, NTA (3/8NT-1/2NPT)
16	3	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
17	1	210500 000009	CONNECTOR, NTA (1/2NT-1/2NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	6	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	4	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	4	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	12	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	3	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

ITEM #	CBK QTY	PART #	DESCRIPTION
71	1	12-09711-000	GLADHAND, SERVICE
72	1	12-09711-001	GLADHAND, EMERGENCY
73	1	12-10474-000	BRACKET, MOUNTING
Ⓒ 78	4	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
87	2		STUD, CLAMPING
89	6		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID	6R	TUBE, NYLON NO.6 RED
8	HOSE ASSY, #8 WIREBRAID	8B	TUBE, NYLON NO.8 BLACK
10	HOSE ASSY, #10 WIREBRAID	8G	TUBE, NYLON NO.8 GREEN
6B	TUBE, NYLON NO.6 BLACK	8R	TUBE, NYLON NO.8 RED
6Y	TUBE, NYLON NO.6 YELLOW	10G	TUBE, NYLON NO.10 GREEN
6G	TUBE, NYLON NO.6 GREEN	10R	TUBE, NYLON NO.10 RED
6O	TUBE, NYLON NO.6 ORANGE		

Diagram D12−12206, Chg. Ltr. D

02/15/94 f421145

Fig. 12

Tandem Rear Axle Truck, Without Antilock, Without Brake Proportioning

See Fig. 1 for a full view of the plumbing diagram wire braid hose, front quick release valve, date of use 4/88 to 4/91. **See Fig. 2**, or **Fig. 3** for partial (detailed) views plumbing diagram wire braid hose, front quick release valve, date of use 4/88 to 4/91.

See Fig. 4 for a full view of the plumbing diagram wire braid hose, front relay valve, date of use 4/88 to 4/91. **See Fig. 5**, or **Fig. 6** for partial (detailed) views plumbing diagram wire braid hose, front relay valve, date of use 4/88 to 4/91.

See Fig. 7 for a full view of the plumbing diagram nylon tubing, front quick release valve, date of use 4/88 to 4/91. **See Fig. 8**, or **Fig. 9** for partial (detailed) views plumbing diagram nylon tubing, front quick release valve, date of use 4/88 to 4/91.

See Fig. 10 for a full view of the plumbing diagram nylon tubing, front relay valve, date of use 4/88 to 4/91. **See Fig. 11**, or **Fig. 12** for partial (detailed) views plumbing diagram nylon tubing, front relay valve, date of use 4/88 to 4/91.

Tandem Rear Axle Truck, Without Antilock, Without Brake Proportioning

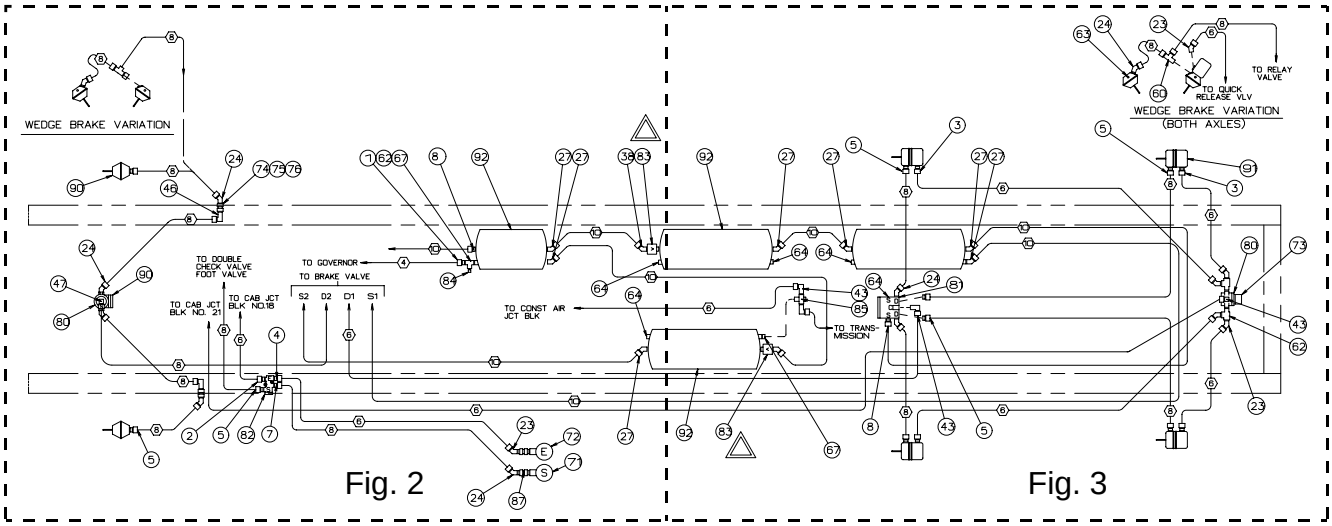


Fig. 2 Fig. 3

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
1	1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	4		210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
4	1	1	210502 000005	CONNECTOR, SAE (#6 HOSE-1/2NPT)
5	9	3	210502 000007	CONNECTOR, SAE (#6 HOSE-3/8NPT)
6	1	1	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
8	2	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	5	9	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	7	13	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	9	9	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	1	210500 000044	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	3	3	210503 000020	TEE, STREET 3/8NPT
63		12	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
71	1	1	12-09711-000	GLADHAND, SERVICE
72	1	1	12-09711-001	GLADHAND, EMERGENCY
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
87	2	2		STUD, CLAMPING
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(A) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

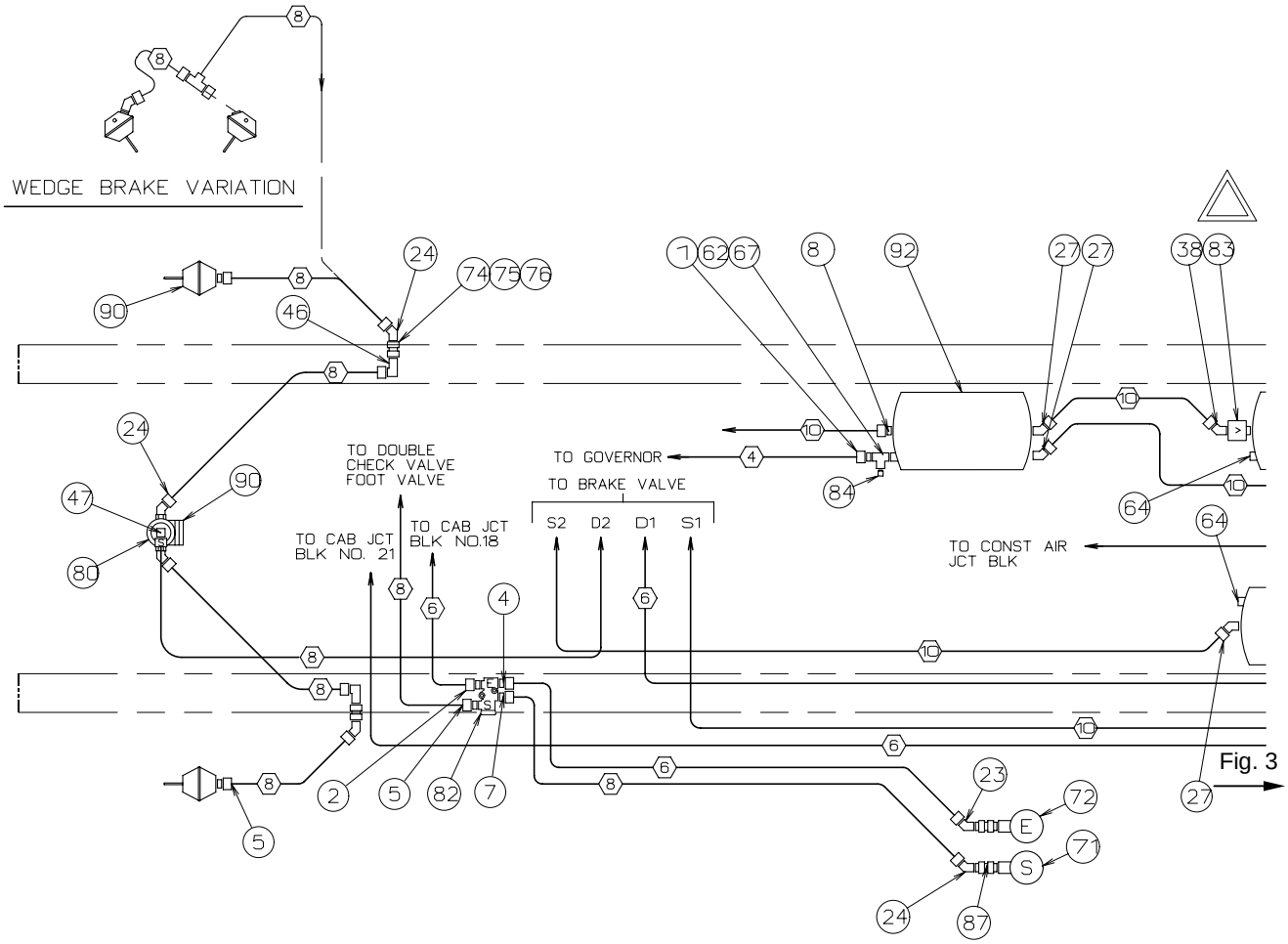
Figs. 2 and 3

Diagram D12−12145, Chg. Ltr. A

02/11/94 f420823a

Fig. 1, Wire Braid Hose, Front Quick Release Valve, Date of Use 4/88 to 4/91

Tandem Rear Axle Truck, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
1	1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	4		210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
4	1	1	210502 000005	CONNECTOR, SAE (#6 HOSE-1/2NPT)
5	9	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	1	1	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
8	2	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	5	9	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	7	13	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	9	9	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	1	210500 000044	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	3	3	210503 000020	TEE, STREET 3/8NPT
63		12	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
71	1	1	12-09711-000	GLADHAND, SERVICE
72	1	1	12-09711-001	GLADHAND, EMERGENCY
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
87	2	2		STUD, CLAMPING
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

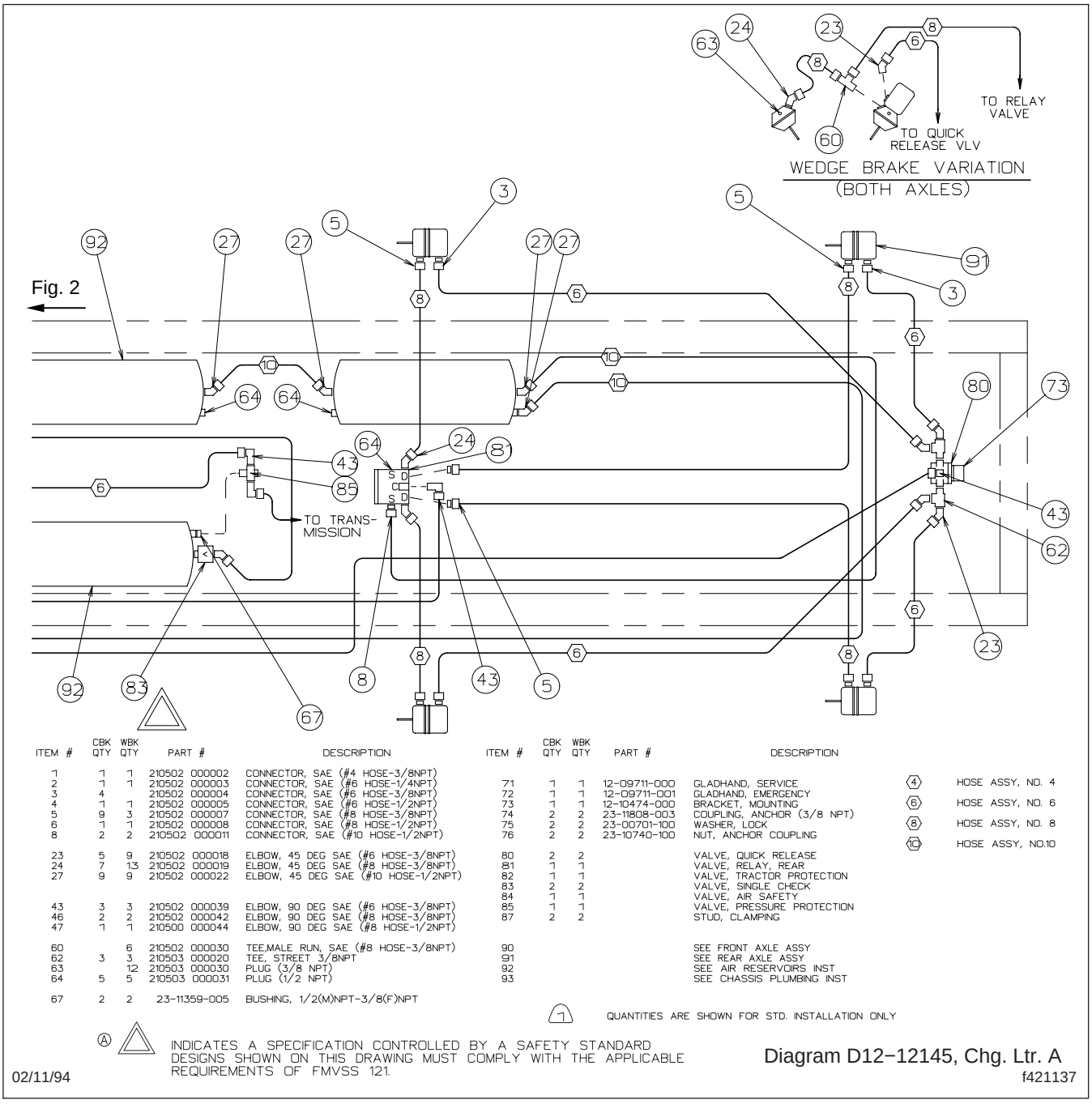
(A) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/11/94

Diagram D12−12145, Chg. Ltr. A
f421136

Fig. 2

Tandem Rear Axle Truck, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
1	1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	4		210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
4	1	1	210502 000005	CONNECTOR, SAE (#6 HOSE-1/2NPT)
5	9	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	1	1	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
8	2	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	5	9	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	7	13	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	9	9	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	1	210500 000044	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	3	3	210503 000020	TEE, STREET 3/8NPT
63		12	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
71	1	1	12-09711-000	GLADHAND, SERVICE
72	1	1	12-09711-001	GLADHAND, EMERGENCY
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
87	2	2		STUD, CLAMPING
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

④	HOSE ASSY, NO. 4
⑥	HOSE ASSY, NO. 6
⑧	HOSE ASSY, NO. 8
⑩	HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓐ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

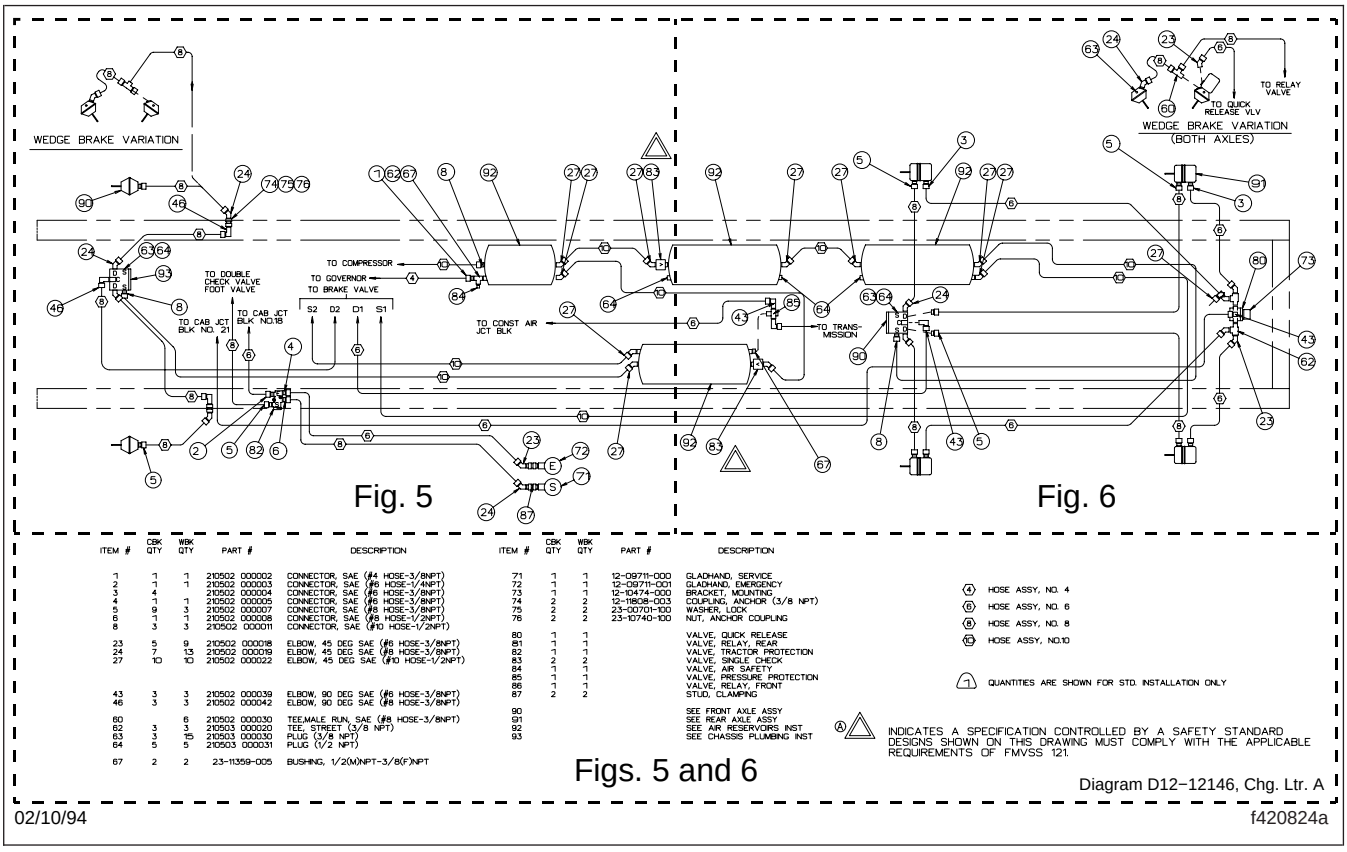
02/11/94

Diagram D12−12145, Chg. Ltr. A

f421137

Fig. 3

Tandem Rear Axle Truck, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
1	1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	4		210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
4	1	1	210502 000005	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	9	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	1	1	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
8	3	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	5	9	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	7	13	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	10	10	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	3	3	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	3	3	210503 000020	TEE, STREET (3/8 NPT)
63	3	15	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
71	1	1	12-09711-000	GLADHAND, SERVICE
72	1	1	12-09711-001	GLADHAND, EMERGENCY
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	12-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
80	1	1		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
86	1	1		VALVE, RELAY, FRONT
87	2	2		STUD, CLAMPING
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

△1 QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

△A INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

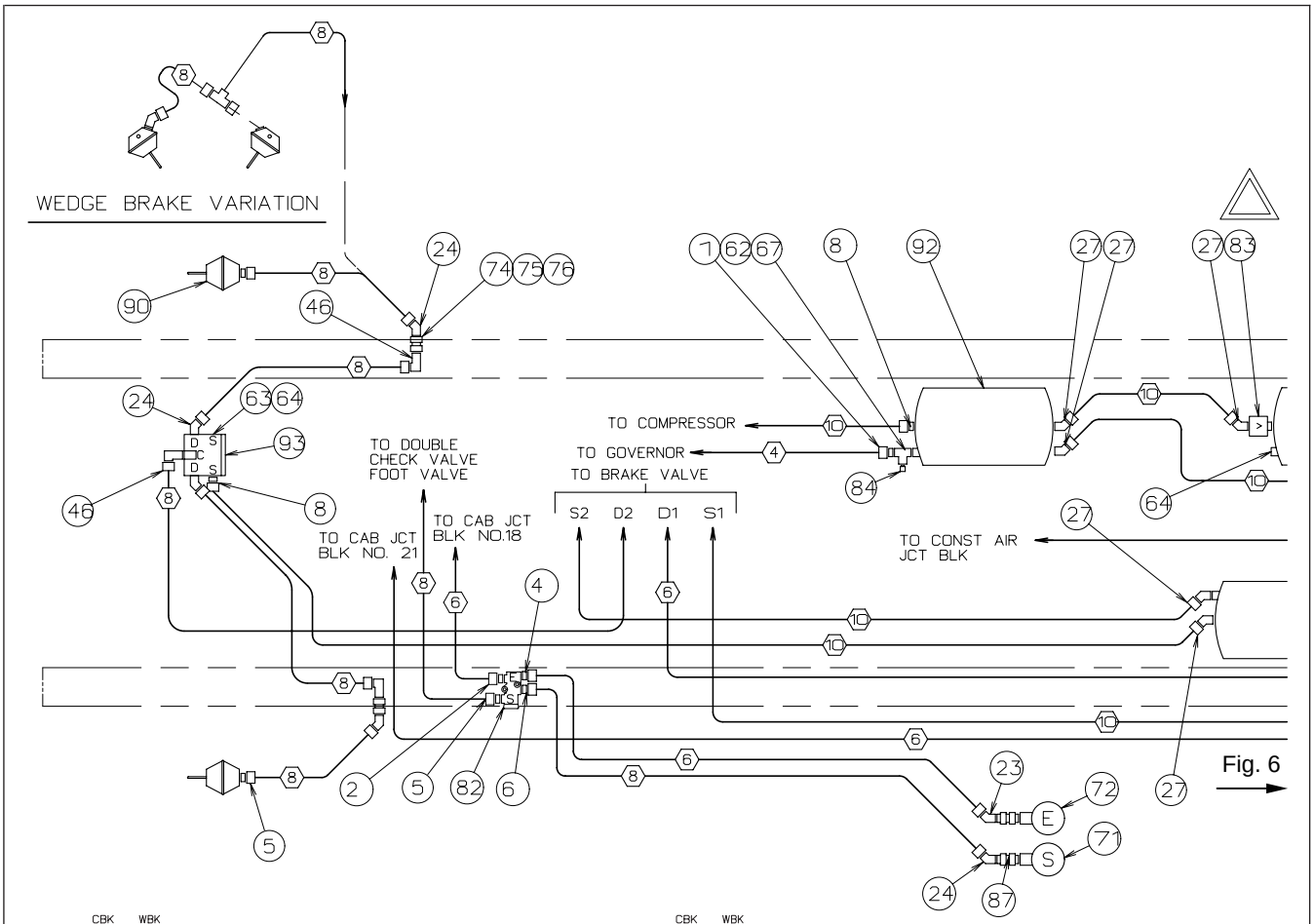
Figs. 5 and 6

Diagram D12−12146, Chg. Ltr. A

02/10/94 f420824a

Fig. 4, Wire Braid Hose, Front Relay Valve, Date of Use 4/88 to 4/91

Tandem Rear Axle Truck, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
1	1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	4		210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
4	1	1	210502 000005	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	9	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	1	1	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
8	3	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	5	9	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	7	13	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	10	10	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	3	3	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	3	3	210503 000020	TEE, STREET (3/8 NPT)
63	3	15	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
71	1	1	12-09711-000	GLADHAND, SERVICE
72	1	1	12-09711-001	GLADHAND, EMERGENCY
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	12-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
80	1	1		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
86	1	1		VALVE, RELAY, FRONT
87	2	2		STUD, CLAMPING
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

Ⓐ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

1 QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

02/10/94

Diagram D12−12146, Chg. Ltr. A f421138

Fig. 5

Tandem Rear Axle Truck, Without Antilock, Without Brake Proportioning

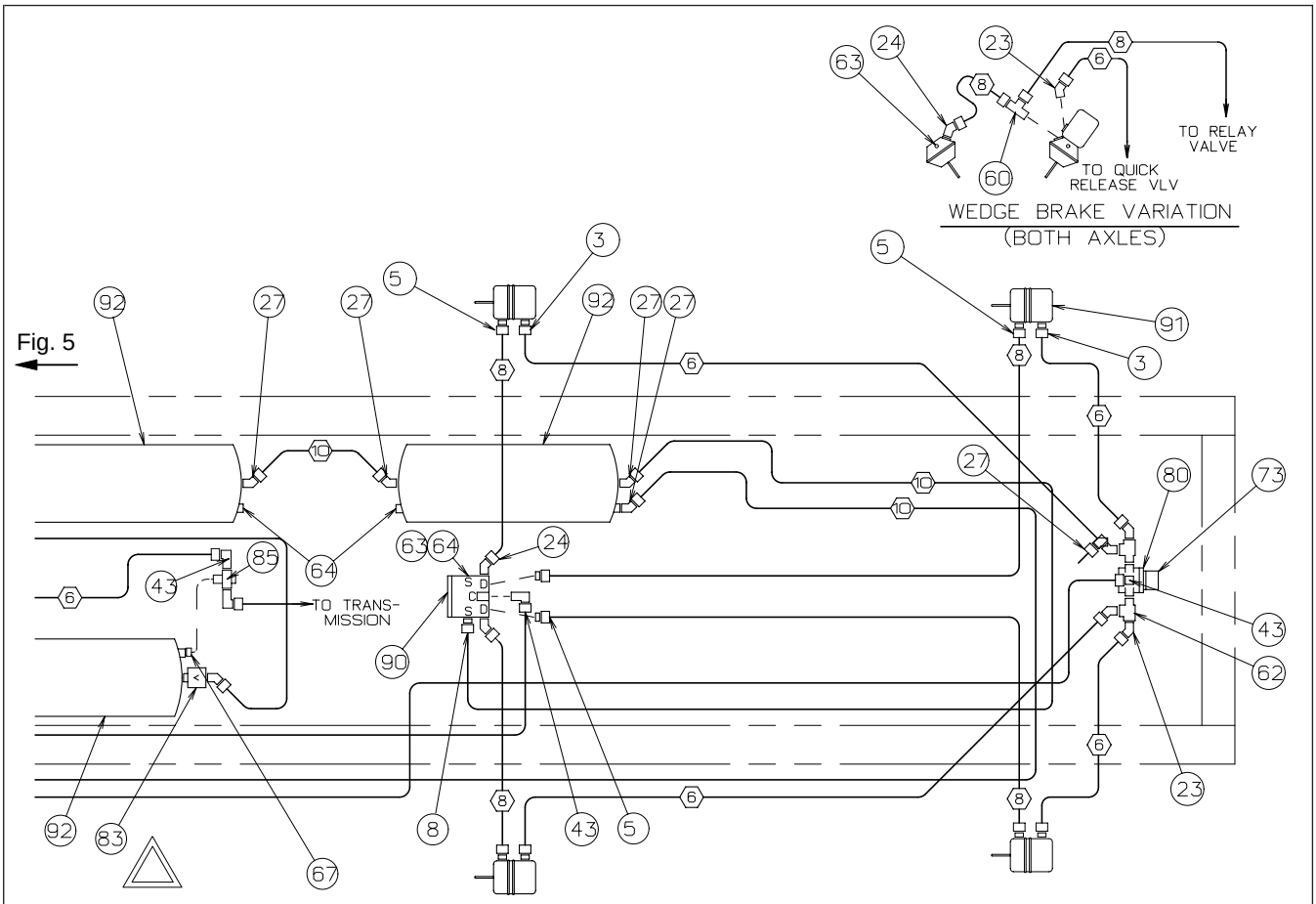


Fig. 5

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
1	1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	4		210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
4	1	1	210502 000005	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	9	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	1	1	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
8	3	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	5	9	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	7	13	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	10	10	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	3	3	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	3	3	210503 000020	TEE, STREET (3/8 NPT)
63	3	15	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
71	1	1	12-09711-000	GLADHAND, SERVICE
72	1	1	12-09711-001	GLADHAND, EMERGENCY
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	12-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
80	1	1		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
86	1	1		VALVE, RELAY, FRONT
87	2	2		STUD, CLAMPING
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

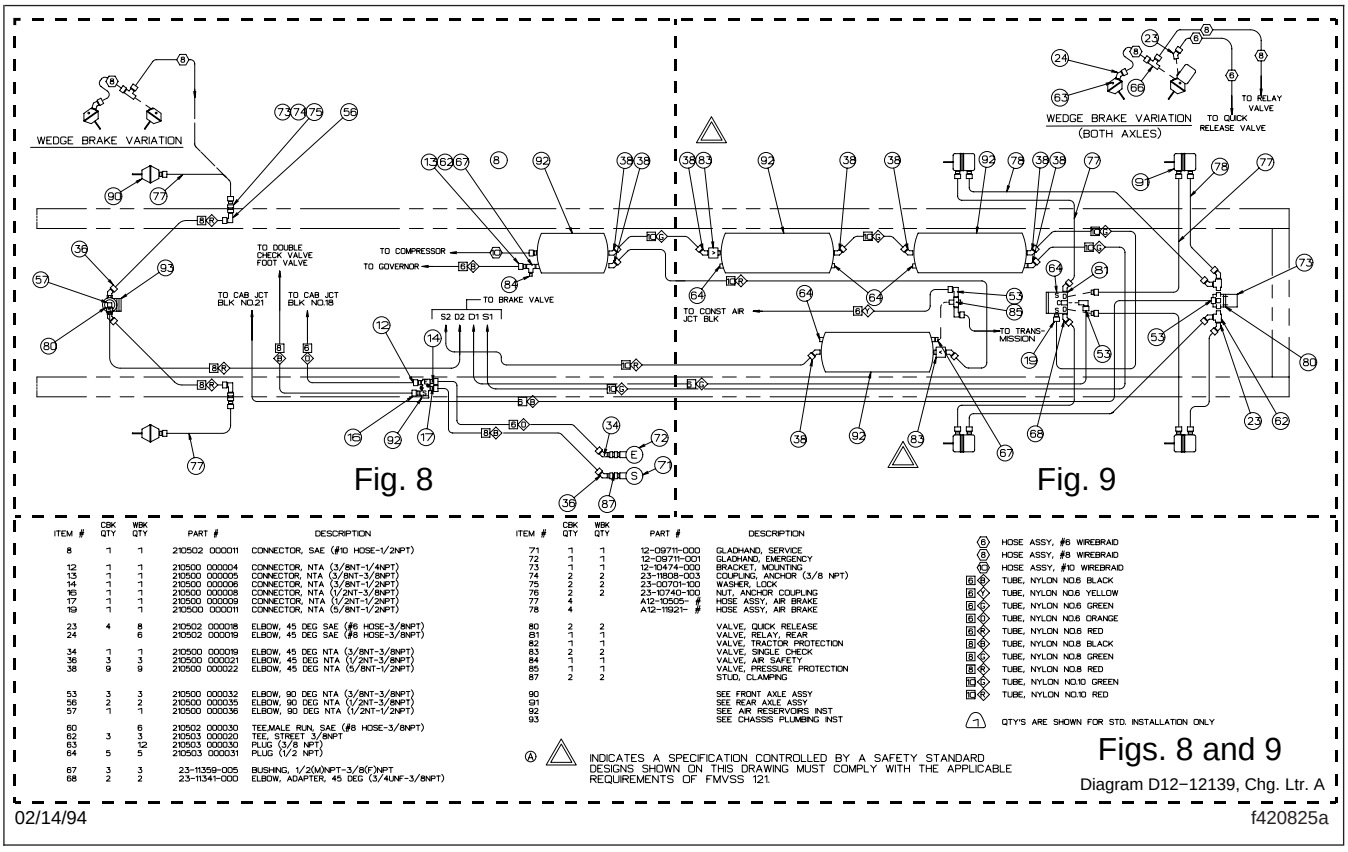
(A) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/15/94

Diagram D12−12146, Chg. Ltr. A f421139

Fig. 6

Tandem Rear Axle Truck, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
8	1	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
14	1	1	210500 000006	CONNECTOR, NTA (3/8NT-1/2NPT)
16	1	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
17	1	1	210500 000009	CONNECTOR, NTA (1/2NT-1/2NPT)
19	1	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	4	8	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24		6	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
34	1	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	3	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	9	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
53	3	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	3	3	210503 000020	TEE, STREET 3/8NPT
63		12	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	3	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
71	1	1	12-09711-000	GLADHAND, SERVICE
72	1	1	12-09711-001	GLADHAND, EMERGENCY
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
77	4		A12-10505- #	HOSE ASSY, AIR BRAKE
78	4		A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
87	2	2		STUD, CLAMPING
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

Ⓐ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

(6)	HOSE ASSY, #6 WIREBRAID
(8)	HOSE ASSY, #8 WIREBRAID
(10)	HOSE ASSY, #10 WIREBRAID
B	TUBE, NYLON NO.6 BLACK
Y	TUBE, NYLON NO.6 YELLOW
G	TUBE, NYLON NO.6 GREEN
O	TUBE, NYLON NO.6 ORANGE
R	TUBE, NYLON NO.6 RED
B	TUBE, NYLON NO.8 BLACK
G	TUBE, NYLON NO.8 GREEN
R	TUBE, NYLON NO.8 RED
G	TUBE, NYLON NO.10 GREEN
R	TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

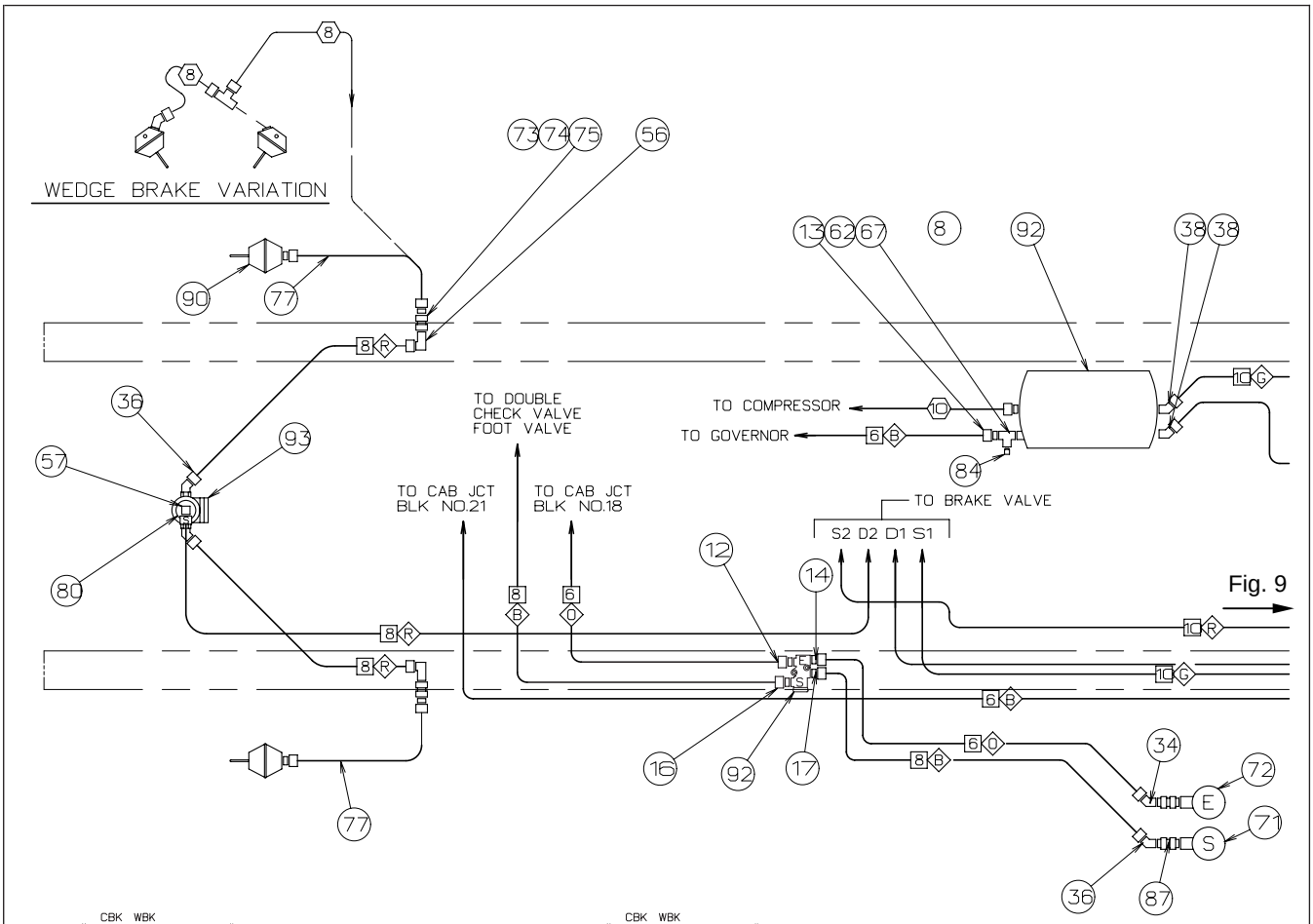
Figs. 8 and 9

Diagram D12−12139, Chg. Ltr. A

02/14/94 f420825a

Fig. 7, Nylon Tubing, Front Quick Release Valve, Date of Use 4/88 to 4/91

Tandem Rear Axle Truck, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
8	1	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
14	1	1	210500 000006	CONNECTOR, NTA (3/8NT-1/2NPT)
16	1	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
17	1	1	210500 000009	CONNECTOR, NTA (1/2NT-1/2NPT)
19	1	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	4	8	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24		6	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
34	1	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	3	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	9	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
53	3	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	3	3	210503 000020	TEE, STREET 3/8NPT
63		12	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	3	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
71	1	1	12-09711-000	GLADHAND, SERVICE
72	1	1	12-09711-001	GLADHAND, EMERGENCY
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
77	4		A12-10505- #	HOSE ASSY, AIR BRAKE
78	4		A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
87	2	2		STUD, CLAMPING
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

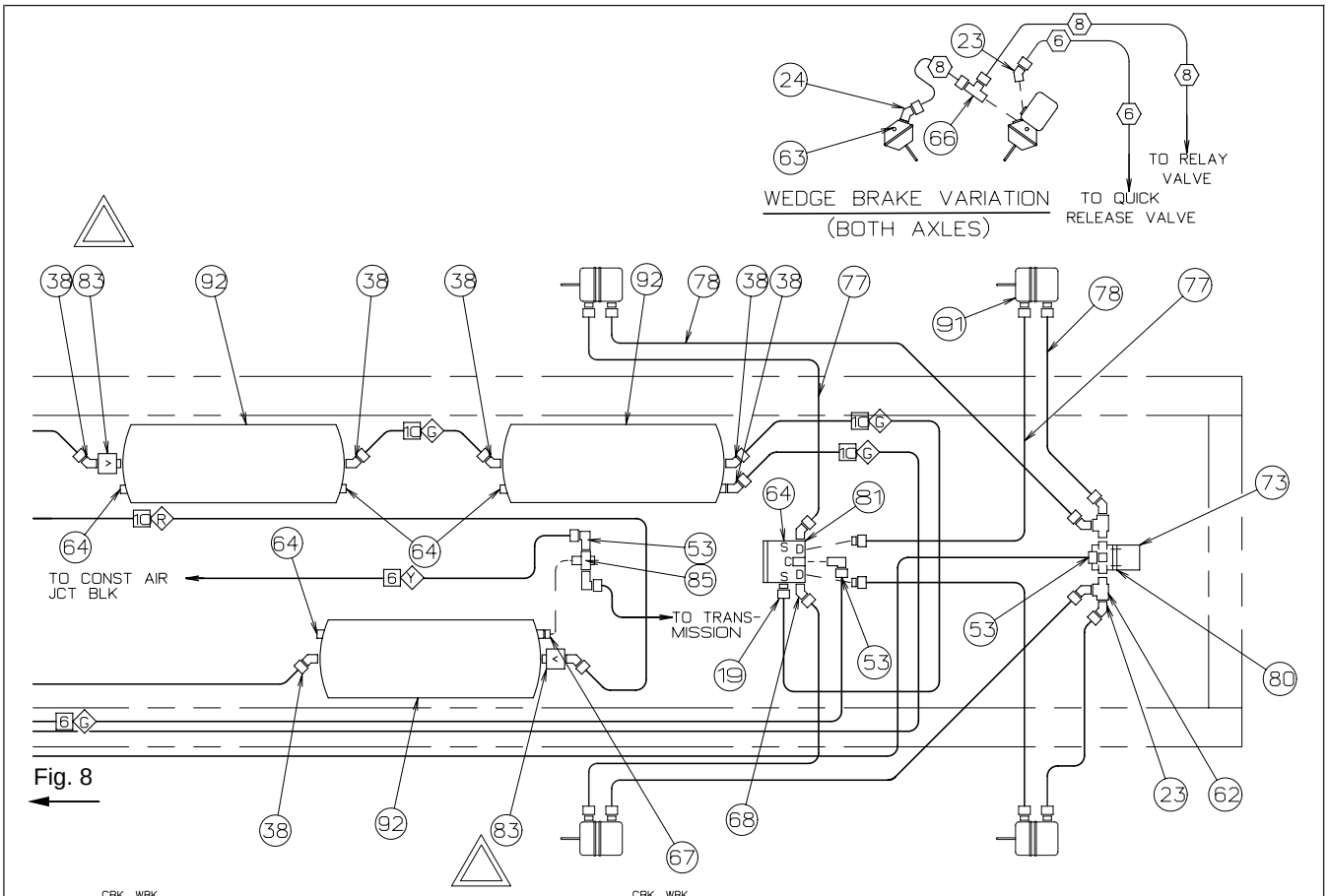
(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓐ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/14/94 Diagram D12−12139, Chg. Ltr. A f421140

Fig. 8

Tandem Rear Axle Truck, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
8	1	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
14	1	1	210500 000006	CONNECTOR, NTA (3/8NT-1/2NPT)
16	1	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
17	1	1	210500 000009	CONNECTOR, NTA (1/2NT-1/2NPT)
19	1	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	4	8	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24		6	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
34	1	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	3	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	9	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
53	3	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	3	3	210503 000020	TEE, STREET 3/8NPT
63		12	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	3	3	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
71	1	1	12-09711-000	GLADHAND, SERVICE
72	1	1	12-09711-001	GLADHAND, EMERGENCY
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
77	4		A12-10505- #	HOSE ASSY, AIR BRAKE
78	4		A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	2		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
87	2	2		STUD, CLAMPING
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

A INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/14/94 Diagram D12−12139, Chg. Ltr. A f421141

Fig. 9

Tandem Rear Axle Truck, Without Antilock, Without Brake Proportioning

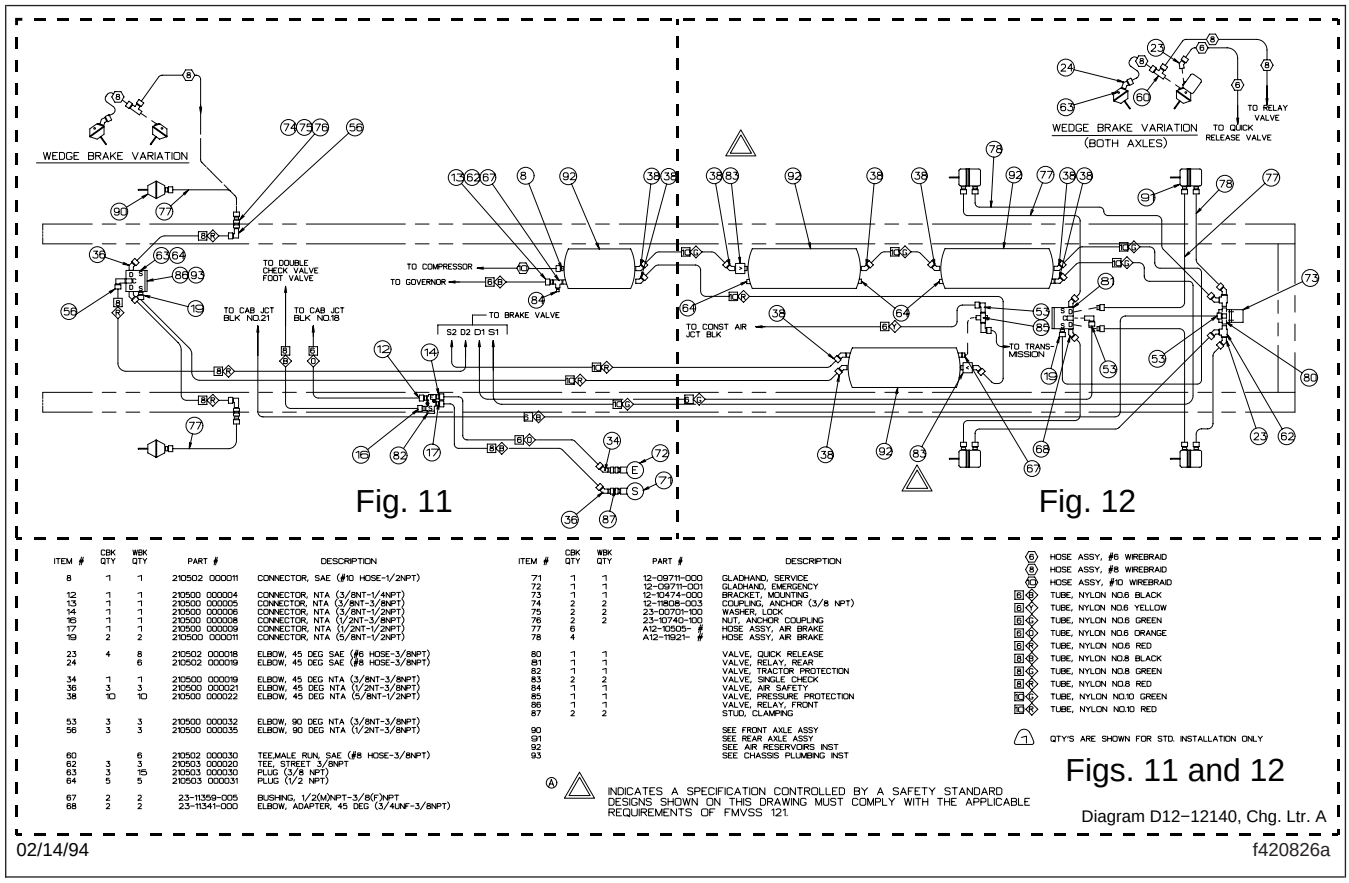


Fig. 11 Fig. 12

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
8	1	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
14	1	1	210500 000006	CONNECTOR, NTA (3/8NT-1/2NPT)
16	1	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
17	1	1	210500 000009	CONNECTOR, NTA (1/2NT-1/2NPT)
19	2	2	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	4	8	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24		6	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
34	1	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	3	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	10	10	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
53	3	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	3	3	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	3	3	210503 000020	TEE, STREET 3/8NPT
63	3	15	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)
71	1	1	12-09711-000	GLADHAND, SERVICE
72	1	1	12-09711-001	GLADHAND, EMERGENCY
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	12-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
77	6		A12-10505- #	HOSE ASSY, AIR BRAKE
78	4		A12-11921- #	HOSE ASSY, AIR BRAKE
80	1	1		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
86	1	1		VALVE, RELAY, FRONT
87	2	2		STUD, CLAMPING
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID
[6] TUBE, NYLON NO.6 BLACK
[6] TUBE, NYLON NO.6 YELLOW
[6] TUBE, NYLON NO.6 GREEN
[6] TUBE, NYLON NO.6 ORANGE
[6] TUBE, NYLON NO.6 RED
[8] TUBE, NYLON NO.8 BLACK
[8] TUBE, NYLON NO.8 GREEN
[8] TUBE, NYLON NO.8 RED
[10] TUBE, NYLON NO.10 GREEN
[10] TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

(A) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

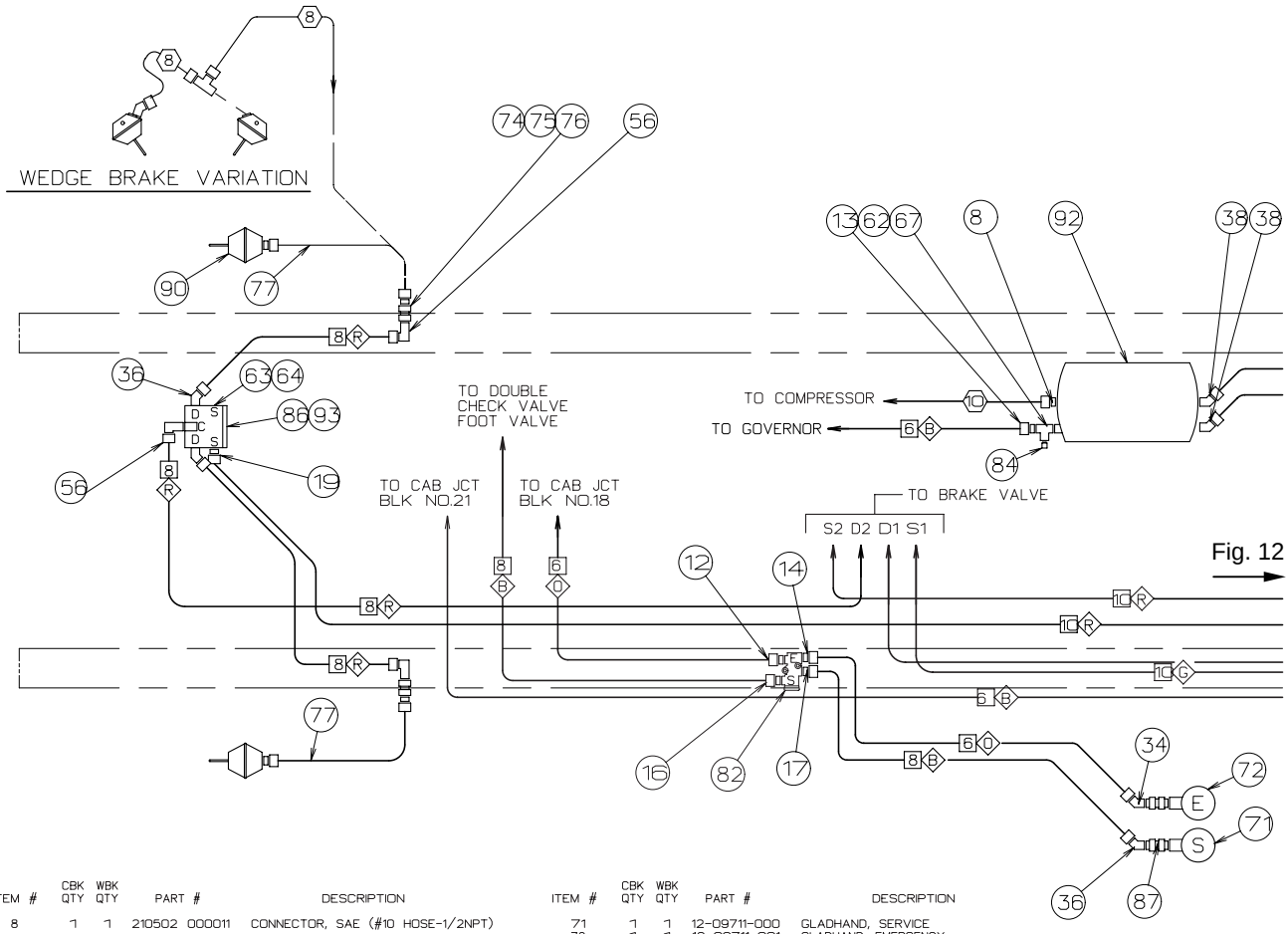
Figs. 11 and 12

Diagram D12−12140, Chg. Ltr. A

02/14/94 f420826a

Fig. 10, Nylon Tubing, Front Relay Valve, Date of Use 4/88 to 4/91

Tandem Rear Axle Truck, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
8	1	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
14	1	1	210500 000006	CONNECTOR, NTA (3/8NT-1/2NPT)
16	1	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
17	1	1	210500 000009	CONNECTOR, NTA (1/2NT-1/2NPT)
19	2	2	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	4	8	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24		6	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
34	1	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	3	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	10	10	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
53	3	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	3	3	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	3	3	210503 000020	TEE, STREET 3/8NPT
63	3	15	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
71	1	1	12-09711-000	GLADHAND, SERVICE
72	1	1	12-09711-001	GLADHAND, EMERGENCY
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	12-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
77	6		A12-10505- #	HOSE ASSY, AIR BRAKE
78	4		A12-11921- #	HOSE ASSY, AIR BRAKE
80	1	1		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
86	1	1		VALVE, RELAY, FRONT
87	2	2		STUD, CLAMPING
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6B	TUBE, NYLON NO.6 BLACK
6Y	TUBE, NYLON NO.6 YELLOW
6G	TUBE, NYLON NO.6 GREEN
6O	TUBE, NYLON NO.6 ORANGE
6R	TUBE, NYLON NO.6 RED
8B	TUBE, NYLON NO.8 BLACK
8G	TUBE, NYLON NO.8 GREEN
8R	TUBE, NYLON NO.8 RED
10G	TUBE, NYLON NO.10 GREEN
10R	TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

(A) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

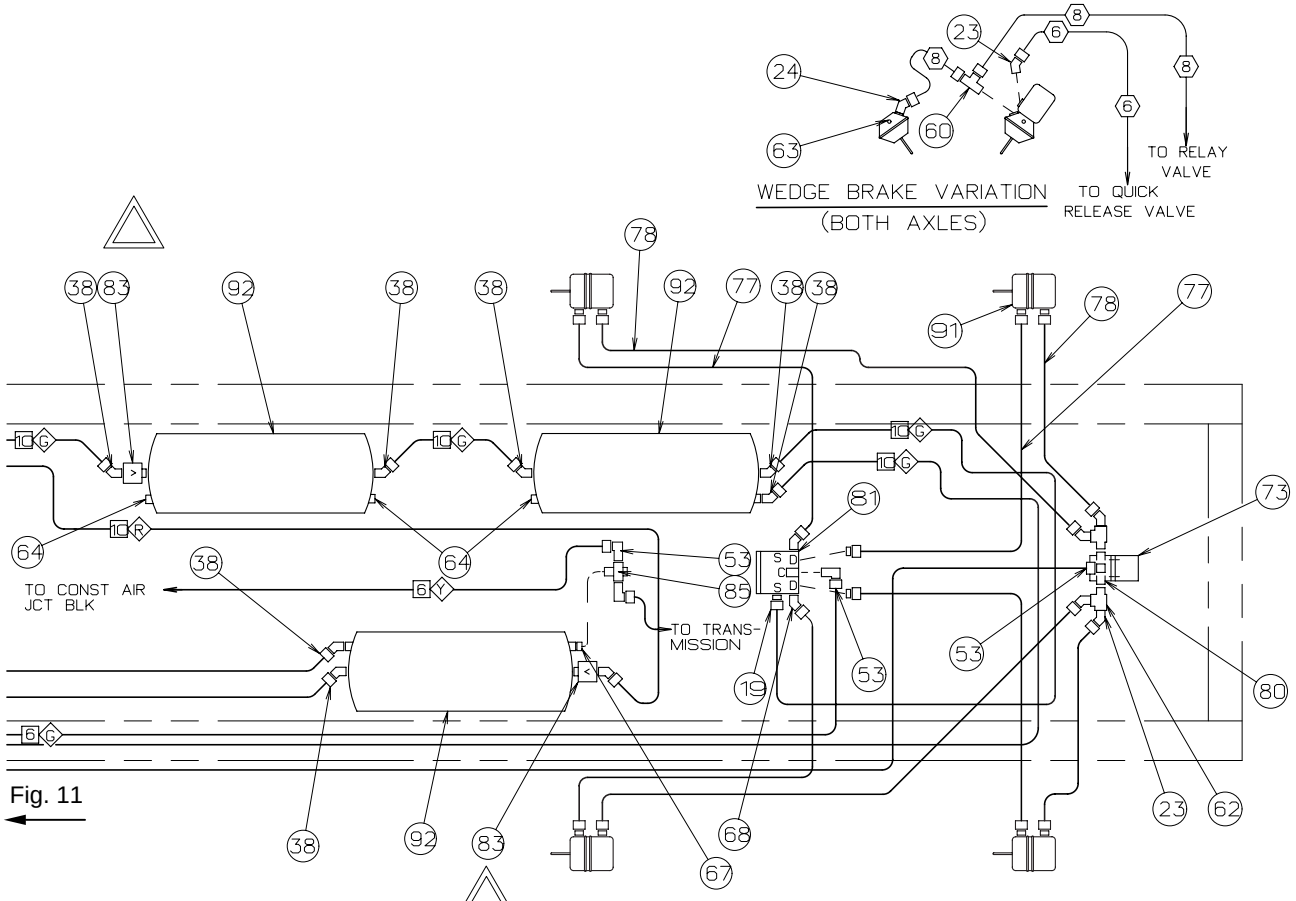
02/14/94

Diagram D12−12140, Chg. Ltr. A

f421142

Fig. 11

Tandem Rear Axle Truck, Without Antilock, Without Brake Proportioning



ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
8	1	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
14	1	1	210500 000006	CONNECTOR, NTA (3/8NT-1/2NPT)
16	1	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
17	1	1	210500 000009	CONNECTOR, NTA (1/2NT-1/2NPT)
19	2	2	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	4	8	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24		6	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
34	1	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	3	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	10	10	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
53	3	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	3	3	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
60		6	210502 000030	TEE,MALE RUN, SAE (#8 HOSE-3/8NPT)
62	3	3	210503 000020	TEE, STREET 3/8NPT
63	3	15	210503 000030	PLUG (3/8 NPT)
64	5	5	210503 000031	PLUG (1/2 NPT)
67	2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	2	23-11341-000	ELBOW, ADAPTER, 45 DEG (3/4UNF-3/8NPT)

ITEM #	CBK QTY	WBK QTY	PART #	DESCRIPTION
71	1	1	12-09711-000	GLADHAND, SERVICE
72	1	1	12-09711-001	GLADHAND, EMERGENCY
73	1	1	12-10474-000	BRACKET, MOUNTING
74	2	2	12-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	2	23-00701-100	WASHER, LOCK
76	2	2	23-10740-100	NUT, ANCHOR COUPLING
77	6		A12-10505- #	HOSE ASSY, AIR BRAKE
78	4		A12-11921- #	HOSE ASSY, AIR BRAKE
80	1	1		VALVE, QUICK RELEASE
81	1	1		VALVE, RELAY, REAR
82	1	1		VALVE, TRACTOR PROTECTION
83	2	2		VALVE, SINGLE CHECK
84	1	1		VALVE, AIR SAFETY
85	1	1		VALVE, PRESSURE PROTECTION
86	1	1		VALVE, RELAY, FRONT
87	2	2		STUD, CLAMPING
90				SEE FRONT AXLE ASSY
91				SEE REAR AXLE ASSY
92				SEE AIR RESERVOIRS INST
93				SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓐ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/14/94

Diagram D12−12140, Chg. Ltr. A

f421143

Fig. 12

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning

See Fig. 1 for a full view of the plumbing diagram nylon tubing, with front quick release valve, with Freightliner air suspension, date of use 7/89 to 4/91. **See Fig. 2**, or **Fig. 3** for partial (detailed) views plumbing diagram nylon tubing, with front quick release valve, with Freightliner air suspension, date of use 7/89 to 4/91.

See Fig. 4 for a full view of the plumbing diagram nylon tubing, with front quick release valve, with Freightliner spring suspension, date of use 7/89 to 4/91. **See Fig. 5**, or **Fig. 6** for partial (detailed) views plumbing diagram nylon tubing, with front quick release valve, with Freightliner spring suspension, date of use 7/89 to 4/91.

See Fig. 7 for full view of the plumbing diagram nylon tubing, with front relay valve, with Freightliner air suspension, date of use 7/89 to 4/91. **See Fig. 8**, or **Fig. 9** for partial (detailed) views plumbing diagram nylon tubing, with front relay valve, with Freightliner air suspension, date of use 7/89 to 4/91.

See Fig. 10 for a full view of the plumbing diagram nylon tubing, with front relay valve, with Freightliner spring suspension, date of use 7/89 to 4/91. **See Fig. 11**, or **Fig. 12** for partial (detailed) views plumbing diagram nylon tubing, with front relay valve, with Freightliner spring suspension, date of use 7/89 to 4/91.

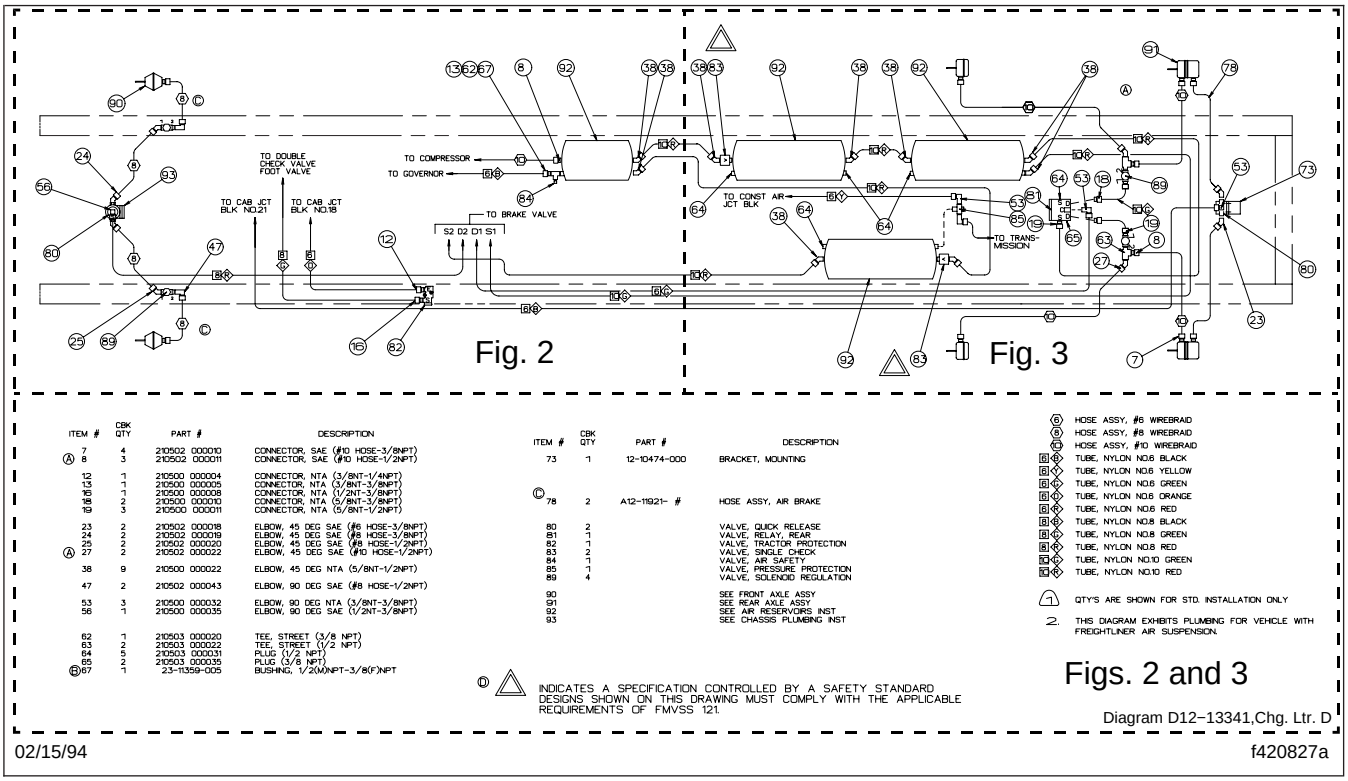
See Fig. 13 for a full view of the plumbing diagram wire braid hose, with front quick release valve, with Freightliner air suspension, date of use 7/89 to 4/91. **See Fig. 14**, or **Fig. 15** for partial (detailed) views plumbing diagram wire braid hose, with front quick release valve, with Freightliner air suspension, date of use 7/89 to 4/91.

See Fig. 16 for a full view of the plumbing diagram wire braid hose, with front quick release valve, with Freightliner spring suspension, date of use 7/89 to 4/91. **See Fig. 17**, or **Fig. 18** for partial (detailed) views plumbing diagram wire braid hose, with front quick release valve, with Freightliner spring suspension, date of use 7/89 to 4/91.

See Fig. 19 for a full view of the plumbing diagram wire braid hose, with front relay valve, with Freightliner air suspension, date of use 7/89 to 4/91. **See Fig. 20**, or **Fig. 21** for partial (detailed) views plumbing diagram wire braid hose, with front relay valve, with Freightliner air suspension, date of use 7/89 to 4/91.

See Fig. 22 for a full view of the plumbing diagram wire braid hose, with front relay valve, with Freightliner spring suspension, date of use 7/89 to 4/91. **See Fig. 23**, or **Fig. 24** for partial (detailed) views plumbing diagram wire braid hose, with front relay valve, with Freightliner spring suspension, date of use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Ⓐ 8	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
15	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	3	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
Ⓐ 27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
38	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG SAE (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
Ⓒ 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Ⓑ HOSE ASSY, #6 WIREBRAID
Ⓒ HOSE ASSY, #8 WIREBRAID
Ⓐ HOSE ASSY, #10 WIREBRAID
TUBE, NYLON NO.6 BLACK
TUBE, NYLON NO.6 YELLOW
TUBE, NYLON NO.6 GREEN
TUBE, NYLON NO.6 ORANGE
TUBE, NYLON NO.6 RED
TUBE, NYLON NO.8 BLACK
TUBE, NYLON NO.8 GREEN
TUBE, NYLON NO.8 RED
TUBE, NYLON NO.10 GREEN
TUBE, NYLON NO.10 RED

1. QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER AIR SUSPENSION.

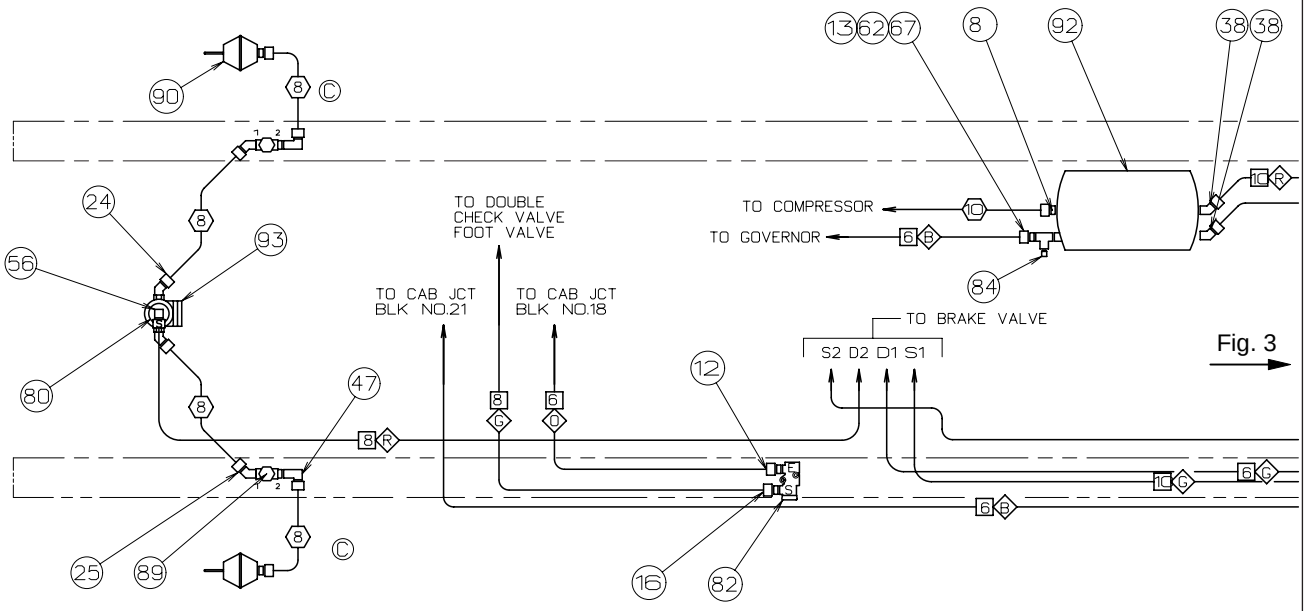
Figs. 2 and 3

Diagram D12−13341,Chg. Ltr. D

02/15/94 f420827a

Fig. 1, Nylon Tubing, With Front Quick Release Valve, With Freightliner Air Suspension, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Ⓐ 8	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	3	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
Ⓐ 27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
38	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG SAE (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
Ⓒ 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID	6 R	TUBE, NYLON NO.6 RED
8	HOSE ASSY, #8 WIREBRAID	8 B	TUBE, NYLON NO.8 BLACK
10	HOSE ASSY, #10 WIREBRAID	8 G	TUBE, NYLON NO.8 GREEN
6 B	TUBE, NYLON NO.6 BLACK	8 R	TUBE, NYLON NO.8 RED
6 Y	TUBE, NYLON NO.6 YELLOW	10 G	TUBE, NYLON NO.10 GREEN
6 G	TUBE, NYLON NO.6 GREEN	10 R	TUBE, NYLON NO.10 RED
6 O	TUBE, NYLON NO.6 ORANGE		

Ⓓ △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

△1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

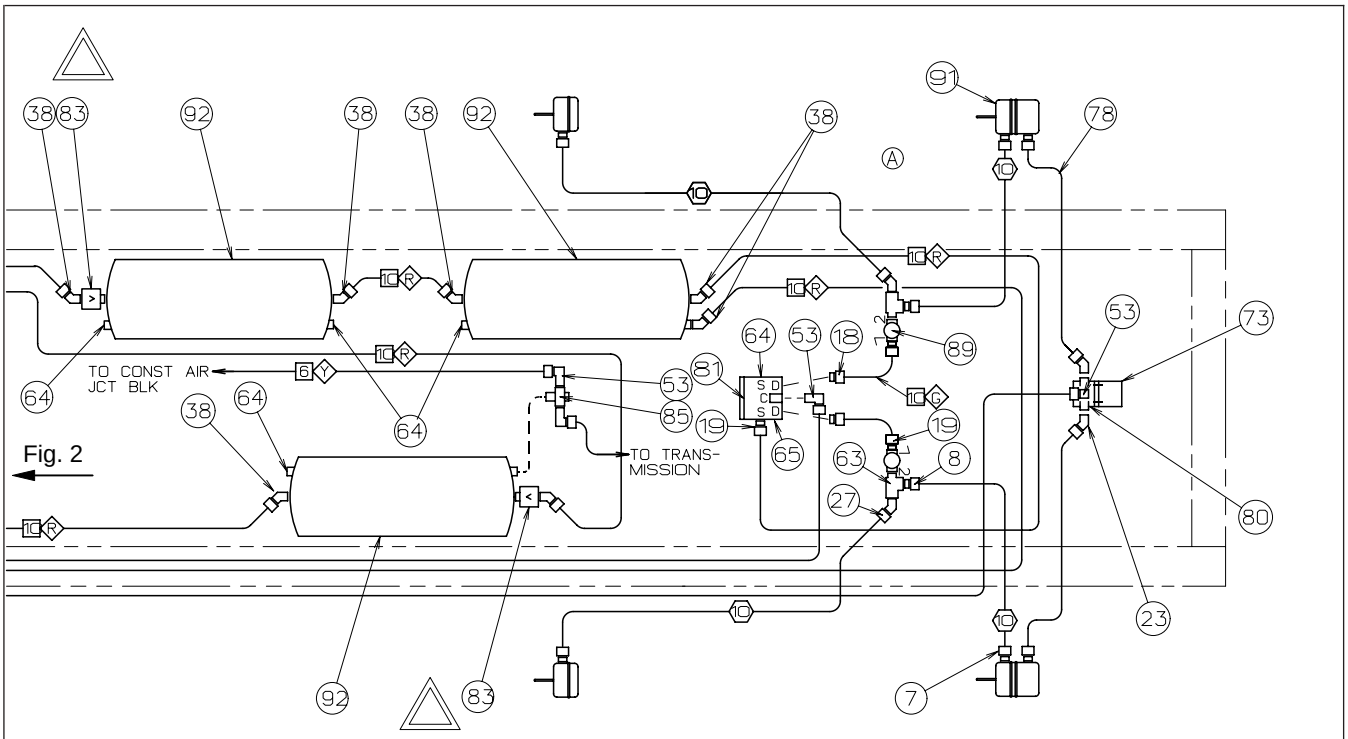
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER AIR SUSPENSION.

Diagram D12−13341, Chg. Ltr. D

02/15/94 f421146

Fig. 2

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Ⓐ 8	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	3	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
Ⓐ 27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
38	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG SAE (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
Ⓒ 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID	6R	TUBE, NYLON NO.6 RED
8	HOSE ASSY, #8 WIREBRAID	8B	TUBE, NYLON NO.8 BLACK
10	HOSE ASSY, #10 WIREBRAID	8G	TUBE, NYLON NO.8 GREEN
6B	TUBE, NYLON NO.6 BLACK	8R	TUBE, NYLON NO.8 RED
6Y	TUBE, NYLON NO.6 YELLOW	10G	TUBE, NYLON NO.10 GREEN
6G	TUBE, NYLON NO.6 GREEN	10R	TUBE, NYLON NO.10 RED
6O	TUBE, NYLON NO.6 ORANGE		

1. QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER AIR SUSPENSION.

Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−13341, Chg. Ltr. D

02/15/94 f421147

Fig. 3

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning

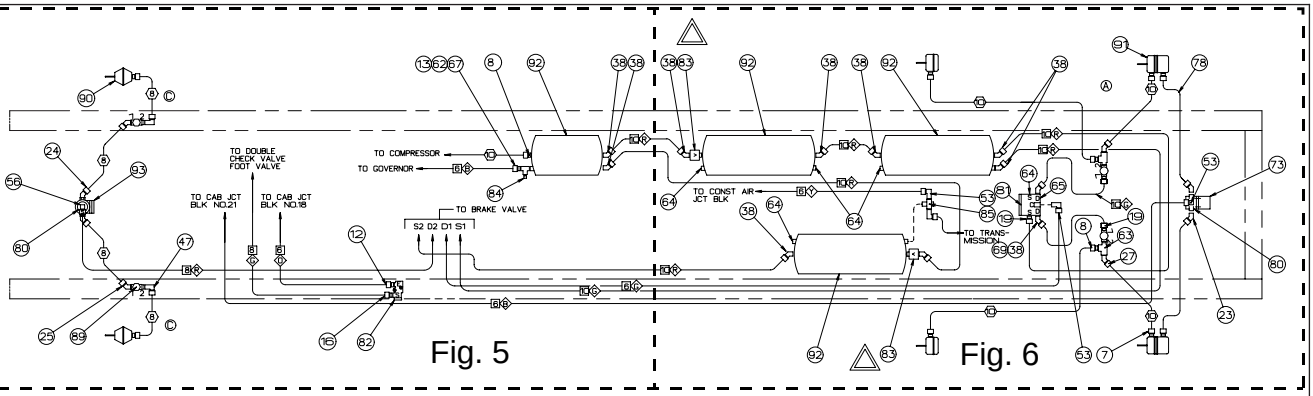


Fig. 5 Fig. 6

ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
(A) 8	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	3	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
(A) 27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
38	15	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG SAE (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
(B) 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
© 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(D) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

(B) HOSE ASSY, #6 WIREBRAID
(B) HOSE ASSY, #8 WIREBRAID
(B) HOSE ASSY, #10 WIREBRAID
[6] TUBE, NYLON NO.6 BLACK
[6] TUBE, NYLON NO.6 YELLOW
[6] TUBE, NYLON NO.6 GREEN
[6] TUBE, NYLON NO.6 ORANGE
[6] TUBE, NYLON NO.6 RED
[8] TUBE, NYLON NO.8 BLACK
[8] TUBE, NYLON NO.8 GREEN
[8] TUBE, NYLON NO.8 RED
[10] TUBE, NYLON NO.10 GREEN
[10] TUBE, NYLON NO.10 RED

1. QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER SPRING SUSPENSION.

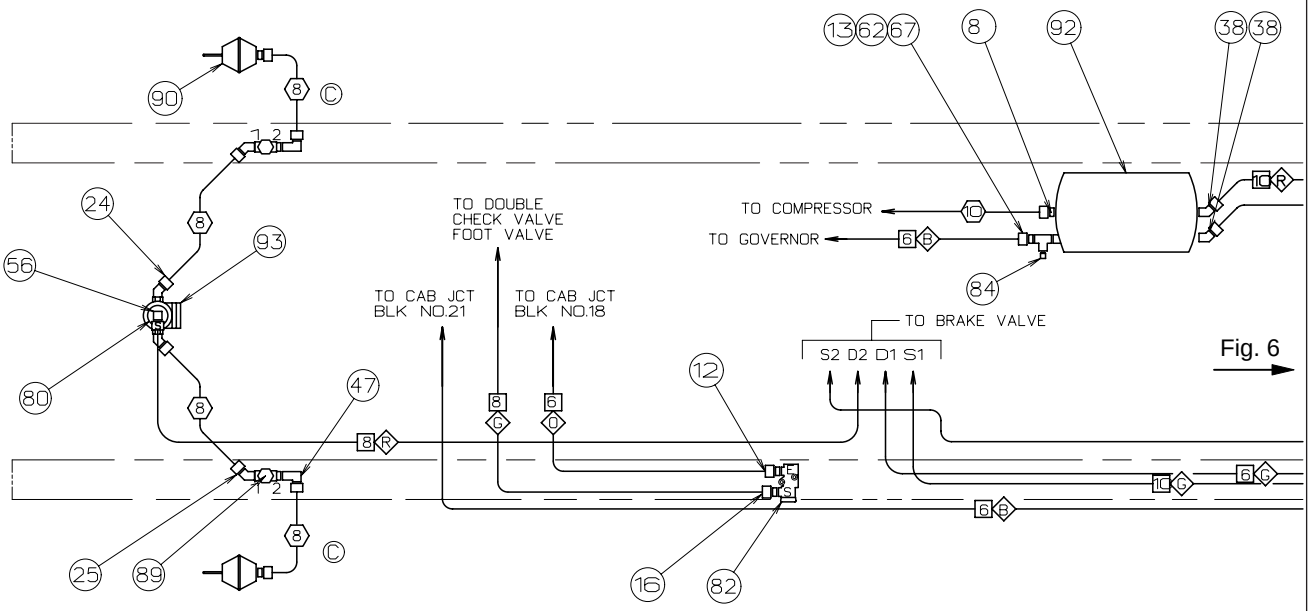
Figs. 5 and 6

Diagram D12−13342, Chg. Ltr. D

02/15/94 f420828a

Fig. 4, Nylon Tubing, With Front Quick Release Valve, With Freightliner Spring Suspension, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Ⓐ 8	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	3	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
Ⓐ 27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
38	15	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG SAE (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
Ⓒ 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID	6 R	TUBE, NYLON NO.6 RED
8	HOSE ASSY, #8 WIREBRAID	8 B	TUBE, NYLON NO.8 BLACK
10	HOSE ASSY, #10 WIREBRAID	8 G	TUBE, NYLON NO.8 GREEN
6 B	TUBE, NYLON NO.6 BLACK	8 R	TUBE, NYLON NO.8 RED
6 Y	TUBE, NYLON NO.6 YELLOW	10 G	TUBE, NYLON NO.10 GREEN
6 G	TUBE, NYLON NO.6 GREEN	10 R	TUBE, NYLON NO.10 RED
6 O	TUBE, NYLON NO.6 ORANGE		

Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

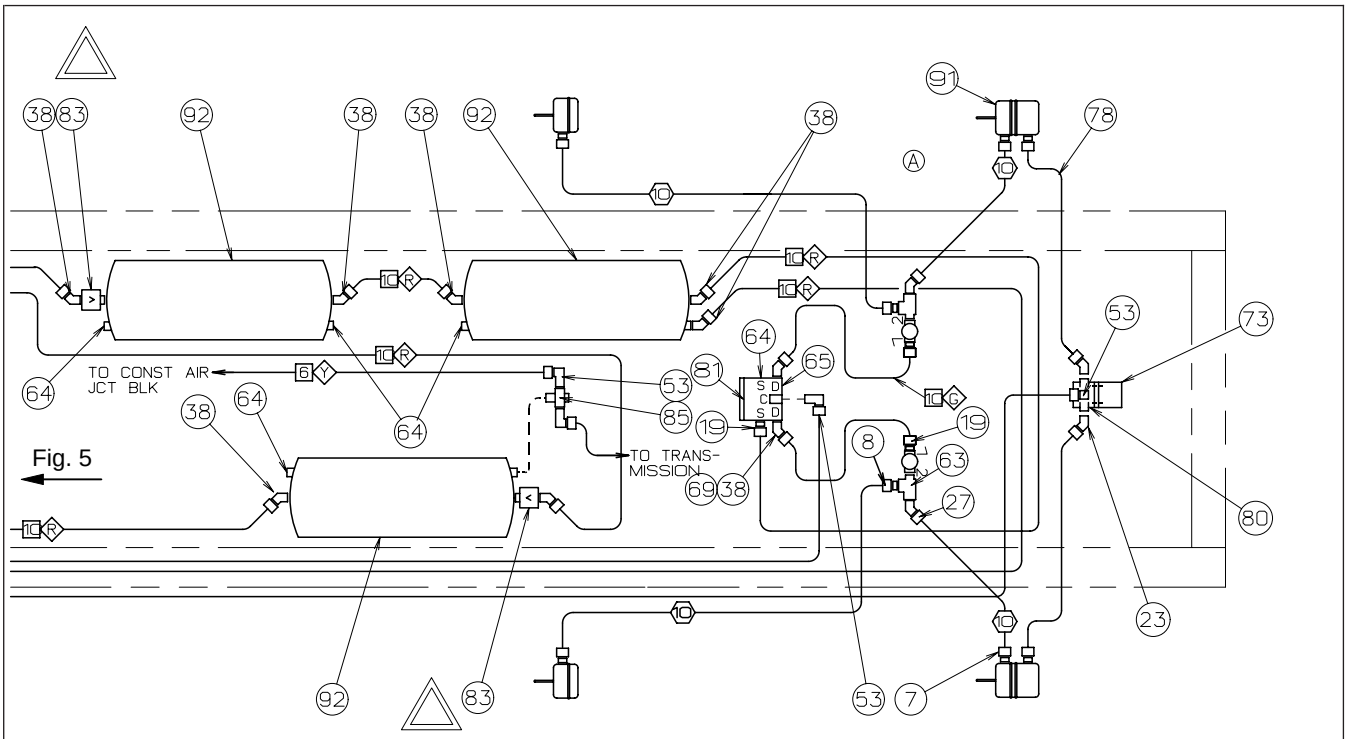
1. QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER SPRING SUSPENSION.

Diagram D12−13342, Chg. Ltr. D

02/18/94 f421148

Fig. 5

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Ⓐ 8	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	3	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
Ⓐ 27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
38	15	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG SAE (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
Ⓒ 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID	6 R	TUBE, NYLON NO.6 RED
8	HOSE ASSY, #8 WIREBRAID	8 B	TUBE, NYLON NO.8 BLACK
10	HOSE ASSY, #10 WIREBRAID	8 G	TUBE, NYLON NO.8 GREEN
6 B	TUBE, NYLON NO.6 BLACK	8 R	TUBE, NYLON NO.8 RED
6 Y	TUBE, NYLON NO.6 YELLOW	10 G	TUBE, NYLON NO.10 GREEN
6 G	TUBE, NYLON NO.6 GREEN	10 R	TUBE, NYLON NO.10 RED
6 O	TUBE, NYLON NO.6 ORANGE		

Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

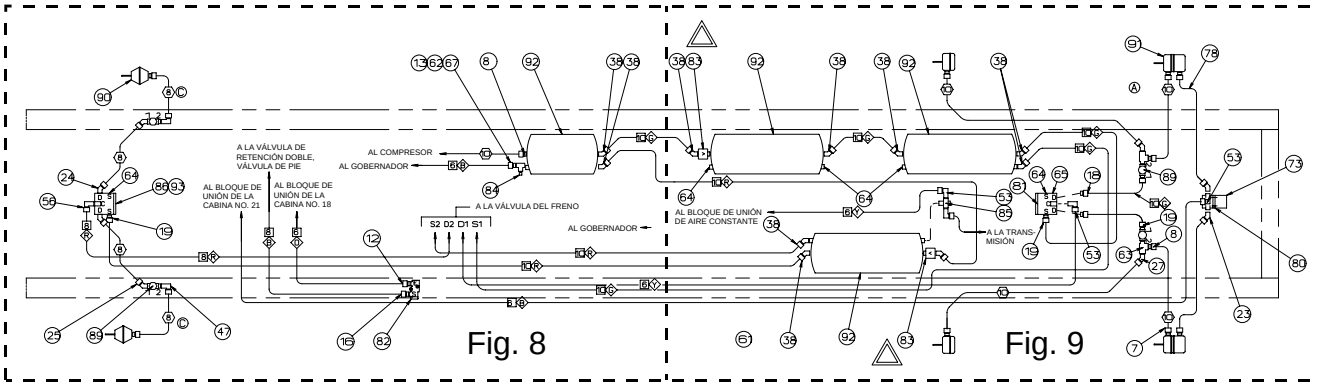
1. QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER SPRING SUSPENSION.

Diagram D12−13342, Chg. Ltr. D

02/18/94 f421149

Fig. 6

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



No.	CANT. FRENO LEVAS	No. REPUESTO	DESCRIPCIÓN
7	4	210502 000010	CONECTOR, SAE (MANGUERA # 10 DE 3/8" NPT)
Ⓐ 8	3	210502 000011	CONECTOR, SAE (MANGUERA # 10 DE 1/2" NPT)
12	1	210500 000004	CONECTOR, NTA (3/8" NT – 1/4" NPT)
13	1	210500 000005	CONECTOR, NTA (3/8" NT – 3/8" NPT)
16	3	210500 000008	CONECTOR, NTA (1/2" NT – 3/8" NPT)
18	2	210500 000010	CONECTOR, NTA (5/8" NT – 3/8" NPT)
19	4	210500 000011	CONECTOR, NTA (5/8" NT – 1/2" NPT)
23	2	210502 000018	CODO DE 45 GRADOS, SAE (MANGUERA # 6 DE 3/8" NPT)
24	2	210502 000019	CODO DE 45 GRADOS, SAE (MANGUERA # 8 DE 3/8" NPT)
25	2	210502 000020	CODO DE 45 GRADOS, SAE (MANGUERA # 8 DE 1/2" NPT)
Ⓐ 27	2	210502 000022	CODO DE 45 GRADOS, SAE (MANGUERA # 10 DE 1/2" NPT)
38	10	210500 000022	CODO DE 45 GRADOS, NTA (5/8" NT – 1/2" NPT)
47	2	210502 000043	CODO DE 90 GRADOS, SAE (MANGUERA # 8 DE 1/2" NPT)
53	3	210500 000032	CODO DE 90 GRADOS, NTA (3/8" NT – 3/8" NPT)
56	1	210500 000035	CODO DE 90 GRADOS, SAE (1/2" NT – 3/8" NPT)
62	1	210503 000020	T DE DOS ACOPLES HEMBRAS (3/8" NPT)
63	2	210503 000022	T DE DOS ACOPLES HEMBRAS (1/2" NPT)
64	5	210503 000031	TAPÓN (1/2" NPT)
65	2	210503 000035	TAPÓN (3/8" NPT)
Θ 67	1	23-11359-005	BUJE, 1/2" (MACHO) NPT – 3/8" (HEMBRA) NPT ADAPTADOR, 1/2"(HEMBRA) NPT – 3/8" (MACHO) NPT

No.	CANT. FRENO LEVAS	No. REPUESTO	DESCRIPCIÓN
73	1	12-10474-000	SOPORTE DE MONTAJE
© 78	2	A12-11921- #	CONJ. DE MANGUERA, FRENO DE AIRE
80	2		VÁLVULA DE DESCARGA RÁPIDA
81	1		VÁLVULA RELEVADORA TRASERA
82	1		VÁLVULA DE PROTECCIÓN DEL TRACTOR
83	2		VÁLVULA DE RETENCIÓN SENCILLA
84	1		VÁLVULA DE SEGURIDAD DE AIRE
85	1		VÁLVULA DE PROTECCIÓN DE PRESIÓN
86	1		VÁLVULA RELEVADORA DELANTERA
89	4		VÁLVULA SOLENOIDE REGULADORA
90			VEA EL ENSAMBLE DEL EJE DELANTERO
91			VEA EL ENSAMBLE DEL EJE TRASERO
92			VEA LA INSTALACIÓN DE LOS DEPÓSITOS DE AIRE
93			VEA LA INSTALACIÓN DE LAS TUBERÍAS DEL CHASIS

Figs. 8 and 9

Ⓓ INDICA UNA ESPECIFICACIÓN CONTROLADA POR UN ESTÁNDAR DE SEGURIDAD. LOS DISEÑOS INDICADOS EN ESTE DIBUJO DEBEN CONFORMARSE A LOS REQUISITOS CORRESPONDIENTES DEL ESTÁNDAR DEL GOBIERNO FEDERAL (EEUU) FMVSS 121.

- Ⓐ 6 CONJ. DE MANGUERA NO. 6 DE ALAMBRE TRENZADO
- Ⓑ 8 CONJ. DE MANGUERA NO. 8 DE ALAMBRE TRENZADO
- Ⓒ 10 CONJ. DE MANGUERA NO. 10 DE ALAMBRE TRENZADO
- TUBO DE NILÓN NO. 6 NEGRO
- TUBO DE NILÓN NO. 6 AMARILLO
- TUBO DE NILÓN NO. 6 VERDE
- TUBO DE NILÓN NO. 6 NARANJA
- TUBO DE NILÓN NO. 6 ROJO
- TUBO DE NILÓN NO. 8 NEGRO
- TUBO DE NILÓN NO. 8 VERDE
- TUBO DE NILÓN NO. 8 ROJO
- TUBO DE NILÓN NO. 10 VERDE
- TUBO DE NILÓN NO. 10 ROJO

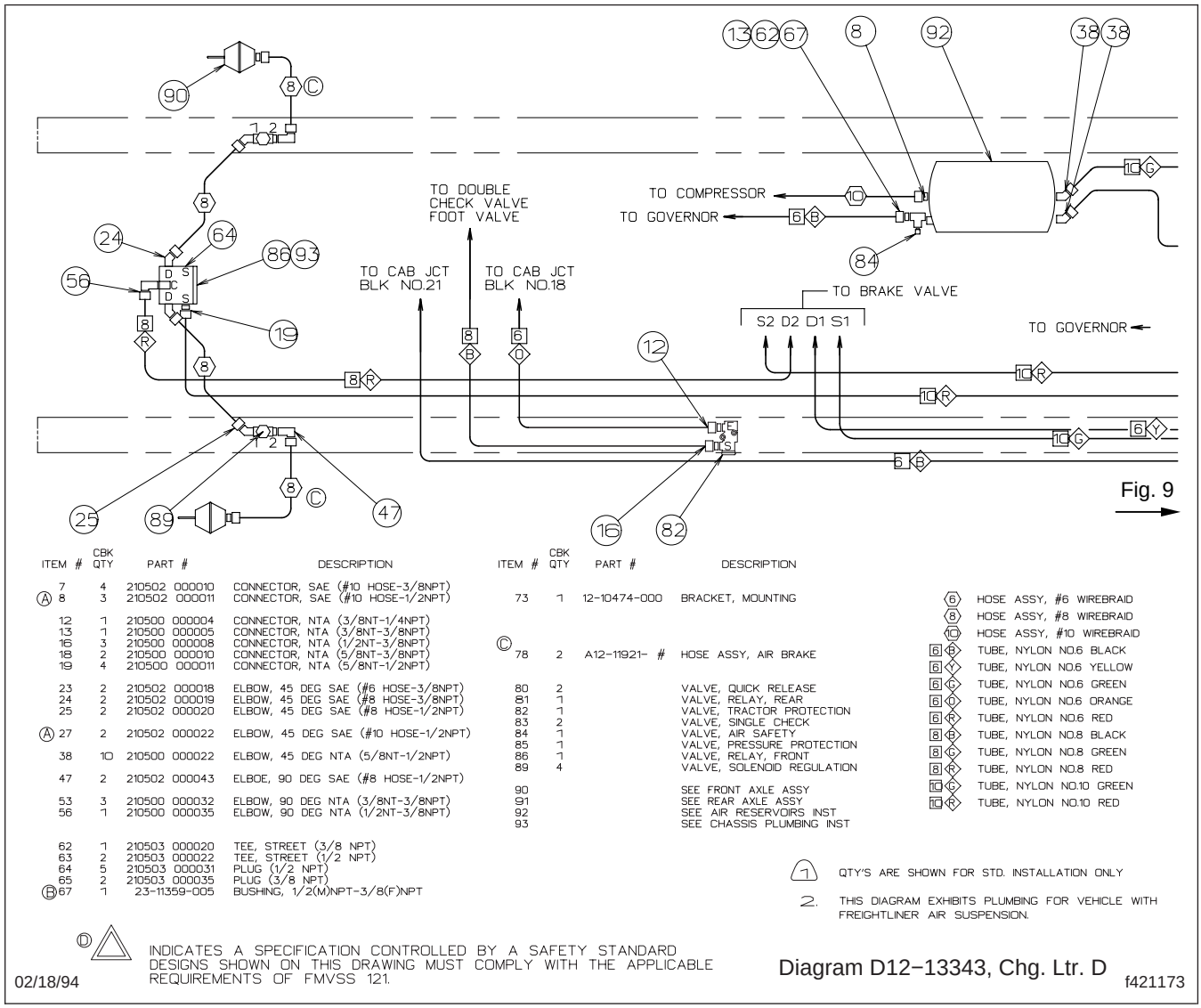
1. LAS CANTIDADES QUE SE MUESTRAN SON PARA LA INSTALACIÓN ESTÁNDAR SOLAMENTE
2. ESTE DIAGRAMA MUESTRA LAS TUBERÍAS DE UN VEHÍCULO CON SUSPENSIÓN DE AIRE FREIGHTLINER.

Diagrama D12−13343, Letra de revisión D

f420829s

Fig. 7, Nylon Tubing, With Front Relay Valve, With Freightliner Air Suspension, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Ⓐ 8	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	3	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	4	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
Ⓐ 27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
38	10	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOE, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
© 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 R	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

1. QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER AIR SUSPENSION.

Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/18/94

Diagram D12−13343, Chg. Ltr. D

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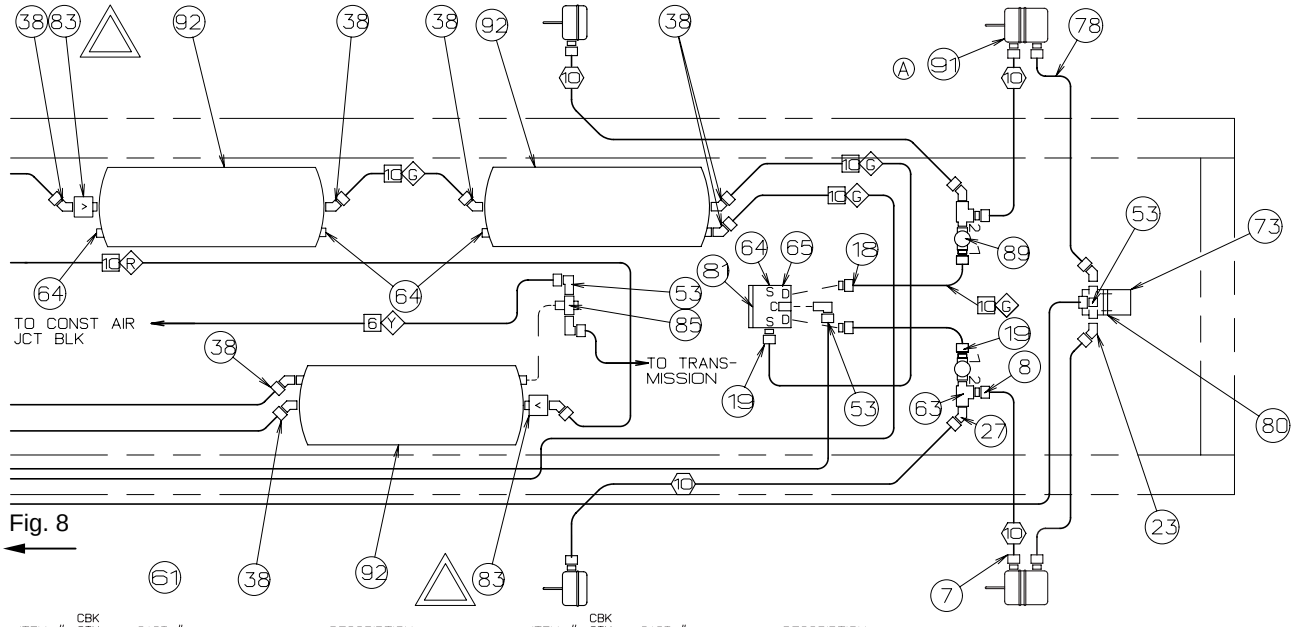
Fig. 8

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Ⓐ 8	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	3	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	4	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
Ⓐ 27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
38	10	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOE, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
© 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

1. QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER AIR SUSPENSION.

Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/18/94

Diagram D12−13343, Chg. Ltr. D

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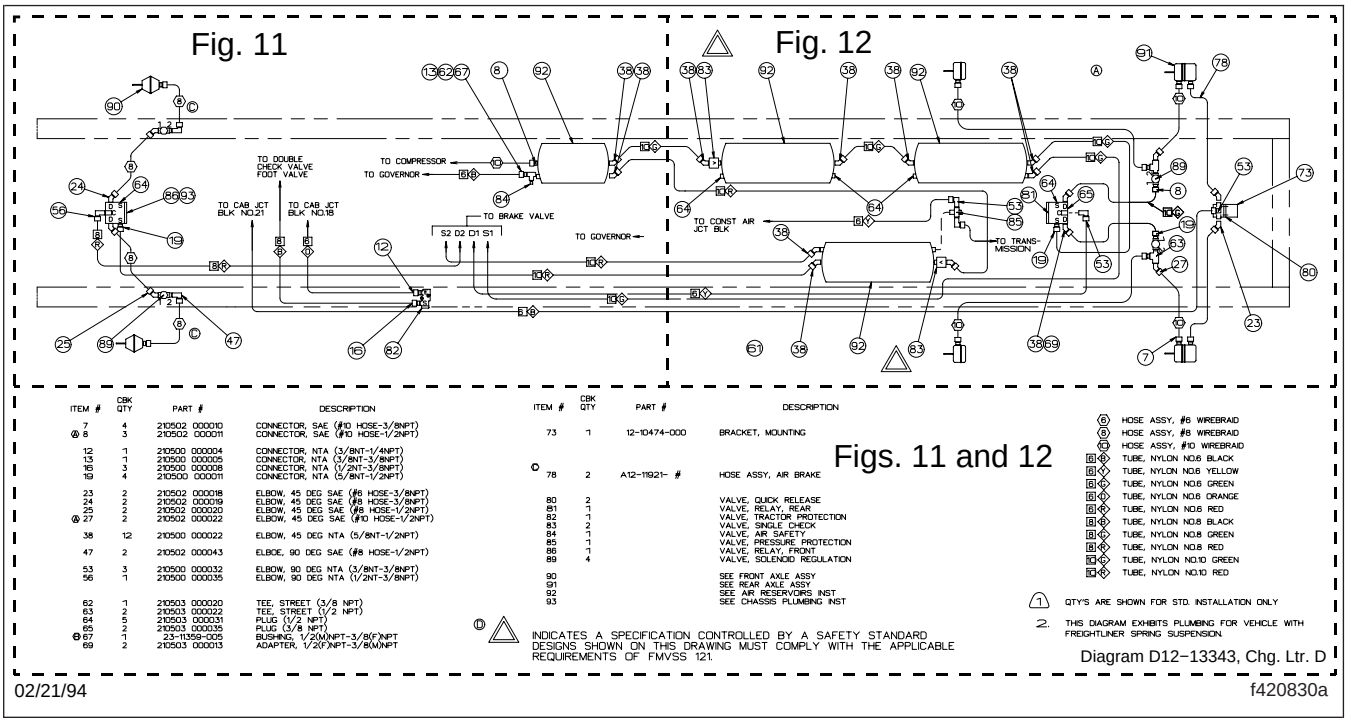
Fig. 9

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Ⓐ 8	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	3	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	4	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
Ⓐ 27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
38	12	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOE, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Θ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
© 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

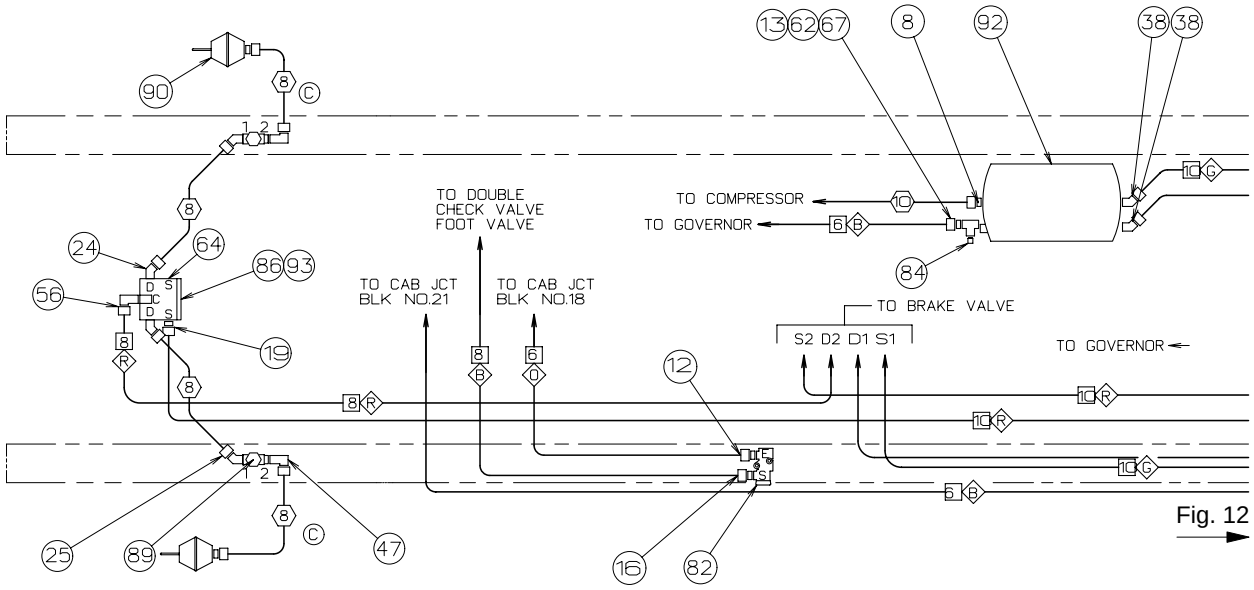
Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Ⓐ	HOSE ASSY, #6 WIREBRAID
Ⓑ	HOSE ASSY, #8 WIREBRAID
Ⓒ	HOSE ASSY, #10 WIREBRAID
6Ⓑ	TUBE, NYLON NO.6 BLACK
6Ⓨ	TUBE, NYLON NO.6 YELLOW
6Ⓖ	TUBE, NYLON NO.6 GREEN
6Ⓞ	TUBE, NYLON NO.6 ORANGE
6Ⓡ	TUBE, NYLON NO.6 RED
8Ⓑ	TUBE, NYLON NO.8 BLACK
8Ⓖ	TUBE, NYLON NO.8 GREEN
8Ⓡ	TUBE, NYLON NO.8 RED
10Ⓖ	TUBE, NYLON NO.10 GREEN
10Ⓡ	TUBE, NYLON NO.10 RED

1. QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER SPRING SUSPENSION.

Fig. 10, Nylon Tubing, With Front Relay Valve, With Freightliner Spring Suspension, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Ⓐ 8	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	3	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	4	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
Ⓐ 27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
38	12	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOE, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
© 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

1. QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER SPRING SUSPENSION.

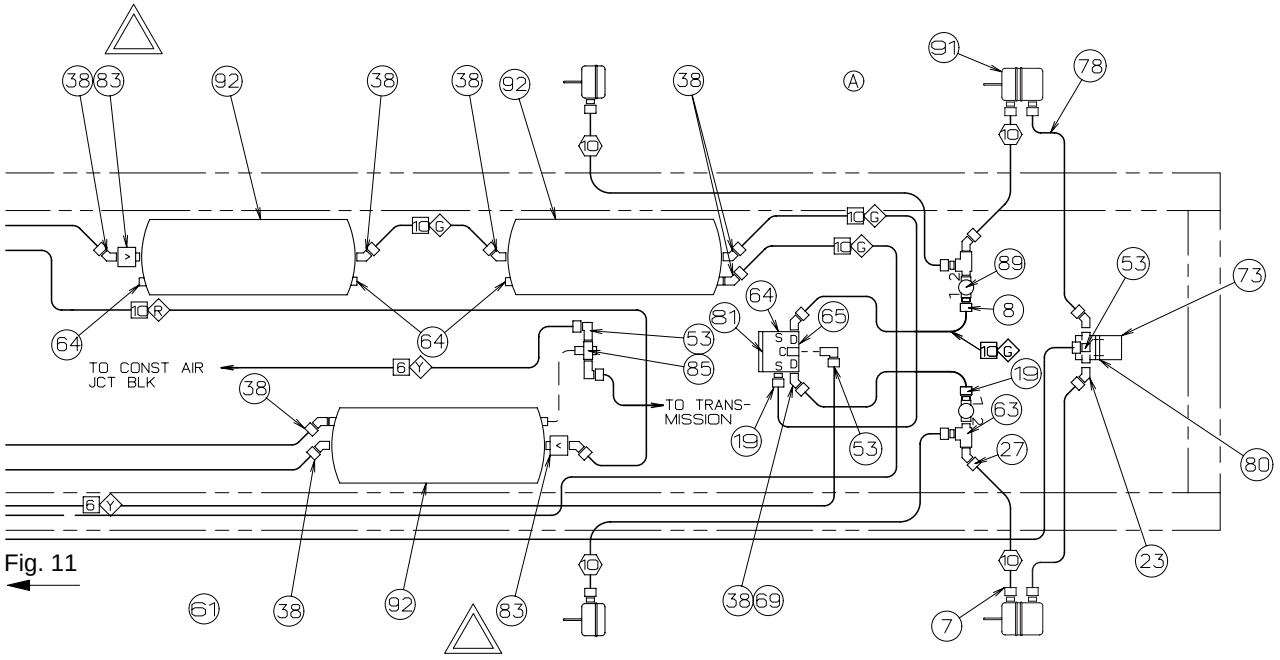
Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−13344, Chg. Ltr. D

02/21/94 f421175

Fig. 11

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Ⓐ 8	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	1	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	3	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	4	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
Ⓐ 27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
38	12	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOE, 90 DEG SAE (#8 HOSE-1/2NPT)
53	3	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
Ⓒ 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

Ⓓ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

1. QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER SPRING SUSPENSION.

Diagram D12−13344, Chg. Ltr. D

02/21/94

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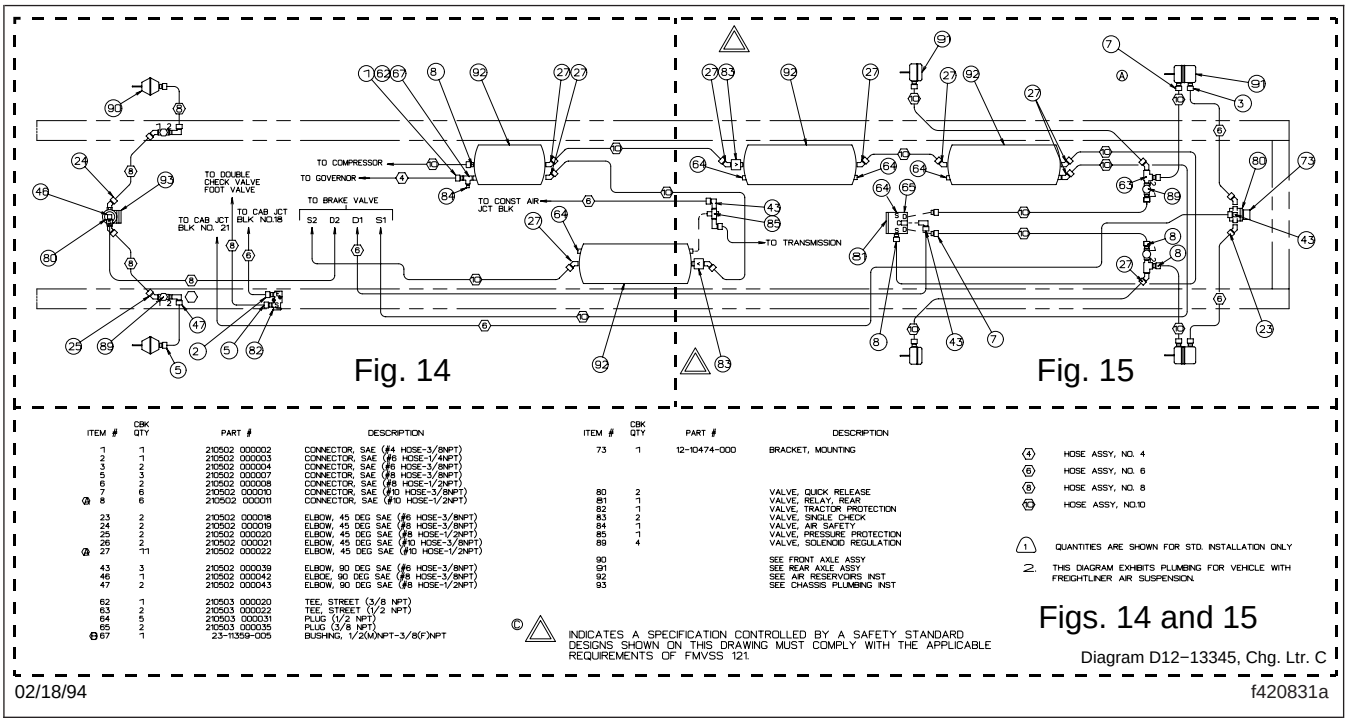
Fig. 12

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	2	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	11	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

1. QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER AIR SUSPENSION.

© INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

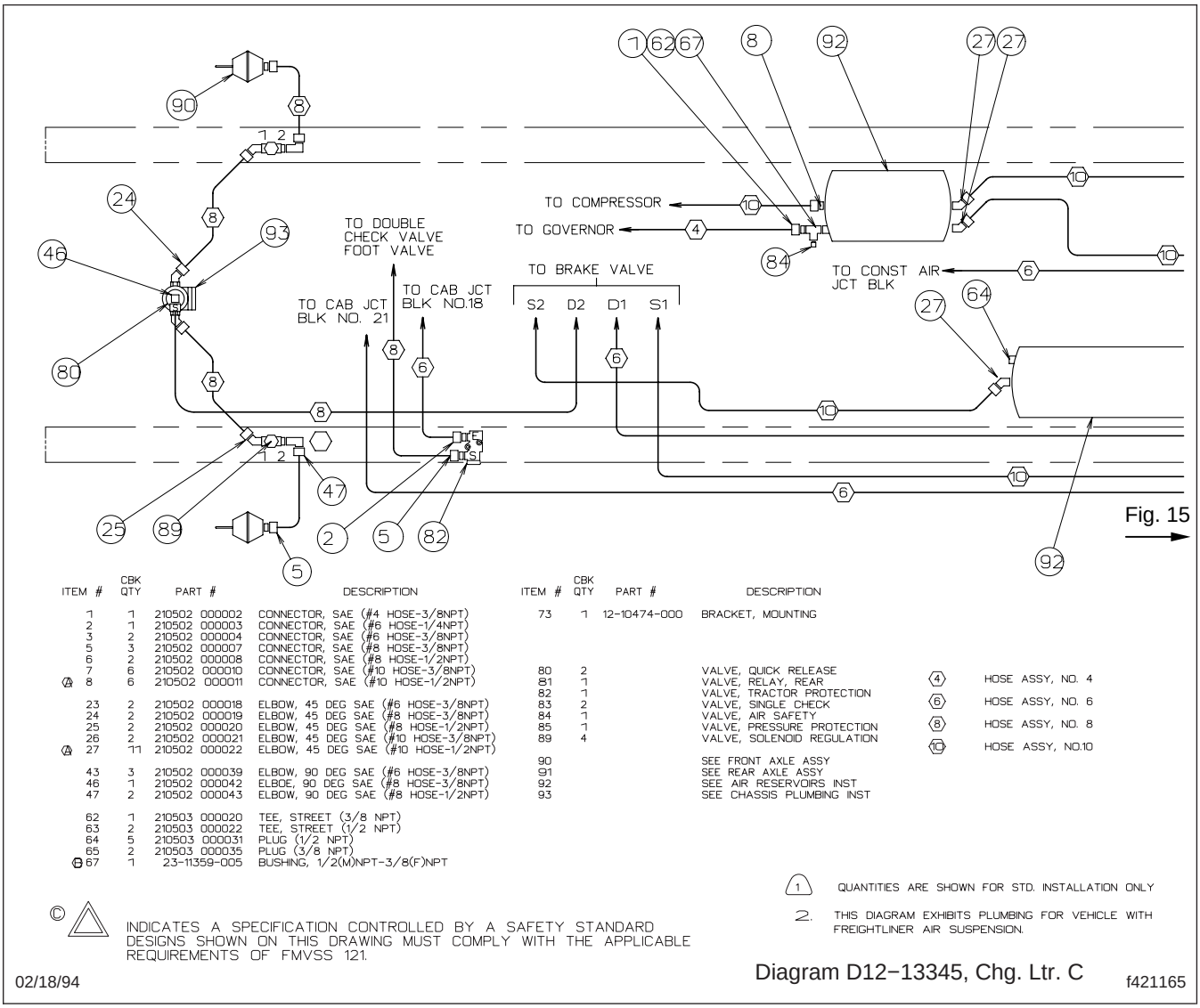
Figs. 14 and 15

Diagram D12−13345, Chg. Ltr. C

02/18/94 f420831a

Fig. 13, Wire Braid Hose, With Front Quick Release Valve, With Freightliner Air Suspension, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	2	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
⚠ 8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
⚠ 27	11	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOE, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

④	HOSE ASSY, NO. 4
⑥	HOSE ASSY, NO. 6
⑧	HOSE ASSY, NO. 8
⑩	HOSE ASSY, NO.10

© ⚠ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

1. QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER AIR SUSPENSION.

02/18/94

Diagram D12−13345, Chg. Ltr. C

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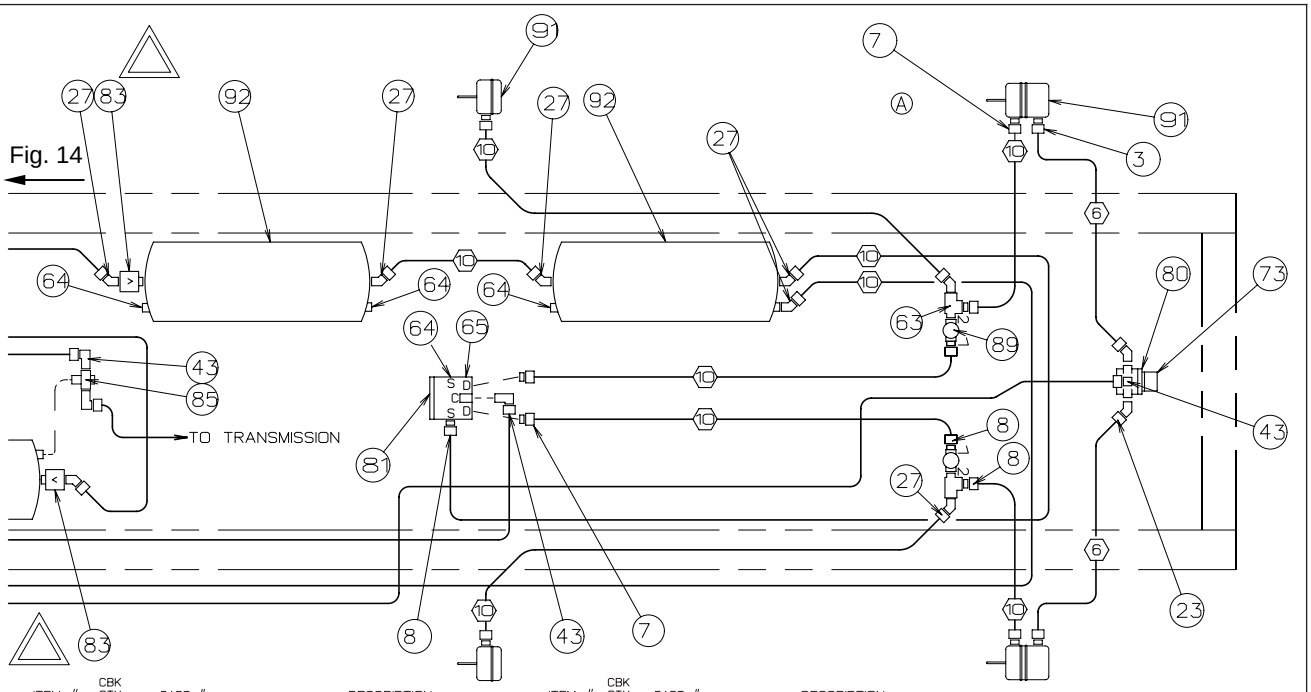
Fig. 14

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	2	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Ⓐ 8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
Ⓐ 27	11	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOE, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

④	HOSE ASSY, NO. 4
⑥	HOSE ASSY, NO. 6
⑧	HOSE ASSY, NO. 8
⑩	HOSE ASSY, NO.10

© INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

1. QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER AIR SUSPENSION.

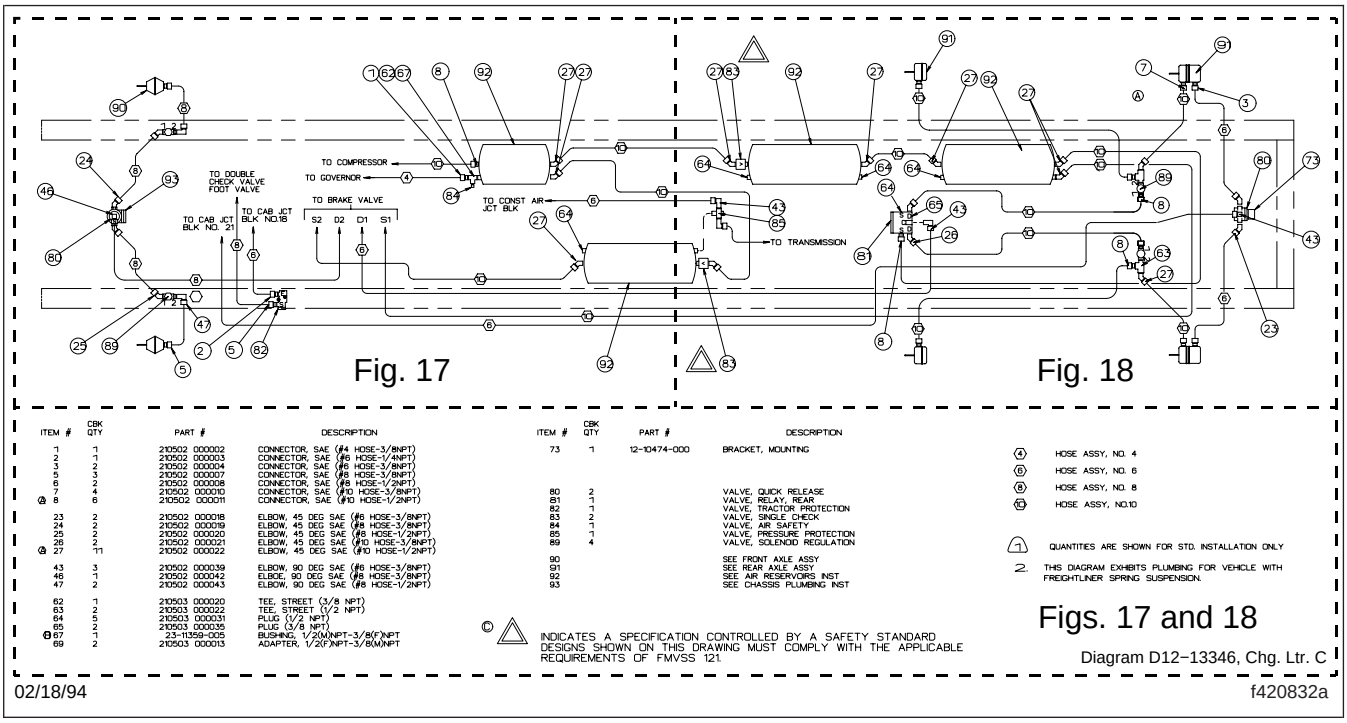
02/18/94

Diagram D12−13345, Chg. Ltr. C

f421166

Fig. 15

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	2	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
⚠ 8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
⚠ 27	11	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOE, 90 DEG SAE (#6 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓒ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

Ⓒ⚠ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

⚠1 QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER SPRING SUSPENSION.

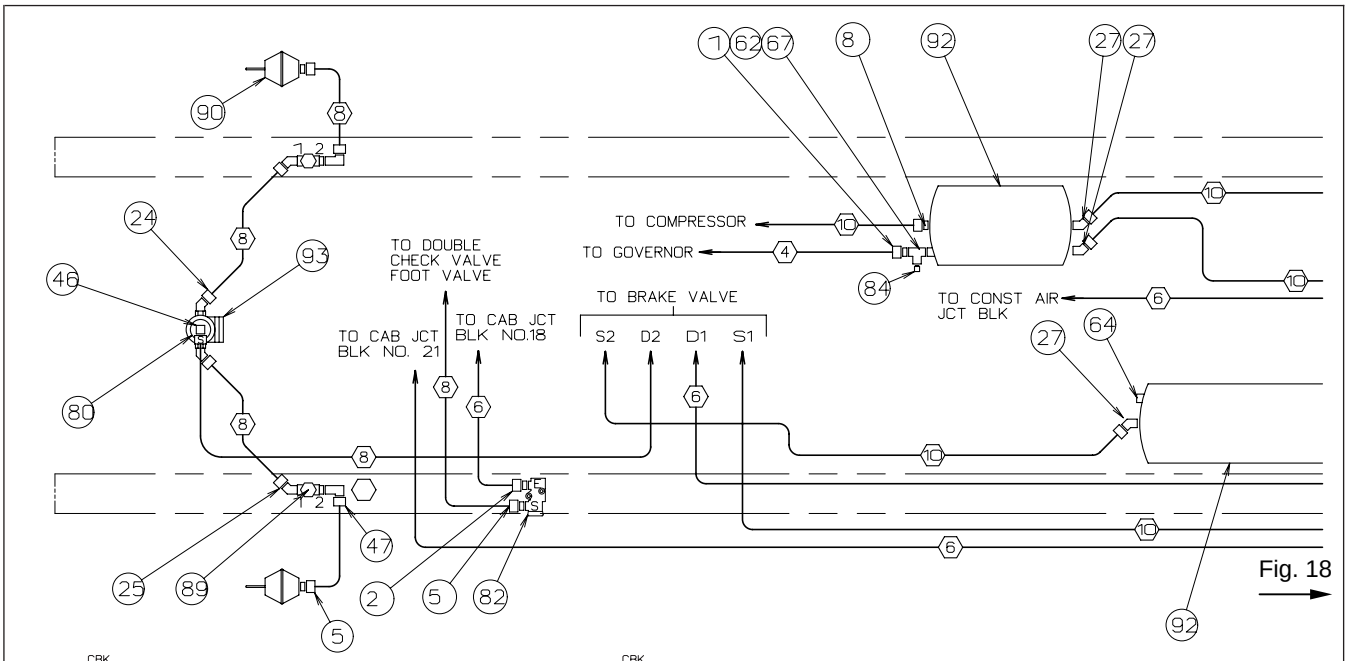
Figs. 17 and 18

Diagram D12−13346, Chg. Ltr. C

02/18/94 f420832a

Fig. 16, Wire Braid Hose, With Front Quick Release Valve, With Freightliner Spring Suspension, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	2	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Δ 8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
Δ 27	11	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOE, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
⊖ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

④	HOSE ASSY, NO. 4
⑥	HOSE ASSY, NO. 6
⑧	HOSE ASSY, NO. 8
⑩	HOSE ASSY, NO.10

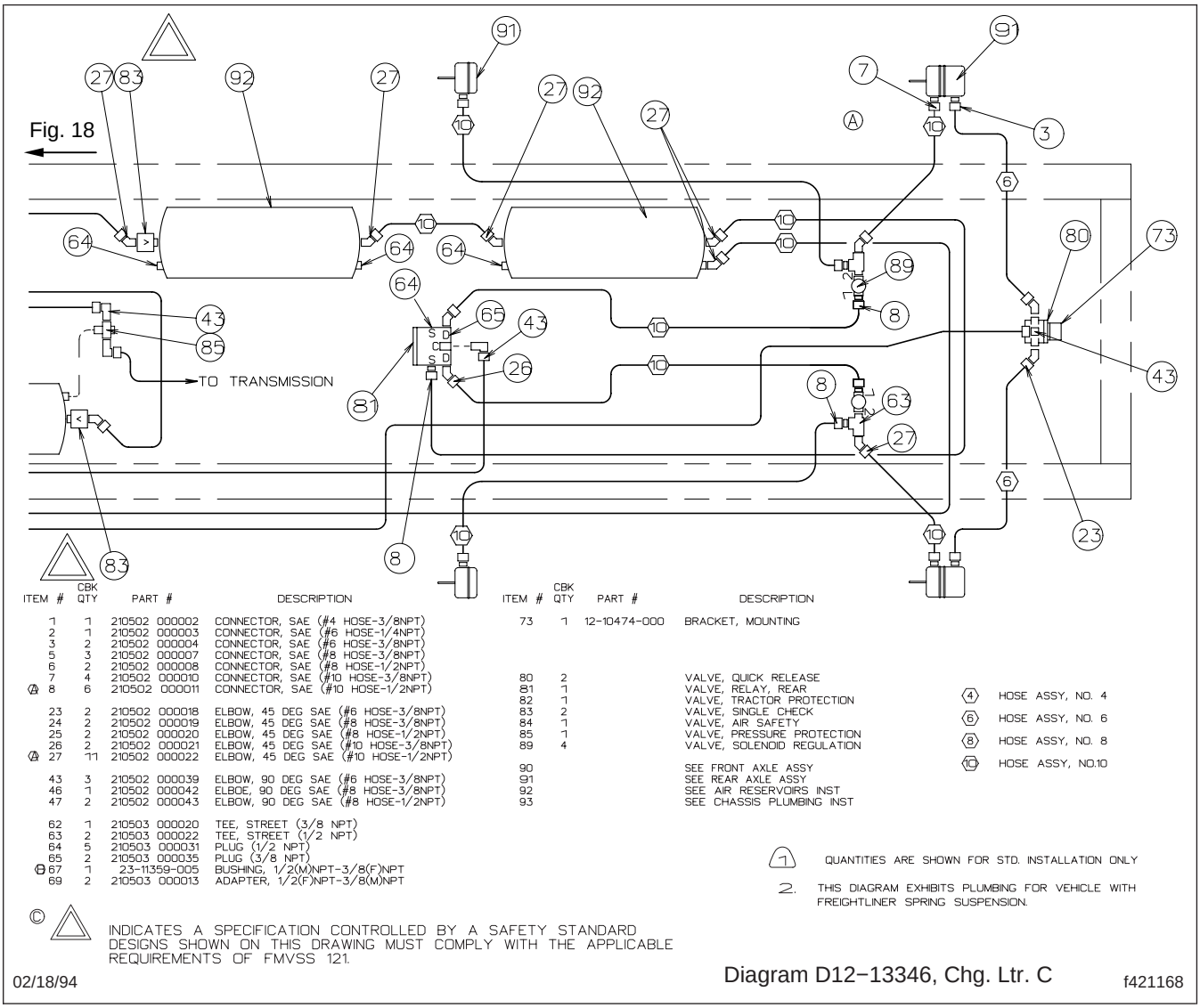
1. QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER SPRING SUSPENSION.

© Δ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/18/94 Diagram D12−13346, Chg. Ltr. C f421167

Fig. 17

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	2	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Ⓐ 8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
Ⓐ 27	11	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOE, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

⟨4⟩ HOSE ASSY, NO. 4
⟨6⟩ HOSE ASSY, NO. 6
⟨8⟩ HOSE ASSY, NO. 8
⟨10⟩ HOSE ASSY, NO.10

△1 QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER SPRING SUSPENSION.

© △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

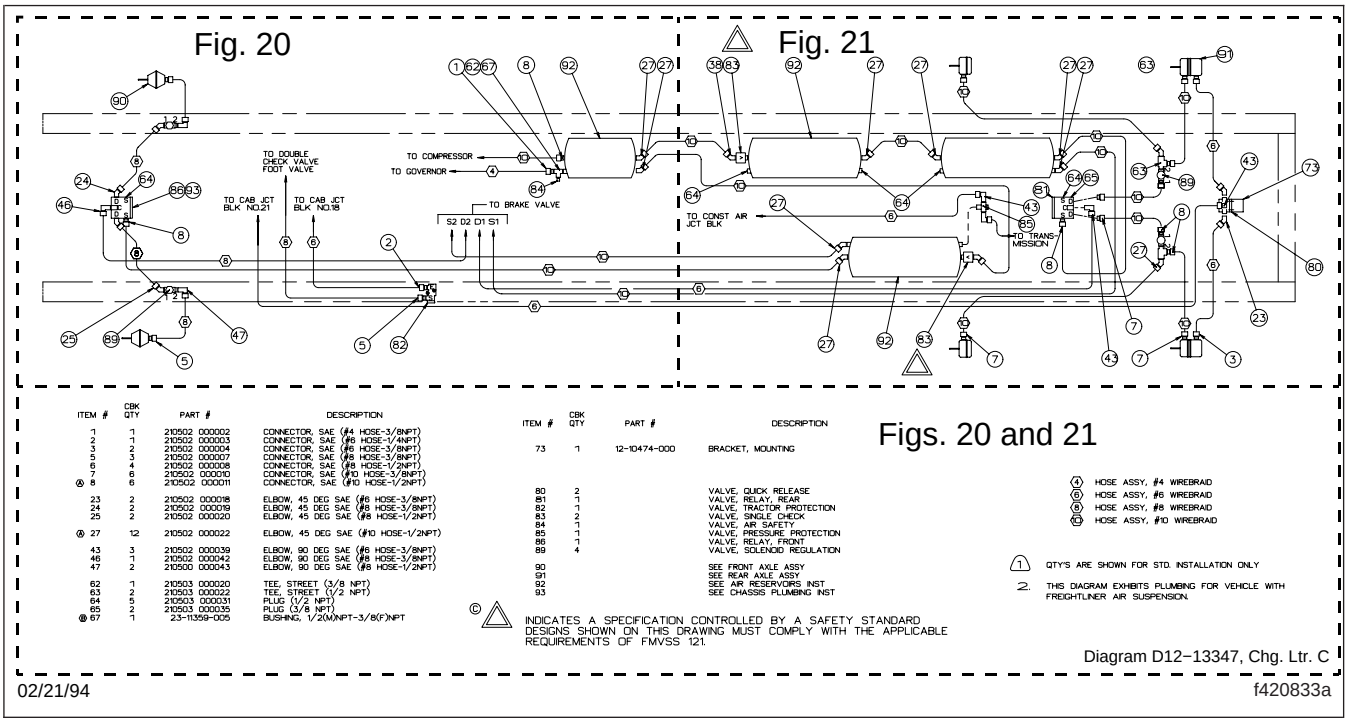
02/18/94

Diagram D12−13346, Chg. Ltr. C

f421168

Fig. 18

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	4	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	8	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Ⓐ 8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
Ⓐ 27	12	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210500 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

Figs. 20 and 21

Ⓐ HOSE ASSY, #4 WIREBRAID
Ⓑ HOSE ASSY, #6 WIREBRAID
Ⓒ HOSE ASSY, #8 WIREBRAID
Ⓓ HOSE ASSY, #10 WIREBRAID

1. QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER AIR SUSPENSION.

© INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121

Diagram D12−13347, Chg. Ltr. C

02/21/94 f420833a

Fig. 19, Wire Braid Hose, With Front Relay Valve, With Freightliner Air Suspension, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning

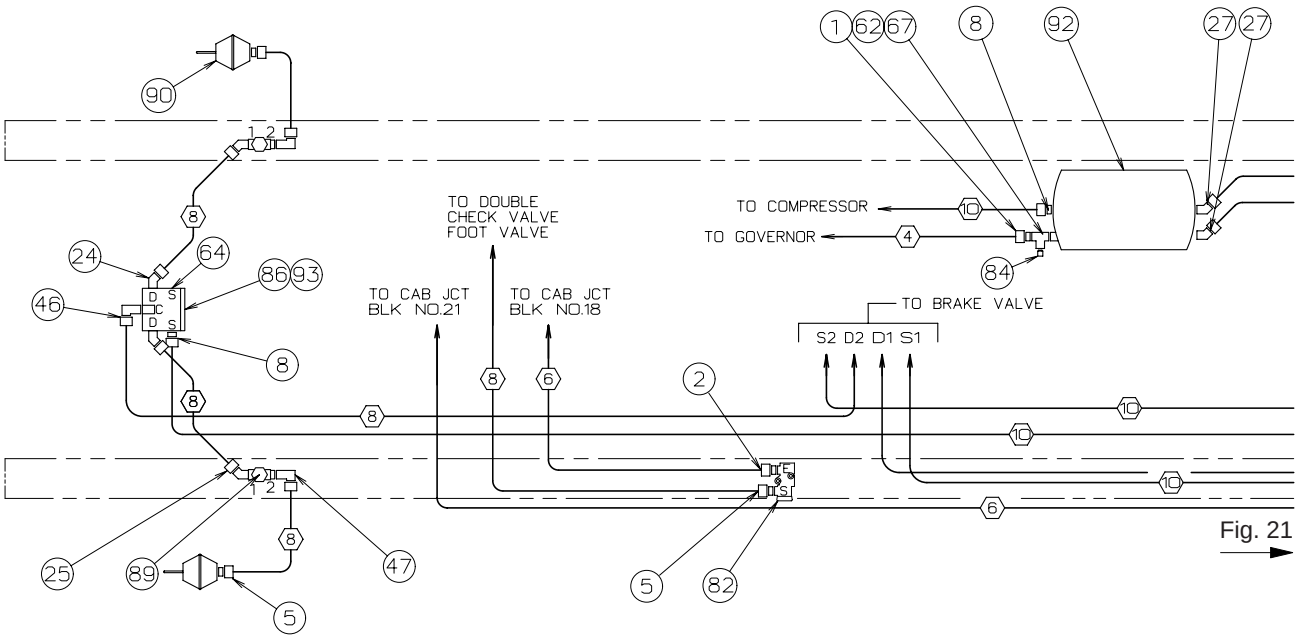


Fig. 21

ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	4	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Ⓐ 8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
Ⓐ 27	12	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210500 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

④	HOSE ASSY, #4 WIREBRAID
⑥	HOSE ASSY, #6 WIREBRAID
⑧	HOSE ASSY, #8 WIREBRAID
⑩	HOSE ASSY, #10 WIREBRAID

© INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

1. QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER AIR SUSPENSION.

Diagram D12−13347, Chg. Ltr. C

02/21/94

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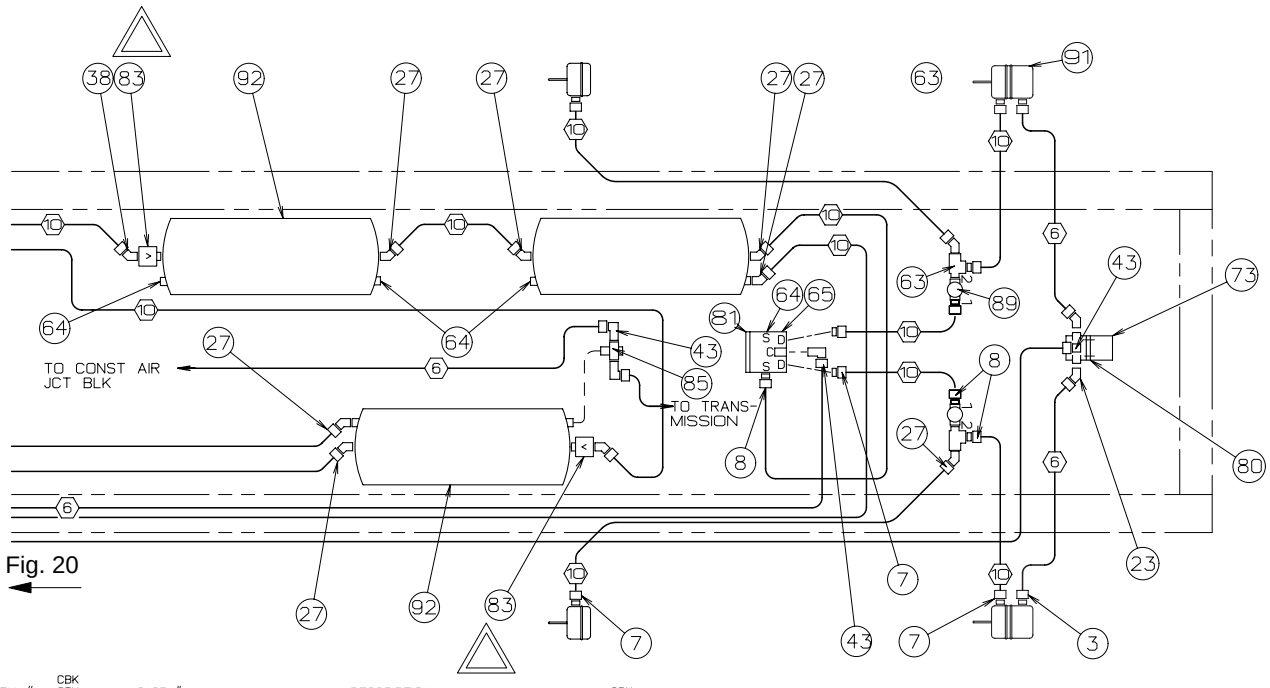
Fig. 20

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	4	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Ⓐ 8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
Ⓐ 27	12	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210500 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

④ HOSE ASSY, #4 WIREBRAID
⑥ HOSE ASSY, #6 WIREBRAID
⑧ HOSE ASSY, #8 WIREBRAID
⑩ HOSE ASSY, #10 WIREBRAID

1. QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER AIR SUSPENSION.

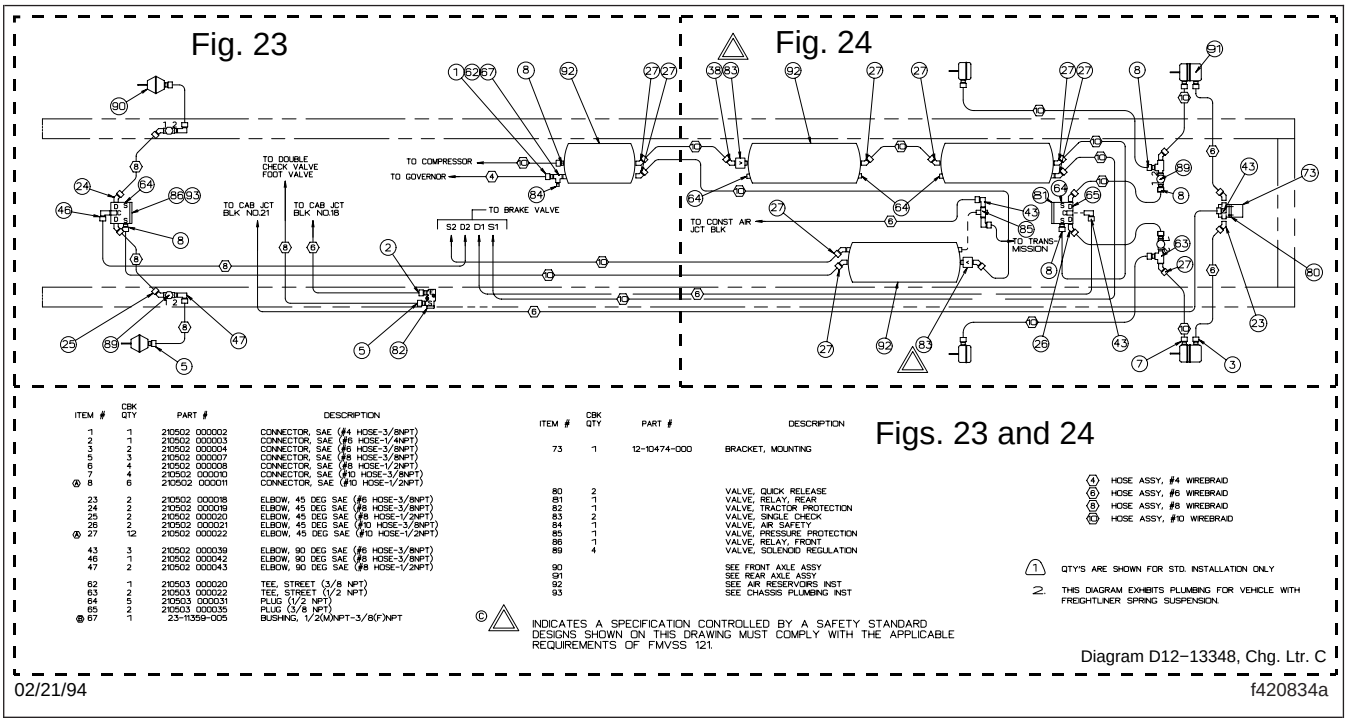
© INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−13347, Chg. Ltr. C

02/21/94 f421170

Fig. 21

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning

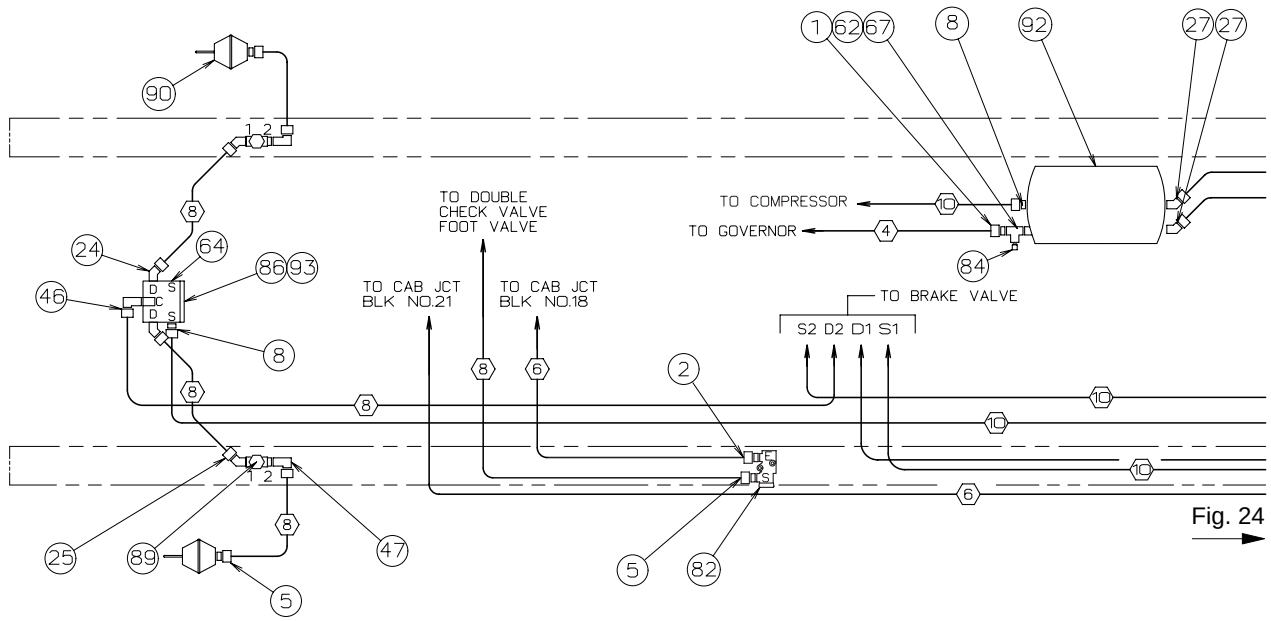


ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	4	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Ⓐ 8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
Ⓐ 27	12	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

Fig. 22, Wire Braid Hose, With Front Relay Valve, With Freightliner Spring Suspension, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	4	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Ⓐ 8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
Ⓐ 27	12	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

④ HOSE ASSY, #4 WIREBRAID
⑥ HOSE ASSY, #6 WIREBRAID
⑧ HOSE ASSY, #8 WIREBRAID
⑩ HOSE ASSY, #10 WIREBRAID

1. QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER SPRING SUSPENSION.

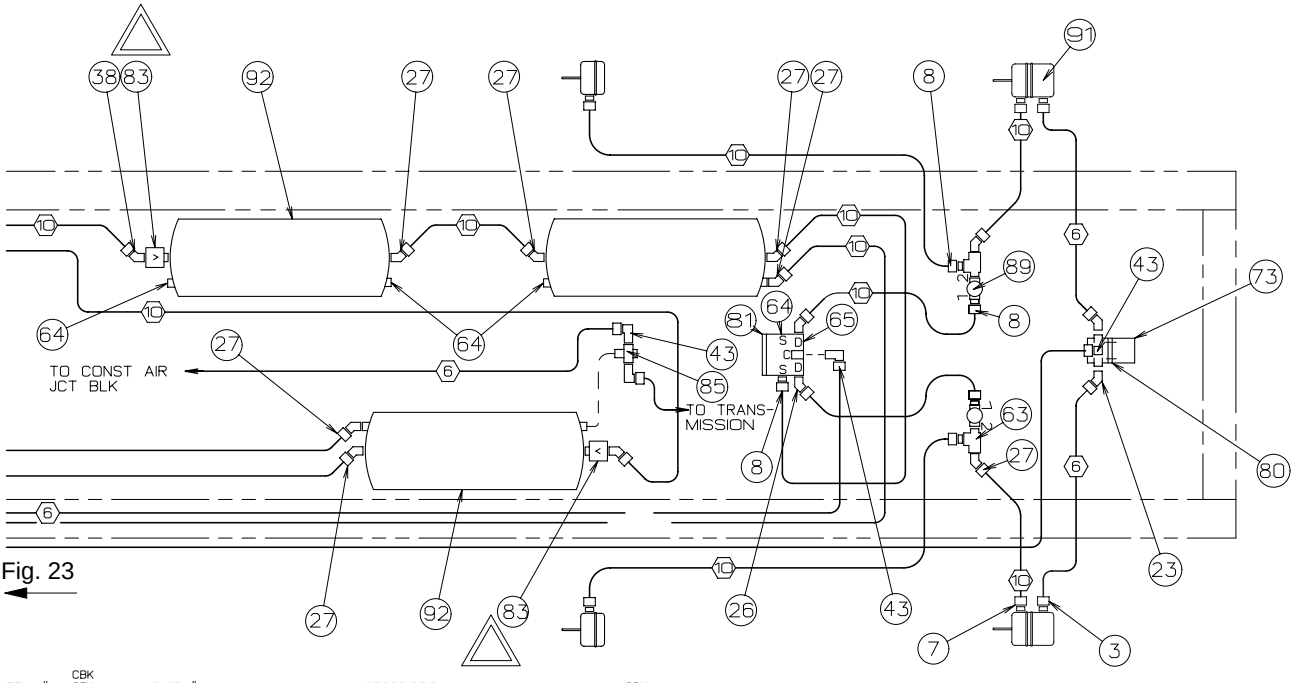
© INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−13348, Chg. Ltr. C

02/22/94 f421171

Fig. 23

Tandem Rear Axle Tractor, With Four-Channel Antilock, Without Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	3	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
6	4	210502 000008	CONNECTOR, SAE (#8 HOSE-1/2NPT)
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
Ⓐ 8	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
Ⓐ 27	12	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
43	3	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000022	TEE, STREET (1/2 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
65	2	210503 000035	PLUG (3/8 NPT)
Ⓑ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, RELAY, REAR
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRONT
89	4		VALVE, SOLENOID REGULATION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

④ HOSE ASSY, #4 WIREBRAID
⑥ HOSE ASSY, #6 WIREBRAID
⑧ HOSE ASSY, #8 WIREBRAID
⑩ HOSE ASSY, #10 WIREBRAID

Ⓒ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

1. QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY
2. THIS DIAGRAM EXHIBITS PLUMBING FOR VEHICLE WITH FREIGHTLINER SPRING SUSPENSION.

Diagram D12−13348, Chg. Ltr. C

02/22/94 f421172

Fig. 24

Tandem Rear Axle Tractor, With Four-Channel Antilock, With Brake Proportioning

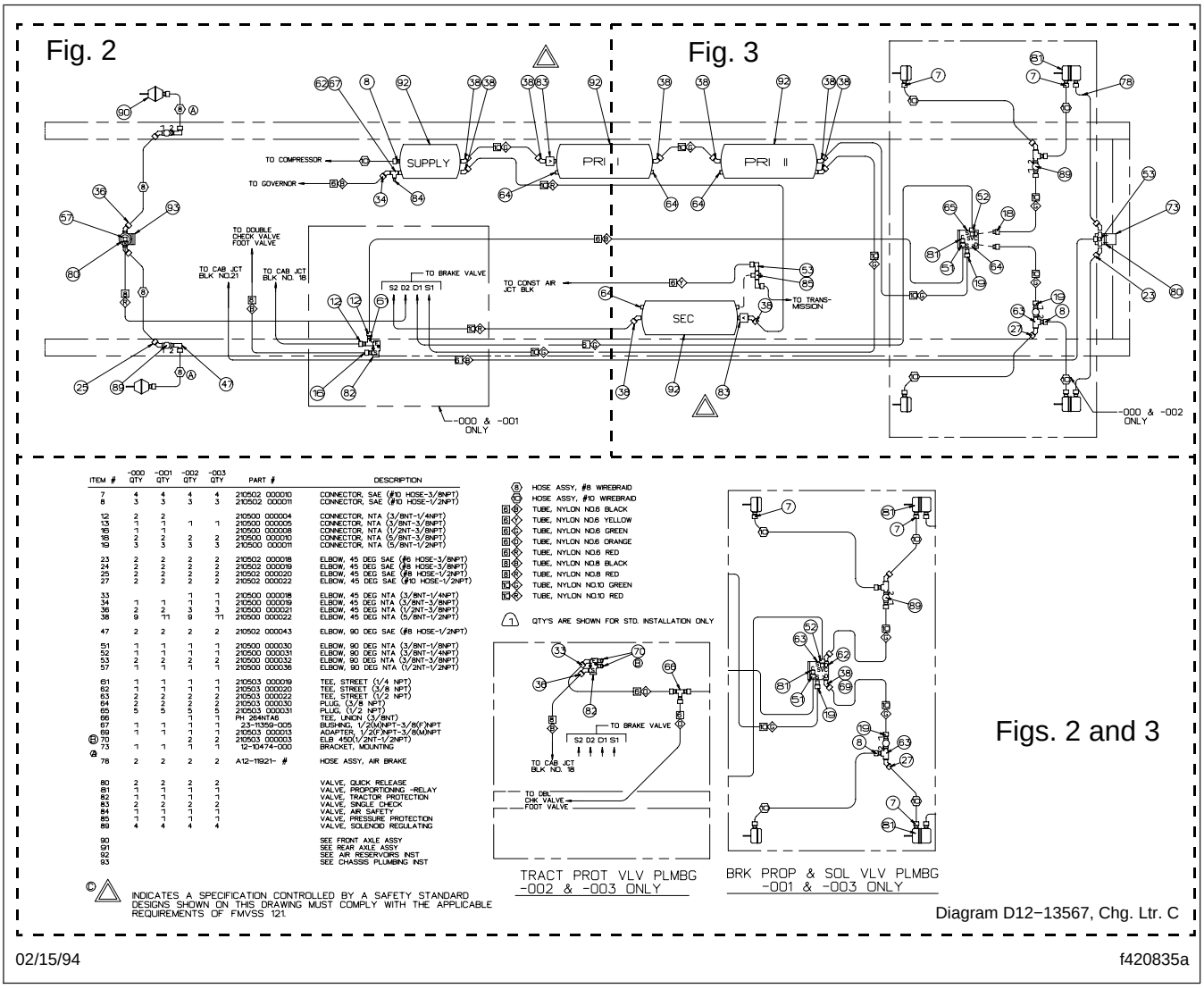
See **Fig. 1** for a full view of the plumbing diagram nylon tubing, with front quick release valve, date of use 7/89 to 4/91. See **Fig. 2**, or **Fig. 3** for partial (detailed) views plumbing diagram nylon tubing, with front quick release valve, date of use 7/89 to 4/91.

See **Fig. 4** for a full view of the plumbing diagram wire braid hose, with front quick release valve, date of use 7/89 to 4/91. See **Fig. 5**, or **Fig. 6** for partial (detailed) views plumbing diagram wire braid hose, with front quick release valve, date of use 7/89 to 4/91.

See **Fig. 7** for a full view of the plumbing diagram nylon tubing, with front relay valve, date of use 7/89 to 4/91. See **Fig. 8**, or **Fig. 9** for partial (detailed) views plumbing diagram nylon tubing, with front relay valve, date of use 7/89 to 4/91.

See **Fig. 10** for a full view of the plumbing diagram wire braid hose, with front relay valve, date of use 7/89 to 4/91. See **Fig. 11**, or **Fig. 12** for partial (detailed) views plumbing diagram wire braid hose, with front relay valve, date of use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Four-Channel Antilock, With Brake Proportioning



ITEM #	-000 QTY	-001 QTY	-002 QTY	-003 QTY	PART #	DESCRIPTION
7	4	4	4	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	3	3	3	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	2			210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	1	1	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	1			210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	2	2	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	3	3	3	3	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	2	2	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	2	2	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	2	2	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	2	2	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
33		1	1	1	210500 000018	ELBOW, 45 DEG NTA (3/8NT-1/4NPT)
34	1	1	1	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	2	2	3	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	9	11	9	11	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	2	2	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	1	1	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	1	1	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	2	2	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
57	1	1	1	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
61	1	1	1	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	1	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	2	2	2	210503 000022	TEE, STREET (1/2 NPT)
64	2	2	2	2	210503 000030	PLUG, (3/8 NPT)
65	5	5	5	5	210503 000031	PLUG, (1/2 NPT)
66			1	1	PH 264NTA6	TEE, UNION (3/8NT)
67	1	1	1	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	1	1	1	1	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT
Ⓑ 70	2	2	2	2	210503 000033	ELB 450(1/2NT-1/2NPT)
Ⓐ 73	1	1	1	1	12-10474-000	BRACKET, MOUNTING
78	2	2	2	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	2	2	2		VALVE, QUICK RELEASE
81	1	1	1	1		VALVE, PROPORTIONING -RELAY
82	1	1	1	1		VALVE, TRACTOR PROTECTION
83	2	2	2	2		VALVE, SINGLE CHECK
84	1	1	1	1		VALVE, AIR SAFETY
85	1	1	1	1		VALVE, PRESSURE PROTECTION
89	4	4	4	4		VALVE, SOLENOID REGULATING
90						SEE FRONT AXLE ASSY
91						SEE REAR AXLE ASSY
92						SEE AIR RESERVOIRS INST
93						SEE CHASSIS PLUMBING INST

Ⓑ	HOSE ASSY, #8 WIREBRAID
Ⓒ	HOSE ASSY, #10 WIREBRAID
[6]	TUBE, NYLON NO.6 BLACK
[6]	TUBE, NYLON NO.6 YELLOW
[6]	TUBE, NYLON NO.6 GREEN
[6]	TUBE, NYLON NO.6 ORANGE
[6]	TUBE, NYLON NO.6 RED
[8]	TUBE, NYLON NO.8 BLACK
[8]	TUBE, NYLON NO.8 RED
[10]	TUBE, NYLON NO.10 GREEN
[10]	TUBE, NYLON NO.10 RED

[1] QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

© INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−13567, Chg. Ltr. C

02/15/94 f420835a

Fig. 1, Nylon Tubing, With Front Quick Release Valve, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Four-Channel Antilock, With Brake Proportioning

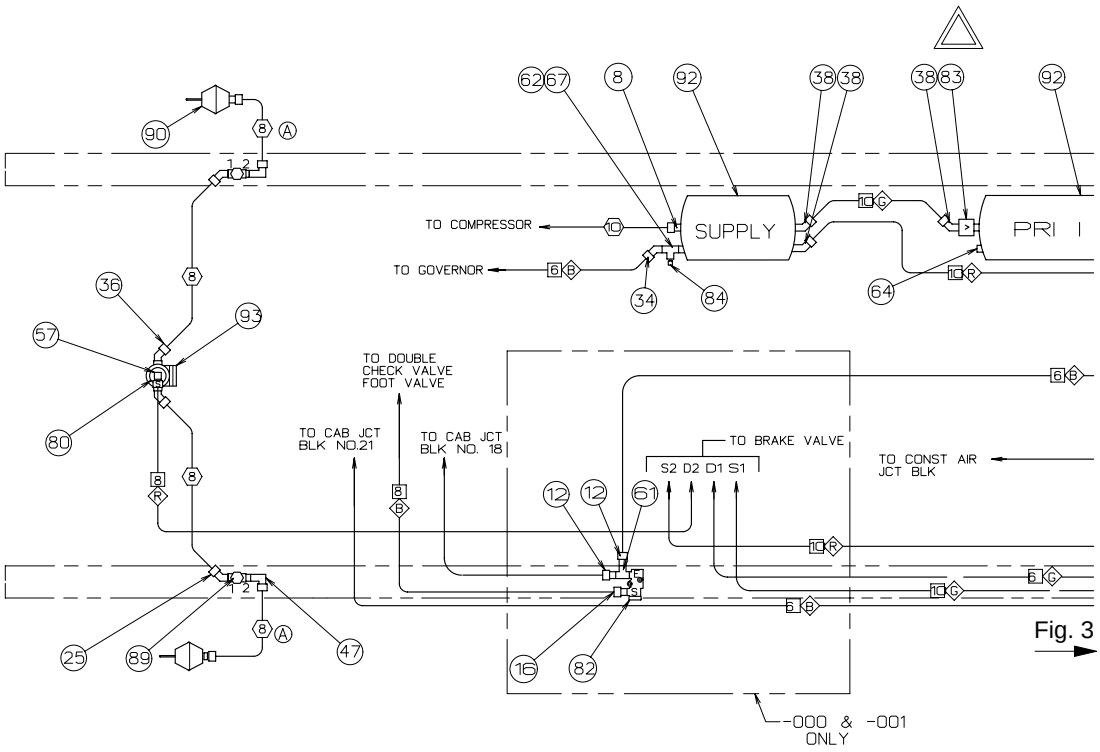


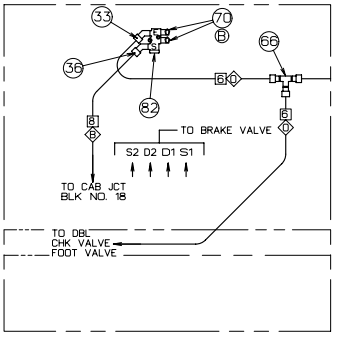
Fig. 3

ITEM #	-000 QTY	-001 QTY	-002 QTY	-003 QTY	PART #	DESCRIPTION
7	4	4	4	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	3	3	3	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	2			210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	1	1	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	1			210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	2	2	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	3	3	3	3	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	2	2	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	2	2	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	2	2	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	2	2	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
33			1	1	210500 000018	ELBOW, 45 DEG NTA (3/8NT-1/4NPT)
34	1	1	1	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	2	2	3	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	9	11	9	11	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	2	2	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	1	1	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	1	1	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	2	2	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
57	1	1	1	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
61	1	1	1	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	1	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	2	2	2	210503 000022	TEE, STREET (1/2 NPT)
64	2	2	2	2	210503 000030	PLUG, (3/8 NPT)
65	5	5	5	5	210503 000031	PLUG, (1/2 NPT)
66			1	1	PH 264NTA6	TEE, UNION (3/8NT)
67	1	1	1	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	1	1	1	1	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT
Ⓑ 70			2	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
73	1	1	1	1	12-10474-000	BRACKET, MOUNTING
Ⓐ 78	2	2	2	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	2	2	2		VALVE, QUICK RELEASE
81	1	1	1	1		VALVE, PROPORTIONING -RELAY
82	1	1	1	1		VALVE, TRACTOR PROTECTION
83	2	2	2	2		VALVE, SINGLE CHECK
84	1	1	1	1		VALVE, AIR SAFETY
85	1	1	1	1		VALVE, PRESSURE PROTECTION
89	4	4	4	4		VALVE, SOLENOID REGULATING
90						SEE FRONT AXLE ASSY
91						SEE REAR AXLE ASSY
92						SEE AIR RESERVOIRS INST
93						SEE CHASSIS PLUMBING INST

Ⓒ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6	TUBE, NYLON NO.6 BLACK
6	TUBE, NYLON NO.6 YELLOW
6	TUBE, NYLON NO.6 GREEN
6	TUBE, NYLON NO.6 ORANGE
6	TUBE, NYLON NO.6 RED
8	TUBE, NYLON NO.8 BLACK
8	TUBE, NYLON NO.8 RED
10	TUBE, NYLON NO.10 GREEN
10	TUBE, NYLON NO.10 RED

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY



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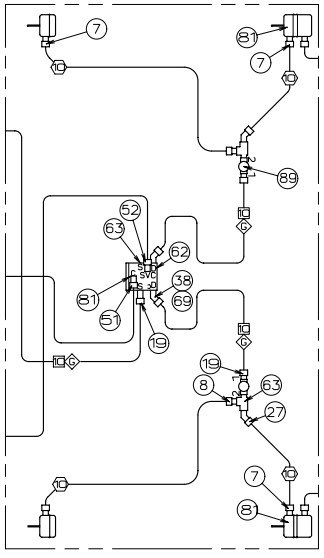

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Diagram D12−13567, Chg. Ltr. C

02/16/94 f421114

Fig. 2

Tandem Rear Axle Tractor, With Four-Channel Antilock, With Brake Proportioning

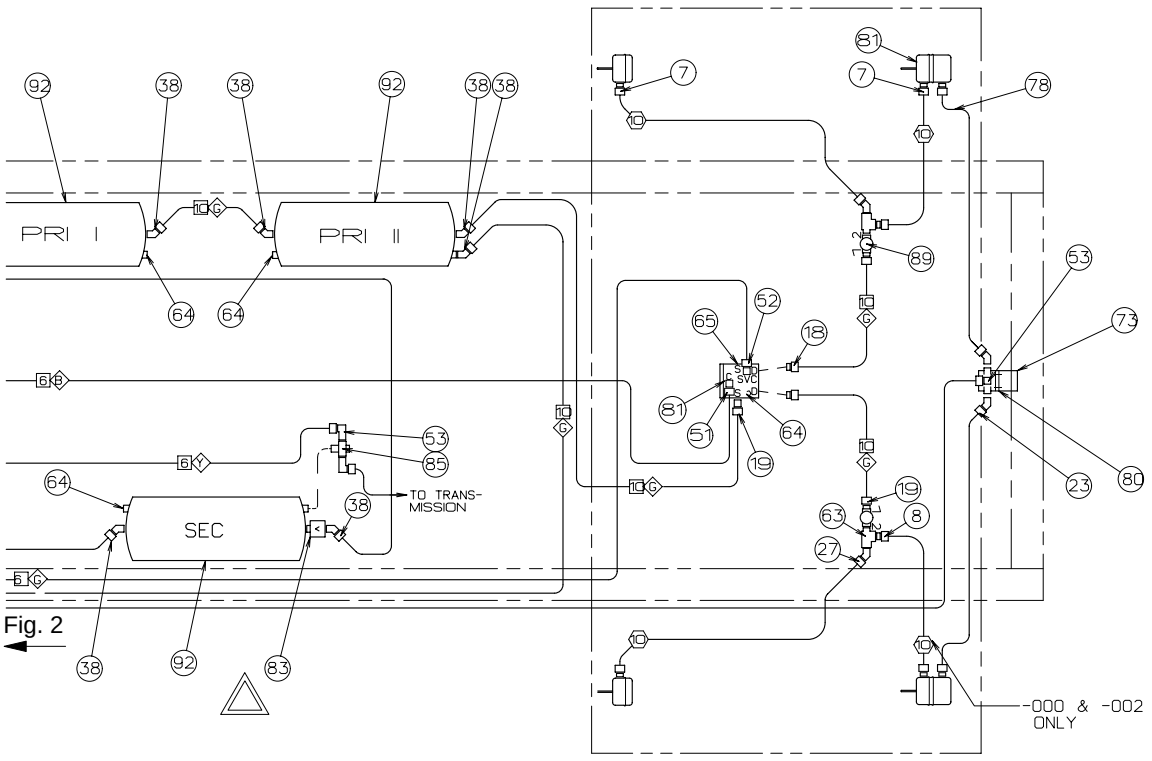


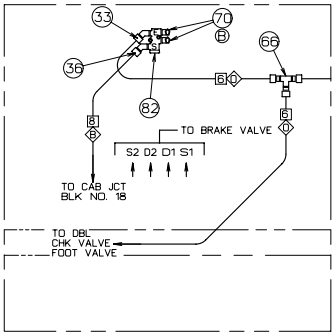
Fig. 2

ITEM #	-000 QTY	-001 QTY	-002 QTY	-003 QTY	PART #	DESCRIPTION
7	4	4	4	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	3	3	3	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	2			210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	1	1	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	1			210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	2	2	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	3	3	3	3	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	2	2	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	2	2	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	2	2	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	2	2	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
33			1	1	210500 000018	ELBOW, 45 DEG NTA (3/8NT-1/4NPT)
34	1	1	1	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	2	2	3	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	9	11	9	11	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	2	2	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	1	1	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	1	1	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	2	2	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
57	1	1	1	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
61	1	1	1	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	1	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	2	2	2	210503 000022	TEE, STREET (1/2 NPT)
64	2	2	2	2	210503 000030	PLUG, (3/8 NPT)
65	5	5	5	5	210503 000031	PLUG, (1/2 NPT)
66			1	1	PH 264NTA6	TEE, UNION (3/8NT)
67	1	1	1	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	1	1	1	1	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT
B 70			2	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
73	1	1	1	1	12-10474-000	BRACKET, MOUNTING
A 78	2	2	2	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	2	2	2		VALVE, QUICK RELEASE
81	1	1	1	1		VALVE, PROPORTIONING -RELAY
82	1	1	1	1		VALVE, TRACTOR PROTECTION
83	2	2	2	2		VALVE, SINGLE CHECK
84	1	1	1	1		VALVE, AIR SAFETY
85	1	1	1	1		VALVE, PRESSURE PROTECTION
89	4	4	4	4		VALVE, SOLENOID REGULATING
90						SEE FRONT AXLE ASSY
91						SEE REAR AXLE ASSY
92						SEE AIR RESERVOIRS INST
93						SEE CHASSIS PLUMBING INST

© INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

8 HOSE ASSY, #8 WIREBRAID
10 HOSE ASSY, #10 WIREBRAID
6B TUBE, NYLON NO.6 BLACK
6Y TUBE, NYLON NO.6 YELLOW
6G TUBE, NYLON NO.6 GREEN
6O TUBE, NYLON NO.6 ORANGE
6R TUBE, NYLON NO.6 RED
8B TUBE, NYLON NO.8 BLACK
8R TUBE, NYLON NO.8 RED
10G TUBE, NYLON NO.10 GREEN
10R TUBE, NYLON NO.10 RED

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY



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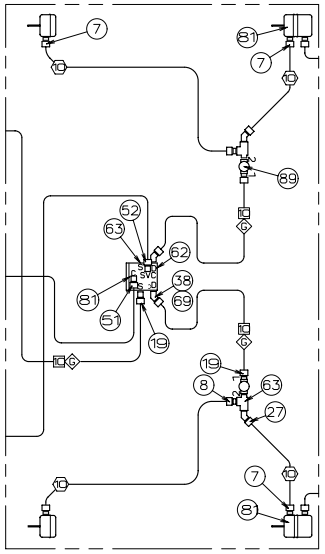
-002 & -003 ONLY



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-001 & -003 ONLY

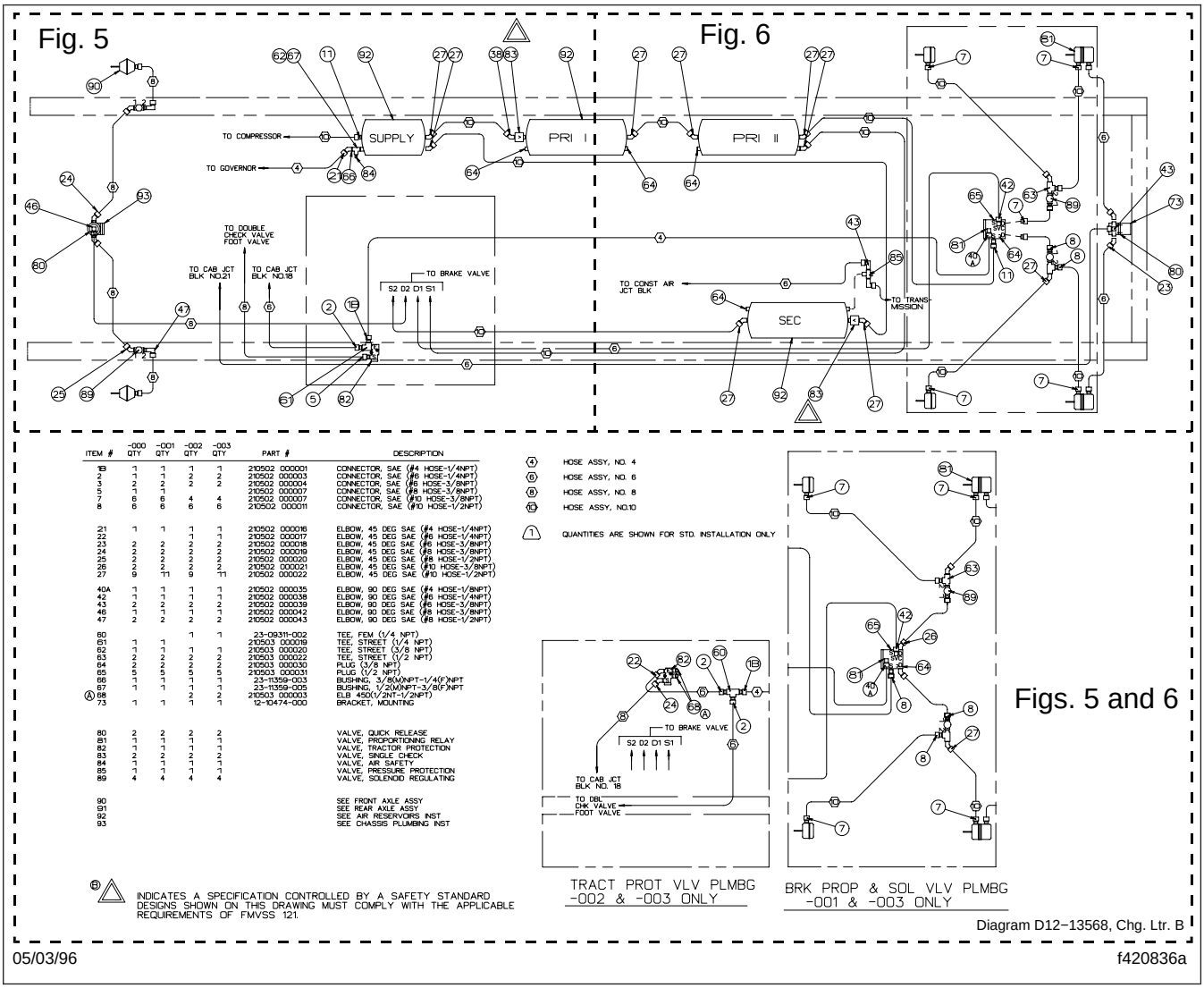
Diagram D12−13567, Chg. Ltr. C

02/16/94

f421115

Fig. 3

Tandem Rear Axle Tractor, With Four-Channel Antilock, With Brake Proportioning



ITEM #	-000 QTY	-001 QTY	-002 QTY	-003 QTY	PART #	DESCRIPTION
1B	1	1	1	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	1	2	2	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	2	2	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	1	1			210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
7	6	6	4	4	210502 000007	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	6	6	6	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	1	1	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22			1	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	2	2	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	2	2	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	2	2	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	2	2	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	9	11	9	11	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	1	1	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	1	1	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	2	2	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	1	1	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	2	2	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60			1	1	23-09311-002	TEE, FEM (1/4 NPT)
61	1	1	1	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	1	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	2	2	2	210503 000022	TEE, STREET (1/2 NPT)
64	2	2	2	2	210503 000030	PLUG (3/8 NPT)
65	5	5	5	5	210503 000031	PLUG (1/2 NPT)
66	1	1	1	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	1	1	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
(A) 68			2	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
73	1	1	1	1	12-10474-000	BRACKET, MOUNTING
80	2	2	2	2		VALVE, QUICK RELEASE
81	1	1	1	1		VALVE, PROPORTIONING RELAY
82	1	1	1	1		VALVE, TRACTOR PROTECTION
83	2	2	2	2		VALVE, SINGLE CHECK
84	1	1	1	1		VALVE, AIR SAFETY
85	1	1	1	1		VALVE, PRESSURE PROTECTION
89	4	4	4	4		VALVE, SOLENOID REGULATING
90						SEE FRONT AXLE ASSY
91						SEE REAR AXLE ASSY
92						SEE AIR RESERVOIRS INST
93						SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

(A) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Fig. 4, Wire Braid Hose, With Front Quick Release Valve, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Four-Channel Antilock, With Brake Proportioning

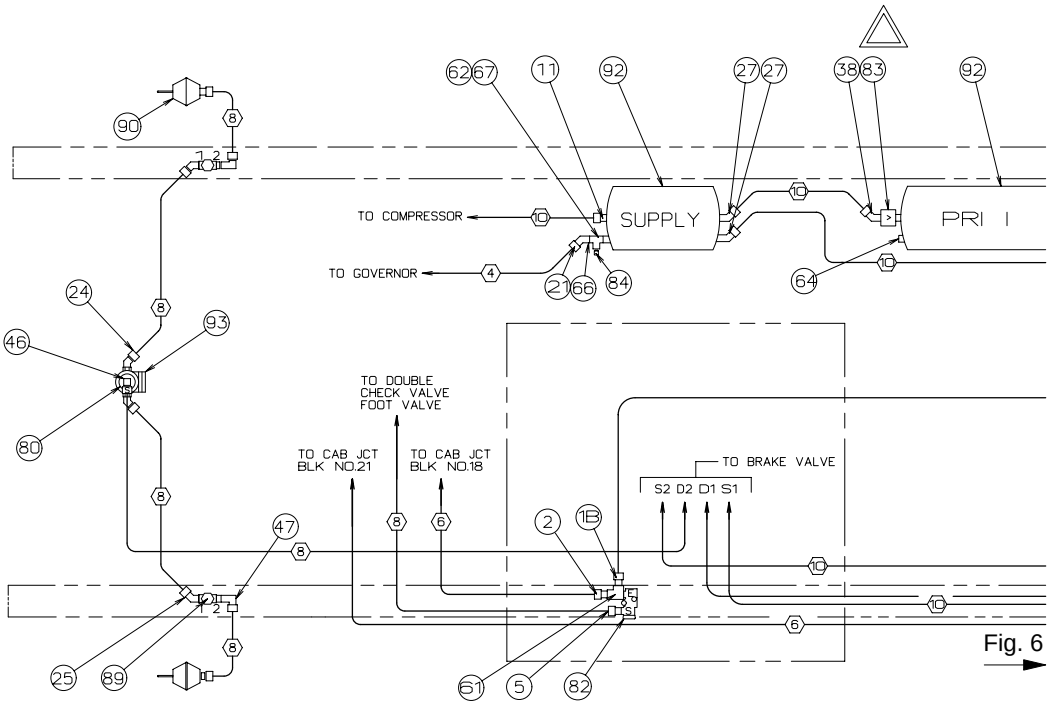
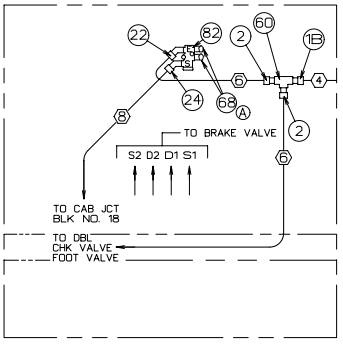


Fig. 6

ITEM #	-000 QTY	-001 QTY	-002 QTY	-003 QTY	PART #	DESCRIPTION
1B	1	1	1	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	1	2	2	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	2	2	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	1	1			210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
7	6	6	4	4	210502 000007	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	6	6	6	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	1	1	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22			1	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	2	2	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	2	2	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	2	2	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	2	2	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	9	11	9	11	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	1	1	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	1	1	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	2	2	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	1	1	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	2	2	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60			1	1	23-09311-002	TEE, FEM (1/4 NPT)
61	1	1			210503 000019	TEE, STREET (1/4 NPT)
62	1	1	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	2	2	2	210503 000022	TEE, STREET (1/2 NPT)
64	2	2	2	2	210503 000030	PLUG (3/8 NPT)
65	5	5	5	5	210503 000031	PLUG (1/2 NPT)
66	1	1	1	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	1	1	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
Ⓐ 68			2	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
73	1	1	1	1	12-10474-000	BRACKET, MOUNTING
80	2	2	2	2		VALVE, QUICK RELEASE
81	1	1	1	1		VALVE, PROPORTIONING RELAY
82	1	1	1	1		VALVE, TRACTOR PROTECTION
83	2	2	2	2		VALVE, SINGLE CHECK
84	1	1	1	1		VALVE, AIR SAFETY
85	1	1	1	1		VALVE, PRESSURE PROTECTION
89	4	4	4	4		VALVE, SOLENOID REGULATING
90						SEE FRONT AXLE ASSY
91						SEE REAR AXLE ASSY
92						SEE AIR RESERVOIRS INST
93						SEE CHASSIS PLUMBING INST

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY



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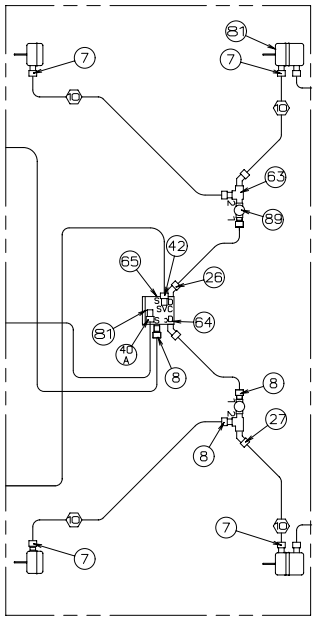

BRK PROP & SOL VLV PLMBG -001 & -003 ONLY

Ⓑ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−13568, Chg. Ltr. B

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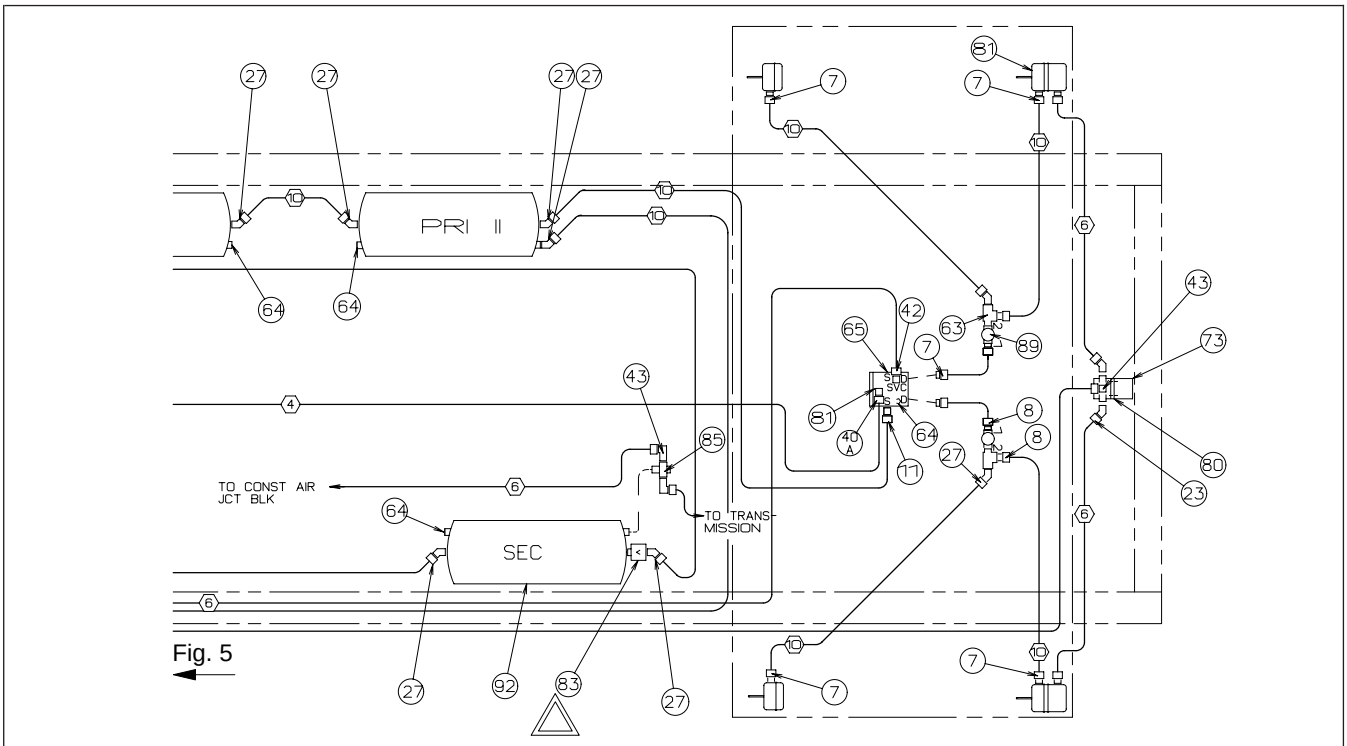
Fig. 5

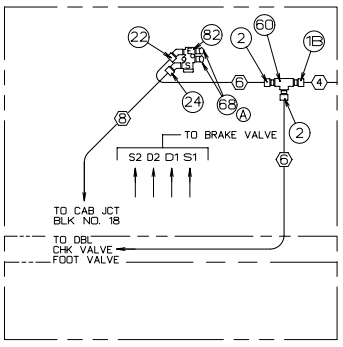
Tandem Rear Axle Tractor, With Four-Channel Antilock, With Brake Proportioning



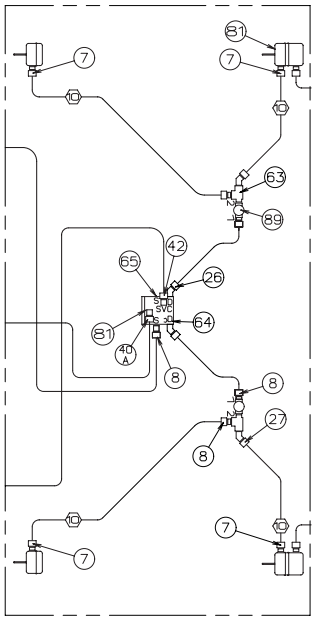
ITEM #	-000 QTY	-001 QTY	-002 QTY	-003 QTY	PART #	DESCRIPTION
1B	1	1	1	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	1	2	2	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	2	2	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	1	1			210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
7	6	6	4	4	210502 000007	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	6	6	6	6	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	1	1	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22			1	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	2	2	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	2	2	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	2	2	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	2	2	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	9	11	9	11	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	1	1	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	1	1	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	2	2	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	1	1	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	2	2	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60			1	1	23-09311-002	TEE, FEM (1/4 NPT)
61	1	1			210503 000019	TEE, STREET (1/4 NPT)
62	1	1	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	2	2	2	210503 000022	TEE, STREET (1/2 NPT)
64	2	2	2	2	210503 000030	PLUG (3/8 NPT)
65	5	5	5	5	210503 000031	PLUG (1/2 NPT)
66	1	1	1	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	1	1	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
Ⓐ 68			2	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
73	1	1	1	1	12-10474-000	BRACKET, MOUNTING
80	2	2	2	2		VALVE, QUICK RELEASE
81	1	1	1	1		VALVE, PROPORTIONING RELAY
82	1	1	1	1		VALVE, TRACTOR PROTECTION
83	2	2	2	2		VALVE, SINGLE CHECK
84	1	1	1	1		VALVE, AIR SAFETY
85	1	1	1	1		VALVE, PRESSURE PROTECTION
89	4	4	4	4		VALVE, SOLENOID REGULATING
90						SEE FRONT AXLE ASSY
91						SEE REAR AXLE ASSY
92						SEE AIR RESERVOIRS INST
93						SEE CHASSIS PLUMBING INST

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

① QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY



TRACT PROT VLV PLMBG -002 & -003 ONLY



BRK PROP & SOL VLV PLMBG -001 & -003 ONLY

Ⓑ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−13568, Chg. Ltr. B

02/16/94

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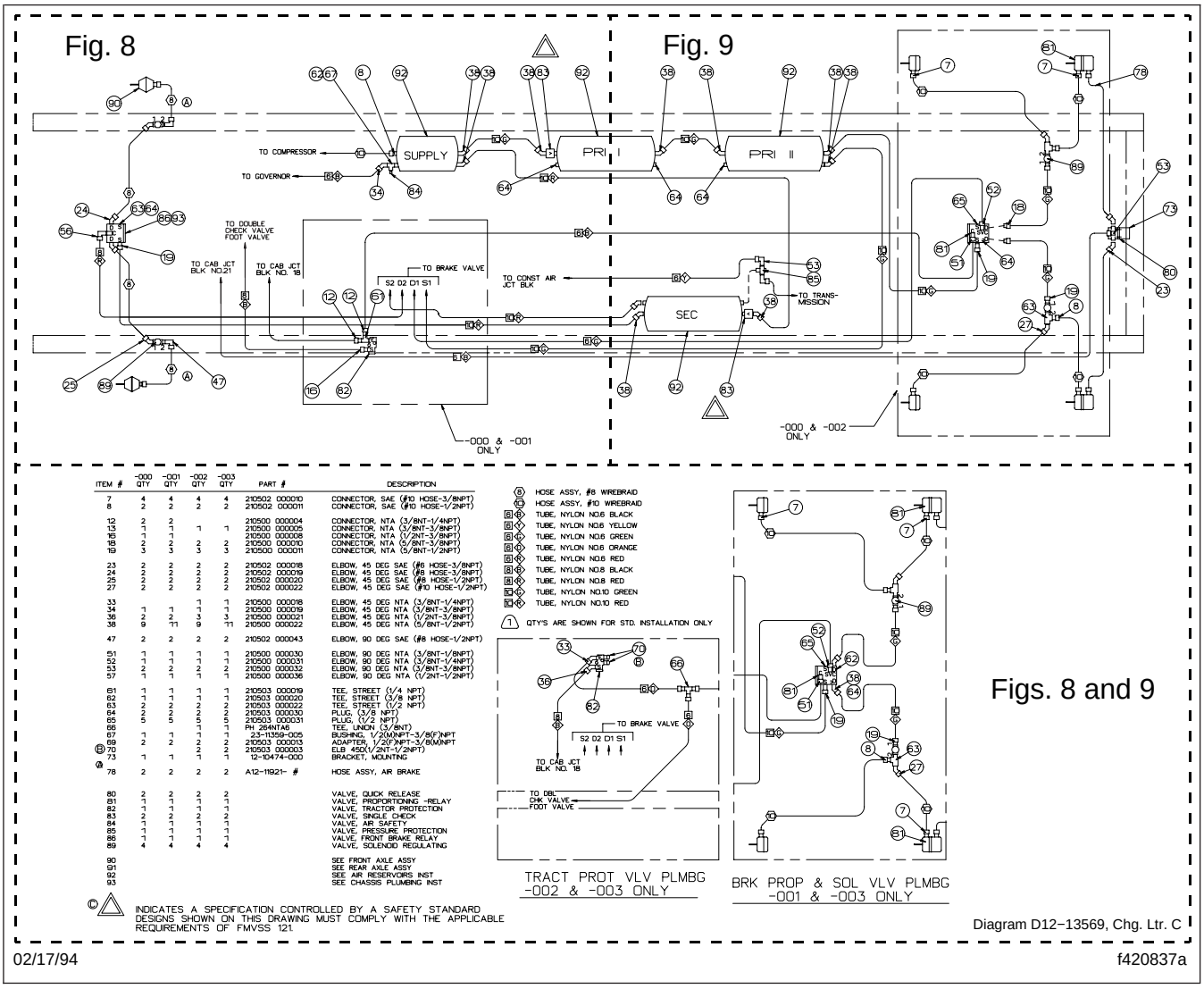
Fig. 6

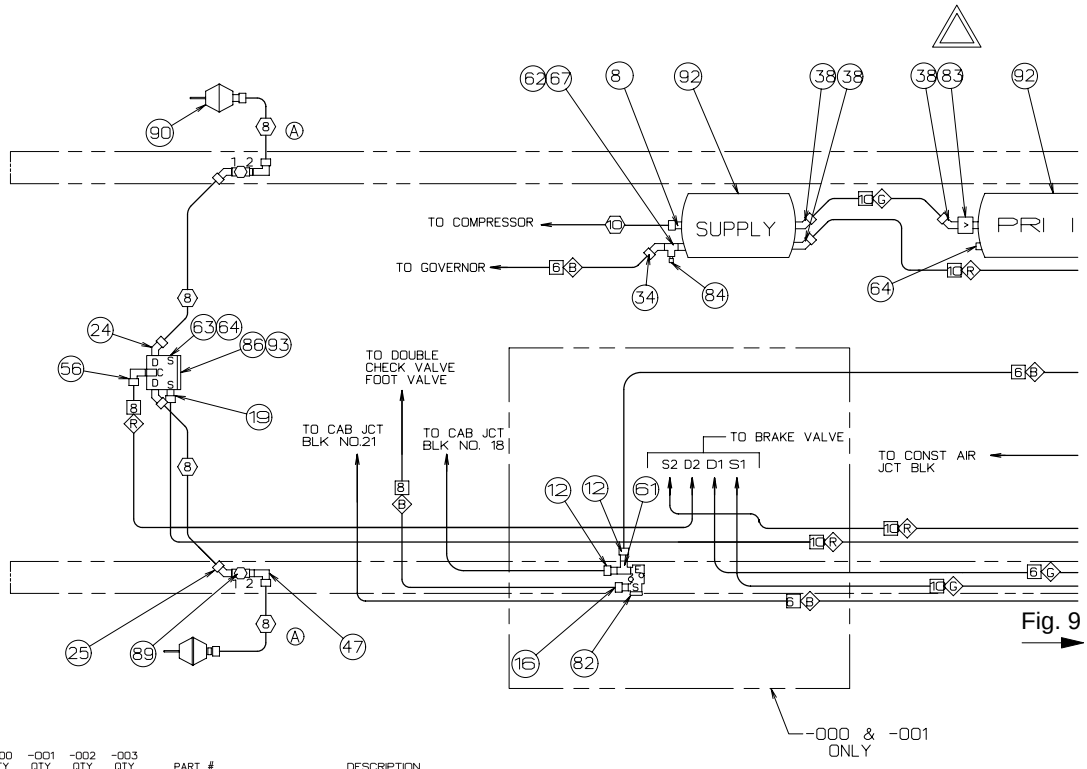
Tandem Rear Axle Tractor, With Four-Channel Antilock, With Brake Proportioning



ITEM #	-000 QTY	-001 QTY	-002 QTY	-003 QTY	PART #	DESCRIPTION
7	4	4	4	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	2	2	2	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	2			210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	1	1	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	1			210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	2	2	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	3	3	3	3	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	2	2	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	2	2	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	2	2	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	2	2	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
33			1	1	210500 000018	ELBOW, 45 DEG NTA (3/8NT-1/4NPT)
34	1	1	1	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	2	2	3	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	9	11	9	11	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	2	2	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	1	1	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	1	1	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	2	2	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
57	1	1	1	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
61	1	1	1	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	1	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	2	2	2	210503 000022	TEE, STREET (1/2 NPT)
64	2	2	2	2	210503 000030	PLUG, (3/8 NPT)
65	5	5	5	5	210503 000031	PLUG, (1/2 NPT)
66			1	1	PH 264NTA6	TEE, UNION (3/8NPT)
67	1	1	1	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
68	2	2	2	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT
B 70	2		2	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
Ⓐ 73	1	1	1	1	12-10474-000	BRACKET, MOUNTING
78	2	2	2	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	2	2	2		VALVE, QUICK RELEASE
81	1	1	1	1		VALVE, PROPORTIONING -RELAY
82	1	1	1	1		VALVE, TRACTOR PROTECTION
83	2	2	2	2		VALVE, SINGLE CHECK
84	1	1	1	1		VALVE, AIR SAFETY
85	1	1	1	1		VALVE, PRESSURE PROTECTION
86	1	1	1	1		VALVE, FRONT BRAKE RELAY
89	4	4	4	4		VALVE, SOLENOID REGULATING
90						SEE FRONT AXLE ASSY
91						SEE REAR AXLE ASSY
92						SEE AIR RESERVOIRS INST
93						SEE CHASSIS PLUMBING INST

Fig. 7, Nylon Tubing, With Front Relay Valve, Date of Use 7/89 to 4/91.

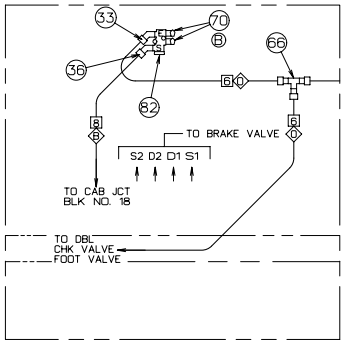
Tandem Rear Axle Tractor, With Four-Channel Antilock, With Brake Proportioning



ITEM #	-000 QTY	-001 QTY	-002 QTY	-003 QTY	PART #	DESCRIPTION
7	4	4	4	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	2	2	2	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	2			210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	1	1	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	1			210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	2	2	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	3	3	3	3	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	2	2	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	2	2	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	2	2	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	2	2	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
33			1	1	210500 000018	ELBOW, 45 DEG NTA (3/8NT-1/4NPT)
34	1	1	1	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	2	2	3	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	9	11	9	11	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	2	2	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	1	1	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	1	1	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	2	2	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
57	1	1	1	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
61	1	1	1	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	1	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	2	2	2	210503 000022	TEE, STREET (1/2 NPT)
64	2	2	2	2	210503 000030	PLUG, (3/8 NPT)
65	5	5	5	5	210503 000031	PLUG, (1/2 NPT)
66			1	1	PH 264NTA6	TEE, UNION (3/8NT)
67	1	1	1	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	2	2	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT
Ⓑ 70			2	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
73	1	1	1	1	12-10474-000	BRACKET, MUNTING
Ⓐ 78	2	2	2	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	2	2	2		VALVE, QUICK RELEASE
81	1	1	1	1		VALVE, PROPORTIONING -RELAY
82	1	1	1	1		VALVE, TRACTOR PROTECTION
83	2	2	2	2		VALVE, SINGLE CHECK
84	1	1	1	1		VALVE, AIR SAFETY
85	1	1	1	1		VALVE, PRESSURE PROTECTION
86	1	1	1	1		VALVE, FRONT BRAKE RELAY
89	4	4	4	4		VALVE, SOLENOID REGULATING
90						SEE FRONT AXLE ASSY
91						SEE REAR AXLE ASSY
92						SEE AIR RESERVOIRS INST
93						SEE CHASSIS PLUMBING INST

(8)	HOSE ASSY, #8 WIREBRAID
(10)	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY



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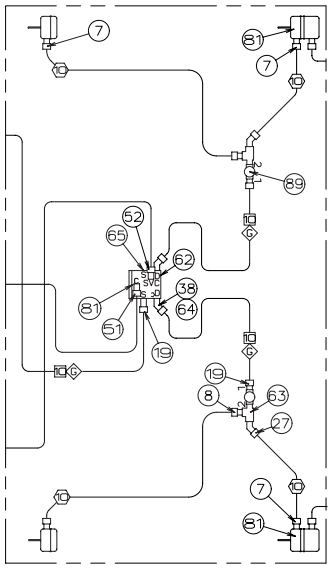

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Diagram D12−13569, Chg. Ltr. C

02/17/94

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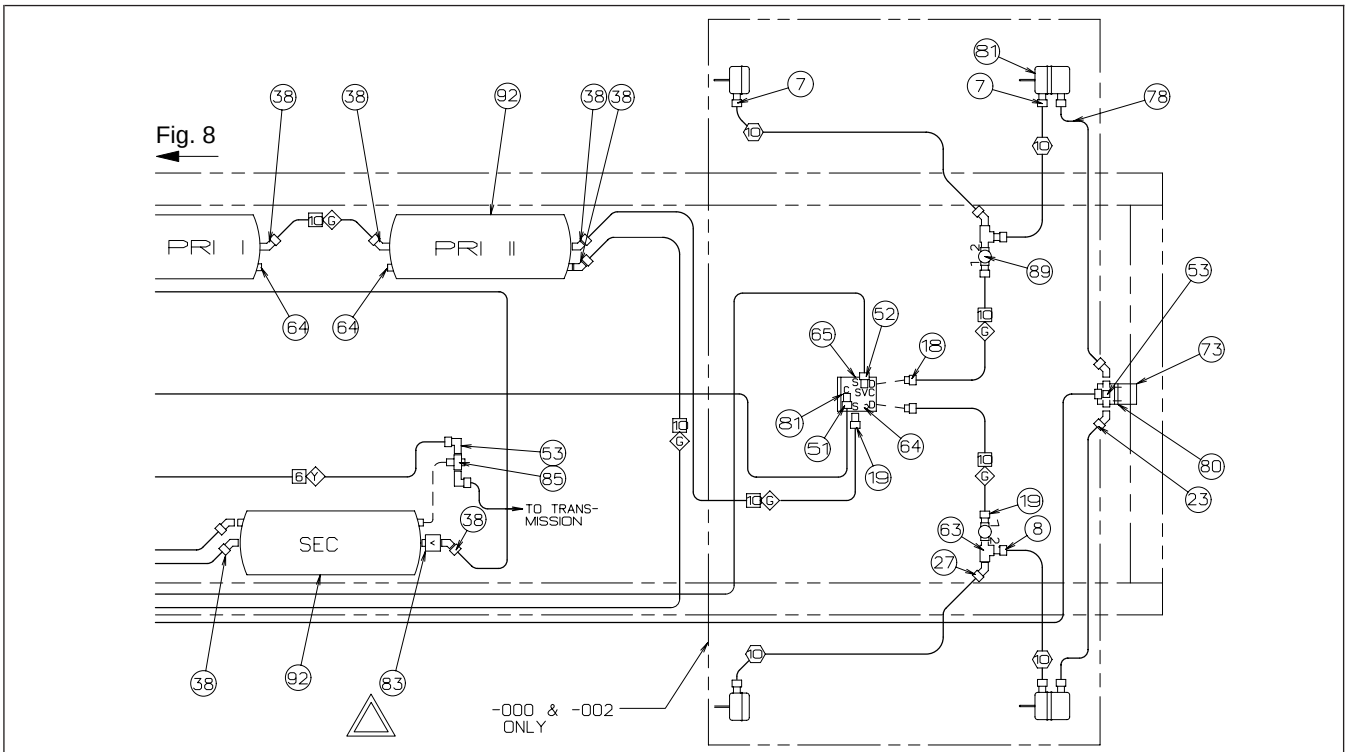
Fig. 8

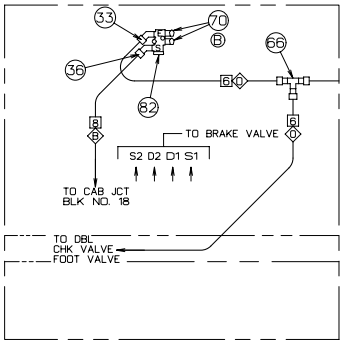
Tandem Rear Axle Tractor, With Four-Channel Antilock, With Brake Proportioning



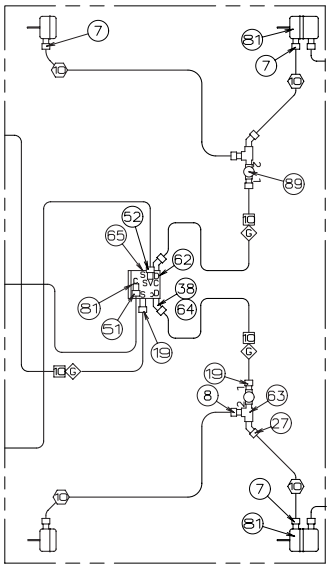
ITEM #	-000 QTY	-001 QTY	-002 QTY	-003 QTY	PART #	DESCRIPTION
7	4	4	4	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	2	2	2	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	2			210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	1	1	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	1			210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	2	2	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	3	3	3	3	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	2	2	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	2	2	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	2	2	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	2	2	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
33			1	1	210500 000018	ELBOW, 45 DEG NTA (3/8NT-1/4NPT)
34	1	1	1	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	2	2	3	3	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	9	11	9	11	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	2	2	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	1	1	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	1	1	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	2	2	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
57	1	1	1	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
61	1	1	1	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	1	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	2	2	2	210503 000022	TEE, STREET (1/2 NPT)
64	2	2	2	2	210503 000030	PLUG, (3/8 NPT)
65	5	5	5	5	210503 000031	PLUG, (1/2 NPT)
66			1	1	PH 264NTA6	TEE, UNION (3/8NT)
67	1	1	1	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	2	2	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT
(B) 70			2	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
73	1	1	1	1	12-10474-000	BRACKET, MOUNTING
(A) 78	2	2	2	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2	2	2	2		VALVE, QUICK RELEASE
81	1	1	1	1		VALVE, PROPORTIONING -RELAY
82	1	1	1	1		VALVE, TRACTOR PROTECTION
83	2	2	2	2		VALVE, SINGLE CHECK
84	1	1	1	1		VALVE, AIR SAFETY
85	1	1	1	1		VALVE, PRESSURE PROTECTION
86	1	1	1	1		VALVE, FRONT BRAKE RELAY
89	4	4	4	4		VALVE, SOLENOID REGULATING
90						SEE FRONT AXLE ASSY
91						SEE REAR AXLE ASSY
92						SEE AIR RESERVOIRS INST
93						SEE CHASSIS PLUMBING INST

(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID
6R TUBE, NYLON NO.6 BLACK
6Y TUBE, NYLON NO.6 YELLOW
6G TUBE, NYLON NO.6 GREEN
6O TUBE, NYLON NO.6 ORANGE
6R TUBE, NYLON NO.6 RED
8R TUBE, NYLON NO.8 BLACK
8R TUBE, NYLON NO.8 RED
10G TUBE, NYLON NO.10 GREEN
10R TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY



TRACT PROT VLV PLMBG -002 & -003 ONLY



BRK PROP & SOL VLV PLMBG -001 & -003 ONLY

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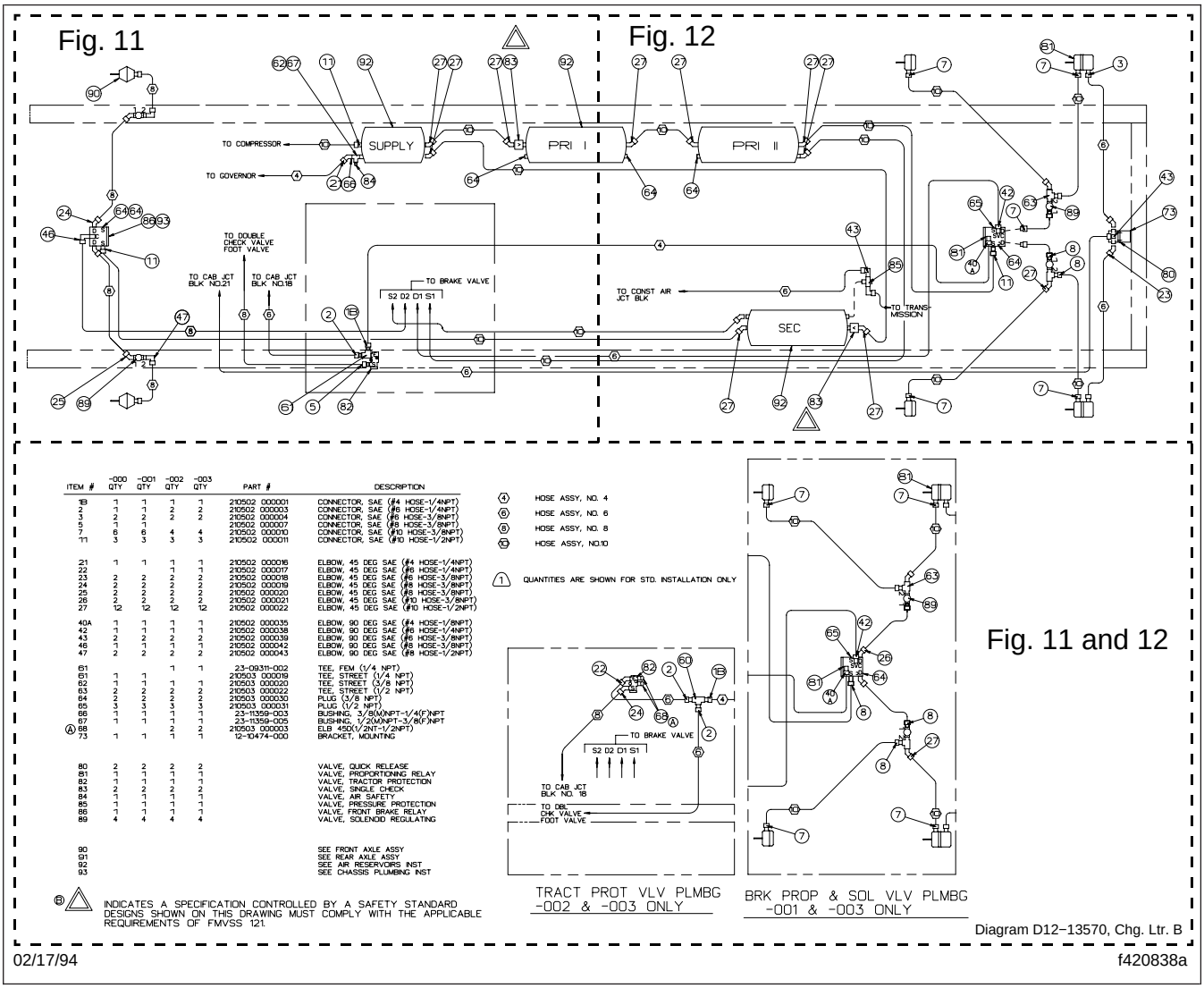
Diagram D12−13569, Chg. Ltr. C

02/17/94 f421161

Fig. 9

Tandem Rear Axle Tractor, With Four-Channel Antilock, With Brake Proportioning



ITEM #	-000 QTY	-001 QTY	-002 QTY	-003 QTY	PART #	DESCRIPTION
1B	1	1	1	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	1	2	2	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	2	2	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	1	1			210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
7	6	6	4	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	3	3	3	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	1	1	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22			1	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	2	2	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	2	2	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	2	2	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
26	2	2	2	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	12	12	12	12	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	1	1	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	1	1	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	2	2	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	1	1	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	2	2	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61			1	1	23-09311-002	TEE, FEM (1/4 NPT)
62	1	1			210503 000019	TEE, STREET (1/4 NPT)
63	1	1	1	1	210503 000020	TEE, STREET (3/8 NPT)
64	2	2	2	2	210503 000022	TEE, STREET (1/2 NPT)
65	3	3	3	3	210503 000030	PLUG (3/8 NPT)
66	1	1	1	1	210503 000031	PLUG (1/2 NPT)
67	1	1	1	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
Ⓐ 68			2	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
73	1	1	1	1	210503 000003	ELB 45D(1/2NT-1/2NPT)
					12-10474-000	BRACKET, MOUNTING
80	2	2	2	2		VALVE, QUICK RELEASE
81	1	1	1	1		VALVE, PROPORTIONING RELAY
82	1	1	1	1		VALVE, TRACTOR PROTECTION
83	2	2	2	2		VALVE, SINGLE CHECK
84	1	1	1	1		VALVE, AIR SAFETY
85	1	1	1	1		VALVE, PRESSURE PROTECTION
86	1	1	1	1		VALVE, FRONT BRAKE RELAY
89	4	4	4	4		VALVE, SOLENOID REGULATING
90						SEE FRONT AXLE ASSY
91						SEE REAR AXLE ASSY
92						SEE AIR RESERVOIRS INST
93						SEE CHASSIS PLUMBING INST

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

① QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓑ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Fig. 10, Wire Braid Hose, With Front Relay Valve, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Four-Channel Antilock, With Brake Proportioning

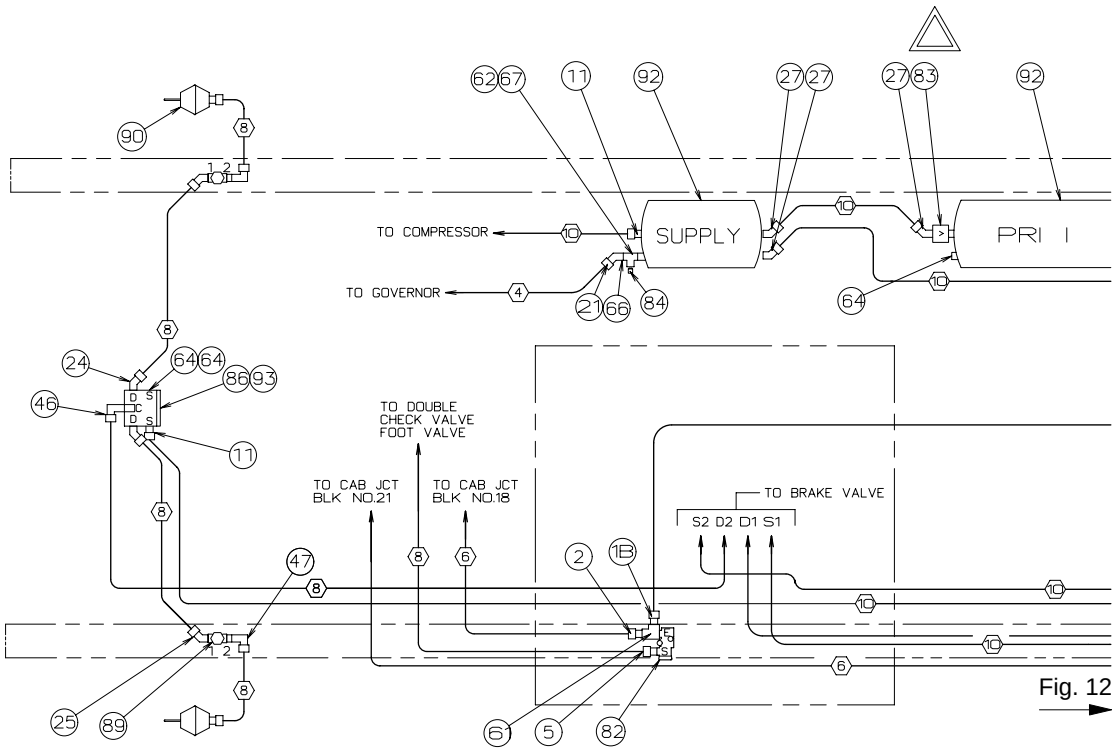


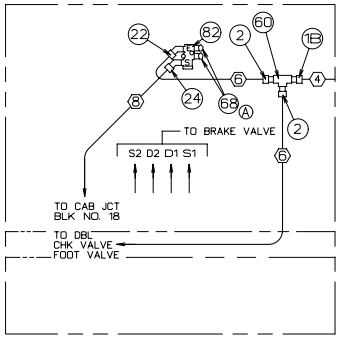
Fig. 12

ITEM #	-000 QTY	-001 QTY	-002 QTY	-003 QTY	PART #	DESCRIPTION
1B	1	1	1	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	1	2	2	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	2	2	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	1	1			210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
7	6	6	4	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	3	3	3	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	1	1	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22			1	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	2	2	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	2	2	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	2	2	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
26	2	2	2	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	12	12	12	12	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	1	1	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	1	1	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	2	2	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	1	1	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	2	2	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61			1	1	23-09311-002	TEE, FEM (1/4 NPT)
61	1	1			210503 000019	TEE, STREET (1/4 NPT)
62	1	1	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	2	2	2	210503 000022	TEE, STREET (1/2 NPT)
64	2	2	2	2	210503 000030	PLUG (3/8 NPT)
65	3	3	3	3	210503 000031	PLUG (1/2 NPT)
66	1	1	1	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	1	1	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
(A) 68			2	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
73	1	1	1	1	12-10474-000	BRACKET, MOUNTING
80	2	2	2	2		VALVE, QUICK RELEASE
81	1	1	1	1		VALVE, PROPORTIONING RELAY
82	1	1	1	1		VALVE, TRACTOR PROTECTION
83	2	2	2	2		VALVE, SINGLE CHECK
84	1	1	1	1		VALVE, AIR SAFETY
85	1	1	1	1		VALVE, PRESSURE PROTECTION
86	1	1	1	1		VALVE, FRONT BRAKE RELAY
89	4	4	4	4		VALVE, SOLENOID REGULATING
90						SEE FRONT AXLE ASSY
91						SEE REAR AXLE ASSY
92						SEE AIR RESERVOIRS INST
93						SEE CHASSIS PLUMBING INST

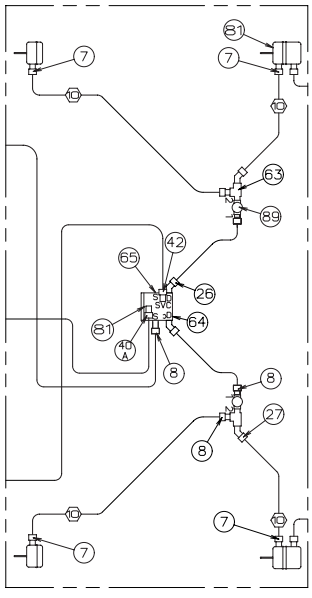
(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

(B) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.



TRACT PROT VLV PLMBG -002 & -003 ONLY



BRK PROP & SOL VLV PLMBG -001 & -003 ONLY

Diagram D12−13570, Chg. Ltr. B

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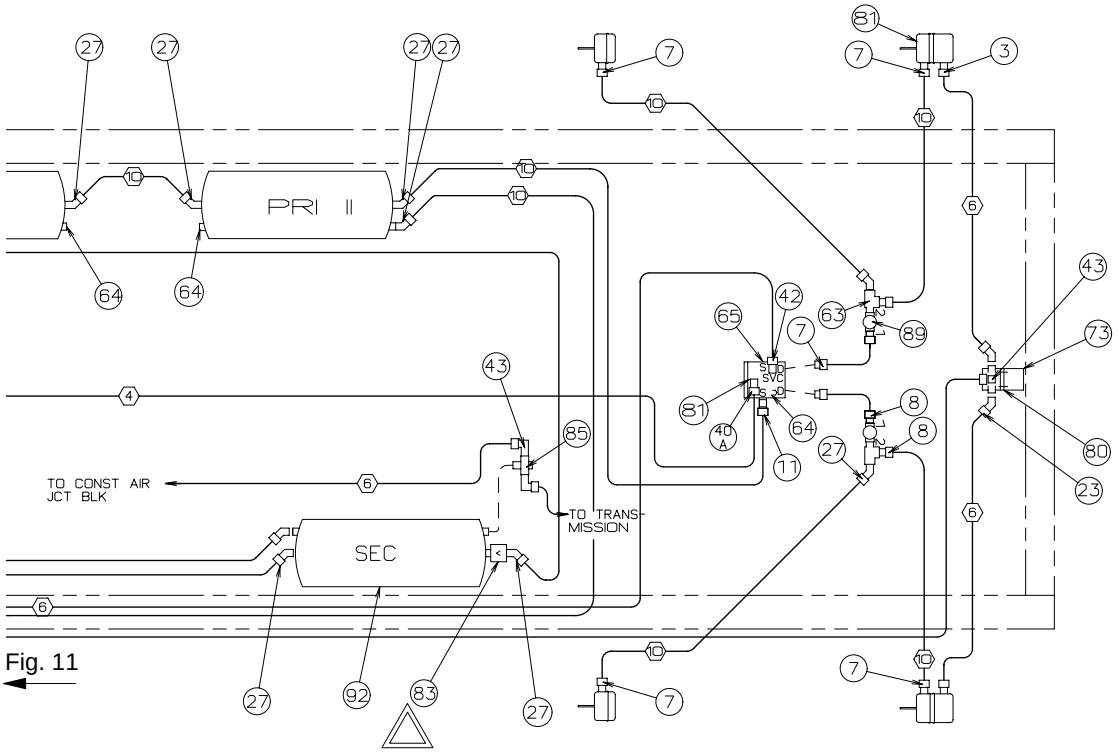
Fig. 11

Tandem Rear Axle Tractor, With Four-Channel Antilock, With Brake Proportioning

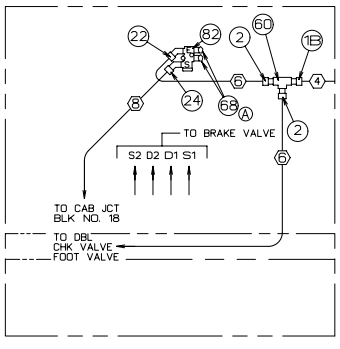


ITEM #	-000 QTY	-001 QTY	-002 QTY	-003 QTY	PART #	DESCRIPTION
1B	1	1	1	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	1	2	2	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	2	2	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	1	1			210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
7	6	6	4	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	3	3	3	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	1	1	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22			1	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	2	2	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	2	2	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	2	2	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
26	2	2	2	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	12	12	12	12	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	1	1	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	1	1	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	2	2	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	1	1	1	1	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	2	2	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61			1	1	23-09311-002	TEE, FEM (1/4 NPT)
61	1	1			210503 000019	TEE, STREET (1/4 NPT)
62	1	1	1	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	2	2	2	210503 000022	TEE, STREET (1/2 NPT)
64	2	2	2	2	210503 000030	PLUG (3/8 NPT)
65	3	3	3	3	210503 000031	PLUG (1/2 NPT)
66	1	1	1	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	1	1	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
Ⓐ 68			2	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
73	1	1	1	1	12-10474-000	BRACKET, MOUNTING
80	2	2	2	2		VALVE, QUICK RELEASE
81	1	1	1	1		VALVE, PROPORTIONING RELAY
82	1	1	1	1		VALVE, TRACTOR PROTECTION
83	2	2	2	2		VALVE, SINGLE CHECK
84	1	1	1	1		VALVE, AIR SAFETY
85	1	1	1	1		VALVE, PRESSURE PROTECTION
86	1	1	1	1		VALVE, FRONT BRAKE RELAY
89	4	4	4	4		VALVE, SOLENOID REGULATING
90						SEE FRONT AXLE ASSY
91						SEE REAR AXLE ASSY
92						SEE AIR RESERVOIRS INST
93						SEE CHASSIS PLUMBING INST

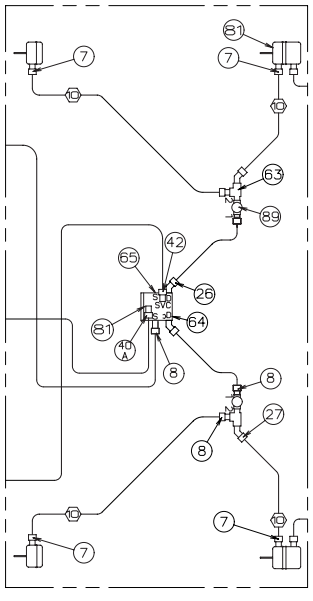
④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

1 QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓑ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.



TRACT PROT VLV PLMBG -002 & -003 ONLY



BRK PROP & SOL VLV PLMBG -001 & -003 ONLY

Diagram D12−13570, Chg. Ltr. B

02/18/94

f421163

Fig. 12

Single Rear Axle Tractor, With Antilock, With Brake Proportioning

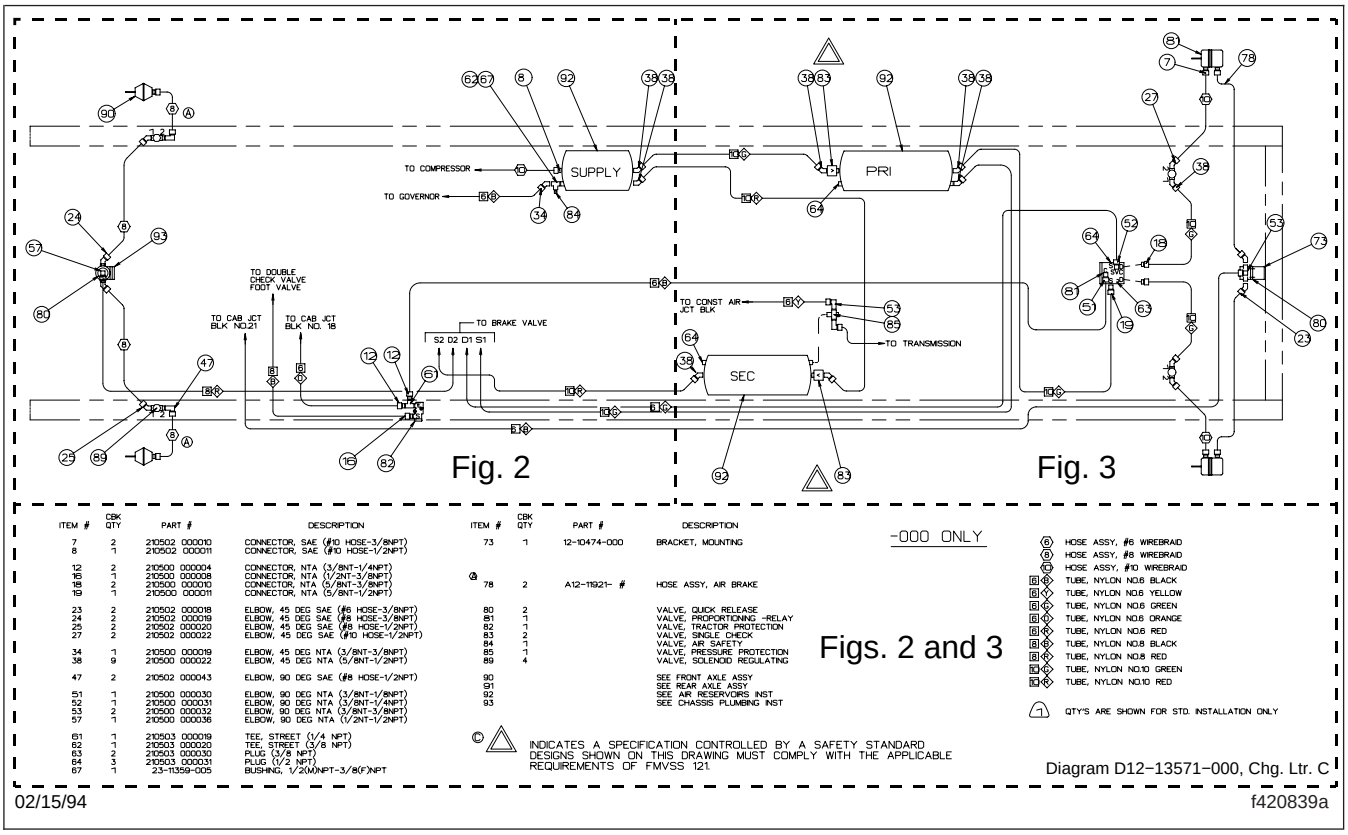
See Fig. 1 for a full view of the plumbing diagram nylon tubing, with tractor protection valve on frame, date of use 7/89 to 4/91. **See Fig. 2**, or **Fig. 3** for partial (detailed) views plumbing diagram nylon tubing, with tractor protection valve on frame, date of use 7/89 to 4/91.

See Fig. 4 for a full view of the plumbing diagram nylon tubing, with tractor protection valve on tunnel, date of use 7/89 to 4/91. **See Fig. 5**, or **Fig. 6** for partial (detailed) views plumbing diagram nylon tubing, with tractor protection valve on tunnel, date of use 7/89 to 4/91.

See Fig. 7 for a full view of the plumbing diagram wire braid hose, with tractor protection valve on frame, date of use 7/89 to 4/91. **See Fig. 8**, or **Fig. 9** for partial (detailed) views plumbing diagram wire braid hose, with tractor protection valve on frame, date of use 7/89 to 4/91.

See Fig. 10 for a full view of the plumbing diagram wire braid hose, with tractor protection valve on tunnel, date of use 7/89 to 4/91. **See Fig. 11**, or **Fig. 12** for partial (detailed) views plumbing diagram wire braid hose, with tractor protection valve on tunnel, date of use 7/89 to 4/91.

Single Rear Axle Tractor, With Antilock, With Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
15	1	210503 000038	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
38	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
Ⓐ 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING -RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-000 ONLY

Figs. 2 and 3

Ⓐ QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

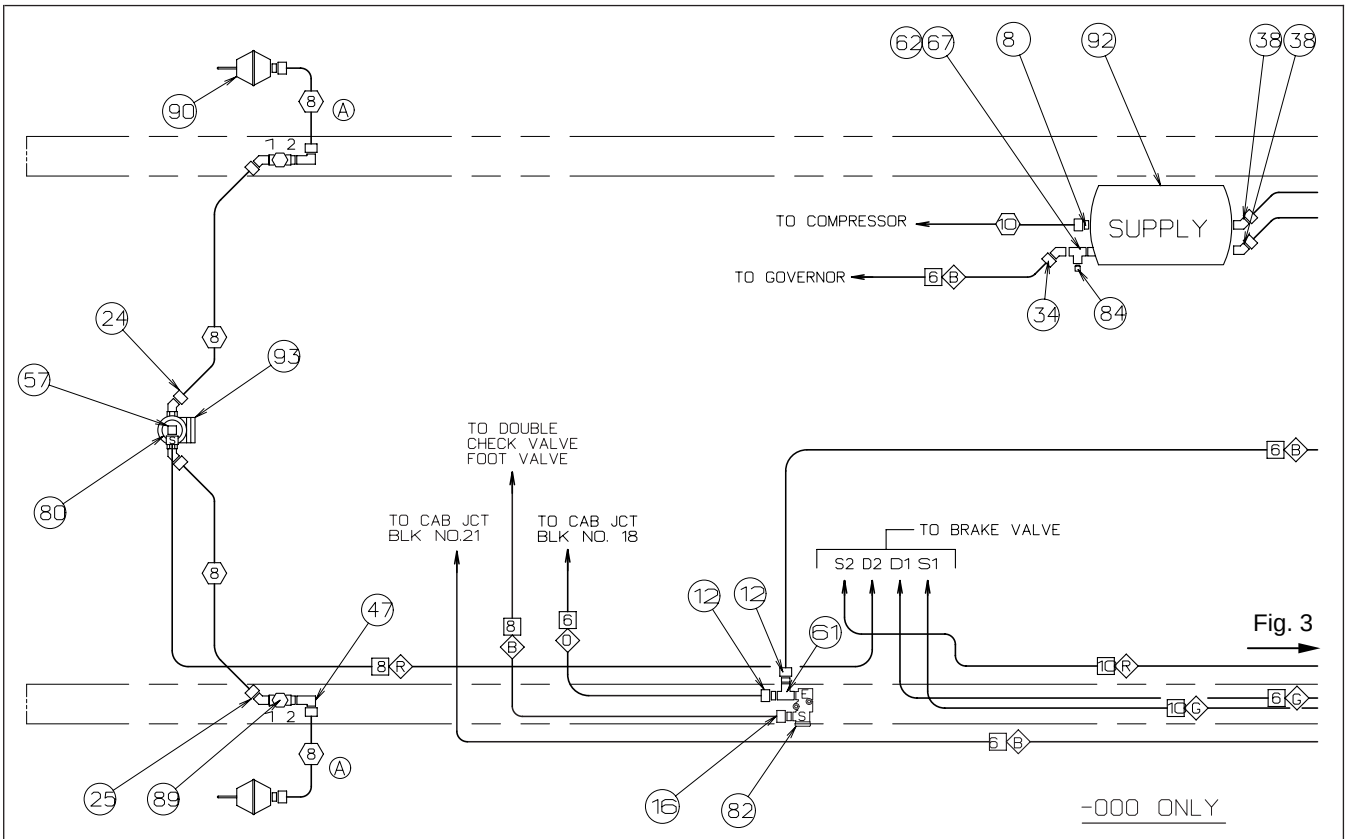
© INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−13571−000, Chg. Ltr. C

02/15/94 f420839a

Fig. 1, Nylon Tubing, With Tractor Protection Valve on Frame, Date of Use 7/89 to 4/91.

Single Rear Axle Tractor, With Antilock, With Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
38	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
Ⓐ 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING -RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

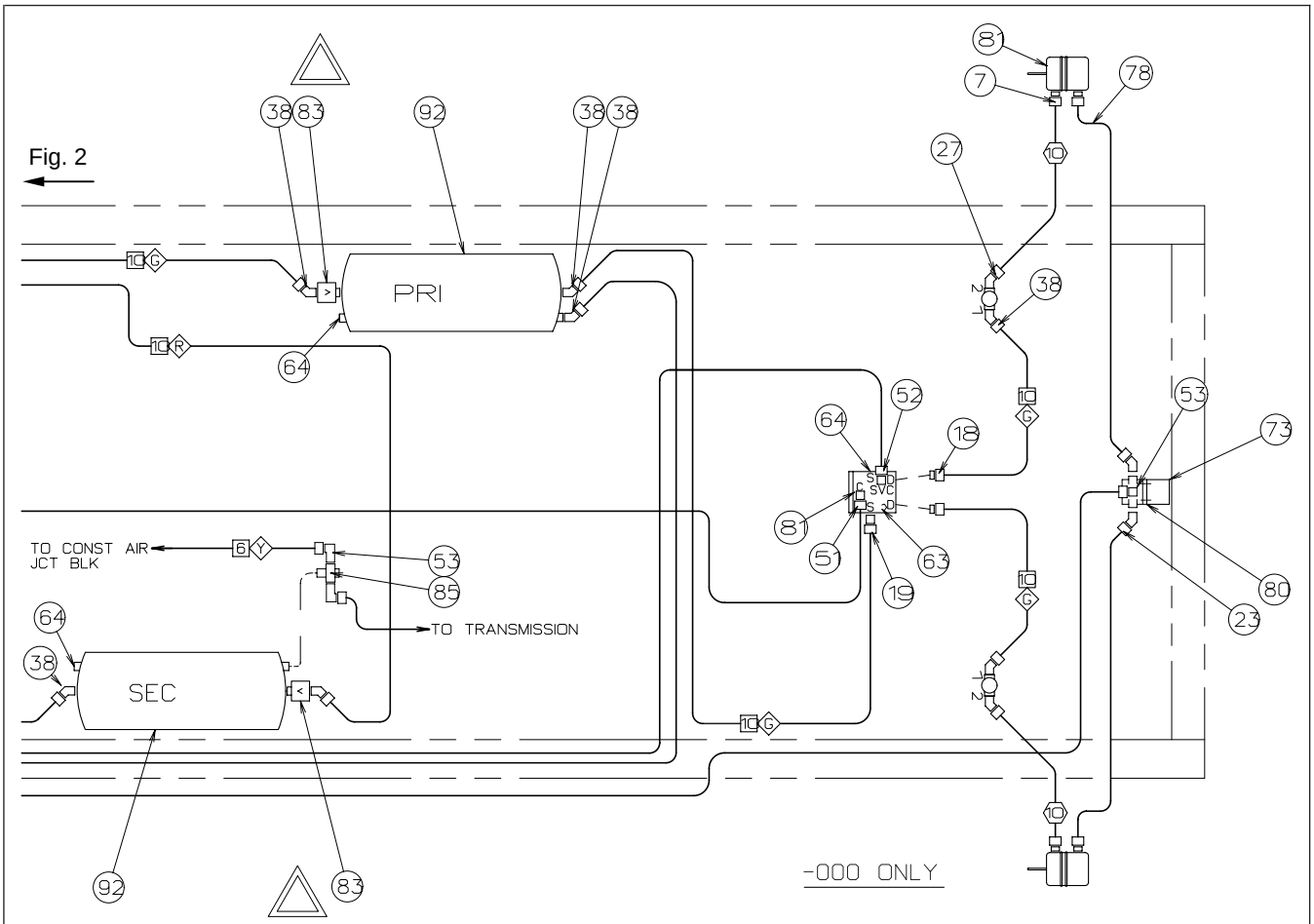
© INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/15/94

Diagram D12−13571−000, Chg. Ltr. C f421150

Fig. 2

Single Rear Axle Tractor, With Antilock, With Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
38	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING -RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

© △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

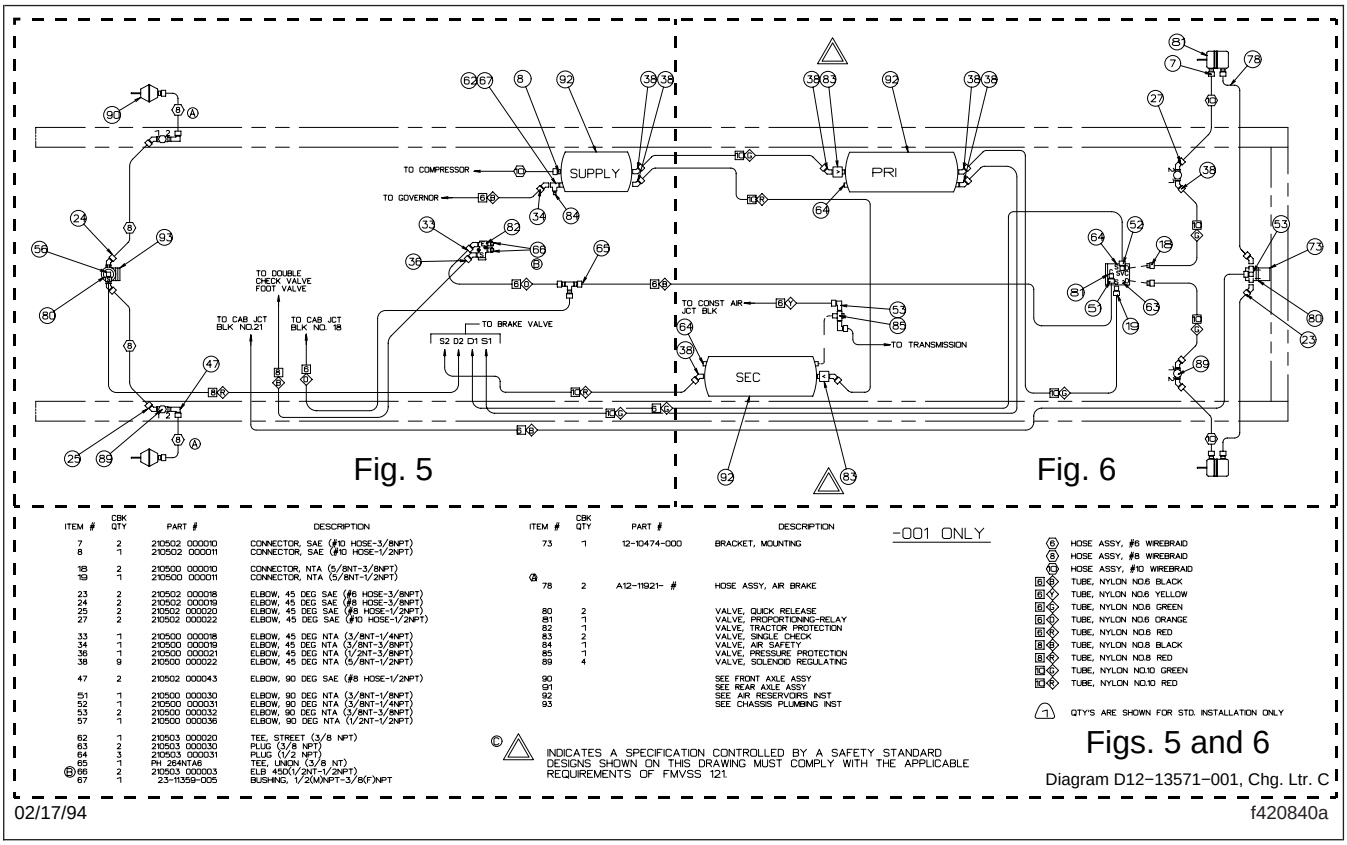
02/15/94

Diagram D12−13571−000, Chg. Ltr. C

f421151

Fig. 3

Single Rear Axle Tractor, With Antilock, With Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
33	1	210500 000018	ELBOW, 45 DEG NTA (3/8NT-1/4NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
65	1	PH 264NTA6	TEE, UNION (3/8 NT)
E 66	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
@ 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING-RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-001 ONLY

(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID
(6) TUBE, NYLON NO.6 BLACK
(6) TUBE, NYLON NO.6 YELLOW
(6) TUBE, NYLON NO.6 GREEN
(6) TUBE, NYLON NO.6 ORANGE
(8) TUBE, NYLON NO.8 RED
(8) TUBE, NYLON NO.8 BLACK
(8) TUBE, NYLON NO.8 RED
(10) TUBE, NYLON NO.10 GREEN
(10) TUBE, NYLON NO.10 RED

QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

© INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

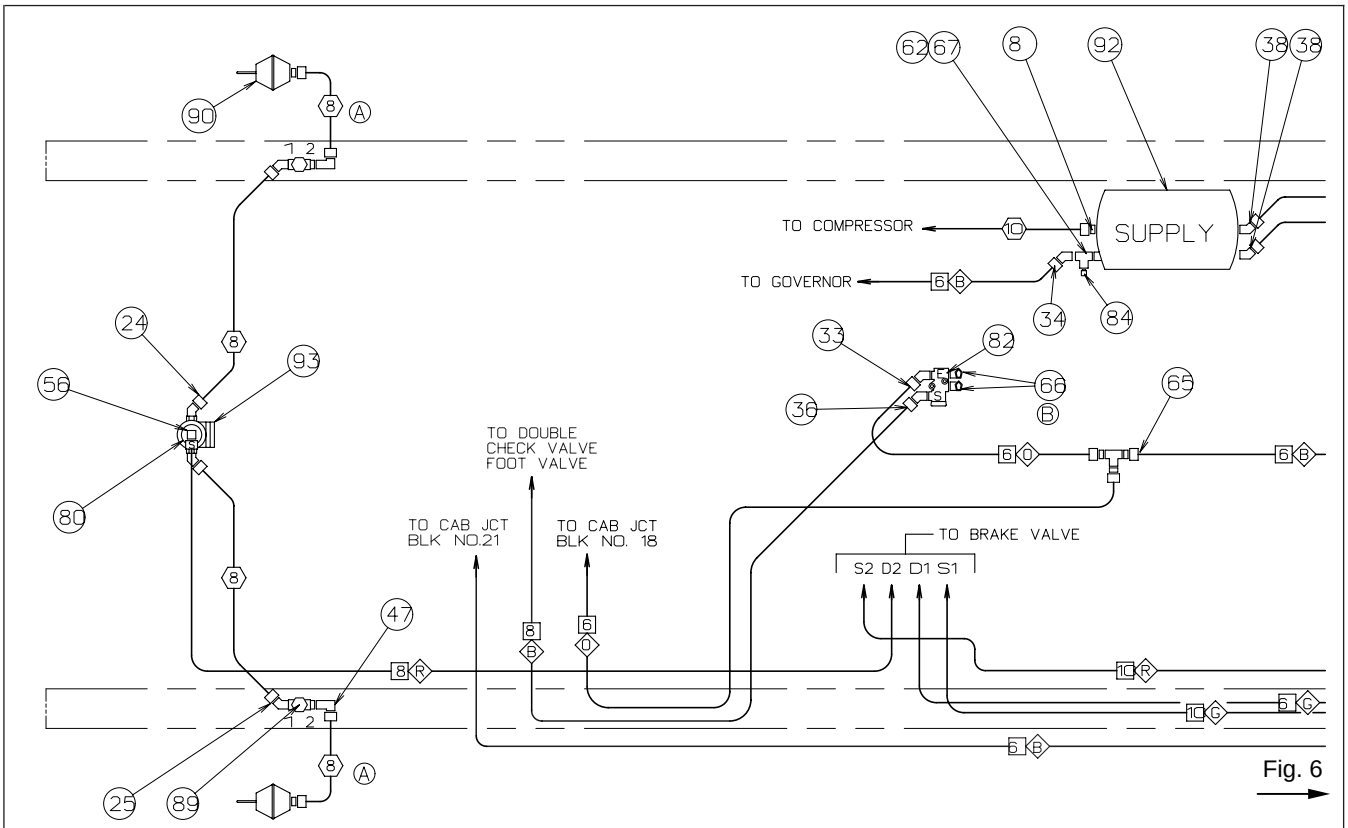
Figs. 5 and 6

Diagram D12−13571−001, Chg. Ltr. C

02/17/94 f420840a

Fig. 4, Nylon Tubing, With Tractor Protection Valve on Tunnel, Date of Use 7/89 to 4/91.

Single Rear Axle Tractor, With Antilock, With Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
33	1	210500 000018	ELBOW, 45 DEG NTA (3/8NT-1/4NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
65	1	PH 264NTA6	TEE, UNION (3/8 NT)
Ⓑ 66	2	210503 000003	ELB 450(1/2NT-1/2NPT)
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
Ⓐ 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING-RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-001 ONLY

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

© △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

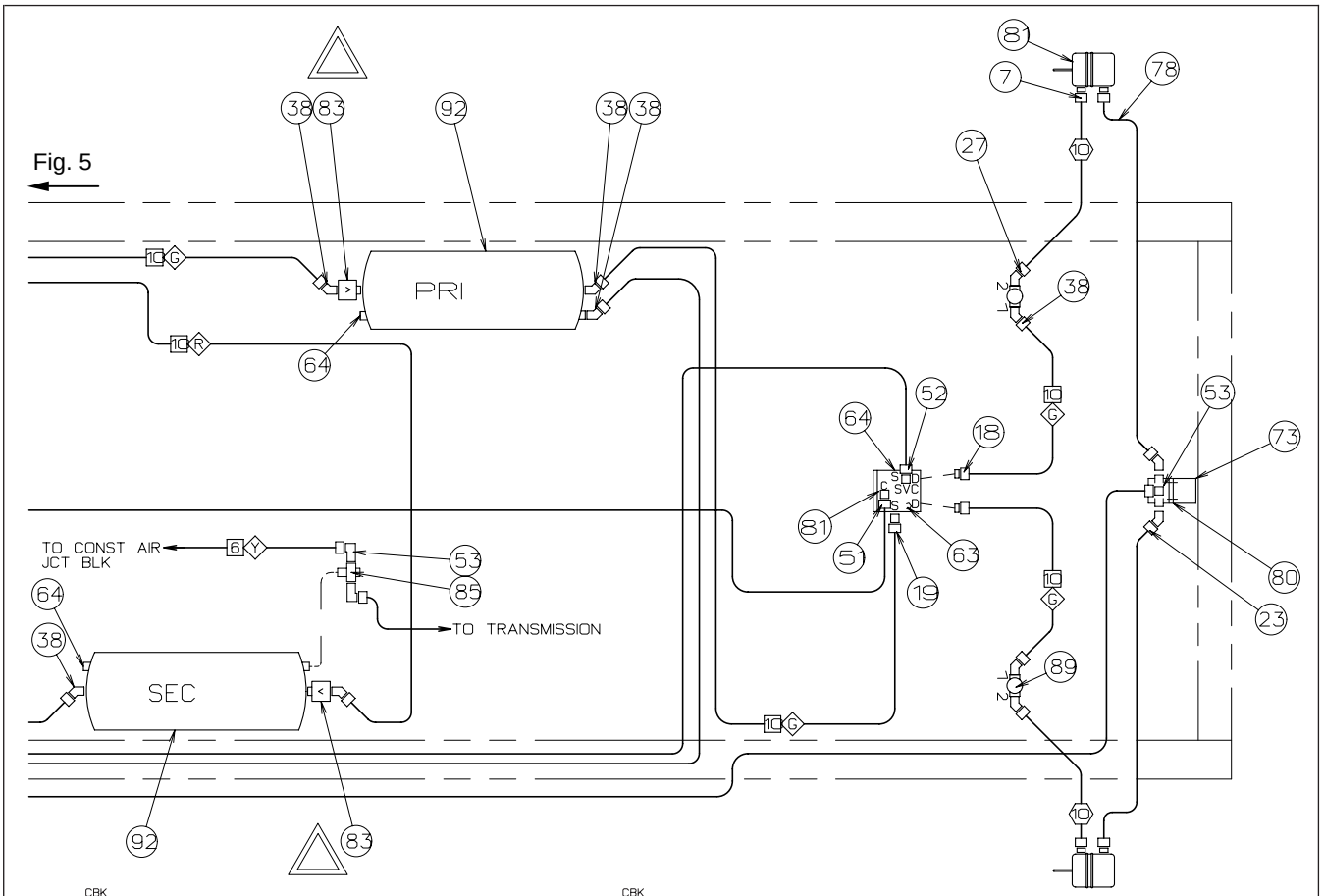
02/17/94

Diagram D12−13571−001, Chg. Ltr. C

f421152

Fig. 5

Single Rear Axle Tractor, With Antilock, With Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	2	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
33	1	210500 000018	ELBOW, 45 DEG NTA (3/8NT-1/4NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	9	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
65	1	PH 264NTA6	TEE, UNION (3/8 NT)
Ⓑ 66	2	210503 000003	ELB 450(1/2NT-1/2NPT)
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
Ⓐ 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING-RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-001 ONLY

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

△1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

© △ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/17/94

Diagram D12−13571−001, Chg. Ltr. C

f421153

Fig. 6

Single Rear Axle Tractor, With Antilock, With Brake Proportioning

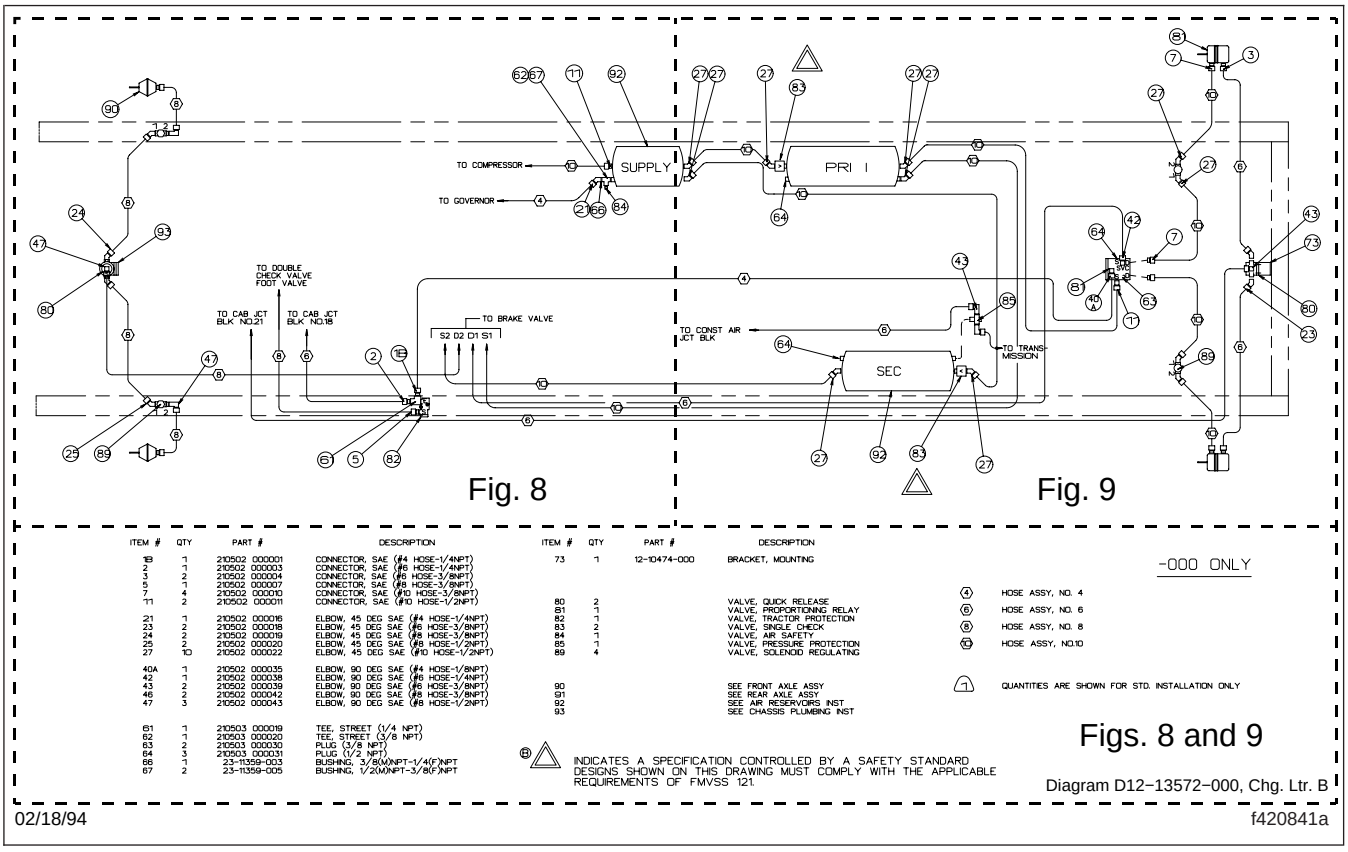


Fig. 8 Fig. 9

ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	1	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	10	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	3	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-000 ONLY

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

△1 QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓢ△ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

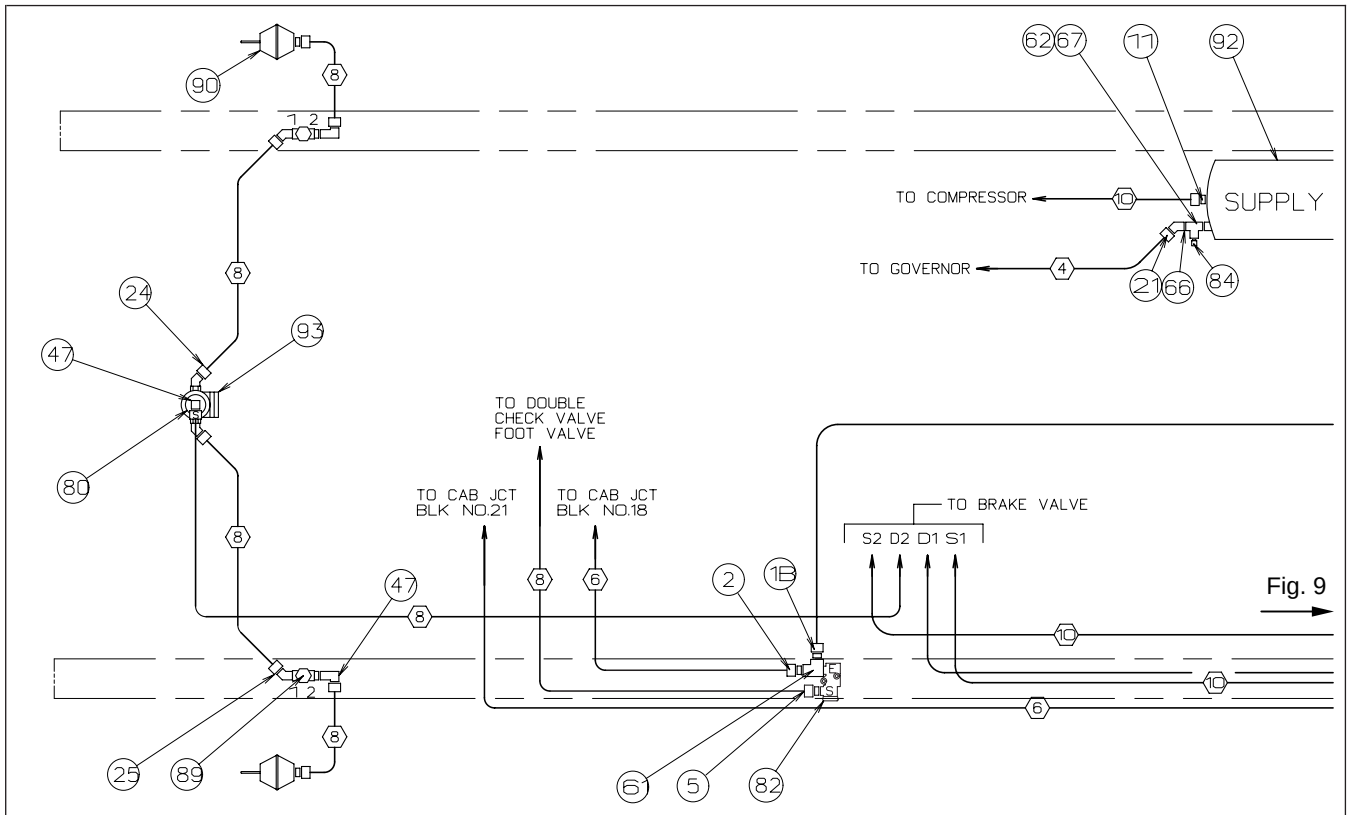
Figs. 8 and 9

Diagram D12−13572−000, Chg. Ltr. B

02/18/94 f420841a

Fig. 7, Wire Braid Hose, With Tractor Protection Valve on Frame, Date of Use 7/89 to 4/91.

Single Rear Axle Tractor, With Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	1	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	10	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	3	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-000 ONLY

(4)	HOSE ASSY, NO. 4
(6)	HOSE ASSY, NO. 6
(8)	HOSE ASSY, NO. 8
(10)	HOSE ASSY, NO.10
(1)	QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

(B) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

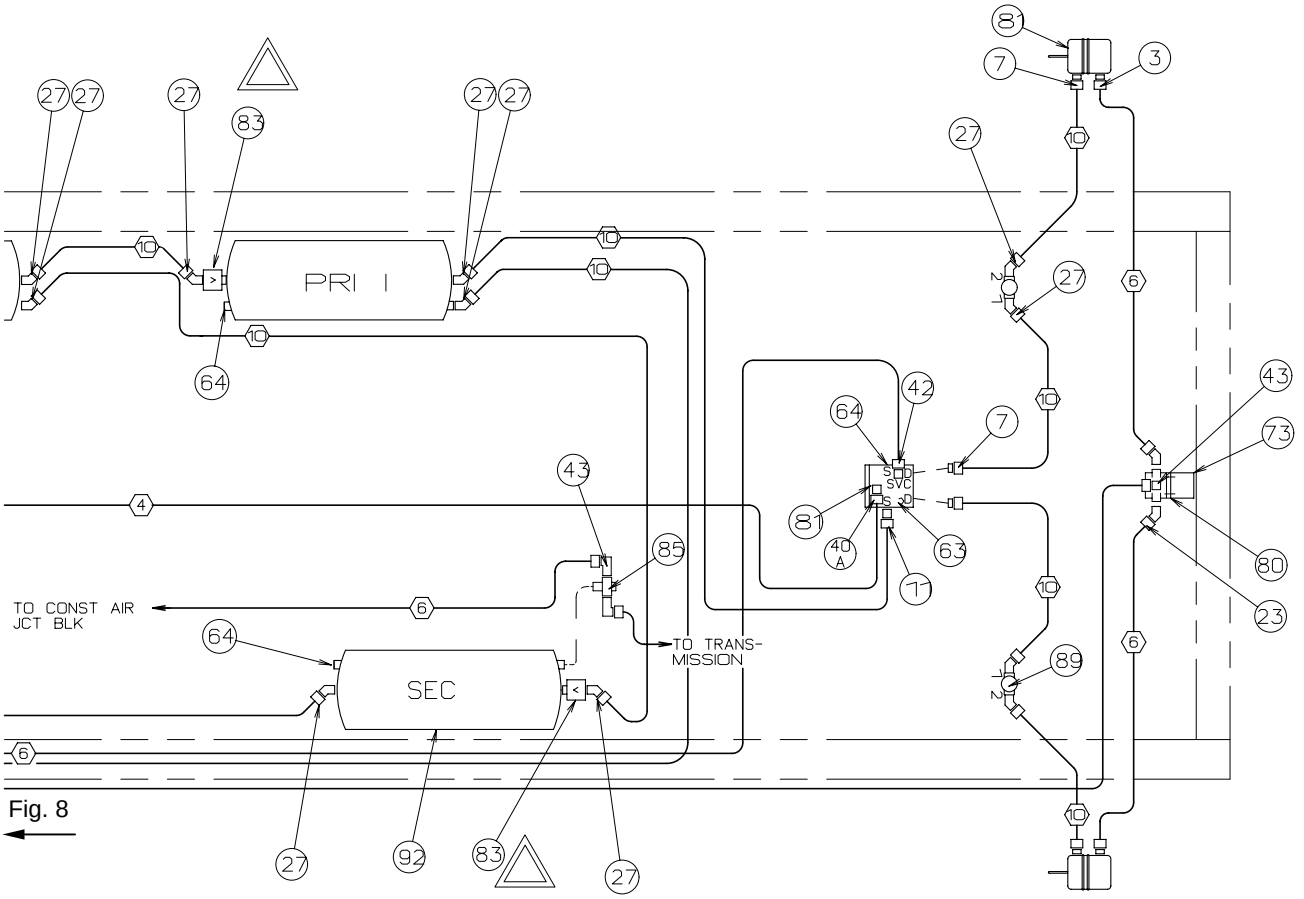
02/18/94

Diagram D12−13572−000, Chg. Ltr. B

f421154

Fig. 8

Single Rear Axle Tractor, With Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	1	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	10	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	3	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-000 ONLY

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

(B) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/18/94

Diagram D12−13572−000, Chg. Ltr. B

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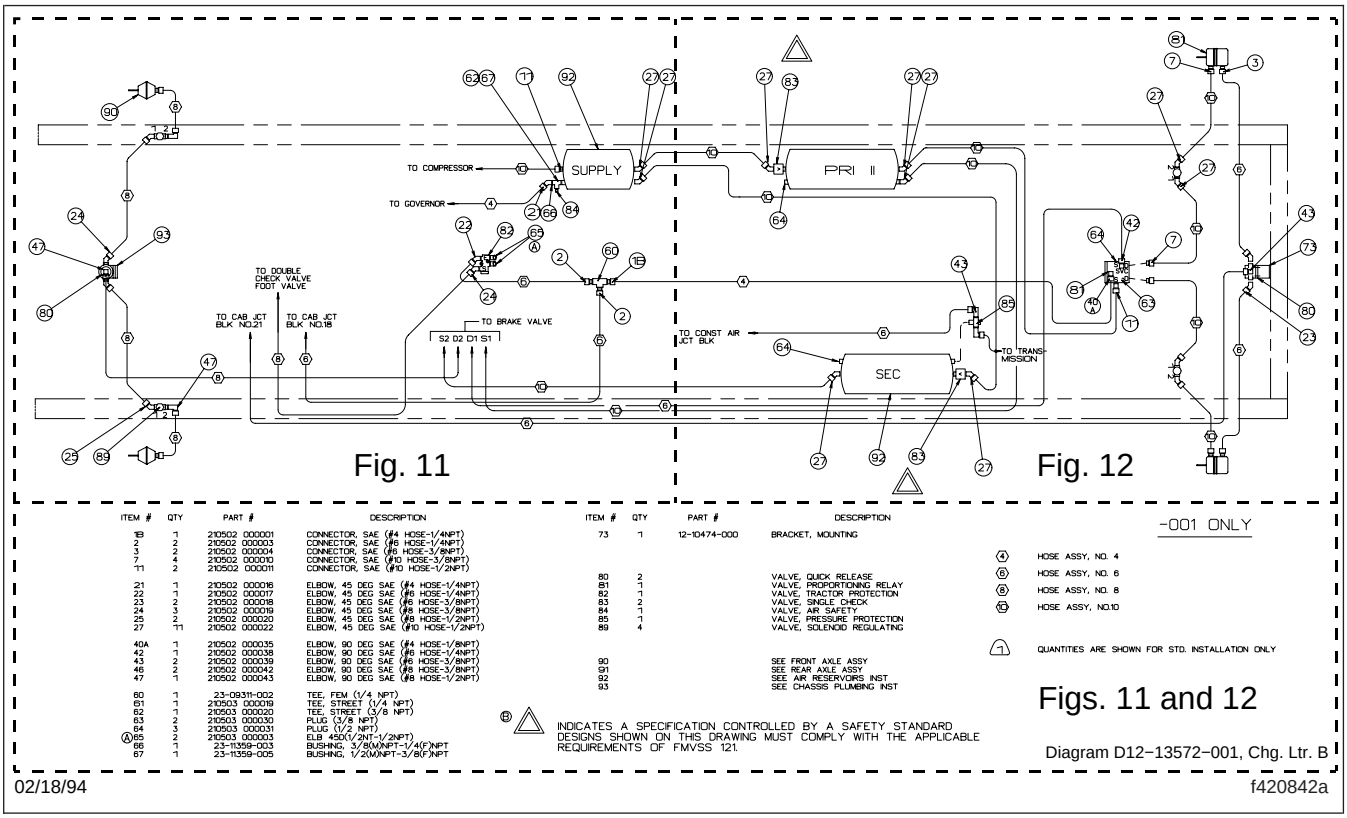
Fig. 9

Single Rear Axle Tractor, With Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	2	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	3	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	11	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60	1	23-09311-002	TEE, FEM (1/4 NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
(A)65	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-001 ONLY

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

△1 QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

△B INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Figs. 11 and 12

Diagram D12−13572−001, Chg. Ltr. B

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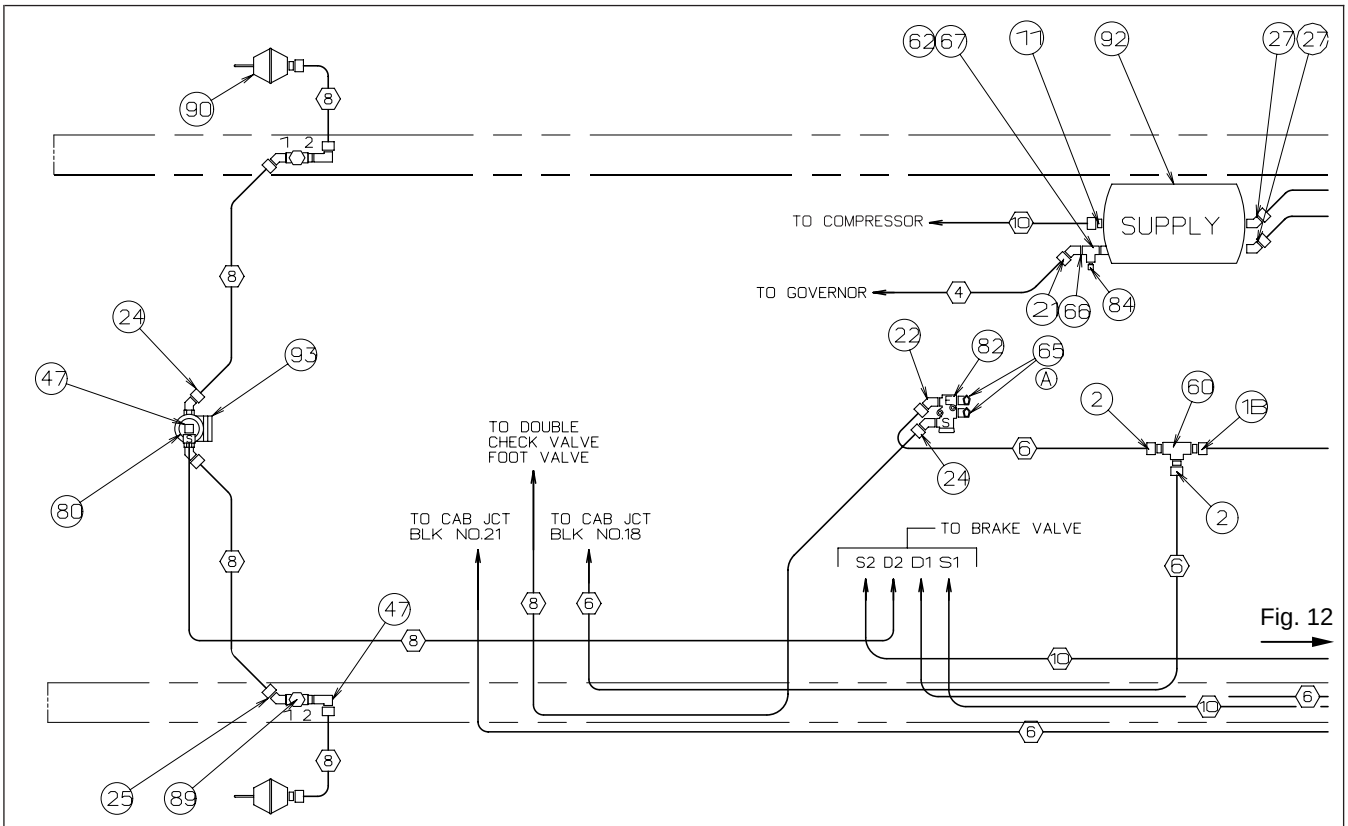
Fig. 10, Wire Braid Hose, With Tractor Protection Valve on Tunnel, Date of Use 7/89 to 4/91.

Single Rear Axle Tractor, With Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	2	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	3	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	11	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60	1	23-09311-002	TEE, FEM (1/4 NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
Ⓐ65	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-001 ONLY

④	HOSE ASSY, NO. 4
⑥	HOSE ASSY, NO. 6
⑧	HOSE ASSY, NO. 8
⑩	HOSE ASSY, NO.10
①	QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓑ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

02/18/94

Diagram D12−13572−001, Chg. Ltr. B

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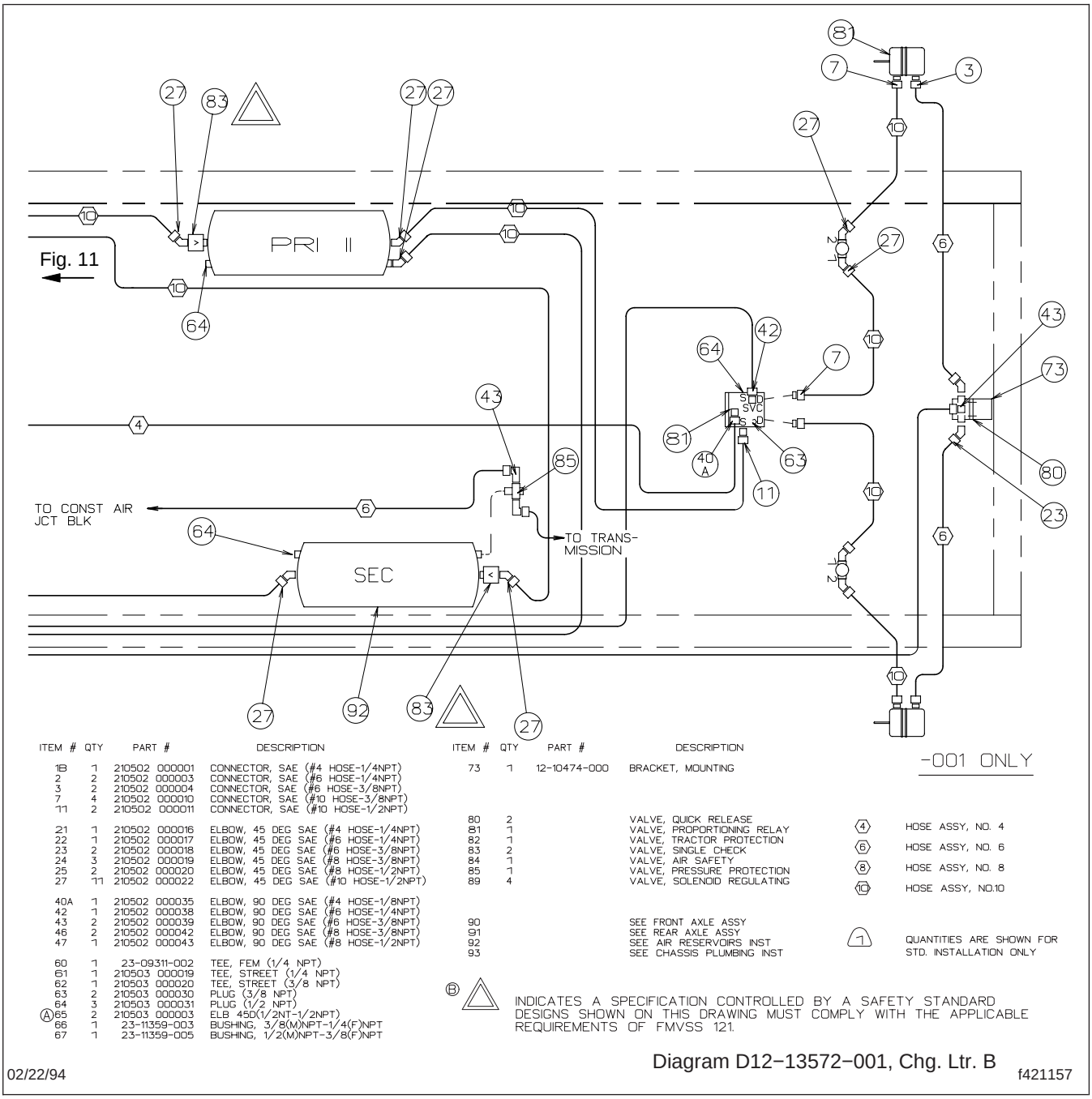
Fig. 11

Single Rear Axle Tractor, With Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	2	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	3	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	11	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60	1	23-09311-002	TEE, FEM (1/4 NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
Ⓐ65	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	4		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

△1 QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓑ△ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−13572−001, Chg. Ltr. B

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Fig. 12

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning

See Fig. 1 for a full view of the plumbing diagram nylon tubing, with front quick release valve, with tractor protection valve on frame, date of use 7/89 to 4/91. **See Fig. 2**, or **Fig. 3** for partial (detailed) views plumbing diagram nylon tubing, with front quick release valve, with tractor protection valve on frame, date of use 7/89 to 4/91.

See Fig. 4 for a full view of the plumbing diagram nylon tubing, with front quick release valve, with tractor protection valve on tunnel, date of use 7/89 to 4/91. **See Fig. 5**, or **Fig. 6** for partial (detailed) views plumbing diagram nylon tubing, with front quick release valve, with tractor protection valve on tunnel, date of use 7/89 to 4/91.

See Fig. 7 for a full view of the plumbing diagram nylon tubing, with front relay valve, with tractor protection valve on frame, date of use 7/89 to 4/91. **See Fig. 8**, or **Fig. 9** for partial (detailed) views plumbing diagram nylon tubing, with front relay valve, with tractor protection valve on frame, date of use 7/89 to 4/91.

See Fig. 10 for a full view of the plumbing diagram nylon tubing, with front relay valve, with tractor protection on tunnel, date of use 7/89 to 4/91. **See Fig. 11**, or **Fig. 12** for partial (detailed) views plumbing diagram nylon tubing, with front relay valve, with tractor protection on tunnel, date of use 7/89 to 4/91.

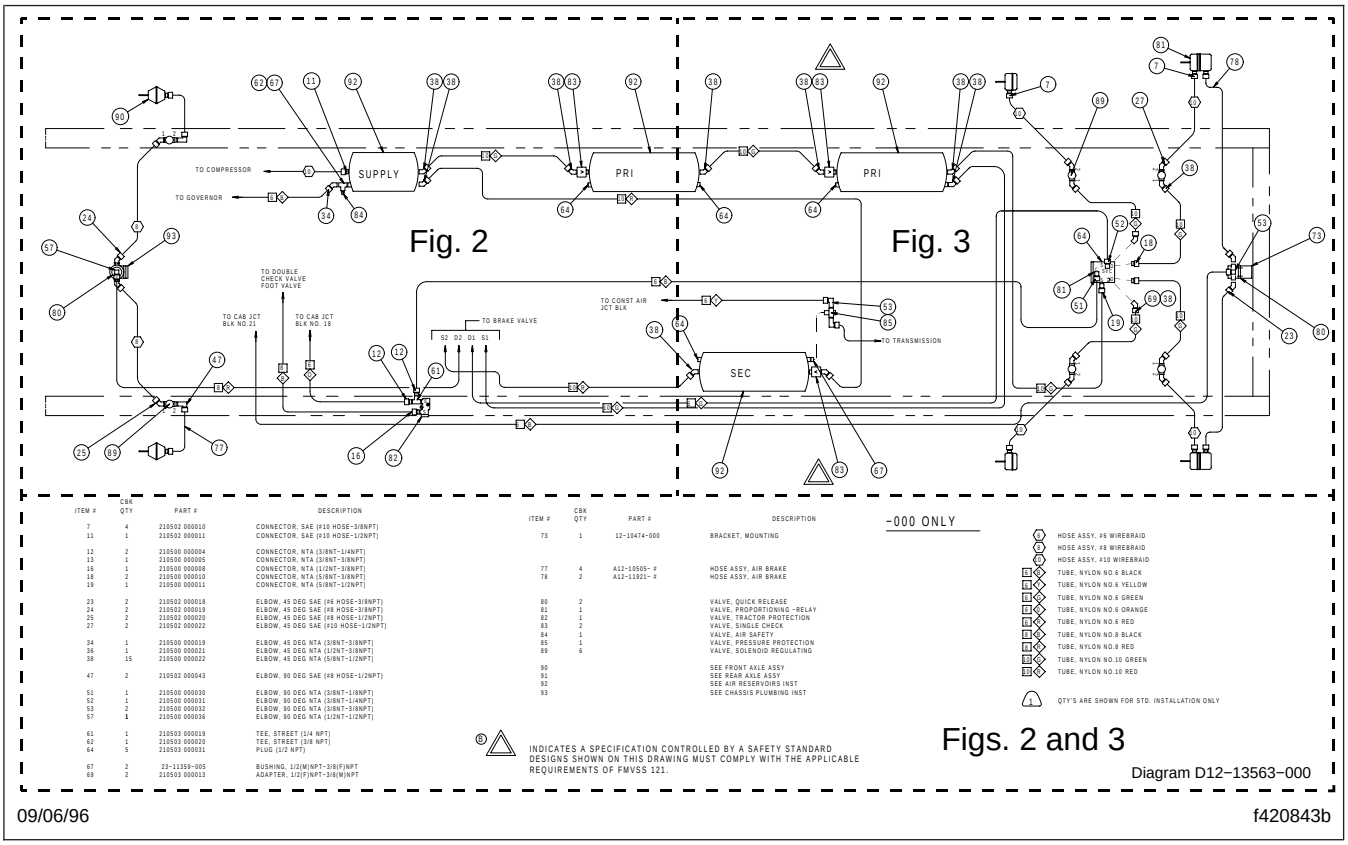
See Fig. 13 for a full view of the plumbing diagram wire braid hose, with front quick release valve, with tractor protection valve on frame, date of use 7/89 to 4/91. **See Fig. 14**, or **Fig. 15** for partial (detailed) views plumbing diagram wire braid hose, with front quick release valve, with tractor protection valve on frame, date of use 7/89 to 4/91.

See Fig. 16 for a full view of the plumbing diagram wire braid hose, with front quick release valve, with tractor protection valve on tunnel, date of use 7/89 to 4/91. **See Fig. 17**, or **Fig. 18** for partial (detailed) views plumbing diagram wire braid hose, with front quick release valve, with tractor protection valve on tunnel, date of use 7/89 to 4/91.

See Fig. 19 for a full view of the plumbing diagram wire braid hose, with front relay valve, with tractor protection valve on frame, date of use 7/89 to 4/91. **See Fig. 20**, or **Fig. 21** for partial (detailed) views plumbing diagram wire braid hose, with front relay valve, with tractor protection valve on frame, date of use 7/89 to 4/91.

See Fig. 22 for a full view of the plumbing diagram wire braid hose, with front relay valve, with tractor protection valve on tunnel, date of use 7/89 to 4/91. **See Fig. 23**, or **Fig. 24** for partial (detailed) views plumbing diagram wire braid hose, with front relay valve, with tractor protection valve on tunnel, date of use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	15	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING -RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-000 ONLY

A	HOSE ASSY, #6 WIREBRAID
B	HOSE ASSY, #8 WIREBRAID
C	HOSE ASSY, #10 WIREBRAID
D	TUBE, NYLON NO.6 BLACK
E	TUBE, NYLON NO.6 YELLOW
F	TUBE, NYLON NO.6 GREEN
G	TUBE, NYLON NO.6 ORANGE
H	TUBE, NYLON NO.6 RED
J	TUBE, NYLON NO.8 BLACK
K	TUBE, NYLON NO.8 RED
L	TUBE, NYLON NO.10 GREEN
M	TUBE, NYLON NO.10 RED

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓑ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD. DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Figs. 2 and 3

Diagram D12−13563−000

09/06/96 f420843b

Fig. 1, Nylon Tubing, With Front Quick Release Valve, With Tractor Protection Valve on Frame, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning

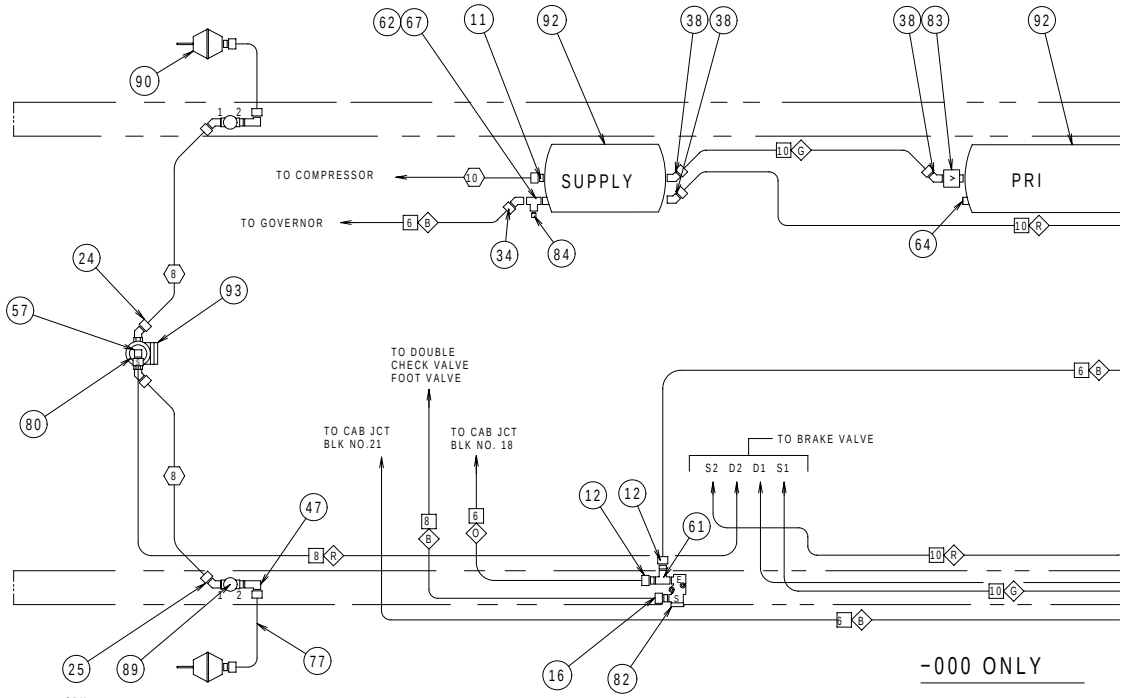


Fig. 3 →

Fig. 3 →

ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	15	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING -RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

(B) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−13563−000

09/27/96

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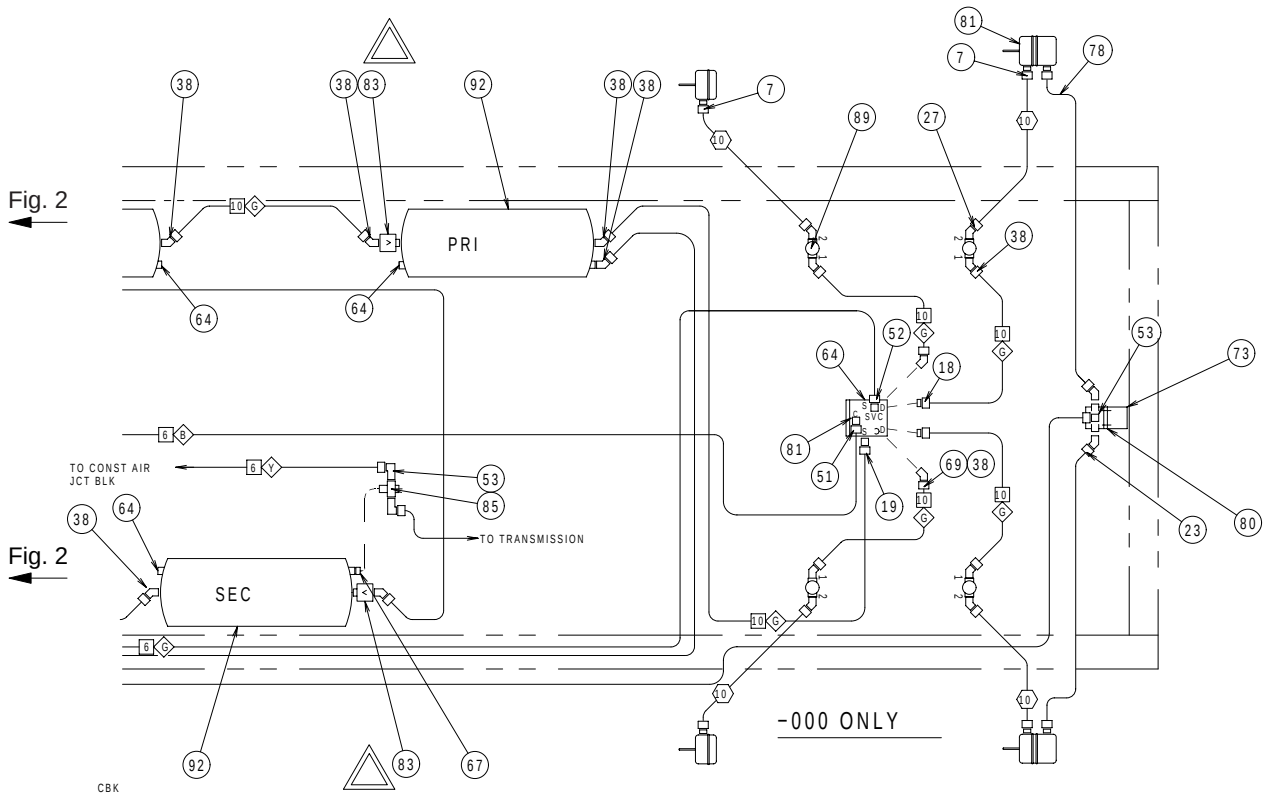
Fig. 2

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	15	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT
73	1	12-10474-000	BRACKET, MOUNTING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING -RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

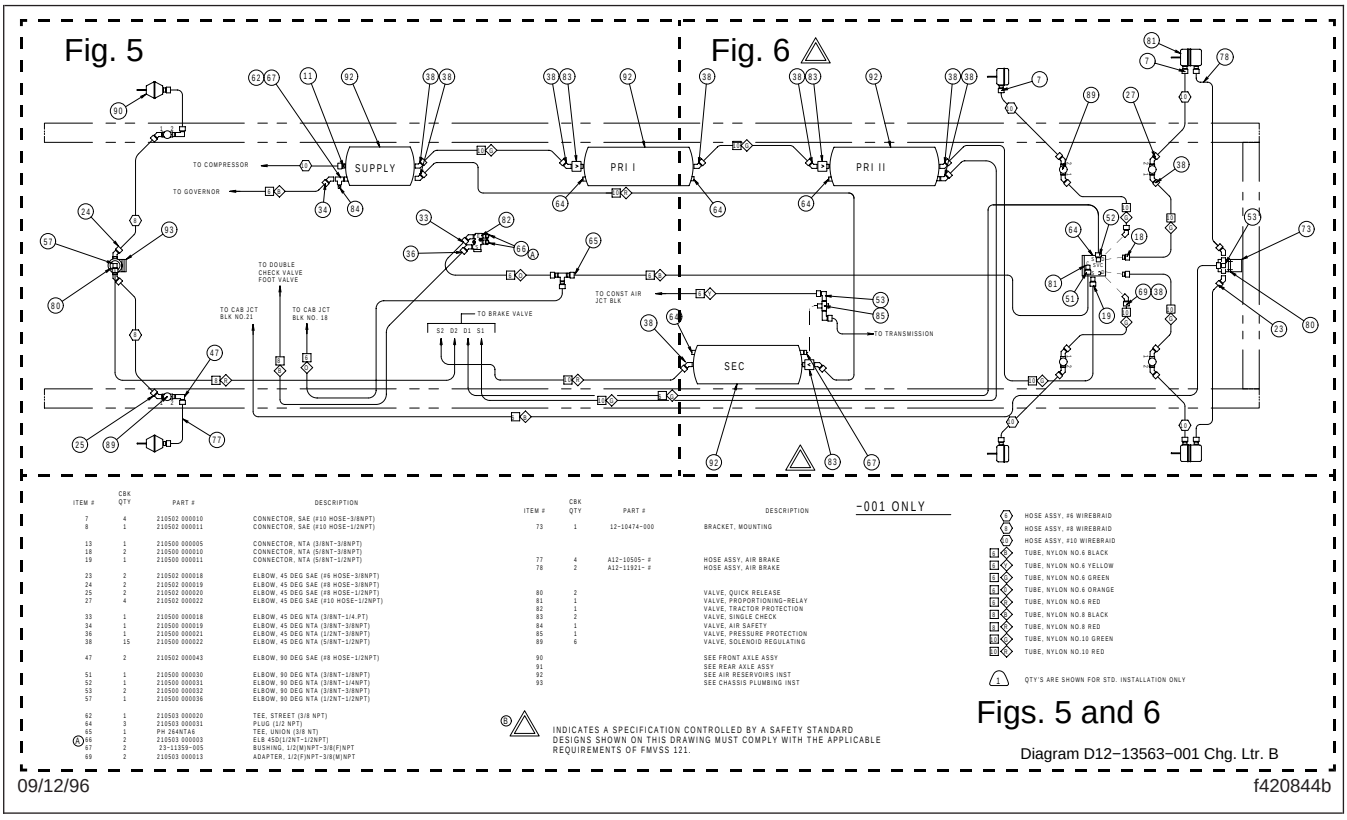
Ⓑ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−13563−000

09/27/96 f421065a

Fig. 3

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning

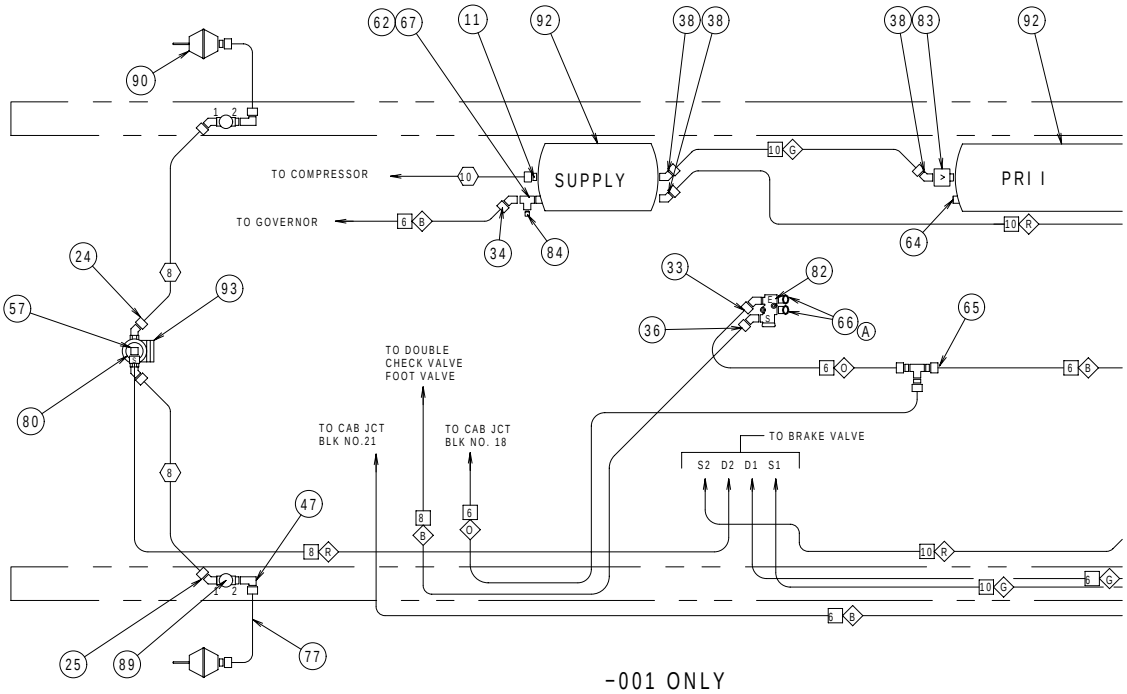


ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	4	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
33	1	210500 000018	ELBOW, 45 DEG NTA (3/8NT-1/4.PT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	15	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
65	1	PH 26ANTA6	TEE, UNION (3/8 NT)
Ⓐ 66	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING-RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

Fig. 4, Nylon Tubing, With Front Quick Release Valve, With Tractor Protection Valve on Tunnel, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



-001 ONLY

ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	4	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
33	1	210500 000018	ELBOW, 45 DEG NTA (3/8NT-1/4.PT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	15	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
65	1	PH 264NTA6	TEE, UNION (3/8 NT)
(A) 66	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING-RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID
6 B TUBE, NYLON NO.6 BLACK
6 Y TUBE, NYLON NO.6 YELLOW
6 G TUBE, NYLON NO.6 GREEN
6 O TUBE, NYLON NO.6 ORANGE
6 R TUBE, NYLON NO.6 RED
8 B TUBE, NYLON NO.8 BLACK
8 R TUBE, NYLON NO.8 RED
10 G TUBE, NYLON NO.10 GREEN
10 R TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

(B) DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−13563−001 Chg. Ltr. B

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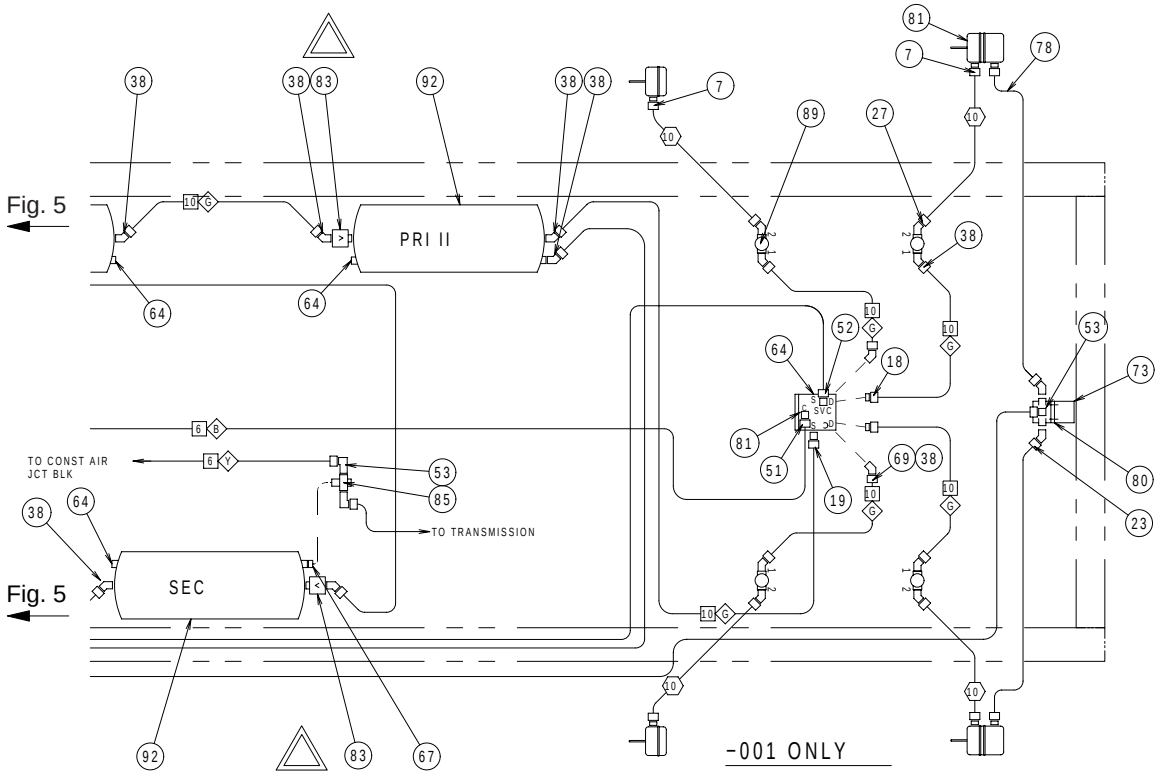
Fig. 5

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	4	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
33	1	210500 000018	ELBOW, 45 DEG NTA (3/8NT-1/4.PT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	15	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
65	1	PH 264NTA6	TEE, UNION (3/8 NT)
(A) 66	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING-RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

(B) DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Diagram D12−13563−001 Chg. Ltr. B

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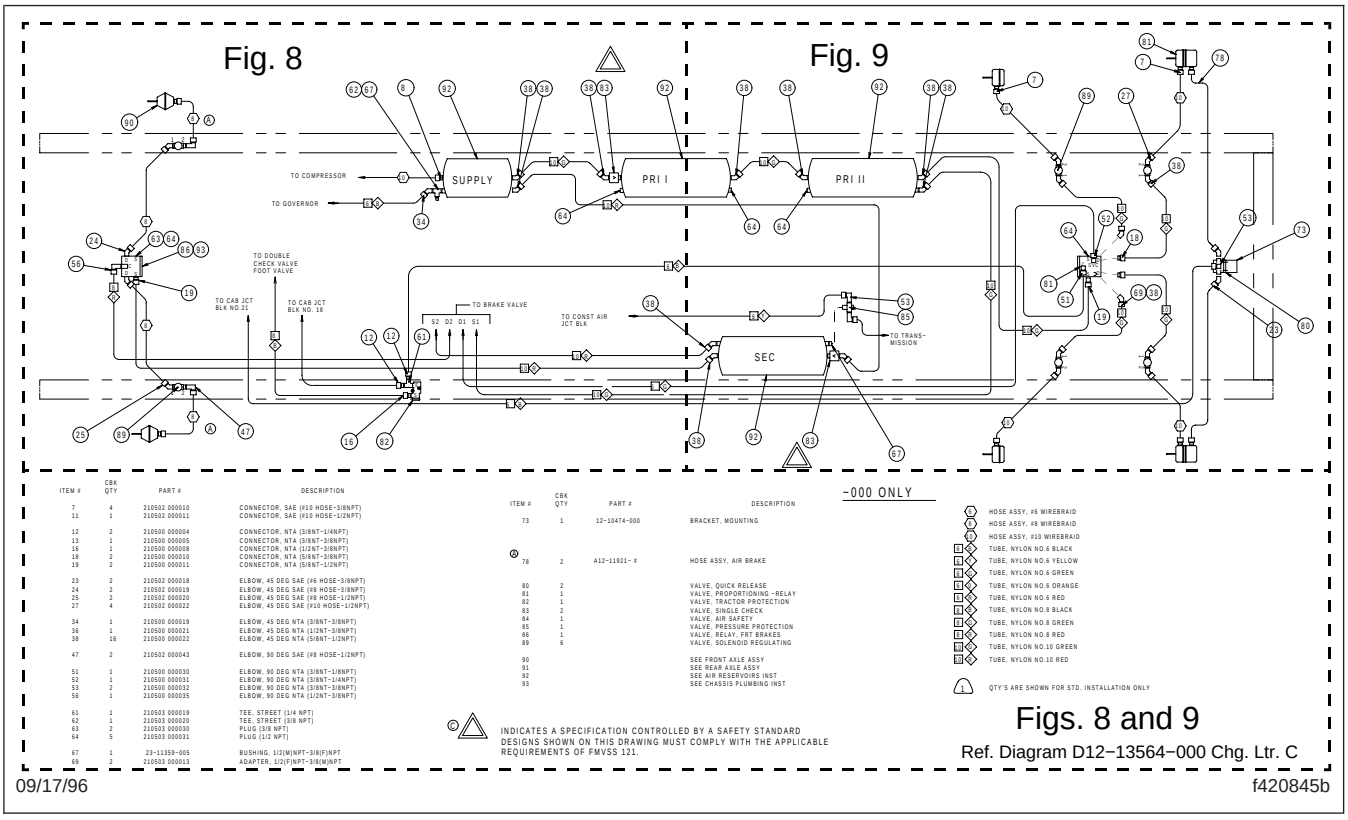
Fig. 6

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



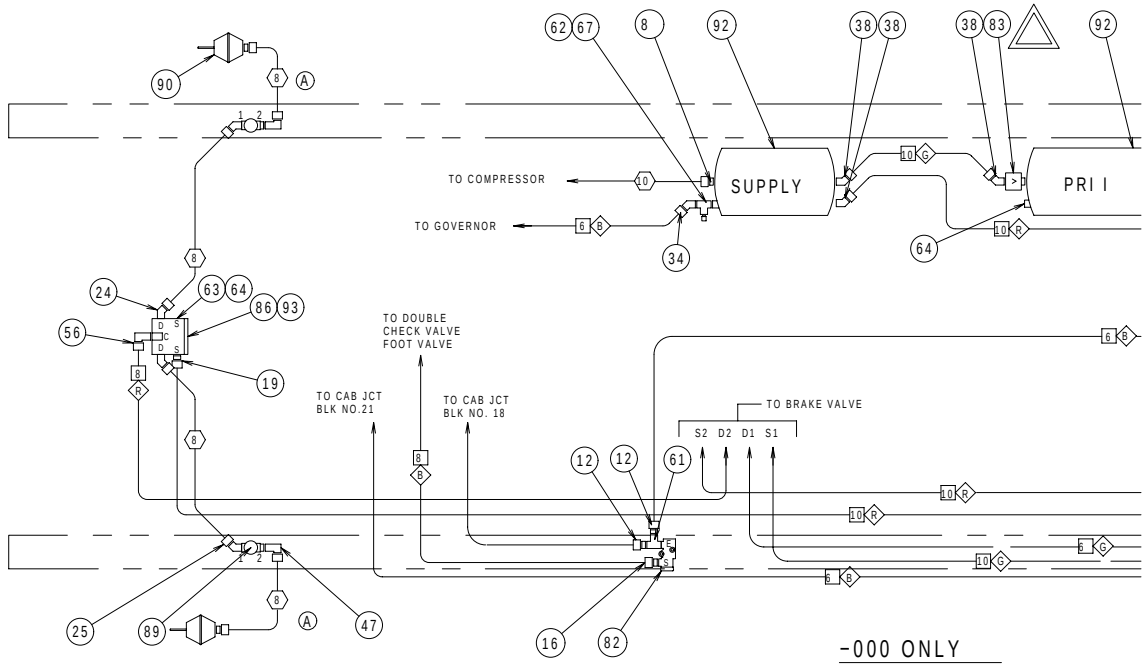
ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE−3/8NPT)
11	1	210502 000011	CONNECTOR, SAE (#10 HOSE−1/2NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT−1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT−3/8NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT−3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT−3/8NPT)
19	2	210500 000011	CONNECTOR, NTA (5/8NT−1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE−3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE−3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE−1/2NPT)
27	4	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE−1/2NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT−3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT−3/8NPT)
38	16	210500 000022	ELBOW, 45 DEG NTA (5/8NT−1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE−1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT−1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT−1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT−3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT−3/8NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
67	1	23−11359−005	BUSHING, 1/2(M)NPT−3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT−3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12−10474−000	BRACKET, MOUNTING
A 78	2	A12−11921− #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING −RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRT BRAKES
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

E	HOSE ASSY, #6 WIREBRAID
F	HOSE ASSY, #8 WIREBRAID
G	HOSE ASSY, #10 WIREBRAID
L	TUBE, NYLON NO.6 BLACK
L	TUBE, NYLON NO.6 YELLOW
L	TUBE, NYLON NO.6 GREEN
L	TUBE, NYLON NO.6 ORANGE
L	TUBE, NYLON NO.6 RED
L	TUBE, NYLON NO.8 BLACK
L	TUBE, NYLON NO.8 GREEN
L	TUBE, NYLON NO.8 RED
L	TUBE, NYLON NO.10 GREEN
L	TUBE, NYLON NO.10 RED

Fig. 7, Nylon Tubing, With Front Relay Valve, With Tractor Protection Valve on Frame, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	2	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	4	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	16	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
Ⓐ 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING -RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRT BRAKES
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓒ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Ref. Diagram D12-13564-000 Chg. Ltr. C

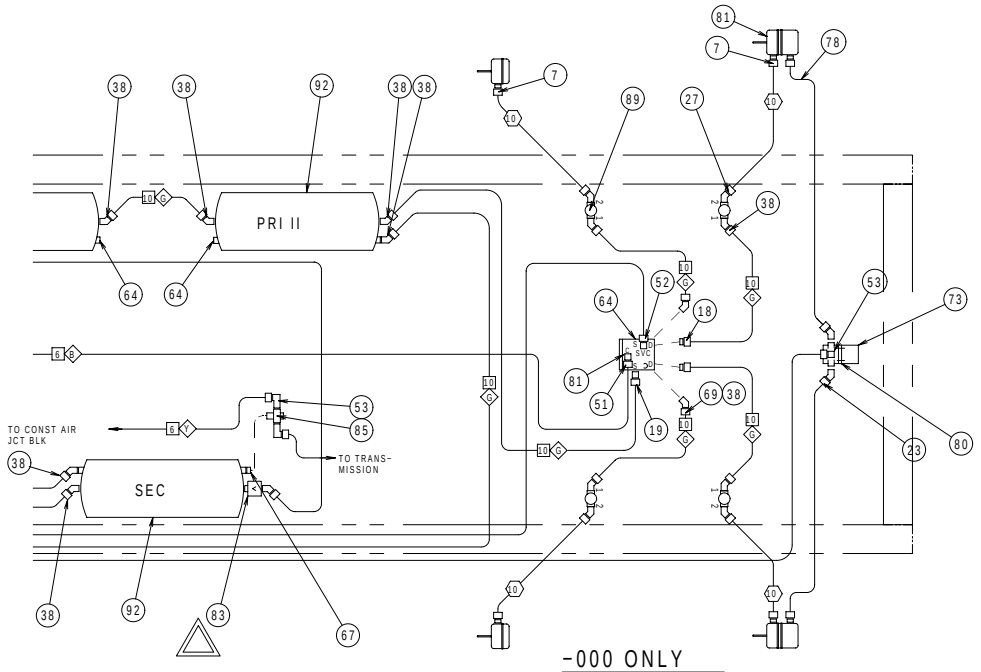
09/27/96 f421068a

Fig. 8

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning

Fig. 8

Fig. 8



-000 ONLY

ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	2	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	4	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	16	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
Ⓐ 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING -RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRT BRAKES
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓒ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

Ref. Diagram D12−13564−000 Chg. Ltr. C

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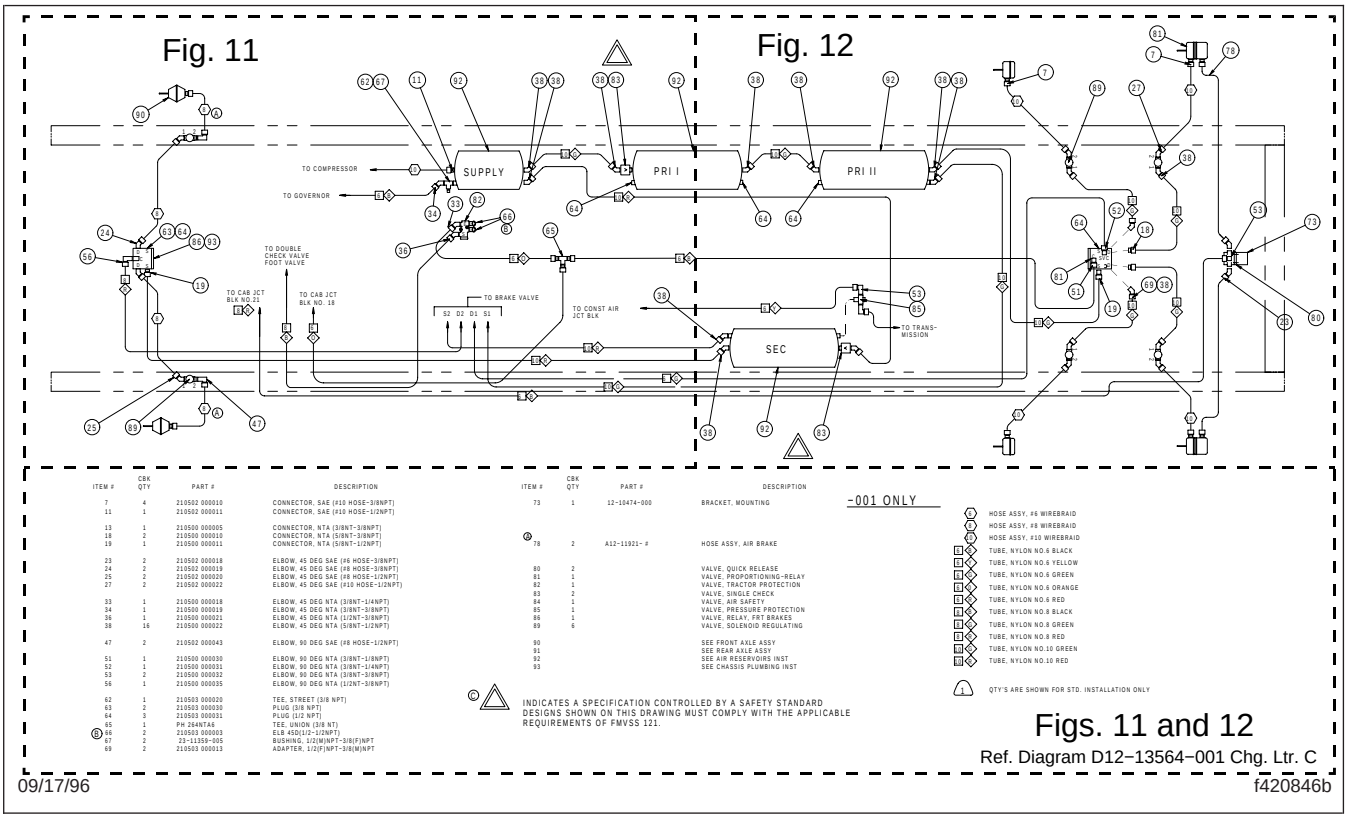
Fig. 9

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



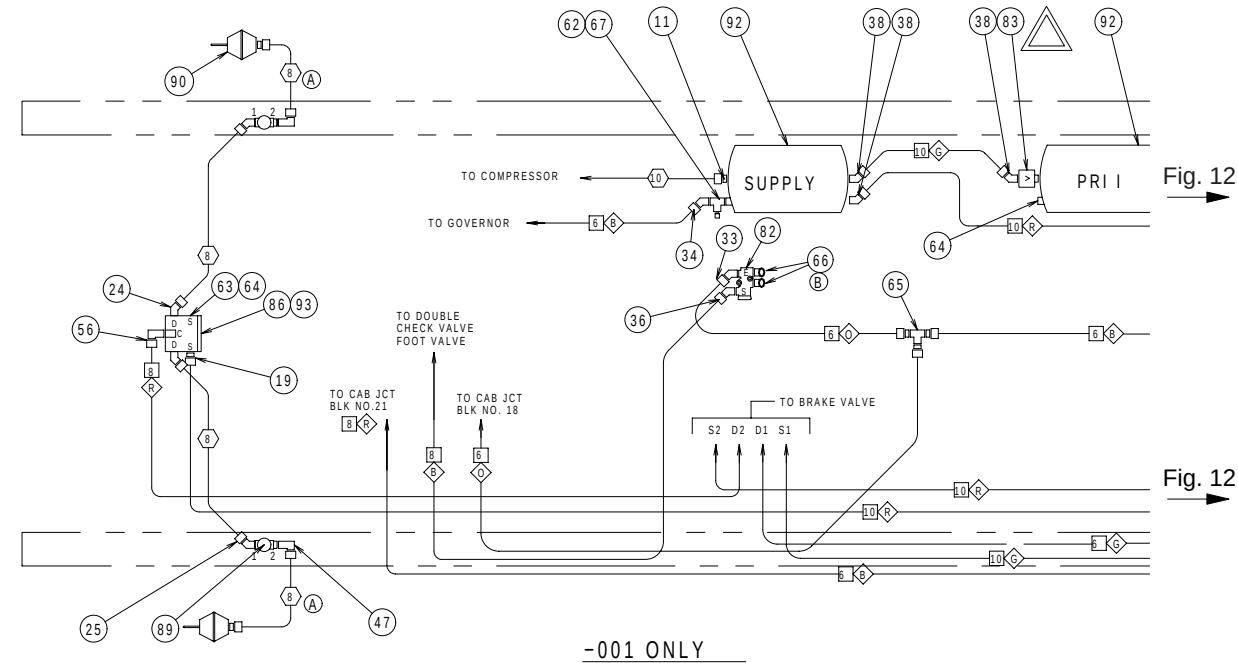
ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE−3/8NPT)
11	1	210502 000011	CONNECTOR, SAE (#10 HOSE−1/2NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT−3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT−3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT−1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE−3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE−3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE−1/2NPT)
27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE−1/2NPT)
33	1	210500 000018	ELBOW, 45 DEG NTA (3/8NT−1/4NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT−3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT−3/8NPT)
38	16	210500 000022	ELBOW, 45 DEG NTA (5/8NT−1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE−1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT−1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT−1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT−3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT−3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
65	1	PH 264NTA6	TEE, UNION (3/8 NT)
B 66	2	210503 000003	ELB 45D(1/2−1/2NPT)
67	2	23−11359−005	BUSHING, 1/2(M)NPT−3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT−3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12−10474−000	BRACKET, MOUNTING
D 78	2	A12−11921− #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING−RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
88	1		VALVE, RELAY, FRT BRAKES
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

X	HOSE ASSY, #6 WIREBRAID
Y	HOSE ASSY, #8 WIREBRAID
Z	HOSE ASSY, #10 WIREBRAID
A	TUBE, NYLON NO.6 BLACK
B	TUBE, NYLON NO.6 YELLOW
C	TUBE, NYLON NO.6 GREEN
E	TUBE, NYLON NO.6 ORANGE
G	TUBE, NYLON NO.6 RED
H	TUBE, NYLON NO.8 BLACK
J	TUBE, NYLON NO.8 GREEN
K	TUBE, NYLON NO.8 RED
M	TUBE, NYLON NO.10 GREEN
N	TUBE, NYLON NO.10 RED

Fig. 10, Nylon Tubing, With Front Relay Valve, With Tractor Protection Valve on Tunnel, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



-001 ONLY

ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
33	1	210500 000018	ELBOW, 45 DEG NTA (3/8NT-1/4NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	16	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
65	1	PH 264NTA6	TEE, UNION (3/8 NT)
Ⓑ 66	2	210503 000003	ELB 45D(1/2-1/2NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
Ⓐ 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING-RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRT BRAKES
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓒ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Ref. Diagram D12−13564−001 Chg. Ltr. C

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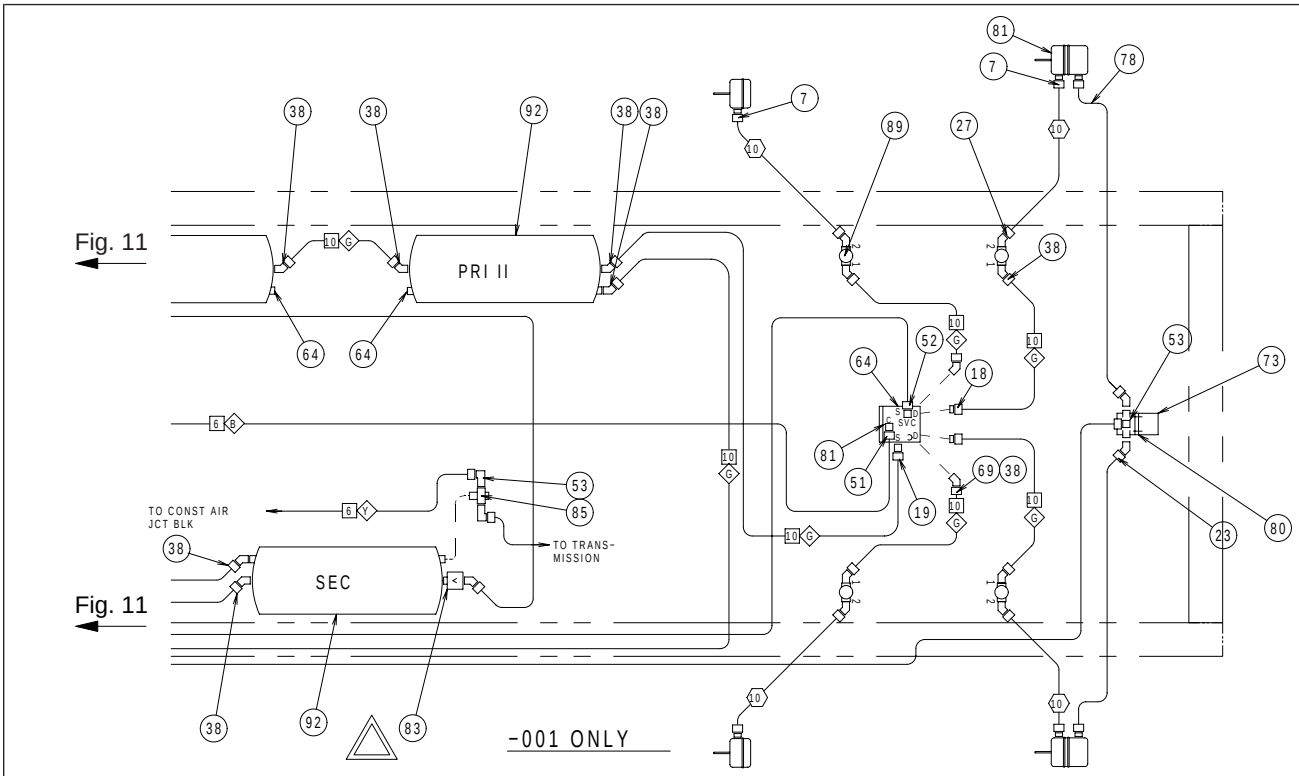
Fig. 11

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



ITEM #	CBK QTY	PART #	DESCRIPTION
7	4	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
13	1	210500 000005	CONNECTOR, NTA (3/8NT-3/8NPT)
18	2	210500 000010	CONNECTOR, NTA (5/8NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
27	2	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
33	1	210500 000018	ELBOW, 45 DEG NTA (3/8NT-1/4NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	1	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	16	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	1	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
65	1	PH 264NTA6	TEE, UNION (3/8 NT)
Ⓑ 66	2	210503 000003	ELB 45D(1/2-1/2NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
69	2	210503 000013	ADAPTER, 1/2(F)NPT-3/8(M)NPT

ITEM #	CBK QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
Ⓐ 78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING-RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRT BRAKES
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓒ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 O	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 G	TUBE, NYLON NO.8 GREEN
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

Ref. Diagram D12−13564−001 Chg. Ltr. C

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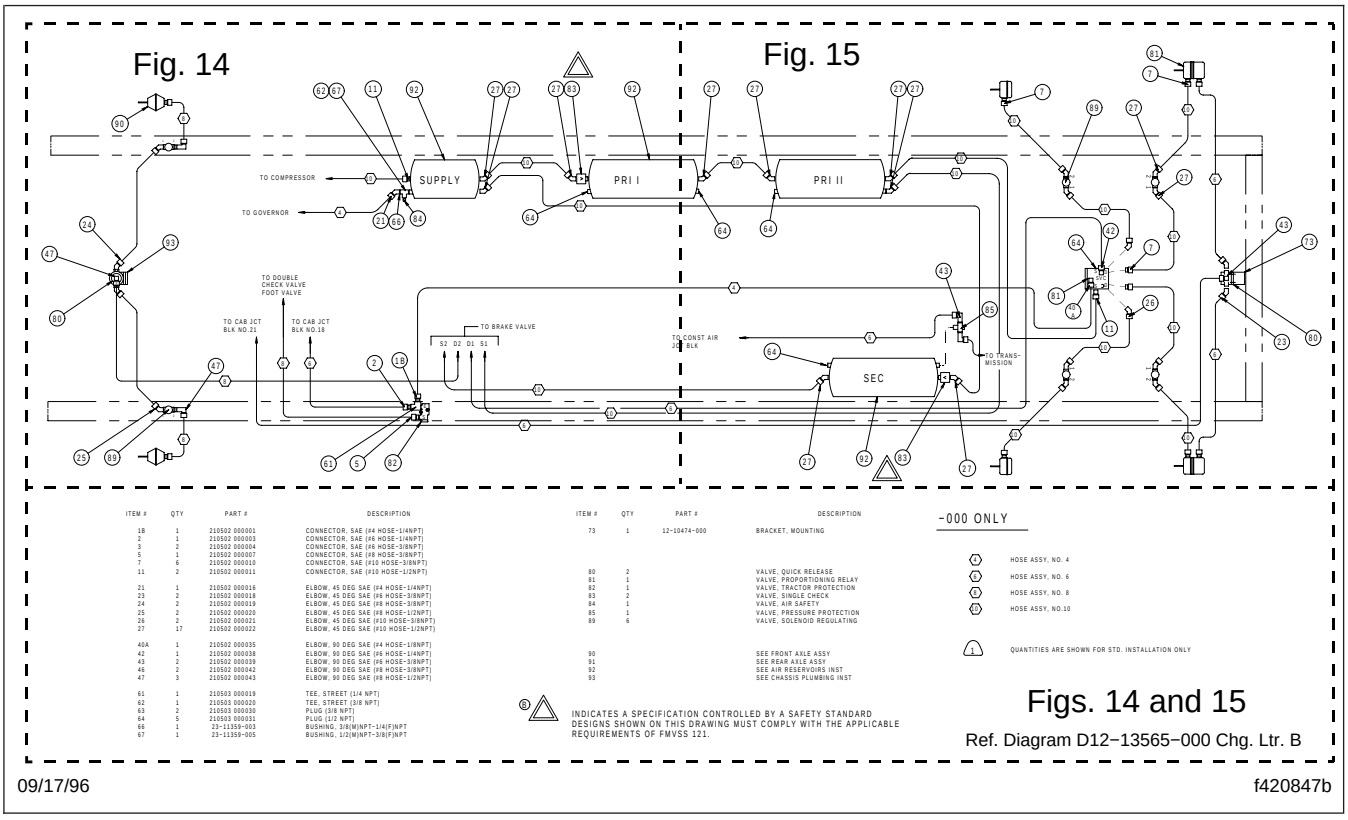
Fig. 12

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE–1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE–1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE–3/8NPT)
5	1	210502 000007	CONNECTOR, SAE (#8 HOSE–3/8NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE–3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE–1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE–1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE–3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE–3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE–1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE–3/8NPT)
27	17	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE–1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE–1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE–1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE–3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE–3/8NPT)
47	3	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE–1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
66	1	23–11359–003	BUSHING, 3/8(M)NPT–1/4(F)NPT
67	1	23–11359–005	BUSHING, 1/2(M)NPT–3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12–10474–000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-000 ONLY

A HOSE ASSY, NO. 4
B HOSE ASSY, NO. 6
C HOSE ASSY, NO. 8
D HOSE ASSY, NO.10

1 QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

3 INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

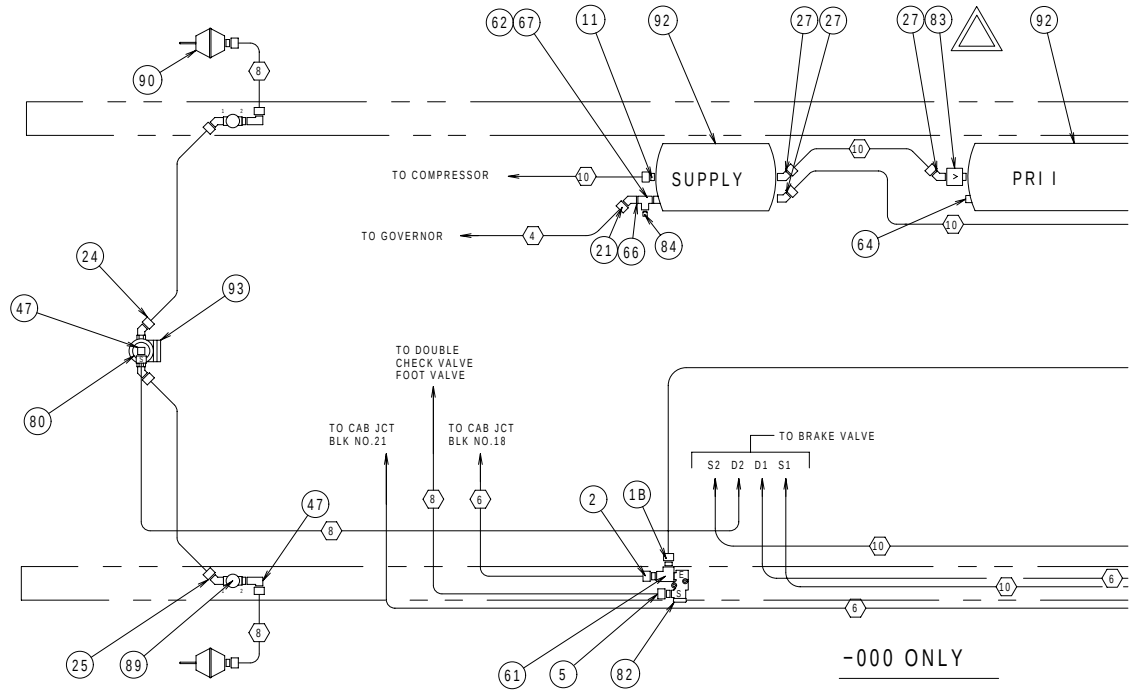
Figs. 14 and 15

Ref. Diagram D12–13565–000 Chg. Ltr. B

09/17/96 f420847b

Fig. 13, Wire Braid Hose, With Front Quick Release Valve, With Tractor Protection Valve on Frame, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	1	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	17	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	3	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(B) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Ref. Diagram D12−13565−000 Chg. Ltr. B

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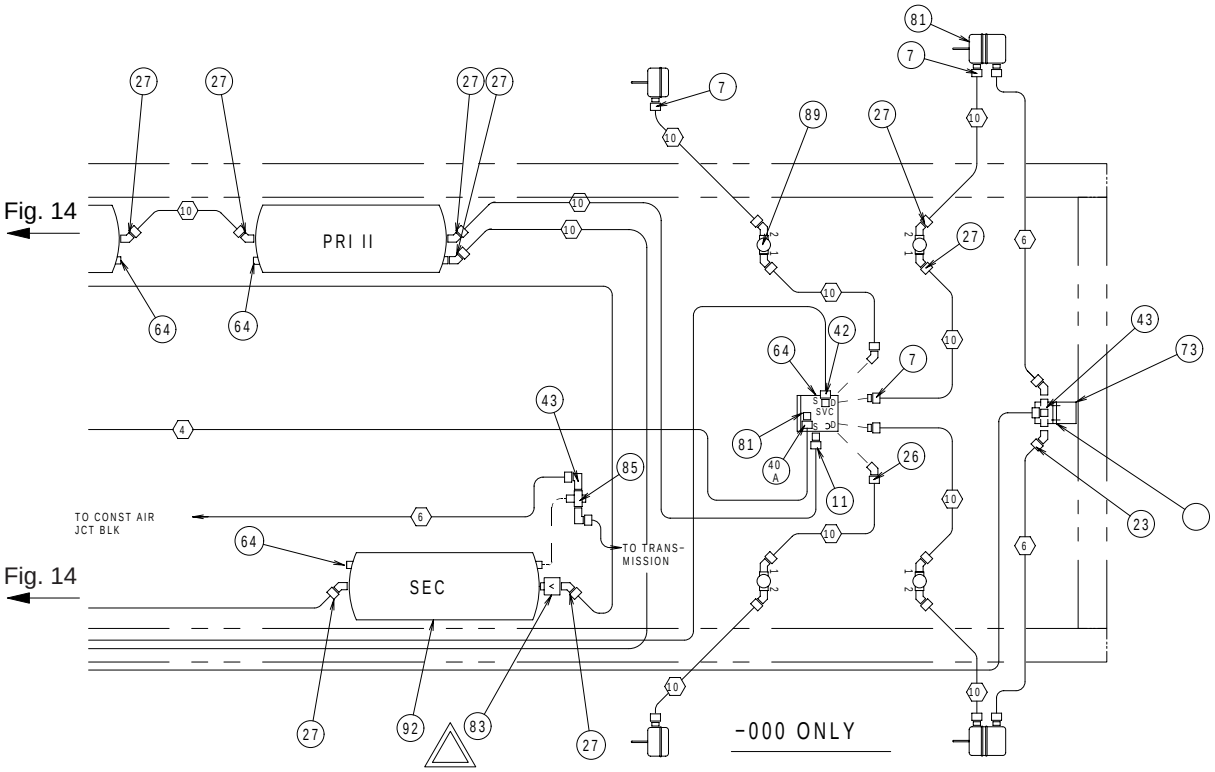
Fig. 14

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	1	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	17	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	3	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(B) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Ref. Diagram D12−13565−000 Chg. Ltr. B

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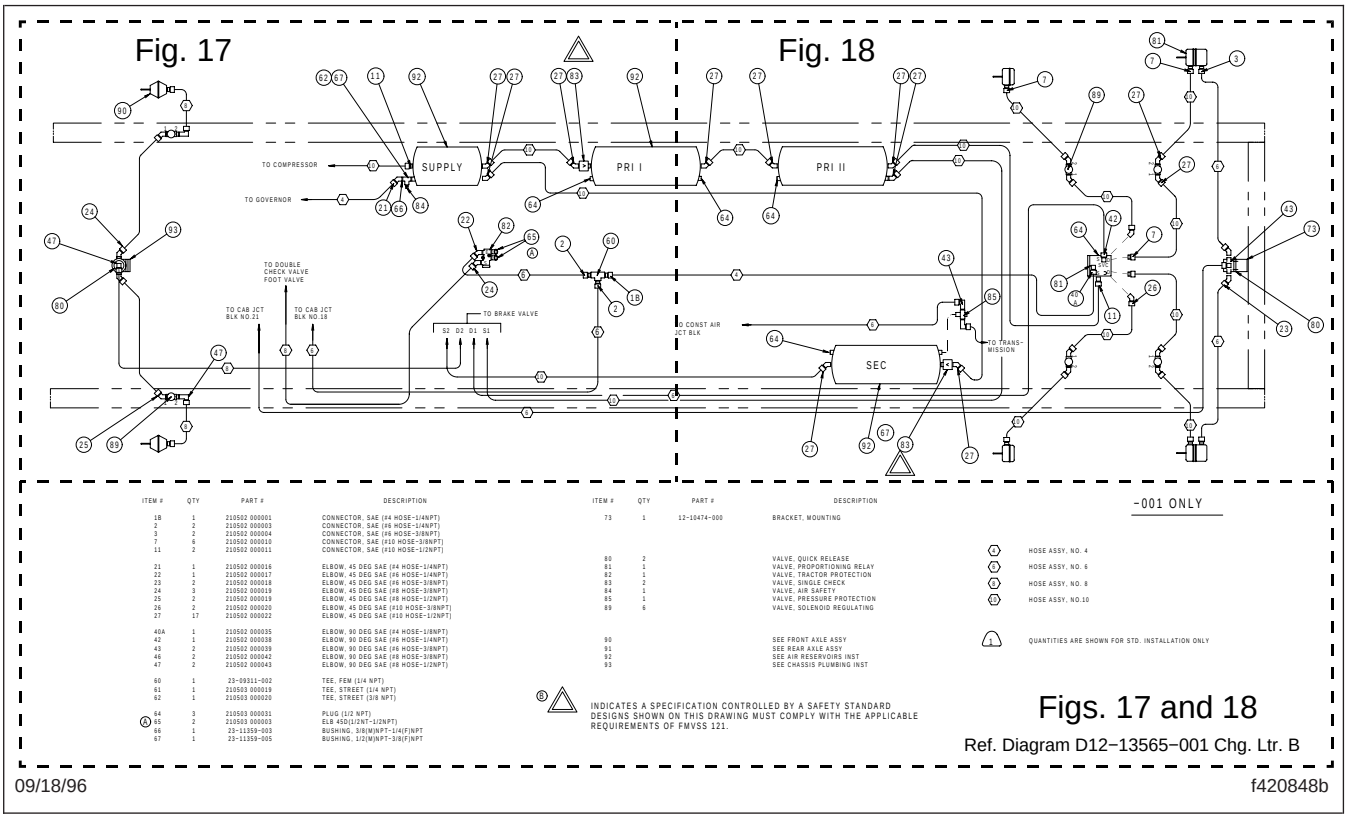
Fig. 15

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	2	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	3	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000020	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	17	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60	1	23-99311-002	TEE, FEM (1/4 NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
(A) 65	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE; SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-001 ONLY

(X) HOSE ASSY, NO. 4
(Y) HOSE ASSY, NO. 6
(Z) HOSE ASSY, NO. 8
(ZZ) HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

(B) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Figs. 17 and 18

Ref. Diagram D12−13565−001 Chg. Ltr. B

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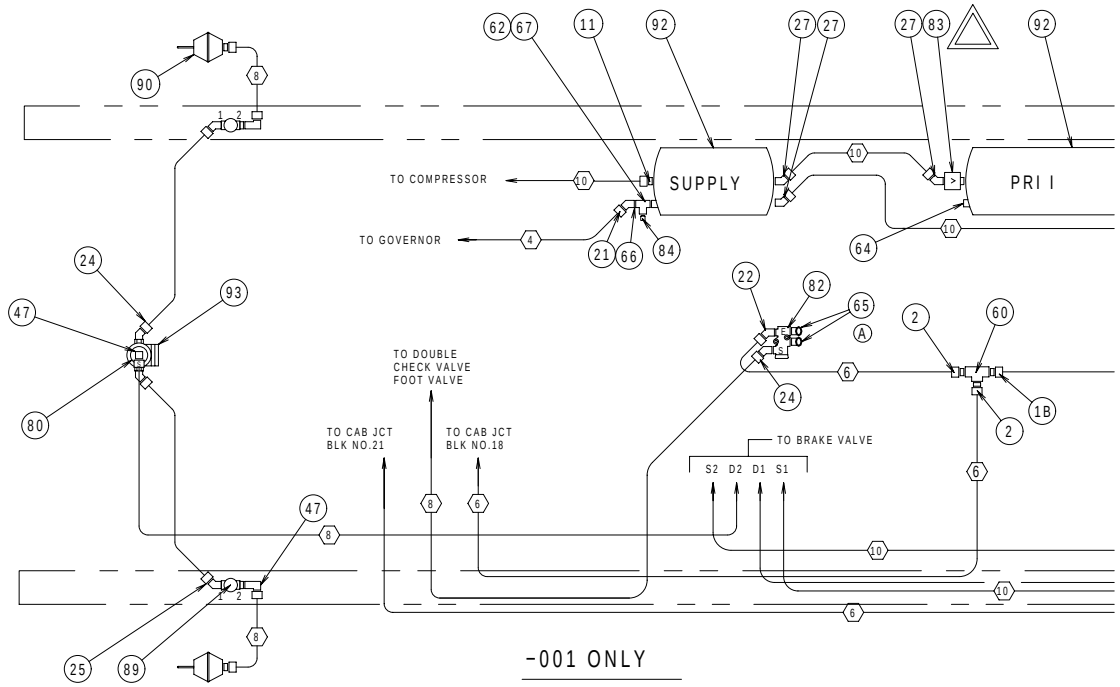
Fig. 16, Wire Braid Hose, With Front Quick Release Valve, With Tractor Protection Valve on Tunnel, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	2	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	3	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000020	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	17	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60	1	23-09311-002	TEE, FEM (1/4 NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
(A) 65	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(4) HOSE ASSY, NO. 4
(6) HOSE ASSY, NO. 6
(8) HOSE ASSY, NO. 8
(10) HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

(B) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Ref. Diagram D12−13565−001 Chg. Ltr. B

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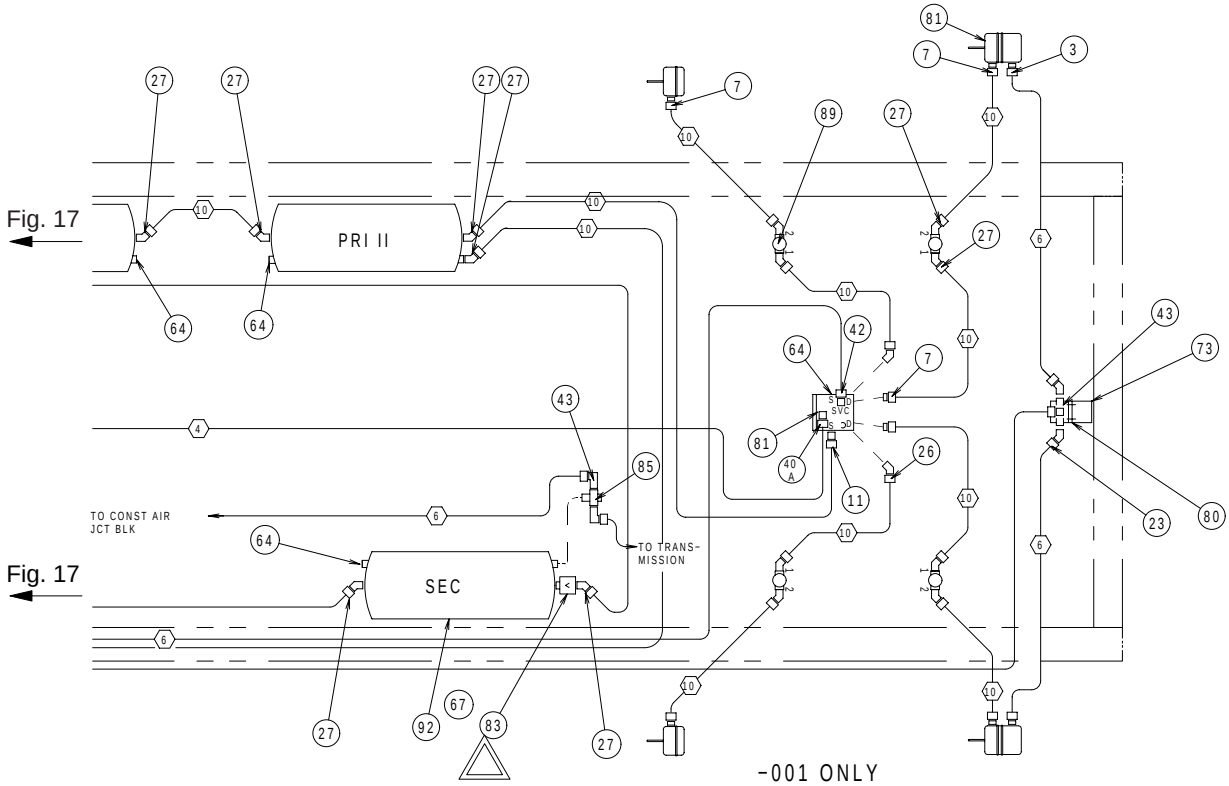
Fig. 17

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	2	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	3	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000020	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	17	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60	1	23-09311-002	TEE, FEM (1/4 NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
(A) 65	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

4	HOSE ASSY, NO. 4
6	HOSE ASSY, NO. 6
8	HOSE ASSY, NO. 8
10	HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

(B) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Ref. Diagram D12−13565−001 Chg. Ltr. B

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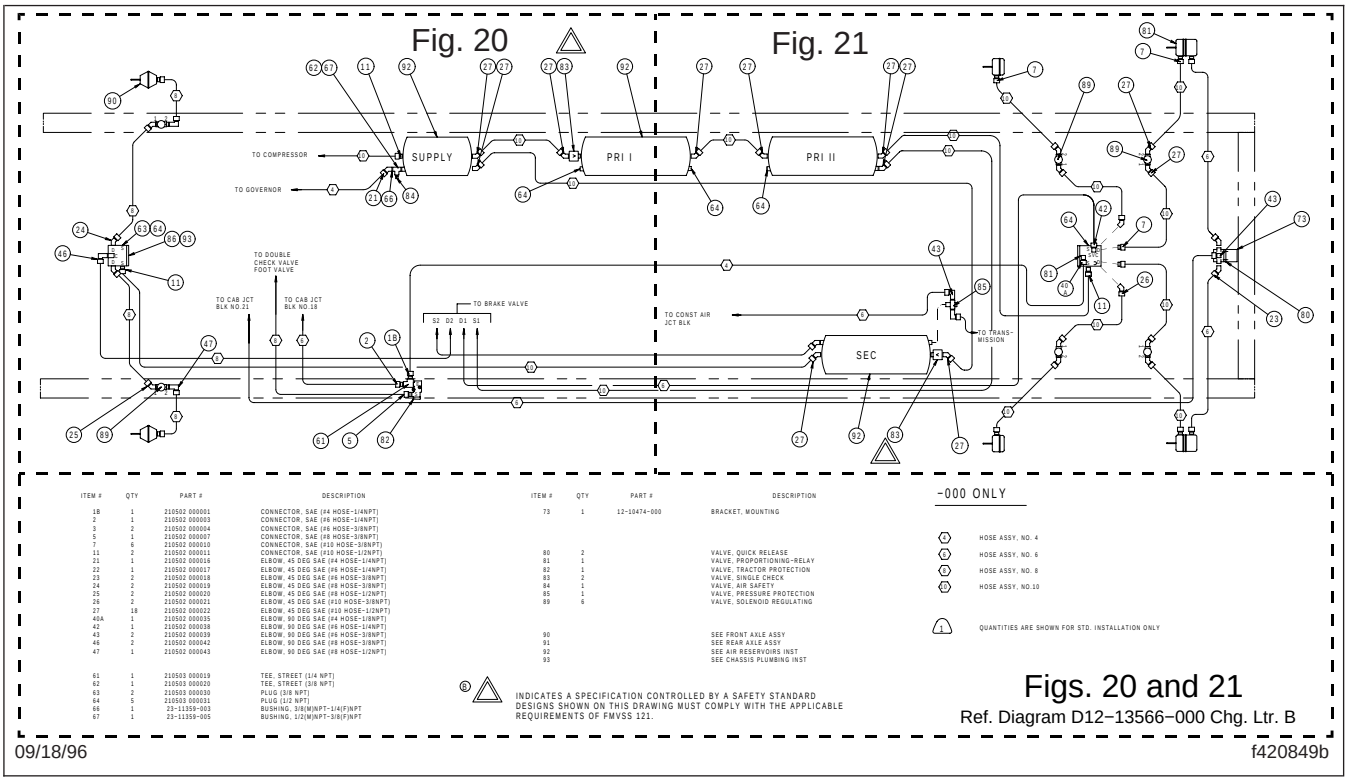
Fig. 18

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	1	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	18	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING-RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-000 ONLY

A HOSE ASSY, NO. 4
B HOSE ASSY, NO. 6
C HOSE ASSY, NO. 8
D HOSE ASSY, NO.10

1 QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

⑥ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Figs. 20 and 21
Ref. Diagram D12−13566−000 Chg. Ltr. B

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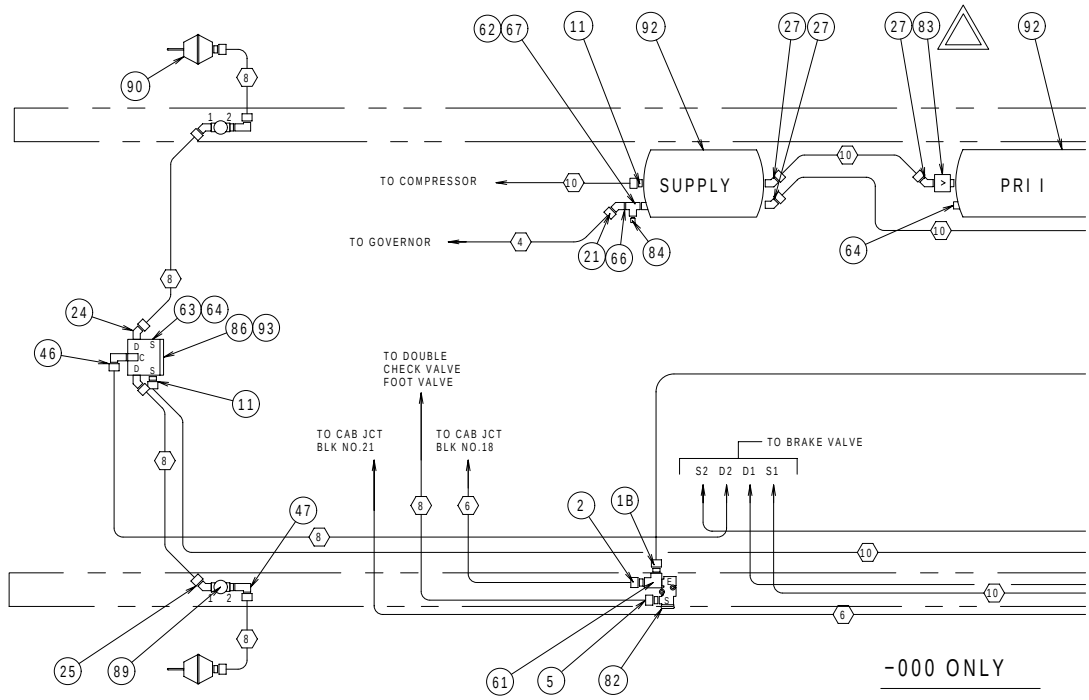
Fig. 19, Wire Braid Hose, With Front Relay Valve, With Tractor Protection Valve on Frame, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	1	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	18	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING-RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

4	HOSE ASSY, NO. 4
6	HOSE ASSY, NO. 6
8	HOSE ASSY, NO. 8
10	HOSE ASSY, NO.10

1 QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓑ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Ref. Diagram D12−13566−000 Chg. Ltr. B

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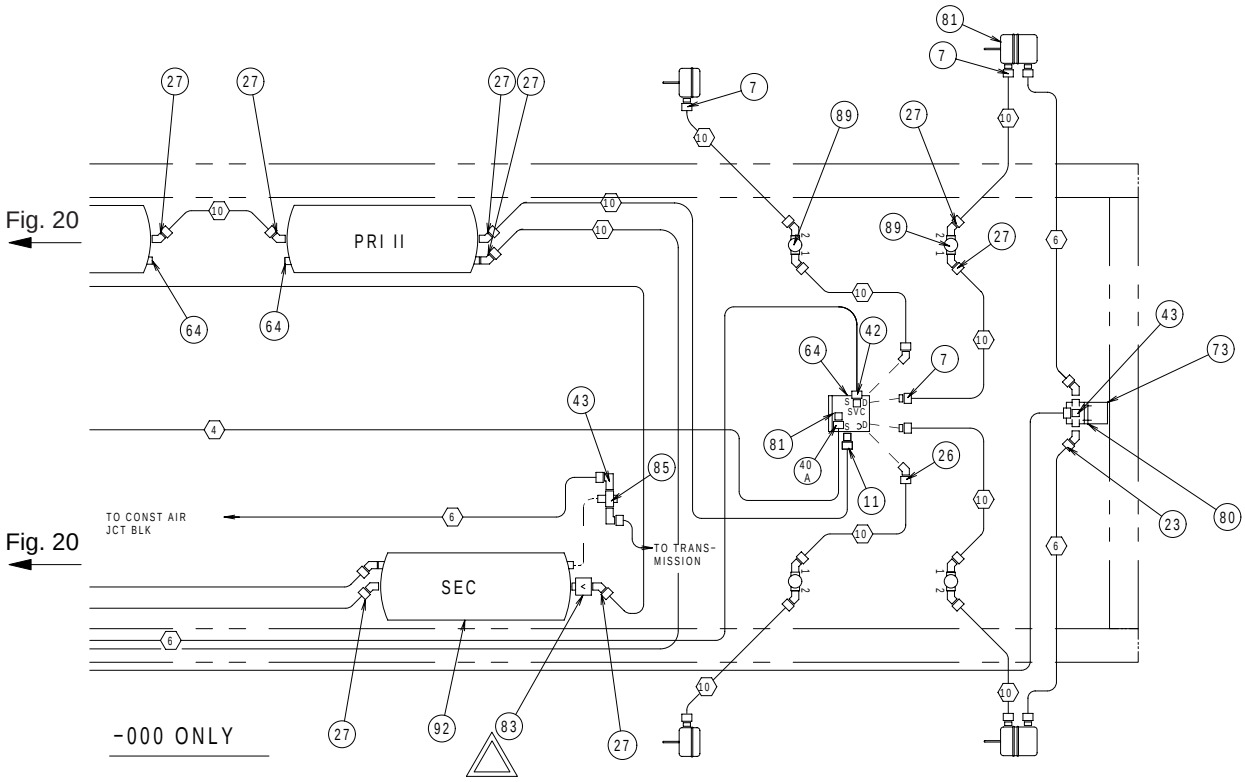
Fig. 20

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	1	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	18	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING-RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

4	HOSE ASSY, NO. 4
6	HOSE ASSY, NO. 6
8	HOSE ASSY, NO. 8
10	HOSE ASSY, NO.10

1 QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓑ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Ref. Diagram D12−13566−000 Chg. Ltr. B

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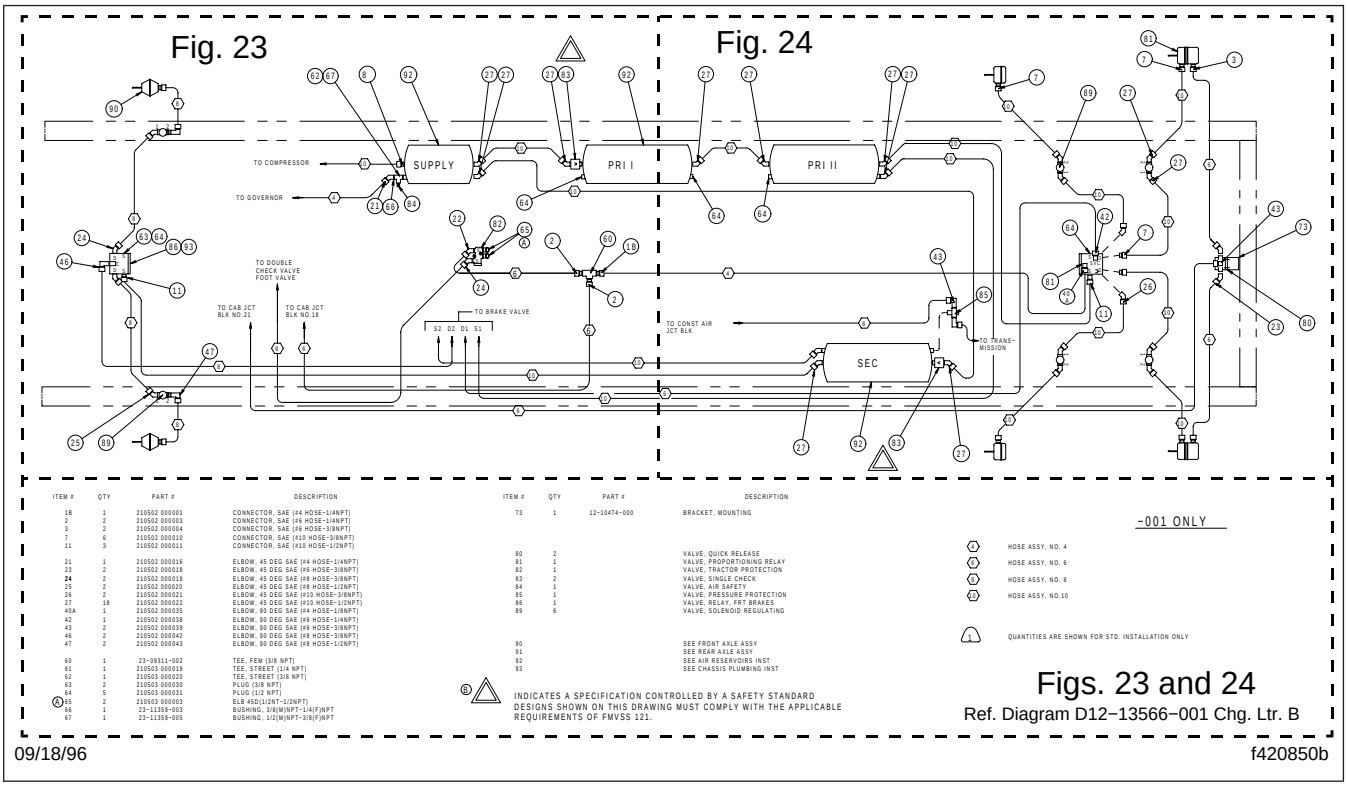
Fig. 21

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	2	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	18	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60	1	23-09311-002	TEE, FEM (3/8 NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
Ⓐ65	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRT BRAKES
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-001 ONLY

4	HOSE ASSY, NO. 4
6	HOSE ASSY, NO. 6
8	HOSE ASSY, NO. 8
10	HOSE ASSY, NO.10
1	QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Ⓐ INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Figs. 23 and 24

Ref. Diagram D12−13566−001 Chg. Ltr. B

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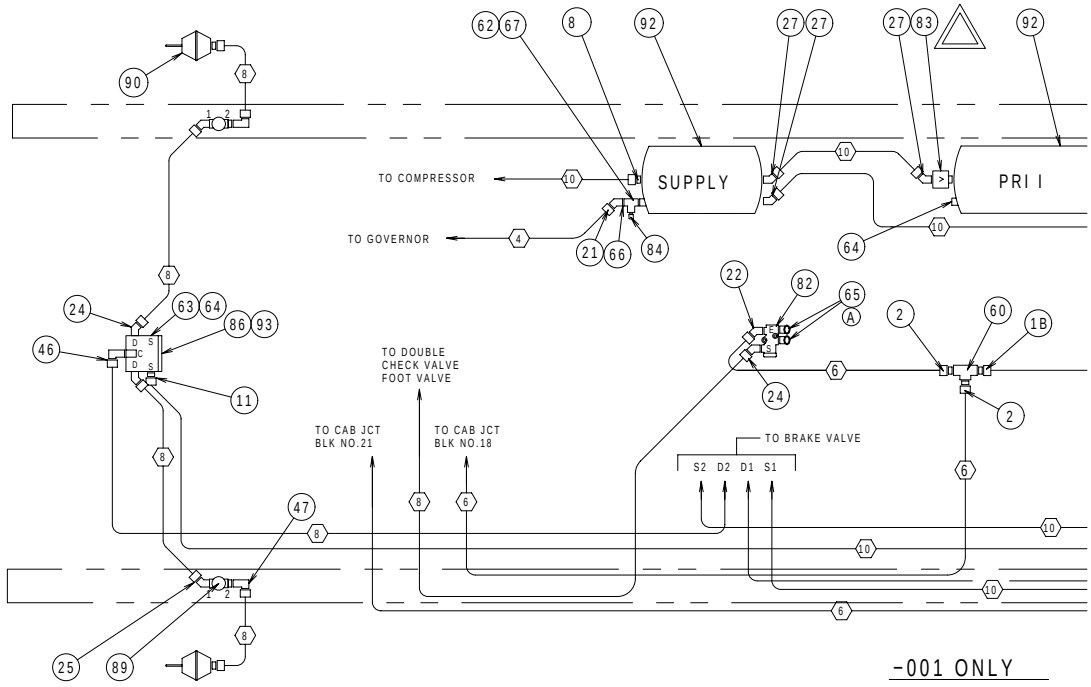
Fig. 22, Wire Braid Hose, With Front Relay Valve, With Tractor Protection Valve on Tunnel, Date of Use 7/89 to 4/91.

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	2	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	18	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60	1	23-09311-002	TEE, FEM (3/8 NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
(A) 65	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRT BRAKES
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(4)	HOSE ASSY, NO. 4
(6)	HOSE ASSY, NO. 6
(8)	HOSE ASSY, NO. 8
(10)	HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

(B) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Ref. Diagram D12−13566−001 Chg. Ltr. B

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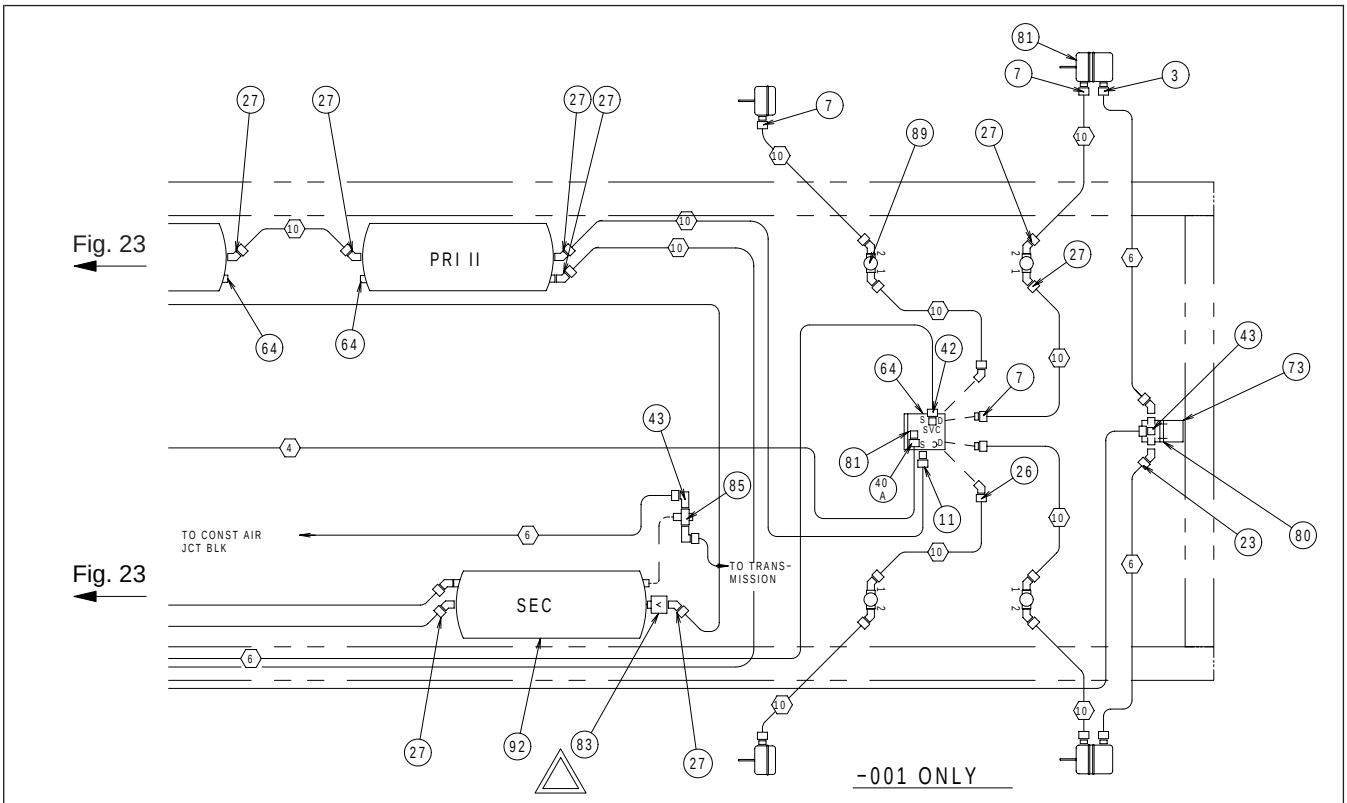
Fig. 23

Tandem Rear Axle Tractor, With Six-Channel Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	2	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
7	6	210502 000010	CONNECTOR, SAE (#10 HOSE-3/8NPT)
11	3	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
25	2	210502 000020	ELBOW, 45 DEG SAE (#8 HOSE-1/2NPT)
26	2	210502 000021	ELBOW, 45 DEG SAE (#10 HOSE-3/8NPT)
27	18	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	2	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
60	1	23-09311-002	TEE, FEM (3/8 NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	5	210503 000031	PLUG (1/2 NPT)
(A) 65	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
86	1		VALVE, RELAY, FRT BRAKES
89	6		VALVE, SOLENOID REGULATING
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(4)	HOSE ASSY, NO. 4
(6)	HOSE ASSY, NO. 6
(8)	HOSE ASSY, NO. 8
(10)	HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

(B) INDICATES A SPECIFICATION CONTROLLED BY A SAFETY STANDARD DESIGNS SHOWN ON THIS DRAWING MUST COMPLY WITH THE APPLICABLE REQUIREMENTS OF FMVSS 121.

Ref. Diagram D12−13566−001 Chg. Ltr. B

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Fig. 24

Single Rear Axle Tractor, Without Antilock, With Brake Proportioning

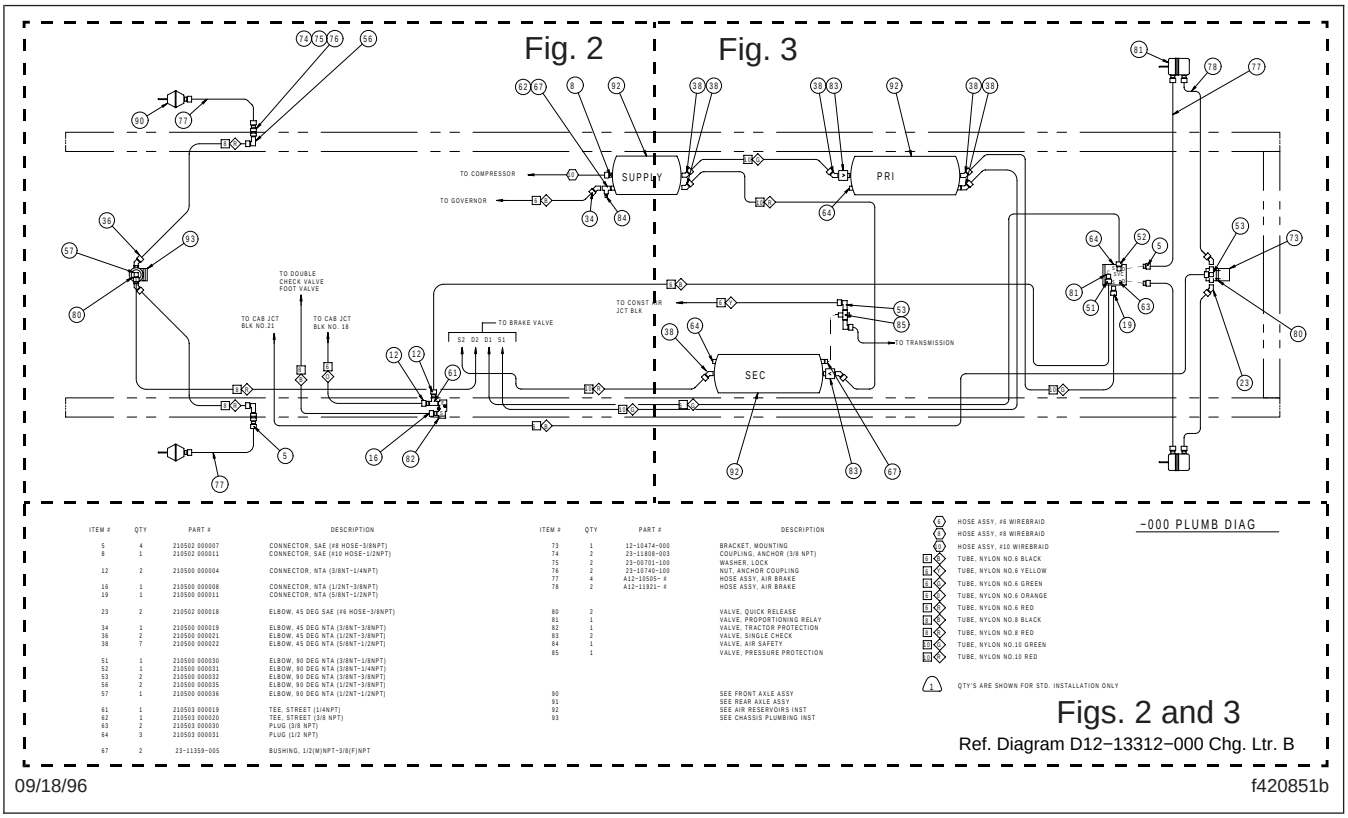
See Fig. 1 for a full view of the plumbing diagram nylon tubing, with tractor protection valve on frame, date of use 1/89 to 4/91. **See Fig. 2**, or **Fig. 3** for partial (detailed) views plumbing diagram nylon tubing, with tractor protection valve on frame, date of use 1/89 to 4/91.

See Fig. 4 for a full view of the plumbing diagram nylon tubing, with tractor protection valve on tunnel, date of use 7/89 to 4/91. **See Fig. 5**, or **Fig. 6** for partial (detailed) views plumbing diagram nylon tubing, with tractor protection valve on tunnel, date of use 7/89 to 4/91.

See Fig. 7 for a full view of the plumbing diagram wire braid hose, with tractor protection valve on frame, date of use 1/89 to 4/91. **See Fig. 8**, or **Fig. 9** for partial (detailed) views plumbing diagram wire braid hose, with tractor protection valve on frame, date of use 1/89 to 4/91.

See Fig. 10 for a full view of the plumbing diagram wire braid hose, with tractor protection valve on tunnel, date of use 7/89 to 4/91. **See Fig. 11**, or **Fig. 12** for partial (detailed) views plumbing diagram wire braid hose, with tractor protection valve on tunnel, date of use 7/89 to 4/91.

Single Rear Axle Tractor, Without Antilock, With Brake Proportioning



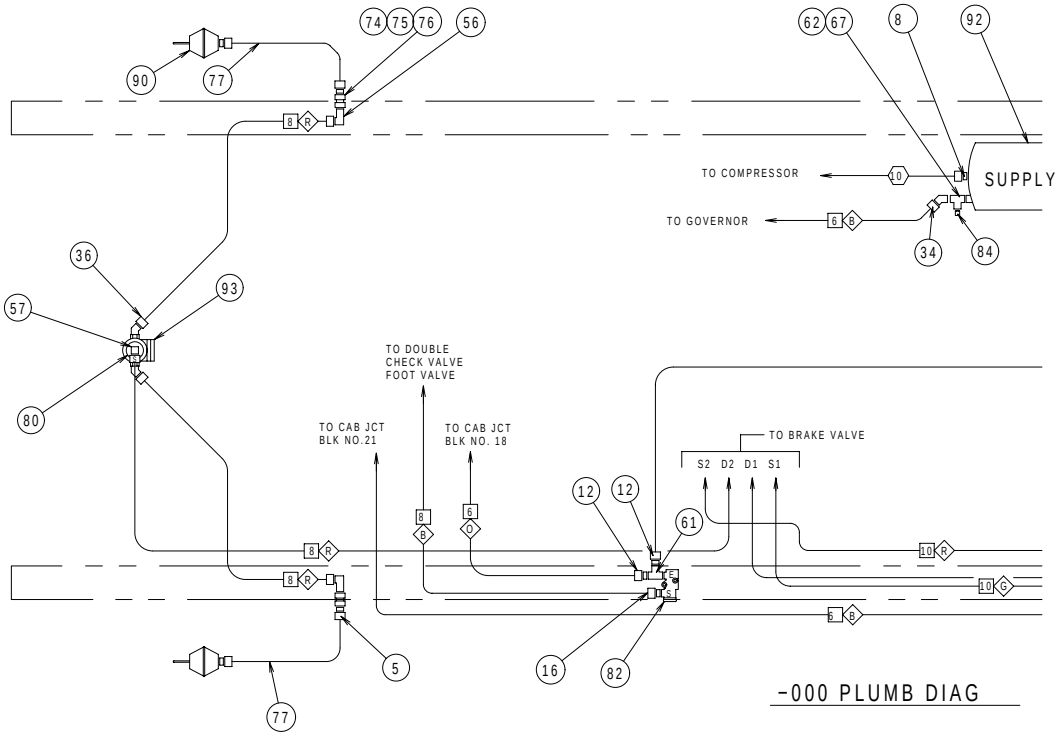
ITEM #	QTY	PART #	DESCRIPTION
5	4	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	7	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

A	HOSE ASSY, #6 WIREBRAID
B	HOSE ASSY, #8 WIREBRAID
C	HOSE ASSY, #10 WIREBRAID
B1	TUBE, NYLON NO.6 BLACK
B2	TUBE, NYLON NO.6 YELLOW
B3	TUBE, NYLON NO.6 GREEN
B4	TUBE, NYLON NO.6 ORANGE
B5	TUBE, NYLON NO.6 RED
B6	TUBE, NYLON NO.8 BLACK
B7	TUBE, NYLON NO.8 RED
B8	TUBE, NYLON NO.10 GREEN
B9	TUBE, NYLON NO.10 RED

1 QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Fig. 1, Nylon Tubing, With Tractor Protection Valve on Frame, Date of Use 1/89 to 4/91.

Single Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
5	4	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	7	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

6	HOSE ASSY, #6 WIREBRAID	6 O	TUBE, NYLON NO.6 ORANGE
8	HOSE ASSY, #8 WIREBRAID	6 R	TUBE, NYLON NO.6 RED
10	HOSE ASSY, #10 WIREBRAID	8 B	TUBE, NYLON NO.8 BLACK
6 B	TUBE, NYLON NO.6 BLACK	8 R	TUBE, NYLON NO.8 RED
6 Y	TUBE, NYLON NO.6 YELLOW	10 G	TUBE, NYLON NO.10 GREEN
6 G	TUBE, NYLON NO.6 GREEN	10 R	TUBE, NYLON NO.10 RED

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Ref. Diagram D12−13312−000 Chg. Ltr. B

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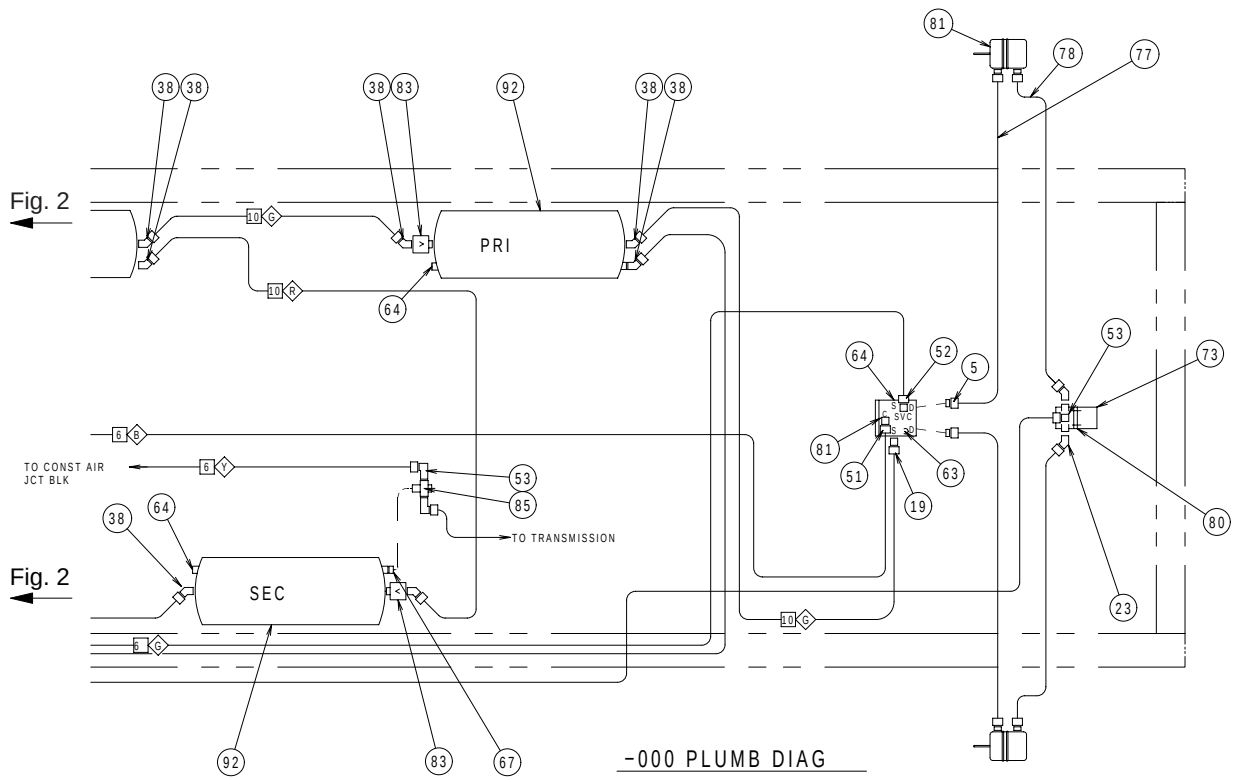
Fig. 2

Single Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
5	4	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
12	2	210500 000004	CONNECTOR, NTA (3/8NT-1/4NPT)
16	1	210500 000008	CONNECTOR, NTA (1/2NT-3/8NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	7	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

6	HOSE ASSY, #6 WIREBRAID	6 O	TUBE, NYLON NO.6 ORANGE
8	HOSE ASSY, #8 WIREBRAID	6 R	TUBE, NYLON NO.6 RED
10	HOSE ASSY, #10 WIREBRAID	8 B	TUBE, NYLON NO.8 BLACK
6 B	TUBE, NYLON NO.6 BLACK	8 R	TUBE, NYLON NO.8 RED
6 Y	TUBE, NYLON NO.6 YELLOW	10 G	TUBE, NYLON NO.10 GREEN
6 G	TUBE, NYLON NO.6 GREEN	10 R	TUBE, NYLON NO.10 RED

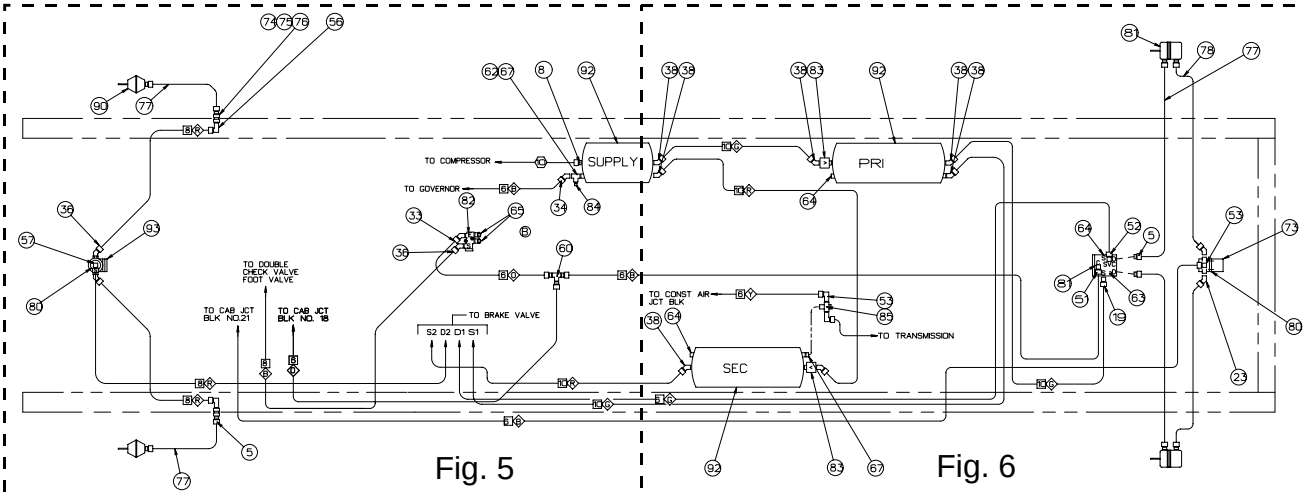
09/30/96

Ref. Diagram D12−13312−000 Chg. Ltr. B

f421081a

Fig. 3

Single Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
5	4	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
33	1	210500 000018	ELBOW, 45 DEG NTA (3/8NT-1/4NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	8	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
60	1	PH 264NTA6	TEE, UNION (3/8 NT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
65	2	210503 000033	ELBOW 45D(1/2NT-1/2NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-001 PLUMB DIAG

Figs. 5 and 6

(6)	HOSE ASSY, #6 WIREBRAID
(8)	HOSE ASSY, #8 WIREBRAID
(10)	HOSE ASSY, #10 WIREBRAID
[6]	TUBE, NYLON NO.6 BLACK
[6]	TUBE, NYLON NO.6 YELLOW
[6]	TUBE, NYLON NO.6 GREEN
[6]	TUBE, NYLON NO.6 ORANGE
[6]	TUBE, NYLON NO.6 RED
[8]	TUBE, NYLON NO.8 BLACK
[8]	TUBE, NYLON NO.8 RED
[10]	TUBE, NYLON NO.10 GREEN
[10]	TUBE, NYLON NO.10 RED
1	QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Diagram D12−13312−001, Chg. Ltr. B

02/07/94 f420852a

Fig. 4, Nylon Tubing, With Tractor Protection Valve on Tunnel, Date of Use 7/89 to 4/91.

Single Rear Axle Tractor, Without Antilock, With Brake Proportioning

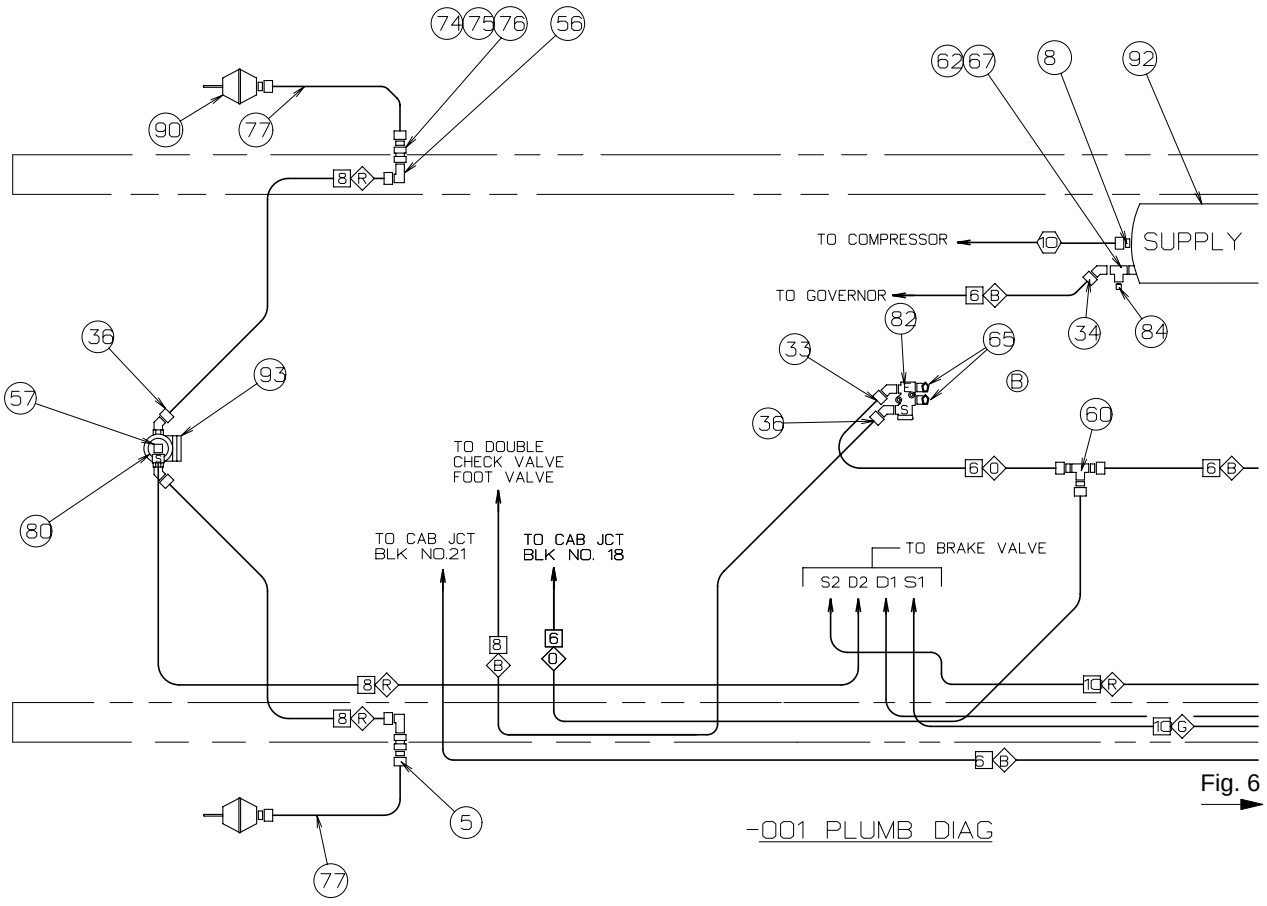


Fig. 6

ITEM #	QTY	PART #	DESCRIPTION
5	4	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
33	1	210500 000018	ELBOW, 45 DEG NTA (3/8NT-1/4NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	8	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
60	1	PH 264NTA6	TEE, UNION (3/8 NT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
(B) 65	2	210503 000003	ELBOW 45D(1/2NT-1/2NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE

ITEM #	QTY	PART #	DESCRIPTION
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

6	HOSE ASSY, #6 WIREBRAID
8	HOSE ASSY, #8 WIREBRAID
10	HOSE ASSY, #10 WIREBRAID
6 B	TUBE, NYLON NO.6 BLACK
6 Y	TUBE, NYLON NO.6 YELLOW
6 G	TUBE, NYLON NO.6 GREEN
6 Q	TUBE, NYLON NO.6 ORANGE
6 R	TUBE, NYLON NO.6 RED
8 B	TUBE, NYLON NO.8 BLACK
8 R	TUBE, NYLON NO.8 RED
10 G	TUBE, NYLON NO.10 GREEN
10 R	TUBE, NYLON NO.10 RED

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

Diagram D12−13312−001, Chg. Ltr. B

02/07/94

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Fig. 5

Single Rear Axle Tractor, Without Antilock, With Brake Proportioning

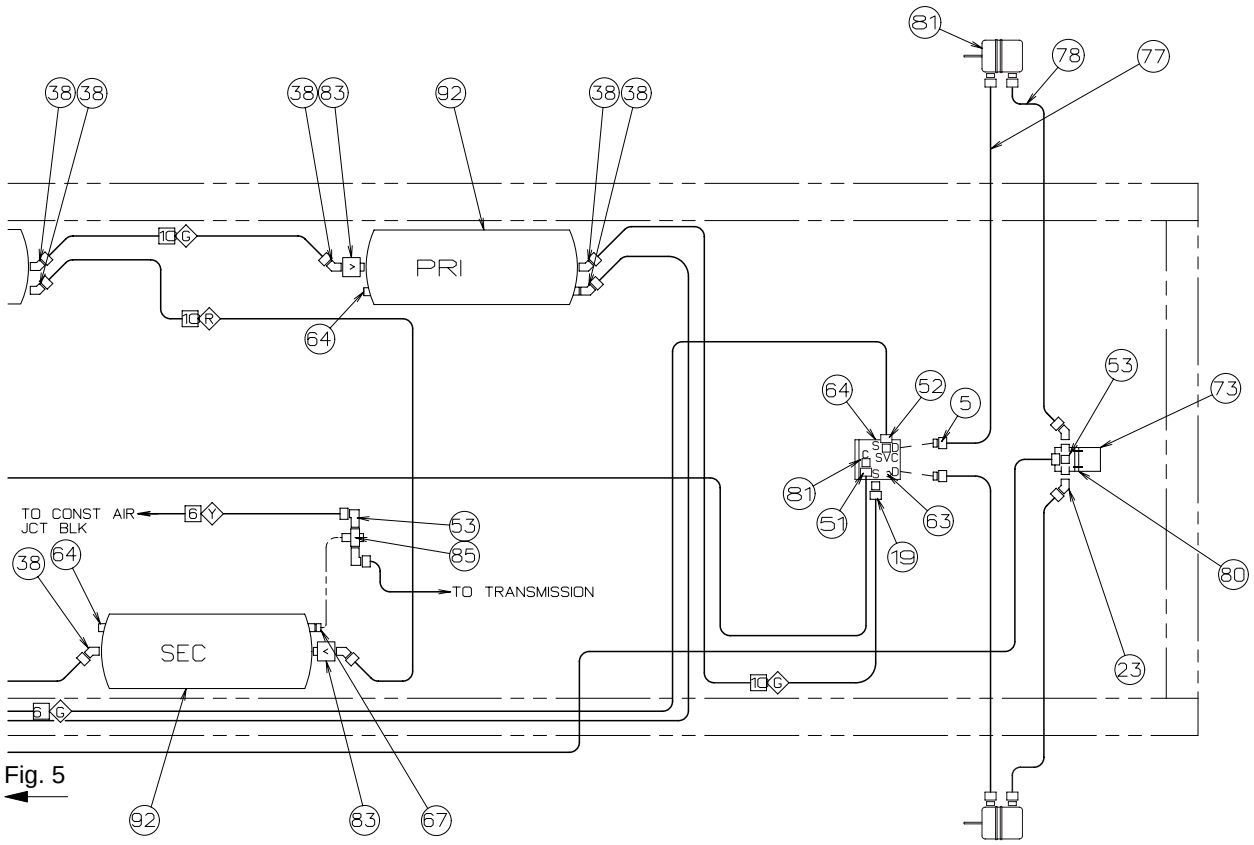


Fig. 5

ITEM #	QTY	PART #	DESCRIPTION
5	4	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
8	1	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
19	1	210500 000011	CONNECTOR, NTA (5/8NT-1/2NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
33	1	210500 000018	ELBOW, 45 DEG NTA (3/8NT-1/4NPT)
34	1	210500 000019	ELBOW, 45 DEG NTA (3/8NT-3/8NPT)
36	2	210500 000021	ELBOW, 45 DEG NTA (1/2NT-3/8NPT)
38	8	210500 000022	ELBOW, 45 DEG NTA (5/8NT-1/2NPT)
51	1	210500 000030	ELBOW, 90 DEG NTA (3/8NT-1/8NPT)
52	1	210500 000031	ELBOW, 90 DEG NTA (3/8NT-1/4NPT)
53	2	210500 000032	ELBOW, 90 DEG NTA (3/8NT-3/8NPT)
56	2	210500 000035	ELBOW, 90 DEG NTA (1/2NT-3/8NPT)
57	1	210500 000036	ELBOW, 90 DEG NTA (1/2NT-1/2NPT)
60	1	PH 264NTA6	TEE, UNION (3/8 NT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
(B) 65	2	210503 000003	ELBOW 45D(1/2NT-1/2NPT)
67	2	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR (3/8 NPT)
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
77	4	A12-10505- #	HOSE ASSY, AIR BRAKE
78	2	A12-11921- #	HOSE ASSY, AIR BRAKE
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

(1) QTY'S ARE SHOWN FOR STD. INSTALLATION ONLY

-001 PLUMB DIAG

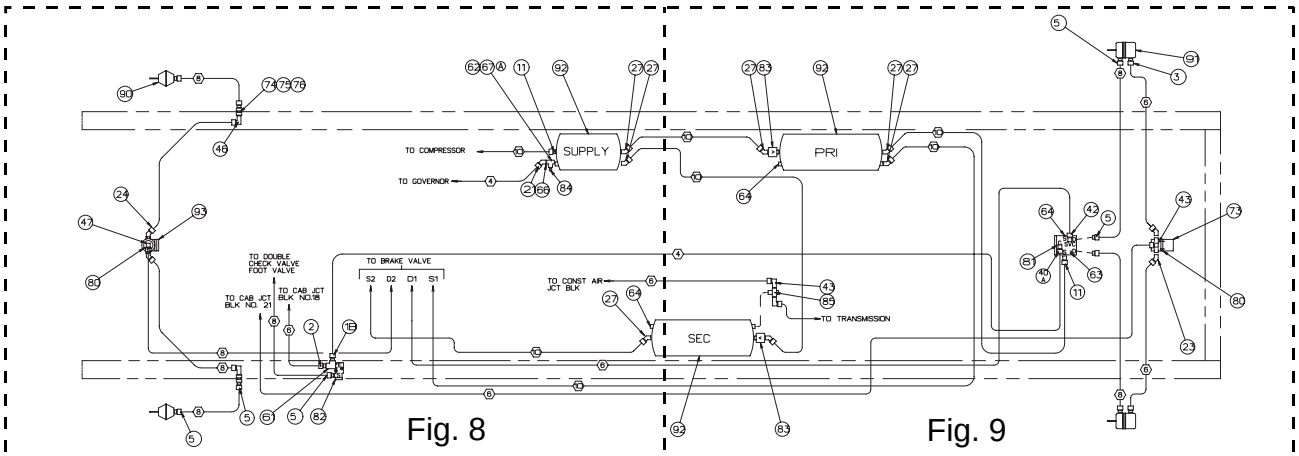
(6) HOSE ASSY, #6 WIREBRAID
(8) HOSE ASSY, #8 WIREBRAID
(10) HOSE ASSY, #10 WIREBRAID
6 B TUBE, NYLON NO.6 BLACK
6 Y TUBE, NYLON NO.6 YELLOW
6 G TUBE, NYLON NO.6 GREEN
6 O TUBE, NYLON NO.6 ORANGE
6 R TUBE, NYLON NO.6 RED
8 B TUBE, NYLON NO.8 BLACK
8 R TUBE, NYLON NO.8 RED
10 G TUBE, NYLON NO.10 GREEN
10 R TUBE, NYLON NO.10 RED

Diagram D12−13312−001, Chg. Ltr. B

02/08/94 f421083

Fig. 6

Single Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	9	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	7	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
Ⓐ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-000 PLUMB DIAG

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

① QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

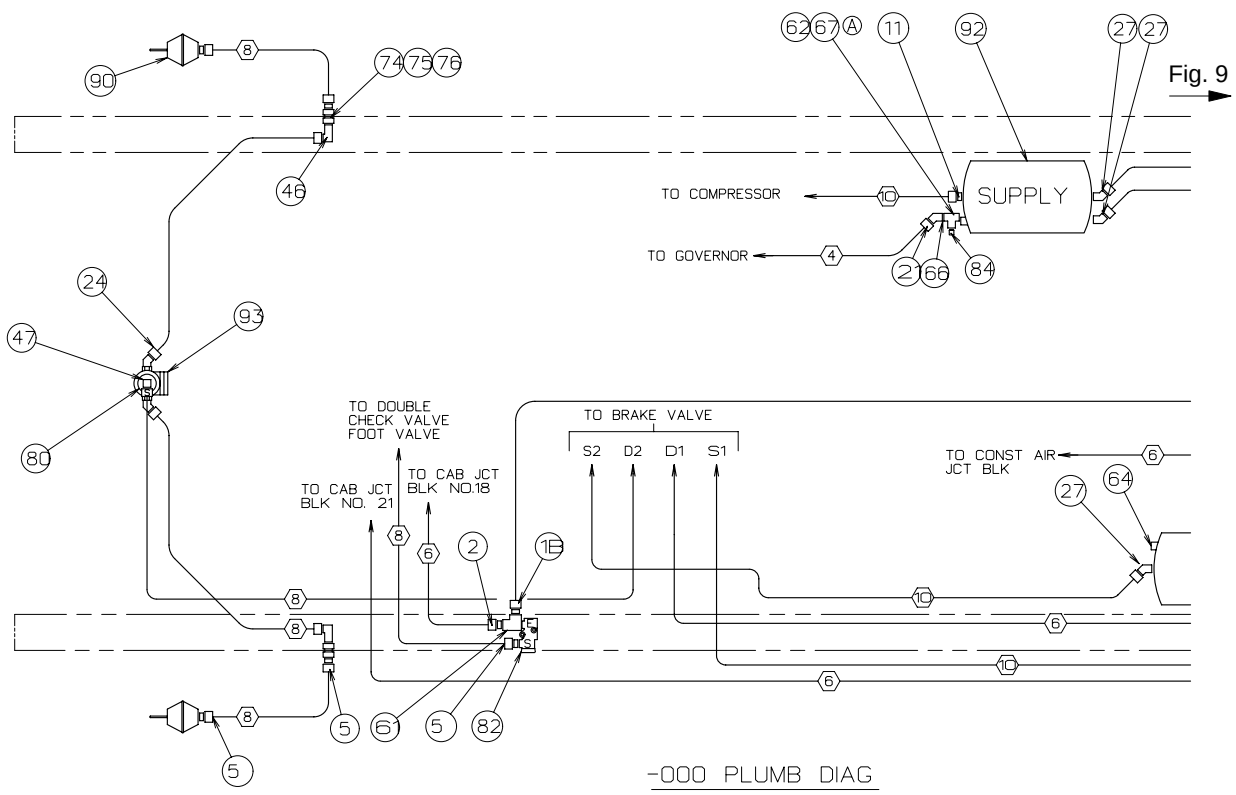
Figs. 8 and 9

Diagram D12−13315−000, Chg. Ltr. C

02/02/94 f420853a

Fig. 7, Wire Braid Hose, With Tractor Protection Valve on Frame, Date of Use 1/89 to 4/91.

Single Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	9	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	7	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
Ⓐ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

④	HOSE ASSY, NO. 4
⑥	HOSE ASSY, NO. 6
⑧	HOSE ASSY, NO. 8
⑩	HOSE ASSY, NO.10

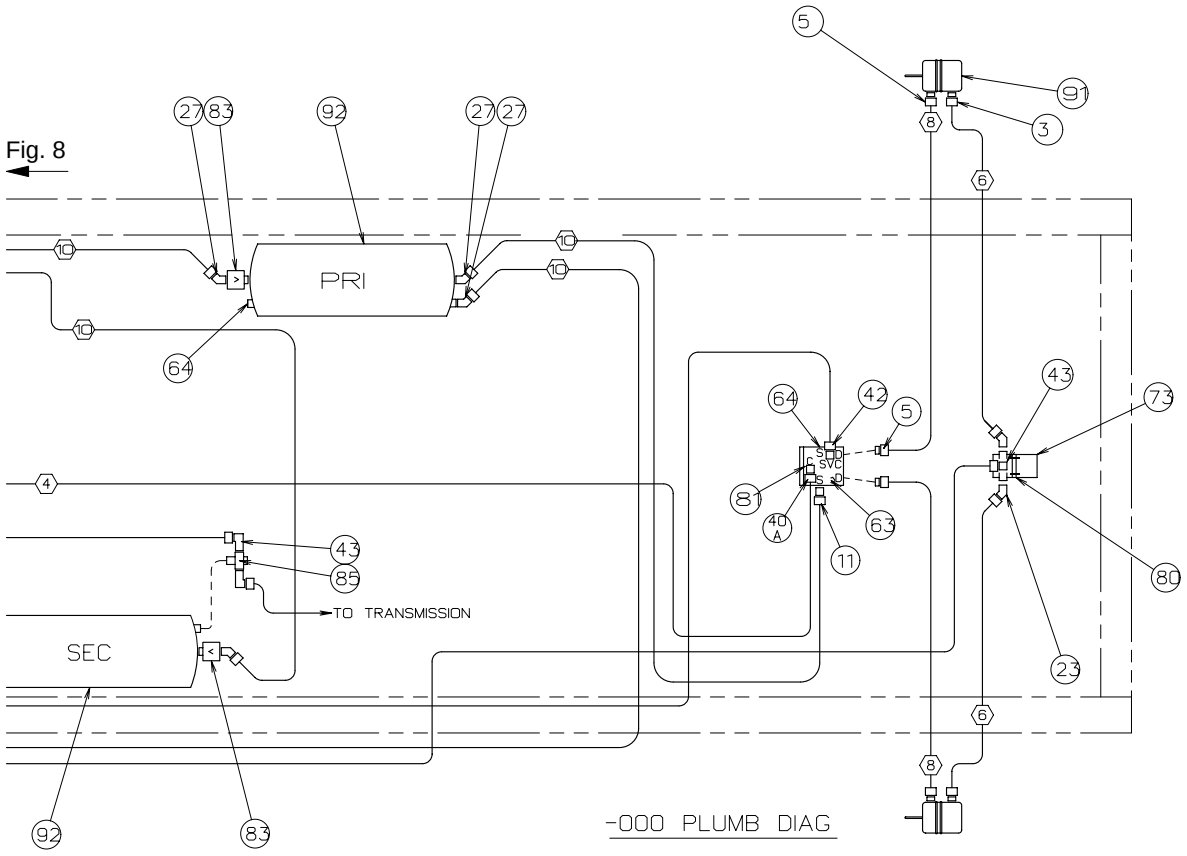
(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Diagram D12−13315−000, Chg. Ltr. C

02/02/94 f421084

Fig. 8

Single Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1B	1	210502 000001	CONNECTOR, SAE (#4 HOSE-1/4NPT)
2	1	210502 000003	CONNECTOR, SAE (#6 HOSE-1/4NPT)
3	2	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	9	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	2	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	7	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61	1	210503 000019	TEE, STREET (1/4 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
Ⓐ 67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

④	HOSE ASSY, NO. 4
⑥	HOSE ASSY, NO. 6
⑧	HOSE ASSY, NO. 8
⑩	HOSE ASSY, NO.10

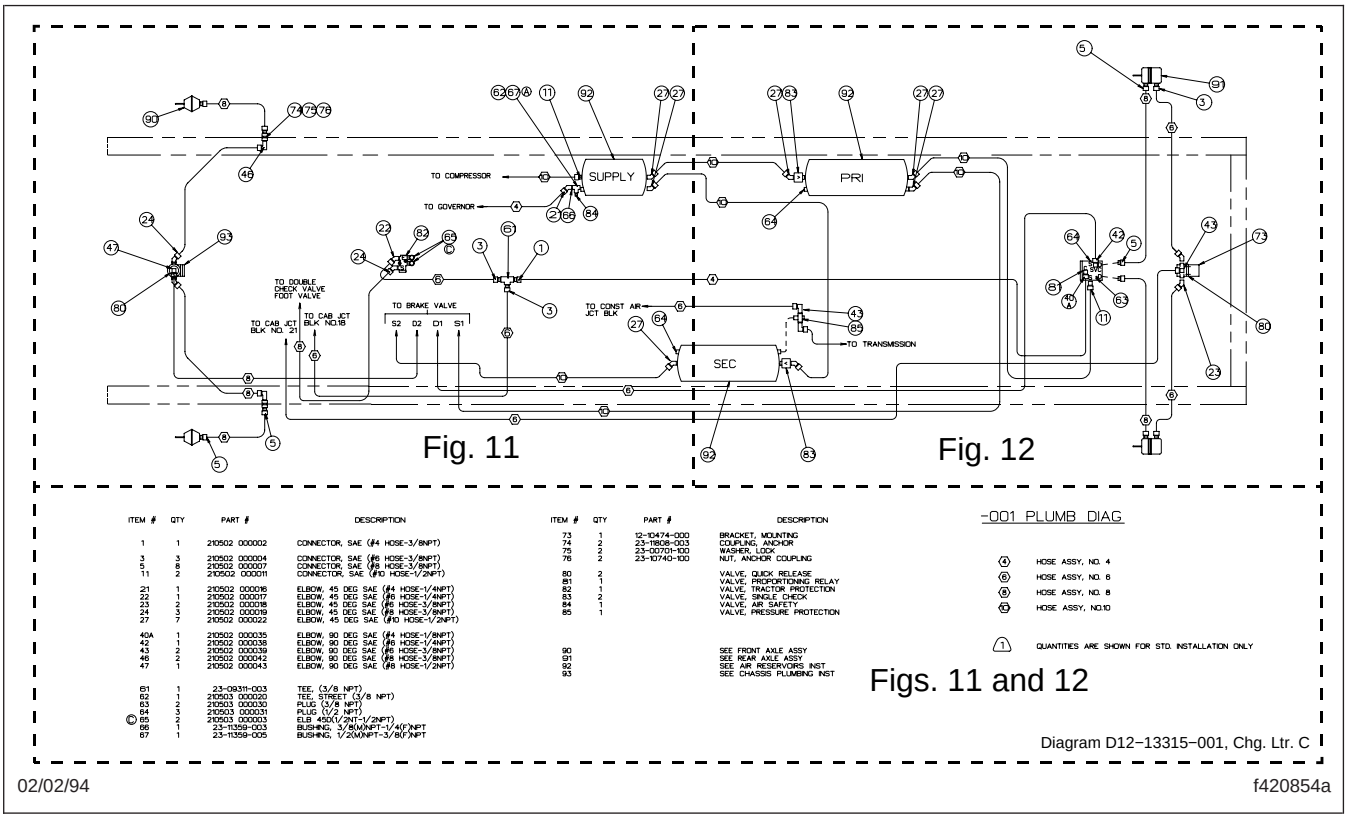
① QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Diagram D12−13315−000, Chg. Ltr. C

02/02/94 f421085

Fig. 9

Single Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
3	3	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	8	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	3	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	7	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61	1	23-09311-003	TEE, (3/8 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
© 65	2	210503 000003	ELB 45D(1/2NPT-1/2NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

-001 PLUMB DIAG

④ HOSE ASSY, NO. 4
⑥ HOSE ASSY, NO. 6
⑧ HOSE ASSY, NO. 8
⑩ HOSE ASSY, NO.10

① QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Figs. 11 and 12

Diagram D12−13315−001, Chg. Ltr. C

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Fig. 10, Wire Braid Hose, With Tractor Protection Valve on Tunnel, Date of Use 7/89 to 4/91.

Single Rear Axle Tractor, Without Antilock, With Brake Proportioning

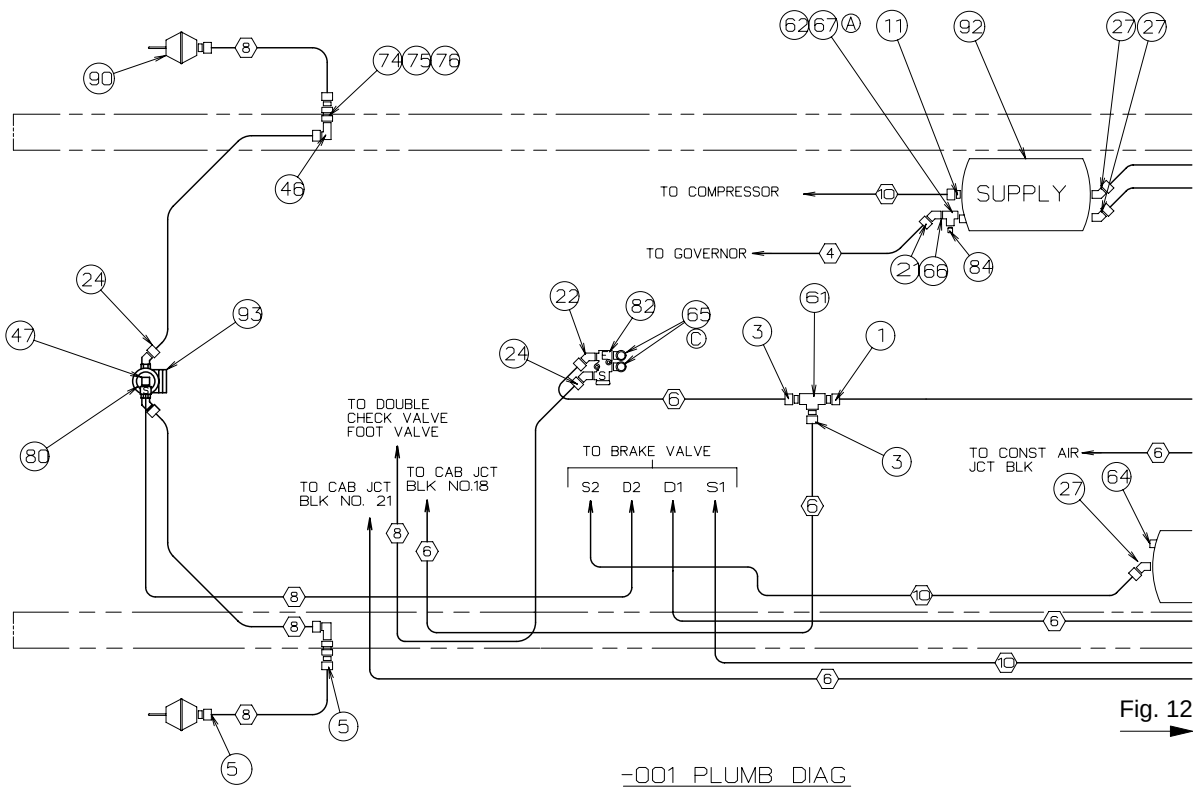

Fig. 12

-001 PLUMB DIAG

ITEM #	QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
3	3	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	8	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	3	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	7	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
61	1	23-09311-003	TEE, (3/8 NPT)
62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
© 65	2	210503 000003	ELB 45D(1/2NT-1/2NPT)
66	1	23-11359-003	BUSHING, 3/8(M)NPT-1/4(F)NPT
67	1	23-11359-005	BUSHING, 1/2(M)NPT-3/8(F)NPT

ITEM #	QTY	PART #	DESCRIPTION
73	1	12-10474-000	BRACKET, MOUNTING
74	2	23-11808-003	COUPLING, ANCHOR
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
82	1		VALVE, TRACTOR PROTECTION
83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

④	HOSE ASSY, NO. 4
⑥	HOSE ASSY, NO. 6
⑧	HOSE ASSY, NO. 8
⑩	HOSE ASSY, NO.10

(1) QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Diagram D12−13315−001, Chg. Ltr. C

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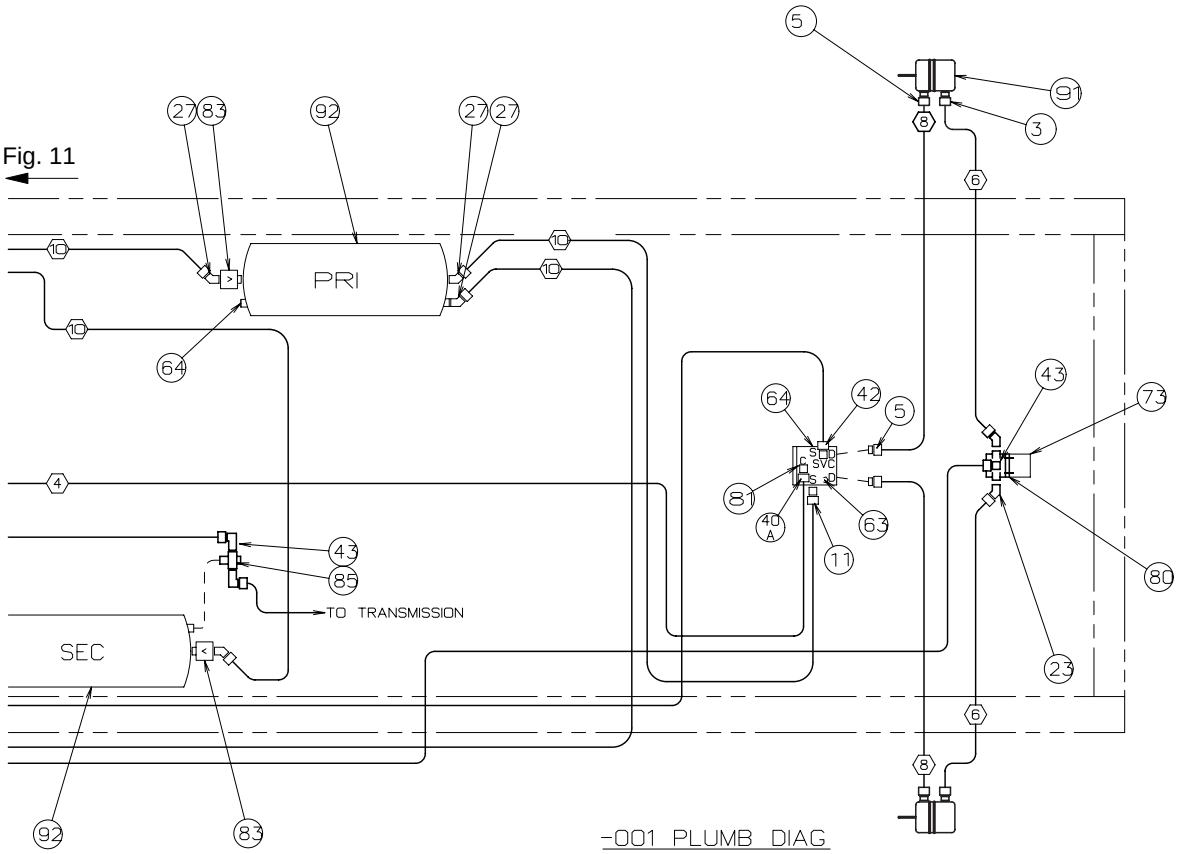
Fig. 11

Single Rear Axle Tractor, Without Antilock, With Brake Proportioning



ITEM #	QTY	PART #	DESCRIPTION
1	1	210502 000002	CONNECTOR, SAE (#4 HOSE-3/8NPT)
3	3	210502 000004	CONNECTOR, SAE (#6 HOSE-3/8NPT)
5	8	210502 000007	CONNECTOR, SAE (#8 HOSE-3/8NPT)
11	2	210502 000011	CONNECTOR, SAE (#10 HOSE-1/2NPT)
21	1	210502 000016	ELBOW, 45 DEG SAE (#4 HOSE-1/4NPT)
22	1	210502 000017	ELBOW, 45 DEG SAE (#6 HOSE-1/4NPT)
23	2	210502 000018	ELBOW, 45 DEG SAE (#6 HOSE-3/8NPT)
24	3	210502 000019	ELBOW, 45 DEG SAE (#8 HOSE-3/8NPT)
27	7	210502 000022	ELBOW, 45 DEG SAE (#10 HOSE-1/2NPT)
40A	1	210502 000035	ELBOW, 90 DEG SAE (#4 HOSE-1/8NPT)
42	1	210502 000038	ELBOW, 90 DEG SAE (#6 HOSE-1/4NPT)
43	2	210502 000039	ELBOW, 90 DEG SAE (#6 HOSE-3/8NPT)
46	2	210502 000042	ELBOW, 90 DEG SAE (#8 HOSE-3/8NPT)
47	1	210502 000043	ELBOW, 90 DEG SAE (#8 HOSE-1/2NPT)
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62	1	210503 000020	TEE, STREET (3/8 NPT)
63	2	210503 000030	PLUG (3/8 NPT)
64	3	210503 000031	PLUG (1/2 NPT)
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74	2	23-11808-003	COUPLING, ANCHOR
75	2	23-00701-100	WASHER, LOCK
76	2	23-10740-100	NUT, ANCHOR COUPLING
80	2		VALVE, QUICK RELEASE
81	1		VALVE, PROPORTIONING RELAY
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83	2		VALVE, SINGLE CHECK
84	1		VALVE, AIR SAFETY
85	1		VALVE, PRESSURE PROTECTION
90			SEE FRONT AXLE ASSY
91			SEE REAR AXLE ASSY
92			SEE AIR RESERVOIRS INST
93			SEE CHASSIS PLUMBING INST

④	HOSE ASSY, NO. 4
⑥	HOSE ASSY, NO. 6
⑧	HOSE ASSY, NO. 8
⑩	HOSE ASSY, NO.10

① QUANTITIES ARE SHOWN FOR STD. INSTALLATION ONLY

Diagram D12−13315−001, Chg. Ltr. C

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Fig. 12

General Description, Exploded View, and Principles of Operation

General Description

The function of the Bendix AD-4 air dryer (**Fig. 1**) is to collect and remove air system contaminants in solid, liquid, and vapor form before they enter the brake system.

The AD-4 consists of a die-cast aluminum end cover secured to a cylindrical steel outer shell with eight capscrews and nuts. **See Fig. 2.** The end cover contains a purge valve mechanism, a safety valve and three threaded air connections. The three air connections are identified with embossed numbers and lettering. The identification and function of each is as shown in the table:

4—CON.—Control port (purge valve control)

1— SUP.—Supply port (air in)

2—DEL.— Delivery port (air out)

A cast-in heater element and replaceable thermostat with an external electrical terminal are provided.

The voltage and wattage requirements of the heater and thermostat are shown with embossed numbers and letters in the recess adjacent to the control port marked CON.

Principles of Operation

CHARGE CYCLE **(See Fig. 3)**

When the compressor is operating, compressed air, along with oil, oil vapor, water, and water vapor flows through the compressor discharge line to the supply port in the air dryer end cover. The flow velocity, or the speed at which the air and its contaminants travel down the discharge line, is reduced substantially as it enters the air dryer end cover baffle system behind the supply port. As air travels through the baffle system, its direction of flow changes by 180 degrees several times, causing contaminants to condense and drop to the bottom, or sump, of the air dryer end cover.

After leaving the end cover baffle system, air flows into the desiccant cartridge. Once in the cartridge the air first flows through an oil separator, which removes oil, oil vapor, and solid contaminants.

Air, still 100 percent saturated with water vapor, leaves the oil separator and enters the desiccant drying bed. Air flowing through the column of desiccant becomes progressively drier as water vapor adheres to the desiccant material in a process known as adsorption. The desiccant cartridge typically removes 95 percent of the water vapor from the air.

The majority of dry air leaves the desiccant cartridge through its integral single check valve to fill the hollow purge volume between the desiccant cartridge and outer shell. Some air will also leave the desiccant cartridge through the purge orifice adjacent to the check valve.

Dry air flows out of the purge volume through the single check valve and out the delivery port to the first (supply) reservoir of the air system.

The air dryer will remain in the charge cycle until air brake system pressure builds to the governor cutout setting.

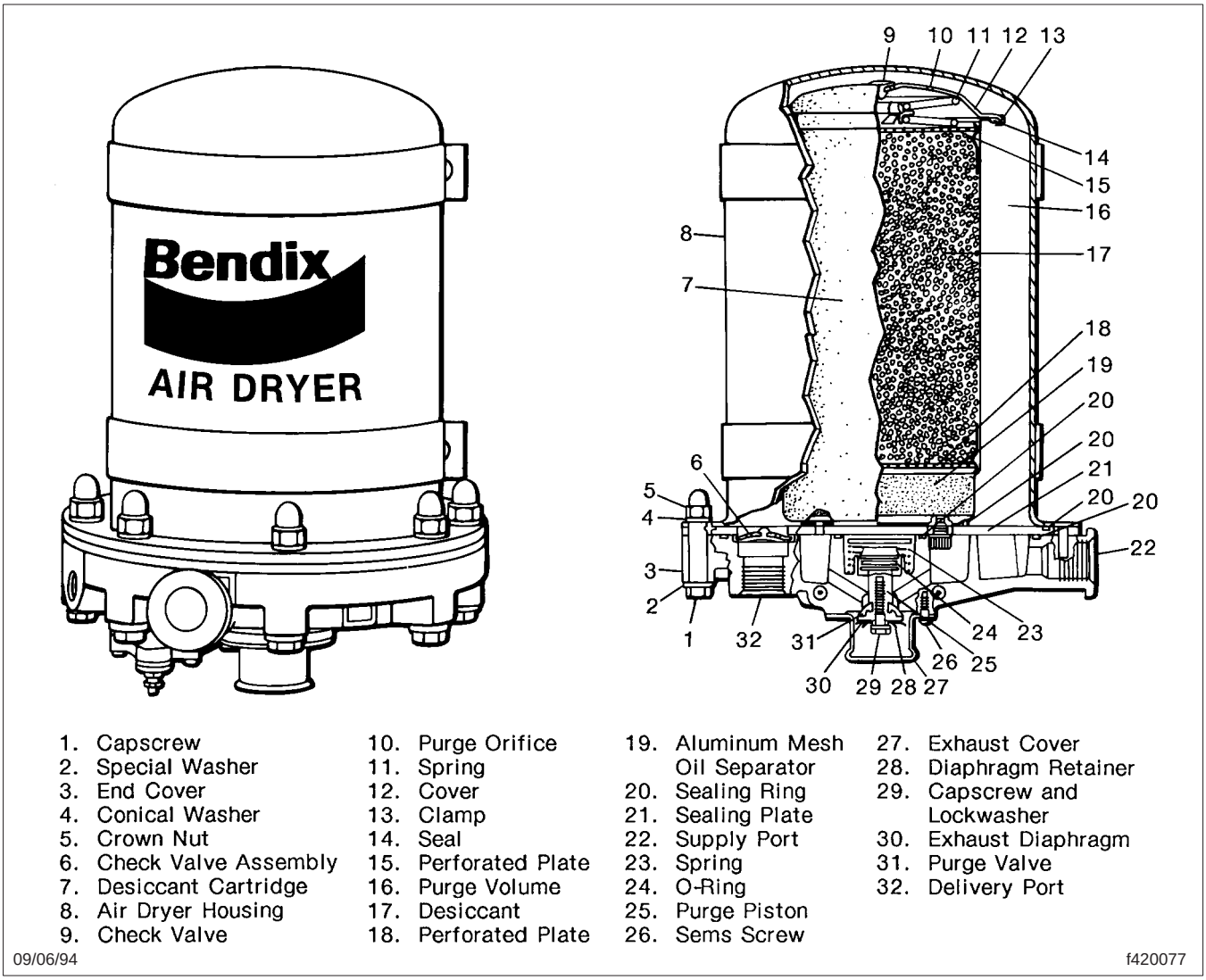
PURGE CYCLE **(See Fig. 4)**

When air brake system pressure reaches the cutout setting of the governor, the compressor unloads (air compression stops) and the purge cycle of the air dryer begins. The line connecting the governor unloader port to the AD-4 end cover control port is pressurized when the governor unloads the compressor. Air pressure at the AD-4 end cover control port is also present on the purge valve piston. The purge valve piston moves in response to air pressure, causing the purge valve to open to the atmosphere. Contaminants in the end cover sump are expelled immediately after the purge valve opens. Also, air that was flowing through the desiccant cartridge changes direction and begins to flow toward the open purge valve. Oil and solid contaminants collected by the oil separator are removed by air flowing from the desiccant drying bed to the open purge valve.

Initial purge and desiccant cartridge decompression lasts only a few seconds and is noted by an audible burst of air at the AD-4 exhaust.

Actual reactivation of the desiccant drying bed begins as dry air flows from the purge orifice and into the desiccant drying bed. Pressurized air from the purge volume expands after passing through the purge orifice; its pressure is lowered and its volume increased. The flow of dry air through the drying bed reactivates the desiccant material by removing the water vapor adhering to it. Generally 15 to 30 sec-

General Description, Exploded View, and Principles of Operation



1. Capscrew
2. Special Washer
3. End Cover
4. Conical Washer
5. Crown Nut
6. Check Valve Assembly
7. Desiccant Cartridge
8. Air Dryer Housing
9. Check Valve
10. Purge Orifice
11. Spring
12. Cover
13. Clamp
14. Seal
15. Perforated Plate
16. Purge Volume
17. Desiccant
18. Perforated Plate
19. Aluminum Mesh Oil Separator
20. Sealing Ring
21. Sealing Plate
22. Supply Port
23. Spring
24. O-Ring
25. Purge Piston
26. Sems Screw
27. Exhaust Cover
28. Diaphragm Retainer
29. Capscrew and Lockwasher
30. Exhaust Diaphragm
31. Purge Valve
32. Delivery Port

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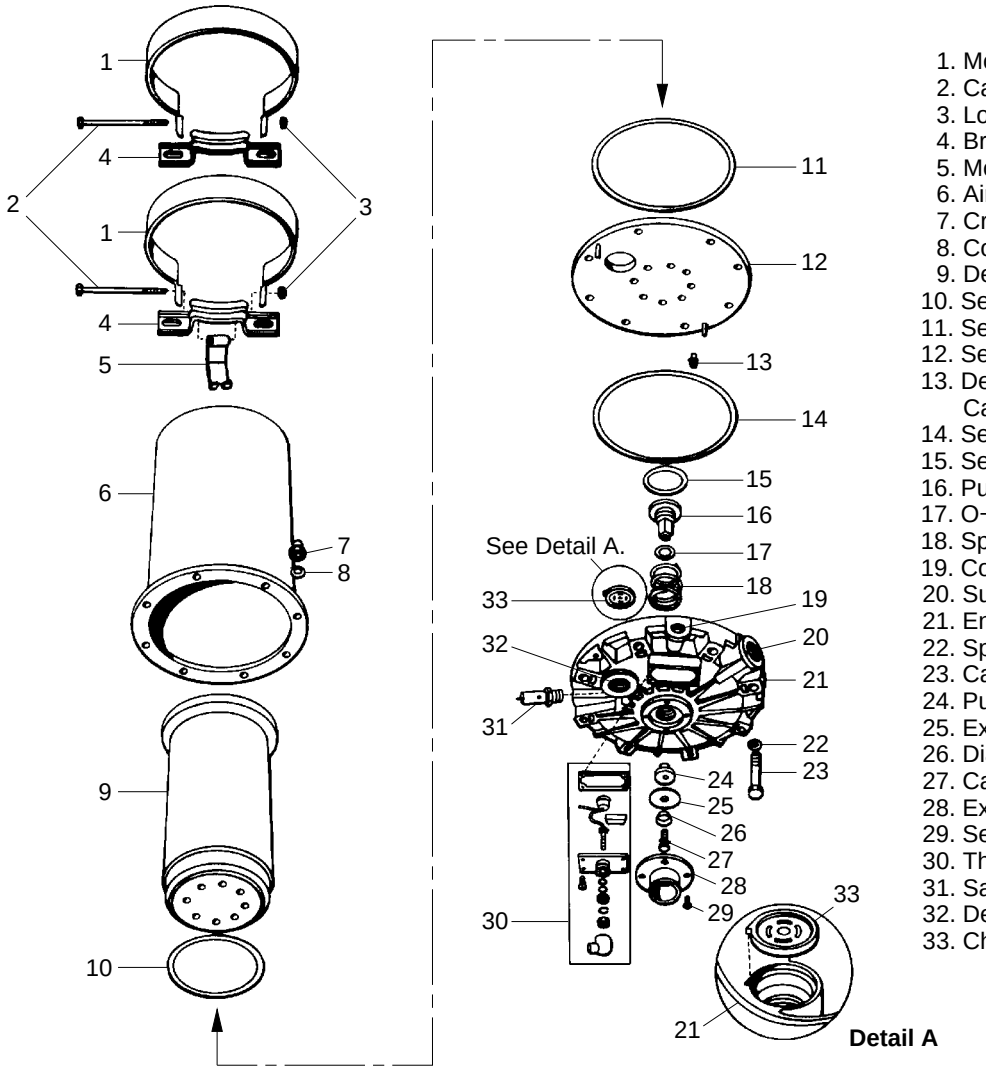
Fig. 1, Bendix AD-4 Air Dryer and Cutaway View

onds are required for the entire purge volume of a standard AD-4 to flow through the desiccant drying bed.

The end cover single check valve prevents air pressure in the brake system from returning to the air dryer during the purge cycle. After the 30 second purge cycle is complete, the air dryer is ready for the next charge cycle to begin. The purge valve will remain open after the purge cycle is complete and will not close until air brake system pressure is reduced and the governor signals the compressor to charge.

NOTE: The air dryer should be periodically checked for operation and tested for leaks. Refer to the brake section in the vehicle maintenance manual for intervals and procedures.

General Description, Exploded View, and Principles of Operation



1. Mounting Strap
2. Capscrews
3. Locknuts
4. Bracket
5. Mounting Bracket Hook
6. Air Dryer Housing
7. Crown Nut
8. Conical Washer
9. Desiccant Cartridge
10. Sealing Ring
11. Sealing Ring
12. Sealing Plate
13. Desiccant Cartridge Capscrew and Lockwasher
14. Sealing Ring
15. Sealing Ring
16. Purge Piston
17. O−Ring
18. Spring
19. Control Port
20. Supply Port
21. End Cover
22. Special Washer
23. Capscrew
24. Purge Valve
25. Exhaust Diaphragm
26. Diaphragm Retainer
27. Capscrew and Lockwasher
28. Exhaust Cover
29. Sems Screw
30. Thermostat Assembly
31. Safety Valve
32. Delivery Port
33. Check Valve Assembly

Fig. 2, Exploded View

General Description, Exploded View, and Principles of Operation

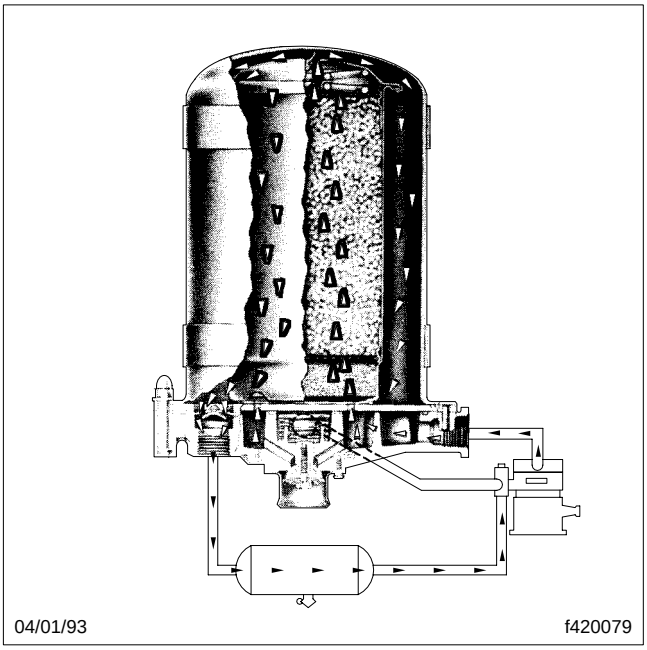


Fig. 3, Charge Cycle

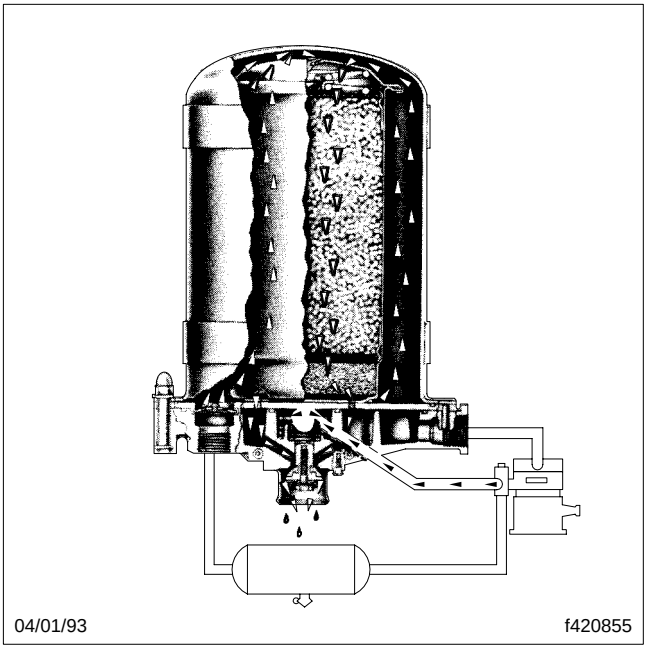


Fig. 4, Purge Cycle

Safety Precautions

When working on or around air brake systems and components, the following precautions should be observed:

1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.
5. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, length, and strength as the original equipment.
6. Make certain that when replacing tubing or hose, all of the original supports, clamps, or suspending devices are installed or replaced.
7. Devices with stripped threads or damaged parts should be replaced. Repairs requiring machining should not be attempted.

Air Dryer Removal and Installation

Removal

IMPORTANT: When working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Park the vehicle on a level surface and prevent movement by means other than the brakes.
2. Drain the air system.
3. Identify and disconnect the three air lines from the end cover and note the position of end cover ports relative to the vehicle.
4. Pull the boot from the thermostat and heater cover and slide it onto the wire to expose the connection. Remove the nut and disconnect the electrical wire from the terminal. **See Fig. 1.**
5. Loosen the two 5/16 x 4-1/2 inch hex bolts securing the mounting straps on the back side of the dryer. Disengage the mounting bracket hook from the end cover. **See Fig. 2.**

Installation

IMPORTANT: When working on or around air brake systems and components, review **Safety Precautions, 100**.

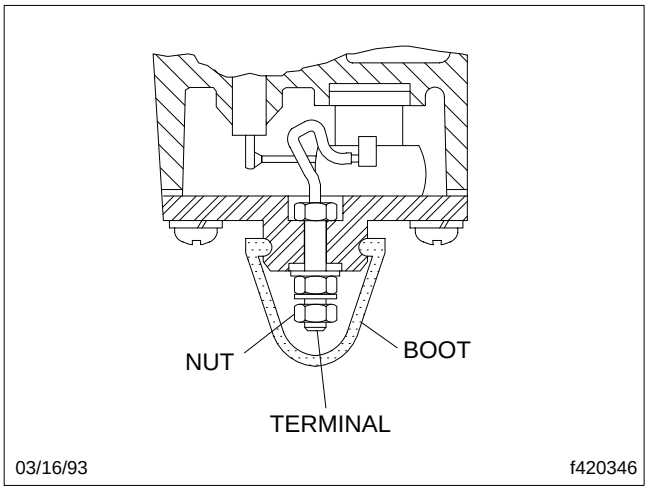


Fig. 1, Thermostat Assembly

1. Slide the AD-4 air dryer into the mounting brackets on the vehicle until the mounting bracket hook catches under the lip of the cover. Torque the mounting bracket bolts 70 to 85 lbf·in (800 to 960 N·cm).
2. Connect the three air lines to the proper port on the cover, as referenced during removal.
3. Connect the thermostat and heater wire and place the boot in position to protect the connection by forcing it over the knob on the plastic cover.
4. Check the operation of the air dryer following instructions in the brake section in the vehicle maintenance manual.

Air Dryer Removal and Installation

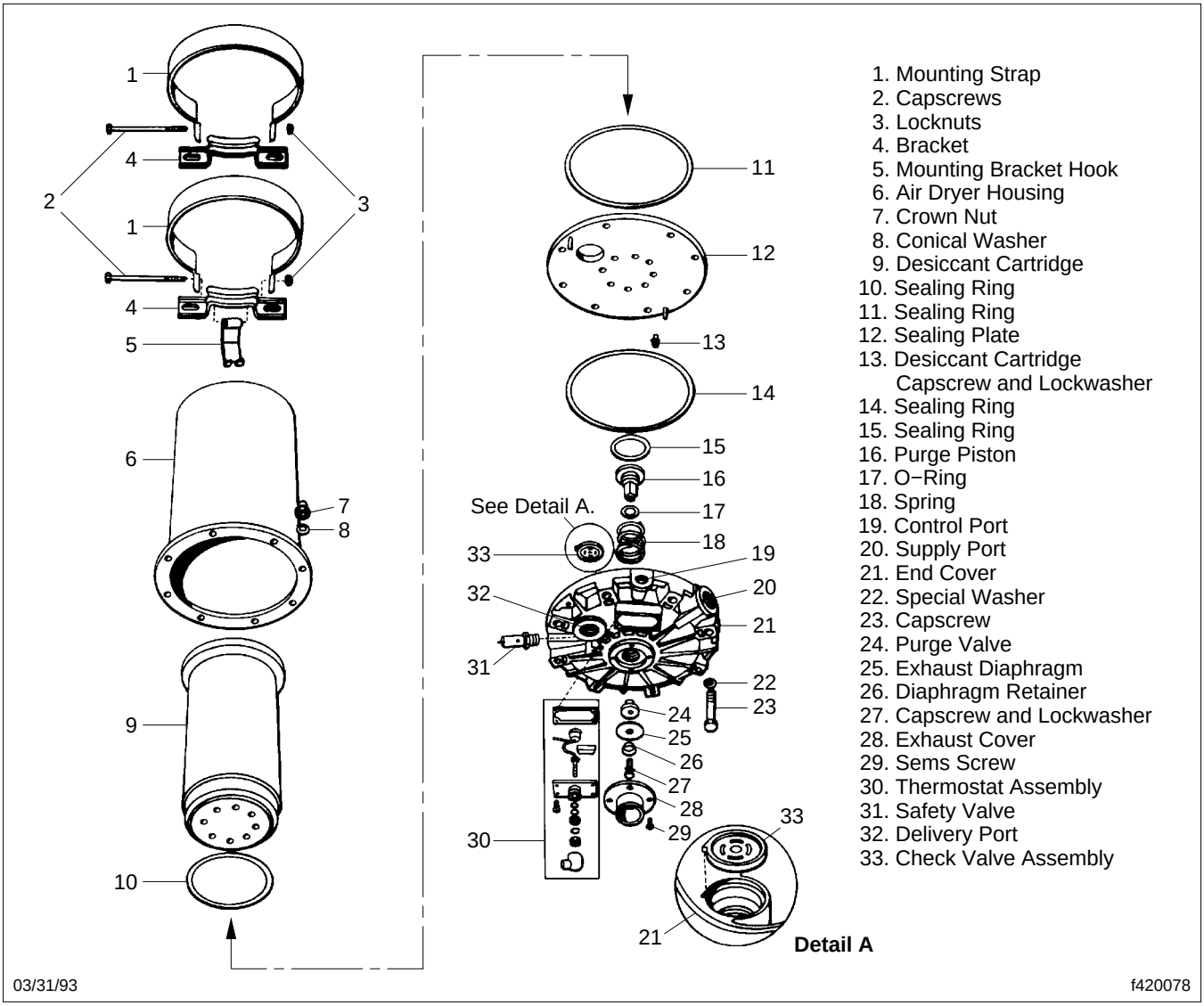


Fig. 2, Thermostat Assembly

Air Dryer Disassembly, Cleaning and Inspection, and Assembly

Disassembly

IMPORTANT: When working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Remove the air dryer from the vehicle, following the instructions in **Subject 110**, "Removal."
2. Mark the end cover and the air dryer housing before separating them so they can be returned to their original positions during assembly.

   Remove the eight 3/8-inch crown nuts, spring washers, special washers, and capscrews from the flange of the air dryer and separate the end cover from the air dryer housing. Separate the desiccant cartridge and sealing plate from the end cover. Remove and discard the three sealing rings. One sealing ring is located in the groove on the sealing plate and the other two are in grooves in the end cover.
3. Remove the 1/4-inch capscrew and lockwasher from the bottom of the purge valve and remove the diaphragm retainer, exhaust diaphragm, and purge valve. Discard the exhaust diaphragm and purge valve. Remove the purge valve piston and discard the O-ring.
4. Remove and discard the check valve assembly in the recess at the delivery port of the end cover.
5. Remove the safety valve from the end cover, but only if it has been determined that it needs replacing.
6. If it has been determined that the thermostat needs replacing, remove the thermostat following the instructions in **Subject 130**, "Disassembly."
7. Remove the exhaust piston and spring from the top side of the cover.
8. Remove the O-ring from the exhaust piston and discard the O-ring.
9. Remove the four 1/4-inch capscrews and lockwashers that secure the sealing plate to the desiccant cartridge and discard the sealing ring at the base of the cartridge.

Cleaning and Inspection

IMPORTANT: When working on or around air brake systems and components, review **Safety Precautions, 100**.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

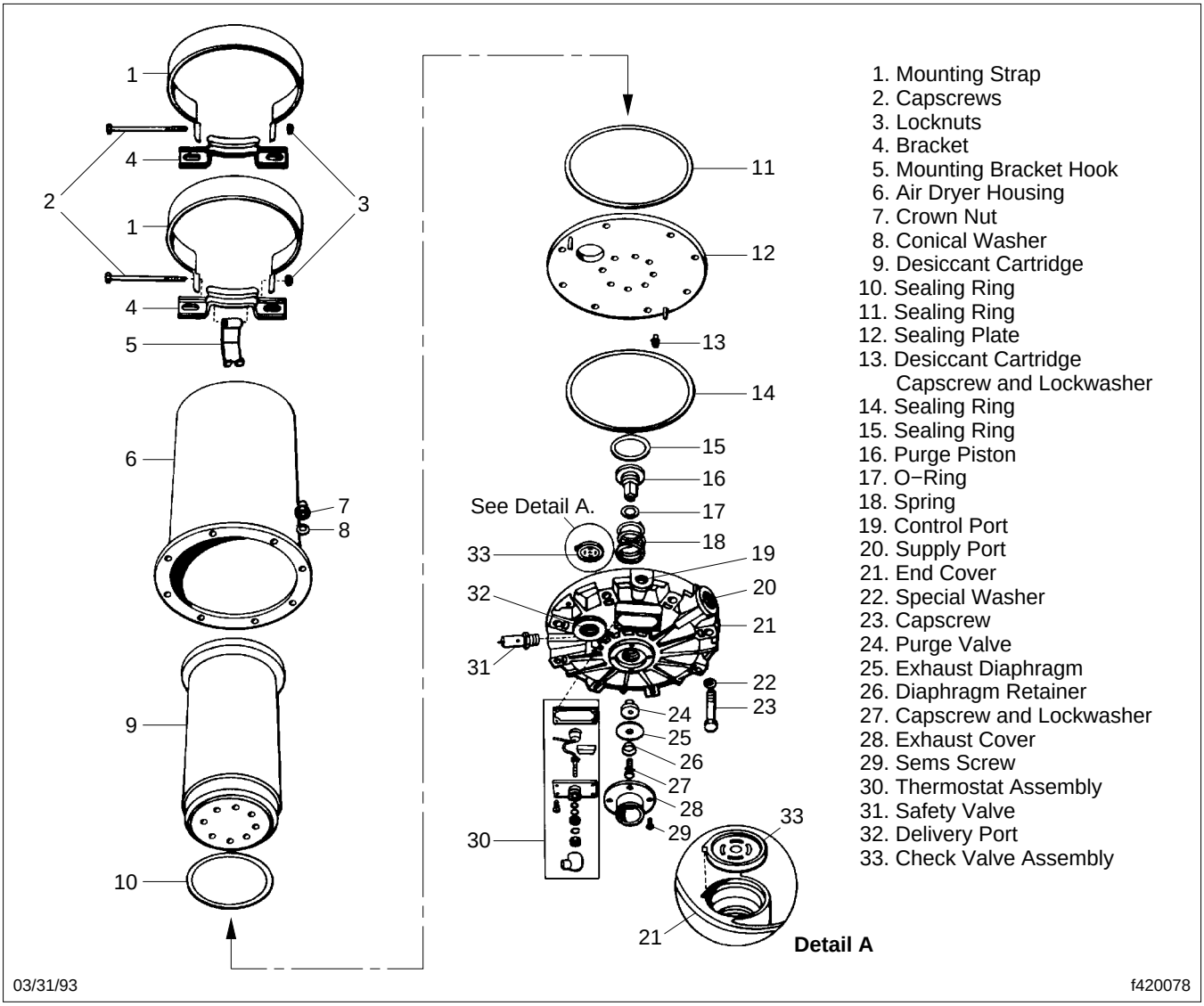
1. Wash all metal parts thoroughly, using a quality commercial solvent, such as mineral spirits.
2. Inspect all parts for wear or damage, and replace any worn or damaged parts.

Assembly (See Fig. 1)

IMPORTANT: When working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Place the purge valve spring into the cavity in the center of the top side of the end cover.
2. Lubricate the piston O-ring with a barium base lubricant and install the O-ring on the purge valve piston. Place the piston inside of the spring installed previously.
3. Turn the cover over on a flat clean surface, making sure the purge valve piston and spring remain in proper position. Compress the spring by pushing down on the cover and align the square shank of the purge valve piston into the mating hole in the cover.
4. Place the washer, diaphragm retainer, diaphragm, and purge valve onto the purge valve capscrew.
5. Install the purge valve capscrew and parts in the exhaust cover and tighten it 30 to 40 lbf·in (340 to 460 N·cm).
6. If removed, install the safety valve and tighten it 120 to 400 lbf·in (1360 to 4520 N·cm), making sure that the exhaust hole is pointed downward when the dryer is installed.

Air Dryer Disassembly, Cleaning and Inspection, and Assembly



1. Mounting Strap
2. Capscrews
3. Locknuts
4. Bracket
5. Mounting Bracket Hook
6. Air Dryer Housing
7. Crown Nut
8. Conical Washer
9. Desiccant Cartridge
10. Sealing Ring
11. Sealing Ring
12. Sealing Plate
13. Desiccant Cartridge Capscrew and Lockwasher
14. Sealing Ring
15. Sealing Ring
16. Purge Piston
17. O−Ring
18. Spring
19. Control Port
20. Supply Port
21. End Cover
22. Special Washer
23. Capscrew
24. Purge Valve
25. Exhaust Diaphragm
26. Diaphragm Retainer
27. Capscrew and Lockwasher
28. Exhaust Cover
29. Sems Screw
30. Thermostat Assembly
31. Safety Valve
32. Delivery Port
33. Check Valve Assembly

Fig. 1

7. If previously removed, install the thermostat following the instructions in **Subject 130**, "Assembly."
8. Place the sealing ring on the bottom of the desiccant cartridge. Attach the cartridge to the smooth side of the plate opposite the cartridge with four 1/4-inch socket head capscrews and lockwashers. Torque the capscrews 80 to 100 lbf·in (900 to 1130 N·cm).
9. Lubricate and install the two sealing rings in the recesses of the end cover. Use a barium base lubricant.
10. Install the check valve assembly into the cover making sure the holes in the metal stamping are facing up and the tang on the check valve assembly fits into the mating recess in the cover.
11. Place the desiccant cartridge and sealing plate assembly onto the cover, taking care not to displace the sealing rings. The large hole in the sealing plate must line up with the check valve

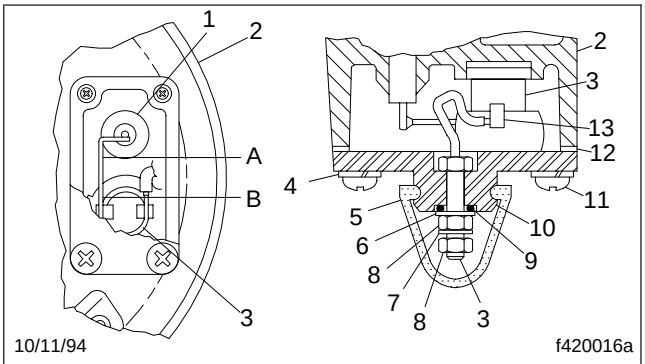
and the spiral pins in the sealing plate must enter the corresponding holes in the end cover.

12. Lubricate the outer sealing ring with a barium base lubricant and install it on the sealing plate. Place the housing of the air dryer over the desiccant cartridge, lining up the marks made on the housing and cover prior to disassembly, and retain the housing with the eight 3/8-inch hexhead bolts, special washers, and crown nuts. Torque the nuts 270 to 330 lbf·in (3060 to 3720 N·cm).

NOTE: If the 3/8-24 x 2-1/4 inch bolts require replacement, ensure that the replacement bolts are grade 5 minimum. Use of inferior bolts can compromise the integrity of the air dryer and lead to damage.

13. Install the air dryer on the vehicle following the instructions in **Subject 110**, "Installation."

Disassembly (See Fig. 1)



A. Point A
B. Point B

1. Heater Post
2. Air Dryer End Cover
3. Thermostat and Terminal Assembly
4. Lockwasher
5. Boot
6. Washer
7. Lockwasher
8. Nut
9. O-Ring
10. Thermostat Cover
11. Screw
12. Thermostat Cover Gasket
13. Spacer

Fig. 1, Thermostat Assembly

IMPORTANT: When working on or around air brake systems and components, review **Safety Precautions, 100**.

NOTE: If it has been determined that the thermostat is inoperative, use the following procedure to disassemble it. It is not necessary to replace this unit every time the air dryer end cover is rebuilt.

1. Remove the nut, lockwasher, second nut, plain washer, and O-ring from the thermostat and terminal assembly. Discard the O-ring and retain the other parts.
2. Remove the four Phillips head screws and the thermostat cover.
3. Remove and discard the thermostat cover gasket.
4. Remove the spacer.
5. Cut the uninsulated thermostat wire at point B (**Fig. 1**); remove and discard the thermostat and terminal assembly.
6. Clean the remaining wire attached to the heater terminal.
7. Clean the thermostat pocket in the end cover.

Assembly (See Fig. 1)

IMPORTANT: When working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Cut the uninsulated wire of the new thermostat at point A (**Fig. 1**).
2. Install the thermostat in the end cover pocket and position the uninsulated wires next to each other.
3. Using a soldering heat sink, clamp the uninsulated leads at point B (**Fig. 1**) and solder the wires with straight rosin core solder. Clean the excess solder off of the end cover.

CAUTION

CAUTION: Do not use acid core solder, as corrosion can result.

4. Install the thermostat terminal in the thermostat cover.
5. Install the O-ring, washer, and nut on the thermostat and terminal assembly. Tighten the nut 20 to 30 lbf·in (220 to 340 N·cm). Install the lockwasher and nut. Tighten the nut finger-tight to allow for reconnection of the electrical wire when installed on the vehicle.
6. Install the spacer over the thermostat.
7. Install the thermostat cover gasket and secure the thermostat cover to the end cover, using the screws and lockwashers.
8. Tighten the screws 30 to 40 lbf·in (340 to 460 N·cm).
9. Test the thermostat as follows:
   - 9.1 At a temperature above 90°F (32°C), check the resistance between the thermostat terminal and the air dryer end cover. The resistance should be 1000 ohms or greater; if not, check for a solder "path" short.
   - 9.2 Chill the entire end cover assembly to 40°F (4°C) or below and check the resistance again. The resistance should be 2

Thermostat Disassembly and Assembly

to 4 ohms for a 12 volt, 60 watt end cover and 4 to 7 ohms for a 24 volt, 120 watt end cover.

Problem—Dryer Is Constantly Cycling or Purging

Possible Cause	Remedy
System leakage is excessive.	Test for leakage, and repair. Allowable leakage is 3 psi (21 kPa) per minute.
There is excessive leakage in the fittings, hoses, and tubing connected to the compressor, air dryer, and wet tank.	Using a soap solution, test for leakage at the fittings, drain valve, and safety valve in the wet tank. Repair or replace as necessary.
Check valve in the air dryer cover is inoperative.	Test the check valve. Build the system pressure to governor cut-out. Wait two minutes for completion of the purge cycle. Using a soap solution on the exhaust of the purge valve, leakage should not exceed a 1-inch (2.5-cm) bubble in 5 seconds. Replace if necessary.
Governor is inoperative.	Test the governor for proper cut-in or cut-out pressures and leakage in both positions.
Purge valve in the air dryer end cover (control side) is leaking.	Remove the air dryer end cover. Apply 120 psi (827 kPa) at the control port. Soap both sides around the purge valve to test for control piston leakage. Allowable leakage is a 1-inch (2.5-cm) bubble in 5 seconds.
Compressor unloader mechanism is leaking excessively.	Remove the air strainer of fitting from the compressor inlet cavity. With the compressor unloaded, check for unloader piston leakage. Slight leakage is allowed.

Problem—Water in Vehicle Reservoirs

Possible Cause	Remedy
Desiccant cartridge is plugged or saturated.	Replace the desiccant cartridge.
Discharge line is the wrong length or material.	Discharge line must consist of at least six feet (1.8 m) of metal tubing between the discharge port of the compressor and the air dryer supply port.
Air system was charged from an outside air source, and the air was supplied to some part of the system other than the supply (wet) tank.	If the system is charged from an outside air source, the outside air must be directed into the supply (wet) tank.
Air dryer is not purging.	Refer to "Problem—Air Dryer Does Not Purge or Exhaust Air."
Purge (air exhaust) is insufficient due to excessive system leakage.	Test for leakage, and repair if necessary. Allowable leakage is 3 psi (21 kPa).

Problem—Safety Valve on Air Dryer is Popping Off or Exhausting Air

Possible Cause	Remedy
Desiccant cartridge is plugged or saturated.	Check the compressor for excessive oil passing, or incorrect installation. Repair or replace as necessary.
The check valve in the air dryer air cover is inoperative.	See if air is passing through the check valve. Repair or replace as necessary.
Fittings, hose, or tubing between the air dryer and wet tank are inoperative.	See if air is reaching the first reservoir. Inspect for kinked tubing or hose. Check for undrilled or restricted hose or tubing fittings.

Troubleshooting

Problem— Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure

Possible Cause	Remedy
Leakage at the air dryer purge valve.	With the compressor loaded, apply a soap solution on the purge valve exhaust to test for leakage. Repair the purge valve as necessary.
The governor is inoperative.	Check the governor for proper cut-in and cut-out pressures, and leakage in both positions. Repair or replace as necessary.
Purge control line is connected to the reservoir or exhaust port of the governor.	Purge control line must be connected to the unloader port of the governor.
Purge valve is frozen open due to an inoperative heater or thermostat, damaged wiring, or a blown fuse.	Check the heater and thermostat operation, following instructions in the brake section in the vehicle maintenance manual.
Inlet and outlet air connections are reversed. Compressor is discharging to the inlet port.	Reconnect the lines properly.
Inoperative check valve between the air dryer and wet tank.	Test the check valve for operation. Repair or replace as necessary.
Discharge line is kinked or blocked.	Check if air passes through the discharge line. Check for kinks, bends, or carbon deposits.
There are sharp bends in the discharge line. Water is collecting and freezing.	Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.
System is leaking excessively.	Test for leakage and repair as necessary. Allowable leakage is 3 psi (21 kPa) per minute.

Problem— Air Dryer Does Not Purge or Exhaust Air

Possible Cause	Remedy
Purge control line is broken, kinked, frozen, plugged, or disconnected.	Check if air flows through the purge control line when the compressor is unloaded. Check for undrilled fittings. The purge control line must be connected to the unloader port of the governor.
Air dryer purge valve is inoperative.	After determining that air reaches the purge valve, repair the purge valve.
The governor is inoperative.	Check the governor for proper cut-in and cut-out pressures, and leakage in both positions. Repair or replace as necessary.
Inlet and outlet air connections are reversed. Compressor is discharging to the inlet port.	Reconnect the lines properly.
Inoperative check valve between the air dryer and wet tank.	Test the check valve for proper operation. Repair or replace as necessary.
Discharge line is kinked or blocked.	Check if air passes through the discharge line. Check for kinks, bends, or carbon deposits.
There are sharp bends in the discharge line. Water is collecting and freezing.	Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.

Problem—Desiccant Material Is Being Expelled from Air Dryer Purge Valve Exhaust (May Look Like Whitish Liquid, Paste, or Small Beads)—or, Unsatisfactory Desiccant Life *

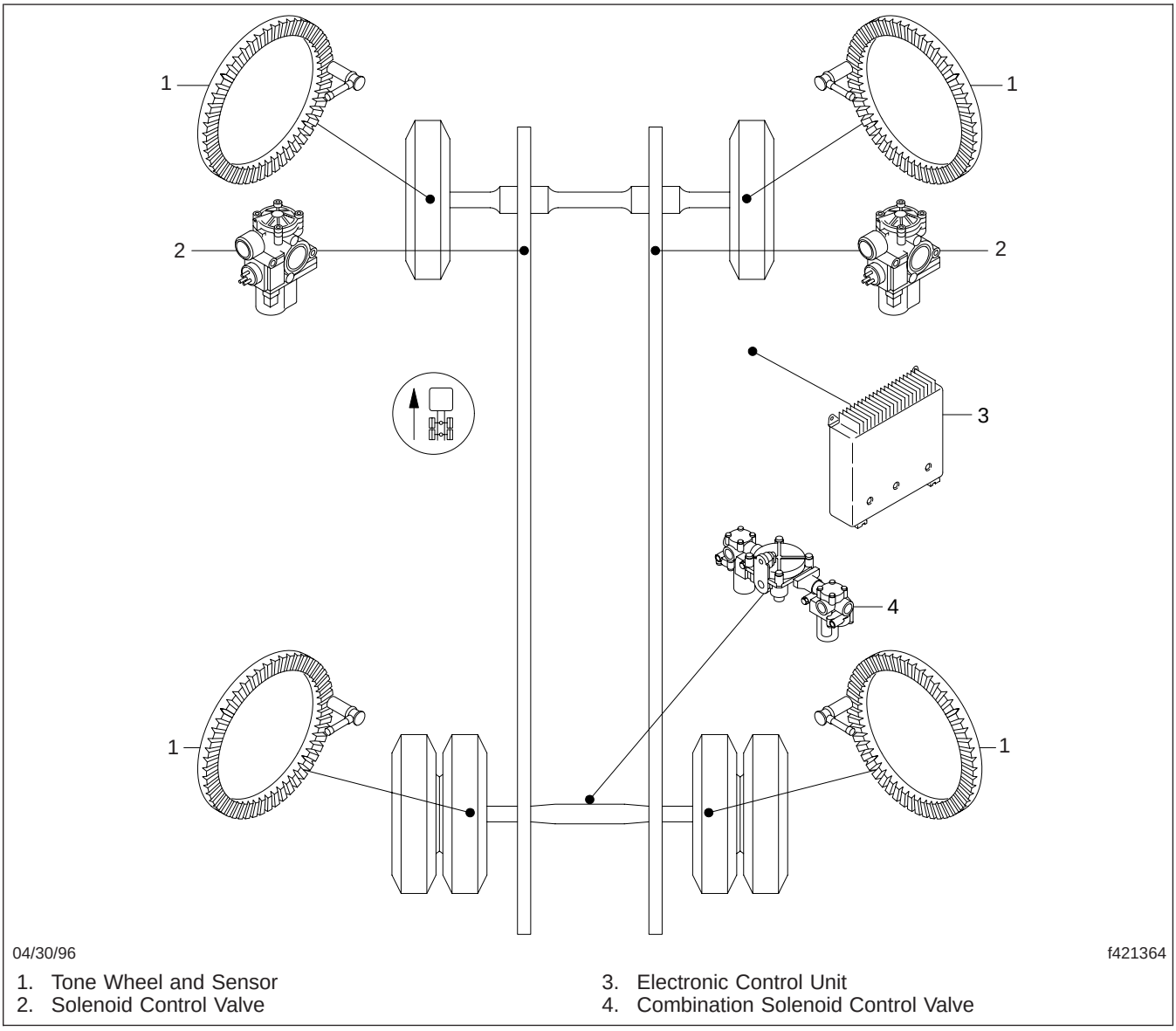
Possible Cause	Remedy
Air dryer is not securely mounted; There is excessive vibration.	Vibration should be held to a minimum. Tighten the mounting fasteners.
Cloth covered perforated plate in the air dryer desiccant cartridge is damaged, or the desiccant cartridge was rebuilt improperly.	Replace the plate or cartridge as necessary.
Compressor is passing excessive oil.	Check for proper compressor installation; if symptoms persist, replace the compressor.
Heater and thermostat, wiring, or a fuse is damaged, and is not allowing the air dryer to purge during cold weather operation.	Check the heater and thermostat operation, following instructions in the brake section in the vehicle maintenance manual.

* This problem usually occurs with one or more additional problems. For additional information, see "Dryer is Constantly Cycling or Purging", "Water in Vehicle Reservoirs", "Safety Valve on Air Dryer is Popping Off or Exhausting Air", "Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure", and "Air Dryer Does Not Purge or Exhaust Air."

Problem—Loud Pinging Noise During Compressor Loaded Cycle

Possible Cause	Remedy
Pinging noise is due to a single cylinder compressor with high pulse cycles.	A slight pinging sound may be heard during system build-up when a single cylinder compressor is used. If this sound is objectionable, it can be reduced substantially by increasing the discharge line volume. This can be accomplished by adding 4 feet (1.2 m) of discharge line, or adding a 90 cubic inch (1475 cm^3) reservoir between the compressor and the air dryer.

General Description (See Fig. 1)



1. Tone Wheel and Sensor
2. Solenoid Control Valve
3. Electronic Control Unit
4. Combination Solenoid Control Valve

Fig. 1, Location of ABS Components, Four-Channel System

The WABCO Antilock Braking System (ABS) is an electronic wheel speed monitoring and control system that works with the standard air brake system. ABS passively monitors vehicle wheel speed at all times, and controls wheel speed during emergency stops. If equipped with Traction Plus or Automatic Traction Control, wheel spin is controlled during reduced-traction situations. In normal braking applications, the standard air brake system is in effect.

ABS includes signal-generating tone wheels and sensors located in the wheel hubs of each sensed wheel. The sensors transmit vehicle wheel speed information to an electronic control unit. According to programmed specifications, the control unit signals

the appropriate solenoid control valve to increase, reduce, or maintain air pressure supply in the brake chamber. This prevents front and rear wheel lockup, and enhances steering control during emergency braking situations. If equipped with Traction Plus or Automatic Traction Control, two additional solenoid valves are installed. During reduced-traction situations, these valves increase or reduce air pressure supply in the brake chamber to provide better traction whenever wheel spin occurs.

Principles of Operation

The ABS electronic control unit (**Fig. 2**) is a digital microcomputer that serves as the information processing and command center for the antilock braking system. The control unit receives and processes vehicle wheel speed information from the sensors. During emergency brake applications, the control unit regulates the braking force applied to each wheel by sending control signals to the solenoid control valves (**Fig. 3**).

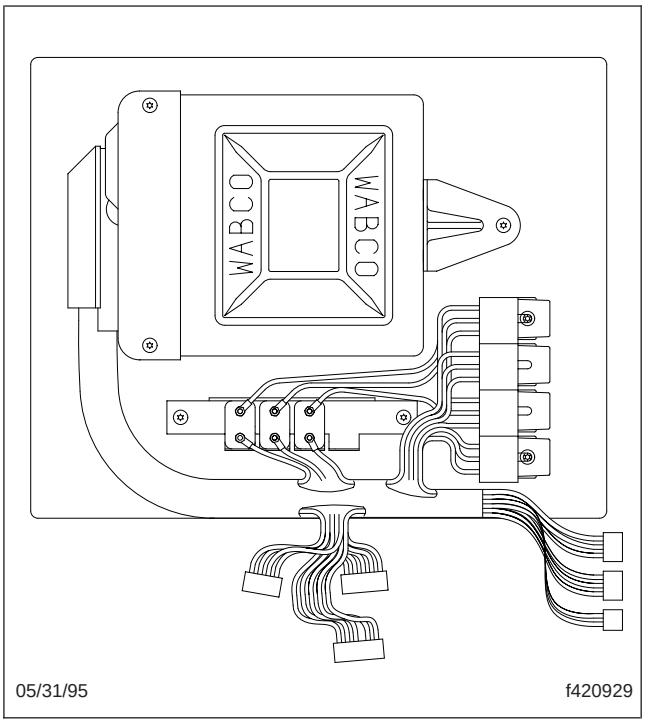


Fig. 2, ABS Electronic Control Unit

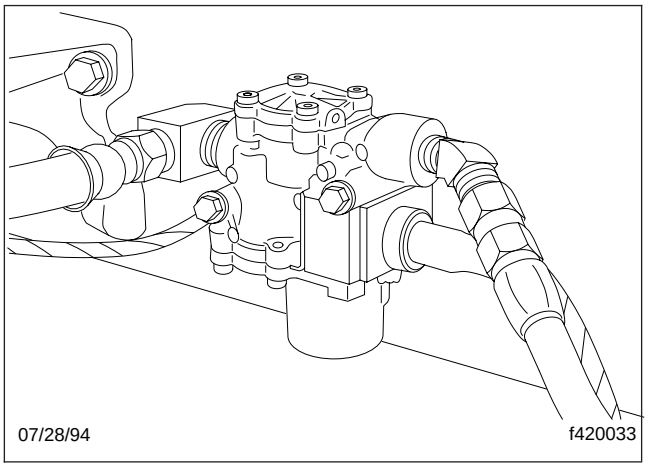


Fig. 3, Solenoid Control Valve

ABS MAJOR COMPONENTS

Wheel Speed Sensor

The wheel speed sensors use pulse feedback from 100-tooth tone wheels located in the front and rear axle wheel hubs. When the vehicle is moving, the teeth of the tone wheel cause interruptions in a magnetic field created by the sensor. The interruptions created in the magnetic field in turn create electrical pulses that are sent by the sensor to the electronic control unit.

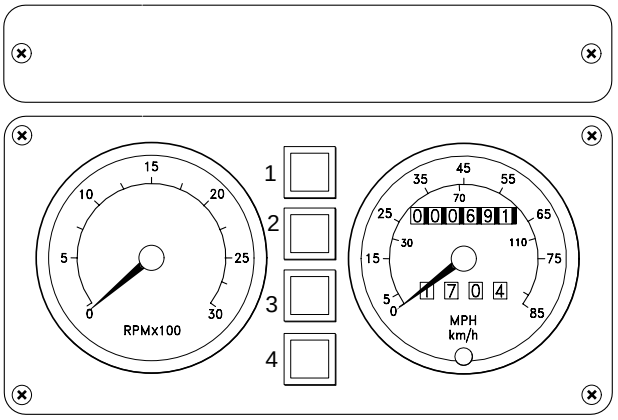
Electronic Control Unit

The WABCO ABS system combines one front-axle control channel with either one rear axle (the four-channel system), or two rear axles (the six-channel system) to form one control circuit. For example, the sensor and solenoid control valve on the left-front axle form a control circuit with the sensor(s) and solenoid control valve(s) on the right-rear axle(s).

The electronic control unit (ECU), located behind the passenger seat, or under the bunk if equipped with a sleeper, contains microcomputers to monitor both control circuits. The ECU receives speed sensor pulses and interprets these signals to calculate wheel speed and a vehicle reference speed. If the calculations indicate wheel slip or lockup, the appropriate control circuit signals the solenoid control valve(s) to increase or decrease braking pressure.

The ECU contains another microcomputer that provides a safety circuit to constantly monitor the wheel sensors, traction control valves (if equipped), sole-

noid control valves, and the electrical circuitry. After the engine is started, the tractor warning light (TRAC ABS) comes on. See **Fig. 4**. Once the vehicle moves faster than about 4 mph (6 km/h), the warning light goes out if all of the tractor's ABS components are working properly.



NOTE: The positions of the warning lights may change depending on vehicle options.

1. Parking Brake
2. Tractor ABS
3. Wheel Spin
4. Trailer ABS

Fig. 4, ABS Dash Indicator Lights

If equipped with the tractor and trailer ABS system, the vehicle also may have one trailer warning light, labelled TRLR ABS. See **Fig. 4**.

After the engine is started, the TRLR ABS light comes on if the trailer is equipped with the WABCO ABS system and if it is correctly connected to the tractor. Once the vehicle moves faster than about 4 mph (6 km/h), the TRLR ABS warning light goes out if all of the trailer's ABS components are working.

NOTE: The following occurs only with ABS systems installed in production.

After the engine is started, the TRLR ABS light stays out if:

A. the trailer is not equipped with an antilock system;

B. the trailer is equipped with an antilock system that is not distributed by WABCO;

C. the trailer is equipped with the WABCO antilock system, but it is not connected correctly to the tractor.

A wheel spin (WHL SPIN) indicator light (if equipped) will come on if one of the drive wheels spins during reduced-traction situations. See **Fig. 4**. Refer to the vehicle driver's manual for operating instructions.

If equipped with an electronic engine, an automatic traction control (ATC) system may be installed. On these vehicles, the ATC system automatically reduces wheel spin during reduced-traction situations.

An "ATC Function" switch (if equipped), may be used under more adverse conditions. Turning on this switch will cause the WHL SPIN light to flash. If the "ATC Function" switch is on and the key is then turned off, then back on, the light will not flash until the switch is turned off and then on again. The ATC system allows some wheel spin (for example, to help burn through a thin layer of ice) during reduced-traction situations.

If, during vehicle operation, the safety circuit senses a failure in any part of the ABS system (a sensor, solenoid control valve, wiring connection, short circuit, etc.), the tractor warning light (TRAC ABS) comes on, and the control circuit where the failure occurred is switched to normal braking action. The remaining control circuit will retain the ABS effect. Even if the ABS system is completely inoperative, normal braking is maintained. An exception would be if a solenoid control valve (or combination solenoid control valve) is damaged and inoperative. As these components are an integral part of the air brake system, normal braking may be impaired or inoperative.

IMPORTANT: If any of the ABS warning lights do not work as described above, there is a possible system malfunction. See **"Troubleshooting, 300"** for fault diagnosis.

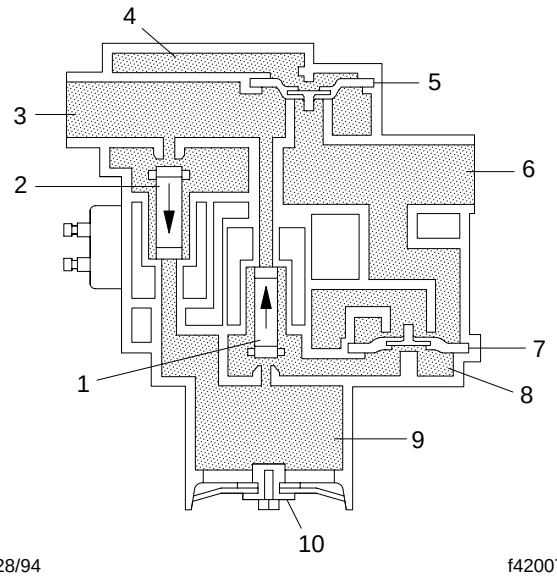
Solenoid Control Valve and Combination Valve

The solenoid control valves are attached to the frame crossmember near the brake chambers. The combination solenoid control valve (for vehicles without traction control manufactured November, 1995 or later), which includes a relay valve, is also attached to the frame crossmember near the rear brake chambers. Depending on the signal received from the electronic control unit, the control valve prevents wheel lockup by reducing, maintaining, or increasing

General Description and Principles of Operation

brake chamber air pressure. During normal braking applications, compressed air flows freely to the brake chamber through the control valve.

If the electronic control unit signals indicate wheel lockup, air pressure is reduced in the brake chamber. Solenoid valve 1 opens allowing compressed air to enter the inlet chamber and pilot chamber 1. See **Fig. 5**.



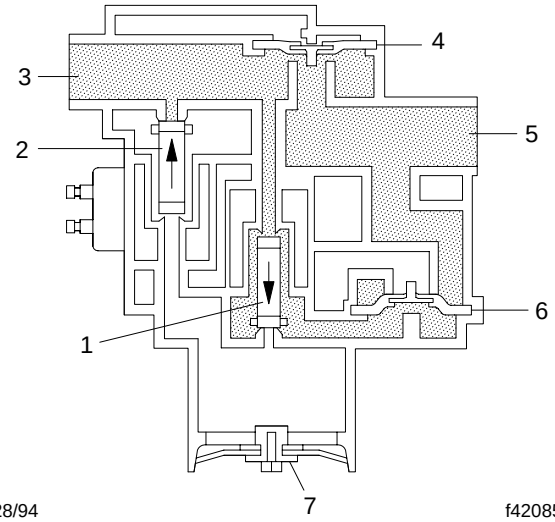
1. Solenoid Valve No. 2
2. Solenoid Valve No. 1
3. Inlet Chamber
4. Pilot Chamber No. 1
5. Diaphragm Valve No. 1
6. Delivery Chamber
7. Diaphragm Valve No. 2
8. Pilot Chamber No. 2
9. Exhaust Chamber
10. Exhaust Port

Fig. 5, Solenoid Valve (both valves open)

At the same time, solenoid valve 1 closes off the exhaust chamber preventing the escape of air from the inlet chamber to atmosphere. Compressed air in the inlet chamber is forced into pilot chamber 1, closing diaphragm valve 1; this prevents air passage to the delivery chamber. Solenoid valve 2 also opens allowing air to vent from pilot chamber 2 through the exhaust port. Complete venting of all air in the delivery chamber occurs as diaphragm valve 2 opens.

As wheel speed increases, the control valve alternately increases, then maintains brake pressure until the proper wheel speed is obtained, or until wheel lockup occurs and the control cycle starts again.

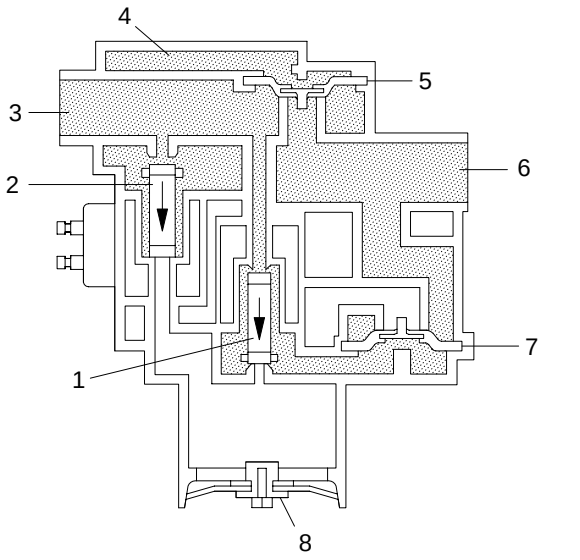
During the pressure increase cycle (**Fig. 6**), both solenoid valves are closed. Compressed air entering through the inlet chamber forces diaphragm valve 1 open, allowing air to pass through the delivery chamber into the brake chamber. At the same time, pressure within the control valve keeps diaphragm valve 2 closed, preventing air from releasing through the exhaust port.



1. Solenoid Valve No. 2
2. Solenoid Valve No. 1
3. Inlet Chamber
4. Diaphragm Valve No. 1
5. Delivery Chamber
6. Diaphragm Valve No. 2
7. Exhaust Port

Fig. 6, Solenoid Valve (both valves closed)

If maintaining brake air pressure (**Fig. 7**), solenoid valve 1 opens and compressed air passes from the inlet chamber into pilot chamber 1. Both of the diaphragm valves are forced closed, sealing the delivery chamber and maintaining brake air pressure.



1. Solenoid Valve No. 2
2. Solenoid Valve No. 1
3. Inlet Chamber
4. Pilot Chamber No. 1
5. Diaphragm Valve No. 1
6. Delivery Chamber
7. Diaphragm Valve No. 2
8. Exhaust Port

Fig. 7, Solenoid Valve (valve no. 1 open)

Wheel Speed Sensor Replacement

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. Refer to the electrical section (wiring) in this manual for information on special terminals and connectors, and on ordering tools for them.

FRONT AXLE

1. Chock the rear tires to prevent vehicle movement. Apply the parking brakes.
2. Twist and pull the sensor, to remove it from the steering knuckle (**Fig. 1**).
3. Remove the sensor cable from the steering knuckle top cap.
4. Disconnect the sensor cable from the chassis harness.
5. Remove the clamping bushing from the steering knuckle.
6. Connect the sensor cable to the chassis harness.

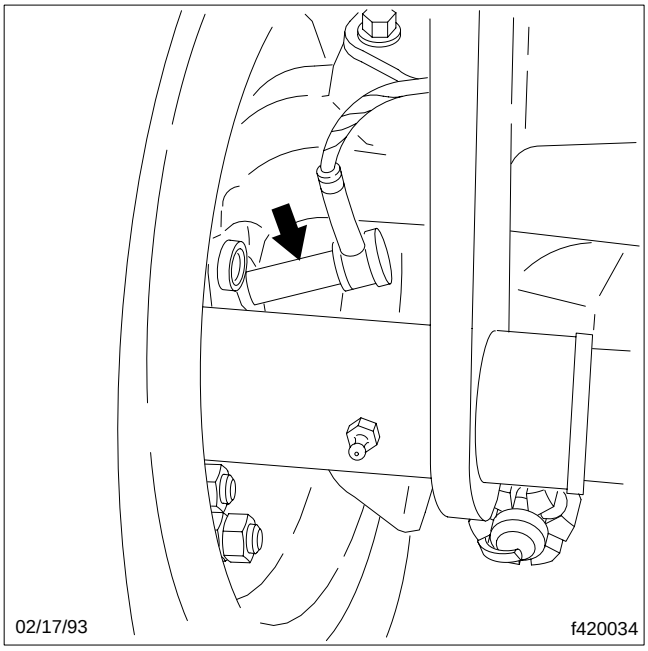


Fig. 1

7. Attach the sensor cable to the steering knuckle top cap.
8. Press the clamping bushing into the brake spider hole until it stops.
9. Coat the sensor with Mobil HP, Valvoline EP 633, Penzoil 707L, or an equivalent. Press the sensor into the clamping bushing until it is stopped by the tone wheel.
10. Remove the chocks from the rear tires.

REAR AXLE

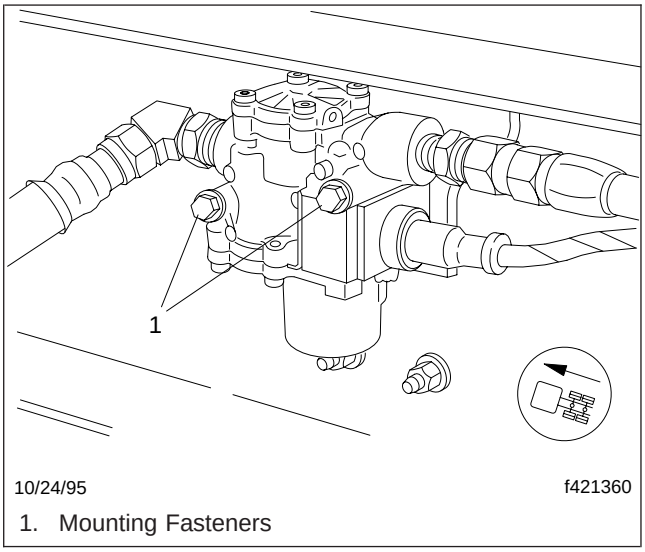
1. Chock the front tires to prevent vehicle movement. Apply the parking brakes.
2. Raise the rear of the vehicle until the tires clear the ground. Place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.
4. Remove the wheel and tire assembly from the rear axle. For instructions, refer to the wheels and tires section in this manual.
5. Remove the brake drum. For instructions, refer to the rear axle section in this manual.
6. Twist and pull the sensor, to remove it from the mounting block in the axle housing.
7. Remove the clamping bushing.
8. Remove the capscrew that attaches the sensor cable and the hose clamp to the axle tube.
9. Disconnect the sensor cable from the chassis harness.
10. Connect the sensor cable to the chassis harness.
11. Attach the hose clamp and sensor cable to the axle tube located between the backing plate and the spring plate.
12. Press the clamping bushing into the mounting block until it stops.
13. Coat the sensor with Mobil HP, Valvoline EP633, Penzoil 707L, or an equivalent. Push the sensor into the clamping bushing until it is stopped by the tone wheel.
14. Install the brake drum on the wheel hub.

Wheel Speed Sensor Replacement

15. Adjust the rear axle brakes. For instructions, refer to the brake section in the vehicle maintenance manual.
16. Install the wheel and tire assembly, and tighten the wheel nuts. Use the tightening sequence and torque values listed in the wheels and tires section in this manual.
17. Remove the safety stands, lower the vehicle, and remove the chocks from the front tires.

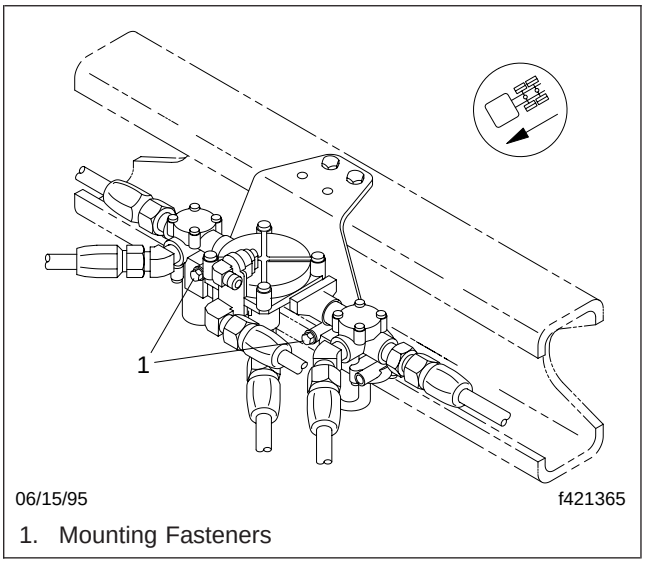
Solenoid Control Valve Removal and Installation

Removal (See Fig. 1 or Fig. 2)



1. Mounting Fasteners

Fig. 1, Solenoid Control Valve Mounting



1. Mounting Fasteners

Fig. 2, Combination Solenoid Control Valve Mounting

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Group 54** in this manual for information on special terminals and connectors, and on ordering tools for them.

1. Chock the front and rear tires.
2. Release the pressure from the air reservoirs.
3. Disconnect the wiring from the solenoid control valves, or combination solenoid control valve.
4. Mark the air lines for ease of installation. Disconnect the air lines.
5. Remove the two mounting nuts, washers, and capscrews.
6. Remove the solenoid control valves or the combination solenoid control valve.

NOTE: The combination solenoid control valve can be disassembled if replacement of the relay valve, automatic traction control valve, or one of the solenoid control valves is needed. For disassembly and assembly instructions, see **Subject 140**.

Installation

1. Install the solenoid valves or the combination solenoid control valve.
2. Install the two mounting capscrews, washers, and nuts. Tighten the mounting nuts 15 lbf·ft (20 N·m).
3. Connect the air lines.
4. Connect the wiring to the solenoid control valves, or combination solenoid control valve.
5. Start the engine and allow the air reservoirs to fill.
6. Remove the chocks from the front and rear tires.

Replacement

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. Refer to the electrical section (wiring) in this manual for information on special terminals and connectors, and on ordering tools for them.

1. Chock the front and rear tires.
2. Disconnect the wiring from the traction control valve.
3. Disconnect the air supply and the air discharge lines.
4. Remove the two mounting capscrews, washers, and nuts.
5. Remove the traction control valve from the frame rail.
6. Install the traction control valve using the above instructions in reverse order. Tighten the mounting nuts 18 lbf·ft (24 N·m).

Wheel Speed Sensor Adjustment, Rear Axle

Adjustment

NOTE: The following adjustment procedure requires the use of special tool T11–17556–000. Use of this tool, available through the PDCs, eliminates the time-consuming task of removing the wheel and tire assembly, and the brake drum. **See Fig. 1.**

1. Park the vehicle on level ground, set the parking brake, and shut down the engine.

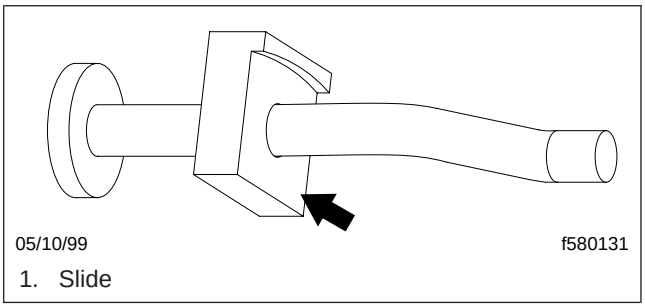


Fig. 1, ABS Sensor Adjustment Tool

2. Chock the front tires.
3. Find the sensor access hole in the rear axle flange.
   - 3.1 View the brake drum and axle from the rear. The ABS sensor wiring harness should be visible passing through a hole in the 12 o'clock position.
   - 3.2 Find the S cam at either the 3 o'clock or 9 o'clock position.
   - 3.3 Just opposite the S cam is the sensor access hole, approximately 3/4 inch (19 mm) diameter.
4. Insert the service tool T11–17556–000 into this hole.
5. Position the slide of the tool on the axle flange to align the tool. **See Fig. 2.**
6. Tap the tool lightly with the palm of your hand. This will ensure the sensor is touching the tone wheel.
7. Remove the tool from the wheel and repeat the procedure on the other rear axle speed sensor.
8. Remove the chocks from the tires.

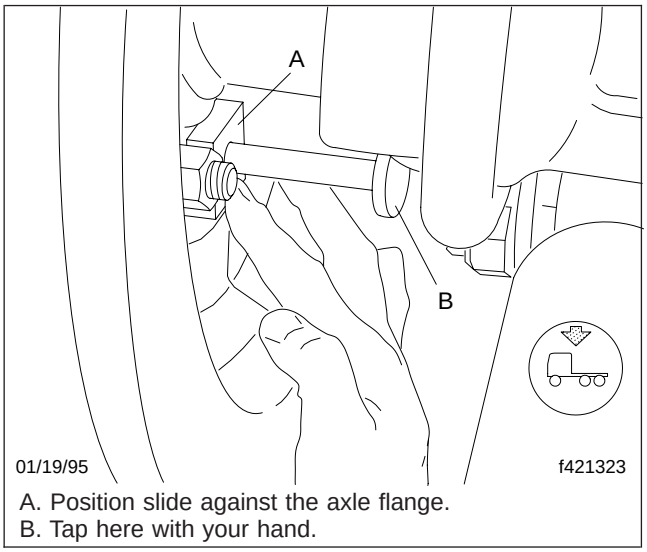
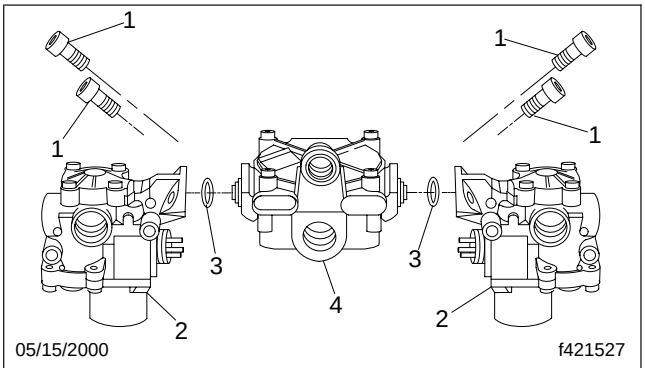


Fig. 2, Position the Tool

Combination Solenoid Control Valve Disassembly and Assembly

Disassembly (See Fig. 1)



1. Allen-Head Bolt
2. ABS Control Valve
3. O-Ring
4. Relay Valve

Fig. 1, Combination Solenoid Control Valve

1. Using a 6 mm allen-head wrench, remove the allen-head bolts.
2. Carefully separate the ABS control valve(s) from the relay valve.
3. Remove and discard the old O-rings.

Assembly (See Fig. 1)

1. Lubricate the replacement O-rings with grease.
2. Plug any unused ports on the replacement valve(s).
3. Attach the ABS control valve(s) to the relay valve. Tighten the allen-head bolts 13 to 15 lbf·ft (18 to 20 N·m).

ABS Tone Ring Installation on Service Hubs

Installation

IMPORTANT: Some ABS service hubs do not have a tone ring installed on the hub. The tone ring must be ordered separately and installed on the hub before installation of the hub onto the axle. Tone rings are made of a special material and require a specific installation procedure for proper installation.

⚠ WARNING

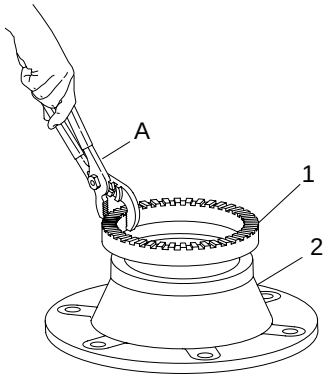
When installing an ABS system, special ABS hubs must be ordered. Machining of older hubs to accommodate the installation of tone rings can cause problems due to insufficient hub bore wall thickness. Machining an older hub with insufficient hub bore wall thickness could result in cracking, causing bearing damage and wheel loss. This could cause an accident resulting in personal injury and property damage.

1. Submerge the tone ring in boiling water or place it in an oven at 250°F (121°C) for approximately 15 minutes.

⚠ CAUTION

Do not attempt to heat the tone ring with a torch as this can damage the ring.

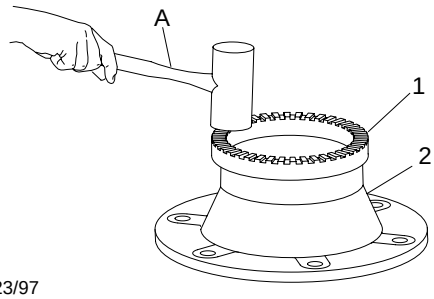
2. Using pliers, remove the tone ring from the boiling water or oven and center it on the machined area of the hub bore. See **Fig. 1**.
3. While the tone ring is still hot, make sure that it is properly centered on the machined surface. Using a rubber mallet, tap the tone ring until it bottoms out around the machined surface on the hub. See **Fig. 2**.
4. Install the hub on the axle. Position a dial indicator with a magnetic base so the dial indicator is against the tone ring teeth. See **Fig. 3**.
5. Rotate the hub and check the ring for runout. The runout should be less than 0.005 inch (0.13 mm). See **Fig. 4**.
6. Install the wheel. For instructions, see **Group 40** of this manual.



12/23/97 f421664

A. Use pliers to apply the ring.
1. Tone Ring 2. Hub

Fig. 1, Install the Ring on the Hub



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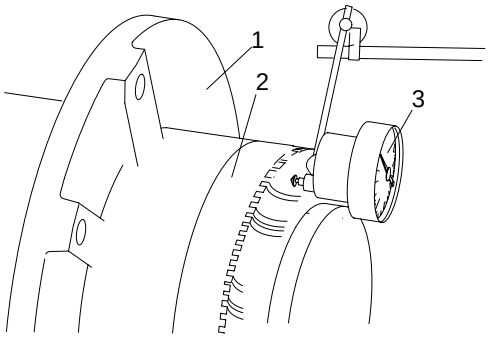
A. Use a rubber mallet.
1. Tone Ring 2. Hub

Fig. 2, Tap the Tone Ring



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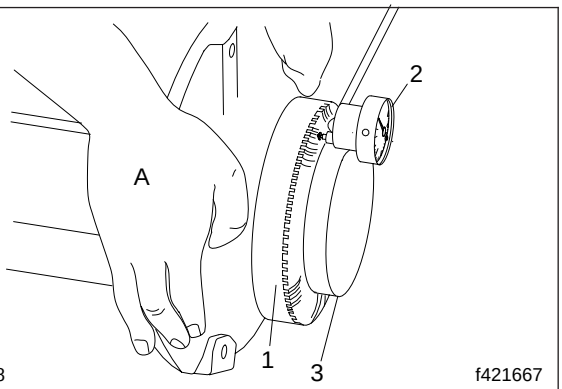
1. Hub 3. Dial Indicator
2. Tone Ring

Fig. 3, Position the Dial Indicator

ABS Tone Ring Installation on Service Hubs



A. Rotate the hub.
1. Tone Ring
2. Dial Indicator
3. Axle

Fig. 4, Check Tone Ring Runout

Using a Test Unit and Adaptor

IMPORTANT: The test unit and adaptor can't be used to troubleshoot ABS systems equipped with the C2 ECU (installed in vehicles since December 1991).

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. Refer to the electrical section (wiring) in this manual for information on special terminals and connectors, and on ordering tools for them.

A test unit and adaptor (**see Fig. 1**), distributed by WABCO, are available to troubleshoot all ABS systems equipped with B3 and C1 ECUs, except the electronic control unit. Replace the control unit if no system faults are found after all of the troubleshooting tests are completed, and if the tractor warning light remains on after the vehicle is moving faster than about 4 mph (6 km/h).

The adaptor (part number 446 007 238 0), plugs into the control unit and the test unit (part number 446 007 002 0).

Before troubleshooting with the test unit and adaptor, check all fuses in the control unit panel, and replace if necessary. Make sure that a charged 12 volt battery is available (the ABS system needs at least 9 volts to work).

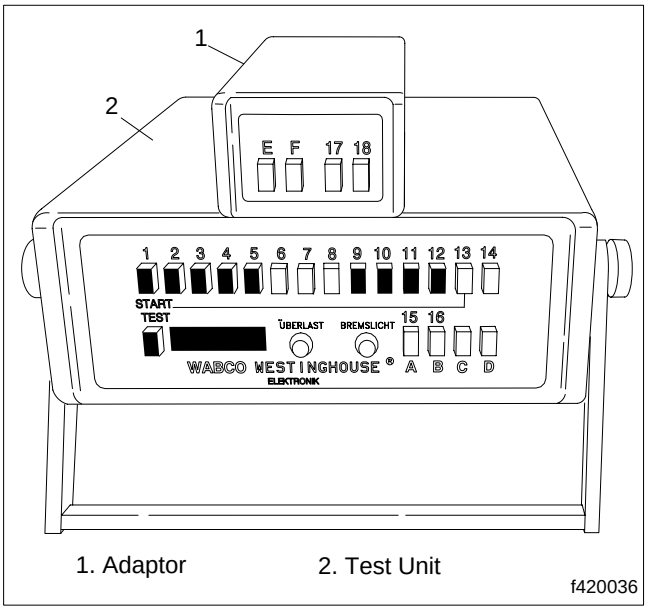
Refer to the appropriate wiring diagram in **Specifications, 400** when troubleshooting the ABS system with a test unit and adaptor.

IMPORTANT: Do the troubleshooting tests in the exact order provided below. If a fault is found with any component of the ABS system during the tests, correct it, then repeat all tests beginning with "Testing the Test Unit and Adaptor."

NOTE: The key switch must be turned on for all of the troubleshooting tests; do not turn it off.

TESTING THE TEST UNIT AND ADAPTOR **(See Fig. 2)**

1. Connect the test unit and adaptor to the ABS system.
2. Turn on the ignition switch.
3. Press button 1 on the test unit. Check that the test unit brake light (Bremslicht) is on.



1. Adaptor 2. Test Unit

f420036

Fig. 1

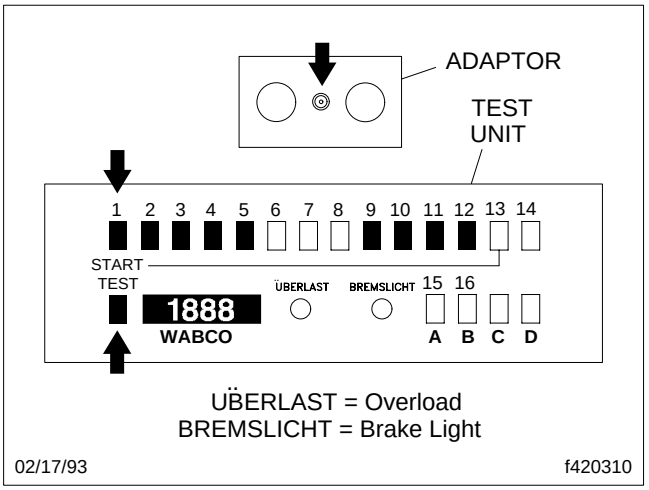


Fig. 2

4. Press the button at the rear of the adaptor. The test unit brake light should go out.

   After releasing the adaptor button, the test unit brake light should come on, and remain on for the remaining tests.
5. On the test unit, press button 1 and the "start test" button at the same time. The digital display should read 1888.

If the test unit displays a different number or no number, either the unit is not working or there is an open circuit in the valve relay power supply.

TEST 1: TESTING THE CIRCUITRY OF THE WARNING LAMP RELAY ANDTHE VALVE RELAY COILS

(See Fig. 3)

1. Make sure that the ignition switch is on, but don't start the engine.
2. Press button 1 on the test unit. The digital display should show a number from 330 to 660 milliamps.

   If the digital display is blank, there is no power supply to the test unit and adaptor.

   If the display number is 000 to 329 milliamps, the warning lamp relay is not working, or there is an open circuit in the wiring.

   If the overload light (Überlast) comes on, or if the display shows a number from 661 to 1999 milliamps, a short circuit exists in the warning lamp relay (or wiring to the relay), or in either (or both) of the valve relays.

   If the problems described in this step occur, troubleshooting tests 2 through 5 will isolate the system fault.

TEST 2: TESTING THE VOLTAGE OUTPUT OF VALVE RELAY 1

(See Fig. 4)

1. Make sure that the ignition switch is on, but don't start the engine.
2. Press button 2 on the test unit. The digital display should show a number from 10.35 to 16.8 volts, or 9.5 to 16.8 volts (this applies only to four-channel systems installed on vehicles after March 1, 1991).

   If the digital display is blank, or shows a number from 00.0 to 10.30 volts (00.0 to 9.45 volts for four-channel systems installed on vehicles after March 1, 1991), valve relay 1 is not working, wiring to the relay is shorted or open, or the vehicle batteries need charging or replacement.

⚠ CAUTION

CAUTION: Before charging the batteries, disconnect the electronic control unit. This will prevent power surges and possible component damage in the electronic control unit.

TEST 3: TESTING VOLTAGE SUPPLY TO VALVE RELAY 2

(See Fig. 5)

1. Make sure that the ignition switch is on, but don't start the engine.
2. Press button 3 on the test unit. The digital display should show a number from 00.0 to 00.3 volt.

   If the digital display is blank, or shows a number from 00.4 to 16.8 volts, the contacts of valve relay 2 are sticking, wiring to valve relay 1 is shorted, or there is no power supply to the test unit and adaptor.

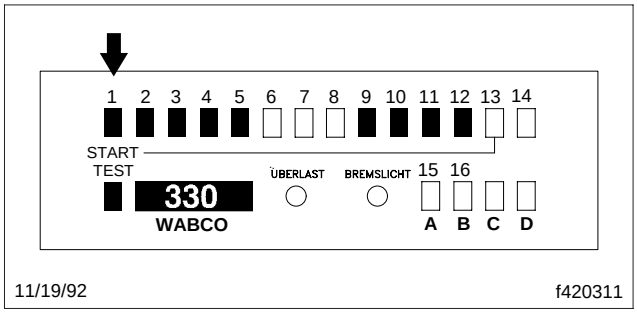


Fig. 3

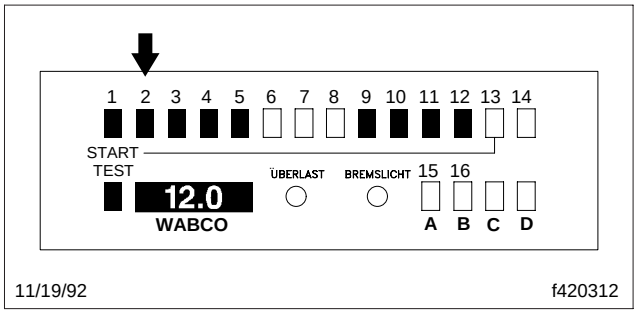


Fig. 4

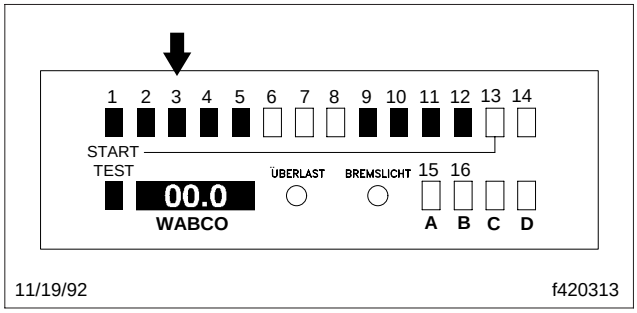


Fig. 5

TEST 4: TESTING THE VOLTAGE OUTPUT OF VALVE RELAY 2

(See Fig. 6)

1. Make sure that the ignition switch is on, but don't start the engine.
2. Press button 4 on the test unit. The tractor warning light (TRAC ABS) and wheel spin indicator light (WHL SPIN) should be on. The digital display should show a number from 10.35 to 16.8 volts, or 9.5 to 16.8 volts (this applies only to four-channel systems installed on vehicles after March 1, 1991).

   If the digital display is blank, there is no power supply to the test unit and adaptor, or the vehicle batteries need charging or replacement. If the display shows a number from 00.0 to 10.3 volts (00.0 to 9.45 volts for four-channel systems installed on vehicles after March 1, 1991), either valve relay 2 is not working, or wiring to the relay is shorted or open.

⚠ CAUTION

CAUTION: Before charging the batteries, disconnect the electronic control unit. This will prevent power surges and possible component damage in the electronic control unit.

TEST 5: TESTING VOLTAGE SUPPLY TO VALVE RELAY 1

(See Fig. 7)

1. Make sure that the ignition switch is on, but don't start the engine.
2. Press button 5 on the test unit. The tractor warning light (TRAC ABS) and wheel spin indicator light (WHL SPIN) should be on. The digital display should show a number from 00.0 to 00.3 volt.

   If the digital display is blank, there is no power supply to the test unit and adaptor. If the display shows a number from 00.4 to 16.8 volts, either the contacts of valve relay 1 are sticking, wiring to the warning light relay is shorted or open, or wiring to relay valve 2 is shorted or open.

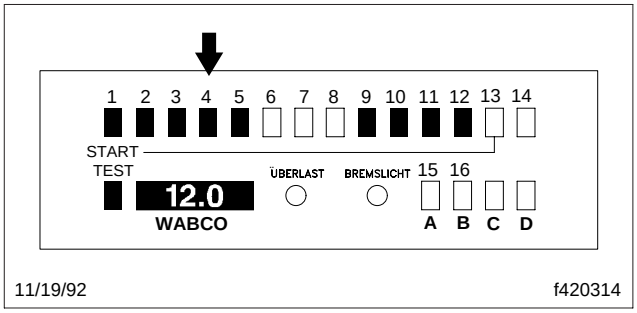


Fig. 6

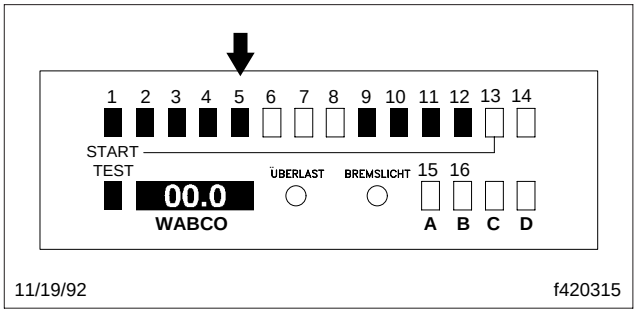


Fig. 7

TEST 6: TESTING THE COIL RESISTANCE OF THE SOLENOID CONTROL VALVES' INLET AND OUTLET VALVES

1. Make sure that the ignition switch is on, but don't start the engine.
2. Test each solenoid valve. The correct digital display for each control valve is a number from 2.0 to 5.0 ohms. If the display reading is not 2.0 to 5.0 ohms, go to step 3. Test each solenoid valve as follows:

   IMPORTANT: On four-channel systems, do steps 2.1 through 2.4. On six-channel systems, do steps 2.1 through 2.6.

2.1 Left side of front axle—press button 6 and button A on the test unit. **See Fig. 8** .

2.2 Right side of front axle—press button 6 and button B on the test unit.

IMPORTANT: In steps 2.3 and 2.4, the rearmost axle is referenced. However, if a four-channel system is installed on a vehicle with *two* rear axles and a spring-type suspension, the wheel sensors are located on the *forward-rear* axle. In all other ABS installations, reference to the rearmost axle is correct for these test steps.

2.3 Left side of rearmost axle—press button 6 and button C on the test unit.

2.4 Right side of rearmost axle—press button 6 and button D on the test unit.

2.5 Left side of forward-rear axle (on six-channel systems)—press button 6 and button D on the test unit; also, press button F on the adaptor.

2.6 Right side of forward-rear axle (on six-channel systems)—press button 6 and button D on the test unit; also, press button E on the adaptor.

3. If the display reading is not 2.0 to 5.0 ohms, use the following fault readings to isolate and correct the problem:

0.0 to 1.9 ohms—means poor circuit connections, a shorted solenoid valve winding, or a short circuit.

5.1 to 19.9 ohms—means a broken coil or an open circuit.

1.—means that the solenoid control valve is not connected to the wiring harness, there is an open circuit in the wiring, or the solenoid control valve needs to be replaced.

TEST 7: TESTING THE COIL RESISTANCE OF THE WHEEL SPEED SENSORS

1. Make sure that the ignition switch is on, but don't start the engine.
2. Test each speed sensor. The correct digital display reading for each sensor is a 1.0 to 1.99 kilo ohms. If the display reading is not 1.0 to 1.99 kilo ohms, go to step 3. Test each sensor as follows:

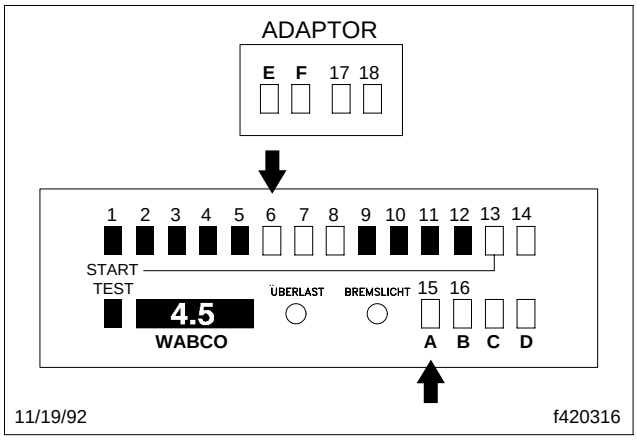


Fig. 8

IMPORTANT: On four-channel systems, do steps 2.1 through 2.4. On six-channel systems, do steps 2.1 through 2.6.

2.1 Left side of front axle—press button 7 and button A on the test unit. **See Fig. 9** .

2.2 Right side of front axle—press button 7 and button B on the test unit.

IMPORTANT: In steps 2.3 and 2.4, the rearmost axle is referenced. However, if a four-channel system is installed on a vehicle with *two* rear axles and a spring-type suspension, the wheel sensors are located on the *forward-rear* axle. In all other ABS installations, reference to the rearmost axle is correct for these test steps.

2.3 Left side of rearmost axle—press button 7 and button C on the test unit.

2.4 Right side of rearmost axle—press button 7 and button D on the test unit.

2.5 Left side of forward-rear axle (on six-channel systems)—press button 7 and button D on the test unit; also, press button F on the adaptor.

2.6 Right side of forward-rear axle (on six-channel systems)—press button 7 and button D on the test unit; also, press button E on the adaptor.

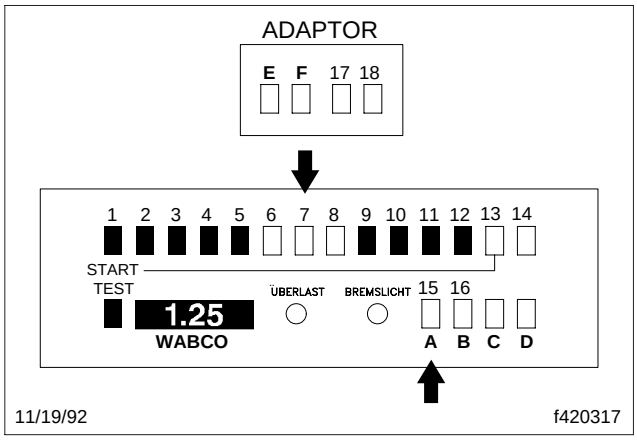


Fig. 9

3. If the display reading is not 1.0 to 1.99 kilo ohms, use the following fault readings to isolate and correct the problem:

   0.00 to 0.99 kilo ohms—means poor circuit connections, or a shorted sensor winding.

   2.00 to 19.90 kilo ohms—means poor circuit connections, or that the sensor needs replacement.

   1.—means an open circuit in either the sensor, or in the wiring to the sensor.

TEST 8: TESTING THE CONTACT RESISTANCE OF THE SENSOR COIL AND WIRING TO VEHICLE GROUND

1. Make sure that the ignition switch is on, but don't start the engine.
2. Test each speed sensor. The correct digital display reading for each sensor is a number from 30.0 to 1. If the display reading is not 30.0 to 1, go to step 3. Test each sensor as follows:

   IMPORTANT: On four-channel systems, do steps 2.1 through 2.4. On six-channel systems, do steps 2.1 through 2.6.

   2.1 Left side of front axle—press button 8 and button A on the test unit. **See Fig. 10** .

   2.2 Right side of front axle—press button 8 and button B on the test unit.

   IMPORTANT: In steps 2.3 and 2.4, the rearmost axle is referenced. However, if a four-channel system is installed on a vehicle with *two* rear axles and a spring-type suspension, the wheel sensors are located on the *forward-rear* axle. In all other ABS installations, reference to the rearmost axle is correct for these test steps.

   2.3 Left side of rearmost axle—press button 8 and button C on the test unit.

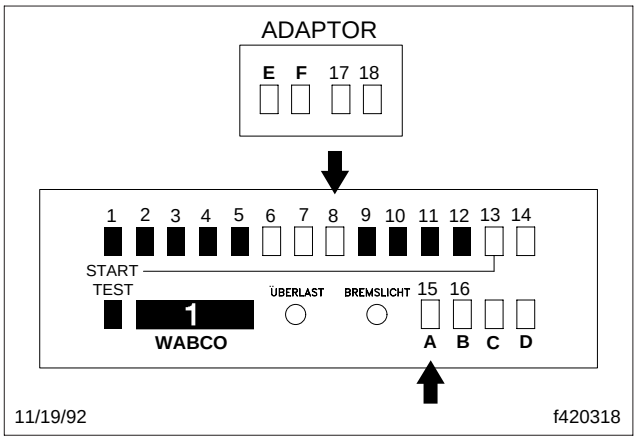


Fig. 10

   2.4 Right side of rearmost axle—press button 8 and button D on the test unit.

   2.5 Left side of forward-rear axle (on six-channel systems)—press button 8 and button D on the test unit; also, press button F on the adaptor.

   2.6 Right side of forward-rear axle (on six-channel systems)—press button 8 and button D on the test unit; also, press button E on the adaptor.

3. If the display reading is 00.0 to 29.9 kilo ohms, either the speed sensor or the wiring to the speed sensor needs replacing.

TEST 9: TESTING THE ENGINE BRAKE RELAY

1. Make sure that all of the buttons on the test unit and adaptor are released (not pressed in).

NOTE: If equipped with a Cummins engine PACE Control System and engine brake, turn off the cruise control.

2. Start the engine.
3. Turn on the engine brake toggle switches (up position). The engine should begin to idle roughly, or shut down.

   If the engine runs smoothly, check the wiring and wiring connections, both toggle switches, and the ABS engine brake relay.
4. Start the engine. Press button 9 on the test unit. **See Fig. 11** . The engine should run smoothly with the engine brake toggle switches on.

   If the engine idles roughly or shuts down after pressing button 9, check the wiring and wiring connections, and the ABS engine brake relay.

NOTE: The ABS engine brake relay acts as an additional on/off switch for the engine brake. If the engine brake does not work, perform Test 9 to check the ABS engine brake relay.

TEST 10: TESTING THE WHEEL SPIN (WHL SPIN) INDICATOR AND TRACTORWARNING LIGHT RELAY

(See Fig. 12)

1. Start the engine.
2. Press button 10 on the test unit. The digital display should show a number from 10.35 to 16.8 volts, or 9.5 to 16.8 volts (this applies only to four-channel systems installed on vehicles built after March 1, 1991), the TRAC ABS warning light and the WHL SPIN indicator light should be on.

   If the digital display shows a number from 00.0 to 10.30 volts (00.0 to 9.45 volts for four-channel systems installed on vehicles built after March 1, 1991), and if the status lights are off, either the engine is off, the wiring for the status lights is connected wrong, wiring to the status lights is shorted or open, or the relays for the status lights need replacing.

TEST 11: TESTING THE TRACTOR WARNING AND WHEEL SPIN (WHL SPIN) INDICATOR LIGHT ACTIVATION **(See Fig. 13)**

1. Start the engine.
2. Press button 11 on the test unit. The digital display should show a number from 10.35 to 16.8 volts, or 9.5 to 16.8 volts (this applies only to four-channel systems installed on vehicles built after March 1, 1991), the TRAC ABS warning light and the WHL SPIN indicator light should be on.

   If the digital display shows a number from 00.0 to 10.30 volts (00.0 to 9.45 volts for four-channel systems installed on vehicles built after March 1, 1991), and if the status lights are off, either the engine is off, the wiring for the status lights is connected wrong, wiring to the status lights is shorted or open, or the relays for the status lights need replacing.

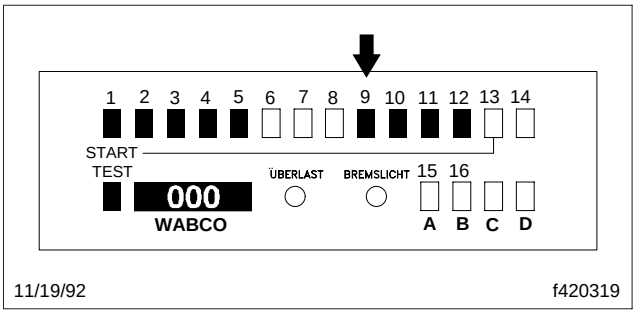


Fig. 11

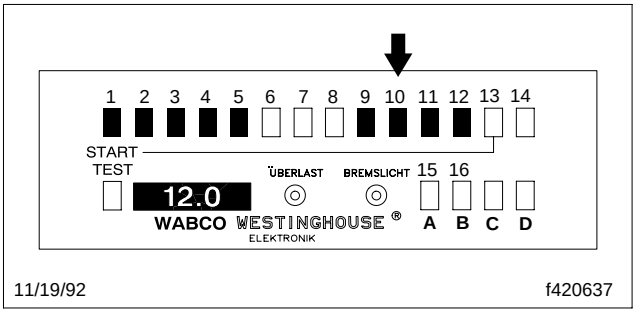


Fig. 12

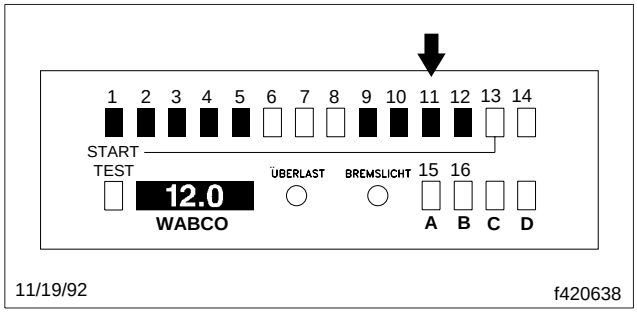


Fig. 13

TEST 12: THIS TEST IS NO LONGER USED

TEST 13: TESTING SOLENOID CONTROL VALVE OPERATION

1. Chock the rear tires to prevent vehicle movement. Release the parking brakes.
2. If necessary, start the engine and build system air pressure to at least 100 psi (689 kPa). Shut down the engine, but leave the ignition switch on.
3. Test each solenoid control valve. Have a person watch the solenoid control valve and brake chamber being tested. With the brake pedal fully depressed, the following cycle should occur as the test button is pressed and released:
   - compressed air enters the brake chamber and the push rod extends as the brake engages;
   - the solenoid control valve partially exhausts air and the push rod partially retracts;
   - the solenoid control valve completely exhausts air and the push rod retracts all the way;
   - air pressure increases in the brake chamber and the push rod extends close to the full application position;
   - full air pressure enters the brake chamber and the push rod extends all the way as the brake engages.

   Also, after pressing the "start test" button, the correct digital display reading for each control valve is 1. At the finish of the brake cycling, the correct reading is a number from 000 to 003. If any different numbers are displayed, or if the brake does not cycle as described, go to step 4.

   Test each solenoid control valve as follows:

IMPORTANT: On four-channel systems, do steps 3.1 through 3.4. On six-channel systems, do steps 3.1 through 3.6.

3.1 Left side of front axle—press button 13 and button A on the test unit. **See Fig. 14** . Depress the brake pedal (the brake light on the test unit should come on), then press the "start test" button on the test unit.

3.2 Right side of front axle—press button 13 and button B on the test unit. Depress the brake pedal (the brake light on the test unit should come on), then press the "start test" button on the test unit.

IMPORTANT: In steps 3.3 and 3.4, the rearmost axle is referenced. However, if a four-channel system is installed on a vehicle with *two* rear axles and a spring-type suspension. the wheel sensors are located on the *forward-rear* axle. In all other ABS installations, reference to the rearmost axle is correct for these test steps.

3.3 Left side of rearmost axle—press button 13 and button C on the test unit. Depress the brake pedal (the brake light on the test unit should come on), then press the "start test" button on the test unit.

3.4 Right side of rearmost axle—press button 13 and button D on the test unit. Depress the brake pedal (the brake light on the test unit should come on), then press the "start test" button on the test unit.

3.5 Left side of forward-rear axle (on six-channel systems)—press button 13 and button D on the test unit; also, press button F on the adaptor. Depress the brake pedal (the brake light on the test unit should come on), then press the "start test" button on the test unit.

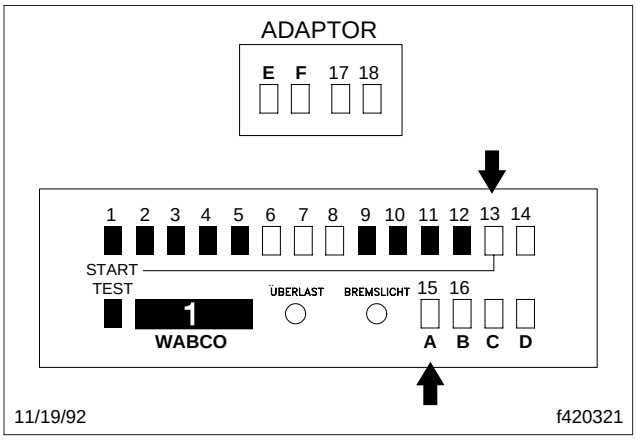


Fig. 14

3.6 Right side of forward-rear axle (on six-channel systems)—press button 13 and button D on the test unit; also, press button E on the adaptor. Depress the brake pedal (the brake light on the test unit should come on), then press the "start test" button on the test unit.

4. If the brake does not cycle as described in step 3, or if the digital readings are incorrect, either the electrical lines of two solenoid control valves are crossed (check by pressing the individual wheel buttons on the test unit); the air supply and discharge lines are crossed; the electrical connector at the solenoid control valve is not correctly plugged in; or the control valve needs replacing.

TEST 14: TESTING SPEED SENSOR OPERATION

1. Make sure that the ignition switch is on.
2. For each sensor tested, raise the vehicle until the tire clears the ground. Place safety stands under the axle.
3. Chock all wheels that are not being tested to prevent them from turning. Release the parking brakes.
4. Test each wheel speed sensor by spinning the wheel one-half revolution-per-second (allow only the wheel being tested to spin). The correct digital display reading for each sensor is 050 to 1999 millivolts. If the reading is not within the range specified for the type of sensor being tested, go to step 5. Test each sensor as follows:

MPORTANT: On four-channel systems, do steps 4.1 through 4.4. On six-channel systems, do steps 4.1 through 4.6.

4.1 Left side of front axle—spin the tire; press button 14 and button A on the test unit. **See Fig. 15**.

4.2 Right side of front axle—spin the tire; press button 14 and button B on the test unit.

IMPORTANT: In steps 4.3 and 4.4, the rearmost axle is referenced. However, if a four-channel system is installed on a vehicle with *two* rear axles and a spring-type suspension. the wheel sensors are located on the *forward-rear* axle. In all other ABS installations, reference to the rearmost axle is correct for these test steps.

4.3 Left side of rearmost axle—spin the tire; press button 14 and button D on the test unit.

4.4 Right side of rearmost axle—spin the tire; press button 14 and button D on the test unit.

4.5 Left side of forward-rear axle (on six-channel systems—spin the tire; press button 14 and button D on the test unit; also, press button F on the adaptor.

4.6 Right side of forward-rear axle (on six-channel systems)—spin the tire; press button 14 and button D on the test unit; also, press button F on the adaptor.

5. If the display reading is not within the range specified for the sensor being tested, either the sensor is not pushed up against the tone wheel, the wrong tone wheel is installed, or sensor electrical wires are crossed (check by pressing the individual wheel buttons on the test unit.)

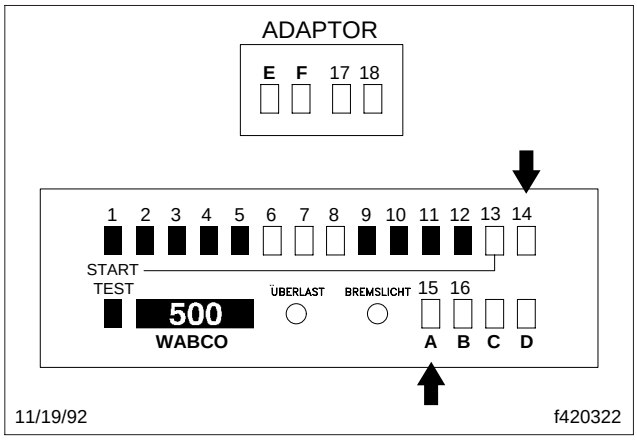


Fig. 15

TEST 15: PART I TESTING THE INFORMATION MODULE AND THE BRAKE LIGHT RELAY ON VEHICLES EQUIPPED WITH A TRAILER ABS ISO CONNECTOR

IMPORTANT: If the vehicle is equipped with Traction Plus, do tests 17 and 18 before tests 15 and 16.

1. Disconnect adaptor 446 007 238 0 from the electronic control unit and the test unit. Do not connect the 35-pin connector to the electronic control unit.
2. Make sure that the ignition switch is on, but don't start the engine.
3. Check that the TRLR W/O ABS light on the dashboard is off.

   If the TRLR W/O ABS light comes on, there is an open or short in the information module wiring or wiring connectors; or the information module needs replacement.
4. Plug ABS test light adaptor 884 900 602 0 into the trailer plug at the rear of the cab (**see Fig. 16**).
5. Check the TRLR W/O ABS light on the dashboard; it should be on. If the TRLR W/O ABS light is off, check the information module wiring, the brake light relay, and the wiring or wiring connectors.
6. Depress the brake pedal. Check the ABS test light at the rear of the cab; it should be on.

   If the test light is not on, check the wiring to the 7-way tractor plug, and check the test light bulb.

TEST 15: PART II TESTING THE INFORMATION MODULE AND THE TRAILER'S ELECTRICAL SUPPLY ON VEHICLES EQUIPPED WITH A TRAILER ABS ISO CONNECTOR

(See Fig. 17)

IMPORTANT: Make sure the batteries are fully charged. If not, test readings in the applicable step below may be up to 1 volt lower than listed.

1. Using the orange test cable 884 900 564 0, connect the test unit to the ABS trailer plug at the rear of the cab. Make sure that test light adaptor 884 900 602 0 is connected to the 7-way tractor plug.
2. Make sure that the ignition switch is on.
3. Press buttons 14 and 15 on the test unit. The digital display should show a number from 9.7 to 15.7 volts, and the TRLR W/O ABS light should be off.

   If the TRLR W/O ABS light is on and the digital display does not show a number from 9.7 to 15.7 volts, check the information module wiring.

   If the TRLR W/O ABS light is on and the digital display is correct, replace the information module.

   If the digital display shows a number from 00.0 to 9.6, there is an open or short in the wiring, or in the wiring connections.

   If the digital display shows a number from 000 to 157, there is no connection to ground at contact 4 of the trailer socket.

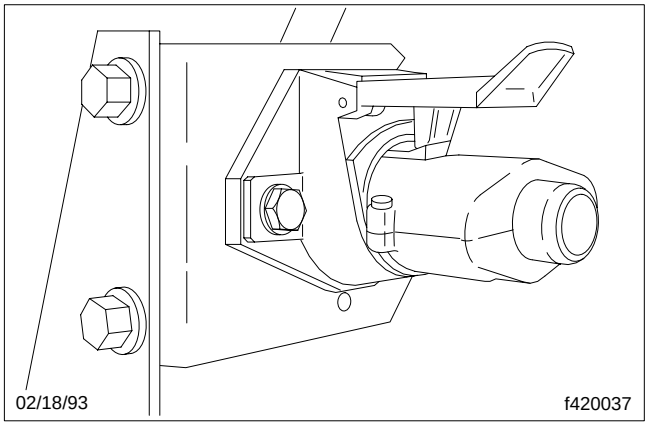


Fig. 16

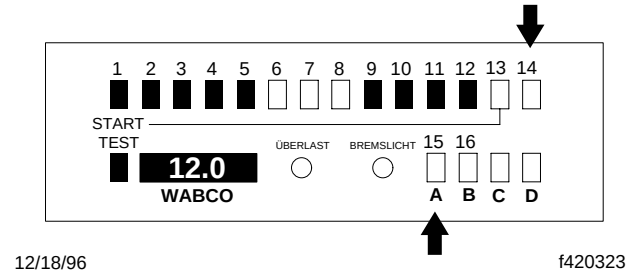


Fig. 17

TEST 16: TESTING THE TRAILER WARNING LIGHT ON VEHICLES EQUIPPED WITH A TRAILER ABS ISO CONNECTOR (See Fig. 18)

1. Make sure that the ignition switch is on, but don't start the engine.
2. Disconnect ABS test light adaptor 884 900 602 0 from the 7-way tractor plug.
3. Press buttons 14 and 16 on the test unit. The digital display should show a number from 9.7 to 15.7, and the TRLR ABS light should be on.

   If the digital display shows a number from 00.0 to 9.6, there is an open or short in the wiring, or in the wiring connections.

   If the digital display shows a number from 000 to 157, there is no connection to ground at contact 4 of the ABS trailer socket.

   If the test unit overload (Uberlast) light comes on, there is a crossed connection at contact 5 of the ABS trailer socket.

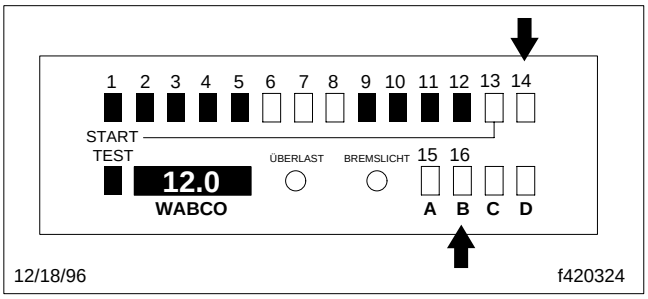


Fig. 18

TESTS 17 AND 18: PART I TESTING THE WIRING AND COIL RESISTANCE OF THE TRACTION CONTROL VALVES

1. Make sure that the ignition switch is on, but don't start the engine.
2. Test each traction control valve. The correct digital display reading for each control valve is a number from 6.0 to 11.0 ohms. If the display reading is not 6.0 to 11.0 ohms, go to step 3. Test each valve as follows:

   2.1 Traction control valve controlling the left side of the vehicle—press button 6 and button D on the test unit; also, press button 17 on the adaptor. **See Fig. 19** .

   2.2 Traction control valve controlling the right side of the vehicle—press button 6 and button D on the test unit; also, press button 18 on the adaptor.

3. If the display reading is not 6.0 to 11.0 ohms, use the following fault readings to isolate and correct the problem:

   0.0 to 5.9 ohms—means a shorted solenoid valve winding, or a short circuit.

   11.1 to 19.9—means poor circuit connections, or that the control valve needs replacement.

   1.—means that the control valve is not connected to the wiring harness, there is an open circuit in the wiring or, there is an open circuit in the valve.

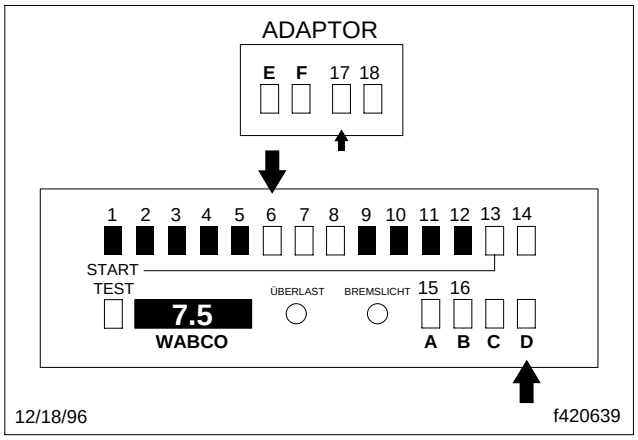


Fig. 19

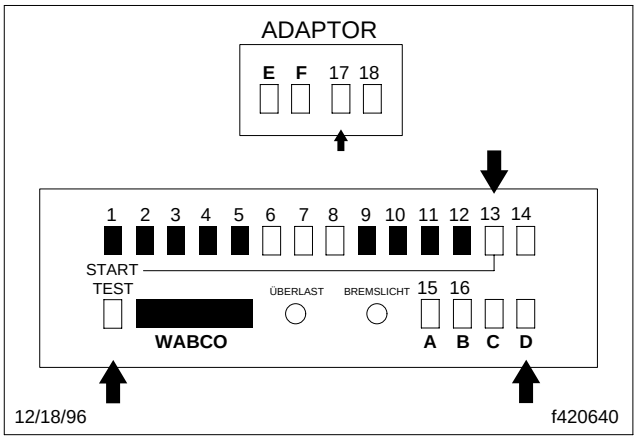


Fig. 20

TESTS 17 AND 18: PART II TESTING THE OPERATION OF THE BRAKE SYSTEM SOLENOID CONTROL VALVES AND THE TRACTION CONTROL VALVES

1. If necessary, start the engine and build system air pressure to at least 100 psi (689 kPa). Shut down the engine, but leave the ignition switch on.

   Also, after pressing the "start test" button, the correct digital display reading for each traction control valve is 1. At the finish of the brake cycling, the correct reading is a number from 000 to 003. If any different numbers are displayed, or if the brake does not cycle properly, go to step 3.

2. Test each valve as follows:

   2.1 Traction valves controlling the left side of the vehicle—press button 13 and button D on the test unit; also, press button 17 on the adaptor. **See Fig. 20** . Press the "start test" button on the test unit.

   2.2 Traction valves controlling the right side of the vehicle—press button 13 and button D on the test unit; also, press button 18 on the adaptor. Press the "start test" button on the test unit.

3. If the brake does not cycle through an application, or if the digital readings are not correct, either the air supply and discharge lines are crossed, or the traction control valve needs replacing.

FINAL TESTS

NOTE: Disconnect the ABS test unit. Then, depending on the type of ABS installation, do one of the following tests.

Tractor Equipped With ABS, but Without the Trailer ABS ISO Connector

1. Attach the 35-pin connector to the electronic control unit.
2. Start the engine.
3. Accelerate the vehicle. At a speed of 4 mph (6 km/h), the TRAC ABS warning light should go out.

   If the TRAC ABS warning light stays on, replace the electronic control unit and repeat this test.

Tractor Equipped With the Trailer ABS ISO Connector, but Trailer Without ABS

1. Attach the 35-pin connector to the electronic control unit.
2. Connect the 7-way trailer plug to the trailer socket at the rear of the cab. If a trailer is not

available, connect ABS test light adaptor 884 900 602 0 at the rear of the cab.

3. Apply the parking brake, then start the engine. The TRLR W/O ABS and TRAC ABS warning lights should come on.

   If the TRLR W/O ABS light does not come on after the engine is started, check the trailer plug connection, trailer brake lights, and the wiring to the trailer brake lights.

4. Release the parking brake. The TRLR W/O ABS warning light should go out.

5. Accelerate the vehicle. At a speed of about 4 mph (6 km/h), the TRAC ABS warning light should go out.

   If the TRAC ABS warning light stays on, replace the electronic control unit and repeat this test.

Tractor Equipped With the Trailer ABS ISO Connector, and Trailer Equipped With ABS

1. Attach the 35-pin connector to the electronic control unit.

2. Connect the 5-way ISO trailer cable to the connector and the 7-way cable at the rear of the cab.

3. Start the engine. The TRLR ABS and TRAC ABS lights should come on.

   If the TRLR ABS light does not come on, check the connection of the trailer plug at the rear of the cab.

4. Accelerate the vehicle. At a speed of about 4 mph (6 km/h), the TRAC ABS and TRLR ABS warning lights should go out.

   If the TRAC ABS warning light stays on, replace the electronic control unit and repeat this test.

   If the TRLR ABS light does not go out, check the trailer's ABS system.

Using the Instrument Panel Blink Codes

This system has built-in diagnostics to ensure that all components are operating properly. Under normal conditions, the tractor warning light (TRAC ABS) comes on after the engine is started. Once the vehicle moves faster than about 4 mph (6 km/h) the warning light should go out if all of the tractor's ABS components are working. If the light stays on, or comes back on later, a problem within the ABS system has occurred. The vehicle can continue to be driven, but the ABS system could be partially or completely inoperative. However, normal braking ability is maintained. To check the type of fault code recorded, stop the vehicle and turn off the engine. Then, turn on the ignition switch, but don't start the engine. If the warning light is still on, there is an "existing" system fault that must be repaired to ensure proper system operation. If the warning light is not on, an "intermittent" fault (indicating a loose connector or broken wire) has been recorded in the ECU memory.

Fault codes can be erased one at a time from the ECU memory. Erase a fault code by turning off the "ABS CHK" switch. After the WHL SPIN light stops flashing, turn off the ignition switch, then turn it back on.

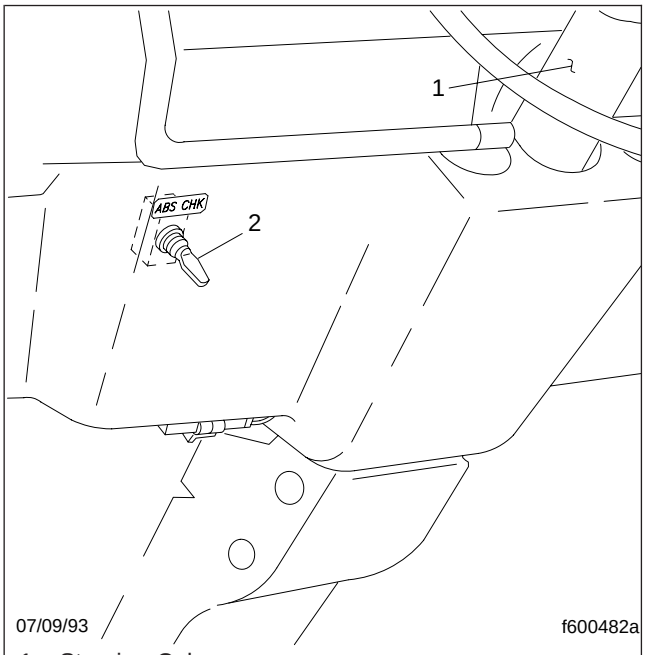
NOTE: An "existing" fault code cannot be erased from ECU memory until the fault is corrected. An "intermittent" fault can be erased from ECU memory without being repaired. However, make sure that an "intermittent" fault code is recorded because it should be repaired as soon as possible if the code occurs again.

IMPORTANT: If the vehicle is equipped with an electronic engine and automatic traction control, don't turn on the "ABS CHK" switch while driving the vehicle. Activating the switch will reduce the engine speed to idle. Always park the vehicle before using the "ABS CHK" switch to read the instrument panel blink codes.

Before troubleshooting with the instrument panel blink codes, check all fuses in the control unit panel, and replace if necessary. Check the wiring to the "ABS CHK" switch and the warning lamps. **Refer to Table 1**, and repair or replace the wiring as needed. Make sure that a charged 12-volt battery is available (the ABS system needs at least 11 volts to work).

NOTE: If troubleshooting the system with the Pro-Link 9000, use the instruction booklet that is supplied with the data cartridge.

Use the "ABS CHK" switch (**Fig. 1**) and the WHL SPIN light to display system faults. Turn on the ignition switch, then move the "ABS CHK" switch up (on position). After a five second pause, the WHL SPIN light will come on for two and one-half seconds (this is the start flash), then the diagnostic code cycle begins. After a two and one-half second pause, the three digit fault code will be displayed.



1. Steering Column
2. ABS Check Switch

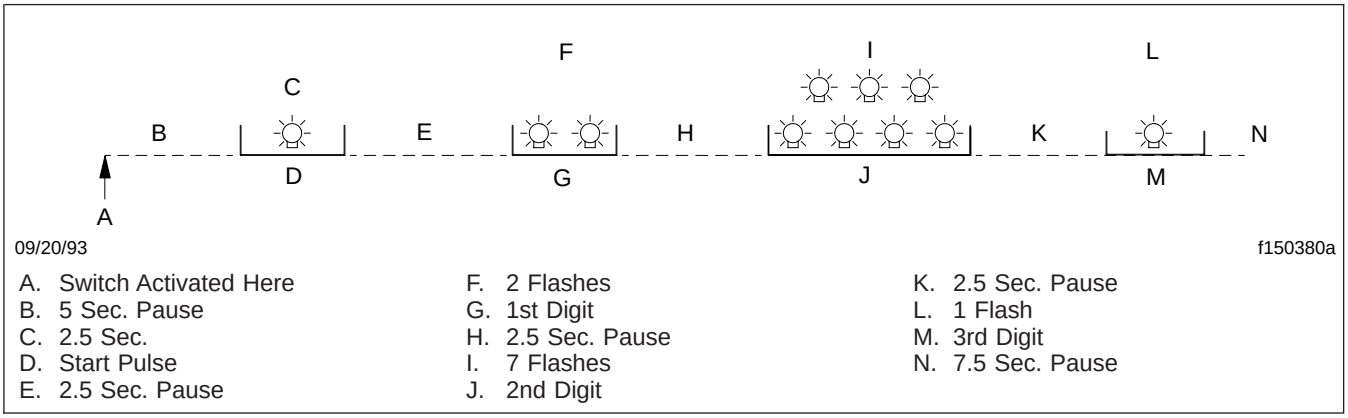
Fig. 1

IMPORTANT: The first digit of the fault code is either a 2 or a 4, depending on whether a 4S/4M system or a 6S/4M system is installed on the vehicle. On 4S/4M systems, the first digit will be a 2 (2 flashes): on 6S/6M systems, the first digit will be a 4 (4 flashes). The example described below is for a 4S/4M system.

For example (**Fig. 2**), after the start flash, fault code 271 is shown by two flashes (each lasting one-

half second and separated by a one-half second pause), a pause of two and one-half seconds, followed by seven flashes (each lasting one-half second and separated by a one-half second pause), another pause, followed by one flash for one-half second. After a seven and one-half second pause, the same fault code will continue to repeat beginning with the two and one-half second "start" flash and ending with a seven and one-half second pause.

Once a fault code has been identified, use a volt/ohmmeter to check the electrical harness at the ECU's 35-pin connector (on 4S-4M systems), or at the ECU's 55-pin connector (6S/6M systems). **See Fig. 4**. Connect the ohmmeter leads to the applicable pins on the connector. Rockwell WABCO test adaptors are also available and connect to the ECU. Adaptor 446 300 314 0 is used to test 4S/4M systems. Use adaptor 446 300 309 0 to test 6S/6M



A. Switch Activated Here
B. 5 Sec. Pause
C. 2.5 Sec.
D. Start Pulse
E. 2.5 Sec. Pause
F. 2 Flashes
G. 1st Digit
H. 2.5 Sec. Pause
I. 7 Flashes
J. 2nd Digit
K. 2.5 Sec. Pause
L. 1 Flash
M. 3rd Digit
N. 7.5 Sec. Pause

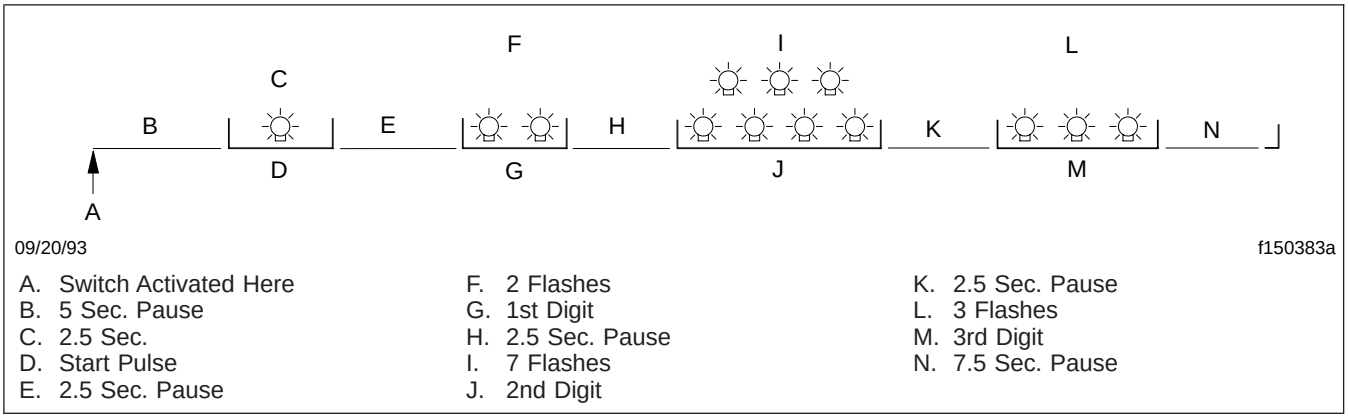
Fig. 2, 4S/4M System Fault Code

IMPORTANT: The key switch must be off when doing **the tests in Table 1.**

See Fig. 3 for another example of a fault code reading.

systems.

IMPORTANT: The ignition switch must be off when connecting or disconnecting the ECU.

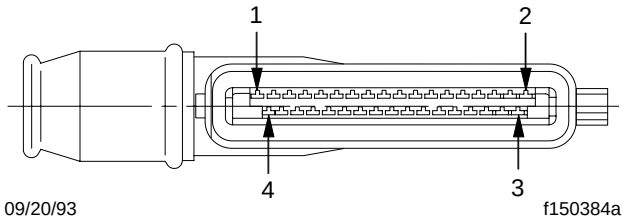


A. Switch Activated Here
B. 5 Sec. Pause
C. 2.5 Sec.
D. Start Pulse
E. 2.5 Sec. Pause
F. 2 Flashes
G. 1st Digit
H. 2.5 Sec. Pause
I. 7 Flashes
J. 2nd Digit
K. 2.5 Sec. Pause
L. 3 Flashes
M. 3rd Digit
N. 7.5 Sec. Pause

Fig. 3, 4S/4M System Fault Code

NOTE: When there are no fault codes in the ECU memory, blink code 2-0-0 (or 4-0-0) is displayed.

After attaching the adaptor (**Fig. 5**) to the ECU, insert the leads from an ohmmeter into the numbered holes on the adaptor.



1. Pin 1
2. Pin 18
3. Pin 35
4. Pin 19

Fig. 4, 35-Pin Connector on 4S/4M Systems

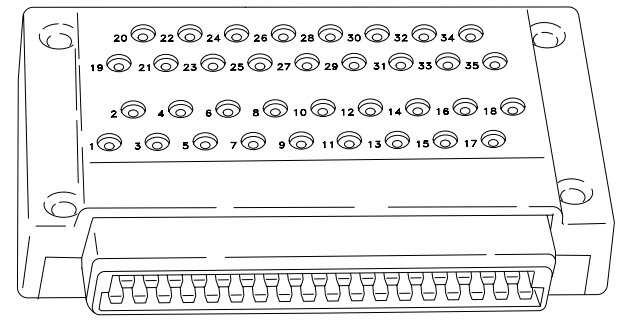


Fig. 5, Test Adaptor for 4S/4M Systems

NOTE: Regardless of the ECU model installed (B3, C1, or C2), the test adaptor 446 300 314 0 can be used to troubleshoot all 4S/4M ABS systems.

Refer to Table 2 for a listing of all fault codes, pins to be tested, and the correct volt/ohmmeter readings. Repair or replace the components and/or wiring if the readings are not correct.

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals.

Refer to the electrical section (wiring) of this manual for information on special terminals and connectors, and ordering tools for them.

Refer to the appropriate wiring diagram in Subject 400 when troubleshooting the ABS system equipped with the instrument panel blink codes. The key switch must be turned on (engine off) to activate the blink codes. However, if using the test adaptors, the key switch must be off, unless otherwise noted.

If a blink code is displayed that is not in **Table 2**, try to erase the code from ECU memory. If a fault can't be repaired, or erased from ECU memory, test the operation of the solenoid control valves and the traction control valves. For instructions, **refer to Table 3**. If a fault still can't be repaired, or erased from ECU memory, contact your Rockwell District Service Manager.

If necessary, start the engine and build system air pressure to at least 100 psi (689 kPa). Shut down the engine, but leave the ignition switch on.

⚠ CAUTION

CAUTION: When doing the tests in Table 3, don't leave the positive volt/ohmmeter test lead connected to pin 9 for more than 10 seconds. Momentarily touch the positive test lead to pin 9 only when you are ready to observe the reading. Leaving the test lead connected to pin 9 for more than 10 seconds could damage the solenoid or traction control valve, or the volt/ ohmmeter.

When testing the solenoid control valves or the traction control valves in **Table 3**, always connect the *positive* volt/ohmmeter test lead to pin 9. Connect the *negative* test lead to the other pin referenced in **Table 3**. Set the volt/ohmmeter to 10 amps.

NOTE: If a 10-amp capacity meter is not available, a jumper wire can be used.

IMPORTANT: The key switch must be on when doing the tests in **Table 3**.

Wiring Tested	Test These Pins	Volt/Ohmmeter Reading	Possible Cause	Remedy
Tractor Warning (TRAC ABS) Light	9 and 26	2 to 50 ohms (depends on bulb wattage)	Wiring light is shorted or open; or the bulb needs replacing.	Repair the wiring, or replace the bulb.

Troubleshooting

Wiring Tested	Test These Pins	Volt/Ohmmeter Reading	Possible Cause	Remedy
Blink Code (Whl Spin) Light	3 and 9	2 to 50 ohms (depends on bulb wattage)	Wiring light is shorted or open; or the bulb needs replacing.	Repair the wiring, or replace the bulb.
ABS CHK Switch	14 and 27 (also, turn the ABS CHK switch on).	0 to 2 ohms	Wiring light is shorted or open; or the switch needs replacing.	Repair the wiring, or replace the switch.

Table 1

WABCO ABS Fault Codes/ Tests Key Switch On to Determine Fault Code Fault Code	Key Switch Off to Test System	Problem	Test These Pins	Volt/Ohmmeter Reading	Remedy
2-0-0 or 4-0-0		No faults.	—	—	—
2-6-6 or 4-6-6 (VR1)	2-6-7 or 4-6-7 (VR2)	Battery voltage to the relay is low, or the relay is not working properly.	+1 and -27 (VR1) * +19 and -27 (VR2) *	0.0 volt	Problem found with key switch on. Repair or replace as needed.
2-6-8 or 4-6-8 Right Front (RF)	2-6-9 or 4-6-9 Left Front (LF)	Wheel speed signal is erratic.	15 and 32 (LF) † 17 and 34 (RF †	Above 0.2 volt AC	A damaged tone wheel, a sensor needs adjustment, or there is excessive hub runout. Repair or replace as needed.
2-6-10 or 4-6-10 Right Front (RF)	2-6-11 or 4-6-11 Left Front (LF)	Sensor circuit damage.	15 and 27 (LF)	Above 30.0 kilo ohms	On the steer axle, there is damage to the wheel sensor and/or sensor wiring to the ECU. Repair or replace as needed.
			15 and 32 (LF)	1.0 to 1.99 kilo ohms	
			17 and 27 (RF	Above 30.0 kilo ohms	
			17 and 34 (RF)	1.0 to 1.99 kilo ohms	
2-6-12 or 4-6-12 Right Front (RF)	2-6-13 or 4-6-13 Left Front (LF)	Sensor out of adjustment.	15 and 32 (LF) † 17 and 34 (RF) †	Above 0.2 volt AC	On the steer axle, adjust the wheel sensor.

WABCO ABS Fault Codes/ Tests					
Key Switch On to Determine Fault Code	**Key Switch Off to Test System**				
Fault Code	**Problem**	**Test These Pins**	**Volt/Ohmmeter Reading**	**Remedy**	
2-7-0 Left Rear (LR) 4-7-8 Left Rear-most (LRM)	2-7-1 Right Rear (RR) 4-7-9 Right Rear-Most (RRM)	Wheel speed signal is erratic.	18 and 35 (LR) † 16 and 33 (RR) † 53 and 54 (LRM) † 51and 52 (RRM) †	Above 0.2 volt AC	On the rear axle, a damaged tone wheel, a sensor needs adjustment, or there is excessive hub runout. Repair or replace as needed.
2-7-2 Left Rear (LR)	2-7-3 Right Rear (RR)	Sensor circuit damage.	18 and 27 (LR)	Above 30.0 kilo ohms	On the rear axle, damage to the wheel sensor and/or sensor wiring to the ECU. Repair or replace as needed.
			18 and 35 (LR)	1.0 to 1.99 kilo ohms	
			16 and 27 (RR)	Above 30.0 kilo ohms	
			16 and 33 (RR)	1.0 to 1.99 kilo ohms	
4-7-10 Left Rear-most (LRM)	4-7-11 Right Rear-most (RRM)		27 and 53 (LRM)	Above 30.0 kilo ohms	
			53 and 54 (LRM)	1.0 to 1.99 kilo ohms	
			27and 51 (RRM)	Above 30.0 kilo ohms	
			51and 52 (RRM)	1.0 to 1.99 kilo ohms	
2-7-4 Left Rear (LR) 4-7-12 Left Rear-most (LRM)	2-7-5 Right Rear (RR) 4-7-13 Right Rear-most (RRM)	Sensor out of adjustment.	18 and 35 (LR) † 16 and 33 (RR) † 53 and 54 (LRM) † 51 and 52 (RRM) †	Above 0.2 volt AC	On the rear axle, adjust the wheel sensor.
2-8-3 2-8-5 or 4-8-3 4-8-5	2-8-7 2-8-9 or 4-8-7 4-8-9	J1922 electronic engine data link in not working properly.	Idle the engine at about 1500 rpm. Short 14 to 27, or turn on the ABS CHK switch. The rpm should decrease.		Damage to the data link and/or data link wiring connections. Repair or replace as needed.

Troubleshooting

WABCO ABS Fault Codes/ Tests					
Key Switch On to Determine Fault Code	Key Switch Off to Test System				
Fault Code	Problem	Test These Pins	Volt/Ohmmeter Reading	Remedy	
2-8-10 or 4-8-10 Right Front (RF)	2-8-11 or 4-8-11 Left Front (LF)	On the steer axle, there is a short circuit in the ABS solenoid control valve to ground connection.	23 and 27 (LF) 24 and 27 (LF) 6 and 27 (RF) 7 and 27 (RF)	4 to 8 ohms	Check the ABS solenoid valve and cab wiring connections. Repair or replace as needed.
2-8-12 or 4-8-12 Right Front (RF)	2-8-13 or 4-8-13 Left Front (LF)	On the steer axle, there is an open circuit in the ABS solenoid control valve and/or wiring to the ground connection.			
2-8-14 or 4-8-14 Right Front (RF)	2-8-15 or 4-8-15 Left Front (LF)	On the steer axle, there is a short circuit in the ABS solenoid control valve and/or wiring to the ground connection.			
2-9-0 or 4-9-0 Right Front (RF)	2-9-1 or 4-9-1 Left Front (LF)	On the steer axle, there is an open circuit in the ABS solenoid control valve and/or wiring.			
2-9-2 or 4-9-2 Left Rear (LR)	2-9-3 or 4-9-3 Right Rear (RR)	On the rear axle, there is a short circuit in the ABS solenoid control valve and/or wiring to the ground connection.	21 and 27 (LR) 22 and 27 (LR) 4 and 27 (RR) 5 and 27 (RR)	4 to 8 ohms	Check the ABS solenoid valve and cab wiring connections. Repair or replace as needed.
2-9-4 or 4-9-4 Left Rear (LR)	2-9-5 or 4-9-5 Right Rear (RR)	On the rear axle, there is an open circuit in the ABS solenoid control valve and/or wiring.			
2-9-6 or 4-9-6 Left Rear (LR)	2-9-7 or 4-9-7 Right Rear (RR)	On the rear axle, there is a short circuit in the ABS solenoid control valve and/or wiring to the ground connection.			

WABCO ABS Fault Codes/ Tests					
Key Switch On to Determine Fault Code	**Key Switch Off to Test System**				
Fault Code	**Problem**	**Test These Pins**	**Volt/Ohmmeter Reading**	**Remedy**	
2-9-8 Left Rear (LR) 4-10-0 Left Rear-most (LRM)	2-9-9 Right Rear (RR) 4-10-1 Right Rear-most (RRM)	On the rear axle, there is an open circuit in the ABS solenoid control valve and/or wiring.	21 and 27 (LR) 22 and 27 (LR) 4 and 27 (RR) 5 and 27 (RR)	4 to 8 ohms	Check the ABS solenoid valve and cab wiring connections. Repair or replace as needed.
2-10-2 Left Rear (LR) or 4-10-2 Left Rear-most (LRM)	2-10-3 Right Rear (RR) or 4-10-3 Right Rear-most (RRM)	Short circuit in the traction control valve and/or wiring to the ground connection.	2 and 27 (LR) 20 and 27 (RR)	8 to 14 ohms	Check the traction control valve and cab wiring connections. Repair or replace as needed.
2-10-4 Left Rear (LR) or 4-10-4 Left Rear-most (LRM)	2-10-5 Right Rear (RR) 4-10-3 Right Rear-most (RRM)	Open circuit in the traction control valve and/or wiring.			
2-10-7 or 4-10-7		Short circuit in the wiring or the relay that controls the engine brake.	With key switch on, short 11 to 27 and 9 to 19 at the same time. The relay contacts should open, disabling the engine brake.		Check the engine brake relay and wiring. Repair or replace as needed.

Troubleshooting

WABCO ABS Fault Codes/ Tests					
Key Switch On to Determine Fault Code	Key Switch Off to Test System				
Fault Code	Problem	Test These Pins	Volt/Ohmmeter Reading	Remedy	
2-10-8 Left Rear (LR) or 4-10-8 Left Rear-most (LRM)	2-10-9 Right Rear (RR) or 4-10-8 Left Rear-most (LRM)	Excessive wheel spin caused by driver or dynamometer. Erase the fault.	—	—	—
2-11-12 or 4-11-12 Right Front (RF)	2-11-13 or 4-11-13 Left Front (LF)	On the steer axle, there is a short circuit in the ABS solenoid control valve and/or wiring to the power supply connection.	23 and 27 (LF) 24 and 27 (LF) 6 and 27 (RF) 7 and 27 (RF)	4 to 8 ohms	Check the ABS solenoid valve, wiring, and cab wiring connections. Repair or replace as needed.
2-11-14 Left Rear (LR) 4-12-0 Left Rear-most (LRM)	2-11-15 Right Rear (RR) 4-12-1 Left Rear-most (LRM)	On the rear axle, there is a short circuit in the ABS solenoid control valve and/or wiring to the power supply connection.	21 and 27 (LR) 22 and 27 (LR) 4 and 27 (RR) 5 and 27 (RR)		
2-12-2 or 4-12-2 Left Rear (LR)	2-12-3 or 4-12-3 Right Rear (RR)	Short circuit in the traction control valve and/or wiring to the power supply connection.	2 and 27 (LR) 20 and 27 (RR)	8 to 14 ohms	
2-12-7 or 4-12-7		Short circuit in the engine brake relay and/or wiring to the ground connection.	—	—	Check the engine brake relay and wiring. Repair or replace as needed.

WABCO ABS Fault Codes/ Tests					
Key Switch On to Determine Fault Code	**Key Switch Off to Test System**				
Fault Code	**Problem**	**Test These Pins**	**Volt/Ohmmeter Reading**	**Remedy**	
2-12-8 or 4-12-8 Right Front (RF)	2-12-9 or 4-12-9 Left Front (LF)	On the steer axle, there is a short circuit in the ABS solenoid control valve and/or wiring to the battery.	23 and 27 (LF) 24 and 27 (LF) 6 and 27 (RF) 7 and 27 (RF)	4 to 8 ohms	Check the ABS solenoid valve, wiring, and cab wiring connections. Repair or replace as needed.
2-12-10 Left Rear (LR) 4-12-12 Left Rear-most (LRM)	2-12-11 Right Rear (RR) 4-12-13 Right Rear-most (RRM)	On the rear axle, there is a short circuit in the ABS solenoid control valve and/or wiring to the battery.	21 and 27 (LR) 22 and 27 (LR) 4 and 27 (RR) 5 and 27 (RR)		
2-12-14 or 4-12-14Left Rear (LR)	2-12-15 or 4-12-15 Right Rear (RR)	Short circuit in the traction control valve and/or wiring to the battery.	2 and 27 (LR) 20 and 27 (RR)	8 to 14 ohms	
2-13-4 or 4-13-4 (VR1)	2-13-5 or 4-13-5 (VR2)	The valve relay is not operating properly.	(VR1) - With the key on, short 8 to 27. Vehicle voltage should read 11.0 to 15.4 volts DC between pins 1 and 27.		Replace the valve relay.
2-13-8 or 4-13-8 (VR1)	2-13-9 or 4-13-9 (VR2)	Vehicle power supply is too high.	(VR2) - With the key on, short 25 to 27. Vehicle voltage should read 11.0 to 15.4 volts DC between pins 19 and 27.		Check the vehicle power supply system. Repair as needed.

* Connect the positive volt/ohmmeter test lead to pins 1 and 19. Connect the negative test lead to pin 27.
† After connecting the volt/ohmmeter test leads, rotate the applicable tire at about 30 rpm (1 revolution every 2 seconds).

Table 2

Troubleshooting

Valve Tested	What to Do	Desired Result	Problem	Remedy
Left Front Solenoid Control Valve	Depress the brake pedal; connect pins 9 and 24. Release the brake pedal;	Left front brake chamber exhausts.	The electrical lines of the two control valves are crossed; the air supply and discharge lines are crossed; the electrical connector at the valve is not correctly plugged in; or, the control valve needs replacing.	Repair or replace as needed.
	Connect pins 9 and 23; depress the brake pedal.	No pressure build up in left front brake chamber.		
Right Front Solenoid Control Valve	Depress the brake pedal; connect pins 9 and 7. Release the brake pedal;	Right front brake chamber exhausts.		
	Connect pins 9 and 6; depress the brake pedal.	No pressure build up in right front brake chamber.		
Left Rear Solenoid Control Valve	Depress the brake pedal; connect pins 9 and 22. Release the brake pedal;	Left rear brake chamber(s) exhausts.		
	Connect pins 9 and 21; depress the brake pedal.	No pressure build up in left rear brake chamber(s).		
Right Rear Solenoid Control Valve	Depress the brake pedal; connect pins 9 and 5. Release the brake pedal;	Right rear brake chamber(s) exhausts.		
	Connect pins 9 and 4; depress the brake pedal.	No pressure build up in right rear brake chamber(s).		
Left Rear Traction Control Valve	Connect pins 9 and 2.	Pressure build up in left rear brake chamber(s).	The air supply and discharge lines are crossed; or, the air supply and discharge lines are blocked.	
Right Rear Traction Control Valve	Connect pins 9 and 20.	Pressure build up in right rear brake chamber(s).		

Table 3

See **Fig. 1** for a full view of the wiring diagram for troubleshooting ABS Systems using a test unit and adaptor. See **Fig. 2**, **Fig. 3**, **Fig. 4**, or **Fig. 5** for partial (detailed) views of the wiring diagram for troubleshooting ABS Systems using a test unit and adaptor.

See **Fig. 6** for a full view of the wiring diagram for troubleshooting 4S/4M ABS Systems using instrument panel blink codes (Effective 12/91 through 6/92). See **Fig. 7**, **Fig. 8**, **Fig. 9**, or **Fig. 10** for partial (detailed) views of the wiring diagram for troubleshooting 4S/4M ABS Systems using instrument panel blink codes (Effective 12/91 through 6/92).

See **Fig. 11** for the wiring diagram for troubleshooting 4S/4M ABS Systems using instrument panel blink codes (Effective 7/92). See **Fig. 12**, **Fig. 13**, **Fig. 14**, or **Fig. 15** for partial (detailed) views of the wiring diagram for troubleshooting 4S/4M ABS Systems using instrument panel blink codes (Effective 7/92).

See **Fig. 16** for the wiring diagram for troubleshooting 6S/4M ABS Systems using instrument panel blink codes (Effective 5/93). See **Fig. 17**, **Fig. 18**, **Fig. 19**, or **Fig. 20** for partial (detailed) views of the wiring diagram for troubleshooting 6S/4M ABS Systems using instrument panel blink codes (Effective 5/93).

Specifications

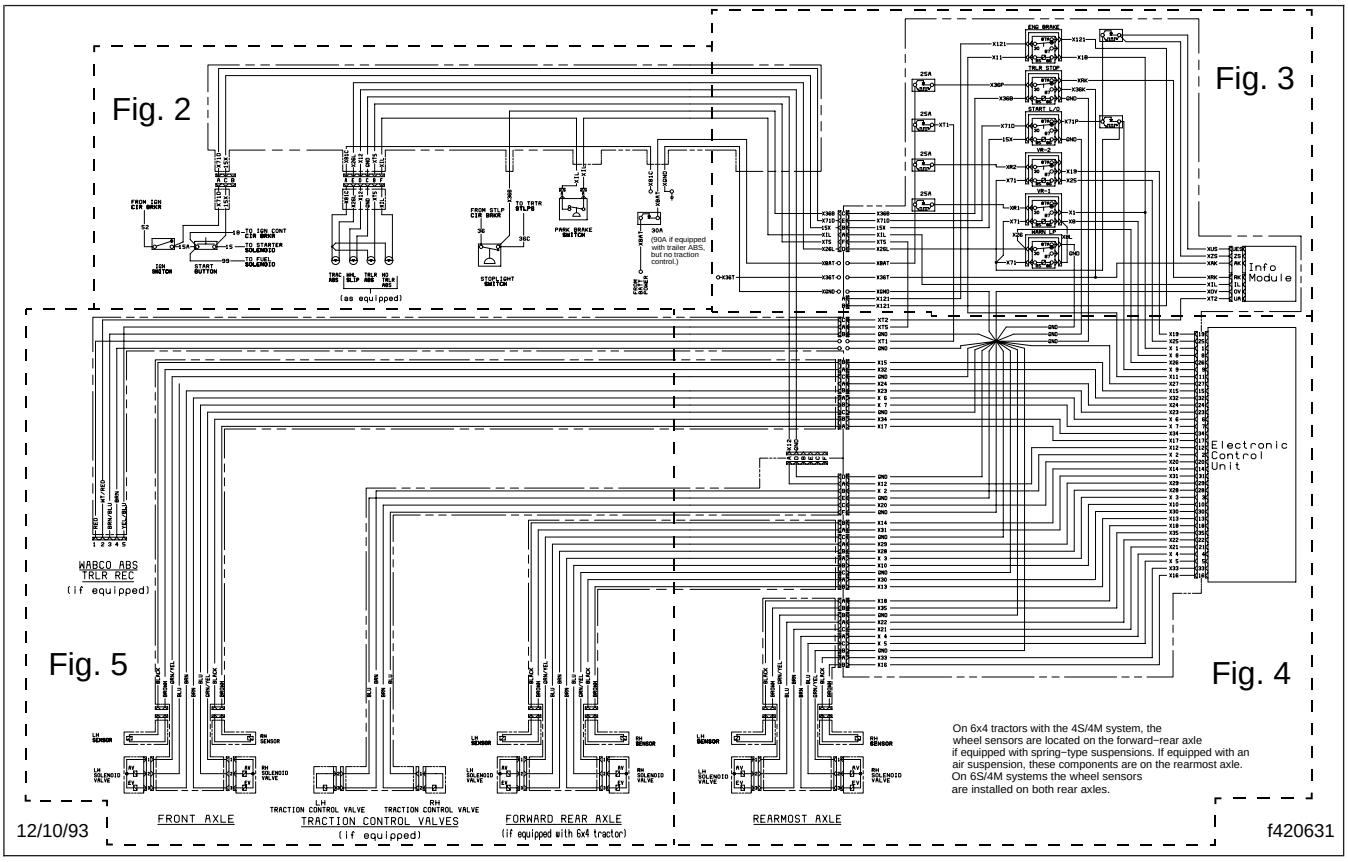


Fig. 1, Wiring Diagram for Troubleshooting ABS Systems Using a Test Unit and Adaptor

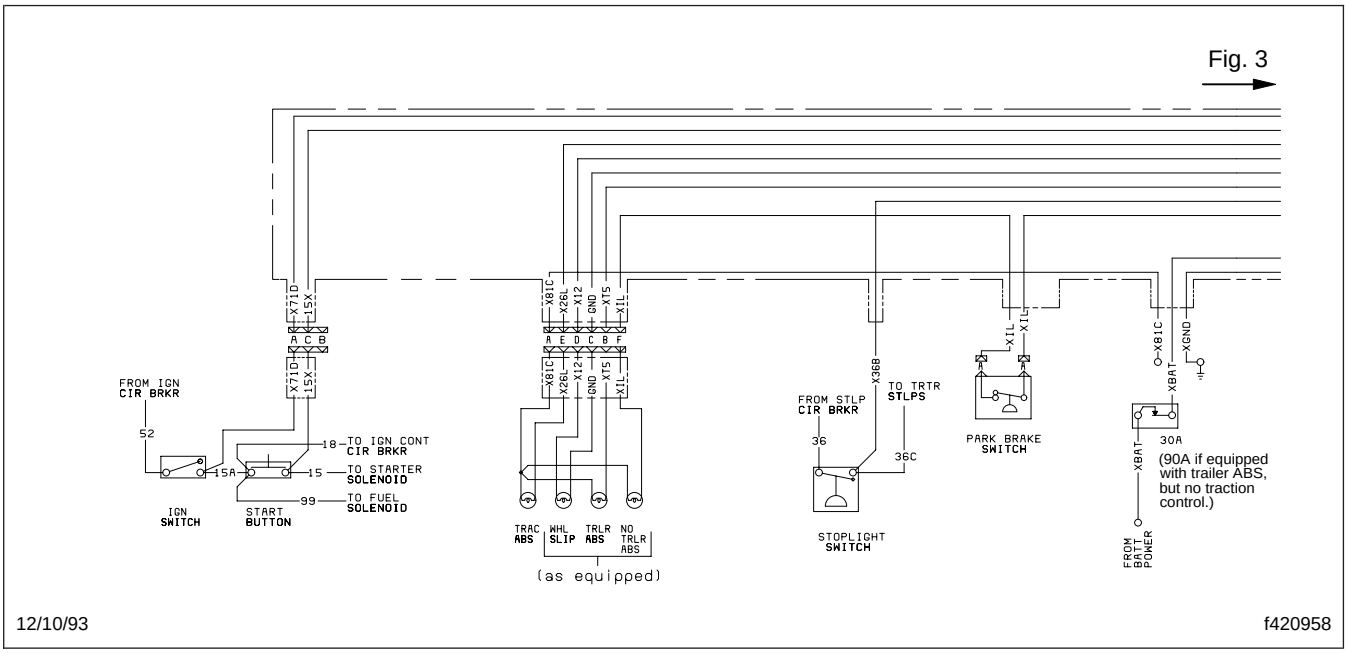


Fig. 3
FROM IGN CIR BRKR
52
15A
IGN SWITCH
START BUTTON
18 TO IGN CONT CIR BRKR
15 TO STARTER SOLENOID
99 TO FUEL SOLENOID
X71D
15X
X81C
X26L
X12
GND
X7S
X1L
TRAC ABS
WHL SLIP
TRLR ABS
NO TRLR ABS
(as equipped)
FROM STLP CIR BRKR
36
36C
STOPLIGHT SWITCH
X36B
TO TRTR STLPS
PARK BRAKE SWITCH
X1L
X1L
X81C
XGND
XBAT
30A
(90A if equipped with trailer ABS, but no traction control.)
FROM BATT POWER
12/10/93
f420958

Fig. 2

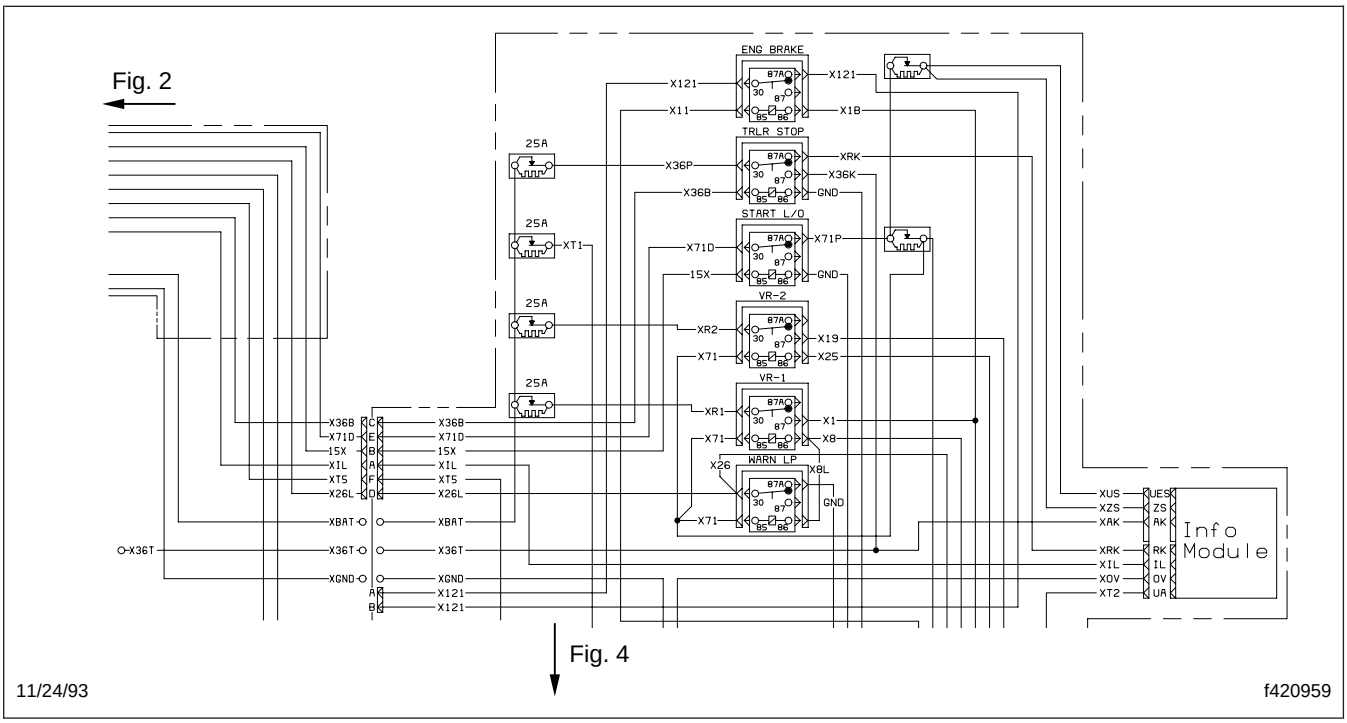


Fig. 2
ENG BRAKE
TRLR STOP
START L/O
VR-2
VR-1
WARN LP
X121
X11
X1B
X36P
XRK
X36K
GND
X71D
X71P
15X
XR2
X19
X25
X71
XR1
X1
X8
X26
X8L
25A
XT1
X36B
X71D
15X
XIL
XT5
X26L
XBAT
X36T
XGND
X121
Info Module
XUS
XZS
XAK
XRK
XIL
XOV
XT2
Fig. 4
11/24/93
f420959

Fig. 3

Specifications

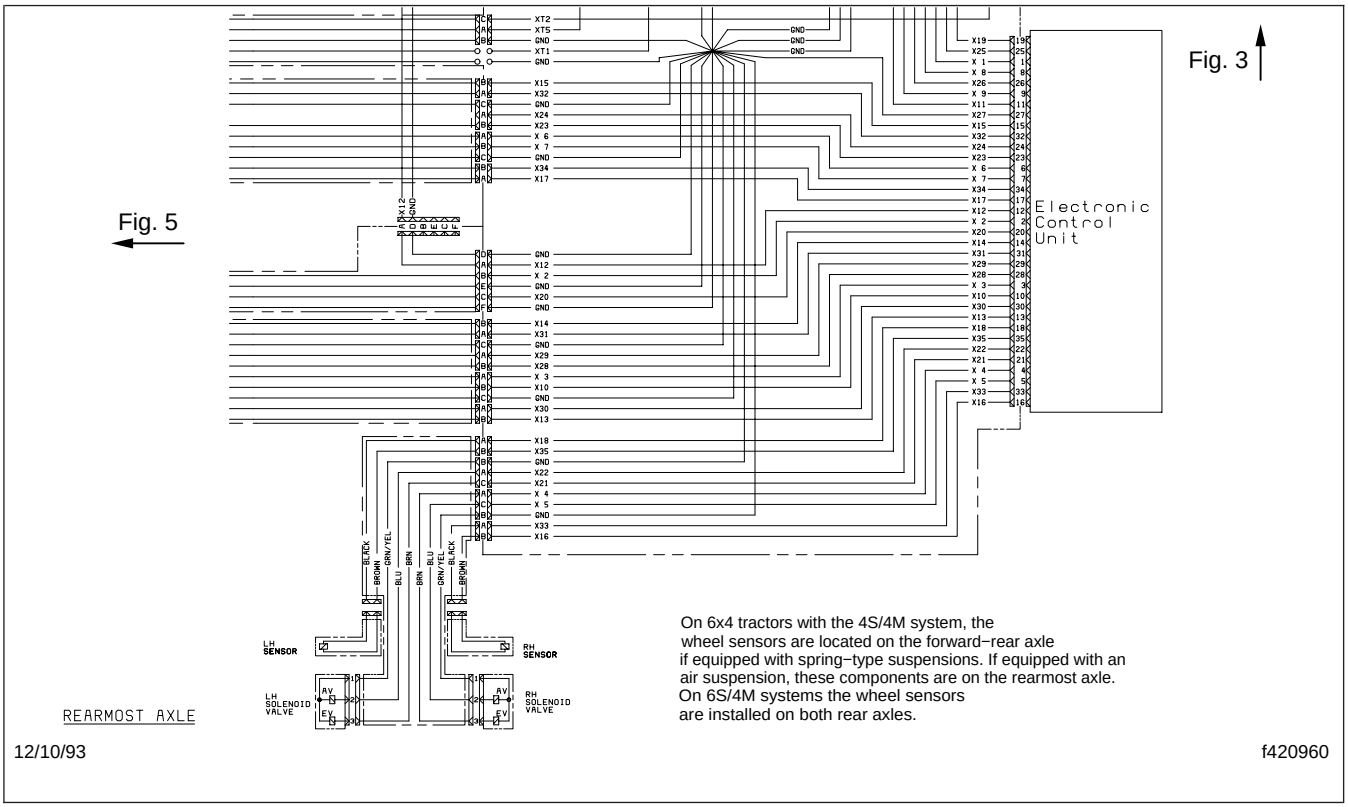


Fig. 4

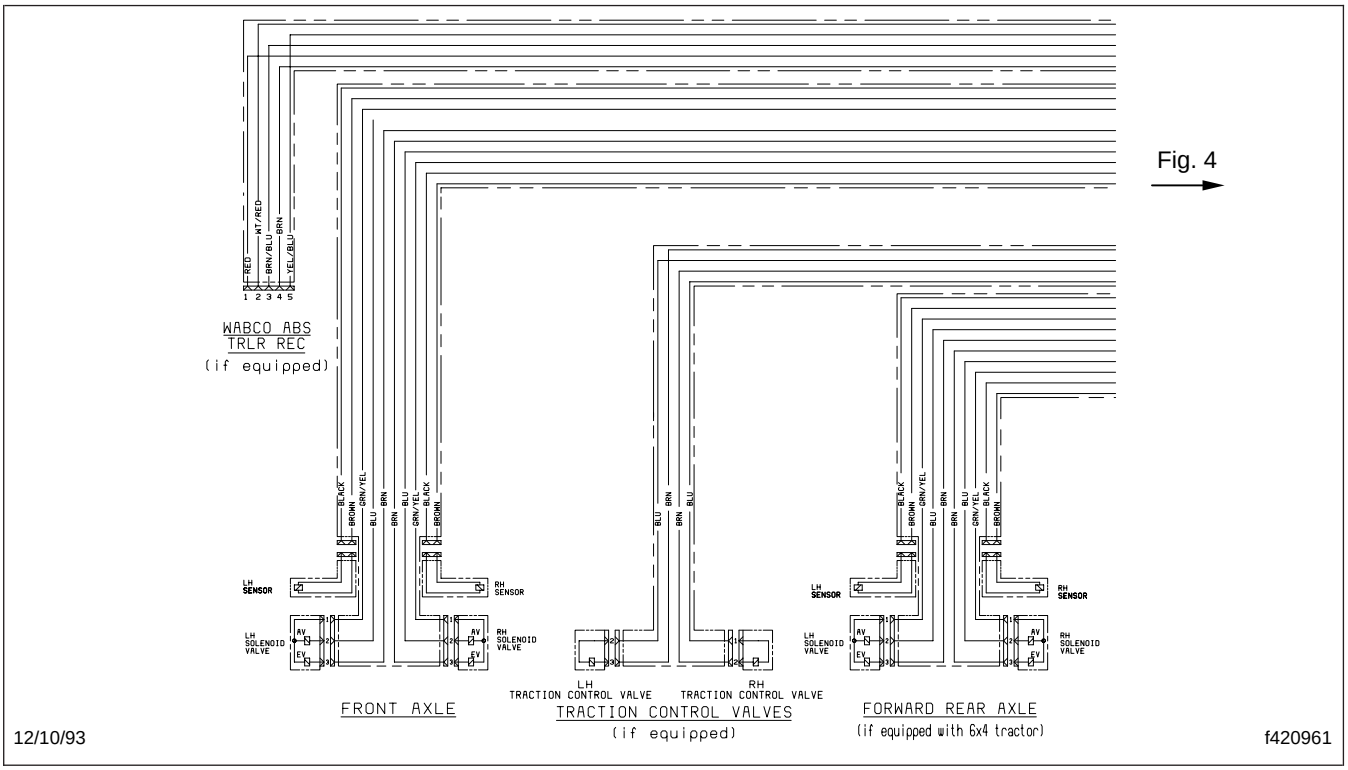


Fig. 4
RED
WT/RED
BRN/BLU
BRN
YEL/BLU
1 2 3 4 5
WABCO ABS
TRLR REC
(if equipped)
BLACK
BROWN
GRN/YEL
BLU
BRN
LH SENSOR
RH SENSOR
LH SOLENOID VALVE
RH SOLENOID VALVE
AV
EV
FRONT AXLE
LH TRACTION CONTROL VALVE
RH TRACTION CONTROL VALVE
TRACTION CONTROL VALVES
(if equipped)
FORWARD REAR AXLE
(if equipped with 6x4 tractor)
12/10/93
f420961

Fig. 5

Specifications

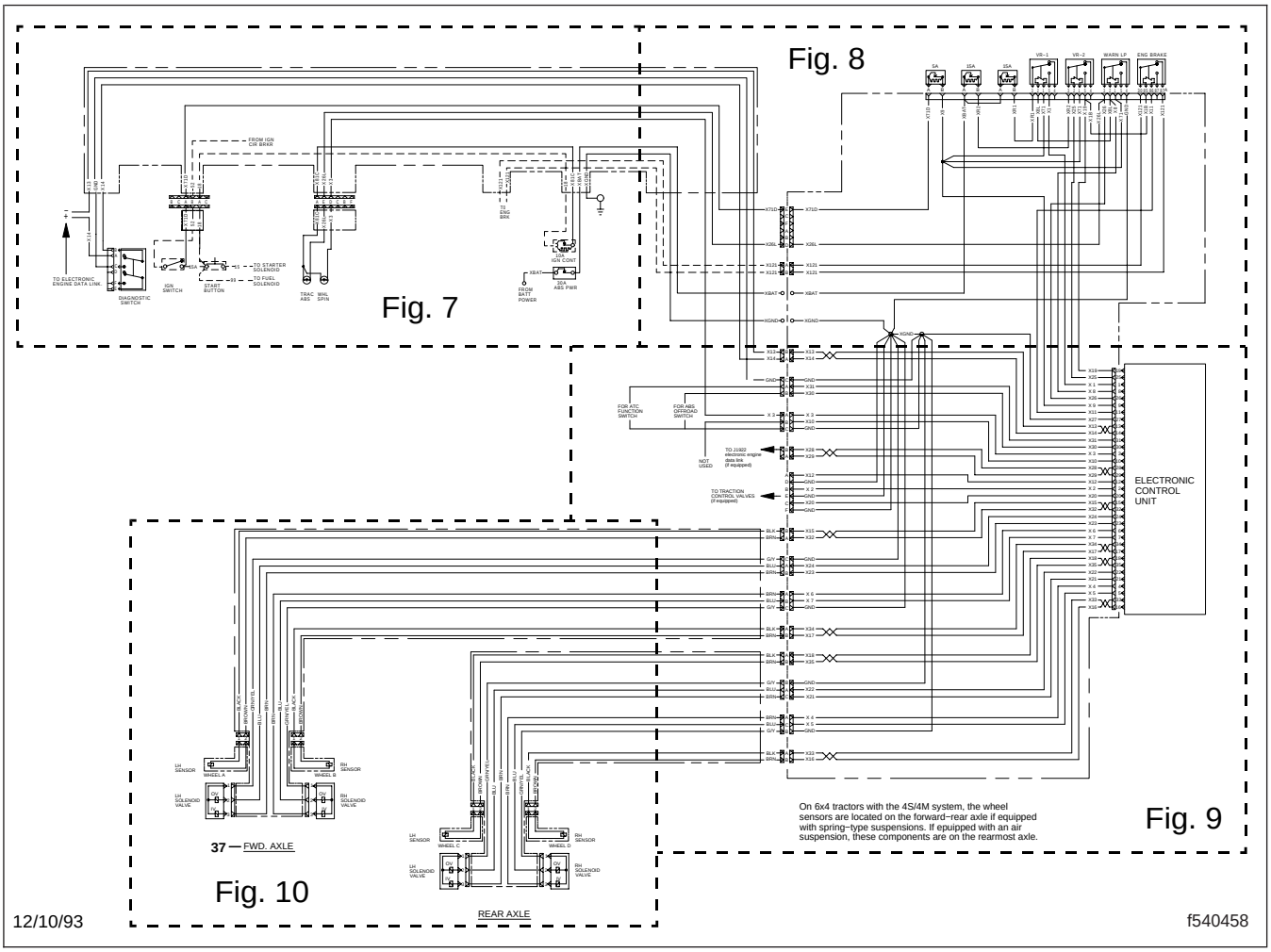


Fig. 6, Wiring Diagram for Troubleshooting 4S/4M ABS Systems Using Instrument Panel Blink Codes (Effective 12/91 through 6/92)

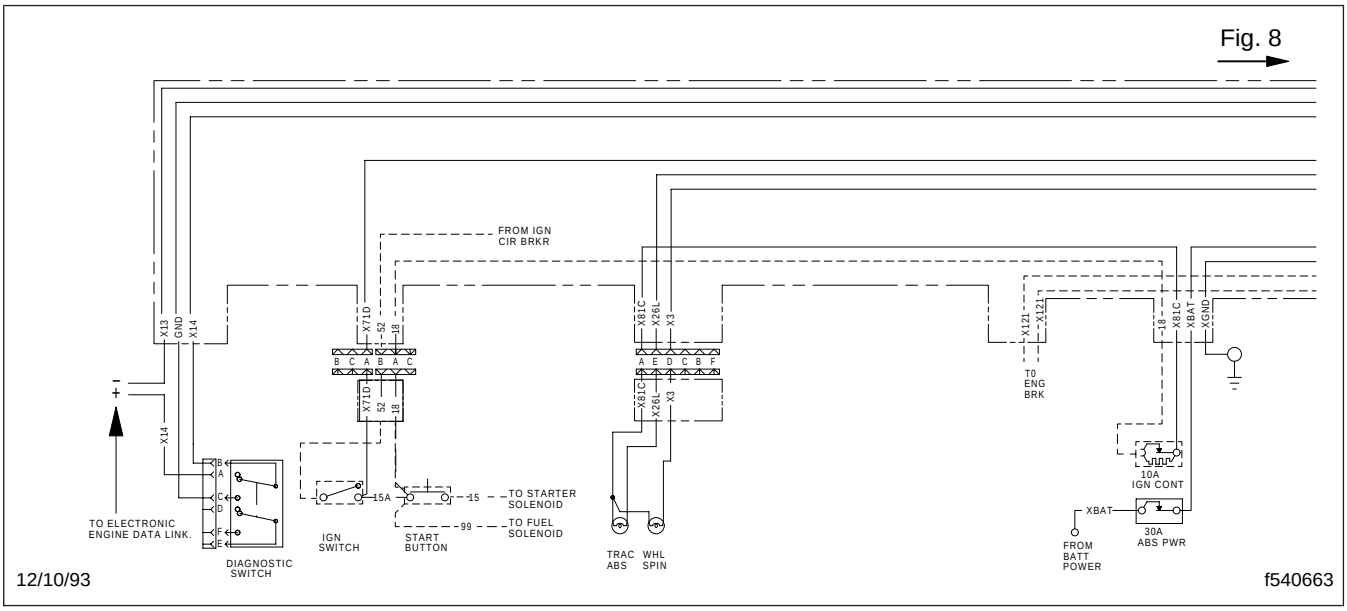


Fig. 8
FROM IGN CIR BRKR
X13
GND
X14
X71D
52
18
X81C
X26L
X3
X121
X121
18
X81C
XBAT
XGND
T0 ENG BRK
10A IGN CONT
XBAT
30A ABS PWR
FROM BATT POWER
TO ELECTRONIC ENGINE DATA LINK.
DIAGNOSTIC SWITCH
IGN SWITCH
15A
15
TO STARTER SOLENOID
99
TO FUEL SOLENOID
START BUTTON
TRAC ABS
WHL SPIN
12/10/93
f540663

Fig. 7

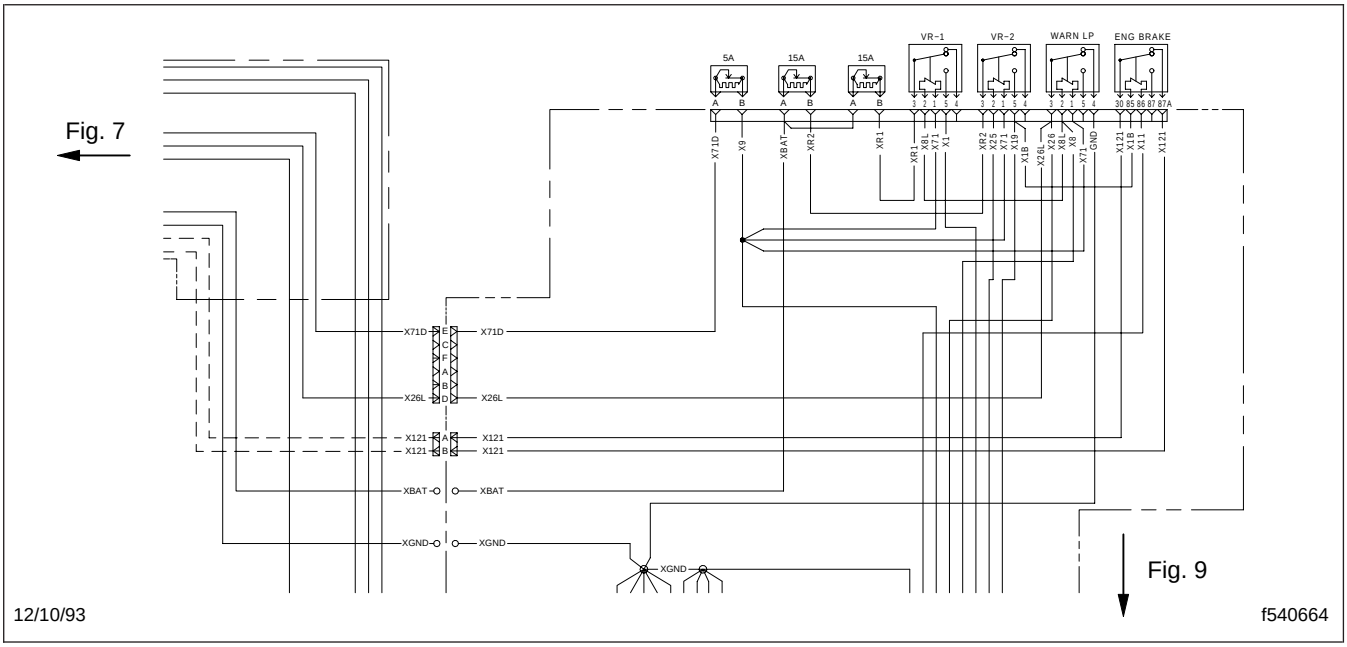
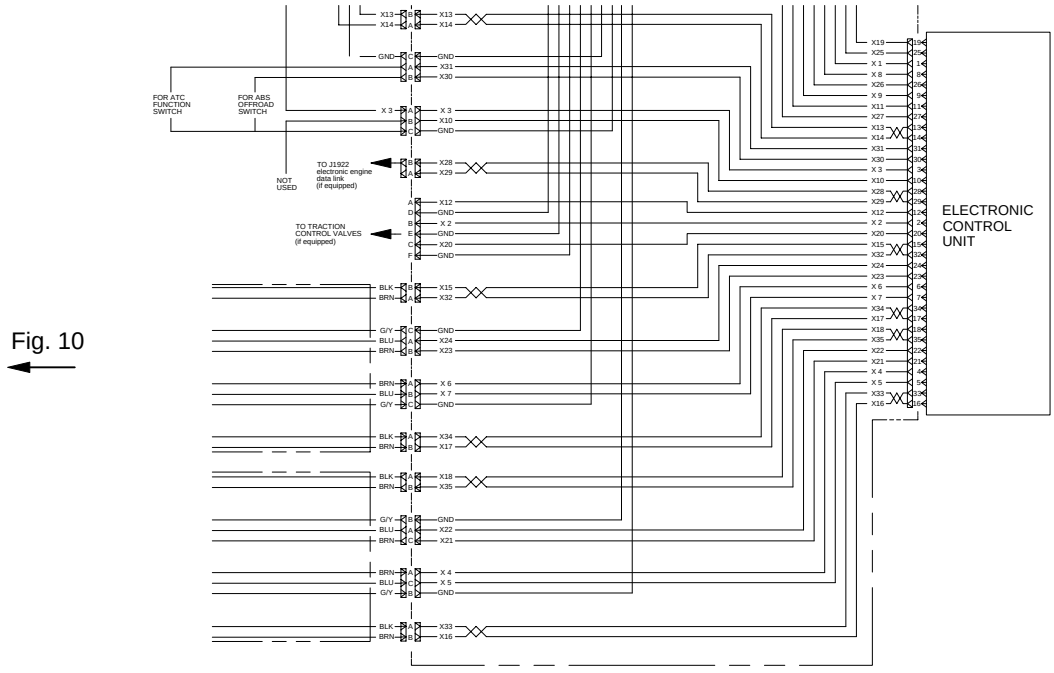


Fig. 7
5A
15A
15A
VR-1
VR-2
WARN LP
ENG BRAKE
X71D
X9
XBAT
XR2
XR1
XR1
X8L
X71
X1
XR2
X25
X71
X18
X26L
X26
X8L
X8
X71
GND
X121
X18
X11
X121
X71D
X71D
X26L
X26L
X121
X121
X121
X121
XBAT
XBAT
XGND
XGND
XGND
Fig. 9
12/10/93
f540664

Fig. 8

Specifications



On 6x4 tractors with the 4S/4M system, the wheel sensors are located on the forward−rear axle if equipped with spring−type suspensions. If epuipped with an air suspension, these components are on the rearmost axle.

12/10/93 f540665

Fig. 9

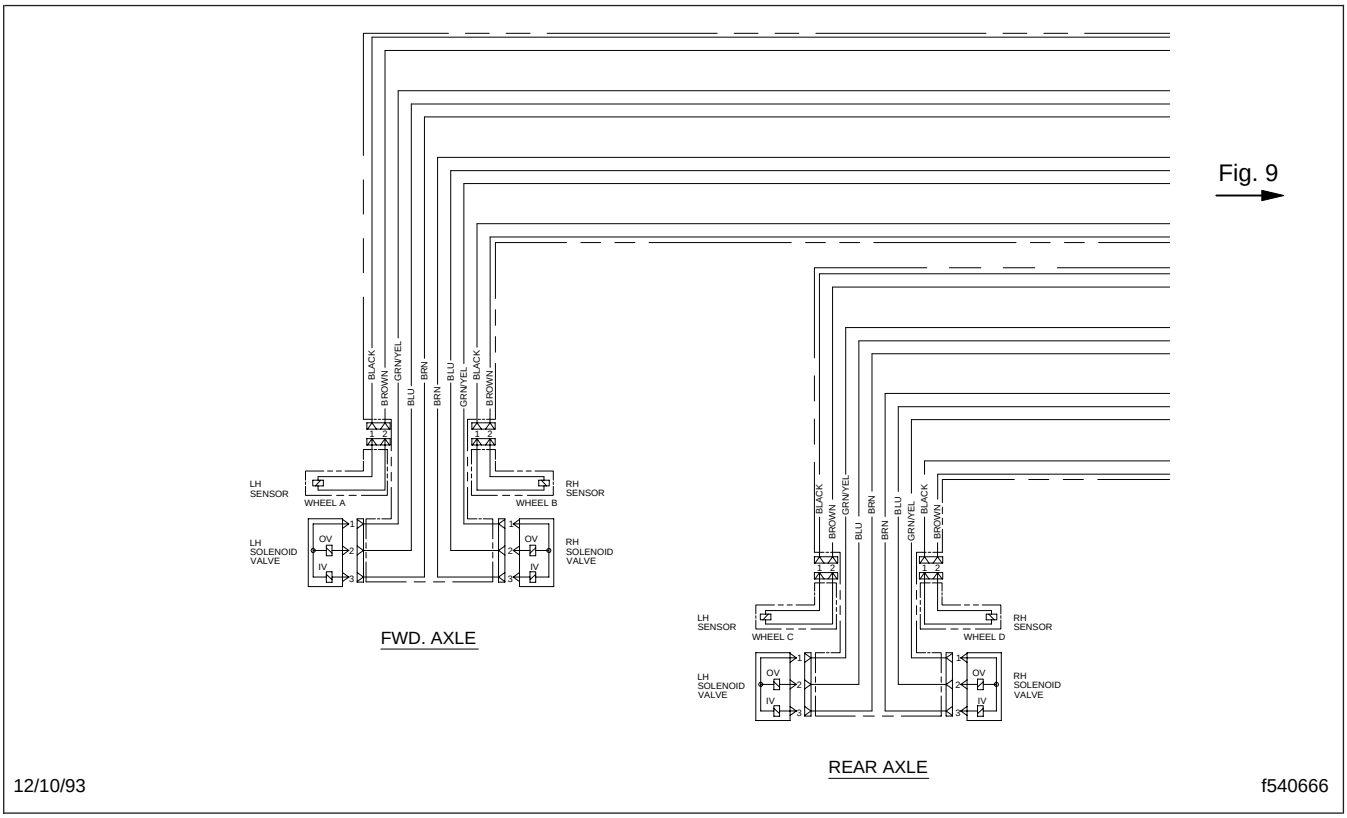


Fig. 9
BLACK
BROWN
GRN/YEL
BLU
BRN
LH SENSOR
WHEEL A
WHEEL B
RH SENSOR
LH SOLENOID VALVE
RH SOLENOID VALVE
OV
IV
FWD. AXLE
WHEEL C
WHEEL D
REAR AXLE
12/10/93
f540666

Fig. 10

Specifications

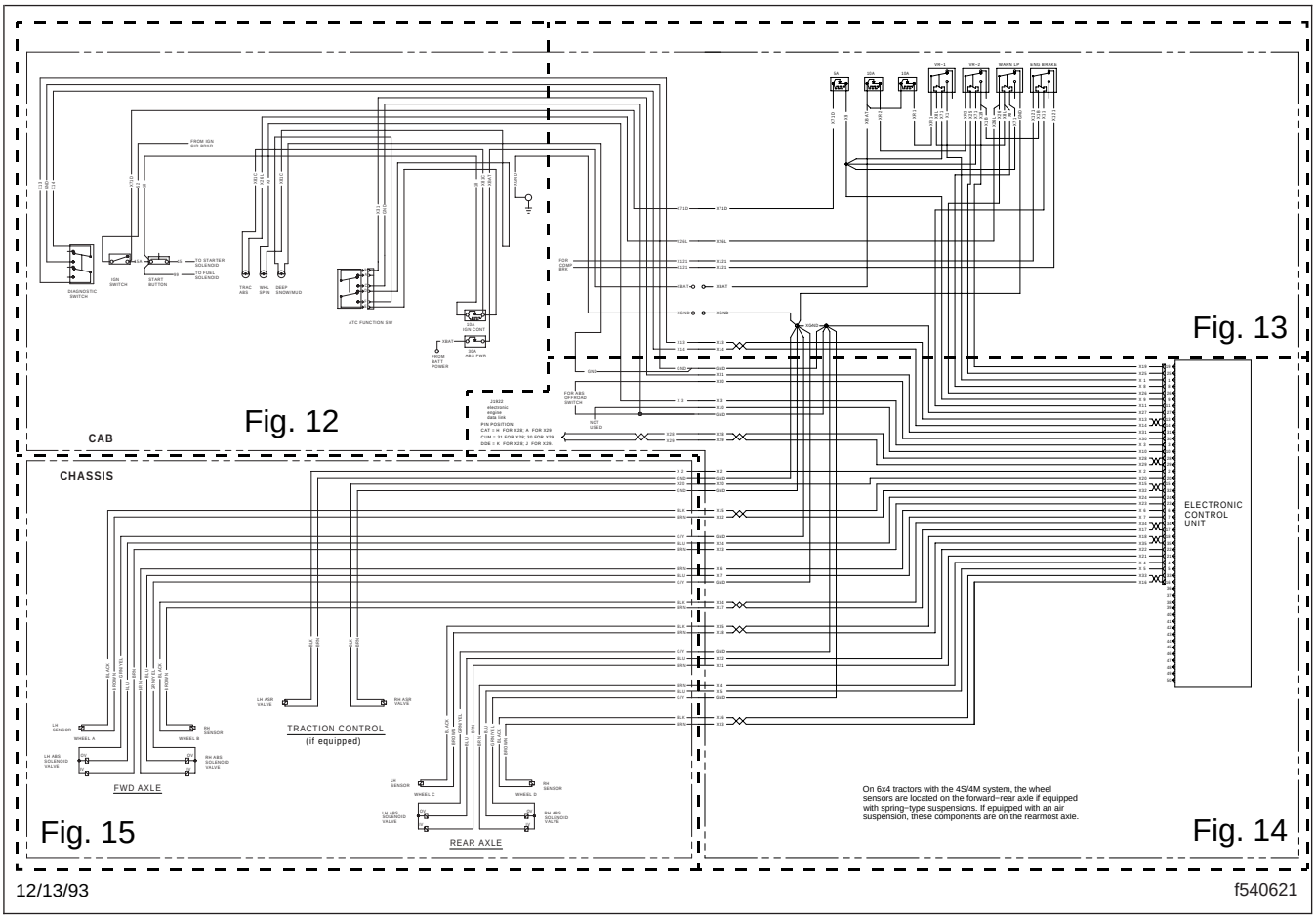


Fig. 11, Wiring Diagram for Troubleshooting 4S/4M ABS Systems Using Instrument Panel Blink Codes (Effective 7/92)

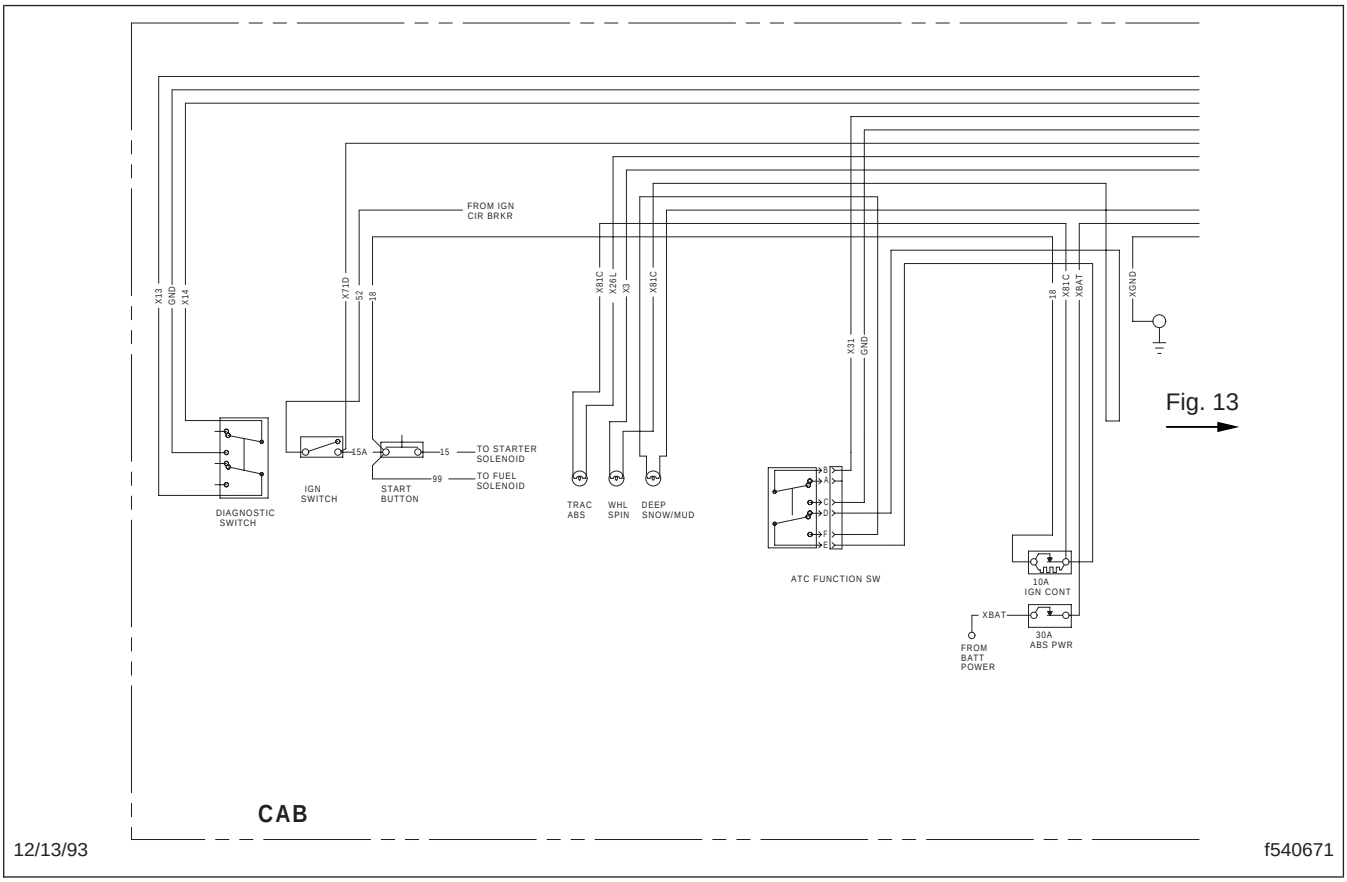

X13
GND
X14
X71D
52
18
FROM IGN
CIR BRKR
X81C
X26L
X3
X81C
X31
GND
18
X81C
XBAT
XGND
Fig. 13
15A
15
TO STARTER
SOLENOID
99
TO FUEL
SOLENOID
IGN
SWITCH
START
BUTTON
DIAGNOSTIC
SWITCH
TRAC
ABS
WHL
SPIN
DEEP
SNOW/MUD
B
A
C
D
F
E
ATC FUNCTION SW
10A
IGN CONT
XBAT
30A
ABS PWR
FROM
BATT
POWER
CAB
12/13/93
f540671

Fig. 12

Specifications

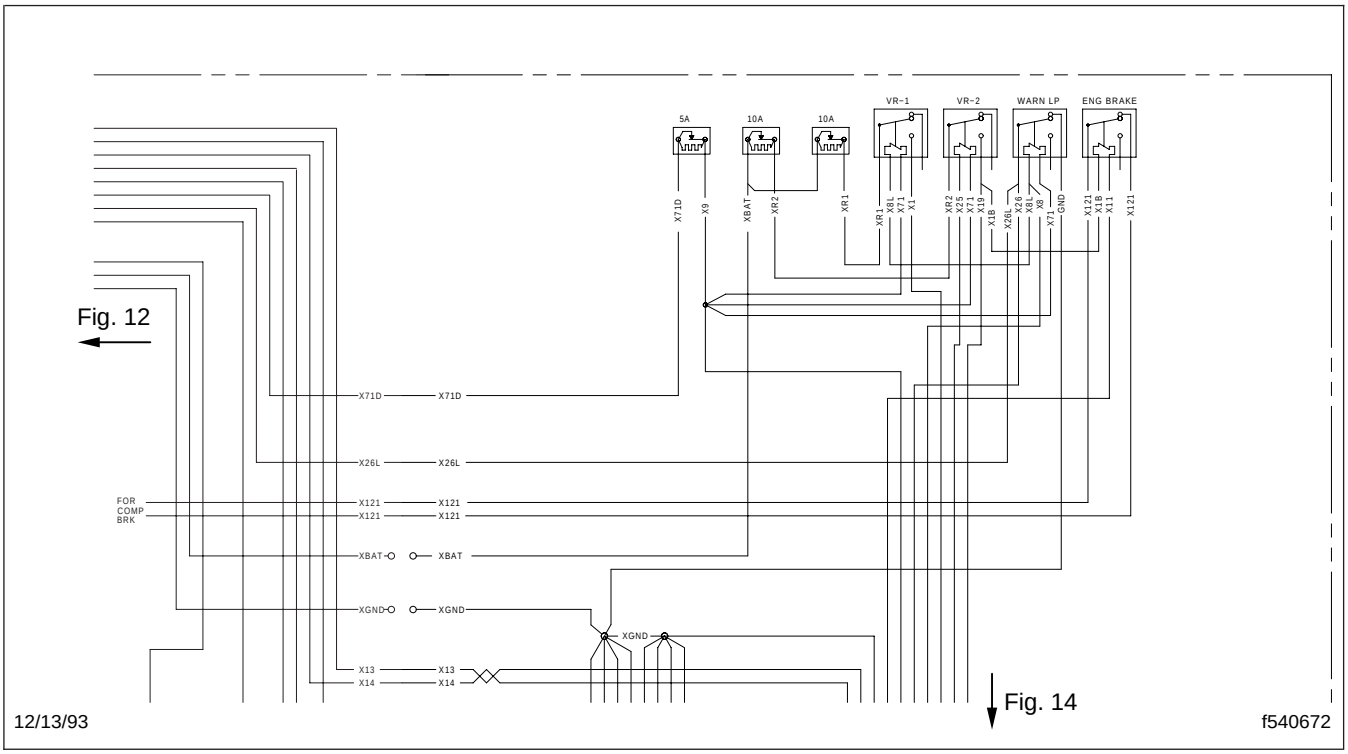


Fig. 13

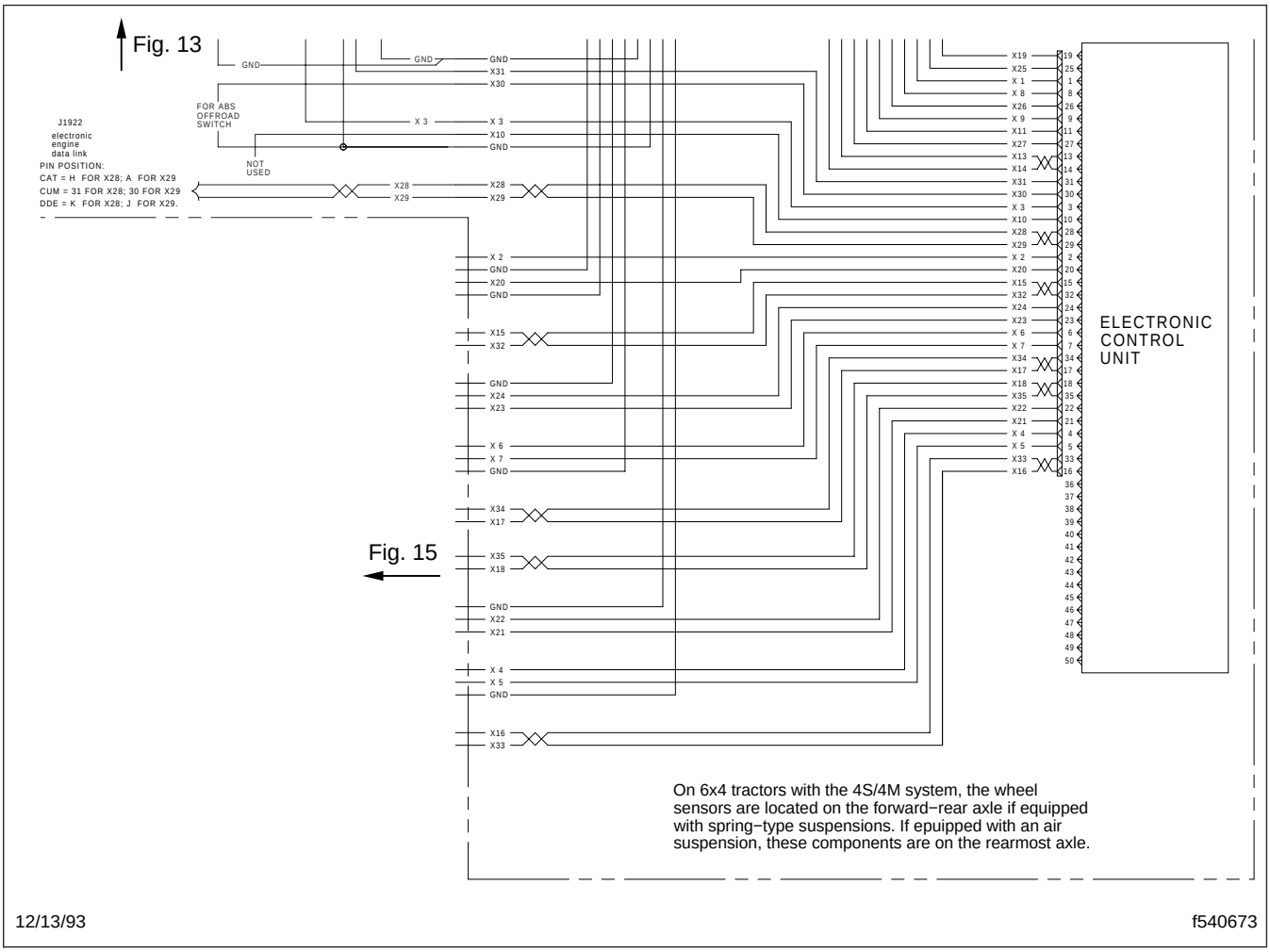


Fig. 13
Fig. 15
GND
FOR ABS OFFROAD SWITCH
NOT USED
J1922
electronic engine data link
PIN POSITION:
CAT = H FOR X28; A FOR X29
CUM = 31 FOR X28; 30 FOR X29
DDE = K FOR X28; J FOR X29.
ELECTRONIC CONTROL UNIT
On 6x4 tractors with the 4S/4M system, the wheel sensors are located on the forward−rear axle if equipped with spring−type suspensions. If epuipped with an air suspension, these components are on the rearmost axle.
12/13/93
f540673

Fig. 14

Specifications

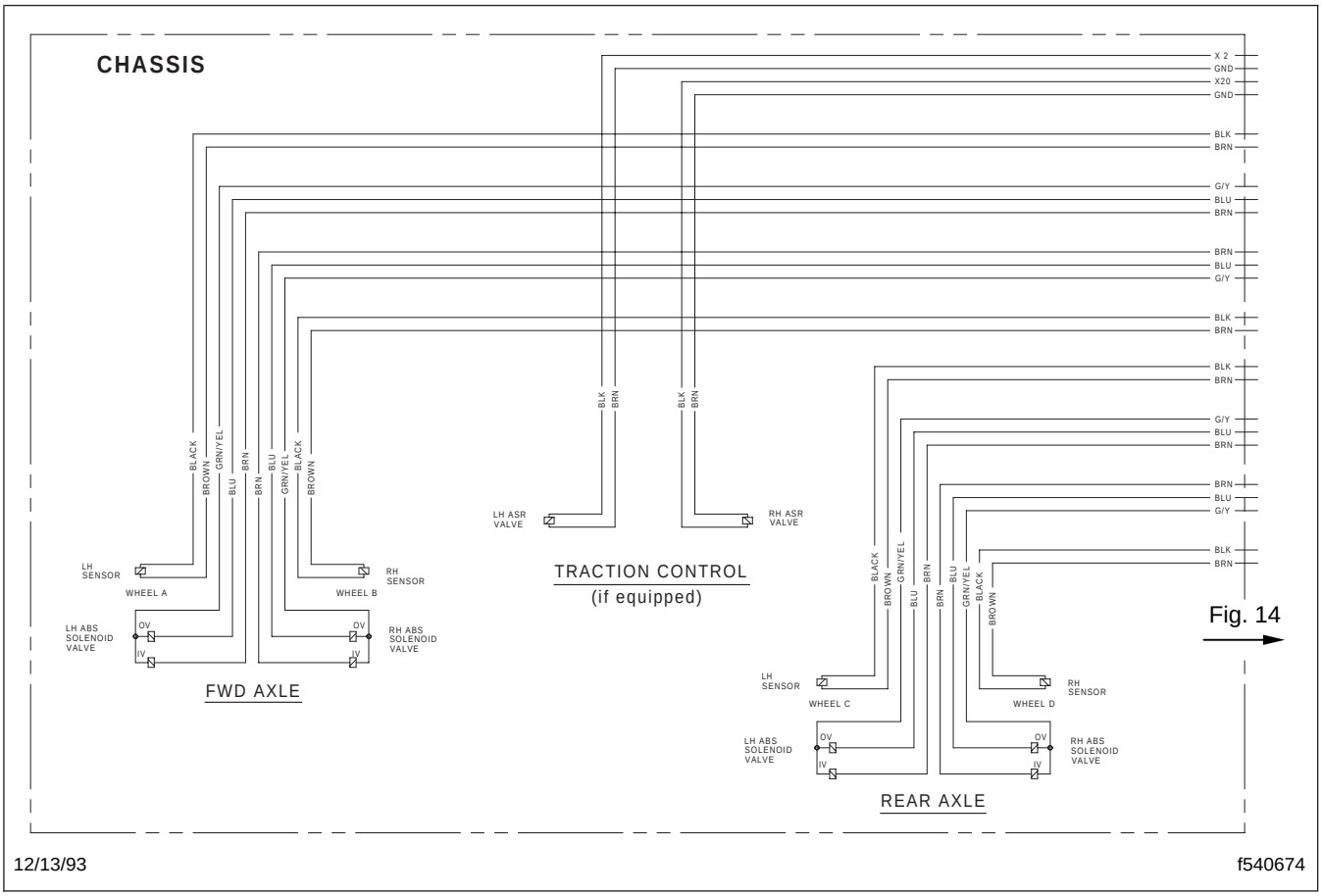


Fig. 15

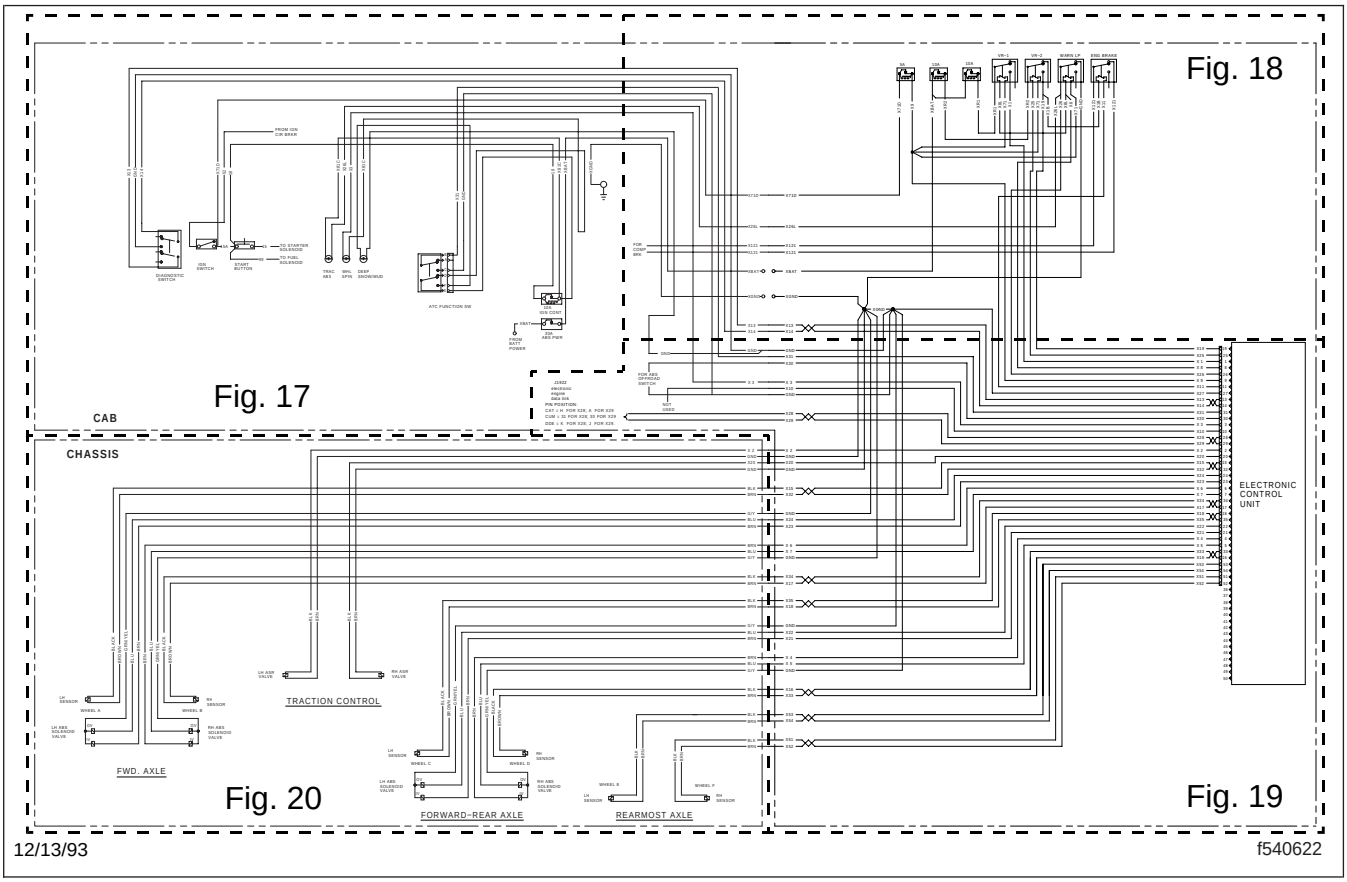


Fig. 16, Wiring Diagram for Troubleshooting 6S/4M ABS Systems Using Instrument Panel Blink Codes (Effective 5/93)

Specifications

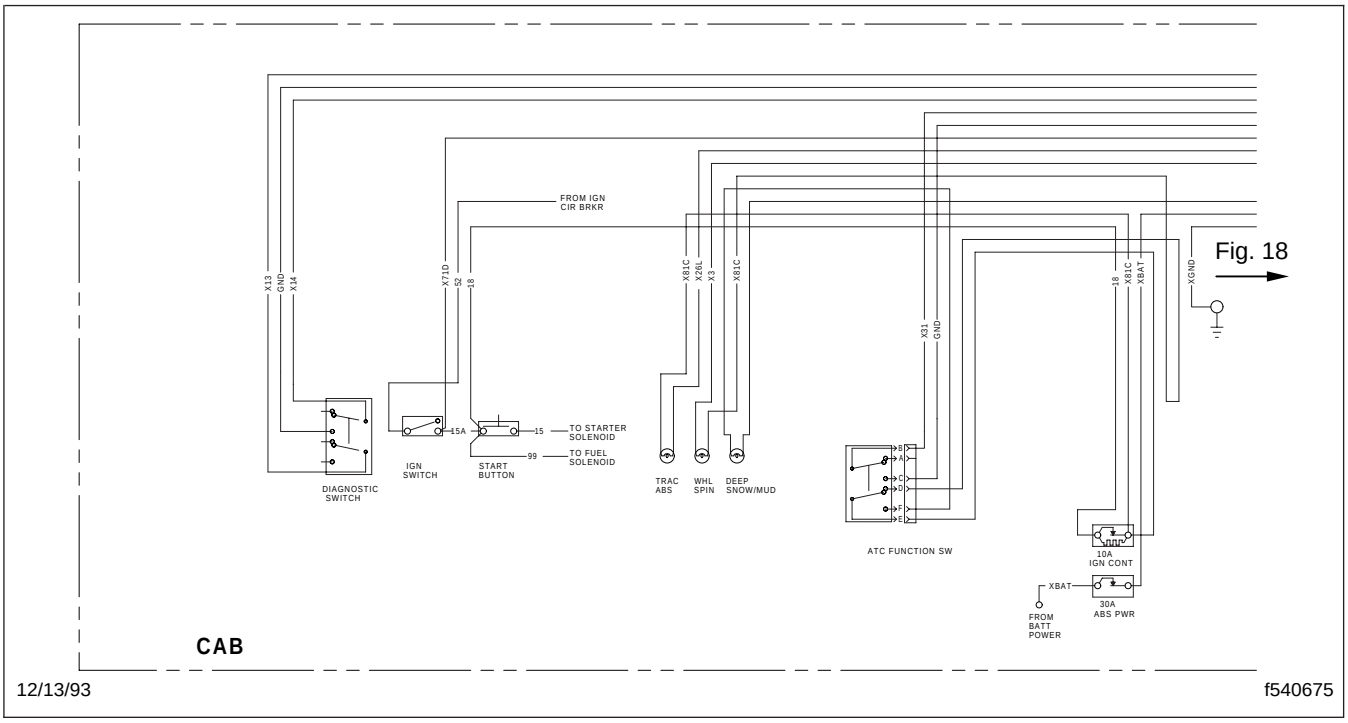


Fig. 17

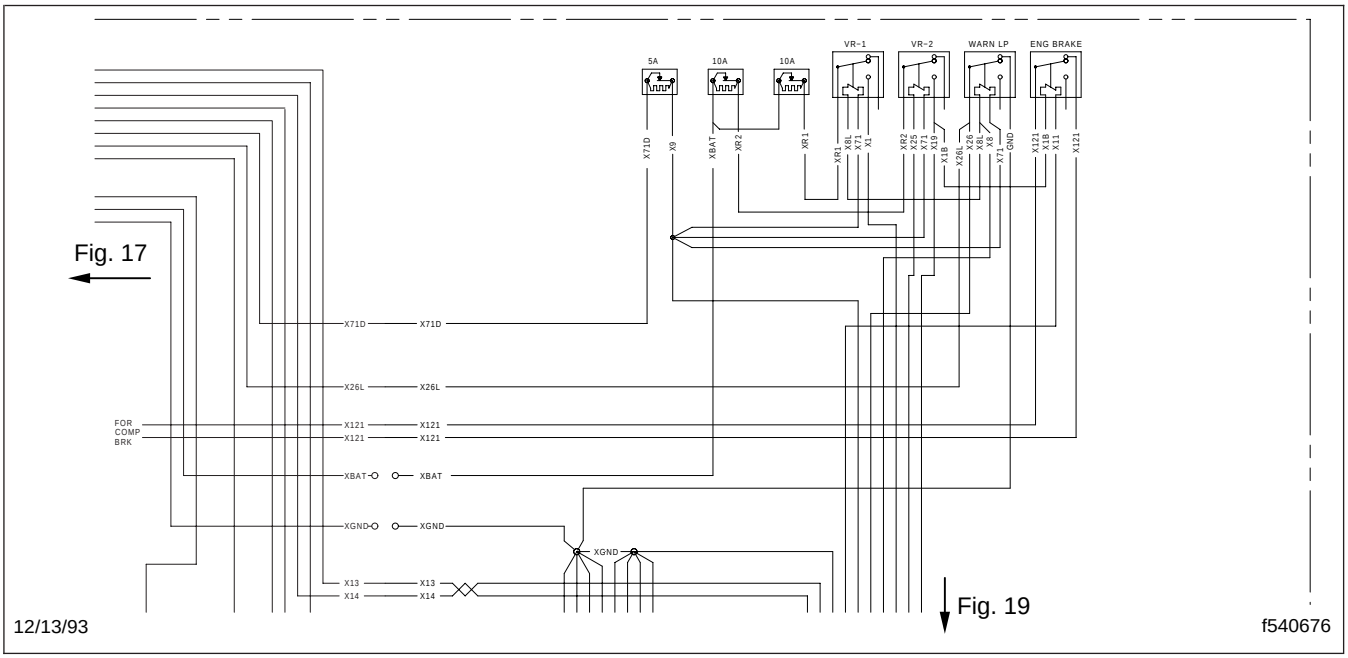


Fig. 18

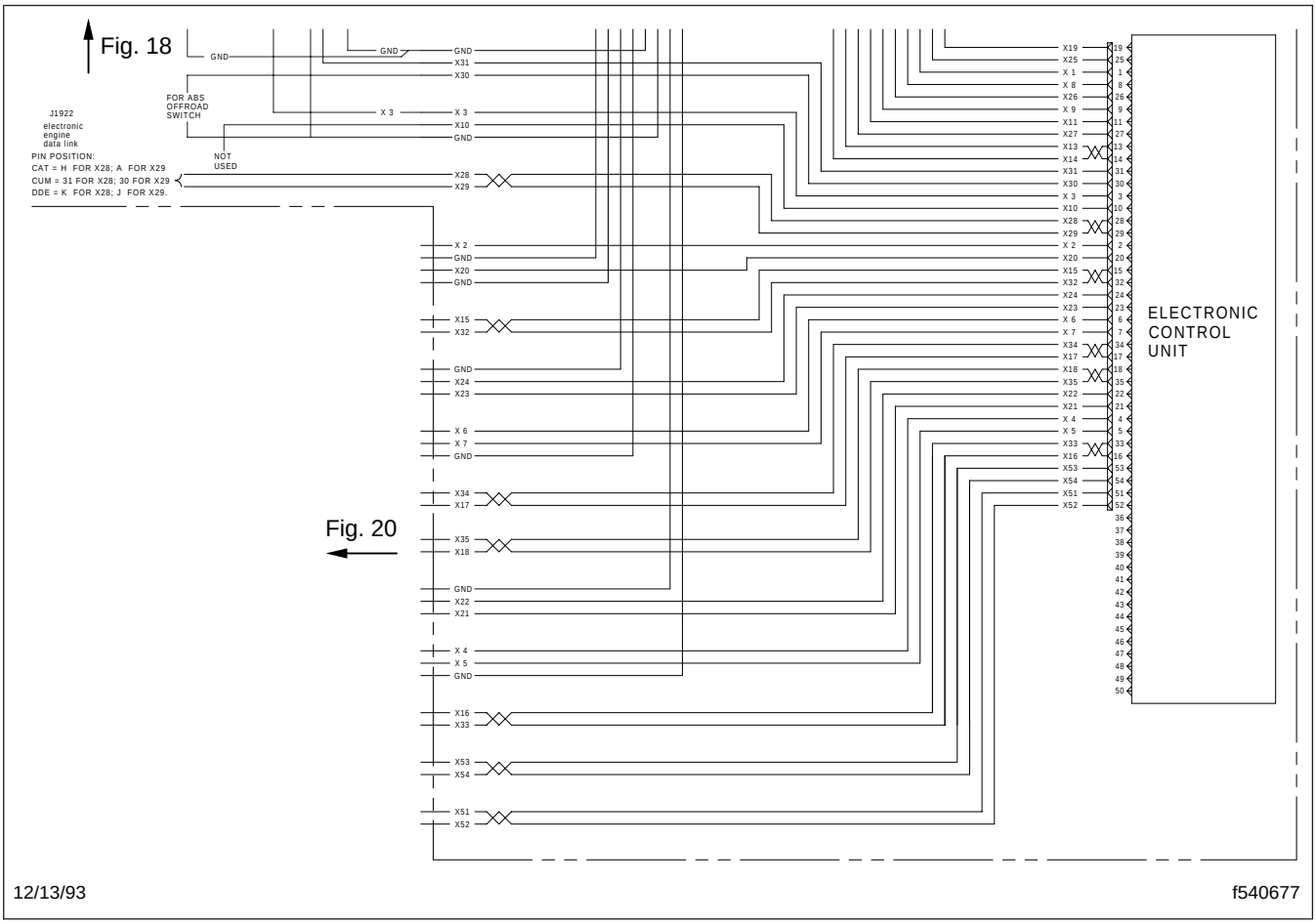


Fig. 18
Fig. 20
GND
FOR ABS OFFROAD SWITCH
J1922 electronic engine data link
PIN POSITION:
CAT = H FOR X28; A FOR X29
CUM = 31 FOR X28; 30 FOR X29
DDE = K FOR X28; J FOR X29.
NOT USED
X 3
X10
X28
X29
X 2
X20
X15
X32
X24
X23
X 6
X 7
X34
X17
X18
X35
X22
X21
X 4
X 5
X33
X16
X53
X54
X51
X52
X31
X30
X25
X 1
X 8
X26
X 9
X11
X27
X13
X14
X19
ELECTRONIC CONTROL UNIT
12/13/93
f540677

Fig. 19

Specifications

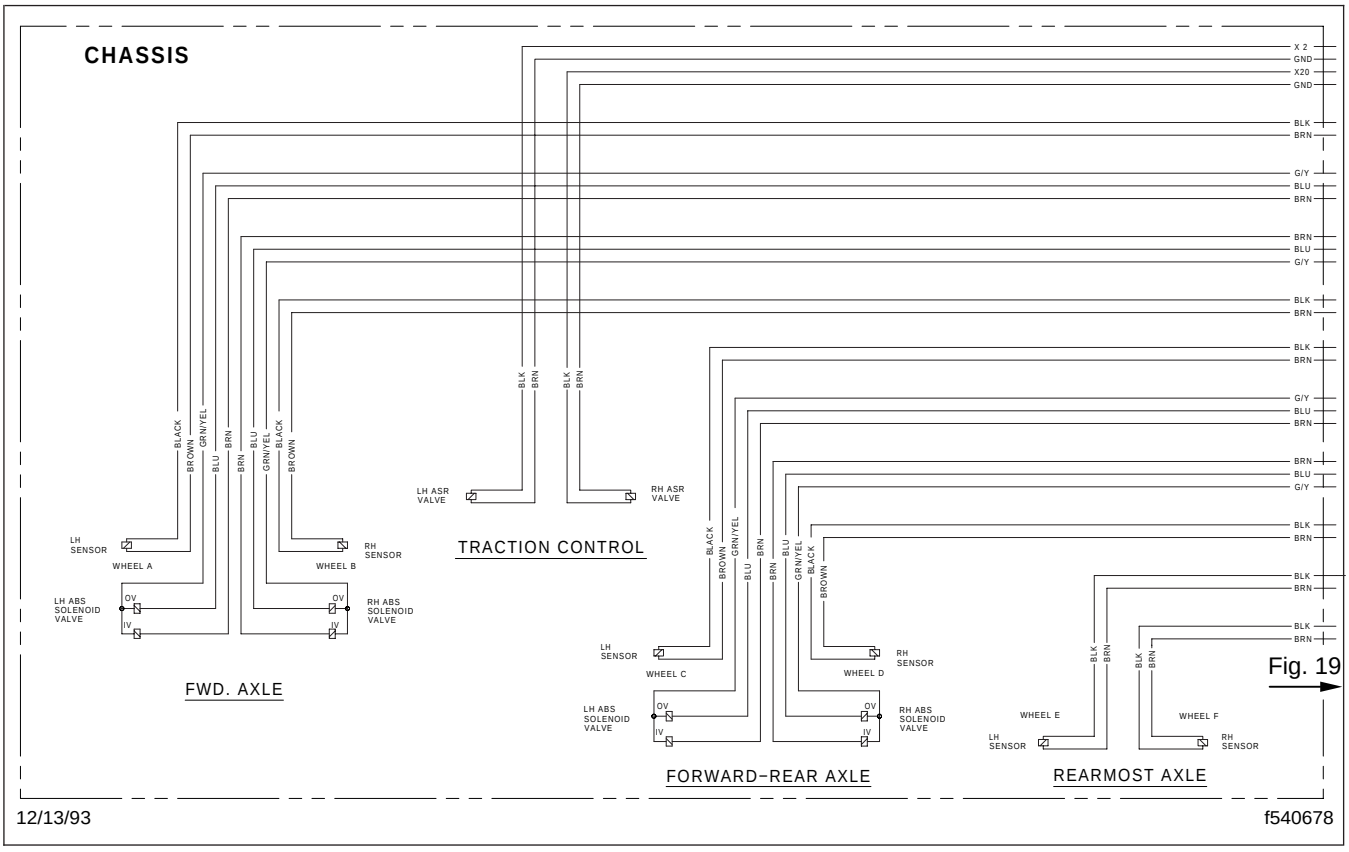


Fig. 20

General Description

The Anchorlok aftercooler **(Fig. 1)** is installed in place of a standard supply reservoir (wet tank). It functions as a wet tank, an aftercooler, and a moisture ejector.

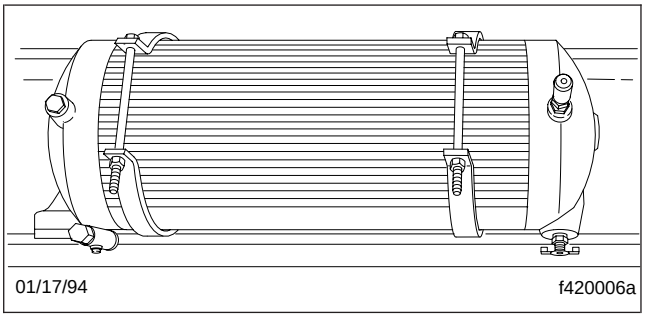


Fig. 1, Anchorlok Aftercooler

The aluminum body is finned for heat dissipation. An aluminum liner circulates the warm air from the air compressor against the sides of the aftercooler, thus cooling the air and condensing moisture. The aftercooler also has a built-in, automatic ejector valve that discharges contaminants from the aftercooler. The automatic ejector valve may have a heater which keeps the contaminants from freezing in the valve.

Principles of Operation

Hot air, carrying oil, water, and other contaminants from the air compressor, enters the inlet port of the aftercooler. The hot air flows between the liner and the finned aluminum body. **See Fig. 2.** The liner forces the hot air to pass closely along the aluminum body, resulting in maximum cooling of the air.

As the heat dissipates, the oil and water condense into sludge. The sludge collects in the bottom of the aftercooler near the automatic ejector valve, which is controlled by the air governor. When the air compressor cuts in, compressed air from the unloader port of the air governor enters the automatic ejector valve, forcing the sludge into the valve. When the air compressor cuts out, the valve opens, and the sludge passes through the drain tube into the atmosphere.

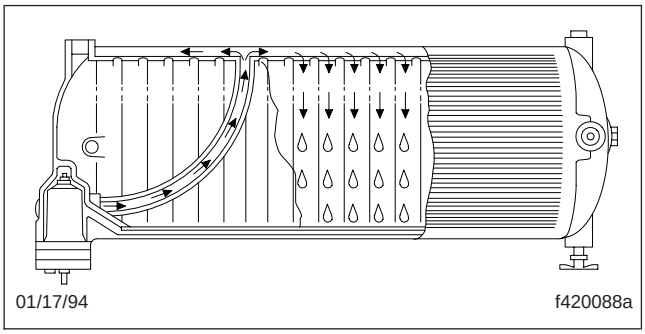
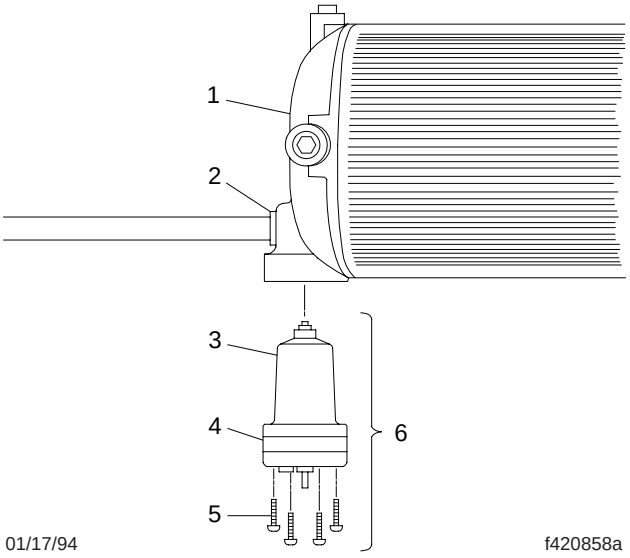


Fig. 2

Automatic Ejector Valve Servicing

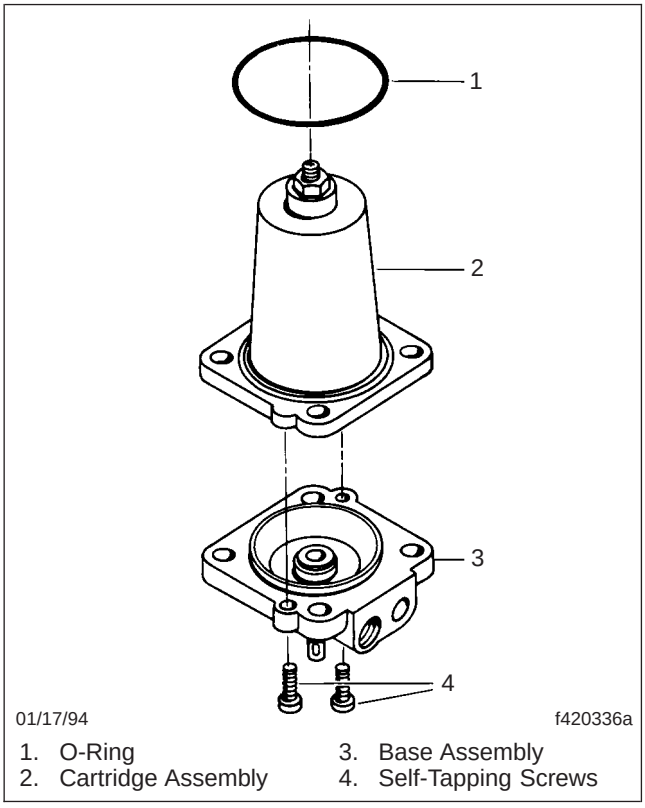
1. Apply the parking brakes, and chock the tires. Drain the air from the air reservoirs.
2. Disconnect the line that runs from the automatic ejector valve to the air governor at the automatic ejector valve. Plug the line to keep out dirt or foreign material.
3. Disconnect the electrical wires that lead to the aftercooler heater.
4. Remove the four allen capscrews from the automatic ejector valve assembly. Remove the automatic ejector valve assembly from the aftercooler. **See Fig. 1.**



1. Aftercooler
2. Inlet Port
3. Cartridge Assembly
4. Valve Base
5. Allen Capscrew
6. Automatic Ejector Valve Assembly

Fig. 1

5. Remove the cartridge assembly from the base assembly by removing the two self-tapping screws. **See Fig. 2.** Replace the O-ring if it is worn.
6. Remove the nylon nut and washer from the base assembly. Then remove the drain tube, sleeve, and diaphragm. **See Fig. 3.** Replace the diaphragm if it is worn.



1. O-Ring
2. Cartridge Assembly
3. Base Assembly
4. Self-Tapping Screws

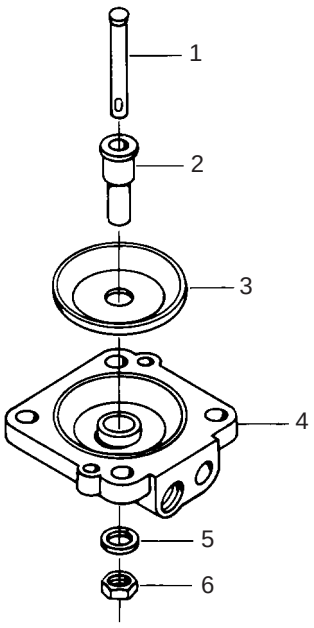
Fig. 2, Automatic Ejector Valve Assembly

WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

7. Clean the automatic ejector valve cavity and the disassembled parts, using kerosene or an alkaline cleaner.
8. Install the diaphragm, sleeve, and drain tube in the base assembly, **as shown in Fig. 3.** Install and tighten the washer and the nylon nut.
9. Lubricate the O-ring with a silicone-type grease, and install the O-ring. Place the cartridge assembly on the base assembly. Install and tighten the two self-tapping screws. **See Fig. 2.**

Automatic Ejector Valve Servicing



1. Drain Tube
2. Sleeve
3. Diaphragm
4. Base Assembly
5. Washer
6. Nylon Nut

Fig. 3

10. Install the automatic ejector valve in the aftercooler, **as shown in Fig. 1.** Install and tighten the four allen capscrews 55 to 65 lbf·in (620 to 740 N·cm).
11. Connect the aftercooler heater wires.
12. Remove the plug from the air governor unloader line. Connect the line to the port in the automatic ejector valve. Tighten the fitting 11 to 13 lbf·ft (15 to 18 N·m).
13. Start the engine, and allow the air pressure to build. After the air governor cuts out, apply the service brakes repeatedly to drain the air supply, so the governor cuts in. Check that the automatic ejector valve ejects when the air governor activates the air compressor. If the O-ring and the diaphragm have been replaced, and the automatic ejector valve still fails to operate, replace the cartridge assembly.

Aftercooler Removal and Installation

Removal

WARNING

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

1. Apply the parking brakes, and chock the tires. Drain the air from the air reservoirs.
2. Mark the air lines for later reference; then, disconnect them from the aftercooler. Plug the lines to keep out dirt or foreign material.
3. Disconnect the electrical wires from the aftercooler heater.
4. Loosen the fasteners on the aftercooler mounting clamps. Remove the aftercooler from the vehicle.

Installation

1. Pour one cup of clean water into the outlet port of the aftercooler, **as shown in Fig. 1,** for a later installation check.

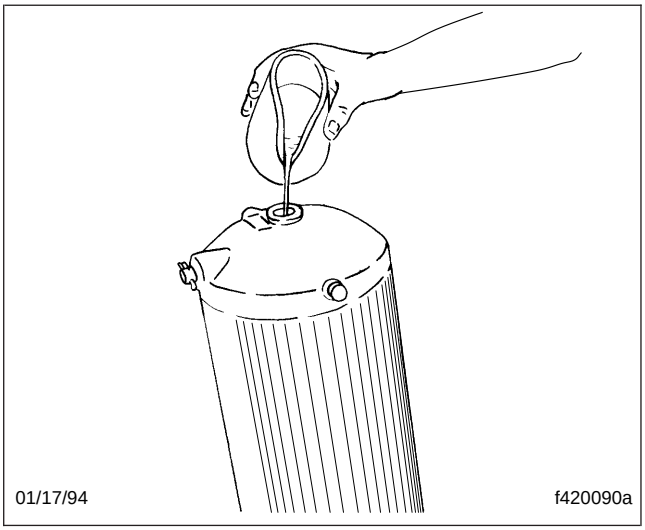


Fig. 1

2. Place the aftercooler in the mounting clamps, with the automatic ejector valve pointed directly toward the ground. Tighten the aftercooler mounting clamp fasteners 10 lbf·ft (14 N·m).
3. If installing a new aftercooler, install fittings in the ports, tightening them 25 ± 5 lbf·ft (34 ± 7 N·m).
4. Remove the plugs from the air lines. Connect all air lines to the aftercooler, as previously marked.
5. Connect the electrical wires to the aftercooler heater.
6. Start the engine, and allow the air pressure to build. After the air governor cuts out, drain the air from the air reservoirs. Check that the automatic ejector valve ejects the water when the air governor cuts in the air compressor at 100 psi (689 kPa). If the automatic ejector valve fails to eject the water, check that the air lines are installed correctly. Refer to the plumbing diagram in **Specifications 400.** If the automatic ejector valve still fails to eject the water, repair the valve.

Troubleshooting Tables

Problem—Automatic Ejector Valve Does Not Operate Properly

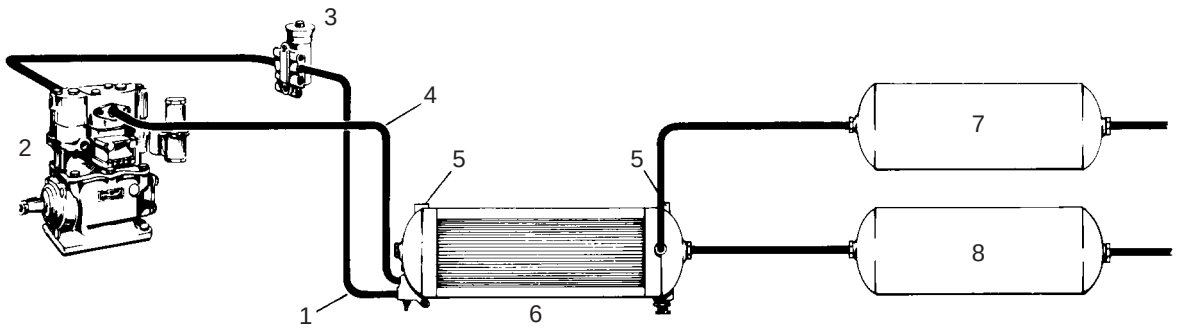
Possible Cause	Remedy
Maintenance procedures have not been followed.	Refer to the brake section in the vehicle maintenance manual for maintenance procedures.
The automatic ejector valve is dirty or sticking.	Clean the valve cavity, and clean or replace the valve as necessary.
The air aftercooler is not plumbed correctly.	Check the plumbing of the air lines, and correct if necessary.
The diaphragm is cracked or has slipped out of place.	Replace the diaphragm.
The cartridge assembly is worn or damaged.	Check the cartridge assembly for wear on the rubber insert of the poppet, and check the plunger assembly shaft for straightness. If worn or bent, replace the cartridge assembly.
The air governor is not working.	Repair or replace the air governor.

Problem—Carbon Build-Up at the Air Inlet Port

Possible Cause	Remedy
The air compressor does not function correctly.	Repair the air compressor, or, if the compressor manufacturer does not recommend disassembly, replace it with a factory rebuilt or a new unit. Steam clean or flush the aftercooler to remove carbon particles.

Specifications

See **Fig. 1** for the air dryer plumbing diagram.



1. Automatic Ejector Valve Line Activated By Air Governor
2. Air Compressor
3. Air Governor
4. Direct Air Supply Line From Air Compressor
5. Auxiliary Ports
6. Aftercooler
7. Primary Air Reservoir
8. Secondary Air Reservoir

Fig. 1, Anchorlok Aftercooler Plumbing Diagram

General Description

The pressure relief valve (**Fig. 1**) protects the air brake system against excessive air pressure build-up. The valve has a spring-loaded cap and O-ring assembly which will exhaust air from the reservoir, if pressure rises above the valve's pressure setting. This setting is determined by the force of the spring.

Principles of Operation

To illustrate the operation of the pressure relief valve, note that the governor cut-out pressure on all Freightliner vehicles is set at a maximum 125 psi (862 kPa). A pressure relief valve with a setting of 150 psi (1034 kPa) is then used. Should system pressure rise to approximately 150 psi (1034 kPa), air pressure will force the cap and O-ring assembly off its seat, and allow the reservoir pressure to vent to the atmosphere. **See Fig. 2** .

When the reservoir pressure decreases sufficiently, the spring force will seat the cap and O-ring assembly, sealing off reservoir pressure. This will occur at approximately 135 psi (931 kPa) for the 150 psi (1034 kPa) valve. Note that the desired pressure setting of the pressure relief valve is determined by the governor cut-out pressure. The opening and closing pressures of the pressure relief valve should always be in excess of the governor cut-out pressure setting.

Normally, the pressure relief valve remains inoperative and only functions if, for any reason, the reservoir pressure rises above the setting of the valve. Constant exhausting of the pressure relief valve can be caused by a faulty pressure relief valve, faulty governor, faulty compressor unloading mechanism, or a combination of any of the preceding.

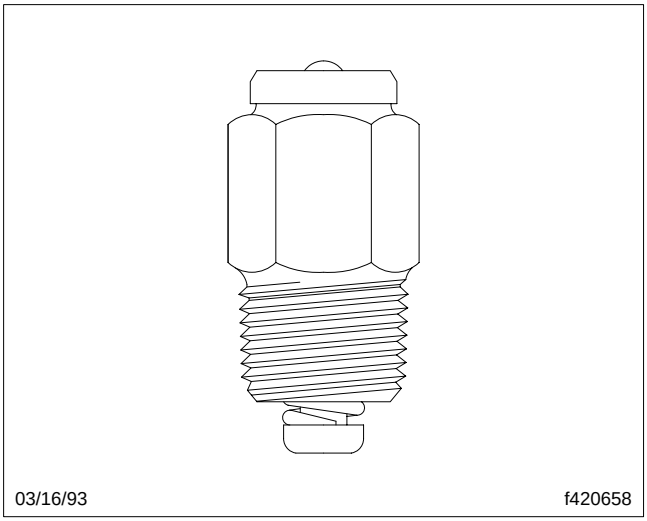


Fig. 1

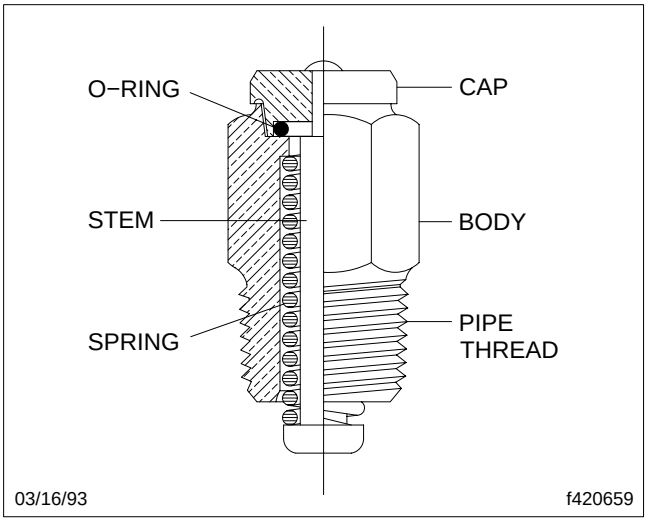


Fig. 2

Operating Check (See Fig. 1)

With air pressure built up in the system, proceed as follows:

⚠ WARNING

WARNING: Wear safety goggles when exhausting the air system because debris could fly out at high speed. Failure to take all necessary precautions could result in personal injury.

1. With your index finger and thumb, pull the cap of the valve, removing the spring load from the O-ring. Air should exhaust from the valve.
2. Release the cap; the airflow should stop.

   Failure of a valve to pass the operating test indicates the valve should be replaced, using the instructions in this section.

Leakage Check

Coat the exhaust port with a soap solution. Leakage resulting in a 1-inch (2.5-cm) bubble in 5 seconds is permitted. Excessive leakage indicates dirt in the valve or a faulty O-ring or seat. The valve should be replaced, using the instructions in this section.

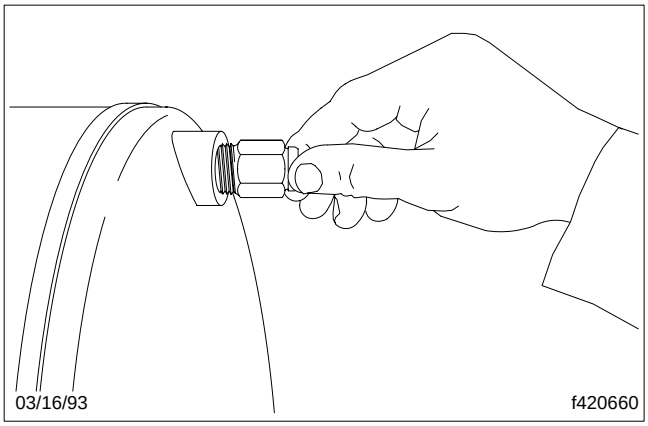


Fig. 1

Removal

1. Chock the tires, and drain the air reservoirs.
2. Using a wrench, unscrew the valve from the reservoir. **See Fig. 1** .

Installation

1. Apply a small quantity of Loctite®242, or an equivalent sealant, to the valve threads.

⚠ WARNING

WARNING: Make sure that excess sealant does not get inside either the male or female fittings. This would allow loose foreign material inside the plumbing, and may clog a valve. This could result in an unexpected loss of brake control, which could cause property damage or personal injury.

2. Install the valve and tighten it finger-tight. With a wrench, tighten it 1-1/2 additional turns past finger-tight.
3. Perform the operating and leakage checks on the valve and the valve fitting. For instructions, **refer to Subject 100.**

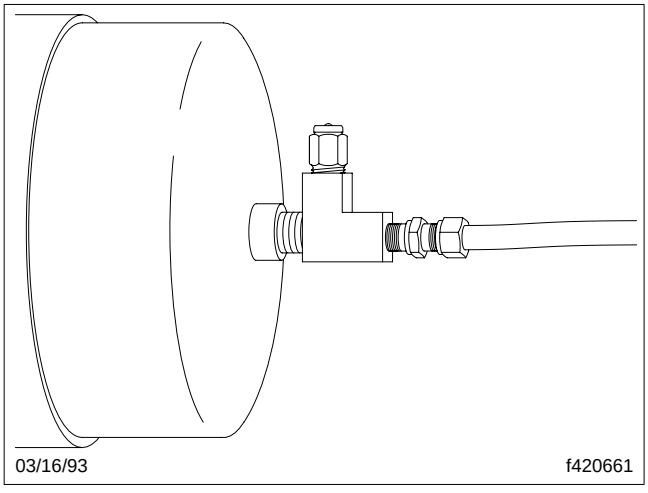


Fig. 1

General Information

The function of the QR-1 quick release valve (**Fig. 1**) is to speed up the release of air pressure from the brake chambers. If the front brake chambers are equipped with a QR-1 valve, and a foot brake application is released, the exhaust port of the quick release valve opens and the air from the front brake chambers is exhausted through the quick release valve. This accelerates the release of the front brakes.

When the front brake chambers are equipped with a QR-1 valve, it is located on the forward face of the front engine crossmember. A delivery line from the foot valve is connected to the port on top of the QR-1 quick release valve; the two side ports are for brake chamber connections, and the exhaust port is located at the bottom of the valve.

Principles of Operation (See Fig. 1)

When the foot brake control is applied, delivery air enters the brake valve port on the QR-1 quick release valve; the diaphragm moves down, sealing the exhaust port. At the same time, air pressure forces the edges of the diaphragm down, allowing air to flow out the brake chamber ports, filling the chambers and applying the front axle brakes.

When the brake chamber air pressure (beneath the diaphragm) equals the air pressure being delivered by the foot valve (above the diaphragm), the outer edge of the diaphragm will seal against the valve body seat. The exhaust port is still sealed by the center portion of the diaphragm. When the foot brake is released, the air above the diaphragm is released back through the foot brake valve exhaust, while the air beneath the diaphragm forces the diaphragm to rise, opening the exhaust port, and allowing air in the brake chambers to exhaust.

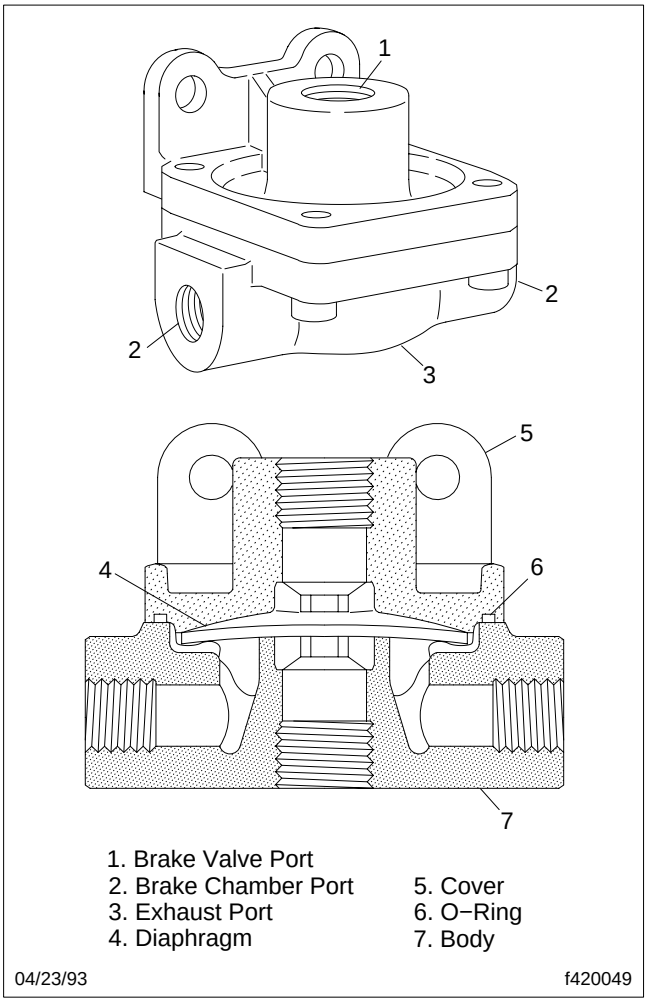


Fig. 1, QR-1 Valve and Cross Section

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

Operating and Leakage Tests

The following tests should also be performed after repairing or replacing the QR-1 valve to ensure that it is functioning properly.

1. With the foot brake applied (pedal pushed in) perform the following checks:

   1.1 Coat the exhaust port with a soap solution; leakage of a one-inch bubble in three seconds is allowable.

   1.2 Coat the valve body and cover with a soap solution. No leakage is permitted between the valve body and cover.

2. If the valve does not function properly, or if leakage is excessive, repair or replace it following the instructions in this section.

Removal

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Chock the tires or hold the vehicle by means other than air brakes.
2. Drain the air brake system by opening the reservoir drain cocks.
3. Mark and disconnect the air lines from the quick release valve.
4. Remove the mounting bolts and the valve.

Installation

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Install the quick release valve with the exhaust port facing down. Securely tighten the mounting bolts.
2. Connect the air lines to the quick release valve in the locations previously marked.
3. Perform the operating and leakage tests **in Subject 110**.

Disassembly, Cleaning and Inspection, and Assembly

Disassembly

1. Remove the quick release valve from the vehicle following the instructions **in Subject 120**.
2. Remove the four screws holding the valve cover on the valve body.
3. If equipped, remove the spring and spring seat.
4. Remove the diaphragm.
5. Remove the cover O-ring.

Cleaning and Inspection

1. Clean all metal parts in mineral spirits. Wipe all rubber parts clean.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

2. It is recommended that all rubber parts and any other part showing signs of wear or deterioration be replaced with genuine Bendix parts.

Assembly

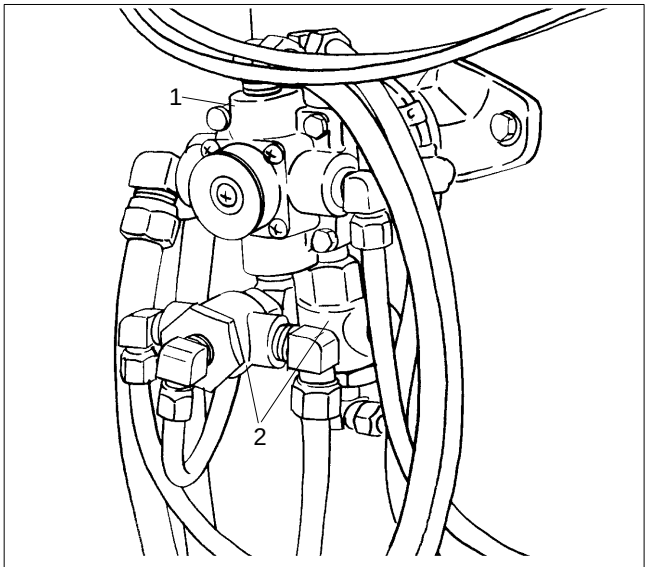
1. If the quick release valve is not equipped with a spring, install the diaphragm into the valve body.

   If the quick release valve is equipped with a spring, position the spring in the valve body. Then, position the diaphragm over the spring seat.
2. Install the O-ring in the valve cover groove and install the valve cover. Tighten the screws 30 to 60 lbf·in (340 to 680 N·cm) evenly and securely.
3. Install the quick release valve, following the instructions **in Subject 120** .

General Information

Freightliner vehicles use one or two shuttle type double check valves. **See Fig. 1** . If a vehicle is equipped with a trailer control valve it has two double check valves. Otherwise, most other vehicles will only have one. A shuttle type valve has a movable shuttle to seal off the lower pressure source. The valves are screwed into the forward side of the foot brake valve under the deck (COEs), or on the left-side firewall (Conventionals).

Double check valves are used in the air brake system to direct a flow of air into a common line from either of two sources, whichever is at the higher pressure.



1. Foot Brake Valve
2. Double Check valves

04/23/93 f420340

Fig. 1, Double Check Valves Installed on a Conventional

Principles of Operation

As pressurized air enters either end of the double check valve inlet port, the moving shuttle responds to the greater pressure source and seals the opposite port. The air flow continues out the delivery port of the valve. The position of the shuttle will reverse if the pressure levels are reversed. Double check valves are designed so the shuttle cannot interfere with the backflow of air in the exhaust mode.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under a vehicle. Dropping air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if they are not correctly disassembled. Use only the correct tools, and observe all precautions regarding use of those tools.

Operating and Leakage Test

1. If the vehicle is not a tractor with a trailer, go to the next step.

   If the vehicle is a tractor with a trailer, proceed as follows:

   1.1 Push in and release the foot brake pedal while checking that the brakes apply and release on both the tractor and trailer.

   1.2 Apply and release the trailer control valve while checking that only the trailer brakes apply and release.

   1.3 Apply the trailer control valve and check the exhaust port of the foot brake valve for leakage using a soap solution. A 1-inch (2.5-cm) bubble or less in five seconds is allowable. Release the valve.

   1.4 Disconnect the air line from the trailer control valve exhaust port. Push the foot brake pedal until it stops and hold it in place. Check the trailer control valve exhaust port for leakage using a soap solution. A 1-inch (2.5-cm) bubble or less in five seconds is allowable.

   1.5 Connect the air line to the trailer control valve exhaust port.

   1.6 Go to the next step.

2. If the double check valve is to be tested on the bench, connect two separately controlled air supplies to the inlet ports.

3. Connect an accurate test gauge to the double check valve outlet port or to a line from the outlet port.

4. Apply and release air to one inlet port (foot brake pedal) while checking that the test gauge registers the application and release.

5. Apply and release air to the other inlet port (trailer control valve) while checking that the gauge registers the application and release.

6. Disconnect the line from one of the double check valve inlet ports. Apply air to the opposite inlet port while checking the first port for leakage using a soap solution. A 1-inch (2.5-cm) bubble or less in five seconds is allowable. Connect the line to the inlet port. Repeat this step, checking the opposite inlet port for leaks.

7. If the double check valve does not function as described, or if the leakage is excessive, replace it. **Refer to Subject 120** for instructions.

   If the valve cannot be replaced, repair it using Bendix parts. **Refer to Subject 130** for instructions.

Removal

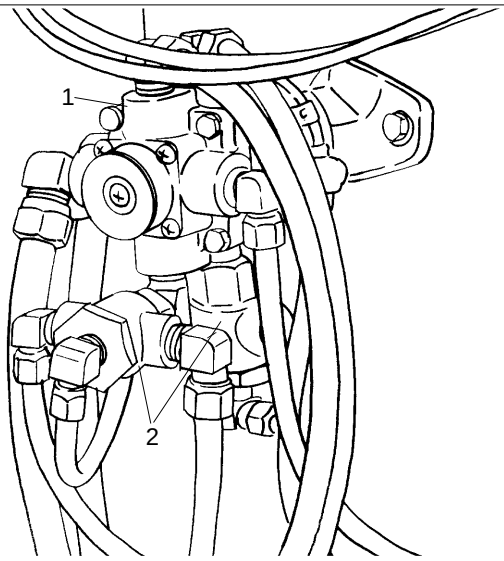
WARNING

WARNING: Wear safety goggles when draining the air system or disconnecting an air line because dirt or sludge particles could fly out at high speeds. Don't direct the airstreams at other people. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

1. Drain the air from the air reservoirs.
2. Disconnect the air lines from the double check valve. **See Fig. 1** .
3. Unscrew the double check valve from the foot brake valve. **See Fig. 1** .

Installation

1. Screw the double check valve into the foot brake valve. Tighten the valve firmly.
2. Connect the air lines to the double check valve as marked. Tighten the air lines firmly.



1. Foot Brake Valve
2. Double Check valves

04/23/93 f420340

Fig. 1, Double Check Valves Installed on a Conventional

Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)

1. Remove the valve from the vehicle. Refer to **Subject 120** for instructions.
2. Remove the end cap from the valve.
3. Remove the O-ring.
4. Remove the shuttle valve and shuttle guide.

Cleaning and Inspection

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Clean all metal parts in a cleaning solvent.
2. Inspect all metal parts for signs of cracks, wear, or deterioration. Replace all parts not considered serviceable.
3. Replace all rubber parts.

Assembly

1. Install the shuttle valve and shuttle guide in the valve body.
2. Coat the O-ring with BW 650M silicone lubricant (BW 291126). It is not necessary to lubricate the shuttle valve.
3. Install the O-ring.
4. Install the end cap on the valve body.
5. Install the valve on the vehicle. Refer to **Subject 120** for instructions.
6. Test the valve. Refer to **Subject 110** for instructions.

Disassembly, Cleaning and Inspection, and Assembly

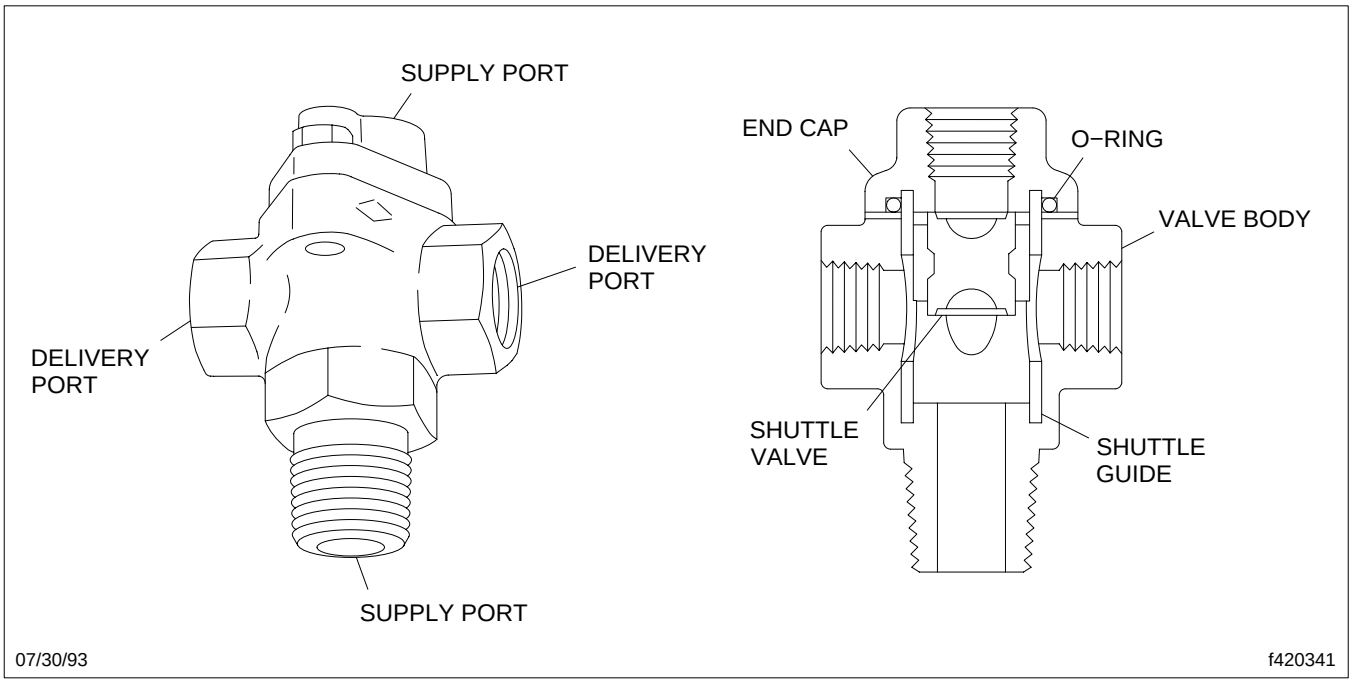


Fig. 1, Double Check Valve

General Description

The MV-2 control module is an integrated control assembly mounted in the control panel. **See Fig. 1.** The bodies for the module, as well as "spool" inserts, are molded of a non-metallic, non-corrosive material. The assembly consists of two push-pull valves and a dual-circuit supply valve which shuttles at a preset pressure differential. The valve spool inserts, as well as the dual-circuit supply valve spool and shuttle, may be removed from the valve bodies without disconnecting the air lines.

The MV-2 module provides: tractor protection control; trailer service air supply; system park; trailer park only; trailer charge with tractor spring brakes applied (tractor park only); and supply reservoir selection.

The MV-2 includes a spring-loaded, dual-circuit supply valve, which selects the primary air reservoir as the air source for both control valves, unless the pressure in the primary air reservoir falls more than 30 psi (207 kPa) below that of the secondary air reservoir. Then, the dual-circuit supply valve will shuttle and establish the secondary air reservoir as the air source. An auxiliary air delivery port, which receives its air supply from the dual-circuit supply valve, is normally plugged. All air connections are located at the bottom of the valves. **See Fig. 2.**

The trailer air supply valve (**see Fig. 1**), actuated by a red knob, delivers air to the trailer supply line, and also will trip automatically and shut off the trailer supply if pressure decreases to 40 5 psi (276 28 kPa).

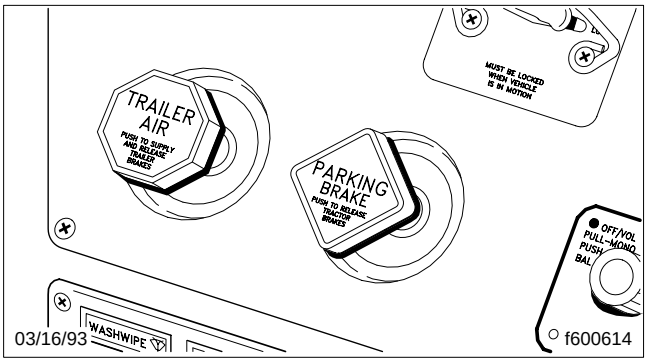


Fig. 1

NOTE: The primary air reservoir is the reservoir that supplies the rear tractor axle(s). The secondary air reservoir is the reservoir that supplies the front axle.

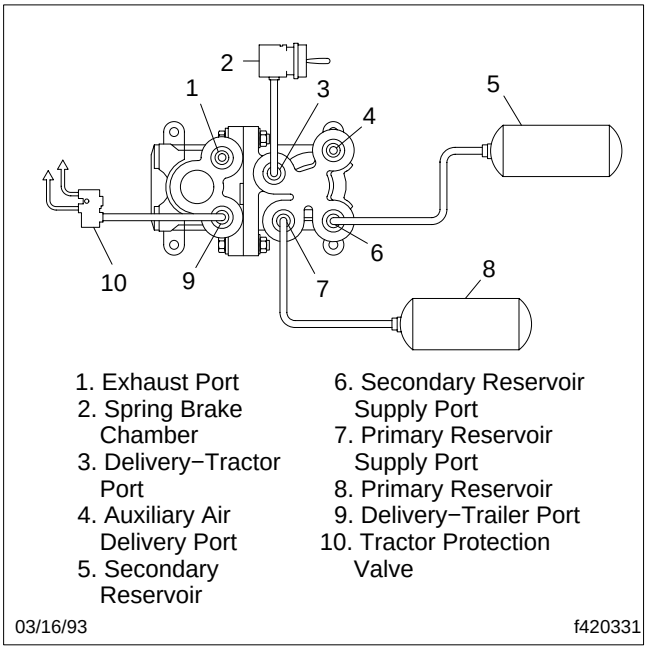


Fig. 2, Brake Control Module Air Connections

The parking brake valve, **as shown in Fig. 1**, actuated by a yellow knob, controls the spring parking brakes on the tractor, and when exhausted, simultaneously causes the trailer supply valve to trip and exhaust, thus applying both the tractor and the trailer parking brakes as required by federal regulations. The trailer parking brakes may be independently released by pushing only the trailer air supply valve (red) knob in.

Principles of Operation

INITIAL CHARGE

With both the primary and the secondary systems completely discharged, both knobs are out. **See Fig. 3.** When system pressure reaches 65 psi (448 kPa), the red knob (trailer air supply) may be pushed in, and should stay in, charging the trailer system and releasing the trailer parking brakes. **See Fig. 4.** The yellow knob (parking brake) may now be pushed in, which will supply air to the tractor parking brakes, releasing them.

NORMAL OPERATION POSITION

When both knobs are pushed in, air is supplied to the trailer and the tractor parking brakes; all parking

General Description and Principles of Operation

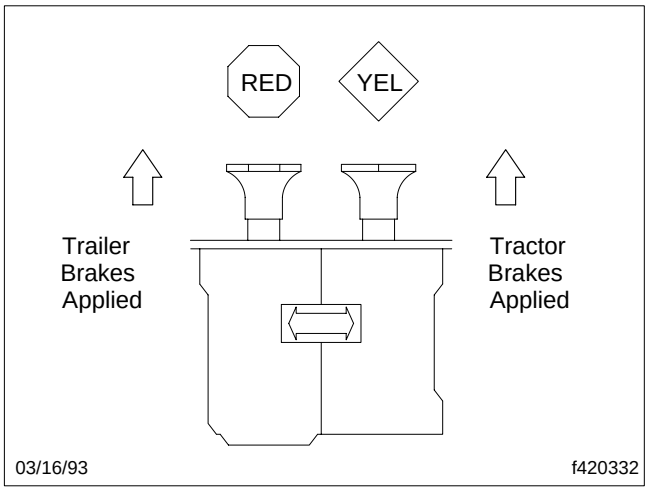


Fig. 3

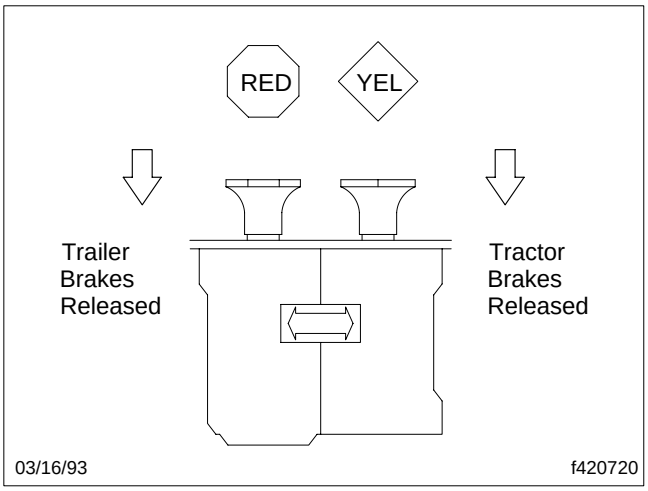


Fig. 5

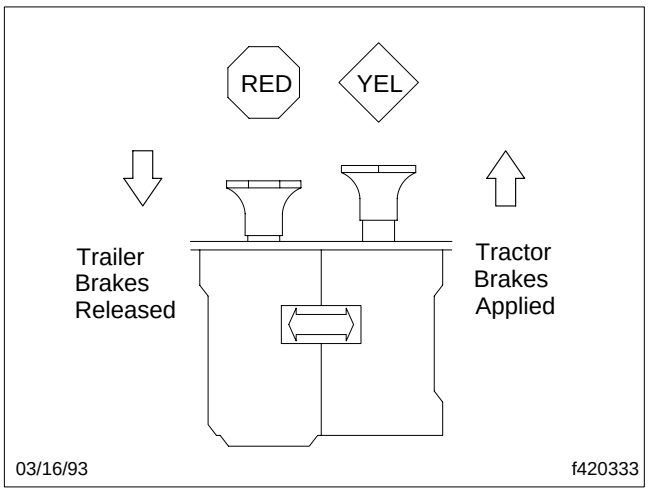


Fig. 4

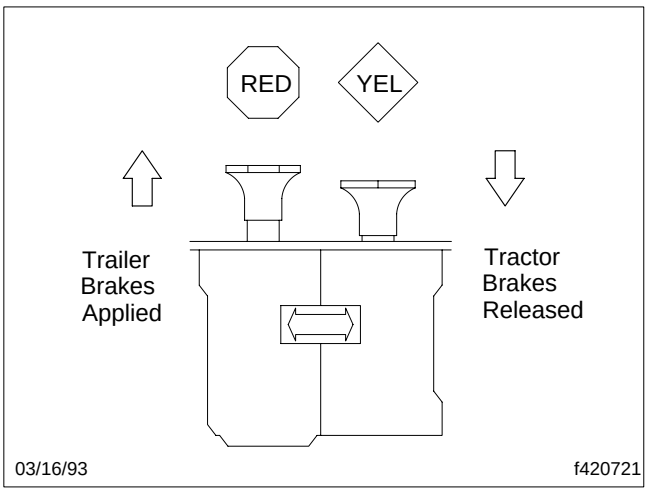


Fig. 6

brakes are released. **See Fig. 5.** This is the normal operating mode.

ACTUATION OF TRAILER PARK OR EMERGENCY BRAKES

To actuate the trailer parking brakes only, the red knob is pulled out, exhausting the trailer supply line. The trailer parking brakes are now applied, either by emergency air or parking brakes, depending on the type of trailer system. This mode would be used to uncouple from the trailer, and during bobtail operation. **See Fig. 6.**

SYSTEM PARK

With both knobs in, the parking brakes on both the tractor and the trailer may be actuated by pulling the yellow (parking brake) knob out. This exhausts the air from the tractor parking brakes and simultaneously causes the red (trailer air supply) knob to pop out, applying the trailer parking brakes. (This complies with federal regulations that one control must apply all the parking brakes on the vehicle.) **See Fig. 3.**

TRAILER CHARGE

If both valves are out, parking the combination vehicle, and it is desired to recharge the trailer (leaving only the tractor parking brakes applied), the red knob may be pushed in, repressurizing the trailer supply line. This mode might also be used to park a combination vehicle with air actuated emergency brakes on the trailer to provide demonstrated parking capability with the tractor spring brakes only. **See Fig. 4.**

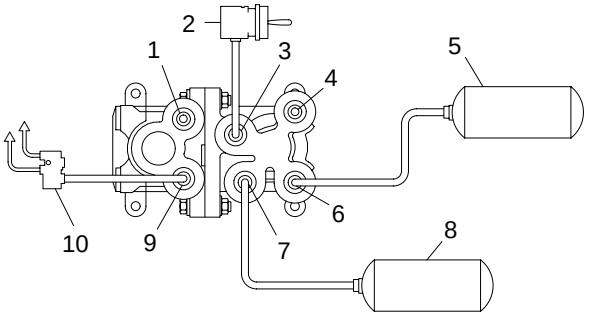
AUTOMATIC APPLICATION

If air pressure drops to 40 5 psi (276 34 kPa) in both the primary and the secondary systems, the red knob (trailer air supply valve) will automatically pop out, applying the emergency or parking brakes on the trailer. If the red knob is held in manually and the pressure decreases to 30 5 psi (207 34 kPa), a tripper piston within the trailer control spool will move upward, exhausting the trailer supply, and applying the trailer parking brakes. If air pressure drops in both the primary and the secondary systems, the yellow (parking brake) knob will pop out at approximately 20 to 30 psi (138 to 207 kPa), applying the tractor parking brakes.

A warning buzzer and light are activated when pressure in either the primary or the second ary system drops below 64 to 76 psi (441 to 524 kPa).

Tests

1. With the air brake system charged to 65 psi (448 kPa), check for leaks, using the following instructions. Repair or replace components as needed.
2. Check for leakage between the body seals, the body, and cover plates. No leakage is permitted.
3. Push in the red knob. The knob must stay in. Leakage at the exhaust port (**Fig. 1** , Ref. 1) must not exceed a 1-inch (25-mm) bubble in 5 seconds.
4. Develop a leak in the line delivering air to the trailer supply circuit (Ref. 9). The red knob must pop out at 40 ± 5 psi (276 ± 34 kPa) and maintain the supply pressure. Leakage at the exhaust port must not exceed a 1-inch (25-mm) bubble in 5 seconds.
5. Hold the red knob in and again develop a leak in the supply circuit. Air must start to escape from the exhaust port when the trailer line pressure reaches 30 5 psi (207 34 kPa).



1. Exhaust Port
2. Spring Brake Chamber
3. Delivery−Tractor Port
4. Auxiliary Air Delivery Port
5. Secondary Reservoir
6. Secondary Reservoir Supply Port
7. Primary Reservoir Supply Port
8. Primary Reservoir
9. Delivery−Trailer Port
10. Tractor Protection Valve

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Fig. 1, Brake Control Module Air Connections

6. Release the red knob and rebuild the supply pressure to at least 40 psi (276 kPa). Push in the yellow knob; the yellow knob must remain in. Leakage at the exhaust port should not exceed a 1-inch (25-mm) bubble in 5 seconds.
7. Develop a leak in the tractor spring brake delivery circuit. The yellow knob must pop out at 25 ± 5 psi (172 ± 34 kPa) and maintain supply pressure. Leakage at the exhaust port should not exceed a 1-inch (25-mm) bubble in 5 seconds.
8. Charge the system to 120 psi (827 kPa), and push both knobs in. Pull the red knob out. The yellow knob must remain in.
9. Push the red knob in and pull the yellow knob out. The red knob must pop out almost instantaneously.
10. Install a gauge to monitor tractor spring brake delivery pressure. Build 120 psi (827 kPa) pressure in the primary and secondary air reservoirs. Push in the yellow knob. Delivery pressure should equal the pressure in the primary air reservoir. Reduce the pressure in the primary air reservoir. Delivery pressure and the primary air reservoir pressure should descend together to 90 to 105 psi (620 to 723 kPa), at which point the dual-circuit supply valve shuttle should switch to equal the secondary air reservoir; delivery pressure should increase to the secondary air reservoir pressure. After the primary air reservoir pressure is reduced to zero, there should not be audible leakage at the primary air reservoir opening. Close the leak which has been created in the primary air reservoir.
11. Leaving the yellow knob in, recharge the secondary air reservoir to 120 psi (827 kPa). The delivery pressure should also read 120 psi (827 kPa). Recharge the primary air reservoir to 100 psi (689 kPa). Slowly vent the secondary air reservoir. As the secondary air reservoir pressure and the delivery line pressure descend, pressure should stabilize at approximately 100 psi (689 kPa).
12. Close all vents or leakage points and charge both reservoirs to 120 psi (827 kPa). Position the red knob out and the yellow knob in. Develop a leak in the spring brake delivery line (**Fig. 1** , Ref. 3) and hold the yellow knob in. Reduce the primary air reservoir pressure to zero; lower the secondary air reservoir pressure to 20 to 30 psi (138 to 207 kPa). The dual-circuit supply valve shuttle should cycle several times during the leak-down period.

Replacement (See Fig. 1)

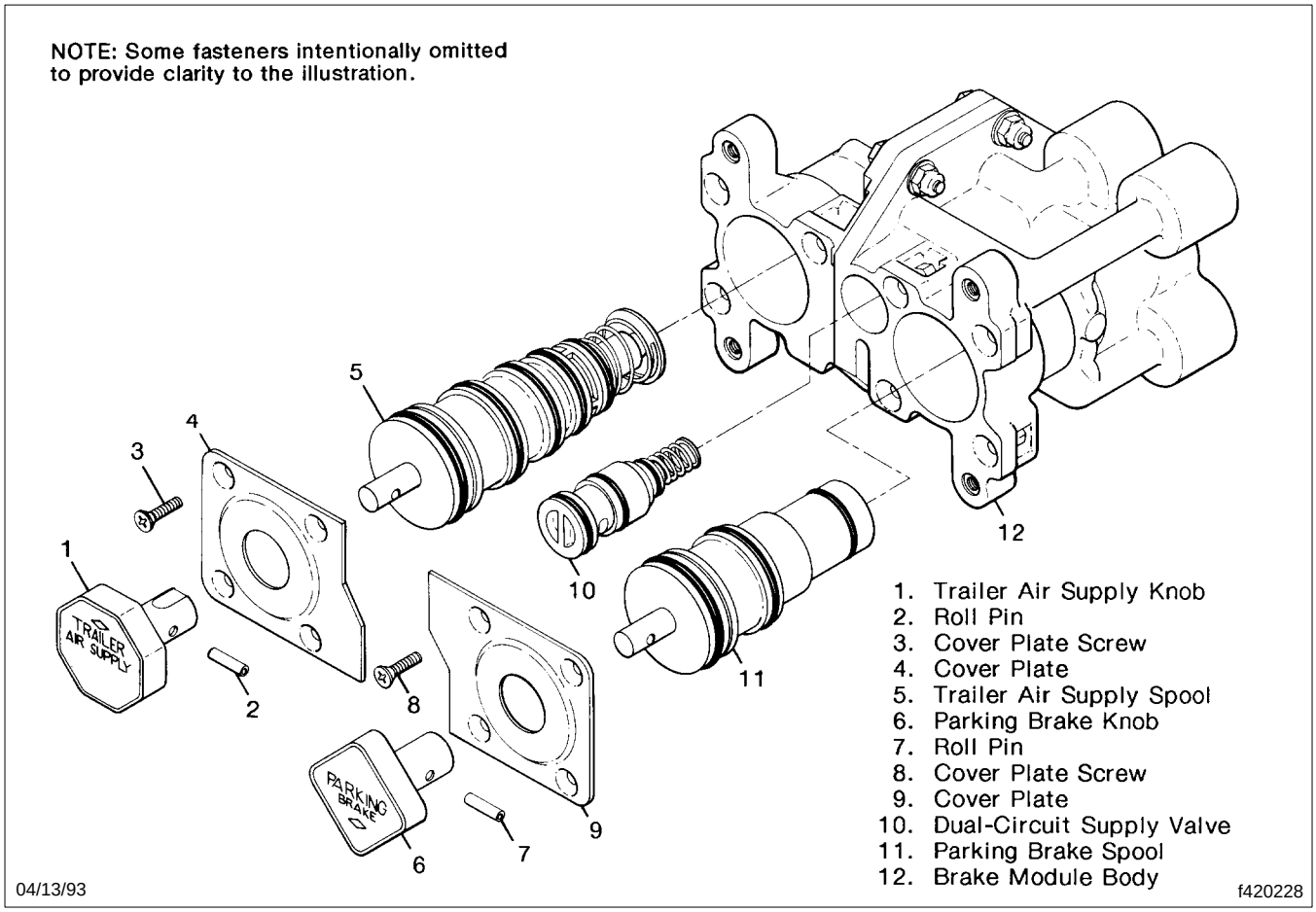


Fig. 1

1. Chock the tires, or otherwise secure the vehicle, and drain all the air reservoirs. It should be unnecessary to remove the control module from the vehicle. Remove the panel, to expose the valve cover plates. It is recommended that the valve be serviced by replacing the complete spool assemblies.

NOTE: The dual-circuit supply valve is located behind the cover plate surrounding the parking brake valve knob. Do not remove the dual-circuit supply valve unless it is to be serviced.

2. Remove the cover plate screws (four in each cover).
3. Carefully pull the spool assemblies out of the body bores by pulling on the knobs.

⚠ CAUTION

CAUTION: When removing a roll pin from a knob, do not place the spool assembly in a vise. To do so could distort or crack the spool assembly.

4. Using a hammer and punch, remove the roll pins, which retain the knobs on the spool stems. Remove the knobs and cover plates.

Spool Replacement

CAUTION

CAUTION: Non-metallic components, which comprise most of the parts of the control module, should not be immersed in any solvent-type cleaner.

5. Old lubricant should be wiped off parts to be reused and the bores of the control module body wiped out with a clean dry cloth. The O-rings and all sliding surfaces should be lubricated with Bendix BW-650-M Silicone Lubricant (291126) or equivalent.
6. Place the cover plates over each plunger stem. The cover plates are identical and are installed convex side up.

CAUTION

CAUTION: Do not place the spool assembly in a vise. To do so could distort or crack the spool assembly.

7. Place the red knob on the longer spool (for trailer air supply), matching the groove in the knob with the tongue in the cover plate (where applicable). Using a hammer and punch, secure the knob with the knob roll pin.
8. Place the yellow knob on the shorter spool (for tractor air supply), matching knob and cover (where applicable) and securing with the knob roll pin as before.

NOTE: If new service replacement spools are being installed, they will be pre-lubricated, and a new roll pin will be found in each spool package.

If old spools are being used, the O-rings and all sliding surfaces should be lubricated with Bendix BW-650-M Silicone Lubricant.

9. Insert the shorter spool assembly (yellow knob) in the tractor supply bore (housing with the dual supply valve). If the entire valve assembly has been removed, position the assembly so that the tractor control body housing is at 3 o'clock. With the open bore (trailer supply) at 9 o'clock, rotate the knob until the wording on the top-center is horizontally readable. The stepped side of the cover plate should be covering the dual-circuit supply valve. Secure the plate with the four, flat-head Phillips screws; then torque 25 lbf·in (280 N·cm).

   Insert the longer spool assembly (red knob) in the remaining bore. The stepped sides of the cover plates should key with each other when the remaining, four, flat-head screws are torqued 25 lbf·in (280 N·cm).
10. Install the panel that surrounds the control knob.
11. Remove the chocks from the tires.

IMPORTANT: Always perform the operating tests in this section, after servicing the MV-2 brake control module, and before operating the vehicle.

Servicing

The dual-circuit supply valve feature may be serviced by replacing four O-rings and one spring, as follows:

1. Chock the tires, then drain all air reservoirs.
2. Remove the panel surrounding the control knobs, to gain access to the valve cover plates.
3. Remove the cover plate screws from the cover plate surrounding the yellow knob. **See Fig. 1.** Then, carefully pull the parking valve spool assembly out of the body bore by pulling on the knob.

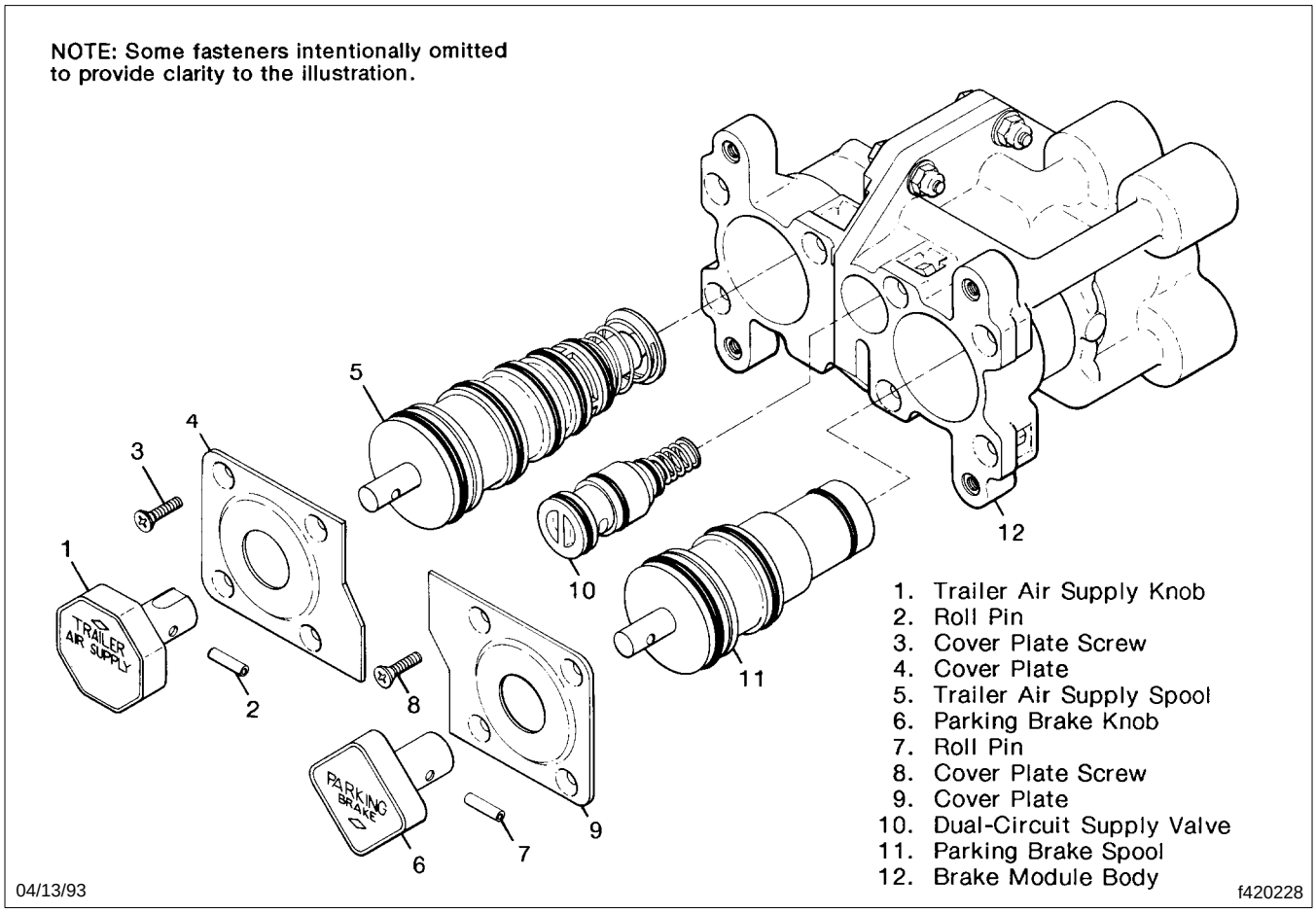


Fig. 1

4. Using needle nose pliers, grasp the cover of the dual-circuit supply valve (located alongside the empty body bore), twist, and pull the dual-circuit supply valve out. The shuttle return spring and shuttle should come out with the spool.

CAUTION

CAUTION: Do not use a solvent type cleaner, as this may damage the components of the control module.

5. Remove the shuttle return spring, shuttle, and four O-rings, and discard the spring and four O-rings. **See Fig. 2.** Clean the inside of the body bore with a clean, dry cloth, and remove the old lubricant from the spool and shuttle.
6. Lubricate the dual-circuit supply valve body bore, new O-rings, shuttle, and spool with Bendix BW-650-M Silicone Lubricant (291126), Dow Corning

Dual-Circuit Supply Valve Servicing

55-M, or equivalent. Place the new shuttle return spring in the body bore.

7. Install new O-rings on the shuttle and valve spool; insert the small end of the shuttle in the spool. **See Fig. 2.**
8. Insert the dual-circuit supply valve assembly in the body bore; press it flush with the top of the body bore.
9. Insert the parking brake valve spool assembly in the body bore, then rotate the knob until the wording on the knob is horizontally readable. The notched side of the cover plate should cover the dual-circuit supply valve.
10. Secure the cover plate with the four cover-plate screws, tightening them 25 lbf·in (280 N·cm).
11. Install the panel that surrounds the control knobs.
12. Remove the chocks from the tires.

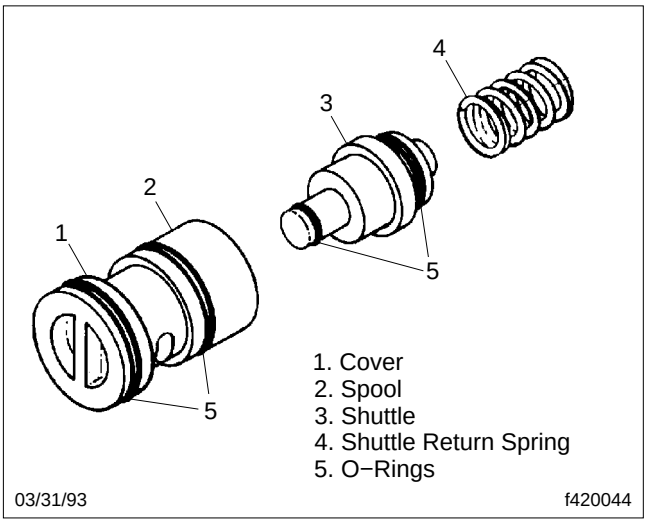


Fig. 2, Dual-Circuit Supply Valve

IMPORTANT: Always perform the operating tests in this section, after servicing the MV-2 brake control module, and before operating the vehicle.

General Information

The Bendix PP-3 trailer air supply valve is a push-pull, button-operated valve, and is installed in the control panel. An air hose from the air reservoir connects to the supply port of the PP-3 valve. The delivery hose to the tractor protection valve is connected to the PP-3 valve delivery port. **See Fig. 1**. The PP-3 valve works in conjunction with the tractor protection valve to supply pressurized air to the trailer brake system.

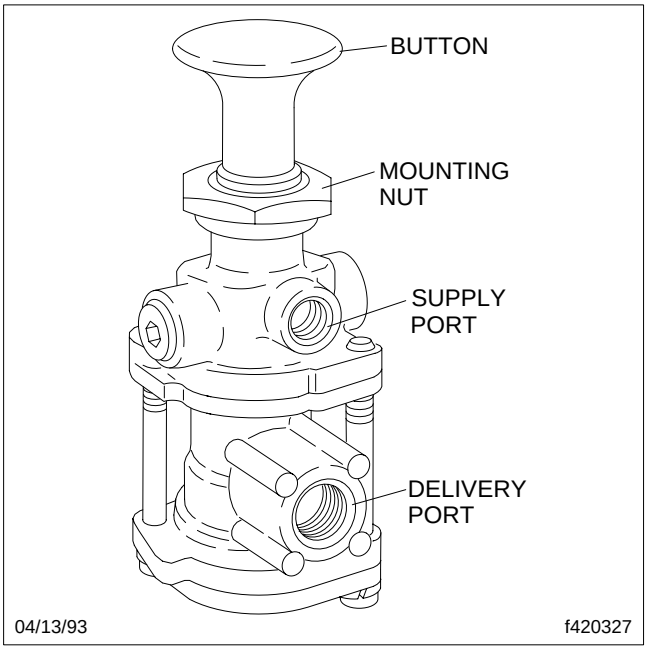


Fig. 1

Principles of Operation

When the PP-3 valve button is pushed in, the inlet and exhaust valve (within the PP-3 valve) opens, allowing pressurized air to flow out the delivery port to the tractor protection valve and trailer air system. The button will remain in when there is 50 psi (345 kPa) of air pressure in the supply line. When the button is pulled out, the air pressure is exhausted out the PP-3 valve exhaust port. The inlet and exhaust valve is closed, shutting off the air supply to the tractor protection valve and trailer system, causing the trailer parking brakes to apply.

If there is a loss of air pressure in the vehicle or trailer air system because of leakage, and the PP-3 valve button is not pulled out, the PP-3 valve will automatically pop out and close when the air pressure drops below 40 psi (276 kPa). If the button is manually held in, and the air pressure drops to 30 psi (207 kPa), the tripper piston (within the valve) will move and open the tripper exhaust. Air is exhausted through the tripper exhaust, causing the trailer parking brakes to apply.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Always chock the tires and stop the engine when working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing air pressure. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been depleted.
3. Never exceed recommended air pressure and always wear safety glasses when working with air pressure. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

Operating and Leakage Tests

To make the following operating and leakage checks, an accurate test gauge installed in a spare hose coupling is required. The vehicle dash gauge should be checked for accuracy against the test gauge prior to making these tests.

1. Apply the parking brakes, and chock the tires.
2. Drain the vehicle air system. Close the drain cocks.
3. Connect the assembled hose coupling and test gauge in the tractor emergency hose coupling. Start the engine and build up system pressure.
4. As reservoir pressure builds up there should be no pressure reading on the test gauge. When system pressure reaches the 30 to 40 psi (207 to 276 kPa) range on the dash gauge, make and hold a foot or hand valve application and observe that no air escapes at the open trailer service hose coupling.
5. When system pressure reaches about 60 psi (413 kPa), the PP-3 valve button should be pushed in. System pressure should show at once on the test gauge connected in the emergency line, and the button of the PP-3 valve should remain in without being held.
6. Build the system pressure up to about 100 psi (689 kPa), then stop the engine. With the engine stopped, wait momentarily, then notice that the dash gauge and test gauge pressure readings equal. While still in this position, make a foot or hand valve application, and observe that air is delivered out the open trailer service coupling.
7. With the PP-3 valve button still in, check for leakage at the PP-3 valve exhaust and tripper exhaust ports. Leakage should not exceed a 1-inch (25-mm) bubble in five seconds at either point.
8. With the PP-3 valve button still in, check for leakage at the tractor protection valve exhaust and open service coupling. Leakage should not be more than a 1-inch (25-mm) bubble in five seconds at either point.
9. Pull the PP-3 valve button out. Pressure on the test gauge connected in the emergency line should drop to zero. Make and hold a hand valve application, and observe that air delivered at the open service coupling does not exceed a 1-inch (25-mm) bubble in five seconds. Release the foot or hand valve application.

IMPORTANT: If the PP-3 valve does not function as described in the above tests, or if leakage is excessive, it is recommended that it be returned to the nearest Bendix HVSG (Heavy Vehicle Systems Group) authorized distributor for a factory rebuilt valve. If this is not possible, the valve should be repaired using genuine Bendix HVSG parts, and the instructions in this section.

Removal

1. Apply the parking brakes, and chock the tires. Drain the air system.
2. Remove the dash panel covering the valves. Remove the bracket and valves from the dash structure. Lift the bracket and valves to a serviceable level.
3. Disconnect the supply and delivery lines from the PP-3 valve. Mark the lines for later assembly reference. Cap the air lines tightly to keep out contaminants.
4. Drive out the PP-3 button spirol pin (**Fig. 1**, Ref. 10), and remove the button. Remove the PP-3 valve mounting nut, then remove the PP-3 valve from the bracket.

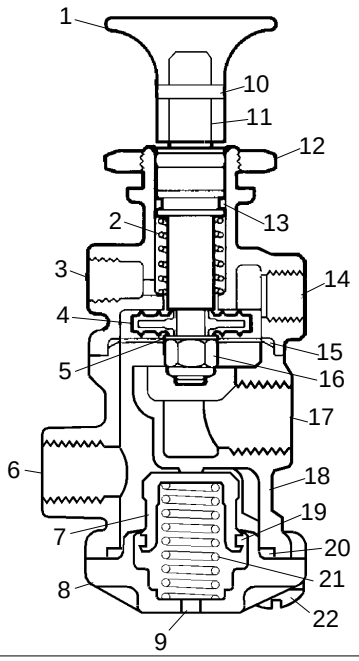
Installation

1. Remove the caps from the air lines. Connect the nylon tube hose fittings to the el-bow fittings in the valve ports, and tighten the nuts finger-tight. Then, using a wrench, tighten the nuts a minimum of two turns, or until no threads show on the fittings.

IMPORTANT: Connect the supply line from the tractor reservoir to the supply port of the PP-3 valve. Connect the delivery line that leads to the tractor protection valve emergency port to the PP-3 valve delivery port. The PP-3 valve exhaust port and tripper exhaust must be open. Two ports marked "Del" on the upper PP-3 control valve body are plugged, and must remain plugged.

2. Place the PP-3 valve in the bracket mounting hole. Install and tighten the valve mounting nut.
3. Install the button on the valve, and attach with the button spirol pin.
4. Install the bracket and valves in the dash. Install the dash panel.

Removal and Installation



1. Button
2. Plunger Spring
3. Supply Port
4. Inlet and Exhaust Port
5. Washer
6. Delivery Port
7. Tripper Piston
8. Cover
9. Tripper Exhaust
10. Spirol Pin
11. Plunger
12. Mounting Nut
13. Plunger O−Ring
14. Pipe Plug
15. Upper and Lower Body Seal O−Ring
16. Inlet and Exhaust Valve Nut
17. Exhaust Port
18. Lower Body
19. Tripper Piston Cover Seal O−Ring
20. Cover Seal O−Ring
21. Tripper Spring
22. Lower Body Capscrews

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Fig. 1, PP-3 Trailer Air Supply Control Valve

Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)

1. Remove the valve from the vehicle. For instructions, refer to **Subject 120**.
2. Remove the two lower body capscrews (Ref. 22) and lockwashers, then the lower body with the cover.
3. Remove the cover with the tripper piston from the lower body.
4. Remove the tripper piston and tripper spring from the cover.
5. Remove the tripper piston and cover seal O-rings.
6. Insert a rod or punch in the upper plunger pin hole, and hold the plunger from turning while the inlet and exhaust valve nut is removed.
7. Remove the washer and the inlet and exhaust valve.
8. Pull the plunger from the upper body.
9. Remove the plunger spring and O-ring (Ref. 13).
10. Remove the upper body seal ring. Do not remove the plugs from the ports marked "Del" in the upper body.

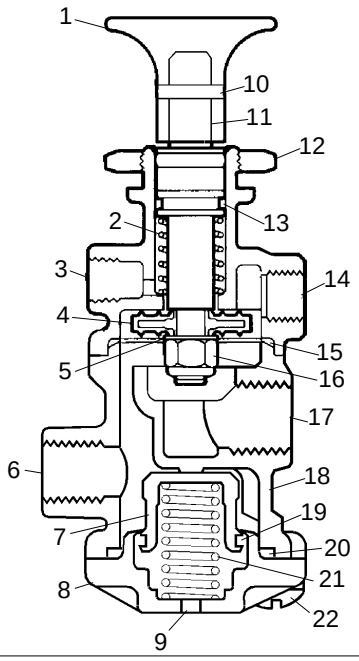
Cleaning and Inspection

1. Wash all metal parts in mineral spirits, and then dry.
2. Make sure the supply port in the PP-3 valve upper body, tripper bypass slot, and tripper exhaust port in the cover are thoroughly cleaned and unrestricted.
3. Inspect all parts for excessive wear or deterioration.
4. Inspect the seats in the upper and lower body for nicks and burrs. Redress seats if damaged.
5. Inspect the plunger and tripper piston bores in the bodies and cover for deep scratches or nicks. They should be smooth and clean.
6. Check the springs for distortion, corrosion, and cracks.
7. Replace all parts not considered serviceable during these inspections, especially the O-rings and valves.

Assembly (See Fig. 1)

1. Lubricate all O-rings and bearing surfaces with silicone lubricant, Bendix part number 291126, or equivalent.
2. Install the plunger O-ring.
3. Position the plunger spring in the upper body, then press the plunger down inside the spring in the body.
4. Place the inlet and exhaust valve, then the washer (Ref. 5), over the threaded, protruding end of the plunger.
5. Install and tighten the valve self-locking nut. Tighten the nut 30 to 40 lbf·in (340 to 460 N·cm).
6. Place the upper and lower body seal O-ring (Ref. 15) in place.
7. Install the tripper piston O-ring (Ref. 19).
8. Position the cover seal O-ring (Ref. 20) on the cover.
9. Position the tripper spring in the cover, then press the tripper spring down over the spring and into the cover bore.
10. Place the cover with the tripper installed into the lower body.
11. Fasten the lower body and cover assembly to the upper assembly with the capscrews and lockwashers. Tighten the capscrews evenly and securely.
12. Install the PP-3 valve in the dash. For instructions, refer to **Subject 120**.
13. Perform the operating and leakage checks. For instructions, refer to **Subject 110**.

Disassembly, Cleaning and Inspection, and Assembly



1. Button
2. Plunger Spring
3. Supply Port
4. Inlet and Exhaust Port
5. Washer
6. Delivery Port
7. Tripper Piston
8. Cover
9. Tripper Exhaust
10. Spirol Pin
11. Plunger
12. Mounting Nut
13. Plunger O−Ring
14. Pipe Plug
15. Upper and Lower Body Seal O−Ring
16. Inlet and Exhaust Valve Nut
17. Exhaust Port
18. Lower Body
19. Tripper Piston Cover Seal O−Ring
20. Cover Seal O−Ring
21. Tripper Spring
22. Lower Body Capscrews

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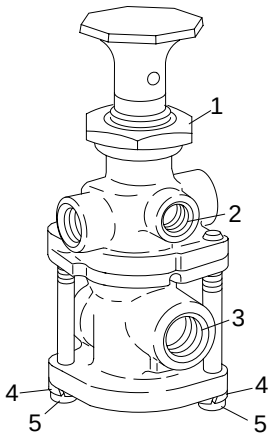
Fig. 1, PP-3 Trailer Air Supply Control Valve

General Description

The PP-7 trailer supply valve (**Fig. 1**) provides in-cab control for the tractor protection system and functions in conjunction with the tractor-trailer parking brake control valve. It is responsible for synchronizing the tractor and trailer parking and emergency brakes.



1. Nut and Thread
2. 1/8" Pipe Thread Supply
3. Exhaust
4. Lockwasher
5. Capscrew

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Fig. 1, PP-7 Trailer Air Supply Valve

It is essentially a combination of two non-modulating, on-off control valves in a single package.

Each of the four pipe-tapped ports of the PP-7 are identified with cast-in, raised letters. The supply and control ports have 1/8-inch NPTF dry seal pipe threads while the delivery and exhaust ports have 1/4-inch NPTF dry seal pipe threads.

Principles of Operation

The PP-7 trailer supply valve is a panel mounted, push-pull operated control valve. The button of the PP-7 valve must be manually pushed in to charge the trailer with air, but will automatically pop out and exhaust if supply air is below 40 psi (276 kPa). 50 psi (345 kPa) or greater supply air pressure is required for the button to remain in after it is pushed in, and it will remain in until the supply air pressure falls below 40 psi (276 kPa), or until the valve is manually actuated.

With less than 50 psi (345 kPa) system air pressure (**Fig. 2**), the button of the PP-7 valve will be out and the tractor-trailer parking brake control valve will not deliver air to the control port of the PP-7 valve. In this condition, supply air cannot flow past the closed plunger inlet, and the plunger exhaust valve is off its seat. With no air pressure on the control port, the control inlet is seated and the exhaust passage through the control piston is open.

If the driver holds the button of the PP-7 valve in after supply air pressure has dropped below the 40 psi (276 kPa) automatic pop-out pressure, the control piston will move into the exhaust position when control port pressure falls below 20 psi (138 kPa).

When system air pressure is greater than 50 psi (345 kPa) (**Fig. 3**), the button of the PP-7 valve can be pushed in and it will stay in. If the vehicle is in the running condition (parking brake released), the tractor-trailer parking brake control valve will be delivering system air pressure to the control port of the PP-7 valve.

With the button of the PP-7 valve pushed in, the plunger inlet will be open and the exhaust valve will be seated, sealing the exhaust vent. Supply air is permitted to flow through the body to the control inlet and exhaust valve. With the tractor-trailer parking brake control valve delivering full system pressure to the control port of the PP-7 valve, the control piston moves into contact with the control valve, closing the exhaust passage through the piston and opening the inlet. Opening the control inlet permits supply air to flow out the delivery port of the PP-7 valve.

NOTE: If the vehicle parking brakes are applied and system air pressure is above 50 psi (345 kPa), the tractor-trailer parking control valve will not be delivering air to the PP-7 control port and the control inlet valve will be closed. In this case, no air will be flowing from the delivery port of the PP-7 valve.

Prior to disconnecting the trailer from the tractor, the button of the PP-7 valve is pulled out by the operator. This will shut off the air supply to the trailer without bleeding down the tractor air system. Pulling the button closes the plunger inlet and unseats the exhaust valve (**Fig. 4**). Air that was flowing out the de-

General Description and Principles of Operation

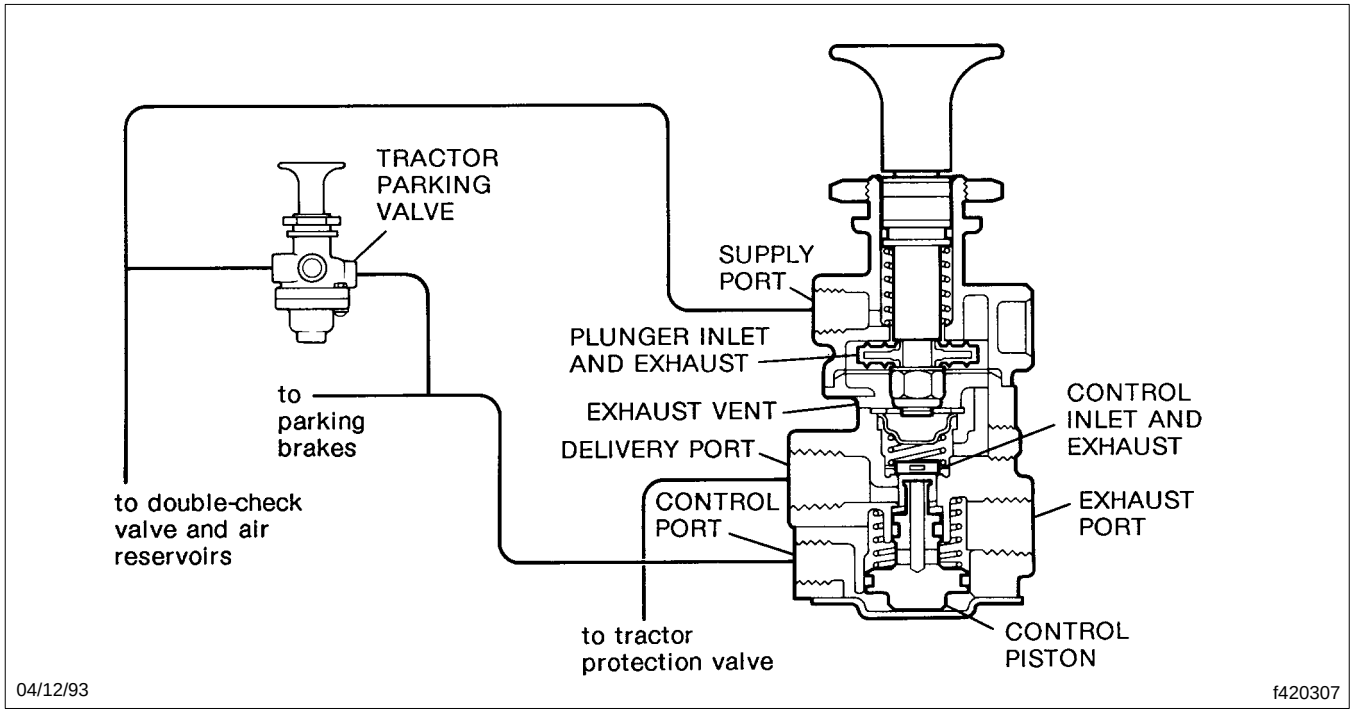


Fig. 2, PP-7 Valve With Less Than 50 psi (345 kPa) System Pressure

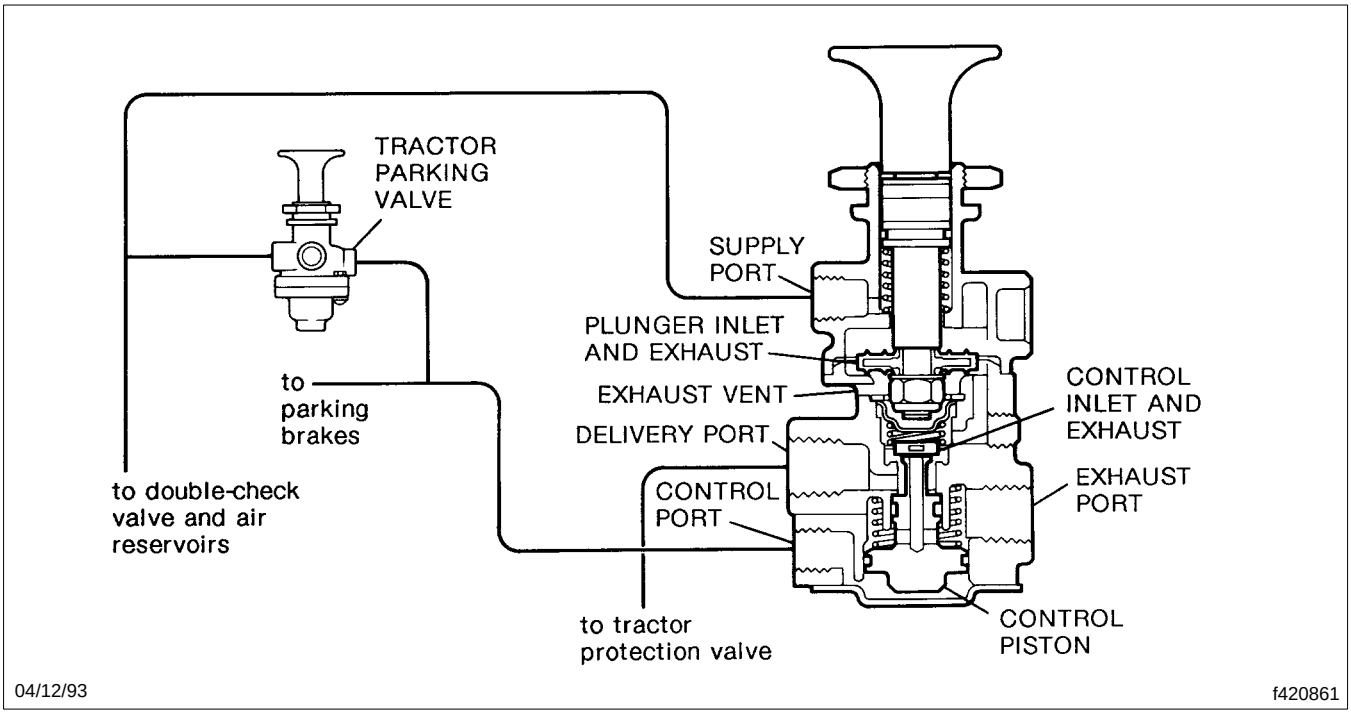


Fig. 3, PP-7 Valve System Fully Charged

livery port returns to the PP-7 valve and is exhausted from the vent in the midsection of the PP-7 valve.

NOTE: If the parking brakes were applied prior to pulling the PP-7 button, no delivery air would be present to exhaust. Delivery air would have been exhausted when the parking brakes were applied.

In the event of trailer breakaway or a sudden complete failure of the trailer supply line, the button of the PP-7 will pop out. In this situation the air pressure retained in the tractor air system should be within approximately 10 psi (69 kPa) of the registered air pressure just prior to the breakaway or failure. The reason for this reaction is that air escaping from the failed supply line cannot be replaced through the supply port of the PP-7 valve as fast as it is being lost. The rapid loss of air pressure within the PP-7 valve results in a momentary reduction below the 40 psi (276 kPa) pop out pressure of the PP-7 plunger.

If a leak develops that is not as severe as a broken line, the PP-7 button will pop out when air pressure in the supply line falls below 40 psi (276 kPa).

During a parking brake application (**Fig. 5**), the tractor-trailer parking brake control valve removes air pressure from the control port of the PP-7, which cuts off the air supply to the trailer. The button of the PP-7 valve remains in.

With air pressure removed from the control port of the PP-7 valve, the control piston moves away from the control inlet and exhaust valve. The inlet valve seats and the exhaust passage through the control piston is open. Air at the delivery port of the PP-7 valve is exhausted at the exhaust port of the PP-7 valve.

General Description and Principles of Operation

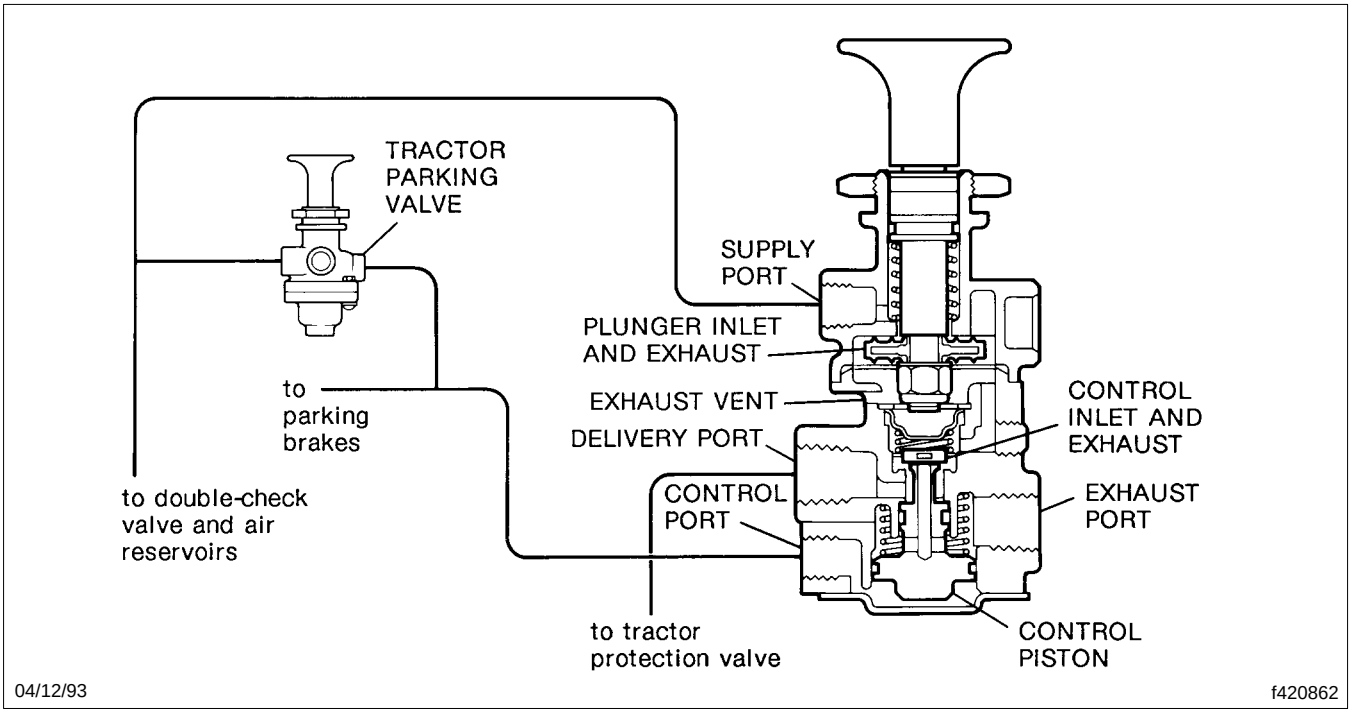


Fig. 4, PP-7 Valve Manual Emergency (Button Pulled Out)

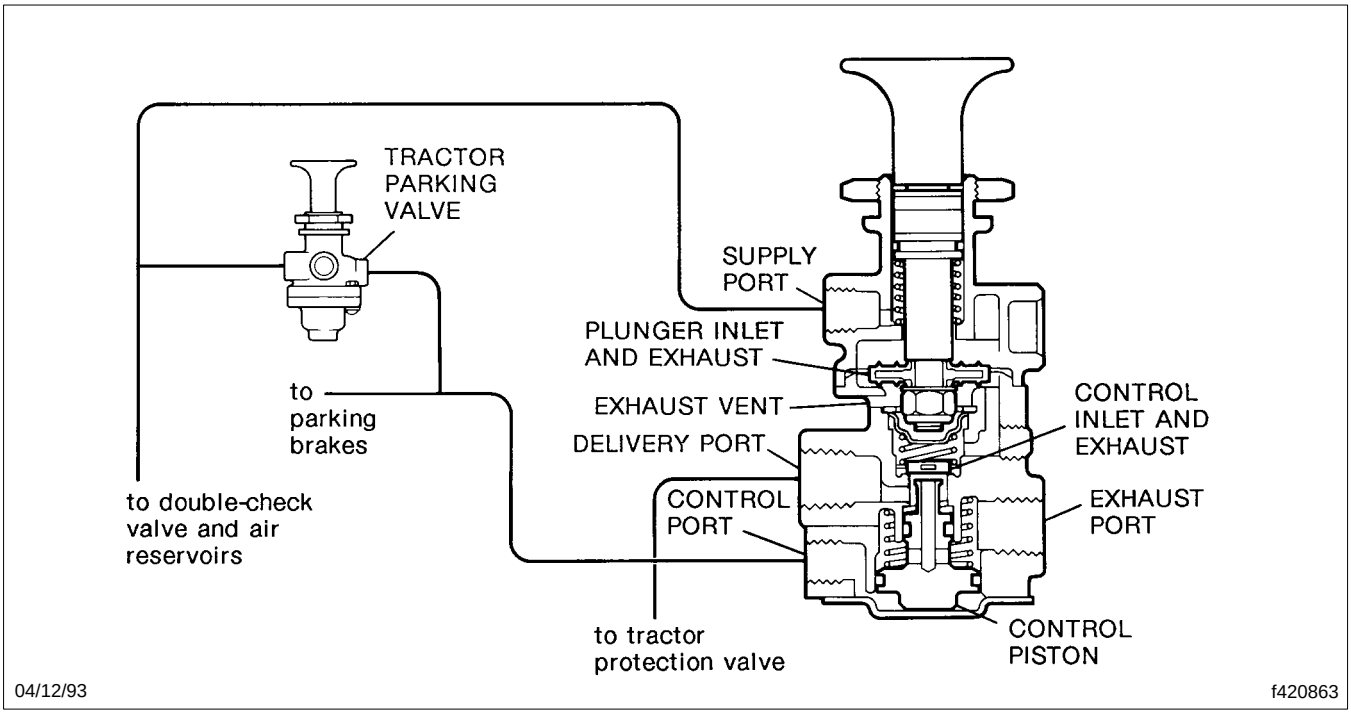


Fig. 5, PP-7 Valve, Park Application

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure, and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

Operating and Leakage Checks

To perform the following test, an accurate vehicle test gauge installed in a spare hose coupling is required. The vehicle dash gauge(s) should be checked for accuracy against the test gauge prior to making these tests.

1. Apply the parking brakes, and chock the tires.
2. With the PP-7 trailer supply valve button out and the tractor-trailer parking brake control valve in the "brakes applied" position, build the air system pressure to governor cut-out (125 psi [862 kPa]).
3. Apply a soap solution to the exhaust vent and the plunger stem of the PP-7 valve to check for leakage. Leakage must not exceed a 1-inch bubble in 5 seconds at either point.
4. Push in the control button of the PP-7 and apply a soap solution to the exhaust vent and the exhaust port. Leakage should not exceed a 1-inch bubble in 5 seconds at either point.
5. Install the test gauge and coupling on the tractor-trailer supply coupling (tractor emergency hose coupling) at the rear of the tractor.
6. Have someone place the tractor-trailer parking brake control valve in the "brakes released" position, and observe an immediate rise in pressure on the test gauge. The pressure registered on the test gauge should equal dash gauge or system pressure.
7. Apply a soap solution to the exhaust port of the PP-7 valve. Leakage should not exceed a 1-inch bubble in 5 seconds.
8. With the tractor air system at governor cut-out pressure (125 psi [862 kPa]), shut off the engine and note the dash gauge pressure. Quickly disconnect the test gauge and hose coupling from the tractor-trailer supply line coupling. Leakage from the tractor-trailer supply line should cease immediately and the button of the PP-7 valve should be out. Dash gauge air pressure after performing the preceding test should be within approximately 10 psi (69 kPa) of the initial pressure.
9. Reconnect the test gauge to the tractor-trailer supply line and depress the button of the PP-7 valve. Open the drain cocks of the No. 1 and No. 2 service reservoirs slightly. Note at what pressure (descending) the button of the PP-7 pops out and exhausts the tractor-trailer supply line. This should occur between 20 to 45 psi (138 to 310 kPa) air system pressure.

IMPORTANT: If the PP-7 trailer supply valve fails to function as described above, or if leakage is excessive, it is recommended that it be returned to the nearest Bendix authorized outlet for a factory remanufactured valve. If this is not possible, the valve should be repaired using only genuine Bendix replacement parts. For part numbers, refer to the *Freightliner Parts Book*.

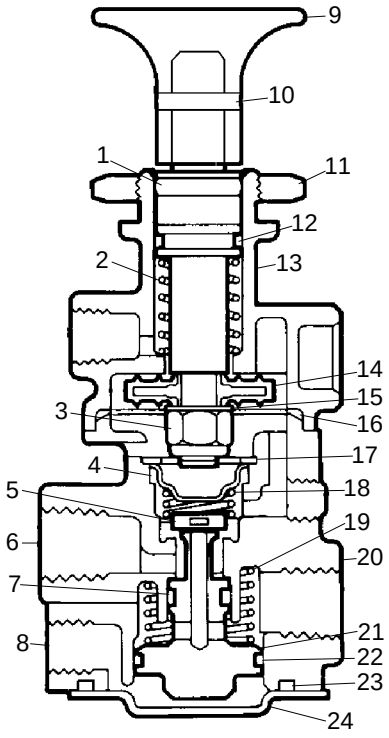
Removal

1. Apply the parking brakes, and chock the tires. Completely drain the air system.
2. Remove the screws attaching the push-pull air brake valves panel to the dash control panel. Lift the panel to a serviceable level.
3. Disconnect all of the air lines leading to and from the PP-7 valve, and mark them for later assembly reference. Cap the air lines tightly to keep out contaminants.
4. Using a drift pin punch, remove the spirol pin (**Fig. 1** , Ref. 10) which secures the button to the plunger. Remove the button.
5. Using a 1-5/16 inch wrench, remove the special thin nut which secures the PP-7 valve to the panel, and remove the valve.

Installation

1. Place the PP-7 valve in the panel mounting hole. Install and tighten the special thin nut.
2. Install the button on the valve, and attach it with the button spirol pin.
3. Remove the caps from the air lines. Connect the air lines to the PP-7 valve, as previously marked. Connect the nylon tube hose fittings to the elbow fittings in the valve ports, and tighten the nuts finger-tight. Then, using a wrench, tighten the nuts a minimum of two turns, or until no thread shows on the fittings.
4. Place the push-pull air brake valves panel on the dash control panel. Install and tighten the attaching screws.

Removal and Installation



1. Plunger
2. Plunger Return Spring
3. Hex Nut
4. O−Ring
5. Inlet and Exhaust Valve
6. Delivery Port, 1/4" Pipe Thread
7. O−Ring
8. Control Port, 1/8" Pipe Thread
9. Button
10. Spirol Pin
11. Thin Nut
12. O−Ring
13. Upper Body
14. Inlet and Exhaust Valve
15. Tru Arc Retaining Ring
16. Sealing Ring (Square Cut)
17. O−Ring
18. Inlet and Exhaust Valve Return Spring
19. Spring
20. Lower Body
21. Piston
22. Large O−Ring
23. End Plate O−Ring
24. End Plate

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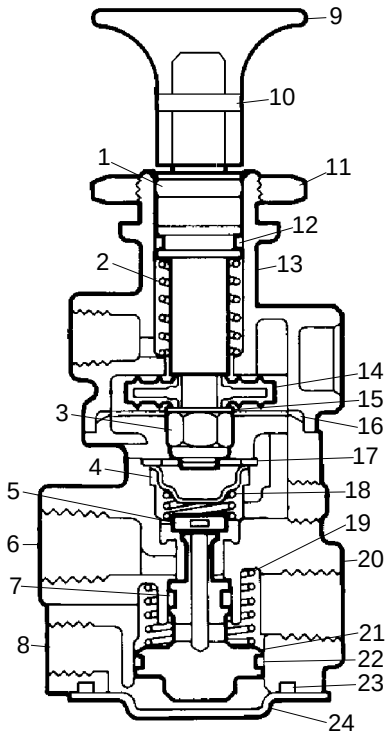
Fig. 1, PP-7 Trailer Air Supply Valve

Disassembly (See Fig. 1)



1. Plunger
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17. O−Ring
18. Inlet and Exhaust Valve Return Spring
19. Spring
20. Lower Body
21. Piston
22. Large O−Ring
23. End Plate O−Ring
24. End Plate

Fig. 1, PP-7 Trailer Air Supply Valve

1. Remove the PP-7 valve from the vehicle. For instructions, see **Subject 120**, "Removal."
2. Mark the upper and lower body halves to show their relationship to each other.
3. Remove the two 1/4–20 capscrews that secure the lower valve body to the upper valve body, using a 7/16-inch wrench. Separate the two body halves.
4. Remove and discard the square cut sealing ring (Ref. 16) between the upper and lower body halves.
5. Remove the end plate (Ref. 24) and O-ring (Ref. 23) from the lower body and discard the O-ring.
6. Remove the control piston (Ref. 21) and piston return spring (Ref 19).
7. Remove the large (Ref. 22) and small diameter (Ref. 7) O-rings from the piston and discard them.
8. Remove the internal tru arc retaining ring (Ref. 15) from the lower body.
9. Remove the O-ring retainer (Ref. 17), then remove and discard the O-ring (Ref. 4).
10. Remove the inlet and exhaust valve (Ref. 5), and the return spring (Ref. 18).
11. Using a 7/16-inch wrench, remove the special (ESNA) hexnut (Ref. 3) from the plunger inlet exhaust valve and washer.
12. Remove the plunger inlet and exhaust valve (Ref. 14), and washer.
13. Remove the plunger (Ref. 1) and the plunger return spring (Ref. 2) from the body.
14. Remove and discard the plunger O-ring (Ref. 12).

Disassembly, Cleaning and Inspection, and Assembly

Cleaning Inspection

1. Clean all metal parts in a good commercial solvent making sure all ports, passages, and bores are clean and open.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

2. Dry the parts thoroughly, and inspect the plunger and piston bores for scratches and nicks.
3. It is recommended that all non-metallic parts and springs be replaced, using only genuine Bendix replacements.

Assembly (See Fig. 1)

Prior to assembly, all internal bores and all non-metallic parts should be coated with a film of silicone lubricant, Bendix part number 291126, or equivalent.

1. Install the inlet and exhaust valve (Ref. 5) and the return spring (Ref. 18) in the lower body.
2. Install the O-ring (Ref. 4) in the body, then the O-ring retainer (Ref. 17) and the tru arc retaining ring (Ref. 15).
3. Install the end plate O-ring (Ref. 23) in the oval groove in the lower body.
4. Install the plunger O-ring (Ref. 12), and place the plunger return spring (Ref. 2) and plunger (Ref. 1) in the upper body.
5. Depress the plunger until the threaded portion extends sufficiently to install the plunger inlet and exhaust valve (Ref. 14), the valve washer, and special hexnut (Ref. 3). Tighten the special hexnut 30 to 40 lbf·in (340 to 460 N·cm).
6. Install the square cut seal ring (Ref. 16) in the upper body.
7. Install the large (Ref. 22) and small diameter O-rings (Ref. 7) on the control piston (Ref. 21).
8. Place the upper and lower bodies together taking care to align the marks made during disassembly.
9. Install the piston return spring (Ref. 19) and the control piston in the lower body.
10. Install the end plate (Ref. 24) on the lower body, and secure it with the two 1/4-20 capscrews.
11. Tighten the capscrews 30 to 40 lbf·in (340 to 460 N·cm).
12. Install the PP-7 valve in the control panel. For instructions, see **Subject 120**, "Removal."
13. Test the rebuilt unit. For instructions, see **Subject 110**.

General Information

The single check valve (**Fig. 1**) is installed in an air line to allow air flow in one direction and prevent air flow in the reverse direction. The check valve is installed in the upstream ends of the primary and secondary brake system air reservoirs to protect brake system air pressure in case the compressor, air pressure regulator or other air delivery component malfunctions. A malfunctioning check valve will allow air to flow out of the brake system, if the system is not being recharged by the compressor.

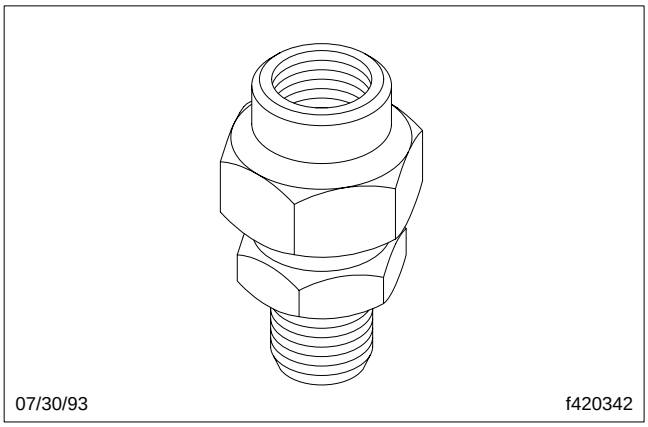


Fig. 1, Single Check Valve

Principles of Operation

When air in the system moves in the normal direction—from the compressor to the air reservoir—the check valve disk (**Fig. 2**, Ref. 4) compresses the spring (Ref. 2) and allows air to pass. When there is a drop in air pressure on the supply side of the valve, the spring pushes the check valve disk against the valve seat (Ref. 5) and prevents air from leaving the brake system.

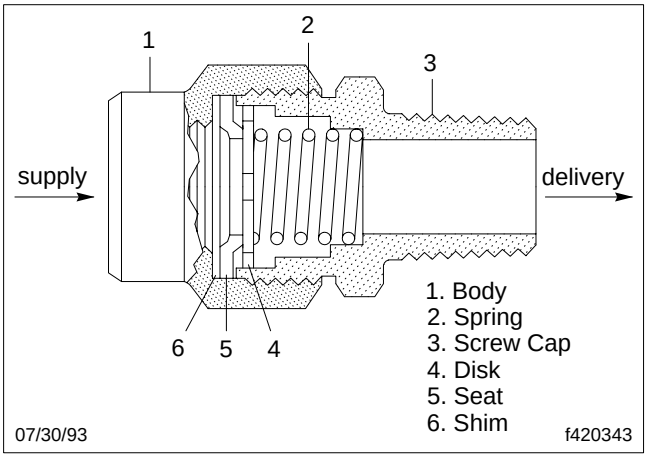


Fig. 2

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the wheels and stop the engine before working under the vehicle. Dropping air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

Leakage Test

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

After repairing or replacing the single check valve, do the following test:

With the brake air system fully pressurized, drain the air from the supply reservoir (we t tank), and remove the air line from the supply side of the check valve. Coat the open end of the check valve with soap suds. A 1-inch (2.5-cm) or smaller bubble in five seconds is acceptable.

If the drain valve is leaking excessively, repair or replace it.

Removal

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Chock the wheels, and open the air reservoir drain cocks to bleed air from the system.
2. Remove the supply line from the check valve.
3. Remove the check valve from the air reservoir.

Installation

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Screw the check valve into the supply end of the air reservoir. To ensure the valve is not reversed, the arrow marked on the valve body must point in the direction of air flow.
2. Leak test the check valve following the instructions **in Subject 110** .
3. Connect the supply line to the open end of the check valve.

Disassembly, Cleaning and Inspection, and Assembly

Disassembly

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Remove the check valve following the instructions **in Subject 120**.
2. Remove the screw cap from the body. **See Fig. 1** .
3. Remove the shim, seat, disk, and spring.

Cleaning and Inspection

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

Use eye protection when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

1. Wash all parts of the check valve in cleaning solvent. Dry the parts of the disassembled check valve with compressed air.

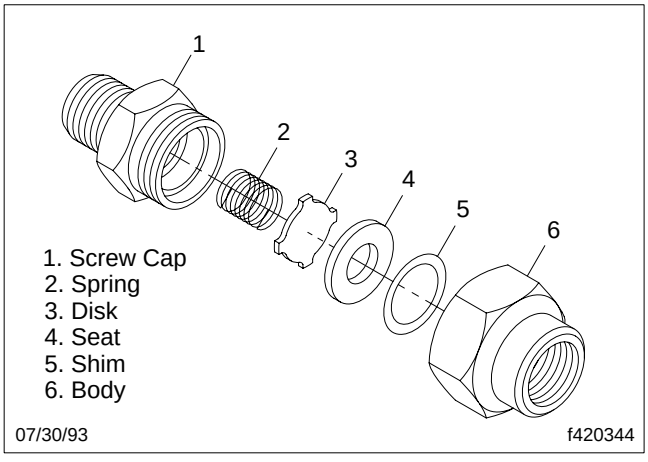


Fig. 1

2. Inspect the disk for signs of wear or deterioration.
3. Check the spring for cracks, corrosion, or damage.
4. Inspect the body and screw cap for cracks or damage. Replace all worn or damaged parts with new parts.

Assembly

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Position the shim, seat, disk, and spring in the body.
2. Screw the screw cap into the body over the other parts. Tighten it securely.
3. Install the check valve following the instructions **in Subject 120** .

General Description

The Bendix TP-5 tractor protection valve (**Fig. 1**) is an optional valve, and, when requested, replaces the TP-3 valve. Air hoses from the foot and hand brake valves connect to the TP-5 valve tractor service ports. The tractor-to-trailer air brake hoses are connected to the TP-5 valve trailer emergency port and trailer service port.

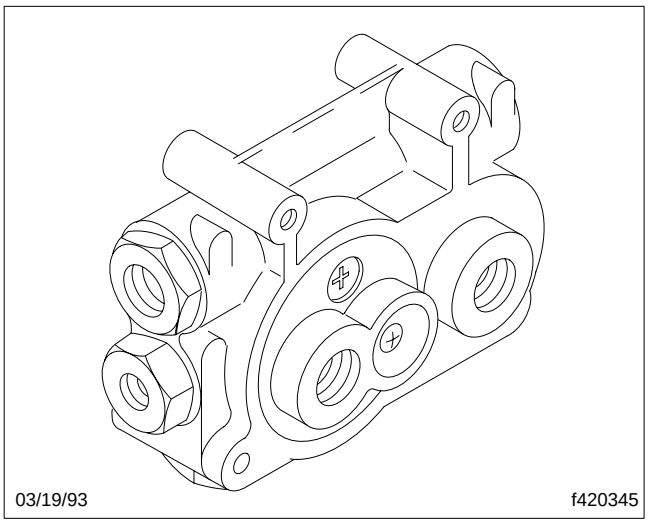


Fig. 1

Principles of Operation (See Fig. 2)

The function of the TP-5 valve is to receive all pneumatic signals pertinent to the operation of the trailer braking system, transmit them to the trailer, and protect the tractor air supply in case of separation of the connecting lines to the trailer.

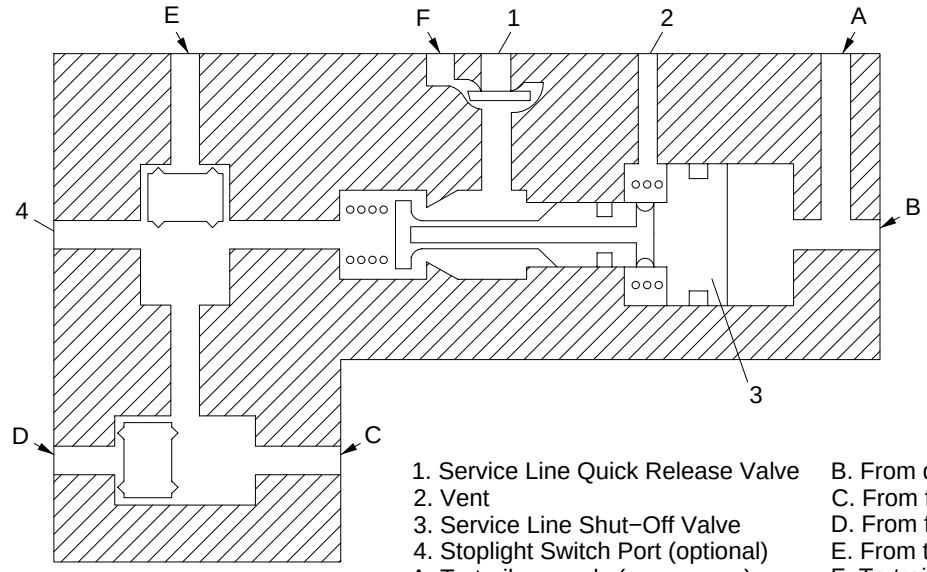
Air from the control valve in the cab enters at the tractor protection delivery port, passes out the trailer emergency port, and simultaneously acts upon the service line shutoff plunger moving the service line inlet valve off its seat and opening the service line passage. With common air to the supply side and service side of the TP-5 valve, it should open at approximately 45 psi (310 kPa).

If the control valve is manually or automatically moved to the exhaust position, the service line shutoff valve will close at approximately 10 psi (69 kPa) and the exhaust passage in the plunger will vent the trailer service line.

The two double check valves in the TP-5 valve serve to pick up the highest pressure service signal from either the tractor primary or secondary circuits, or hand control valve signal, operating the brakes accordingly.

The trailer service line port is in the valve cover. The valve cover also houses a quick release valve. The quick release valve diaphragm seals off the exhaust port on service line application and upon release of application, allows the trailer service line air to exhaust through the exhaust port, permitting faster release times for trailer brakes.

General Description and Principles of Operation



1. Service Line Quick Release Valve
2. Vent
3. Service Line Shut−Off Valve
4. Stoplight Switch Port (optional)

A. To trailer supply (emergency)
B. From dash valve trailer delivery
C. From foot brake valve secondary delivery
D. From foot brake valve primary delivery
E. From trailer hand control valve
F. To trailer service

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Fig. 2, TP-5 Valve Schematic Diagram

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

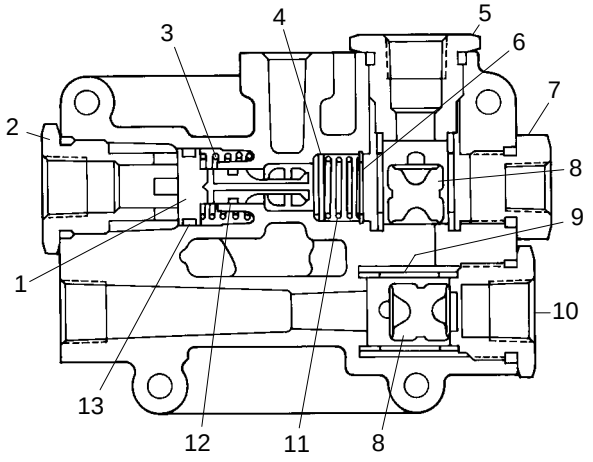
1. Chock the tires and stop the engine before working under a vehicle. Dropping air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

Test

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

The following tests should be performed after repairing or replacing the TP-5 valve to ensure that the valve is functioning properly.

1. Fully charge the air brake system, chock the tires, and place the brake control valve in the emergency position.
2. Disconnect the trailer service line hose coupling. Make a trailer hand control valve application. Hold your finger over the 1/16-inch vent hole in the service line shutoff valve area of the TP-5 valve casting. Check for leakage at the hose coupling and at the TP-5 valve exhaust port. Excessive leakage at either port indicates fault at the inlet valve (**Fig. 1** , Ref. 4).



1. Service Line Shutoff Plunger
2. Capnut
3. Spring
4. Inlet Valve
5. Capnut
6. Snap Ring
7. Capnut
8. Double Check Shuttles
9. Double Check Guides
10. Capnut
11. Spring
12. Small O−Ring
13. Large O−Ring

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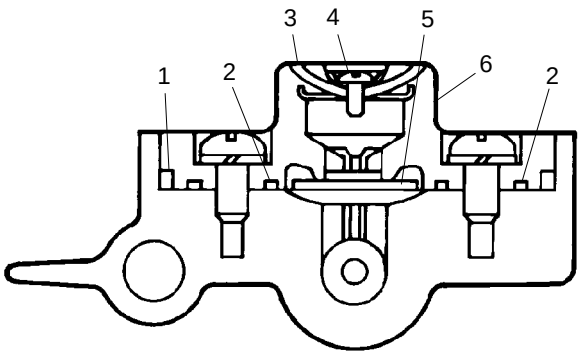
Fig. 1, TP-5 Valve Body (sectional view)

3. Release the hand control valve application and place the brake control valve in the normal position.
4. Connect the tractor service hose coupling to a test gauge, apply the hand control valve and note that there is pressure at the service hose coupling.
5. Check for leakage at the service line quick-release valve. Excessive leakage would indicate a damaged quick-release valve diaphragm (**Fig. 2** , Ref. 5).
6. With service line pressure still applied through the hand control valve, check for leakage at the brake valve exhaust. Excessive leakage indicates a damaged double check valve shuttle.



1. Large O−Ring
2. Small O−Ring
3. Exhaust Check Valve Diaphragm
4. 6−32 Panhead Screw
5. Quick−Release Valve Diaphragm
6. Valve Cover

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Fig. 2, TP-5 Valve Cover (sectional view)

7. Check for leakage at the 1/16-inch vent hole. Leakage indicates that an O-ring (**Fig. 1** , Ref. 12 or 13) is damaged.
8. Release the hand control valve application and check for leakage at the vent hole. If leakage continues, the large O-ring (**Fig. 1** , Ref. 13) is leaking. If leakage stops, the smaller O-ring (Ref. 12) is leaking.
9. Make and hold a foot brake application. Check for leakage at the exhaust port of the hand con-

Operating and Leakage Test

trol valve. Excessive leakage indicates fault at the double check valve shuttle.

10. Release the foot brake application, disconnect the line from the primary service brake circuit at the TP-5 valve delivery port marked PCD, and block off the end of the line from the brake valve. Make a foot brake application and check for leakage at the delivery port.
11. Reconnect the primary circuit line and reverse the procedure with the secondary circuit line marked SCD. Excessive leakage in either capnut (**Fig. 1** , Ref. 2 or 10) indicates fault at the double check valve shuttle. Restore the secondary circuit connection to the TP-5 valve.
12. If the valve does not function as described, or if leakage is excessive, the valve should be exchanged, repaired, or replaced following the instructions in this section.

Removal

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Chock the tires and drain the air brake system.
2. Remove the trailer hose assembly connected to the TP-5 valve.
3. Remove the lines from the TP-5 valve, marking them for later assembly reference.
4. Remove the TP-5 valve from the vehicle.

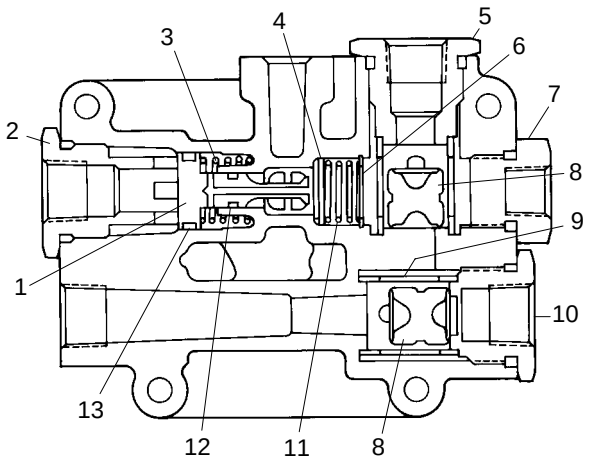
Installation

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Install the new or repaired TP-5 valve on the vehicle.
2. Attach the lines to the TP-5 valve as previously referenced.
3. Attach the trailer hose assembly to the back of the cab.
4. Test the new or repaired valve, following the instructions **in Subject 110** .

Disassembly

1. Remove the TP-5 valve from the vehicle, following the instructions **in Subject 120**.
2. Remove the four capnuts (**Fig. 1** , Refs. 2, 5, 7, and 10) from the valve body. Identify the capnuts to their respective ports before removing them. Remove the O-rings from the capnuts.
3. Remove the service line shutoff plunger (**Fig. 1** , Ref. 1) and spring (Ref. 3).
4. Remove the double check guides and double check shuttles. See **Fig. 1** , Refs. 8 and 9.
5. Reach into the port marked BLK-SLS with a set of snap-ring pliers, and remove the snap ring (**Fig. 1** , Ref. 6), spring (Ref. 11), and inlet valve (Ref. 4).



1. Service Line Shutoff Plunger
2. Capnut
3. Spring
4. Inlet Valve
5. Capnut
6. Snap Ring
7. Capnut
8. Double Check Shuttles
9. Double Check Guides
10. Capnut
11. Spring
12. Small O−Ring
13. Large O−Ring

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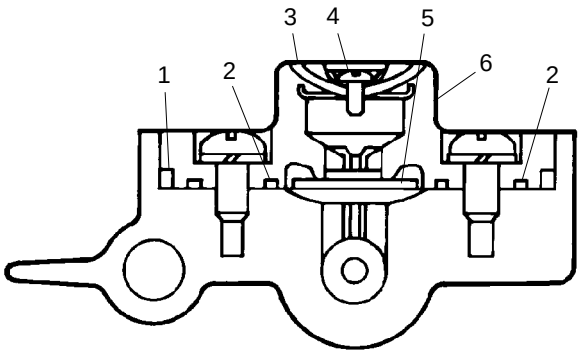
Fig. 1, TP-5 Valve Body (sectional view)

6. Remove the two screws that hold the valve cover to the valve body. Remove the two small O-rings and one large O-ring. **See Fig. 2** , Refs. 1 and 2. Remove the quick-release valve diaphragm (Ref. 5).
7. Remove the 6-32 panhead screw (**Fig. 2** , Ref. 4) and remove the exhaust check valve diaphragm (Ref. 3).

WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

8. Clean all parts, bores, and passages with a solvent equivalent to mineral spirits.



1. Large O−Ring
2. Small O−Ring
3. Exhaust Check Valve Diaphragm
4. 6−32 Panhead Screw
5. Quick−Release Valve Diaphragm
6. Valve Cover

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Fig. 2, TP-5 Valve Cover (sectional view)

Assembly

NOTE: Before assembly, lubricate all O-rings, bores, pistons, etc. with BW-650-M lubricant or an equivalent, and replace all worn or deteriorated parts.

1. Install the inlet valve, spring, and snap ring in the valve body.

Disassembly and Assembly

2. Install the double check guides, double check shuttles, and their respective capnuts.
3. Install the O-rings on the service line shutoff plunger, and install the spring, plunger, and corresponding capnut with O-ring.
4. Install the quick-release valve diaphragm in the valve body and the O-rings in the valve cover. Install the valve cover to the valve body.
5. Replace the exhaust check valve diaphragm in the valve cover.
6. Install the TP-5 valve on the vehicle, following the instructions **in Subject 120**.

General Information

The R-6 relay valve (**Fig. 1**) is a control relay station in the air brake system to speed the application and release of the brakes. Mounted at the rear of the vehicle, it is operated by remote control and gives the same amount of air pressure to the brake chambers as it receives from the service brake foot valve or other source.

The R-6 valve is piston operated and has an insert-type inlet and exhaust valve that can be serviced without removing the lines from the valve body.

Principles of Operation

Compressed air from the service brake foot valve, or other source, enters through the service port of the R-6 valve. **See Fig. 2** . Air fills the cavity in the top half of the valve and pushes on the diaphragm of the relay piston, which forces the piston down. The exhaust seat, attached to the base of the piston, drops until it seals the exhaust portion of the inlet/exhaust valve. At this point, no air can escape through the exhaust port.

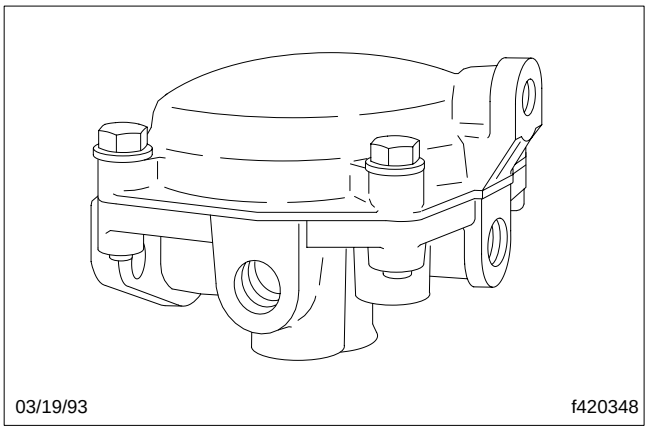


Fig. 1, Relay Valve, Bendix R-6

With the exhaust valve sealed, the piston continues pushing down on the inlet/exhaust valve until the inlet portion of the valve moves off its seat and permits air to move from the system reservoirs to the brake chambers.

Compressed air filling the brake chambers also raises the piston's diaphragm. As the diaphragm rises, the piston lifts enough to close the inlet valve while keeping the exhaust valve closed, thus balancing the air delivered to the brake chambers with the air from the service brake foot valve. For faster piston reaction, the piston return spring helps the air system raise the diaphragm.

When air pressure from the service brake foot valve is reduced, the diaphragm inflates fully, pulling the relay piston up high enough to open the exhaust seat. With the exhaust valve open, the compressed air in the brake chambers exhausts to the atmosphere, and the brakes release.

General Information and Principles of Operation

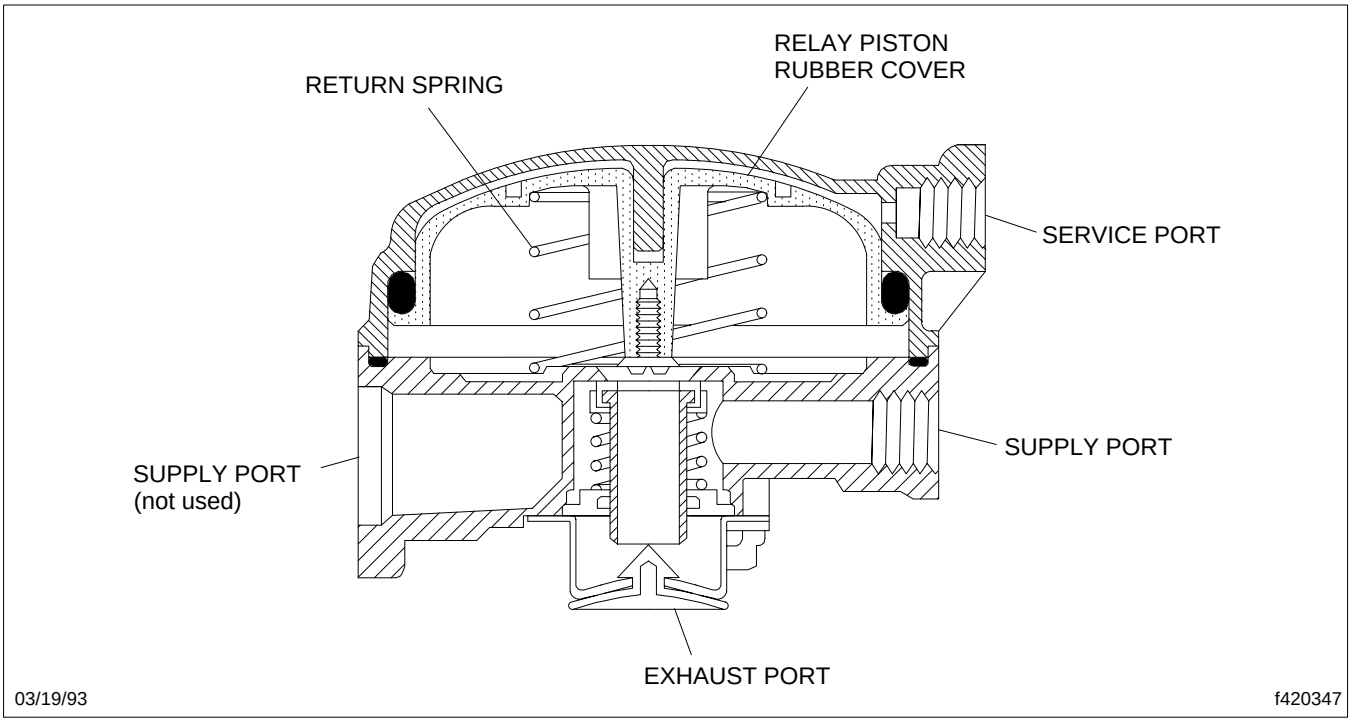


Fig. 2

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under the vehicle. Releasing air from the system may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

Operation Test

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Start the vehicle and build the brake system to cut-out pressure, 120 psi (827 kPa).
2. Make several service brake applications and check for prompt application and release of the brakes. The brakes should apply within 0.40 second and release within 0.50 second.
3. If brake response is slow, troubleshoot the brake system. For instructions, refer to the brake system troubleshooting section in this manual. If the R-6 valve is malfunctioning, repair or replace it.

Leakage Test

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Start the vehicle and build the brake system to cut-out pressure, 120 psi (827 kPa).
2. With the service brakes released, apply a soap-water solution to the exhaust port of the R-6 valve. Leakage at the exhaust port should not exceed a 3-inch (7.5-cm) bubble in three seconds. Excessive leakage indicates damage or wear to the inlet valve and guide seal O-ring.
3. While holding a full service brake application, apply a soap-water solution to the exhaust port. Leakage at the exhaust port should not exceed a 3-inch (7.5-cm) bubble in three seconds.

   If leakage is excessive, replace the inlet/ exhaust valve assembly. **See Fig. 1**, Refs. 8 through 15.
4. After replacing the inlet/exhaust valve assembly, repeat step 3. If valve leakage is still excessive, replace the valve.

IMPORTANT: If the R-6 valve does not function as described in the above test or if leakage is excessive, replace it. For instructions, **refer to Subject 120**.

Operation and Leakage Tests

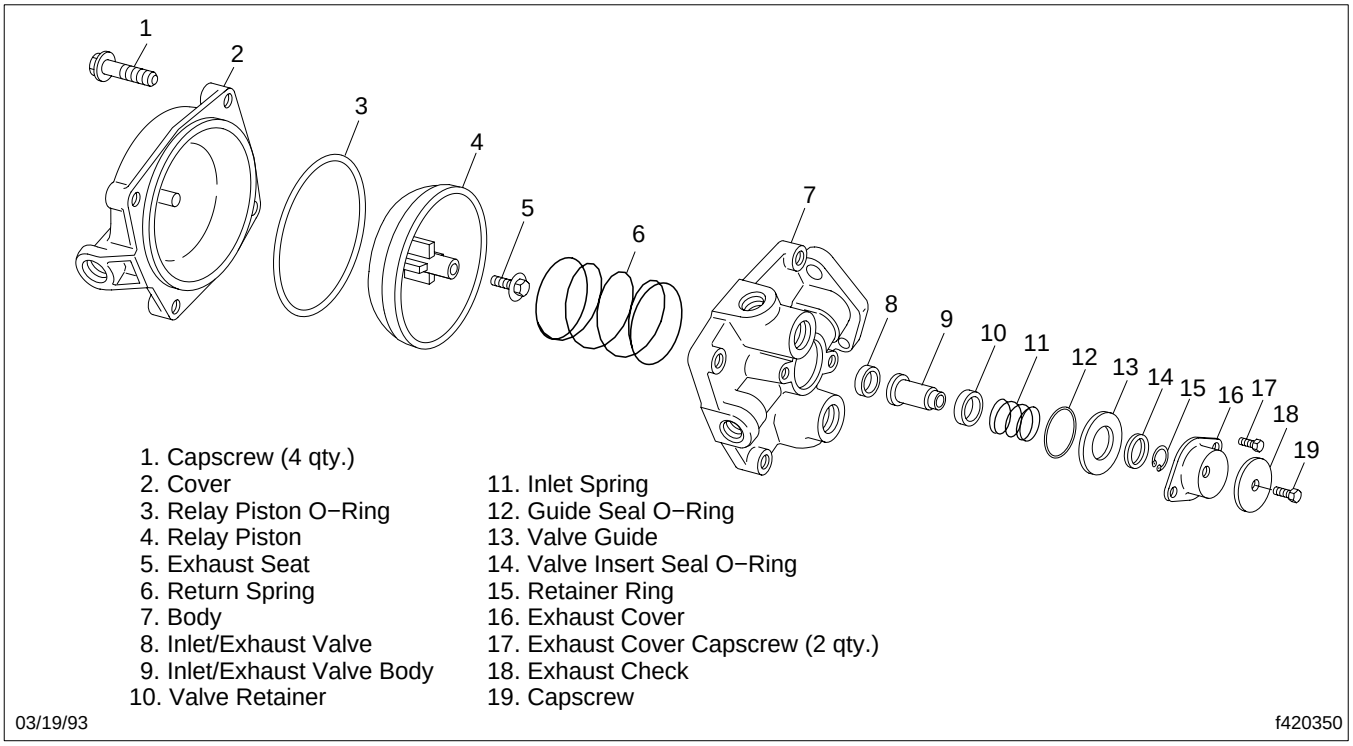


Fig. 1

Removal

IMPORTANT: Before working on or around air brake systems and components, **review "Safety Precautions, 100."**

1. Chock the tires, and open the air reservoir drain cocks to bleed air from the system.
2. Remove all air hoses from the R–6 valve (**see Fig. 1**). Cap the hoses and mark them for reassembly.
3. Remove the valve mounting bolts. Remove the valve.

Installation

IMPORTANT: Before working on or around air brake systems and components, **review "Safety Precautions, 100."**

1. Attach the R–6 valve to the vehicle, using the bolts, washers, and nuts. Tighten the nuts 132 to 180 lbf·in (1500 to 2040 N·cm).
2. Remove the caps from the air lines, and depending on the type of air hose used, do either A or B:

   A. Nylon Tubing: Connect the hose fittings to the valve ports, and tighten the nuts finger-tight. Using a wrench, tighten the nuts at least two turns, or until no threads show on the fittings.

   B. Wire Braid Hoses: Connect the hose fittings to the valve ports, and hand-tighten the nuts. Using a wrench, tighten the nuts until resistance is felt. Tighten one-sixth turn more. Do not overtighten.
3. Close the air reservoir drain cocks. Start the vehicle engine to pressurize the air system.
4. Test the R–6 valve following the **instructions in Subject 110**.

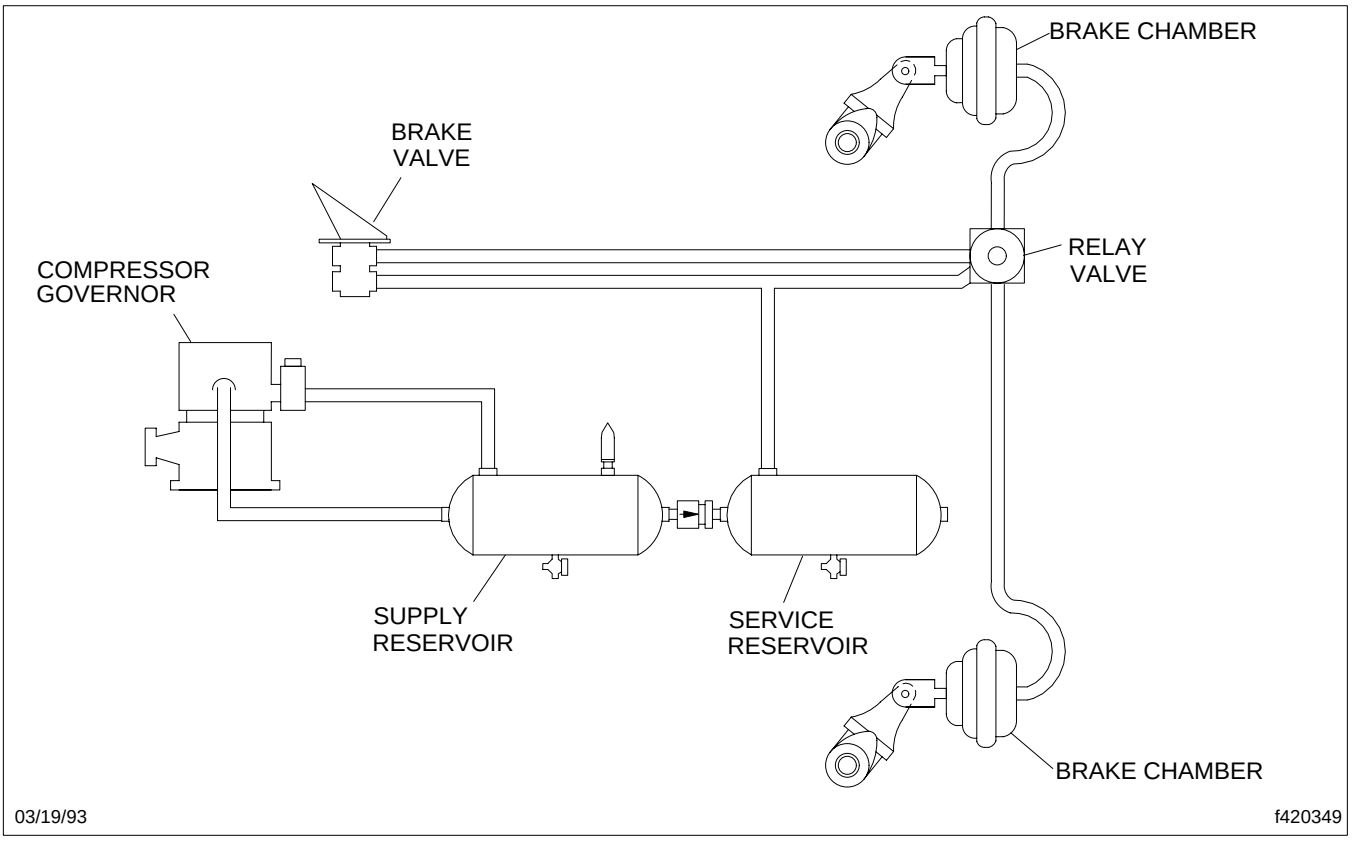


Fig. 1, Plumbing Diagram

Disassembly, Cleaning and Inspection, and Assembly

Disassembly

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Remove the valve from the vehicle. For instructions, refer to **Subject 120**.

NOTE: Prior to disassembly, draw an alignment mark across the valve cover and body, for reassembly alignment. **See Fig. 1.**

2. Remove the four cover capscrews. **See Fig. 2**, Ref. 1.
3. Remove the valve cover (Ref. 2), relay piston (Ref. 4), and return spring (Ref. 6).

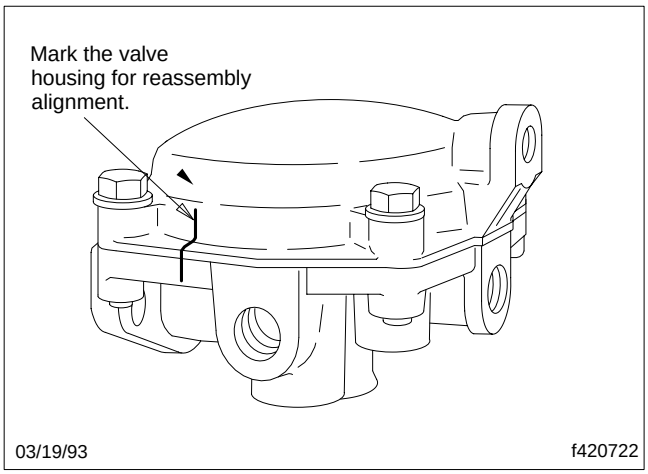


Fig. 1, Valve Marked for Reassembly

4. Remove the relay piston from the cover.
5. Remove the exhaust cover capscrews (Ref. 17), exhaust cover (Ref. 16), and the inlet/ exhaust valve assembly (Ref. 8 through 15) from the body.
6. If they are to be replaced, remove the exhaust seat (Ref. 5) from the relay piston, and remove the exhaust check (Ref. 18) from the exhaust cover.

NOTE: Don't do steps 7 through 10 if the complete inlet/exhaust valve assembly is being replaced.

7. Press the valve guide (Ref. 13) down against the inlet spring (Ref. 11) and remove the retainer ring (Ref. 15).
8. Remove the valve insert seal O-ring (Ref. 14), valve guide (Ref. 13), inlet spring (Ref. 11), and valve retainer (Ref. 10).
9. Remove the inlet/exhaust valve (Ref. 8) from the inlet/exhaust valve body (Ref. 9).
10. Remove the guide seal O-ring (Ref. 12) from the valve guide (Ref. 13).

Cleaning and Inspection

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

1. Wash all metal parts of the R-6 valve in cleaning solvent. Dry the metal parts of the disassembled valve with compressed air.
2. Wipe all rubber parts clean with a clean cloth. Examine all rubber parts for cracks, tears, or other deterioration. If any rubber parts are worn, cracked, torn or otherwise damaged, replace them with new parts.
3. Examine all metal parts for wear, cracks, or other damage. If any metal parts are worn, cracked or otherwise damaged, replace them with new parts.
4. Check the springs for distortion and corrosion. If the springs are distorted or corroded, replace them.

Disassembly, Cleaning and Inspection, and Assembly

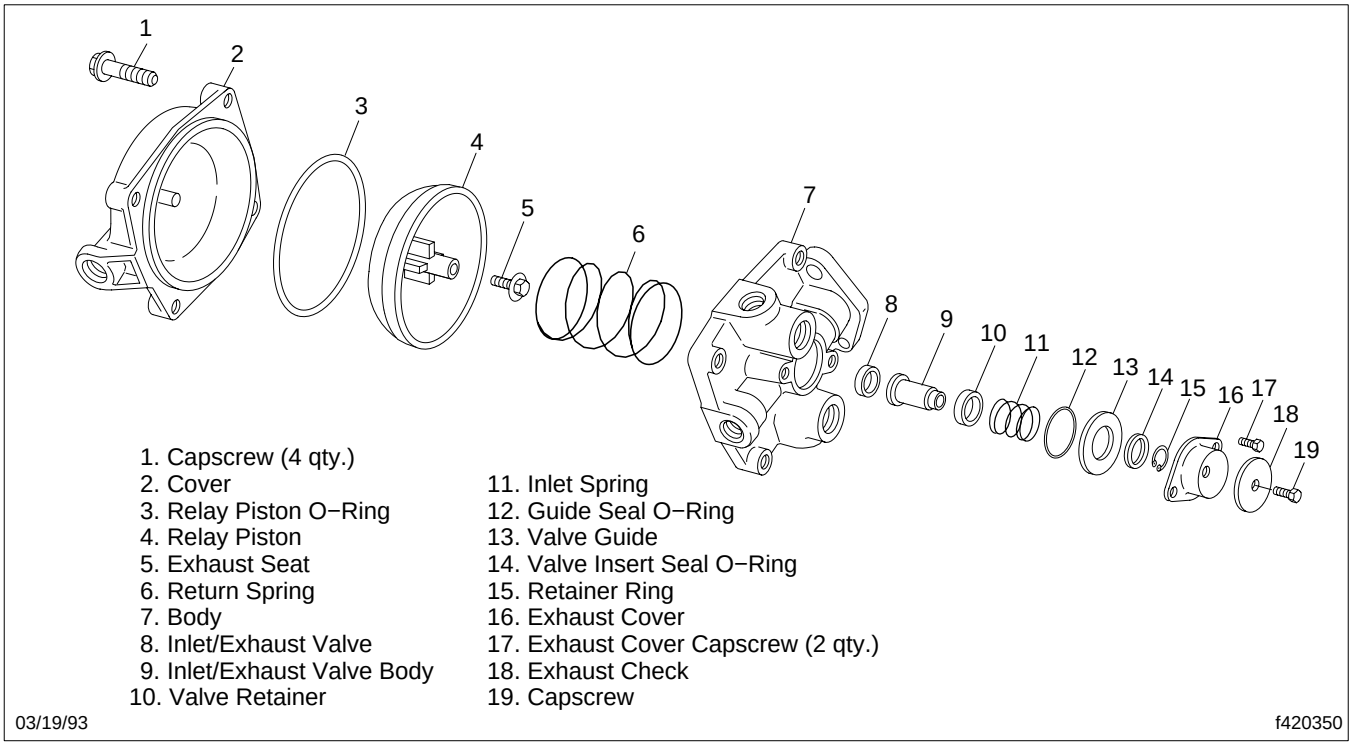


Fig. 2

Assembly

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Lubricate the O-rings and all sliding parts with Dow Corning 55-M pneumatic grease or equivalent.

NOTE: If installing a new inlet/exhaust valve assembly, disregard steps 2 through 6.

2. Install the inlet/exhaust valve over the inlet/ exhaust valve body. **See Fig. 2**, Refs. 8 and 9.
3. Position the valve retainer (Ref. 10) over the inlet/exhaust valve body (Ref. 9).
4. Install the inlet spring (Ref. 11) over the inlet/ exhaust valve body. Install the guide seal O-ring (Ref. 12) in the inner groove in the valve guide (Ref. 13).
5. Press the valve guide down against the inlet spring, and install the retainer ring (Ref. 15).
6. Install the valve insert seal O-ring (Ref. 14).
7. Install the inlet/exhaust valve assembly in the valve body (Ref. 7).
8. Install the exhaust cover with the exhaust cover capscrews and torque 20 to 30 lbf·in (220 to 340 N·cm).
9. Install the exhaust check (Ref. 18) with the capscrew (Ref. 19).
10. Install the relay piston O-ring (Ref. 3). Position the relay piston (Ref. 4) in the cover.
11. Position the return spring (Ref. 6) over the guide in the body.
12. Use the alignment mark to assemble the body to the cover. Make sure the exhaust seat (Ref. 5) is centered inside the return spring.
13. Secure the cover to the body with the capscrews (Ref. 1). Torque the capscrews 80 to 120 lbf·in (900 to 1360 N·cm).
14. Install the R-6 valve on the vehicle following the instructions in **Subject 120**.

15. Test the R-6 valve following the instructions in **Subject 110**.

Specifications

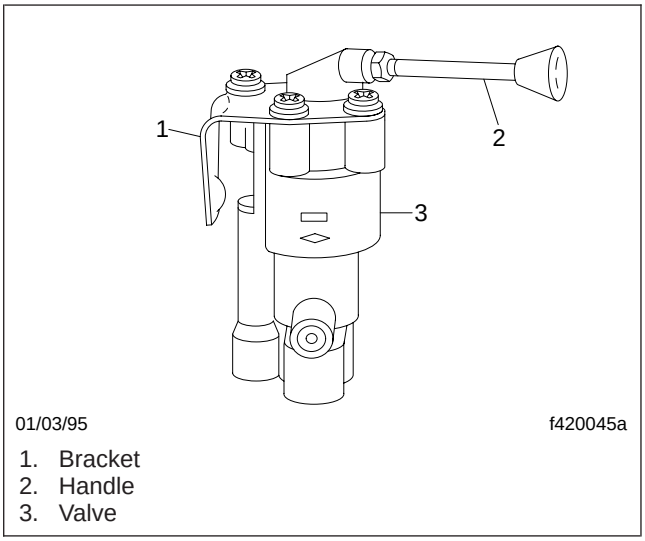
Description	Torque lbf·in (N·cm)
Valve Cover Capscrews	80–120 (900–1360)
Valve Mounting Capscrews	132–180 (1500–2040)
Exhaust Cover Capscrews	20–30 (220–340)

Table 1, Torque Values

General Information

A hand-operated TC–7 brake valve (**Fig. 1**) is included in some air brake systems for tractor units pulling trailers, in addition to the standard foot brake valve and related equipment. This valve allows the driver independent control of the trailer brakes, which can be useful when checking trailer brakes, or changing adjustable fifth wheel locations.

The TC–7 brake valve is mounted on the right-side of the steering column. See **Fig. 2**.



1. Bracket
2. Handle
3. Valve

Fig. 1, TC-7 Valve

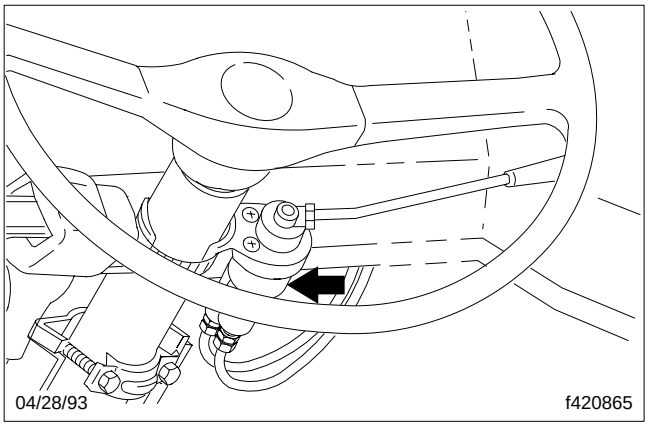
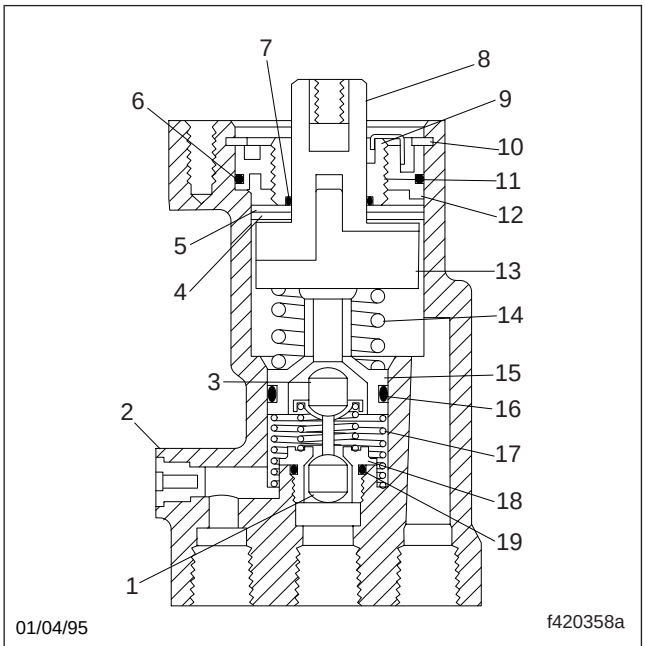


Fig. 2, Trailer Brake Hand Control Valve

Principles of Operation (See Fig. 3)

When the TC–7 valve's control handle is moved down from the released position, force is exerted on the pressure graduating spring through the action of the cam and cam follower. The force of the spring on the piston causes it to move down.

The exhaust seat, which is in the center of the piston, contacts the exhaust valve and closes the exhaust passage in the piston. The continued downward movement of the piston moves the inlet valve off its seat. Reservoir air flows through the open inlet valve and out the delivery port.



1. Inlet Valve
2. Body
3. Exhaust Valve
4. Sealing Ring
5. Friction Washer
6. O-Ring
7. O-Ring
8. Cam Follower
9. Lockwasher (special)
10. Retaining Ring
11. Adjusting Ring
12. Adjusting Ring Adapter
13. Cam
14. Graduating Spring
15. Piston
16. O-Ring
17. Spring
18. Inlet Seat
19. O-Ring

Fig. 3, TC-7 Valve (sectional view)

The air that flows through the open inlet valve also becomes effective on the bottom area of the piston. As the force of the air pressure against the piston balances the force of the depressed graduating

General Information and Principles of Operation

spring above, the piston lifts slightly and the inlet valve returns to its seat. The exhaust valve remains seated so the flow of air through the valve is stopped and air in the service line is held.

When the control handle is moved up, the force above the piston is decreased. The air will then lift the piston, moving it away from the exhaust valve. With the exhaust passage open, air in the service line exhausts out the port of the valve.

Safety Precautions

When working on or around air brake systems and components, the following precautions should be observed:

1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing compressed air—it may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure, and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood the recommended procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

⚠ WARNING

WARNING: Do not use the TC-7 brake valve to apply the trailer brakes for parking. It is not designed for this purpose. The air could bleed out of the trailer air tank allowing the vehicle to roll, which could cause personal injury or damage to the vehicle.

Test

The following test should also be performed after repairing or replacing the TC-7 brake valve to ensure that the valve is functioning properly.

1. Park the vehicle on a level surface and chock the tires.
2. Connect an accurate test gauge to the delivery port of the TC-7 valve, or connect the gauge to the service hose coupling located behind the cab. When the gauge is connected to the service hose coupling, install a dummy hose coupling on the supply (emergency) hose coupling, and place the dash valve in the trailer charging position. When the TC-7 valve control handle is moved to the fully applied position, the gauge should register full reservoir pressure.

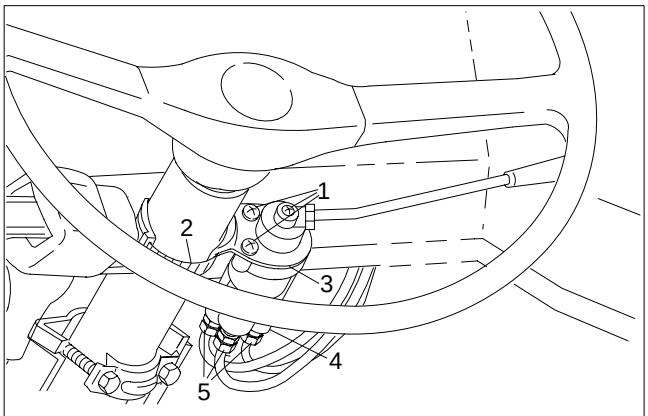
NOTE: TC-7 valves are set to deliver full reservoir pressure. Intermediate positions should deliver proportional intermediate pressures. Upon manual release, the gauge should immediately register zero.

3. Locate the exhaust port or exhaust line and apply a soap solution.
4. With the valve in the released position, exhaust leakage should not exceed a 1-inch (2.5-cm) bubble in 5 seconds.

   With the valve fully applied, leakage at the exhaust should not exceed a 1-inch (2.5-cm) bubble in 3 seconds.
5. If the TC-7 valve does not function properly or if leakage is excessive, repair or replace the TC-7 valve following the instructions in this section.

Removal

1. Chock the tires or hold the vehicle on a level surface by means other than air brakes.
2. Drain the air system by opening both the primary and secondary reservoir drain cocks.
3. Remove the under dash cover located under the steering column.
4. For later reference, mark the three air lines (**Fig. 1** , Ref. 5) connected to the TC-7. Disconnect the air lines from the valve.
5. Loosen the clamp (Ref. 2) which holds the TC-7 valve mounting bracket to the steering column. Remove the valve from the steering column by sliding the bracket out of the clamp.
6. Remove the mounting bracket (Ref. 3) from the valve by removing the three Phillips screws (Ref. 1).
7. If necessary, remove the valve control handle.



1. Phillips Screws
2. Clamp
3. Mounting Bracket
4. TC−7 Valve
5. Air line Connections

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Fig. 1, TC-7 Valve Installed on a Steering Column

Installation

1. If removed, install the control handle on the TC-7 valve. Tighten the handle mounting screw 30 to 60 lbf·in (340 to 680 N·cm).
2. Install the mounting bracket on the TC-7 valve. Tighten the three Phillips screws 30 to 60 lbf·in (340 to 680 N·cm).
3. Slide the mounting bracket through the clamp on the steering column. Position the valve on the steering column **as shown in Fig. 1** , and tighten the clamp firmly.
4. Using the reference marks made during removal, attach the air lines to the TC-7 valve. Tighten the lines firmly using two wrenches.
5. Install the under dash cover under the steering column. Tighten the screws firmly.
6. Perform the operating and leakage test. **Refer to Subject 110** for instructions.

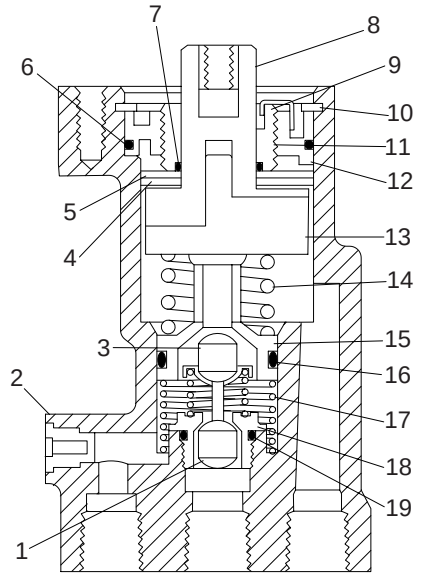
Disassembly (See Fig. 1)

The following assembly and disassembly instructions are written for the use of the Bendix maintenance kit, number 102145.

If the valve is disassembled in a vise, be sure that the vise is not over-tightened because the valve body and internal parts could become distorted.

Disassemble the TC-7 valve as follows:

1. Remove the TC-7 valve from the vehicle following the instructions in **Subject 120**.



1. Inlet Valve
2. Body
3. Exhaust Valve
4. Sealing Ring
5. Friction Washer
6. O−Ring
7. O−Ring
8. Cam Follower
9. Lockwasher (Special)
10. Retaining Ring
11. Adjusting Ring
12. Adjusting Ring Adapter
13. Cam
14. Graduating Spring
15. Piston
16. O−Ring
17. Spring
18. Inlet Seat
19. O−Ring

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Fig. 1, TC-7 Valve (sectional view)

2. Remove and discard the adjusting ring lockwasher. Remove and retain the adjusting ring.

NOTE: A spanner wrench can be used to rotate the adjusting ring, but if such a wrench is not available, the adjusting ring can be installed with a small screwdriver inserted in one of the inner notches of the ring.

3. Remove and discard the retaining ring.

NOTE: Before removing the friction washer, note whether it is installed with ribs against or away from the sealing ring. It must be installed the same way during assembly.

4. Remove the adjusting ring adapter, cam follower, sealing ring, and friction washer. Discard the sealing ring and O-rings. Retain all other parts.
5. Remove and retain the cam and the graduating spring.
6. Remove and retain the piston. Remove and discard the O-ring from the piston.
7. Remove and discard the piston return spring.
8. Using an 11/16-inch deep-well socket wrench, remove and discard the inlet and exhaust valve assembly and O-ring.

Assembly (See Fig. 1)

WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

Prior to assembly, wash the parts retained during disassembly in mineral spirits and dry them thoroughly.

Lubricate the body bores, cam, cam follower, and all O-rings and O-ring grooves using Bendix lubricant 291126 or a silicone lubricant equivalent to Dow Corning No. 10.

NOTE: Do not lubricate the sealing ring, friction washer, or cam follower serrations.

Assemble the TC-7 valve as follows:

1. Install the O-ring on the inlet and exhaust valve assembly, and install the inlet and exhaust valve assembly using an 11/16-inch deep-well socket

Disassembly and Assembly

wrench. Tighten the inlet and exhaust valve assembly 15 lbf·in (180 N·cm).

2. Install the piston return spring.
3. Install the O-ring on the piston, and install the piston in the valve body.
4. Install the graduating spring in the valve body.
5. Install the cam in the valve body with the flat side toward the graduating spring. Index the cam "ears" to corresponding slots in the valve body.
6. Install the rubber sealing ring on the cam follower.
7. Install the friction washer on the cam follower in the same manner as noted during disassembly.
8. Install the cam follower in the valve body.

NOTE: A stop "ear" on the cam follower will prevent improper assembly of the cam follower; however, make certain that the positioning "ear" of the friction washer fits in the wide slot in the valve body.

9. Install the O-ring in the adjusting ring adapter and install the O-ring in the adjusting ring.
10. Install the adjusting ring in the adapter until the adjusting ring is flush with the underside of the adapter.

NOTE: There are two indexing lugs on the adapter that fit into slots in the valve body when the adapter is installed. Be sure to install the adjusting ring with its wrench slots accessible (up) after the valve is assembled.

11. Position the adapter and the adjusting ring assembly over the cam follower, making certain the adapter lugs fit into the body slots.

NOTE: If the lugs on the adapter are not in their valve body slots, the snap ring cannot be installed completely.

12. Push down on the cam follower and install the snap ring. Be certain the snap ring is completely seated in its groove.
13. Before installing the lockwasher, adjust the valve as follows:

    13.1 If the delivered pressure is below specified final delivery pressure, it can be adjusted by removing the head and adjusting ring lockwasher, and rotating the adjusting ring clockwise to raise the delivery pressure.

    Care should be taken not to raise the delivery pressure beyond the design limits; the exhaust opening could be restricted.

    13.2 If the delivery pressure is above specified final delivery pressure, it can be lowered by rotating the adjusting ring counterclockwise.

    NOTE: A spanner wrench can be used to rotate the adjusting ring, but if such a wrench is not available, the adjusting ring can be turned with a small screwdriver inserted in one of the inner notches of the ring.

    13.3 After adjustment is complete, install the lockwasher to hold the adjustment.

14. Install the TC-7 valve on the vehicle following the instructions in **Subject 120**.

Specifications

Description	Torque: lbf·in (N·cm)
Valve Mounting (Phillips) Screws	30–60 (340–680)
Control Handle Mounting Screws	30–60 (340–680)
Inlet and Exhaust Valve Assembly	15 (180)

Table 1, Torque Values

General Information

The Bendix TP-3 tractor protection valve is usually mounted either in the frame rail channel (**see Fig. 1**), on the air tower assembly, or in the tunnel (for COEs). An air hose from the dash-mounted trailer air supply valve connects to the TP-3 valve tractor emergency port. **See Fig. 2** . An air hose from the foot and hand brake valves connects to the TP-3 valve tractor service port. The tractor-to-trailer air brake hoses are connected to the TP-3 valve trailer emergency port and trailer service port.

Principles of Operation

When the trailer air supply valve is open, air flows through the TP-3 valve emergency ports (**see Fig. 2**) to the trailer air brake system, and releases the trailer parking brakes. The air within the TP-3 valve exerts pressure on a plunger, which unseats an inlet valve, and opens the service ports. **See Fig. 3** . This allows service application of the trailer air brakes.

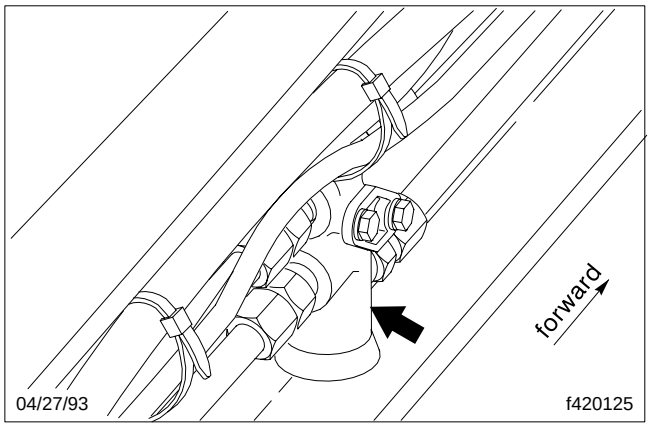


Fig. 1

At least 45 psi (310 kPa) pressure on the plunger is required to open the inlet valve. Whenever the air supply is shut off (at the trailer air supply valve), or the pressure drops below the minimum 45 psi (310 kPa), the plunger rises, seating the inlet valve and closing the service ports to protect the tractor brake system pressure.

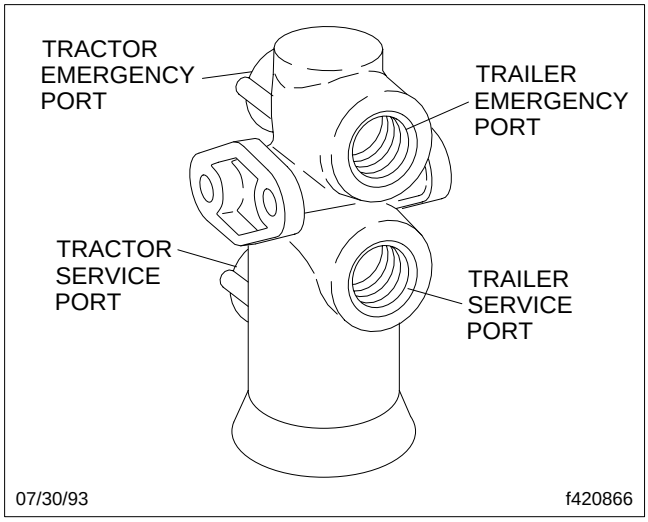


Fig. 2

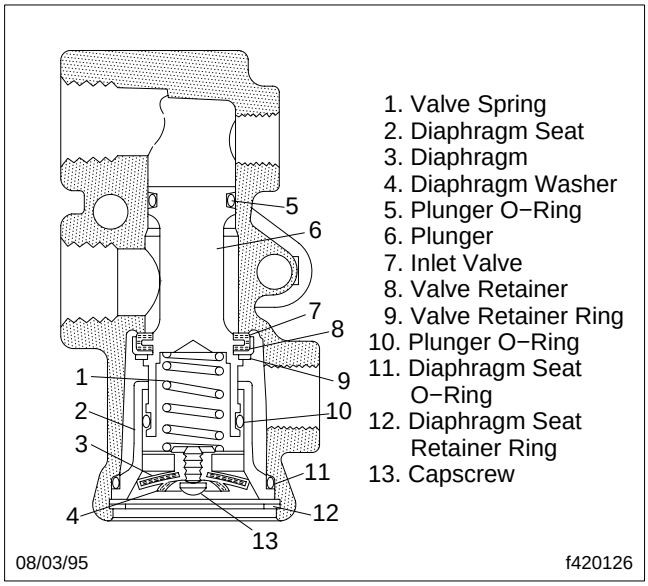


Fig. 3

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under the vehicle. Releasing air from the system may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

Leakage Test

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Chock the tires. Place the trailer air supply valve in the emergency position, and disconnect the trailer air lines from the trailer supply and service couplings. Apply a soap-water solution to the couplings.
2. With tractor reservoirs charged to at least 100 psi (689 kPa) make and hold a full service brake application. Leakage at either tractor hose coupling should not exceed a 1-inch (2.5-cm) bubble in five seconds.
3. Connect the trailer supply line hose coupling, and place the trailer supply valve in the "run" position. Leakage at the service coupling should not exceed a 1-inch (2.5-cm) bubble in five seconds.
4. Connect the service brake coupling, and make and hold a full service brake application. Leakage at the diaphragm end of the TP-3 valve should not exceed a 1-inch (2.5-cm) bubble in three seconds.

IMPORTANT: If leakage is excessive, replace the valve.

Removal

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Chock the tires, and open the air reservoir drain cocks to bleed the air from the system.
2. Remove the trailer hose assemblies from the TP-3 valve. Disconnect the tractor service and supply lines. Mark the lines for later assembly reference. Cap the air lines tightly to keep out contaminants.
3. Remove the fasteners attaching the TP-3 valve to the vehicle, and remove the valve.

Installation

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Place the TP-3 valve on the vehicle, and attach it with bolts, washers, and nuts. Tighten the nuts 11 to 15 lbf·ft (15 to 20 N·m).
2. The delivery line from the trailer air supply valve is connected to the tractor emergency port of the TP-3 valve. **See Fig. 1.** The delivery line from the brake valve (double check valve) is connected to the tractor service port of the TP-3 valve. Trailer hose assemblies are installed in the trailer emergency and trailer service ports of the TP-3 valve. Remove the caps from the air lines, and depending on the type of air hose, use the following instructions to connect the air hoses to the TP-3 valve:

   If equipped with nylon tube air hoses, connect the hose fittings to the valve ports, and tighten the nuts finger-tight. Then, using a wrench, tighten the nuts at least two turns, or until no threads show on the fitting.

   If equipped with wire braid hoses, connect the hose fittings to the valve ports, and hand-tighten the nuts. Using a wrench, tighten the nuts until there is resistance. Tighten one-sixth turn more. Do not overtighten.
3. Close the drain cocks to the air reservoirs. Start the vehicle engine to pressurize the air system.
4. Leak test the TP-3 valve following the instructions in **Subject 110**.

Removal and Installation

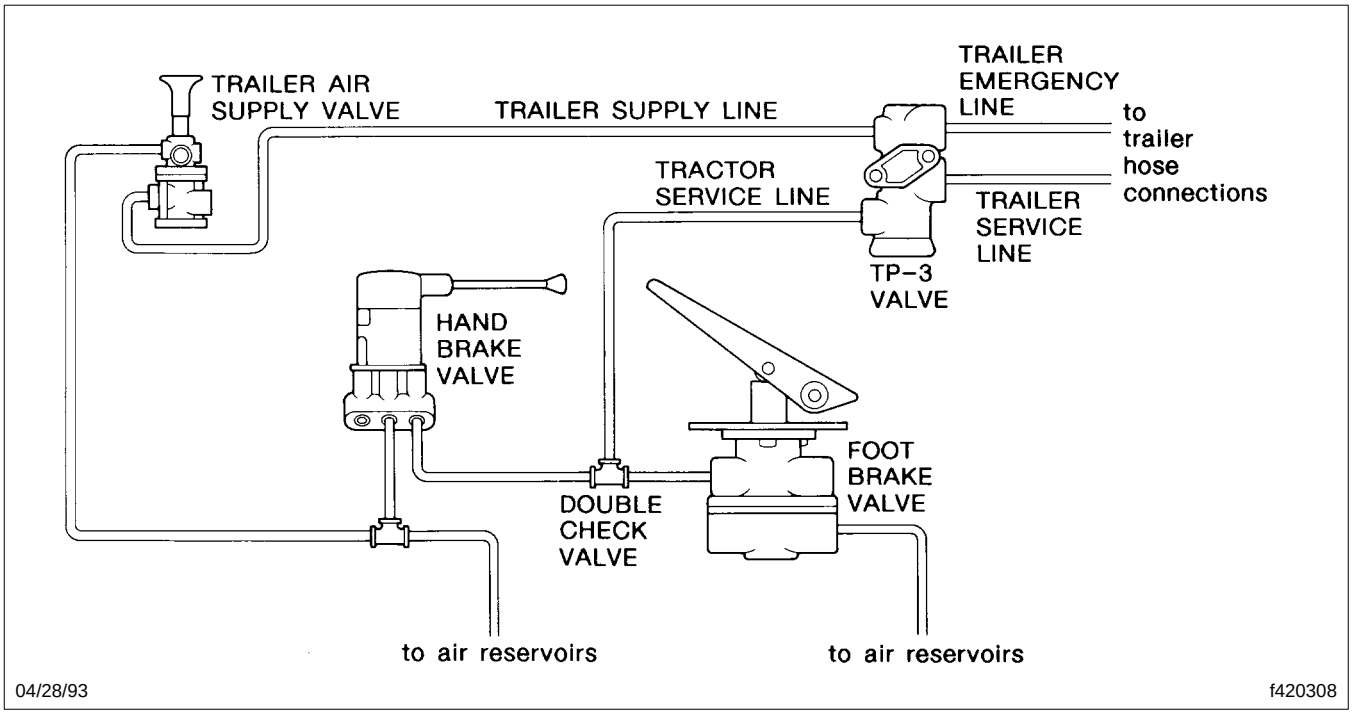


Fig. 1

Disassembly, Cleaning and Inspection, and Assembly

Disassembly

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Remove the valve from the vehicle. For instructions, **refer to Subject 120** .
2. Holding the diaphragm seat in the body, remove the diaphragm seat retainer ring. **See Fig. 1**, Refs. 2 and 12.
3. Allow the valve spring to expand until the valve diaphragm seat assembly, valve spring, and plunger assembly can be removed.
4. Remove the diaphragm seat O-ring (Ref. 11) from the valve housing.
5. Remove the capscrew (Ref. 13) and diaphragm washer (Ref. 4) from the diaphragm seat assembly.
6. Remove the valve retainer ring (Ref. 9), valve retainer (Ref. 8), inlet valve (Ref. 7), and O-rings (Refs. 5 and 10) from the plunger.

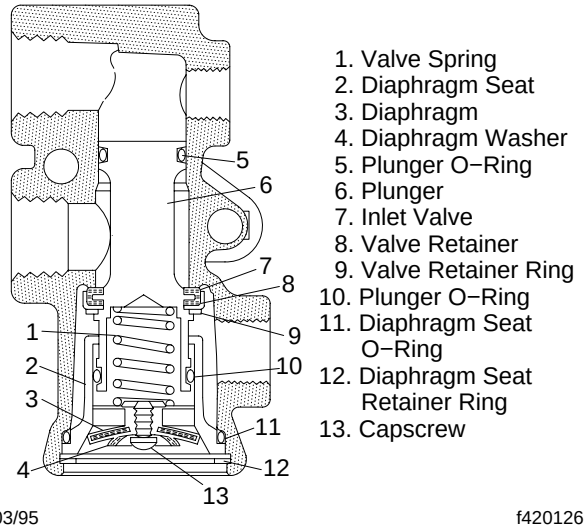


Fig. 1

Cleaning and Inspection

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

1. Wash all metal parts of the TP-3 valve in cleaning solvent. Dry the metal parts of the disassembled valve with compressed air.
2. Wipe all rubber parts clean with a clean cloth. Examine all rubber parts for cracks, tears, or other deterioration. If any rubber parts are worn, cracked, torn or otherwise damaged, replace them with new parts.
3. Examine all metal parts for wear, cracks, or other damage. If any metal parts are worn, cracked or otherwise damaged, replace them with new parts.
4. Check the spring for distortion and corrosion. If the spring is distorted or corroded, replace it.

Assembly

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Lubricate the O-rings and all sliding parts with Dow Corning 55-M pneumatic grease or equivalent.
2. Install the inlet valve (**Fig. 1**, Ref. 7) on the plunger.
3. Install the valve retainer (Ref. 8) over the inlet valve.
4. Install the valve retainer ring (Ref. 9) beneath the inlet valve retainer.

Disassembly, Cleaning and Inspection, and Assembly

5. Install both plunger O-rings (Refs. 5 and 10) in the proper grooves.
6. Place the plunger and valve assembly in the valve body.
7. Install the capscrew (Ref. 13), diaphragm washer (concave side down, Ref. 4), and diaphragm (Ref. 3) into the diaphragm seat (Ref. 2).
8. Place the inlet valve spring (Ref. 1) into the plunger.
9. Install the diaphragm seat O-ring (Ref. 11) in the body.
10. Install the diaphragm seat assembly over the spring and plunger assembly, and force them into the valve body.
11. Install the diaphragm seat retainer ring, making sure the retainer ring snaps fully into the groove.
12. Install the TP-3 valve on the vehicle following the instructions in **Subject 120**.

General Description

The function of the Bendix AD-9 air dryer (**Fig. 1**) is to collect and remove air system contaminants in solid, liquid, and vapor form before they enter the brake system.

The AD-9 air dryer consists of the desiccant cartridge and a die-cast aluminum end cover secured to a cylindrical steel outer shell with eight capscrews and nuts. The end cover contains a check valve assembly, a safety valve, three threaded air connections and the purge valve housing assembly. The removable purge valve housing assembly features a purge valve mechanism and a turbocharger cutoff that are designed to prevent loss of engine turbo boost pressure during the purge cycle of the air dryer.

To ease servicing, the desiccant cartridge and discharge check valve assembly are screw-in types. The purge valve housing assembly, which includes the heater and thermostat assembly, and the discharge check valve assembly, can be serviced without removing the air dryer from the vehicle. The screw-in desiccant cartridge requires removal of the air dryer assembly from the vehicle.

The AD-9 has three female pipe thread air connections; each is identified as follows (see **Table 1**):

Pipe Thread Air Connections	
Port I.D.	**Function/Connection**
4-CON	Control Port (purge valve control and turbo cutoff)
11-SUP	Supply Port (air in)
2-DEL	Delivery Port (air out)

Table 1, Pipe Thread Air Connections

Principles of Operation

The AD-9 air dryer alternates between two operational modes or cycles during operation: the charge cycle and the purge cycle.

Charge Cycle

(See **Fig. 2**)

When the compressor is loaded (compressing air), pressurized air, along with oil, oil vapor, water, and water vapor flow through the compressor discharge line to the supply port of the air dryer end cover. As air travels through the end-cover assembly, its direction of flow changes several times, reducing the temperature, causing contaminants to condense and drop to the bottom or sump of the air dryer end cover.

After exiting the end cover, air flows into the desiccant cartridge. Once in the cartridge, air first flows through an oil separator, which removes water, oil, oil vapor, and solid contaminants.

Air exits the oil separator and enters the desiccant drying bed. Air flowing through the column of desiccant becomes progressively drier as water vapor sticks to the desiccant material in a process known as adsorption. The desiccant cartridge, using the adsorption process typically removes 95 percent of the water vapor from the pressurized air.

Most of the dry air exits the desiccant cartridge through its integral single check valve to fill the purge volume between the desiccant cartridge and outer shell. Some air also exits the desiccant cartridge through the purge orifice adjacent to the check valve.

Dry air flows out of the purge volume through the single check valve assembly and out the delivery port to the first (supply) reservoir of the air system.

The air dryer remains in the charge cycle until air brake system pressure builds to the governor cutout setting.

Purge Cycle

(See **Fig. 3**)

When the brake system pressure reaches the governor cutout setting, the compressor unloads (air compression stopped), and the purge cycle of the air dryer begins. When the governor unloads the compressor, it pressurizes the unloader mechanism and line connecting the governor unloader port to the AD-9 end cover control port. The purge piston moves in response to air pressure causing the purge valve to open to atmosphere and partially close off the supply of air from the compressor. This is further discussed under "Turbo Cutoff Feature."

Contaminants in the end cover sump are expelled immediately when the purge valve opens. Also, air that was flowing through the desiccant cartridge changes direction and begins to flow toward the open purge valve. Oil and solid contaminants col-

General Description and Principles of Operation

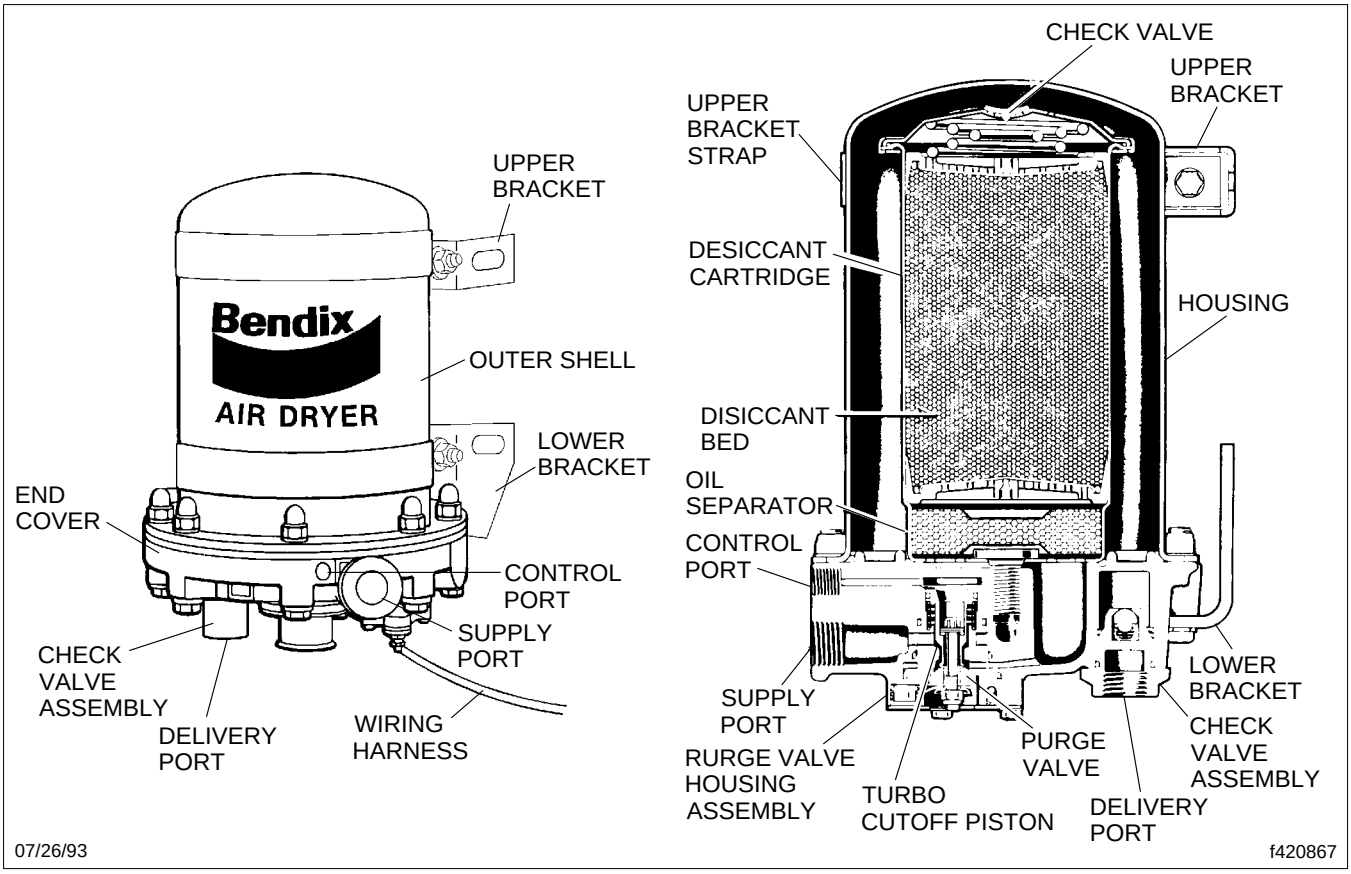


Fig. 1, Bendix AD-9 Air Dryer and Cutaway View

lected by the oil separator are removed by air flowing from the desiccant drying bed to the open purge valve.

The initial purge and desiccant cartridge decompression last only a few seconds and are signaled by an audible burst of air at the AD-9 exhaust. The actual reactivation of the desiccant drying bed begins as dry air flows from the purge volume through the desiccant cartridge purge orifice and into the desiccant drying bed. Pressurized air from the purge volume expands after passing through the purge orifice; its pressure is lowered and its volume increased. Dry air flowing through the drying bed reactivates the desiccant material by removing the water vapor sticking to it. Generally, it takes 15 to 30 seconds for the entire purge volume of a standard AD-9 to flow through the desiccant drying bed.

The end cover single check valve assembly prevents compressed air in the brake system from returning to the air dryer during the purge cycle. After the 30 second purge cycle is complete, the air dryer is ready for the next charge cycle to begin.

The purge valve will remain open after the purge cycle is complete, and will not close until air brake system pressure is reduced and the governor signals the compressor to charge.

NOTE: The air dryer should be periodically checked for operation and tested for leaks. See Group 12 of the *Heavy-Duty Trucks Maintenance Manual* for intervals and procedures.

TURBO CUTOFF FEATURE

(See Fig. 4)

Primarily, the turbo cutoff valve prevents loss of engine turbocharger air pressure through the AD-9 in systems where the compressor intake is connected to the engine turbocharger. The turbo cutoff valve also reduces the puffing of air out the open exhaust

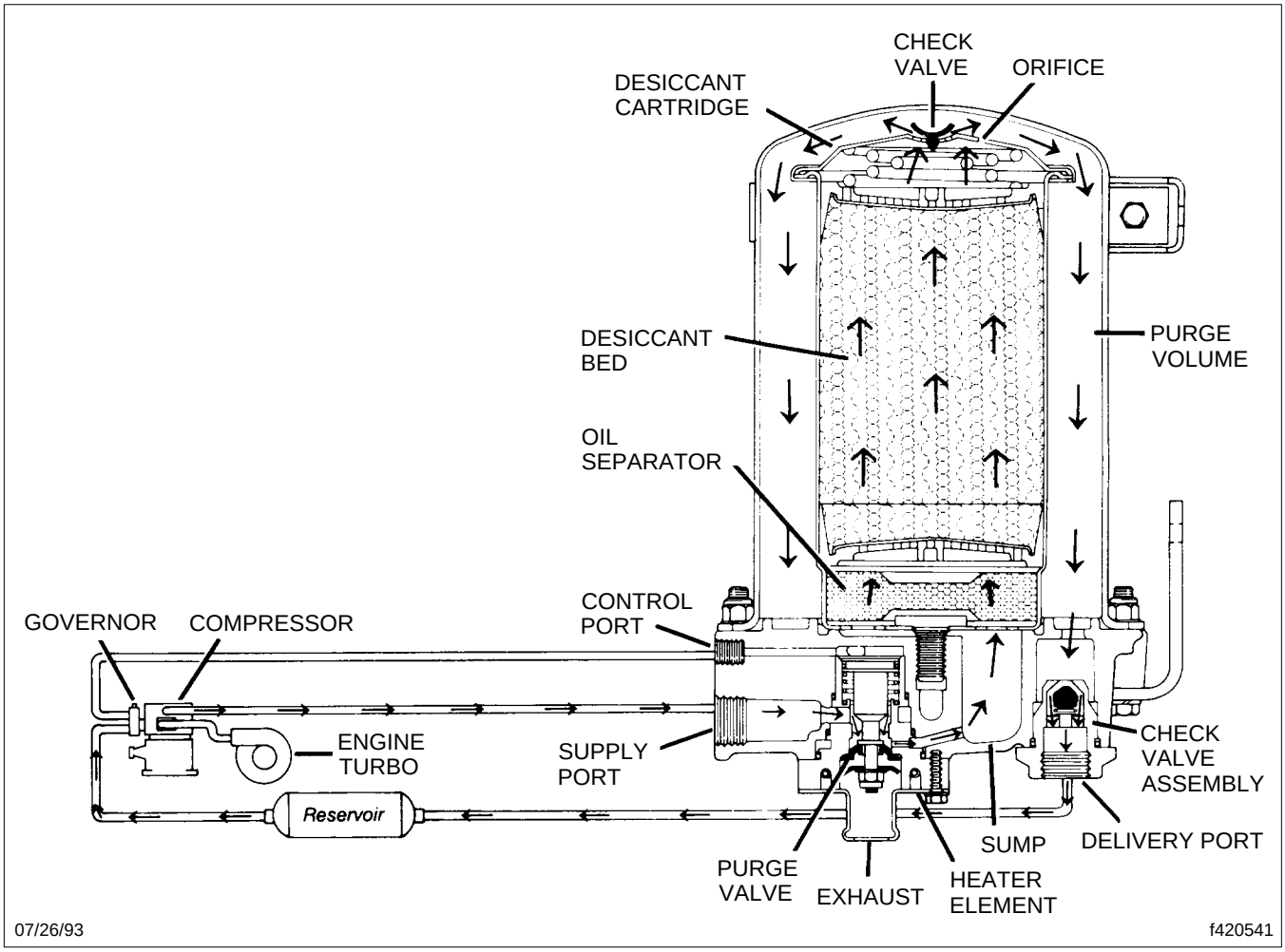


Fig. 2, AD-9 Charge Cycle

when a naturally aspirated, single cylinder compressor equipped with an inlet check valve is in use.

At the beginning of the purge cycle, the downward travel of the purge piston is stopped when the turbo cutoff valve (tapered portion of the purge piston) contacts its mating metal seat in the purge valve housing. With the turbo cutoff valve seated (closed position), air in the discharge line and AD-9 supply port is restricted from entering the air dryer. While the turbo cutoff *effectively* prevents loss of turbocharger boost pressure to the engine, some seepage of air may be detected under certain conditions of compressor engine and turbocharger operation. Even so, there will be low pressure trapped in the discharge line.

General Description and Principles of Operation

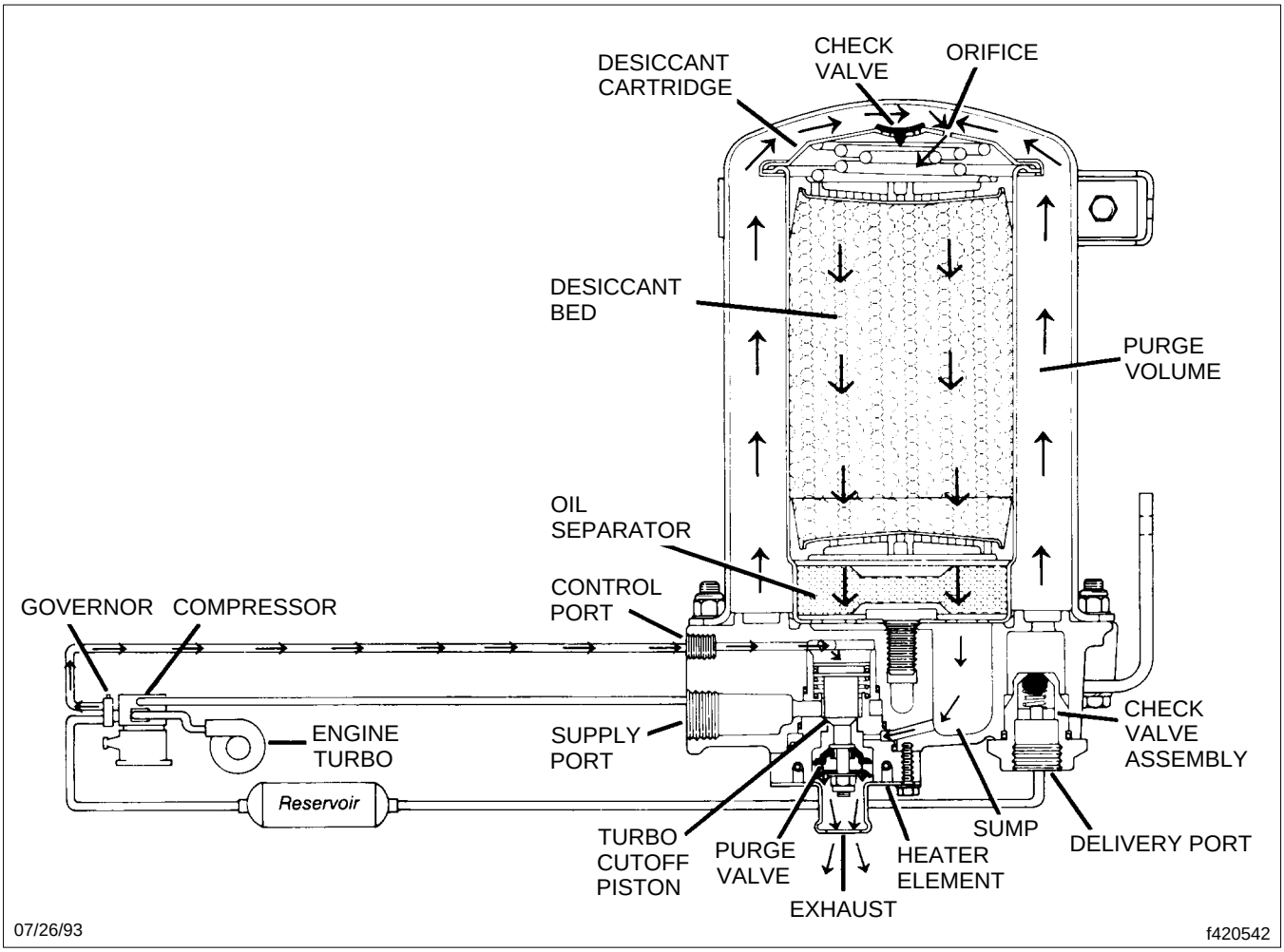


Fig. 3, AD-9 Purge Cycle

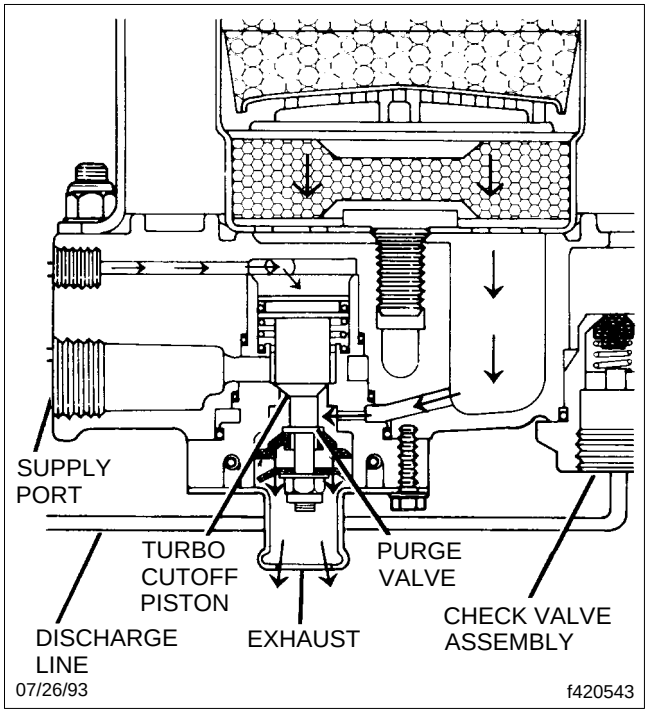


Fig. 4, AD-9 Turbo Cutoff

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters, which may apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure, and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Don't disassemble a component until you have read and understood the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools, and observe all precautions pertaining to use of those tools.
5. Replacement hardware, tubing, hose, fittings, etc. should be the equivalent size, type, length, and strength of the original equipment.

   Make sure that when replacing tubing or hose, all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace devices with stripped threads or damaged parts. Repairs requiring machining should not be attempted.

Removal

IMPORTANT: Before working on or around air brake systems and components, read **"Safety Precautions, 100."**

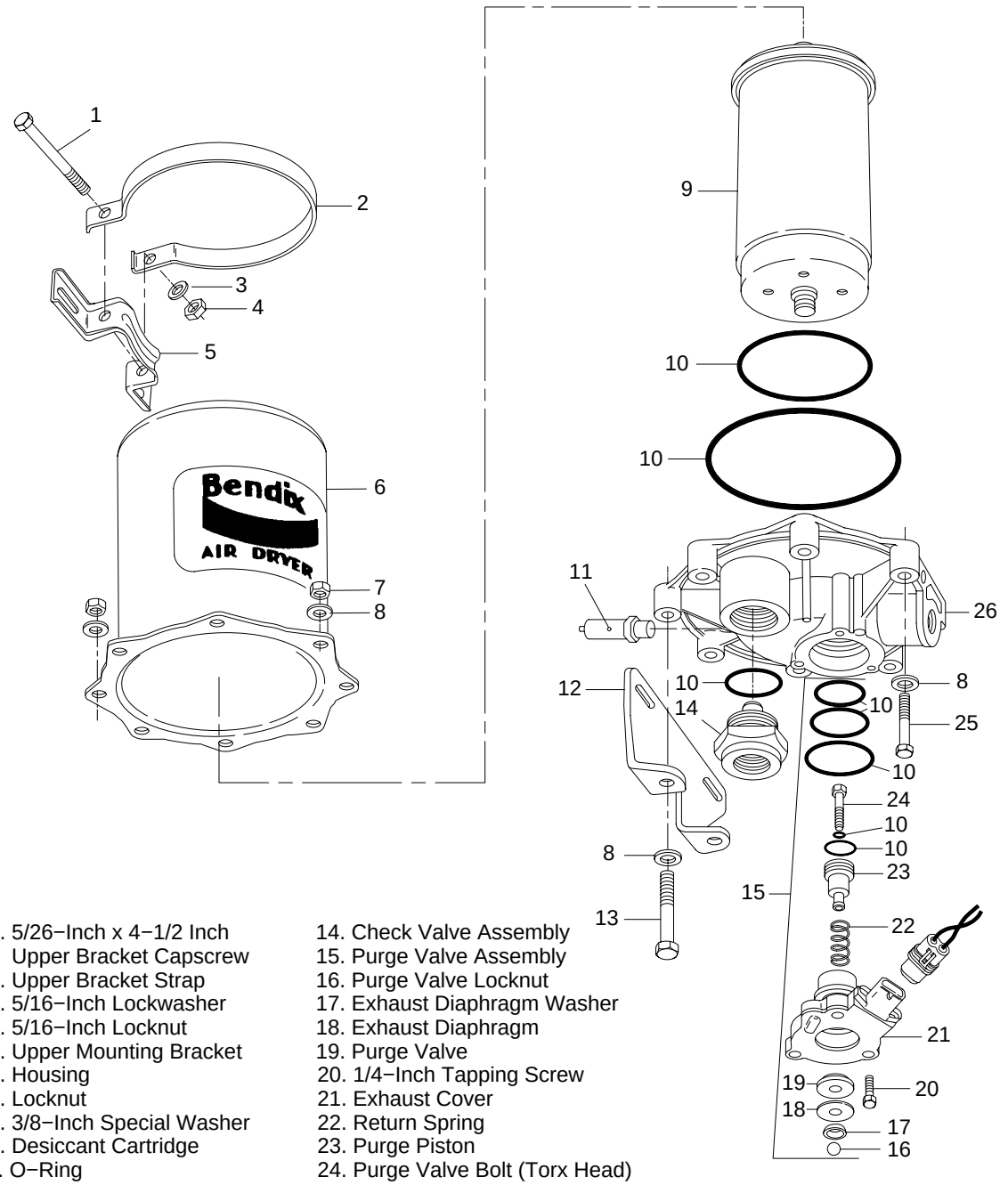
1. Park the vehicle on a level surface and chock the tires.
2. Drain all reservoirs to zero pressure.
3. Remove the air dryer.
   - 3.1 Identify and disconnect the three air lines from the end cover, and note the position of end cover ports relative to the vehicle.
   - 3.2 Unplug the vehicle wiring harness from the heater and thermostat assembly connector on the purge valve housing assembly.
   - 3.3 Loosen the hexbolt securing the upper mounting strap.
   - 3.4 Remove, save, and mark the two end cover capscrews, locknuts, and four special washers that retain the lower mounting bracket to the end cover. Also mark the two holes of the end cover. (These bolts are longer than the other six bolts.)
   - 3.5 Remove the air dryer from its mounting brackets.

Installation (See Fig. 1)

IMPORTANT: Before working on or around air brake systems and components, read **Safety Precautions, 100**.

1. Install the assembled air dryer on the vehicle.
   - 1.1 Position the air dryer up into the upper mounting bracket and strap. Align the two unused holes in the end cover with the bottom mounting bracket so that the bottom bracket supports the air dryer. The end cover should rest on the bracket.
   - 1.2 Using the remaining two capscrews (Ref. 13), four special washers (Ref. 8), and two locknuts (Ref. 7), secure the air dryer to the lower bracket. Tighten the two remaining capscrews 270 to 385 lbf·in (3060 to 4340 N·cm).
   - 1.3 Tighten the bolt and nut on the upper mounting bracket strap 80 to 120 lbf·in (900 to 1360 N·cm).
   - 1.4 As referenced earlier in "Removal," connect the three air lines to the ports on the end cover.
   - 1.5 Connect the vehicle wiring harness to the air dryer heater and thermostat assembly connector by plugging it into the air dryer connector until its lock tab snaps in place.
2. Test the air dryer following instructions in the brake section in the vehicle maintenance manual.

Removal and Installation



1. 5/26−Inch x 4−1/2 Inch Upper Bracket Capscrew
2. Upper Bracket Strap
3. 5/16−Inch Lockwasher
4. 5/16−Inch Locknut
5. Upper Mounting Bracket
6. Housing
7. Locknut
8. 3/8−Inch Special Washer
9. Desiccant Cartridge
10. O−Ring
11. Safety Valve
12. Lower Mounting Bracket
13. 3/8−Inch Capscrew (Long)
14. Check Valve Assembly
15. Purge Valve Assembly
16. Purge Valve Locknut
17. Exhaust Diaphragm Washer
18. Exhaust Diaphragm
19. Purge Valve
20. 1/4−Inch Tapping Screw
21. Exhaust Cover
22. Return Spring
23. Purge Piston
24. Purge Valve Bolt (Torx Head)
25. 3/8−Inch Capscrew
26. End Cover

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Fig. 1, AD-9 Exploded View

Disassembly, Cleaning and Inspection, and Assembly

When a major rebuild of the air dryer is undertaken, several replacement parts and maintenance kits are available that do not require full disassembly. Use the instructions provided with these parts or kits. **See Fig. 1** during disassembly.

Disassembly

IMPORTANT: Before working on or around air brake systems and components, read **Safety Precautions, 100**.

⚠ CAUTION

CAUTION: While servicing the air dryer, don't use a clamping device (vise, C-clamp, etc.) to hold any die cast aluminum part, as damage may result. To hold the end cover, install a pipe nipple in the supply port, and clamp the nipple in a vise.

1. Remove the air dryer from the vehicle. Refer to **Subject 110**.
2. Remove the check valve assembly (Ref. 14) and O-ring (Ref. 10). Remove the O-ring from the check valve assembly.
3. Remove the purge valve housing assembly.
   - 3.1 Remove the three self-tapping screws (Ref. 20) that secure the purge valve housing assembly (Ref. 15) to the end cover assembly (Ref. 26).
   - 3.2 Pull the purge valve housing assembly out of the end cover assembly.
   - 3.3 Remove three O-rings (Ref. 10) from the exterior of the purge valve housing assembly.

   NOTE: These O-rings may lodge in and have to be removed from the end cover bores.
4. Disassemble the purge valve housing assembly.
   - 4.1 If a flat non-extended exhaust cover (Ref. 21) is used, leave it intact while servicing the purge valve housing assembly.

     If an extended type exhaust cover is used for the attachment of an exhaust hose, *carefully* peel off the exhaust cover from the purge valve housing. *Use a thin flat blade to pry the exhaust cover off, taking care not to damage the potting material (RTV sealant) under the cover.*
   - 4.2 Remove the locknut (Ref. 16) from the bottom of the purge valve housing assembly. A Torx head or 12-point socket is used to hold the head of the bolt (Ref. 24). If present, remove the diaphragm washer (Ref. 17) and diaphragm (Ref. 18), and the purge valve (Ref. 19) from the purge valve housing.
   - 4.3 Remove the Torx head bolt (Ref. 24) from the opposite end, then the purge piston (Ref. 23), the return spring (Ref. 22) and two O-rings (one on the outside diameter and the other in the inside of the purge piston).

⚠ CAUTION

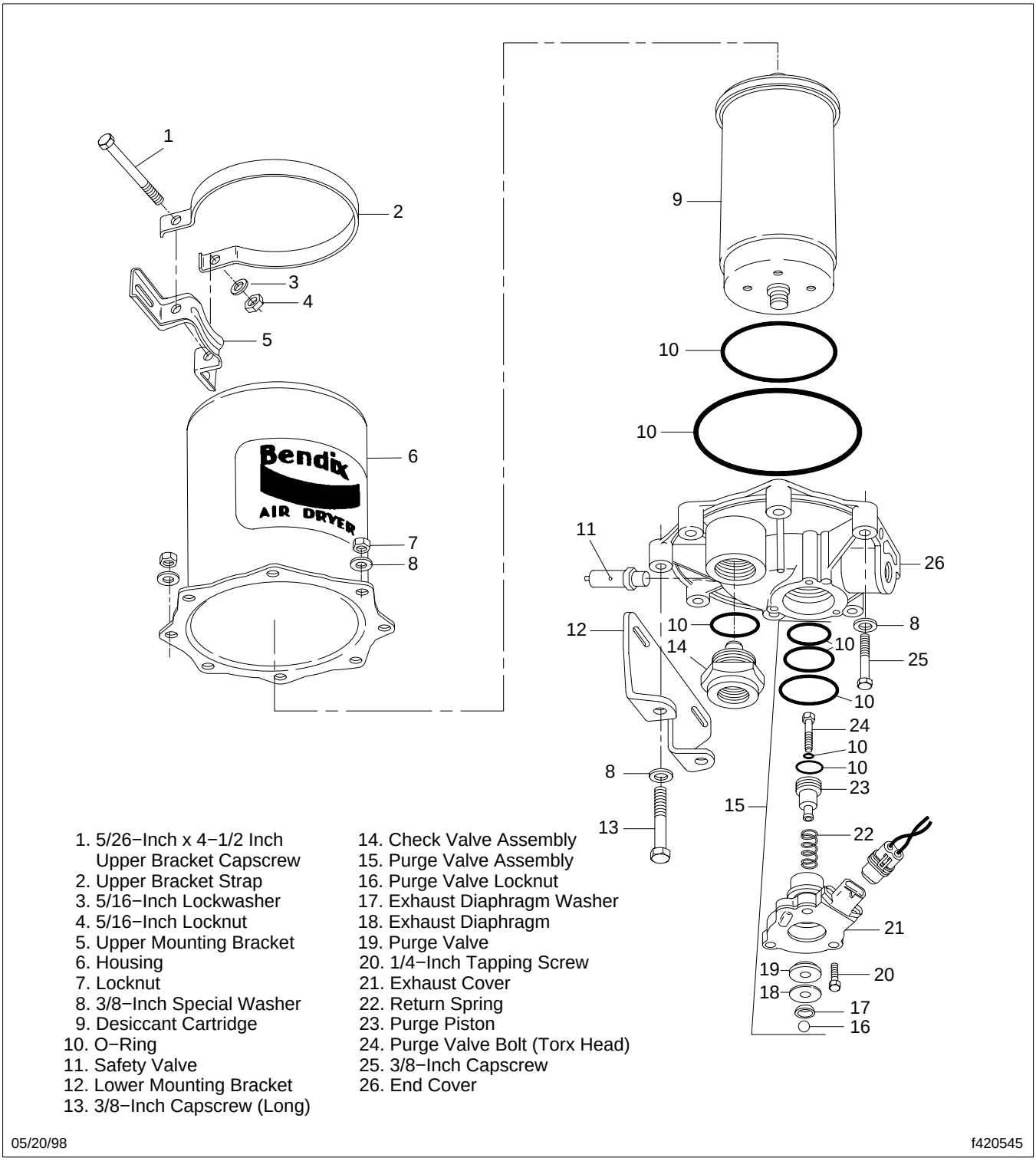
CAUTION: The heater and thermostat assembly is not available as a service port. Don't remove it; if the heater and thermostat are inoperative, replace the entire purge valve housing assembly, which includes these parts.

5. Remove the remaining six capscrews (Ref. 25), locknuts (Ref. 7), and twelve special washers (Ref. 8) that secure the end cover to the housing (Ref. 6). Separate the end cover and desiccant cartridge (Ref. 9) from the housing (Ref. 6).
6. Remove the end-cover-to-outer-housing O-ring.
7. Don't remove the safety valve (Ref. 11) from the end cover unless it is known to be inoperative. If replacement is needed, apply thread sealant or Teflon® tape on the threads of the replacement valve and tighten 120 to 400 lbf·in (1360 to 4520 N·m). Make sure the drain hole (slot) is facing down.
8. Place a strap or chain wrench around the desiccant cartridge (Ref. 9) so that it is about 2 to 3 inches (5 to 8 cm) away from the end cover. Rotate the cartridge counterclockwise until it completely separates from the end cover.

NOTE: Torque of up to 50 lbf·ft (68 N·m) may be needed to do this disassembly.

9. Remove the desiccant cartridge O-ring from the end cover.

Disassembly, Cleaning and Inspection, and Assembly



1. 5/26−Inch x 4−1/2 Inch Upper Bracket Capscrew
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20. 1/4−Inch Tapping Screw
21. Exhaust Cover
22. Return Spring
23. Purge Piston
24. Purge Valve Bolt (Torx Head)
25. 3/8−Inch Capscrew
26. End Cover

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Fig. 1, AD-9 Exploded View

Cleaning and Inspection

IMPORTANT: Before working on or around air brake systems and components, read **Safety Precautions, 100**.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Wash all metal parts thoroughly, using a quality commercial solvent, such as mineral spirits.
2. Check for severe corrosion, pitting, and cracks on the inside and outside of all metal parts that will be reused. Superficial corrosion and pitting on the outside of the upper and lower body halves is acceptable.
3. Inspect the bores of both the end cover and the purge-valve housing for deep scuffing or gouges.
4. Make sure that all purge-valve housing and end cover passages are open and free of blockages.
5. Inspect the pipe threads in the end cover. Make sure they are clean and free of thread sealant.
6. Inspect the purge-valve housing bore and seats for excessive wear and scuffing.
7. Inspect the purge valve piston seat for excessive wear.
8. Inspect all air line fittings for corrosion. Clean all old thread sealant from the pipe threads.
9. Replace all removed O-rings with new ones that are provided in the kits.

   Replace parts that show any of the conditions described in the previous steps.

Assembly (See Fig. 1)

IMPORTANT: Before working on or around air brake systems and components,read **Safety Precautions, 100**.

1. Before assembly, coat all O-rings, O-ring grooves, and bores with a generous amount of barium-base lubricant. **See Fig. 1** during assembly unless otherwise advised.
2. Assemble the purge-valve housing.
   - 2.1 Install the O-ring on the purge piston (Ref. 23). Place the return spring (Ref. 22) in the purge-valve housing. Place the O-ring in the bore of the purge piston. Install the Torx head bolt (Ref. 24) in the purge piston. Insert the purge piston (Ref. 23) in the inside diameter of the spring (Ref. 22). Push the piston into the purge-valve housing until it bottoms.
   - 2.2 While holding the purge piston in, install the following parts over the purge valve bolt (Ref. 24) from the opposite end of the purge-valve housing: the purge valve (Ref. 19) with its rubber side first, followed by the diaphragm (Ref. 18) (if present) and the diaphragm washer (Ref. 17) (if present) or the flatwasher, and finally the locknut (Ref. 16). Torque the purge valve locknut and bolt 60 to 80 lbf·in (680 to 900 N·cm).
   - 2.3 Install the three O-rings in their correct locations on the purge-valve housing.
   - 2.4 If the exhaust cover (Ref. 21) was removed, install it on the purge-valve housing assembly, making sure the "bubble" portion is positioned over the thermostat.
   - 2.5 Install the assembled purge-valve housing in the end cover; make sure you orient both parts so that the connector is about 10 degrees clockwise from the supply port. Also, make sure the purge-valve housing is fully seated against the end cover.
   - 2.6 Secure the purge-valve housing to the end cover using the three self-tapping screws (Ref. 20). Start all three screws by hand, then torque 85 to 125 lbf·in (960 to 1400 N·cm).
3. Install an O-ring on the check-valve assembly (Ref. 14), then install the assembly in the end cover using a socket. Tighten 200 to 250 lbf·in (2260 to 2820 N·cm).
4. Install the desiccant cartridge in the end cover.

Disassembly, Cleaning and Inspection, and Assembly

4.1 Install the smaller desiccant cartridge O-ring in its groove in the end cover (Ref. 26). Using a light coat of barium grease, lubricate the bottom of the desiccant cartridge in the area that will contact the O-ring and end cover.

4.2 Screw the desiccant cartridge (Ref. 9) into the end cover until the cartridge contacts the O-ring. Using a strap or chain wrench positioned 2 to 3 inches (5 to 8 cm) from the bottom of the cartridge, turn the desiccant cartridge clockwise 180 to 225 degrees beyond the position where initial contact was made with the O-ring. Torque should not exceed 50 lbf·ft (68 N·m).

5. Install the end cover housing over the desiccant cartridge.

5.1 Install the large O-ring on the shoulder in the end cover (Ref. 26). Place the housing (Ref. 6) over the desiccant cartridge and align the holes.

5.2 Install the six capscrews (Ref. 25), locknuts (Ref. 7), and the twelve special washers (Ref. 8), making sure they are positioned as referenced earlier. The two longer capscrews (Ref. 13) will be used to secure the air dryer to its mounting bracket.

5.3 Tighten the six capscrews and nuts in a star pattern **as shown in Fig. 2**, depending on lower bracket location. Tighten 270 to 385 lbf·in (3060 to 4340 N·cm).

NOTE: The two remaining bolt holes in the end cover and two 3/8-inch capscrews must be the ones marked during disassembly to ensure correct orientation of the ports and adequate length of the capscrews.

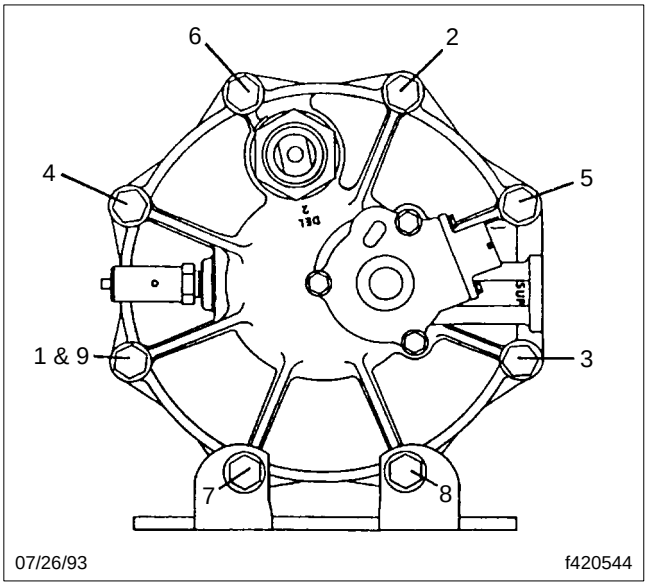


Fig. 2, End Cover to Housing Torque Pattern

Testing

During cold-weather operation, check the operation of the end cover heater and thermostat assembly.

1. With the ignition on, check for voltage to the heater and thermostat assembly. Unplug the electrical connector at the air dryer, and place the test leads on each of the pins of the male connector. If there is no voltage, look for a blown fuse, broken wires, or corrosion in the vehicle wiring harness. Check that a good ground path exists.
2. Check the thermostat and heater operation. Turn off the ignition switch and cool the end cover assembly to below 40°F (4°C). Using an ohmmeter, check the resistance between the electrical pins in the female connector. The resistance should be 1.5 to 3.0 ohms for the 12-volt heater assembly, and 6.8 to 9.0 ohms for the 24-volt heater assembly.

NOTE: Some early models of the AD-9 will have resistance readings of 1.0 to 2.5 ohms for the 12-volt heater assembly, and 4.8 to 7.2 ohms for the 24-volt heater assembly. If the resistance is higher than this, replace the purge-valve housing assembly, which includes the heater and thermostat assembly.

3. Warm the end cover assembly to over 90°F (32°C) and again check the resistance. It should exceed 1000 ohms. If it does, the thermostat and heater assembly is operating properly. If it doesn't, replace the purge-valve housing assembly, which includes the heater and thermostat assembly.

Problem—Air Dryer Is Constantly Cycling or Purging

Possible Cause	Remedy
Excessive system leakage.	Test for excessive leakage. Eliminate leaks, as needed. Allowable leakage is as follows: • Single Vehicle—1 psi/min (7 kPa/min) per service reservoir • Tractor/Trailer—3 psi/min (21 kPa/min) per service reservoir
There is excessive leakage in the fittings, hoses, and tubing connected to the compressor, air dryer, and wet tank.	Using a soap solution, test for leakage at the fittings, drain valve, and safety valve in the wet tank. Repair or replace as needed.
Check valve assembly in the air dryer end cover is not working.	Remove the check valve assembly from the end cover. Apply compressed air to the delivery side of the valve. Apply a soap solution at opposite end, and check for leakage. Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. If there is excessive leakage, replace the check valve assembly.
Governor is inoperative.	Test the governor for proper cut-in or cut-out pressures and excessive leakage in both positions.
Leaking purge-valve housing assembly or O-rings in the air dryer end cover.	With the supply port open to atmosphere, apply 120 psi (830 kPa) at the control port. Apply a soap solution to the supply port and exhaust port (purge valve seat area). Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. Repair or replace as needed.
Compressor unloader mechanism is leaking excessively.	Remove the air strainer or fitting from the compressor inlet cavity. With the compressor unloaded, check for unloader piston leakage. Slight leakage is allowed.
Holset "E" type compressor.	Test the air dryer system. For instructions, refer to Bendix Product Bulletin PRO-08-19 entitled "Troubleshooting the Holset "E" Compressor System with Bendix Air Dryer."
Lack of air at the governor RES port (rapid cycling of the governor).	Test the governor for proper pressure at the RES port. Pressure should not drop below cut-in pressure when the compressor begins the unloaded cycle. If the pressure does drop, check for kinks or restrictions in the line connected to the RES port. The line connected to the RES port on the governor must be the same diameter, or larger than the lines connected to the UNL ports on the governor.

Problem—Water in the Vehicle Reservoirs

Possible Cause	Remedy
Desiccant cartridge assembly contains excessive contaminants.	Replace the desiccant cartridge.
Discharge line is of improper length or material.	Discharge line must consist of at least 6 ft (1.8 m) of wire braid Teflon hose, copper tubing, or a combination of both between the discharge port of the compressor and the air dryer supply port. Discharge line lengths and inside diameter requirements are dependent on the vehicle application. Contact your local Bendix representative for further information.
Air system was charged from an outside air source that did not pass through an air dryer.	If the system must have an outside air fill provision, the outside air should pass through an air dryer. This practice should be minimized.
Air dryer is not purging.	Refer to "Problem—Air Dryer Does Not Purge or Exhaust Air."
Purge (air exhaust) is insufficient due to excessive system leakage.	Refer to "Problem—Air Dryer Is Constantly Cycling or Purging."

Troubleshooting

Possible Cause	Remedy
Air bypasses the desiccant cartridge assembly.	Replace the desiccant cartridge/end cover O-ring. Make sure the desiccant cartridge assembly is properly installed.
Purge (air exhaust) time is significantly less than the minimum allowable.	Replace the desiccant cartridge/end cover O-ring. Make sure the desiccant cartridge assembly is properly installed. Replace the desiccant cartridge assembly.
Excessive air usage—air dryer not compatible with vehicle air system.	Install an accessory bypass system. Consult your Bendix representative for additional information.

Problem—Safety Valve on Air Dryer Is Popping Off or Exhausting Air

Possible Cause	Remedy
Desiccant cartridge is plugged or saturated.	Check the compressor for excessive oil passing, or incorrect installation. Repair or replace as needed.
The check valve in the air dryer air cover is inoperative.	Test to determine if air is passing through the check valve. Repair or replace as needed.
There is a problem in the fittings, hose, or tubing between the air dryer and the wet tank.	See if air is reaching the first reservoir. Inspect for kinked tubing or hose. Check for undrilled or restricted hose or tubing fittings.
Pinging noise is due to a single cylinder compressor with high pulse cycles.	A slight pinging sound may be heard during system build-up when a single cylinder compressor is used. If this sound is deemed objectionable, it can be reduced substantially by increasing the discharge line volume. This is done by adding a 90 in ^{3} (1475 cm ^{3}) reservoir between the compressor and the air dryer.
Safety valve setting is lower than the maximum system pressure.	Reduce the system pressure, or install a safety valve with a higher pressure setting.

Problem—Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure

Possible Cause	Remedy
Air dryer purge valve is leaking excessively.	With the compressor loaded, apply a soap solution on the purge valve exhaust to test for excessive leakage. Repair the purge valve as needed.
The governor is inoperative.	Check the governor for proper cut-in and cut-out pressures, and excessive leakage in both positions. Repair or replace as needed.
Purge control line is connected to the reservoir or exhaust port of the governor.	Connect the purge control line to the unloader port of the governor.
Purge valve is frozen open due to an inoperative heater or thermostat, bad wiring, or a blown fuse.	Test the heater and thermostat, following instructions in this manual.
Inlet and outlet air connections are reversed—unable to build system pressure.	Reconnect the lines properly.
Discharge line is kinked or blocked.	See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits.
There are excessive bends in the discharge line. Water is collecting and freezing.	Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.

Possible Cause	Remedy
System is leaking excessively.	Test for excessive leakage. Eliminate leaks, as needed. Allowable leakage is as follows: • Single Vehicle—1 psi/min (7 kPa/min) per service reservoir • Tractor/Trailer—3 psi/min (21 kPa/min) per service reservoir
Purge valve stays open; supply air leaks to control side.	Replace the purge valve assembly O-rings.

Problem—Air Dryer Does Not Purge or Exhaust Air

Possible Cause	Remedy
Purge control line is broken, kinked, frozen, plugged, or disconnected.	See if air flows through the purge control line when the compressor is unloaded. The purge control line must be connected to the unloader port of the governor.
Air dryer purge valve isn't working.	See if air reaches the purge valve. If it does, repair the purge valve.
The governor is inoperative.	Check the governor for proper cut-in and cut-out pressures, and excessive leakage in both positions. Repair or replace as needed.
Inlet and outlet air connections are reversed—unable to build system pressure.	Reconnect the lines properly.
Discharge line is kinked or blocked.	See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits.
There are excessive bends in the discharge line. Water is collecting and freezing.	Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.

Problem—Desiccant Is Being Expelled from the Air Dryer Purge Valve Exhaust (May Look Like Whitish Liquid, Paste, or Small Beads); or, Unsatisfactory Desiccant Life

Possible Cause	Remedy
This problem usually occurs with one or more of the previous problems.	Refer to the appropriate corrections listed previously.
Air dryer is not securely mounted; there is excessive vibration.	Vibration should be held to a minimum. Tighten the mounting fasteners.
Cloth-covered perforated plate in the air dryer desiccant cartridge is damaged, or the cartridge was rebuilt incorrectly.	Replace the plate or cartridge as needed. High operating temperatures may cause deterioration of filter cloth. Check the installation.
Compressor is passing excessive oil.	Check for proper compressor installation; if symptoms persist, replace the compressor.
Heater and thermostat, wiring, or a fuse is at fault, and isn't allowing the air dryer to purge during cold weather.	Test the heater and thermostat, following instructions in this manual.
Desiccant cartridge not attached properly to the end cover.	Check the torque and tighten if necessary. Refer to **Subject 120 for instructions.**

Troubleshooting

Problem—Pinging Noise Is Excessive During Compressor Loaded Cycle

Possible Cause	Remedy
Pinging noise is due to a single cylinder compressor with high pulse cycles.	A slight pinging sound may be heard during system build-up when a single cylinder compressor is used. If this sound is deemed objectionable, it can be reduced substantially by increasing the discharge line volume. This is done by adding a 90 in ^{3} (1475 cm ^{3}) reservoir between the compressor and the air dryer.

Problem—Constant Air Seepage at the Purge Valve (Non-Charging Mode)

Possible Cause	Remedy
Air compressor inlet is pressurized by the engine turbocharger.	Some pressure leakage past the metal seat of the turbocharger cutoff feature of the AD-9 air dryer is normal, and may be heard. This slight loss of air will not affect the engine or turbocharger performance.
Check valve assembly in the air dryer end cover is not working.	Remove the check valve assembly from the end cover. Apply compressed air to the delivery side of the valve. Apply a soap solution at opposite end, and check for leakage. Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. If there is excessive leakage, replace the check valve assembly.

Problem—Air Dryer Purge Piston Cycles Rapidly in the Unloaded Mode

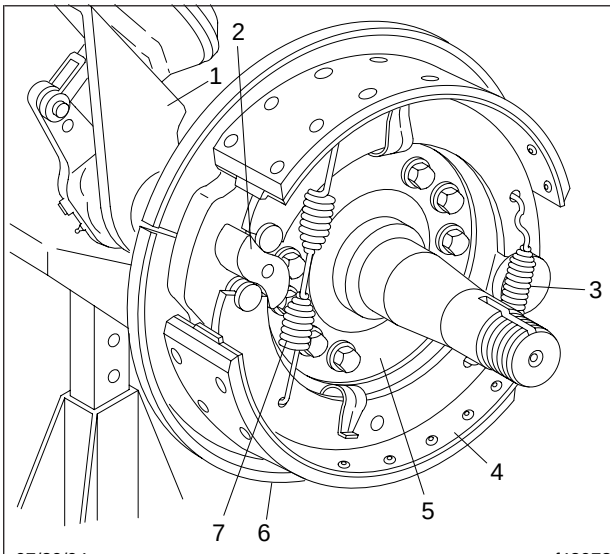
Possible Cause	Remedy
Compressor does not "unload."	Check the governor installation: there is no air line from the governor to the compressor, or the line is restricted. Repair or replace as needed.

General Information

Dana® Spicer® brakes are actuated by an S-type cam head, which is forged integrally with the camshaft and supported with nylon bushings. See **Fig. 1**. Cam pressure is applied through the cam rollers.

These brakes are used on both the front steer axle and rear axle.

Meritor steer axles have seven holes for attaching the spider to the axle flange. There is an eighth hole that is left open on the brake spider, on both the left and right sides of the steer axle. See **Fig. 2**. The seven holes used for attachment of the spider to the axle flange are 0.656 inch in diameter. The eighth hole is oversized at 0.687 inch in diameter.



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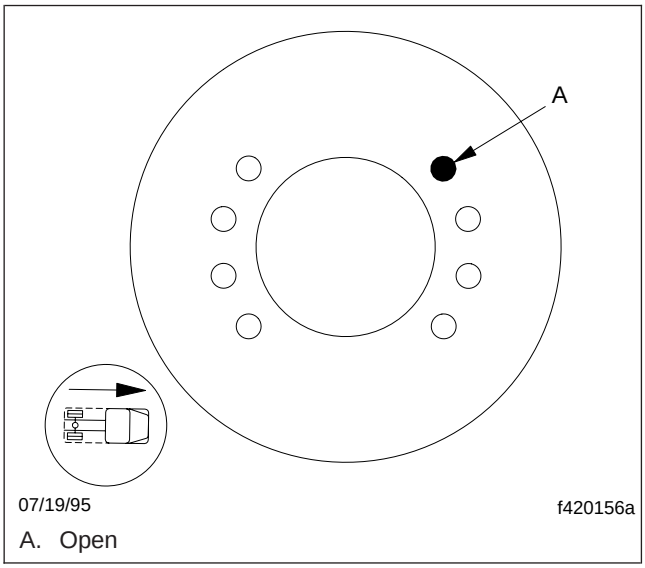
1. Air Chamber Bracket
2. Camshaft
3. Shoe Retaining Spring
4. Shoe Assembly
5. Spider
6. Dust Shield
7. Shoe Return Spring

Fig. 1, Front Axle Brake

When the brake pedal is depressed, compressed air enters the brake chamber, causing the diaphragm to move a pushrod assembly.

The pushrod, which is connected to a slack adjuster, turns the slack adjuster and brake camshaft. As the camshaft turns, the S-head, which is between the brake shoe rollers, forces the brake shoes against the brake drum, and braking occurs.

When the brakes are released and air is exhausted from the brake chamber, the actuator return spring (within the brake chamber) and the brake shoe return spring, return the camshaft, brake shoes, slack adjuster, and pushrod to their released positions.



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A. Open

Fig. 2, Attachment Holes

General Safety Precautions

WARNING

When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.

When working on or around a vehicle, observe the following precautions:

- Park the vehicle on a level surface and apply the parking brakes. Shut down the engine and chock the tires.
- If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air pressure drops.
- Disconnect the batteries.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure. Always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Do not remove, disassemble, assemble, or install a component until you have read and understand the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools and observe all precautions pertaining to use of those tools.
- Replacement hardware, tubing, hose, fittings, etc. should be the equivalent size, type, length, and strength of the original equipment.
- Make sure when replacing tubes or hoses that all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices that have stripped threads or damaged parts. Repairs requiring machining should not be attempted.
- Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

Asbestos and Non-Asbestos Safety

WARNING

Wear a respirator at all times when servicing the brakes, starting with the removal of the wheels and continuing through assembly. Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH.

Because some brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Exposure to airborne asbestos brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer.

Because medical experts believe that long-term exposure to some *non-asbestos* fibers could also be a health hazard, the following precautions should also be observed if servicing non-asbestos brake linings.

Areas where brake work is done should be separate from other operations, if possible. As required by OHSA regulations, the entrance to the areas should have a sign displayed indicating the health hazard.

During brake servicing, an air purifying respirator with high-efficiency filters must be worn. The respirator and filter must be approved by MSHA or NIOSH, and worn during all procedures.

Safety Precautions

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system is not available, the brake assembly must be cleaned in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with a HEPA filter system, remove dust from the brake drums, brake backing plates, and brake parts. After vacuuming, any remaining dust should be removed using a rag soaked in water and wrung until nearly dry. Do not use compressed air or dry brushing to clean the brake assembly.

If grinding or other machining of the brake linings is necessary, other precautions must be taken because exposure to asbestos dust is highest during such operations. In addition to the use of an approved respirator, there must be local exhaust ventilation such that worker exposure is kept as low as possible.

Work areas should be cleaned by industrial vacuums with HEPA filters or by wet wiping. Compressed air or dry sweeping should never be used for cleaning. Asbestos-containing waste, such as dirty rags, should be sealed, labeled, and disposed of as required by EPA and OSHA regulations. Respirators should be used when emptying vacuum cleaners and handling asbestos waste products.

Workers should wash before eating, drinking, or smoking, should shower after work, and should not wear work clothes home. Work clothes should be vacuumed after use and then laundered, without shaking, to prevent the release of asbestos fibers into the air.

Brake Shoe Removal and Installation

WARNING

Before starting the following procedures, see "Safety Precautions" in Subject 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Raise the front or rear axle and place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
3. Remove the wheels and brake drums. For instructions, see **Section 33.02** for front axles or **Section 35.02** for rear axles.

CAUTION

Failure to follow the proper procedure when backing off the automatic slack adjusters could damage the slack adjusters.

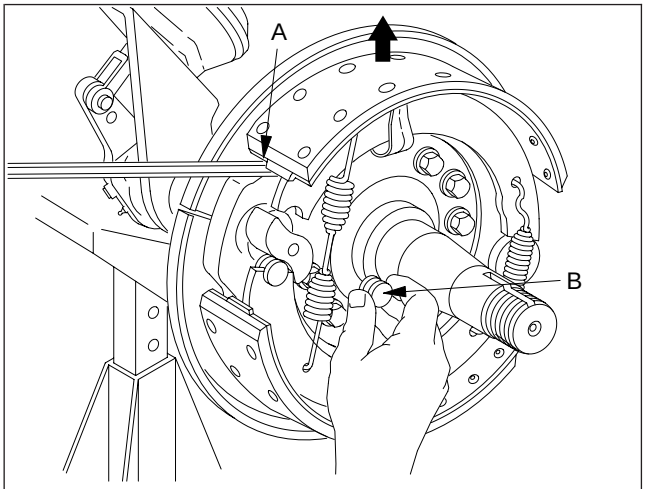
4. Back off the slack adjusters:
   - *Manual slack adjusters*: Back off the slack adjuster until the brake shoes no longer contact the drum.
   - *Automatic slack adjusters*: For instructions, see **Section 42.29** for Meritor, **Section 42.33** for Gunite® or **Section 42.36** for Haldex®.
5. If equipped with 16-1/2-inch series brakes, go to the next step.

   On 15-inch series brakes, remove the brake shoes.

   5.1 Using a large screwdriver or lever, lift the upper shoe to stretch the return spring.

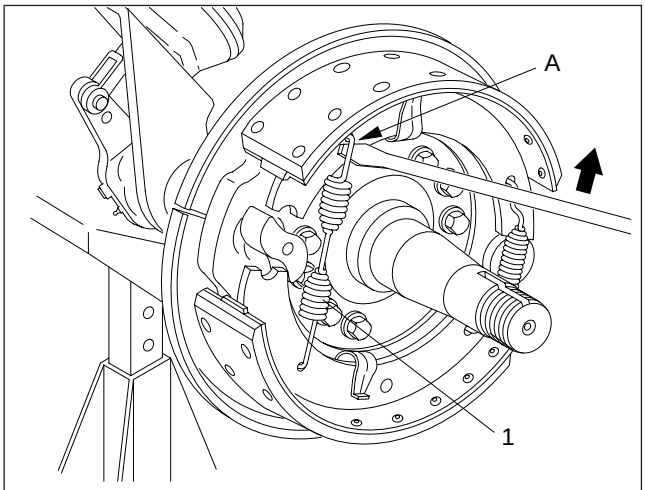
   Remove the upper cam roller. See **Fig. 1**. Repeat for the lower shoe and cam roller.

   5.2 Stretch the shoe return spring and unhook it from the upper shoe web. See **Fig. 2**.



A. Lift upper shoe to stretch spring.
B. Remove roller.

Fig. 1, Remove the Upper Cam Roller



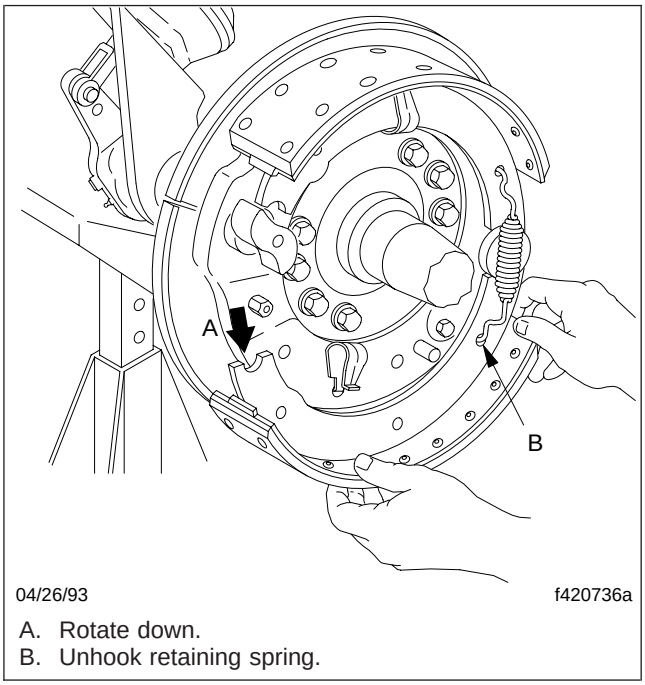
A. Stretch spring to unhook from shoe web.
1. Shoe Return Spring

Fig. 2, Stretch the Shoe Return Spring

5.3 Rotate the lower shoe downward and turn it to allow disengagement of the shoe retaining spring from the lower shoe web. See **Fig. 3**.

5.4 Rotate the upper shoe upward and remove the shoe and shoe retaining spring.

Brake Shoe Removal and Installation



A. Rotate down.
B. Unhook retaining spring.

Fig. 3, Rotate the Lower Shoe Downward

5.5 Discard the cam rollers, shoe return spring, and shoe retaining spring.

NOTE: If equipped with Extended Service brakes, pry the roller retainer loops out of both shoe web holes. See **Fig. 4**. Pivot the roller retainer to swing the loops clear of the shoe webs.

6. On 16-1/2-inch series brakes, remove the brake shoes.

   6.1 Using a large screwdriver or lever, lift the upper shoe to stretch the return spring. Remove the cam roller and the pin or retainer, as equipped. See **Fig. 5**.

   Repeat for the lower shoe and roller pin (or retainer).

   6.2 Push the cam end of both shoes toward the cam and unhook the shoe return spring.

   NOTE: If equipped with Extended Service brakes, position a suitable lever to engage the rod of the spring. See **Fig. 6**. Force the lever down to stretch the spring and allow removal of the upper spring hook.

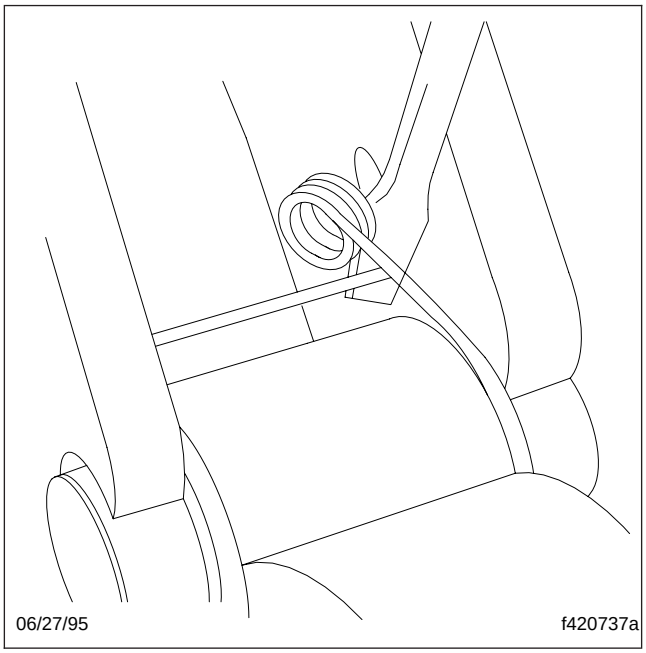
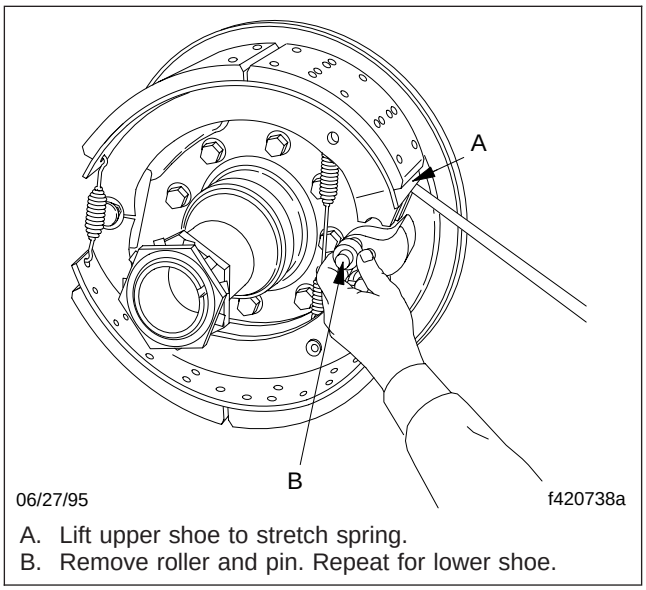


Fig. 4, Pry Out the Roller Retainer Loops

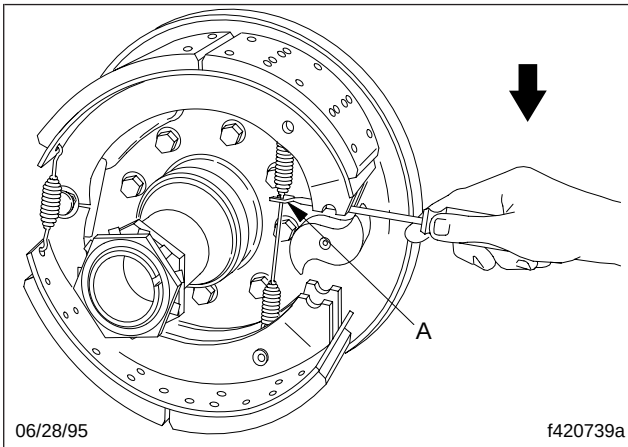


A. Lift upper shoe to stretch spring.
B. Remove roller and pin. Repeat for lower shoe.

Fig. 5, Removing the Cam Rollers

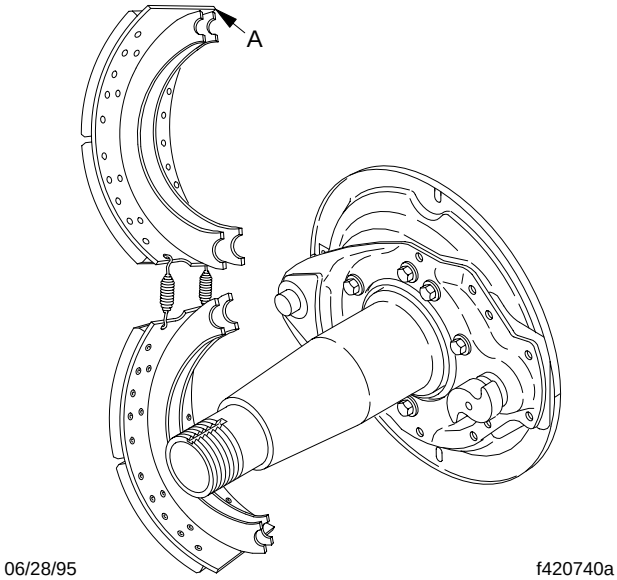
   6.3 Rotate both shoes around the anchor pin. Remove the shoes. See **Fig. 7**.

   6.4 Discard the cam rollers and pins, and the shoe return spring (or shoe retainer springs on Extended Service brakes).



A. Stretch spring using suitable tool positioned as shown.

Fig. 6, Remove the Upper Spring Hook



A. Rotate both shoes around anchor pin and lift off brake shoes.

Fig. 7, Remove the Brake Shoes

7. Inspect the brake shoes and linings for wear or damage. For instructions, see **Subject 120**.

Installation

IMPORTANT: For best brake performance, do not mix Extended Service brakes with other Dana® Spicer® series brakes. Use the same brake series on the entire vehicle.

1. Apply a thin film of temperature resistant grease (Kendall M-621, or an equivalent) to the cam roller and, for all models except Extended Service brakes, the anchor pin recesses of each shoe web.
2. If equipped with 16-1/2-inch brakes, go to the next step.

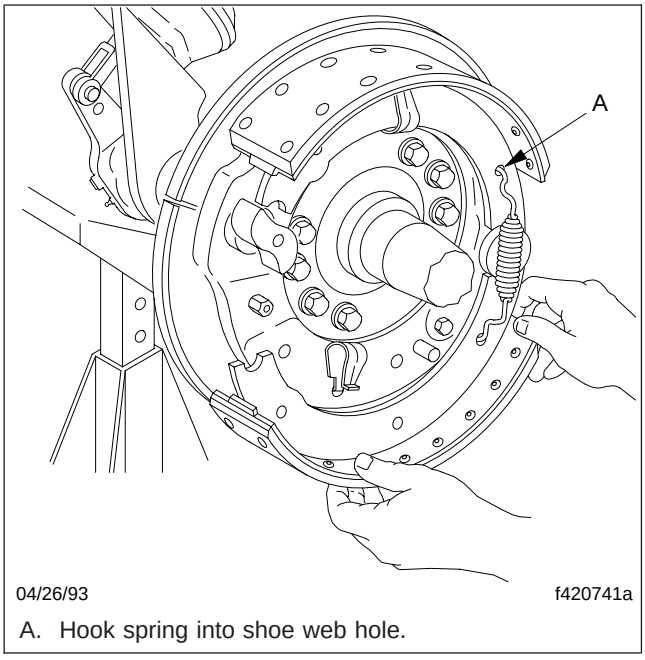
   On 15-inch series brakes, install the brake shoes.

   2.1 Place the upper brake shoe and lining web on the anchor pin and rotate down. Continue rotation until the shoe is held in place by the shoe hold-down spring.

   2.2 Hook one end of the new shoe retaining spring into the hole in the upper shoe web so that the coil lays across the anchor pin. See **Fig. 8**.

   Hook the opposite end of the spring into the hole on the lower shoe web.

   Stretch the spring to allow positioning of the lower shoe web against the anchor pin.



A. Hook spring into shoe web hole.

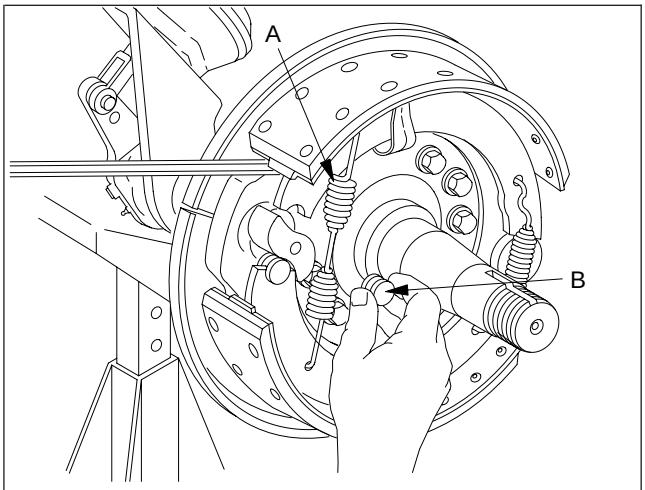
Fig. 8, Attach the New Shoe Retaining Spring

Brake Shoe Removal and Installation

2.3 Rotate the lower shoe into position so that the shoe web rests on the barrel nut (if equipped) or against the anchor pin.

2.4 Hook one end of the new shoe return spring in the lower shoe web hole. Using a screwdriver, stretch the shoe return spring hook in the upper shoe web hole.

2.5 Using a large screwdriver or lever, stretch the shoe return spring to allow insertion of the new cam roller on the upper shoe web. See **Fig. 9**. Install the new cam roller on the lower shoe web.



A. Install new return spring.
B. Install rollers.

Fig. 9, Install the Cam Rollers

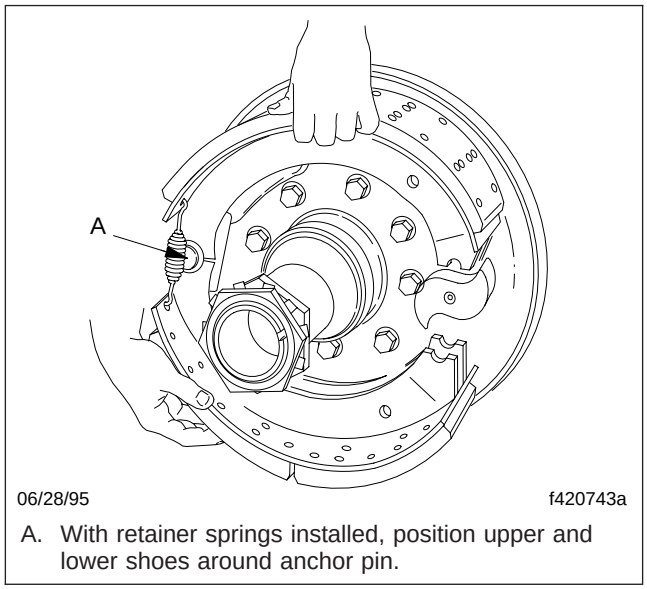
3. If equipped with 16-1/2-inch series brakes, install the brake shoes.

3.1 Hook the ends of the new retainer springs into the holes in both shoe tables. Make sure that the hooks are pointing out.

3.2 Position the upper and lower shoes around the anchor pin. See **Fig. 10**.

3.3 Install a new shoe return spring.

On Extended Service brakes, position a suitable lever to engage the rod of the spring. See **Fig. 6**. Force the lever down to stretch the spring and allow installation of the upper spring hook. Assemble the roller retainer on the ends of the roller. See **Fig. 11**.



A. With retainer springs installed, position upper and lower shoes around anchor pin.

Fig. 10, Position the Upper and Lower Shoes

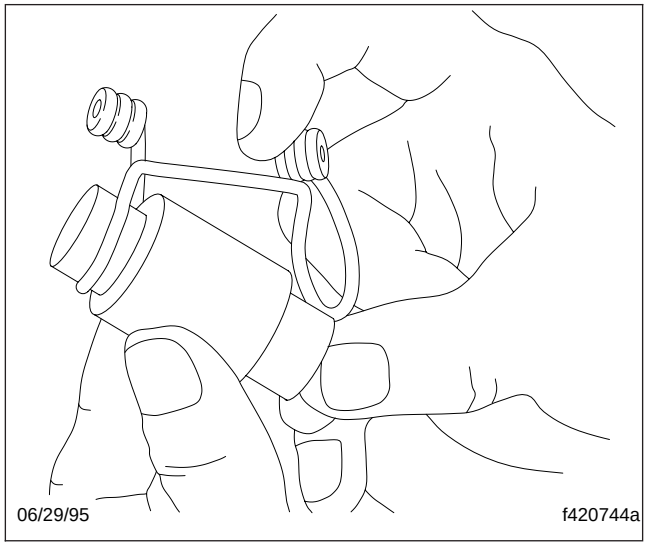
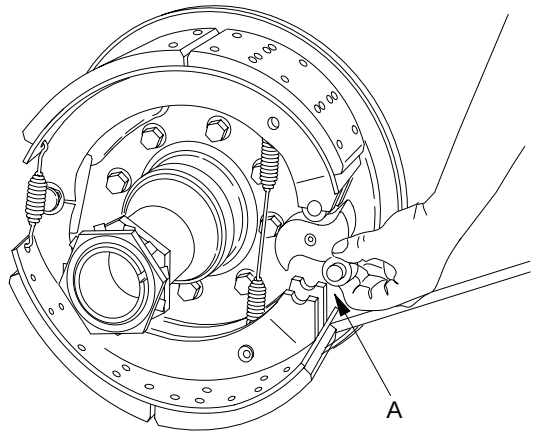


Fig. 11, Roller Retainer Assembly

3.4 Using a lever or a large screwdriver, stretch the shoe return spring to allow insertion of the new pin and roller (or the new roller and retainer assembly on Extended Service brakes) on the lower shoe web. See **Fig. 12**.

On Extended Service brakes, squeeze the loops and swing the retainer assembly into position. See **Fig. 13**. Snap the loops into the web holes. Make sure both retainer loops are engaged in the web holes.

Repeat on the upper shoe.



A. Using a lever, stretch return spring and install cam roller and pin.

Fig. 12, Install the Cam Rollers

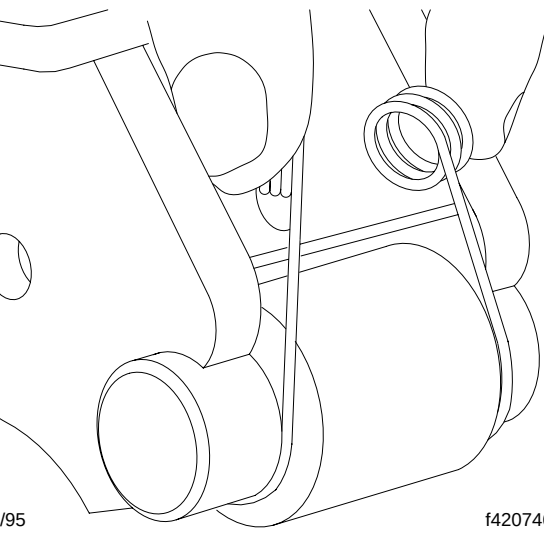


Fig. 13, Position the Retainer Assembly

4. Install the wheels and brake drums. For instructions, see **Section 33.02** for front axles or **Section 35.02** for rear axles.

   If working on the rear axle, manually uncage the power spring of the parking brake chamber. For instructions, see **Section 42.31** for MGM® E or TR series, **Section 42.39** for Anchorlok® or **Section 42.42** for MGM L series.

5. Adjust the brakes at the slack adjusters. For instructions, see **Subject 150**.

6. Remove the safety stands and lower the vehicle.

7. Remove the chocks from the tires.

⚠ WARNING

Do not operate the vehicle until you have adjusted the brakes and checked for proper brake operation. Failure to do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

8. Check for proper brake operation.

   8.1 To ensure that the braking system is working correctly, make ten 40 to 20 mph (60 to 30 km/h) snubs to seat the linings.

   8.2 Make ten stops from 20 mph (30 km/h) at 50 percent air pressure.

   8.3 Make a full-pressure stop from 20 mph (30km/h).

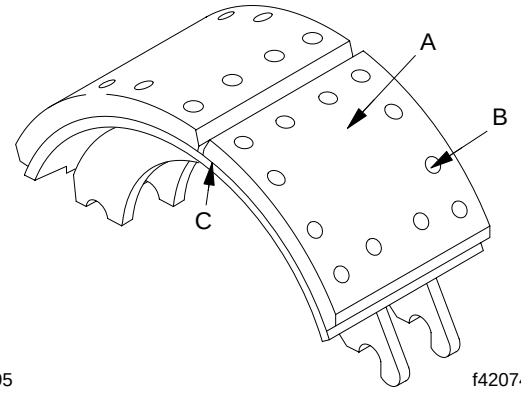
   8.4 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than the others shows a lack of braking effort on those wheels.

WARNING

Before starting the following procedures, see "Safety Precautions" in Subject, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Inspection

1. Remove the brake shoes. For instructions, see **Subject 110**.
2. Check the linings:
   - *15-inch series brakes*: If the linings are grease- or oil-soaked, cracked, or worn to less than 3/16-inch (4.5-mm) thickness at any point, replace them. The lining surface should be no closer than 1/16 inch (1.5 mm) to any rivet head (see **Fig. 1**).
   - *16-1/2-inch series brakes*: If the linings are grease- or oil-soaked, cracked, or worn to less than 1/4-inch (6.4-mm) thickness at any point, replace them.



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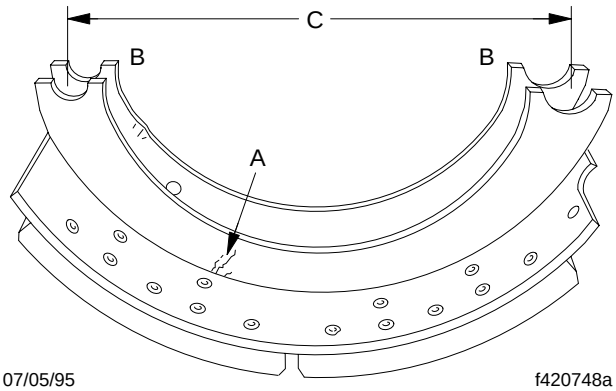
A. Check for cracks or contamination.
B. No closer than 1/16 inch (1.5 mm) to any rivet head.
C. 3/16-inch (4.5-mm) minimum thickness.

Fig. 1, 15-Inch Series Brake Shoe

3. Check the shoes for bent or cracked webs or tables, broken welds, loose rivets, or out-of-round rivet holes. See **Fig. 2**. Replace the shoes if any of these conditions exist.



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A. Check table and web for cracks or bends.
B. Check both ends for wear and elongation.
C. Measure this distance.

Fig. 2, Measuring the Shoe Span

4. Check the anchor pin for looseness and camshaft roller recesses in the shoe webs for visible wear. Replace the shoe if needed.
5. Check the shoe span. Measure the distances between the centerlines of the anchor pin and camshaft roller pin recesses in the shoe web (see **Fig. 2**):
   - *15-inch series brakes*: If the measurement is more than 11-3/4 inches (298 mm), replace the shoe.
   - *16-1/2-inch series brakes*: If the measurement is more than 12-9/16 inches (319 mm), replace the shoe.

⚠ WARNING

Before starting the following procedures, see "Safety Precautions" in Subject, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Replacement

IMPORTANT: For the best brake performance, do not mix brake linings between axles. When relining brake shoes, both wheel ends of each axle must have the same linings. On tandem axles, all four wheel ends must also have the same linings. However, it is not necessary for the steering axle brakes to have the same linings as the rear drive axle brakes. Also, when the minimum thickness is reached for any of the brake linings on an axle, reline both brakes on that axle at the same time.

NOTE: Replace the springs each time the brakes are relined. Dana® Spicer® recommends replacement of the rollers and pins at each reline.

1. Remove the brake shoes. For instructions, see **Subject 110**.

⚠ CAUTION

Drilling out rivets or cutting off rivet heads with a chisel can cause the rivet hole to become out-of-round. This could damage the brake shoe.

2. Using a suitable riveting mandrel, push out (do not drill out) the old rivets.
3. Clean the shoe table. For instructions, see **Subject 140**.

⚠ CAUTION

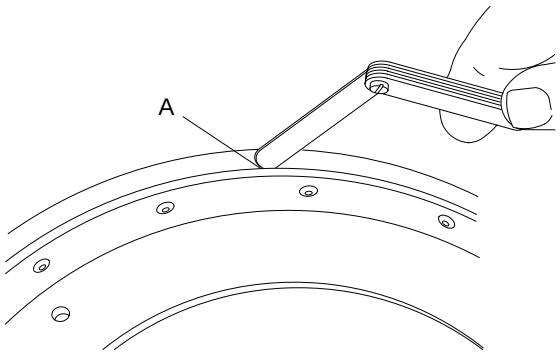
Make sure that the replacement lining material conforms to FMSI 1308. The FMSI number indicated is a standard for lining size and shape only. Use of an improper FMSI lining specification or friction material type may cause brake dragging, grabbing, or improper brake performance.

4. Align the brake shoe and lining rivet holes. Using a C-clamp, clamp the lining to the brake shoe.
5. Insert the correct sized rivets into all holes in the new block, and temporarily hold them in place with masking tape.

IMPORTANT: Use rivets that have the correct material, shank diameter, length, head size, and shape. Use tubular rivets that are 1/4-inch (6-mm) diameter by 1/2-inch (13-mm) long, SAE No. 10–8, made of zinc- or brass-plated steel.

6. Begin riveting at the center of each edge of the shoe and lining, and work toward each end.
7. Check for a close fit between the lining and shoe table.

   Try to insert a 0.006-inch (0.15-mm) feeler gauge between the lining and shoe table along the edges. See **Fig. 1**. It should not be possible to insert the gauge anywhere along the edge, except at each end beyond the last row of rivets. A larger clearance may exist in these areas.



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A. Try to insert a 0.006-inch (0.15-mm) feeler gauge between the lining and shoe table along the edges.

Fig. 1, Insert the Feeler Gauge

IMPORTANT: Always adjust the brakes at the slack adjusters after replacing the linings. For instructions, see **Subject 150**.

Brake Components Disassembly and Inspection, Cleaning, and Assembly

⚠ WARNING

Before starting the following procedures below, see "Safety Precautions" in Subject, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Disassembly and Inspection

NOTE: For depictions of the brake components, see **Fig. 1** and **Fig. 2**.

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Check the drum for cracks, heat checks, glazing, grooving, run-out, and out-of-round. See **Fig. 3**.

   Measure the drum diameter. Replace the drum if it exceeds the maximum diameter stamped on it. Replace cracked drums.

   Some drums that are glazed, grooved, or out-of-round can be repaired. For detailed instructions, see **Section 33.02** for front axles or **Section 35.02** for rear axles.
3. Disconnect the slack adjuster from the pushrod clevis:
   - *Manual slack adjusters*: Remove the cotter pin and clevis pin from the brake chamber pushrod clevis.
   - *Automatic slack adjusters*: For instructions, see **Section 42.29** for Meritor, **Section 42.33** for Gunite® or **Section 42.36** for Haldex®.
4. With the brake shoes removed, use a dial indicator to measure the up-and-down and side-to-side end play of the camshaft. Replace the bushings if there is more than 0.020 inch (0.5 mm) of movement.

⚠ CAUTION

Do not hammer on the manual slack adjuster to remove it. Damage to the adjuster or camshaft spline may result.

5. Remove the slack adjuster:
   - *Manual slack adjusters*: While depressing the locking sleeve, turn the adjuster nut until the adjuster is clear of the brake chamber pushrod clevis. Remove the lock-ring and the outer spacing washers from the camshaft. Using a suitable puller, remove the slack adjuster.
   - *Automatic slack adjusters*: For instructions, see **Section 42.29** for Meritor, **Section 42.33** for Gunite® or **Section 42.36** for Haldex®.
6. Check the slack adjuster for damage and for binding.

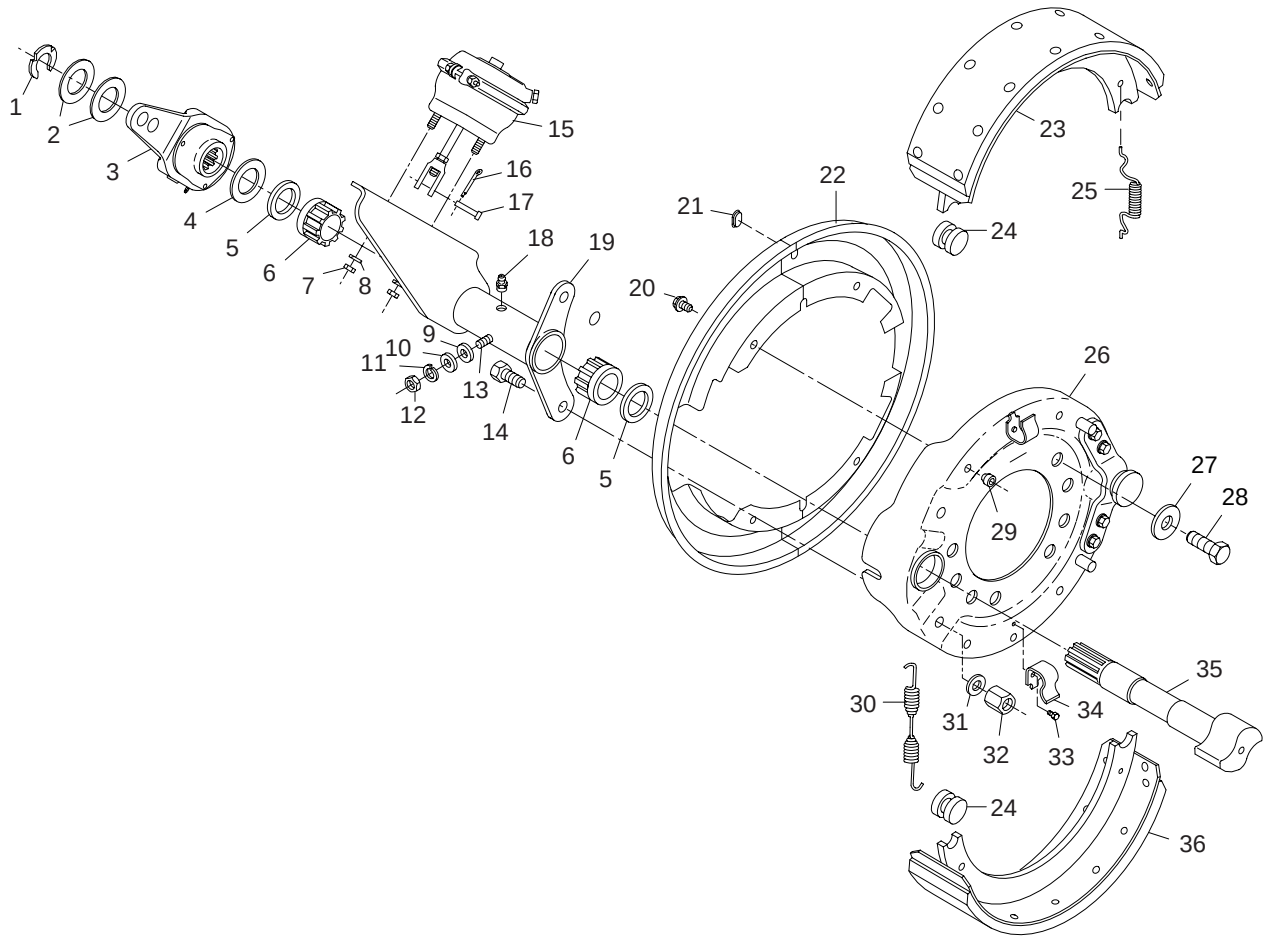
   6.1 Check the slack adjuster clevis for cracks or bushing wear. Check the splines for chipped teeth and deformation. Replace as needed.

   6.2 Depress the locking sleeve and turn the adjuster nut with a wrench at least one turn in each direction. If there is binding, or if excessive force is needed to turn the adjuster, replace it.

   IMPORTANT: If any slack adjuster problem is found, repair or replace the unit, depending on the manufacturer's recommendations.
7. Remove the camshaft by grasping its head and pulling the camshaft outboard.
8. Check the camshaft spline end for cracks, or worn or deformed splines. Replace the camshaft if damaged.
9. Check the camshaft bushing journals for wear or corrosion. Replace the camshaft if it is worn or if roughness is felt in the journal area.
10. Inspect the camshaft head for brinelling, cracking, or flat spots. Replace the camshaft if a ridge can be felt between the worn area and the cam head surface.
11. Remove the brake chamber stud nuts and lockwashers that attach the brake chamber to the camshaft support bracket. Check the chamber and parts for problems.

    Check the brake chamber for a cracked housing, bent pushrod, loose clamp ring, loose air fitting, air leaks, or clogged vent holes. Repair or replace parts as needed. For instructions, see **Section 42.31** for MGM® E or TR series, **Sec-**

Brake Components Disassembly and Inspection, Cleaning, and Assembly



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NOTE: Not all fasteners are shown.

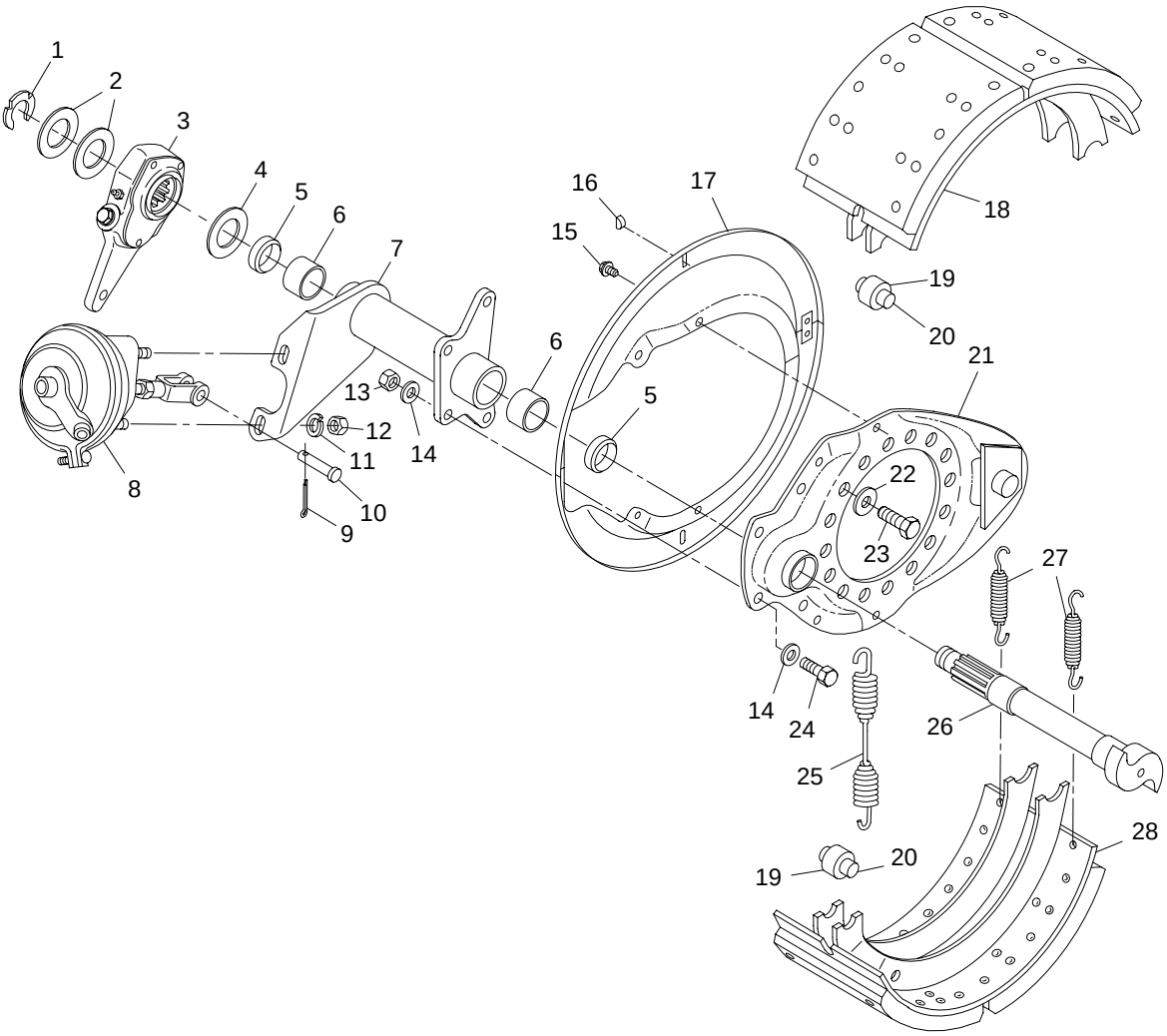
1. Snap Ring
2. Camshaft Outer Washers
3. Slack Adjuster
4. Camshaft Inner Washer
5. Grease Seal
6. Camshaft Bushing
7. Stud Nut
8. Lockwasher
9. Spacer
10. Plain Washer
11. Lockwasher
12. Nut
13. Stabilizing Screw
14. Bracket Mounting Bolt
15. Brake Chamber
16. Cotter Key
17. Clevis Pin
18. Grease Fitting
19. Camshaft Support Bracket
20. Dust Shield Screw
21. Lining Inspection Plug
22. Dust Shield
23. Upper Brake Shoe and Lining
24. Cam Roller
25. Retaining Spring
26. Brake Spider and Anchor Pin Assembly
27. Hardened Washer
28. Spider Mounting Bolt
29. Nutsert
30. Return Spring
31. Lockwasher
32. Barrel Nut
33. Bolt
34. Shoe Hold-Down Spring
35. Camshaft
36. Lower Brake Shoe and Lining

Fig. 1, Front Axle Brake

tion 42.32 for Midland, **Section 42.39** for Anchorlok® or **Section 42.42** for MGM L series.

12. Remove and inspect the camshaft support bracket. Remove and discard its gasket. Check

Brake Components Disassembly and Inspection, Cleaning, and Assembly



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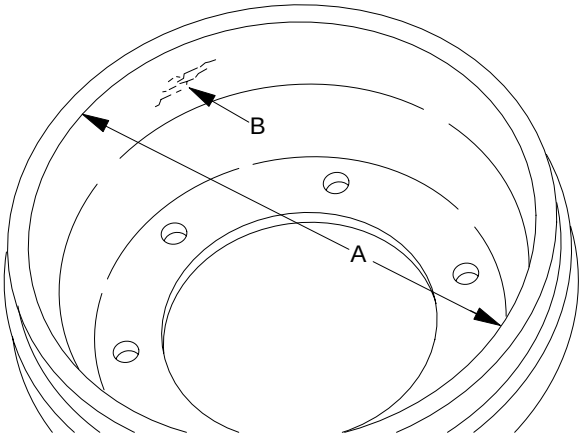
NOTE: Not all fasteners are shown.

1. Snap Ring
2. Camshaft Outer (Shim) Washers
3. Slack Adjuster
4. Camshaft Inner (Shim) Washer(s)
5. Spring-Loaded Lip Seal
6. Camshaft Bushing
7. Camshaft Mounting Bracket
8. Brake Chamber
9. Clevis Pin Cotter Pin
10. Brake Chamber Clevis Pin
11. Lockwasher
12. Stud Nut
13. Locknut
14. Washer
15. Dust Shield Capscrew
16. Dust Shield Plug
17. Dust Shield (Two-Piece)
18. Upper Brake Shoe and Lining
19. Cam Roller
20. Cam Roller Pin
21. Spider
22. Hardened Washer
23. Spider Mounting Bolt
24. Bracket Mounting Bolt
25. Return Spring
26. Camshaft
27. Retaining Springs
28. Lower Brake Shoe and Lining

Fig. 2, Rear Axle Brake

Brake Components Disassembly and Inspection, Cleaning, and Assembly



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A. Check for diameter and for out-of-round.
B. Check for cracks, heat checks, glazing, and grooves.

Fig. 3, Check the Drum

the bracket for a bent, broken, or cracked arm, and for cracked welds. Replace the bracket if any of these conditions exist.

13. Remove and inspect the old bushing and the grease seal.

    13.1 Check the camshaft bushing for wear. The inner surface must be smooth. If it is rough or abrasive, replace the bushing.

    13.2 Inspect the seal. Replace it if the lip is nicked, cut, or distorted.

14. On 15-inch brakes, check the stabilizing screw for bends, looseness, or damaged threads.

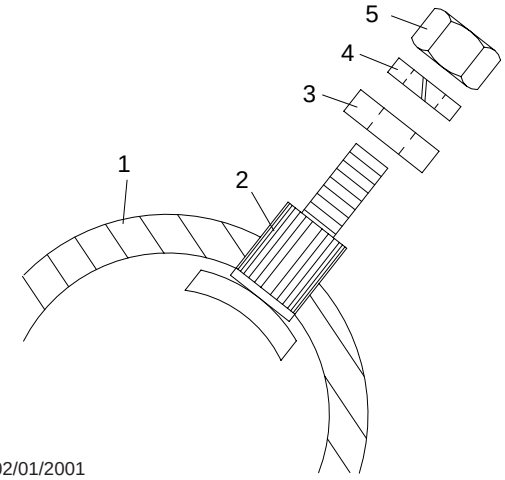
⚠ WARNING

Wear protective eye gear when driving the screw into the camshaft bracket tube with a pin punch and hammer. Failure to wear this gear could result in personal injury due to flying metal debris.

15. If necessary, replace the stabilizing screw.

    15.1 Remove the damaged screw by driving it into the camshaft bracket tube with a pin punch and hammer.

    15.2 Aligning the screw head with the inside diameter of the air chamber bracket tube, install the new screw. See **Fig. 4**.



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NOTE: Align the head with the inside diameter of the air chamber bracket tube.

1. Air Chamber Bracket Tube
2. Screw
3. Spacer
4. Lockwasher
5. Nut

Fig. 4, Align the Screw Head

    15.3 Install the spacer, lockwasher, and nut. Tighten the nut 23 to 27 lbf·ft (31 to 37 N·m) to draw the screw serrations uniformly through the camshaft bracket tube wall.

    15.4 Remove the nut and washer before assembling the bracket on the spider.

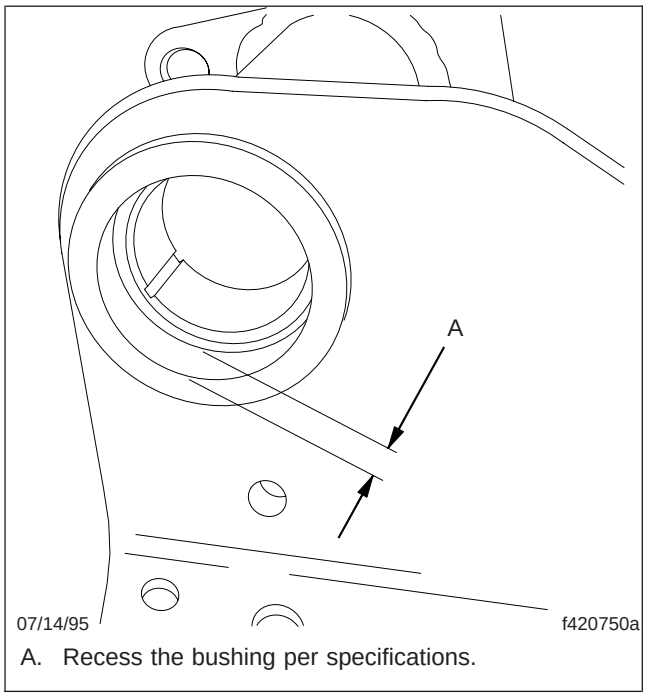
16. Using a suitable piloted driver, install the new bushing or seal:

    15-inch brakes: Install the new bushing to a depth of 3/8 inch (9.5 mm) from each end of the bracket tube. See **Fig. 5**.

    16-1/2-inch brakes: Install the new bushing to a depth of 22/32 inch (17.5 mm) at the slack adjuster end of the bracket tube and to a depth of 9/32 inch (7.1 mm) at the cam head end of the bracket tube.

    Install the grease seal flush with the end of the air chamber bracket tube.

IMPORTANT: Grease seals are installed in both the bracket and the brake spider so that the



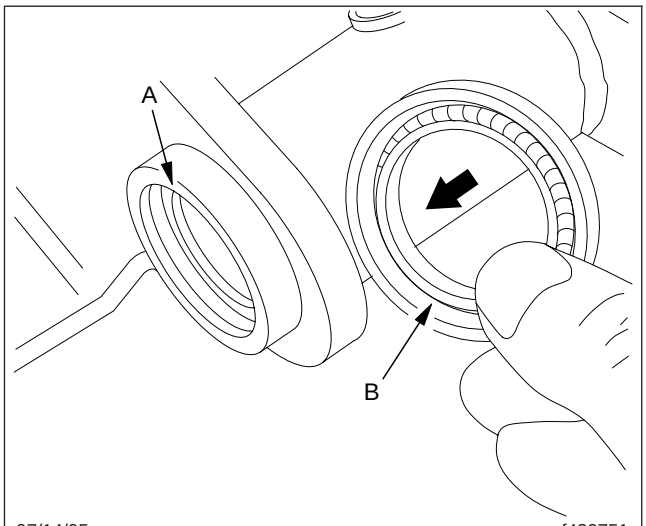
A. Recess the bushing per specifications.

Fig. 5, Install the New Bushing

seal lip is facing toward the slack adjuster end of the bracket tube. See **Fig. 6**.

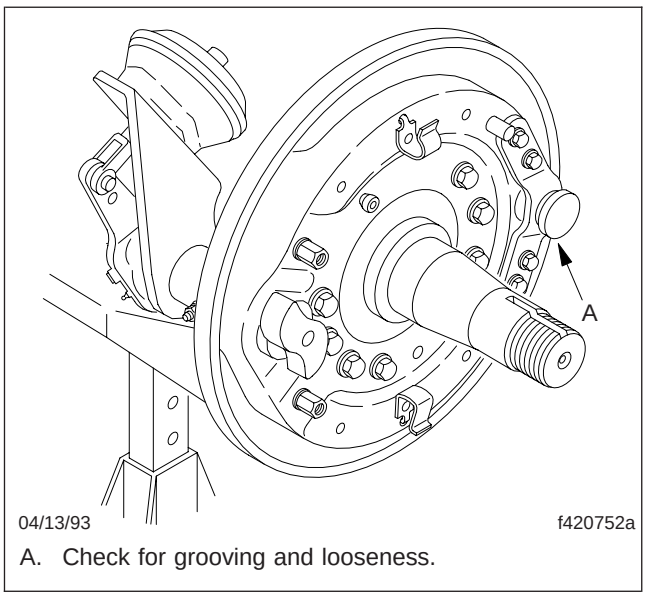
17. Remove the spider-to-axle attaching nuts, hardened washers, and bolts. Remove the spider from the axle flange.
18. If equipped, remove the capscrews that attach the dust shield to the spider. Remove the dust shield.
19. Inspect the spider and parts for damage. Replace as needed.
    - 19.1 Check for cracks at the bolt holes, cam area, and around the anchor pin. Replace if damaged.
    - 19.2 Check the anchor pin. See **Fig. 7**. If the pin is loose, or grooved more than 0.03 inch (0.8 mm) below the original surface, replace the spider assembly.
    - 19.3 Check the anchor pin and brake spider bushings for deterioration. The inner surfaces must be smooth. If any surface is rough or abrasive, replace the part.
    - 19.4 On 15-inch brakes, check the anchor pin reinforcement plate attaching nuts for tightness. See **Fig. 8**. If needed, tighten the nuts 35 to 40 lbf·ft (47 to 54 N·m).

      Check the anchor pin retaining nut for tightness. See **Fig. 8**. If needed, tighten the nut 475 to 525 lbf·ft (644 to 712 N·m).



A. Install the seals flush with the end of the tube.
B. Lip side of both seals must face toward the slack adjuster end of the bracket.

Fig. 6, Install the Grease Seals



A. Check for grooving and looseness.

Fig. 7, Check the Anchor Pin

Brake Components Disassembly and Inspection, Cleaning, and Assembly

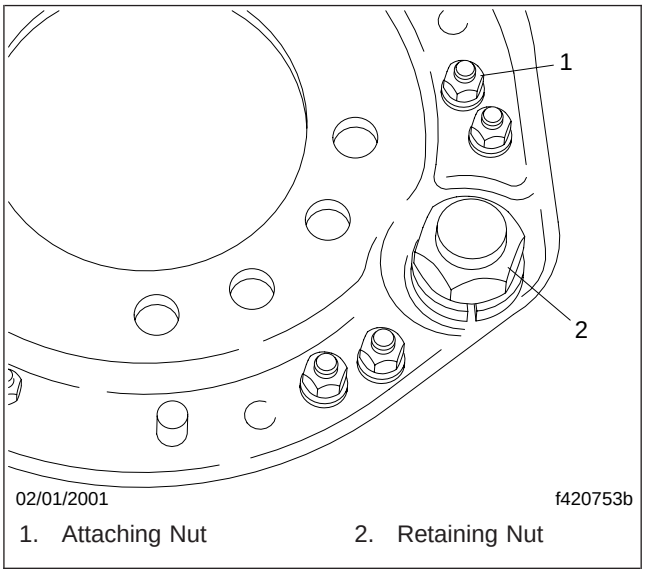


Fig. 8, Check the Anchor Pin Reinforcement Plate

IMPORTANT: If the anchor pin turns while checking the retaining nut torque, replace the spider assembly. Dana® Spicer® recommends replacement of the complete spider and pin assembly. Do not try to repair the spider assembly.

Cleaning

1. Wire-brush all removed parts that have been exposed to mud, road dirt, and salt, including the exterior of the drum, spider, brake chamber bracket, and dust shields. If relining the shoes, thoroughly wire-brush the shoe tables, and paint with a rust inhibitive coating.

⚠ CAUTION

A thick layer of oxidation and dirt on the outside of a brake drum acts as an insulator and may hinder normal heat dissipation. Make sure oxidation and dirt are removed by wire-brushing, or damage to brake parts could occur.

2. Using an industrial vacuum cleaner with a HEPA filter system, pick up excessive dust. Wipe the inside of the drums with a greaseless solvent to remove lining dust.
3. Thoroughly clean all remaining brake parts with a suitable shop solvent. Wipe dry with a clean, lint-free cloth, or use low-pressure filtered and compressed air.

Assembly

1. Install the dust shield (if equipped).

   If installing a one-piece dust shield, position it against the spider, and install the capscrews. Tighten the capscrews 11 to 16 lbf·ft (15 to 22 N·m).

   If installing a two-piece dust shield, position both halves against the spider. Tighten the attaching screws finger-tight. Reposition the dust shield halves to allow a space of 1/8 inch (3 mm) along the mating edges. See **Fig. 9**. Tighten the screws 11 to 16 lbf·ft (15 to 22 N·m).

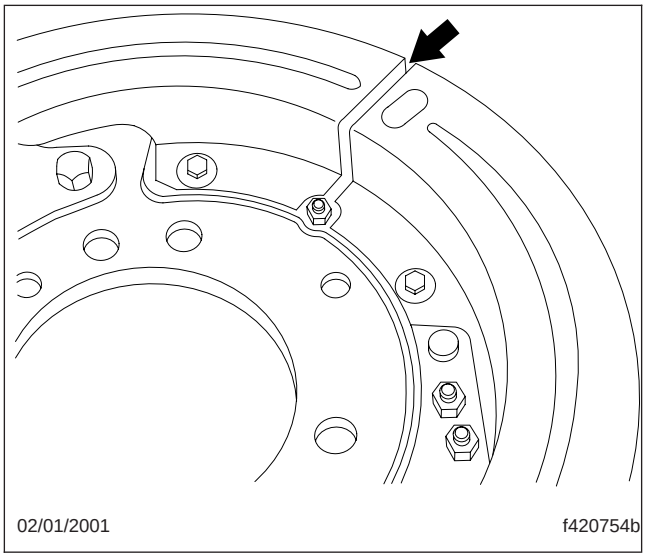


Fig. 9, Space Between Dust Shield Halves

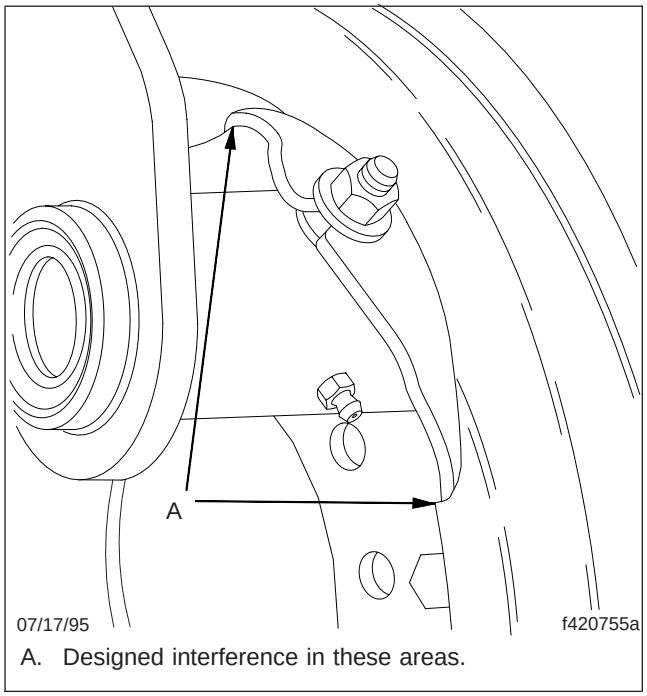
NOTE: A designed interference fit at the upper dust shield-to-brake chamber bracket area may cause the need to slightly deform the upper dust shield by hand to allow the upper half to align properly with the lower half. See **Fig. 10**.

2. Install the spider.

   Place the spider on the axle flange. Using a hardened washer under the bolt head and the nut, install the mounting fasteners. Tighten the bolts in a cross pattern:

   - 1/2–13: 60 to 80 lbf·ft (81 to 108 N·m)

- 5/8–11 (flanged hexhead capscrew): 160 to 200 lbf·ft (217 to 271 N·m)
- 5/8–11 (hexhead capscrew): 130 to 160 lbf·ft (176 to 217 N·m)



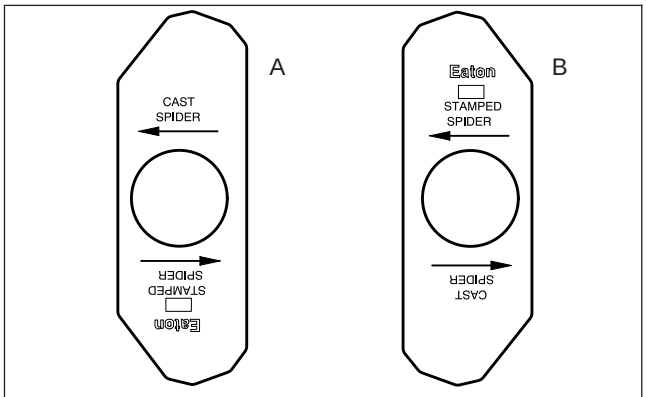
A. Designed interference in these areas.

Fig. 10, Upper Dust Shield-to-Brake Chamber Bracket

3. Install the brake chamber and bracket.
   - 3.1 Place the brake chamber on the mounting bracket with the chamber mounting studs through the bracket holes. Install the lockwashers and stud nuts. Tighten the nuts. See the brake chamber mounting torque table in **Specifications, 400**.
   - 3.2 Place the bracket against the spider, and install the lockwashers and barrel nuts. Tighten the nuts 55 to 65 lbf·ft (75 to 88 N·m).
   - 3.3 Install the washer, lockwasher, and nut on the stabilizing screw (if equipped). Tighten the nut 23 to 27 lbf·ft (31 to 37 N·m).
4. Install the camshaft and parts in the spider. Install the slack adjuster.
   - 4.1 Apply a thin film of chassis grease on the inside of the camshaft bushings and journals. Do not grease the camshaft head area.
   - 4.2 Apply a thin film of rust preventive grease (Meritor 0-637, or an equivalent) on the camshaft splines.
   - 4.3 Carefully slip the camshaft into the spider and the mounting bracket tube.

   IMPORTANT: If equipped with Extended Service brakes, a special washer is installed between the cam head and the spider. See **Fig. 11** for installation instructions.

   - 4.4 Install the thick camshaft washer on the camshaft.



A. CAST SPIDER Position cam head washer under cam head with "CAST SPIDER" arrow pointing toward center of spider.
B. STAMPED SPIDER Position cam head washer under cam head with "STAMPED SPIDER" arrow pointing toward center of spider.

Fig. 11, Install the Special Washer

   - 4.5 Install the slack adjuster on the camshaft with the adjuster nut on the side opposite the brake chamber.
   - 4.6 Install the thin outer washer(s) and snap ring.
5. Use a dial indicator to measure the end play of the camshaft. There should be no more than 0.005 to 0.045 inch (0.1 to 1.1 mm) movement. Add outer washers as needed to correct.

Brake Components Disassembly and Inspection, Cleaning, and Assembly

6. Pressure lube the camshaft bracket bushings.

   Pump multipurpose chassis grease (NLGI grade 1 or 2) into the chamber bracket until it appears at the slack adjuster end of the bracket. Use care that no grease enters the drum cavity. If grease leaks out under the cam head, the camshaft grease seal is worn or damaged, or is installed backwards.

NOTE: The use of meter-type fittings, having a maximum 40 psi (276 kPa) pressure relief at shutoff, is recommended.

7. Adjust the brakes at the slack adjusters. For instructions, see **Subject 150**.
8. Install the brake shoes. For instructions, see **Subject 110**.
9. Remove the chocks from the tires.

⚠ WARNING

Before starting the following procedures, see "Safety Precautions" in Subject, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Pre-Adjustment Checks and General Adjustment Information

Before adjusting the brakes, check and adjust:

- The wheel bearings. For instructions, see **Group 33** for front axles or **Group 35** for rear axles;
- The slack adjuster and the brake chamber for loose fasteners. Tighten as necessary. For proper torque, see **Specifications, 400**. For slack adjuster installation instructions, see **Section 42.29** for Meritor, **Section 42.33** for Gunite® or **Section 42.36** for Haldex®.

Brakes with automatic slack adjusters should never have to be manually adjusted while in service. The only time automatic slack adjusters should be manually adjusted is during installation or after the brakes have been relined.

For cam brakes, there are two brake chamber stroke measurement specifications, applied chamber stroke and free-stroke.

The procedure for adjusting the brake chamber stroke (at the slack adjuster's manual adjusting nut) may vary between each slack adjuster manufacturer. But, there are three basic procedures in completing a manual brake chamber stroke adjustment. They consist of:

A. Adjusting the approximate brake chamber stroke from the manual adjusting nut of the slack adjuster.

B. Measuring and readjusting the free-stroke.

C. Measuring and readjusting the applied chamber stroke.

The force used to move the slack adjuster from its released position to its applied position (where the brake linings contact the brake drum) distinguishes the free-stroke from the applied chamber stroke. The free-stroke is measured using a lever to move the slack adjuster (from the released to the applied positions). The applied chamber stroke is measured using an 80 to 90 psi (550 to 620 kPa) brake application to move the slack adjuster (from the released to applied positions). The stroke (free or applied chamber) is the distance that the large clevis pin moves when the brakes are applied.

With the engine off, 100 psi (689 kPa) of air tank pressure will apply the required (80 to 90 psi [550 to 620 kPa]) brake application for measuring the applied chamber stroke. The applied chamber stroke measurement can be used for diagnostic purposes. If the applied chamber stroke is too long or too short, this may indicate excessive wear in the cam, cam bushings, return springs, or air chamber. The applied chamber stroke should always be readjusted (minimized) to within the specified limit; but it should not be reduced to the point where the free stroke is too short and the brakes drag. To check for brake drag, spin the wheel end, tap the rim lightly with a hammer, and listen for a sharp ringing sound. If a dull thud is heard, the brake is dragging.

IMPORTANT: The U.S. Department of Transportation (DOT), Federal Highway Administration has issued the applied chamber stroke specifications for cam brakes. When the applied chamber stroke is checked and readjusted, it must not be greater than the DOT specification. See **Table 1**.

Brake Adjustment

Stroke Limits		
Chamber Type (Size)	**Maximum Allowable (Applied) Stroke inch (mm) ***	**Desired Free-Stroke inch (mm)**
16	1-3/4 (44)	5/8–3/4 (16–19)
16 (long stroke) †	2 (51)	
20	1-3/4 (44)	
20 (long stroke) †	2 (51)	
24	1-3/4 (44)	
24 (long stroke) †	2 (51)	
30	2 (51)	
30 (long stroke) †	2-1/2 (64)	
36	2-1/4 (57)	

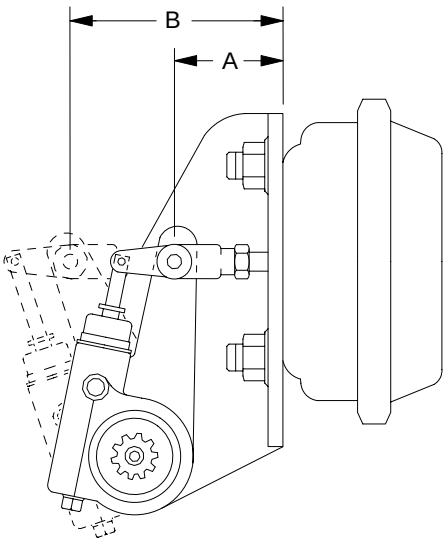
* These specifications are relative to a brake application with 80 to 90 psi (550 to 620 kPa) air pressure in the brake chambers.
† Long stroke design is indicated by a tag, or embossing, on the brake chamber.

Table 1, Stroke Limits

Adjustment

Gunite Automatic Slack Adjuster

1. See "Pre-Adjustment Checks and General Adjustment Information" before adjusting the brakes.
2. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
3. Raise the front or rear axle and place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
4. Fully release the brakes. The brake chamber pushrod must be fully retracted.
5. Set the initial brake chamber stroke (coarse adjustment).
   - 5.1 Turn the adjusting hexnut clockwise until the brake linings contact the drum.
   - 5.2 Turn the adjusting hexnut counterclockwise a half-turn. There should be about 30 lbf·ft (41 N·m) resistance. A ratcheting sound should be heard.
6. Measure and adjust the free-stroke.
   - 6.1 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 1**. Record this measurement as dimension A.



NOTE: Subtract measurement A from B.
A. Measurement with Brakes Released.
B. Measurement with Brakes Applied.

Fig. 1, Measure the Stroke

   - 6.2 Using a pry bar as a lever, move the slack adjuster until the brake linings contact the brake drum.
   - 6.3 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin again. See **Fig. 1**. Record this measurement as dimension B.

6.4 Subtract dimension A from dimension B. The difference between these measurements is the free-stroke.

6.5 The free-stroke should be 5/8- to 3/4-inch (16- to 19-mm). If it is not, turn the adjusting nut in the required direction. Measure the free-stroke again and readjust it until it is correct.

7. Measure and adjust the applied chamber stroke (fine adjustment).

7.1 Start the engine and build air pressure to 100 psi (689 kPa). Shut down the engine.

7.2 Fully apply the brakes. Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 1**. Record this measurement as dimension C.

7.3 Subtract dimension A (measured in the previous step) from dimension C. The difference between these measurements is the applied chamber stroke.

7.4 The applied chamber stroke must not exceed the value listed in **Table 2**. If the stroke is not correct, turn the adjusting hexnut in the required direction. Measure the applied stroke again and adjust it until it is correct.

If the stroke varies or remains greater than the specified range, check brake components. For instructions, see **Subject 140**. If necessary, replace the slack adjuster. For instructions, see **Section 42.33**.

IMPORTANT: Make sure there is clearance between the slack adjuster and other vehicle components when the brakes are applied and the pushrod travels its maximum stroke.

8. Apply the parking brakes.
9. Remove the safety stands and lower the front axle.
10. Remove the chocks from the tires.

Maximum Adjusted Brake Chamber Stroke, Gunite Automatic Slack Adjusters		
Chamber Size	**Maximum Chamber Stroke Inch (mm)**	
	Standard Stroke	**Long Stroke**
16	1-3/4 (44)	2 (51)
20		
24	1-3/4 (44)	2 (51) — *2-1/2 inch rated stroke*
		2-1/4 (63) — *3-inch rated stroke*
30	2 (51)	2-1/2 (57)

Table 2, Maximum Adjusted Brake Chamber Stroke, Gunite Automatic Slack Adjusters

Meritor Automatic Slack Adjuster

1. See "Pre-Adjustment Checks and General Adjustment Information" before adjusting the brakes.
2. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
3. Raise the front or rear axle. Place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
4. Fully release the brakes (the air chamber pushrod must be fully retracted).
5. Check the condition of the boot on the slack adjuster. It should be held in the proper position with a retaining clip. If the boot is torn or cracked, see **Section 42.29** for slack adjuster disassembly and inspection procedures.
6. Check the free-stroke.

6.1 With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 1**. Record this measurement as dimension A.

6.2 Use a pry bar to move the slack adjuster and apply the brakes. Again, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 1**. Record this measurement as dimension B.

Brake Adjustment

6.3 The difference between the two measurements is the initial free-stroke, and sets the clearance between the linings and the drum.

6.4 The free-stroke must be 5/8 to 3/4 inch (16 to 19 mm).

If the free-stroke is correct, go to the next step and check for correct brake chamber stroke.

If the free-stroke is incorrect, remove the pressure relief capscrew, spring, and pawl assembly from the slack adjuster housing. See **Fig. 2**. If equipped with a pull-pawl assembly, carefully insert a screwdriver and raise the relief cap about 1/8 inch (3 mm). See **Fig. 3**.

⚠ CAUTION

Before turning the adjusting nut, remove the pressure relief capscrew, spring, and pawl assembly. If equipped with a pull-pawl assembly, raise the relief cap about 1/8 inch (3 mm). Failure to do so could strip the teeth on the pawl.

6.5 Turn the adjusting nut 1/8-turn, as shown in **Fig. 4**. Measure the stroke again, and adjust until it is correct.

7. Check for correct brake chamber stroke.

7.1 With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 1**. Record this measurement as dimension A.

7.2 Build air pressure to 100 psi (689 kPa). Shut down the engine. Fully apply the brakes and measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 1**. Record this measurement as dimension C. The difference between the measurements is the brake chamber stroke.

7.3 The brake chamber stroke must be less than the measurements shown in **Table 3**. If the brake chamber stroke is incorrect, remove the pressure relief capscrew, spring, and pawl assembly from the slack adjuster housing. See **Fig. 2**. If equipped with a pull-pawl assembly, carefully insert a screwdriver and raise the relief cap about 1/8 inch (3 mm). See **Fig. 3**.

Maximum Adjusted Brake Chamber Stroke With Meritor Automatic Slack Adjusters	
Chamber Size	**Stroke inches (mm)**
12	Less than 1-3/8 (35)
16, 20, 24	Less than 1-3/4 (44)
30	Less than 2 (51)

Table 3, Maximum Adjusted Brake Chamber Stroke With Meritor Automatic Slack Adjusters

⚠ CAUTION

Before turning the adjusting nut, remove the pressure relief capscrew, spring, and pawl assembly. If equipped with a pull-pawl assembly, raise the relief cap about 1/8 inch (3 mm). Failure to do so could strip the teeth on the pawl.

7.4 Turn the adjusting nut 1/8-turn, as shown in **Fig. 4**. Measure the stroke again and adjust until correct.

If the stroke varies or remains greater than the specified range, check brake components. For instructions, see **Subject 140**. If necessary, replace the slack adjuster. For instructions, see **Section 42.29**.

⚠ CAUTION

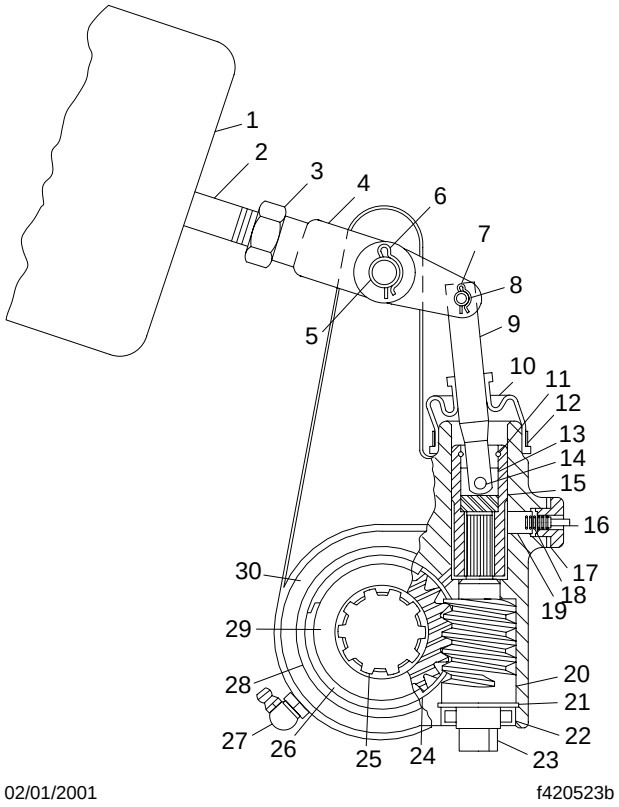
Do not make the adjusted chamber stroke too short. The free-stroke must not be less than 5/8 to 3/4 inch (16 to 19 mm). If the chamber stroke is too short, the linings can drag and damage the brake.

7.5 If removed, install the pawl assembly, spring, and the pressure relief capscrew. Tighten the capscrew 15 to 20 lbf·ft (20 to 27 N·m). Or, remove the screwdriver from the pull-pawl assembly (if equipped).

8. Apply the parking brakes.

9. Remove the safety stands and lower the vehicle.

10. Remove the chocks from the tires.



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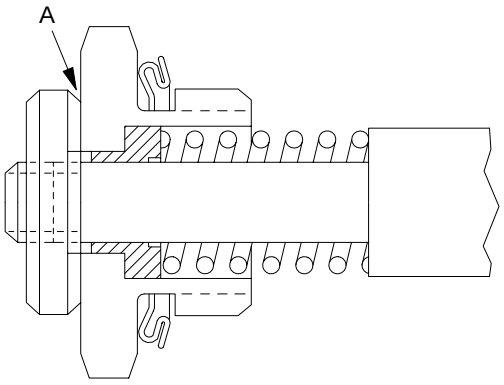
1. Brake Air Chamber
2. Brake Chamber Pushrod
3. Clevis Jam Nut
4. Clevis
5. Large Clevis Pin
6. Large Cotter Pin
7. Small Cotter Pin
8. Small Clevis Pin
9. Actuator Rod
10. Boot
11. Piston Retaining Ring
12. Boot Retaining Clamp
13. Actuator Piston
14. Roller Pin
15. Actuator Adjusting Screw
16. Pressure Relief Capscrew (shown 90 degrees out of position)
17. Gasket
18. Pawl Spring
19. Pawl Assembly
20. Worm
21. Worm Retaining Snap Ring
22. Worm Seal
23. Worm Manual Adjusting Nut End
24. Gear-to-Body Seal
25. Camshaft Splines
26. Gear Retaining Ring
27. Grease Fitting
28. Gear Thrustwasher
29. Gear
30. Slack Adjuster

Fig. 2, Meritor Automatic Slack Adjuster



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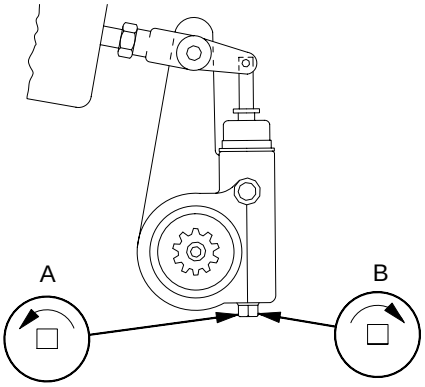
A. Insert screwdriver here.

Fig. 3, Pull-Pawl Assembly (sectional view)



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A. Shorten stroke.
B. Lengthen stroke.

Fig. 4, Turn the Adjusting Nut

Haldex® Automatic Slack Adjuster

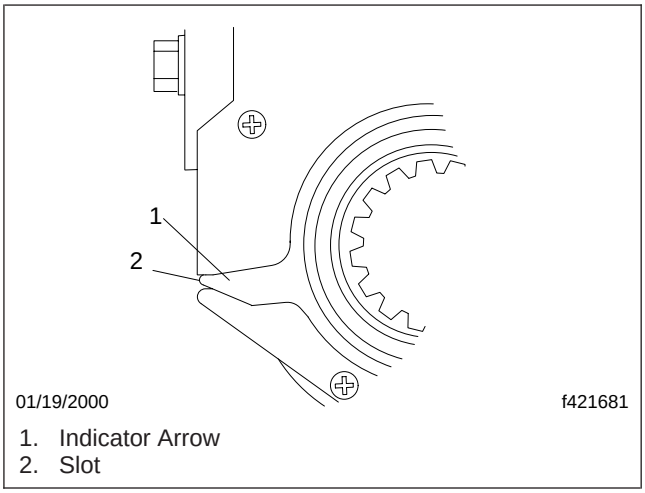
1. See "Pre-Adjustment Checks and General Adjustment Information" before adjusting the brakes.
2. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
3. Raise the front or rear axle. Place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
4. Fully release the brakes (the air chamber pushrod must be fully retracted).

Brake Adjustment

CAUTION

If the slack adjuster is equipped with an installation indicator, the indicator must be in the slotted area as shown in Fig. 5. If the installation indicator is not within the slotted area, the control arm is installed in the wrong position. This may result in tight brakes and excessive lining wear and possible brake damage.

5. If the slack adjuster is equipped with an installation indicator, check that the installation indicator is within the slotted area. See **Fig. 5**. If the installation indicator is not within the slotted area, the control arm is not properly installed. For slack adjuster installation instructions, see **Section 42.36**.



1. Indicator Arrow
2. Slot

Fig. 5, Installation Indicator

6. Check the de-adjustment torque (the internal clutch slippage) of the slack adjuster.

   6.1 Place a torque wrench on the 7/16-inch adjusting hexnut. See **Fig. 6**.

   6.2 While turning the torque wrench in a counterclockwise direction, measure how much torque is required to overcome the resistance of the internal clutch. A normal ratcheting sound will occur while the adjusting hexnut is backed off in the counterclockwise direction. The minimum allowable de-adjustment torque is 13 lbf·ft (17.6 N·m).

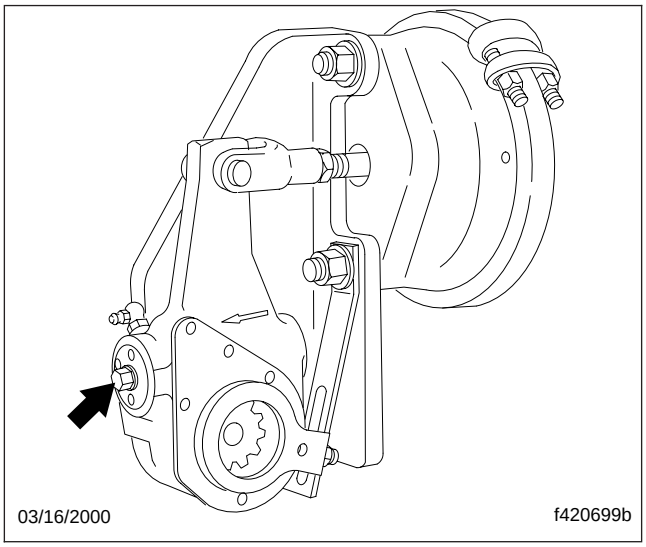


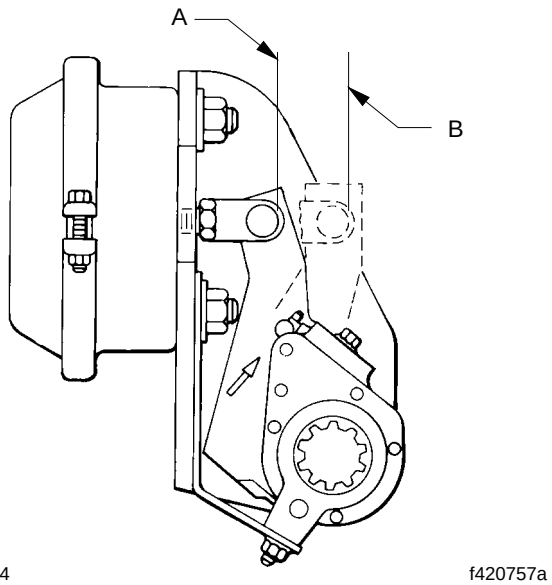
Fig. 6, Adjusting Hexnut

If the clutch slips with a torque less than 13 lbf·ft (17.6 N·m), the slack adjuster must be replaced. For instructions see **Section 42.36**.

7. Turn the adjusting hexnut clockwise until the brake lining meets the brake drum. Back off counterclockwise a 3/4-turn. See **Fig. 6**. There will be a ratcheting sound.

8. Measure the distance from the bottom of the air chamber to the far side of the clevis-pin hole. See **Fig. 7**. Record the exact distance as measurement A. Apply and hold an 80 psi (551 kPa) brake application. Measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. See **Fig. 7**. Record the exact distance as measurement B. Subtract measurement A from measurement B to determine the applied stroke. Compare this value to the value in **Table 4**.

   If the stroke varies or remains greater than the specified range, check the brake components. For instructions, see **Subject 140**. If necessary, replace the slack adjuster. For instructions, see **Section 42.36**.



NOTE: Subtract measurement A from B.

1. Measurement With Brakes Released.
2. Measurement With Brakes Applied.

Fig. 7, Brake Stroke Check, Haldex Automatic Slack Adjuster

Maximum Adjusted Brake Chamber Stroke With Haldex Automatic Slack Adjusters	
Chamber Size	**Stroke inches (mm)**
16	3/4–1-3/4 (19–44)
20	1–1-3/4 (25–44)
24	1–1-7/8 (25–48)
30	1-1/2–2 (38–51)

Table 4, Maximum Adjusted Brake Chamber Stroke With Haldex Automatic Slack Adjusters

9. Apply the parking brakes.
10. Remove the safety stands and lower the vehicle.
11. Remove the chocks from the tires.

Bendix Manual Slack Adjuster

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Raise the front or rear axle. Place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.

IMPORTANT: On slack adjusters equipped with an adjusting screw locking sleeve, wipe clean the locking sleeve area, and depress the locking sleeve when positioning the wrench or socket over the adjusting screw. Do not try to turn the adjusting screw without fully depressing the locking sleeve.

3. With the parking brakes released, rotate the adjusting screw until the brakes begin to drag when the drum is turned. Back off the adjustment until the wheel turns freely. Turn the adjusting screw nut until the locking sleeve engages it.
4. Measure the distance from the bottom of the brake chamber to the centerline of the clevis. See **Fig. 8**. Record the exact distance as measurement A. Apply and hold an 80 psi (551 kPa) brake application. Measure the distance from the bottom of the brake chamber to the centerline of the clevis-pin. See **Fig. 8**. Record the exact distance as measurement B. Subtract measurement A from measurement B to determine the applied stroke. Compare this value to the value in **Table 5**.

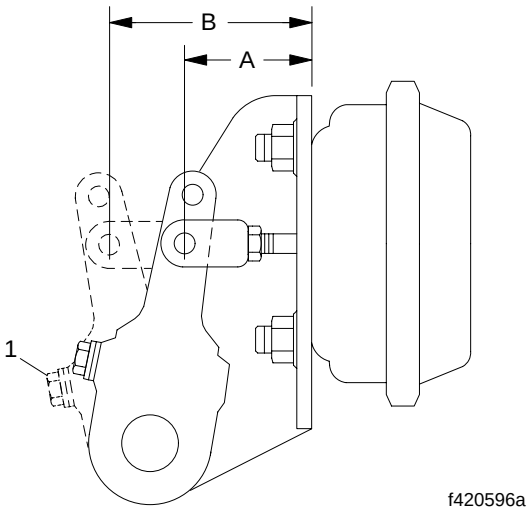
Maximum Adjusted Brake Chamber Stroke With Bendix Manual Slack Adjusters	
Chamber Size	**Stroke inches (mm**
12	Less than 1-1/2
16, 20, 24	Less than 1-3/4
24 *, 30	Less than 2 (

* Long Stroke

Table 5, Maximum Adjusted Brake Chamber Stroke With Bendix Manual Slack Adjusters

5. If the applied stroke equals or exceeds the maximum applied stroke, adjust the brakes.
   - 5.1 Wipe clean the adjusting screw hexhead. See **Fig. 8**. Position a wrench or socket over the adjusting screw hexhead.
   - 5.2 Turn the adjusting screw until it is tight. Back off the adjustment until the drum is free. Normally, the adjusting screw will need to be backed off 2 or 3 clicks.

Brake Adjustment



A. Measurement With Brakes Released.
B. Measurement With Brakes Applied.
1. Adjusting Screw Hexhead

Fig. 8, Measure the Stroke

5.3 To see if the drum is free, strike the brake drum with a steel tool and listen for a clear ringing sound. If a dull thud is heard, the brake is dragging.

IMPORTANT: Checking the brake adjustment when the wheel is off the ground may be unreliable. Looseness or wear anywhere in the wheel bearings will cause the drum to be misaligned while the wheel is off the ground. Check the brake adjustment with the wheel on the ground.

On slack adjusters equipped with an adjusting screw locking sleeve, make sure that the locking sleeve is engaged around the adjusting screw hexhead after adjustment, thus locking the adjusting screw in place.

6. Apply the parking brakes.
7. Remove the safety stands and lower the vehicle.
8. Remove the chocks from the tires.

Specifications

Torque Values		
Description	**Size**	**Torque lbf·ft (N·m)**
Camshaft Support Bracket Mounting Nuts	1/2–13	55–65 (75–88)
Spider Mounting Bolts	1/2–13	60–80 (81–108)
Spider Mounting Hexhead Capscrew	5/8–11	130–160 (176–217)
Spider Mounting Flanged Hexhead Capscrew		160–200 (217–271)
Dust Shield Mounting Capscrews	—	11–16 (15–22)
Anchor Pin Reinforcement	—	35–40 (47–54)
Anchor Pin Retaining Nut	—	475–525 (644–712)

Table 1, Torque Values

Brake Chamber Mounting Torques		
Manufacturer	**Chamber Size square inches**	**Torque lbf·ft (N·m)**
Midland	12, 16	30 (41)
	20, 24, 30, 36	100 (136)
MGM	24, 30, 36	100–115 (136–156)

Table 2, Brake Chamber Mounting Torques

General Information

The automatic slack adjuster has two main functions:

- As a lever it converts the straight-line force of the brake chamber push rod to torque on the brake camshaft. Rotation of the camshaft forces the brake shoes against the drum.
- As an automatic slack adjuster, it maintains the lining-to-drum clearance needed for proper brake chamber push rod stroke.

The slack adjuster is installed between the brake chamber push rod and the brake camshaft. A clevis connects the brake chamber push rod to the top of the slack adjuster. The bottom of the slack adjuster is splined to the brake camshaft. The splines hold the slack adjuster internal gear to the camshaft, so the camshaft turns when the slack adjuster moves.

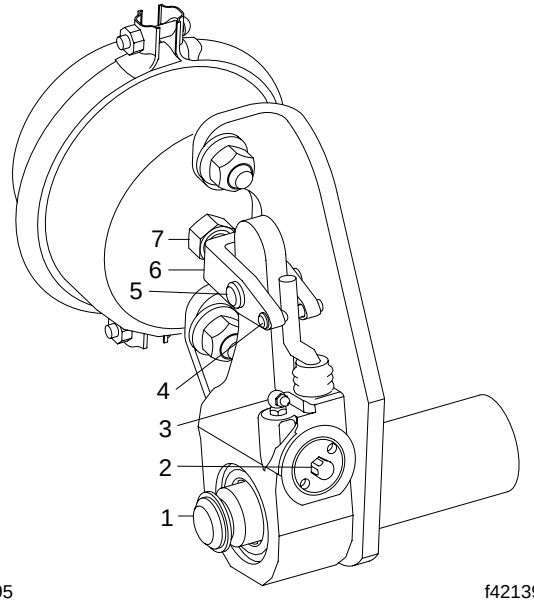
When the brakes are applied, the brake chamber push rod moves outward forcing the slack adjuster and camshaft to rotate. This movement forces the brake shoes against the drum.

Whenever the brakes are released, the slack adjuster detects any increase in the lining-to-drum clearance. Excessive brake clearance is eliminated internally by the adjuster's one-way clutch and worm shaft, thus ensuring optimum leverage for the brake chamber push rod.

IMPORTANT: This automatic slack adjuster cannot be rebuilt. If it is damaged or inoperative, replace the unit. Also, when installing or replacing the automatic slack adjuster, a new clevis must be installed.

Removal

1. With the vehicle parked on a level surface, chock the tires. If you are removing a rear slack adjuster, release the parking brake, then cage the parking brake power spring. For instructions, refer to the applicable brake chamber section in this group.
2. Back off the clevis jam nut. See **Fig. 1**.



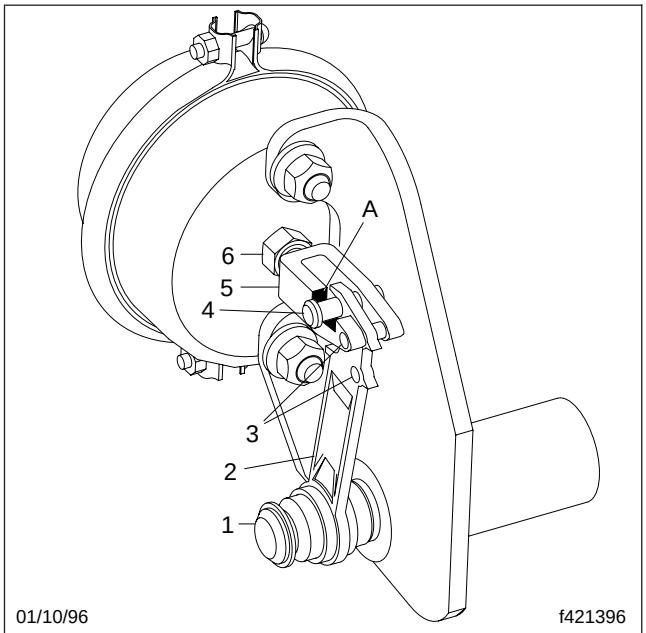
1. Camshaft
2. Manual Adjuster Shaft
3. Grease Fitting
4. 1/4" Clevis Pin
5. 1/2" Clevis Pin
6. Clevis
7. Clevis Jam Nut

Fig. 1, Slack Adjuster Mounting

3. Remove the cotter pins and clevis pins.
4. Rotate the manual adjuster shaft counterclockwise until the slack adjuster clears the clevis.
5. Remove the snap ring from the brake camshaft, then slide the slack adjuster off the camshaft.
6. Remove the clevis from the brake chamber pushrod.

Installation

1. Coat the end of the brake chamber pushrod, the camshaft splines, and the splines of the slack adjuster gear with an anticorrosion grease.
2. Install a new clevis (with the 1/2-inch clevis pin) on the brake chamber pushrod. Thread the clevis up to the jam nut. Do not tighten the jam nut.
3. Fit an installation guide over the camshaft splines so the 1/2-inch clevis-pin slot on the guide faces the brake chamber. See **Fig. 2**.



A. Clevis shown cut away for clarity.

1. Camshaft
2. Installation Guide
3. 1/4" Holes
4. 1/2" Clevis Pin
5. Clevis
6. Clevis Jam Nut

Fig. 2, Using the Slack Adjuster Installation Guide

4. Swing the installation guide into the clevis until the slot (top or bottom) engages the 1/2-inch pin.
5. Check the alignment of the 1/4-inch holes in the guide and the clevis. Screw the clevis on or off the pushrod until the 1/4-inch clevis pin can be

Slack Adjuster Removal and Installation

inserted through the clevis and the guide. Tighten the jam nut against the clevis 50 lbf·ft (68 N·m).

Remove the installation guide from the camshaft.

IMPORTANT: If the pushrod extends through the clevis more than 1/16 inch (1.6 mm), remove the clevis and cut the rod to length. If the push-rod does not engage a minimum 1/2 inch in the clevis body, cut a new pushrod to length and install it. For instructions, refer to the applicable brake chamber section in this group.

6. Using the original snap ring, install the automatic slack adjuster on the brake camshaft.
7. Turn the manual adjuster shaft clockwise until the clevis pin holes align with the clevis. Install the 1/2-inch and 1/4-inch clevis pins and secure with new cotter pins.

⚠ WARNING

Manually adjusting an automatic slack adjuster to bring the pushrod stroke within legal limits is likely masking a mechanical problem. Adjustment is not repairing. Before adjusting an automatic slack adjuster, troubleshoot the foundation brake system and inspect it for worn or damaged components. Improperly maintaining the vehicle braking system may lead to brake failure, resulting in property damage, personal injury, or death.

NOTE: Make sure there is clearance between the slack adjuster and other vehicle components when the brakes are applied and the pushrod travels its maximum stroke.

8. Set the initial free-stroke, as follows.
   - 8.1 Turn the adjusting hexnut clockwise until the brake linings contact the drum.
   - 8.2 Turn the adjusting hexnut counterclockwise one-half turn.
9. If a rear axle slack adjuster was installed, manually uncage the parking brake. For instructions, refer to the applicable brake chamber section in this group.
10. Measure the brake chamber applied stroke, as follows.
    - 10.1 With the brakes fully released, use a ruler to measure the distance from the bottom of the brake chamber to the centerline of the 1/2-inch clevis pin. See **Fig. 3**, Ref. A.

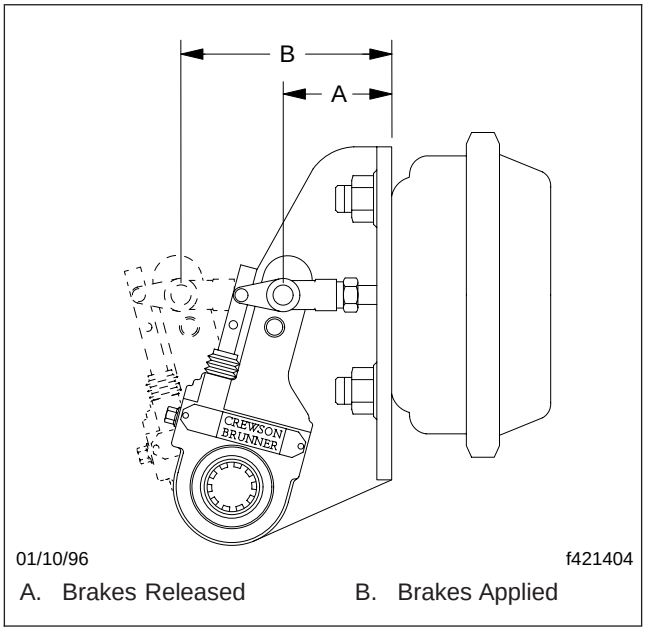


Fig. 3, Brake Stroke Check

- 10.2 Build air pressure to at least 85 psi (586 kPa). Apply the brakes, then measure the distance from the bottom of the brake chamber to the centerline of the 1/2-inch clevis pin. See **Fig. 3**, Ref. B. The difference between the measurements is the brake chamber stroke.
- 10.3 The brake chamber stroke must be less than the measurements shown in **Table 1.** If it isn't, check the foundation brakes for problems such as worn cams, bushings, pins and rollers, or broken springs. Repair or replace as needed. For instructions, refer to the applicable brake section in this group. Then, repeat the previous steps as needed.

Brake Chamber Stroke Specifications			
Chamber Type (Size)	Maximum Applied Stroke*: inch (mm)	Free-Stroke: inch (mm)	
		New Brake Installation	In-Service Brake
Standard Stroke			
16	1-1/2 (38)		
20 and 24	1-3/4 (44)	5/8 to 3/4 (16 to 19)	1/2 to 5/8 (13 to 16)
30	2 (51)		
36	2-1/2 (64)		

* Specifications are relative to a brake application with 80–90 psi (550–620 kPa) air pressure in the brake chambers.

Table 1, Brake Chamber Stroke Specifications

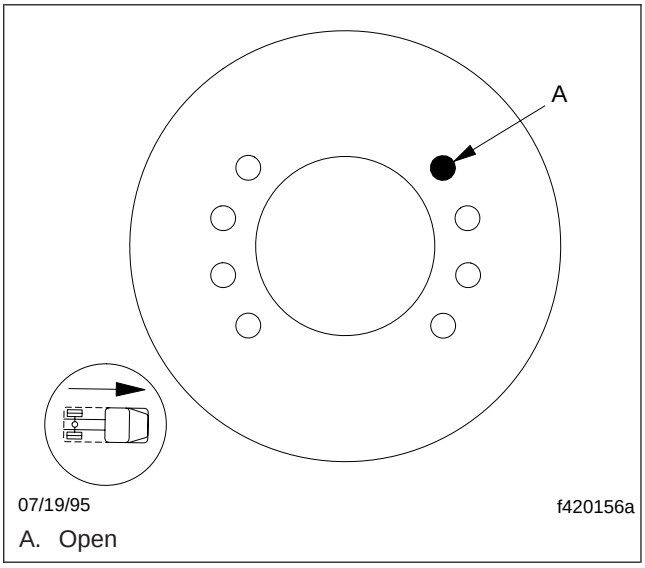
11. Apply the parking brakes.

General Information

The Q and Q Plus™ series brakes are actuated by an S-type cam head, which is forged integrally with the camshaft and supported with nylon bushings. Cam pressure is applied through the cam rollers.

These brakes are used on both the front steer axle and rear drive axles.

Meritor steer axles have seven holes for attaching the spider to the axle flange. There is an eighth hole that is left open on the brake spider, on both the left and right sides of the steer axle. See **Fig. 1**. The seven holes used for attachment of the spider to the axle flange are 0.656 inch in diameter. The eighth hole is oversized at 0.687 inch in diameter.



A. Open

Fig. 1, Attachment Holes

As of March 1, 1994, Meritor began attaching an identifying label to the web of all on-highway shoe and lining assemblies. The label is made of Mylar, and is attached with a heat-resistant adhesive. At the same time, the lining edge code changed to the new Meritor lining designation. The new lining edge code shows the supplier lining designation and the corresponding Meritor designation. See **Table 1**.

Edge Codes		
Vendor Code		**Meritor Designation**
Abex	931-162	R301
	197	R201
	1083-7	R501
	1083-63	R401
Carlisle	E145-A	R202
	NAB-9ML	R302
	NAB10	R502
	NAB11	R402
Ferodo	NAB456	R403
	867	R203

Table 1, Edge Codes

The label includes three lines of information. See **Fig. 2**. The first line identifies the shoe as "Q PLUS" or "BRAKES" (non-Q Plus). The second line gives the Meritor aftermarket lining material designation. See "Meritor Designation" in **Table 1**. The third line gives the service part number to use for replacing the shoe and lining assembly.

When the brake pedal is depressed, compressed air enters the brake chamber, causing the diaphragm to move a pushrod assembly.

The pushrod, which is connected to a slack adjuster, turns the slack adjuster and brake camshaft. As the camshaft turns, the S-head, which is between the brake shoe rollers, forces the brake shoes against the brake drum and braking occurs.

When the brakes are released and air is exhausted from the brake chamber, the actuator return spring (within the brake chamber) and the brake shoe return spring, return the camshaft, brake shoes, slack adjuster, and the pushrod to their released positions.

General Information

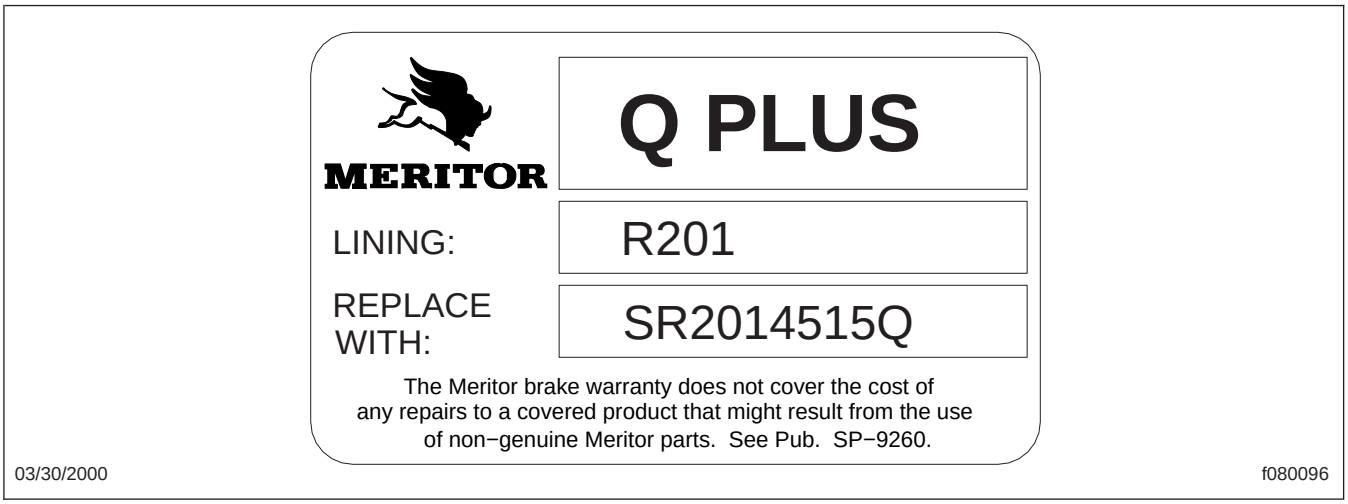


Fig. 2, Sample Meritor Brake Shoe Label

General Safety Precautions

⚠ WARNING

When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.

When working on or around a vehicle, observe the following precautions:

- Park the vehicle on a level surface and apply the parking brakes. Shut down the engine and chock the tires.
- If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air pressure drops.
- Disconnect the batteries.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure. Always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Do not remove, disassemble, assemble, or install a component until you have read and understand the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools and observe all precautions pertaining to use of those tools.
- Replacement hardware, tubing, hose, fittings, etc. should be the equivalent size, type, length, and strength of the original equipment.
- Make sure when replacing tubes or hoses that all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices that have stripped threads or damaged parts. Repairs requiring machining should not be attempted.
- Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

Asbestos and Non-Asbestos Safety

⚠ WARNING

Wear a respirator at all times when servicing the brakes, starting with the removal of the wheels and continuing through assembly. Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH.

Because some brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Exposure to airborne asbestos brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer.

Because medical experts believe that long-term exposure to some *non-asbestos* fibers could also be a health hazard, the following precautions should also be observed if servicing non-asbestos brake linings.

Areas where brake work is done should be separate from other operations, if possible. As required by OHSA regulations, the entrance to the areas should have a sign displayed indicating the health hazard.

During brake servicing, an air purifying respirator with high-efficiency filters must be worn. The respirator and filter must be approved by MSHA or NIOSH, and worn during all procedures.

Safety Precautions

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system is not available, the brake assembly must be cleaned in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with a HEPA filter system, remove dust from the brake drums, brake backing plates, and brake parts. After vacuuming, any remaining dust should be removed using a rag soaked in water and wrung until nearly dry. Do not use compressed air or dry brushing to clean the brake assembly.

If grinding or other machining of the brake linings is necessary, other precautions must be taken because exposure to asbestos dust is highest during such operations. In addition to the use of an approved respirator, there must be local exhaust ventilation such that worker exposure is kept as low as possible.

Work areas should be cleaned by industrial vacuums with HEPA filters or by wet wiping. Compressed air or dry sweeping should never be used for cleaning. Asbestos-containing waste, such as dirty rags, should be sealed, labeled, and disposed of as required by EPA and OSHA regulations. Respirators should be used when emptying vacuum cleaners and handling asbestos waste products.

Workers should wash before eating, drinking, or smoking, should shower after work, and should not wear work clothes home. Work clothes should be vacuumed after use and then laundered, without shaking, to prevent the release of asbestos fibers into the air.

Safety Precautions

⚠ WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with the removal of the wheels and continuing through assembly.

Because some brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Because medical experts believe that long-term exposure to some *non-asbestos* fibers could also be a health hazard, the following precautions should also be observed if servicing non-asbestos brake linings.

Exposure to airborne brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer.

During brake servicing, an air purifying respirator with high-efficiency filters must be worn. The respirator and filter must be approved by MSHA or NIOSH, and worn during all procedures.

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is removed from the cylinder by the vacuum.

If an enclosed system is not available, the brake assembly must be cleaned in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with a HEPA filter system, remove dust from the brake drums, brake backing plates, and brake parts. After vacuuming, any remaining dust should be removed using a rag soaked in water and wrung until nearly dry.

To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Do not use compressed air or dry brushing to clean the brake assembly.

⚠ WARNING

Before starting the following procedures, see "Safety Precautions" in Subject, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Raise the front or rear axle and place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
3. Remove the wheels and brake drums. For instructions, see **Section 33.02** for front axles or **Section 35.02** for rear axles.

⚠ CAUTION

Failure to follow the proper procedure when backing off automatic slack adjusters could damage the automatic slack adjusters.

4. Back off the slack adjusters:
   - *Manual slack adjusters*: Back off the slack adjuster until the cam is in the start or released position.
   - *Automatic slack adjusters*: For instructions, see **Section 42.29** for Meritor, **Section 42.33** for Gunite® or **Section 42.36** for Haldex®.
5. If equipped with 15-inch Q series brakes, go to the next step.

   If equipped with Q Plus™ series brakes, or 16-1/2-inch Q series brakes, remove the brake shoes.

   5.1 Push down on the bottom brake shoe. Pull on the roller retaining clip to remove the bottom cam roller. See **Fig. 1**.

   5.2 Lift the top brake shoe and pull on the roller retaining clip to remove the top cam roller.

   5.3 Lift the bottom shoe to release tension on the brake return spring. Remove the spring. See **Fig. 2**.

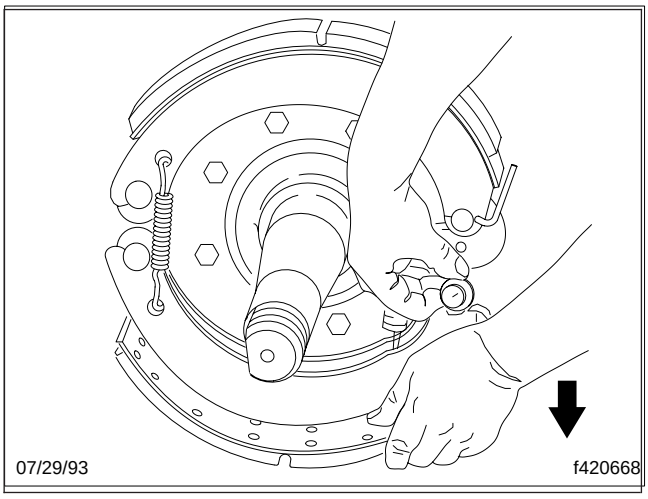


Fig. 1, Push the Bottom Shoe Down

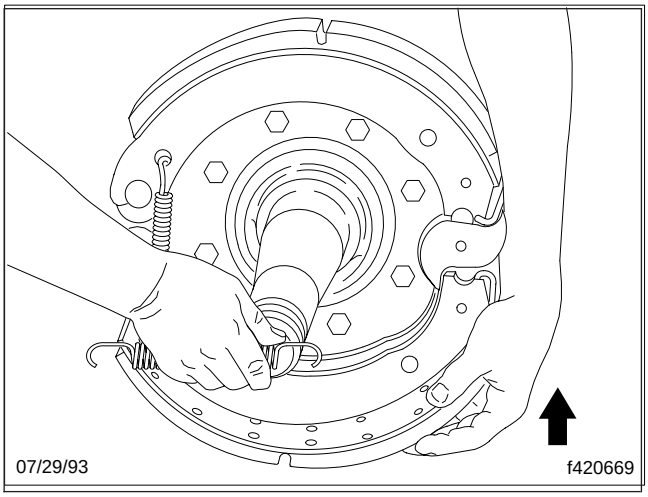


Fig. 2, Lift the Bottom Shoe Up

   5.4 Rotate the bottom shoe to release tension on the two retaining springs. Remove the springs and brake shoe. See **Fig. 3**.

6. If equipped with 15-inch Q series brakes, remove the brake shoes.

   6.1 Push down on the bottom brake shoe. Remove the bottom cam roller.

   6.2 Lift the top brake shoe and remove the top cam roller.

   6.3 Remove the brake shoe return spring.

Brake Shoe Removal and Installation

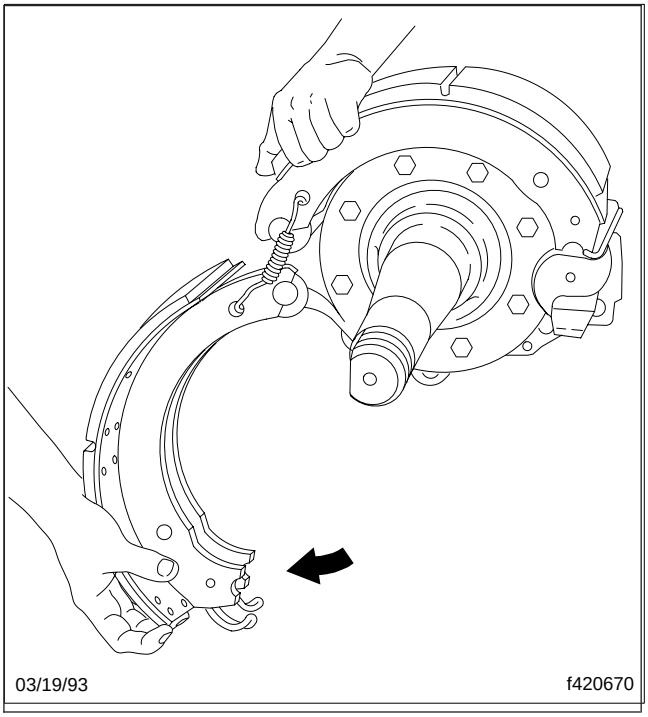


Fig. 3, Rotate the Bottom Shoe

6.4 Rotate the bottom shoe to release tension on the retaining spring. Remove the spring and the brake shoes.

7. Inspect the brake shoes and linings for wear or damage. For instructions, see **Subject 120**.

Installation

IMPORTANT: For best brake performance, do not mix Q and Q Plus series brakes. Use the same brakes series on the entire vehicle.

1. Apply a thin film of a temperature resistant grease (Meritor 0-616, or an equivalent) on the anchor pins where they touch the brake shoes. Also, apply a multi-purpose chassis grease (Meritor 0-617-A or 09-617-B, or an equivalent) on the retainer clips, spider, and shoe rollers where they touch the brake shoes.

IMPORTANT: Do not apply any grease on the outer diameter of the roller that touches the cam head.

2. If equipped with Q Plus series brakes, or 16-1/2-inch Q series brakes, install the brakes shoes.

If equipped with 15-inch Q series brakes, go to the next step.

2.1 Place the upper brake shoe in position on the top anchor pin. Hold the lower brake shoe on the bottom anchor pin and attach two new brake shoe retaining springs. See **Fig. 4**.

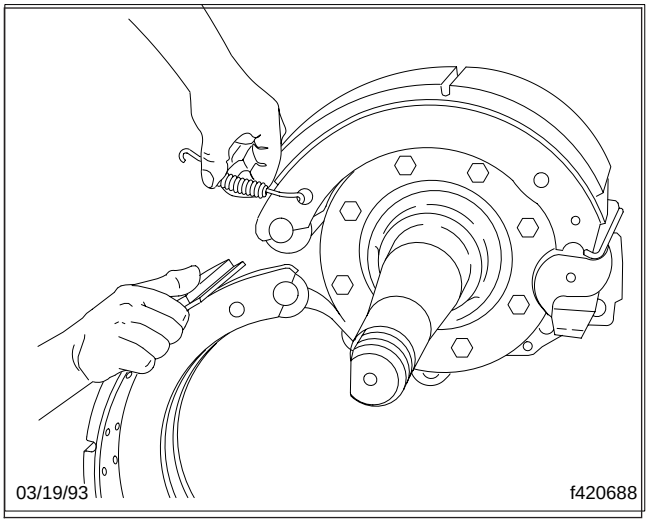


Fig. 4, Lower Brake Shoe on Bottom Anchor Pin

2.2 Turn the lower brake shoe forward and attach a new brake shoe return spring. See **Fig. 5**.

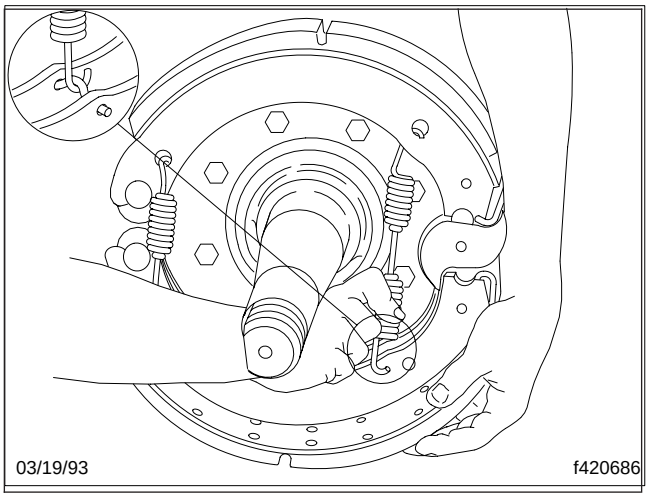
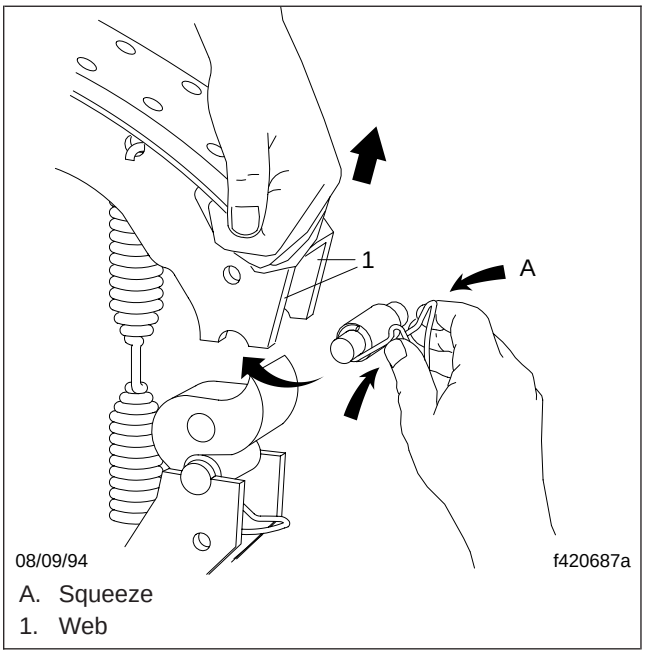


Fig. 5, New Brake Shoe Return Spring

2.3 Pull each brake shoe away from the cam to allow enough space to install the cam

rollers and retainers. Press the ears of the retainer together to permit the retainer to fit between the brake shoe webs. See **Fig. 6**.



A. Squeeze
1. Web

Fig. 6, Cam Roller and Retainer

2.4 Push the retainer into the brake shoe until the ears lock in the holes in the shoe webs. See **Fig. 7**.

3. If equipped with 15-inch Q series brakes, install the brake shoes.

3.1 Install the retainer spring on the shoes and install the shoes on the anchor pins. See **Fig. 8**. Hold the bottom shoe in position and install the return spring.

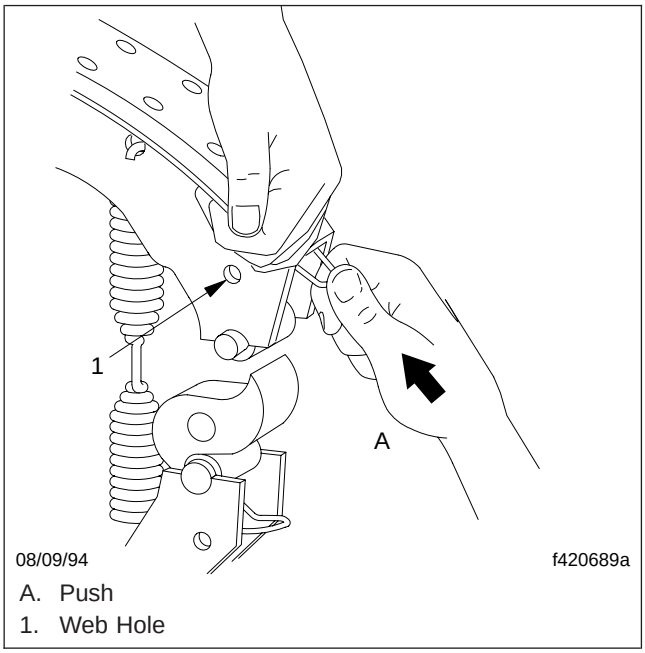
3.2 Pull each shoe away from the cam to allow enough space. Install the cam rollers.

4. Install the wheels and brake drums. For instructions, see **Section 33.02** for front axles or **Section 35.02** for rear axles.

5. Adjust the brakes at the slack adjusters. For instructions, see **Subject 150**.

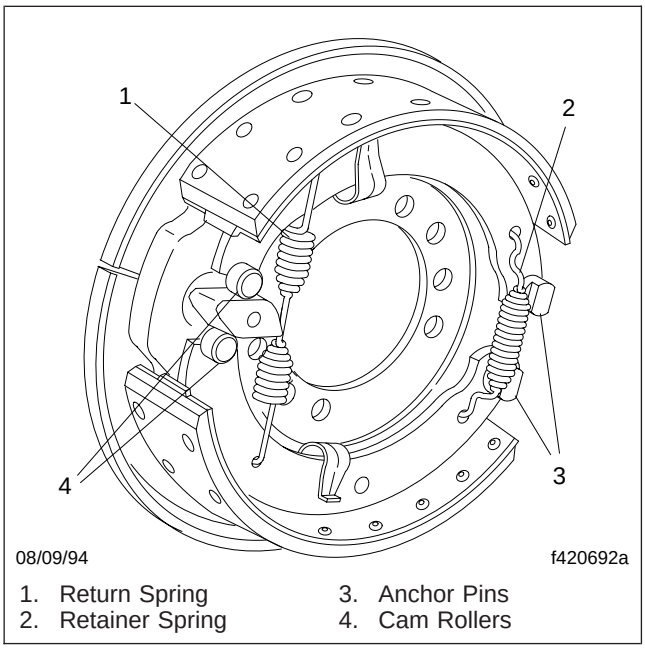
6. Remove the safety stands and lower the vehicle.

7. Remove the chocks from the tires.



A. Push
1. Web Hole

Fig. 7, Retainer in Web Hole



1. Return Spring
2. Retainer Spring
3. Anchor Pins
4. Cam Rollers

Fig. 8, Installing Retainer Spring and Shoes

Brake Shoe Removal and Installation

⚠ WARNING

Do not operate the vehicle until you have adjusted the brakes and checked for proper brake operation. Failure to do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

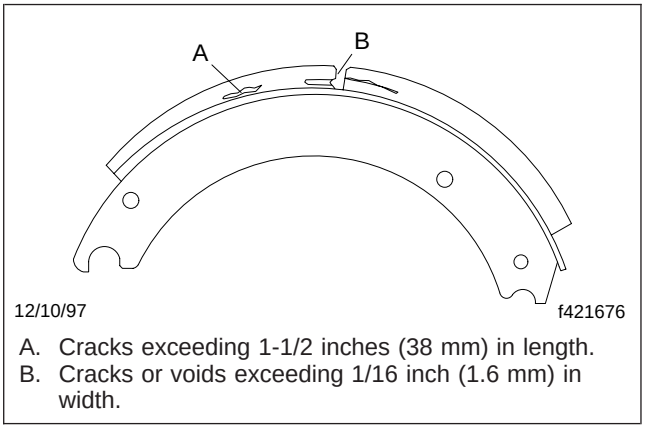
8. Check for proper brake operation.
   - 8.1 Make ten 40 to 20 mph (60 to 30 km/h) snubs to seat the linings.
   - 8.2 Make ten stops from 20 mph (30 km/h) at 50 percent air pressure.
   - 8.3 Make a full-pressure stop from 20 mph (30 km/h).
   - 8.4 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than others shows a lack of braking effort on those wheels.

⚠ WARNING

Before starting the following procedures, see "Safety Precautions" in Subject, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

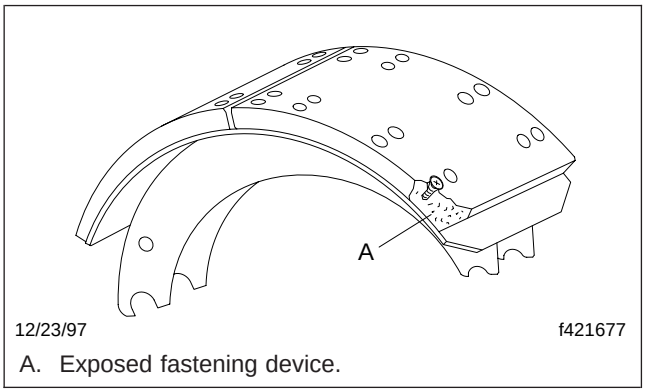
Inspection

1. Remove the brake shoes using the instructions in **Subject 110**.
2. Check the linings.
   - 2.1 If the linings are grease-or oil-soaked, cracked, or worn to less than 1/4-inch (6.4-mm) thickness at any point, replace them.
   - 2.2 Replace the linings if the lining surface is closer than 1/32 inch (0.8 mm) to any rivet head.
   - 2.3 The lining is considered worn-out and the vehicle should not be driven if:
     - Cracks on the lining surface exceed 1/16 inch (1.6 mm);
     - The lining edge shows cracks or voids over 1/16 inch (1.6 mm) in width and 1-1/2 inches (38 mm) in length. See **Fig. 1**;
     - Portions of the lining are missing, exposing a rivet when viewed from the edge. See **Fig. 2**;



A. Cracks exceeding 1-1/2 inches (38 mm) in length.
B. Cracks or voids exceeding 1/16 inch (1.6 mm) in width.

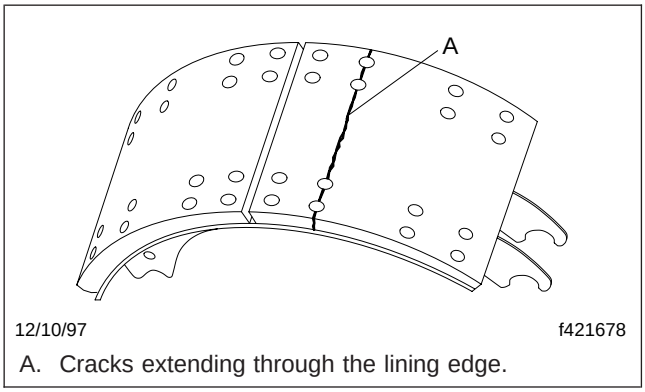
Fig. 1, Cracks and Voids



A. Exposed fastening device.

Fig. 2, Portions of the Brake Lining Missing

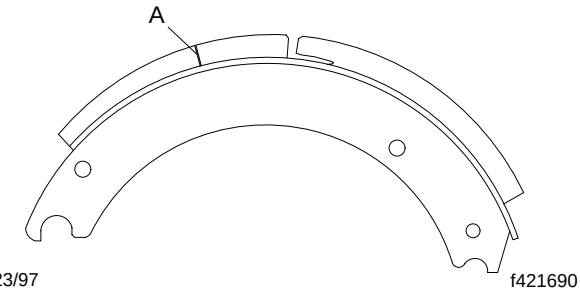
     - Cracks extend across the lining face and through the lining edge, or the lining is loose on the shoe. See **Fig. 3**.
   - 2.4 The vehicle is still operational but linings should be replaced as soon as possible if:
     - Horizontal or vertical cracks in the lining edge exhibit no loss of material and do not exceed 1/16 inch (1.6 mm) in width or 1-1/2 inch (38 mm) in length. See **Fig. 4**;
     - Corner portions of the lining are missing with no fastener exposed. See **Fig. 5**;
     - Surface cracks extend from hole to hole or if there is scoring and contamination from road debris. See **Fig. 6**.



A. Cracks extending through the lining edge.

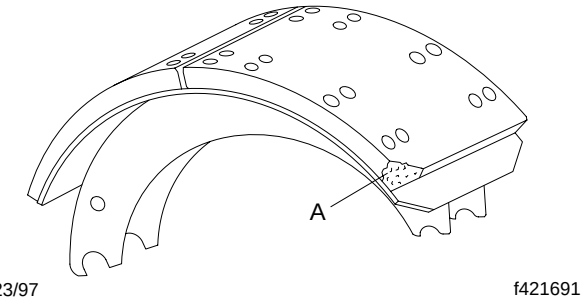
Fig. 3, Cracks in the Brake Lining

Brake Shoe and Lining Inspection



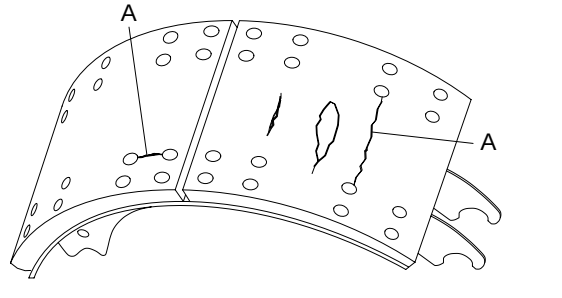
A. Cracks not exceeding 1-1/2 inches (38 mm) in length or 1/16 inch (1.6 mm) in width.

Fig. 4, Cracks and Voids



A. Corner segment missing with no fastener exposed.

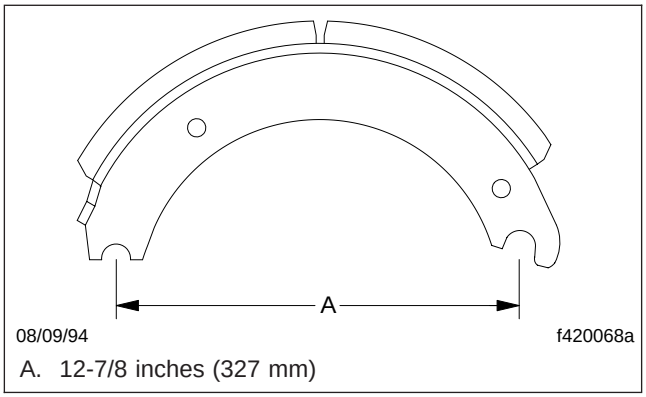
Fig. 5, Portions of the Brake Lining Missing



A. Cracks extending from hole to hole.

Fig. 6, Cracks in the Brake Lining

3. Check the shoes for bent or cracked webs or tables, broken welds, loose or out-of-round rivet or bolt holes. Replace the shoes if any of these conditions exist.
4. Check the anchor pin for looseness. Check the camshaft roller recesses in the shoe webs for visible wear. Replace the shoe if needed.
5. Check the shoe span. Measure the distances between the centerlines of the anchor pin and the camshaft roller pin recesses in the shoe web. If the measurement is more than 12-7/8 inches (327 mm), replace the shoe. See **Fig. 7**.



A. 12-7/8 inches (327 mm)

Fig. 7, Measuring the Shoe Span

⚠ WARNING

Before starting the following procedures, see "Safety Precautions" in Subject, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Replacement

IMPORTANT: For the best brake performance, do not mix brake linings between axles. When relining brake shoes, both wheel ends of each axle must have the same linings. On tandem axles, all four wheel ends must also have the same linings. However, it is not necessary for the steering axle brakes to have the same linings as the rear drive axle brakes. Also, when the minimum thickness is reached for any of the brake linings on an axle, reline both brakes on that axle at the same time.

Combination linings with different friction ratings for the primary and secondary shoes are often used. When combination linings are used, install the forward blocks on the primary shoe (following the rotation of the drum, the first shoe after passing the cam or wheel cylinder is the primary shoe).

If the cam is behind the axle, the top shoe is the primary and the lower shoe is the secondary shoe. See Fig. 1. If the cam is in front of the axle, the lower shoe is the primary shoe. See Fig. 2.

Replacement Using Rivets

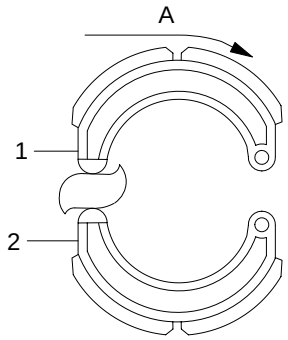
With the brake shoe removed, do the following:

1. Using a suitable riveting mandrel, push out the old rivets.

⚠ CAUTION

Drilling out rivets or cutting off rivet heads with a chisel can cause the rivet hole to become out-of-round. This could damage the brake shoe.

2. Clean the shoe table. For instructions, see Subject 140.
3. Align the brake shoe and lining rivet holes. Using a C-clamp, clamp the lining to the brake shoe.



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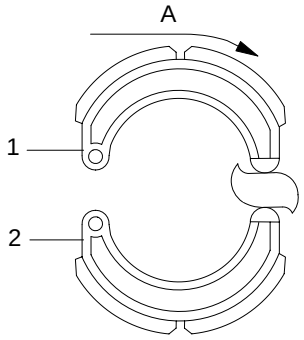
A. Right wheel rotation.
1. Primary Shoe
2. Secondary Shoe

Fig. 1, Camshaft Behind Axle



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A. Right wheel rotation.
1. Secondary Shoe
2. Primary Shoe

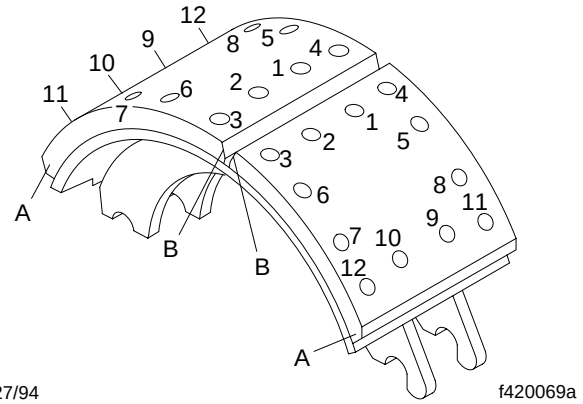
Fig. 2, Camshaft Ahead of Axle

4. Insert the correct sized rivets into all holes and threads, and temporarily hold them in place with masking tape.

IMPORTANT: Use rivets that have the correct material, shank diameter, length, head size, and shape. Use tubular rivets that are 1/4-inch diameter by 9/16-inch long, SAE No. 10, made of plated steel or brass.

5. Begin riveting at the center of each edge of the shoe and lining, and work toward each end. See Fig. 3.
6. Check for a close fit between the lining and shoe table.

Brake Shoe Lining Replacement



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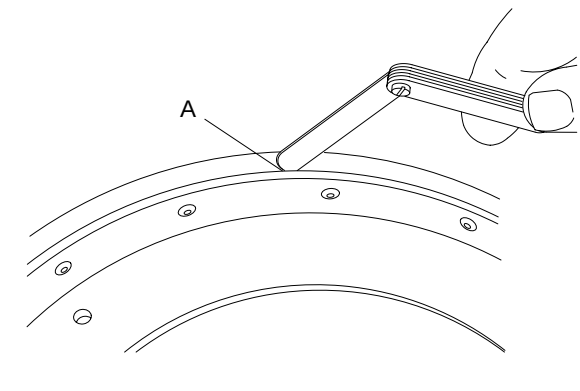
A. Toe
B. Heel

Fig. 3, Rivet or Bolt Attachment Sequence

Try to insert a 0.010-inch (0.25-mm) feeler gauge between the lining and shoe table along the edges. See **Fig. 4**. It should not be possible to insert the feeler gauge anywhere along the edge, except at each end beyond the last row of rivets. See **Fig. 5**. A larger clearance, up to 0.025 inch (0.64 mm), may exist in these areas.



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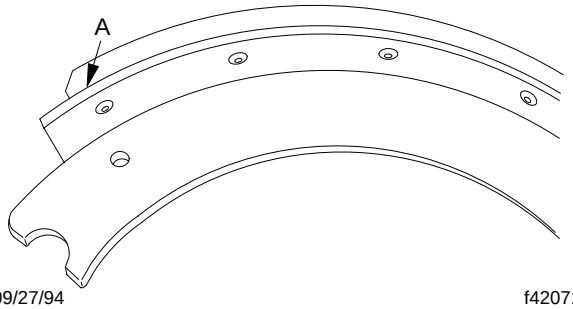
A. Try to insert a 0.010-inch (0.25-mm) feeler gauge between the lining and shoe table along the edges.

Fig. 4, Feeler Gauge

7. Circle grind the brake lining to obtain the correct lining-to-drum contact. With the cam in the full-release position, the new brake linings must be ground 0.070 inch (1.8 mm) less than the drum diameter. The cam must be adjusted and the lining ground until there is an 80 percent lining-to-drum contact, which must be continuous and in the center of the lining.



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A. Clearance up to 0.025 inch (0.64 mm) may exist in this area.

Fig. 5, End of Edge

Replacement Using Bolts

1. Clean the shoe table. For instructions, see **Subject 140**.
2. Align the brake shoe and lining bolt holes. Using a C-clamp, clamp the lining to the brake shoe.
3. Insert the correct sized bolts, and new lockwashers, into all holes and threads. Loosely install the nuts.
4. Tighten the nuts as follows in the sequence shown in **Fig. 3**: on 3/8-inch brass bolts 18 to 23 lbf·ft (24 to 31 N·m); on 1/4-inch brass bolts 80 to 100 lbf·in (900 to 1120 N·cm).
5. Circle grind the brake lining to obtain the correct lining-to-drum contact. With the cam in the full-release position, the new brake linings must be ground 0.070 inch (1.8 mm) less than the drum diameter. The cam must be adjusted and the lining ground until there is an 80 percent lining-to-drum contact, which must be continuous and in the center of the lining.

Brake Components Disassembly and Inspection, Cleaning, and Assembly

⚠ WARNING

Before starting the following procedures, see "Safety Precautions" in Subject, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Disassembly and Inspection

NOTE: For an illustration of the brake components, see **Fig. 1**.

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Check the drum for cracks, heat-checks, glazing, grooving, and run-out. See **Fig. 2**. Measure the drum diameter. Replace the drum if it exceeds the maximum diameter stamped on it. Replace cracked drums. Some drums that are glazed, grooved, or out-of-round can be repaired. For detailed instructions, see **Group 33** for front axles or **Group 35** for rear axles.
3. Disconnect the slack adjuster from the pushrod clevis:
   - *Manual slack adjusters*: Remove the cotter pin and clevis pin from the brake chamber pushrod clevis.
   - *Automatic slack adjusters*: For instructions, see **Section 42.29** for Meritor, **Section 42.33** for Gunite® or **Section 42.36** for Haldex®.
4. With the brake shoes removed, use a dial indicator to measure the up-and-down and side-to-side end play of the camshaft. Replace the bushings if there is more than 0.030 inch (0.8 mm) of movement.

⚠ CAUTION

Do not hammer on the manual slack adjuster to remove it. Damage to the adjuster or camshaft spline may result.

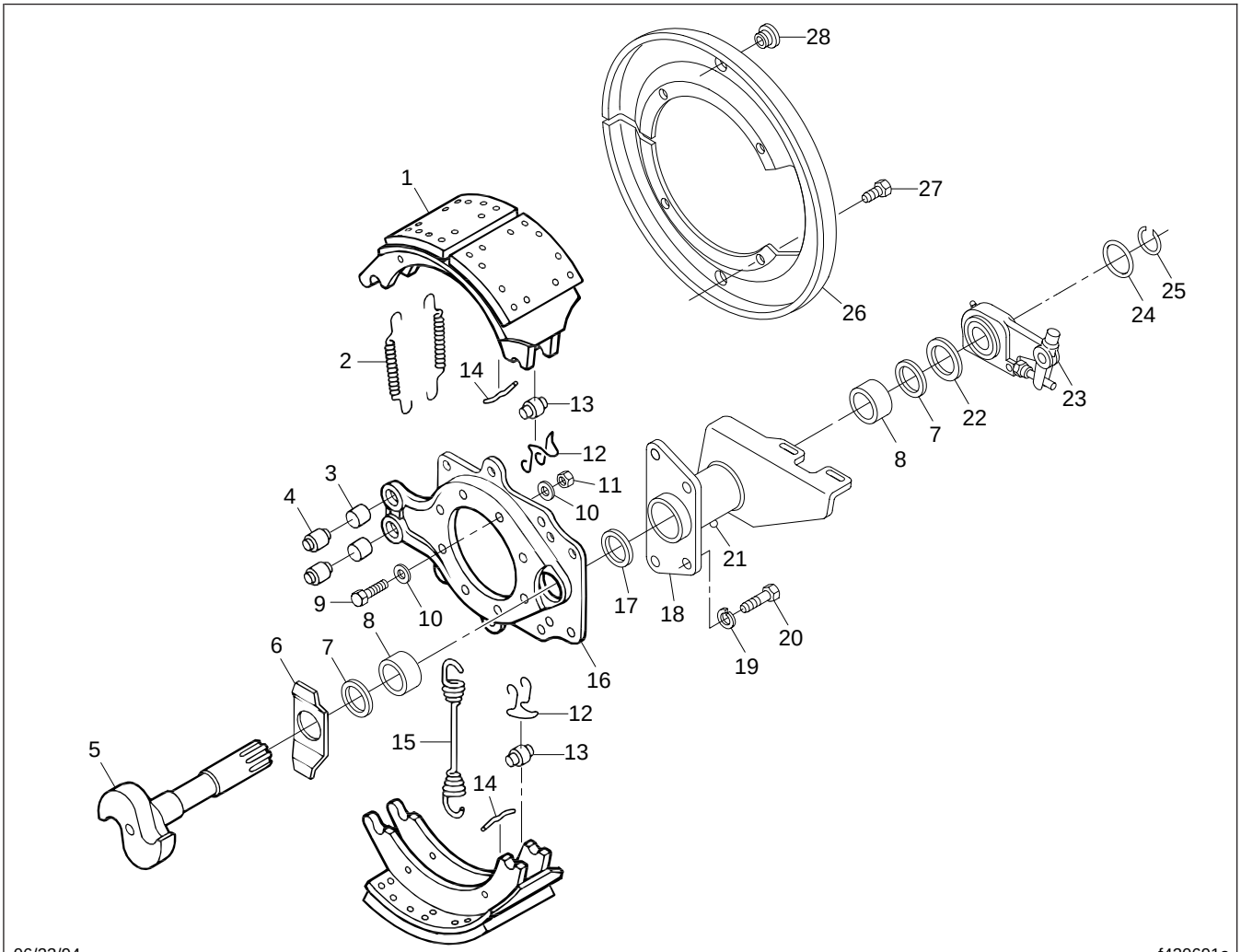
5. Remove the slack adjuster:
   - *Manual slack adjusters*: While depressing the locking sleeve, turn the adjuster nut until the slack adjuster is clear of the brake chamber pushrod clevis. Remove the lockring and the outer spacing washers from the camshaft. Using a suitable puller, remove the slack adjuster.
   - *Automatic slack adjusters*: For instructions, see **Section 42.29** for Meritor, **Section 42.33** for Gunite® or **Section 42.36** for Haldex®.
6. Check the slack adjuster for damage and for binding.
   - 6.1 Check the slack adjuster clevis for cracks or bushing wear. Check the splines for chipped teeth and deformation. Replace as needed.
   - 6.2 Depress the locking sleeve and turn the adjuster nut with a wrench at least one turn in each direction. If there is binding, or if excessive force is needed to turn the slack adjuster, replace it.

IMPORTANT: If any slack adjuster problem is found, repair or replace the unit, depending on the manufacturer's recommendations.

7. Remove the camshaft by grasping its head and pulling the camshaft outboard.
8. Check the camshaft spline end for cracks, or worn or deformed splines. Replace the camshaft if it is damaged.
9. Check the camshaft bushing journals for wear or corrosion. Replace the camshaft if it is worn or if roughness is felt in the journal area.
10. Inspect the camshaft head for brinelling, cracking, or flat spots. Replace the camshaft if a ridge can be felt between the worn area and the cam head surface.
11. Remove the brake chamber stud nuts and lockwashers that attach the brake chamber to the camshaft support bracket.

    Check the chamber for a cracked housing, bent pushrod, loose clamp ring, loose air fitting, air leaks, or clogged vent holes. Repair or replace brake chamber parts as needed. For instructions, see **Section 42.31** for MGM® E or TR series, **Section 42.32** for Midland, **Section 42.39** for Anchorlok® or **Section 42.42** for MGM L series.
12. Remove and inspect the camshaft support bracket. Remove and discard its gasket.

Brake Components Disassembly and Inspection, Cleaning, and Assembly



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NOTE: 16-1/2-inch Q series and all Q Plus™ series shown.

1. Brake Shoe and Lining Assembly
2. Brake Shoe Retaining Spring
3. Anchor Pin Bushing
4. Brake Shoe Anchor Pin
5. S-Head Camshaft
6. Camhead Washer
7. Camshaft Grease Seal
8. Camshaft, Spider, and Bracket Bushing
9. Spider Mounting Bolt
10. Hardened Washer
11. Nut
12. Brake Shoe Roller Retainer
13. Brake Shoe Roller
14. Brake Shoe Return Spring Pin
15. Brake Shoe Return Spring
16. Brake Spider
17. Camshaft Support Bracket Gasket
18. Camshaft Support Bracket
19. Bracket Capscrew Washers
20. Camshaft Support Bracket Capscrew
21. Grease Fitting
22. Camshaft Washer
23. Automatic Slack Adjuster Assembly
24. Spacing Washer
25. Camshaft Lockring
26. Dust Shield
27. Dust Shield Capscrew
28. Plug

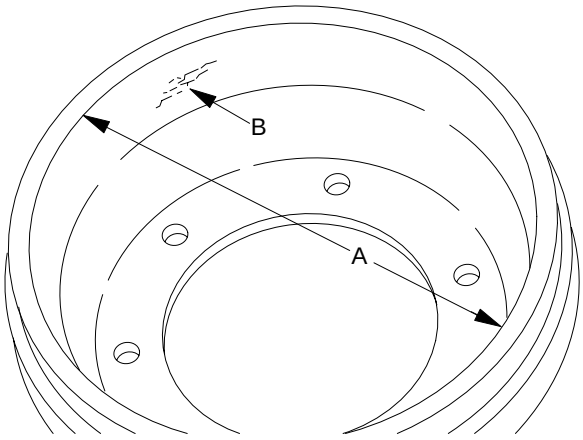
Fig. 1, Cam-Master Q Series Brakes

Check the bracket for a bent, broken or cracked arm, and cracked welds. Replace the bracket if any of these conditions exist.

13. Remove and inspect the old bushing and the grease seal.
    - 13.1 Check the camshaft bushing for wear. The inner surface must be smooth. If it is rough or abrasive, replace the bushing.
    - 13.2 Inspect the seal. Replace it if the lip is nicked, cut, or distorted.
14. Install the new bushing or seal with a suitable piloted driver.

IMPORTANT: Grease seals are installed in both the bracket and the brake spider so that the seal lip is facing toward the slack adjuster end of the bracket tube. See **Fig. 3**.

15. Remove the spider-to-axle attaching nuts, hardened washers, and bolts. Remove the spider from the axle flange.



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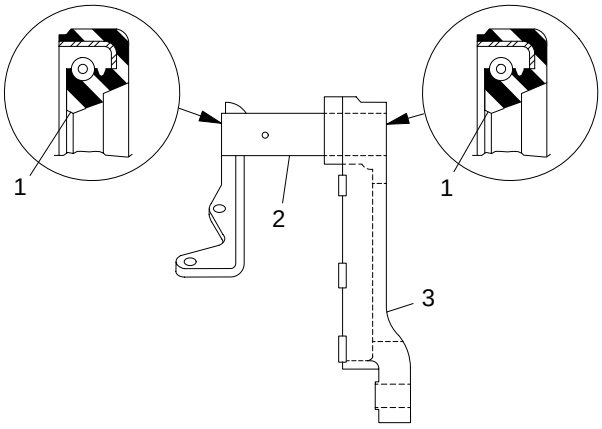
A. Check for diameter and for out-of-round.
B. Check for cracks, heat checks, glazing, and grooves.

Fig. 2, Brake Drum

16. If equipped, remove the four capscrews that attach the dust shield to the spider. Remove the dust shield.
17. Inspect the spider and parts for damage. Replace as needed.



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NOTE: The seal lip is facing toward the slack adjuster.

1. Seal Lip
2. Camshaft Support Bracket
3. Brake Spider

Fig. 3, Positioning of Seals on the Camshaft

- 17.1 Check for cracks at the bolt holes, cam area, and around the anchor pin. Replace if damaged.
- 17.2 Check the anchor pin. If the pin is worn or loose, replace it.
- 17.3 Check the anchor pin and brake spider bushings for wear. The inner surfaces must be smooth. If any surface is rough or abrasive, replace the part.
- 17.4 Inspect the seal. Replace it if its lip is nicked, cut, or distorted.

18. Using a suitable piloted driver, install the new bushings and seal.

IMPORTANT: Grease seals are installed in both the bracket and the brake spider so that the seal lip is toward the slack adjuster end of the bracket tube. See **Fig. 3**.

Cleaning

After removing the brake parts being serviced, do the following:

1. Wire-brush all parts exposed to mud, road dirt, and salt, including the exterior of the drum, spider, brake chamber bracket, and dust shields (if

Brake Components Disassembly and Inspection, Cleaning, and Assembly

equipped). If relining the shoes, thoroughly wire-brush the shoe tables, and paint them with a rust inhibitive coating.

⚠ CAUTION

A thick layer of oxidation and dirt on the outside of a brake drum acts as an insulator and may hinder normal heat dissipation. Make sure oxidation and dirt are removed by wire-brushing, or damage to brake components could occur.

2. Using an industrial vacuum cleaner with a HEPA filter system, pick up excessive dust accumulation. Wipe the interior of the drums with a greaseless solvent to remove lining dust.
3. Thoroughly clean all remaining brake parts with a suitable shop solvent. Wipe dry with a clean, lint-free cloth, or use low-pressure, filtered and compressed air.

Assembly

1. Install the dust shield, if equipped.

   Position the dust shield against the spider and install the capscrews. Tighten the capscrews:

   - 3/8–16 Grade 5: 25 to 35 lbf·ft (34 to 47 N·m)
   - 3/8–16 Grade 8: 35 to 50 lbf·ft (47 to 68 N·m)

2. Install the spider.

   Place the spider on the axle flange. Using a hardened washer under the bolt head and the nut, install the mounting fasteners. Tighten the bolts in a cross pattern:

   - 1/2–13: 60 to 80 lbf·ft (81 to 108 N·m)
   - 5/8–11 (flanged hexhead capscrew): 160 to 200 lbf·ft (217 to 271 N·m)
   - 5/8–11 (hexhead capscrew): 130 to 160 lbf·ft (176 to 217 N·m)

3. Install the brake chamber and bracket.

   3.1 Place the brake chamber on the mounting bracket with the chamber mounting studs through the bracket holes. Install the hardened flatwashers, lockwashers, and stud nuts. Tighten the nuts:

   - 3/8–16: 37 to 50 lbf·ft (47 to 68 N·m)
   - 1/2–13: 70 to 100 lbf·ft (95 to 136 N·m)

   NOTE: If replacing a brake chamber, make sure that the new chamber is the same size, and made by the same manufacturer, as the brake chamber on the other side of the axle.

   3.2 Place the bracket against the spider and install the lockwashers and capscrews. Tighten the capscrews:

   - 1/2–13: 60 to 80 lbf·ft (81 to 108 N·m)
   - 5/8–11: 105 to 145 lbf·ft (142 to 196 N·m)

4. Install the camshaft and parts in the spider. Install the slack adjuster.

   4.1 Apply a thin film of chassis grease on the inside of the camshaft bushings and journals. Do not grease the camshaft head area.

   4.2 Apply a thin film of rust preventive grease (Meritor 0-637, or an equivalent) on the camshaft splines.

   4.3 Carefully slip the camshaft into the spider and the mounting bracket tube.

   4.4 Install the thick camshaft washer on the camshaft.

   4.5 Install the slack adjuster on the camshaft, with the adjuster nut on the side opposite the brake chamber.

   4.6 Install the outer washers and snap ring.

5. Use a dial indicator to measure the end play of the camshaft. There should be no more than 0.060 inch (1.5 mm) movement.
6. Pressure lube the camshaft bracket bushings.

   Pump multipurpose chassis grease (NLGI grade 1 or 2) into the chamber bracket until it appears at the slack adjuster end of the bracket. Use care that no grease enters the drum cavity. If grease leaks out under the cam head, the camshaft grease seal is worn or damaged, or is installed backwards.

NOTE: The use of meter-type fittings, having a maximum 40 psi (276 kPa) pressure relief at shutoff, is recommended.

7. Align the slack adjuster with the clevis:
   - *Manual slack adjusters*: While depressing the locking sleeve, turn the adjusting nut counterclockwise until the appropriate hole in the adjuster is aligned with the hole in the brake chamber pushrod clevis.
   - *Automatic slack adjusters*: For instructions, see **Section 42.29** for Meritor, **Section 42.33** for Gunite® or **Section 42.36** for Haldex®.
8. Install the brake shoes. For instructions, see **Subject 110**.
9. Remove the chocks from the tires.

⚠ WARNING

Before starting the following procedures, see "Safety Precautions" in Subject, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Pre-Adjustment Checks and General Adjustment Information

Before adjusting the brakes, check and adjust the following:

- Adjust the wheel bearings. For instructions, see **Group 33** for front axles or **Group 35** for rear axles.
- Check the slack adjuster and the brake chamber for loose fasteners and tighten as necessary. For torque specifications, see **Specifications 400**. For slack adjuster installation instructions, see **Section 42.29** for Meritor, **Section 42.33** for Gunite® or **Section 42.36** for Haldex®.

Brakes with automatic slack adjusters should never have to be manually adjusted while in service. The only time automatic slack adjusters should be manually adjusted is during installation or after the brakes have been relined.

For cam brakes, there are two brake chamber stroke measurement specifications, applied chamber stroke and free-stroke.

The procedure for adjusting the brake chamber stroke (at the slack adjuster's manual adjusting nut) may vary between each slack adjuster manufacturer. But, there are three basic procedures in completing a manual brake chamber stroke adjustment. They consist of:

A. Adjusting the approximate brake chamber stroke from the manual adjusting nut of the slack adjuster.

B. Measuring and readjusting the free-stroke.

C. Measuring and readjusting the applied chamber stroke.

The force used to move the slack adjuster from its released position to its applied position (where the brake linings contact the brake drum) distinguishes the free-stroke from the applied chamber stroke. The free-stroke is measured using a lever to move the slack adjuster (from the released to the applied positions). The applied chamber stroke is measured using an 80 to 90 psi (550 to 620 kPa) brake application to move the slack adjuster (from the released to applied positions). The stroke (free or applied chamber) is the distance that the large clevis pin moves when the brakes are applied.

With the engine off, 100 psi (689 kPa) of air tank pressure will apply the required (80 to 90 psi [550 to 620 kPa]) brake application for measuring the applied chamber stroke. The applied chamber stroke measurement can be used for diagnostic purposes. If the applied chamber stroke is too long or too short, this may indicate excessive wear in the cam, cam bushings, return springs, or air chamber. The applied chamber stroke should always be readjusted (minimized) to within the specified limit; but it should not be reduced to the point where the free stroke is too short and the brakes drag. To check for brake drag, spin the wheel end, tap the rim lightly with a hammer, and listen for a sharp ringing sound. If a dull thud is heard, the brake is dragging.

IMPORTANT: The U.S. Department of Transportation (DOT), Federal Highway Administration has issued the applied chamber stroke specifications for cam brakes. When the applied chamber stroke is checked and readjusted, it must not be greater than the DOT specification. See **Table 1**.

Brake Adjustment

Stroke Limits		
Chamber Type (Size)	**Maximum Allowable (Applied) Stroke inch (mm) ***	**Desired Free-Stroke inch (mm)**
16	1-3/4 (44)	5/8–3/4 (16–19)
16 (long stroke) †	2 (51)	
20	1-3/4 (44)	
20 (long stroke) †	2 (51)	
24	1-3/4 (44)	
24 (long stroke) †	2 (51)	
30	2 (51)	
30 (long stroke) †	2-1/2 (64)	
36	2-1/4 (57)	

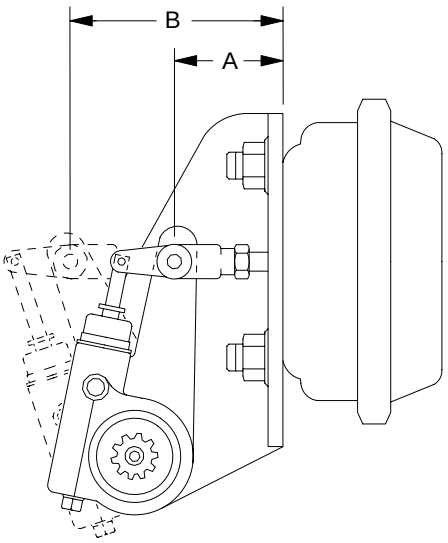
* These specifications are relative to a brake application with 80 to 90 psi (550 to 620 kPa) air pressure in the brake chambers.
† Long stroke design is indicated by a tag, or embossing, on the brake chamber.

Table 1, Stroke Limits

Adjustment

Gunite Automatic Slack Adjuster

1. See "Pre-Adjustment Checks and General Adjustment Information" before adjusting the brakes.
2. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
3. Raise the front or rear axle and place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
4. Fully release the brakes. The brake chamber pushrod must be fully retracted.
5. Set the initial brake chamber stroke (coarse adjustment).
   - 5.1 Turn the adjusting hexnut clockwise until the brake linings contact the drum.
   - 5.2 Turn the adjusting hexnut counterclockwise a half-turn. There should be about 30 lbf·ft (41 N·m) resistance. A ratcheting sound should be heard.
6. Measure and adjust the free-stroke.
   - 6.1 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 1**. Record this measurement as dimension A.



NOTE: Subtract measurement A from B.
A. Measurement with Brakes Released.
B. Measurement with Brakes Applied.

Fig. 1, Measure the Stroke

   - 6.2 Using a pry bar as a lever, move the slack adjuster until the brake linings contact the brake drum.
   - 6.3 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin again. See **Fig. 1**. Record this measurement as dimension B.

6.4 Subtract dimension A from dimension B. The difference between these measurements is the free-stroke.

6.5 The free-stroke should be 5/8- to 3/4-inch (16- to 19-mm). If it is not, turn the adjusting nut in the required direction. Measure the free-stroke again and readjust it until it is correct.

7. Measure and adjust the applied chamber stroke (fine adjustment).

7.1 Start the engine and build air pressure to 100 psi (689 kPa). Shut down the engine.

7.2 Fully apply the brakes. Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 1**. Record this measurement as dimension C.

7.3 Subtract dimension A (measured in the previous step) from dimension C. The difference between these measurements is the applied chamber stroke.

7.4 The applied chamber stroke must not exceed the value listed in **Table 2**. If the stroke is not correct, turn the adjusting hexnut in the required direction. Measure the applied stroke again and adjust it until it is correct.

If the stroke varies or remains greater than the specified range, check brake components. For instructions, see **Subject 140**. If necessary, replace the slack adjuster. For instructions, see **Section 42.33**.

IMPORTANT: Make sure there is clearance between the slack adjuster and other vehicle components when the brakes are applied and the pushrod travels its maximum stroke.

8. Apply the parking brakes.

9. Remove the safety stands and lower the front axle.

10. Remove the chocks from the tires.

Maximum Adjusted Brake Chamber Stroke, Gunite Automatic Slack Adjusters		
Chamber Size	**Maximum Chamber Stroke Inch (mm)**	
	Standard Stroke	**Long Stroke**
16	1-3/4 (44)	2 (51)
20		
24	1-3/4 (44)	2 (51) — *2-1/2 inch rated stroke*
		2-1/4 (63) — *3-inch rated stroke*
30	2 (51)	2-1/2 (57)

Table 2, Maximum Adjusted Brake Chamber Stroke, Gunite Automatic Slack Adjusters

Meritor Automatic Slack Adjuster

1. See "Pre-Adjustment Checks and General Adjustment Information" before adjusting the brakes.

2. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.

3. Raise the front or rear axle. Place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.

4. Fully release the brakes (the air chamber pushrod must be fully retracted).

5. Check the condition of the boot on the slack adjuster. It should be held in the proper position with a retaining clip. If the boot is torn or cracked, see **Section 42.29** for slack adjuster disassembly and inspection procedures.

6. Check the free-stroke.

6.1 With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 1**. Record this measurement as dimension A.

6.2 Use a pry bar to move the slack adjuster and apply the brakes. Again, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 1**. Record this measurement as dimension B.

Brake Adjustment

6.3 The difference between the two measurements is the initial free-stroke, and sets the clearance between the linings and the drum.

6.4 The free-stroke must be 5/8 to 3/4 inch (16 to 19 mm);

If the free-stroke is correct, go to the next step.

6.5 If the free-stroke is incorrect, remove the pressure relief capscrew, spring, and pawl assembly from the slack adjuster housing. See **Fig. 2**. If equipped with a pull-pawl assembly, carefully insert a screwdriver and raise the relief cap about 1/8 inch (3 mm). See **Fig. 3**.

⚠ CAUTION

Before turning the adjusting nut, remove the pressure relief capscrew, spring, and pawl assembly. If equipped with a pull-pawl assembly, raise the relief cap about 1/8 inch (3 mm). Failure to do so could strip the teeth on the pawl.

6.6 Turn the adjusting nut 1/8 turn, as shown in **Fig. 4**. Measure the stroke again, and adjust until it is correct.

If necessary, replace the slack adjuster. For instructions, see **Section 42.29**.

7. Check for correct brake chamber stroke.

7.1 With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 1**. Record this measurement as dimension A.

7.2 Build air pressure to 100 psi (689 kPa). Shut down the engine. Fully apply the brakes. Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 1**. Record this measurement as dimension C. The difference between the measurements is the brake chamber stroke.

7.3 The brake chamber stroke must be less than the measurements shown in **Table 3**. If the brake chamber stroke is incorrect, remove the pressure relief capscrew, spring, and pawl assembly from the slack adjuster housing. See **Fig. 2**. If equipped with a pull-pawl assembly, carefully insert a screwdriver and raise the relief cap about 1/8 inch (3 mm). See **Fig. 3**.

Maximum Adjusted Brake Chamber Stroke, Meritor Automatic Slack Adjusters	
Chamber Size	**Stroke inch (mm)**
9, 12	Less than 1-3/8 (35)
16, 20, 24	Less than 1-3/4 (44)
24 *, 30	Less than 2 (51)
36	Less than 2-1/4 (57)

* Long Stroke

Table 3, Maximum Adjusted Brake Chamber Stroke, Meritor Automatic Slack Adjusters

⚠ CAUTION

Before turning the adjusting nut, remove the pressure relief capscrew, spring, and pawl assembly. If equipped with a pull-pawl assembly, raise the relief cap about 1/8 inch (3 mm). Failure to do so could strip the teeth on the pawl.

7.4 Turn the adjusting nut 1/8-turn, as shown in **Fig. 4**. Measure the stroke again and adjust until correct.

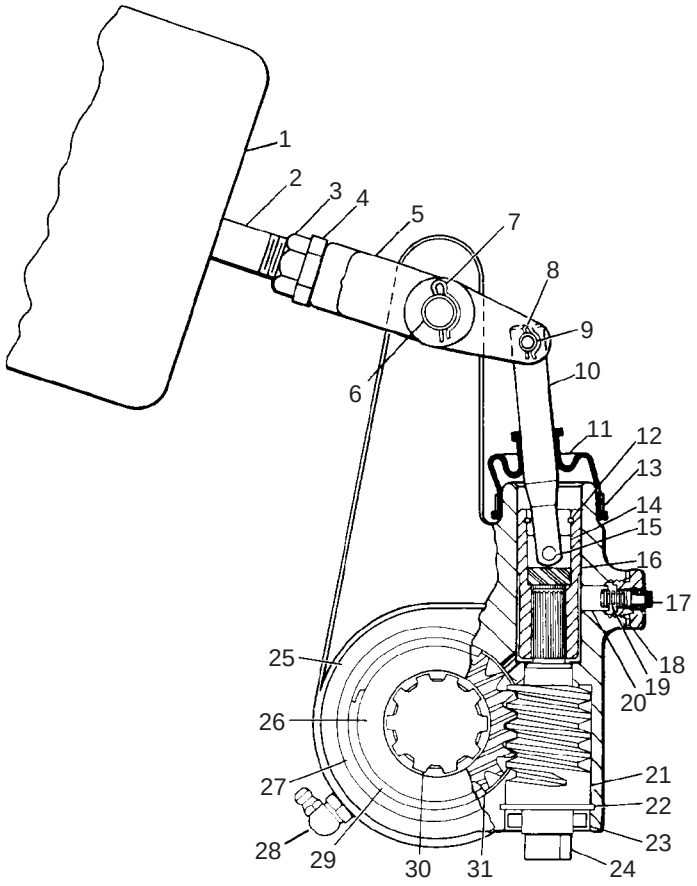
If necessary, replace the slack adjuster. For instructions, see **Section 42.29**.

⚠ CAUTION

Do not make the adjusted chamber stroke too short. The free-stroke must not be less than 5/8 to 3/4 inch (16 to 19 mm). If the chamber stroke is too short, the linings can drag and damage the brake.

If the stroke varies or remains greater than the specified range, check the brake components. For instructions, see Subject 140.

7.5 If removed, install the pawl assembly, spring, and the pressure relief capscrew. Tighten the capscrew 15 to 20 lbf·ft (20 to 27 N·m). Or, remove the screwdriver from the pull-pawl assembly, if equipped.



1. Brake Air Chamber
2. Brake Chamber Pushrod
3. Clevis Jam Nut
4. Quick-Connect Collar (if equipped)
5. Clevis
6. Large Clevis Pin
7. Large Cotter Pin
8. Small Cotter Pin
9. Small Clevis Pin
10. Actuator Rod
11. Boot
12. Piston Retaining Ring
13. Boot Retaining Clamp
14. Actuator Piston
15. Roller Pin
16. Actuator Adjusting Screw
17. Pressure Relief Capscrew (shown 90 degrees out of position)
18. Gasket
19. Pawl Spring
20. Pawl Assembly
21. Worm
22. Worm Retaining Snap Ring
23. Worm Seal
24. Manual (Worm) Adjusting Nut End
25. Slack Adjuster
26. Gear
27. Gear Thrustwasher
28. Grease Fitting (if equipped)
29. Gear Retaining Ring
30. Camshaft Splines
31. Gear-to-Body Seal

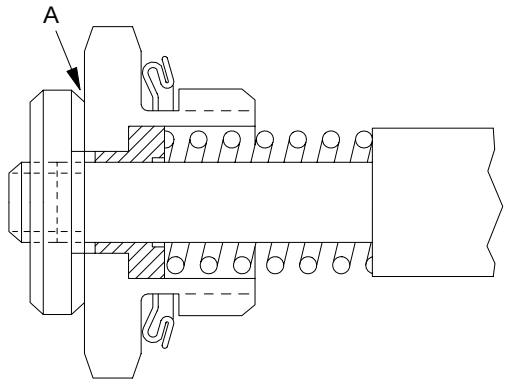
Fig. 2, Meritor Automatic Slack Adjuster

8. Apply the parking brakes.
9. Remove the safety stands and lower the vehicle.
10. Remove the chocks from the tires.

Haldex® Automatic Slack Adjuster

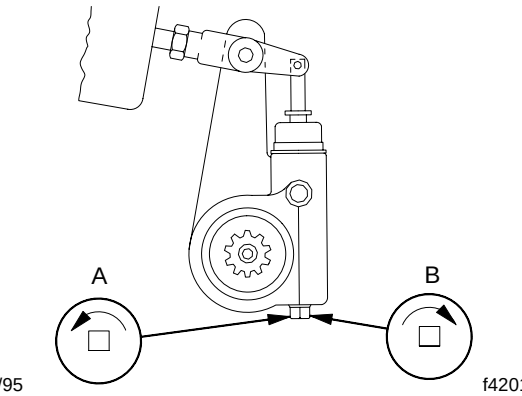
1. See "Pre-Adjustment Checks and General Adjustment Information" before adjusting the brakes.
2. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.

Brake Adjustment



A. Insert screwdriver here.

Fig. 3, Disengage the Pull-Pawl



A. Shorten stroke.
B. Lengthen stroke.

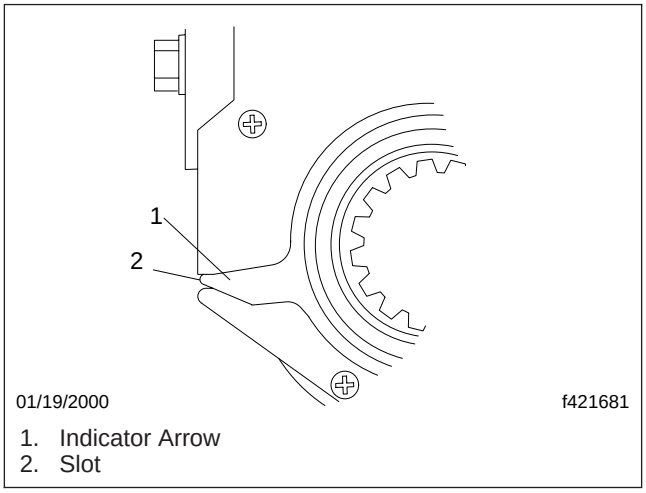
Fig. 4, Turn the Adjusting Nut

3. Raise the front or rear axle. Place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
4. Fully release the brakes (the air chamber push-rod must be fully retracted).

⚠ CAUTION

If the slack adjuster is equipped with an installation indicator, the indicator must be in the slotted area as shown in Fig. 5. If the installation indicator is not within the slotted area, the control arm is installed in the wrong position. This may result in tight brakes and excessive lining wear and possible brake damage.

5. If the slack adjuster is equipped with an installation indicator, check that the installation indicator is within the slotted area. See **Fig. 5**. If the installation indicator is not within the slotted area, the control arm is not properly installed. For slack adjuster installation instructions, see **Section 42.36**.



1. Indicator Arrow
2. Slot

Fig. 5, Installation Indicator

6. Check the de-adjustment torque (the internal clutch slippage) of the slack adjuster.
   - 6.1 Place a torque wrench on the 7/16-inch adjusting hexnut. See **Fig. 6**.
   - 6.2 While turning the torque wrench in a counterclockwise direction, measure how much torque is required to overcome the resistance of the internal clutch. A normal ratcheting sound will occur while the adjusting hexnut is backed off in the counterclockwise direction. The minimum allowable de-adjustment torque is 13 lbf·ft (17.6 N·m).

     If the clutch slips with a torque less than 13 lbf·ft (17.6 N·m), the slack adjuster must be replaced. For instructions see **Section 42.36**.
7. Turn the adjusting hexnut clockwise until the brake lining meets the brake drum. Back off counterclockwise 3/4 turn. See **Fig. 6**. There will be a ratcheting sound.

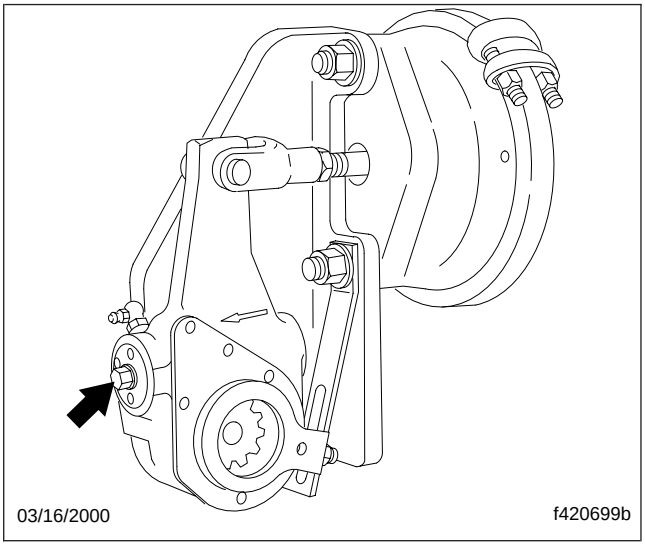


Fig. 6, Adjusting Hexnut

8. Measure the distance from the bottom of the air chamber to the far side of the clevis-pin hole. See **Fig. 7**. Record the exact distance as measurement A. Apply and hold an 80 psi (551 kPa) brake application. Measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. See **Fig. 7**. Record the exact distance as measurement B. Subtract measurement A from measurement B to determine the applied stroke. Compare this value to the value in **Table 4**.

   If the stroke varies or remains greater than the specified range, check the brake components. For instructions, see **Subject 140**. If necessary, replace the slack adjuster. For instructions, see **Section 42.36**.

Maximum Adjusted Brake Chamber Strokes With Haldex Automatic Slack Adjusters	
Chamber Size	**Stroke inch (mm)**
16	3/4–1-3/4 (19–44)
20	1–1-3/4 (25–44)
24	1–1-7/8 (25–48)
30	1-1/2–2 (38–51)

Table 4, Maximum Adjusted Brake Chamber Strokes With Haldex Automatic Slack Adjusters

9. Apply the parking brakes.

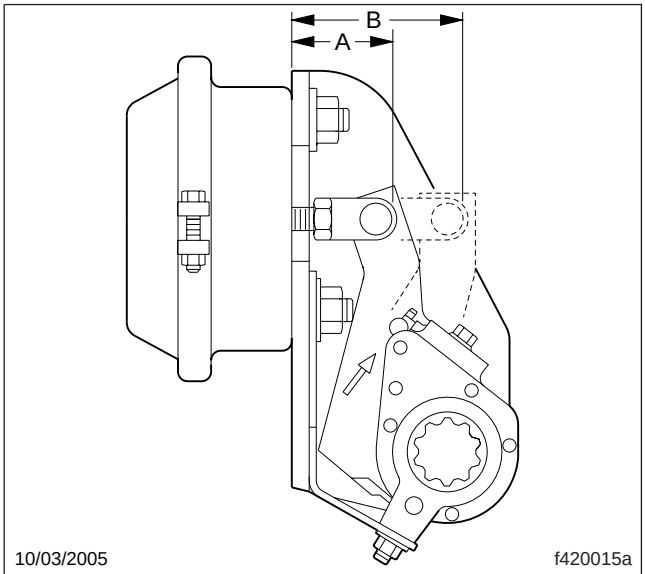


Fig. 7, Brake Stroke Check, Haldex Automatic Slack Adjuster

10. Remove the safety stands and lower the vehicle.
11. Remove the chocks from the tires.

Bendix Manual Slack Adjuster

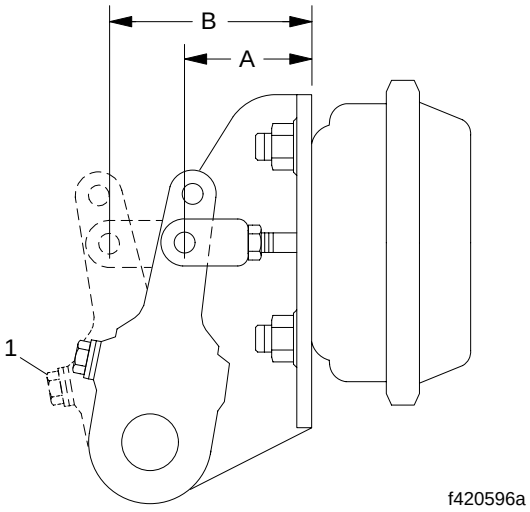
1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Raise the front or rear axle. Place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.

IMPORTANT: On slack adjusters equipped with an adjusting screw locking sleeve, wipe clean the locking sleeve area, and depress the locking sleeve when positioning the wrench or socket over the adjusting screw. Do not try to turn the adjusting screw without fully depressing the locking sleeve.

3. With the parking brakes released, rotate the adjusting screw until the brakes begin to drag when the drum is turned. Back off the adjustment until the wheel turns freely. Turn the adjusting screw nut until the locking sleeve engages it.
4. Measure the distance from the bottom of the brake chamber to the centerline of the clevis.

Brake Adjustment

See **Fig. 8**. Record the exact distance as measurement A. Apply and hold an 80 psi (551 kPa) brake application. Measure the distance from the bottom of the brake chamber to the centerline of the clevis-pin. See **Fig. 8**. Record the exact distance as measurement B. Subtract measurement A from measurement B to determine the applied stroke. Compare this value to the value in **Table 5**.



A. Measurement With Brakes Released.
B. Measurement With Brakes Applied.
1. Adjusting Screw Hexhead

Fig. 8, Measure the Stroke

Maximum Adjusted Brake Chamber Strokes With Bendix Manual Slack Adjusters	
Chamber Size	**Stroke inch (mm)**
9, 12	Less than 1-1/2 (38)
16, 20	Less than 1-3/4 (44)
24	Less than 1-7/8 (48)
24 *, 30	Less than 2 (51)
36	Less than 2-1/4 (57)

* Long Stroke

Table 5, Maximum Adjusted Brake Chamber Strokes With Bendix Manual Slack Adjusters

5. If the applied stroke equals or exceeds the maximum applied stroke, adjust the brakes.

5.1 Wipe clean the adjusting screw hexhead. See **Fig. 8**. Position a wrench or socket over the adjusting screw hexhead.

5.2 Turn the adjusting screw until it is tight. Back off the adjustment until the drum is free. Normally, the adjusting screw will need to be backed off 2 or 3 clicks.

5.3 To see if the drum is free, strike the brake drum with a steel tool and listen for a clear ringing sound. If a dull thud is heard, the brake is dragging.

IMPORTANT: Checking the brake adjustment when the wheel is off the ground may be unreliable. Looseness or wear anywhere in the wheel bearings will cause the drum to be misaligned while the wheel is off the ground. Check the brake adjustment with the wheel on the ground.

On slack adjusters equipped with an adjusting screw locking sleeve, make sure the locking sleeve is engaged around the adjusting screw hexhead after adjustment, thus locking the adjusting screw in place.

6. Apply the parking brakes.
7. Remove the safety stands and lower the vehicle.
8. Remove the chocks from the tires.

Specifications

Fastener Torques				
Description	**Grade**	**Size**	**Torque**	
			lbf·in (N·cm)	**lbf·ft (N·m)**
Brake Shoe Lining Nuts	—	3/8-Inch	—	18–23 (24–31)
		1/4-Inch	80–100 (900–1120)	—
Dust Shield Capscrews	5	3/8–16	—	25–35 (34–47)
	8	3/8–16	—	35–50 (47–68)
Spider Mounting Bolts	8	1/2–13	—	60–80 (81–108)
Spider Mounting Hexhead Capscrew		5/8–11	—	130–160 (176–217)
Spider Mounting Flanged Hexhead Capscrew				160–200 (217–271)
Brake Chamber Mounting Nuts	8	3/8–16	—	37–50 (47–68)
		1/2–13	—	70–100 (95–136)
Brake Chamber Bracket-to-Spider Capscrews	8	1/2–13	—	60–80 (81–108)
		5/8–11	—	105–145 (142–196)

Table 1, Fastener Torques

General Description

The Bendix PP–DC parking brake air valve is installed on trucks with air brakes, and is used to control the rear axle parking brakes. It is a push-pull type of valve, and is mounted on the right side of the dash.

Principles of Operation

When the valve knob is pulled out, air is exhausted from the parking brake chambers, releasing the springs, and applying the parking brakes. When the knob is pushed in, air flows into the parking brake chambers from one of the reservoirs, and compresses the springs, releasing the parking brakes.

The PP–DC has a double check valve feature. The valve uses air pressure from the air system (primary or secondary) with the higher pressure for the parking brakes. If the pressure drops below 20 to 30 psi (138 to 207 kPa) in both air systems, the brakes will automatically apply. The parking brakes will not apply automatically unless pressure is lost from both systems.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

- Chock the tires and stop the engine before working under a vehicle. Keep hands away from brake chamber push rods and slack adjusters; the brakes may apply as air system pressure drops.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

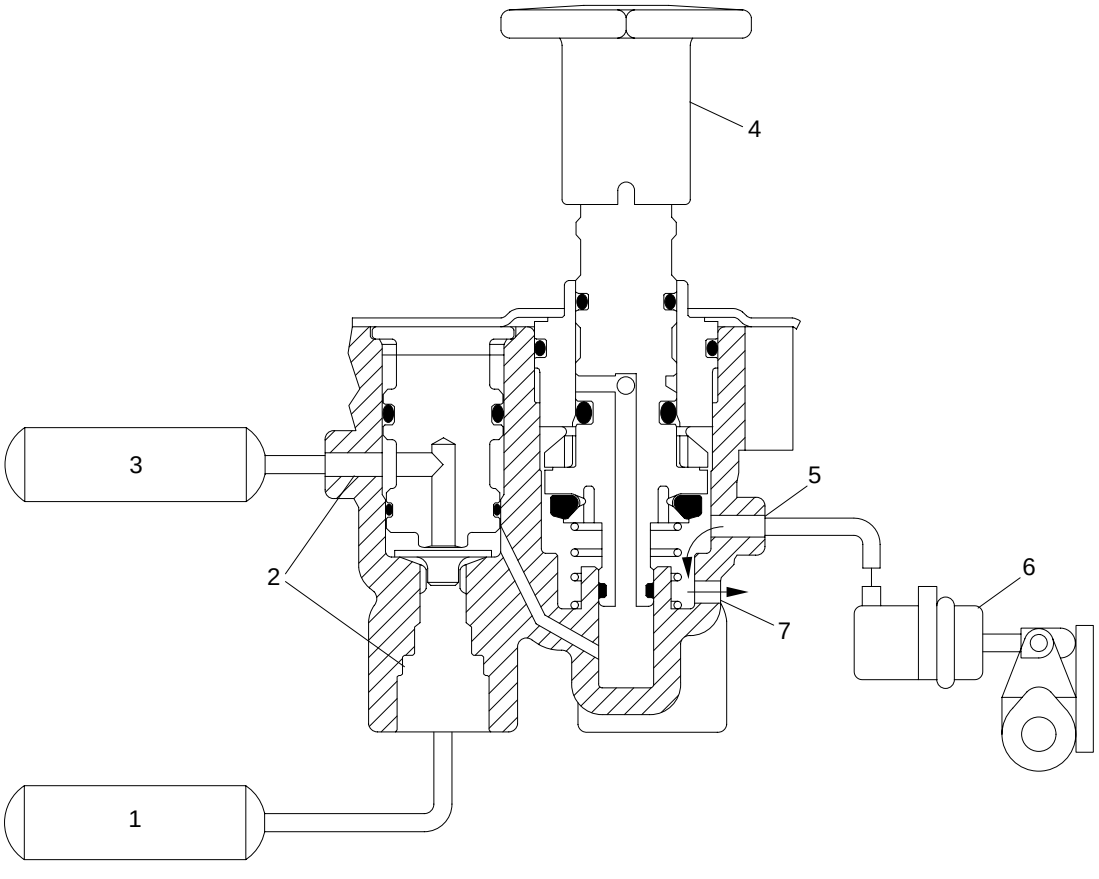
Parking Brake Hand Valve Tests

IMPORTANT: To do the following tests, connect two separate 120 psi (827 kPa) air sources to the PP–DC supply ports. **See Fig. 1.** Tee an accurate test gauge into the supply lines, and provide for a means to control supply line pressure. Connect a small volume air source with a gauge to the delivery port.

Operating Test

1. Chock the tires.
2. Start the engine and build up the air pressure to the normal operating level.
3. With the valve knob pulled out, supply either supply port with 120 psi (827 kPa) of pressure. Push the valve knob in. Air pressure should rise in the delivery line and equal supply line pressure.

   Pull the valve knob out. Delivery pressure should exhaust to zero.
4. Build air pressure to each supply source to 120 psi (827 kPa). Decrease supply pressure at the secondary service reservoir supply port at a rate of 10 psi (69 kPa) per second.



1. Primary Service Reservoir
2. Supply Port
3. Secondary Service Reservoir
4. Valve Knob
5. Delivery Port
6. Brake Chamber
7. Exhaust Port

Fig. 1, Parking Brake Hand Valve (sectional view)

Parking Brake Hand Valve Tests

Primary supply pressure and delivery pressure should not drop below 100 psi (689 kPa). Repeat this step for decreasing primary service reservoir pressure.

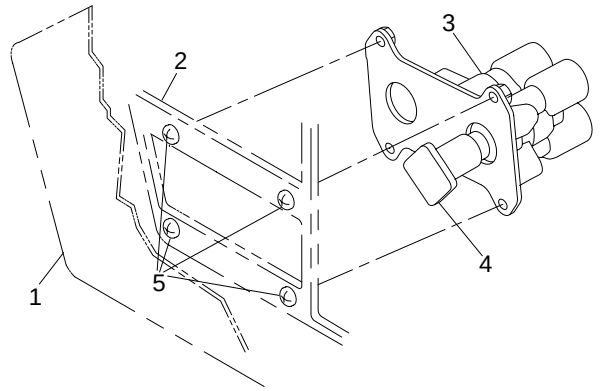
5. Build air pressure to each supply source to 120 psi (827 kPa). Then, decrease both supply pressures to below 20 to 30 psi (138 to 207 kPa). The valve knob should automatically pop out when the pressure is within that range.
6. If the valve does not work as described, repair the valve or replace it following instructions under **Subject 130.**

Leak Testing

1. Chock the tires.
2. Supply the valve with 120 psi (827 kPa) from the primary reservoir supply port.
3. With the valve knob pulled out, coat the exhaust port and the plunger stem with a soapy solution. Leakage at either fitting should not exceed a 1-inch (2.5-cm) bubble every five seconds.There should be no leakage from the secondary reservoir supply port.
4. Supply the valve with 120 psi (827 kPa) from the secondary reservoir supply port. There should be no leakage from the primary reservoir supply port.
5. With the valve knob pushed in, coat the exhaust port and the plunger stem with a soapy solution. Leakage at the fittings should not exceed a 1-inch (2.5-cm) bubble every three seconds. If it does, replace or repair the valve, following instructions in **Subject 130.**

Parking Brake Hand Valve Removal and Installation

Removal (See Fig. 1)



1. Top-Center Dash Panel
2. Instrument Panel
3. Parking Brake Valve
4. Knob
5. Mounting Screws

Fig. 1, Parking Brake Hand Valve Mounting

WARNING

WARNING: Review the precautions under Safety Precautions, 100 before doing any work on the parking brake valve. Failure to do so could result in personal injury.

1. Park the vehicle on a level surface, apply the parking brakes, chock the tires, and drain the air tanks.
2. Remove the top-center dash panel.
3. Turn the valve knob (Ref. 4) counterclockwise and remove it from the valve stem.
4. Mark the air lines for later reference, then disconnect them from the valve assembly.

NOTE: The primary supply line is green; the secondary supply line is red; the exhaust line is black and 1/2-inch (13-mm) in diameter; the delivery line is black and 3/8-inch (9.6-mm) in diameter.

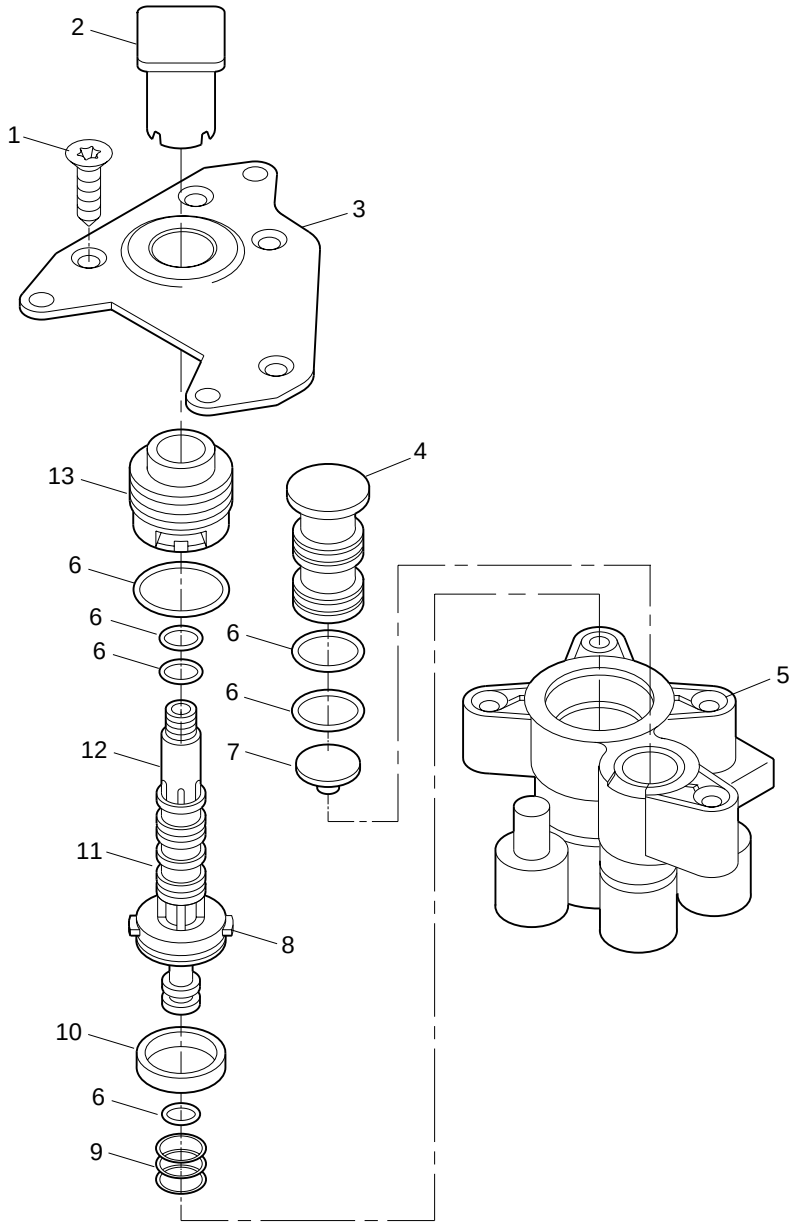
5. Remove the four screws (Ref. 5) that attach the valve to the instrument panel (Ref. 2). Remove the valve (Ref. 3).

Installation

1. Position the valve assembly in the instrument panel. Install the four mounting screws.
2. Connect the air lines to the applicable fittings.
   - 2.1 Tighten the fittings hand tight.
   - 2.2 Using a wrench, tighten the fittings until the connections feel firm.
   - 2.3 Tighten the fittings an additional one-sixth turn.
3. Screw the valve knob onto the valve stem.
4. Leak test the fittings, following the instructions in **Subject 110.**
5. Install the top-center dash panel.

Parking Brake Hand Valve Disassembly and Assembly

Disassembly (See Fig. 1)



1. Screw
2. Valve Knob
3. Cover
4. Check Valve Seat
5. Valve Body
6. O-Ring
7. Check Valve
8. Index Tab
9. Plunger Spring
10. Exhaust Seal
11. Plunger
12. Plunger Stem
13. Guide Spool

Fig. 1, Exploded View

Parking Brake Hand Valve Disassembly and Assembly

1. Remove the valve assembly from the dash, following the instructions in **Subject 120.**
2. Put the valve assembly in a soft-jawed or padded vise.
3. Remove the screws that attach the cover to the body. Remove the cover.
4. Pull the plunger stem and remove the plunger and guide spool from the body.
5. Remove and discard the plunger spring.
6. Using a screwdriver (if needed), carefully remove the check valve seat from the body. Use care not to damage either the check valve seat or the valve body.
7. Remove and discard the check valve seat O-rings.
8. Turn the body upside down and gently tap it on a flat surface to remove the check valve. Discard the check valve.
9. Remove the guide spool from the plunger. Remove and discard the O-ring.
10. Remove and discard the O-rings from the plunger. Also, remove and discard the exhaust seal.

Assembly (See Fig. 1)

1. Clean and dry all the parts.
2. Check all the parts. Replace a part if any wear or damage is found.
3. Lightly grease all the parts—including the new parts from the maintenance kit—with Dow Corning 55 silicone pneumatic grease or equivalent.
4. Position the check valve in its seat in the body with the flat surface of the valve facing up. If needed, reach into the body to make sure that the valve is seated evenly in the bore.
5. Install the O-rings on the check valve seat and install the assembly into the body. Make sure that the check valve seat is even with the valve body surface.
6. Install the plunger spring into the body. Make sure that the spring is upright and seated properly in the body bore.

NOTE: The plunger spring should surround the protrusion or "lip" at the bottom of the body bore.

7. Install the O-rings onto the plunger, then install the plunger into the body.

   For ease of installation, line up the plunger's index tabs with the spaces in the body bore.
8. Install the O-ring on the guide spool. Install the spool over the plunger and into the body. Firmly press the guide spool into position.
9. Install the screws that attach the cover to the body. Tighten the screws 35 lbf·in (400 N·cm).
10. Install the valve in the dash, then leak test it. Follow the instructions in **Subject 120** for installation and **Subject 110** for leak testing.

General Description

The Meritor automatic slack adjuster has two main functions:

- As a lever, it converts the straight-line force of the brake chamber push rod to torque on the brake camshaft. Rotation of the camshaft forces the brake shoes against the brake drum.
- As an automatic adjuster, it automatically maintains brake chamber push rod stroke, which controls lining-to-drum clearance during operation.

With an automatic slack adjuster, brakes adjust automatcially when needed. As long as the push-rod stroke doesn't exceed the desired length, no adjustment takes place. Adjustment is made on the return stroke, as air is released and the forces in the gearset are low. The force to make an adjustment comes directly from the brake shoe return spring and the brake chamber return spring.

Principles of Operation (See Fig. 1)

The externally splined end of the worm fits the internal splines on the actuator. Angled serrations on the spring-held pawl correspond with serrations on the actuator exterior. The serrations are formed to allow free upward movement of the actuator, and to lock in on the actuator serrations on a downward movement. As the brake is applied, the brake chamber push rod, connected to the end of the clevis, moves outward, forcing the slack adjuster arm to turn on the brake camshaft centerline. The actuator rod is connected to the clevis at one end, and to a small piston at the other end.

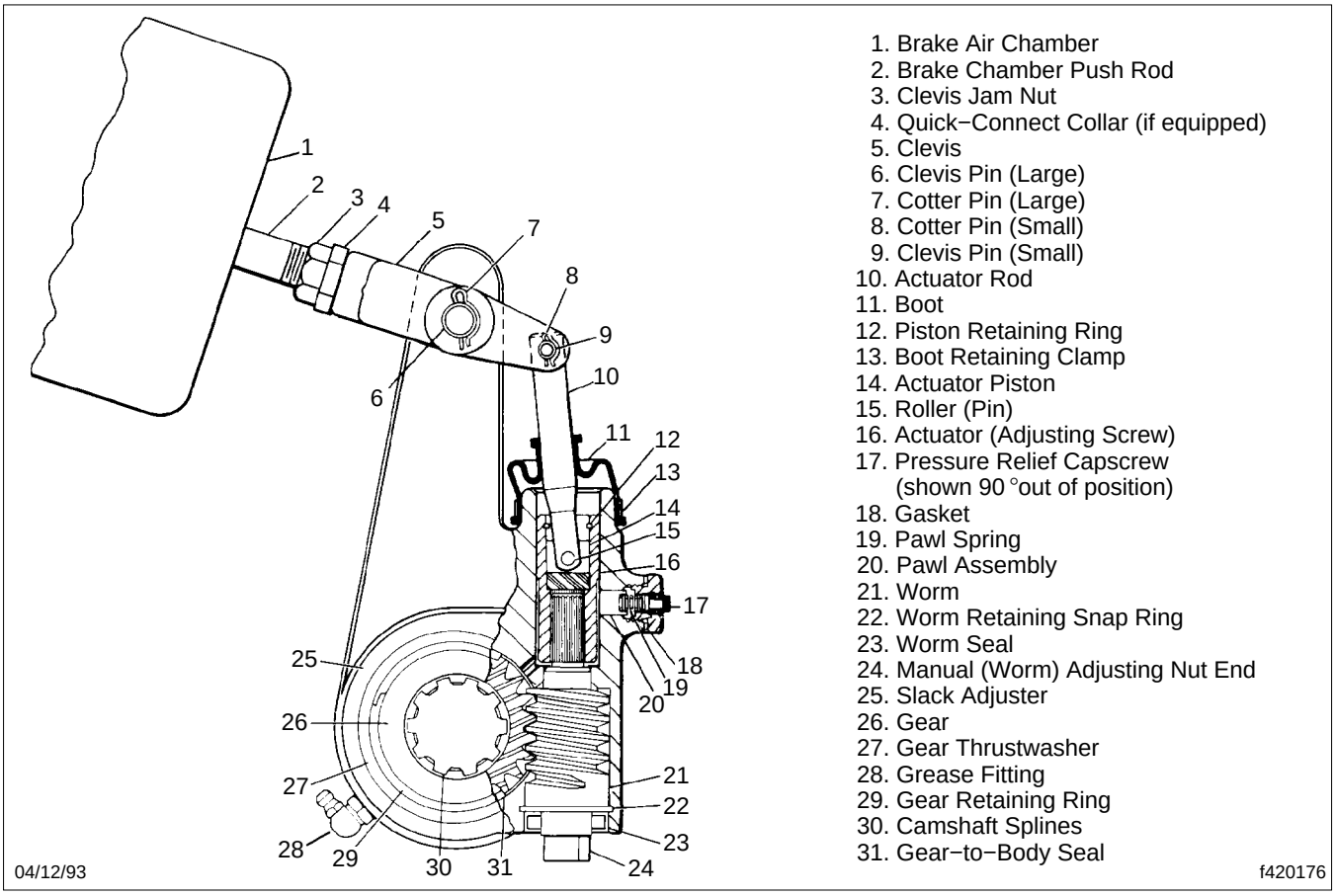
NOTE: The slack adjuster may be equipped with a quick-connect clevis, or a one-piece clevis. See **Fig. 2**.

As the slack adjuster arm moves, the actuator rod is moved upward and outward, pulling the piston (Ref. 14) upward.

When lining wear becomes excessive, the brake chamber push-rod stroke goes beyond the desired length. The piston then makes contact with the retaining ring (Ref. 12) and pulls up the actuator. As the actuator moves upward and reaches a preset distance, it slides over one serration on the pawl.

When the push rod moves back toward the brake chamber, the actuator is forced downward. Because the serrations in the pawl and actuator are now locked in, the actuator, following the curve of its serrations as it moves downward, turns slightly. This action causes the worm to turn, advancing the gear (Ref. 26) and the camshaft to automatically adjust the brake.

General Description and Principles of Operation



1. Brake Air Chamber
2. Brake Chamber Push Rod
3. Clevis Jam Nut
4. Quick−Connect Collar (if equipped)
5. Clevis
6. Clevis Pin (Large)
7. Cotter Pin (Large)
8. Cotter Pin (Small)
9. Clevis Pin (Small)
10. Actuator Rod
11. Boot
12. Piston Retaining Ring
13. Boot Retaining Clamp
14. Actuator Piston
15. Roller (Pin)
16. Actuator (Adjusting Screw)
17. Pressure Relief Capscrew (shown 90 °out of position)
18. Gasket
19. Pawl Spring
20. Pawl Assembly
21. Worm
22. Worm Retaining Snap Ring
23. Worm Seal
24. Manual (Worm) Adjusting Nut End
25. Slack Adjuster
26. Gear
27. Gear Thrustwasher
28. Grease Fitting
29. Gear Retaining Ring
30. Camshaft Splines
31. Gear−to−Body Seal

Fig. 1, Parts of the Slack Adjuster

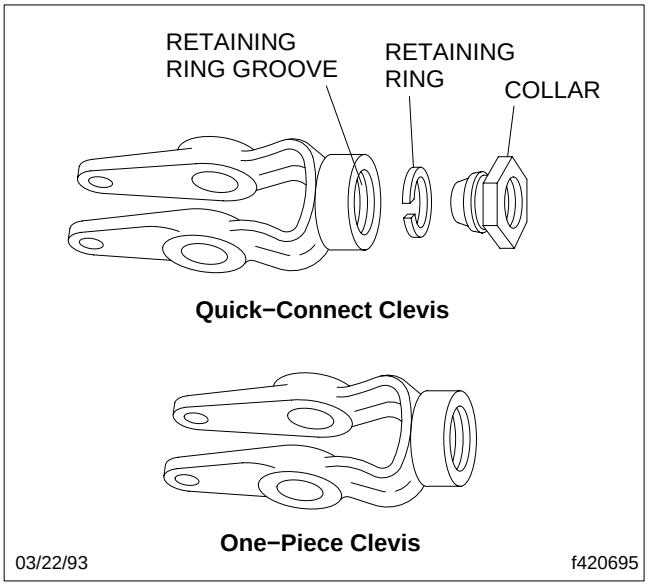


Fig. 2, Clevis Options

Slack Adjuster Removal and Installation

Removal

1. With the vehicle parked on a level surface, set the parking brakes, and shut down the engine. Chock the tires.

⚠ WARNING

Manually cage each parking brake chamber power spring in the release (no application) position before continuing. Loss of brake chamber air pressure will cause sudden application of the parking brakes, which could result in personal injury.

2. If the rear slack adjusters will be removed, release the parking brakes, then cage the power spring of the parking brake chamber.
3. Remove the retainer clips from the large and small clevis pins. Remove the clevis pins. See **Fig. 1**.

⚠ CAUTION

Disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.

4. Using a screwdriver or an equivalent tool, pry the pawl button out about 1/32 inch (0.8 mm). See **Fig. 2**.

   Wedge the tool in place. Pull-pawls are spring-loaded; when the tool is removed, the pull-pawl will engage the teeth automatically.
5. Using a wrench, manually turn the square adjusting nut clockwise to move the slack adjuster away from the clevis. See **Fig. 3**.
6. Remove the snap ring, washer(s), and seal (if equipped) that secure the slack adjuster in place on the brake camshaft; save them for later installation.
7. Remove the slack adjuster from the camshaft.
8. Note the location and number of any remaining spacing washers on the camshaft. Remove the spacers and seal (LX500 and MX500 series only), and save them for later installation.

Installation

NOTE: For brake chambers that have pushrods with threaded clevises, measure the pushrod length before installing the new slack adjuster. With the brakes fully released, and no air pressure to the chamber, check the dimension between the chamber face and the centerline of the 1/2 inch clevis pin hole. It should be 2.25 inches (57 mm) for long stroke chambers, and 2.75 inches (70 mm) for standard stroke chambers.

1. Inspect the parts and prepare the slack adjuster for installation.
2. Check the brake camshaft splines for wear or corrosion.

IMPORTANT: The following lubricants provide corrosion protection. Do not mix them with other types of lubricants.

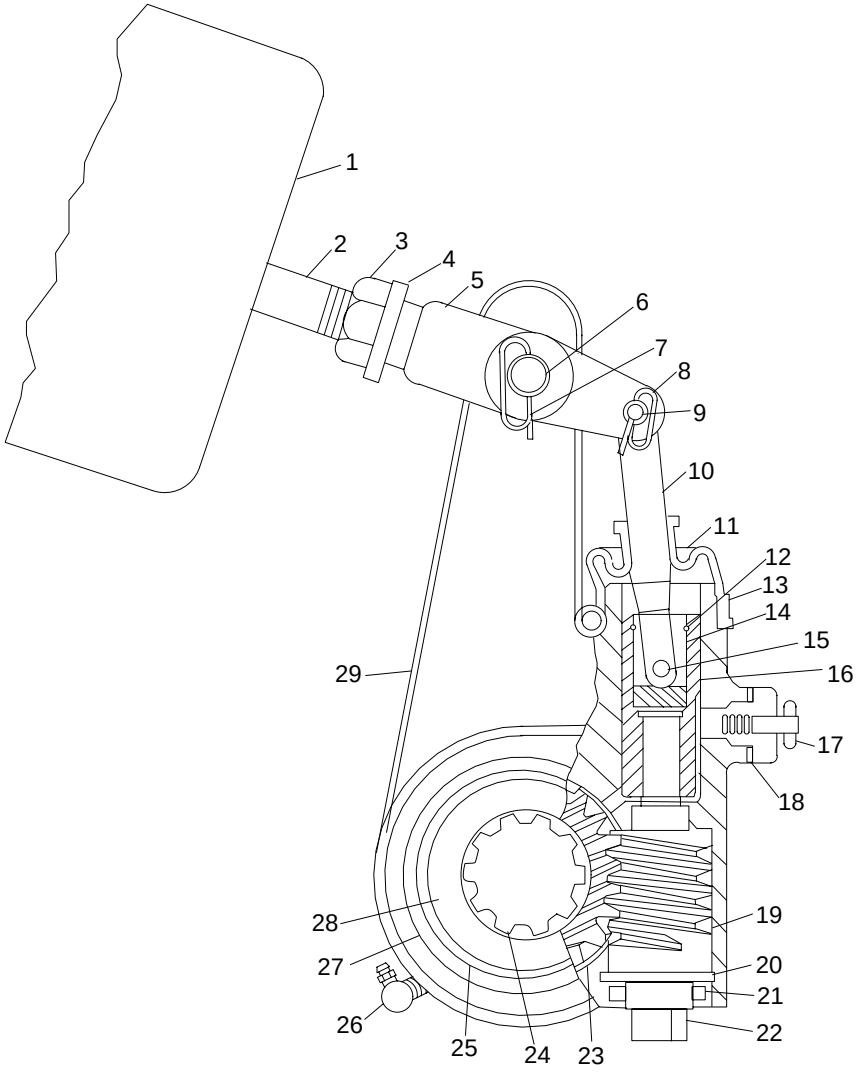
3. Coat the camshaft splines and the splines of the slack adjuster gear with Meritor 0-637, Meritor 0-695 (LX500 and MX500 only), Southwest SA 8249496, or an equivalent.
4. Apply the service brake several times. Make sure the return spring retracts the pushrod quickly and completely. Replace the return spring or brake chamber, if needed.
5. Slide the spacing washer(s) on the camshaft.

   On LX500 and MX500, install the slack adjuster seal with the lip facing the brake spider.
6. If reinstalling the same slack adjuster:
   - 6.1 Slide the slack adjuster on the camshaft, with the actuator rod on the side opposite the brake chamber.
   - 6.2 On LX500 and MX500, install the orange slack adjuster seal on the camshaft. The lip on the seal must face the snap ring.
   - 6.3 Install the outer washer(s) and snap ring on the camshaft.

⚠ CAUTION

Disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could

Slack Adjuster Removal and Installation



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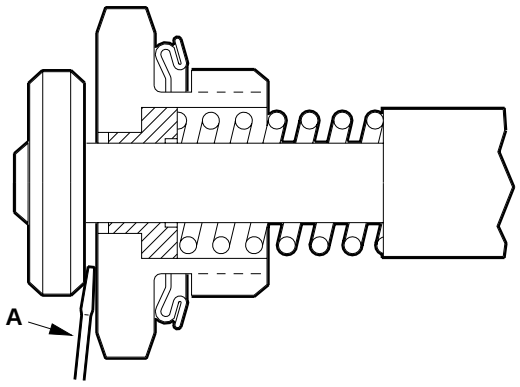
1. Brake Air Chamber
2. Brake Chamber Pushrod
3. Clevis Jam Nut
4. Quick-Connect Collar (if equipped)
5. Clevis
6. Clevis Pin (large)
7. Retainer Clip (large)
8. Retainer Clip (small)
9. Clevis Pin (small)
10. Actuator Rod
11. Boot
12. Piston Retaining Ring
13. Boot Retaining Clamp
14. Actuator Piston
15. Roller (Pin)
16. Actuator (Adjusting Sleeve)
17. Pull-Pawl Assembly (shown 90 degrees out of position)
18. Gasket
19. Worm
20. Worm Retaining Snap Ring
21. Worm Seal
22. Manual Adjusting Nut
23. Gear-to-Body Seal
24. Camshaft Splines
25. Gear Retaining Ring
26. Grease Fitting (if equipped)
27. Gear Thrustwasher
28. Gear
29. Slack Adjuster Housing

Fig. 1, Meritor Automatic Slack Adjuster



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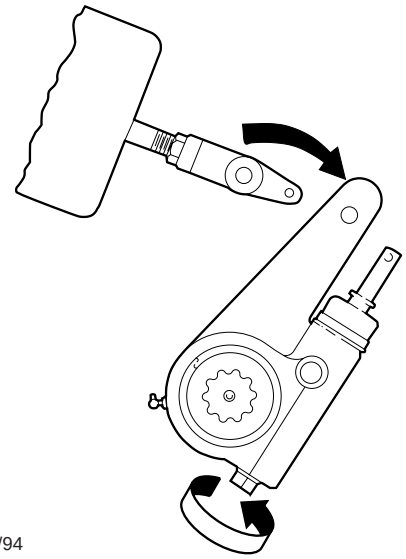
A. Insert a screwdriver here to pry the pull-pawl button out about 1/32 inch (0.8 mm).

Fig. 2, Pull-Pawl Assembly



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Turn the manual adjusting nut clockwise.

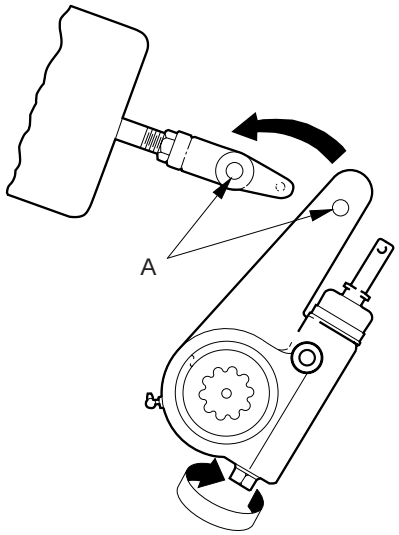
Fig. 3, Slack Adjuster Removal

damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.

6.4 Using a screwdriver or an equivalent tool, pry the pawl button out at least 1/32 inch (0.8 mm). See **Fig. 2**. Wedge the tool in place.

IMPORTANT: Never pull the pushrod out to meet the slack adjuster or push the slack adjuster into position. Always turn the adjusting nut for positioning.

6.5 Using a wrench, turn the manual adjusting nut counterclockwise to align the hole in the slack adjuster housing with the large hole in the clevis. See **Fig. 4**.



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A. Turning the adjusting nut counterclockwise, align the large holes in the slack adjuster and clevis.

Fig. 4, Slack Adjuster Installation

7. If installing a new slack adjuster:

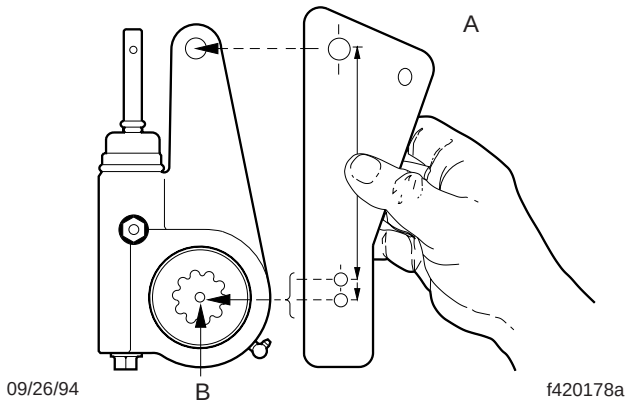
7.1 Using an installation template, measure the old and new slack adjusters. Measure from the center of the large clevis-pin hole to the center of the camshaft opening. See **Fig. 5**.

Make sure the old and new slack adjusters are the same length.

7.2 Slide the slack adjuster on the camshaft, with the actuator rod on the side opposite the brake chamber.

7.3 On LX500 and MX500 series, install the orange slack adjuster seal on the camshaft. The lip on the seal must face the snap ring.

Slack Adjuster Removal and Installation



A. Using a template, measure the slack adjuster arm length.
B. Camshaft Center

Fig. 5, Slack Adjuster Measurement

7.4 Install the outer washer(s) and snap ring on the camshaft.

7.5 Using a dial indicator, measure the in-and-out (axial) end play of the camshaft. If necessary, add the appropriate number of spacing washers to achieve the correct axial end play.

- For all Cam-Master brakes, except LX500 and MX500 series, there should be no more than 0.060 inch (1.52 mm) movement.
- For LX500 and MX500, the axial end play should be no more than 0.020 inch (0.51 mm).

⚠ CAUTION

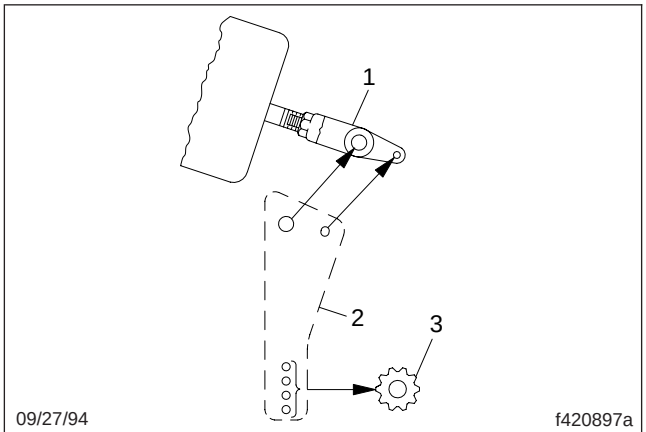
Disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.

7.6 Using a screwdriver or an equivalent tool, pry the pawl button out about 1/32 inch (0.8 mm). See **Fig. 2**. Wedge the tool in place.

IMPORTANT: Never pull the pushrod out to meet the slack adjuster or push the slack adjuster into position. Always turn the adjusting nut for positioning.

7.7 Using a wrench, turn the manual adjusting nut counterclockwise to align the hole in the slack adjuster housing with the large hole in the clevis. See **Fig. 4**.

7.8 With the brakes fully released, place the installation template over the clevis and camshaft end. See **Fig. 6**.



Place the template over the clevis and camshaft end.
1. Clevis
2. Template
3. Camshaft End

Fig. 6, Template Placement

7.9 Temporarily insert the large clevis pin through the large holes in the template and the clevis.

7.10 Select the hole in the lower part of the template that matches the length of the slack adjuster. Hold the template in place on the center of the camshaft with a pencil.

7.11 Make sure the small hole in the clevis is completely visible through the 1/8-inch hole at the top of the template.

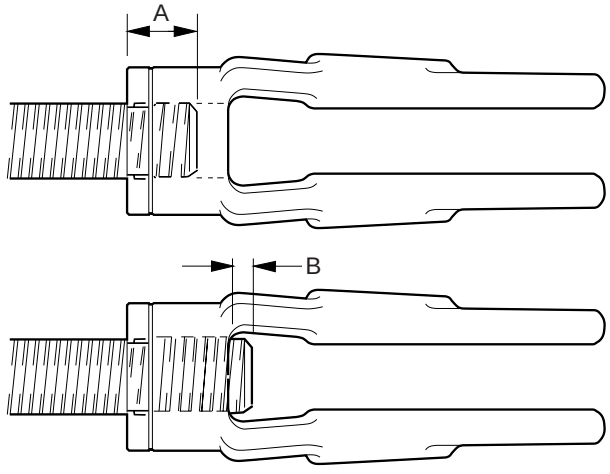
If it is not, loosen the clevis jam nut, and turn the clevis adjusting nut to adjust the position of the clevis on the pushrod until the small clevis hole is completely visible.

IMPORTANT: The pushrod must be installed in the clevis at least 1/2 inch (13 mm) and not extend beyond it more than 1/8 inch (3 mm).

7.12 Make sure there is at least 1/2 inch (13 mm) of thread engagement between the clevis and the pushrod. Also, check that the pushrod does not extend through the clevis more than 1/8 inch (3 mm). See **Fig. 7**.

If necessary, cut the pushrod, install a new pushrod, or install a new brake chamber.

7.13 Temporarily insert the small clevis pin through the template, clevis, and actuator rod to make sure the alignment is correct. Repeat the adjustment, if necessary. When the alignment is correct, remove both clevis pins and the template.



A. Minimum 1/2 inch (13 mm).
B. Maximum 1/8 inch (3 mm).

Fig. 7, Checking Pushrod Engagement

8. Apply antiseize compound to the two clevis pins.
9. Insert both clevis pins with their pinheads on the inboard side of the slack adjuster. Be sure the small clevis pin is inserted through the hole in the actuator rod. Install new retaining clips to secure the clevis pins.
10. If it was loosened, tighten the clevis jam nut to the following values.
    - For 1/2–20 threads, tighten the clevis jam nut 20 to 30 lbf·ft (27 to 41 N·m).
    - For 5/8–18 threads, tighten the jam nut 25 to 50 lbf·ft (34 to 68 N·m).
11. Lube the slack adjuster through the grease fitting until the lubricant is forced out through the pawl slot or through the gear splines around the inboard snap ring.
12. Adjust the brakes. See "Brake Adjustment" below.

Brake Adjustment

NOTE: A properly working self-adjusting slack adjuster does not require manual adjustment while in service.

⚠ WARNING

Manually adjusting an automatic slack adjuster to bring the pushrod stroke within legal limits is likely masking a mechanical problem. Adjustment is not repairing. Before adjusting an automatic slack adjuster, troubleshoot the foundation brake system and inspect it for worn or damaged components. Improperly maintaining the vehicle braking system may lead to brake failure, resulting in property damage, personal injury, or death.

1. If a rear axle slack adjuster was installed, manually uncage the parking brake.
2. Fully release the brakes (the air chamber pushrod must be fully retracted).

⚠ CAUTION

Before turning the manual adjusting nut on the slack adjuster, disengage the pull-pawl. Failure to do so could damage the pull-pawl teeth. A damaged pull-pawl will not allow the slack adjuster to automatically adjust the brake clearance.

3. Using a screwdriver, pry the pull-pawl button out at least 1/32 inch (0.8 mm) to disengage the pull-pawl teeth from the slack adjuster actuator. See **Fig. 2**. Wedge the screwdriver in place. The pull-pawl will need to be disengaged until the brake adjustment is complete.

Slack Adjuster Removal and Installation

NOTE: When the screwdriver is removed, the pull-pawl will engage automatically.

4. Using the manual adjusting nut on the slack adjuster, adjust the brake chamber stroke (coarse adjustment), as follows. See **Fig. 8**.

   4.1 Turn the adjusting nut counterclockwise until the brake linings touch the brake drum.

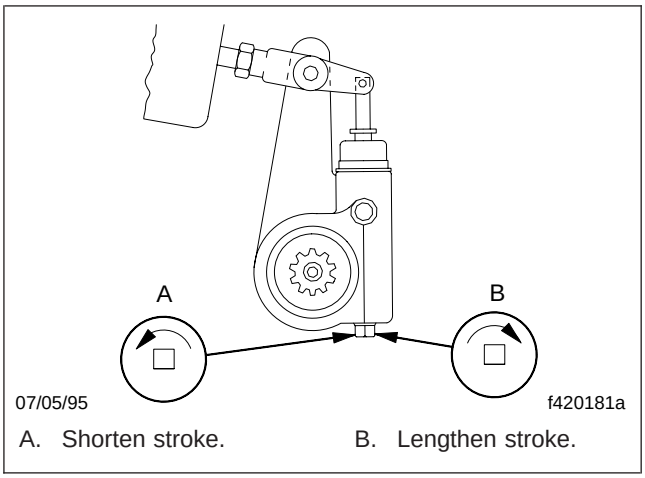


Fig. 8, Adjusting the Stroke

   4.2 Then, turn the adjusting nut clockwise 1/2 turn.

5. Measure and adjust the free-stroke, as follows.

   5.1 With the brakes released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. Record this measurement as dimension A. See **Fig. 9**.

   5.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum.

   Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. Record this measurement as dimension B. See **Fig. 9**.

   5.3 Subtract dimension A from dimension B. The difference between these measurements is the free-stroke.

   5.4 The free-stroke for a new brake installation should be 5/8 to 3/4 inch (16 to 19 mm). For a brake that is in service, the free-stroke should be 1/2 to 5/8 inch (13 to 16 mm). If it is not, turn the adjusting nut 1/8 turn, as shown in **Fig. 8**. Then, measure the free-stroke again; readjust it until it is correct.

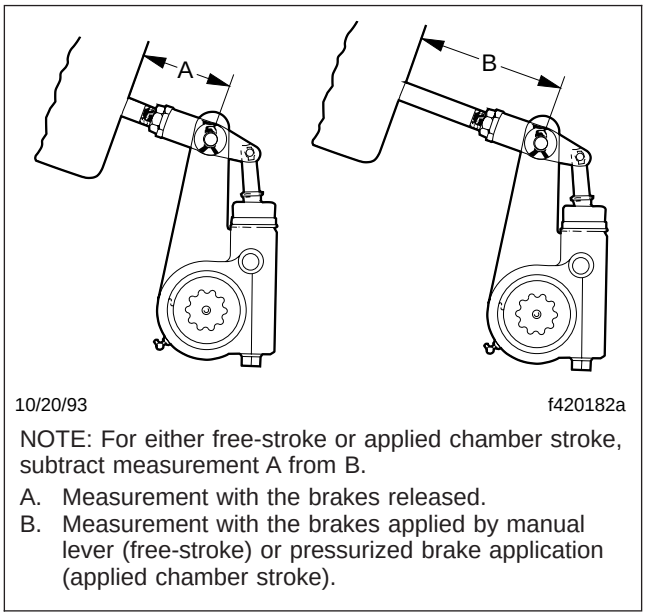


Fig. 9, Measuring the Stroke

6. Measure and adjust the applied chamber stroke (fine adjustment), as follows.

   6.1 If system pressure is not already at 100 psi (689 kPa), start the engine and build air pressure, then shut down the engine.

   6.2 With the brakes released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. Record this measurement as dimension A. See **Fig. 9**.

   6.3 Fully apply the brakes. Then, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 9**, Ref. B. Record this measurement as dimension B.

   6.4 Subtract dimension A from dimension B. The difference between these measurements is the true applied chamber stroke.

CAUTION

The adjusted applied chamber stroke should be as short as possible but not so short that the free-stroke is too short and the linings drag. If the linings drag, the brakes could be damaged.

6.5 The applied chamber stroke must not exceed the maximum value specified in **Table 1**.

If the applied chamber stroke is incorrect, turn the adjusting nut 1/8-turn counterclockwise to shorten the stroke, or 1/8-turn clockwise to lengthen it. See **Fig. 8**. Measure the applied stroke again and readjust it until it is correct.

6.6 If the slack adjuster is not maintaining the correct applied chamber stroke, check the condition of the foundation brakes. See **Section 42.27, Subject 140**.

7. Remove the screwdriver from the pull-pawl assembly. This will engage the pull-pawl with the actuator.

WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

8. In a safe area, check for proper brake operation before you put the vehicle in service, as follows.

8.1 Apply and release the brakes several times to check for air leaks and proper operation of the slack adjusters.

8.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.

8.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than others show a lack of braking effort on those wheels.

Brake Chamber Stroke Specifications			
Chamber Type (Size)	Maximum Applied Stroke*: inch (mm)	Free-Stroke: inch (mm)	
		New Brake Installation	In-Service Brake
Long Stroke†			
16 and 20	2-1/2 (64)	5/8–3/4 (16–19)	1/2–5/8 (13–16)
24 and 30	3 (76)		

* Specifications are relative to a brake application with 80–90 psi (550–620 kPa) air pressure in the brake chambers.

† Long stroke design is indicated by a tag, or embossing, on the brake chamber.

Table 1, Brake Chamber Stroke Specifications

Lubricant Specifications	
Lubricant Type	**Temperature**
Meritor 0-616-A Texaco Thermotex EP No. 1 Shell Darina No. 1 Texaco Hytherm EP No. 1 Aralub 3837 Tribolube 12, Grade 1 Meritor 0-692 Amoco Super Permalube No. 2 Citco Premium Lithium EP No. 2 Exxon Ronex MP No. 2 Kendall L-427 Super Blu No. 2 Mobilith AW No. 1 Sohio Factran EP No. 2	Above -40°F (-40°C)
Meritor 0-645 Mobil 28	Below -40°F (-40°C)

Table 1, Lubricant Specifications

Maximum Chamber Stroke	
Chamber Size	**Cam Brake**
9	Less than 1-3/8 inches (35 mm)
12	Less than 1-3/8 inches (35 mm)
16	Less than 1-3/4 inches (44 mm)
20	Less than 1-3/4 inches (44 mm)
24	Less than 1-3/4 inches (44 mm)
24 *	Less than 2 inches (51 mm)
30	Less than 2 inches (51 mm)
36	Less than 2-1/4 inches (57 mm)

* Long stroke.

Table 2, Maximum Adjusted Brake Chamber Strokes

Slack Adjuster Arm Lengths	
Slack Adjuster Arm Length inches (mm)	**Chamber Size**
5 (127)	9, 12, 16, 20, 24, 30
5-1/2 (140)	9, 12, 16, 20, 24, 30, 36
6 (152)	24, 30, 36
6-1/2 (165)	30, 36

Table 3, Slack Adjuster Arm Lengths

General Information

The R–14 relay valve (**Fig. 1**) is a control relay station in the air brake system to speed the application and release of the brakes. Mounted at the rear of the vehicle, it is operated by remote control and gives the same amount of air pressure to the brake chambers as it receives from the service brake foot valve or other source.

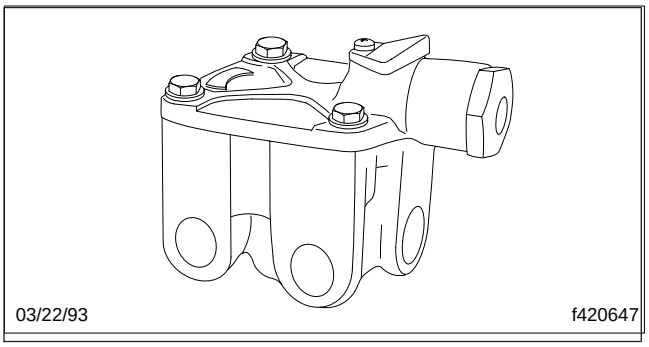


Fig. 1, R-14 Relay Valve

The R–14 valve is piston operated and has an insert-type inlet and exhaust valve that can be serviced without removing the lines from the valve body.

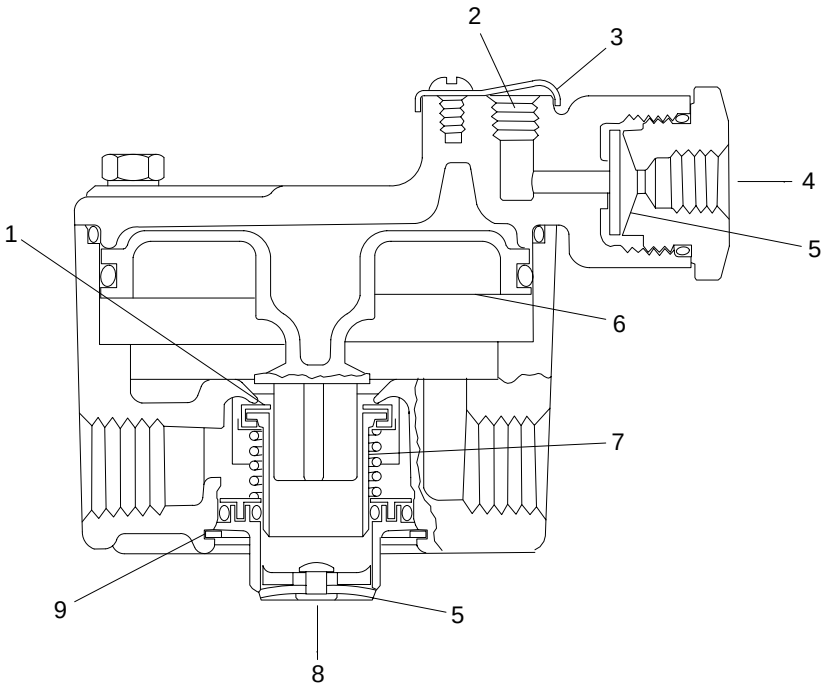
Principles of Operation

ANTI-COMPOUNDING (SERVICE AND PARK APPLICATION)

An "anti-compound" feature allows the R–14 to be used as either a service or spring brake relay valve. Anti-compounding does not allow *simultaneous* service and parking brake application. An exhaust cover is installed that protects the 1/8-inch balance port when the R–14 anti-compound feature is not in use. See **Fig. 2.**

In applications where the R–14 is used to control spring brake chambers, the anti-compound feature may be utilized. To utilize, the exhaust cover of the quick release portion of the R–14 is removed and a line is installed, which is connected to the delivery of the service brake valve or relay valve. With no compressed air at the service port of the R–14, the parking brakes apply. When service brake application is made, air from the service brake valve enters the exhaust port of the quick release of the R–14 and moves the diaphragm, blocking the service port. Air then proceeds into the cavity above the relay piston, forces the piston down, closing the exhaust and opening the inlet to deliver air to the spring brake cavity.

General Information and Principles of Operation



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1. Exhaust Seat
2. Balance/Quick Exhaust (anti-compound)
3. Exhaust Cover
4. Service Port
5. Diaphragm
6. Relay Piston
7. Inlet/Exhaust Valve
8. Exhaust Port
9. Retaining Ring

Fig. 2, R-14 Relay Valve

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

A. Chock the tires and stop the engine before working under the vehicle. Releasing air from the system may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.

B. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.

C. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.

D. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

Operation Test

IMPORTANT: Before working on or around air brake systems and components, refer to **"Safety Precautions, 100."**

1. Start the vehicle and build the brake system to cut-out pressure, 120 psi (827 kPa).
2. Make several service brake applications and check for prompt application and release of the brakes.
3. If brake response is slow, troubleshoot the brake system. For instructions, refer to the brake system troubleshooting section. If the R-14 valve is malfunctioning, repair or replace it.

Leakage Test

IMPORTANT: Before working on or around air brake systems and components, refer to **"Safety Precautions, 100."**

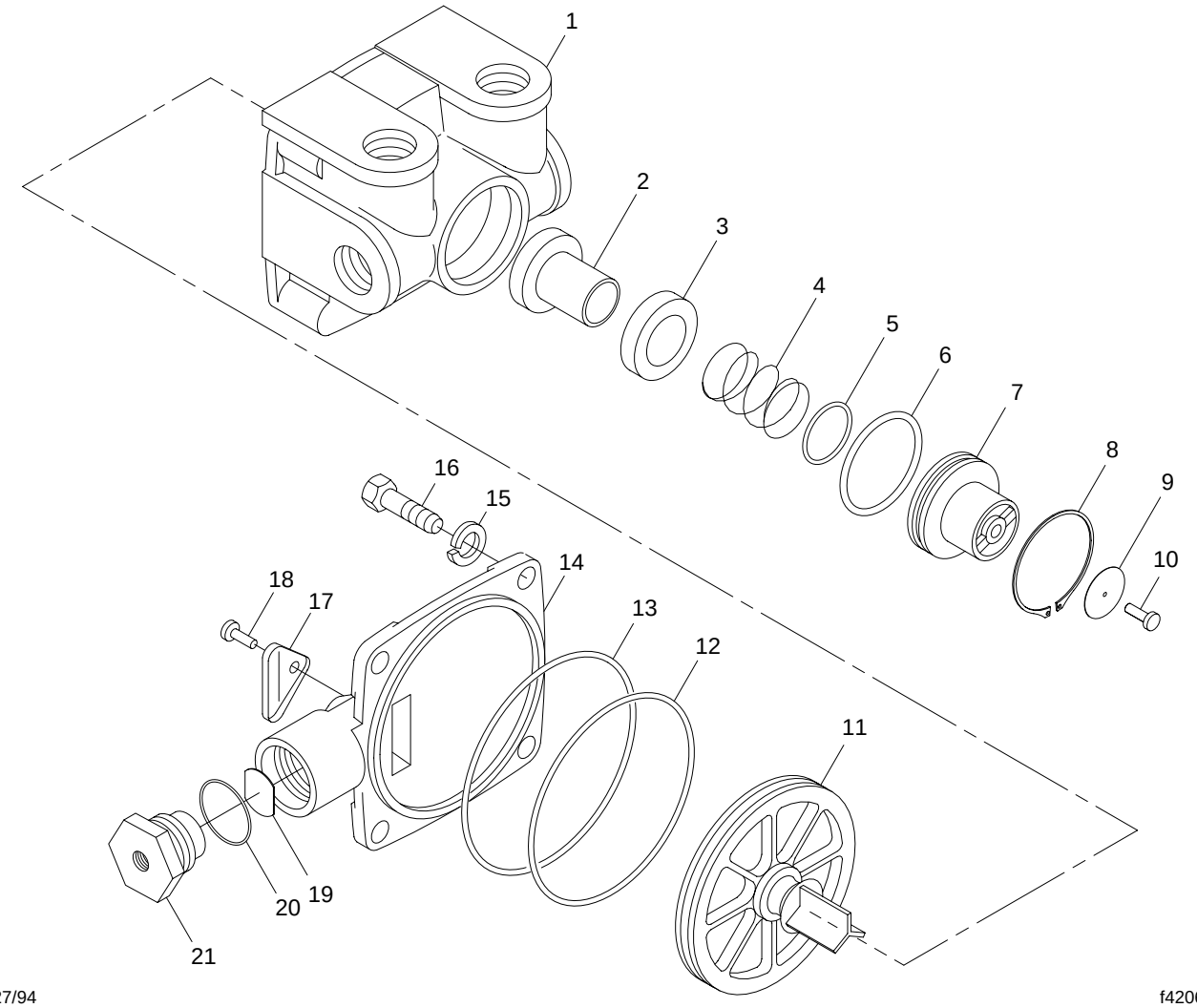
1. Start the vehicle and build the brake system to cut-out pressure, 120 psi (827 kPa).
2. With the service brakes released, apply a soap solution to the outside of the valve—where the cover joins the body—to check for O-ring leakage. No leakage is permitted. See **Fig. 1**, Refs. 1 and 14.
3. While holding a full service brake application, apply a soap solution to the exhaust port. Leakage at the exhaust port should not exceed a 1-inch (2.5-cm) bubble in three seconds.

NOTE: If the anti-compound feature is in use, the line attached to the balance port must be disconnected to perform this test.

4. If the R-14 is used to control the spring brakes, release the park control, apply a soap solution to the balance port. Leakage at the balance port should not exceed a 1-inch (2.5-cm) bubble in three seconds.

IMPORTANT: If the R-14 valve does not function as described in the above test, or if leakage is excessive, replace it. For instructions, refer to **Subject 120**.

Operation and Leakage Tests



1. Body
2. Inlet/Exhaust Valve
3. Valve Retainer
4. Valve Spring
5. O-Ring
6. O-Ring
7. Exhaust Cover
8. Retainer Ring
9. Diaphragm
10. Rivet
11. Relay Piston
12. O-Ring
13. O-Ring
14. Valve Cover
15. Lockwasher (4 qty)
16. Capscrew (4 qty)
17. Exhaust Cover
18. Screw, Phillips #10-24
19. Diaphragm
20. O-Ring
21. Cap Nut

Fig. 1

Removal

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100**.

1. Chock the tires, and open the air reservoir drain cocks to bleed air from the system.
2. Remove all air hoses from the R-14 valve (see **Fig. 1**). Cap the hoses and mark them for reassembly.
3. Remove the valve mounting bolts. Remove the valve.

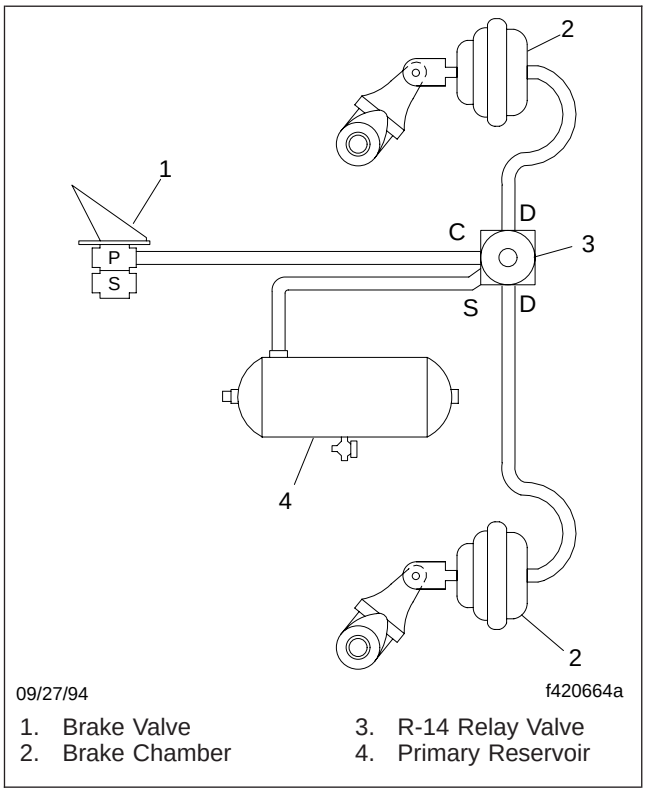
Installation

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100**.

1. Attach the R-14 valve to the vehicle, using the bolts, washers, and nuts. Tighten the nuts 132 to 180 lbf·in (1500 to 2040 N·cm).
2. Remove the caps from the air lines, then depending on the type of air hose, do one of the following:

   Nylon Tubing: Connect the hose fittings to the valve ports, and tighten the nuts finger-tight. Using a wrench, tighten the nuts at least two turns, or until no threads show on the fittings.

   Wire Braid Hoses: Connect the hose fittings to the valve ports, and hand-tighten the nuts. Using a wrench, tighten the nuts until resistance is felt. Tighten one-sixth turn more. Do not overtighten.
3. Close the air reservoir drain cocks. Start the vehicle engine to pressurize the air system.
4. Test the R-14 valve following the instructions in **Subject 110**.



1. Brake Valve
2. Brake Chamber
3. R-14 Relay Valve
4. Primary Reservoir

Fig. 1, Plumbing Diagram

Disassembly, Cleaning and Inspection, and Assembly

Disassembly

IMPORTANT: Before working on or around air brake systems and components, refer to **"Safety Precautions, 100."**

1. Remove the valve from the vehicle. For instructions, refer to **Subject 120**.

NOTE: Prior to disassembly, draw an alignment mark across the valve cover and body, for reassembly alignment. See **Fig. 1**.

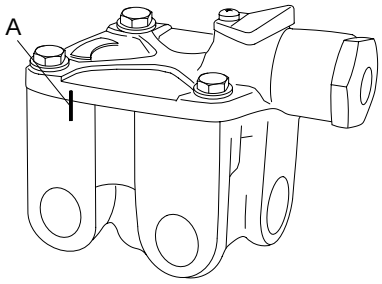
2. Disassemble the valve.
   - 2.1 Referring to **Fig. 2**, remove the four cover capscrews (Ref. 16) and lockwashers (Ref. 15).
   - 2.2 Remove the valve cover (Ref. 14), and O-ring (Ref. 13).
   - 2.3 Remove the relay piston (Ref. 11), and the O-ring (Ref. 12).
   - 2.4 While depressing the exhaust cover (Ref. 7), remove the retainer ring (Ref. 8); slowly remove the exhaust cover and the valve spring (Ref. 4). Remove the O-rings (Refs. 5 and 6) from the exhaust cover.
   - 2.5 Remove the inlet/exhaust valve (Ref. 2). Remove the valve retainer (Ref. 3) from the inlet/exhaust valve.
   - 2.6 Remove the Phillips head screw (Ref. 18) and the exhaust cover (Ref. 17).
   - 2.7 Remove the service port cap nut (Ref. 21) and the O-ring (Ref. 20).
   - 2.8 Remove the diaphragm (Ref. 19) located inside the service port.

Cleaning and Inspection

IMPORTANT: Before working on or around air brake systems and components, refer to **"Safety Precautions, 100."**

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.



A. Mark the valve housing for reassembly alignment.

Fig. 1, Valve Marked for Reassembly

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

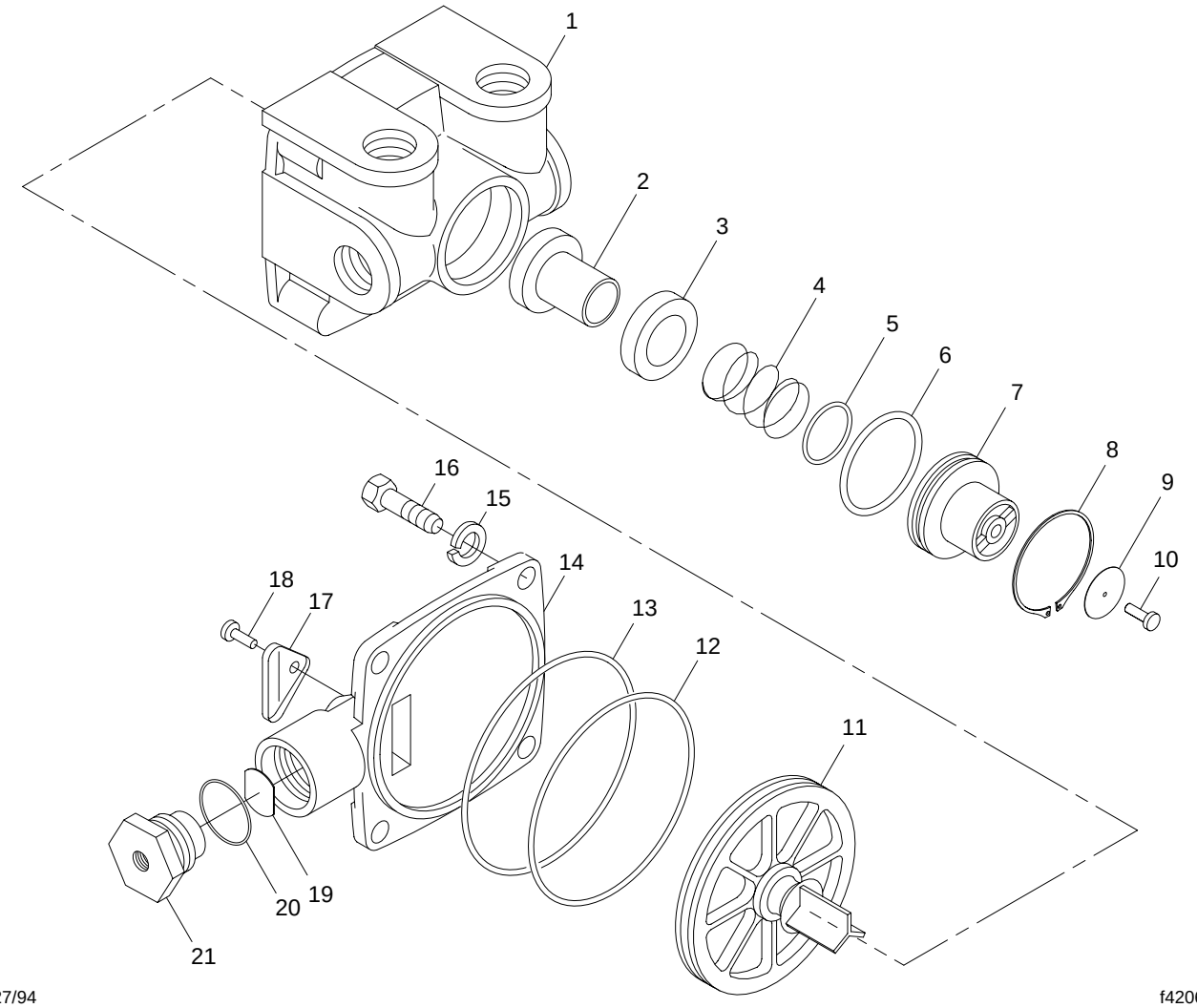
1. Wash all metal parts of the R-14 valve in cleaning solvent. Dry the metal parts of the disassembled valve with compressed air.
2. Wipe all rubber parts clean with a clean cloth. Examine all rubber parts for cracks, tears, or other deterioration. If any rubber parts are worn, cracked, torn or otherwise damaged, replace them with new parts.
3. Examine all metal parts for wear, cracks, or other damage. If any metal parts are worn, cracked or otherwise damaged, replace them with new parts.
4. Check the springs for distortion and corrosion. If the springs are distorted or corroded, replace them.

Assembly

IMPORTANT: Before working on or around air brake systems and components, refer to **"Safety Precautions, 100."**

1. Lubricate the O-rings and all sliding parts with Dow Corning 55-M pneumatic grease or equivalent. Assemble the valve (see **Fig. 2**).
   - 1.1 Install the O-ring (Ref. 12) on the relay piston.
   - 1.2 Install the inner and outer O-rings (Refs. 5 and 6) on the exhaust cover.

Disassembly, Cleaning and Inspection, and Assembly



1. Body
2. Inlet/Exhaust Valve
3. Valve Retainer
4. Valve Spring
5. O-Ring
6. O-Ring
7. Exhaust Cover
8. Retainer Ring
9. Diaphragm
10. Rivet
11. Relay Piston
12. O-Ring
13. O-Ring
14. Valve Cover
15. Lockwasher (4 qty)
16. Capscrew (4 qty)
17. Exhaust Cover
18. Screw, Phillips #10-24
19. Diaphragm
20. O-Ring
21. Cap Nut

Fig. 2

1.3 Install O-ring (Ref. 13) on the valve cover.

1.4 Install the relay piston in the body, taking care not to damage the piston O-ring.

1.5 Noting the reference mark made during disassembly, secure the valve cover with four capscrews and lockwashers. Torque the capscrews 80 to 120 lbf·in (900 to 1360 N·cm).

1.6 Install the valve retainer on the inlet/ exhaust valve assembly. Install the

inlet/exhaust valve assembly in the body.

1.7 Install the exhaust cover. While depressing the exhaust cover, install the retaining ring, making sure the retaining ring is completely seated in the groove.

1.8 Place the diaphragm in the service port making sure it is positioned between the guide ribs. Install the service port capnut and O-ring, then torque to 150 lbf·in (1700 N·cm).

1.9 Install the exhaust cover (Ref. 17), using the screw (Ref. 18). Torque to 25 lbf·in (280 N·cm).

2. Install the R-14 relay valve on the vehicle following the instructions in **Subject 120.**

3. Test the R-14 valve following the instructions in **Subject 110.**

Specifications

Description	Torque lbf·in (N·cm)
Valve Cover Capscrews	80–120 (900–1360)
Valve Mounting Capscrews	132–180 (1500–2040)
Service Port Capnut	150 (1700)
Phillips Screw, # 10-24	25 (280)

Table 1, Torque Values

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: On MGM "TR" Series chambers, the parking/emergency brake section is factory sealed (no clamp ring) and is a *non-serviceable* unit. On "E" Series chambers, the parking/emergency brake section is attached with a clamp ring. *Do not ever perform any service on this clamp ring.*

General Information

MGM "E" and "TR" Series tandem cam brake chambers consist of a service brake section and a parking/emergency spring brake section. See **Fig. 2** and **Fig. 3**. The service brake section is the smaller section near the clevis assembly.

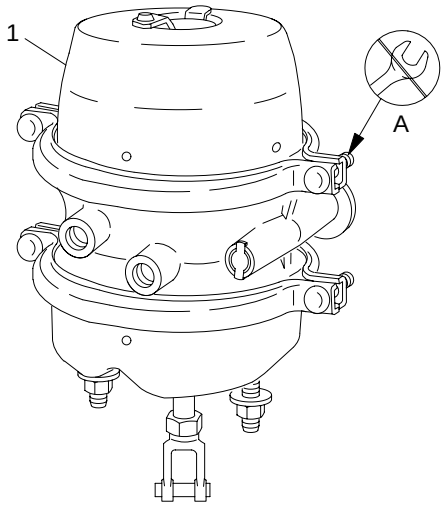
In the service brake section, the flange case and non-pressure chamber contain a service return spring, piston rod assembly, and service brake diaphragm.

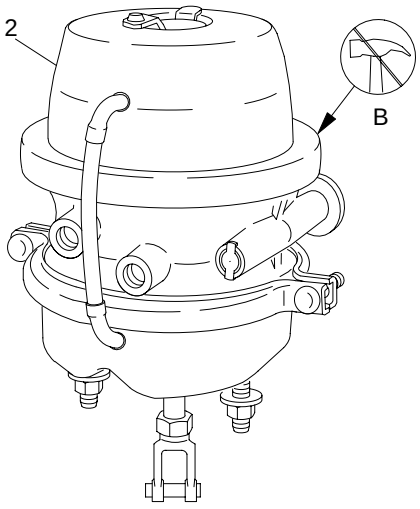
In the parking/emergency brake section, the flange case and the head contain a return spring, a push rod assembly, a parking (spring) brake diaphragm, a piston, a power spring, and a detachable release bolt.

All MGM brake chambers are mounted to the frame using prevailing torque locknuts and hardened flatwashers.

MGM "E" and "TR" Series chambers may be equipped with an external breather tube that protects the parking brake chamber from contaminants. These chambers are called Model "E-T" or "TR-T" chambers. See **Fig. 3.**

Periodic maintenance of the brake chambers is required. Also, whenever the service brake chamber is disassembled (*do not attempt to disassemble the parking brake chamber*), the parts should be inspected for damage. For maintenance schedules and procedures, and for inspection of brake chamber parts, refer to the vehicle maintenance manual.





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A. Do not remove this clamp ring.

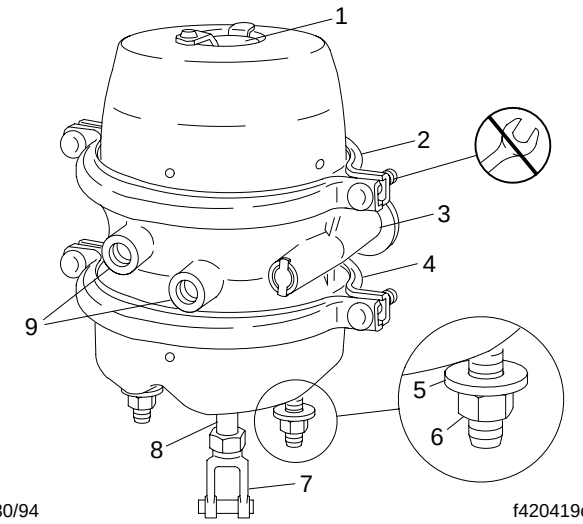
1. Model E (E Series) Brake Chamber

B. Do not remove the factory-sealed clamp ring.

2. Model TR-T (TR Series) Brake Chamber

Fig. 1

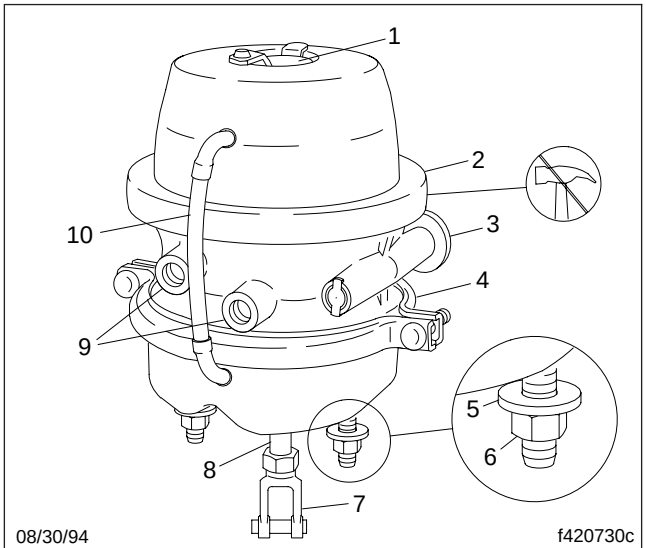
General Information and Principles of Operation



Do not remove the parking brake clamp ring.

1. End Cover Cap
2. Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports

Fig. 2, Model E (E Series) Brake Chamber



Do not remove the factory-sealed clamp ring.

1. End Cover Cap
2. Factory Sealed Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports
10. External Breather Tube

Fig. 3, Model TR-T (TR Series) Brake Chamber

Principles of Operation

Service Brakes

As the brake pedal is depressed, compressed air enters the service brake chamber through a port. Air pressure acts upon a diaphragm, which forces the piston rod toward the non-pressure chamber, applying a straight-line force to the slack adjuster, which converts it to a rotational force. This in turn rotates the camshaft and applies the brakes.

Then, when the brake pedal is released, air is exhausted from the service brake chamber, and the return spring allows the diaphragm, piston rod, and slack adjuster to return to their normal positions, releasing the brakes.

Parking/Emergency Brakes

During parking brake release, compressed air enters the parking brake chamber and acts upon the diaphragm and piston, fully compressing the power spring. When the power spring is compressed, the parking brakes are released; the service brakes can then be operated at the brake pedal.

During parking brake application, air is exhausted from the parking brake chamber. The power spring releases, forcing the piston and parking brake diaphragm toward the flange case. The resulting motion on the push rod forces the service brake diaphragm and piston rod outward, applying the brakes.

Power Spring Manual Compression and Reset

DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1), for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

Manual Compression (Parking Brake Release)

1. Chock the tires.
2. Remove the end cover cap from the center-hole in the head of the chamber. See **Fig. 2**.

DANGER

Do not attempt to cage the power spring if the parking brake chamber is damaged severely enough to lose its structural integrity. If the power spring were to break loose, it could result in death, severe personal injury, or property damage.

A DAMAGED PARKING BRAKE CHAMBER IS EXTREMELY DANGEROUS! Only qualified service personnel should attempt to remove and disarm a damaged chamber. Using a torch, burn off the piston rod in the space between the clevis and the base of the service chamber.

Remove the chamber carefully from its bracket, and disarm it inside a suitable container. For disarming procedures, consult the MGM service manual.

3. Manually release the parking brake (cage the power spring).

   3.1 Using a hand wrench (*don't use an impact wrench*), unscrew the release nut, and remove the nut, flatwasher, and release bolt from the storage pocket on the side of the chamber. See **Fig. 3**.

   IMPORTANT: If these parts are not stored on the chamber, they must be otherwise obtained or purchased; the parking brake cannot be manually released without them.

   3.2 Apply at least 90 psi (620 kPa) air pressure to the parking brake inlet port (set parking brake in the "release" position).

   3.3 Insert the release bolt into the center-hole in the chamber head (see **Fig. 4**). Insert the bolt until it bottoms out into the hole in the piston inside the chamber.

   IMPORTANT: If you are not absolutely sure that the formed end of the bolt has engaged the piston correctly, repeat this step. Repeat it until you are absolutely sure.

   3.4 Turn the release bolt one-quarter turn clockwise, and pull the bolt out to lock its formed end into the piston.

   IMPORTANT: If the bolt doesn't lock into the piston in less than 1/2-inch (13-mm) outward movement, repeat these steps until you are sure it does lock.

   3.5 Then, holding the bolt locked into the piston, install the flatwasher and release nut on the end of the release bolt, and turn down the nut against the flatwasher until it is finger-tight. See **Fig. 5**.

CAUTION

Don't exceed 50 lbf·ft (68 N·m) torque on the release nut; and don't use an impact wrench on this nut. Too much torque could distort the head of the chamber and prevent manual release of the parking brake.

   3.6 Using a hand wrench (*don't use an impact wrench*), turn the release nut clockwise until the bolt extends 3 inches (76 mm) above the nut. See **Fig. 6**.

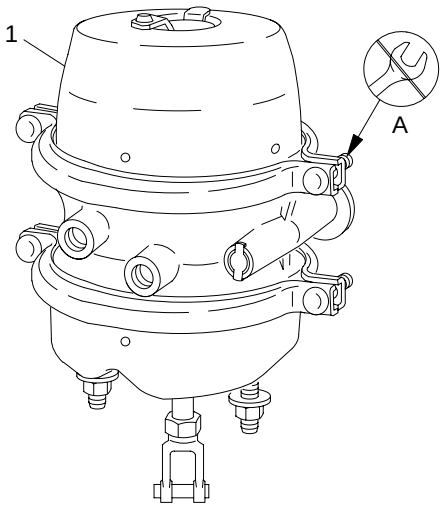
   IMPORTANT: Don't exceed the 3-inch (76-mm) length.

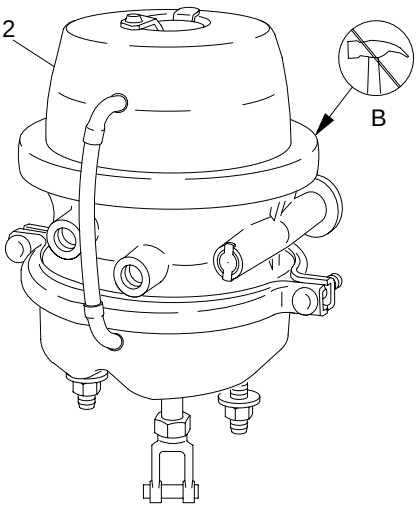
4. Once the power spring has been caged, exhaust the compressed air from the parking brake.

Manual Reset (Parking Brake Reset)

1. Uncage the power spring.

Power Spring Manual Compression and Reset





06/25/93 f420731a

A. Do not remove this clamp ring.
1. Model E (E Series) Brake Chamber
B. Do not remove the factory-sealed clamp ring.
2. Model TR-T (TR Series) Brake Chamber

Fig. 1

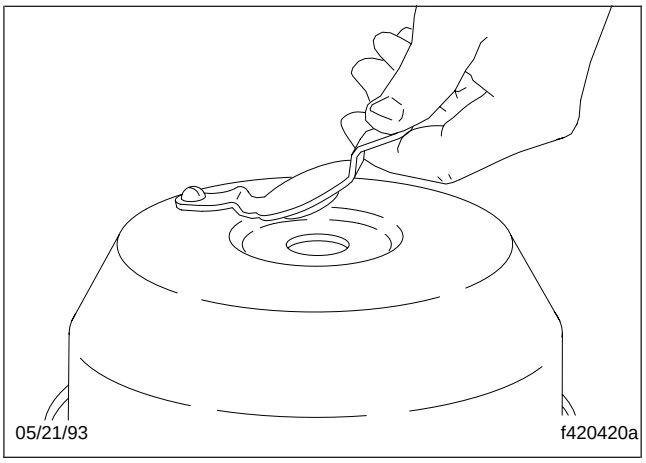


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Fig. 2

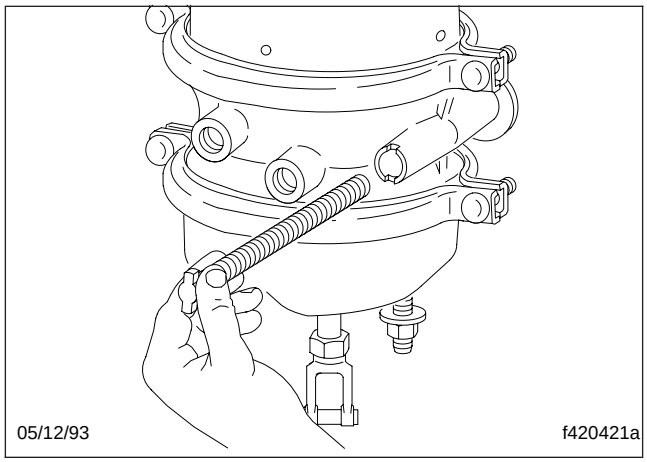

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Fig. 3

1.1 Apply at least 90 psi (620 kPa) air pressure to the parking brake inlet port (set parking brake in the "release" position).

⚠ CAUTION

Don't exceed 50 lbf·ft (68 N·m) torque on the release nut; and don't use an impact wrench on this nut. Too much torque could distort the head of the chamber and prevent manual release of the parking brake.

1.2 With air applied to the parking brake section (the parking brake control valve is in the "release" position), use a hand wrench to turn the release nut *counterclockwise* until the bolt bottoms out in the unit.

1.3 Remove the nut and flatwasher.

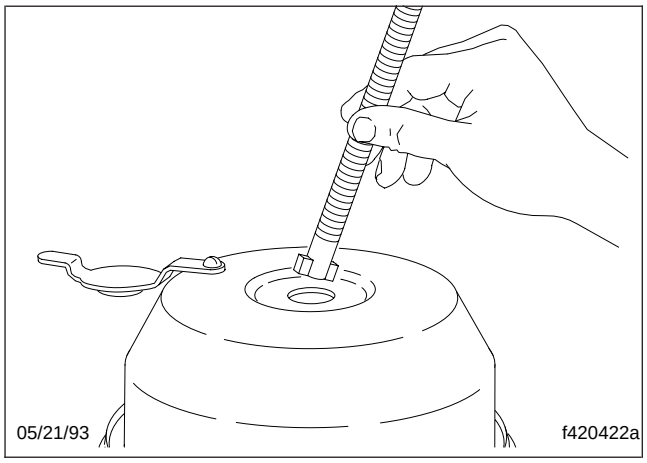


Fig. 4

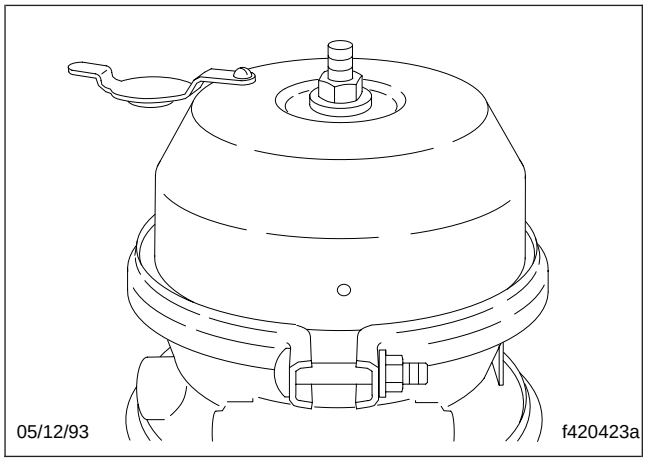
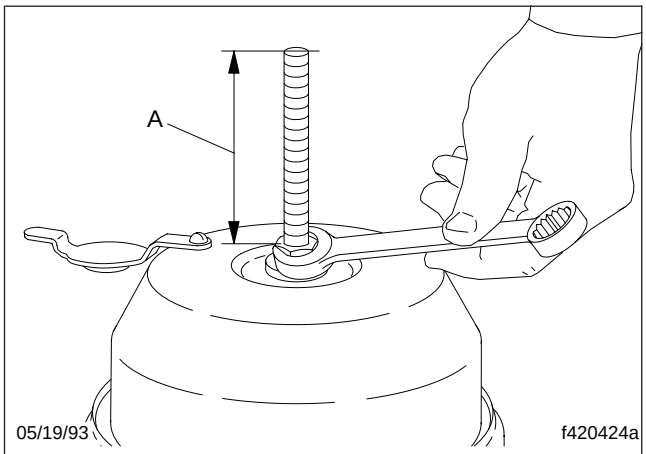


Fig. 5

1.4 Push the release bolt into the piston and turn the release bolt one-quarter turn counterclockwise to unlock its formed end from the piston. Remove the release bolt from the center-hole of the chamber.

2. Using a hand wrench (*don't use an impact wrench*), install the release bolt, flatwasher, and release nut in the storage pocket. MGM recommends 10 lbf·ft (14 N·m) torque on the nut against the flatwasher (see **Fig. 7**).

3. Snap the end cover cap in place over the center-hole in the chamber head. See **Fig. 8**.



Don't exceed the 3-inch (76-mm) length.
A. Measure this distance.

Fig. 6

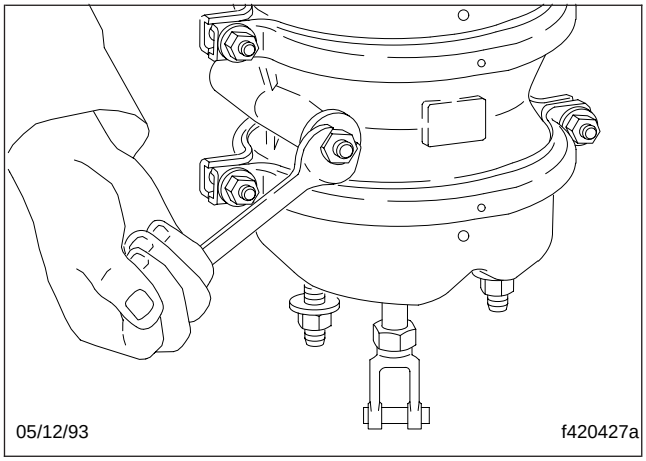


Fig. 7

CAUTION

If the external breather tube or end cover cap is missing or incorrectly installed, road dirt and debris can adversely affect the operation of the brake chamber. Once inside the chamber, dirt and debris cause the internal parts to deteriorate and shorten their lives. Operating the unit without the external breather tube or end cover cap in place voids the MGM warranty.

4. Check the plastic end cover cap periodically, and replace it with a new one at once if damaged or missing. For intervals, refer to the vehicle maintenance manual.

Power Spring Manual Compression and Reset

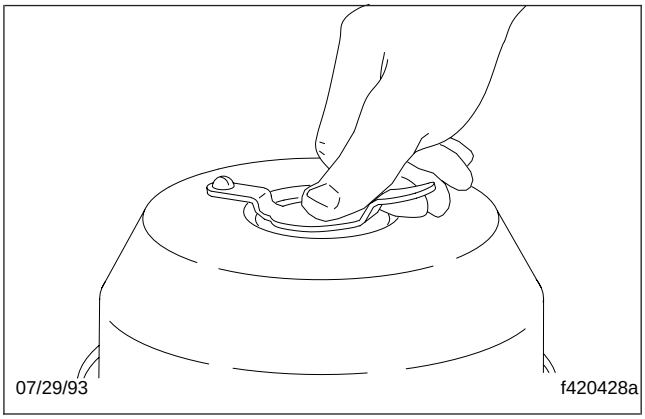


Fig. 8

5. Remove the chocks from the tires.

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

Removal

1. To make removal and installation of the parking brake section easier (without removing the service brake chamber), lock off the service chamber piston rod.

   1.1 Apply the service brakes by actuating the driver's foot brake treadle valve.

   1.2 With the brakes applied, clamp a pair of locking-jaw pliers on the piston rod to lock the rod in place when the air pressure is released (see **Fig. 2**).

⚠ WARNING

Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

2. Manually release the parking brake (cage the power spring). For instructions, see **Subject 100**.
3. Mark the air lines for later reference. Then carefully disconnect them from the brake chamber.

   On chambers equipped with an external breather tube, disconnect the tube and elbow from the service brake chamber.

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

4. Remove the parking brake section from the service brake section.

   4.1 Using a hand wrench (*don't use an impact wrench*), remove the clamp nuts on the *service* clamp ring (*do not disassemble the parking brake section*).

   4.2 While holding the parking brake section securely in place, remove the service clamp ring. Then remove the parking brake section from the service brake non-pressure chamber (see **Fig. 3**).

5. Remove the service brake diaphragm from the bottom of the parking brake section.

Installation

IMPORTANT: At this time, take the opportunity to inspect the parking/emergency brake section, and replace it if it shows signs of damage, corrosion, or rust. Follow the detailed inspection instructions in the vehicle maintenance manual.

1. Inspect all parts in the service (non-pressure) chamber. Replace any damaged or worn parts with genuine MGM-engineered replacement parts.
2. Place the new service brake diaphragm in the bottom recess of the parking brake section (see **Fig. 4**).
3. Install the (new, if needed) parking/emergency brake section.

   3.1 If installing a new parking brake section, be sure it is the same size and make as the old one.

   3.2 Check that the release bolt is fully extended outward. For instructions, see **Subject 100**.

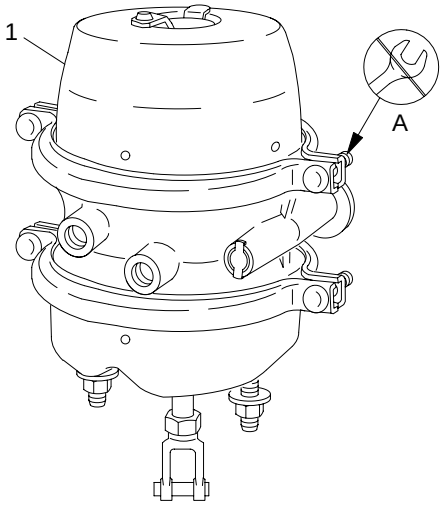
   3.3 Install the parking brake section on the service chamber so that all mating parts are aligned straight and the air lines are positioned to mate with the vehicle air supply lines.

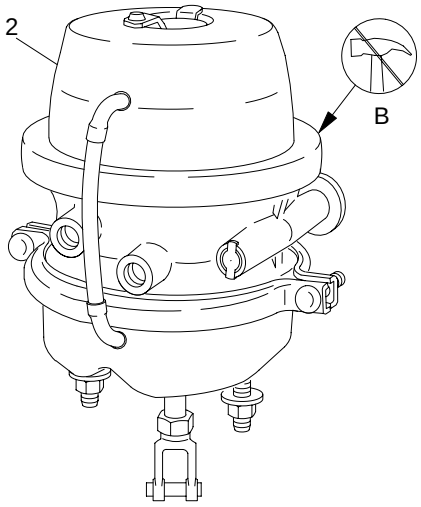
4. Install the service brake clamp ring.

   4.1 With the service brake clamp ring in place, install the clamp bolts and nuts.

   4.2 Using a hand wrench (*don't use an impact wrench*), alternately tighten each clamp nut in increments of 60 to 120 lbf·in

Service Brake Diaphragm Replacement





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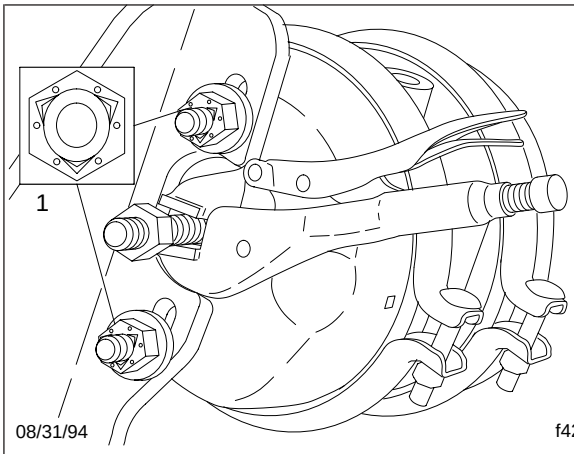
A. Do not remove this clamp ring.

B. Do not remove the factory-sealed clamp ring.

1. Model E (E Series) Brake Chamber

2. Model TR-T (TR Series) Brake Chamber

Fig. 1



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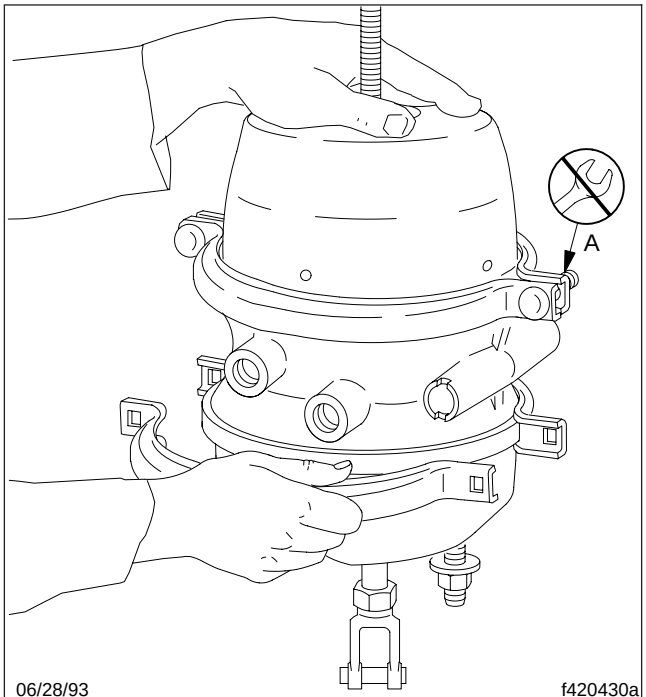
1. Prevailing Torque Locknut

Fig. 2

(680 to 1360 N·cm) while constantly re-checking the alignment of mating parts.

If realignment is needed, loosen the nuts again, and repeat this substep.

4.3 Firmly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. Tighten



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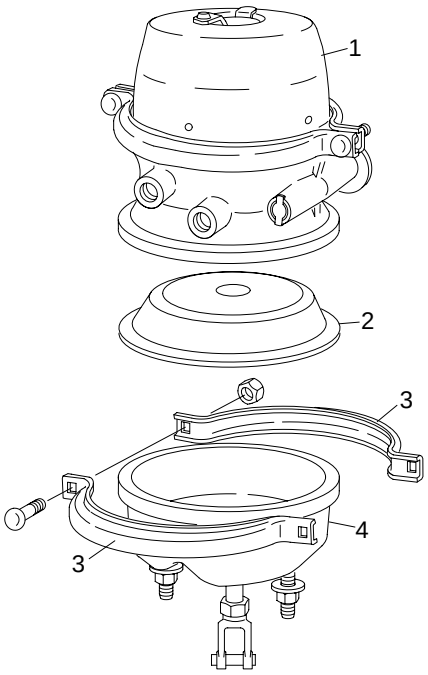
A. Do not remove this clamp ring.

Fig. 3



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1. Parking/Emergency Brake Section
2. Service Brake Diaphragm
3. Service Brake Clamp Ring
4. Service Brake (Non-Pressure) Chamber

Fig. 4

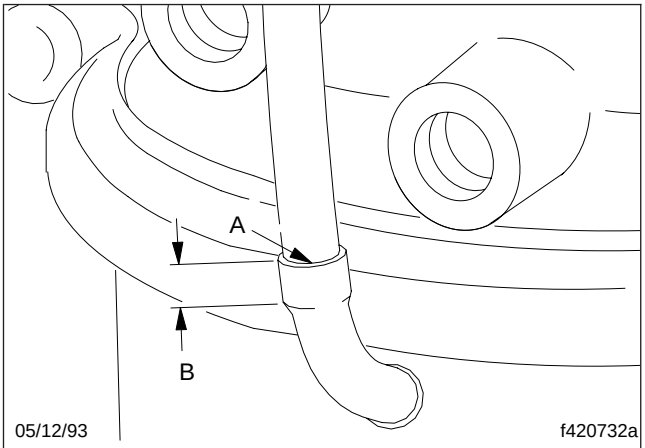
the nuts to a final torque of 25 to 30 lbf·ft (34 to 41 N·m).

5. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 25 lbf·ft (34 N·m).
6. Using the vehicle system air, charge the parking brake with full line pressure—at least 100 psi (690 kPa). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 25 lbf·ft (34 N·m).
7. With the parking brake still charged with full line pressure, apply and hold the foot brake treadle valve down to charge the service brake chamber. Remove the locking-jaw pliers from the service piston rod so that the piston returns to a normal position in the chamber.

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

8. Test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, firmly tap the circumference of the clamp ring with a rubber mallet, and retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). MGM recommends 25 to 30 lbf·ft (34 to 41 N·m) torque on the clamp hexnuts.
9. On chambers equipped with an external breather tube, make sure that the open end of the tube is free of grease, dirt, and other debris. Then, apply a high-quality rubber cement to the tube and insert it into the elbow at least 1/2 inch (13 mm). See **Fig. 5**. Insert the tube into the service brake chamber.



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A. Apply adhesive here.
B. Check for 1/2" (13 mm) minimum engagement.

Fig. 5

10. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring, and snap the end cover cap in place. For instructions, see **Subject 100**.
11. Adjust the brakes at the slack adjuster.

Service Brake Diaphragm Replacement

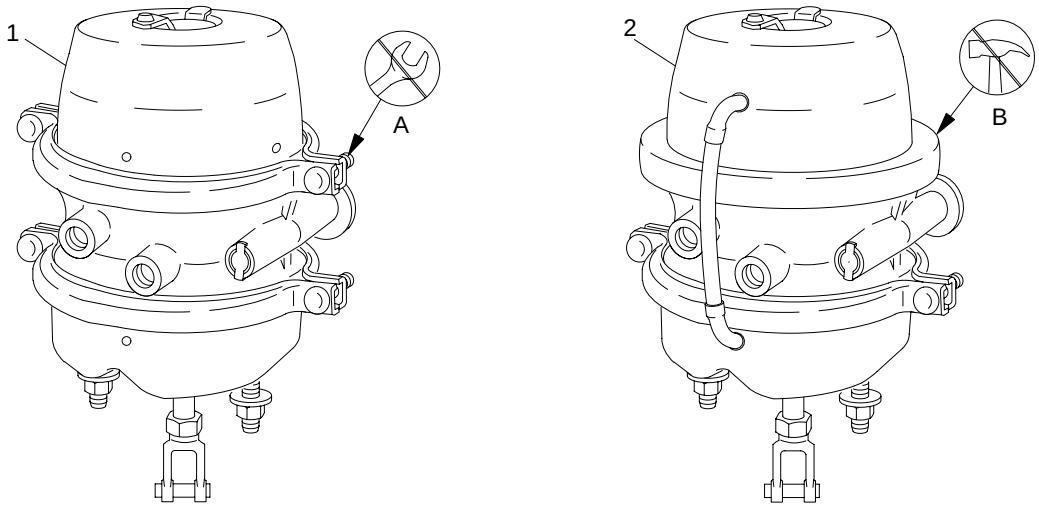
IMPORTANT: After replacing any brake chamber components, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, refer to the applicable slack adjuster section in **Group 42** of this manual.

Replacement

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: The parking/emergency brake section can be replaced as a unit. For instructions, refer to **Subject 110**.



06/25/93 f420731a

A. Do not remove this clamp ring.
1. Model E (E Series) Brake Chamber
B. Do not remove the factory-sealed clamp ring.
2. Model TR-T (TR Series) Brake Chamber

Fig. 1

Combination Service and Parking Brake Chamber Removal and Installation

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

Removal (See Fig. 2 or Fig. 3)

⚠ WARNING

WARNING: Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

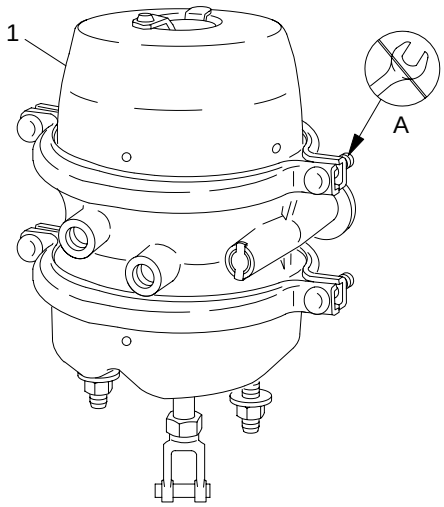
1. Manually release the parking brake (cage the power spring). For instructions, refer to **Subject 100**.
2. Mark the air lines for later reference. Then carefully disconnect them from the brake chambers.
3. Remove the brake chamber from the vehicle.
   - 3.1 Remove the cotter pin(s) from the clevis pin(s), then remove the clevis pin(s) from the clevis. Disconnect the clevis from the slack adjuster.

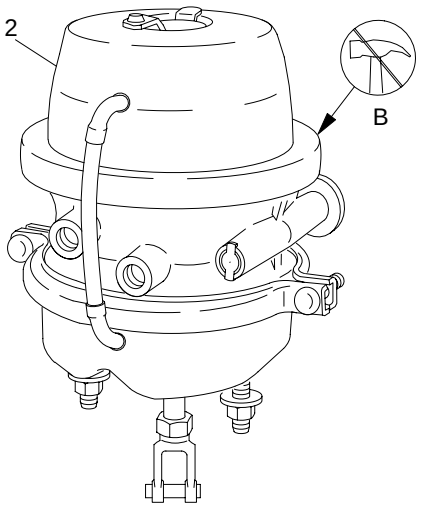
   NOTE: Gunite and Rockwell automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

   - 3.2 Make sure the parking brake has been released manually (the power spring has been caged). For instructions, refer to **Subject 100**. Also, make sure that the service brake piston is fully retracted (in the brakes "OFF" position). Then, record both of the following dimensions in either mm or inches, measuring outward from the base of the service brake chamber (see **Fig. 4**):

     X dimension: to end of threaded piston rod

     Y dimension: to centerline of (large) clevis pin





06/25/93 f420731a

A. Do not remove this clamp ring.

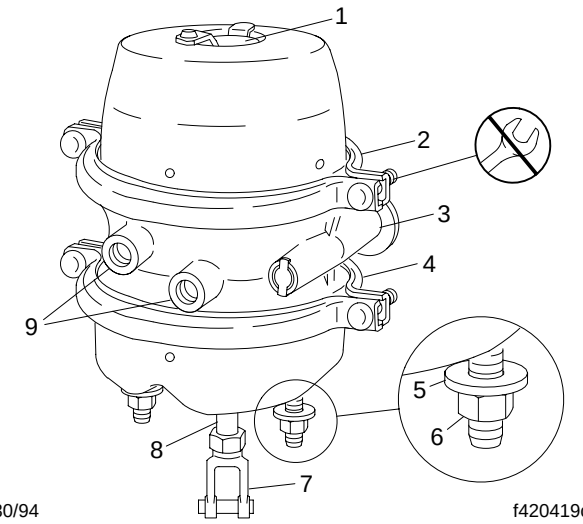
1. Model E (E Series) Brake Chamber

B. Do not remove the factory-sealed clamp ring.

2. Model TR-T (TR Series) Brake Chamber

Fig. 1

Combination Service and Parking Brake Chamber Removal and Installation



Do not remove the parking brake clamp ring.

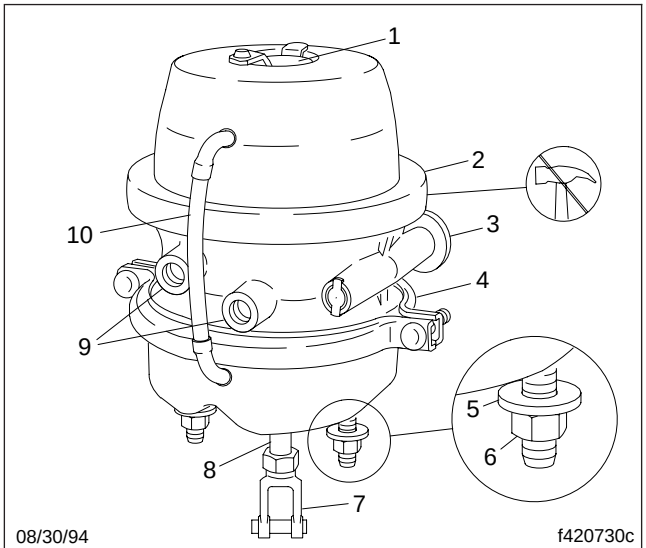
1. End Cover Cap
2. Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports

Fig. 2, Model E (E Series) Brake Chamber

IMPORTANT: If new chambers are to be attached to manual slack adjusters, the Y dimension is the most critical measurement. When installing the new assembly, its service piston rod must be cut (see **Fig. 5**) to exactly duplicate this "rod-plus-clevis" length *after* the clevis assembly is installed on the piston rod.

If new chambers are to be attached to automatic slack adjusters, the X dimension is the most critical measurement. When installing the new assembly, its service piston rod must be cut (see **Fig. 5**) to exactly duplicate the "rod only" length *before* the clevis assembly is installed on the piston rod.

3.3 From each mounting stud, remove any installed nuts and washers. Then, cautiously remove the brake chamber from the mounting bracket.



Do not remove the factory-sealed clamp ring.

1. End Cover Cap
2. Factory Sealed Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports
10. External Breather Tube

Fig. 3, Model TR-T (TR Series) Brake Chamber

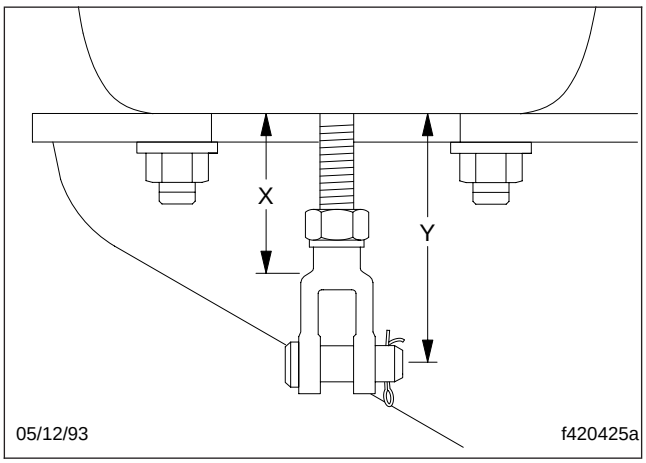


Fig. 4

Combination Service and Parking Brake Chamber Removal and Installation

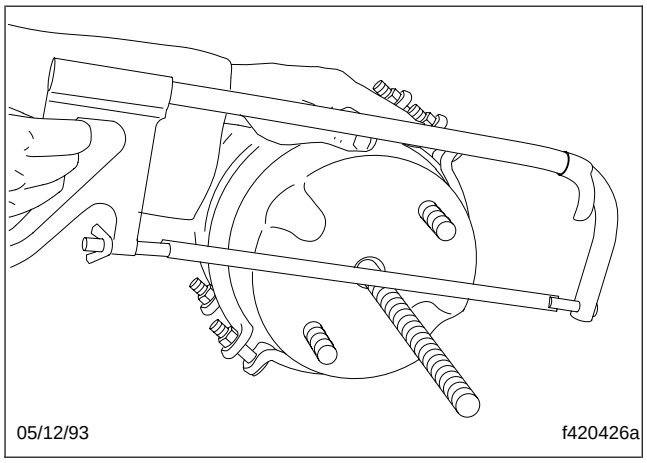


Fig. 5

Installation (See Fig. 2 or Fig. 3)

1. If installing a new brake chamber unit, do the following steps:

   1.1 First, make sure the power spring is caged (release bolt fully extended outward). If not, go to **Subject 100** and do the applicable steps.

   1.2 Make sure that the piston rod is the same length as the rod on the old unit (measure the rods when *both* chambers are caged).

   1.3 Be sure the new chamber is the same size and make as the brake chamber installed on the other side of the axle.

   1.4 Remove the prevailing torque locknut and hardened flatwasher from each of the mounting studs on the chamber.

2. Clean the face of the mounting bracket, and install the chamber on the bracket, paying close attention to positioning the chamber air inlet ports for correct alignment to the vehicle air lines.

⚠ WARNING

WARNING: Tighten the mounting nuts with a hand wrench, not an impact wrench. An impact wrench could damage the mounting fasteners, reducing the force of the brakes. This could result in personal injury or property damage.

3. Install one hardened flatwasher and prevailing torque locknut on each mounting stud. Using a hand wrench (*don't use an impact wrench*), tighten the nuts 100 to 115 lbf·ft (136 to 156 N·m). Make sure the flatwasher is installed between the locknut and the mounting bracket.

   On chambers equipped with an external breather tube, make sure that the tube is installed in the side of the chamber that faces away from the road surface. An improperly installed breather tube voids the MGM warranty.

4. Check mating and alignment with the vehicle air lines.

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

   4.1 Using a hand wrench (*don't use an impact wrench*), loosen the clamp nuts on the *service* clamp ring (*do not disassemble the parking brake section*).

   4.2 Reposition the air inlet ports, as needed, to mate with vehicle air supply lines.

   Alternately tighten each clamp nut in increments of 60 to 120 lbf·in (680 to 1360 N·cm) while constantly rechecking the alignment of mating parts.

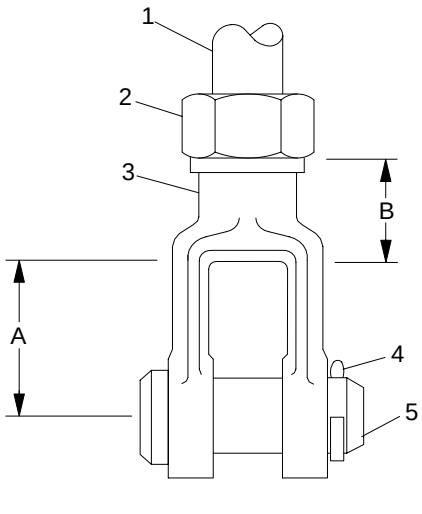
   If realignment is needed, loosen the nuts again, and repeat this substep.

   4.3 Firmly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. Tighten the nuts to a final torque of 25 to 30 lbf·ft (34 to 41 N·m).

5. With manual slack adjusters, connect the slack adjuster to the clevis, then install the clevis pin. Insert the cotter pin in the clevis pin, and lock it in place. Check the piston-rod engagement with the clevis. At least seven threads engagement is required; there should be 1-inch (25-mm) clearance from the centerline of the clevis pin hole to the end of the piston rod. See **Fig. 6.** Adjust if needed.

Combination Service and Parking Brake Chamber Removal and Installation

With automatic slack adjusters, refer to the applicable slack adjuster section in **Group 42** in this manual for installation instructions.



A. Minimum of 1 inch (25 mm) clearance between centerline of clevis pin hole and piston rod end.
B. Minimum of 7 threads engagement.

1. Piston Rod
2. Piston Rod Nut
3. Clevis
4. Cotter Pin
5. Clevis Pin

Fig. 6, Piston Rod Engagement With the Clevis

6. Inspect the piston rod to be sure it is working free, not binding, and is square with the chamber bottom within ±3° in any direction from zero to full stroke. If there is misalignment, make corrections by loosening the locknuts and repositioning the chamber on the mounting bracket, or by shimming the slack adjuster to the right or left on the camshaft.
7. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 25 lbf·ft (34 N·m).
8. Using the vehicle system air, charge the parking brake with full line pressure, at least 100 psi (690 kPa). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 25 lbf·ft (34 N·m).

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: If the service brake clamp ring was loosened to reposition the air inlet ports, apply air to the parking brake, and then apply and hold the foot brake treadle valve down to charge the service brake chamber. Now test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, firmly tap the circumference of the clamp ring with a rubber mallet, and retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). MGM recommends 25 to 30 lbf·ft (34 to 41 N·m) torque on the clamp hexnuts.

9. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring, and snap the end cover cap in place. For instructions, refer to **Subject 100**.
10. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this manual.

IMPORTANT: After replacing any brake chamber, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, refer to the applicable slack adjuster section in **Group 42** in this manual.

Specifications

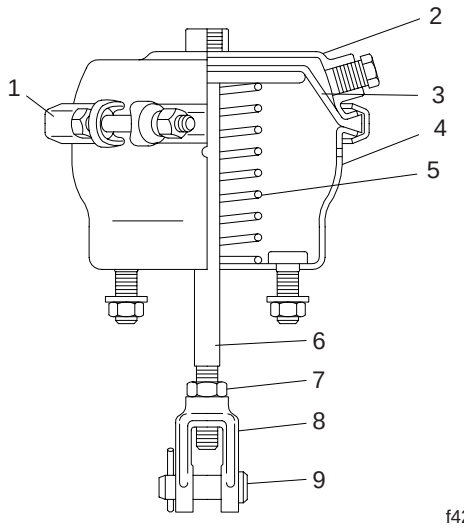
Description	Torque lbf·ft (N·m)
Spring Brake Release Bolt Nut (in storage pocket)	10 (14)
Service Brake Clamp Ring Nut	25–30 (34–41)
Brake Chamber Mounting Stud Nut	100–115 (136–156)
Air Hose Fitting-to-Chamber	25 (34)

Table 1, Torque Values

General Description

Brake chambers convert the energy of compressed air into the mechanical force and motion needed to apply the brakes. Two chambers operate the brakes, one on each side of the axle.

Each brake chamber consists of two dished metal sections: the cover assembly and the body assembly, which are separated by a nylon-neoprene diaphragm. A metal two-segment clamp ring holds the assemblies together. **See Fig. 1.**



1. Clamp Ring
2. Cover Assembly
3. Diaphragm
4. Body Assembly
5. Piston Rod Spring
6. Piston Rod Assembly
7. Piston Rod Nut
8. Clevis
9. Clevis Pin

Fig. 1, Sectional View

In front of the diaphragm are the body, piston rod assembly, and a piston rod spring. The threaded piston rod assembly extends through the bottom of the body and connects to the clevis. **See Fig. 1.**

Different sized brake chambers are identified by numbers, which specify the effective area of the diaphragm. For example, a type 16 brake chamber has 16 square inches of effective area.

Principles of Operation

The greater the air pressure admitted to the brake chamber, the greater the force applied by the piston rod. Piston rod force is determined by multiplying the delivered air pressure by the effective diaphragm area. For example, if 60 psi (415 kPa) is admitted to a type 16 brake chamber, the force on the end of the piston rod is about 960 lb (436 kg).

When the brake pedal is depressed, air pressure from the brake valve passes through the port in the brake chamber cover to move the diaphragm and piston rod assembly forward. This compresses the spring, and applies a straight-line force to the slack adjuster, which converts it to a rotational force. This in turn rotates the camshaft and applies the brakes.

When the brake pedal is released, compressed air behind the diaphragm exhausts through the quick release valve. The spring then allows the piston rod assembly and diaphragm to return to their previous positions.

NOTE: For both of these tests, the air system must be pressurized to at least 80 psi (550 kPa).

Operating Test

1. Chock the tires.
2. Apply the brakes. Check that each piston rod moves out promptly, without binding.
3. Release the brakes. Check that each piston rod returns to the released position promptly, without binding.
4. Check the brake chamber stroke. It should be as short as possible without causing the brakes to drag. If needed, adjust the travel of the piston rod at the slack adjuster. For instructions, refer to the foundation brake section in this manual.

Leakage Test

1. Apply the brakes and hold them on full line pressure of at least 80 psi (550 kPa).
2. Using a soap solution, coat the clamp ring. Leakage is excessive if it produces a 1-inch (25-mm) bubble within five seconds.

⚠ CAUTION

CAUTION: Don't overtighten the clamp ring. This can distort the flange sealing surface, or the clamp ring itself.

3. If the leakage is excessive, tighten the clamp ring flange nuts evenly until the leakage is reduced. For acceptable torque ranges, refer to **Specifications, 400**.
4. Using a soap solution, coat the area around the piston-rod hole. No leakage is permitted. If there is leakage, replace the diaphragm. For instructions, refer to **Subject 110**.

NOTE: This procedure is for service of a leaking brake chamber *diaphragm only*. If there are any other problems, refer to the applicable subjects elsewhere in this section.

Replacement

1. Chock the tires.

⚠ WARNING

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

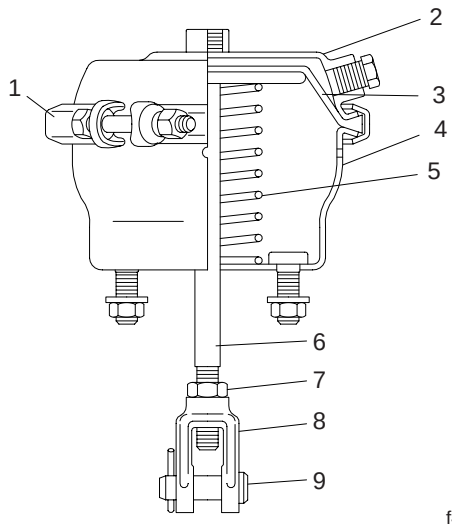
Follow the manufacturer's recommendations when working on any air device so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or compressed-air propulsion.

2. Drain the air reservoirs and lines.
3. Back off the slack adjuster; for instructions, refer to the applicable slack adjuster section in this manual. Pull out the piston rod. **See Fig. 1.** Clamp the rod at the chamber body to protect it from damage.
4. Before disassembly, mark a reference line along the chamber to allow the parts to be reassembled later in their old positions. **See Fig. 2.**
5. Replace the diaphragm.
   - 5.1 Remove one clamp ring bolt and flange nut completely and loosen the other bolt and flange nut enough to remove the clamp ring.
   - 5.2 Remove the cover assembly, and replace the diaphragm.

⚠ CAUTION

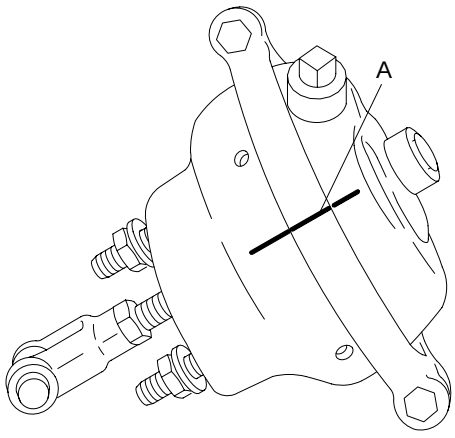
CAUTION: Don't overtighten the clamp ring. This can distort the flange sealing surface, or the clamp ring itself.

   - 5.3 Position the cover assembly and clamp ring (aligning the reference marks), and install the clamp ring bolt and flange nut. Tighten the flange nuts evenly to eliminate leakage. For acceptable torque ranges, refer to **Specifications, 400**.
6. Release the clamp on the piston rod.



1. Clamp Ring
2. Cover Assembly
3. Diaphragm
4. Body Assembly
5. Piston Rod Spring
6. Piston Rod Assembly
7. Piston Rod Nut
8. Clevis
9. Clevis Pin

Fig. 1, Sectional View



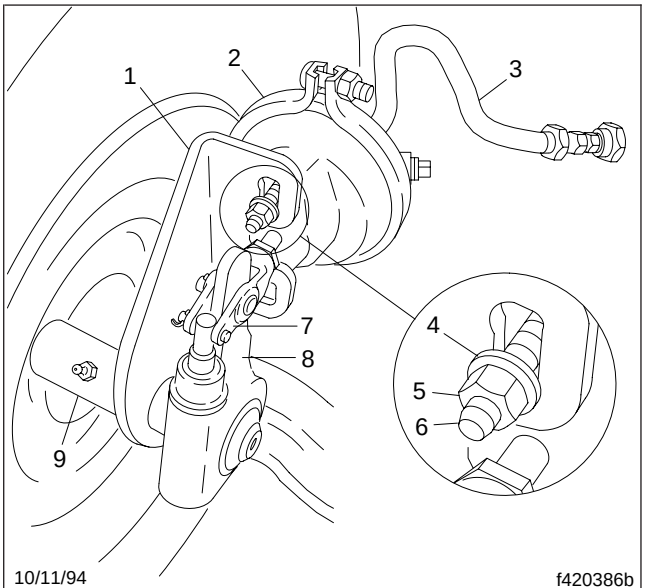
A. Reference Line

Fig. 2

Diaphragm Replacement

7. Do both of the tests **in Subject 100**.
8. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable foundation brake section in this manual.
9. Remove the chocks from the tires.

Removal (See Fig. 1)



1. Chamber Mounting Bracket
2. Brake Chamber
3. Air Line
4. Hardened Flatwasher (2 qty.)
5. Prevailing Torque Locknut (2 qty.)
6. Chamber Mounting Stud (2 qty.)
7. Clevis Assembly
8. Slack Adjuster (Automatic Type)
9. Camshaft Tube

Fig. 1

1. Chock the tires.

⚠ WARNING

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at other people. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in severe personal injury.

Follow the manufacturer's recommendations when working on any air device so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or compressed-air propulsion.

2. Drain the air reservoirs and lines.
3. Carefully disconnect the air line from the brake chamber.
4. Remove the brake chamber.
   - 4.1 Remove the cotter pin(s) from the clevis pin(s).

     NOTE: Gunite and Rockwell automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.
   - 4.2 Remove the clevis pin(s) from the slack adjuster.
   - 4.3 From each mounting stud, remove any installed nuts and washers. Remove the brake chamber from the vehicle.

Installation (See Fig. 1)

1. Before installing a new chamber, be sure the new chamber is the same size and make as the brake chamber on the other side of the axle.
2. Install the brake chamber.
   - 2.1 Attach the brake chamber to the mounting bracket using a hardened flatwasher and prevailing torque locknut. Install the flatwasher between the locknut and the mounting bracket.
   - 2.2 Tighten the locknuts. **See Table 1** for the correct torque value.

Description	Chamber Size (in ^{2})	Torque lbf·ft (N·m)
Brake Chamber Mounting-Stud Locknuts	12	30 (41)
	16 (7/16-inch Stud)	40 (54)
	16 (1/2-inch Stud)	75 (102)
	20	100 (136)
	24	100 (136)

Table 1, Mounting-Stud Locknut Torque Values

   - 2.3 Connect the clevis pins to the slack adjuster.
   - 2.4 Install and lock the cotter pin(s) to secure the clevis pin(s).

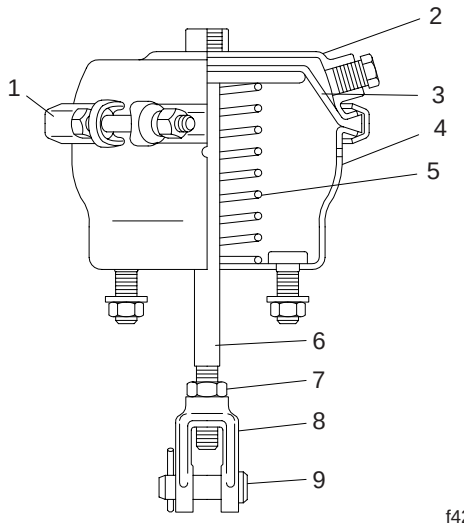
Brake Chamber Removal and Installation

NOTE: Gunite and Rockwell automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

3. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable foundation brake section in this manual.
4. Connect the air line to the brake chamber.
   - 4.1 Check that the hoses are properly supported and, if needed, clamped to provide good clearance.
   - 4.2 Before connecting the air line, make sure the fittings are clean and free of debris.
   - 4.3 Connect the air line as follows: tighten the nut finger-tight. Using a wrench, further tighten the nut until there is resistance, then tighten one-sixth turn more.
5. Do both of the tests **in Subject 100**.
6. Remove the chocks from the tires.

Brake Chamber Disassembly, Inspection and Cleaning, and Assembly

Disassembly (See Fig. 1)

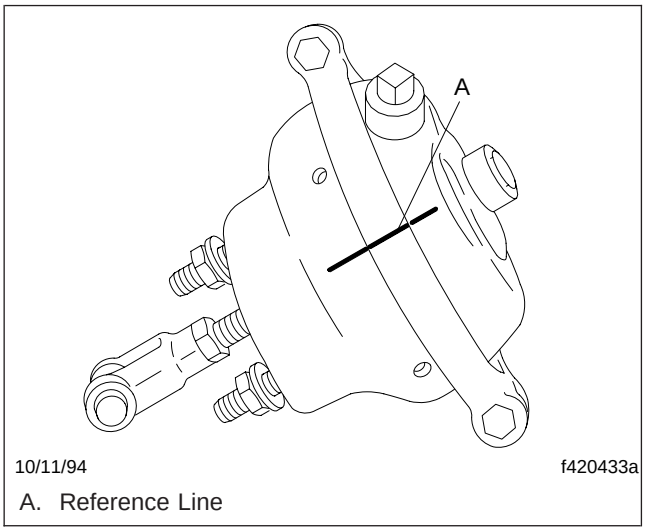


1. Clamp Ring
2. Cover Assembly
3. Diaphragm
4. Body Assembly
5. Piston Rod Spring
6. Piston Rod Assembly
7. Piston Rod Nut
8. Clevis
9. Clevis Pin

Fig. 1, Sectional View

NOTE: If the brake chamber is to be disassembled without removing the body assembly from the vehicle, first back off the slack adjuster. For instructions, refer to the applicable slack adjuster section in this manual.

1. Before disassembly, mark a reference line along the chamber to allow the parts to be reassembled later in their old positions. See **Fig. 2**.
2. Pull out the piston rod. Clamp the rod at the chamber body to protect it from damage.
3. Disassemble the brake chamber.
   - 3.1 Remove one clamp ring bolt and flange nut completely and loosen the other bolt and flange nut enough to remove the clamp ring.
   - 3.2 Remove the cover assembly and the diaphragm.
   - 3.3 Remove the clevis locknut and clevis from the piston rod, and release the clamp on the piston rod, being careful to contain the piston rod assembly and body until the return spring is relaxed.
   - 3.4 Remove the piston rod assembly and spring.



A. Reference Line

Fig. 2

Inspection and Cleaning

1. Clean all metal parts with cleaning solvent.
2. Inspect all parts for wear or damage; replace as needed.
   - 2.1 Check the cover and the body for dents. If any are too deep to be pounded out, replace as needed.
   - 2.2 Check the diaphragm for wear or deterioration and replace it if necessary. Midland recommends replacement of the diaphragm whenever the service brake chamber is opened for inspection.
   - 2.3 Inspect all other parts not considered serviceable. Replace if necessary.

Assembly (See Fig. 1)

1. Stand the piston rod assembly upright on a flat surface (if the chamber was removed from the vehicle).
2. Assemble the brake chamber.

Brake Chamber Disassembly, Inspection and Cleaning, and Assembly

2.1 Place the return spring on the piston rod.

2.2 Place the body on the piston rod assembly, and press the body down, working against the tension of the spring, until the body bottoms out on the flat surface. Clamp the rod at the body, making sure to protect the rod from damage. Insert the piston rod assembly through the body and clamp the rod (if the body wasn't removed from the vehicle).

2.3 Place the diaphragm in the body.

⚠ CAUTION

Don't overtighten the clamp ring. This can distort the flange sealing surface, or the clamp ring itself.

2.4 Position the cover assembly and clamp ring (aligning the reference marks), and install the clamp ring bolt and flange nut. Tighten the flange nuts evenly to eliminate leakage. For acceptable torque ranges, see **Specifications, 400**.

3. Install the clevis locknut and clevis, and release the clamp on the piston rod.
4. If the brake chamber was removed from the vehicle, install it. For instructions, see **Subject 120**.
5. Do both of the tests found in **Subject 100**.

Specifications

Description	Chamber Size: in ^{2}	Torque: lbf·ft (N·m)
Brake Chamber Mounting-Stud Locknuts	12	30 (41)
	16 (7/16-inch Stud)	40 (54)
	16 (1/2-inch Stud)	75 (102)
	20	100 (136)
	24	100 (136)

Table 1, Mounting-Stud Locknut Torque Values

Description	Chamber Size: in ^{2}	Torque: lbf·in (N·cm)
Clamp Ring Flange Nuts	12	200–250 (2260–2820)
	16	200–250 (2260–2820)
	20	110–225 (1240–2540)
	24	150–225 (1700–2540)

Table 2, Clamp Ring Torque Values

Description	Chamber Size: in ^{2}	Torque: lbf·ft (N·m)
Piston Rod Nuts	12	20–30 (27–41)
	16 (7/16-inch Stud)	20–30 (27–41)
	16 (1/2-inch Stud)	20–30 (27–41)
	20	33–90 (45–122)
	24	33–90 (45–122)

Table 3, Piston Rod Nut Torque Values

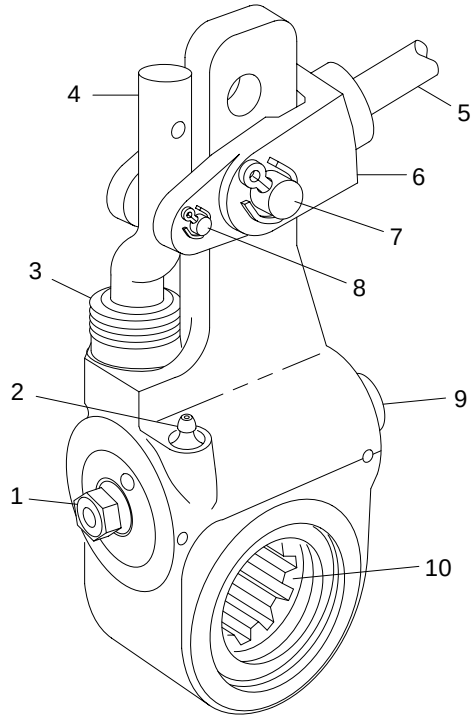
General Description (See Fig. 1)

The Gunite [1] automatic slack adjuster has two main functions:

- As a lever it converts the straight-line force of the brake chamber push rod to torque on the brake camshaft. Rotation of the camshaft forces the brake shoes against the drum.
- As an automatic slack adjuster, it maintains the lining-to-drum clearance needed for proper brake chamber push rod stroke.

the slack adjuster is installed between the brake chamber push rod and the brake camshaft. A clevis connects the brake chamber push rod to the top of the slack adjuste. The bottom of the slack adjuster is splined to the brake camshaft. The splines hold the slack adjuster internal gear to the camshaft, so the camshaft turns when the slack adjuster moves. When the brakes are applied, the brake chamber push rod moves outward forcing the slack adjuster and camshaft to rotate. This movement forces the brake shoes against the drum.

The brakes are adjusted when the slack adjuster senses an increase in the lining-to-drum clearance. The slack adjuster's internal worm shaft and ratchet shorten excessive lining-to-drum clearance. This provides maximum leverage for the brake chamber push rod. The automatic slack adjuster adjusts the brakes at the beginning of the brake application.



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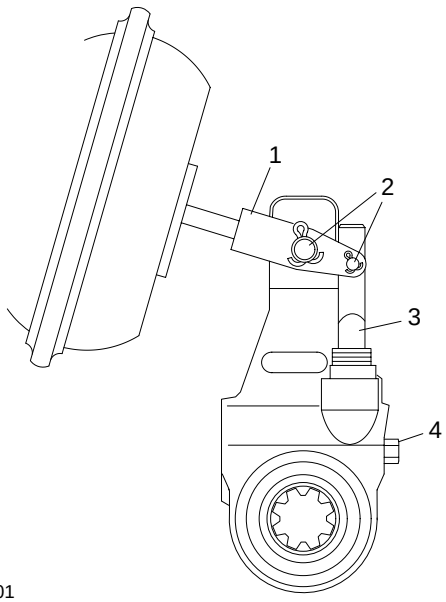
1. 7/16-Inch Adjusting Hexnut
2. Grease Fitting
3. Boot
4. Link
5. Brake Chamber Push Rod
6. Clevis
7. 1/2-Inch Clevis Pin
8. 1/4-Inch Clevis Pin
9. Grease Relief Opening
10. Slack Adjuster Spline

Fig. 1

[1] Formerly Kelsey-Hayes

IMPORTANT: This automatic slack adjuster cannot be rebuilt. If it is damaged or inoperative, replace the unit.

Factory-installed brake chambers have welded clevises on the pushrod. See **Fig. 1**. On a replacement brake chamber, the clevis is threaded onto the pushrod, and has a jam nut installed. See **Fig. 2**.

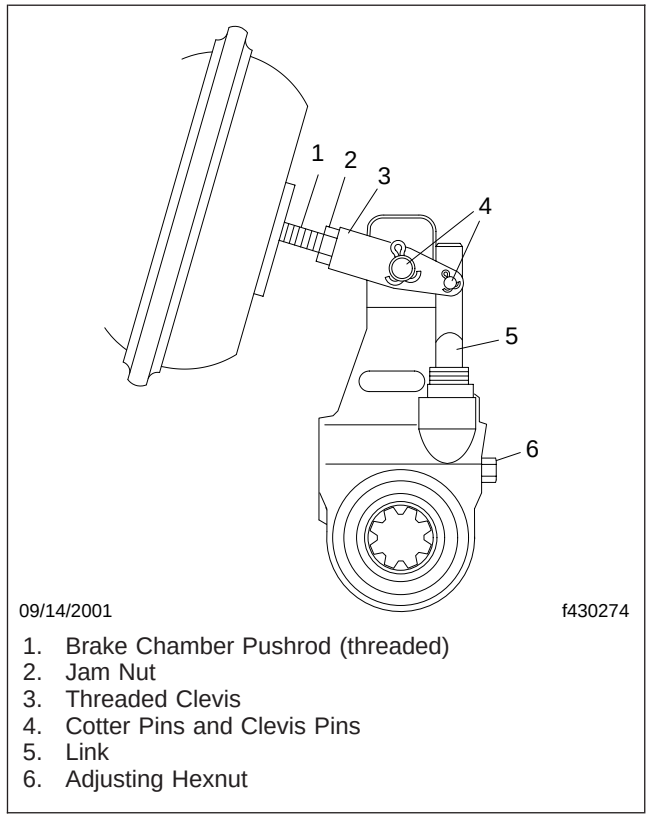


1. Brake Chamber Pushrod and Clevis Assembly
2. Cotter Pins and Clevis Pins
3. Link
4. Adjusting Hexnut

Fig. 1, Slack Adjuster (attached to welded clevis)

Removal

1. With the vehicle parked on a level surface, chock the tires. If you are removing a rear slack adjuster, cage the parking brake power spring. For instructions, refer to the applicable brake chamber section in this group.
2. Remove the cotter pins and clevis pins.
3. Rotate the adjusting hexnut counterclockwise until the slack adjuster clears the clevis.
4. Remove the snap ring from the brake camshaft, then slide the slack adjuster off the camshaft.



1. Brake Chamber Pushrod (threaded)
2. Jam Nut
3. Threaded Clevis
4. Cotter Pins and Clevis Pins
5. Link
6. Adjusting Hexnut

Fig. 2, Slack Adjuster (attached to threaded clevis)

Installation

NOTE: For brake chambers that have pushrods with threaded clevises, measure the pushrod length before installing the new slack adjuster. With the brakes fully released, and no air pressure to the chamber, check the dimension between the chamber face and the centerline of the 1/2-inch clevis pin hole. It should be 2.25 inches (57 mm) for long stroke chambers, and 2.75 inches (70 mm) for standard stroke chambers.

1. Coat the camshaft splines, and the splines of the slack adjuster gear with an anticorrosive grease.
2. Using the old snap ring, install the automatic slack adjuster on the brake camshaft.
3. Turn the adjusting hexnut clockwise to rotate the slack adjuster toward the brake chamber until the holes line up.

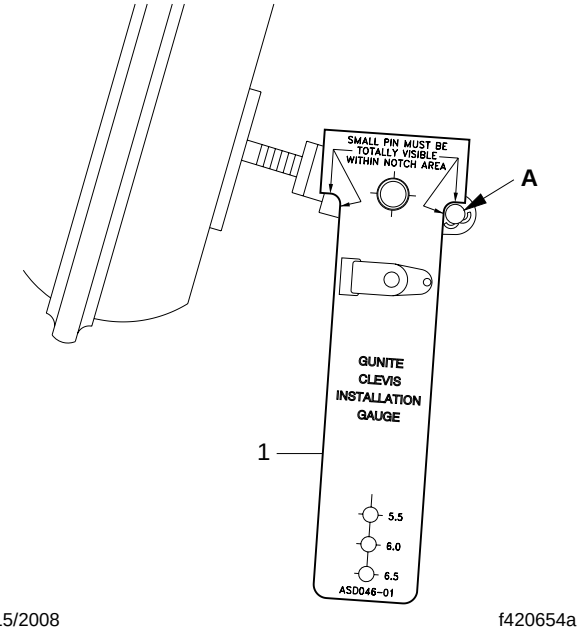
Slack Adjuster Removal and Installation

4. Install the clevis pins and cotter pins.

⚠ WARNING

Manually adjusting an automatic slack adjuster to bring the pushrod stroke within legal limits is likely masking a mechanical problem. Adjustment is not repairing. Before adjusting an automatic slack adjuster, troubleshoot the foundation brake system and inspect it for worn or damaged components. Improperly maintaining the vehicle braking system may lead to brake failure, resulting in property damage, personal injury, or death.

5. If the pushrod has a threaded clevis, use the gauge supplied with the new slack adjuster to check the adjustment of the clevis, as follows. See **Fig. 3**.



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A. Adjust the clevis in or out to position the 1/4-inch clevis pin within the notched area of the gauge.

1. Installation Gauge

Fig. 3, Checking the Clevis Adjustment

5.1 Position the 1/2-inch hole in the gauge over the end of the 1/2-inch clevis pin.

5.2 Align the applicable 1/4-inch hole in the bottom of the gauge over the center of the camshaft.

5.3 Check that the 1/4-inch pin is visible in the notched area of the gauge. If the pin is not in the right location, back off the slack adjuster and readjust the pushrod length, then repeat this step.

NOTE: Make sure there is clearance between the slack adjuster and other vehicle components when the brakes are applied and the pushrod travels its maximum stroke.

6. Set the initial free-stroke, as follows.

6.1 Turn the adjusting hexnut clockwise until the brake linings contact the drum.

6.2 Turn the adjusting hexnut counterclockwise one-half turn. There should be about 30 lbf·ft (41 N·m) resistance, and a ratcheting sound will be heard.

7. Measure the brake chamber applied stroke, as follows.

7.1 With the brakes fully released, use a ruler to measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 4**.

7.2 Build air pressure to at least 85 psi (586 kPa). Apply the brakes, then measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 4**. The difference between the measurements is the brake chamber stroke.

7.3 The brake chamber stroke must be within the range shown in **Table 1**. If it is not, check the foundation brakes for problems such as worn cams, bushings, pins and rollers, or broken springs. Repair or replace as needed. For instructions, refer to the applicable brake section in this group. Then, repeat the two previous steps.

8. If a rear axle slack adjuster was installed, manually uncage the parking brake. Refer to the applicable brake chamber section in this group for instructions.

9. Apply the parking brakes.

10. Remove the chocks from the tires.

11. In a safe area, check for proper brake operation, as follows.

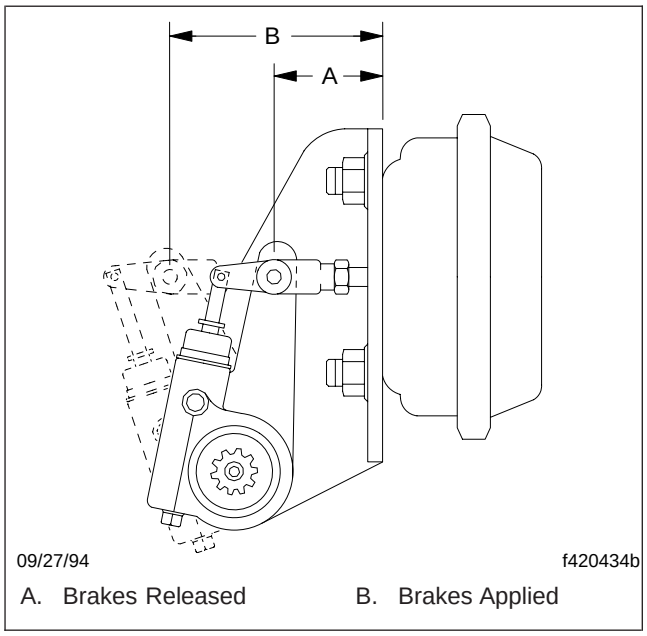


Fig. 4, Stroke Measurements

11.1 Apply and release the brakes several times to check for correct operation of the slack adjusters.

11.2 Perform six low-speed stops to ensure correct parts replacement and full vehicle control.

11.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than the others show a lack of braking effort on those wheels.

Brake Chamber Stroke Specifications			
Chamber Type (Size)	**Maximum Applied Stroke*: inch (mm)**	**Free-Stroke: inch (mm)**	
		New Brake Installation	**In-Service Brake**
Long Stroke†			
16 and 20	2-1/2 (64)	5/8 to 3/4 (16 to 19)	1/2 to 5/8 (13 to 16)
24 and 30	3 (76)		

* Specifications are relative to a brake application with 80–90 psi (550–620 kPa) air pressure in the brake chambers.

† Long stroke design is indicated by a tag, or embossing, on the brake chamber.

Table 1, Brake Chamber Stroke Specifications

Approved Lubricants

Lubricant Type	Temperature
Lubriplate Aero	Above -40°F (-40°C)
Texaco Multifak EP-2 Mobil Grease 77	Above -20°F (-29°C)

Table 1, Approved Lubricants

Maximum Adjusted Brake Chamber Strokes

Chamber Size	Maximum Chamber Stroke
16 20 24	Less than 1-3/4 inches (44 mm)
24 * 30	Less than 2 inches (51 mm)

* Long Stroke

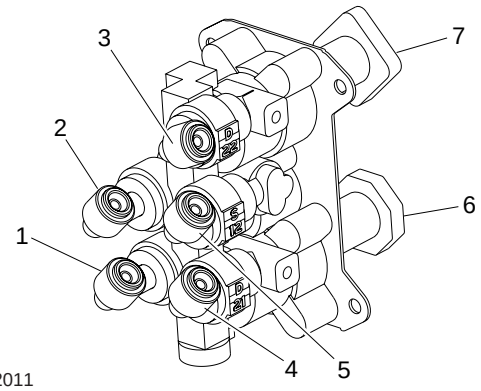
Table 2, Maximum Adjusted Brake Chamber Strokes

General Description

The dash-mounted MV-3 control module is a two-button, push-pull control valve housed in a single body, which includes a dual circuit supply valve and a check valve.

The valve body, plungers, and spools are made out of a nonmetallic, noncorrosive material. All air connections are at the back of the valve. See **Fig. 1**.

The MV-3 module has several functions: tractor protection; trailer service air control; system park; trailer park only; trailer charge with tractor spring brakes applied (tractor park only); and supply reservoir selection.



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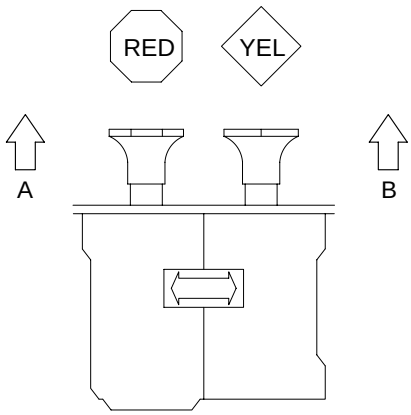
1. Exhaust
2. Primary Reservoir Supply
3. Delivery–Tractor Spring Brakes
4. Delivery–Trailer Supply
5. Secondary Reservoir Supply
6. Trailer Air Supply Knob
7. Parking Brake Control Valve Knob

Fig. 1, MV-3 Parking Brake Valve

The MV-3 includes a spring-loaded, dual-circuit supply valve, which selects the primary air reservoir as the air source for both control valves, unless the pressure in the primary air reservoir falls below that of the secondary air reservoir. Then, the dual-circuit supply valve will shuttle and establish the secondary air reservoir as the air source.

The trailer air supply valve, actuated by the red knob and the yellow knob, delivers air to the trailer supply line. See **Fig. 2**. The parking brake valve, actuated by a yellow knob, controls the spring parking brakes on the tractor, and when exhausted, simultaneously causes the trailer supply valve to trip and exhaust, thus applying both the tractor and the trailer parking brakes as required by federal regulations. See **Fig. 2**. The trailer parking brakes may be independently released by pushing only the trailer air supply valve (red) knob in.



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A. Trailer Brakes Applied
B. Tractor Brakes Applied

Fig. 2, Trailer and Tractor Delivery Air Discharged (control knobs out)

Principles of Operation

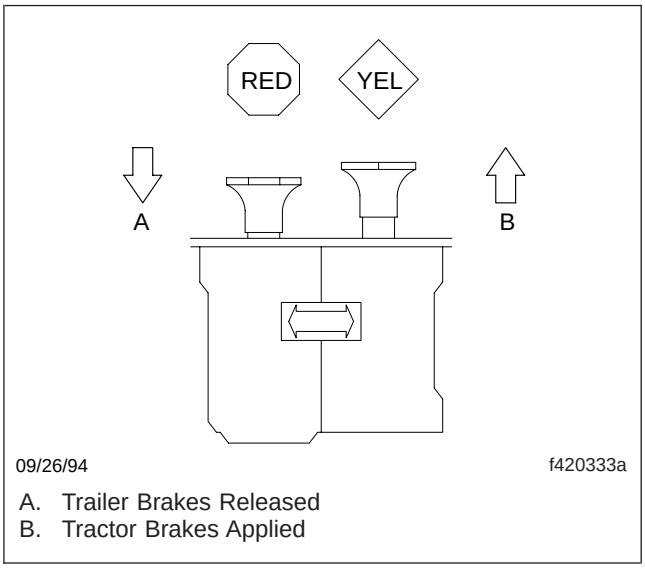
Initial Charge

With both the primary and the secondary systems completely discharged, both knobs are out. See **Fig. 2**. When system pressure reaches 65 psi (448 kPa), the red knob (trailer air supply) may be pushed in, and should stay in, charging the trailer system and releasing the trailer parking brakes. See **Fig. 3**. The yellow knob (parking brake) may now be pushed in, which will supply air to the tractor parking brakes, releasing them.

Normal Operation Position

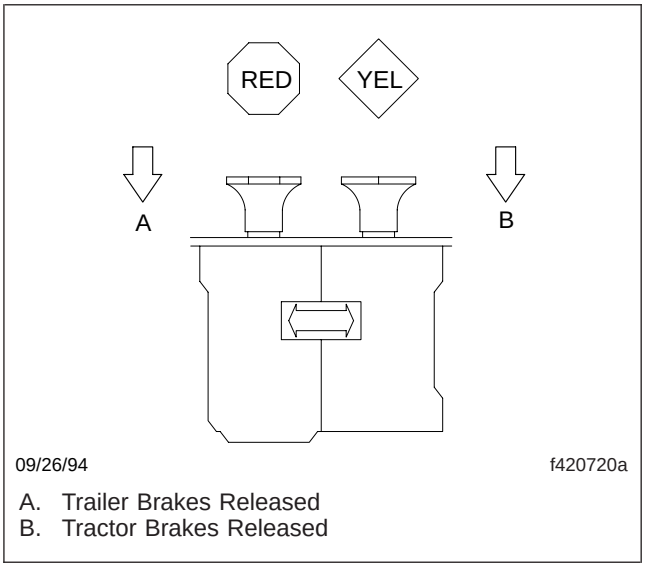
When both knobs are pushed in, air is supplied to the trailer and the tractor parking brakes; all parking brakes are released. See **Fig. 4**. This is the normal operating mode.

General Description and Principles of Operation



A. Trailer Brakes Released
B. Tractor Brakes Applied

Fig. 3, Trailer Parking Brakes Released (red control knob pushed in)

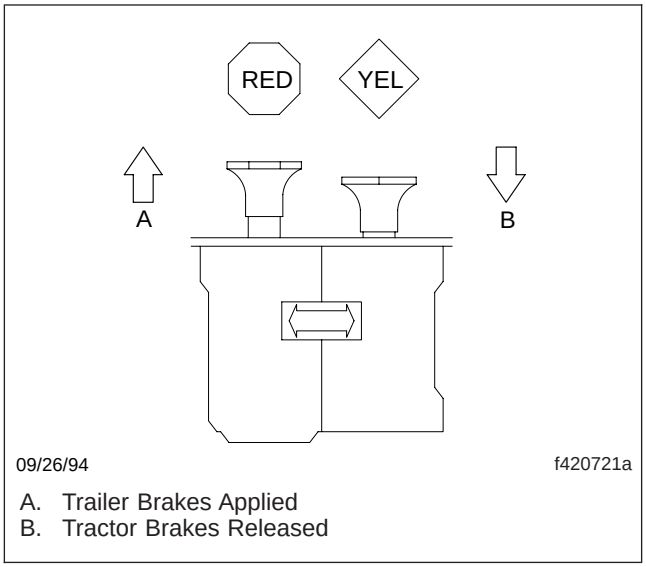


A. Trailer Brakes Released
B. Tractor Brakes Released

Fig. 4, Trailer and Tractor Brakes Released (both control knobs pushed in)

Actuation of Trailer Park or Emergency Brakes

To actuate the trailer parking brakes only, the red knob is pulled out, exhausting the trailer supply line. The trailer parking brakes are now applied, either by emergency air or parking brakes, depending on the type of trailer system. This mode would be used to uncouple from the trailer, and during bobtail operation. See **Fig. 5**.



A. Trailer Brakes Applied
B. Tractor Brakes Released

Fig. 5, Trailer Parking Brakes Applied (red control knob pulled out)

System Park

With both knobs pushed in, the parking brakes on both the tractor and the trailer may be actuated by pulling the yellow (parking brake) knob out. This exhausts the air from the tractor parking brakes and simultaneously causes the red (trailer air supply) knob to pop out, applying the trailer parking brakes (this complies with federal regulations that one control must apply all the parking brakes on the vehicle). See **Fig. 2**.

Trailer Charge

If both valves are out, parking the combination vehicle, and it is desired to recharge the trailer (leaving only the tractor parking brakes applied), the red knob may be pushed in, repressurizing the trailer supply line. This mode might also be used to park a combination vehicle with air-actuated emergency brakes on the trailer to provide demonstrated parking capability with the tractor spring brakes only. See **Fig. 3**.

Automatic Applications

If air pressure drops to 20 to 45 psi (138 to 310 kPa) in both the primary and the secondary systems, the

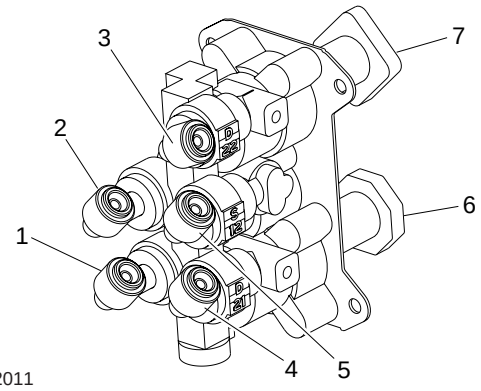
red knob (trailer air supply valve) will automatically pop out, applying the emergency or parking brakes on the trailer. If the red knob is held in manually and the pressure decreases to 25 to 35 psi (172 to 241 kPa), a tripper piston within the MV-3 valve will move upward, exhausting the trailer supply, and applying the trailer parking brakes. If air pressure drops in both the primary and the secondary systems, the yellow (parking brake) knob will pop out at about 20 to 40 psi (138 to 276 kPa), applying the tractor parking brakes.

A warning buzzer and light are activated when pressure in either the primary or the secondary system drops below 64 to 76 psi (441 to 524 kPa).

Tests

With the air brake system charged to 120 psi (827 kPa), check for leaks, using the following instructions. Repair or replace components as needed.

1. Apply a soap solution and check for leakage between the body and cover plate. Leakage at the exhaust port should produce less than a 1-inch (25-mm) bubble in five seconds.
2. With the trailer supply line sealed, push in the red knob. The knob must stay in. Leakage at the exhaust port must not exceed a 1-inch (25-mm) bubble in 5 seconds. See **Fig. 1**.



1. Exhaust
2. Primary Reservoir Supply
3. Delivery–Tractor Spring Brakes
4. Delivery–Trailer Supply
5. Secondary Reservoir Supply
6. Trailer Air Supply Knob
7. Parking Brake Control Valve Knob

Fig. 1, MV–3 Parking Brake Valve

3. Slowly reduce pressure in both service reservoirs. The red knob must pop out at 20 to 35 psi (138 to 310 kPa).

NOTE: Trip-on pressure is the pressure at which the valve automatically changes position or "pops out." It is advised to use an accurate pressure gauge other than those in the truck when performing tests.

4. Hold the red knob in and continue to reduce pressure in all service reservoirs. Air must start to escape from the exhaust port when the trailer line pressure reaches 20 to 35 psi (138 to 241 kPa).
5. Release the red knob and rebuild the supply pressure to 120 psi (827 kPa). Push in the yellow knob; the yellow knob must remain in. Leakage at the exhaust port should not exceed a 1-inch (25-mm) bubble in 5 seconds.
6. Pull the red knob out. Slowly reduce pressure in all service reservoirs. There is not a federal trip pressure requirement for the yellow knob, but it will pop out at 20 to 30 psi (138 to 207 kPa).
7. Charge the system to 120 psi (827 kPa), and push both knobs in. Pull the red knob out. The yellow knob must remain in. Push the red knob in and pull the yellow knob out. The red knob must pop out at once.
8. Install a gauge to monitor tractor spring brake delivery pressure. Build 120 psi (827 kPa) pressure in the primary and secondary air reservoirs. Push in the yellow knob. Delivery pressure should equal the pressure in the primary air reservoir. Reduce the pressure in the primary air reservoir. The dual-circuit supply valve shuttle should switch to the secondary air reservoir. After the primary air reservoir pressure is reduced to zero, there should not be audible leakage at the primary air reservoir opening. Stop the leak that was created in the primary air reservoir.
9. Leaving the yellow knob in, recharge the secondary air reservoir to 120 psi (827 kPa). The delivery pressure should also read 120 psi (827 kPa). Recharge the primary air reservoir to 100 psi (690 kPa). Slowly vent the secondary air reservoir. As the secondary air reservoir pressure and the delivery line pressure descend, pressure should stabilize at about 100 psi (690 kPa).
10. Close all leakage points and charge both reservoirs to 120 psi (827 kPa). Position the red knob out and the yellow knob in. Develop a leak in the spring brake delivery line and hold the yellow knob in. See **Fig. 1**. The air reservoir pressures will go to zero. The dual-circuit supply valve shuttle should cycle during the leak-down period.
11. If the MV-3 fails to operate as described, or leakage exceeds the limits stated, replace or repair it using genuine Bendix parts.

Removal

⚠ WARNING

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

1. Park the vehicle on a level surface, apply the parking brakes, chock the tires, and drain all air tanks to zero pressure.
2. Unscrew the red and yellow buttons from the stems of the spools on the MV-3 valve by turning them in a counterclockwise direction. Mark these buttons in relation to the valve for later reference.
3. Remove the top-center dash panel.
4. Remove the screws from the center dash panel. Using care not to damage any of the air lines or wiring behind the panel, pull the panel away from the dash.
5. Mark and then remove the air lines from the back of the valve.
6. Remove and save the four mounting screws and washers from the four corners of the cover plate.
7. Pull the valve out of the dash.

Installation

1. Connect the air lines to the proper ports as marked during removal.
2. Align the valve in the dash and install the four screws and washers into the corners of the cover plate.
3. Replace the center dash panel.
4. Install the top-center dash panel.
5. Attach the red and yellow buttons onto the threaded stems of the spools, making sure that they are oriented correctly as noted during removal.
6. Remove the chocks.

Disassembly, Cleaning and Inspection, and Assembly

Disassembly

1. Remove the six screws (**Fig. 1** , Ref. 3) from the cover plate (Ref. 4) and carefully remove the cover plate from the valve.
2. Remove the cap (Ref. 5) and O-ring (Ref. 6) from the bore of the tripper valve. Remove the tripper piston (Ref. 7), large spring (Ref. 8), small spring (Ref. 9), and check valve (Ref. 10). These parts will all fall out of the cavity of the MV-3 by tilting the body forward. Remove the O-ring (Ref. 11) from its groove on the piston.
3. Remove the two main spools from the body of the MV-3 valve by grasping the stem and pulling firmly. Remove the spring (Ref. 21) from the bottom of each spool cavity.
4. Pull the guide cap (Ref. 12) and guide spool (Ref. 14) over the threaded end of one of the plungers (Ref. 18). Remove the O-ring (Ref. 13) from the guide cap and the O-ring (Ref. 15) from the guide spool. Remove the other O-rings (Refs. 16, 17, and 20) and the exhaust seal (Ref. 19) from the plunger.
5. Repeat step 4 on the remaining spool assembly.
6. Remove the retaining ring (Ref. 22) from the cavity of the MV-3 body that contains the dual circuit supply valve.
7. Using a pair of needle nose pliers, grasp the bar in the center of the cap and dual circuit supply valve (Ref. 23) and remove the dual circuit valve assembly. Remove the three O-rings (Refs. 24, 25, and 26) from the valve or from the cavity of the body, if some have remained there. Other than the three external O-rings, don't disassemble the piston assembly further.

NOTE: If during the removal of this assembly from the body the cap dislodges from the rest of the valve, the remaining parts can be removed using bent wire. The spring, piston and O-ring that are internal to the dual circuit valve assembly are nonserviceable.

Cleaning and Inspection

The nonmetallic components making up most of the parts of the MV-3 *should not be immersed in any solvent type cleaner* . Old lubricant should be wiped out with a clean dry cloth.

If any visible damage to the body or the spools is found, replace the complete unit.

Assembly

DUAL CIRCUIT SUPPLY VALVE

1. Lubricate all O-rings, bores, and sliding surfaces with silicone lubricant Bendix 291126, Dow Corning 55-M, or equivalent.
2. Install O-rings (Refs. 24, 25, and 26) onto the cap and dual circuit supply valve (Ref. 23). Then install the assembly—small diameter first—into its cavity in the body.
3. Install the retaining ring (Ref. 22) making sure it is fully seated in its groove.

SPOOLS

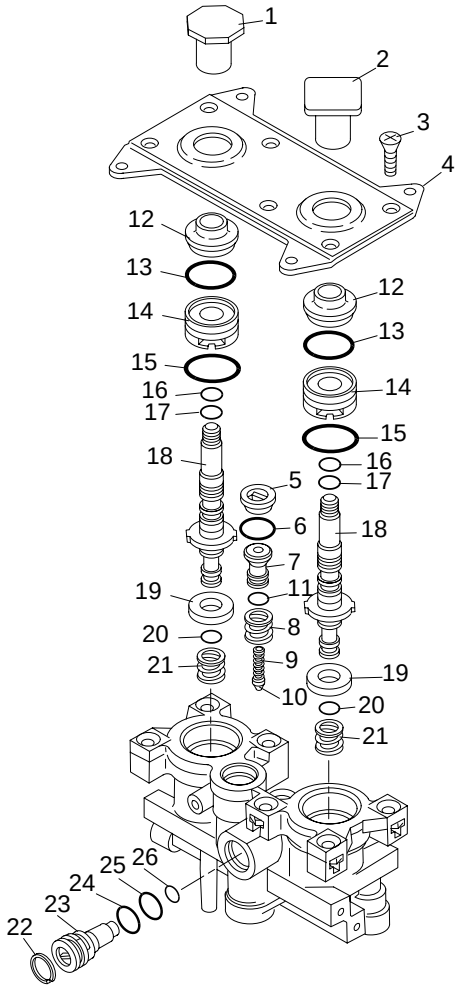
1. Install the O-rings (Refs. 16, 17, and 20) and the exhaust seal (Ref. 19) onto the stem of plungers (Ref. 18).

⚠ CAUTION

CAUTION: The exhaust seal (Ref. 19) must be installed so that its beveled surface mates with the beveled surface of the plunger (Fig. 2).

2. Install the O-ring (Ref. 15) onto the guide spool (Ref. 14) and the O-ring (Ref. 13) onto the guide cap (Ref. 12). Place the guide cap on top of the guide spool, and install the entire assembly over the threaded end of the plunger (Ref. 18); press down firmly until it snaps into place.
3. Install the spring (Ref. 21) over the boss in the bottom of the spool cavity in the body of the MV-3 valve. Place the spool assembly into the body, keeping the spool square to the body. Press and turn the stem until the spool is fully seated in its cavity. Note the assembly is keyed and can be installed one way only.
4. Repeat steps 2, 3, and 4 for the opposite spool.

Disassembly, Cleaning and Inspection, and Assembly



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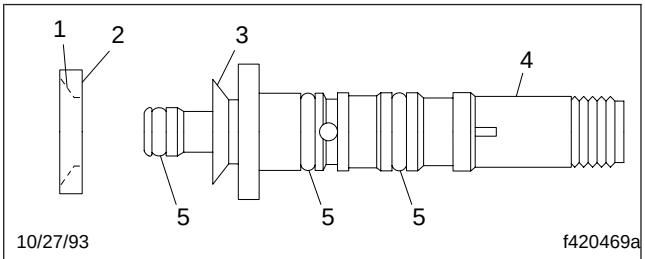
1. Red Button
2. Yellow Button
3. Screw
4. Cover Plate
5. Cap
6. O-Ring
7. Tripper Piston
8. Spring, Large Diameter
9. Spring, Small Diameter
10. Check Valve
11. O-Ring
12. Guide Cap
13. O-Ring
14. Guide Spool
15. O-Ring
16. O-Ring
17. O-Ring
18. Plunger
19. Exhaust Seal, Beveled
20. O-Ring
21. Spring
22. Retaining Ring
23. Cap and Dual Circuit Valve Assembly
24. O-Ring
25. O-Ring
26. O-Ring

Fig. 1

SHUTTLE AND CHECK VALVE

1. Install the O-ring (Ref. 11) into its groove on the tripper piston (Ref. 7); then install the O-ring (Ref. 6) onto the cap (Ref. 5).
2. Install the large spring (Ref. 8) on the piston (Ref. 7) and the small spring (Ref. 9) on the boss of the check valve (Ref. 10).
3. Install the spring and check valve into their cavity in the body of the MV-3 valve (tapered end of the



1. Inside Diameter Bevel
2. Exhaust Seal
3. Mating Exhaust Seal Bevel
4. Plunger
5. O-Rings

Fig. 2

valve to enter cavity first). Make sure the spring (Ref. 9) is centered in the bore.

4. Install the piston assembly into the cavity, making sure the spring (Ref. 9) mates with the bore of the piston.
5. Install the cap (Ref. 5) with O-ring (Ref. 6).
6. Attach the cover plate (Ref. 4) to the valve body using the six screws. Torque them 25 lbf·in (280 N·cm).
7. Check the operation of the valve using the instructions **in Subject 100**.

General Description

The GTD 4000-2 quick release valve provides fast release of the trailer brake. It is installed on the tractor protection valve on vehicles equipped with a tractor/trailer air system, and connects to the trailer air brake line.

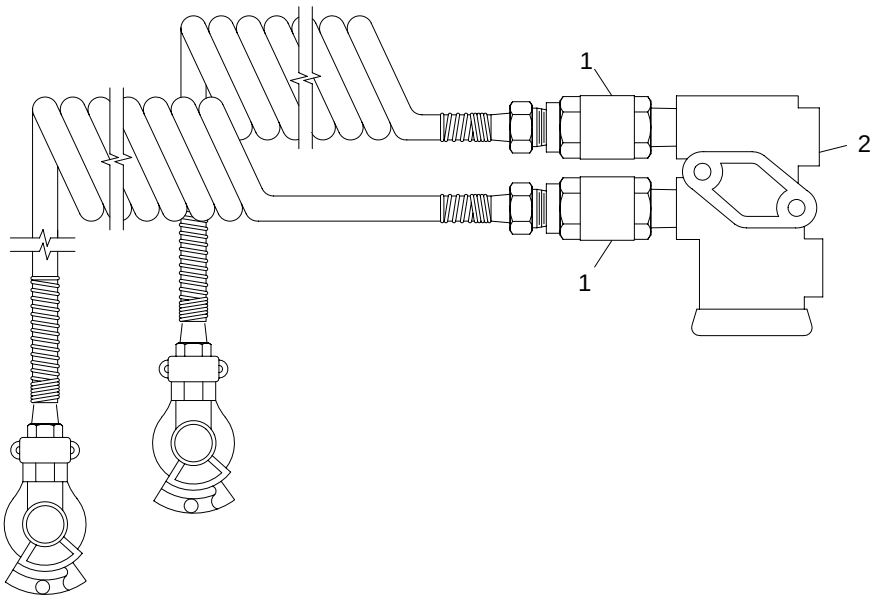
The valve is screwed into the service delivery port of the tractor protection valve. On some ve-hicles a second quick-release valve is screwed into the parking brake delivery port of the tractor protection valve. **See Fig. 1**.

Principles of Operation (See Fig. 2)

When the brakes are applied, air passes through the quick-release valve to the trailer service brakes. When the brakes are released slowly, air passes from the trailer brakes through the quick release valve, and exhausts at the foot valve.

When the brakes are released quickly, the sudden pressure drop moves the diaphragm inside the quick release valve, which prevents the air from exhausting through the foot valve. Instead, it exhausts through the quick-release valve, which releases the trailer brakes more quickly.

General Description and Principles of Operation



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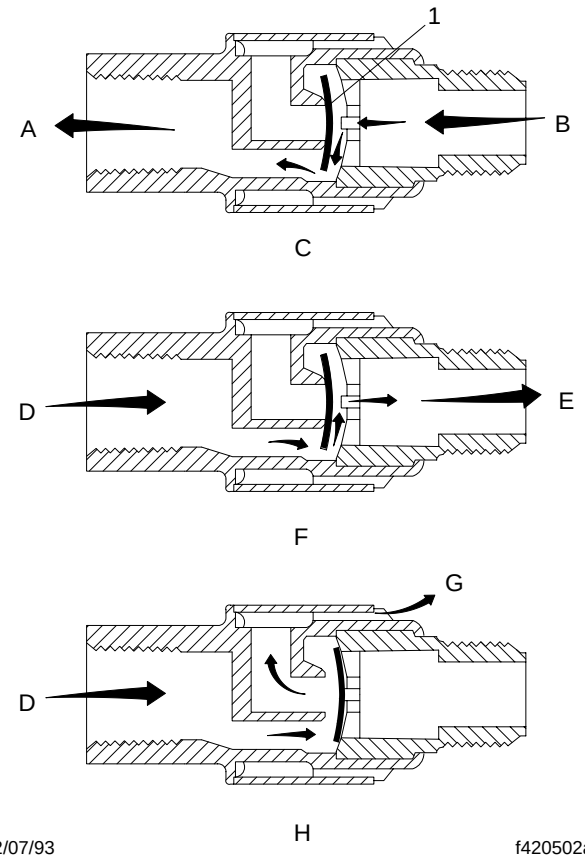
NOTE: Not all parts are shown.

1. Quick-Release Valve
2. Tractor Protection Valve

Fig. 1



A. Air flow to trailer
B. Air flow from tractor
C. Brakes Applied
D. Air flow to trailer
E. Air flow to tractor
F. Brakes Released Slowly
G. Air flow to atmosphere
H. Brakes Released Quickly
1. Diaphragm

Fig. 2

Operation Test

1. With the system pressurized and the trailer brakes connected, apply the brakes, then slowly release them. There should be no audible leakage or exhaust from the quick-release valve.
2. Apply the brakes a second time, then release them quickly. Air should exhaust through the quick-release valve.

   If the valve fails the above test, replace it.

Leakage Test

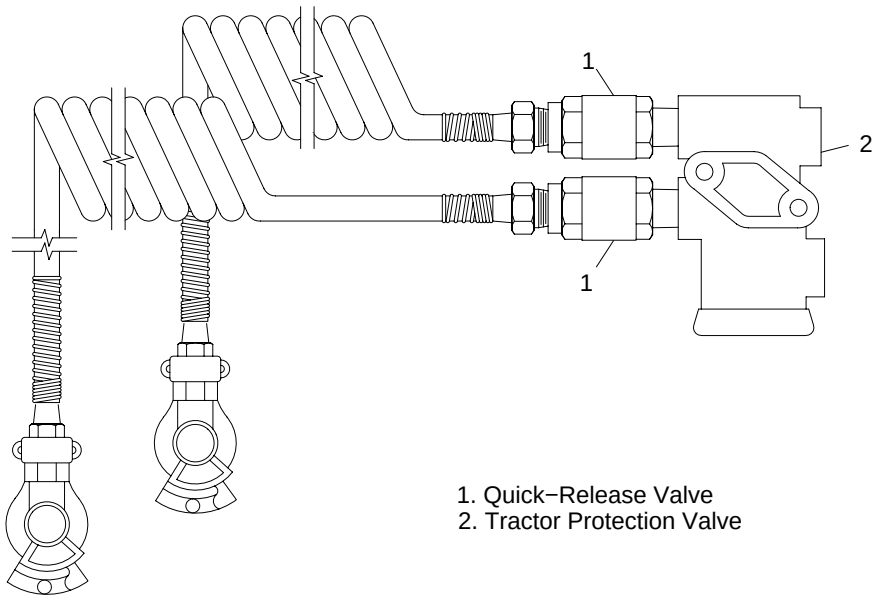
1. Pressurize the air system.
2. Coat the quick-release valve with a soapy solution. Leakage resulting in a 1-inch (2.5-cm) bubble or less every ten seconds is acceptable. If the leakage is more than above, replace the valve.

Removal

⚠ WARNING

WARNING: Wear safety goggles when draining the air system or disconnecting an air line because dirt or sludge particles could fly out at high speeds. Don't direct the air stream at other people. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

1. Drain the air from the air reservoirs.
2. Carefully disconnect the air line from the quick-release valve.
3. Unscrew the quick-release valve from the tractor protection valve. **See Fig. 1.**



1. Quick−Release Valve
2. Tractor Protection Valve

NOTE: Not all parts are shown.

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Fig. 1

Installation

1. Screw the quick-release valve into the applicable delivery port of the tractor protection valve. Make sure the arrow stamped on the valve is pointing toward the trailer air line.
2. Connect the air line to the quick-release valve. Tighten the connection firmly.

General Description

The Haldex (SAB) automatic slack adjuster serves two main functions:

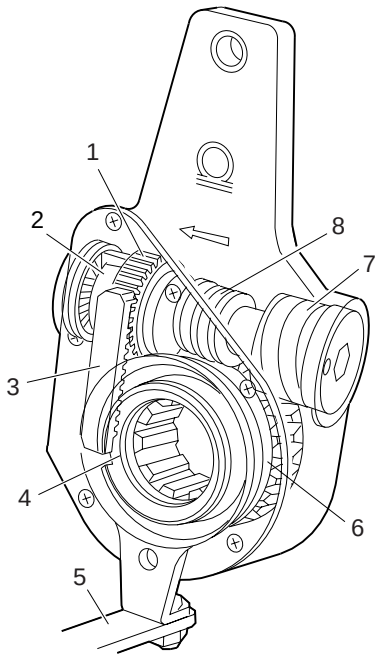
- As a lever, it converts the straight-line force of the air brake chamber push rod to torque on the brake camshaft. Rotation of the camshaft spreads the brake shoes out against the brake drum, applying the brakes.
- As an adjuster, it maintains cam brake chamber push rod stroke and lining-to-drum clearance automatically during normal use.

Principles of Operation

When the brakes are applied, the slack adjuster rotates and moves the shoes into contact with the drum. The clearance notch (**Fig. 1** , Ref. 4) corresponds to the normal lining-to-drum clearance. Different notches are available to meet the requirements of various vehicles and brake duty cycles. As the brake application continues, the rack (Ref. 3) moves upward and rotates the one-way clutch (Ref. 1) which slips in this direction.

As the brake pressure increases, the torque increase on the slack adjuster causes a relative movement between the body and the camshaft. This motion forces the worm shaft (Ref. 8) over to compress the coil spring (Ref. 7), releasing the cone clutch (Ref. 2). If the brakes are out of adjustment, any further torque will change the position of the one-way clutch in relation to the cone clutch.

When the brake begins its return stroke, the coil spring load returns to normal and the cone clutch is again engaged. The rack is pulled back to its original position in the notch. Any additional travel brought about by brake lining wear causes the rack to turn the locked one-way clutch and rotates the worm shaft through the locked cone clutch. The worm shaft then rotates the worm wheel (Ref. 6) and camshaft, adjusting the brakes.



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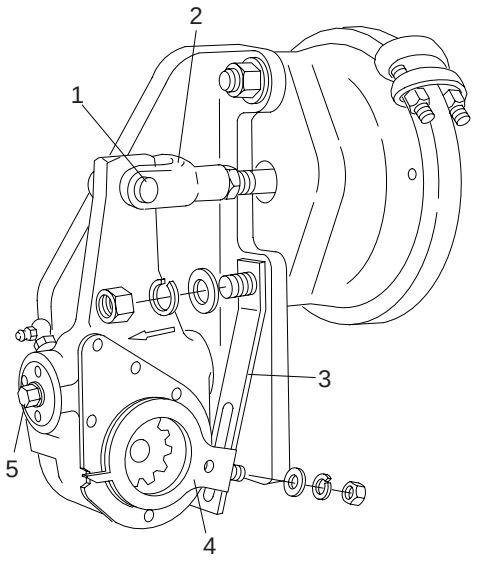
1. One-Way Clutch
2. Cone Clutch
3. Rack
4. Clearance Notch
5. Control Arm Anchor Bracket (design will vary depending on the axle)
6. Worm Wheel
7. Coil Spring
8. Worm Shaft

Fig. 1

Slack Adjuster Removal and Installation

Removal

1. With the vehicle parked on a level surface, set the parking brakes, and shut down the engine. Chock the tires.
2. If a rear-axle slack adjuster will be removed, release the parking brakes and cage the power spring of the parking brake chamber. For instructions, refer to the applicable brake chamber section in this group.
3. Remove the anchor bracket fasteners and the anchor bracket. See **Fig. 1**.



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1. Clevis Pin
2. Clevis
3. Anchor Bracket
4. Control Arm
5. Adjusting Hexnut

Fig. 1, Anchor Bracket Removal/Installation

4. Remove the cotter pin from the clevis pin. Remove the clevis pin.
5. Remove the snap ring that secures the slack adjuster on the camshaft.

CAUTION

Do not use an impact wrench on the adjusting hexnut. To do so may damage the slack adjuster or camshaft.

6. Using a 7/16-inch box wrench, turn the adjusting hexnut counterclockwise to move the adjuster arm out of the clevis. A minimum of 13 lbf·ft (18 N·m) is required to overcome the internal clutch. You will hear a ratcheting sound.
7. Remove the slack adjuster from the camshaft.

Installation

NOTE: For brake chambers that have pushrods with threaded clevises, measure the pushrod length before installing the new slack adjuster. With the brakes fully released, and no air pressure to the chamber, check the dimension between the chamber face and the centerline of the 1/2 inch clevis pin hole. It should be 2.25 inches (57 mm) for long stroke chambers, and 2.75 inches (70 mm) for standard stroke chambers.

1. Check that the brake-chamber pushrod is fully retracted.
2. Apply antiseize compound to the camshaft splines.

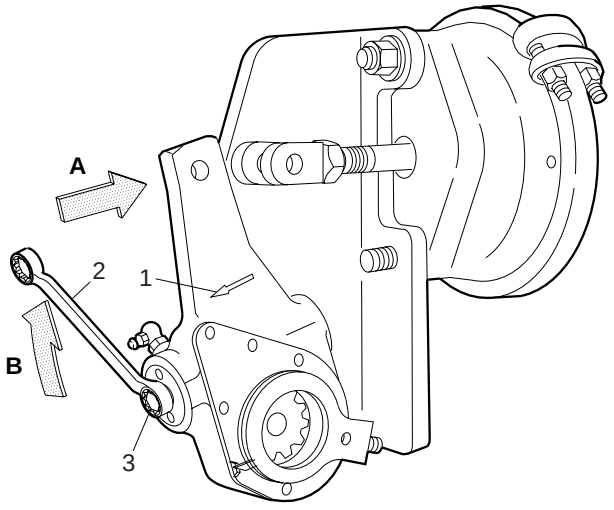
IMPORTANT: When correctly installed, the brake-chamber pushrod pushes in the direction of the arrow on the slack adjuster housing.

3. Install the slack adjuster on the camshaft, with the adjusting hexnut pointing away from the brake chamber. See **Fig. 2**.
4. Using a snap ring, secure the slack adjuster on the camshaft. Use at least one inner washer and enough outer washers to allow no more than 0.060-inch (1.52-mm) movement on the shaft.

IMPORTANT: Never pull the pushrod out to meet the slack adjuster or push the slack adjuster into position. Always turn the adjusting hexnut for positioning.

5. Using a 7/16-inch box wrench, turn the adjusting hexnut clockwise until the slack adjuster hole is aligned with the pushrod clevis hole. See **Fig. 2**.
6. Apply antiseize compound to the clevis pin, and insert the pin in the clevis hole. Do not install the cotter pin at this time.

Slack Adjuster Removal and Installation



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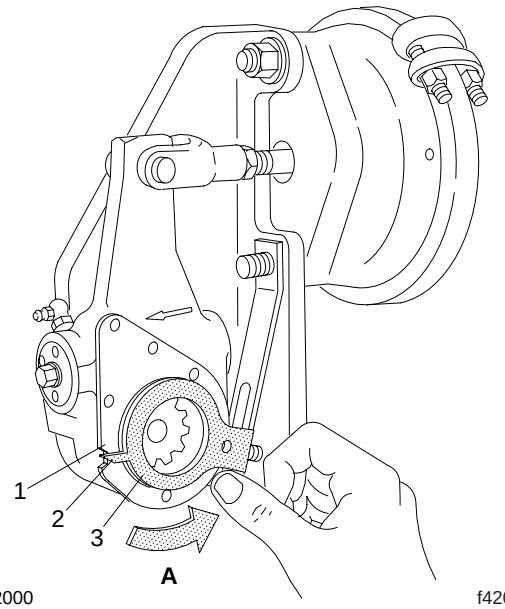
A. Use only the adjusting hexnut to align the slack adjuster with the pushrod clevis.
B. Turn the adjusting hexnut clockwise.

1. Direction of Applied Stroke
2. Box Wrench, 7/16 inch
3. Adjusting Hexnut

Fig. 2, Slack Adjuster Installation



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NOTE: The installation indicator must be aligned with the indicator notch.

A. Rotate the control arm counterclockwise until it stops.

1. Indicator Notch
2. Installation Indicator
3. Control Arm

Fig. 3, Aligning the Control Arm

CAUTION

Never hammer the control arm. Hammering may damage the slack adjuster or camshaft splines.

7. Rotate the control arm away from the adjusting hexnut toward the brake chamber until it comes to a definite internal stop. Make sure the installation indicator is in the center of the indicator notch on the slack adjuster. See **Fig. 3**.

IMPORTANT: If the installation indicator is not aligned with the indicator notch, the brakes will be too tight.

NOTE: The anchor bracket and slack adjuster housing design will vary, depending on the axle. The anchor bracket mounting location is determined by the length of the control arm.

8. Install the control-arm anchor bracket, as follows. See **Fig. 1**.
   - 8.1 Tighten the anchor bracket fastener at the control arm 10 to 15 lbf·ft (14 to 20 N·m), making sure the control arm does not move from its position.
   - 8.2 Tighten the fastener at the brake chamber mounting stud according to the brake chamber manufacturer's specifications.
9. Adjust the brakes. See "Brake Adjustment".

Brake Adjustment

NOTE: A properly working self-adjusting slack adjuster does not require manual adjustment while in service.

WARNING

Manually adjusting an automatic slack adjuster to bring the pushrod stroke within legal limits is likely masking a mechanical problem. Adjustment is not repairing. Before adjusting an automatic slack adjuster, troubleshoot the foundation brake

system and inspect it for worn or damaged components. Improperly maintaining the vehicle braking system may lead to brake failure, resulting in property damage, personal injury, or death.

1. Adjust the brake lining clearance by manually turning the adjusting hexnut clockwise until the brake lining contacts the brake drum, then back off the hexnut counterclockwise 1/2 turn. You will hear a ratcheting sound.

IMPORTANT: Incorrect installation can cause dragging brakes.

2. Make sure the brakes are still fully released, then check the position of the installation indicator on the control arm. It must be within the indicator notch on the slack adjuster.

   If the indicator is out of position, loosen the control arm fasteners and repeat the control-arm adjustment procedure. Then, tighten the bracket fasteners.

⚠ WARNING

Install and lock a new cotter pin in the clevis pin. Failure to do so could allow the pushrod to disengage from the slack adjuster, causing a loss of braking ability that could result in personal injury and property damage.

3. Install and lock a new cotter pin in the clevis pin.

IMPORTANT: Ensure that the air system has at least 100 psi prior to uncaging the brake chamber. This will aid in the uncaging of the parking brake since the parking brake should be fully released.

4. If a rear-axle slack adjuster was installed, manually uncage the parking brake. For instructions, refer to the applicable brake chamber section in this group.

⚠ WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

IMPORTANT: To check the brake adjustment, measure both the applied and free strokes.

NOTE: The location of the measurements is the same for both strokes but the applied stroke is measured with the brakes applied, while a lever is used to manually move the slack adjuster to measure the free stroke.

5. Measure the free stroke, as follows. The free stroke is the distance the slack adjuster has to travel to move the brake shoes against the drum.

   5.1 With the brakes released, measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. Record the exact distance as measurement A.

   5.2 Using a lever, move the slack adjuster until the brake shoes contact the drum. Measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. Record the exact distance as measurement B.

   5.3 Subtract measurement A from measurement B to determine the free stroke. For new brake installations, the free stroke should be 5/8 to 3/4 inch (16 to 19 mm). For in-service brakes, the free stroke should be 1/2 to 5/8 inch (13 to 16 mm). If it is not in this range, refer to **Troubleshooting 300**.

6. Measure the applied stroke, as follows.

   6.1 With the brakes released (pushrod fully retracted), measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. See **Fig. 4**. Record the exact distance as measurement A.

   6.2 Apply and hold an 80 psi (551 kPa) brake application. Measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. Record the exact distance as measurement B.

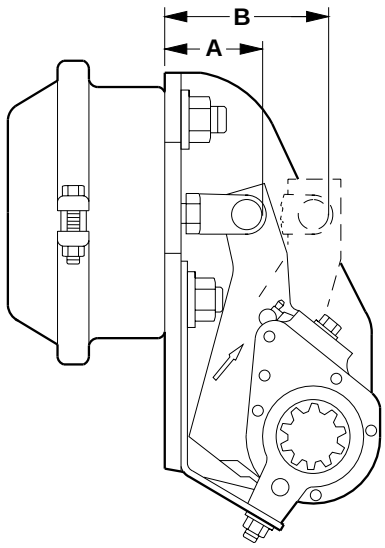
   6.3 Subtract measurement A from measurement B to determine the applied stroke. Compare this value to the value in **Table 1**.

   6.4 If the stroke varies or is greater than the maximum allowed length, refer to **Section 42.27, Subject 140**.

7. Apply the parking brakes.

Slack Adjuster Removal and Installation

8. Remove the chocks from the tires.
9. In a safe area, check for proper brake operation, as follows.
   - 9.1 Apply and release the brakes several times to check for correct operation of the slack adjusters.
   - 9.2 Perform six low-speed stops to ensure correct parts replacement and full vehicle control.
   - 9.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than the others show a lack of braking effort on those wheels.



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NOTE: Measurements are from the bottom of the brake chamber to the far side of the clevis-pin hole.

A. Measurement with brakes released.
B. Measurement with brakes applied at 80 psi (551 kPa).

Fig. 4, Brake Applied Stroke Check

Brake Chamber Stroke Specifications			
Chamber Size	Maximum Applied Stroke: inch (mm)	Free Stroke: inch (mm)	
		New Brake Installation	In-Service Brake Installation
16	1-3/4 (44)	5/8–3/4 (16–19)	1/2–5/8 (13–16)
20			
24	1-7/8 (48)		
30	2 (51)		

Table 1, Brake Chamber Stroke Specifications

Problem—Tight or Dragging Brakes

Possible Cause	Remedy
The control arm anchor bracket is not positioned properly.	See instructions **in Subject 100**.
System air pressure is too low to fully release the spring brake.	Check that the air governor cuts out at the recommended setting.
A spring brake diaphragm is ruptured or a piston seal is leaking.	Replace the diaphragm or spring brake piston seal.
A return spring in the brake chamber is broken.	Replace the spring brake return spring.
The push rod binds on the chamber housing.	Check for correct alignment and correct chamber mounting bracket. Adjust or replace parts as needed.
The air supply does not exhaust completely.	Test the air system valves for leakage and correct operation.
The brake drums are out-of-round.	Turn the brake drums, if possible. If the maximum allowable diameter of any brake drum has been exceeded, replace the drum. Also, turn or replace the other drum on the axle. For turning the drums, refer to the brake manufacturer's service manual.
Extreme differences exist in lining-to-drum clearances between shoes on the same wheel.	Check for proper operation of the brake mechanism. Lubricate or overhaul as needed.
The wheel bearings are out of adjustment.	Adjust the wheel bearings, or replace them if damaged. For instructions refer to the front and rear axle groups in this manual.
The brake shoe return spring is broken.	Replace the brake shoe return spring.

Problem— Brake Chamber Push Rod Travel Is Excessive

Possible Cause	Remedy
The control arm anchor bracket is loose, broken, or bent.	Tighten or replace the anchor bracket as required.
There is excessive wear between the anchor bracket bolt and the control arm slot.	Replace the worn parts.
The control arm assembly is damaged or worn, resulting in lateral movement between the control arm and the cover plate.	Replace the slack adjuster.
The camshaft bushings are worn.	Replace the worn camshaft bushings.
The camshaft binds.	Lubricate the camshaft or overhaul the brake mechanism as needed.
The brake chamber mounting is loose.	Tighten the brake chamber mounting fasteners.
The slack adjuster is bound against the camshaft housing. There is no end play.	Check that the correct camshaft and camshaft tube have been used and that they are assembled correctly. Overhaul the brake mechanism as needed.
The slack adjuster clutch assembly is worn.	Replace the slack adjuster.

Truck Without Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

See Fig. 1 for a full view of the plumbing diagram truck without brake proportioning, with 6-channel antilock (if equipped), and with 24-inch or larger front brake chambers. **See Fig. 2**, or **Fig. 3** for partial (detailed) views of the plumbing diagram for truck without brake proportioning, with 6-channel antilock (if equipped), and with 24-inch or larger front brake chambers.

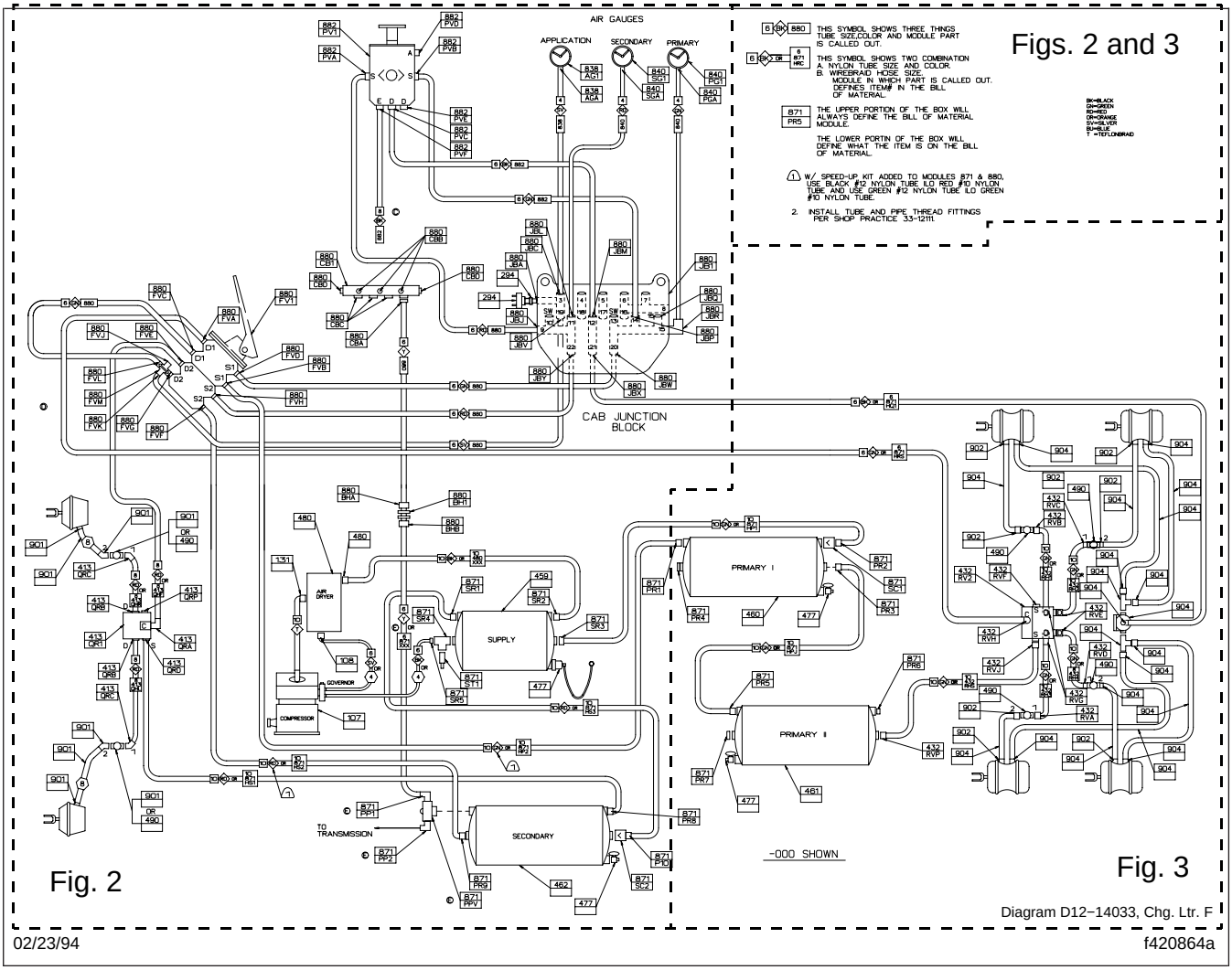

Fig. 1, Truck Without Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

Truck Without Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

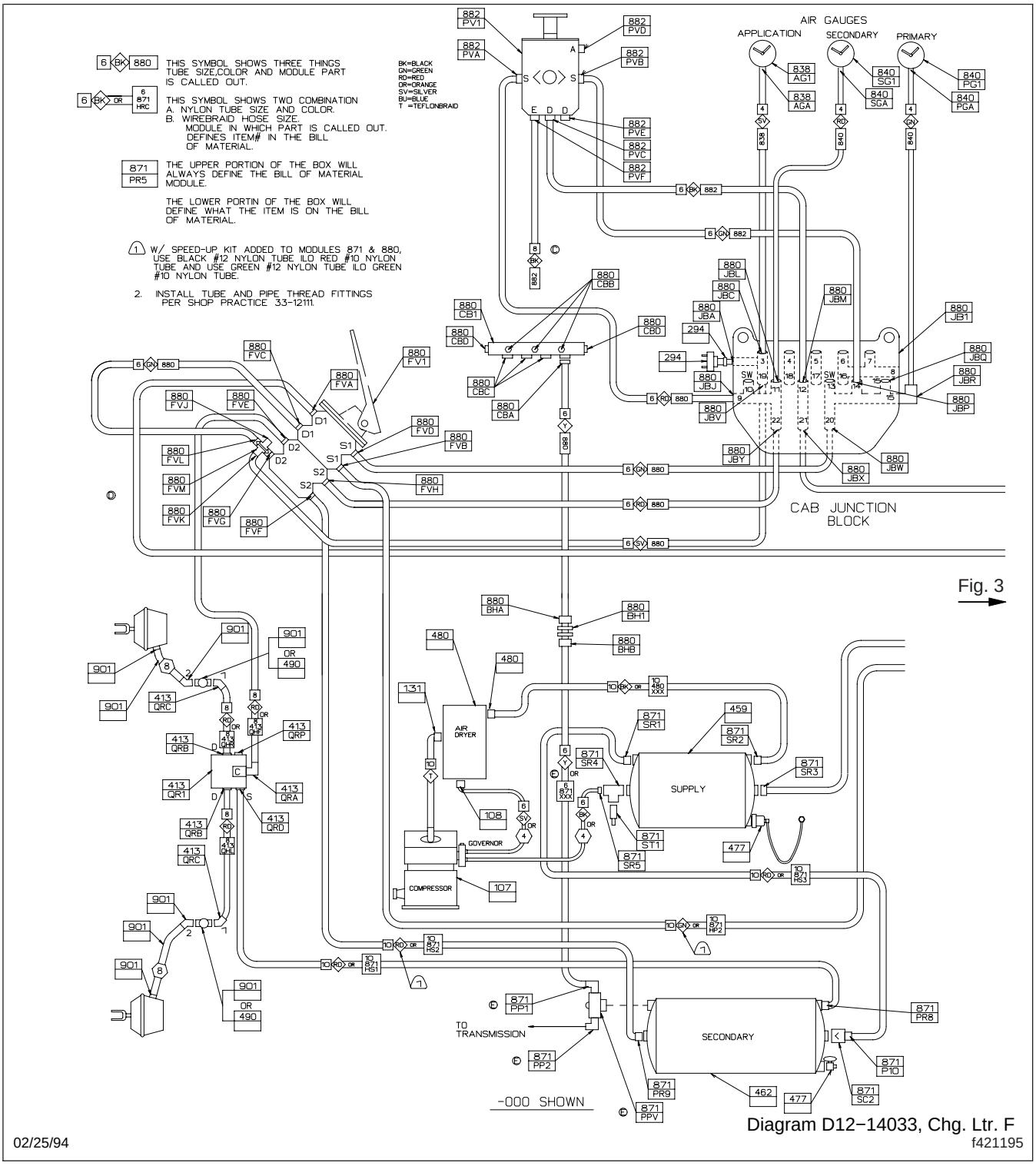

Fig. 2

Truck Without Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

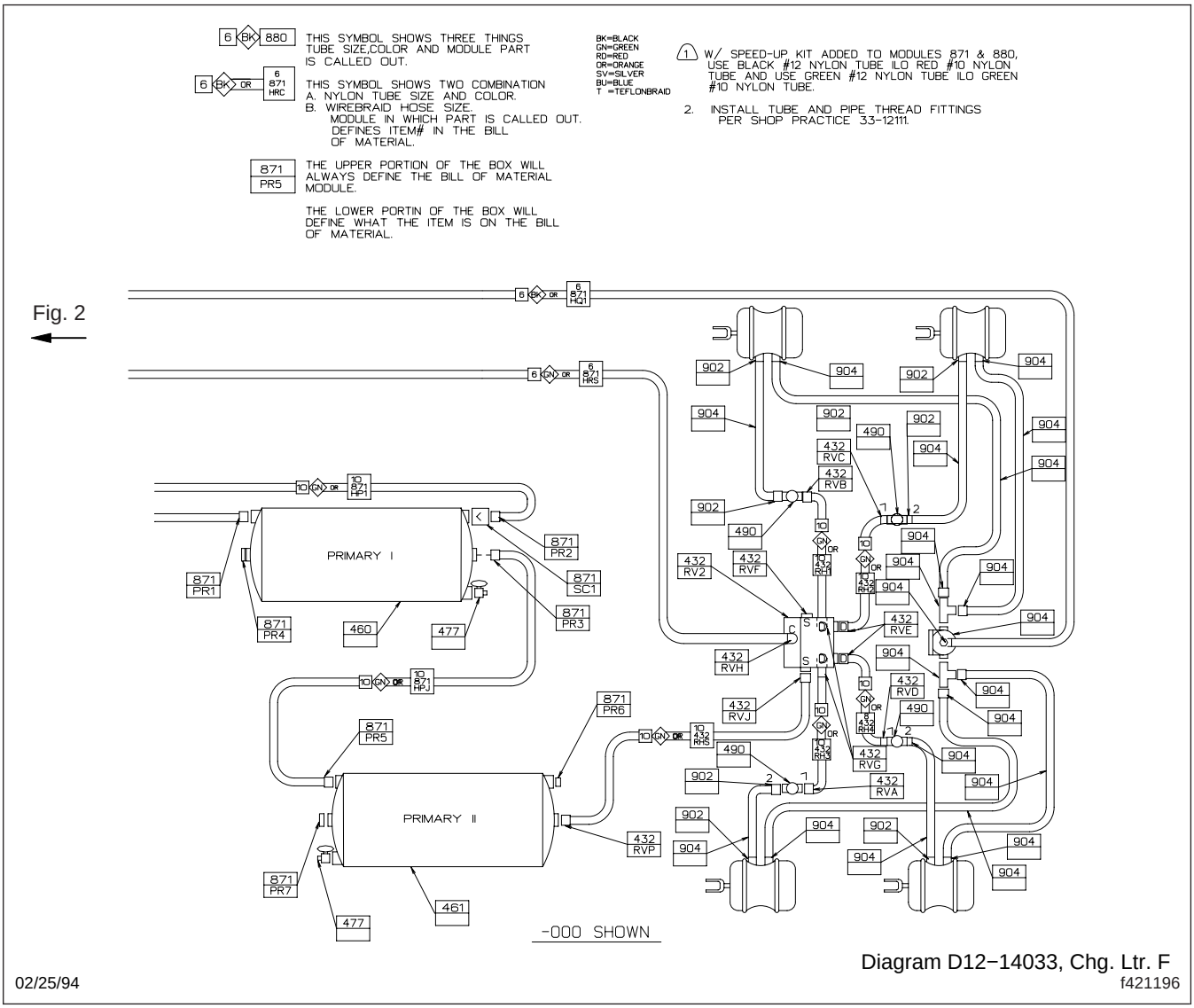

Fig. 2

Diagram D12−14033, Chg. Ltr. F

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Fig. 3

Truck Without Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

See Fig. 1 for a full view of the plumbing diagram truck without brake proportioning, with 6-channel antilock (if equipped), and with 20-inch or smaller front brake chambers. **See Fig. 2**, or **Fig. 3** for partial (detailed) views of the plumbing diagram for truck without brake proportioning, with 6-channel antilock (if equipped), and with 20-inch or smaller front brake chambers.

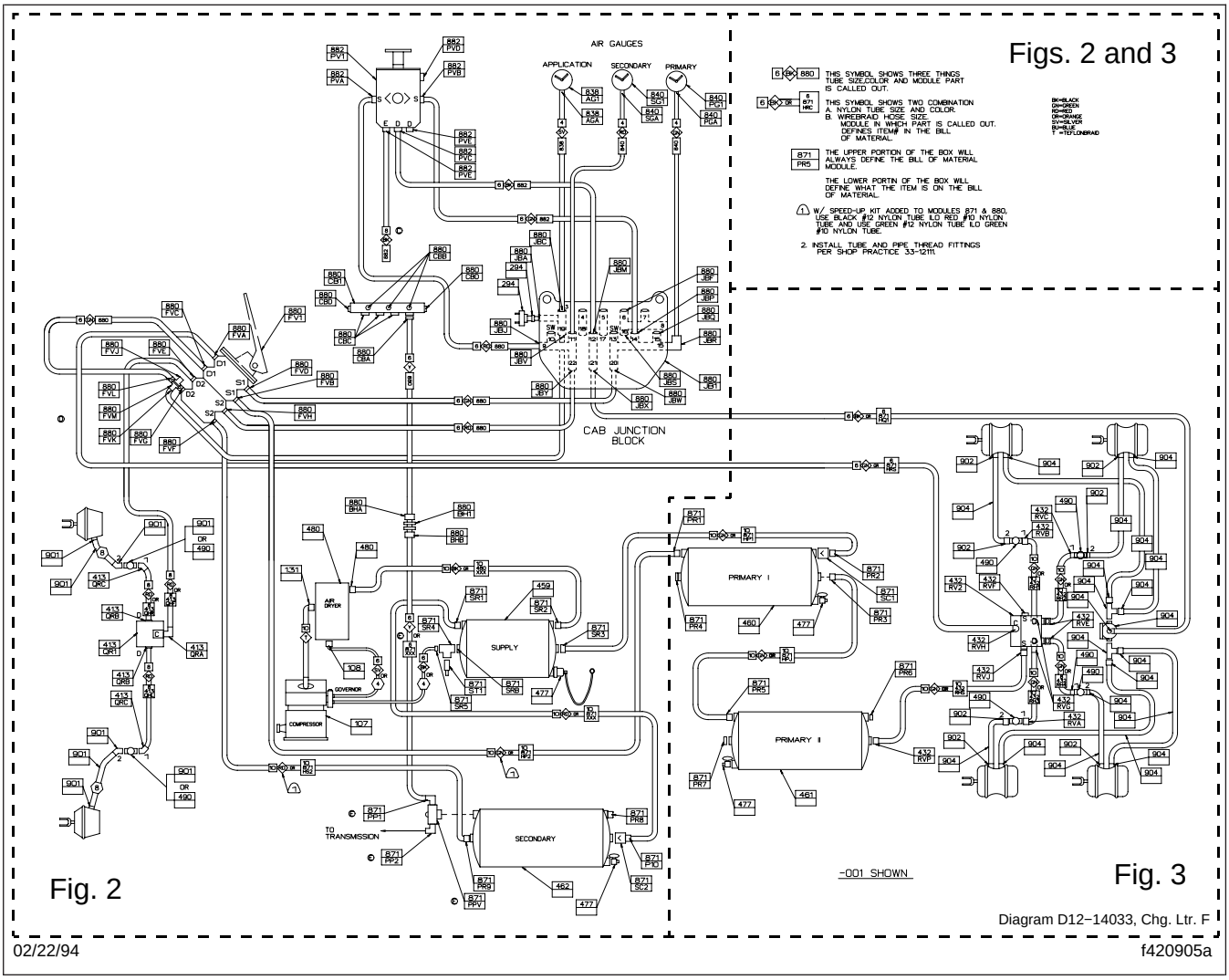

Fig. 1, Truck Without Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

Truck Without Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

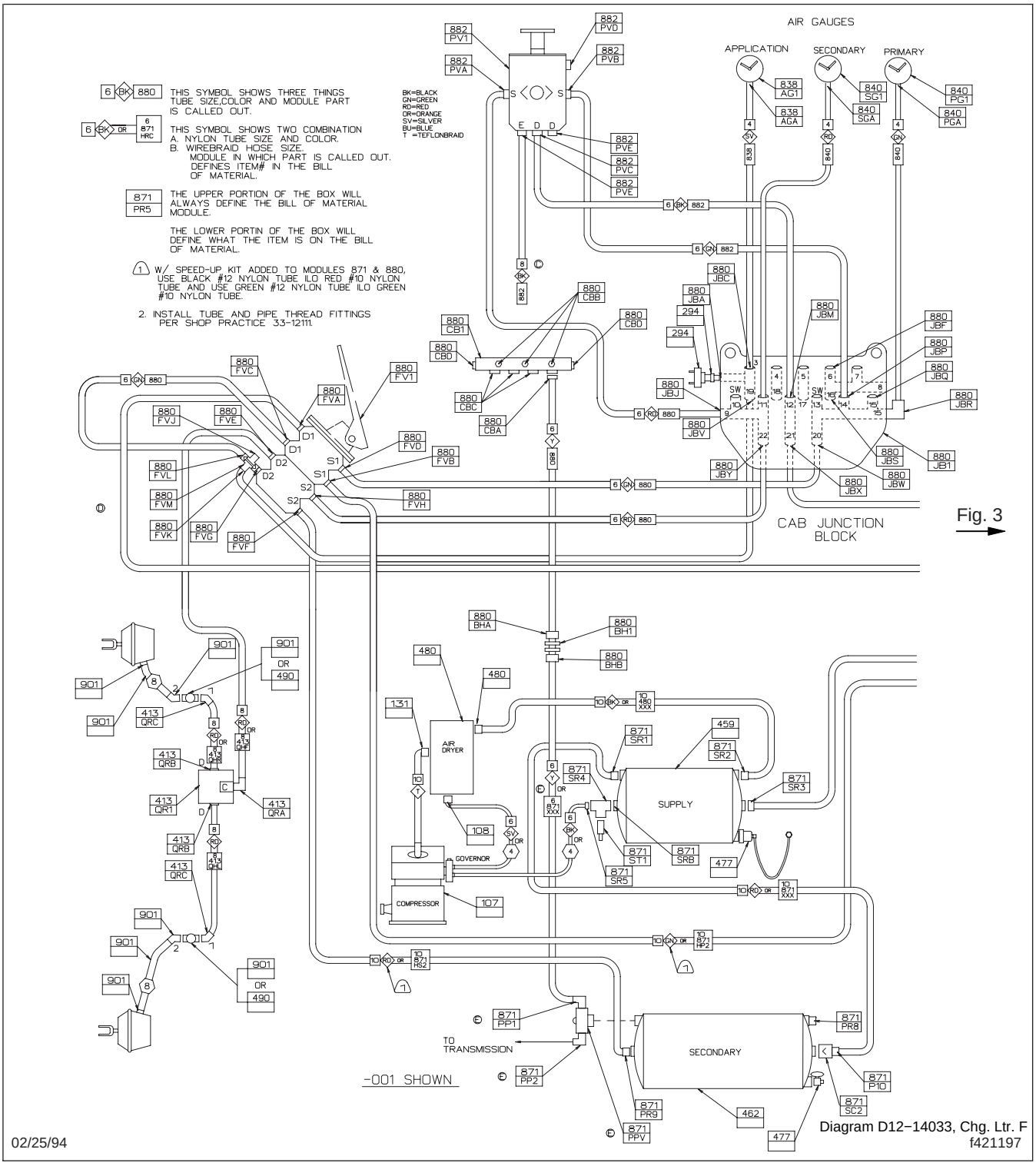

Fig. 3

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Diagram D12−14033, Chg. Ltr. F
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Fig. 2

Truck Without Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

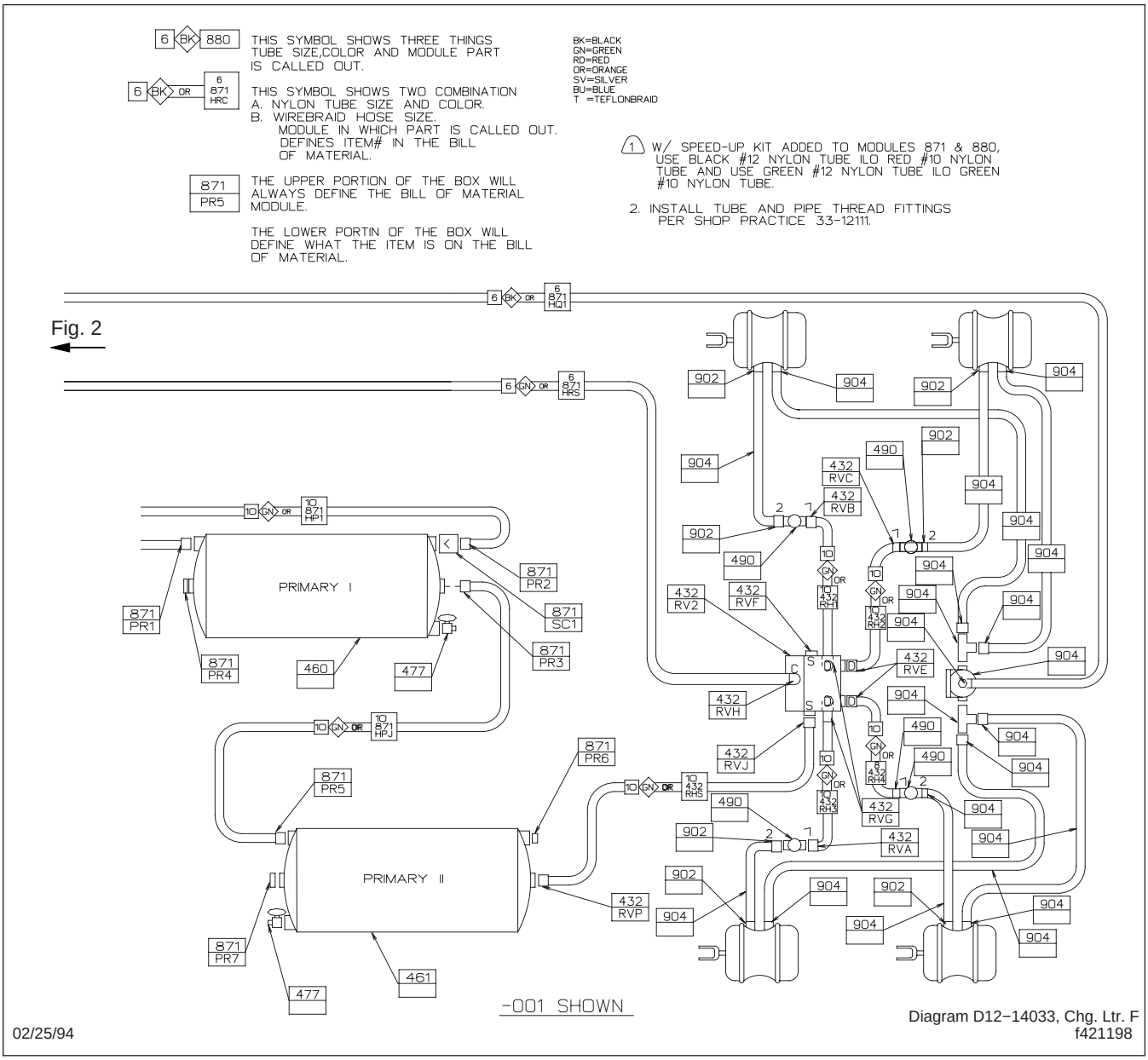

Fig. 3

Truck Without Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

See Fig. 1 for a full view of the plumbing diagram truck without brake proportioning, with 4-channel antilock (if equipped), and with 24-inch or larger front brake chambers. **See Fig. 2**, or **Fig. 3** for partial (detailed) views of the plumbing diagram for truck without brake proportioning, with 4-channel antilock (if equipped), and with 24-inch or larger front brake chambers.

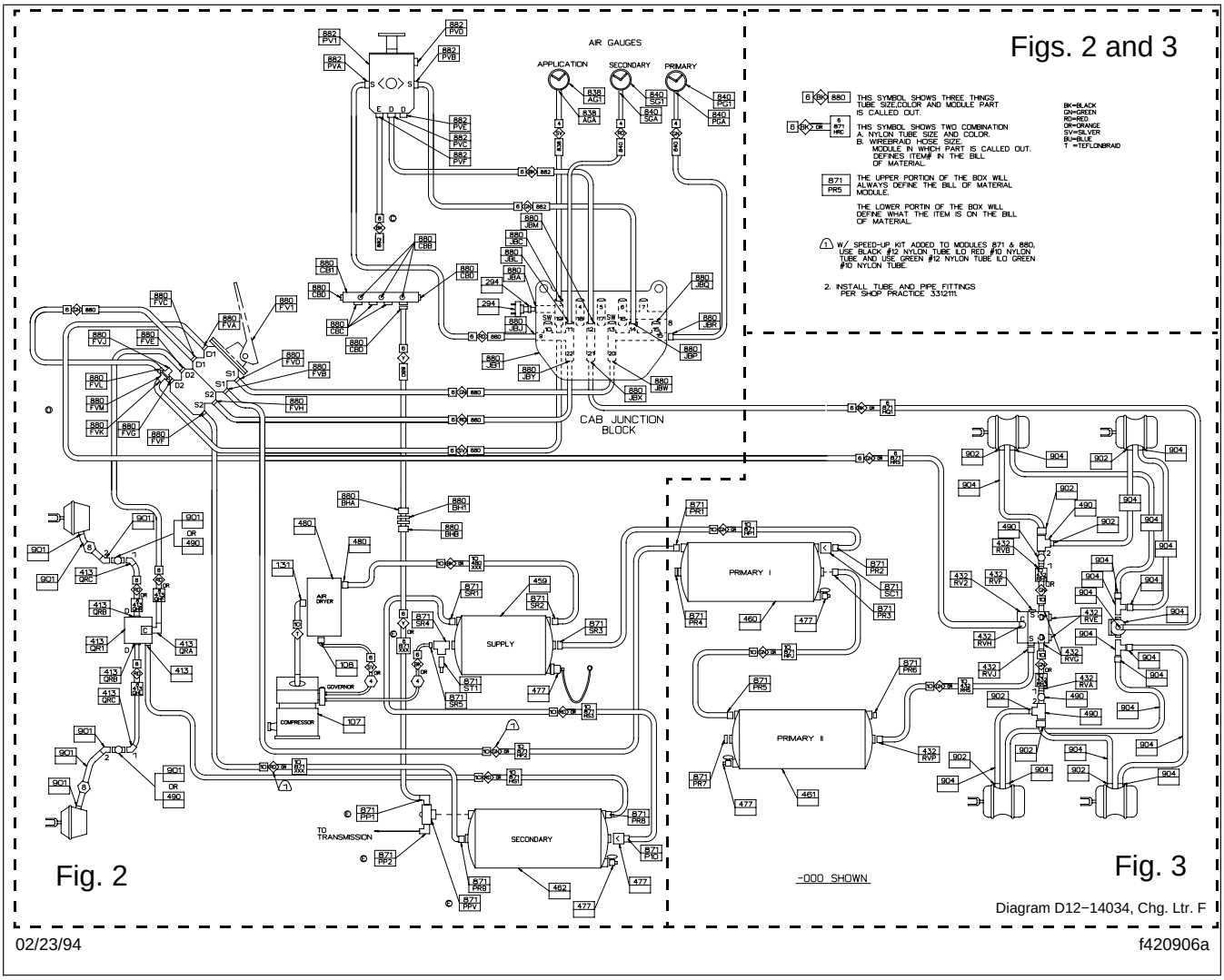

Fig. 1, Truck Without Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

Truck Without Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

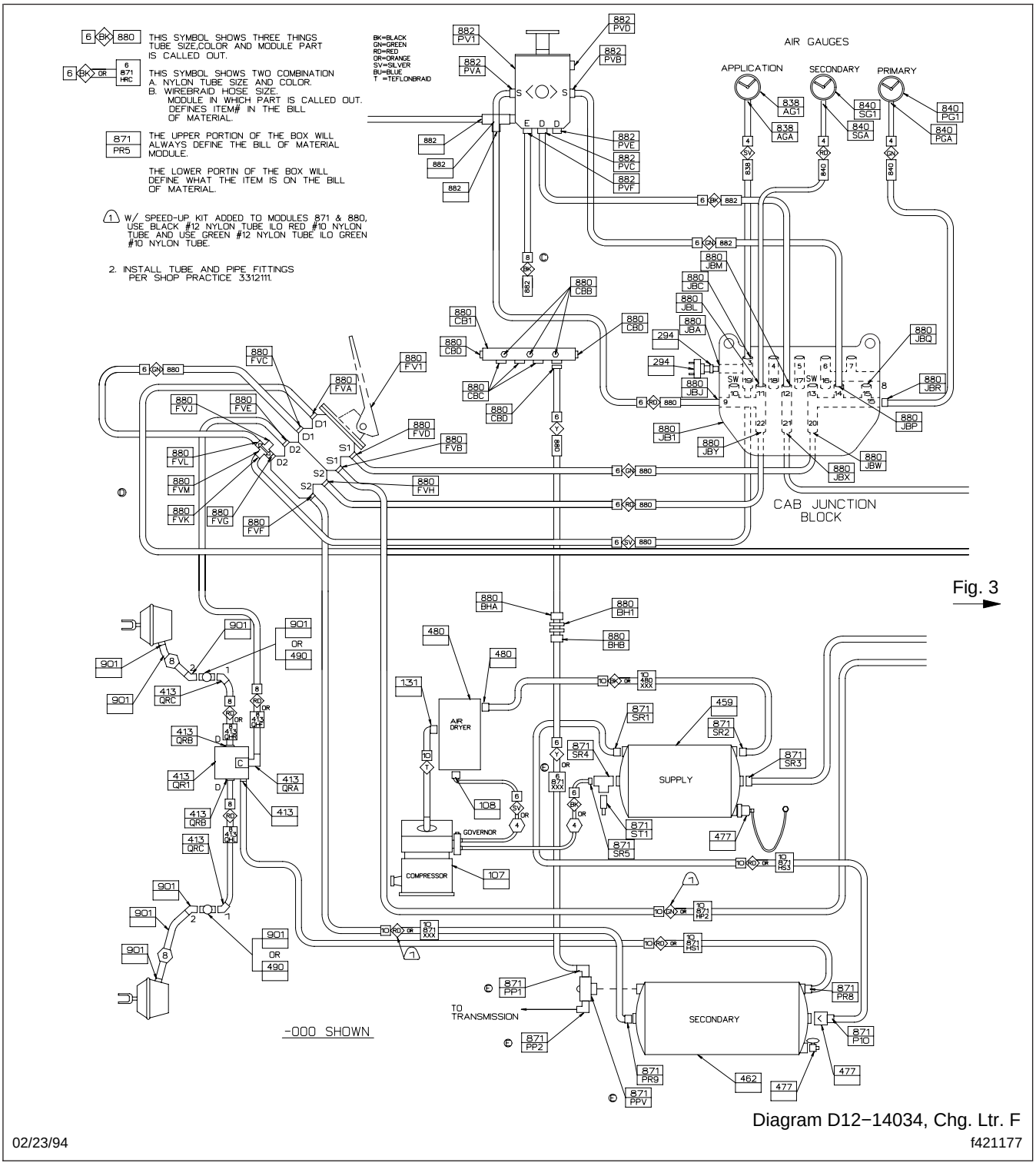

Fig. 2

Truck Without Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

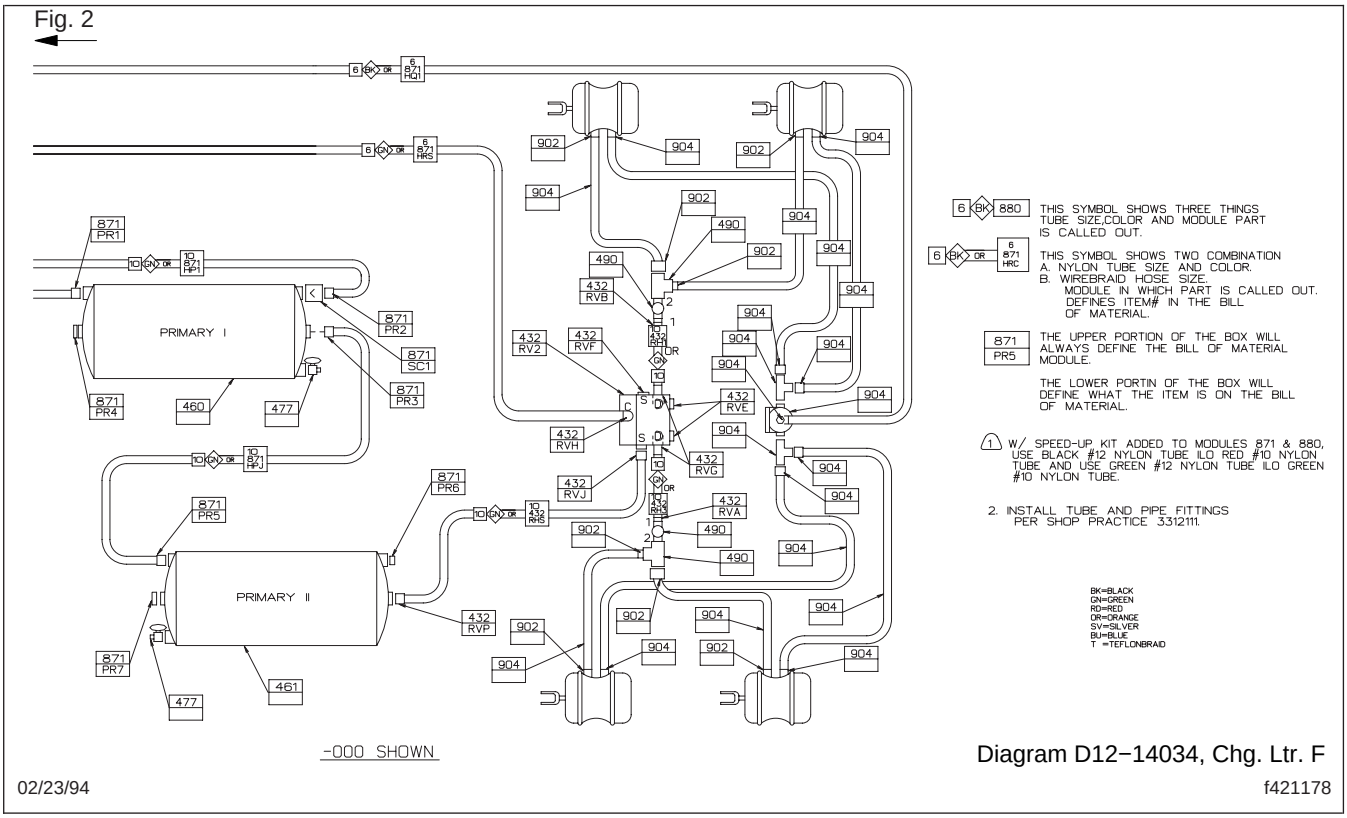

Fig. 3

Truck Without Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

See Fig. 1 for a full view of the plumbing diagram truck without brake proportioning, with 4-channel antilock (if equipped), and with 20-inch or smaller front brake chambers. **See Fig. 2**, or **Fig. 3** for partial (detailed) views of the plumbing diagram for truck without brake proportioning, with 4-channel antilock (if equipped), and with 20-inch or smaller front brake chambers.

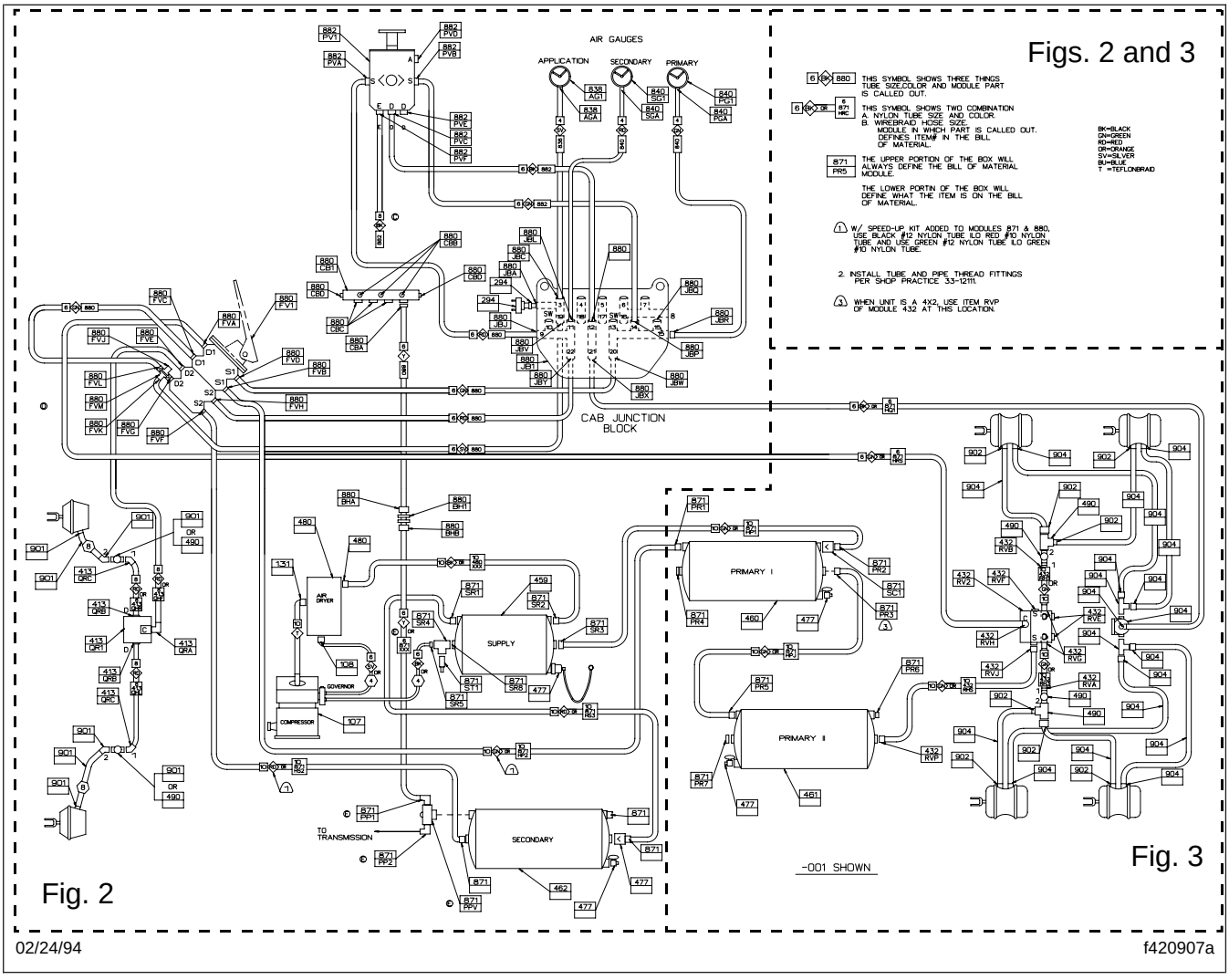

Fig. 1, Truck Without Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

Truck Without Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

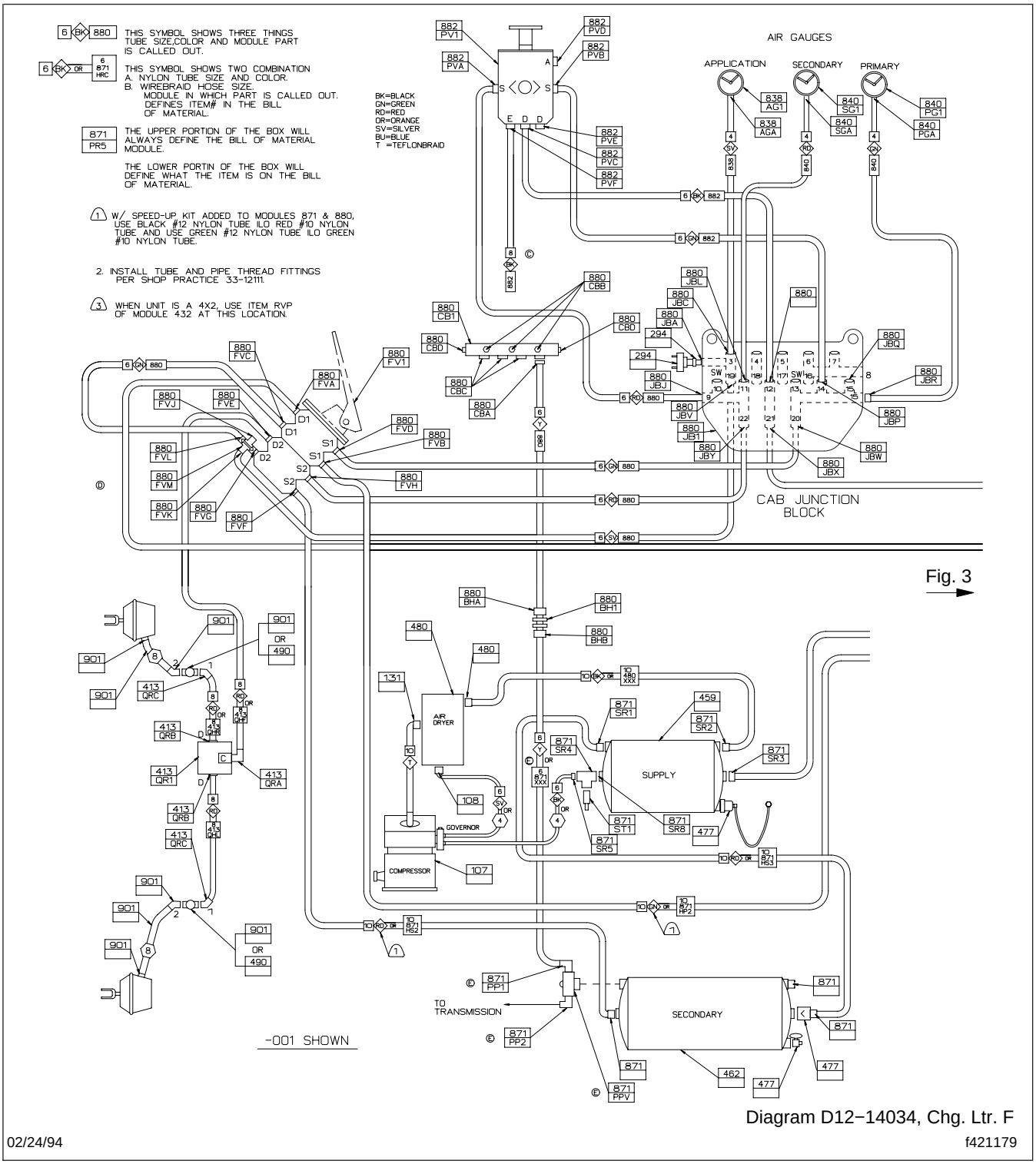

Fig. 3

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Fig. 2

Truck Without Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

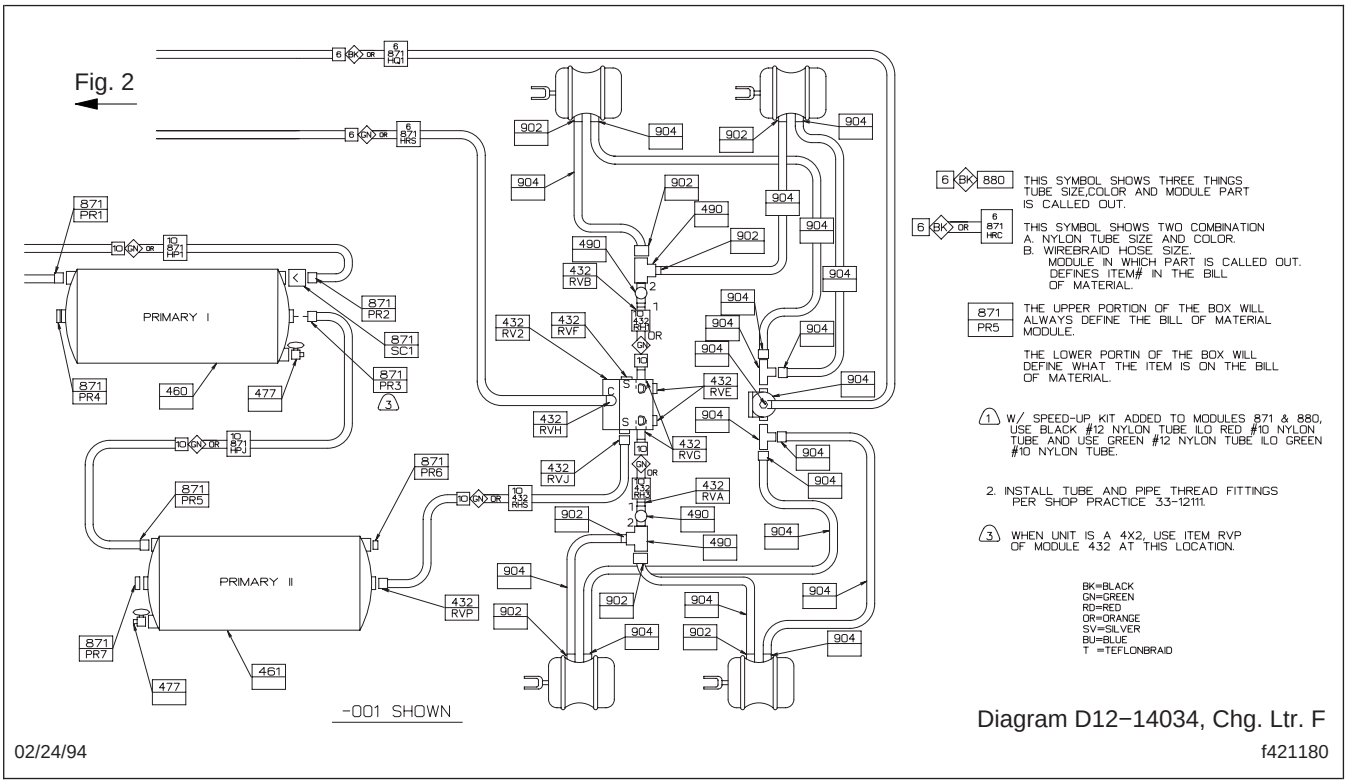


Fig. 3

Tractor With Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

See Fig. 1 for a full view of the plumbing diagram tractor with brake proportioning, with 6-channel antilock (if equipped), and with 24-inch or larger front brake chambers. **See Fig. 2**, or **Fig. 3** for partial (detailed) views of the plumbing diagram for tractor with brake proportioning, with 6-channel antilock (if equipped), and with 24-inch or larger front brake chambers.

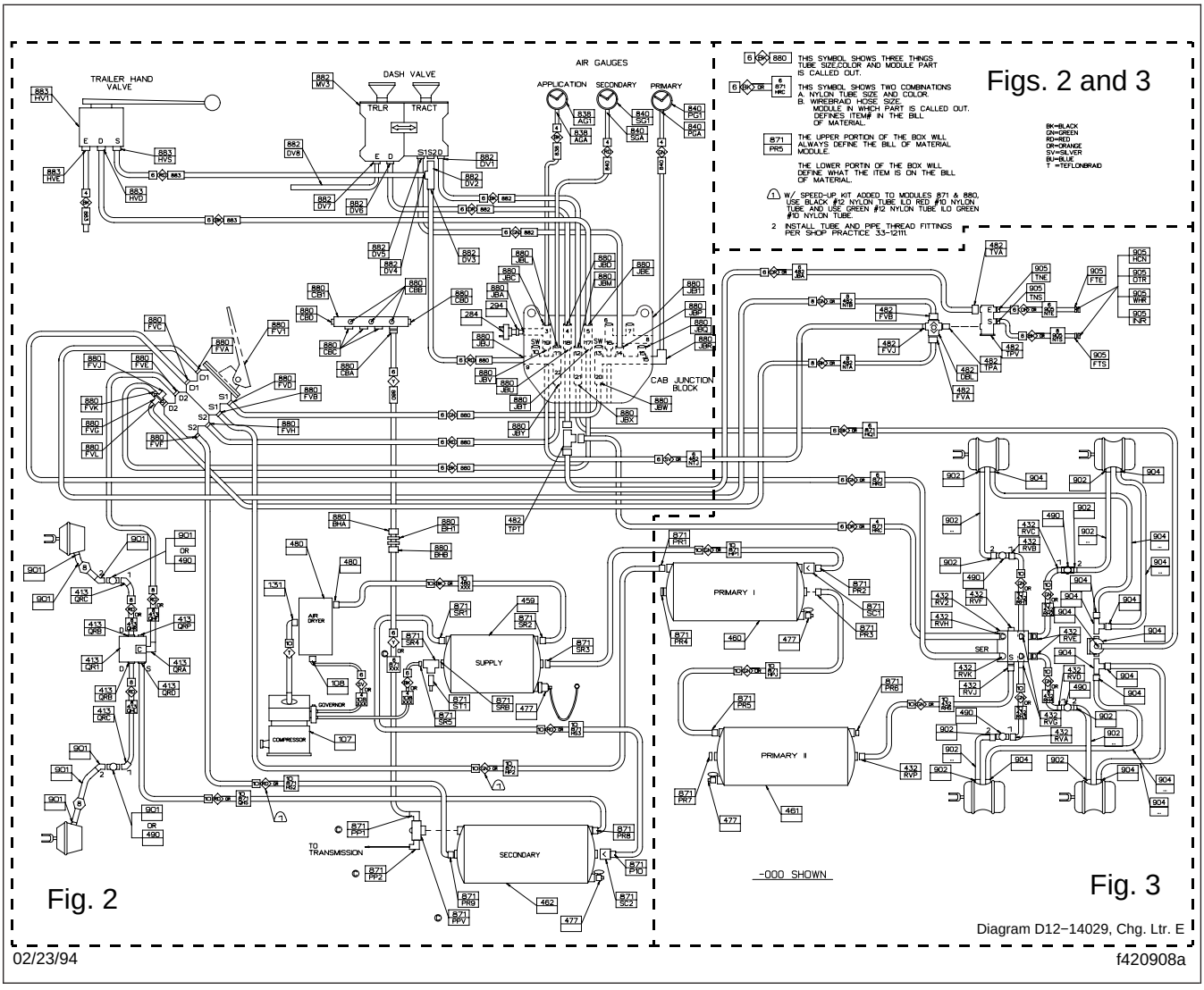


Fig. 1, Tractor With Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

Tractor With Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

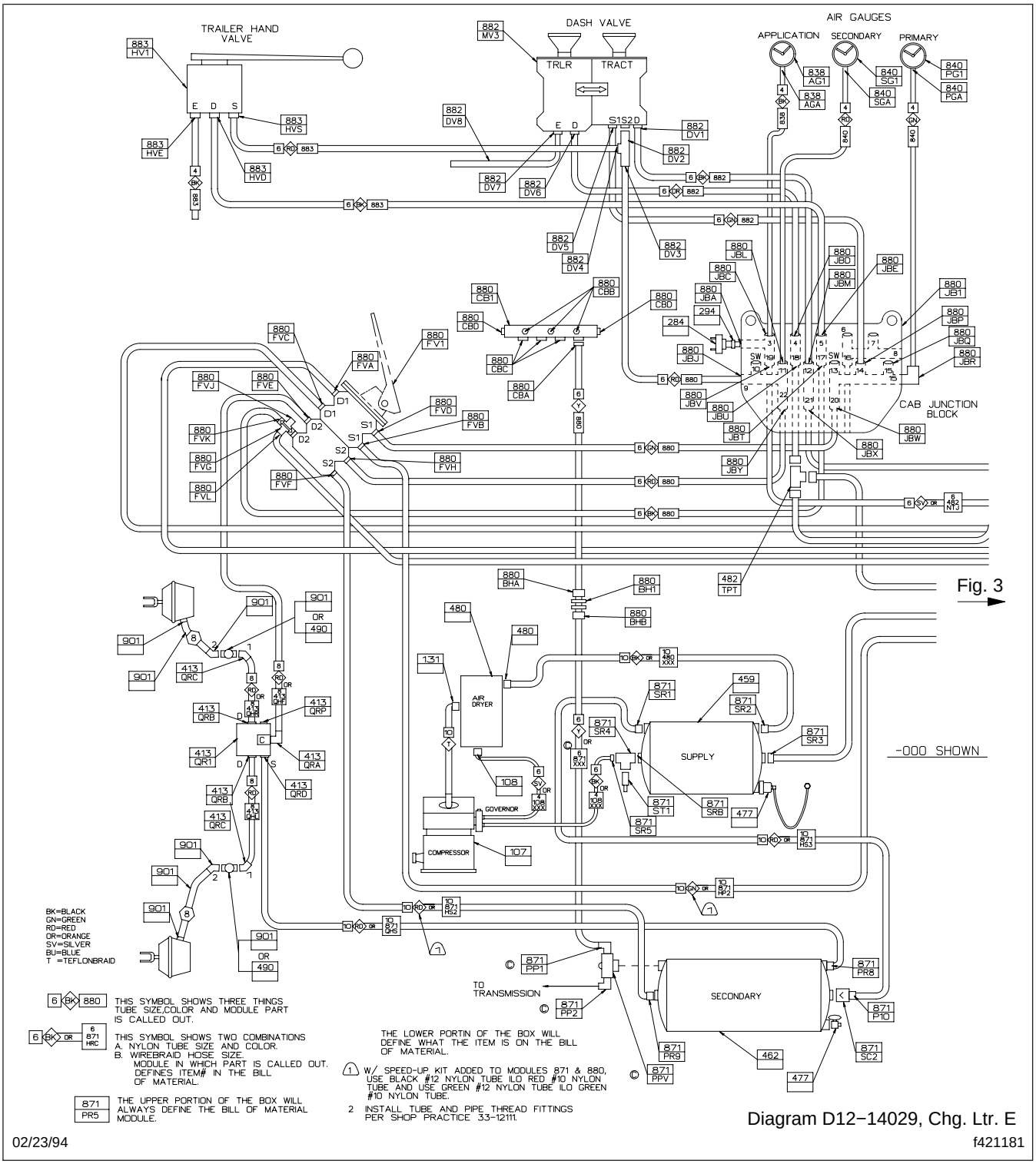


Fig. 2

Tractor With Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

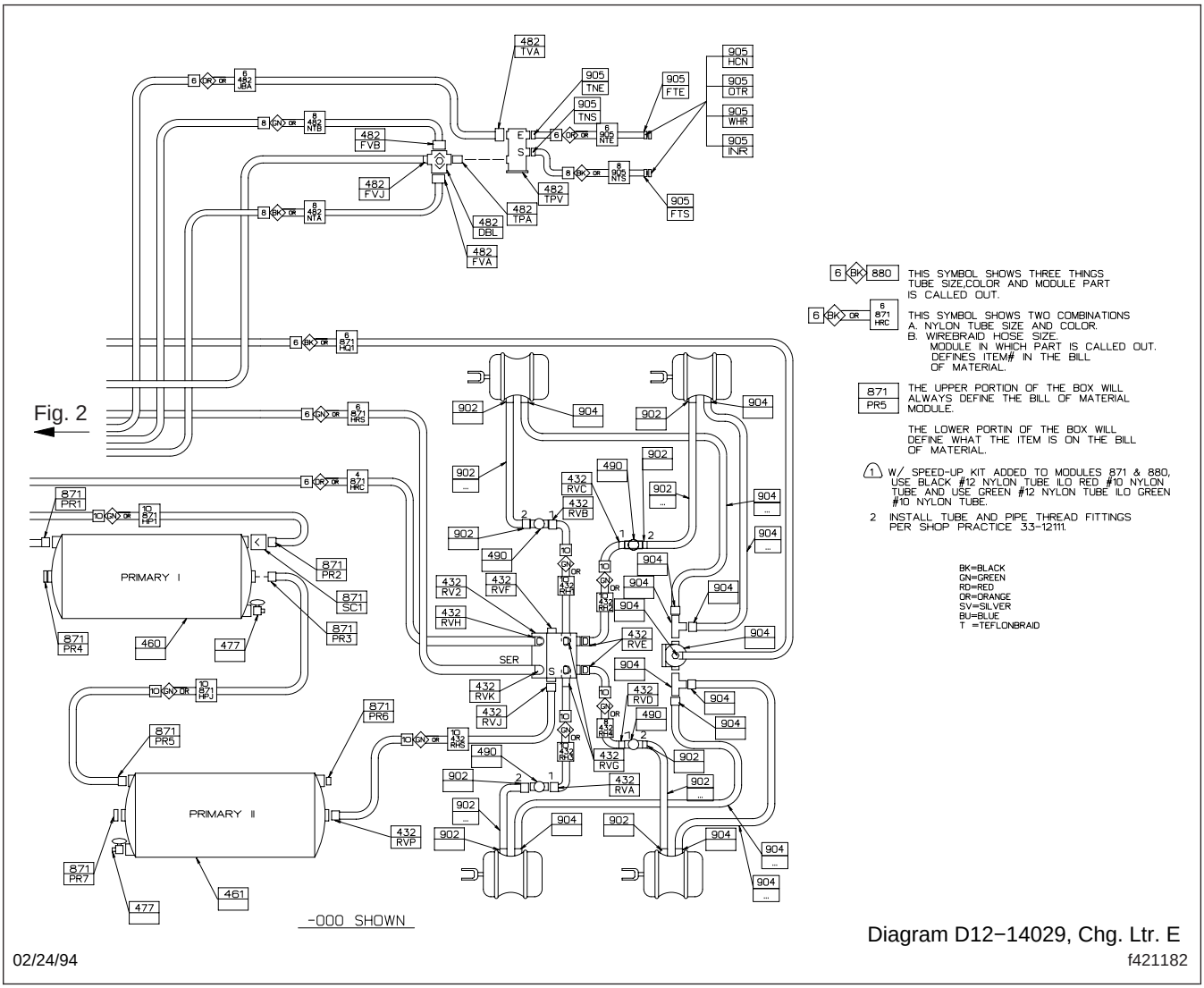


Fig. 3

Tractor With Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

See **Fig. 1** for a full view of the plumbing diagram tractor with brake proportioning, with 6-channel antilock (if equipped), and with 20-inch or smaller front brake chambers. See **Fig. 2**, or **Fig. 3** for partial (detailed) views of the plumbing diagram for tractor with brake proportioning, with 6-channel antilock (if equipped), and with 20-inch or smaller front brake chambers.

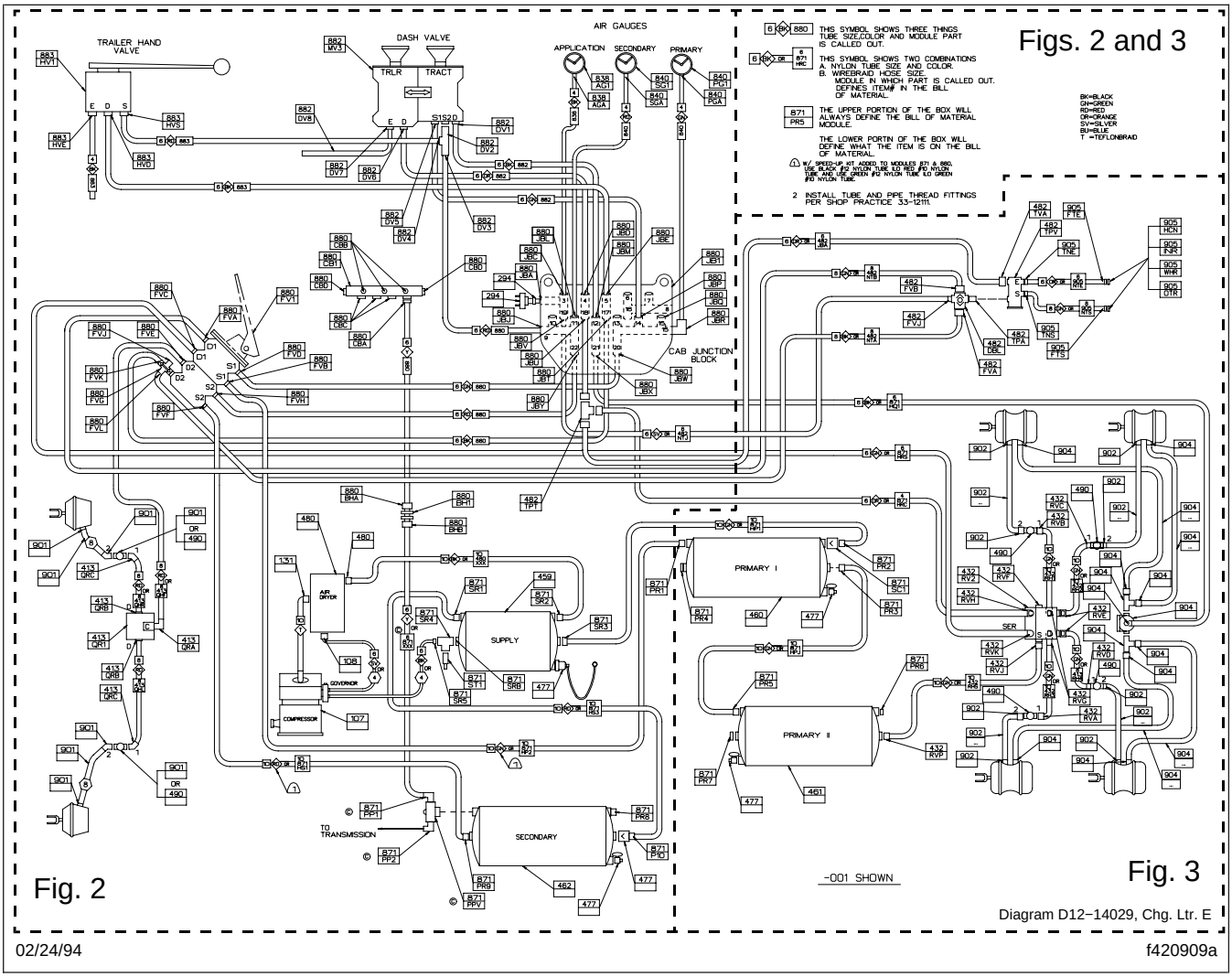


Fig. 1, Tractor With Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

Tractor With Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

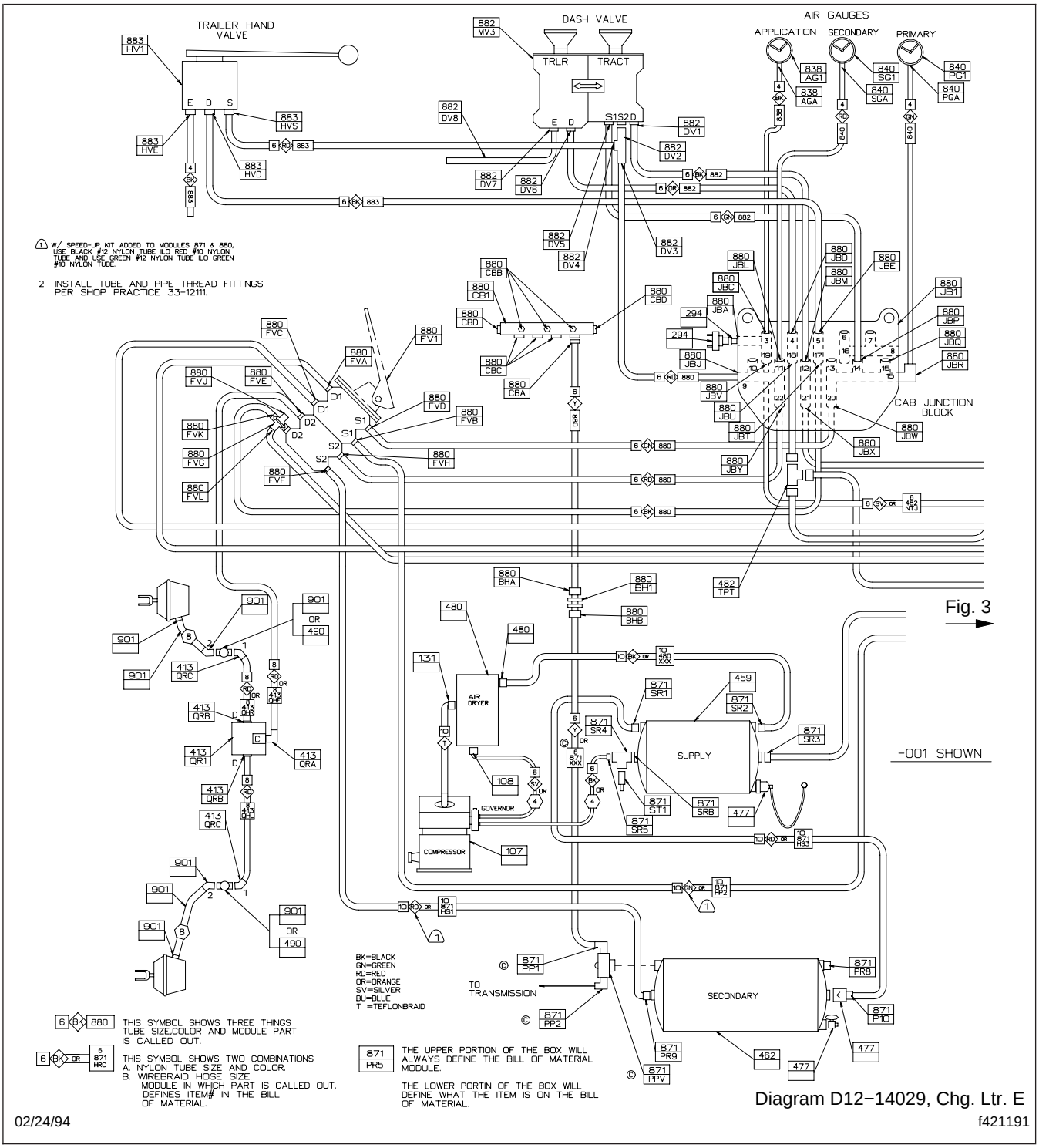


Fig. 2

Tractor With Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

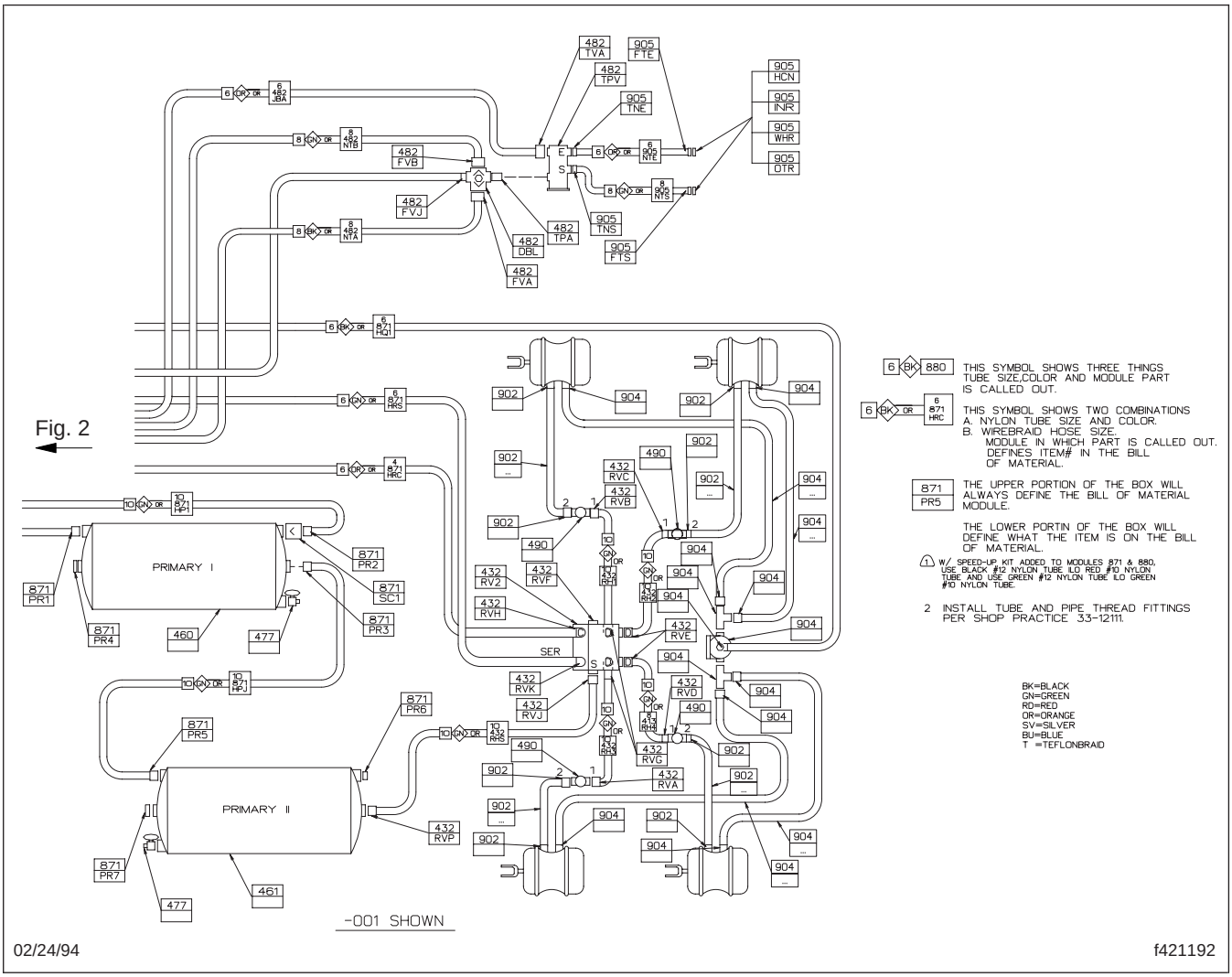


Fig. 3

Tractor With Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

See Fig. 1 for a full view of the plumbing diagram tractor with brake proportioning, with 4-channel antilock (if equipped), and with 24-inch or larger front brake chambers. **See Fig. 2**, or **Fig. 3** for partial (detailed) views of the plumbing diagram for tractor with brake proportioning, with 4-channel antilock (if equipped), and with 24-inch or larger front brake chambers.

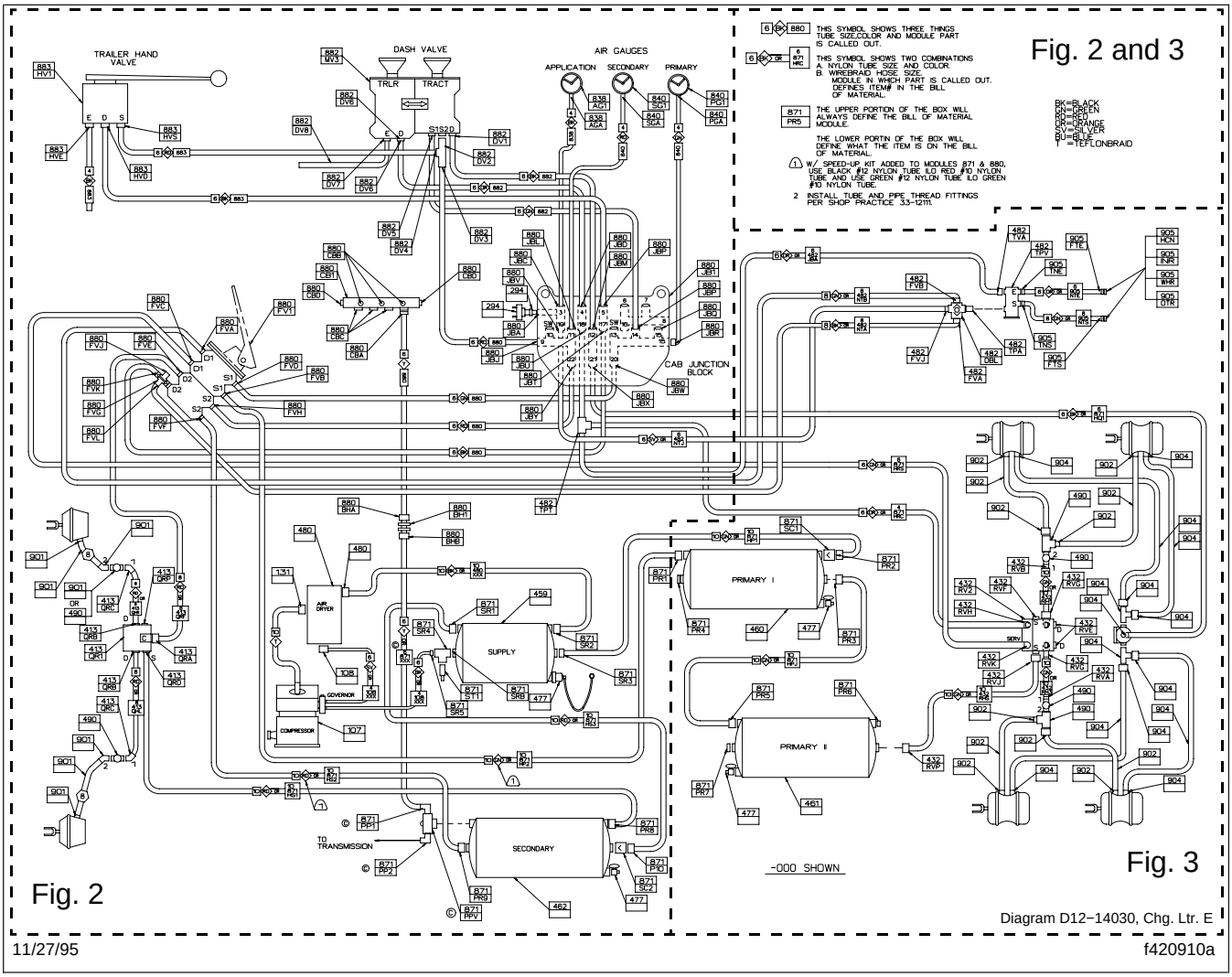


Fig. 1, Tractor With Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

Tractor With Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

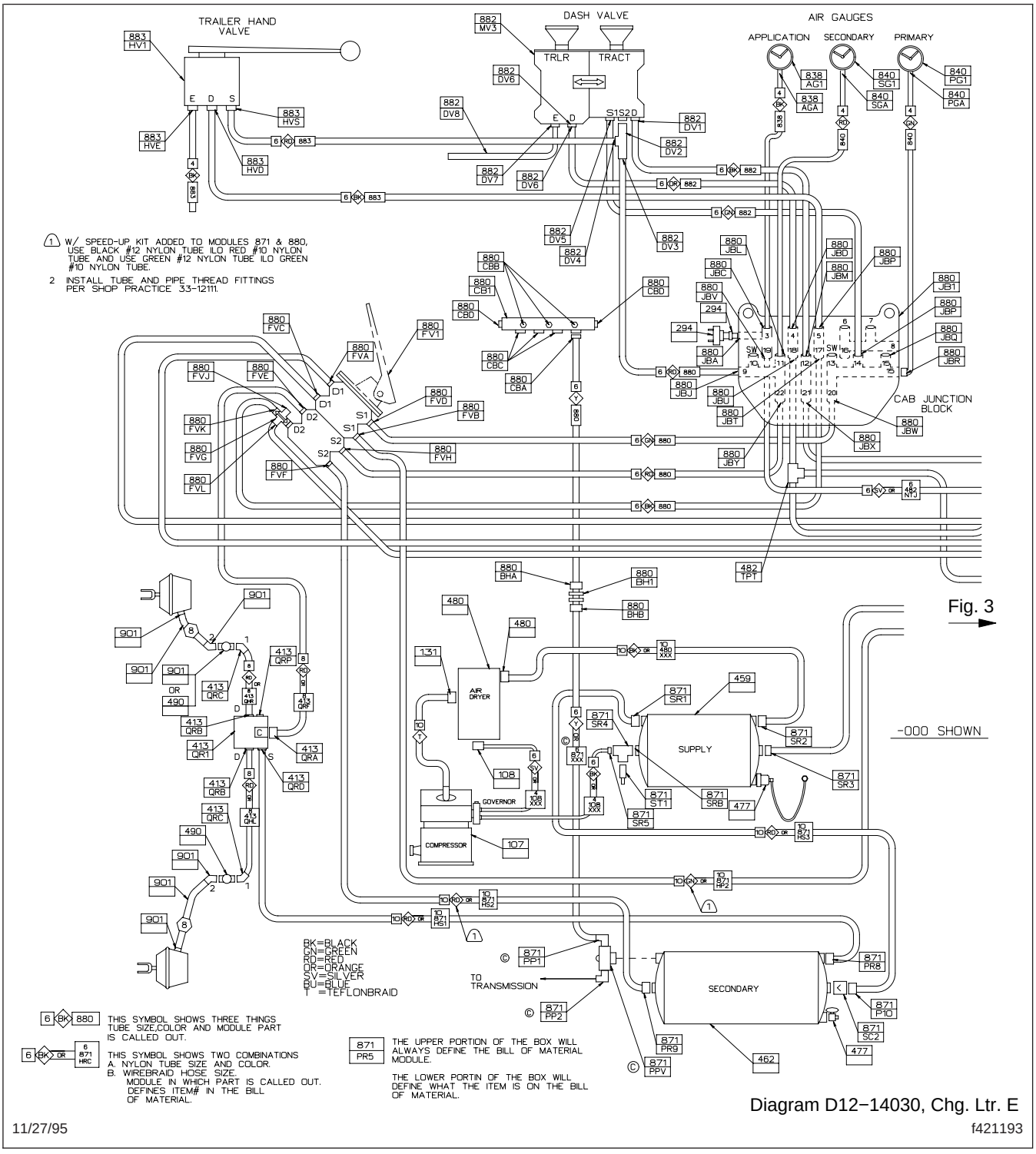


Fig. 2

Tractor With Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

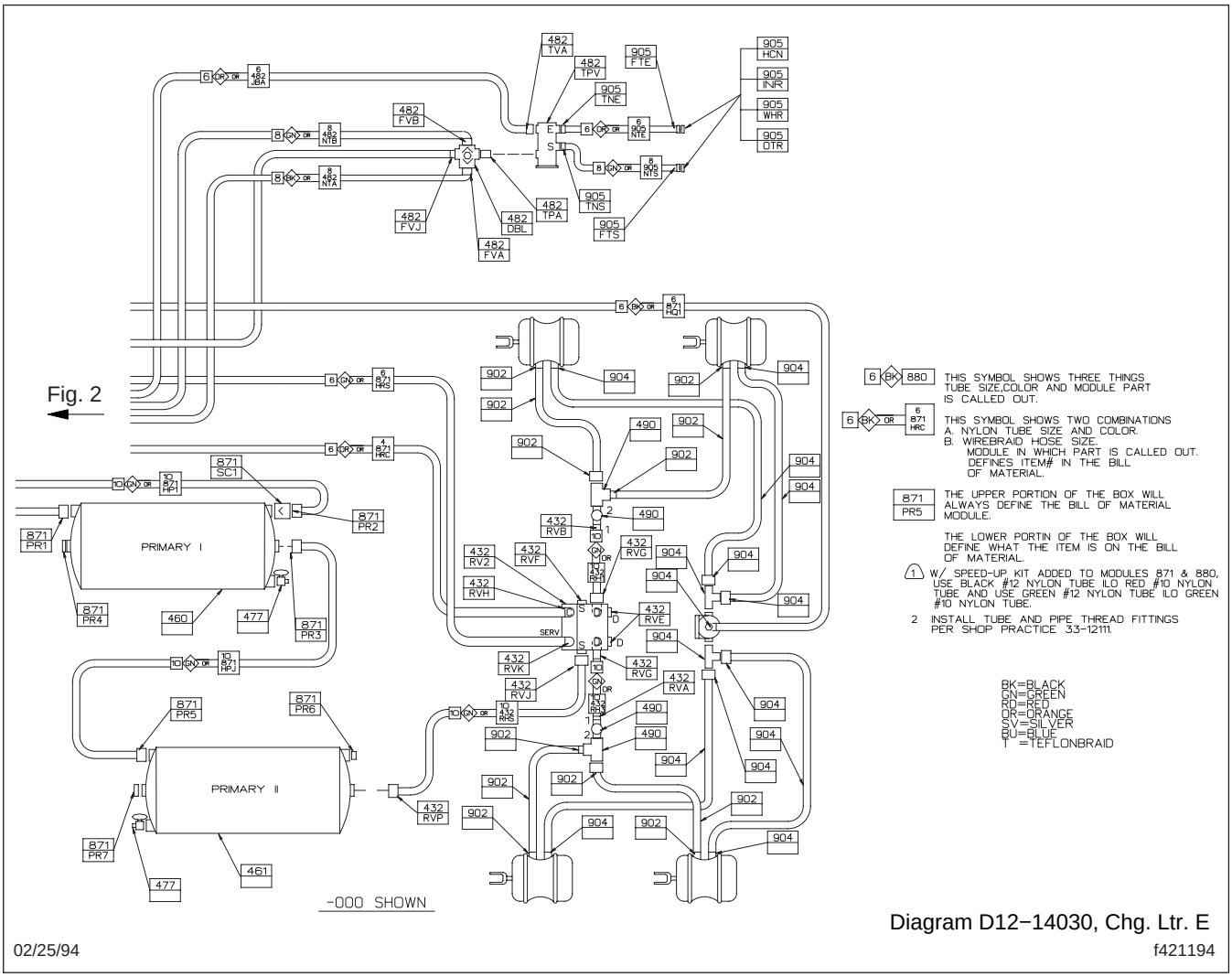


Fig. 3

Tractor With Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

See Fig. 1 for a full view of the plumbing diagram tractor with brake proportioning, with 4-channel antilock (if equipped), and with 20-inch or smaller front brake chambers. **See Fig. 2**, or **Fig. 3** for partial (detailed) views of the plumbing diagram for tractor with brake proportioning, with 4-channel antilock (if equipped), and with 20-inch or smaller front brake chambers.

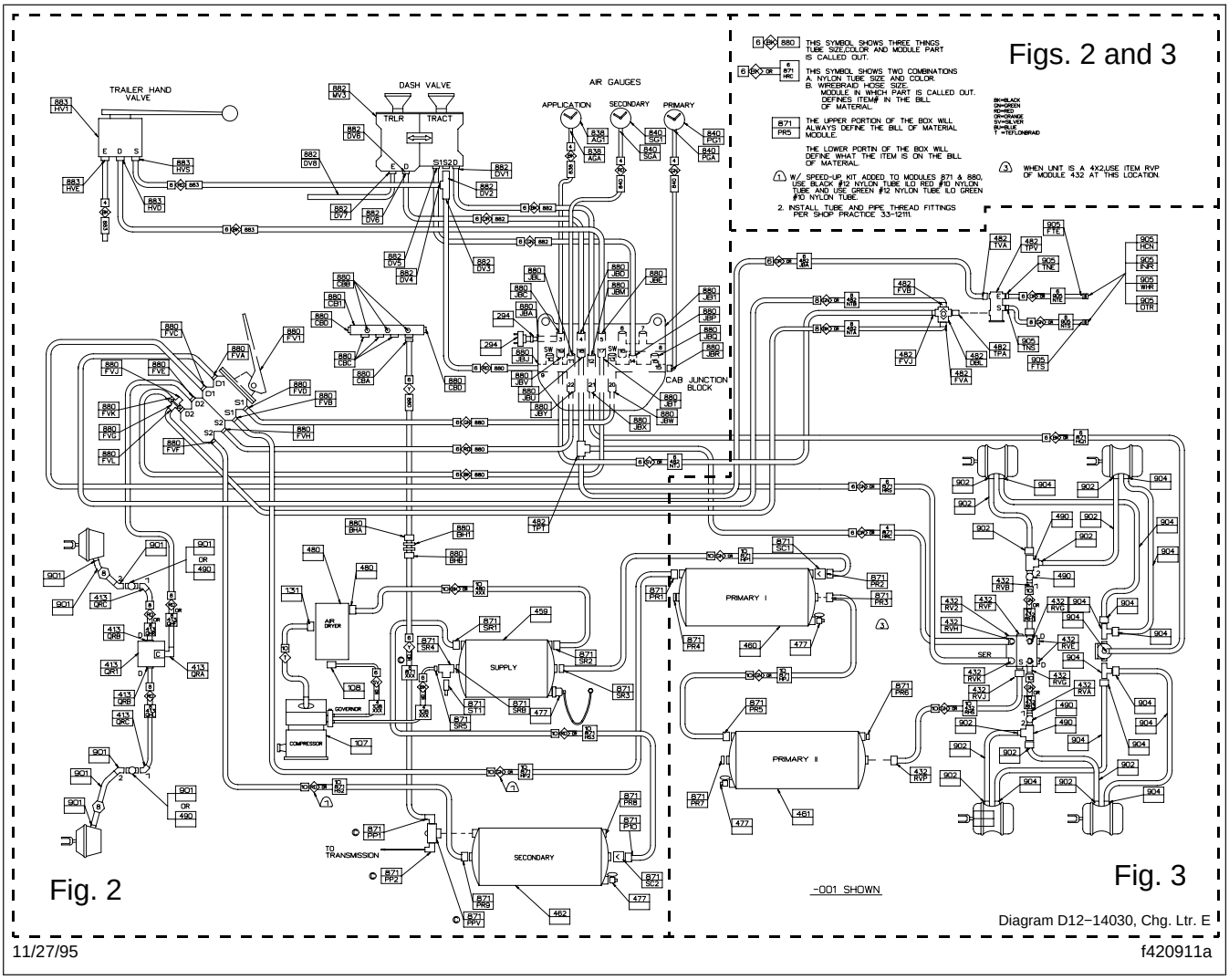


Fig. 1, Tractor With Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

Tractor With Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

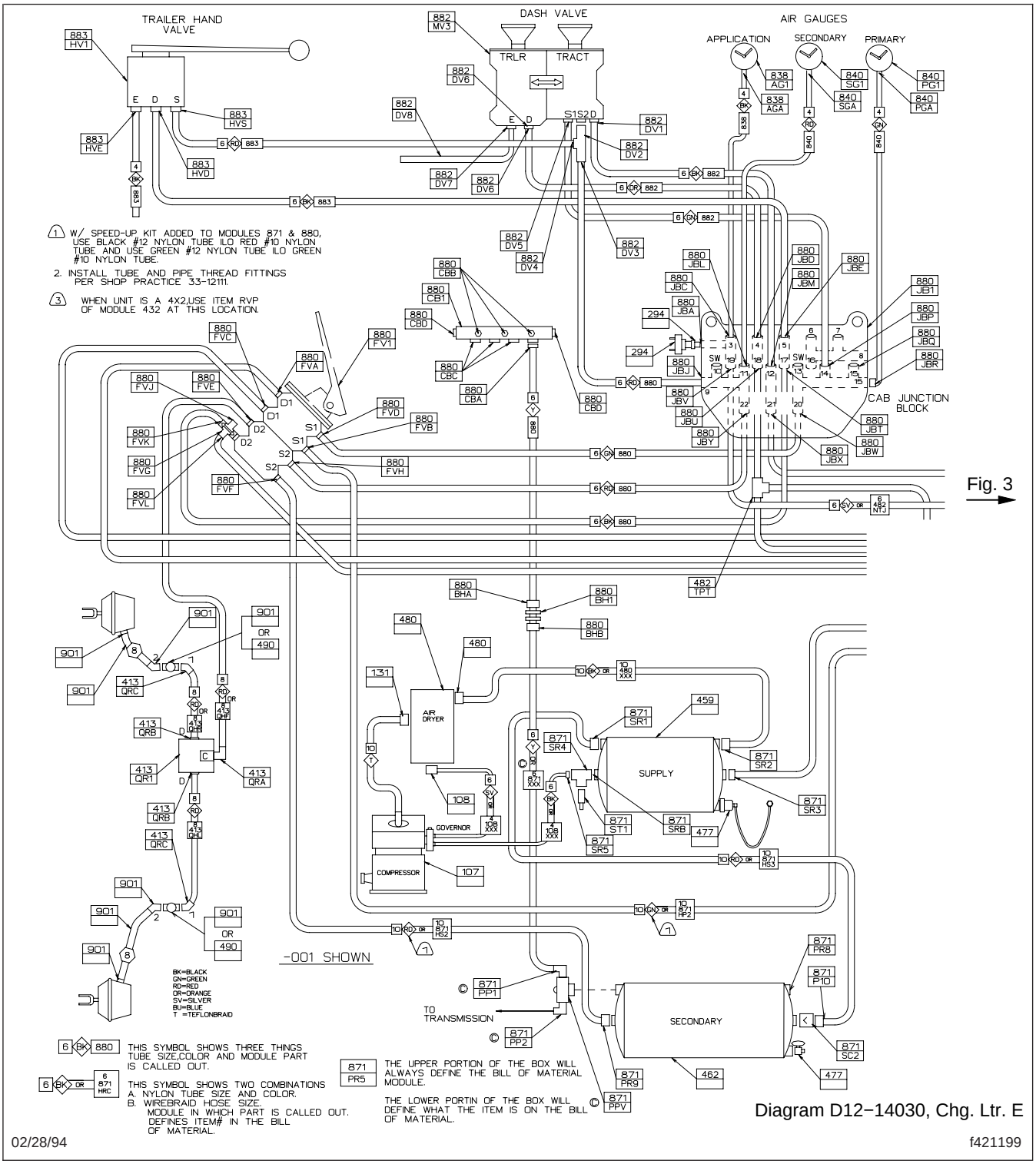


Fig. 3

Diagram D12−14030, Chg. Ltr. E

Fig. 2

Tractor With Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

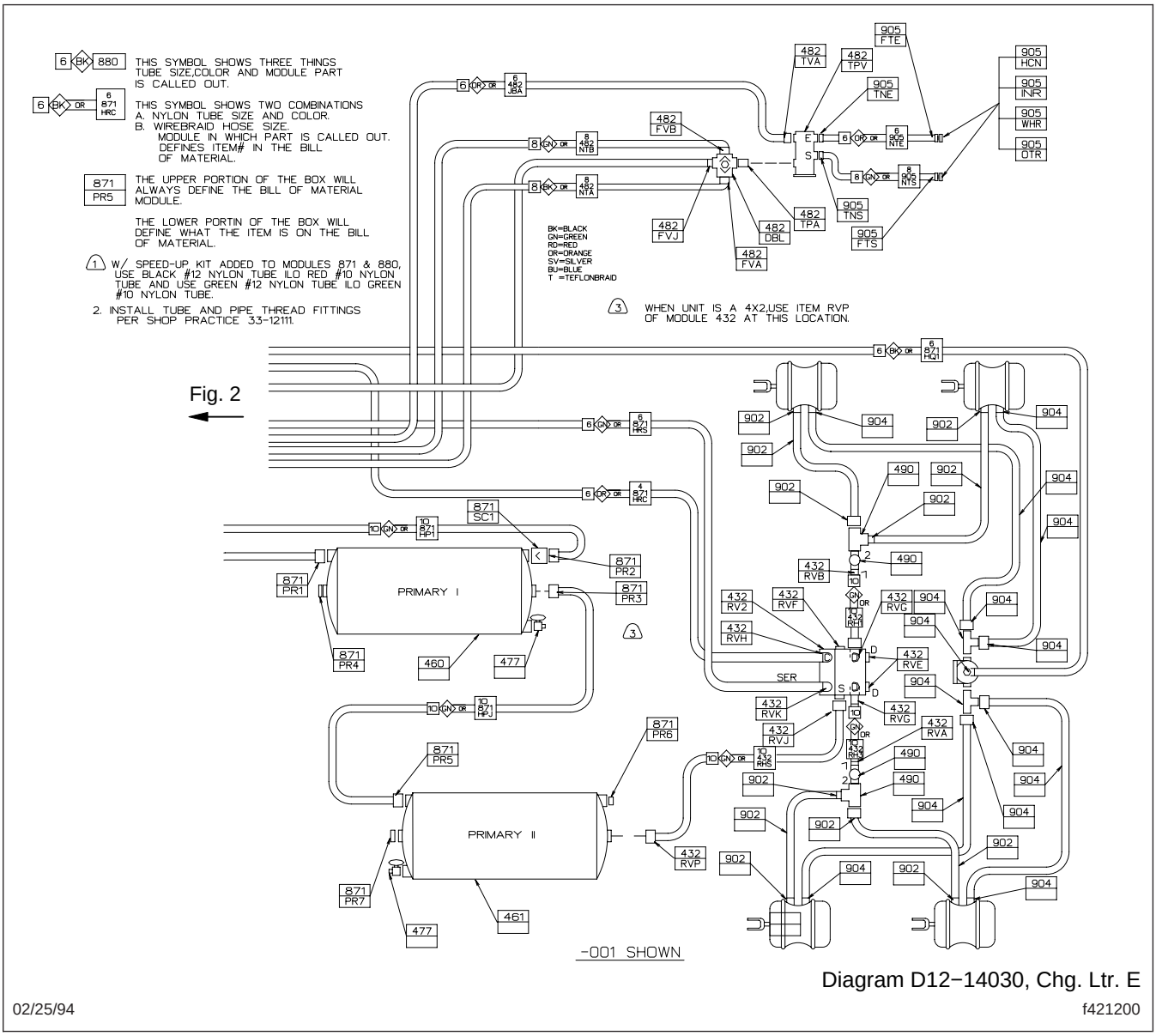


Diagram D12−14030, Chg. Ltr. E

Fig. 3

Tractor Without Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

See Fig. 1 for a full view of the plumbing diagram tractor without brake proportioning, with 6-channel antilock (if equipped), and with 24-inch or larger front brake chambers. **See Fig. 2**, or **Fig. 3** for partial (detailed) views of the plumbing diagram for tractor without brake proportioning, with 6-channel antilock (if equipped), and with 24-inch or larger front brake chambers.

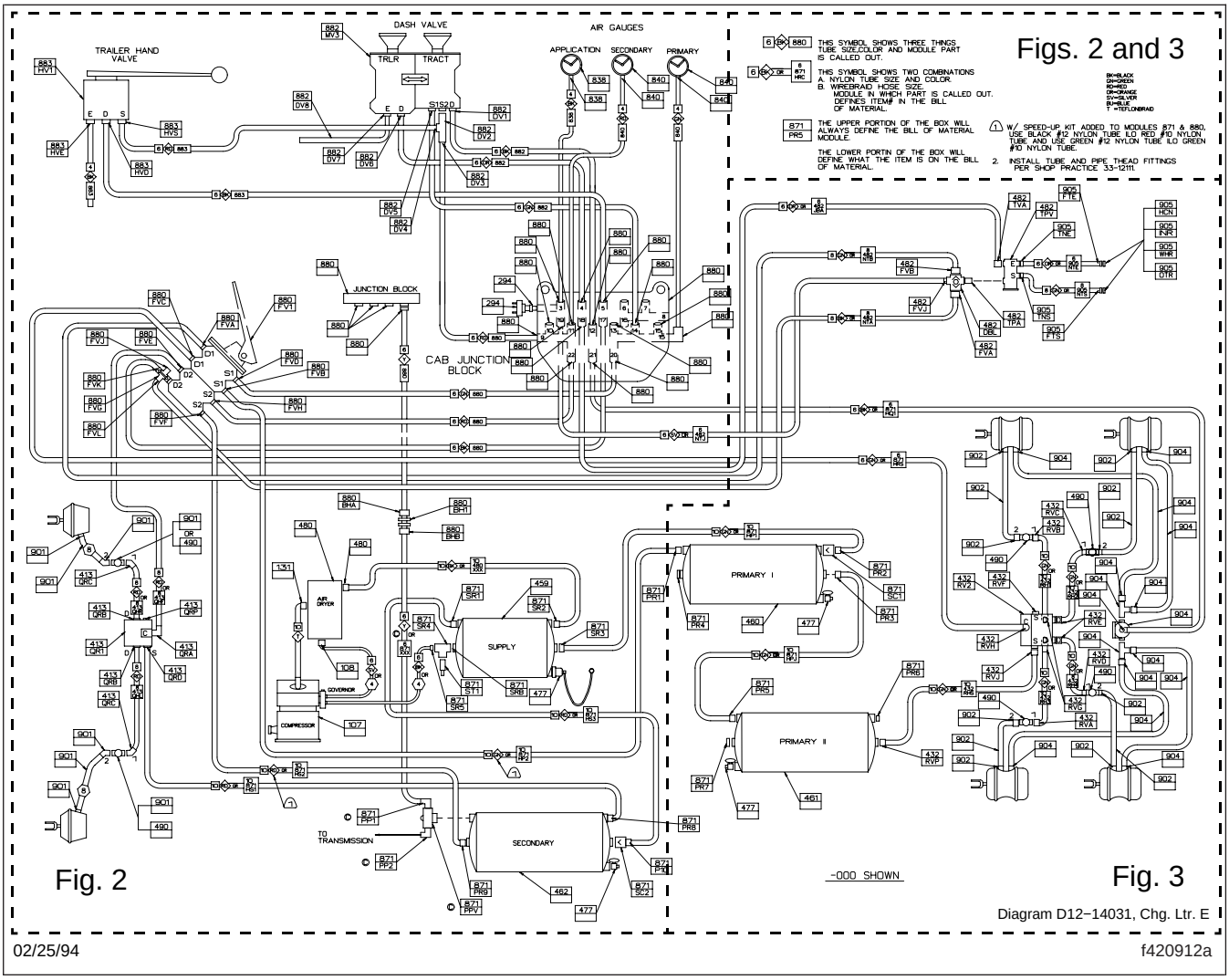


Fig. 1, Tractor Without Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

Tractor Without Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

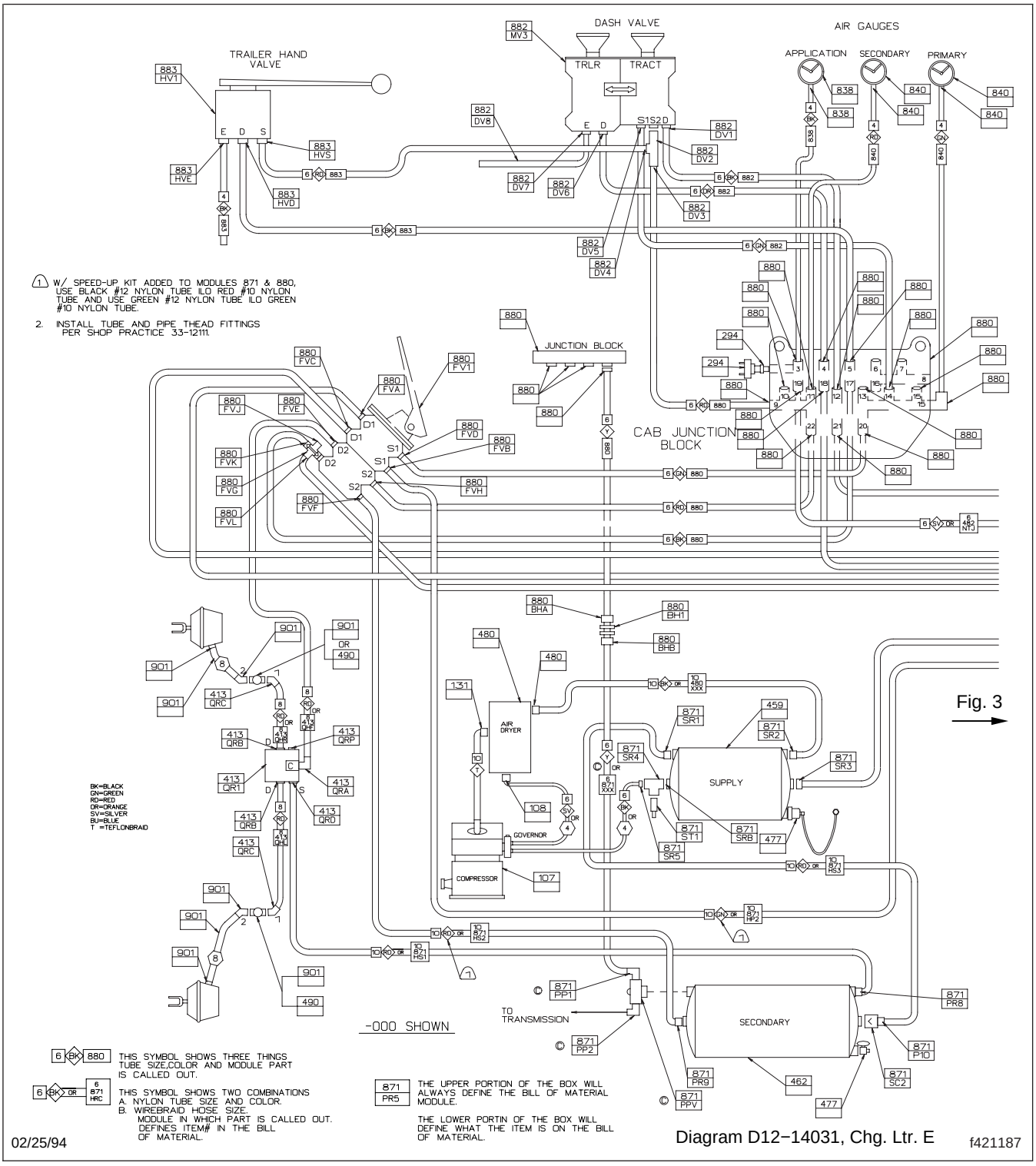


Fig. 3

Fig. 2

Tractor Without Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

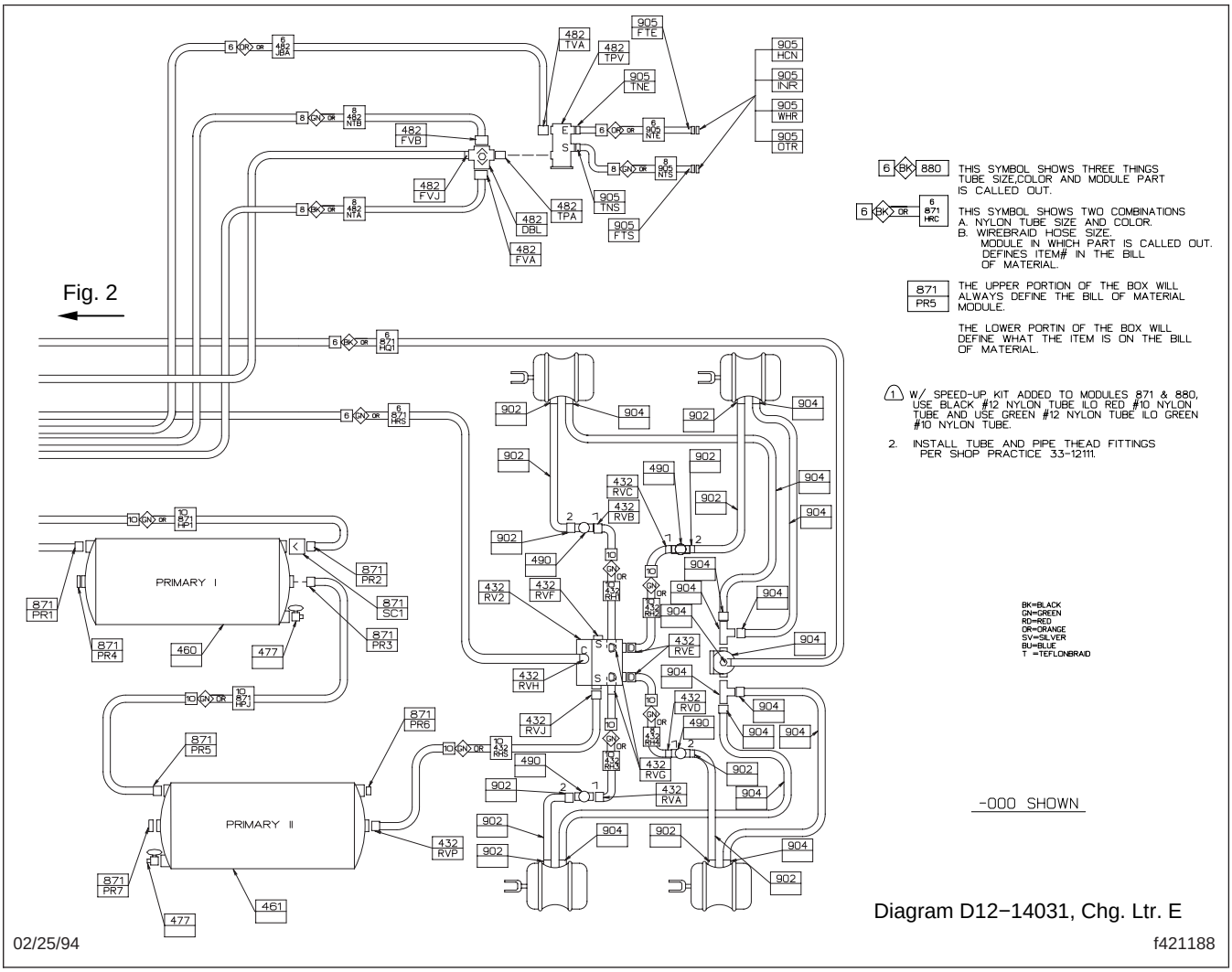


Fig. 3

Tractor Without Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

See Fig. 1 for a full view of the plumbing diagram tractor without brake proportioning, with 6-channel antilock (if equipped), and with 20-inch or smaller front brake chambers. **See Fig. 2**, or **Fig. 3** for partial (detailed) views of the plumbing diagram for tractor without brake proportioning, with 6-channel antilock (if equipped), and with 20-inch or smaller front brake chambers.

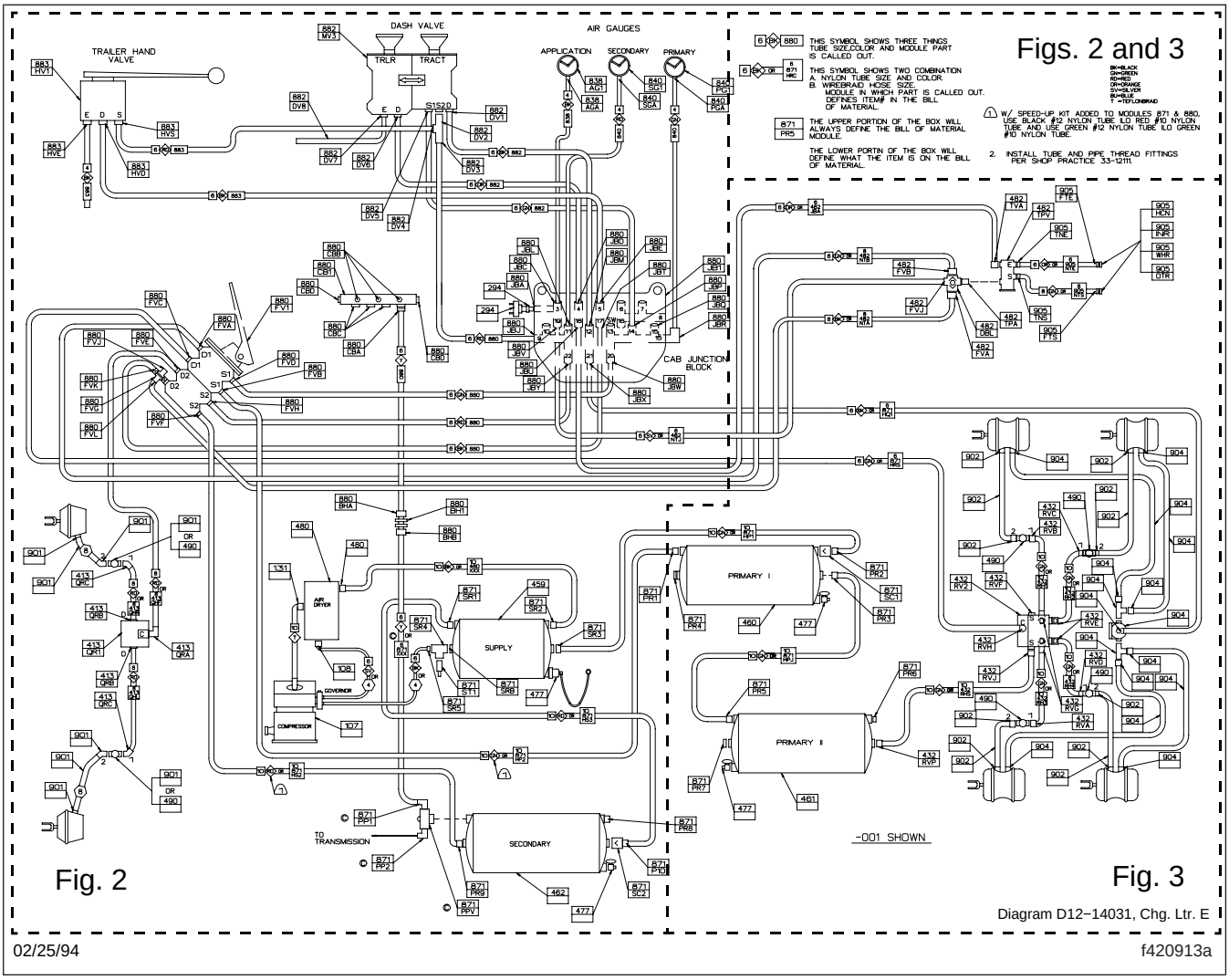


Fig. 1, Tractor Without Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

Tractor Without Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

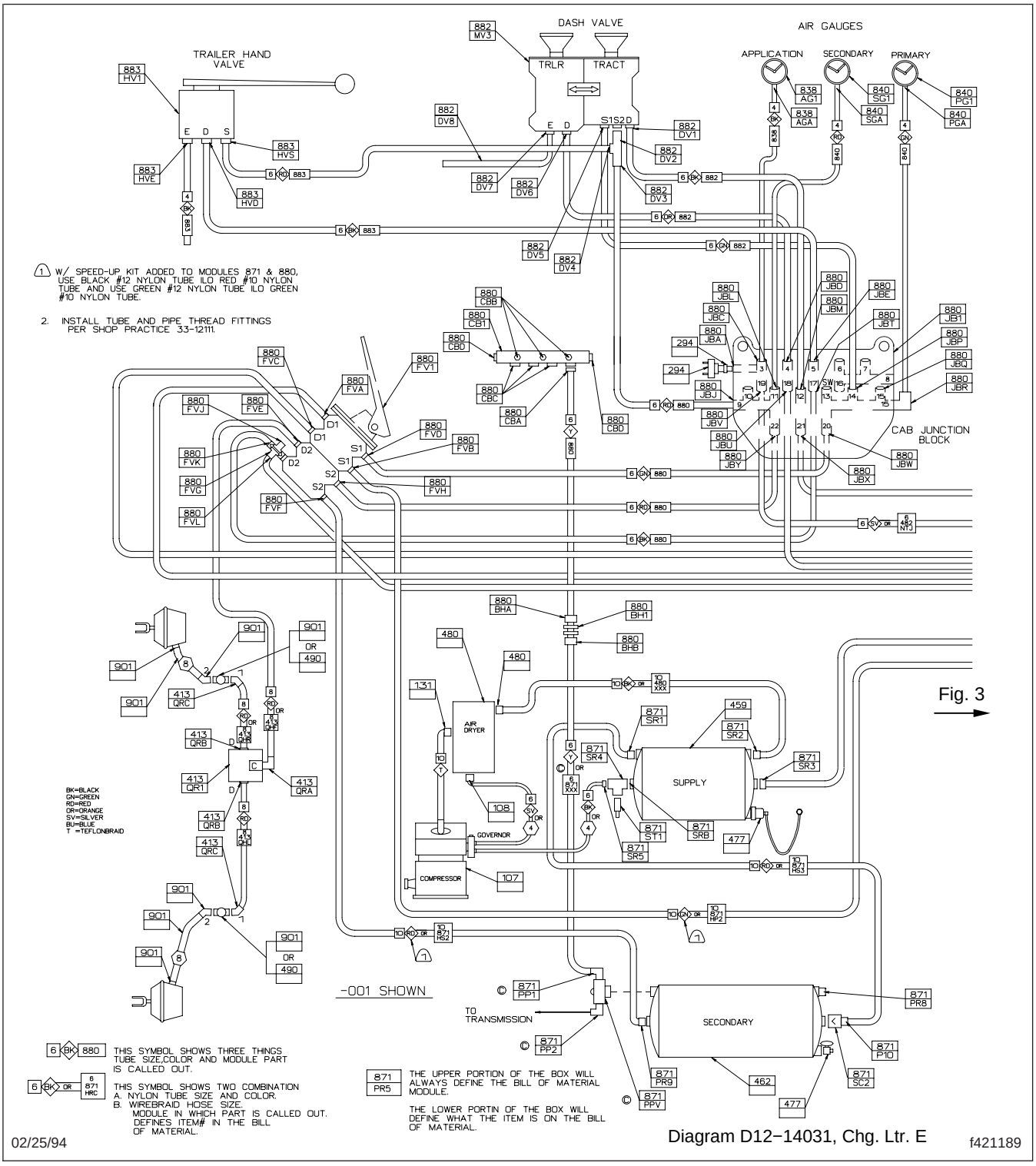


Fig. 3

Fig. 2

Tractor Without Brake Proportioning, With 6-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

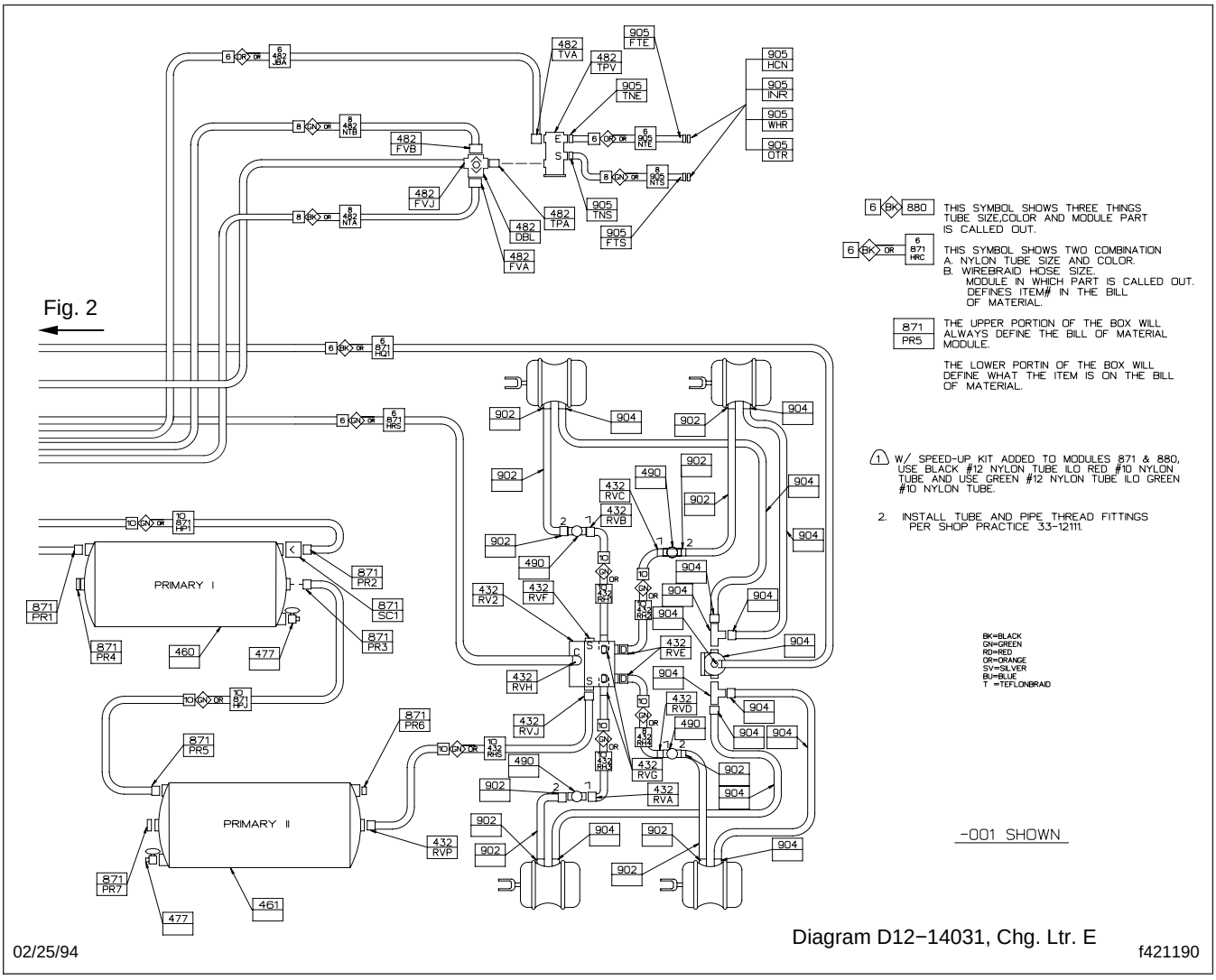


Fig. 3

Tractor Without Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

See Fig. 1 for a full view of the plumbing diagram tractor without brake proportioning, with 4-channel antilock (if equipped), and with 24-inch or larger front brake chambers. **See Fig. 2**, or **Fig. 3** for partial (detailed) views of the plumbing diagram for tractor without brake proportioning, with 4-channel antilock (if equipped), and with 24-inch or larger front brake chambers.

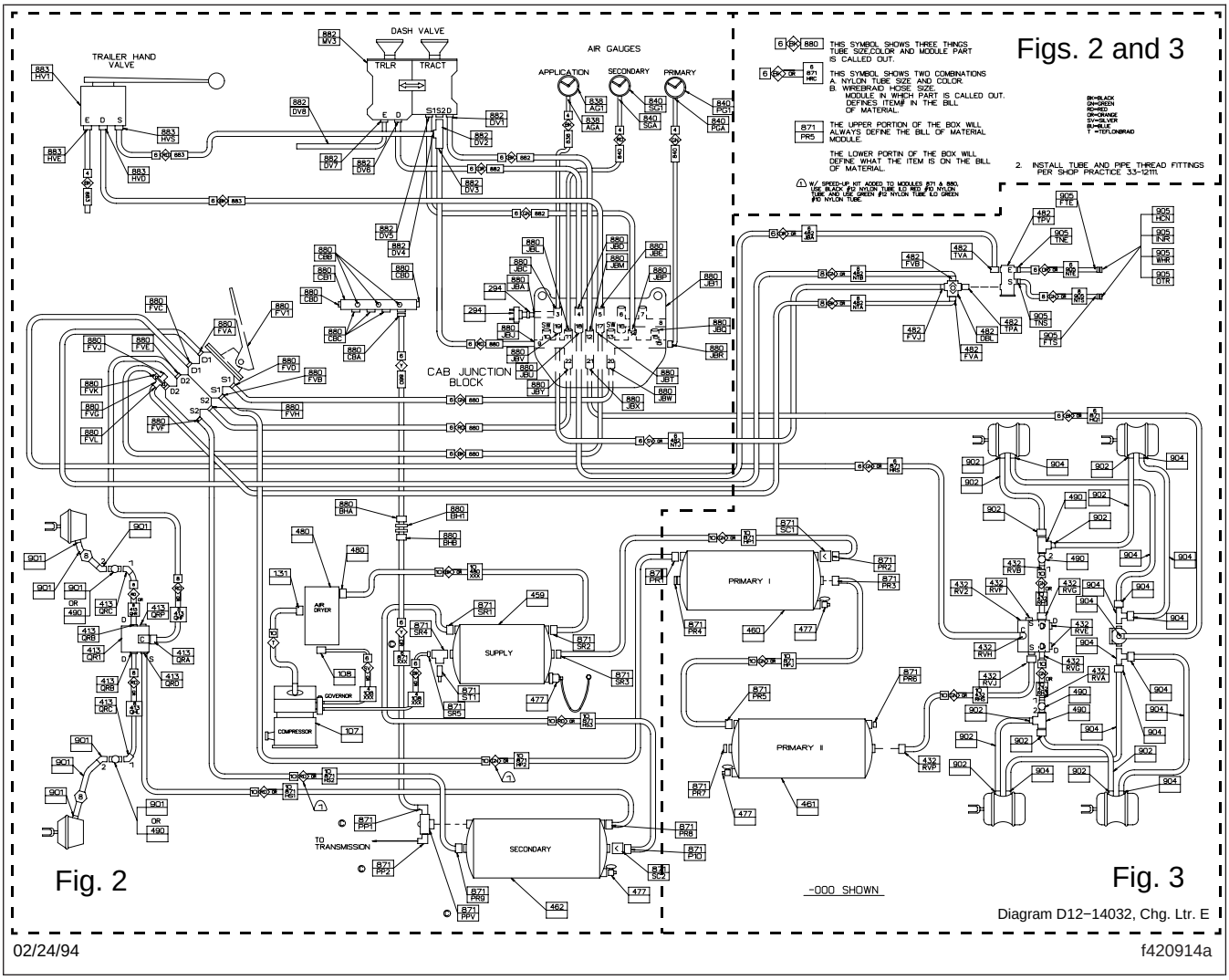


Fig. 1, Tractor Without Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

Tractor Without Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

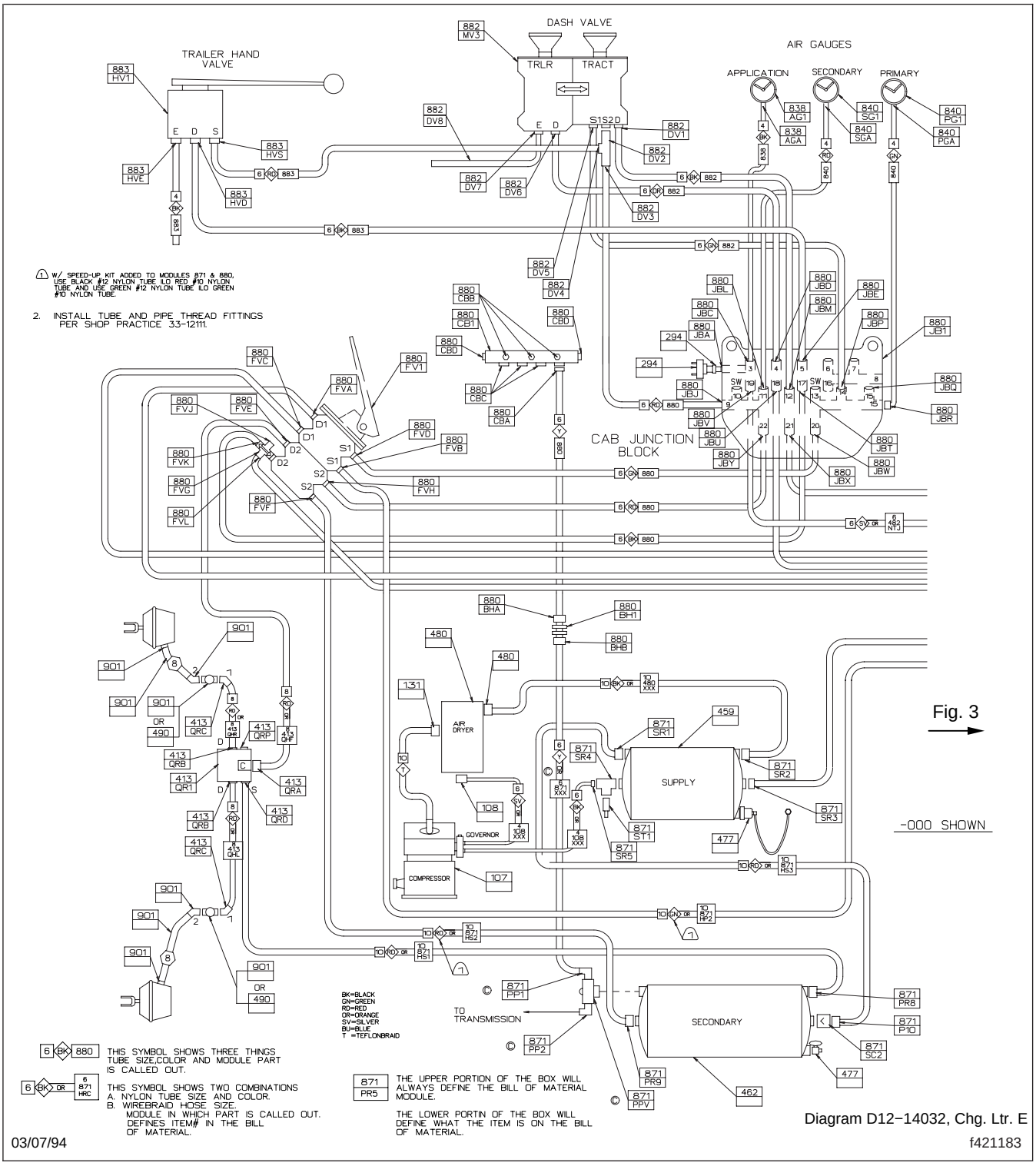


Fig. 2

Tractor Without Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 24-Inch or Larger Front Brake Chambers

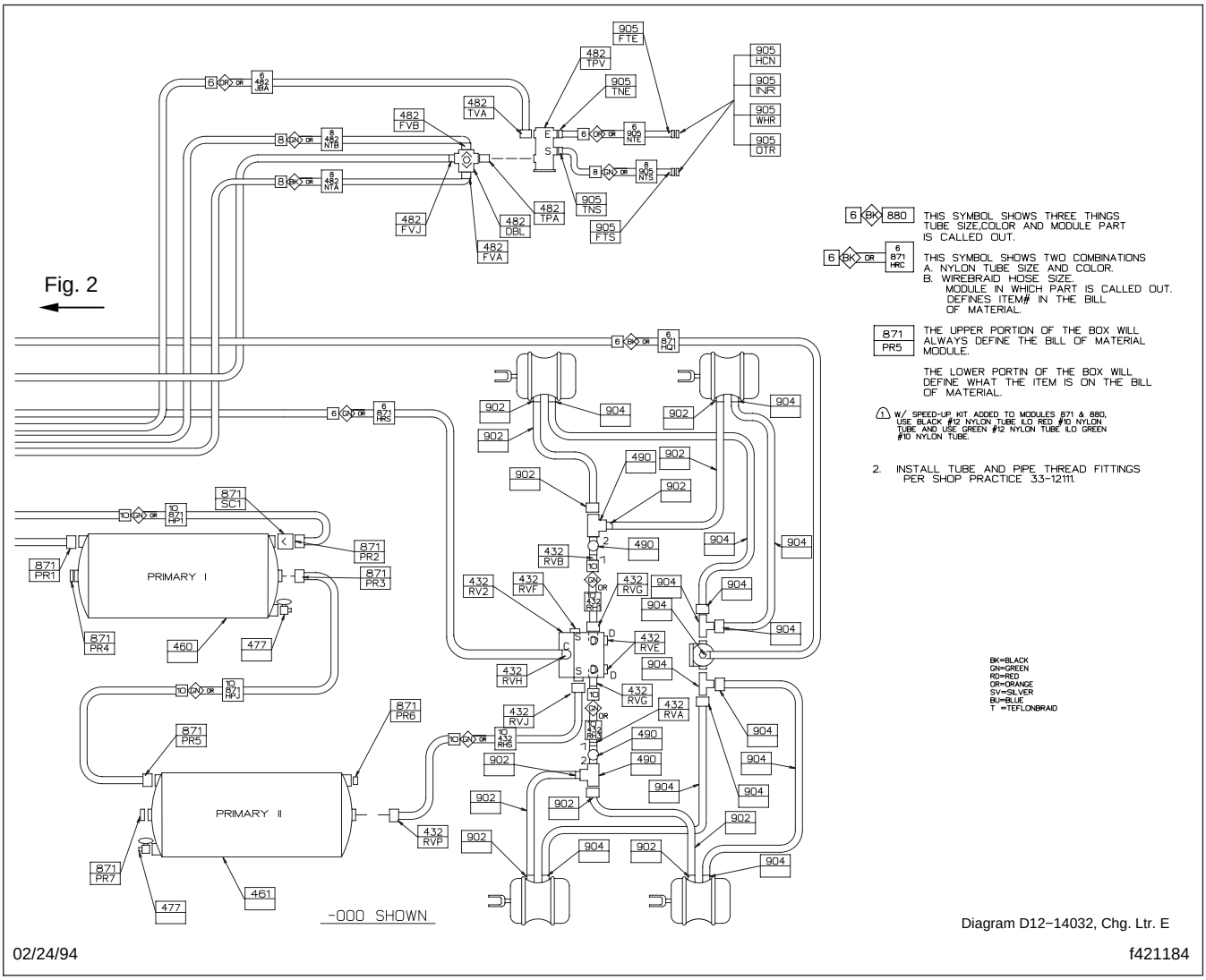


Fig. 3

Tractor Without Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

See Fig. 1 for a full view of the plumbing diagram tractor without brake proportioning, with 4-channel antilock (if equipped), and with 20-inch or smaller front brake chambers. **See Fig. 2**, or **Fig. 3** for partial (detailed) views of the plumbing diagram for tractor without brake proportioning, with 4-channel antilock (if equipped), and with 20-inch or smaller front brake chambers.

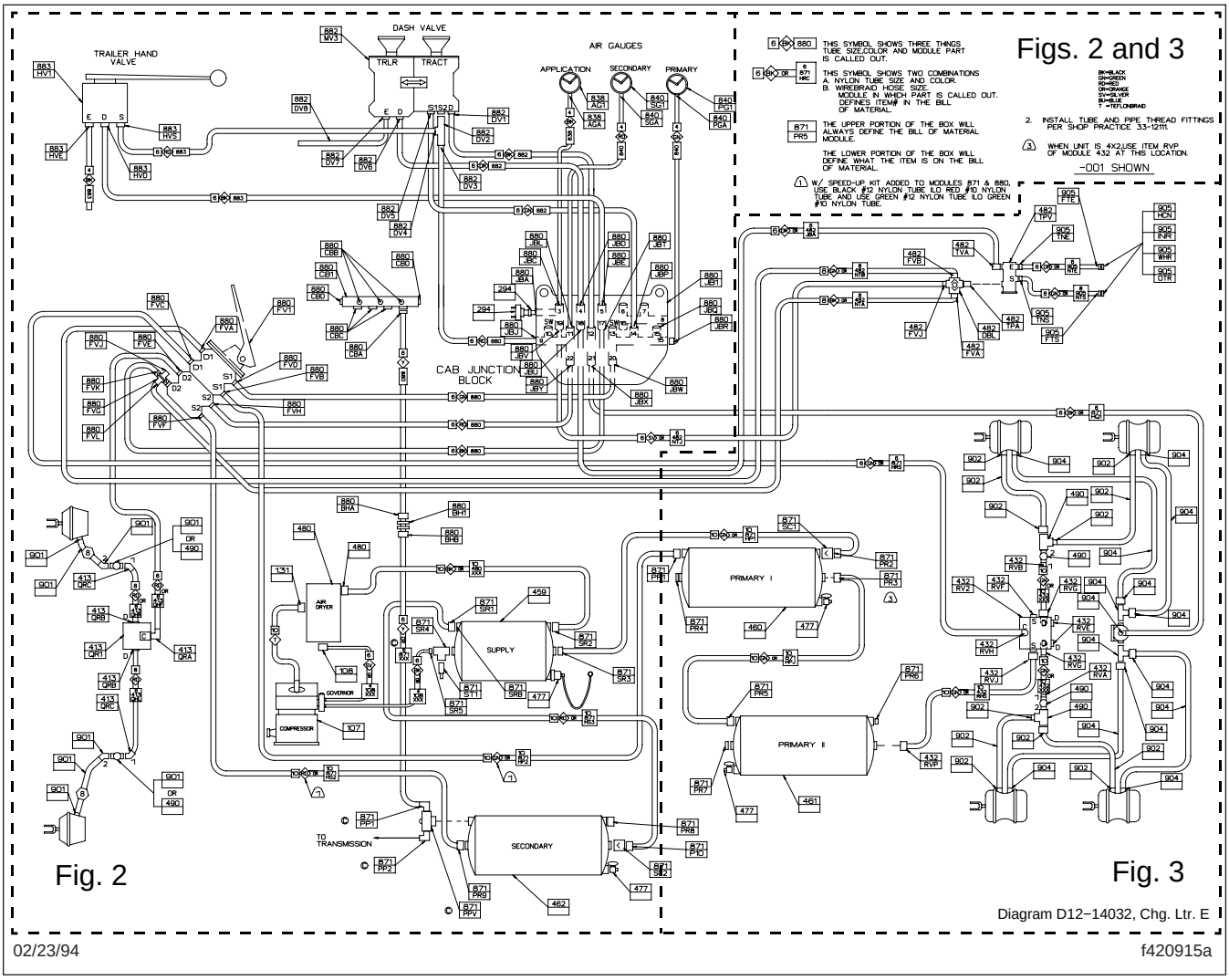


Fig. 1, Tractor Without Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

Tractor Without Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

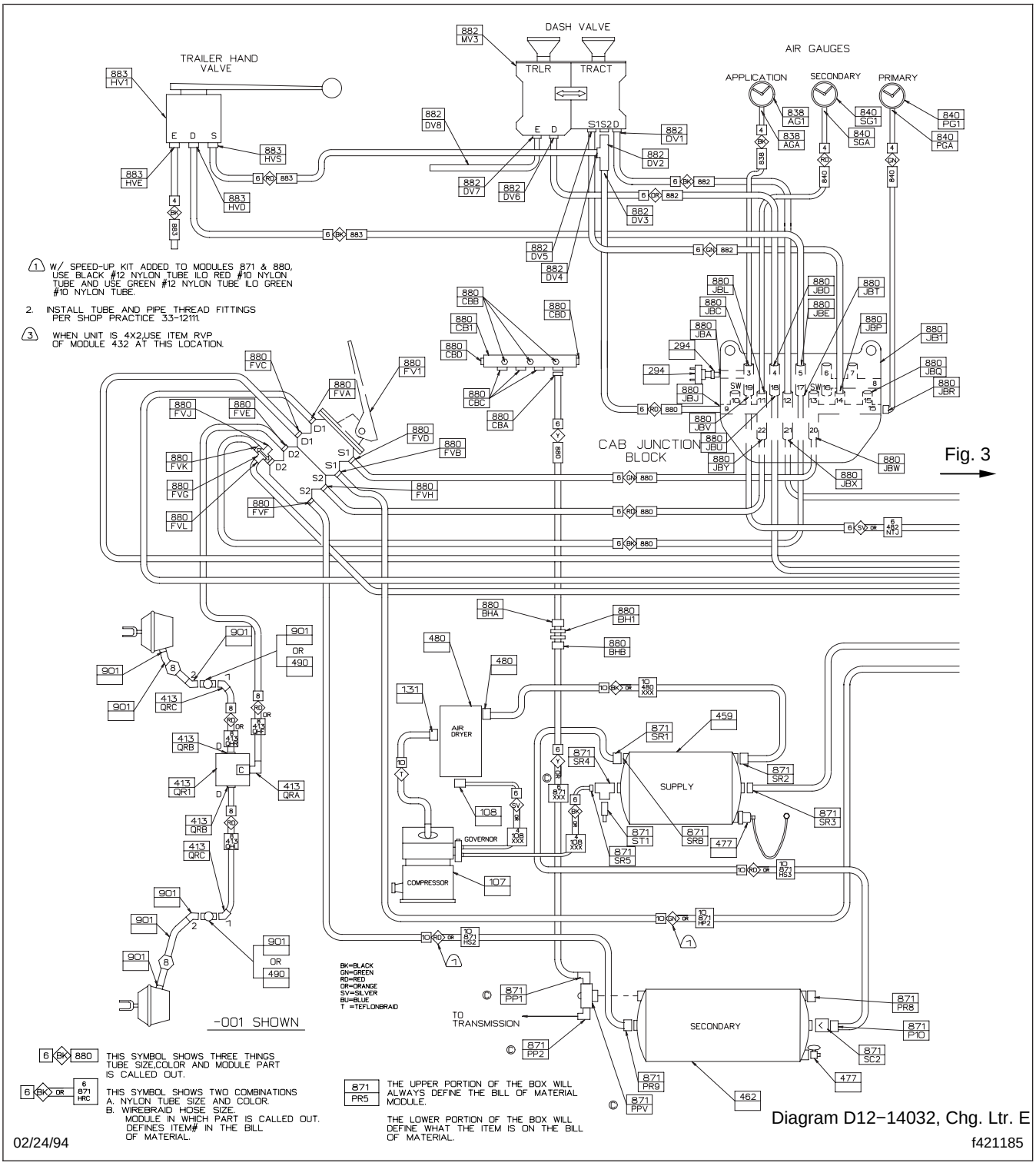


Fig. 3

Diagram D12−14032, Chg. Ltr. E

Fig. 2

Tractor Without Brake Proportioning, With 4-Channel Antilock (If Equipped), and With 20-Inch or Smaller Front Brake Chambers

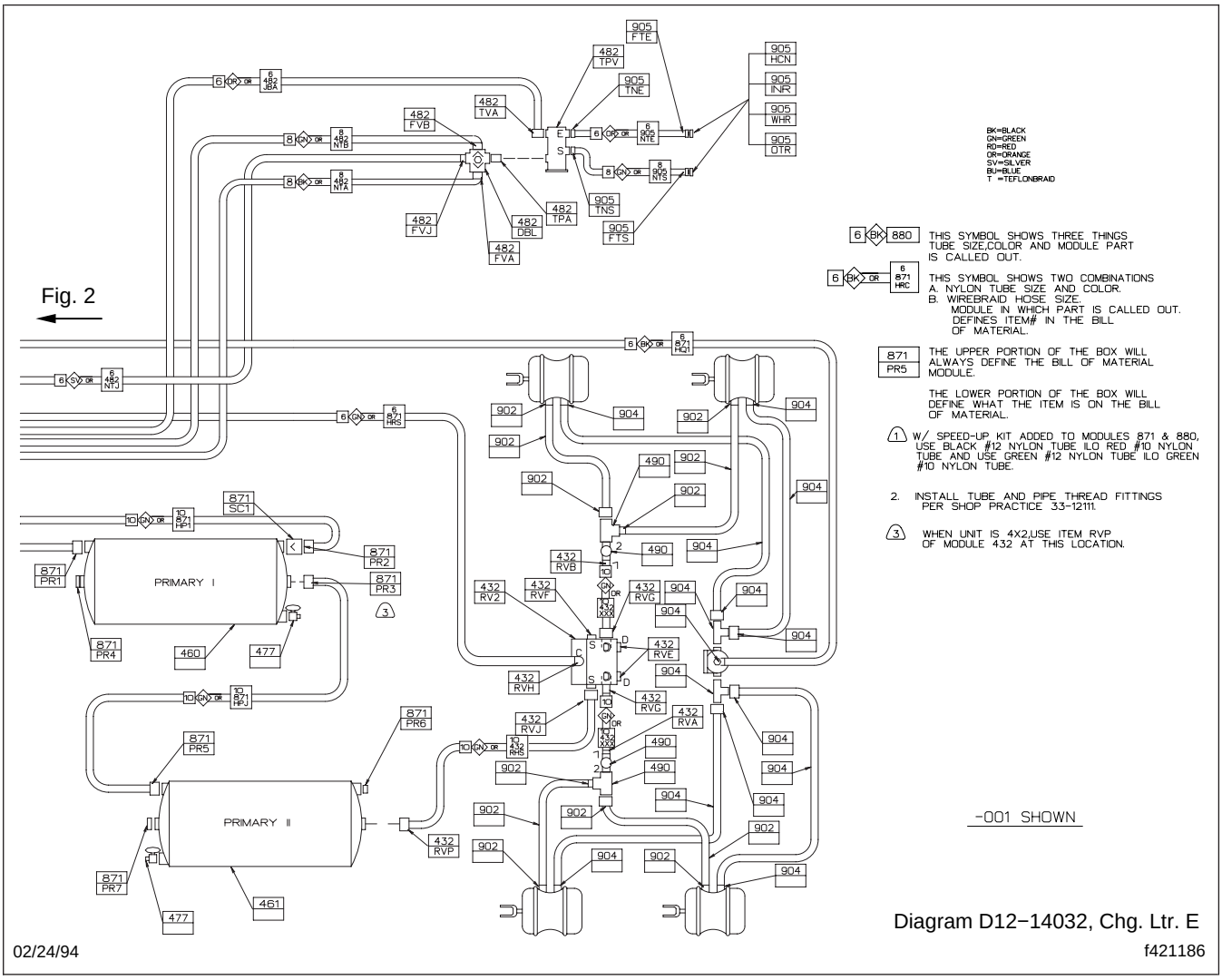


Fig. 3

General Description and Principles of Operation (See Fig. 1 and Fig. 2)

The BP-R1 bobtail proportioning relay valve is a combination of two individual valves in a single housing. The lower portion (body) of the BP-R1 contains a standard service brake relay valve, which functions as a relay station to speed up brake application and release. The upper portion (cover) houses a brake proportioning valve, which adjusts the proportion of normal brake application pressure to the rear brake chambers when the tractor is not towing a trailer.

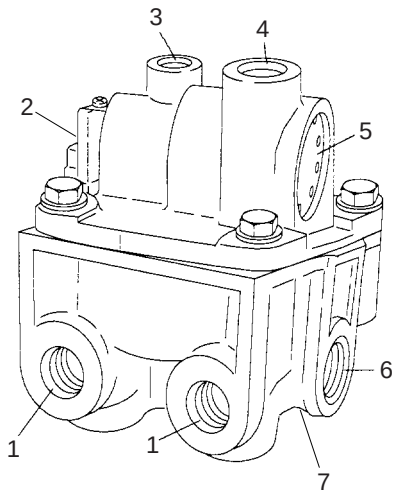
Used in tractor air brake systems only, the BP-R1 is installed in place of a standard relay valve. It functions as a standard service relay during operation of a tractor-trailer combination. During bobtail tractor operation, the BP-R1 improves controllability and reduces stopping distances by limiting air pressure to the rear brake chambers, whose axle load has been greatly reduced, while retaining normal air pressure to the front brake chambers. This reduces the chance of wheel lock and instability in emergency stops.

The rear brake proportioning system is standard on all tractors. The valve is mounted on the crossmember between the rear brake chambers. See the plumbing diagram **in "Specifications, 400."**

A control line from the control port of the BP-R1 valve is connected by a tee to the inlet supply port of the tractor protection valve. This line is charged with full line pressure when a trailer is connected and its spring brakes are released; or is completely exhausted when the tractor is bobtailed and the dash valve trailer charge knob is not applied.

TRAILER SUPPLY VALVE APPLIED (TRACTOR/TRAILER MODE)

On vehicles equipped with a proportioning system, air pressure at the control port allows full service air from the foot valve to pass through the proportioning portion of the valve. This gives full braking effort to the rear axles when a trailer is connected.



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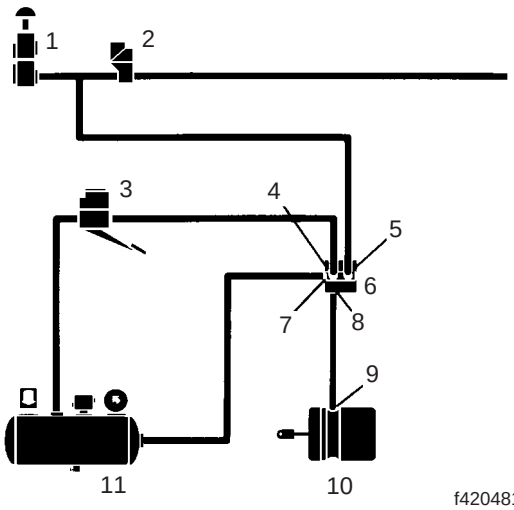
1. Delivery (4)
2. Exhaust
3. Control
4. Service
5. Exhaust
6. Supply (2)
7. Exhaust (on bottom)

Fig. 1



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1. Trailer Supply
2. Tractor Protection
3. Dual Brake Valve
4. Service Port
5. Control Port
6. BP-R1
7. Supply
8. Delivery Port (4)
9. Service
10. Brake Chamber
11. Primary Reservoir

Fig. 2

General Description and Principles of Operation

TRAILER SUPPLY VALVE PULLED OUT (BOBTAIL MODE)

When the trailer supply valve is activated to disconnect the trailer, air in the BP-R1 control port is exhausted to atmosphere. In this mode, service application air exerts force on one side of the blend-back piston and also flows through the piston to exert force on the proportioning piston. The blend-back piston remains stationary at application pressures below 80 psi (551 kPa). Air also flows through the proportioning piston to exert force on both sides of it. Proportioning occurs due to the difference in effective area on each end of the proportioning piston. Service applications of more than 80 psi (551 kPa) cause the blend-back piston to begin to move. Above 80 psi (551 kPa) the different pressures on each side of this piston cause a "blend back" from proportioned delivery to a full one-to-one delivery.

Safety Precautions

⚠ WARNING

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

When working on or around air brake systems and components, observe the following precautions.

1. Apply the parking brakes, chock the tires, and stop the engine when working under the vehicle. Keep hands away from brake chamber push rods and slack adjusters, which may apply as air system pressure drops.
2. Wear safety goggles.
3. Never connect or disconnect a hose or line containing air under pressure; it may whip as air escapes. Never remove a component or pipe plug unless you are sure all system pressure has been depleted.
4. Don't disassemble a component before reading and understanding recommended procedures. Use only the correct tools and follow basic tool safety.
5. Replacement hardware, tubing, hose, fittings, etc. should be the same size, type, length, and strength as the original equipment. When replacing tubing or hose, be sure that all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace any components that have stripped threads or damaged parts. Don't attempt to repair parts by machining.
7. Never exceed recommended air pressure.

Operating Tests

1. Park the vehicle on a level surface and chock the tires.
2. Before testing the air brake proportioning system, do the following:
   - 2.1 Check the operation of the air compressor. Check the pressure levels of the air reservoirs.
   - 2.2 Be sure that all related valves are operating, and the system is plumbed **as shown in Subject 400**.
   - 2.3 Check the operation of the brake chambers following the instructions in the brake section in the vehicle maintenance manual.
   - 2.4 Inspect all tubing for kinks, dents, and other damage. Replace damaged tubing.
   - 2.5 Inspect all hoses for cracks, drying out, overheating, and other damage. Replace damaged hoses.
   - 2.6 Inspect all air line fittings. Tighten loose connections; replace fittings that are damaged.
3. Drain all air tanks to zero pressure.
4. Install a tee at the BP-R1 service port and at one of the delivery ports, then install a gauge in each.
5. Connect the tractor service and emergency gladhands to hose couplings that have been plugged; or, connect them to a trailer. Build the tractor system air pressure to governor cut-out.
6. With the dashboard trailer supply valve and system park control valve activated for tractor/trailer operation, apply, *hold* , and then release the brakes several times, varying the application pressures while watching the reaction of the gauges installed on the BP-R1. Note that a prompt application occurs and that it can be held, then promptly released.
7. Check the BP-R1 differential pressure by applying 10 psi (69 kPa) to the service port and noting the pressure registered at the delivery port. Subtract delivery port pressure from the 10 psi (69 kPa) service pressure to obtain the differential.

NOTE: For BP-R1 valves that *don't incorporate* a relay piston spring (**Fig. 1**, Ref. 9), the measured differential should be about 4 psi (28 kPa). When a spring is in use, the differential will be higher.

8. Make and hold a full brake application of 100 psi (689 kPa) or greater, and note that full pressure is delivered to the chambers.
9. Activate the dash mounted trailer supply valve for bobtail tractor operation. Make a *slow* brake application and watch the gauges installed in step 4. Both gauge readings should rise until the delivery pressure is 5 to 10 psi (34 to 69 kPa). Then the service supply pressure should continue rising while delivery pressure remains constant. Hold the brake application at 20 psi (138 kPa) and check that the delivery pressure is 5 to 10 psi (34 to 69 kPa). Release the application.
10. Make another brake application and *slowly* increase the pressure at the BP-R1 service port to between 60 and 70 psi (414 to 483 kPa) while observing the gauge installed at the delivery port. Note that when service port pressure rises to between 20 and 30 psi (138 to 207 kPa), delivery pressure begins to rise above the initial pressure noted in step 9. The rise of delivery pressure should be at a proportioned rate of *about* three-to-one. At 70 psi (483 kPa) service pressure, delivered pressure should be 15 to 25 psi (103 to 172 kPa).
11. Make a full brake application, and note that both test gauges register the same pressure.
12. Remove the test gauges from the BP-R1.
13. Remove the chocks from the tires. Test drive the vehicle (without a trailer) in a safe area at slow speed with the trailer supply valve pulled out (bobtail position). Make several brake applications to become familiar with the feel of the system before placing the vehicle back in service.

Operating Tests

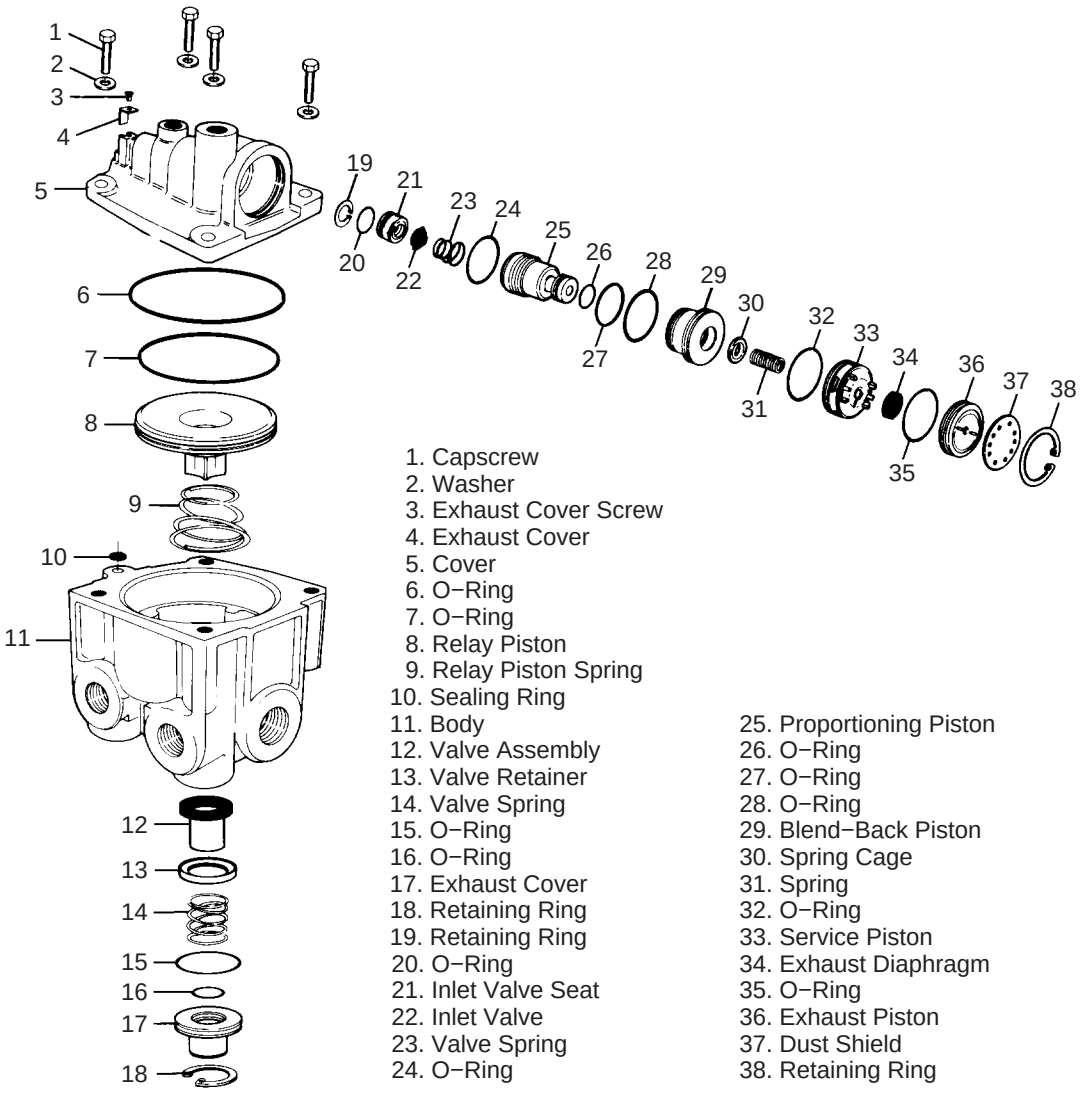


Fig. 1

Removal

1. Park the vehicle on a level surface, apply the parking brakes, chock the tires, and drain all air tanks to zero pressure.

⚠ WARNING

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

2. Mark and then disconnect the air lines from the valve.
3. Remove the two bolts attaching the valve to the vehicle. Remove the valve.

Installation

1. Install the valve on the vehicle. Tighten the bolts 15 lbf·ft (20 N·m).
2. Connect the air lines to the proper ports, as marked during removal.
3. Check the proportioning valve operation using the instructions **under Subject 110**.

Disassembly, Cleaning and Inspecting, and Assembly

Disassembly

CAUTION

CAUTION: The BP-R1 may be lightly clamped in a bench vise during disassembly, however, over-clamping will cause damage to the valve and result in leakage or malfunction.

If a vise is to be used, position the valve so that the jaws bear on the supply ports on opposing sides of the valve's body.

1. Remove all air fittings and plugs from the valve.
2. Mark the relationship of the valve cover to the body, and if the valve is equipped with a mounting bracket, mark the relationship of the bracket to the cover.
3. While holding the exhaust cover (**Fig. 1**, Ref. 17), remove and discard the retaining ring (Ref. 18) that secures it to the body (Ref. 11).
4. Remove and discard the exhaust cover along with both O-rings (Refs. 15 and 16).
5. Remove and discard the valve spring (Ref. 14), valve retainer (Ref. 13), and the valve assembly (Ref. 12) from the body.
6. Remove and retain the four capscrews and washers (Refs. 1 and 2) that secure the cover (Ref. 5) to the body.
7. Separate the cover from the body, then remove and discard the sealing ring and O-ring (Refs. 10 and 6).
8. Remove and retain the relay piston (Ref. 8) and relay piston spring (Ref. 9) from the body.

NOTE: The relay piston spring is *not used in all valves* .

9. Remove and discard the O-ring (Ref. 7) from the relay piston.
10. Remove and discard the dust shield (Ref. 37) and the retaining ring (Ref. 38) from the valve cover, then remove and save the exhaust piston (Ref. 36).
11. Remove and discard the exhaust piston O-ring (Ref. 35) and the exhaust diaphragm (Ref. 34).
12. Remove and save the service piston (Ref. 33) from the valve cover, then remove and discard the service piston O-ring (Ref. 32).
13. Remove the spring (Ref. 31) and spring cage (Ref. 30) from the valve cover. Discard the spring and retain the spring cage.
14. Remove and retain the blend-back piston (Ref. 29) from the valve cover, then remove and discard both O-rings (Refs. 27 and 28).
15. Remove and save the proportioning piston (Ref. 25) from the valve cover, then remove and discard both O-rings (Refs. 26 and 24).
16. While holding the inlet valve seat (Ref. 21) in place, remove and discard the retaining ring (Ref. 19) from the proportioning piston.
17. Remove the inlet valve seat, the inlet valve (Ref. 22), and the valve spring (Ref. 23) from the proportioning piston, then remove and discard the O-ring (Ref. 20) from the valve seat. Discard the valve and spring also.
18. Remove and discard the exhaust cover screw (Ref. 3) and exhaust cover (Ref. 4).

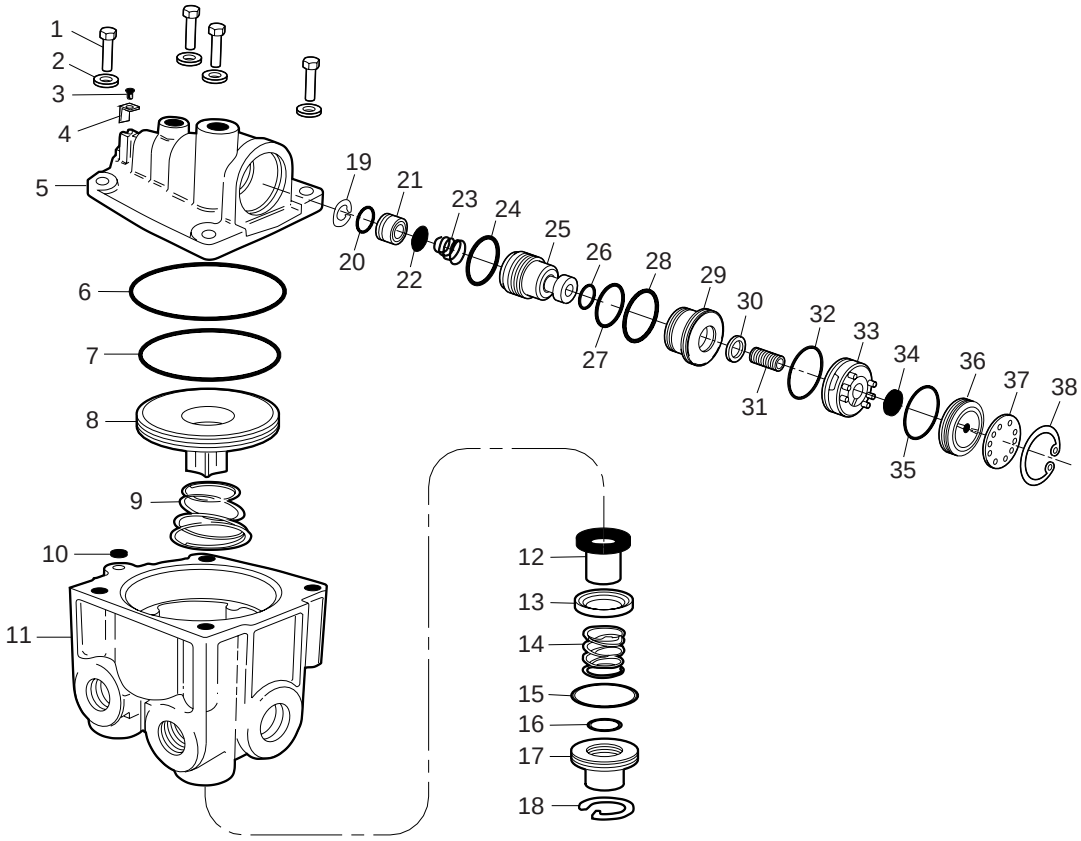
Cleaning and Inspection

WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Using mineral spirits or an equivalent solvent, clean and thoroughly dry all metal parts. Don't damage any bores with metal tools.
2. Wash all non-metallic parts (Refs. 8, 17, 21, 25, 29, 30, 33, and 36) in a soap and water solution, making certain to rinse and dry thoroughly.
3. Inspect the interior and exterior of all metal parts that will be re-used. Check for severe corrosion, pitting, gouges and cracks. Superficial corrosion or pitting of the exterior portion of the body and cover is acceptable. Replace the entire valve if the interior of the body or cover show signs of corrosion or pitting.
4. Inspect each non-metallic part for cracks, wear or distortion. Replace the entire valve if these conditions exist.
5. Replace all rubber parts.

Disassembly, Cleaning and Inspecting, and Assembly



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1. Capscrew
2. Washer
3. Exhaust Cover Screw
4. Exhaust Cover
5. Cover
6. O-Ring
7. O-Ring
8. Relay Piston
9. Relay Piston Spring
10. Sealing Ring
11. Body
12. Valve Assembly
13. Valve Retainer
14. Valve Spring
15. O-Ring
16. O-Ring
17. Exhaust Cover
18. Retaining Ring
19. Retaining Ring
20. O-Ring
21. Inlet Valve Seat
22. Inlet Valve
23. Valve Spring
24. O-Ring
25. Proportioning Piston
26. O-Ring
27. O-Ring
28. O-Ring
29. Blend-Back Piston
30. Spring Cage
31. Spring
32. O-Ring
33. Service Piston
34. Exhaust Diaphragm
35. O-Ring
36. Exhaust Piston
37. Dust Shield
38. Retaining Ring

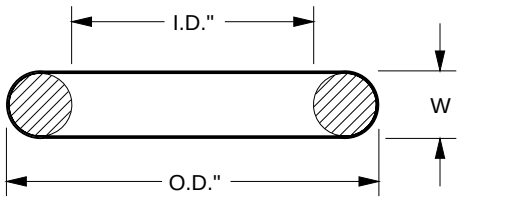
Fig. 1

6. Make certain the air channel running between the top surface of the body and its supply port is clear and free of blockages.
7. Make certain all air channels and exhaust passages in the valve cover are clear and free of blockages.
8. Inspect the pipe threads in the body and valve cover. Make certain they are clean and free of thread sealant.
9. If the valve was equipped with a relay piston spring, check it for signs of corrosion, pitting, and cracks. Replace as needed.

10. Inspect all air line fittings for corrosion; replace as needed. Be sure to remove all old thread sealant before re-use.

Assembly

1. Prior to assembly, lubricate all O-rings (identify them by referring to **Table 1**), seals, and pistons, as well as body and cover bores, using the lubricant provided in the Bendix maintenance kit. Use all of the lubricant, and spread it evenly on the rubbing surfaces.



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Key No.	I.D.	O.D.	W
6	3.487	3.693	0.103
7	3.234	3.512	0.139
15	1.424	1.630	0.103
16	0.862	1.068	0.103
20	0.489	0.629	0.070
24	0.739	0.879	0.070
26	0.412	0.552	0.070
27	0.737	0.943	0.103
28	1.112	1.318	0.103
32	1.176	1.316	0.070
35	1.356	1.496	0.070

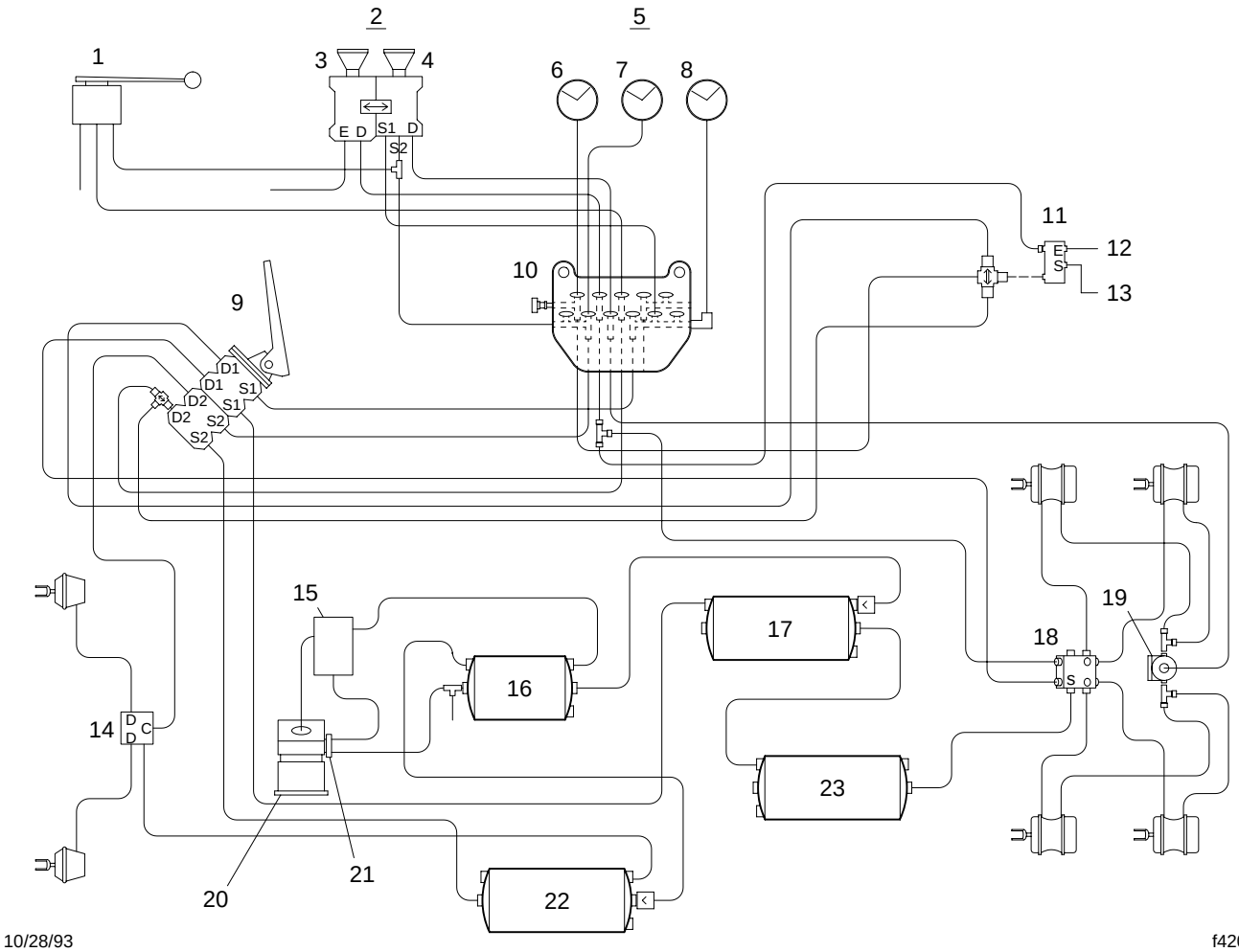
Table 1, O-Ring Identification (Sectional View)

2. Install the O-ring (**Fig. 1** , Ref. 20) on the inlet valve seat (Ref. 21).
3. Install the small end of the valve spring (Ref. 23) over the rubber of the inlet valve (Ref. 22), making sure the spring coils rest on the valve's four tabs.
4. Insert the spring and valve into the valve seat, making sure the four tabs are inside the seat's bore.
5. Insert the valve, seat, and spring assembly into the proportioning piston (Ref. 25)—large end of the spring first.
6. While holding the seat in place, install the retaining ring (Ref. 19) to secure it in the piston. Make certain the retaining ring is fully seated in its groove. Make sure the valve is straight against the exhaust seat and free to move.
7. Install both the large and small diameter O-rings (Refs. 24 and 26) on the proportioning piston.
8. Install both the large and small diameter O-rings (Refs. 28 and 27) on the blend-back piston (Ref. 29), then insert the small diameter of the proportioning piston into the small diameter end of the blend-back piston.
9. Carefully insert the assembled proportioning and blend-back pistons to the edge of the bore in the cover (Ref. 5). Don't cut or pinch the O-rings.
10. With the bore of the cover facing up, install the spring cage (Ref. 30) in the blend-back piston so that its flat side rests against the blend-back piston (its depressed side out towards spring [Ref. 31]).
11. Install the O-ring (Ref. 32) on the service piston (Ref. 33), then install the spring (Ref. 31) in the cage (Ref. 30) so that its coils are in the inside diameter of the cage.
12. Install the O-ring (Ref. 35) on the exhaust piston (Ref. 36), and place the exhaust diaphragm (Ref. 34) between the six posts of the service piston.
13. Place the exhaust piston on the service piston with its six-ribbed side facing the service piston. Then install both pistons while pushing the proportioning and blend-back pistons all the way into the cover.
14. Install the dust shield (Ref. 37) in the cover.
15. While holding the dust shield in the cover, install the retaining ring (Ref. 38), making certain it is fully seated in its groove.
16. Install the exhaust cover (Ref. 4) using the screw (Ref. 3) to retain it. Torque the screw 8 to 15 lbf·in (100 to 160 N·cm).

Disassembly, Cleaning and Inspecting, and Assembly

17. Install the valve retainer (Ref. 13) on the valve assembly (Ref. 12) so that the flange of the retainer (Ref. 13) surrounds the rubber portion of the valve. Install the valve assembly in the body.
18. Install the valve spring (Ref. 14) in the body.
19. Install the large and small diameter O-rings (Refs. 15 and 16) in the exhaust cover (Ref. 17), then install the exhaust cover in the body, taking care not to damage the O-rings. Hold the exhaust cover in place.
20. While depressing the exhaust cover, install the retaining ring (Ref. 18) in the body. Make sure this ring is fully seated in its groove in the body.
21. If the BP-R1 was equipped with a relay piston spring (Ref. 9), install the spring in the body, large diameter first.
22. Using lubricant to hold them in place, install the large O-ring and small sealing ring (Refs. 6 and 10) on the cover.
23. Install the O-ring (Ref. 7) on the relay piston (Ref. 8), then install the piston in the body.
24. After noting the relationship marks made prior to disassembly, install the mounting bracket (not shown) on the cover, then secure the cover and mounting bracket on the body using the four capscrews and washers (Refs. 1 and 2). Torque the capscrews 120 to 150 lbf·in (1360 to 1700 N·cm).

See Fig. 1 for a system plumbing diagram.



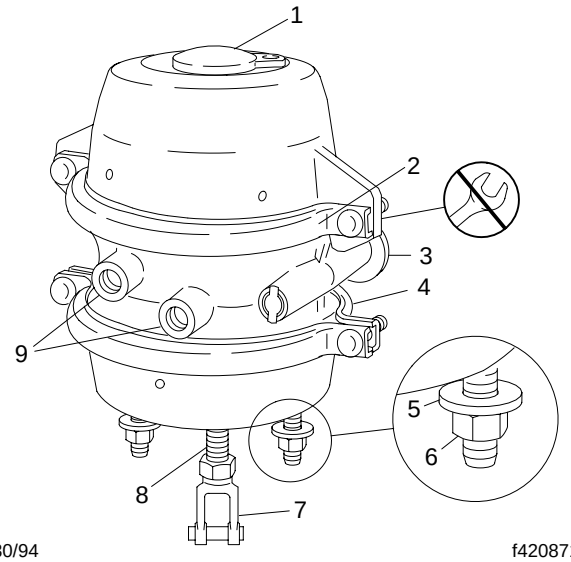
1. Trailer Hand Valve
2. Dash Valves
3. Trailer Valve
4. Tractor Valve
5. Air Gauges
6. Application Air Gauge
7. Secondary Air Gauge
8. Primary Air Gauge
9. Foot Valve
10. Cab Junction Block
11. Tractor Protection
12. Emergency
13. Service
14. QR Valve
15. Air Dryer
16. Supply
17. Primary 1
18. BP-R1 Valve
19. QR Valve
20. Compressor
21. Governor
22. Secondary
23. Primary 2

Fig. 1

⚠ DANGER

Don't loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: On some Anchorlok models, the parking/emergency brake section is factory sealed (no clamp ring) and is a *non-serviceable* unit. On other models, the parking/emergency brake section is attached with a clamp ring. *Do not ever perform any service on this clamp ring.*



NOTE: On some models, the parking brake clamp ring is permanently sealed.

1. Dust Plug
2. Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports

Fig. 1, Parts of the Brake Chamber

General Information

Anchorlok brake chambers consist of a service brake section and a parking/emergency spring brake section. See **Fig. 1**. The service brake section is the smaller section near the clevis assembly.

In the service brake section, the service brake chamber contains a service return spring, piston rod assembly, and service brake diaphragm.

In the parking/emergency brake section, the adaptor and the parking brake chamber contain a return spring, a push rod assembly, a parking (spring) brake diaphragm, a pressure plate, a power spring, and a detachable release bolt.

All Anchorlok brake chambers are mounted to the frame using prevailing torque locknuts and hardened flatwashers.

Periodic maintenance of the brake chambers is required. Also, whenever the service brake chamber is disassembled (*do not attempt to disassemble the parking brake chamber*), the parts should be inspected for damage. For maintenance schedules and procedures, and for inspection of brake chamber parts, refer to the vehicle maintenance manual.

Principles of Operation

SERVICE BRAKES

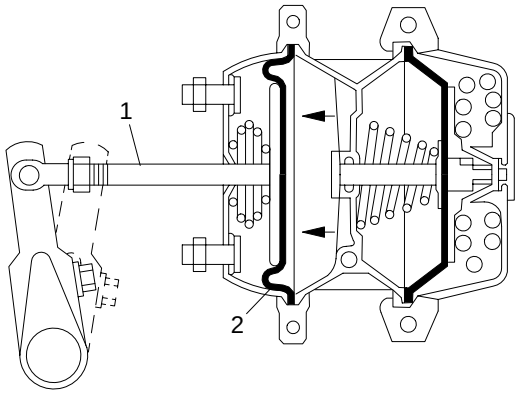
As the brake pedal is depressed, compressed air enters the service brake chamber through a port. Air pressure acts upon a diaphragm, which forces the piston rod toward the non-pressure chamber, applying a straight-line force to the slack adjuster, which converts it to a rotational force. This in turn rotates the camshaft and applies the brakes. See **Fig. 2**.

Then, when the brake pedal is released (see **Fig. 3**), air is exhausted from the service brake chamber, and the return spring allows the diaphragm, piston rod assembly, and slack adjuster to return to their normal positions, releasing the brakes.

PARKING/EMERGENCY BRAKES

During parking brake release, compressed air enters the parking/emergency brake chamber below the diaphragm, forcing the diaphragm against the pressure plate to compress the power spring and release the parking/emergency brake. See **Fig. 4**. During parking brake application, a control valve in the cab exhausts air from the parking/emergency brake chamber. This allows the power spring to extend and apply the brakes. See **Fig. 5**.

General Information and Principles of Operation



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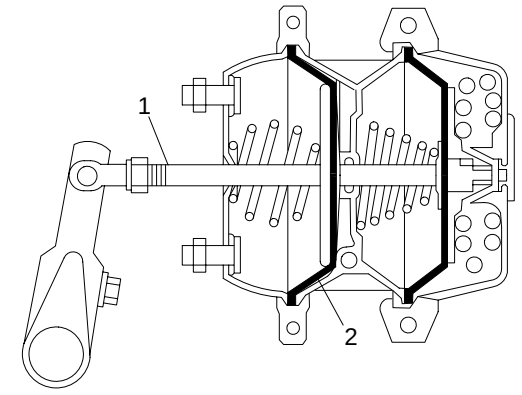
1. Piston Rod Assembly
2. Service Brake Diaphragm

Fig. 2, Service Brakes Applied



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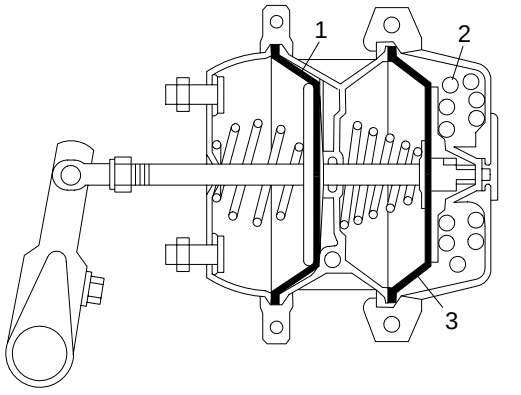
1. Piston Rod Assembly
2. Service Brake Diaphragm

Fig. 3, Service Brakes Released

Emergency brake application begins when air pressure in the service brake reservoir drops below about 80 to 85 psi (550 to 585 kPa). Maximum parking brake force is applied when air is entirely exhausted fom the parking/emergency brake chamber.



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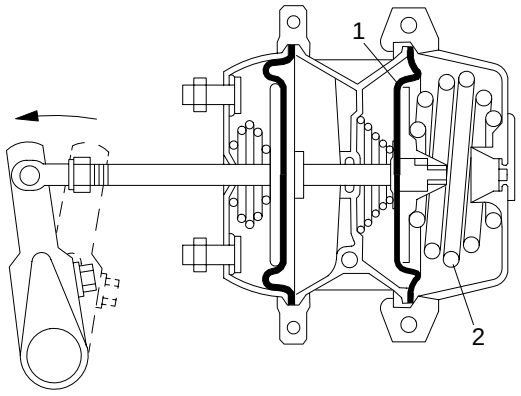
1. Service Brake Diaphragm
2. Power Spring
3. Parking/Emergency Brake Diaphragm

Fig. 4, Parking/Emergency Brakes Released



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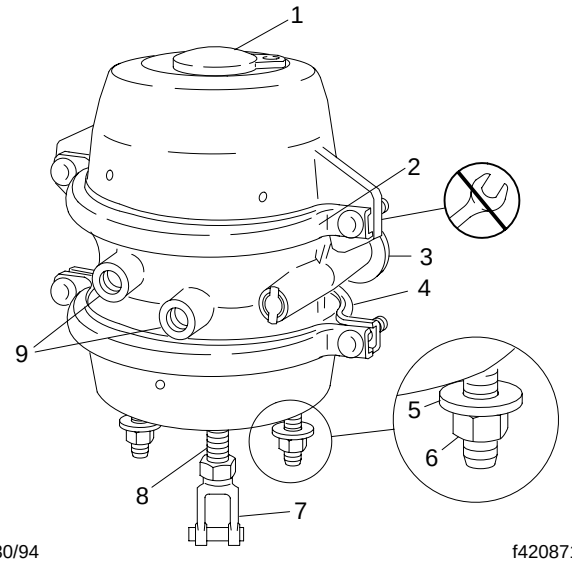
1. Parking/Emergency Brake Diaphragm
2. Power Spring

Fig. 5, Parking/Emergency Brakes Applied

Power Spring Manual Compression and Reset

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.



NOTE: On some models, the parking brake clamp ring is permanently sealed.

1. Dust Plug
2. Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports

Fig. 1, External Parts of the Parking Brake Chamber

Manual Compression (Parking Brake Release)

1. Chock the tires.
2. Remove the dust plug from the center-hole in the head of the chamber. See **Fig. 2**.

⚠ DANGER

Do not attempt to cage the power spring if the safety hooks have been removed, or if the parking brake chamber is damaged severely enough to lose its structural integrity. If the power spring were to break loose, it could result in death, severe personal injury, or property damage.

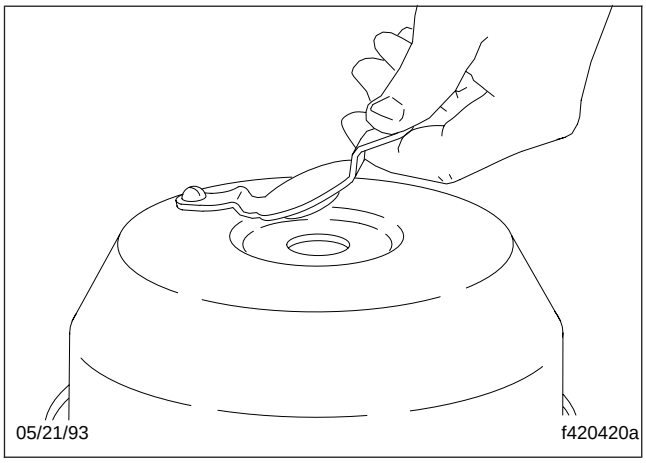


Fig. 2, Removing the Dust Plug

A DAMAGED PARKING BRAKE CHAMBER IS EXTREMELY DANGEROUS! Only qualified service personnel should attempt to remove and disarm a damaged chamber.

3. Using a torch, burn off the piston rod in the space between the clevis and the base of the service chamber. Remove the chamber carefully from its bracket, and disarm it inside a suitable container. For disarming procedures, consult the Anchorlok installation instructions.
4. Manually release the parking brake (cage the power spring).

   4.1 Using a hand wrench, (*don't use an impact wrench*), unscrew the release nut, and remove the nut, flatwasher, and release bolt from the storage pocket on the side of the chamber. See **Fig. 3**.

   IMPORTANT: If these parts are not stored on the chamber, they must be otherwise obtained or purchased; the parking brake cannot be manually released without them.

   4.2 Insert the release bolt into the center-hole in the chamber head (see **Fig. 4**). Continue to insert the bolt until it bottoms out into the hole in the pressure plate inside the chamber.

Power Spring Manual Compression and Reset

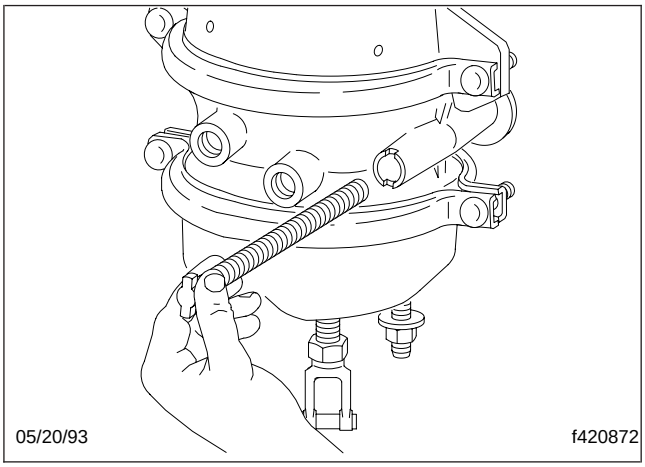


Fig. 3, Removing the Release Bolt from the Storage Pocket

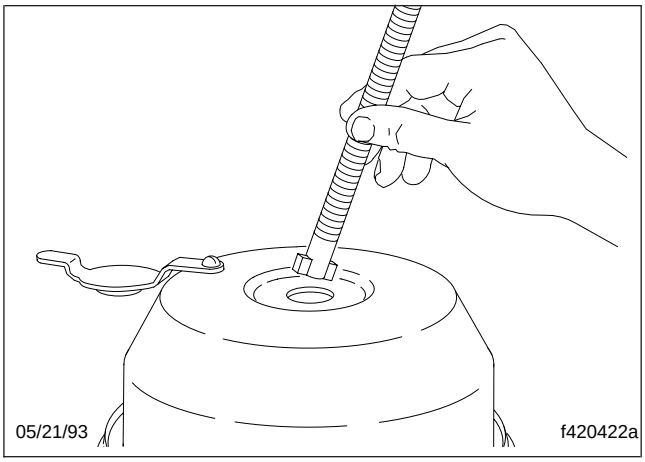


Fig. 4, Installing the Release Bolt

IMPORTANT: If you are not absolutely sure that the formed end of the bolt has engaged the pressure plate correctly, repeat this step. Repeat it until you are absolutely sure.

4.3 Turn the release bolt one-quarter turn clockwise. Pull to seat the formed end of the release bolt in the recess of the pressure plate.

4.4 Holding the release bolt locked into the pressure plate, install the flatwasher and release nut on the end of the bolt, and turn down the nut against the flatwasher until it is finger-tight. See **Fig. 5**.

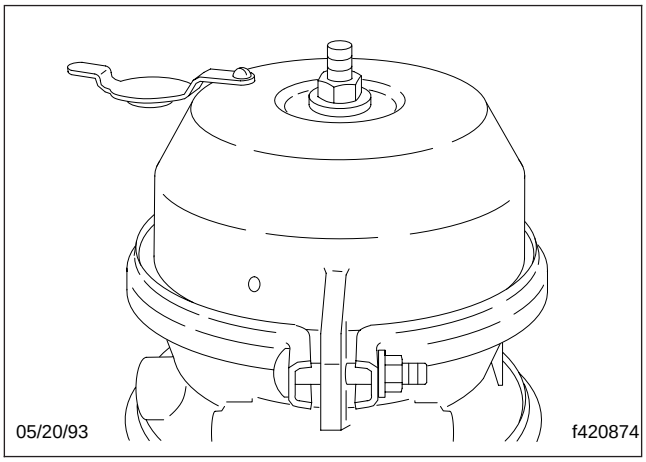


Fig. 5, Starting the Release Bolt Nut

⚠ DANGER

Exhaust all air pressure before tightening the release nut more than finger-tight. Tightening this nut under pressure can damage the pressure plate and result in sudden release of the power spring, causing severe personal injury or death.

⚠ CAUTION

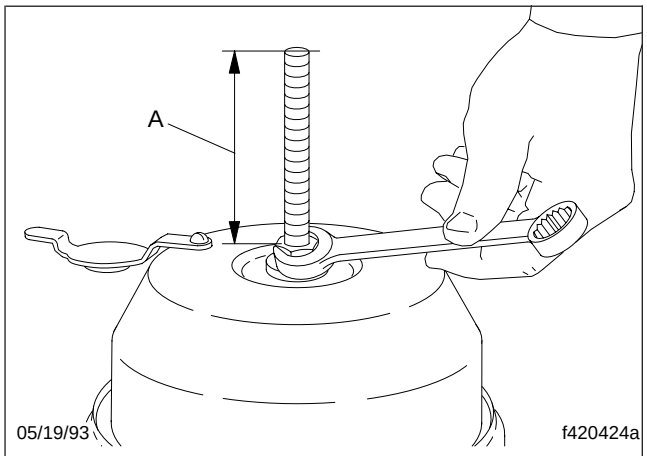
If equipped with S-cam brakes, don't exceed 35 lbf·ft (47 N·m) torque on the release nut; if equipped with wedge brakes, don't exceed 20 lbf·ft (27 N·m) torque on the release nut.

4.5 Using a hand wrench (*don't use an impact wrench*), turn the release nut clockwise until the power spring is caged (see **Fig. 6**).

On parking/emergency brake chambers that are permanently sealed (no clamp ring), the bolt should extend above the nut at least 2.9 inches (74 mm) on 24-inch chambers, or 2.875 inches (73 mm) on 30-inch chambers.

On parking/emergency brake chambers that are sealed with a clamp ring, the bolt should extend above the nut at least 2.8 inches (71 mm) on 24-inch chambers, or 2.7 inches (69 mm) on 30-inch chambers.

IMPORTANT: Do not exceed these bolt lengths. If the bolt lengths can't be obtained



A. Measure this distance.

Fig. 6, Measuring the Release Bolt at Full Compression

without exceeding the recommended maximum torque values, replace the tandem brake chamber.

Manual Reset (Parking Brake Reset)

1. Uncage the power spring.

CAUTION

Don't use an impact wrench on this nut. Too much torque could damage the pressure plate and prevent manual release of the parking brake.

1.1 With air applied to the parking brake section (the parking brake control valve is in the "release" position), use a hand wrench to turn the release nut *counterclockwise* until the power spring extends back into the parking/emergency brake chamber.

NOTE: When the power spring is fully extended, force will no longer be felt on the release nut.

1.2 Remove the nut and flatwasher.

1.3 Turn the release bolt one-quarter turn counterclockwise and unlock the bolt from the receptacle in the pressure plate. Remove the release bolt from the center-hole of the chamber.

2. Using a hand wrench, (*don't use an impact wrench*), install the release bolt, flatwasher, and release nut in the storage pocket. Tighten the nut 60 to 96 lbf·in (680 to 1080 N·cm). See See **Fig. 7**.

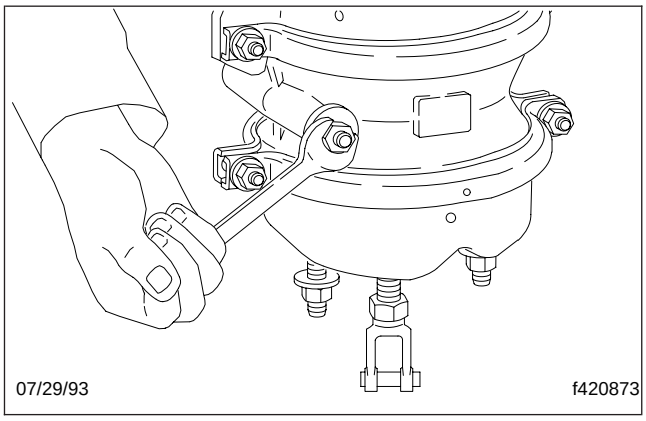


Fig. 7, Storing the Release Bolt

3. Snap the dust plug in place over the center-hole in the chamber head. See **Fig. 8**.

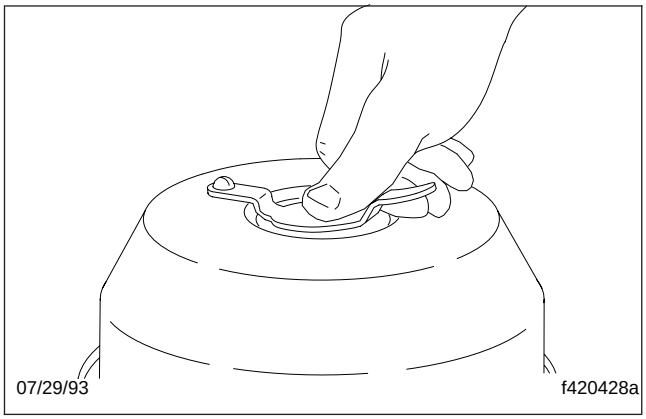


Fig. 8, Installing the Dust Plug

CAUTION

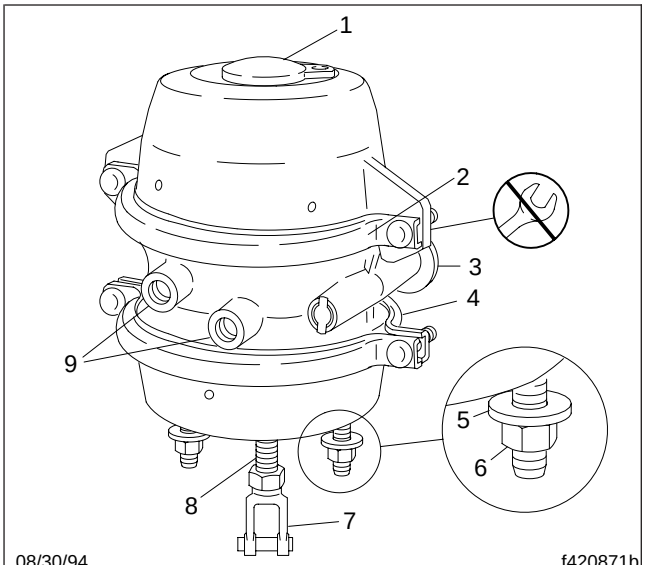
If a dust plug is missing or incorrectly installed, road dirt and debris can enter the brake chamber and cause the internal parts to deteriorate.

4. Check the plastic dust plug periodically, and replace it with a new one at once if damaged or missing. For intervals, refer to the vehicle maintenance manual.

5. Remove the chocks from the tires.

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.



NOTE: On some models, the parking brake clamp ring is permanently sealed.

1. Dust Plug
2. Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports

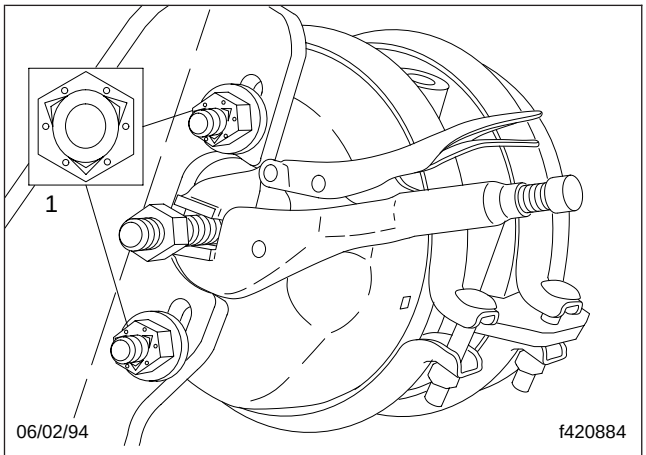
Fig. 1, Parts of the Brake Chamber

Removal

1. To make removal and installation of the parking brake section easier (without removing the service brake chamber), lock off the service chamber piston rod.

   1.1 Apply the service brakes by actuating the driver's foot brake treadle valve.

   1.2 With the brakes applied, clamp a pair of locking-jaw pliers on the piston rod to lock the rod in place when the air pressure is released (see Fig. 2).



1. Prevailing Torque Locknut

Fig. 2, Clamp Rod With Brakes Applied

⚠ WARNING

Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

2. Manually release the parking brake (cage the power spring). For instructions, refer to **Subject 100**.
3. Mark the air lines for later reference. Then carefully disconnect them from the brake chamber.

⚠ DANGER

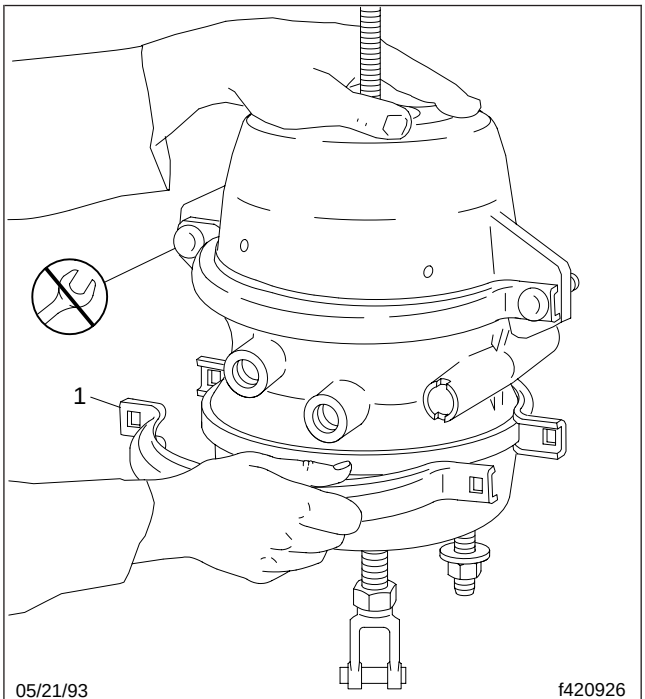
Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

4. Remove the parking brake and adaptor from the service brake section.

   4.1 Using a hand wrench (*don't use an impact wrench*), remove the clamp nuts on the *service* brake clamp ring (*do not disassemble the parking brake section*).

Service Brake Diaphragm Replacement

4.2 While holding the parking brake section securely in place, remove the service clamp ring. Then remove the parking brake section from the service brake non-pressure chamber (see **Fig. 3**).



1. Service Brake Clamp Ring

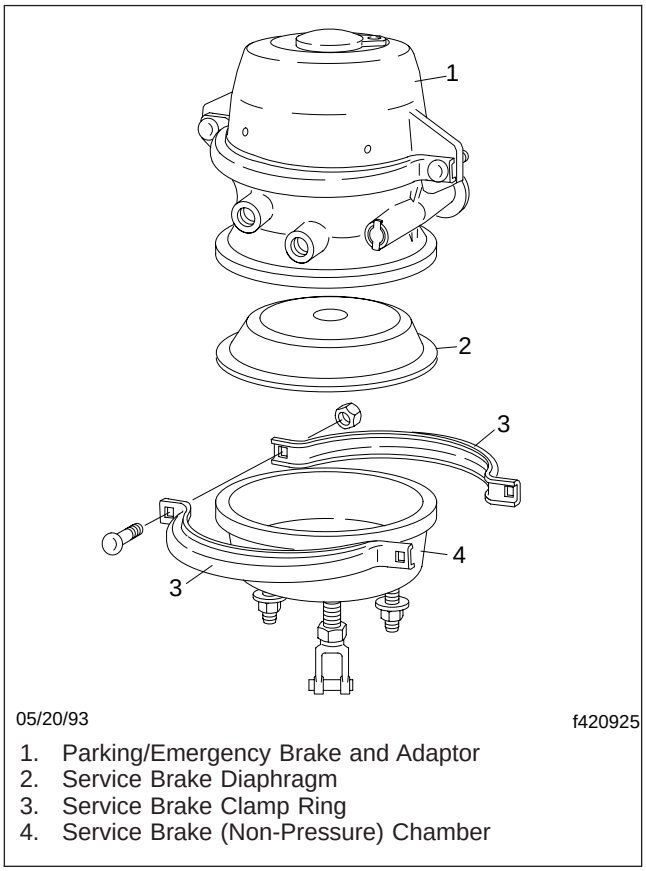
Fig. 3, Remove Service Brake Clamp Ring

5. Remove the service brake diaphragm from the bottom of the parking brake section.

Installation

IMPORTANT: At this time, take the opportunity to inspect the parking/emergency brake section, and replace it if it shows signs of damage, corrosion, or rust. Follow the detailed inspection instructions in the vehicle maintenance manual.

1. Inspect all parts in the service (non-pressure) chamber. Replace any damaged or worn parts.
2. Place the new service brake diaphragm in the bottom recess of the adaptor (see **Fig. 4**).
3. Install the (new, if needed) parking/emergency brake section.



1. Parking/Emergency Brake and Adaptor
2. Service Brake Diaphragm
3. Service Brake Clamp Ring
4. Service Brake (Non-Pressure) Chamber

Fig. 4, Installing the Diaphragm

3.1 If installing a new parking brake section, be sure it is the same size and make as the old one.

3.2 Check that the release bolt is fully extended outward. For instructions, refer to **Subject 100**.

3.3 Install the parking brake section on the service chamber so that all mating parts are aligned straight and the air lines are positioned to mate with the vehicle air supply lines.

4. Install the service brake clamp ring.

4.1 With the service brake clamp ring in place, install the clamp bolts and nuts.

4.2 Using a hand wrench (*don't use an impact wrench*), alternately tighten each clamp nut in increments of 60 to 120 lbf·in (680

to 1360 N·cm) while constantly rechecking the alignment of mating parts.

If realignment is needed, loosen the nuts again, and repeat this substep.

4.3 Lightly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. Tighten the nuts to a final torque of 18 to 25 lbf·ft (24 to 34 N·m).

5. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 25 lbf·ft (34 N·m).
6. Using the vehicle system air, charge the parking brake with full line pressure—at least 100 psi (690 kPa). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 25 lbf·ft (34 N·m).
7. With the parking brake still charged with full line pressure, apply and hold the foot brake treadle valve down to charge the service brake chamber. Remove the locking-jaw pliers from the service piston rod so that the piston returns to a normal position in the chamber.

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

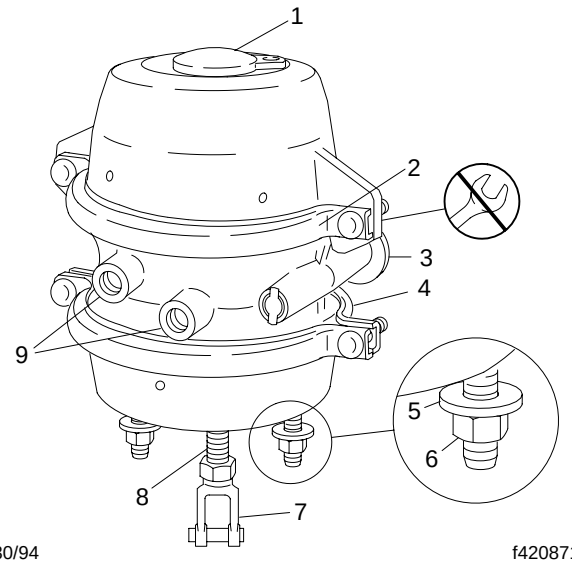
8. Test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, release all air pressure from the chamber, then retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). Anchorlok recommends 18 to 25 lbf·ft (24 to 34 N·m) torque on the clamp hexnuts.
9. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring, and snap the dust plug in place. For instructions, refer to **Subject 100**.
10. Adjust the brakes at the slack adjuster.

IMPORTANT: After replacing any brake chamber components, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, refer to the applicable slack adjuster section in **Group 42** in this manual.

Replacement

DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.



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NOTE: On some models, the parking brake clamp ring is permanently sealed.

1. Dust Plug
2. Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports

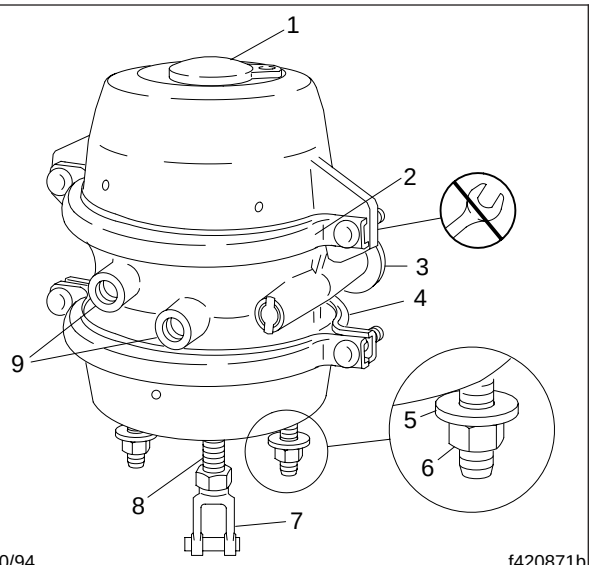
Fig. 1, Parts of the Brake Chamber

IMPORTANT: The parking/emergency brake section can be replaced as a unit. For instructions, refer to **Subject 110**.

Combination Service and Parking Brake Chamber Removal and Installation

DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.



NOTE: On some models, the parking brake clamp ring is permanently sealed.

1. Dust Plug
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6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports

Fig. 1, Parts of the Brake Chamber

Removal

WARNING

Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

1. Manually release the parking brake (cage the power spring). For instructions, refer to **Subject 100**.
2. Mark the air lines for later reference. Then carefully disconnect them from the brake chambers.
3. Remove the brake chamber from the vehicle.

   3.1 Remove the cotter pin(s) from the clevis pin(s), then remove the clevis pin(s) from the clevis. Disconnect the clevis from the slack adjuster.

   NOTE: Gunite and Meritor automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

   3.2 From each mounting stud, remove any installed nuts and washers. Then, cautiously remove the brake chamber from the mounting bracket.

Installation

1. If installing a new brake chamber unit, do the following steps:

   1.1 First, make sure the power spring is caged (release bolt fully extended outward). If not, go to **Subject 100** and do the applicable steps.

   1.2 Make sure that the piston rod is the same length as the rod on the old unit (measure the rods when *both* chambers are caged).

   1.3 Be sure the new chamber is the same size and make as the brake chamber installed on the other side of the axle.

   1.4 Remove the prevailing torque locknut and hardened flatwasher from each of the mounting studs on the chamber.

2. Clean the face of the mounting bracket, and position the chamber on the bracket. Pay close attention to positioning the chamber air inlet ports for correct alignment to the vehicle air lines.

WARNING

Tighten the mounting nuts with a hand wrench, not an impact wrench. An impact wrench could damage the mounting fasteners, reducing the

Combination Service and Parking Brake Chamber Removal and Installation

force of the brakes. This could result in personal injury or property damage.

3. Install one hardened flatwasher and prevailing torque locknut on each mounting stud. Using a hand wrench (*don't use an impact wrench*), tighten the nuts 110 to 150 lbf·ft (149 to 203 N·m). Make sure that the hardened flatwasher is installed between the locknut and the mounting bracket.
4. Check mating and alignment with the vehicle air lines.

DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

4.1 Using a hand wrench (*don't use an impact wrench*), loosen the clamp nuts on the *service* clamp ring (*do not disassemble the parking brake section*).

4.2 Reposition the air inlet ports, as needed, to mate with vehicle air supply lines.

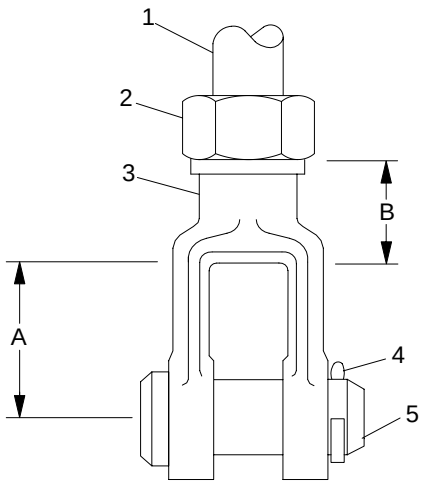
Alternately tighten each clamp nut in increments of 60 to 120 lbf·in (680 to 1360 N·cm) while constantly rechecking the alignment of mating parts.

If realignment is needed, loosen the nuts again, and repeat this substep.

4.3 Lightly tap around the circumference of the service clamp ring to ensure full seating of the clamp. Tighten the nuts to a final torque of 18 to 25 lbf·ft (24 to 34 N·m).

5. With manual slack adjusters, connect the slack adjuster to the clevis, then install the clevis pin. Insert the cotter pin in the clevis pin, and lock it in place. Check the piston-rod engagement with the clevis. At least seven threads of engagement are required; there should be 1-inch (25-mm) clearance from the centerline of the clevis pin hole to the end of the piston rod. See Fig. 2. Adjust as needed.

   With automatic slack adjusters, refer to the applicable slack adjuster section in Group 42 in this manual for installation instructions.



A. Minimum clearance of 1 inch (25 mm) between centerline of clevis pin hole and piston rod end.
B. Minimum of 7 threads engagement.
1. Piston Rod
2. Piston Rod Nut
3. Clevis
4. Cotter Pin
5. Clevis Pin

Fig. 2, Piston Rod Engagement With the Clevis

6. Inspect the piston rod to be sure it is working free, not binding, and is square with the chamber bottom from zero to full stroke. If there is misalignment, make corrections by loosening the locknuts and repositioning the chamber on the mounting bracket, or by shimming the slack adjuster to the right or left on the camshaft.
7. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 25 lbf·ft (34 N·m).
8. Using the vehicle system air, charge the parking brake with full line pressure, at least 100 psi (690 kPa). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 25 lbf·ft (34 N·m).

Combination Service and Parking Brake Chamber Removal and Installation

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: If the service brake clamp ring was loosened to reposition the air inlet ports, apply air to the parking brake, and then apply and hold the foot brake treadle valve down to charge the service brake chamber. Now test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, release all air pressure from the chamber, then retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). Anchorlok recommends 18 to 25 lbf·ft (24 to 34 N·m) torque on the clamp hexnuts.

9. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring, and snap the dust plug in place. For instructions, refer to **Subject 100**.
10. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this manual.

IMPORTANT: After replacing any brake chamber, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, refer to the applicable slack adjuster section in **Group 42** in this manual.

Specifications

Torque Values		
Description	**Torque**	
	lbf·ft (N·m)	**lbf·in (N·cm)**
Spring Brake Release Bolt Nut:		
(in storage pocket)	—	60–96 (680–1080)
(caged—on S-cam brakes)	35 (47)	—
(caged—on wedge brakes)	20 (27)	—
Service Brake Clamp Ring Nut	18–25 (24–34)	—
Brake Chamber Mounting Stud Locknut	110–150 (149–203)	—
Air Hose Fitting-to-Chamber	25 (34)	—

Table 1, Torque Values

With Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), With Hand Valve, and With 2 Dash Valves

See Fig. 1 for a full view of the plumbing diagram with brake proportioning, with 4- or 6-sensor antilock braking (if equipped), with hand valve, and with 2 dash valves. **See Fig. 2**, **Fig. 3**, **Fig. 4**, or **Fig. 5** for partial (detailed) views plumbing diagram with brake proportioning, with 4- or 6-sensor antilock braking (if equipped), with hand valve, and with 2 dash valves.

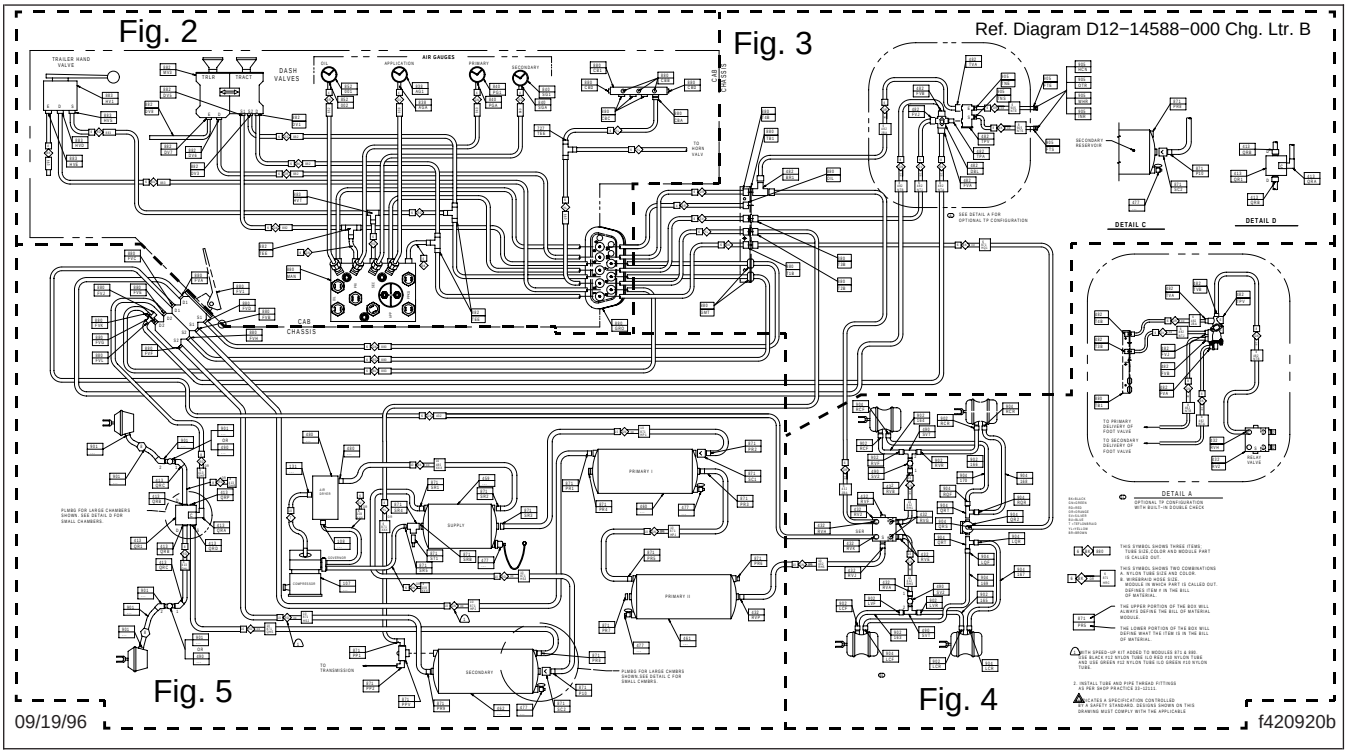


Fig. 1, With Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), With Hand Valve, and With 2 Dash Valves

With Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), With Hand Valve, and With 2 Dash Valves

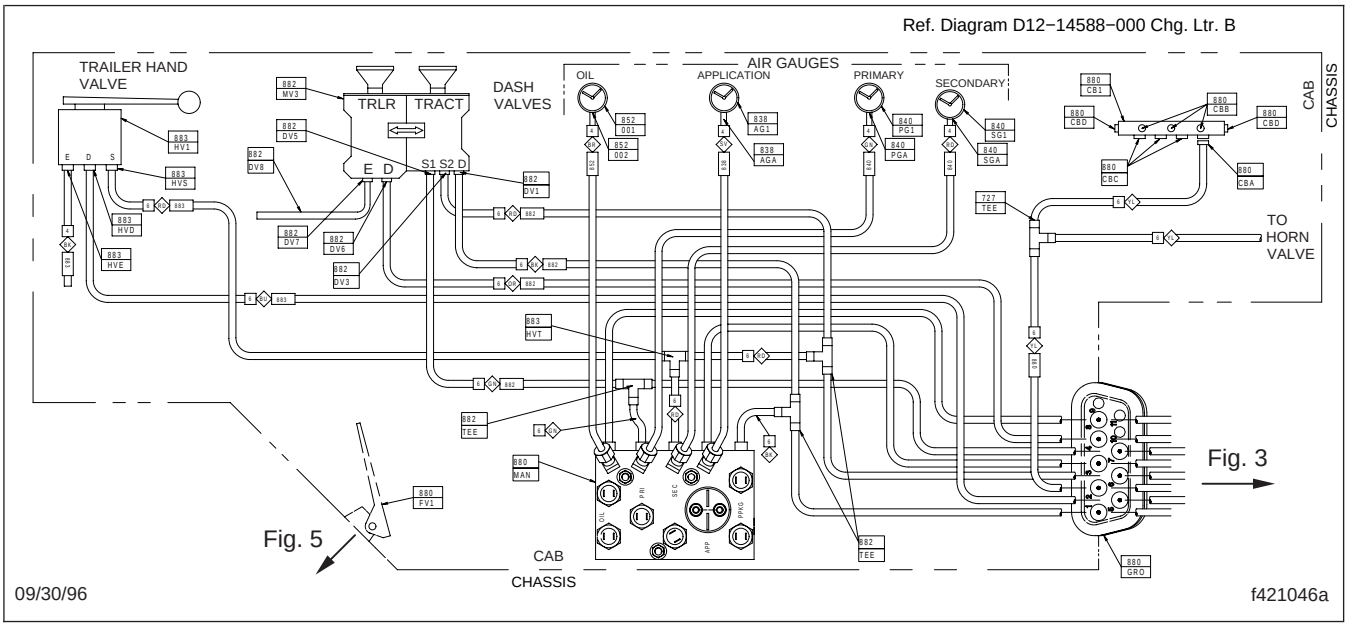


Fig. 2

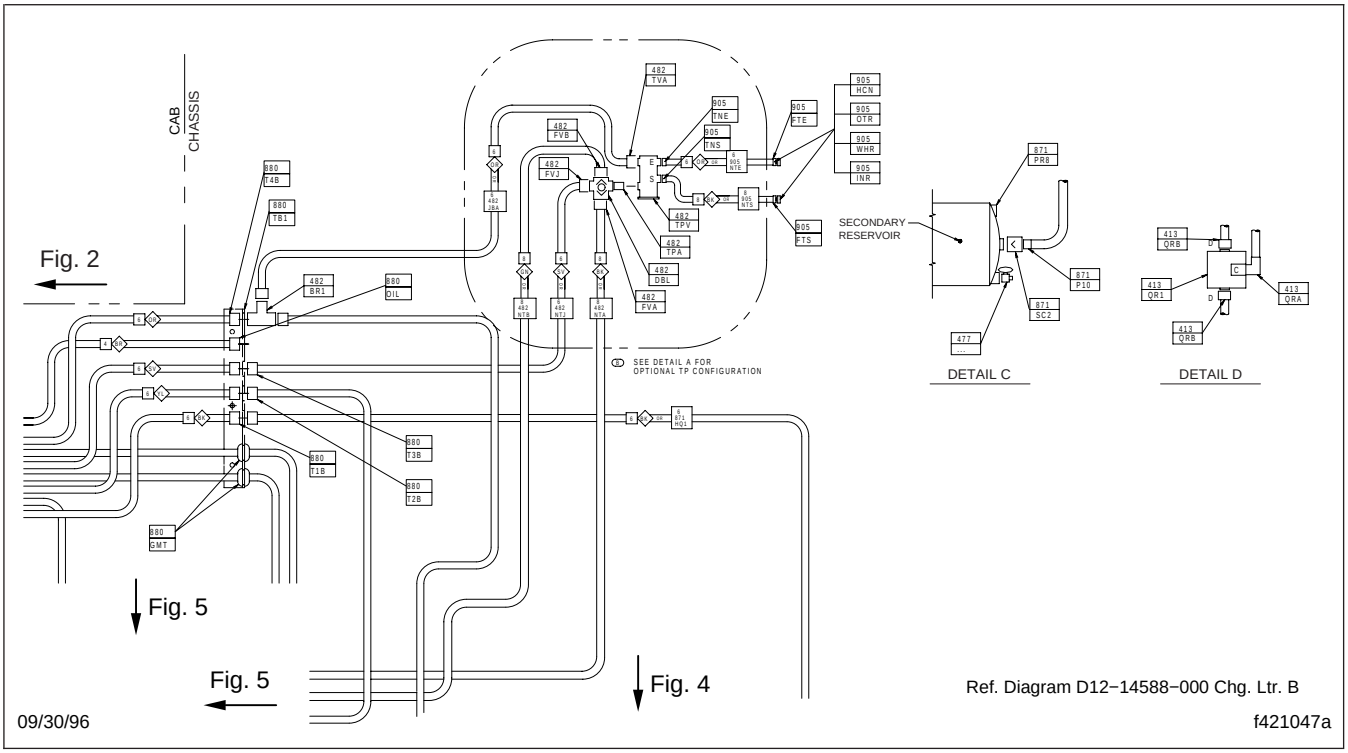


Fig. 3

With Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), With Hand Valve, and With 2 Dash Valves

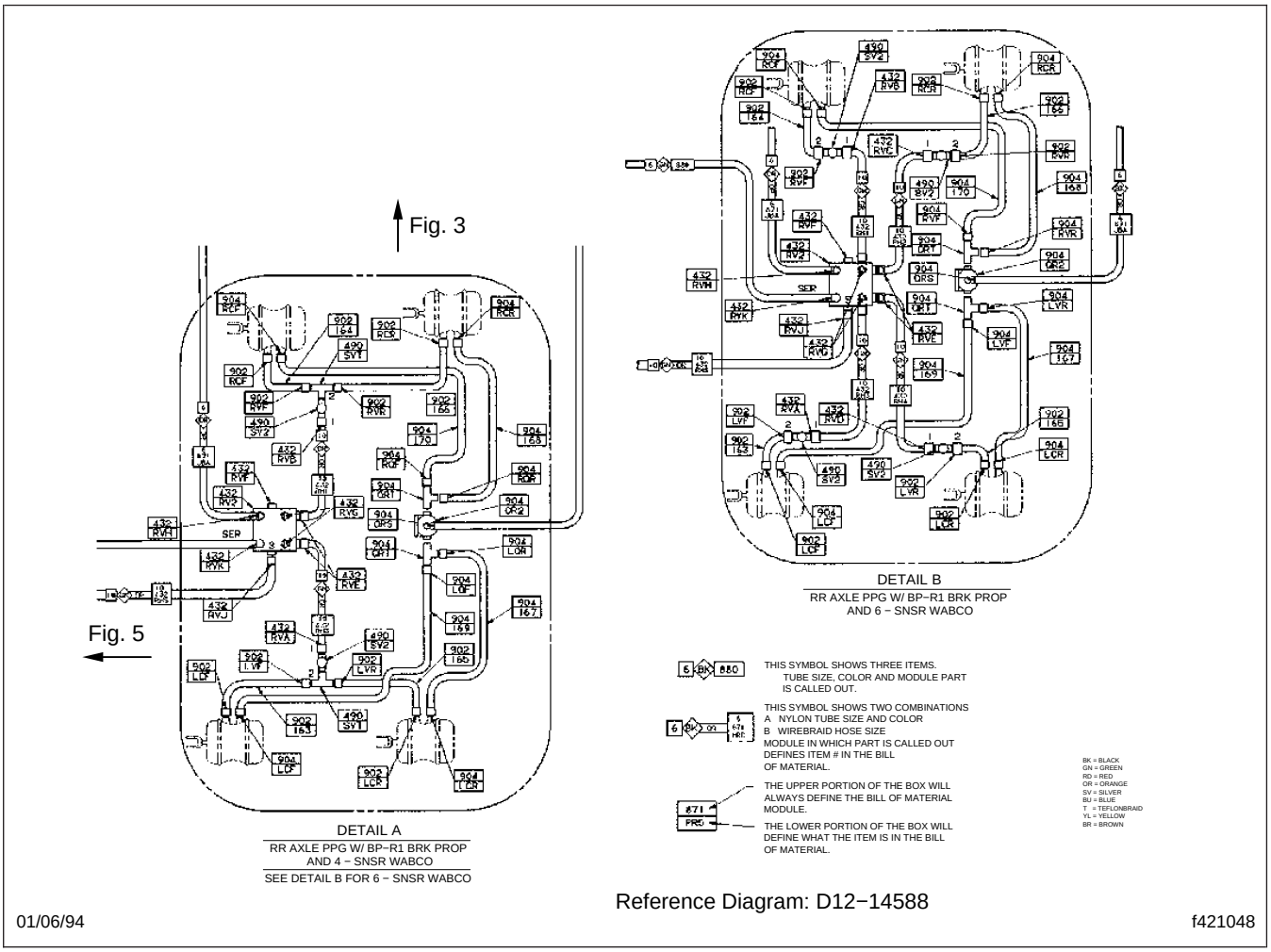


Fig. 4

With Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), With Hand Valve, and With 2 Dash Valves

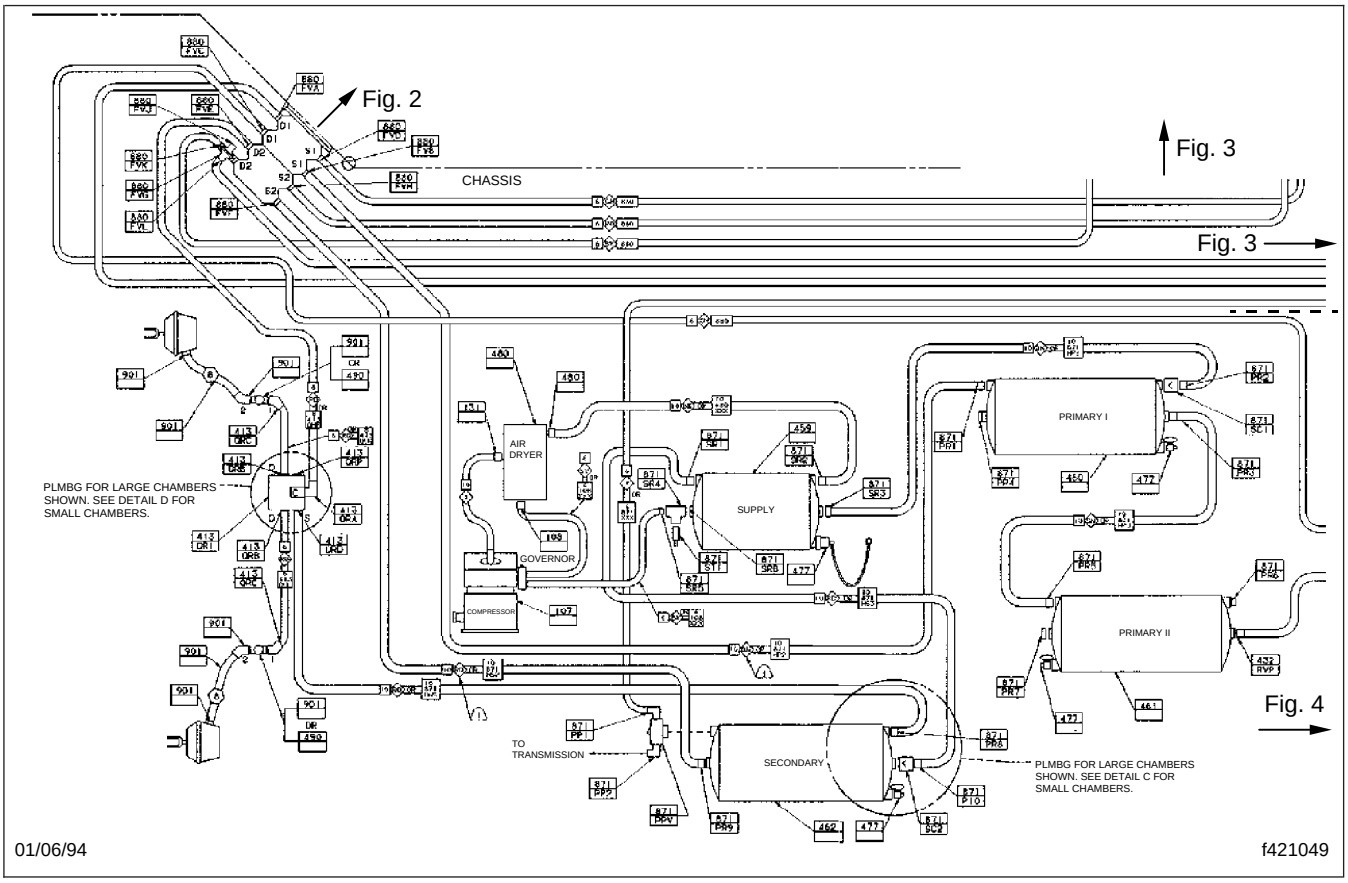


Fig. 5

Without Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), With Hand Valve, and With 2 Dash Valves

See Fig. 1 for a full view of the plumbing diagram without brake proportioning, with 4- or 6-sensor antilock braking (if equipped), with hand valve, and with 2 dash valves. **See Fig. 2**, **Fig. 3**, **Fig. 4**, or **Fig. 5** for partial (detailed) views plumbing diagram without brake proportioning, with 4- or 6-sensor antilock braking (if equipped), with hand valve, and with 2 dash valves.

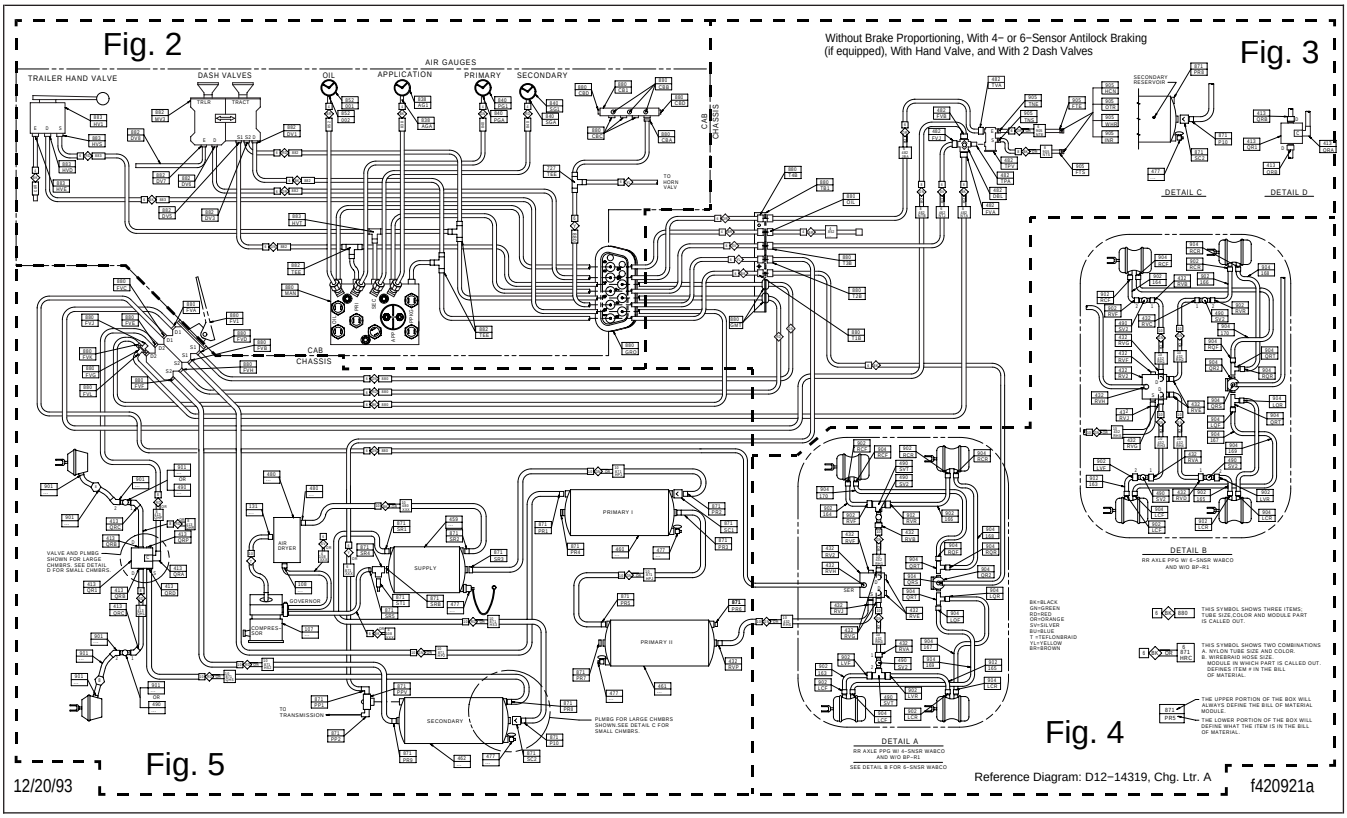


Fig. 1, Without Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), With Hand Valve, and With 2 Dash Valves

Without Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), With Hand Valve, and With 2 Dash Valves

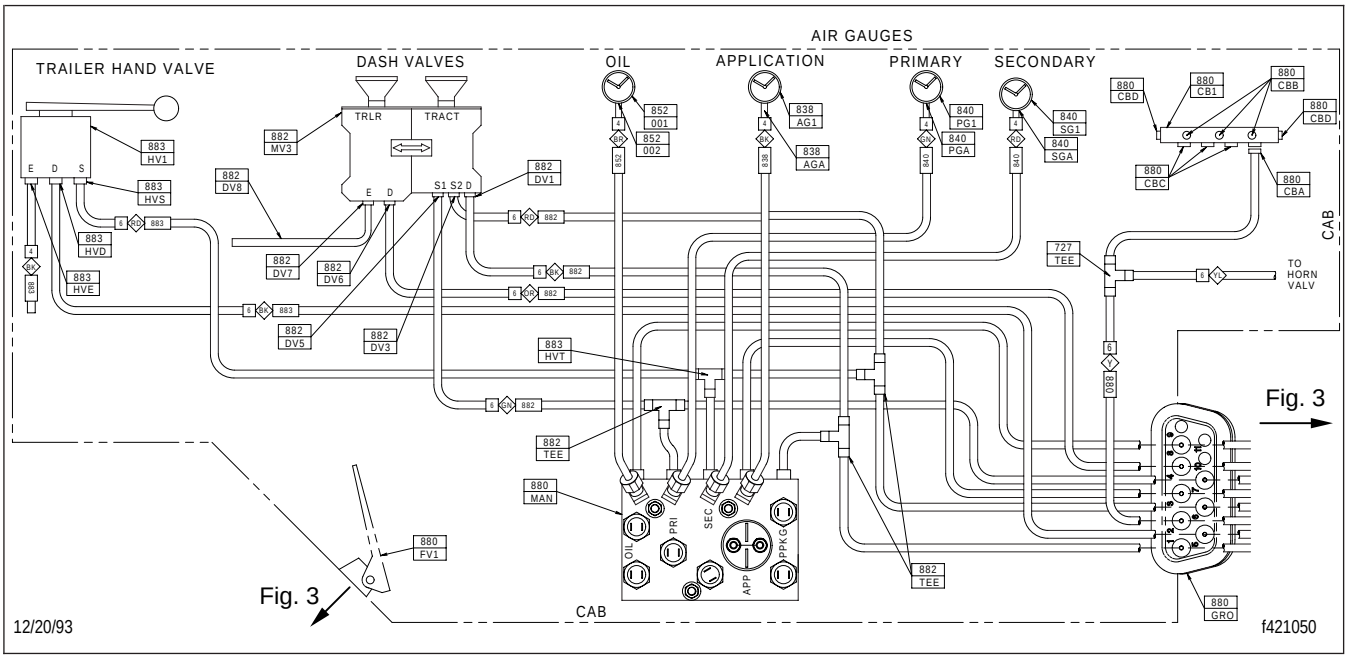


Fig. 2

Without Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), With Hand Valve, and With 2 Dash Valves

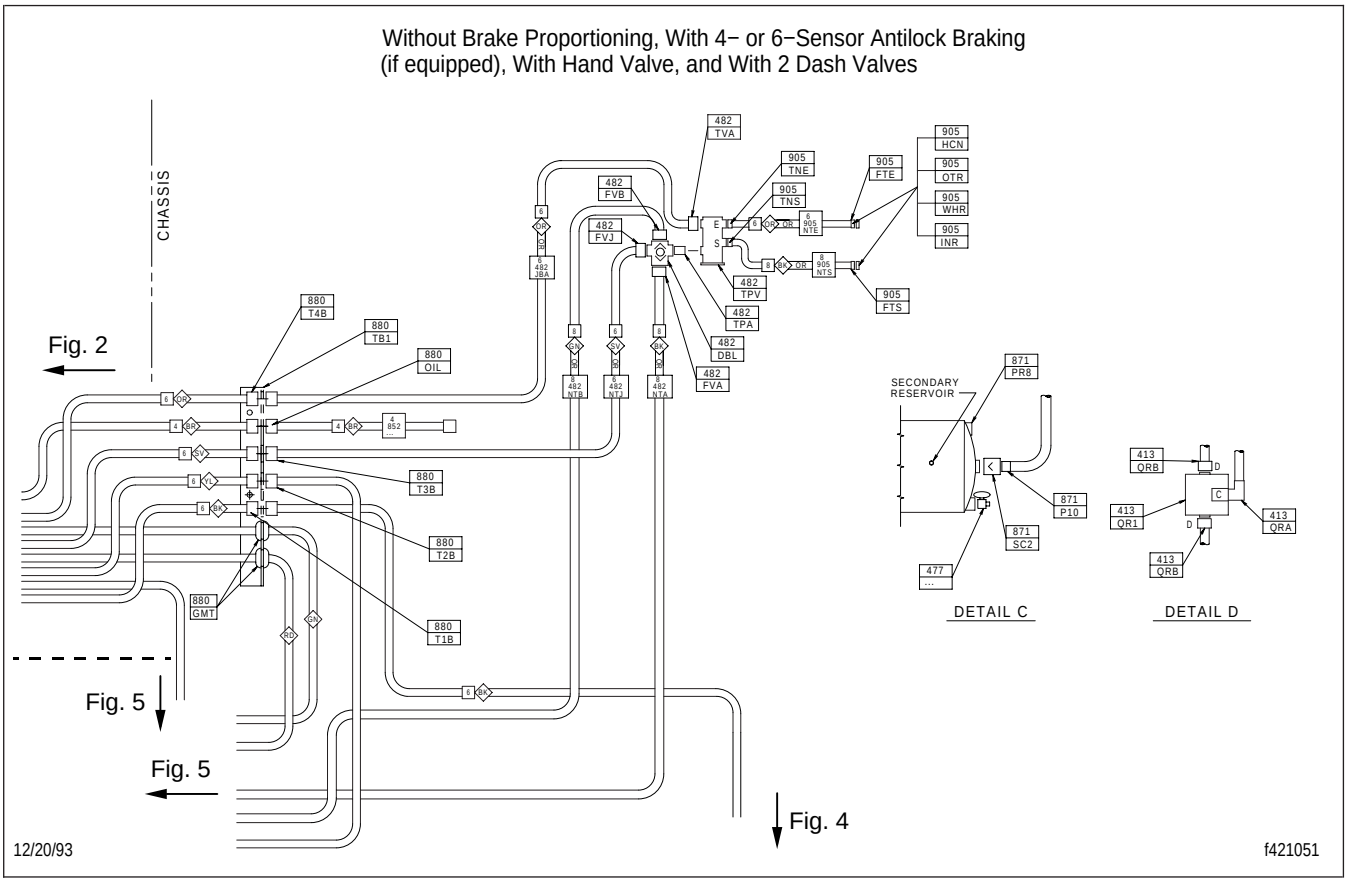


Fig. 3

Without Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), With Hand Valve, and With 2 Dash Valves

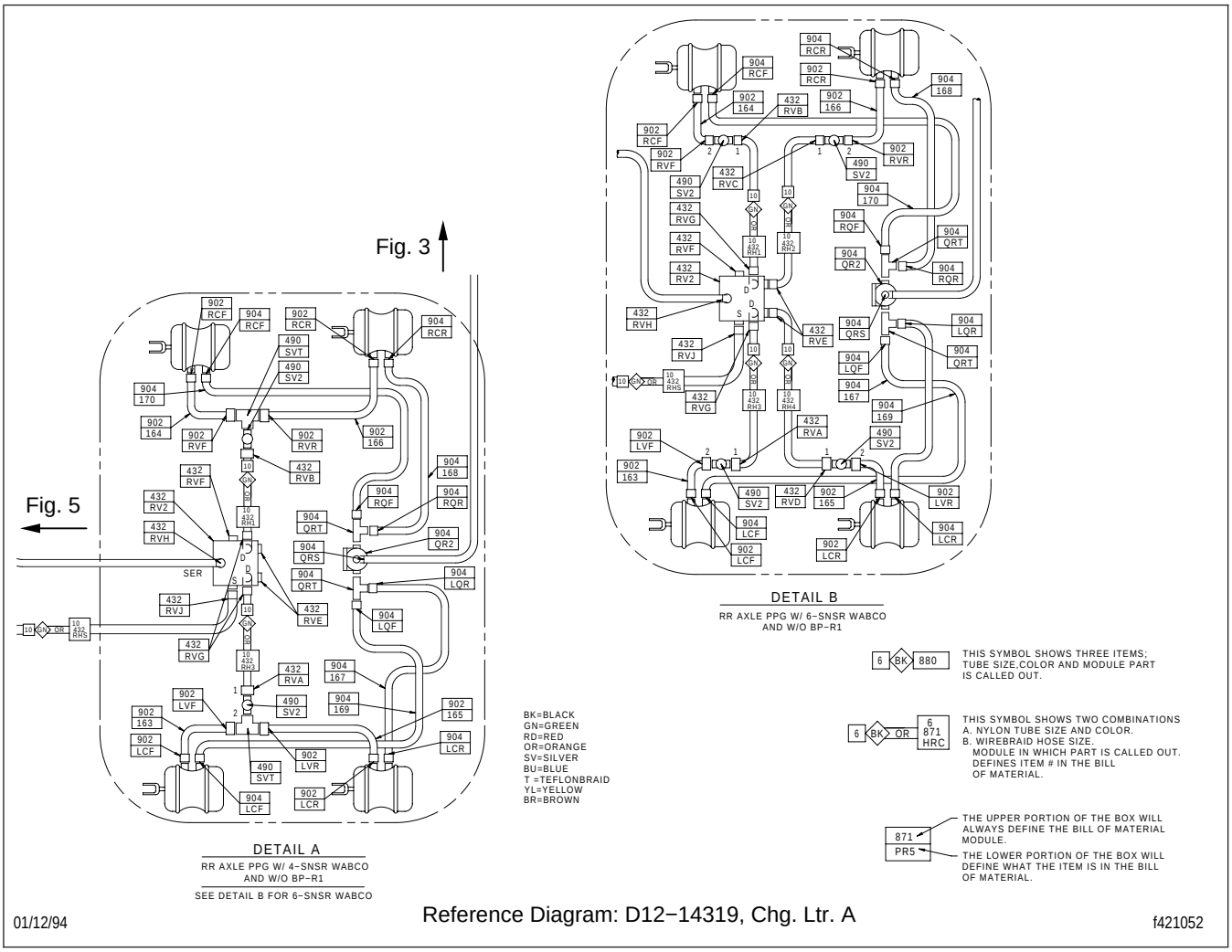


Fig. 4

Without Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), With Hand Valve, and With 2 Dash Valves

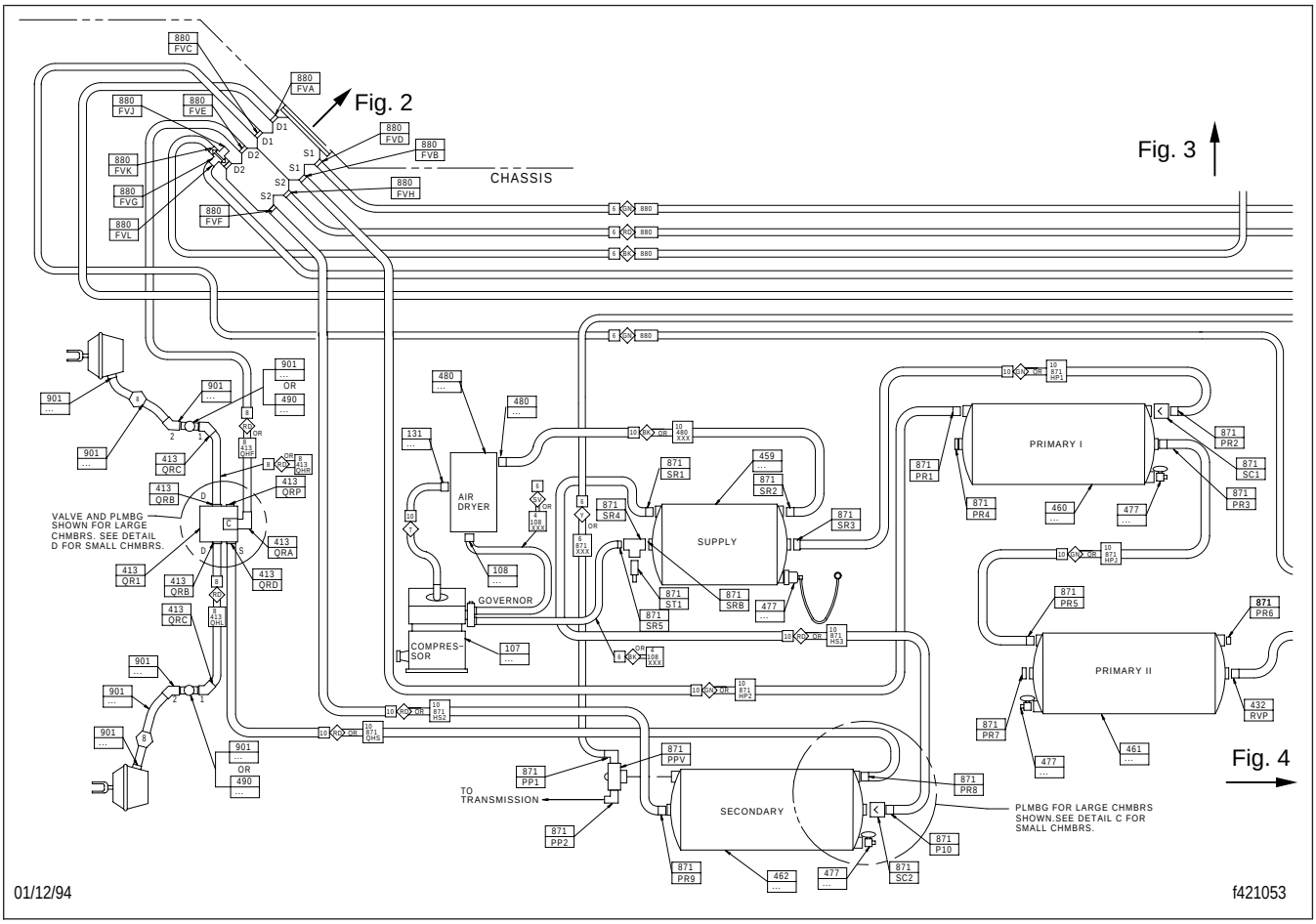


Fig. 5

Without Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), Without Hand Valve, and With 1 Dash Valve

See Fig. 1 for a full view of the plumbing diagram without brake proportioning, with 4- or 6-sensor antilock braking (if equipped), without hand valve, and with 1 dash valve. **See Fig. 2**, **Fig. 3**, **Fig. 4**, or **Fig. 5** for partial (detailed) views plumbing diagram without brake proportioning, with 4- or 6-sensor antilock braking (if equipped), without hand valve, and with 1 dash valve.

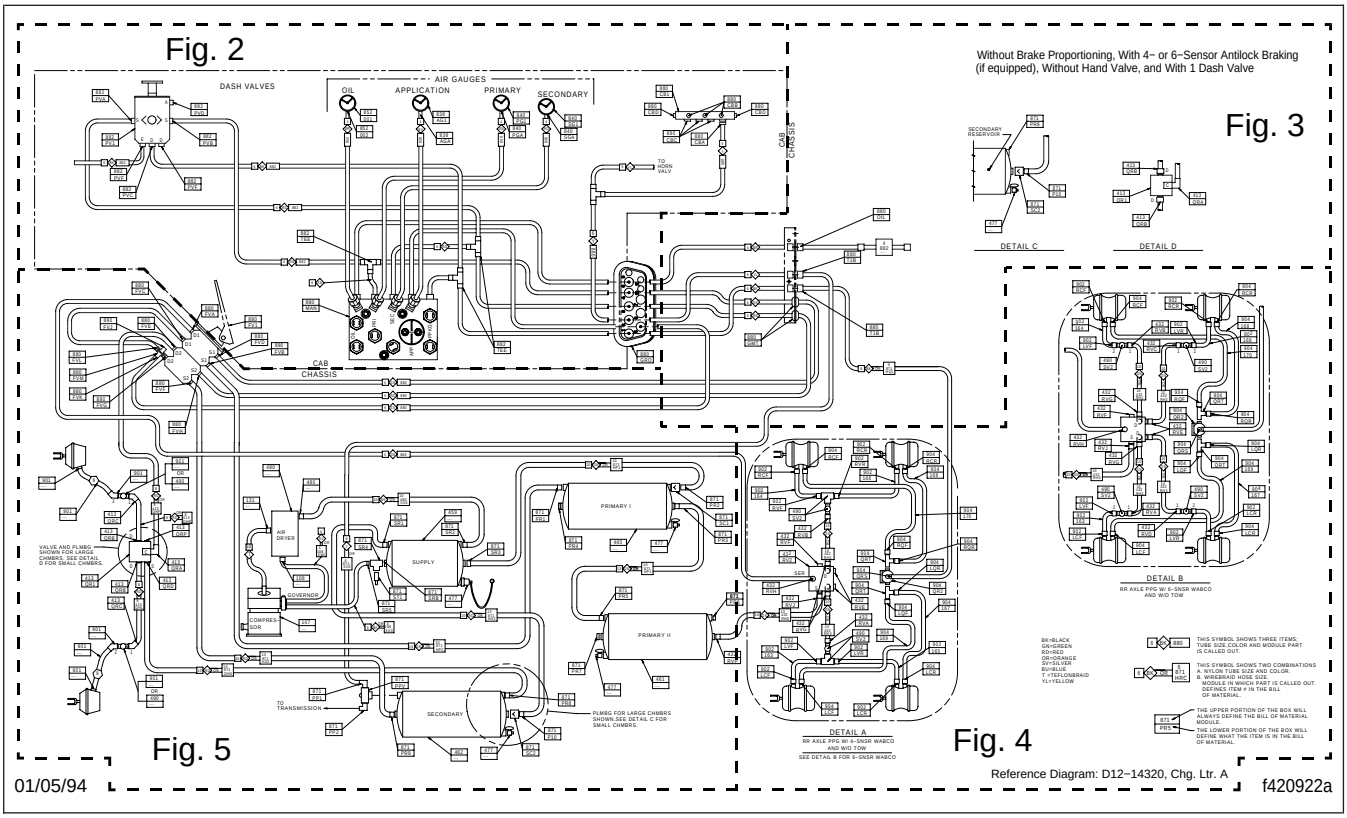


Fig. 1, Without Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), Without Hand Valve, and With 1 Dash Valve

Without Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), Without Hand Valve, and With 1 Dash Valve

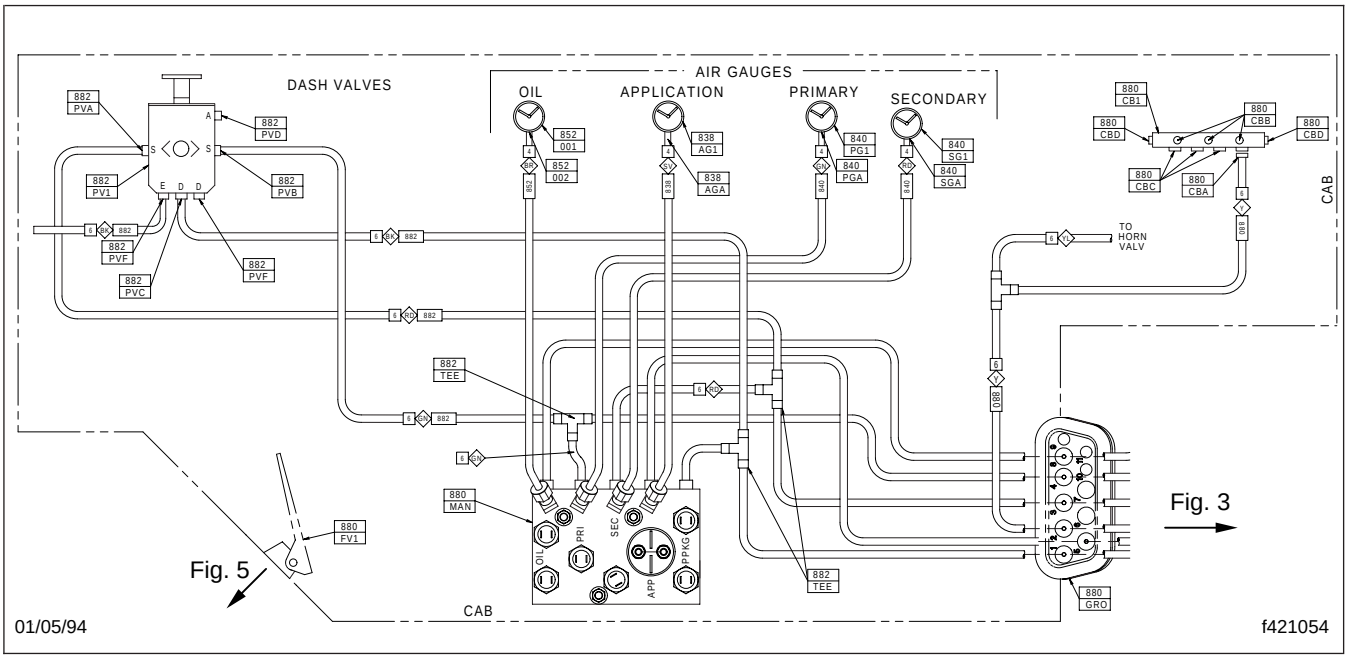


Fig. 2

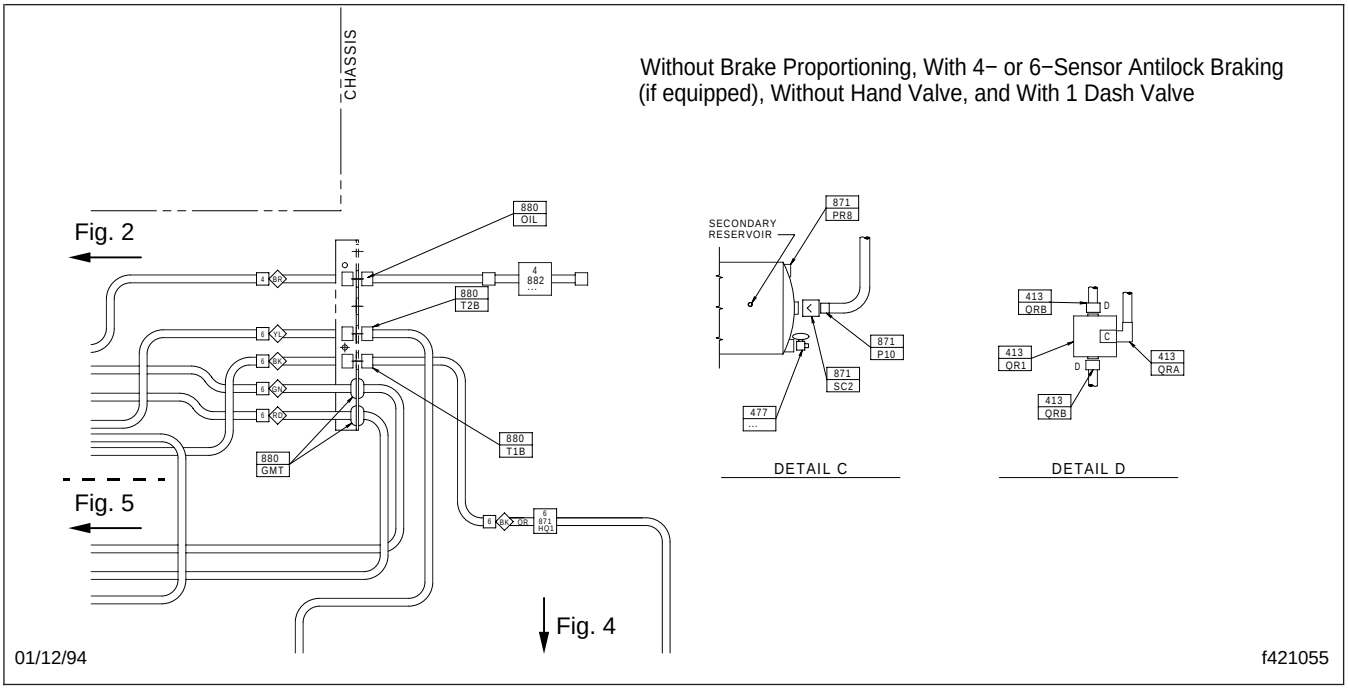
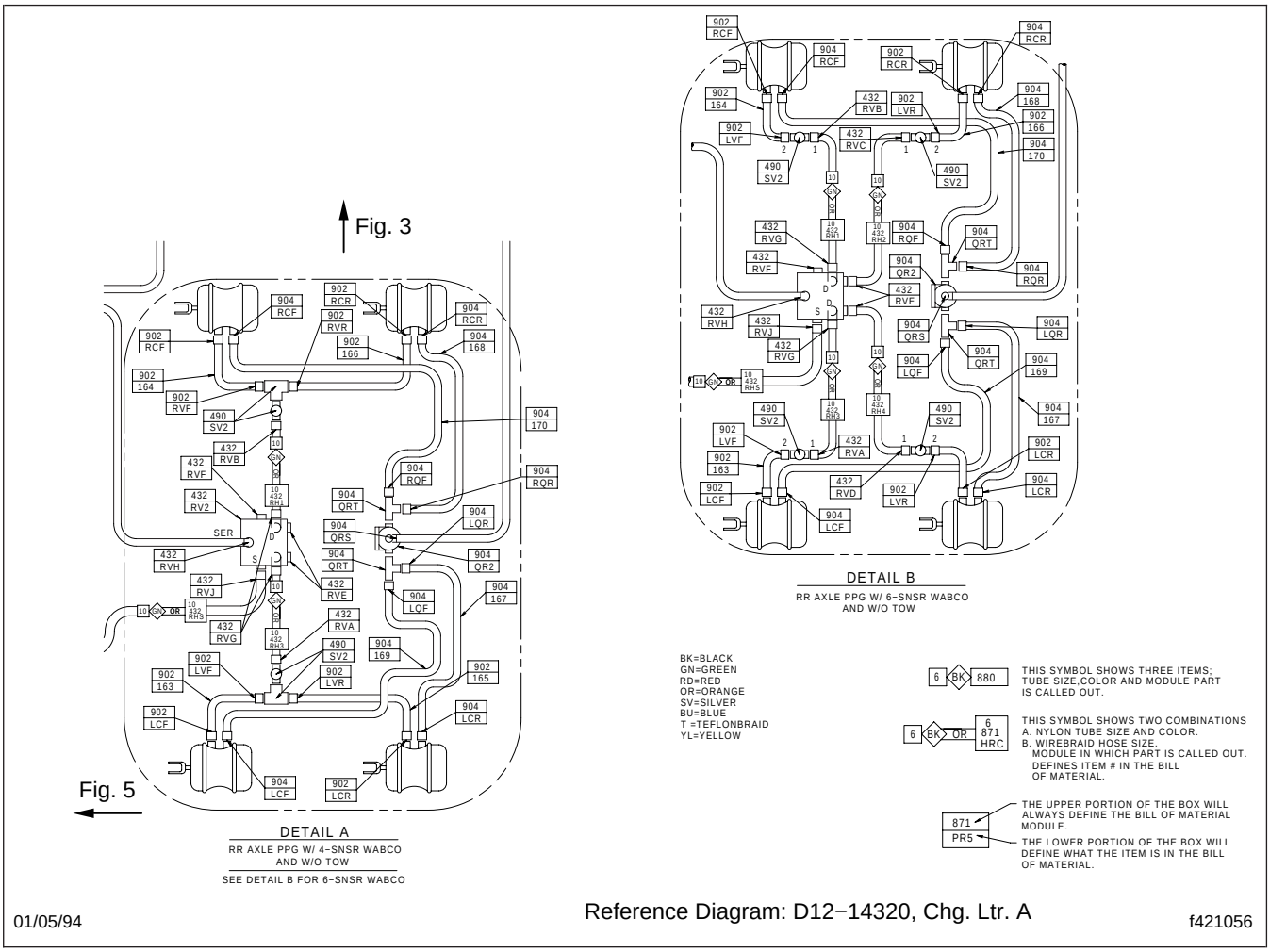


Fig. 3

Without Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), Without Hand Valve, and With 1 Dash Valve



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Reference Diagram: D12−14320, Chg. Ltr. A

f421056

Fig. 4

Without Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), Without Hand Valve, and With 1 Dash Valve

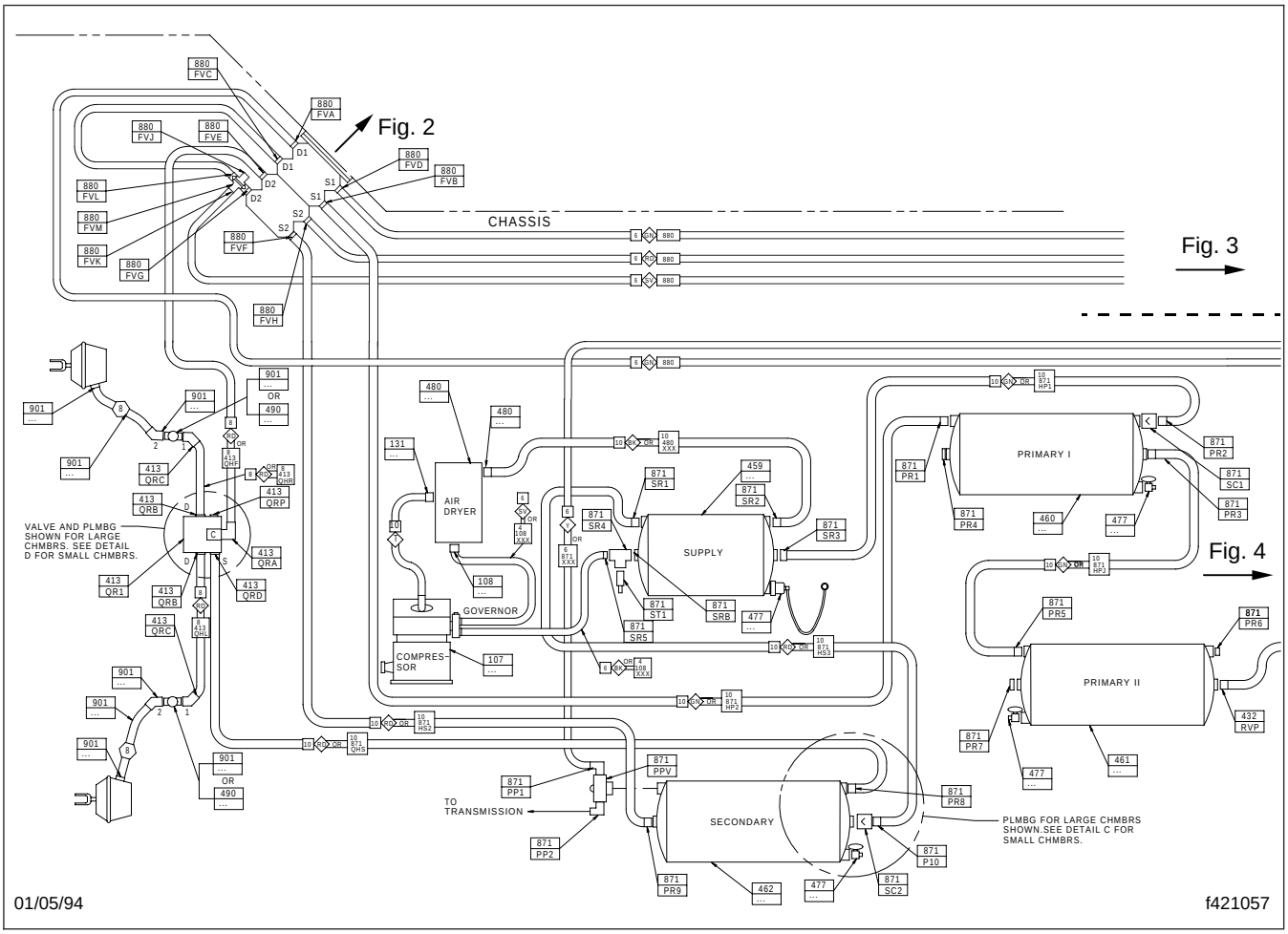


Fig. 5

With Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), With Hand Valve, and With 3 Dash Valves

See Fig. 1 for a full view of the plumbing diagram with brake proportioning, with 4- or 6-sensor antilock braking (if equipped), with hand valve, and with 3 dash valves. **See Fig. 2**, **Fig. 3**, **Fig. 4**, or **Fig. 5** for partial (detailed) views plumbing diagram with brake proportioning, with 4- or 6-sensor antilock braking (if equipped), with hand valve, and with 3 dash valves.

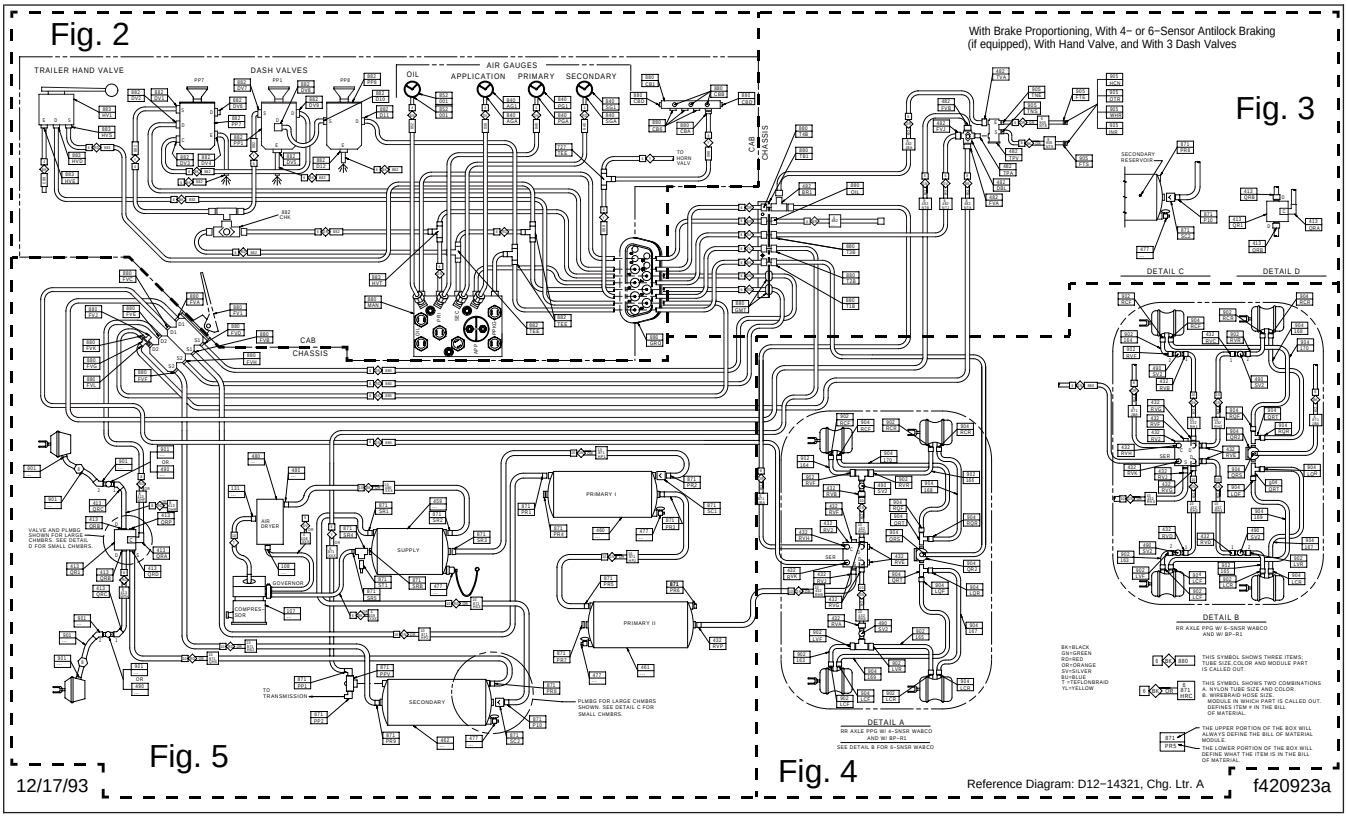


Fig. 1, With Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), With Hand Valve, and With 3 Dash Valves

With Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), With Hand Valve, and With 3 Dash Valves

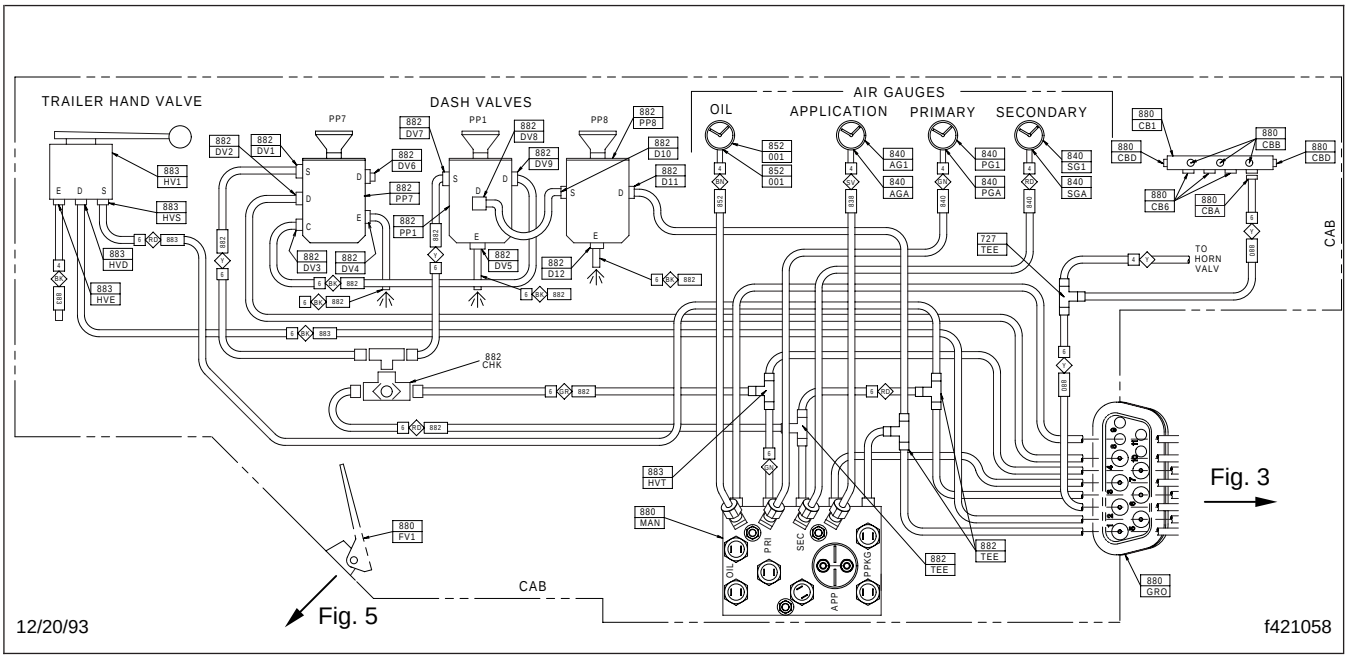


Fig. 2

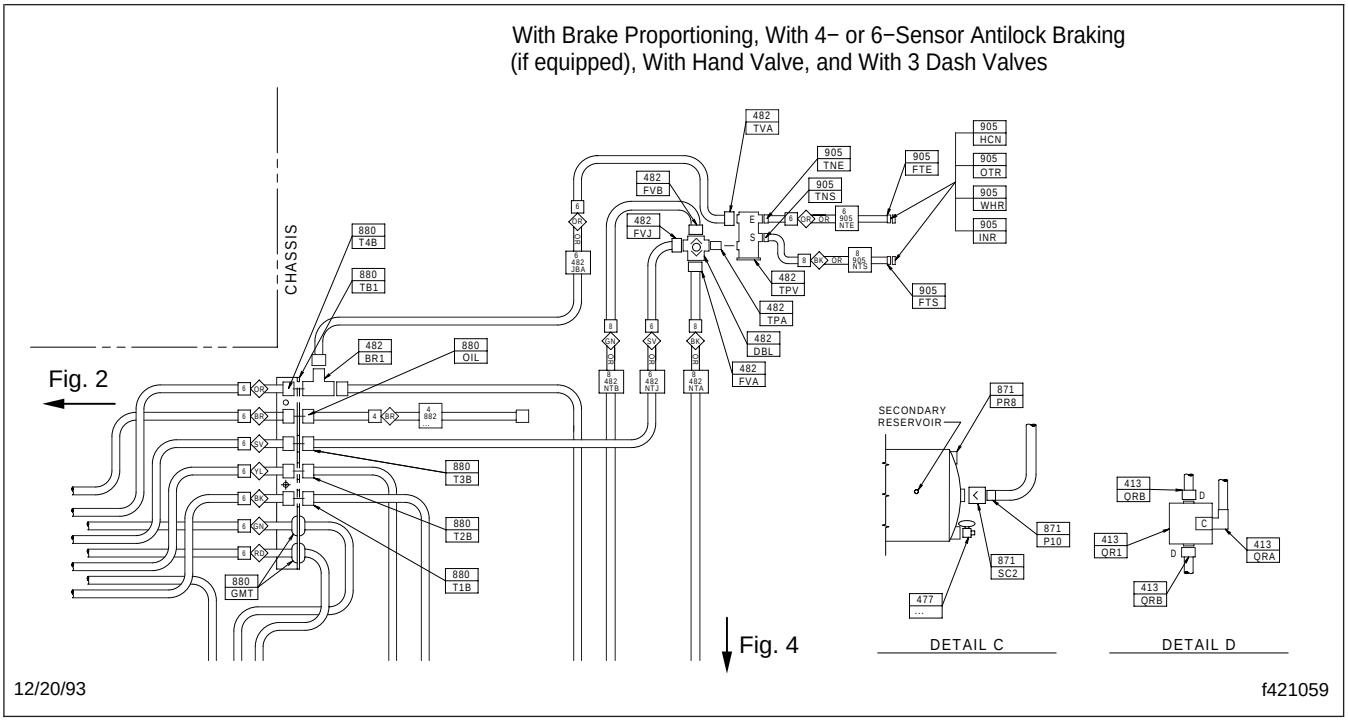


Fig. 3

With Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), With Hand Valve, and With 3 Dash Valves

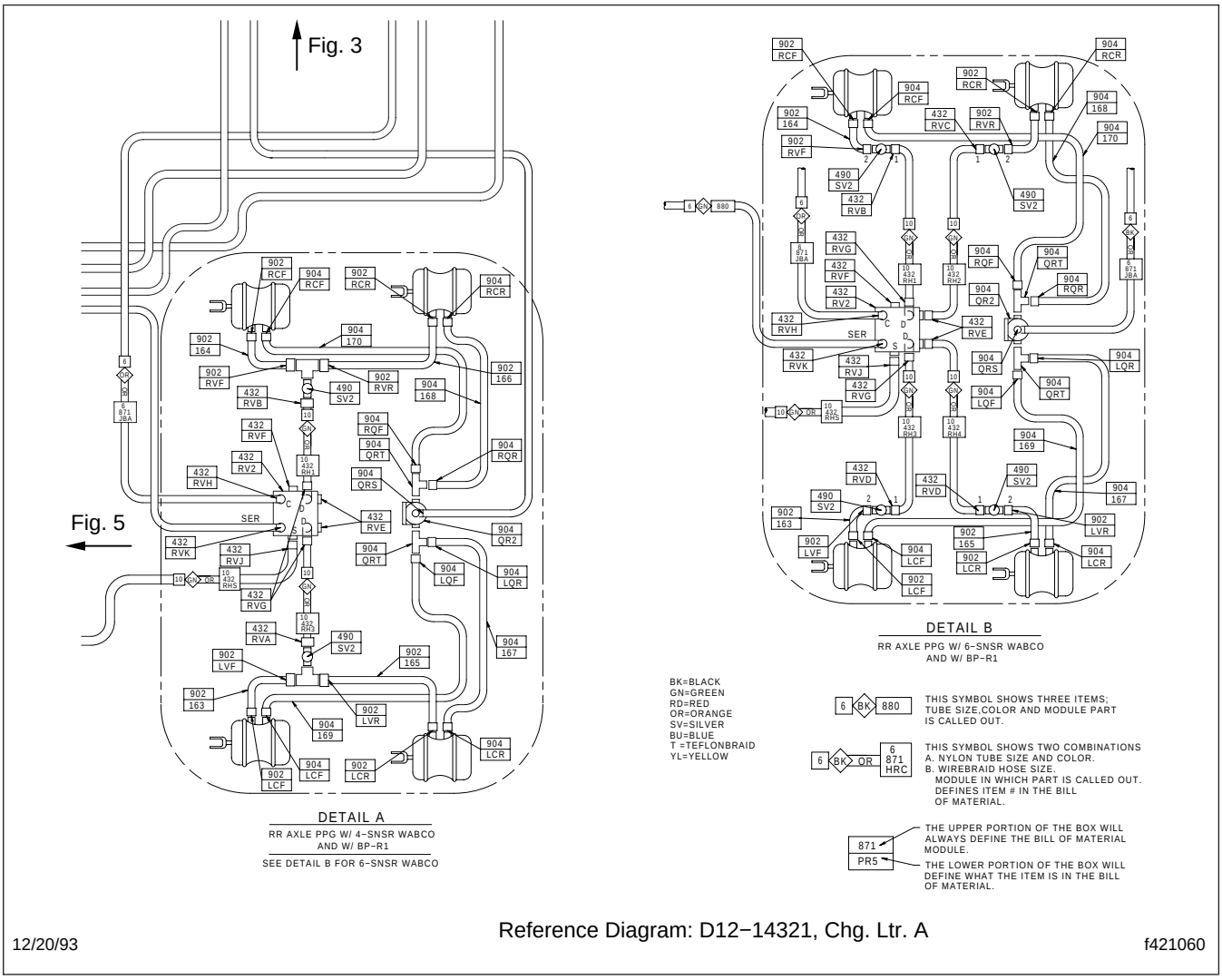


Fig. 4

With Brake Proportioning, With 4- or 6-Sensor Antilock Braking (if equipped), With Hand Valve, and With 3 Dash Valves

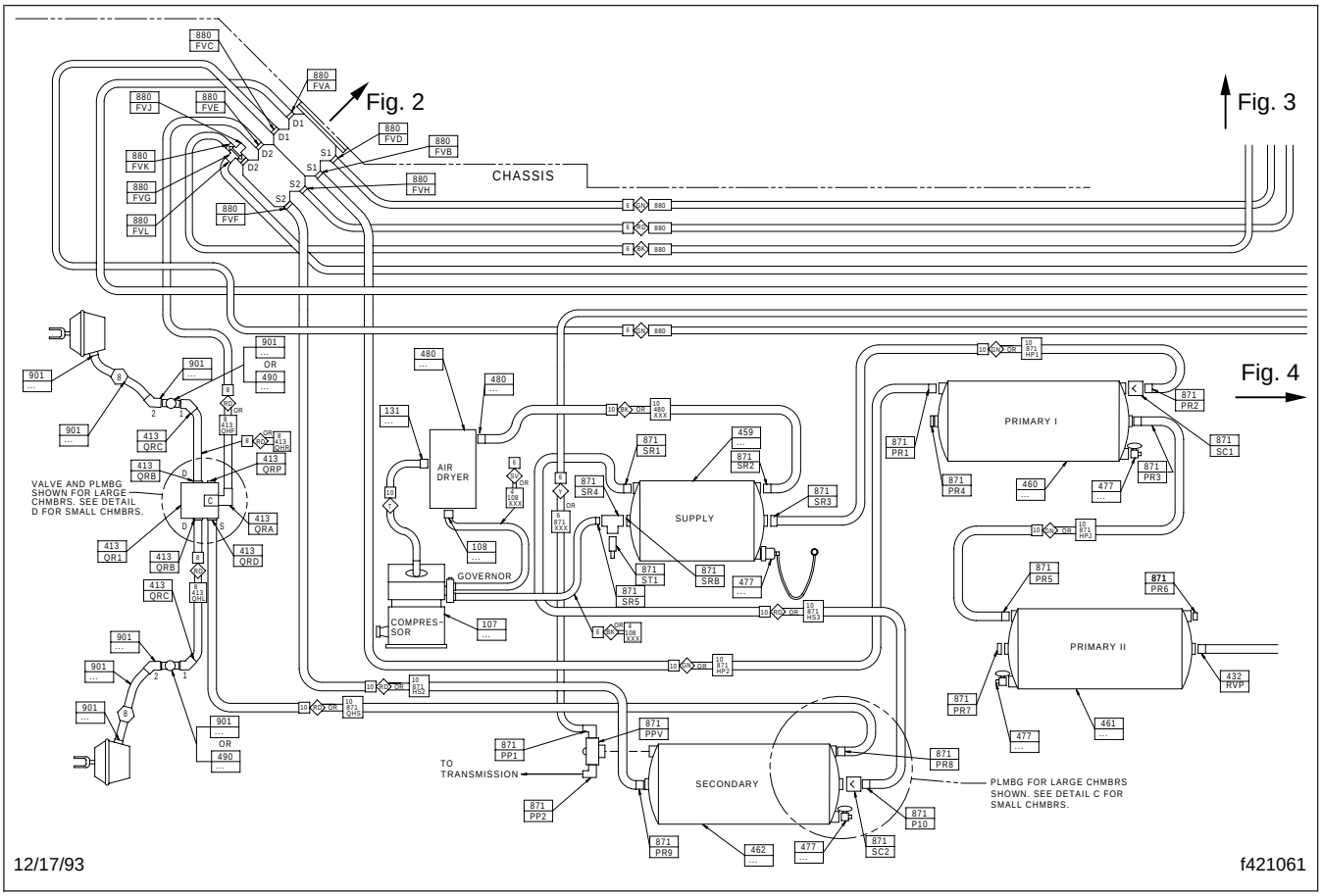
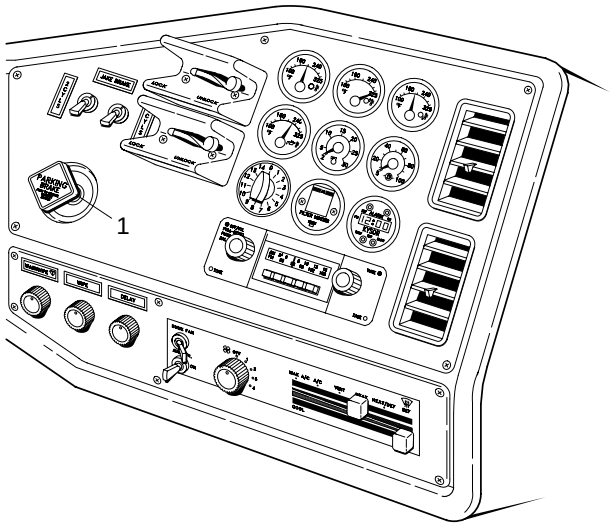


Fig. 5

General Description

The Sloan PV–1 parking brake air valve is installed on trucks with air brakes, and is used to control the rear axle parking brakes. It is a push-pull type of valve, and is mounted on the right side of the dash. **See Fig. 1.**



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1. Parking Brake Valve

Fig. 1

Principles of Operation

When the valve knob is pulled out, air is exhausted from the rear parking brake chambers, releasing the springs, and applying the parking brakes. When the knob is pushed in, air flows into the parking brake chambers from one of the reservoirs, and compresses the springs, releasing the parking brakes.

The PV–1 has a double check valve feature. If the pressure drops in either air system (primary or secondary), the valve will automatically use air pressure from the system with the higher pressure for the parking brakes. This prevents the parking brakes from applying unless pressure is lost from both systems.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under a vehicle. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

Operating Test

1. Chock the tires.
2. Start the engine and build up the air pressure to the normal operating level.
3. Push the parking brake knob in to release the parking brakes.
4. Turn off the engine, then drain one of the air reservoirs.
5. Check if the parking brakes apply.

   If they do, the double check valve feature isn't working; replace the entire PV–1 valve assembly.

   If the parking brakes don't apply, go to the next step.
6. Start the engine again, and build up the air pressure to the normal operating level.
7. With the parking brakes still released, turn off the engine; then drain the other air reservoir.
8. Check if the parking brakes apply.

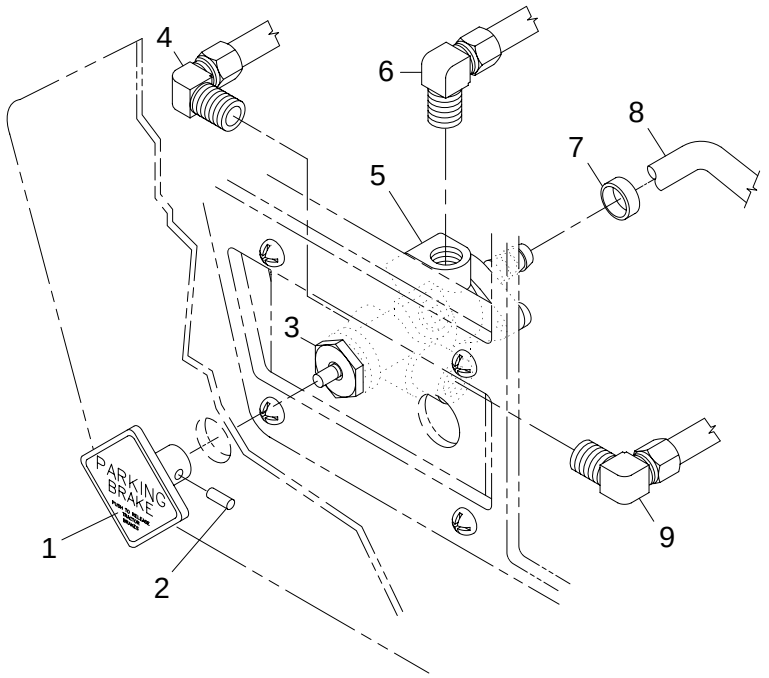
   If they do, the double check valve feature isn't working; replace the entire PV–1 valve assembly.

   If the parking brakes don't apply, the double check valve feature is working.

Leak Testing

1. Chock the tires.
2. Start the engine, and build up the air pressure to the normal operating level.
3. Coat the delivery line and exhaust line fittings on the parking valve with a soapy solution.
4. Release the parking brakes.
5. Check the leakage. Leakage at the fittings should not exceed a 1-inch (2.5-cm) bubble every three seconds. If it does, replace or rebuild the valve, following instructions under **Subject 120** or **Subject 130.**
6. Apply the parking brakes.

Removal (See Fig. 1)



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1. Knob
2. Roll Pin
3. Panel Mounting Nut
4. Primary Supply Line
5. Parking Brake Valve
6. Delivery Line
7. Gasket
8. Exhaust Line
9. Secondary Supply Line

Fig. 1

⚠ WARNING

WARNING: Review the precautions under "Safety Precautions, 100" before doing any work on the parking brake valve. Failure to do so could result in personal injury.

1. Park the vehicle on a level surface, apply the parking brakes, chock the tires, and drain all air tanks to zero pressure.
2. Drive out the roll pin (Ref. 2), then remove the knob from the valve stem.
3. Remove the top-center dash panel.
4. Mark the air supply, delivery, and exhaust lines for later reference, then disconnect them from the valve assembly.
5. Remove the panel mounting nut (Ref. 3), then remove the valve assembly from the dash panel assembly.

Installation

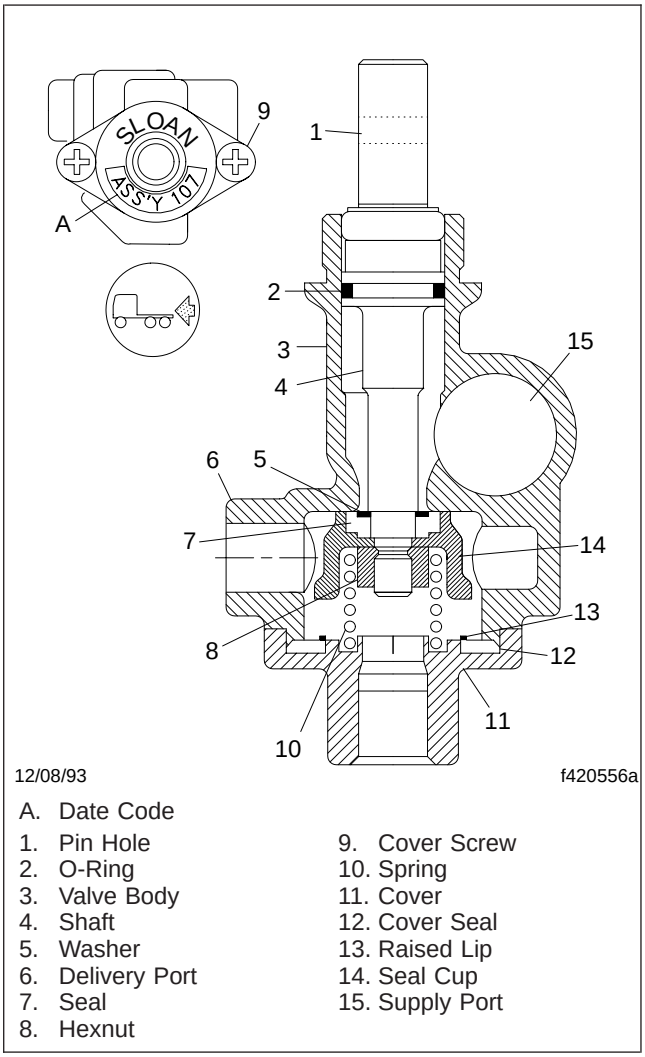
1. Put the valve assembly into the dash, then install the panel mounting nut. Don't tighten the nut completely.
2. Turn the valve assembly so the air lines will reach their fittings.
3. Connect the air supply, delivery, and exhaust lines to the applicable fittings.
   - 3.1 Tighten the fitting hand tight.
   - 3.2 Using a wrench, tighten the fitting until the connection feels firm.

Removal and Installation

3.3 Tighten the fitting an additional one-sixth turn.

4. Tighten the panel mounting nut firmly.
5. Put the knob onto the valve stem, making sure the label on the valve is parallel with the top of the dash. Then drive in the roll pin.
6. Install the top-center dash panel.
7. Leak test the fittings, following the instructions under **Subject 110.**

Disassembly (See Fig. 1)



A. Date Code
1. Pin Hole
2. O-Ring
3. Valve Body
4. Shaft
5. Washer
6. Delivery Port
7. Seal
8. Hexnut
9. Cover Screw
10. Spring
11. Cover
12. Cover Seal
13. Raised Lip
14. Seal Cup
15. Supply Port

Fig. 1

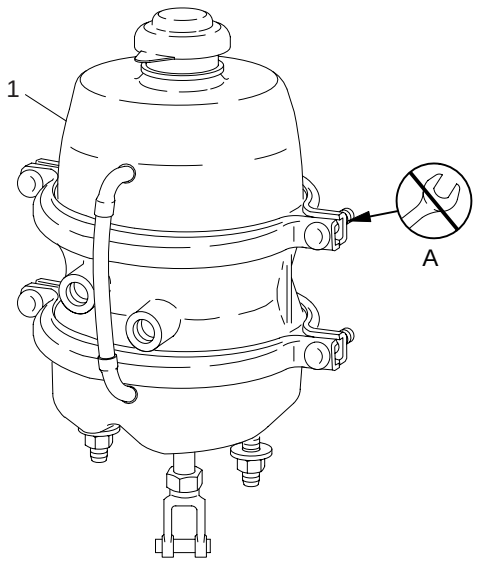
1. Remove the valve assembly from the dash, following the instructions under **Subject 120.**
2. Put the valve assembly in a soft-jawed or padded vise.
3. Remove the screws (Ref. 9) from the cover (Ref. 11).
4. Carefully remove the cover, cover seal (Ref. 12), and spring (Ref. 10). Discard the cover seal.
5. Insert a rod through the pin hole (Ref. 1) of the shaft to keep it from turning, then remove the hexnut (Ref. 8) from the bottom of the shaft.
6. Remove and discard the seal cup (Ref. 14), seal (Ref. 7), and the washer (Ref. 5) from the shaft.
7. Remove the shaft (Ref. 4) from the valve body.
8. Remove and discard the O-ring (Ref. 2) from the shaft.

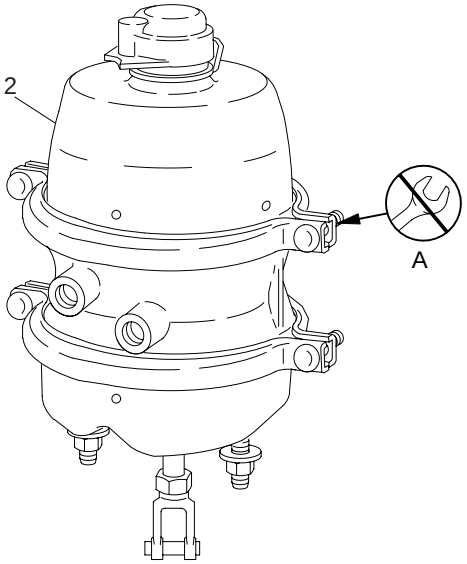
Assembly (See Fig. 1)

1. Clean and dry all the parts.
2. Check all the parts. If any wear or damage is found, replace the entire valve assembly.
3. Lightly grease all the parts—including the new parts from the seal kit—with Dow Corning 55 silicone pneumatic grease or equivalent.
4. Install a new O-ring (Ref. 2) on the shaft (Ref. 4).
5. Install the shaft in the valve body.
6. Install a new washer (Ref. 5) on the step of the shaft.
7. Assemble a new seal (Ref. 7) into the new seal cup (Ref. 14), then install them on the step of the shaft, with the seal against the washer (Ref. 5).
8. Apply Loctite 222® or equivalent on the threads of the new hexnut (Ref. 8).
9. Install the hexnut—counter-bored side toward the seal (Ref. 7)—on the end of the shaft. Tighten the nut 40 lbf·in (460 N·cm).
10. Install a new cover seal (Ref. 12) in the cover with the raised lip (Ref. 13) on the cover seal toward the valve.
11. Grease the sealing surfaces of the seal cup (Ref. 14), and the cover seal (Ref. 12).
12. Install the spring (Ref. 10) and then the cover (Ref. 11).
13. Install the cover screws. Tighten them firmly.
14. Install the valve in the dash, then leak test it. Follow the instructions under **Subject 120** and **Subject 110.**

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.





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A. Do not remove this clamp ring.
1. Model L-T Brake Chamber
2. Model L Brake Chamber

Fig. 1, L Series Brake Chambers

General Information

MGM "L" series tandem cam brake chambers consist of a service brake section and a parking/emergency spring brake section. **See Fig. 2.** The service brake chamber is in the smaller section near the clevis assembly. Some installations include only the service brake chamber. **See Fig. 3.**

In the service brake section, the flange case (or pressure cap for service-only chambers) and non-pressure chamber contain a service return spring, piston rod assembly, and service brake diaphragm.

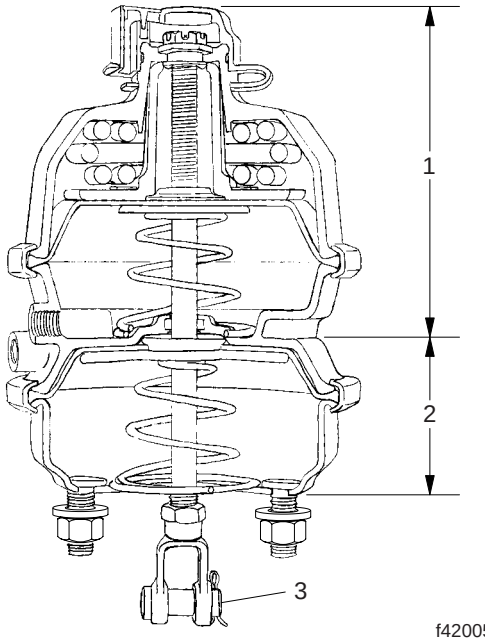
In the parking/emergency brake section, the flange case and the head assembly contain a return spring, a push rod assembly, a parking (spring) brake diaphragm, a piston, a power spring, and an integral (contained inside the chamber) release bolt and nut.

All MGM brake chambers are mounted to the frame using prevailing torque locknuts and hardened flat-washers.

To protect internal components from contaminants, MGM Model "L-T" brake chambers are equipped with an external breather tube. Model "L" employs a filtered breather cap. **See Fig. 2.**

Periodic maintenance of the brake chamber is required. Also, whenever the service brake chamber is disassembled (*do not attempt to disassemble the parking brake chamber*), the parts should be inspected for damage. For maintenance schedules and procedures, and for inspection of brake chamber parts, refer to the vehicle maintenance manual.

General Information and Principles of Operation



1. Parking (Spring) Brake
2. Service Brake
3. Clevis Assembly

Fig. 2, L Series Cam Brake Chambers (sectional view)

Principles Of Operation

SERVICE BRAKES

As the brake pedal is depressed, compressed air enters the service brake chamber through a port. Air pressure acts upon a diaphragm, which forces the piston rod toward the non-pressure chamber, applying a straight-line force to the slack adjuster, which converts it to a rotational force. This in turn rotates the camshaft and applies the brakes.

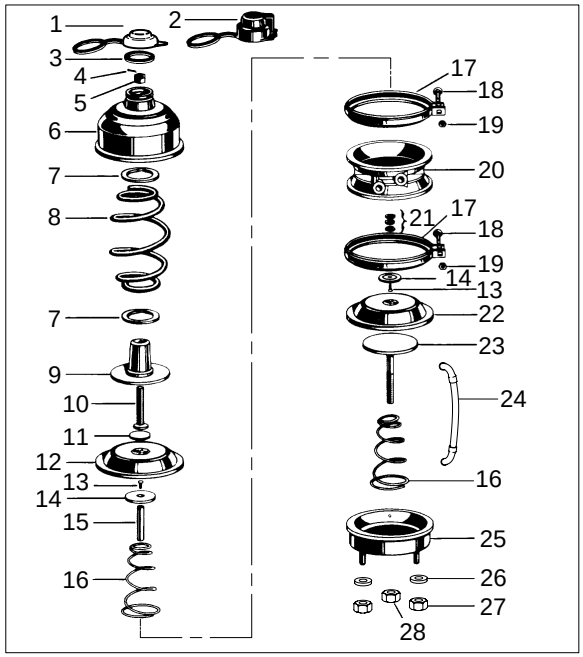
Then, when the brake pedal is released, air is exhausted from the service brake chamber. The return spring allows the diaphragm, piston rod, and slack adjuster to return to their normal positions, releasing the brakes.

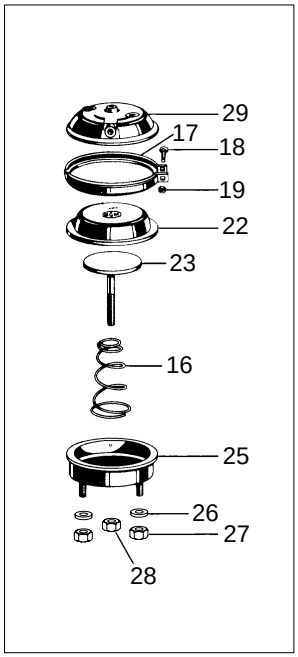
PARKING/EMERGENCY BRAKES

During parking brake release, compressed air enters the parking brake chamber and acts upon the diaphragm and piston, fully compressing the power spring. When the power spring is compressed, the parking brakes are released; the service brakes can then be operated at the brake pedal.

During parking brake application, air is exhausted from the parking brake chamber. The power spring releases, forcing the piston and parking brake diaphragm toward the flange case. The resulting motion on the push rod forces the service brake diaphragm and the piston rod forward, applying the brakes.

Emergency brake application automatically begins when the air pressure in the brake system drops below approximately 80 psi (550 kPa). Full emergency brake application occurs when the air pressure drops below aproximately 40 psi (275 kPa).





09/01/94 f421038a

A. Combined Service Brake and Parking/Emergency Brake Chamber

B. Service Brake Chamber

1. End Cap and Retainer (on Model L-T only)
2. Breather Cap (on Model L only)
3. Filter (on Model L only)
4. Lockpin
5. Release Nut
6. Head Assembly
7. Thrustwasher
8. Power Spring
9. Piston
10. Integral Release Bolt
11. Piston Plug
12. Parking (Spring) Brake Diaphragm
13. Screw
14. Push Rod Plate
15. Push Rod
16. Return Spring
17. Clamp Ring
18. Clamp Ring Bolt
19. Clamp Ring Nut
20. Flange Case
21. Seal and Guide
22. Service Brake Diaphragm
23. Piston Rod
24. Breather Tube and Elbows (on Model L-T only)
25. Non-Pressure Chamber
26. Hardened Flatwasher
27. Prevailing Torque Locknut
28. Piston Rod Jam Nut
29. Pressure Cap

Fig. 3, L Series Cam Brake Chambers (exploded view)

DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

Manual Compression (Parking Brake Release)

1. Chock the tires.
2. Remove the end cap (breather cap if so equipped). See **Fig. 2**.

DANGER

Do not attempt to cage the power spring if the parking brake chamber is damaged severely enough to lose its structural integrity. If the power spring were to break loose, it could result in death, severe personal injury, or property damage.

A DAMAGED PARKING BRAKE CHAMBER IS EXTREMELY DANGEROUS! Only qualified service personnel should attempt to remove and disarm a damaged chamber. Using a torch, burn off the piston rod in the space between the clevis and the base of the service chamber.

Remove the chamber carefully from its bracket, and disarm it inside a suitable container. For disarming procedures, consult the MGM service manual.

3. Manually release the parking brake (cage the power spring).
   - 3.1 Apply at least 90 psi (620 kPa) air pressure to the parking brake inlet port (set parking brake in the "release" position).

CAUTION

Don't exceed 50 lbf·ft (68 N·m) torque on the release bolt; and don't use an impact wrench on this bolt. Too much torque could distort the head of the chamber and prevent manual release of the parking brake.

   - 3.2 Using a hand wrench, (*don't use an impact wrench*), turn the release bolt *counterclockwise* until the bolt is fully extended, or about 2-1/4 to 2-1/2 inches (57 to 64 mm). See **Fig. 3**, dimension A.
4. Once the power spring has been caged, exhaust the compressed air from the parking brake.

Manual Reset (Parking Brake Reset)

1. If the threads of the release bolt are dry, coat them with a light film of low-temperature molybdenum (moly) grease.
2. Uncage the power spring.
   - 2.1 Apply at least 90 psi (620 kPa) air pressure to the parking brake inlet port (set parking brake in the "release" position).

CAUTION

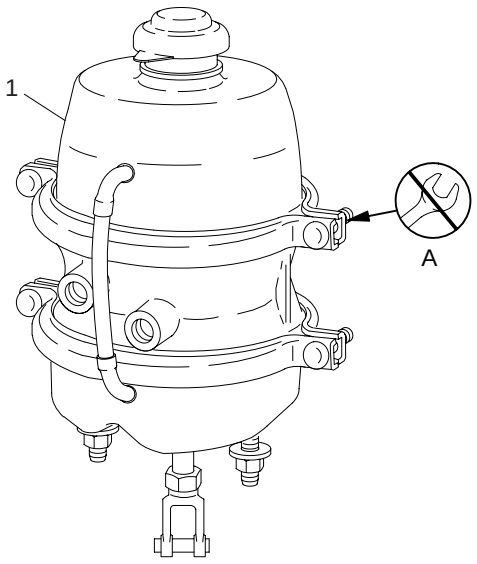
Don't exceed 50 lbf·ft (68 N·m) torque on the release bolt; and don't use an impact wrench on this bolt. Too much torque could distort the head of the chamber and prevent manual release of the parking brake.

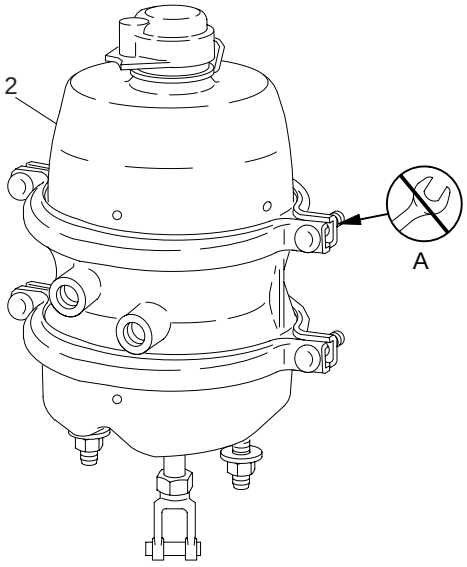
   - 2.2 Using a hand wrench (*don't use an impact wrench*), turn the release bolt *clockwise* until the bolt is fully engaged into the unit and the slotted nut bottoms out onto the head insert.
   - 2.3 Tighten the release bolt 45 to 50 lbf·ft (61 to 68 N·m). See **Fig. 4**.
3. Snap the end cap tightly into place. On chambers equipped with a breather cap, make sure the drain tab is pointing to the ground. Regardless of the position in which the brake chamber is installed, the arrow on the drain tab must be pointed downwards. See **Fig. 5**, reference A.

CAUTION

If the external breather tube or breather cap is missing or incorrectly installed, road dirt and debris can adversely affect the operation of the brake chamber. Once inside the chamber, dirt and debris cause the internal parts to deteriorate

Power Spring Manual Compression and Reset





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A. Do not remove this clamp ring.
1. Model L-T Brake Chamber
2. Model L Brake Chamber

Fig. 1, L Series Brake Chambers

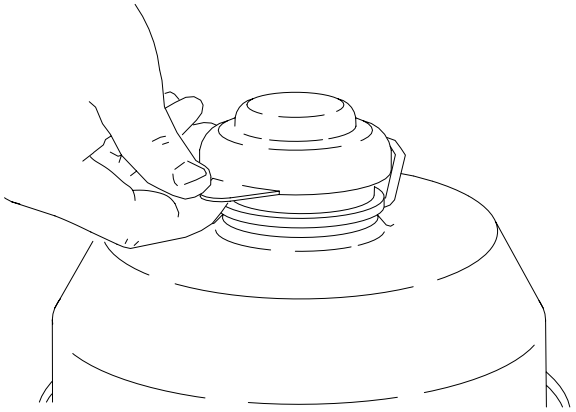

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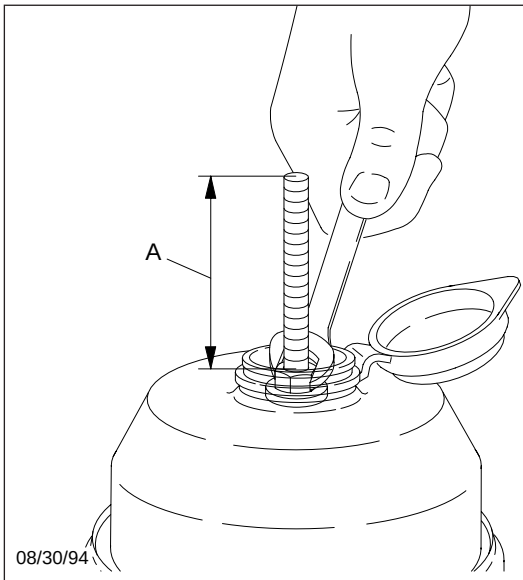
Fig. 2

and shorten their lives. Operating the unit without the external breather tube or breather cap in place voids the MGM warranty.

4. Check the breather tube or cap periodically, and replace it with a new one at once if damaged or missing. Also, replace the breather cap if the foam filter is contaminated with dirt or debris. For intervals, see the vehicle maintenance manual.



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Make sure the bolt extends at least 2-1/4 inches (57 mm) above the lip on the chamber head.
A. Measure this distance.

Fig. 3

5. Remove the chocks from the tires.

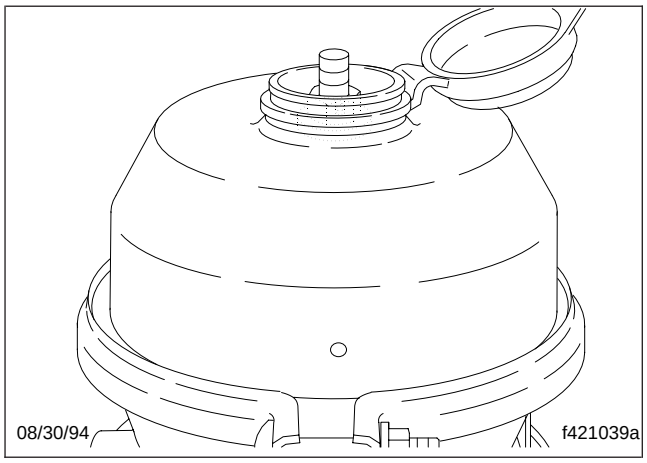


Fig. 4

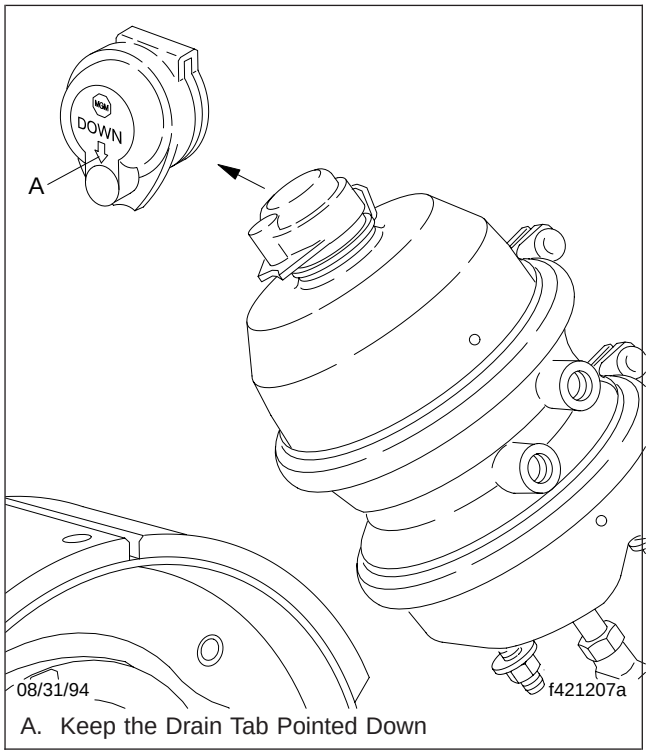


Fig. 5, Breather Cap Installation (on Model L only)

Service Brake Diaphragm Replacement

DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

Removal

1. To make removal and installation of the parking brake section easier (without removing the service brake chamber), lock off the service chamber piston rod.

   1.1 Apply the service brakes by actuating the driver's foot brake treadle valve.

   1.2 With the brakes applied, clamp a pair of locking-jaw pliers on the piston rod to lock the rod in place when the air pressure is released (see Fig. 2).

WARNING

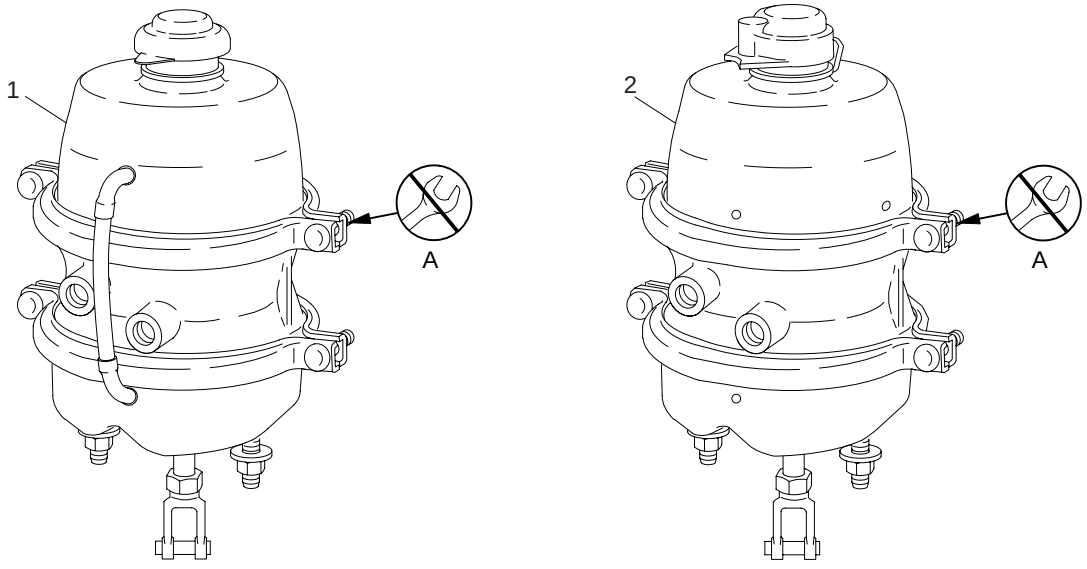
WARNING: Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

2. Manually release the parking brake (cage the power spring). For instructions, refer to **Subject 100**.
3. Mark the air lines for later reference. Then carefully disconnect them from the brake chamber.

   On chambers equipped with an external breather tube, disconnect the tube and elbow from the service brake chamber.

DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended



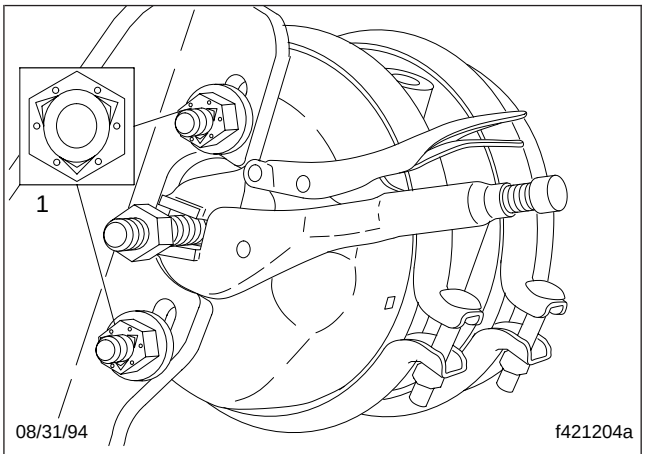
08/30/94 f421302

A. Do not remove this clamp ring.

1. Model L-T Brake Chamber
2. Model L Brake Chamber

Fig. 1, L Series Brake Chambers

Service Brake Diaphragm Replacement



1. Prevailing Torque Locknut

Fig. 2

to be serviced. Serious injury or death may result from the sudden release of the power spring.

4. Remove the parking brake section from the service brake section.

   4.1 Using a hand wrench (*don't use an impact wrench*), remove the clamp nuts on the *service* clamp ring (*do not disassemble the parking brake section*).

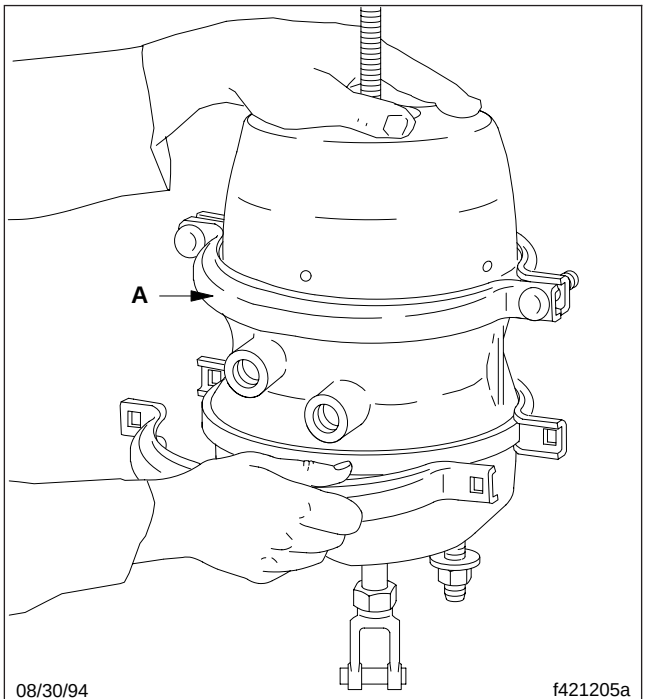
   4.2 While holding the parking brake section securely in place, remove the service clamp ring. Then remove the parking brake section from the service brake non-pressure chamber (see **Fig. 3**).

5. Remove the service brake diaphragm from the bottom of the parking brake section.

Installation

IMPORTANT: At this time, take the opportunity to inspect the parking/emergency brake section, and replace it if it shows signs of damage, corrosion, or rust. Follow the detailed inspection instructions in the vehicle maintenance manual.

1. Inspect all parts in the service (non-pressure) chamber. Replace any damaged or worn parts with genuine MGM-engineered replacement parts.



A. Do not remove this clamp ring.

Fig. 3

2. Place the new service brake diaphragm in the bottom recess of the parking brake section (see **Fig. 4**).
3. Install the (new, if needed) parking/emergency brake section.

   3.1 If installing a new parking brake section, be sure it is the same size and make as the old one.

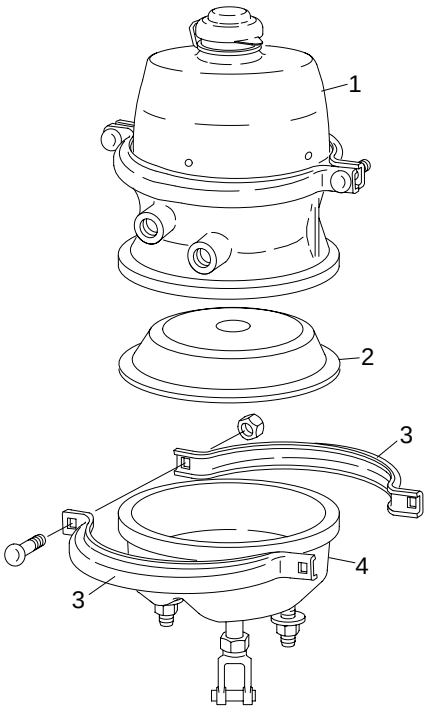
   3.2 Check that the release bolt is fully extended outward. For instructions, refer to **Subject 100**.

   3.3 Install the parking brake section on the service chamber so that all mating parts are aligned straight and the air lines are positioned to mate with the vehicle air supply lines.

4. Install the service brake clamp ring.

   4.1 With the service brake clamp ring in place, install the clamp bolts and nuts.

   4.2 Using a hand wrench (*don't use an impact wrench*), alternately tighten each clamp



1. Parking/Emergency Brake Section
2. Service Brake Diaphragm
3. Service Brake Clamp Ring
4. Service Brake (Non-Pressure) Chamber

Fig. 4

nut in increments of 60 to 120 lbf·in (680 to 1360 N·cm) while constantly rechecking the alignment of mating parts.

If realignment is needed, loosen the nuts again, and repeat this substep.

4.3 Firmly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. Tighten the nuts to a final torque of 25 to 30 lbf·ft (34 to 41 N·m).

5. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 25 lbf·ft (34 N·m).
6. Using the vehicle system air, charge the parking brake with full line pressure, at least 100 psi (690 kPa). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 25 lbf·ft (34 N·m).
7. With the parking brake still charged with full line pressure, apply and hold the foot brake treadle valve down to charge the service brake chamber. Remove the locking-jaw pliers from the service piston rod so that the piston returns to a normal position in the chamber.

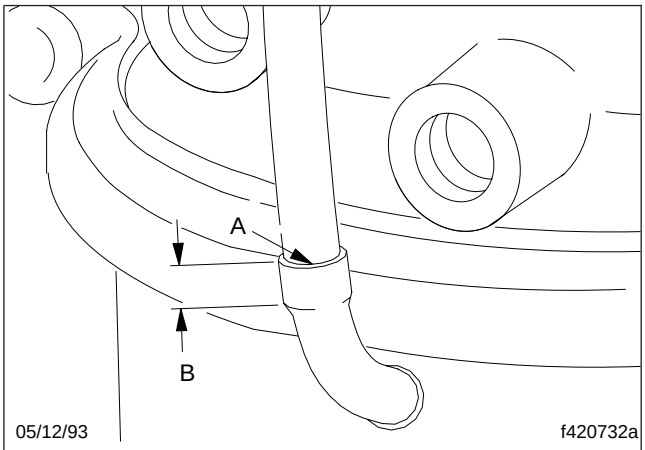
⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

8. Test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, firmly tap the circumference of the clamp ring with a rubber mallet, and retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). MGM recommends 25 to 30 lbf·ft (34 to 41 N·m) torque on the clamp hexnuts.
9. On chambers equipped with an external breather tube, make sure that the open end of the tube is free of grease, dirt, and other debris. Then, apply a high-quality rubber cement to the tube and insert it into the elbow at least 1/2 inch (13 mm). See **Fig. 5**. Insert the tube into the service brake chamber.
10. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring. For instructions, refer to **Subject 100**.
11. Snap the end cap into place. On chambers equipped with a breather cap, snap the breather cap into place, taking care to point the drain tab downwards. Replace the breather cap if the foam filter is contaminated with dirt or debris.
12. Adjust the brakes at the slack adjuster.

IMPORTANT: After replacing any brake chamber components, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service

Service Brake Diaphragm Replacement



A. Apply adhesive here.
B. Check for 1/2" (13 mm) minimum engagement.

Fig. 5

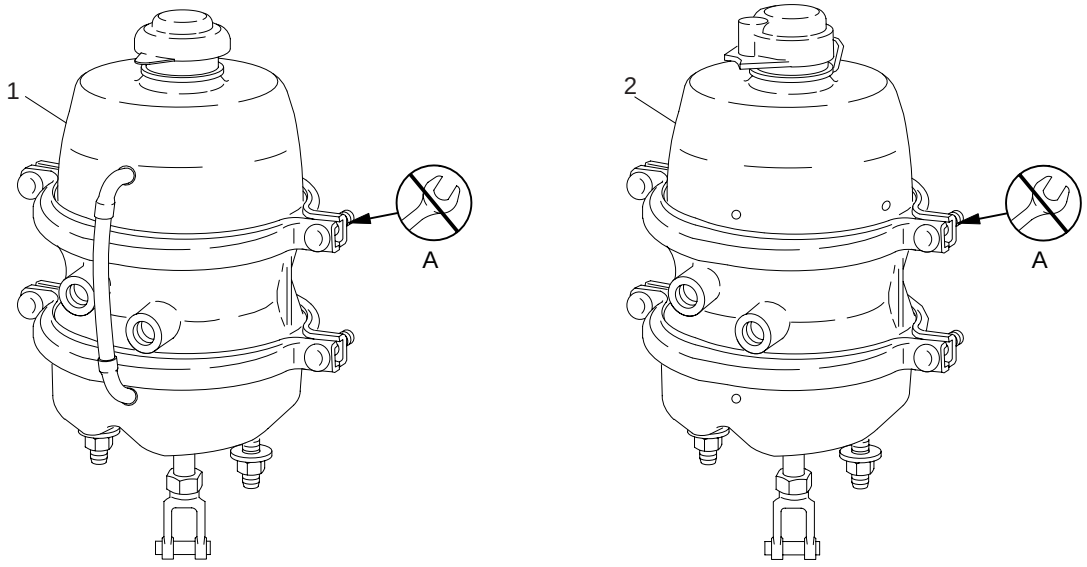
brake, can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, refer to the applicable slack adjuster section in **Group 42** in this manual.

Replacement

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: The parking/emergency brake section can be replaced as a unit. For instructions, refer to **Subject 110**.



A. Do not remove this clamp ring.

1. Model L-T Brake Chamber

2. Model L Brake Chamber

Fig. 1, L Series Brake Chambers

Combination Service and Parking Brake Chamber Removal and Installation

DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

Removal (See Fig. 2 or Fig. 3)

WARNING

WARNING: Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

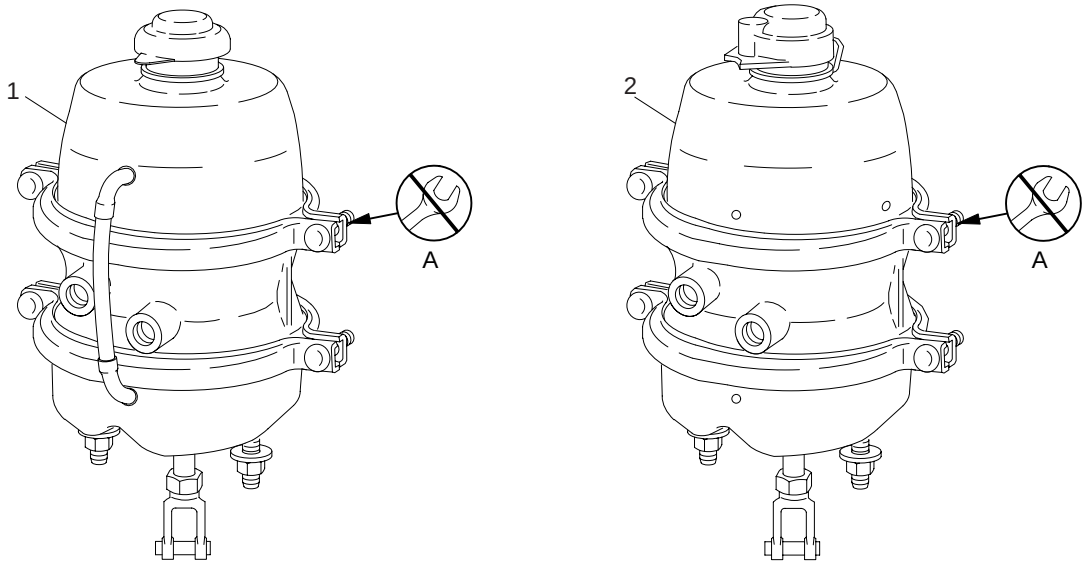
1. Manually release the parking brake (cage the power spring). For instructions, refer to **Subject 100**.
2. Mark the air lines for later reference. Then carefully disconnect them from the brake chamber.
3. Remove the brake chamber from the vehicle.
   - 3.1 Remove the cotter pin(s) from the clevis pin(s), then remove the clevis pin(s) from the clevis. Disconnect the clevis from the slack adjuster.

   NOTE: Gunite and Rockwell automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

   - 3.2 Make sure the parking brake has been released manually (the power spring has been caged). For instructions, refer to **Subject 100**. Also, make sure that the service brake piston is fully retracted (in the brakes "OFF" position). Then, record both of the following dimensions in either mm or inches, measuring outward from the base of the service brake chamber (see **Fig. 4**):

     X dimension: to end of threaded piston rod

     Y dimension: to centerline of (large) clevis pin

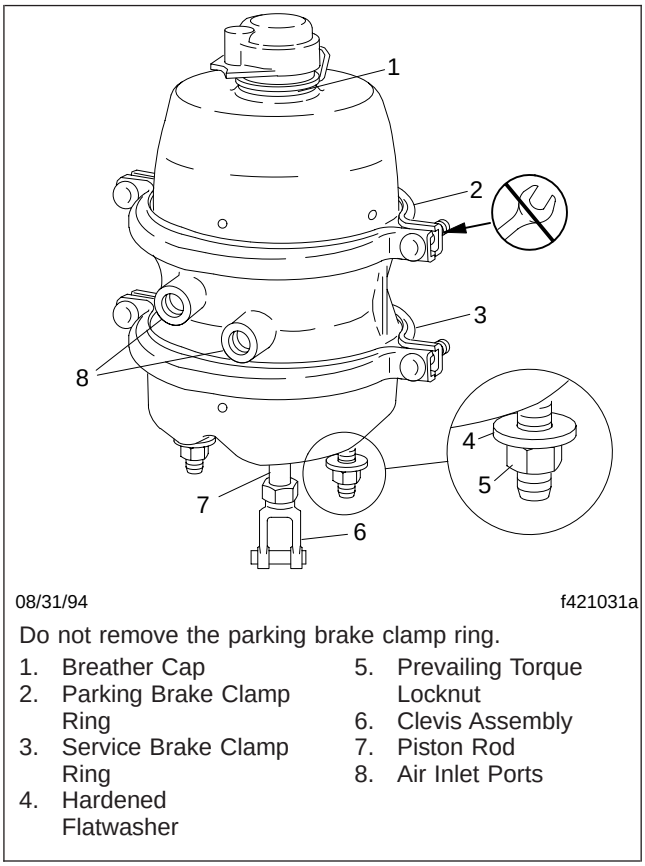


A. Do not remove this clamp ring.

1. Model L-T Brake Chamber
2. Model L Brake Chamber

Fig. 1, L Series Brake Chambers

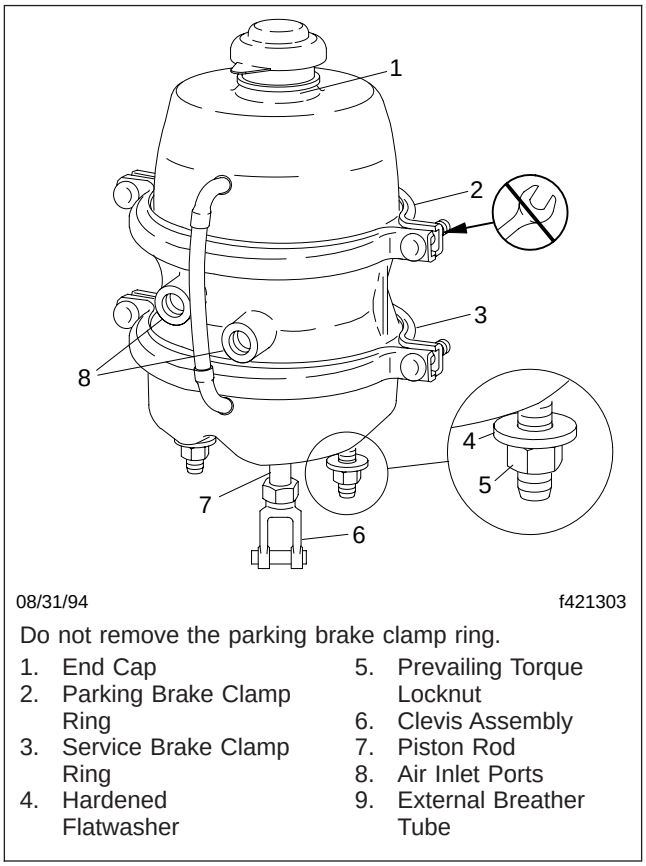
Combination Service and Parking Brake Chamber Removal and Installation



Do not remove the parking brake clamp ring.

1. Breather Cap
2. Parking Brake Clamp Ring
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Clevis Assembly
7. Piston Rod
8. Air Inlet Ports

Fig. 2, Model L Brake Chamber



Do not remove the parking brake clamp ring.

1. End Cap
2. Parking Brake Clamp Ring
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Clevis Assembly
7. Piston Rod
8. Air Inlet Ports
9. External Breather Tube

Fig. 3, Model L-T Brake Chamber

IMPORTANT: If new chambers are to be attached to manual slack adjusters, the Y dimension is the most critical measurement. When installing the new assembly, cut its service piston rod (see **Fig. 5**) to exactly duplicate this "rod-plus-clevis" length *after* the clevis assembly is installed on the piston rod.

If new chambers are to be attached to automatic slack adjusters, the X dimension is the most critical measurement. When installing the new assembly, cut its service piston rod (see **Fig. 5**) to exactly duplicate the "rod only" length *before* the clevis assembly is installed on the piston rod.

3.3 From each mounting stud, remove any installed nuts and washers. Then, cautiously remove the brake chamber from the mounting bracket.

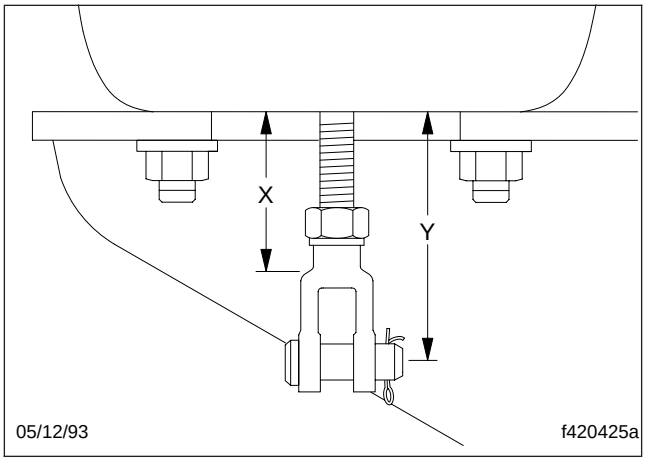


Fig. 4

Combination Service and Parking Brake Chamber Removal and Installation

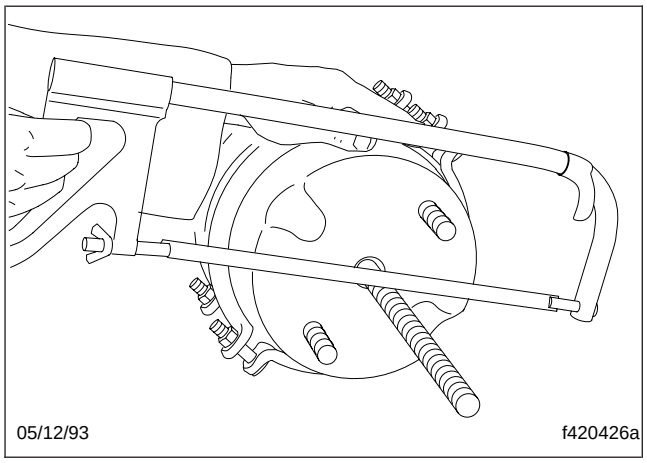


Fig. 5

Installation (See Fig. 2 or Fig. 3)

1. If installing a new brake chamber unit, do the following steps:
   - 1.1 First, make sure the power spring is caged (release bolt fully extended outward). If not, go to **Subject 100** and do the applicable steps.
   - 1.2 Make sure that the piston rod is the same length as the rod on the old unit (measure the rods when *both* chambers are caged).
   - 1.3 Be sure the new chamber is the same size and make as the brake chamber installed on the other side of the axle.
   - 1.4 Remove the prevailing torque locknut and hardened flatwasher from each of the mounting studs on the chamber.
2. Clean the face of the mounting bracket, and position the chamber on the bracket. Pay close attention to positioning the chamber air inlet ports for correct alignment to the vehicle air lines.

⚠ WARNING

WARNING: Tighten the mounting nuts with a hand wrench, not an impact wrench. An impact wrench could damage the mounting fasteners, reducing the force of the brakes. This could result in personal injury or property damage.

3. Install one hardened flatwasher and prevailing torque locknut on each mounting stud. Using a hand wrench (*don't use an impact wrench*), tighten the nuts 100 to 115 lbf·ft (136 to 156 N·m). Make sure that the hardened flatwasher is installed between the locknut and the mounting bracket.

   On chambers equipped with an external breather tube, make sure that the tube is installed in the side of the chamber that faces away from the road surface. An improperly installed breather tube voids the MGM warranty.
4. Check mating and alignment with the vehicle air lines.

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

- 4.1 Using a hand wrench (*don't use an impact wrench*), loosen the clamp nuts on the *service* clamp ring (*do not disassemble the parking brake section*).
- 4.2 Reposition the air inlet ports, as needed, to mate with vehicle air supply lines.

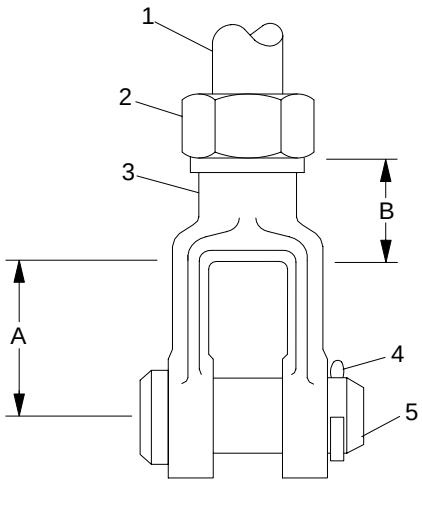
  Alternately tighten each clamp nut in increments of 60 to 120 lbf·in (680 to 1360 N·cm) while constantly rechecking the alignment of mating parts.

  If realignment is needed, loosen the nuts again, and repeat this substep.
- 4.3 Firmly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. Tighten the nuts to a final torque of 25 to 30 lbf·ft (34 to 41 N·m).

5. With manual slack adjusters, connect the slack adjuster to the clevis, then install the clevis pin. Insert the cotter pin in the clevis pin, and lock it in place. Check the piston-rod engagement with the clevis. At least seven threads of engagement are required; there should be 1-inch (25-mm) clearance from the centerline of the clevis pin hole to the end of the piston rod. See **Fig. 6.** Adjust as needed.

Combination Service and Parking Brake Chamber Removal and Installation

With automatic slack adjusters, refer to the applicable slack adjuster section in **Group 42** in this manual for installation instructions.



A. Minimum clearance of 1 inch (25 mm) between centerline of clevis pin hole and piston rod end.
B. Minimum of 7 threads engagement.

1. Piston Rod
2. Piston Rod Nut
3. Clevis
4. Cotter Pin
5. Clevis Pin

Fig. 6, Piston Rod Engagement With the Clevis

6. Inspect the piston rod to be sure it is working free, not binding, and is square with the chamber bottom within ±3° from zero to full stroke. If there is misalignment, make corrections by loosening the locknuts and repositioning the chamber on the mounting bracket, or by shimming the slack adjuster to the right or left on the camshaft.
7. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 25 lbf·ft (34 N·m).
8. Using the vehicle system air, charge the parking brake with full line pressure, at least 100 psi (690 kPa). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 25 lbf·ft (34 N·m).

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: If the service brake clamp ring was loosened to reposition the air inlet ports, apply air to the parking brake, and then apply and hold the foot brake treadle valve down to charge the service brake chamber. Now test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, firmly tap the circumference of the clamp ring with a rubber mallet, and retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). MGM recommends 25 to 30 lbf·ft (34 to 41 N·m) torque on the clamp hexnuts.

9. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring. For instructions, refer to **Subject 100**.
10. Snap the end cap into place. On chambers equipped with a breather cap, snap the breather cap into place, taking care to point the drain tab downwards. Replace the breather cap if the foam filter is contaminated with dirt or debris.
11. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this manual.

IMPORTANT: After replacing any brake chamber, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, refer to the applicable slack adjuster section in **Group 42** in this manual.

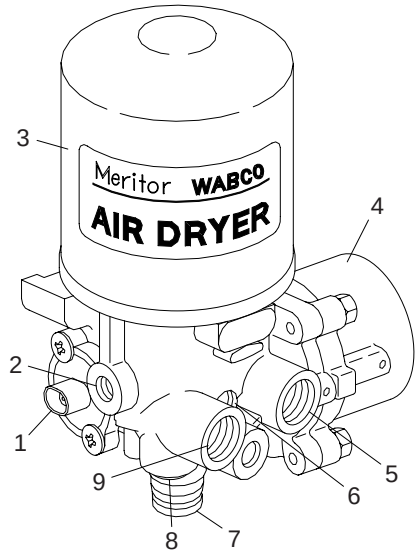
Specifications

Description	Torque lbf·ft (N·m)
Parking Brake Release Bolt Nut	50 (68)
Service Brake Clamp Ring Nut	25–30 (34–41)
Brake Chamber Mounting Stud Locknut	100–115 (136–156)
Air Hose Fitting-to-Chamber	25 (34)

Table 1, Torque Values

General Information

The System Saver 1000 and 1200 are desiccant air dryers, mounted vertically between the air compressor and the supply reservoir. See **Fig. 1** and **Fig. 2**. The air dryer receives hot compressed air, which it cools and filters before sending it to the supply reservoir, reducing the build-up of dirt and moisture in the vehicle air system.



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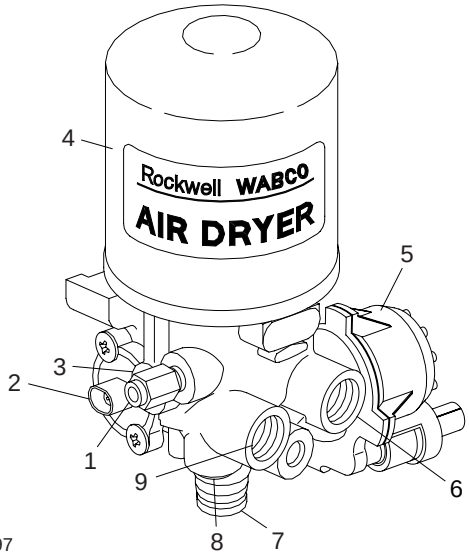
1. Heater/Thermostat Assembly
2. Governor Port (to air governor)
3. Desiccant Canister
4. Regeneration Valve Assembly
5. Outlet Port (to air supply reservoir)
6. Bypass Valve Assembly
7. Exhaust Port (Purge Valve Assembly)
8. Turbocharger Cutoff Valve
9. Inlet Port (from air compressor)

Fig. 1, System Saver 1000

The air dryer consists of a light weight aluminum and steel body. The desiccant cartridge is contained in a spin-off canister at the top of the air dryer.

The bottom half of the air dryer houses the following components.

- Bypass Valve (System Saver 1000)–this valve allows air flow in the air dryer to go directly to the outlet port, bypassing the desiccant filter.



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1. Pressure Relief Valve
2. Heater/Thermostat Assembly
3. Governor Port (to air governor)
4. Desiccant Canister
5. Regeneration Valve Assembly
6. Outlet Port (to air supply reservoir)
7. Exhaust Port (Purge Valve Assembly)
8. Turbocharger Cutoff Valve
9. Inlet Port (from air compressor)

Fig. 2, System Saver 1200

- Pressure Relief Valve (System Saver 1200)–this valve protects the air dryer from over pressurization. The valve is attached directly to the air dryer.
- Desiccant Canister–a cylindrical steel housing that contains the filter elements and the desiccant needed to filter and dry the air that passes through it.
- Heater/Thermostat Assembly–located in the air dryer base, this assembly is designed to prevent the collected moisture from freezing.
- Outlet Check Valve–this valve prevents air in the system from flowing back through the air dryer and escaping out the purge valve during the compressor unload cycle.
- Pressure-Controlled Check Valve–this valve is separate from the air dryer and is installed on the system air tank. The valve allows air to back flow from the system tank to the supply tank as long as air system pressure remains

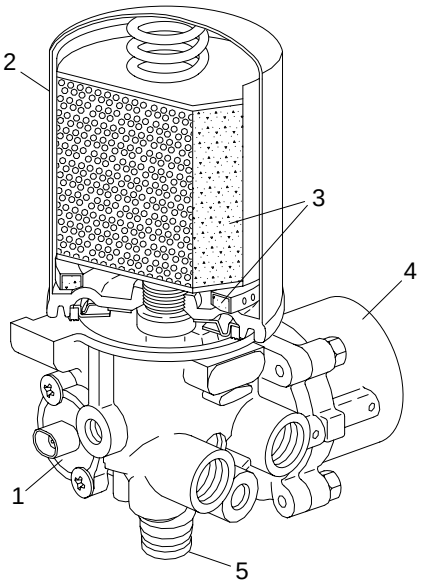
between the normal cut in and cut out range of the air governor.

- Purge Valve–this valve allows the collected moisture and contaminants to be expelled from the air dryer during the purge cycle.
- Regeneration Valve–this valve allows air from the supply and system tanks to bypass the outlet check valve and flow into the regeneration valve. Air then flows through an orifice where the air expands and back flushes moisture off of the desiccant. The air is then exhausted through the purge valve.
- Silencer (Muffler)–an optional component that is attached to the purge valve and used to eliminate most of the noise during the air dryer purge cycle.
- Turbocharger Cut-Off Valve–this valve closes the path between the air compressor and the air dryer purge valve to help maintain boost pressure for maximum engine horsepower during the compressor unload cycle.

Principles of Operation

Hot, compressed air enters the air dryer through the inlet port. As the hot air is forced into the desiccant cartridge, the temperature of the compressed air falls to nearly ambient. Oil and water vapor condense and initially settle into the base of the dryer. The moisture-laden air also passes through the desiccant bed, where any remaining moisture is retained by the desiccant. The clean air then passes through the air dryer outlet port to the supply reservoir. See **Fig. 3** .

When the compressor reaches 125 psi (862 kPa), the purge valve opens allowing the initial decompression of the dryer and expels the water and contaminants collected in the base of the dryer. The regeneration valve, along with the pressure-controlled check valve, allows the system air to flow back through the dryer. This back flow dries the desiccant for the next cycle.



1. Heater/Thermostat Assembly
2. Desiccant Canister
3. Filter
4. Regeneration Valve Assembly
5. Exhaust Port (Purge Valve Assembly)

Fig. 3, Sectional View

Safety Precautions

⚠ WARNING

When draining the air system, do not look into the air jets or direct them toward another person, as dirt or sludge particles may be in the air-stream. Do not disconnect pressurized hoses because they may whip as air escapes from the line. Failure to take all necessary precautions during service operations of the air brake system can cause personal injury.

When working on or around air brake systems and components, observe the following precautions.

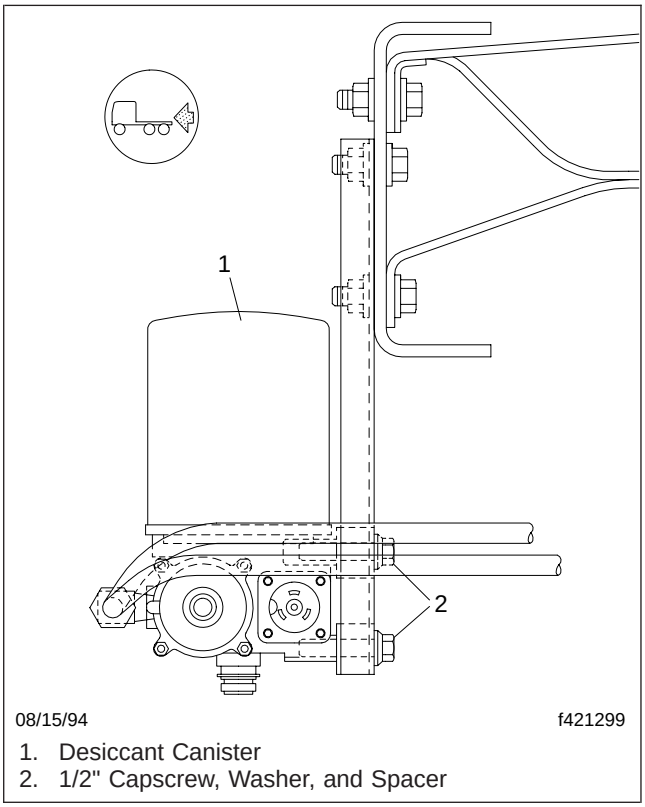
1. Apply the parking brake, chock the tires, and stop the engine when working under the vehicle. Draining the air system may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters, which may apply as air system pressure drops.
2. Wear safety goggles.
3. Never connect or disconnect a hose or line containing air under pressure; it may whip as air escapes. Never remove a component or pipe plug unless you are sure all system pressure has been depleted.
4. Don't disassemble a component before reading and understanding recommended procedures. Use only the correct tools and follow basic tool safety.
5. Replacement hardware, tubing, hose, fittings, etc. should be the same size, type, length, and strength as the original equipment. When replacing tubing or hose, be sure that all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace any components that have stripped threads or damaged parts. Don't attempt to repair parts by machining.
7. Never exceed recommended air pressure.

WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

NOTE: Figures shown in this subject are of the System Saver 1000 air dryer. However, service procedures for the 1000 and 1200 are the same except for the bypass valve (System Saver 1000) and the pressure relief valve (System Saver 1200).

Removal (See Fig. 1)



1. Desiccant Canister
2. 1/2" Capscrew, Washer, and Spacer

Fig. 1, Air Dryer Installation (outboard rail mounting shown)

1. Drain the air system.
2. Disconnect the wiring harness from the air dryer.
3. Mark the air lines for later reference; then, disconnect them from the air dryer.
4. Remove the capscrews, washers, and spacers that attach the air dryer to the mounting bracket.
5. Remove the air dryer.

Installation (See Fig. 1)

1. Position the air dryer on the mounting bracket. Install the spacers, washers, and capscrews. Tighten them 22 to 30 lbf·ft (30 to 41 N·m).
2. Make sure the air lines are clean. Replace any line or fitting that is crimped or damaged.
3. Connect the remaining air lines to the air dryer as previously marked. Tighten the nut on each fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance.
4. Connect the air dryer wiring harness.

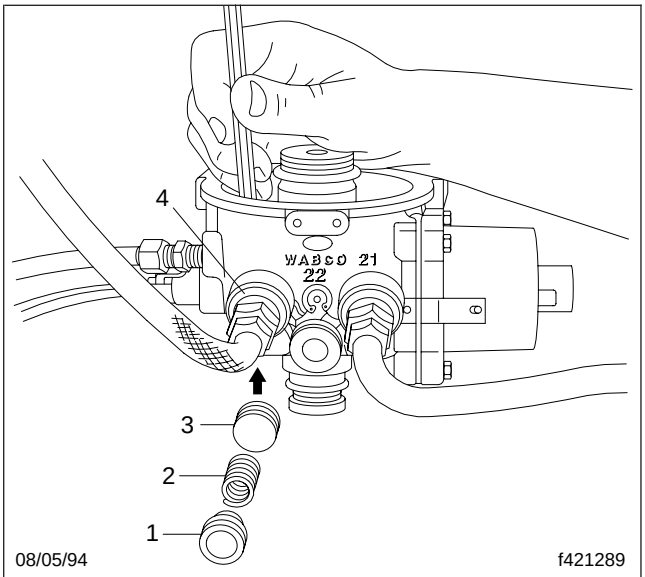
Replacement

WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

NOTE: Figures shown in this subject are of the System Saver 1000 air dryer. However, service procedures for the 1000 and 1200 are the same except for the bypass valve (System Saver 1000) and the pressure relief valve (System Saver 1200).

1. Drain the air system.
2. Remove the snap ring at the bottom of the valve assembly. The valve cover and spring may fall out of the cavity when the snap ring is removed. See Fig. 1.



1. Cover
2. Spring
3. Piston
4. Inlet Port

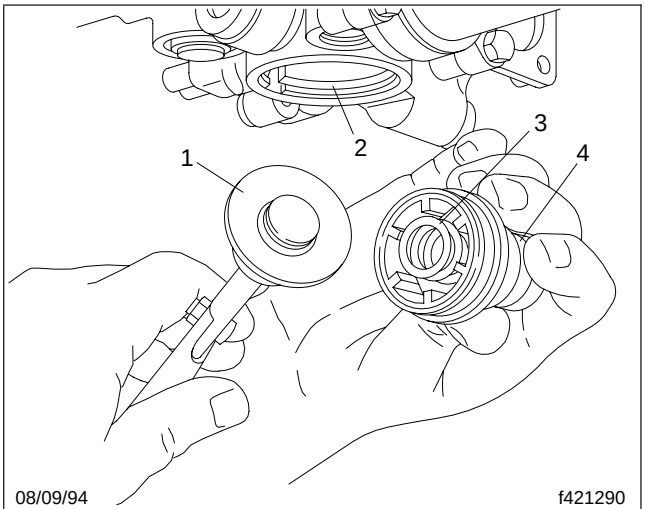
Fig. 1, Push the Piston, Spring, and the Cover Out of the Valve Cavity.

3. Using a strap wrench, turn the desiccant cartridge counterclockwise and remove it.
4. Using a wooden stick, push the piston, spring, and the cover out of the valve cavity.
5. Clean the valve cavity with a commercial cleaning solvent.
6. Install new O-rings on the piston and the cover.
7. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-rings and the valve cavity.
8. Install the new piston with its hollow side facing out.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

9. Install the new spring, cover, and snap ring to hold the components in place.
10. Thread the desiccant cartridge onto the dryer base (turn clockwise). When the seal contacts the base, tighten the cartridge one complete turn more. Do not over tighten.

Replacement (See Fig. 1)



1. Valve Assembly
2. Exhaust Port
3. Spring
4. Valve Head

Fig. 1, Remove the Valve Assembly

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

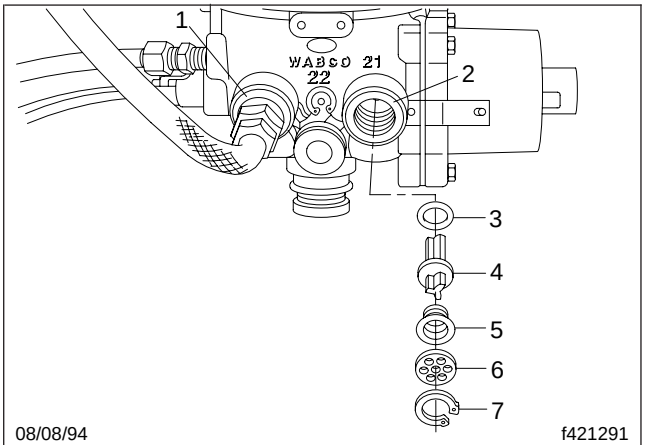
NOTE: Figures shown in this subject are of the System Saver 1000 air dryer. However, service procedures for the 1000 and 1200 are the same except for the bypass valve (System Saver 1000) and the pressure relief valve (System Saver 1200).

1. Drain the air system.
2. Remove the snap ring, valve head, and the spring from the exhaust port.
3. Pull the valve assembly out of the exhaust port.
4. Remove the O-ring from the base of the exhaust port.
5. Clean the purge valve cavity area with a commercial cleaning solvent.
6. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the valve cavity and to all of the new O-rings. Install the O-rings in the base of the exhaust port and on the valve head.
7. Position the new valve assembly in the valve cavity.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

8. Install the spring in the valve head, and position them in the valve cavity.
9. Install the snap ring to secure the valve head in position.

Replacement (See Fig. 1)



1. Inlet Port
2. Outlet Port
3. O-Ring
4. Valve Body
5. Spring
6. Washer
7. Snap Ring

Fig. 1, Outlet Check Valve Assembly

WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

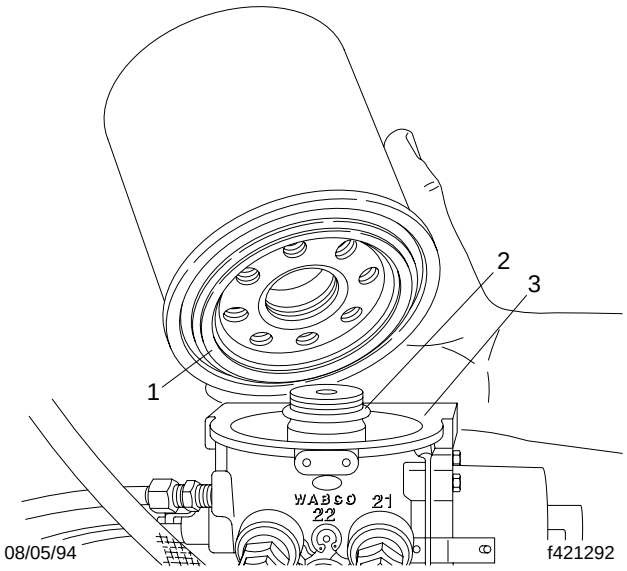
NOTE: Figures shown in this subject are of the System Saver 1000 air dryer. However, service procedures for the 1000 and 1200 are the same except for the bypass valve (System Saver 1000) and the pressure relief valve (System Saver 1200).

1. Drain the air system.
2. Disconnect the air line from the outlet port.
3. Remove the snap ring, washer, valve body, and the O-ring.
4. Clean the cavity area with a commercial cleaning solvent.
5. Install a new O-ring on the valve body.
6. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring and the valve cavity.
7. Install the new valve body. Make sure that the long end of the body is inserted first into the valve cavity.
8. Install the new spring with its small end around the "Y" shaped fins on the valve body.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

9. Install a new washer and snap ring to secure the assembly in the valve cavity.
10. Connect the air line to the outlet port. Tighten the nut on the fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance. Tighten the nut one-sixth turn more.

Replacement (See Fig. 1)



1. Seal
2. O-Ring
3. Air Dryer Base

Fig. 1, Desicant Cartridge Replacement

⚠ WARNING

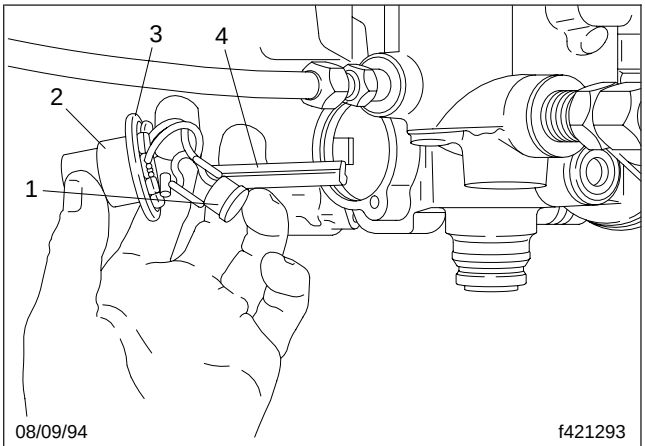
Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

NOTE: Figures shown in this subject are of the System Saver 1000 air dryer. However, service procedures for the 1000 and 1200 are the same except for the bypass valve (System Saver 1000) and the pressure relief valve (System Saver 1200).

1. Drain the air system.
2. Using a strap wrench, turn the desiccant cartridge counterclockwise and remove it.
3. Remove and discard the O-ring.
4. Clean the top surface of the dryer base with a commercial cleaning solvent.
5. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring and the dryer base. Install the O-ring.
6. Thread the desiccant cartridge onto the dryer base (turn clockwise). When the seal contacts the base, tighten the cartridge one complete turn more. Do not over tighten.

IMPORTANT: If the air dryer base is damaged, preventing a tight seal, replace the air dryer.

Replacement (See Fig. 1)



1. Thermostat
2. Receptacle
3. O-Ring
4. Element

Fig. 1, Heater/Thermostat Replacement

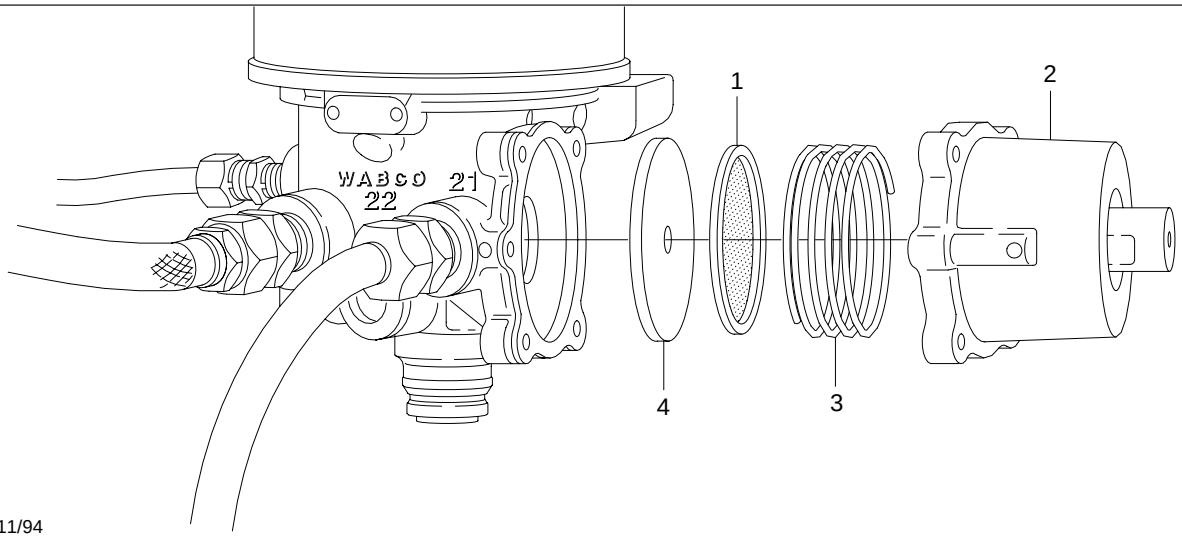
WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

NOTE: Figures shown in this subject are of the System Saver 1000 air dryer. However, service procedures for the 1000 and 1200 are the same except for the bypass valve (System Saver 1000) and the pressure relief valve (System Saver 1200).

1. Drain the air system.
2. Disconnect the wiring harness.
3. Remove the screws that attach the heater/thermostat receptacle. Remove the receptacle and the O-ring.
4. Remove the retaining screw that holds the assembly in place. Remove and discard the heater/thermostat assembly.
5. Clean the heater/thermostat assembly area with a commercial cleaning solvent.
6. Position the new heater/thermostat assembly in the cavity. Install the retaining screw.
7. Position the new receptacle and O-ring, and install the screws. Tighten the screws securely.
8. Connect the wiring harness.

Replacement (See Fig. 1)



1. Diaphragm
2. Valve Housing Assembly
3. Spring
4. Retainer

Fig. 1, Regeneration Valve Replacement

WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

NOTE: Figures shown in this subject are of the System Saver 1000 air dryer. However, service procedures for the 1000 and 1200 are the same except for the bypass valve (System Saver 1000) and the pressure relief valve (System Saver 1200).

1. Drain the air system.

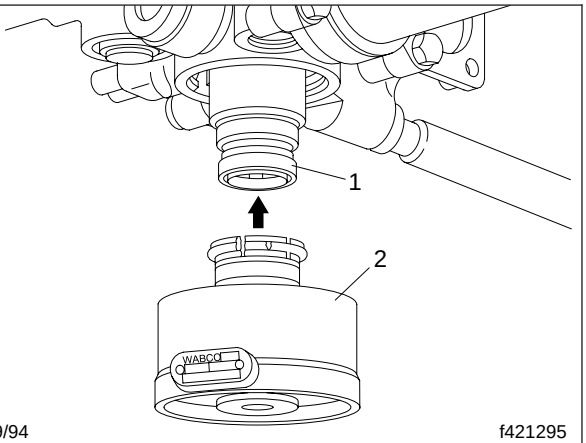
NOTE: When the valve housing is removed, the spring and the retainer will fall out of the housing.

2. Remove the four mounting bolts and remove the valve housing assembly.
3. Remove the rubber diaphragm.
4. Clean the groove where the diaphragm lip fits with a commercial cleaning solvent.
5. Install a new diaphragm with its lip in the groove.

IMPORTANT: If the groove is damaged, preventing a tight seal, replace the air dryer.

6. Install the new spring and retainer (with the retainer lip facing out).
7. Position the valve housing on the air dryer. Install the bolts and tighten them to 53 lbf·in (600 N·cm).

Replacement (See Fig. 1)



1. Purge Valve Head
2. Silencer

Fig. 1, Silencer Replacement

WARNING

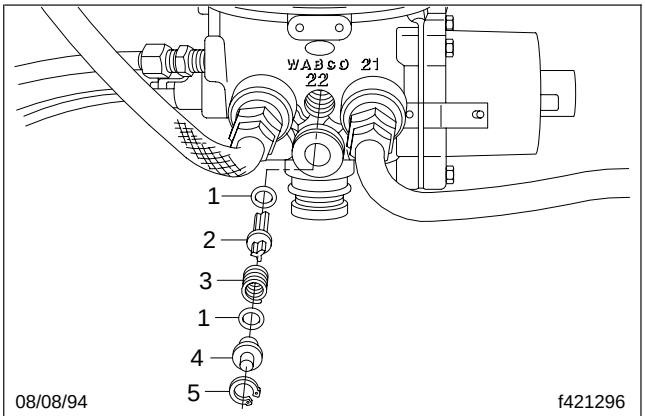
Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

NOTE: Figures shown in this subject are of the System Saver 1000 air dryer. However, service procedures for the 1000 and 1200 are the same except for the bypass valve (System Saver 1000) and the pressure relief valve (System Saver 1200).

1. Using snap ring pliers, expand the snap ring and pull the silencer off of the purge valve head.
2. Push the new silencer onto the purge valve head until the silencer snaps into place.

Bypass (Relief) Valve Replacement (System Saver 1000)

Replacement (See Fig. 1)



1. O-Ring
2. Valve Body
3. Spring
4. Cover
5. Snap Ring

Fig. 1, Bypass (Relief) Valve Replacement

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

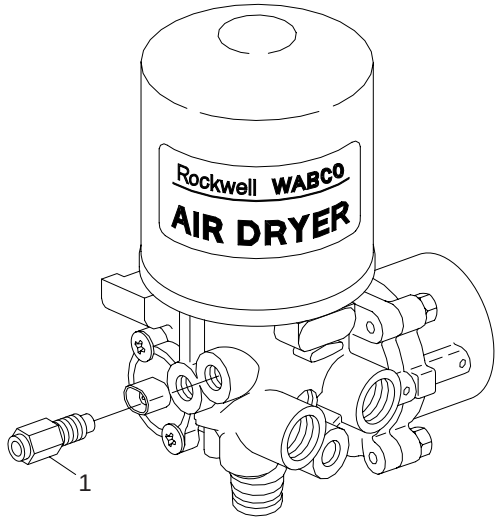
1. Drain the air system.
2. Remove the snap ring, cover, spring, and valve body.
3. Clean the cavity area with a commercial cleaning solvent.
4. Install new O-rings on the valve body and cover.
5. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-rings and the valve cavity.
6. Install the new valve body. Make sure that the long end of the body is inserted first into the valve cavity.
7. Install the new spring so it fits around the "Y" shaped fins on the valve body.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

8. Install the new cover and snap ring to secure the assembly in the valve cavity.

Pressure Relief Valve Replacement (System Saver 1200)

Replacement (See Fig. 1)



1. Pressure Relief Valve

Fig. 1, Pressure Relief Valve Replacement

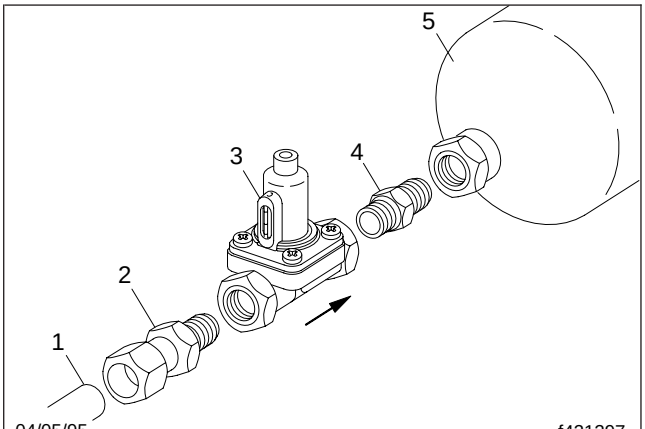
⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Remove the old pressure relief valve.
3. Screw the replacement valve into the dryer base. Do not exceed a torque of 30 lbf·ft (41 N·m) for a 3/8 inch thread, or 65 lbf·ft (88 N·m) for 1/2 inch thread.

NOTE: The threads on the replacement pressure relief valve provided by Rockwell WABCO are coated with sealant. They do not require any additional sealant.

Replacement (See Fig. 1)



1. Air Line
2. Nylon Tube Connector
3. Pressure-Controlled Check Valve
4. Hex Nipple Pipe Fitting
5. Air Tank

Fig. 1, Check Valve Assembly Replacement

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

NOTE: Figures shown in this subject are of the System Saver 1000 air dryer. However, service procedures for the 1000 and 1200 are the same except for the bypass valve (System Saver 1000) and the pressure relief valve (System Saver 1200).

1. Drain the air system.
2. Disconnect the air line from the pressure-controlled check valve.
3. Remove the valve and the hex nipple fitting from the air tank .
4. Install the pipe fitting on the new valve.
5. Install the new valve on the air tank with the arrow on the valve pointing towards the tank.
6. Apply liquid Loctite® Hydraulic Sealant (brown), or an equivalent, to the air line threads. Connect the air line to the valve. Tighten the air line securely.

NOTE: Always apply sealant to the external threads so that any excess will be scraped off externally rather that internally to the joint.

Operating Tests

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

AIR DRYER OPERATING CHECK

1. Drain the air system.
2. Start the engine and build the air pressure to as close to cutout pressure as possible (about 125 psi [862 kPa]).
3. When the compressor reaches the unload cycle, the air dryer purges, beginning regeneration of the air dryer.
4. During the purge cycle, which lasts about 10 to 15 seconds, the wet tank and system tank with the pressure-controlled check valve will drop about 10 psi (69 kPa). Check the secondary air gauge in the cab dash panel.
5. If the gauge needle does not show a pressure drop of about 10 psi (69 kPa), one of the following problems may exist.
   - A pressure-controlled check valve is not installed.
   - The pressure-controlled check valve is installed in the wrong air tank.
   - The pressure-controlled check valve is installed on a one-way check valve, instead of in place of a one-way check valve.
   - There is an extra check valve located somewhere between the air dryer and the secondary air tank (usually at the wet tank).
   - The system air gauge is not plumbed to the system tank air system.
6. If system air pressure drops 15 psi (103 kPa) or more during the purge cycle, and there are no other air-operated components in use, then there are air leaks or other system problems. See **Troubleshooting 300** for other possible causes.

PRESSURE-CONTROL CHECK VALVE OPERATING CHECK

IMPORTANT: Install a calibrated air gauge (accurate to within 1 psi [7 kPa]) in the system air tank with the pressure-controlled check valve to check the valve. Do not use the cab air gauges.

1. Start the engine and build the air pressure to as close to cutout pressure as possible (about 125 psi [862 kPa]).
2. Stop the engine after the air compressor has unloaded.
3. Drain the opposite system air tank(s) down to about 80 psi (552 kPa).
4. Check the calibrated air gauge. It should read 95 ± 5 psi (655 ± 34 kPa).

   If the gauge reading is less that 85 psi (586 kPa), either the pressure-control check valve is installed backwards, it is damaged, or there are air leaks in the system tank air system.

   If the gauge reading does not change, or the reading does not fall below 105 psi (724 kPa), make the checks under "Air Dryer Operating Check." If none of those problems exist, replace the control valve.

Troubleshooting Tables

Problem—Purge Cycle is Too Long (more than 30 seconds)

Problem—Purge Cycle is Too Long (more than 30 seconds)	
Possible Cause	**Remedy**
The air dryer outlet check valve is stuck open.	Replace the check valve assembly.
The turbocharger cutoff valve is leaking.	Replace the turbocharger cutoff valve.
The regeneration valve is not working correctly.	Replace the regeneration valve.

Problem—Purge Cycle is Too Short (less than 8 seconds)

Problem—Purge Cycle is Too Short (less than 8 seconds)	
Possible Cause	**Remedy**
The air governor is not working.	Replace the air governor.
The pressure-controlled check valve is not working correctly.	Replace the pressure-controlled check valve.
The regeneration valve is not working correctly.	Replace the regeneration valve.

Problem—System Air Pressure Drops Rapidly

Problem—System Air Pressure Drops Rapidly	
Possible Cause	**Remedy**
Fittings are loose or damaged.	Tighten or replace loose or damaged fittings.
Air reservoir, tubing, or hoses are damaged.	Repair or replace damaged items.
The air dryer outlet check valve is stuck open.	Clean or replace the outlet check valve assembly.

Problem—Excessive Cycling of the Air Dryer

Problem—Excessive Cycling of the Air Dryer	
Possible Cause	**Remedy**
Fittings are loose or damaged.	Tighten or replace loose or damaged fittings.
Air reservoir, tubing, or hoses are damaged.	Repair or replace damaged items.
The air dryer outlet check valve is leaking or stuck open.	Replace the outlet check valve assembly.
High air usage or demand for a particular system.	Increase air system capacity or reduce air demand.
The governor is not working properly.	Replace the air governor.

Troubleshooting

Problem—Excessive Cycling of the Air Dryer	
Possible Cause	**Remedy**
The air compressor needs to be serviced or replaced.	Rebuild or replace the air compressor.

Problem—Water and/or Oil in the Vehicle Air Reservoirs

Problem—Water and/or Oil in the Vehicle Air Reservoirs	
Possible Cause	**Remedy**
The desiccant cartridge contains excessive contaminants.	Replace the desiccant cartridge.
Purge cycle is too short.	Refer to "Problem—Purge Cycle is too Short (less than 8 seconds)."
The bypass (relief) valve (System Saver 1000) is leaking.	Replace the bypass valve.
The pressure relief valve (System Saver 1200) is leaking.	Replace the pressure relief valve.
Too much oil is pumped from the air compressor.	Rebuild or replace the air compressor.
The regeneration valve is not working correctly.	Replace the regeneration valve.
The air dryer is mounted too close to a heat source.	Locate the air dryer away from heat sources and where air can flow around it.
Discharge line is of improper length or material.	Discharge line must consist of at least 6 ft. (1.8 m) of wire braid Teflon hose, copper tubing, or a combination of both between the discharge port of the compressor and the air dryer supply port. Discharge line lengths and inside diameter requirements are dependent on the vehicle application. Contact your local Rockwell WABCO representative for further information.

Problem—The Air Compressor Runs Continuously (System Pressure Will Not Build Up)

Problem—The Air Compressor Runs Continuously (System Pressure Will Not Build Up)	
Possible Cause	**Remedy**
Fittings are loose or damaged.	Tighten or replace loose or damaged fittings.
Air reservoir, tubing, or hoses are damaged.	Repair or replace damaged items.
The air compressor needs to be serviced or replaced.	Rebuild or replace the air compressor.
The purge valve is stuck open.	Replace the purge valve.
The line between the air compressor and the air dryer is blocked, leaks, or is plumbed incorrectly.	Repair or replace the line as needed.
The governor is not working properly.	Replace the air governor.
The turbocharger cutoff valve or the outlet check valve is stuck in the closed position.	Replace the turbocharger cutoff valve or the outlet check valve.
The desiccant cartridge or cartridge seal is leaking.	Tighten or replace the desiccant cartridge.

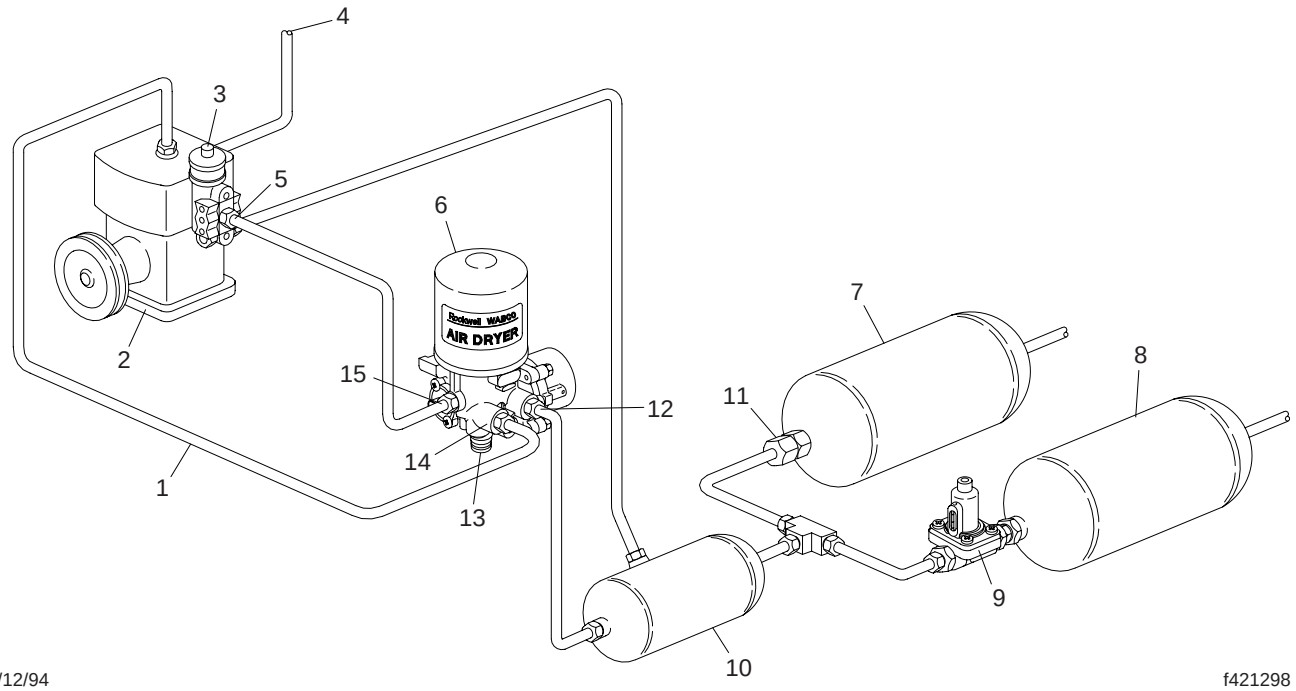
Problem—The Air Compressor Runs Continuously (System Pressure Will Not Build Up)	
Possible Cause	**Remedy**
The wrong air line is connected to port 4 on the air dryer.	Correct the air line plumbing.
The air dryer outlet port is plumbed incorrectly.	Connect the outlet port line to the supply air tank.
The air dryer base is cracked.	Replace the air dryer.

Problem—The Air Dryer Does Not Unload When the Air Compressor Goes Into Standby Mode

Problem—The Air Dryer Does Not Unload When the Air Compressor Goes Into Standby Mode	
Possible Cause	**Remedy**
The line between the air governor and the air dryer purge port is missing, loose, or damaged.	Install or replace the air line, or tighten the fittings.
The heater/thermostat assembly is not working.	Replace the heater/thermostat assembly or check the electrical connections.

See **Fig. 1**for the System Saver 1000 plumbing diagram.

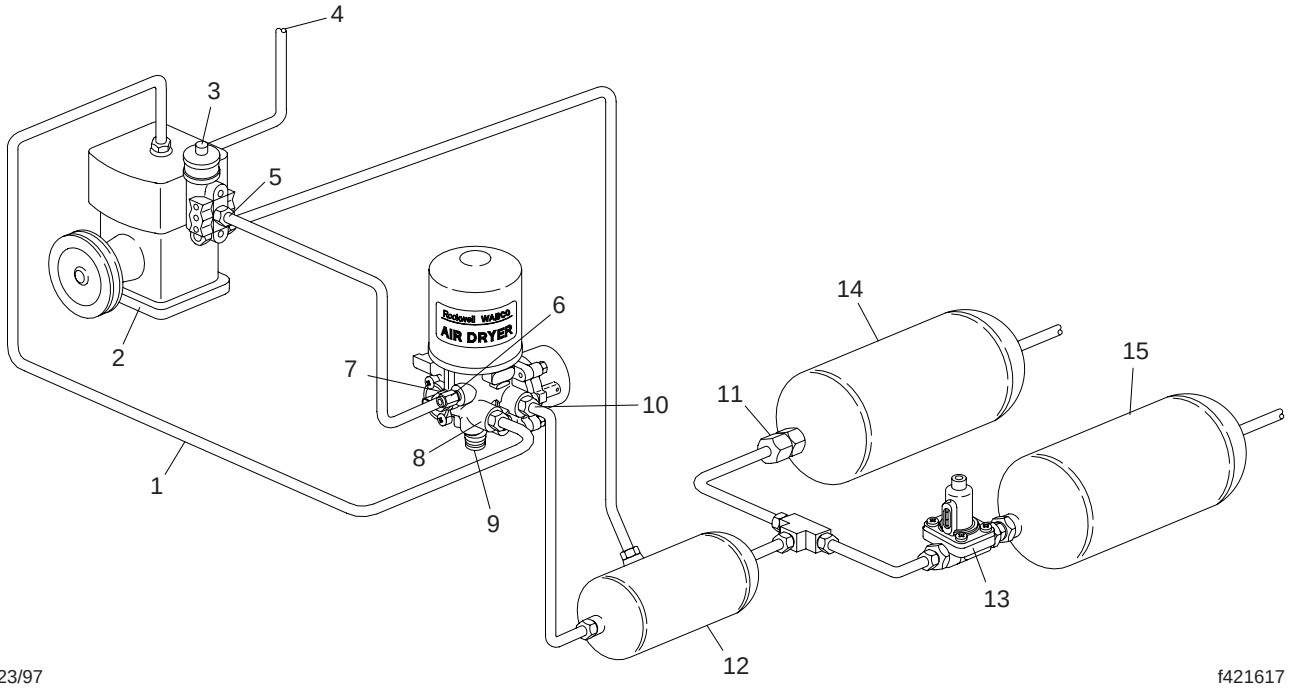
See **Fig. 2**for the System Saver 1200 plumbing diagram.



1. Compressor Discharge Line
2. Air Compressor
3. Air Governor
4. Compressor Intake Line
5. Unloader Port
6. Air Dryer
7. System Reservoir
8. System Reservoir
9. Pressure-Control Check Valve
10. Supply Tank
11. Check Valve
12. Air Dryer Outlet
13. Purge Valve
14. Air Dryer Inlet
15. Air Governor Port

Fig. 1, Air Dryer Plumbing Diagram, System Saver 1000

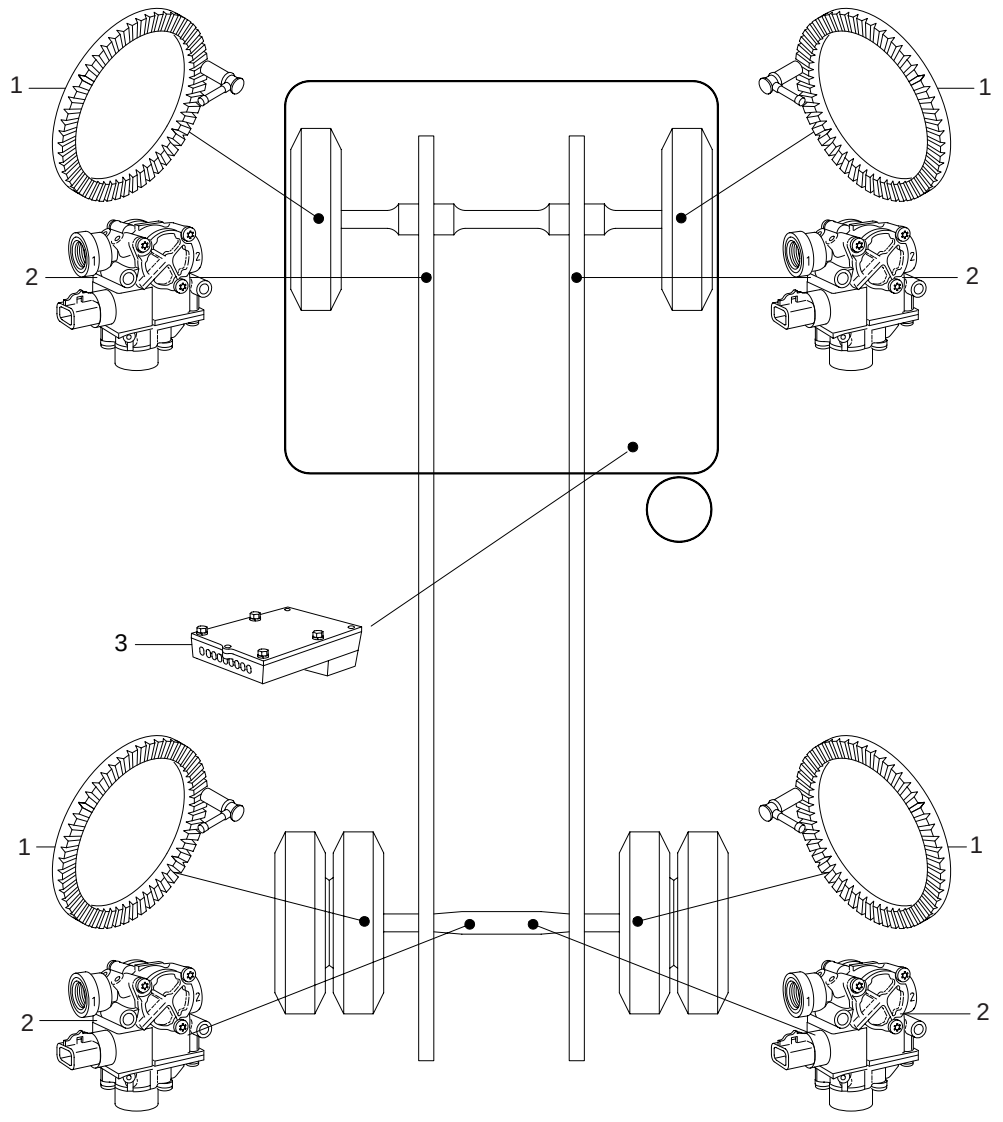
Specifications



1. Compressor Discharge Line
2. Air Compressor
3. Air Governor
4. Compressor Intake Line
5. Unloader Port
6. Pressure Relief Valve
7. Governor Port
8. Air Dryer Inlet
9. Purge Valve
10. Air Dryer Outlet
11. Check Valve
12. Supply Tank
13. Pressure-Controlled Check Valve
14. System Reservoir
15. System Reservoir

Fig. 2, Air Dryer Plumbing Diagram, System Saver 1200

General Information (See Fig. 1)



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1. Tone Wheel and Sensor
2. Modulator Assembly
3. Electronic Control Unit (ECU)

Fig. 1, Location of ABS Components, Four-Channel System

The Bendix® antilock braking system (ABS) is an electronic wheel-speed monitoring and control system that works with the standard air brake system. ABS passively monitors vehicle wheel speed at all times, and controls wheel speed during emergency

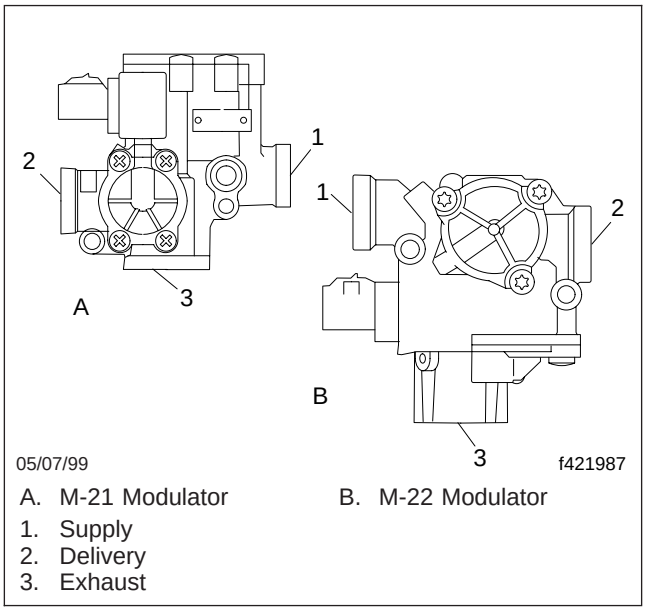
General Information

stops. In normal braking applications, the standard air brake system is in effect.

ABS includes signal-generating tone wheels and sensors located in the wheel hubs of each sensed wheel. The sensors transmit vehicle wheel speed information to an electronic control unit (ECU). According to programmed specifications, the ECU signals the appropriate modulator assembly to increase, reduce, or maintain air pressure supply in the brake chamber. This prevents front and rear wheel lockup, and enhances steering control during emergency braking situations.

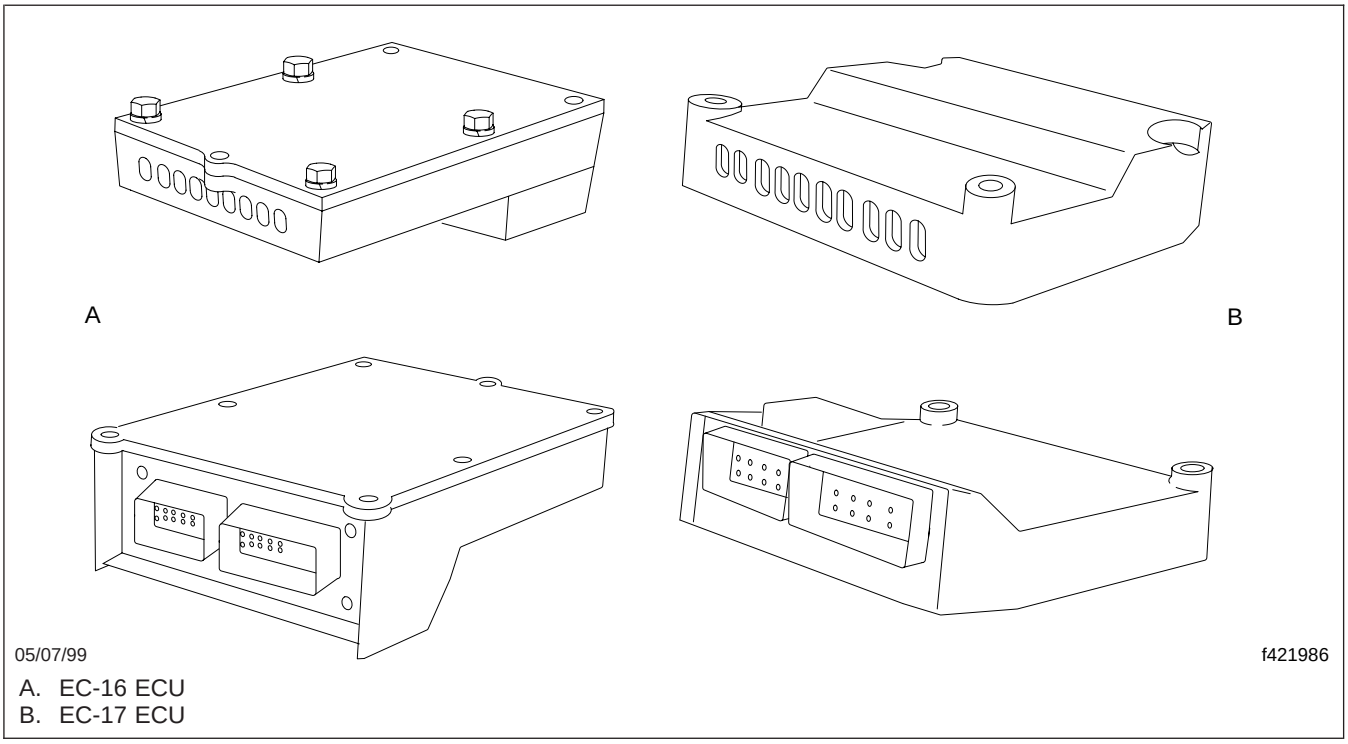
Principles of Operation

The ABS electronic control unit (ECU) (**Fig. 2**) is a digital microcomputer that serves as the information processing and command center for the antilock braking system. The ECU receives and processes vehicle wheel speed information from the sensors. During emergency brake applications, the ECU regulates the braking force applied to each wheel by sending control signals to the modulator assembly (**Fig. 3**).



A. M-21 Modulator
B. M-22 Modulator
1. Supply
2. Delivery
3. Exhaust

Fig. 3, M-21 and M-22 Modulator Assemblies



A. EC-16 ECU
B. EC-17 ECU

Fig. 2, EC-16 and EC-17 ABS Electronic Control Units

ABS MAJOR COMPONENTS

Wheel Speed Sensor

The wheel speed sensors use pulse feedback from 100-tooth tone wheels located in the front and rear axle wheel hubs. When the vehicle is moving, the teeth of the tone wheel cause interruptions in a magnetic field created by the sensor. The interruptions created in the magnetic field in turn create electrical pulses that are sent by the sensor to the ECU.

Electronic Control Unit (ECU)

The ECU receives speed sensor pulses and interprets these signals to calculate wheel speed and a vehicle reference speed. If the calculations indicate wheel slip or lockup, the appropriate control circuit signals the modulator assembly to increase or decrease braking pressure.

There are three versions of the ECU. The older versions (EC-15 and EC-16) are factory programmed with vehicle particulars, such as the number of speed sensors, if the traction control feature was enabled and the type of traction control (torque limiting, differential braking, or both).

The current, self-configuring ECU (EC-17) can be most easily identified while installed on the vehicle. Identification can be made by observing the reaction of the diagnostic display when the ignition is turned on and power is applied to the ECU. The current configuration of the ECU is displayed via the troubleshooting LEDs and occurs during the normal self-test sequence. Only the LEDs that correspond to the sensors identified during the self-configuration will illuminate. If all antilock components are working properly, the red LEDs will turn off and the single, green, VLT LED will be illuminated. This configuration review is repeated each time the ignition is turned on.

IMPORTANT: The LED display is optional on the EC-17. The EC-17N control unit does not have an LED display and the AlliedSignal Bendix Diagnostic Communication Interface (DCI) must be used for diagnostics or reconfiguration.

On the older versions of the ECU, *all* diagnostic LEDs will illuminate and then go out if all antilock components are working properly. During normal operation, all the red LEDs will be off and the single, green, VLT LED will be illuminated. See **Troubleshooting, 300** for more information on the LED display.

The ECU contains a safety circuit to constantly monitor the wheel sensors, modulator assemblies, and the electrical circuitry. After the ignition is switched on, the tractor warning light (TRAC ABS) comes on. See **Fig. 4**. On vehicles with newer ECUs, the TRAC ABS light will go out shortly after the ignition is turned on. On vehicles with the older ECUs, the TRAC ABS light will stay lit until the vehicle reaches 7 mph (11 km/h). The TRAC ABS light will stay on if the tractor's ABS components are not working properly.

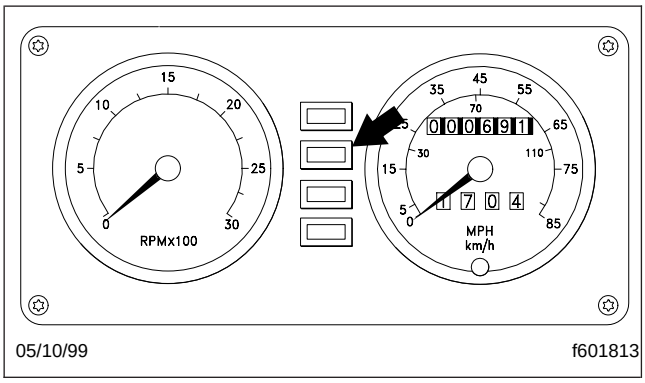


Fig. 4, TRAC ABS Indicator Light

When vehicle power is supplied to the EC-17, a modulator "chuff" test is performed. When the brake pedal is depressed while the ECU is powered up, the modulator "chuff" test can be heard. This test will verify if the modulator is connected correctly and is functional. The modulators will exhaust air in the sequence of right front, left front, right rear and left rear. If they do not follow this sequence, proceed with modulator troubleshooting. See **Troubleshooting, 300**.

If, during vehicle operation, the safety circuit senses a failure in any part of the ABS system (a sensor, modulator assembly, wiring connection, short circuit, etc.), the TRAC ABS light comes on, and the control circuit where the failure occurred is switched to normal braking action. Remaining control circuits will retain the ABS effect. Even if the ABS system is completely inoperative, normal braking is maintained. The vehicle is not disabled.

IMPORTANT: If the ABS warning lights do not work as described above, there is a possible system malfunction. If this occurs, the vehicle will continue to have normal braking ability, but without ABS. Service the ABS as soon as pos-

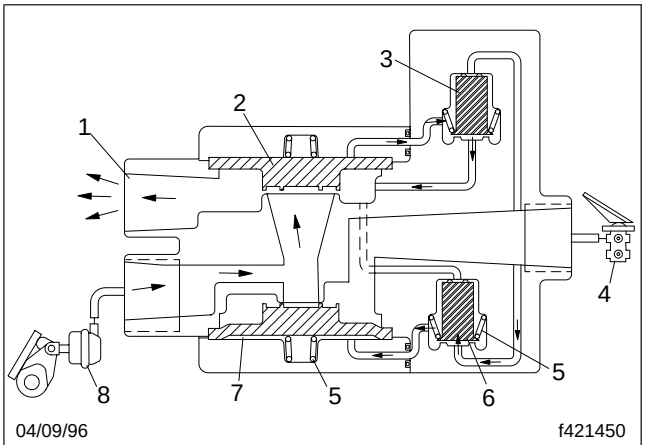
sible. Refer to **Troubleshooting, 300** for fault diagnosis.

Modulator Assembly

To ensure proper operation, ABS solenoid/modulator valves must be plumbed properly. If the valve plumbing is removed during service, care must be taken to ensure the air lines are plumbed to the correct valve ports when reinstalled.

Depending on the signal received from the ECU, the modulator assembly prevents wheel lockup by reducing, maintaining, or increasing brake chamber air pressure. During normal braking applications, compressed air flows freely to the brake chamber through the modulator assembly.

If the ECU receives signals indicating wheel lockup during a brake application, the ECU energizes both the supply and exhaust solenoids in the modulator assembly. See **Fig. 5**. Energizing the supply solenoid causes its exhaust to close and inlet to open. With the inlet of the supply solenoid open, application air is permitted to flow to the control side of the supply diaphragm. Air pressure acting on the supply diaphragm causes it to close the supply diaphragm and prevent further delivery of air to the brake chamber.



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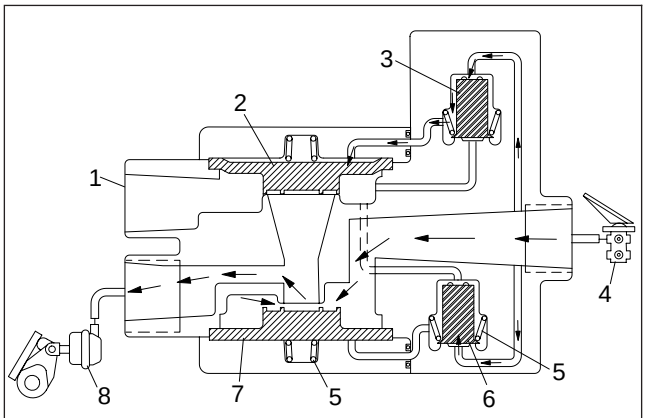
1. Exhaust Port
2. Exhaust Diaphragm
3. Exhaust Solenoid Energized
4. Brake Valve
5. Spring
6. Supply Solenoid Energized
7. Supply Diaphragm
8. Brake Chamber

Fig. 5, Wheel Lockup

Energizing the exhaust solenoid closes its inlet and opens its exhaust. By closing the exhaust solenoid inlet, application air is prevented from flowing to the control side of the exhaust diaphragm. Air pressure, which was present on the control side of the exhaust diaphragm flows out the exhaust port of the modulator assembly. With control air pressure removed from the exhaust diaphragm, brake application air forces the exhaust diaphragm to unseat which allows it to flow out the modulator exhaust port.

As wheel speed increases, the modulator assembly alternately increases, then maintains brake pressure until the proper wheel speed is obtained, or until wheel lockup occurs and the control cycle starts again.

During the pressure increase cycle (**Fig. 6**), brake application air enters the supply port of the modulator assembly and flows to, and through, the open exhaust solenoid, then to the exhaust diaphragm. Air pressure, along with spring force, seats the exhaust diaphragm on the exhaust passage thus preventing the escape of service air. At the same time, application air flows to the supply diaphragm and forces it away from its seat. Air flows past the open supply and out the modulator assembly delivery port to the service brake chambers.



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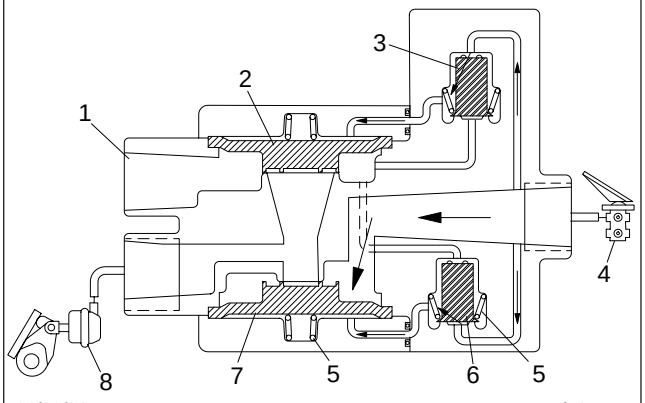
1. Exhaust Port
2. Exhaust Diaphragm
3. Exhaust Solenoid
4. Brake Valve
5. Spring
6. Supply Solenoid
7. Supply Diaphragm
8. Brake Chamber

Fig. 6, Pressure Increase

If maintaining brake air pressure (**Fig. 7**), the ECU energizes the supply solenoid and de-energizes the exhaust solenoid. This seats both diaphragms and prevents further exhaust of brake chamber air pressure and prevents the application air from flowing out of the delivery port to the brake chamber.



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1. Exhaust Port
2. Exhaust Diaphragm
3. Exhaust Solenoid
4. Brake Valve
5. Spring
6. Supply Solenoid
7. Supply Diaphragm
8. Brake Chamber

Fig. 7, Maintaining Pressure

Replacement

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Group 54** of this manual for information on special terminals and connectors, and for information on ordering tools for them.

FRONT AXLE

1. Chock the rear tires to prevent vehicle movement. Apply the parking brakes.
2. Twist and pull the sensor to remove it from the steering knuckle (**Fig. 1**).

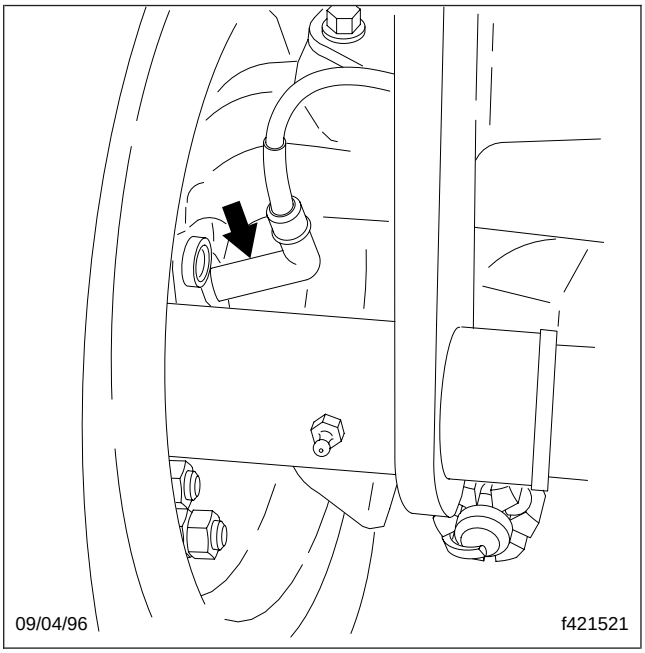


Fig. 1, Wheel Speed Sensor

3. Remove the sensor cable from the steering knuckle top cap.
4. Disconnect the sensor cable from the chassis harness.
5. Remove the clamping bushing from the brake spider hole.
6. Connect the sensor cable to the chassis harness.
7. Attach the sensor cable to the steering knuckle top cap.
8. Push the clamping bushing into the brake spider hole until it stops.
9. Coat the sensor with Mobil HP, Valvoline EP 633, Penzoil 707L, or an equivalent grease. Push the sensor into the clamping bushing until it is stopped by the tone wheel
10. Remove the chocks from the rear tires.

REAR AXLE

1. Chock the front tires to prevent vehicle movement. Apply the parking brakes.
2. Raise the rear of the vehicle until the tires clear the ground. Place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.
4. Remove the wheel and tire assembly from the rear axle. For instructions, see **Group 40** of this manual.
5. Remove the brake drum. For instructions, see **Group 35** of this manual.
6. Twist and pull the sensor to remove it from the mounting block in the axle housing.
7. Remove the clamping bushing.
8. Remove the capscrew that attaches the sensor cable and the hose clamp to the axle tube.
9. Disconnect the sensor cable from the chassis harness.
10. Connect the sensor cable to the chassis harness.
11. Attach the hose clamp and sensor cable to the axle tube located between the backing plate and the spring plate.
12. Push the clamping bushing into the mounting block until it stops.
13. Coat the sensor with Mobil HP, Valvoline EP633, Penzoil 707L, or an equivalent grease. Push the sensor into the clamping bushing until it is stopped by the tone wheel.
14. Install the brake drum on the wheel hub.
15. Adjust the rear axle brakes. For instructions, see **Group 42** of this manual.

Wheel Speed Sensor Replacement

16. Install the wheel and tire assembly, and tighten the wheel nuts. Use the tightening sequence and torque values listed in **Group 40** of this manual.
17. Remove the safety stands, lower the vehicle, and remove the chocks from the front tires.

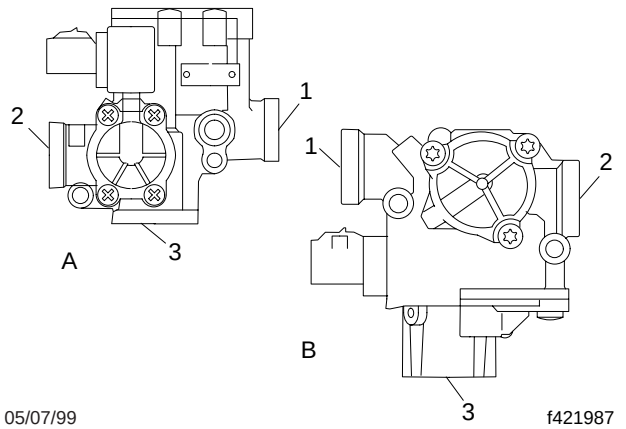
Replacement

WARNING

Reversal of supply and delivery air lines plumbed to the modulator could cause the vehicle brakes to lock up, and remain locked, during a hard brake application. Locked brakes may cause the vehicle to slide or cause loss of steering and/or stability, possibly resulting in vehicle damage or personal injury.

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Group 54** of this manual for information on special terminals and connectors, and for information on ordering tools for them.

1. Chock the front and rear tires.
2. Release the pressure from the air reservoirs.
3. Disconnect the wiring from the modulator assembly.
4. Disconnect the air supply line (**Fig. 1**) and the air discharge line.



A. M-21 Modulator
B. M-22 Modulator
1. Supply
2. Delivery
3. Exhaust

Fig. 1, M-21 and M-22 Modulator Assemblies

IMPORTANT: Modulator porting is reversed on the M-21 modulator.

5. Remove the two mounting capscrews and nuts.
6. Remove the modulator assembly.
7. Position the modulator assembly and install the two mounting capscrews and nuts. Tighten the mounting nuts 18 lbf·ft (24 N·m).
8. Connect the air supply line (**Fig. 1**) and the air discharge line.

IMPORTANT: Modulator porting is reversed on the M-21 modulator.

9. Connect the wiring to the modulator assembly.
10. Remove the chocks from the front and rear tires.

Adjustment

NOTE: The following adjustment procedure requires the use of special tool T11–17556–000. Use of this tool, available through the PDCs, eliminates the time-consuming task of removing the wheel and tire assembly, and the brake drum. See **Fig. 1**.

1. Park the vehicle on level ground, set the parking brake, and shut down the engine.

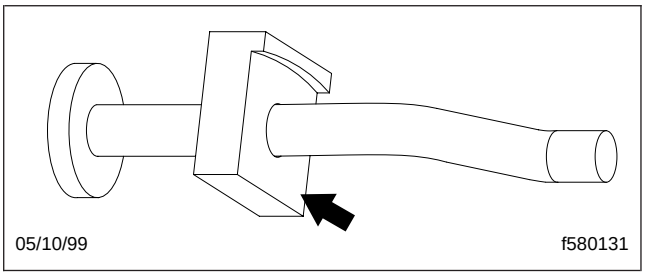
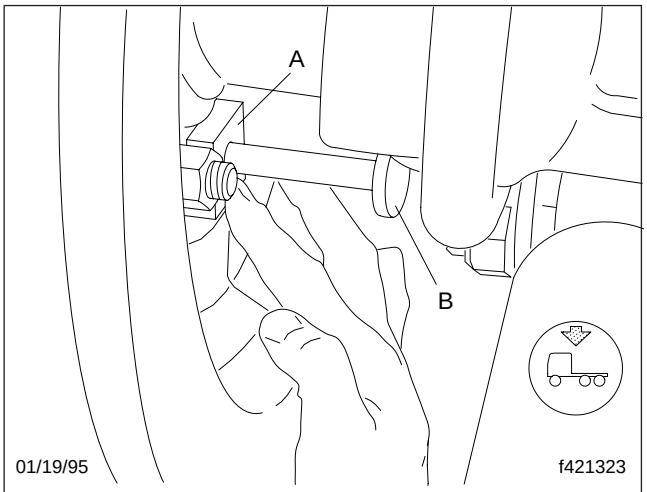


Fig. 1, ABS Sensor Adjustment Tool Slide

2. Chock the front tires.
3. Find the sensor access hole in the rear axle flange.
   - 3.1 View the brake drum and axle from the rear. The ABS sensor wiring harness should be visible passing through a hole in the 12 o'clock position.
   - 3.2 Find the S-cam at either the 3 o'clock or 9 o'clock position.
   - 3.3 Just opposite the S-cam is the sensor access hole, approximately 3/4 inch (19 mm) diameter.
4. Insert service tool T11–17556–000 into this hole.
5. Position the slide of the tool on the axle flange to align the tool. See **Fig. 2**.
6. Tap the tool lightly with the palm of your hand. This will ensure the sensor is touching the tone wheel.
7. Remove the tool from the wheel and repeat the procedure on the other rear axle speed sensor.
8. Remove the chocks from the tires.



A. Position the slide against the axle flange.
B. Tap here with your hand.

Fig. 2, Position the Tool

Using the Electronic Control Unit (ECU) Panel Lights (LEDs)

This system has built-in diagnostics to ensure that all components are operating properly. After the ignition is turned on, the tractor warning light (TRAC ABS) comes on. On vehicles with newer ECUs the TRAC ABS light will go out shortly after the ignition is turned on. On vehicles with the older ECUs the TRAC ABS light will stay lit until the vehicle reaches 7 mph (11 km/h). The TRAC ABS light will go out if the tractor's ABS components are working properly. See "Electronic Control Unit (ECU)" in **Subject 050** for more information. If the light stays on, or comes back on later, a problem within the ABS system has occurred. The vehicle can continue to be driven, but the ABS system could be partially or completely inoperative. However, normal braking ability is maintained. To check the type of fault code recorded, stop the vehicle and turn off the engine. Then, turn on the ignition switch, but do not start the engine. If the warning light is still on, there is a system fault that must be repaired to ensure proper system operation. Faults are displayed by the ECU panel lights. See **Fig. 1**. If the warning light is not on, an "intermittent" fault has occurred. An intermittent fault could involve a power surge, taking the system out of voltage range for a moment. In such cases, the problem basically corrects itself; the ECU memory is cleared and the system is restored to full ABS capability.

NOTE: LED lamps are not serviceable.

Following is a list of the faults displayed by the ECU panel lights (**Fig. 1**). Once a fault has been recorded, turn on the ignition switch, but do not start the engine.

- FRT (front): This red lighted display indicates the location of a malfunctioning component or its wiring. This light will always come on with either the right (RHT) or left (LFT) display light, and the modulator (MOD) or sensor (SEN) display light.
- MID (middle or forward sensed rear axle on 6S/4M systems only): This red lighted display indicates the location of a malfunctioning sensor or its wiring. This light will always come on with either the RHT or LFT display light, and the SEN display light.

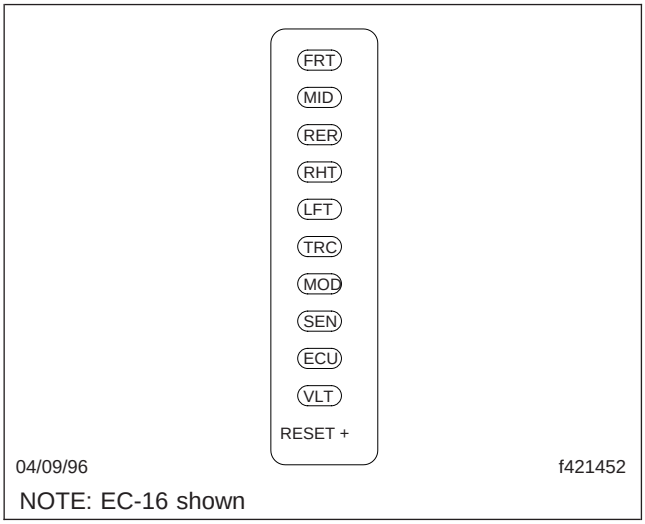


Fig. 1, ECU Panel Lights (LEDs)

- RER (rear): This red lighted display indicates the location of a malfunctioning component or its wiring. This light will always come on with either the RHT or LFT display light, and the MOD or SEN display light.
- RHT (right): This red lighted display indicates the location of a malfunctioning component or its wiring. This light will always come on with either the FRT or RER display light, and the MOD or SEN display light.
- LFT (left): This red lighted display indicates the location of a malfunctioning component or its wiring. This light will always come on with either the FRT or RER display light, and the MOD or SEN display light.
- TRC (traction control, if equipped): This red lighted display indicates a problem within the traction control system. This light may come on by itself, or with the MOD display light (indicating a problem within the automatic traction control relay valve).
- MOD (modulator): This red lighted display indicates an open or short circuit in the solenoid(s) of one of the modulators. This light will always come on with two positioning display lights RHT or LFT plus FRT or RER. The light may also come on with the TRC display light which would indicate a problem within the automatic traction control relay valve or its wiring. Also, the red MOD light will come on if:

Troubleshooting

- The traction enable/disable switch is in the wrong position;
- Traction engine serial communication is lost;
- The traction solenoid is not connected or not operating properly.

- SEN (sensor): This red lighted display indicates an open or short circuit in the sensor circuit. This light will always come on with two positioning display lights RHT or LFT plus FRT, MID, or RER.
- ECU (electronic control unit): This red lighted display indicates that the ECU is inoperative.
- VLT (voltage): This green lighted display is always on during vehicle operation. The light indicates proper system voltage. If vehicle power is out of range (below 11 or above 17 volts), the light will flash until the power problem is corrected.
- RESET: Beneath the reset display is a magnetically sensitive switch used to clear fault codes and reset the ABS diagnostic system. This switch is also used to self-configure the ECU.

A system fault cannot be cleared from ECU memory until the fault is corrected. Once corrected, faults can be cleared one at a time from ECU memory. To clear a fault, pass a small magnet (capable of lifting a three ounce weight) over the RESET display on the ECU (**Fig. 1**). Once all of the lights on the ECU come on, remove the magnet. Holding the magnet against the RESET display for longer than 10 to 20 seconds could cause the ECU to go into a self-configuration mode.

Before troubleshooting, check all fuses in the control unit panel, and replace if necessary. Check the wiring to the warning lights. Refer to **Table 1**, and repair or replace the wiring as needed. Make sure that a charged 12-volt battery is available (the ABS system needs at least 11 volts to work).

IMPORTANT: The key switch must be on when doing the tests in **Table 1**.

Once a fault code has been identified, use a volt/ohmmeter to check the electrical harness at the ECU's 30-pin or 18-pin connector. See **Fig. 2** and **Fig. 3**. Touch the ohmmeter leads to the applicable terminals on the connector, not the ECU.

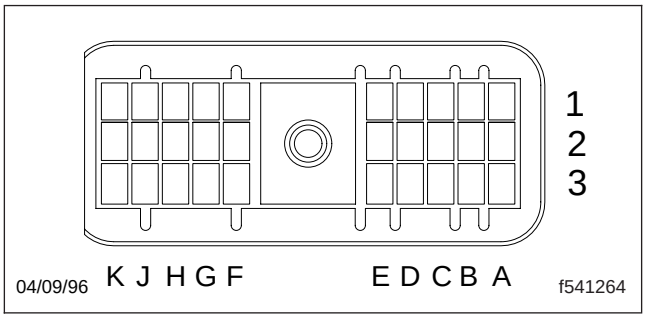


Fig. 2, 30-Pin Connector, Terminal View

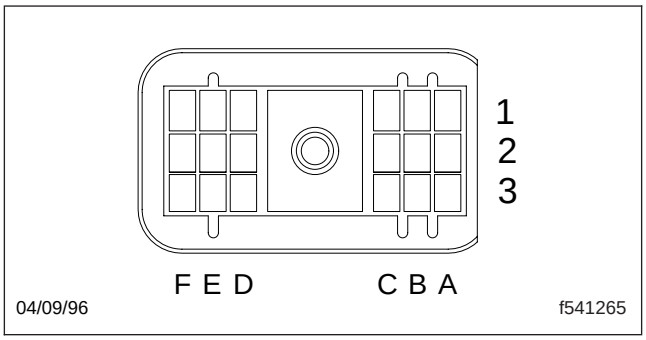


Fig. 3, 18-Pin Connector, Terminal View

IMPORTANT: The ignition switch must be off when connecting or disconnecting the ECU.

Refer to the problem charts for a listing of all diagnostic panel displays (system faults), terminals to be tested, and the correct volt/ohmmeter readings. Repair or replace the components and/or wiring if the readings are not correct.

NOTE: If a dealer has Freightliner Service Link, fault code information can be read from Service Link. For more information, see Service Bulletin 00-20.

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals.

See **Group 54** of this manual for information on special terminals and connectors, and on ordering tools for them.

Refer to the appropriate wiring diagram in **Specifications, 400** when troubleshooting the ABS system.

Warning Lamp Wiring Check				
Wiring Tested	**Test These Pins**	**Volt/Ohmmeter Reading**	**Possible Cause**	**Remedy**
Tractor Warning (TRAC ABS) Light	On the 30-pin connector, pins E3 and A1, E3 and A2, and E3 and A3.	Voltage should be the same as battery voltage.	Wiring to the light is shorted or open; or the bulb needs replacing.	Repair the wiring, or replace the bulb.
WHL SPIN Light (if equipped with ATC)	On the 30-pin connector, pin C2.			

Table 1, Warning Lamp Wiring Check

Problem—Battery Voltage is Too Low or Too High (Green VLT LED is Flashing)

Problem—Battery Voltage is Too Low or Too High (Green VLT LED is Flashing)	
Possible Cause	**Remedy**
Damaged ECU or unsatisfactory battery voltage and wiring continuity	If VLT or ECU is displayed, test the voltage on the 30-pin connector between battery terminals B1, K2, K3, and ground terminals A1, A2, and A3. Voltage between the terminals should be 11 to 17 volts. If the voltage readings are okay, replace the ECU. If the voltage readings are incorrect, check the battery voltage and wiring continuity. Repair or replace as needed.

Problem—Sensor Out of Adjustment, Wheel Speed Erratic, or Sensor Circuit Damage (Red SEN LED is On)

Problem—Sensor Out of Adjustment, Wheel Speed Erratic, or Sensor Circuit Damage (Red SEN LED is On)	
Possible Cause	**Remedy**
Damage to the tone wheel, wheel sensor, and/or sensor wiring to the ECU on the axle	If RHT or LFT and FRT plus SEN is displayed, measure the resistance on the 30-pin connector between terminals J1 and J2 (left front), and H2 and H3 (right front). If the readings are not 1500 to 2500 ohms, measure the resistance between the terminals at the sensor. Repair or replace as needed. If RHT or LFT and RER plus SEN is displayed, measure the resistance on the 18-pin connector between terminals F2 and F3 (left rearmost), and E2 and E3 (right rearmost). If the readings are not 1500 to 2500 ohms, measure the resistance between the terminals at the sensor. Repair or replace as needed. If RHT or LFT and MID plus SEN is displayed on the 18-pin connector, measure the resistance between terminals C2 and C3 (left rear), and B2 and B3 (right rear). If the readings are not 1500 to 2500 ohms, measure the resistance between the terminals at the sensor. Repair or replace as needed.
A sensor may be out of adjustment, or there is excessive hub runout	
Tire size is mismatched	Repair or replace as needed.

Troubleshooting

Problem—Open or Short Circuit in the Modulator, and/or Wiring to the Ground Connection (Red MOD LED is On)

Problem—Open or Short Circuit in the Modulator, and/or Wiring to the Ground Connection (Red MOD LED is On)	
Possible Cause	**Remedy**
Damage to the modulator valve and cab wiring connections on the axle	If RHT or LFT and FRT plus MOD is displayed, measure the resistance on the 30-pin connector between terminals G1 and H1 (left front), C1 and D1 (right front), F1 and H1 (left front), and C1 and E1 (right front). The resistance between the terminals should read 3.5 to 5.0 ohms. Measure the resistance between terminals G1 and F1 (left front), and D1 and E1 (right front). Resistance between the terminals should read 7 to 10 ohms. Also, there should be no continuity between any of the previously referenced terminals, and ground terminals A1, A2, A3, and J3. If the above readings are not correct, check the resistance between the pins at the modulator valve (see **Fig. 4**). Resistance between pins A and B, and B and C should be 3.5 to 5.0 ohms. Resistance between pins A and C should be 7 to 10 ohms. There should be no continuity between any of these pins and ground. Repair or replace as needed. If RHT or LFT and RER plus MOD is displayed, measure the resistance on the 18-pin connector between terminals E1 and F1 (left rear), A1 and B1 (right rear), D1 and F1 (left rear), and A1 and C1 (right rear). Resistance should read 3.5 to 5.0 ohms. Measure the resistance between terminals D1 and E1 (left rear), and B1 and C1 (right rear). Resistance between the terminals should read 7 to 10 ohms. Also, there should be no continuity between any of the previously referenced terminals, and ground terminals A1, A2, A3, and J3. If the above readings are not correct, check the resistance between the pins at the modulator valve (see **Fig. 4**). Resistance between pins A and B, and B and C should be 3.5 to 5.0 ohms. Resistance between pins A and C should be 7 to 10 ohms. There should be no continuity between any of these pins and ground. Repair or replace as needed.

Problem—Open or Short Circuit in the Traction Control Relay Valve and/or Wiring to the Ground Connection (Red

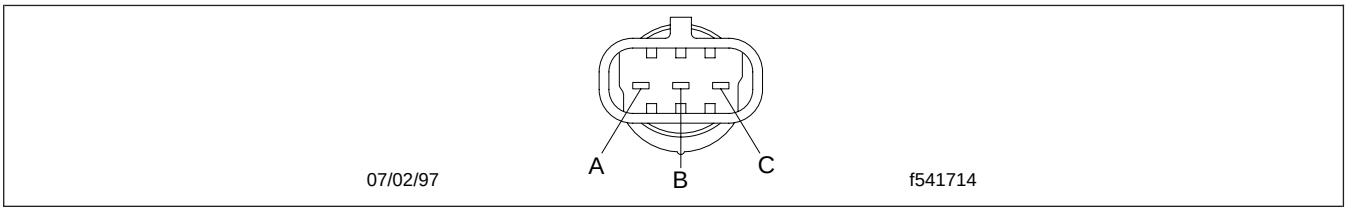


Fig. 4, Modulator Valve Connector Pin Identification

TRC LED and Red MOD LED are On)

Problem—Open or Short Circuit in the Traction Control Relay Valve and/or Wiring to the Ground Connection (Red TRC LED and Red MOD LED are On)	
Possible Cause	**Remedy**
Open or shorted circuit in the traction control relay valve and/or cab wiring connections	If TRC and MOD is displayed, measure the resistance on the 18-pin connector between terminals D2 and D3. Resistance between the terminals should be 10 to 12 ohms. Check continuity at the 30-pin connector between terminals A1, A2, A3, and terminals D2 and D3. There should be no continuity between these terminals. If the above readings are not correct, check the resistance between the pins at the connector at the relay valve. Resistance between the pins should be 10 to 12 ohms. There should be no continuity between ground pins A1, A2, and A3 (on the 30-pin connector), and the pins D2 and D3 at the valve connector. Repair or replace as needed.

Problem—J 1922 Electronic Engine Data Link is Not Working Properly (Red TRC LED is On)

Problem—J 1922 Electronic Engine Data Link is Not Working Properly (Red TRC LED is On)	
Possible Cause	**Remedy**
Damage to the data link and/or data link wiring	If TRC is displayed, check for continuity between terminals B2 and B3 on the 30-pin connector, and the two corresponding terminals on the engine's electronic control module. Repair or replace as needed.

See **Fig. 1** for a full view of the wiring diagram for the Bendix ABS system. See **Fig. 2** and **Fig. 3** for partial (detailed) views of **Fig. 1**.

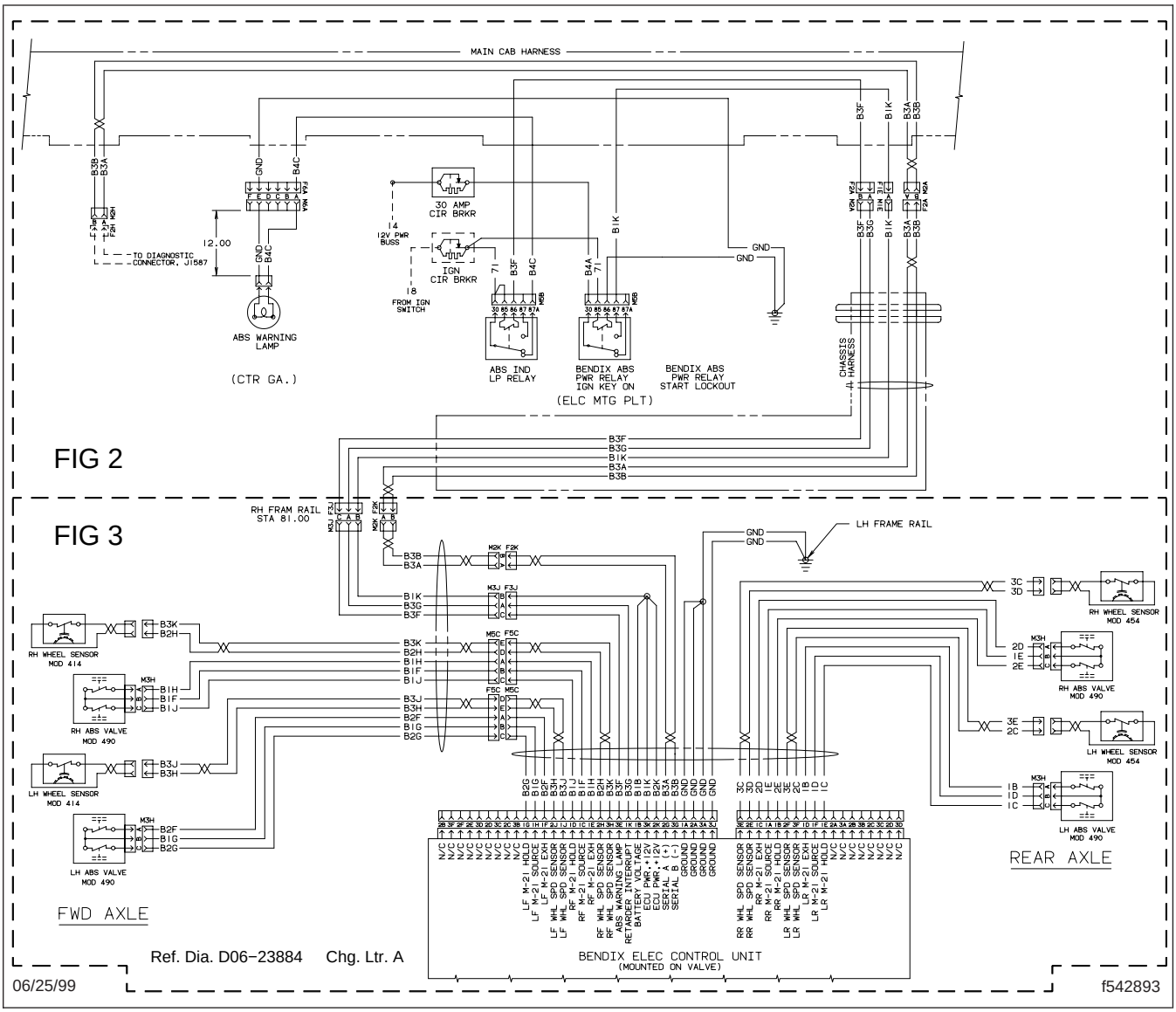


Fig. 1, Wiring Diagram for the Bendix ABS System

Specifications

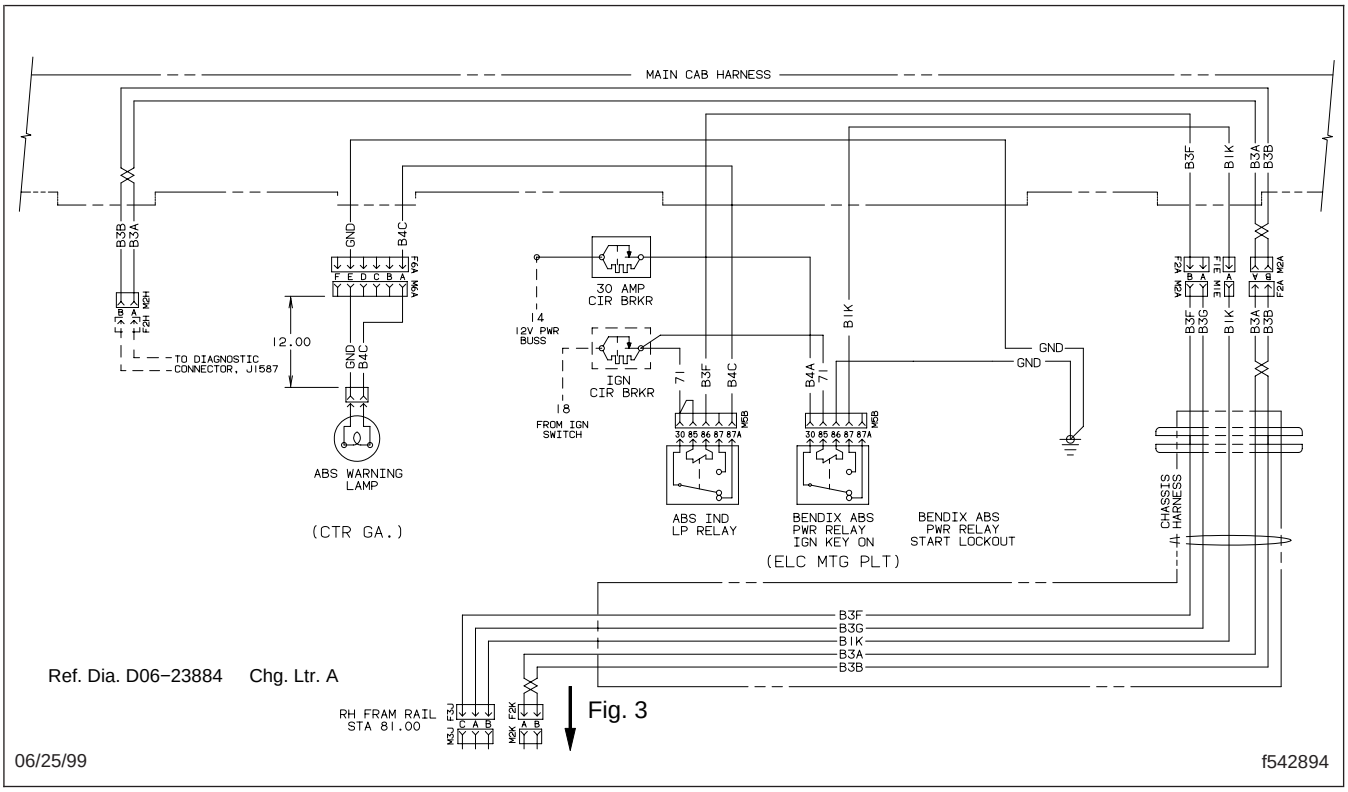


Fig. 2, Partial View of the Bendix ABS System Wiring Diagram

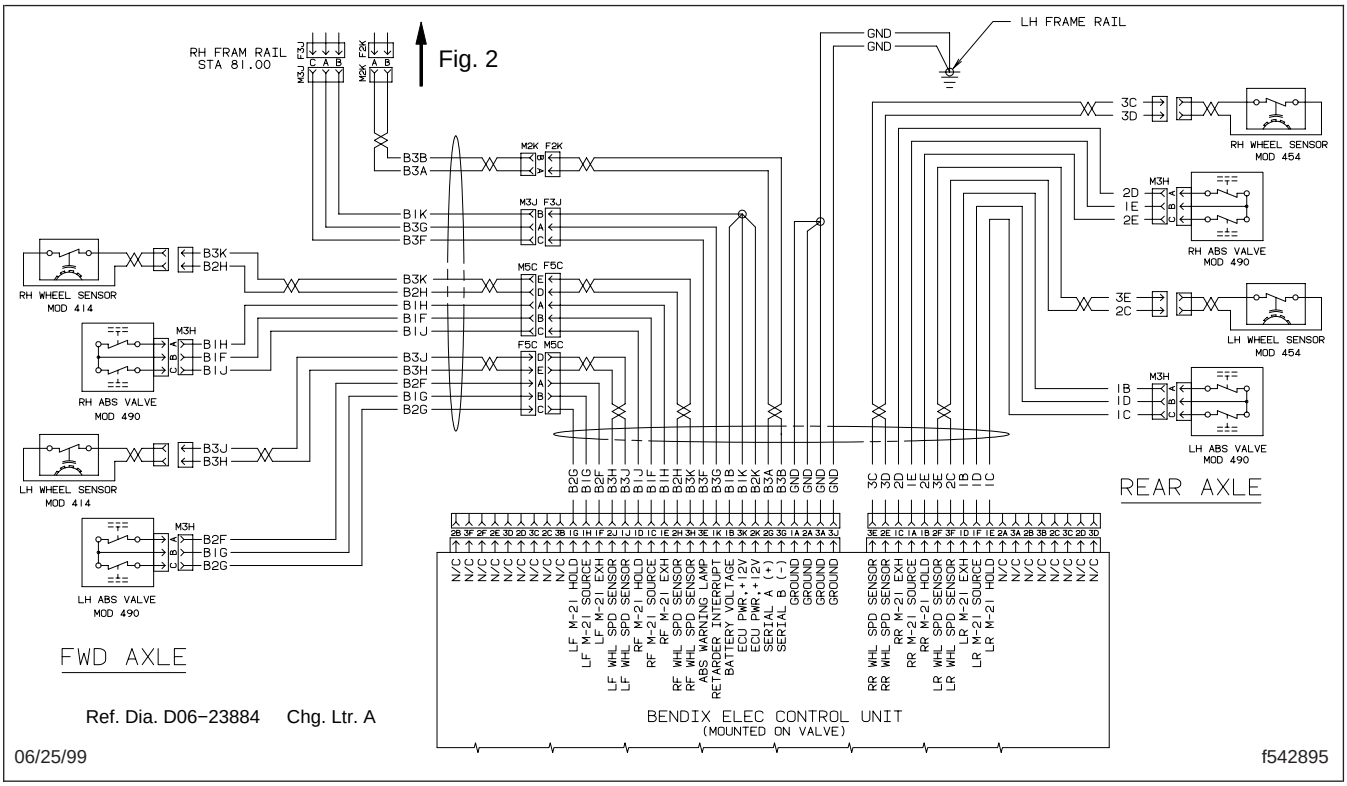
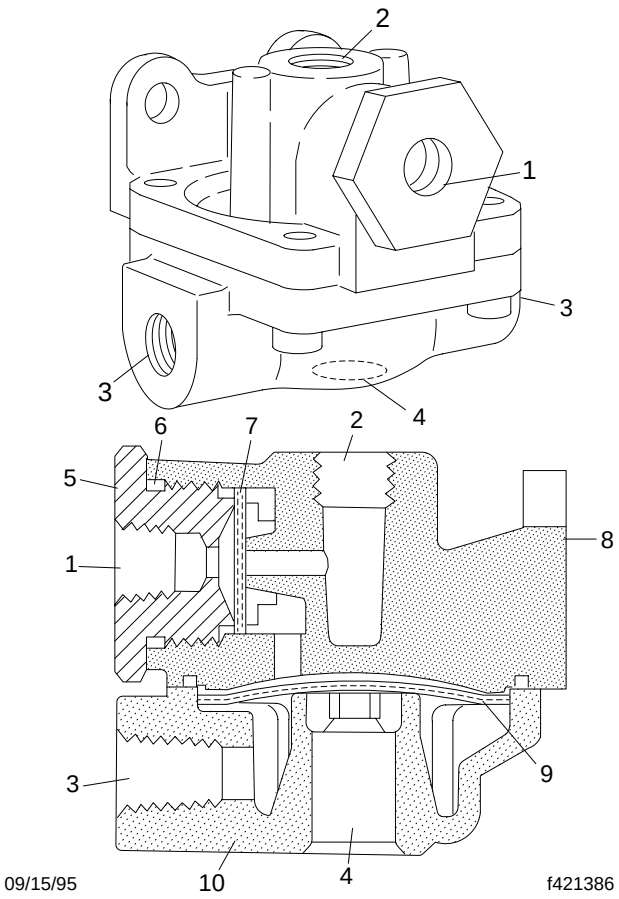


Fig. 3, Partial View of the Bendix ABS System Wiring Diagram

General Information

The QR–1C quick release valve **(Fig. 1)** is a dual function valve. Its primary function is to speed up the release of air pressure from the service brake chambers. Additionally, the valve works as an anti-compound device. The double check valve feature prevents a service and parking brake application from occuring at the same time.



1. Supply Port
2. Balance Port
3. Delivery Port
4. Exhaust
5. Cap Nut
6. Sealing Ring
7. Double Check Diaphragm
8. Body
9. Quick Release Diaphragm
10. Cover

Fig. 1, QR-1C Valve and Cross Section

The QR–1C valve is generally mounted near the rear axle. A balance line from the relay valve delivery port (port 2 on the WABCO combination valve) is connected to the balance port on top of the QR–1C quick release valve; the two side ports are for brake chamber connections; the supply port is connected to the delivery port of the parking brake control valve, and the exhaust port is located at the bottom of the valve.

Principles of Operation **(See Fig. 1)**

Parking Brakes Released

When the parking brakes are released, air from the parking brake control valve flows through the QR–1C valve. This forces the double check diaphragm and the quick release diaphragm to flex and seal the balance and exhaust ports. Air flows into the inlet ports of the parking brake chambers from the QR–1C valve delivery ports.

Parking Brakes Applied

When the parking brakes are applied, supply line air pressure to the QR–1C valve is exhausted through the parking brake control valve. As air pressure is exhausted from one side of the double check diaphragm and the quick release diaphragm, both diaphragms flex in the opposite direction to open the balance and exhaust ports. Parking brake pressure is released at the exhaust port of the QR–1C valve while a small amount of air trapped between the two diaphragms is released through a relay valve or the foot valve exhaust port.

Anti-Compounding

When a service brake application is made with the parking brakes applied, service air enters the balance port and flows through the QR–1C valve into the inlet ports of the parking brake chambers. This prevents application of the service and parking brakes at the same time. Service air passing through the QR–1C valve flexes the double check and quick release diaphragms, sealing the supply and exhaust ports. When the service brake application is released, air is exhausted from the parking brakes.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

Operating and Leakage Tests

⚠ WARNING

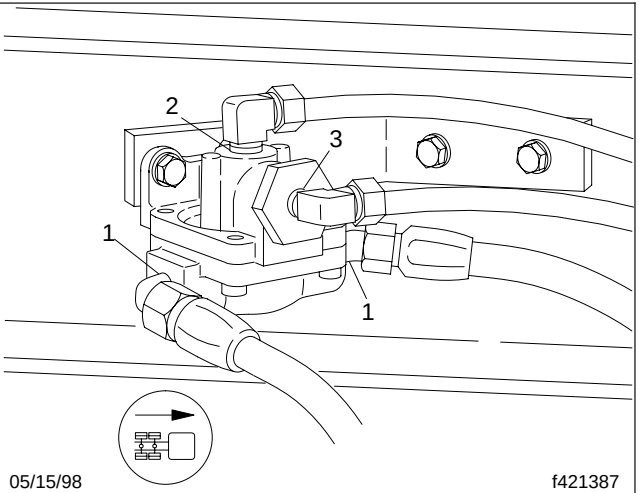
Before working on or around air brake systems and components, review the safety precautions in Subject 100. Failure to do so could result in personal injury.

The following tests should also be performed after repairing or replacing the QR–1C valve to ensure that it is functioning properly.

1. Chock the tires.
2. Drain the air system.
3. Release the parking brakes.
4. Remove the air line from the valve balance port. Build system air pressure to 120 psi (827 kPa). Coat the exhaust and balance ports with a soap solution; leakage of a one-inch bubble in five seconds at either port is allowable. Install the air line at the balance port.
5. Apply the parking brakes. Step on the foot brake; the QR–1C valve should exhaust air at the exhaust port.
6. Drain the air system.
7. Remove the air line from the valve supply port. Build system air pressure to 120 psi (827 kPa). With the foot valve depressed, coat the supply port and the seam between the body and cover with a soap solution; leakage of a one-inch bubble in five seconds at the supply port is allowable. No leakage between the body and cover is permitted. Install the air line at the supply port.
8. If the valve does not function properly, or if leakage is excessive, repair or replace it following the instructions in this section.

QR–1C Quick Release Valve Removal and Installation

Removal (See Fig. 1)



NOTE: Valve mounting inside the left frame rail shown.

1. Delivery Port
2. Balance Port
3. Supply Port

Fig. 1, QR-1C Valve Mounting (plumbing and location will vary depending on vehicle configuration)

⚠ WARNING

Before working on or around air brake systems and components, review the safety precautions in Subject 100. Failure to do so could result in personal injury.

1. Chock the tires or hold the vehicle by means other than air brakes.
2. Drain the air brake system.
3. Mark and disconnect the air lines from the quick release valve.
4. Remove the mounting bolts and the valve.

Installation (See Fig. 1)

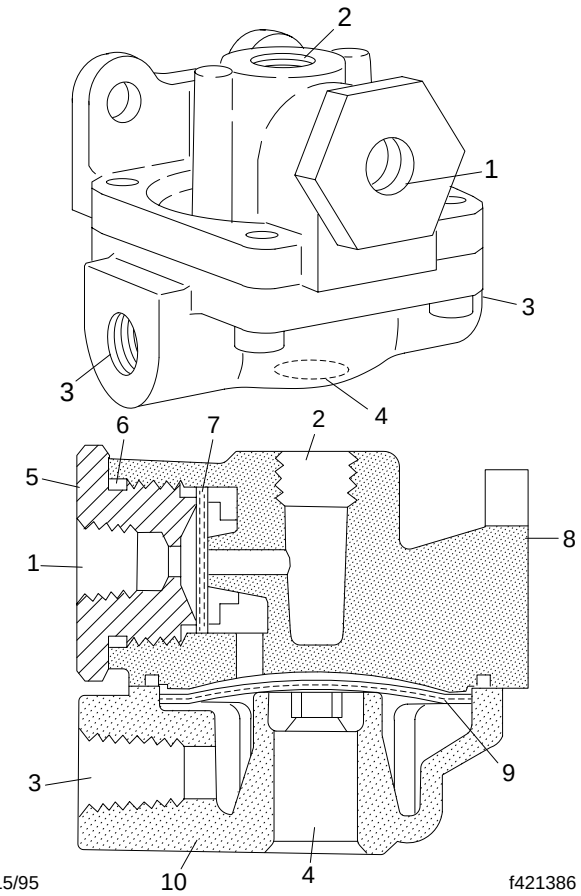
⚠ WARNING

Before working on or around air brake systems and components, review the safety precautions in Subject 100. Failure to do so could result in personal injury.

1. Install the quick release valve with the exhaust port facing down. Securely tighten the mounting bolts.
2. Connect the air lines to the quick release valve in the locations previously marked.
3. Perform the operating and leakage tests in **Subject 110.**

QR–1C Quick Release Valve Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)



1. Supply Port
2. Balance Port
3. Delivery Port
4. Exhaust
5. Cap Nut
6. Sealing Ring
7. Double Check Diaphragm
8. Body
9. Quick Release Diaphragm
10. Cover

Fig. 1, QR-1C Valve and Cross Section

1. Remove the quick release valve from the vehicle following the instructions in **Subject 120.**
2. Mark the valve body and cover for ease of installation.
3. Remove the cap nut at the supply port. Remove the sealing ring from the cap nut.
4. Remove the double check diaphragm.
5. Remove the four screws holding the valve cover on the valve body.
6. Separate the cover from the body and remove the sealing ring and the quick release diaphragm.

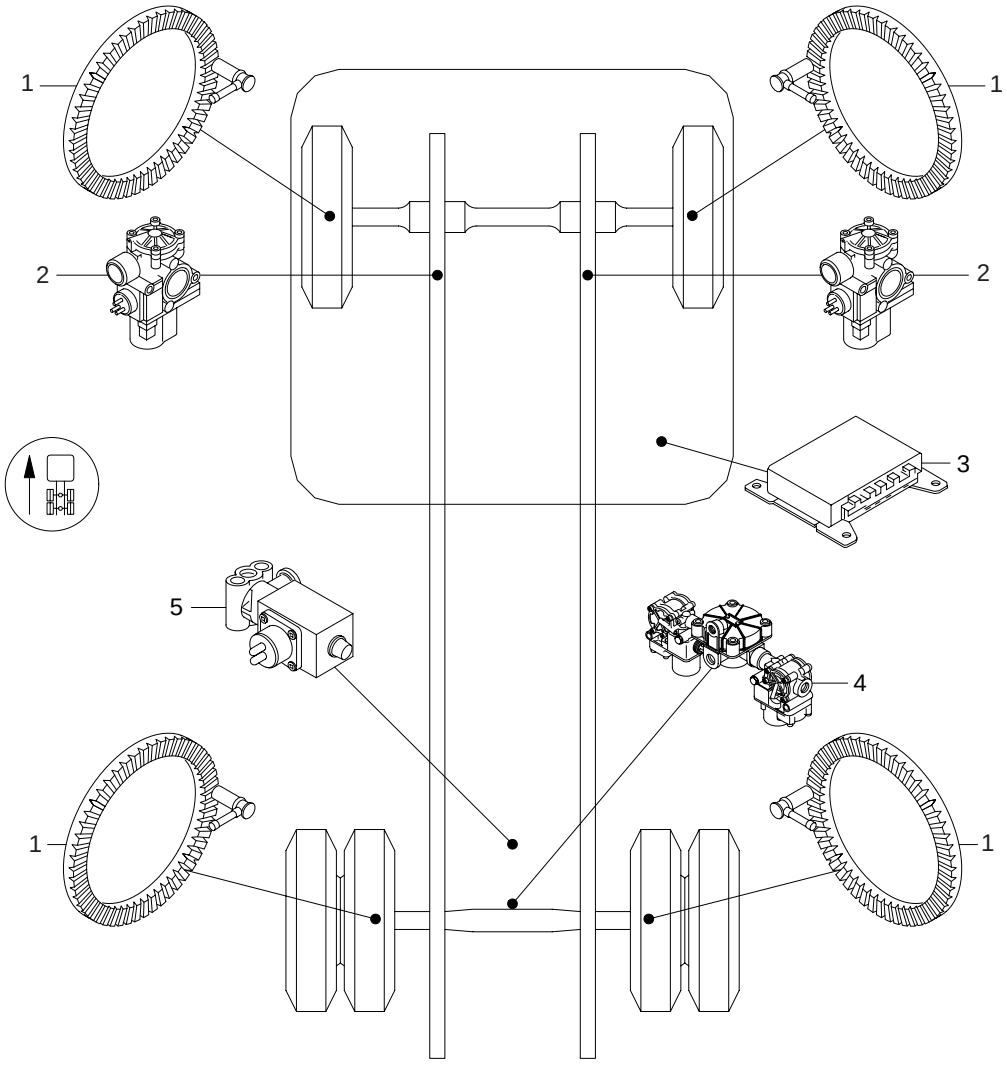
Cleaning and Inspection

1. Clean all metal parts in mineral spirits. Wipe all rubber parts clean.
2. It is recommended that all rubber parts and any other part showing signs of wear or deterioration be replaced with genuine Bendix parts.

Assembly

1. Install the sealing ring on the cap nut.
2. Install the double check diaphragm in the valve body.
3. Install the cap nut. Tighten the nut 150 to 400 lbf·in (1700 to 4520 N·cm).
4. Install the quick release diaphragm in the cover.
5. Install the valve cover on the body. Tighten the screws 30 to 60 lbf·in (340 to 680 N·cm) evenly and securely.
6. Install the quick release valve, following the instructions in **Subject 120.**
7. Do the operating and leakage test as instructed in **Subject 110.**

General Description (See Fig. 1)



10/01/97 f421627

1. Wheel End Sensor and Tone Wheel
2. Front (Steer) Pressure Modulator Valve
3. Electronic Control Unit (ECU)
4. Combination (Rear Axle Module) Pressure Modulator Valve Assembly
5. Automatic Traction Control (ATC) Valve

Fig. 1, Location of ABS/ATC Components

The Eaton Antilock Braking System (ABS) is an electronic wheel speed monitoring and control system that works with the standard air brake system. Its advanced electronic technology prevents wheel lockups by maintaining precise control of vehicle brake pressure. This ensures optimum vehicle stability while minimizing the stopping distance. During vehicle operation, the ABS Electronic Control Unit

(ECU) continuously monitors all the wheel speed sensors. This wheel speed data allows the ECU to: detect an impending wheel lock; maintain an optimum wheel slip; and maximize the overall braking effectiveness.

The ABS system monitors and controls the brake pressure as follows:

- Each wheel speed sensor monitors and communicates wheel rotation information (speed signal pulses) to the ECU;
- The signals from the wheel speed sensors are then received and interpreted by the ECU. The ECU constantly calculates the relationship of wheel speed, acceleration and deceleration;
- Then, based on this wheel speed information, the ECU operates the ABS pressure modulator valves to regulate the air pressure in the brake chambers;
- During normal braking, air flows freely through the modulator valves to the brake chambers;
- During an emergency braking situation, the ECU signals the pressure modulator valves to increase, reduce, or maintain air pressure supply in the brake chamber.

The ABS indicator lamp reveals the condition of the ABS system. Under normal conditions, whenever the ignition is turned on, the ABS indicator lamp lights steadily for a two-second bulb check. If there are no problems, the ABS indicator lamp goes out. If it remains on, or lights during vehicle operation, then the ABS system requires service.

NOTE: In the case of a speed sensor failure which has been corrected, the ABS indicator lamp will remain on until the speed sensor output has been verified by the ECU. In this case it is necessary to operate the vehicle above a speed of five miles per hour before the indicator light goes out.

The Automatic Traction Control (ATC) System is an option on all ABS applications. The ATC system helps improve traction on slippery or unstable driving surfaces by reducing drive wheel overspin. This system consists of two control circuits; the brake control circuit and the engine throttle control circuit. If only one drive wheel slips, the ATC brake control circuit is activated, and then braking force is applied to the slipping wheel which adds torque to the traction wheel. Brake pressure is increased until the speed of the slipping is the same as the non slipping wheel. To prevent overheating of the brakes, the ATC system automatically deactivates after being applied for an extended amount of time. Then, after allowing sufficient time to cool the brakes, the ATC system will automatically reactivate. As an added safety feature, the brake controller is deactivated at speeds above 19 mph (30 km/h). If both driving wheels slip equally, the engine controller is activated, and then the engine torque is reduced to minimize the drive wheel spin. This option requires the addition of an ATC valve and an SAE J1922 engine interface. The ECU configures itself for traction control when it detects the presence of the ATC valve.

There are three ATC modes of operation:

- During the high-speed mode (highway speed operation), the engine is throttled back to control spin out;
- During the low-speed mode (low speed operation), both the engine controls and the brake controls are used to enhance vehicle traction;
- During the mud and snow mode (optional), a dash switch allows the driver to select more engine power and wheel spin if needed.

The ATC system can not increase traction to a particular wheel, it can only utilize the available traction.

The ATC (Wheel Spin) indicator lamp reveals the condition of the ATC system. The indicator lamp lights when the ignition is switched on and remains lit until the driver applies the brake pedal. The light flashes rapidly in the ATC mode, and it flashes slowly when the "mud and snow" mode is selected.

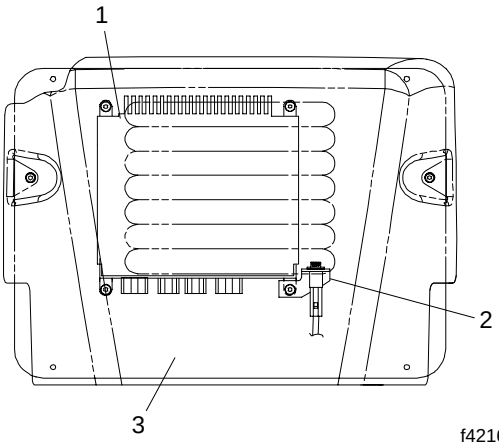
Principles of Operation

ABS and ATC MAJOR COMPONENTS

Electronic Control Unit (ECU)

The ECU monitors and controls the ABS/ATC system. It receives and evaluates wheel speed information from four speed sensors, and if necessary, transmits control signals to the modulator valves. If the ECU detects no impending wheel lockups, the standard braking system is in effect. The ECU operates actively through the ABS release and hold modes of operation during emergency braking situations. The

ABS release and hold modes are activated by the ECU as it signals the appropriate modulator valve to reduce braking force at that halting wheel until the threat of a skid is eliminated. With automatic traction control (ATC), the ECU also sends control signals to the ATC valve and engine control interface. If a drive wheel slips, the ECU signals the ATC valve to release supply air to the brake chamber of the slipping wheel. This adds braking force to the slipping wheel, which results in the transfer of torque from the wheel with less traction to the wheel with more traction. If both drive wheels slip, the ECU signals the engine controller to reduce engine torque, which will reduce the drive wheel slip. Also, the ECU monitors the ABS/ATC system for malfunctions and stores fault codes into memory. The ECU is mounted inside the right rear compartment of the cab behind the passenger seat. See **Fig. 2**.



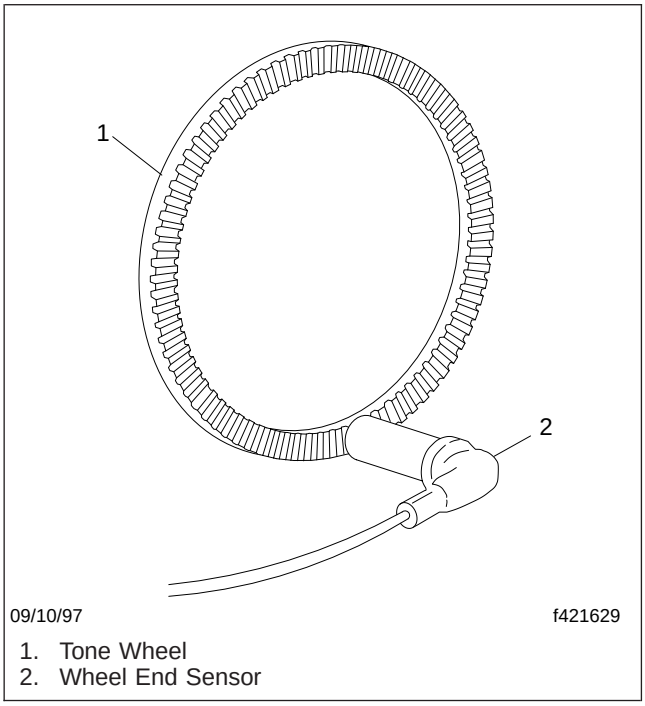
1. Electronic Control Unit
2. Diagnostic Switch
3. Right Rear Corner of Cab

Fig. 2, Electronic Control Unit (ECU)

Speed Sensors

Each wheel of an axle under ABS control is monitored by a speed sensor. Speed sensors for drive axles and steer axles are mounted at the wheel ends.

The Eaton ABS uses standard wheel end sensors (**Fig. 3**). The sensors generate an alternating current signal in response to the movement of the teeth on the tone wheel. Either front sensor is accessible on the inboard side of the steering knuckle. Either rear drive axle sensor is accessible by removing the wheel and drum assembly.



1. Tone Wheel
2. Wheel End Sensor

Fig. 3, Wheel End Sensor Assembly

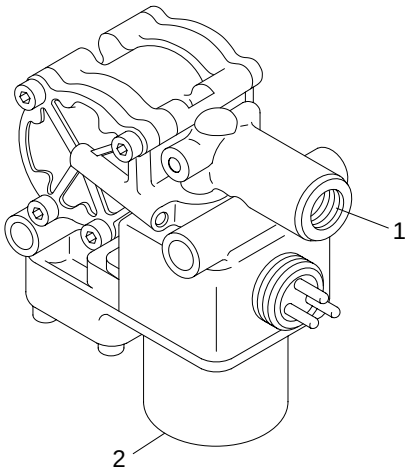
Modulator Valves

The ABS air modulator valves control air pressure to the individual brake assemblies. The system utilizes four modulator valves. The steer axle uses separate modulator valves (**Fig. 4**) and the drive axles incorporate two modulator valves into a combination (rear axle module) valve (**Fig. 5**).

The pressure modulator valves regulate air pressure to the brake chambers. A pressure modulator valve is located near each brake chamber or pair of brake chambers on any ABS equipped axle. Each modulator valve contains two solenoids for air control. The hold solenoid maintains air pressure; the release solenoid removes (vents) pressure from the brake chamber. The ECU signals each modulator valve to hold or release air by activating the appropriate solenoid. Each modulator valve carries a three pin terminal connection that connects with the ECU harness. See **Fig. 4**.

The combination (rear axle module) valve (**Fig. 5**) is an assembly of two pressure modulator valves and a standard relay valve. These assemblies have four

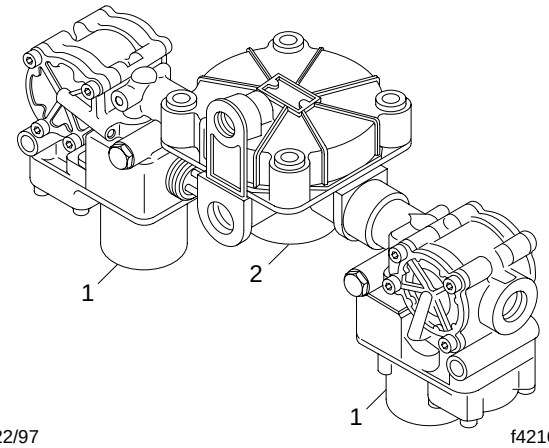
General Information



1. Supply
2. Exhaust Port

Fig. 4, Pressure Modulator Valve

solenoids which are controlled in the same manner as the solenoids housed in the front axle pressure modulator valves. These valves are available with a crack pressure setting between 4.0 and 5.0 psi (27.5 and 34.5 kPa). The crack pressure is the ascending input pressure flow required to initiate output pressure flow. Pressure is identified on a stamped washer mounted on the relay valve.



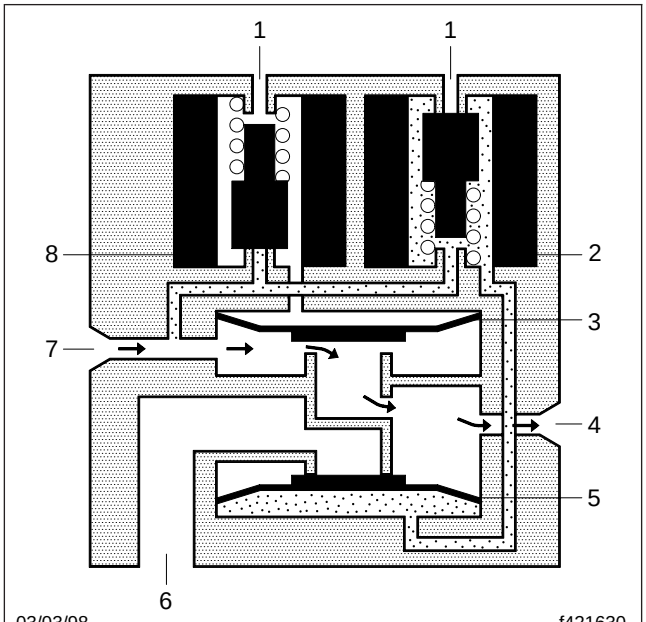
1. Modulator Valve
2. Relay Valve

Fig. 5, Combination (rear axle module) Valve

The modulator valves have four modes of operation: the normal and ABS apply mode; the normal release mode; the ABS hold mode; and the ABS release mode.

The normal apply and ABS apply mode operates as follows (see **Fig. 6**):

- Neither solenoid is activated;
- The supply air enters the inlet port;
- Inlet air is routed through solenoid #2 which then forces the release diaphragm to block the exhaust port;
- At the same time, the hold diaphragm is vented through solenoid #1, which allows supply air to flow to the outlet;
- Supply air flows from the inlet port to the outlet port.

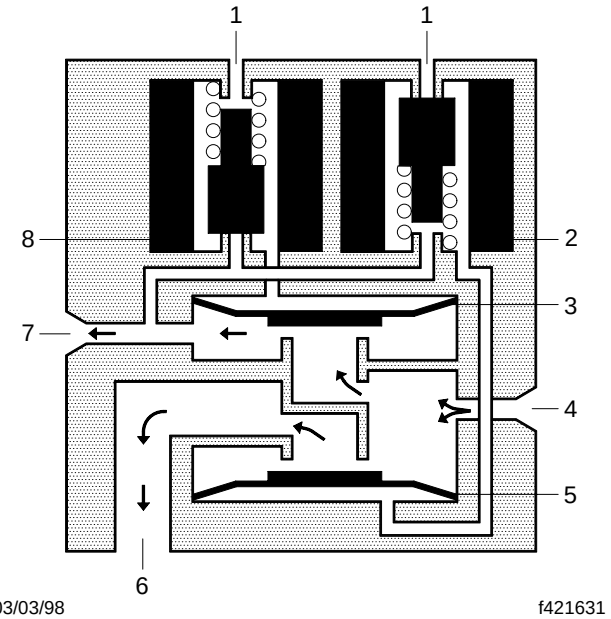


1. Vent
2. Solenoid #2
3. Hold Diaphragm
4. Outlet Port
5. Release Diaphragm
6. Exhaust Port
7. Inlet Port
8. Solenoid #1

Fig. 6, Normal Apply and ABS Apply Mode

The normal release mode operates as follows (see **Fig. 7**):

- Neither solenoid is activated;
- The hold diaphragm is vented through solenoid #1 and there is no pressure at the inlet port;
- The release diaphragm is not pressurized and the outlet pressure forces the exhaust port open;
- Pressurized air flows from the outlet port to the inlet port and also from the outlet port to the exhaust port.

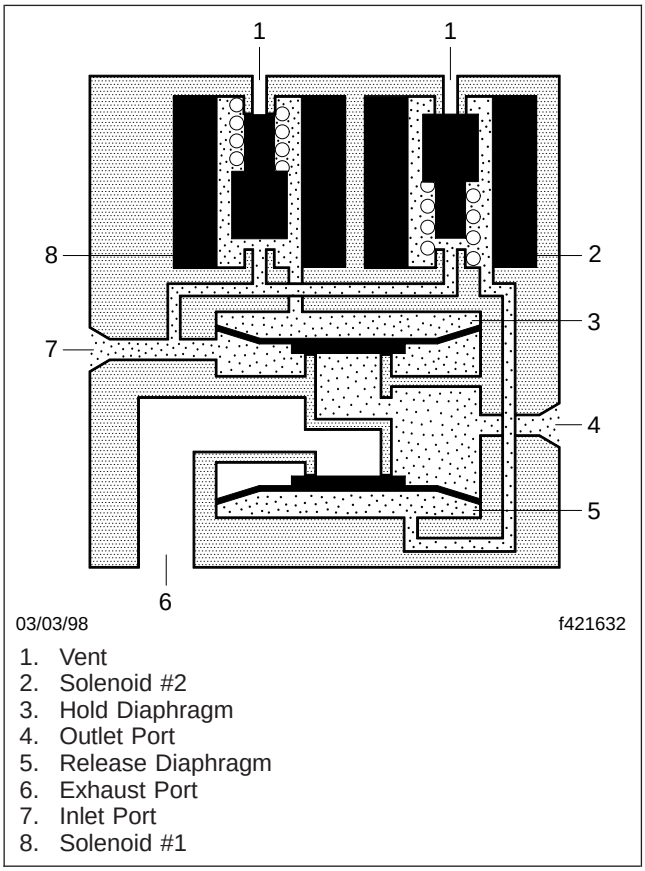


1. Vent
2. Solenoid #2
3. Hold Diaphragm
4. Outlet Port
5. Release Diaphragm
6. Exhaust Port
7. Inlet Port
8. Solenoid #1

Fig. 7, Normal Release Mode

The ABS hold mode operates as follows (see **Fig. 8**):

- Solenoid #1 is activated;
- Supply air enters the inlet port;
- Inlet air routes through both the #1 and #2 solenoids;
- Both the hold and release diaphragm cavities become pressurized;
- The hold diaphragm closes off the air passage between the inlet and outlet port and the release diaphragm closes off the exhaust port;
- No air flows through the valve.



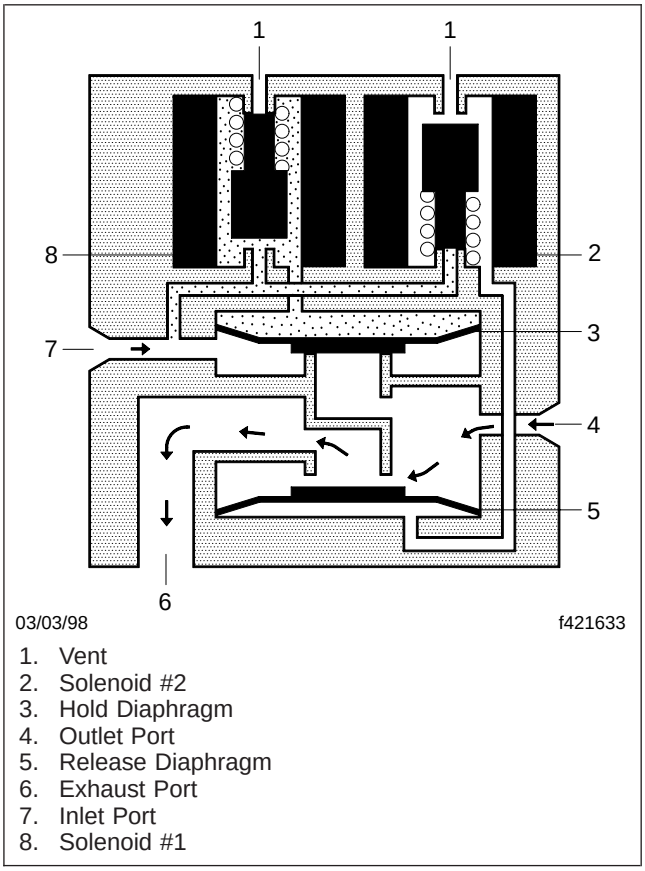
1. Vent
2. Solenoid #2
3. Hold Diaphragm
4. Outlet Port
5. Release Diaphragm
6. Exhaust Port
7. Inlet Port
8. Solenoid #1

Fig. 8, ABS Hold Mode

The ABS release mode operates as follows (see **Fig. 9**):

- Both solenoids are activated;
- Supply air enters the inlet port;
- Inlet air routes through solenoid #1;
- The hold diaphragm cavity becomes pressurized;
- The hold diaphragm closes off the air passage between the inlet and outlet port;

- The release diaphragm is vented through solenoid #2, which allows the outlet air pressure to force open the exhaust port;
- Pressurized air flows from the outlet port to the exhaust port.



1. Vent
2. Solenoid #2
3. Hold Diaphragm
4. Outlet Port
5. Release Diaphragm
6. Exhaust Port
7. Inlet Port
8. Solenoid #1

Fig. 9, ABS Release Mode

Automatic Traction Control (ATC) Valve

When in the traction control mode of operation, the ATC valve (**Fig. 10**) applies full system pressure to the relay valve to provide differential (side to side) braking. The valve is located near the rear axle.

ABS and ATC (Wheel Spin) Indicator Lamps

The amber ABS indicator lamp (**Fig. 11**) is located on the driver's instrument panel. The indicator lamp warns the driver of any ABS malfunctions. It is also

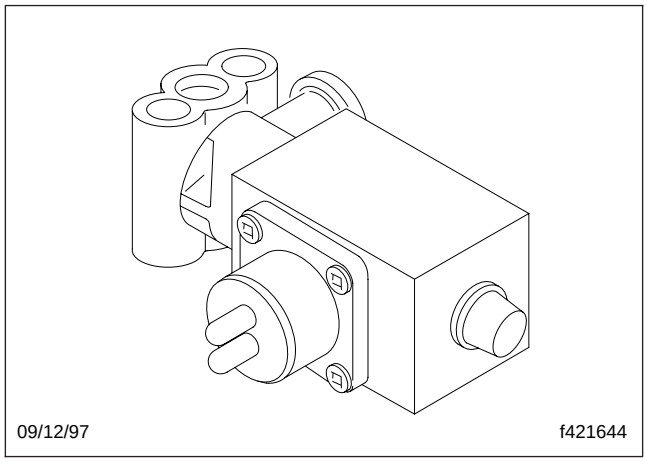
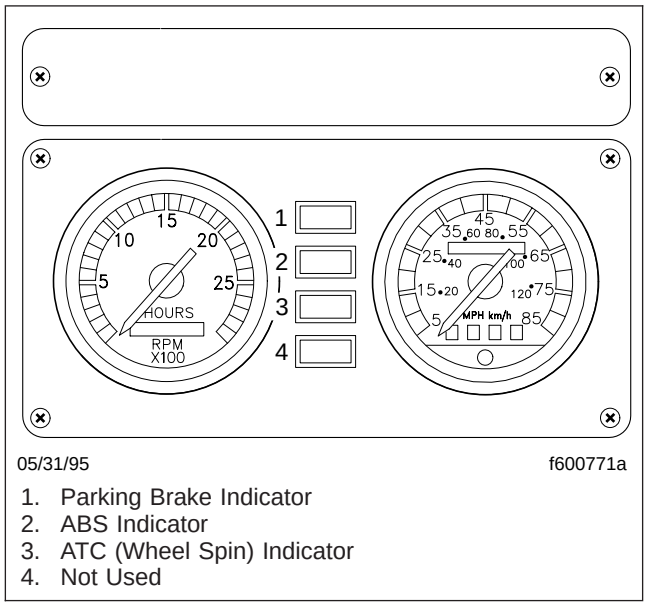


Fig. 10, ATC Valve

capable of blinking diagnostic fault codes when the ECU is in the diagnostic mode.



1. Parking Brake Indicator
2. ABS Indicator
3. ATC (Wheel Spin) Indicator
4. Not Used

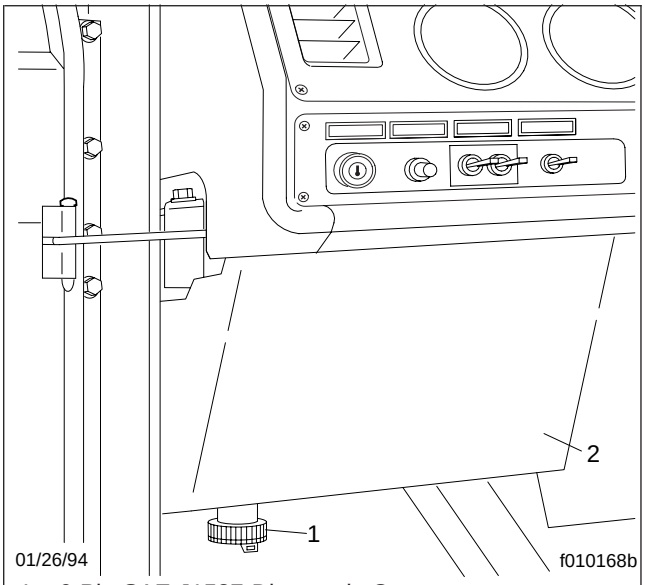
Fig. 11, Driver's Instrument Panel

The ATC (Wheel Spin) indicator lamp (**Fig. 11**) is located on the driver's instrument panel. This indicator lights when a loss of traction condition exists and the ATC system is activated.

NOTE: In some cases, vehicles without ATC are equipped with an ATC (Wheel Spin) indicator lamp. In these cases, the lamp indicates a slip condition but no control action is taken.

Diagnostic Port Connector

The diagnostic port connector is an industry standard connector, which is used to provide a connector to the J1587 diagnostic link. This connector also provides power and ground to the diagnostic test equipment. See **Fig. 12**.



1. 6-Pin SAE J1587 Diagnostic Connector
2. Upper Steering Column Cover Panel

Fig. 12, Diagnostic Connector Location

Front Axle Speed Sensor Replacement

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Group 54** (wiring) in this manual for information on special terminals and connectors, and special tools.

1. Apply the parking brakes. Chock the rear tires to prevent vehicle movement.
2. Disconnect the sensor cable from the harness.

NOTE: While conducting the next step, avoid pulling on the cable.

3. Using a twisting and pulling motion, remove the speed sensor from the bushing in the steering knuckle (**Fig. 1**).

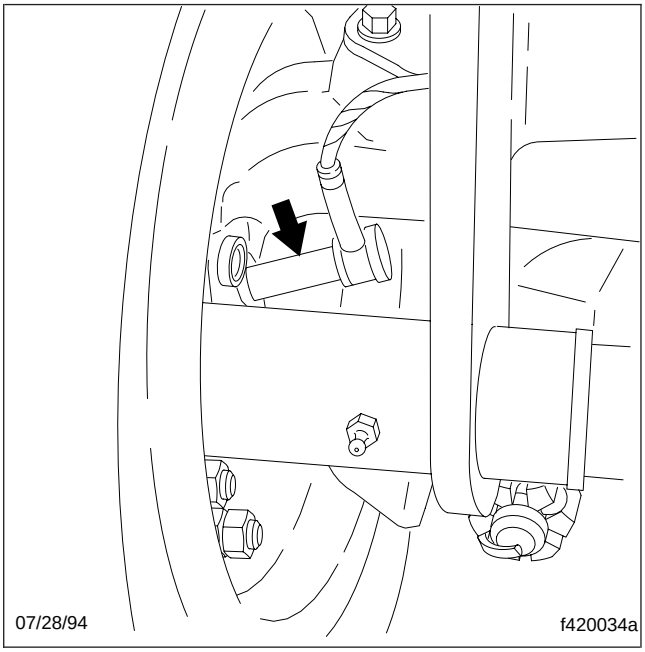
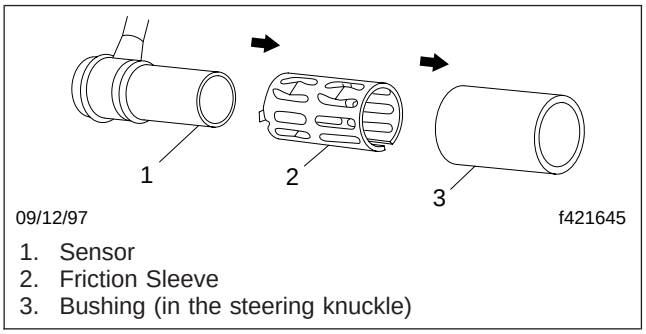


Fig. 1, Remove the Wheel Speed Sensor

4. Remove the speed sensor friction sleeve from the bushing in the steering knuckle (**Fig. 2**).
5. Install the speed sensor friction sleeve into the bushing (in the steering knuckle) with the flange stops toward the inboard side of the vehicle.



1. Sensor
2. Friction Sleeve
3. Bushing (in the steering knuckle)

Fig. 2, Front Wheel Speed Sensor Components

CAUTION

The speed sensor must slide freely in and out of the mounting sleeve bore. Operating the vehicle with seized components will damage the speed sensor and the tone wheel.

6. Lubricate the body of the speed sensor with Penzoil 707L, Valvoline LP, or Mobil HP.
7. By hand, push the speed sensor completely into the bushing (in the steering knuckle) until the speed sensor stops against the tone wheel.

   The speed sensor is properly installed and adjusted when it is touching the tone wheel.
8. Connect the sensor cable to the harness.
9. Remove the chocks from the rear tires.

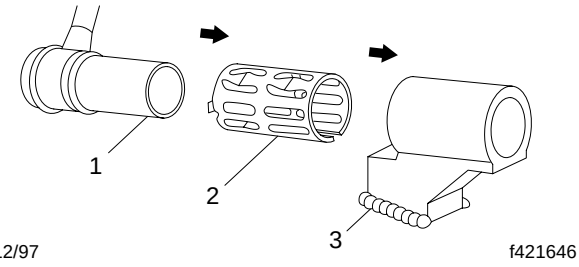
Rear Axle Speed Sensor Replacement

1. Apply the parking brakes. Chock the front tires to prevent vehicle movement.
2. Raise the rear of the vehicle until the tires clear the ground. Place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.
4. Remove the wheel and tire assembly from the rear axle. For instructions, see **Group 40** in this manual.
5. Remove the brake drum. For instructions, see **Group 35** in this manual.

NOTE: While conducting the next step, avoid pulling on the cable.

Wheel Speed Sensor Replacement

6. Using a twisting and pulling motion, remove the speed sensor from the mounting block on the axle housing.
7. Remove the friction sleeve from the mounting block on the axle housing (**Fig. 3**).



1. Sensor
2. Friction Sleeve
3. Mounting Block (on axle housing)

Fig. 3, Rear Wheel Speed Sensor Components

8. Disconnect any fasteners that attach the speed sensor cable to other components and disconnect the speed sensor from the harness.
9. Install the friction sleeve on the mounting block (on the axle housing) with the flange stops toward the inboard side of the vehicle.

⚠ CAUTION

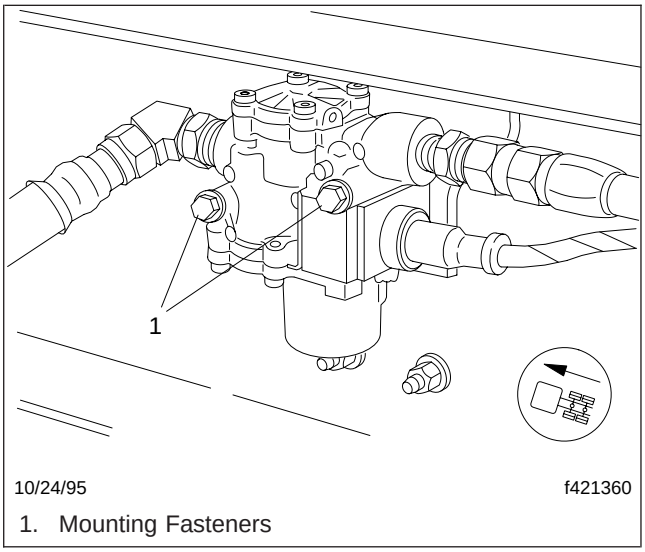
The speed sensor must slide freely in and out of the mounting sleeve bore. Operating the vehicle with seized components will damage the speed sensor and the tone wheel.

10. Lubricate the body of the speed sensor with Penzoil 707L, Valvoline LP, or Mobil HP.
11. By hand, push the speed sensor completely into the bushing (on the axle housing) until the speed sensor stops against the tone wheel.

    The speed sensor is properly installed and adjusted when it is touching the tone wheel.
12. Route the cable to the frame.
13. Connect sensor cable to harness and install fasteners to hold sensor cables in position.
14. Install the brake drum on the wheel hub. For instructions, see **Group 35** in this manual.
15. Adjust the rear axle brakes. For instructions, see **Group 42** in this manual.
16. Install the wheel and tire assembly to the rear axle and tighten the wheel nuts. For instructions, see **Group 40** in this manual.
17. Remove the safety stands, lower the vehicle, and remove the chocks from the front tires.

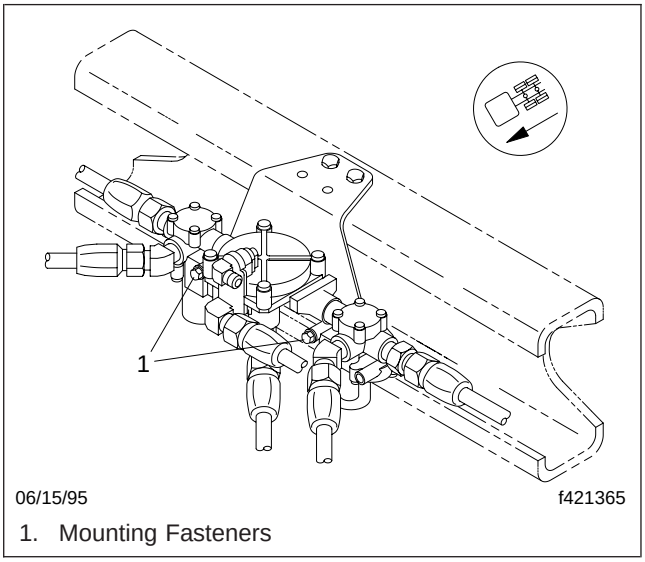
Replacement (See Fig. 1 and Fig. 2)

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Group 54** (wiring) in this manual for information on special terminals and connectors, and special tools.



1. Mounting Fasteners

Fig. 1, Front Pressure Modulator Valve Mounting (inside right-hand rail mounting shown)



1. Mounting Fasteners

Fig. 2, Combination (rear axle module) Valve Mounting

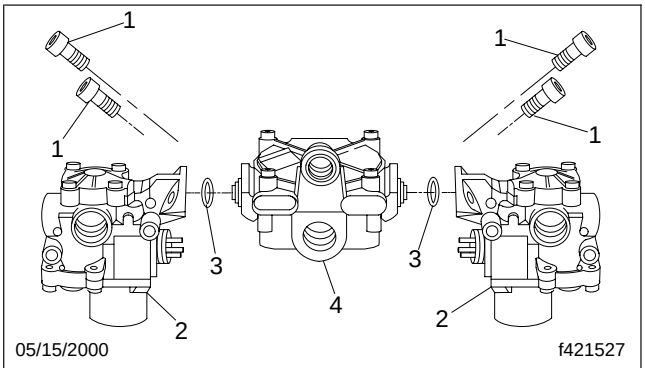
1. Turn the ignition switch to the off position.
2. Apply the parking brakes. Chock the front and rear tires to prevent vehicle movement.
3. Release the pressure from the air reservoirs.
4. Disconnect the wiring from the pressure modulator valve or the combination (rear axle module) valve.
5. Mark the air lines for ease of installation. Disconnect the air lines.
6. Remove the two mounting capscrews, washers, and nuts.
7. Remove the pressure modulator valve or combination (rear axle module) valve.

NOTE: The combination (rear axle module) valve can be disassembled, if the relay valve or one of the pressure modulator valves need replacing. For disassembly and assembly instructions, see **Subject 120**.

8. Install the pressure modulator valve or the combination valve using the above instructions in reverse order. Tighten the mounting nuts 18 lbf·ft (24 N·m).
9. Test the pressure modulator valve.
   - 9.1 Check the pressure modulator valve for leaks by applying and holding the brakes. No audible air leaks are permitted.
   - 9.2 Using a MPSI Pro-Link 9000® hand-held tester, go to component test (#4) menu screen (on the hand-held tester) and select the valve routines option. This will verify the operation and the proper location of the pressure modulator valve. For more information on the use of the hand-held tester, see **Subject 300**.

Combination (Rear Axle Module) Valve Disassembly and Assembly

Disassembly (See Fig. 1)



1. Allen-Head Bolt
2. Pressure Modulator Valve
3. O-Ring
4. Relay Valve

Fig. 1, Combination (rear axle module) Valve

1. Using a 6 mm allen-head wrench, remove the allen-head bolts.
2. Carefully separate the pressure modulator valves from the relay valve.
3. Remove and discard the old O-rings

Assembly (See Fig. 1)

1. Lubricate the replacement O-rings with grease provided with replacement valve(s) kit.
2. Plug any unused ports on the replacement valve(s).
3. Attach the ABS control valve(s) to the relay valve. Tighten the allen-head bolts 13 to 15 lbf·ft (18 to 20 N·m).
4. Install the combination valve, see **Subject 110** for instructions.
5. Test the relay valve assembly.

   5.1 With the front and rear wheels chocked, release the parking brake and fully charge the air system (governor cut out point).

   5.2 With the engine off, apply the service brake several times, then hold and check all the wheels for prompt application and release. If a sluggish response is noted at all of the wheels, inspect for a kinked or obstructed air line leading to or from the valve.

   5.3 Check for air leaks.

   Apply and hold the brakes. Coat the outside of the relay valve (where the cover joins the body and where the pressure modulator valves meet the body) with a soap solution. No air leakage is permitted.

   Increase the system air pressure to the governor cut-off. Turn the engine off and then on. With the brakes released, coat the exhaust port of the relay valve with a soap solution. Leakage of a 1-inch (2.5-cm) bubble in five seconds is permissible.

   5.4 Depress the foot valve. Coat the exhaust port with a soap solution. Leakage of a 1-inch (2.5-cm) bubble in three seconds is permissible. Release the foot valve.

Replacement (See Fig. 1)

⚠ WARNING

Do not start and engage the transmission with one wheel raised from the floor. For vehicles equipped with ATC, if the transmission is engaged with one of the drive axles raised, all the driving torque from the transmission will go to the wheel on the floor (the drive axle not raised). This could cause the vehicle to move on its own and result in personal injury or property damage.

NOTE : Wire repairs may require the use of special tools for certain connectors and terminals. See **Group 54** (wiring) in this manual for information on special terminals and connectors, and special tools.

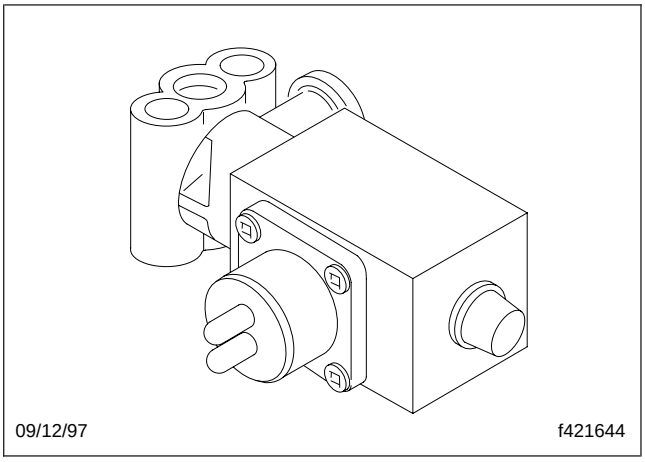


Fig. 1, ATC Valve Mounting

1. Apply the parking brakes. Chock the front and rear tires to prevent vehicle movement.
2. Release the pressure from the air reservoirs.
3. Disconnect the wiring from the ATC valve.
4. Mark the air lines for ease of installation. Disconnect the air lines.
5. Remove the two mounting capscrews, washers, and nuts.
6. Remove the ATC valve.
7. Install the ATC valve using the above instructions in reverse order. Tighten the mounting nuts 18 lbf·ft (24 N·m).
8. Test the ATC valve.
   - 8.1 Check ATC valve for leaks by applying and holding the brakes. No audible air leaks are permitted.
   - 8.2 Using a MPSI Pro-Link 9000® hand-held tester, go to test (#4) menu screen (on the hand-held tester) and select the TCV option. This will verify the operation of the ATC (wheel spin) indicator light and the operation of the ATC valve. For more information on the use of the hand-held tester, see **Subject 300**.

Troubleshooting

Eaton recommends the use of a MPSI Pro-Link 9000® hand-held tester and a multimeter or digital volt-ohmmeter (DVOM) to troubleshoot the ABS system. An important part of the Eaton Antilock Brake System is the system diagnostics. The electronic control unit internally checks the systems components and, if necessary, stores retrievable diagnostic fault codes. The fault codes and the MPSI Pro-Link 9000® hand-held tester can pinpoint solutions to any system faults. The wiring schematics (in **Specifications 400**) and the multimeter can be used to check sensor and solenoid resistance, and determine component or wiring harness faults. A test adaptor may be required to use the multimeter.

Configuration Code, Fault Codes, and Diagnostic Methods

If the ABS indicator lamp lights and stays lit, then a system malfunction (configuration conflict) has occurred. It signifies that a fault code may exist.

The configuration code defines what system components are equipped on the vehicle. It is stored and retrieved as a four digit number.

A fault code defines what type of malfunction has occurred, and it is stored and retrieved as a group of two numbers. The possible combinations of the two numbers in a fault code include:

- two 2-digit numbers;
- one 2-digit number and one 1-digit number;
- or, two one-digit numbers.

There are two ways to retrieve and display a configuration and/or fault code(s); the automatic diagnostics method, or the manual blink code diagnostics method.

AUTOMATIC DIAGNOSTICS METHOD

The automatic diagnostics method uses either an MPSI Pro-Link 9000® hand-held tester (**Fig. 1**) or the Freightliner ServiceLink PC platform to automatically display a fault code(s) (two numbers) on the tester display screen. For more information on using the ServiceLink computer and ServiceLink software, see Service Bulletin 00-20.

The MPSI Pro-Link 9000® hand-held tester, along with Eaton's proprietary cartridge, employs menu-driven tests (**Fig. 2**) for diagnosing malfunctions in the ABS system. This method can be used to: obtain short descriptions of the failures; retrieve and clear fault codes; and report the systems configuration code. Also, the tester can initiate test sequences to invoke ECU outputs and can read system parameters such as wheel speeds. A standard heavy-duty truck cartridge may be used to retrieve the fault codes, but cannot initiate test sequences. The Eaton proprietary cartridge has nine functions in its menu. See **Fig. 2**.

When retrieving fault codes, the hand-held tester illuminates four lines of text on its display. The first three lines of text display a short description of the failure and the last line displays the fault code. If more than one code is active, arrows appear on line 4 to indicate that you can scroll the list. If arrows do not appear, there is only one actual fault present.

MPSI Pro-Link 9000® Hand-held Tester Assembly and Disassembly

(See Fig. 1)

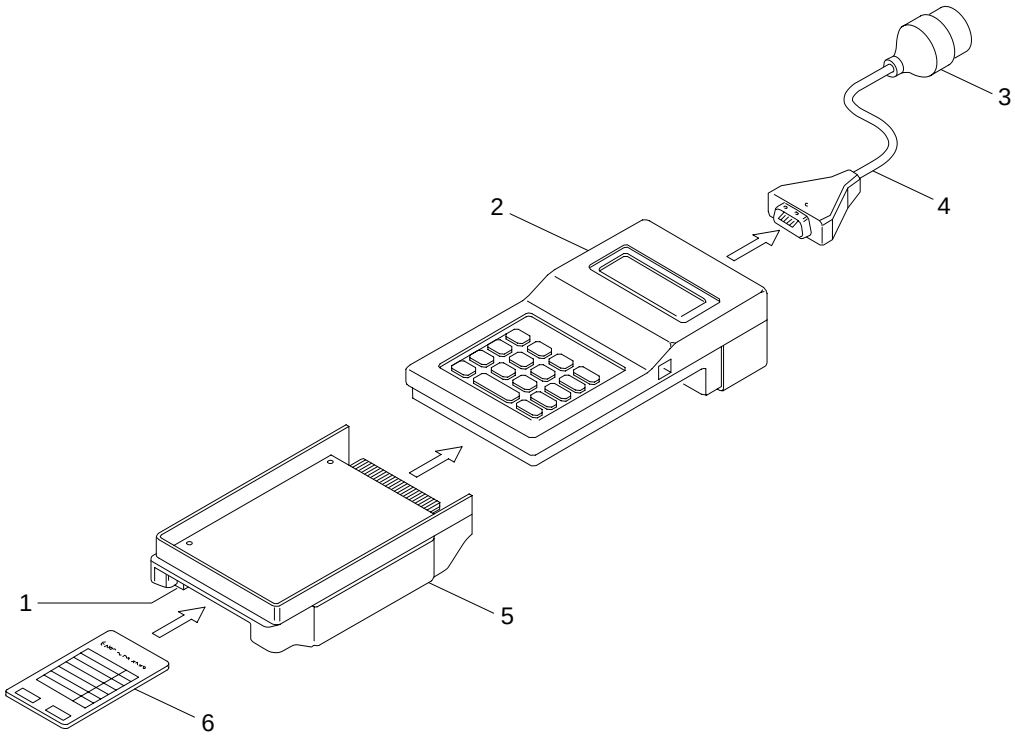
⚠ WARNING

Do not operate the vehicle while conducting this test. The hand-held tester activates output tests for all output devices. Since these tests can affect the operation of the vehicles braking system, the test has a built-in safety protection operation, which disables the test if one axle is not detected to have zero speed. If this test were initiated during vehicle operation and the speed sensors malfunctioned, the brakes could fail and result in both personal injury and property damage.

1. Install the cable.
   - 1.1 Align the 15-pin connector with the socket on the back of the hand-held tester.
   - 1.2 Install the connector carefully and secure with the attached thumb screws.
   - 1.3 Connect the other end of the cable to the diagnostic connector (J1587).

   NOTE: Before connecting the test cartridge to the hand-held tester, disconnect the ve-

Troubleshooting



1. Release Button
2. MPSI Pro-Link 9000®
3. Connector
4. Power Cable
5. MPC™ Cartridge
6. Eaton Application Card

Fig. 1, MPSI Pro-Link 9000® Hand-held Tester Set-up

hicle adaptor (that contains the 12 volt power feed) from the vehicle.

2. Install the MPC™ cartridge.
   - 2.1 Hold the cartridge flat and slide it onto the back of the hand-held tester. Do not hold the cartridge at an angle; it must sit flat.
   - 2.2 Slide the cartridge forward until it locks into place.
3. Install the Eaton application card.
   - 3.1 Align the application card with the slot in the bottom of the MPC™ cartridge. The chart side of the card must be facing up.
   - 3.2 Install the card into the cartridge.

NOTE: Do not force the card. It can only be inserted one way.

4. Remove the Eaton application card.
   - 4.1 Push the release button on the MPC™ cartridge.
   - 4.2 Remove the card.
5. Remove MPC™ cartridge.
   - 5.1 Place your thumb on the slanted surface of the keyboard and your fingers on the cartridge.
   - 5.2 Make a motion similar to snapping your fingers. The retention latches will release the cartridge.
   - 5.3 Continue sliding the cartridge straight out until the edgeboard is clear of the connector in the hand-held tester.

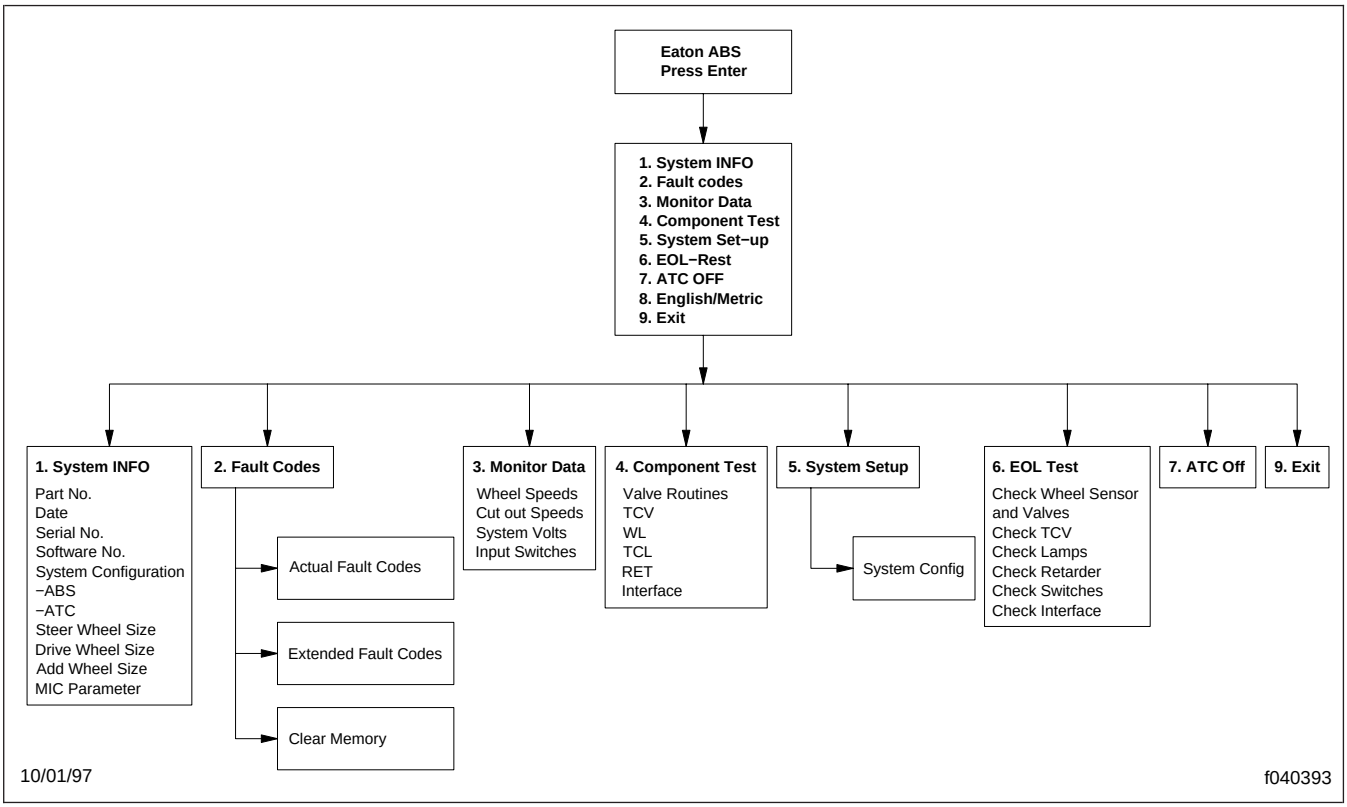


Fig. 2, Hand-Held Tester Menu Options

Retrieving the Configuration Code, and Retrieving and Clearing Fault Codes

For a listing of possible configuration code reports, see **Table 1**. For a list of fault codes, see **Table 3**, **Table 4**, **Table 5**, **Table 6**, **Table 7**, **Table 8** and **Table 9**.

1. Assemble the MPSI Pro-Link 9000® Hand-held Tester.
2. Turn the ignition switch to the on position, but don't start the engine.
3. If the tester powers up and displays the Eaton copyright screen (the tester identifies the Eaton Generation 4 ABS ECU), then go to the next step. Otherwise, locate the cause of the tester not powering up (identifying the ECU).
   - 3.1 Check that the tester is in good working condition.
   - 3.2 Check that all the J1587 wiring and connections are complete.
   - 3.3 If the tester is in good working condition and the J1587 circuitry is okay, then there must be an open circuit in the ECU. Replace the ECU.
4. After the Eaton copyright screen is displayed on the tester, press enter to display the menu options.
5. After the menu screen is displayed on the tester, select either #2 (fault codes) or #5 (system setup).
6. If #2 was selected, choose either actual fault codes, extended fault codes, or clear memory. If #5 was selected, then choose system configuration to display the configuration code.

NOTE: The fault codes are stored either as two 2-digit numbers, one 2-digit number and one 1-digit number, or two one-digit numbers. The configuration code is stored as a 4-digit number.

MANUAL BLINK CODE DIAGNOSTICS METHOD

The manual blink code diagnostics method uses the diagnostic switch (fastened to the ABS ECU inside the right rear compartment of the cab), the ignition switch, the brake light switch, the ABS indicator lamp, and the ATC (wheel spin) indicator lamp to report configuration codes, report and clear fault codes, and disable the ATC for dynamometer testing.

A blink code is a flash sequence displayed at the ABS indicator lamp. The diagnostic switch is used to recall the system configuration code and/or fault code input (stored in memory) through flash sequences (blink codes) at the ABS indicator lamp.

The configuration code is reported by four blink codes (a 4-digit number), which consist of four flash sequences. The configuration code is stored as a 4-digit number. See **Table 1** for a listing of possible configuration reports.

Configuration Code Reports	
Displays (automatic retrieval)/flashes (manual retrieval)	**Description**
1 2 1 2/ 1 (1.5 second pause) 2 (4.5 second pause) 1 (1.5 second pause) 2	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Not Equipped and Retarder Relay Not Equipped and Interaxle Lock Not Equipped, ATC Engine Control Not Equipped and ATC Brake Control Not Equipped
1 2 2 2/ 1 (1.5 second pause) 2 (4.5 second pause) 2 (1.5 second pause) 2	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Equipped and Retarder Relay Not Equipped and Interaxle Lock Not Equipped, ATC Engine Control Not Equipped and ATC Brake Control Not Equipped
1 2 3 2/ 1 (1.5 second pause) 2 (4.5 second pause) 3 (1.5 second pause) 2	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Not Equipped and Retarder Relay Equipped and Interaxle Lock Not Equipped, ATC Engine Control Not Equipped and ATC Brake Control Not Equipped
1 2 4 2/ 1 (1.5 second pause) 2 (4.5 second pause) 4 (1.5 second pause) 2	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Equipped and Retarder Relay Equipped and Interaxle Lock Not Equipped, ATC Engine Control Not Equipped and ATC Brake Control Not Equipped
1 2 5 2/ 1 (1.5 second pause) 2 (4.5 second pause) 5 (1.5 second pause) 2	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Not Equipped and Retarder Relay Not Equipped and Interaxle Lock Equipped, ATC Engine Control Not Equipped and ATC Brake Control Not Equipped
1 2 6 2/ 1 (1.5 second pause) 2 (4.5 second pause) 6 (1.5 second pause) 2	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Equipped and Retarder Relay Not Equipped and Interaxle Lock Equipped, ATC Engine Control Not Equipped and ATC Brake Control Not Equipped
1 2 7 2/ 1 (1.5 second pause) 2 (4.5 second pause) 7 (1.5 second pause) 2	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Not Equipped and Retarder Relay Equipped and Interaxle Lock Equipped, ATC Engine Control Not Equipped and ATC Brake Control Not Equipped
1 2 8 2/ 1 (1.5 second pause) 2 (4.5 second pause) 8 (1.5 second pause) 2	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Equipped and Retarder Relay Equipped and Interaxle Lock Equipped, ATC Engine Control Not Equipped and ATC Brake Control Not Equipped
1 2 1 5/ 1 (1.5 second pause) 2 (4.5 second pause) 1 (1.5 second pause) 5	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Not Equipped and Retarder Relay Not Equipped and Interaxle Lock Not Equipped, ATC Engine Control Equipped and ATC Brake Control Equipped
1 2 2 5/ 1 (1.5 second pause) 2 (4.5 second pause) 2 (1.5 second pause) 5	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Equipped and Retarder Relay Not Equipped and Interaxle Lock Not Equipped, ATC Engine Control Equipped and ATC Brake Control Equipped
1 2 3 5/ 1 (1.5 second pause) 2 (4.5 second pause) 3 (1.5 second pause) 5	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Not Equipped and Retarder Relay Equipped and Interaxle Lock Not Equipped, ATC Engine Control Equipped and ATC Brake Control Equipped

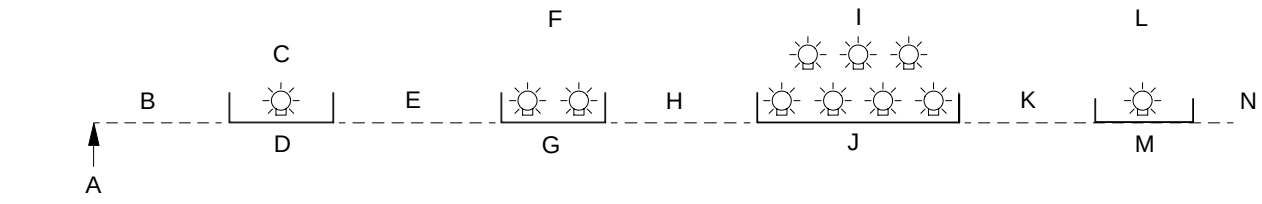
Configuration Code Reports	
Displays (automatic retrieval)/flashes (manual retrieval)	**Description**
1 2 4 5/ 1 (1.5 second pause) 2 (4.5 second pause) 4 (1.5 second pause) 5	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Equipped and Retarder Relay Equipped and Interaxle Lock Not Equipped, ATC Engine Control Equipped and ATC Brake Control Equipped
1 2 5 5/ 1 (1.5 second pause) 2 (4.5 second pause) 5 (1.5 second pause) 5	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Not Equipped and Retarder Relay Not Equipped and Interaxle Lock Equipped, ATC Engine Control Equipped and ATC Brake Control Equipped
1 2 6 5/ 1 (1.5 second pause) 2 (4.5 second pause) 6 (1.5 second pause) 5	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Equipped and Retarder Relay Not Equipped and Interaxle Lock Equipped, ATC Engine Control Equipped and ATC Brake Control Equipped
1 2 7 5/ 1 (1.5 second pause) 2 (4.5 second pause) 7 (1.5 second pause) 5	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Not Equipped and Retarder Relay Equipped and Interaxle Lock Equipped, ATC Engine Control Equipped and ATC Brake Control Equipped
1 2 8 5/ 1 (1.5 second pause) 2 (4.5 second pause) 8 (1.5 second pause) 5	12 volt system, 4 Sensors/4 Modulator Valves, Engine Interface Equipped and Retarder Relay Equipped and Interaxle Lock Equipped, ATC Engine Control Equipped and ATC Brake Control Equipped

Table 1, Configuration Code Reports

The fault codes are reported by a pair of blink codes (two 2-digit numbers, one two-digit number and one 1-digit number, or two 1-digit numbers), which consist of two flash sequences. The fault code reporting process consists of: the first flash sequence; a 1.5 second pause; and finally the second flash sequence. There is a 1.5 second pause between the two flash sequences in a fault code. Also, there is a 4.5 second pause between fault codes. The flash sequence pairs continue, with 4.5 second pauses between them, until all fault codes are reported. See **Fig. 3**.

Reading the Configuration Code, Reading and Clearing Fault Codes, and Disabling the ATC for Dynamometer Testing

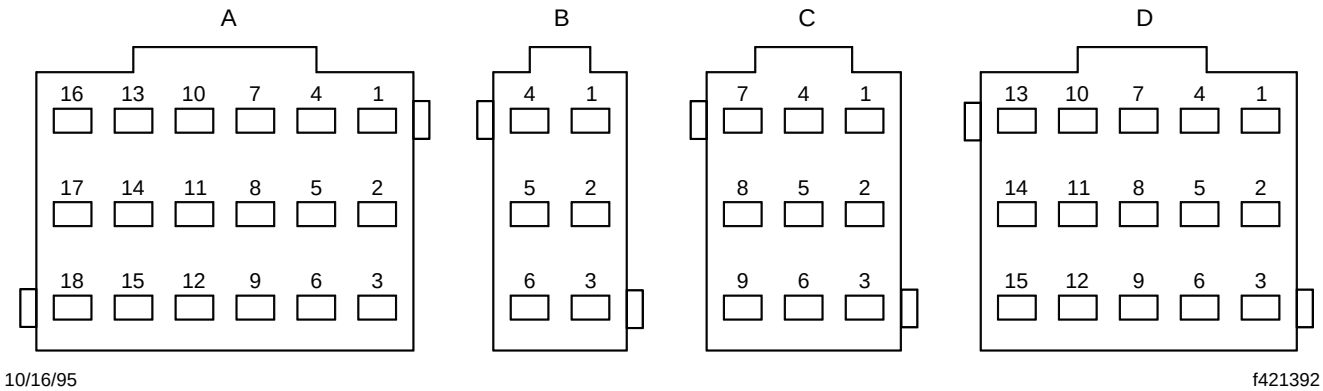
NOTE: When pressing the diagnostic switch for a designated amount of time (from 1 to 3 seconds), use a counting method such as one thousand one, one thousand two, etc. for the



A. Diagnostic Switch Activated Here
B. Retrieval Starts
C. First Flash Sequence (first number, 1)
D. First Blink Code Begins
E. 1-1/2 Second Pause
F. Second Flash Sequence (second number, 2)
G. First Blink Code Ends
H. 4-1/2 Second Pause
I. First Flash Sequence (first number, 7)
J. Next Blink Code Begins
K. 1-1/2 Second Pause
L. Second Flash Sequence (second number, 1)
M. Next Blink Code Ends
N. 4-1/2 Second Pause (then go to next blink code)

Fig. 3, Typical Blink Code Report (1-2 7-1)

Troubleshooting



A. 18-Pin Connector
B. 6-Pin Connector
C. 9-Pin Connector
D. 15-Pin Connector

Fig. 4, ECU Harness Connectors

time (second) interval. This will allow more accurate configuration and/or fault code retrieval and reduce the possibility of misreading blink code information.

1. Read and record the configuration code.
   - 1.1 Turn the ignition key to the on position (engine off).
   - 1.2 Press and hold the diagnostic switch closed for at least one second but less than three seconds and then release the switch.
   - 1.3 Immediately press the diagnostic switch closed a second time (for at least one second but less than three seconds) and then release the switch.
   - 1.4 Read and record the flashing pulses at the ABS indicator lamp.
2. Read and record the fault code(s). See **Fig. 3**.
   - 2.1 Turn the ignition key to the on position (engine off).
   - 2.2 If the vehicle is equipped with ATC, apply and release the brakes once before proceeding. This will turn off the ATC (wheel spin) indicator lamp.
   - 2.3 Press and hold the diagnostic switch for at least one second but less than three seconds and then release the switch (remember, count one thousand one).
   - 2.4 Read and record the flashing pulses at the ABS indicator lamp (in pairs).
   - 2.5 Continue reading and recording the flashing pulses (in pairs) until all the fault codes are recorded.
   - 2.6 After retrieving and recording all the fault codes, see **Table 3**, **Table 4**, **Table 5**, **Table 6**, **Table 7**, **Table 8** and **Table 9** for a list of fault codes.
3. Clear fault code(s).
   - 3.1 With the ignition key in the off position, press and hold the diagnostic switch closed. Turn the ignition key to the on position.
   - 3.2 Wait two seconds and then release the diagnostic switch.
   - 3.3 If the vehicle is equipped with ATC, apply and release the brakes once before proceeding. This will turn off the ATC (wheel spin) indicator lamp.
   - 3.4 The fault codes are now cleared.
   - 3.5 To verify that the fault codes are cleared, repeat the step on reading fault codes.

4. Disable the ATC system for dynamometer testing.
   - 4.1 Turn the ignition key to the on position (engine on).
   - 4.2 Press and hold the diagnostic switch closed for at least three seconds and then release it.
   - 4.3 The ATC (wheel spin) light turns on and the ABS light flashes 17 times, then pauses and flashes 8 times. These blink codes indicate that the ATC is disabled.

   NOTE: At the next ignition cycle the ATC will be reactivated.

ECU Harness Connectors

When checking for either open circuits or short circuits in the ABS circuitry, see **Fig. 4** and **Table 2** for circuit descriptions and connector pinouts.

Circuit Descriptions and Associated Pin Numbers for ECU Harness Connectors

ECU Connector	Pin Number	Freightliner Wire Number	Circuit Description (Related Fault Code Table)
A (18-Pin)	1	1992–A	SAE 1922– (ECU Fault Codes Table)
A (18-Pin)	2		No Connection
A (18-Pin)	3	1992+A	SAE 1922+ (ECU Fault Codes Table)
A (18-Pin)	4		No Connection
A (18-Pin)	5		No Connection
A (18-Pin)	6	376T	(Mud and Snow) Traction Control Switch (ATC Fault Code Table)
A (18-Pin)	7	376C	Ignition, Switched (Power [Battery] Fault Code Table)
A (18-Pin)	8	376B	System Voltage B2 (Power [Battery] Fault Code Table)
A (18-Pin)	9	376A	System Voltage B1 (Power [Battery] Fault Code Table)
A (18-Pin)	10	GND3	Ground-ECU
A (18-Pin)	11	GND2	Ground-Diagonal 1 (Power [Battery] Fault Code Table)
A (18-Pin)	12	GND1	Ground-Diagonal 2 (Power [Battery] Fault Code Table)
A (18-Pin)	13	1587–A	SAE J1587–
A (18-Pin)	14	1587+A	SAE J1587+
A (18-Pin)	15		No Connection, Warning Light Interlock
A (18-Pin)	16	376S	ATC (Wheel Spin) Indicator Lamp (ATC Fault Code Table)
A (18-Pin)	17	376R	Retarder Relay
A (18-Pin)	18	376	ABS Indicator Lamp/Diagnostic Switch
B (6-Pin)	4	377LF–	Speed Sensor 1 (Left Steer –) (Speed Sensor Fault Codes Table)
B (6-Pin)	1	378LFO	Pressure Modulator Valve (PMV) 1 (Left Steer), Release Solenoid (Pressure Modulator Valve Fault Code Table)
B (6-Pin)	2	378LFI	Pressure Modulator Valve (PMV) 1 (Left Steer), Hold Solenoid (Pressure Modulator Valve Fault Code Table)

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Circuit Descriptions and Associated Pin Numbers for ECU Harness Connectors			
ECU Connector	**Pin Number**	**Freightliner Wire Number**	**Circuit Description (Related Fault Code Table)**
B (6-Pin)	3	378LF–	Pressure Modulator Valve (PMV) 1 (Left Steer), Common (Pressure Modulator Valve Fault Code Table)
B (6-Pin)	5	377LF+	Speed Sensor 1 (Left Steer +) (Speed Sensor Fault Codes Table)
B (6-Pin)	6	376J	Brake Light Switch
C (9-Pin)	1		No Connection
C (9-Pin)	2		No Connection
C (9-Pin)	3		No Connection
C (9-Pin)	4	377RF+	Speed Sensor 2 (Right Steer +) (Speed Sensor Fault Codes Table)
C (9-Pin)	5	377RF–	Speed Sensor 2 (Right Steer –) (Speed Sensor Fault Codes Table)
C (9-Pin)	6		No Connection
C (9-Pin)	7	378RFO	Pressure Modulator Valve (PMV) 2 (Right Steer), Release Solenoid (Pressure Modulator Valve Fault Code Table)
C (9-Pin)	8	378RFI	Pressure Modulator Valve (PMV) 2 (Right Steer), Hold Solenoid (Pressure Modulator Valve Fault Code Table)
C (9-Pin)	9	378RF–	Pressure Modulator Valve (PMV) 2 (Right Steer), Common (Pressure Modulator Valve Fault Code Table)
D (15-Pin)	1	378LRO	Pressure Modulator Valve (PMV) 3 (Left Rear), Release Solenoid (Pressure Modulator Valve Fault Code Table)
D (15-Pin)	2	378LRI	Pressure Modulator Valve (PMV) 3 (Left Rear), Hold Solenoid (Pressure Modulator Valve Fault Code Table)
D (15-Pin)	3	378LR–	Pressure Modulator Valve (PMV) 3 (Left Rear), Common (Pressure Modulator Valve Fault Code Table)
D (15-Pin)	4	378T–	ATC Valve – (ATC Fault Code Table)
D (15-Pin)	5	377LR+	Speed Sensor 3 (Left Rear +) (Speed Sensor Fault Codes Table)
D (15-Pin)	6	377LR–	Speed Sensor 3 (Left Rear –) (Speed Sensor Fault Codes Table)
D (15-Pin)	7	378T+	ATC Valve + (ATC Fault Code Table)
D (15-Pin)	8	377RR+	Speed Sensor 4 (Right Rear +) (Speed Sensor Fault Codes Table)
D (15-Pin)	9	377RR–	Speed Sensor 4 (Right Rear –) (Speed Sensor Fault Codes Table)
D (15-Pin)	10	378RRO	Pressure Modulator Valve (PMV) 4 (Right Rear), Release Solenoid (Pressure Modulator Valve Fault Code Table)
D (15-Pin)	11	378RRI	Pressure Modulator Valve (PMV) 4 (Right Rear), Hold Solenoid (Pressure Modulator Valve Fault Code Table)

Circuit Descriptions and Associated Pin Numbers for ECU Harness Connectors			
ECU Connector	**Pin Number**	**Freightliner Wire Number**	**Circuit Description (Related Fault Code Table)**
D (15-Pin)	12	378RR–	Pressure Modulator Valve (PMV) 4 (Right Rear), Common (Pressure Modulator Valve Fault Code Table)
D (15-Pin)	13		No Connection
D (15-Pin)	14		No Connection
D (15-Pin)	15		No Connection

Table 2, Circuit Descriptions and Associated Pin Numbers for ECU Harness Connectors

Fault Code Tables

To locate and correct any ABS malfunctions, follow these four basic guidelines.

A. Access the active fault codes using either the blink code procedure, the MPSI Pro-Link 9000® Hand-held Tester, or the Freightliner ServiceLink computer and software.

B. Using the fault code tables, look up the code description, the possible causes of the fault condition, and the recommended procedures to repair the fault condition.

C. Perform the recommended repair procedures.

D. After the repairs are completed, clear all the codes and check for any additional codes.

See **Fig. 4** and **Table 2** for ECU harness connector information, which corresponds to the fault code tables.

No Faults			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action**
1	1	No Faults	No Action

Table 3, No Faults

Speed Sensor Fault Codes			
First Blink Code (manual retrieval)/ FirstNumber (automatic retrieval) *	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action †**
2 (left front), 3 (right front), 4 (left rear), or 5 (right rear) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	1	The sensor air gap is too large.	If necessary, clean and lubricate the sensor. Press the sensor into the mounting hole until it bottoms against the tone wheel. Clear the fault code and verify that the fault code is corrected by test driving the vehicle. The warning light will remain on until proper speed sensor outputs are detected even though the fault has been cleared. See **Subject 100** in this section for lubrication requirements.

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Speed Sensor Fault Codes			
First Blink Code (manual retrieval)/ FirstNumber (automatic retrieval) *	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action †**
2 (left front) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	2	The air gap is too large or the sensor is shorted.	Using a multimeter, check the resistance in the left steer speed sensor (1) circuit. Unplug connector B at the ECU and measure the resistance between pin B-4 and pin B-5. Unplug the speed sensor cable from the connector at the wheel location and measure the resistance between the two pins. The correct resistance for the speed sensor circuit is between 950 to 1900 ohms. If the sensor resistance is out of range, replace the sensor. Clean and lubricate the sensor. Press the sensor into the mounting hole until it bottoms against the tone wheel. Clear the fault code and verify that the fault code is corrected by test driving the vehicle. The warning light will remain on until proper speed sensor outputs are detected even though the fault has been cleared. See **Subject 100** in this section for lubrication requirements.
3 (right front) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	2	The air gap is too large or the sensor is shorted.	Using a multimeter, check the resistance in the right steer speed sensor (2) circuit. Unplug connector C at the ECU and measure the resistance between pin C-4 and pin C-5. Unplug the speed sensor cable from the connector at the wheel location and measure the resistance between the two pins. The correct resistance for the speed sensor circuit is between 950 to 1900 ohms. If the sensor resistance is out of range, replace the sensor. Clean and lubricate the sensor. Press the sensor into the mounting hole until it bottoms against the tone wheel. Clear the fault code and verify that the fault code is corrected by test driving the vehicle. The warning light will remain on until proper speed sensor outputs are detected even though the fault has been cleared. See **Subject 100** in this section for lubrication requirements.
4 (left rear) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	2	The air gap is too large or the sensor is shorted.	Using a multimeter, check the resistance in the left rear speed sensor (3) circuit. Unplug connector D at the ECU and measure the resistance between pin D-5 and pin D-6. Unplug the speed sensor cable from the connector at the wheel location and measure the resistance between the two pins. The correct resistance for the speed sensor circuit is between 950 to 1900 ohms. If the sensor resistance is out of range, replace the sensor. Clean and lubricate the sensor. Press the sensor into the mounting hole until it bottoms against the tone wheel. Clear the fault code and verify that the fault code is corrected by test driving the vehicle. The warning light will remain on until proper speed sensor outputs are detected even though the fault has been cleared. See **Subject 100** in this section for lubrication requirements.

Speed Sensor Fault Codes			
First Blink Code (manual retrieval)/ FirstNumber (automatic retrieval) *	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action †**
5 (right rear) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	2	The air gap is too large or the sensor is shorted.	Using a multimeter, check the resistance in the right rear speed sensor (4) circuit. Unplug connector D at the ECU and measure the resistance between pin D-8 and pin D-9. Unplug the speed sensor cable from the connector at the wheel location and measure the resistance between the two pins. The correct resistance for the speed sensor circuit is between 950 to 1900 ohms. If the sensor resistance is out of range, replace the sensor. Clean and lubricate the sensor. Press the sensor into the mounting hole until it bottoms against the tone wheel. Clear the fault code and verify that the fault code is corrected by test driving the vehicle. The warning light will remain on until proper speed sensor outputs are detected even though the fault has been cleared. See **Subject 100** in this section for lubrication requirements.
2 (left front), 3 (right front), 4 (left rear), or 5 (right rear) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	3	The speed sensor signal is noisy.	Examine the tone wheel for damage. Replace the tone wheel and/or hub if necessary. Check the wheel bearing adjustment. Adjust the wheel bearing if necessary. Clear the fault code and verify that the fault code is corrected by test driving the vehicle. The warning light will remain on until proper speed sensor outputs are detected even though the fault has been cleared.
2 (left front), 3 (right front), 4 (left rear), or 5 (right rear) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	4	The wheel locked for an excessive period of time during the ABS cycle.	Check the mechanical function of the brakes. Check for kinked or restricted hoses. Make any necessary repairs. Clear the fault code and verify that the fault code is corrected by test driving the vehicle. The warning light will remain on until proper speed sensor outputs are detected even though the fault has been cleared.
2 (left front), 3 (right front), 4 (left rear), or 5 (right rear) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	5	An excessive rate of deceleration is found at the wheel or the sensor is shorted.	Check the sensor resistance (see codes 2 2, 3 2, 4 2, and 5 2) to see if it is shorted. Clear the fault code and test drive the vehicle. The warning light will remain on until the proper speed sensor output is detected even though the fault has been cleared. If the fault recurs, check the tone wheel for excessive runout or damage. Repair tone wheel and/or adjust wheel bearings.

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Speed Sensor Fault Codes			
First Blink Code (manual retrieval)/ FirstNumber (automatic retrieval) *	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action †**
2 (left front), 3 (right front), 4 (left rear), or 5 (right rear) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	6	The sensor connection is shorted low or high, or the sensor is open.	Use multimeter to verify proper sensor resistance. See fault codes 2 2, 3 2, 4 2, and 5 2 for speed sensor resistance testing procedures. Check the harness for shorts or opens. Repair the harness and/or replace the sensor as necessary. Clear the fault code and verify that the fault code is corrected by test driving the vehicle. The warning light will remain on until proper speed sensor outputs are detected even though the fault has been cleared.
2 (left front), 3 (right front), 4 (left rear), or 5 (right rear) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	7	There is an internal error at the sensor port of the ECU	Clear the fault code and test drive the vehicle. The warning light will remain on until the proper speed sensor output is detected even though the fault has been cleared. If the fault recurs, or cannot be cleared, replace the ECU.
2 (left front), 3 (right front), 4 (left rear), or 5 (right rear) NOTE: The first blink code of the speed sensor fault codes represents which speed sensor is at fault.	8	A sensor has been found in the wrong location.	Check the control unit configuration and verify that the sensors are wired in the proper locations for the configuration. See the electrical schematics in **Specifications 400** for wiring information.

* The first blink code of the speed sensor fault codes represents which speed sensor is at fault. 2 indicates the left steer speed sensor; 3 indicates the right steer speed sensor; 4 indicates the left rear speed sensor; 5 indicates the right rear speed sensor.

† When harnesses and components are being measured for proper resistance values, always measure the resistance at both the ECU harness connector and at the component.

Table 4, Speed Sensor Fault Codes

Pressure Modulator Valve Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval) *	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action †**
8 (left front) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	1	There is a short circuit between the release solenoid and supply voltage.	Use a multimeter to check that the left steer pressure modulator valve resistances are correct. Unplug connector B at the ECU and measure the resistance between pin B-3 (common) and pin B-1 (release), pin B-3 (common) and pin B-2 (hold), and, pin B-1 (release) and pin B-2 (hold). Unplug the connector at the pressure modulator valve and measure the resistance between pin 1 (common [grn/yel]) and pin 2 (release [blu]), pin 1 (common [grn/yel]) and pin 3 (hold [brn]), and, pin 2 (release [blu]) and pin 3 (hold [brn]). The resistance between the common connection and the release connection, and, the common connection and the hold connection should range between 3 to 8 ohms. The resistance between the release connection and the hold connection should be between 6 to 16 ohms. If the resistances are correct at the valve and not correct at the ECU connector, then check the harness for a short circuit in the wiring. See **Fig. 5** for pressure modulator valve connector pin locations.
9 (right front) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	1	There is a short circuit between the release solenoid and supply voltage.	Use a multimeter to check that the right steer pressure modulator valve resistances are correct. Unplug connector C at the ECU and measure the resistance between pin C-9 (common) and pin C-7 (release), pin C-9 (common) and pin C-8 (hold), and, pin C-7 (release) and pin C-8 (hold). Unplug the connector at the pressure modulator valve and measure the resistance between pin 1 (common [grn/yel]) and pin 2 (release [blu]), pin 1 (common [grn/yel]) and pin 3 (hold [brn]), and, pin 2 (release [blu]) and pin 3 (hold [brn]). The resistance between the common connection and the release connection, and, the common connection and the hold connection should range between 3 to 8 ohms. The resistance between the release connection and the hold connection should be between 6 to 16 ohms. If the resistances are correct at the valve and not correct at the ECU connector, then check the harness for a short circuit in the wiring. See **Fig. 5** for pressure modulator valve connector pin locations.

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Pressure Modulator Valve Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval) *	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action †**
10 (left rear) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	1	There is a short circuit between the release solenoid and supply voltage.	Use a multimeter to check that the left rear pressure modulator valve resistances are correct. Unplug connector D at the ECU and measure the resistance between pin D-3 (common) and pin D-1 (release), pin D-3 (common) and pin D-2 (hold), and, pin D-1 (release) and pin D-2 (hold). Unplug the connector at the pressure modulator valve and measure the resistance between pin 1 (common [grn/yel]) and pin 2 (release [blu]), pin 1 (common [grn/yel]) and pin 3 (hold [brn]), and, pin 2 (release [blu]) and pin 3 (hold [brn]). The resistance between the common connection and the release connection, and, the common connection and the hold connection should range between 3 to 8 ohms. The resistance between the release connection and the hold connection should be between 6 to 16 ohms. If the resistances are correct at the valve and not correct at the ECU connector, then check the harness for a short circuit in the wiring. See **Fig. 5** for pressure modulator valve connector pin locations.
11 (right rear) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	1	There is a short circuit between the release solenoid and supply voltage.	Use a multimeter to check that the right rear pressure modulator valve resistances are correct. Unplug connector D at the ECU and measure the resistance between pin D-12 (common) and pin D-10 (release), pin D-12 (common) and pin D-11 (hold), and, pin D-10 (release) and pin D-11 (hold). Unplug the connector at the pressure modulator valve and measure the resistance between pin 1 (common [grn/yel]) and pin 2 (release [blu]), pin 1 (common [grn/yel]) and pin 3 (hold [brn]), and, pin 2 (release [blu]) and pin 3 (hold [brn]). The resistance between the common connection and the release connection, and, the common connection and the hold connection should range between 3 to 8 ohms. The resistance between the release connection and the hold connection should be between 6 to 16 ohms. If the resistances are correct at the valve and not correct at the ECU connector, then check the harness for a short circuit in the wiring. See **Fig. 5** for pressure modulator valve connector pin locations.
8 (left front), 9 (right front), 10 (left rear), or 11 (right rear) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	2	There is a short circuit between the release solenoid and ground.	Use a multimeter to check that the valve resistances are correct. See fault codes 8 1, 9 1, 10 1, and 11 1 for pressure modulator valve resistance testing procedures.

Pressure Modulator Valve Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval) *	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action †**
8 (left front), 9 (right front), 10 (left rear), or 11 (right rear) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	3	There is an open circuit at the release solenoid.	Use a multimeter to check that the valve resistances are correct. See fault codes 8 1, 9 1, 10 1, and 11 1 for pressure modulator valve resistance testing procedures.
8 (left front), 9 (right front), 10 (left rear), or 11 (right rear) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	4	There is an open circuit in the common line to the valve.	Use a multimeter to check that the valve resistances are correct. See fault codes 8 1, 9 1, 10 1, and 11 1 for pressure modulator valve resistance testing procedures.
8 (left front), 9 (right front),10 (left rear), or 11 (right rear) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	5	There is a short between the hold solenoid and the supply voltage.	Use a multimeter to check that the valve resistances are correct. See fault codes 8 1, 9 1, 10 1, and 11 1 for pressure modulator valve resistance testing procedures.
8 (left front), 9 (right front), 10 (left rear), or 11 (right rear) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	6	There is a short between the hold solenoid and ground.	Use a multimeter to check that the valve resistances are correct. See fault codes 8 1, 9 1, 10 1, and 11 1 for pressure modulator valve resistance testing procedures.

Troubleshooting

Pressure Modulator Valve Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval) *	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action †**
8 (left front), 9 (right front), 10 (left rear), or 11 (right rear) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	7	There is an open circuit at the hold solenoid.	Use a multimeter to check that the valve resistances are correct. See fault codes 8 1, 9 1, 10 1, and 11 1 for pressure modulator valve resistance testing procedures.
8 (left front), 9 (right front), 10 (left rear), or 11 (right rear) NOTE: The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault.	8	A valve has been found wired in the wrong location.	Check the control unit configuration and verify that the valves are wired in the proper location for the configuration. See the electrical schematics in **Specifications 400** for wiring information.
10 (diagonal 1, [right front, left rear])	10	A short to the supply voltage has been found on the common line of one or more of the valves that are connected to the diagonal one circuit (right steer and left rear valves).	Unplug the ECU and check for a short to the supply voltage (12 volts) on pins C-9, or D-3. If any of these pins are shorted to the supply voltage, then repair the harness. If no short to the supply voltage is found in the harness, then replace the ECU. See the electrical schematics in **Specifications 400** for wiring information. NOTE: Before replacing the ECU, clear the fault codes and verify that the fault is still present.
10 (diagonal 1, [right front, left rear])	11	A short to ground has been found on the common line of one or more of the valves that are connected to the diagonal one circuit (right steer and left rear valves).	Unplug the ECU and check for a short to ground on pins C-9 or D-3. If any of these pins are shorted to ground, then repair the harness. If no short to ground is found in the harness, then replace the ECU. See the electrical schematics in **Specifications 400** for wiring information. NOTE: Before replacing the ECU, clear the fault codes and verify that the fault is still present.

Pressure Modulator Valve Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval) *	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action †**
11 (diagonal 2 [left front, right rear])	10	A short to the supply voltage has been found on the common line of one or more of the valves that are connected to the diagonal two circuit (left steer and right rear valves).	Unplug the ECU and check for a short to the supply voltage (12 volts) on pins B-3 or D-12. If any of these pins are shorted to the supply voltage, then repair the harness. If no short to the supply voltage is found in the harness, then replace the ECU. See the electrical schematics in **Specifications 400** for wiring information. NOTE: Before replacing the ECU, clear the fault codes and verify that the fault is still present.
11 (diagonal 2 [left front, right rear])	11	A short to ground has been found on the common line of one or more of the valves that are connected to the diagonal two circuit (left steer and right rear valves).	Unplug the ECU and check for a short to ground on pins B-3 or D-12. If any of these pins are shorted to ground, then repair the harness. If no short to ground is found in the harness, then replace the ECU. See the electrical schematics in **Specifications 400** for wiring information. NOTE: Before replacing the ECU, clear the fault codes and verify that the fault is still present.

* The first blink code of the pressure modulator valve fault codes represents which pressure modulator valve is at fault. 8 indicates the left steer (PMV 1); 9 indicates the right steer (PMV 2); 10 indicates the left rear (PMV 3); 11 indicates the right rear (PMV 4).
† When harnesses and components are being measured for proper resistance values, always measure the resistance at both the ECU harness connector and at the component.

Table 5, Pressure Modulator Valve Fault Codes

Automatic Traction Control (ATC) Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action ***
14	5	The solenoid in the ATC valve is shorted to the supply voltage.	Use a multimeter to check that the ATC valve resistance is correct. Unplug connector D at the ECU and measure the resistance between pins D-4 and D-7. Unplug the connector at the ATC valve and measure the resistance at the ATC valve. The correct resistance for the ATC circuit is between 9 to 15 ohms. If the resistance at the valve is correct and is incorrect at the ECU connector, then check the harness for a short in the wiring.
14	6	The solenoid in the ATC valve is shorted to ground.	Use a multimeter to check that the ATC valve resistance is correct. Unplug connector D at the ECU and measure the resistance between pins D-4 and D-7. Unplug the connector at the ATC valve and measure the resistance at the ATC valve. The correct resistance for the ATC circuit is between 9 to 15 ohms. If the resistance at the valve is correct and is incorrect at the ECU connector, then check the harness for a short in the wiring.

Automatic Traction Control (ATC) Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action ***
14	7	There is an open circuit in the ATC valve.	Use a multimeter to check that the ATC valve resistance is correct. Unplug connector D at the ECU and measure the resistance between pins D-4 and D-7. Unplug the connector at the ATC valve and measure the resistance at the ATC valve. The correct resistance for the ATC circuit is between 9 to 15 ohms. If the resistance at the valve is correct and is incorrect at the ECU connector, then check the harness for an open circuit in the wiring.
14	8	An ATC valve is found when it should not be present.	Verify proper system configuration and components. Clear the faults. If an error cannot be cleared or recurs, replace the control unit.

* When harnesses and components are being measured for proper resistance values, always measure the resistance at both the ECU harness connector and at the component.

Table 6, Automatic Traction Control (ATC) Fault Codes

ECU Fault Codes			
First Blink Code (manual retrieval) /First Number (automatic retrieval)	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action ***
14	9	The engine interface (ECU) is shorted to ground or to the supply voltage.	Use multimeter to check the vehicle harness for shorts. See the vehicle wiring schematic for wiring information. If the wiring is okay and the fault cannot be cleared, then replace the ECU.
14	10	An error has been reported from the engine data link.	Check the engine control unit for proper diagnostic link function.
14	11	The engine interface (ECU) is shorted to ground or to the supply voltage.	Use multimeter to check for vehicle harness for shorts. See the vehicle wiring schematic for wiring information. If the wiring is okay and the fault cannot be cleared, then replace the ECU.
14	12	No connection found to diagnostic link (J1922)	Check for proper connections between the J1922 data link and pins A1 and A3 of the ABS ECU. Verify that the polarity is correct. A3 is positive (+) polarity and A1 is negative (–) polarity. If the vehicle is not equipped with a J1922 engine link, use a diagnostic tool to change the configuration of the ECU.
15	1,2,3,4,5,6,7,8,9,10, or 11	ECU internal fault.	If the fault cannot be cleared, then replace the ECU.

* When harnesses and components are being measured for proper resistance values, always measure the resistance at both the ECU harness connector and at the component.

Table 7, ECU Fault Codes

Power (Battery) Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action ***
16	1	Excessive voltage found on diagonal 1.	Verify that the vehicle system voltage is okay (9 to 16 volts). If the voltage is out of range, correct the system voltage problem. Unplug connector A at the ECU and turn on the ignition switch. If voltage at pin A-9 is different than the system voltage, repair the wiring. Clear the faults and verify that the warning light turns off after the bulb check.
16	2	Low voltage on diagonal 1.	Verify that the vehicle system voltage is okay (9 to 16 volts). If the voltage is out of range, correct the system voltage problem. Unplug connector A at the ECU and turn on the ignition switch. If voltage at pin A-9 is different than the system voltage, repair the wiring. Clear the faults and verify that the warning light turns off after the bulb check.
16	3	No voltage found on diagonal 1.	Verify that the vehicle system voltage is okay (9 to 16 volts). If the voltage is out of range, correct the system voltage problem. Unplug connector A at the ECU and turn on the ignition switch. If voltage at pin A-9 is different than the system voltage, repair the wiring. Clear the faults and verify that the warning light turns off after the bulb check.
16	4	No ground found on diagonal 1.	Unplug connector A at the ECU and measure the resistance to ground at pin A-12. If continuity to ground is not present, repair the harness.
16	5	Excessive voltage found at diagonal 2.	Verify that the vehicle system voltage is okay (9 to 16 volts). If the voltage is out of range, correct the system voltage problem. Unplug connector A at the ECU and turn on the ignition switch. If voltage at pin A-8 is different than the system voltage, repair the wiring. Clear the faults and verify that the warning light turns off after the bulb check.
16	6	Low voltage at diagonal 2.	Verify that the vehicle system voltage is okay (9 to 16 volts). If the voltage is out of range, correct the system voltage problem. Unplug connector A at the ECU and turn on the ignition switch. If voltage at pin A-8 is different than the system voltage, repair the wiring. Clear the faults and verify that the warning light turns off after the bulb check.
16	7	No voltage found at diagonal 2.	Verify that the vehicle system voltage is okay (9 to 16 volts). If the voltage is out of range, correct the system voltage problem. Unplug connector A at the ECU and turn on the ignition switch. If voltage at pin A-8 is different than the system voltage, repair the wiring. Clear the faults and verify that the warning light turns off after the bulb check.

Power (Battery) Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action ***
16	8	No ground found at diagonal 2.	Unplug connector at the ECU and measure the resistance to ground at pin A-11. If continuity to ground is not present, repair the harness.
16	9	Excessive voltage found on the switched ignition input.	Verify that the vehicle system voltage is okay (9 to 16 volts). If the voltage is out of range, correct the system voltage problem. Unplug connector A at the ECU and turn on the ignition switch. If voltage at pin A-7 is different than the system voltage, repair the wiring. Clear the faults and verify that the warning light turns off after the bulb check.
16	10	Low voltage found on the switched ignition input.	Verify that the vehicle system voltage is okay (9 to 16 volts). If the voltage is out of range, correct the system voltage problem. Unplug connector A at the ECU and turn on the ignition switch. If voltage at pin A-7 is different than the system voltage, repair the wiring. Clear the faults and verify that the warning light turns off after the bulb check.
16	11	Voltage difference between diagonal 1 and diagonal 2 supply is too high.	Verify that the vehicle system voltage is okay (9 to 16 volts). If the voltage is out of range, correct the system voltage problem. Unplug connector A at the ECU and turn on the ignition switch. If voltage at pin A-8 is different than the voltage at pin A-9, by greater than 0.5 volts, repair the wiring. Check the circuit breakers and/or fuses on the diagonal supply line. Clear the faults and verify that the warning light turns off after the bulb check.

* When harnesses and components are being measured for proper resistance values, always measure the resistance at both the ECU harness connector and at the component.

Table 8, Power (Battery) Fault Codes

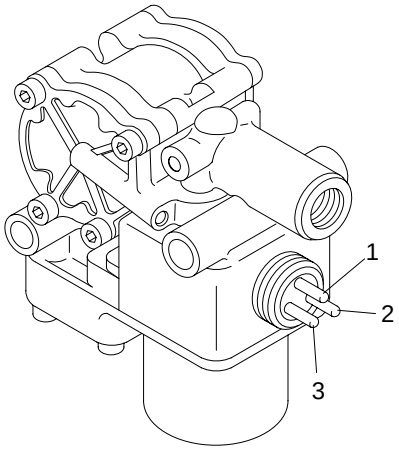
Miscellaneous Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action ***
17	1	The retarder control relay is shorted to the supply voltage or has an open circuit.	Use multimeter to verify proper voltage at the retarder control relay.
17	2	The retarder relay is shorted to ground.	Use multimeter to verify proper voltage at the retarder control relay.

Miscellaneous Fault Codes			
First Blink Code (manual retrieval)/ First Number (automatic retrieval)	**Second Blink Code (manual retrieval)/ Second Number (automatic retrieval)**	**Condition**	**Action ***
17	3	The J1922 data link is not functioning.	Unplug connector A. The voltage should measure between 0 to 2.5 volts on pin A-1 and the voltage should measure between 2.5 to 5 volts on pin A-3. Make any necessary wiring harness corrections.
17	4	J1922 data link time out.	Unplug connector A. The voltage should measure between 0 to 2.5 volts on pin A-1 and the voltage should measure between 2.5 to 5 volts on pin A-3. Make any necessary wiring harness corrections.
17	5	Tire size, front to rear, out of range.	There is too great a distance in the rolling radius of the front and rear tires. Steer axle tire radius cannot be more than 20% above the rear axle tire radius or 10% below. If the static loaded radius of the rear tires is outside the range of 15.9 to 21.5 inches (40.4 to 54.6 cm), then the ECU must be re-calibrated using a diagnostic tool.
17	6	Tire size out of range or parameter fault.	There is too great a distance in the rolling radius of the front and rear tires. Steer axle tire radius cannot be more than 20% above the rear axle tire radius or 10% below. If the static loaded radius of the rear tires is outside the range of 15.9 to 21.5 inches (40.4 to 54.6 cm), then the ECU must be re-calibrated using a diagnostic tool.
17	7	Brake light switch not pushed at this power cycle.	Press brake pedal. If error does not clear, check for missing connection at brake light switch. If the brake is not applied, you should measure the resistance at the brake light bulb (is the bulb broken?). If the brake is applied, you should measure vehicle system voltage (9 to 16 volts) at the brake light bulb.
17	8	ATC system is disabled for dynamometer test.	Cycle the ignition switch to re-enable the ATC system.

* When harnesses and components are being measured for proper resistance values, always measure the resistance at both the ECU harness connector and at the component.

Table 9, Miscellaneous Fault Codes

Troubleshooting



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1. Pin 1-common (the resistance specification between pin 1 to pin 2 is 3 to 8 ohms and the resistance specification between pin 1 to pin 3 is 3 to 8 ohms)
2. Pin 2-release (the resistance specification between pin 2 and pin 3 is 6 to 16 ohms)
3. Pin 3-hold

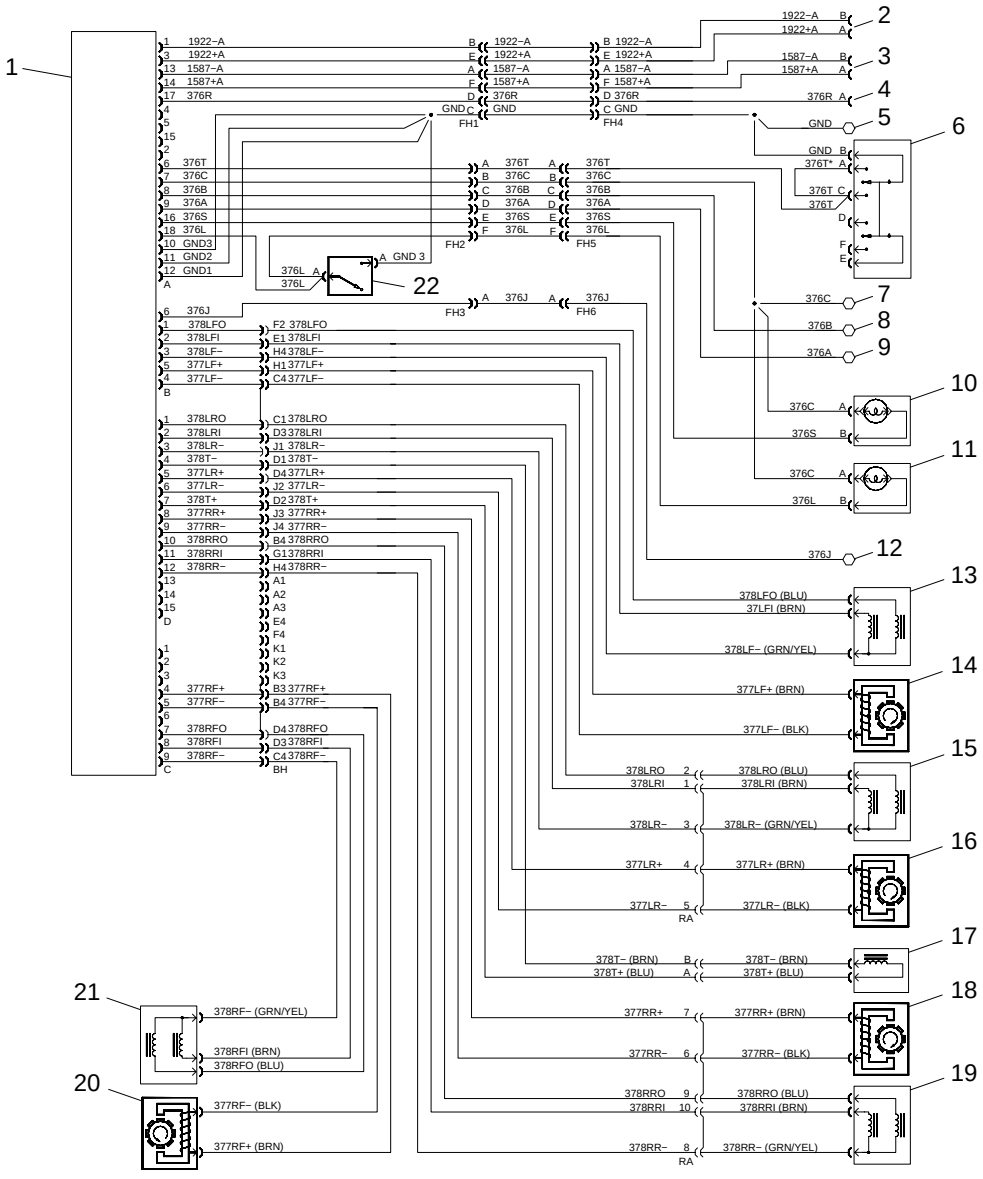
Fig. 5, Pressure Modulator Valve Connector Pin Locations

Wiring Diagrams

See **Fig. 1** for a full view of the Conventional ABS/ ATC electrical system.

See **Fig. 2** for a full view of the FLB COE ABS/ATC electrical system.

Specifications



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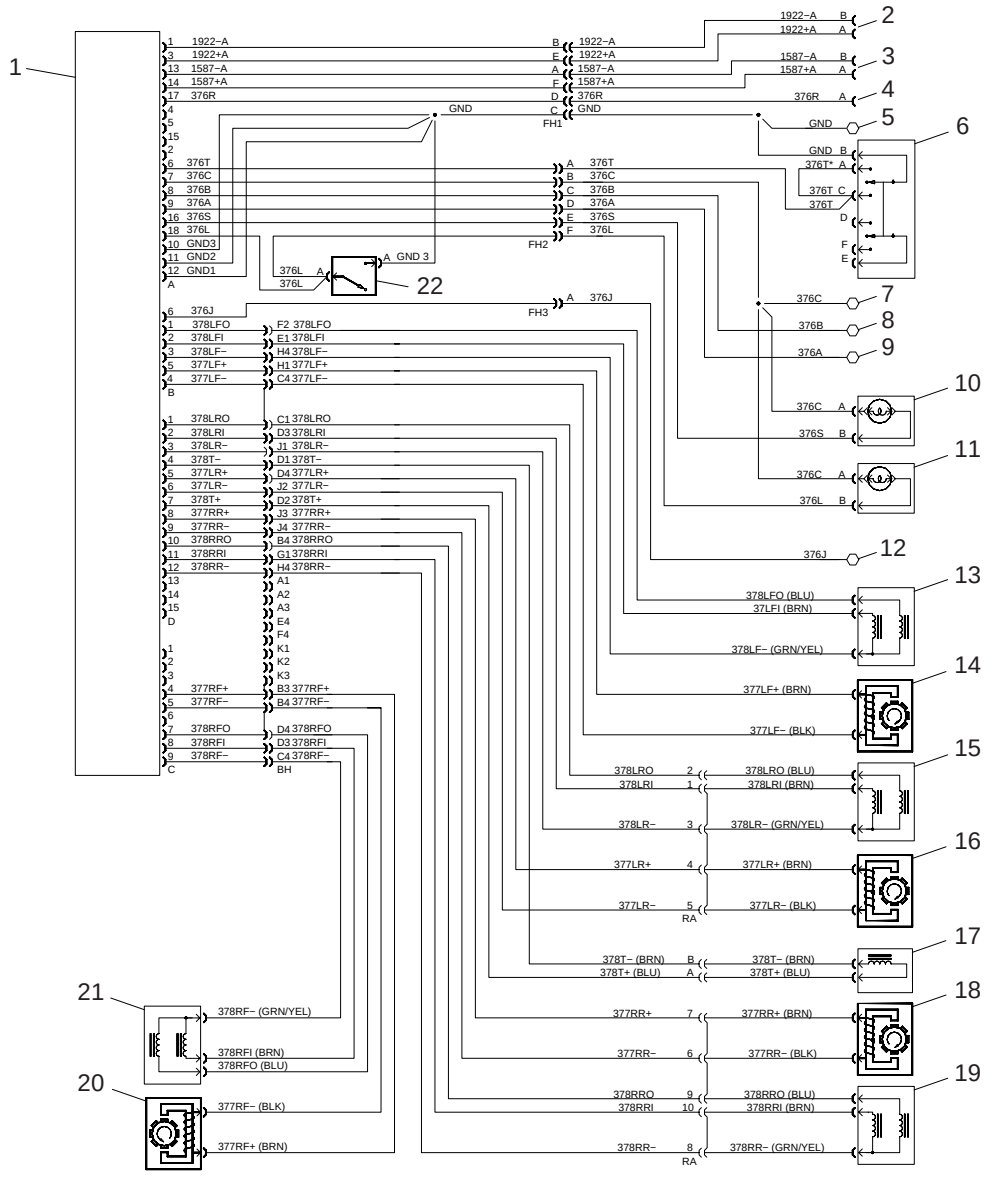
1. Eaton ABS ECU
2. Engine Interface
3. J-1587 Diagnostic Connector
4. Retarder Relay Circuit
5. Ground Stud
6. Traction Control Switch (mud & snow)
7. Ignition Power
8. Constant Power
9. Constant Power
10. ATC (wheel spin) Indicator Lamp
11. ABS Indicator Lamp
12. Stop Light Circuit
13. Left Front Pressure Modulator Valve
14. Left Front Speed Sensor
15. Left Rear Pressure Modulator Valve
16. Left Rear Speed Sensor
17. ATC Valve
18. Right Rear Speed Sensor
19. Right Rear Pressure Modulator Valve
20. Right Front Speed Sensor
21. Right Front Pressure Modulator Valve
22. Diagnostic Switch

Fig. 1, Eaton ABS/ATC Electrical System Schematic (Conventional)



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1. Eaton ABS ECU
2. Engine Interface
3. J-1587 Diagnostic Connector
4. Retarder Relay Circuit
5. Ground Stud
6. Traction Control Switch (mud & snow)
7. Ignition Power
8. Constant Power
9. Constant Power
10. ATC (wheel spin) Indicator Lamp
11. ABS Indicator Lamp
12. Stop Light Circuit
13. Left Front Pressure Modulator Valve
14. Left Front Speed Sensor
15. Left Rear Pressure Modulator Valve
16. Left Rear Speed Sensor
17. ATC Valve
18. Right Rear Speed Sensor
19. Right Rear Pressure Modulator Valve
20. Right Front Speed Sensor
21. Right Front Pressure Modulator Valve
22. Diagnostic Switch

Fig. 2, Eaton ABS/ATC Electrical System Schematic (FLB COE)

General Information

The air/oil junction block is a major pass-through point between the cab and the chassis for the pneumatic system. Many gauges and electrical switches have connections here as well. To service any of these connections requires access to this block.

FLA/FLD MODELS

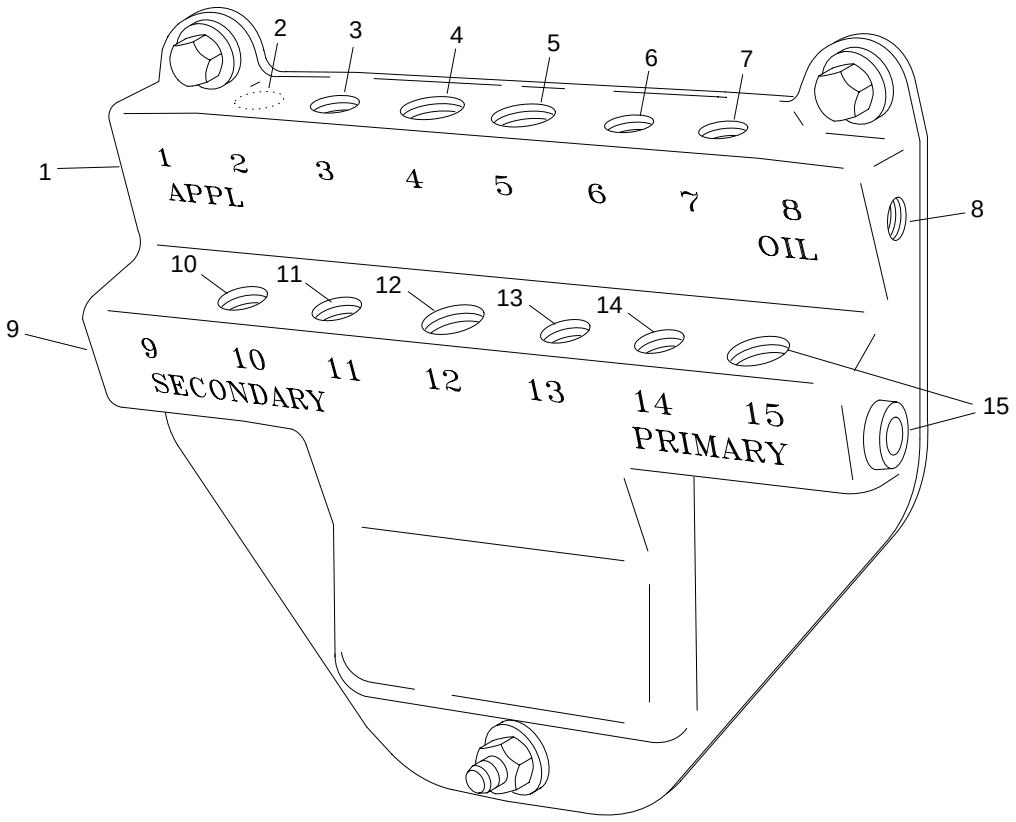
The cab side of the air/oil junction block provides 15 ports, while the chassis side provides seven ports. This allows multiple porting for the major pneumatic systems, primary and secondary (supply), and application (delivery), as well as the engine oil system. For a typical installation, see **Fig. 1**.

For connections to the chassis side of the air/oil junction block, see **Fig. 2**.

FLB MODELS

The FLB air/oil junction block also provides multiple porting for the major pneumatic systems, primary and secondary (supply), application (delivery), and parking, as well as the engine oil system. Five ports are provided at the top edge of the block, where the chassis lines enter. On the face of the block, near the top, oil, primary, secondary, and application lines exit and route into the cab. Additional ports (plugged) are available on the face and at the bottom edge of the block. For a typical installation, see **Fig. 3**.

General Information



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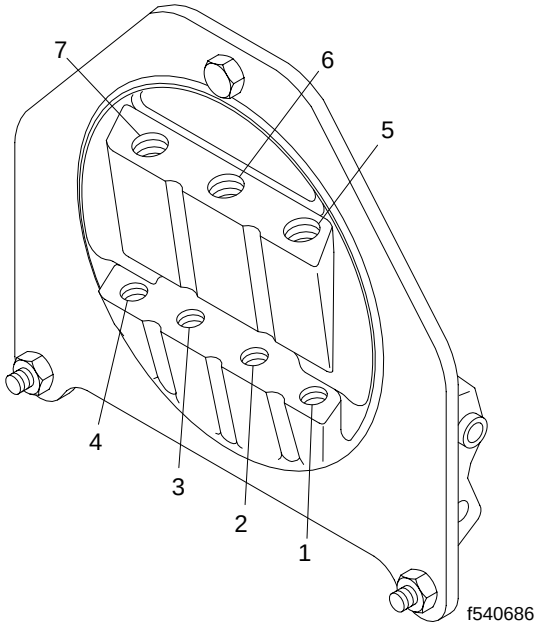
NOTE: Installations may vary.

1. Port #1: Stop Light Switch
2. (not installed)
3. Port #3: Air Pressure Gauge (application)
4. Port #4: Dash Park Valve (trailer delivery)
5. Port #5: Hand Valve (delivery)
6. Port #6: Oil Pressure Gauge
7. Port #7: Low Oil Pressure Warning Switch
8. Port #8: Low Oil Pressure Shutdown Switch
9. Port #9: Park and Hand Valves (secondary supply)
10. Port #10: Low Air Pressure Switch (secondary)
11. Port #11: Air Pressure Gauge (secondary)
12. Port #12: Dash Park Valve (tractor delivery)
13. Port #13: Low Air Pressure Switch (primary)
14. Port #14: Dash Park Valve (primary supply)
15. Port #15: (side): Air Pressure Gauge (primary), Port #15: (top): no installation

Fig. 1, Typical Air/Oil Junction Block Connections (cab side), FLA and FLD



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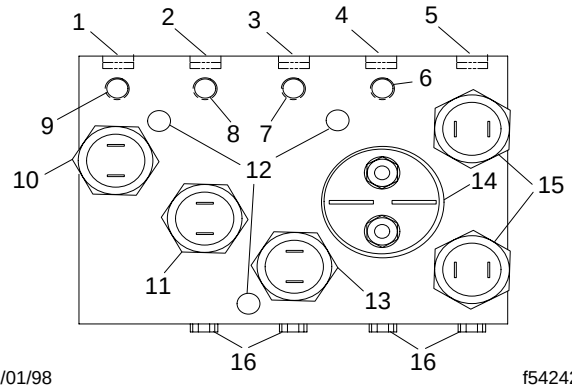
NOTE: Installations may vary.

1. Port #16: Engine Oil Pressure
2. Port #17: Hand Valve (delivery)
3. Port #18: Trailer Charge (emergency)
4. Port #19: Application Air
5. Port #20: Foot Valve (primary supply)
6. Port #21: Tractor Park
7. Port #22: Foot Valve (secondary supply)

Fig. 2, Typical Air/Oil Junction Block Connections (chassis side), FLA and FLD



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NOTE: Installations may vary.

1. Engine Oil Pressure
2. Primary Air Supply
3. Secondary Air Supply
4. Application Air
5. Tractor Park
6. Application Air Gauge Port
7. Secondary Air Gauge Port
8. Primary Air Gauge Port
9. Oil Pressure Gauge Port
10. Low Oil Warning/Shutdown Switch
11. Low Air Pressure Warning Switch
12. Mounting Screw Locations
13. Low Air Pressure Warning Switch
14. Brake Light Switch
15. Parking Brake Circuit Related Optional Switches
16. Additional Port Locations (plugged)

Fig. 3, Typical Air/Oil Junction Block Connections, FLB

Air/Oil Junction Block Removal and Installation, (FLA)

Removal

On the FLA COE, the air/oil junction block is located on the left-hand side of the tunnel, behind the kick panel. See **Fig. 1**.

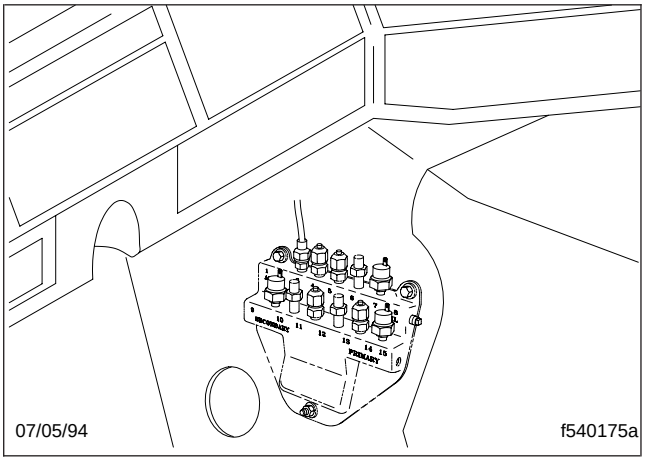


Fig. 1, FLA Air/Oil Junction Block Location

1. Park the vehicle in a level area, shut down the engine, and chock the tires.
2. Disconnect the batteries.

⚠ WARNING

Wear safety goggles when draining the air system or loosening an air line, because dirt or sludge could fly out at high speeds. Don't direct the air streams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

3. Bleed all the air from the primary and secondary tanks.
4. Remove the air/oil junction block.
   - 4.1 Remove the kick panel and the carpeting behind it.
   - 4.2 Remove the under-dash panel and the right-hand metal support bracket.
   - 4.3 Remove the two upholstery screws at the top of the tunnel and pull back the carpeting to expose the air/oil junction block.
   - 4.4 Mark lines 1 to 15 for reference (see **Fig. 2**). Disconnect any lines needed to expose the three mounting bolts (one in-facing, two out-facing) attaching the air/oil junction block to the tunnel wall.
   - 4.5 Disconnect lines 1 to 15 (and any switches) from the air/oil junction block.

⚠ WARNING

Before tilting the cab, review the Danger and Warning notices in Group 60 of the vehicle service manual. Failure to follow these instructions could cause the cab to hit or crush a person, possibly resulting in serious injury or death.

   - 4.6 Tilt the cab (manually if necessary). For instructions see **Group 60** in this manual.
   - 4.7 Locate the air/oil junction block on the cab wall, forward of the tunnel liner. Mark and disconnect lines 16 to 22 from the chassis side of the air/oil junction block. See **Fig. 3**.
   - 4.8 Remove the three mounting bolts attaching the air/oil junction block to the cab wall (this job may require two people, one on each side of the cab wall).
   - 4.9 Inside the cab, remove the air/oil junction block from the tunnel wall.

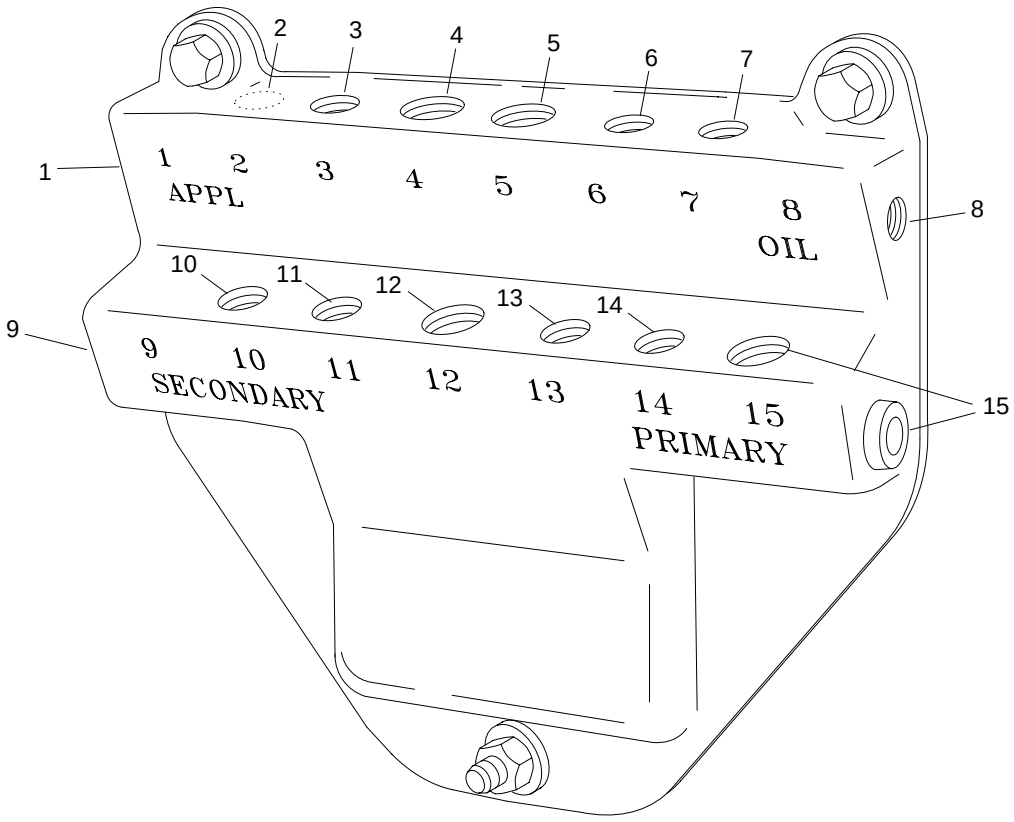
Installation

1. Install the air/oil junction block.
   - 1.1 Inside the cab, position the air/oil junction block on the tunnel wall.
   - 1.2 Install the three mounting bolts, locknuts, and hardened washers. The two upper bolts face out from the cab. The one lower bolt faces into the cab.
   - 1.3 Connect lines 16 to 22 (as previously marked) to the chassis side of the air/oil junction block.

⚠ WARNING

Before returning the cab to normal operating position, review the Danger and Warning notices in Group 60 of this manual. Failure to follow these

Air/Oil Junction Block Removal and Installation, (FLA)



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NOTE: Installations may vary.

1. Port #1: Stop Light Switch
2. (not installed)
3. Port #3: Air Pressure Gauge (application)
4. Port #4: Dash Park Valve (trailer delivery)
5. Port #5: Hand Valve (delivery)
6. Port #6: Oil Pressure Gauge
7. Port #7: Low Oil Pressure Warning Switch
8. Port #8: Low Oil Pressure Shutdown Switch
9. Port #9: Park and Hand Valves (secondary supply)
10. Port #10: Low Air Pressure Switch (secondary)
11. Port #11: Air Pressure Gauge (secondary)
12. Port #12: Dash Park Valve (tractor delivery)
13. Port #13: Low Air Pressure Switch (primary)
14. Port #14: Dash Park Valve (primary supply)
15. Port #15 (side): Air Pressure Gauge (primary), Port #15 (top): no installation

Fig. 2, Typical FLA Air/Oil Junction Block Connections (cab side)

instructions could cause the cab to hit or crush a person, possibly resulting in serious injury or death.

1.4 Return the tilted cab to the normal operating position, following the procedures in **Group 60** of this manual.

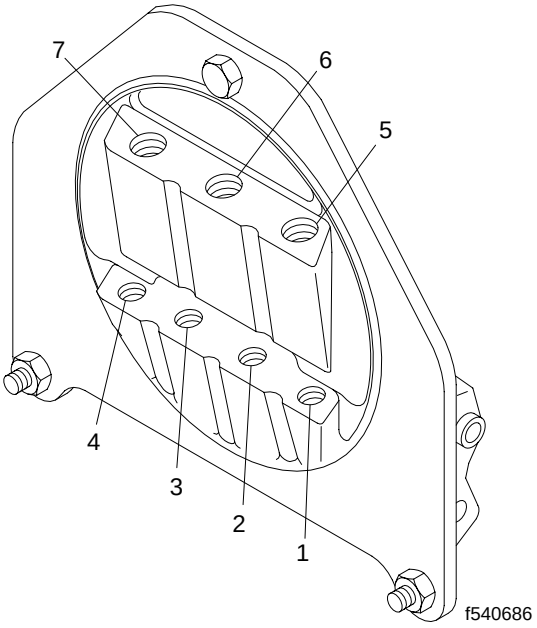
1.5 Connect lines 1 to 15 (as previously marked) to the cab side of the air/oil junction block. Install any switches removed previously.

1.6 Run the air compressor until the primary and secondary tanks are filled to operating pressure. Shut down the engine and listen for air leaks.

1.7 Install the carpeting on the tunnel wall.

1.8 Install the right-hand metal support bracket and the under-dash panel.

Air/Oil Junction Block Removal and Installation, (FLA)



NOTE: Installations may vary

1. Port #16: Engine Oil Pressure
2. Port #17: Hand Valve (delivery)
3. Port #18: Trailer Charge (emergency)
4. Port #19: Application Air
5. Port #20: Foot Valve (primary supply)
6. Port #21: Tractor Park
7. Port #22: Foot Valve (secondary supply)

Fig. 3, Typical FLA Air/Oil Junction Block Connections (chassis side)

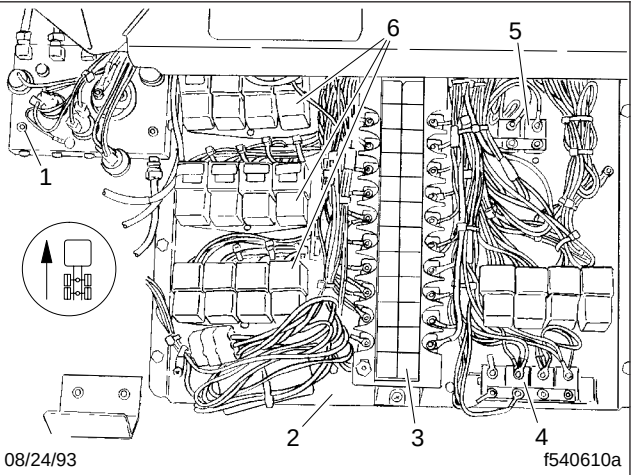
1.9 Install the kick panel.

2. Connect the batteries.
3. Remove the chocks from the tires.

Air/Oil Junction Block Removal and Installation, (FLB)

Removal

On the FLB COE, the air/oil junction block is located to the left of the electrical mounting plate, under the tunnel left-hand cover. See **Fig. 1**.



1. Air/Oil Junction Block
2. Electrical Mounting Plate
3. Circuit Breaker Bus Bar
4. Four-Position Junction Block
5. Two-Position Junction Block
6. Relays

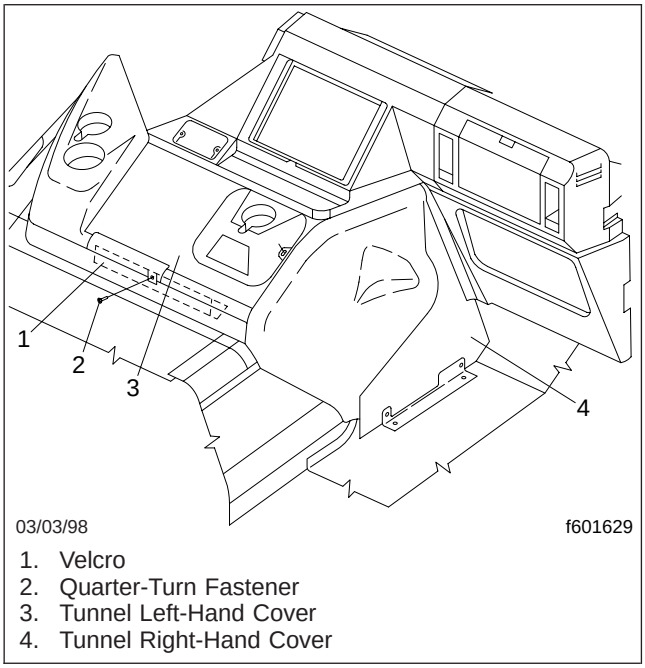
Fig. 1, FLB Air/Oil Junction Block Location

1. Park the vehicle in a level area, shut down the engine, and chock the tires.
2. Disconnect the batteries.

⚠ WARNING

Wear safety goggles when draining the air system or loosening an air line, because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

3. Bleed all the air from the primary and secondary tanks.
4. Uncover the air/oil junction block.
   - 4.1 Loosen the quarter-turn fastener at the lower rear edge of the cover. Then pull back on the cover to detach the Velcro® (see **Fig. 2**).



1. Velcro
2. Quarter-Turn Fastener
3. Tunnel Left-Hand Cover
4. Tunnel Right-Hand Cover

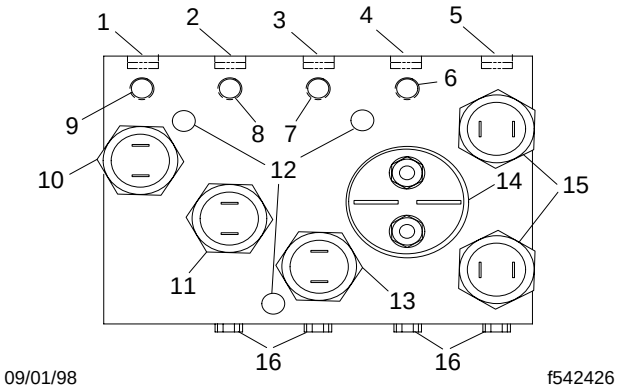
Fig. 2, FLB Dash and Tunnel Covers

   - 4.2 Remove the tunnel left-hand cover.
5. Locate the air/oil junction block on the tunnel wall. See **Fig. 3**.
6. Detach the electrical leads and remove the switches from the junction block.
7. Disconnect the lines at the top edge and face of the junction block.
8. Remove the three mounting screws attaching the air/oil junction block to the tunnel wall and remove the junction block.

Installation

1. Position the air/oil junction block on the tunnel wall.
2. Install the three mounting screws. See **Fig. 3**.
3. Connect the lines at the top edge and face of the junction block.
4. Install the switches and connect the electrical connectors.

Air/Oil Junction Block Removal and Installation, (FLB)



NOTE: Installations may vary.

1. Engine Oil Pressure
2. Primary Air Supply
3. Secondary Air Supply
4. Application Air
5. Tractor Park
6. Application Air Gauge Port
7. Secondary Air Gauge Port
8. Primary Air Gauge Port
9. Oil Pressure Gauge Port
10. Low Oil Warning/Shutdown Switch
11. Low Air Pressure Warning Switch
12. Mounting Screw Locations
13. Low Air Pressure Warning Switch
14. Brake Light Switch
15. Parking Brake Circuit Related Optional Switches
16. Additional Port Locations (plugged)

Fig. 3, Typical FLB Air/Oil Junction Block Connections

5. Run the air compressor until the primary and secondary tanks are filled to operating pressure. Shut down the engine and listen for air leaks.
6. Cover the air/oil junction block.
   - 6.1 Position the tunnel left-hand cover over the electrical mounting plate.
   - 6.2 Fasten the Velcro (see **Fig. 2**). Tighten the quarter-turn fastener.
7. Connect the batteries.
8. Remove the chocks from the tires.

Air/Oil Junction Block Removal and Installation, (FLD)

Removal

On the FLD Conventional, the air/oil junction block is mounted on the cab frontwall ahead of the steering column (see **Fig. 1**). However, it is not necessary to remove the steering column to gain access to the junction block.

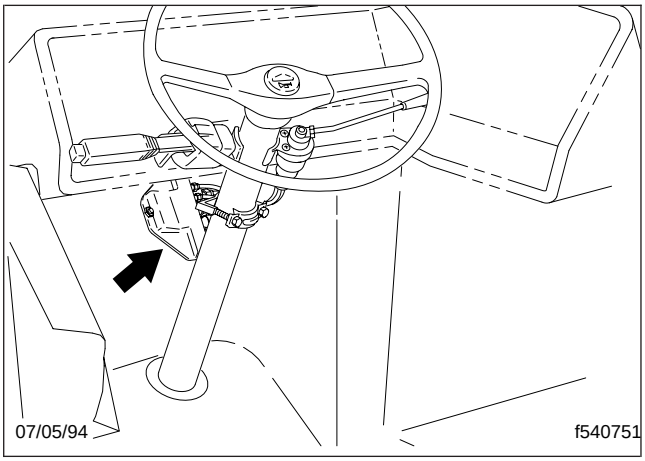


Fig. 1, FLD Air/Oil Junction Block Location

1. Park the vehicle in a level area, shut down the engine, and chock the tires.
2. Disconnect the batteries.

⚠ WARNING

Wear safety goggles when draining the air system or loosening an air line, because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

3. Bleed all air from the primary and secondary tanks.
4. Open the hood. The air/oil junction block is installed on the rear side of the cab frontwall, just below the driver's side wiper motor and above the steering column (see **Fig. 2**).
5. Remove the air/oil junction block.
   - 5.1 On the air/oil junction block, mark lines 16 to 22 for reference. For easier access, disconnect the engine electrical harness clamp and cut out tie straps as needed.
   - 5.2 Disconnect lines 16 to 22 from the air/oil junction block (see **Fig. 3**).
   - 5.3 From inside the cab, remove the lower steering column support jacket.
   - 5.4 Remove both left-hand and right-hand cab frontwall carpeting and the insulating material behind the carpet.
   - 5.5 With the cab frontwall exposed (see **Fig. 4**), remove the three mounting bolts (one in-facing, two out-facing) attaching the air/oil junction block to the cab frontwall. This job may require two people, one on each side of the cab frontwall.
   - 5.6 Loosen the clamp on the large electrical harness extending along the steering column.

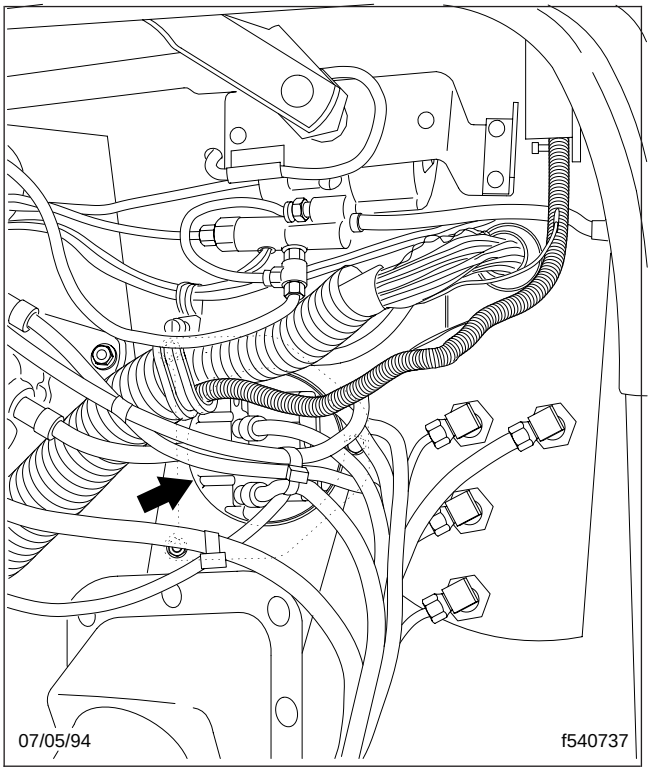
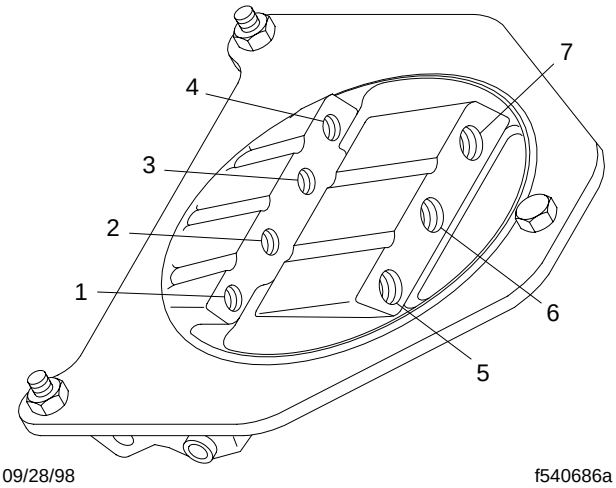


Fig. 2, FLD Air/Oil Junction Block Installed (engine compartment view)

Air/Oil Junction Block Removal and Installation, (FLD)



NOTE: Installations may vary

1. Port #16: Engine Oil Pressure
2. Port #17: Hand Valve (delivery)
3. Port #18: Trailer Charge (emergency)
4. Port #19: Application Air
5. Port #20: Foot Valve (primary supply)
6. Port #21: Tractor Park
7. Port #22: Foot Valve (secondary supply)

Fig. 3, Typical FLD Air/Oil Junction Block Connections (chassis side)

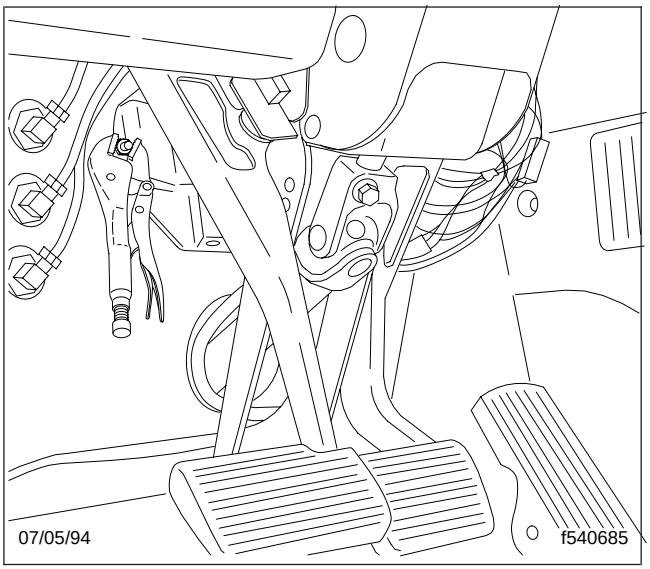


Fig. 4, FLD Air/Oil Junction Block Installed (from cab)

5.7 From the engine compartment, push the air/oil junction block into the cab. See **Fig. 5**.

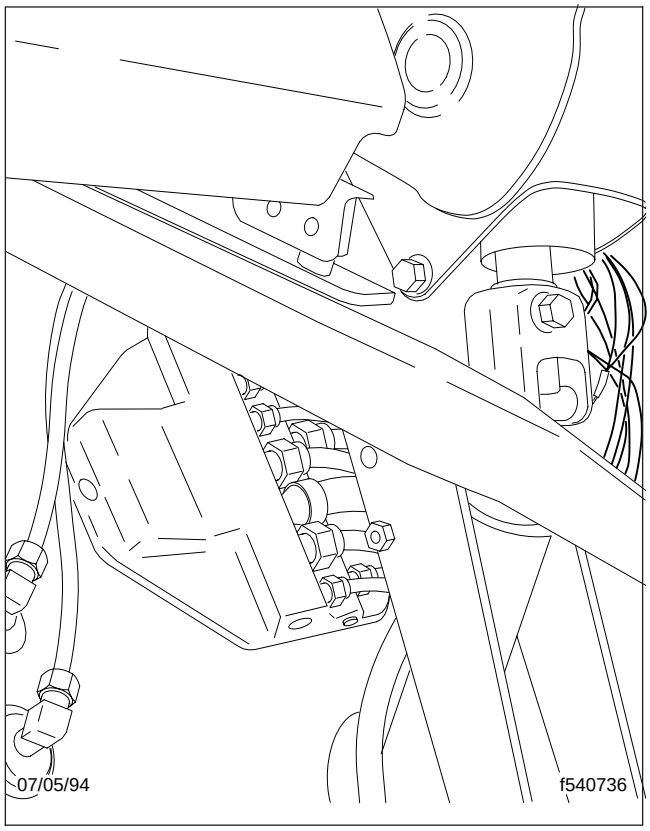


Fig. 5, FLD Air/Oil Junction Block Removed From Cab Frontwall

NOTE: There is sealant attaching the junction block to the cab frontwall. You must detach the junction block from the sealant as you push it into the cab.

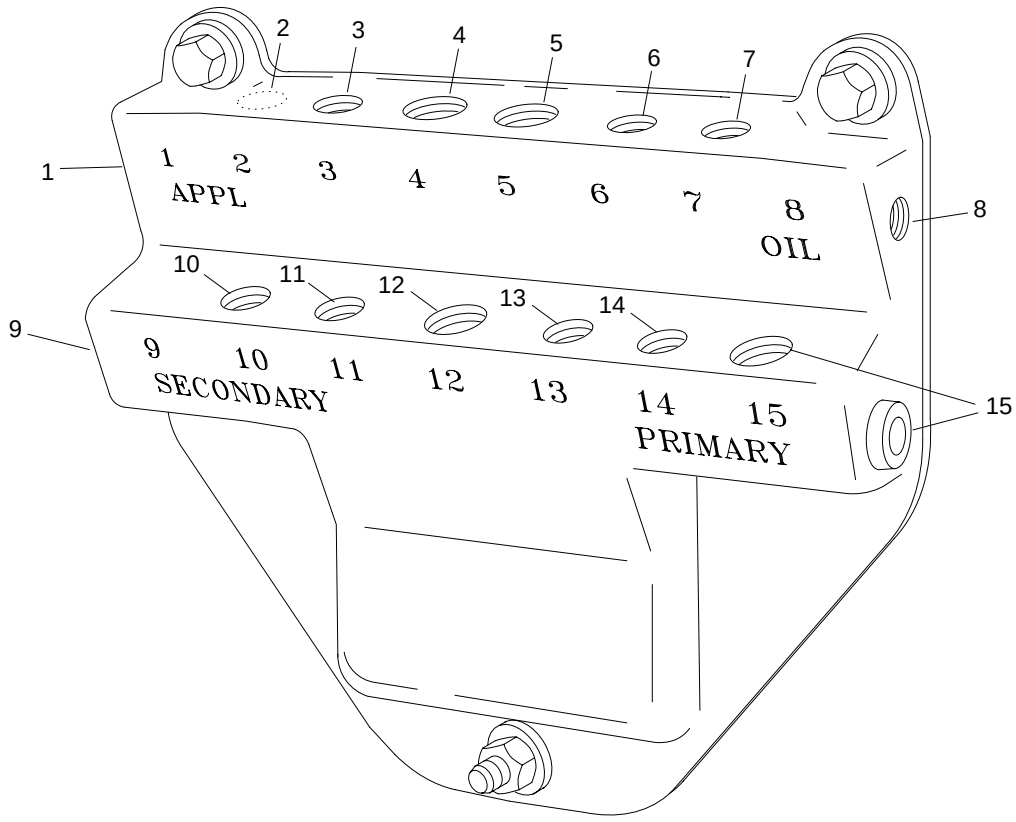
5.8 Inside the cab at the air/oil junction block, mark lines 1 to 15 for reference (see **Fig. 6**).

5.9 Disconnect lines 1 to 15 and remove any switches located on the air/oil junction block.

Installation

1. Install the air/oil junction block.

Air/Oil Junction Block Removal and Installation, (FLD)



NOTE: Installations may vary.

1. Port #1: Stop Light Switch
2. (not installed)
3. Port #3: Air Pressure Gauge (application)
4. Port #4: Dash Park Valve (trailer delivery)
5. Port #5: Hand Valve (delivery)
6. Port #6: Oil Pressure Gauge
7. Port #7: Low Oil Pressure Warning Switch
8. Port #8: Low Oil Pressure Shutdown Switch
9. Port #9: Park and Hand Valves (secondary supply)
10. Port #10: Low Air Pressure Switch (secondary)
11. Port #11: Air Pressure Gauge (secondary)
12. Port #12: Dash Park Valve (tractor delivery)
13. Port #13: Low Air Pressure Switch (primary)
14. Port #14: Dash Park Valve (primary supply)
15. Port #15 (side): Air Pressure Gauge (primary), Port #15 (top): no installation

Fig. 6, Typical FLD Air/Oil Junction Block Connections (cab side)

1.1 Inside the cab, connect lines 1 to 15 to the air/oil junction block and install any switches.

NOTE: Remove the old sealant from the cab wall and the junction block (if it is not being replaced with a new part) and apply fresh sealant to the junction block and cab wall before placing the junction block in position.

1.2 From inside the cab, position the air/oil junction block on the cab frontwall

1.3 Install the three mounting bolts, locknuts, and hardened washers. The two inboard bolts face out from the cab. The one outboard bolt faces into the cab.

1.4 Attach the electrical harness clamp.

1.5 From the engine side, connect hoses 16 to 22 (as previously marked) to the air/oil

Air/Oil Junction Block Removal and Installation, (FLD)

junction block (see **Fig. 2**). Attach any clamps or tie straps removed previously.

1.6 Run the air compressor until the primary and secondary tanks are filled to operating pressure. Shut down the engine and listen for air leaks.

1.7 Inside the cab, install the insulation and carpeting on both sides of the steering column.

1.8 Install the lower column support jacket.

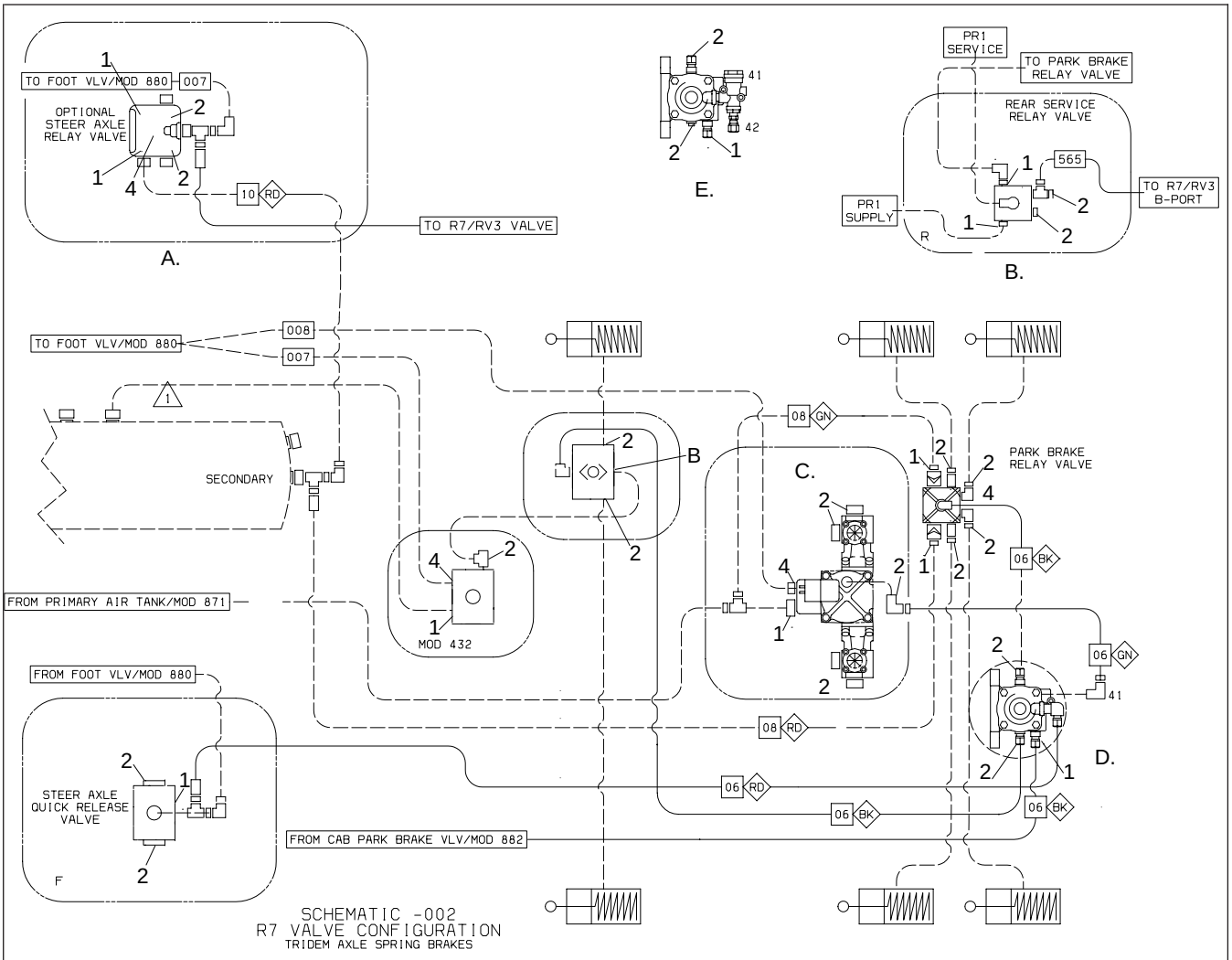
2. Connect the batteries.
3. Remove the chocks from the tires.

Brake Plumbing, with Antilock Braking, with Anti-Compounding, with R7/RV3 Spring Brake Modulation Valve

See **Fig. 1** for vehicles equipped with parking brakes on all rear axles.

See **Fig. 2** for vehicles equipped with parking brakes on two axles.

See **Fig. 3** for vehicles equipped with parking brakes on one axle.

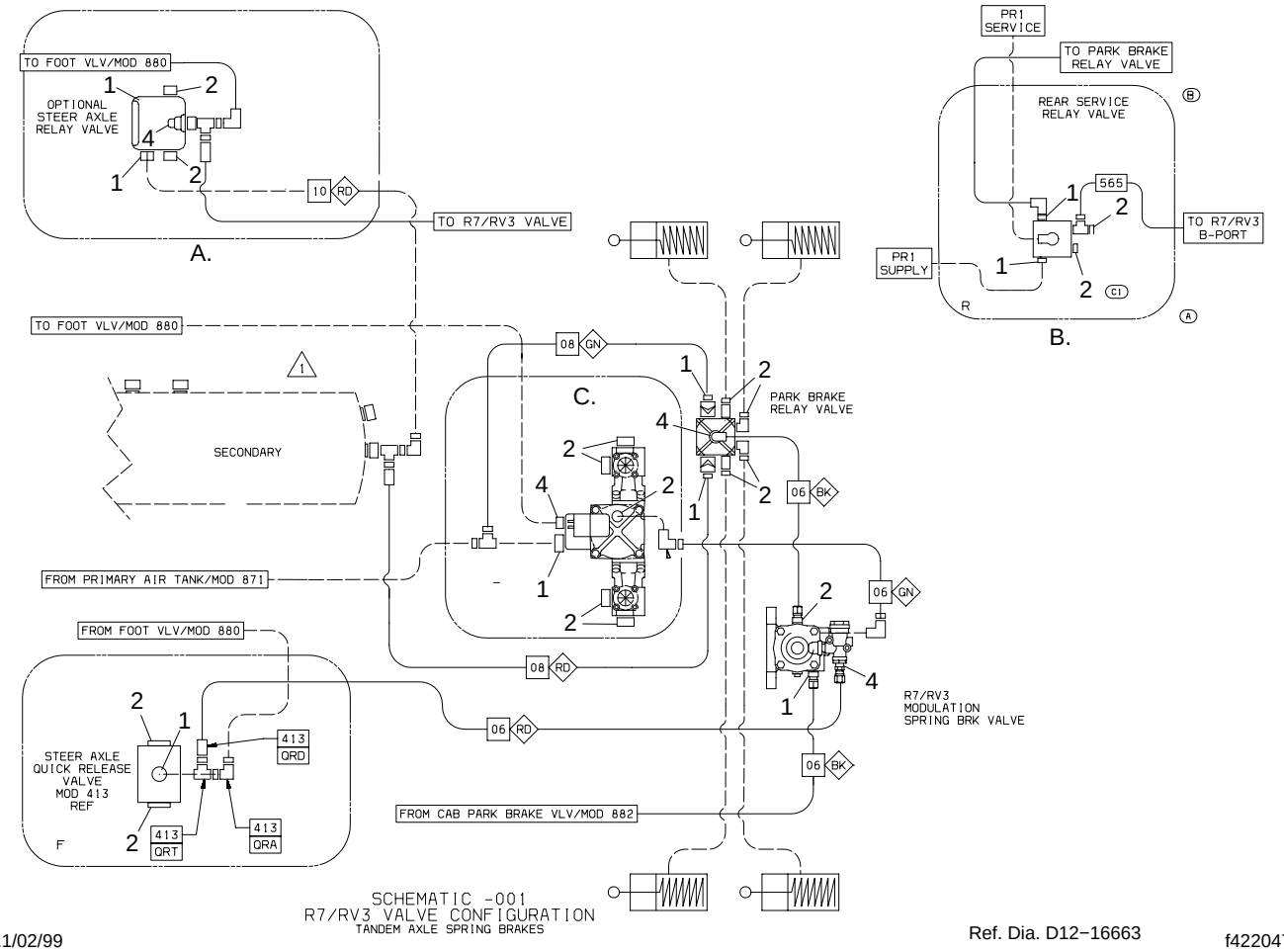


A. Steer Axle Relay Valve
B. Rear Service Relay Valve (two options shown)
C. Third Axle Service Brake Relay Valve
D. Third Axle Park Brake Relay Valve (without check valve)
E. Third Axle Park Brake Relay Valve (with check valve)

1. Supply Air
2. Delivery Air
3. Exhaust Air
4. Control Air

Fig. 1, With Park Brake Plumbing on Three Axles, with R7/RV3 Spring Brake Modulation Valve

Brake Plumbing, with Antilock Braking, with Anti-Compounding, with R7/RV3 Spring Brake Modulation Valve

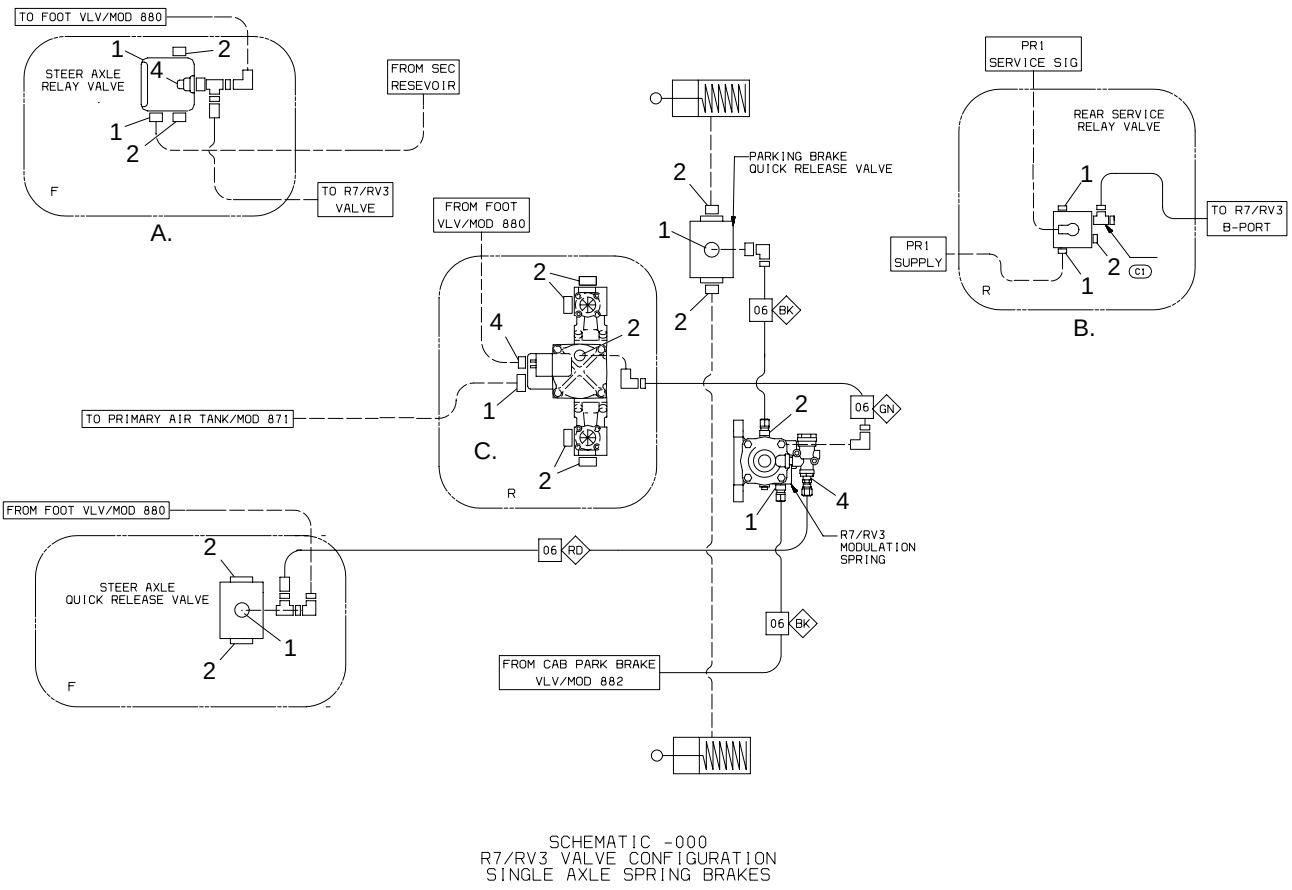


A. Vehicles with the Steer Axle Relay Valve
B. Rear Service Relay Valve
C. Vehicles with an ABS Combination Valve

1. Supply Air
2. Delivery Air
3. Exhaust Air
4. Control Air

Fig. 2, With Park Brake Plumbing on Two Axles, with R7/RV3 Spring Brake Modulation Valve

Brake Plumbing, with Antilock Braking, with Anti-Compounding, with R7/RV3 Spring Brake Modulation Valve



A. Vehicles with the Steer Axle Relay Valve
B. Rear Service Relay Valve
C. Vehicles with an ABS Combination Valve

1. Supply Air
2. Delivery Air
3. Exhaust Air
4. Control Air

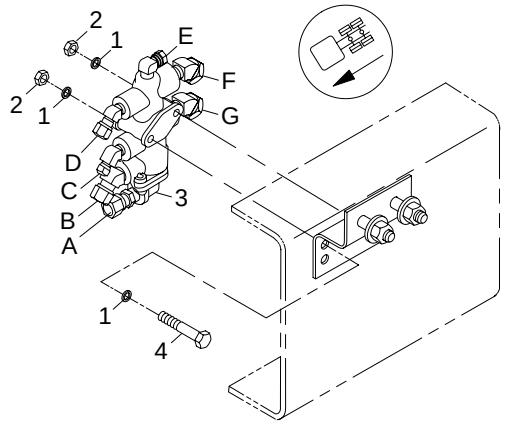
Fig. 3, With Park Brake Plumbing on One Axle, with R7/RV3 Spring Brake Modulation Valve

General Information

The Bendix TP–3DC is a tractor protection valve which includes an integral double check valve. The TP–3DC serves two purposes. First, as required by Federal Law, the valve protects the tractor brakes in the event of trailer breakaway or a severe air system leak. Secondly, when used with a dash-mounted trailer supply control valve, the TP–3DC valve can be used to shut off the trailer control line before the trailer is disconnected.

The TP–3DC also includes an integral single check valve which prevents air from getting trapped in the trailer control line. Trapped air in this line could cause service/spring brake compounding and, if the trailer is parked with air applied, a trailer roll-away situation.

The TP–3DC tractor protection valve is mounted either under the left hand deck or in the frame rail channel (see **Fig. 1**).



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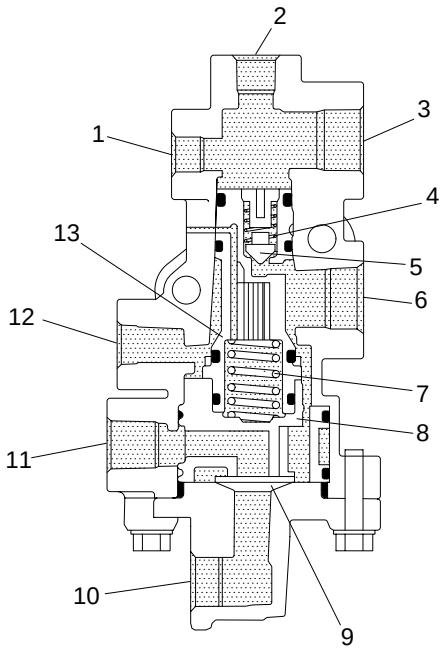
A. From service brake foot valve, primary circuit
B. From service brake foot valve, secondary circuit
C. To air manifold (stop lamp switch)
D. From trailer supply valve
E. To proportioning relay (if installed)
F. To trailer emergency port
G. To trailer service port
1. 1/4" Flatwasher
2. 1/4–20 Locknut
3. TP–3DC Tractor Protection Valve
4. 1/4–20 Capscrew

Fig. 1, TP-3DC Mounting Location and Connections

TP–3DC valve port designations and internal components are shown in **Fig. 2**.



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1. Tractor Supply
2. Auxiliary Supply
3. Trailer Supply
4. Tee Plug and Spring
5. Single Check Valve
6. Trailer Control
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control (Primary)
11. Tractor Control (Secondary)
12. Stop Lamp Switch Port
13. Plunger

Fig. 2, TP-3DC, Sectional View

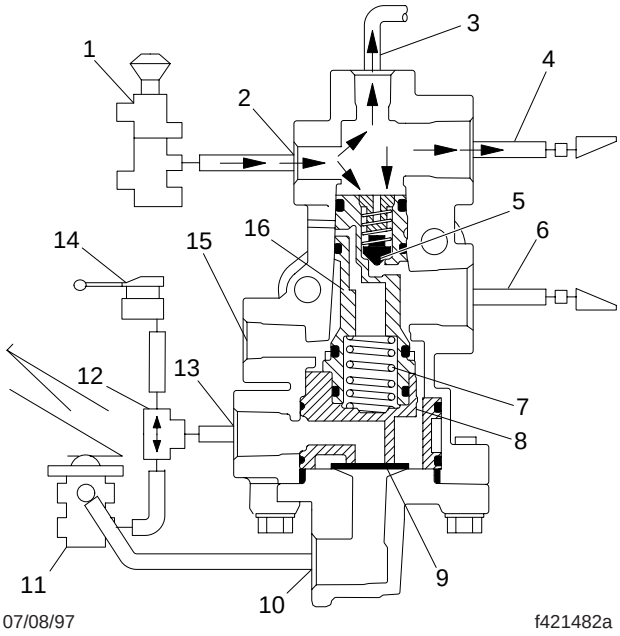
Principles of Operation

INITIAL CHARGE **(See Fig. 3)**

Pushing in the red trailer air supply knob on the instrument panel causes air to flow into the TP–3DC valve at the tractor supply port. Air flows through the valve housing, exiting via the auxiliary supply port (if used) and the trailer supply port, to pressurize the trailer brake system and release the trailer parking brakes.

As air pressure builds in the trailer supply circuit, the single check valve seats, and the valve plunger be-

General Information and Principles of Operation



1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

Fig. 3, Initial Charge

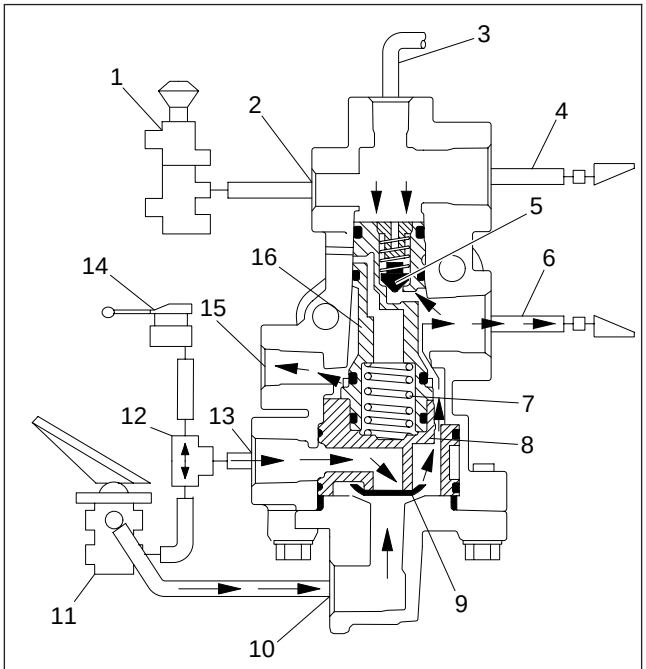
gins to move (against spring pressure) toward the guide. When pressure reaches about 45 psi (310 kPa), the plunger bottoms against the guide and the inlet valve is open.

The TP–3DC valve is in the "run" mode, and ready to receive and deliver a service brake application from either the foot valve or the hand valve.

SERVICE BRAKE APPLICATION

(See Fig. 4)

When the foot pedal is pressed, air flows to the TP–3DC valve tractor control primary and secondary ports. If the trailer control valve (handvalve) is also used, the external double check valve delivers the higher pressure (trailer control or foot valve secondary) to the TP–3DC Tractor Control secondary port.



1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

Fig. 4, Service Brake Application

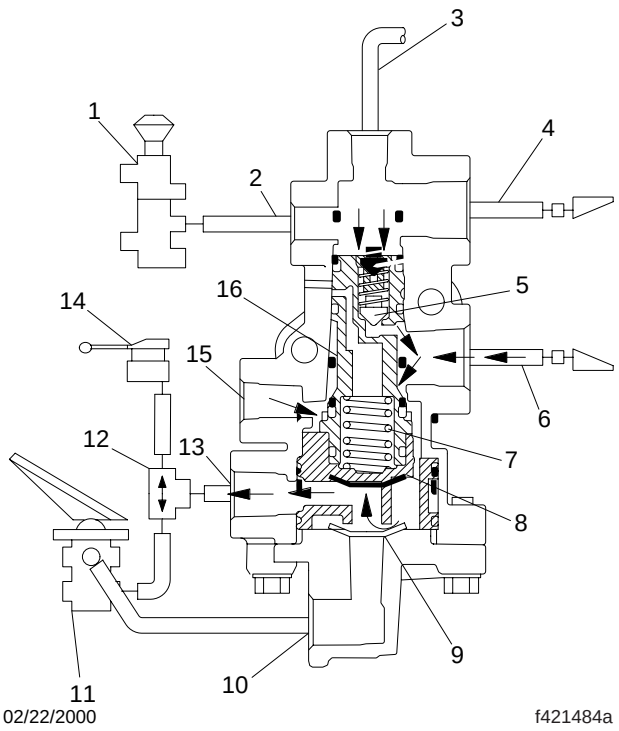
Inside the TP–3DC valve, the higher pressure (primary or secondary) moves the diaphragm to seal off the port at the lower pressure.

With the plunger bottomed against the guide and the inlet valve open (as described earlier), the higher pressure air flows through the valve to the trailer control port and the stop lamp switch, applying the brakes and activating the stop lamps.

NOTE: While air pressure also reaches the TP–3DC single check valve, the valve stays closed because supply pressure is acting on the other side.

SERVICE BRAKE RELEASE

(See Fig. 5)



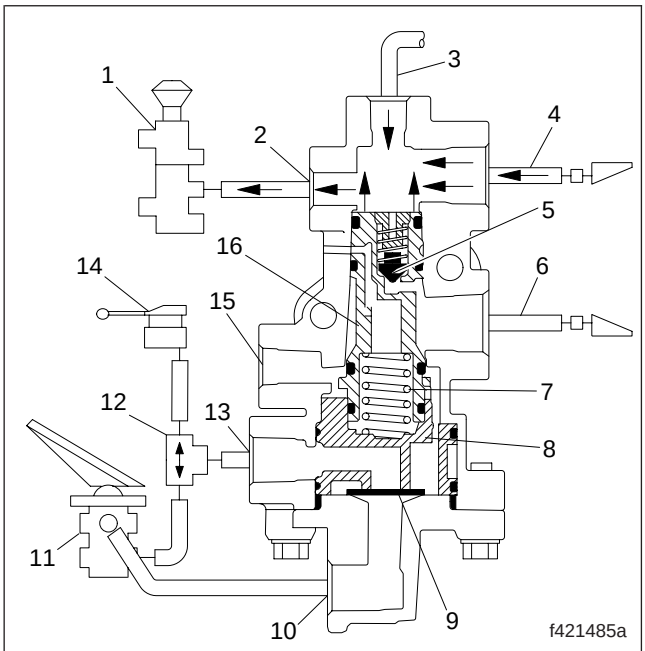
1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

Fig. 5, Service Brake Release

When the foot pedal is released, air stops flowing into the TP–3DC valve at the tractor control primary or secondary port. At the same time, air in the trailer control line returns to the valve, flowing back through the open inlet valve.

The air forces the diaphragm to seat, sealing off the tractor control primary port. The air then exits the valve at the tractor control (secondary) port and flows to the foot valve or hand valve where it is exhausted.

TRACTOR PROTECTION **(See Fig. 6)**



1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

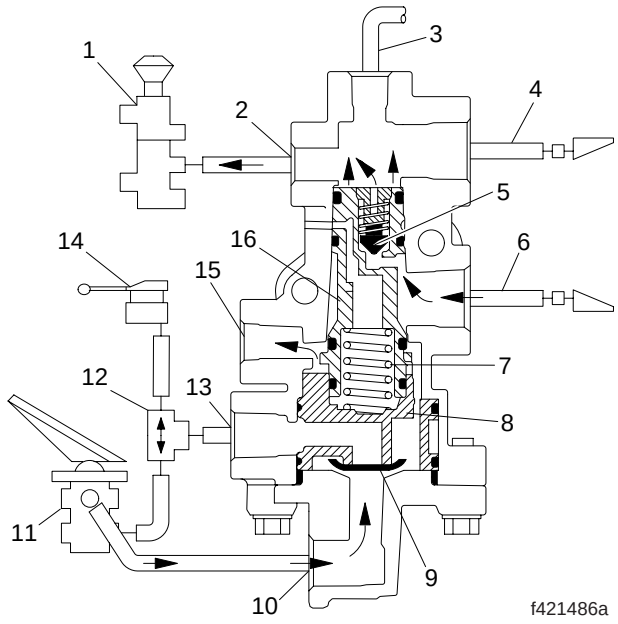
Fig. 6, Tractor Protection

If the red trailer air supply knob on the instrument panel is pulled out (or if a large leak develops in the trailer supply circuit), pressure in the trailer supply circuit (and the auxiliary supply circuit, if used) is vented. When pressure drops to about 20 to 30 psi (138 to 207 kPa), the pressure can no longer overcome the spring force inside the TP–3DC valve and the inlet valve closes.

With the inlet valve closed, air pressure from the brake foot or hand control valves will not reach the trailer control circuit when the brakes are applied.

General Information and Principles of Operation

ANTI-COMPOUNDING (See Fig. 7)



1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

Fig. 7, Anti-Compounding

If the red trailer air supply knob on the instrument panel is pulled out while the service brakes are applied, the single check valve in the TP–3DC prevents simultaneous spring and service brake application. As pressure in the trailer supply circuit drops, the spring in the TP–3DC valve forces the inlet valve closed (as described above in "Tractor Protection." Any pressure in the trailer control circuit is relieved by passing first through the single check valve and then exhausting at the trailer supply valve.

If the service brakes (hand or foot) are released and applied again, the closed inlet valve prevents air pressure from reaching the trailer control circuit.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

1. Chock the tires and stop the engine before working under the vehicle. Releasing air from the system may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

Leakage Test

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Chock the tires, start the engine, and run it until the air system is fully charged.
2. Shut down the engine and place the trailer air supply valve in the emergency position by pulling the red knob out.
3. Disconnect the trailer control line hose coupling and apply a soap-water solution to the coupling.
4. With tractor reservoirs charged to at least 100 psi (689 kPa) make and hold a full service brake application using either the foot valve or the trailer control valve. Leakage at the hose coupling should not exceed a 1-inch (2.5-cm) bubble in five seconds.
5. Release the service brake application and place the trailer supply valve in the "run" position by pushing the red knob in. Connect the trailer control valve to a test gauge.
6. Make a service brake application and note that service air pressure is present at the trailer control line hose coupling.
7. Disconnect the air line at the TP–3DC tractor control port (primary), plug the line, and apply a soap-water solution to the valve.
8. Make a service brake application and check for leakage at the open tractor control port. Leakage should not exceed a 1-inch (2.5-cm) bubble in five seconds.
9. Reconnect the air line to the tractor control port (primary) and disconnect the air line at the tractor control port (secondary). Then, plug the disconnected line and apply a soap-water solution to the valve.
10. Make a service brake application and check for leakage at the open tractor control port. Leakage should not exceed a 1-inch (2.5-cm) bubble in five seconds.

IMPORTANT: If the valve does not function as described, or if leakage is excessive, repair or replace the valve.

Removal

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Chock the tires, and open the air reservoir drain cocks to bleed the air from the system.
2. Remove the trailer hose assemblies from the TP–3DC valve. Disconnect the tractor service and supply lines. Mark the lines for later assembly reference. Cap the air lines tightly to keep out contaminants.
3. Remove the fasteners attaching the TP–3DC valve to the vehicle, and remove the valve.

Installation

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

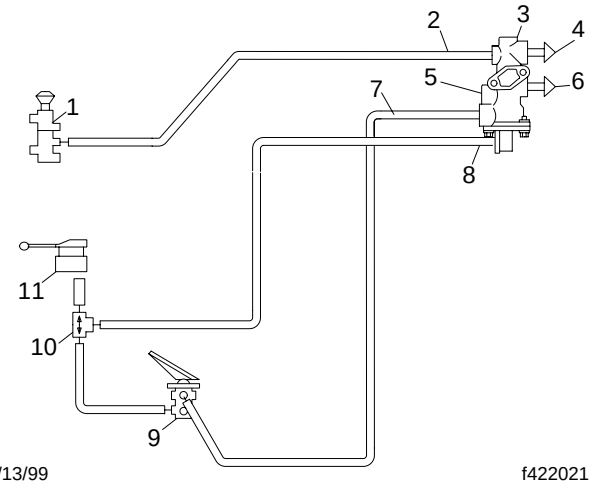
1. Place the TP–3DC valve in position on the vehicle, and install the bolts, washers, and nuts. Tighten the nuts 11 to 15 lbf·ft (15 to 20 N·m).

NOTE: The delivery line from the trailer air supply valve is connected to the tractor emergency port of the TP–3DC valve. See **Fig. 1**. The delivery line from the brake valve (double check valve) is connected to the tractor service port of the TP–3DC valve. Trailer hose assemblies are installed in the trailer emergency and trailer service ports of the TP–3DC valve.

2. Remove the caps from the air lines, and depending on the type of air hose, use the following instructions to connect the air hoses to the TP–3DC valve:

   If equipped with nylon tube air hoses, connect the hose fittings to the valve ports, and tighten the nuts finger-tight. Then, using a wrench, tighten the nuts at least two turns, or until no threads show on the fitting.

   If equipped with wire braid hoses, connect the hose fittings to the valve ports, and hand-tighten the nuts. Using a wrench, tighten the nuts until there is resistance. Tighten one-sixth turn more. Do not overtighten.

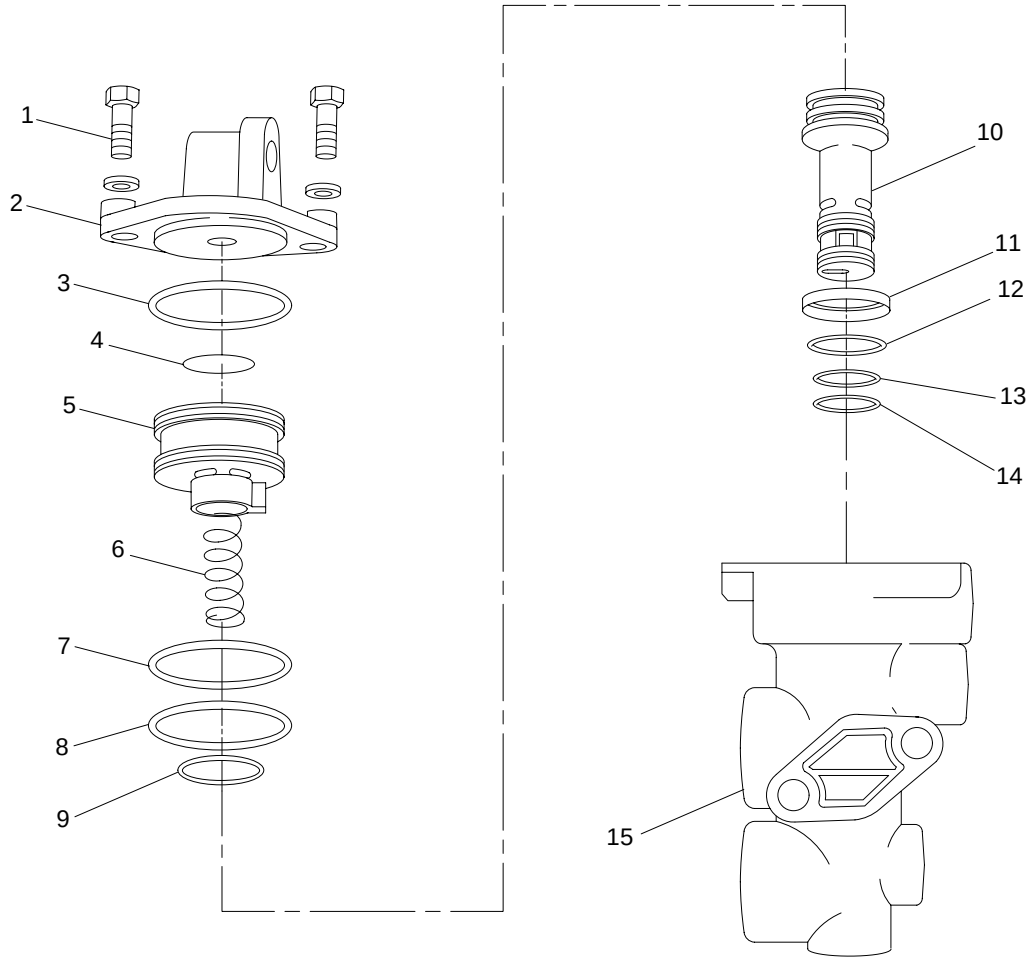


1. Trailer Air Supply Valve
2. Tractor Supply
3. Auxiliary Supply Port
4. Trailer Supply
5. Stop Lamp Switch Port
6. Trailer Control
7. Tractor Control (Primary)
8. Tractor Control (Secondary)
9. Foot Brake Valve
10. Double Check Valve
11. Trailer Control Valve

Fig. 1, Partial Plumbing Diagram, With TP-3DC

3. Close the drain cocks to the air reservoirs. Start the vehicle engine to pressurize the air system.
4. Leak test the TP–3DC valve following the instructions in **Subject 110**.

Disassembly (See Fig. 1)



1. 1/4" Hex/Torx Screw
2. Valve Cover
3. Cover O-Ring
4. Diaphragm
5. Guide
6. Valve Spring
7. Guide O-Ring
8. Guide O-Ring
9. Plunger O-Ring
10. Plunger
11. Collar
12. O-Ring
13. Plunger O-Ring
14. Plunger O-Ring
15. Valve Body

Fig. 1, Exploded View of TP-3DC Valve

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Remove the valve from the vehicle and retain the mounting hardware. For instructions, see **Subject 120**.
2. Scribe a line across the valve cover (Ref. 2) and valve body (Ref. 15) to ensure proper alignment during assembly.
3. Remove the two 1/4-inch screws (Ref. 1) which secure the valve cover to the valve body and

Disassembly, Cleaning and Inspection, and Assembly

allow the valve spring to expand until the valve cover can be removed.

4. Remove the cover O-ring (Ref. 3) and discard it.
5. Remove the diaphragm (Ref. 4) from the valve body and discard it.
6. Remove the guide (Ref. 5) from the valve body.
7. Remove the O-rings (Refs. 7 and 8) from the guide and discard them.
8. Remove the valve spring from the plunger, then the plunger from the valve body.
9. Remove the O-rings (Refs. 9, 13, and 14) from the plunger and discard them.
10. Remove the collar (Ref. 11) and the O-ring (Ref. 12) from the plunger. Discard the O-ring, but keep the collar.

Cleaning and Inspection

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

1. Wash all metal parts of the TP–3DC valve in cleaning solvent, then dry them using compressed air.
2. Examine the cover, body, guide, and plunger for corrosion, excessive wear, cracks, or other damage. If any of these conditions are found on a part, replace the part with a new one.
3. Check the spring for distortion and corrosion. If the spring is distorted or corroded, replace it.
4. Check the valve body bores for deep scratches or gouging

Assembly

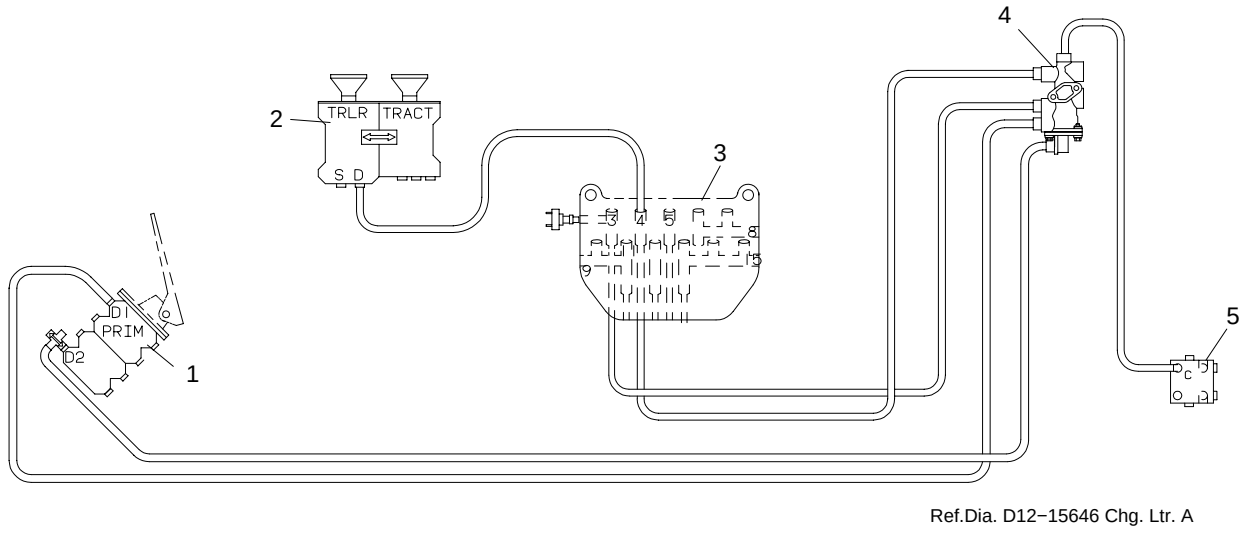
IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Lubricate the O-rings, O-ring grooves, body bores, and all sliding parts with the lubricant provided in the overhaul kit (Bendix silicone lubricant #291126 or equivalent).
2. Install the O-rings (Refs. 9, 13, and 14) on the plunger.
3. Install the O-ring (Ref. 12) on the plunger and then the collar (Ref. 11) over the O-ring. Make sure that the collar is fully seated and firmly in place over the O-ring.
4. Install the plunger into the valve body and the spring (Ref. 6) into the plunger.
5. Install the O-rings (Refs. 7 and 8) in their grooves on the guide.
6. Align the indexing tab on the guide with the notch in the valve body and install the guide in the valve body.
7. Place the diaphragm (Ref. 4) in its recess on the guide.
8. Place the O-ring (Ref. 3) on the cover.
9. Place the cover on the guide and press them down, against spring pressure, until the cover is seated against the valve body.
10. Install the two 1/4-inch screws and tighten them 30 to 60 lbf·in (340 to 675 N·cm).
11. Install the TP–3DC valve on the vehicle following the instructions in **Subject 120**.

See **Fig. 1** for a TP–3DC plumbing diagram.

Torque Values		
Description	**Torque lbf·in (N·cm)**	**Torque lbf·ft (N·m)**
Valve Cover Capscrews	30–60 (340–675)	—
Valve Mounting Capscrews	—	11–15 (15–20)

Table 1, Torque Values



1. Foot Valve
2. Dash Valves
3. Cab Junction Block
4. TP–3DC Valve
5. Relay Valve

Fig. 1, TP-3DC Plumbing Diagram

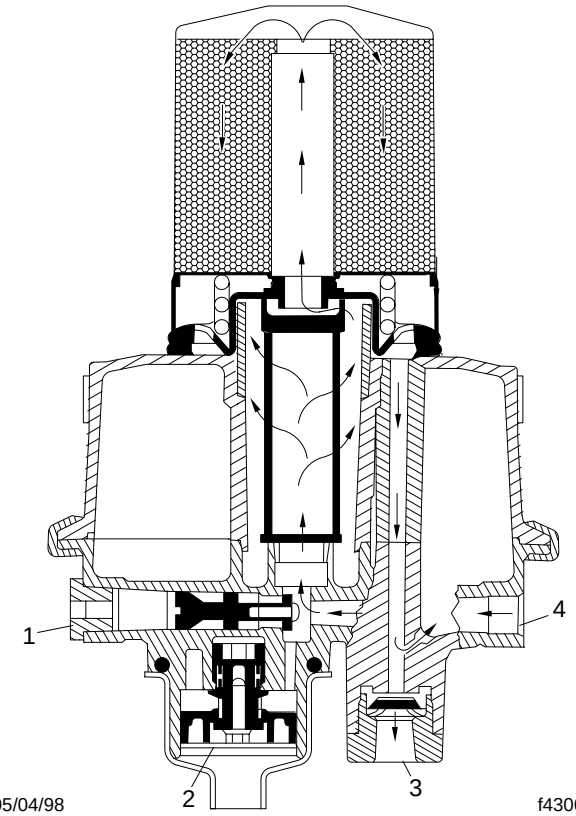
General Information

The function of the air dryer is to collect and remove air system contaminants in solid, liquid, and vapor form before they enter the brake system.

The air dryer consists of a replaceable desiccant cartridge, coalescent filter, purge valve, check valve, and Turbo-Saver™ Valve. The desiccant cartridge, coalescent filter, and purge valve housing assembly, which includes the heater and thermostat assembly, can be serviced without removing the air dryer from the vehicle.

Principles of Operation

Drying Cycle



1. Control Port
2. Purge Valve
3. Outlet Port
4. Inlet Port

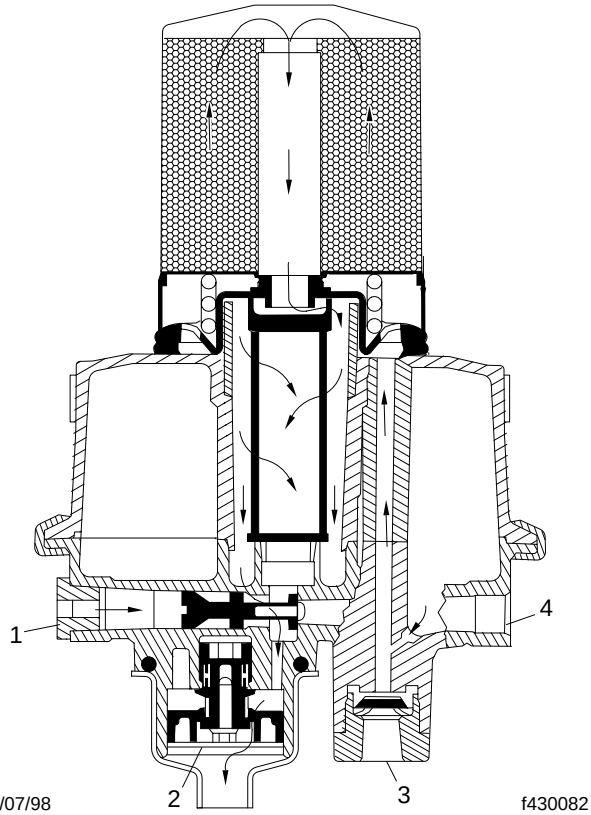
Fig. 1, Drying Cycle

During the drying cycle (**Fig. 1**), contaminated, wet compressed air at up to 160°F (71°C) coming from the air compressor enters the air dryer through the inlet port. The Turbo-Saver Valve, in the closed position, then forces the compressed air through the coalescent filter, where water droplets and contaminants are removed from the air stream.

The compressed air then moves through the desiccant cartridge bed and the remaining moisture is removed. Some of the clean, dry compressed air is diverted to the purge area to dry the desiccant bed. The balance flows through the outlet port into the vehicle air system.

General Information

Purge Cycle



1. Control Port
2. Purge Valve
3. Outlet Port
4. Inlet Port

Fig. 2, Purging Cycle

When the reservoir reaches the governor cutout pressure, air pressure from the governor unloading port enters the air dryer. This signal from the governor causes the Turbo-Saver Valve to shift, close and block the inlet, while simultaneously causing the purge valve to open and the purge cycle (**Fig. 2**) to begin. The sudden opening of the purge valve permits the pressurized air in the coalescent filter sump to flush moisture and contaminants from the housing. Decompressing rapidly, opening of the purge valve also back-flushes the desiccant bed and coalescent filter. Air trapped in the purged reservoir is metered through the purge orifice and allowed to slowly pass over the desiccant bed at a pressure slightly higher than atmospheric. The relatively small volume of air can easily absorb the water previously absorbed by the desiccant bed during the drying cycle. The moist air is then expelled through the purge valve.

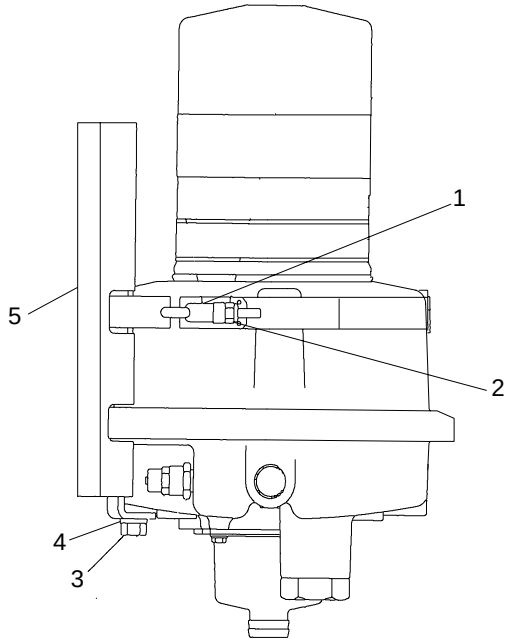
Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters, which may apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure, and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Don't disassemble a component until you have read and understood the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools, and observe all precautions pertaining to use of those tools.
5. Replacement hardware, tubing, hose, fittings, etc. should be the equivalent size, type, length, and strength of the original equipment.

   Make sure that when replacing tubing or hose, all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace devices with stripped threads or damaged parts. Repairs requiring machining should not be attempted.

Removal



1. Mounting Strap
2. Mounting Strap Locknut
3. 3/8-Inch Bolt
4. Lockwasher
5. Mounting Bracket

Fig. 1, Air Dryer Removal and Installation

WARNING

Before working on or around air brake systems and components, read Safety Precautions 100. Failure to do so could result in personal injury.

1. Park the vehicle on a level surface and chock the tires. Drain the air reservoirs.
2. Remove the air dryer. See **Fig. 1**.
   - 2.1 Mark and disconnect the air lines from the air dryer, and note the position of dryer ports relative to the vehicle.
   - 2.2 Unplug the vehicle wiring harness from the heater/thermostat assembly.
   - 2.3 Loosen the mounting strap locknut.
   - 2.4 Remove the 3/8-inch bolt from the bottom of the dryer.
   - 2.5 Remove the air dryer from the mounting bracket.

Installation

WARNING

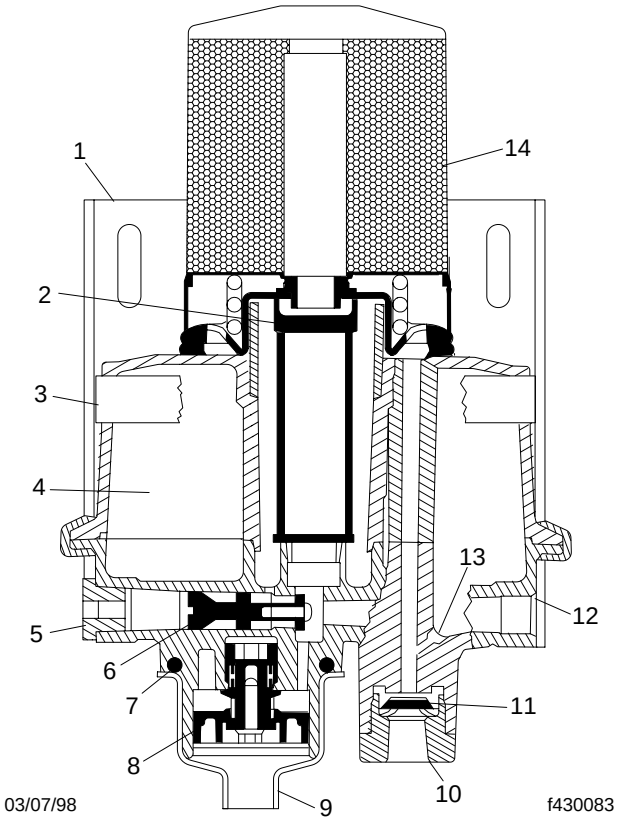
Before working on or around air brake systems and components, read Safety Precautions 100. Failure to do so could result in personal injury.

1. Position the air dryer through the mounting strap and bracket as noted in "Removal." See **Fig. 1**.
2. Insert the 3/8-inch bolt and lockwasher into the bottom of the dryer and tighten the bolt 20 to 25 lbf·ft (27 to 34 N·m).
3. Tighten the air dryer mounting strap locknut 50 lbf·in (565 N·cm).
4. As referenced earlier in "Removal," connect the air lines to the appropriate ports on the air dryer.
5. Connect the vehicle wiring harness to the air dryer heater and thermostat assembly connector. Plug it into the air dryer connector until the lock tab snaps in place.
6. Test the air dryer using the instructions in **Subject 170**.
7. Remove the chocks from the tires.

Air Dryer Disassembly, Inspection and Cleaning, and Assembly

Disassembly

Refer to **Fig. 1** when performing disassembly procedures.



1. Mounting Bracket
2. Coalescent Filter
3. Mounting Strap
4. Internal Purge Volume
5. Control Port
6. Turbo-Saver™ Valve
7. Heater
8. Purge Valve Assembly
9. Purge Exhaust Cover
10. Outlet Port
11. Outlet Check Valve
12. Inlet Port
13. Purge Orifice
14. Desiccant Cartridge

Fig. 1, Midland Air Dryer (sectional view)

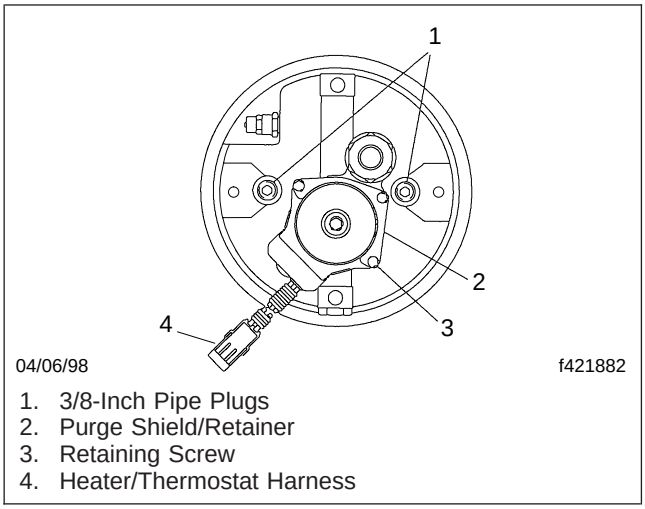
⚠ WARNING

Before working on or around air brake systems and components, read Safety Precautions 100. Failure to do so could result in personal injury.

1. Shut down the engine, apply the parking brake and chock the tires.
2. Drain the air reservoirs.

IMPORTANT: Do not proceed with disassembly until the dryer has completed the purge cycle and the compressor is fully unloaded.

3. Remove the air dryer. For instructions, see **Subject 110**.
4. Using a strap wrench, loosen the desiccant cartridge at the base of the cartridge and remove it by hand.
5. Remove the coalescent filter.
6. Remove and discard the O-ring on the threaded cartridge mounting nipple.
7. Remove the three screws holding the plastic purge shield in place. See **Fig. 2**. Discard the screws and the old purge shield.



1. 3/8-Inch Pipe Plugs
2. Purge Shield/Retainer
3. Retaining Screw
4. Heater/Thermostat Harness

Fig. 2, Air Dryer (bottom view)

8. Remove the pressure relief valve assembly with a 11/16-inch deep socket or box end wrench.
9. Using a 5/16-inch allen wrench, remove the two 3/8-inch pipe plugs (**Fig. 2**) from the bottom side of the lower housing. Drain any water or other contaminants from the unit.

Inspection and Cleaning

1. Inspect the bottom of the coalescent filter cavity for contaminants or debris. The presence of solid contaminants or debris indicates the purge valve,

Air Dryer Disassembly, Inspection and Cleaning, and Assembly

Turbo-Saver™ Valve and outlet check valve should also be serviced and/or replaced.

2. Clean any debris and/or contaminants from the interior of the air dryer.

Assembly

1. Install a new pressure relief valve. Tighten the valve 12 to 16 lbf·ft (16 to 22 N·m). If dry sealant is not present on the pipe threads, apply pipe sealant.

IMPORTANT: When installing the pressure relief valve, do not remove or damage the sponge rubber sleeve on the valve body. The sleeve is necessary to protect the valve from contamination.

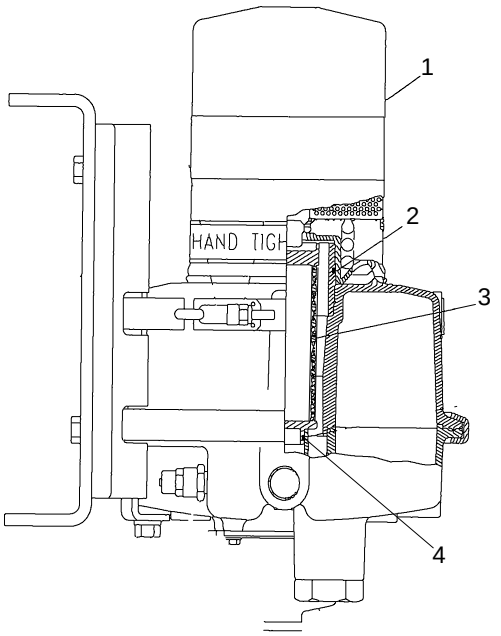
2. Position the heater in the recessed area in the bottom housing and install the new plastic purge shield and metal shield retainer with three new screws. Tighten each screw 30 to 50 lbf·in (339 to 565 N·cm).
3. Apply sealant to the 3/8-inch pipe plugs and install them in the bottom housing. Using a 5/16-inch allen wrench, tighten the screws 10 to 15 lbf·ft (14 to 20 N·m).
4. Install a small O-ring in the groove on the neck of the new coalescent filter. Apply a light coat of lubricant to the O-ring and insert the coalescent filter into the center bore of the upper housing. The filter must be centered in the cavity and the top of the filter must not extend above the cartridge mounting nipple.
5. Install the large O-ring in the groove on the cartridge mounting nipple. Apply a light coat of lubricant to the O-ring.
6. Apply a light coat of thread lubrication to the threads on the cartridge mounting nipple.
7. Apply a light coat of lubricant to the gasket on the desiccant cartridge and install the cartridge on the air dryer. Hand tighten the cartridge 1/2 to 1 full turn after the gasket makes contact.
8. Install the air dryer. For instructions, see **Subject 110**.

Desiccant Cartridge and Coalescent Filter Replacement

Replacement

⚠ WARNING

Before working on or around air brake systems and components, read Safety Precautions 100. Failure to do so could result in personal injury.



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1. Desiccant Cartridge
2. O-Ring
3. Coalescent Filter
4. O-Ring

Fig. 1, Air Dryer (sectional view)

1. Park the vehicle, shut down the engine and chock the tires.
2. Drain the vehicle air reservoirs.
3. Using a strap wrench, loosen the desiccant cartridge at the base of the cartridge. Spin the cartridge off by hand and discard it. See **Fig. 1**.
4. Remove the O-ring from the threaded neck and discard it.
5. Remove the coalescent filter and discard it.
6. Install a new small O-ring on the bottom of the coalescent filter in the O-ring groove.
7. Insert the coalescent filter with the O-ring end going into the air dryer opening first. The "X" section of the coalescent filter will then be facing out.
8. Install the new, medium-size O-ring over the threaded neck of the desiccant cartridge.
9. Screw on the desiccant cartridge until resistance is detected. Then, tighten the cartridge 1/4 to 3/4 of a turn by hand.
10. Perform the operational tests in **Subject 170**.
11. Remove the chocks from the tires.

Turbo-Saver Valve Replacement

⚠ WARNING

Before working on or around air brake systems and components, read Safety Precautions 100. Failure to do so could result in personal injury.

1. Shut down the engine, apply the parking brake, and chock the tires. Drain the air reservoirs.
2. Loosen the desiccant cartridge with a strap wrench at the base of the cartridge and spin off by hand.
3. Remove the coalescent filter.

NOTE: If necessary, replace the desiccant cartridge and coalescent filter during this procedure.

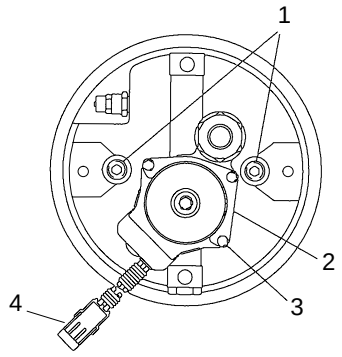
4. Remove the control port end cap and discard the O-ring.
5. Disconnect the inlet and control air lines from the dryer.
6. Using a large, flat-blade screwdriver in the control port side, and a 1/4-inch hex head screwdriver in the inlet side, loosen and remove the screw. Remove the turbo-saver piston and discard it. Using a long, needle-nose pliers, remove the valve disc through the coalescent filter housing.
7. Install the small O-ring on the turbo-saver piston body.
8. Using a long, needle-nose pliers, hold the valve disc in position through the coalescent filter housing.
9. Insert a 1/4-inch hex head thread forming screw through the dryer inlet, and through the valve disc. Lubricate the control port bore.
10. Through the control port opening, insert the new turbo-saver piston body and screw together. Tighten the screw 20 to 28 lbf·in (226 to 316 N·cm).
11. Install a new O-ring on the control port end cap and thread the end cap into the dryer. Tighten the end cap 35 to 50 lbf·ft (47 to 68 N·m).
12. Install the coalescent filter.
13. Thread the desiccant cartridge onto the dryer and hand tighten.
14. Connect the inlet and control air line.
15. Perform the operational checks in **Subject 170**.

Replacement

⚠ WARNING

Before working on or around air brake systems and components, read Safety Precautions 100. Failure to do so could result in personal injury.

1. Shut down the engine, apply the parking brake, and chock the tires. Drain the air reservoirs.
2. Remove the three hexhead screws and purge valve cover shield and set aside. See **Fig. 1**.



1. 3/8-Inch Pipe Plug
2. Retainer/Shield
3. Hexhead Screw
4. Heater/Thermostat Heater

Fig. 1, Purge Valve Replacement

3. Remove the large snap ring.
4. Using pliers, pull out the purge valve assembly and discard it.
5. Install the large and small O-rings on the new purge valve assembly.
6. Lubricate the purge piston bore.
7. Insert the new purge valve assembly in the dryer housing.
8. Install the new snap ring.
9. Install the purge valve cover shield and install the three hexhead screws. Tighten the screws 40 to 55 lbf·in (452 to 621 N·cm).
10. Remove the chocks.

Replacement

WARNING

Before working on or around air brake systems and components, read Safety Precautions 100. Failure to do so could result in personal injury.

1. Shut down the engine, apply the parking brake, and chock the tires. Drain the air reservoirs.
2. Disconnect the dryer outlet air line.
3. Remove the outlet end cap.
4. Remove the O-ring from the end cap. Discard the seal assembly, spring and O-ring.
5. Install the new O-ring on the outlet end cap.
6. Install the new seal assembly and spring. The seal assembly must be centered.
7. Thread the outlet end cap into the dryer body and tighten it 35 to 50 lbf·ft (68 to 81 N·m).
8. Connect the air outlet line.
9. Remove the chocks.

Operational Check

WARNING

Before working on or around air brake systems and components, read Safety Precautions 100. Failure to do so could result in personal injury.

1. Chock the tires, start the engine, and build the air pressure to 100 psi (689 kPa). Shut down the engine.
2. Check for air leaks at the inlet and the outlet of the dryer.
3. Correct any leakage. If leakage is detected, drain the air system and tighten the fittings.
4. Restart the engine and charge the air system to cut-out pressure. At cut-out pressure the purge valve opens and immediately expels a large volume of air, followed by a slow flow of air lasting about 30 seconds.
5. Check for leakage at the following locations to ensure that the air dryer does not cycle excessively.
    - Compressor unloader mechanism
    - Governor
    - Drain cock and safety valve in the supply reservoir
    - All air connections leading to and from the supply reservoir

For an air dryer air plumbing diagram, see **Specifications 400**.

Troubleshooting Tables

Problem—Long Purge Cycle (More Than 40 Seconds)

Problem—Long Purge Cycle (More Than 40 Seconds)	
Possible Cause	**Remedy**
The outlet check valve is damaged.	Replace the outlet check valve. See **Subject 160**.
The purge orifice is partially plugged.	Clean the orifice with a wire or drill bit.

Problem—Slow Wet Tank Build-Up

Problem—Slow Wet Tank Build-Up	
Possible Cause	**Remedy**
The filter and/or desiccant is plugged.	Replace the desiccant cartridge and coalescent filter. See **Subject 130**.

Problem—Water Appears in the Wet Tank

Problem—Water Appears in the Wet Tank	
Possible Cause	**Remedy**
The desiccant cartridge is plugged or saturated.	Replace the desiccant cartridge. See **Subject 130**.
There is no purge cycle.	Refer to the table "No Purge Cycle" in this subject.
The purge orifice is blocked.	Clean the purge orifice with a wire or drill bit.

Problem—Relief Valve Opens During Operation

Problem—Relief Valve Opens During Operation	
Possible Cause	**Remedy**
The relief valve is faulty.	Replace the relief valve.
There are restrictions in the air lines.	Check for damaged or crimped air lines between the dryer and wet tank. If necessary, replace the lines.

Problem—Purge Cycle Causes Compressor Cut-In

Problem—Purge Cycle Causes Compressor Cut-In	
Possible Cause	**Remedy**
The purge valve seals are leaking.	Replace the purge valve. See **Subject 150**.
The air line between the governor and the dryer is damaged or oversize.	Replace the air line. For instructions, see **Section 42.00**.

Troubleshooting

Problem—No Purge Cycle

Problem—No Purge Cycle	
Possible Cause	**Remedy**
The governor is damaged.	Disconnect the air line from the governor. Air should come from the governor line when the compressor unloads. If not, repair/replace the governor. For instructions, see **Group 13**.
The air line between the governor and the air dryer is restricted or frozen.	Ensure the air line is clear of debris and/or water (ice).
The purge valve is stuck.	Replace the purge valve. See **Subject 150**.

Problem—Air is Constantly Leaking from the Purge Valve

Problem—Air is Constantly Leaking from the Purge Valve	
Possible Cause	**Remedy**
The purge valve seal is damaged.	Replace the purge valve. See **Subject 150**.
There are dirt particles on the valve seat.	Remove and clean the purge valve. See **Subject 120**.
The purge valve is frozen.	Inspect the heater/thermostat assembly. See the table "Heater is Inoperative."
The governor is faulty.	Disconnect the air line to the purge valve. If the purge air stops and air comes from the governor line, repair or replace the governor. For instructions, see **Group 13**.

Problem—Heater is Inoperative

Problem—Heater is Inoperative	
Possible Cause	**Remedy**
A fuse is blown.	Check the fuse. If it is blown, replace it with an 8 to 10 amp fuse.
Wires are broken or a connection is bad.	Repair or replace the wiring to the heater.
The element or thermostat is damaged.	Replace the heater/thermostat assembly.

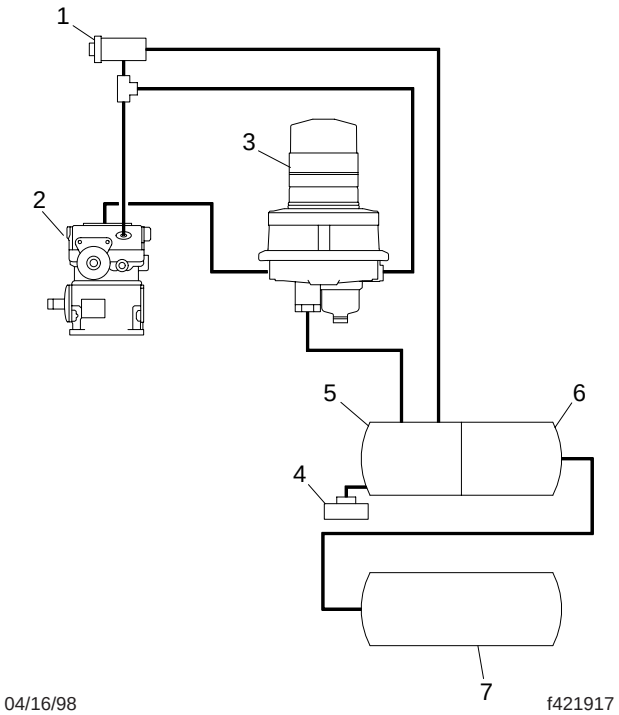
Problem—The Heater Stays on Continuously

Problem—The Heater Stays on Continuously	
Possible Cause	**Remedy**
Damaged thermostat	Replace the heater assembly.

For an air dryer air plumbing diagram, see **Fig. 1**.

Torque Values		
Description	**Torque**	
	lbf·in (N·cm)	**lbf·ft (N·m)**
3/8-Inch Mounting Bolt	—	20 to 25 (27 to 35)
Air Dryer Mounting Strap Locknut	50 (565)	—
Pressure Relief Valve	—	12 to 16 (16 to 22)
Purge Shield Retainer Screws	30 to 50 (339 to 565)	—
3/8-Inch Pipe Plugs	—	10 to 15 (14 to 20)
Turbo-Saver™ Piston Body Screw	20 to 28 (226 to 316)	—
Port End Cap	—	35 to 50 (47 to 68)

Table 1, Torque Values



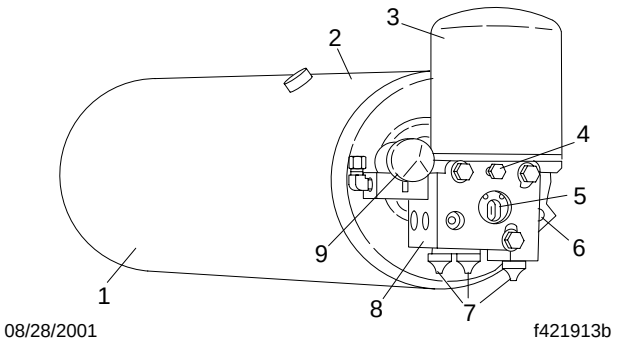
1. Governor
2. Air Compressor
3. Air Dryer
4. Automatic Drain Valve
5. Wet Tank
6. Primary Air Reservoir
7. Secondary Air Reservoir

Fig. 1, Air Dryer Air Plumbing Diagram

General Information

The function of the dryer reservoir module (DRM) (**Fig. 1**) is to provide the vehicle with an integrated air dryer, secondary reservoir, purge volume, and governor.

NOTE: Some DRM configurations also include an integrated primary reservoir.



NOTE: DRM shown without splash shield.

1. Integrated Reservoir (Secondary Volume)
2. Integrated Reservoir (Purge Volume)
3. Desiccant Cartridge
4. Safety Valve
5. Heater/Thermostat Assembly
6. Auxiliary Delivery Port
7. Pressure Protection Valves
8. AD-IS Air Dryer
9. Governor

Fig. 1, Dryer Reservoir Module

Principles of Operation

The air dryer collects and removes air system contaminants in solid, liquid, and vapor form before they enter the brake system. It provides clean, dry air to the components of the brake system, which also increases the life of the system.

Charge Cycle

When the compressor is loaded, compressed air, oil, oil vapor, water, and water vapor flow through the compressor discharge line to the supply port of the air dryer body.

As air travels through the air dryer assembly, its temperature falls, causing some of the contaminants to condense and drop to the bottom of the air dryer assembly, ready to be expelled at the next purge cycle. See **Fig. 2**.

The air then flows into the desiccant cartridge. Once in the desiccant cartridge, air flows through an oil separator that removes oil and solid contaminants.

Air then flows into the desiccant drying bed. Air flowing through the desiccant becomes progressively dryer as water vapor adheres to the desiccant material.

Dry air exits the bottom of the desiccant cartridge and flows through the center of the base assembly. The air then flows to the delivery check valve, to the safety valve and also through an orifice plug into the purge volume reservoir. Air traveling through the delivery check valve flows to the governor and three pressure protection valves.

As pressure builds during the initial charge, the purge volume fills. When the air pressure reaches 103 psi (710 kPa), the first pressure protection valve opens, filling the primary reservoir. When the primary reservoir pressure reaches 109 psi (752 kPa) the second pressure protection valve opens and air is supplied to the secondary reservoir and accessory pressure protection valve. When air pressure in the secondary reservoir reaches 85 psi (586 kPa), the remaining pressure protection valve opens and supplies air to the accessories.

NOTE: There is no external air line from the air dryer to the secondary reservoir. Air is supplied by a line passing through the purge reservoir.

The air dryer will remain in the charge cycle until the air brake system pressure builds to the governor cutout setting of approximately 130 psi (896 kPa).

Purge Cycle

When air brake system pressure reaches the cutout setting of the governor, the governor unloads the compressor and the purge cycle begins. When the governor unloads the compressor, it pressurizes the compressor unloader mechanism and the dryer control port. The purge piston moves in response to air pressure, causing the purge valve to open and the turbo cutoff valve to close. When the purge valve opens, water and contaminants are expelled. Air flowing through the desiccant cartridge changes direction and begins to flow toward the open purge valve. Oil and solid contaminants collected in the oil separator are removed by air flowing from the purge

General Information

volume, through the desiccant drying bed, and out through the open purge valve. See **Fig. 3**.

The purge cycle lasts only a few seconds and is detected by an audible burst of air at the air dryer exhaust.

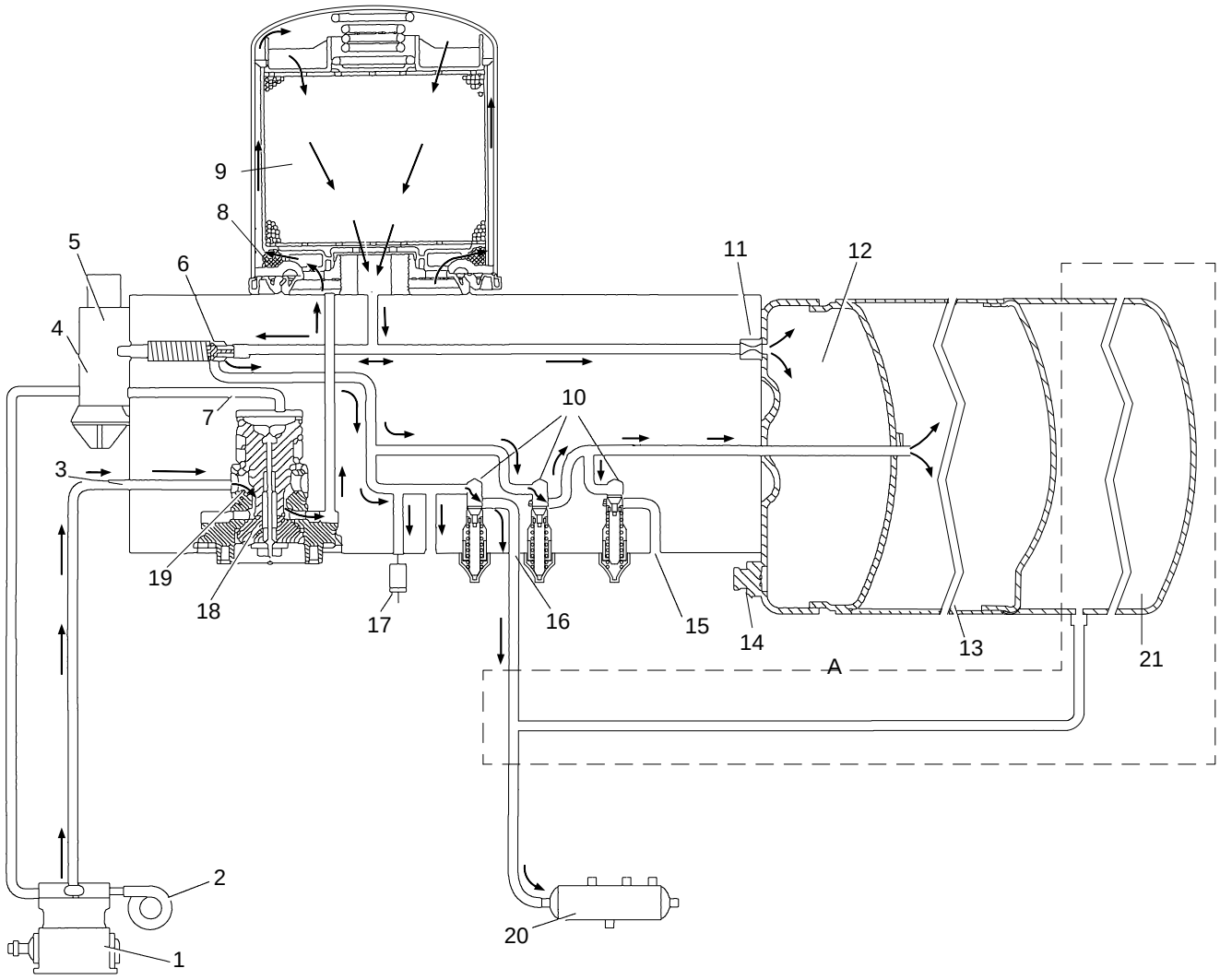
The reactivation of the desiccant drying bed begins as dry air flows from the purge volume, through the purge orifice, and into the desiccant bed. Pressurized air from the purge volume expands after passing through the purge orifice; its pressure is lowered and its volume is increased. The flow of dry air through the drying bed reactivates the desiccant material by removing the water vapor adhering to it. Approximately 30 seconds is required for the entire purge volume of a standard air dryer to flow through the desiccant dryer bed.

The delivery check valve assembly prevents air pressure in the brake system from returning to the air dryer during the purge cycle. After the purge cycle is complete, the air dryer is ready for the next charge cycle to begin.

Turbo Cutoff Feature

The primary function of the turbo cutoff valve is to prevent loss of turbocharger air pressure through the air dryer in systems where the compressor intake is connected to the engine turbocharger.

During the purge cycle, the downward travel of the purge piston is stopped when the turbo cutoff valve contacts its mating metal seat in the purge valve housing. With the turbo cutoff valve seated (closed position), air in the compressor discharge line and air dryer inlet port cannot enter the air dryer. This maintains turbocharger boost pressure to the engine.

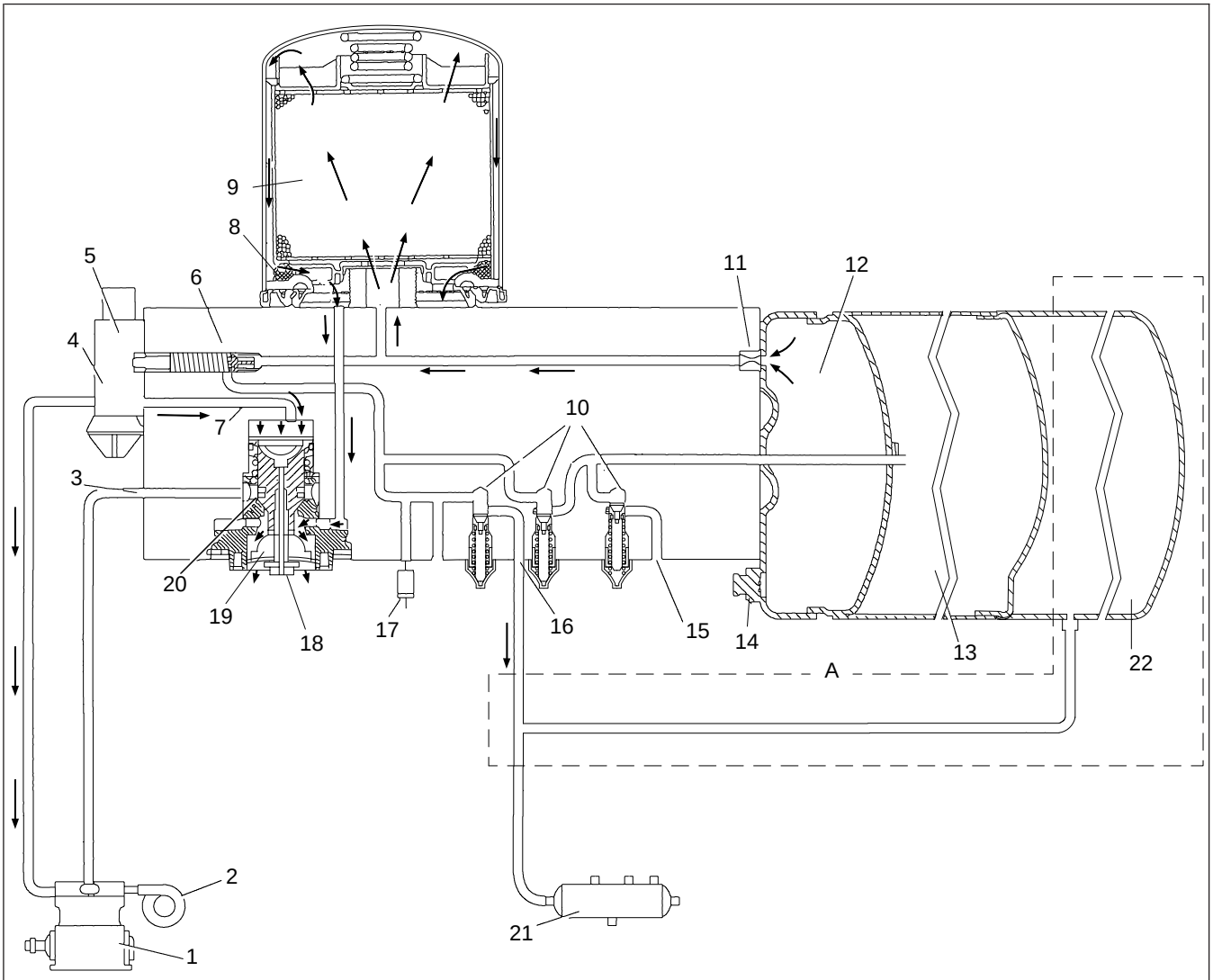


A. NOTE: Class 8 vehicles have an integrated primary reservoir.

1. Compressor
2. Engine Turbo
3. Inlet Port
4. Unloader Port
5. Governor
6. Delivery Check Valve
7. Purge Control Passage
8. Oil Separator
9. Desiccant Bed
10. Pressure Protection Valves
11. Purge Orifice
12. Integrated Reservoir (Purge Volume)
13. Integrated Reservoir (Secondary Volume)
14. Purge Volume Drain Cock
15. Auxiliary Port
16. Primary Port
17. Safety Valve
18. Purge Valve (closed)
19. Turbo Cutoff Valve (open)
20. Primary Reservoir
21. Integrated Reservoir (Primary Volume)

Fig. 2, Air Dryer Charge Cycle

General Information



A. NOTE: Class 8 vehicles have an integrated primary reservoir.

1. Compressor
2. Engine Turbo
3. Inlet Port
4. Unloader Port
5. Governor
6. Delivery Check Valve
7. Purge Control Passage
8. Oil Separator
9. Desiccant Bed
10. Pressure Protection Valves
11. Purge Orifice
12. Integrated Reservoir (Purge Volume)
13. Integrated Reservoir (Secondary Volume)
14. Purge Volume Drain Cock
15. Auxiliary Port
16. Primary Port
17. Safety Valve
18. Exhaust
19. Purge Valve (open)
20. Turbo Cutoff Valve (closed)
21. Primary Reservoir
22. Integrated Reservoir (Primary Volume)

Fig. 3, Air Dryer Purge Cycle

Safety Precautions

Before attempting to work on the air brake system, observe the following precautions:

- Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized. The wheels of the vehicle must always be chocked so that depletion of air will not permit the vehicle to roll.
- When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.
- Hoses will whip dangerously if disconnected under pressure. Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.
- As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber pushrods and spring actuators that apply automatically with the loss of pressure. This also applies when checking the service brake system.
- Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.
- Used reservoirs must not be used as replacements in order to eliminate the possibility of component failure.
- The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured in order to prevent valve failure.
- Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.
- To avoid injury, keep clear of the air chamber pushrod when brakes are applied or when air is exhausted from the system.

Replacement

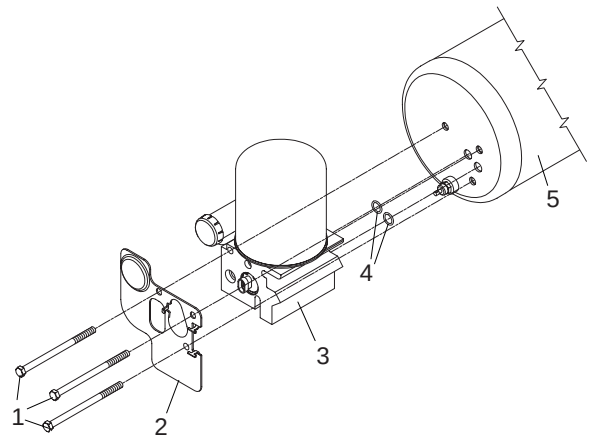
WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

1. Park the vehicle on a level surface, shut down the engine, apply the parking brake, and chock the tires.
2. Drain the air reservoirs, including the purge reservoir drain valve located under the air dryer.
3. Mark and remove the air lines from the air reservoir.

IMPORTANT: It may be necessary to remove the air reservoir to replace the air dryer. For instructions on air reservoir removal, see **Subject 160**.

4. Unplug the wiring harness from the heater/thermostat assembly.
5. Remove the three capscrews fastening the air dryer to the air reservoir. See **Fig. 1**.



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1. Capscrews
2. Splash Shield
3. Air Dryer
4. O-Rings
5. Reservoir

Fig. 1, Air Dryer Removal and Installation

6. Remove the air dryer.
7. Remove the governor and delivery check valve from the air dryer. For instructions, see **Subject 130**.
8. Remove the desiccant cartridge. For instructions, see **Subject 120**.

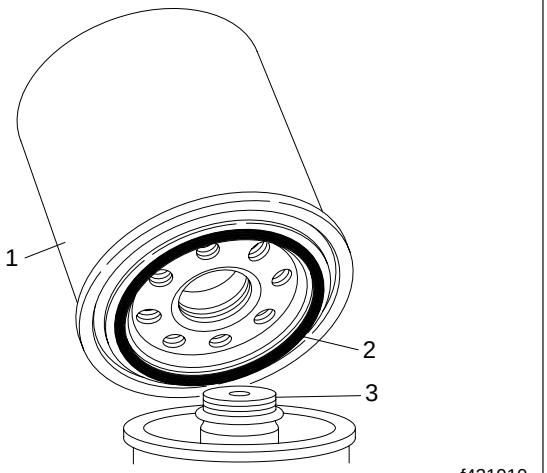
Installation

1. Install the delivery check valve and governor onto the air dryer. For instructions, see **Subject 130**.
2. If removed, install the desiccant cartridge. For instructions, see **Subject 120**.
3. Install the air dryer, making sure the two O-rings are installed between the air dryer and air reservoir. Use the three capscrews to fasten the air dryer to the reservoir. Tighten the capscrews 30 to 35 lbf·ft (41 to 47 N·m). See **Fig. 1**.
4. Connect the air lines and plug the wiring harness into the heater/thermostat assembly.
5. Perform the operational tests in **Subject 170**.

Replacement

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.



1. Desiccant Cartridge
2. Cartridge Sealing Ring
3. Threaded Base Post

Fig. 1, Desiccant Cartridge Replacement

1. Park the vehicle, shut down the engine, apply the parking brake, and chock the tires.
2. Drain the air reservoirs, including the purge reservoir drain valve located under the air dryer.

IMPORTANT: It may be necessary to remove the air reservoir to replace the desiccant cartridge. For instructions on air reservoir removal and installation, see **Subject 160**.

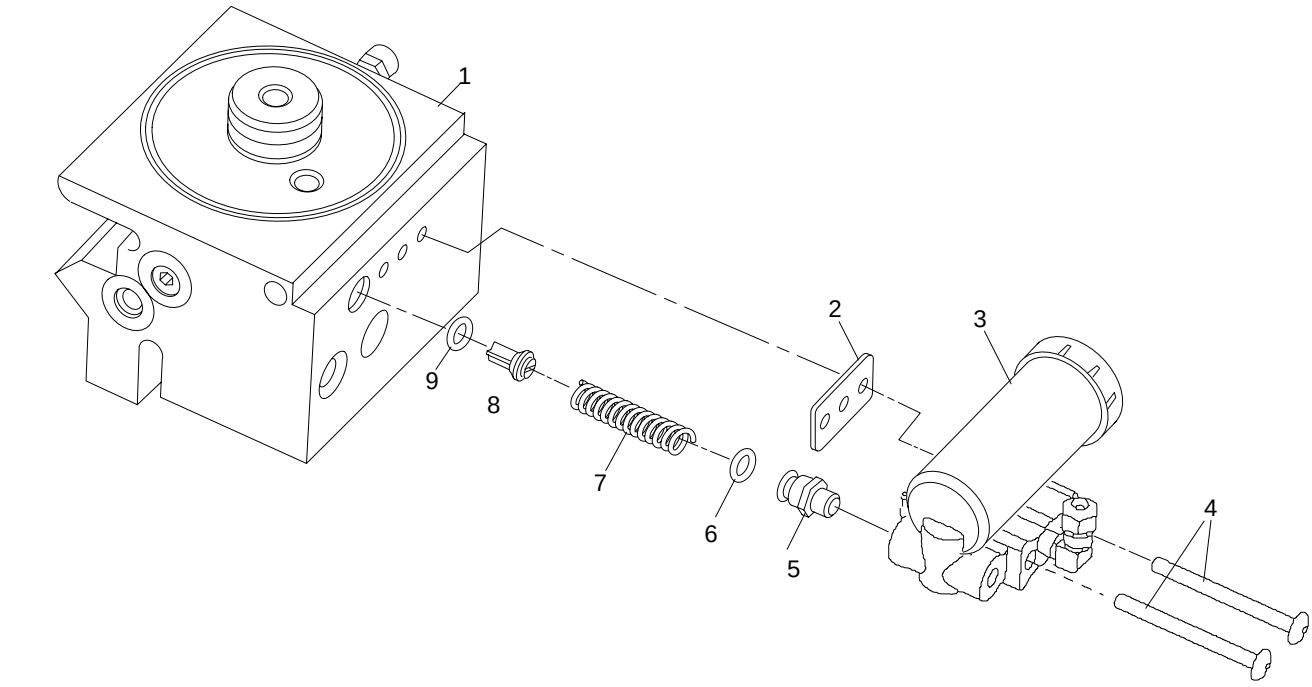
3. Using a strap wrench or equivalent, loosen the desiccant cartridge. Spin the cartridge off by hand and discard it. See **Fig. 1**.
4. On the new desiccant cartridge, lubricate the sealing rings with silicone grease.

IMPORTANT: Only use the silicone grease supplied with AlliedSignal replacement kits.

5. Screw the desiccant cartridge onto the body, by hand, until the seal makes contact with the body. Rotate the cartridge clockwise about one full turn. If necessary, use a strap wrench to tighten the cartridge.
6. Remove the chocks from the tires.

Delivery Check Valve and Governor Replacement

Replacement



1. Air Dryer Base
2. Gasket
3. Governor
4. Capscrews
5. Adaptor
6. O-Ring
7. Spring
8. Check Valve Body
9. O-Ring

Fig. 1, Delivery Check Valve Replacement

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

1. Park the vehicle on a level surface, shut down the engine, apply the parking brake, and chock the tires.
2. Drain the air reservoirs, including the purge reservoir drain valve located under the air dryer.

IMPORTANT: It may be necessary to remove the air reservoir to replace the delivery check valve. For instructions on air reservoir removal and installation, see **Subject 160**.

3. Disconnect the air line from the governor and mark it for later reference. Remove the capscrews attaching the governor to the air dryer. See **Fig. 1**.
4. Remove the governor, adaptor fitting, and the adaptor O-ring. Remove the governor gasket and discard.
5. Remove the spring and check valve.
6. Lubricate the new smaller O-ring and check valve body with silicone grease.

IMPORTANT: Only use the silicone grease supplied with AlliedSignal replacement kits.

7. Install the O-ring on the check valve body and push the O-ring down, over the longer set of three guide lands, until it is in the O-ring groove of the check valve body.
8. Install one end of the check valve spring over the check valve's shorter set of three guide lands.

Delivery Check Valve and Governor Replacement

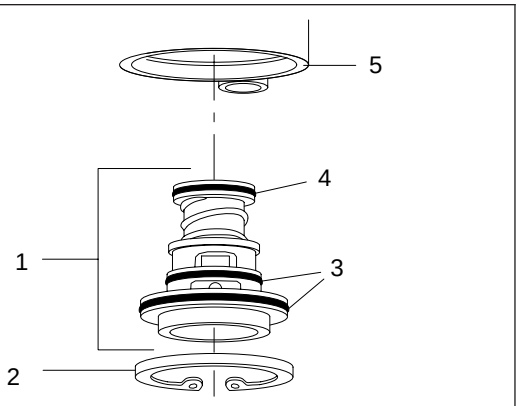
Turn the valve about 1/4 turn while holding the spring, if necessary, to secure the valve in place. Install the assembled check valve body, O-ring, and spring in the delivery port so the O-ring rests on its seat and the free end of the spring is visible.

9. Install the adaptor fitting into the governor. Using the silicone grease, lubricate the remaining larger O-ring, and install it into the groove of the adaptor. Install the gasket supplied in the kit. Install the governor and torque the capscrews 10 lbf·ft (14 N·m).
10. Perform the operational tests in **Subject 170**.
11. Remove the chocks

Replacement

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.



1. Purge Valve Assembly
2. Retaining Ring
3. O-Rings
4. Quad-Ring
5. Air Dryer

Fig. 1, Purge Valve Replacement

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Drain the air reservoirs, including the purge reservoir drain valve located under the air dryer.
3. Remove the purge valve assembly from the air dryer end cover. See **Fig. 1**.
   - 3.1 Remove and discard the snap ring that secures the purge valve assembly in the end cover.
   - 3.2 Remove the purge valve assembly.
4. Lubricate the new O-rings and O-ring grooves of the new purge valve assembly.
5. Lubricate the end cover bore of the new purge valve assembly.

IMPORTANT: Use only the silicone grease supplied with the AlliedSignal replacement kit.

6. Install the two new O-rings on the purge valve housing cover and the new quad-ring on the purge piston.
7. Install the new purge valve assembly in the end cover while making sure the purge valve housing is fully seated against the end cover.
8. Install the new retaining ring in its groove in the end cover.
9. Perform the operational tests in **Subject 170**.
10. Remove the chocks from the tires.

Replacement

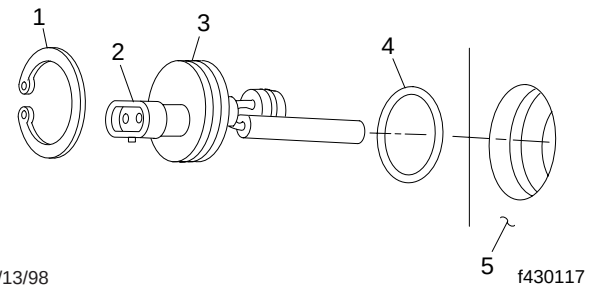
WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

1. Shut down the vehicle, apply the parking brake, and chock the tires.

IMPORTANT: It may be necessary to remove the air reservoir to replace the heater and thermostat. For instructions on air reservoir removal, see **Subject 160**.

2. Remove the splash shield cover. It is secured with three lock tabs.
3. Lift the lock tab on the vehicle wiring harness connector and disconnect it from the air dryer base.
4. Remove and discard the retaining ring that secures the heater and thermostat assembly in the air dryer body.
5. Carefully pull the heater and thermostat assembly straight out of the air dryer body and discard it. See **Fig. 1**.



1. Retaining Ring
2. Heater/Thermostat Connector Plug
3. Heater/Thermostat Assembly
4. O-Ring
5. Air Dryer Body

Fig. 1, Heater and Thermostat Assembly

6. Using the grease provided with the AlliedSignal replacement kit, lubricate the O-ring groove and O-ring of the new assembly with silicone grease.

IMPORTANT: Do not lubricate the heater stick or thermostat.

7. Install the O-ring on the heater/thermostat assembly. Then, slide the assembly into the air dryer body, making sure not to scrape insulation from the wires.
8. Install the retaining ring in the groove of the air dryer body, making certain that it is fully seated in the groove.
9. Remove the protective cover from the assembly.
10. Before proceeding, turn the ignition on without starting the engine. Make sure vehicle power is present at the contacts of the vehicle wire harness.
11. Remove the chocks from the tires.

Replacement

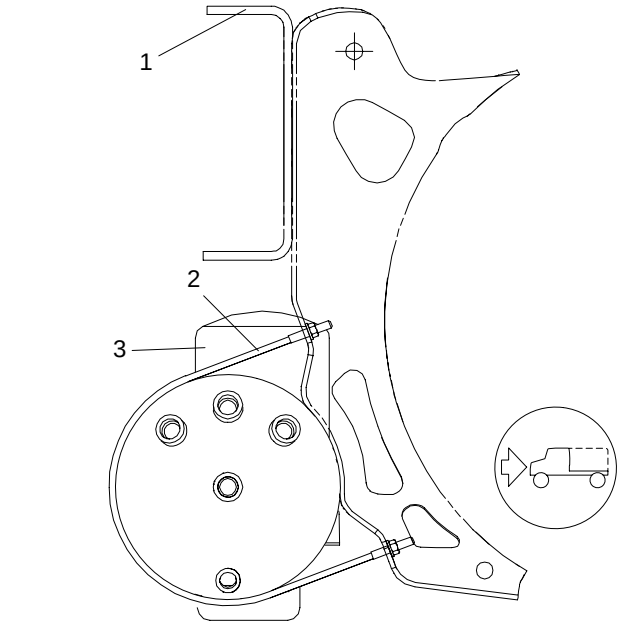
NOTE: The dryer reservoir module (DRM) can be mounted in various locations, depending on the vehicle configuration. The DRM is typically mounted under the driver's-side steps or along the frame rail, behind the cab.

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Drain the air reservoirs, including the purge reservoir drain valve located under the air dryer.
3. Mark and disconnect all reservoir air lines and couplers for later assembly. Cap the exposed ports tightly to keep out contaminants. If access is limited, remove the components after removing the reservoir from its mount.
4. Remove the reservoir. The DRM is installed along the frame rail using a strap fastener (**Fig. 1** or **Fig. 2**), remove the air dryer. For instructions, see **Subject 110**. Then, remove the reservoir strap fasteners and remove the reservoir.

NOTE: If access is limited, connect all air lines and couplers to the new reservoir, removing the caps as each component is installed.

5. Install the reservoir using the straps. Tighten the fasteners 30 to 40 lbf·ft (41 to 54 N·m). Tighten the lower strap fastener 136 lbf·ft (184 N·m). Then, install the air dryer. For instructions, see **Subject 110**.
6. As marked earlier, connect all air lines and couplers to the new reservoir, removing the caps as each component is installed. Tighten the connections as instructed elsewhere in this group.

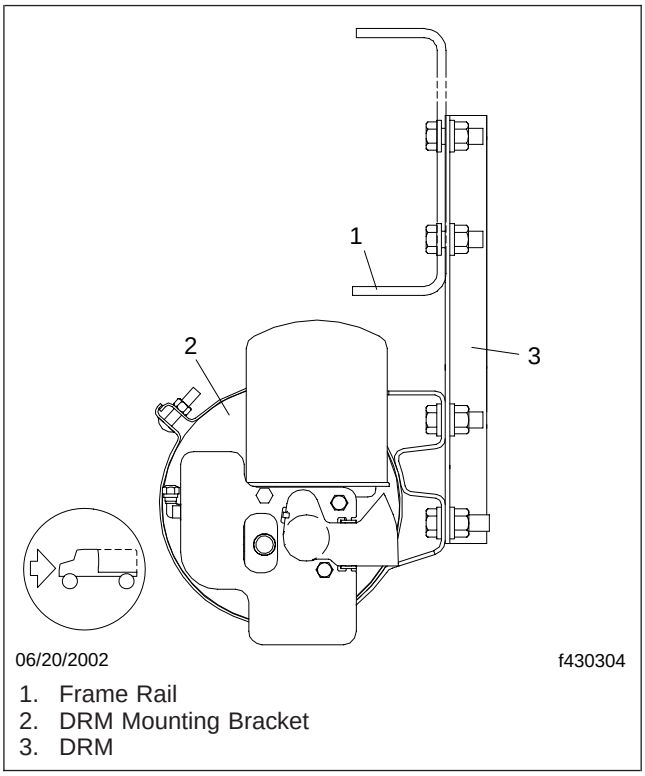
   Install the air dryer. For instructions, see **Subject 110**.
7. Perform operational test in **Subject 170**.
8. Remove the chocks from the tires.



1. Frame Rail
2. U-Bolt Strap
3. DRM

Fig. 1, Dryer Reservoir Module (fuel-tank bracket mounted)

Air Reservoir Replacement



1. Frame Rail
2. DRM Mounting Bracket
3. DRM

Fig. 2, Dryer Reservoir Module (frame-rail mounted)

Operational Tests

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.

1. Park the vehicle, shut down the engine, and chock the tires.
2. Install an accurate pressure gauge in one of the spare governor ports labeled "RES."
3. Close all drain cocks and start the engine. Build the air system to governor cutout and shut down the engine.
4. Check all air lines and fittings leading to and from the air dryer for leakage. Note the pressure on the air gauge after the governor cutout pressure is reached, a rapid loss of pressure could indicate a leak at the delivery check valve, governor, unloader piston in the compressor purge valve (purge piston), D-ring seals between the dryer and the reservoir, reservoirs or points downstream from the reservoirs.
5. Test the delivery check valve for leakage.
   - 5.1 Build system pressure to governor cutout. Wait 2 minutes for completion of purge cycle. Using soap solution at exhaust of purge valve, leakage should not exceed a 1 inch bubble in less than 5 seconds.
   - 5.2 Allow a full minute for the normal dryer purge cycle to empty the purge reservoir, switch off the engine and "fan" the brakes so that the system pressure reaches governor cut-in. The purge valve will return to its closed position. The purge reservoir has a drain valve which is opened by moving the center lever away from its closed position.
   - 5.3 Open the drain valve and wait 10 seconds to allow any residual purge pressure to be released. Release the lever, closing the drain valve.
   - 5.4 Carefully remove the air dryer cartridge using a strap wrench and then test for air leaking through the center of the threaded boss by applying a soap solution to the boss.
   - 5.5 Replace the delivery check valve if there is excessive leakage (exceeding a 1 inch bubble in 5 seconds).
   - 5.6 Regrease the seal on the air dryer cartridge before reinstalling. Be sure the drain valve on the purge reservoir is not leaking before restoring vehicle to service.

NOTE: If after replacing the delivery check valve, rapid loss of system air pressure continues, the delivery check valve and turbo cut-off valve are still leaking. Check the valves.

6. Check for excessive leakage around the purge valve with the compressor in the loaded mode (compressing air). Apply a soap solution to the purge valve exhaust port and observe that leakage does not exceed a 1-inch bubble in 1 second. If the leakage exceeds the maximum specified, refer to **Troubleshooting 300**.
7. Build up system pressure to governor cutout and note that AD-IS purges with an audible escape of air. Fan the service brakes to reduce system air pressure to governor cut-in. Note that the system once again builds to full pressure and is followed by an AD-IS purge. If system does not follow this pattern, refer to **Troubleshooting 300**.
8. Check the operation of the end cover heater and thermostat assembly during cold weather operation as follows:
   - 8.1 Check the electric power to the air dryer. With the ignition or engine kill switch in the ON position, check for voltage to the heater and thermostat assembly using a voltmeter or test-light. Unplug the electrical connector at the air dryer and place the test leads on each of the connections of the female connector on the vehicle power lead. If there is no voltage, look for a blown fuse, broken wires, or corrosion in the vehicle wiring harness. Check to see if a good ground path exists.
   - 8.2 Test the thermostat and heater operation. Turn off the ignition switch and cool the thermostat and heater assembly to below 40°F (4°C). Using an ohmmeter, check

Operational Tests

the resistance between the electrical pins in the air dryer connector half. The resistance should be 1.5 to 3.0 ohms for the 12-volt heater assembly and 6 to 9 ohms for the 24-volt heater assembly.

Warm the thermostat and heater assembly to about 90°F (32°C) and check the resistance again. The resistance should exceed 1000 ohms. If the resistance values obtained are within the stated limits, the thermostat and heater assembly is operating properly. If the resistance values obtained are outside the stated limits, replace the heater and thermostat assembly. For instructions, see **Subject 150**.

9. Check the pressure protection valves. Observe the pressure gauges of the vehicle as system pressure builds from zero. The primary gauge should rise until it reaches approximately 109 psi (752 kPa), then level off as the second pressure protection valve opens and allow the secondary volume to build. When the secondary pressure gauge passes through approximately 85 psi (586 kPa) there should be an associated leveling off of pressure as the third and fourth pressure protection valves open. Then, both the primary and secondary gauges should reach their full pressure of about 130 psi (896 kPa)
10. Remove the chocks.

Troubleshooting Tables

Problem—Air Dryer is Constantly Purging (Cycling) or Purging Excessively

Problem—Air Dryer is Constantly Purging (Cycling) or Purging Excessively	
Possible Cause	**Remedy**
There is excessive system leakage.	Using a soap-and-water solution, test for leakage at the air line fittings, drain cock (or valve), and system valves. Repair or replace as necessary. NOTE: A drop of 3 psi (21 kPa) in system air pressure per minute is normal.
The application air lines are leaking excessively.	Check the application air line, brake valve, and the service and parking brake chambers for air leaks. Repair or replace the damaged component(s).
The delivery check valve leaking excessively.	Replace the Check Valve. See **Subject 130**.
The compressor unloader O-rings are leaking excessively.	Troubleshoot the compressor. See **Group 13**.
Defective Governor	Replace the governor. See **Subject 130**.

Problem—There is Water in the Air Reservoirs

Problem—There is Water in the Air Reservoirs	
Possible Cause	**Remedy**
Maximum air dryer inlet temperature is exceeded due to improper discharge line length or improper line material.	Check for excessive debris build-up in the discharge line. Replace line in necessary.
The air dryer is not purging.	See **Problem—System Will Not Charge**
Purge time is insufficient due to excessive system leakage.	See **Problem—Air Dryer is Constantly Purging (Cycling)**
The air by-passes the desiccant cartridge assembly.	If the vehicle uses a Holset compressor, inspect the feedback check valve for proper installation and operation.
The compressor is running loaded for long periods of time.	Check the vehicle air system for leakage.
The desiccant cartridge requires replacement.	Replace the desiccant cartridge. See **Subject 120**.

Problem—Safety Valve on the Air Dryer is Exhausting Air

Problem—Safety Valve on the Air Dryer is Exhausting Air	
Possible Cause	**Remedy**
There is a defective delivery check valve in the end cover of the air dryer.	Test to determine if air is passing through the check valve. Repair or replace the check valve. For replacement, see **Subject 130**.
The air system pressure is over 140 psi (965 kPa).	Replace the governor.
The safety valve setting is too low.	Replace the safety valve.

Troubleshooting

Problem—Constant Exhaust of Air at the Air Dryer Purge Valve

Problem—Constant Exhaust of Air at the Air Dryer Purge Valve	
Possible Cause	**Remedy**
The air dryer purge valve is leaking excessively.	Test for leakage. With the compressor loaded, apply soap solution on the purge valve exhaust. If necessary, replace the purge valve. For instructions, see **Subject 140**.
The governor is defective.	Check the governor for proper "cut-in" and "cut-out" pressure, and excessive leakage in both positions. Repair or Replace the governor. For replacement instructions, see **Group 13**.
The purge valve is frozen open. The heater and thermostat, wiring, or blown fuse.	Perform the heater operating test in **Subject 160**.
There is excessive system leakage.	See **Problem—Air Dryer is Constantly Purging (Cycling)**
The air dryer delivery check valve is defective.	See **Problem—Air Dryer is Constantly Purging (Cycling)**
The turbo cutoff valve is leaking.	Repair or replace the turbo cutoff valve. For instructions, see **Subject 140**.
The purge valve control piston is leaking.	Repair or replace the purge valve. For instructions, see **Subject 140**.

Problem—The Air System Will Not Charge

Problem—The Air System Will Not Charge	
Possible Cause	**Remedy**
The inlet and outlet air connections are reversed.	Connect the compressor discharge to the air dryer supply port. Reconnect the lines properly.
Kinked or blocked discharge line.	Check to determine if air passes through the discharge line. Check for kinks, bends, excessive carbon deposits, or ice blockage.
There are excessive bends in the discharge line (water collects and freezes).	The discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.
The turbo cutoff valve is stuck closed.	Repair or replace the turbo cutoff valve. For instructions, see **Subject 140**.
The purge valve is leaking excessively.	Repair or replace the purge valve. For instructions, see **Subject 140**.

Problem—The Air Dryer Does Not Purge or Exhaust Air

Problem—The Air Dryer Does Not Purge or Exhaust Air	
Possible Cause	**Remedy**
The governor adaptor is plugged.	Test to determine if air flows through the purge control port when the compressor is unloaded. Check for adaptor obstruction. See **Problem—Constant Exhaust of Air at the Air Dryer Purge Valve**
The air dryer purge valve is faulty.	If air is flowing through the purge valve in the "Remedy" above, repair or replace the purge valve. For replacement instructions, see **Subject 140**.
There are excessive bends in the discharge line (water collects and freezes).	The discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.
The governor is defective.	Check the governor for proper "cut-in" and "cut-out" pressure, and excessive leakage in both positions. Repair or Replace the governor. For replacement instructions, see **Group 13**.

Problem—The Air Dryer Does Not Purge or Exhaust Air	
Possible Cause	**Remedy**
The purge valve control piston is leaking.	Repair or replace the purge valve. For instructions, see **Subject 140**.

Problem—Desiccant Material is Being Expelled from the Air Dryer Purge Valve Exhaust

Problem—Desiccant Material is Being Expelled from the Air Dryer Purge Valve Exhaust	
Possible Cause	**Remedy**
The air dryer is not securely mounted.	Replace the air dryer. For instructions, see **Subject 110**.
The desiccant cartridge is saturated or malfunctioning.	Replace the air dryer. For instructions, see **Subject 110**.
The compressor is passing excessive oil.	Troubleshoot the compressor. See **Group 13**. If necessary, replace the air dryer. For instructions, see **Subject 110**.

Problem—"Pinging" Noise is Excessive During Compressor Loading Cycle

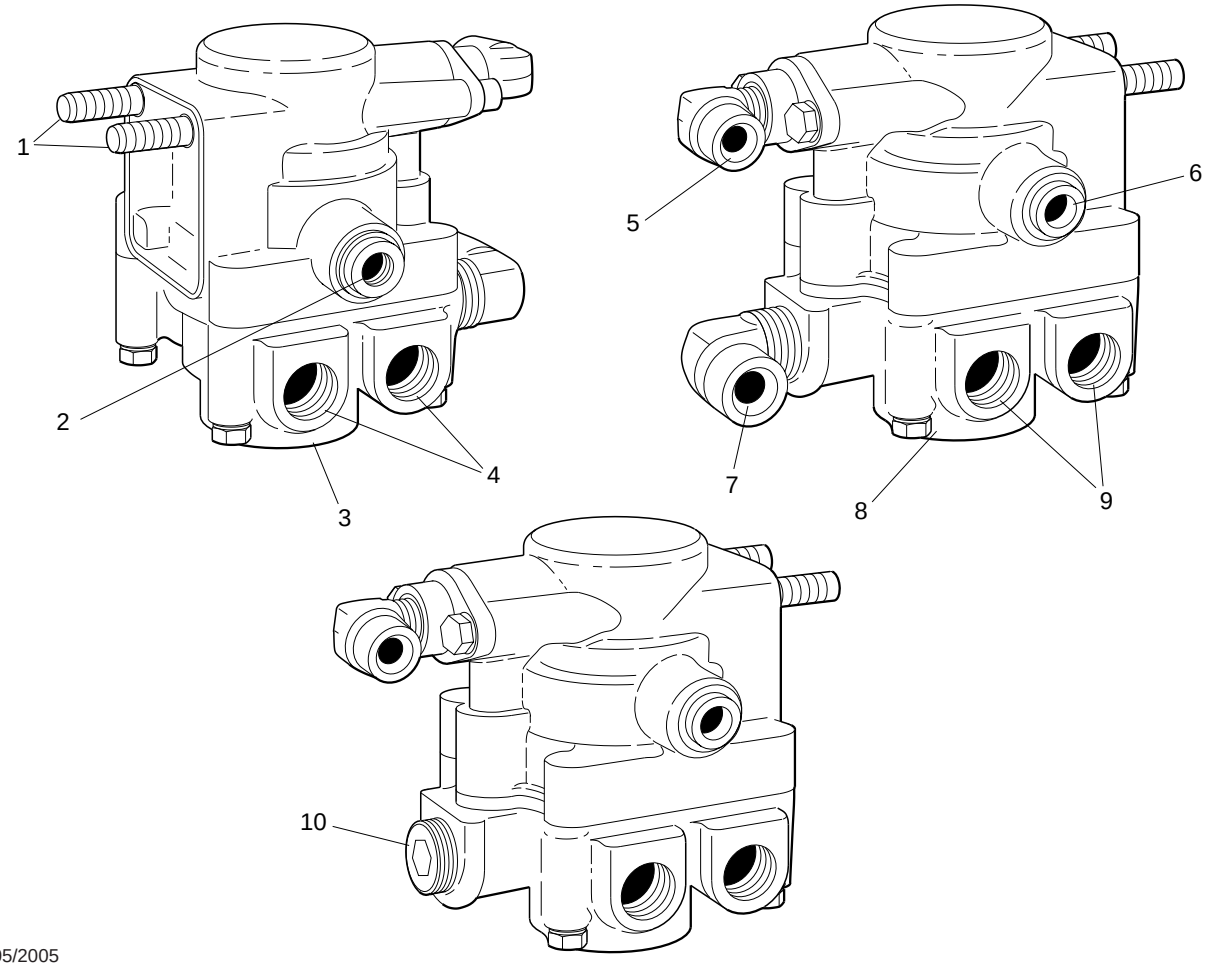
Problem—"Pinging" Noise is Excessive During Compressor Loading Cycle	
Possible Cause	**Remedy**
The compressor is a single cylinder with high pulse cycles.	A slight "pinging" sound may be heard during system build up when a single cylinder compressor is used. No remedy is needed.

Description

The Bendix SR-7™ spring brake modulating valve (see **Fig. 1** and **Fig. 2**) is used in conjunction with a dual air brake system and spring brake actuator, and performs the following functions:

- Provides a rapid application of the spring brake actuator when parking.
- Modulates the spring brake actuator application using the dual brake valve should a primary failure occur in the service brake system.
- Prevents compounding of service and spring brake forces.

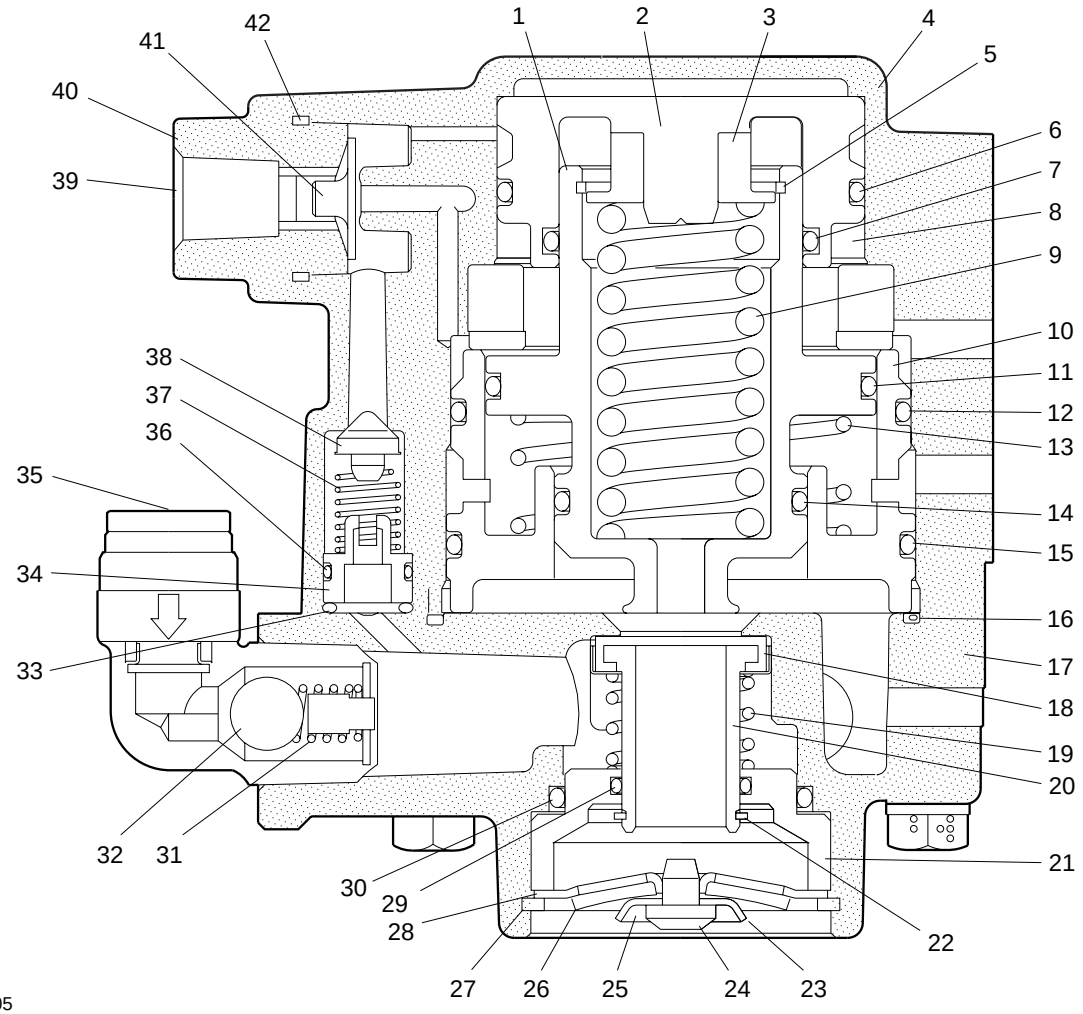
The SR-7 valve has one park control, one service control, one supply, one balance, four delivery NPT ports, and an exhaust port protected by an exhaust diaphragm. The valve incorporates two mounting studs for mounting the valve to the frame rail or crossmember.



1. Mounting Studs
2. 42 Control Port
3. Exhaust
4. Delivery
5. 41 Park Control (from dash valve)
6. 41 Balance Port
7. Supply Port
8. Exhaust
9. Delivery
10. Pipe Plug (QRV applications only)

Fig. 1, SR-7 Spring Brake Modulating Valve (exterior views)

General Information



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1. Main Piston
2. Control Piston
3. Spring Guide
4. Upper Body
5. Retaining Ring
6. O-Ring
7. O-Ring
8. Spacer
9. Main Piston Spring
10. Static Piston
11. O-Ring
12. O-Ring
13. Static Piston Spring
14. O-Ring
15. O-Ring
16. O-Ring
17. Lower Body
18. Valve Retainer
19. Spring
20. Inlet/Exhaust Valve
21. Lower Valve Guide
22. Retaining Ring
23. Exhaust Port
24. #10 Torx Screw
25. Diaphragm Washer
26. Diaphragm
27. Retaining Ring
28. Valve Seat
29. O-Ring
30. O-Ring
31. Spring
32. Ball Check Valve
33. O-Ring
34. Check Valve Guide
35. Supply Port
36. O-Ring
37. Spring
38. Inline Single Check Valve
39. Park Control Port
40. Check Valve Cover
41. Double Check Valve
42. O-Ring

Fig. 2, SR-7 Spring Brake Modulating Valve (sectional view)

CAUTION

Do not attempt to disassemble the SR-7 valve. The valve contains high spring forces that could result in personal injury if disassembly is attempted.

Operation

The operation guidelines in this subject represent the relay-valve-based SR-7. A quick-release-based valve functions similarly to the relay-valve-based version with the exception that all air delivered to the spring brakes passes through the park control port through the inline single check valve. The SR-7 quick release style can be easily identified by the pipe plug in the supply port of the valve. See **Fig. 1**. For vehicle-specific plumbing diagrams, go to **EZWiring**.

Charging the Spring Brake Actuators Below 107 psi (737 kPa)

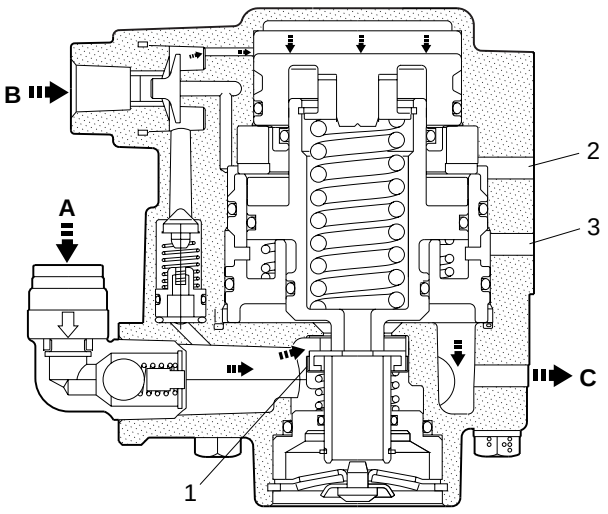
With the air brake system charged and the parking brakes released (by pushing in the dash valve button), air enters the park control port. This opens the SR-7 valve, to supply air pressure to the spring brake chambers. As illustrated, air pressure in the chambers is below 107 psi (737 kPa) (nominal). See **Fig. 3**.

Charging the Spring Brake Actuators Above 107 psi (737 kPa)

Once the SR-7 valve delivery pressure reaches 107 psi (nominal), the inlet and exhaust are closed (valve lap position). This maintains the spring brake hold-off pressure at 107 psi (nominal). See **Fig. 4**.

Normal Service Application

During a service brake application, the valve remains in the lap position. The SR-7 valve monitors the presence of air pressure in both primary and secondary delivery circuits. See **Fig. 5**.



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A. Secondary reservoir constant pressure
B. Control line pressure
C. Delivery to spring brakes
1. Inlet/Exhaust Valve Open
2. Balance Port
3. Control Port

Fig. 3, Charging the Spring Brake Actuators Below 107 psi (737 kPa)

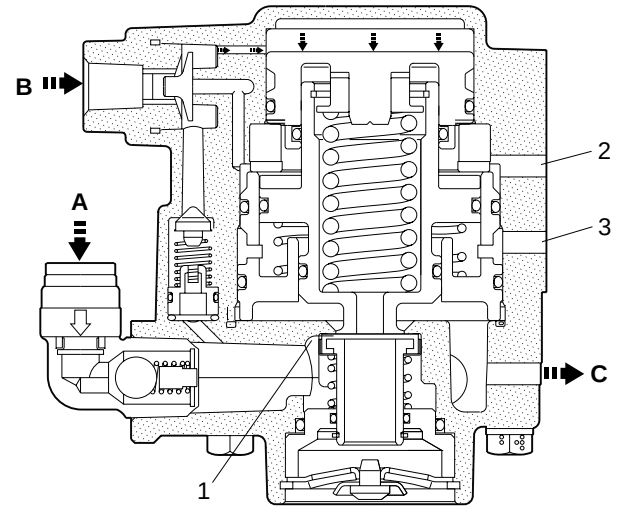
Parking

Actuating the park brakes (by pulling out the dash valve button) exhausts spring brake air pressure through the SR-7 valve exhaust port. See **Fig. 6**.

Service Application with Loss of Air in Primary Circuit

With the parking brakes released (dash valve button in) and the absence of air in the primary circuit delivery, a service brake application from the secondary circuit causes the pressure in the spring brakes to be exhausted proportionally to this application. This is known as spring brake modulation. A 30 psi (207 kPa) service brake application will exhaust the spring brake pressure to approximately 60 psi (414 kPa). See **Fig. 7**.

General Information



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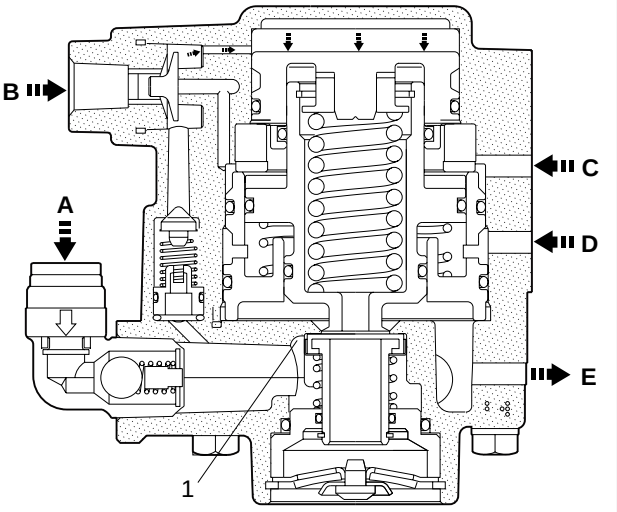
A. Secondary reservoir constant pressure
B. Control line pressure
C. Delivery to spring brakes
1. Inlet/Exhaust Valve Seated
2. Balance Port
3. Control Port

Fig. 4, Charging the Spring Brake Actuators Above 107 psi



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A. Secondary reservoir constant pressure
B. Control line pressure
C. Balance port—primary circuit pressure
D. Control port—secondary circuit pressure
E. Delivery to spring brakes
1. Inlet/Exhaust Valve Seated

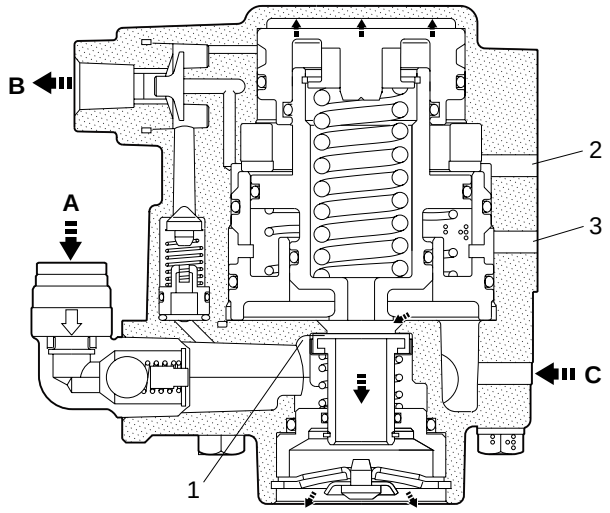
Fig. 5, Normal Service Application

Service Application with Loss of Air in Secondary Circuit

With the parking brakes released (dash valve button in) and the absence of air in the secondary circuit reservoir, the external single check valve in the supply port seals to prevent air leakage to atmosphere from the SR-7 valve. The dash valve delivery air flows through the inline single check valve and becomes SR-7 valve supply air. This air is delivered to maintain at least 107 psi (737 kPa) (nominal) in the spring brake chambers. See **Fig. 8**.

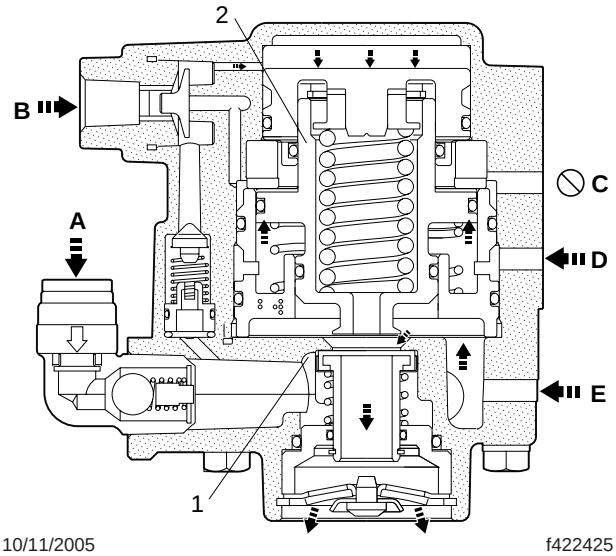
Anti-Compounding

The SR-7 valve provides anti-compounding of the service and spring brake forces. When the park brakes are actuated (by pulling out the dash valve button), a service brake application will cause the SR-7 valve to deliver air pressure to the spring brake chambers. Thus the vehicle is held stationary using a service brake application. When the service brake application is released, the delivery pressure is exhausted from the spring brake chambers and the vehicle remains parked using the spring brake actuators. See **Fig. 9**.



A. Secondary reservoir constant pressure
B. Control line pressure
C. Delivery to spring brakes
1. Inlet/Exhaust Valve Seated
2. Balance Port
3. Control Port

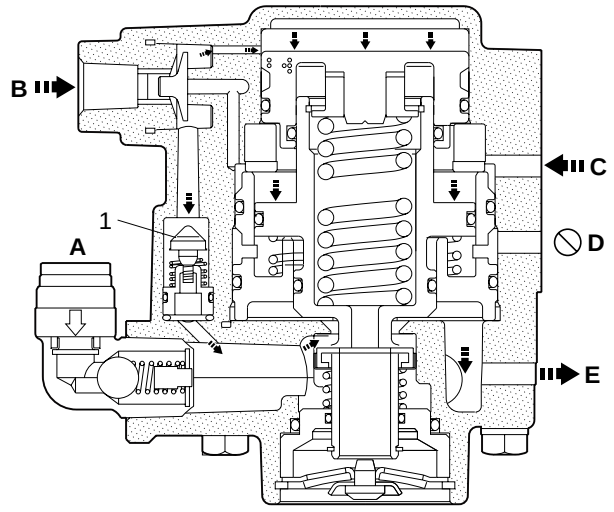
Fig. 6, Parking



A. Secondary reservoir constant pressure
B. Control line pressure
C. Balance port—loss of primary circuit pressure
D. Control port—secondary circuit pressure
E. Delivery to spring brakes
1. Inlet Valve Seated
2. Main Piston Moves Up

Fig. 7, Service Application with Loss of Air in Primary Circuit

General Information



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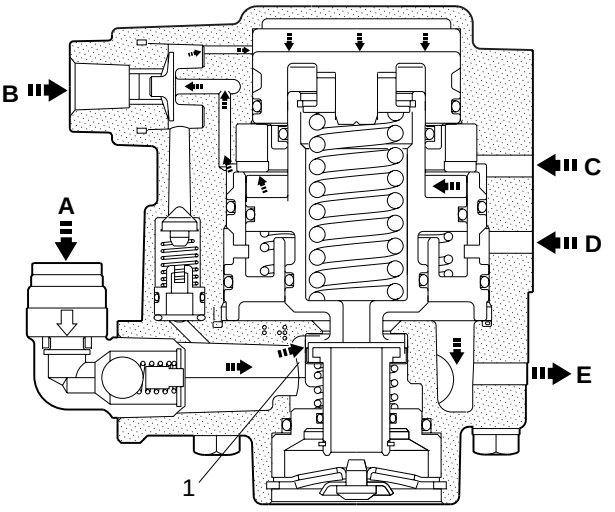
A. Secondary reservoir no pressure
B. Control line pressure
C. Balance port—primary circuit pressure
D. Control port—loss of secondary circuit pressure
E. Delivery to spring brakes
1. Inline Single Check Valve

Fig. 8, Service Application with Loss of Air in Secondary Circuit



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A. Secondary reservoir constant pressure
B. Control line pressure
C. Balance port—primary circuit pressure
D. Control port—secondary circuit pressure
E. Delivery to spring brakes
1. Inlet/Exhaust Valve Open

Fig. 9, Anti-Compounding

Safety Precautions

Before attempting to work on the air brake system, observe the following precautions:

- Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized. The wheels of the vehicle must always be chocked so that depletion of air will not permit the vehicle to roll.
- When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.
- Hoses will whip dangerously if disconnected under pressure. Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.
- As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber pushrods and spring actuators that apply automatically with the loss of pressure. This also applies when checking the service brake system.
- Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.
- Used reservoirs must not be used as replacements, in order to eliminate the possibility of component failure.
- The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured, in order to prevent valve failure.
- Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.
- To avoid injury, keep clear of the air chamber pushrod when brakes are applied or when air is exhausted from the system.

Removal

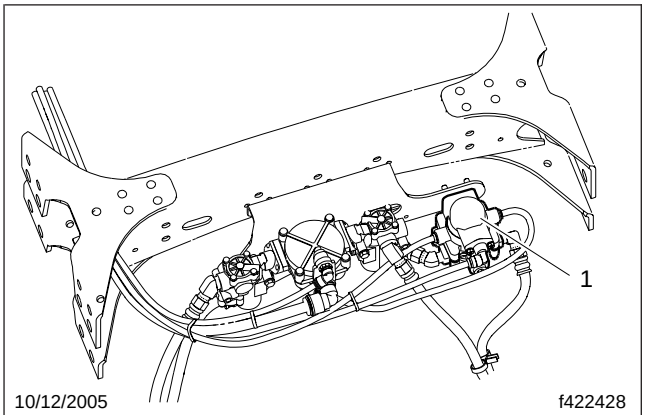
WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so could result in personal injury.

CAUTION

Do not attempt to disassemble the SR-7 valve. The valve contains high spring forces that could result in personal injury if disassembly is attempted.

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the tires.
2. Drain the air system.
3. Identify all the air lines attached to the valve, for reinstallation. See **Fig. 1** for a view of a typical installation, or access EZWiring for vehicle-specific plumbing diagrams.



1. SR-7 Valve

Fig. 1, SR-7 Spring Brake Modulating Valve Installation (typical)

4. Disconnect all the air lines from the valve.
5. Remove the two mounting nuts that secure the valve to the crossmember bracket, and remove the valve.
6. If the valve is being replaced, note the orientation of all fittings, then remove the fittings for use on the new valve.

Installation

1. If a new valve is being installed, install the fittings removed from the old valve.
2. Position the valve on the crossmember bracket and install the mounting nuts. Tighten to 15 to 18 lbf·ft (20 to 24 N·m).
3. Attach all the air lines as noted during removal.
4. Before returning the vehicle to service, perform the operating and leakage tests in **Subject 120**, *Tests*.

Operating Test

WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so could result in personal injury.

CAUTION

Do not attempt to disassemble the SR-7 valve. The valve contains high spring forces that could result in personal injury if disassembly is attempted.

1. Chock the tires.
2. Charge the air brake system to governor cut-out pressure.
3. Place the parking control valve in the PARK position. Observe that the spring brake actuators apply promptly.
4. Remove one line from a delivery port of the SR-7 valve and install a test gauge that is known to be accurate. See Fig. 1 for the port locations.
5. Place the parking control valve in the RELEASE position. Observe that the spring brake actuators fully release.
6. With the parking control valve still in the RELEASE position, note the gauge pressure reading. Correct spring brake actuator hold-off pressure is 107 psi (737 kPa) nominal.
7. Place the parking control valve in the PARK position. The gauge reading should drop to zero promptly. A lag (more than 3 seconds) in the drop of pressure would indicate faulty operation.
8. With the parking control valve still in the PARK position, gradually apply the foot brake valve and note a pressure reading increase on the gauge installed in the SR-7 valve delivery port.
9. Place the parking control valve in the RELEASE position.
10. Drain the reservoir that supplies the rear service brake circuit; apply the foot brake valve several times and note that the pressure reading on the gauge decreases each time the foot brake valve is applied (spring brake modulation). After the foot brake valve has been applied several times, the pressure reading on the gauge will drop to the point where release of the spring brake actuators will no longer occur.

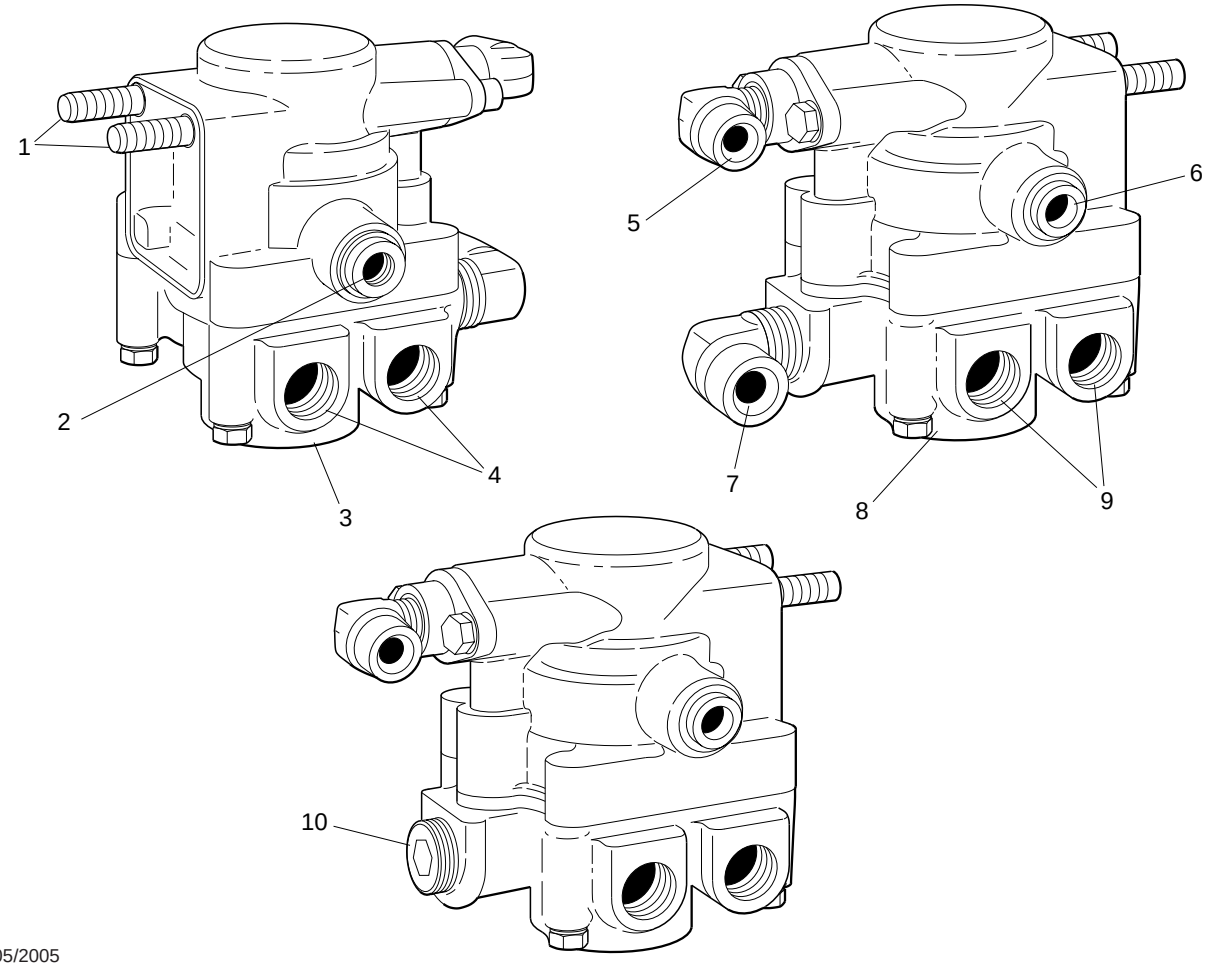
NOTE: The SR-7 valve is not serviceable. If the valve does not function as described, replace it.

Leakage Test

Place the park control valve in the RELEASE position; using a soap solution, coat all ports including the exhaust port. A 1-inch (25-mm) bubble in three seconds is permitted.

NOTE: The SR-7 valve is not serviceable. If the valve does not function as described, or if leakage is excessive, replace it.

Tests



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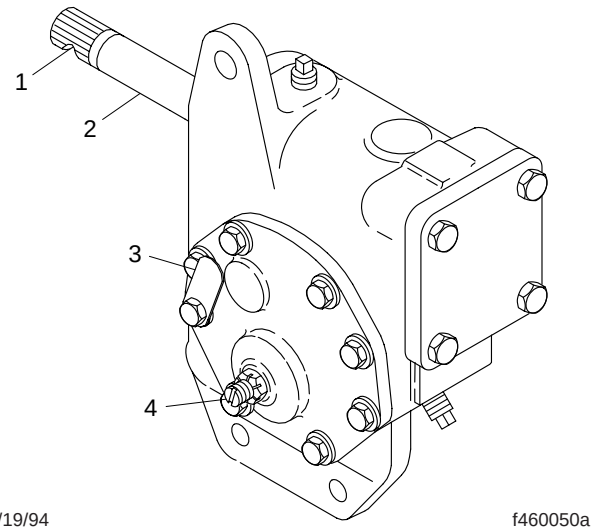
1. Mounting Studs
2. 42 Control Port
3. Exhaust
4. Delivery
5. 41 Park Control (from dash valve)
6. 41 Balance Port
7. Supply Port
8. Exhaust
9. Delivery
10. Pipe Plug (QRV applications only)

Fig. 1, SR-7 Spring Brake Modulating Valve (exterior views)

General Information (See Fig. 1)



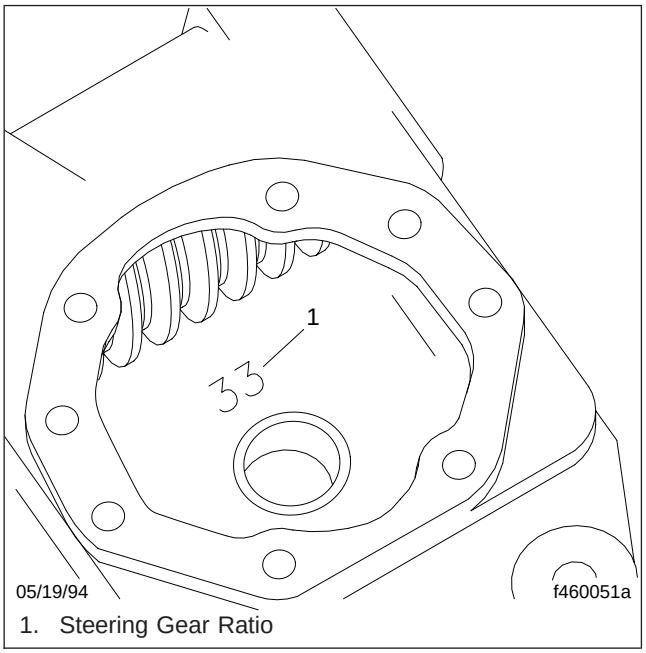
1. Whistle Notch
2. Worm (input) Shaft
3. I.D. Tag
4. Roller (output) Shaft Adjusting Screw and Locknut

Fig. 1, TRW Model 503 Steering Gear

The TRW model 503 AA172 worm and roller type manual steering gear is optional on COEs, and model 503 AA186 is optional on Conventionals. The "worm and roller" designation refers to the gears inside the steering gear housing: the worm (input) shaft and the roller (output) shaft. The ratio of these gears is 32.5:1. Steering gear model numbers are stamped on an ID tag attached to the shaft cover. The 32.5:1 steering gear ratio is stamped "33" inside the housing. See **Fig. 2**.

The worm shaft is secured in the housing by a pair of bearing cage (retainer) assemblies. The worm shaft meshes with a roller tooth mounted on the roller shaft shoulder.

The steering gear is designed with integral stops in the housing to limit the travel of the roller shaft and thereby prevent mesh runout of the roller tooth with the worm shaft. These stops are not intended to absorb road shock or act as wheel stops. The vehicle axle stops are designed with a safety factor of several degrees at each end of gear travel (the travel of the roller shaft) to prevent gear contact with the integral stops in the housing.



1. Steering Gear Ratio

Fig. 2, Steering Gear Ratio Stamp

Most steering action is performed with the front wheels straight ahead. Thus, in the steering gear, maximum wear occurs at the center portion of the worm shaft tooth. To compensate for wear, backlash is provided in the off-center portions of the tooth. Backlash is the amount of clearance (free play) between meshing teeth that will allow rotation of the driven gear (in this case, the roller portion of the roller shaft) in a direction opposite the driving rotation of a second gear (the worm shaft). In the TRW manual steering gear, backlash occurs about one-half turn each way from the center portion of the worm shaft, and gradually increases to develop the largest amount of backlash at the end of gear travel. This permits adjustment for lost motion in the center position without causing a bind in the off-center travel of the roller shaft.

In the steering gear, elimination of looseness caused by wear in the center portion of the worm shaft tooth is accomplished by means of preload adjustments. Preload adjustments are provided on the worm shaft bearings, and on the roller shaft mesh.

Centralizing the steering gear places the roller (output) shaft in the center of its travel to give the most desirable characteristics during straight-ahead driving. All manual steering gears are centralized at the factory.

General Information

In the field, make sure the steering gear is centralized when:

- Steering gear preload adjustments are checked. Instructions are included in **Subject 120**;
- The drag link or steering gear is serviced or adjusted.

If the steering gear is removed from the vehicle, centralize the gear before installing it; instructions are included in **Subject 130**.

Principles of Operation

When the steering wheel is turned, the force is transmitted through the steering driveline to the worm shaft. The worm shaft tooth, meshed with the roller shaft tooth inside the steering gear housing, causes the roller shaft to turn in the same direction as the worm shaft, but the total output travel is greatly reduced.

A pitman arm is connected to the end of the roller shaft, outside the steering gear housing. The pitman arm converts the rotary motion of the roller shaft to lateral motion. The lateral motion is transmitted through the drag link assembly and the steering arms to the steering knuckles. The steering knuckles pivot on the axle center (beam) and cause the wheels to turn.

Steering System Inspection

WARNING

All steering mechanisms are life-and-limb items. As such, it is imperative that the instructions in this subject are followed to the letter. Failure to observe these procedures may result in loss of steering.

When steering problems exist, inspect the vehicle for road-worthiness, then, if necessary, verify the steering problem by test driving the vehicle or taking a ride with the driver. If the problem occurs only when the vehicle is loaded, make the test drive with the vehicle loaded.

Once the problem is verified, check the simple causes before moving on to the more complicated possibilities. Perform the following checks in the order given whenever rapid tire wear, hard steering effort, or erratic steering indicates a problem in the steering system.

1. Check that the front tires are the same size and model. Be sure they are equally and adequately inflated. Underinflated tires will cause hard steering. See **Group 40** of this manual for tire inflation specifications.
2. If the steering problem occurs only when the vehicle is loaded, make sure the fifth wheel is adequately lubricated. For instructions, see Group 31 of the *Heavy-Duty Trucks Maintenance Manual*.
3. Check the steering linkage for loose, damaged, or worn parts. The steering linkage includes the tie rod, steering arms, bushings, and other components that carry movement of the pitman arm to the steering knuckles. The wheels should turn smoothly from stop to stop. For service operations, refer elsewhere in this group.
4. Inspect the drag link, steering driveline, and upper steering column for worn or damaged parts. For service instructions, refer elsewhere in this group.
5. Make sure the steering driveline, especially the universal joints, and portions of the steering linkage are adequately lubricated. See Group 46 of the *Heavy-Duty Trucks Maintenance Manual* for instructions.
6. Check the front axle wheel alignment including wheel bearing adjustment, caster and camber angles, and toe-in, using the instructions in **Group 33** of this manual.
7. Check the rear axle alignment. Rear axle misalignment can cause hard or erratic steering. If needed, align the rear axle(s) using the instructions in **Group 35** of this manual.
8. Inspect the front axle suspension for worn or damaged parts, using the instructions in **Group 32** of this manual.

NOTE: Before doing the remaining checks, apply the parking brakes and chock the rear tires. Raise the vehicle until the front tires leave the pavement, then place safety stands under the frame rails. Be sure the stands will support the weight of the vehicle.

9. With the front wheels straight ahead, turn the steering wheel until motion is seen at the wheels. Align a reference mark on the steering wheel with a mark on a ruler, then slowly turn the steering wheel in the opposite direction until motion is again seen at the wheels. Measure the lash (free play) at the steering wheel. See **Fig. 1**.

   Too much lash exists if the steering wheel movement exceeds:

   2-3/4 inches (70 mm) for 22-inch (550-mm) steering wheels.

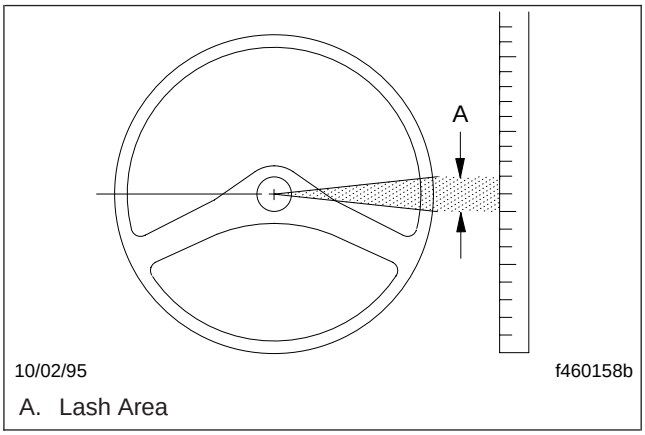
   2-1/2 inches (64 mm) for 20-inch (500-mm) steering wheels.

   If there is too much lash, refer to **Troubleshooting, 300** for possible causes and corrective measures.
10. Turn the steering wheel through a full right and full left turn. If the front wheels cannot be turned to the right and left axle steering stops without binding or noticeable interference, one or more of the following may be the cause:

    10.1 The worm shaft bearings or the roller shaft mesh are adjusted too tightly. Check the steering gear preload using the instructions in **Subject 120**.

    10.2 The worm shaft or worm shaft bearings are worn or damaged. Replace the component(s) using the instructions in **Subject 140**.

Steering System Inspection



A. Lash Area

Fig. 1, Measuring Lash at the Steering Wheel

10.3 The roller shaft is worn or damaged. Replace the roller shaft using the instructions in **Subject 140**.

11. Secure the steering wheel in the straight ahead driving position. Move the front wheels from side to side. Any play in the steering gear bearings will be felt in the drag link ball stud at the pitman arm. If any bearing play exists, make adjustments in the following order:

    11.1 Adjust the worm shaft bearings.

    11.2 Adjust the roller shaft total mesh preload.

    Check the steering gear preload using the instructions in **Subject 120**.

⚠ WARNING

Do not drive the vehicle if there is too much lash or free play in the steering gear. Excessive lash is a sign of an improperly adjusted steering gear, or worn or otherwise damaged steering gear parts. Driving the vehicle in this condition could ultimately result in a loss of steering control.

12. Remove the safety stands, lower the vehicle, and remove the chocks.

Preload Checks and Adjustments

⚠ WARNING

All steering mechanisms are life-and-limb items. As such, it is imperative that the instructions in this subject are followed to the letter. Failure to observe these procedures may result in loss of steering.

WORM SHAFT BEARING PRELOAD CHECK

1. Position the front wheels straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be performed. Apply the parking brakes and chock the tires.
2. Disconnect the drag link from the pitman arm. For instructions, refer elsewhere in this group.
3. Disconnect the steering driveline from the steering gear worm (input) shaft. For instructions, refer elsewhere in this group.

⚠ CAUTION

When heat is applied to remove the end yoke from the worm shaft, use care not to damage the worm shaft seal. Replace the seal if it is damaged during end yoke removal.

4. Turn the worm shaft to the end of travel in either direction. Note that lash (free play) increases as the shaft is turned away from the center.

   Check the worm shaft bearing preload *in the lash area*, that is, away from the center of the gear. To do this check, use an inch-pound torque wrench to rotate the worm shaft back and forth about one-quarter turn. The output shaft should not turn.

   The torque needed to rotate the worm shaft in the lash area should be 7 to 14 lbf·in (80 to 160 N·cm) for steering gears without a worm shaft seal installed, and 9 to 16 lbf·in (100 to 180 N·cm) for gears in which a worm shaft seal has been installed.

   If the worm shaft bearing preload measurement is not within specifications, adjust the preload.

   If the worm shaft bearing preload falls within specifications, check the roller shaft total mesh preload.

WORM SHAFT BEARING PRELOAD ADJUSTMENT (See Fig. 1)

1. If not already done, perform the steps under "Worm Shaft Bearing Preload Check."
2. Clean the steering gear.
3. Remove the fill plug and the drain plug from the steering gear. Drain the lubricant and dispose of it.
4. Remove the worm shaft cover screws and the worm shaft cover.
5. If worm shaft preload is loose or less than the torque specification required, remove the shims.

NOTE: Removal of shims will increase preload; adding shims will decrease preload. The shims may be in five sizes: 0.002, 0.003, 0.005, 0.0075, and 0.010 inch. Remove only one shim at a time, but do not remove 0.0075-inch rubber-covered shims. The size of the shim to be removed or added will depend on the amount of lash. Use a micrometer to identify the

6. Assemble the worm shaft cover and shims.

NOTE: Rubber covered shims (if applicable) must be assembled with the rubber (dark) sides against the housing and the worm shaft cover.

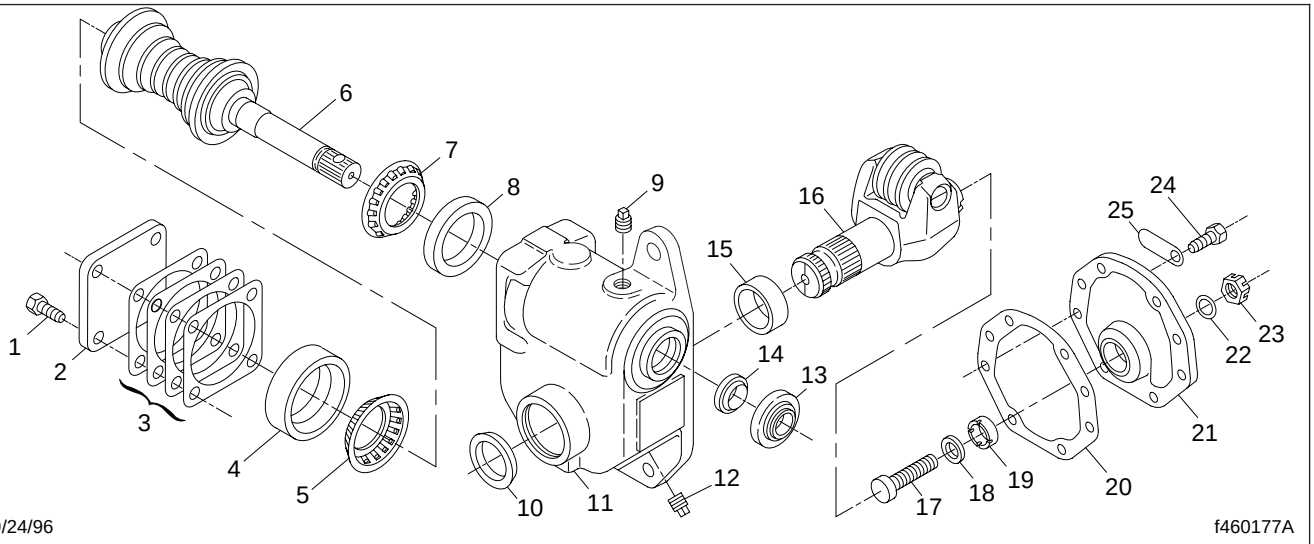
7. Install the worm shaft cover screws. Obtain a light preload before final tightening of the screws.

⚠ CAUTION

Do not final torque the screws immediately. Rotate the worm shaft assembly with one hand, while slowly tightening the worm cover screws with the other hand, to prevent damaging the bearing surfaces if the initial amount of shims is inadequate.

8. Using the tightening sequence shown in **Fig. 2**, tighten the worm shaft cover screws to a final torque of 45 to 55 lbf·ft (61 to 75 N·m).

Preload Checks and Adjustments



1. Worm Cover Screws (4 qty.)
2. Worm Cover
3. Worm Cover Shims
4. Bearing Cup
5. Bearing Cage (retainer) Assembly
6. Worm (input) Shaft
7. Bearing Cage (retainer) Assembly
8. Bearing Cup
9. Filler and Vent Plug
10. Roller Shaft Seal
11. Housing
12. Drain Plug
13. Boot
14. Worm Shaft Seal
15. Bushing
16. Roller (output) Shaft Assembly
17. Adjusting Screw
18. Washer
19. Shaft Cover Bushing
20. Shaft Cover Gasket
21. Shaft Cover
22. O-Ring
23. Adjusting Screw Locknut
24. Shaft Cover Screws
25. Identification Tag

Fig. 1, Steering Gear Assembly

9. Check the worm bearing preload using the instructions under "Worm Shaft Bearing Preload Check. "If necessary, repeat the adjustment using a different selection of shims.

ROLLER SHAFT TOTAL MESH PRELOAD CHECK (See Fig. 1)

IMPORTANT: Do not check the roller shaft total mesh preload unless the worm shaft bearing preload is known to fall within the specifications under "Worm Shaft Bearing Preload Check." Checking the roller shaft total mesh preload when the worm shaft bearing preload is out of adjustment will result in inaccurate measurements.

1. After making the correct worm shaft bearing preload adjustment, centralize the steering gear by turning the worm shaft through full travel, counting the number of turns required. Starting at the end of travel, turn back half that number of turns. This will place the roller tooth of the roller shaft in the approximate center of the worm tooth.

   Check the alignment mark on the output shaft of the steering gear. If the alignment mark is at a right angle to the worm shaft, the gear is centered. See **Fig. 3**. If not, turn the worm shaft backward or forward until the output shaft alignment mark is at a right angle to the worm shaft.

2. Rotate the worm shaft with a torque wrench approximately 180 degrees through the center position. The correct torque is 20 to 31 lbf·in (220 to 340 N·cm) on steering gears without a worm shaft seal installed, and 23 to 34 lbf·in (260 to 380 N·cm) on steering gears with a worm shaft seal installed.

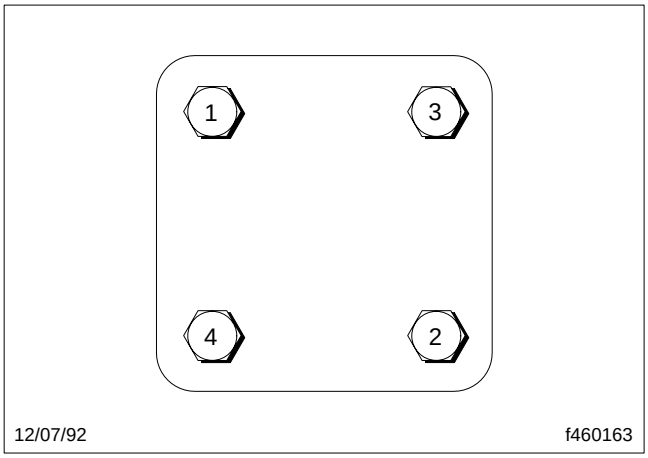


Fig. 2, Worm Cover Screws, Tightening Sequence

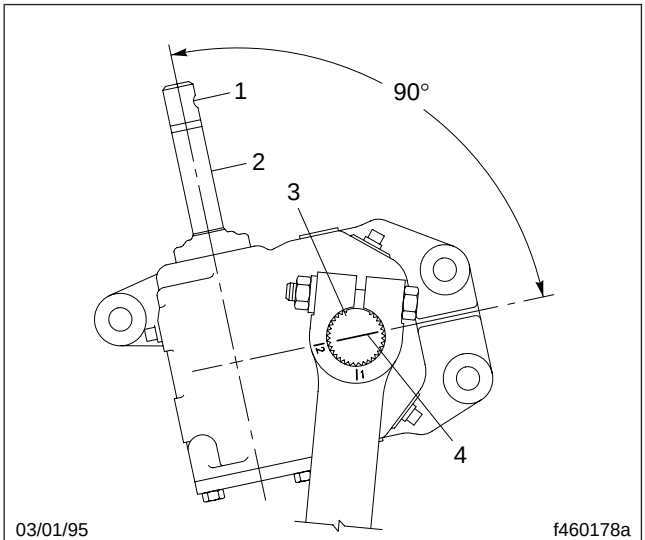
If the roller shaft total mesh preload measurement is not within specifications, adjust the preload.

If the roller shaft total mesh preload is within specifications, perform the applicable steps under "Roller Shaft Total Mesh Preload Adjustment."

ROLLER SHAFT TOTAL MESH PRELOAD ADJUSTMENT

1. If not already done, check the roller shaft total mesh preload using the instructions under "Roller Shaft Total Mesh Preload Check."
2. If adjustment is necessary, loosen the adjusting screw locknut. See **Fig. 4**.
3. Centralize the steering gear.
4. Turn the slotted adjusting screw clockwise to increase the preload or counterclockwise to decrease the preload; then check the adjustment. See **Fig. 5**. The correct torque is 20 to 31 lbf·in (220 to 340 N·cm) on steering gears without a worm shaft seal installed, and 23 to 34 lbf·in (260 to 380 N·cm) on steering gears with a worm shaft seal installed.

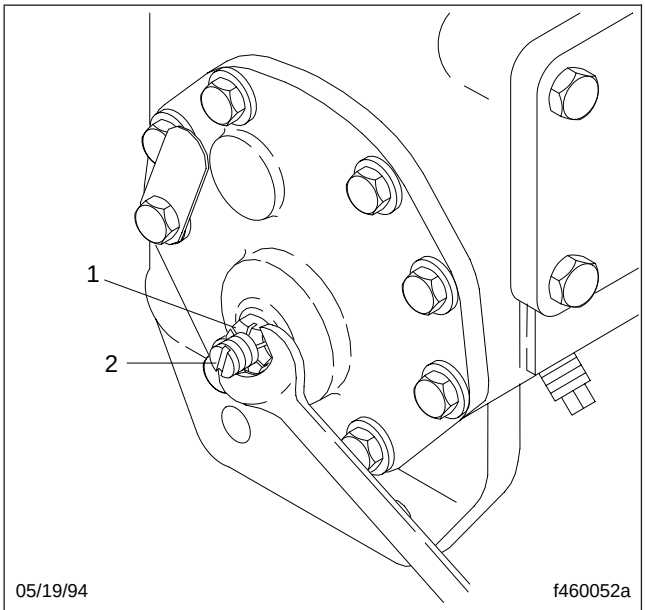
   Repeat the adjustment until the preload is within specifications.
5. Hold the adjusting screw in place with a screwdriver while tightening the adjusting screw locknut 25 to 40 lbf·ft (34 to 54 N·m).
6. Recheck the preload.



NOTE: When the gear is centered, the output shaft alignment mark is at a right angle to the input shaft.

1. Whistle Notch
2. Input Shaft
3. Output Shaft
4. Output Shaft Alignment Mark

Fig. 3, Check the Alignment Mark

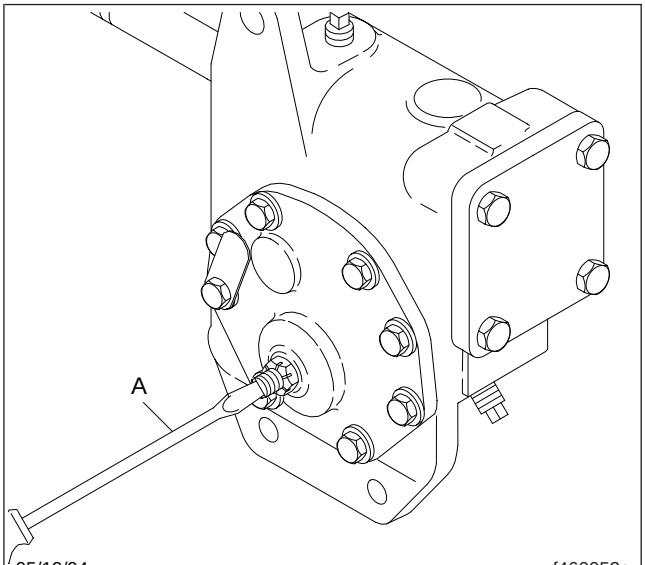


1. Locknut
2. Adjusting Screw

Fig. 4, Loosen the Adjusting Screw

7. Fill the steering gear with lubricant as follows:

Preload Checks and Adjustments



A. Turn clockwise to increase the preload; turn counterclockwise to decrease the preload.

Fig. 5, Checking the Adjustment

7.1 If not already done, remove the filler plug (and pressure relief fitting) from the steering gear housing. Thoroughly clean the plug.

7.2 Add lubricant until it is within 1/2 inch (13 mm) of the filler hole. Refer to the lubricant recommendations table under **Specifications, 400**.

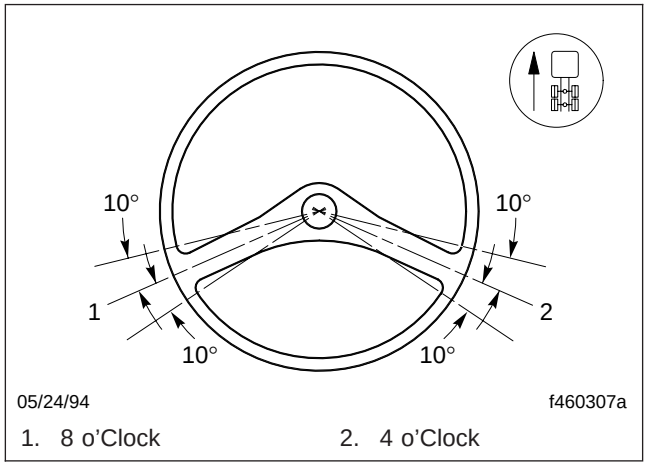
7.3 Install the filler plug (and pressure relief fitting) and tighten it 12 to 15 lbf·ft (16 to 20 N·m).

8. Turn the steering wheel so that its spokes are within ±10 degrees of the 4 o'clock and 8 o'clock positions. See **Fig. 6**.

9. With the steering wheel centered (see **Fig. 6**), connect the steering driveline to the steering gear worm (input) shaft. For instructions, refer to the applicable section in this group. Do not move the steering gear worm (input shaft).

10. Install the drag link. Refer to the instructions elsewhere in this group.

11. After the steering driveline has been connected to the steering gear worm shaft, check the position of the steering wheel spokes. The spokes should be within ±10 degrees of the 4 o'clock and 8 o'clock positions. Adjust the position of the steering wheel on the upper column and jacket assembly, if necessary. For instructions, refer to the applicable section in this group.



1. 8 o'Clock 2. 4 o'Clock

Fig. 6, Steering Wheel Position (with tires pointed straight ahead)

12. Verify the adjustments by test driving the vehicle or taking a ride with the driver.

If, during straight-ahead driving on a level road, the steering wheel spokes do not point directly toward the 4 o'clock and 8 o'clock positions (±10 degrees), it means that the steering gear is not centered. The probable cause was the failure to keep the vehicle's front wheels in a straight-ahead position during repair or adjustment of the steering gear.

Make adjustments as follows:

12.1 Note the approximate number of degrees the steering wheel spokes point away from the 4 o'clock and 8 o'clock positions during straight-ahead driving.

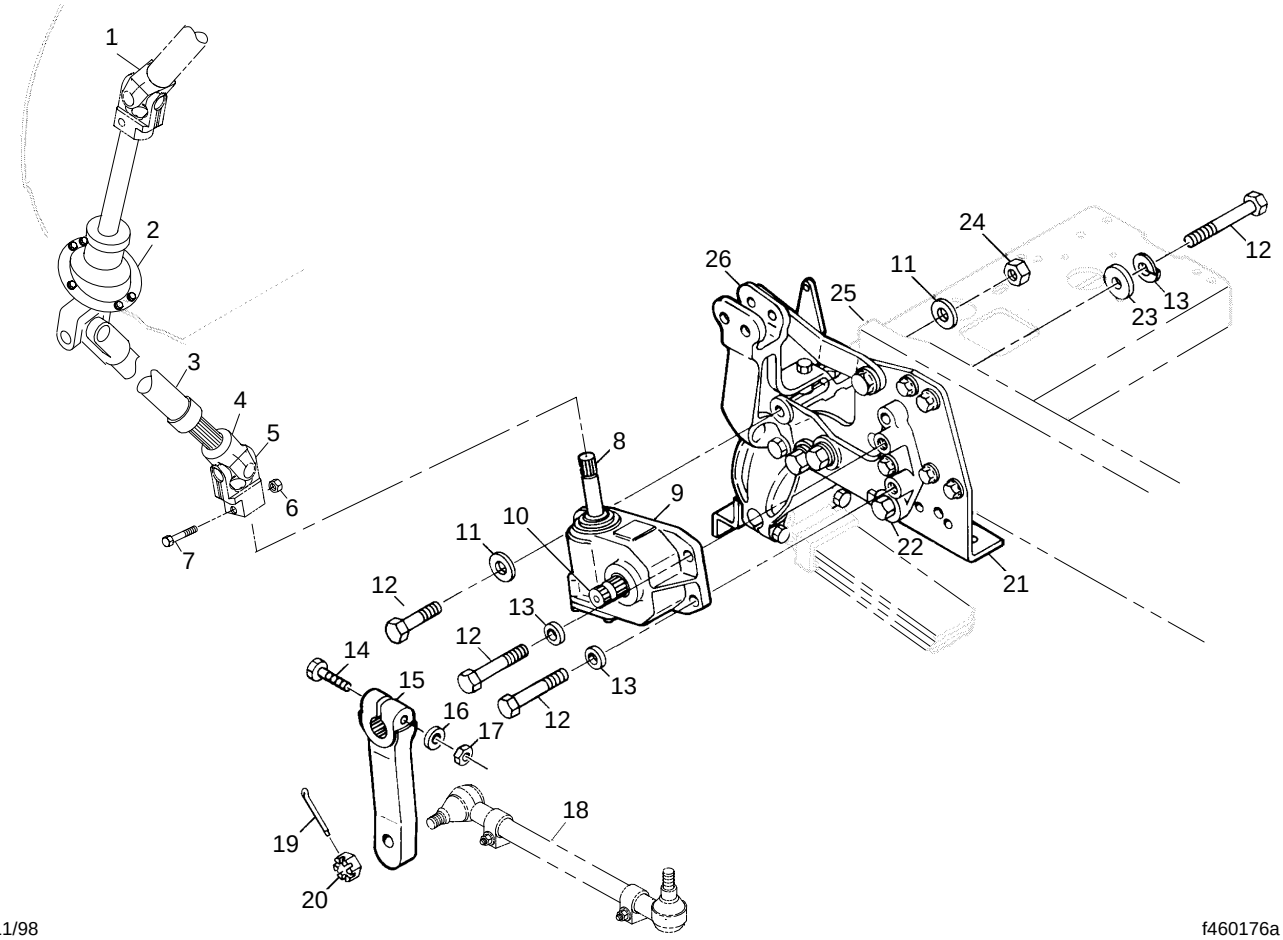
12.2 Using the instructions elsewhere in this group, lengthen or shorten the drag link. Each turn of the drag link will result in partial turning of the steering wheel. All adjustments must result in a centered steering gear (and correctly positioned steering wheel spokes) when the vehicle's front wheels are straight ahead.

12.3 Again, test drive the vehicle or take a ride with the driver. Observe that the steering wheel spokes point correctly during

straight-ahead driving on a level road. Repeat the adjustments at the drag link if needed.

Removal

See **Fig. 1, Fig. 2, or Fig. 3** when removing the steering gear.

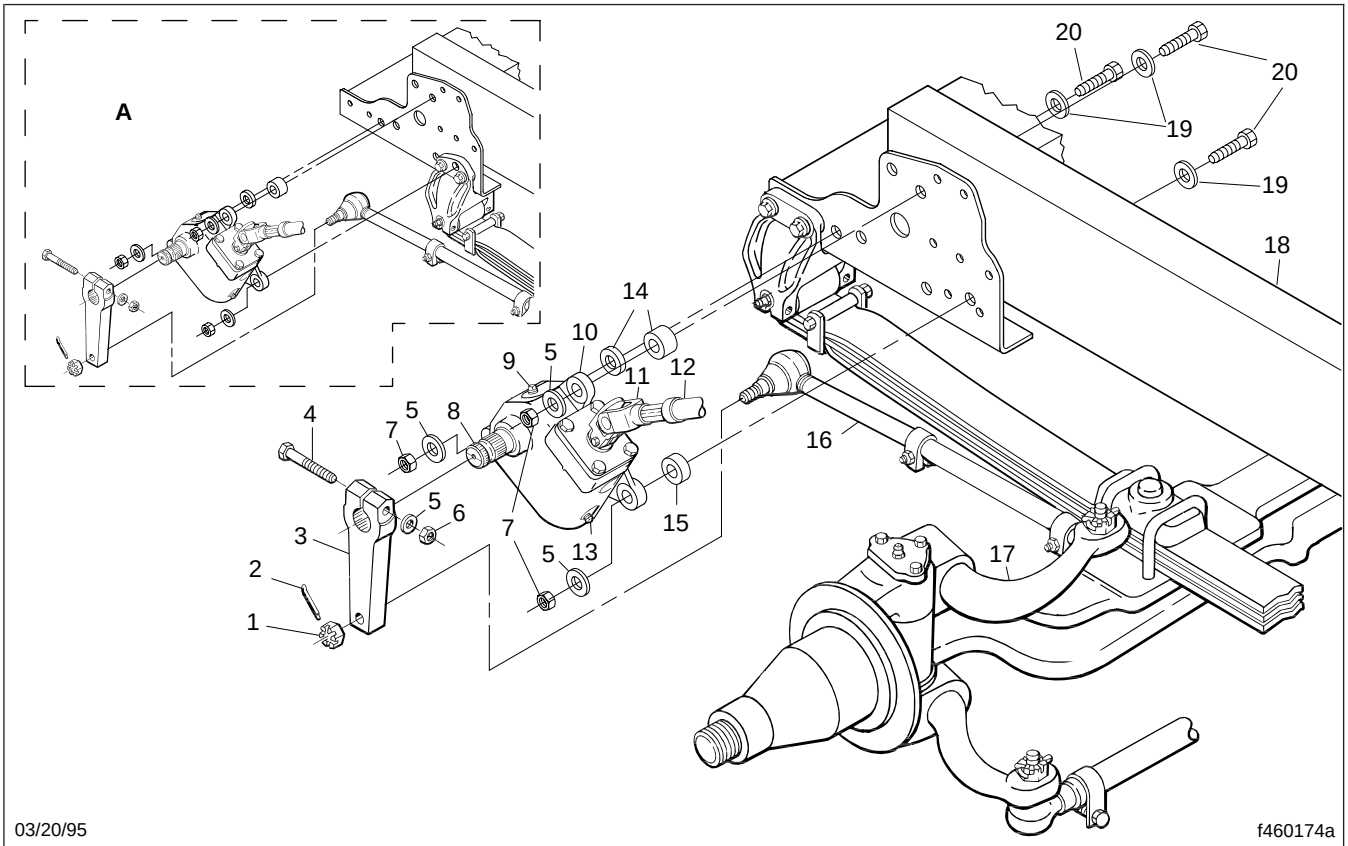


NOTE: Not all fasteners are shown.

1. Upper Steering Driveline End Yoke
2. Deck Bearing Assembly
3. Lower Driveline Tube
4. Lower Driveline Shaft and Yoke Assembly
5. Lower End Yoke
6. Pinch Bolt Nut
7. Lower End Yoke Pinch Bolt
8. Input (worm) Shaft
9. Steering Gear
10. Output (roller) Shaft
11. Hardened Washer
12. Mounting Bolt
13. Washer
14. Pitman Arm Pinch Bolt
15. Pitman Arm
16. Washer
17. Pinch Bolt Nut
18. Drag Link
19. Cotter Pin
20. Castle Nut
21. Frame Extension
22. Steering Gear Mounting Bracket
23. Spacer
24. Flanged Nut
25. Frame
26. Cab Mounting Bracket

Fig. 1, Manual Steering Gear Installation, COE

Steering Gear Removal and Installation



A. Setback Installation (built before March 1992)

1. Castle Nut
2. Cotter Pin
3. Pitman Arm
4. Pitman Arm Pinch Bolt
5. Washer
6. Pinch Bolt Nut
7. Flanged Nut
8. Output (roller) Shaft
9. Filler Plug
10. Steering Gear
11. Lower Yoke
12. Steering Driveline
13. Drain Plug
14. Spacer
15. Spacer (axle forward only)
16. Drag Link
17. Axle Steering Arm
18. Frame Rail
19. Washer
20. Mounting Capscrew

Fig. 2, Manual Steering Gear Installation, FLD Conventional

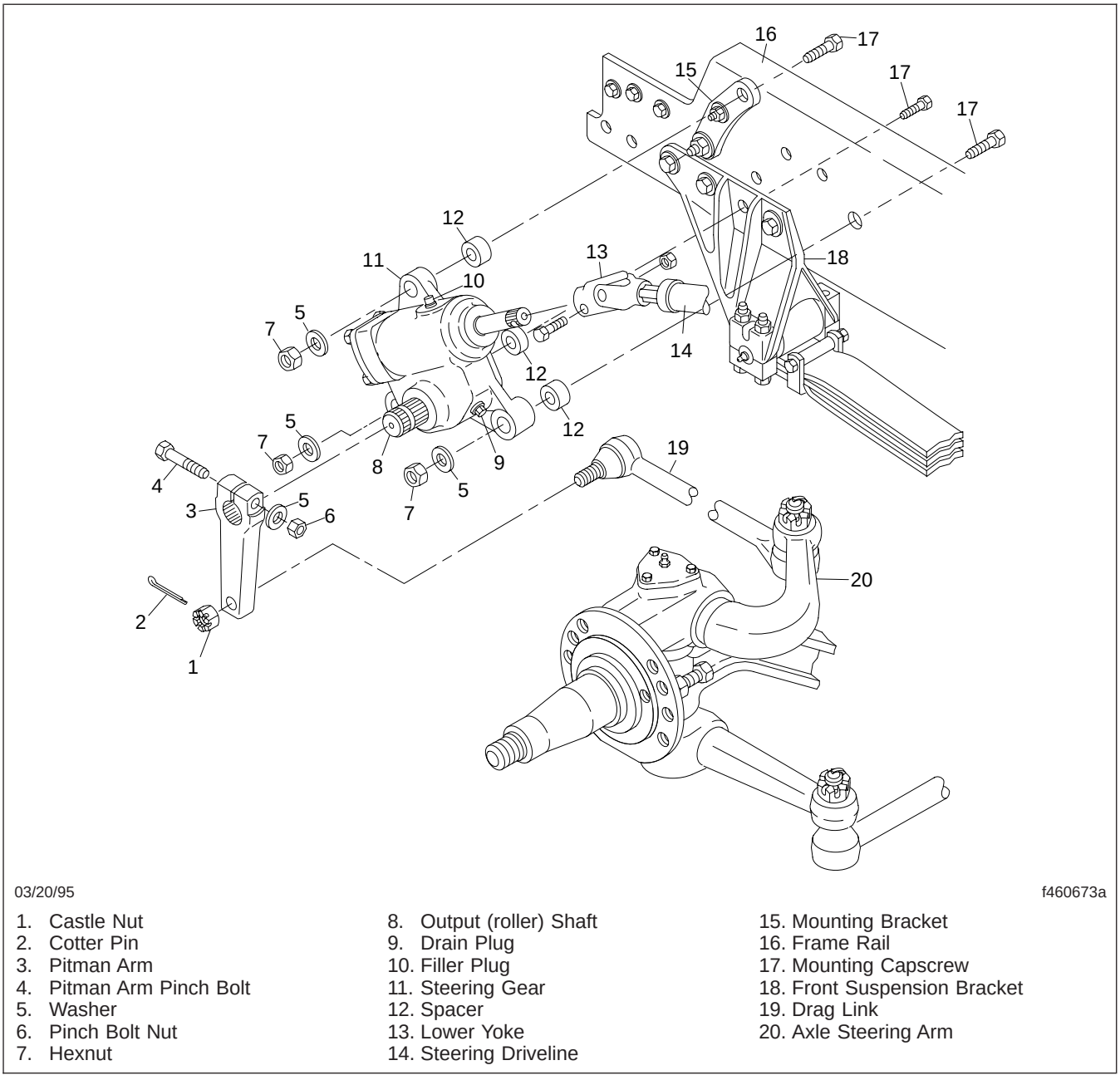
⚠ WARNING

All steering mechanisms are life-and-limb items. As such, it is imperative that the instructions in this subject are followed to the letter. Failure to observe these procedures may result in loss of steering, which could result in personal injury or property damage.

1. Position the front wheels straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be performed. Apply the parking brakes, and chock the tires.
2. Disconnect the drag link from the pitman arm. For instructions, refer elsewhere in this group.
3. Disconnect the steering driveline from the steering gear worm (input) shaft. For instructions, refer elsewhere in this group.

⚠ CAUTION

When heat is applied to remove the end yoke from the worm shaft, use care not to damage the



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1. Castle Nut
2. Cotter Pin
3. Pitman Arm
4. Pitman Arm Pinch Bolt
5. Washer
6. Pinch Bolt Nut
7. Hexnut
8. Output (roller) Shaft
9. Drain Plug
10. Filler Plug
11. Steering Gear
12. Spacer
13. Lower Yoke
14. Steering Driveline
15. Mounting Bracket
16. Frame Rail
17. Mounting Capscrew
18. Front Suspension Bracket
19. Drag Link
20. Axle Steering Arm

Fig. 3, Manual Steering Gear Installation, FLD Conventional (setback axle models built since March 1992)

worm shaft seal. Replace the seal if it is damaged during end yoke removal.

4. Remove the pitman arm pinch bolt nut, washer, and pinch bolt. Remove the pitman arm. Discard the nut.

CAUTION

Use a suitable puller to remove the pitman arm. Using a hammer or torch to remove the pitman arm could damage the roller shaft assembly, the housing bearings, or the roller shaft seal.

Steering Gear Removal and Installation

5. Remove the steering gear mounting bolts and nuts. Remove the steering gear from the vehicle.

CAUTION

The steering gear weighs about 80 lbs (36 kg) when dry. Use extreme care when removing, lifting, or carrying the steering gear.

Installation

See **Fig. 1, Fig. 2, or Fig. 3** when installing the steering gear.

WARNING

All steering mechanisms are life-and-limb items. As such, it is imperative that the instructions in this subject are followed to the letter. Failure to observe these procedures may result in loss of steering, which could result in personal injury or property damage.

1. Centralize the steering gear by turning the worm shaft through full travel, counting the number of turns required. Then, starting at the end of travel, turn back half that number of turns.

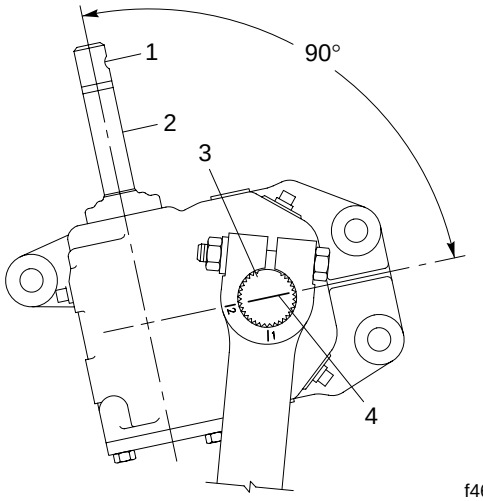
   Check the alignment mark on the output shaft of the steering gear. If the alignment mark is at a right angle to the worm shaft, the gear is centered. If not, adjust the worm shaft backward or forward until the output shaft alignment mark is at a right angle to the worm shaft. See **Fig. 4**. Be sure the steering gear remains centralized as remaining operations are performed.

2. Place the steering gear against the frame rail. Install the mounting bolts from the inboard side. Install and tighten the nuts 190 lbf·ft (258 N·m).

NOTE: The mounting bolts must be periodically checked for tightness. Refer to the steering section in the vehicle maintenance manual for recommended intervals.

3. Install the pitman arm on the steering gear, aligning the timing marks.

NOTE: The pitman arm may not fit over the splines on the sector shaft without spreading the slot in the arm. To wedge the slot open, clamp the pitman arm in a vise, with the slot at the top;



NOTE: When the gear is centered, the output shaft alignment mark is at a right angle to the input shaft.
1. Whistle Notch
2. Input Shaft
3. Output Shaft
4. Output Shaft Alignment Mark

Fig. 4, Check the Alignment Mark

then, using a ball peen hammer, drive a chisel into the slot. Hold the chisel in place, remove the pitman arm from the vise, and install the pitman arm on the sector shaft. Remove the chisel from the slot.

WARNING

Never leave a chisel wedged in the pitman arm slot. When using a chisel to spread the slot in the pitman arm, maintain a firm grip on the chisel at all times. Otherwise, it may fly loose, which could cause an injury.

4. Install the pitman arm pinch bolt, washer, and a new nut. Tighten the nut 130 to 155 lbf·ft (176 to 210 N·m).

5. Fill the steering gear with lubricant, as follows:

   5.1 If not already done, remove the filler plug (and the pressure relief fitting) from the steering gear housing. Thoroughly clean the plug.

5.2 Add lubricant until it is within 1/2 inch (13 mm) of the filler hole. Refer to the lubricant recommendations table in **Specifications, 400**.

5.3 Install the filler plug (and pressure relief fitting) and tighten it 12 to 15 lbf·ft (16 to 20 N·m).

6. Turn the steering wheel so that its spokes are within ±10 degrees of the 4 o'clock and 8 o'clock positions.

7. Connect the steering driveline to the steering gear worm (input) shaft. Do not move the steering gear worm (input) shaft. For instructions, refer to the applicable section in this group.

8. Install the drag link. Refer to the instructions elsewhere in this group.

9. After the steering driveline has been connected to the steering gear worm (input) shaft, check the positions of the steering wheel spokes. The spokes should be within ±10 degrees of the 4 o'clock and 8 o'clock positions. Adjust the position of the steering wheel on the upper column and jacket assembly if necessary. For instructions, refer to the applicable section in this group.

10. Verify that adjustments made to the steering system are correct by test driving the vehicle or taking a ride with the driver.

    If, during straight-ahead driving on a level road, the steering wheel spokes do not point directly toward the 4 o'clock and 8 o'clock positions (±10 degrees), it is a sign that the steering gear is not centered. The probable cause was the failure to keep the vehicle's front wheels in a straight-ahead position during repair or adjustment of the steering gear.

    Make adjustments as follows:

    10.1 Note the approximate number of degrees the steering wheel spokes point away from the 4 o'clock and 8 o'clock positions (±10 degrees), during straight-ahead driving.

    10.2 Using the instructions elsewhere in this group, lengthen or shorten the drag link. Each turn of the drag link will result in partial turning of the steering wheel. All adjustments must result in a centered steering gear (and correctly positioned steering wheel spokes) when the vehicle's front wheels are straight ahead.

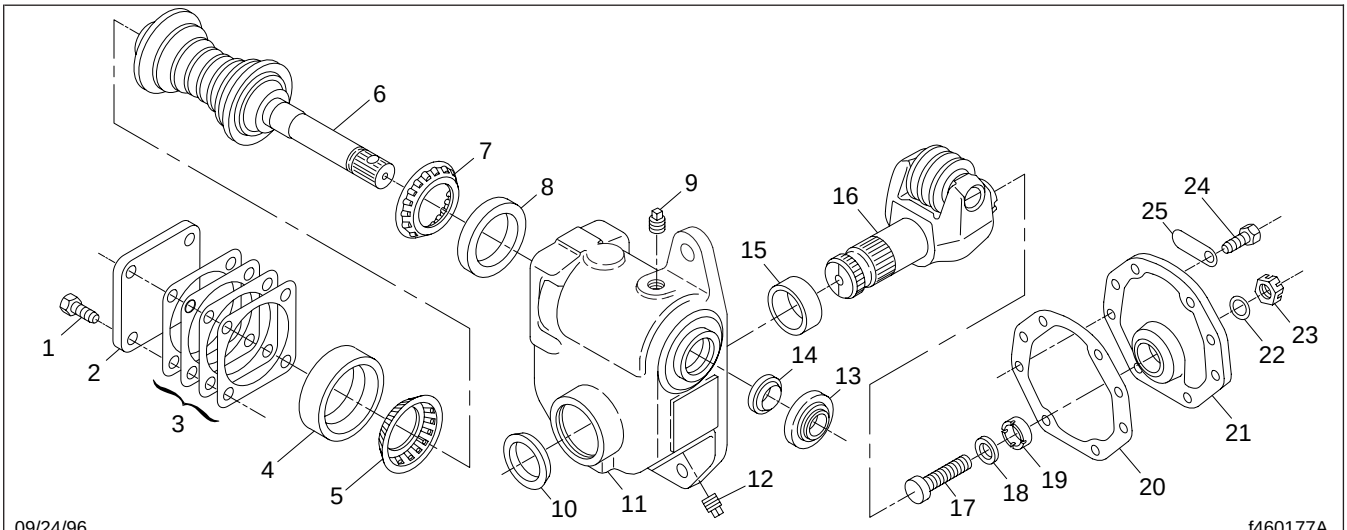
    10.3 Again, test drive the vehicle or take a ride with the driver. Observe that the steering wheel spokes point correctly during straight-ahead driving on a level road. Repeat the adjustments at the drag link, if needed.

Steering Gear Disassembly, Inspection and Component Replacement, and Assembly

Disassembly (See Fig. 1)

⚠ WARNING

All steering mechanisms are life-and-limb items. As such, it is imperative that the instructions in this subject are followed to the letter. Failure to observe these procedures may result in loss of steering.

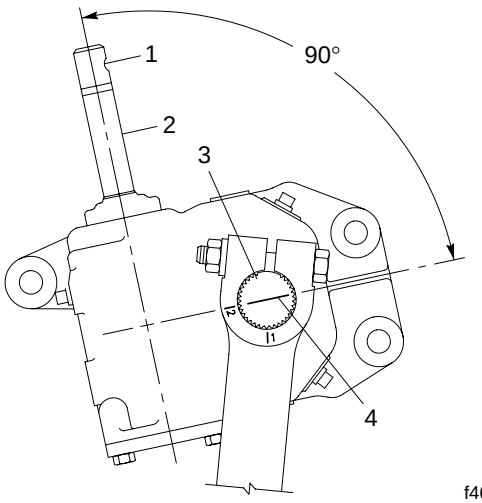


1. Worm Cover Screws (4 qty.)
2. Worm Cover
3. Worm Cover Shims
4. Bearing Cup
5. Bearing Cage (retainer)
6. Worm (input) Shaft
7. Bearing Cage (retainer) Assembly
8. Bearing Cup
9. Filler and Vent Plug
10. Roller Shaft Seal
11. Housing
12. Drain Plug
13. Boot
14. Worm Shaft Seal
15. Bushing
16. Roller (output) Shaft Assembly
17. Adjusting Screw
18. Washer
19. Shaft Cover Bushing
20. Shaft Cover Gasket
21. Shaft Cover
22. O-Ring
23. Adjusting Screw Locknut
24. Shaft Cover Screws (8 qty.)
25. Identification Tag

Fig. 1, Steering Gear Assembly

1. Clean the steering gear. Remove the filler plug and drain plug, and drain the lubricant from the unit. Discard the lubricant. Clean both plugs.
2. Remove the steering gear from the vehicle. For instructions, refer to **Subject 130**.
3. Rotate the worm shaft to place the roller shaft on center or in the straight-ahead position. See **Fig. 2**.
4. Loosen the adjusting screw locknut. See **Fig. 3**.
5. Remove the shaft cover screws, as shown in **Fig. 4**.
6. Remove the roller shaft and shaft cover as one assembly. See **Fig. 5**. It may be necessary to tap the end of the shaft with a soft mallet to break the shaft cover loose.
7. Remove the shaft cover gasket. See **Fig. 5**.
8. Disconnect the roller shaft from the shaft cover. While holding the shaft cover, separate the roller shaft by removing the adjusting screw locknut and O-ring, and turning the adjusting screw clockwise.
9. Remove and discard the roller shaft seal. See **Fig. 6**.
10. Remove the worm cover screws as shown in **Fig. 7**. Then, remove the worm cover and shims.
11. Remove the upper bearing cup and the cage (retainer) assembly (see **Fig. 8**) by pulling on the end of the worm (input) shaft.

Steering Gear Disassembly, Inspection and Component Replacement, and Assembly



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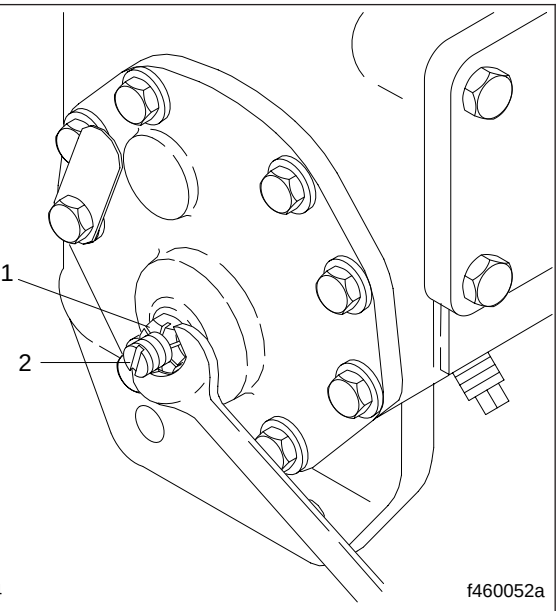
1. Whistle Notch
2. Input Shaft
3. Output Shaft
4. Output Shaft Alignment Mark

Fig. 2, Check the Alignment Mark



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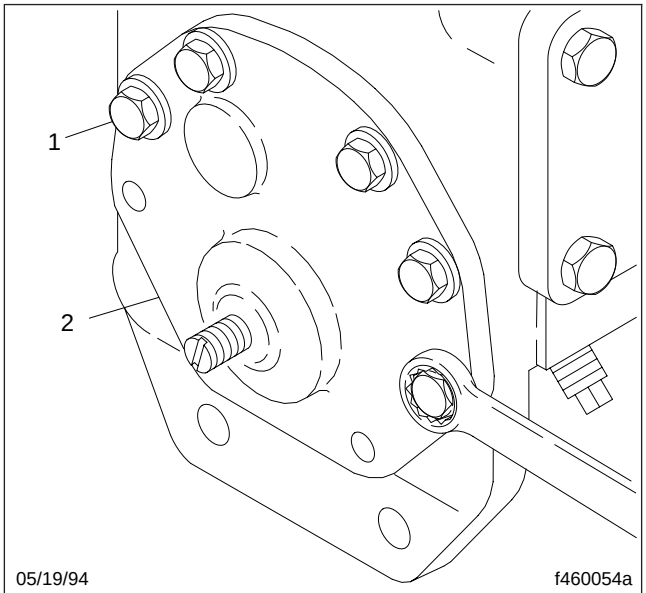
1. Locknut 2. Adjusting Screw

Fig. 3, Loosen the Locknut

NOTE: If the bearing cup cocks during removal, do not use force; tap the bearing cup in place, and repeat the procedure.



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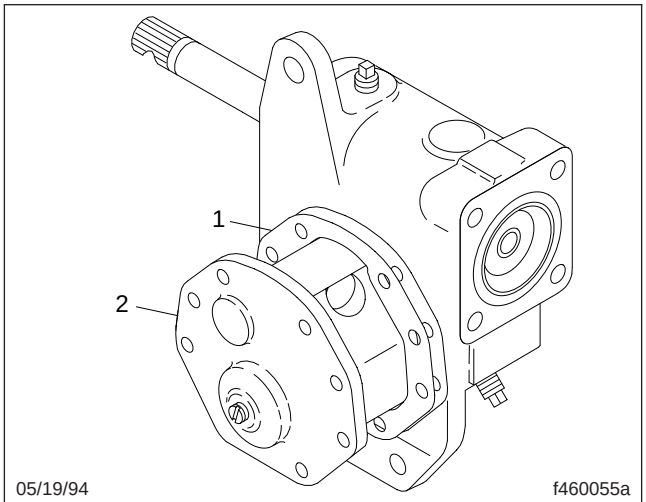
1. Shaft Cover Screw 2. Shaft Cover

Fig. 4, Remove the Shaft Cover Screws



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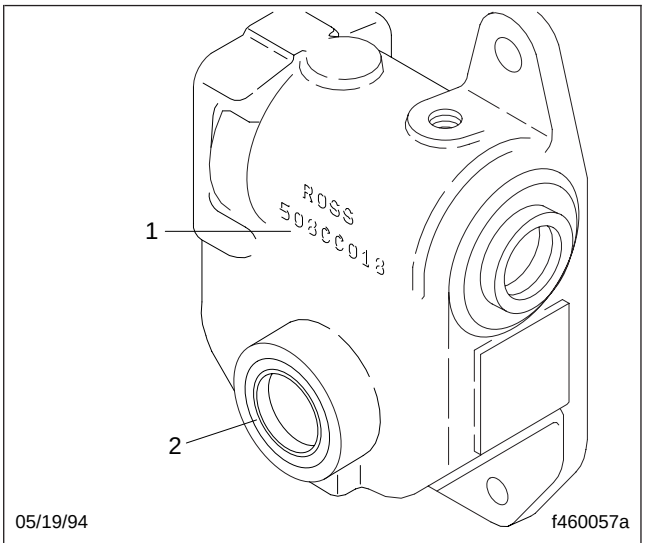
1. Shaft Cover Gasket
2. Roller Shaft and Shaft Cover Assembly

Fig. 5, Remove the Shaft Cover Gasket

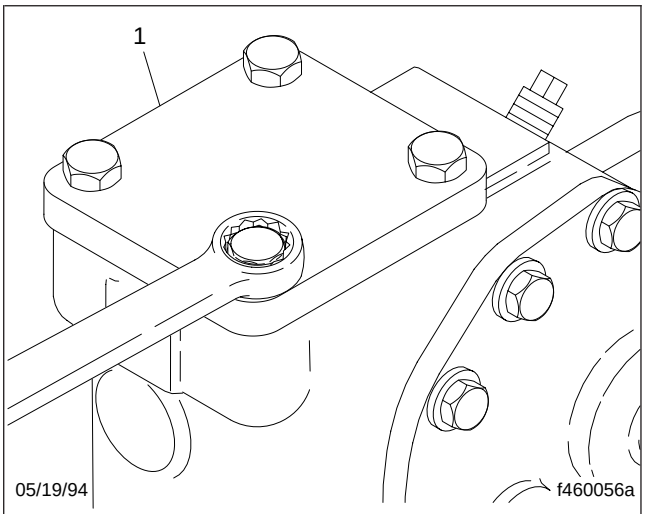
12. Remove the worm shaft assembly.
13. Remove the lower bearing cage (retainer) assembly.
14. Remove and discard the worm shaft seal.

Steering Gear Disassembly, Inspection and Component Replacement, and Assembly



1. Housing Part Number
2. Roller Shaft Seal and Bushing

Fig. 6, Remove the Roller Shaft Seal

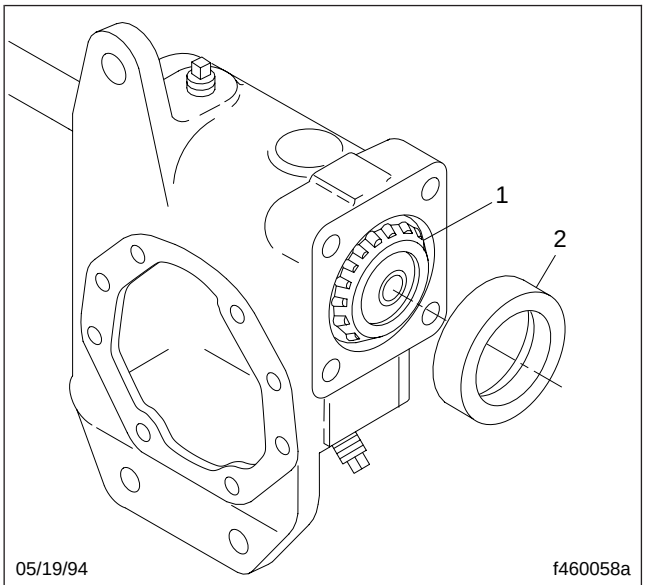


1. Worm Cover

Fig. 7, Remove the Worm Cover Screws

Inspection and Component Replacement (See Fig. 1)

The use of genuine factory replacement parts, *in the proper combination* of housing, worm, and roller shaft assembly, is necessary when servicing the parts of steering gear assemblies to ensure proper functional operation.



1. Cage (retainer) Assembly
2. Bearing Cup

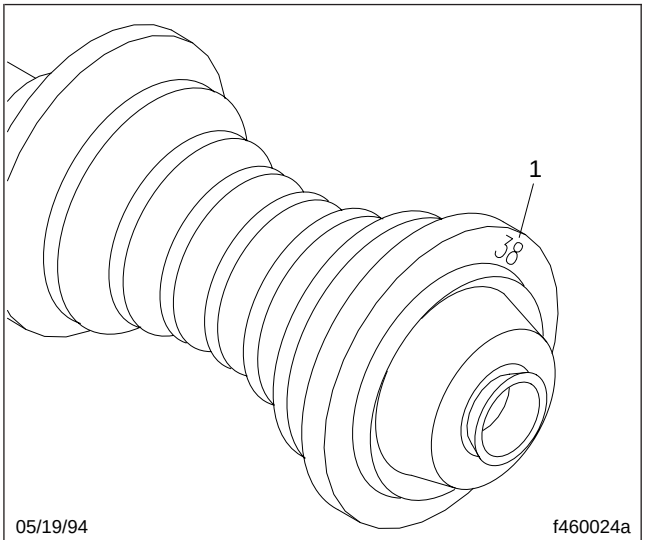
Fig. 8, Remove the Bearing Cup and Cage Assembly

When the steering gear is serviced, replacement parts must be matched by part number to the original factory-installed component. Each steering gear housing, worm shaft, and roller shaft is stamped with a part number to ensure correct identification. Replacement parts must be identically matched to these numbers, since component size can differ, depending on the steering gear ratio. Refer to the Freightliner *Parts Book* for the proper combination of steering gear components.

NOTE: The steering gear housing part number is cast on the outside face of the housing for identification. See **Fig. 6**. The worm shaft part number is stamped on the end of the finished part (see **Fig. 9**), and the roller shaft part number is stamped on the top of the roller tooth (see **Fig. 10**).

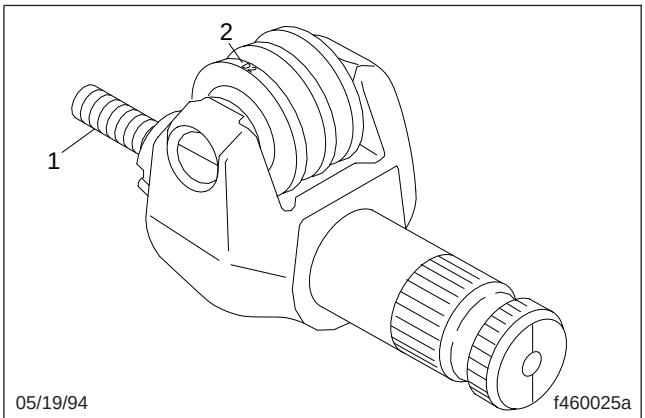
NOTE: TRW Gear Division of TRW, Inc. and Freightliner Corporation will not be liable for the malfunction of any serviced steering gear unit and/or assembly which contains either a non-genuine factory replacement part, or contains the wrong combination of components improperly assembled or adjusted.

Steering Gear Disassembly, Inspection and Component Replacement, and Assembly



1. Worm Shaft Part Number

Fig. 9, Worm Shaft Part Number Stamp



1. Roller Shaft Adjusting Screw
2. Roller Shaft Part Number Stamp Location

Fig. 10, Roller Shaft Adjusting Screw

1. Check the end play of the roller shaft adjusting screw (end play refers to the in-and-out movement of the adjusting screw). See **Fig. 10**. If the end play exceeds 0.008 inch (0.20 mm), reduce it with a new threaded adjusting screw retainer and a thrustwasher, and adjust 0.001 to 0.003 inch (0.03 to 0.08 mm) end play. Carefully stake (2 places) the outer flange of the threaded adjusting screw retainer, using a chisel point punch, into the slots on the end of the roller shaft.

NOTE: Excessive end play of the adjusting screw will be noticeable when making roller shaft total mesh preload adjustment, because the turning torque will be uneven (left to right/ right to left) when turning the gear across center or to the straight-ahead position.

⚠ WARNING

Excessive end play in the adjusting screw will make it impossible to adjust the roller shaft total mesh preload within specifications. Failure to reduce this end play, as instructed above, could ultimately result in a loss of steering control.

2. Check the clearance between the shaft cover bushing and the outboard end of the roller shaft. See **Fig. 5**. If the clearance exceeds 0.010 inch (0.03 mm), replace the shaft cover bushing.

IMPORTANT: If the shaft cover contains a bronze bushing, replace them with a new shaft cover and bushing assembly.

NOTE: Use a piloted mandrel to install the new bushing so that it is flush with the outer face of the bearing boss.

3. Insert the roller shaft in the housing, then check the clearance between the inboard end of the roller shaft and the bushing(s).

   If the roller-shaft-to-bushing(s) clearance exceeds 0.010 inch (0.03 mm), replace the bushing(s) as follows:

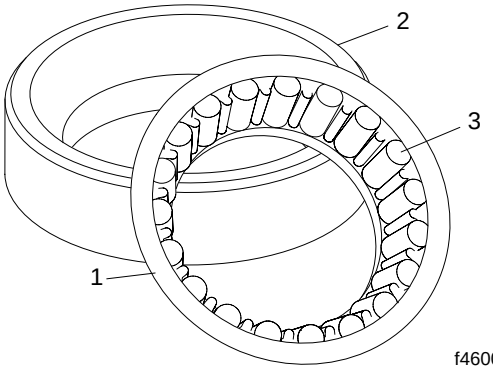
   3.1 Press out the old bushing(s) with a piloted mandrel.

   3.2 Install a new housing bushing(s) with a piloted mandrel. Press each bushing into the bore from the outside (see **Fig. 6**) until the outer face of the bushing is flush with the inner face of the seal counterbore.

   NOTE: The inside diameter of the new bushing should be 1.750 to 1.751 inches (44.45 to 44.48 mm).

4. Check the bearing cage (retainer) assemblies (**Fig. 11**) on each end of the worm shaft. Inspect the bearing cups (races), the tapered rollers, and the cages (retainers) for pitting, brinelling and

other damage. If the bearing components are not in good condition, replace them with new assemblies.

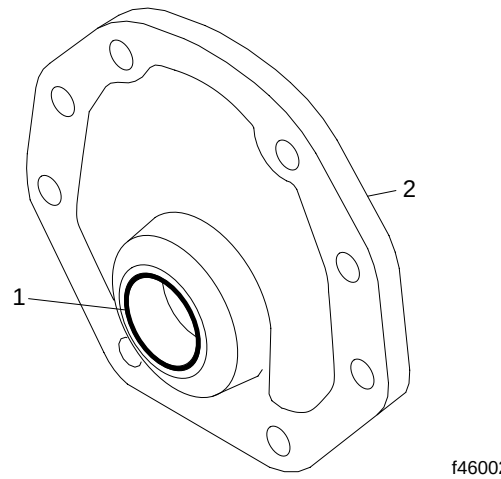


1. Cage (retainer)
2. Bearing Cup
3. Tapered Roller

Fig. 11, Bearing Cage Assemblies

NOTE: Replace the bearing components only in full assemblies. A full assembly includes the cup, the tapered rollers, and the cage.

5. Inspect the roller shaft bushing(s) (**Fig. 6**) and sealing surfaces for wear and pitting. Also inspect the shaft cover bushing (**Fig. 12**) for damage. If necessary, the bushing surfaces may be lightly polished with very fine abrasive cloth.



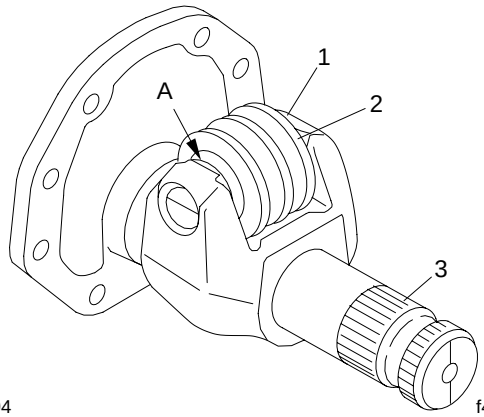
1. Bushing
2. Shaft Cover

Fig. 12, Shaft Cover Bushing

6. Check the roller/tooth portion of the roller shaft (**Fig. 13**) for freedom of movement, excessive lash, and roughness. Inspect the tooth and splines of the roller shaft for gouges or other damage. Replace the roller shaft assembly, if damaged.

NOTE: Insert a feeler gauge between the roller tooth and the shoulder, to check excessive lash (sideplay). See **Fig. 13**. If the clearance exceeds 0.010 inch (0.03 mm), replace the roller shaft.

Assembly (See Fig. 1)



A. Check the sideplay here with a feeler gauge.
1. Shoulder
2. Roller Tooth
3. Splines

Fig. 13, Roller Shaft

⚠ WARNING

All steering mechanisms are life-and-limb items. As such, it is imperative that the instructions in this subject are followed to the letter. Failure to observe these procedures may result in loss of steering.

Clean all steering gear internal parts, then coat them with lubricant before assembly. Use SAE 90 hypoid gear oil, API Service Classification GL–5, when ambient temperatures are continuously above 30°F (–1°C); use SAE 75 hypoid gear oil, API Service Classification GL–5, when ambient temperatures are continuously below 30°F (–1°C). Refer to the lubrication table under **Specifications, 400**.

Steering Gear Disassembly, Inspection and Component Replacement, and Assembly

1. Install the lower bearing cage (retainer) assembly in the bearing cup.
2. Insert the worm shaft assembly in the housing. Use care not to unseat the bearing cage (retainer) assembly previously installed in the bearing cup.
3. Position the upper bearing cage assembly on the worm shaft.
4. Insert the bearing cup in the housing bore. See **Fig. 8**. Do not use force to seat the cup. If installed correctly, the cup will seat in the bore with minimal effort required.

NOTE: If the bearing cup cocks during installation, do not use force; tap the bearing cup out, and repeat the procedure.

5. Install the shims (**Fig. 14**) and the worm cover.

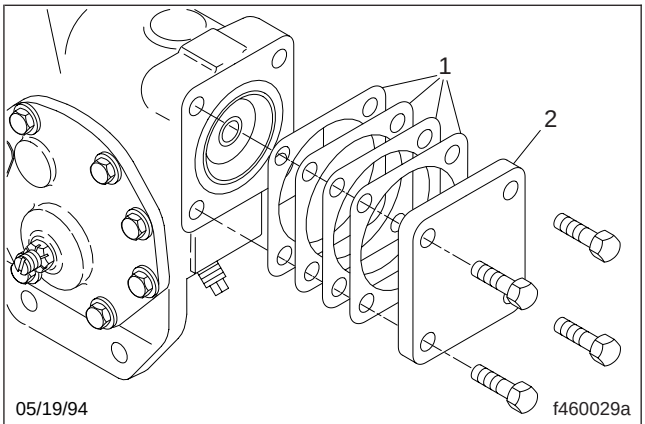


Fig. 14, Install the Shims and Worm Cover

NOTE: Rubber covered shims (if applicable) must be assembled with the rubber sides against the housing and the worm cover.

6. Install the worm cover screws. Tighten the screws finger tight.

CAUTION

Do not final torque the worm cover screws immediately. Rotate the worm shaft assembly with one hand while slowly tightening the worm cover screws with the other hand to prevent damaging the bearing surfaces if the initial amount of shims is inadequate. Once a light preload is obtained by using a torque gauge, final torque the worm cover screws 45 to 55 lbf·ft (61 to 75 N·m). Tighten the screws using the sequence shown in Fig. 15.

7. *Always recheck the worm shaft preload* after final torquing of the worm cover screws is completed. For instructions, refer to **Subject 120**. If necessary, repeat the adjustment using a different selection of shims.

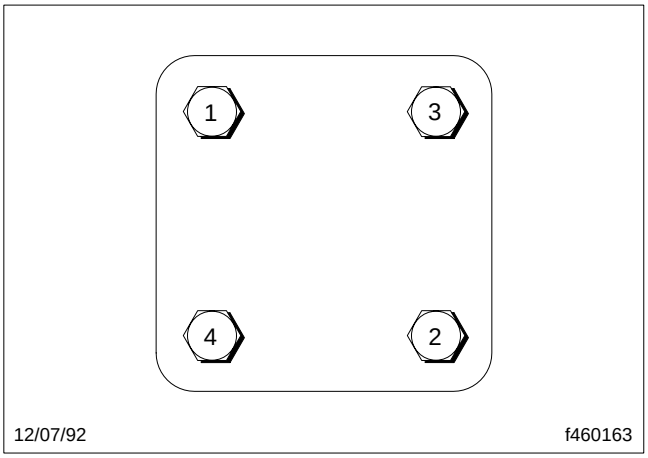


Fig. 15, Worm Cover Screws, Tightening Sequence

NOTE: When checking the preload (this step only), use the torque value for steering gears without a worm shaft seal installed.

8. Insert the adjusting screw of the roller shaft into the shaft cover from the bearing side of the cover. Install the O-ring and locknut on the adjusting screw. Draw the roller shaft into the bearing until the shaft bottoms in the shaft cover. Then, reverse the adjusting screw rotation one full turn.
9. Install the shaft cover gasket. Install the roller shaft and shaft cover assembly.

NOTE: Rotate the worm shaft so that the whistle notch is located as shown in **Fig. 2**. The center tooth of the roller shaft must engage the center of the worm gear.

10. Install the shaft cover screws, tightening them finger tight. Then, rotate the worm shaft to one-half turn from *each end* of travel; lash must be present in each position with no perceptible binding. Final torque the shaft cover screws 45 to 55 lbf·ft (61 to 75 N·m).

11. Adjust the roller shaft total mesh preload using the instructions in **Subject 120**.

NOTE: When checking the preload (this step only), use the torque value for steering gears without a worm shaft seal installed.

12. Carefully press in the new worm shaft and roller shaft seals as follows:

    12.1 Place the lubricated seal in the counterbore, with the longest lip facing into the gear.

    12.2 Using a mandrel large enough to contact all portions of the seal case (metal retainer), press in the lubricated seal until it bottoms in the counterbore.

13. Install the drain plug in the housing. Tighten the plug 12 to 16 lbf·ft (16 to 22 N·m). Do not fill the housing with lubricant at this time. Add lubricant to the steering gear after the unit is installed on the vehicle. Refer to **Subject 130**.

Troubleshooting Chart

The following troubleshooting information should be used to diagnose steering system problems. For more troubleshooting information, see **Group 33**.

Problem—Excessive Lash or Free Play at the Steering Wheel

Problem—Excessive Lash or Free Play at the Steering Wheel	
Possible Cause	**Remedy**
The steering wheel is loose on the upper steering column.	Inspect the parts for damage caused by the looseness. Replace damaged components. If no damage exists, secure the steering wheel.
The steering gear mounting bolt nuts are loose.	Tighten the nuts to one of the following torque specs: • 190 lbf·ft (258 N·m) for a 5/8–11 bolt and nut • 310 lbf·ft (420 N·m) for a 7/8–9 bolt and nut • 350 lbf·ft (475 N·m) for a 7/8–14 bolt and nut
The pitman arm is loose on the roller (output) shaft.	Inspect the pitman arm and the roller (output) shaft splines for damage caused by the looseness. Replace damaged components. If no damage exists, install and tighten a new pitman arm retaining nut.
Steering drivelines universal joints are worn.	Replace worn universal joints.
Steering knuckle bushings are worn.	Replace the bushings, using the instructions in **Group 33**.
Wheel bearings are worn or require adjustment.	Inspect and adjust the wheel bearings, using the instructions in **Group 33**. Replace the bearings if necessary.
Steering gear parts are worn or the steering gear requires preload adjustments.	Replace worn parts if preload adjustments cannot be made.
The drag link or tie rod ends are worn or damaged.	Repair or replace parts as needed.

Problem—No Recovery When Leaving a Turn

Problem—No Recovery When Leaving a Turn	
Possible Cause	**Remedy**
Tire pressure is low.	Inflate the tires to the specifications in **Section 40.00**.
Steering driveline universal joints are binding.	Check the universal joints for damage and inadequate lubrication. Correct the condition(s) as required.
The fifth wheel is inadequately lubricated.	Lubricate the fifth wheel as instructed in the vehicle maintenance manual.
Steering knuckle kingpins are binding.	Inspect the kingpins and bushings for wear or damage. If needed, replace the components. Lubricate the kingpins as instructed in the vehicle maintenance manual.
The steering linkage is binding or lacks lubrication.	Replace components, adjust, or lubricate, as required.
Front axle alignment is incorrect.	Align the axle as instructed in **Group 33**.
Steering gear parts are worn, or the steering gear requires preload adjustments.	Replace worn parts if preload adjustments cannot be made.

Specifications

Steering Gear Torque Values		
Description	**Bolt or Nut Size**	**Torque lbf·ft (N·m)**
Steering Gear Mounting Bolts and Nuts with Hardened Washers	5/8–11	190 (258)
	7/8–9	310 (420)
	7/8–14	350 (475)
Worm Cover Screws	7/16–14	45–55 (61–75)
Shaft Cover Screws	7/16–14	45–55 (61–75)
Adjusting Screw Locknut	5/8–18	25–40 (34–54) *
Pitman Arm Pinch Bolt Nut	5/8–18	130–155 (176–210)

* Torque while holding the screw.

Table 1, Steering Gear Torque Values

Steering Gear Lubricants	
Temperature Continuously Above +30°F (–1°C)	**Hypoid Gear Oil SAE 90 API Service Classification GL –5**
Temperature Continuously Below +30°F (–1°C)	Hypoid Gear Oil SAE 75 API Service Classification GL –5

Table 2, Steering Gear Lubricants

TRW Model 503 Steering Gear Specifications		
Description	**Specification**	
	lbf·in (N·cm)	**inch (mm)**
Worm Shaft Preload Check at 70°F (21°C):		
Without Worm Shaft Seal Installed	7–14 (80–160)	—
With Worm Shaft Seal Installed	9–16 (100–180)	—
Roller Shaft Total Mesh Preload Check at 70°F (21°F):		
Without Worm Shaft Seal Installed	20–31 (220–340)	—
With Worm Shaft Seal Installed	23–34 (260–380)	—
Shaft-Cover-Bushing-to-Roller-Shaft Maximum Clearance	—	0.010 (0.254)
Roller-Shaft-to-Housing-Bushing(s) Maximum Clearance	—	0.010 (0.254)
Housing Bushing(s) Inside Diameter	—	1.750–1.751 (44.45–44.48)
Roller Shaft Adjusting Screw Maximum End Play	—	0.008 (0.203)
Roller Shaft Tooth/Shoulder Maximum Lash	—	0.010 (0.254)

Table 3, TRW Model 503 Steering Gear Specifications

Specifications

WARNING

If the vehicle is operated at temperatures below 30°F (–1°C) with SAE 90 weight oil in the steering gear, the steering can gradually become sluggish and resistant to the point where the driver may have difficulty performing an evasive maneuver. When operating in temperatures continuously below 30°F (–1°C), install SAE 75 weight oil.

General Description

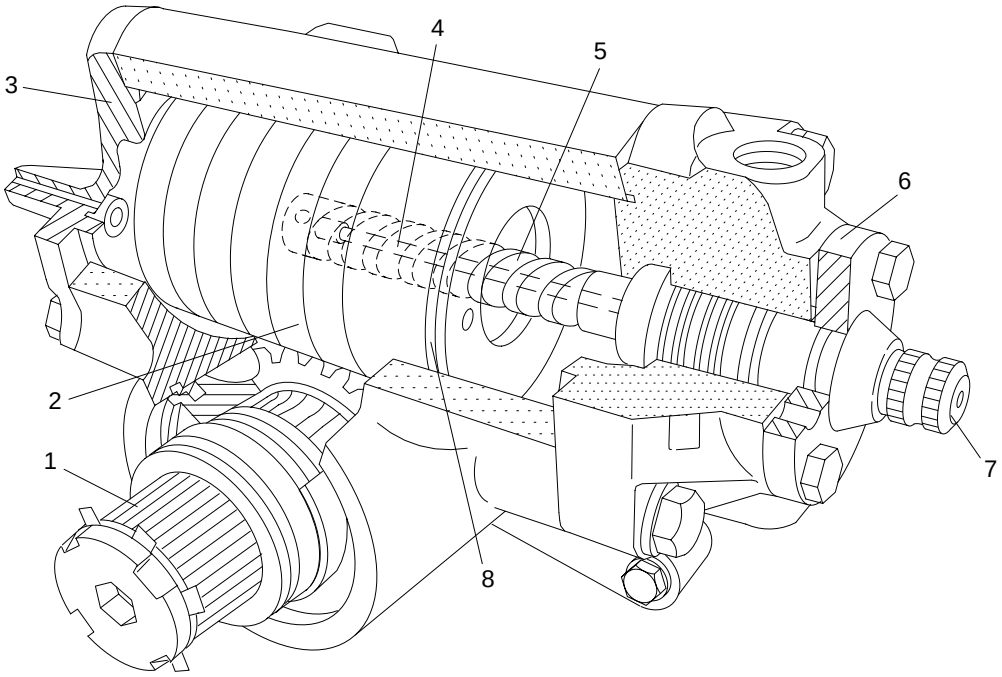
NOTE: Procedures in this section have been slightly modified from the original component manufacturer's service manual. See the manufacturer's service literature (**www.rhsheppard.com/home.htm**) for additional information.

The Sheppard M100 integral power steering gear provides full-time hydraulic steering. This gear is installed as an option on vehicles with a front axle capacity of up to 14,000 pounds (6350 kg).

Principles of Operation

When the driver turns the steering wheel, the force is transmitted to the steering gear input shaft via the steering driveline. The input shaft is connected to a torsion bar within the steering gear. As the input shaft turns, the twisting force on the torsion bar turns the rotary valve, which causes the fluid pressure to build up at one end of the piston. The fluid pressure buildup forces the piston to move inside the bore of the gear housing. The rack teeth on the piston mesh with the teeth on the sector shaft so that the sector shaft rotates when the piston moves. As the sector shaft turns, it moves the pitman arm. The pitman arm connects to the steering linkage, which turns the wheels. See **Fig. 1**.

General Information



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1. Sector (output) Shaft
2. Piston Rack
3. Cylinder Head
4. Torsion Bar
5. Rotary Valve Shaft Ball Thread
6. Bearing Cap Cover
7. Input (actuating) Shaft
8. Piston Ring

Fig. 1, Sheppard M100 Power Steering Gear

Removal

1. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance stopping at the spot where the work is to be done. Apply the parking brakes and chock the tires.

NOTICE

Do not turn the steering wheel or the steering shaft more than a half turn (except for alignment purposes) during the removal and installation procedures. Doing so may damage the clockspring in a vehicle equipped with an air bag.

2. Clean all outside dirt from around the fittings and hose connections.
3. Drain the power steering system. Disconnect all hydraulic lines from the gear, marking the lines for later reference during installation. Seal the lines and the fittings to keep dirt out.
4. Disconnect the pitman arm from the steering gear. See **Fig. 1**, **Fig. 2**, or **Fig. 3**. For instructions, see **Subject 160**.
5. Disconnect the steering driveline from the steering gear input shaft.

   5.1 Remove and discard the pinch bolt and nut from the lower end of the steering driveline yoke.

NOTICE

Do not pound the U-joint or input shaft coupling on or off the input shaft. Internal damage to the steering gear can result.

   5.2 Remove the steering driveline yoke from the steering gear input shaft.

WARNING

The steering gear is heavy. Use caution when removing, lifting, or carrying the steering gear. Failure to do so could cause personal injury.

6. Remove the fasteners that attach the steering gear to the frame rail. Remove the spacers and the steering gear.

IMPORTANT: Note the position and number of spacers on each fastener. Spacer installation will vary depending on the type of frame rail used and whether the vehicle has a setback or set-forward axle.

Installation

1. On COEs, from the inboard side, insert two bolts and washers through the frame rail. Install a spacer on each bolt, then place the steering gear on the frame rail. Install the third bolt from the outboard side of the frame rail. Install the washers and nuts, and tighten the nuts 388 lbf·ft (526 N·m).

   On FLD Conventionals, align the holes in the steering gear housing with the holes in the frame rail or forward frame extension. Place a washer over each bolt, and install the three bolts from the outboard side of the frame rail. Install a spacer(s) on each bolt between the steering gear and either the frame extension (set-forward axles) or the mounting bracket and frame rail (setback axles). Install a washer and nut on the end of each bolt and tighten the nuts 388 lbf·ft (526 N·m).
2. Install the pitman arm on the steering gear. For instructions, see **Subject 160**.
3. Connect the steering driveline to the steering gear input shaft.

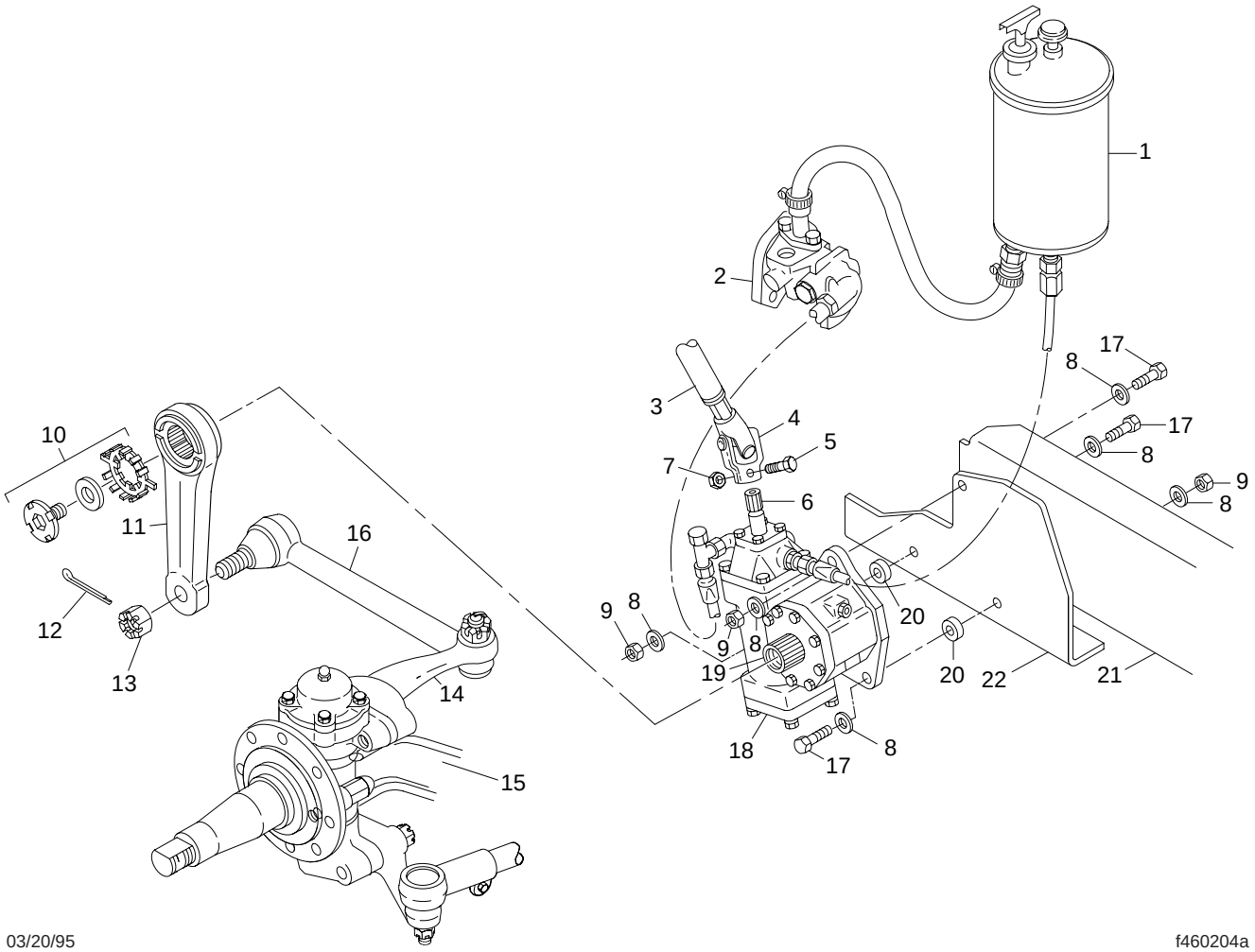
   3.1 Clean the steering gear actuating shaft and the inside of the steering driveline yoke.

   3.2 Slide the yoke on the input shaft and install a new pinch bolt and nut. Tighten the nut to one of the following torque specs:

   - 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16 pinch bolt and nut
   - 30 to 35 lbf·ft (41 to 47 N·m) for an M10 pinch bolt and nut

   3.3 Apply torque seal, OPG F900WHITE, to the exposed pinch bolt threads and to the nut.
4. Connect the hydraulic lines to the gear as marked earlier or as shown in the plumbing diagram in **Specifications 400**. Tighten the nut on each fitting finger-tight, then with a wrench, tighten the nut until there is firm resistance. Tighten the nut 1/6-turn more.

Steering Gear Removal and Installation



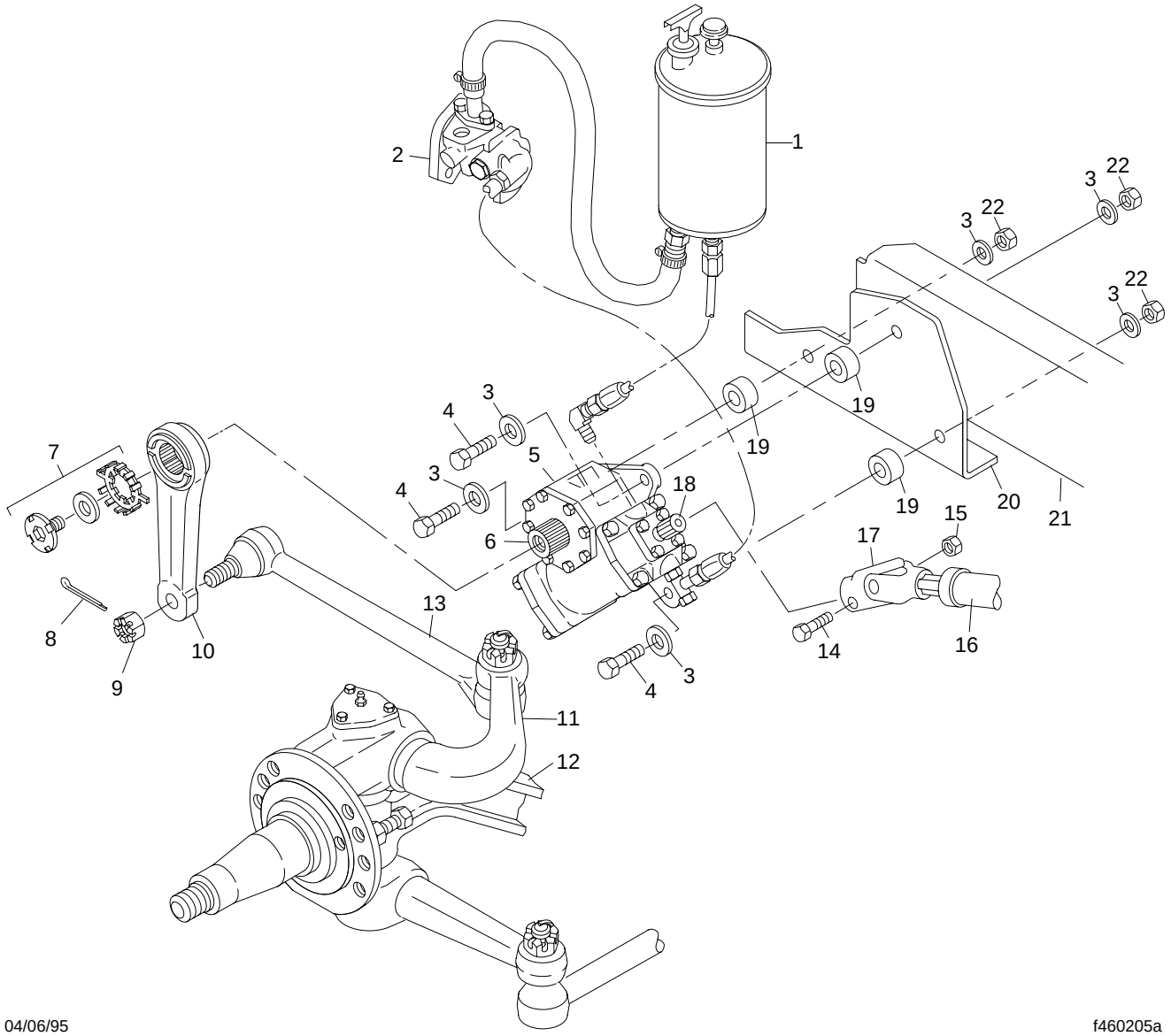
1. Power Steering Reservoir
2. Power Steering Pump
3. Steering Driveline
4. Lower End Yoke
5. Pinch Bolt
6. Input (actuating) Shaft
7. Nut
8. Washer
9. Nut
10. Pitman Arm Retainer Assembly
11. Pitman Arm
12. Cotter Pin
13. Castle Nut
14. Axle Steering Arm
15. Front Axle
16. Drag Link
17. Bolt
18. Steering Gear
19. Sector (output) Shaft
20. Spacer
21. Frame Rail
22. Frame Extension

Fig. 1, Sheppard Integral Power Steering Gear Installation, COE

5. Position the steering wheel so that the spokes point within ±10 degrees of the 4 o'clock and 8 o'clock positions. See **Fig. 4**.

NOTICE

Do not turn the steering wheel at this time. Doing so can cause air to enter the system, possibly causing an unexpected loss of power steering assist.

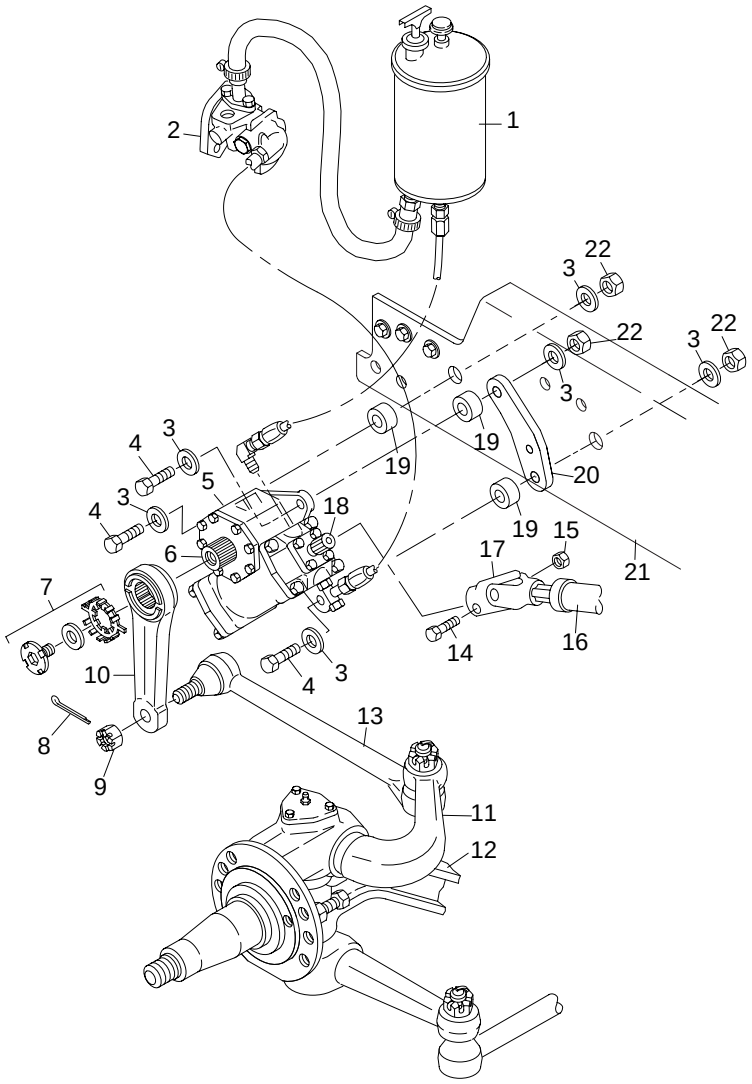


1. Power Steering Reservoir
2. Power Steering Pump
3. Washer
4. Bolt
5. Steering Gear
6. Sector (output) Shaft
7. Pitman Arm Retainer Assembly
8. Cotter Pin
9. Castle Nut
10. Pitman Arm
11. Axle Steering Arm
12. Front Axle
13. Drag Link
14. Pinch Bolt
15. Nut
16. Steering Driveline
17. Lower End Yoke
18. Input (actuating) Shaft
19. Spacer
20. Mounting Bracket (if equipped)
21. Frame Rail
22. Nut

Fig. 2, Sheppard Integral Power Steering Gear Installation, 120 Conventional

6. Connect the pitman arm to the steering gear. For instructions, see **Subject 160**.
7. Adjust the automatic relief plunger. For instructions, see **Subject 130**.

Steering Gear Removal and Installation



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1. Power Steering Reservoir
2. Power Steering Pump
3. Washer
4. Bolt
5. Steering Gear
6. Sector (output) Shaft
7. Pitman Arm Retainer Assembly
8. Cotter Pin
9. Castle Nut
10. Pitman Arm
11. Axle Steering Arm
12. Front Axle
13. Drag Link
14. Pinch Bolt
15. Nut
16. Steering Driveline
17. Lower End Yoke
18. Input (actuating) Shaft
19. Spacer
20. Mounting Bracket (if equipped)
21. Frame Rail
22. Nut

Fig. 3, Sheppard Integral Power Steering Gear Installation, FLD Conventional (setback axle models built since March 1992)

8. Complete the post-service checks as instructed in **Subject 170**.

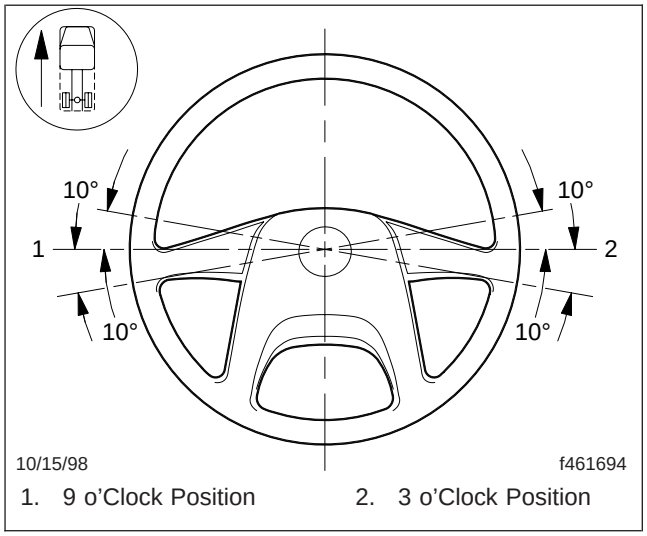


Fig. 4, Steering Wheel Centered

Replacement

1. Shut down the engine, apply the parking brakes, and chock the tires.

IMPORTANT: Do not remove the steering gear for this procedure.

2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60**.

NOTICE

Do not turn the input shaft during repairs. Damage to the steering gear will result.

3. Remove the pinch bolt on the lower end yoke of the steering shaft.

NOTICE

Do not pound the U-joint or input shaft coupling on or off the input shaft. Internal damage to the steering gear can result.

4. Remove the lower yoke from the steering gear input shaft. If necessary, secure the shaft so it will not interfere with your work.

IMPORTANT: Do not pull the slip shaft out of the steering shaft. Installation of the slip shaft requires rephasing.

5. Place a drain pan under the power steering gear. Draining the system is not necessary, but some fluid will be lost.
6. Remove the rubber boot from the input shaft.
7. Remove the capscrews that attach the bearing cap cover to the bearing cap and remove the bearing cap cover.

IMPORTANT: The thrust washer will stick to the bearing cap cover. Install the thrust washer on the bearing cap before proceeding.

8. Place the bearing cap cover on a clean work surface. Pry the salt seal out of the bearing cap cover and discard the seal. See **Fig. 1**.
9. Press the oil seal out of the bearing cap cover using a suitable size socket or seal driver. Use of an arbor press is recommended. See **Fig. 2**. Discard the oil seal.

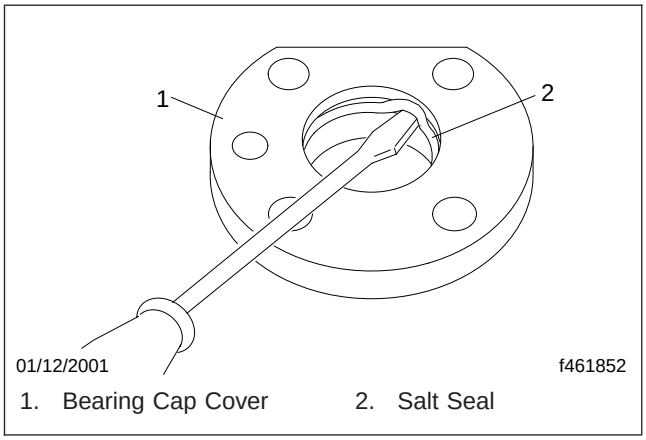


Fig. 1, Salt Seal Removal

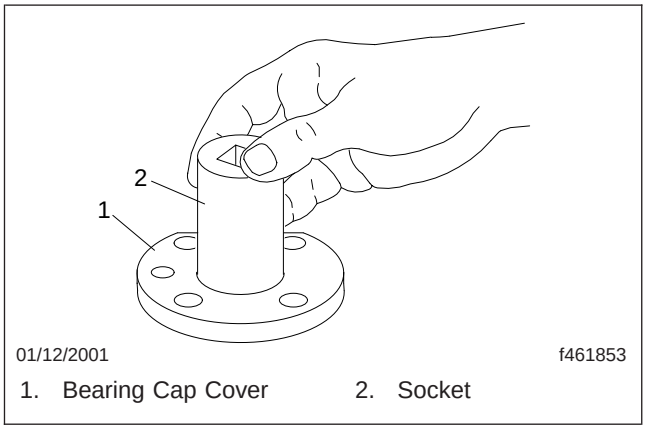


Fig. 2, Oil Seal Removal

10. Remove the O-ring from the bearing cap cover. Discard the O-ring.
11. Clean the bearing cap cover with a suitable solvent.
12. Place the bearing cap cover face down on a clean work surface. With the garter spring visible inside the oil seal, install the oil seal in the bearing cap cover using a suitable size driver and an arbor press. Coat the outside diameter of the oil seal with clean chassis lube. The garter spring will be visible when the oil seal is properly installed.
13. Install a new O-ring in the bearing cap cover. Make sure the oil seal is properly installed before proceeding.

Input Shaft Seal Replacement

14. With the lip of the salt seal facing out, press a new salt seal into the bearing cap cover until it is flush with the face of the cover. See **Fig. 3**.

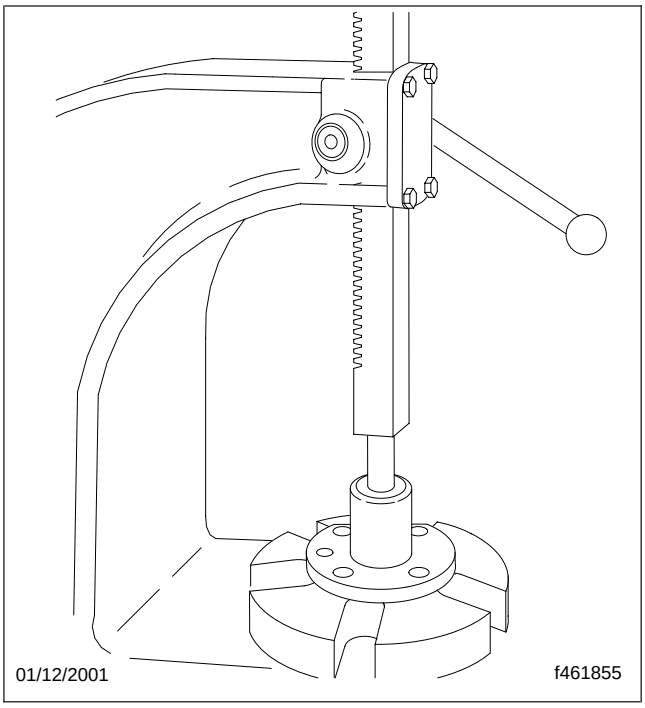


Fig. 3, Salt Seal Installation

15. Tape the input shaft splines before installing the bearing cap cover, to prevent seal damage.
16. Using capscrews, attach the bearing cap cover to the bearing cap and tighten the capscrews 53 to 64 lbf·ft (72 to 87 N·m).

NOTE: Two rubber boots are included in the replacement kit. Choose the rubber boot that will provide the tightest fit on the input shaft.

17. Install the rubber boot on the input shaft. Make sure the boot is below the spline and contacts the bearing cap cover when installed.
18. Remove the tape from the input shaft splines.
19. Install the U-joint following the instructions in **Section 46.04**, Subject 100, for COEs or in **Section 46.05**, Subject 100, for conventionals.

⚠ WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

20. If needed, fill the power steering reservoir with automatic transmission fluid that meets Dexron III or TES-389 specifications.
21. Start the engine and check for leaks.
22. Remove the drain pan and return the hood or cab to the operating position. For cab tilt instructions, see **Group 60**.

Replacement

1. Shut down the engine, apply the parking brakes, and chock the tires.

NOTE: Removal of the power steering gear is not necessary to perform this procedure. Partial disassembly of the steering gear is required to replace the sector shaft seals. Be sure to time the sector shaft after replacement.

2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60**.

NOTICE

Do not turn the steering wheel or the steering shaft during this procedure. Turning either the steering wheel or steering shaft will result in steering gear damage.

3. Disconnect the pitman arm from the steering gear. For instructions, see **Subject 160**.
4. Remove and discard the rubber boot on the sector shaft.
5. If the snap ring cover is equipped with a protective cap, pry the cap out of the bore.

IMPORTANT: When working with snap ring covers, you will need to remove the factory installed silicone protectant from the snap ring and carefully clean the cover area before disassembly.

6. Remove the snap ring on the sector shaft cover.
7. Clean the shaft before removing the sector shaft cover.

NOTE: A slide hammer may be used to remove the sector shaft. It may also be necessary to start the engine to force the sector shaft cover out of the housing.

8. Remove the sector shaft cover and sector shaft from the housing. Separate the cover from the sector shaft. Discard the sector shaft.

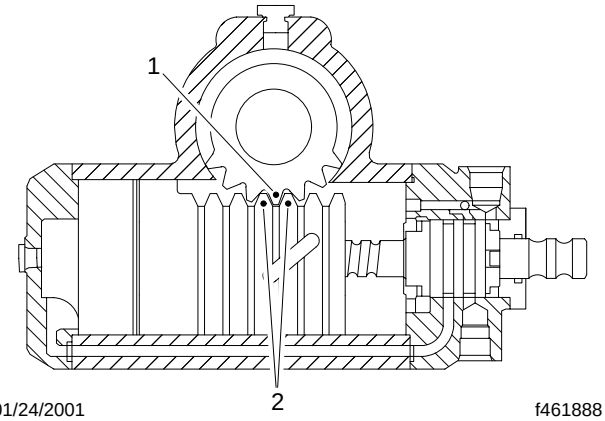
NOTE: It may be necessary to remove the dust cover from the frame side of the sector shaft. Use a gasket scraper or screwdriver to remove the frame side dust cover.

9. Pry the excluder seal from the sector shaft cover. Using a seal pick, remove the oil seal from the sector shaft cover and the steering gear housing. Remove the O-ring from the cover. Discard all seals.

NOTE: Lightly coat the new seals with clean motor oil to facilitate installation of the sector shaft.

IMPORTANT: The sector shaft oil seal has a lip. Do not press on the lip of the oil seal when installing. Press only on the body of the seal. It will be necessary to bend the oil seal when installing. Once the seal is installed, you may have to work the seal into place with your fingers or a blunt seal pick to properly seat the seal.

10. Install a new oil seal in the steering gear housing and the sector shaft cover. When properly fitted, the oil seal will ride between the bearing and the cover. The black lip of the seal must face the inside of the steering gear and the blue side must face the outside of the steering gear.
11. Install a new sector shaft in the housing. Make sure that the timing mark on the sector shaft is placed between the two timing marks on the piston rack. See **Fig. 1**. It may be necessary to tap on the sector shaft to properly seat it into the housing.



1. Sector Shaft Timing Mark
2. Piston Rack Timing Marks

Fig. 1, Timing Mark Alignment

12. Install the sector shaft cover on the steering gear. Make sure that the cover is properly seated

Sector Shaft Replacement

when installing. Snap ring covers must be flush or below the snap ring groove to be properly installed.

13. Apply a coat of clean chassis lube in the lip of the excluder seal. With the lip of the excluder seal facing out and using an appropriate size seal driver, install the excluder seal in the cover. See **Fig. 2**. Apply a bead of grease over the excluder seal and slide the rubber boot over the sector shaft.

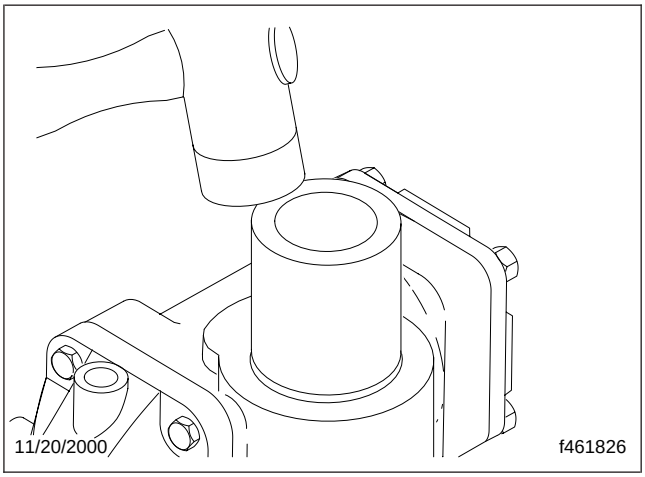


Fig. 2, Installing the Excluder Seal

14. Install the pitman arm. For instructions, see **Subject 160**.

⚠ WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

15. If needed, fill the power steering reservoir with automatic transmission fluid that meets Dexron III or TES-389 specifications.
16. Return the hood or cab to the operating position. For cab tilt instructions, see **Group 60**.

Adjustment

The only circumstances in which the automatic relief plungers require adjusting are when the tire size is changed, the wheel cut is reduced, or a replacement steering gear is installed. Do not adjust the automatic relief plungers under any other circumstances.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60**.
3. Verify that the steering gear has automatic relief plungers. Steering gears with automatic relief plungers will have the word AUTO cast into the housing. See **Fig. 1**. Steering gears with automatic relief plungers also have plastic caps on the plunger bosses.

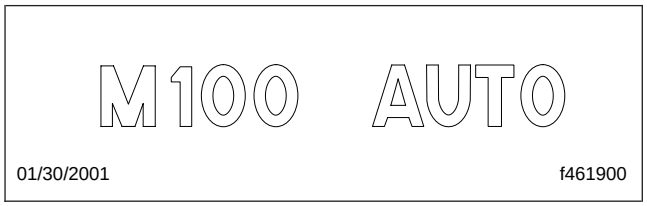


Fig. 1, Automatic Relief Plunger Identifier

4. Remove the plastic caps from both plunger bosses.

NOTICE

Make sure there are no sharp edges on the punch that could damage the bore. Take care when using the punch to ensure that the relief plunger bore is not damaged. If the relief plunger bore is damaged, a leak may occur.

5. Using a 1/4-inch punch and ball-peen hammer, carefully drive the relief plunger in until it bottoms in the bore. Repeat this procedure for the other relief plunger.
6. Replace the plastic caps.
7. Set the automatic relief plungers. For instructions, see **Subject 140**.

Setting the Automatic Relief Plunger

The only circumstances in which the automatic relief plungers need to be set are when the tire size is changed, the wheel cut is extended, or a replacement steering gear is installed. Do not set the automatic relief plungers under any other circumstances.

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60**.
3. Verify that the steering gear has automatic relief plungers. Steering gears with automatic relief plungers will have the word AUTO cast into the housing. See **Fig. 1**. Steering gears with automatic relief plungers also have plastic caps on the plunger bosses.

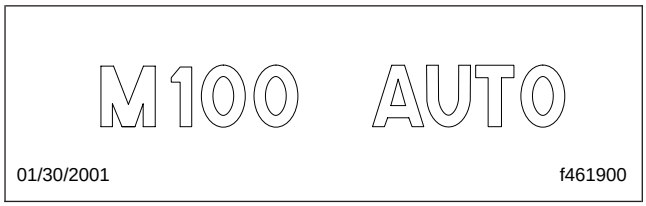


Fig. 1, Automatic Relief Plunger Identifier

4. Using a jack, raise the vehicle until the front wheels are off the ground.

NOTE: Check that the axle stops are set correctly before setting the relief plungers.

5. Start the engine and turn the tires to a full-lock position in both directions. With the tires off the ground, the automatic relief plungers will be set to the correct position when the spindle contacts the axle stop.

NOTE: As the tires reach the end of travel, you will feel the piston contact the relief plunger. Continue turning the tires until the spindle reaches the axle stop bolt.

6. Return the tires to the straight-ahead position.
7. Lower the vehicle until the tires contact the ground. Remove the jack
8. Shut off the engine.
9. Return the hood or cab to the operating position. For cab tilt instructions, see **Group 60**.

There is a relief plunger in the cylinder head and one in the bearing cap. Follow the appropriate set of procedures for the relief plunger you are repairing.

Cylinder Head Automatic Relief Plunger Repair

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60**.
3. Verify that the steering gear has automatic relief plungers. Steering gears with automatic relief plungers will have the word AUTO cast into the housing. See **Fig. 1**. Steering gears with automatic relief plungers also have plastic caps on the plunger bosses.

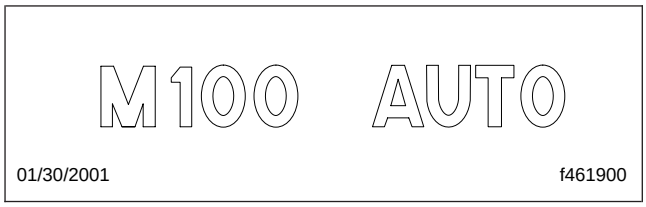


Fig. 1, Automatic Relief Plunger Identifier

4. Place a drain pan under the steering gear.
5. Mark the cylinder head and the steering gear housing for later reference during installation. Remove the capscrews that attach the cylinder head to the housing. Remove the cylinder head.

NOTICE

When driving the relief plunger assembly, do not allow the 1/4-inch punch to contact the bore, and do not hit the plunger with excessive force. Failure to follow these directions could result in damage to the steering gear or relief plunger assembly.

6. Place the cylinder head in a vise and remove the plastic cap from the plunger boss.
7. Using a 1/4-inch punch and hammer, carefully drive the relief plunger assembly in until it bottoms in the bore. The spring pin, flange, and plunger body should be accessible for repair at this point.

NOTICE

Do not allow the screwdriver bit to slip off the plunger body. Damage to the bore could result.

NOTE: The relief plunger flange is held in place with patch lock and the threads are staked at the factory. It will require approximately 15 to 20 lbf·in (150 to 205 N·cm) to remove the flange.

8. Carefully insert a screwdriver bit into the plunger bore to hold the slotted head of the relief plunger body in place. Using an open-end wrench to hold the flange in place, carefully turn the flange to remove the flange from the plunger body. See **Fig. 2**. Discard the flange.

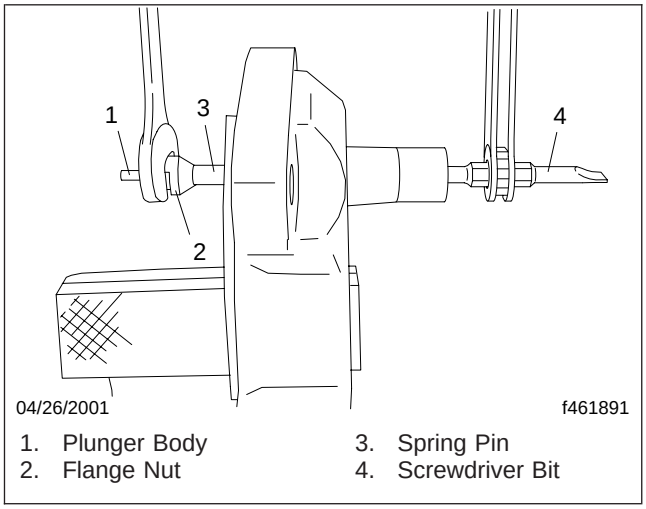


Fig. 2, Flange Removal

9. Remove the plunger body from the spring pin and discard the plunger body. It may be necessary to tap the plunger body to remove it from the spring pin. Use of a 1/8-inch pin punch is recommended.

IMPORTANT: Check the plunger bore for nicks or gouges before installing the plunger assembly. Be careful not to introduce dirt or contaminants in the plunger bore when reassembling.

NOTE: The plunger body has patch lock on the threads. It will require approximately 15 to 20 lbf·in (150 to 205 N·cm) to overcome the patch lock.

Automatic Relief Plunger Repair

10. Coat the O-ring on the new plunger assembly with a light coat of grease. Install the plunger body through the spring pin. See **Fig. 3**.

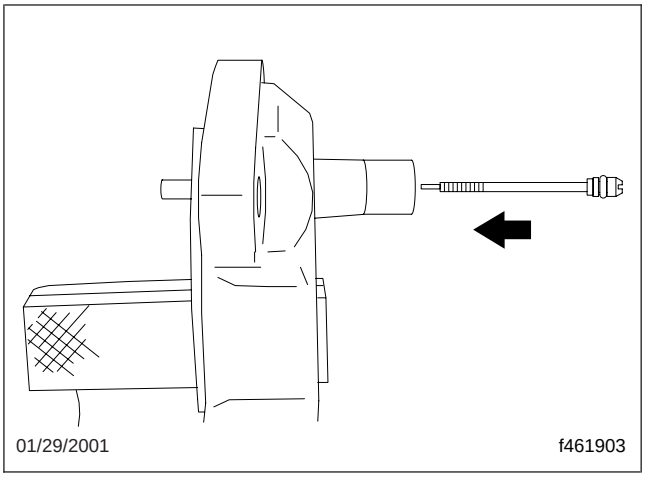


Fig. 3, Plunger Body Installation

WARNING

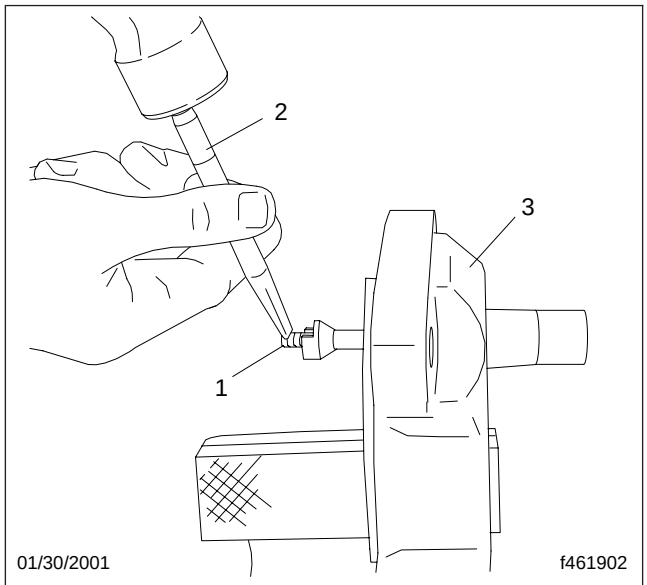
The flange must contact the spring pin. If it does not, a leak or steering gear damage may result. This could cause steering failure, possibly resulting in personal injury or property damage.

11. Use a screwdriver bit and ratchet to hold the plunger body in place. Using an open-end wrench, install the flange on the plunger body until the flange contacts the spring pin.

WARNING

Use extreme caution when staking the threads of the plunger body. Hitting the threads too hard could bend the plunger, which could cause steering failure, possibly resulting in personal injury or property damage.

12. With the flange against the spring pin, use a center punch to stake the threads of the plunger body. See **Fig. 4**. Be careful not to bend the plunger when staking the threads.
13. Align the marks on the cylinder head with the marks on the steering gear housing and install the cylinder head on the housing using the cylinder head capscrews. Tighten the capscrews 114 to 124 lbf·ft (154 to 168 N·m).
14. Install the plastic cap on the plunger boss.



1. Plunger Body
2. Center Punch
3. Cylinder Head

Fig. 4, Stake the Threads

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

15. If needed, fill the power steering reservoir with automatic transmission fluid that meets Dexron III or TES-389 specifications.
16. Start the engine. Check the fluid level in the power steering reservoir and add more fluid if necessary. Check for leaks.
17. Set the automatic relief plunger. For instructions, see **Subject 140**.
18. Remove the drain pan and return the hood or cab to the operating position. For cab tilt instructions, see **Group 60**.

Bearing Cap Automatic Relief Plunger Repair

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60**.
3. Verify that the steering gear has automatic relief plungers. Steering gears with automatic relief plungers will have the word AUTO cast into the housing. See **Fig. 1**. Steering gears with automatic relief plungers also have plastic caps on the plunger boss.
4. Place a drain pan under the steering gear.
5. Mark the bearing cap and steering gear housing for reassembly.
6. Disconnect the steering driveline from the steering gear input shaft. For instructions, see **Subject 100**.
7. Remove the plastic cap from the plunger boss.

NOTICE

When driving the relief plunger assembly, do not allow the 1/4-inch punch to contact the bore, and do not hit the plunger with excessive force. Failure to follow these directions could result in damage to the steering gear or relief plunger assembly.

8. Using a 1/4-inch punch and hammer, carefully drive the relief plunger assembly in until it bottoms in the bore.
9. Remove the four capscrews that attach the bearing cap to the steering gear housing.

NOTICE

Do not force the input shaft when turning it out of the housing. The shaft could bind and steering damage could result.

10. Separate the bearing cap assembly from the housing by turning the input shaft out of the housing. Turn the shaft until it stops.

NOTICE

Do not allow the screwdriver bit to slip off the plunger body. Damage to the bore could result.

NOTE: The relief plunger flange is held in place with patch lock and the threads are staked at the factory. It will require approximately 15 to 20 lbf·in (150 to 205 N·cm) to remove the flange.

11. Carefully insert a screwdriver bit into the plunger bore to hold the slotted head of the relief plunger body in place. Using an open-end wrench to hold the flange in place, carefully turn the flange to remove the flange from the plunger body. See **Fig. 5**. Discard the flange.

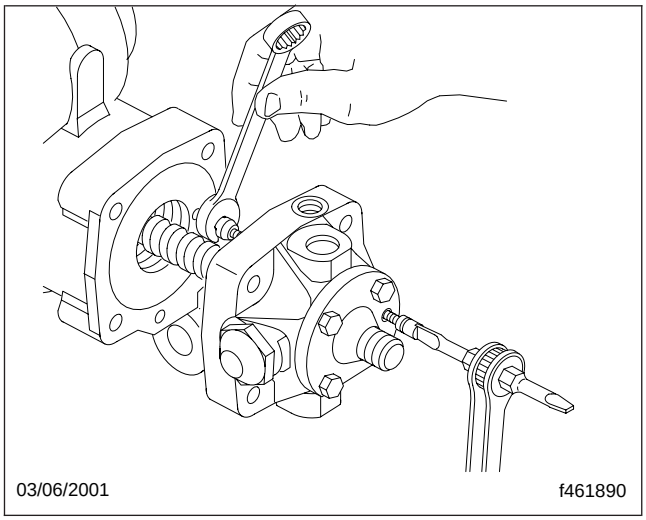


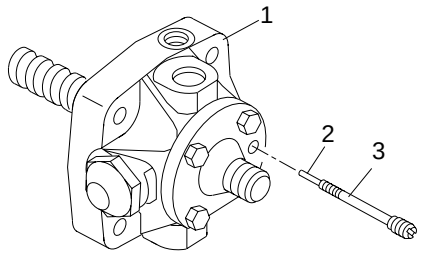
Fig. 5, Flange Removal

12. Remove the plunger body from the spring pin and discard the plunger body. It may be necessary to tap the plunger body to remove it from the spring pin. Use of a 1/8-inch pin punch is recommended.

IMPORTANT: Check the plunger bore for nicks or gouges before installing the plunger assembly. Be careful not to introduce dirt or contaminants in the plunger bore when reassembling.

13. Coat the O-ring on the new plunger assembly with a light coat of grease. Install the plunger body through the spring pin. See **Fig. 6**.

Automatic Relief Plunger Repair



1. Bearing Cap
2. Plunger Body
3. Spring Pin

Fig. 6, Install the Plunger Body

WARNING

The flange must contact the spring pin. If it does not, a leak or steering gear damage may result. This could cause steering failure, possibly resulting in personal injury or property damage.

NOTE: The plunger body has patch lock on the threads. It will require approximately 15 to 20 lbf·in (150 to 205 N·cm) to overcome the patch lock.

14. Use a screwdriver bit and ratchet to hold the plunger body in place. Using an open-end wrench, install the flange on the plunger body until the flange contacts the spring pin.

WARNING

Use extreme caution when staking the threads of the plunger body. Hitting the threads too hard could bend the plunger, which could cause steering failure, possibly resulting in personal injury or property damage.

15. With the flange against the spring pin, use a center punch to stake the threads of the plunger body. See **Fig. 4**. Be careful not to bend the plunger when staking the threads.
16. Align the marks on the bearing cap with the marks on the steering gear housing and install the bearing cap on the housing using the bearing cap capscrews. Tighten the capscrews 114 to 140 lbf·ft (154 to 190 N·m).
17. Install the plastic cap on the plunger boss.
18. Connect the steering driveline to the steering gear input shaft. For instructions, see **Subject 100**.

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

19. If needed, fill the power steering reservoir with automatic transmission fluid that meets Dexron III or TES-389 specifications.
20. Start the engine. Check the fluid level in the power steering reservoir and add more fluid if necessary. Check for leaks.
21. Set the automatic relief plunger. For instructions, see **Subject 140**.
22. Remove the drain pan and return the hood or cab to the operating position. For cab tilt instructions, see **Group 60**.

Pitman Arm Removal and Installation

Removal

NOTE: This procedure is for removing the pitman arm from the steering gear. If replacement of the pitman is required, the pitman arm must also be removed from the drag link.

NOTE: The pitman arm is easiest to remove while the steering gear is installed on the vehicle.

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60**.

DANGER

Do not use a hammer or apply heat to the pitman arm to remove it. Doing so could damage the sector shaft, the pitman arm, or the seals, and possibly lead to loss of vehicle control resulting in death or serious personal injury.

IMPORTANT: The pitman arm has alignment tabs, while the retainer has restraining tabs. Do not bend the aligning tabs out of the pitman arm.

3. Using a punch, bend the retaining tabs out of the pitman arm retainer.
4. Lubricate the face of the retainer with clean chassis lube.

IMPORTANT: Failure to lubricate the face of the retainer will cause difficulty in removing the pitman arm.

5. Slide the pitman arm puller over the pitman arm. Align the hole in the puller with the Allen socket in the retainer.
6. Insert the Allen drive socket through the puller and into the retainer socket. Use an impact wrench to back off the retainer. The retainer will act as a jack screw to disconnect the pitman arm from the steering gear.

Installation

WARNING

If the pitman arm is not installed to the proper specifications, it could come loose, causing an accident that could result in death or severe personal injury.

1. Align the timing marks on the pitman arm with the timing marks on the sector shaft and install the pitman arm on the sector shaft. The timing marks will appear like those in **Fig. 1** or **Fig. 2**.

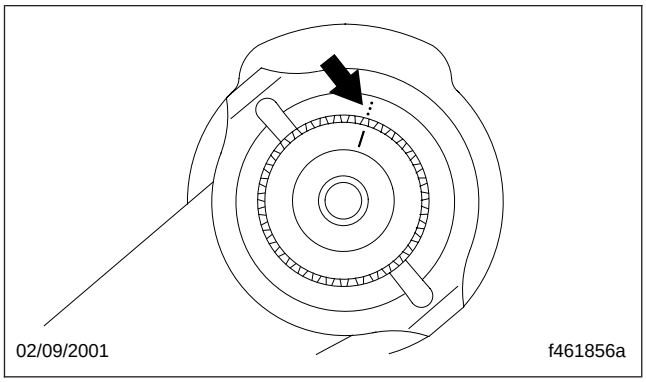


Fig. 1, Timing Mark Alignment

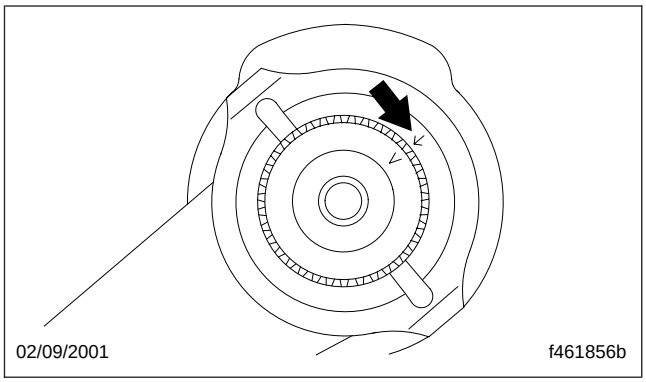


Fig. 2, Timing Mark Alignment

2. Install the pitman arm retainer on the sector shaft. Be sure to align the tabs in the notches of the pitman arm. Coat the threads of the retainer with antiseize compound. A coating of antiseize should be applied to both sides of the friction washer if a new retainer is being used.
3. Tighten the retainer 350 lbf·ft (475 N·m).

Pitman Arm Removal and Installation

WARNING

Do not back off the torque value to align the tabs. If the pitman arm is not installed to the proper specifications, it could come loose, causing an accident that could result in death or severe personal injury.

4. Continue tightening the retainer past the specified value until two of the notches in the retainer align with the tabs of the washer.

WARNING

Once the retainer is tightened to specifications and locked in place, do not retighten the retainer. Constant tightening of the retainer may cause the pitman arm to come loose, causing an accident that could result in death or severe personal injury.

5. Using a punch and hammer, bend the retaining tabs of the washer in to the notches on the retainer. See **Fig. 3**. Apply torque seal, OGP F900WHITE, to the tabs.

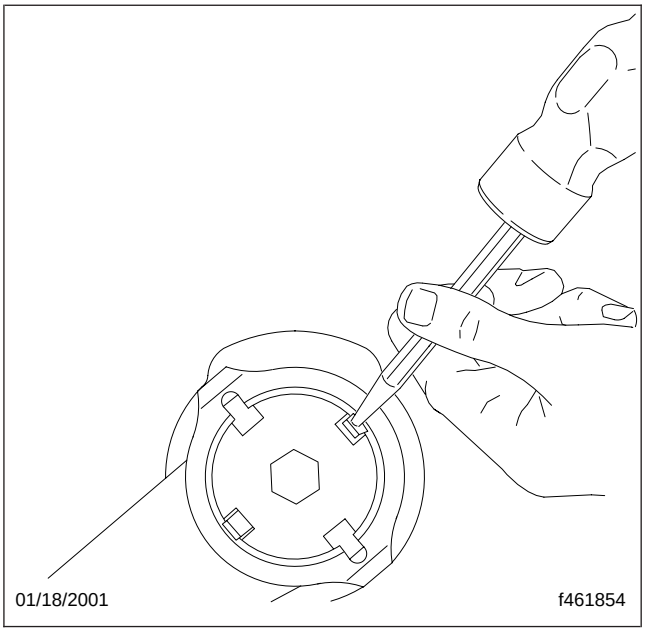


Fig. 3, Bending the Restraining Tabs

6. Reset the automatic relief plungers. For instructions, see **Subject 140**.

7. Lower the hood or tilt the cab. For cab tilt instructions, see **Group 60**.

Post-Service Checks

After power steering components have been worked on and before the vehicle is placed into service, the following items must be checked.

⚠ WARNING

Failure to check the following items could result in damage to the power steering system. This could cause a loss of hydraulic assist, which could cause personal injury or property damage.

1. Operate the engine at low idle while turning the steering wheel through several full-left and full-right turns. With the engine running and the power steering system at operating temperature, turn the steering wheel slowly from stop to stop while checking the power steering reservoir for frothing or a change in the fluid level (signs that air is trapped in the system).

   If air is present, inspect the system for leaking hoses or loose fittings. Replace the hoses or tighten the fittings as necessary. Bleed the air from the system.
2. With the engine turned off and warm, check the power steering reservoir fluid level. The power steering fluid level should be between the MIN COLD mark and the middle mark just above it. If needed, add fluid that meets Dexron III or TES-389 specifications.
3. At full-left and full-right wheel cuts, be sure the axle stops (on the rear-side of the spindle) are set so there is at least 1/2-inch (13-mm) clearance between the tires and any fixed components that are attached to the vehicle. Clearance between moving components should be 3/4 inch (19 mm). If clearance is less than the above, reset the axle stops.
4. Check that the relief plungers are set correctly. If needed, adjust them. For instructions on adjusting the automatic relief plungers, see **Subject 130**.
5. If there are still problems with the power steering system, go to **Section 46.17** and perform the troubleshooting procedures as instructed. Otherwise, go to the next step.
6. Test drive the vehicle or take a ride with the driver. Check the steering wheel spoke position.

   If during straight-ahead driving on a level road, the steering wheel spokes are not centered as shown in **Fig. 1**, remove the steering wheel and reposition it.

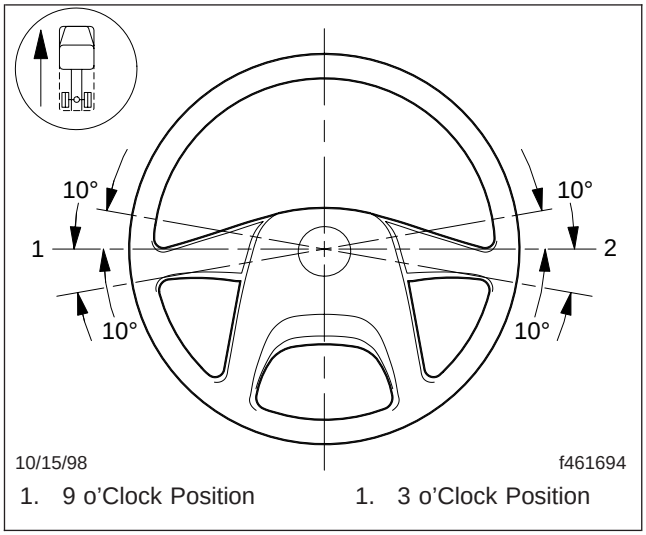


Fig. 1, Steering Wheel Centered

⚠ WARNING

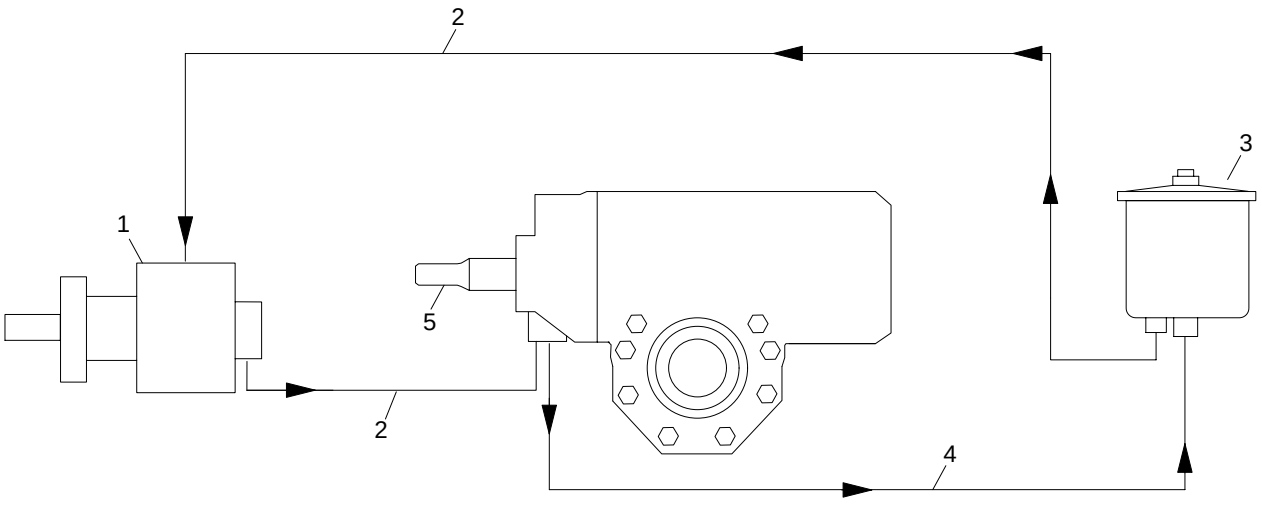
Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

Sheppard M100 power steering gears use ATF fluid that meets Dexron III or TES-389 specifications.

Tools and replacement/repair kits can be ordered from:

R. H. Sheppard Co., Inc.
101 Philadelphia Street
Hanover, Pennsylvania 17331-0877
1-800-274-7437

See **Fig. 1** for a plumbing diagram of the power steering system.



1. Power Steering Pump
2. Supply Line
3. Power Steering Reservoir
4. Return Line
5. Power Steering Gear

Fig. 1, Plumbing Diagram of the Power Steering System

General Information

The Vickers V20F power steering pump supplies the hydraulic fluid needed to operate the power steering system. The primary components of the pump include a ported body, a cover, and a pumping cartridge.

Fluid from the power steering reservoir enters the pumping cartridge through the inlet port in the body. A rotor inside the pumping cartridge is driven by the pump drive shaft and the engine accessory drive. When the rotor turns, vanes move along the surface of a cam ring. Hydraulic fluid is circulated under pressure and forced between the vanes creating sealed chambers that carry and discharge the fluid through a pressure plate to the outlet port in the pump cover.

The cover's integral flow control and relief valve limit the fluid flow and the system pressure to preset values. Fluid that is not used to operate the system is recirculated to the power steering reservoir.

Removal

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Clean all dirt from around the fittings and hose connections.
4. Disconnect the hydraulic pressure line between the power steering gear and the pump from the elbow fitting on the pump. Plug the line and cap the fitting. If the pump is being replaced, remove the elbow and plug the port in the pump.
5. At the power steering pump, disconnect the supply and return hoses from the reservoir. Drain the power steering fluid from the hoses. Plug the supply and return hoses, and cap the fittings.
6. On Cummins L10 and NTC engines, and Caterpillar 3176 and 3406 engines, remove the capscrews that attach the pump to the engine accessory drive mounting flange. Slide the pump out of the shaft coupling or sleeve, and remove the pump from the engine.

   On Caterpillar 3306 engines, remove the capscrews that attach the adapter flange to the engine accessory drive. Slide the pump, adapter flange, and gear out of the accessory drive. Remove the nut, washer, gear, and shaft key from the end of the drive shaft. Remove the two nuts that attach the pump to the adapter flange. Remove the flange.

   On Detroit Diesel Series 60 engines, remove the two capscrews that attach the pump to the adapter flange. Slide the pump out of the coupling. If necessary, remove the sprocket from the shaft. Check around the adapter flange for oil leaks. If there are leaks, remove the adapter flange from the engine. Remove all old gasket material.

Installation

1. Using engine oil, lightly lubricate a new gasket and the pump shaft.
2. On Cummins L10 and NTC engines and Caterpillar 3176 and 3406 engines, install the new gasket on the pump mounting flange, then place the pump on the engine accessory drive mounting. Turn the pump or shaft as needed to mesh the shaft with the shaft coupling or sleeve. Without applying unnecessary force, seat the pilot of the pump mounting flange in the accessory drive mounting. Install the washers and capscrews, and torque them 27 to 32 lbf·ft (37 to 43 N·m).

   On Caterpillar 3306 engines, install the new gasket on the pump mounting flange. Place the adapter flange on the pump. Apply Loctite® 242 or an equivalent sealant to the adapter flange studs. Install the nuts and tighten them 32 lbf·ft (43 N·m). Using engine oil, lightly lubricate a new O-ring and install the O-ring on the adapter flange. Install the shaft key, gear, washer, and nut on the drive shaft. Tighten the nut 45 lbf·ft (61 N·m). Seat the pump mounting assembly in the accessory drive mounting. Install the capscrews and torque them 27 to 32 lbf·ft (37 to 43 N·m).

   On Detroit Diesel Series 60 engines, make sure the clip is installed in the sprocket, and that the coupling and sprocket are installed in the engine accessory drive. If the adapter flange was removed, use engine oil to lightly lubricate a new O-ring. Install the O-ring on the flange, and install the flange on the engine. Cross tighten the six capscrews 22 to 25 lbf·ft (30 to 34 N·m). Install the new gasket on the pump-mounting flange, then position the pump on the adapter flange. Turn the pump or shaft as needed to mesh the shaft with the sprocket. Without applying unnecessary force, seat the pump mounting flange pilot in the adapter flange. Install the two capscrews. Torque them 27 to 32 lbf·ft (37 to 43 N·m).
3. Connect the pump supply and return hoses.
4. Connect the hydraulic pressure line to the elbow fitting at the pressure line port. If a new pump is installed, install the elbow fitting. Tighten the fitting nut finger tight. Use a wrench to tighten the nut until there is resistance. Then tighten it one-sixth turn more.
5. Check the fluid level of the power steering reservoir and add fluid if necessary. Start the engine and let it idle for two minutes. Do not turn the steering wheel; doing so can cause air to enter the system.

   Turn off the engine, and check the fluid level in the reservoir.

Removal and Installation

6. Start the engine again. To remove air from the system, steer the vehicle from full left to full right several times. Adjust the steering gear poppet or pressure-relief valves. For instructions, see **Group 46**.

   If necessary, add fluid to the full line on the reservoir or dipstick.

7. If the steering gear does not have a manual bleed screw, turn the steering wheel from full lock to full lock two or three times with the engine running at idle. Repeat this step, and add fluid as necessary until there are no bubbles in the reservoir.

   If the steering gear is equipped with a manual bleed screw, turn the steering wheel from full lock to full lock two or three times with the engine running at idle. Then loosen the manual bleed screw about one turn and look for clear fluid or fluid mixed with bubbles at the threaded area of the bleed screw. Repeat this step and add fluid as necessary, until only clear fluid discharges. Tighten the manual bleed screw 27 to 33 lbf·in (305 to 373 N·cm). If necessary, fill the reservoir to the full line on the reservoir or dipstick.

   Turn off the engine, and check the fluid level in the reservoir.

8. Remove the chocks from the tires.

Disassembly

1. Remove the power steering pump. For instructions, see **Subject 100**.
2. Clamp the pump body in a vise with the cover facing up. See **Fig. 1**.

CAUTION

Do not use excessive pressure to clamp the pump body. Applying excessive pressure could damage the pump body.

3. Remove the four capscrews from the cover, and remove the cover and O-ring.
4. Remove the relief valve plugs from the pump cover.
5. Insert a suitable tool through the snap ring end of the cover and carefully push out the relief valve and spring.

CAUTION

Do not disassemble the relief valve. Valve specifications are set by the manufacturer. The valve may not work properly if disassembled, and damage to the pump could occur.

6. Remove the pressure plate and spring.
7. Note the position of the cam ring, then remove the guide pins and cam ring.
8. Turn the pump body over. If applicable, remove the shaft key, and the snap ring that holds the bearing in place.
9. Using a soft hammer, tap the splined end of the shaft out of the pump body.
10. Remove the snap ring from the shaft.
11. Support the bearing inner race on a press, and press the shaft out of the bearing.
12. Using a suitable hooked tool, pull the shaft seal out of the pump body.

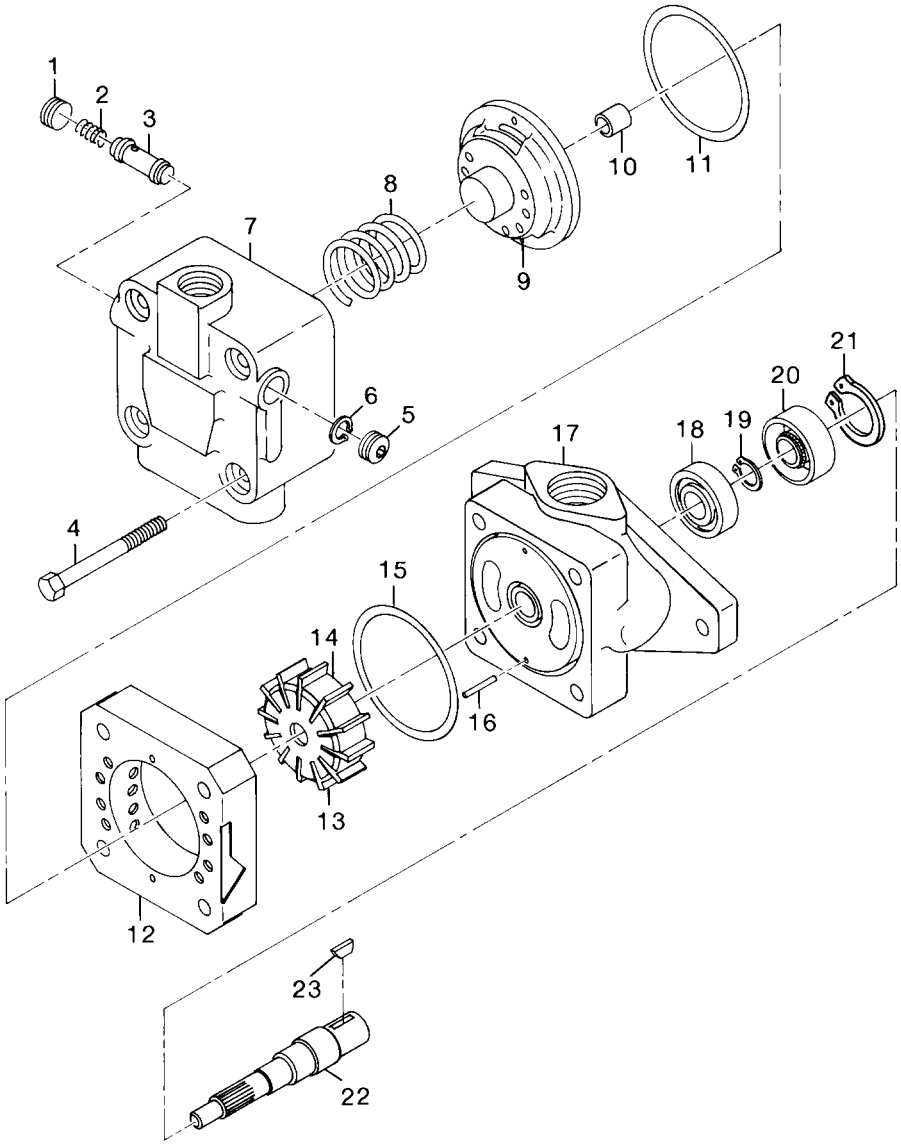
Inspection

1. Clean all parts in an approved cleaning solvent.
2. Check the body, pressure plate, cam ring, and rotor for scoring or wear. Replace parts if necessary.
3. Check the vanes for burrs. Check the rotor slots for wear. Replace parts if necessary.
4. Check the bearings for wear and looseness. Applying pressure, turn the bearings and check for pitted or cracked bearing races. Replace the bearing if necessary.
5. Check the oil seal mating surface on the shaft for wear. If wear marks on the shaft cannot be removed by light polishing, replace the shaft.
6. Check that the relief valve moves easily within the cover bore. If the cover bore is worn or pitted, replace the cover.
7. Check the relief valve for burrs. Remove burrs by polishing, but take care not to round off the corners of the valve ends.

Assembly

1. Coat all parts with hydraulic fluid. If using a new assembly part, remove any burrs from the sharp edges of the part.
2. Insert the small end of the relief valve in the bore of the pump cover. On one side of the cover, install the spring and relief valve plug. Install the other relief valve plug and snap ring.
3. Support the bearing inner race, and press the shaft through the bearing. Install the small snap ring on the shaft.
4. Lubricate the sealing lip of the shaft seal with chassis grease. Check that the shaft seal garter spring is facing toward the cover end of the pump, then press the seal in place.
5. Slide the drive shaft into the pump body until the bearing is seated. If necessary, use a soft hammer and lightly tap the end of the shaft.
6. Install new O-rings in the pump body and cover.
7. Insert the cam ring guide pins in the pump body. Make sure that the arrow on the perimeter of the ring points in the direction of rotation, then install the cam ring. See **Fig. 2**.
8. Install the rotor on the drive shaft. Insert the vanes in the rotor slots. Make sure that the ra-

Disassembly, Inspection, and Assembly



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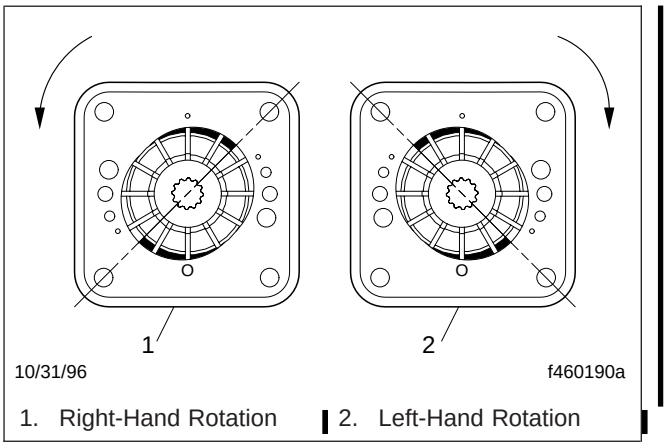
1. Relief Valve Plug
2. Spring
3. Relief Valve
4. Capscrew
5. Relief Valve Plug
6. Snap Ring
7. Cover
8. Spring
9. Pressure Plate
10. Bushing
11. O-Ring
12. Cam Ring
13. Roll Vane
14. Rotor
15. O-Ring
16. Guide Pin
17. Body
18. Shaft Seal
19. Snap Ring
20. Bearing
21. Snap Ring
22. Drive Shaft
23. Key (optional)

Fig. 1, Hydraulic Power Steering Pump Assembly

dius edges of the vanes are positioned toward the cam ring.

9. Place the pressure plate on the guide pins.



1. Right-Hand Rotation
2. Left-Hand Rotation

Fig. 2, Cam Ring Positions (view from cover end)

10. Position the spring on the pressure plate, then install the pump cover. Tighten the capscrews 80 lbf·ft (108 N·m).
11. Turn the drive shaft to ensure that there is no internal binding.

⚠ WARNING

Failure to correct binding could damage the pump. This could result in an unexpected loss of power steering assist, which could cause personal injury or property damage.

12. Install the shaft key (if applicable).
13. Install the power steering pump. For instructions, see **Subject 100**.

Specifications

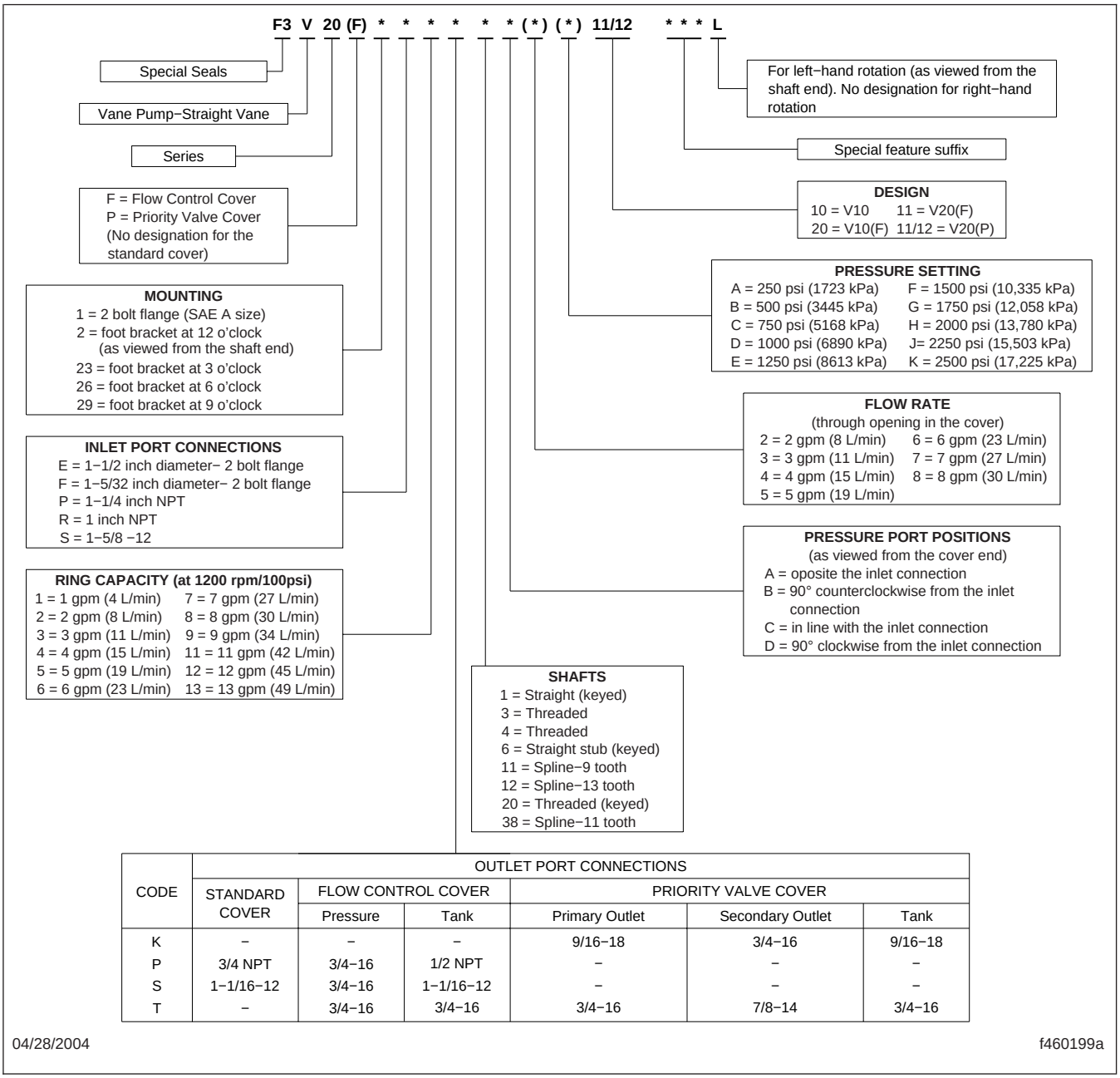
Approved Power Steering Fluids	
Fluid Type	**Approved Fluid**
Automatic Transmission Fluid*	Dexron® II
	Dexron® III
Heavy-Duty Engine Oil* IMPORTANT: Do not use heavy-duty engine oil in vehicles built from November 4, 2002.	Union 10W–40
	Texaco 10W–40
	Chevron 10W–40
	Union 15W–40
	Shell Rotella T 30W

* Do not mix fluid types.

Table 1, Approved Power Steering Fluids

See **Fig. 1** for model number breakdown.

Specifications



CODE	OUTLET PORT CONNECTIONS					
	STANDARD COVER	FLOW CONTROL COVER		PRIORITY VALVE COVER		
		Pressure	Tank	Primary Outlet	Secondary Outlet	Tank
K	−	−	−	9/16−18	3/4−16	9/16−18
P	3/4 NPT	3/4−16	1/2 NPT	−	−	−
S	1−1/16−12	3/4−16	1−1/16−12	−	−	−
T	−	3/4−16	3/4−16	3/4−16	7/8−14	3/4−16

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Fig. 1, Model Number Breakdown

General Description

NOTE: Procedures in this section have been slightly modified from the original component manufacturer's service manual. See the manufacturer's service literature (**trucksteering.trw-.com**) for additional information.

TRW TAS power steering gears are integral hydraulic power steering gears that contain a manual steering mechanism, a hydraulic control valve, and a hydraulic power cylinder.

The pressure required for the steering gear to overcome resistance at the steered wheels is provided by the power steering pump. The rotary control valve directs the flow of hydraulic fluid to the appropriate cylinder cavity in the steering gear (and in the auxiliary cylinder in a dual steering gear system) at the proper flow rate and pressure. As the steering wheel is turned faster or slower, more or less fluid is required by the gear.

Principles of Operation

When the driver turns the steering wheel, that force travels from the steering wheel to the steering gear input shaft. A torsion bar, pinned at one end to the input shaft and at the other end to the worm shaft, turns with the input shaft and exerts a rotational force on the worm shaft. In response to the force exerted by the torsion bar, the worm shaft moves the rack piston forward or backward in the gear housing by means of a series of recirculating balls in the spiral channels of the worm shaft. As the rack piston slides back and forth, it turns the sector shaft. The sector shaft swings the pitman arm, which pulls or pushes the drag link. The drag link moves the axle steering arm, steering the vehicle.

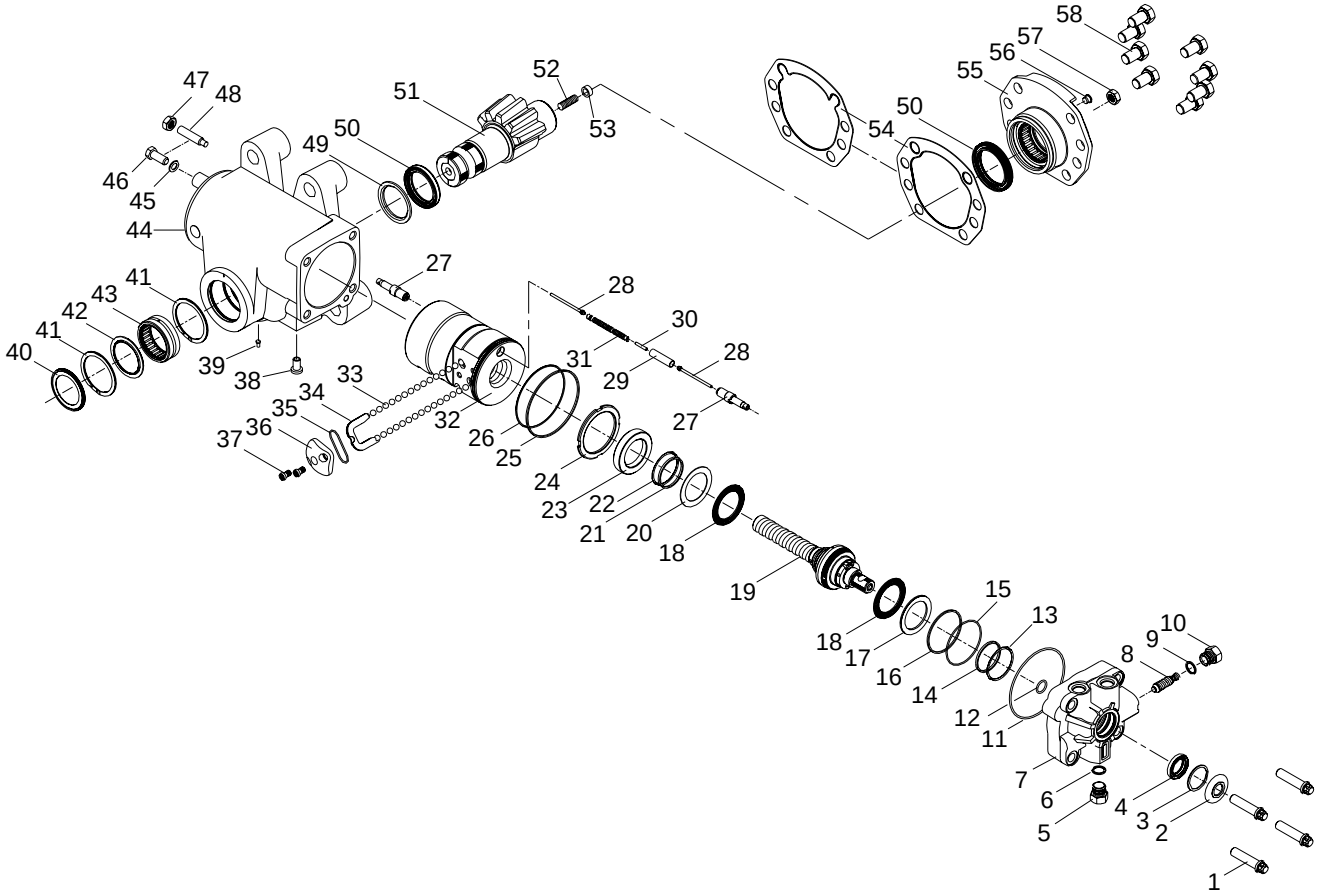
The rack piston's axial movement is resisted by its engagement to the sector shaft, which is linked to the steered wheels. Because of this resistance, the torsion bar activates the control valve, which directs pressurized fluid to the upper or lower cylinder cavity (depending on the direction of turn). The pressurized fluid assists in moving the rack piston up or down in the cylinder bore.

Most TAS steering gears are equipped with two poppet (unloading) valves, one at each end of the rack piston. As the front wheels reach the axle stop—the farthest the wheels can turn in either direction—one poppet or the other, depending on the direction of the turn, will trip to prevent steering system damage. The tripped poppet reduces pressure in the gear, heat generated by the power steering pump, and outside forces acting on the steering linkage.

Some TAS steering gears are also supplied with an internal pressure relief valve (PRV). The PRV limits maximum supply pressure to protect the power steering gear, but it does not reduce pressure as the steered wheels approach the axle stops.

See **Fig. 1** for an exploded diagram of a TRW TAS power steering gear.

General Information



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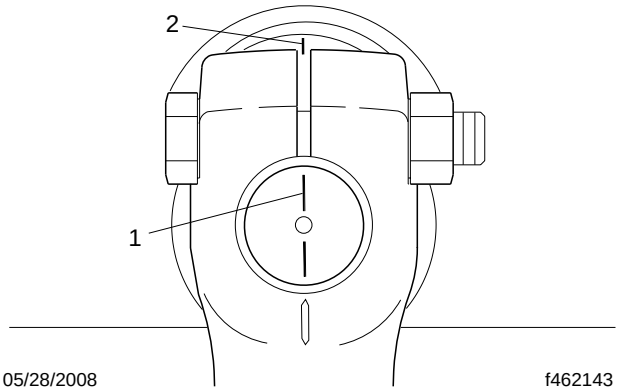
1. Bolts, Valve Housing
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Auxiliary Port Plug
6. O-Ring, Auxiliary Port Plug
7. Valve Housing
8. Relief Valve
9. O-Ring, Relief Valve
10. Relief Valve Cap
11. Seal Ring, Large
12. Seal Ring, Small
13. Seal Ring
14. O-Ring
15. Seal Ring
16. O-Ring, Valve Housing
17. Thrust Washer, Thick
18. Roller Thrust Bearing
19. Input Shaft/Valve/Worm Assembly
20. Thrust Washer, Thin
21. Seal Ring
22. O-Ring
23. Bearing Adjuster
24. Adjuster Locknut
25. Seal Ring, Rack Piston
26. O-Ring, Backup
27. Poppet Adjuster Seat and Sleeve Assembly
28. Poppet
29. Push Tube
30. Spacer Rod
31. Poppet Spring
32. Rack Piston
33. Steel Balls
34. Ball Return Guide Halves
35. Seal, Ball Return Guide Cap
36. Ball Return Guide Cap
37. Torx® Screws
38. Plug, Auto-Bleed
39. Grease Fitting
40. Dirt and Water Seal, Trunnion
41. Retaining Ring
42. Dirt Seal
43. Roller Bearing
44. Gear Housing
45. Washer, Stopscrew
46. Fixed Stop Screw, Poppet
47. Service Sealing Jam Nut
48. Service Poppet Adjusting Screw
49. Washer, Spacer
50. Output Seal
51. Sector Shaft
52. Adjusting Screw, Shaft
53. Retainer, Adjusting Screw
54. Gasket, Side Cover
55. Side Cover and Bushing/Bearing Assembly
56. Vent Plug, Side Cover
57. Jam Nut
58. Special Bolts, Side Cover

Fig. 1, TRW TAS85 Power Steering Gear Components

Sector Shaft Adjustment

NOTE: If the steering gear is installed on the frame rail, sector shaft adjustment can only be completed if the adjusting screw jam nut (located on the side cover) is accessible.

1. Apply the parking brakes and chock the rear tires.
2. With the engine on, turn the steering wheel until the timing mark on the sector shaft lines up with the timing mark on the housing. The sector shaft is now at its center of travel. See **Fig. 1**. Shut down the engine.



1. Housing Timing Mark
2. Sector Shaft Alignment Mark

Fig. 1, Timing Mark Placement

3. Remove the cotter pin and castle nut that attach the drag link to the pitman arm. Disconnect the drag link from the pitman arm.

IMPORTANT: To avoid resetting the poppets, do not turn the input shaft more than 1-1/2 turns from the center-of-travel position while the drag link is disconnected.

4. From the center-of-travel position, grasp the pitman arm at the lower end of the arm and gently try to move the arm back and forth. See **Fig. 2**. If the pitman arm is loose or lash (free play) is detected, the sector shaft is out of adjustment.
5. Loosen the adjusting screw jam nut.
6. If no lash was detected in step 4, use a screwdriver to turn the sector shaft adjusting screw

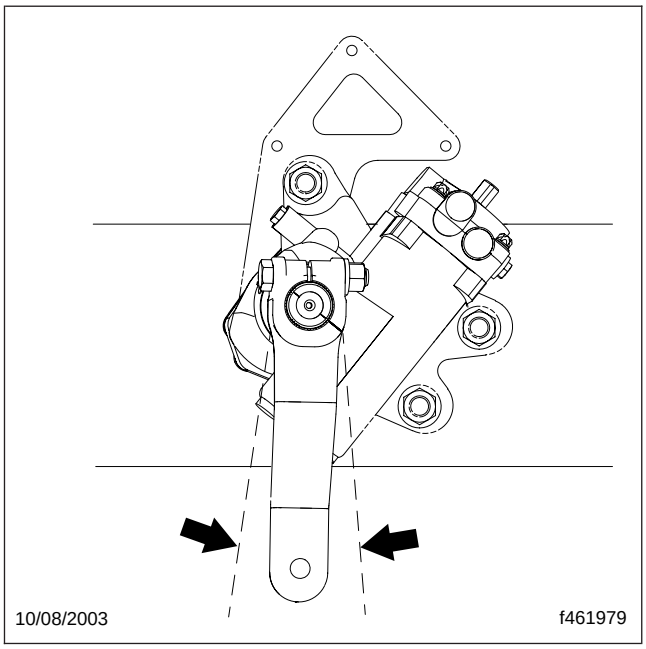


Fig. 2, Lash Check

counterclockwise until you feel lash at the sector shaft. See **Fig. 3**.

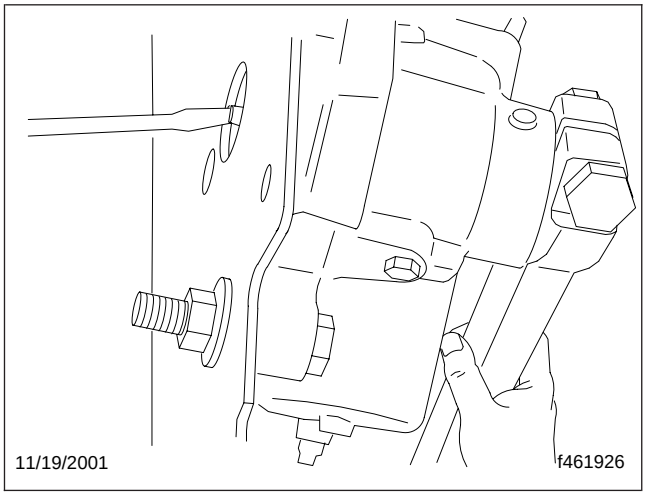


Fig. 3, Adjusting the Sector Shaft

IMPORTANT: Do not use more than 10 lbf·ft (14 N·m) of force when tightening the adjusting screw.

7. Slowly turn the adjusting screw clockwise until no lash is felt at the pitman arm. From this position, turn the adjusting screw clockwise 1/8 to 3/16 of

a turn more. Hold the adjusting screw in place and tighten the jam nut 43 lbf·ft (58 N·m).

8. Turn the steering wheel 1/4 of a turn to each side of center and recheck the pitman arm for lash. If lash is detected, adjust the sector shaft again.
9. Using a castle nut, attach the drag link to the pitman arm. Tighten the castle nut using the appropriate torque value.
    - 3/4–16: 90 to 170 lbf·ft (122 to 230 N·m)
    - 7/8–14: 160 to 300 lbf·ft (217 to 407 N·m)

WARNING

Failure to install and lock a new cotter pin in the ball stud and nut could result in disengagement of the parts and loss of steering control, which could result in personal injury or property damage.

10. Continue to tighten the castle nut until a slot on the nut aligns with the hole in the ball stud. Do **not** reverse the tightening direction of the nut when locating the cotter pin hole. Install a new cotter pin in the ball stud and nut, then lock the cotter pin in place.

NOTICE

Do not use a power grease gun to add grease to the sector shaft bearing. Doing so could damage the high-pressure seal and contaminate the hydraulic fluid.

11. Using only a hand-operated grease gun, add grease to the sector shaft bearing through the grease fitting in the housing until grease begins to extrude past the dirt and water seal.

Resetting the Poppet Valves

IMPORTANT: The axle stops must be set so that there are at least 1-3/4 steering wheel turns from a straight-ahead position to both a full-left and a full-right turn; otherwise the poppet valves will not work.

1. Verify that the axle stops are adjusted properly. See **Group 33** for instructions.
2. Start the engine and allow the vehicle to idle for 5 to 10 minutes to warm the hydraulic fluid.
3. Shut down the engine, apply the parking brakes, and chock the rear tires.
4. Hold the poppet screw with a wrench and turn the sealing nut back toward the wrench until the nut is flush with the base of the hex area of the poppet screw.
5. Make sure that the engine is off and the wheels are in the straight-ahead position.

NOTICE

Make sure the drive end of the adjusting screw is not below the face of the nut. If the drive end of the adjusting screw is below the face of the nut, the poppet seat flange will break when the upper poppet is prepared for setting.

6. Using a 7/32-inch Allen wrench, turn the adjusting screw and nut assembly (without turning the nut on the screw) into the housing until the nut is firmly against the housing. Tighten the nut against the housing. See **Fig. 4**.

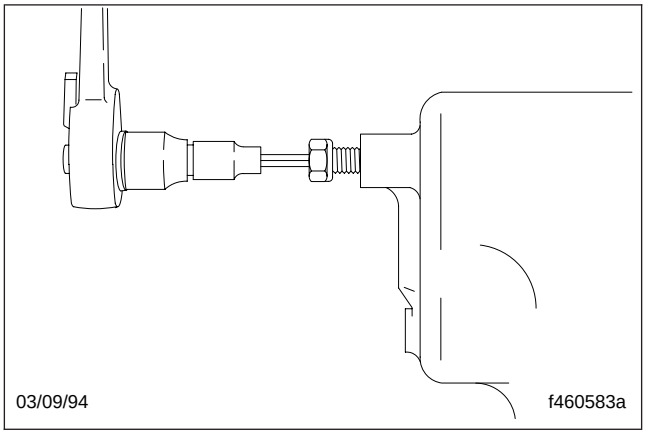


Fig. 4, Adjusting Screw and Nut Assembly

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

7. Fill the power steering reservoir nearly full with automatic transmission fluid. Do not turn the steering wheel.
8. Place a jack under the center of the front axle and jack up the front of the vehicle so the steer axle tires are off the ground.
9. Push the upper poppet out to prepare it for setting.
   - 9.1 Start the engine and let it idle.
   - 9.2 Note which sector shaft timing mark is nearest the housing piston bore.

NOTICE

Do not hold the steering wheel at full turn for more than 10 seconds at a time. The heat buildup at pump relief pressure may damage components.

   - 9.3 Turn the steering wheel in the direction that makes this timing mark move toward the adjusting screw just installed. Turn the wheel in this direction until axle stop contact is made.
   - 9.4 Pull hard on the steering wheel. Put up to 40 lbf (178 N) pull on a 20-inch diameter steering wheel.
10. Set the upper poppet.
   - 10.1 Turn the steering wheel in the opposite direction (the timing mark will move away from the adjusting screw) until the other axle stop is contacted.
   - 10.2 Pull hard on the steering wheel. Put up to 40 lbf (178 N) pull on a 20-inch diameter steering wheel.
   - 10.3 Release the steering wheel and shut off the engine.
11. Loosen the sealing nut and back out the adjusting screw until the adjusting screw is 1 inch (2.5 cm) past the nut. See **Fig. 5**. Tighten the nut against the housing.
12. Set the lower poppet.
   - 12.1 Start the engine and let it idle.

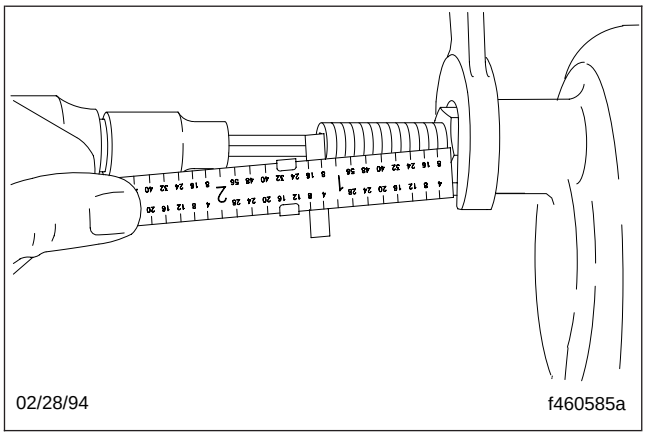


Fig. 5, Adjusting Screw Position

   - 12.2 Turn the steering wheel in the original direction (the timing mark will move toward the adjusting screw) until axle stop contact is made.
   - 12.3 Hold the steering wheel in this position with up to 40 lbf (178 N) pull on a 20-inch diameter steering wheel for 10 seconds, then release. Repeat this hold-and-release process as many times as necessary while completing the next step.
13. Position the adjusting screw.
   - 13.1 With the steering wheel held tightly at full turn, loosen the nut and hold it in place with a wrench.

IMPORTANT: Do not attempt to turn the adjusting screw in any farther. Pause the turning-in process each time the driver releases the steering wheel. Continue turning only while the steering wheel is held at full turn.

   - 13.2 Using an Allen wrench and finger pressure only, turn the adjusting screw clockwise until the Allen wrench stops.

⚠ WARNING

If the adjusting screw protrudes more than 1-1/16 inches (27 mm) from the sealing nut, the screw could fall out of the steering gear, resulting in loss of power steering. This could cause an accident resulting in personal injury or property damage.

Steering Gear Adjustments

13.3 Back off the adjusting screw 3-1/4 turns and tighten the nut 35 lbf·ft (47 N·m).

⚠ WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

14. The poppets have now been completely reset. Check the power steering reservoir. If needed, add fluid.
15. Lower the vehicle.

Steering Gear Removal and Installation

Removal

1. Verify correct axle stop adjustment. Ensuring correct axle stop adjustment now will eliminate the need to reset the steering gear poppet valves after the gear is installed. For instructions, refer to **Group 33**.
2. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping where the work is to be done.
3. Shut down the engine, apply the parking brakes, and chock the tires.
4. Clean all fittings and hose connections on the steering gear until they are free of dirt.
5. Drain the fluid from the power steering system. Disconnect all hydraulic lines from the gear, marking the lines for later reference. Seal the lines and the fittings to keep out dirt.
6. Disconnect the pitman arm from the steering gear sector shaft.
   - 6.1 Remove and discard the pinch bolt, washer, and nut from the pitman arm.
   - 6.2 Remove the pitman arm using a suitable puller, then swing the pitman arm and drag link out of the way.
7. Disconnect the steering driveline from the steering gear input shaft.
   - 7.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

NOTICE

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

   - 7.2 Remove the lower end yoke from the input shaft.

8. If necessary to gain access, support the frame rail and remove the front suspension spring hanger bracket. For instructions, see **Section 32.00, Subject 100**.

WARNING

The steering gear is heavy. Use caution when removing, lifting, or carrying the steering gear. Failure to do so could cause personal injury.

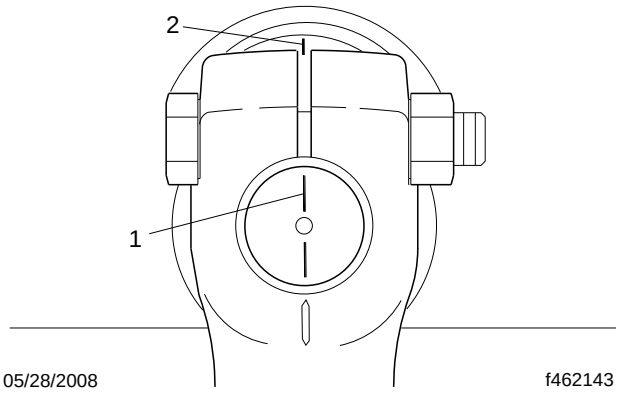
9. Remove the fasteners that attach the steering gear to the frame rail. Remove the steering gear.

Installation

1. Install the steering gear and mounting fasteners. See **Specifications 400** for reference figures for the various vehicle configurations.

   Tighten the fasteners 427 lbf·ft (579 N·m).

2. Center the steering gear so that the timing mark on the sector shaft is aligned with the timing mark on the steering gear housing. See **Fig. 1**. Keep the steering gear centered as the installation continues.



1. Housing Timing Mark
2. Sector Shaft Alignment Mark

Fig. 1, Timing Mark Placement

3. Connect the steering driveline to the steering gear input shaft.
   - 3.1 Clean the steering gear input shaft and the inside of the driveline yoke.
   - 3.2 Apply a thin film of grease to the yoke spline.
   - 3.3 Slide the yoke on the input shaft and install a new pinch bolt and nut. Tighten the nut to one of the following specifications:

Steering Gear Removal and Installation

- M10 pinch bolt and nut: 30 to 35 lbf·ft (41 to 47 N·m)
- 7/16 pinch bolt and nut: 55 to 65 lbf·ft (75 to 88 N·m)

3.4 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.

WARNING

Never leave a chisel wedged in the pitman arm slot. When using a chisel to spread the slot in the pitman arm, maintain a firm grip on the chisel at all times. Otherwise the chisel may fly loose, which could cause an injury.

NOTE: The pitman arm may not fit over the splines on the sector shaft without spreading the slot in the arm. Use a ball-peen hammer to drive a chisel into the slot. Hold the chisel in place. Install the pitman arm on the sector shaft. Remove the chisel from the slot.

4. Install the pitman arm.

4.1 Position the pitman arm on the steering gear, aligning the timing mark as shown in **Fig. 2**. See the Pitman Arm Alignment table in **Specifications 400** for pitman arm timing mark specifications.

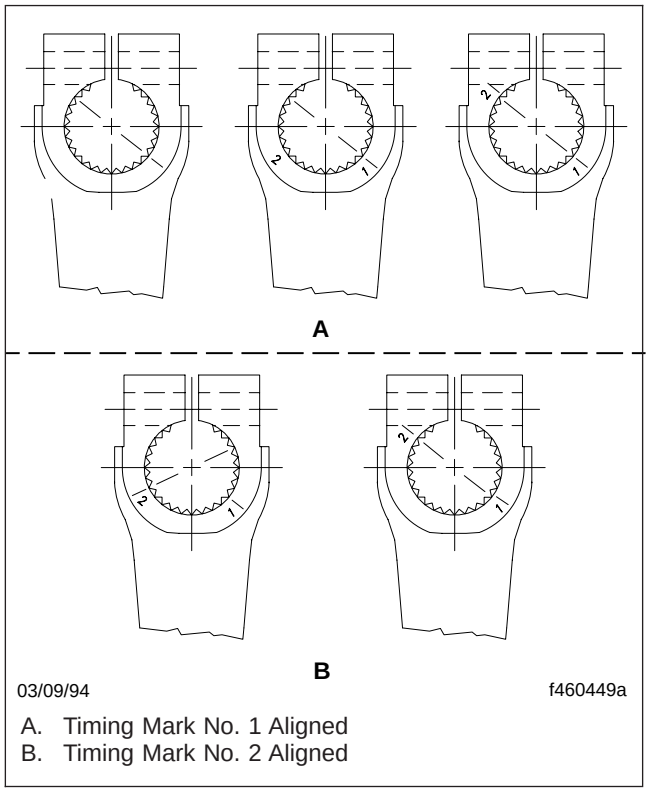
4.2 Using a new pinch bolt, nut, and washer (if applicable), attach the pitman arm to the steering gear sector shaft.

Tighten the nut 230 lbf·ft (313 N·m).

4.3 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.

5. If they were removed, attach the hydraulic line fittings to the steering gear. Tighten the fittings 38 lbf·ft (52 N·m). Tighten the pressure line fitting jam nut 41 lbf·ft (56 N·m).

6. Remove the plugs from the hydraulic lines. Connect the lines to the steering gear as previously marked. Tighten the nut on each fitting finger tight. Then, use a wrench to tighten the nut until there is firm resistance. Tighten 1/6 of a turn more.



A. Timing Mark No. 1 Aligned
B. Timing Mark No. 2 Aligned

Fig. 2, Typical Pitman Arms and Timing

7. Connect the batteries.

8. Fill and bleed the steering system.

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

8.1 Fill the power steering reservoir nearly full with automatic transmission fluid. Do not turn the steering wheel.

8.2 Start the engine and let it idle for ten seconds, then shut it off. Check and fill the reservoir. Repeat this step at least three times, checking the fluid level in the reservoir each time.

IMPORTANT: Do not let the fluid level drop significantly or allow the reservoir to empty. Doing so may introduce air into the system.

8.3 Start the engine and let it idle for two minutes. Do not turn the steering wheel. Shut off the engine and check the fluid level in the reservoir. If needed, add more fluid.

8.4 Start the engine again. Steer the vehicle from full left to full right several times. Check and, if necessary, refill the reservoir.

Automatic bleed systems should now be free of trapped air. Skip to the last step in this procedure.

If the vehicle has a manual bleed system (**Fig. 3**), proceed to the next step.

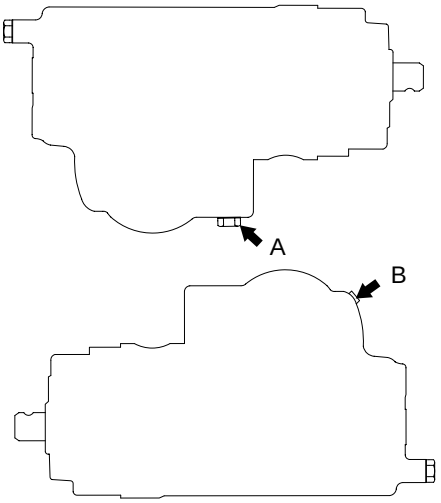
IMPORTANT: Do not turn the steering wheel while the bleed screw is loosened.

8.5 With the wheels in the straight-ahead position, loosen the manual bleed screw two to three turns. Allow air and aerated fluid to bleed out until only clear fluid is seen. Close the bleed screw and add fluid to the reservoir if needed.

Repeat this step until all air is out of the system.

Tighten the bleed screw 45 lbf·in (509 N·cm).

9. Close the hood and perform the post-service checks in **Subject 130**.



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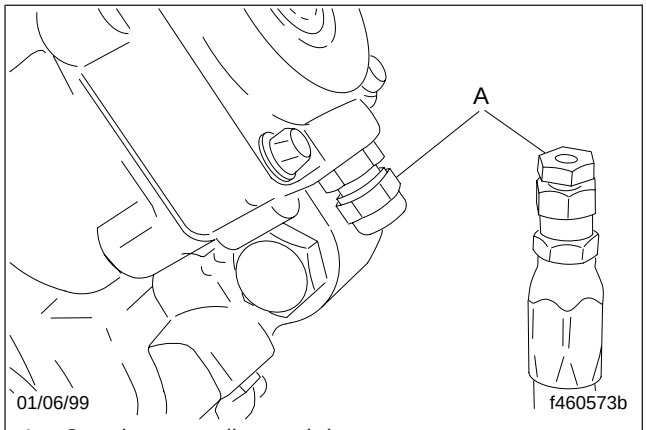
A. Steering gear with automatic bleed plug. Do not remove the bleed plug.
B. Steering gear with manual bleed plug.

Fig. 3, Steering Gear Bleed Systems

Replacement

NOTE: The power steering pump is used in this procedure to force out the input shaft seal. To use this procedure, the power steering pump should have a minimum of 1500 psi (10 342 kPa) available.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the return line from the steering gear and plug the line. See **Fig. 1**. Cap the return port of the gear with a high-pressure fitting.



A. Cap the return line and the return port.

Fig. 1, Disconnected Return Line

NOTICE

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

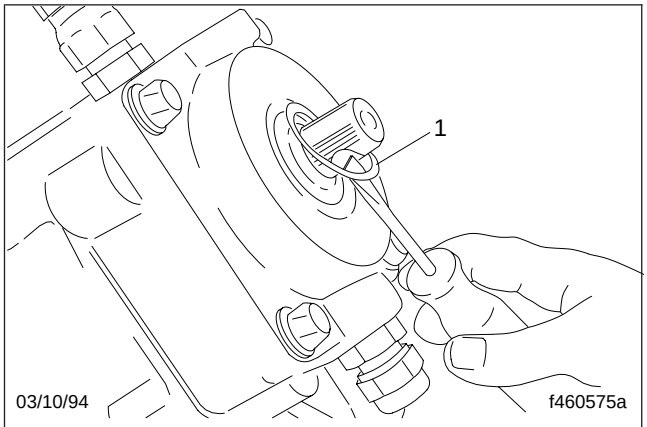
3. Disconnect the steering driveline from the steering gear input shaft.

   3.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

   IMPORTANT: Do not turn the steering gear input shaft when removing the lower end yoke.

   3.2 Remove the lower end yoke from the input shaft. Push the driveline shaft into the driveline tube as you remove the lower end yoke.

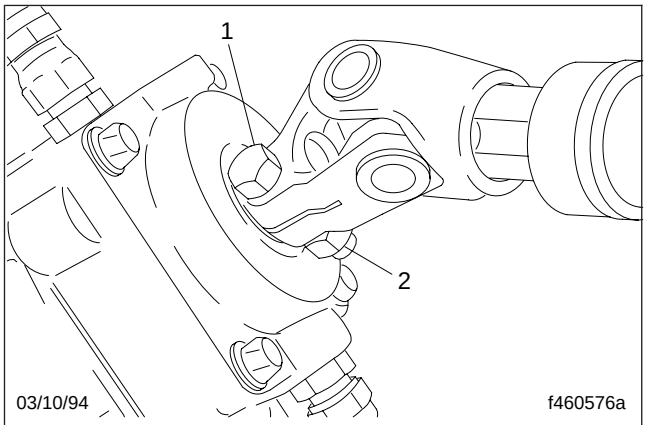
4. Remove the dirt and water seal from the steering gear. Save this seal to determine the correct size of the new seal.
5. Using a clean cloth, remove all grease from around the input shaft.
6. Using a screwdriver inserted into the notch formed in the end of the retaining ring, remove the retaining ring. See **Fig. 2**. Be careful not to scratch the bore with the screwdriver.



1. Retaining Ring

Fig. 2, Retaining Ring Removal

7. Slip the driveline lower end yoke back on the input shaft, then insert but do not tighten the pinch bolt. See **Fig. 3**.

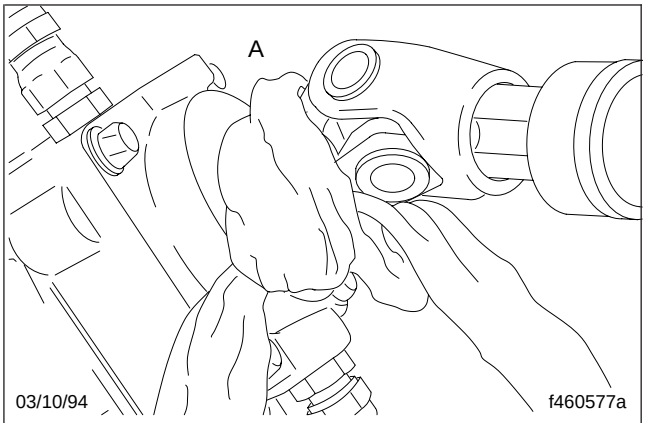


1. Pinch Bolt 2. Pinch Bolt Nut

Fig. 3, Pinch Bolt Installation

Input Shaft Seal Replacement

8. Tie or wrap a shop towel around the input shaft area and place a drip pan under the vehicle to catch the oil. See **Fig. 4**.



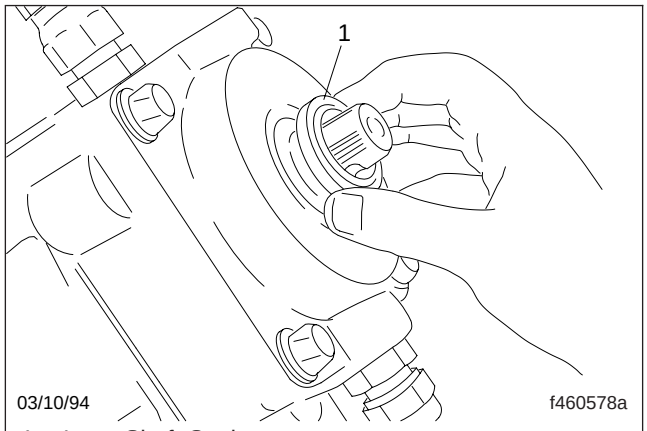
A. Cover the input shaft area.

Fig. 4, Shop Towel Covering the Input Shaft

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

9. If needed, fill the power steering reservoir with automatic transmission fluid.
10. With the vehicle in neutral, momentarily turn the starter. If the engine starts, quickly turn it off. This should force out the input shaft seal.
11. Remove the shop towel, pinch bolt, and input yoke. Remove the input shaft seal. See **Fig. 5**.
12. Inspect the seal area of the valve housing for seal fragments. Remove any seal fragments.
13. Check the seal for heat damage. If the seal is stiff and brittle, and not pliable like the new seal, it is probably heat damaged. Determine and fix the cause of any excessive heat in the vehicle. Discard the old seal.



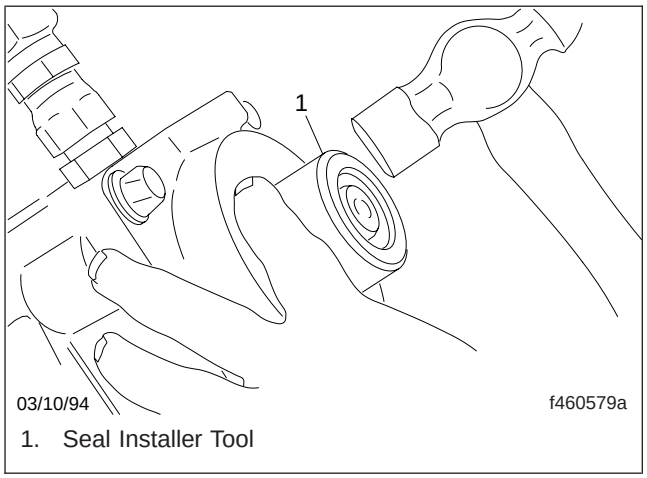
1. Input Shaft Seal

Fig. 5, Input Shaft Seal Removal

WARNING

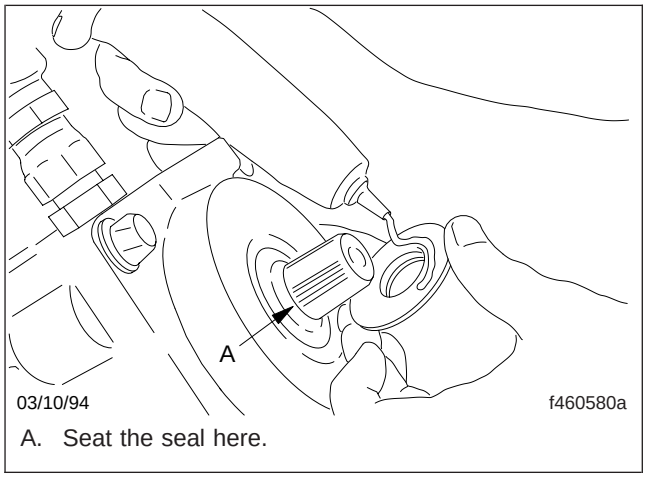
Do not use a socket to install the input shaft seal. You will not be able to control the seal installation depth with a socket and this could lead to leaks. Leaks could result in loss of steering assist and spillage on the roadway, which could result in personal injury or property damage.

14. Install a new input shaft seal.
    - 14.1 Using Exxon Polyrex® EP2 grease (045422), lubricate the inside diameter of the new input shaft seal and install it on the input shaft.
    - 14.2 Using a hammer and seal driver (J37073), tap the driver until the shoulder of the driver is square against the valve housing. See **Fig. 6**. Remove any seal material that may have sheared off in the seal bore or retaining ring groove.
15. Install a new retaining ring in the groove.
16. Using Exxon Polyrex EP2 grease, pack the end of the valve housing bore and around the input shaft with clean grease.
17. Install a new dirt and water seal.
    - 17.1 Choose the correct size dirt and water seal by comparing the replacement seals to the old seal.
    - 17.2 Apply Exxon Polyrex EP2 grease to the new dirt and water seal and install it on the input shaft. See **Fig. 7**. Seat it in the



1. Seal Installer Tool

Fig. 6, Seal Installer Tool Position



A. Seat the seal here.

Fig. 7, Dirt and Water Seal Installation

groove behind the serrations and against the valve housing.

Wipe any excess grease from the valve housing bore and input shaft once the seal has been installed.

18. Connect the steering driveline to the steering gear input shaft.

    18.1 Clean the input shaft and the inside of the driveline yoke.

    18.2 Apply a thin film of grease to the yoke splines.

    18.3 Slide the yoke on the input shaft and install a new pinch bolt and nut. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).

    18.4 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.

19. Connect the return line to the steering gear return port.

20. Fill and bleed the steering system.

⚠ WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

    20.1 Fill the power steering reservoir nearly full with automatic transmission fluid. Do not turn the steering wheel.

    20.2 Start the engine and let it idle for ten seconds, then shut it off. Check and fill the reservoir. Repeat this step at least three times, checking the fluid level in the reservoir each time.

IMPORTANT: Do not let the fluid level drop significantly or allow the reservoir to empty. Doing so may introduce air into the system.

    20.3 Start the engine and let it idle for two minutes. Do not turn the steering wheel. Shut off the engine and check the fluid level in the reservoir. If needed, add more fluid.

    20.4 Start the engine again. Steer the vehicle from full left to full right several times. Check and, if necessary, refill the reservoir.

    Automatic bleed systems should now be free from trapped air.

    If the vehicle has a manual bleed system (**Fig. 8**), proceed to the next step.

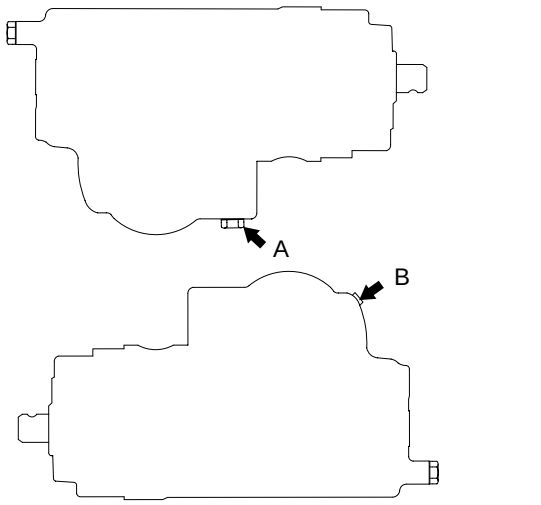
IMPORTANT: Do not turn the steering wheel while the bleed screw is loosened.

Input Shaft Seal Replacement

20.5 With the wheels in the straight-ahead position, loosen the manual bleed screw two to three turns. Allow air and aerated fluid to bleed out until only clear fluid is seen. Close the bleed screw and add fluid to the reservoir if needed.

Repeat this step until all air is out of the system.

Tighten the bleed screw 45 lbf·in (509 N·cm).



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A. Steering gear with automatic bleed plug. Do not remove the bleed plug.
B. Steering gear with manual bleed plug.

Fig. 8, Steering Gear Bleed Systems

21. Perform the post-service checks in **Subject 130**.

Post-Service Checks

After power steering components have been worked on and before the vehicle is placed into service, the following items must be checked.

⚠ WARNING

Failure to check the following items could result in damage to the power steering system. This could cause loss of steering assist and spillage on the roadway, which could cause personal injury or property damage.

1. Operate the engine at low idle while turning the steering wheel through several full-left and full-right turns. With the engine running and the power steering system at operating temperature, turn the steering wheel slowly from stop to stop while checking the power steering reservoir for frothing or a change in the fluid level (signs that air is trapped in the system).

   If air is present, inspect the system for leaking hoses or loose fittings. Replace the hoses or tighten the fittings as necessary. Bleed the air from the system.
2. With the engine turned off and warm, check the power steering reservoir fluid level. If needed, add power steering fluid.
3. At full-left and full-right wheel cuts, be sure the axle stops (on the rear-side of the spindle) are set so there is at least 1/2-inch (13-mm) clearance between the tires and any fixed components that are attached to the vehicle. Clearance between moving components should be 3/4 of an inch (19 mm). If clearance is less than this, reset the axle stops.
4. Check that the poppets are set correctly. If necessary, adjust them. For instructions, see **Subject 100**.
5. If there are still problems with the power steering system, perform the troubleshooting procedures in **Section 46.17**. Otherwise, go to the next step.
6. Test drive the vehicle and check the steering wheel spoke position. With the front tires pointing straight ahead, check the position of the steering wheel spokes. They must be pointing within ±10 degrees of the 9 o'clock and 3 o'clock positions on a four-spoke steering wheel. If not, remove the steering wheel and install it in the correct position. See **Fig. 1**.

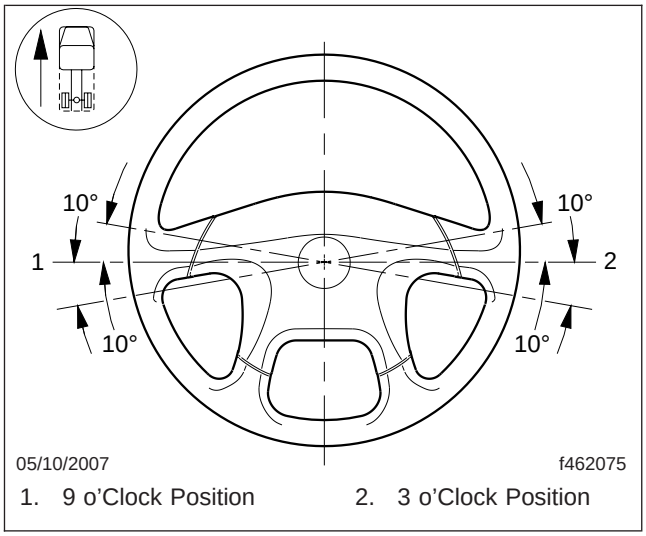


Fig. 1, Steering Wheel Centered

Specifications

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

TRW TAS power steering gears use automatic transmission fluid that meets Dexron II, Dexron III, Mercon, or ATF +4™ specifications.

Exxon Polyrex® EP2 Grease (045422) is approved for use on steering gear components.

Special tools can be ordered from:

SPX Kent-Moore
28635 Mount Road
Warren, Michigan 48092-3499
1-800-328-6657

SPX Kent-Moore Tools		
Part Number		Tool
TAS65	TAS85	
J37070	J37070	Adjuster Tool
J37464	J37464	Adjuster Locknut Tool
J37071	J38779	Bearing and Seal Tool
J37073	J37073	Input Seal Installer
J38713	J38713	Poppet Adjuster Seat Tool, Heavy-Duty (preferred)
J36452	J36452	Poppet Adjuster Seat Tool
J37130	J37130	Relief Valve Plug
J8092	J8092	Tool Handle

Table 1, SPX Kent-Moore Tools

See **Fig. 1** for an illustration of the steering system plumbing diagram.

See **Fig. 2** for a diagram of the TAS65 steering gear on an FLA COE with set-forward axle.

See **Fig. 3** for a diagram of the TAS65 steering gear on an FLA COE with setback axle (built before February 1990).

See **Fig. 4** for a diagram of the TAS65 steering gear on an FLA COE with setback axle (built after January 1990).

See **Fig. 5** for a diagram of the TAS65 steering gear on an FLD 112 Conventional with setback axle (built before March 1992).

See **Fig. 6** for a diagram of the TAS65 steering gear on an FLD 120 Conventional with set-forward axle.

See **Fig. 7** for a diagram of the TAS65 steering gear on an FLD 120 Conventional with setback axle (built before February 1990).

See **Fig. 8** for a diagram of the TAS65 steering gear on an FLD 120 Conventional with setback axle (built from January 1990 to March 1992).

See **Fig. 9** for a diagram of the FLD 120 Conventional with setback axle (built after March 1992).

See **Fig. 10** for a diagram of the TAS85 steering gear on an FLB COE with set-forward axle.

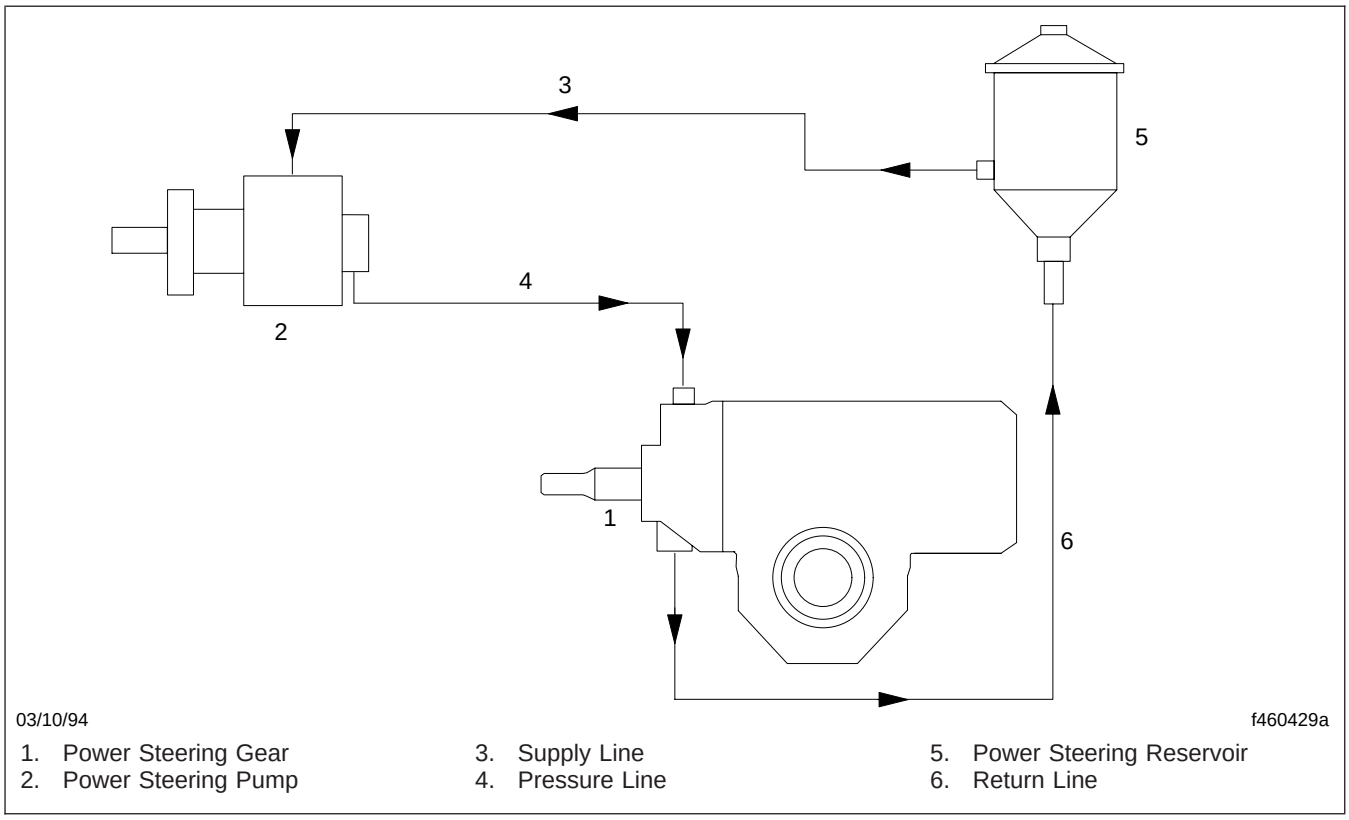
See **Fig. 11** for a diagram of the TAS85 steering gear on an FLD Conventional with setback or set-forward axle (built from March 1994).

Specifications

Pitman Arm Alignment					
Vehicle			Rear Suspension Ride Height*	Wheelbase	Pitman Arm Timing Mark
Vehicles Built Before February 1990	FLA	Set-Forward Axle	—	—	no. 2
		Setback Axle	—	—	no. 2
	FLD 120	Set-Forward Axle	—	—	no. 1
		Setback Axle	—	—	no. 1
Vehicles Built After January 1990	FLA	Set-Forward Axle	Any	Any	no. 2
		Setback Axle	Low Ride	Less than 140 inches	no. 1
				140 inches and more	no. 2
			High Ride	Any	no. 1
	FLB	Set-Forward Axle	Any	Any	no. 2
	FLD 112	Setback Axle	Low Ride	Any	no. 1
	FLD 120	Set-Forward Axle	Any	Any	no. 1
		Setback Axle	Low Ride	Any	no. 2
			High Ride	Any	no. 2

* Rear suspension ride height is determined by measuring the distance between the centerline of the rear axle and the bottom of the vehicle frame rail, with the vehicle loaded. Low ride height is 9-11/16 inches (246 mm) or less; high ride height is greater than 9-11/16 inches (246 mm).

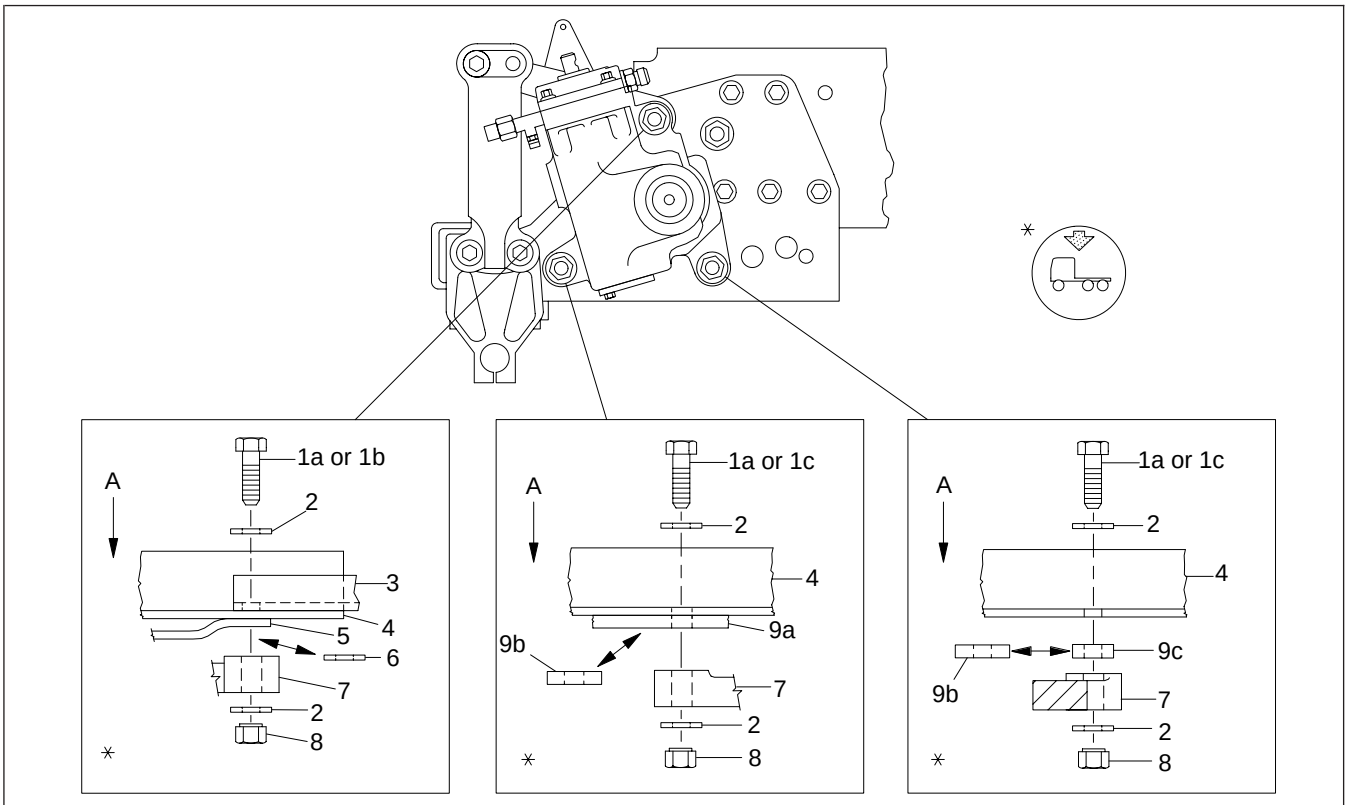
Table 2, Pitman Arm Alignment



1. Power Steering Gear
2. Power Steering Pump
3. Supply Line
4. Pressure Line
5. Power Steering Reservoir
6. Return Line

Fig. 1, Steering System Plumbing Diagram

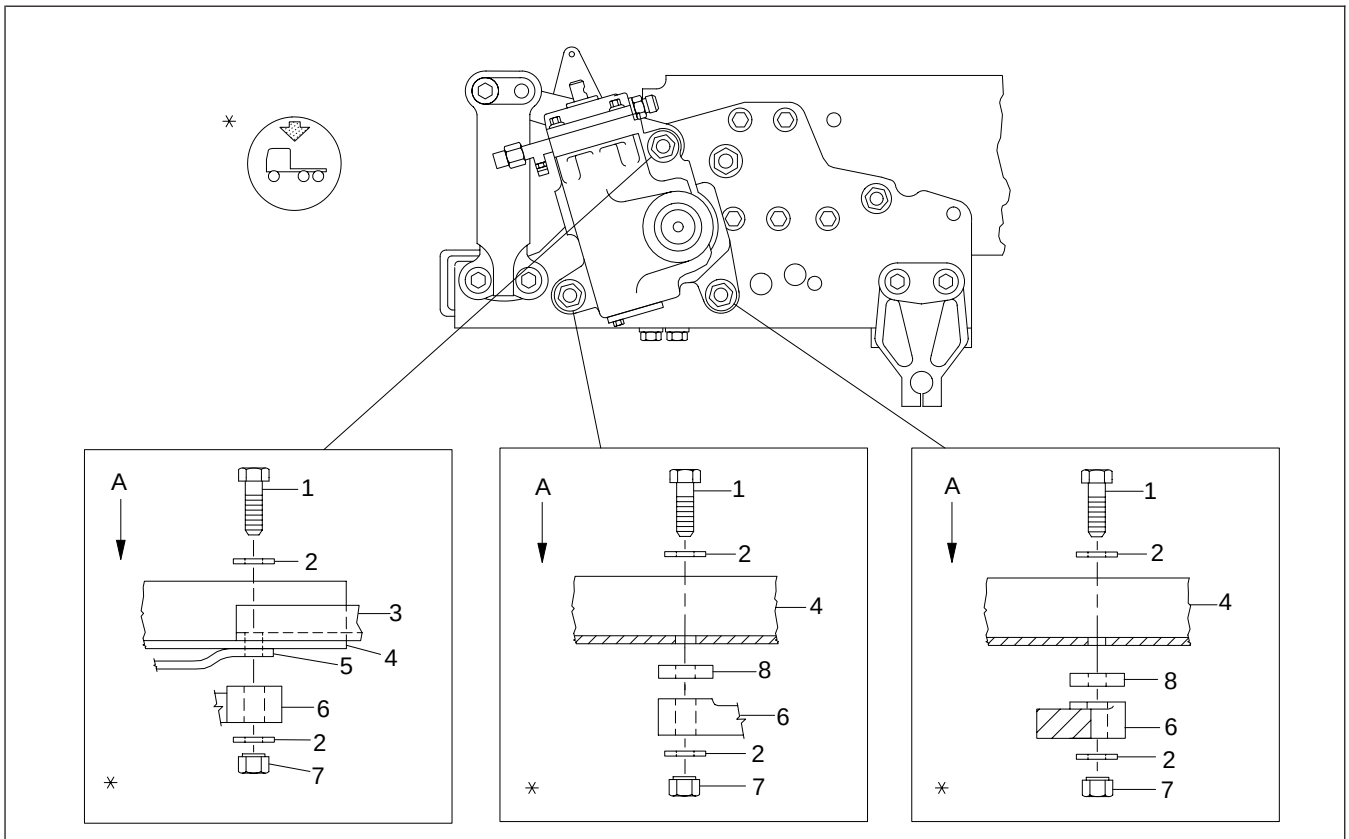
Specifications



A. Outboard

1a. 7/8–9 x 4-1/2 Capscrew, Grade 8 (only with front axle capacity up to 12,000 lb)
1b. 7/8–9 x 5 Capscrew, Grade 8 (only with front axle capacity over 12,000 lb)
1c. 7/8–9 x 4-1/4 Capscrew, Grade 8 (only with front axle capacity over 12,000 lb)
2. Washer
3. Frame Rail
4. Frame Extension
5. Cab Mount Strut
6. Washer (only with front axle capacity over 12,000 lb)
7. Steering Gear
8. 7/8–9 Nut
9a. Front Suspension Bracket (only with front axle capacity over 12,000 lb)
9b. 3/8-inch Thick x 1-1/2-inch Dia. Spacer (only with front axle capacity up to 12,000 lb)
9c. 1/2-inch Thick Spacer (only with front axle capacity over 12,000 lb)

Fig. 2, FLA COE With Set-Forward Axle and TAS65 Gear

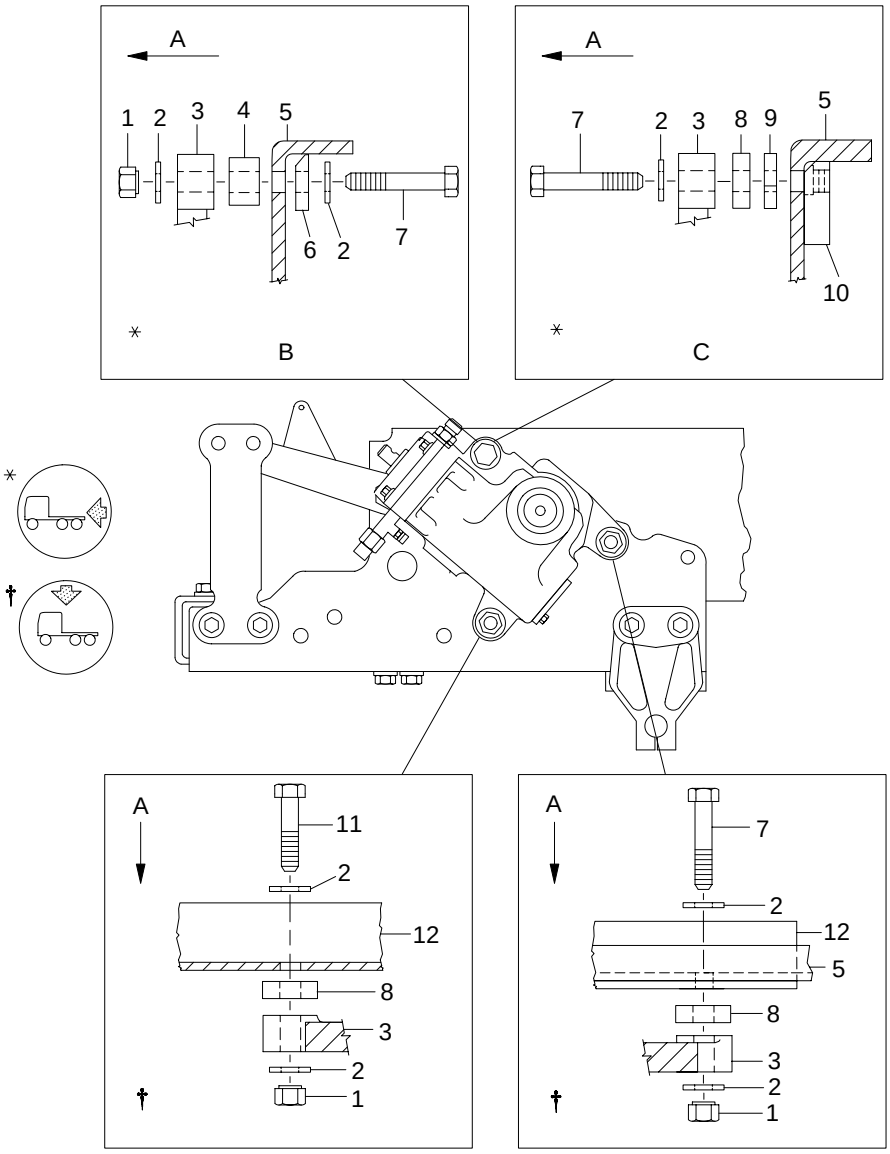


A. Outboard

1. 7/8–9 x 4-1/2 Capscrew, Grade 8
2. Washer
3. Frame Rail
4. Frame Extension
5. Cab Mount Strut
6. Steering Gear
7. 7/8–9 Nut
8. 3/8-inch Thick x 1-1/2-inch Dia. Spacer

Fig. 3, FLA COE With Setback Axle and TAS65 Gear (built before February 1990)

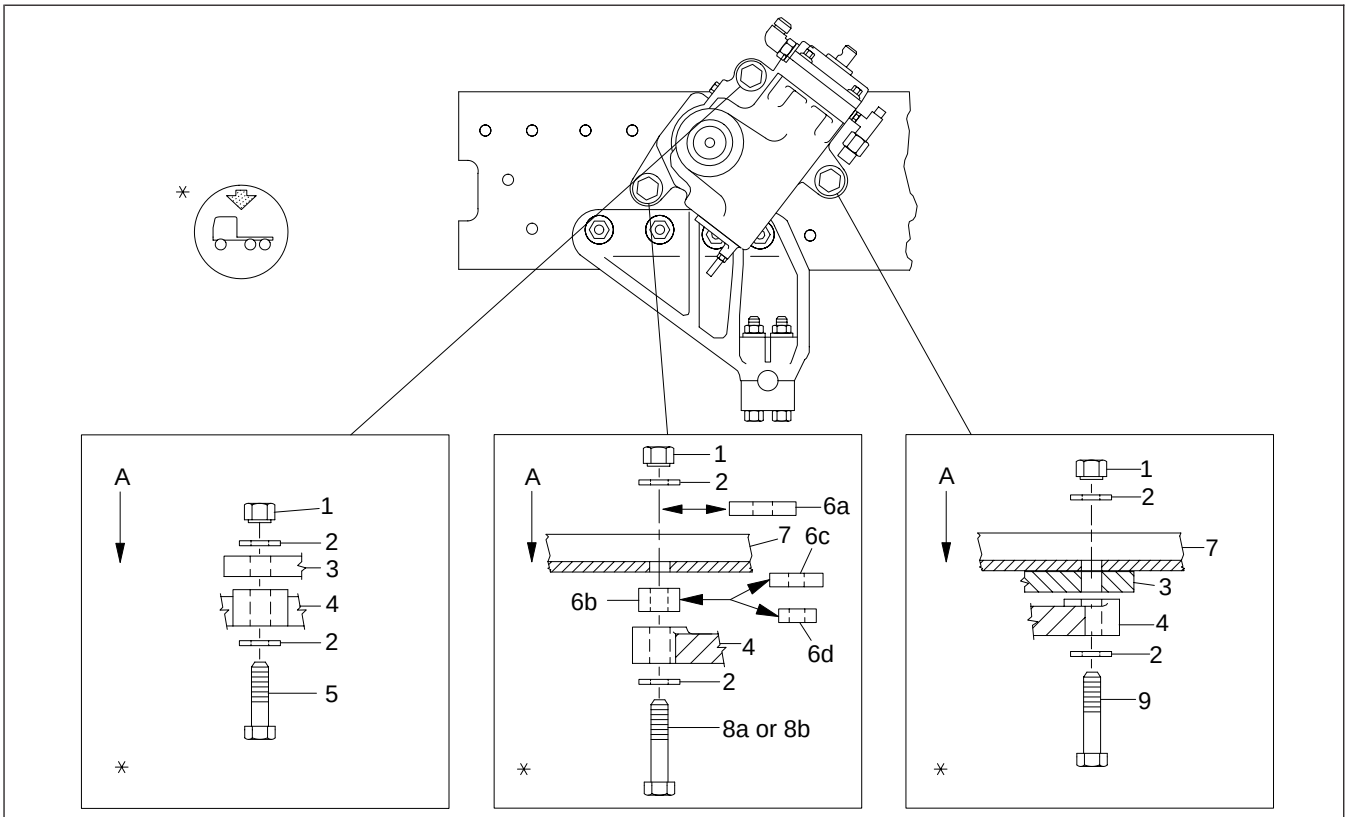
Specifications



A. Outboard
B. Installation for Steel Frame Rails
C. Installation for Aluminum Frame Rails

1. 7/8–9 Nut
2. Washer
3. Steering Gear
4. 1-inch Thick x 1-1/2-inch Dia. Spacer
5. Frame Rail
6. 3/8-inch Thick Chamfered Spacer
7. 7/8–9 x 5-1/2 Capscrew, Grade 8
8. 5/8-inch Thick x 1-1/2-inch Dia. Spacer
9. 3/8-inch Thick Spacer
10. 7/8–9 Threaded Backing Plate
11. 7/8–9 x 4-1/2 Capscrew, Grade 8
12. Frame Extension

Fig. 4, FLA COE With Setback Axle and TAS65 Gear (built after January 1990)



A. Outboard

1. 7/8–9 Nut
2. Washer
3. Gear Mounting Bracket
4. Steering Gear
5. 7/8–9 x 4-1/4 Capscrew, Grade 8

6a. 3/8-inch Thick x 2-1/4-inch Dia. Spacer (aluminum rails only)
6b. 3/4-inch Thick x 1-1/2-inch Dia. Spacer (steel rails only)
6c. 3/8-inch Thick x 1-7/8-inch Dia. Spacer (aluminum rails only)
6d. 3/8-inch Thick x 1-1/2-inch Dia. Spacer (aluminum rails only)

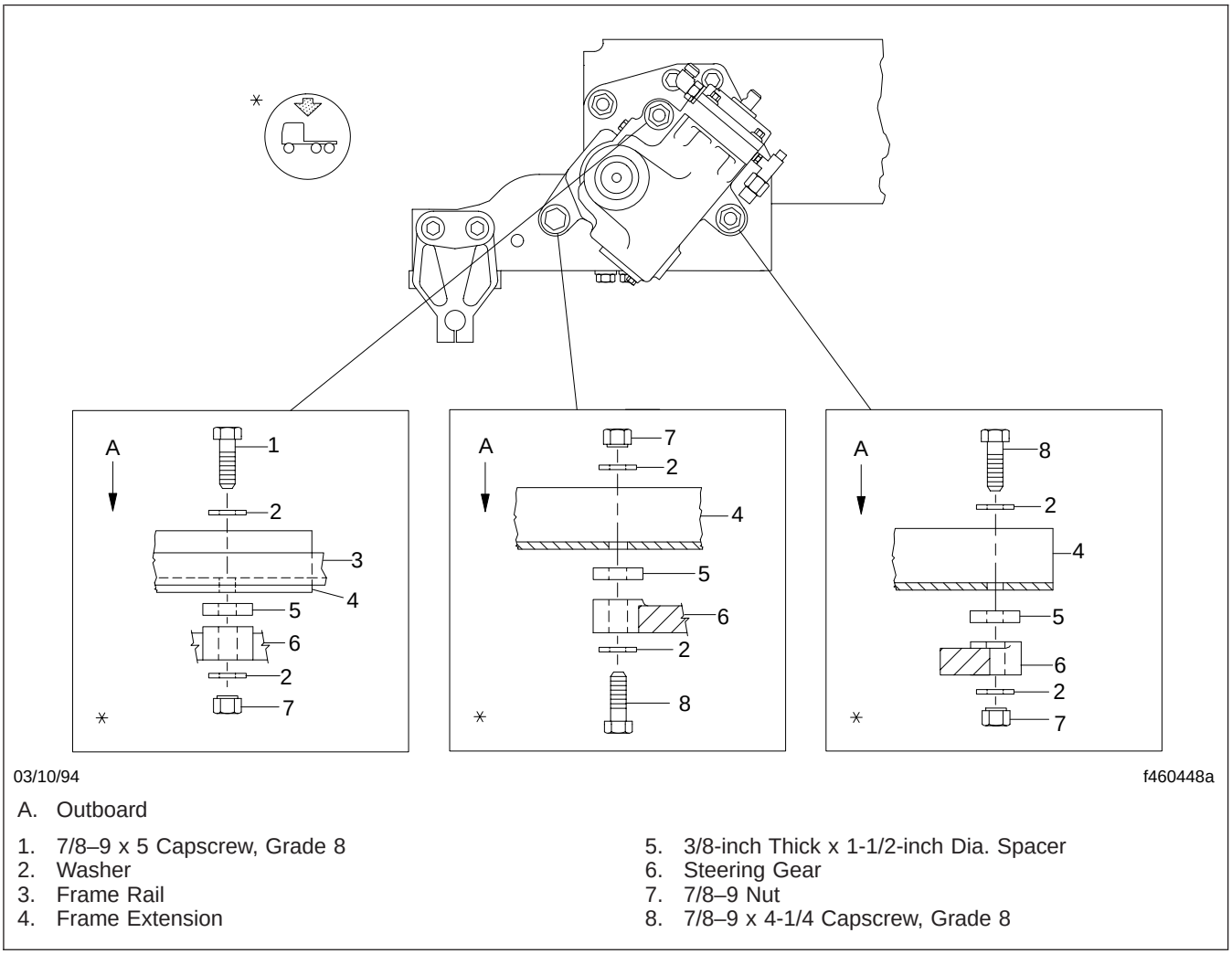
7. Frame Rail

8a. 7/8–9 x 5 Capscrew, Grade 8 (steel rails only)
8b. 7/8–9 x 5-1/2 Capscrew, Grade 8 (aluminum rails only)

9. 7/8–9 x 5 Capscrew, Grade 8

Fig. 5, FLD 112 Conventional With Setback Axle and TAS65 Gear (built before March 1992)

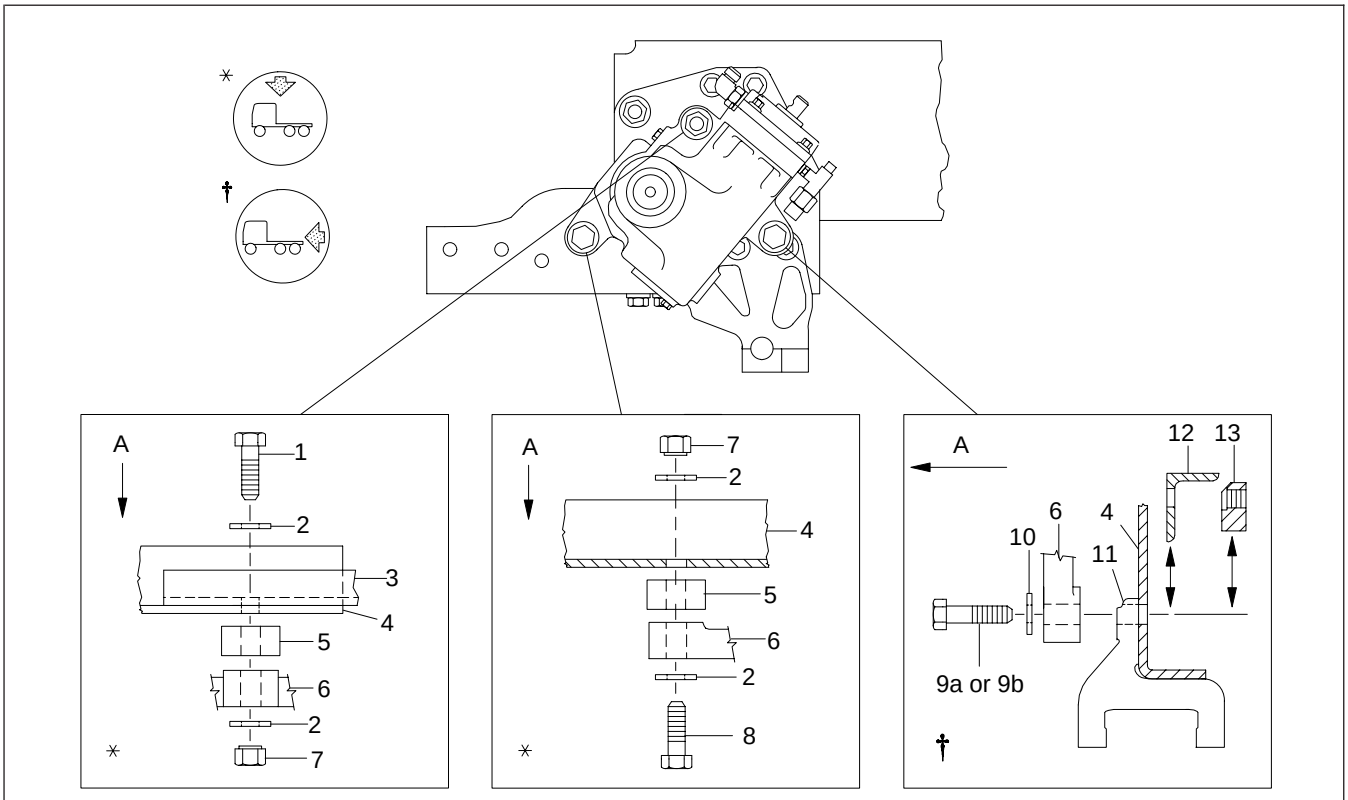
Specifications



A. Outboard

1. 7/8–9 x 5 Capscrew, Grade 8
2. Washer
3. Frame Rail
4. Frame Extension
5. 3/8-inch Thick x 1-1/2-inch Dia. Spacer
6. Steering Gear
7. 7/8–9 Nut
8. 7/8–9 x 4-1/4 Capscrew, Grade 8

Fig. 6, FLD 120 Conventional With Set-Forward Axle and TAS65 Gear



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A. Outboard

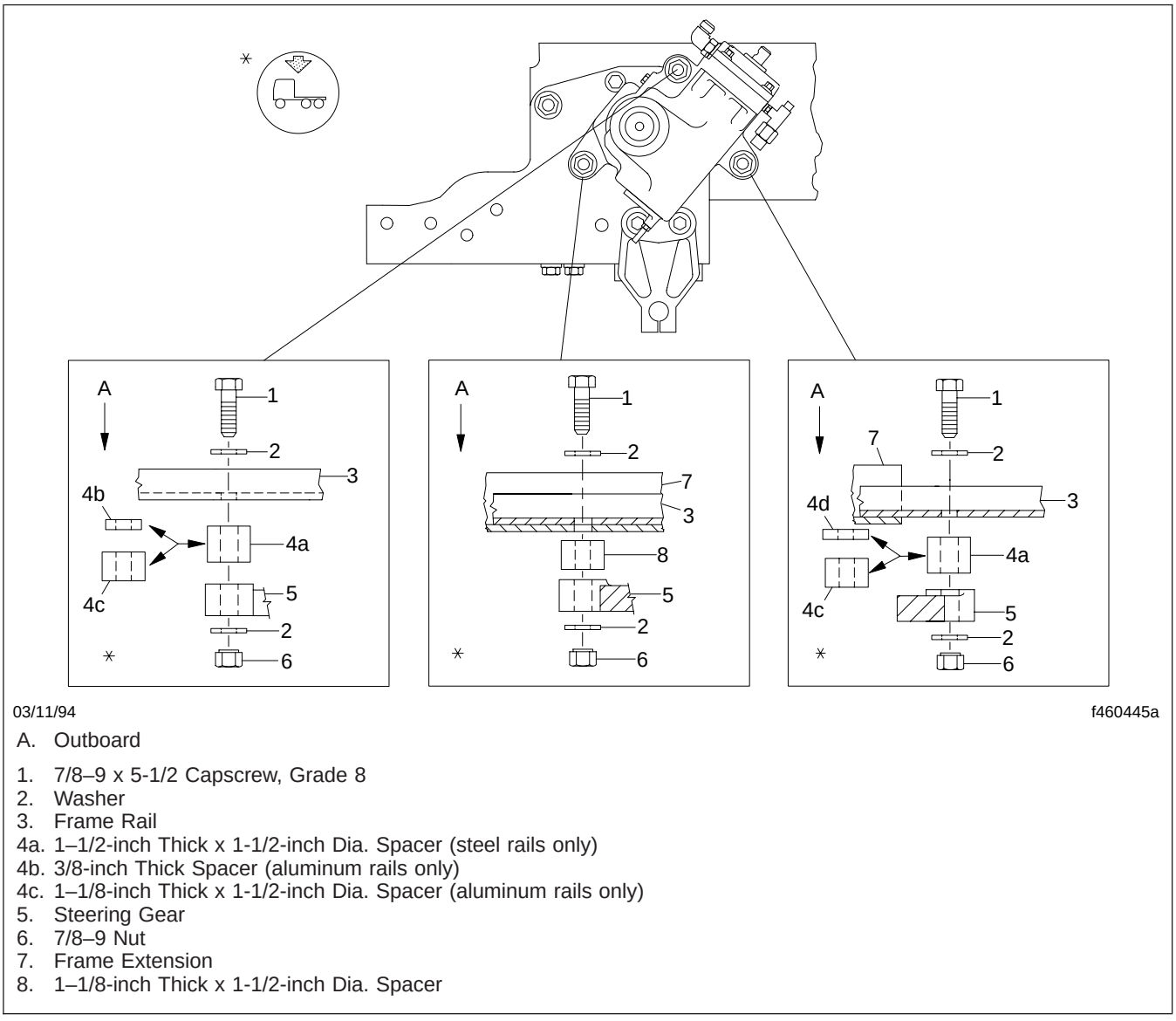
1. 7/8–9 x 5-1/2 Capscrew, Grade 8
2. Washer
3. Frame Rail
4. Frame Extension
5. 1-inch Thick x 1-1/2-inch Dia. Spacer
6. Steering Gear
7. 7/8–9 Nut
8. 7/8–9 x 4-3/4 Capscrew, Grade 8

9a. 7/8–9 x 3-1/2 Capscrew, Grade 8 (only with front axle capacity up to 12,000 lb)
9b. 7/8–9 x 5-1/2 Capscrew, Grade 8 (only with front axle capacity over 12,000 lb)

10. Washer
11. Front Suspension Bracket (7/8–9 tapped only with front axle capacity up to 12,000 lb)
12. Frame Stiffener (only with front axle capacity over 12,000 lb)
13. Tapping Plate (only with front axle capacity over 12,000 lb)

Fig. 7, FLD 120 Conventional With Setback Axle and TAS65 Gear (built before February 1990)

Specifications



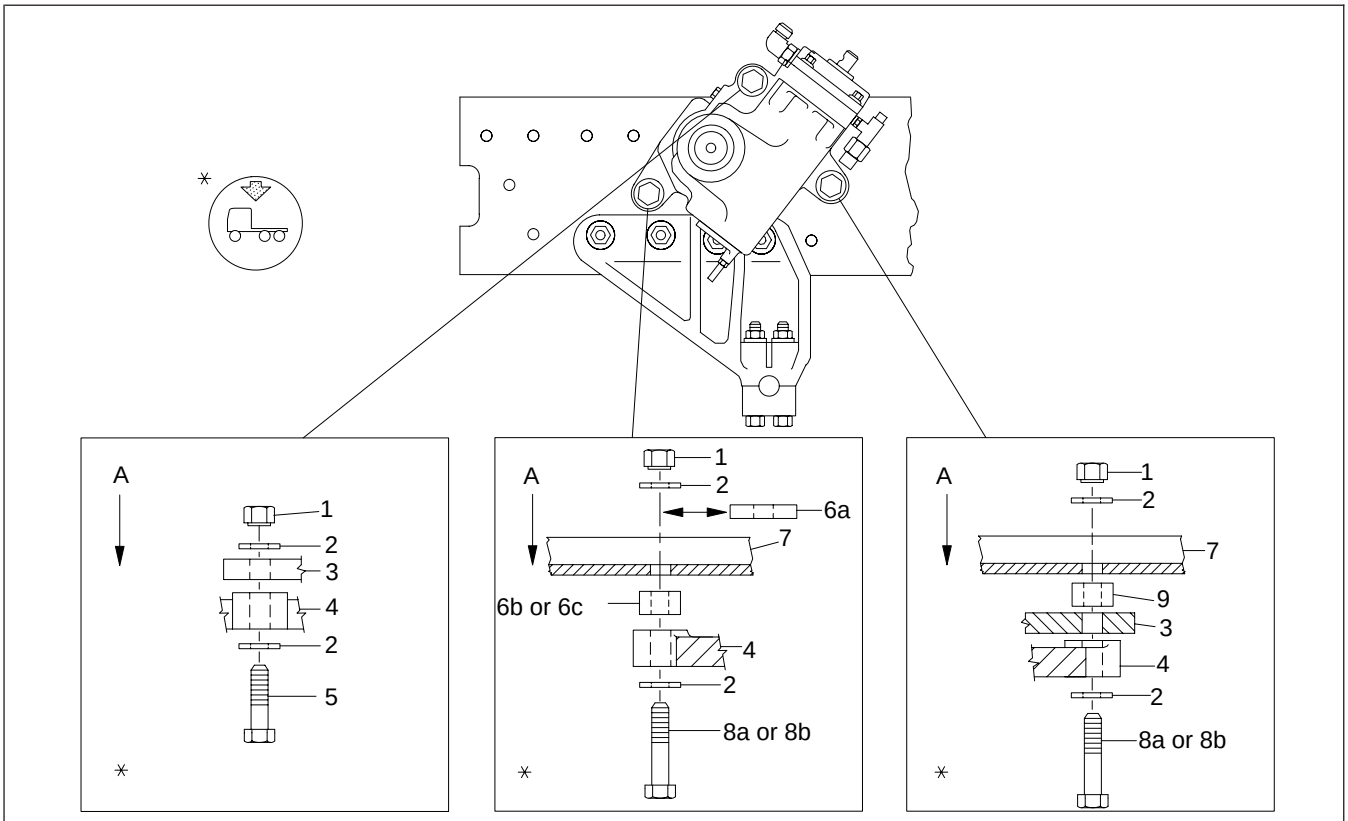
A. Outboard

1. 7/8–9 x 5-1/2 Capscrew, Grade 8
2. Washer
3. Frame Rail

4a. 1–1/2-inch Thick x 1-1/2-inch Dia. Spacer (steel rails only)
4b. 3/8-inch Thick Spacer (aluminum rails only)
4c. 1–1/8-inch Thick x 1-1/2-inch Dia. Spacer (aluminum rails only)

5. Steering Gear
6. 7/8–9 Nut
7. Frame Extension
8. 1–1/8-inch Thick x 1-1/2-inch Dia. Spacer

Fig. 8, FLD 120 Conventional With Setback Axle and TAS65 Gear (built from January 1990 to March 1992)



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A. Outboard

1. 7/8–9 Nut
2. Washer
3. Gear Mounting Bracket
4. Steering Gear
5. 7/8–9 x 4-1/4 Capscrew, Grade 8

6a. 3/8-inch Thick Spacer x 2–1/4-inch Dia. Spacer
6b. 3/4-inch Thick Spacer x 1-1/2-inch Dia. Spacer (steel rails only)
6c. 3/8-inch Thick Spacer x 1-7/8-inch Dia. Spacer (aluminum rails only)

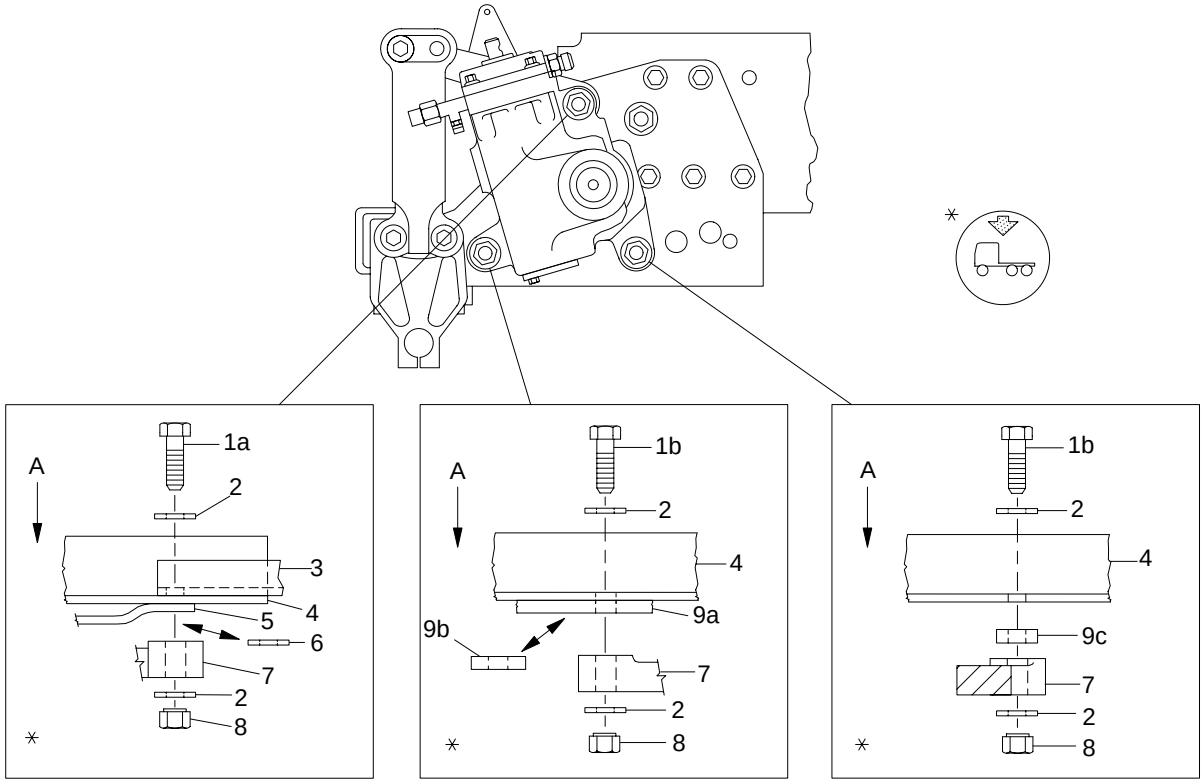
7. Frame Rail

8a. 7/8–9 x 5 Capscrew, Grade 8 (aluminum rails only)
8b. 7/8–9 x 5-1/2 Capscrew, Grade 8 (aluminum rails only)

9. Mounting Bracket Spacer (steel rails only)

Fig. 9, FLD Conventional With Setback Axle (built after March 1992)

Specifications



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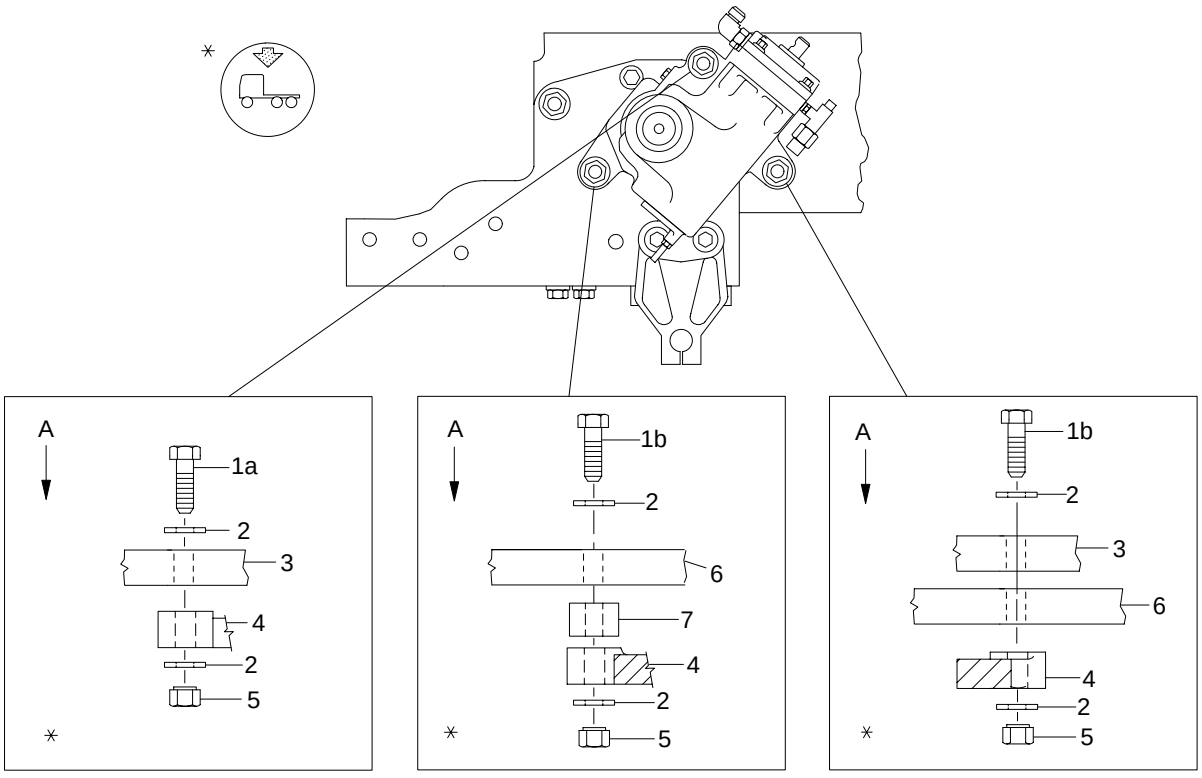
A. Outboard

1a. 7/8–9 x 5 Capscrew, Grade 8 (only with front axle capacity over 12,000 lb)
1b. 7/8–9 x 4-1/2 Capscrew, Grade 8 (only with front axle capacity up to 12,000 lb)
2. Washer
3. Frame Rail
4. Frame Extension
5. Cab Mount Strut
6. Washer
7. Steering Gear
8. 7/8–9 Nut
9a. Front Suspension Bracket (only with front axle capacity over 12,000 lb)
9b. 15/16-inch Thick x 1/2-inch Dia. Spacer (only with front axle capacity up to 12,000 lb)
9c. 15/16-inch Thick x 1/2-inch Dia. Spacer

Fig. 10, FLB COE With Set-Forward Axle and TAS85 Gear



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NOTE: Installation shown is typical. Installations for FLDs will vary depending on frame rail type/size and vehicle configuration.

A. Outboard

1a. 7/8–9 x 4-1/2 Capscrew, Grade 8
1b. 7/8–9 x 4-3/4 Capscrew, Grade 8
2. Washer
3. Gear Mounting Bracket
4. Steering Gear
5. 7/8–9 Nut
6. Frame Rail
7. 15/16-inch Thick x 3/4-inch Dia. Spacer

Fig. 11, FLD Conventional With Setback or Set-Forward Axle and TAS85 Gear (built from March 1994)

General Information

The steering driveline assembly, see **Fig. 1**, connects the steering column and the steering gear input shaft. The driveline assembly consists of an upper, nonadjustable section connected by a universal joint to a lower, two-piece, telescoping section.

The upper, nonadjustable section is connected to the base of the steering column and is supported by a bearing mounted to the cab deck.

The lower, telescoping section consists of a tubular top half, splined on the inside. The bottom half of the lower section is an externally splined shaft that slides freely in the tubular top half. This slip joint allows for changes in the cab position when the cab is tilted, and eases installation and removal of the steering driveline assembly.

Three universal joints allow the steering driveline assembly to twist at the angles necessary to transfer the motion of the steering wheel to the steering gear. The first of the three universal joints connects the upper, nonadjustable driveline section to the base of the steering column. The second universal joint connects the base of the nonadjustable driveline section to the top of the telescoping driveline section. The third connects the base of the telescoping section to the steering gear input shaft.

The universal joint journal crosses are secured to integral yokes at the ends of the upper and lower driveline sections. The first and third universal joints are secured to the steering column and the steering gear input shaft with internally serrated yokes. The yokes mate with the externally serrated steering column and steering gear input shaft, and are held in place with pinch bolts that engage notches in the column and shaft. If the yokes are marked with red paint, they have been installed with adhesive also. Whether or not adhesive is present when the driveline is removed, use adhesive and mark the yokes with red paint when installing the driveline.

General Information

1. Upper Column and Jacket Assembly
2. Wheel Tube Shaft
3. Pinch-Bolt Nut
4. Upper End Yoke
5. Upper End Yoke Pinch Bolt
6. U-Joint Assembly
7. U-Joint Journal Cross
8. Journal Cross Seal
9. Needle Bearing Cup Snap Ring
10. Needle Bearing Cup
11. Journal Cross Grease Fitting
12. Pinch-Bolt Nut
13. Upper Driveline Yoke
14. Upper Driveline Yoke Pinch Bolt
15. Upper Driveline Shaft
16. Crescent Retaining Ring
17. Felt Washer
18. Locknut
19. Deck Bearing
20. Deck Bearing Support Bracket
21. Deck Bearing Gasket
22. Bearing Shim
23. Capscrew
24. Bolt
25. Washer
26. Driveline Tube and Yoke Assembly
27. Intermediate Yoke Assembly
28. Grease Fitting
29. Driveline Tube
30. Lower Driveline Shaft and Yoke Assembly
31. Pinch-Bolt Nut
32. Lower End Yoke
33. Lower End Yoke Pinch Bolt
34. Seal Protector
35. Steering Gear Input Shaft
36. Ross Integral Power Steering Gear*
37. Boot Cover
38. Ross Manual Steering Gear*

* Actual steering gear models may vary.

NOTE: Not all fasteners are shown.

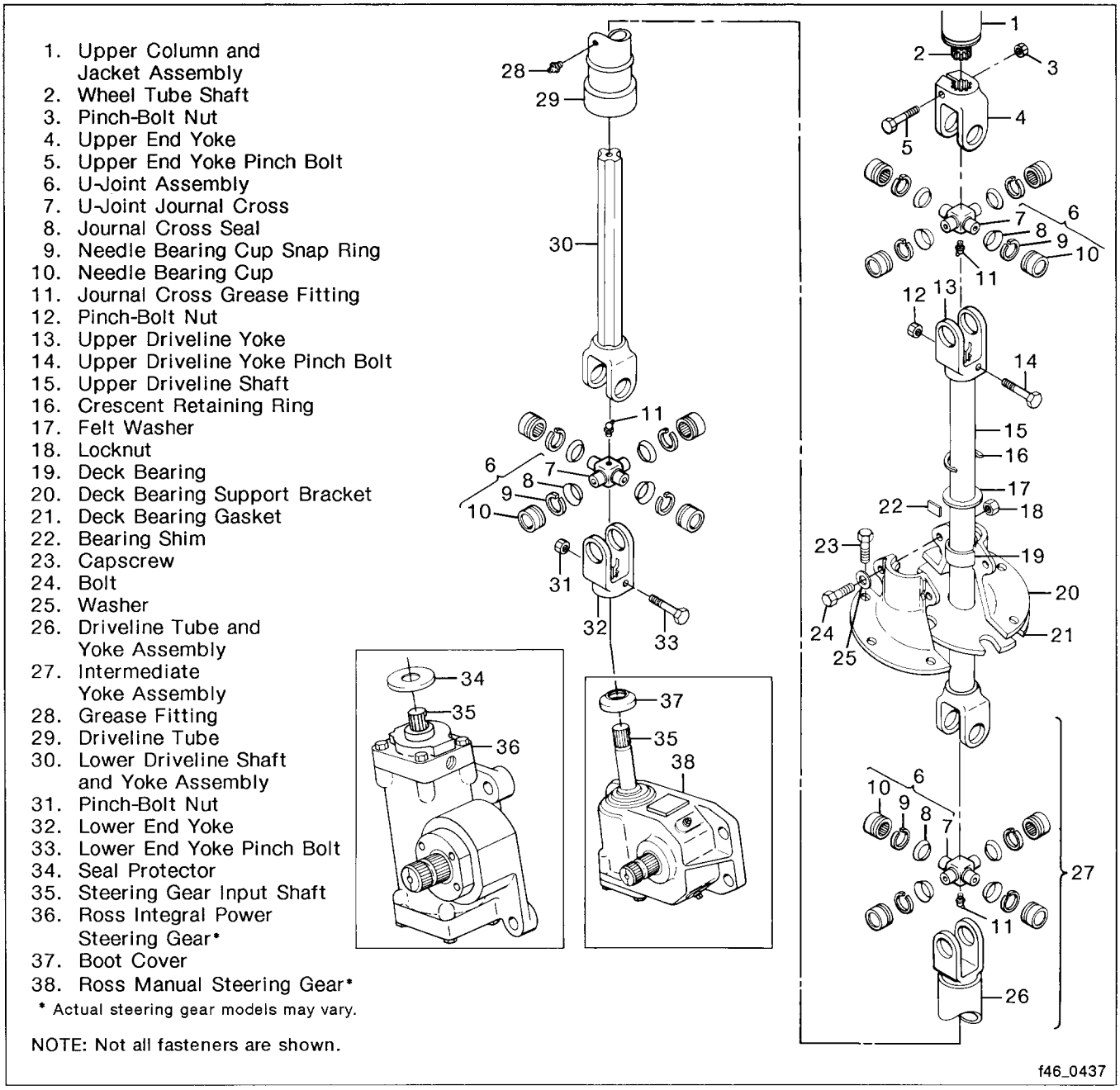


Fig. 1, Steering Driveline, COE

Steering Driveline Removal and Installation

Removal

NOTE: You don't need to loosen the steering wheel and column assembly to do this procedure.

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be performed. Apply the parking brakes, and chock the tires.
2. Remove or secure all loose articles in the cab. Tilt the cab. For instructions, refer to the vehicle driver's manual.
3. Remove the pinch bolt nut and pinch bolt from the lower end yoke. See **Fig. 1**. Discard the nut and the bolt. With paint or a grease pencil, mark alignment arrows between the yoke and the shaft.
4. Remove the yoke from the steering gear input shaft.

   If the yoke is marked with red paint, it is secured to the input shaft with adhesive. Heat the base of the lower end yoke with a torch until the bond begins to weaken. At 300°F (149°C) the bond will be reduced to half strength.

   Do not turn the steering gear input shaft when removing the lower end yoke. Push the driveline shaft into the driveline tube as you remove the lower end yoke.
5. Check the shaft and tube of the lower telescoping driveline section for aligning arrows at the slip joint. See **Fig. 2**. If the arrows are not visible, mark the driveline tube and shaft for alignment.
6. Remove the pinch bolt nut and pinch bolt from the upper end yoke. Discard the nut and the bolt.
7. Remove the capscrews, bolts, locknuts, and washers that secure and clamp the deck bearing support bracket assembly. See **Fig. 3**. Remove the crescent retaining ring and felt washer.

IMPORTANT: If heat is used to remove the upper end yoke, be careful not to damage the cab interior.

8. Remove the upper end yoke from the steering column shaft. If the yoke is marked with red paint, it is secured to the steering column with adhesive. Heat the base of the upper end yoke with a torch until the adhesive bond begins to weaken at 300°F (149°C).
9. Remove the driveline assembly from the vehicle. Collect the washer, dust cup, spring, and bearing spacer as they drop from the end of the steering column assembly. See **Fig. 4**.

Installation

1. Clean the end of the steering column shaft and the steering gear input shaft with a clean dry cloth.
2. Using a wire brush and Loctite® Safety Solvent or an equivalent, clean the serrations of the end yokes and the shafts.

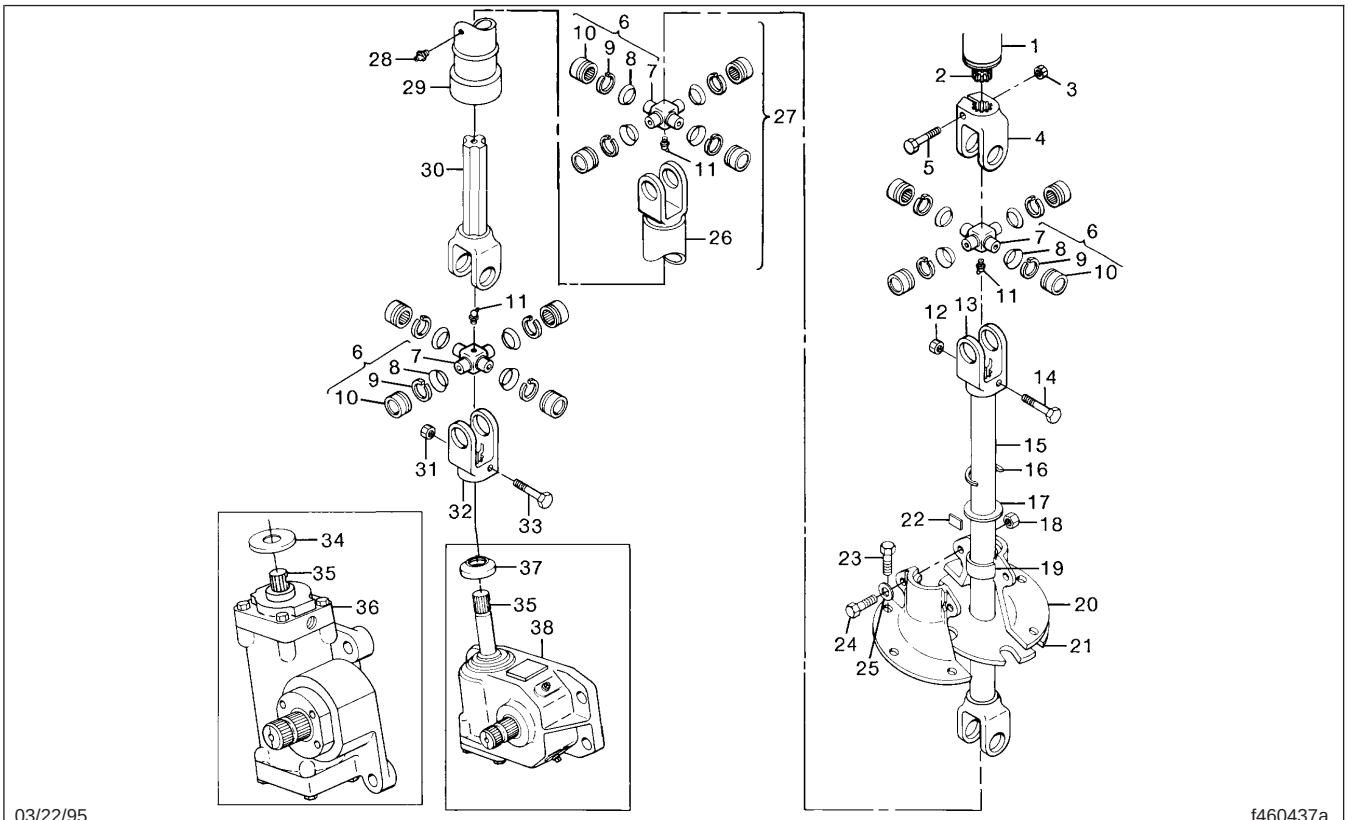
IMPORTANT: If Loctite Safety Solvent is not available, use *clean* solvents such as trichloroethylene, trichloroethane, perchloroethylene, MEK, acetone, or alcohol. *Do not use* kerosene, gasoline, naphtha, fuel oil, Varsol, or Stoddard solvents.

3. Apply Loctite Primer N to the serrated portion of the steering column shaft. Let it dry five minutes.
4. Insert the bearing spacer, bearing spring, dust cup, and washer in the lower end of the steering column. See **Fig. 4**.
5. Apply a bead of Loctite No. 680 adhesive to the serrated area inside the upper end yoke.

IMPORTANT: Curing of the adhesive will begin immediately after installation of the end yoke on the steering column shaft. The pinch bolt nut must be torqued within four minutes. If this time is exceeded, disassemble the parts, clean them, and treat them again. Allow the assembled parts to cure for thirty minutes before applying steering load pressures.

6. Position the upper end of the driveline through the hole in the cab deck and slide the upper end yoke onto the steering column shaft. Then install a new end yoke pinch bolt. Before installing the pinch bolt, make sure the pinch bolt is centered in the steering column shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install a new pinch bolt nut and tighten it 37 lbf·ft (50 N·m).

Steering Driveline Removal and Installation



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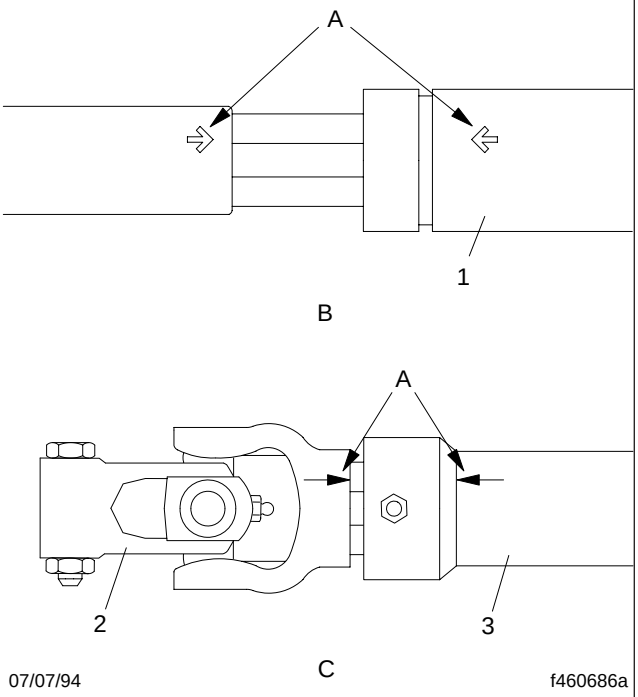
NOTE: Not all fasteners are shown.

1. Upper Column and Jacket Assembly
2. Wheel Tube Shaft
3. Pinch Bolt Nut
4. Upper End Yoke
5. Upper End Yoke Pinch Bolt
6. U-Joint Assembly
7. U-Joint Journal Cross
8. Journal Cross Seal
9. Needle Bearing Cup Snap Ring
10. Needle Bearing Cup
11. Journal Cross Grease Fitting
12. Pinch Bolt Nut
13. Upper Driveline Yoke
14. Upper Driveline Yoke Pinch Bolt
15. Upper Driveline Shaft
16. Crescent Retaining Ring
17. Felt Washer
18. Locknut
19. Deck Bearing
20. Deck Bearing Support Bracket
21. Deck Bearing Gasket
22. Bearing Shim
23. Capscrew
24. Bolt
25. Washer
26. Driveline Tube and Yoke Assembly
27. Intermediate Yoke Assembly
28. Grease Fitting
29. Driveline Tube
30. Lower Driveline Shaft and Yoke Assembly
31. Pinch Bolt Nut
32. Lower End Yoke
33. Lower End Yoke Pinch Bolt
34. Seal Protector
35. Steering Gear Input Shaft
36. Ross Integral Power Steering Gear
37. Boot Cover
38. Ross Manual Steering Gear

Fig. 1, Steering Driveline, COE

NOTE: It may be necessary to apply downward pressure on the steering wheel when installing the yoke to prevent the wheel tube shaft from moving up in the jacket.

7. Apply Torque Seal OGP F900WHITE to the exposed pinch bolt thread and to the locknut. To show adhesive has been used, mark the end of the steering column shaft with red paint.
8. Position the deck bearing support halves around the deck bearing. Install, but do not tighten, the bolts, washers, and locknuts. Install the felt washer and crescent retaining ring into the cavity above the deck bearing. Make sure the top and



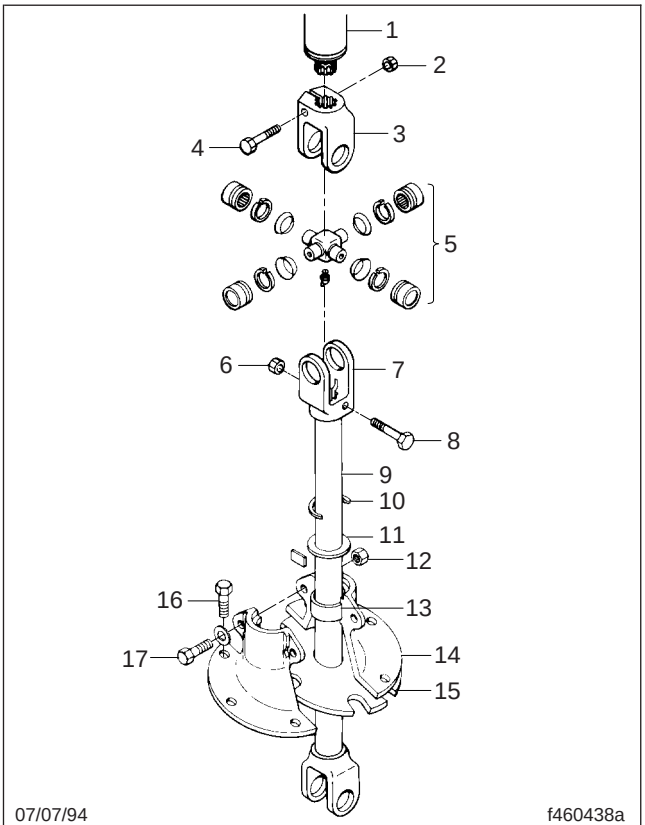
A. Align arrows.
B. Earlier Installation
C. Current Installation

1. Driveline Tube Shaft
2. Lower End Yoke
3. Driveline Tube and Yoke Assembly

Fig. 2, Assembling the Slip Joint

bottom bearing O-ring seals are seated correctly, then tighten the bolts 15 lbf·ft (20 N·m).

9. Make sure the deck bearing is seated both in the deck bearing support and against the shoulder of the end yoke. See **Fig. 5**. If necessary, loosen the six steering column clamp capscrews and adjust the steering column assembly up and down to position the deck bearing. Tighten the clamp capscrews 15 lbf·ft (20 N·m).
10. Before attaching the lower end yoke to the steering gear, be sure the front tires are straight ahead, the steering gear is centered, and the arrows on the driveline shaft and the driveline tube are aligned. See **Fig. 2**.



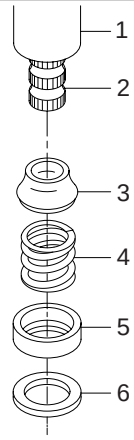
1. Steering Column and Jacket Assembly
2. Pinch Bolt Nut
3. Upper End Yoke
4. Upper End Yoke Pinch Bolt
5. Universal Joint Assembly
6. Pinch Bolt Nut
7. Upper Driveline Yoke
8. Upper Driveline Yoke Pinch Bolt
9. Upper Driveline Section
10. Crescent Retaining Ring
11. Felt Washer
12. Locknut
13. Deck Bearing
14. Deck Bearing Support Bracket
15. Deck Bearing Gasket
16. Capscrew
17. Bolt

Fig. 3, Deck Bearing and Upper Driveline Assembly

⚠ WARNING

If the arrow on the driveline shaft is not aligned with the arrow on the driveline tube, the universal joints will not be oriented correctly. Assembling

Steering Driveline Removal and Installation



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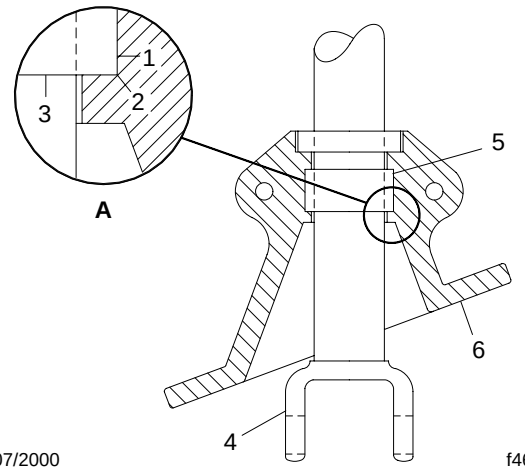
1. Jacket
2. Wheel Tube Shaft
3. Lower Bearing Spacer
4. Bearing Spring
5. Dust Cup
6. Washer

Fig. 4, Steering Column Lower Section Assembly



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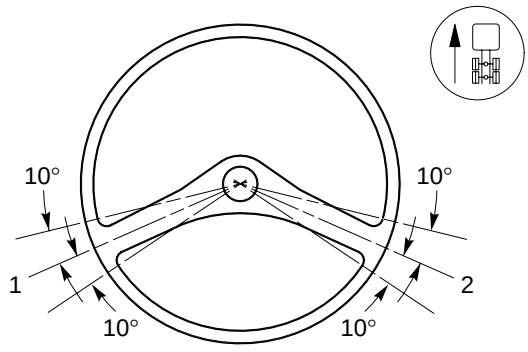
A. Detail A

1. Deck Bearing
2. Deck Bearing Seat
3. End Yoke Shoulder
4. End Yoke
5. Deck Bearing
6. Deck Bearing Support Bracket

Fig. 5, Deck Bearing

the driveline with the universal joints incorrectly oriented could cause binding at the universal joints, resulting in possible personal injury or property damage.

11. Line up the cross holes of the lower end yoke with the whistle notch of the steering gear input shaft.
12. Apply Loctite Primer N to the steering gear input shaft. Let it dry for five minutes.
13. Apply Loctite No. 680 adhesive to the lower end yoke as described in the applicable step above.
14. Install the lower end yoke on the steering gear input shaft and install and tighten a new pinch bolt and pinch bolt nut as described in the applicable step above.
15. Apply Torque Seal OGP F900WHITE to the exposed pinch bolt thread and to the locknut. To show adhesive has been used, mark the lower end yoke with red paint.
16. Grease the driveline tube and both universal joints with a lithium-based grease (NLGI grade 2) until grease appears at the lower end of the tube splines and the universal joint cross seals.
17. Check the position of the steering wheel when the front tires are straight ahead. The steering wheel spokes must be at the 4 o'clock and 8 o'clock (±10 degrees) positions. See **Fig. 6**.



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1. 8 o'Clock
2. 4 o'Clock

Fig. 6, Steering Wheel Positioning

18. Make sure there is at least 1/4-inch (6-mm) clearance around the steering driveline over its entire length. The brake valve fittings under the cab deck should be positioned away from the driveline assembly.
19. Return the cab to the operating position and secure the cab latches.

Chock the rear tires.

20. Raise the front of the vehicle, so that the front tires are off the ground, then place safety stands under the frame.
21. Turn the steering wheel through full travel, checking for hard steering or binding. If hard steering or binding occurs, check the assembly and installation of the driveline components.

⚠ WARNING

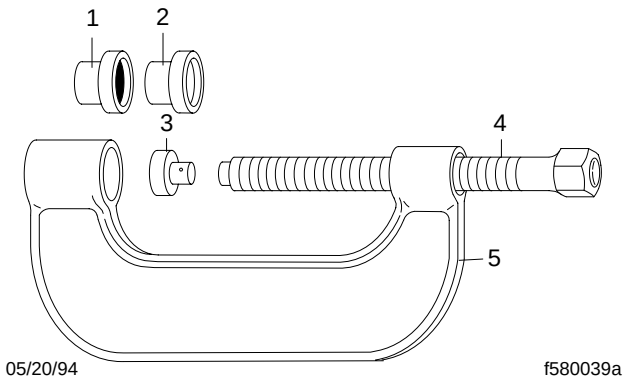
All steering mechanisms are life-and-limb items. As such, steering components must work smoothly, without binding. Binding in the steering components must be repaired before operating the vehicle. Operating the vehicle with binding in the steering system could result in loss of vehicle control and possible personal injury and property damage.

22. Remove the safety stands, lower the vehicle to the ground, and remove the chocks.

Steering Driveline Disassembly and Assembly

Disassembly

1. Remove the steering driveline from the vehicle. Refer to **Subject 100** for instructions.
2. Slide the shaft of the lower, telescoping driveline section out of the tubular top half of that section.
3. Removal of steering driveline universal joints requires the use of a universal joint tool. See **Fig. 1.** Clamp the universal joint tool frame into a vise.



1. Bushing Adaptor
2. Bearing Driver
3. Expansion Plug
4. Pressure Screw
5. Frame

Fig. 1, Universal Joint Tool Assembly

4. Wearing safety goggles, remove the needle bearing cup snap rings from the needle bearing cups by pushing an open end of the snap rings with a screwdriver.
5. Select a universal joint tool expansion plug of slightly smaller diameter than the needle bearing cup, and place it on the pressure screw. Select a bushing adapter of slightly larger inside diameter than the needle bearing cup, and place it on the opposite end of the tool.
6. Place the top yoke of the nonadjustable driveline section in the universal joint tool. Position the bushing adaptor to receive a needle bearing cup, and position the expansion plug against the opposite needle bearing cup.
7. Tighten the pressure screw to press the needle bearing cup out of the driveline yoke, then remove the needle bearing cup. Reverse the driveline section and yoke assembly, and press against the universal joint cross to force out the other needle bearing cup. In some cases it may be necessary to give the pressure screw a sharp blow with a brass hammer while the screw is under pressure.
8. Remove the driveline section and yoke assembly from the universal joint tool, then remove the upper end yoke and the universal joint cross from the upper driveline yoke.
9. Place the upper end yoke in the universal joint tool. Position the bushing adaptor to receive a needle bearing cup, and position the expansion plug against the opposite needle bearing cup.
10. Tighten the pressure screw to press the needle bearing cup out of the upper end yoke, then remove the needle bearing cup. Reverse the upper end yoke in the universal joint tool and press against the universal joint cross to force out the other needle bearing cup. In some cases it may be necessary to give the pressure screw a sharp blow with a brass hammer while the screw is under pressure.
11. Remove the upper end yoke from the universal joint tool, then remove the universal joint cross from the upper end yoke.
12. Repeat the previous steps as needed for the lower end yoke and the intermediate yoke assembly.

Assembly

1. Installing the steering driveline universal joints requires the use of a universal joint tool (**Fig. 1**). Clamp the universal joint tool frame into a vise.
2. Select a universal joint tool expansion plug of slightly smaller diameter than the needle bearing cup, and place it on the pressure screw. Place a bearing driver on the opposite end of the tool.
3. Position the universal joint cross in the upper end yoke so that the universal joint cross lube fitting points toward one of the yoke ears.
4. Make certain the universal joint cross seals are in place on the needle bearing cups, then start both needle bearing cups into the yoke ears from the outside. Place the upper end yoke in the universal joint tool with the bearing driver against one of the needle bearing cups and the expansion plug against the opposite needle bearing cup.

Steering Driveline Disassembly and Assembly

5. Tighten the pressure screw, making sure that both needle bearing cups press straight into the yoke ears. Work the universal joint cross during this operation to ensure free movement. If the needle bearing cups do not seat correctly, or if the universal joint binds, give the yoke shoulder near each cup a sharp blow with a brass hammer.
6. Press the needle bearing cup on the screw end of the universal joint tool all the way in, until there is enough clearance to insert a needle bearing cup snap ring. Insert the snap ring. Ensure the snap rings are fully seated in their grooves.

⚠ WARNING

WARNING: Use new snap rings when assembling the universal joints. Used snap rings are often distorted and over-stressed from disassembly and can work loose, resulting in a loss of steering control and possible personal injury or property damage.

7. Reverse the upper end yoke in the universal joint tool, and push the other needle bearing cup until there is clearance to insert the other snap ring. Insert the snap ring, then remove the upper end yoke from the universal joint.
8. With the universal joint cross lube fitting facing away from the base of the upper end yoke, position the universal joint cross and upper end yoke in the driveline yoke assembly.

NOTE: The universal joint cross lube fitting should face away from the base of the upper end yoke to provide access for lubrication when the steering driveline is installed on the vehicle.

9. Repeat the previous steps as needed for the upper driveline section top yoke.
10. Repeat previous steps as needed for the lower driveline section yoke and the intermediate yoke assembly.
11. Slide the bottom half of the lower telescoping driveline section into the tubular upper half so that the arrows on each half are aligned.

⚠ WARNING

If the arrow on the driveline shaft is not aligned with the arrow on the driveline tube, the universal joints will not be oriented correctly. Assembling the driveline with the universal joints incorrectly oriented could cause binding at the universal joints, resulting in possible personal injury or property damage.

12. Install the steering driveline in the vehicle. Refer to **Subject 100.**

Replacement

1. Remove the upper driveline yoke pinch-bolt nut and pinch bolt. Discard the nut and the bolt.
2. Loosen the fasteners holding the two halves of the deck bearing support bracket together and to the floor. Spread the halves enough to remove the upper driveline section from the steering column by sliding the driveline section down through the deck.

IMPORTANT: Use care not to damage any cab interior components when applying heat to the end yoke.

3. If the yoke is marked with red paint, it is secured to the steering column with adhesive; heat the upper driveline yoke with a torch, until the bond begins to weaken. At 300°F (149°C) the bond will be reduced to half strength.
4. Remove the bolts, locknuts, and washers that clamp the deck bearing support bracket assembly. Remove the crescent retaining ring and felt washer. See **Fig. 1.**

   Remove the capscrews that attach the two halves of the deck bearing support bracket to the deck. Remove the two halves of the deck support bracket and gasket. Remove the deck bearing from the driveline.
5. Apply a small amount of lubricant on the steering shaft at the bearing seat and install the new deck bearing on the driveline shaft.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

6. Use a wire brush and Loctite Safety Solvent or an equivalent to clean the splines of the upper driveline section yoke and steering column.

IMPORTANT: If Loctite Safety Solvent is not available, use *clean* solvents such as trichloroethylene, trichloroethane, perchloroethylene, MEK, acetone, or alcohol. *Do not use* kerosene, gasoline, naptha, fuel oil, Varsol, or Stoddard solvents.

7. Apply Locquic General Purpose Primer T to the steering column shaft splines.
8. Apply a bead of Loctite No. 680 adhesive to the splines of the upper driveline section top yoke. Slide the yoke onto the steering column.

IMPORTANT: After the yoke has been assembled to the column, curing will start immediately and the pinch-bolt nut must be tightened within four minutes. If this time is exceeded, the parts must be disassembled, cleaned, and treated again. The assembly must be allowed to cure for thirty minutes before applying steering load pressures.

9. Install a new yoke pinch bolt and pinch-bolt nut. Before tightening the nut, make sure the pinch bolt is centered in the driveshaft notch. The pinch bolt is centered if it can slip in and out of the yoke with ease.
10. Tighten the nut 37 lbf·ft (51 N·m).
11. Apply white Torque Seal F-900 to the exposed pinch-bolt threads and locknut. To show adhesive has been used, mark the end of the steering column shaft with red paint.
12. Position the deck bearing support halves around the deck bearing. Install, but do not tighten, the bolts, washers, and locknuts. Install the felt washer and crescent retaining ring into the cavity above the deck bearing. Make sure the top and bottom bearing O-ring seals are seated correctly, then tighten the bolts 15 lbf·ft (20 N·m).

1. Crescent Retaining Ring
2. Felt Washer
3. Bearing Shim
4. Bolt
5. Washer
6. Locknut
7. Bearing Support Bracket
8. Capscrew
9. Deck Bearing Gasket

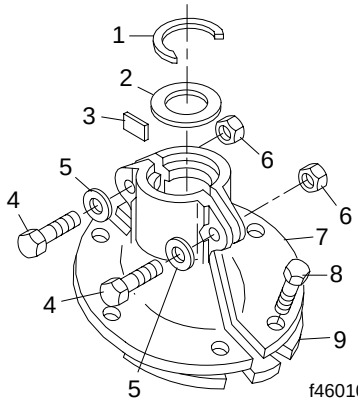


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Fig. 1, Deck Bearing Support Bracket

Specifications

Torque Values		
Description	**Size**	**Torque: lbf·ft (N·m)**
Upper End Yoke Pinch-Bolt Nut	3/8–16	37 (50)
Lower End Yoke Pinch-Bolt Nut	7/16–20	60 (81)
Upper Driveline Yoke Pinch-Bolt Nut	7/16–20	60 (81)
Steering Column Clamp Capscrews	—	15 (20)

Table 1, Torque Values

General Information (See Fig. 1)

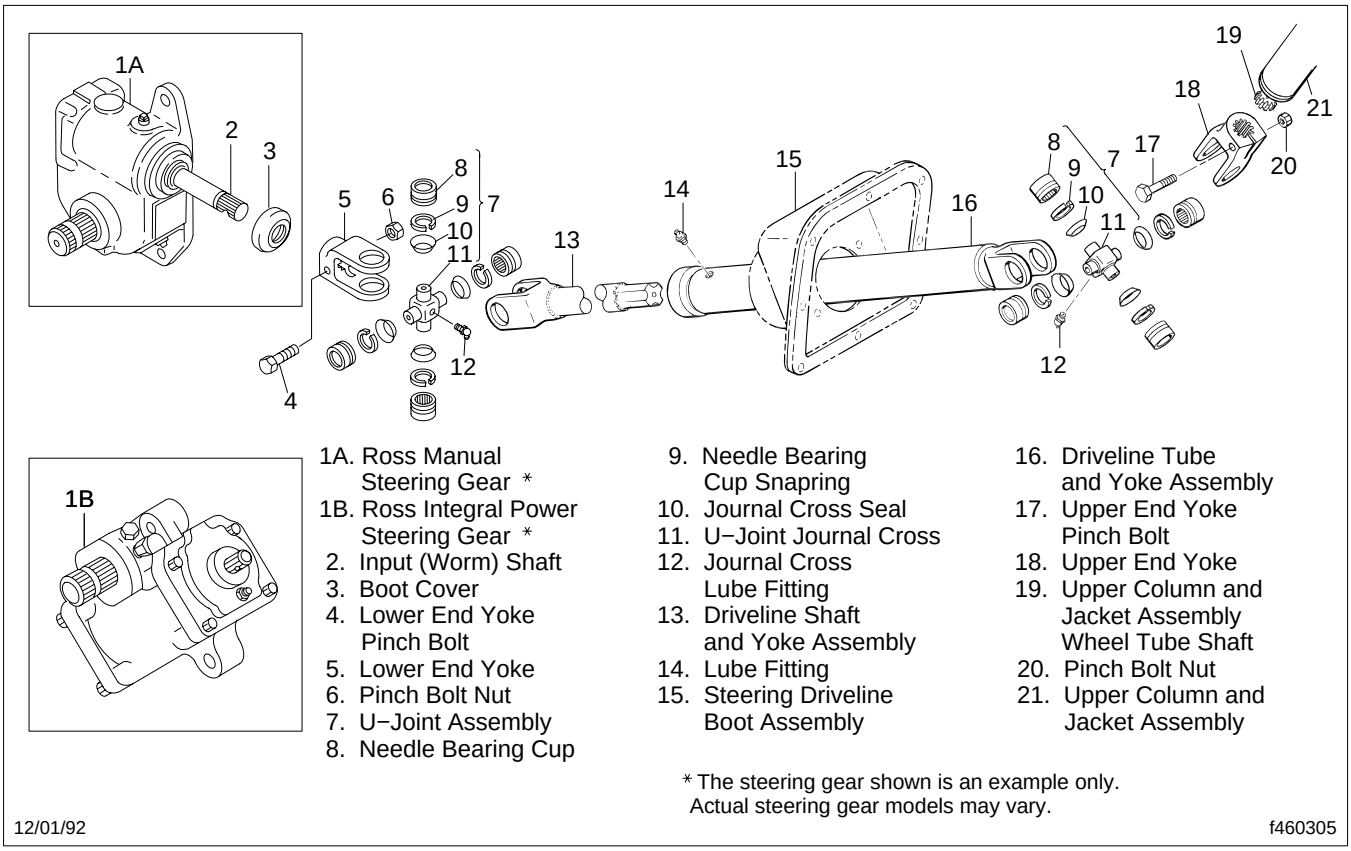
The steering driveline connects the steering column assembly to the steering gear, by means of a two-part, telescoping shaft with integral yokes and universal joint crosses at both ends. **See Fig. 1.**

The two-part driveline shaft consists of a tubular upper section, splined on the inside, and an externally splined lower section. The lower section is inserted in the tubular upper section, and slides freely to lengthen and shorten the driveline for installation and removal. The adjustable length of the steering driveline also allows for the slight movement between the cab suspension and the chassis frame during vehicle operation.

The top end of the upper driveline section and the bottom end of the lower driveline section are equipped with integral yokes. Each yoke is secured to two needle cups of a universal joint cross. The other two cups of each cross are secured to yokes, internally serrated to match the external serrations of the steering column and the steering gear input shaft. The serrated yokes are secured to the shafts with a pinch bolt, which engages a notch in the shaft. If the yokes are marked with red paint, they have been installed with adhesive also. Whether or not adhesive is present when the driveline is removed, use adhesive and mark the yokes with red paint when installing the driveline.

The universal joints allow the steering driveline to twist at the angles necessary to transfer the motion of the steering wheel to the steering gear.

General Information



1A. Ross Manual Steering Gear *
1B. Ross Integral Power Steering Gear *
2. Input (Worm) Shaft
3. Boot Cover
4. Lower End Yoke Pinch Bolt
5. Lower End Yoke
6. Pinch Bolt Nut
7. U−Joint Assembly
8. Needle Bearing Cup
9. Needle Bearing Cup Snapring
10. Journal Cross Seal
11. U−Joint Journal Cross
12. Journal Cross Lube Fitting
13. Driveline Shaft and Yoke Assembly
14. Lube Fitting
15. Steering Driveline Boot Assembly
16. Driveline Tube and Yoke Assembly
17. Upper End Yoke Pinch Bolt
18. Upper End Yoke
19. Upper Column and Jacket Assembly Wheel Tube Shaft
20. Pinch Bolt Nut
21. Upper Column and Jacket Assembly

* The steering gear shown is an example only. Actual steering gear models may vary.

Fig. 1, Steering Driveline

Removal

NOTE: It is not necessary to loosen the steering wheel and column assembly to do this procedure.

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be performed.
2. Apply the parking brakes, chock the tires, and open the hood.
3. Remove and discard the pinch bolt and nut from the lower end yoke. See **Fig. 1**.
4. Remove the yoke from the steering gear input shaft.

   If the yoke is marked with red paint, it is secured to the steering gear input shaft with adhesive. Heat the base of the lower end yoke with a torch until the bond begins to weaken. At 300°F (149°C) the bond will be reduced to half strength.

CAUTION

Use care not to damage the input shaft seal when applying heat to the end yoke. Replace the seal if it is damaged.

5. Do not turn the steering gear input shaft when removing the lower end yoke. Push the driveline shaft into the driveline tube as you remove the lower end yoke.
6. Remove and discard the pinch bolt and nut from the upper end yoke.
7. Remove the upper end yoke from the steering column shaft. If the upper end yoke is marked with red paint, it is secured with adhesive. Heat the base of the yoke with a torch until the adhesive bond begins to weaken at 300°F (149°C). Pull the driveline down until it is free of the boot. Remove the driveline.

Installation

1. Clean the end of the steering column shaft and the steering gear input shaft with a clean dry cloth.
2. Using a wire brush and Loctite® Safety Solvent, or an equivalent, clean the splines of the end yokes and the shafts.

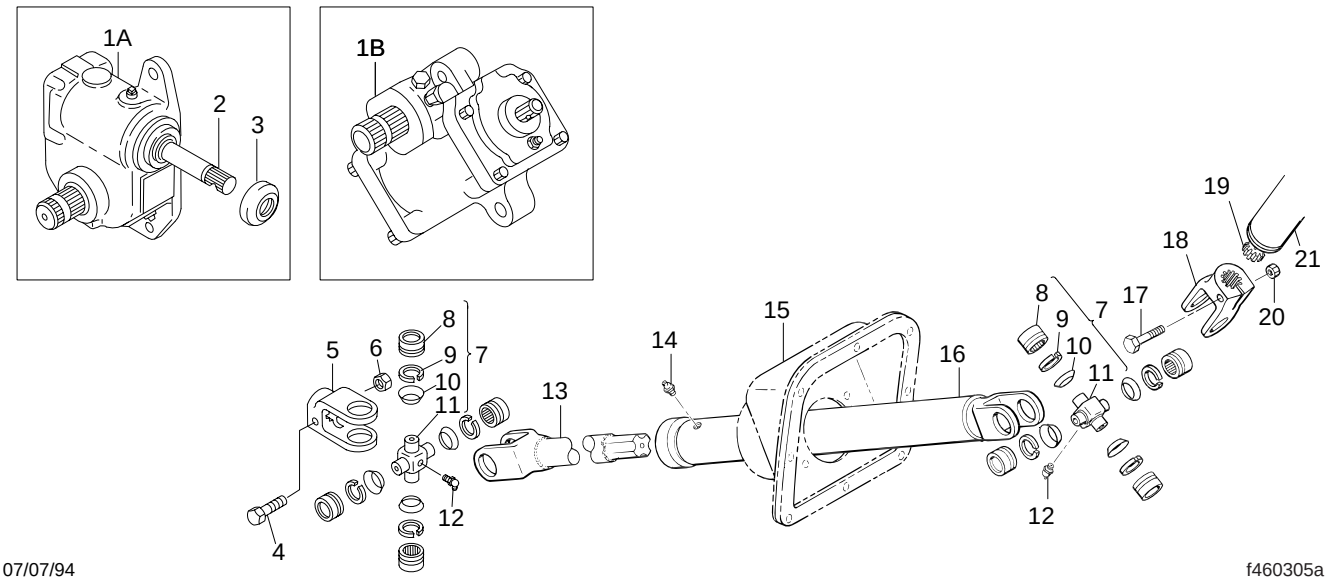
IMPORTANT: If Loctite Safety Solvent is not available, use **clean** solvents, such as trichloroethylene, trichloroethane, perchloroethylene, MEK, acetone, or alcohol. **Do not** use kerosene, gasoline, naphtha, fuel oil, Varsol, or Stoddard solvents.

3. Apply Loctite Primer N to the serrated portion of the steering column shaft. Let it dry five minutes.
4. Apply a bead of Loctite 680 adhesive to the serrations inside the base of the upper end yoke.

IMPORTANT: Curing of the adhesive will begin immediately after installation of the end yoke on the steering column shaft. The nut must be torqued within four minutes. If this time is exceeded, disassemble the parts, clean them, and treat them again. Allow the assembled parts to cure for thirty minutes before applying steering load pressures.

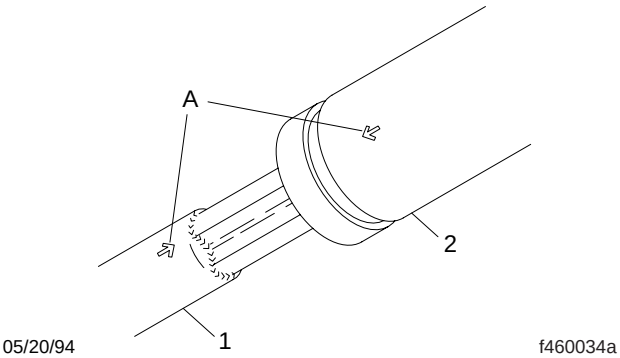
5. Slide the upper end yoke on the steering column shaft, then install a new pinch bolt. Before installing the nut, make sure the pinch bolt is centered in the steering column shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install a new nut and tighten it to one of the following torque specs:
   - 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16 pinch bolt and nut
   - 30 to 35 lbf·ft (41 to 47 N·m) for an M10 pinch bolt and nut
6. Apply torque seal, OGP F900WHITE, to the exposed bolt threads and to the nut. To show adhesive has been used, mark the end of the steering column shaft with red paint.
7. Before attaching the lower end yoke to the steering gear input shaft, be sure the front tires are straight ahead, the steering gear is centered, and the arrows on the driveline shaft and the driveline tube are aligned. See **Fig. 2**.

Steering Driveline Removal and Installation



1A. Manual Steering Gear
1B. Integral Power Steering Gear
2. Input (worm) Shaft
3. Boot Cover
4. Pinch Bolt
5. Lower End Yoke
6. Nut
7. U-Joint Assembly
8. Needle Bearing Cup
9. Needle Bearing Cup Snap Ring
10. Journal Cross Seal
11. U-Joint Journal Cross
12. Journal Cross Lube Fitting
13. Driveline Shaft and Yoke Assembly
14. Lube Fitting
15. Steering Driveline Boot Assembly
16. Driveline Tube and Yoke Assembly
17. Pinch Bolt
18. Upper End Yoke
19. Wheel Tube Shaft
20. Nut
21. Upper Column and Jacket Assembly

Fig. 1, Steering Driveline



A. Align arrows.
1. Lower Driveline Shaft 2. Driveline Tube

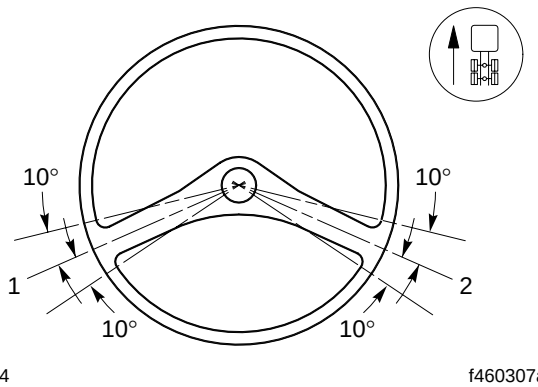
Fig. 2, Driveline Universal Joint Phasing

⚠ WARNING

If the arrow on the driveline shaft is not aligned with the arrow on the driveline tube, the universal joints will not be oriented correctly. Assembling the driveline with the universal joints incorrectly oriented could cause binding at the universal joints, resulting in possible personal injury or property damage.

8. Slide the bushing of the rubber boot up around the driveline shaft.
9. Apply Loctite Primer N to the steering gear input shaft. Let it dry for five minutes.
10. Apply a bead of Loctite 680 adhesive to the serrations inside the base of the lower end yoke.

11. Install the lower end yoke on the steering gear input shaft, then install a new pinch bolt. Before installing the nut, make sure the pinch bolt is centered in the steering gear input shaft. The pinch bolt is centered if it can slip in and out of the input shaft with ease. Install a new nut and tighten it to one of the following torque specs:
    - 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16 pinch bolt and nut
    - 30 to 35 lbf·ft (41 to 47 N·m) for an M10 pinch bolt and nut
12. Apply torque seal, OGP F900WHITE, to the exposed bolt threads and to the nut. To show adhesive has been used, mark the lower end yoke with red paint.
13. Grease the driveline tube and both universal joints with a lithium-based grease (NLGI grade 2) until grease appears at the lower end of the tube splines and the universal joint cross seals.
14. Check the position of the steering wheel when the front tires are straight ahead. The steering wheel spokes must be within ±10 degrees of the 4 o'clock and 8 o'clock positions. See **Fig. 3**.



1. 8 o'Clock Position 2. 4 o'Clock Position

Fig. 3, Steering Wheel Centered

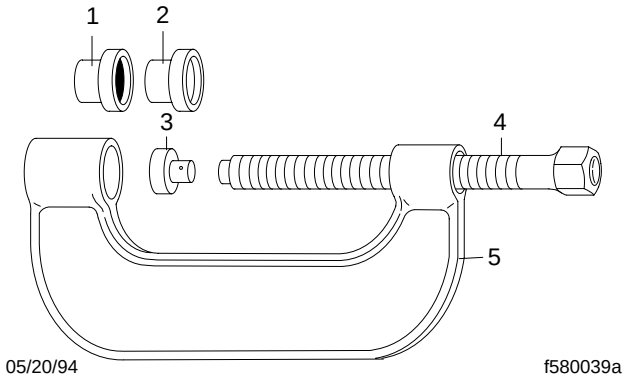
15. Close the hood.
16. Raise the front of the vehicle so that the front tires are off the ground, then place safety stands under the frame.
17. Turn the steering wheel through full travel, checking for hard steering or binding. If hard steering or binding occurs, check the assembly and installation of the driveline components.

WARNING

All steering mechanisms are life-and-limb items, which must work smoothly, without binding. Steering components that bind must be repaired before operating the vehicle. Otherwise, operating the vehicle could result in loss of vehicle control and possible personal injury and property damage.

18. Remove the safety stands, lower the vehicle to the ground, and remove the chocks.

Disassembly (See Fig. 1)



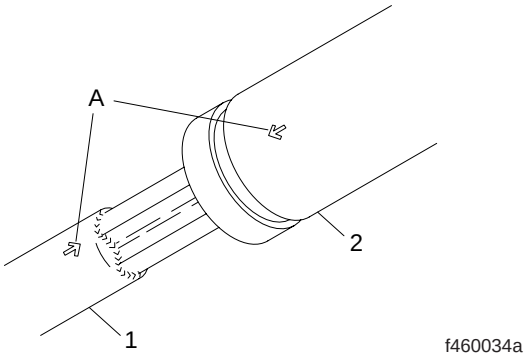
1. Bushing Adaptor
2. Bearing Driver
3. Expansion Plug
4. Pressure Screw
5. Frame

Fig. 1, Universal Joint Tool Assembly

1. Remove the steering driveline from the vehicle. Refer to **Subject 100** for instructions.
2. Slide the driveline yoke assembly out of the driveline tube and yoke assembly.
3. Removal of steering driveline universal joints requires the use of a universal joint tool **(Fig. 1).** Clamp the universal joint tool frame into a vise.
4. Wearing safety goggles, remove the needle bearing cup snap rings from the needle bearing cups by pushing the open ends of the snap rings with a screwdriver.
5. Select a universal joint tool expansion plug of slightly smaller diameter than the needle bearing cup, and place it on the pressure screw. Select a bushing adapter of slightly larger inside diameter than the needle bearing cup, and place it on the opposite end of the tool.
6. Place the integral yoke of the driveline tube in the universal joint tool. Position the bushing adaptor to receive a needle bearing cup, and position the expansion plug against the opposite needle bearing cup.
7. Tighten the pressure screw to press the needle bearing cup out of the driveline yoke, then remove the needle bearing cup. Reverse the driveline tube and yoke assembly, and press against the universal joint cross to force out the other needle bearing cup. In some cases it may be necessary to give the pressure screw a sharp blow with a brass hammer while the screw is under pressure.
8. Remove the driveline tube and yoke assembly from the universal joint tool, then remove the upper end yoke and the universal joint cross from the driveline yoke.
9. Place the upper end yoke in the universal joint tool. Position the bushing adaptor to receive a needle bearing cup, and position the expansion plug against the opposite needle bearing cup.
10. Tighten the pressure screw to press the needle bearing cup out of the upper end yoke, then remove the needle bearing cup. Reverse the upper end yoke in the universal joint tool and press against the universal joint cross to force out the other needle bearing cup. In some cases it may be necessary to give the pressure screw a sharp blow with a brass hammer while the screw is under pressure.
11. Remove the upper end yoke from the universal joint tool, then remove the universal joint cross from the upper end yoke.
12. Repeat the previous six steps above for the driveline shaft and yoke assembly and the lower end yoke.

Steering Driveline Disassembly and Assembly

Assembly (See Fig. 2)



A. Align Arrows
1. Lower Driveline Shaft
2. Driveline Tube

Fig. 2, Driveline Universal Joint Phasing

1. Installing the steering driveline universal joints requires the use of a universal joint tool **(Fig. 1).** Clamp the universal joint tool frame into a vise.
2. Select a universal joint tool expansion plug of slightly smaller diameter than the needle bearing cup, and place it on the pressure screw. Place a bearing driver on the opposite end of the tool.
3. Position the universal joint cross in the upper end yoke so that the universal joint cross lube fitting points toward one of the yoke ears.
4. Make certain the universal joint cross seals are in place on the needle bearing cups, then start both needle bearing cups into the yoke ears from the outside. Place the upper end yoke in the universal joint tool with the bearing driver against one of the needle bearing cups and the expansion plug against the opposite needle bearing cup.
5. Tighten the pressure screw, making sure that both needle bearing cups press straight into the yoke ears. Work the universal joint cross during this operation to ensure free movement. If the needle bearing cups do not seat correctly, or if the universal joint binds, give the yoke shoulder near each cup a sharp blow with a brass hammer.
6. Press the needle bearing cup on the screw end of the universal joint tool all the way in, until there is enough clearance to insert a needle bearing cup snap ring. Insert a new snap ring. Ensure the snap rings are fully seated in their grooves.

WARNING

WARNING: Use new snap rings when assembling the universal joints. Used snap rings are often distorted and over-stressed from disassembly and can work loose, resulting in a loss of steering control and possible personal injury or property damage.

7. Reverse the upper end yoke in the universal joint tool, and push the other needle bearing cup until there is clearance to insert the other snap ring. Insert the snap ring, then remove the upper end yoke from the universal joint.
8. With the universal joint cross lube fitting facing away from the base of the upper end yoke, position the universal joint cross and upper end yoke in the driveline tube and yoke assembly.

NOTE: The universal joint cross lube fitting should face away from the base of the upper end yoke to provide access for lubrication when the steering driveline is installed on the vehicle.

9. Make certain the universal joint cross seals are in place on the needle bearing cups, then start both needle bearing cups into the yoke ears. Place the driveline tube and yoke assembly in the universal tool with the bearing driver against one of the needle bearing cups and the expansion plug against the opposite needle bearing cup.
10. Tighten the pressure screw, making sure that both needle bearing cups press straight into the yoke ears. Work the universal joint cross during this operation to ensure free movement. If the needle bearing cups do not seat correctly, or if the universal joint binds, give the yoke shoulder near each cup a sharp blow with a brass hammer.
11. Press the needle bearing cup on the screw end of the universal joint tool all the way in, until there is enough clearance to insert a needle bearing cup snap ring. Reverse the driveline tube and yoke assembly in the universal joint tool and push the other needle bearing cup until there is enough clearance to insert the other snap ring.

Insert the snap ring, then remove the driveline tube and yoke assembly from the universal joint tool.

12. Repeat previous steps as needed for the lower end yoke and the driveline shaft and yoke assembly.
13. Slide the lower driveline shaft into the driveline tube, so that the arrow on the driveline shaft is aligned with the arrow on the driveline tube. **See Fig. 2.**

WARNING

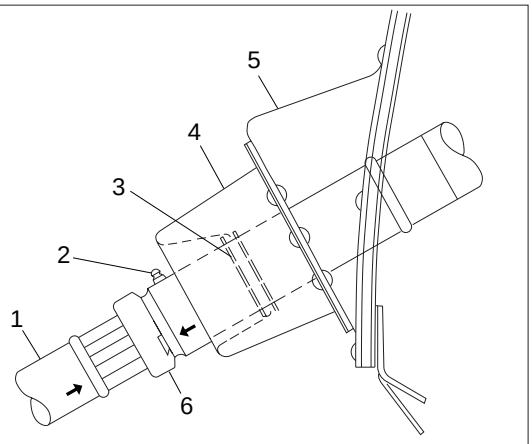
If the arrow on the driveline shaft is not aligned with the arrow on the driveline tube, the universal joints will not be oriented correctly. Assembling the driveline with the universal joints incorrectly oriented could cause binding at the universal joints, resulting in possible personal injury or property damage.

14. Install the steering driveline in the vehicle. Refer to **Subject 100** for instructions.

Steering Column Boot Replacement

Replacement (See Fig. 1)

1. Remove the steering driveline from the vehicle. Refer to **Subject 100** for instructions.
2. Drill out the six boot retaining rivets.
3. Use a punch to drive out the rivet shanks.
4. Remove the boot assembly.
5. Position the new boot assembly on the steering boot transition.
6. Secure the boot assembly with six 3/16-inch rivets.
7. Install the driveline in the vehicle. Refer to **Subject 100** for instructions.



1. Lower Driveline Shaft
2. Lube Fitting
3. Bushing
4. Boot
5. Steering Boot Transition
6. Upper Driveline Tube

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Fig. 1, Steering Driveline Boot Assembly

Specifications

Steering Driveline End Yoke Pinch Bolt Nut Torque Values	
Size	**Torque: lbf·ft (N·m)**
M10 x 1.25	30–35 (41–47)
3/8–16	35–40 (47–54)
7/16–20	55–65 (75–88)

Table 1, Steering Driveline End Yoke Pinch Bolt Nut Torque Values

General Description

Either a fixed-length drag link assembly (**Fig. 1**) or an adjustable-length drag link assembly (**Fig. 2** and **Fig. 3**) connects the steering gear pitman arm to the axle steering arm. The ball stud and socket assemblies at each end of the drag link prevent binding when the relative angles of the pitman arm and steering arm change, which happens when the vehicle is steered or the front axle moves up or down.

FIXED-LENGTH DRAG LINKS

Both ball-stud sockets of a fixed-length drag link assembly are an integral part of the drag link; they cannot be moved to change its length. **See Fig. 1.** The ball studs and sockets are a dual-seat design.

A fixed-length drag link assembly is used on vehicles equipped with either single-gear Ross TAS65 power steering or Sheppard M100 power steering. Forward-axle vehicles with a Sheppard M100 steering gear use an "offset" drag link, having a bend near the pitman arm end. Either end of a *straight* fixed-length drag link can be installed as the pitman arm end.

ADJUSTABLE-LENGTH DRAG LINKS

Adjustable-length drag link assemblies have ball-stud sockets with stems that thread into the ends of a hollow, threaded drag link tube. The ball studs and sockets are a low-end-movement design.

An adjustable-length drag link assembly with a movable socket at each end is used on vehicles equipped with either Ross manual steering (except with a Freightliner FK-120 front axle), Ross HFB70 power steering, or dual-gear power steering (Ross TAS65 main gear and RCB64 slave gear). **See Fig. 2.** The stem of one socket has right-hand threads, and the stem of the other has left-hand threads. This allows length adjustment of an installed drag link by turning the drag link tube. Tightening a clamp pinch-bolt near each end of the tube prevents the sockets or tube from turning, and causing unintentional changes to the adjustment.

The drag link used on a vehicle with manual steering and a Freightliner FK-120 front axle has a fixed-position (staked) socket at the axle steering arm end and a movable socket at the pitman arm end. **See Fig. 3.** The staked end doesn't need a clamp and pinch-bolt, that might otherwise contact the FK-120 axle beam.

General Description

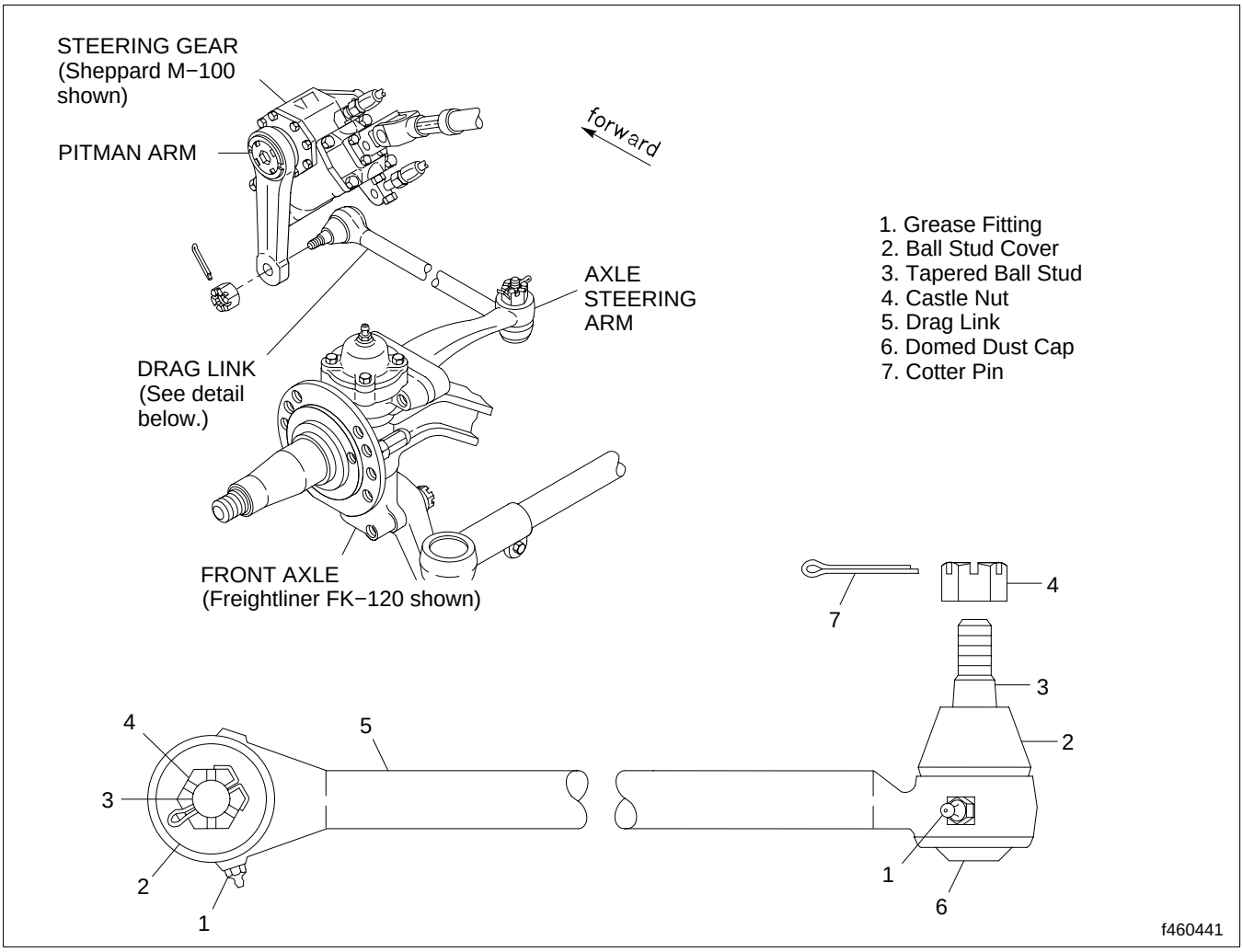


Fig. 1, Fixed-Length Drag Link

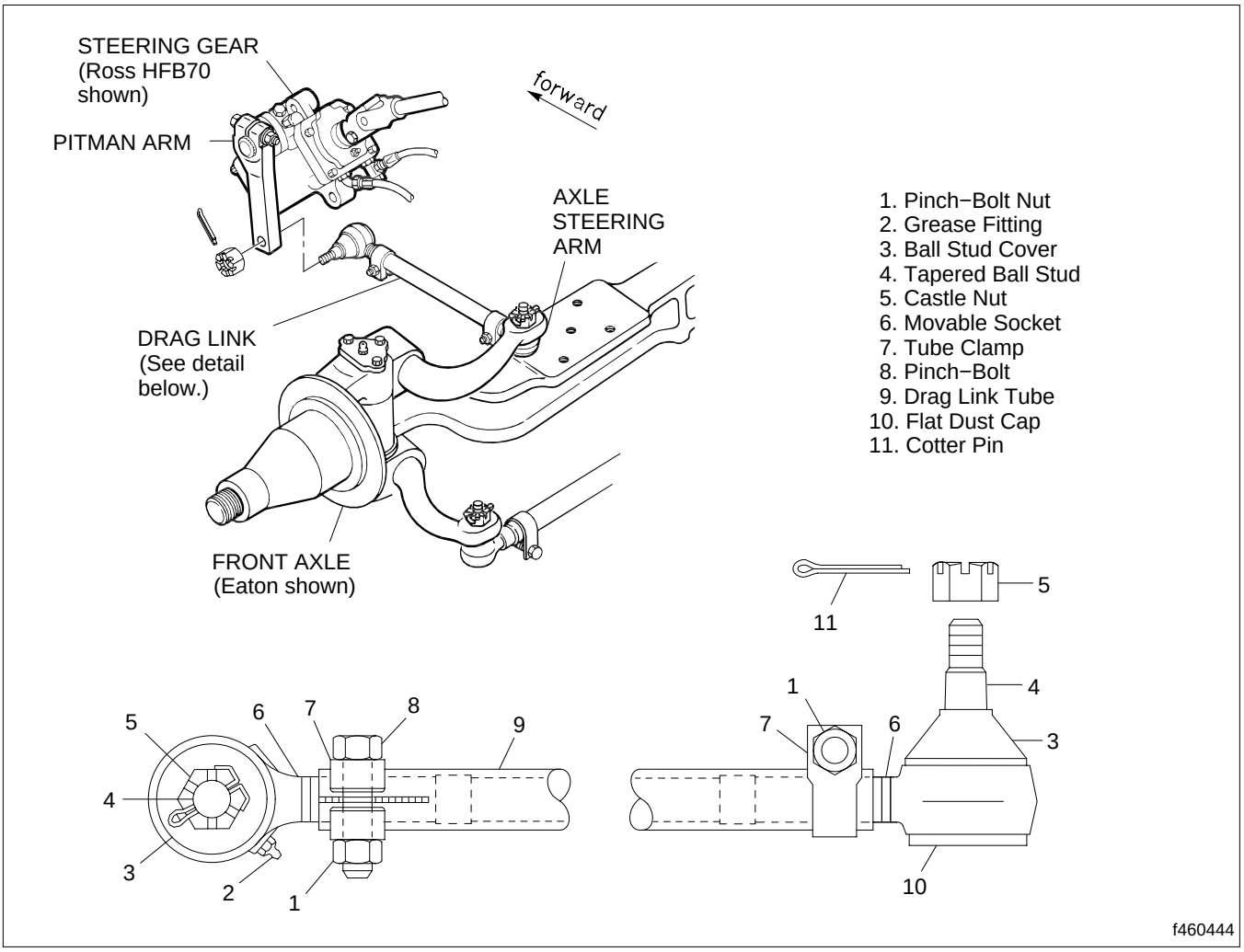


Fig. 2, Adjustable-Length Drag Link With Two Movable Sockets

General Description

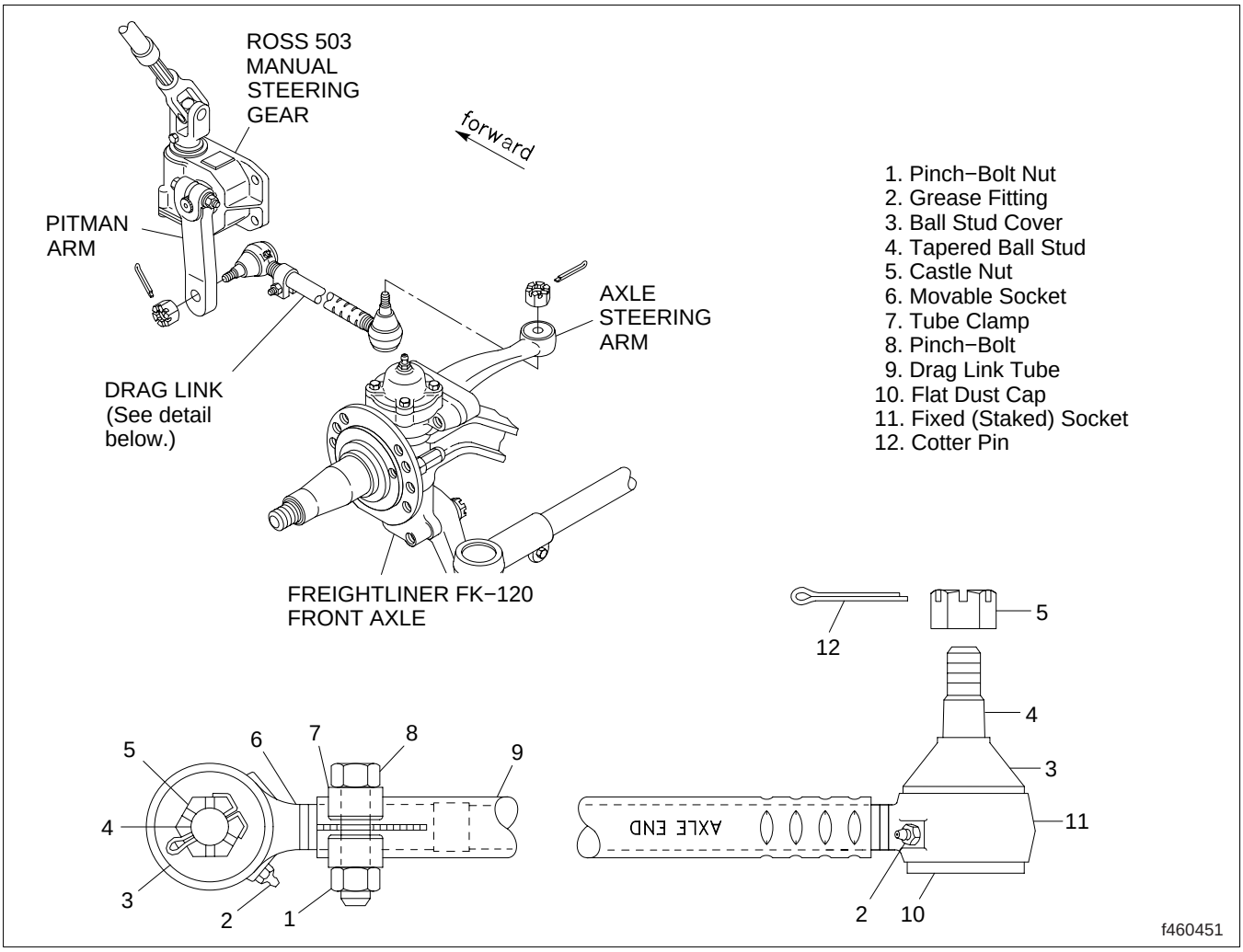
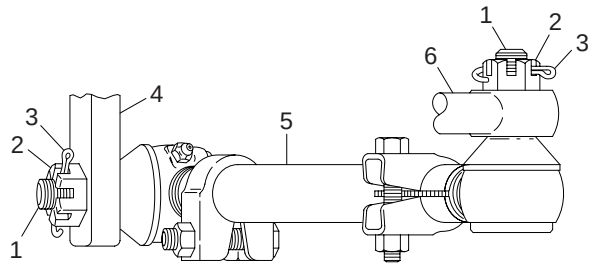


Fig. 3, Adjustable-Length Drag Link With One Movable and One Fixed (Staked) Socket

Removal

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service work will be done. *Do not move the tires from the straight-ahead position during removal or at any time while the drag link is removed.*
2. Apply the parking brakes and chock the rear tires.
3. Tilt the hood or cab. Follow the instructions in the vehicle driver's manual.
4. At both ends of the drag link, remove the cotter pins and castle nuts from the ball studs. See **Fig. 1**.



1. Ball Stud
2. Castle Nut
3. Cotter Pin
4. Steering Gear Pitman Arm
5. Drag Link (adjustable-length shown)
6. Axle Steering Arm

Fig. 1, Drag Link Ball Studs

5. Using a ball stud removal tool, remove the ball studs from the pitman arm and the axle steering arm.

Installation

FIXED-LENGTH DRAG LINK

NOTE: A *straight* fixed-length drag link is reversible; either ball stud can be installed in the axle steering arm. See **Fig. 2**.

1. Insert the axle-end ball stud up through the bottom of the axle steering arm, then install the castle nut, finger-tight.

IMPORTANT: For a Sheppard M100 gear on a set-forward axle COE or set-forward axle 120 Conventional, insert, up through the axle steering arm, the ball stud that is farthest from the bend in the drag link. See **Fig. 3**.

2. Turn the steering wheel as needed to align the hole in the lower end of the pitman arm with the forward ball stud. Insert the ball stud in the pitman arm from the inboard side. Install the castle nut. See **Fig. 2**.
3. Tighten both of the castle nuts:
   - 3/4–16, 90 to 170 lbf·ft (122 to 230 N·m)
   - 7/8–14, 160 to 300 lbf·ft (217 to 407 N·m)

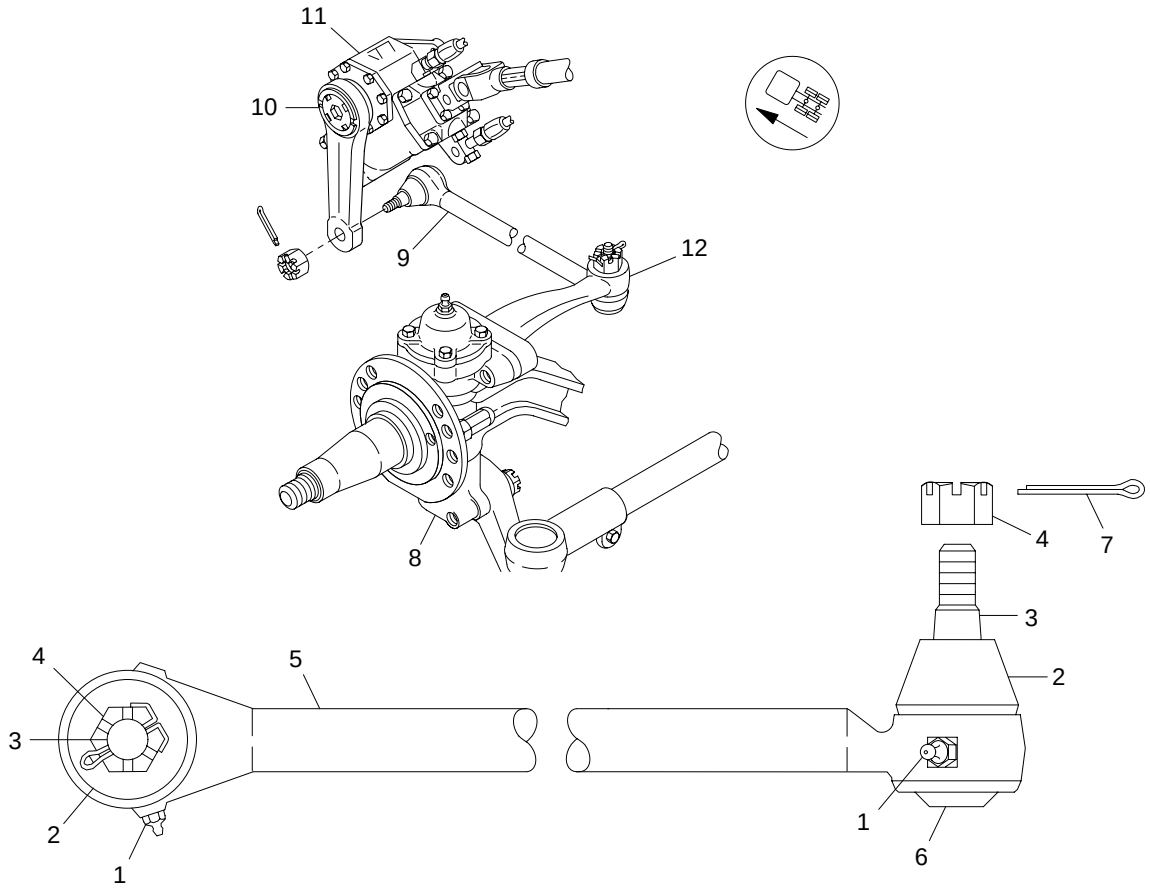
   If needed, continue tightening each nut until a slot on the nut aligns with the hole in the ball stud. *Do not back off the nut to align it with the cotter pin hole.*
4. Install and lock a new cotter pin in each of the ball studs and nuts.

⚠ WARNING

Failure to install and lock new cotter pins in the ball studs and nuts could result in disengagement of the components, causing loss of steering control, which could result in personal injury and property damage.

5. Wipe the dirt from the socket grease fittings. Apply chassis grease with a pressure gun until all old grease is forced out of each socket.
6. Check the axle stop settings, and adjust them if needed. For instructions, see **Section 33.03, Subject 110**.
7. Check the settings of the steering gear poppet valves (Ross or Sheppard with auto poppet) or relief valve plungers (Sheppard with manual adjustment). Adjust them if needed. For instructions on checking and adjusting, see the applicable steering gear section in **Group 46**.
8. With the front tires straight ahead, and no load on the vehicle, check the position of the steering wheel spokes. See **Fig. 4**. They should be within ±10 degrees of the 4 and 8 o'clock positions. If

Removal and Installation



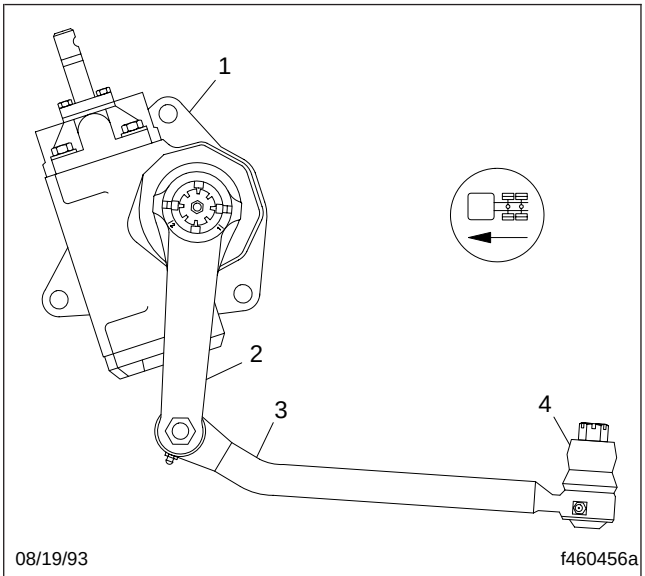
1. Grease Fitting
2. Ball Stud Cover
3. Tapered Ball Stud
4. Castle Nut
5. Drag Link
6. Domed Dust Cap
7. Cotter Pin
8. Front Axle (Freightliner FK–120 shown)
9. Drag Link (see detail)
10. Pitman Arm
11. Steering Gear (Sheppard M–100 shown)
12. Axle Steering Arm

Fig. 2, Fixed-Length Drag Link

not, remove the steering wheel and install it in the correct position.

ADJUSTABLE-LENGTH DRAG LINK WITH ONE MOVABLE AND ONE FIXED SOCKET

1. Center the steering gear by turning the steering wheel until the alignment mark on the steering gear output shaft is at a right angle (90 degrees) to the steering gear input shaft. See **Fig. 5**. Do not move the front tires from the straight-ahead position.
2. Insert the axle-end ball stud (the ball stud in the fixed-position socket) up through the bottom of the axle steering arm. See **Fig. 6**. Install the castle nut, finger-tight.
3. Don't move the front tires from the straight-ahead position, and don't move the pitman arm or turn the steering wheel; the manual steering gear must remain centered. Turn the socket (into or out of the drag link tube) as needed to shorten or lengthen the drag link until the ball stud can be inserted in the pitman arm from the inboard side. See **Fig. 6**.



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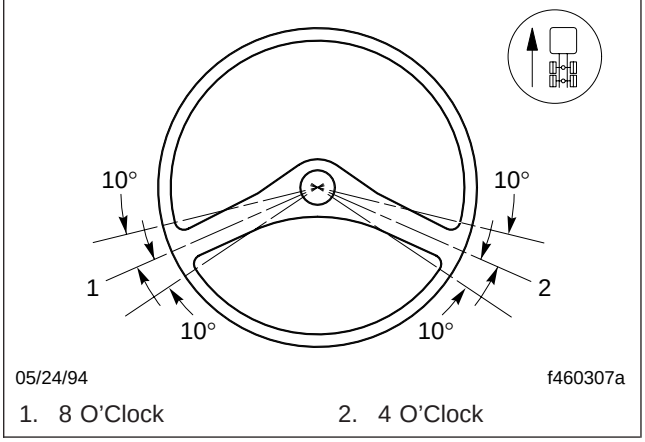
NOTE: The position of the drag link is reversed on right-hand drive vehicles.

1. Sheppard M–100 Steering Gear
2. Pitman Arm
3. Drag Link
4. Axle Steering Arm

Fig. 3, Drag Link Assembly



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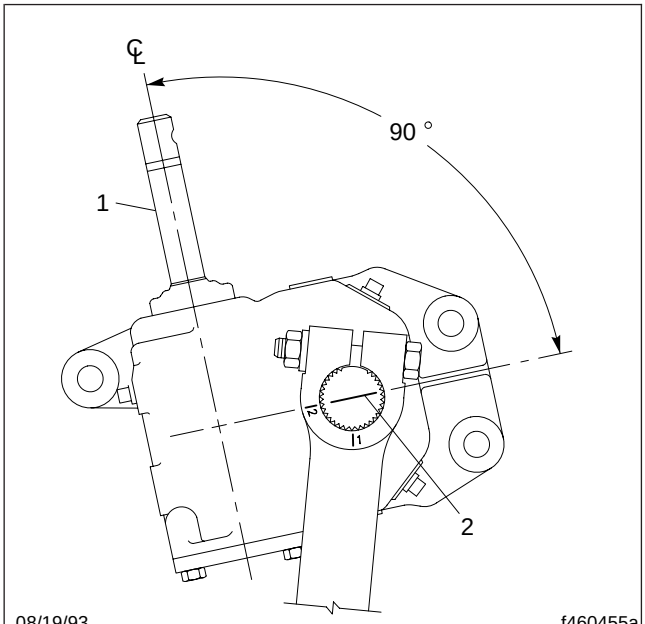
1. 8 O'Clock 2. 4 O'Clock

Fig. 4, Steering Wheel Spoke Position

4. At the end with the movable socket, make sure the socket stem is threaded into the drag link tube at least 1-3/4 inches (45 mm); at least 21 threads must remain engaged in the drag link tube. See **Fig. 7**.



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The timing mark alignment shown is for Ross manual steering.

1. Input Shaft
2. Steering Gear Output Shaft Timing Mark

Fig. 5, Timing Mark Alignment

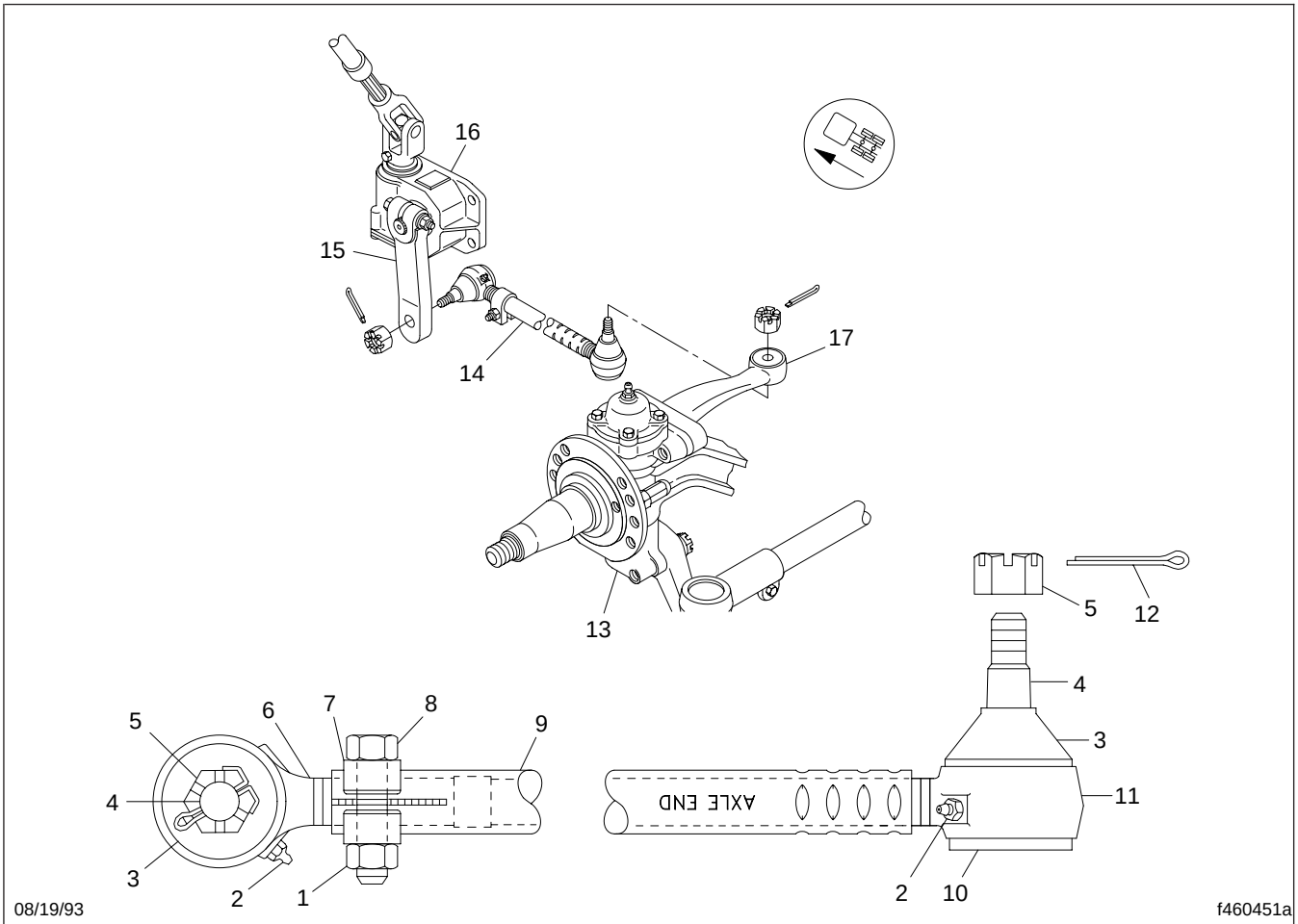
⚠ WARNING

Failure to maintain at least the minimum thread engagement of the movable socket stem in the drag link tube could result in disengagement of the parts and loss of steering control, possibly causing personal injury.

5. Install the ball stud in the pitman arm, then install the castle nut.
6. Tighten both of the castle nuts:
   - 3/4–16, 90 to 170 lbf·ft (122 to 230 N·m)
   - 7/8–14, 160 to 300 lbf·ft (217 to 407 N·m)

   If needed, continue tightening each nut until a slot on the nut aligns with the hole in the ball stud. *Do not back off the nut to align it with the cotter pin hole.*
7. Install and lock a new cotter pin in each of the ball studs and nuts.

Removal and Installation



Drag link shown has one movable and one fixed (staked) socket.

NOTE: The position of the drag link is reversed on right-hand drive vehicles.

1. Pinch-Bolt Nut
2. Grease Fitting
3. Ball Stud Cover
4. Tapered Ball Stud
5. Castle Nut
6. Movable Socket
7. Tube Clamp
8. Pinch Bolt
9. Drag Link Tube
10. Flat Dust Cap
11. Fixed (Staked) Socket
12. Cotter Pin
13. Freightliner FK–120 Front Axle
14. Drag Link (see detail)
15. Pitman Arm
16. Ross 503 Manual Steering Gear
17. Axle Steering Arm

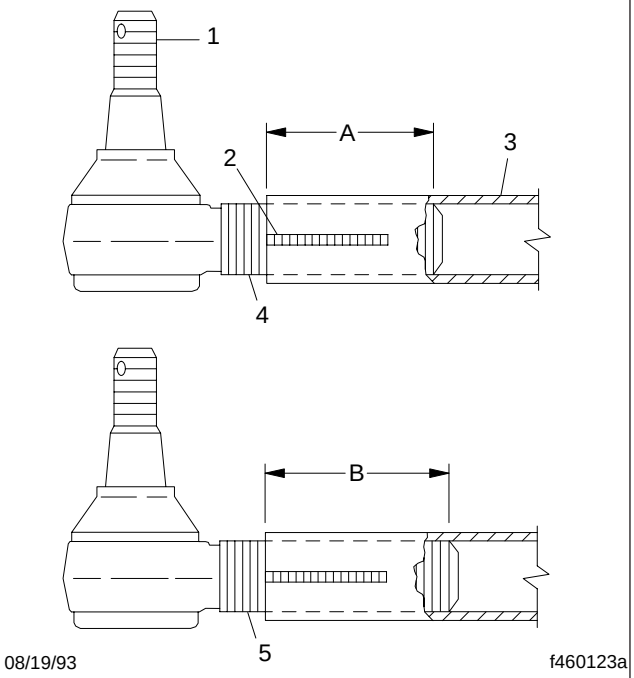
Fig. 6, Adjustable-Length Drag Link

⚠ WARNING

Failure to install and lock new cotter pins in the ball studs and nuts could result in disengagement of the components, causing loss of steering control, which could result in personal injury and property damage.

8. Close the hood or return the cab to the upright position, as instructed in the vehicle driver's manual.

   Drive the vehicle back and forth in a straight line for a short distance, to position the front tires straight ahead. Set the parking brakes and chock the rear tires.



NOTE: Tube clamps and fasteners are not shown.

A. At least 1-3/4" (45 mm) or 21 threads
B. At least 2" (51 mm) or 24 threads

1. Ball Stud
2. Slot
3. Drag Link Tube
4. 1-1/8–12 Socket Stem
5. 1-1/4–12 Socket Stem

Fig. 7, Minimum Thread Engagement

9. Check that the timing mark on the steering gear output shaft is at a right angle (90 degrees) to the input shaft. See **Fig. 5**.

   If the output shaft timing mark isn't at the correct angle, remove the ball stud from the pitman arm. With the front tires in the straight-ahead position, turn the steering wheel until the output shaft timing mark is at a right angle to the input shaft, then turn the socket in or out of the drag link tube until the ball stud can be inserted in the pitman arm.

10. Install the ball stud and castle nut. Tighten the castle nut:

    - 3/4–16, 90 to 170 lbf·ft (122 to 230 N·m)
    - 7/8–14, 160 to 300 lbf·ft (217 to 407 N·m)

    If needed, continue tightening each nut until a slot on the nut aligns with the hole in the ball stud. *Do not back off the nut to align it with the cotter pin hole.*

⚠ WARNING

Failure to install and lock a new cotter pin in the ball stud and nut could result in disengagement of the components, causing loss of steering control, which could result in personal injury and property damage.

11. Install and lock a new cotter pin in the ball stud and nut.

IMPORTANT: If you lengthened the drag link, check for minimum thread engagement of the socket stem in the drag link tube. See **Fig. 7**.

12. Align the movable socket with the fixed socket. See **Fig. 8**.

    12.1 Turn the drag link tube to center the ball stud in the fixed-position socket.

    12.2 While holding the tube to keep it from turning, rotate the movable socket until its ball stud is centered and the sockets are at right angles to each other.

    12.3 Tighten the clamp pinch-bolt nut 55 lbf·ft (75 N·m).

13. Wipe the dirt from the socket grease fittings. Apply chassis grease with a pressure gun until all old grease is forced out of each socket.

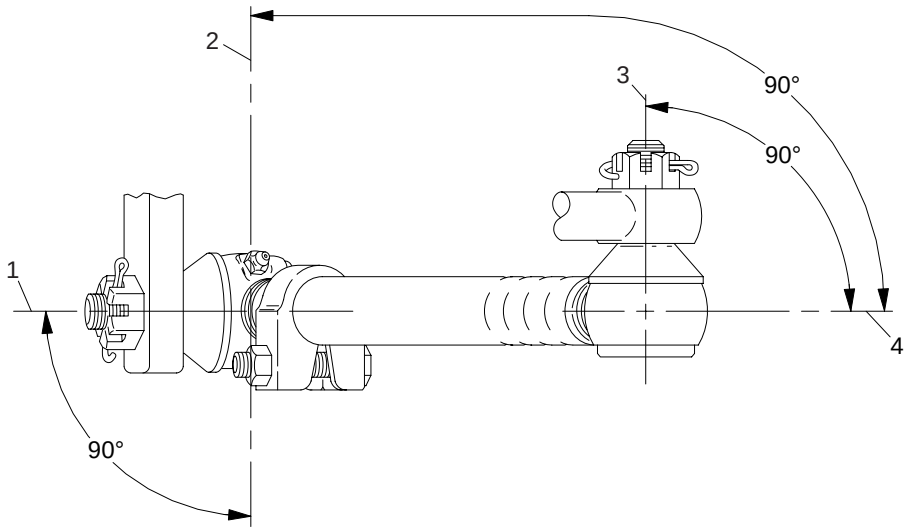
14. Check the axle stop settings, and adjust them if needed. For instructions, see **Section 33.03, Subject 110**.

15. With the front tires straight ahead, and no load on the vehicle, check the position of the steering wheel spokes. See **Fig. 4**. They should be within ±10 degrees of the 4 and 8 o'clock positions. If not, remove the steering wheel and install it in the correct position.

ADJUSTABLE-LENGTH DRAG LINK WITH TWO MOVABLE SOCKETS

NOTE: If both drag links are removed from a vehicle with dual power steering gears, complete all of the following installation instructions

Removal and Installation



1. Horizontal Centerline of Pitman Arm Ball Stud
2. Vertical Centerline of Movable Socket
3. Vertical Centerline of Steering Arm Ball Stud
4. Horizontal Centerline of Fixed (Staked) Socket

Fig. 8, Alignment of Movable Socket

for the main gear (Ross TAS65) drag link, then repeat the instructions for the slave gear (Ross RCB64) drag link.

1. Position the socket stems in the drag link tube (see **Fig. 7**):

⚠ WARNING

Failure to maintain at least the minimum thread engagement of the socket stems in the drag link tube could result in disengagement of the parts and loss of steering control, possibly causing personal injury.

1.1 Turn one of the socket and ball stud assemblies out, until the last thread on the inboard end of the socket stem is visible in the slot of the drag link tube.

1.2 For socket stems with 1-1/8–12 threads, measure outward along the slot 1-3/4 inches (45 mm) from the last thread, or count outward 21 threads (including the last one).

For socket stems with 1-1/4–12 threads, measure outward along the slot 2 inches (51 mm) from the last thread, or count outward 24 threads (including the last one).

1.3 If the measurement (any of the additional threads) extends beyond the end of the drag link tube, hold your thumbnail in the first thread valley beyond that point where the measurement ends. Turn the drag link tube until the end of it is against your thumbnail.

If the measurement (additional threads) doesn't go to the end of the drag link tube, turn the tube or the socket until the first thread valley beyond that point where the measurement ends is even with the end of the tube.

1.4 Tighten the clamp pinch bolt enough to prevent unintentional movement of the socket.

1.5 Repeat the previous steps for the other socket.

IMPORTANT: Thread engagement of both sockets in the drag link tube must be within 1/8 inch (3 mm) of being equal.

2. Insert the axle-end ball stud up through the bottom of the axle steering arm, then install the castle nut, finger-tight.

NOTE: The drag link is reversible; either ball stud can be installed in the axle steering arm. See **Fig. 9**.

3. Hold the drag link tube to keep it from turning, while turning the socket at the pitman arm end, to position its ball stud so it is pointing outboard. See **Fig. 9**. As needed, turn it out as much as 1/4 turn (lengthening the drag link), or in as much as 3/4 turn (shortening the drag link).
4. Turn the steering wheel as needed to align the hole in the lower end of the pitman arm with the forward ball stud. Insert the ball stud in the pitman arm from the inboard side, then install the castle nut, finger-tight. See **Fig. 9**.
5. Tighten both of the castle nuts:
   - 3/4–16, 90 to 170 lbf·ft (122 to 230 N·m)
   - 7/8–14, 160 to 300 lbf·ft (217 to 407 N·m)

   If needed, continue tightening each nut until a slot on the nut aligns with the hole in the ball stud. *Do not back off the nut to align it with the cotter pin hole.*
6. Install and lock a new cotter pin in each of the ball studs and nuts.

⚠ WARNING

Failure to install and lock new cotter pins in the ball studs and nuts could result in disengagement of the components, causing loss of steering control, which could result in personal injury and property damage.

7. Turn the drag link tube to shorten the drag link, until the distance between the ball stud centerlines equals the applicable drag link length. For detailed information, see the drag link length table in **Specifications, 400**.

IMPORTANT: Before the drag link is shortened, the sockets are at their minimum thread engagement in the drag link tube. See **Fig. 7**. Do not lengthen the drag link, or minimum thread engagement will not be maintained.

⚠ WARNING

Failure to maintain at least the minimum thread engagement of the socket stems in the drag link tube could result in disengagement of the parts and loss of steering control, possibly causing personal injury.

8. Close the hood or return the cab to the upright position, as instructed in the applicable driver's manual.

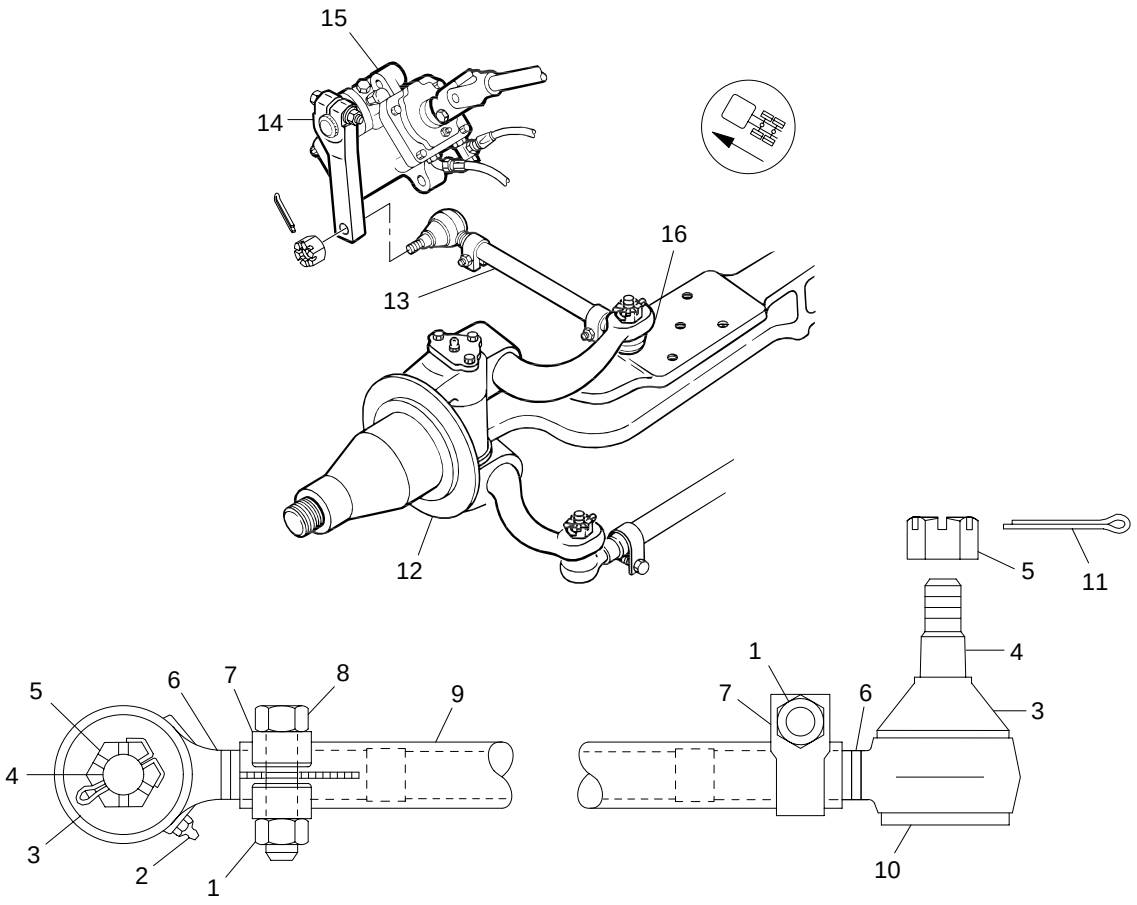
   Drive the vehicle back and forth in a straight line for a short distance, to position the front tires straight ahead. Set the parking brakes and chock the rear tires.
9. For a vehicle with Ross manual steering, check that the timing mark on the steering gear output shaft is at a right angle (90 degrees) to the input shaft. See **Fig. 5**.

   For a vehicle with Ross HFB70 or dual-gear power steering (this applies to both the main gear and the slave gear), check that the timing mark on the steering gear output shaft is within plus or minus 6 degrees of a right angle to the input shaft. See **Fig. 10**. If the output shaft is *not* at the correct angle, hold the front tires in the straight-ahead position, while turning the drag link tube until the output shaft timing mark is angled correctly.

IMPORTANT: If you lengthened the drag link, check for minimum thread engagement of the socket stems in the drag link tube. See **Fig. 7**.

10. Align the movable sockets. See **Fig. 8**.
    - 10.1 Make sure the clamps, pinch bolts, and pinch-bolt nuts won't interfere with other parts when the vehicle is steered.
    - 10.2 Turn the drag link tube one-half turn in either direction, as needed to reposition the clamps.
    - 10.3 While holding the tube to keep it from turning, rotate the movable socket until its ball stud is centered and the sockets are at right angles to each other.
    - 10.4 Tighten the clamp pinch-bolt nut 55 lbf·ft (75 N·m).

Removal and Installation

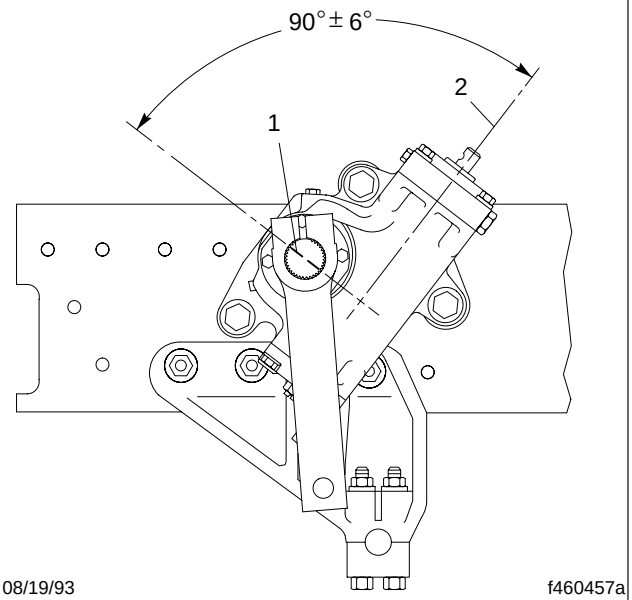


Drag link shown has two movable sockets.

1. Pinch-Bolt Nut
2. Grease Fitting
3. Ball Stud Cover
4. Tapered Ball Stud
5. Castle Nut
6. Movable Socket
7. Tube Clamp
8. Pinch Bolt
9. Drag Link Tube
10. Flat Dust Cap
11. Cotter Pin
12. Front Axle (Eaton shown)
13. Drag Link (see detail)
14. Pitman Arm
15. Steering Gear (Ross HFB70 shown)
16. Axle Steering Arm

Fig. 9, Adjustable-Length Drag Link

11. Wipe the dirt from the socket grease fittings. Apply chassis grease with a pressure gun until all old grease is forced out of each socket.
12. Check the axle stop settings, and adjust them if needed. For instructions, see **Section 33.03, Subject 110**.
13. For power steering gears, check the settings of the poppet valves, and adjust them if needed. For instructions on checking and adjusting, see the applicable steering gear section in **Group 46**.
14. With the front tires straight ahead, and no load on the vehicle, check the position of the steering wheel spokes. See **Fig. 4**. They should be within ±10 degrees of the 4 and 8 o'clock positions. If not, remove the steering wheel and install it in the correct position.



The timing mark alignment shown is for Ross HFB70 or dual gear power steering.

1. Steering Gear Output Shift Timing Mark
2. Input Shaft

Fig. 10, Timing Mark Alignment

Testing

WARNING

WARNING: All steering mechanisms are life-and-limb items. Because of this, follow the instructions in this subject exactly. Failure to do so may result in loss of steering, which could cause personal injury or property damage.

Have someone gently turn the steering wheel back and forth; check for looseness between the ball stud end, and both the pitman arm and steering arm. Also check for looseness of the ball stud nut.

If the ball stud *end* is loose, replace the drag link. If the ball stud *nut* is loose, replace the nut and cotter key. Tighten the ball stud nut to the applicable torque value in **Table 1**.

Dia–Thd	Torque lbf·ft (N·m)
7/8–14	160–300 (217–407)
7/8–14	160–300 (217–407)

Table 1, Ball Stud Nut Torque Values

Grasp the drag link near the pitman arm end, push and pull laterally to check for axial looseness in the ball stud end. If there is looseness, replace the drag link. For instructions, refer to **Subject 100**. If there is 1/8-inch (3-mm) looseness or more, do not drive the vehicle until the drag link is replaced.

Grasp the drag link near the steering arm end. Push and pull vertically to check for axial looseness in the ball stud end. If there is looseness, replace the drag link. For instructions, refer to **Subject 100**. If there is 1/8-inch (3-mm) looseness or more, do not drive the vehicle until the drag link is replaced.

Grease the drag link until the old grease is purged.

Specifications

Steering Gear	Vehicle		Drag Link Length to Within 1/8 inch (3 mm)
			inches (mm)
Ross HFB70	FLA	Set-Forward Axle	17-5/8 (448)
	FLD 112	Setback Axle	30-7/8 (784)
	FLD 120	Set-Forward Axle	18-1/2 (470)
		Setback Axle	32-1/8 (816)
Ross 503	FLA	Set-Forward Axle	18-7/8 (479) *
	FLD 120	Set-Forward Axle	19-1/4 (489) *
		Setback Axle	33-1/2 (851) *
Ross Dual TAS65 (& RCB64) Left Side	FLA	Set-Forward Axle	19-3/8 (492)
	FLD 120	Set-Forward Axle	18-3/4 (476)
		Setback Axle	32-1/4 (819)
Ross Dual RCB64 (& TAS65) Right Side	FLA	Set-Forward Axle	18-3/4 (476)
	FLD 120	Set-Forward Axle	18-3/4 (476)
		Setback Axle	32-1/4 (819)

* Use only as a check; adjust the drag link to the length that allows the Ross 503 manual steering gear to be centralized when the front wheels are in the straight-ahead position.

Table 1, Adjustable-Length Drag Link Length

General Information

The Eaton model BB pump is a high-pressure, gear-driven, roller vane pump, that pressurizes fluid from a remote-mounted reservoir for the operation of a power steering gear. Major parts of the pump are the pump body, pumping element components, end plate, pump shaft, and pump cover. See **Fig. 1**.

The pump body contains the cavity for the end plate and pumping element components (which include a locating pin, drive pin, carrier, ten rollers, cam ring with elliptical inner surface, and port plate). To seal in steering fluid and seal out engine oil, a pump shaft oil seal is pressed into the front of the body. As an integral part of the body, a nonreplaceable bushing supports the pump shaft near one end.

A second nonreplaceable pump shaft bushing is an integral part of the pump cover. The cover's outlet passage contains a flow control orifice that limits the flow of pressurized fluid to the steering gear. Joined to that passage is another that contains a spring and combination valve for flow-control and pressure-relief.

Principles of Operation

Low-pressure fluid from the power steering reservoir comes through the inlet tube assembly and into the pump inlet chamber. Once inside, the fluid enters the pumping chambers by passing through the large inlet notches in the end plate, port plate, and front and back of the cam ring. See **Fig. 2**.

Fluid entering the inlet chamber pushes against the larger surface at the back of the end plate to counterbalance the pressurized fluid pushing against the smaller surfaces of the end plate cavities. This balance of pressure maintains the correct running clearances between the pumping element components. The seals in the end plate cavities are held against the port plate to separate pressurized fluid from low-pressure fluid. See **Fig. 3**.

A locating pin fits into a hole in the pump body and passes through notches in the end plate, port plate, and cam ring to align them and prevent them from turning with the pump shaft. A drive pin locks the carrier to the pump shaft, and snap rings keep the shaft from moving back and forth in the carrier. As the carrier is driven by the shaft, the carrier drives the rollers. Centrifugal force causes the rollers to move outward and to follow the elliptical surface inside the cam ring. Fluid pressure under any roller equals the fluid pressure above that same roller to ensure that the rollers are held against the cam ring.

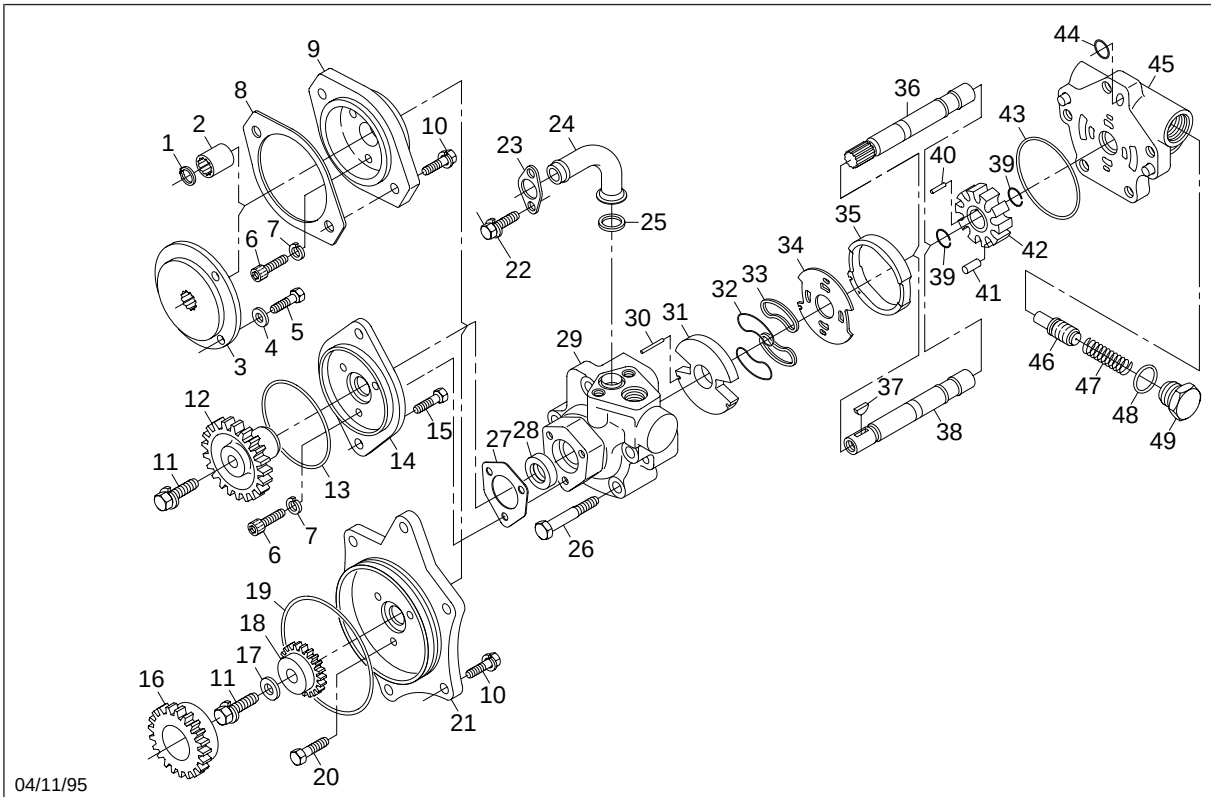
Ten pumping chambers are formed between the carrier and the cam ring (and end plate and cover)—one pumping chamber between each adjacent pair of rollers. At the smallest distance from the carrier to the cam ring, which is just before the inlet area, the volume of the pumping chamber is very small. See **Fig. 4**, item A. As the moving rollers pass the inlet area, the distance increases a small amount, but this greatly increases the volume. This creates a partial vacuum at the inlet area so that fluid from the reservoir fills the space. See **Fig. 4**, item B. As soon as the rollers are past the inlet area, the fluid is trapped and carried to the outlet area. See **Fig. 4**, item C. As the rollers pass the outlet area, the distance decreases, squeezing the large volume of trapped fluid into the outlet passage in the cover. See **Fig. 4**, item D.

The pumping element's two inlet areas are directly across the pump shaft from each other as are the two outlet areas. Thus, whatever the hydraulic force is on one side of the pump shaft, it is balanced by an equal force on the opposite side. Each pumping chamber is filled and pressurized twice during a full rotation of the carrier. For each full rotation, the volume of fluid pumped is always the same. The faster the carrier rotates, the greater the pump's output (gallons per minute of total flow)

If the flow rate to the steering gear was not controlled by some means, changes in engine speed (causing changes in total flow) would cause changes in steering gear response. The flow control orifice at the pump outlet and the combination valve in the pump cover limit the maximum pressure in the system and the maximum flow to the steering gear (the controlled flow).

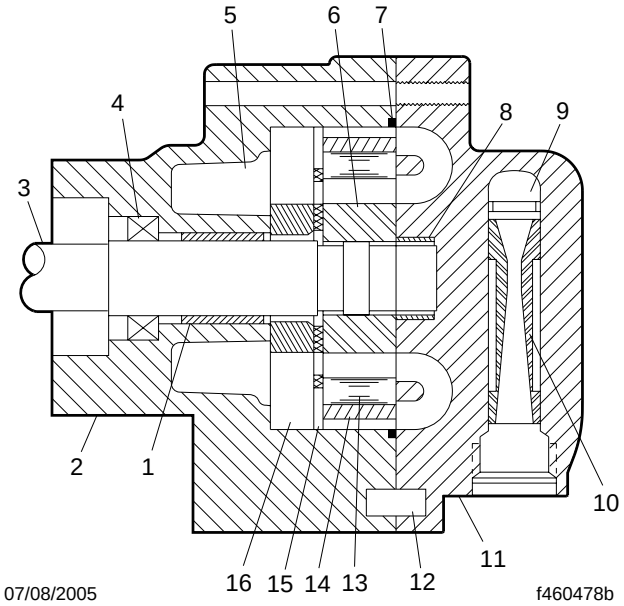
When the pump operates at low speed, most of its output passes through the flow control orifice, circulates through the steering gear, and returns to the reservoir. The small amount of excess output (total flow minus controlled flow) builds fluid pressure behind the flow control orifice. Because the pressure against the flow-control end of the combination valve will be slightly greater than the combined force of the spring and fluid pressures at the relief-valve end, the combination valve will be forced open a small amount. The excess output goes past the flow-control end of the valve, into the bypass passage to

General Information



1. Coupling Clip (NTC)
2. Shaft Coupling (NTC)
3. Drive Gear Sleeve (3176 and 3406)
4. Washer
5. Mounting Bolt
6. Bolt
7. Lockwasher
8. Gasket (3176, 3406, L10, and NTC)
9. Pump Mounting Flange (3176, 3406, L10, and NTC)
10. Bolt and Lockwasher
11. Bolt and Lockwasher
12. Drive Gear (3306)
13. O-Ring (3306)
14. Pump Mounting Flange (3306)
15. Bolt
16. Coupling (Series 60)
17. Washer
18. Sprocket (Series 60)
19. O-Ring (Series 60)
20. Bolt
21. Pump Mounting Flange (Series 60)
22. Inlet Tube Assembly Bolt and Lockwasher
23. Inlet Tube Clamp
24. Inlet Tube (90-degree bend shown)
25. Inlet Tube Gasket
26. Bolt
27. Gasket
28. Pump Shaft Oil Seal
29. Pump Body
30. Locating Pin
31. End Plate
32. O-Ring
33. End Plate Seal
34. Port Plate
35. Cam Ring
36. Pump Shaft (NTC, L10, 3176, and 3406)
37. Drive Gear/Sprocket Key
38. Pump Shaft (3306 and Series 60)
39. Carrier Snap Ring
40. Carrier Drive Pin
41. Roller
42. Carrier
43. O-Ring
44. O-Ring
45. Pump Cover
46. Combination Valve (flow control and pressure relief)
47. Valve Spring
48. O-Ring
49. Combination Valve Cap

Fig. 1, Power Steering Pump and Mounting Components



1. Pump Shaft Bushing
2. Pump Body
3. Pump Shaft
4. Pump Shaft Oil Seal
5. Inlet Chamber
6. Carrier
7. O-Ring
8. Pump Shaft Bushing
9. Outlet Passage
10. Flow Control Orifice
11. Pump Cover
12. Pump Cover Dowel Pin
13. Roller
14. Cam Ring
15. Port Plate
16. End Plate

Fig. 2, Pump Assembly (top view)

the pump inlet where it is recirculated through the pump. See **Fig. 5**.

When the pump operates at high speed, the amount of excess output is much greater. Controlled flow increases, but total flow increases an even greater amount. The increased pressure behind the flow control orifice forces the combination valve to open even further. See **Fig. 6**.

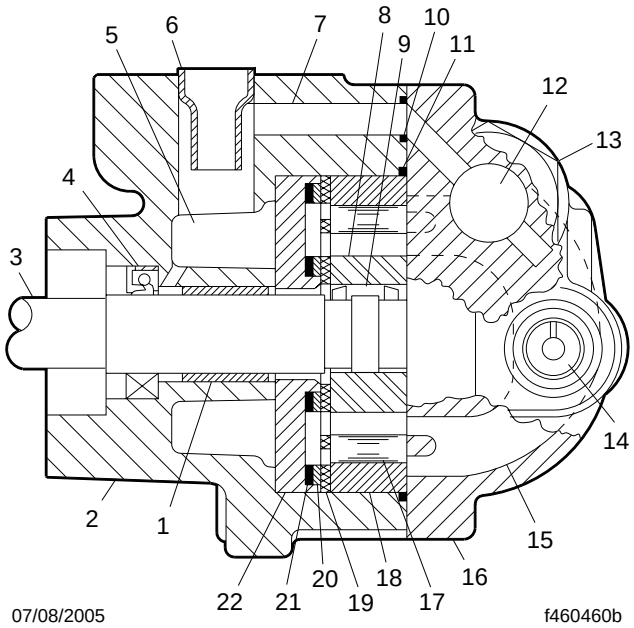
Any time the pump is operating and the steering gear's actuating (control) valve is in the neutral position, a constant flow of low-pressure fluid (the controlled flow) is circulated throughout the gear and returned to the reservoir. If some fluid was not returned to the reservoir, the fluid and system would soon overheat.

When the gear's actuating (control) valve is moved from the neutral position (when the steering wheel is turned), the fluid flow is directed by it to the correct end of the steering gear piston. The pump will build enough pressure (load pressure) against the piston to overcome whatever forces are acting against the vehicle wheels. Load pressure is low when the vehicle makes a high-speed turn, and is high when the vehicle is maneuvered at very low speed. High load pressure results in back-pressure at the outlet end of the flow control orifice, slightly decreasing the amount of controlled flow. This prevents load pressure from building too rapidly.

During normal steering conditions, fluid pressure behind the flow control orifice remains greater than load pressure in the steering gear. Thus, pressure against the flow-control end of the combination valve is always greater than pressure against the relief-valve end ensuring that pressure cannot build in any part of the system to the point of causing damage. See **Fig. 6**.

When abnormal steering conditions occur, the combination valve acts as a pressure relief valve. If for example, the vehicle wheels are against a curb that prevents them from turning and force is applied to turn the steering wheel, load pressure will build until it is equal to pressure behind the flow control orifice. Fluid pressure against the ends of the combination

General Information

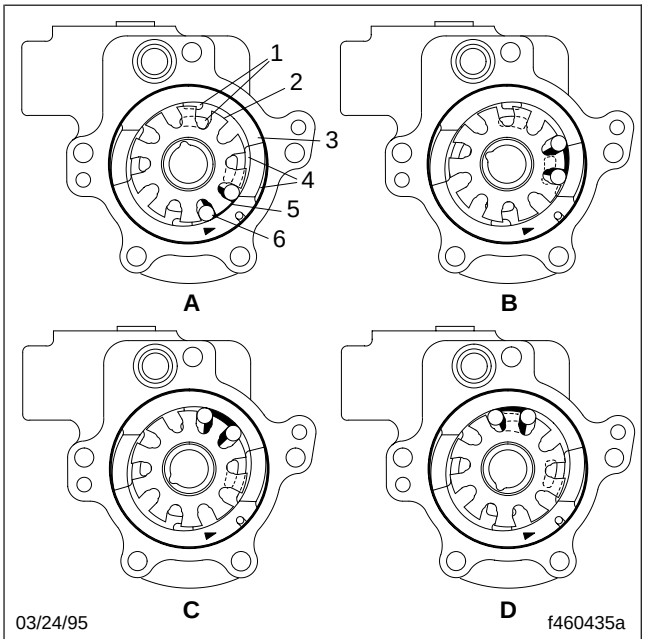


1. Pump Shaft Bushing
2. Pump Body
3. Pump Shaft
4. Pump Shaft Oil Seal
5. Inlet Chamber
6. Pump Inlet
7. Bypass Passage
8. Carrier
9. Carrier Drive Pin
10. O-Ring
11. O-Ring
12. Combination Valve (flow control and pressure relief)
13. Combination Valve Cap
14. Flow Control Orifice
15. Outlet Passage
16. Pump Cover
17. Roller
18. Cam Ring
19. Port Plate
20. End Plate Seal
21. O-Ring
22. End Plate

Fig. 3, Pump Assembly (side view)

valve will be balanced, causing the flow-control spring to close the valve. Pressure will build rapidly until it is high enough to overcome the force of the relief-ball spring. When the relief ball opens up the spring chamber to the bypass passage, there is an immediate drop in pressure at the relief-valve end of the combination valve. Pressure cannot build back up in the passage because the relief-valve orifice restricts the amount of fluid flow to no more than what the relief ball can relieve. The drop in pressure at that end allows the combination valve to open all the way, preventing pressure from building to the point of causing damage. See **Fig. 7**. Because all of the pump's output is being recirculated to the pump inlet and no cooling takes place, operating the pump at relief valve pressure for more than a few seconds will cause the fluid and pump to overheat.

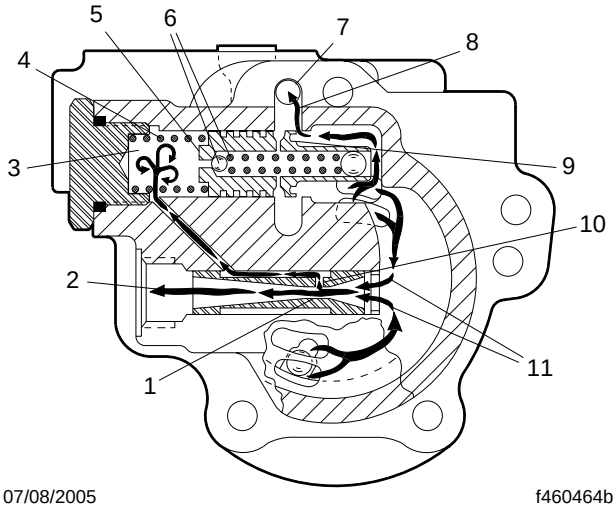
Whenever the vehicle wheels are turned against either axle stop, an unloading (poppet/relief) valve in one end or the other of the steering gear will automatically reduce load pressure by allowing fluid to return to the reservoir. If not for the unloading valves, the pump would operate at relief valve pressure and overheating would occur.



A. Volume of the pumping chamber is small just before the inlet area. Fluid is at low pressure.
B. Volume of the pumping chamber greatly increases as it passes the inlet area. Low-pressure fluid from the reservoir fills the chamber.
C. Fluid is pressurized as the pumping chamber volume decreases just before the outlet area.
D. Pressurized fluid is released in to the outlet passage.

1. Outlet Area
2. Carrier
3. Cam Ring
4. Inlet Area
5. Pumping Chamber
6. Roller

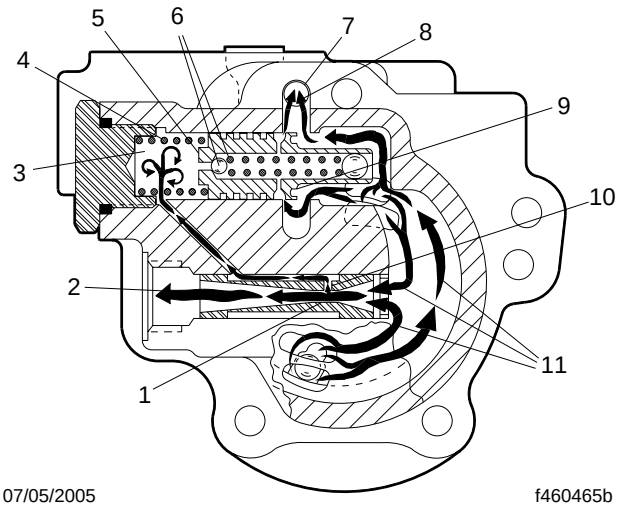
Fig. 4, Pumping Chambers



1. Flow Control Orifice
2. Controlled Flow (most of the pump's output)
3. Spring Chamber
4. Flow Control Spring (slightly compressed)
5. Combination Valve (relief valve end)
6. Relief Ball and Spring (closed)
7. Bypass Passage to Pump Inlet
8. Excess Fluid (small amount)
9. Combination Valve (flow control end)
10. Relief Valve Orifice
11. Pressurized Fluid (low output)

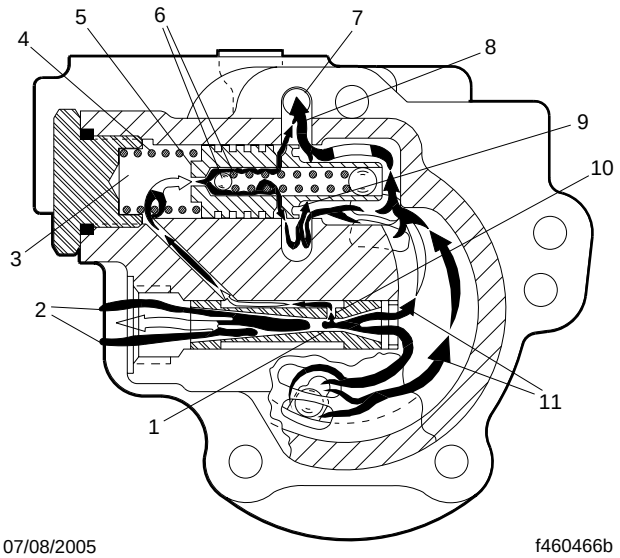
Fig. 5, Conditions During Low-Speed Pump Operation

General Information



1. Flow Control Orifice
2. Controlled Flow (large amount)
3. Spring Chamber
4. Flow Control Spring (compressed)
5. Combination Valve (relief valve end)
6. Relief Ball and Spring (closed)
7. Bypass Passage to Pump Inlet
8. Excess Fluid (large amount)
9. Combination Valve (flow control end)
10. Relief Valve Orifice
11. Pressurized Fluid (high output)

Fig. 6, Conditions During High-Speed Pump Operation



1. Flow Control Orifice
2. High Load Pressure from Steering Gear
3. Spring Chamber
4. Flow Control Spring (compressed)
5. Combination Valve (relief valve end)
6. Relief Ball and Spring (open)
7. Bypass Passage to Pump Inlet
8. Excess Fluid (all of the pump's outlet)
9. Combination Valve (flow control end)
10. Relief Valve Orifice
11. Pressurized Fluid

Fig. 7, Conditions When Load Pressure Builds to Relief-Valve Pressure

Pre-Service Checks

This subject is intended to help locate causes of problems that affect the power steering system, but may or may not originate in it. Before servicing the power steering system, do the following preservice checks. After servicing the power steering system, do the checks in **Subject 150**.

When steering problems exist, first inspect the vehicle for roadworthiness. Then, if necessary, verify the steering problem by test driving the vehicle or taking a ride with the driver. If the problem occurs only when the vehicle is loaded, make the test drive with the vehicle loaded.

Once the problem is verified, check the simple possibilities before moving on to the more complicated ones. The following checks should be made whenever steering problems occur.

1. If the steering problem occurs only when the vehicle is loaded, make sure the fifth wheel plate is lubricated. For instructions, see the vehicle driver's manual.
2. Make sure the power steering reservoir is filled to the correct level and the filter is not clogged. For fluid level checking and filter changing instructions, see the steering section in the vehicle maintenance manual.
3. Check the front tires for proper inflation, irregular wear, or mismatched tires. Check the front wheels for loose wheel nuts, damage, an out-of-round condition, and lateral runout. For instructions, see the wheels and tires section.
4. Check the steering gear mounting bolts for tightness. For torque values, refer to the steering section in the vehicle maintenance manual.
5. Make sure the steering linkage and steering driveline U-joints are lubricated. The steering linkage includes the tie rod, tie-rod ends, knuckle bearings, knuckle bushings, drag link, and other components that carry movement of the pitman arm to the steering knuckles. For lubrication instructions, refer to the steering section in the vehicle maintenance manual.

   Check the steering linkage, ball joints, and kingpins for loose, damaged, or worn parts. The wheels must turn smoothly from stop to stop. For inspection and service procedures, refer elsewhere in this group and to the front axle manufacturer's service manual.

   Inspect the steering driveline and steering column for worn or damaged parts. For service instructions, refer elsewhere in this group.
6. Inspect the front axle suspension for worn or damaged parts using instructions in the suspension section in this manual.
7. Make sure all steering system hoses that may have been replaced are not misrouted, restricted, or too small in inside diameter. Replace any hoses that are worn or that do not have the same inside diameter as original equipment. Reroute any hose that is kinked or sharply bent. Refer to the power steering hose sizes table in **Specifications 400** for the minimum bend radius of each hose.
8. Place a thermometer in the steering reservoir. Warm the fluid in the steering system to the normal operating temperature of 125° to 135°F (51° to 57°C) by operating the engine at low idle while turning the steering wheel through several full-left and full-right turns.

   With the engine running and the steering system at operating temperature, turn the steering wheel slowly from stop to stop while checking the reservoir for frothing or a change in fluid level (an indication that air is trapped in the system). If air is present, inspect the system for leaking hoses or loose fittings. Replace hoses or tighten loose fittings as needed.
9. Check front axle wheel alignment, including turning angles, wheel bearing adjustment, caster and camber angles, and toe-in, using instructions in the front axle section.
10. Check rear axle alignment using instructions in the rear axle section in this manual. Rear axle misalignment can cause hard or erratic steering.

    If there are still problems with the power steering system after completing all the above steps, perform the troubleshooting procedures in **Section 46.17, Subject 300**.

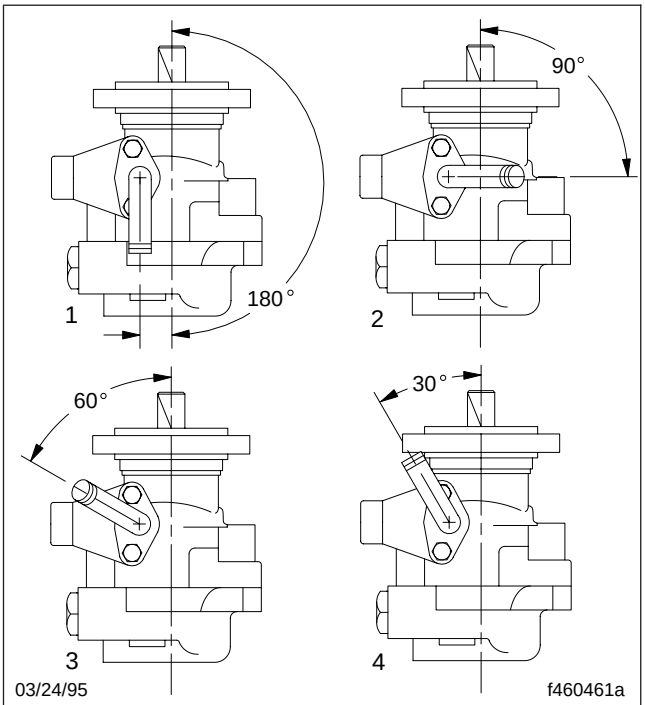
Removal

1. Remove all dirt from fittings and hose connections at the steering gear, steering pump, and reservoir.
2. From the elbow fitting on the pump, disconnect the fluid pressure line between the gear and the pump. Plug the line and cap the fitting.
3. At the reservoir, disconnect the pump supply hose. Drain the steering fluid from the reservoir and supply hose. After draining, connect the hose to the reservoir and tighten the hose clamp.
4. Disconnect the supply hose at the pump inlet tube. Plug or cap the hose.
5. Remove the capscrews that attach the pump flange to the engine, then remove the pump.
6. Remove and discard the gasket located between the flange and the engine, if so equipped. If needed, scrape the gasket and sealant from the sealing surface on the engine. Use care not to damage the sealing surface.
7. Tip the pump to drain the fluid from the inlet tube while turning the pump shaft to remove fluid from internal cavities.
8. If the pump will be replaced or disassembled, perform the following substeps:
   - 8.1 Clamp the edges of the pump mounting flange in a soft-jawed vise. Do not clamp on the sealing surface or pilot of the flange, and do not clamp on the pump body or pump cover.
   - 8.2 Remove the elbow from the pressure line port and plug the port. Remove and discard the O-ring from the elbow. Retain the elbow for later installation.

Installation

Caterpillar 3176

1. If needed, loosen the capscrews that attach the inlet tube assembly to the pump and turn the tube until it points in the direction shown in **Fig. 1**. Tighten the capscrews 100 lbf·in (1120 N·cm).



1. Caterpillar 3176 and 3306
2. Caterpillar 3406
3. Cummins L10 and Detroit Diesel Series 60
4. Cummins NTC

Fig. 1, Pump Inlet Tube Orientation

2. At the back of the timing gear plate, inspect the internal splines in the steering pump drive gear sleeve. Replace the sleeve if any splines are worn or damaged. Check the sleeve mounting bolts for tightness and tighten them if needed.
3. Using clean engine oil, lightly lubricate the pump shaft and flange pilot for ease of installation.
4. Install a new gasket on the pump mounting flange, then install the pump on the timing gear plate. Turn the pump shaft as needed to mesh it with the drive gear sleeve. Without applying unnecessary force, seat the pilot of the pump flange in the timing gear plate.
5. Install and tighten the pump mounting capscrews 27 to 32 lbf·ft (37 to 43 N·m).
6. Fill and bleed the power steering system. For instructions, see **Subject 120**.

Pump Removal and Installation

Caterpillar 3306

1. If needed, loosen the capscrews that attach the inlet tube assembly to the pump and turn the tube until it points in the direction shown in **Fig. 1**. Tighten the capscrews 100 lbf·in (1120 N·cm).
2. Install a new O-ring seal on the pump mounting flange pilot.
3. Using clean engine oil, lightly lubricate the pump drive gear, flange pilot O-ring seal, and flange pilot for ease of installation.
4. Install the pump on the timing gear plate. Turn the pump or drive gear as needed to mesh the drive gear teeth with the camshaft gear teeth. Seat the pilot of the pump flange in the timing gear plate, being careful not to pinch the flange pilot O-ring seal.
5. Install and tighten the mounting capscrews 27 to 32 lbf·ft (37 to 43 N·m).
6. Fill and bleed the power steering system. For instructions, see **Subject 120**.

Caterpillar 3406

1. If needed, loosen the capscrews that attach the inlet tube assembly to the pump and turn the tube until it points in the direction shown in **Fig. 1**. Tighten the capscrews 100 lbf·in (1120 N·cm).
2. At the front of the engine timing gear cover, inspect the internal splines in the steering pump drive gear sleeve. Replace the sleeve if the splines are worn or damaged. Check the sleeve mounting capscrews for tightness and tighten them if needed.
3. Using clean engine oil, lightly lubricate the pump shaft and flange pilot for ease of installation.
4. Install a new gasket on the pump mounting flange, then install the pump on the engine timing gear cover. Turn the pump shaft as needed to mesh it with the drive gear sleeve. Without applying unnecessary force, seat the pilot of the pump flange in the timing gear cover.
5. Apply Loctite® 242 to the steering pump mounting studs. Install and tighten the nuts 35 lbf·ft (47 N·m).
6. Fill and bleed the power steering system. For instructions, see **Subject 120**.

Cummins L10

1. If needed, loosen the capscrews that attach the inlet tube assembly to the pump and turn the tube until it points in the direction shown in **Fig. 1**. Tighten the capscrews 100 lbf·in (1120 N·cm).
2. Using clean engine oil, lightly lubricate the pump shaft and flange pilot for ease of installation.
3. Install a new gasket on the pump mounting flange, then install the pump on the engine accessory drive cover. Turn the pump or shaft as needed to mesh the shaft splines with the splines in the auxiliary drive. Without applying unnecessary force, seat the pilot of the pump flange in the accessory drive cover.
4. Install and tighten the capscrews 27 to 32 lbf·ft (37 to 43 N·m).
5. Fill and bleed the power steering system. For instructions, see **Subject 120**.

Cummins NTC

1. If needed, loosen the capscrews that attach the inlet tube assembly to the pump and turn the tube until it points in the direction shown in **Fig. 1**. Tighten the capscrews 100 lbf·in (1120 N·cm).
2. Remove the shaft coupling from the engine lubricating oil pump shaft. Inspect the internal splines and replace it if the splines are worn or damaged.

   Inspect the coupling clip for damage and for correct seating in the groove inside the center of the coupling. Seat it if needed, or replace it if damaged.

   Install the coupling on the lubricating oil pump shaft.
3. Using clean engine oil, lightly lubricate the pump shaft and flange pilot for ease of installation.
4. Install a new gasket on the pump mounting flange, then install the pump on the lubricating oil pump cover. Turn the pump or shaft as needed to mesh the shaft splines with the shaft coupling. Without applying unnecessary force, seat the

pilot of the pump flange in the lubricating oil pump cover.

5. Install and tighten the capscrews 27 to 32 lbf·ft (37 to 43 N·m).
6. Fill and bleed the power steering system. For instructions, see **Subject 120**.

Detroit Diesel Series 60

1. If needed, loosen the capscrews that attach the inlet tube assembly to the pump and turn the tube until it points in the direction shown in **Fig. 1**. Tighten the capscrews 100 lbf·in (1120 N·cm).
2. Remove the pump coupling from the engine power steering drive gear. Inspect the internal and external splines and replace it if the splines are worn or damaged. Install the coupling in the drive gear.
3. Install a new O-ring seal in the groove of the pump mounting flange pilot.
4. Using clean engine oil, lightly lubricate the sprocket and the flange pilot O-ring seal and pilot for ease of installation.
5. Install the pump on the timing gear cover. Turn the pump or sprocket as needed to mesh the sprocket splines with the pump coupling splines. Seat the pilot of the pump flange in the timing gear cover, being careful not to pinch the flange pilot O-ring seal.
6. Install the capscrews and washers. Tighten the capscrews 22 lbf·ft (30 N·m) using the torque pattern shown in **Fig. 2**.
7. Fill and bleed the power steering system. For instructions, see **Subject 120**.

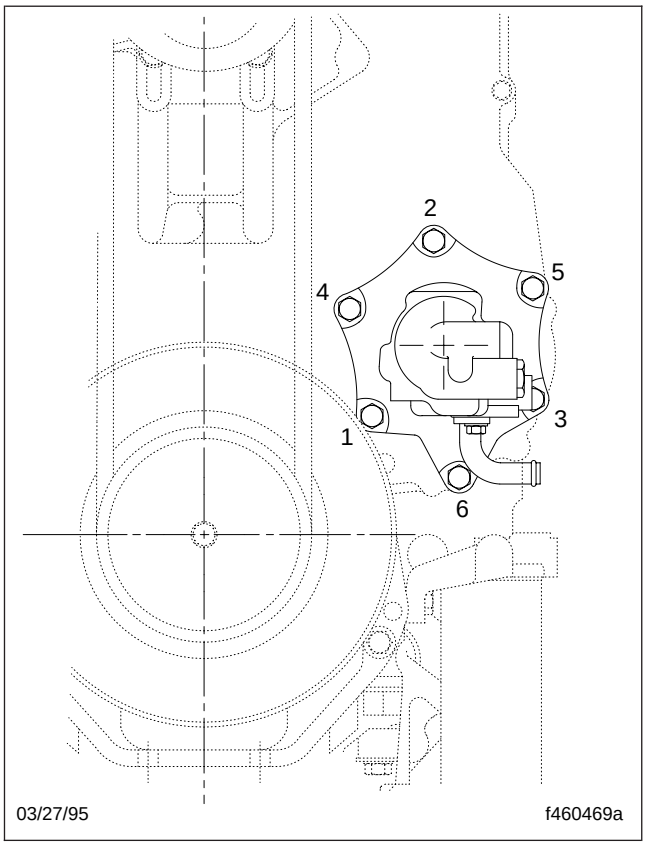


Fig. 2, Detroit Diesel Series 60 Pump Capscrew Torque Pattern

Filling and Bleeding

IMPORTANT: For the first eight steps below, do not turn the steering wheel. Doing so can cause air to enter the power steering system, which can make it more difficult and time-consuming to bleed air from the system.

1. Attach the supply hose to the pump inlet tube and tighten the hose clamp.
2. If the pump was disassembled and assembled, or if a new pump is installed, install a new O-ring on the pressure-line port elbow and install the elbow in the pressure line port. Tighten the elbow 30 lbf·ft (40 N·m), then tighten it more to the position that allows easiest installation of the fluid pressure line.
3. Connect the pressure line to the pump pressure-line port elbow. See **Fig. 1**. Tighten the fitting nut finger-tight. Use a wrench to tighten it until resistance is felt, then tighten it one-sixth turn more.
4. Install a new filter in the power steering reservoir. Fill the reservoir nearly full. For specified fluids, see the steering section in the vehicle maintenance manual.
5. Disconnect the fluid pressure line from the power steering gear and place the end of it in a container of at least 2 quart (2 L) capacity. Cap the steering gear fitting.
6. Crank the engine for ten seconds without allowing it to start; if it does start, shut it down immediately. Check the reservoir and fill it as needed. Do not allow the reservoir fluid level to drop more than 2 inches (5 cm) below the full mark or air can enter the system.

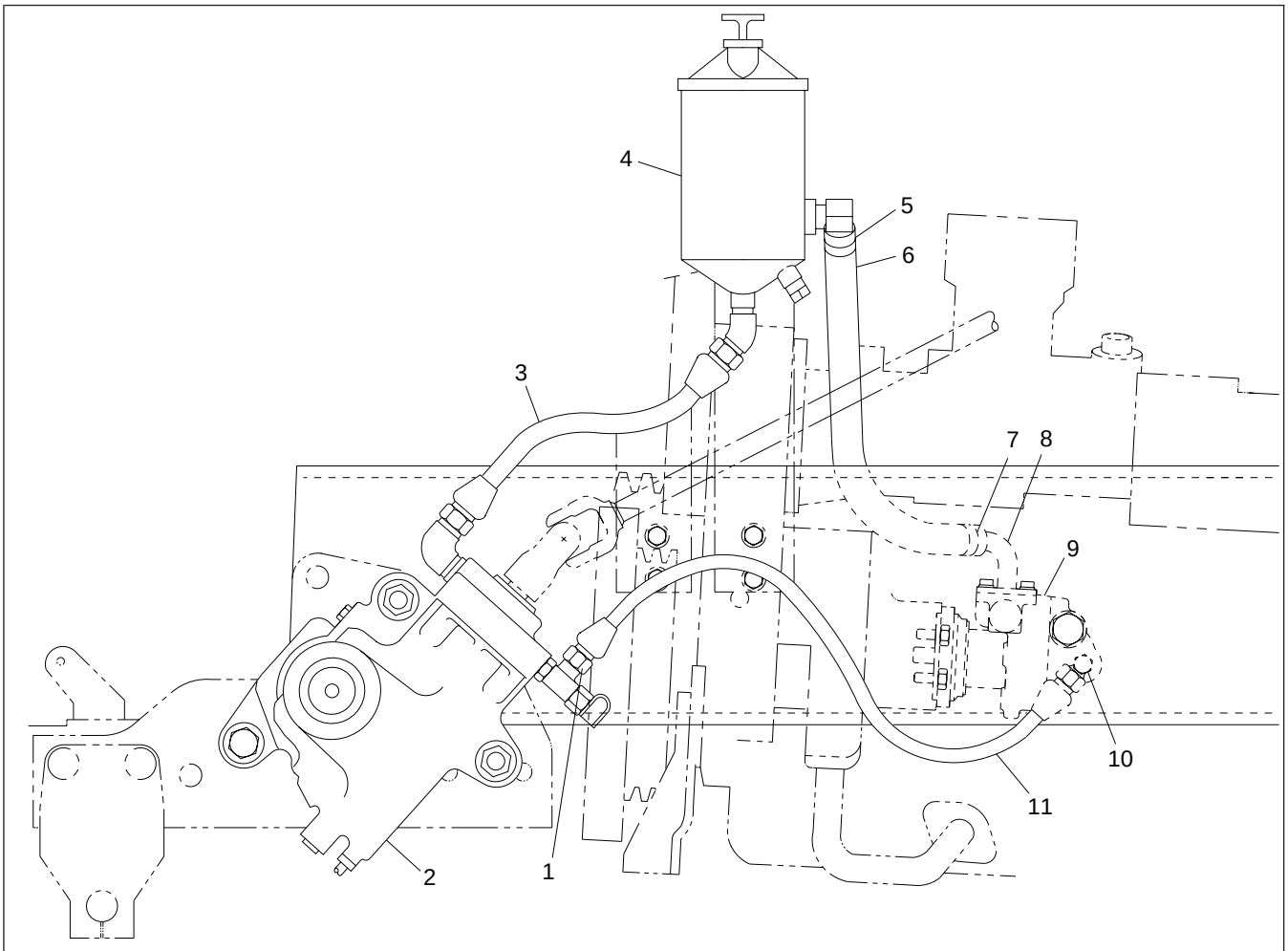
   Repeat this step until a stream of fluid is forced from the pressure line indicating that the pump has primed.
7. Connect the pressure line to the steering gear. Tighten the fitting nut as it was done in the applicable above.
8. Start the engine and let it idle for two minutes without turning the steering wheel. Shut the engine off and check the reservoir fluid level. Fill the reservoir as needed.
9. Start the engine again. Turn the steering wheel from full left to full right several times. Fill the reservoir as needed.

CAUTION

Do not hold the wheel in the full-left or full-right position more than five seconds. Doing so may cause the fluid and pump to overheat.

10. Check the system for leaks. As needed, replace leaking hoses and tighten loose fittings, then repeat the previous five steps.

Filling and Bleeding the Power Steering System



1. Pressure Line Fitting
2. Power Steering Gear
3. Return Line
4. Power Steering Fluid Reservoir
5. Hose Clamp
6. Supply Line
7. Hose Clamp
8. Pump Inlet Tube
9. Power Steering Pump
10. Pressure Line Elbow
11. Fluid Pressure Line

Fig. 1, Power Steering Components and Lines (NTC/120 conventional installation shown)

Disassembly

See **Fig. 1** for an exploded, assembly drawing of the steering pump.

1. Using a suitable solvent, remove all dirt and oil from the outside of the pump.
2. Clamp the edges of the pump mounting flange in a soft-jawed vise. Do not clamp on the sealing surface of the flange and do not clamp on the pump body or pump cover. Clamp the pump in a position that will allow loosening of all pump fasteners and the combination-valve cap.
3. For a pump used on a Caterpillar 3306, hold the drive gear to prevent it from turning and remove the bolt and lockwasher that attach the drive gear to the pump shaft. Remove the drive gear and shaft key. From the pump flange pilot, remove and discard the O-ring. See **Fig. 2**.

   For a pump used on a Detroit Diesel Series 60, hold the sprocket to prevent it from turning and remove the bolt, lockwasher, and large flatwasher that attach the sprocket to the pump shaft. Remove the sprocket and shaft key. From the pump flange pilot, remove and discard the O-ring. See **Fig. 3**.

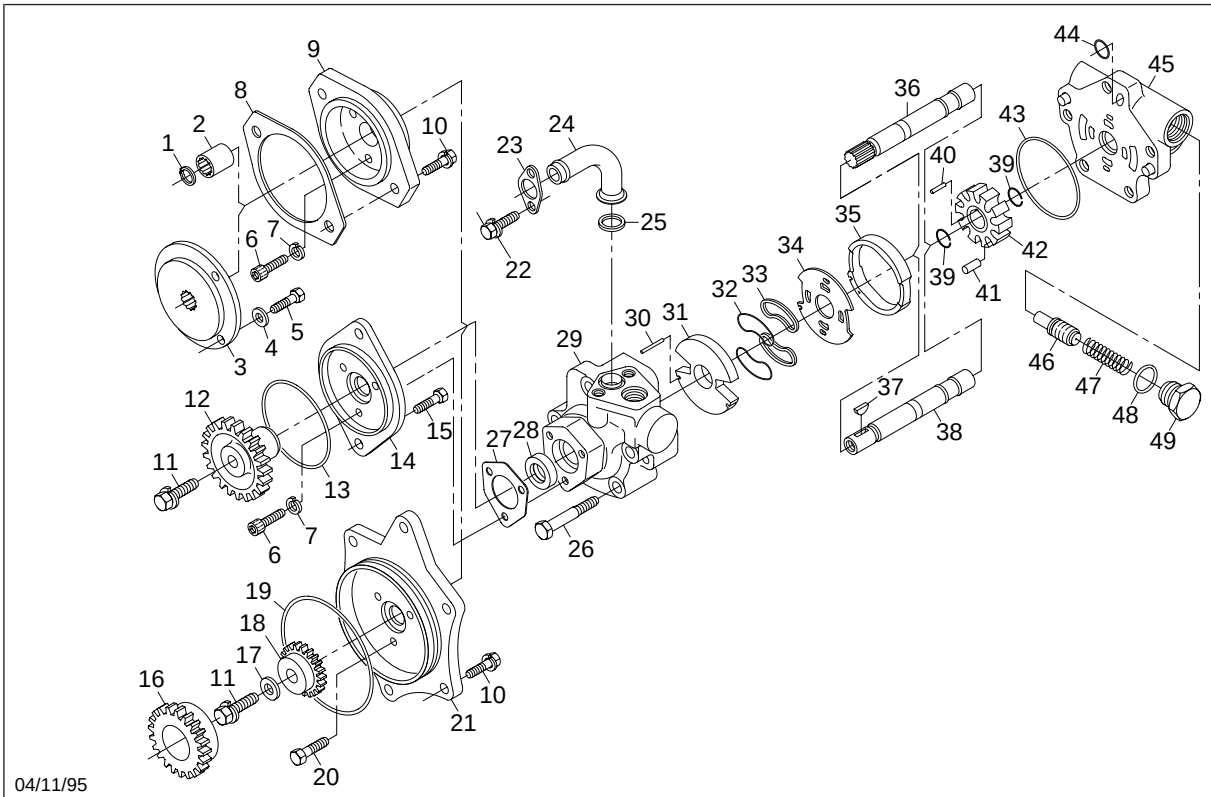
   For **all** pumps, loosen but do not remove the mounting-flange-to-body bolts, inlet-tube-clamp-to-body bolts, and body-to-cover bolts. Carefully loosen but do not remove the combination-valve cap. It is pushed outward by spring force.
4. Remove the pump from the vise. Remove the three Allen-head or hexhead bolts and lockwashers that attach the mounting flange to the pump body. Remove the flange and remove and discard the flange gasket. If needed, scrape the gasket sealing surfaces on the flange and the pump. Use care not to damage the sealing surfaces.
5. Use a suitable block, either with or without the previously removed flange loosely piloted onto the pump shaft, to steady the pump for continued disassembly.
6. Remove the bolts and washers that attach the inlet tube clamp to the pump body. Remove the inlet tube and tube clamp as an assembly, then remove the inlet tube gasket. See **Fig. 4**.
7. From the pump cover, carefully remove the combination-valve cap. It is pushed outward by spring force. See **Fig. 5**. From the cap, remove and discard the O-ring.

   Remove the valve spring and combination valve by shaking the pump or by gently tapping the pump against a wooden or padded surface. See **Fig. 6**. Do not use metal tools or similar instruments; they could damage the valve or the valve bore.
8. Remove the five bolts that attach the pump cover to the pump body. Carefully remove the cover by pulling it up while gently tapping it away from the body using a plastic or rubber mallet. See **Fig. 7**. To disengage the dowel pins and pump shaft, the cover must be lifted straight up from the body. Do not allow any of the internal components to be removed with the cover.
9. For assembly reference, record or mark on the pump body the position of the locating pin and the direction of the cam ring rotation arrow. See **Fig. 8**. Use dye or some other semipermanent marker when marking the pump body.
10. Remove and discard both body-to-cover O-rings. See **Fig. 9**.
11. Using a clean magnet, pull the ten rollers out of the carrier. See **Fig. 10**. Do not use pliers or similar tools; they could raise a burr.
12. Lift out the carrier and shaft assembly. See **Fig. 11**. The carrier is held in place on the shaft by snap rings.
13. Remove the cam ring, port plate, end plate, and locating pin. See **Fig. 12**.
14. Remove the end plate seals and O-rings from the end plate, but do not discard them. See **Fig. 13**.
15. Using care not to damage the shaft bushing, use a small-diameter punch from inside the pumping element cavity to drive the pump shaft oil seal out of its bore. See **Fig. 14**. Discard the oil seal.

Inspection

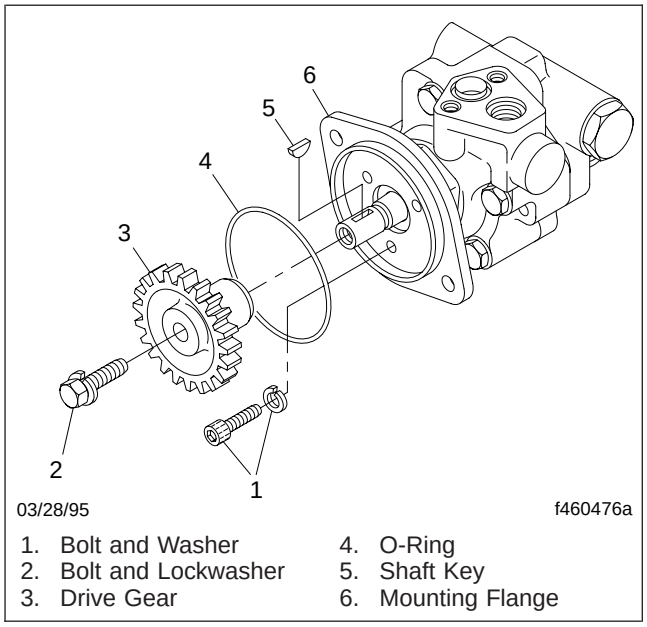
1. Wash all components (except seals) in a suitable solvent, then allow them to air-dry.

Disassembly, Inspection, and Assembly



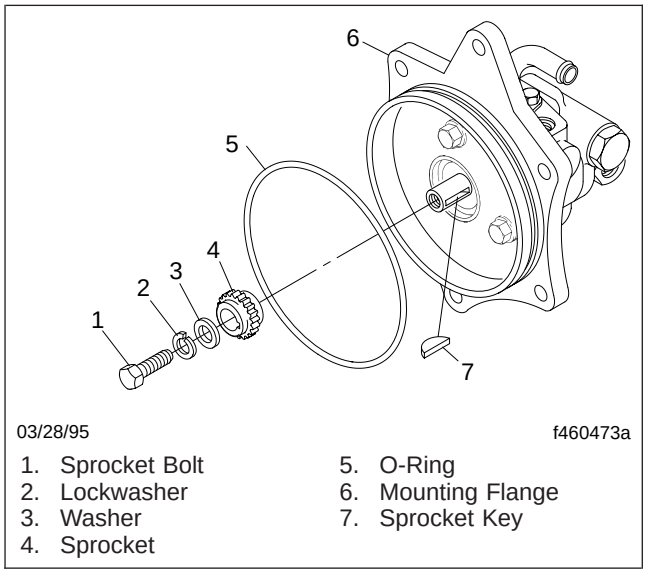
1. Coupling Clip (NTC)
2. Shaft Coupling (NTC)
3. Drive Gear Sleeve (3176 and 3406)
4. Washer
5. Mounting Bolt
6. Bolt
7. Lockwasher
8. Gasket (3176, 3406, L10, and NTC)
9. Pump Mounting Flange (3176, 3406, L10, and NTC)
10. Bolt and Lockwasher
11. Bolt and Lockwasher
12. Drive Gear (3306)
13. O-Ring (3306)
14. Pump Mounting Flange (3306)
15. Bolt
16. Coupling (Series 60)
17. Washer
18. Sprocket (Series 60)
19. O-Ring (Series 60)
20. Bolt
21. Pump Mounting Flange (Series 60)
22. Inlet Tube Assembly Bolt and Lockwasher
23. Inlet Tube Clamp
24. Inlet Tube (90-degree bend shown)
25. Inlet Tube Gasket
26. Bolt
27. Gasket
28. Pump Shaft Oil Seal
29. Pump Body
30. Locating Pin
31. End Plate
32. O-Ring
33. End Plate Seal
34. Port Plate
35. Cam Ring
36. Pump Shaft (NTC, L10, 3176, and 3406)
37. Drive Gear/Sprocket Key
38. Pump Shaft (3306 and Series 60)
39. Carrier Snap Ring
40. Carrier Drive Pin
41. Roller
42. Carrier
43. O-Ring
44. O-Ring
45. Pump Cover
46. Combination Valve (flow control and pressure relief)
47. Valve Spring
48. O-Ring
49. Combination Valve Cap

Fig. 1, Power Steering Pump and Mounting Components



1. Bolt and Washer
2. Bolt and Lockwasher
3. Drive Gear
4. O-Ring
5. Shaft Key
6. Mounting Flange

Fig. 2, Steering Pump Used on Caterpillar 3306 Engine

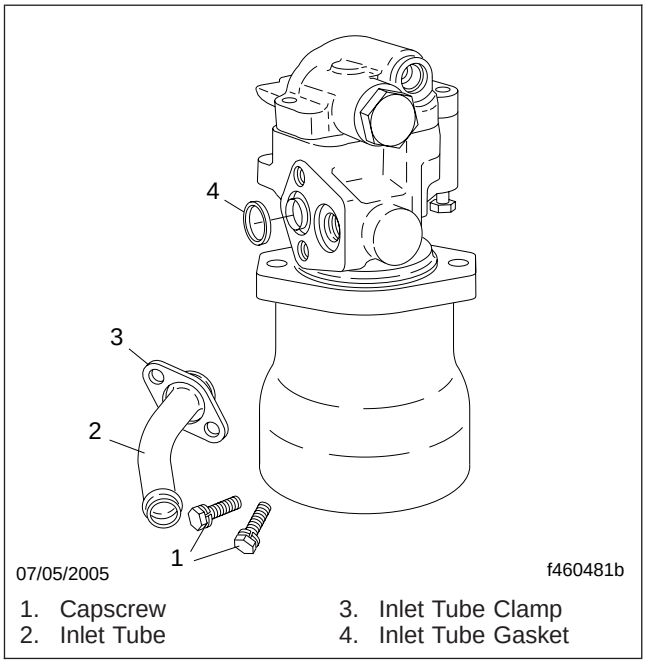


1. Sprocket Bolt
2. Lockwasher
3. Washer
4. Sprocket
5. O-Ring
6. Mounting Flange
7. Sprocket Key

Fig. 3, Steering Pump Used on Detroit Diesel Series 60 Engine

2. Inspect the pump-body shaft bushing for burning, scoring, and wear. The bushing is not serviceable as a separate part; if the bushing is damaged or worn, replace the pump body.

IMPORTANT: If the pump body is being replaced and was marked with the position of the locating pin and the direction of the cam ring rotation arrow during disassembly, keep the old pump body for assembly reference or mark the



1. Capscrew
2. Inlet Tube
3. Inlet Tube Clamp
4. Inlet Tube Gasket

Fig. 4, Remove the Inlet Tube and Gasket

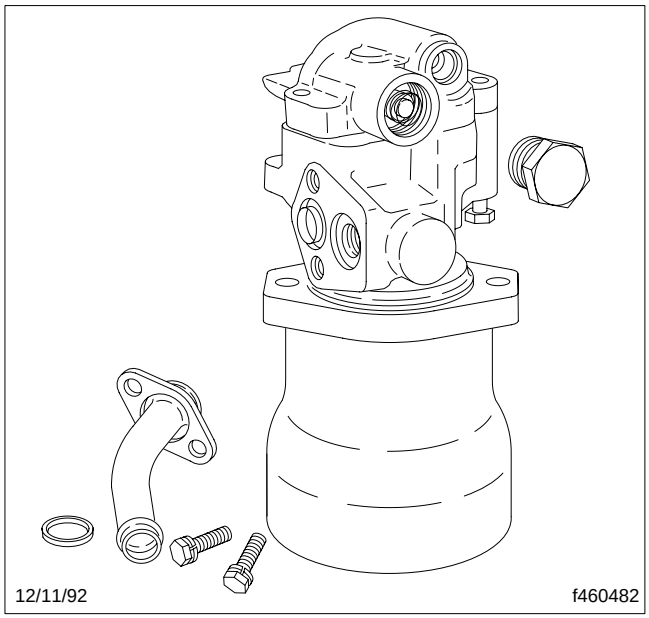
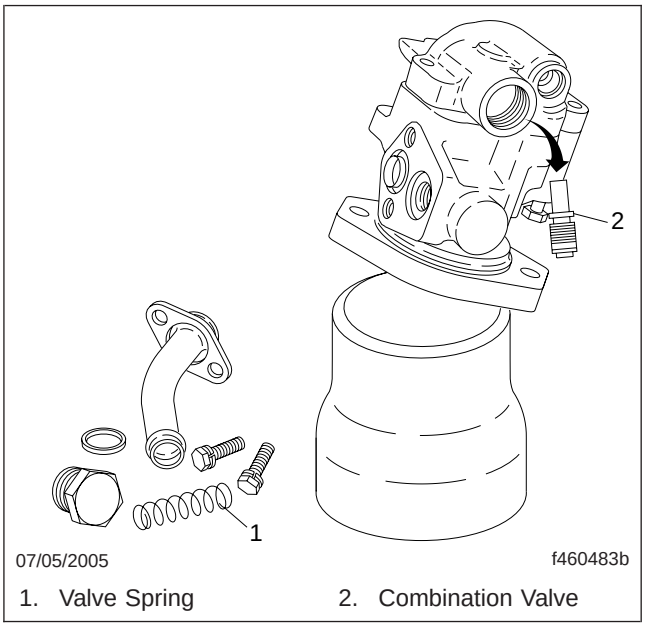


Fig. 5, Remove the Combination-Valve Cap

Disassembly, Inspection, and Assembly



1. Valve Spring 2. Combination Valve

Fig. 6, Remove the Valve Spring and Combination Valve

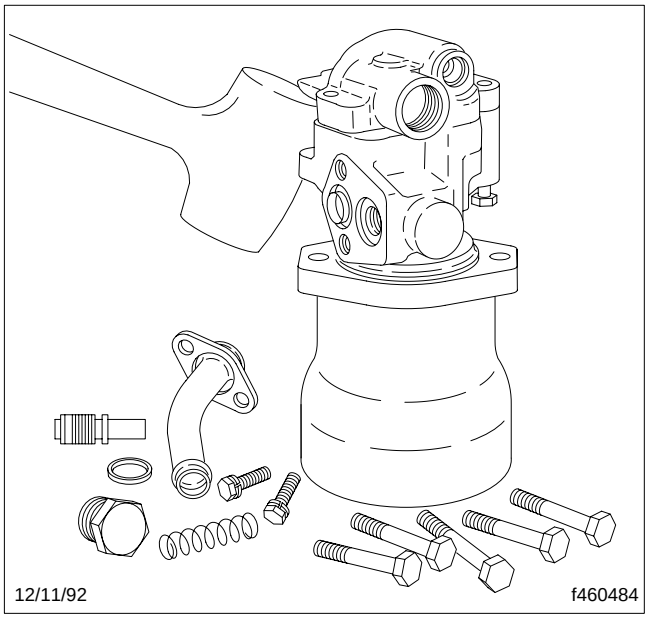


Fig. 7, Remove the Cover

new body with the same marks in the same locations. See **Fig. 8**.

3. Inspect the pump-cover shaft bushing for burning, scoring, and wear. The bushing is not serviceable as a separate part. If the bushing is damaged or worn, replace the pump cover.

   Inspect the port face of the pump cover for scoring and pitting. Lapping or polishing of the face to remove up to 0.002 inch (0.05 mm) is acceptable, taking care to maintain a flat, polished surface. Clean the ports after refacing. Replace the pump cover if damage is more severe.

4. Inspect the shaft for wear, burning, and scoring in the areas of the bushings, oil seal, and spline drive. If any wear, burning, or scoring is found, replace the shaft. Also replace the pump shaft if either the body bushing or cover bushing is worn to the point that the pump body or pump cover requires replacement.

5. Inspect the carrier on the ends and on the roller drive faces for excessive wear and scoring. If the ends are worn or scored, or if the wear pattern on any roller drive face is greater than 0.06 inch (1.5 mm) in width, replace the carrier.

NOTE: The carrier is serviced only as part of a pumping element kit that also includes the rollers, cam ring, and port plate.

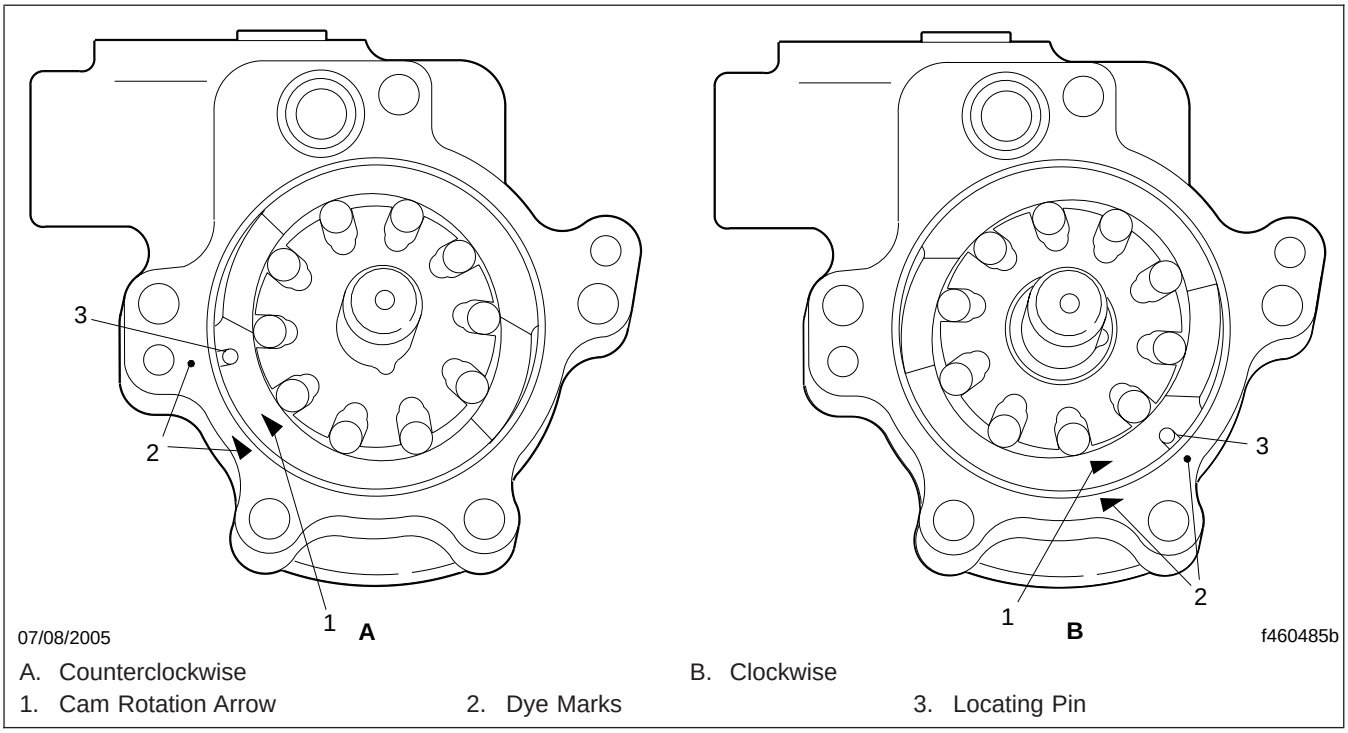
6. If either of the carrier snap rings is bent or broken, replace both of them.

7. Inspect the internal surface of the cam ring for wear and scoring. Polish in some areas is normal. If wear is severe enough to raise a noticeable burr on either inside corner of the cam ring face, replace the cam ring. The cam ring is serviced only as part of the pumping element kit.

8. Inspect the ten rollers for pitting, scoring, and wear. If any roller is damaged or worn, replace all the rollers. The rollers are serviced only as part of the pumping element kit.

9. Inspect the port plate for excessive scoring and galling. Because the port plate is flexible, polishing and **minor** scratching of the surface is normal. If scoring or galling is minor, the port plate can be hand-polished; maximum allowable removal of material is 0.0001 inch (0.0025 mm). If wear is more severe, replace the port plate. The port plate is serviced only as part of the pumping element kit.

10. Inspect the end plate for cracks in the areas of the seal cavities. Replace the end plate if cracks are found.



A. Counterclockwise
B. Clockwise
1. Cam Rotation Arrow
2. Dye Marks
3. Locating Pin

Fig. 8, Rotation Arrows

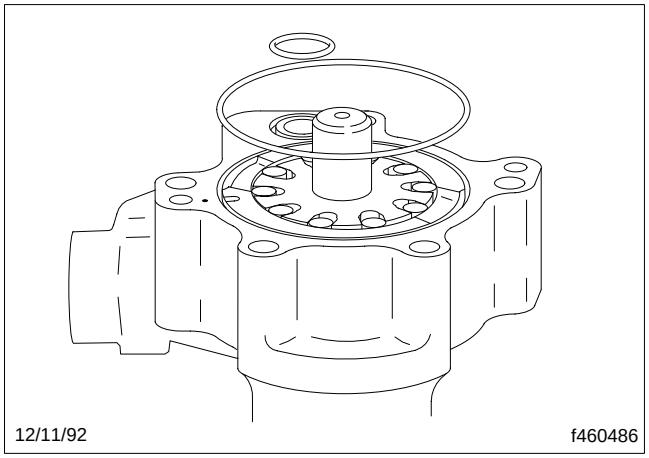


Fig. 9, Remove the O-Rings

Inspect the end plate O-rings and end plate seals for cracks and excessive swelling. Replace all O-rings and seals if any damage is found.

11. Be sure both the combination valve and the pump-cover valve bore are dry. Insert the valve (long, small-diameter end first) in the cover and check for free movement in and out of the bore.

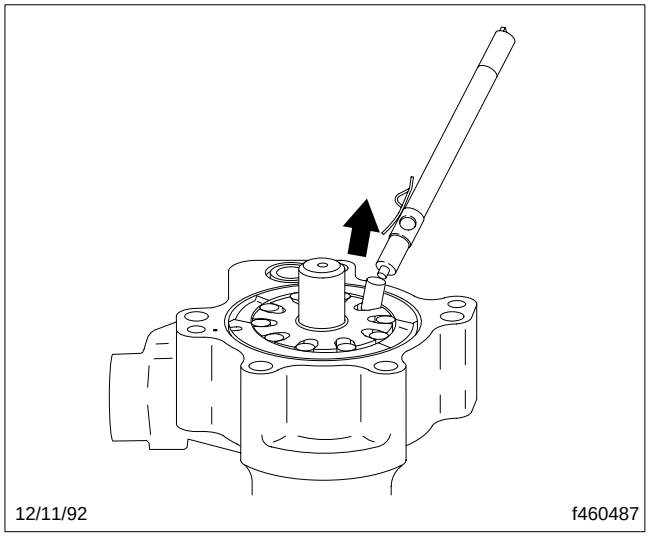


Fig. 10, Remove the Rollers

See **Fig. 15**. The valve must move smoothly in the bore. Use a crocus cloth to remove any burrs from the valve. Minor polishing of the valve outside diameter is acceptable up to 0.0001 inch (0.0025 mm) material removal.

Disassembly, Inspection, and Assembly

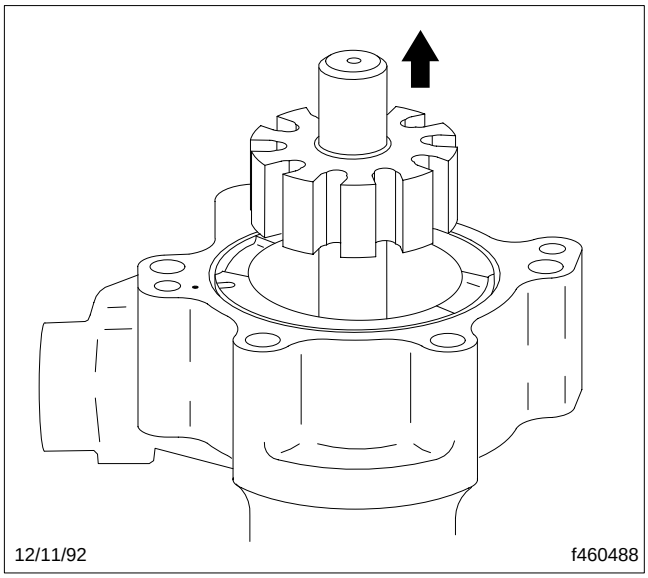


Fig. 11, Remove the Carrier and Shaft Assembly

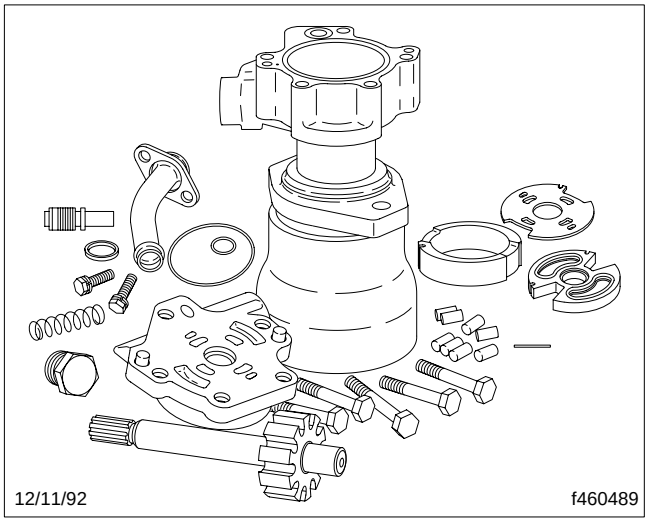


Fig. 12, Remove Components

It is difficult to visually determine if valve components are damaged or worn. If the problem with the pump was low pressure or hard steering, and the pumping element shows no signs of excessive wear, replace the combination valve and valve spring.

If it is necessary to replace the combination valve because of excessive wear, inspect the condition of the pump-cover valve bore. Replace the cover if the bore is worn.

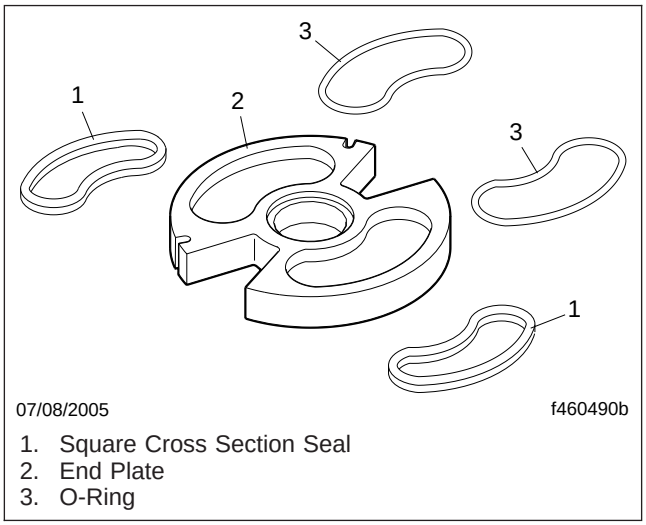


Fig. 13, Remove the Seals and O-Rings

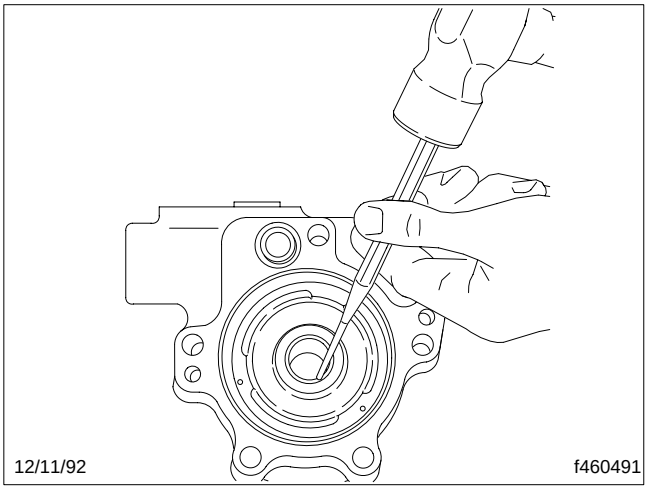


Fig. 14, Drive Out the Oil Seal

12. Inspect the pump inlet tube for cracks and chafing. If the tube is cracked or badly chafed, replace the inlet-tube-and-adapter assembly.
13. For a pump used on a Caterpillar 3306, inspect the external teeth on the drive gear. See **Fig. 2**. Replace the gear if the teeth are damaged or badly worn.

    For a pump used on a Detroit Diesel Series 60, inspect the external teeth on the sprocket. See **Fig. 3**. Replace the sprocket if the teeth are damaged or badly worn.

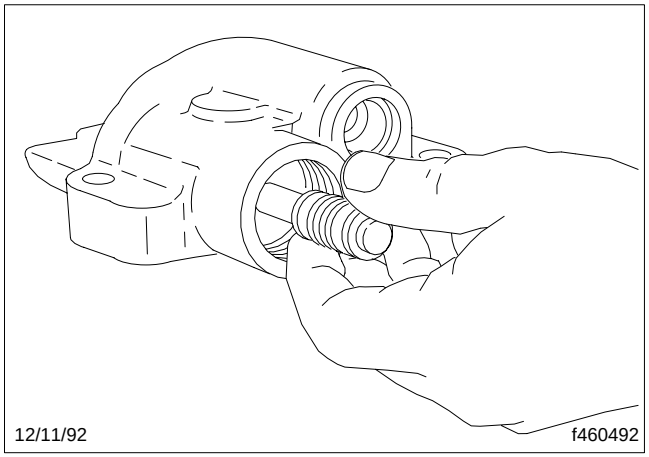


Fig. 15, Install the Valve

Assembly

1. With the steel cage facing out, install a new pump shaft oil seal in the pump body using a special seal installation tool or a length of steel tubing of about the same outer diameter as the seal. See **Fig. 16** and **Fig. 17**. Use caution to avoid caving the oil seal case due to excessive installation pressure; however, the seal must bottom in the bore.

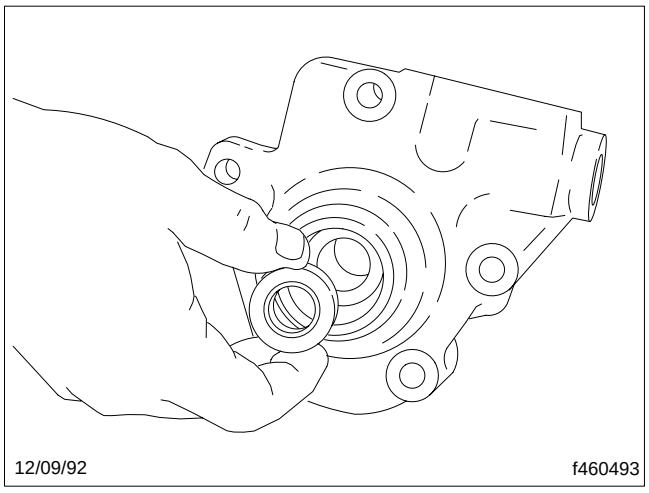


Fig. 16, Steel Cage Facing Out

2. Lubricate the oil seal and pump body bushing with a generous amount of lithium-based grease.
3. Install an end plate O-ring into the bottom of each seal cavity in the end plate, then install an end plate seal over the top of each O-ring. See **Fig. 18**. All O-rings and seals must fit snug all the way around in the seal cavities. If they do not, replace them.

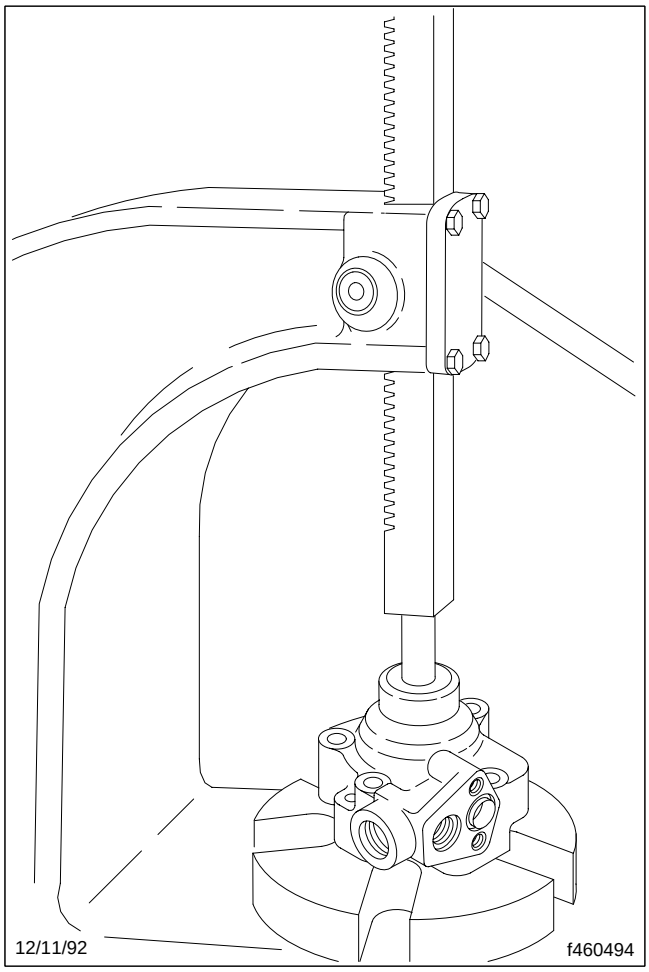


Fig. 17, Install a New Oil Seal

4. Install the locating pin in the same position that was recorded or marked during disassembly, or see **Fig. 19** and **Fig. 20** and install the pin as shown. Be sure it is well seated in the hole inside the pump body.
5. Install the end plate in the pump body with the seals exposed and the plain face down. With one of the locating pin notches of the end plate fitted over the locating pin, the other locating pin notch must be within a few degrees of aligning with the other locating pin hole inside the pump body. See **Fig. 19**.

Disassembly, Inspection, and Assembly

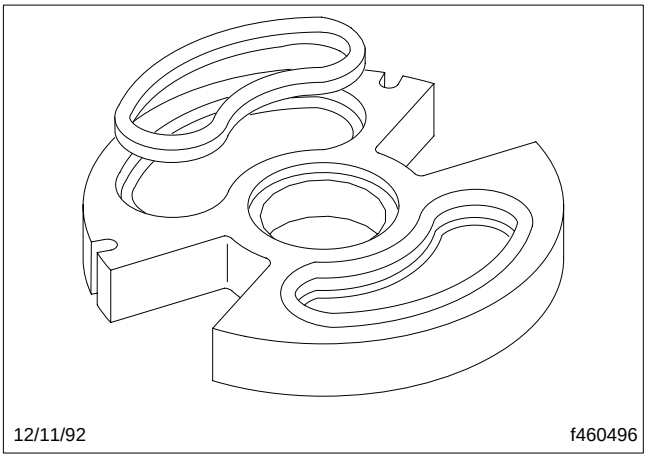


Fig. 18, Install the O-Ring

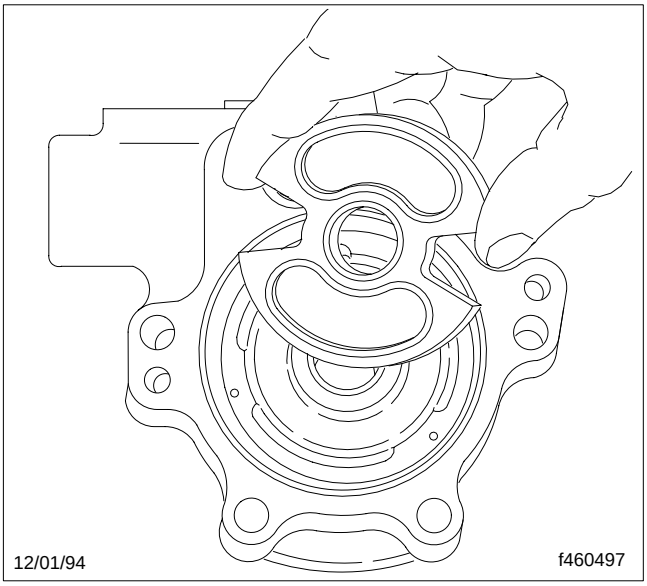


Fig. 19, Install the Pin

6. Install the port plate so the locating pin notch aligns with the locating pin, **and** the two large notches, align with the large notches in the end plate. See **Fig. 20**. If the large notches do not align, flip the port plate over so the opposite face is exposed.
7. Install the cam ring so the rotation arrow is pointing in the same direction as noted or marked during disassembly. With the cam ring locating pin notch aligned with the locating pin, the recesses in the cam ring outer circumference must align with the large notches in the port plate and end plate. See **Fig. 21**.
8. Using a small amount of clean steering system fluid, lubricate the face of the port plate and the internal surface of the cam ring. Do not cover the end of the cam ring with fluid.
9. If **none** of the parts of the carrier/shaft assembly need to be replaced, go to the next step.

   If the **carrier and the shaft** both need to be replaced, use the old carrier/shaft assembly as a guide for assembling the new parts. Being careful not to scratch the new shaft, install a new snap ring in the groove that is close to its center. See **Fig. 22**. Install a new drive pin in the keyway, then install the carrier over the drive pin. See **Fig. 23**. Install the carrier with its identification groove facing the same end of the shaft as the identification groove on the old carrier/shaft assembly. See **Fig. 24**. Install a new snap ring in the groove that is near the end of the shaft. See **Fig. 25**.

   If **only the carrier** needs to be replaced, note the end of the shaft that the carrier identification groove is facing. See **Fig. 24**. Without scratching the shaft, remove the snap ring that is near the end of it. Remove the old carrier and drive pin. Install the new carrier on the shaft over a new drive pin. See **Fig. 23**. Install the carrier with its identification groove facing the same end of the shaft that the old carrier's groove had been facing. Install the snap ring. See **Fig. 25**.

   If **only the shaft** needs to be replaced, note the end of the shaft that the carrier identification groove is facing. See **Fig. 24**. Remove the snap ring that is near the end of the shaft. Remove the carrier, drive pin, and the other snap ring. Being careful not to scratch the new shaft, install a snap ring in the groove that is close to its center. See **Fig. 22**. Install the drive pin in the keyway, then install the carrier over the drive pin. See **Fig. 23**. Install the carrier with its identification groove facing the same end of the new shaft that it had been facing on the old shaft. Install the other snap ring. See **Fig. 25**.

   If **only the snap rings** need to be replaced, remove the old ones and install the new ones, one at a time, without removing the carrier and drive pin. Be careful not to scratch the shaft.

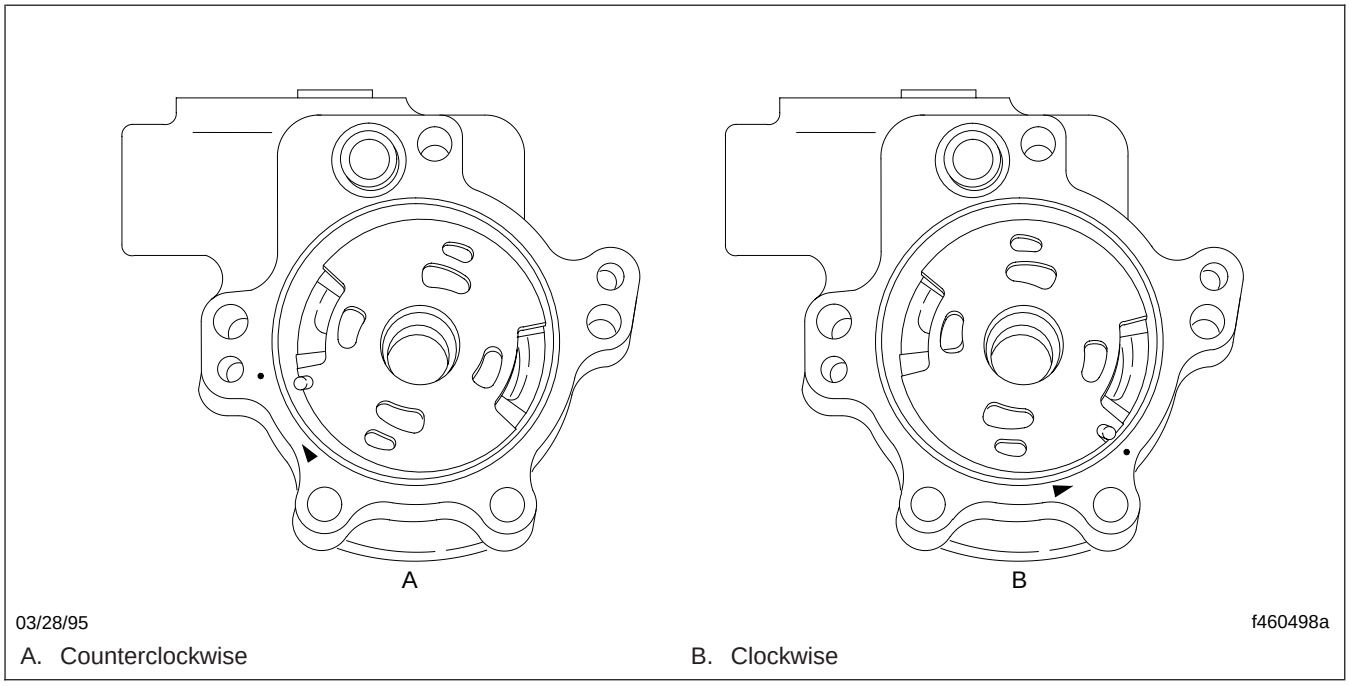


Fig. 20, Install the Port Plate

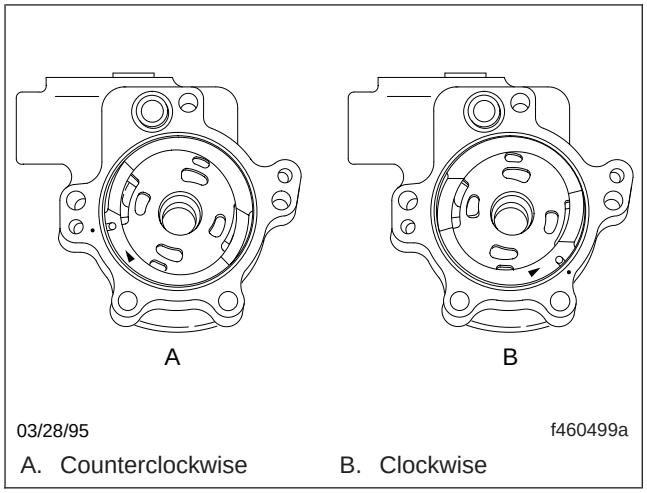


Fig. 21, Alignment of Port Plate and End Plate

10. Install the carrier/shaft assembly in the pump body being careful not to damage the lip on the shaft oil seal.
11. Install the ten rollers in the carrier. Lubricate the shaft and the face of the carrier with a small amount of clean steering system fluid. Do not cover the end of the cam ring with fluid.

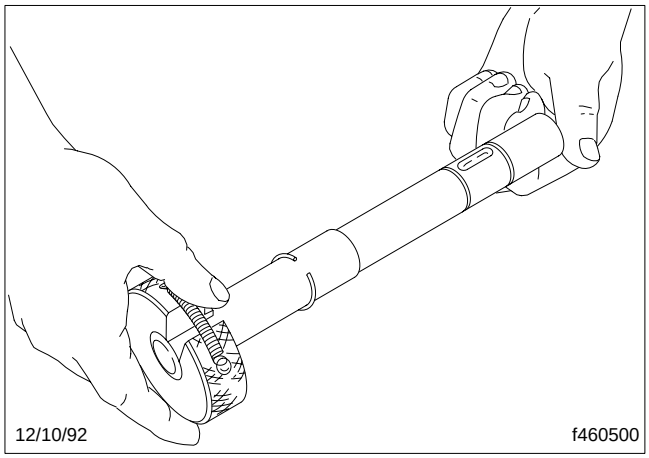


Fig. 22, Install the Snap Ring

12. Install new O-rings in the flow bypass hole in the pump body and in the groove between the pump body and the cam ring. See **Fig. 9**.
13. Using clean steering system fluid, lubricate the pump cover bushing and the face of the pump cover. Install the pump cover, aligning the cover dowel pins with the dowel pin holes in the pump body. Install the five body-to-cover bolts finger-tight.

Disassembly, Inspection, and Assembly

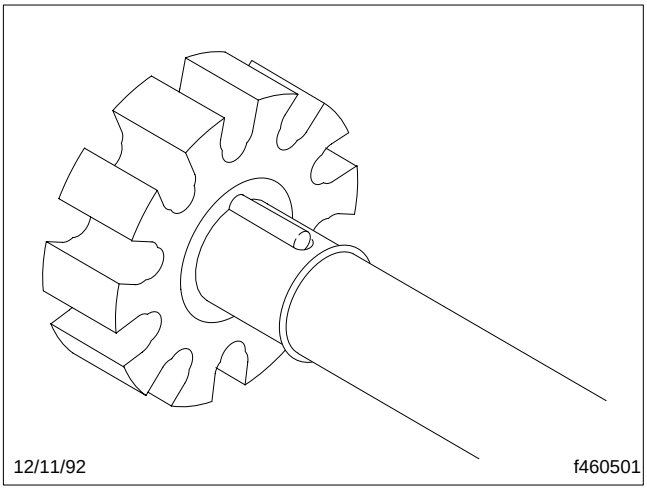


Fig. 23, Install the Carrier

14. Using a small amount of steering system fluid, lubricate the pump-cover valve bore. Insert the combination valve in the pump-cover bore, with the long, small-diameter end in first. See **Fig. 26**. The valve must slide smoothly in the bore.

    Lubricate a new O-ring and install it on the valve cap. Install the valve spring in the pump-cover bore, then install the valve cap finger-tight. See **Fig. 5**.

15. Install a new inlet-tube gasket on the pump body. Install the inlet tube and tube clamp as an assembly. See **Fig. 4**. Install the tube clamp bolts and washers finger-tight.

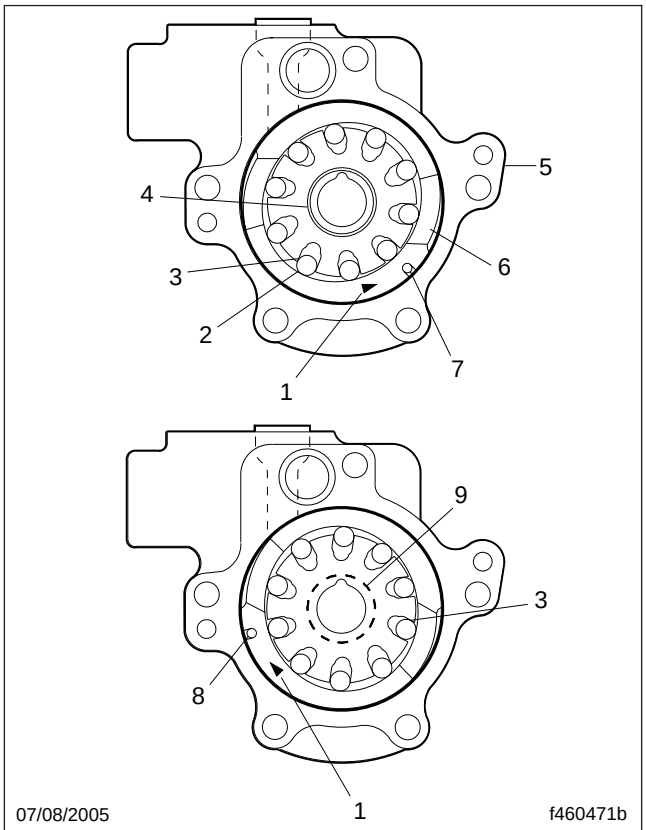
16. Install a mounting flange gasket on the pump body. Position the mounting flange on the pump body as shown in **Fig. 27**. Install finger-tight the three Allen-head or hexhead bolts and lockwashers.

17. Clamp the edges of the pump mounting flange in a soft-jawed vise. Do not clamp on the sealing surface of the mounting flange and do not clamp on the pump body or pump cover. Clamp the pump in a position that will allow tightening of all pump fasteners and the combination-valve cap.

18. Tighten the five body-to-cover bolts 35 lbf·ft (50 N·m).

19. Tighten the three mounting-flange-to-body bolts 35 lbf·ft (50 N·m).

20. Tighten the combination-valve cap 48 lbf·ft (65 N·m).



1. Cam Rotation Arrow
2. Roller
3. Drive Face of Carrier
4. Carrier Identification Groove (face up)
5. Pump Body
6. Cam Ring
7. Pin Location for 3176, 3306, or NTC
8. Pin Location for 3406, L10, or Series 60
9. Carrier Identification Groove (face down)

Fig. 24, Carrier Identification Groove

21. Turn the pump shaft to check for free, smooth rotation. The maximum turning torque is 10 lbf·in (120 N·cm). If torque is more than that, disassemble the pump and check it for burrs, pinched seals, and contamination. Fix the problem. Then clean, lubricate, and reassemble the pump.

22. Remove the pump from the vise.

    For a pump used on a Caterpillar 3306, position the shaft key in the pump shaft, then install the drive gear over the key. See **Fig. 2**. Hold the drive gear to prevent it from turning while install-

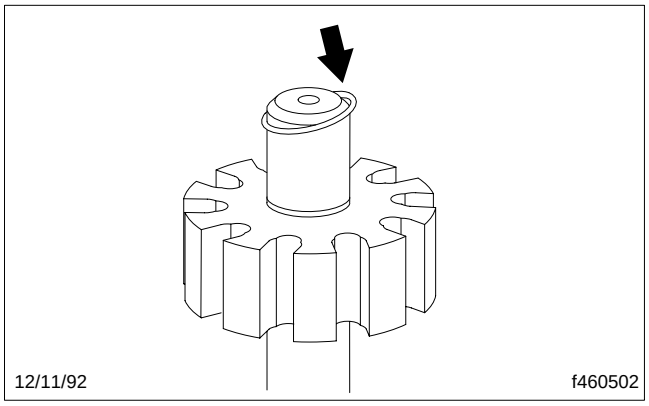


Fig. 25, Install the Snap Ring

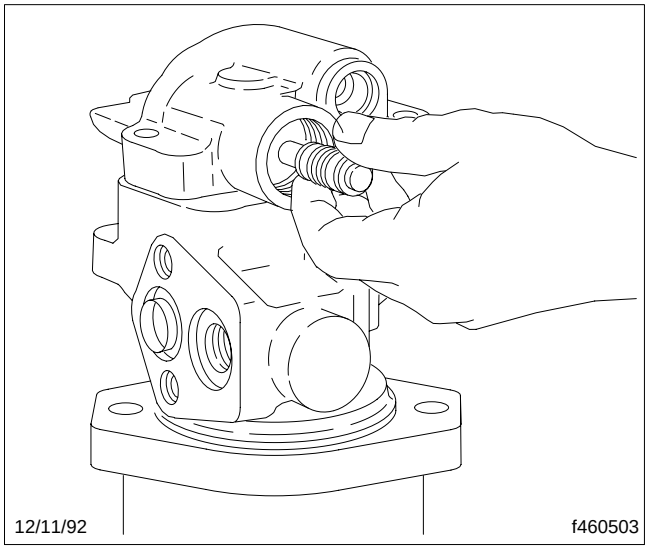
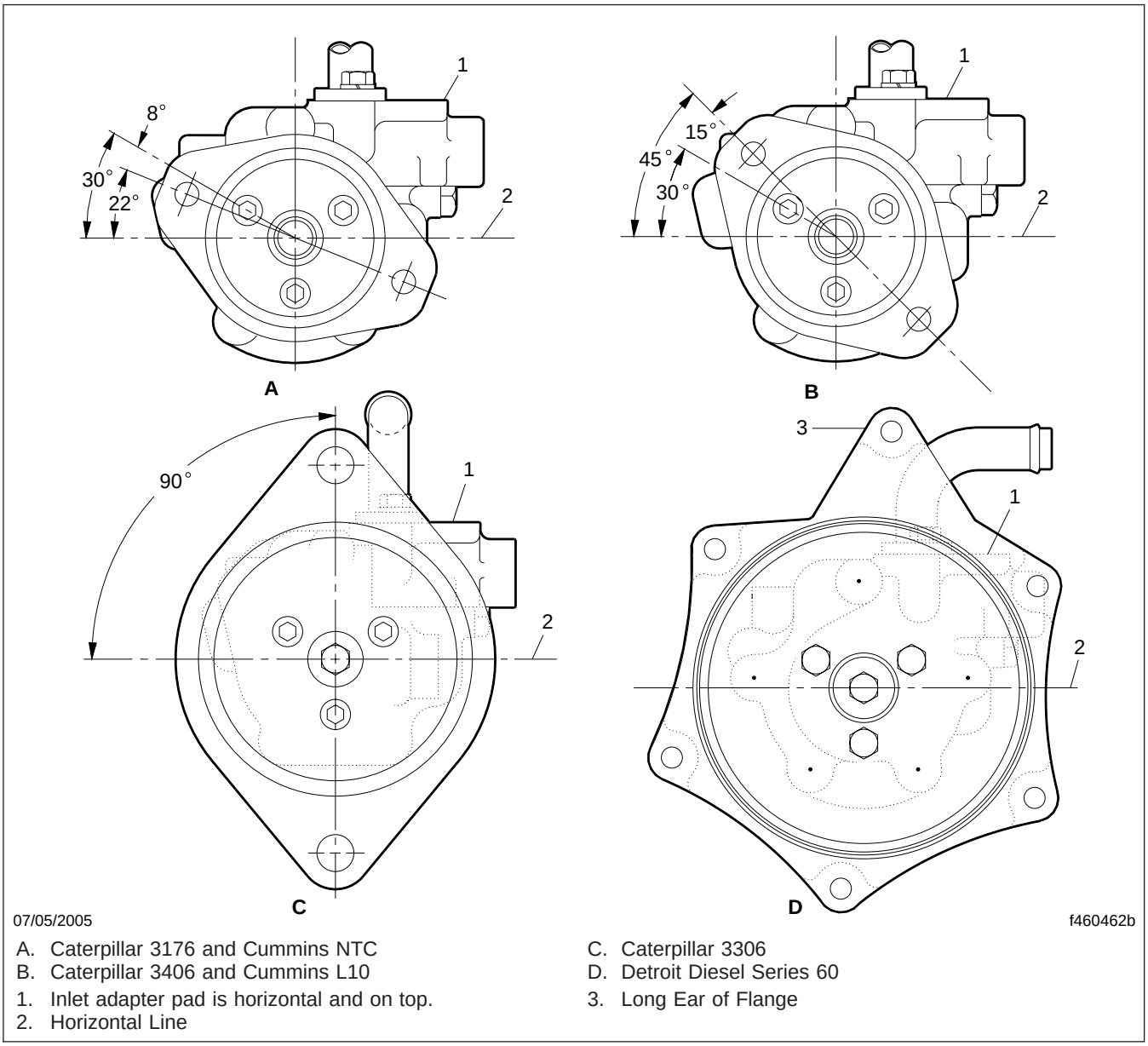


Fig. 26, Install the Combination Valve

ing the bolt and lockwasher and tightening the bolt 33 lbf·ft (45 N·m).

For a pump used on a Detroit Diesel Series 60, position the shaft key in the pump shaft, then install the sprocket over the key. See **Fig. 3**. Hold the sprocket to prevent it from turning while installing the large flatwasher, lockwasher, and bolt and tightening the bolt 33 lbf·ft (45 N·m).

Disassembly, Inspection, and Assembly



A. Caterpillar 3176 and Cummins NTC
B. Caterpillar 3406 and Cummins L10
C. Caterpillar 3306
D. Detroit Diesel Series 60
1. Inlet adapter pad is horizontal and on top.
2. Horizontal Line
3. Long Ear of Flange

Fig. 27, Pump Mounting Flange Installation (shaft end view)

Replacement

1. Using the instructions in **Subject 110**, remove the pump.
2. Using a suitable solvent, remove all dirt and oil from the outside of the pump.
3. Clamp the edges of the pump mounting flange in a soft-jawed vise. Do not clamp on the sealing surface of the flange and do not clamp on the pump body or pump cover.
4. Carefully loosen but do not remove the combination-valve cap. Remove the pump from the vise. Carefully remove the combination-valve cap. It is pushed outward by spring force. See **Fig. 1**. From the cap, remove and discard the O-ring.

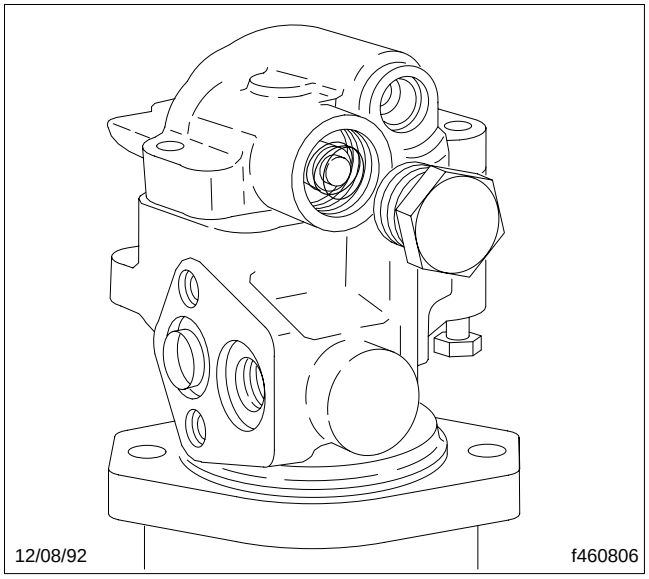


Fig. 1, Remove the Combination-Valve Cap

5. Remove the valve spring and the combination valve by shaking the pump or by gently tapping the pump against a wooden or padded surface. See **Fig. 2**. Do not use metal tools or similar instruments; they could damage the valve bore.
6. Using a clean, dry, lint-free cloth, remove any oil from the pump-cover valve bore. Insert the new (dry) combination valve (long, small-diameter end first) in the cover and check for free movement in and out of the bore. See **Fig. 3**. The valve must move smoothly in the bore. Remove the valve

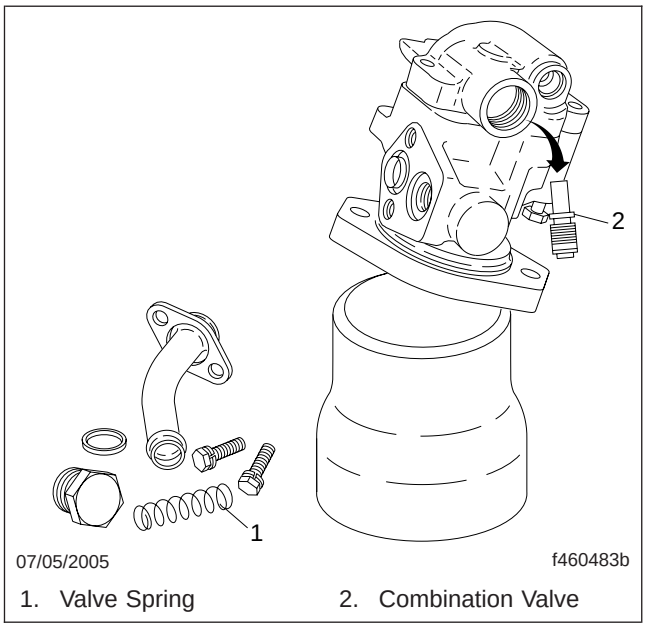


Fig. 2, Remove the Valve Spring and Combination Valve

and inspect the condition of the bore. Replace the pump cover if the valve bore is worn.

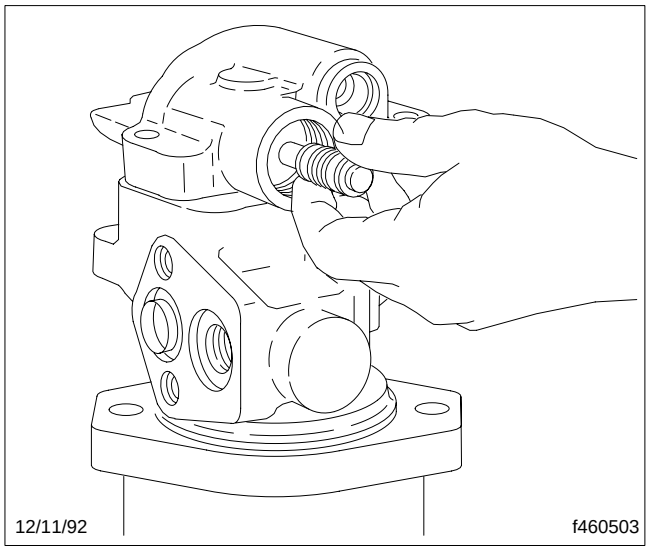


Fig. 3, Install the Combination Valve

7. Using a small amount of clean steering system fluid, lubricate the pump-cover valve bore. Insert the new combination valve in the pump-cover bore putting the long, small-diameter end in first.

Combination Valve Replacement

8. Lubricate a new O-ring and install it on the valve cap. Install a new valve spring in the pump-cover bore, then install the valve cap finger-tight. See **Fig. 1**.
9. Clamp the edges of the pump mounting flange in a soft-jawed vise. Do not clamp on the sealing surface of the flange and do not clamp on the pump body or pump cover.
10. Tighten the combination-valve cap 48 lbf·ft (65 N·m).
11. Using the instructions in **Subject 110**, install the pump.

Post-Service Checks

After power steering components have been worked on and before the vehicle is placed into service, do the following checks.

⚠ WARNING

Failure to do the following checks could result in damage to the power steering system. This could cause a loss of hydraulic assist, which could result in personal injury or property damage.

1. Place a thermometer in the power steering reservoir. Warm the fluid in the steering system to the normal operating temperature of 125° to 135°F (51° to 57°C) by operating the engine at low idle while turning the steering wheel through several full-left and full-right turns.

   With the engine running and the steering system at operating temperature, turn the steering wheel slowly from stop to stop while checking the steering reservoir for frothing or a change in fluid level (an indication that air is trapped in the system). If air is present, check the system for leaking hoses or loose fittings. Replace the hoses or tighten the fittings as needed. Bleed any air from the system.

2. With the engine turned off and warm, check the steering reservoir fluid level using the instructions in the steering section in the vehicle maintenance manual.

3. At full-left and full-right wheel cuts, be sure the axle stops (on the rear-side of the spindle) are set so there is at least 1/2-inch (13-mm) clearance between the tires and any fixed components that are attached to the vehicle. Clearance to moving components must be at least 1 inch (25 mm).

   If clearance is less, reset the axle stops using the front axle wheel alignment instructions in the steering section in this manual.

IMPORTANT: If the axle stops are reset, the steering gear's unloading valves (poppet/relief valves) must also be reset. See the applicable power steering gear section elsewhere in this group.

If there are still problems with the power steering system, perform the troubleshooting procedures in **Section 46.17, Subject 300**.

Specifications

Power Steering Hose Sizes and Minimum Bend Radii		
Application	**Hose Size**	**Minimum Bend Radius inches (mm)**
Suction (Supply) Hose (Reservoir-to-Pump)	No. 12	5 (127)
Pressure Hose (Pump-to-Gear)	No. 8	4-5/8 (117)
Return Hose (Gear-to-Reservoir)	No. 10	2-1/4 (57)

Table 1, Power Steering Hose Sizes and Minimum Bend Radii

Power Steering System Specifications by Engine Installation										
Engine	**Pump Size (cu. in. per revolution)**	**Pump Rotation Direction***	**Pump (engine) Rotation Speed**		**Relief Valve Opening Pressure psi (kPa) x 100**		**Flow Rate gpm (L/min)**		**System Back Pressure† psi (kPa)**	
			RPM at Engine Idle	**RPM at No-Load Maximum**	**Min.‡**	**Max.§**	**Min.¶**	**Max.****	**Normal**	**Maximum**
L10	1.35	LH (CCW)	700 (700)	2460 (2460)	21 (145)	22 (152)	2.7 (10.2)	6.0 (22.7)	70 (482)	100 (689)
NTC	1.00	RH (CW)	900 (600)	3584 (2390)	21 (145)	22 (152)	2.7 (10.2)	6.0 (22.7)	70 (482)	100 (689)
Cat 3176	1.35	RH (CW)	700 (700)	2310 (2310)	21 (145)	22 (152)	2.7 (10.2)	6.0 (22.7)	70 (482)	100 (689)
Cat 3306	1.35	RH (CW)	750 (750)	2485 (2485)	21 (145)	22 (152)	2.7 (10.2)	6.0 (22.7)	70 (482)	100 (689)
Cat 3406B	1.35	LH (CCW)	700 (700)	2310 (2310)	21 (145)	22 (152)	2.7 (10.2)	6.0 (22.7)	70 (482)	100 (689)
DDE Series 60	1.35	LH (CCW)	714 (600)	2648 (2225)	21 (145)	22 (152)	2.7 (10.2)	6.0 (22.7)	70 (482)	100 (689)

* The direction of pump rotation is given as it is viewed from the driven end of the pump.

† System back pressure is measured at engine idle rpm and with the steering wheel stationary.

‡ The relief valve ball must be seated (closed) at the minimum pressure.

§ The relief valve ball must be fully open at the maximum pressure.

¶ Minimum flow rates are measured at engine idle rpm and at 1750 psi (12 100 kPa) of system pressure.

** Maximum flow rates are measured at engine no-load maximum rpm and with the steering wheel stationary.

Table 2, Power Steering System Specifications by Engine Installation

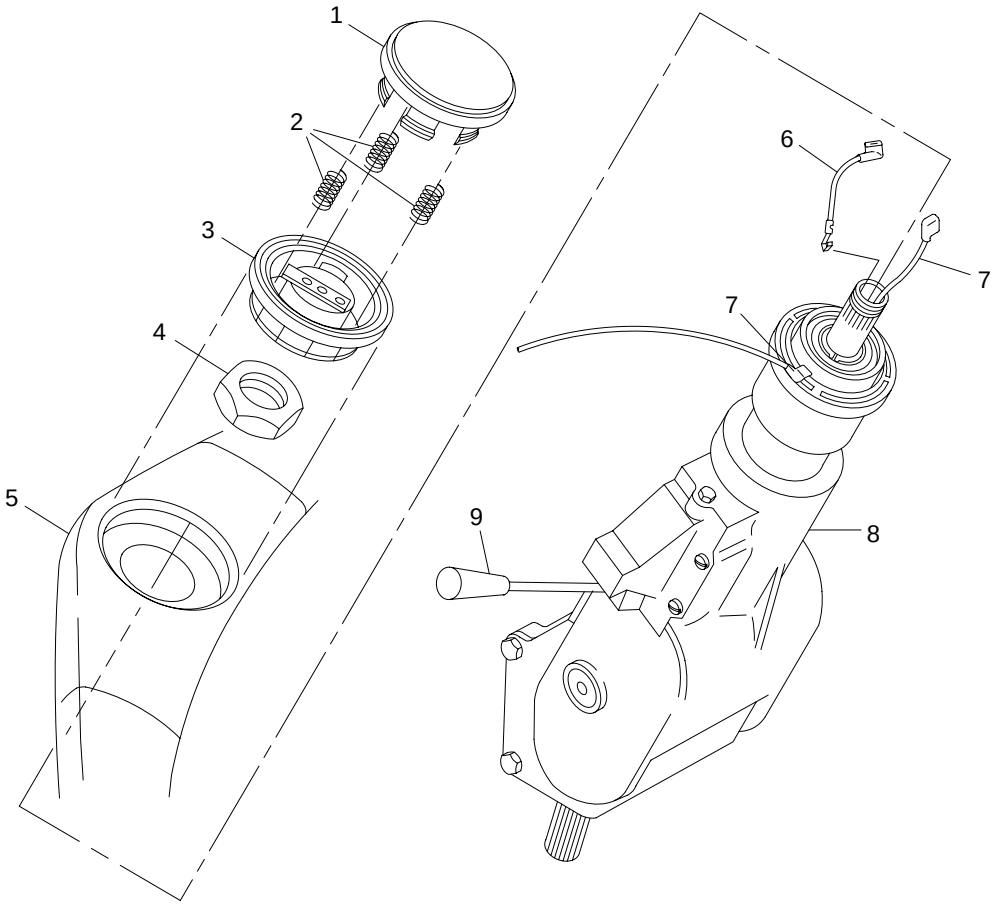
Power Steering Gear Hydraulic Specifications		
Steering Gear	**Maximum Internal Leakage gpm (L/min)**	**Poppet/Relief Valve Maximum Opening Pressure psi (kPa)**
TRW TAS65	1.5 (5.7)	1900 (13 000)
Sheppard M100	1.0 (3.8)	1900 (13 000)

Table 3, Power Steering Gear Hydraulic Specifications

General Information

The tilt/telescoping steering column has a tilt range of 15 degrees and a telescoping range of 2-5/8 inches (67 mm). A control lever (**Fig. 1**) is located just below the turn signal switch. For operating instructions, refer to the vehicle driver's manual.

At the upper end of the steering column assembly are threads to accept a wheel nut and tapered external serrations to match the internal serrations of the steering wheel hub. At the lower end, the shaft is serrated to connect with the steering driveline upper end yoke.



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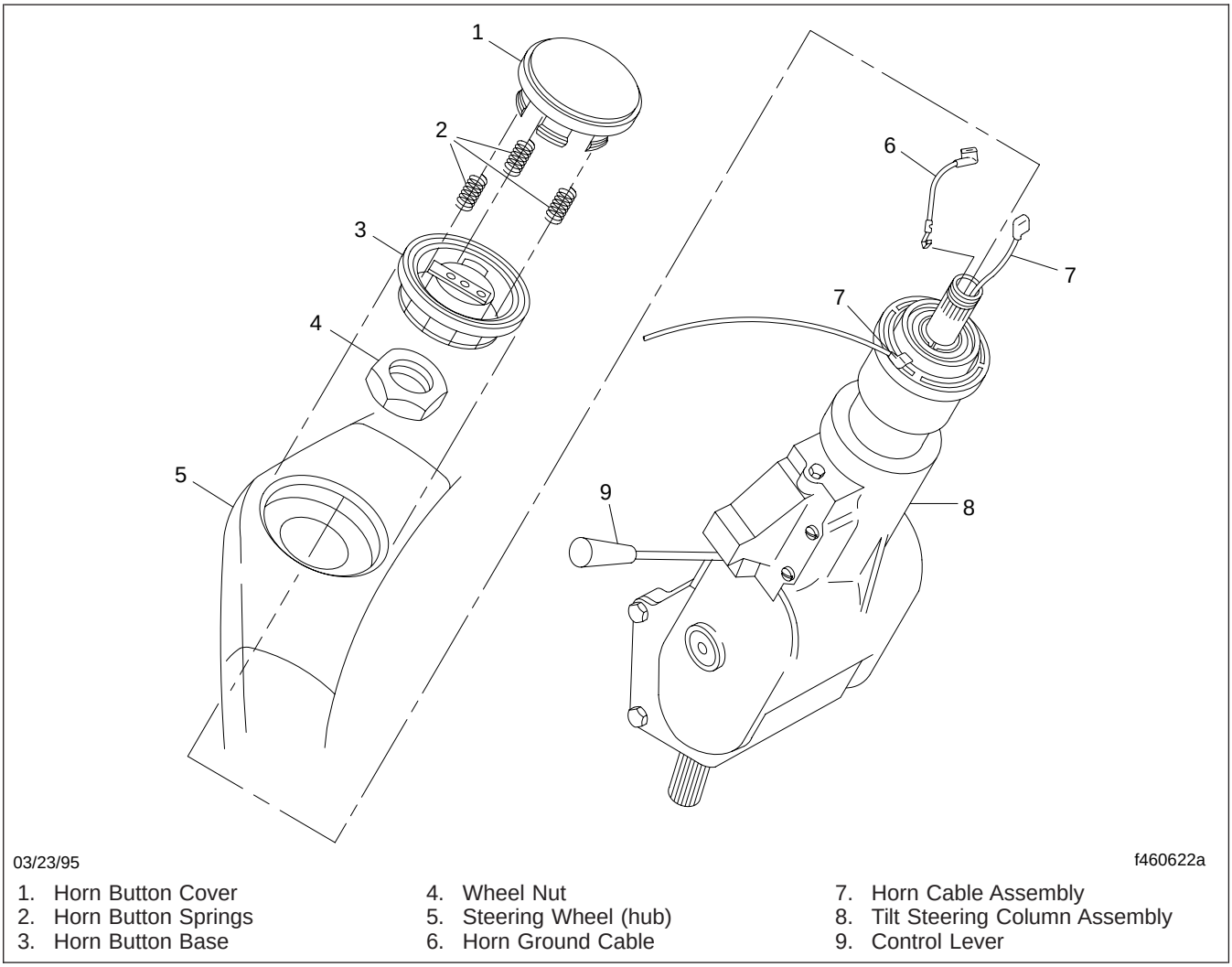
1. Horn Button Cover
2. Horn Button Springs
3. Horn Button Base
4. Wheel Nut
5. Steering Wheel Hub
6. Horn Ground Cable
7. Horn Cable Assembly
8. Tilt Steering Column Assembly
9. Control Lever

Fig. 1, Steering Wheel Installation

Removal (See Fig. 1)



1. Horn Button Cover
2. Horn Button Springs
3. Horn Button Base
4. Wheel Nut
5. Steering Wheel (hub)
6. Horn Ground Cable
7. Horn Cable Assembly
8. Tilt Steering Column Assembly
9. Control Lever

Fig. 1, Steering Wheel Installation

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be performed. Do not turn the steering wheel at any time during this procedure.

   Apply the parking brakes, and chock the tires.

2. Using a small screwdriver, pry under the outermost ring of the steering wheel horn button. Lift the horn button from the steering wheel hub, then disconnect the wire terminals at the horn button.

3. Without turning the steering wheel, remove the wheel nut from the end of the wheel tube shaft. Using a steering wheel puller, remove the wheel from the shaft.

IMPORTANT: Be careful when you are removing the steering wheel, or you could damage the horn wires. A steel block measuring 1-5/8 x 5/8

Steering Wheel Removal and Installation

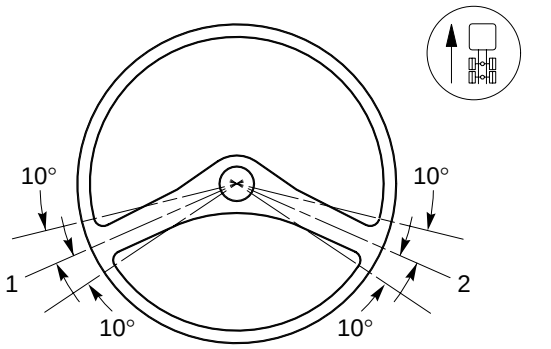
x 1/4 inch can be used with the puller to protect the wires during steering wheel removal.

Installation (See Fig. 1)

NOTE: Before installing the steering wheel, make sure the front tires are pointed straight ahead, and the steering gear is centered.

1. Place the steering wheel on the steering column so that the steering wheel spokes are positioned at 4 o'clock and 8 o'clock, or within 10 degrees of either side. **See Fig. 2.**

   Insert the horn ground wires (from the center of the wheel tube shaft) through the center of the wheel nut. Install the wheel nut, and tighten it 60 lbf·ft (81 N·m).



1. 8 o'Clock 2. 4 o'Clock

Fig. 2, Center the Steering Wheel

2. Connect the ground wire terminals to the horn button. Pack the horn wires with dielectric grease.
3. With the steering wheel in the straight-ahead position, push the horn button into place (with the logo aligned with the wheel spokes) in the steering wheel hub.

Tilt/Telescoping Column Removal and Installation

Removal

1. Park the vehicle on a level surface. Make sure the front tires are pointing forward. Shut down the engine, apply the parking brakes, and chock the tires.

IMPORTANT: Once the vehicle is parked, do not turn the steering wheel at any time during the following procedures.

2. Disconnect the batteries.
3. Remove the under-dash panels from each side of the steering column. See **Fig. 1**.
4. Remove the lower steering column cover panel.
5. Remove and discard the pinch bolt and nut from the upper end yoke.
6. Loosen the clamp which holds the trailer brake control valve mounting bracket to the steering column. Remove the control valve from the steering column by sliding the bracket out of the clamp.
7. Loosen the clamp bolt on the turn signal switch mounting bracket. Remove the turn signal switch mounting assembly from the steering column. Disconnect the wiring connector from the turn signal switch.
8. Disconnect the horn wire from the steering column.
9. Remove the upper end yoke from the steering column shaft.
10. Remove the two rear capscrews that attach the steering column and spacer block to the mounting bracket.
11. Loosen the two forward capscrews.
12. Remove the steering column assembly from the vehicle.

Installation

1. Position the steering column and spacer block on the steering column mounting bracket. Tighten the capscrews 15 lbf·ft (20 N·m).

NOTE: To ease installation, hold the column control lever down and tilt the steering column.

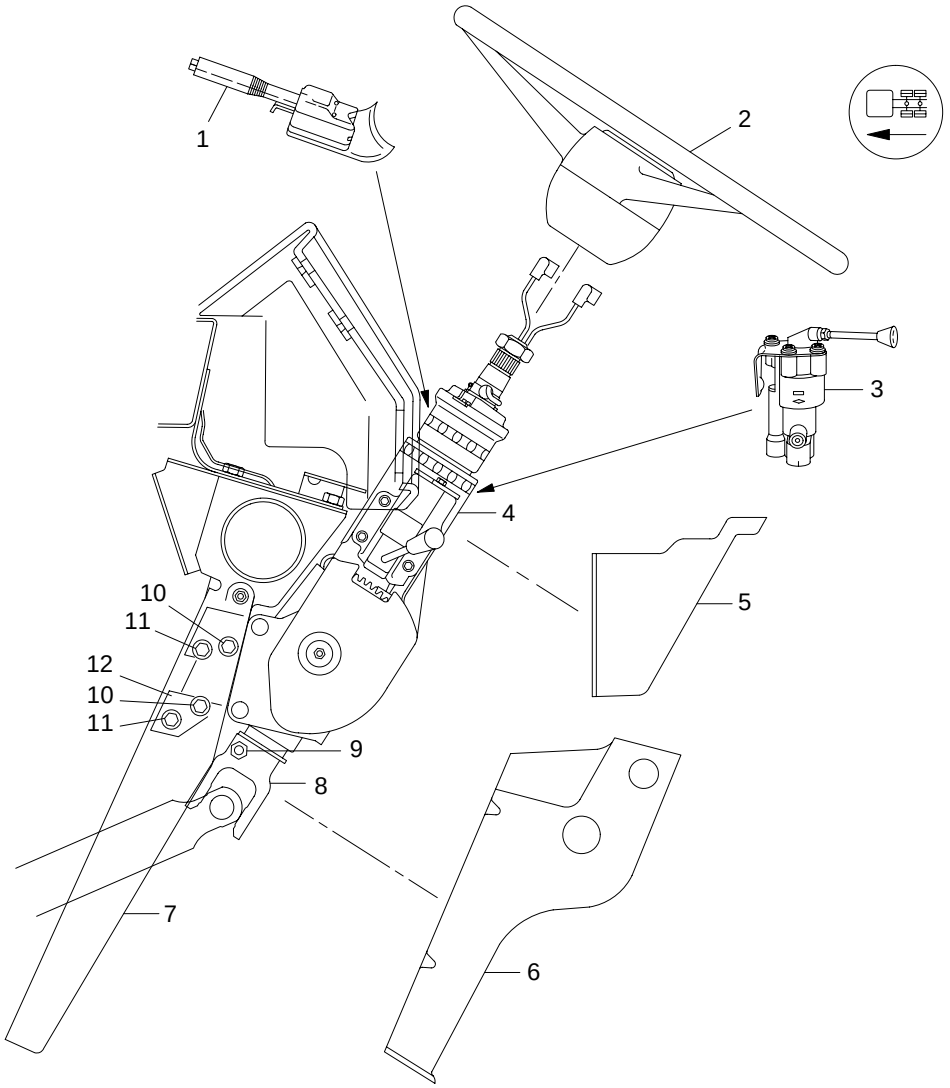
2. Wipe the end of the column shaft with a clean, dry cloth.
3. Slide the upper end yoke on the column shaft. Install a new pinch bolt. Before installing the nut, make sure the pinch bolt is centered in the steering column shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install and tighten a new nut. Tighten the nut to one of the following torque specs:
   - 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16 pinch bolt and nut
   - 30 to 35 lbf·ft (41 to 47 N·m) for an M10 pinch bolt and nut
4. Apply torque seal, OGP F900WHITE, to the exposed bolt threads and to the nut.
5. Connect the horn wire. Secure the wire to the steering column with electrical tape.
6. Place the turn signal switch mounting assembly on the steering column. Align the switch so that it is pointed directly to the left, toward the driver's door. Firmly tighten the clamp bolt. Connect the turn signal harness connector.

NOTE: Make sure there is slack in the turn signal harness. This will allow the turn signal switch assembly to move with the tilt/telescoping column assembly.

7. Slide the trailer brake control valve mounting bracket through the clamp on the steering column. Firmly tighten the clamp.
8. Install the under-dash panels on each side of the steering column. Tighten the fasteners securely.
9. Install the lower steering column cover. Tighten the fasteners securely.
10. Check the position of the steering wheel when the front tires are pointing forward. The steering wheel spokes must be within ±10 degrees of the 4 o'clock and 8 o'clock positions. See **Fig. 2**.

    If necessary, remove the steering wheel and reposition it. See **Subject 100** for instructions.
11. Connect the batteries.
12. Remove the chocks from the tires.

Tilt/Telescoping Column Removal and Installation



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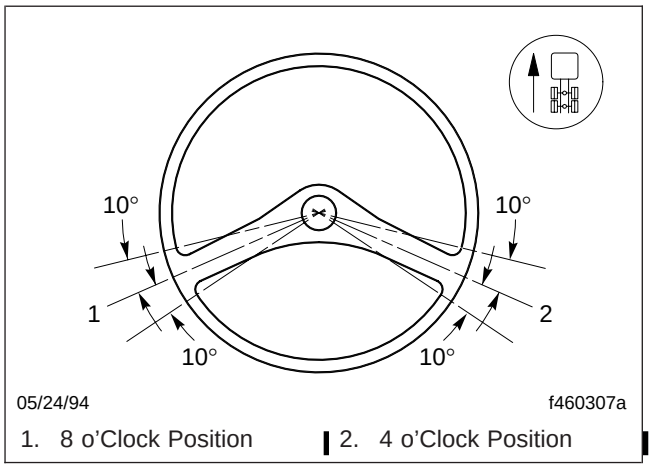
NOTE: FLD Conventional steering shaft shown.

1. Turn Signal Switch and Mounting Bracket
2. Steering Wheel
3. Trailer Brake Control Valve
4. Tilt Steering Column Assembly
5. Under-Dash Panel
6. Lower Steering Column Cover
7. Steering Column Mounting Bracket
8. Upper End Yoke
9. Pinch Bolt and Nut
10. Rear 5/16–18 Capscrew
11. Forward 5/16–18 Capscrew
12. Spacer Block

Fig. 1, Tilt Steering Column Installation

13. Test drive the vehicle and make sure the steering column assembly operates smoothly. If it does not operate smoothly, repeat the service operations.



1. 8 o'Clock Position 2. 4 o'Clock Position

Fig. 2, Steering Wheel Centered

Disassembly (See Fig. 1)

WARNING

WARNING: All steering mechanisms are critical safety items. Because of this, follow the instructions in this subject to the letter. Failure to do so may result in loss of steering, which could cause an accident resulting in personal injury or property damage.

Wear eye protection during disassembly of the tilt steering wheel column assembly. Parts of the assembly are spring-loaded, and could be ejected, which could result in serious eye injury.

NOTE: If replacing only the following parts, it is not necessary to remove the steering wheel and column assembly from the vehicle: control lever, spring cover plate, actuator housing, cam actuator, pivot pin, lockpin, antirattle spring, disengagement plate, spring and wedgelock, and the spring and lockbar.

1. To minimize spring tension within the column assembly, hold the control lever all the way down, then move the steering wheel to the upright (non-tilt) position; release the control lever.

   Pull up the control lever and move the steering wheel up until it stops; release the control lever.
2. Remove the steering wheel from the column assembly. Refer to **Subject 100** for instructions.
3. Remove the steering column assembly from the vehicle. Refer to **Subject 110** for instructions.
4. Unscrew the control lever (Ref. 36).
5. Remove the 10–24 x 5/8-inch tapping screw (Ref. 32) from the spring cover plate (Ref. 33). Remove the plate.
6. Remove the four tapping screws (Refs. 32 and 34) from the actuator housing and bushing assembly (Ref. 35). Remove the actuator housing.

NOTE: On some tilt/telescoping column assemblies, two of the self-tapping screws (Ref. 32) are 5/8-inch long, and the other two screws (Ref. 34) are 7/8-inch long.

7. Remove the spring (Ref. 31), cam actuator (Ref. 38), pivot pin (Ref. 39), lockpin (Ref. 30), and anti-rattle spring (Ref. 37).
8. Remove the disengement plate (Ref. 29), spring and wedgelock (Refs. 28 and 40), and spring and lockbar (Refs. 27 and 41).

   Remove all grease from the wedgelock/ lockbar cavity.
9. Detach the springs (Refs. 43 and 45) from the main housing assembly (Ref. 26). Remove the upper spring cover (Ref. 42).
10. Remove the four bolts (Ref. 8) from the support bracket (Ref. 25) and lower bearing housing (Ref. 21).
11. Remove the spring (Ref. 8) from the jacket tube (Ref. 16).
12. Remove the lower spring cover (Ref. 44), springs (Refs. 43 and 45), and spring retaining rod (Ref. 22) from the lower bearing housing.
13. Remove the retaining ring (Ref. 19) from the lower end of the universal joint assembly (Ref. 23). Remove the universal joint assembly from the lower bearing housing.
14. Using a suitable bearing puller, remove the bearings (Ref. 20) from the lower bearing housing.

    Using a 3/16-inch allen wrench, remove the pipe plug (Ref. 24) from the end of the universal joint assembly.
15. Remove the stopscrew (Ref. 2) and lockwasher (Ref. 1) from the main housing assembly (Ref. 26).
16. Push the wheel tube and jacket tube (Refs. 15 and 16) out through the lower end of the main housing assembly.
17. Remove the two retaining rings (Refs. 9 and 10) from the top end of the wheel tube and sleeve assembly and the jacket tube.

CAUTION

CAUTION: Keep the jacket tube clean and free of lubricant. Also, don't dent or scratch the jacket tube. Dents or scratches could restrict the telescoping action of the tilt steering column assembly.

Column Disassembly and Assembly

18. Insert an 8 x 3/4-inch (20 x 2 cm) rod into the splined sleeve end of the wheel tube. Using a press, press out the wheel tube and sleeve assembly. Remove the retaining ring (Ref. 14).
19. Using a suitable bearing removal tool, press the bearings (Ref. 11) off of the wheel tube and sleeve assembly. Remove the retaining ring (Ref. 13).
20. Remove the self-tapping screws (Ref. 4), stop cover (Ref. 3), and the stop pins (Ref. 5) from the main housing assembly.
21. Remove the setscrews (Ref. 7) from the support bracket. Remove the two pivot screws (Ref. 6), then separate the support bracket (Ref. 25) from the main housing.

NOTE: For ease of removal, it may be necessary to heat the setscrews and pivot screws. Don't exceed 500°F (260°C) as the material hardness of these fasteners will be affected.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

22. Using a petroleum-based solvent, clean the pivot screws, setscrews, and the internal threads of the support bracket.

Assembly (See Fig. 1)

⚠ WARNING

WARNING: Wear eye protection during assembly of the tilt steering wheel column assembly. Parts of the assembly are spring-loaded, and could be ejected, which could result in serious eye injury.

1. Position the support bracket (Ref. 25) in the main housing (Ref. 26). Make sure that the bracket teeth are on the same side of the housing as the cam actuator (Ref. 38).
2. Install but don't tighten the pivot screws (Ref. 6). Insert a 1/2 x 3 inch (13 x 76 mm) bolt and nut through the center of the support bracket, between the bracket flanges.

   Back off the nut to spread the flange bosses against the main housing and provide clearance for installation of the lower bearing housing (Ref. 21).

   Remove the pivot screws (Ref. 6).
3. Apply a light coating of lithium grease under the head of each pivot screw (Ref. 6) then, apply Loctite RC680 to the threads of the pivot screws.

NOTE: Use care and avoid getting any grease on the pivot screw threads, or Loctite RC680 under the pivot screw head.

4. First tighten the pivot screw on the cam-actuator side of the housing 40 to 45 lbf·in (460 to 500 N·cm). Install and tighten the other pivot screw 40 to 45 lbf·in (460 to 500 N·cm).
5. Apply Loctite RC680 to the threads of the setscrews (Ref. 7). Install the setscrews and tighten them 50 to 60 lbf·in (560 to 680 N·cm).

NOTE: Use care and avoid getting any Loctite RC680 under the setscrew head.

6. Remove the 1/2 x 3-inch bolt and nut from the support bracket.
7. Install two new retaining rings (Refs. 13 and 14) on the top end of the wheel tube and sleeve assembly (Ref. 15).
8. Apply Loctite RC680 around the wheel tube in the bearing support area. Install a new bearing (Ref. 11) against the upper retaining ring.
9. Install the bearing spacer (Ref. 12). Install a new bearing (Ref. 11) until it clears the upper retaining ring groove. Install a new retaining ring (Ref. 10).
10. Insert the wheel tube and sleeve assembly (Ref. 15) into the jacket tube (Ref. 16). Align the split in the bearing spacer (Ref. 12) with the screw hole in the top end of the jacket tube.
11. Using a tubular bearing installation tool, apply pressure against the outer race of the upper bearing and press the wheel tube and sleeve assembly into the jacket tube.

    Install retaining rings (Refs. 9 and 17) in the grooves of the jacket tube.

12. Place the jacket tube assembly spring-end down on a pedestal that is about 4 inches (10 cm) high and 2-1/4 inches (6 cm) in diameter. Make sure that the cutouts on the lower collet in the main housing assembly are aligned with the holes for the lockpin (Ref. 30) and stopscrew (Ref. 2).
13. Slide the main housing assembly down over the jacket tube assembly. As the upper end of the jacket tube approaches the upper tapered collet of the main housing, push the collet down with a screwdriver (or other suitable tool) to pilot the wheel tube assembly into the housing bore.
14. Align the jacket tube's guide slot with the stopscrew (Ref. 2) hole in the main housing assembly (Ref. 26). Install the lockwasher and stopscrew (Refs. 1 and 2). Tighten the stopscrew 10 to 15 lbf·ft (14 to 20 N·m).
15. Press a new bearing (Ref. 20) into each end of the lower bearing housing (Ref. 21).
16. Slide the shaft of the universal joint assembly (Ref. 23) into the lower bearing housing until it seats against the lower bearing.

    Install the retaining ring (Ref. 19) on the universal joint shaft.
17. Install the pipe plug (Ref. 24) in the slotted end of the universal joint shaft. Tighten the pipe plug finger-tight.

NOTE: Don't overtighten the pipe plug. Overtightening the pipe plug will make it difficult to install the universal joint shaft in the wheel tube and sleeve assembly (Ref. 15).

18. Install the spring retaining rod (Ref. 22) in the lower bearing housing.
19. Hook one end of the green spring (Ref. 43) on the right side of the spring retaining rod (Ref. 22). Hook one end of the other spring (Ref. 45) on the left side of the spring retaining rod.
20. Clamp the serrated end of the wheel tube and sleeve assembly (Ref. 15) in a soft-jawed vise.
21. Push all the way down on the jacket tube (Ref. 16), then install the spring (Ref. 18).
22. Install the universal joint assembly (Ref. 23) through the spring (Ref. 18) and into the wheel tube and sleeve assembly (Ref. 15). Make sure that a slot in the splined shaft of the universal joint assembly aligns with the wide groove in the splined sleeve of the wheel tube and sleeve assembly.
23. Holding down on the universal joint assembly, align the lower bearing housing (Ref. 21) and support bracket (Ref. 25) screw holes. Install the bolts (Ref. 8). Tighten them 25 to 35 lbf·ft (34 to 47 N·m).
24. Position the lockbar (Ref. 41) on the main housing. Make sure that the lockbar locating pin is out, and that the teeth mesh with the support bracket teeth.
25. With the tapered end pointing towards the support bracket teeth, place the wedgelock (Ref. 40) on the main housing, under the lockbar.
26. Position the disengagement plate (Ref. 29) over the lockbar and wedgelock locating pins.
27. Insert the lockpin (Ref. 30) into the cam actuator (Ref. 38). Make sure that the spring hole in the cam and lockpin are facing each other.

    Insert the pivot pin (Ref. 39) through the cam actuator and lockpin. Check that the pivot pin is flush at the bottom of the cam actuator.
28. Attach one end of the anti-rattle spring (Ref. 37) to the lockpin, and the other end to the cam actuator.

    Lightly oil the lockpin assembly. Insert the lockpin into the bushing on the main housing assembly. Make sure that the ears on the cam actuator (Ref. 38) fit under the raised tabs on the disengagement plate (Ref. 29).
29. Insert the actuator housing spring (Ref. 31) into the end of the lockpin (Ref. 30). Using four self-tapping screws (Refs. 32 and 34), attach the actuator housing (Ref. 35) to the main housing. Tighten the screws 40 to 60 lbf·in (460 to 680 N·cm).

NOTE: On some tilt/telescoping column assemblies, two of the self-tapping screws (Ref. 32) are 5/8-inch long, and the other two screws (Ref. 34) are 7/8-inch long.

30. Attach the lockbar and wedgelock springs (Refs. 27 and 28). Install the spring cover plate (Ref. 33) over the lockbar and wedgelock springs. Tighten the self-tapping screw (Ref. 32) 40 to 60 lbf ·in (460 to 680 N ·cm).

Column Disassembly and Assembly

31. Screw the control lever (Ref. 36) into the cam actuator (Ref. 38).
32. Push down on the control lever and tilt the steering column all the way down. Release the control lever.
33. Snap the lower spring cover (Ref. 44) onto the retaining rod, between the springs.
34. Slide the upper spring cover (Ref. 42) over the springs, engaging the slot on the lower spring cover.
35. Push down on the control lever, then tilt the steering column all the way up. Release the control lever. Using a suitable spring assembly tool, hook the loose ends of the springs (Refs. 43 and 45) in the holes of the main housing assembly (Ref. 26).
36. Insert and lightly tap the stop pins (Ref. 5) to seat them into the holes lettered "D" and "K."
37. Install the stop cover (Ref. 3) with the self-tapping screws (Ref. 4). Tighten the screws 40 to 60 lbf·in (460 to 680 N·cm).
38. Push the jacket tube (Ref. 16) and wheel tube assembly (Ref. 15) all the way down. Using a 3/16-inch allen wrench that is 12-inches (30-cm) long, tighten the pipe plug (Ref. 24) just enough to keep the jacket tube and wheel tube assembly in position when the lockpin (Ref. 30) is disengaged.

    Loosen the pipe plug about a one-eighth turn to allow the wheel tube assembly to telescope freely under spring tension.
39. Check the operation of the tilt/telescoping column assembly as follows:

    39.1 Unlock the column assembly by pushing and holding the control lever all the way down. Tilt the column to any position, then release the control lever to lock it in place. Tilt the column to several other positions to ensure proper operation.

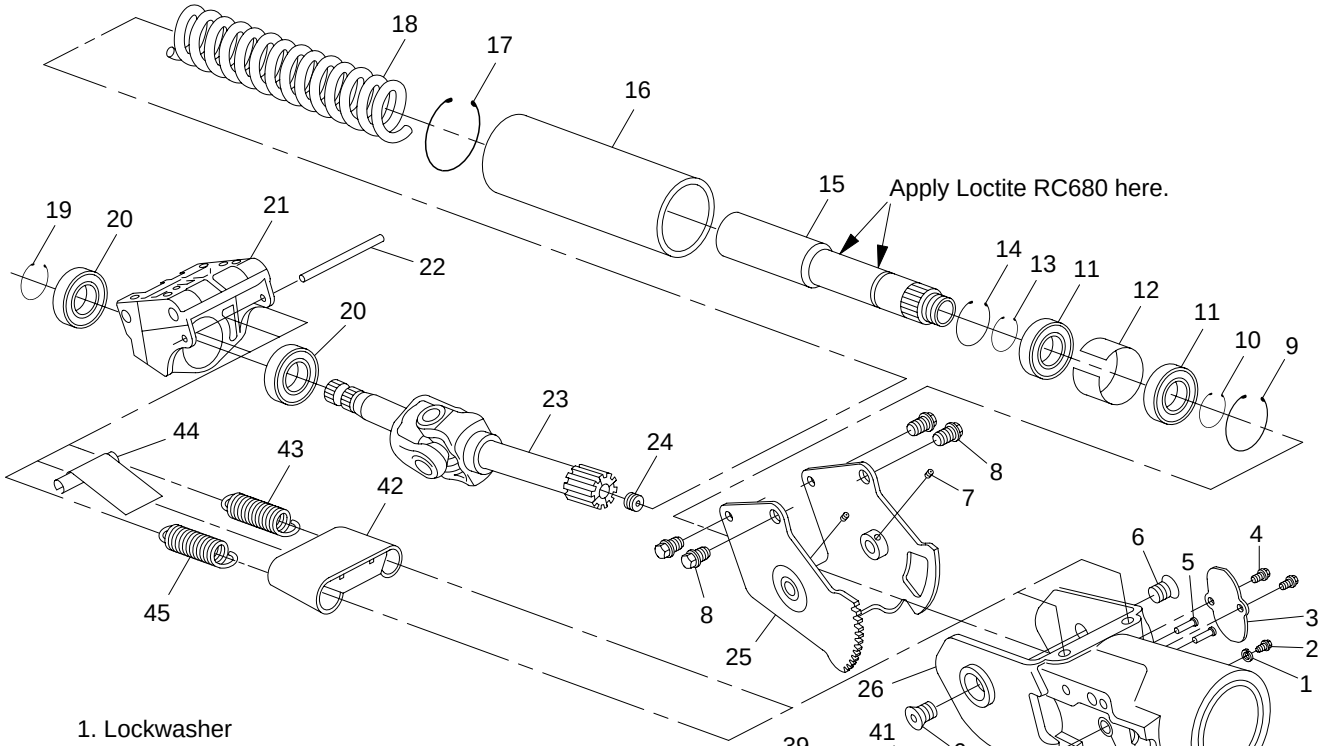
    39.2 Unlock the column assembly by pulling and holding the control lever all the way up. Move the column up or down to any position, then release the control lever to lock it in place. Telescope the column to several other positions to ensure proper operation.

    If the column telescoping action is sluggish or sticks, spray a small amount of Tri-Flow lubricant, or an equivalent, on the jacket tube (Ref. 16) while the column is all the way up.

NOTE: The tilt/telescoping column assembly must sit at room temperature for 24 hours to allow the Loctite RC680 to dry.

40. Install the tilt/telescoping column assembly. Refer to **Subject 110** for instructions.
41. Install the steering wheel. Refer to **Subject 100** for instructions.

Column Disassembly and Assembly



1. Lockwasher
2. Stopscrew
3. Stop Cover
4. 10−24 x 1/2" Self−Tapping Screw
5. Stop Pin
6. Pivot Screw
7. Setscrew
8. 3/8−16 x 1" Bolt
9. Retaining Ring
10. Retaining Ring
11. Bearing
12. Bearing Spacer
13. Retaining Ring
14. Retaining Ring
15. Wheel Tube and Sleeve Assembly
16. Jacket Tube
17. Retaining Ring
18. Spring
19. Retaining Ring
20. Bearing
21. Lower Bearing Housing
22. Spring Retaining Rod
23. Universal Joint Assembly
24. Pipe Plug
25. Support Bracket
26. Main Housing Assembly
27. Lockbar Spring
28. Wedgelock Spring
29. Disengagement Plate
30. Lockpin
31. Actuator Housing Spring
32. 10−24 x 5/8" Self−Tapping Screw
33. Spring Cover Plate
34. 10−24 x 7/8" Self−Tapping Screw
35. Actuator Housing and Bushing Assembly
36. Control Lever
37. Anti−Rattle Spring
38. Cam Actuator
39. Pivot Pin
40. Wedgelock
41. Lockbar
42. Upper Spring Cover
43. Right−Side Spring (Green)
44. Lower Spring Cover
45. Left−Side Spring

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Fig. 1

Specifications

Torque Values			
Description	**Size**	**Torque**	
		lbf·in (N·cm)	**lbf·ft (N·m)**
Self-Tapping Screws	10–24	40–60 (460–680)	—
Bolts	3/8 x 16 x 1 Inch	—	25–35 (34–47)
Main Housing Stopscrew	—	—	10–15 (14–20)
Support Bracket Setscrews	—	50–60 (560–680)	—
Main Housing Pivot Screws	—	40–45 (460–500)	—
Steering Column Mounting Bracket Capscrews	5/16–18	—	28 (38)
Steering Driveline Upper End Yoke Pinch Bolt Nut	3/8–16	—	35–40 (47–54)
	3/8–24	—	40–48 (54–65)
	M10 x 1.25	—	30–35 (41–47)
Steering Wheel Nut	—	—	60 (81)

Table 1, Torque Values

General Information (See Fig. 1)

The steering wheel is cushion-rimmed, with two low-mounted spokes for unimpaired gauge visibility. A button for the electric horn is mounted in the center of the wheel hub.

Major parts of the steering column assembly are a jacket (tube), bearing assemblies (staked in place in the top and bottom of the jacket), a steering column shaft, and wiring and contact assemblies for the electric horn. At the upper end of the steering column shaft are threads to accept a wheel nut, and straight

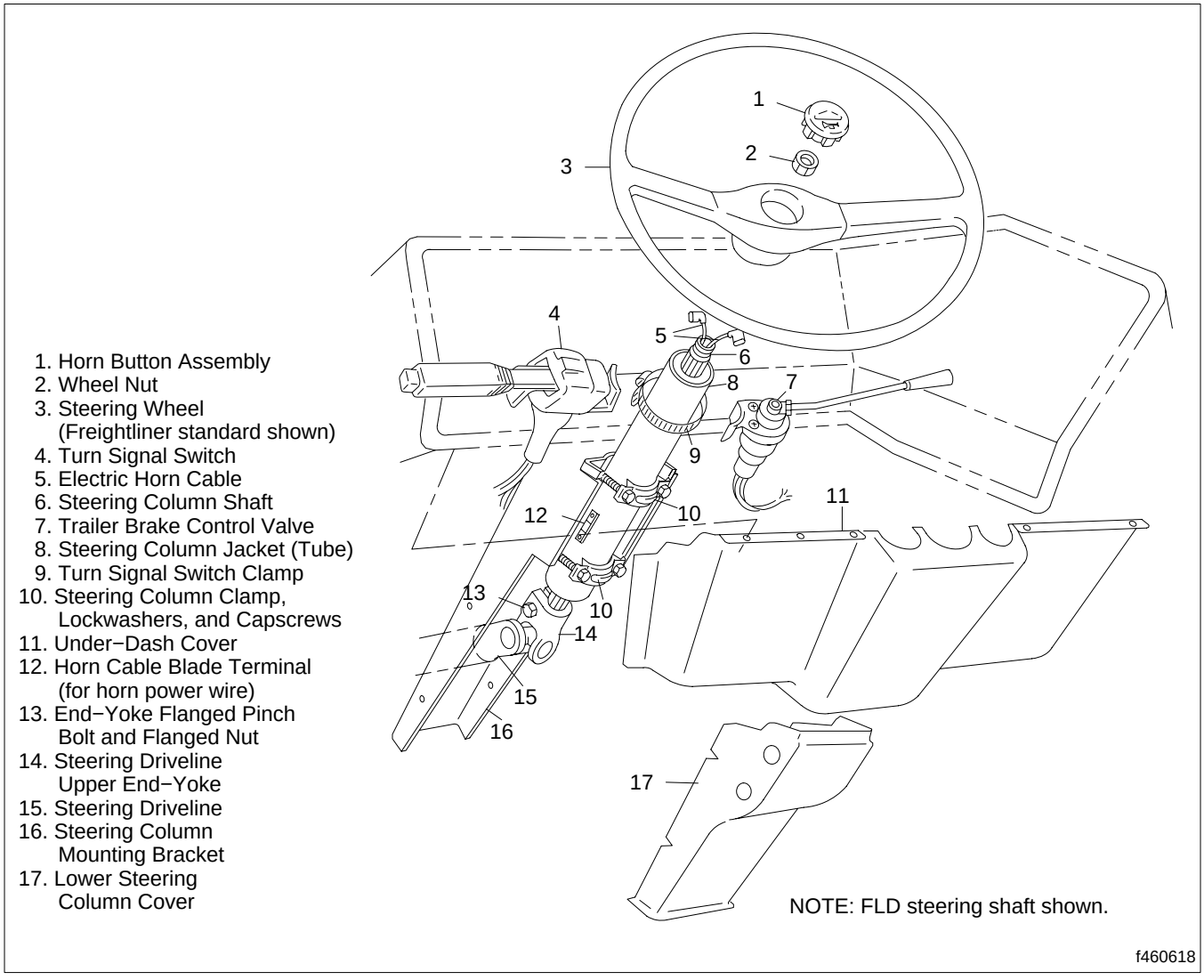


Fig. 1, Steering Wheel and Column Assembly Installation

A turn signal switch is clamped just below the steering wheel, onto the left side of the steering column. If the vehicle is equipped with a trailer brake control valve, it is clamped onto the right side of the steering column.

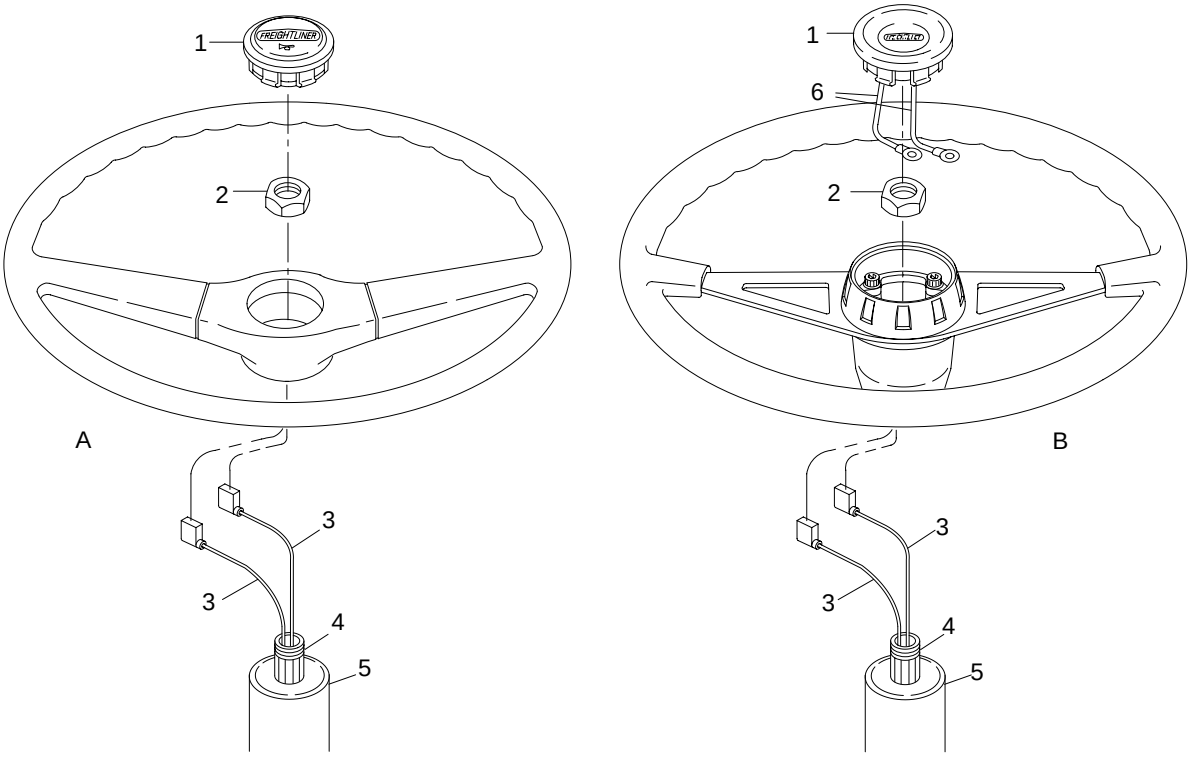
external serrations to match the internal serrations of the steering wheel hub. The lower end has straight external serrations to match the internal serrations of the steering driveline upper end-yoke. The steering column assembly is attached to the dash steering column bracket with two clamps that are hidden by

General Information

the under-dash cover. A lower steering column cover extends from the under-dash cover to the floor. The steering column assembly is not repairable; if any steering column parts are damaged or badly worn, the steering column assembly must be replaced.

Steering Wheel Removal and Installation

Removal (See Fig. 1)



A. Freightliner Standard Steering Wheel
B. VIP Sport Steering Wheel
1. Horn Button Assembly
2. Wheel Nut
3. Electric Horn Cable
4. Steering Column Shaft
5. Steering Column Jacket
6. Horn Button Pigtail Wires

Fig. 1, Steering Wheel Installation

NOTE: Remove the steering wheel only if the steering wheel or steering column is being replaced. If the wheel and column are being removed to allow servicing of the dash, remove the steering wheel and column as an assembly; see **Subject 110**.

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the place where service operations will be performed. Don't turn the steering wheel or front tires at any time during this procedure.

   Apply the parking brakes, and chock the tires.

2. Using a small screwdriver, pry under the outermost ring of the steering wheel horn button. Lift the horn button assembly out of the steering wheel hub; then pull the horn cable ends off the horn button terminals or pigtail wires.

3. While holding the steering wheel to keep it from turning, remove the wheel nut from the end of the steering column shaft.

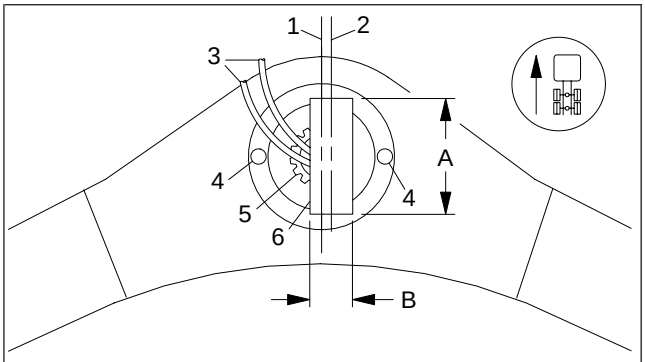
4. Using a steering wheel puller, remove the wheel from the shaft.

IMPORTANT: Be careful when removing the steering wheel, or you could damage the horn wires. A steel block measuring 1-5/8 x 5/8 x 1/4 inch (40 x 15 x 6 mm) can be used between the puller and the end of the steering column shaft to protect the wires during steering wheel re-

Steering Wheel Removal and Installation

moval. Position the center of the steel block a little to one side of the center of the shaft, with both wires on the opposite side of the shaft. See **Fig. 2**.

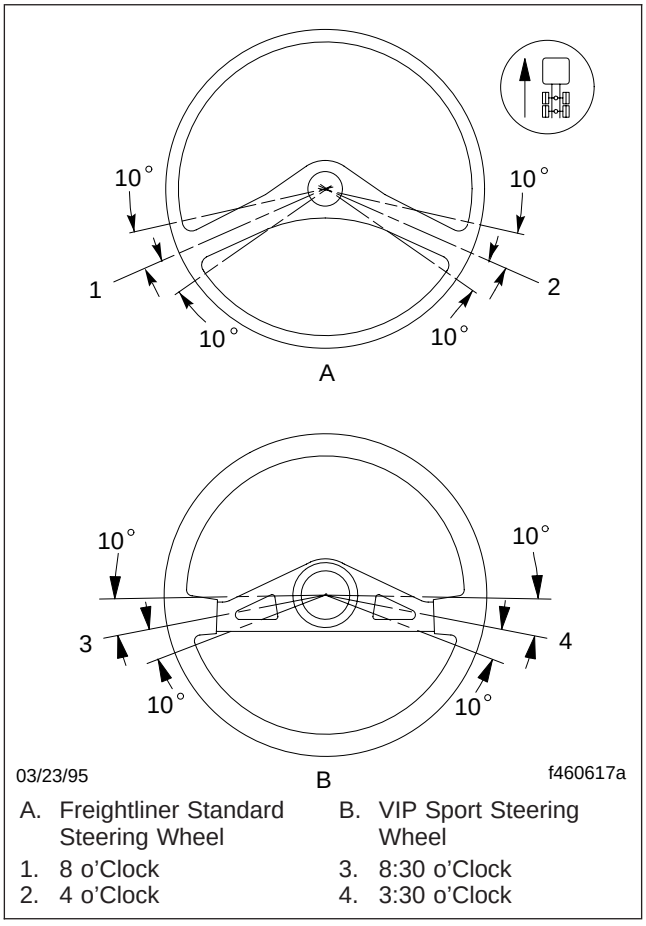
Installation (See Fig. 1)



A. 1-5/8" (40 mm)
B. 5/8" (16 mm)
1. Centerline of Steering Column Shaft
2. Centerline of Steel Block
3. Electric Horn Harness
4. Threaded Hole for Steering Wheel Puller
5. Steering Column Shaft
6. 1/4" (6mm) Thick Steel Block

Fig. 2, Position the Steel Block

1. If the steering column assembly is being replaced, install the new column before installing the steering wheel; see **Subject 110**.
2. Before installing the steering wheel, be sure the front tires are straight ahead and the steering gear is centered. Then, verify that the steering system is properly connected and adjusted. Check that the toe-in is correct, the pitman arm is aligned with the timing mark on the steering gear output shaft, the drag link is installed and adjusted to the proper length, and the steering driveline U-joints are properly phased.
3. Insert the horn cables (from the center of the steering column shaft) through the center of the steering wheel, then place the wheel on the steering column with the wheel spokes in the positions shown in **Fig. 3**.
4. Insert the horn cables through the center of the wheel nut, and install the nut on the steering column shaft; tighten the nut 60 lbf·ft (81 N·m).
5. Connect the horn cable ends to the horn button terminals or pigtail wires. Pack the horn wires with dielectric grease.
6. Holding the horn button so its logo is aligned with the steering wheel spokes, push it into place in the hub.



A. Freightliner Standard Steering Wheel
B. VIP Sport Steering Wheel
1. 8 o'Clock
2. 4 o'Clock
3. 8:30 o'Clock
4. 3:30 o'Clock

Fig. 3, Center the Steering Wheel

Steering Column Assembly Removal and Installation

Removal

NOTE: The steering column assembly is not repairable. If any steering column parts are damaged or badly worn, the steering column assembly must be replaced. For an illustration of the steering column assembly, see **Fig. 1**.

1. Park the vehicle on a level surface. Make sure the front tires are pointing forward. Shut down the engine, apply the parking brakes, and chock the tires.

IMPORTANT: Once the vehicle is parked, do not turn the steering wheel at any time during the following procedures.

2. Disconnect the batteries.
3. Remove the under-dash cover and the steering column cover from the vehicle.
4. Disconnect the horn power wire.
5. If the steering column assembly is being replaced, remove the steering wheel. For instructions, see **Subject 100**.
6. Loosen the clamp that holds the trailer brake control valve and the turn signal switch assembly on the steering column. Slide the control valve bracket up and out of the clamp, and set the control valve to one side. Remove the turn signal switch assembly from the steering column. Set the turn signal switch assembly to one side. Remove the clamp.
7. Remove and discard the pinch bolt and nut from the upper end yoke.
8. Remove the capscrews and washers that attach the steering column clamps and the column to the steering column mounting bracket. Remove the clamps and the steering column assembly from the vehicle.

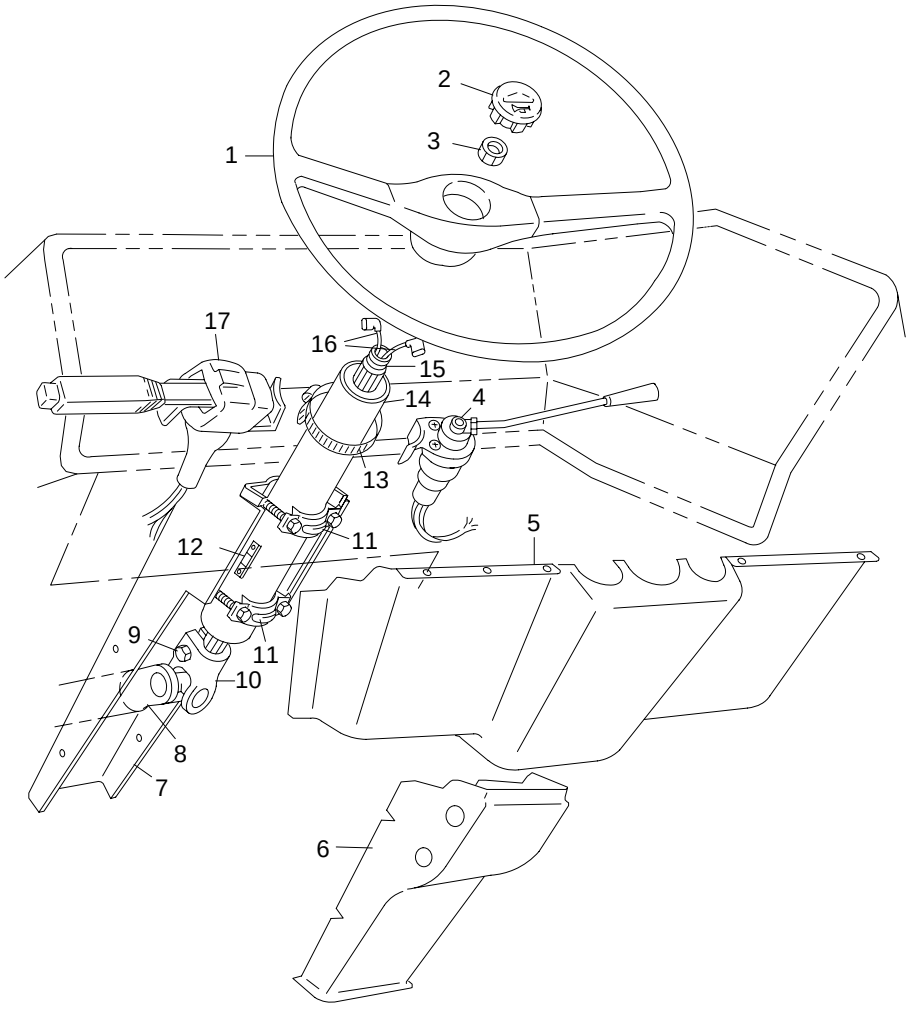
Installation

1. Position the front of the steering column assembly against the dash and the steering column mounting bracket. The head of the bolt on the front of the column must fit into the mounting bracket. The bolt is 2 inches (51 mm) up from the bottom of the steering column jacket.
2. Install the steering column clamps, capscrews, and washers. Tighten the capscrews 15 lbf·ft (20 N·m).
3. Wipe the end of the steering column shaft with a clean, dry cloth.

IMPORTANT: If the steering wheel was not removed, make sure the front tires are pointing forward and the steering gear is centered. Before connecting the steering driveline to the steering column shaft, secure the steering wheel so its spokes are positioned as shown in **Fig. 2**.

4. Slide the upper end yoke on the steering column shaft. Install a new pinch bolt. Before installing the nut, make sure the pinch bolt is centered in the steering column shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install and tighten a new nut to one of the following torque specs:
   - 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16–20 pinch bolt and nut
   - 30 to 35 lbf·ft (41 to 47 N·m) for an M10 x 1.25 pinch bolt and nut
5. Apply torque seal, OGP F900WHITE, to the exposed bolt threads and to the nut.
6. If the steering wheel was removed, install it. For instructions, see **Subject 100**.
7. Connect the horn wire to the blade terminal.
8. Place the turn signal switch clamp on the steering column. Join the ends of the clamp, but do not tighten it. Install the turn signal switch. Align it so it is pointed directly to the left, toward the driver's door.
9. Slide the trailer brake control valve mounting bracket down through the clamp on the right side of the steering column. Firmly tighten the clamp.
10. Install the lower steering column cover. Securely tighten the fasteners.
11. Install the under-dash cover and check that the turn signal switch wiring harness and the trailer brake control valve and air hoses are aligned with the cutouts in the under-dash cover. If needed, loosen the mounting clamp and reposition the switch or valve to align with the cutouts. Tighten the clamp. Secure the under-dash cover by tightening the fasteners.

Steering Column Assembly Removal and Installation



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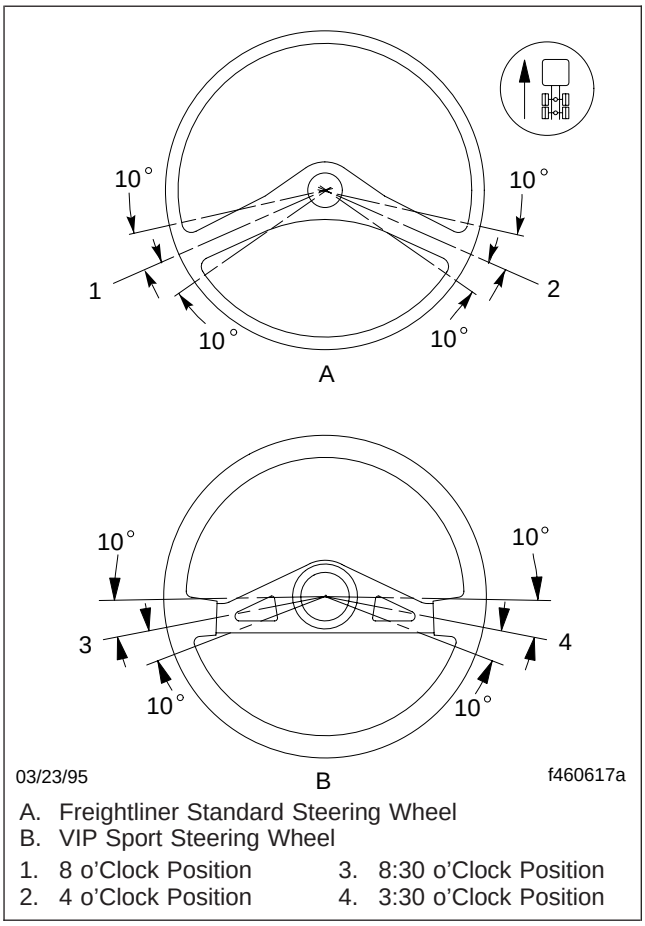
NOTE: FLD steering shaft shown.

1. Steering Wheel
2. Horn Button Assembly
3. Wheel Nut
4. Trailer Brake Control Valve
5. Under-Dash Cover
6. Lower Steering Column Cover
7. Steering Column Mounting Bracket
8. Steering Driveline
9. End Yoke Flanged Pinch Bolt and Flanged Nut
10. Steering Driveline Upper End Yoke
11. Steering Column Clamp, Washers, and Capscrews
12. Horn Cable Blade Terminal (for horn power wire)
13. Turn Signal Switch Clamp
14. Steering Column Jacket (tube)
15. Steering Column Shaft
16. Electric Horn Cable
17. Turn Signal Switch

Fig. 1, Steering Wheel and Column Assembly Installation

12. Connect the batteries.
13. Remove the chocks from the tires.
14. Test drive the vehicle and make sure the steering column assembly operates smoothly. If it does not operate smoothly, repeat the service operations.

Steering Column Assembly Removal and Installation



A. Freightliner Standard Steering Wheel
B. VIP Sport Steering Wheel

1. 8 o'Clock Position
2. 4 o'Clock Position
3. 8:30 o'Clock Position
4. 3:30 o'Clock Position

Fig. 2, Center the Steering Wheel

Check the position of the steering wheel spokes when the vehicle is traveling straight ahead on a level road. The steering wheel spokes must be positioned as shown in **Fig. 2**. If needed, remove the steering wheel and reposition it. For instructions, see **Subject 100**.

Specifications

Torque Values		
Description	**Size**	**Torque: lbf·ft (N·m)**
Steering Wheel Retaining Nut	—	60 (81)
Steering Column Clamp-to-Column Mounting Bracket Capscrew	—	15 (20)
Steering Driveline Upper End Yoke Pinch Bolt Nut	3/8–16	35–40 (47–54)
	3/8–24	40–48 (54–65)
	M10 x 1.25	30–35 (41–47)

Table 1, Torque Values

General Information

The TRW HFB70 power steering gears can be installed on vehicles with front axle capacities up to 16,000 pounds (7257 kg). The steering gear is mounted on the vehicle frame rail. **Fig. 1** or **Fig. 2**. The steering gear incorporates a manual steering mechanism, hydraulic control valve, and a hydraulic power cylinder. The control valve is a rotary design, which directs oil flow from the power steering pump to the upper or lower cylinder cavity.

Principles of Operation

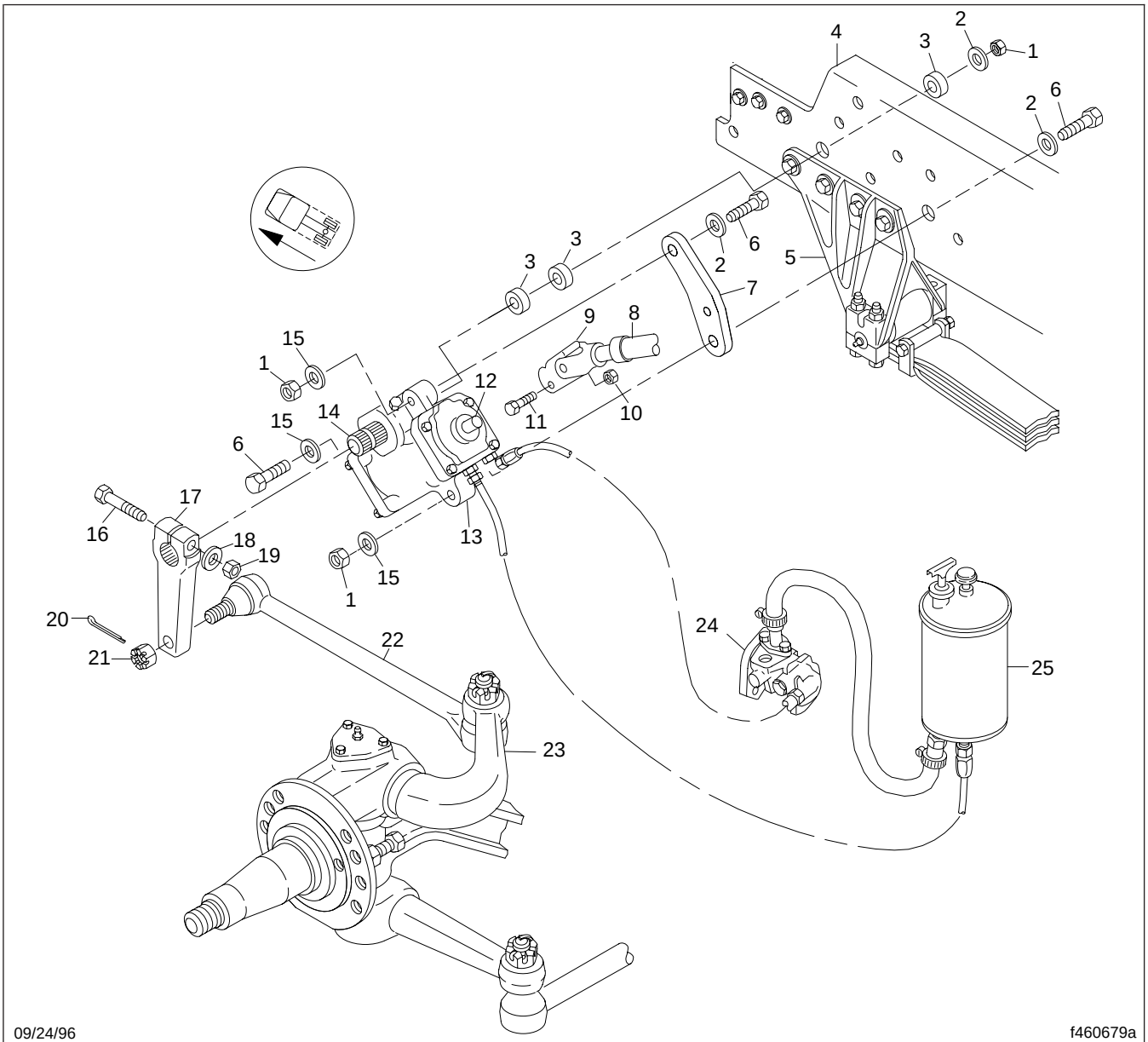
When the steering wheel is turned, force is transmitted from the steering wheel to the steering gear input shaft. A torsion bar, pinned at one end to the input shaft and at the other to the worm shaft, turns with the input shaft and exerts a rotational force on the worm shaft. In response, the worm shaft, acting through the recirculating ball mechanism, tries to move the rack piston up or down (as applicable) in the gear housing cylinder bore. See **Fig. 3**.

The movement of the rack piston is resisted by its engagement to the sector shaft, which is linked to the steered wheels. Because of this resistance, the torsion bar is twisted by the input shaft thereby actuating the control valve. Pressurized fluid, directed by the control valve to the upper or lower cylinder cavity (depending on the direction or turn), assists in moving the rack piston up or down (as applicable) in the cylinder bore. The rack piston then turns the sector shaft to steer the vehicle.

If the steered wheels receive a shock load, the shock forces are transmitted through the sector shaft to the rack piston and on to the worm shaft. The internal construction of the steering gear causes the control valve to send high-pressure fluid to the correct cylinder cavity to resist the shock forces. By absorbing the shock forces hydraulically, the steering gear prevents kick-back at the steering wheel.

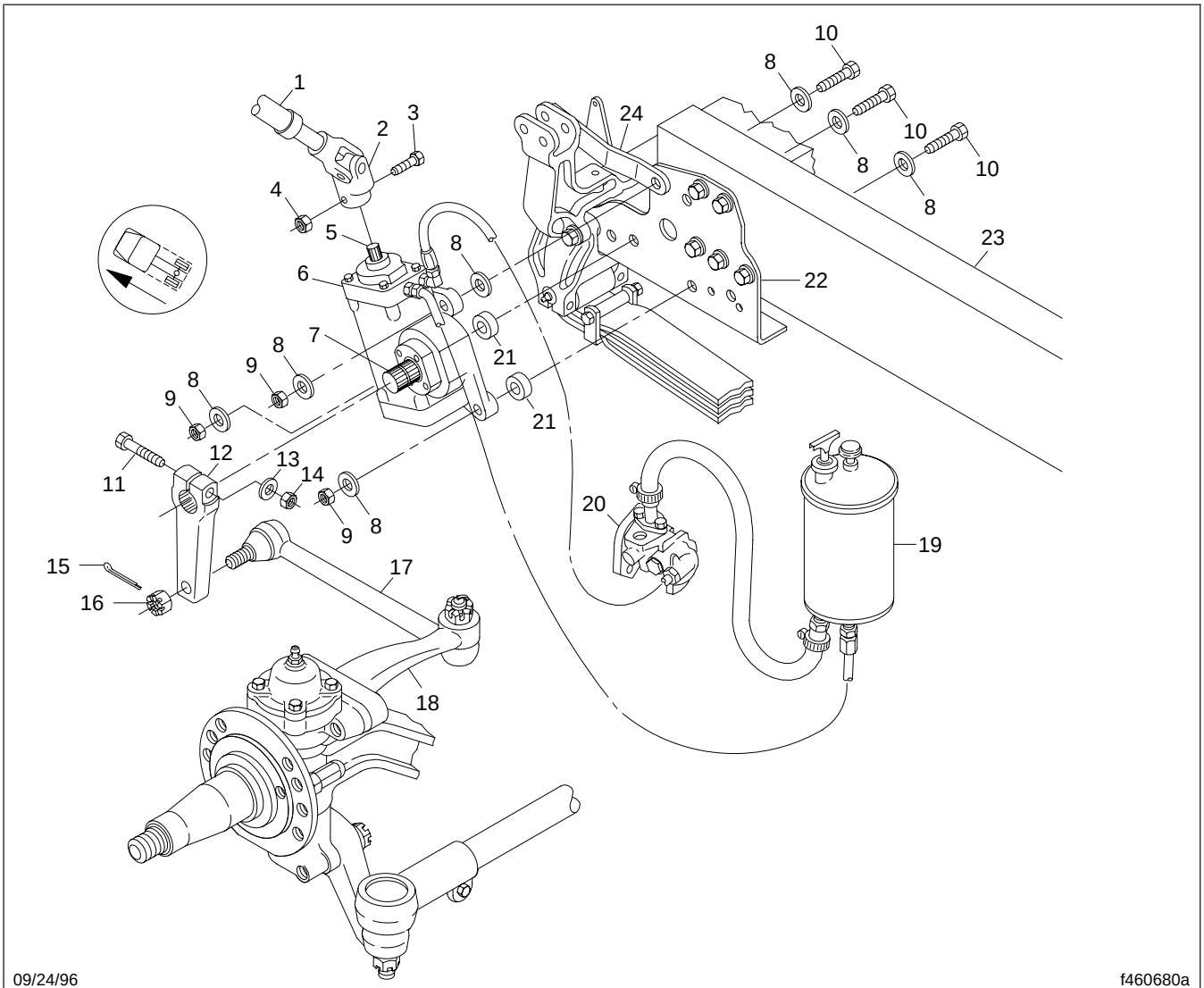
On each end of the rack piston is a poppet (unloading valve). The appropriate poppet will trip as the steered wheels approach the axle stop for that direction of turn. The tripped poppet reduces pressure in the gear, heat generated by the pump, and outside forces acting on the steering linkage.

General Information



1. Mounting Nut
2. Hardened Washer
3. Spacer
4. Left Frame Rail
5. Front Suspension Bracket
6. Mounting Bolt
7. Steering Gear Mounting Bracket
8. Steering Driveline
9. Lower End Yoke
10. Nut
11. Pinch Bolt
12. Input (worm) Shaft
13. Steering Gear
14. Sector (output) Shaft
15. Hardened Washer
16. Pinch Bolt
17. Pitman Arm
18. Washer
19. Nut
20. Cotter Pin
21. Castle Nut
22. Drag Link
23. Axle Steering Arm
24. Power Steering Pump
25. Power Steering Reservoir

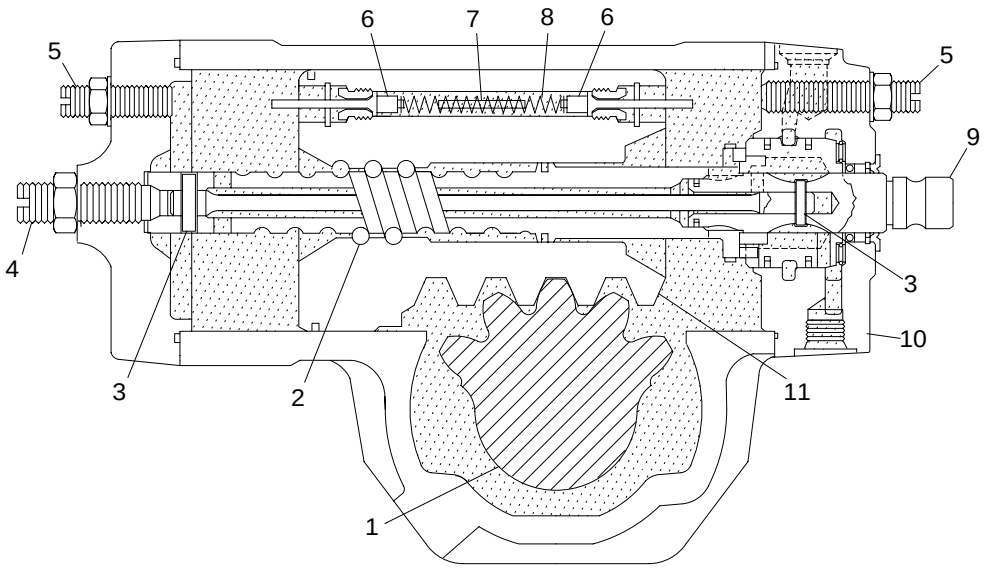
Fig. 1, TRW HFB70 Power Steering Installation (FLD)



1. Steering Driveline
2. Lower End Yoke
3. Pinch Bolt
4. Nut
5. Input (worm) Shaft
6. Steering Gear
7. Sector (output) Shaft
8. Hardened Washer
9. Mounting Nut
10. Mounting Bolt
11. Pinch Bolt |
12. Pitman Arm |
13. Washer
14. Nut
15. Cotter Pin
16. Castle Nut
17. Drag Link |
18. Axle Steering Arm |
19. Power Steering Reservoir |
20. Power Steering Pump
21. Spacer
22. Frame Extension |
23. Left Frame Rail
24. Cab Mount Strut

Fig. 2, TRW HFB70 Power Steering Installation (FLA)

General Information



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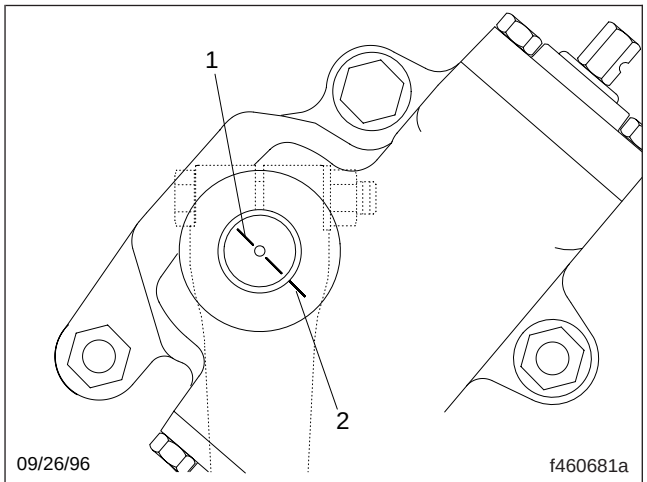
1. Sector Shaft
2. Ball (recirculating)
3. Pin
4. Preload
5. Poppet Adjusting Screw
6. Poppet Assembly
7. Spacer Rod
8. Poppet Spring
9. Input Shaft
10. Gear Housing
11. Rack Piston

Fig. 3, Steering Gear (section view)

Sector Shaft Adjustment

1. Position the sector (output) shaft at its center of travel by turning the steering wheel until the alignment mark on the sector shaft is at a right angle to the input shaft centerline and in line with the timing mark on the end of the housing trunnion. See **Fig. 1**.
2. Disconnect the drag link from the pitman arm. For instructions, refer elsewhere in this group.
3. With the sector shaft centered, grasp the pitman arm and gently try to move it back and forth. Fingertip force is adequate to detect lash (free play) of a loose sector shaft. See **Fig. 2**. There should be no movement of the input shaft or sector shaft. If there is no lash, no adjustment is needed.

   If there is lash, loosen the sector shaft adjusting screw jam nut and turn the adjusting screw clockwise until the sector shaft and rack piston are in contact. Use no more than 10 lbf·ft (14 N·m) of torque. Then turn the adjusting screw counterclockwise one turn. At this point there should be lash at the pitman arm.



1. Sector Shaft Timing Mark
2. Housing Trunnion Timing Mark

Fig. 1, Timing Marks

4. To adjust, slowly turn the adjusting screw clockwise until no lash is felt at the pitman arm. Hold the adjusting screw in place and tighten the jam nut 40 to 45 lbf·ft (54 to 61 N·m).

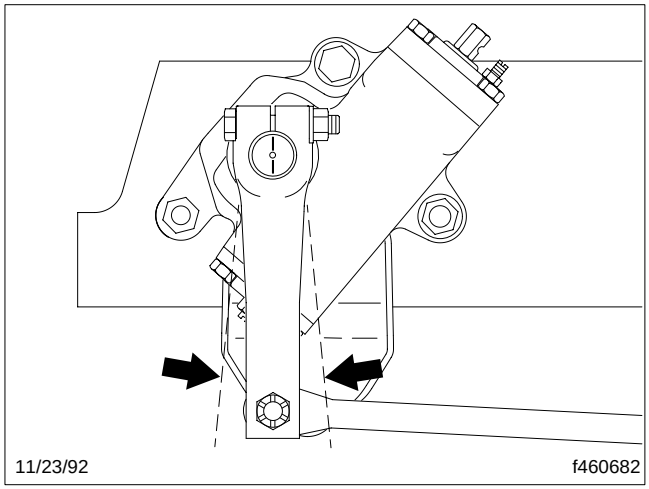


Fig. 2, Check Free Play

5. Again check the pitman arm for lash. Turn the steering wheel one-quarter turn each side of center. No lash should be felt. If lash exists, repeat steps as required.
6. Connect the drag link to the pitman arm. For instructions, refer elsewhere in this group.

Poppet Valves Adjustment

1. Check the settings of the axle stops and adjust them if necessary. For instructions, refer to the front axle section.
2. Install a flow meter kit in the supply line from the pump to the steering gear. Make sure that the flow meter can be pressurized. Warm the power steering fluid to operating temperature of 125° to 135°F (51° to 57°C).
3. Loosen both of the poppet valve adjusting screw jam nut.
4. With the engine at idle, have someone turn the steering wheel to the full-lock right position. Check the pressure gauge.

IMPORTANT: When the steering wheel is at the full-lock position, make sure the stop screw on the back of the wheel spindle contacts the axle boss. Failure to maintain contact while adjusting the poppet valve could cause incorrect adjustment.

In-Vehicle Adjustments

CAUTION

If power steering pump relief pressure is reached while the steering wheel is at full-lock, release the steering wheel from this position. Do not allow the pump relief pressure to be maintained for longer than five seconds or damage to the pump may result.

5. If the pressure gauge reading is less than 2000 psi (13 800 kPa), back out the poppet valve adjusting screw until the relief pressure reading is 1960 psi (13 514 kPa).

NOTE: The right-turn poppet valve adjusting screw is at the rear of the steering gear.

6. If system pressure exceeds the maximum pump relief pressure, repair the power steering pump. Refer elsewhere in this group for pump repair instructions.
7. Release the steering wheel from the full-lock right position enough to allow insertion of a 1/16- to 1/8-inch (1.6- to 3.2-mm) thick flatwasher between the axle beam and the right-side axle stop pin.
8. Bring the steering wheel back to the full-lock right position against the flatwasher. While holding the poppet valve adjusting screw jam nut in place with a wrench, immediately screw in the poppet valve adjusting screw until the pressure gauge reading drops by 200 to 400 psi (1379 to 2758 kPa).

   While holding the poppet valve adjusting screw in place, tighten the jam nut 12 to 18 lbf·ft (16 to 24 N·m).
9. With the engine at idle, have someone turn the steering wheel to the full-lock left position. Check the pressure gauge. Repeat steps above as required and adjust the other poppet valve adjusting screw.

NOTE: The left-turn poppet valve adjusting screw is on the front of the steering gear.

Removal

IMPORTANT: Before removing the steering gear, refer to **Section 46.17, Subject 300** to identify the problem.

1. Verify correct axle stop adjustment. For instructions, refer to the front axle section in this manual. Ensuring correct axle stop adjustment now will eliminate the possibility of resetting steering gear poppet valves after the gear is reinstalled.
2. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where the work is to be done. Apply the parking brakes and chock the tires.
3. Clean all outside dirt from around the fittings and hose connections.
4. Drain the power steering system. Disconnect all hydraulic lines from the gear, marking the lines for later assembly reference. Seal the lines and the fittings to keep out dirt.
5. Disconnect the pitman arm from the steering gear sector shaft. See **Fig. 1** or **Fig. 2**.
   - 5.1 Remove and discard the pinch bolt, washer, and nut from the pitman arm.
   - 5.2 Using a suitable puller, remove the pitman arm and swing the arm and drag link out of the way.
6. Disconnect the steering driveline from the steering gear input shaft.
   - 6.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

CAUTION

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

   - 6.2 Remove the lower end yoke from the input shaft.
7. Clean the entire assembly before removing the gear.

WARNING

The steering gear is heavy. Use caution when removing, lifting, or carrying the steering gear. Failure to do so could cause personal injury.

8. Remove the fasteners that attach the steering gear to the frame rail. Remove the steering gear.

Installation

1. Install the steering gear and fasteners. Torque the fasteners 427 lbf·ft (579 N·m).
2. If not previously done, center the steering gear. The sector (output) shaft alignment mark must be at a right angle to the steering gear input shaft centerline. Make sure the steering gear remains centered as the service work continues.
3. Install the pitman arm.
   - 3.1 Position the pitman arm on the steering gear, aligning the timing mark as shown in **Fig. 3**.

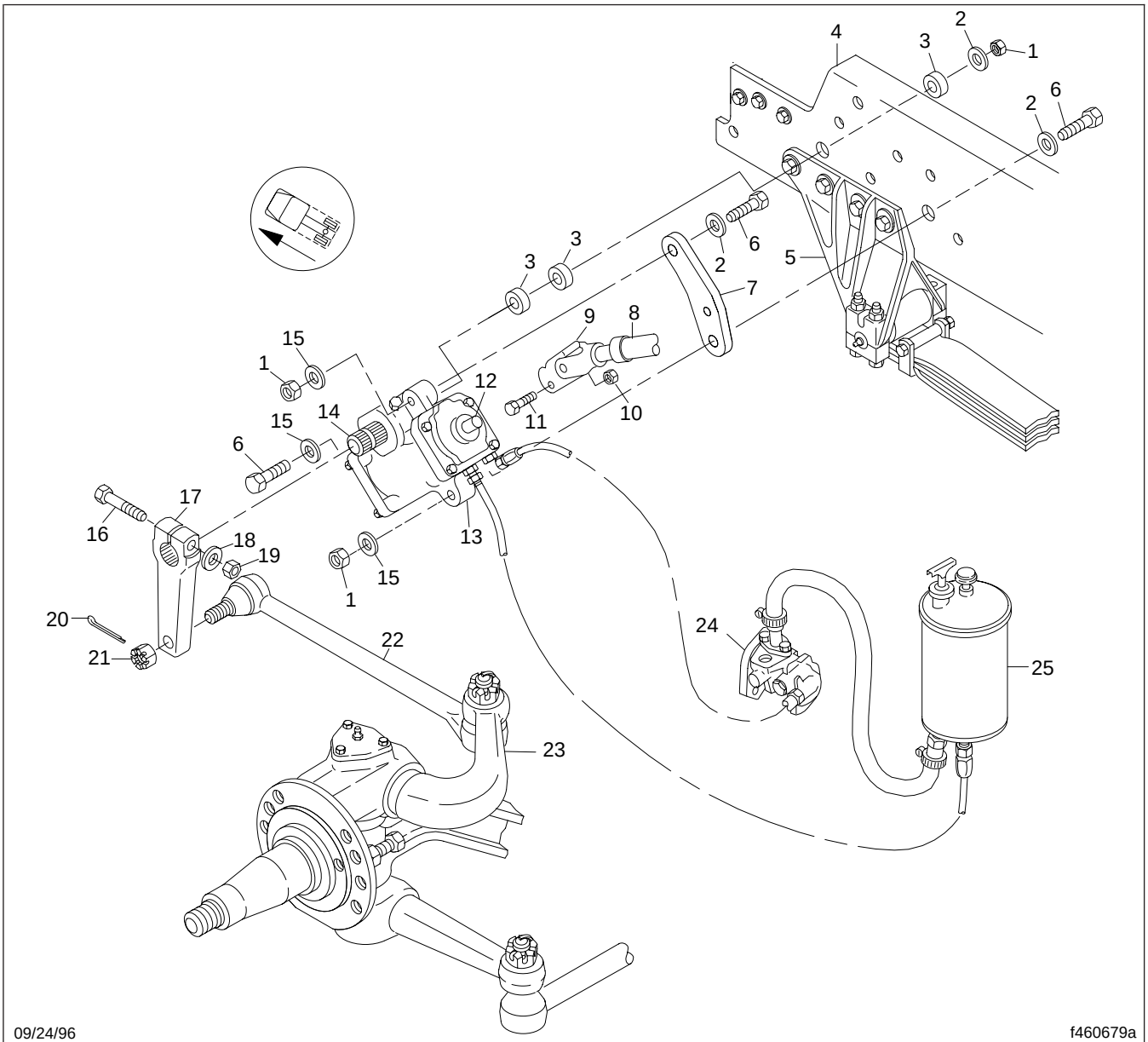
   NOTE: The pitman arm may not fit over the splines on the sector shaft without spreading the slot in the arm. Use a ball-peen hammer to drive a chisel into the slot. Hold the chisel in place. Install the pitman arm on the sector shaft. Remove the chisel from the slot.

WARNING

Never leave a chisel wedged in the pitman arm slot. When using a chisel to spread the slot in the pitman arm, maintain a firm grip on the chisel at all times. Otherwise the chisel may fly loose, which could cause an injury.

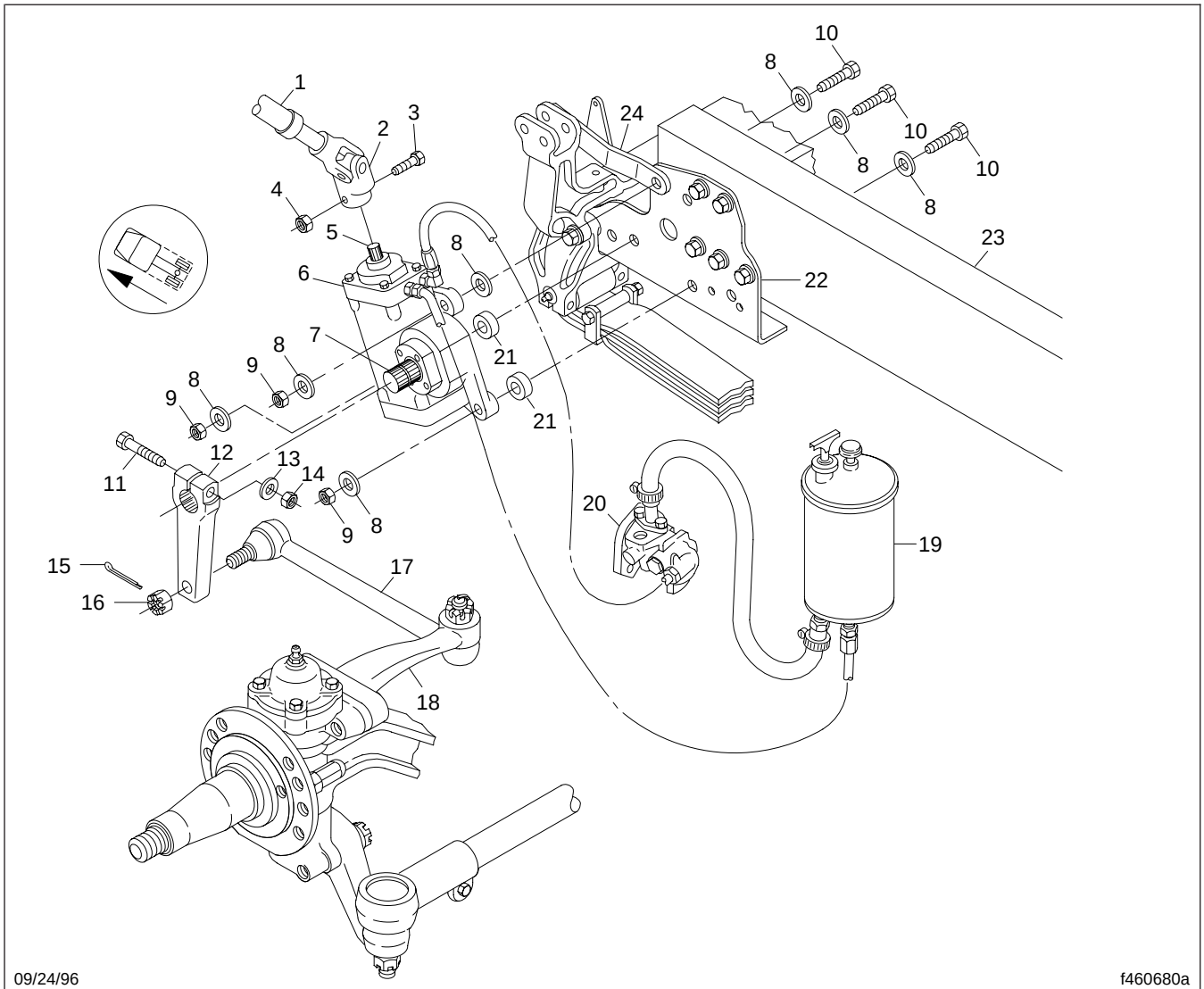
   - 3.2 Using a new pinch bolt, nut, and washer, install the pitman arm. Torque the nut 215 to 245 lbf·ft (292 to 332 N·m).
   - 3.3 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and to the nut.
4. Connect the steering driveline to the steering gear input shaft.
   - 4.1 Clean the steering gear input shaft and the inside of the driveline yoke.

Steering Gear Removal and Installation



1. Mounting Nut
2. Washer
3. Spacer
4. Left Frame Rail
5. Front Suspension Bracket
6. Mounting Bolt
7. Steering Gear Mounting Bracket
8. Steering Driveline
9. Lower End Yoke
10. Nut
11. Pinch Bolt
12. Input (worm) Shaft
13. Steering Gear
14. Sector (output) Shaft
15. Washer
16. Pinch Bolt
17. Pitman Arm
18. Washer
19. Nut
20. Cotter Pin
21. Castle Nut
22. Drag Link
23. Axle Steering Arm
24. Power Steering Pump
25. Power Steering Reservoir

Fig. 1, TRW HFB70 Power Steering Installation (FLD Conventional)



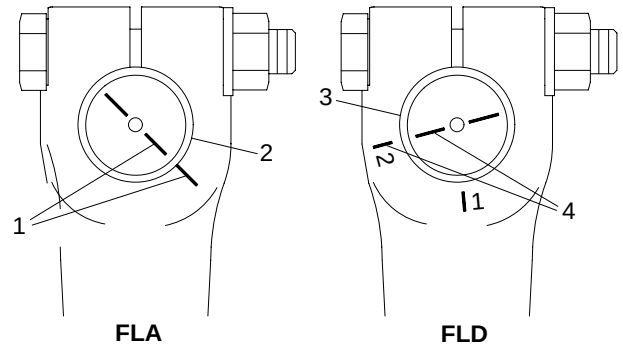
1. Steering Driveline
2. Lower End Yoke
3. Lower End Yoke Pinch Bolt
4. Nut
5. Input (worm) Shaft
6. Steering Gear
7. Sector (output) Shaft
8. Washer
9. Mounting Nut
10. Mounting Bolt
11. Pinch Bolt
12. Pitman Arm
13. Washer
14. Nut
15. Cotter Pin
16. Castle Nut
17. Drag Link
18. Axle Steering Arm
19. Power Steering Reservoir
20. Power Steering Pump
21. Spacer
22. Frame Extension
23. Left Frame Rail
24. Cab Mount Strut

Fig. 2, TRW HFB70 Power Steering Installation (FLA)

4.2 Apply a thin film of grease to the yoke spline.

4.3 Slide the yoke on the input shaft and install a new pinch bolt and nut. Tighten the nut to one of the following torque specs:

Steering Gear Removal and Installation



1. Timing Marks
2. Steering Gear Sector Shaft
3. Steering Gear Sector Shaft
4. Timing Marks

Fig. 3, Align the Timing Marks

- 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16–20 pinch bolt and nut
- 30 to 35 lbf·ft (41 to 47 N·m) for an M10 x 1.25 pinch bolt and nut

4.4 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and to the nut.

5. Connect the hydraulic lines.

5.1 If they were removed, attach the hydraulic line elbow fittings to the steering gear. Torque the fittings 38 lbf·ft (51 N·m). Torque the pressure line fitting jam nut 41 lbf·ft (56 N·m).

5.2 Remove the plugs from the hydraulic lines. Connect the lines to the steering gear as previously marked. Tighten the nut on each fitting finger tight. Then, use a wrench to tighten the nut until there is firm resistance. Tighten one-sixth turn more.

6. Fill and bleed the steering system.

IMPORTANT: For the next two substeps, do not turn the steering wheel. Doing so can cause air to enter the system, which can make it more difficult and time-consuming to bleed air from the system.

6.1 Fill the power steering reservoir with Dexron® II or III until nearly full. Crank the starter for 10 seconds without allowing the engine to start. If the engine does start, shut it down immediately. Check and fill the reservoir as needed. Repeat this procedure three times, each time checking and filling the reservoir.

6.2 Start the engine and let it idle for two minutes. Shut down the engine, and check the fluid level in the reservoir.

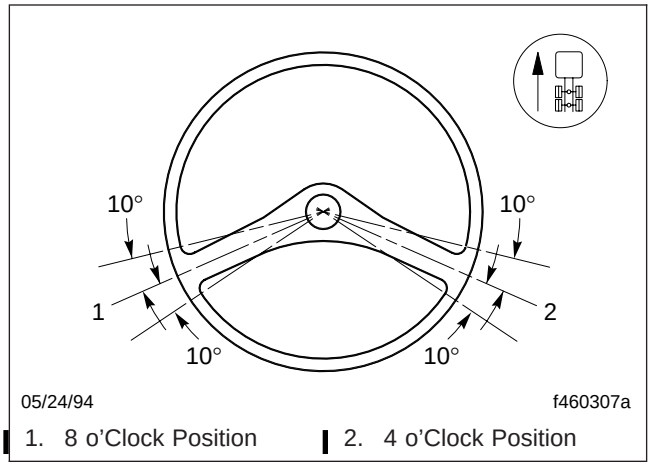
6.3 Start the engine again. Steer the vehicle from full-left to full-right several times. As necessary, add fluid to the full line on the reservoir dipstick.

NOTE: Adjust the poppets following the procedure in **Subject 100**.

7. Go to **Subject 150** and do the checks as instructed.

8. Test drive the vehicle or take a ride with the driver.

Check the steering wheel spoke position. With the front tires pointing straight ahead, check the position of the steering wheel spokes. They must be within ±10 degrees of the 4 o'clock and 8 o'clock positions. See **Fig. 4**. If they are not, remove the steering wheel and install it in the correct position. For instructions, refer to the applicable section in this group.



1. 8 o'Clock Position
2. 4 o'Clock Position

Fig. 4, Steering Wheel Centered

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

Disassembly

⚠ WARNING

All steering mechanisms are safety items. Because of this, follow the instructions in this subject to the letter. Failure to do so may result in loss of steering, which could cause an accident resulting in personal injury or property damage.

IMPORTANT: The special tools required for disassembly and assembly of the steering gear parts are available from the SPX Kent-Moore or an affiliated dealer. See the table on special tools in **Specifications 400** to be sure that you have the required tools before beginning the service procedures.

Make sure that the steering gear is placed on a clean surface. Clean and dry the gear before disassembly. As the gear is disassembled, clean all parts in a clean, petroleum-based solvent, and blow-dry them only.

⚠ WARNING

Never steam clean or high-pressure wash the hydraulic steering components. Do not force or abuse closely fitted parts. Doing so could cause damage to steering system parts, which could cause an accident resulting in personal injury or property damage.

Keep each part separate to avoid nicks and burrs. Discard all seals, O-rings, and gaskets, and replace them with new parts.

For an exploded assembly drawing of the steering gear, see **Fig. 1**.

1. Clamp the gear mounting bosses in a vise, so that the steering gear input shaft is horizontal. Rotate the input shaft to position the alignment mark on the sector shaft halfway between two trunnion cover bolts and pointing up. See **Fig. 2**.
2. Remove and discard the pinch bolt and nut from the pitman arm. Using a suitable puller, remove the pitman arm.
3. Remove the protective boot, the grease fittings, and the dirt and water seal from the trunnion cover. See **Fig. 3**. Discard the boot and the seal.
4. Using a fine grade of emery paper, remove any paint or corrosion from the nonserrated area of the sector shaft. Loosen the sector shaft adjusting screw jam nut.
5. Remove the four trunnion cover bolts and washers. See **Fig. 4**. Remove the trunnion cover. Remove and discard the trunnion cover O-ring, the Teflon® backup washer, and the two-piece sector shaft seal. See **Fig. 5**.
6. Tape the serrations and bolt groove of the sector shaft, using **one layer** of masking tape. See **Fig. 6**.
7. Prepare for fluid to drain, and remove the eight special bolts from the side cover. See **Fig. 7**.

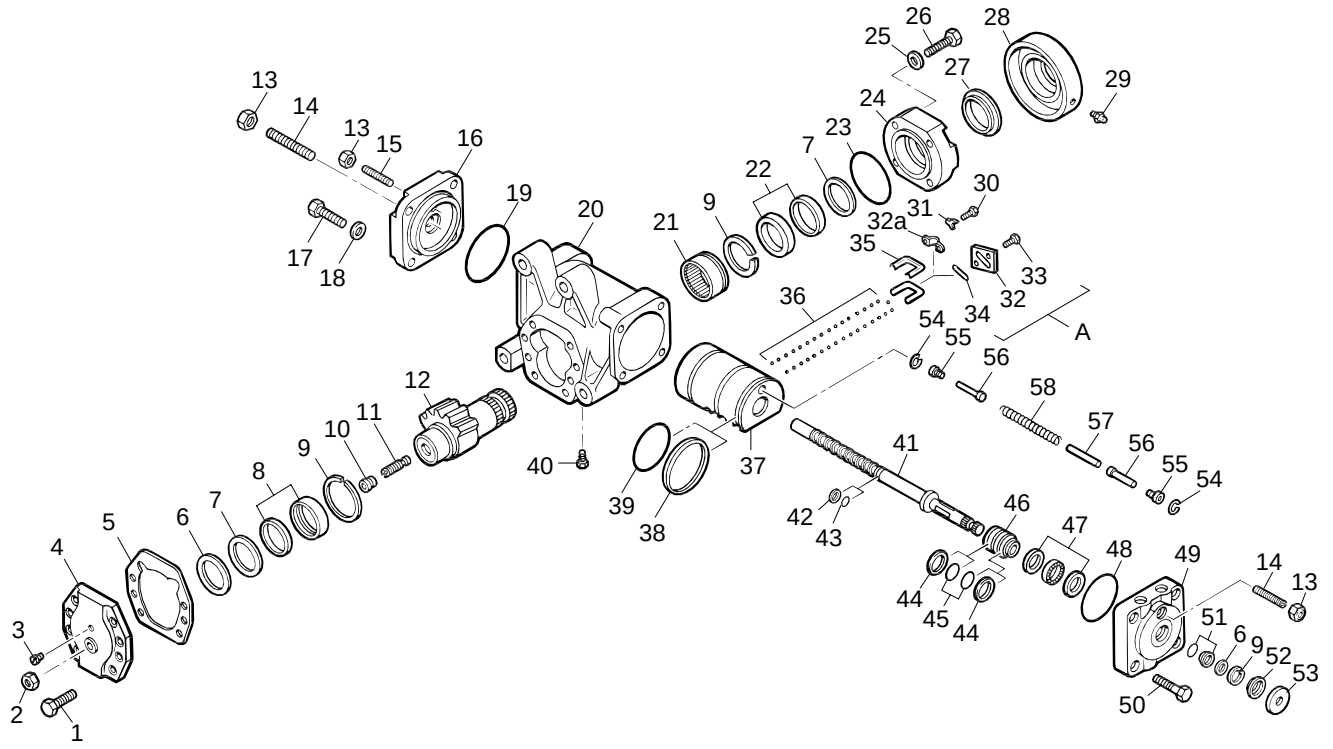
IMPORTANT: These special bolts are equipped with either a ring or washer-design on the underside of the head. See **Fig. 8**. If replacing one or more bolts, use bolts that are the same **type and length** as those that were removed. Do not use substitutes.

8. Begin to remove the side cover and sector shaft as an assembly. See **Fig. 9**. As a means of starting the removal of the side cover and sector shaft assembly, a soft hammer or wooden handle may be used. Stop removal when the bearing rolls in the housing bearing are half exposed. Coat the bearing rolls with grease. See **Fig. 10**.

IMPORTANT: Be sure that no rolls are lost during disassembly. If one or more of the rolls is lost, the entire bearing must be replaced, as instructed in step 10. If the bearing is identified as BR-970, there are 41 rolls. If the bearing is identified as BR-970-1, there are 42 rolls. The number on the housing bearing may not be visible while it is in place.

NOTE: The housing bearing may have caged (retained) rolls, which do not require special precautions. However if the bearing rolls are not caged, remove this assembly slowly or it may come out too quickly to allow the bearing rolls in the housing bearing race to be retained. Follow the shaft end with bearing tool J26743 to retain the rolls; or, when the rolls are half exposed, coat them with grease to retain them in the housing bearing. See **Fig. 10**.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments



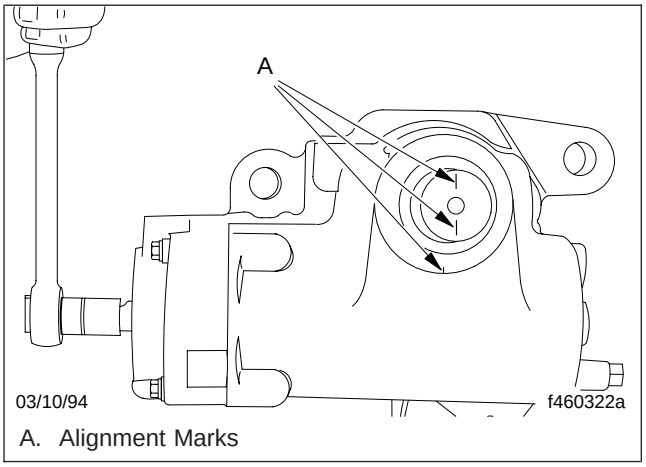
A. If Equipped
1. Ring Head Bolt
2. Jam Nut
3. Vent Plug
4. Side Cover (with bushing or roller bearing)
5. Side Cover Gasket
6. Backup Washer (steel)
7. Backup Washer (Teflon®)
8. Two-Piece Side Cover Seal
9. Retaining Ring
10. Adjusting Screw Retainer
11. Sector Shaft Adjusting Screw
12. Sector (output) Shaft
13. Adjusting Screw Jam Nut
14. Worm Shaft Adjusting Screw
15. Poppet Adjusting Screw
16. End Cover
17. End Cover Bolt
18. End Cover Washer
19. O-Ring, End Cover
20. Gear Housing
21. Housing Bearing
22. Two-Piece Sector Shaft Seal
23. O-Ring, Trunnion Cover
24. Trunnion Cover
25. Washer
26. Trunnion Cover Bolt
27. Dirt and Water Seal, Trunnion Cover
28. Protective Boot
29. Grease Fitting
30. Bolt
31. Locktab
32. Ball Return Guide Cap
33. Allen Head Screw
34. Guide Cap Seal
35. Ball Return Guide Halves
36. Steel Balls
37. Rack Piston
38. Rack Piston Seal
39. O-Ring, Rack Piston
40. Bleed Screw
41. Worm (input) Shaft
42. Worm Shaft Seal
43. O-Ring, Input Shaft
44. Valve Sleeve Seal
45. O-Ring, Valve Sleeve
46. Valve Sleeve
47. Thrustwashers and Thrust Bearing
48. O-Ring, Valve Housing
49. Valve Housing
50. Valve Housing Bolt
51. Two-Piece Input Shaft Seal
52. Dirt and Water Seal, Valve Housing
53. Seal Protector
54. Poppet Retaining Ring
55. Poppet Seal
56. Poppet
57. Nylon Spacer Rod
58. Spring

Fig. 1, TRW HFB70 Steering Gear

9. Finish removing the side cover and sector shaft as an assembly. Remove and discard the side cover gasket.

10. If the housing bearing race is damaged or if one or more of the rolls are lost, replace the housing bearing.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments



A. Alignment Marks

Fig. 2, Alignment Marks

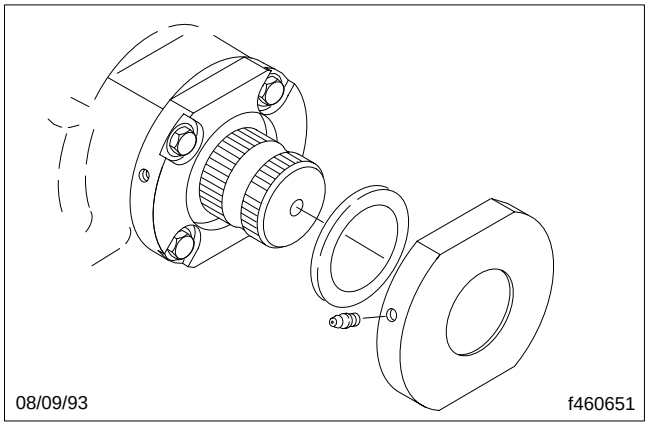


Fig. 3, Remove the Boot, Fitting, and Seal

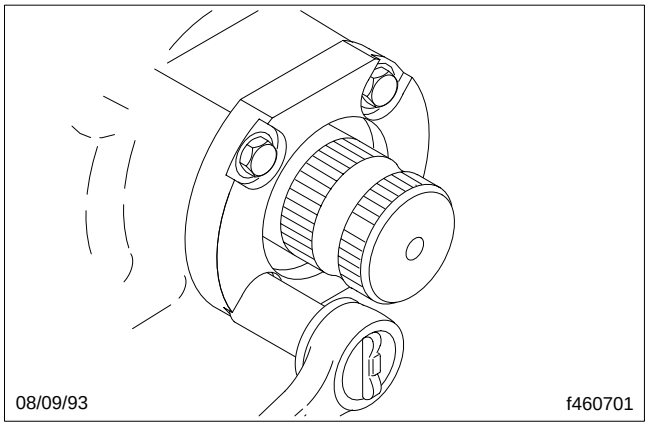


Fig. 4, Remove the Bolts

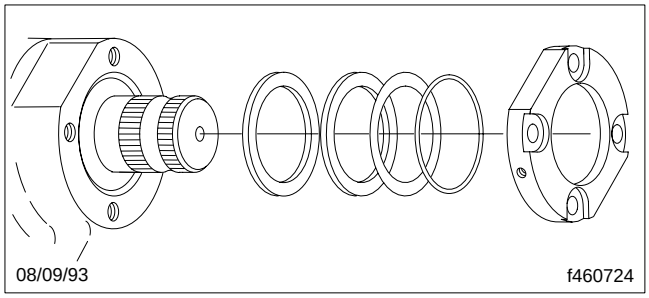


Fig. 5, Remove the O-Ring, Washer, and Two-Piece Seal

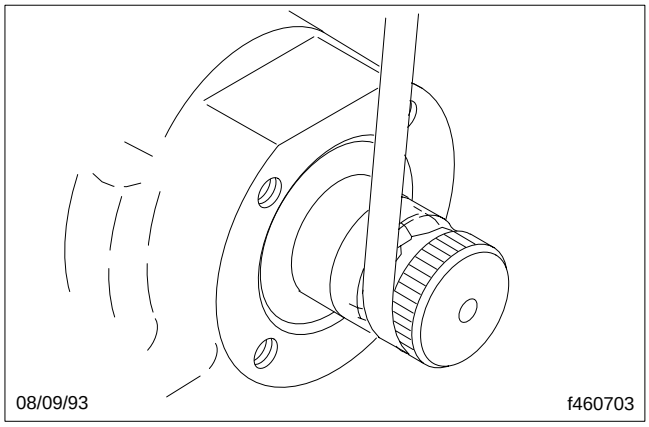


Fig. 6, Tape the Serrations and Bolt Groove

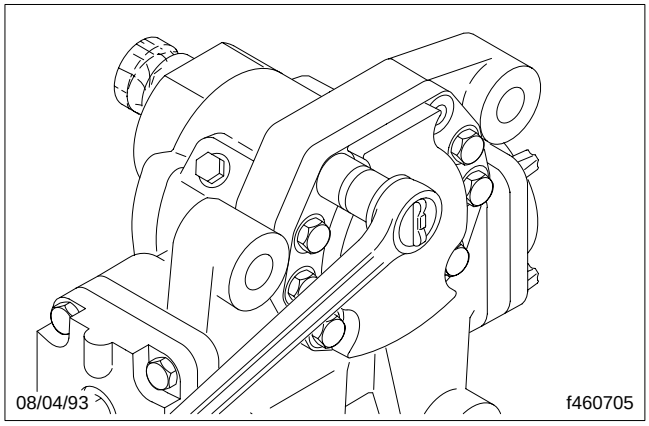


Fig. 7, Remove the Bolts

10.1 Using bearing mandrel J26743, apply pressure from the side cover opening and press the bearing and retaining ring out through the trunnion cover opening away from the cylinder bore.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

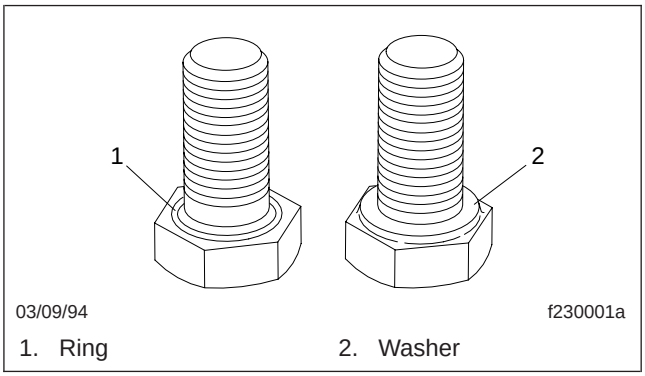


Fig. 8, Bolts With Ring or Washer

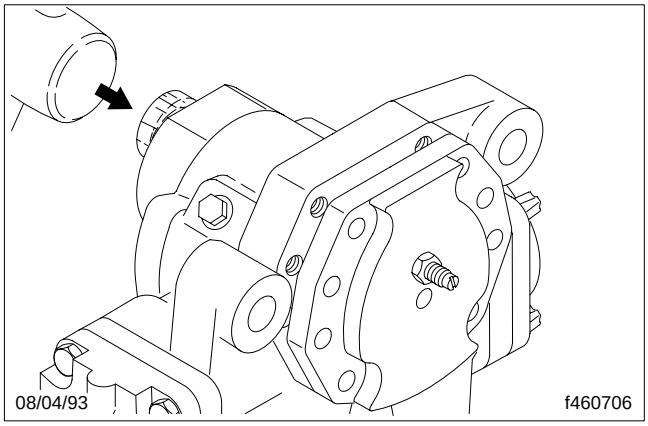


Fig. 9, Remove the Side Cover and Sector Shaft

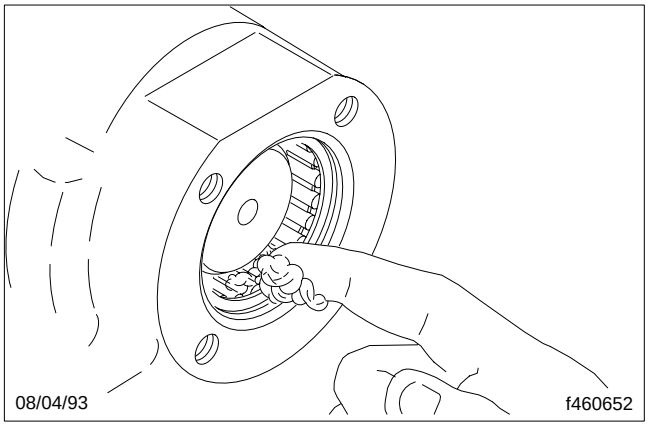


Fig. 10, Lubricate the Bearing Rolls

NOTE: Maintain firm, square contact between the housing and the base of the press to avoid damaging the housing bearing bore.

10.2 Remove the retaining ring from the bearing, and discard the bearing.

IMPORTANT: If the bearing is cocked while pressing it out, it will burnish the bore, causing it to become oversized. If this happens, the steering gear housing will have to be replaced.

11. Remove the sector shaft adjusting screw jam nut. See **Fig. 11**.

12. Screw the sector shaft adjusting screw through the side cover. See **Fig. 12**. Place the side cover exterior side down and lift the sector shaft out vertically. See **Fig. 13**.

IMPORTANT: On models with roller bearings in the side cover, this will allow the bearing rolls to fall into the side cover, where they can easily be collected. Immediately collect all of the side cover bearing rolls and count them. Do not lose any rolls during disassembly or the complete side cover assembly will have to be replaced.

⚠ WARNING

Do not mix the rolls from the side cover with the rolls from the housing bearing. The bearing race and rolls are a matched set. Interchanging the rolls could result in bearing or seal failure. This could cause a loss of power steering, which could cause personal injury or property damage.

13. Remove the side cover retaining ring, the two-piece side cover seal, the Teflon® backup washer, and the steel backup washer, from the side cover. See **Fig. 14**. Discard the two-piece seal and the Teflon® backup washer. Remove and discard the rubber plug. See **Fig. 15**.

14. Loosen the worm shaft preload adjusting screw jam nut. Loosen the worm shaft preload adjusting screw about two turns. See **Fig. 16**. Loosen the poppet adjusting screw jam nut and the poppet adjusting screw about two turns.

15. Remove the four end cover bolts. See **Fig. 17**. Prepare for some fluid to drain, then remove the end cover. See **Fig. 18**.

16. Remove and discard the end cover O-ring. See **Fig. 19**.

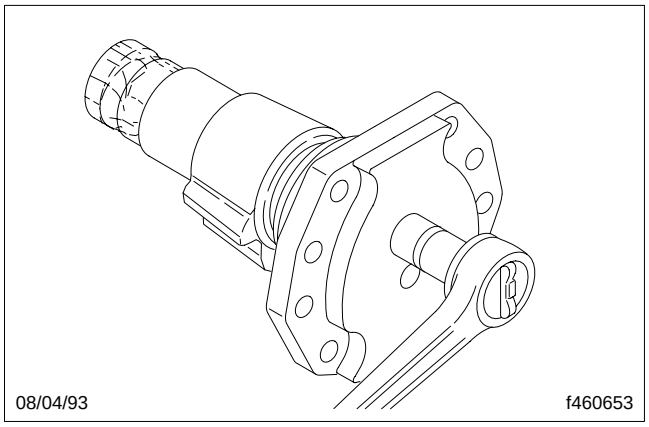


Fig. 11, Remove the Jam Nut

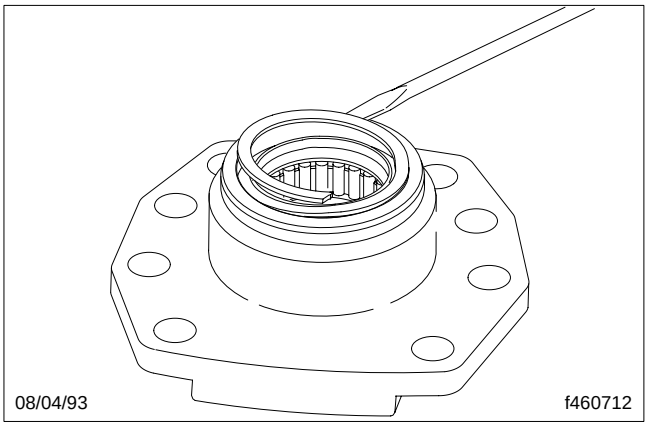


Fig. 14, Remove the Retaining Ring

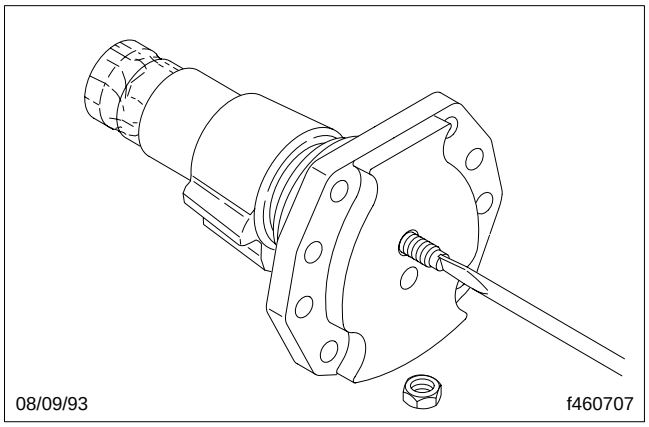


Fig. 12, Install the Adjusting Screw

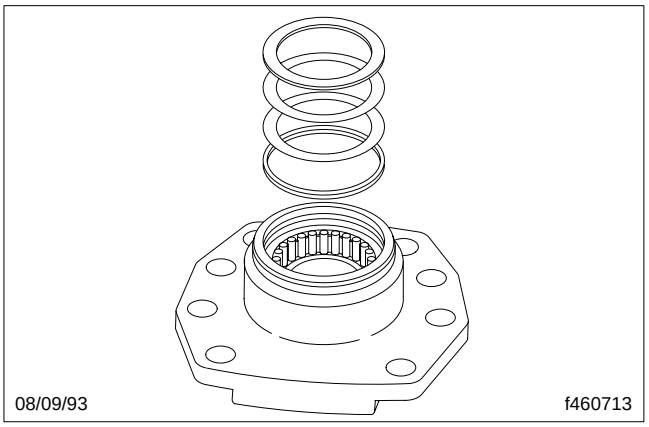


Fig. 15, Remove the Two-Piece Seal and the Backup Washers

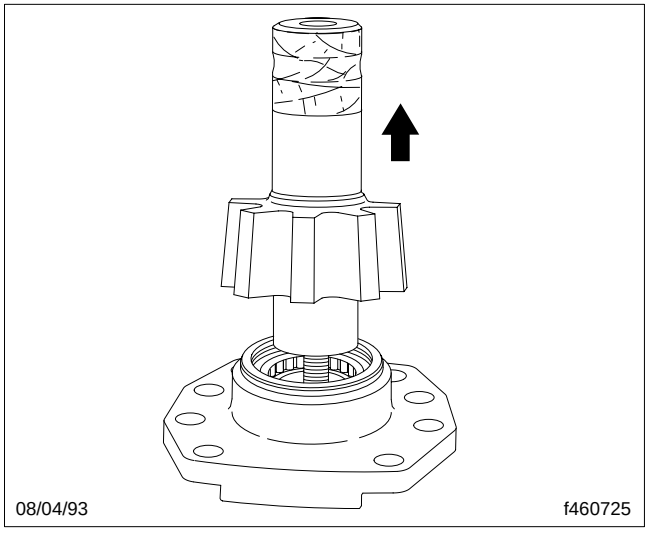


Fig. 13, Lift Out the Sector Shaft

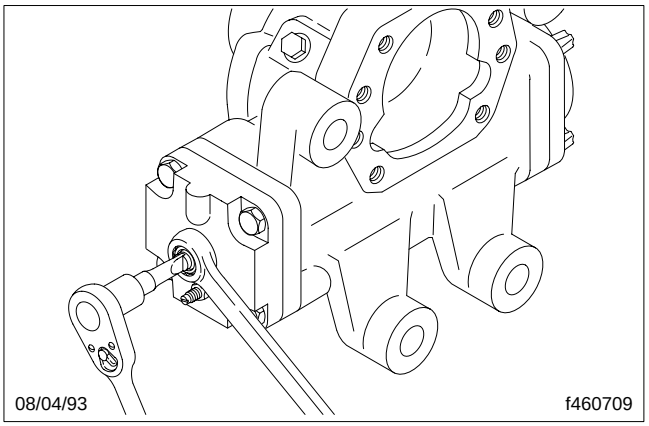


Fig. 16, Loosen the Adjusting Screw

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

17. Clean any paint or foreign material from the non-serrated area of the input shaft, using a fine grade of emery paper. **Fig. 20**.
18. Loosen the valve housing poppet adjusting screw jam nut and poppet adjusting screw about two turns.
19. Remove the four valve housing bolts. See **Fig. 21**. Prepare for some fluid to drain, then remove the valve housing. See **Fig. 22**.

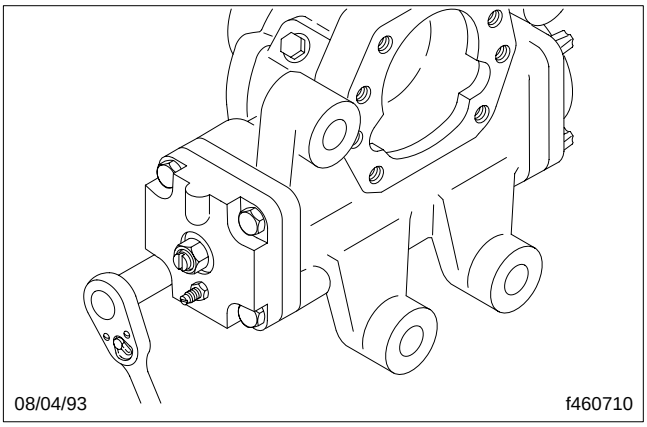


Fig. 17, Remove the Bolts

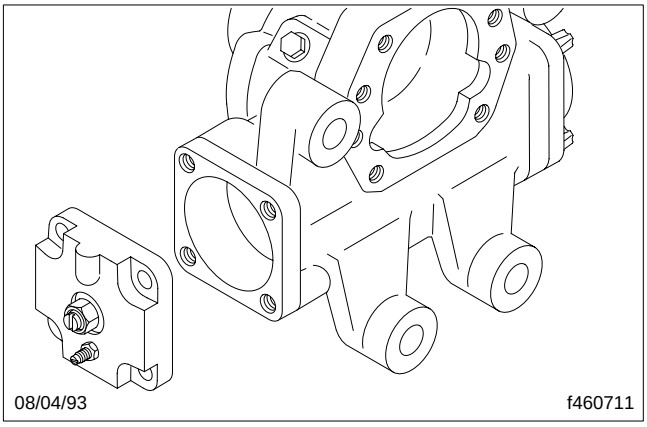


Fig. 18, Remove the End Cover

20. If the valve sleeve is still in the housing, remove it. See **Fig. 23**.
21. Remove the first thrustwasher, the thrust bearing, and the second thrustwasher from the valve housing. See **Fig. 24**.

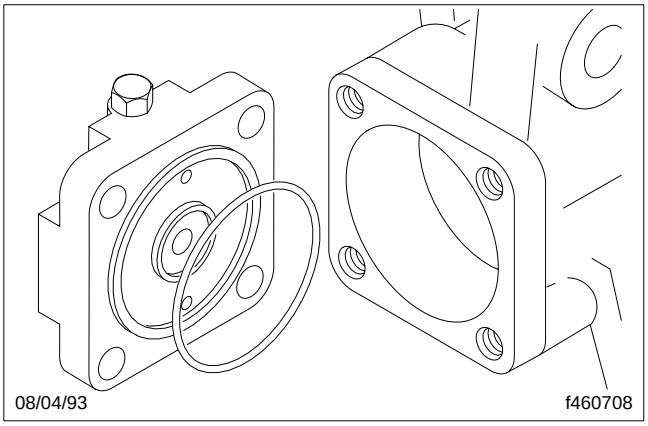


Fig. 19, Remove the O-Ring

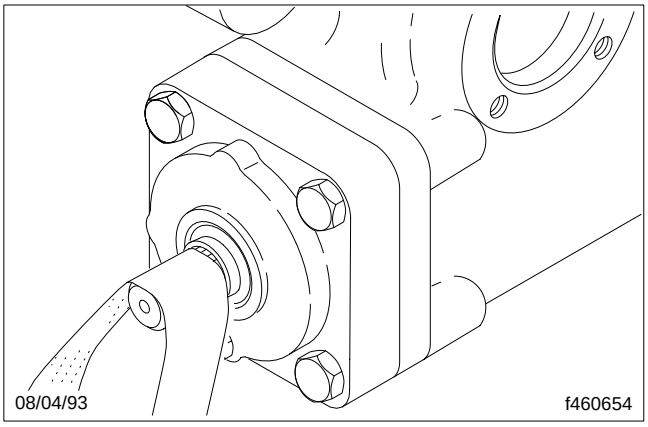


Fig. 20, Clean the Input Shaft

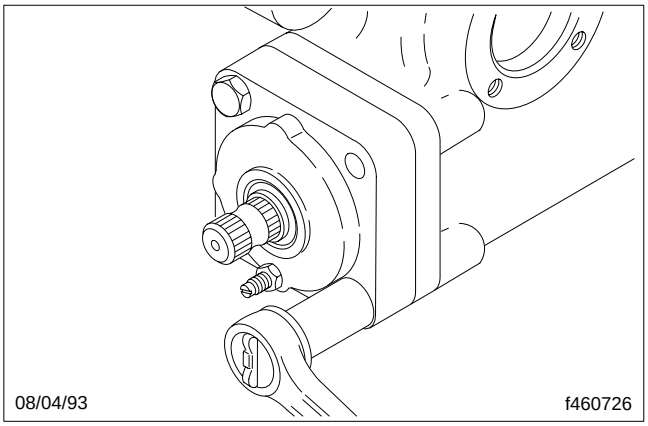


Fig. 21, Remove the Bolts

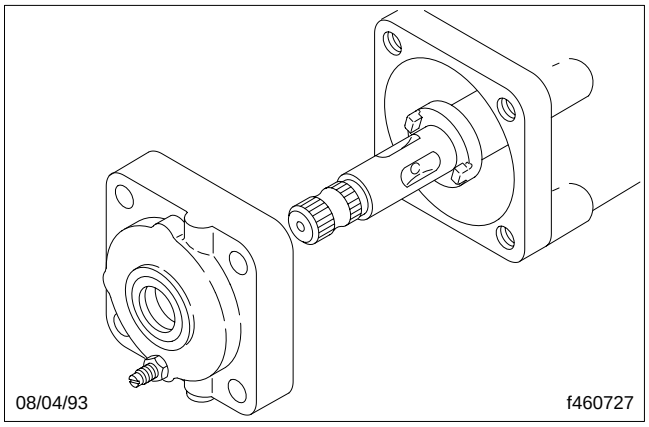


Fig. 22, Remove the Valve Housing

NOTE: The first thrustwasher may stay on the end of the valve sleeve. If so, remove it from the sleeve.

22. Remove and discard the valve housing O-ring.
23. Remove and discard the valve housing dirt and water seal. See **Fig. 25**.
24. Remove the valve housing retaining ring. See **Fig. 26**.
25. Remove the steel backup washer and the two-piece input shaft seal from the valve housing. See **Fig. 27**. Discard the shaft seal.
26. Remove and discard the two Teflon® seal rings from the valve sleeve. See **Fig. 28**.
27. Remove and discard the two backup O-rings from the grooves in the valve sleeve. See **Fig. 29**.

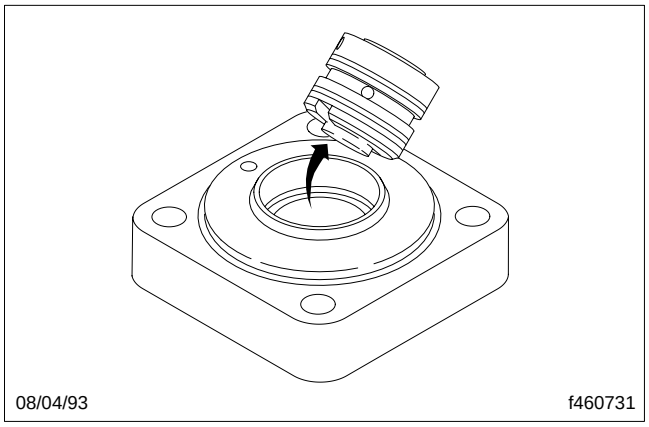


Fig. 23, Remove the Valve Sleeve

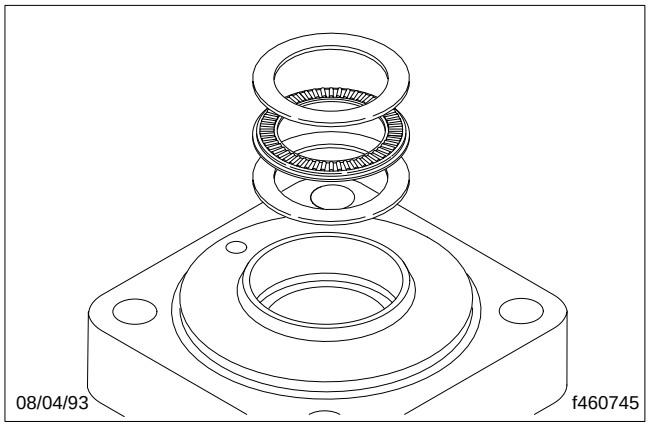


Fig. 24, Remove the Thrust Bearing and Thrustwashers

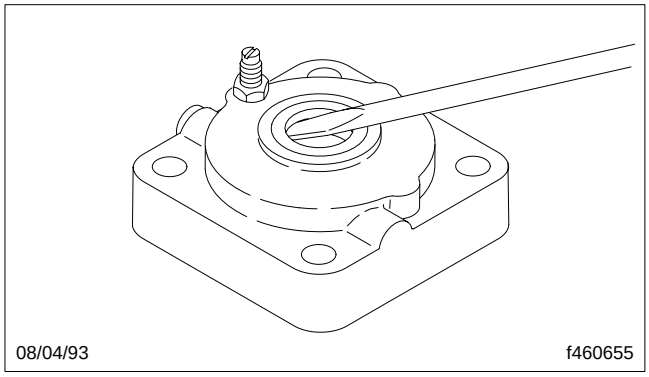


Fig. 25, Remove the Dirt and Water Seal

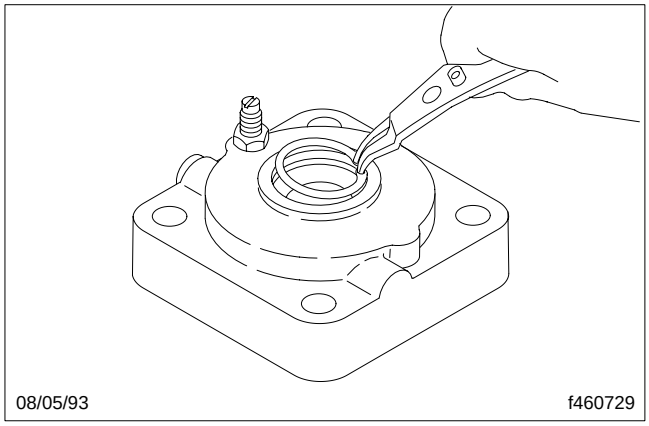


Fig. 26, Remove the Retaining Ring

CAUTION

The worm shaft portion of the assembly will be inside the rack piston, with the input shaft por-

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

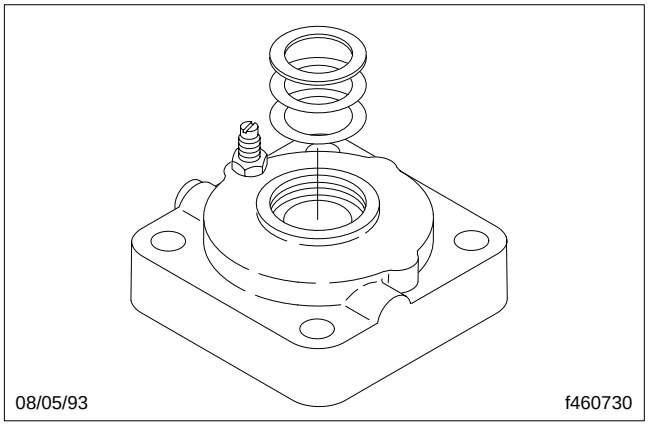


Fig. 27, Remove the Washer and Seal

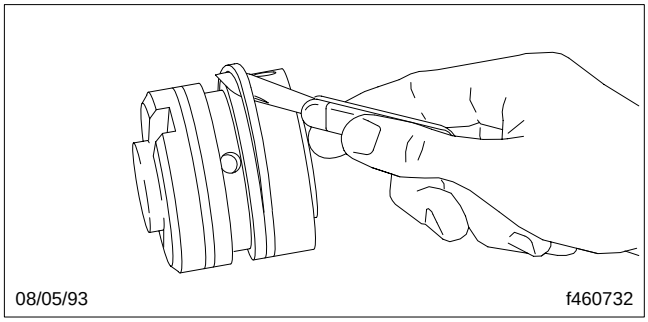


Fig. 28, Remove the Seal Rings

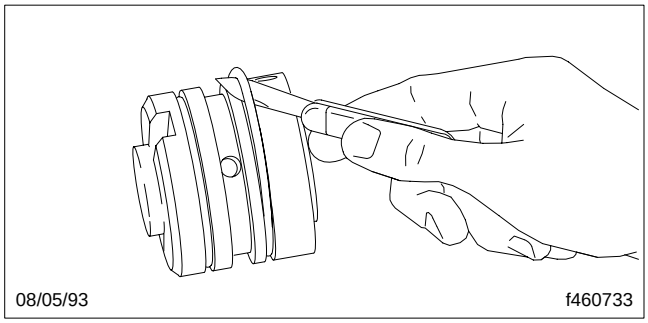


Fig. 29, Remove the O-Rings

tion of the worm protruding from the rack. Be careful when removing this assembly from the housing. Removing the rack piston assembly from the long end of the housing prevents the Teflon® rack piston seal from getting caught in the sector shaft cavity.

28. Remove the rack piston and worm shaft from the gear housing as an assembly. See **Fig. 30**.

    Set the rack piston and worm shaft assembly on a clean rag to keep the piston from rolling.

29. For rack pistons with a ball return guide clip, bend the tangs down on the two ball return guide clip locking tabs. See **Fig. 31**. Remove the two bolts, the locking tabs, and the guide clip. Discard the locking tabs. See **Fig. 32**.

    For rack pistons with a ball return guide cap, remove the two Allen-head screws, the ball return guide cap, and the ball return guide cap seal. See **Fig. 33** and **Fig. 34**. Discard the screws and the cap seal.

30. Remove the halves of the ball return guide. See **Fig. 35**. Then remove the 34 steel balls from the rack piston by rotating the worm shaft until the balls fall out. See **Fig. 36**. **Do not loose any of these balls or you will have to replace the entire set.**

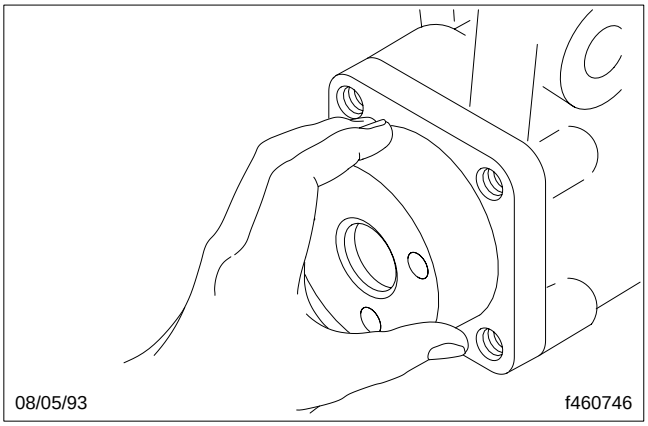


Fig. 30, Remove the Rack Piston and Worm Shaft

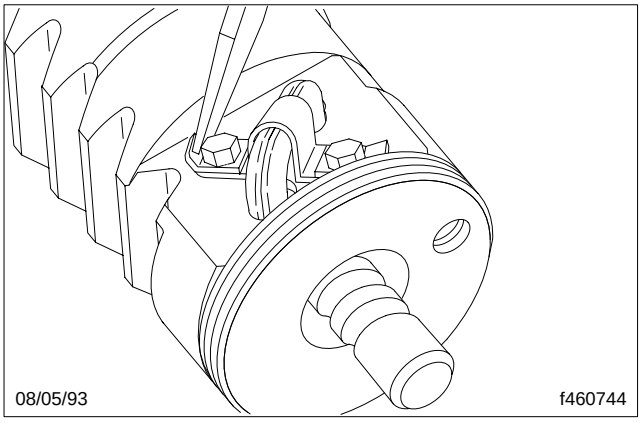


Fig. 31, Bend the Tangs Down

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

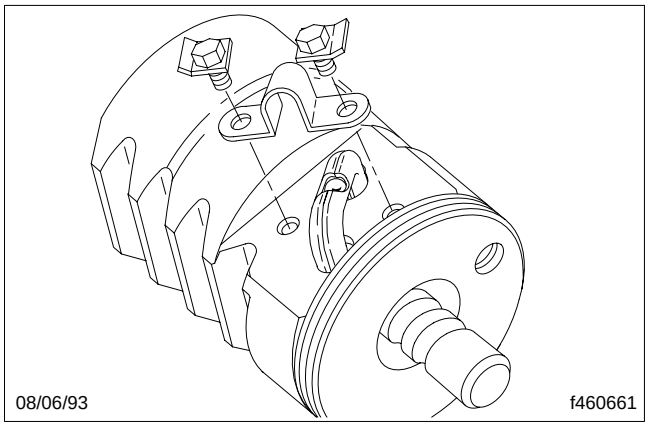


Fig. 32, Remove the Guide Clips

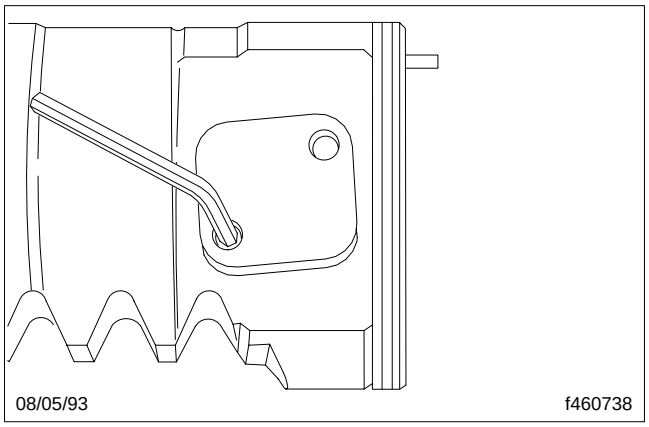


Fig. 33, Remove the Screws

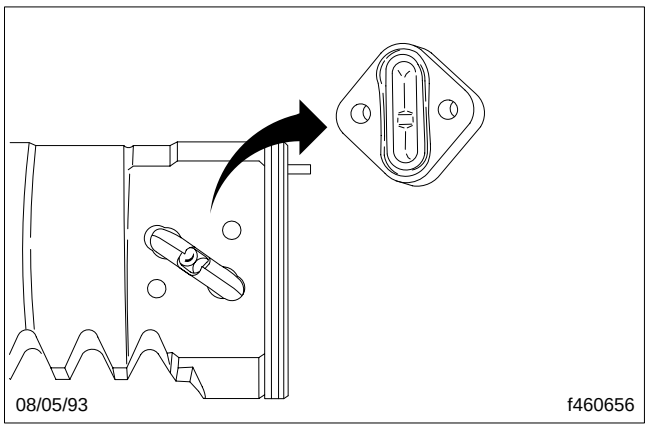


Fig. 34, Remove the Ball Return Guide Cap and Seal

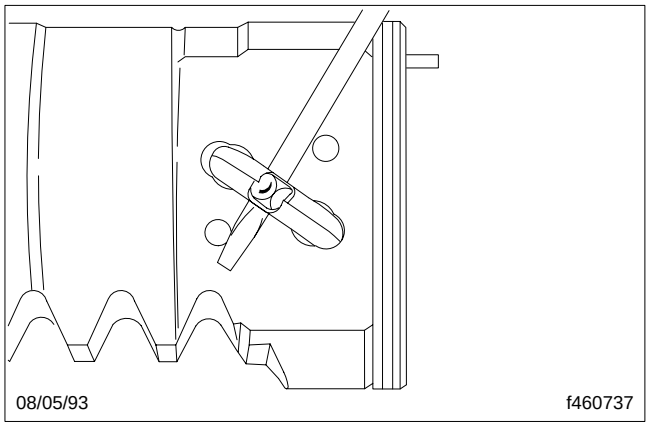


Fig. 35, Remove the Ball Return Guide

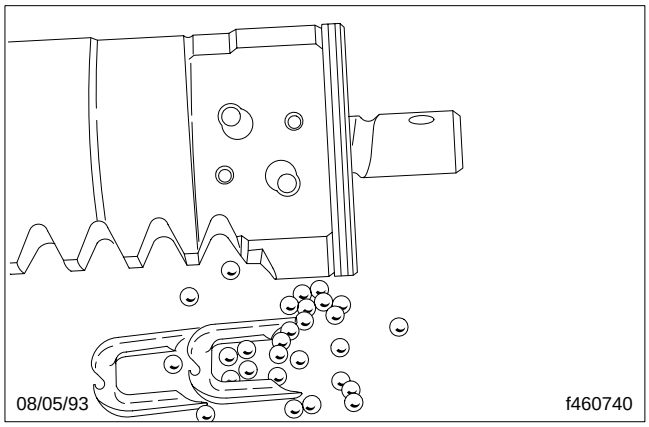


Fig. 36, Remove the Steel Balls

⚠ WARNING

Never mix different sets of steel balls. Doing so may cause a loss of steering control, which could cause an accident resulting in serious injury or property damage.

NOTE: The ball return guide is closely fitted with the rack piston. It may be necessary to remove the halves by carefully inserting a screwdriver between the rack and the guide.

31. Remove the worm shaft from the rack piston. See **Fig. 37**.
32. Remove and discard the rack piston seal ring and the backup O-ring. See **Fig. 38** and **Fig. 39**.
33. Remove and discard the worm shaft seal ring and O-ring. See **Fig. 40**.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

IMPORTANT: Do not disassemble the input shaft or worm shaft assembly any further. These are not serviceable. See **Fig. 41**.

⚠ WARNING

Wear eye protection when removing the poppets. The poppets are spring-loaded and could be ejected, which could result in serious eye injury.

34. The poppets will usually not require servicing. If it is necessary to service the poppets, position the rack piston in a soft-jawed vise. Remove the two poppet retaining rings, two poppet seats, two poppets, the nylon spacer rod, and the poppet spring. See **Fig. 42**, **Fig. 43**, and **Fig. 44**.

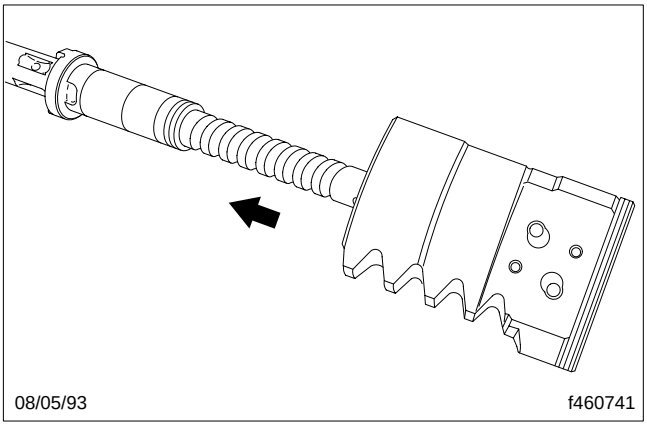


Fig. 37, Remove the Worm Shaft

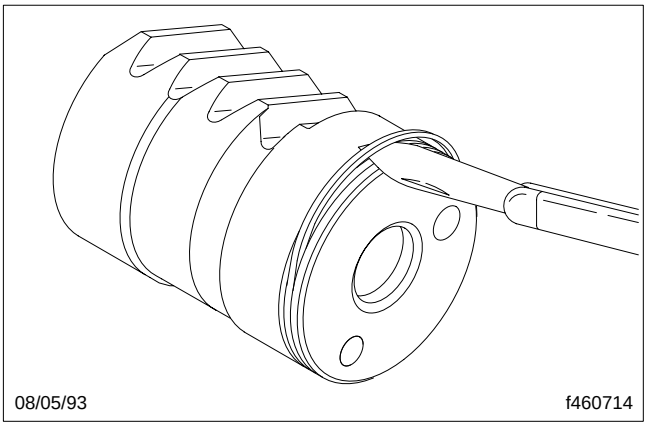


Fig. 38, Remove the Seal Ring

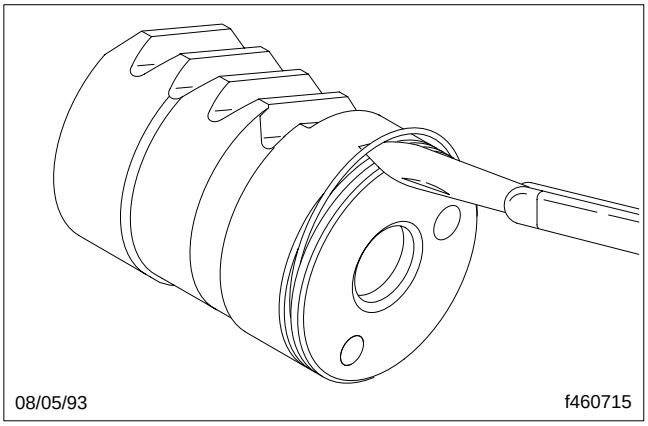


Fig. 39, Remove the O-Ring

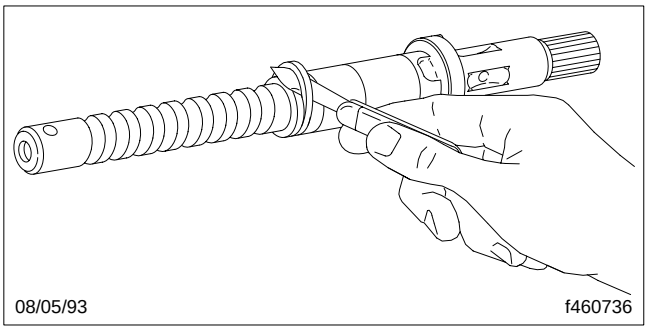


Fig. 40, Remove the Seal Ring and O-Ring

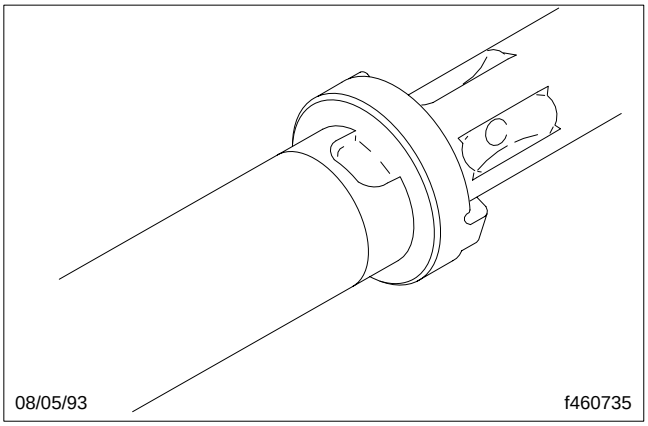


Fig. 41, Input Shaft/Worm Shaft Assembly

Inspection

All sealing surfaces and seal cavities must be free of nicks and corrosion. If any part is nicked or corroded where sealing occurs, replace the part to ensure proper sealing.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

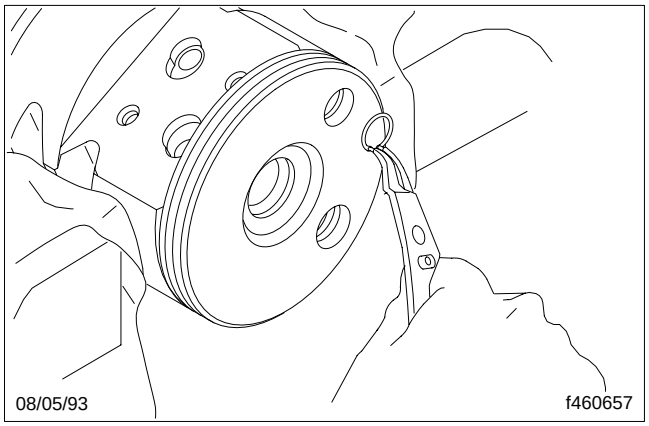


Fig. 42, Remove the Retaining Rings

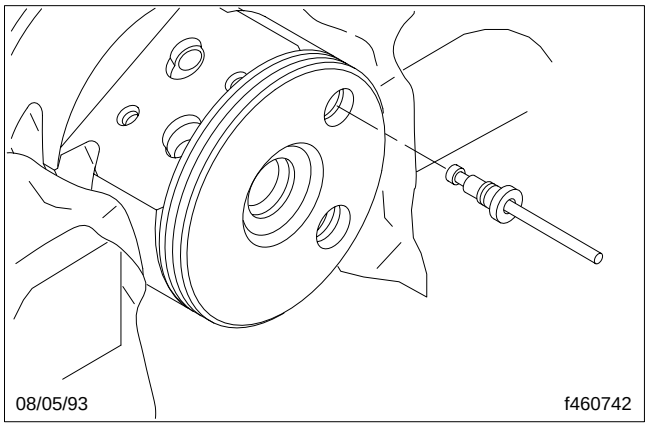


Fig. 43, Remove the Poppet Seats

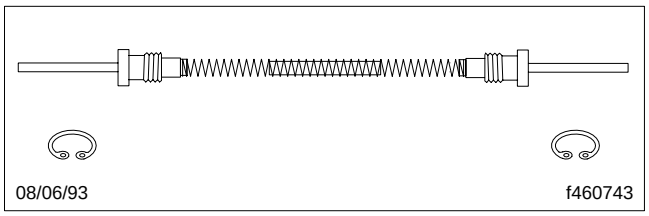


Fig. 44, Remove the Poppets, Spacer Rod, and Spring

Wash all parts in clean petroleum-based solvent, then blow-dry them.

1. Inspect the rack piston teeth for cracks and wear. See **Fig. 45**. If a step can be detected by running your fingernail horizontally across the teeth surfaces, replace both the rack piston and the sector shaft.
2. Inspect the rack piston internal ball-track grooves for brinelling (dents) or spalling (flaking). See **Fig. 46**. If either condition exists, replace the rack piston, the worm shaft/input shaft assembly, the set of 34 steel balls, and the valve sleeve.
3. Inspect the worm shaft ball-track grooves for brinelling or spalling. See **Fig. 47**. If either condition exists, replace the worm shaft/input shaft assembly, the rack piston, the set of 34 steel balls, and the valve sleeve. Inspect the upper shaft-seal area, near the input shaft serrations, for nicks. Run your fingernail across the sealing surface to detect steps. See **Fig. 48**.

NOTE: The input shaft is pinned to the worm shaft by the torsion bar pin. The assembly is flexible and may appear slightly bent at this joint. See **Fig. 49**. This slight bend is normal.

4. Inspect the housing cylinder bore. See **Fig. 50**. Minor scoring marks running lengthwise through the bore are normal and should not be compared to the scoring that might be found in the cylinder bores of an internal combustion engine. Replace the housing only if it has been tested for internal leakage and it is determined that the scoring is responsible for internal leakage greater than 1.5 gpm (5.7 L/min). For troubleshooting procedures, see **Section 46.17, Subject 300**.

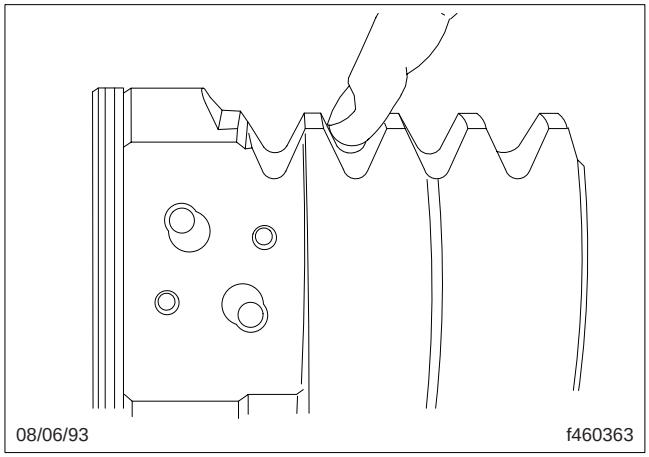


Fig. 45, Inspect the Rack Piston Teeth

NOTE: In evaluating the results of this test, make sure that internal leakage exceeding 1.5 gpm (5.7 L/min) is attributed only to the housing and not to the seals in the worm shaft, rack piston, and valve assembly.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

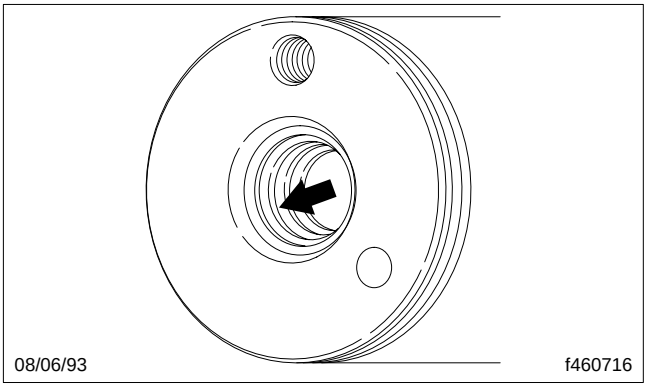


Fig. 46, Inspect the Internal Ball-Track Grooves

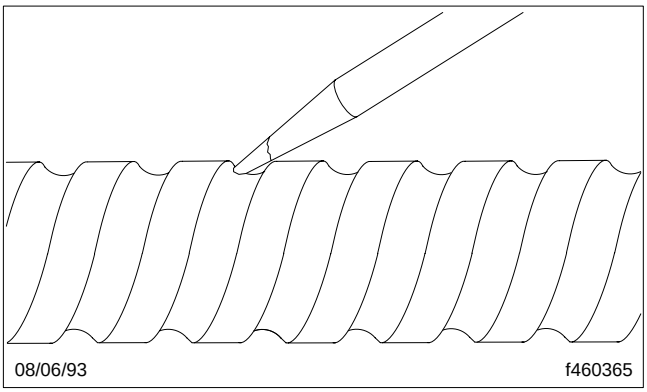


Fig. 47, Inspect the Worm Shaft Ball-Track Grooves

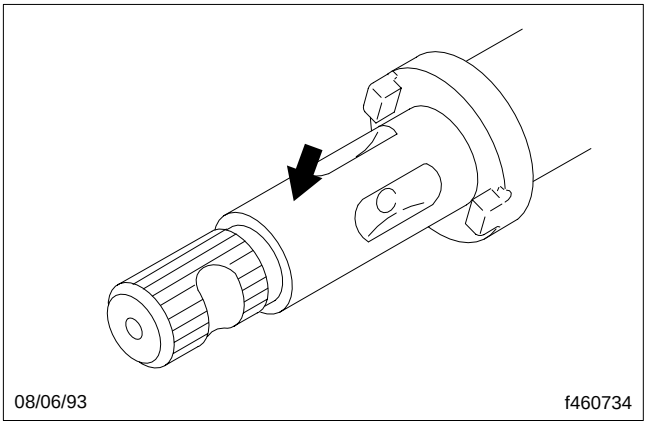


Fig. 48, Check the Sealing Surface

5. Inspect the housing faces for nicks that would prevent proper sealing. See **Fig. 51**. Replace the gear housing if these nicks cannot be easily removed with a fine-toothed flat file without changing the dimensional characteristics.

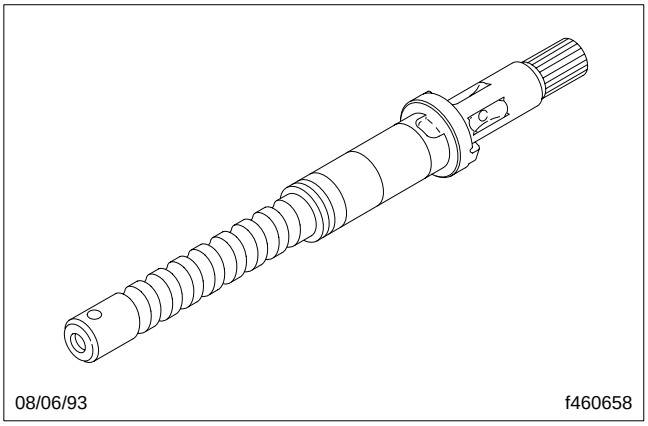


Fig. 49, Input Shaft and Worm Shaft Joint

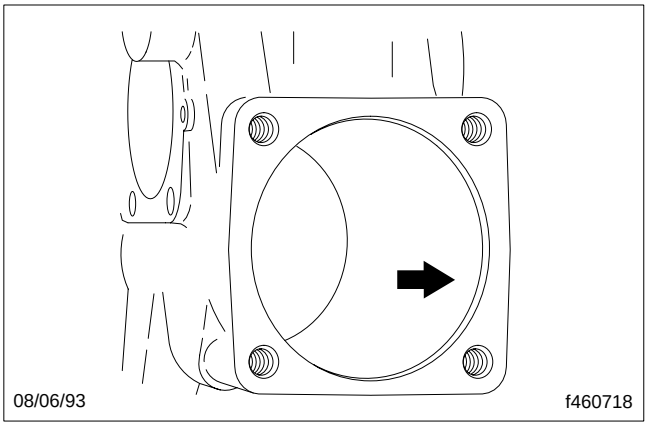


Fig. 50, Housing Cylinder Bore

6. Inspect the housing bearing for brinelling or spalling. See **Fig. 52**. If either condition exists, replace the housing bearing. For instructions, refer to the appropriate steps in "Disassembly" and "Assembly."

   Inspect the side cover bearing for brinelling or spalling. If the side cover bearing is damaged, replace the complete side cover assembly. See **Fig. 53**.

7. Inspect the sector shaft bearing sealing areas for brinelling or spalling. See **Fig. 54**. Run your fingernail across these areas to detect steps. Also inspect for cracks. If any of these conditions exist, replace the sector shaft.

8. Check the sector shaft assembly for damaged adjusting screw threads. Make sure the adjusting screw retainer is locked in place and has no cracks. The adjusting screw must turn by hand

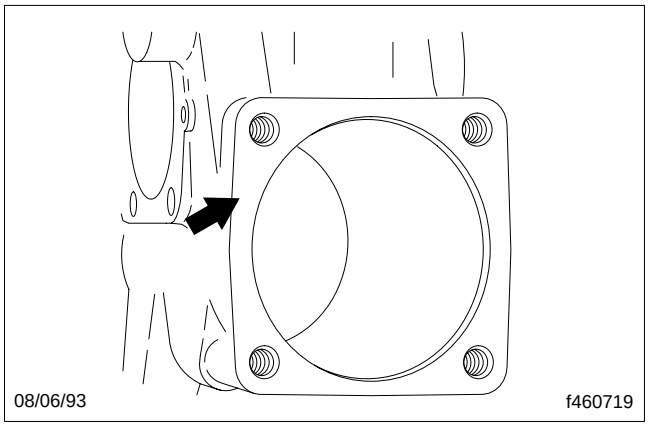


Fig. 51, Housing Face

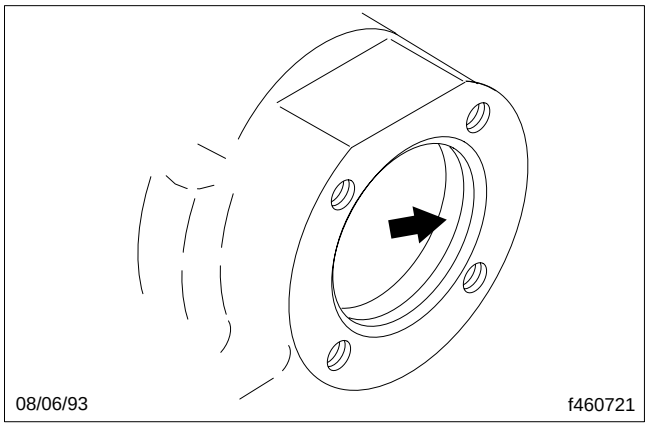


Fig. 52, Housing Bearing

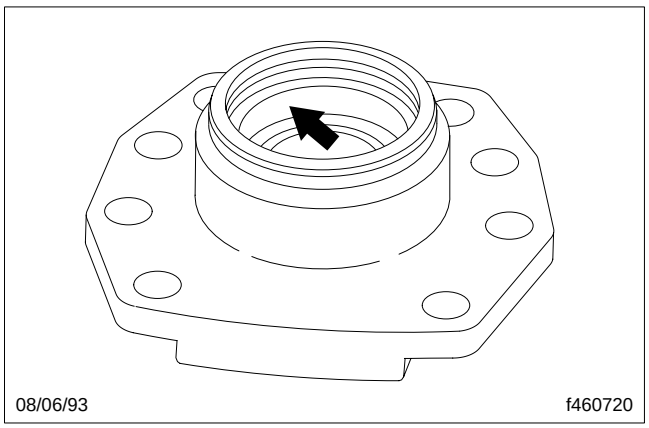


Fig. 53, Side Cover Bearing

with no end play (lash). If the adjusting screw is damaged, replace it and its retainer.

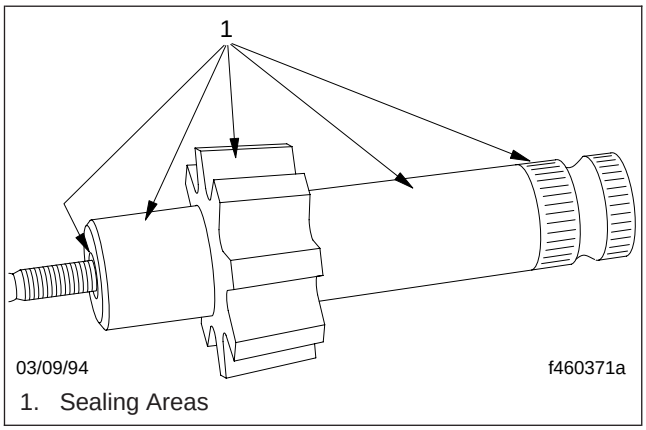


Fig. 54, Sector Shaft Bearing Sealing Areas

9. Inspect the thrust bearing rollers for any deterioration. Inspect the two thrustwashers for brinelling, spalling, or cracks. See **Fig. 55**. Replace any part if these conditions are detected.

Assembly

IMPORTANT: The special tools required for disassembly and assembly of the steering gear parts are available from the SPX Kent-Moore or an affiliated dealer. See the table on special tools in **Specifications 400** to be sure that you have the required tools before beginning the service procedures.

Replace all seals, seal rings, and gaskets with new ones each time the gear is disassembled. Individual seals, seal rings, and gaskets—as well as complete seal kits—are available from Freightliner part distributors.

1. Using seal installation tool J26739, assemble the new worm shaft backup O-ring and then the new Teflon® worm shaft seal ring. See **Fig. 56** and **Fig. 57**. Compress the seal ring with compression tool J26740 and set the worm shaft aside for 10 minutes. See **Fig. 58**.

⚠ CAUTION

Allow 10 minutes for the ring and seal to properly seat before may tear or be cut when placing the worm into the rack.

2. If installing a new housing bearing, install the retaining ring into the groove on the outside di-

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

ameter of the bearing. Then press the bearing into the housing from the trunnion side using bearing mandrel J26743 against the lettered end of the bearing shell so the retaining-ring end is away from the housing bore. See **Fig. 59**. Be sure the bearing mandrel is clean. Be sure the housing is square with the press base and that the bearing is not cocked.

3. Whether or not a new bearing race was installed, apply a generous amount of clean grease to the bearing race to retain the bearing rolls. Then place the bearing rolls into the bearing race. Be sure that the rolls have been counted correctly, and the quantity matches the quantity required for the housing bearing part number.

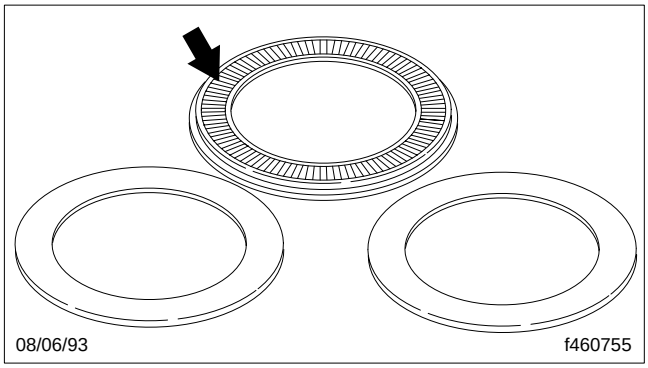
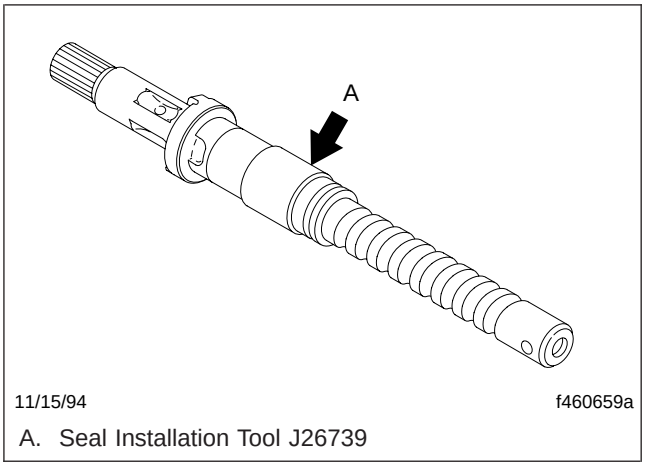


Fig. 55, Thrust Bearing Rollers and Thrustwashers



A. Seal Installation Tool J26739

Fig. 56, Seal Installation Tool

NOTE: If bearing BR-970 is being installed, install 41 rolls. If bearing BR-970-1 is being installed, install 42 rolls.

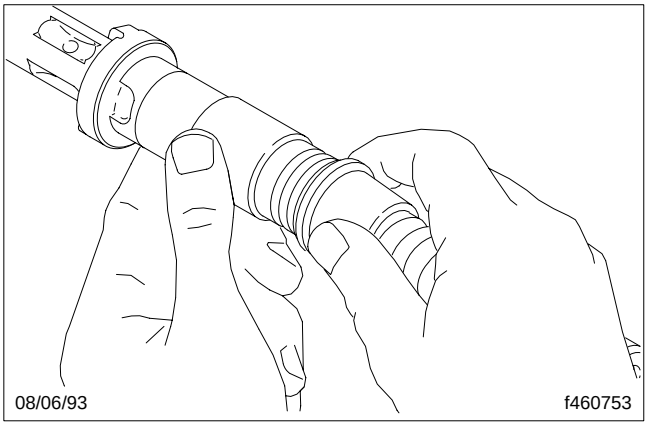


Fig. 57, Worm Shaft Seal Ring

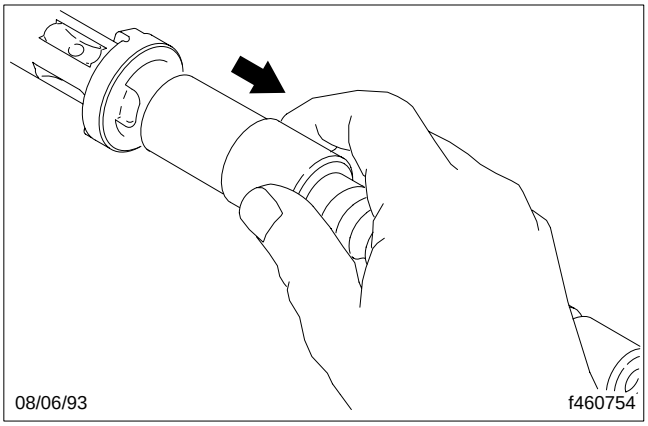


Fig. 58, Compress the Seal Ring

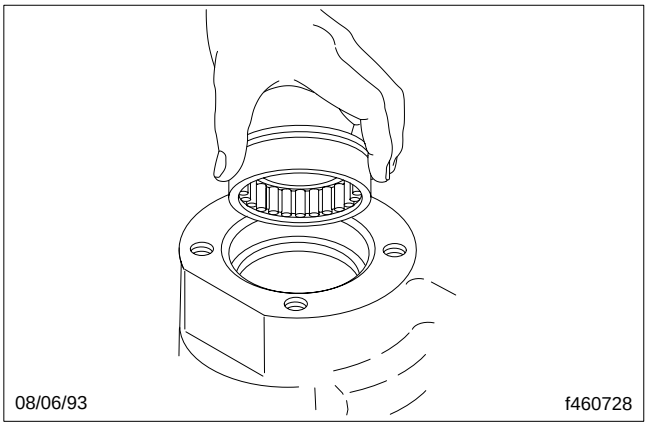


Fig. 59, Press the Bearing into the Housing

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

WARNING

The bearing rolls must be in place to ensure proper installation of the bearing. If the rolls are improperly installed, the bearing race may collapse or the flange may break. Do not mix the housing bearing rolls with the side cover bearing rolls (if applicable). Interchanging the rolls could result in bearing or seal damage. This could cause a loss of steering, which could result in an accident causing personal injury or property damage.

4. Install a new rack piston backup O-ring and a new Teflon® rack piston seal ring. See **Fig. 60** and **Fig. 61**. Do not stretch these rings when installing them. After they are installed, coat them with a liberal amount of grease.

5. Install the parts of the poppet assembly in the following order: one poppet seat, then (from the other end of the poppet hole in the piston) one poppet, the poppet spring, the nylon spacer rod, the other poppet, and the other poppet seat. See **Fig. 62**, **Fig. 63**, and **Fig. 64**.

WARNING

Wear eye protection while assembling the poppets. The poppets are spring-loaded and could be ejected, which could result in serious eye injury.

6. Tighten the poppet seats 20 to 25 lbf·ft (27 to 34 N·m). Install both retaining rings.

7. If more than 10 minutes have passed since installing the worm shaft seal and ring, grease the sealing surface inside the rack piston, and install the worm shaft/input shaft assembly into the rack piston. See **Fig. 65**.

8. Install the ball return guides.

   8.1 For ball return guides with a hole in the top, install the guides in the rack piston. Make sure they are seated.

WARNING

Do not seat the guides with a hammer. This could damage them and cause steering gear lockup or loss of steering, resulting in an accident causing personal injury or property damage.

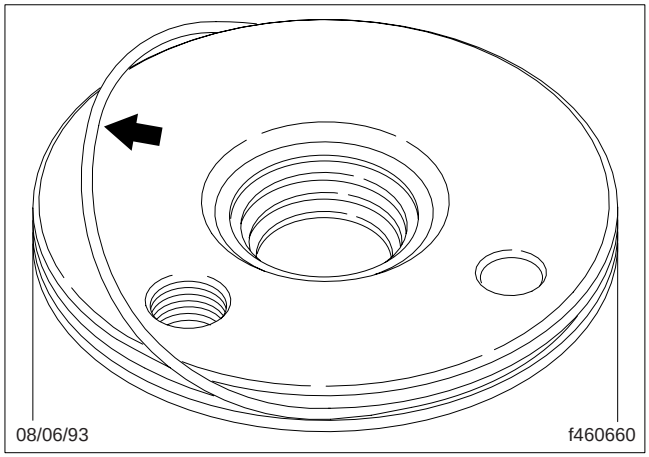


Fig. 60, Rack Piston O-Ring

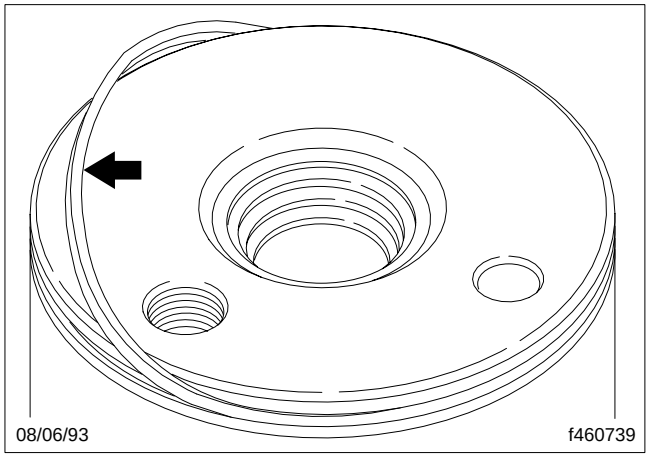


Fig. 61, Rack Piston Seal Ring

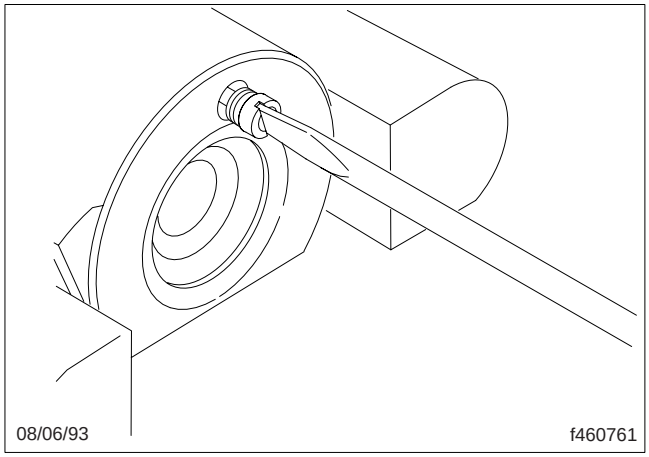


Fig. 62, Install the Poppet Seal

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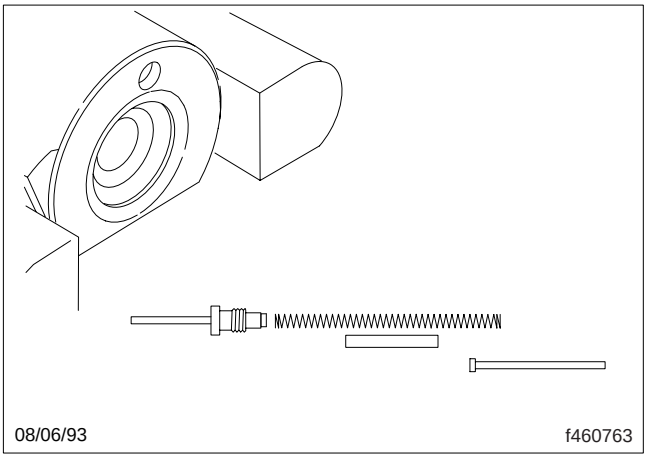

Fig. 63, Poppet, Poppet Spring, and Spacer Rod

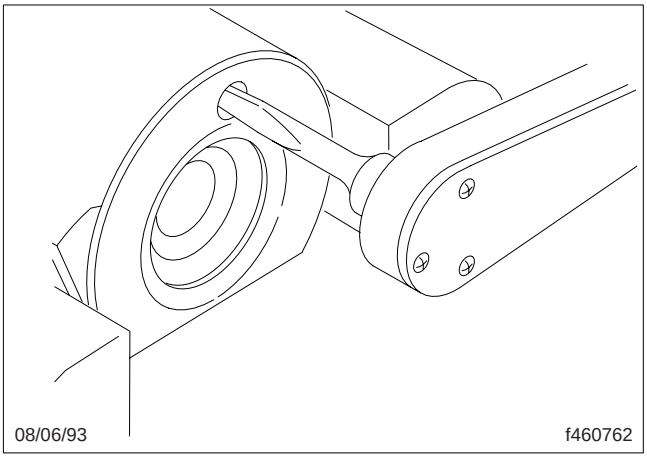

Fig. 64, Install the Poppet Seal

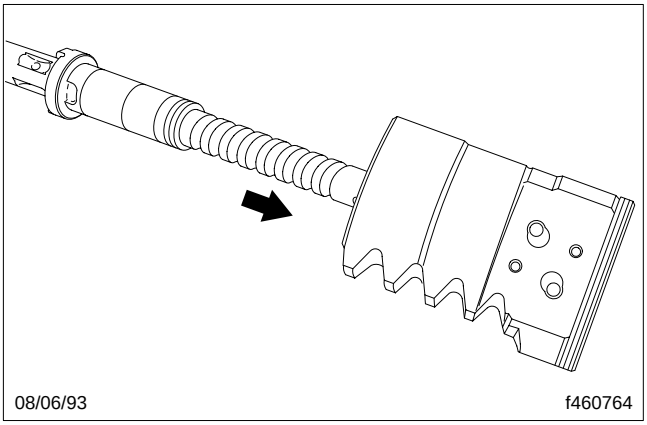

Fig. 65, Install the Worm Shaft/Input Shaft Assembly into the Rack Piston

8.2 Place the 34 balls in the ball return guides and rack piston. Drop them through the hole provided in the ball return guides. As the balls are dropped into the guide, turn the worm shaft to pull them down into the grooves. See **Fig. 66**.

⚠ WARNING

Make sure the ball return guide stays down and in place while you are inserting the steel balls or turning the worm shaft. Failure to hold the ball guide down may result in a ball being trapped outside the closed loop. A trapped ball could cause a steering lockup, which could result in an accident causing personal injury or property damage.

8.3 For ball return guides without a hole in the top, insert the eraser end of a pencil into one hole of the rack piston as far as it will go. Drop 22 balls (of the 34 total) into the other hole of the rack piston. See **Fig. 67**. Turn the worm shaft to advance the balls toward the other hole. There will be resistance after the 22nd ball is dropped. A ball will be visible at the base of each hole. Remove the pencil.

⚠ WARNING

Do not turn the worm shaft or allow the rack piston to move after removing the pencil. If the worm shaft or rack piston moves, a ball can move into the dead track beyond the ball return guides. This can result in steering lockup, which could result in an accident causing personal injury or property damage.

8.4 Apply a generous amount of clean grease on the ball return guides, and insert the remaining 12 balls into a guide half. See **Fig. 68**. Join the guide halves and install in the rack piston.

9. If equipped with the ball return guide clip, assemble it and make sure that both bolt hole faces are in full contact with the rack piston surface. See **Fig. 69**. Install the two locktabs and the two bolts. Tighten the bolts 14 to 22 lbf·ft (19 to 30 N·m). See **Fig. 70**. Bend the locking tabs up against the bolt head flats. See **Fig. 71**.

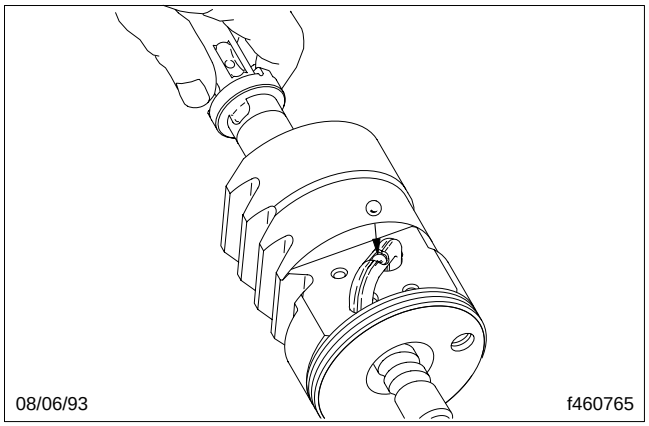

Fig. 66, Place the Balls in the Ball Return Guide

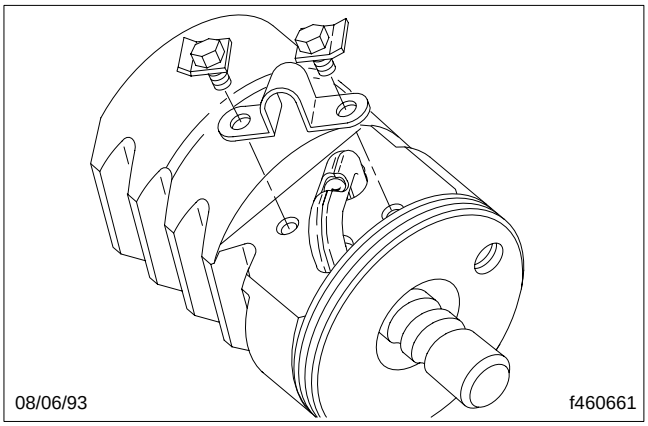

Fig. 69, Install the Ball Return Guide Clip

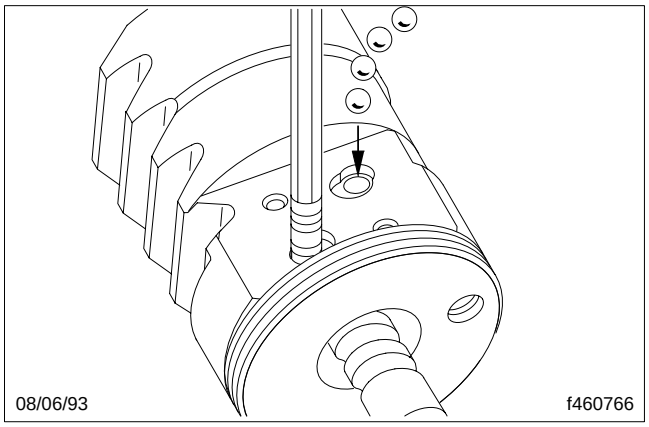

Fig. 67, Place the Balls in the Rack Piston

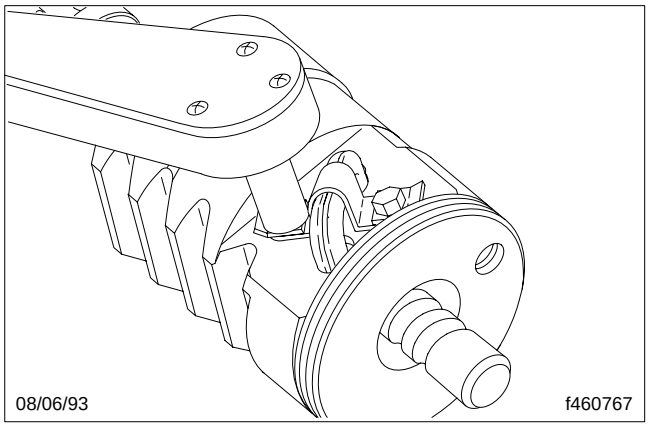

Fig. 70, Tighten the Bolts

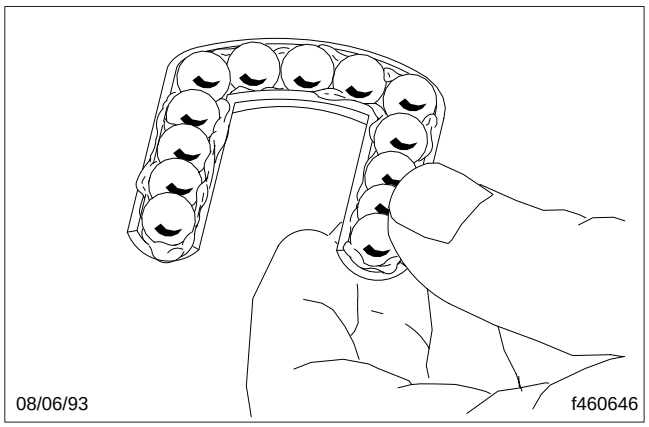

Fig. 68, Insert the Balls in the Guide Half

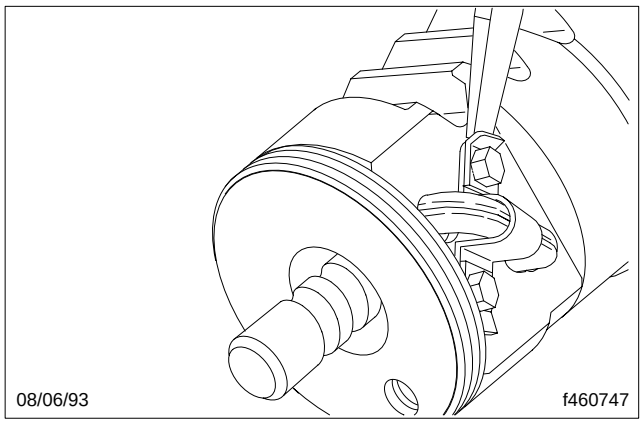

Fig. 71, Bend the Locking Tabs

10. If equipped with the ball return guide cap, grease the cap seal and install the seal in the ball return guide cap groove. See **Fig. 72**. Install the guide cap so that the seal is in full contact with the rack piston surface. Install two new Allen-head

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screws and tighten them 14 to 22 lbf·ft (19 to 30 N·m). See **Fig. 73**.

WARNING

Turn the worm shaft from one end of travel to the other to be sure the balls are installed properly. If the worm shaft will not turn, remove the balls and install them again. If the steering gear is installed on a vehicle when the worm shaft does not turn, the gear will not work correctly. This could cause loss of steering control, which could result in an accident causing personal injury or property damage.

11. Apply a generous amount of clean grease to the Teflon® rack piston seal and to the housing cylinder bore. See **Fig. 74**. Install the rack piston and worm shaft as an assembly in the gear housing, so that the Teflon® rack piston seal goes in last. See **Fig. 75**.

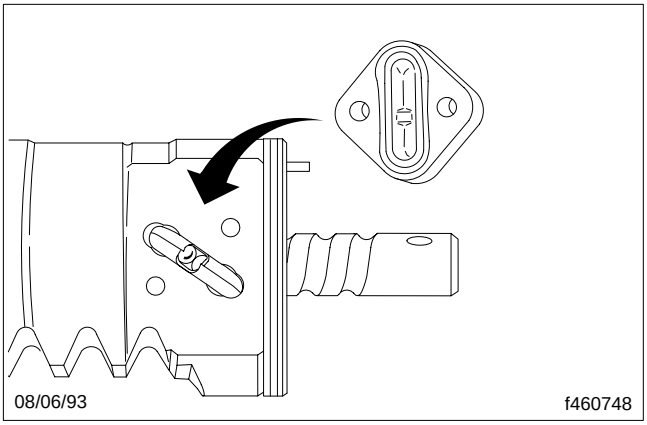

Fig. 72, Install the Seal in the Groove Return Guide Cap Groove

WARNING

Be sure the seal is placed in the housing last. Otherwise, a large section of the seal will be cut, and the vehicle will have no power steering assist. This could cause an accident resulting in personal injury or property damage.

NOTE: To ease the later assembly of the sector shaft, turn the rack piston and worm shaft assembly in the housing so that the rack teeth are exposed in the sector shaft cavity of the housing.

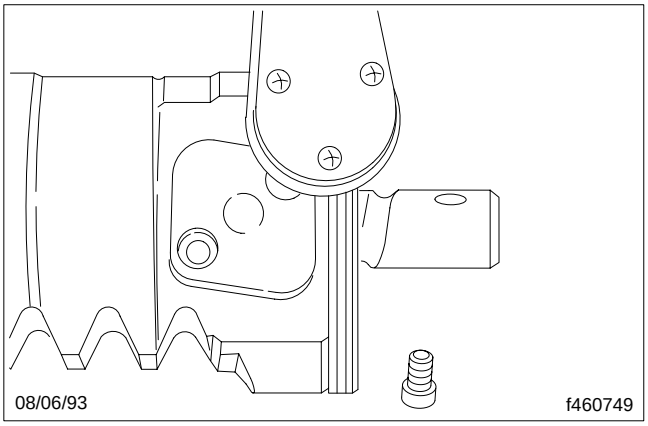

Fig. 73, Tighten the Screws

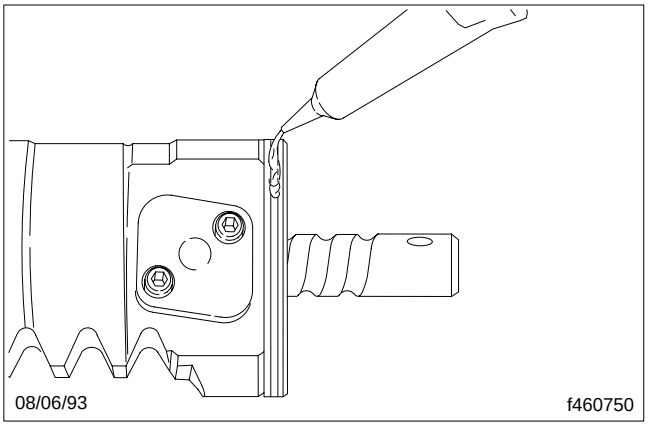

Fig. 74, Lubricate the Cylinder Bore

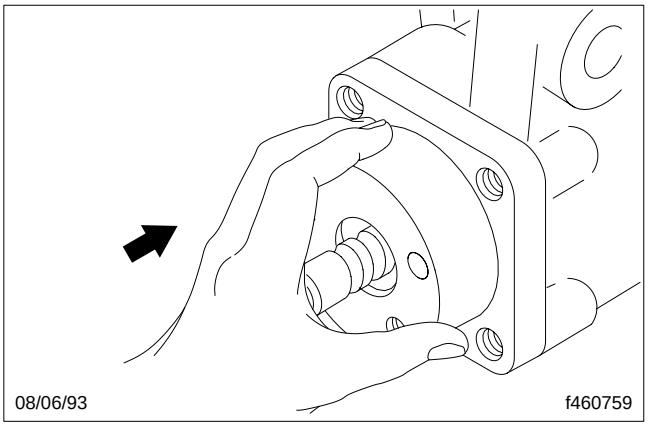

Fig. 75, Install the Rack Piston/Worm Shaft Assembly

12. Install the worm shaft adjusting screw jam nut on the nonslotted end of the worm shaft preload ad-

justing screw, so that the seal on the jam nut faces the end cover.

13. Assemble and install one poppet valve adjusting screw and jam nut in the same manner. Assemble the other poppet valve adjusting screw jam nut onto the poppet valve adjusting screw.

NOTE: The poppet valve adjusting screws may not be of the same length. If not, insert the shorter adjusting screw into the end cover a few turns.

⚠ WARNING

If the screw lengths are unequal, install the shorter screw in the end cover. Otherwise the poppet assembly could break and cause a steering lockup, which could result in an accident causing personal injury or property damage.

14. Install the worm shaft preload adjusting screw in the end cover a few turns.
15. Grease the end cover O-ring groove and install the new end cover O-ring. See **Fig. 76**.

NOTE: When installed, the O-ring should extend slightly above the machined surface of the end cover.

16. Position the end cover so that the poppet adjusting screw is aligned with the end of the poppet. See **Fig. 77**.

    Make sure the rack piston teeth are fully visible in the sector shaft cavity of the housing. This ensures proper location of the poppets so that the poppet adjusting screw will contact the poppets.

    Install the four end cover bolts and tighten 150 to 170 lbf·ft (203 to 230 N·m). See **Fig. 78**.

17. Grease two new valve-sleeve backup O-rings and two new Teflon® seal rings. Install the backup O-rings on the valve sleeve. See **Fig. 79**. Then use seal installation tool J26741 to install the seal rings on the valve sleeve. See **Fig. 80**.
18. Using special tool J26742, compress the Teflon® seal rings. See **Fig. 81**. Leave the tool on for 10 minutes.

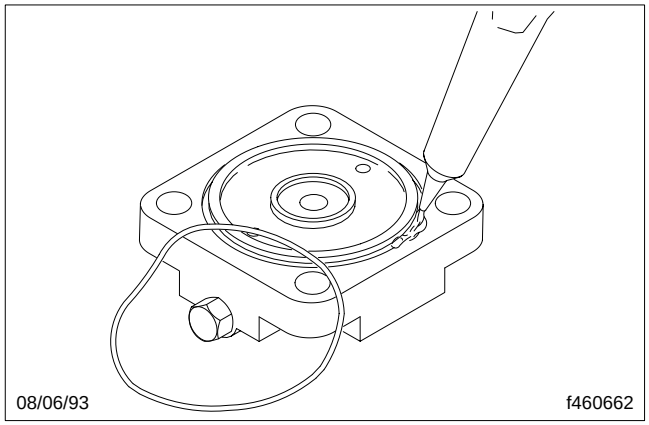

Fig. 76, Lubricate the O-Ring Groove

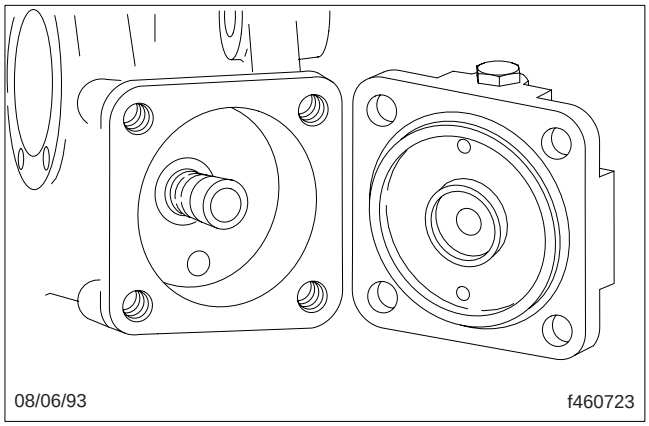

Fig. 77, Position the End Cover

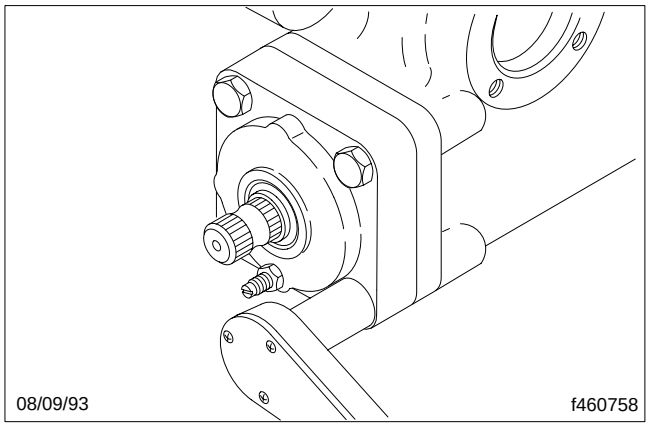

Fig. 78, Install the Bolts

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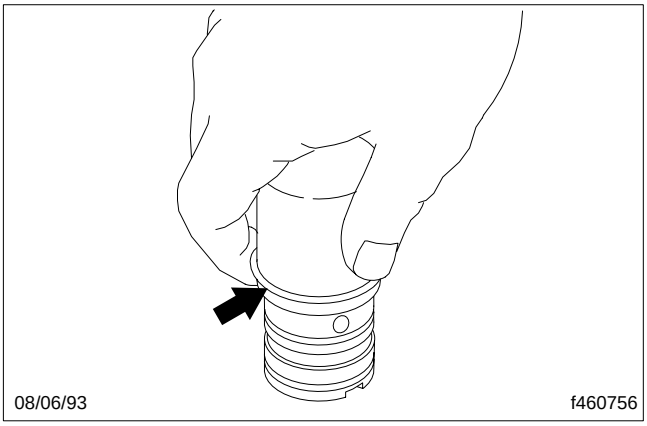


Fig. 79, O-Ring

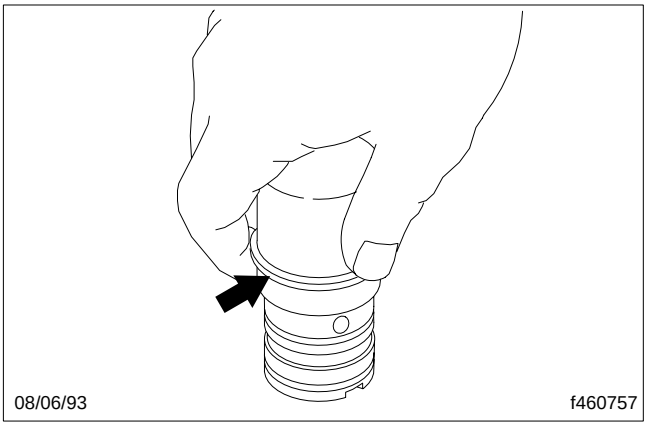


Fig. 80, Seal Ring

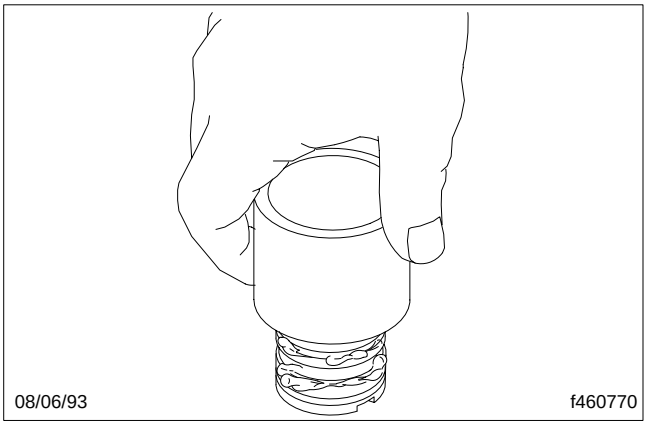


Fig. 81, Compress the Seal Rings

⚠ CAUTION

Allow at least 10 minutes for the seals to properly seat. Otherwise the valve sleeve will be difficult to install in the valve housing, and the seal may be cut during installation.

19. Turn the poppet valve adjusting screw into the valve housing 4 or 5 turns. Final adjustments will be made later.
20. Apply clean grease to the O-ring groove in the valve housing. Install a new valve housing O-ring in the groove. See **Fig. 82**.

NOTE: When installed, the valve housing O-ring should extend slightly above the machined surface of the valve housing.

21. Apply a generous amount of clean grease to one thrustwasher. Install the bearing in the valve housing and on the first thrustwasher. Be sure the washer is centered. See **Fig. 83**.
22. Apply a generous amount of clean grease to the thrust bearing. Install the bearing in the valve housing and on the first thrustwasher. Be sure the bearing is centered. See **Fig. 84**.

⚠ WARNING

The thrustwasher and thrust bearing must be flat and centered in the counterbore surface of the valve housing. See Fig.85. Otherwise the thrustwasher could break when the valve housing is installed on the gear housing. A broken thrustwasher could cause the steering gear to malfunction. This could cause a loss of vehicle control, which could result in an accident causing personal injury or property damage.

23. Remove the compression tool from the valve sleeve. Apply more grease to the valve sleeve seals. Grease the thrustwasher face on the end of the valve sleeve that is without the drive slots. Place the second thrustwasher on this face. See **Fig 86**.

⚠ WARNING

The thrustwasher must fit securely on the valve sleeve. If not, it can break and cause a loss of vehicle control. This could cause an accident resulting in personal injury or property damage.

24. Install the valve sleeve and the attached thrustwasher into the valve housing. See **Fig. 87**. When the valve sleeve is in place, it should measure between 0.370 and 0.400 inch (9 and 10 mm) above the face of the valve housing to the end of the valve sleeve nose. See **Fig. 88**.

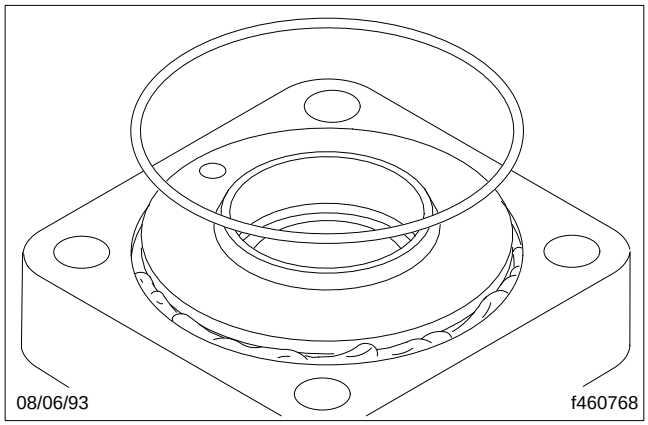


Fig. 82, Install the O-Rings

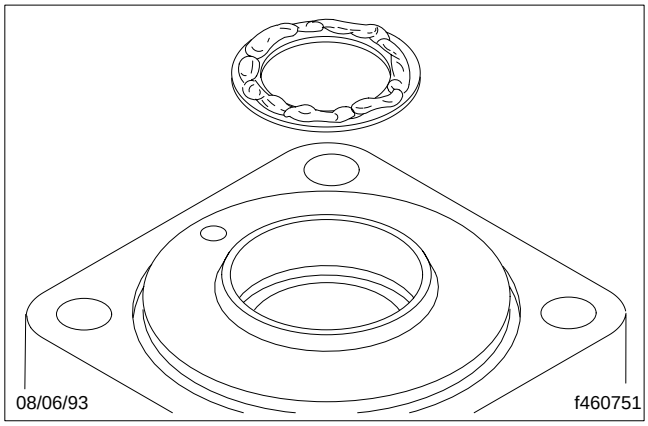


Fig. 83, Lubricate and Install the Thrustwasher

⚠ WARNING

Do not force the valve sleeve in the valve housing. Make sure the valve sleeve seal rings are compressed. A bad installation or measurement could cause the thrustwashers or thrust bearing to break during gear operation. This could result in a loss of vehicle control, which could cause an accident resulting in personal injury or property damage.

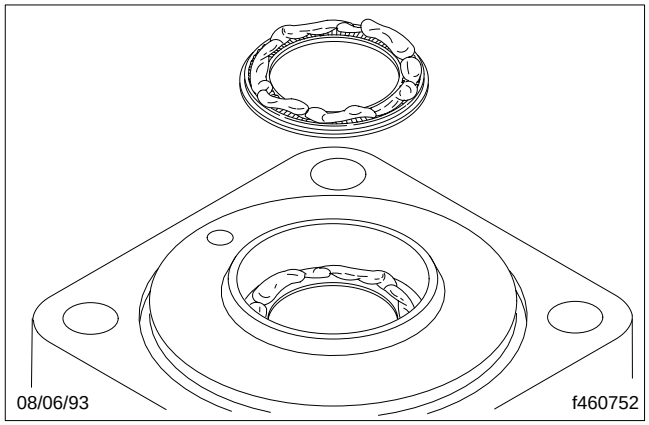


Fig. 84, Lubricate and Install the Thrust Bearing

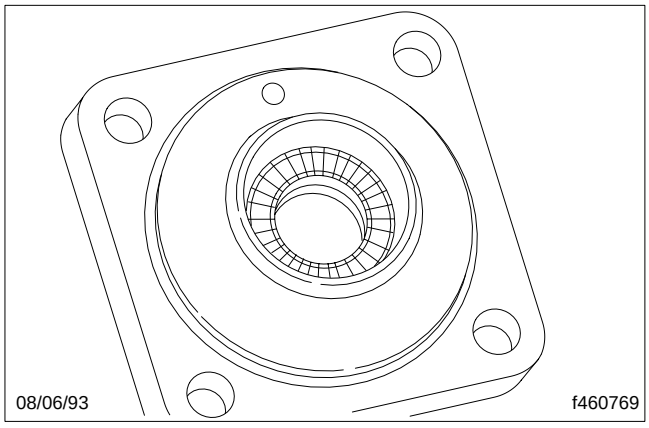


Fig. 85, Thrustwasher and Thrust Bearing in the Valve Housing

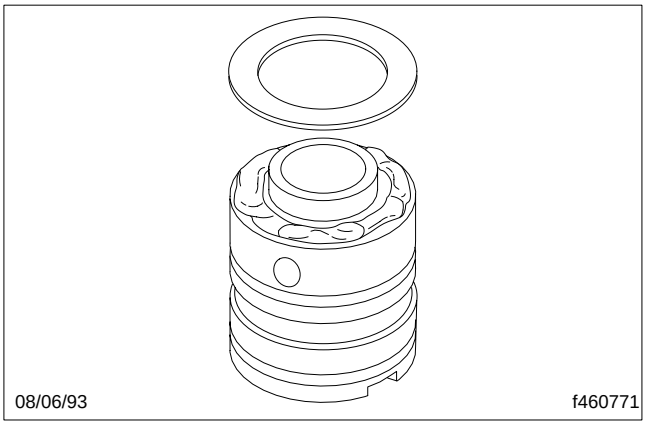


Fig. 86, Install the Thrustwasher

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

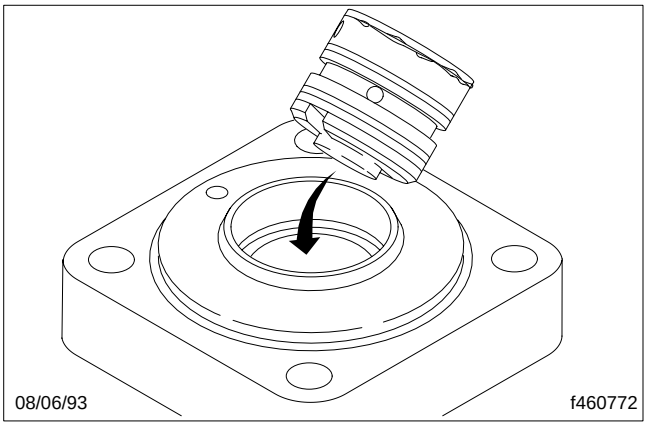
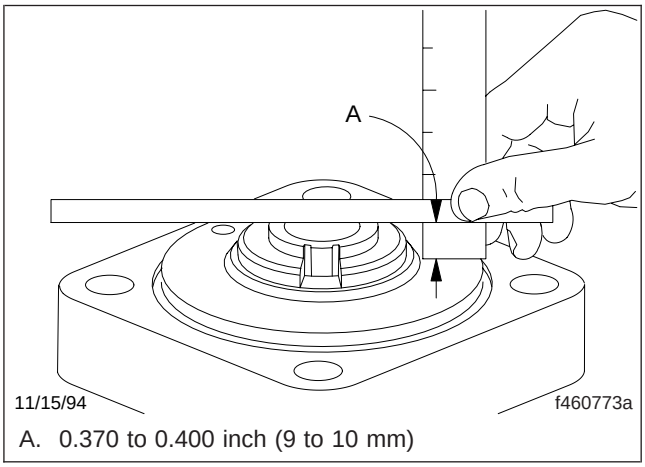


Fig. 87, Install the Valve Sleeve



A. 0.370 to 0.400 inch (9 to 10 mm)

Fig. 88, Check the Location of the Valve Sleeve

25. Move the rack piston flush with the open end of the gear housing. Turn the worm shaft until it extends out of the rack piston as far as it will go.

WARNING

The worm shaft and valve sleeve units are assembled and sold as a matched set. Use only prematched sets for replacement. Never mate an old valve sleeve with a new worm shaft, or an old worm shaft with a new valve sleeve. This can result in damage to the gear and personal injury to the driver during vehicle operation.

26. Locate the timing mark (a faint punched mark on the chamfered edge of the valve sleeve or an indented mark on the front of the sleeve). See **Fig. 89**. Locate the timing mark on the worm shaft. See **Fig. 90**.

    Grasp the valve housing and valve sleeve as an assembly with your thumbs on the valve housing and your fingers applying pressure on the valve sleeve to keep it in the valve housing. See **Fig. 91**.

    Align the previously located timing marks. See **Fig. 89** and **Fig. 90**. Place the valve housing and valve sleeve, as an assembly, on the input-shaft end of the worm shaft until the drive lugs are fully engaged. See **Fig. 92**.

NOTE: Valve sleeves are identified with and matched to a right-or left-hand lead of the worm screw. Because the screw has a right-hand thread (that is, goes into the rack piston when turned clockwise), the valve sleeve will have the letter "R" stamped between the seal lands. For a left-hand worm lead (which will come out of the rack piston when turned clockwise), the mating valve sleeve has no identifying letter or has the letter "L" stamped between the seal lands.

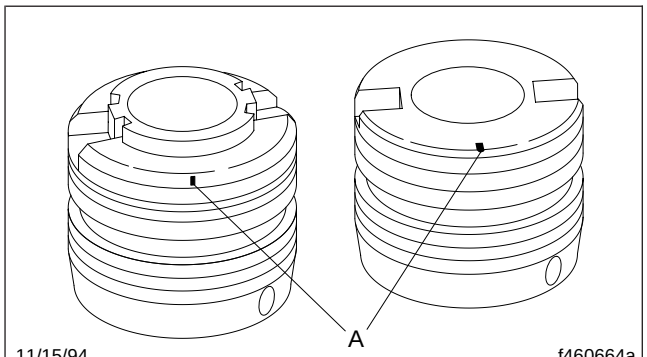
WARNING

If an incorrect valve sleeve is placed on a worm and assembled into the gear, the gear will malfunction. The mechanism will jerk the steering wheel with such force that it could cause a loss of vehicle control. This could cause an accident resulting in personal injury or property damage.

27. Maintain pressure on the valve end of the valve housing to ensure continued engagement of the drive lugs and thrust bearing package. See **Fig. 93**. While maintaining this pressure, turn the valve housing and align the poppet adjusting screw with the poppet in the rack piston. While continuing pressure, turn the input shaft to bring the valve housing into contact with the gear housing face.

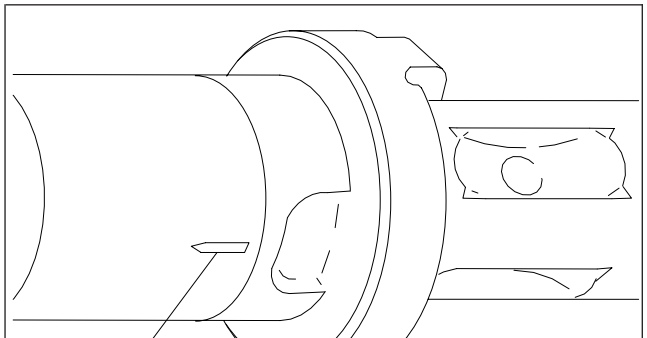
28. Install the four valve housing bolts in the valve housing and tighten them 145 to 155 lbf·ft (197 to 210 N·m). See **Fig. 94**.

29. Apply a generous amount of clean wheel bearing grease (do not substitute another type of grease) to the bearing race inside the side cover.



A. Timing Marks

Fig. 89, Timing Marks



A. Timing Mark

Fig. 90, Timing Mark

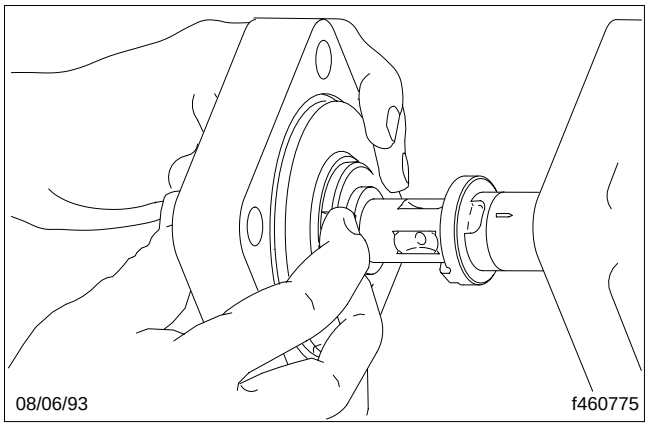
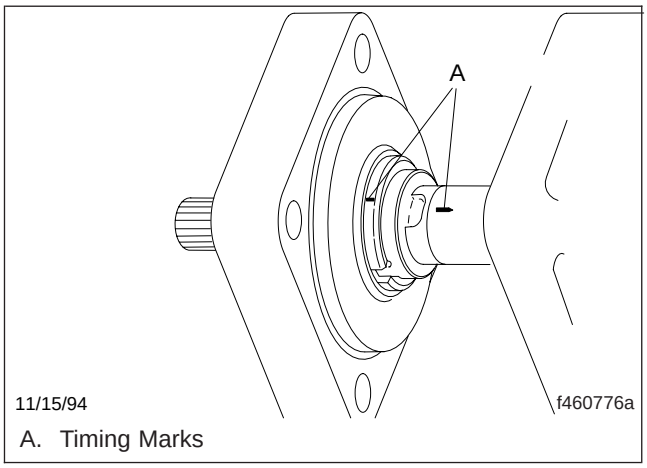


Fig. 91, Grasp the Valve Housing and Valve Sleeve as an Assembly



A. Timing Marks

Fig. 92, Timing Marks

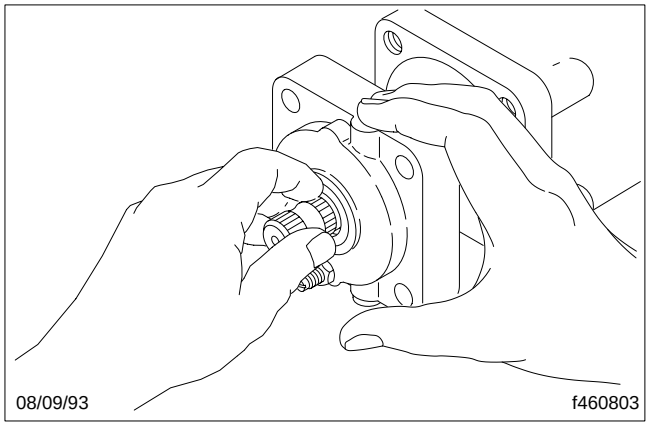


Fig. 93, Maintain Pressure on the Valve End of the Housing

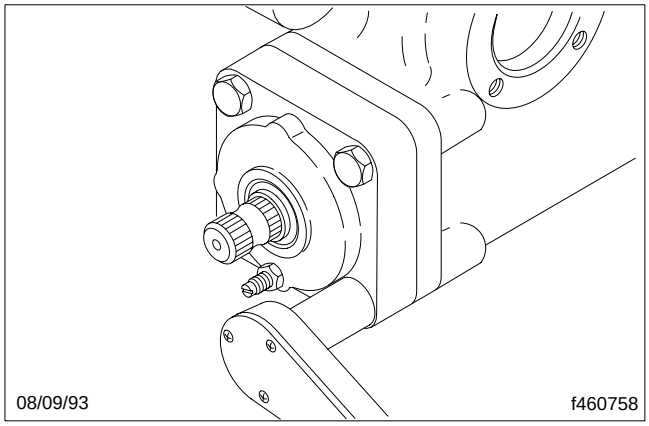


Fig. 94, Install the Bolts

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

CAUTION

Use only wheel bearing grease. This bearing is sealed and will receive no lubrication from the hydraulic fluid in the gear. Without wheel bearing grease, the bearing could wear prematurely.

30. If applicable, insert the bearing rolls into the side cover bearing race. See **Fig. 95**. If equipped with bearing BR-970, insert 41 rolls. If equipped with bearing BR-970-1, insert 42 rolls.

NOTE: Apply clean wheel bearing grease to loose rolls, to retain them in the bearing race.

31. Install the steel backup washer, a new Teflon® backup washer, and a new two-piece side cover seal in the side cover. See **Fig. 96**.

NOTE: In newer seal kits and on some units, the Teflon® backup washer is an integral part of the two-piece seal.

32. Assemble the two-piece seal so that the words OIL SIDE are visible after it is installed.

WARNING

The words OIL SIDE must be visible once the seal is in place. Otherwise the seal will malfunction. This could result in a loss of power steering assist, which could result in an accident causing personal injury or property damage.

33. Install the side cover retaining ring in the ring groove of the side cover. See **Fig. 97**.

34. Apply a generous amount of clean grease to the short bearing area of the sector shaft. Insert the sector shaft into the side cover. Turn the sector shaft adjusting screw into the side cover until it seats. See **Fig. 98**. Then back out the adjusting screw one turn so that the side cover turns freely on the sector shaft.

35. Install the sector shaft adjusting screw jam nut on the sector shaft adjusting screw a few threads. Final adjustment will be made later.

36. Press a new rubber plug into the hole provided in the side cover until the plug is flush. See **Fig. 99**.

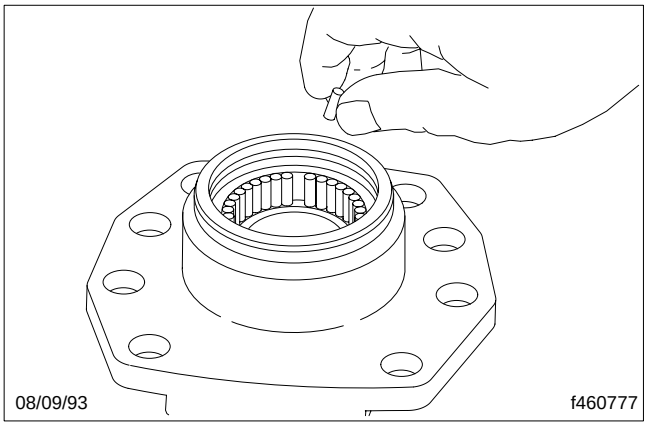


Fig. 95, Install the Bearing Rolls

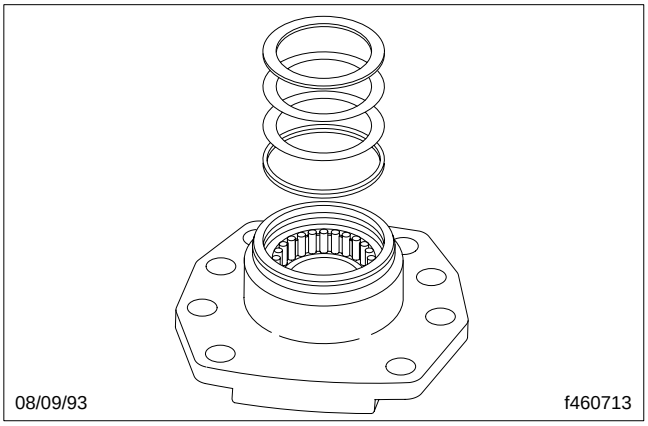


Fig. 96, Install the Backup Washers and the Two-Piece Seal

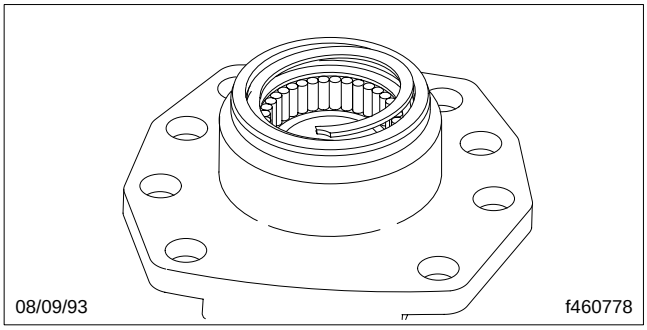


Fig. 97, Install the Retaining Ring

WARNING

Do not weld or plug this hole permanently. This is a safety vent that works only if the side cover output shaft seal fails. If the seal fails and the

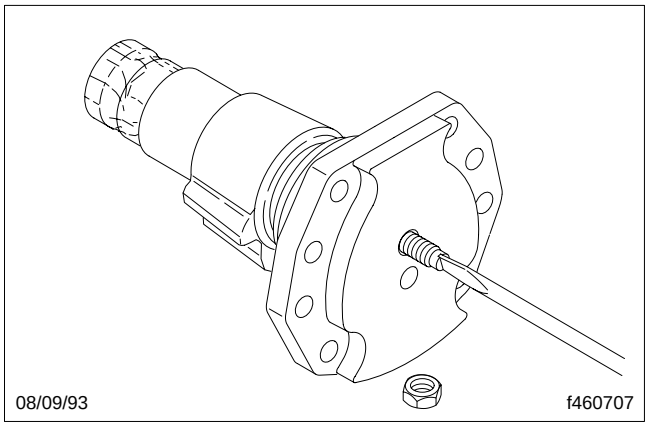


Fig. 98, Turn the Adjusting Screw

plug cannot vent, the steering gear can lock up or otherwise malfunction. This could result in a loss of steering control, which could result in an accident causing personal injury or property damage.

37. Apply clean grease to a new side cover gasket and install it on the side cover. See **Fig. 100**. Apply enough grease to hold the gasket in place.
38. There are four teeth on the rack piston. See **Fig. 101**. Position the rack piston so that the tooth space identified by the pencil in **Fig. 102** (it is the space between the second and the third tooth) is in the center of the sector shaft opening.

⚠ WARNING

If the rack piston is not centered, steering gear travel will be severely limited in one direction. This could cause an accident resulting in personal injury or property damage.

39. With the rack piston centered, tighten the worm shaft adjusting screw 15 to 20 lbf·ft (20 to 27 N·m). Then loosen the adjusting screw 1/4 to 1/2 turn and note the torque required to rotate the input shaft 90 degrees each side of center. See **Fig. 103**. Loosen the adjusting screw if the noted input shaft torque exceeds 15 lbf·in (169 N·cm). Return the rack piston to the center position.
40. Remove any tape on the sector shaft serrations. Retape the serrations and bolt groove with **one layer** of masking tape. Install the sector shaft and side cover, as an assembly, into the gear housing. Make sure that the center tooth of the sector shaft engages the center space (between the second and third teeth) of the rack piston.

⚠ WARNING

When placing the sector shaft through the housing bearing, do not knock any of the bearing rolls out of the bearing race. Do not pinch the side cover gasket. If either is done, the bearing or seal could be damaged. This could result in a loss of power steering assist, which could result in an accident causing personal injury or property damage.

41. Install the eight special side cover bolts into the side cover and tighten them 150 to 170 lbf·ft (203 to 230 N·m).
42. Place the trunnion cover on a bench with the exterior side down. Install a new Teflon® backup washer.
43. Install a new two-piece sector shaft seal so that the words OIL SIDE are visible after the seal is in place. See **Fig. 104**.

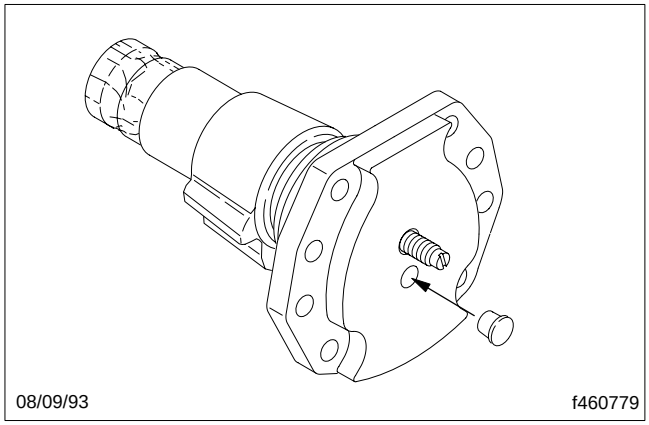


Fig. 99, Install a Plug into the Side Cover

⚠ WARNING

The words OIL SIDE must be visible once the seal is in place. Otherwise the seal will malfunction. This could result in a loss of power steering assist, which could result in an accident causing personal injury or property damage.

44. Grease a new trunnion cover O-ring and install it in the trunnion cover O-ring groove.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

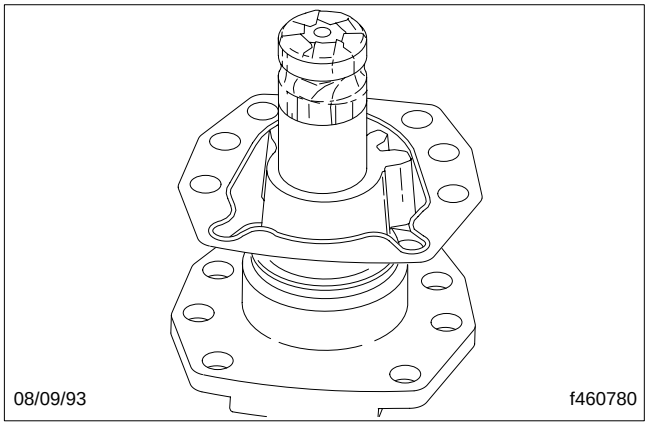


Fig. 100, Install the Side Cover Gasket

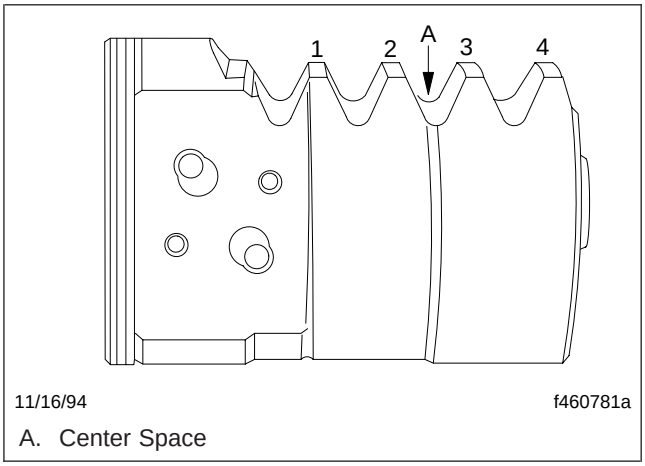


Fig. 101, Rack Piston Teeth

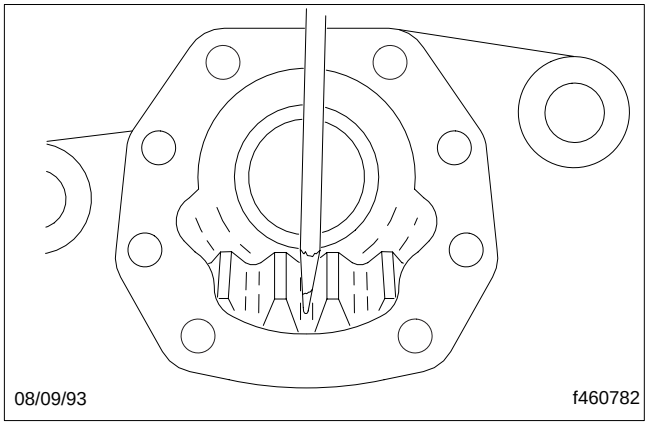


Fig. 102, Position the Rack Piston

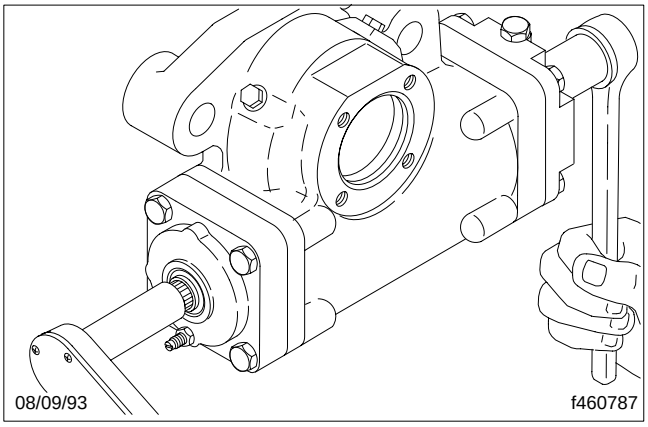


Fig. 103, Rotate the Input Shaft

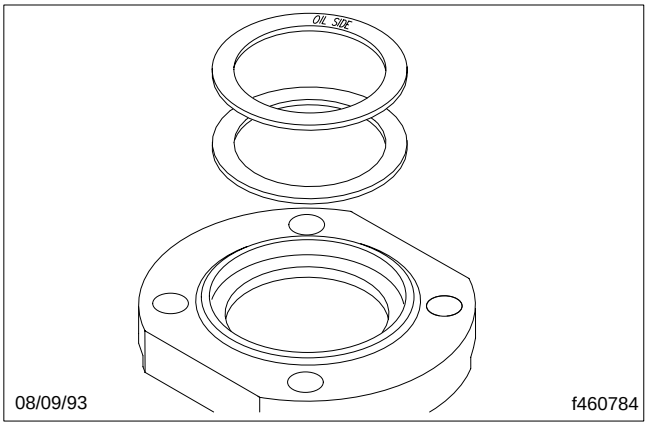


Fig. 104, Install the Two-Piece Seal

45. Inspect the housing bearing to make sure that all the bearing rolls are in place. Then install the trunnion cover. See **Fig. 105**. Install the four trunnion cover bolts and tighten them 15 to 22 lbf·ft (20 to 30 N·m). See **Fig. 106**. Pack the cavity around the seal area of the sector shaft with Mobil Temp 1 or 2 grease or an equivalent.

    Install a new dirt and water seal, using a suitable blunt-end drift. Install a new protective boot on the sector shaft and trunnion cover. Locate the boot grease fitting hole toward the input shaft end of the gear assembly. See **Fig. 107**. Insert the grease fitting into the protective boot.

46. Apply clean grease to the input shaft seal assembly (seal and O-ring) and to the input shaft. Install a new two-piece input shaft seal (with the flat side out), and the steel backup washer, using

seal-driving tool J28490. See **Fig. 108** and **Fig. 109**. Install the retaining ring.

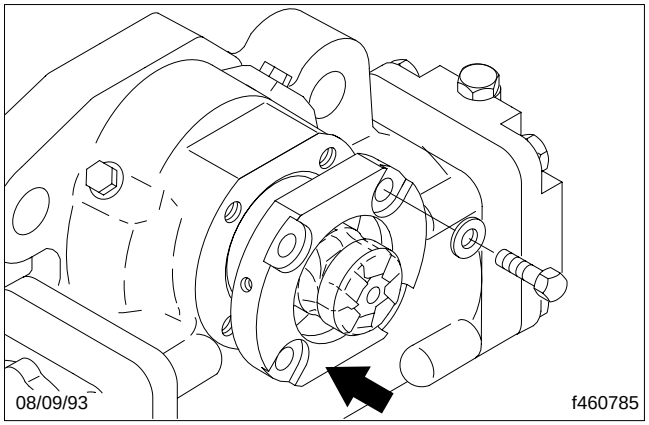


Fig. 105, Trunnion Cover

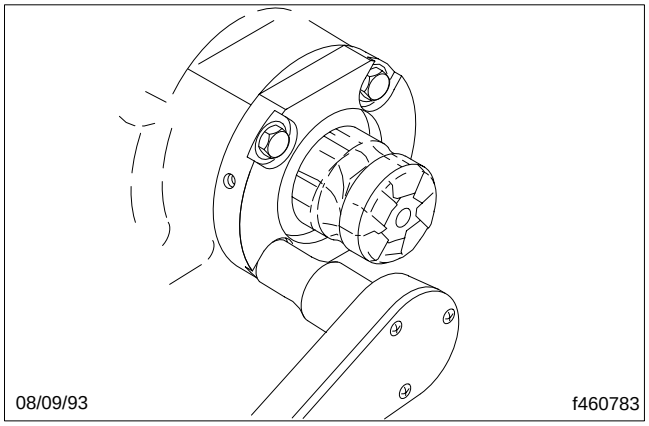


Fig. 106, Install the Bolts

47. Pack the area around the input shaft with clean water-resistant grease and install the dirt and water seal, using seal-driving tool J28490 or a suitable blunt-end drift.
48. Apply clean grease to the cupped side of the new seal protector and install it, cupped side in, on the input shaft and into the serration relief groove. See **Fig. 110**.
49. Install the manual bleed screw (if equipped) and tighten it 27 to 33 lbf·in (305 to 373 N·cm).

Final Adjustments

Before installing the steering gear on the vehicle, make these adjustments.

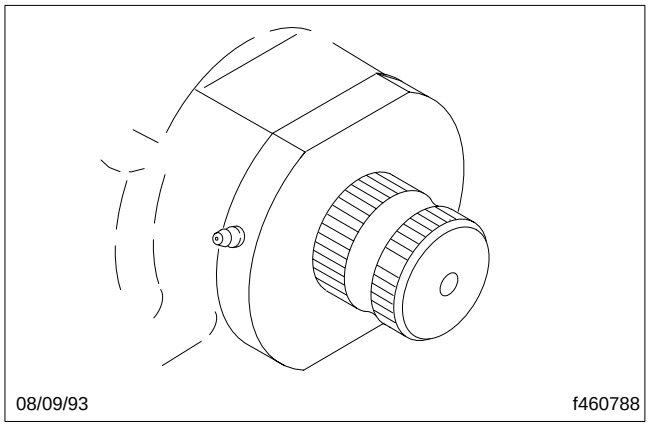


Fig. 107, Install the Protective Boot

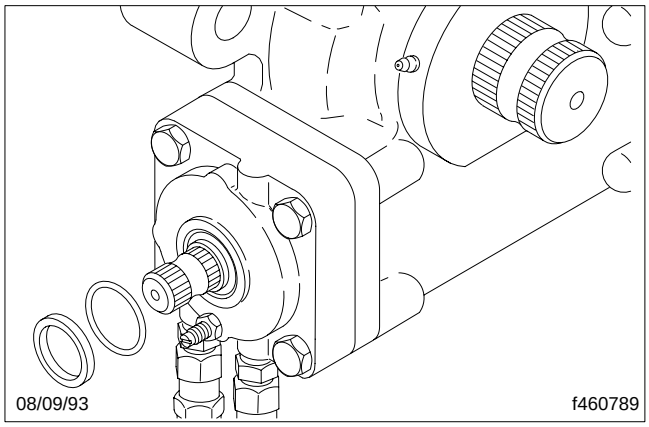


Fig. 108, Install the Two-Piece Seal and the Backup Washer

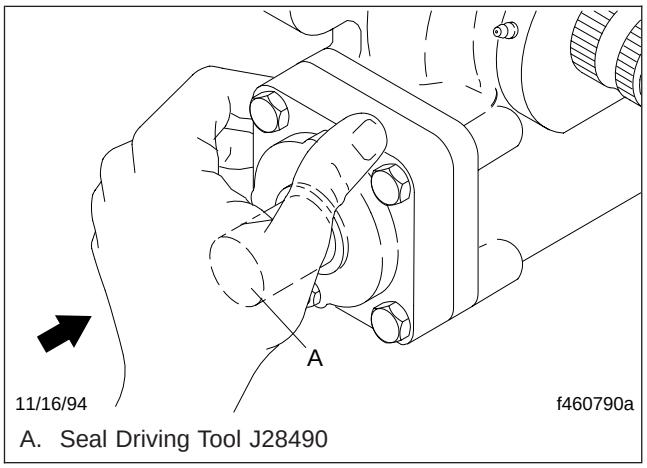


Fig. 109, Seal Driving Tool

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

NOTE: Worm shaft preload adjustment was done when the input shaft was installed in the valve housing during the assembly procedure.

1. To center the steering gear, turn the input shaft until the timing mark on the end of the sector shaft is at a right angle to the input shaft. See **Fig. 111**.

NOTE: Use a 12-point socket and an inch-pound torque wrench to turn the input shaft.

2. Adjust the sector shaft adjusting screw while turning the input shaft 180 degrees each side of center until the input shaft reaches a torque of 25 to 30 lbf·in (280 to 340 N·cm). See **Fig. 112**.
3. Back out the sector shaft adjusting screw one turn. Note the torque now required to turn the input shaft 180 degrees each side of center. Then tighten the adjusting screw in, to increase the noted torque by 2 to 4 lbf·in (23 to 45 N·cm).

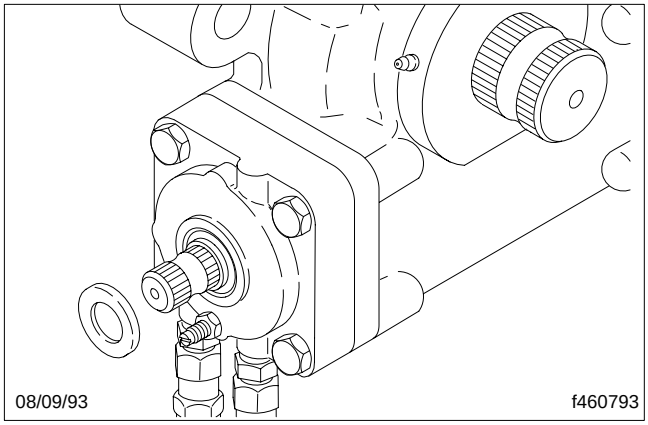
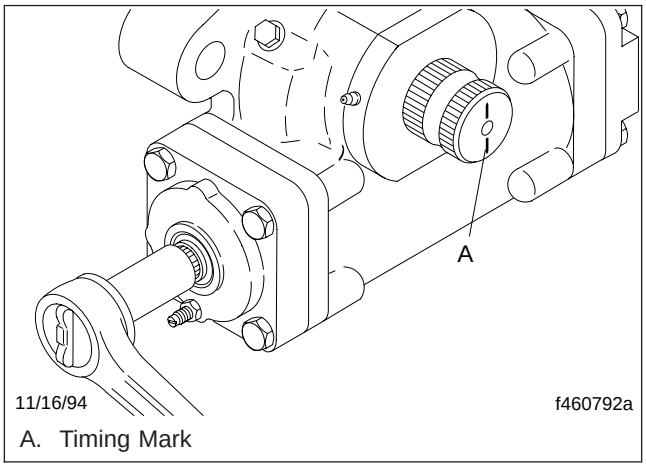


Fig. 110, Install the Seal Protector

4. Tighten the sector shaft adjusting screw jam nut 40 to 45 lbf·ft (54 to 61 N·m). The torque now required to turn the input shaft should not exceed 20 lbf·in (226 N·cm) at any point in the steering gear travel. If it does exceed 20 lbf·in (226 N·cm), repeat the necessary steps.
5. While turning the input shaft back and forth slightly, adjust the worm shaft preload adjusting screw to increase the maximum noted input torque by 10 to 15 lbf·in (113 to 169 N·cm). Make sure that the worm shaft adjusting screw jam nut does not contact the end cover while making this adjustment.



A. Timing Mark

Fig. 111, Align the Timing Mark

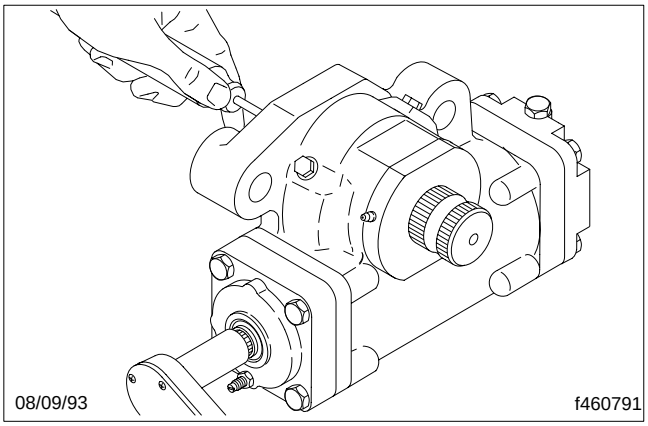


Fig. 112, Adjust the Adjusting Screw

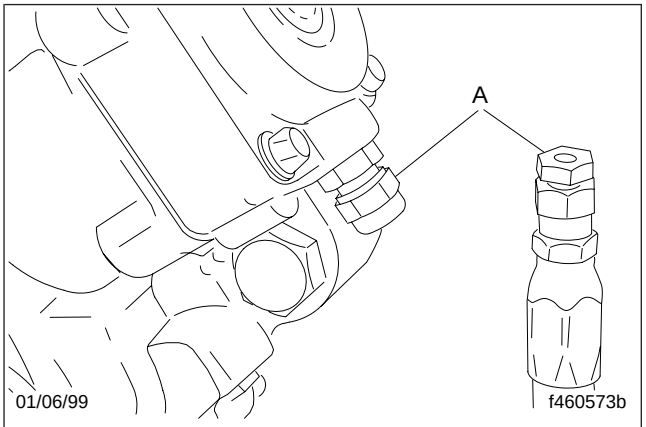
Tighten the jam nut 70 to 80 lbf·ft (95 to 108 N·m). Be sure that the adjusting screw does not move.

6. The torque now required to turn the input shaft should not exceed 35 lbf·in (395 N·cm). If it does exceed 35 lbf·in (395 N·cm), repeat the necessary steps.

Removal

NOTE: For clarity the figures in this subject show the steering gear on a mock-up frame and steering driveline.

1. Disconnect the return line from the steering gear and plug the line. Also cap the return port of the gear with a high pressure fitting. See **Fig. 1**.



A. Cap the return line and the return port.

Fig. 1, Disconnect the Return Line

2. Disconnect the steering driveline from the steering gear input shaft as follows:

   2.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

⚠ CAUTION

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

   2.2 Remove the lower end yoke from the input shaft. Do not turn the steering gear input shaft when removing the lower end yoke. Push the driveline shaft into the driveline tube as you remove the lower end yoke.

3. Remove the seal protector and clean the area around the input shaft with a fine grade emery paper. See **Fig. 2** and **Fig. 3**. Be sure to remove any paint.

4. Remove the dirt and water seal from the steering gear. See **Fig. 4**.

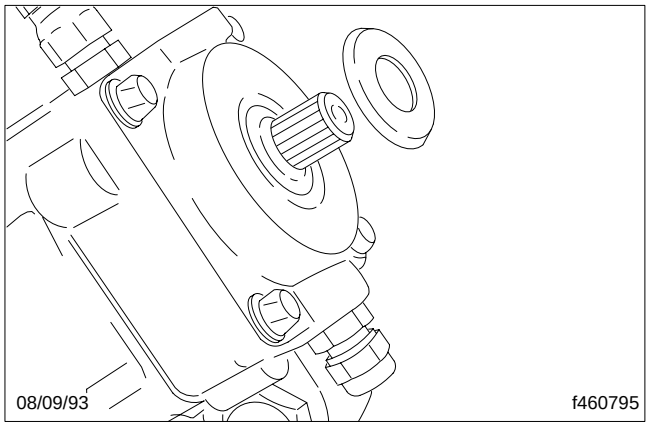


Fig. 2, Remove the Seal Protector

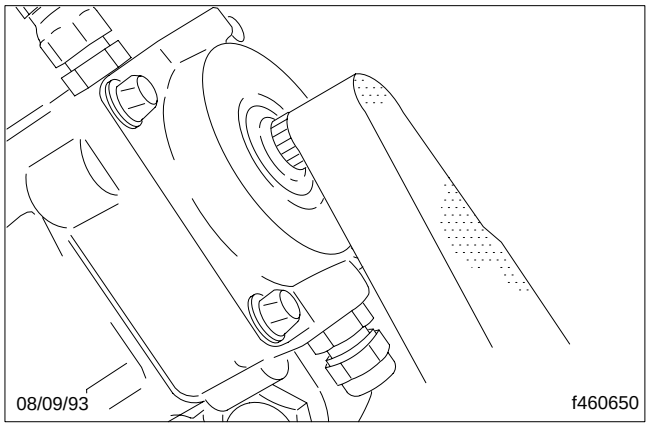
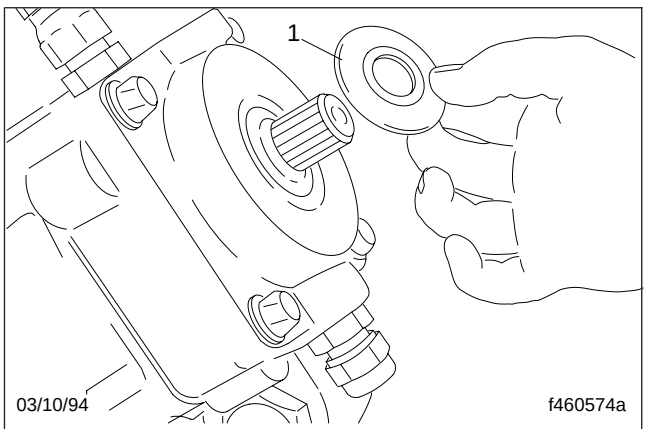


Fig. 3, Clean the Input Shaft

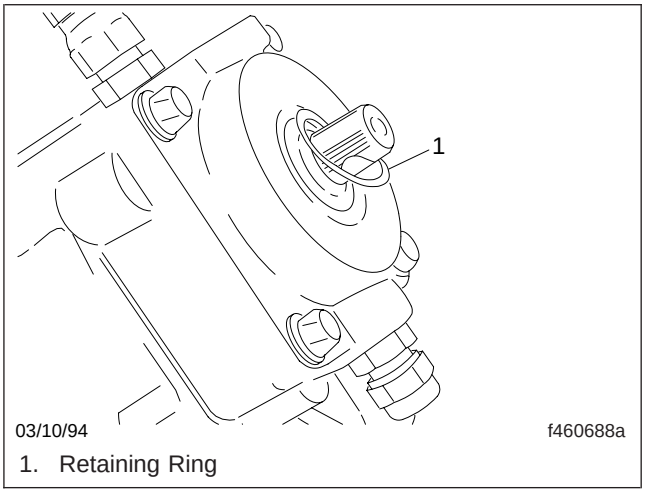


1. Dirt and Water Seal

Fig. 4, Remove the Dirt and Water Seal

Input Shaft Seal Removal and Installation

5. Wipe out the grease and then remove the retaining ring. See **Fig. 5**.



1. Retaining Ring

Fig. 5, Remove the Retaining Ring

⚠ WARNING

Wear eye protection when using compressed air. Particles blown by compressed air could contact your eyes and possibly cause serious injury.

6. Tie or wrap a shop towel around the input shaft area and blow compressed air through the return port. See **Fig. 6**. The compressed air will force the two-piece input shaft seal and the steel backup washer out of the gear and some fluid will leak out. See **Fig. 7**. Discard the two-piece seal and disconnect the shop air hose.

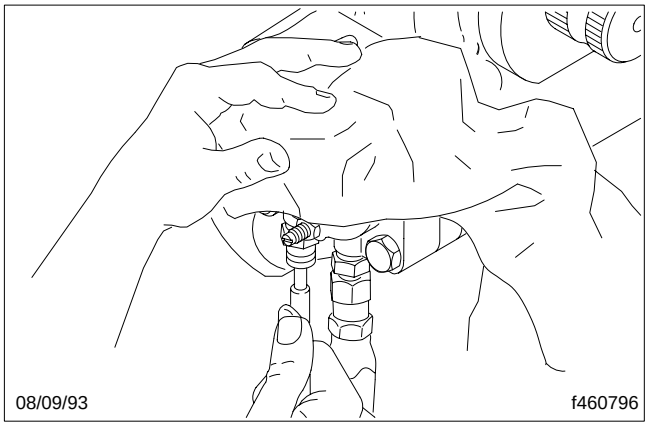


Fig. 6, Blow Compressed Air Through the Return Port

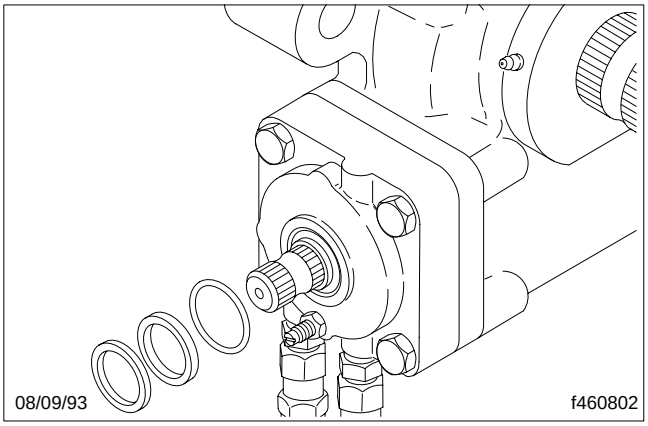
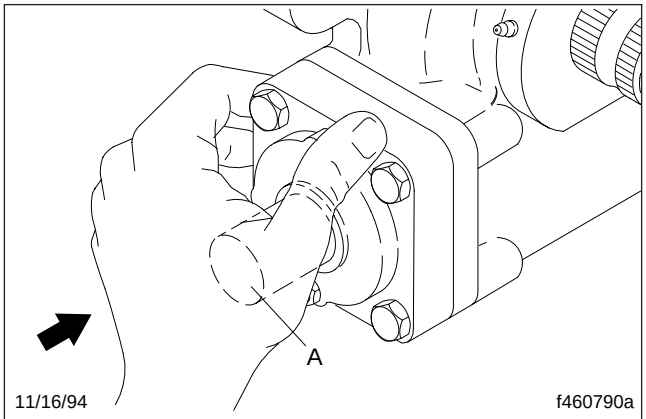


Fig. 7, Two-Piece Seal and Backup Washer

Installation

1. Apply clean grease to a new input shaft seal assembly and to the input shaft. Install the two-piece seal (with the flat side out) and steel backup washer, using seal driving tool J28490. See **Fig. 8**. Install the retaining ring.



A. Seal Driving Tool J28490

Fig. 8, Using the Seal Driving Tool

2. Pack the area around the input shaft with clean Mobil Temp 1 or 2 grease, or an equivalent. See **Fig. 9**.
3. Install a new dirt and water seal using seal driving tool J28490 or a suitable blunt-end drift. See **Fig. 10**.

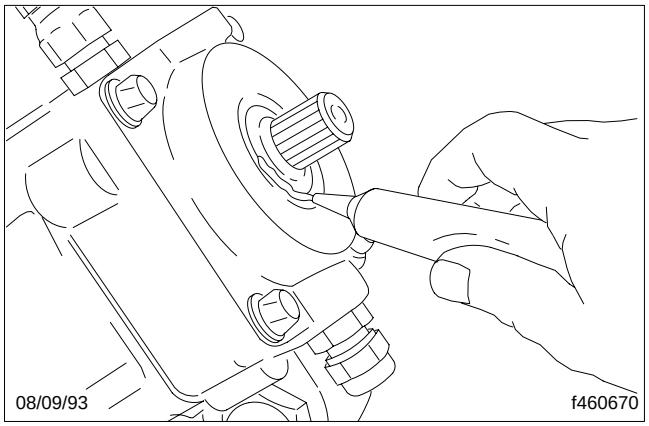


Fig. 9, Lubricate the Input Shaft

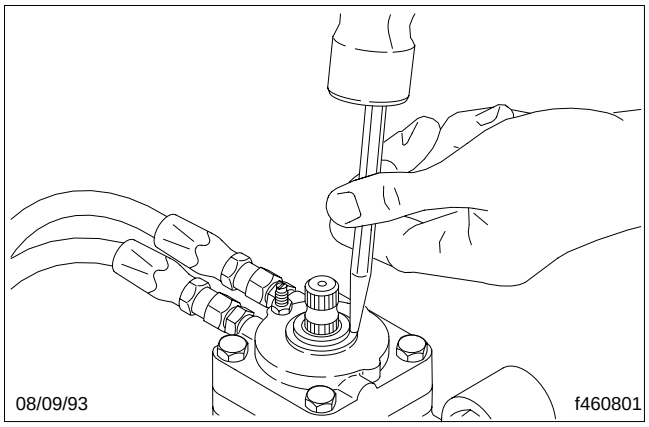


Fig. 10, Install the Dirt and Water Seal

4. Add more grease to the seal area and install the seal protector in the relief groove with the cupped side facing the steering gear. See **Fig. 11**.
5. Connect the steering driveline to the steering gear input shaft.
   - 5.1 Clean the input shaft and the inside of the driveline yoke.
   - 5.2 Apply a thin film of grease to the yoke splines. Use lithium-based NLGI grade 2 grease.
   - 5.3 Slide the yoke on the input shaft and install a new pinch bolt. Before installing the nut, make sure the pinch bolt is centered in the steering column shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install a new nut and tighten it 55 to 65 lbf·ft (75 to 88 N·m).
   - 5.4 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and to the nut.

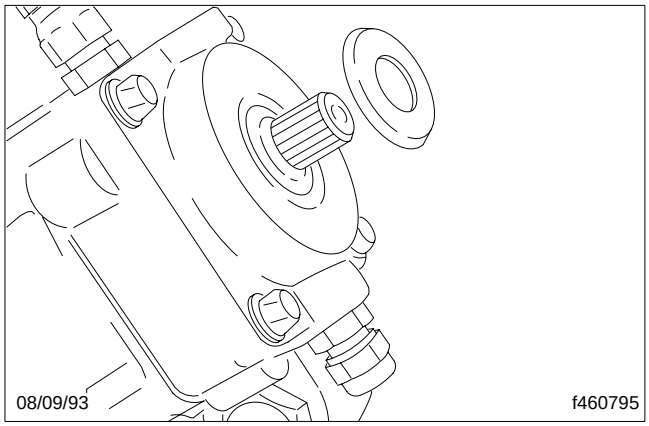


Fig. 11, Install the Seal Protector

6. Connect the return line to the steering gear return port.
7. Fill and bleed the steering system.

   IMPORTANT: For the two substeps below, do not turn the steering wheel. Doing so can cause air to enter the system, which can make it more difficult and time-consuming to bleed air from the system.

   - 7.1 Fill the power steering reservoir with Dexron® II or III until nearly full.

     Crank the engine for 10 seconds without allowing it to start. If the engine does start, shut it down immediately. Check and fill the reservoir as needed.

     Repeat this procedure three times, each time checking and filling the reservoir.
   - 7.2 Start the engine and let it idle for two minutes. Shut down the engine and check the fluid level in the reservoir.
   - 7.3 Start the engine again. Steer the vehicle from full-left to full-right several times. As needed, add fluid to the full line on the reservoir dipstick.

NOTE: If needed, remove air from the system by adjusting the poppets. For instructions, refer to **Subject 100**.

Removal

NOTE: For clarity, the figures in this subject show the steering gear mounted on a mock-up frame and steering driveline.

If there is a leak in the trunnion cover area, remove the trunnion cover and replace the sector (output) shaft seal package as follows:

1. Place the front tires in a straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations are to be performed. Apply the parking brakes and chock the tires.
2. Remove and discard the pinch bolt, washer, and nut from the pitman arm.

NOTE: If factory alignment marks are not present, use a marking pen or paint to make a reference mark on the pitman arm and the sector shaft.

3. Remove the pitman arm using a suitable puller, and swing the pitman arm and drag link out of the way.
4. Remove the protective boot, the grease fitting, and the dirt and water seal from the trunnion cover. See **Fig. 1** and **Fig. 2**. Discard the protective boot and the dirt and water seal.

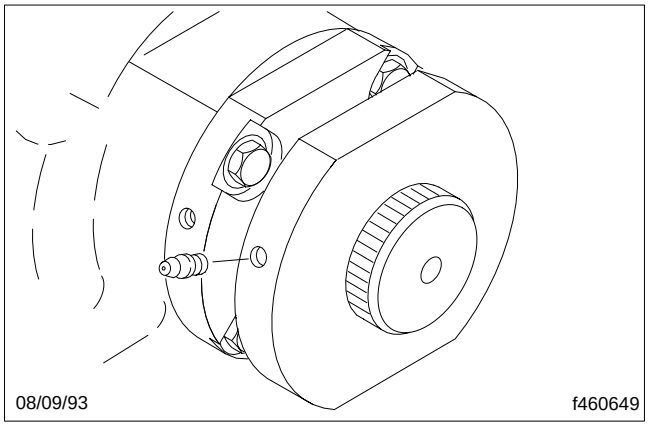


Fig. 1, Remove the Grease Fitting

5. Clean the nonserrated area of the sector shaft with a fine grade of emery paper as shown in **Fig. 3**. Be sure to remove any paint.

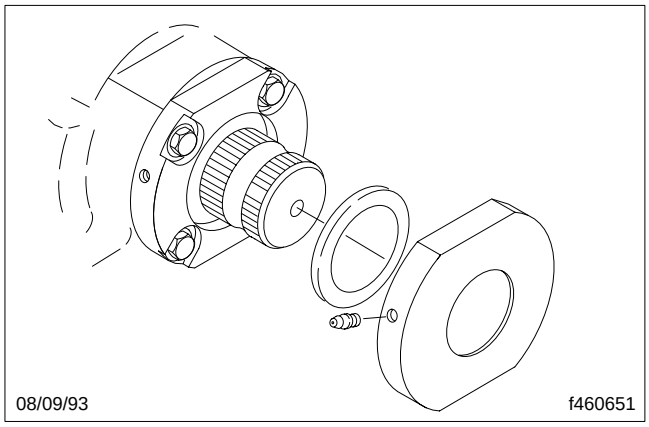


Fig. 2, Remove the Boot and Seal

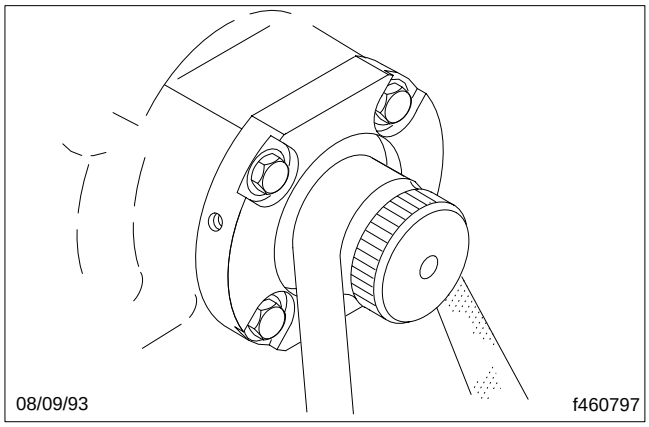


Fig. 3, Clean the Sector Shaft

6. Remove the four trunnion cover bolts and trunnion cover, as shown in **Fig. 4**. Remove and discard the sector shaft seal package, consisting of the Teflon® backup washer, the two-piece sector shaft seal, and the trunnion cover O-ring. See **Fig. 5**.

Installation

1. Clean the trunnion cover in petroleum-based solvent and inspect its seal cavity and sealing face for nicks or corrosion. Replace the trunnion cover with a new one if these conditions exist.
2. Place the trunnion cover on a bench to install the new seal package. Start with the new Teflon® backup washer. Next, install the new two-piece sector shaft seal so that the words OIL SIDE are visible after the seal is in place. See **Fig. 6**.

Sector Shaft Seal Removal and Installation

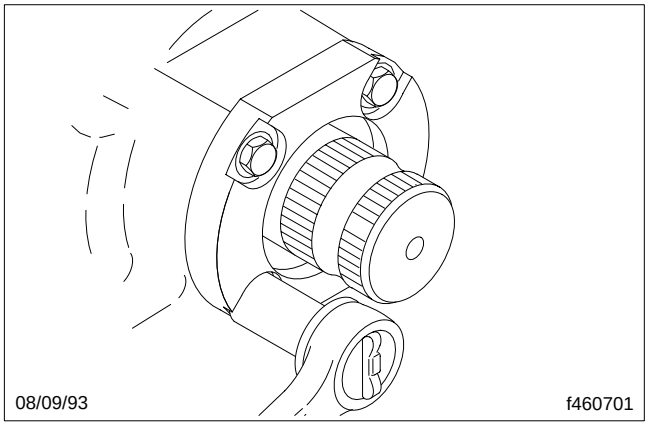


Fig. 4, Remove the Bolts

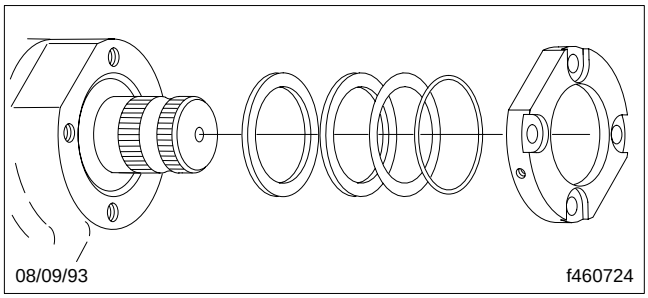


Fig. 5, Remove the Sector Shaft Seal Package

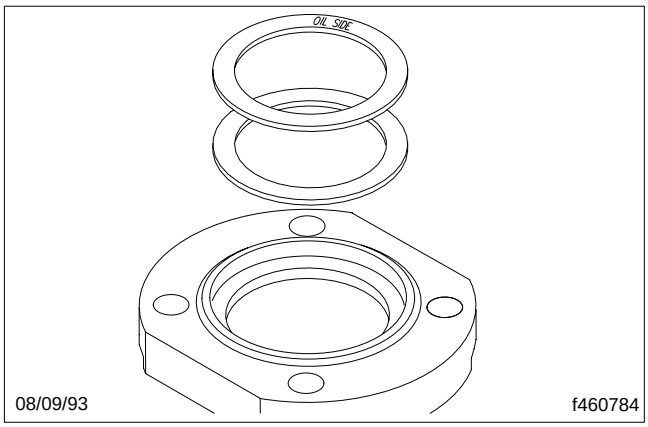


Fig. 6, Install the Two-Piece Seal

⚠ WARNING

The words OIL SIDE must be visible after the seal is in place, as shown in Fig.6. If not, the seal will malfunction. This could cause a loss of power steering assist and result in an accident possibly causing personal injury or property damage.

3. Grease the new trunnion cover O-ring and install it in the cover groove.
4. Cover the serrations of the sector shaft with one layer of masking tape to avoid damaging the seals during trunnion cover installation. See **Fig. 7**.

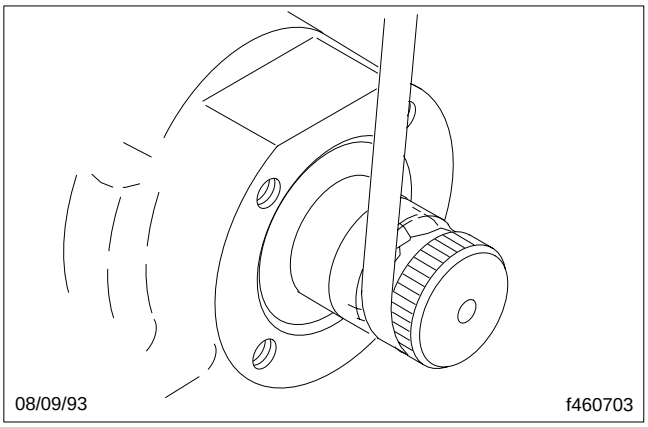


Fig. 7, Tape the Serrations

5. Install the trunnion cover. See **Fig. 8**.

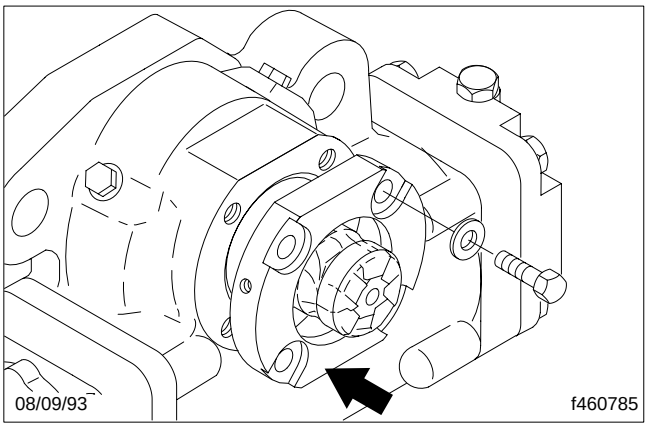


Fig. 8, Trunnion Cover

6. Install the four trunnion cover bolts. Torque the bolts 15 to 22 lbf·ft (20 to 30 N·m). See **Fig. 9**. Pack the cavity around the seal area of the sector shaft with Mobil Temp® 1 or 2 grease or an equivalent. Install a new dirt and water seal using a suitable blunt-end drift as shown in **Fig. 10**.
7. Grease the new protective boot inside the smaller diameter ring and install it on the sector shaft. See **Fig. 11**. Position the protective boot

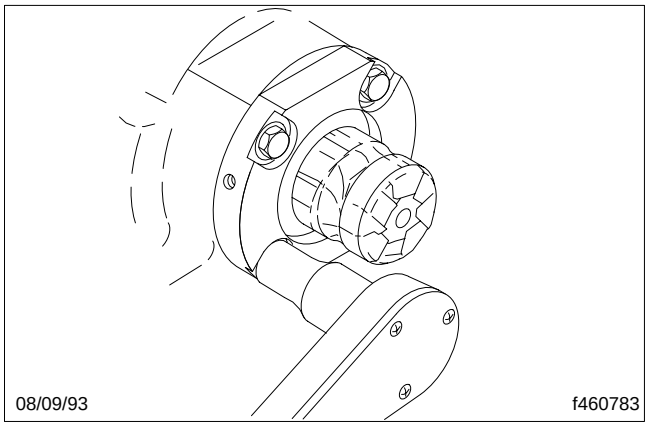


Fig. 9, Install the Bolts

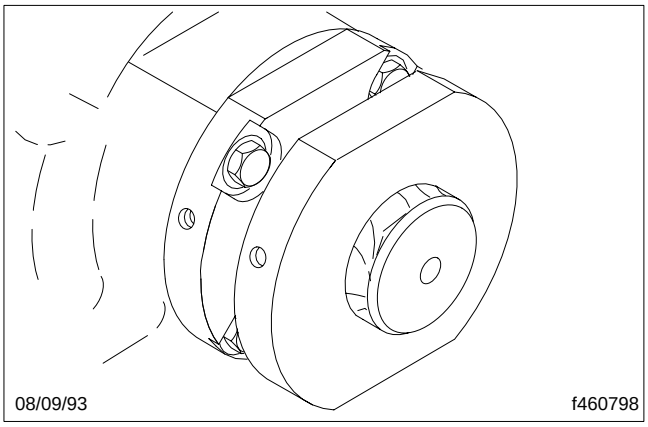


Fig. 11, Lubricate the Boot

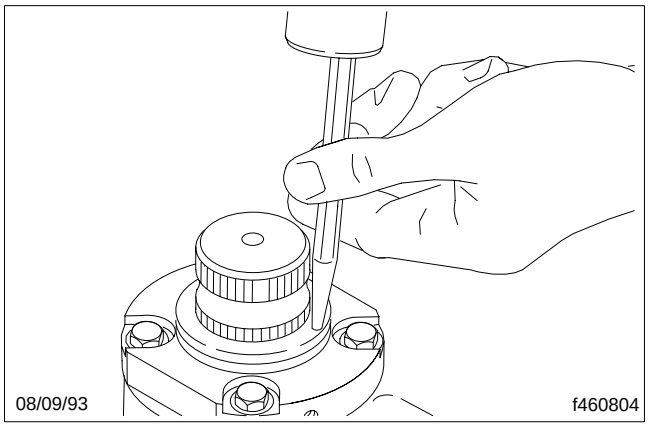


Fig. 10, Install a Dirt and Water Seal

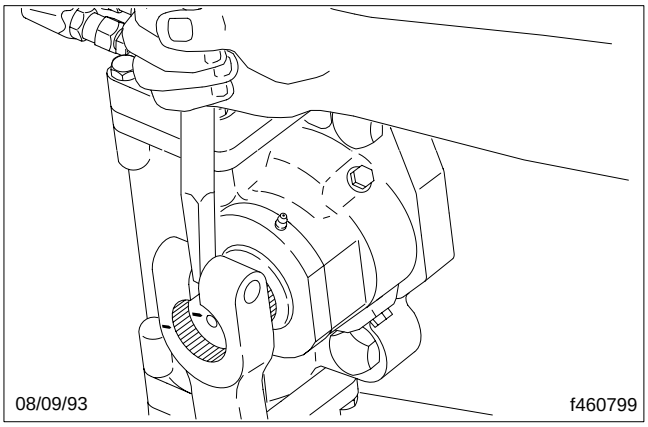


Fig. 12, Align the Marks

so that the grease fitting hole faces toward the input shaft end of the gear assembly.

8. Insert the grease fitting into the protective boot. Remove the tape from the sector shaft.
9. Attach the pitman arm to the sector shaft. Be sure that the mark on the pitman arm aligns with the mark on the sector shaft. See **Fig. 12**.

NOTE: The pitman arm may not fit over the splines on the sector shaft without spreading the slot in the arm. Use a ball-peen hammer to drive a chisel into the slot. Hold the chisel in place. Install the pitman arm on the sector shaft. Remove the chisel from the slot.

⚠ WARNING

Never leave a chisel wedged in the pitman arm slot. When using a chisel to spread the slot in the pitman arm, maintain a firm grip on the chisel at all times. Otherwise the chisel may fly loose, which could cause an injury.

10. Install a new pinch bolt, washer, and nut. See **Fig. 13**. Tighten the nut 215 to 245 lbf·ft (290 to 332 N·m).
11. Fill and bleed the steering system.

    IMPORTANT: For the two substeps below, do not turn the steering wheel. Doing so can cause air to enter the system, which can make it more difficult and time-consuming to bleed air from the system.

Sector Shaft Seal Removal and Installation

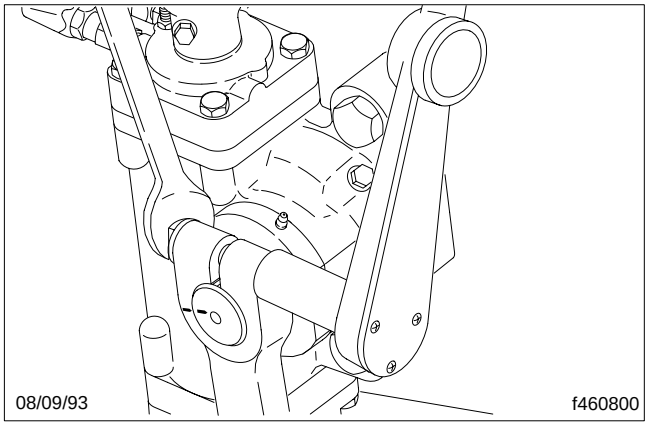


Fig. 13, Install the Pinch Bolt and Nut

11.1 Fill the power steering reservoir with Dexron® II or III until nearly full.

Crank the engine for 10 seconds without allowing it to start. If the engine does start, shut it down immediately. Check and fill the reservoir as needed.

Repeat this procedure three times, each time checking and filling the reservoir.

11.2 Start the engine and let it idle for two minutes. Shut down the engine and check the fluid level in the reservoir.

11.3 Start the engine again. Steer the vehicle from full left to full right several times. As needed, add fluid to the full line on the reservoir dipstick.

NOTE: If needed, remove air from the system by adjusting the poppets. For instructions, refer to **Subject 100**.

Checks

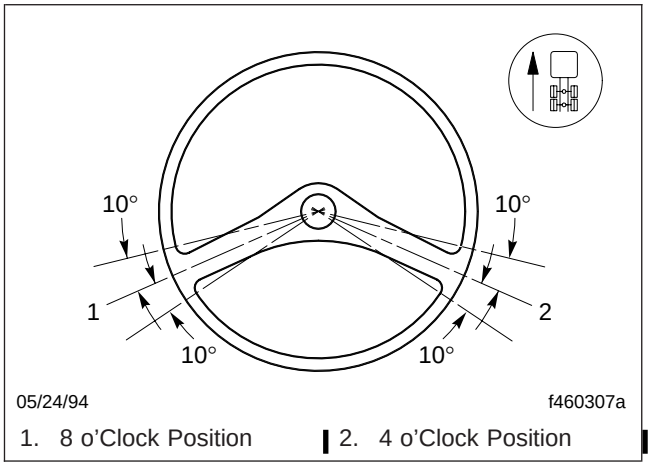
After power steering components have been worked on and before the vehicle is placed into service, make the following checks.

⚠ WARNING

Failure to make the following checks could result in damage to the power steering system. This could cause a loss of hydraulic assist, which could cause personal injury or property damage.

1. With the engine turned off and warm, check the power steering reservoir fluid level.
2. Check for air in the system.
   - 2.1 Place a thermometer in the power steering reservoir, then warm the hydraulic system to normal operating temperature of 125° to 135°F (51° to 57°C) by operating the engine at low idle while turning the steering wheel through several full left and right turns.
   - 2.2 With the engine running and the power steering system at operating temperature, turn the steering wheel slowly from stop to stop while checking the power steering reservoir for frothing or a change in the fluid level (a sign that air is trapped in the system). If air is present, inspect the system for leaking hoses or loose fittings. Replace the hoses or tighten the fittings as needed. Bleed the air from the system.
3. At full-left and full-right wheel cuts, be sure the axle stops (on the rear-side of the spindle) are set so there is at least 1/2-inch (13-mm) clearance between the tires and any fixed components that are attached to the vehicle. Clearance between moving components should be 3/4 inch (19 mm). If clearance is less than this, reset the axle stops.
4. If there are still problems with the power steering system, see **Section 46.17, Subject 300**, and perform the troubleshooting procedures. Otherwise go to the next step.
5. Test drive the vehicle or take a ride with the driver.

With the front tires pointing straight ahead, check the position of the steering wheel spokes. They must be within ±10 degrees of the 4 o'clock and 8 o'clock positions. See **Fig. 1**. If not, remove the steering wheel and install it in the correct position. For instructions, refer to the applicable section in this group.



1. 8 o'Clock Position
2. 4 o'Clock Position

Fig. 1, Steering Wheel Centered

Troubleshooting

If there is a complaint about the steering system, do the checks below before servicing the steering gear or pump. This procedure is intended as a general guideline for the mechanic or technician to follow when diagnosing steering complaints.

The first step is always to talk to the driver. Get a detailed explanation of what the problem is and when it happens. Ask about any repairs, modifications, or prior adjustments. Then, if the truck is roadworthy, test drive it or ride with the driver and try to duplicate the problem.

After identifying the complaint, refer to the appropriate box in **Table 1** that best fits the complaint. Form SD–94, "Checklist for Troubleshooting Hydraulic Power Steering System Performance," should also be used to record test information. Form SD–94 (**Fig. 1** and **Fig. 2**) is available and can be ordered through your dealer. Dealers can order this form through the TAO electronic mail system.

- At the TAO Mail Menu, key in B for bulletin boards.
- Tab down to Pub–Forms–FTL and key in L for list.
- At Freightliner Manuals Order Form, key in U.

If you don't have access to the TAO electronic mail system, contact Publishing Distribution at (503) 735–7343.

The table on form SD–94 will refer you to a series of checks or tests to do for each type of complaint. The easiest and least costly checks are listed first. By doing the checks in order, starting with the lowest number, you can avoid unnecessary labor and expense. Instructions for doing the checks are given on the following pages. Each numbered step in the instructions corresponds with the diagnostic checks in **Table 1**. The numbers and checks in this table correspond to the numbered steps that follow.

Troubleshooting and Diagnostic Checks

FREIGHTLINER LLC
A DaimlerChrysler Company

Checklist for Troubleshooting Hydraulic Power Steering System Performance

Repair Order Date: _____ TRW Phone Number: 1−800−TRW−0899
(with the TRW−CSD authorization number the warranty claim will be honored by TRW)

Repair Order Number: _____

Dealer Code: _____ TRW Authorization Number: _____

Claim Number: _____

Vehicle Indentification

Vehicle Model: _____ Serial Number: _____ Date in Service: _____
Mileage: _____ Mileage when steering complaint first occurred: _____
Vehicle Application: _____ Normal Steering Axle Load: _____

Steering System Description

Steering Pump Manu.: _____ Model Number: _____
Steering Gear Manu.: _____ Model Number: _____ Date Code: _____
Reservoir Capacity: ☐ 2 quarts (1.9 liters) ☐ 4 quarts (3.8 liters) ☐ 9 quarts (8.5 liters)
Type of Fluid: ☐ ATF ☐ 10W ☐ 10W−30 ☐ 10W−40 ☐ Other: _____

Steering Complaint and Appropriate Diagnostic Checks

LH	RH	Both	COMPLAINT	DIAGNOSTIC CHECKS 1 Tire Press./ Vehicle Load	2 Fifth Wheel Lube	3 Vehicle Align− ment	4 Loose/ Binding Compo− nents	5 Noise	6 System Operat− ing Temp	7 System Leaks or Restric− tions	8 Pump Perform− ance	9 Gear Poppet Adjust− ment	10 Gear Internal Leakage
			Hard or Heavy Steering	•	•		•		•	•	•	•	•
			Low Assist										
			Binding	•	•		•		•	•	•	•	•
			Locking										
			Occasional Loss of Assist										
			Reduced Wheel Cut									•	
			Vehicle Pulls to One Side	•		•					•		
			Darting Oversteer	•	•	•	•						
			Vehicle Wanders										
			Noisy Steering					•		•	•		
			Steering Gear External Seal Leaks						•	•	•		
			Excessive Heat										

Other (describe as completely as possible) _____

Vehicle Checks

1 Tire Pressure/Load:

					Front Tire Pressure Left	Right
Oversize front tires?	☐ Yes	☐ No				
Heavy load operation?	☐ Yes	☐ No	☐ psi	☐ kPa	_____	_____
Rear tire pressure even?	☐ Yes	☐ No				

2 Fifth Wheel Lube and Condition: ☐ OK ☐ Not OK

3 Vehicle Alignment and Wheel Bearing Adjustment:

				Left	Right
Rear axle: _____	Front axle:	Caster		_____	_____
Wheel Bearings: ☐ OK ☐ Not OK		Camber		_____	_____

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Fig. 1, Front Side, "Checklist for Troubleshooting Hydraulic Power Steering System Performance"

Vehicle Checks (Continued)

4 Binding Components:

Lubrication of drag link, tie rod, and knuckle pins?	❑ Yes	❑ No
COE steering column bearing binds?	❑ Yes	❑ No
Steering driveline U−Joints bind?	❑ Yes	❑ No
Steering driveline phasing OK?	❑ Yes	❑ No
Sector shaft adjustment OK?	❑ Yes	❑ No
Front tire self−return OK?	❑ Yes	❑ No

5 Noise

Fluid level: ❑ OK ❑ Too low ❑ Too high

Fluid condition: ❑ OK ❑ Discolored ❑ Odorous ❑ Foamy ❑ Other: _____

Inlet tube or fittings leaking?

Front spring pin shims required?

Loose steering components?

Normal "hissing" at full turn?

"Hissing" at less than full turn?

Hoses kinked or collapsed?

6 System Operating Temperature: ❑ °F ❑ °C

Outside (ambient) temperature _____°, Test start _____°

10 min. _____°, 20 min. _____°, 30 min. _____°, 40 min. _____°

7 System Leaks or Restrictions:

Hoses kinked or collapsed?

Leaking fittings?

Leaking seals?

Total System and Component Back Pressure: ❑ psi ❑ kPa

Total system: _____, Steering gear: _____, Booster: _____, Reservoir: _____,

Pump−to−gear hose: _____, Pump supply hose: _____, Gear−to−booster hose: _____,

Booster−to−reservoir hose: _____, Gear−to−reservoir hose: _____

Hydraulic Checks

Power steering fluid temperature: _____°F (_____°C)

(to be 150 to 160°F [66 to 71°C]; see ˆSystem Setup for Hydraulic Checks˜ in applicable service/workshop manual)

Idle RPM: (see ˆSystem Setup for Hydraulic Checks˜ in applicable service/workshop manual for correct idle rpm)

	Idle	Highway
	_____rpm	1500 rpm

8 Pump Performance:

Erratic response:	❑ Yes	❑ No
Pump relief pressure:	❑ psi	❑ kPa
Pump relief valve operation:	❑ OK	❑ Not Okay

Pump flow:

x Load Valve Open

x

x Load Valve Closed

Idle Speed	
Pressure	Flow: ❑ gpm ❑ Lpm
500 psi	
1000 psi	
1500 psi	

9 Steering Gear Poppet Adjustment:

Poppet valve trip pressure: ❑ psi ❑ kPa

	Left Turn	Right Turn
	_____	_____

10 Steering Gear Internal Leakage:

TRW:	❑ gpm	❑ Lpm	_____	_____
	❑ psi	❑ kPa	_____	_____
Sheppard:				

Attempted Corrections and Results

Pump repairs: _____

Steering gear repairs: _____

_____

Other components repairs: _____

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Fig. 2, Back Side, "Checklist for Troubleshooting Hydraulic Power Steering System Performance"

Troubleshooting and Diagnostic Checks

Troubleshooting and Diagnostic Steps										
Step*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Complaint	**Tire Press./ Vehicle Load**	**Fifth Wheel Lube**	**Vehicle Align-ment**	**Loose/ Binding Components**	**Noise**	**System Operat-ing Temp.**	**System Leaks or Restric-tions**	**Pump Perfor-mance**	**Gear Poppet Adjust-ment**	**Gear Internal Leakage**
Hard or Heavy Steering	•	•		•		•	•	•	•	•
Low Assist										
Binding	•	•		•		•	•	•	•	•
Locking										
Occasional Loss of Assist										
Reduced Wheel Cut									•	
Vehicle Pulls to One Side	•		•					•		
Darting/ Oversteer	•	•	•	•						
Vehicle Wanders										
Noisy Steering					•		•	•		
Steering Gear External Seal Leaks						•	•	•		
Excessive Heat										

***** The numbers in this table correspond to the numbered steps in the diagnostic checks.

Table 1, Troubleshooting and Diagnostic Steps

Diagnostic Checks

1. Check tire pressure and load.

   1.1 Check the tire pressure. Low pressure causes increased steering effort due to extra friction with the road surface. Check the tires for damage or erratic wear. Make sure the tires on each side of the front and rear axles are inflated to the correct pressure. Unequal tire pressure causes unequal friction between the tire and the road. This can cause pulling to one side. Correct the pressures if needed. See **Fig. 3**.

   1.2 Check whether duplex or oversized tires have been installed, and that the tire sizes are correctly matched. Extra tire width causes increased steering effort due to extra friction with the road surface. Also, the power steering gear poppets will need to be adjusted if the axle stops were turned out to reduce wheel cut due to the

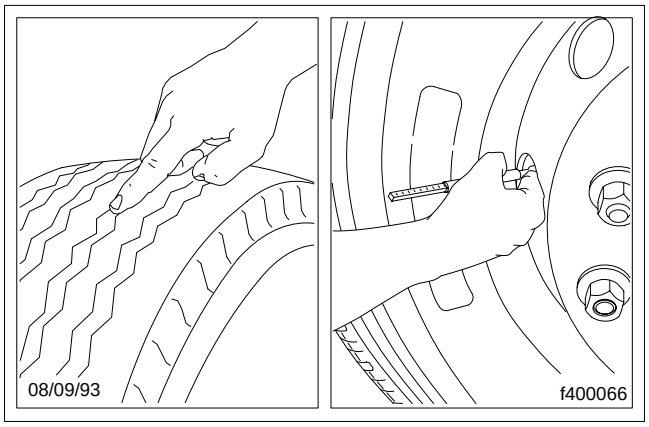


Fig. 3, Check the Tire and the Tire Pressure

change in tires. Refer to **Subject 100** for instructions.

1.3 Determine whether the vehicle is operated at or over the rated load. Increased load causes greater steering effort. It may be necessary to modify the power steering, wheels, tires, or springs.

2. Check the fifth wheel.

   See if the fifth wheel is adequately lubricated. A dry fifth wheel plate makes it difficult to change direction. See **Fig. 4**. Check the plate surface for burrs, gouges, or irregularities.

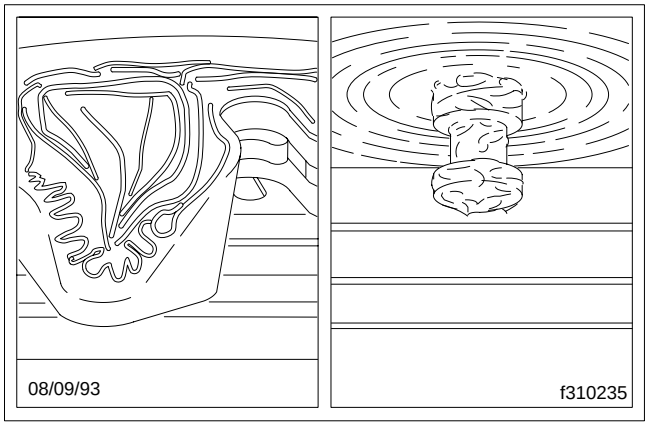


Fig. 4, Check the Fifth Wheel

3. Check the wheel bearing adjustment and axle alignment.

   3.1 Check wheel bearing adjustment. Refer to the front axle and rear axle sections in this manual for instructions.

   3.2 Check the front and rear axles for correct alignment. Adjust them back to specifications if necessary. Refer to the front axle and rear axle sections in this manual for instructions.

4. Check for loose or binding components.

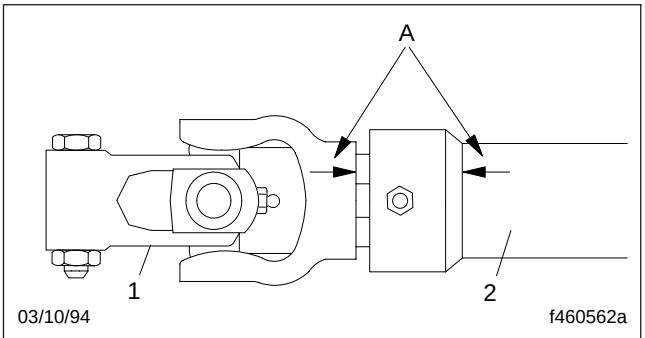
   Check whether any steering components are loose or binding, need maintenance, or need adjustment as follows:

   4.1 Lubricate the drag link, tie rods, and knuckle pins. Refer to the applicable sections in the vehicle maintenance manual.

   4.2 Chock the rearmost tires and raise the front tires off the ground. With the engine shut down, turn the steering wheel and check for looseness or binding. Make sure all components are free to move but are not excessively loose.

   4.3 Check the steering driveline U-joints for looseness or binding. Lubricate them if needed. For instructions, refer to the applicable section in the vehicle maintenance manual.

   4.4 Check for correct steering driveline phasing. See **Fig. 5**. Reset the phasing if needed.



A. Align arrows.

1. Lower End Yoke
2. Driveline Tube and Yoke Assembly

Fig. 5, Check for Correct Steering Driveline Phasing

4.5 Check the sector shaft adjustment. Refer to **Subject 100** for instructions.

⚠ WARNING

Failure to connect the input yoke and the pitman arm, and to tighten all fasteners to the prescribed torque value, can cause loss of steering and vehicle control, which could result in personal injury or property damage.

4.6 With the engine off, chock the rearmost tires and place the front tires on radius plates (turntables). Disconnect the drag link from the steering arm. See **Fig. 6**.

By hand, pull the tire to one axle stop and release. The tire should self-return to almost straight ahead. See **Fig. 7**. Repeat in opposite direction. If the tire does not return to near straight ahead, check for a binding or lack of lubrication problem in the steering axle kingpin bushings or tie rod linkage. Connect the drag link and tighten the castle nut and install a new cotter pin. Refer to the drag link section in this manual.

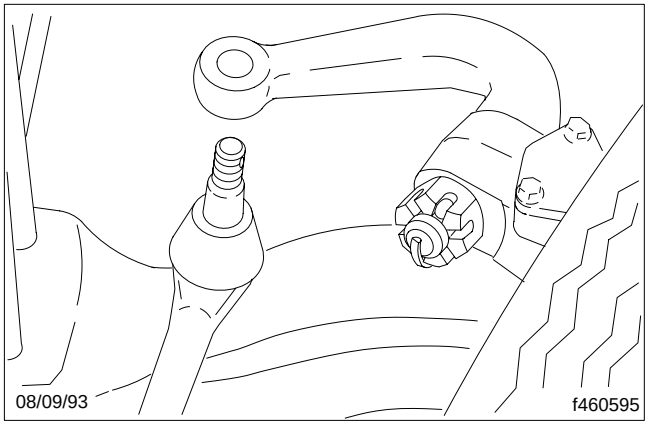


Fig. 6, Connect the Drag Link

⚠ WARNING

Failure to connect the drag link and the steering arm, and to tighten all fasteners to the prescribed torque value can cause loss of steering and vehicle control, which could result in personal injury or property damage.

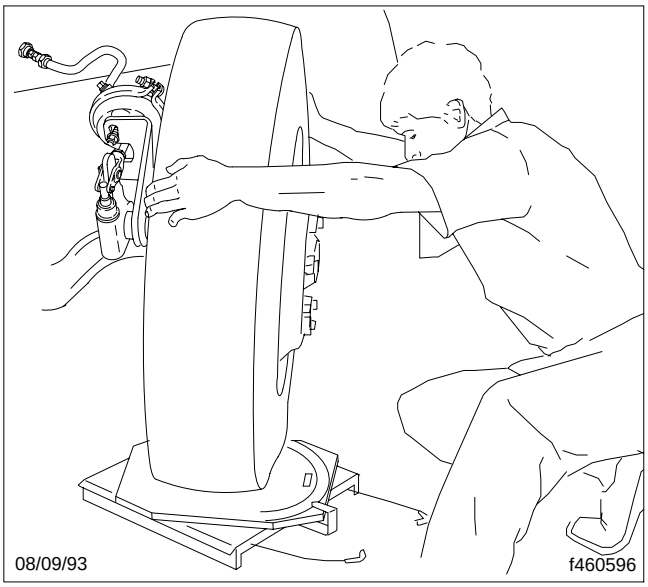


Fig. 7, Pull the Tire to One Axle Stop

4.7 Visually inspect all suspension fasteners and components for wear or looseness.

5. Check for noise.

NOTE: Noises from the power steering system do not necessarily mean there is a problem. Some noises are normal and are the result of proper operation. See **Table 2**.

6. Test the system operating temperature.

6.1 Park the vehicle outside.

6.2 Check for correct fluid level. If required, add fluid.

6.3 Place a thermometer in the fluid reservoir to monitor fluid temperature.

6.4 Run the vehicle at governed rpm for 40 minutes to bring the fluid to an elevated temperature. Check and record fluid temperature on the checklist (form SD–94) at the start of the 40 minute test, and at 10, 20, 30, and 40 minutes.

Do not allow the temperature to exceed 150°F (66°C) above the outside temperature (ambient), or 250°F (121°C). If this temperature is exceeded, stop the 40 minute test and record the last noted temperature on the checklist.

6.5 If the temperature does not exceed 150°F (66°C) above the outside temperature (ambient), or 250°F (121°C) during the 40 minute test, excessive system heat is probably not the cause of the complaint. Go on to the next test for the complaint. See **Table 1**.

6.6 If at any time the temperature exceeded 150°F (66°C) above the outside temperature (ambient), or 250°F (121°C), the system is operating at excessive temperature levels, and steering system performance and life may be affected. Damage to hoses, seals, and other components may result if the vehicle is operated at excessive steering system temperatures.

6.7 Excessive system restrictions or excessive pump flow may be the cause of the complaint. Go on to the next test for the complaint. See **Table 1**.

7. Check for leaks, restrictions, and test system back pressure.

7.1 Check for correct fluid level. If required, add fluid.

7.2 The inspection and test must be done with the power steering fluid at operating temperature 125° to 135°F (51° to 57°C). With the engine at idle, monitor the fluid temperature with a thermometer in the fluid reservoir. If the fluid is too cold, raise the temperature by turning the steering wheel from stop to stop until the desired temperature is reached.

7.3 With the engine at idle, visually inspect all hoses and fittings for signs of kinked or collapsed hoses, or leaking fittings. Visually inspect all external seals. Repair all leaking fittings, and replace parts as required. Replace any leaking seals. Inspect the seal bores and sealing surfaces for scrapes or burrs. Be sure the seals are installed correctly using the recommended tools. If the steering gear input shaft seal is excessively hard, do check (step) no. 6 (Test System Operating Temperature), if not already done.

7.4 Install a low pressure gauge 200 to 300 psi (1378 to 2069 kPa) maximum between the pressure line and the pump (location P2). See **Fig. 8**.

⚠ CAUTION

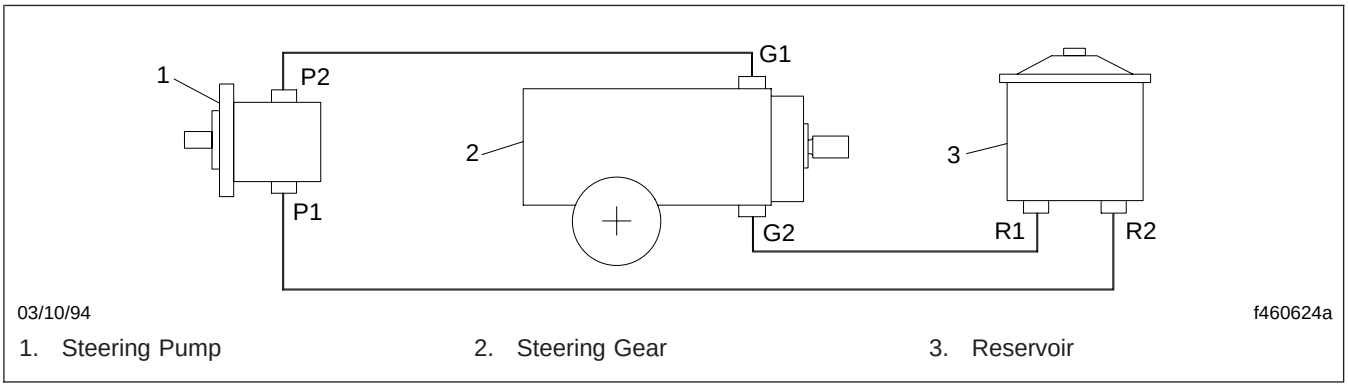
Don't move the steering wheel or allow the system pressure to exceed the rating of the gauge during the following procedure or damage to the gauge may result.

7.5 Run the engine at idle and check for correct fluid level; if required, add fluid. If bubbles or foam appear in the reservoir, check the hose fittings for looseness or leaks.

Power Steering System Noises	
Symptom	**Action to Take**
Growling or Other Abnormal Steering Noise	Check the fluid level. Check for air bubbles or foam. Check for hose and fitting leaks. Add fluid if needed. If the fluid has air, check for inlet tube/hose leaks. Correct all leaks.
A Change from the Usual Pump Sound	Check the power steering fluid reservoir. Check for air bubbles or foam in the fluid. If the fluid has air, check for inlet tube/hose leaks. Correct all leaks.
Clicking Noise During a Turn	Check for loose steering components. Check the front suspension for insufficient spring pin shims. Tighten any loose steering components. Add front spring pin shims if needed.
Hissing When the Steering Wheel Is at or Near Full Turn	Fluid flowing past a poppet valve makes a hissing noise. This is normal. No action is needed.
Hissing at Less Than Full Turn	Do the Steering Gear Poppet Test.

Table 2, Power Steering System Noises

7.6 With the engine at idle, read the total system back pressure on the pressure gauge. Record the reading on the checklist (form SD–94).



1. Steering Pump 2. Steering Gear 3. Reservoir

Fig. 8, Locations Where Pressure is Measured

7.7 If the total system back pressure (P2) is greater than 100 psi (689 kPa), go to the next substep. If the pressure at P2 is less than these values, restriction is not a problem, go to the next test for the complaint. See **Table 1**.

7.8 System back pressure has been determined to be excessive and the component at fault can be pinpointed by checking pressures at key locations in the steering system. With the engine at idle, use the low pressure gauge and hose connection adapters necessary to measure pressures at all locations identified in **Fig. 8**. Each time the gauge is moved, ensure that the fluid level is correct, and air is removed from the system by repeating the applicable substep above.

7.9 Determine the individual component restrictions by subtracting the values shown in **Table 3**. Record the values on form SD–94.

7.10 Refer to the column on the right in **Table 3** for action to take if any component exceeds the maximum allowable restriction as listed for each component.

8. Test pump performance.

8.1 Set up the system for hydraulic checks. Refer to **Subject 305** for instructions.

8.2 Make sure the fluid temperature is 125° to 135°F (51° to 57°C) and the vehicle is stationary with the front wheels pointing forward and the rear-most tires chocked.

8.3 Run the engine at idle. Refer to the engine idle table in **Subject 305** for the correct engine idle speed.

8.4 Slowly close the load valve. When the valve is completely closed, read the pressure gauge. See **Fig. 9**.

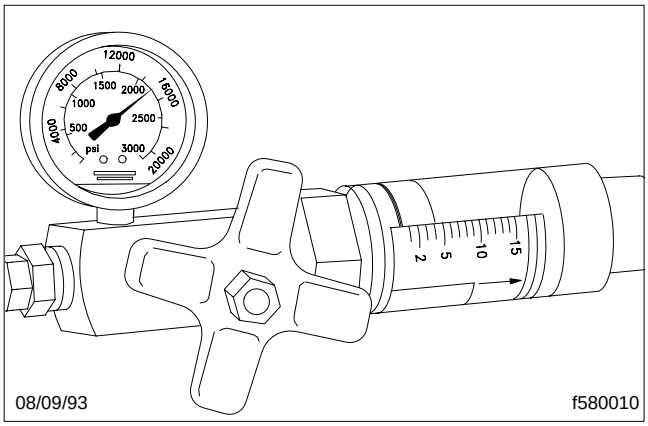


Fig. 9, Pressure Gauge and Flow Meter

CAUTION

Don't leave the valve closed for longer than 5 seconds since this could damage the power steering system.

8.5 If the pressure rises rapidly, appears to be uncontrolled, or rises above the maximum

pressure of 2065 psi (14 240 kPa), open the load valve immediately. Indicate on form SD–94 whether the pump response was erratic or not. If the response was erratic, replace the pressure relief valve in the pump. For instructions, refer to the pump section in this group. If the pressure was constant, go to the next substep. With the fluid temperature at 125° to 135°F (51° to 57°C) repeat the previous substep above and this substep.

8.6 If the pump pressure measures 1960 to 2065 psi (13 515 to 14 240 kPa), it is acceptable. Go to the substep after the next. If the pressure is not within this range, replace the pressure relief valve if not done previously in this test. With the fluid temperature at 125° to 135°F (51° to 57°C) repeat the previous two substeps above. If the pressure relief valve has been replaced, go to the next substep.

8.7 If the pressure was not within the above applicable range, and the relief valve has been previously replaced, replace the pump. For instructions, refer to the pump section in this group. If the pump was replaced, evaluate its performance by repeating check 8.

8.8 Record the relief pressure on form SD–94.

8.9 With the engine at idle, test the pump relief valve reaction. Note the flow rate with the load valve open.

8.10 Close the load valve until the pump relief pressure is reached (previously determined). The flow rate should drop to zero.

8.11 Immediately open the load valve and note the flow rate. It should return to the value previously noted.

8.12 If the flow rate returns immediately, the relief valve is acceptable. Go to the next substep.

If the flow rate does not return immediately, the pump relief valve is not working correctly. Replace the relief valve if not previously done, following the instructions in the pump section in this group.

8.13 Repeat the previous four substeps above with the engine at 1500 rpm.

8.14 Record on form SD–94 whether the relief valve operated "OK" or "Not OK" at idle and 1500 rpm. Near the bottom of the form, list any pump repairs that were made.

8.15 With the engine at idle, test the pump flow. Slowly close the load valve until the pressure gauge reads 1000 psi (6895 kPa).

Total System and Component Restrictions		
Total System and Component Restrictions	**Maximum Allowable**	**Action to Take**
P2 = Total System	100 psi (689 kPa)	Check pressures at the key locations.
P2-G1 = Hose: Pump-to-Gear	12 psi (83 kPa)	Check for a kinked or plugged hose. Replace the hose if necessary.
G1-G2 = Steering Gear	55 psi (379 kPa)	The gear rotary valve is damaged. Replace the gear. See instructions in this manual.
G2-R1 = Hose: Gear-to-Reservoir	12 psi (83 kPa)	Check for a kinked or plugged hose. Replace the hose if necessary.
R1-R2 = Reservoir	2 qt: 4 psi (28 kPa) 9 qt: 8 psi (55 kPa)	Replace the filter. Check for internal blockage.

Total System and Component Restrictions		
Total System and Component Restrictions	**Maximum Allowable**	**Action to Take**
R2-P1 = Hose: Pump Supply	12 psi (83 kPa)	Check for a kinked, collapsed, or plugged hose. Replace the hose if necessary.

Table 3, Total System and Component Restrictions

8.16 Read the flow gauge and record the flow rate on form SD–94.

8.17 Open the load valve.

8.18 Run the engine at 1500 rpm. Leave the load valve open, do *not* close the load valve. Read the flow gauge and record the flow rate on form SD–94.

8.19 At idle the minimum flow rate is 3.3 gpm (12.5 Lpm). The maximum flow rate at either engine speed is 4.4 gpm (16.7 Lpm). If the flow rate is below the minimum, repair or replace the pump. For instructions, refer to the pump section in this group. If the flow rate is above the maximum, replace the flow control and relief valve in the pump. For instructions, refer to the pump section in this group.

9. Check the steering gear poppet relief valve and the axle stop adjustment.

NOTE: Poppets limit the steering assist when the front wheels approach the axle stops. Improper adjustment can apply excessive force to the steering linkage or loss of assist as the steering wheel approaches either full left or full right turns.

9.1 If the turning angle is inadequate, make sure the axle stops are set to the maximum possible turn angle. Make sure the axle stop settings limit the steering travel so there is 1/2-inch (13-mm) clearance from all stationary components, and 3/4-inch (19-mm) clearance from all moving components.

9.2 Make sure the pitman arm is oriented on the steering gear sector shaft correctly. Refer to **Subject 110**.

9.3 Set up the system for hydraulic checks. Refer to **Subject 305** for instructions.

9.4 Make sure the fluid temperature is 125° to 135°F (51° to 57°C) and the vehicle is stationary with the front wheels pointing forward.

9.5 Run the engine at idle with the load valve open. Refer to the engine idle table in **Subject 305** for the correct engine idle speed.

9.6 Turn the steering wheel to either full-lock position.

CAUTION

If power steering pump relief pressure is reached while the steering wheel is at full-lock, release the steering wheel from this position. Do not allow the pump relief pressure to be maintained for longer than five seconds or damage to the pump may result.

9.7 Note the pressure gauge reading.

9.8 Repeat the previous three substeps above for the opposite turn direction, and note the pressure gauge reading.

9.9 The pressure readings at the axle stops should be at least 200 psi (1380 kPa) less than pump relief pressure. If the pressures are acceptable, record on form SD–94 and go on to the next test for the complaint. See **Table 1**. If the pressure is too high, adjust the poppet valves.

For instructions, refer to **Subject 100**.

10. Test for steering gear internal leakage.

10.1 Set up the system for hydraulic checks. Refer to **Subject 305** for instructions.

10.2 Make sure the fluid temperature is 125° to 135°F (51° to 57°C) and the vehicle is stationary with the front wheels pointing forward.

10.3 Run the engine at idle with the load valve open. Refer to the engine idle table in **Subject 305** for the correct engine idle speed.

10.4 Place an unhardened steel spacer, 1-inch (2.5-cm) thick between the axle and the axle stop at one side of the axle. See **Fig. 10**. The spacer should have an extension or handle long enough to keep your fingers clear of the axle stop area. A brazing rod or welding rod works well for this purpose.

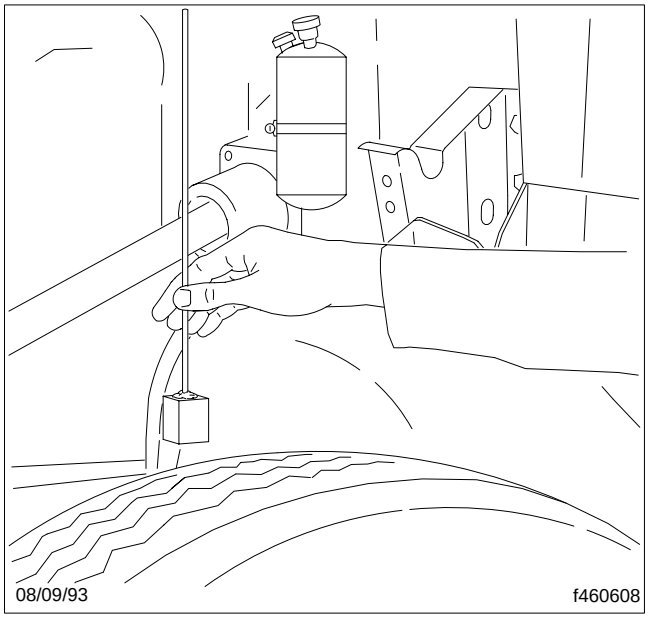


Fig. 10, Position the Steel Spacer

⚠ WARNING

Keep your fingers clear of the axle stops and spacer block during this test. Make sure that the spacer block contacts the axle stop squarely. Contact that is not square could break the axle stop, or dangerously eject the spacer block, causing injury.

While running this test, do not hold the steering wheel in the full turn position for longer than 5 seconds at a time to avoid damaging the pump.

10.5 Have someone turn the steering wheel until the axle stop contacts the spacer block. Apply 20 lb (9 kg) to the rim of the steering wheel. See **Fig. 11**.

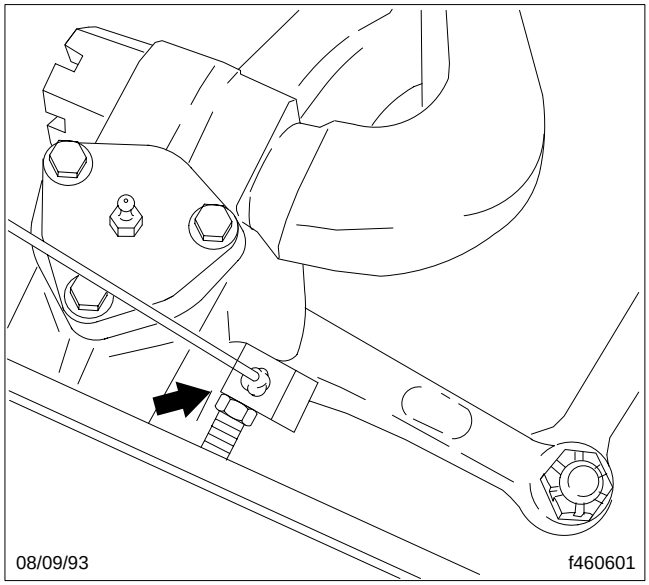


Fig. 11, Axle Stop Contacting the Steel Spacer

10.6 Read the internal leakage rate on the flow meter.

10.7 Record the reading on form SD–94.

10.8 Repeat the previous four substeps above for the opposite turn direction.

10.9 The maximum permissible internal leakage is 1.0 gpm (3.8 Lpm). If leakage is greater in either turning direction, replace the steering gear components as needed following the instructions in **Subject 120**.

System Setup

NOTE: Use a 1 to 10 gpm (3.8 to 38 Lpm) flow meter, a pressure gauge 0 to 2500 psi minimum (0 to 17 225 kPa), and a load valve, preferably in one test unit.

1. Install the test unit between the pump high-pressure line and the steering gear. See **Fig. 1**.
2. Fill and bleed the steering system. Refer to **Subject 110** for instructions.
3. Checks must be done with the power steering fluid at operating temperature 125° to 135°F (51° to 57°C). Monitor the fluid temperature with a thermometer in the fluid reservoir. See **Fig. 2**. If the fluid is too cold, raise the temperature as follows:

   Run the engine at idle.

   Partially close the load valve on the test unit until the pressure gauge reads 1000 psi (6895 kPa).

⚠ CAUTION

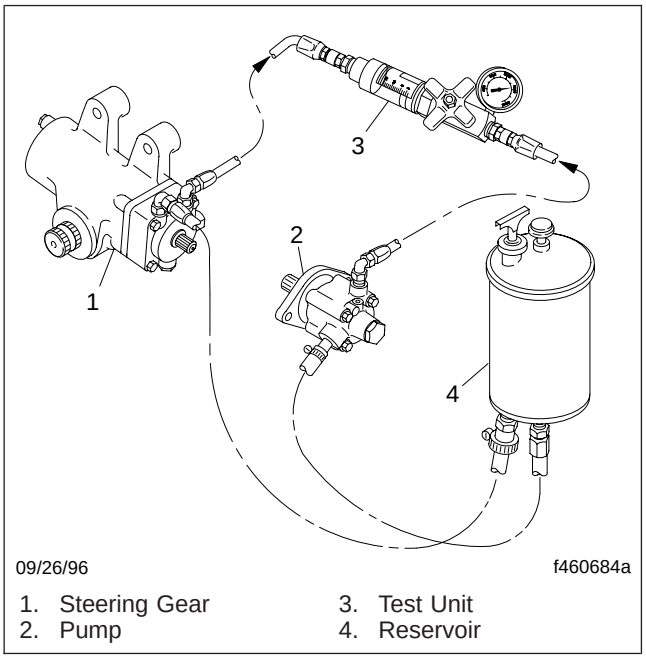
Do not leave the load valve fully closed since this could damage the power steering system.

4. Open the valve when the fluid temperature reaches 125° to 135°F (51° to 57°C).

⚠ CAUTION

Do not allow the fluid temperature to exceed 250°F (121°C) since this could damage the power steering system.

5. Record all data from the hydraulic checks on form SD–94, "Checklist for Troubleshooting Hydraulic Power Steering System Performance."



1. Steering Gear
2. Pump
3. Test Unit
4. Reservoir

Fig. 1, Steering System Test Unit

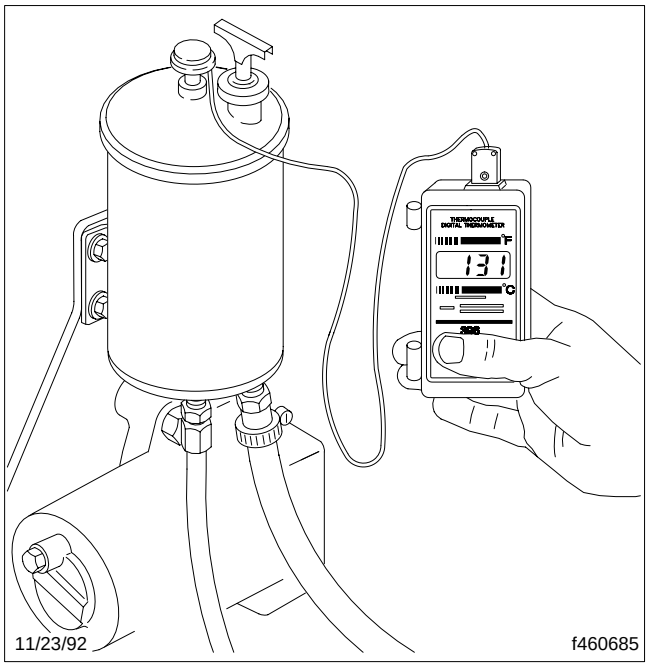


Fig. 2, Monitor the Fluid Temperature

Special tools can be ordered from:

SPX Kent-Moore
28635 Mound Road
Warren, Michigan 48092
1-800-328-6657

Special Tools		
SPX Kent-Moore Part Number	**Tool**	**Application**
J26739	Seal Installation Tool	Worm Shaft Seal Installation
J26740	Seal Compression Tool	Worm Shaft Seal Compression
J26741	Seal Installation Tool	Valve Sleeve Seal Ring Installation
J26742	Seal Compression Tool	Valve Sleeve Teflon® Seal Ring Compression
J26743	Bearing Mandrel	Housing Bearing Removal and Installation
J28490	Seal Driving Tool	Input Shaft Seal Installation

Table 1, Special Tools

⚠ WARNING

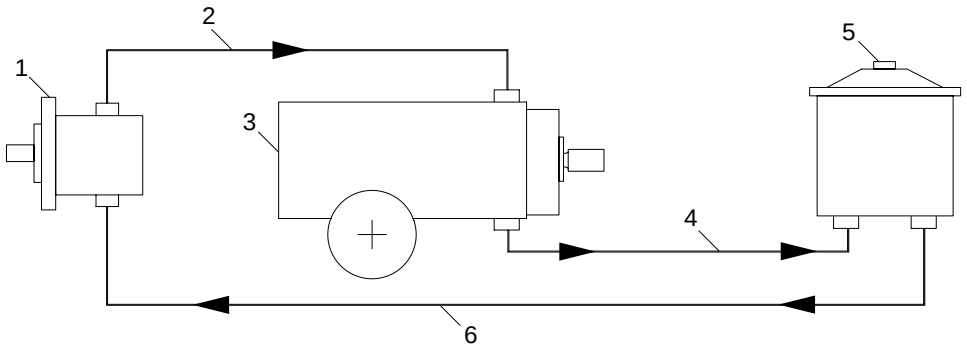
Fill only with approved clean automatic transmission fluid. Any mixture or any unapproved fluid could lead to seal deterioration and leaks. Any fluid leak could eventually cause loss of power steering assist which could cause personal injury due to loss of vehicle control.

Approved Power Steering Fluids	
Fluid Type	**Approved Fluid**
Automatic Transmission Fluid	Dexron® II Dexron® III

Table 2, Approved Power Steering Fluids

See **Fig. 1** for a steering system plumbing diagram.

Specifications



1. Steering Pump
2. Pressure Line
3. Steering Gear
4. Return Line
5. Reservoir
6. Supply Line

Fig. 1, Steering System Plumbing (two-line system shown)

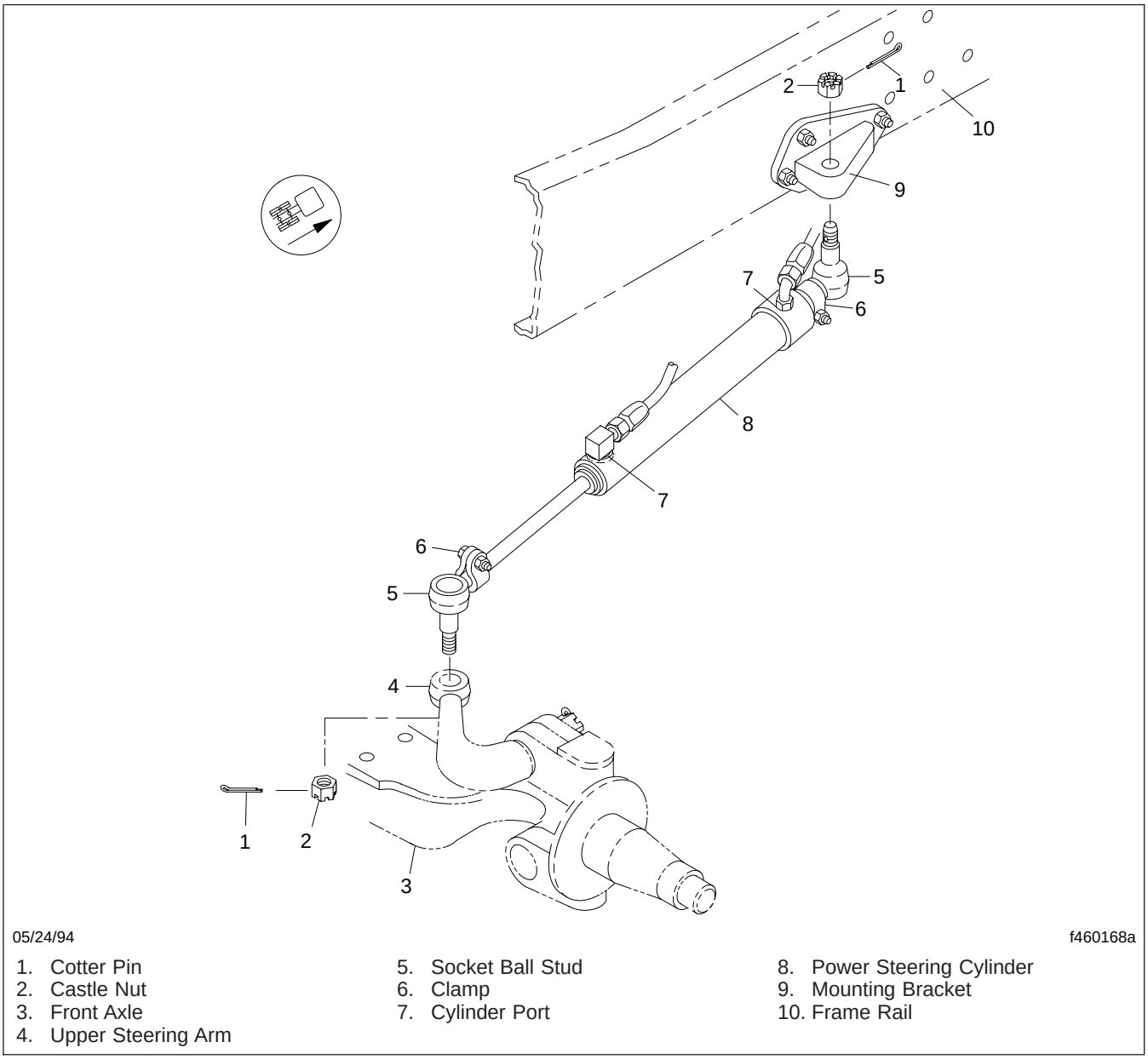
Removal

1. Position the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance stopping at the spot where service operations are to be performed. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Clean all outside dirt from around the fittings and hose connections.
4. Disconnect the hydraulic lines from the elbows on the cylinder, marking the lines for later assembly reference. Seal the lines and the cylinder fittings to prevent fluid from leaking out of the lines, and to keep out dirt. See **Fig. 1**.
5. Remove the tie-straps and the hose hanger bracket, and move the hydraulic lines out of the way.
6. At both ends of the cylinder, remove the cotter pins and nuts from the socket ball studs.
7. Using a ball stud removal tool, disconnect the steering cylinder from the forward mounting bracket and the axle steering arm.

Installation

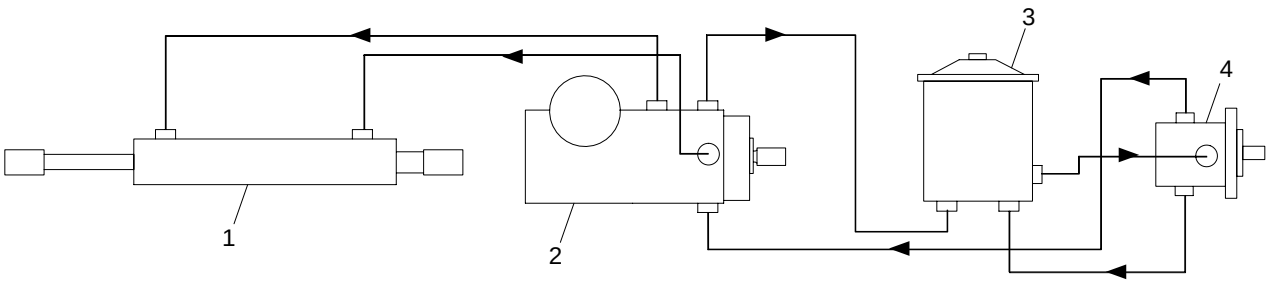
1. Before installing the cylinder, check the ball stud covers or dust seals for extreme wear, cuts, or other damage. Inspect the socket ball studs, ball stud nuts, piston rod, piston cylinder, and grease fittings for wear or damage. Replace parts as necessary.
2. Position the socket ball studs in the axle steering arm and the frame mounting bracket. Make sure the cylinder ports are facing up.
3. Install and torque the ball stud nuts 160 lbf·ft (217 N·m). If required, continue tightening each nut until a slot on the nut aligns with the hole in the ball stud. **Do not back off the nut when locating the cotter pin hole.**
4. Install new cotter pins through the ball studs and nuts, and lock the cotter pins in place.
5. Torque both of the clamp nuts 45 to 60 lbf·ft (60 to 80 N·m).
6. Using a pressure gun, lubricate the ball studs with chassis grease until the old grease is forced out.
7. Remove the seals from the hydraulic lines and the cylinder elbow fittings. Connect the hydraulic lines. See **Fig. 2**. Tighten the nut on each fitting finger-tight. Using a wrench, tighten the nut until there is firm resistance, then tighten one-sixth turn more.
8. Secure the hydraulic lines with tie-straps and the hose hanger bracket.
9. Check the power steering reservoir lubricant level. For instructions, see Group 42.
10. Close the hood.

Removal and Installation



1. Cotter Pin
2. Castle Nut
3. Front Axle
4. Upper Steering Arm
5. Socket Ball Stud
6. Clamp
7. Cylinder Port
8. Power Steering Cylinder
9. Mounting Bracket
10. Frame Rail

Fig. 1, Power Steering Cylinder



1. Steering Cylinder
2. Steering Gear
3. Steering Reservoir
4. Steering Pump

Fig. 2, Hydraulic Lines

General Information

The TRW PS Series power steering pump supplies power steering fluid for the operation of the power steering gear. The main components of the power steering pump are the housing, input shaft, cam ring, rotor, vanes, control valve, and cover assembly.

Principles of Operation

The input shaft, powered by the adaptor gear in the engine gear case or by the crankshaft pulley, turns the rotor, which is inside the cam ring. As the rotor turns, centrifugal force pushes the vanes out toward the surface of the cam ring. As fluid enters the cam ring through the inlet port, the rotor vanes force it out through the outlet port and into the system. The fluid operates the steering gear. Eventually the fluid returns to the power steering reservoir, then back to the power steering pump.

If the system pressure gets too high, a relief valve inside the control valve is forced off its seat, shunting fluid into a relief passage connected to the inlet port. The fluid then recirculates inside the pump instead of going to the outlet port. When the system pressure drops to the correct level, the relief valve seats, closing off the relief passage to the inlet port. The fluid flow returns to normal, flowing from the inlet port to the outlet port and then into the power steering system.

Steering Pump Removal and Installation

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Clean all dirt from around the fittings and hose connections.
4. Put a container under the pump, then disconnect the hoses from the fittings on the pump. Plug the hoses and cap the fittings to keep out dirt and to prevent fluid from leaking.
5. Remove the pump.
   - 5.1 Remove the capscrews and washers that attach the pump to the engine accessory drive mounting flange.
   - 5.2 Pull the pump straight out from the engine. Keep it level to avoid spilling fluid.
6. Turn the pump upside down over a container and let the fluid drain out.
7. Discard the gasket from the pump mounting flange.

Installation

1. Using engine oil, lightly lubricate a new gasket and the pump shaft.
2. Install the pump.
   - 2.1 Install a new gasket on the pump mounting flange, then place the pump on the engine accessory drive mounting.
   - 2.2 Install the washers and capscrews, and tighten them 27 to 32 lbf·ft (37 to 43 N·m).
3. Connect the inlet hose, from the power steering reservoir, to the inlet port. Tighten it 26 lbf·ft (35 N·m).
4. Connect the outlet hose, from the power steering gear, to the outlet port.
5. Bleed the power steering system.
   - 5.1 Check the fluid level in the power steering reservoir and if needed, fill it to the correct level.
   - 5.2 Start the engine and let it idle for several minutes.
   - 5.3 Turn the wheels to a full-left and full-right turn. Repeat about three times.
   - 5.4 Check the fluid level in the power steering reservoir. Add fluid as necessary to the full line on the reservoir dipstick.
   - 5.5 Shut down the engine.
6. Close the hood.
7. Remove the chocks from the tires.

Steering Pump Disassembly, Inspection, and Assembly

CAUTION

Be careful when working on the pump housing; it is aluminum, and can be easily damaged. When putting the pump in a vise, pad the vise jaws and clamp only the cover. Tighten the vise just enough to hold the pump.

Disassembly

WARNING

Wear safety goggles or glasses when disassembling the power steering pump. Some of the parts are held in place by springs or snap rings, which can release with considerable force, possibly causing injury.

NOTE: Prepare for fluid drainage before disassembling the pump.

1. Remove the power steering pump from the engine, following the instructions in **Subject 100**.
2. Carefully remove the end plug and spring from the pump housing. See **Fig. 1**.
3. Remove and discard the O-ring from the plug.

IMPORTANT: TRW does not recommend disassembly of the control valve spool assembly.

4. Remove the control valve spool assembly by hand, or by pushing it with a small rod. Do not push on the small screen in the relief valve seat assembly.
5. Using a solvent-proof marker, make a mark across the housing and the cover. See **Fig. 2**. Remove the capscrews and washers that attach the housing to the cover. Using a twisting motion, separate the housing from the cover.
6. Remove the spring.
7. Using a solvent-proof marker, draw a line across the top plate and the bottom plate. See **Fig. 3**.
8. Holding the cam ring in place, remove the top plate. Remove and discard the O-ring and backup O-ring.
9. Holding the bottom plate in place, remove the cam ring. Note and record whether the dots near the locating pin holes on the cam ring are up or down. See **Fig. 4**.
10. Look for wear on the outside edge of the vanes. Note and record the direction of the wear for assembly. Carefully remove the rotor and vanes, as the vanes will slip from their slots in the rotor.
11. Remove the locating pins. Make marks on the outside of the cover (not on the sealing surface) to note from which holes the locating pins were removed.
12. Remove the bottom plate.
13. Turn the cover over and remove the large retaining ring.
14. Press out the input shaft and ball bearing assembly.
15. Remove the spacer from the cover.
16. Using care not to damage the bore, remove the shaft seal.

Inspection

1. Using a solvent compatible with the power steering fluid, clean all the parts. Then, using filtered compressed air, dry all the parts.

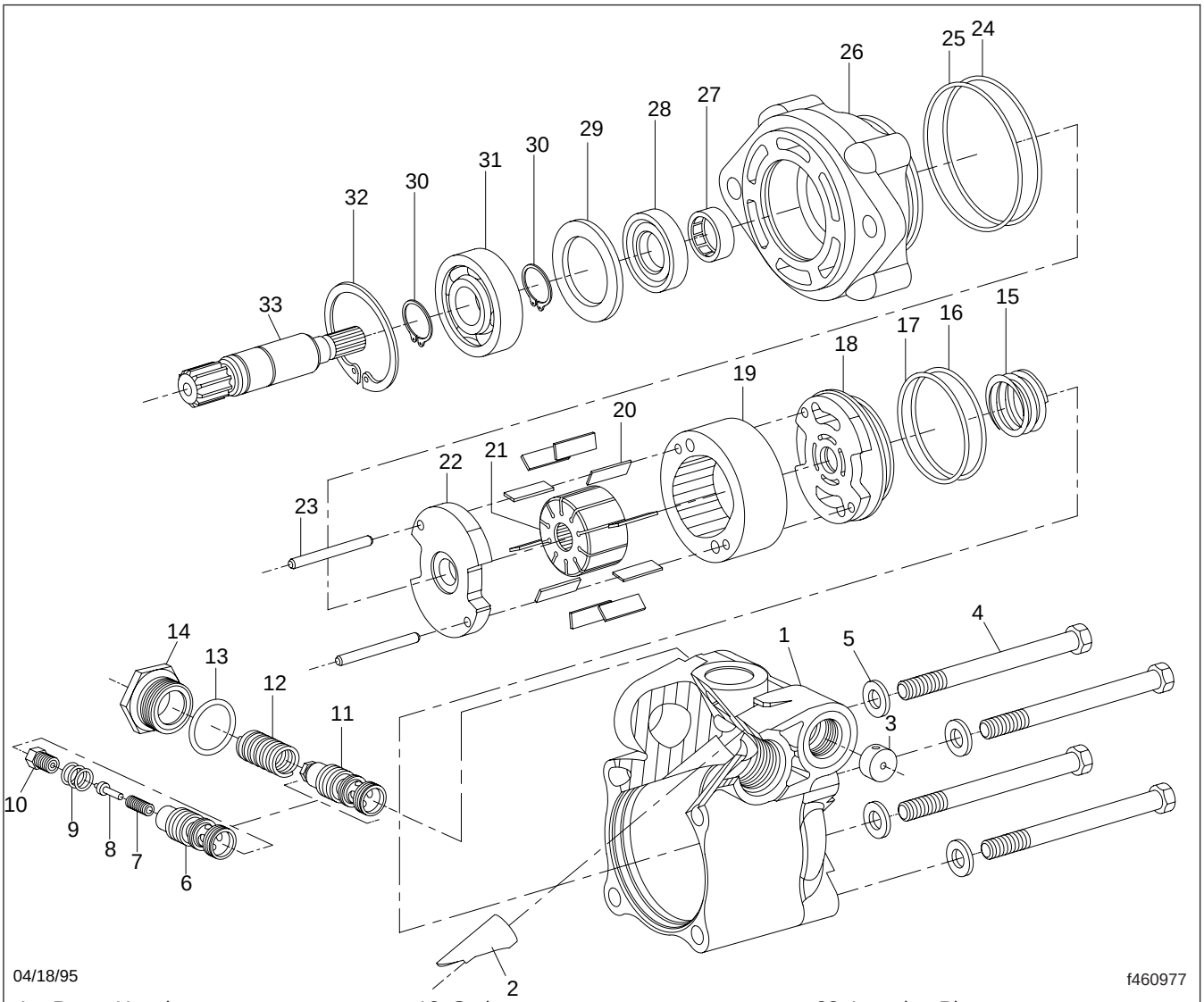
NOTE: Replace any parts that are damaged or worn.

2. Inspect the housing for cracks, stripped threads, a damaged valve bore, and damaged sealing areas. See **Fig. 5**.
3. Inspect the cover for nicks in the O-ring seal grooves. Make sure that the seal drain hole is open, and that the seal bore is free of nicks and other damage. See **Fig. 6**.

   Make sure that the surface on which the bottom plate rests is flat and free of nicks and other damage.
4. Check that the needles roll freely in the needle bearing. If needed, replace the needle bearing.

   4.1 Place the cover in a press with the flange side down. Using an 11/16-inch socket, press the needle bearing out of the cover.

Steering Pump Disassembly, Inspection, and Assembly



1. Pump Housing
2. Boost Tube
3. Orifice
4. Capscrew
5. Washer
6. Spool
7. Spring
8. Poppet
9. Shims
10. Relief Valve Seat Assembly
11. Control Valve Spool Assembly
12. Spring
13. O-Ring
14. End Plug
15. Spring
16. O-Ring
17. Backup O-Ring
18. Top Plate
19. Cam Ring
20. Vane
21. Rotor
22. Bottom Plate
23. Locating Pin
24. Small O-Ring
25. Large O-Ring
26. Cover
27. Needle Bearing
28. Shaft Seal
29. Spacer
30. Small Retaining Ring
31. Ball Bearing
32. Large Retaining Ring
33. Input Shaft

Fig. 1, Power Steering Pump Assembly

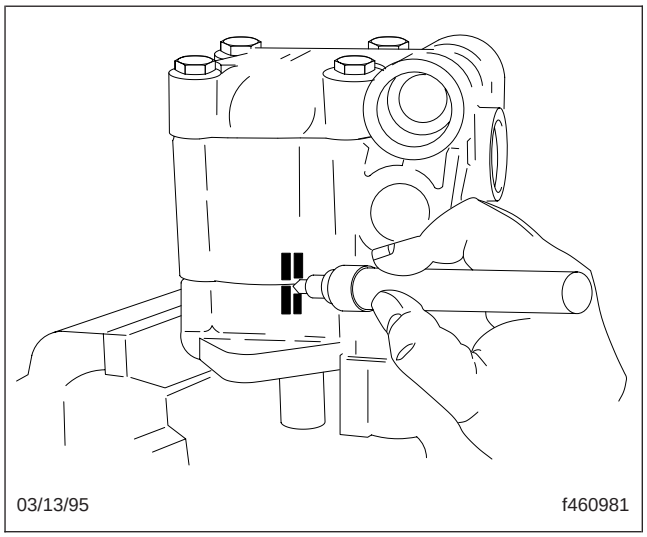


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Fig. 2, Marking the Housing and the Cover

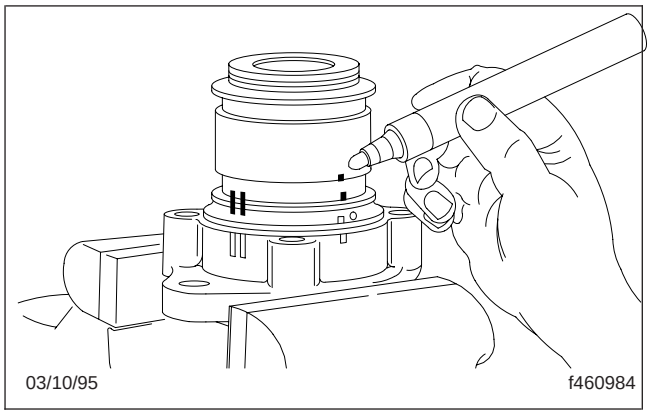

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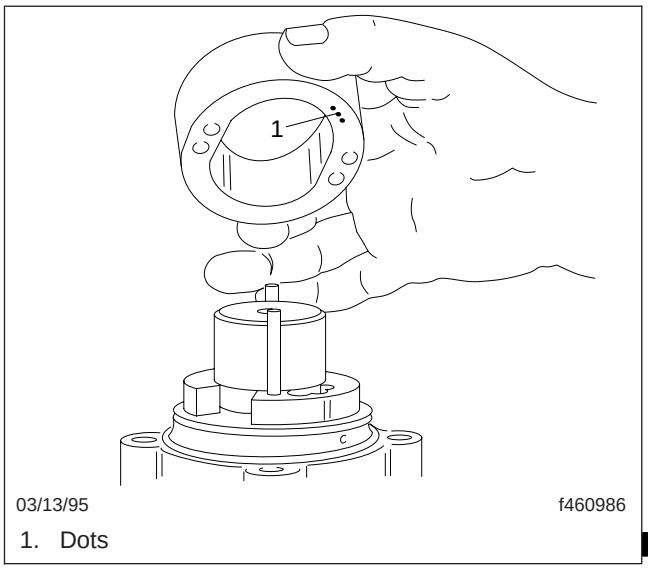
Fig. 3, Marking the Top Plate and the Bottom Plate

⚠ CAUTION

Make sure that the press is clean and free of debris. Debris could damage the face of the cover, which will affect pump operation.

4.2 Put the cover in a clean press with the flange side up. Make sure that the lettered side of the needle bearing is facing toward the press.

4.3 Using a 7/8-inch deep socket, press the new needle bearing into the cover until it is flush with the inside surface of the cover.



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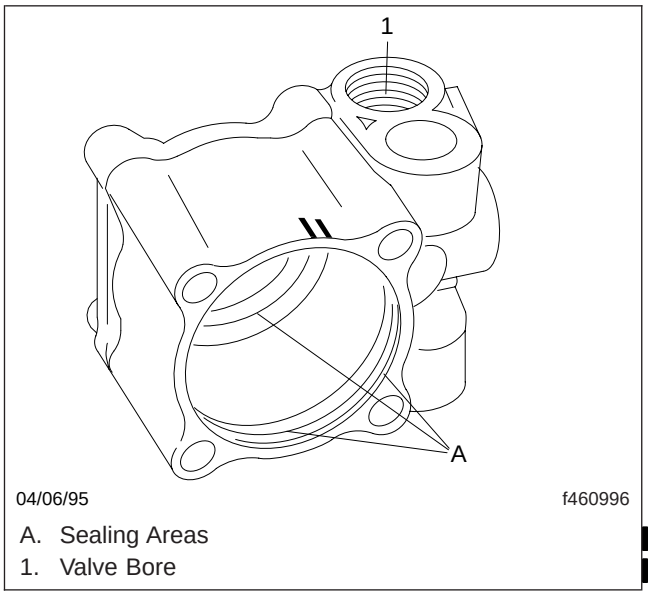
1. Dots

Fig. 4, Checking Whether the Dots are Up or Down.



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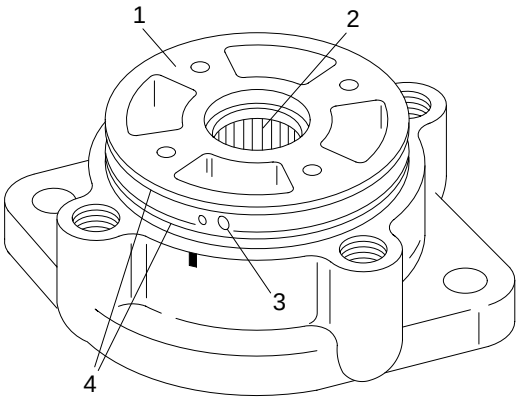
A. Sealing Areas
1. Valve Bore

Fig. 5, Inspect the Housing

5. Inspect the top plate for seal area nicks, abnormal wear, or erosion. A polished pattern from the rotor and vanes is normal. Grooves you can feel with your fingernail are not normal.
6. Look for abnormal wear, erosion, or surface damage on the inside of the cam ring.
7. Check the vanes on the rotor for damage or too much play in the rotor slots. If you can move the

Steering Pump Disassembly, Inspection, and Assembly



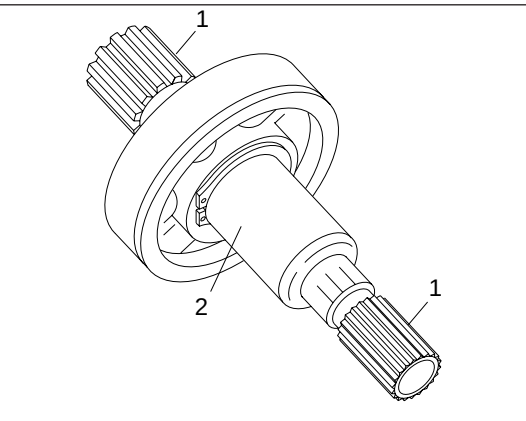
1. Bottom Plate Surface
2. Needle Bearing
3. Seal Drain Hole
4. Seal Grooves

Fig. 6, Inspect the Cover

vanes from side to side in the slots, replace the whole rotor assembly.

NOTE: If the vanes are removed, make sure they are installed with the rounded edge out.

8. Check the bottom plate for abnormal wear patterns.
9. Check the input shaft for damaged splines and abnormal wear grooves around the seal area. See **Fig. 7**. Replace the input shaft if there are grooves that can be detected with your fingernail.



1. Splines
2. Shaft Seal Area

Fig. 7, Check the Input Shaft

9.1 Remove the retaining ring (engine drive end) from the shaft.

Remove the Woodruff key, if equipped.

9.2 Applying pressure to the engine drive end of the input shaft, press the input shaft from the ball bearing.

9.3 Press the new input shaft (from the small splined end) into the ball bearing until the shaft bottoms out on the retaining ring.

9.4 Install the retaining ring on the input shaft with the sheared edge pointing away from the bearing. Make sure that the retaining ring is properly seated.

IMPORTANT: TRW does not recommend disassembly of the control valve spool assembly.

10. Check the control valve spool assembly for wear or chipping. If needed, back flush with air and solvent. Check the assembly for nicks or burrs.

Assembly

CAUTION

Make sure that the press is clean and free of debris. Debris could damage the face of the cover, which will affect pump operation.

1. Coat the outside surface of the shaft seal with a petroleum-based chassis grease. With the lettered side facing toward the needle bearing, press the seal into the cover. The installed seal should be flush with, or just below, the sealing surface on the cover.
2. Grease the inside surface of the shaft seal using a petroleum-based chassis grease.
3. Install the spacer. Make sure that it lies flat.

CAUTION

Do not allow the splines to contact the shaft seal. The splines could damage the shaft seal.

4. Insert the input shaft (small splined end first) into the cover. Do not allow the splines to contact the shaft seal. Insert the shaft into the seal by hand until the ball bearing contacts the cover.

Using a 7/8-inch socket, press the shaft and bearing into the cover.

CAUTION

When placing the cover in a padded vise, do not use excessive clamping force. This could damage the cover.

5. Place the cover in a padded vise and install the large retaining ring with the sheared edge out.

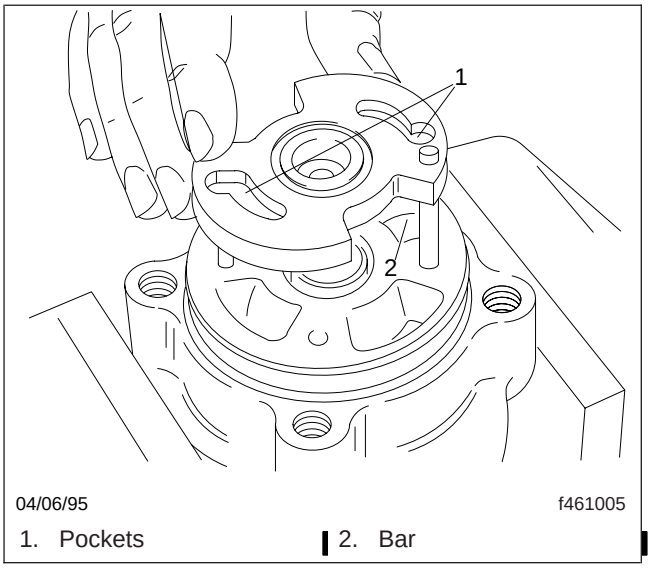
   Turn the cover assembly over.

6. Install the new large and small O-rings in the cover. Make sure that they are seated properly.

7. Using the marks made during disassembly as a guide, install the locating pins.

IMPORTANT: In one of the four cutouts in the cover there is a bar. When installed, the bottom plate must cover this bar.

8. Install the bottom plate with the pockets facing up. See **Fig. 8**. Make sure that the marks made during disassembly are aligned.



1. Pockets 2. Bar

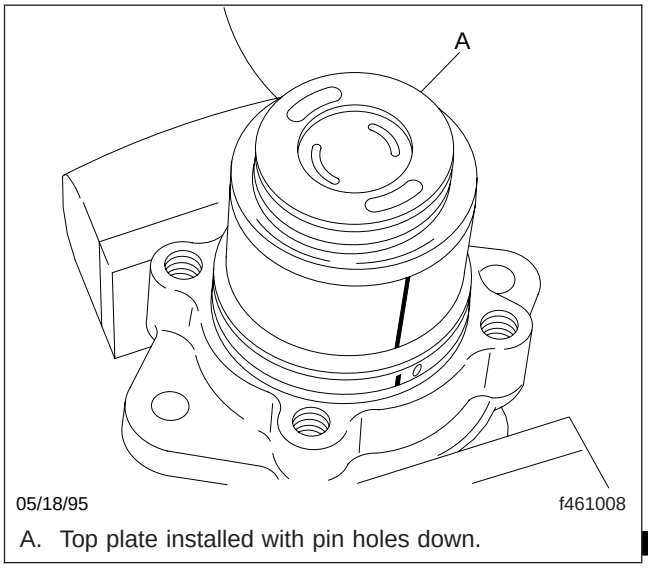
Fig. 8, Installing the Bottom Plate

9. Install the cam ring with the dots facing up or down as noted during disassembly. Make sure that the cam ring is flush with the bottom plates large outside diameter, and that the marks made during disassembly are aligned.

10. Install the rotor and vanes. Make sure that squared edge on each vane points toward the center of the rotor.

11. Install the top plate with the pin holes down. Make sure that the locating pins are engaged in the pin holes, not the pockets. See **Fig. 9**.

    Make sure that the top plate is flush with the cam, and that the marks made during disassembly are aligned.



A. Top plate installed with pin holes down.

Fig. 9, Installing the Top Plate

NOTE: The backup O-ring will fit tighter on the top plate after loosely wrapping (no twisting) it around two fingers, then allowing it to unwrap.

12. Install the backup O-ring on the top plate. Seat the O-ring at the bottom of the groove.

13. Install a new O-ring (without allowing it to roll) on the top plate. Seat the O-ring at the top of the groove.

14. Grease both the O-ring and the backup O-ring.

CAUTION

The housing may have sharp edges. Use care to not cut your finger when applying grease to the housing.

15. Grease the sealing areas of the housing. See **Fig. 10**.

Steering Pump Disassembly, Inspection, and Assembly

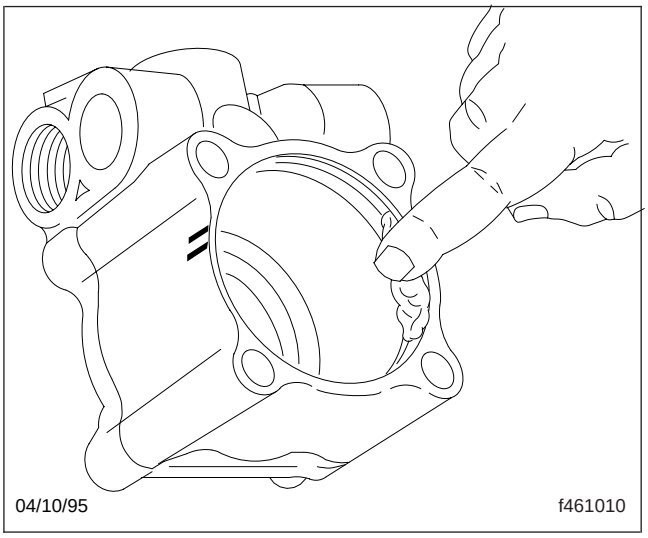


Fig. 10, Greasing the Sealing Areas

16. Place the spring on the top plate.
17. Place the housing over the cover assembly. Make sure that the marks made during disassembly are aligned. See **Fig. 11**.

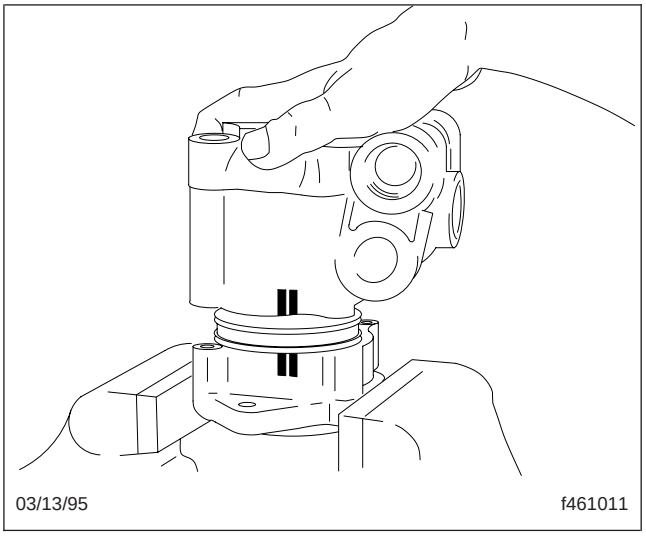


Fig. 11, Installing the Housing

CAUTION

Evenly thread the capscrews into the cover. If not evenly threaded into the cover, damage could occur to the seals, top plate, or housing.

18. Install the capscrews and washers. Evenly thread all four capscrews into the cover. Alternately tighten the capscrews 30 lbf·ft (41 N·m).
19. Screw the relief valve seat assembly into the control valve spool assembly. Tighten the assembly 87 lbf·in (983 N·cm).

NOTE: Placing the spool assembly in a collet will assist the tightening procedure.

20. Insert the valve spool assembly (screen end last) into the housing. Make sure that the spool slides freely in the housing.
21. Install the spring in the housing.
22. Install a new O-ring on the end plug.
23. Lightly grease the O-ring and the end plug threads. Install the end plug and tighten 30 lbf·ft (41 N·m).
24. Install the Woodruff key in the new input shaft (if removed during the input shaft replacement).
25. Turn the pump by hand and make sure that it turns freely.
26. Install the power steering pump on the engine, following the instructions in **Subject 100**.

Specifications

Approved Power Steering Fluids		
Fluid Type	**Approved Fluid**	
Automatic Transmission Fluid *	Dexron® II	
	Dexron® III	
Heavy-Duty Engine Oil * IMPORTANT: Do not use heavy-duty engine oil in vehicles built from November 4, 2002.	Union	10W–40
	Texaco	10W–40
	Chevron	10W–40
	Mobil Super	10W–40
	Union	15W–40
	Unocal	15W–40
	Shell Rotella T	30W

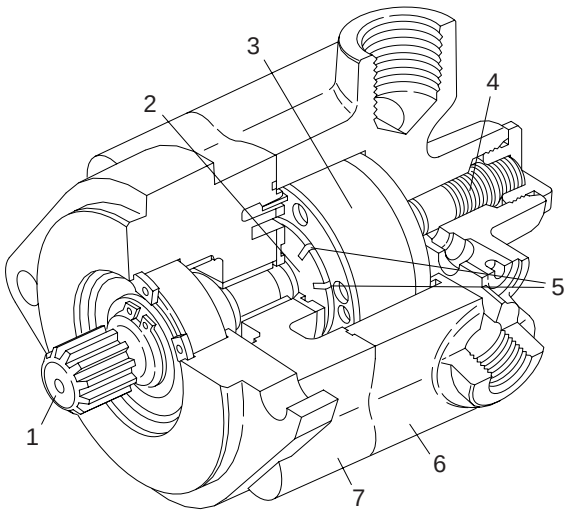
* Do not mix engine oil with automatic transmission fluid (ATF). Use the same lubricant for parts as is used in the power steering system.

Table 1, Approved Power Steering Fluids

General Information

The LuK Automotive Hydraulics LF 73 power steering pump supplies power steering fluid for the operation of the power steering gear. The pump is mounted on the driver's side of the engine, at the rear of the gear case or the air compressor. It is powered by an adaptor gear in the engine.

The main components of the power steering pump are the housing, driveshaft, cam ring, rotor, vanes, and control valve. See **Fig. 1**.



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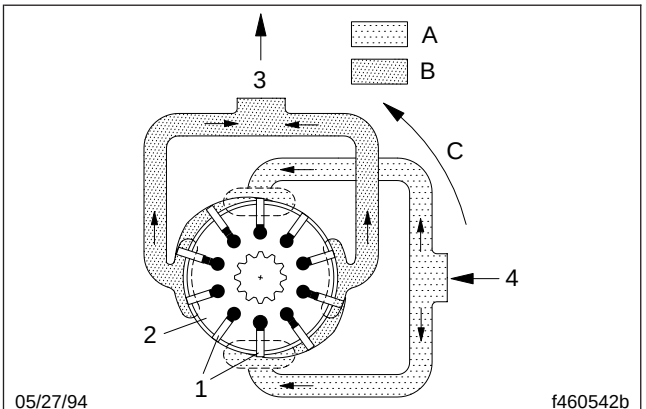
1. Driveshaft
2. Rotor
3. Cam Ring
4. Control Valve
5. Vane
6. Housing
7. Flange Assembly

Fig. 1, Pump Components

Principles of Operation

The driveshaft, powered by the adaptor gear in the engine gear case, turns the rotor, which is inside the cam ring. As the rotor turns, centrifugal force pushes the vanes out toward the surface of the cam ring. As fluid enters the cam ring through the inlet port, the rotor vanes force it out through the outlet port and into the system. The fluid operates the steering gear. Eventually the fluid returns to the power steering reservoir and then back to the power steering pump. See **Fig. 2**.



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A. Low Pressure Fluid
B. High Pressure Fluid
C. Rotation
1. Vane
2. Rotor
3. Outlet
4. Inlet

Fig. 2, Power Steering Pump Flow Diagram

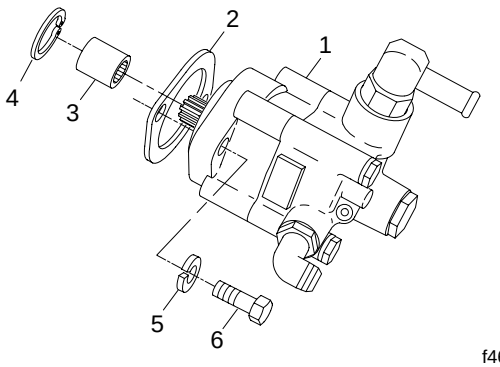
If the system pressure gets too high, a poppet inside the control valve is forced off its seat, shunting fluid into a relief passage connected to the inlet port. The fluid then recirculates inside the pump instead of going to the outlet port. When the system pressure drops to the correct level, the poppet seats, closing off the relief passage to the inlet port. The fluid flow returns to normal, flowing from the inlet port to the outlet port and then into the power steering system.

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Clean all dirt from around the fittings and hose connections.
4. Put a container under the inlet port of the pump, then disconnect the hose from the fitting. Plug the hose to keep out dirt and to prevent fluid from leaking.

   Repeat this step at the pump outlet port.
5. On Cummins, Caterpillar, and Detroit Diesel Series 55 engines, remove the capscrews that attach the pump to the engine accessory drive mounting flange. See **Fig. 1**. Slide the pump out of the shaft coupling or sleeve and remove the pump from the engine.

   On Detroit Diesel Series 50 and 60 engines, remove the capscrews that attach the pump to the adaptor flange. See **Fig. 2**. Slide the pump out of the coupling. Remove the sprocket from the shaft if necessary. Check around the adaptor flange for oil leaks. If there are leaks, remove the adaptor flange from the engine. Remove all old gasket material.



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1. Pump
2. Gasket
3. Coupling (Cummins N14 engines only)
4. Coupling Clip (Cummins N14 engines only)
5. Washer
6. Capscrew

Fig. 1, Cummins, Caterpillar, and Detroit Diesel Series 55 Power Steering Pump Installation

Installation

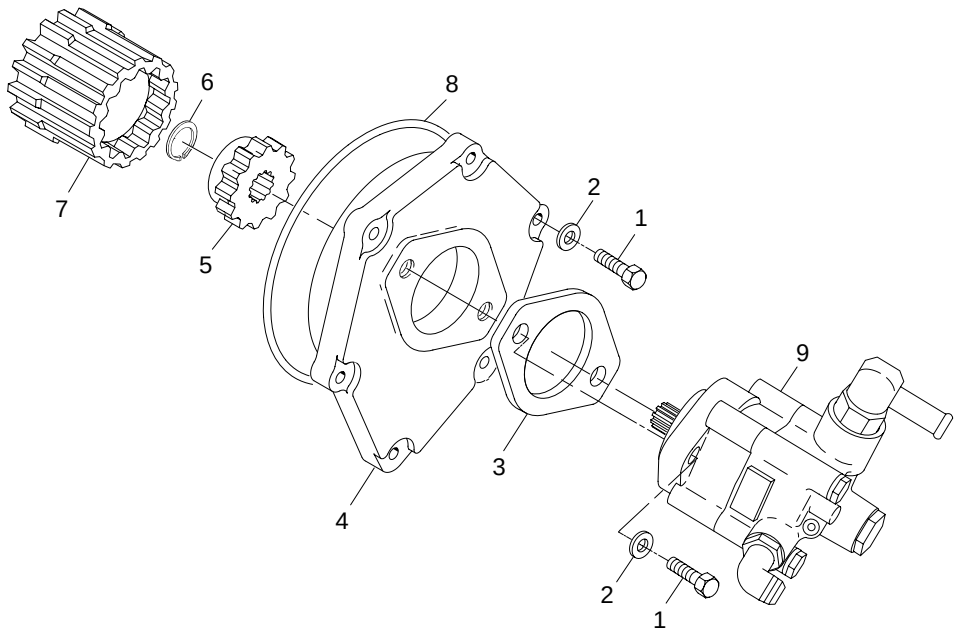
1. Using engine oil, lightly lubricate a new gasket and the pump shaft.
2. On Cummins, Caterpillar, and Detroit Diesel Series 55 engines, install the new gasket on the pump mounting flange, then place the pump on the engine accessory drive mounting. Turn the pump or shaft as needed to mesh the shaft with the shaft coupling or sleeve. Seat the pilot of the pump mounting flange in the accessory drive mounting, without applying unnecessary force. Install the washers and capscrews. Tighten the capscrews 27 to 32 lbf·ft (37 to 43 N·m).

   On Detroit Diesel Series 50 and 60 engines, make sure the clip is installed in the sprocket and that the coupling and sprocket are installed in the engine accessory drive. If the adaptor flange was removed, use engine oil to lightly lubricate a new O-ring. Install the O-ring on the flange and install the flange on the engine. Cross tighten the capscrews 22 to 25 lbf·ft (30 to 34 N·m). Install the new gasket on the pump mounting flange, then position the pump on the adaptor flange. Turn the pump or shaft as needed to mesh the shaft with the sprocket. Seat the pump mounting flange pilot in the adaptor flange without applying unnecessary force. Apply Loctite® 242, or an equivalent sealant, to the mounting capscrews. Install the washers and capscrews. Tighten the capscrews 27 to 32 lbf·ft (37 to 43 N·m).
3. Connect the hoses to the pump inlet and outlet ports.
4. Check the fluid level of the power steering reservoir and add fluid if necessary. Start the engine and let it idle for two minutes. Do not turn the steering wheel. Doing so can cause air to enter the system.

   Turn off the engine and check the fluid level in the reservoir.
5. Start the engine again. To remove air from the system, steer the vehicle from full left to full right several times.

   Add fluid as necessary to the full line on the reservoir dipstick.

Steering Pump Removal and Installation



1. Capscrew
2. Washer
3. Gasket
4. Adaptor Flange
5. Sprocket
6. Clip
7. Coupling
8. O-Ring
9. Power Steering Pump

Fig. 2, Detroit Diesel Series 50 and 60 Power Steering Pump Installation

6. If the steering gear does not have a manual bleed screw, turn the steering wheel from full lock to full lock two or three times with the engine running at idle. Repeat this step and add fluid as necessary until there are no bubbles in the reservoir.

   If the steering gear is equipped with a manual bleed screw, turn the steering wheel from full lock to full lock two or three times with the engine running at idle. Then loosen the manual bleed screw about one turn and look for clear fluid or fluid mixed with bubbles at the threaded area of the bleed screw. Repeat this step and add fluid as necessary until only clear fluid shows. Tighten the manual bleed screw 27 to 33 lbf·in (300 to 360 N·cm). Fill the reservoir if necessary to the full line on the dipstick.

7. Close the hood and remove the chocks from the tires.

CAUTION

Be careful when working on the pump housing; it is aluminum, and can be easily damaged. When putting it in a vise, pad the vise jaws. Tighten the vise just enough to hold the pump.

Replacement

WARNING

Wear safety goggles or glasses when disassembling the power steering pump. Some of the parts are held in place by springs or snap rings, which can release with considerable force, possibly causing injury.

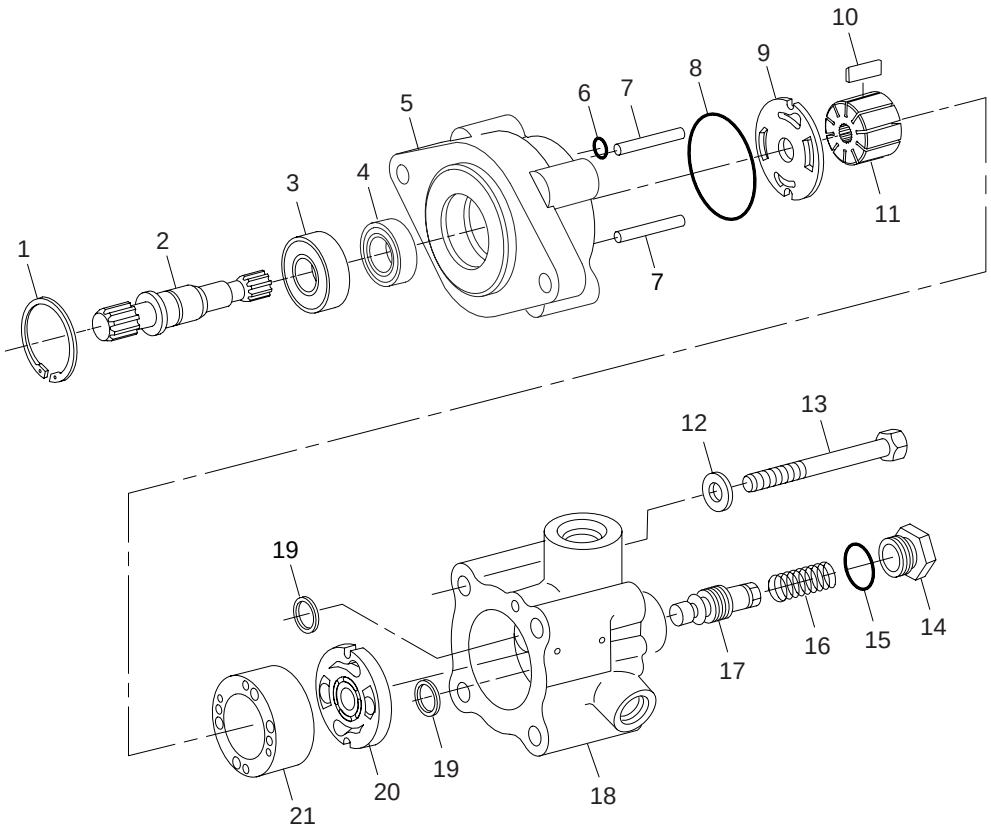
NOTE: The shaft seal kit contains a replacement seal for LF and VT series pumps. The seal for the LF series pump is smaller.

1. Remove the power steering pump from the engine, following the instructions in **Subject 100**.
2. Carefully remove the end plug and the spring from the pump body. See **Fig. 1**.
3. Remove the control valve. Be careful not to scratch the control valve.
4. Remove and discard the O-ring from the plug.
5. Put the pump housing in a padded vise, then remove the capscrews that attach the housing to the flange assembly.
6. Remove and discard the combination O-rings/backup rings from the pump housing.
7. Remove the pressure plate, guide pins, cam ring, rotor, vanes, and wear plate as a unit and set it aside.
8. Remove and discard the small and large O-rings from the flange assembly.
9. Remove the snap ring holding the shaft seal in place. Discard the snap ring.
10. Put the flange assembly in a vise with the inner end of the shaft pointing up. Carefully tap out the driveshaft.
11. Remove and discard the shaft seal.
12. Using a solvent compatible with the power steering fluid, clean all the parts. Then, using filtered compressed air, dry all the parts.
13. Coat all the parts with clean power steering fluid. For approved power steering fluids, see **Specifications 400**.
14. Place the spacer over the outer (drive) end of the shaft with the cupped side of the spacer facing the inner end of the shaft.
15. Using power steering fluid, lubricate the new shaft seal. Carefully place the seal over the outer (drive) end of the shaft, up against the spacer. The lettered side of the seal should be visible.

NOTE: To correctly install the driveshaft seal, it is necessary to make a suitable driver from tubular stock. See **Fig. 2** for the applicable dimensions.

16. Using a suitable driver, install the shaft seal into the bore in the flange assembly. Make sure the spring side of the seal faces the flange. See **Fig. 3**. Seat the seal firmly against the shoulder in the bore.
17. Install the small snap ring in the groove on the driveshaft with the sharp edge facing toward the bushing.
18. Put the flange assembly in a padded vise with the drive end of the shaft pointing up. Install a new large O-ring in the flange assembly.
19. Install a new small O-ring in the flange assembly.
20. Install the pressure plate, guide pins, cam ring, rotor, vanes, and wear plate as a unit. Make sure that the two guide pins are seated in the flange assembly.
21. Using power steering fluid, lubricate the new combination O-ring/backup rings. Install the rings in the pump housing with the black side facing the housing, and the white, plastic side exposed.
22. Lining up the mounting holes, install the pump housing over the flange assembly.
23. Install the capscrews and washers in the pump housing. Tighten them in a cross pattern 29 to 37 lbf·ft (40 to 50 N·m).
24. Install the control valve in the pump housing.

Steering Pump Shaft Seal Replacement



1. Snap Ring
2. Driveshaft
3. Driveshaft Bushing
4. Shaft Seal
5. Flange Assembly
6. Small O-Ring
7. Guide Pin
8. Large O-Ring
9. Wear Plate
10. Vane
11. Rotor
12. Washer
13. Capscrew
14. End Plug
15. End Plug O-Ring
16. Spring
17. Control Valve
18. Pump Housing
19. Combination O-Ring/Backup Ring
20. Pressure Plate
21. Cam Ring

Fig. 1, Power Steering Pump Assembly

CAUTION

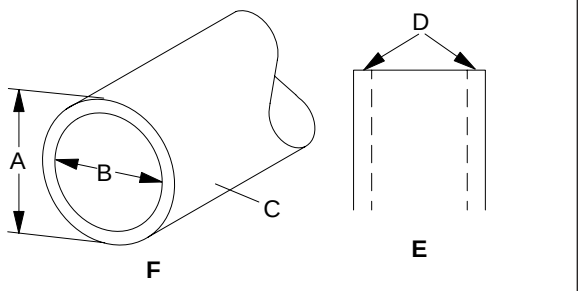
Make sure you install the control valve correctly in its bore. If it is installed backwards, the power steering pump will not work and will quickly overheat, which could cause severe damage to the pump.

24.1 Lubricate the control valve with power steering fluid. For approved power steering fluids, see **Specifications 400**. Install the control valve, with the hex end up, into the bore in the pump housing. See **Fig. 4**.

24.2 Install the spring over the hex end of the control valve.

24.3 Install a new O-ring on the end plug, then install the end plug. Tighten it 33 to 40 lbf·ft (45 to 55 N·m).

25. Turn the shaft by hand. It should turn smoothly and without binding.



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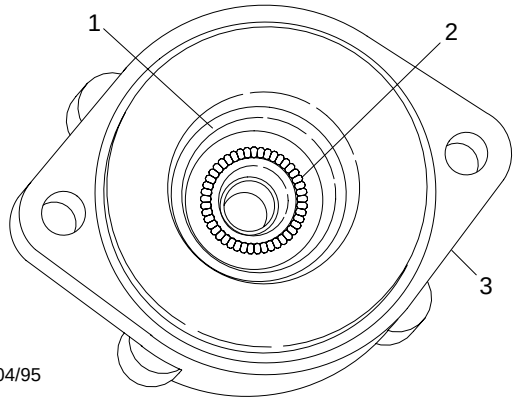
A. Slightly smaller than the o.d. of the shaft seal.
B. Slightly larger than the o.d. of the driveshaft.
C. To be made of tubular stock.
D. The ends must be square.
E. Side View
F. Front View

Fig. 2, Shaft Seal Installation Tool



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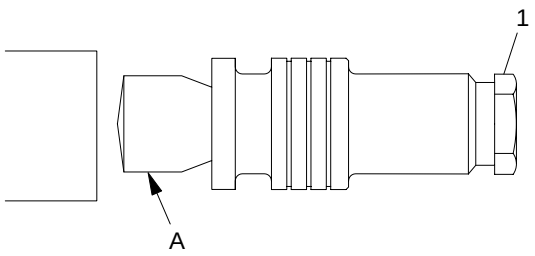
1. Shaft Seal
2. Garter Spring
3. Flange

Fig. 3, Install the Shaft Seal



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A. Insert this end first.
1. Hex End

Fig. 4, Install the Control Valve

26. Install the power steering pump on the engine. For instructions, refer to **Subject 100**.

Specifications

Approved Power Steering Fluids		
Fluid Type	**Approved Fluid**	
Automatic Transmission Fluid *	Dexron® II	
	Dexron® III	
Heavy-Duty Engine Oil *	Union	10W–40
IMPORTANT: Do not use heavy-duty engine oil in vehicles built from November 4, 2002.	Texaco	10W–40
	Chevron	10W–40
	Mobil Super	10W–40
	Union	15W–40
	Shell Rotella T	30W

* Do not mix engine oil with automatic transmission fluid (ATF). Use the same lubricant for parts as is used in the power steering system.

Table 1, Approved Power Steering Fluids

Removal

1. Turn off the engine, apply the parking brakes, chock the tires, and open the hood.
2. Clean all dirt from around the fittings and hose connections on the power steering pump. See **Fig. 1**.
3. Place a container under the power steering pump. Then disconnect the hoses from the fittings on the pump. Plug the hoses and cap the fittings to keep out dirt and to prevent fluid from leaking.
4. Remove the power steering pump.
   - 4.1 Remove the capscrews and washers that attach the pump to the engine.
   - 4.2 Pull the pump straight out from the engine. Keep it level to avoid spilling fluid.

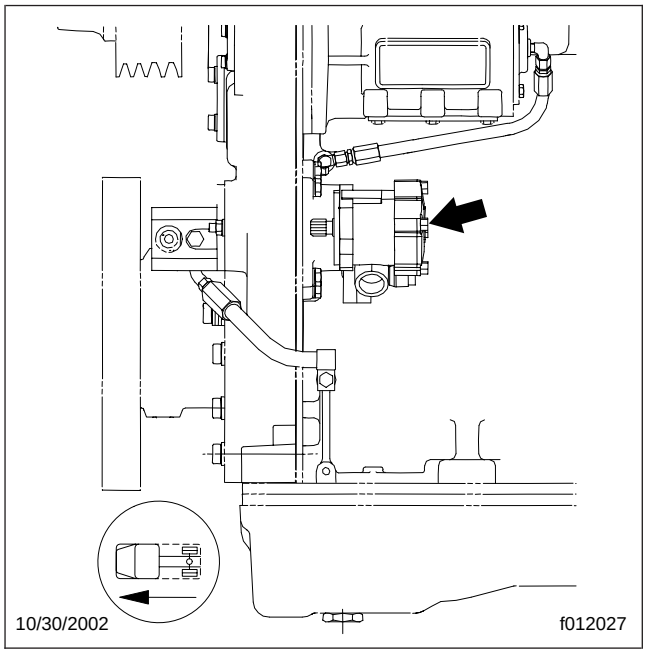


Fig. 1, TRW EV Power Steering Pump

5. Turn the pump upside down over a container and let the fluid drain out.
6. Remove and discard the gasket from the steering pump.

Installation

1. Install a new gasket on the steering pump. Using engine oil, lightly lubricate the gasket and the pump shaft.
2. Using washers and capscrews, attach the steering pump to the engine and torque the capscrews 27 to 32 lbf·ft (37 to 43 N·m).
3. Connect the inlet hose (from the power steering reservoir) to the inlet port.
4. Connect the outlet hose (from the power steering gear) to the outlet port.
5. Bleed the power steering system.
   - 5.1 Check the fluid level in the power steering reservoir and if needed, fill it to the correct level.
   - 5.2 Start the engine and let it idle for several minutes.
   - 5.3 Turn the wheels to a full-left and full-right turn. Repeat about three times.
   - 5.4 Check the fluid level in the power steering reservoir. Add fluid as necessary to the full line on the reservoir dipstick.
   - 5.5 Shut down the engine.
6. Close the hood and remove the chocks from the tires.

Specifications

The following hydraulic fluids are approved for use in the steering system:

- Automatic Transmission Fluid (ATF), Dexron® II
- Automatic Transmission Fluid (ATF), Dexron® III

EV Pump Specifications:

- Length: 3.85 inches (98.0 mm)
- Height: 4.72 inches (119.8 mm)
- Width: 3.16 inches (80.0 mm)
- Weight: 4.9 pounds (2.2 kg)
- Displacements: 1.10, 1.34, and 1.53 cubic inches per revolution (cir) (18, 22, and 25 cc/rev)
- Flow Control Settings: 4.23 and 6.35 gpm (16 and 24 L/min)
- Relief Pressure Settings: 2175, 2320, 2683, and 2828 psi (150, 160, 185, and 195 bar)

General Description

NOTE: Procedures in this section have been slightly modified from the original component manufacturer's service manual. See the manufacturer's service literature (**trucksteering.trw-.com**) for additional information.

The TRW THP and PCF power steering gears are integral hydraulic power steering gears that contain a manual steering mechanism, a hydraulic control valve, and a hydraulic power cylinder.

The pressure required for the steering gear to overcome resistance at the steered wheels is provided by the power steering pump. The rotary control valve directs the flow of hydraulic fluid to the appropriate cylinder cavity in the steering gear (and in the auxiliary cylinder in a dual steering gear system) at the proper flow rate and pressure. As the steering wheel is turned faster or slower, more or less fluid is required by the gear.

Principles of Operation

When the driver turns the steering wheel, that force travels from the steering wheel to the steering gear input shaft. A torsion bar, pinned at one end to the input shaft and at the other end to the worm shaft, turns with the input shaft and exerts a rotational force on the worm shaft. In response to the force exerted by the torsion bar, the worm shaft moves the rack piston forward or backward in the gear housing by means of a series of recirculating balls in the spiral channels of the worm shaft. As the rack piston slides back and forth, it turns the sector shaft. The sector shaft swings the pitman arm, which pulls or pushes the drag link. The drag link moves the axle steering arm, steering the vehicle.

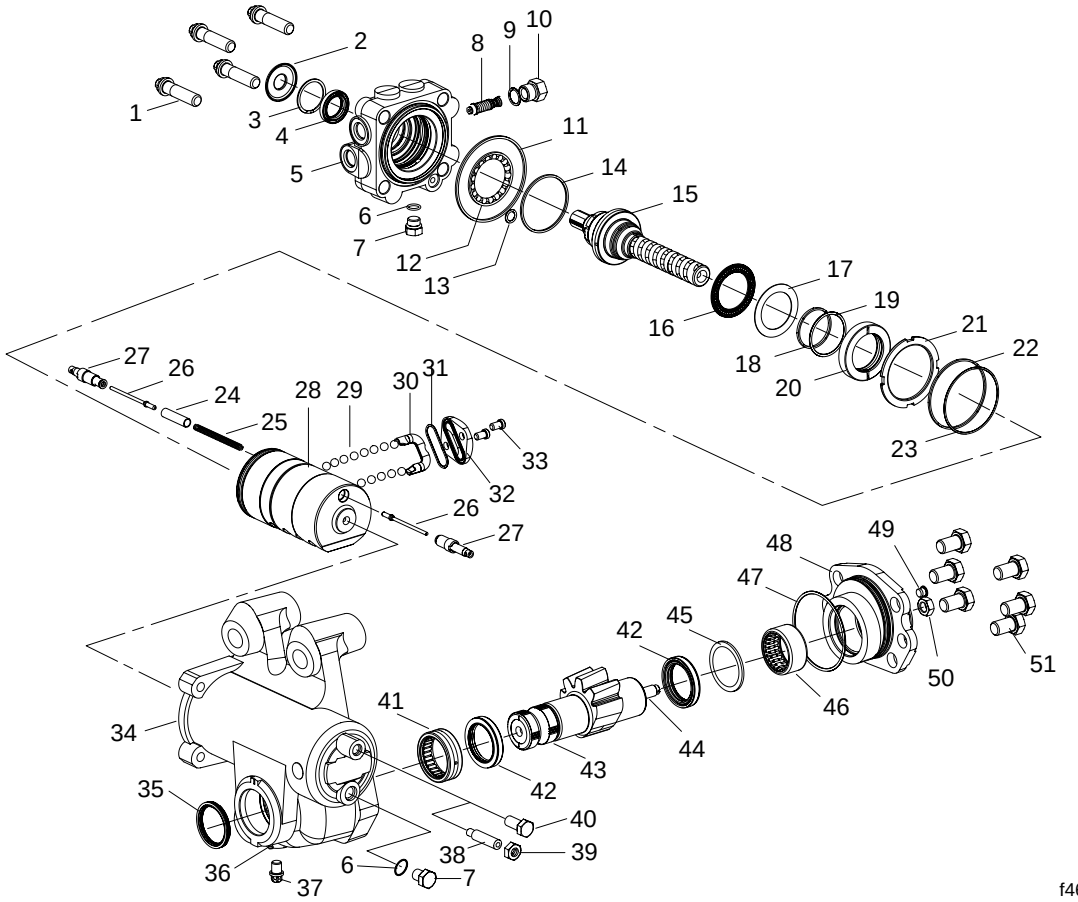
The rack piston's axial movement is resisted by its engagement to the sector shaft, which is linked to the steered wheels. Because of this resistance, the torsion bar activates the control valve, which directs pressurized fluid to the upper or lower cylinder cavity (depending on the direction of turn). The pressurized fluid assists in moving the rack piston up or down in the cylinder bore.

Most THP and PCF steering gears are equipped with two poppet (unloading) valves, one at each end of the rack piston. As the front wheels reach the axle stop—the farthest the wheels can turn in either direction—one poppet or the other, depending on the direction of the turn, will trip to prevent steering system damage. The tripped poppet reduces pressure in the gear, heat generated by the power steering pump, and outside forces acting on the steering linkage.

Some THP and PCF steering gears are also supplied with an internal pressure relief valve (PRV). The PRV limits maximum supply pressure to protect the power steering gear, but it does not reduce pressure as the steered wheels approach the axle stops.

See **Fig. 1** for an exploded view of the steering gear.

General Information



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1. Valve Housing Capscrew
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Valve Housing
6. Auxiliary Port O-Ring (2)
7. Auxiliary Port Plug (2)
8. Relief Valve
9. O-Ring
10. Relief Valve Cap
11. Valve Housing O-Ring
12. Bearing Assembly
13. O-Ring
14. Seal Ring
15. Input Shaft Assembly
16. Thrust Bearing
17. Thrust Washer
18. Seal Ring
19. O-Ring
20. Bearing Adjuster
21. Adjuster Locknut
22. O-Ring
23. Seal Ring
24. Push Tube
25. Poppet Spring
26. Poppet
27. Poppet Seat and Sleeve Assembly
28. Rack Piston
29. Ball
30. Ball Return Guide
31. Cap Seal
32. Ball Return Guide Cap
33. Torx® Capscrew
34. Gear Housing
35. Dirt and Water Seal
36. Grease Fitting
37. Automatic Bleed Plug
38. Poppet Adjusting Screw
39. Poppet Adjusting Screw Nut
40. Poppet Fixed Stop Screw
41. Roller Bearing
42. Output Seal
43. Sector Shaft Assembly
44. Sector Shaft Adjusting Screw
45. Washer
46. Roller Bearing
47. Side Cover O-Ring
48. Side Cover Assembly
49. Vent Plug, Side Cover
50. Adjusting Screw Jam Nut
51. Capscrew

Fig. 1, TRW THP/PCF Steering Gear

Removal

1. Verify that the axle stops are adjusted correctly. Ensuring correct axle stop adjustment will eliminate the possibility of resetting steering gear poppet valves after the gear is installed. See **Group 33** for instructions.
2. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping where the work is to be done.
3. Shut down the engine, apply the parking brakes, and chock the tires.
4. Disconnect the batteries and open the hood.
5. Clean all fittings and hose connections on the steering gear until they are free of dirt.
6. Drain the fluid from the power steering system. Disconnect the hydraulic lines from the steering gear, marking the lines for later reference. Plug the lines and the fittings to keep out dirt.
7. Remove the pitman arm.
   - 7.1 Remove and discard the pinch bolt, nut, and washer (if applicable) that attach the pitman arm to the steering gear sector shaft.
   - 7.2 Using a two-jaw puller, remove the pitman arm from the steering gear sector shaft. See **Fig. 1**.
8. Disconnect the steering driveline from the steering gear input shaft.
   - 8.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

NOTICE

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

   - 8.2 Remove the end yoke from the input shaft.

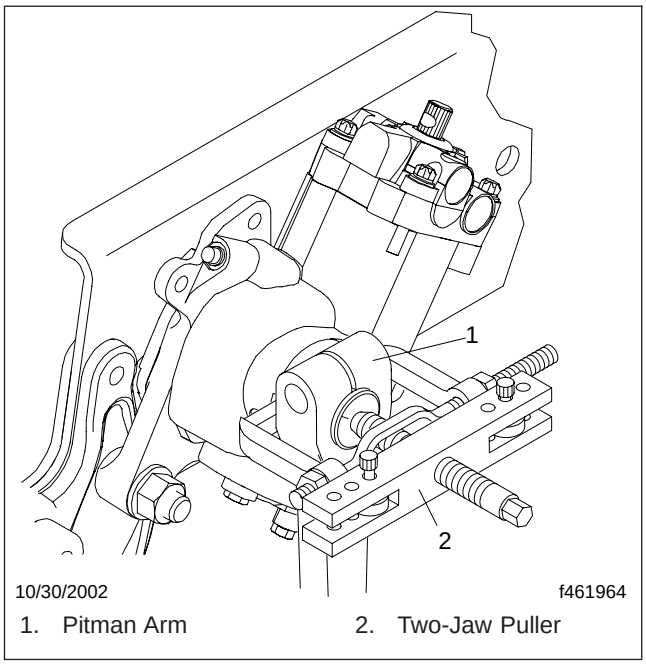


Fig. 1, Pitman Arm Removal

WARNING

The steering gear is heavy. Use caution when removing, lifting, or carrying the steering gear. Failure to do so could cause personal injury.

9. Remove the fasteners that secure the steering gear to the frame rail. Remove the steering gear.

Installation

1. Mount the steering gear on the frame rail and install the mounting fasteners. Tighten the fasteners 342 to 434 lbf·ft (464 to 588 N·m).
2. Center the steering gear so that the timing mark on the sector shaft is aligned with the timing mark on the steering gear. Keep the steering gear centered as the installation continues.
3. Connect the steering driveline to the steering gear input shaft.
   - 3.1 Align the hole in the steering driveline lower end yoke with the indentation on the input shaft.

Steering Gear Removal and Installation

3.2 Using a new pinch bolt and nut, attach the driveline lower end yoke to the input shaft. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).

3.3 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.

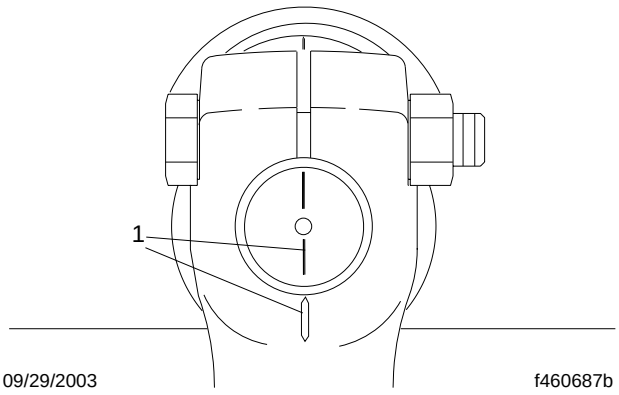
⚠ WARNING

Never leave a chisel wedged in the pitman arm slot. When using a chisel to spread the slot in the pitman arm, wear safety glasses and maintain a firm grip on the chisel at all times. Otherwise, the chisel may fly loose, which could cause an injury.

NOTE: The pitman arm may not fit over the splines on the sector shaft without spreading the slot in the arm. To wedge the slot open, drive a chisel into the slot using a ball-peen hammer. Hold the chisel in place and install the pitman arm on the sector shaft. Remove the chisel from the slot.

4. Install the pitman arm.

4.1 Make sure that the timing mark on the pitman arm is aligned with the timing mark on the sector shaft. See **Fig. 2**.



1. Timing Marks Aligned

Fig. 2, Typical Pitman Arm and Timing Marks

4.2 Using a new pinch bolt, nut, and washer (if applicable), attach the pitman arm to the steering gear sector shaft.

4.3 Tighten the nut 230 lbf·ft (312 N·m).

4.4 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.

5. If the hydraulic line fittings were removed, attach them to the steering gear. Tighten the fittings 37 lbf·ft (50 N·m). Tighten the jam nut on the pressure line fitting to a maximum 41 lbf·ft (56 N·m).

6. Remove the plugs from the hydraulic lines. Connect the hydraulic lines to the steering gear. Tighten the nut on each fitting finger tight, then use a wrench to tighten the nut until there is firm resistance. Tighten one-sixth turn more.

7. Connect the batteries.

8. Fill and bleed the steering system. For instructions, refer to **Subject 110**.

9. Close the hood and perform the post-service checks in **Subject 150**.

Filling and Air Bleeding the System

⚠ WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

1. Fill the power steering reservoir nearly full with automatic transmission fluid. Do not turn the steering wheel.
2. Start the engine and let it idle for ten seconds, then shut it off. Check and fill the reservoir. Repeat this step at least three times, checking the fluid level in the reservoir each time.

IMPORTANT: Do not let the fluid level drop significantly or allow the reservoir to empty. Doing so may introduce air into the system.

3. Start the engine and let it idle for two minutes. Do not turn the steering wheel. Shut off the engine and check the fluid level in the reservoir. If needed, add more fluid.
4. Start the engine again. Turn the steering wheel from full-left to full-right several times. If needed, add more fluid to the reservoir.

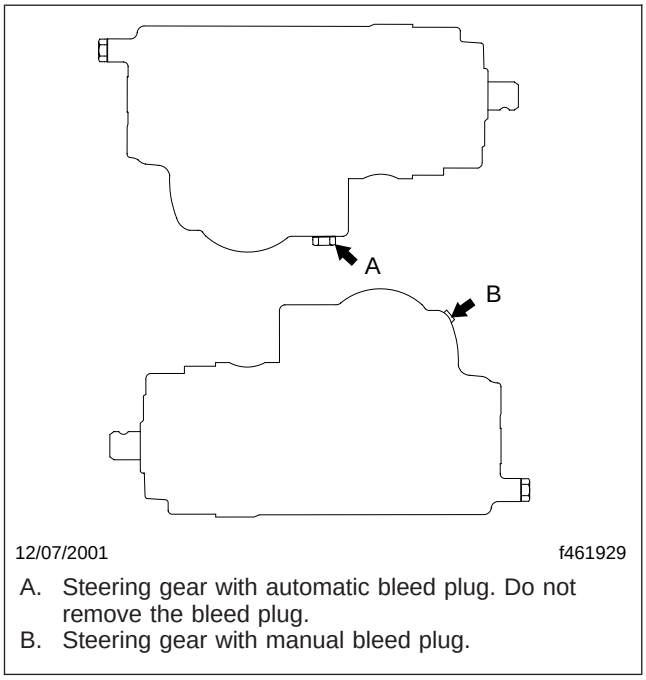
   Automatic bleed systems should now be free of trapped air.

   If the vehicle has a manual bleed system (**Fig. 1**), proceed to the next step.

IMPORTANT: Do not turn the steering wheel while the bleed screw is loosened.

5. With the wheels in the straight-ahead position, loosen the manual bleed screw two to three turns. Allow air and aerated fluid to bleed out until only clear fluid is seen. Close the bleed screw and add fluid to the reservoir if needed.

   Repeat this step until all air is out of the system.
6. Tighten the bleed screw 45 lbf·in (509 N·cm).



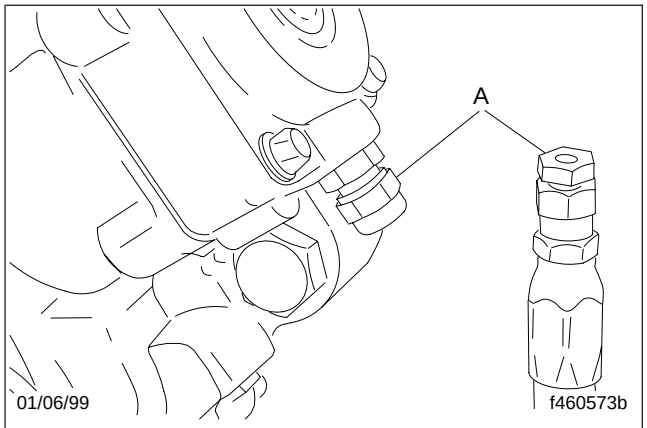
A. Steering gear with automatic bleed plug. Do not remove the bleed plug.
B. Steering gear with manual bleed plug.

Fig. 1, Steering Gear Bleed Systems

Replacement

NOTE: The power steering pump is used in this procedure to force out the input shaft seal. To use this procedure, the power steering pump should have a minimum of 1500 psi (10 342 kPa) available.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the return line from the steering gear and plug the line. See **Fig. 1**. Cap the return port of the steering gear with a high pressure fitting.



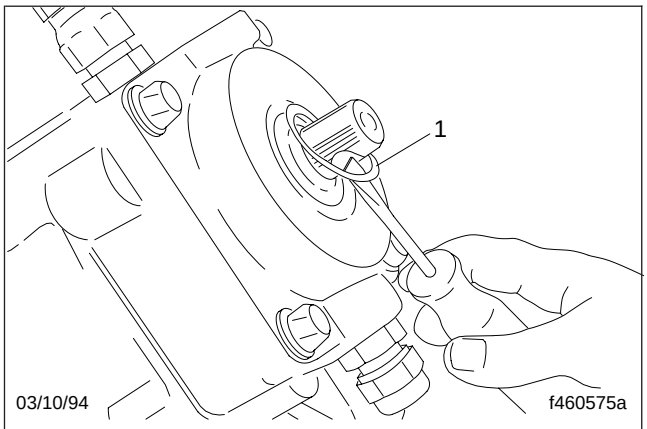
A. Cap the return line and the return port.

Fig. 1, Disconnected Return Line

NOTICE

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

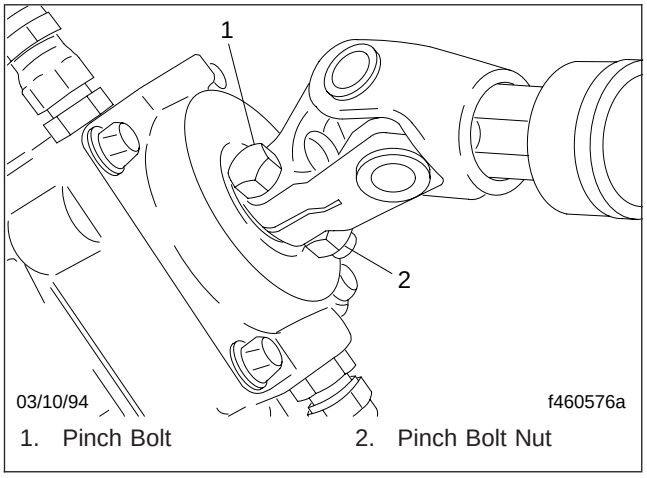
3. Disconnect the steering driveline from the steering gear input shaft.
4. Remove the dirt and water seal from the steering gear. Save this seal to determine the correct size of the new seal.
5. Using a clean cloth, remove all grease from around the input shaft.
6. Using a screwdriver inserted into the notch formed in the end of the retaining ring, remove the retaining ring. See **Fig. 2**. Be careful not to scratch the bore with the screwdriver.



1. Retaining Ring

Fig. 2, Retaining Ring Removal

7. Using a pinch bolt and nut, attach the steering driveline to the input shaft but do not tighten the nut. See **Fig. 3**.



1. Pinch Bolt 2. Pinch Bolt Nut

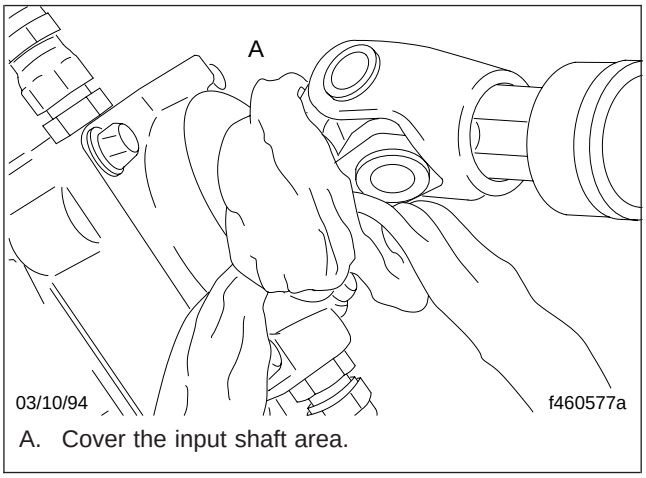
Fig. 3, Pinch Bolt Installation

8. Tie or wrap a shop towel around the input shaft and place a drain pan under the steering gear to catch the oil. See **Fig. 4**.

WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and

Input Shaft Seal Replacement

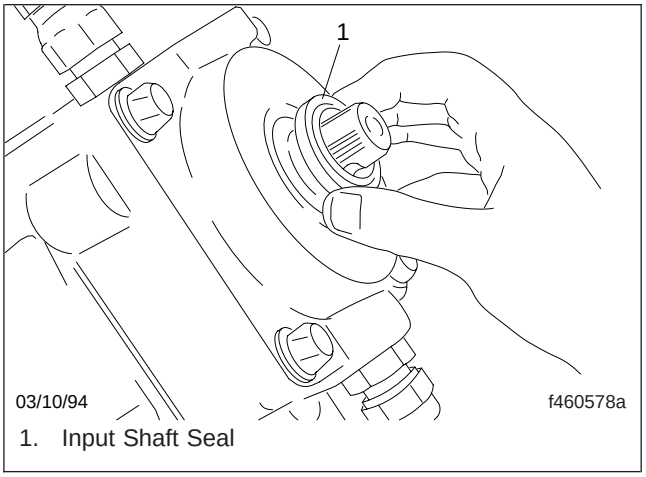


A. Cover the input shaft area.

Fig. 4, Shop Towel Covering the Input Shaft

spillage on the roadway, which could cause personal injury or property damage.

9. If needed, fill the power steering reservoir with automatic transmission fluid.
10. With the vehicle in neutral, momentarily turn the starter. If the engine starts, quickly turn it off. This should force out the input shaft seal.
11. Remove the shop towel, pinch bolt, and input yoke. Remove the input shaft seal. See **Fig. 5**.



1. Input Shaft Seal

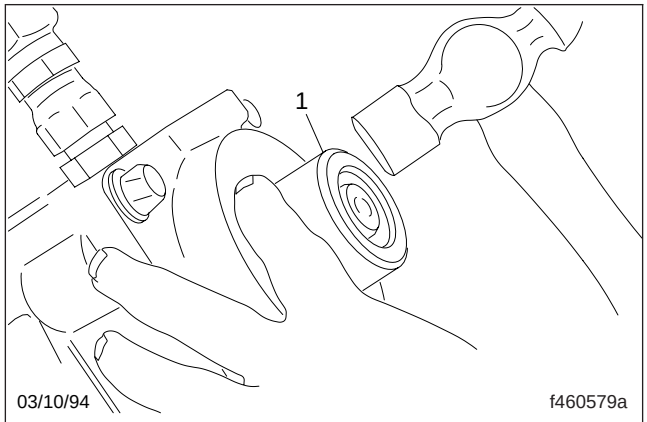
Fig. 5, Input Shaft Seal Removal

12. Inspect the seal area of the valve housing for seal fragments. Remove all seal fragments.
13. Check the input shaft seal for heat damage. If the seal is stiff and brittle, it is probably heat damaged. Determine and fix the cause of excessive heat in the vehicle.

WARNING

Do not use a socket to install the input shaft seal. You will not be able to control the seal installation depth with a socket and this could lead to leaks. Leaks could result in loss of steering assist and spillage on the roadway, which could result in personal injury or property damage.

14. Install a new input shaft seal.
    - 14.1 Using Exxon Polyrex® EP2 grease (045422), lubricate the inside diameter of the new input shaft seal and install it on the input shaft.
    - 14.2 Using a hammer and seal driver (J37073), tap the driver until the shoulder of the driver is square against the valve housing. See **Fig. 6**. Remove any seal material that may have sheared off in the seal bore or retaining ring groove.



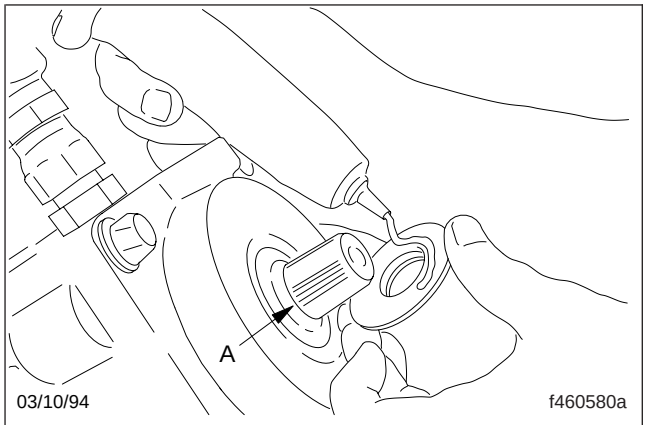
1. Seal Installer Tool

Fig. 6, Seal Installer Tool Position

15. Install a new retaining ring in the groove.
16. Using Exxon Polyrex EP2 grease (045422), pack the end of the valve housing bore.
17. Install a new dirt and water seal.
    - 17.1 Choose the correct size dirt and water seal by comparing the replacement seals to the old seal.

17.2 Apply Exxon Polyrex EP2 grease to the new dirt and water seal and install it on the input shaft. See **Fig. 7**. Seat it in the groove behind the serrations and against the valve housing.

Wipe any excess grease from the valve housing bore and input shaft once the seal has been installed.



A. Seat the seal here.

Fig. 7, Dirt and Water Seal Installation

18. Using a new pinch bolt and nut, attach the steering driveline to the input shaft. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).
19. Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.
20. Connect the return line to the steering gear return port.
21. Bleed the air from the system. For instructions, see **Subject 110**.

Adjustment

NOTE: If the steering gear is installed on the frame rail, sector shaft adjustment can only be completed if the adjusting screw jam nut (located on the side cover) is accessible.

1. Apply the parking brakes and chock the rear tires.
2. With the engine on, turn the steering wheel until the timing mark on the sector shaft lines up with the timing mark on the housing. The sector shaft is now at its center of travel. Shut down the engine.
3. Remove the cotter pin and castle nut that attach the drag link to the pitman arm. Remove the drag link from the pitman arm.

IMPORTANT: To avoid resetting the poppets, do not turn the input shaft more than 1-1/2 turns from the center-of-travel position while the drag link is disconnected.

4. From the center-of-travel position, grasp the pitman arm at the lower end of the arm and gently try to move the arm back and forth. If the pitman arm is loose or lash (free play) is detected, the sector shaft is out of adjustment.
5. Loosen the adjusting screw jam nut.
6. If no lash was detected in step 4, use a screwdriver to turn the sector shaft adjusting screw counterclockwise until you feel lash at the sector shaft. See **Fig. 1**.

IMPORTANT: Do not use more than 10 lbf·ft (14 N·m) of force when tightening the adjusting screw.

7. Slowly turn the shaft adjusting screw clockwise until you feel no lash at the sector shaft. From this position, turn the screw clockwise 1/8 to 3/16 of a turn more. Hold the adjusting screw in place and tighten the jam nut 43 lbf·ft (58 N·m).
8. Turn the steering wheel 1/4 of a turn each side of center then back to center and check the pitman arm for lash. There should be no lash. If lash is detected, loosen the jam nut and repeat the previous step as well as this step.
9. Using a castle nut, attach the drag link to the pitman arm. Tighten the castle nut using the appropriate torque value:

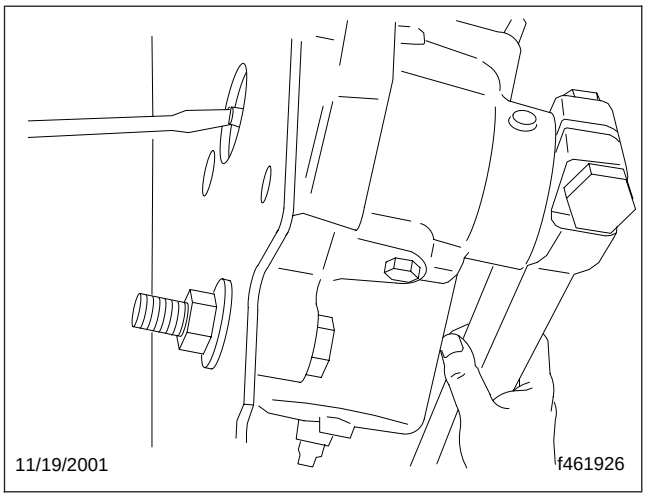


Fig. 1, Adjusting the Sector Shaft

- 3/4–16: 90 to 170 lbf·ft (122 to 230 N·m)
- 7/8–14: 160 to 300 lbf·ft (217 to 407 N·m)

⚠ WARNING

Failure to install and lock a new cotter pin in the ball stud and nut could result in disengagement of the parts and loss of steering control, which could result in personal injury or property damage.

10. Continue to tighten the castle nut until a slot on the nut aligns with the hole in the ball stud. Do **not** reverse the tightening direction of the nut when locating the cotter pin hole. Install a new cotter pin in the ball stud and nut, then lock the cotter pin in place.

NOTICE

Do not use a power grease gun to add grease to the sector shaft bearing. Doing so could damage the high-pressure seal and contaminate the hydraulic fluid.

11. Using only a hand-operated grease gun, add grease to the sector shaft bearing through the grease fitting in the housing until grease begins to extrude past the dirt and water seal.

Resetting the Poppet Valves

1. Check that the axle stops are adjusted properly. See **Group 33** for instructions.
2. Start the engine and allow the vehicle to idle for 5 to 10 minutes to warm the hydraulic fluid.
3. Shut down the engine, apply the parking brakes, and chock the rear tires.
4. Hold the poppet screw with a wrench and turn the sealing nut back toward the wrench until the nut is flush with the base of the hex area of the poppet screw.
5. Make sure that the engine is off and the wheels are in the straight-ahead position.

NOTICE

Make sure the drive end of the adjusting screw is not below the face of the nut. If the drive end of the adjusting screw is below the face of the nut, the poppet seat flange will break when the upper poppet is prepared for setting.

6. Using a 7/32-inch Allen wrench, turn the adjusting screw and nut assembly (without turning the nut on the screw) into the housing until the nut is firmly against the housing. Tighten the nut against the housing. See **Fig. 1**.

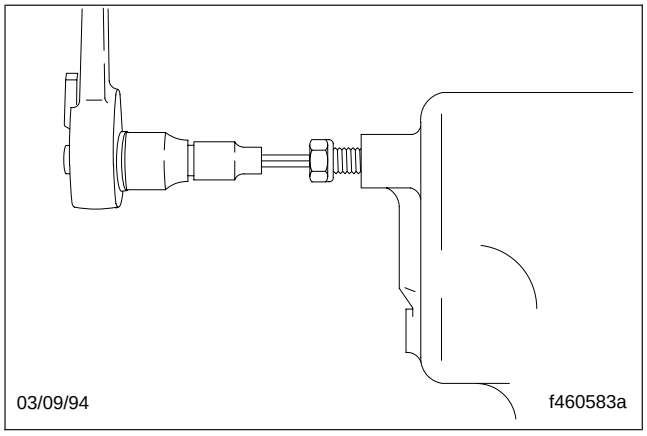


Fig. 1, Adjusting Screw and Nut Assembly

7. Place a jack under the center of the front axle and jack up the front of the vehicle so the steer axle tires are off the ground.
8. Push the upper poppet out to prepare it for setting.
   - 8.1 Start the engine and let it idle.
   - 8.2 Note which sector shaft timing mark is nearest the housing piston bore.

NOTICE

Do not hold the steering wheel at full turn for more than 10 seconds at a time. The heat buildup at pump relief pressure may damage components.

   - 8.3 Turn the steering wheel in the direction that makes this timing mark move toward the adjusting screw just installed. Turn the wheel in this direction until axle stop contact is made.
   - 8.4 Pull hard on the steering wheel. Put up to 30 lbf (133 N) pull on a 20-inch diameter steering wheel.
9. Set the upper poppet.
   - 9.1 Turn the steering wheel in the opposite direction (the timing mark will move away from the adjusting screw) until the other axle stop is contacted.
   - 9.2 Pull hard on the steering wheel. Put up to 30 lbf (133 N) pull on a 20-inch diameter steering wheel.
   - 9.3 Release the steering wheel and shut off the engine.
10. Loosen the sealing nut and back out the adjusting screw until the adjusting screw is one inch (2.5 cm) past the nut. See **Fig. 2**. Tighten the nut against the housing.
11. Set the lower poppet.
   - 11.1 Start the engine and let it idle.
   - 11.2 Turn the steering wheel in the original direction (the timing mark will move toward the adjusting screw) until axle stop contact is made.
   - 11.3 Hold the steering wheel in this position with up to 30 lbf (133 N) pull on a 20-inch diameter steering wheel for 10 seconds, then release. Repeat this hold-and-release process as many times as necessary while completing the next step.
12. Position the adjusting screw.

Poppet Adjustment on a Single Gear

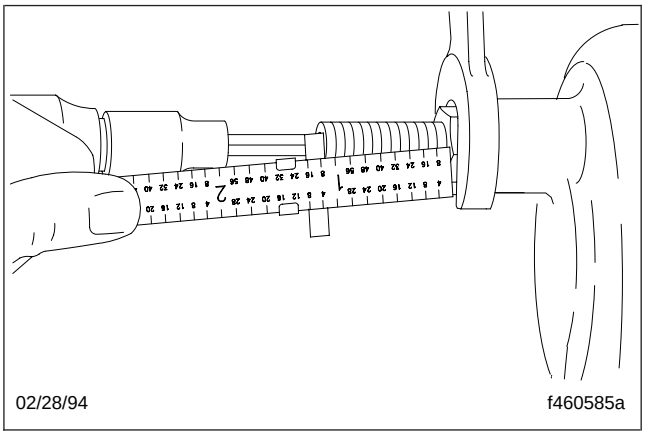


Fig. 2, Adjusting Screw Position

12.1 With the steering wheel held tightly at full turn, loosen the nut and hold it in place with a wrench.

12.2 Using an Allen wrench and finger pressure only, turn the adjusting screw clockwise until the Allen wrench stops. Do not attempt to turn the adjusting screw in any farther. Pause the turning-in process each time the driver releases the steering wheel. Continue turning only while the steering wheel is held at full turn.

12.3 Back off the adjusting screw 3-1/4 turns and tighten the nut 35 lbf·ft (47 N·m).

⚠ WARNING

If the adjusting screw protrudes more than 1-1/16 inches (27 mm) from the sealing nut, the screw could fall out of the steering gear, resulting in loss of power steering. This could cause an accident resulting in personal injury or property damage.

IMPORTANT: Once the poppet adjusting screw and sealing nut are in place, and the poppet valves have been manually adjusted, the adjustment procedure must be repeated if steering travel is either increased or decreased in the future.

⚠ WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

13. The poppets have now been completely reset. Check the power steering reservoir. The power steering fluid level should be between the MIN COLD mark and the middle mark just above it. If needed, add fluid.

14. Lower the vehicle.

Post-Service Checks

After power steering components have been worked on and before the vehicle is placed into service, the following items must be checked.

⚠ WARNING

Failure to check the following items could result in damage to the power steering system. This could cause loss of steering assist and spillage on the roadway, which could cause personal injury or property damage.

1. Operate the engine at idle while turning the steering wheel through several full-left and full-right turns. With the engine running and the power steering system at operating temperature, turn the steering wheel slowly from stop to stop while checking the power steering reservoir for frothing or a change in the fluid level (signs that air is trapped in the system).

   If air is present, inspect the system for leaking hoses or loose fittings. Replace the hoses or tighten the fittings as necessary. Bleed the air from the system. Refer to **Subject 110** for instructions.

2. With the engine turned off and warm, check the power steering reservoir fluid level. If needed, add power steering fluid.

3. At full-left and full-right turns, be sure the axle stops on the rear side of the spindle are set so there is at least 1/2 inch (13 mm) of clearance between the tires and any fixed components that are attached to the vehicle. Clearance between moving components should be at least 3/4 inch (19 mm). If clearance is less than the above, reset the axle stops.

4. Check that the poppets are set correctly. If needed, adjust them. For instructions, refer to **Subject 140**.

5. Test drive the vehicle. Check the steering wheel spoke position. If, during straight-ahead driving on a level road, the steering wheel spokes are not within ±10 degrees of the 9 o'clock and 3 o'clock positions, remove the steering wheel and reposition it. See **Fig. 1**.

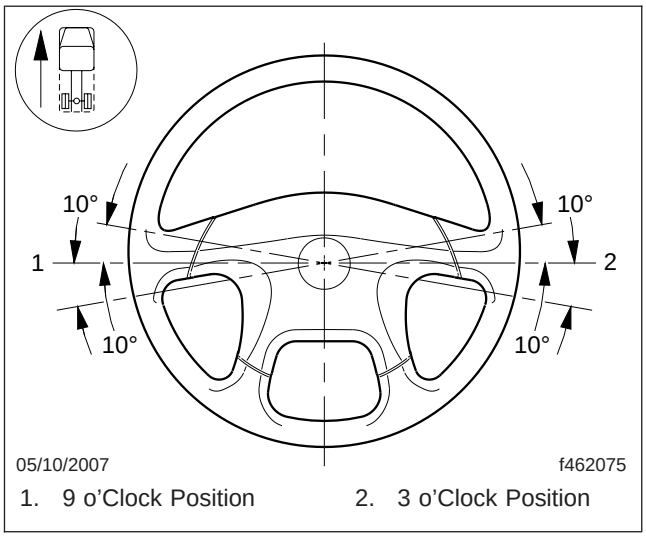


Fig. 1, Steering Wheel Centered

Specifications

⚠ WARNING

Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.

THP and PCF power steering gears use automatic transmission fluid that meets Dexron II, Dexron III, Mercon, or ATF +4™ specifications.

Exxon Polyrex® EP2 Grease (045422) is approved for use on steering gear components.

Special tools can be ordered from:

SPX Kent-Moore
28635 Mound Road
Warren, Michigan 48092-3499
1-800-328-6657

SPX Kent-Moore Tools	
Tool Name	**Part Number**
Bearing and Seal Tool	J37071 and J37071–A
Special Tool	J36452–A
Bearing Adjuster Tool	J37070
Seal Driver Tool	J37073
Adjuster Locknut Tool	J37464

Table 1, SPX Kent-Moore Tools

General Information

A *Checklist for Troubleshooting Power Steering Problems*, form STI-492, has been developed to accompany the procedures below. Form STI-492 can be downloaded or printed **here** after logging into **www.AccessFreightliner.com**.

Each step and substep in these troubleshooting procedures corresponds to a step or substep on form STI-492. Use **Table 1** to determine which steps should be completed, based on the customer's complaint. It is very important that the information provided by the driver is communicated accurately to prevent wasting of diagnostic time. For example, if complaints include "Pulling to one side" and "Noisy steering," steps 1, 3, 4, 5, and 6 will be the tests for the most likely failure modes.

Start with the lowest test number and work up to the highest. For example, when completing steps 1, 3, and 6 to determine the cause of a vehicle pulling to one side, start with step 1 and finish with step 6.

Troubleshooting Steps

NOTE: Some of these inspections and procedures can be found in the Pretrip and Post-Trip Inspections and Maintenance chapter in the vehicle driver's/operator's manual.

Steps 1 through 4 may have been performed by the customer. Verify the vehicle service history with the customer to prevent redundant testing.

All measurements and readings must be recorded on STI-492.

Refer to the applicable section in this manual to repair or replace steering system components.

1. Check the tire pressure and load.

   1.1 Check the tires for damage.

   1.2 Check that the front tires are inflated to the correct pressure, and the tire pressure is equal on both sides. Correct the pressure if needed.

   Low pressure causes increased steering effort due to friction with the road surface. Unequal tire pressure causes unequal friction between the tire and the road. This can cause pulling to one side.

Steering Complaint and Troubleshooting Steps Checklist												
LH	RH	Both	Complaint	Troubleshooting Steps								
				1	2	3	4	5	6	7	8	9
			Hard or heavy steering	•	•		•	•	•	•	•	•
			Low assist									
			Binding									
			Locking									
			Occasional loss of assist									
			Reduced wheel cut								•	
			Pulling to one side*	•		•			•			
			Darting/oversteering	•	•	•	•		•			
			Wandering									
			Noisy steering				•	•	•			
			External seals leaking					•	•			•
			Excessive heat									

* If there is consistent pull to one side, a braking issue could feel like a steering assist problem. Refer to **Group 42** in this manual to ensure the brake system is functioning properly.

Table 1, Steering Complaint and Troubleshooting Steps Checklist

Troubleshooting Procedures

1.3 Check that the rear tires are inflated to the correct pressure, and the tire pressure is equal on both sides. Correct the pressure if needed.

1.4 Check that the tire sizes are correctly matched, and whether duplex or oversized tires (that were not originally specified for the vehicle) have been installed.

Extra tire width causes increased steering effort due to extra friction with the road surface. If the axle stops were turned out to reduce wheel cut due to a change in tires, the power steering gear poppets may need to be adjusted.

1.5 Communicate with the driver or operator to determine whether the vehicle is operated at or over the rated load.

Increased load causes greater steering effort. Make sure the vehicle is being operated within rated capacities.

2. Check fifth wheel lubrication and condition.

A dry fifth wheel plate makes it difficult to change direction. Check the plate surface for burrs, gouges, and irregularities.

3. Check vehicle alignment and wheel bearing adjustment.

3.1 Check the vehicle service history for the last known alignment, and inspect tire wear for indications that an alignment needs to be completed.

3.2 Check front axle caster and camber measurements.

3.3 Ensure wheel bearings and rear axle are in good condition, and that toe is set correctly.

3.4 Ensure the rear axle is properly aligned.

4. Check for loose and binding components. Check whether any steering components need maintenance or adjustment.

4.1 Check for proper lubrication of the drag link, tie rods, and knuckle pins. Apply lubrication as needed.

4.2 Check the COE steering column, if equipped. Chock the rearmost tires. With the engine shut down, turn the steering wheel and check for looseness or binding. Make sure all components are free to move, but are not excessively loose.

4.3 Check the steering driveline U-joints for looseness or binding. Lubricate them if needed.

4.4 Check the sector shaft adjustment.

- With the vehicle on the ground, the engine idling, and the front tires pointed straight ahead, turn the steering wheel until slight motion is observed at the front wheels.
- Align a reference mark on the steering wheel to a rule, then, with the engine running, slowly turn the steering wheel in the opposite direction until motion is again detected at the wheels.
- Measure the lash (free play) at the rim of the steering wheel.

Excessive lash exists if steering wheel movement exceeds 2-1/2 inches (64 mm) with a 20-inch (508-mm) steering wheel, or 2-1/4 inches (57 mm) with an 18-inch (457-mm) steering wheel.

4.5 Check that the front wheels self-return without binding.

- With the engine off, chock the rearmost tires and place the front tires on radius plates (turntables).
- Disconnect the drag link from the steering arm.
- By hand, pull one tire to the axle stop and release. The tire should self-return to almost straight ahead.
- Repeat with the opposite tire.

If a tire does not return to near straight ahead, check for binding or lack of lubrication in the steering axle kingpin bushings or tie rod linkage.

- Connect the drag link and tighten the castle nut, then install a new cotter pin.

4.6 Inspect all suspension fasteners and components for wear or looseness.

5. Check the steering system for leaks and restrictions, and test the system back pressure.

5.1 Inspect hoses, fittings, and seals for damage or leaks.

- With the engine idling, inspect for kinked or collapsed hoses. Repair or replace any collapsed or kinked hoses. If collapsed hoses are found, ensure the steering system is filled with the correct automatic transmission fluid.
- Inspect fittings for leaks. Repair leaking fittings; replace parts as needed.
- Inspect all external seals. Replace leaking seals.

  Inspect the seal bores and sealing surfaces for scrapes or burrs. Make sure the seals are installed correctly using the recommended tools.
- If you replaced the steering gear input shaft seal and found it to be excessively hard, test the system operating temperature in step 6.

5.2 Inspect the steering gear for external leakage.

- Clean the area around the input shaft and inspect the input shaft for signs of leakage after operating the vehicle under normal conditions through steering maneuvers.
- Inspect the sector shaft for signs of leakage. A well greased or heavily used steering gear may weep oil from the grease seal, but a confirmed leak will be evidenced by fluid collecting while the vehicle is being operated under normal conditions.
- Inspect the vent plug in the trunnion housing for signs of leakage. Any fluid in or around the rubber vent plug indicates leakage from an internal steering gear seal.

NOTICE

Do not turn the steering wheel or allow system pressure to exceed the rating of the gauge during the following test. Damage to the gauge could occur.

5.3 Check total steering system back pressure.

- Install a low pressure gauge—300 psi (2068 kPa) maximum—between the steering pump and the steering gear.
- Check for correct fluid level. If necessary, add fluid. If bubbles or foam appear in the reservoir, check hose fittings for looseness or leaks.
- With the engine idling, read the total system back pressure on the pressure gauge.
- If the total system back pressure is greater than 100 psi (689 kPa), or 140 psi (965 kPa) for a vehicle with hydraulic brakes, replace the steering fluid filter and re-test the system. If the system back pressure is still excessive, go to the next substep.

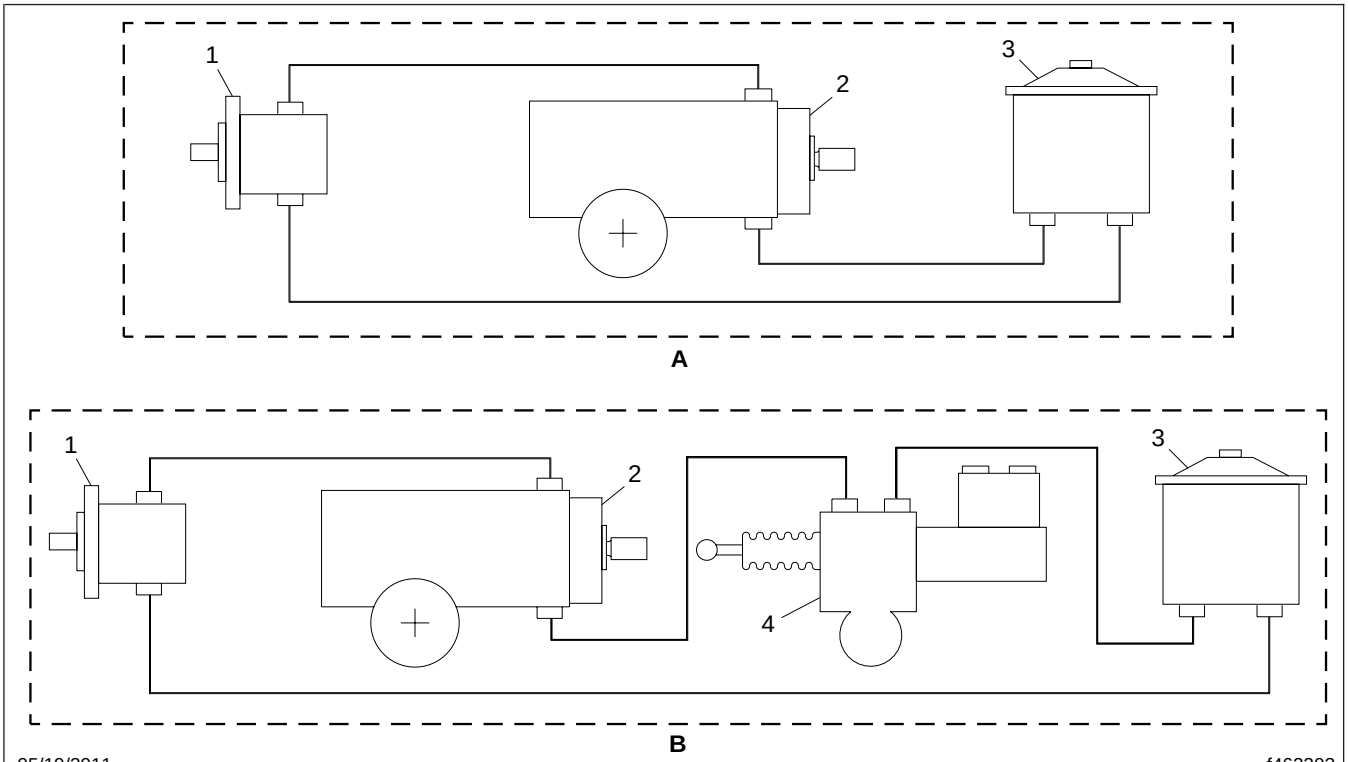
  If the total system back pressure is less than 100 psi (689 kPa), or 140 psi (965 kPa) for a vehicle with hydraulic brakes, restriction is not a problem—go to step 6.

5.4 Leave the low pressure gauge in place and check individual steering system components for excessive restriction. See **Fig. 1** for a plumbing diagram.

- Bypass the steering gear by disconnecting the steering gear input and output lines from the gear and coupling them together. See **Fig. 2** for an example.

  If the drop in system pressure from the value found in substep 5.3 is greater than 55 psi (379 kPa), the steering gear has excessive restriction. If the drop in pressure is less than 55 psi (379 kPa), reconnect the

Troubleshooting Procedures



A. Vehicles With Air Brakes
1. Steering Pump
2. Steering Gear

B. Vehicles With Hydraulic Brakes
3. Reservoir
4. Brake Booster

Fig. 1, Plumbing Diagrams

gear input and output lines to the gear and continue with this substep.

- If the vehicle is equipped with hydraulic brakes, bypass the brake booster by disconnecting the booster input and output lines and coupling them together.

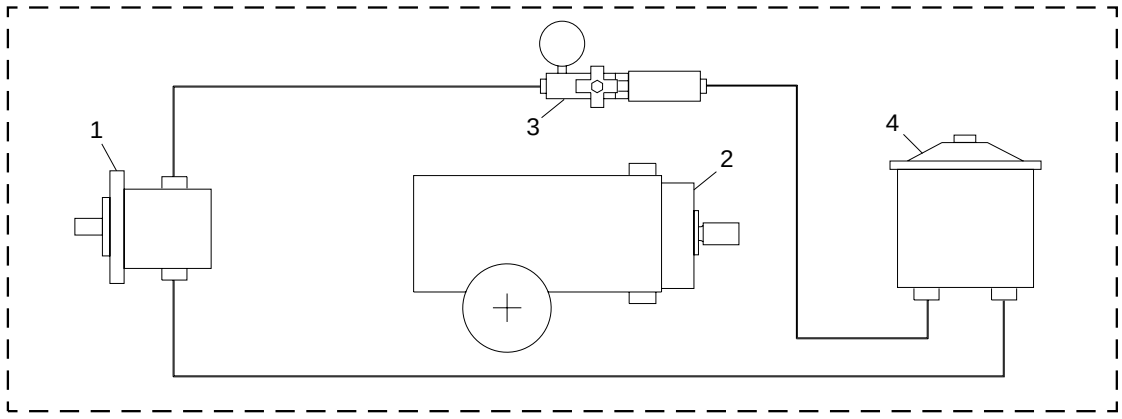
  If the drop in system pressure from the value found in substep 5.3 is greater than 40 psi (276 kPa), the brake booster has excessive restriction. If the drop in pressure is less than 40 psi (276 kPa), reconnect the booster input and output lines and continue with this substep.

- Test each hydraulic line in the power steering system individually by bypassing them one at a time, as was done with the steering gear and brake booster, if equipped.

  If the drop in system pressure from the value found in substep 5.3 is greater than 12 psi (83 kPa) for any one line, replace the line and test total system back pressure again.

6. Check steering pump performance. Power steering fluid temperature should be approximately 180°F (82°C) to best replicate fluid temperatures under normal driving conditions.

   If the system fails the tests in the following substeps, replace the pressure relief valve (PRV) and complete the tests in the substeps below again. If the system fails again, replace the pump.



1. Steering Pump
2. Steering Gear
3. Low Pressure Gauge
4. Reservoir

Fig. 2, Testing Steering Gear Restriction

Install the PSSA between the steering pump and the gear for the following substeps. See the following heading, **Power Steering System Analyzer Setup**, for instructions on PSSA installation.

NOTICE

Do not leave the load valve closed for longer than five seconds during the following test. Doing so could damage the power steering system.

6.1 Check for erratic pump response.

- Slowly close the load valve and watch the pressure and flow readings as the valve closes, then open the valve immediately.
- If the pressure rises rapidly or appears uncontrolled, open the load valve immediately.
- If the response was erratic, replace the PRV or pump, as required. If the response was smooth and controlled, go to the next substep.

6.2 Check the pump relief pressure.

- Slowly close the load valve. When the valve is completely closed, read the pressure gauge, then open the valve.
- If the pump relief pressure does not exceed the relief pressure in **Table 2** or **Table 3**, refer to the pump manufacturer's service literature to verify the exact relief pressure for the pump.
- If the pump relief pressure does not exceed the relief pressure in **Table 2**, **Table 3**, or the pump manufacturer's specifications, replace the PRV or pump, as required.
- If the pump relief pressure exceeds the relief pressure in **Table 2** or **Table 3**, it is acceptable. Go to the next substep.

6.3 Test the pump relief valve reaction at idle.

- Run the engine at idle and note the flow rate with the load valve open.

Troubleshooting Procedures

Minimum Measured Pump Flow and Relief Pressure at Engine Idle				
Power Steering Gear	**Flow at 1500 rpm, No Load: gpm (L/min)**	**Flow at 1000 psi (6900 kPa): gpm (L/min)**	**Flow at 1800 psi (12 400 kPa): gpm (L/min)**	**Typical Relief Pressure: psi (kPa)**
Sheppard M100	3.7 (14.0)	2.8 (10.6)	2.3 (8.7)	2175 ± 100 (15 000 ± 700)*
TRW TAS40	3.7 (14.0)	2.1 (7.9)†	1.6 (6.1)	
TRW TAS55		2.4 (9.1)†	1.9 (7.2)	
TRW TAS65		2.8 (10.6)†	2.3 (8.7)	
TRW TAS85		3.3 (12.5)	2.8 (10.6)	
TRW TAS65 With C28 or C32 Linear Cylinder	5.8 (22.0)	4.9 (18.5)	4.4 (16.7)	
TRW TAS65 With RCS65				
TRW TAS85 With C28 or C32 Linear Cylinder		5.4 (20.4)†	4.9 (18.5)	
TRW TAS85 With RCS65				
ThyssenKrupp LZS5 Rack and Pinion	3.7 (14.0)	3.3 (12.5)	2.8 (10.6)	2300 ± 116 (15 500 ± 800)

* On vehicles with TRW TAS steering gears and hydraulic brakes, typical relief pressure is 2375 ± 100 psi (16 375 ± 690 kPa).

† Approximate value based on flow at 1800 psi (12 400 kPa).

Table 2, Minimum Measured Pump Flow and Relief Pressure at Engine Idle

Minimum Measured Pump Flow and Relief Pressure for High-Pressure Gears at Engine Idle				
Power Steering Gear	**Flow at 1500 rpm, No Load: gpm (L/min)**	**Flow at 1000 psi (6900 kPa): gpm (L/min)**	**Flow at 2300 psi (15 860 kPa): gpm (L/min)**	**Typical Relief Pressure: psi (kPa)**
Sheppard HD94	3.7 (14.0)	2.6 (9.8)	1.8 (6.8)	2683 ± 100 (18 500 ± 700)
TRW THP45		2.2 (8.3)	1.4 (5.3)	
TRW THP60 or PCF60		2.6 (9.8)	1.8 (6.8)	
TRW THP60 With Linear Cylinder	5.8 (22.0)	4.1 (15.5)	3.3 (12.5)	
TRW THP60 With RCH45				

Table 3, Minimum Measured Pump Flow and Relief Pressure for High-Pressure Gears at Engine Idle

- Close the load valve until the pump relief pressure is reached. Smoothly and quickly open the load valve and note the flow rate. Repeat this action three times. The flow rate should return to the flow rate first noted with the load valve open.
- If the flow rate does not return smoothly and quickly, the pump relief valve is not working correctly. Replace the replace the PRV or pump, as required.
- If the flow rate returns smoothly and quickly, the pump relief valve is acceptable. Go to the next substep.

6.4 Test the pump relief valve reaction at 1500 rpm.

- Run the engine at 1500 rpm and note the flow rate with the load valve open.
- Close the load valve until the pump relief pressure is reached. Smoothly and quickly open the load valve and note the flow rate. Repeat this ac-

tion three times. The flow rate should return to the flow rate first noted with the load valve open.

- If the flow rate does not return smoothly and quickly, replace the PRV or pump, as required.
- If the flow rate returns smoothly and quickly, the pump relief valve is acceptable. Go to the next substep.

6.5 Test the flow of the pump at idle with a load applied.

For vehicles with low-pressure steering gears, run the engine at idle and slowly close the load valve until the pressure gauge reads 1000 psi (6900 kPa). Read the flow rate on the gauge, then set the pressure to 1800 psi (12 400 kPa). Read the flow gauge, then open the load valve. Compare the values to those in **Table 2**.

For vehicles with high-pressure steering gears, use 1000 psi (6900 kPa) and 2300 psi (15 860 kPa) as the test load pressures. See **Table 3** for minimum flow rate.

6.6 Test the maximum flow of the pump with no load applied.

- Run the engine at 1500 rpm, make sure the load valve is completely open, and read the flow gauge.
- If the flow rate is below the minimum indicated in **Table 2** or **Table 3**, replace the PRV or pump, as required.
- If the flow rate is above 5.5 gpm (20.8 L/min) on a vehicle with a single steering gear, or 7.7 gpm (28.8 L/min) on a vehicle with an assist cylinder installed, replace the pump.

7. Test the steering gear internal leakage.

Select TRW integral steering gears and all ThyssenKrupp rack and pinion steering gears are equipped with an internal PRV that significantly limits maximum supply pressure to protect the steering gear. These gears, unlike gears on vehicles fitted with hydraulic brake boosters, cannot be tested for internal leakage by plugging the internal PRV in the gear. The pump output must be limited to prevent excessive pressure from damaging the gear, and the internal PRV passage must be blocked to direct oil flow through the gear.

Use PartsPro® for the specific VIN to determine if the steering gear is equipped with an internal PRV, which will be listed as a serviceable part under module 536.

If a TRW steering gear has an internal PRV but no hydraulic brake booster, see the following heading, **Internal Leakage Test Setup, TRW Steering Gears With an Internal PRV**, for instructions on setting up the necessary test components before proceeding with the following substeps.

ThyssenKrupp rack and pinion steering gears are also equipped with an internal PRV, but cannot be tested for internal leakage.

IMPORTANT: Make sure the fluid temperature is approximately 180°F (82°C) and the vehicle is stationary with the front wheels pointing forward.

7.1 Run the engine at idle with the load valve open.

WARNING

Keep fingers clear of the stop bolt and spacer block during the following test. Make sure that the spacer block contacts the axle stop squarely. Contact that is not square could break the stop bolts or eject the spacer block, which could cause serious personal injury.

7.2 Place an unhardened steel spacer, 1-inch (25-mm) thick, between the axle and the stop bolt on one side of the axle.

The spacer should have an extension or handle long enough to keep fingers clear of the axle stop area. A brazing rod or welding rod works well for this purpose.

NOTICE

While running the following test, do not hold the steering wheel in the full-turn position for more than five seconds. Doing so could damage the pump.

Troubleshooting Procedures

7.3 Have someone turn the steering wheel, applying enough force to completely close the rotary valve.

Complete closure of the rotary valve requires approximately 20 lbf (27 N) pull on the steering wheel, and will be indicated by a pressure reading nearly equal to the system relief pressure (tested in substep 6.2).

7.4 Hold the steering wheel in the full-turn position. Note the steering gear internal leakage on the PSSA.

7.5 Repeat the previous substeps for the opposite turn.

The maximum permissible internal leakage for a single gear is 1.0 gpm (3.8 L/min). If leakage is greater in either turning direction, replace the steering gear components as needed.

For systems with two or more steering gears and/or linear cylinders, the total acceptable internal leakage is 1.0 gpm (3.8 L/min) for each steering gear/ram in the system. Maximum internal leakage on a dual-gear system is 2.0 gpm (7.6 L/min). If the leakage is more than 2.0 gpm (7.6 L/min) on a dual-gear system, isolate the auxiliary cylinder from the system using the substeps that follow.

7.6 Disconnect the auxiliary cylinder hydraulic lines at the main gear auxiliary ports.

7.7 Plug the main steering gear ports with suitable steel or high-pressure plugs or caps.

7.8 Repeat the internal leakage test.

If the internal leakage is less than 1 gpm (3.8 L/min), repair or replace the auxiliary gear or linear cylinder. If the internal leakage is greater than 1 gpm (3.8 L/min), repair or replace the main gear.

8. Check the steering gear poppet relief valve and stop bolt adjustment.

NOTE: Poppets limit the steering assist when the front wheels approach the stop bolts. Improper adjustment can apply excessive force to the steering linkage, or cause loss of assist, as the steering wheel approaches either full-left or full-right turn.

8.1 Check the steering system for stop bolt adjustment.

Make sure the stop bolt settings limit the steering travel so there is ½-inch (13-mm) clearance from all stationary components, and 3/4-inch (19-mm) clearance from all moving components.

8.2 Make sure the pitman arm is situated on the steering gear sector shaft correctly. Check that the pitman arm and sector shaft timing marks are aligned.

NOTICE

If power steering pump relief pressure is reached while the steering wheel is at full lock, release the steering wheel from this position. Do not allow the pump relief pressure to be maintained for longer than five seconds or damage to the pump may result.

8.3 Check the poppet relief pressure.

- Install the PSSA between the steering pump and the steering gear. See the following heading, **Power Steering System Analyzer Setup**, for instructions on PSSA installation.
- Run the engine at idle with the load valve open. Turn the steering wheel to either full-lock position. Note the pressure gauge reading, then repeat for the opposite turn.
- The pressure should drop slightly before the stop bolts are contacted. If the pressure increases (from contact with the stop bolts), the poppets must be manually reset.

  If the pressure is relieved and assist is lost when the wheel is too far from the axle stop bolts, refer to the applicable section in this manual for gear-specific information.
- After poppet replacement or adjustment, test again for correct poppet relief function and record the new pressure.

8.4 Check for normal hissing sound at full turn.

NOTE: Noise from the power steering system does not necessarily mean there is a problem. Some noises are normal and are the result of proper operation.

See **Table 4** for possible causes and remedies for common noises associated with the power steering system and power steering pump.

8.5 Check for abnormal power steering noise.

Listen for a hissing sound at less than full turn. If a hissing sound is heard, check the steering gear poppet and the axle stop adjustment.

NOTICE

If the temperature exceeds 250°F (121°C), damage to hoses, seals, and other components may result if the vehicle continues to operate at excessive steering system temperatures. If this temperature is exceeded, stop the test and record the last noted temperature on STI-492.

9. Test the system operating temperature.

- Run the engine at governed speed.
- Observe the power steering fluid temperature until it stabilizes.
- Record the power steering fluid temperature in 10-minute intervals until 40 minutes have passed.
- If the temperature does not exceed 250°F (121°C) during the test, excessive heat due to system components is probably not the cause of the complaint. The system may still experience overheating due to driving and load conditions.

  If the temperature exceeds 250°F (121°C), excessive steering system back pressure or excessive pump flow may be the cause of the high temperature problem. If system back pressure or restriction values found in substeps 5.3 and 5.4 above were close to the maximum allowable, complete step 5 again. If steering pump flow and relief pressures found in step 6 above were close to the maximum allowable, complete step 6 again.
- If excessive heat continues to be a problem, a cooler may need to be added to the system.

Power Steering System Noise	
Noise	**Remedy**
Growling or other abnormal steering noise	Check the fluid level. Check for air bubbles and foam. Check for hose and fitting leaks. If there is air in the fluid, check for inlet tube and hose leaks. Correct all leaks.
A change from the usual pump sound	Check the steering fluid reservoir for air bubbles and foam. If there is air in the fluid, check for inlet tube and hose leaks. Correct all leaks.
Clicking noise during a turn	Check for loose steering components. Tighten any loose steering components. Check the front suspension for insufficient spring pin shims. Add front spring pin shims if needed.
Hissing when the steering wheel is at or near full turn	This is normal; no action is needed.
Steering Pump intake line is plugged	Drain the system. Clear the intake line if needed. Fill the system.
Air leak at the pump or reservoir connections, fittings, or shaft seal	Check all the connections by pouring power steering fluid over them, and listening for a reduction in sound. Tighten all connections as needed.
Pump input shaft is misaligned	Replace the pump.

Table 4, Power Steering System Noise

Troubleshooting Procedures

Power Steering System Analyzer Setup

The hydraulic power steering system is tested with a Power Steering System Analyzer (PSSA), and with the hydraulic fluid at operating temperature. The PSSA and adaptor kit are available from SPX Kent-Moore.

A PSSA is a combination of a flow meter, a shutoff valve, and a high-pressure gauge. See **Fig. 3**. The PSSA will allow you to measure flow and pressure, and provide a load on the pump in the hydraulic lines of the steering system.

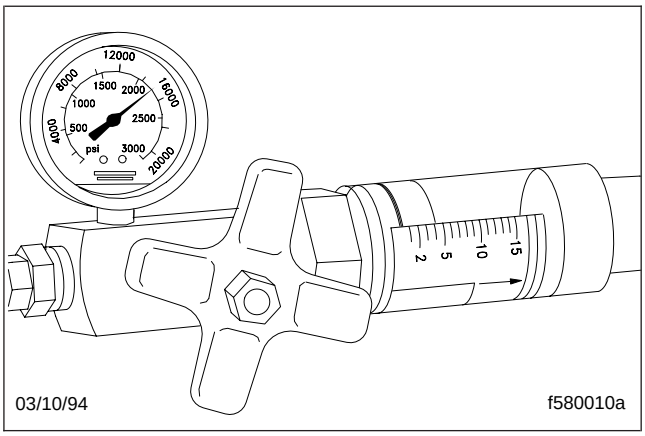


Fig. 3, Power Steering System Analyzer

1. Install a PSSA between the pump high-pressure line and the steering gear.
2. Fill and bleed the steering system as needed.

NOTICE

Do not leave the load valve fully closed for longer than five seconds. Doing so could damage the power steering system.

3. Run the engine at idle.
4. Partially close the load valve on the PSSA until the pressure gauge reads 1000 psi (6895 kPa).
5. Open the valve when the fluid temperature reaches about 180°F (82°C).

Internal Leakage Test Setup, TRW Steering Gears With an Internal PRV

Select TRW steering gears are equipped with an internal PRV that limits maximum supply pressure to protect the steering gear. These gears cannot be tested for internal leakage using the standard procedure. The pump output must be limited to prevent excessive pressure from damaging the gear, and the internal PRV passage must be blocked to direct oil flow through the gear.

Use PartsPro® to determine if a specific TRW steering gear is equipped with an internal PRV, which will be listed as a serviceable part under module 536.

If your TRW steering gear has an internal PRV, complete the following steps to set up the necessary internal leakage test components. See **Table 5** for a list of required leakage test components. The plumbing fittings and hose part numbers are recommended, but may be replaced with identical parts from other suppliers, if necessary.

The ThyssenKrupp rack and pinion steering gear is also equipped with an internal PRV, but cannot currently be tested for internal leakage.

IMPORTANT: The front wheels must be raised or on turnplates during this procedure.

1. Turn the engine off. Remove the relief valve cap, O-ring, and relief valve from the steering gear. See **Fig. 4**.
2. Install the relief valve plug, J-37130, in the internal PRV hole. Install the relief valve cap and O-ring over the plug.
3. Assemble the relief valve cartridge body, relief valve, and tee fittings as shown in **Fig. 4**.
4. Install the PSSA and other test components as shown in **Fig. 4**.
5. Open the external relief valve (**Fig. 4**, Item 15) on the relief valve cartridge. Ensure the PSSA shutoff valve is fully open.
6. Raise the front wheels off the ground and turn the steering wheel to the right and left full-lock positions five times to bleed air from the system.
7. Start the engine and bleed the remaining air out of the system by continuing to turn the wheel from side to side.

NOTICE

Do not leave the PSSA shutoff valve fully closed for longer than five seconds. Doing so could damage the power steering system.

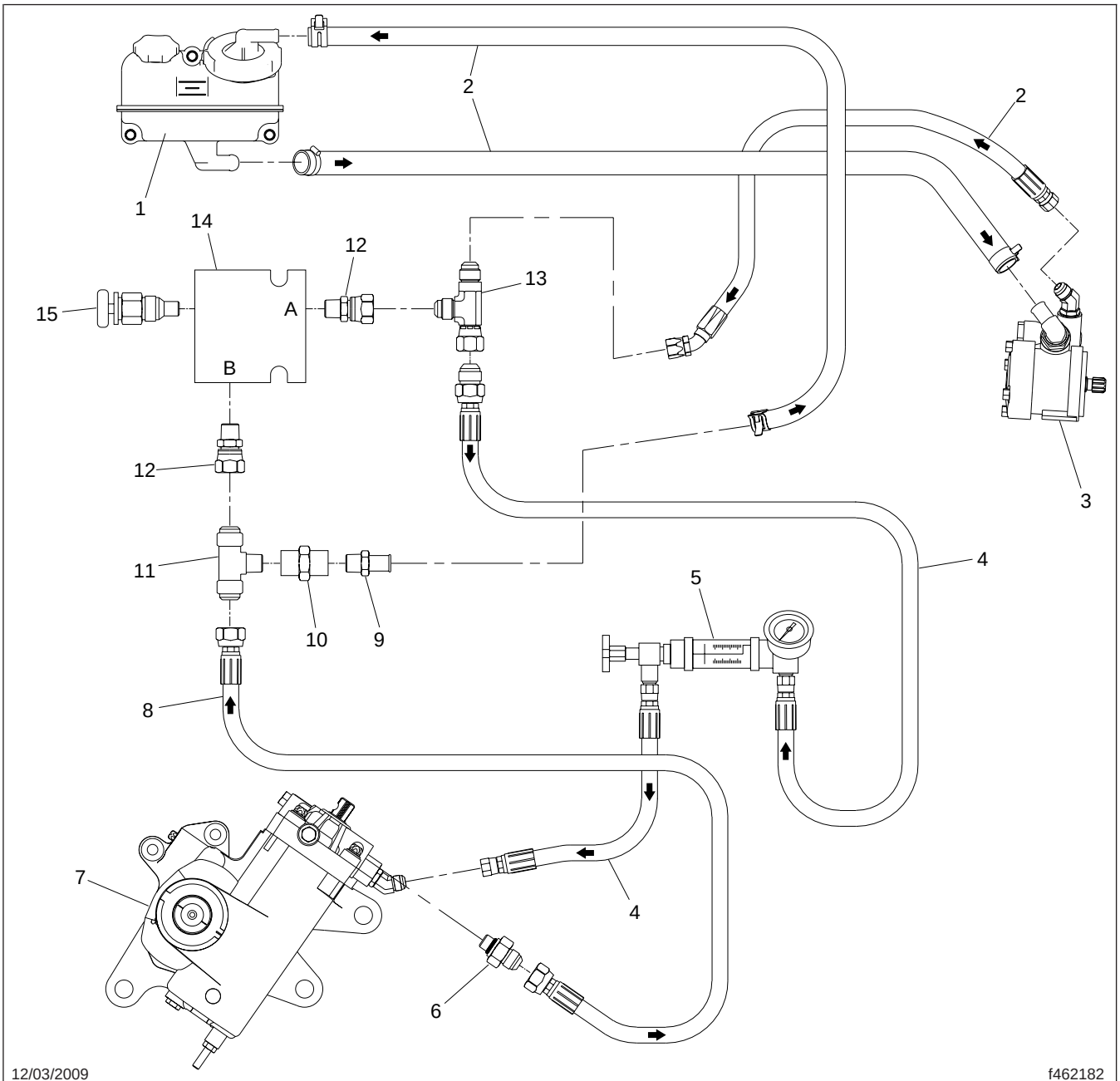
8. With the engine on, close the shutoff valve on the PSSA.
9. Set the system relief pressure by closing the external relief valve (**Fig. 4**, Item 15) until the gauge on the PSSA reaches 2,000 psi (13 790 kPa), then fully open the shutoff valve on the PSSA.
10. Continue with the steering gear internal leakage test (step 9 of the **Troubleshooting Steps** heading above).

Internal Leakage Test Components			
Part	**Available From**	**Part Number (Vendor P/N)**	**Item #, Fig. 4**
Power Steering System Analyzer (PSSA)	SPX Kent-Moore	J-26487	5
PSSA Adaptor Kit	SPX Kent-Moore	J-28593	—
Relief Valve Plug	SPX Kent-Moore	J-37130	—
Connector, Straight Thread with O-Ring	Daimler Trucks PDC	23-11470-088	6
Power Steering Hose, 42"	Daimler Trucks PDC	14-12694-042	8
Connector, 3/8" Male NPT to 5/8" Beaded Hose Barb	Daimler Trucks PDC	23-11321-001	9
Pipe Coupling, 3/8" NPT	Parker Hannifin	PH 3/8 GG S (3/8 GG-S)	10
Tee, Male JIC with Male NPT Branch*	Parker Hannifin	PH 8STXS (8 STX-S)	11
Swivel Adaptor, 3/8" Male NPT to Female 37 degree JIC (qty 2)	Weatherhead	WH 9100X8X6 (9100x8x6)	12
Swivel Nut Run Tee	Parker Hannifin	PH 8 R6X S (8 R6X-S)	13
3/8" Female NPT Aluminum Relief Valve Threaded Cartridge Body	Parker Hannifin	B10-2-A6P (PH B102A6P)	14
Aluminum Hydraulic Threaded Cartridge Relief Valve with Knob	Parker Hannifin	PH RAH101K30 (RAH101K30)	15

* Use steel 37 degree JIC fittings only.

Table 5, Internal Leakage Test Components

Troubleshooting Procedures



A. High-Pressure Input Port
B. Low-Pressure Output Port

1. Power Steering Fluid Reservoir
2. Existing Power Steering Fluid Lines (Qty 3)
3. Power Steering Pump
4. PSSA Fluid Lines (Qty 2)
5. PSSA
6. Connector, Straight Thread with O-Ring
7. Power Steering Gear (TAS85 shown)
8. Power Steering Hose, 42"
9. Connector, Male NPT to Beaded Hose Barb
10. Pipe Coupling
11. Tee, Male JIC with Male NPT Branch
12. Swivel Adaptor (Qty 2)
13. Swivel Nut Run Tee
14. Relief Valve Threaded Cartridge Body
15. External Relief Valve, Threaded Cartridge Type

Fig. 4, Internal Leakage Test Component Installation

General Description and Principles of Operation

The fuel system delivers fuel to the engine. It consists of the engine fuel system components, the fuel tanks and tank mounting components, and the fuel lines and shutoff valves.

The engine fuel system components include fuel filters, injectors, fuel transfer pumps, and a fuel governor. For service and maintenance procedures, refer to the applicable engine manufacturer's service and maintenance manuals.

The fuel tanks, which provide a clean storage area for fuel, are held in place by metal straps and brackets that transfer the load to the vehicle frame. A cab access step assembly or an air fairing attaches to the fuel tank straps and brackets.

Flexible, reinforced wire-braid hoses (fuel lines) bring fuel from the tank to the engine, and return surplus fuel from the engine to the tank. Dual tank installations with single suction and return lines have a crossover fuel line to equalize the level of fuel in the tanks. A shutoff valve in the crossover line attaches to the bottom fitting of the primary tank and shuts off fuel flow to or from the secondary tank. Dual tank installations with dual suction and return lines have two fuel shutoff valves that shut off both the supply line and the return line for the secondary tank.

All vehicles have a fuel gauge sending unit in the primary tank, with a fuel gauge mounted in the cab instrument panel.

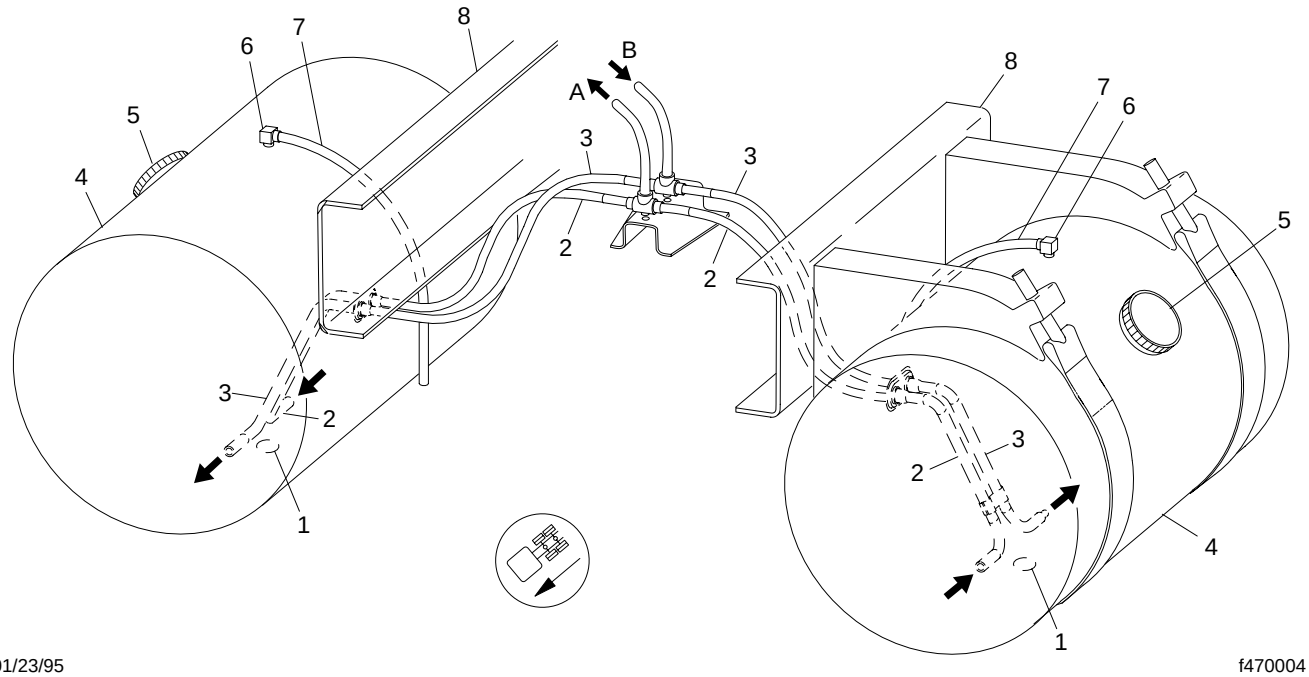
Vehicles built after May 7, 1993, and with aluminum fuel tanks are equipped with the EquiFlo® Inboard Fuel System. This system consists of inboard-routed fuel lines, with the suction and return lines installed in a common opening of the fuel tank(s); a new quarter-turn, non-vented fuel cap, and shut-off valves (when so equipped) located on top of the transmission. The fuel tank vent and line are located on the top of the tank. See **Fig. 1.**

The fuel lines, which are reinforced wire braid, are routed inboard of the frame rails and upward to a point on the transmission, where the shut-off valves (if so equipped) are located. The top and bottom of the fuel tanks are free of any fuel lines or fittings, which reduces the risk of damage from road debris, trailer swing, running over curbs, or being stepped on. Overall, the routing of the fuel lines has been simplified, and the length of the lines shortened to reduce the chance for kinks in the lines, or damage to them from chassis components.

The system eliminates the need for crossover lines in dual tank systems. Fuel is drawn equally from and returned to each tank, so that their levels stay equal. The suction and return fuel lines, although entering the fuel tank via the same opening, are designed to direct the fuel flow to opposite ends ends of the tank. See **Fig. 1.** This ensures thorough mixing of the fuel before it is drawn up by the suction line, so that bubbles can dissipate, and (in the case of electronic engines) warm fuel is not recirculated.

Other advantages of the EquiFlo fuel system are a cleaner fuel tank appearance, improved cold weather fuel flow, and improved access to optional fuel shutoff valves.

General Description and Principles of Operation



NOTE: Arrows indicate direction of flow.

A. To fuel pump
B. From engine

1 Drain
2. Supply (Suction) Line
3. Return Line
4. Fuel Tank
5. Fuel Cap
6. Vent
7. Vent Line
8. Frame Rail

Fig. 1, EquiFlo Inboard Fuel System

Removal

1. Remove the nuts, washers, and bolts (Ref. 5) that attach the bottom of the step assembly to the fuel tank straps, see **Fig. 1)**.
2. Remove the nuts, washers, and bolts (Ref. 4) that attach the step assembly to the fuel tank bracket. Remove the step assembly.

Installation

1. Position the top of the step assembly on the fuel tank bracket. Install the bolts, washers, and nuts that attach the top of the step assembly to the fuel tank straps, see **Fig. 1**. Tighten the nuts 28 lbf·ft (38 N·m).
2. Install the bolts, washers, and nuts that attach the bottom of the step assembly to the fuel tank straps. Tighten the nuts 15 lbf·ft (20 N·m).

Removal and Installation

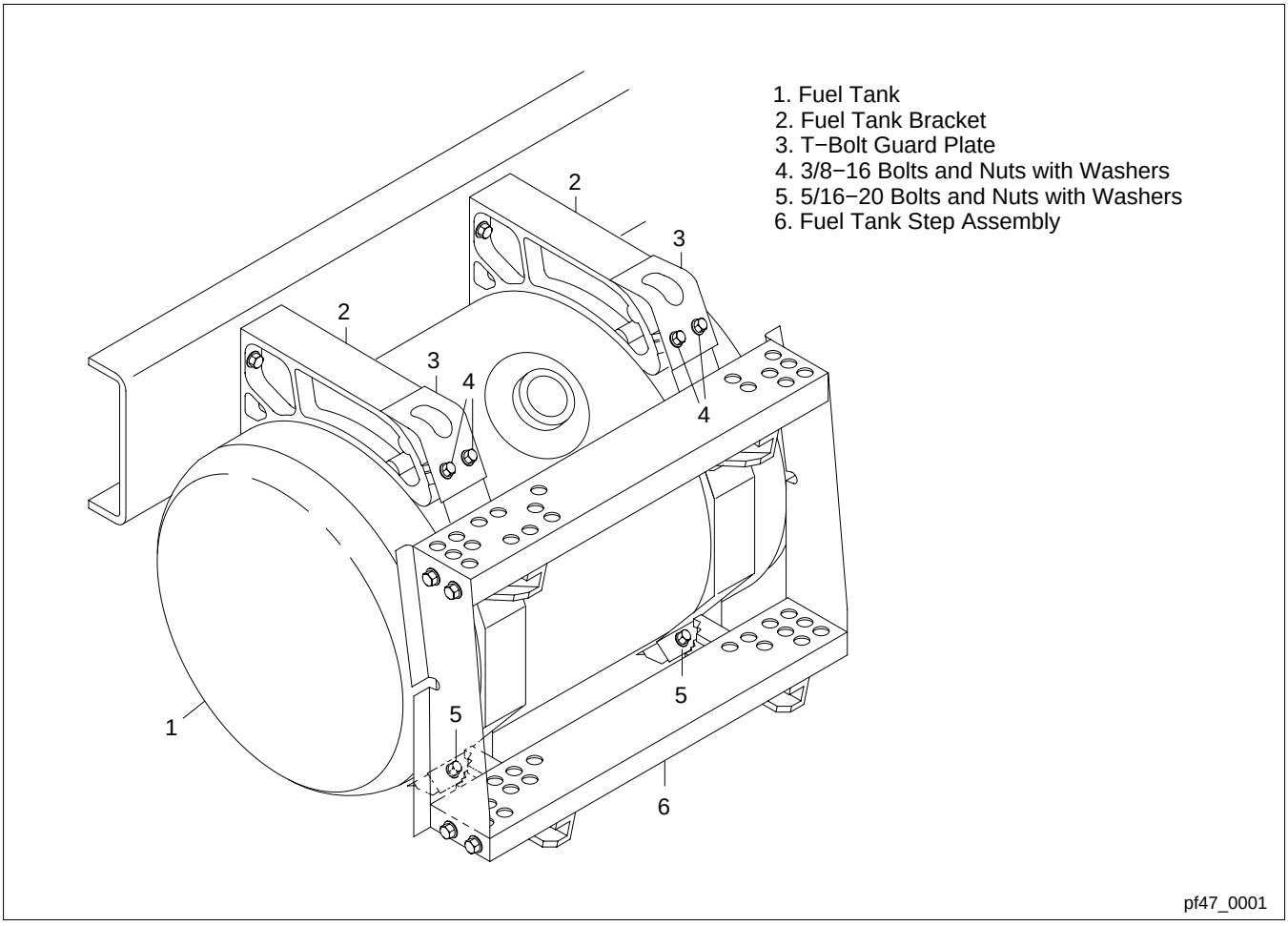


Fig. 1, Tank-Mounted Cab Access Step Assembly

Replacement

If there is any damage to the fuel tank, replace it.

IMPORTANT: Fuel tanks made after January 1, 1973, are subject to U.S. Federal Motor Carrier Safety Regulation 393.67. This law calls for certain standards relating to strength, leakage, and venting. These standards are achieved through the use of specific materials and construction methods. *These standards also apply to replacement fuel tanks.*

⚠ WARNING

WARNING: Do not drain fuel near, or expose fuel vapor to, open flame or intense heat. To do so is a dangerous practice, which would create a hazardous work area. This could lead to personal injury or property damage.

1. Remove the cab access step assembly; refer to **Subject 100**.

   If equipped with an air fairing, remove it using the instructions in the frame section in this manual.

IMPORTANT: On dual tank installations, close the fuel shutoff valve(s) before draining the tank.

2. Remove the drain plug from the fuel tank that is to be replaced.

   If the fuel is to be re-used, store it in a clean container, and keep it free from contaminants.

3. Disconnect the fuel suction line and return line from the tank, and cap the lines.

   On dual tank installations with a crossover line, disconnect the crossover line from the bottom of the tank that is to be replaced. Cap the line.

4. Disconnect the wires from the fuel tank sending unit, if so equipped. Remove the sending unit and gasket, and save them for installation on the new tank.

   If the tank isn't equipped with a sending unit, remove the block-off plate and gasket, and save them for installation on the new tank.

   Remove and clean all of the pipe plugs, and save them for installation on the new tank.

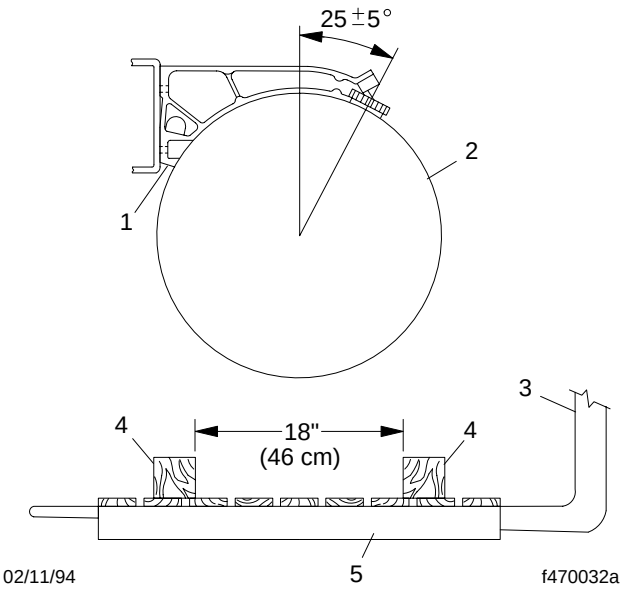
5. To prevent the fuel tank from rolling during and after removal, nail several 2 x 4 or 4 x 4 wooden blocks to the top of a pallet, then place the pallet on the forks of a fork lift. See **Fig. 1**.

   Move the fork lift and pallet into place to support the fuel tank as the tank straps are being removed.

6. Remove the nuts and washers from the tank strap T-bolts at the outboard end of the tank bracket. See **Fig. 2**.

   Remove the tank straps and isolators.

7. After removing the tank, inspect the tank straps, isolators, and brackets for damage. Replace worn or damaged parts with new parts; see **Subject 130** for bracket replacement procedures.



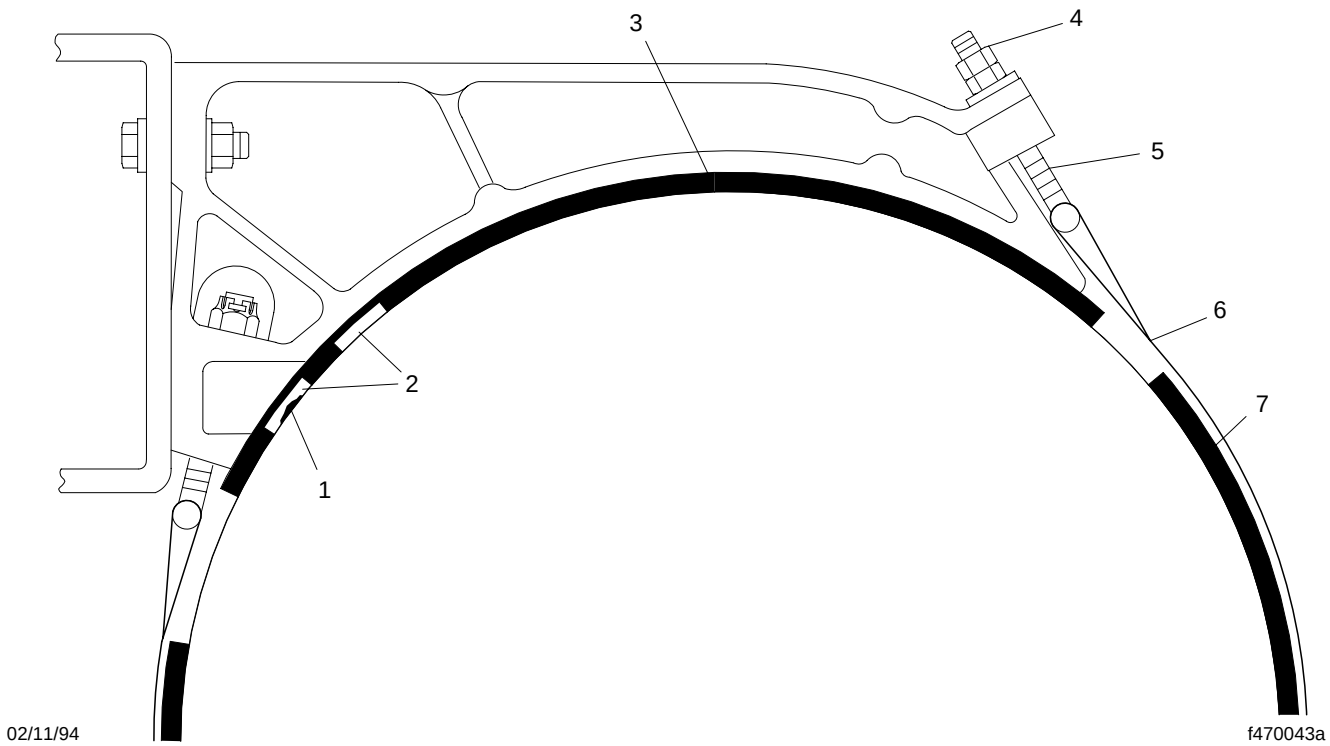
1. Fuel Tank Bracket
2. Fuel Tank
3. Lift-Truck Forks
4. 4 x 4 Wooden Block
5. Wooden Pallet

Fig. 1

8. Using the fork lift and pallet, place the fuel tank in its approximate installed position. Make sure the fuel filler neck is rotated 25 ± 5 degrees outboard of vertical. See **Fig. 1**.

   Move the tank fore or aft until the distance from the front of the tank to the centerline of the rear

Fuel Tank Replacement



1. Tank Longitudinal Weld Seam
2. Bracket Isolator Relief
3. Bracket Isolator
4. 5/8–11 Hexnuts and Washer
5. Outboard T-Bolt
6. Fuel Tank Strap
7. Strap Isolator

Fig. 2, Fuel Tank Strap Assembly (example)

fastener on the front spring shackle bracket is at least 2-3/4 inches (70 mm).

Make sure that the rear of the fuel tank does not extend past the forward edge of the forward spring bracket. Clearance from other frame-mounted parts, like the battery box or tilt pump, must be at least 1/2 inch (13 mm).

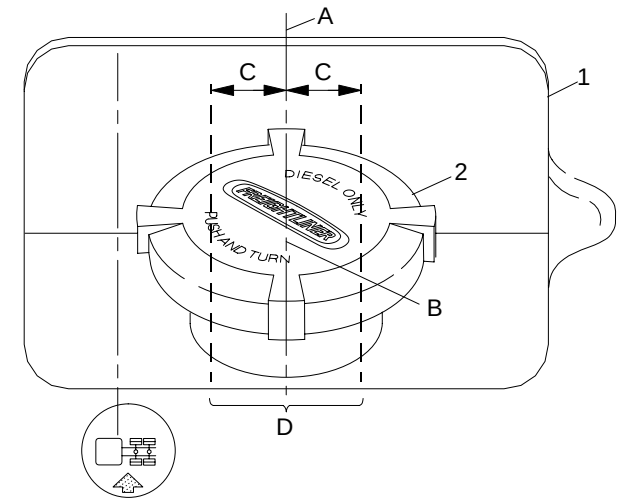
NOTE: On FLDs equipped with side fairings, the fuel tank filler neck does not have to be centered in the fill door opening of the side fairing. The centerline of the fuel tank cap is to be within 1 inch (25 mm) of either side of the centerline of the fill door opening. See **Fig. 3**. Don't move the fuel tanks to center the fuel tank filler neck in the fill door opening.

9. Position the tank straps around the tank; then insert the isolators under the brackets so that the relief in each isolator aligns with the tank longitudinal weld seam. See **Fig. 2**.

CAUTION

CAUTION: Fuel tanks can be damaged by direct isolator pressure on the tank weld seam, and by overtightening the fuel tank straps. Be sure the weld seam aligns with reliefs in the isolators and that the straps are tightened to specification.

10. Install a spherical washer, spherical nut, and jam nut on each outboard tank strap T-bolt. Tighten the first (spherical retention) nuts alternately in stages until each is 30 to 45 lbf·ft (41 to 60 N·m). When both retention nuts are torqued, hold each with a wrench while tightening its jam nut 50 to 65 lbf·ft (68 to 88 N·m).



A. Centerline of fill door opening
B. Centerline of fuel cap
C. 1 inch (25 mm)
D. Fuel cap centerline to be within this area.
1. Fill Door Opening
2. Fuel Cap

Fig. 3

11. Install the fuel tank sending unit and gasket, or the block-off plate and gasket. Attach the wires to the sending unit. Evenly tighten the slotted cap-screws.
12. Make certain the fuel lines are clean, then install them on their fittings on the fuel tank; see **Subject 140** for general guidelines.

    Coat the pipe plug threads with Loctite® 592, or an equivalent. Install pipe plugs in any remaining open threaded holes.
13. Install the cab access step assembly. For instructions, see **Subject 100**.

    If equipped with an air fairing, install it using the instructions in the frame section in this manual.
14. Fill the fuel tank with clean fuel. Prime the engine fuel pump; refer to the engine manufacturer's operation and maintenance manual.

    On dual tank installations, open the fuel shutoff valve(s).

Replacement

1. Remove the cab access step assembly; refer to **Subject 100**.

   If equipped with an air fairing, remove it using the instructions in the frame section in this manual.

2. Support the fuel tank, using a floor jack or fork lift, and padding to protect the tank.

3. Remove the nuts and washer from the tank strap T-bolt at the outboard end of the tank bracket, see **Fig. 1**.

   On straps with inboard T-bolts, remove the cotter pin, castle nut, and washer from the tank strap T-bolt at the frame rail; then remove the strap and isolator.

   On straps without inboard T-bolts, remove the tank bracket mounting fasteners; then remove the bracket, strap, and both isolators.

4. Inspect the isolator(s) for wear or damage, and replace if needed.

5. *On straps with inboard T-bolts,* position the isolator and the new tank strap on the tank; then install a washer and castle nut on the tank strap T-bolt at the frame rail. Install a new cotter pin and lock it in place.

   On straps without inboard T-bolts, apply Alumilastic® compound or equivalent to the bracket where it contacts the strap; then install the tank strap and bracket on the frame rail with the original fasteners. Tighten the nuts 160 lbf·ft (217 N·m).

CAUTION

CAUTION: Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the components or parts.

CAUTION

CAUTION: Do not mix tank strap types. On a tank, both straps should be either the type with inboard T-bolt, or the type without inboard T-bolt; not one of each type.

6. Position the tank strap, with strap isolator, around the tank; then insert the bracket isolator under the bracket so that a relief in the isolator aligns with the tank longitudinal weld seam. See **Fig. 1.**

CAUTION

CAUTION: Fuel tanks can be damaged by direct isolator pressure on the tank weld seam, and by over-tightening the fuel tank straps. Be sure the weld seam aligns with reliefs in the isolators and that the straps are tightened to specification.

7. Install a spherical washer, spherical nut, and jam nut on the outboard tank strap T-bolt. Tighten the first (spherical retention) nut 30 to 45 lbf·ft (41 to 60 N·m); then hold the retention nut with a wrench while tightening the jam nut 50 to 65 lbf·ft (68 to 88 N·m).

8. Install the cab access step assembly; refer to **Subject 100**.

   If equipped with an air fairing, install it using the instructions in the frame section in this manual.

Fuel Tank Strap Replacement

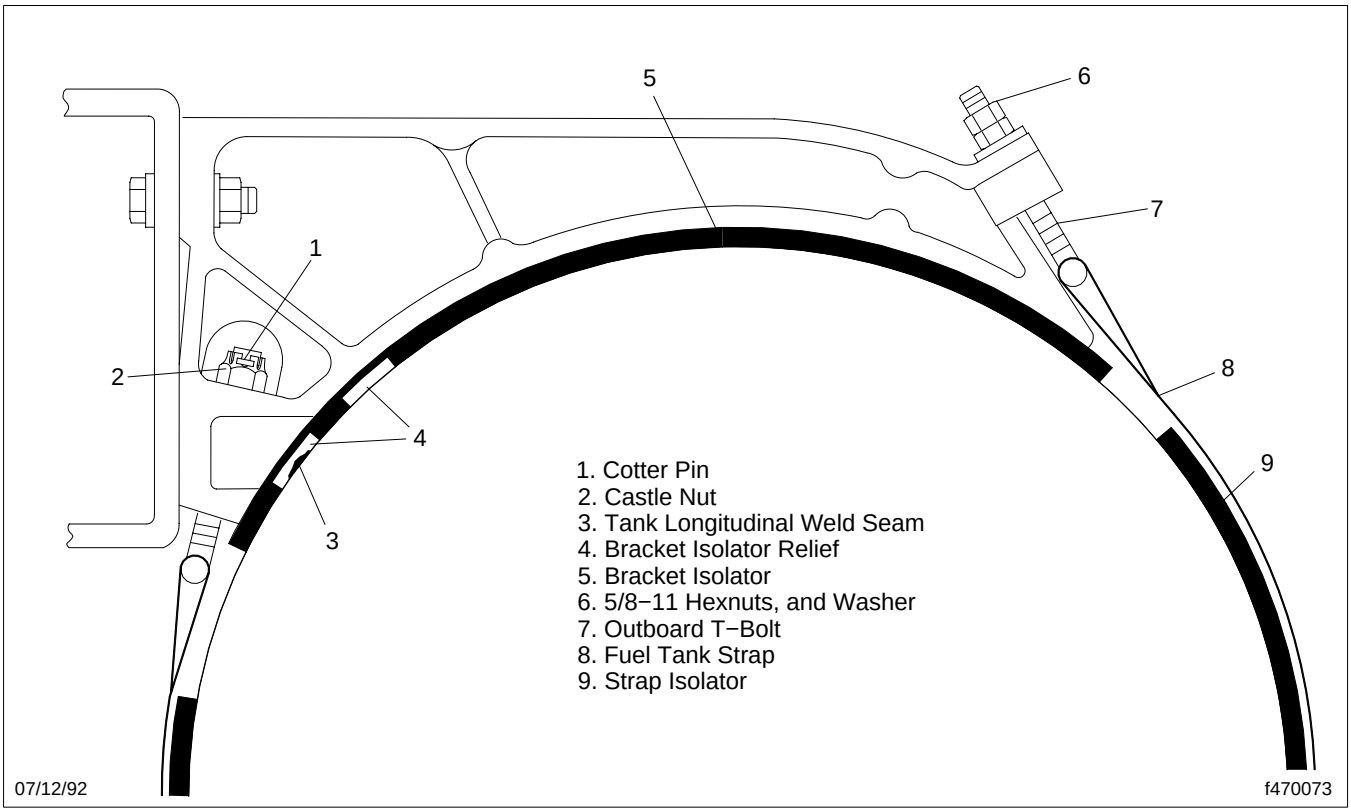


Fig. 1, Fuel Tank Strap Assembly (example shown with inboard T-bolt)

Replacement

1. Support the tank and remove the fuel tank strap from the bracket that is being replaced; refer to **Subject 120**.
2. For installations with inboard T-bolts, remove the fasteners that attach the bracket to the frame rail; then remove the bracket, see **Fig. 1**.
3. For installations without inboard T-bolts, install the bracket and strap; refer to **Subject 120**.
4. For installations with inboard T-bolts, install the bracket as follows.

    4.1 Apply Alumilastic® compound, or equivalent, between the fuel tank bracket and the frame rail.

CAUTION

CAUTION: Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the components or parts.

    4.2 Position the new tank bracket against the frame rail. From inside the frame rail, install the 5/8-11 grade 8 bolts and washers. Install hardened washers and hexnuts. Tighten the hexnuts 160 lbf·ft (217 N·m).

    4.3 Install the fuel tank strap; refer to **Subject 120**.

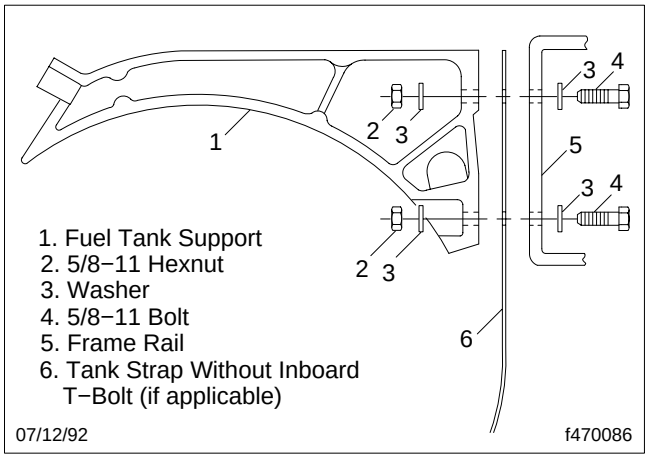


Fig. 1, Fuel Tank Bracket Assembly

General Guidelines

If fuel lines are worn, damaged, or deteriorated, replace them. Use the following guidelines for installing and routing them.

- Fuel lines must be free of droops, sharp bends, or kinks in the lines.
- Fuel lines must not extend more than two inches (5 cm) below the fuel tank unless they are completely enclosed in a protective housing.
- Fuel lines must be routed in a continuous upward slope from the fuel tank to prevent high and low spots in the hoses.
- Fuel lines must be routed at least six inches (15 cm) from exhaust pipes.
- Heat shields and/or hose insulation must be used to protect any section of fuel line that is less than six inches (15 cm) from a heat source.
- Fuel lines must be routed to allow routinely serviceable components such as dipsticks, filters, and water separators to be readily accessed without the need to disconnect the fuel lines.
- Fuel lines must be secured to prevent chafing, kinking, or other damage.
- Fuel lines must be long enough to allow movement of the parts to which they are attached.
- Coat all pipe threads (tapered threads) with Loctite® 592, or an equivalent.
- Finger-tighten pipe fittings; then tighten one and one half turns. Tighten more if necessary to seal.
- Fuel lines and fittings must be free of leaks, to prevent fuel loss or entry of air into the line, which may result in a loss of prime by the engine fuel system.
- Drains or other bottom fittings must not extend more than 3/4 inch (19 mm) below the lowest part of the fuel tank or sump.

Priming the Fuel System

Before doing any of the following procedures make sure there is an adequate amount of fuel in the tank(s). Do not fill the tank(s) to more than 95 percent of liquid capacity. The 5 percent air space is needed for fuel expansion.

⚠ WARNING

WARNING: Federal regulations prohibit filling a fuel tank to more than 95 percent of its liquid capacity. A tank with air space is much less susceptible to rupture in an accident than one that has little or no air space. Fuel tank rupture could result in fuel spillage which could cause environmental damage, or possible fire.

⚠ CAUTION

CAUTION: Don't crank the engine for more than 30 seconds at a time during any of the following procedures; wait two minutes after each try to allow the starter to cool. Failure to do so could cause starter damage.

Vehicles Equipped With dual Tanks and Equiflo® Inboard Fuel System

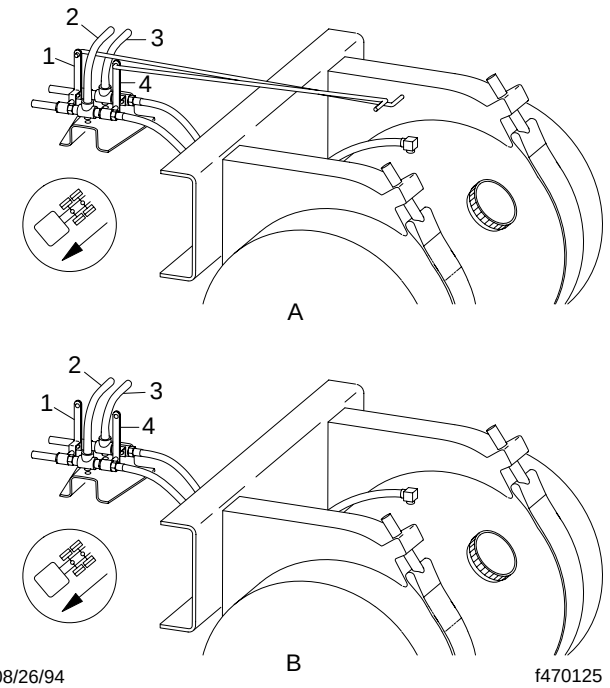
1. If the engine is equipped with a priming pump, do the following:
   - 1.1 Unlock and operate the engine's priming pump plunger until there is resistance.
   - 1.2 Push the plunger in and tighten it by hand.
   - 1.3 Start the engine; if it doesn't start, more priming is needed.

     Once the engine has started, it may run rough. If this occurs, run the engine at low idle until it runs smoothly.
2. If the engine is not equipped with a priming pump, do the following:

⚠ CAUTION

CAUTION: Be careful when closing or opening fuel shut-off valves. Using too much force on the handles could damage the valves themselves.

- 2.1 If equipped with fuel shut-off valves, open them to let fuel flow between the tanks. See **Fig. 1.**



A. FLD Conventional
B. FLB COE

1. Shut-Off Valve, Right Tank
2. Return Line (from engine)
3. Supply Line (to fuel pump)
4. Shut-Off Valve, Left Tank

Fig. 1

- 2.2 Remove the fuel tank cap from one of the fuel tanks.

⚠ CAUTION

CAUTION: When pressurizing the fuel tanks, do not apply more than 5 psi (35 kPa) to the tanks. Too much air pressure could deform the fuel tanks, which could lead to an eventual fuel tank rupture.

- 2.3 Using an air hose connected to the vent line, pressurize the other fuel tank, applying *no more than 5 psi* (35 kPa) air pressure. Pressurize the tank until no more

Priming the Fuel System

bubbles are visible in the first tank. This indicates all air has been purged from the system.

NOTE: You can also pressurize the fuel tank by removing the cap, and inserting an air hose into the fill neck. Cover the fill neck opening with your hand or a rag.

2.4 Replace the cap on the first fuel tank; then plug the vent line on that tank.

2.5 Pressurize the second tank again; then loosen the fuel supply line at the fuel transfer pump on the engine.

2.6 Check the fuel supply line for a constant flow of fuel. When the line is clear of bubbles, tighten its connection while maintaining fuel tank pressure.

2.7 Start the engine.

Vehicles Equipped With a Single Tank

1. If the engine is equipped with a priming pump, do the following:
   - 1.1 Unlock and operate the engine's priming pump plunger until there is resistance.
   - 1.2 Push the plunger in and tighten it by hand.
   - 1.3 Start the engine; if it doesn't start, more priming is needed.

     Once the engine has started, it may run rough. If this occurs, run the engine at low idle until it runs smoothly.
2. If the engine is not equipped with a priming pump, do the following:
   - 2.1 Remove the fuel tank cap.
   - 2.2 Loosen the fuel supply line at the fuel transfer pump.

⚠ CAUTION

CAUTION: When pressurizing the fuel tanks, do not apply more than 5 psi (35 kPa) to the tanks. Too much air pressure could deform the fuel tanks, which could lead to an eventual fuel tank rupture.

   - 2.3 Partially cover the fuel tank opening with your hand. Using an air hose, apply *no more than 5 psi* (35 kPa) air pressure to the fuel tank and look for a constant fuel flow at the loosened fuel supply line.
   - 2.4 Remove the air hose and tighten the fuel supply line.

   IMPORTANT: To prevent fuel loss or entry of air into a fuel line, make sure that all fuel line connections are tight.

   - 2.5 Start the engine. Once the engine has started, it may run rough. If this occurs, run the engine at low idle until it runs smoothly.

Vehicles Equipped With Dual Tanks and Dual Suction and Return Lines

1. Disconnect the fuel return line from the primary tank, and plug the tank return port.
2. Open (if necessary) the control valve to each tank to allow fuel flow between the tanks.
3. Remove the fuel tank cap from each tank.
4. Partially cover the fuel tank opening with your hand. Using an air hose, apply no more than 5 psi (35 kPa) air pressure to the primary tank to fill the supply lines with fuel. Apply air pressure until air bubbles appear. Close the control valve to the secondary tank.
5. Loosen the fuel supply line at the fuel transfer pump.
6. Using an air hose, apply no more than 5 psi (35 kPa) air pressure to the primary tank and look for a constant fuel flow at the loosened fuel supply line.
7. Remove the air hose and tighten the fuel supply line.
8. Remove the plug from the primary tank's return port, and connect the fuel return line.

IMPORTANT: To prevent fuel loss or entry of air into a fuel line, make sure that all fuel line connections are tight.

9. Open the control valve to the secondary tank. Install the fuel tank caps.

10. Start the engine. Once the engine has started, it may run rough. If this occurs, run the engine at low idle until it runs smoothly.

Vehicles Equipped With Dual Tanks and Single Suction and Return Lines (With Crossover Line)

Use the same procedure provided under "Vehicles Equipped With a Single Tank." Do the procedure on the tank equipped with the supply line.

General Description

Racor 325R and 330R Series Fuel Heater/Water Separators (See Fig. 1)

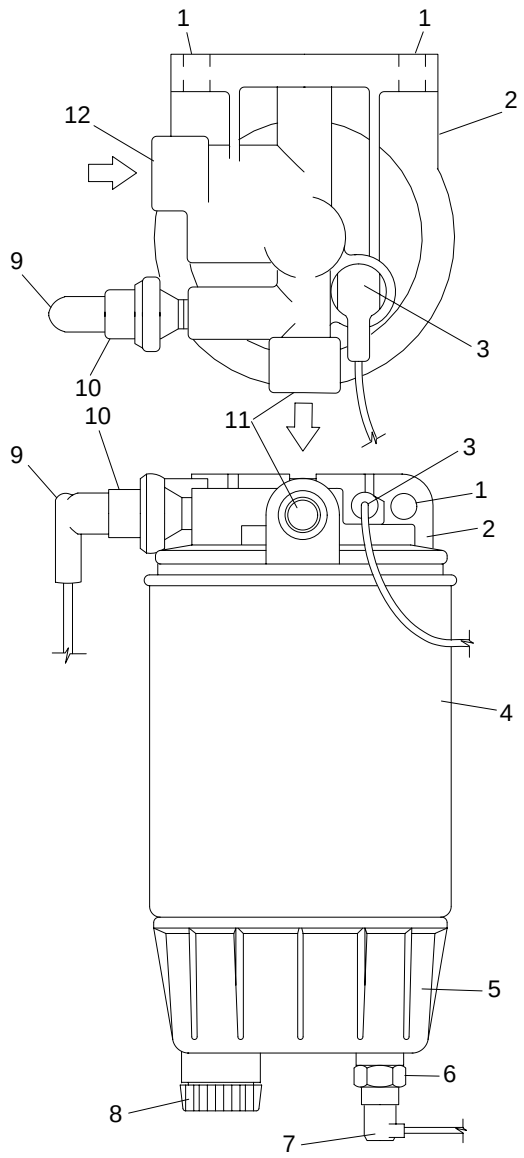
The 325R and 330R series of fuel heater/water separator removes water and solid contaminants from diesel fuel. These units differ only in the fuel flow rate which is dictated by the size of the filter element. The 325R and 330R allow fuel flow at the rate of 60 and 75 gallons per hour respectively. These units are made up of three main sections; a head assembly, fuel filter element, and a contaminant collection bowl. These units have a standard 12 volt heater built into the head assembly. The 325R and 330R series are available in different configurations with optional 12 volt in-bowl fuel heater and water sensor probe. See **Specifications 400**.

Racor 460R and 490R Series Fuel Heater/Water Separators (See Fig. 2)

The 460R and 490R series of fuel heater/water separator removes water and solid contaminants from diesel fuel. These units differ only in the fuel flow rate which is dictated by the size of the filter element. The 460R and 490R allow fuel flow at a rate of 60 and 90 gallons per hour respectively. These units are made up of three main sections; a head assembly, fuel filter element, and a contaminant collection bowl. The head assembly contains a fuel priming pump. The 460R and 490R series are available in different configurations with optional 12 or 24 volt in-bowl fuel heater and water sensor probe. See **Specifications 400**.

Racor 690R and 6120R Series Fuel Heater/Water Separators (See Fig. 3)

The 690R and 6120R series of fuel heater/water separator removes water and solid contaminants from diesel fuel. These units differ in the fuel flow rate and by the contaminant collection bowl volume. The 690R and 6120R allow fuel flow at a rate of 90 and 120 gallons per hour respectively. These units are made up of three main section; a head assembly, fuel filter element, and a contaminant collection bowl. The 690R and 6120R series fuel heater/water separators are available in different configurations with optional 12 or 24 volt in-bowl fuel heater and water sensor probe. See **Specifications 400**.



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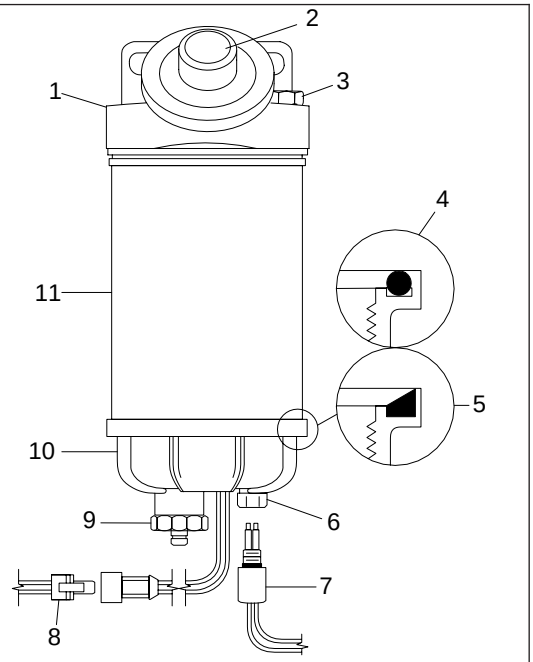
1. Mounting Hole
2. Mounting Head
3. Heater Connector
4. Filter Element
5. Collection Bowl
6. Water Sensor
7. Water Sensor Connector
8. Drain Valve
9. Vacuum Switch Connector
10. Vacuum Switch
11. Fuel Outlet
12. Fuel Inlet

Fig. 1, Racor 325R Fuel Heater/Water Separator (330R similar)

General Description and Principles of Operation



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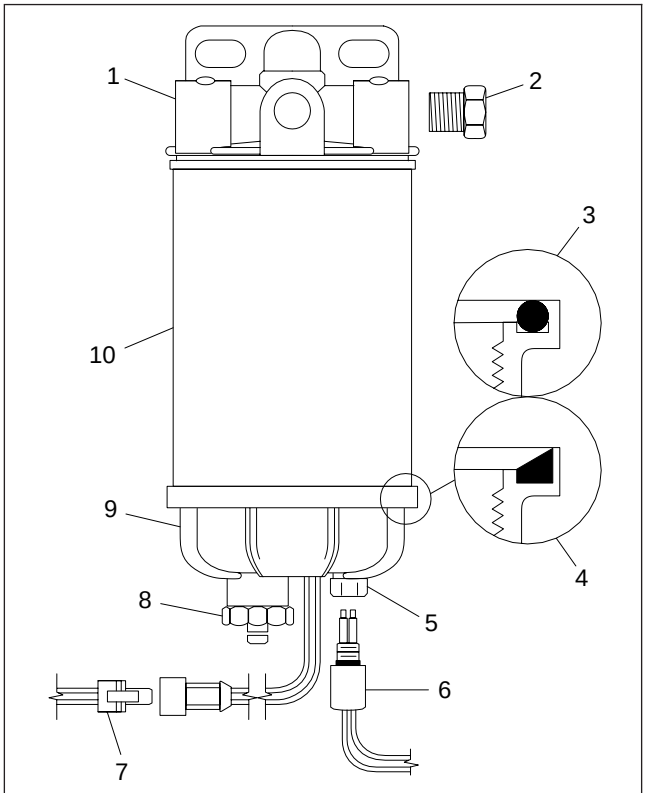
1. Mounting Head
2. Fuel Primer Pump
3. Vent Plug
4. Bowl O-Ring
5. Bowl Bevel Cut Gasket
6. Bowl Probe Plug
7. Water Sensor Probe
8. Heater Connector
9. Bowl Drain Assembly
10. Bowl with Drain Assembly
11. Filter Element

Fig. 2, Racor 490R Fuel Heater/Water Separator (460R similar)

Racor 900FG and 1000FG Series Fuel Heater/Water Separators

(See Fig. 4)

The 900FG and 1000FG series of fuel heater/water separator removes water and solid contaminants from diesel fuel. These units differ in the fuel flow rate and height. The 900FG is 17 inches (432mm) tall while the 1000FG is 22 inches (559 mm) tall. The 900FG and 1000FG allow fuel flow at a rate of 90 and 180 gallons per hour respectively. The 900FG and 1000FG series fuel heater/water separators are available in different configurations with optional 12 or 24 volt in-bowl fuel heater and water sensor probe. See **Specifications 400**.



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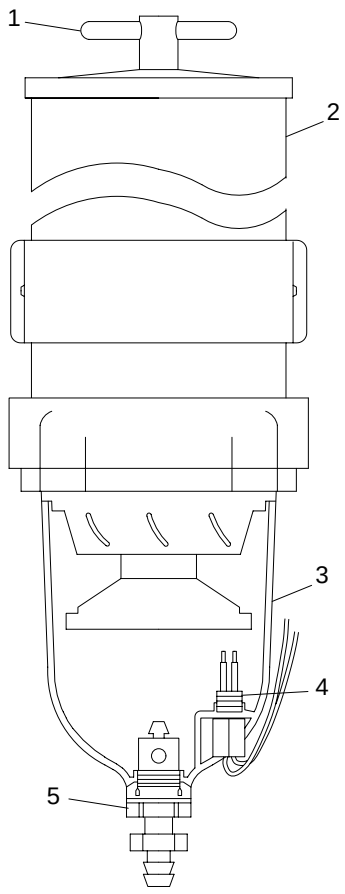
1. Mounting Head
2. Metal Plug 3/8" NPT
3. Bowl O-Ring
4. Bowl Bevel Cut Gasket
5. Bowl Probe Plug
6. Water Sensor Probe
7. Heater Connector
8. Bowl Drain Assembly
9. Bowl with Drain Assembly and Water Sensor
10. Filter Element

Fig. 3, Racor 690R Fuel Heater/Water Separator

Racor 6400 Fuel Heater/Water Separator **(See Fig. 5)**

The 6400 fuel heater/water separator removes water and solid contaminants from diesel fuel. These fuel/water separators allows fuel flow at the rate of 120 gallons per hour. These units heat fuel using engine coolant. The 6400 series is available in different configurations with optional 12 or 24 volt in-bowl fuel heater and water sensor probe. An internal automatic coolant thermostat is also available. See **Specifications 400**.



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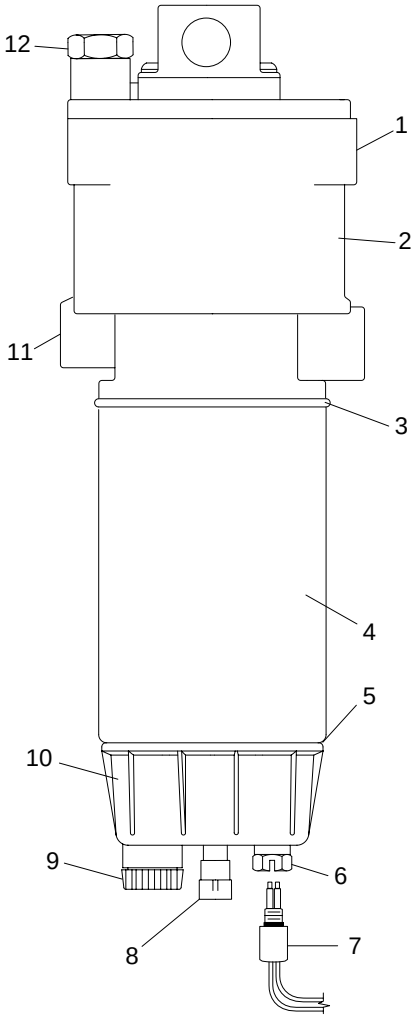
1. T-Handle
2. Filter Element Housing
3. Contaminant Collection Bowl
4. Water Sensor Probe
5. Drain Valve

Fig. 4, Racor 900FG and 1000FG Fuel Heater/Water Separator



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1. Fuel Inlet
2. Head Assembly
3. Filter Top Seal
4. Filter Element
5. Bowl O-Ring Seal
6. Water Sensor Probe Plug
7. Water Sensor Probe
8. Bowl Heater Connector
9. Drain Valve
10. Contaminant Collection Bowl
11. Fuel Outlet
12. Priming Plug

Fig. 5, Racor 6400 Fuel Heater/Water Separator

Principles of Operation

Racor 325R and 330R Series Fuel Heater/Water Separators

Fuel enters the head assembly at the top of the unit. As the fuel passes through the filter element, water and solid contaminant particles are stripped from the fuel and collect on the filter element. As more water particles collect on the element, they coagulate and fall into the contaminant collection bowl. Water and heavier contaminants can then be removed by opening the drain valve at the base of the unit. These units have a standard in-head electric fuel heater. The heater is a self regulating type, that changes its heat output depending on the temperature of the

General Description and Principles of Operation

fuel. The optional electric bowl heater is a resistance type heater that places the heat directly below the filter element and works like the standard heater. The optional water sensor allows remote monitoring of the contaminant collection bowl water level. When the water sensor probe tip is covered by water, its conductivity increases. When conductivity reaches a certain value a remote electronically controlled warning display indicator lights.

Racor 460R and 490R Series Fuel Heater/Water Separators

Fuel enters the head assembly at the top of the unit. As the fuel passes through the filter element, water and solid contaminant particles are stripped from the fuel and collect on the filter element. As more water particles collect on the element, they coagulate and fall into the contaminant collection bowl. Water and heavier contaminants can then be removed by opening the drain valve at the base of the unit. A built-in hand priming pump is built into the unit head. It allows manual priming when necessary. The optional electric bowl heater is a resistance type heater that places the heat directly below the filter element. The heater is a self regulating type, that changes its heat output depending on the temperature of the fuel. The heater begins to function when the fuel temperature is below 45°F (7°C) and shuts off when the fuel temperature is above 75°F (24°C). The optional water sensor allows remote monitoring of the contaminant collection bowl water level. When the water sensor probe tip is covered by water, its conductivity increases. When conductivity reaches a certain value a remote electronically controlled warning indicator lights.

Racor 690R and 6120R Series Fuel Heater/Water Separators

Fuel enters the head assembly at the top of the unit. As the fuel passes through the filter element, water and solid contaminant particles are stripped from the fuel and collect on the filter element. As more water particles collect on the element, they coagulate and fall into the contaminant collection bowl. Water and heavier contaminants can then be removed by opening the drain valve at the base of the unit. The optional electric bowl heater is a resistance type heater that places the heat directly below the filter element. The heater is a self regulating type, that changes its heat output depending on the temperature of the fuel. The heater begins to function when the fuel temperature is below 45°F (7°C) and shuts off when the fuel temperature is above 75°F (24°C). The water sensor option allows remote monitoring of the contaminant collection bowl water level. The optional water sensor allows remote monitoring of the contaminant collection bowl water level. When the water sensor probe tip is covered by water, its conductivity increases. When conductivity reaches a certain value a remote electronically controlled warning indicator lights.

Racor 900FG and 1000FG Series Fuel Heater/Water Separators

Fuel enters the assembly at the center of the unit, then passes through a centrifuge that spins off large solids and water droplets. The heavier solids and water fall toward the contaminant collection bowl. Fuel then passes through a filter element that traps the smaller particles. Smaller water particles are not permitted to pass through the filter so they coagulate then fall into the contaminant collection bowl. The standard electric heater is a resistance type heater that places the heat directly below the filter element. The optional electric bowl heater is a resistance type heater that places the heat directly below the filter element. The heater is a self regulating type, that changes its heat output depending on the temperature of the fuel. The heater begins to function when the fuel temperature is below 45°F (7°C) and shuts off when the fuel temperature is above 75°F (24°C). The optional water sensor allows remote monitoring of the contaminant collection bowl water level. When the water sensor probe tip is covered by water, its conductivity increases. When conductivity reaches a certain value a remote electronically controlled warning indicator lights.

Racor 6400 Fuel Heater/Water Separator

Fuel and coolant enter the head assembly at the top of the unit. The fuel is immediately heated by engine coolant as it flows through the coiled liquid-to-liquid heat exchanger. As the fuel passes through the filter element, water particles are stripped from the fuel and coagulate and fall into the contaminant collection bowl. Water and heavier contaminants can then be removed by opening the drain valve at the base of the unit. If the unit is equipped with a Nautilus element, the filter does not remove particulates and un-

der normal operating conditions, does not require periodic replacement. The optional electric bowl heater is a resistance type heater that places the heat directly below the filter element. The heater is a self regulating type, that changes its heat output depending on the temperature of the fuel. The heater begins to function when the fuel temperature is below 45°F (7°C) and shuts off when the fuel temperature is above 75°F (24°C). If the unit is equipped with an automatic coolant thermostat valve, coolant flow through the unit is regulated to maintain optimum fuel temperature. The water sensor allows remote monitoring of the contaminant collection bowl water level. When the water sensor probe tip is covered by water, its conductivity increases. When conductivity reaches a certain value a remote electronically controlled warning indicator lights.

Racor 325R and 330R Fuel Heater/Water Separator Removal and Installation

Removal (See Fig. 1)

⚠ WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Disconnect the heater connector, vacuum switch connector and the water sensor probe connector.
3. Place a suitable container under the fuel heater/water separator, then drain the fuel from the fuel heater/water separator by opening the drain valve.
4. Place a shop towel under the fuel outlet fitting, then hold the fitting with an open-end wrench. Using a flare-nut wrench, carefully loosen the fuel outlet fitting, then drain any residual fuel into the container. Remove the fitting from the fuel heater/water separator.

   Repeat this step for the fuel inlet fitting.
5. Loosen the two hexnuts on the mounting head. Grasp the fuel heater/water separator in one hand, and carefully remove the two hexnuts and washers and capscrews; then remove the fuel heater/water separator unit.

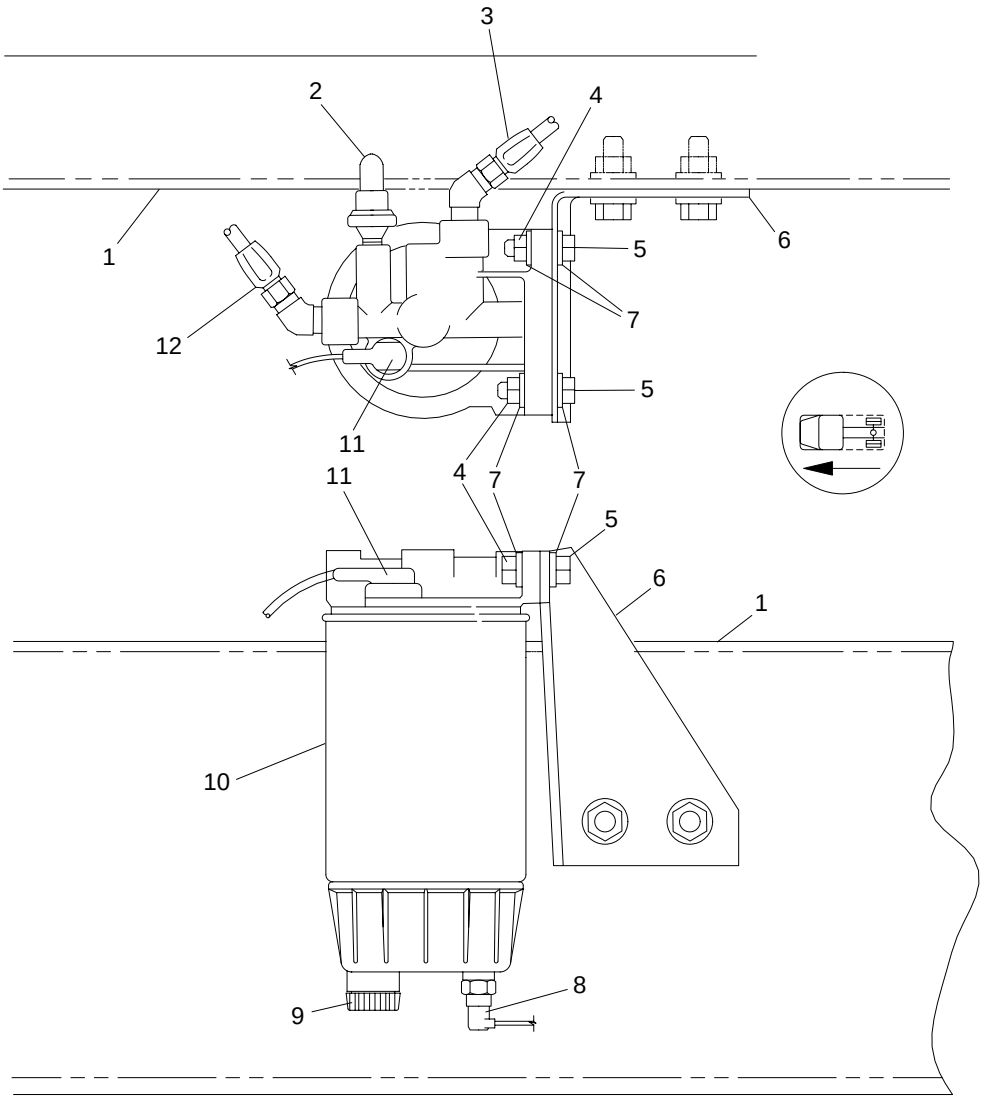
Installation

1. Hold the fuel heater/water separator in place; then install the two capscrews, hexnuts and hardened washers on the mounting head.

NOTE: Do not use teflon tape when sealing the fuel fittings.

2. Check that the threads on the fuel inlet and outlet fittings are clean. Apply a soft-set pipe thread sealant on the fittings, then install them to the fuel heater/water separator.
3. Prime the fuel separator.
   - 3.1 Spin the filter element and bowl assembly together from the mounting head.
   - 3.2 Lubricate the filter element square-cut gasket with clean motor oil or diesel fuel.
   - 3.3 Fill the filter element and bowl assembly with clean diesel fuel.
   - 3.4 Spin the filter element and bowl assembly onto the mounting head until the gasket contacts the mounting head; then turn the filter assembly 1/3 to 3/4 additional turns.
4. Connect the heater connector, vacuum switch connector and the water sensor probe connector.
5. Start the engine and check for fuel leaks. Repair any leaks with the engine OFF.
6. Remove the tire chocks.

Racor 325R and 330R Fuel Heater/Water Separator Removal and Installation



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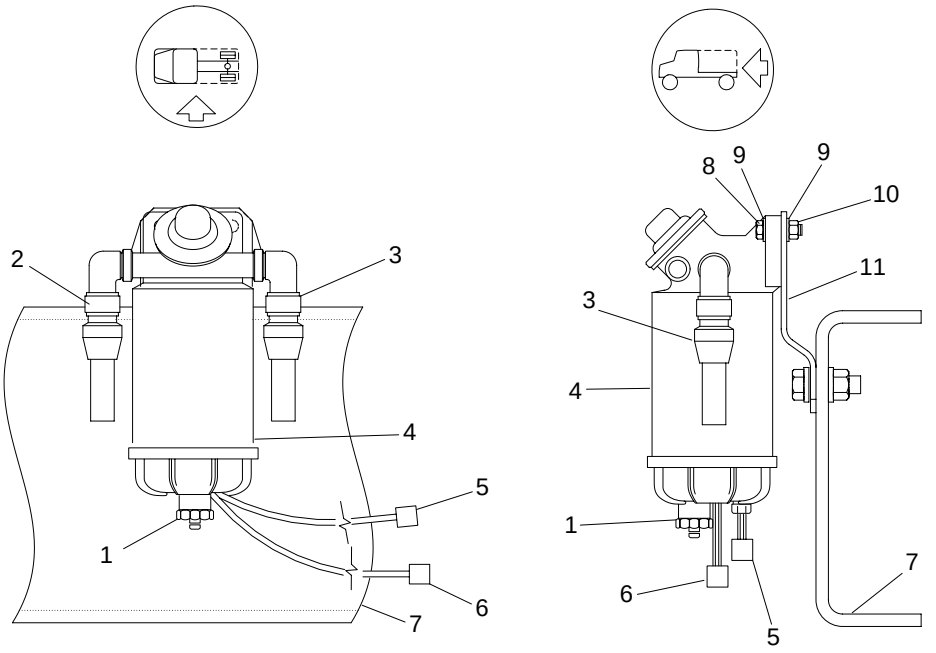
1. Frame Rail
2. Vacuum Sensor Connector
3. Fuel Inlet
4. Hexnut
5. Capscrew
6. Mounting Bracket
7. Hardened Washer
8. Water Sensor Probe
9. Drain Valve
10. Filter Element
11. Heater Connector
12. Fuel Outlet

Fig. 1, Racor 325R Fuel Heater/Water Separator (330R similar)

Racor 460R and 490R Fuel Heater/Water Separator Removal and Installation

Removal (See Fig. 1)



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1. Drain Valve
2. Fuel Inlet
3. Fuel Outlet
4. Filter Element
5. Water Sensor Connector
6. Heater Connector
7. Frame Rail
8. Capscrew
9. Hardened Washer
10. Hexnut
11. Mounting Bracket

Fig. 1, Racor 460R Fuel Heater/Water Separator (490R similar)

⚠ WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Disconnect the heater connector, and the water sensor probe connector if equipped.
3. Place a suitable container under the fuel heater/water separator, then drain the fuel from the fuel heater/water separator by opening the drain valve.
4. Place a shop towel under the fuel outlet fitting, then hold the fitting with an open-end wrench. Using a flare-nut wrench, carefully loosen the fuel outlet fitting, then drain any residual fuel into the container. Remove the fitting from the fuel heater/water separator.

   Repeat this step for the fuel inlet fitting.
5. Loosen the two hexnuts on the mounting head. Grasp the fuel heater/water separator in one hand, and carefully remove the two hexnuts, hardened washers, and capscrews; then remove the fuel heater/water separator unit.

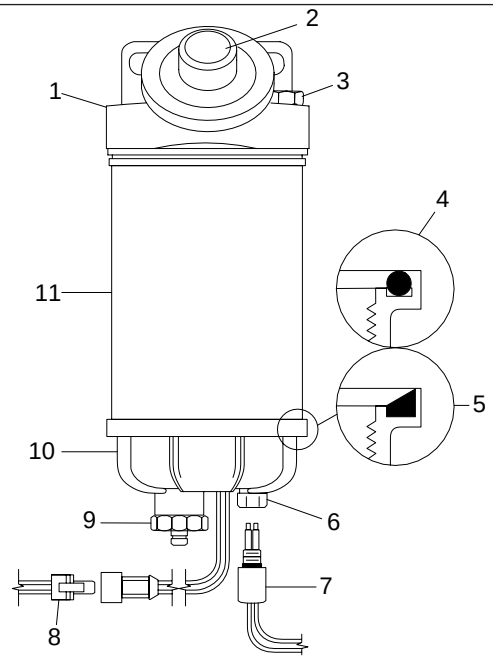
Installation

1. Hold the fuel heater/water separator in place; then install the two capscrews, hexnuts, and hardened washers on the mounting head.

Racor 460R and 490R Fuel Heater/Water Separator Removal and Installation

NOTE: Do not use teflon tape when sealing the fuel fittings.

2. Check that the threads on the fuel inlet and outlet fittings are clean. Apply a soft-set pipe thread sealant on the fittings, then install them on the fuel heater/water separator.
3. Connect the heater connector and the water sensor probe connector, if equipped.
4. Prime the fuel separator.
   4.1 Loosen the vent plug; then, operate the primer pump until fuel purges at the vent plug. See **Fig. 2**.



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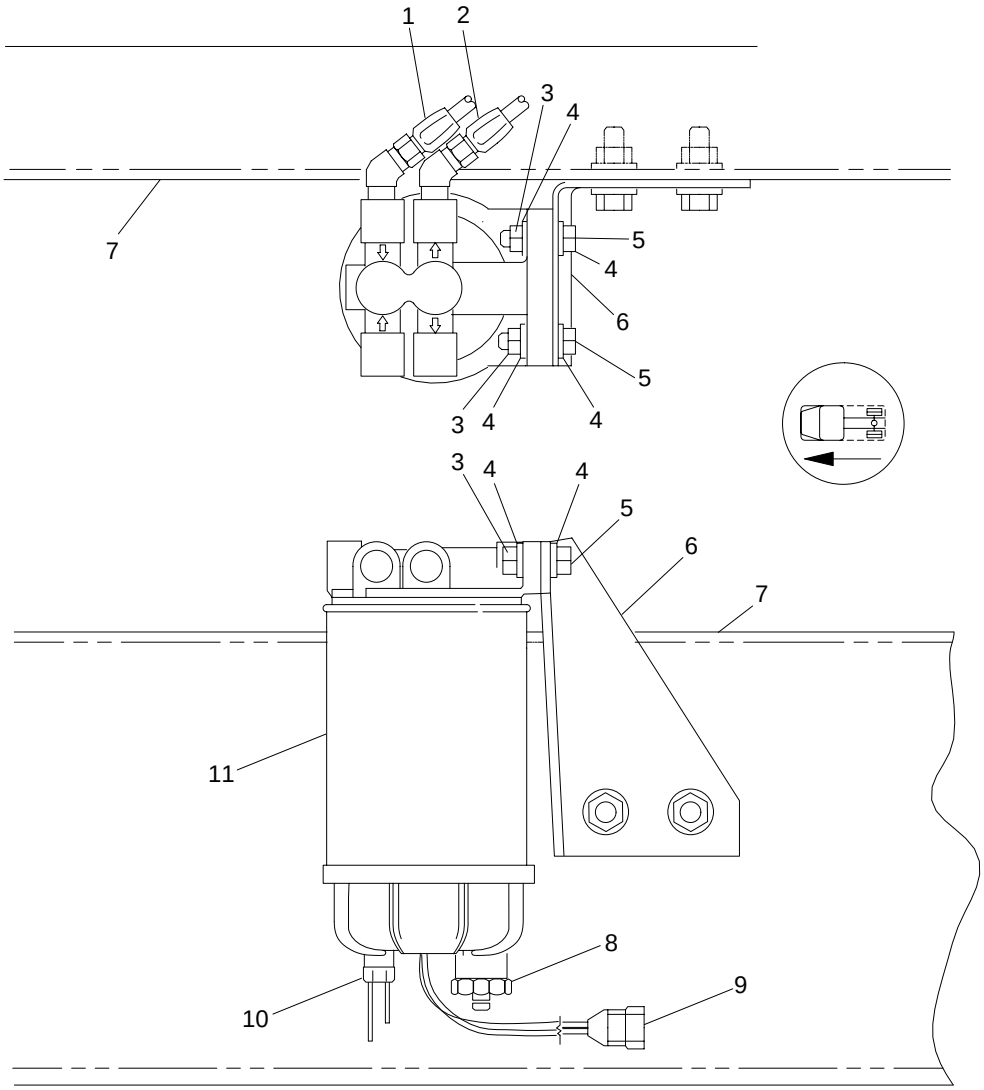
1. Mounting Head
2. Fuel Primer Pump
3. Vent Plug
4. Bowl O-Ring
5. Bowl Bevel-Cut Gasket
6. Bowl Probe Plug
7. Water Sensor Probe
8. Bowl Heater Connector
9. Drain Valve
10. Contaminant Collection Bowl
11. Filter Element

Fig. 2, Racor 490 Fuel/Water Separator

   4.2 Close the vent plug.
5. Start the engine and check for fuel leaks. Repair any leaks with the engine OFF.
6. Remove the tire chocks.

Racor 690R and 6120R Fuel Heater/Water Separator Removal and Installation

Removal (See Fig. 1)



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1. Fuel Inlet Fitting
2. Fuel Outlet Fitting
3. Hexnut
4. Hardened Washer
5. Capscrew
6. Mounting Bracket
7. Frame Rail
8. Drain Valve
9. Heater Connector
10. Water Sensor Probe
11. Filter Element

Fig. 1, Racor 690R Fuel Heater/Water Separator (6120R similar)

Racor 690R and 6120R Fuel Heater/Water Separator Removal and Installation

⚠ WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Disconnect the heater connector, and the water sensor probe connector if equipped.
3. Place a suitable container under the fuel heater/water separator, then drain the fuel from the fuel heater/water separator by opening the drain valve.
4. Place a shop towel under the fuel outlet fitting, then hold the fitting with an open end wrench. Using a flare-nut wrench, carefully loosen the fuel outlet fitting, then drain any residual fuel into the container. Remove the fitting from the fuel heater/water separator.

   Repeat this step for the fuel inlet fitting.
5. Loosen the two hexnuts on the mounting head. Grasp the fuel heater/water separator in one hand, and carefully remove the two hexnuts, hardened washers and capscrews; then remove the fuel heater/water separator unit.

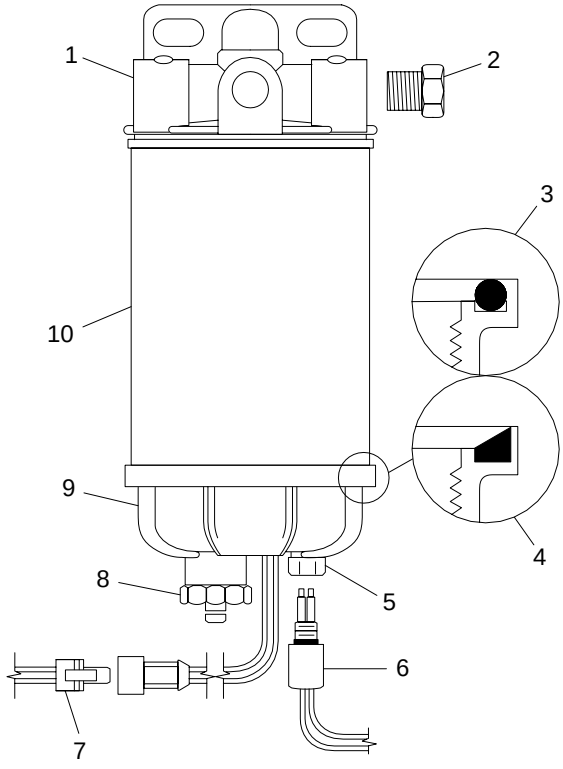
Installation

1. Hold the fuel heater/water separator in place; then install the two capscrews, hexnuts, and hardened washers on the mounting head.

NOTE: Do not use teflon tape when sealing the fuel fittings.

2. Check that the threads on the fuel inlet and outlet fittings are clean. Apply a soft-set pipe thread sealant on the fittings, then install them on the fuel heater/water separator.
3. Connect the heater connector and the water sensor probe connector, if equipped.
4. Prime the fuel heater/water separator.

   4.1 Remove the vent plug (see **Fig. 2**).



1. Mounting Head
2. Vent Plug
3. Bowl O-Ring
4. Bowl Bevel-Cut Gasket
5. Bowl Probe Plug
6. Water Sensor Probe
7. Heater Connector
8. Drain Valve
9. Contaminant Collection Bowl
10. Filter Element

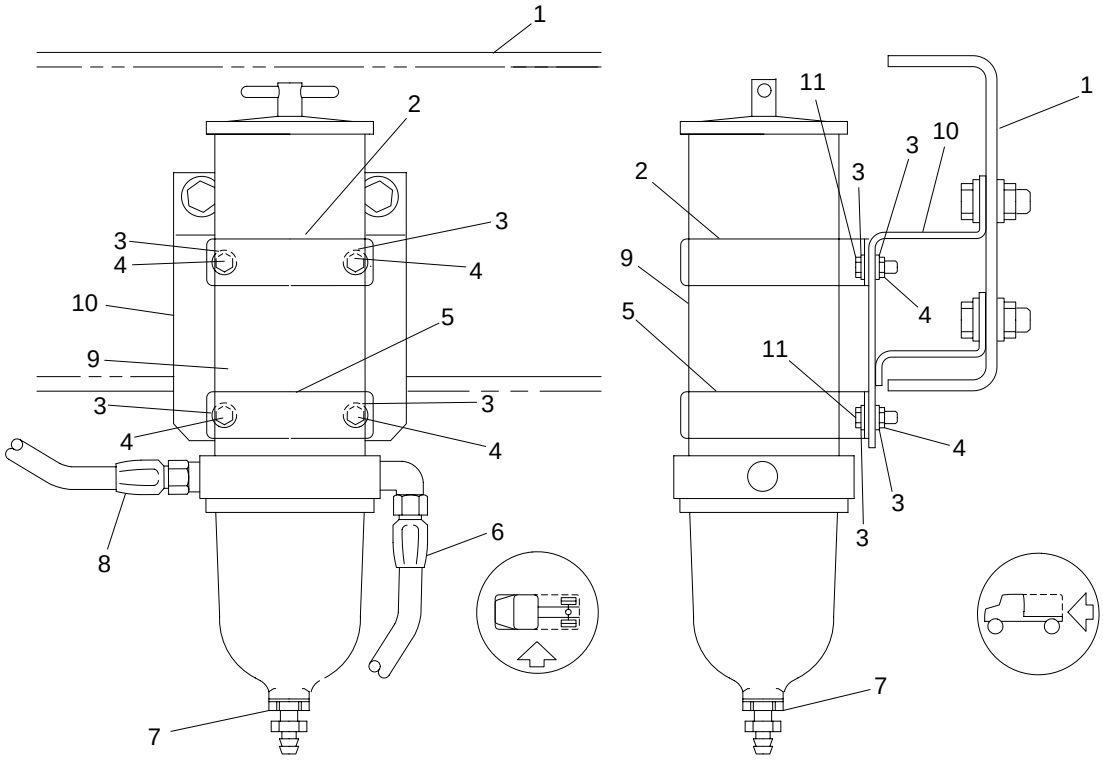
Fig. 2, Racor 690R Fuel Heater/Water Separator (6120R similar)

   4.2 Manually fill the unit with clean diesel fuel.

   4.3 Replace the vent plug.
5. Start the engine and check for fuel leaks. Repair any leaks with the engine OFF.
6. Remove the tire chocks.

Racor 900FG and 1000FG Fuel Heater/Water Separator Removal and Installation

Removal (See Fig. 1 and Fig. 2)



1. Frame Rail
2. Upper Body Clamp Bracket
3. Hardened Washer
4. Hexnut
5. Lower Body Clamp Bracket
6. Fuel Outlet Fitting
7. Drain Valve
8. Fuel Inlet Fitting
9. Filter Element Housing
10. Mounting Bracket
11. Capscrew

Fig. 1, Racor 1000FG Fuel Heater/Water Separator Mounted Inside the Frame Rail (900FG similar)

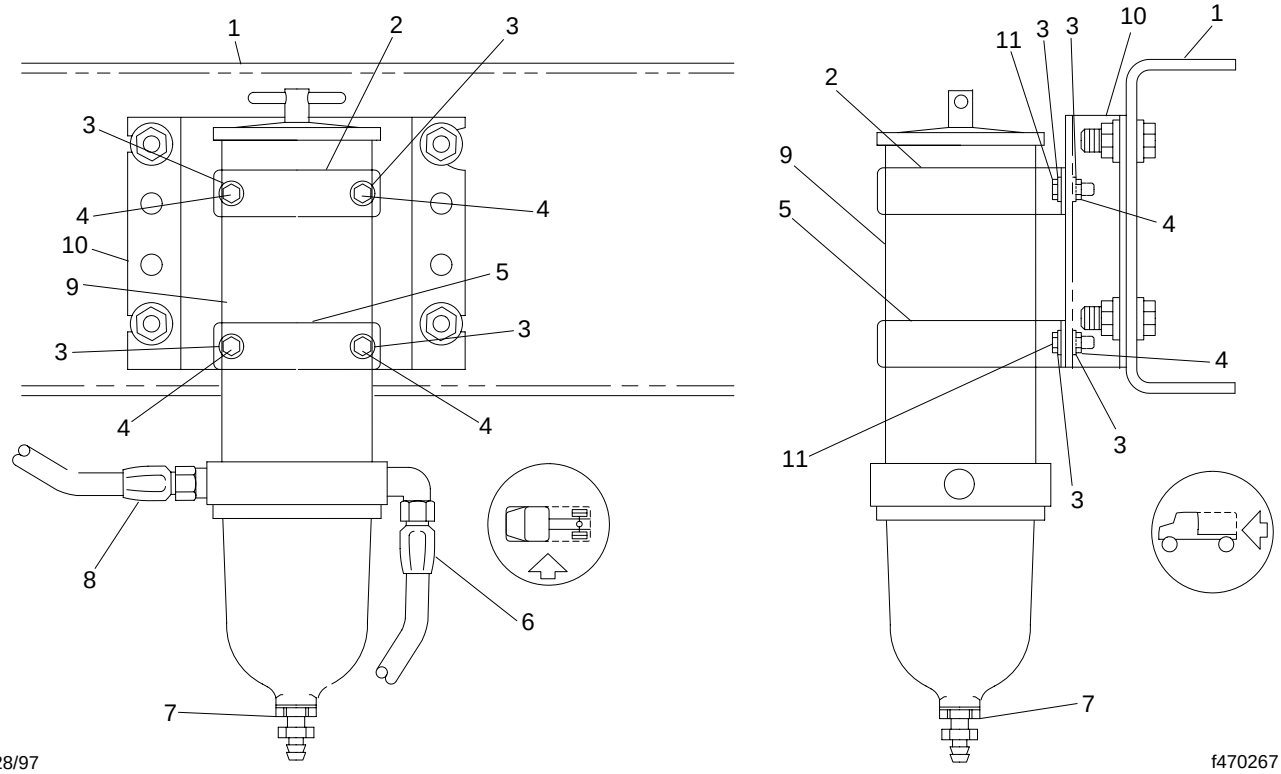
⚠ WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Disconnect the heater connector, and the water sensor probe connector, if equipped.
3. Place a suitable container under the fuel heater/water separator, then drain the fuel from the fuel heater/water separator by opening the drain valve.
4. Place a shop towel under the fuel outlet fitting, then hold the fitting with an open-end wrench. Using a flare-nut wrench, carefully loosen the fuel outlet fitting, then drain any residual fuel into the container. Remove the fitting from the fuel heater/water separator.

   Repeat this step for the fuel inlet fitting.
5. The 900FG has one mounting bracket and the 1000FG has two mounting brackets. Loosen the two hexnuts on the mounting bracket(s). Grasp

Racor 900FG and 1000FG Fuel Heater/Water Separator Removal and Installation



1. Frame Rail
2. Upper Body Clamp Bracket
3. Hardened Washer
4. Hexnut
5. Lower Body Clamp Bracket
6. Fuel Outlet Fitting
7. Drain Valve
8. Fuel Inlet Fitting
9. Filter Element Housing
10. Mounting Bracket
11. Capscrew

Fig. 2, Racor 1000FG Fuel Heater/Water Separator Mounted Outside of the Frame Rail (900FG similar)

the fuel heater/water separator in one hand, and carefully remove the hexnuts, hardened washers, capscrews; then remove the mounting brackets and fuel heater/water separator unit.

Installation

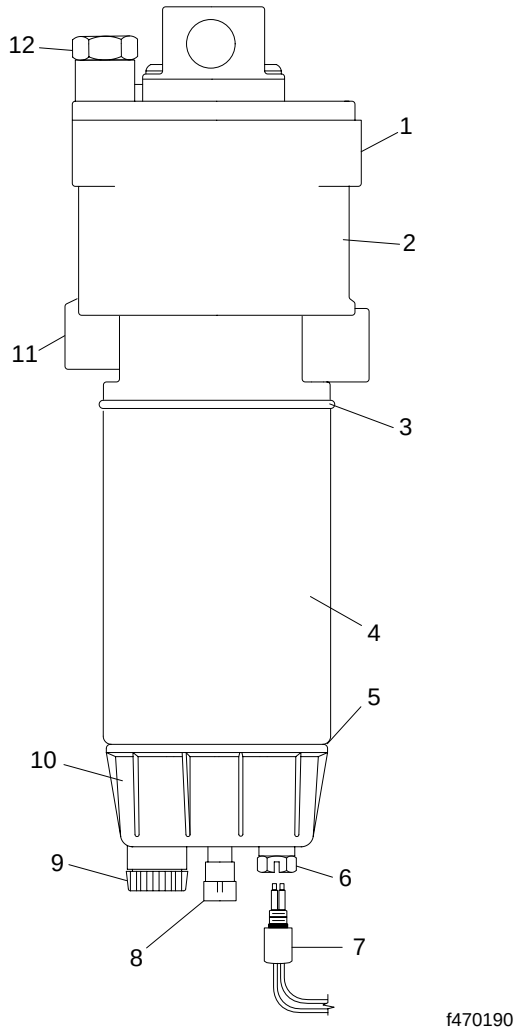
1. Hold the fuel heater/water separator in place along with the mounting bracket; then install the two capscrews, hexnuts, and hardened washers on the mounting bracket. If installing a 1000FG unit install the second mounting bracket, with two capscrews, hexnuts, and hardened washers.

NOTE: Do not use teflon tape when sealing the fuel fittings.

2. Check that the threads on the fuel inlet and outlet fittings are clean. Apply a soft-set pipe thread sealant on the fittings, then install them on the fuel heater/water separator.
3. Connect the heater connector, and the water sensor probe connector, if equipped.
4. Prime the fuel/water separator.
   - 4.1 Remove the fuel/water separator lid by turning the T-handle.
   - 4.2 Fill the fuel/water separator with clean diesel fuel.
   - 4.3 Replace the fuel/water separator lid. Tighten the T-handle hand-tight only.
5. Start the engine and check for fuel leaks. Repair any leaks with the engine OFF.
6. Remove the tire chocks.

Racor 6400 Fuel Heater/Water Separator Removal and Installation

Removal (See Fig. 1)



1. Fuel Inlet
2. Head Assembly
3. Filter Top Seal
4. Filter Element
5. Bowl O-Ring Seal
6. Water Sensor Probe Plug
7. Water Sensor Probe Plug
8. Bowl Heater Connector
9. Drain Valve
10. Contaminant Collection Bowl
11. Fuel Outlet
12. Priming Plug

Fig. 1, Racor 6400 Fuel Heater/Water Separator

WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Disconnect the bowl heater connector, and the water sensor probe connector if equipped.

WARNING

Do not remove or loosen the surge tank cap until the engine and cooling system have completely cooled. Use extreme care when removing the cap. The sudden release of pressure from removing the cap prior to the system cooling can result in a surge of scalding coolant that could cause serious personal injury.

3. With the engine cool, loosen the SAE cap on the surge tank to release cooling system pressure.

WARNING

Do not attempt to drain the cooling system until the coolant and engine are cool. Draining the cooling system prior to the system cooling could cause severe personal injury due to scalding.

4. Place a suitable container under the radiator and drain the cooling system until the level is below the fuel heater/water separator, then tighten the drain valve.
5. Place a suitable container under the fuel heater/water separator, then loosen the coolant inlet, and coolant outlet fittings. Carefully remove the fittings from the unit and allow the remainder of the coolant to drain into the container. Store the coolant for system replenishment.
6. Place a suitable container under the fuel heater/water separator, then drain the fuel from the fuel heater/water separator by opening the drain valve.
7. Place a shop towel under the fuel outlet fitting, then hold the fitting with an open-end wrench. Using a flare-nut wrench, carefully loosen the

Racor 6400 Fuel Heater/Water Separator Removal and Installation

fuel outlet fitting, then drain any residual fuel into the container. Remove the fitting from the fuel heater/water separator.

Repeat this step for the fuel inlet fitting.

8. Loosen the four hexnuts on the mounting head. Grasp the fuel heater/water separator in one hand, and carefully remove the hexnuts, hardened washers, and capscrews; then remove the fuel heater/water separator unit.

Installation

1. Hold the fuel heater/water separator in place; then install the four capscrews, hexnuts, and hardened washers on the mounting head.

NOTE: Do not use teflon tape when sealing the coolant or fuel fittings.

2. Check that the threads on the coolant inlet and outlet fittings are clean. Apply a soft-set pipe thread sealant on the fittings, then install them on the fuel heater/water separator.
3. Check that the threads on the fuel inlet and outlet fittings are clean. Apply a soft-set pipe thread sealant on the fittings, then install them on the fuel heater/water separator.
4. Connect the heater connector and the water sensor probe connectors, if equipped.
5. Prime the fuel heater/water separator.
   - 5.1 Remove the priming plug.
   - 5.2 Fill the fuel heater/water separator with clean diesel fuel.
   - 5.3 Replace the priming plug.
6. Replenish the engine coolant.
7. Start the engine and check for fuel and coolant leaks. Repair any leaks with the engine OFF.
8. Remove the tire chocks.

325R and 330R Fuel Heater/Water Separator Configuration Table			
325R	**P**	**12**	**10**
325R = 60 GPH	In-bowl water sensor probe. Omitted if not equipped.	12 = 12 volts in-bowl fuel heater. Omitted if not equipped.	10 = 10 micron filter
330R = 75 GPH			30 = 30 micron filter

Table 1, 325R and 330R Series Fuel Heater/Water Separator Configuration Table

460R and 490R Fuel Heater/Water Separator Configuration Table			
460R	**P**	**12**	**10**
460R = 60 GPH	In-bowl water sensor probe. Omitted if not equipped.	12 = 12 volt in-bowl fuel heater	2 = 2 micron filter
490R = 90 GPH		24 = 24 volt in-bowl fuel heater	10 = 10 micron filter
		Omitted if not equipped.	30 = 30 micron filter

Table 2, 460R and 490R Series Fuel Heater/Water Separator Configuration Table

690R and 6120R Fuel Heater/Water Separator Configuration Table			
690R	**P**	**12**	**10**
690R = 90 GPH	In-bowl water sensor probe. Omitted if not equipped.	12 = 12 volt in-bowl fuel heater	2 = 2 micron filter
6120R = 120 GPH		24 = 24 volt in-bowl fuel heater	10 = 10 micron filter
		Omitted if not equipped.	30 = 30 micron filter

Table 3, 690R and 6120R Series Fuel Heater/Water Separator Configuration Table

900FG and 1000FG Fuel Heater/Water Separator Configuration Table			
900FG	**P**	**324**	**10**
900FG = 90 GPH	In-bowl water sensor probe. Omitted if not equipped.	312 = 12 volt in-bowl fuel heater.	2 = 2 micron filter
1000FG = 180 GPH		324 = 24 volt in-bowl fuel heater.	10 = 10 micron filter
		Omitted if not equipped.	30 =30 micron filter

Table 4, 900FG and 1000FG Series Fuel Heater/Water Separator Configuration Table

Specifications

6400 Series Fuel Heater/Water Separator Configuration Table			
6400	**P**	**N**	**12**
6400 - Base Model	In-bowl water sensor probe. Omitted if not equipped.	10 = 10 micron filter	12 = 12 volt in-bowl fuel heater.
6401 *		30 = 30 micron filter	24 = 24 volt in-bowl fuel heater.
		N = Nautilus †	Omitted if not equipped.

* This model includes an automatic coolant thermostat.
† The Nautilus filter element is for water separation only. It does not remove particulates from the diesel fuel.

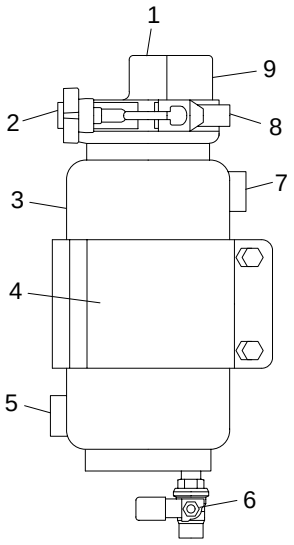
Table 5, 6400 Series Fuel Heater/Water Separator Configuration Table

General Description

Webb 525, 525/ACV and 525ACV/F Fuel Heater/Water Separators

(See Fig. 1, Fig. 2, or Fig. 3)

The Webb 525 series of fuel heater/water separators heat and remove water and solid contaminants from diesel fuel. These units are liquid-to-liquid heat exchangers, as well as fuel filters. Fuel is heated by engine coolant as it's drawn through the heater unit. The Webb 525 fuel heater/water separator is available in three configurations, the 525, 525/ACV, and the 525ACV/F. Each model of the 525 is a coolant-type fuel heater/water separator. The 525/ACV is equipped with an automatic coolant valve (ACV) to regulate fuel temperature. The 525ACV/F includes an automatic coolant valve and a secondary top-mounted fuel filter.



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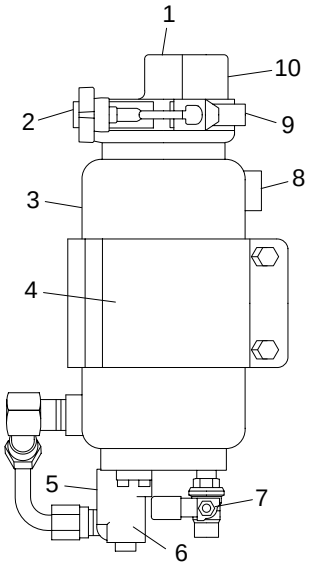
1. Fuel Inlet
2. T-Handle
3. Fuel Heater/Water Separator Housing
4. Mounting Bracket
5. Coolant Inlet
6. Drain Valve
7. Coolant Outlet
8. Cover Clamp
9. Fuel Outlet

Fig. 1, Webb 525 Fuel Heater/Water Separator



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1. Fuel Inlet
2. T-Handle
3. Fuel Heater/Water Separator Housing
4. Mounting Bracket
5. Coolant Inlet
6. Automatic Coolant Valve (ACV) Unit
7. Drain Valve
8. Coolant Outlet
9. Cover Clamp
10. Fuel Outlet

Fig. 2, Webb 525/ACV

Webb Hot STK and Hot STK/ACV In-Tank/Standpipe Fuel Heaters

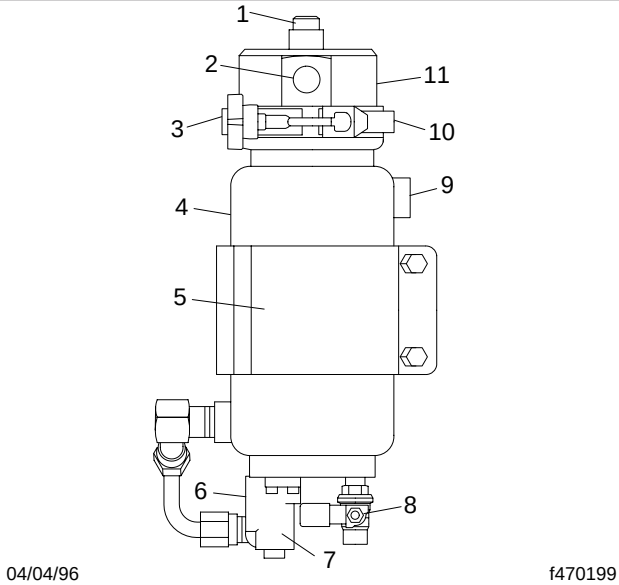
(See Fig. 4 or Fig. 5)

The Webb hot STK and hot STK/ACV in-tank/standpipe fuel heaters are liquid-to-liquid heat exchangers. Fuel is heated by engine coolant as the coolant circulates through the fuel tank standpipe. The hot STK/ACV is equipped with an automatic coolant valve (ACV) to regulate fuel temperature.

Webb W8791 and W8791/ACV Inline Fuel Heaters **(See Fig. 6)**

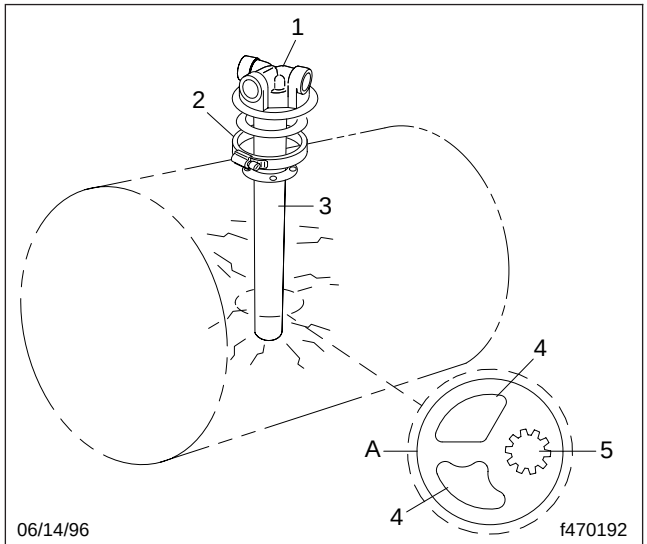
The Webb W8791 inline fuel heater is a liquid-to-liquid heat exchanger. Fuel is heated by engine coolant as it's drawn through the heater unit. The W8791 is also available with an automatic coolant valve (ACV) to regulate fuel temperature.

General Description and Principles of Operation



1. Secondary Fuel Filter Nipple
2. Fuel Inlet
3. T-Handle
4. Fuel Heater/Water Separator Housing
5. Mounting Bracket
6. Coolant Inlet
7. Automatic Coolant Valve (ACV) Unit
8. Drain Valve
9. Coolant Outlet
10. Cover Clamp
11. Fuel Outlet

Fig. 3, Webb 525ACV/F



A. Standpipe Cross-section
1. Fuel Heater Head
2. Clamp
3. Heated Fuel Standpipe
4. Coolant Passage
5. Fuel Passage (not used)

Fig. 4, Webb Hot STK In-Tank/Standpipe Fuel Heater, Typical Installation

Principles of Operation

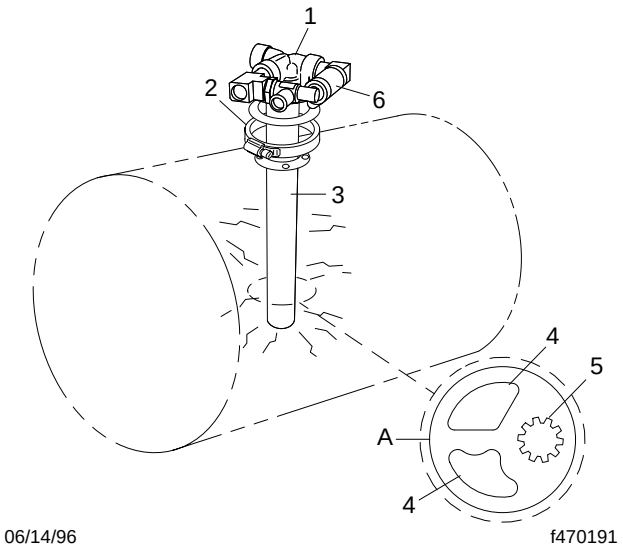
Webb 525, 525/ACV and 525ACV/F Fuel Heater/Water Separators

(See Fig. 7)

Diesel fuel enters the fuel inlet at the top of the separator, then flows down the center tube toward the bottom. Water and contaminants are stripped from the fuel by the stripper screen as the fuel flows upward toward the fuel outlet. The water and heavy contaminants collect at the bottom, where they can be removed by opening the drain valve at the base of the unit. On the 525 and the 525/ACV, the fuel exits the stripper screen then exits the fuel/water separator ; on the 525ACV/F, the fuel exits the stripper screen then flows through the secondary fuel filter where it is further cleaned, before exiting the unit. The fuel is heated by engine coolant that passes around the fuel in a separate water jacket. The hot coolant keeps the fuel at a temperature where ice crystals and wax will not form. The automatic coolant valve on ACV-equipped models uses a power pill (fuel temperature thermostat) to regulate the amount of coolant flowing through the coolant jacket. When fuel temperature is low the ACV opens, allowing coolant to heat the fuel. When fuel temperature reaches 80°F (27°C) the ACV closes to restrict coolant flow through the 525.

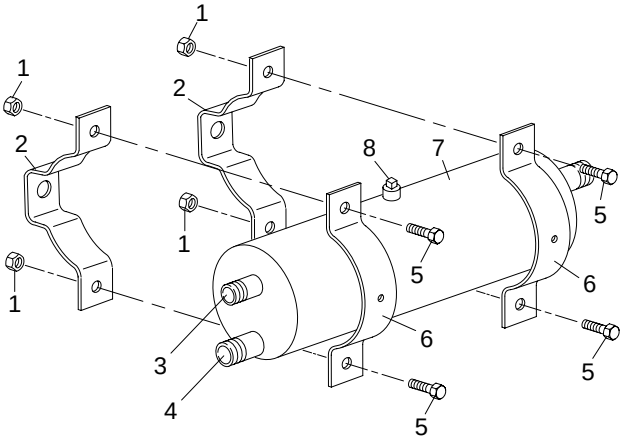
Webb Hot STK and Hot STK/ACV In-Tank/Standpipe Fuel Heaters

Engine coolant flows through the in-tank stand-pipe, radiating heat throughout the fuel tank. This process prevents the formation of ice crystals and wax in the fuel tank. The ACV version of the standpipe heater is equipped with an automatic coolant valve that regulates the flow of coolant into the standpipe. The automatic coolant valve on ACV-equipped models uses a fuel temperature thermostat to regulate the amount of coolant flowing through the standpipe. When fuel temperature is low the ACV opens, allowing coolant to heat the fuel. When fuel temperature reaches 80°F (27°C) the ACV closes to restrict coolant flow through the unit.



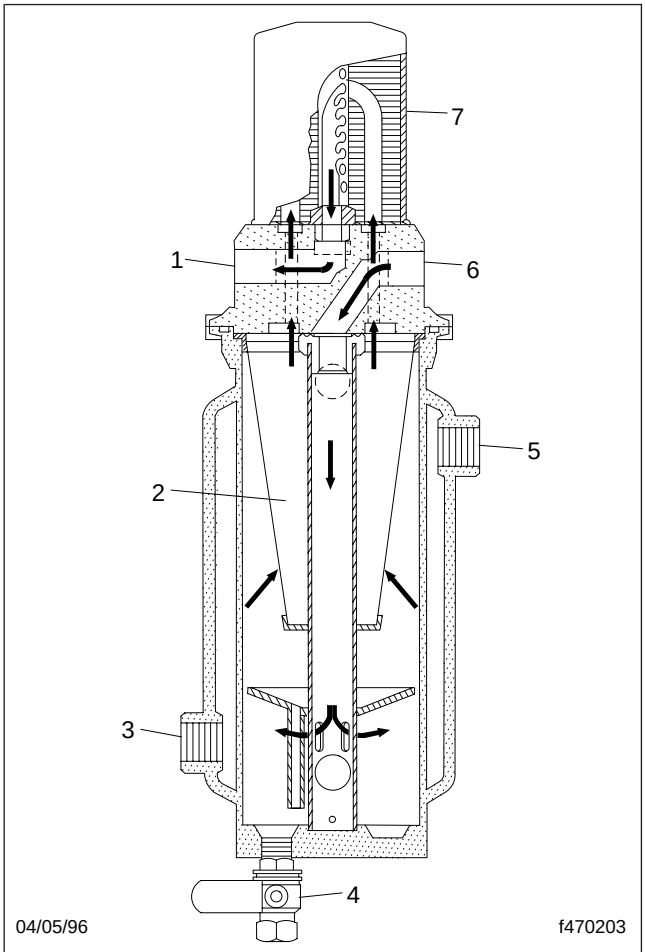
A. Standpipe Cross-section
1. Fuel Heater Head
2. Clamp
3. Heated Fuel Standpipe
4. Coolant Passage
5. Fuel Passage
6. ACV Unit

Fig. 5, Webb Hot STK/ACV In-Tank/Standpipe Fuel Heater, Typical Installation



1. Locknut
2. Mounting Bracket Saddle
3. Coolant Port
4. Fuel Port
5. Capscrew
6. Mounting Bracket
7. Fuel Heater
8. Coolant Vent Plug

Fig. 6, Webb W8791 Inline Fuel Heater



1. Fuel Outlet
2. Stripper Screen
3. Coolant Inlet
4. Drain Valve
5. Coolant Outlet
6. Fuel Inlet
7. Secondary Fuel Filter

Fig. 7, Fuel Flow Through the Webb 525ACV/F Fuel Heater/Water Separator (525 and 525/ACV similar)

Webb W8791 and W8791/ACV Inline Fuel Heaters

Engine coolant flows through the inline fuel heater. Coolant fills the cavity within the housing that surrounds the fuel passage. The coolant heats the fuel as it passes through the fuel heater. This process prevents the formation of ice crystals and wax in the fuel. The automatic coolant valve on ACV-equipped models uses a fuel temperature thermostat to regulate the amount of coolant flowing through the unit. When fuel temperature is low the ACV opens, allowing coolant to heat the fuel. When fuel temperature

General Description and Principles of Operation

reaches 80°F (27°C) the ACV closes to restrict coolant flow through the unit.

Webb 525, 525/ACV, and 525ACV/F Fuel Heater/Water Separator Removal and Installation

Removal (See Fig. 1 , Fig. 2, Fig. 3, and Fig. 4)

WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.

WARNING

Do not remove or loosen the surge tank cap until the engine and cooling system have completely cooled. Use extreme care when removing the cap. The sudden release of pressure from removing the cap prior to the system cooling can result in a surge of scalding coolant that could cause serious personal injury.

2. With the engine cool, loosen the SAE cap on the surge tank to release cooling system pressure.

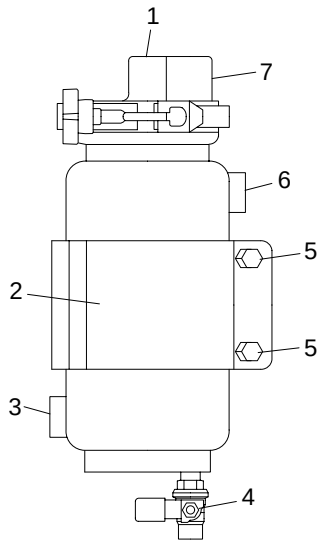
WARNING

Do not attempt to drain the cooling system until the coolant and engine are cool. Draining the cooling system prior to the system cooling could cause severe personal injury due to scalding.

3. Place a suitable container under the radiator and drain the cooling system until the level is below the fuel heater/water separator, then tighten the drain valve.
4. Place a suitable container under the fuel heater/water separator, then loosen the coolant inlet, and coolant outlet fittings. Carefully remove the fittings from the unit and allow the remainder of the coolant to drain into the container. Store the coolant for system replenishment.
5. Place a suitable container under the fuel heater/water separator, then drain the fuel from the fuel heater/water separator by opening the drain valve.
6. Loosen the fuel inlet and outlet fittings, then drain any residual fuel into the container. Remove the fittings from the fuel heater/water separator.
7. Loosen the two capscrews on the mounting bracket. Grasp the fuel heater/water separator in one hand, and carefully remove the two capscrews from the mounting bracket.

NOTE: When the two capscrews are removed from the mounting bracket, the bracket will separate.

8. Remove the fuel heater/water separator from the vehicle.



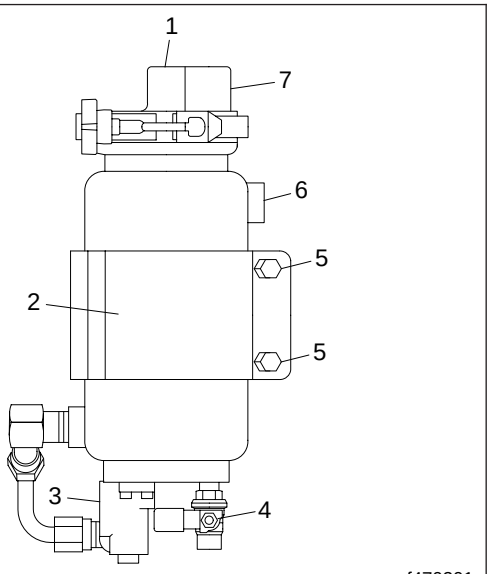
1. Fuel Inlet
2. Mounting Bracket
3. Coolant Inlet
4. Drain Valve
5. Mounting Bracket Capscrew
6. Coolant Outlet
7. Fuel Outlet

Fig. 1, Webb 525 Fuel Heater/Water Separator

Installation

1. Place the fuel heater/water separator in the mounting bracket half mounted to the vehicle. Place the other half of the bracket over the fuel

Webb 525, 525/ACV, and 525ACV/F Fuel Heater/Water Separator Removal and Installation



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1. Fuel Inlet
2. Mounting Bracket
3. Coolant Inlet
4. Drain Valve
5. Mounting Bracket Capscrew
6. Coolant Outlet
7. Fuel Outlet

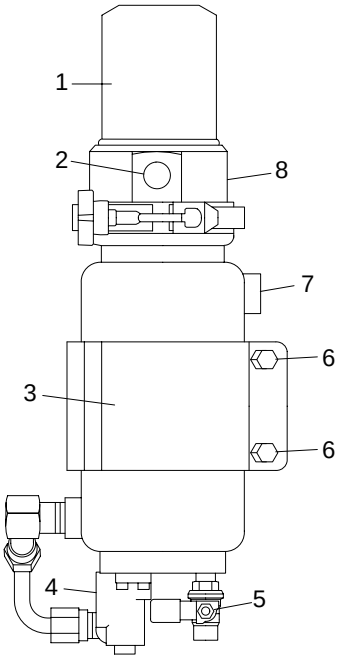
Fig. 2, Webb 525/ACV Fuel Heater/Water Separator

heater/water separator, then secure the bracket with the two capscrews.

2. Tighten the mounting bracket capscrews until snug.

NOTE: Do not use teflon tape when sealing the coolant or fuel fittings.

3. Check that the threads on the coolant inlet and outlet fittings are clean. Apply a soft-set pipe thread sealant on the fittings, then install them to the fuel heater/water separator.
4. Check that the threads on the fuel inlet and outlet fittings are clean. Apply a soft-set pipe thread sealant on the fittings, then install them to the fuel heater/water separator.
5. Loosen the T-handle, then remove the cover.
6. Check that the drain valve is in the closed position.
7. Fill the unit with clean diesel fuel.



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1. Secondary Fuel Filter
2. Fuel Inlet
3. Mounting Bracket
4. Coolant Inlet
5. Drain Valve
6. Mounting Bracket Capscrew
7. Coolant Outlet
8. Fuel Outlet

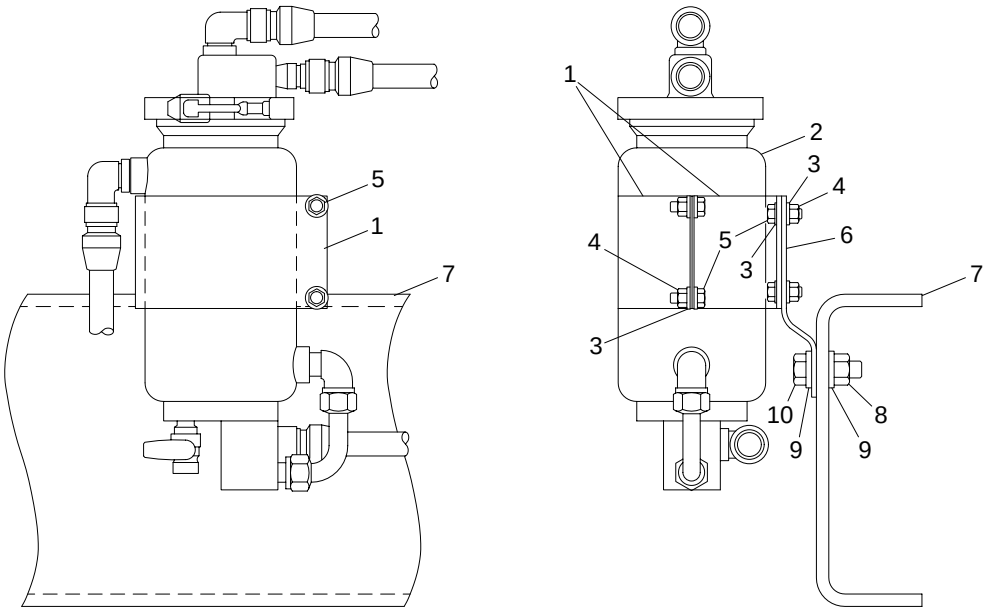
Fig. 3, Webb 525ACV/F Fuel Heater/Water Separator

⚠ CAUTION

Do not tighten the T-handle with pliers or a wrench. Overtightening the T-handle will cause a fuel leak at the cover.

8. Install the cover and cover clamp, then tighten the T-handle until snug.
9. Start the engine and check for fuel leaks. Repair any leaks with the engine OFF.
10. Remove the tire chocks.

Webb 525, 525/ACV, and 525ACV/F Fuel Heater/Water Separator Removal and Installation



1. Bracket Set
2. Separator Body
3. Flatwasher
4. 3/8–16 Hexnut
5. 3/8–16 Capscrew
6. Mounting Bracket
7. Frame Rail
8. 5/8–11 Locknut
9. Hardened Flatwasher
10. 5/8–11 Capscrew

Fig. 4, Webb 525 series Fuel Heater/Water Separator Mounting (525/ACV shown, 525 and 525ACV/F similar)

Webb 525, 525/ACV, and 525ACV/F Fuel Heater/Water Separator Stripper Screen Removal, Cleaning, and Installation

Removal (See Fig. 1 or Fig. 2)

⚠ WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Place a suitable container under the fuel heater/water separator.
3. Open the drain valve by rotating the drain valve handle, then empty all of the fuel out of the unit.

NOTE: If fuel does not flow when the drain valve is opened, insert a suitable tool into the drain valve to release sediment and encourage fuel flow.

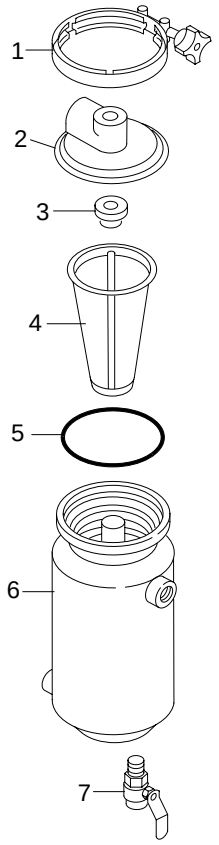
4. On the 525ACV/F, use a chain or strap wrench and remove the secondary fuel filter before loosening the T-handle.
5. Loosen the T-handle to release the cover clamp.
6. Squeeze the cover clamp until the T-handle can be rotated off the cover clamp, then remove the cover clamp from the fuel heater/water separator unit.
7. Remove the fuel heater/water separator cover, then remove the check seal.

NOTE: Do not discard the check seal. It must be reinstalled for the unit to work properly.

8. Grasp the large tabs on the stripper screen. Pull upward on the screen while twisting slightly to remove the screen from the unit.

Cleaning

NOTE: Do not attempt to clean the stripper screen with a brush. Cleaning the stripper screen in this manner will destroy the screen.



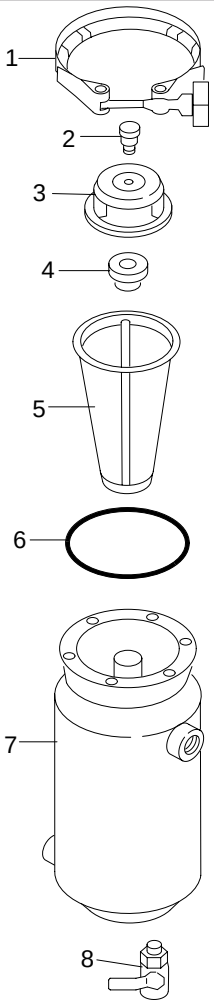
1. Cover Clamp
2. Cover
3. Check Seal
4. Stripper Screen
5. O-Ring
6. Fuel Heater/Water Separator Housing
7. Drain Valve

Fig. 1, Webb 525 and 525/ACV Fuel Heater/Water Separator, Exploded View

NOTE: Do not attempt to clean secondary fuel filters. Secondary fuel filters are sealed units and cannot be cleaned.

Rinse the stripper screen in clean diesel fuel, or Stanisol. The stripper screen is designed to be reused. Do not replace the stripper screen unless sediment cannot be adequately removed from the screen.

Webb 525, 525/ACV, and 525ACV/F Fuel Heater/Water Separator Stripper Screen Removal, Cleaning, and Installation



1. Cover Clamp
2. Secondary Fuel Filter Nipple
3. Cover
4. Check Seal
5. Stripper Screen
6. O-Ring
7. Fuel Heater/Water Separator Housing
8. Drain Valve

Fig. 2, Webb 525ACV/F Fuel Heater/Water Separator, Exploded View

Installation

1. Install the cleaned stripper screen by pushing the screen over the center tube until it bottoms out.
2. Install the check seal on the fuel inlet tube.
3. Check that the drain valve is fully closed.
4. Fill the fuel heater/water separator with clean diesel fuel.
5. Inspect the cover O-ring for cracks or other damage. Replace as needed.
6. Coat the O-ring with a light grease and place it on the cover, then install the cover on the unit.

⚠ CAUTION

Do not tighten the T-handle with pliers or a wrench. Overtightening the T-handle will cause a fuel leak at the cover.

7. Place the cover clamp around the cover and the housing. Squeeze the clamp together to seat the T-handle, then tighten until snug.
8. On the 525ACV/F, apply a light coat of diesel fuel to the secondary fuel filter gasket, then screw the filter on to the cover until snug. Use a chain or strap wrench and tighten an additional one-half turn.
9. Start the engine and check for fuel leaks. Repair all fuel leaks with the engine OFF.
10. Remove the tire chocks.

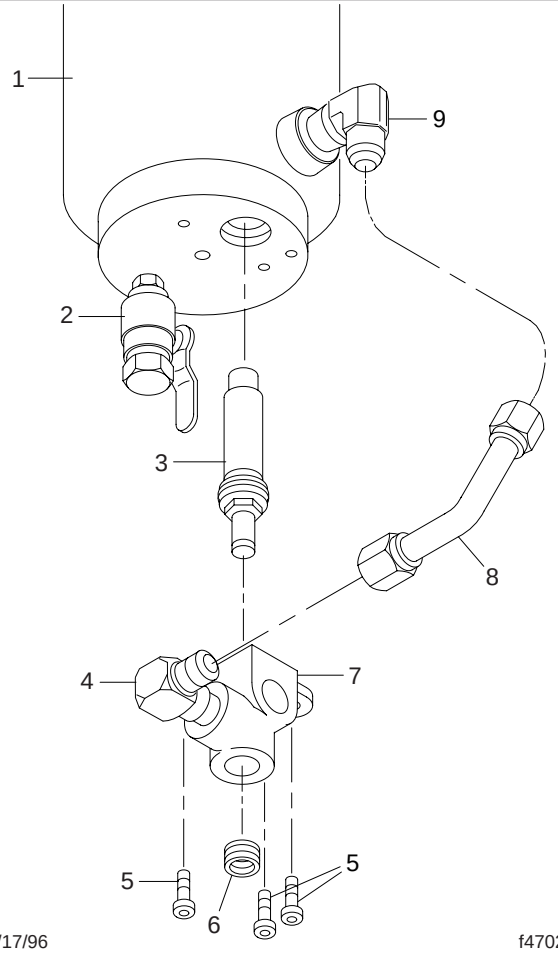
Webb 525/ACV and 525ACV/F Fuel Heater/Water Separator Automatic Coolant Valve (ACV) and ACV Power Pill Replacement

Replacement

⚠ WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

1. Remove the fuel heater/water separator. For instructions, see **Subject 100**.
2. Place the fuel heater/water separator upside down on a clean work area.
3. Secure the 90-degree fittings (see **Fig. 1**, Ref. 4 and 9) with an open-end wrench, then using a flare-nut wrench loosen the flare nuts at each fitting and remove the steel tube.
4. Remove the three allen-head screws from the ACV housing, then remove it from the fuel heater/water separator.
5. Remove the power pill from the fuel heater/water separator housing.
6. Clean the sealing area on the ACV housing, and the fuel heater/water separator, but do not use a harsh abrasive that may damage the aluminum body or housing.
7. Coat the power pill's O-rings with a light oil, then insert the power pill into the fuel heater/water separator.
8. Place the ACV housing over the power pill, then press firmly into place.
9. Apply a light coat of anti-seize compound to the three allen-head screws, then install them in the ACV housing. Tighten the allen head screws 75 lbf·in (850 N·cm).
10. Align the steel tube with the 90-degree fittings, then tighten the flare nuts until snug.
11. Install the fuel heater/water separator using the instructions in **Subject 100**.



1. Fuel Heater/Water Separator
2. Drain Valve
3. Power Pill
4. 90-Degree Fitting
5. Allen-Head Screw
6. Pipe Plug
7. ACV Housing
8. Steel Tube
9. Housing-Mounted 90-Degree Fitting

Fig. 1, ACV as Mounted on Webb 525/ACV and 525ACV/F Fuel Heater/Water Separator

Webb Hot STK and Hot STK/ACV In-Tank/Standpipe Fuel Heater Replacement

Replacement

⚠ WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

NOTE: The Webb Hot STK and Hot STK/ACV contain an integral coolant-type fuel heater. There are no serviceable parts. If the Hot STK, or Hot STK/ACV is leaking, it must be replaced.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Disconnect the fuel outlet fitting from the fuel heater (Hot STK ACV only).

⚠ WARNING

Do not remove or loosen the surge tank cap until the engine and cooling system have completely cooled. Use extreme care when removing the cap. The sudden release of pressure from removing the cap prior to the system cooling can result in a surge of scalding coolant that could cause serious personal injury.

3. Loosen the SAE cap on the cooling system surge tank to relieve system pressure.

⚠ WARNING

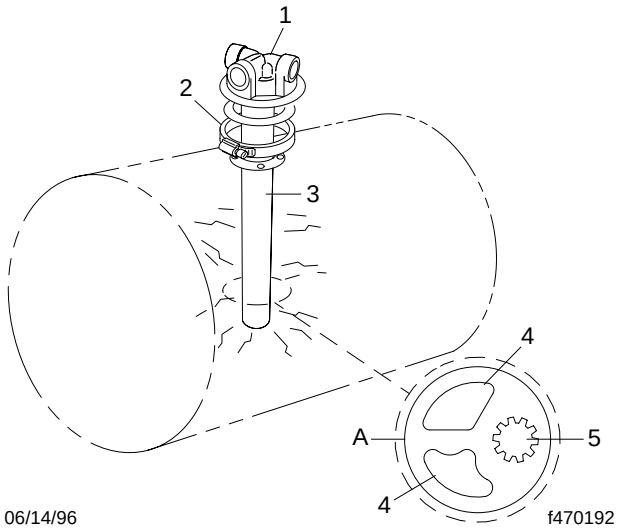
Do not attempt to drain the cooling system until the coolant and engine are cool. Draining the cooling system prior to the system cooling could cause severe personal injury due to scalding.

4. Drain the cooling system until the coolant level is below the coolant fittings on the fuel heater head.
5. Place a suitable container under the fuel tank. Use as flare-nut wrench and loosen the coolant fittings on the Webb Hot STK, or Hot STK/ACV. Disconnect the fittings from the fuel heater head and drain any residual coolant from the coolant lines into the container. See **Fig. 1**, **Fig. 2**, **Fig. 3**, and **Fig. 4**.
6. Loosen the clamp that secures the fuel heater to the fuel tank. See **Fig. 5**.
7. Carefully lift the fuel heater out of the fuel tank.
8. Install the Hot STK or Hot STK/ACV fuel heater.
   - 8.1 Place the clamp around the flange at the base of the fuel heater head.
   - 8.2 Lower the fuel heater into the fuel tank.
   - 8.3 Position the head of the fuel heater to accept the coolant lines.
   - 8.4 Place the clamp around the adapter flange on the fuel tank, then tighten the clamp until snug.

NOTE: Do not use teflon tape when sealing the fuel or coolant fittings.

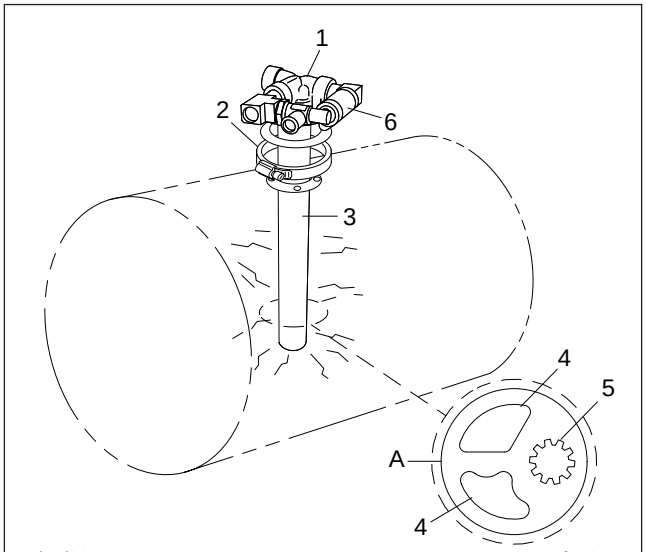
9. Install the coolant fittings to the fuel heater.
   - 9.1 Check that the coolant fittings are clean, then apply Loctite® 592 or equivalent to the fittings threads.
   - 9.2 Install the coolant fittings to the fuel heater and tighten until snug.
10. Install the fuel fittings to the fuel heater (Hot STK/ACV only).
    - 10.1 Check that the fuel fitting is clean, then apply a Loctite 592 or equivalent to the fitting threads.
    - 10.2 Install the fuel fitting to the fuel heater and tighten until snug.
11. Fill the cooling system.
12. Start the engine and check for fuel and coolant leaks. Repair any leak with the engine OFF.
13. Remove the tire chocks.

Webb Hot STK and Hot STK/ACV In-Tank/Standpipe Fuel Heater Replacement



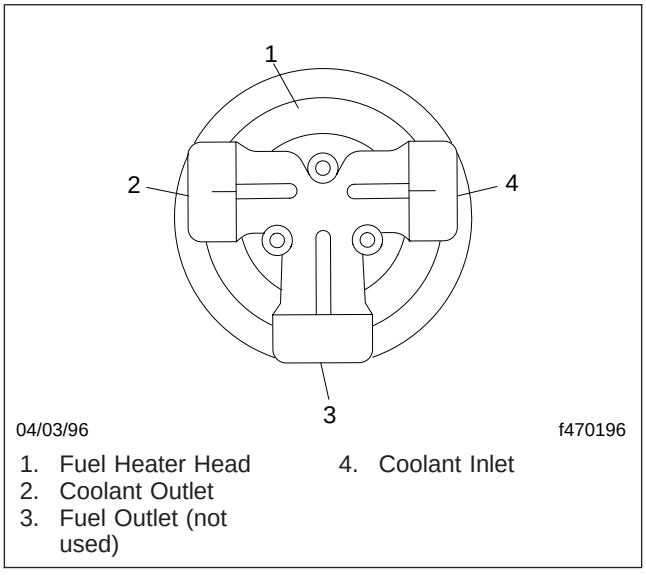
A. Standpipe Cross-Section
1. Fuel Heater Head
2. Clamp
3. Heated Fuel Standpipe
4. Coolant Passage
5. Fuel Passage (not used)

Fig. 1, Webb Hot STK In-Tank/Standpipe Fuel Heater, Typical Installation



A. Standpipe Cross-Section
1. Fuel Heater Head
2. Clamp
3. Heated Fuel Standpipe
4. Coolant Passage
5. Fuel Passage
6. Automatic Coolant Valve (ACV) Unit

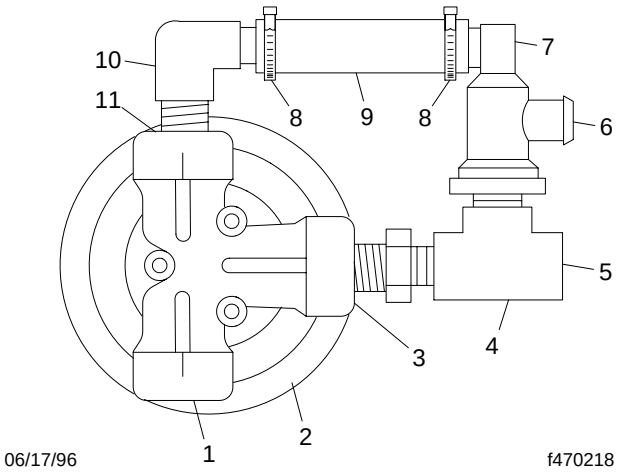
Fig. 2, Webb Hot STK/ACV In-Tank/Standpipe Fuel Heater, Typical Installation



1. Fuel Heater Head
2. Coolant Outlet
3. Fuel Outlet (not used)
4. Coolant Inlet

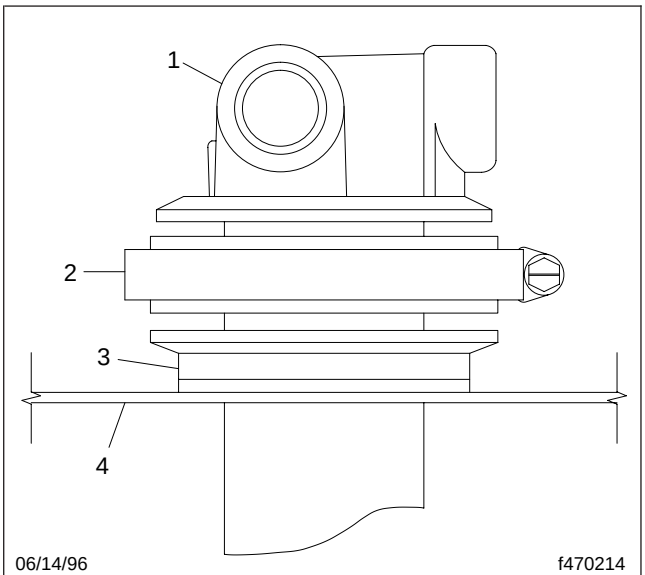
Fig. 3, Webb Hot STK Coolant and Fuel Port Locations

Webb Hot STK and Hot STK/ACV In-Tank/Standpipe Fuel Heater Replacement



1. Coolant Outlet
2. Fuel Heater Head
3. Fuel Port
4. Fuel Fitting Assembly
5. Fuel Outlet
6. Coolant Inlet
7. Automatic Coolant Valve (ACV)
8. 5/8" Hose Clamp
9. Hose
10. 90-Degree Hose Fitting
11. Coolant Port

Fig. 4, ACV Assembly Mounted on the Webb Hot STK/ ACV Fuel Heater



1. Fuel Heater Head
2. Clamp
3. Adaptor Flange
4. Fuel Tank

Fig. 5, Webb Hot STK/ACV Fuel Heater Head Mounting

Webb Hot STK/ACV In-Tank/Standpipe Automatic Coolant Valve (ACV) Replacement

Replacement (See Fig. 1)

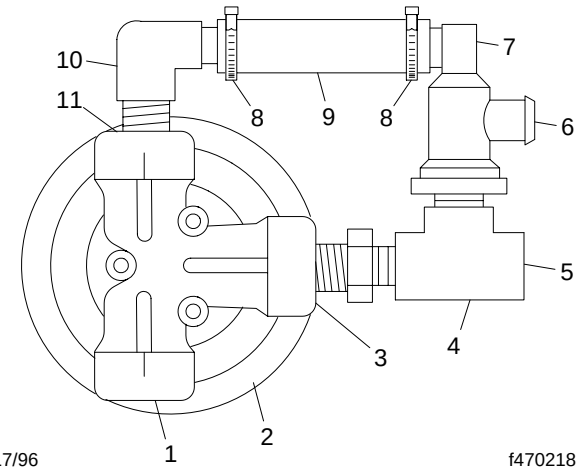
⚠ WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

1. Park the vehicle on a level surface. Apply the parking brakes and chock the tires.
2. Place a suitable container under the radiator, then drain the coolant until the level is below the Hot STK/ACV mounting head. Tighten the drain valve.
3. Place a suitable container under the fuel tank.
4. Disconnect the hose clamp closest to the ACV unit.
5. Carefully separate the coolant inlet hose from the ACV unit.
6. Carefully separate the coolant hose from the ACV unit.
7. Place a suitable container under the fuel tank to catch any residual fuel.
8. Place a shop towel under the fuel outlet fitting, then hold the fitting with an open-end wrench.
9. Using a flare-nut wrench, Carefully remove the ACV unit from the fuel outlet fitting.
10. Clean the thread area of any debris or fuel and allow to dry.

NOTE: The ACV has pipe sealant applied to the threads. No other sealant is required. If the thread sealant has been removed, apply Loctite®592 or equivalent to the ACV threads. Do not use teflon tape.

11. Install the new ACV unit by hand to prevent cross-threading the unit.
12. Tighten the ACV by securing the fuel outlet fitting with an open-end wrench, and turning the the ACV clockwise with a flare-nut wrench.
13. Tighten the unit until it is snug, and the coolant ports are positioned properly for hose installation.
14. Place a new hose clamp onto the coolant hose, then secure the hose to the ACV unit. Tighten the clamp until snug.
15. Place a new hose clamp over the coolant inlet hose, then install the hose onto the ACV unit. Tighten the hose clamp until snug.
16. Fill the cooling system using the instructions in Group 20 of the *Heavy-Duty Trucks Maintenance Manual*.
17. Start the engine and check for coolant and fuel leaks. Repair any leaks with the engine OFF.



1. Coolant Outlet
2. Hot STK Mounting Head
3. Fuel Port
4. Fuel Outlet Fitting
5. Fuel Outlet
6. Coolant Inlet
7. Automatic Coolant Valve (ACV) Unit
8. Hose Clamp
9. Coolant Hose
10. 90-Degree Fitting
11. Coolant Inlet Port

Fig. 1, ACV as Mounted on Webb Hot STK/ACV Fuel Heater

Webb W8791 and W8791/ACV Fuel Heater Replacement

Replacement

⚠ WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.

⚠ WARNING

Do not remove or loosen the surge tank cap until the engine and cooling system have completely cooled. Use extreme care when removing the cap. The sudden release of pressure from removing the cap prior to the system cooling can result in a surge of scalding coolant that could cause serious personal injury.

2. Loosen the SAE cap on the cooling system surge tank to relieve system pressure.

⚠ WARNING

Do not attempt to drain the cooling system until the coolant and engine are cool. Draining the cooling system prior to the system cooling could cause severe personal injury due to scalding.

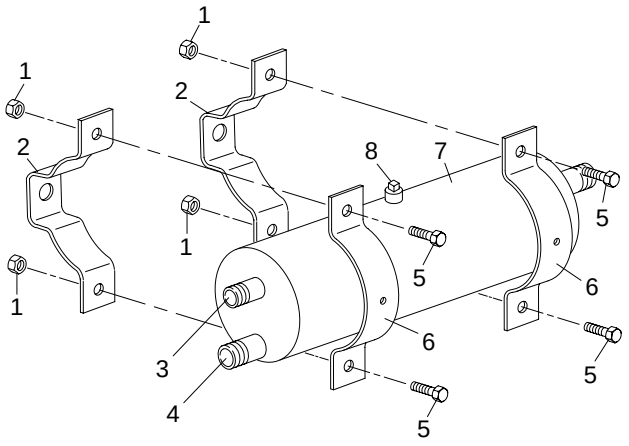
3. Drain the cooling system.
4. Drain the coolant from the fuel heater.
   - 4.1 Place a suitable container under the fuel heater. Use a flare-nut wrench and loosen the coolant fittings.
   - 4.2 Disconnect the fittings and allow any residual coolant from the coolant hoses to drain into the container.
5. Drain the fuel from the fuel heater.
   - 5.1 Place a suitable container under the fuel heater.
   - 5.2 Use a flare-nut wrench and disconnect the fuel inlet fitting, then allow any fuel to drain into the container.
   - 5.3 Use a flare-nut wrench to disconnect the fuel outlet fitting, then allow any fuel to drain into the container.
6. Remove the fuel heater from the vehicle. See **Fig. 1**.
   - 6.1 Cap the fuel and coolant ports with pipe plugs, or other suitable closure.
   - 6.2 Loosen the four locknuts and capscrews.
   - 6.3 Remove the upper locknuts and capscrews.
   - 6.4 Hold pressure against the fuel heater and carefully remove the lower capscrews and locknuts, then remove the mounting brackets.
   - 6.5 Carefully lower the fuel heater away from the frame.
   - 6.6 Remove the covers from the coolant ports and drain any residual coolant into the proper container.
   - 6.7 Remove the covers from the fuel ports and drain any residual fuel into the proper container.
7. Place the fuel heater on the mounting bracket saddles.
8. Install the mounting brackets, then install the four capscrews and locknuts. Tighten the capscrews and locknuts until snug.

NOTE: Do not use teflon tape when sealing the coolant or fuel fittings.

9. Check that the coolant fittings are clean, then apply a soft-setting pipe thread sealant to the fittings.
10. Install the coolant fittings on the fuel heater and tighten until snug.
11. Check that the fuel fittings are clean, then apply a soft-setting pipe thread sealant to the fittings.
12. Install the fuel fittings on the fuel heater and tighten until snug.
13. Fill the cooling system.

Webb W8791 and W8791/ACV Fuel Heater Replacement

14. Loosen the coolant vent plug, then bleed the air out of the system until no air bubbles are present, and only coolant appears at the vent.
15. Tighten the coolant vent plug.
16. Top off the cooling system, replace the surge tank cap, and start the engine.
17. Check for coolant and fuel leaks. Repair any coolant or fuel leak with the engine OFF.
18. Remove the tire chocks.



1. Locknut
2. Mounting Bracket Saddle
3. Coolant Port
4. Fuel Port
5. Capscrew
6. Mounting Bracket
7. Fuel Heater
8. Coolant Vent Plug

Fig. 1, Webb W8791 Inline Fuel Heater

Webb W8791/ACV Fuel Heater Automatic Coolant Valve (ACV) and ACV Thermostat Replacement

Replacement

WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.

WARNING

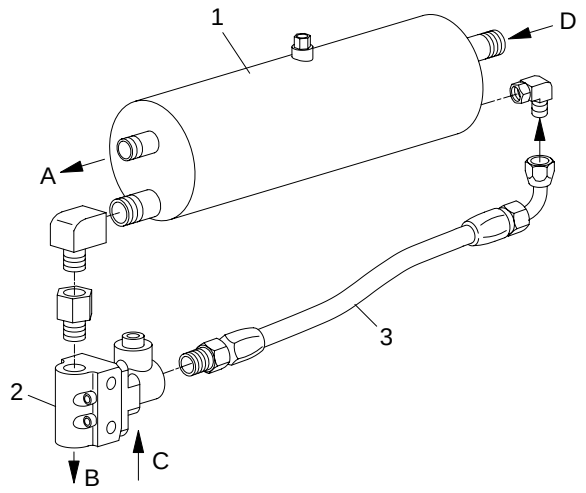
Do not remove or loosen the surge tank cap until the engine and cooling system have completely cooled. Use extreme care when removing the cap. The sudden release of pressure from removing the cap prior to the system cooling can result in a surge of scalding coolant that could cause serious personal injury.

2. Place a suitable container under the radiator and drain the cooling system.

WARNING

Do not attempt to drain the cooling system until the coolant and engine are cool. Draining the cooling system prior to the system cooling could cause severe personal injury due to scalding.

3. Place a suitable container under the W8791 fuel heater and disconnect the coolant inlet line. See **Fig. 1**. Drain any residual coolant into the container.
4. Place a suitable container under the ACV and disconnect the fuel outlet fitting. Drain any fuel into the container.
5. Remove the four capscrews from the ACV body. See **Fig. 2**.
6. Separate the coolant and fuel blocks, then remove the thermostat and gasket.
7. Install a new thermostat and gasket.



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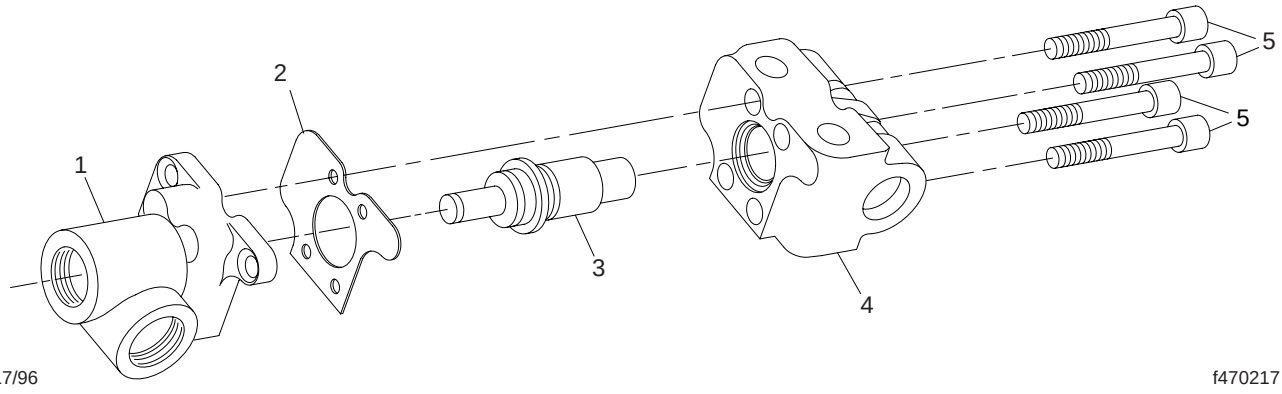
A. Coolant Outlet
B. Fuel Outlet
C. Coolant Inlet
D. Fuel Inlet
1. Fuel Heater
2. Automatic Coolant Valve Unit
3. Flexible Coolant Hose

Fig. 1, ACV as Mounted on W8791/ACV Fuel Heater

NOTE: The O-rings on the thermostat are pre-greased.

8. Press the coolant and fuel blocks back together. Twist the blocks as needed to properly seat the components.
9. Install the capscrews, then tighten them 75 lbf·in (850 N·cm).
10. Fill the cooling system using the instructions in Group 20 of the *Heavy-Duty Trucks Maintenance Manual*.
11. Start the engine and check for coolant and fuel leaks. Repair any leaks with the engine OFF.
12. Remove the chocks from the tires.

Webb W8791/ACV Fuel Heater Automatic Coolant Valve (ACV) and ACV Thermostat Replacement



1. Coolant Block
2. Gasket
3. Automatic Coolant Valve Thermostat
4. Fuel Block
5. Capscrews

Fig. 2, W8791 Fuel Heater ACV, Exploded View

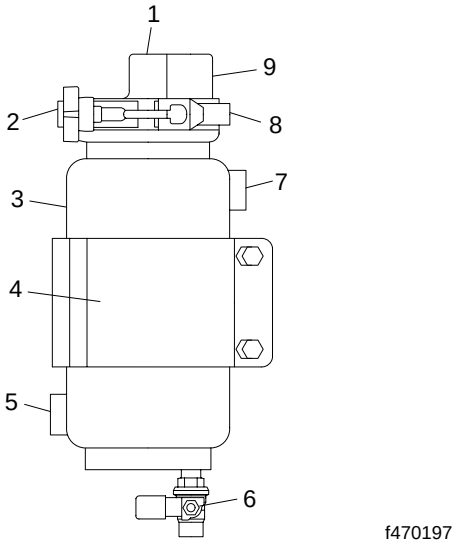
Troubleshooting

⚠ WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

Problem—Fuel Heater/Water Separator Loses Prime (525, 525ACV and 525ACV/F)

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Check that the cover clamp T-handle is hand tight only. Overtightening the clamp with pliers, or a wrench could cause a vacuum leak. See **Fig. 1**.



1. Fuel Inlet
2. T-Handle
3. Fuel Heater/Water Separator Housing
4. Mounting Bracket
5. Coolant Inlet
6. Drain Valve
7. Coolant Outlet
8. Cover Clamp
9. Fuel Outlet

Fig. 1, Webb 525 Fuel Heater/Water Separator (525/ACV and 525ACV/F similar)

3. Loosen the cover clamp, reposition to ensure a good seal and hand tighten.
4. If the cover was not loose, and the engine will not start, prime the fuel heater/water separator by filling the unit with clean diesel fuel.

   4.1 Disconnect the fuel line at the inlet port of the transfer pump, or primary fuel filter. Check that the line is full of fuel, and plug it to prevent fuel loss.

   4.2 Disconnect the fuel inlet line at the fuel heater/water separator.

   4.3 Make a fitting that will adapt to a regulated shop air line and the fuel inlet line on the fuel heater/water separator. Check that the fuel inlet line is full of fuel, and that the outside surface of the fuel heater/water separator is clean and dry.

   4.4 Check that the regulated air pressure line is set to 40 psi (28 bar) maximum pressure.

⚠ CAUTION

Pressurize the inlet side of the fuel heater/water separator only. Pressurizing the outlet side will cause damage to the check seal and ball.

   4.5 Apply air pressure to the fuel inlet of the fuel heater/water separator.

   NOTE: It may take more than five minutes before a leak becomes visible. Fuel will leak at the location of the vacuum leak.

   4.6 If a leak is not located after 15 minutes, and the fuel heater/water separator is known to lose prime overnight, check the fuel filter head and fuel pump for a possible fitting or seal leak.

5. Release the air pressure to the fuel inlet.
6. Place a suitable container under the fuel heater/water separator, and open the drain valve to release the internal pressure and prevent fuel spray.
7. Disconnect the air pressure fitting, and reconnect the fuel lines.
8. Start the engine and check for coolant and fuel leaks. Repair any leaks with the engine OFF.

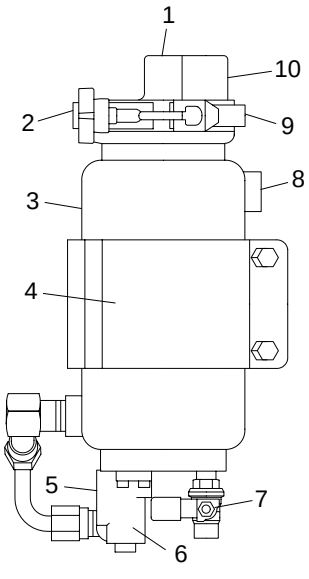
Troubleshooting

9. Remove the chocks from the tires.

Problem—Fuel Gels In Cold Weather

Webb 525/ACV and 525ACV/F

(See Fig. 2or Fig. 3)



1. Fuel Inlet
2. T-Handle
3. Fuel Heater/Water Separator Housing
4. Mounting Bracket
5. Coolant Inlet
6. Automatic Coolant Valve (ACV) Unit
7. Drain Valve
8. Coolant Outlet
9. Cover Clamp
10. Fuel Outlet

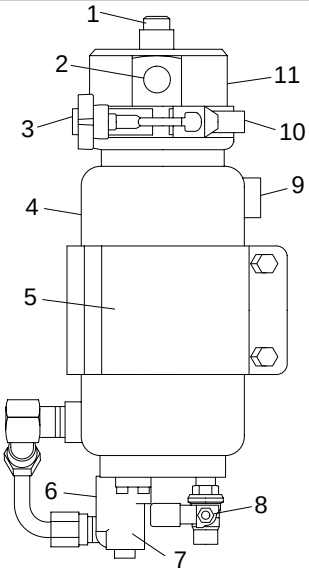
Fig. 2, Webb 525/ACV

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.

⚠ WARNING

Do not remove or loosen the surge tank cap until the engine and cooling system have completely cooled. Use extreme care when removing the cap. The sudden release of pressure from removing the cap prior to the system cooling can result in a surge of scalding coolant that could cause serious personal injury.

2. With the engine cool, loosen the SAE cap on the surge tank to release cooling system pressure.



1. Secondary Fuel Filter Nipple
2. Fuel Inlet
3. T-Handle
4. Fuel Heater/Water Separator Housing
5. Mounting Bracket
6. Coolant Inlet
7. Automatic Coolant Valve (ACV) Unit
8. Drain Valve
9. Coolant Outlet
10. Cover Clamp
11. Fuel Outlet

Fig. 3, Webb 525ACV/F

⚠ WARNING

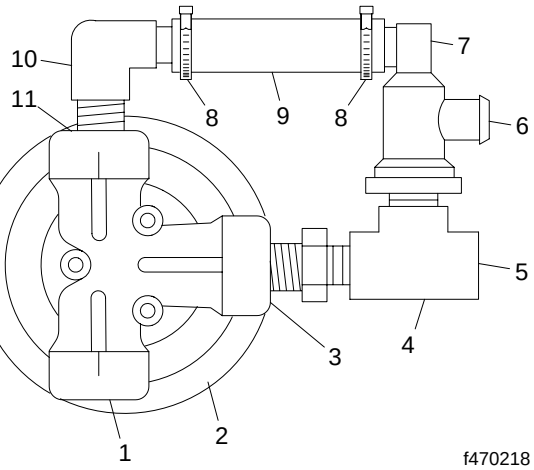
Do not attempt to drain the cooling system until the coolant and engine are cool. Draining the cooling system prior to the system cooling could cause severe personal injury due to scalding.

3. Place a suitable container under the radiator and drain the engine coolant until the level is below the fuel heater/water separator, then tighten the drain valve.
4. Drain the fuel from the separator, then tighten the drain valve.
5. Place a suitable container under the fuel water separator, then disconnect the coolant inlet fitting from the ACV, and the coolant outlet fitting from the fuel heater/water separator.
6. Fill the fuel heater/water separator with ice water.
7. Blow air through the coolant inlet and check for air flow at the coolant outlet. If no air flow is

present, replace the power pill. See **Subject 120** for replacement.

8. Replenish the engine coolant supply.
9. Start the engine and check for coolant and fuel leaks. Repair any leaks with the engine OFF.
10. Remove the chocks from the tires.

Webb Hot STK/ACV (See Fig. 4)



1. Coolant Outlet
2. Hot STK Mounting Head
3. Fuel Port
4. Fuel Outlet Fitting
5. Fuel Outlet (not used)
6. Coolant Inlet
7. Automatic Coolant Valve (ACV) Unit
8. Hose Clamp
9. Coolant Hose
10. 90-Degree Fitting
11. Coolant Inlet Port

Fig. 4, ACV as Mounted on the Webb Hot STK/ACV Fuel Heater

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.

WARNING

Do not remove or loosen the surge tank cap until the engine and cooling system have completely cooled. Use extreme care when removing the cap. The sudden release of pressure from removing the cap prior to the system cooling can result in a surge of scalding coolant that could cause serious personal injury.

2. With the engine cool, loosen the SAE cap on the surge tank to release cooling system pressure.

WARNING

Do not attempt to drain the cooling system until the coolant and engine are cool. Draining the cooling system prior to the system cooling could cause severe personal injury due to scalding.

3. Place a suitable container under the radiator and drain the engine coolant until the level is below the fuel heater, then tighten the drain valve.
4. Loosen the hose clamps at the ACV unit, then remove the hoses.
5. Place a shop towel under the fuel outlet fitting, then remove the ACV.
6. Place the sensing portion of the ACV into ice water.
7. Blow air through the coolant inlet and check for air flow at the other orifice. If no air flow is present, replace the ACV. See **Subject 140** for replacement.
8. Replenish the engine coolant supply.
9. Start the engine and check for coolant and fuel leaks. Repair any leaks with the engine OFF.
10. Remove the chocks from the tires.

Webb 8791ACV (See Fig. 5)

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.

WARNING

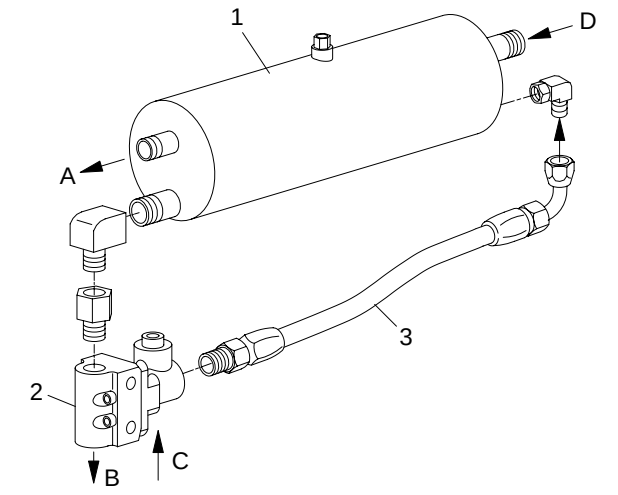
Do not remove or loosen the surge tank cap until the engine and cooling system have completely cooled. Use extreme care when removing the cap. The sudden release of pressure from removing the cap prior to the system cooling can result in a surge of scalding coolant that could cause serious personal injury.

2. Loosen the SAE cap on the cooling system surge tank to relieve system pressure.

WARNING

Do not attempt to drain the cooling system until the coolant and engine are cool. Draining the cooling system prior to the system cooling could cause severe personal injury due to scalding.

Troubleshooting



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A. Coolant Outlet
B. Fuel Outlet
1. Fuel Heater
2. Automatic Coolant Valve Unit
C. Coolant Inlet
D. Fuel Inlet
3. Flexible Coolant Hose

Fig. 5, ACV as Mounted on the W8791 Fuel Heater

3. Place a suitable container under the radiator and drain the engine coolant until the level is below the fuel heater, then tighten the drain valve.
4. Place a suitable container under the ACV unit, then remove the fuel outlet fitting. Drain any residual fuel from the fuel heater.
5. Disconnect the flexible hose from the ACV unit.
6. Secure the fitting mounted to the fuel block (see **Fig. 6**) side of the ACV, then slowly rotate the unit counterclockwise to remove it from the fuel heater.
7. Submerse the fuel block section in ice water, then blow air through the coolant inlet and check for air flow at the other orifice. If no air is present, replace the thermostat. See **Subject 160** for replacement.
8. Replenish the engine coolant supply.
9. Start the engine and check for coolant and fuel leaks. Repair any leaks with the engine OFF.
10. Remove the chocks from the tires.

Problem—Fuel Overheating

Webb 525/ACV and 525ACV/F

(See Fig. 2 or Fig. 3)

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.

⚠ WARNING

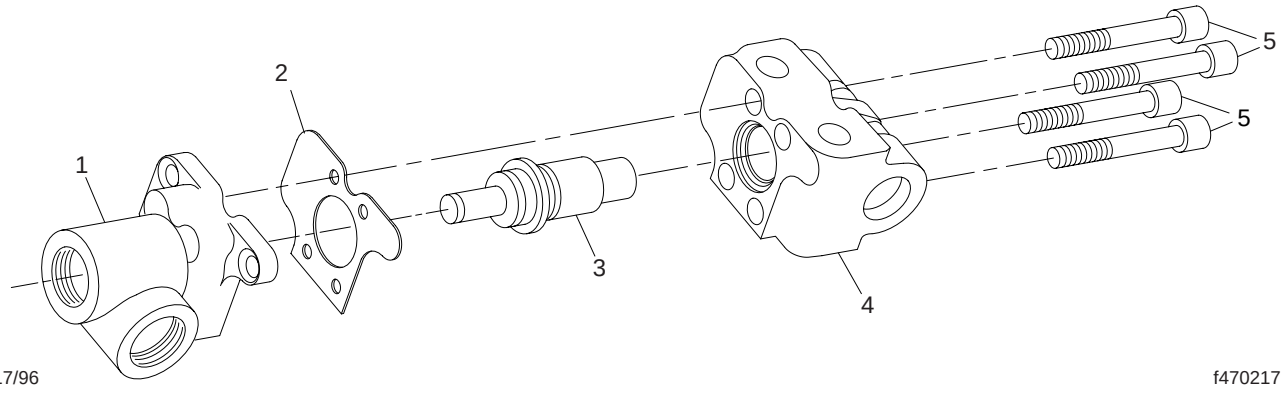
Do not remove or loosen the surge tank cap until the engine and cooling system have completely cooled. Use extreme care when removing the cap. The sudden release of pressure from removing the cap prior to the system cooling can result in a surge of scalding coolant that could cause serious personal injury.

2. Loosen the SAE cap on the cooling system surge tank to relieve system pressure.

⚠ WARNING

Do not attempt to drain the cooling system until the coolant and engine are cool. Draining the cooling system prior to the system cooling could cause severe personal injury due to scalding.

3. Place a suitable container under the radiator and drain the engine coolant until the level is below the fuel heater, then tighten the drain valve.
4. Drain the fuel from the separator, then tighten the drain valve.
5. Place a suitable container under the fuel water separator, then disconnect the coolant inlet fitting from the ACV, and the coolant outlet fitting from the fuel heater/water separator.
6. Fill the fuel heater/water separator with water warmed to over 80°F (27°C).
7. Blow air into the coolant inlet and check for air flow at the coolant outlet. If air flow is present at the outlet, replace the power pill. See **Subject 120** for replacement.
8. Replenish the engine coolant supply.
9. Start the engine and check for coolant and fuel leaks. Repair any leaks with the engine OFF.
10. Remove the chocks from the tires.



1. Coolant Block
2 Gasket
3 Automatic Coolant Valve Thermostat
4 Fuel Block
5 Capscrews

Fig. 6, W8791/ACV Fuel Heater ACV Exploded View

Webb Hot STK/ACV (See Fig. 4)

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.

⚠ WARNING

Do not remove or loosen the surge tank cap until the engine and cooling system have completely cooled. Use extreme care when removing the cap. The sudden release of pressure from removing the cap prior to the system cooling can result in a surge of scalding coolant that could cause serious personal injury.

2. Loosen the SAE cap on the cooling system surge tank to relieve system pressure.

⚠ WARNING

Do not attempt to drain the cooling system until the coolant and engine are cool. Draining the cooling system prior to the system cooling could cause severe personal injury due to scalding.

3. Place a suitable container under the radiator and drain the engine coolant until the level is below the fuel heater, then tighten the drain valve.
4. Loosen the hose clamps at the ACV unit, then remove the hoses.
5. Place a shop towel under the fuel fitting assembly, then remove the ACV.
6. Place the sensing portion of the ACV into water warmed above 80°F (27°C).
7. Blow air through the coolant inlet and check for air flow at the other orifice. If air flow is present, replace the ACV. See **Subject 140** for replacement.
8. Replenish the engine coolant supply.
9. Start the engine and check for coolant and fuel leaks. Repair any leaks with the engine OFF.
10. Remove the chocks from the tires.

Webb 8791ACV (See Fig. 5)

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.

⚠ WARNING

Do not remove or loosen the surge tank cap until the engine and cooling system have completely cooled. Use extreme care when removing the cap. The sudden release of pressure from removing the cap prior to the system cooling can result in a surge of scalding coolant that could cause serious personal injury.

2. Loosen the SAE cap on the cooling system surge tank to relieve system pressure.

Troubleshooting

⚠ WARNING

Do not attempt to drain the cooling system until the coolant and engine are cool. Draining the cooling system prior to the system cooling could cause severe personal injury due to scalding.

3. Place a suitable container under the radiator and drain the engine coolant until the level is below the fuel heater, then tighten the drain valve.
4. Place a suitable container under the ACV unit, then remove the fuel outlet fitting. Drain any residual fuel from the fuel heater.
5. Place a suitable container under the ACV, then disconnect the flexible hose from the ACV unit.
6. Secure the fitting mounted to the fuel block side of the ACV, then slowly rotate the unit counterclockwise to remove it from the fuel heater.
7. Place the fuel block portion of the ACV (see **Fig. 6**) in water warmed above 80°F (27°C).
8. Blow air through the coolant inlet and check for air flow at the other orifice. If air flow is present, replace the thermostat. See **Subject 160** for replacement.
9. Replenish the engine coolant supply.
10. Start the engine and check for coolant and fuel leaks. Repair any leaks with the engine OFF.
11. Remove the chocks from the tires.

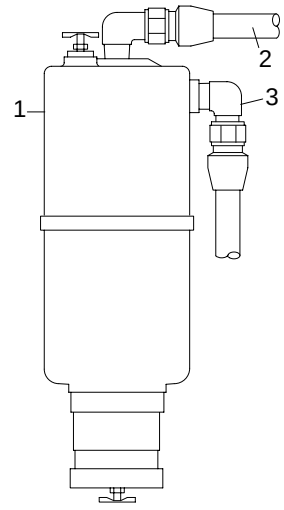
Specifications

Fastener Torques	
Description	**Torque lbf·in (N·cm)**
525ACV and 525ACV/F ACV-Housing Allen Screws	75 lbf·in (850 N·cm)
W8791ACV ACV-Housing Allen Screws	75 lbf·in (850 N·cm)

Table 1, Fastener Torques

General Description

The ConMetCo fuel/water separator (see **Fig. 1**) removes water and solid contaminants from diesel fuel. Installed on the left frame rail between the fuel tank and the fuel transfer pump, the separator has no moving parts and contains no filters.



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1. Fuel/Water Separator
2. Intake Line
3. Exhaust Line

Fig. 1, ConMetCo Fuel/Water Separator, Basic Model

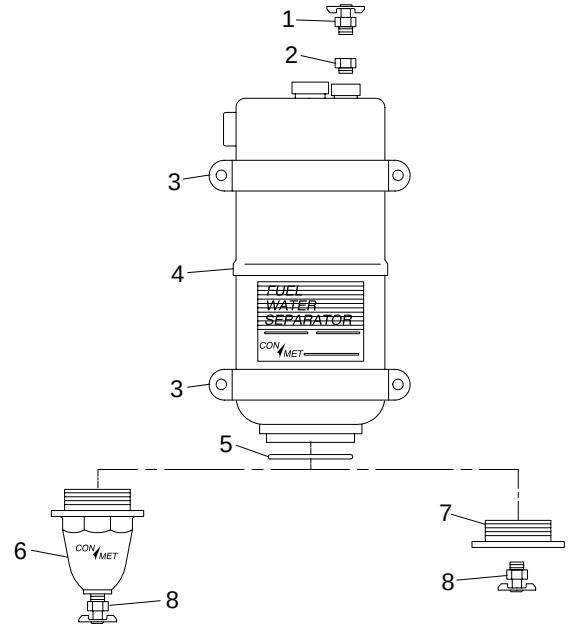
It is available in a basic model, or with a sight bowl, and/or a heater activated by a mechanical thermostat. All fuel and coolant line fittings are 1/2-inch NPT.

Principles of Operation

Diesel fuel enters at the top of the separator (see **Fig. 2**) and flows down through a specially-designed baffle, causing the water in the fuel to coalesce in large droplets which then accumulate in the bottom of the unit and can be drained by opening a valve.

The heater, if installed (see **Fig. 3**), routes engine coolant through a tube to heat the fuel as it trickles down through the baffle. If a sight bowl is also installed, a heater rod warms the water in the sight bowl.

Fuel passing through the thermostat activates a valve that controls coolant flow and regulates fuel



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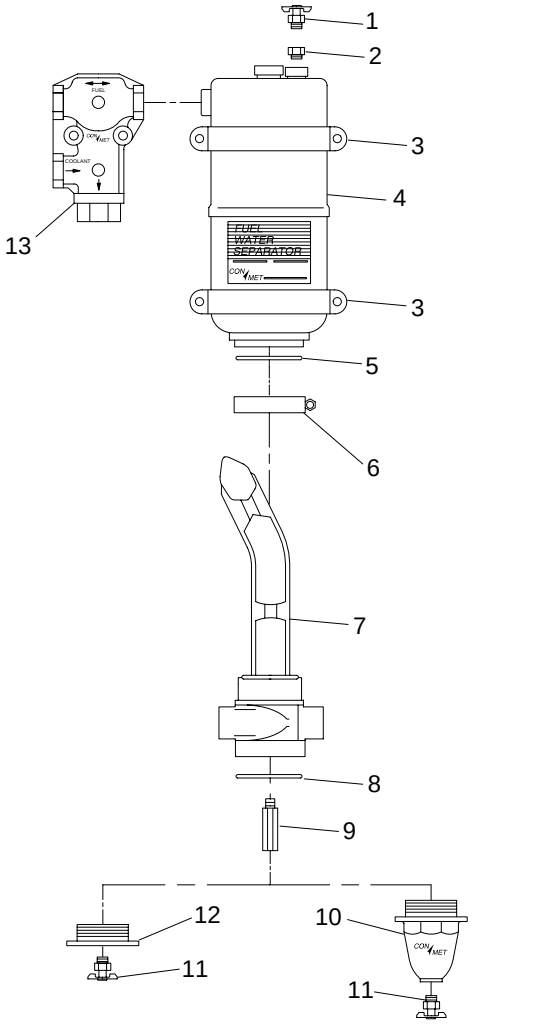
NOTE: Either bottom closure or sight bowl is installed, not both.

1. Vacuum Breaker Valve
2. Reducer Bushing
3. Mounting Band
4. Separator Body
5. Gasket
6. Sight Bowl
7. Bottom Closure
8. Drain Valve

Fig. 2, Separator Model with Sight Bowl Option

temperature. To prevent mixing, fuel and coolant are completely separated.

General Information



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NOTE: Either bottom closure or sight bowl is installed, not both.

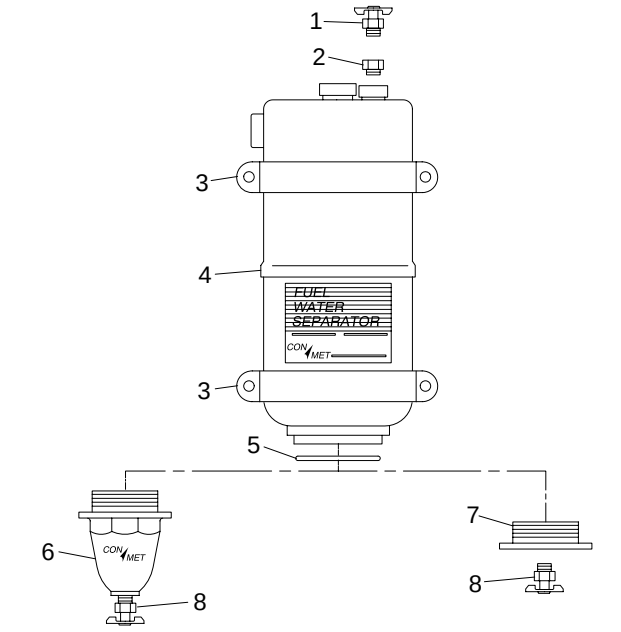
1. Vacuum Breaker Valve
2. Reducer Bushing
3. Mounting Band
4. Separator Body
5. O-Ring
6. V-Clamp
7. Heater Tube
8. Gasket
9. Sight Bowl Heater Rod
10. Sight Bowl
11. Drain Valve
12. Bottom Closure
13. Thermostat

Fig. 3, Separator Model with Heater Option

ConMetCo Fuel/Water Separator Removal and Installation

Removal

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the hood.
2. Drain the fuel/water separator. See **Fig. 1**.



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NOTE: Either bottom closure or sight bowl is installed, not both.

1. Vacuum Breaker Valve
2. Reducer Bushing
3. Mounting Band
4. Separator Body
5. Gasket
6. Sight Bowl
7. Bottom Closure
8. Drain Valve

Fig. 1, ConMetCo Fuel/Water Separator

2.1 Place a suitable container under the separator body.

2.2 With the engine shut down, open the drain valve (Ref. 8) on the bottom of the separator body (Ref. 4).

2.3 If the accumulated water does not drain immediately, open the vacuum breaker valve (Ref.1) on the top of the separator body.

2.4 When the unit is completely drained, close the drain valve.

2.5 If opened, close the vacuum breaker valve.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

3. If a heater is installed, drain the coolant. See **Section 20.01** for instructions.
4. Disconnect the 1/2-inch NPT fuel line fittings to the intake and exhaust lines on the separator body.

   If a heater is installed, disconnect the 1/2-inch NPT coolant line fittings to the heater body. Also, disconnect the 1/2-inch NPT fuel line and coolant line fittings to the thermostat.

NOTE: If installed, remove the thermostat. For instructions, see **Subject 110**.

5. Remove the mounting capscrews, lockwashers and hexnuts that secure the mounting bands to the mounting bracket. See **Fig. 2**. Remove the fuel/water separator from the vehicle.
6. If installed, remove the sight bowl and clean it. See **Fig. 3**.

   6.1 Unscrew the sight bowl from the separator body.

   6.2 Wipe the sight bowl clean using a soft cloth.

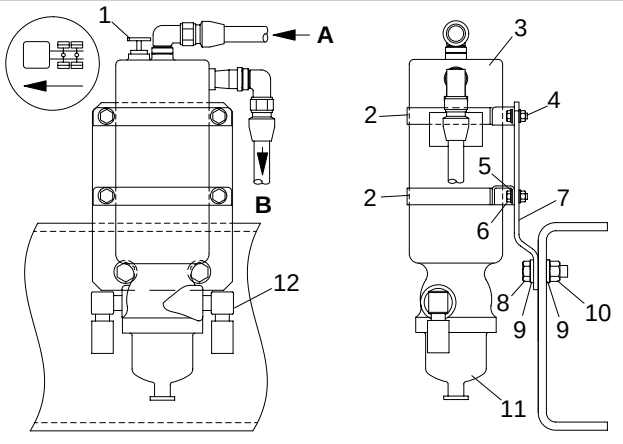
   6.3 Inspect the gasket for damage and install a new one if necessary. Lubricate the gasket with a thin film of engine oil and install it on the sight bowl.

   6.4 Lubricate the threads on the sight bowl with a thin film of engine oil.

   6.5 Hand tighten the sight bowl until the gasket has fully contacted the separator body, and then tighten 1/4 to 1/3 turn more.

   6.6 Make sure the drain valve is tightened and closed.

ConMetCo Fuel/Water Separator Removal and Installation



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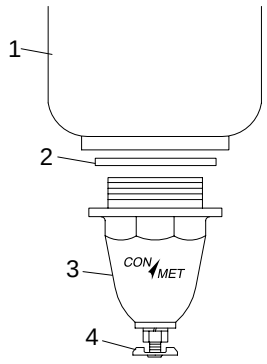
A. From Fuel Tanks
B. To Engine

1. Vacuum Breaker Valve
2. Mounting Band
3. Separator Body
4. 5/16–18 Mounting Band Capscrew
5. Lockwasher
6. 5/16–18 Hexnut
7. Mounting Bracket
8. 5/8–11 Mounting Bracket Capscrew
9. Hardened Flatwasher
10. 5/8–11 Locknut
11. Sight Bowl (if installed)
12. Coolant Line (if installed)

Fig. 2, ConMetCo Fuel/Water Separator Mounting



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1. Separator Body
2. Gasket
3. Sight Bowl
4. Drain Valve

Fig. 3, Sight Bowl

Installation

1. Check the mounting bracket locknuts for tightness. If necessary, tighten the locknuts 113 lbf·ft (153 N·m).
2. Mount the new fuel/water separator vertically on the mounting bracket. Install the mounting bands, and secure them with the 5/16–18 mounting capscrews, lockwashers, and hexnuts. Tighten the hexnuts 15 lbf·ft (20 N·m). See **Fig. 2**.
3. Attach the 1/2-inch NPT fuel line fittings to the inlet and outlet ports on the separator body.

   If removed, attach the 1/2-inch NPT coolant line fittings to the heater body. Also, attach the 1/2-inch NPT fuel and coolant line fittings to the thermostat.
4. Apply Loctite® 271 (or equivalent) to all fitting threads. Tighten all fittings until they are airtight.
5. Prime the fuel/water separator with clean diesel fuel.

   5.1 Open the vacuum breaker valve.

   5.2 Fill the unit with clean diesel fuel.

   5.3 Close the vacuum breaker valve and be sure it is airtight.

IMPORTANT: To prevent fuel leaks, be sure the vacuum breaker valve is closed airtight.

6. Start the engine and check for leakage. With the engine shut down, repair any leaks.
7. Lower the hood, and remove the chocks from the tires.

ConMetCo Fuel/Water Separator Heater and Thermostat Replacement

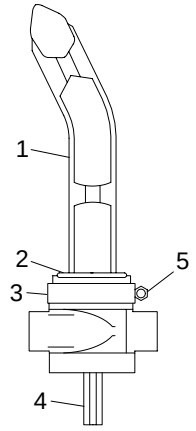
Heater Replacement

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the hood.
2. Drain the fuel/water separator. For detailed instructions, see **Subject 100**.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

3. Drain the coolant. See **Section 20.01** for instructions.
4. Disconnect the 1/2-inch NPT coolant line fittings from the heater tube body.
5. Loosen the clamp nut and slowly, and carefully lower the heater tube out of the separator body. See **Fig. 1**. Remove the V-clamp and O-ring with the heater.



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1. Heater Tube
2. O-Ring
3. V-Clamp
4. Sight Bowl Heater
5. Clamp Nut

Fig. 1, Fuel Heater Assembly

6. Attach the 1/2-inch NPT coolant line fittings to the new heater. Apply Loctite® 271 (or equivalent) to all fitting threads. Tighten all fittings until they are airtight.

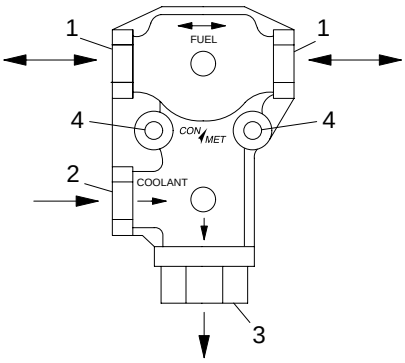
⚠ CAUTION

To prevent fuel leaks, rotate the heater so that it does not contact any internal components of the separator body.

7. With the V-clamp and O-ring already in place, carefully insert the new heater tube into the separator body.
8. When the O-ring is firmly seated, tighten the clamp nut 30 to 40 lbf·in (340 to 460 N·cm)
9. Refill cooling system. See **Section 20.01** for instructions.
10. Lower the hood, and remove the chocks from the tires.

Thermostat Replacement

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Disconnect the 1/2-inch NPT fuel line fittings from the thermostat.
3. Mark and disconnect the 1/2-inch NPT coolant line fittings from the thermostat.
4. Remove the thermostat mounting bolts. See **Fig. 2**. Remove the thermostat from the vehicle.



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1. Fuel In/Out
2. Engine Coolant In
3. Engine Coolant Out
4. Mounting Bolts

Fig. 2, Thermostat

5. Install the 5/16-inch thermostat mounting bolts. See **Fig. 2**. Install the new thermostat on the vehicle.

ConMetCo Fuel/Water Separator Heater and Thermostat Replacement

6. Attach the 1/2-inch NPT fuel line fittings to the new thermostat. Apply Loctite® 271 (or equivalent) to all fitting threads. Tighten all fittings until they are airtight.
7. Attach the 1/2-inch NPT coolant line fittings to the new thermostat as marked. Apply Loctite®271 (or equivalent) to to all fitting threads. Tighten all fittings until they are airtight.
8. Lower the hood, and remove the chocks from the tires.

Troubleshooting

Problem—Leaking Air in the Fuel System

Problem—Leaking Air in the Fuel System	
Possible Cause	**Remedy**
The vacuum breaker valve is loose.	Tighten the vacuum breaker valve. Make sure it is airtight.
There are loose or broken fuel fittings, valves, or filters.	Tighten or repair the fuel fittings, valves, or filters as needed.

Problem—Leaking Fuel

Problem—Leaking Fuel	
Possible Cause	**Remedy**
The sight bowl is loose.	Tighten the sight bowl. For instructions, see **Subject 100**.
The sight bowl is cracked or broken.	Replace the sight bowl. For instructions, see **Subject 100**.
The fuel heater is loose.	Tighten the fuel heater V-clamp. For instructions, see **Subject 110**.
The fuel heater is incorrectly installed.	Install the fuel heater correctly, so that it is not touching any components in the separator body. For instructions, see **Subject 110**.
There are loose or broken fittings somewhere within the fuel system, including in the return lines.	Tighten or repair the fuel fittings as needed.

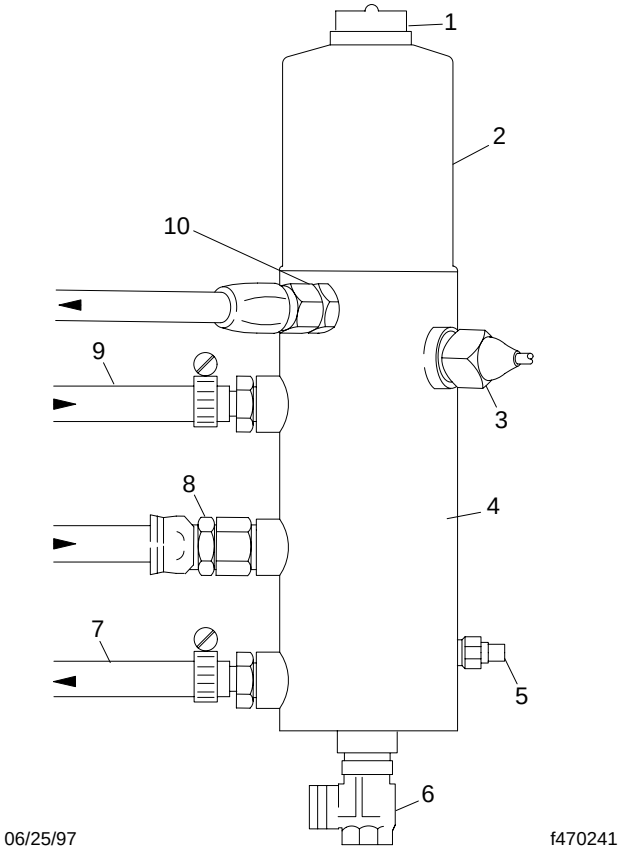
Specifications

Fastener Torques			
Description	**Size**	**Torque**	
		lbf·ft (N·m)	**lbf·in (N·cm)**
Mounting Band Hexnuts	5/16–18	15 (20)	—
Mounting Bracket Locknuts	5/8–11	113 (153)	—
Heater Element V-Clamp	—	—	30–40 (340–460)

Table 1, Fastener Torques

General Description

Davco 321 Fuel Heater/Water Separator (See Fig. 1)

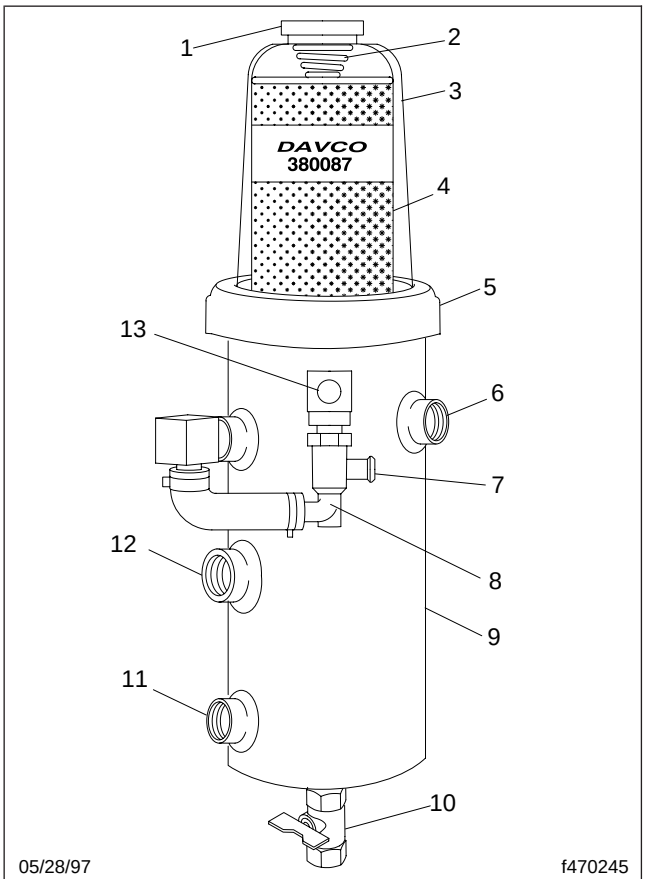


1. Filter Vent
2. Filter
3. Electric Fuel Preheater
4. Fuel Heater/Water Separator Housing
5. Water Sensor Probe
6. Drain Valve
7. Coolant Outlet Hose
8. Fuel Inlet
9. Coolant Inlet Hose
10. Fuel Outlet

Fig. 1, Davco 321 Fuel Heater/Water Separator

The 321 has two fuel ports and two coolant ports. The unit has an optional thermostatically controlled electronic fuel pre-heater. A replaceable filter element traps contaminants before they leave the unit. The unit heats the diesel fuel and strips water and dirt out of the fuel so that wax won't form and water won't reach the engine. An optional water sensor probe sends a warning signal to a readout when water is above a certain level. An optional thermal control valve regulates fuel temperature.

Davco 380 Fuel Heater/Water Separator (See Fig. 2)



1. Filter Vent
2. Filter Spring
3. Filter Cover
4. Filter Element
5. Fuel Collar
6. Fuel Preheater Port
7. Coolant Inlet
8. Thermal Control Valve Assembly
9. Fuel Heater/Water Separator Housing
10. Drain Valve
11. Coolant Outlet
12. Fuel Inlet
13. Fuel Outlet

Fig. 2, Davco 380 Fuel Heater/Water Separator

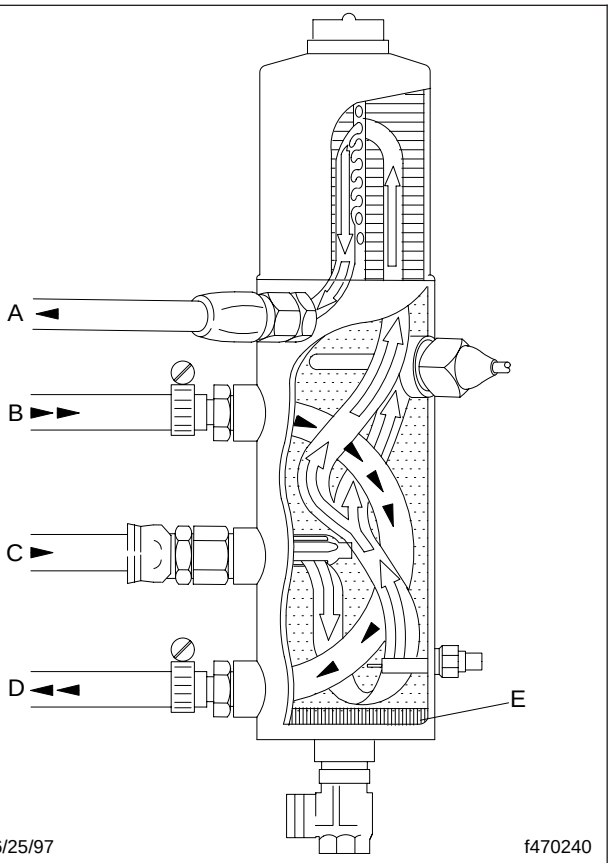
The 380 has two fuel ports and two optional coolant ports. The unit has an optional thermostatically controlled electronic fuel pre-heater. A clear filter cover allows a quick inspection of filter condition. A replaceable filter element traps contaminants before they

General Description and Principles of Operation

leave the unit. The unit heats the diesel fuel and strips water and dirt out of the fuel so that wax won't form and water won't reach the engine. An optional water sensor probe sends a warning signal to a readout when water is above a certain level. An optional thermal control valve regulates fuel temperature.

Principles of Operation

Davco 321 Fuel Heater/Water Separator (See Fig. 3)



A. Fuel Outlet
B. Coolant Inlet
C. Fuel Inlet
D. Coolant Outlet
E. Collected Water

Fig. 3, Davco 321 Fuel Flow

Fuel enters the fuel/water separator through a check valve at the fuel inlet port. As fuel enters the fuel heater/water separator, larger particles of water fall to the bottom of the unit where they collect and can be removed by opening a drain valve at the bottom of the unit.

An optional thermostatically controlled electronic fuel pre-heater heats the fuel before entering the filter element. Fuel continues up into the filter, located at the top of the unit, where any residual water and dirt particles are stripped out of the fuel. The fuel then exits the filter and enters the fuel outlet port for distribution to the engine. Each time the engine is stopped the excess dirt is flushed from the filter and settles to the collection area at the base of the unit where it can be drained along with the trapped water.

The optional thermal control valve regulates fuel temperature by using a thermal control valve to sense fuel temperature. Coolant passes through the unit housing and acts as a liquid-to-liquid heat exchanger that transfers engine coolant heat to the fuel. When fuel temperature is low, the thermal control valve permits hot coolant to pass through the housing of the fuel heater/water separator. As fuel temperature increases, the valve restricts coolant flow through the unit. The thermal control valve is fully open below 40°F (4°C) and fully closed above 60°F (16°C).

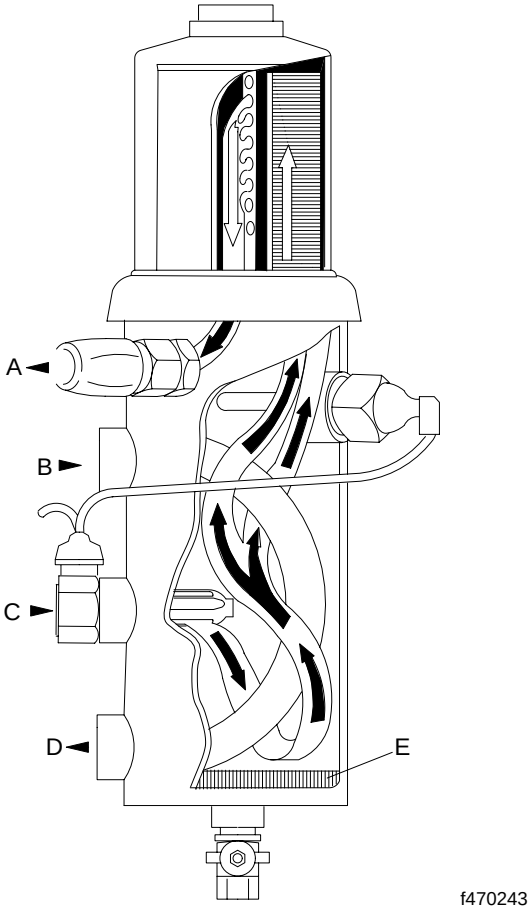
If the vehicle is equipped with an optional water-in-fuel indicator sensor, a probe is installed in the fuel heater/water separator housing. When the probe is covered by water, the water conducts electricity from the probe to the housing. This turns on the water-in-fuel indicator.

Davco 380 Fuel Heater/Water Separator (See Fig. 4)

Fuel enters the fuel/water separator through a check valve at the fuel inlet port. As fuel enters the fuel heater/water separator, larger particles of water fall to the bottom of the unit where they collect and can be removed by opening a drain valve at the bottom of the unit.

An optional thermostatically controlled electronic fuel pre-heater heats the fuel before entering the filter element. Fuel continues up into the filter, located at the top of the unit, where any residual water and dirt particles are stripped out of the fuel. The fuel then exits the filter and enters the fuel outlet port for distribution to the engine.

Each time the engine is stopped, the excess dirt is flushed from the filter and settles to the collection area at the base of the unit where it can be drained



A. Fuel Outlet
B. Coolant Inlet
C. Fuel Inlet
D. Coolant Outlet
E. Collected Water

Fig. 4, Davco 380 Fuel Flow

with the trapped water. The 380 unit has a transparent polymer filter cover that allows a visual check of the filter. When the filter is new, the level of fuel visible through the filter cover is low; most of the filter is not covered by the fuel. As the lower portion of the filter becomes restricted, the fuel level rises over that restricted portion of the filter element. As the filter become more restricted the level of fuel covering the filter rises until the entire filter is covered; when this happens the filter should be replaced.

The optional thermal control valve regulates fuel temperature by using a thermal control valve to sense fuel temperature. Coolant passes through the unit housing and acts as a liquid-to-liquid heat exchanger that transfers engine coolant heat to the fuel. When fuel temperature is low, the thermal control valve permits hot coolant to pass through the housing of the fuel heater/water separator. As fuel temperature increases, the valve restricts coolant flow through the unit. The thermal control valve is fully open below 40°F (4°C) and fully closed above 60°F (16°C).

If the vehicle is equipped with an optional water-in-fuel indicator sensor, a probe is installed in the fuel heater/water separator housing. When the probe is covered by water, the water conducts electricity from the probe to the housing. This turns on the water-in-fuel indicator.

Davco 321 Fuel Heater/Water Separator Removal and Installation

Removal

⚠ WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Disconnect the heater connector, preheater connector and the water sensor probe connector if equipped, see **Fig. 1** and **Fig. 2**.

⚠ WARNING

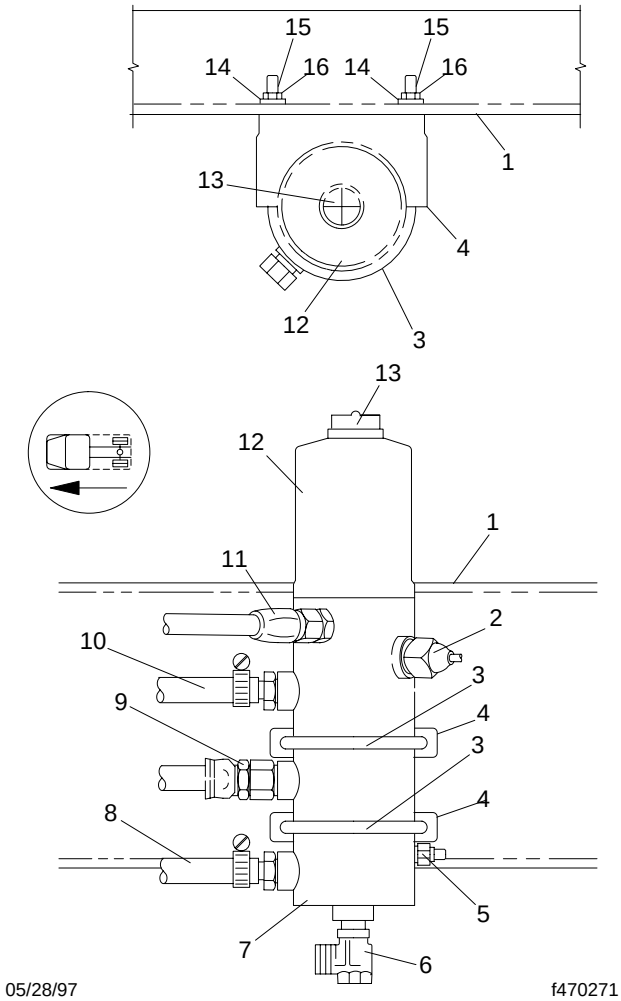
Do not remove or loosen the surge tank cap until the engine and cooling system have completely cooled. Use extreme care when removing the cap. The sudden release of pressure from removing the cap prior to the system cooling can result in a surge of scalding coolant that could cause serious personal injury.

3. With the engine cool, loosen the surge tank cap on the surge tank to release cooling system pressure.

⚠ WARNING

Do not attempt to drain the cooling system until the coolant and engine are cool. Draining the cooling system prior to the system cooling could cause severe personal injury due to scalding.

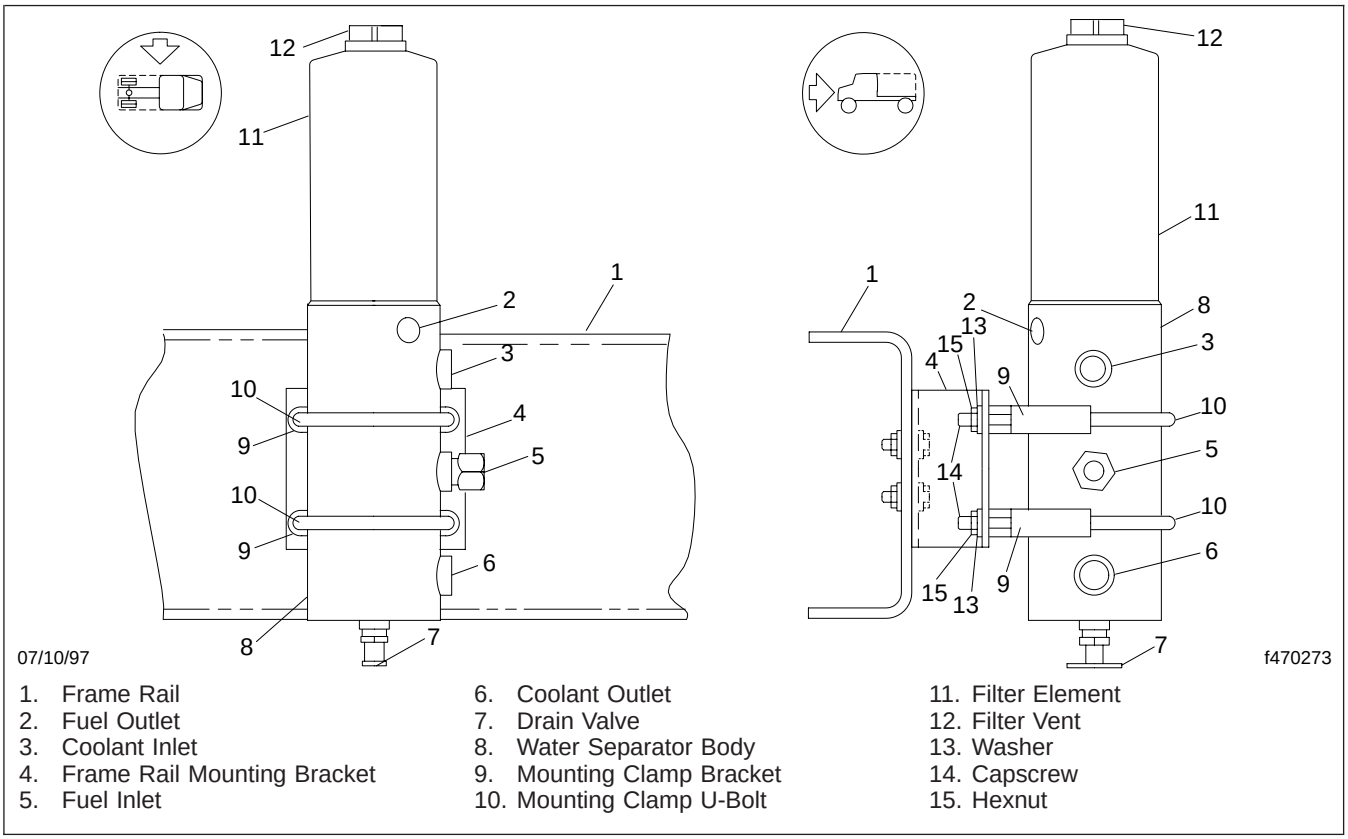
4. Place a suitable container under the radiator and drain the cooling system until the level is below the fuel heater/water separator, then close the drain valve.
5. Place a suitable container under the fuel heater/water separator, then loosen the coolant inlet, and coolant outlet fittings. Carefully remove the fittings from the unit and allow the remainder of the coolant to drain into the container. Store the coolant for system replenishment.
6. Place a suitable container under the fuel heater/water separator. Open the filter vent using a 1-1/8 wrench; then drain the fuel from the fuel heater/water separator by opening the drain valve.



1. Frame Rail
2. Fuel Preheater Connector
3. Mounting Clamp U-Bolt
4. Mounting Clamp Bracket
5. Water Sensor Probe
6. Drain Valve
7. Water Separator Body
8. Coolant Outlet Hose
9. Fuel Inlet Fitting
10. Coolant Inlet Hose
11. Fuel Outlet Fitting
12. Filter Element
13. Filter Vent
14. Washer
15. Capscrew
16. Hexnut

Fig. 1, Davco 321 Fuel Heater/Water Separator Mounted to Frame

Davco 321 Fuel Heater/Water Separator Removal and Installation



1. Frame Rail
2. Fuel Outlet
3. Coolant Inlet
4. Frame Rail Mounting Bracket
5. Fuel Inlet
6. Coolant Outlet
7. Drain Valve
8. Water Separator Body
9. Mounting Clamp Bracket
10. Mounting Clamp U-Bolt
11. Filter Element
12. Filter Vent
13. Washer
14. Capscrew
15. Hexnut

Fig. 2, Davco 321 Fuel Heater/Water Separator Mounted With Bracket

7. Place a shop towel under the fuel outlet fitting, then hold the fitting with an open-end wrench. Using a flare-nut wrench, carefully loosen the fuel outlet fitting, then drain any residual fuel into the container. Remove the fitting from the fuel heater/water separator.

   Repeat this step for the fuel inlet fitting.

8. Loosen the hexnuts on the both mounting bracket U-bolts. Grasp the fuel heater/water separator in one hand, and carefully remove the hexnuts and washers; then remove the fuel heater/water separator unit along with the mounting brackets.

Installation

1. Position both mounting clamp U-Bolts and brackets on the water separator body.
2. Hold the fuel heater/water separator in place on the frame rail; then install the capscrews, hexnuts and washers on the mounting clamp U-bolts.

NOTE: Do not use teflon tape when sealing the coolant or fuel fittings.

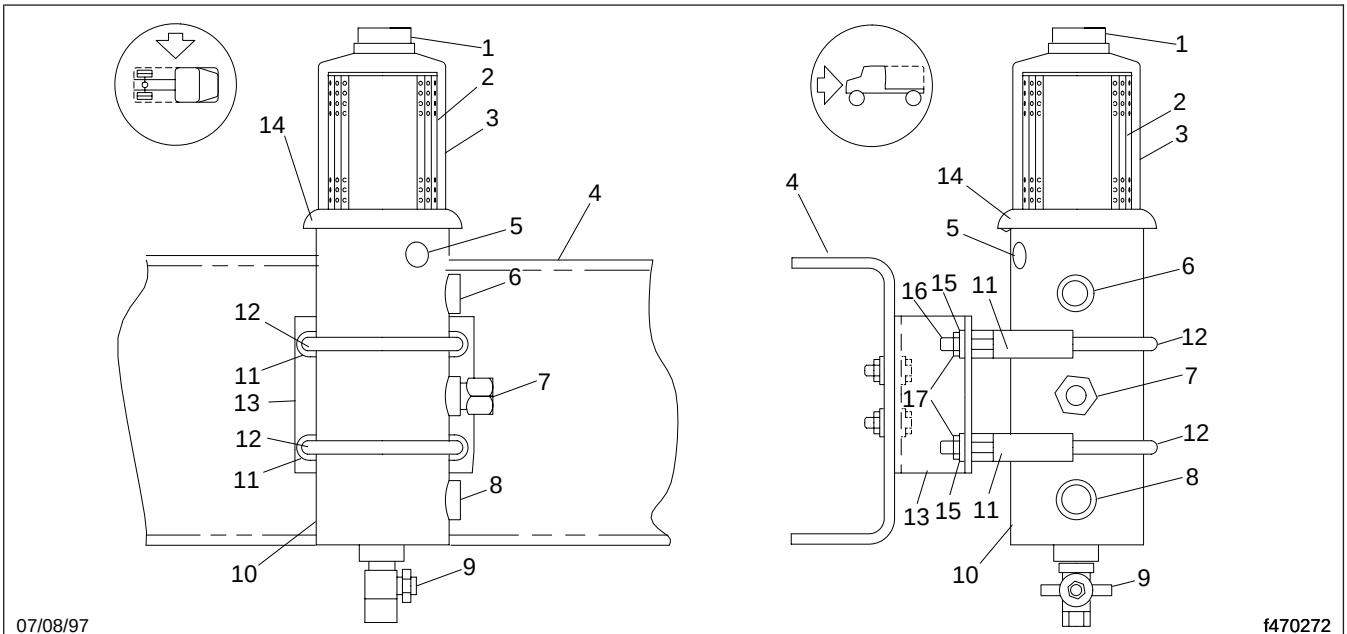
3. Check that the threads on the coolant inlet and outlet fittings are clean. Apply a soft-set pipe thread sealant on the fittings, then install them to the fuel heater/water separator.
4. Check that the threads on the fuel inlet and outlet fittings are clean. Apply a soft-set pipe thread sealant on the fittings, then install them to the fuel heater/water separator.
5. Connect the heater connector and the water sensor probe connector.
6. Remove the filter element and fill the fuel heater/water separator with fuel to the top of the fuel port. Replace the filter element

Davco 321 Fuel Heater/Water Separator Removal and Installation

7. Refill the coolant system.
8. Start the engine, then raise the rpm for 1 to 2 minutes to purge air from the system and check for fuel leaks. Repair all fuel leaks with the engine OFF.
9. Remove the tire chocks.

Davco 380 Fuel Heater/Water Separator Removal and Installation

Removal (See Fig. 1)



1. Filter Vent
2. Filter Element
3. Filter Cover
4. Frame Rail
5. Fuel Outlet
6. Coolant Inlet
7. Fuel Inlet
8. Coolant Outlet
9. Drain Valve
10. Water Separator Body
11. Mounting Bracket Clamp
12. Mounting Bracket U-Bolt
13. Frame Rail Mounting Bracket
14. Filter Collar
15. Washer
16. Capscrew
17. Hexnut

Fig. 1, Davco 380 Fuel Heater/Water Separator Mounted With Bracket

⚠ WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Disconnect the heater connector, preheater/thermoswitch in-line connector.

⚠ WARNING

Do not remove or loosen the surge tank cap until the engine and cooling system have completely cooled. Use extreme care when removing the cap. The sudden release of pressure from removing the cap prior to the system cooling can result in a surge of scalding coolant that could cause serious personal injury.

3. With the engine cool, loosen the surge tank cap on the surge tank to release cooling system pressure.

⚠ WARNING

Do not attempt to drain the cooling system until the coolant and engine are cool. Draining the cooling system prior to the system cooling could cause severe personal injury due to scalding.

Davco 380 Fuel Heater/Water Separator Removal and Installation

4. Place a suitable container under the radiator and drain the cooling system until the level is below the fuel heater/water separator, then tighten the drain valve.
5. Place a suitable container under the fuel heater/water separator, then loosen the coolant inlet, and coolant outlet fittings. Carefully remove the fittings from the unit and allow the remainder of the coolant to drain into the container. Store the coolant for system replenishment.
6. Place a suitable container under the fuel heater/water separator. Open the filter vent; then drain the fuel from the fuel heater/water separator by opening the drain valve.
7. Place a shop towel under the fuel outlet fitting, then hold the fitting with an open-end wrench. Using a flare-nut wrench, carefully loosen the fuel outlet fitting, then drain any residual fuel into the container. Remove the fitting from the fuel heater/water separator.

   Repeat this step for the fuel inlet fitting.
8. Loosen the hexnuts on the both mounting bracket U-bolts. Grasp the fuel heater/water separator in one hand, and carefully remove the hexnuts and washers; then remove the fuel heater/water separator unit along with the mounting brackets.

Installation

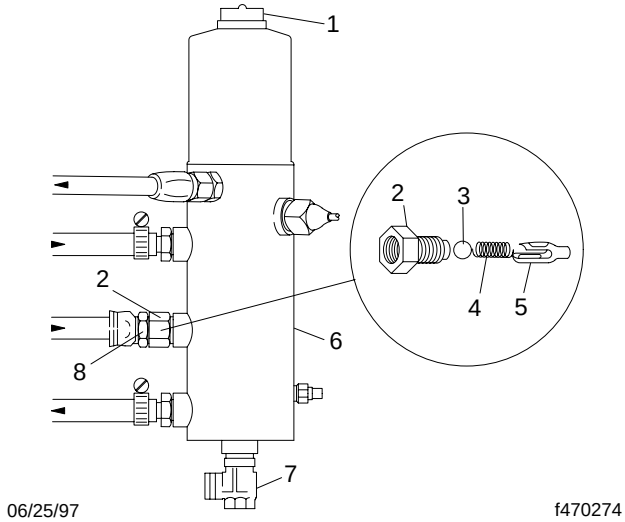
1. Position both mounting clamp U-Bolts and brackets on the water separator body.
2. Hold the fuel heater/water separator in place on the frame rail; then install the capscrews, hexnuts and washers on the mounting clamp U-bolts.

NOTE: Do not use teflon tape when sealing the coolant or fuel fittings.

3. Check that the threads on the coolant inlet and outlet fittings are clean. Apply a soft-set pipe thread sealant on the fittings, then install them to the fuel heater/water separator.
4. Check that the threads on the fuel inlet and outlet fittings are clean. Apply a soft-set pipe thread sealant on the fittings, then install them to the fuel heater/water separator.
5. Connect the preheater/thermoswitch in-line connector.
6. Remove the filter vent from the fuel heater/water separator; then fill with fuel until fuel is about 1 inch above the collar. Replace the filter vent.
7. Refill the coolant system.
8. Start the engine, then raise the rpm for 1 to 2 minutes to purge air from the system and check for fuel leaks. Repair all fuel leaks with the engine OFF.
9. Remove the tire chocks.

Davco 321 and 380 Fuel Heater/Water Separator Check Ball Valve Replacement

Replacement (See Fig. 1)



1. Filter Vent
2. Check Valve Body
3. Check Ball
4. Spring
5. Retainer
6. Water Separator Body
7. Drain Valve
8. Fuel Inlet

Fig. 1, Davco Check Valve Assembly (321 shown, 380 similar)

⚠ WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Place a suitable container under the fuel heater/water separator. Open the filter vent. Drain the fuel below the collar level by opening the drain valve; then close the drain valve.
3. Place a shop towel under the fuel inlet fitting, then hold the check valve body with an open-end wrench. Using a flare-nut wrench, carefully loosen the fuel inlet fitting, then drain any residual fuel into the container. Remove the fitting from the check valve body.
4. Remove the check valve body from the water separator body.
5. Remove and discard the check ball, spring and retainer.
6. Check that the threads on the check valve body and fuel inlet fitting are clean then install the new check ball, spring and retainer.

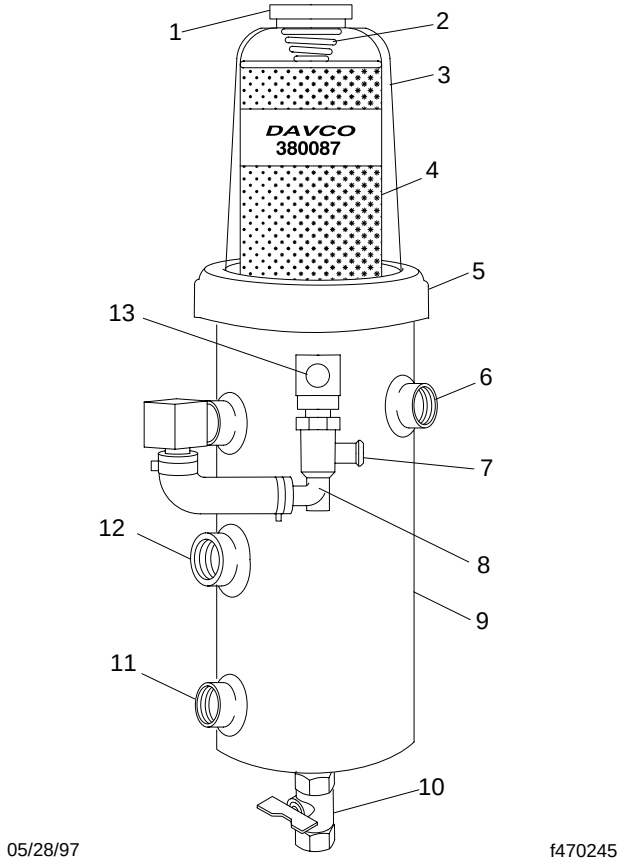
NOTE: Do not use teflon tape when sealing the fuel fittings.

7. Apply a soft-set pipe thread sealant to the check valve body threads; then install the check valve body in the water separator body.
8. Check that the threads on the fuel inlet fitting are clean. Apply a soft-set pipe thread sealant to the threads, then install the fitting into the check valve body.
9. If the unit is the 321 series, remove the filter element and fill the fuel heater/water separator to the top of the fuel port. Replace the filter element.

   If the unit is the 380 series, remove the filter vent; then fill with fuel until fuel is about 1 inch above the collar. Replace the filter vent.
10. Start the engine, then raise the rpm for 1 minute to purge air from the system and check for fuel leaks. Repair all fuel leaks with the engine OFF.
11. Remove the tire chocks.

Davco 380 Fuel Heater/Water Separator Thermal Control Valve Replacement

Replacement (See Fig. 1 and Fig. 2)

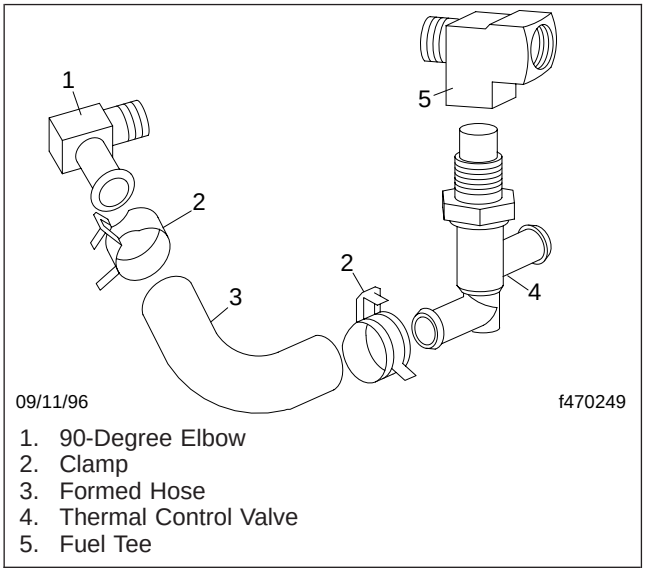


1. Filter Vent
2. Filter Spring
3. Filter Cover
4. Filter Element
5. Filter Collar
6. Fuel Preheater Port
7. Coolant Inlet
8. Thermal Control Valve Assembly
9. Fuel Heater/Water Separator Body
10. Drain Valve
11. Coolant Outlet
12. Fuel Inlet
13. Fuel Outlet

Fig. 1, Davco 380 Fuel Heater/Water Separator

⚠ WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.



1. 90-Degree Elbow
2. Clamp
3. Formed Hose
4. Thermal Control Valve
5. Fuel Tee

Fig. 2, Davco 380 Fuel Heater/Water Separator Thermal Control Assembly

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Place a suitable container under the fuel heater/water separator. Open the filter vent then; drain the fuel from the fuel heater/water separator by opening the drain valve.
3. Close the drain valve.

⚠ WARNING

Do not remove or loosen the surge tank cap until the engine and cooling system have completely cooled. Use extreme care when removing the cap. The sudden release of pressure from removing the cap prior to the system cooling can result in a surge of scalding coolant that could cause serious personal injury.

4. With the engine cool, loosen the surge tank cap on the surge tank to release cooling system pressure.

Davco 380 Fuel Heater/Water Separator Thermal Control Valve Replacement

⚠ WARNING

Do not attempt to drain the cooling system until the coolant and engine are cool. Draining the cooling system prior to the system cooling could cause severe personal injury due to scalding.

5. Place a suitable container under the radiator and drain the cooling system until the level is below the fuel heater/water separator, then close the drain valve.
6. Open the thermal control valve assembly hose clamps and slide them to toward the center of the formed hose.
7. Remove the formed hose from the 90-degree elbow and the thermal control valve.
8. Remove the fuel tee from the fuel heater/water separator body with the thermal control valve attached.
9. Separate the fuel tee from the thermal control valve.

NOTE: Do not use teflon tape when sealing the fuel fittings.

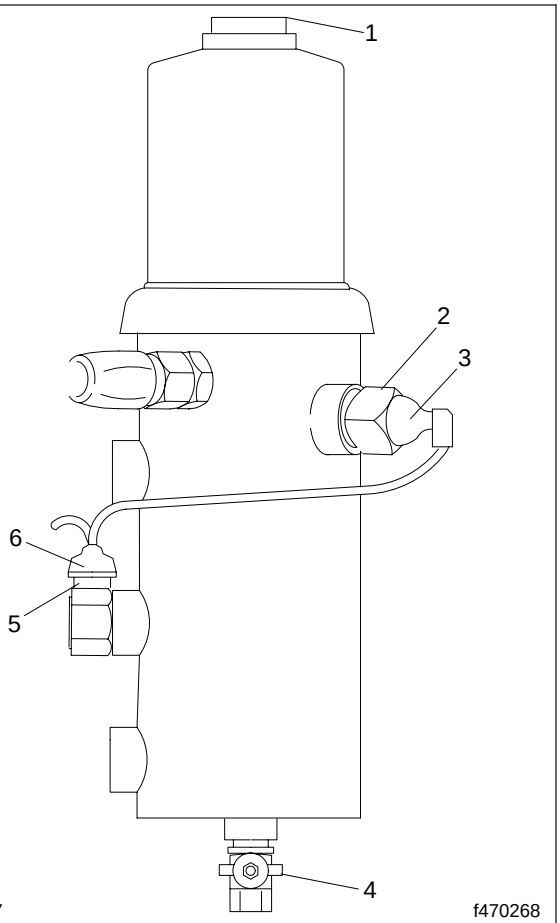
10. Apply a soft-set pipe thread sealant to the new thermal control valve threads; then install the control valve in the fuel tee, making certain that the control valve is aligned properly. See **Fig. 1**.
11. Check that the threads on the fuel tee fitting are clean. Apply a soft-set pipe thread sealant to the threads; then install the fuel tee in the fuel heater/water separator body. Align the control valve so that the formed hose will meet the control valve coolant port. See **Fig. 1**.
12. Place the formed hose onto the 90-degree elbow and the thermal control valve ports.
13. Move the hose clamps back to the 90-degree elbow and the temperature control valve ports.
14. Refill the coolant system.
15. Remove the filter vent; then add fuel at the fuel vent opening with until the fuel is about 1 inch above the collar. Replace the filter vent.
16. Start the engine, then raise the rpm for 1 to 2 minutes to purge air from the system and check for fuel leaks. Repair all fuel leaks with the engine OFF.
17. Remove the tire chocks.

Davco 321 and 380 Fuel Heater/Water Separator Thermoswitch and Preheater Removal and Installation

Preheater Removal (See Fig. 1)

⚠ WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.



1. Filter Vent
2. Preheater
3. Preheater Connector and Boot
4. Drain Valve
5. Thermoswitch
6. Thermoswitch Connector and Boot

Fig. 1, Davco Preheater 380 shown (321 similar)

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Place a suitable container under the fuel heater/water separator. Open the filter vent then; drain the fuel from the fuel heater/water separator by opening the drain valve.
3. Close the drain valve.
4. Disconnect the preheater connector and remove the preheater.

Preheater Installation (See Fig. 1)

⚠ WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

NOTE: Do not use teflon tape when sealing the fuel fittings.

1. Clean the preheater threads. Apply a soft-set pipe thread sealant to the preheater threads; then install the preheater into the water separator body
2. If the unit is the 321 series, remove the filter element and fill the fuel heater/water separator to the top of the fuel port. Replace the filter element.

   If the unit is the 380 series, remove the filter vent; then fill with fuel until fuel is about 1 inch above the collar. Replace the filter vent.
3. Start the engine, then raise the rpm for 1 to 2 minutes to purge air from the system and check for fuel leaks. Repair all fuel leaks with the engine OFF.
4. Shut off the engine and remove the tire chocks.

Troubleshooting

⚠ WARNING

Diesel fuel is flammable and can ignite if exposed to an open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame or intense heat could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

Problem—Fuel Heater/Water Separator Loses Prime

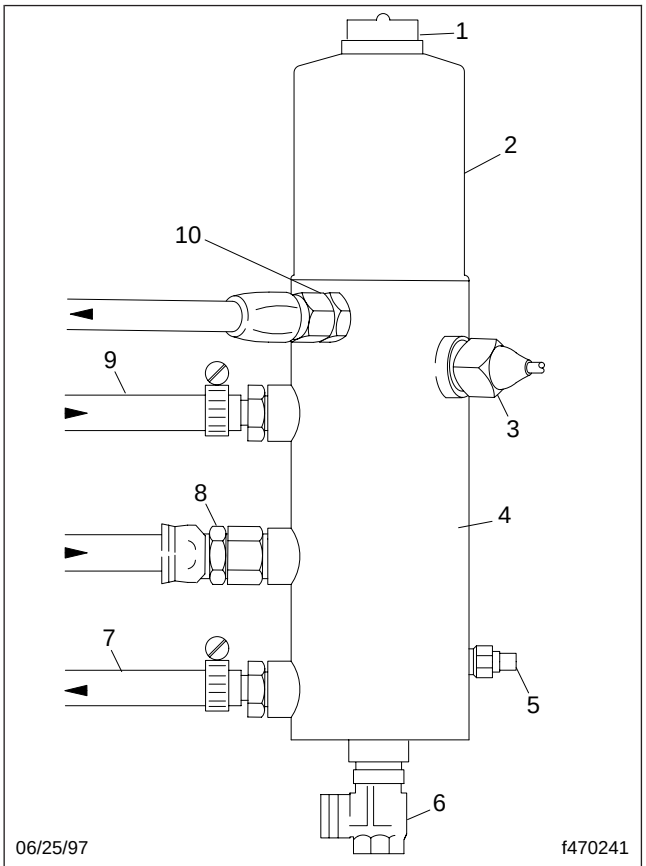
1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Visually inspect the fuel heater/water separator for physical damage. See **Fig. 1** and **Fig. 2**. If the filter element is damaged, replace the filter element. See **Subject 100**.

⚠ CAUTION

Do not use a wrench or any tool to tighten the filter vent or filter. Overtightening the filter or filter vent may cause a fuel leak.

3. Check the filter and filter vent; they should be tight.
4. Check the fuel heater/water separator for leaks.
   - 4.1 Place a suitable container under the fuel heater/water separator. Open the filter vent (use a 1-1/8 wrench on 321 models); then drain the fuel from the fuel heater/water separator by opening the drain valve.
   - 4.2 Close the filter vent.
   - 4.3 Place a shop towel under the fuel outlet fitting, then hold the fitting with an open-end wrench. Using a flare-nut wrench, carefully loosen the fuel outlet fitting, then drain any residual fuel into the container. Remove the fitting from the fuel heater/water separator.

     Repeat this step for the fuel inlet fitting.

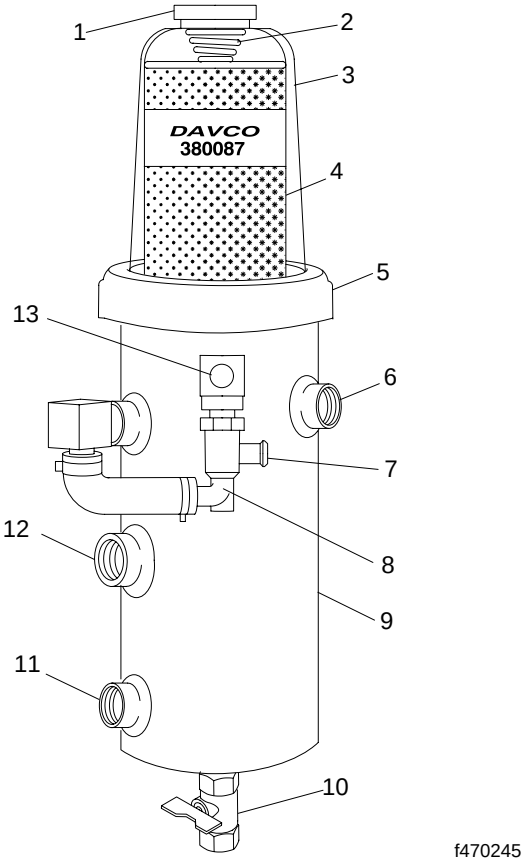


1. Filter Vent
2. Filter Element
3. Fuel Preheater
4. Fuel Heater/Water Separator Body
5. Water Sensor Probe
6. Drain Valve
7. Coolant Outlet
8. Fuel Inlet
9. Coolant Inlet
10. Fuel Outlet

Fig. 1, Davco 321 Fuel Heater/Water Separator

- 4.4 Plug the fuel outlet at the fuel heater/water separator body.
- 4.5 Make a fitting that will adapt a regulated shop air line to fit the fuel inlet line on the fuel heater/water separator.
- 4.6 Set the regulated air pressure line to 30 psi (200 kPa) maximum pressure.
- 4.7 Apply a bubbling leak detection fluid to the exterior of the fuel heater/water separator body.
- 4.8 Apply air pressure to the fuel inlet of the fuel heater/water separator.

Troubleshooting



1. Filter Vent
2. Filter Spring
3. Filter Cover
4. Filter Element
5. Filter Collar
6. Fuel Preheater Port
7. Coolant Inlet
8. Thermal Control Valve Assembly
9. Fuel Heater/Water Separator Body
10. Drain Valve
11. Coolant Outlet
12. Fuel Inlet
13. Fuel Outlet

Fig. 2, Davco 380 Fuel Heater/Water Separator

4.9 If a leak is located at the filter element or seal area, replace the suspect filter element or seal.

If a leak is located at the fuel heater/water separator body, replace the suspect unit. See **Subject 100** for the 321 unit or **Subject 110** for the 380 unit.

If a leak is not located, and the fuel heater/water separator is known to lose prime overnight, check the fuel pump and fuel lines for a possible fitting or seal leak.

5. Release the air pressure to the fuel inlet.
6. Place a suitable container under the fuel heater/water separator, and open the drain valve to release the internal pressure and prevent fuel spray.
7. Disconnect the air pressure fitting, and reconnect the fuel lines.
8. If the unit is the 321 series, remove the filter element and fill the fuel heater/water separator to the top of the fuel port. Replace the filter element.

   If the unit is the 380 series, remove the filter vent; then fill with fuel until fuel is about 1 inch above the collar. Replace the filter vent.
9. Start the engine, then raise the rpm for 1 to 2 minutes to purge air from the system and check for fuel leaks. Repair all fuel leaks with the engine OFF.
10. Shut the engine off. Remove the chocks from the tires.

Problem—Fuel Gels In Cold Weather

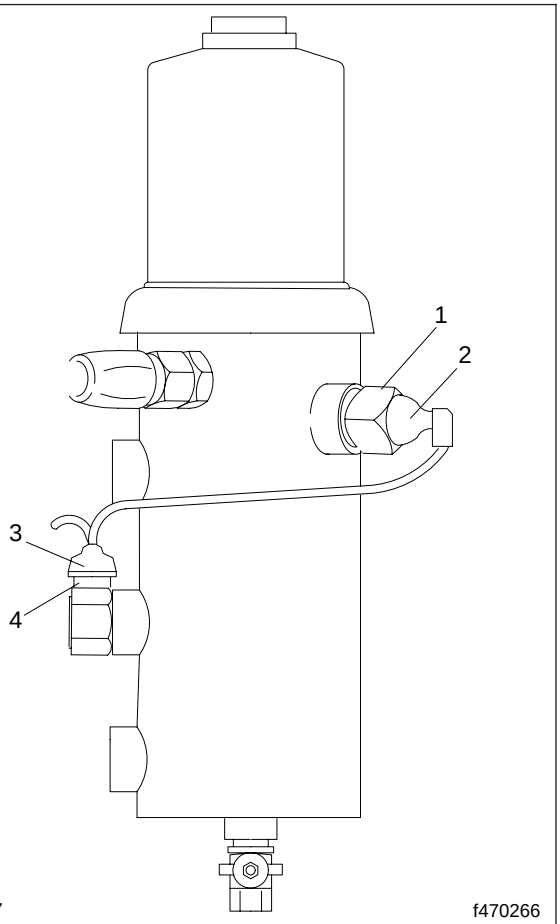
321 and 380 Models Equipped with a Thermal Control Valve or an Electric Preheater (See Fig. 2 and Fig. 3)

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. If the fuel/water separator in not equipped with a thermal control valve, skip to step 7.

⚠ WARNING

Do not remove or loosen the surge tank cap until the engine and cooling system have completely cooled. Use extreme care when removing the cap. The sudden release of pressure from removing the cap prior to the system cooling can result in a surge of scalding coolant that could cause serious personal injury.

3. With the engine cool, loosen the surge tank cap on the surge tank to release cooling system pressure.



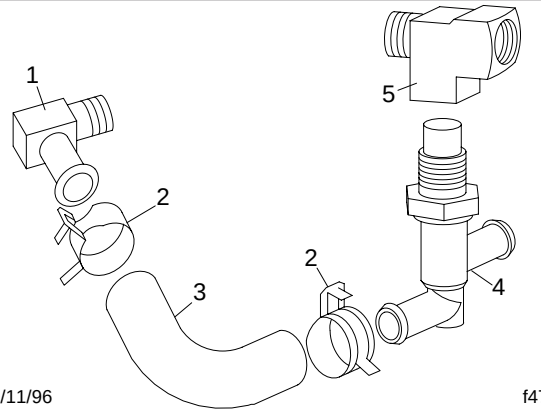
1. Fuel Preheater
2. Preheater Connector
3. Thermoswitch Connector
4. Thermoswitch

Fig. 3, Davco Fuel Water Separator with Fuel Preheater

⚠ WARNING

Do not attempt to drain the cooling system until the coolant and engine are cool. Draining the cooling system prior to the system cooling could cause severe personal injury due to scalding.

4. Remove the thermal control valve. See **Fig. 4**. For Instructions, refer to **Subject 130**.
5. Place the thermal control valve in ice water for about 2 minutes.
6. Blow air into the coolant inlet and check for air flow at the coolant outlet. If no air flow is present,



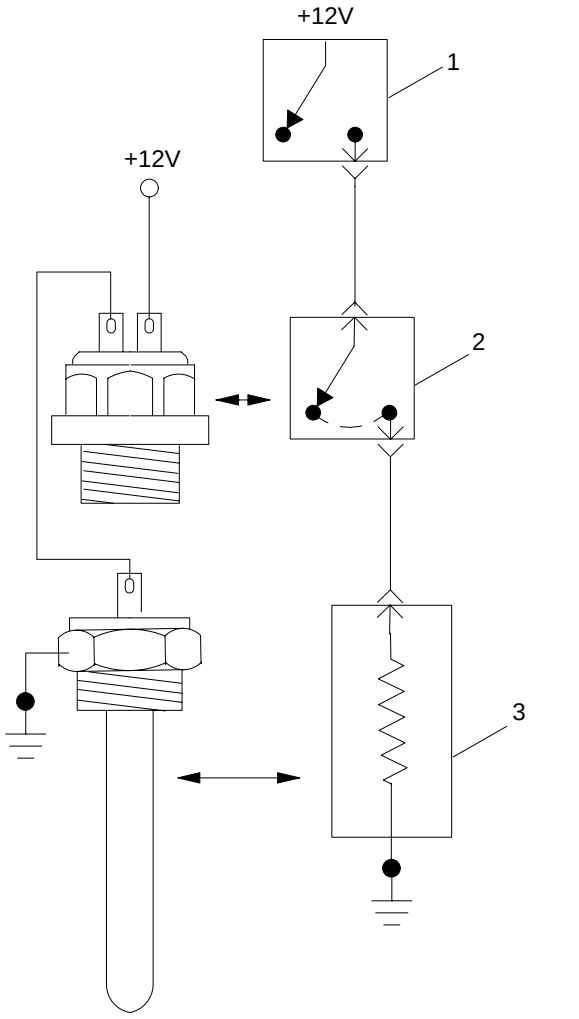
1. 90-Degree Elbow
2. Clamp
3. Formed Hose
4. Thermal Control Valve
5. Fuel Tee

Fig. 4, Davco Fuel Heater/Water Separator Thermal Control Assembly

replace the thermal control valve. See **Subject 130** for replacement.

7. Check the preheater resistance if equipped. See **Fig. 5**.
   - 7.1 Pull back the rubber boot at the preheater to expose the electrical connector
   - 7.2 Using an ohmmeter set to its lowest resistance range, measure the resistance from the preheater terminal to ground. The resistance should be between 0.86 and 1.06 ohms for 321 models, or between 0.52 and .63 ohms for 380 models. If the resistance is out range, replace the preheater. See **Subject 140**.
8. Check the thermoswitch
   - 8.1 Disconnect the thermoswitch connector.
   - 8.2 Remove the thermoswitch from the fuel heater/water separator.
   - 8.3 Chill the thermoswitch with dry ice or CO_2 until the thermoswitch temperature is below 32°F (0°C); then measure the resistance with an ohmmeter to its lowest resistance range. At this temperature thermoswitch should be closed and the ohmmeter should read zero ohms. If the reading is not zero ohms, replace the thermoswitch. See **Subject 140**.

Troubleshooting



1. Ignition Switch
2. Thermoswitch
3. Preheater

Fig. 5, Davco Fuel Preheater Schematic (typical)

9. Check for a break in the wire between the thermoswitch and the preheater.
   - 9.1 Locate the thermoswitch connector terminal that leads to the preheater.
   - 9.2 Using and ohmmeter on its lowest resistance range, measure the resistance between the thermoswitch connector terminal that leads to the preheater and the preheater connector terminal. If the resistance in not zero ohms, repair/replace the open in the wire as necessary.
10. Check the voltage at the thermoswitch.
    - 10.1 Locate the thermoswitch connector terminal that leads to the ignition switch and connect the positive voltmeter lead to that terminal.
    - 10.2 Connect the voltmeter ground terminal to a known good vehicle ground.
    - 10.3 Select the 20 volt range on the voltmeter; then turn the ignition switch on with the engine off. If the voltmeter does not read battery voltage (about 12 volts) check the ignition wire for an open.

Make all resistance measurements with the ignition switch off.

11. Verify that the fuel heater/water separator is grounded by checking resistance between battery negative and the body of the fuel heater/water separator with the ohmmeter set to its lowest resistance range.
12. Remove the chocks from the tires.

Problem—Fuel Overheating

321 and 380 Models Equipped With a Thermal Control Valve or Electric Preheater

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. If the fuel/water separator is not equipped with a thermal control valve, skip to step 7.

⚠ WARNING

Do not remove or loosen the surge tank cap until the engine and cooling system have completely cooled. Use extreme care when removing the cap. The sudden release of pressure from removing the cap prior to the system cooling can result in a surge of scalding coolant that could cause serious personal injury.

3. With the engine cool, loosen the surge tank cap on the surge tank to release cooling system pressure.

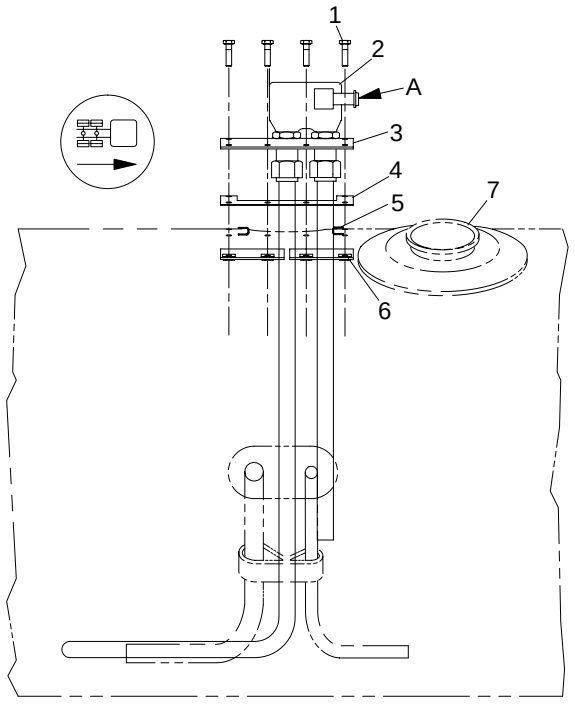
WARNING

Do not attempt to drain the cooling system until the coolant and engine are cool. Draining the cooling system prior to the system cooling could cause severe personal injury due to scalding.

4. Remove the thermal control valve. See **Subject 130**.
5. Place the thermal control valve in 90°F (33°C) water for about 2 minutes.
6. Blow air into the coolant inlet and check for air flow at the coolant outlet. If air flow is present, replace the thermal control valve. See **Subject 130** for replacement.
7. Check the thermoswitch if equipped. See **Fig. 5)**.
   - 7.1 Disconnect the thermoswitch connector.
   - 7.2 Remove the thermoswitch from the fuel heater/water separator.
   - 7.3 Heat the thermoswitch with a flameless heater until the thermoswitch temperature is above 60°F (16°C); then measure the resistance with an ohmmeter to its lowest resistance range. At temperatures above 60°F (16°C) the temperature thermoswitch should be open and the ohmmeter should show no continuity (open circuit). Replace the thermoswitch if the ohmmeter shows any continuity. See **Subject 140**.
8. Remove the chocks from the tires.

General Information

The Arctic Fox fuel heater Model C406 (see **Fig. 1**) is installed in the fuel tank facing the fuel filler neck. It comes in two different lengths to accomodate 23- and 27-inch cylindrical tanks.



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NOTE: Right-hand tank shown

A. Orient coolant fittings toward the fuel filler neck.

1. Mounting Capscrew
2. Fuel Heater
3. Mounting Flange
4. Gasket
5. Mounting Clip
6. Backing Plate
7. Fuel Filler Neck

Fig. 1, Arctic Fox Fuel Heater

Twelve 1/4-inch (6 mm) capscrews bolt the heater to the tank, attaching to a mounting flange that is an integral part of the heater head. A heating coil, consisting of a coolant tube in the form of a closed loop, extends down into the tank.

To prevent overheating, the unit is equipped with a temperature probe that monitors fuel temperature. It is connected to a bypass thermostat that controls an automatic coolant shut-off valve.

Principles of Operation

Hot engine coolant is routed through the heating coil, warming the fuel as it passes. A bypass thermostat shuts off the coolant flow when the fuel in the tank reaches a temperature of approximately 80°F (27°C).

The hot coolant is then directed through a bypass circuit within the thermostat head, which sends it straight back to the engine. For this reason, the head of the fuel heater stays hot even when the heating circuit has been bypassed.

Replacement

IMPORTANT: When installed in the fuel tank, the clearance between the bottom of the fuel heater and the inside of the tank wall must be at least 1 inch (25 mm) and no more than 2 inches (51 mm).

1. Apply the parking brakes, shut down the engine, and chock the tires.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

2. Drain the coolant. See **Section 20.01** for instructions.
3. Mark the coolant fittings and lines. Disconnect the coolant lines from the fittings on the fuel heater.

⚠ WARNING

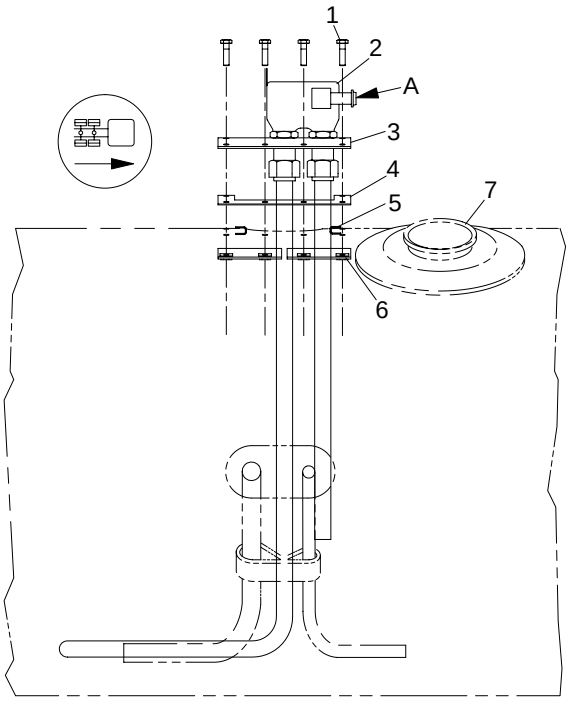
Do not expose the fuel to, or work with the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

4. Remove the twelve 1/4-inch capscrews attaching the fuel heater mounting flange to the fuel tank. See **Fig. 1**.
5. Remove the fuel heater from the fuel tank.
   - 5.1 Carefully work the fuel heater coil out of the fuel tank around the backing plate.
   - 5.2 Remove the fuel heater gasket.
6. Install the new fuel heater in the fuel tank.
   - 6.1 Position a new gasket on the hole in the fuel tank. Align the holes in the gasket with those in the tank.
   - 6.2 Insert the heater coil into the tank, making sure that it does not contact anything inside the tank, such as the tank wall, the fuel gauge, the standpipe, or tank baffles. Also make sure the heating element is positioned in the same direction as when removed.
   - 6.3 Line up the heater mounting flange with the gasket and the holes in the tank, and insert the twelve 1/4-inch mounting capscrews. Using the sequence shown in **Fig. 2**, tighten the capscrews 40 to 60 lbf·in (460 to 680 N·cm).

   NOTE: Be sure the heads of the capscrews are snug to the top of the mounting flange.

   - 6.4 Now tighten each capscrew 78 to 95 lbf·in (880 to 1080 N·cm).

IMPORTANT: To ensure that the gasket seals properly, follow the tightening sequence exactly.



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NOTE: Right-hand tank shown

A. Orient coolant fittings toward the fuel filler neck.

1. Mounting Capscrew
2. Fuel Heater
3. Mounting Flange
4. Gasket
5. Mounting Clip
6. Backing Plate
7. Fuel Filler Neck

Fig. 1, Arctic Fox Fuel Heater Installation

Fuel Heater Replacement

7. Connect the coolant lines to the heater, as marked. Apply Loctite® 271 (or equivalent) to all fitting threads. Tighten all fittings until they are airtight.

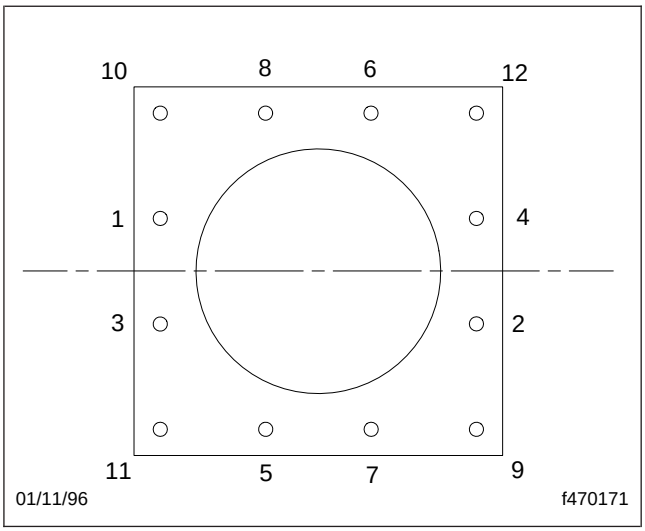


Fig. 2, Fastener Tightening Sequence

IMPORTANT: Keep all lines as straight and short as possible.

8. Fill the cooling system with clean coolant. See **Section 20.01** for instructions.
9. Start the engine and check for coolant leaks. With the engine shut down, repair any leaks.
10. Lower the hood, and remove the chocks from the tires.

General Information

The Hayden fuel cooler (see **Fig. 1**) consists of a heat exchanger, fuel tubing, and a rubber mounting block.

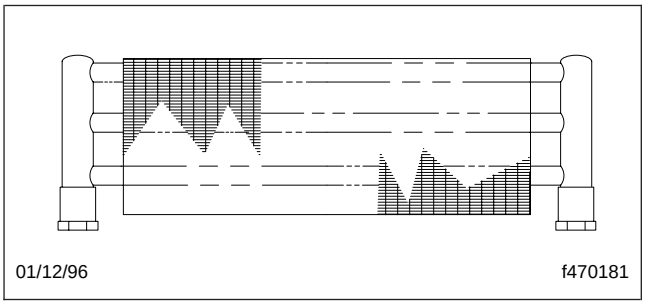


Fig. 1, Hayden Fuel Cooler

The fuel cooler bolts to a mounting bracket with a retaining plate and biscuits. The bracket is bolted to the frame rail.

Fuel in the return line flows through the cooler and exchanges heat with the air flowing underneath the vehicle during operation. The cooled fuel then returns to the fuel tanks.

Hayden Fuel Cooler Removal and Installation

Removal

1. Apply the parking brakes, shut down the engine, and chock the tires.

⚠ WARNING

Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

2. Mark the fuel fittings and lines. Disconnect the fuel lines from the fittings on the fuel cooler. See **Fig. 1.** Have a basin ready to catch the fuel that comes out of the lines. Tie up the fuel lines to prevent dripping.
3. Remove the fuel cooler from its mounting bracket. See **Fig. 1.**
   - 3.1 Remove the four 5/16–18 locknuts and rear washers from the mounting bracket.
   - 3.2 Remove the capscrews, front washers, biscuits, and retaining plates.
   - 3.3 Drain the fuel in the fuel cooler into a basin.

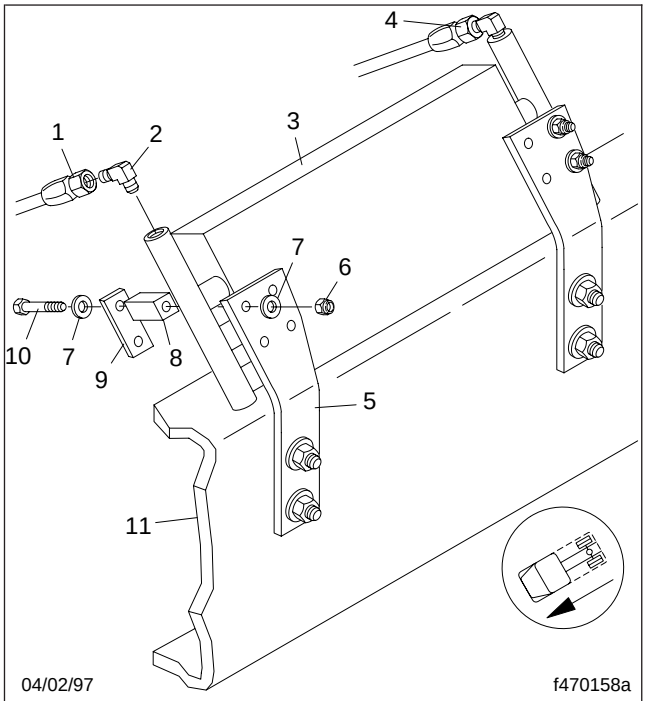
Installation

1. Install the fuel cooler on its mounting bracket.
   - 1.1 Position the retaining plates, biscuits, front washers, and 5/16–18 capscrews on the fuel cooler and mounting bracket.
   - 1.2 Install the 5/16–18 locknut and rear washer. Tighten the locknuts 25–30 lbf·in (280–340 N·cm).
2. Connect the fuel lines to the fuel cooler.
   - 2.1 Apply Loctite® 271 (or equivalent) to all fitting threads.

⚠ CAUTION

To avoid damaging the connections, use a back-up wrench on the fuel cooler fittings when tightening the fuel line fittings.

   - 2.2 Connect the fuel lines and tighten the fittings 15 lbf·ft (20 N·m).
3. Prime the engine fuel pump; refer to the engine manufacturer's operation and maintenance manual.
4. Start the engine and check for fuel leaks. With the engine shut down, repair any leaks.
5. Remove the chocks from the tires.



1. Frame Rail
2. 5/16–18 Mounting Capscrew
3. Washer
4. Retaining Plate
5. Biscuit
6. 90° Elbow
7. Fuel Cooler
8. 5/16–18 Locknut
9. Mounting Bracket
10. Fuel Fitting (from engine)
11. Fuel Fitting (to fuel tank)

Fig. 1, Fuel Cooler Fittings and Mounting

Troubleshooting

Problem—The Fuel Cooler Is Not Cooling the Fuel

Problem—The Fuel Cooler Is Not Cooling the Fuel	
Possible Cause	**Remedy**
The cooling fins are dirty.	Wearing eye protection, clean the fuel cooler fins carefully. If necessary, use water flowing at low pressure to remove debris lodged in the fins. **CAUTION** **Do not direct a high-pressure stream of water at the fuel cooler. This will damage the fins.**
The cooling fins are bent.	Using a 12 fin/inch fin comb, straighten any bent fins.
The fuel cooler is clogged with contaminated fuel.	Using a compatible fuel system fluid, flush out the fuel cooler in both directions (through both fittings).
There are hairline cracks in the fuel cooler.	Replace the fuel cooler.
The fuel cooler's fuel tubing is dented badly enough to restrict fuel flow past the fuel cooler.	Replace the fuel cooler.

Problem—The Fuel Cooler Is Leaking

Problem—The Fuel Cooler Is Leaking	
Possible Cause	**Remedy**
The fuel line connections are loose.	Tighten the connections until the leaks disappear. Do not tighten more than 15 lbf·ft (20 N·m) and use a back-up wrench on the fuel cooler fitting. Start the engine and make sure there are no more leaks.
The sealant on the fittings is not adequate.	Remove the fittings, clean off any dried or cracked sealant, and apply Loctite® 271 (or equivalent) to all fitting threads.
The fitting(s) are cracked or stripped.	Replace the fitting(s).

Specifications

Fastener Torque Values			
Fastener Description	**Size**	**Torque Value**	
		lbf·ft (N·m)	**lbf·in (N·cm)**
Mounting Locknuts	5/16–18	—	25–30 (280–340)
Fuel Line Fittings	—	15 (20)	—

Table 1, Fastener Torque Values

General Description (See Fig. 1 and Fig. 2)

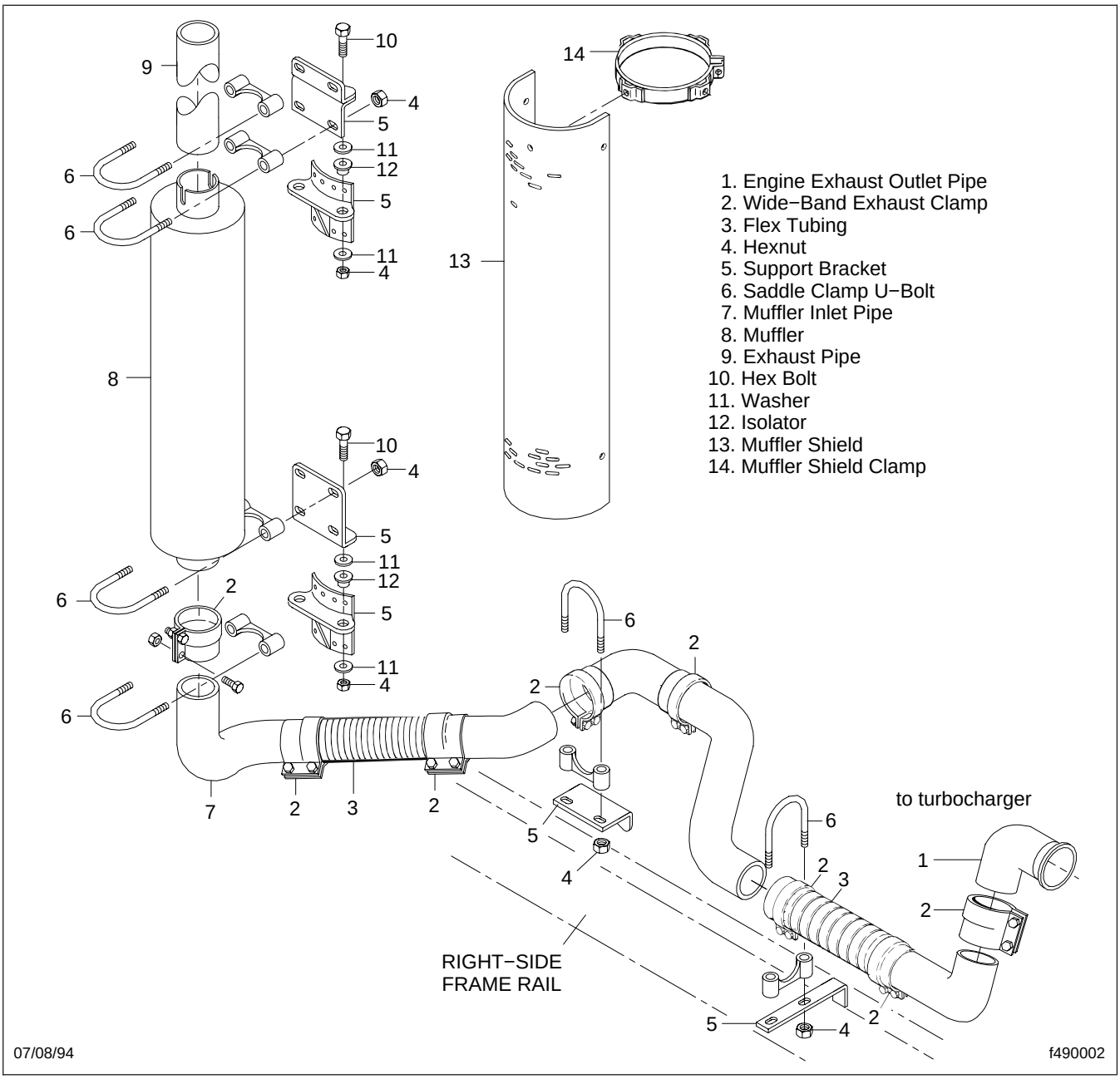


Fig. 1

The exhaust system routes hot exhaust gas away from the cab, and reduces engine exhaust noise. The exhaust system consists of the engine outlet exhaust pipe, flex tubing, the muffler inlet exhaust pipe, the muffler, muffler support components, muffler shield, and the upper outlet stack. A V-type clamp (

General Description

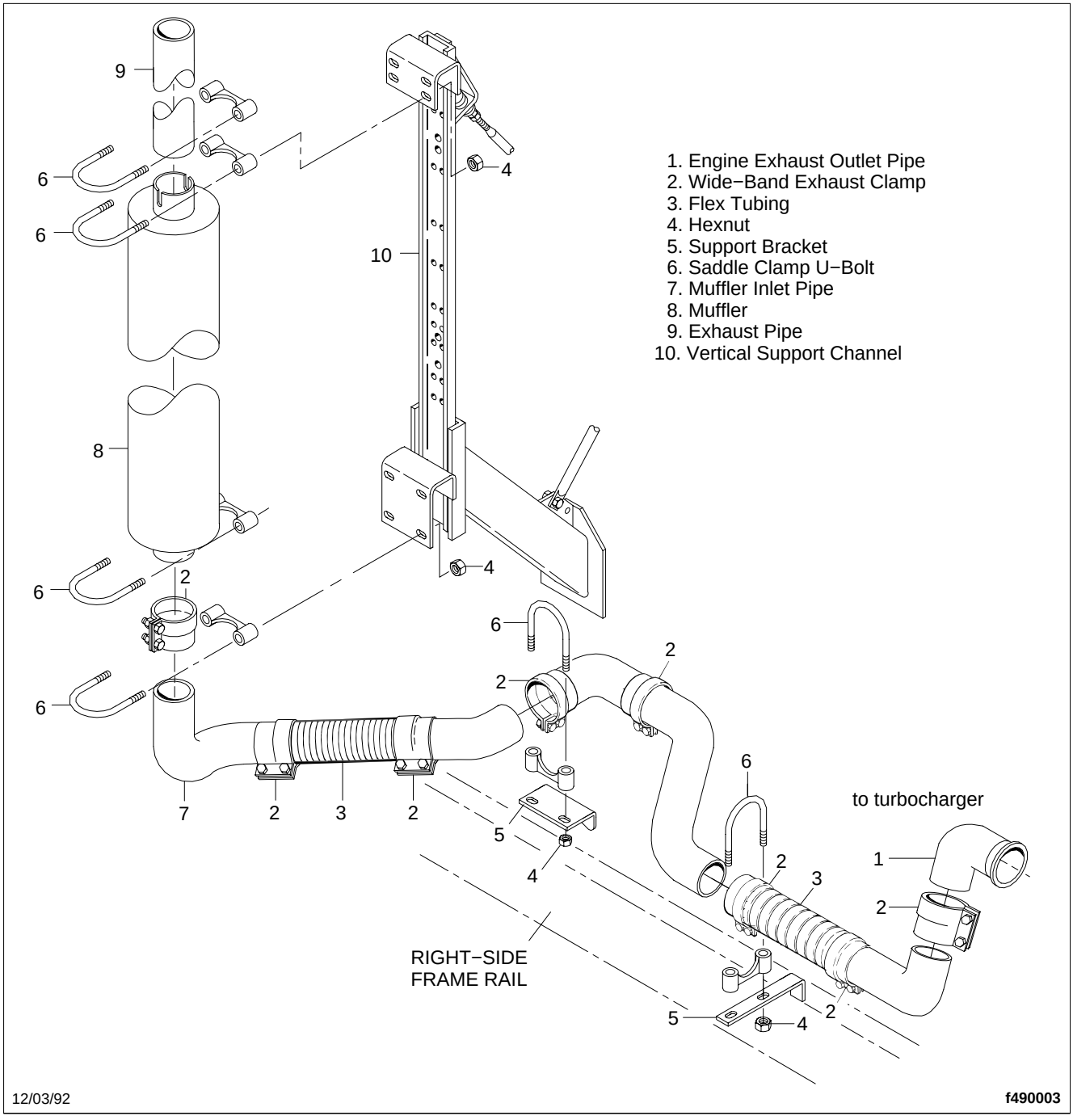


Fig. 2

Fig. 3) joins the outlet exhaust pipe to the engine's turbocharger outlet. Wide-band exhaust clamps connect and seal all of the other joints between the outlet exhaust pipe and the muffler.

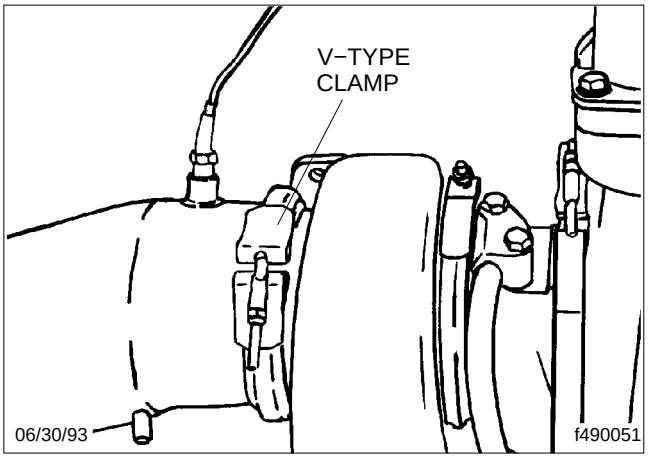


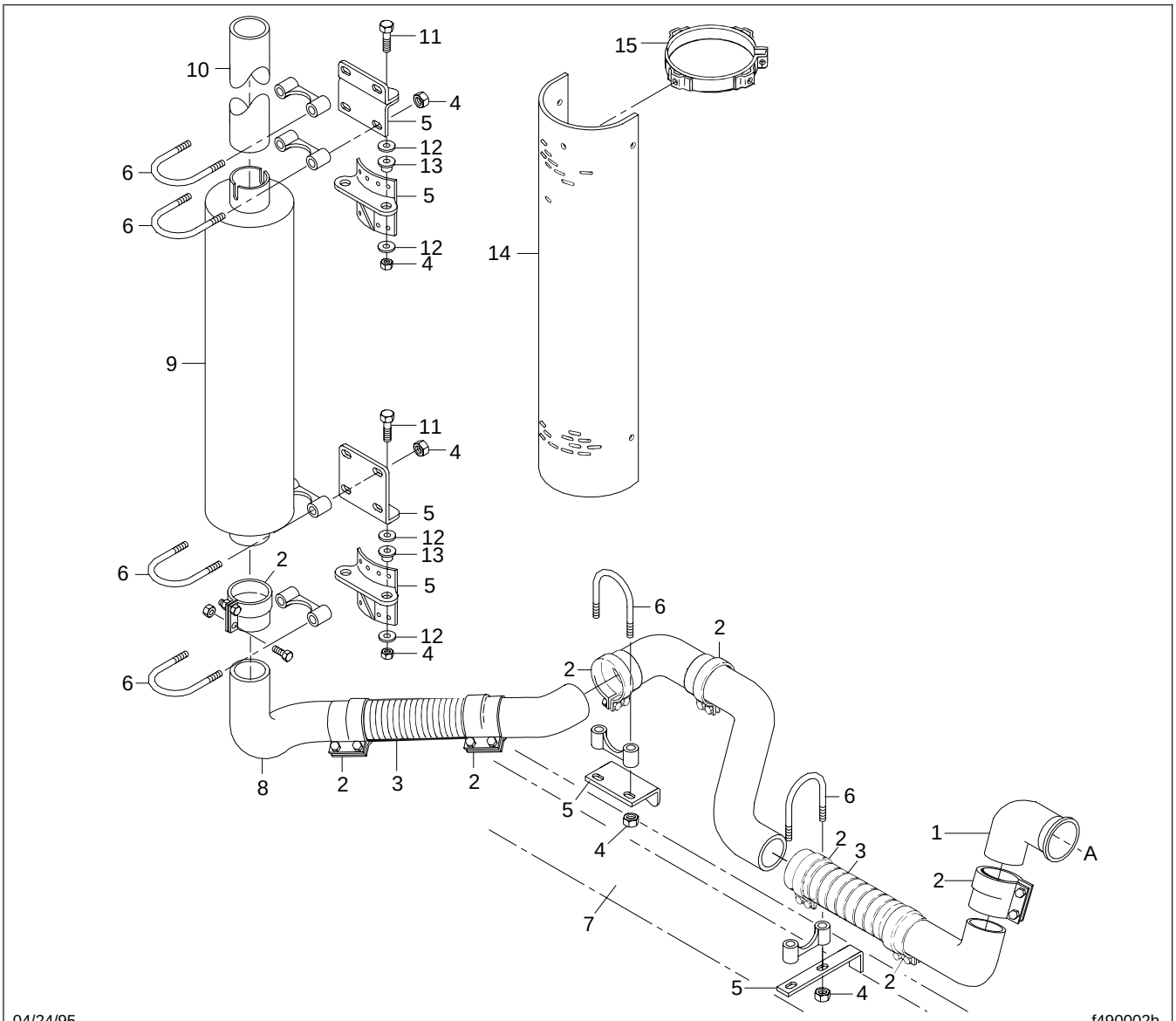
Fig. 3

Replacement

NOTE: On 120 Conventionals with sleepers, the muffler is attached to support brackets that are installed on the sleeper (**Fig. 1**). On all COEs, and 120 Conventionals without sleepers, the muffler is attached to a vertical support channel (**Fig. 2**).

1. Remove the flanged hexnuts from the saddle clamp U-bolts that attach the exhaust pipe to the support channel or support bracket. Remove the saddle clamps, then lift out the exhaust pipe.
2. Remove the wide-band exhaust clamp at the muffler inlet pipe connection.
3. At the muffler inlet connection, hold the muffler against the vertical support channel or the support brackets, and remove the flanged hexnuts from the saddle clamp U-bolts.
4. Lift the muffler off of the inlet pipe. Remove the assembly from the vehicle.
5. If equipped with a muffler shield, remove both shield clamp assembly clamping bolts and nuts. Slide the shield off the end of the muffler.
6. Slide the shield assembly over the new muffler, and install the clamping bolts and nuts. Do not tighten the nuts more than what is needed to hold the clamps in place.
7. If replacing the flexpipe, refer to **Subject 130** for instructions.
8. Place the lower end of the muffler over the inlet pipe. Support the lower edge of the muffler body on the muffler support bracket, or on the bottom of the support channel.
9. Shift the shield up or down until the bottom edge is 2-1/2 inches (64 mm) below the bottom of the muffler body. Tighten the shield clamp nuts 13 lbf·ft (18 N·m).
10. Install the wide-band exhaust clamp at the muffler inlet connection. Refer to **Subject 110** for instructions.
11. Install the saddle clamp U-bolt that attaches the muffler to the lower support bracket, or support channel. Tighten the saddle clamp flanged nuts alternately (in three increments), to 24 lbf·ft (33 N·m).
12. Insert the bottom of the exhaust pipe in the top of the muffler. Install the saddle clamps, with the flanged nuts on the U-bolt inboard. If the vehicle is equipped with an exhaust rain cap, turn the exhaust pipe until the pivot on the rain cap is inboard, and the rain cap opens outboard. Tighten the saddle clamp flanged nuts alternately (in three increments), to 24 lbf·ft (33 N·m).
13. Run the engine, and check for exhaust leakage at the exhaust clamp joint.

Vertical Muffler Replacement

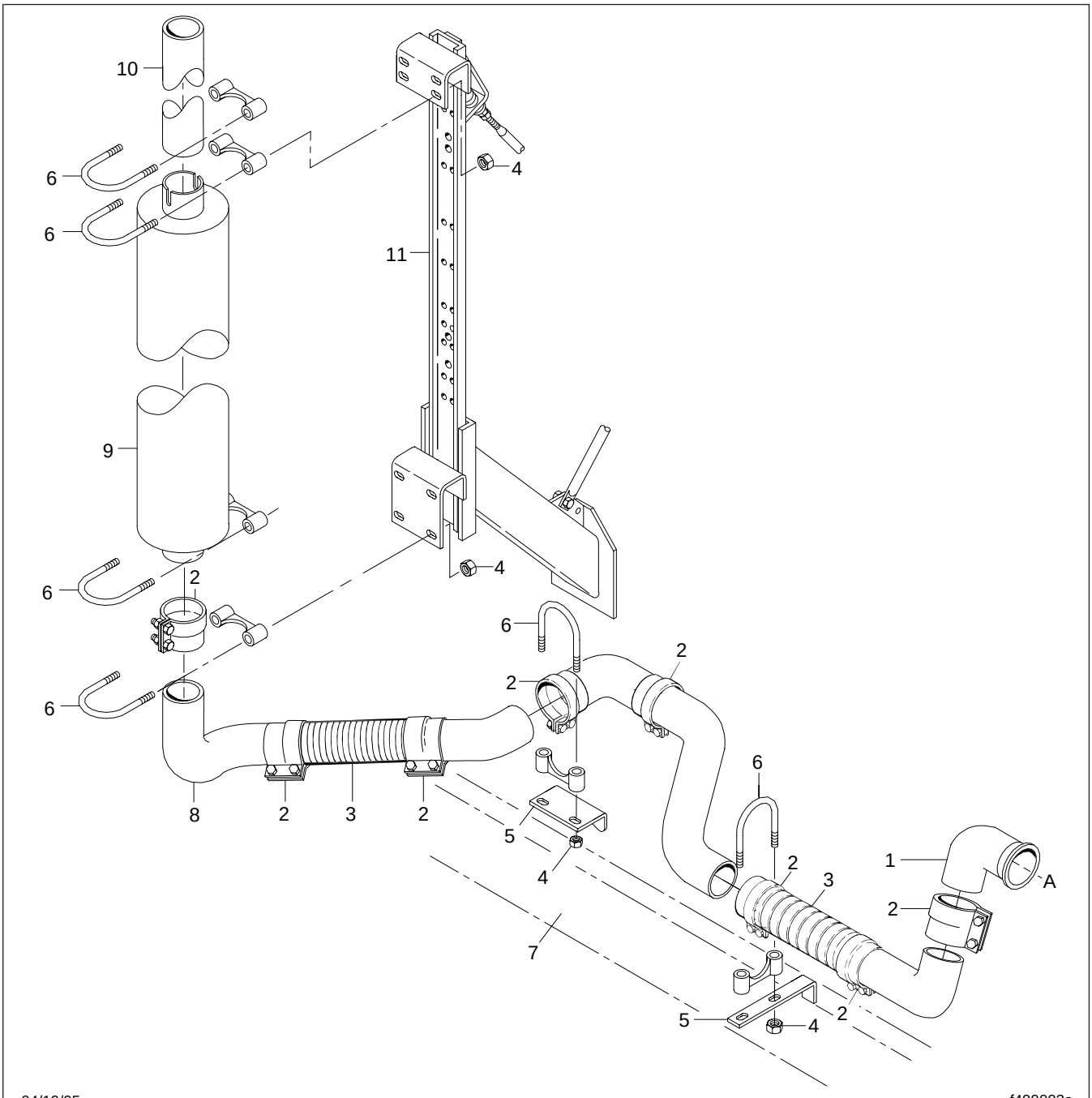


A. To Turbocharger

1. Engine Exhaust Outlet Pipe
2. Wide-Band Exhaust Clamp
3. Flexpipe
4. Hexnut
5. Support Bracket
6. Saddle Clamp U-Bolt
7. Right-Side Frame Rail
8. Muffler Inlet Pipe
9. Muffler
10. Exhaust Pipe
11. Hexbolt
12. Flatwasher (may not be present)
13. Isolator
14. Muffler Heat Shield
15. Muffler Heat Shield Clamp

Fig. 1, Muffler Installion (120 Conventional with sleeper)

Vertical Muffler Replacement

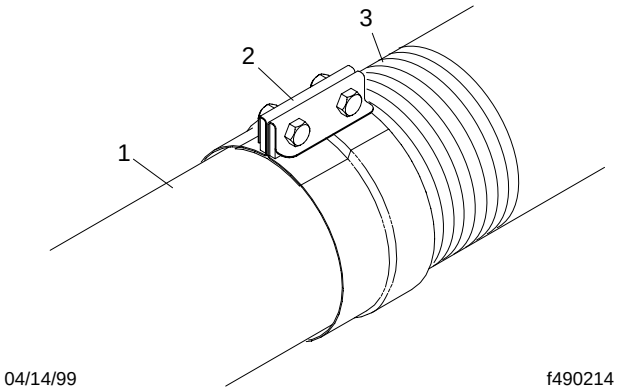


A. To Turbocharger
1. Engine Exhaust Outlet Pipe
2. Wide-Band Exhaust Clamp
3. Flexpipe
4. Hexnut
5. Support Bracket
6. Saddle Clamp U-Bolt
7. Right-Side Frame Rail
8. Muffler Inlet Pipe
9. Muffler
10. Exhaust Pipe
11. Verical Support Channel
15. Muffler Heat Shield Clamp

Fig. 2, Muffler Installation (120 Conventional without sleeper and all COEs)

Replacement (See Fig. 1)

1. Remove and discard the leaking or damaged wide-band exhaust clamp.
2. Insert one end of the flexpipe into the large-diameter side of the exhaust clamp until it contacts the step in the center of the clamp.
3. Insert about 3 inches (76 mm) of the exhaust piping into the small-diameter side of the exhaust clamp.



1. Exhaust Tubing
2. Exhaust Clamp
3. Flexpipe

Fig. 1, Wide-Band Exhaust Clamp

4. Make sure again that the end of the flexpipe is up against the step at the middle of the exhaust clamp.
5. Tighten snugly the hexbolt on the large-diameter (flexpipe) side of the clamp.
6. Tighten the hexbolt on the small-diameter side of the clamp 45 lbf·ft (61 N·m).
7. Tighten the hexbolt on the large-diameter side of the clamp 45 lbf·ft (61 N·m).
8. Check the hexbolt on the small-diameter side of the clamp. If needed, tighten 45 lbf·ft (61 N·m).
9. If a new flexpipe was installed, remove the flow-direction indicators from it.
10. Run the engine, and check for leaks. If needed, remove and install the exhaust clamp again.

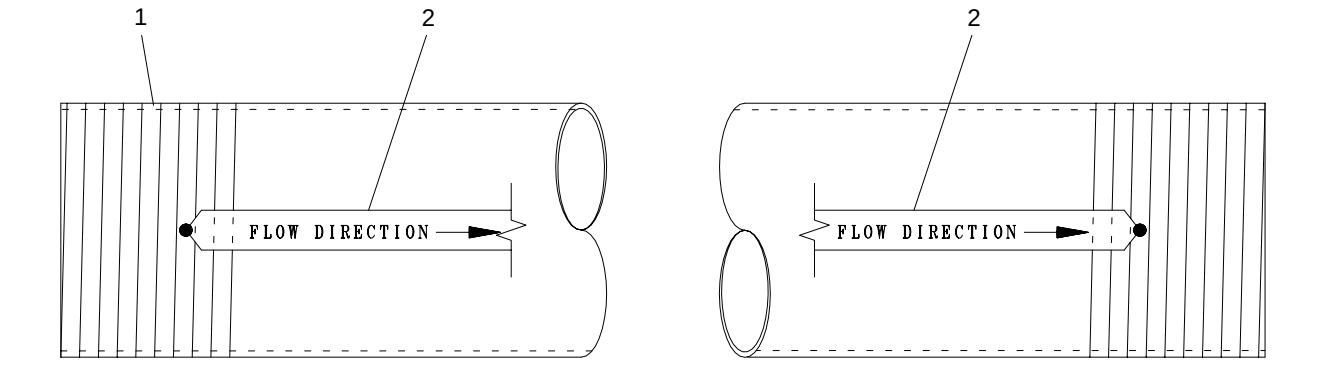
Muffler Shield Replacement

Replacement

1. Remove the six capscrews that attach the muffler shield to the muffler shield clamps, and remove the muffler shield.
2. Position the new muffler shield against the clamps, and install all six capscrews. Tighten the capscrews 13 lbf·ft (18 N·m).

Replacement

1. Position the flexpipe according to the flow-direction indicators on the pipe. See **Fig. 1**.



1. Flexpipe
2. Flow-Direction Indicator

Fig. 1, Exhaust Flexpipe

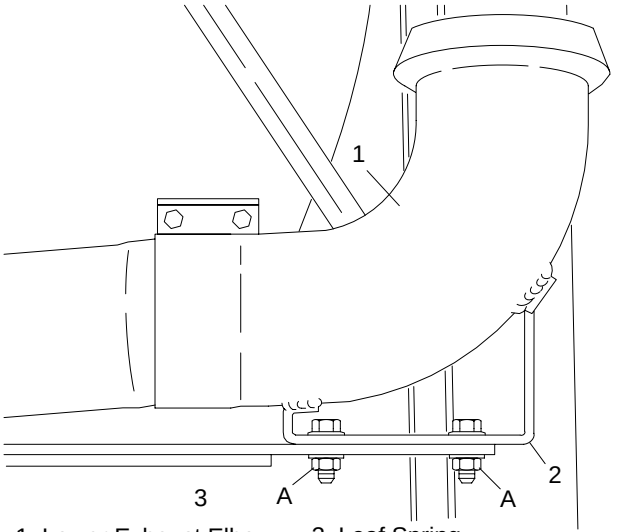
2. Connect one end of the new flexpipe to the exhaust pipe.
3. Connect the other end of the flexpipe to the muffler or other exhaust pipe, as applicable.
4. Make sure the flow-direction indicators on the flexpipe are straight and taut. They also serve as installation guides to indicate the correct amount of pipe extension.
5. Install the wide-band exhaust clamps that were removed. For instructions, refer to **Subject 110**.
6. When the exhaust clamps are tightened, remove the flow-direction indicators from the new flexpipe.

General Description

A breaking exhaust system is used when more room at the back of the cab is needed. The exhaust muffler and top stack assembly is clamped to the rear corner of the cab, or recessed in a well. When the cab is in the operating position, the bell at the bottom of the muffler fits over the top of the lower exhaust elbow outlet. The lower elbow is mounted on a leaf spring and moves vertically when the bell is seated on it. When the cab is tilted, the bell is lifted off of the lower exhaust elbow.

Lower Exhaust Elbow-to-Muffler Bell Centering Adjustment

1. Tilt the cab until the muffler bell clears the lower exhaust elbow. For cab tilting instructions, refer to the vehicle driver's manual.
2. Loosen the fasteners that attach the lower exhaust elbow bracket to the leaf spring (**Fig. 1**, Ref. A).
3. Loosen the fasteners that attach the leaf spring to the frame-rail-mounted spring bracket.
4. Move the elbow inboard, outboard, or fore and aft, as needed, to align the exhaust elbow with the muffler bell.
5. Tighten the nuts that attach the lower exhaust elbow bracket to the leaf spring 58 lbf·ft (79 N·m). Tighten the nuts that attach the leaf spring to the spring bracket 58 lbf·ft (79 N·m).



1. Lower Exhaust Elbow
2. Lower Exhaust Elbow Bracket
3. Leaf Spring

NOTE: Cab is in tilted position.

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Fig. 1

6. Return the cab to the operating position. Check the adjustment. The muffler bell must be centered over and seat tightly on the lower exhaust elbow. If not centered, repeat the above procedure. If it is not seated, proceed to **Subject 110**.

Lower Exhaust Elbow Deflection Adjustment

1. Check that the muffler bell is centered over the lower exhaust elbow. If needed, center the muffler bell using the instructions in **Subject 100**.
2. Tilt the cab until the muffler bell clears the lower exhaust elbow. For cab tilting instructions, refer to the vehicle driver's manual.
3. Loosen the nuts on the exhaust clamp bracket U-bolts. **See Fig. 1.**
4. Loosen the nut on the exhaust alignment bracket assembly bolt. **See Fig. 2.**
5. Slide the muffler and top stack assembly up or down, as needed, so that the lower exhaust elbow will move to a vertical position when the cab is in the operating position.
6. Tighten the exhaust clamp U-bolt nuts 24 lbf·ft (33 N·m).
7. Tighten the exhaust alignment bracket nut 13 lbf·ft (18 N·m).
8. Return the cab to the operating position. Check the adjustment. The lower exhaust elbow should move to a vertical position. If not, repeat the above procedure.

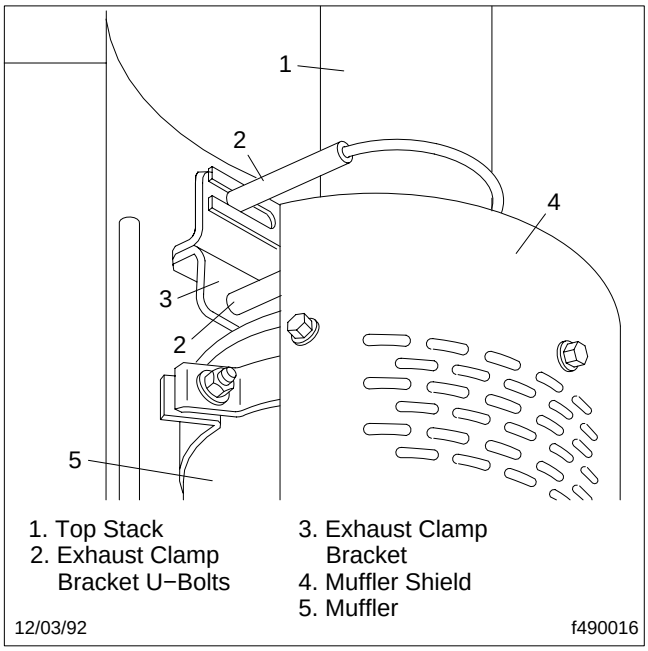


Fig. 1, In-Well Breaking Exhaust

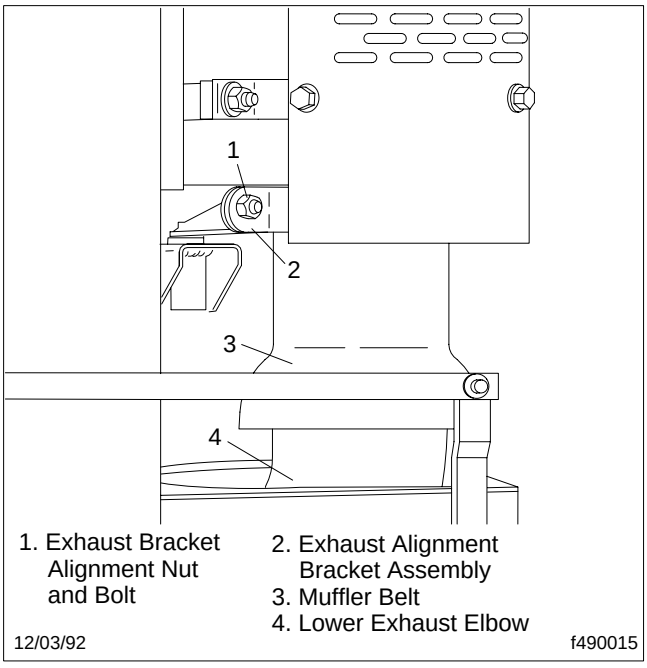


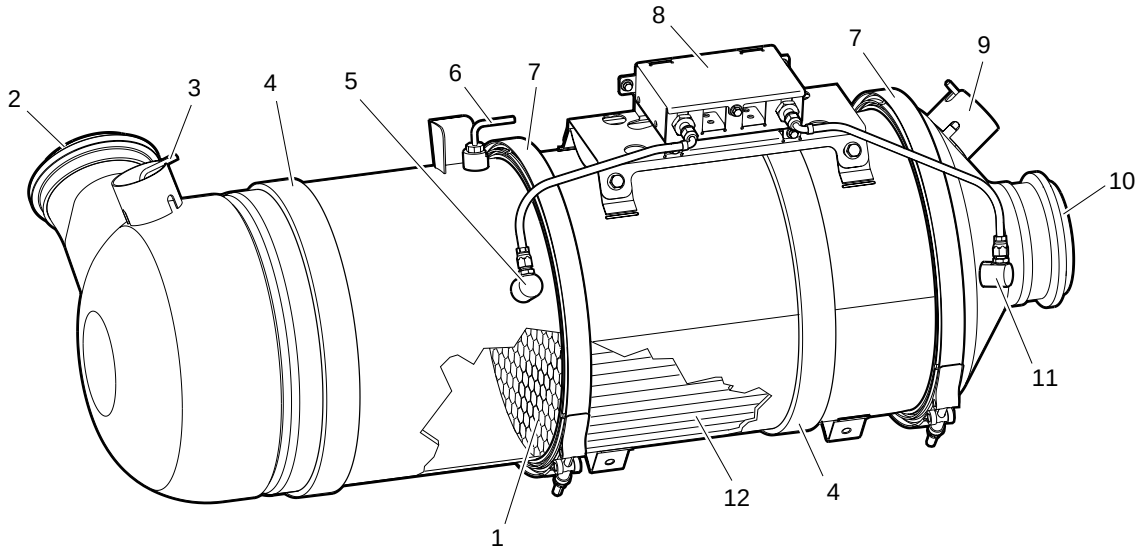
Fig. 2

General Information

The aftertreatment system (ATS), introduced to meet the requirements of the EPA07 emission control regulations, includes all the piping and equipment between the turbocharger outlet and the tip of the exhaust pipe. It resembles the exhaust system on pre-EPA07 vehicles, but includes an aftertreatment device (ATD) instead of a muffler (see **Fig. 1**), and other equipment. Monitoring and operation of the ATS is controlled by an electronic control module (ECM).

ways chassis-mounted, but can be mounted either vertically or horizontally. ATS exhaust piping is stainless steel.

Inside the ATD, the exhaust first passes through the diesel oxidation catalyst (DOC) where combustion gases are chemically broken down to water and carbon dioxide, then through the (DPF), where solid particles are trapped. The trapped particles are almost completely vaporized in the DPF in regeneration, sometimes shortened to the term, "regen." The soot from engine oil additives which cannot be vaporized is burned to ash and held in the DPF until it eventu-



1. Diesel Particulate Filter (DPF) Ceramic Honeycomb Substrate Openings
2. Marmon Fitting at Inlet from Turbocharger
3. Diesel Oxidation Catalyst (DOC) Intake Temperature Sensor
4. ATD Mounting Band
5. DPF Intake Pressure Sensor
6. DOC Outlet Temperature Sensor (connection to sensor housing not shown)
7. DPF V-Band Mounting Clamps
8. Sensor Housing
9. DPF Outlet Temperature Sensor (connection to sensor housing not shown)
10. Exhaust Outlet Marmon Fitting
11. DPF Outlet Pressure Sensor
12. DPF Substrate Tubes

Fig. 1, ATD Components (typical)

EPA07 emissions regulations limit NOx to just over 1 gram per brake horsepower hour (g/bhp-hr) and particulate matter cannot exceed 0.01 g/bhp-hr. EPA07 engines require ultralow sulphur diesel (ULSD) fuel, for low emissions and long life of the diesel particulate filter (DPF), a honeycomb soot filter inside the ATD.

Engine manufacturers use different methods and equipment to reduce emissions from their engines, but an ATD is used on all of them. The ATD is ally builds up, and the DPF must be removed and physically cleaned.

IMPORTANT: To minimize soot buildup on the DPF, low-ash oil is necessary for maximum service between physical cleanings. Only low-ash oil should be used in EPA07 engines.

NOTE: Freightliner documentation deals only with removal and installation of the components of the ATS. Refer to the engine manufacturer's

service literature for all testing, disassembly, cleaning, and repair of the ATD and other components.

IMPORTANT: The ATS is part of an integrated engine and emissions management system, controlled by the ECM. Follow the engine manufacturer's procedures, and use the correct equipment when diagnosing or working on any part of the ATS.

Regeneration

There are two types of regeneration; passive and active.

Passive regeneration happens whenever the ATD internal temperature is 572°F (300°C) or higher. This happens during normal loaded vehicle operation, and exhaust gas temperature is no higher than normal. Under load and at highway speeds, passive regeneration may be all that is necessary to keep the DPF clear. But running light loads, or at low speeds, does not generate enough heat in the ATD for passive regeneration, and soot builds up in the DPF.

As soot builds up in the DPF, it creates back pressure and decreases engine efficiency. So at intervals determined by the ECM, which keeps track of measurements such as engine hours, fuel consumed, and mileage, the ATS raises the temperature inside the ATD to burn the built-up soot to ash. This reduces the back pressure and allows the DPF to continue operating efficiently for tens of thousands of miles.

During active regeneration, engine rpm rise to fast-idle speed and extra fuel is injected into the ATD to raise its interior temperature very high, over 1112°F (600°C), and turn the trapped soot to harmless ash. There are two types of active regeneration; at-speed and parked.

- When conditions permit, the ECM automatically initiates at-speed regeneration. The exact conditions for regeneration vary, according to the engine manufacturer's design. Generally, it can happen only when the vehicle speed is above 7.5 mph, and active regeneration stops when the vehicle slows to 5 mph or below.
- Parked regeneration is initiated by a driver or technician when the vehicle is safely parked with the exhaust outlet well away from any flammable substance, a specific sequence of procedures is followed, and the driver pushes the regeneration button on the dashboard. The parked regeneration sequence varies according to engine and vehicle configuration, but it must be exactly followed or regeneration cannot happen. Follow the exact sequence prescribed for the vehicle, according to the engine manufacturer's literature.

EPA07 Aftertreatment Device Removal and Installation

Removal

These instructions are generalized, because vehicle configurations vary widely. The basic procedures apply to all aftertreatment systems. For service and repair beyond removal and installation, refer to the engine manufacturer's service literature.

NOTE: For test or service procedures on components of the ATS, consult the engine manufacturer's service literature.

NOTICE

The ATD assembly weighs from 125 to 150 pounds (57 to 68 kg) and must be protected from impact or sharp jolts. Dropping the ATD, or subjecting it to jarring impact can crack the diesel particulate filter (DPF) inside, which is built on a ceramic substrate. If that happens, the DPF is ruined and must be replaced.

A secure support is necessary to remove and install the ATD safely. The ATD must be held securely to protect it from falling, or hitting hard against something else.

The horizontal ATD lifting device (TLZ00785) is designed to handle a horizontal ATD. Vertical ATDs require a shop hoist secured to the lifting ears on top.

The aftertreatment device (ATD) is constructed so that its exterior operating temperature is comparable to that of a standard muffler, but during active regeneration, when a fuel mist is injected to raise its temperature and destroy soot deposits, its interior (see **Fig. 1**) and the outlet become hot enough to melt or ignite many common materials.

⚠ WARNING

Aftertreatment Device (ATD) internal temperatures can remain hot enough to cause personal injury, or ignite combustible materials, for hours after the engine is shut down.

To avoid potentially serious burns or material damage:

- Let the ATD cool before handling it; be especially careful when opening it to expose the DPF.
- Wear appropriate protective gear.
- Be careful not to place the ATD where flammable gases or other combustible materials may come into contact with hot interior parts.

1. Set the parking brake and chock the tires.

NOTE: Never attempt to start the vehicle with the ATD removed or with the ATD sensors disconnected, unless the engine manufacturer's documentation allows it for a diagnostic procedure.

2. Disconnect the connections at the sensor housing and the diesel oxidation catalyst (DOC) inlet temperature sensor. See **Fig. 1**.
3. Mark the Marmon fitting joints and mounting bracket orientation to the ATD, so that it can be installed exactly as it was removed. See **Fig. 2**.

NOTE: There are guide pins (see **Fig. 3**) to position the ATD during vehicle manufacture, but they are designed to break off if they are stressed. The most important thing about ATD mounting is that the other ATS components, particularly the bellows, must align correctly.

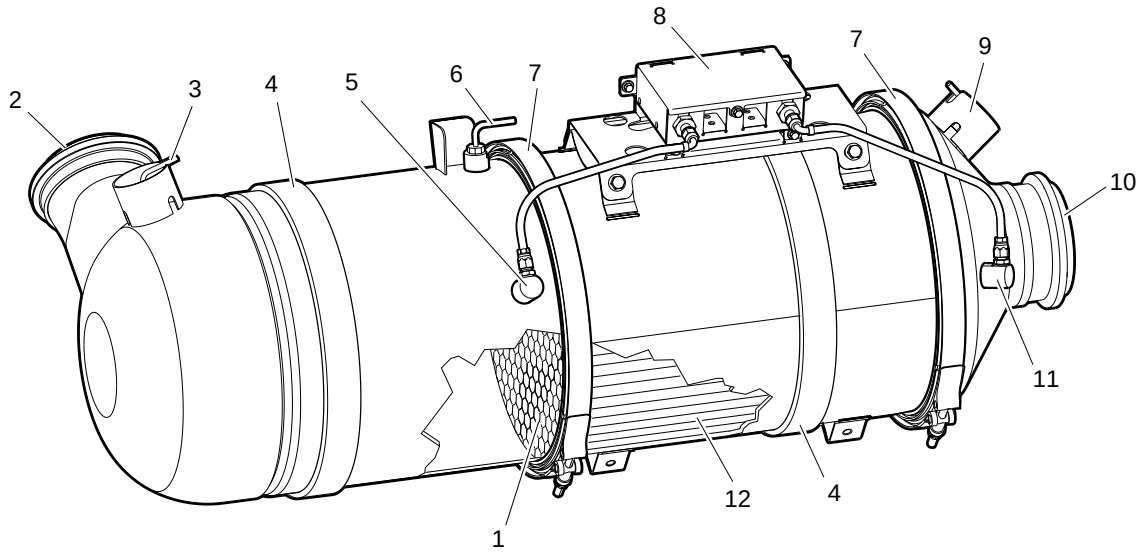
4. If the ATD is horizontally mounted, raise the ATD-handling device into place against it, so that the ATD is supported securely. If the ATD is vertically mounted, attach a shop crane or similar device to the lifting ears and take up the slack so that the lifting device is beginning to take the weight of the ATD.
5. The exhaust pipe may require support, such as a rope sling, to support it when the ATD is removed. If such support is required, install it now.

NOTICE

Be careful not to stress or twist the bellows as the ATD is manipulated. The bellows is not designed to support weight or withstand undue stress and can easily be damaged, requiring expensive replacement.

6. Remove the clamps from the Marmon fittings at the ATD inlet and outlet.
7. Remove the two mounting bands that hold the ATD to its mounting brackets, so that the ATD is held by the ATD handling device.

EPA07 Aftertreatment Device Removal and Installation



1. Diesel Particulate Filter (DPF) Front End Honeycomb
2. Marmon Fitting at Inlet from Turbocharger
3. Diesel Oxidation Catalyst (DOC) Intake Temperature Sensor
4. ATD Mounting Band
5. DPF Intake Pressure Sensor
6. DOC Outlet Temperature Sensor (connection to sensor housing not shown)
7. DPF V-Band Mounting Clamp
8. Sensor Housing
9. DPF Outlet Temperature Sensor (connection to sensor housing not shown)
10. Exhaust Outlet Marmon Fitting
11. DPF Outlet Pressure Sensor
12. DPF Ceramic Substrate

Fig. 1, Typical ATD

NOTE: It may be necessary to raise the vehicle, or remove heat shields or body panels, to remove the ATD.

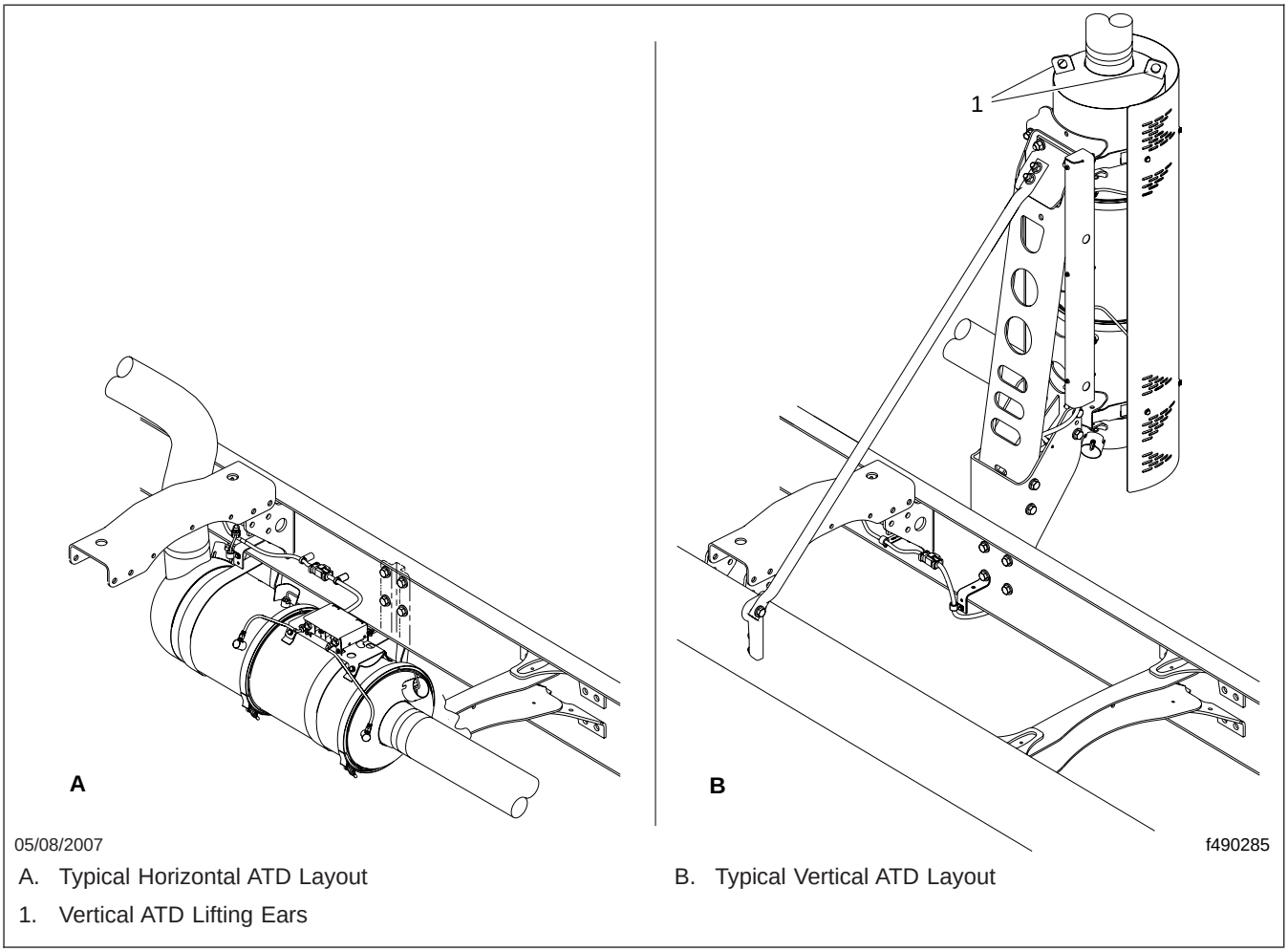
8. Move the ATD handling device slightly, so that the ATD positioning pin (see **Fig. 4**) clears its hole in the mounting bracket. Carefully remove the ATD from the vehicle.

NOTE: ATD component service procedures, such as cleaning the DPF or servicing the sensors, are documented in the engine manufacturers' service literature.

Installation

1. Use the ATD handling device to move the ATD into position, so the inlet and exhaust align with the inlet and exhaust piping. Be sure the ATD positioning pin engages its hole in the ATD mounting bracket, or that the positioning marks align.
2. Install the ATD mounting bands, but do not tighten them yet.
3. Position the V-band clamps on the Marmon fittings and tighten them to the value shown in **Table 1**.
4. Tighten the ATD mounting bands to the value shown in **Table 1**.
5. Connect the harness to the sensor housing and the front temperature sensor.
6. Remove the ATD handling device.
7. If a support was fastened around the exhaust pipe, remove it.
8. Operate the vehicle and check for leaks.

EPA07 Aftertreatment Device Removal and Installation



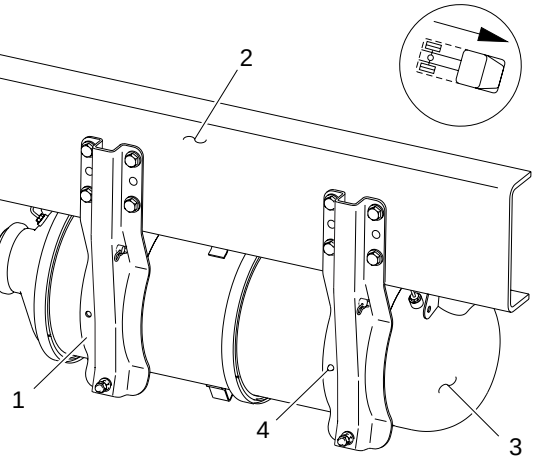
A. Typical Horizontal ATD Layout

B. Typical Vertical ATD Layout

1. Vertical ATD Lifting Ears

Fig. 2, ATD Mounting Options

EPA07 Aftertreatment Device Removal and Installation



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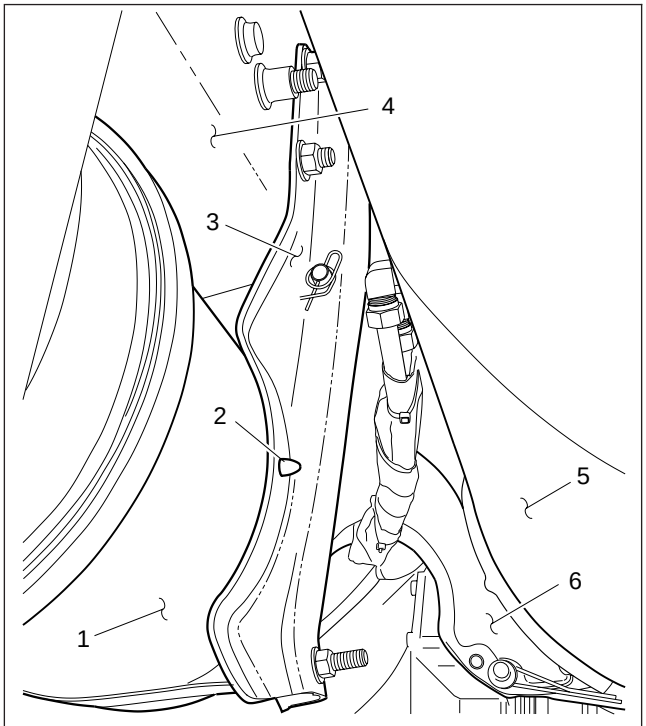
1. ATD Mounting Bracket
2. Chassis Frame Rail
3. ATD Inlet End
4. ATD Positioning Pin

Fig. 3, ATD Mounting on Frame Rail

ATD Torque Values	
Fitting	**Torque: lbf·ft (N·m)**
Mounting Bands	Initial: 15 (20) Final: 30 (41)
Temperature Sensor Nuts	26–29 (35–39)
Pressure Line Tube Nuts	11–13 (15–17)
Pressure Sensor Jam Nuts	15–18 (20–25)
Marmon V-Band Clamps	12–13 (16–17)
Compression Fittings	15–18 (20–25)
Bellows Torco Clamps	Target: 41 (56) Range: 35–48 (48–64)

Table 1, ATD Torque Values



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1. ATD
2. ATD Positioning Pin
3. ATD Mounting Bracket
4. Chassis Frame Rail
5. Fuel Tank
6. Fuel Tank Mounting Bracket

Fig. 4, ATD Mounting Bracket

EPA07 Aftertreatment System Bellows Replacement

Replacement

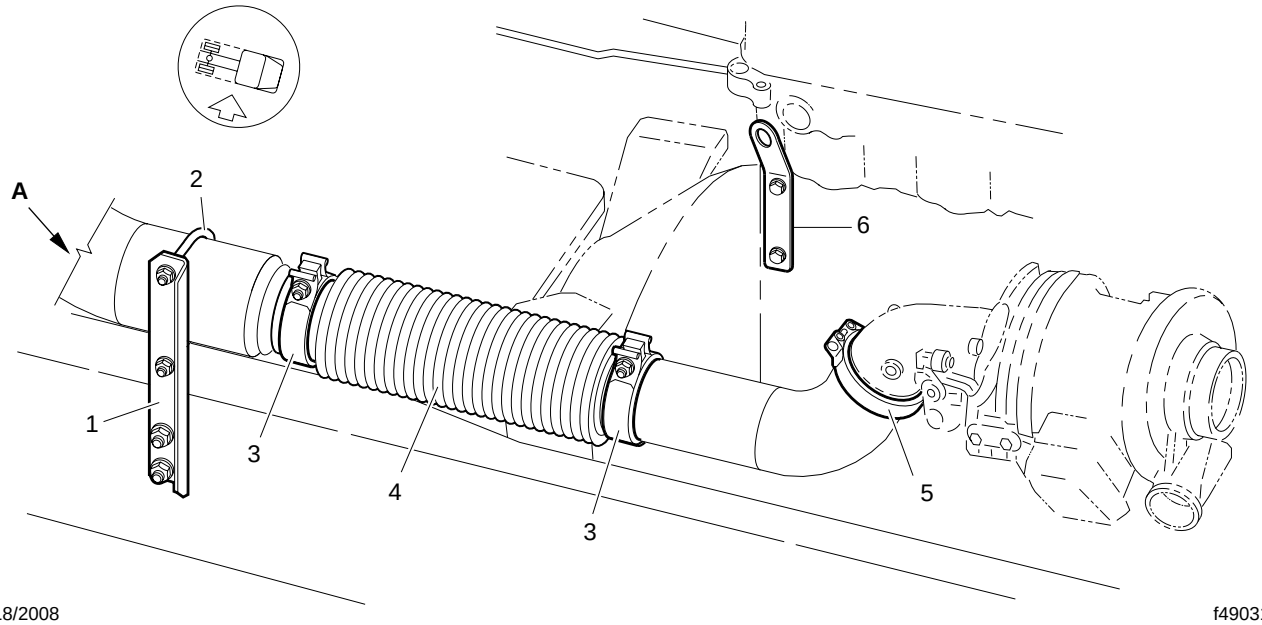
1. Open the hood.
2. Open the tool box under the passenger-side door, and remove the cover.
3. Remove the right quarter fender and mud flap. For instructions, see **Group 88**.
4. Remove the V-clamp (**Fig. 1**, Item 5) that holds the turbo outlet pipe to the turbocharger.
5. Remove the U-clamp that holds the aftertreatment device (ATD) inlet pipe to the support bracket on the frame rail (**Fig. 1**, Item 2).
6. Remove the clamp that holds the exhaust pipe to the front of the ATD, then disconnect the exhaust pipe from the ATD.
7. Remove the bellows and exhaust pipes as a unit from under the vehicle. If the vehicle is equipped with side fairings, remove the parts from the rear of the vehicle.
8. Place the assembly on a work bench. Loosen and spread the seal clamps on the ends of the bellows. Pry the ends of the bellows off the exhaust pipes, being careful not to damage the exhaust pipe ends. If it is not possible to remove the bellows this way, proceed as follows:

WARNING

Always wear a face shield and other appropriate protection when using a cutting wheel.

The cut edges of the bellows are extremely sharp, and can cause serious injury. Wear appropriate protective gear, including heavy gloves and a face shield, when removing the bellows from the exhaust pipes.

9. If you cannot remove the bellows by prying, use a cutoff wheel to cut through each end of the bellows between the exhaust pipe ends. Be careful not to cut the exhaust pipes. Discard the center section of the bellows when it is cut loose.



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A. To the Aftertreatment Device (ATD)

1. Frame-rail Support Bracket
2. U-Clamp
3. Seal Clamp
4. Bellows
5. V-Clamp
6. Bellows Support Bracket

Fig. 1, Bellows Installation

EPA07 Aftertreatment System Bellows Replacement

10. Carefully remove the bellows ends and clamps from the exhaust pipes, either by prying them off, or by driving them off with a soft drift. Be careful not to damage the exhaust pipes.

IMPORTANT: Take the following measurements *before* installing the bellows.

The main section of the ATD inlet pipe is a larger diameter than the turbo outlet pipe. Make sure you measure at the **end** of the pipe, where it inserts into the bellows. The two measurements should be identical. If they are not, loosen the U-clamp nuts that hold the ATD inlet pipe to the frame-rail support bracket, and move the pipe up or down as needed.

NOTICE

The ends of the ATD inlet pipe and the turbo outlet pipe must be in exact vertical and horizontal alignment before installing the new bellows. If they are not aligned the bellows will be twisted, and will fail after a short time.

11. Attach the turbo outlet pipe to the turbocharger, then to the bellows support bracket. Tighten the clamps enough to hold the pipe in place.
12. Attach the ATD inlet pipe to the ATD and the frame-rail support bracket. Tighten the clamps enough to hold the pipes in place.
13. Using a ruler or tape measure, measure the vertical distance between the end of the ATD inlet pipe and the frame rail. See **Fig. 2**. Do the same for the end of the turbo outlet pipe. The two measurements must be the same. If the measurements are different, loosen the U-clamp nuts on the frame-rail support bracket, and raise or lower the ATD inlet pipe as needed. Tighten the U-clamp nuts enough to hold the pipe in place.
14. Using a ruler (or a T-square) and a tape measure, measure the distance between each pipe end and the frame rail. See **Fig. 3**. If these two measurements are different, do one or more of the following adjustments (see **Fig. 4**):
    - Check that the U-clamp on the bellows support bracket is installed correctly, and is not crooked.
    - Rotate the turbo outlet pipe at the turbocharger.
    - Support the ATD with a suitable jack, then loosen the ATD straps and rotate the ATD.
    - Rotate the ATD inlet pipe at the Marmon flange on the ATD.
15. With the two pipe ends in horizontal and vertical alignment and the bellows not installed, measure the distance between them. See **Fig. 5**.

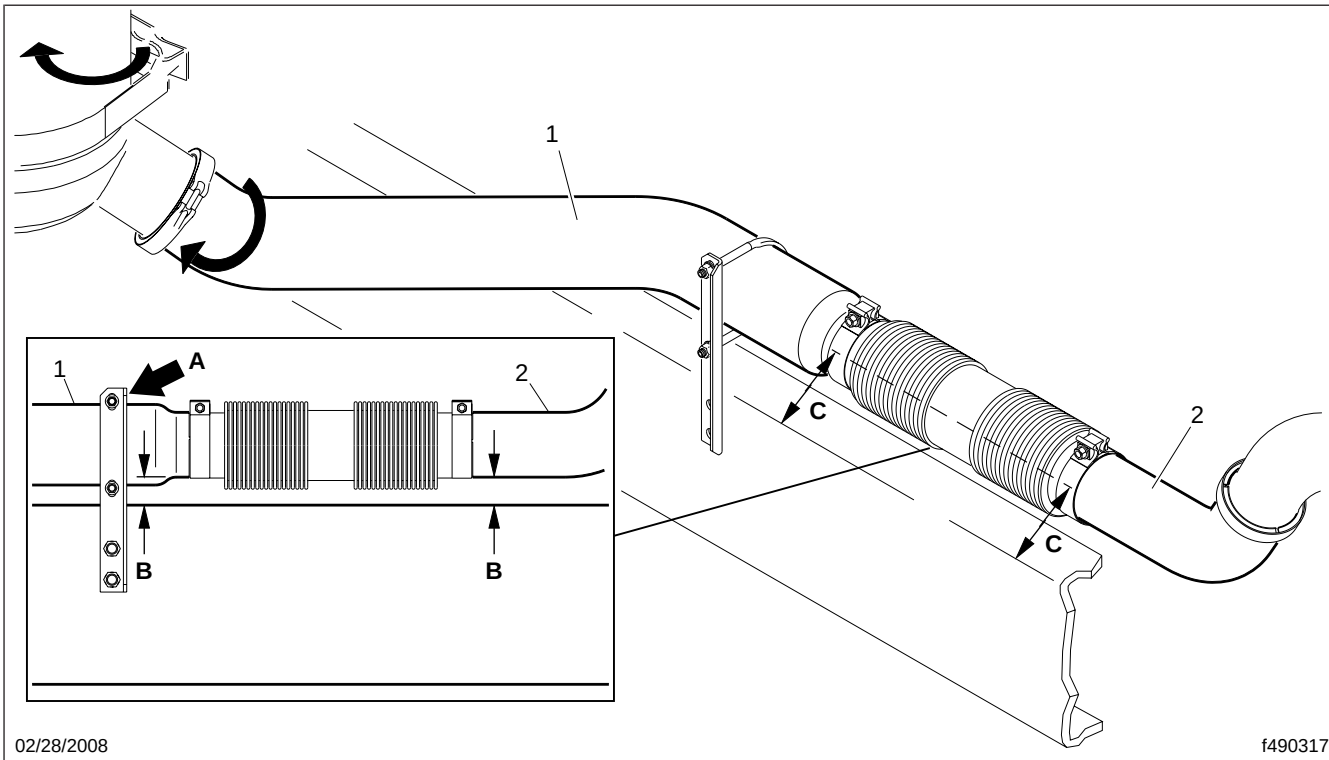
    The distance between the pipe ends is to be at least 14 inches (35.5 cm), but not more than 14-3/8 inches (36.5 cm).

    If the distance is less than the above, remove the turbo outlet pipe and the ATD inlet pipe, and cut off an equal amount from each pipe end, as needed; otherwise, go to the next step. Make sure you remove all burrs from the cut ends of the pipes.

IMPORTANT: If they were loosened, do not tighten the ATD mounting straps until the U-clamp nuts on the frame-rail support bracket are tightened to their final torque. To do otherwise will affect the alignment of the exhaust pipes.

16. When the horizontal and vertical alignment is the same for both exhaust pipes and the distances between the pipe ends is correct, tighten the U-clamp nuts on the frame-rail support bracket that holds the ATD inlet pipe in place. See **Subject 100** for torque values.
17. Tighten the V-clamp that holds the inlet pipe to the ATD. See **Subject 100** for torque values.
18. If applicable, tighten the mounting straps on the ATD, then remove the jack.
19. Remove the turbo outlet pipe from the turbocharger.
20. Remove any dirt or soot from the outer surface of the exhaust pipe ends to ease the installation of the new bellows.
21. Install the new bellows on the ATD inlet pipe, with the clamp nuts on top and facing outboard (**Fig. 2**).
22. Insert the end of the turbo outlet pipe into the bellows, then connect the pipe to the turbocharger and to the new bellows support bracket. See **Subject 100** for torque values.
23. Tighten the bellows seal clamps; see **Subject 100** for torque values.

EPA07 Aftertreatment System Bellows Replacement



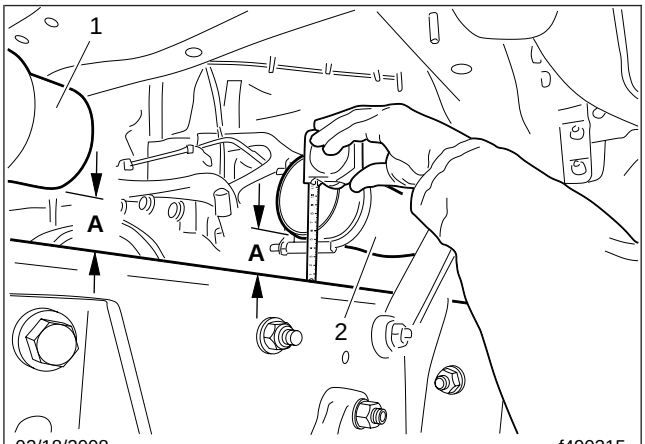
A. Up-and-down adjustment to be done at this bracket.
B. Vertical measurements to be the same.
C. Horizontal (in-and-out) measurements to be the same.

1. ATD Inlet Pipe
2. Turbo Outlet Pipe (support bracket not shown)

Fig. 2, Rotation and Adjustment Areas for Exhaust Pipe alignment (vertical ATD installation shown)

24. Start the engine and check for leaks. Shut down the engine, and tighten any clamps as needed.

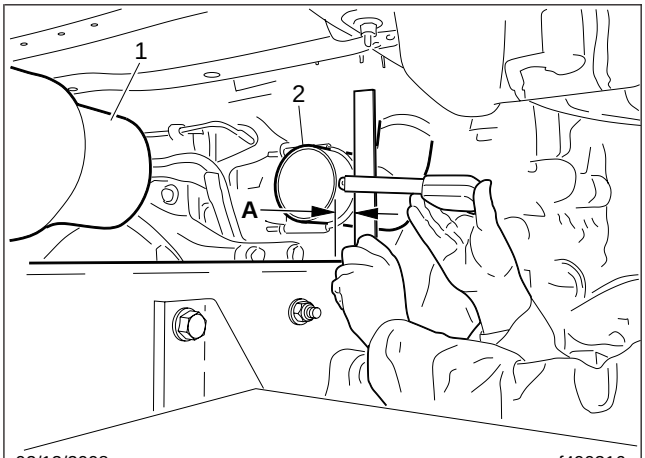
EPA07 Aftertreatment System Bellows Replacement



A. This distance must be the same at both exhaust-pipe ends.

1. ATD Inlet Pipe 2. Turbo Outlet Pipe

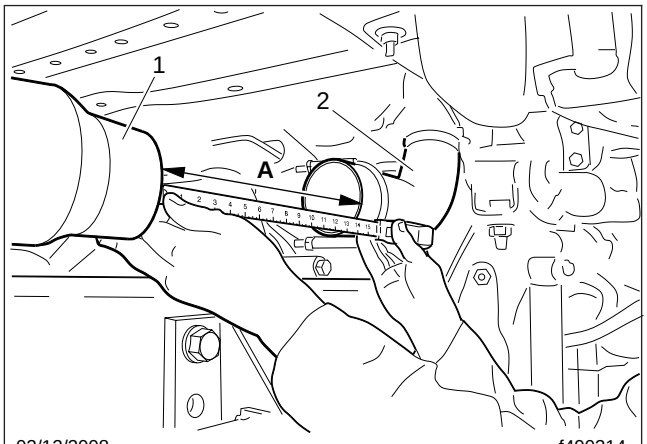
Fig. 3, Measuring the Vertical Distance



A. This distance must be the same at both exhaust-pipe ends.

1. ATD Inlet Pipe 2. Turbo Outlet Pipe

Fig. 4, Measuring the Horizontal Distance



A. This distance should be a minimum of 14 inches (35.5 cm) and a maximum of 14-3/8 inches (36.5 cm).

1. ATD Inlet Pipe 2. Turbo Outlet Pipe

Fig. 5, Measuring the Distance Between Pipe Ends

General Information

The on-highway environment places severe demands on a vehicles electrical system. The following material describes the methods for repairing and sealing electrical connections that will provide the durability necessary for the automotive environment.

There are four distinct components for making a wire repair that will withstand:

- the mechanical demands of vibration, strain, and thermal cycling
- the electrical requirement of oxidation free conductivity
- the insulating properties to resist shorting to adjacent objects
- the ability to seal for corrosion protection

When troubleshooting electrical systems, consider body height and suspension travel. Interference and strain may be caused by normal frame flexing and body accessories that are not apparent when a vehicle is stationary.

Wire Repair and Splicing

Disconnect the batteries at the negative terminals before performing any repairs to the electrical system.

IMPORTANT: Before repairing or replacing any damaged electrical system components, locate and correct the cause of the damage before continuing with the repair.

Wire that is discolored or melted due to an external heat source may need to be re-routed or installation of a heat shield may be necessary. If wire length permits, a splice may be made with a single connector. Often a length of wire will need to be added and two splices are made. Carefully check damaged wire for signs of corrosion that has wicked up into the insulation and through the wire. If the wire conductor has become green or black, cut off the discolored wire and replace it with a new section.

Corrosion on battery cable terminals may be cleaned with a mild solution of baking soda and water, and scrubbed with a wire brush.

Wiring Diagram Decal

A decal of the standard wiring diagram is placed in each vehicle. On COEs, the decal is on the underside of the tunnel top cover. See **Fig. 1**. On FLD Conventionals, the decal is on the back of the dash skirt. See **Fig. 2**.

Complete wiring diagrams are located elsewhere in this group, along with listings of wire gauge sizes, circuit numbers, and circuit descriptions.

Electrical Power **(Fig. 3)**

The bus bar has 24 circuit-breaker positions: two ignition-controlled and fifteen hot positions are standard; seven other hot positions are optional.

The circuit breakers bolt directly to the bus bar. To minimize heat build-up from high-amp circuit breakers, they are separated by spaces or by low-amp circuit breakers.

Twelve Bosch relays (standard) are placed in three rows of holders that are sloped for easy access. There are spaces for optional relays. Each relay has a decal that identifies the circuit it controls.

Circuit Breakers

Circuit breakers protect against circuit over load. If a circuit becomes overloaded (usually caused by a short to ground), the circuit breaker opens, stopping current flow.

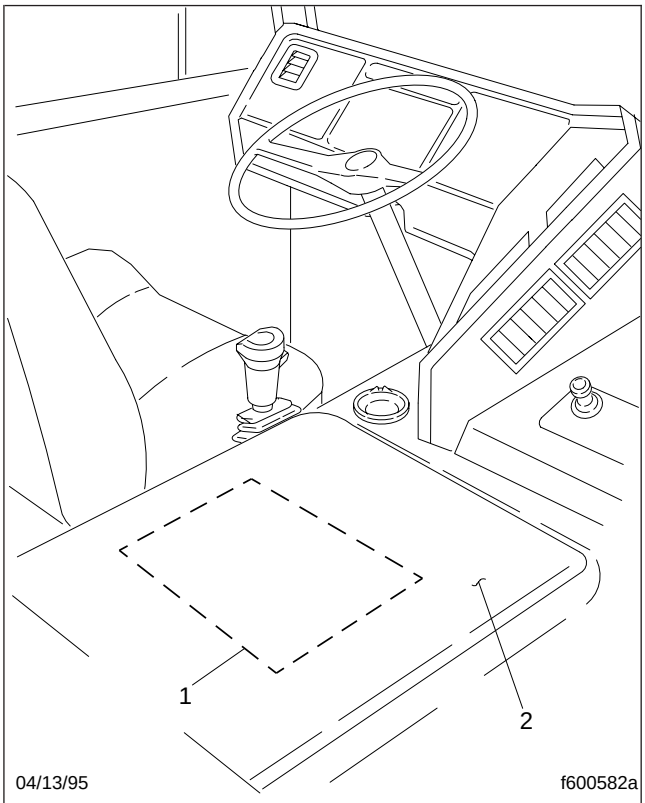
Two types of circuit breakers are used: Type I (cycling) and Type II (noncycling). Type I circuit breakers, used in the headlight circuits, continually reset if there is an overload or short. Type II circuit breakers will reset only after the circuit is repaired. See **Fig. 4**.

Junction Blocks for Seven-Way Cable

A junction block is used where the seven-way cable enters the cab. On COEs, the junction block is located behind the kick panel on the right side of the tunnel. See **Fig. 5**.

On FLD Conventionals, the junction block is located behind the access panel under the center section of the dash. See **Fig. 6**. The main cab-power feeds are the upper and lower studs on the driver's side of the junction block for the seven-way cable.

General Information



1. Wiring Diagram
2. Tunnel Cover

Fig. 1, Wiring Diagram Location

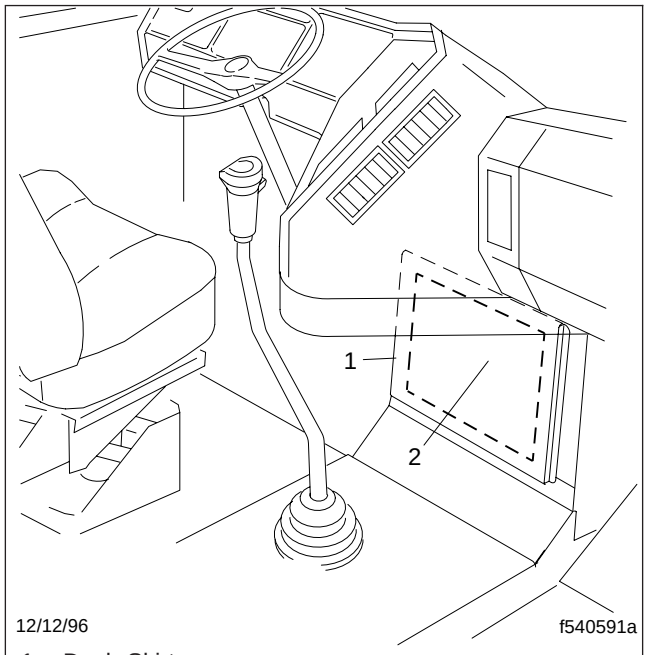
On FLD Conventionals built before March 15, 1990, a single main cab-power stud is used. It is located to the left of the junction block.

Lighting Circuits

The left and right headlights are on separate relay-controlled circuits. Another relay operates the tractor marker lights and taillights. Separate relays control the trailer marker lights and taillights, which are isolated from each other and from the tractor lights.

A two-pole/three-position headlight switch is used. The center position turns all lights off. The down position turns on the panel lights and all marker lights and taillights; the up position adds the headlights. The ignition switch must be on for the high beams to operate.

The panel light control has a solid-state rheostat, and is relay-controlled.



1. Dash Skirt
2. Standard Wiring Diagram

Fig. 2, Wiring Diagram on Dash Skirt

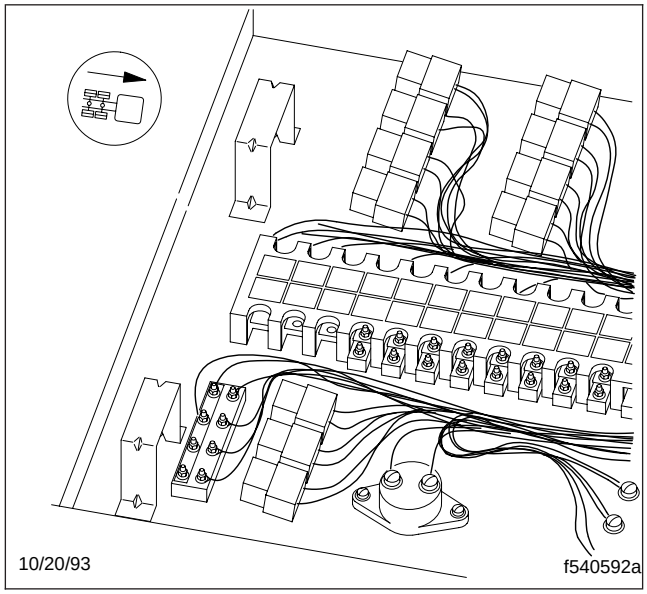
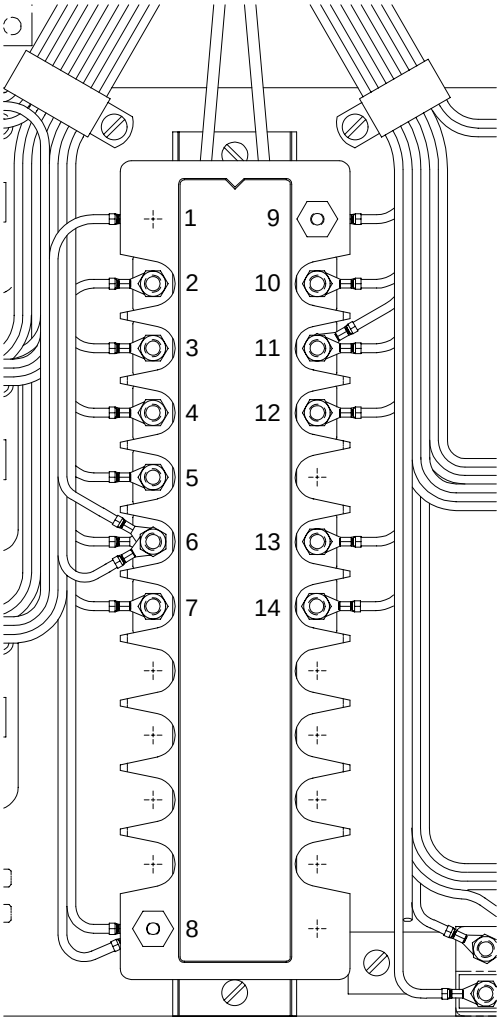


Fig. 3, FLA Electrical Panel

NOTE: The panel light control can be damaged by power surges and shorts to ground. Make sure the headlight switch is off (preventing



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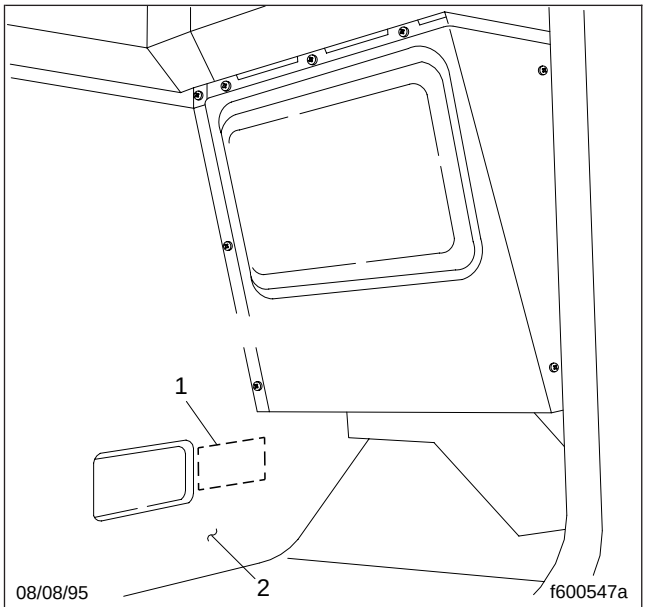
1. Trailer Marker Lights
2. Left Headlight/DRLs
3. Turn Signal Flasher
4. Voltmeter
5. Ignition Switch
6. Horn/Cigarette Lighter
7. Brake Lights
8. Dome Lights
9. Trailer Tail Lights
10. Right Headlight
11. HVAC
12. Tractor Marker Lights/Tail Lights
13. A/C Clutch
14. Panel Lights

Fig. 4, FLB/FLD Circuit Breaker Layout (detail)

power flow to the panel light circuit) before replacing panel lights.



1. Junction Block (behind kick panel)
2. Kick Panel

Fig. 5, COE Junction Block

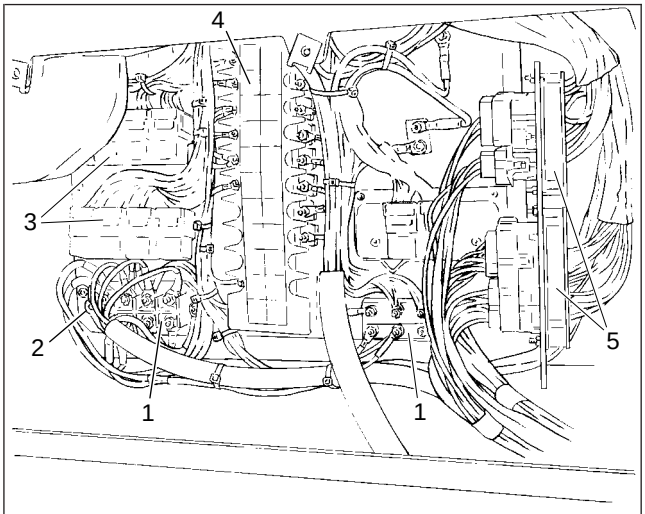
Protection of Wiring (See Fig. 7)

Wiring must be protected wherever there is a possibility of damage to it. If this can't be done by making minor routing changes, use some type of protective covering. The following is a list of materials used to protect wiring.

A. *Loom*—Electrical loom is an asphalt-saturated cotton braid, and is used in a variety of sizes for general use where protection is needed. A multiple conductor wire with a braided nylon covering is used for most of the chassis wiring; a second protective loom is not needed.

B. *Electrical Tape*—Vinyl plastic tapes in 10-mil and 7-mil thicknesses are recommended. 10-mil tape is used as a harness wrapping where continuous coverage is needed. 7-mil tape is for general use such as harness taping or closure of loom ends.

C. *Rubber Sheathing*—Rubber sheathing is used to cover the speedometer and tachometer drive cables, in areas where they could contact wiring or electrical terminals. It is also used as a gen-



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1. Circuit Breaker Panel
2. Junction Block
3. Main Cab - Power Feed Studs (circuit 14 studs on junction block)
4. Cab-to-Chassis Connectors (prior to March 15, 1990, the connectors were located on the front of the chassis)

Fig. 6, FLD Conventional Circuit Breaker Panel, Junction Block, and Cab-to-Chassis Connectors

eral protectant in some light-duty areas. Exposed battery cables may be protected with rubber heater hose, depending on the operating conditions.

D. *Grommets*—Grommets made of rubber or other materials are used wherever the wiring passes through a hole in sheet metal.

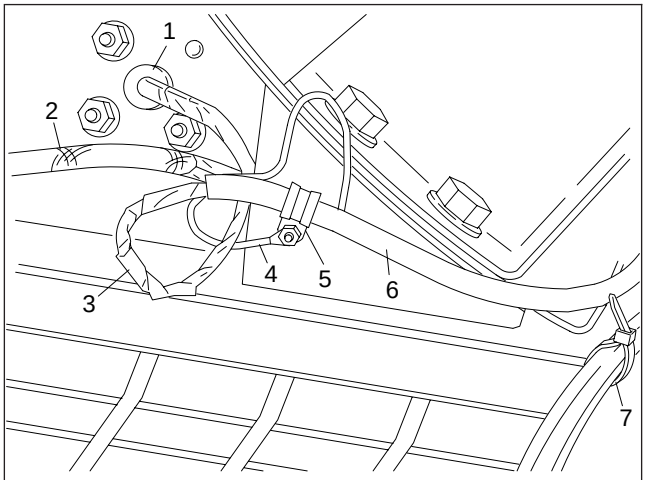
E. *Clamps*—Wiring may be supported by using clamps to hold it securely to the vehicle. Clamps are spaced at 8- to 12-inch (20- to 30-cm) intervals to prevent movement. If metal clamps are needed to hold bundles of wires, use only cushion-type metal clamps.

F. *Tie Straps*—All wires that are routed together must be fastened at 8- to 12-inch (20- to 30-cm) intervals. If anchor clamps or wiring connections are greater distances apart, use a plastic tie strap to keep the wires from separating or becoming damaged. For bundles of wires in exposed locations, a heavier tie strap is used, which has a 120-psi (827-kPa) minimum tensile strength. For bundles of wires in a protected area such as under the dash, a lighter strap, which has a 50-psi (345-kPa) minimum tensile strength, may be used.

Tie straps are also used to prevent nonlocking multiple-wire connectors from separating. See **Fig. 8**. It is better to route the tie strap through an unused connector opening; otherwise, tie-strap the connector by inserting the strap between the middle two wires, and around the connector halves.

NOTICE

Do not use flat-strip aluminum tie straps for holding electrical wiring. The abrasive edge on these tie straps may cause breaks in the wire insulation, allowing the aluminum tie strap to come in contact with the wire. This could cause a short circuit, and damage the wiring.



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1. Grommet
2. Loom
3. Electrical Tape
4. Ground Jumper
5. Clamp
6. Rubber Sheathing
7. Tie Strap

Fig. 7, Hood Ground Jumper and Wiring Protection, 120 Conventional

Wiring Connections

All of the wiring terminals are corrosion-resistant. The terminal is made of either a noncorrosive material, such as brass, bronze, or copper, or coated with a corrosion-resistant material, such as cadmium, zinc, nickel, or chrome.

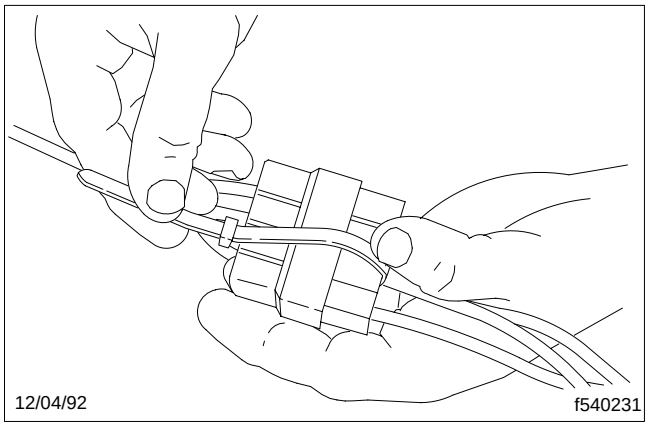


Fig. 8, Tie-Strapping Multiple-Wire Connectors

IMPORTANT: Many electrical components are mounted outside of the cab in areas subjected to harsh weather, road spray, etc. Some components also have exposed metal electrical terminals, which, when subjected to harsh conditions, may suffer corrosion at the electrical connection. Spray dielectric sealant on all exposed electrical terminals, and use dielectric grease on all covered terminals.

In general, there are two types of wiring terminals: permanent and quick-disconnect. Ring terminals (with stopnuts) are used mainly in the circuit breaker panel assembly (see **Fig. 1**), and when a permanent and stationary connection is needed. The wires joined by this type of connection are separately routed, although two or more wires may be connected to the same terminal stud.

Most quick-disconnect connections use a male blade terminal and a female slot receptor. They are used whenever a group of wires is routed as a harness, or where the wires may need future disconnecting. Blade terminals are used on the wiring harness of each dashboard gauge or indicator light installation, and also on much of the auxiliary lighting equipment. The wires may be connected individually, but are usually grouped together and routed through a multiple-wire connector. See **Fig. 8**. The multiple-wire connector allows the wiring assemblies of a component or a wiring harness to be disconnected and connected as a unit.

Weather Pack® connectors (see **Fig. 9**) use pin-and-sleeve terminals. They are weatherproof, and are used primarily outside the cab, where wiring is exposed to the elements. Weather Pack connectors are either single- or multiple-pin connectors.

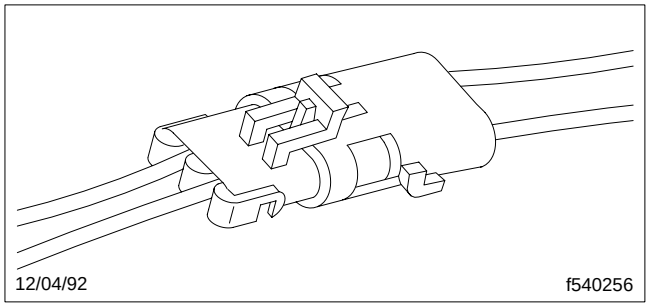


Fig. 9, Weather Pack Connector

Wiring Repair Using Phillips STA-DRY® Solderless Connectors

Parts and Tools

Parts are available through the Parts Distribution Centers (PDCs) in packages of 25 connectors. Use the connectors and adhesive lined shrinkable tubing shown in **Table 1** when making a wiring splice.

Tools needed for wiring repair using solderless connectors include the following.

- A dimple-type crimp tool with a minimum 3/16 inch width. See **Fig. 1** for an example of a proper crimp tool. A typical manufacturer for this tool is Thomas & Betts.
- A heat gun rated at 1000°F (538°C).

Procedure

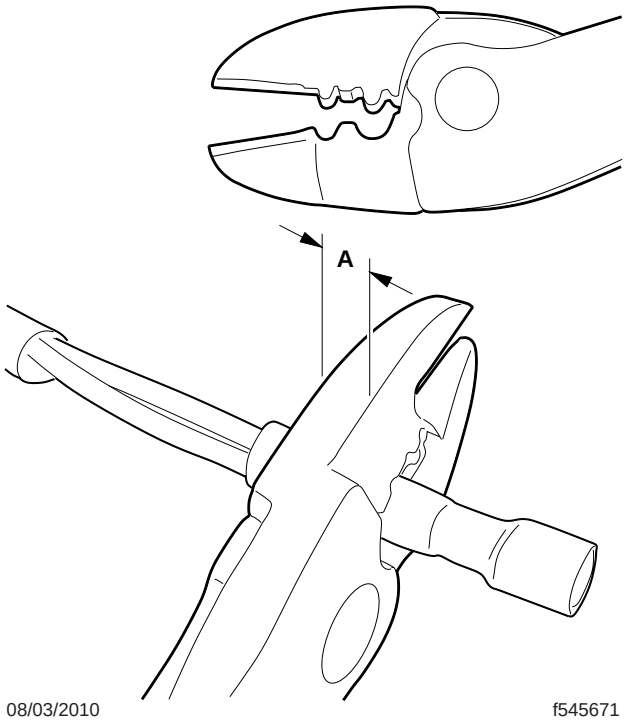
1. Dress the wires to be spliced by stripping the insulation to expose 1/4 inch of copper. Slide a 3-inch section of adhesive coated shrink tubing onto one of the wires.
2. Crimp the splice connector onto the wires. Use the type of crimp tool that makes a dimple in the connector. The dimple must be at least 3/16 inch wide or there will be too much space inside the connector and the solder will not flow into the wire. This crimp provides the mechanical retention needed. See **Fig. 2**.
3. Pull test the wires by hand to ensure the crimp is mechanically solid.
4. A crimp tool that is too narrow will leave excessive air gaps in the crimp. The connection will not have the required amount of mechanical strength and the solder will not bond the wire to the connector. **Figure 3** shows an example of a bad crimp when the wrong tool is used.
5. Heat the properly crimped splice connector with the heat gun while slowly rotating the wire. The solder will take longer to flow than it will for the shrinkable insulation to contract. Heat until the solder band has completely melted into the connector. If the shrinkable insulation ruptures and a small amount of solder bubbles out, gently shake the splice to remove the solder. See **Fig. 4**.
6. When the connector has cooled, center the shrinkable tubing over the splice and heat the tubing until it has completely sealed the splice and a small fillet of adhesive is visible at the ends of the shrink tube. See **Fig. 4**.
7. A three-wire tap splice can be made following the same procedure. Use a connector that is large enough to fit all the strands of the wires. See **Fig. 5** for an example of the completed splice.

Solderless Connector Parts		
Wire Size: gauge (mm)	**Connector Part Number***	**Shrinkable Tubing (Daimler Part Number)**
20 to 18 (0.5 to 0.8)	PHM 1 1863	1/4 inch with internal adhesive coating (48-02461-025)
16 10 14 (1 to 2)	PHM 1 1862	1/4 inch with internal adhesive coating (48-02461-025)
12 to 10 (3 to 5)	PHM 1 1861	3/8 inch with internal adhesive coating–4 foot length (48-02461-038)
8 or larger (5 or larger)	Replace the terminal or the entire cable	Use adhesive lined red for positive cables and black for negative cables.

* Twenty-five connectors per pack.

Table 1, Solderless Connector Parts

Wiring Repair Using Phillips STA-DRY® Solderless Connectors



A. Minimum 3/16 inch width.

Fig. 1, Dimple-Type Crimp Tool

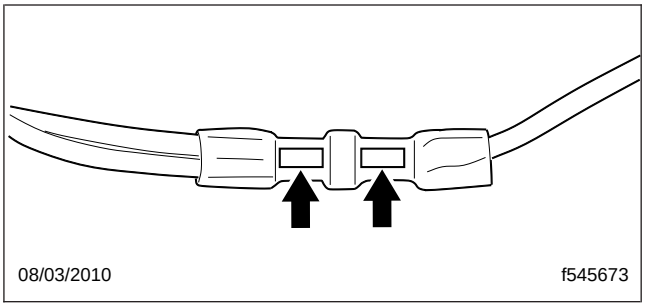
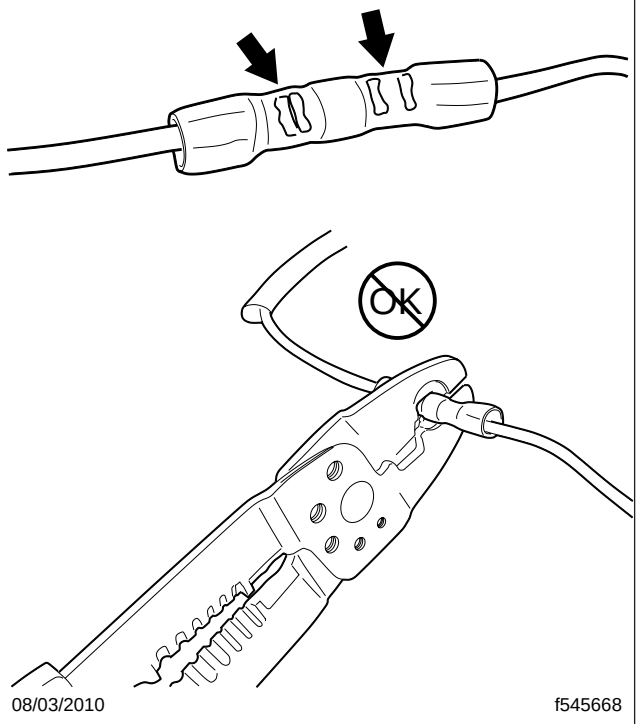
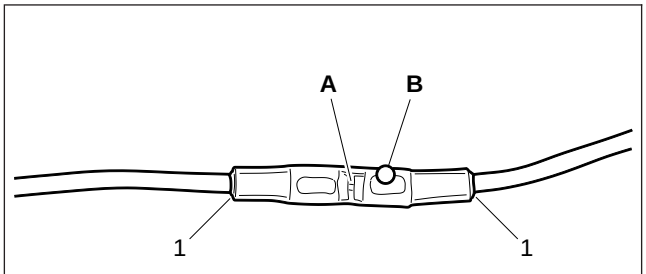


Fig. 2, Properly Crimped Splice



NOTE: Even with two crimps, there is too much air gap; the solder will not bond.

Fig. 3, Wrong Tool Being Used and a Crimp That Will Fail

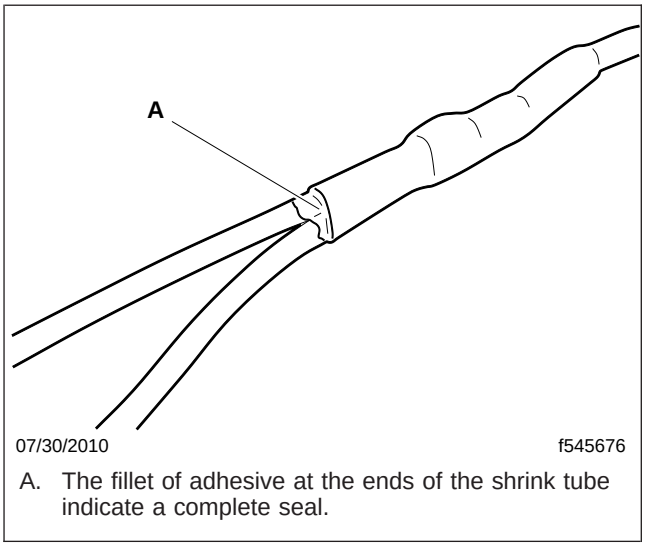


A. The solder band is completely melted.
B. Insulation rupture; gently shake off the solder bead.

1. Adhesive Fillet

Fig. 4, Solder Bead Rupture

Wiring Repair Using Phillips STA-DRY® Solderless Connectors



A. The fillet of adhesive at the ends of the shrink tube indicate a complete seal.

Fig. 5, Completed Three-Wire Tap Splice

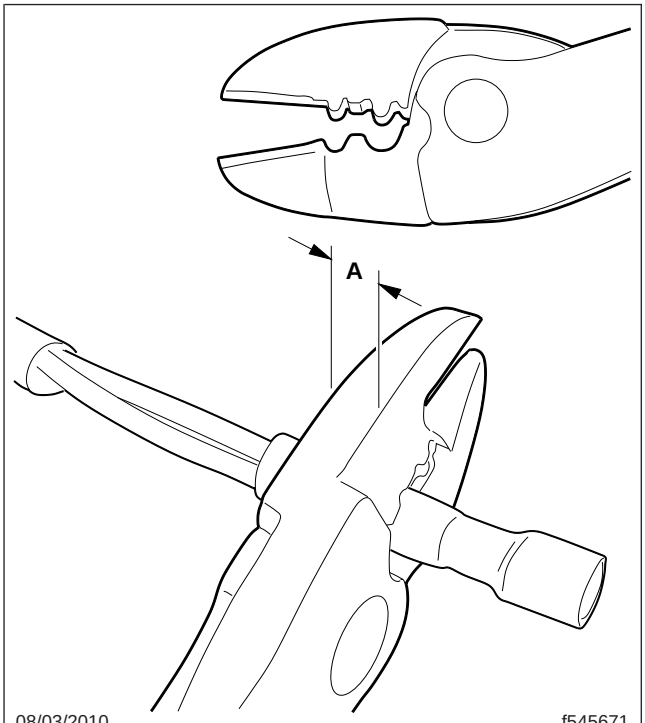
Wiring Repair Using Daimler Trucks North America (DTNA) Kit ESY ES66 404

Parts and Tools

Parts are available through the Parts Distribution Centers (PDCs) in kits with material for 50 splices. This kit may be used on 16 to 14 gauge (1 to 2 mm) wire.

Tools needed for wiring repair using solderless connectors include the following.

- A dimple-type crimp tool with a minimum 3/16 inch width. See **Fig. 1** for an example of a proper crimp tool. A typical manufacturer for this tool is Thomas & Betts.
- A heat gun rated at 250°F (121°C).



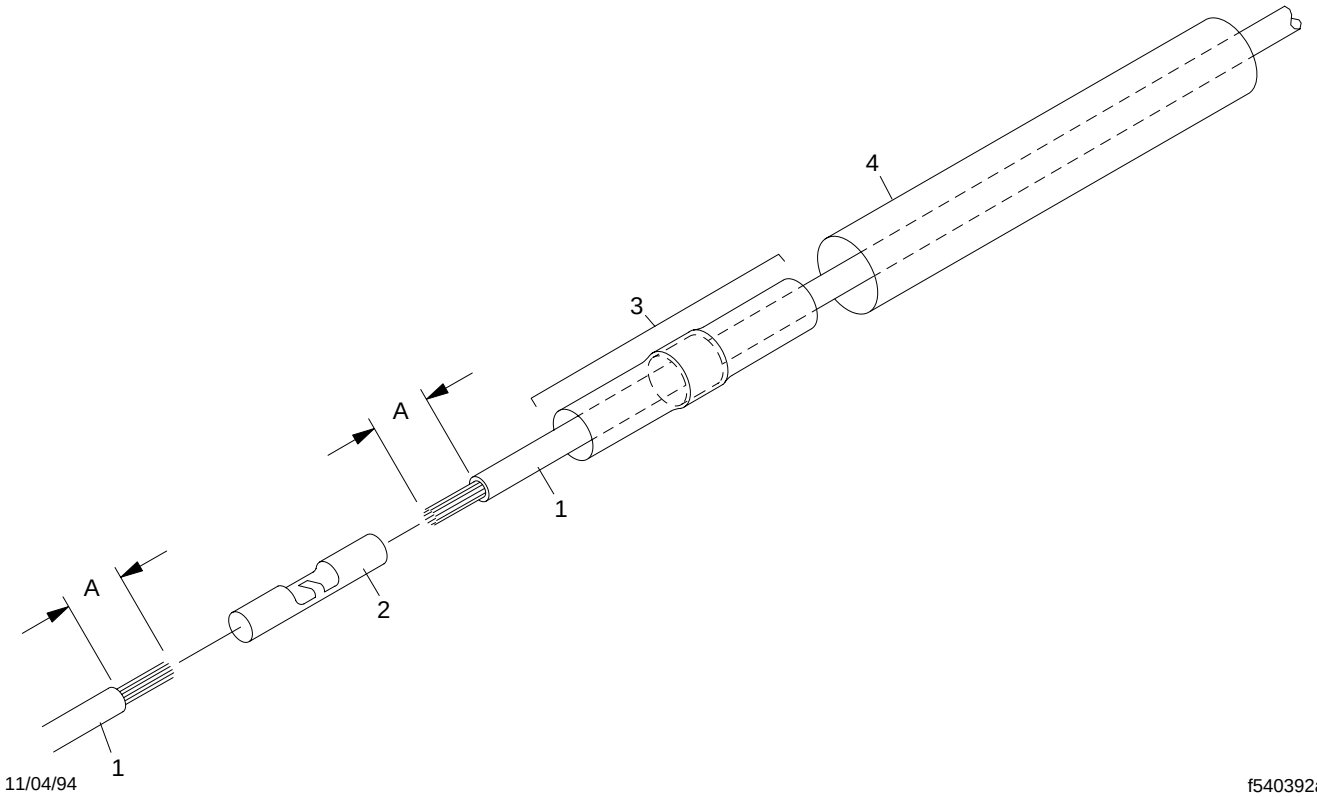
A. Minimum 3/16 inch width.

Fig. 1, Dimple-Type Crimp Tool

Procedure

1. Dress the wires to be spliced by stripping the insulation to expose 1/4 inch of copper. Slide a piece of the shrink tubing from the kit onto one of the wires.
2. Slide a shrinkable solder sleeve from the kit onto one of the wires.
3. Place the wires that will be spliced into each end of the barrel connector. See **Fig. 2** for an example of the splice.
4. Crimp each end of the barrel using a dimple-type crimp tool to secure the wires. See **Fig. 1** for an example of a proper crimp tool.
5. Pull test the wires by hand to ensure the crimp is mechanically solid.
6. Slide the shrinkable solder sleeve onto the barrel connector so the solder band is at the center of the barrel connector.
7. Heat the splice using a heat gun rated at 250°F (121°C) until the sleeve has completely shrunk against the wire and the solder flows into the barrel connector. A small fillet of adhesive may be visible at the ends of the connector. See **Fig. 3**.
8. Slide the shrinkable tubing over the splice and apply heat with a heat gun rated at 250°F (121°C) until it has completely shrunk against the wire insulation. A small fillet of adhesive should be visible at the ends of the shrinkable tubing.

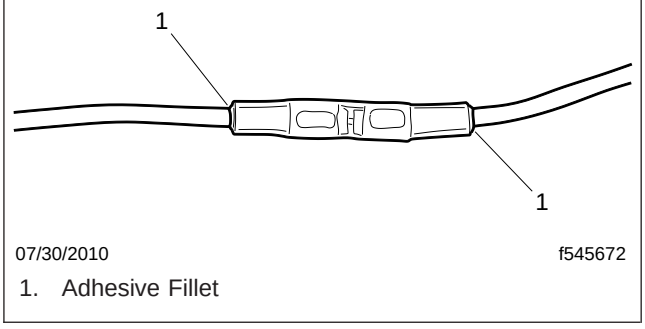
Wiring Repair Using Daimler Trucks North America (DTNA) Kit ESY ES66 404



A. 1/4 inch (6.4 mm)

1. Wire End
2. Barrel Connector
3. Solder Sleeve
4. Shrink Tube

Fig. 2, Splice Prepared with Parts in Kit ESY ES66 404



1. Adhesive Fillet

Fig. 3, Heated Solder Sleeve with Solder Band Melted into the Splice

Parts

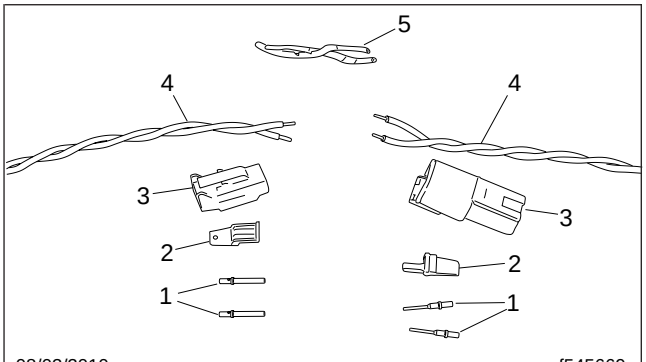
Twisted-pair datalink wires may be spliced using a mating connector set. See **Table 1** for a typical set of datalink connector parts.

Datalink Connector Parts		
Description	**Part Number**	**Quantity**
Connector Body Plug	23-13148-204	1
Terminal Lock	23-13303-015	1
Terminals	23-13210-020	2
Connector Body Receptacle	23-13148-206	1
Terminal Lock	23-13303-013	1
Terminals	23-13210-030	2

Table 1, Datalink Connector Parts

Procedure

1. Cut out any damaged section of datalink wire, keeping the lengths of the two wires equal. See **Fig. 1** for an example of a damaged section of datalink wire that has been removed and the datalink prepared for repair.



1. Terminals
2. Terminal Lock
3. Connector
4. Twisted-Pair Datalink Wires
5. Damaged Section of Datalink Wires

Fig. 1, Datalink Splice Parts

2. Crimp the terminals onto the wires using the proper crimp tool.
3. Pull test the terminals by hand to ensure the crimp is mechanically solid.
4. Insert the terminated wires into the connector body and install the terminal lock. The protocol for J1939 is for the yellow wire to be in cavity 1 and the green wire to be in cavity 2. Note that the lock is installed while holding the wires in position. Test the installation. If the wires slipped back during the lock installation, they will pull out of the connector.
5. Make certain the wires are twisted as close to the entry point of the connector as possible. Plug the two connector halves together. See **Fig. 2**.

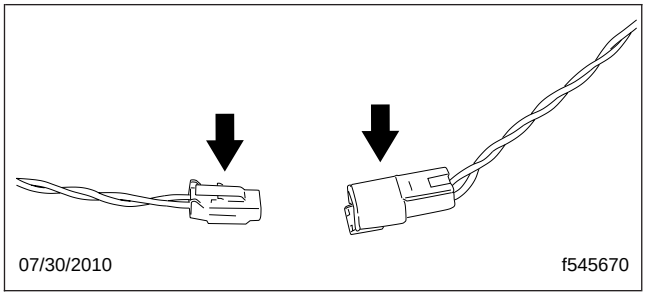


Fig. 2, Datalink Connectors

Connection Protection

Use the dielectric protectants and procedures provided here to protect electrical connections from corrosion. A list of approved dielectric protectants is shown in **Table 1**.

The components listed in **Table 2** have electrical connections that need to be protected.

When disconnecting any of these circuits, clean the connection and remove the old dielectric material. Completely cover the exposed area after assembly using the product and procedure in this bulletin. Always follow the product manufacturers recommendations for work area ventilation.

Approved Dielectric Protectants			
Material	**Type**	**Manufacturer**	**Product**
Dielectric Red Enamel	Spray On	3M®	1602 IVI
		Glyptal	1201A
	Brush On	Glyptal	1201E 2100
Dielectric Grease	Lithium Base	Fiske Brothers Lubriplate® (FLP)	DS-ES
	Synthetic	Nye	Nyogel 760G

Table 1, Approved Dielectric Protectants

Electrical Component Protection and Procedure		
Protection	**Component**	**Procedure**
Dielectric Red Enamel	Starter - All Exposed Connections	Protect connections and cable terminals.
	Magnetic Switch	Protect connections and cable terminals.
	Alternator	Protect all connections. Do not allow dielectric material to enter the alternator.
	Bolt and Stud Ground Connections (outside cab)	Cover all terminals, studs, and nuts with dielectric enamel.
	Battery Cut-Off Switch Connections	Protect connections and cable terminals.
	Exposed Battery Cable Connections (located outside of the battery box)	Protect connections and cable terminals.
	Power Distribution Modules	Protect battery power studs on chassis mounted PDMs.
	Mega Fuses (when located outside of the battery box)	Place tape across the part of the fuse with the labeling, then apply the dielectric material. Remove the tape.

Electrical Connection Protection

Electrical Component Protection and Procedure		
Protection	**Component**	**Procedure**
Dielectric Grease, Lithium Base	Tail Lamp Bulb Sockets (non LED)	Remove the bulb, apply grease to the inside of socket. Replace the bulb.
	Battery Terminals	Apply grease to battery terminals before connecting interconnect cables.
	Battery Interconnect Cable Connections	Apply grease to connection studs and pads before connecting battery cables.
	Parked HVAC Power Connections	Disconnect the two power and one ground cable where they enter the basket on the underside of the cab. Apply grease, then connect.
	Inverter Power Connections	Disconnect the power and ground feeds at the cab pass through. Apply grease, then connect.
	Mega Fuses (if located in the battery box)	Apply grease to protect exposed terminals and connections.
Dielectric Grease, Synthetic	Connections with serial data circuits or with very low voltage signals.	Apply synthetic grease to the terminals inside the connector.

Table 2, Electrical Component Protection and Procedure

A Vehicle Electrical System – The Basics

NOTE: This subject is intended to provide a brief review of the electrical symbols and theory necessary for basic troubleshooting. For comprehensive coverage of electrical theory and practice as it applies to motor vehicles, refer to Freightliner Self-Paced Training Basic Electricity Units SDF–006 (Volts, Ohms & Amps), SDF–007 (Magnetism), SDF–008 (Symbols & Diagrams) & SDF–009 (Terms).

The vehicle electrical system can be divided into four basic categories: power suppliers, power controllers, directional controllers, and appliances. Every system has these four categories, in one form or another.

Power Suppliers

Everyone knows that the battery (see **Fig. 1**, Ref. A for symbol) is a very important source of electrical power in a motor vehicle. A typical battery (wet cell) is an electro-chemical device consisting of metal plates (usually lead) and an acid-water solution (sulfuric acid). The battery has both positive and negative plates, which are stacked together like a deck of cards, but not allowed to touch each other. The chemical reaction that takes place inside the battery results in an electron build-up on one set of plates, and an electron deficit on the other set of plates. The electrons will follow any available pathway to get from one set of plates to the other.

The alternator (Ref. B), on the other hand, converts mechanical power supplied by the engine into electrical power. The alternator produces power whenever the engine is running, to operate lights, motors, etc., and also to keep the battery fully charged.

There may be other "power suppliers" in the vehicle electrical system, too, but they are something different and we won't discuss them here. Basically, they take power supplied by the battery/alternator and modify it somehow (usually reduce the voltage) for use in an electronic subsystem (like engine control or ABS).

Power Controllers

Power controllers such as fuses and circuit breakers (Refs. C and D) are the "safety valves" in an electrical system. If too many electrons flow through the

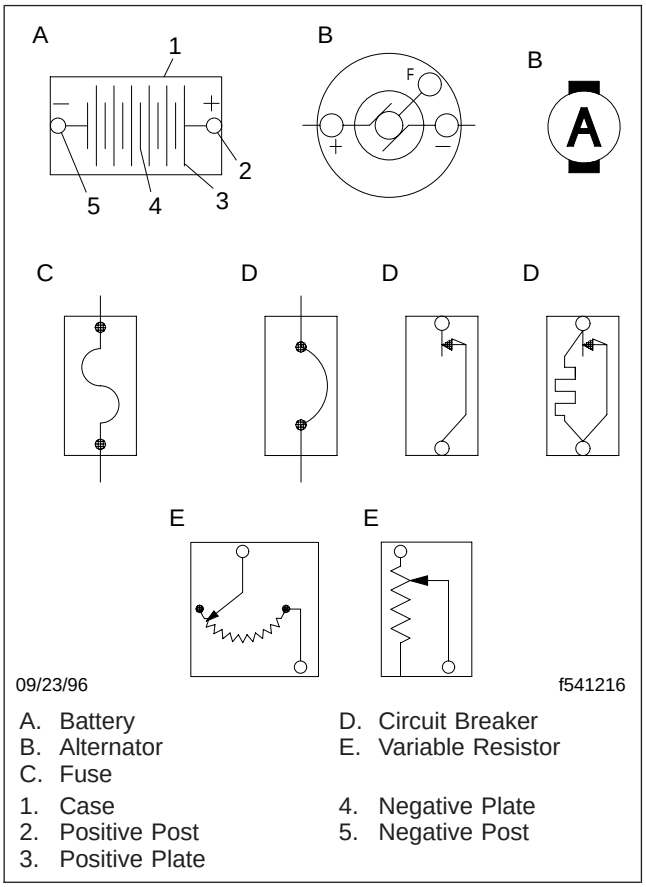


Fig. 1, Symbols, Power Suppliers and Controllers

fuse or circuit breaker, it gets hot and either melts (fuse) or its contacts open (circuit breaker) to open the power pathway in a controlled manner. The fuse or circuit breaker is the built-in "weak link" in a circuit; it is supposed to interrupt the flow of electrons before other parts of the circuit are damaged.

The rheostat or variable resistor (Ref. E) is also a power controller. A rheostat is a device that is specifically designed to reduce electron flow (current) in a circuit. A good example of a common rheostat is the instrument panel illumination bulb dimmer (I/P dimmer, for short). The I/P dimmer takes battery voltage and, by restricting the flow of electrons, reduces the voltage available "downstream" of the rheostat. So, as you increase rheostat resistance by twisting the I/P dimmer knob, you lower voltage to the illumination bulbs and they burn less brightly.

Directional Controllers

The electrons stored on the battery plates need pathways to complete their circuit. The vehicle electrical system provides pathways in the form of wires, terminals, the cab, the frame, component cases or housings, and even fasteners (screws, bolts, washers). The important thing about pathways is that they provide very easy routes for the electrons to take; very little energy is lost or consumed as the electrons travel along. The materials most commonly used as power pathways are copper (wiring), aluminum (cab structure, frame rails, component housings), steel (cab structure, frame rails), and cast iron (engine block, transmission case).

It's not desirable or practical to operate all electrical equipment at the same time. For instance, you want the starting motor to operate only when starting the engine, and you want to be able to turn off the headlights. Switches and relays (see **Fig. 2**, Refs. A and B for symbols) work like drawbridges, closing and opening to allow and interrupt the flow of electrons in a circuit. Typically, switches are used in low power circuits, and relays are used in moderate to high power circuits.

Appliances

Appliances are the reason we create power sources, power controllers, and directional controllers — we want electrons to go somewhere and do something for us. Electric motors, light bulbs, heating elements (for mirrors), solenoids, solid-state devices (like radios and control modules), and gauges (see Refs. C to H for symbols) all do something for us when they use those electrons. Electric motors turn shafts, light bulbs provide illumination, heating elements melt ice or evaporate condensation, solenoids provide linear motion, etc. From an electrical standpoint, appliances fit into our discussion here because a large voltage drop occurs as the electrons travel through the appliance.

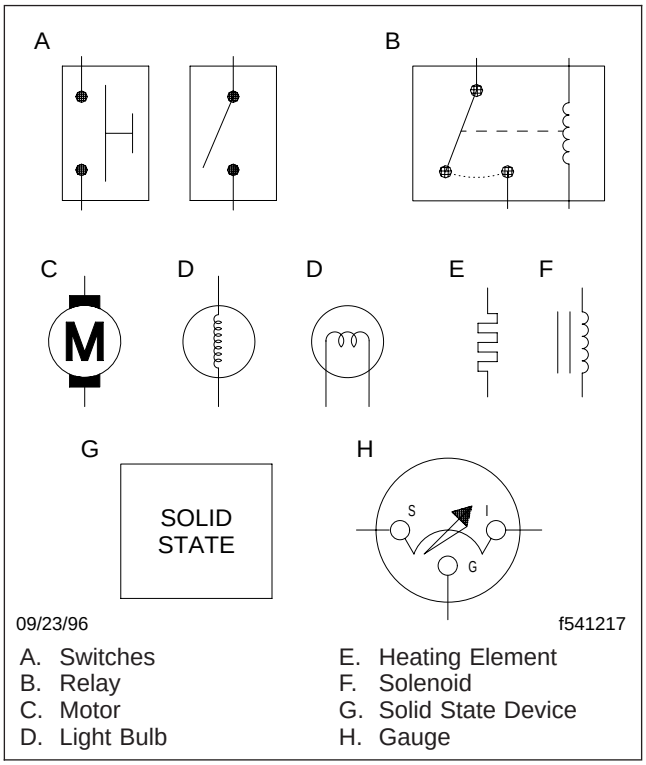


Fig. 2, Symbols, Directional Controllers and Appliances

Troubleshooting Tools

Here are some of the tools used during electrical troubleshooting:

Voltmeter

A DC voltmeter (see **Fig. 3**) is used to measure circuit voltage. Connect the black (–) lead to ground and the red (+) lead to the place where you want to measure voltage.

Ohmmeter

An ohmmeter (see **Fig. 4**) is used to measure circuit resistance and check continuity. When checking circuit resistance, the circuit's normal power source must be removed by disconnecting the battery or pulling a fuse or circuit breaker. If this isn't done, there's a good chance that the ohmmeter will be damaged.

A battery inside the ohmmeter supplies the voltage necessary to make resistance measurements.

Volt-Ohm-Milliammeter (VOM)

The VOM is simply three separate devices combined into one. It's a voltmeter, an ohmmeter, and an ammeter. Typically, you operate a rotary switch on the VOM to select the type of measurement you want to make; when measuring current flow (ammeter function) you often have to connect the positive (+) lead to a different port on the VOM.

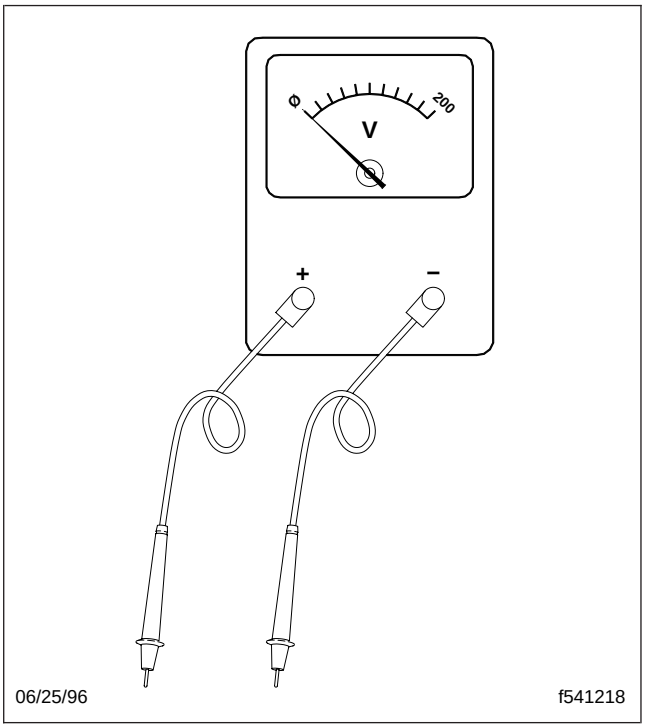


Fig. 3, Voltmeter

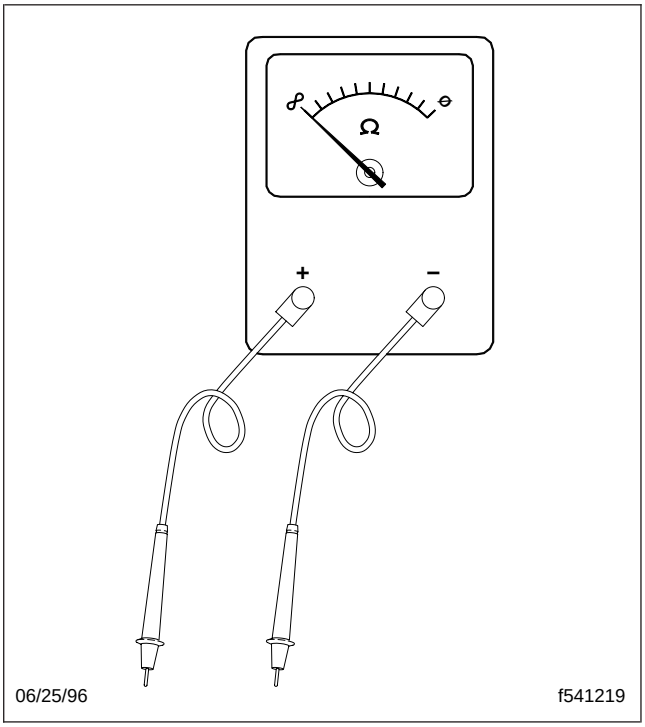


Fig. 4, Ohmmeter

A very common modern alternative to the VOM is the Digital Volt-Ohm Millammeter or DVOM. See **Fig. 5**. This tool is a solid-state version of the VOM and usually has a large, easy to read, digital LCD display instead of a needle.

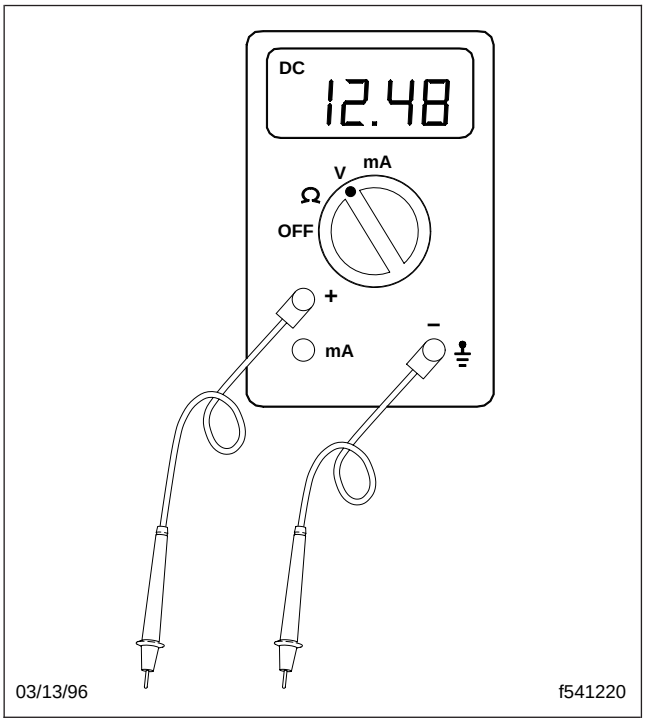


Fig. 5, Digital Volt-Ohm-Milliammeter (DVOM)

Jumper Wire

A jumper wire (see **Fig. 6**, Ref. A) is simply a length of wire with an alligator clip or test probe at each end. You can use a jumper wire to connect two points of a circuit, bypassing (or jumping over) fuses, switches, etc.

NOTE: Never connect a jumper wire across an appliance! This would be a short circuit from battery to ground and could cause an injury or a fire.

Actually, it's a good idea to use a fused jumper wire (Ref. B) at all times. That way an accidental short will blow the fuse, protecting both you and the rest of the circuit.

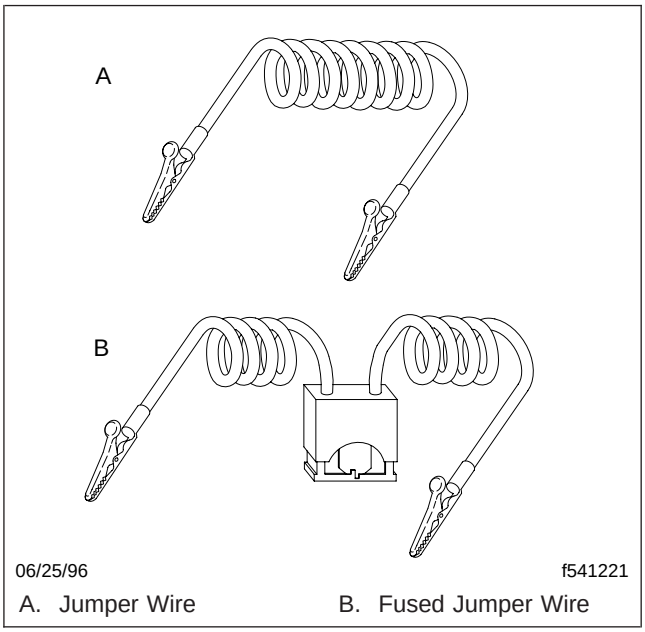


Fig. 6, Jumper Wires

Test Lamp

A test lamp (see **Fig. 7**) is a 12V (or 24V, if appropriate) light bulb with a length of wire attached to each terminal. The test lamp can be used for quick, but imprecise, voltage checks.

Typically, the bulb is enclosed in a clear plastic handle (screwdriver-like) with a pointed metal probe coming out one end and a wire coming out the other end. Clamp the wire to a good ground and touch the metal probe to the desired test point. If enough voltage is present, the bulb will illuminate.

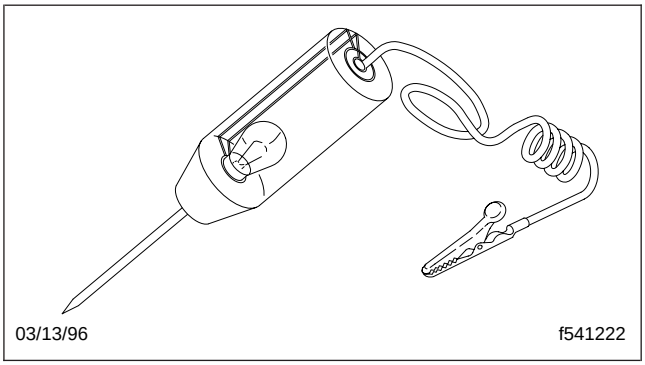


Fig. 7, Test Lamp

A Sample Circuit

See **Fig. 8** for a sample circuit. Notice that every one of the categories discussed previously is present: power supplier (the battery, Ref. A), power controller (the circuit breaker, Ref. B), directional controllers (wiring and switch, Ref. C), and appliance (electric motor, Ref. D). This kind of circuit is called a series circuit; all the parts are arranged, one after the other, in series. There's only one possible path the electrons can take. This is a simple circuit, but it is also typical.

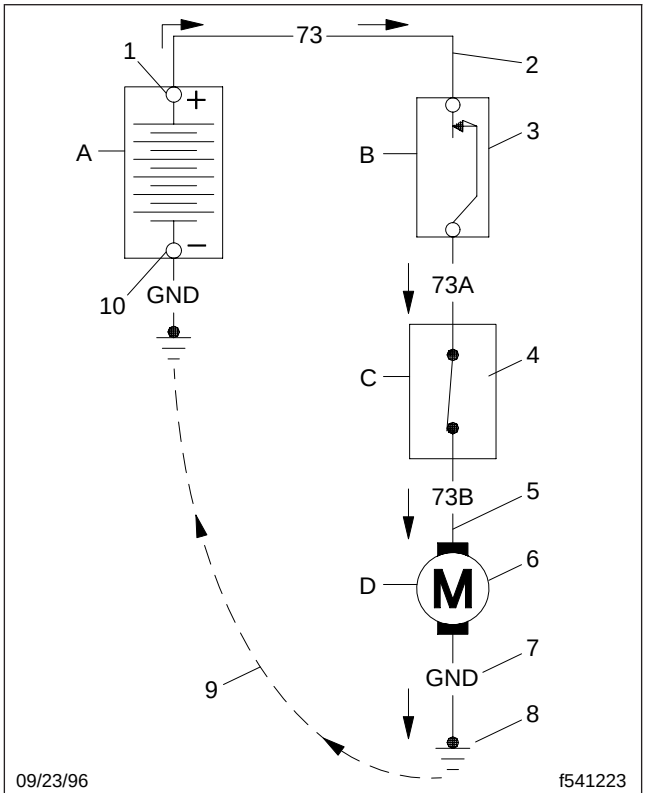


Fig. 8, Sample Circuit Number One

The circuit starts at the battery positive terminal (Ref. 1) follows wire 73 (Ref. 2) to the circuit breaker (Ref.

3), and continues on to the switch (Ref. 4). When the switch contacts are closed, the circuit continues through the switch and wire 73B (Ref. 5) to the electric motor (Ref. 6). So long as the motor is operative (isn't damaged or burned-out) the circuit continues through the motor to the GND wire (Ref. 7) and on to the chassis ground point (Ref. 8). Although it isn't usually shown on a schematic, the circuit actually continues through chassis metal (Ref. 9) back to the battery negative terminal (Ref. 10).

Troubleshooting the Sample Circuit

To find out what's wrong if the switch is closed, but the motor doesn't run, work around the circuit, checking for voltage at key points. If voltage is present, keep going; if voltage isn't present, find out why:

Is the battery dead? Check battery voltage using a voltmeter. See **Fig. 9**. Connect the voltmeter red (+) lead to the battery (+) terminal and the voltmeter black (–) lead to the battery (–) terminal. Voltage should be at least 12 volts. Low or no voltage could mean that there is corrosion between the battery post and terminal. If the battery terminals are loose or obviously corroded, fix them. If not, loosen the clamp bolts and disconnect the terminals. Soft, shiny or greyish metal should be present on both the battery post and the inside of the terminal, not hard, dark and scaly metal. Clean the battery posts and the terminals, if necessary. If the terminal connections seem to be okay, the battery needs to be charged, or the battery should be replaced.

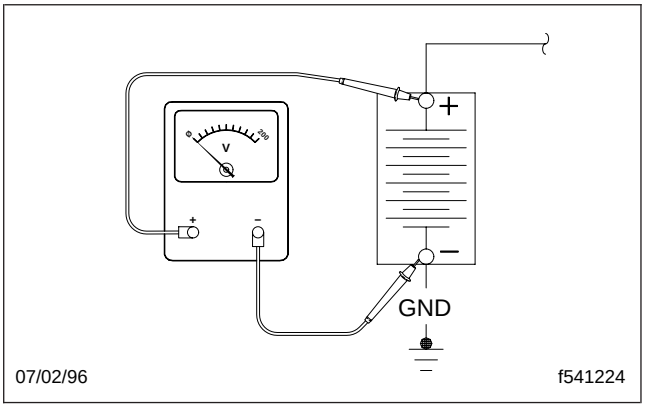


Fig. 9, Checking Battery Voltage

Is battery voltage present at the circuit breaker? Check, using a voltmeter. See **Fig. 10**. Connect the voltmeter red (+) lead to the circuit breaker (the side fed by the battery) and the voltmeter black (–) lead to the battery (–) terminal. Again, voltage should be at least 12 volts. If it isn't, the problem may be a broken wire 73, or an inadequate or damaged crimp where a wire terminal is connected to wire 73 (see **Fig. 11**).

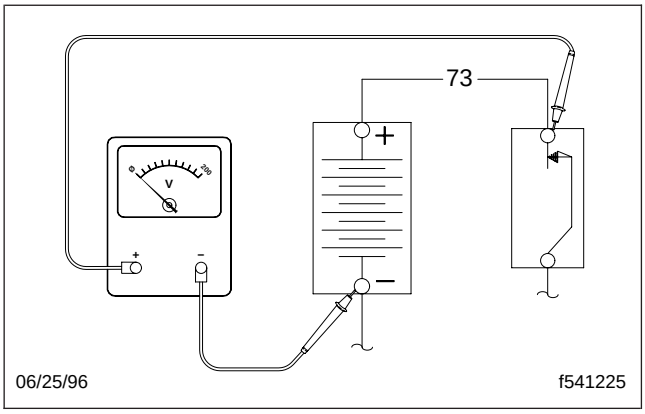
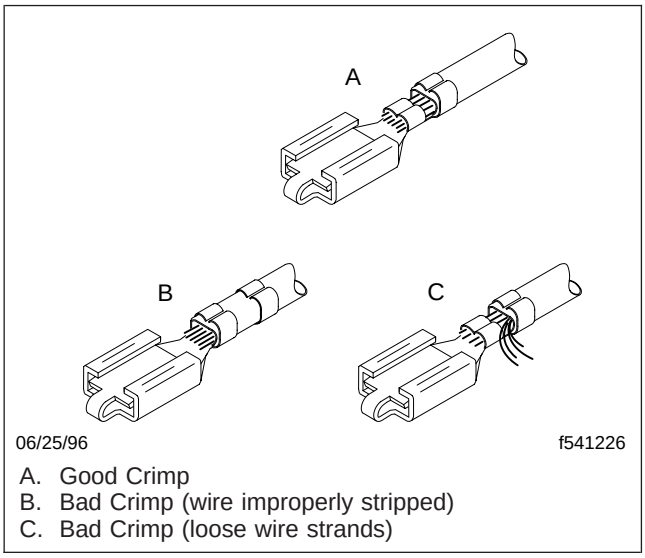


Fig. 10, Voltage Check at Circuit Breaker



A. Good Crimp
B. Bad Crimp (wire improperly stripped)
C. Bad Crimp (loose wire strands)

Fig. 11, Good and Bad Crimps

Is battery voltage present at the other end of the circuit breaker? See **Fig. 12**. If not, the circuit breaker is faulty and should be replaced.

Is battery voltage present at the switch? See **Fig. 13**. If it isn't, possible causes again include a broken wire or inadequate/damaged terminal crimps.

Is battery voltage present at the switch outlet when the switch is closed? See **Fig. 14**. If not, the switch is faulty and should be replaced.

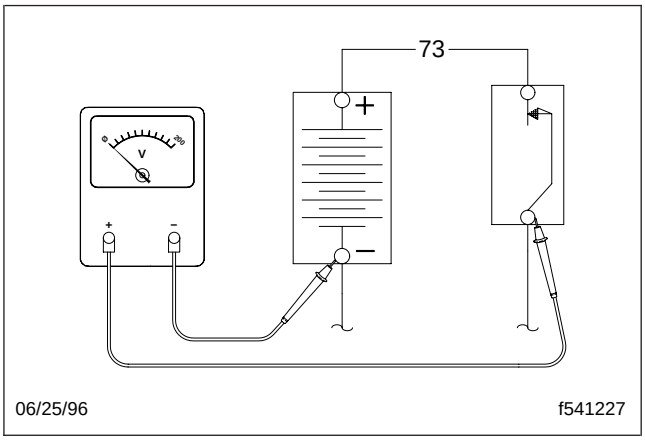


Fig. 12, Voltage Check after Circuit Breaker

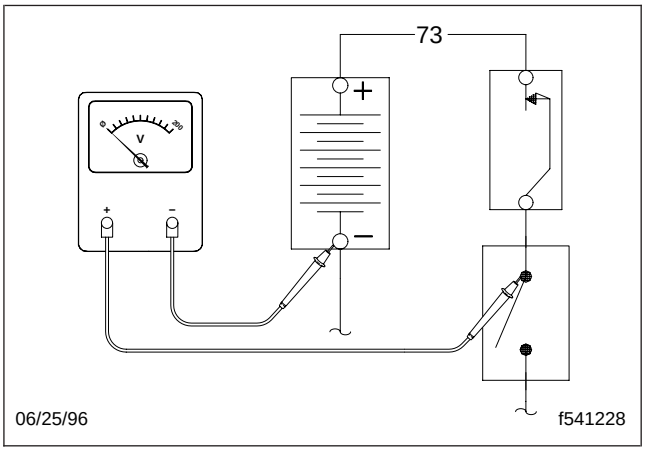


Fig. 13, Voltage Check at the Switch

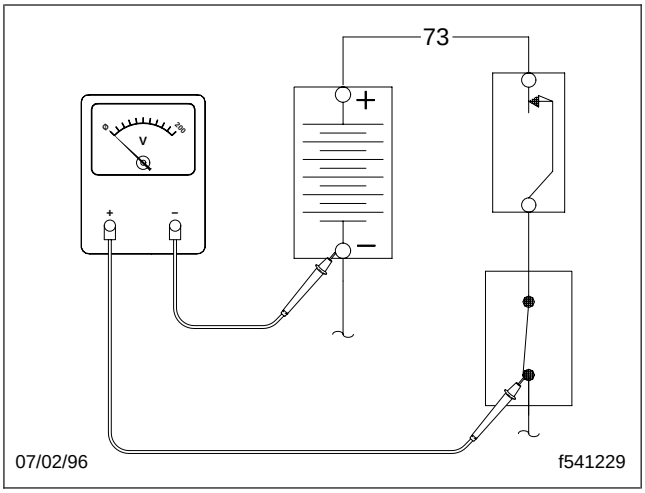


Fig. 14, Voltage Check after the Switch

Is battery voltage present at the motor? See **Fig. 15**. If not, wire 73B could be broken or an inadequate/ damaged terminal crimp could be the cause.

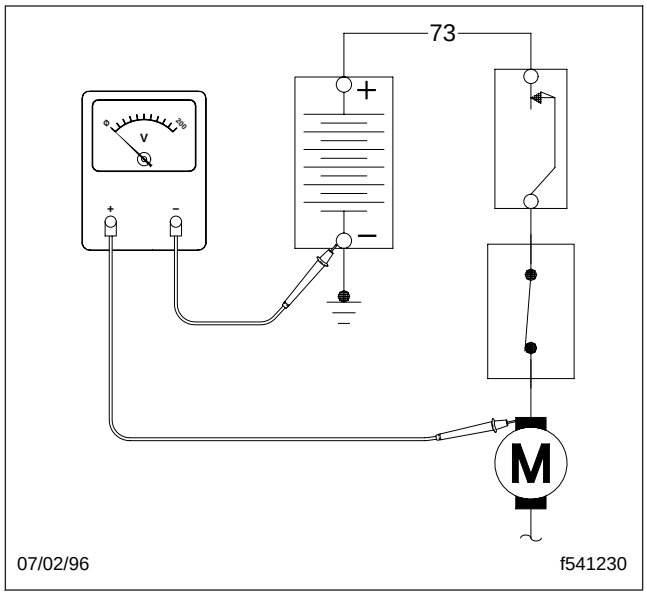


Fig. 15, Voltage Check at the Motor

Is the motor obviously damaged or burned-out? If it is, replace it. If it doesn't appear to be, continue troubleshooting.

If voltage is present at all the points mentioned above, perhaps the ground circuit is faulty. Note that voltage tests are performed only on parts of the circuit that appear before the appliance. This is because a large voltage drop occurs across the appliance and, unless you know exactly what voltage should be present after the appliance, a voltage measurement won't be very meaningful.

The most commonly used method for troubleshooting ground circuits is checking circuit resistance with an ohmmeter.

NOTE: One very important thing to remember when checking circuit resistance with an ohmmeter is that voltage must not be present in the circuit being tested, or the ohmmeter will be damaged. A battery inside the ohmmeter provides all the voltage necessary to make the resistance measurement. Make sure the appropriate power switch for the circuit being tested is off. For circuits receiving battery voltage all the

time, shut off power using the main disconnect switch or, if necessary, disconnect the batteries.

Check circuit resistance between the GND wire terminal and the vehicle frame or body. See **Fig. 16**. Resistance should be very low; usually less than one ohm for this type of connection. If resistance is more than five ohms, there is a problem that needs to be corrected. The cause could be a loose screw securing the terminal to the frame or body, or corrosion between the terminal and the frame or body. Make sure that the bare metal of the frame or body is exposed at the ground point — paint, rust, grease, and dirt can act as an insulator, causing high resistance.

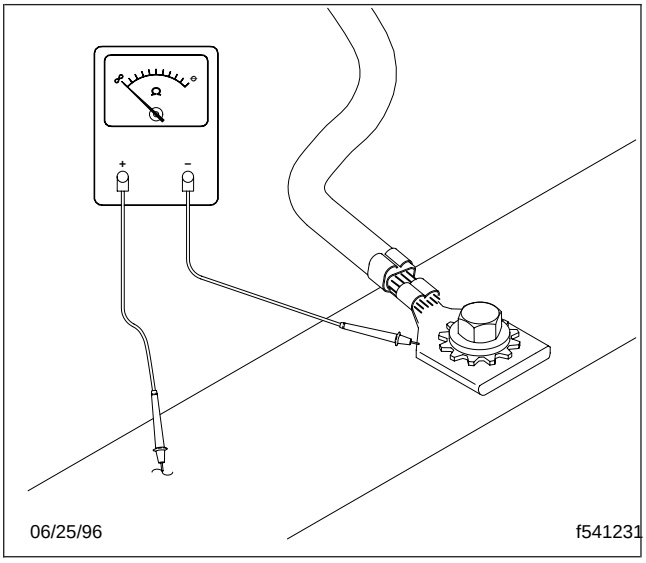


Fig. 16, Resistance Check at the Ground Point

Check circuit resistance between the motor ground terminal and the vehicle frame or body. See **Fig. 17**. Again, resistance should be very low — if it is more than 5 ohms, there's a problem. Inspect for damaged or inadequate crimps where a wire is connected to a terminal. See **Fig. 11**. Check for corrosion at connections and check for a damaged wire.

At some point during the steps outlined above, you should have discovered the cause of the problem. If you didn't, the motor may be malfunctioning; replace it. If the new motor doesn't work, go back to the beginning, checking voltage and resistance readings again.

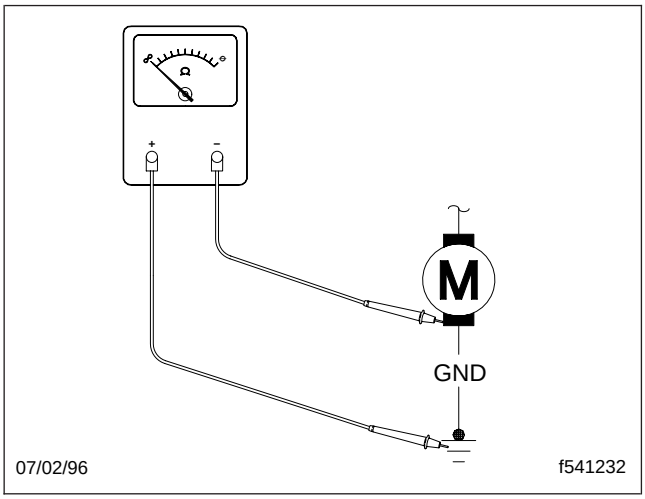


Fig. 17, Resistance Check of Ground Circuit

Short Cuts

Sometimes, it may be very difficult to access voltage measurement points in the circuit. In those cases, it makes sense to check the easy-to-access points first, regardless of their position in the circuit; check the battery terminals, fuse, and motor.

Or, check voltage at the motor first with the switch turned on; if voltage is present at the motor, it must be present at the battery, circuit breaker, and switch, so you can skip those voltage tests.

The same strategy applies to the resistance tests; if low resistance is measured between the motor and the frame, there's no point in measuring resistance between the GND wire terminal and the frame. Use short cuts whenever it makes sense, not just when access to a component is a problem.

Troubleshooting Steps

Take an orderly approach to electrical troubleshooting. Follow the same set of steps every time to improve your chances of a quick, accurate diagnosis:

Step 1 – Verify that the problem exists.

Using information provided by the owner/operator of the vehicle, operate the system and see all the symptoms for yourself. The owner/operator complaint may be inaccurate or misleading. Also, you may no-

tice symptoms that the owner/operator didn't notice or didn't think were important enough to report.

Step 2 – Narrow down the possible causes of the problem.

Perform basic checks to quickly eliminate possible causes. Are the battery terminals loose or corroded? Is the alternator belt loose? Any obvious damage to the vehicle? Blown fuses? Loose or corroded ground wires? Lenses showing that moisture is trapped inside a lamp?

If you don't find anything, check the wiring schematics or service bulletins for clues. What other component/system shares a fuse/circuit breaker or ground point with the faulty component/system? Is that component/system operating properly?

Step 3 – Test for the cause of the problem.

Use the appropriate test equipment and procedures to zero in on the cause of the problem. Check for voltage. Check for continuity. Check for appropriate resistance values. Check for appropriate current flow.

Step 4 – Verify that you have located the cause of the problem.

If you think a switch is faulty, use jumper wires to bypass the switch and verify that the component now operates. Likewise for a suspected bad ground - run a jumper directly from the component to the frame or cab. If you think that one shorted lamp is blowing a fuse or tripping a breaker, disconnect that lamp and verify that the rest now operate normally. Connect a known good component without actually removing the old one, if possible — does the component operate?

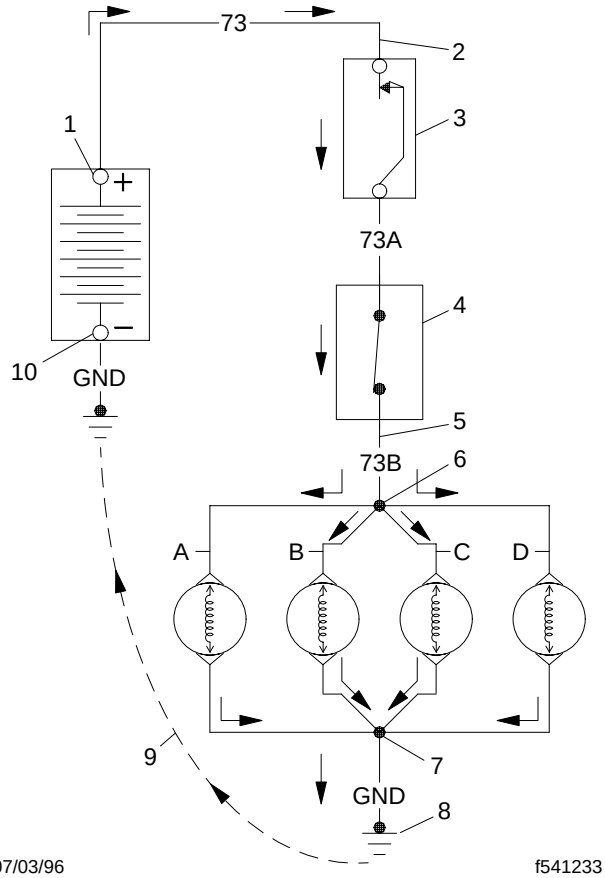
Step 5 – Make the necessary repairs.

Perform any repairs or parts replacement necessary.

Step 6 – Verify that the problem is gone.

Operate the system to make sure that all symptoms are gone. Just as important, make sure that no new symptoms have appeared.

Another Sample Circuit



A. Path "A"
B. Path "B"
C. Path "C"
D. Path "D"
1. Battery (+)
2. Circuit #73
3. Circuit Breaker
4. Switch
5. Circuit #73B
6. Power Circuit Splice
7. Ground Circuit Splice
8. Ground Point
9. Path Through Chassis
10. Battery (–)

Fig. 18, Sample Circuit Number Two

The following circuit (see **Fig. 18**) is a little more complicated than the first one. This one includes parallel circuits. Most of the parts in the circuit are arranged, one after the other, just like the parts in the series circuit we looked at earlier. The light bulbs, however, aren't arranged one after the other; they appear side by side or "in parallel."

In parallel circuits, the electrons are not limited to following just one path back to the battery — they

can follow any of several parallel paths. Many vehicle illumination circuits are parallel circuits where several bulbs come on at the same time.

So, the circuit starts at the battery positive terminal (Ref. 1) follows wire 73 (Ref. 2) to the circuit breaker (Ref. 3), and continues on to the switch (Ref. 4). When the switch contacts are closed, the circuit continues through the switch and wire 73B (Ref. 5) to the splice (Ref. 6). Up to this point we've been tracing a series circuit.

Assuming that resistance in each of the bulb circuits is equal, an equal number of electrons will travel down each of the four bulb circuits (Refs. A, B, C, & D). If all the light bulb filaments are intact (none of the bulbs are burned-out), electrons travel through the bulbs and their individual GND wires to the ground splice (Ref. 7) and on to the chassis ground point (Ref. 8). Although it isn't usually shown, the circuit actually continues through chassis metal (Ref. 9) back to the battery negative terminal (Ref. 10).

Troubleshooting the Sample Circuit

Let's look at two possible circuit failures — none of the bulbs illuminate when the switch is closed, and some, but not all, of the bulbs illuminate when the switch is closed.

None of the Bulbs Operate — if none of the bulbs illuminate, it's very possible that the problem is in the series part of the circuit — the part of the circuit that is just like the circuit we looked at earlier. So, the troubleshooting steps are exactly the same. Work around the circuit, checking for voltage at key points. If voltage is present, keep going; if voltage isn't present, find out why. Review "A Sample Circuit" if necessary.

Unlike the first sample circuit in which we checked for voltage at the electric motor, this sample circuit has an extra "component" — the splice which feed the individual bulb circuits. Check for battery voltage at the splice. See **Fig. 19**. If battery voltage isn't present, wire 73B could be broken or an inadequate/ damaged terminal crimp could be the cause.

If voltage is present at the splice, lack of voltage is not likely to be the cause of the problem, since the splice is the transition point between the series circuit and the parallel circuit. If voltage is present at the splice, that would mean that all four circuits leading to the bulbs would have to be faulty or all four bulbs would have to be burned out and that's unlikely.

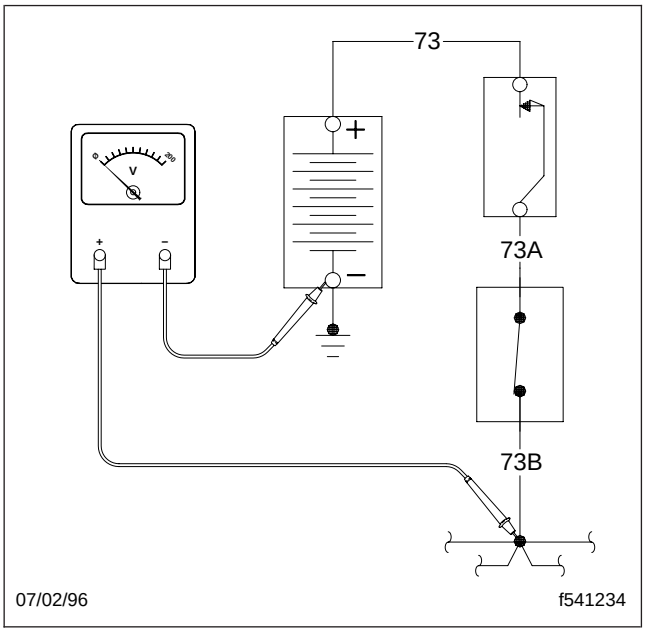


Fig. 19, Checking for Power at the Splice

Check the ground circuit instead. Review "A Sample Circuit" if necessary.

NOTE: Remember, when checking circuit resistance with an ohmmeter, voltage must not be present in the circuit being tested, or the ohmmeter will be damaged. A battery inside the ohmmeter provides all the voltage necessary to make the resistance measurement. Make sure the appropriate power switch for the circuit being tested is off. For circuits receiving battery voltage all the time, shut off power using the main disconnect switch or, if necessary, disconnect the batteries.

The ground circuit of this sample circuit, like the power circuit, has an extra "component," and it's the ground splice. Check circuit resistance between this ground splice and the vehicle frame or body. See **Fig. 20**. Again, resistance should be very low — if it is more than 5 ohms, there's a problem. Inspect for damaged or inadequate crimps where a wire is connected to a terminal and check for a damaged wire.

If you still haven't found the cause, check the individual bulb ground circuits that run between each bulb and the ground splice. But if none of the bulbs are working, it means that all four of the circuits are faulty (which is very unlikely).

Troubleshooting

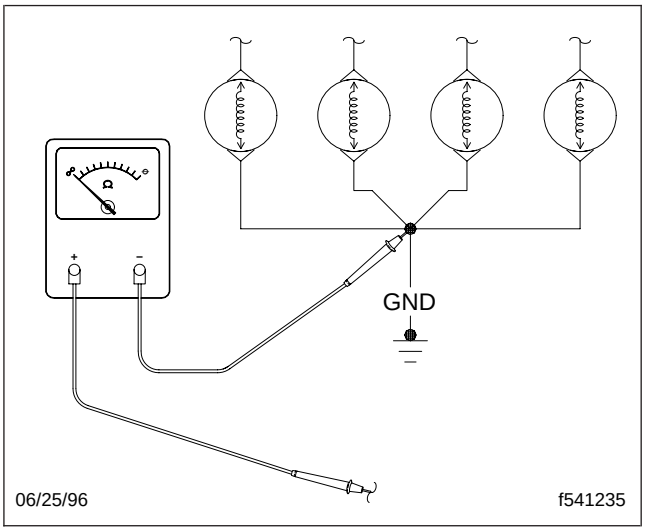


Fig. 20, Checking the Shared Ground Circuit

Check resistance between each bulb socket ground terminal and the ground splice. See **Fig. 21**. Resistance between each terminal and the splice should be very low.

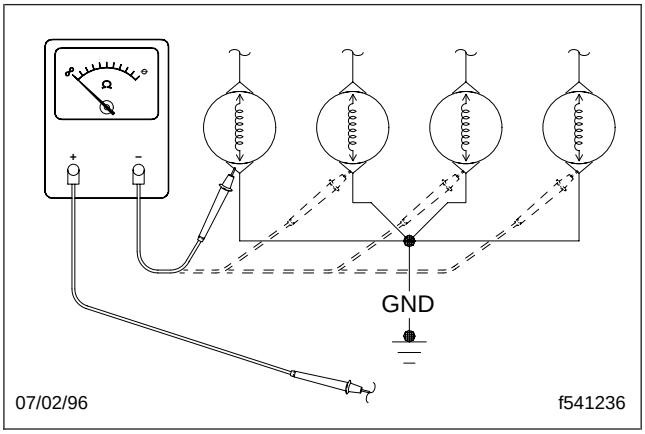


Fig. 21, Checking the Individual Ground Circuits

Some, But Not All of the Bulbs Operate — This kind of failure is a lot easier to troubleshoot since most of the possible circuit faults are immediately eliminated.

If even just one of the bulbs is operating, you can skip voltage tests all the way up to the circuit 73B splice; if one of the bulbs is operating, voltage must be reaching the splice. And, you can assume that the shared ground circuit between the ground splice and the actual ground point is also intact for the same reason.

The problem, then, must be in the individual power or ground circuits for each non-functioning bulb, or the bulb itself.

So, check for battery voltage at the circuit 73B terminal for each of the non-functioning bulbs. If battery voltage is present, use the DVOM to check resistance between the bulb socket ground terminal and the ground splice.

Basic Wiring Diagrams

For the basic wiring diagram used through October 25, 1990, for FLAs and FLDs *Without* Daytime Running Lights, [1] **see Fig. 1**.

For the basic wiring diagram used through October 25, 1990, for FLAs and FLDs *With* Daytime Running Lights, [1] **see Fig. 2**.

For the basic wiring diagram used from October 26, 1990, for FLAs and FLDs *without* daytime running lights, [1] and *without* DDEC III, **see Fig. 3**.

For the basic wiring diagram used from October 26, 1990, for FLAs and FLDs *with* daytime running lights, [1] but *without* DDEC III, **see Fig. 4**.

For the basic wiring diagram for FLBs *without* daytime running lights, [1] and *without* DDEC III, **see Fig. 5**.

For the basic wiring diagram for FLBs *with* daytime running lights, [1] but *without* DDEC III, **see Fig. 6**.

For the basic wiring diagram for FLBs *with* DDEC III (with an EDM), but *without* daytime running lights, [1] **see Fig. 7**.

For the basic wiring diagram for FLBs *with* DDEC III (with an EDM), and *with* daytime running lights, [1] **see Fig. 8**.

For the basic wiring diagram for FLDs *with* DDEC III (with an EDM), but *without* daytime running lights, [1] **see Fig. 9**.

For the basic wiring diagram for FLDs *with* DDEC III (with an EDM), and *with* daytime running lights, [1] **see Fig. 10**.

Circuit Overlays for Basic Wiring Diagrams

For optional-starting-circuit overlays, **see Fig. 11**.

For optional-ammeter-circuit overlays, **see Fig. 12**.

WIRING CIRCUIT NUMBER/ DESCRIPTION TABLES

[1] Daytime running lights are standard on Canadian vehicles built after December 1989.

Specifications

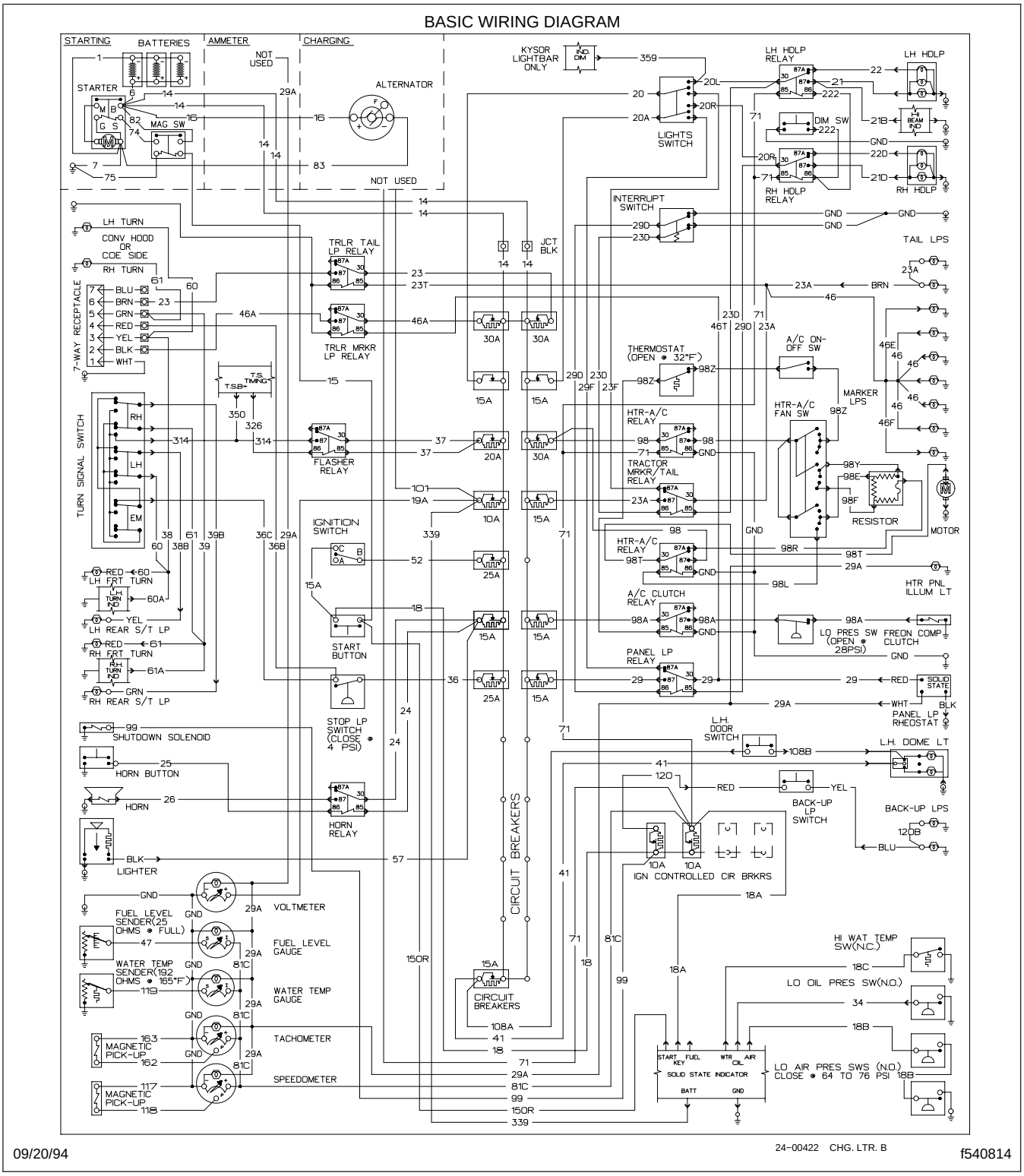


Fig. 1, Basic Wiring Diagram Used Through October 25, 1990, for FLAs and FLDs Without Daytime Running Lights

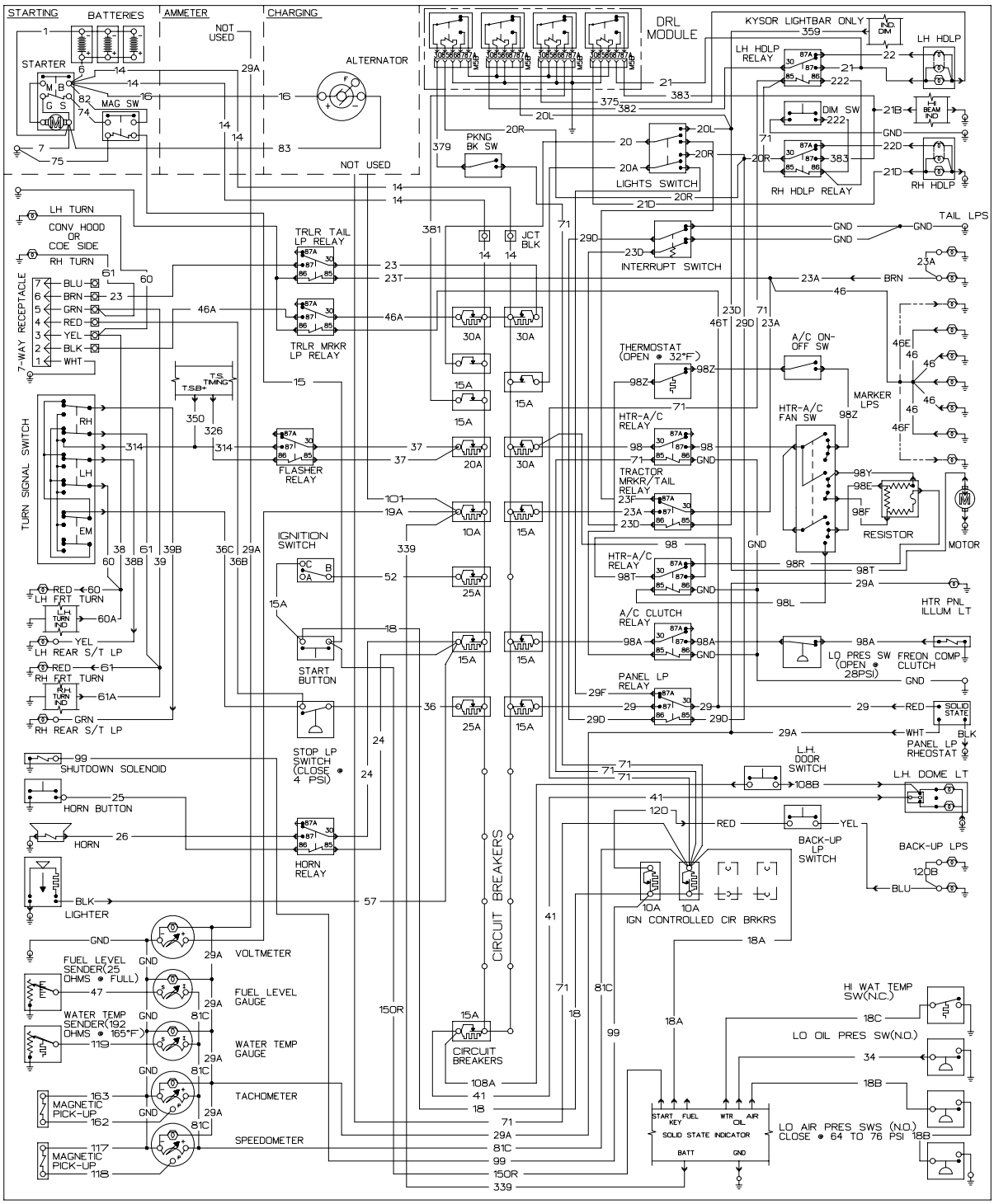


Fig. 2, Basic Wiring Diagram Used Through October 25, 1990, for FLAs and FLDs With Daytime Running Lights

Specifications

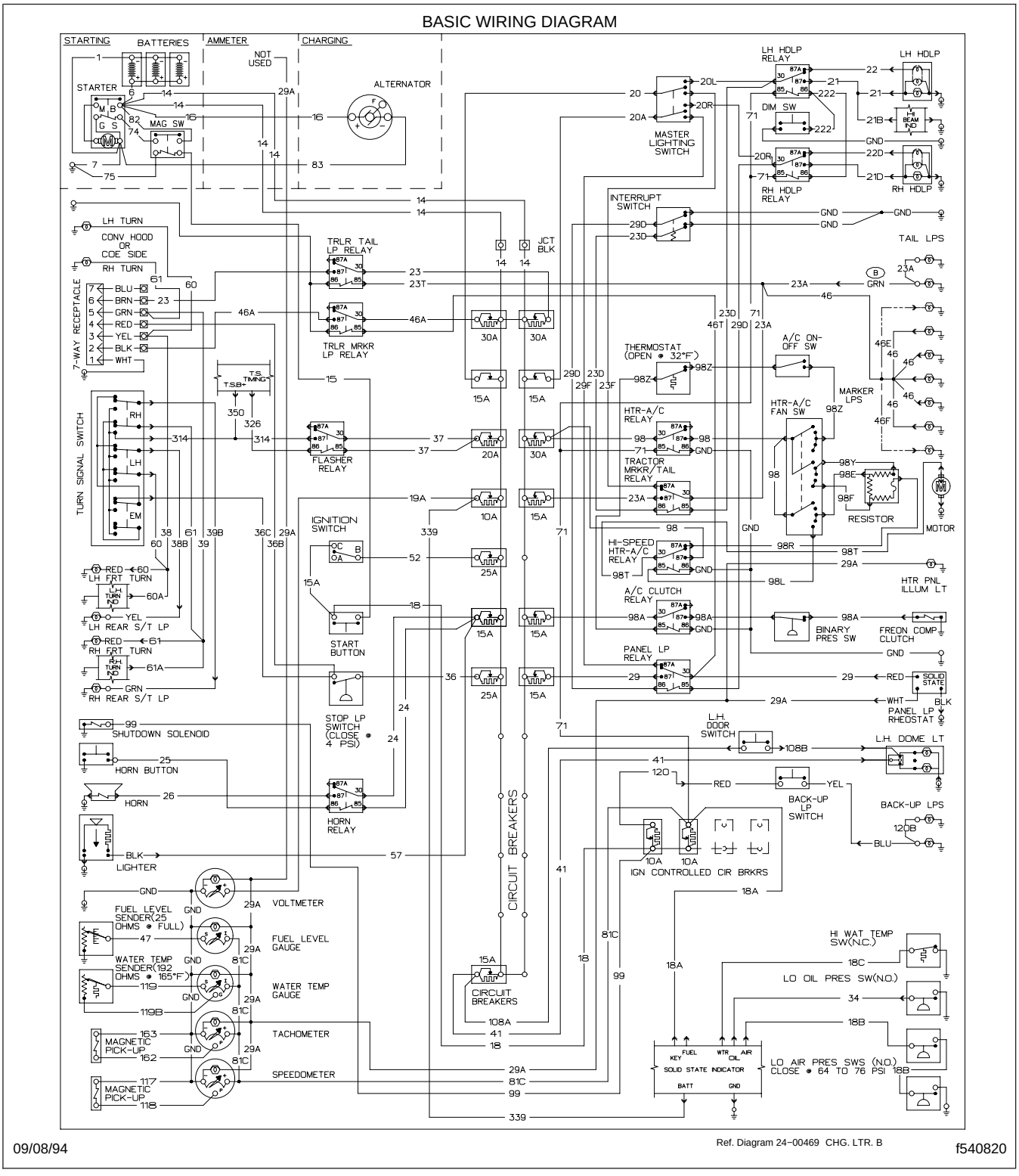
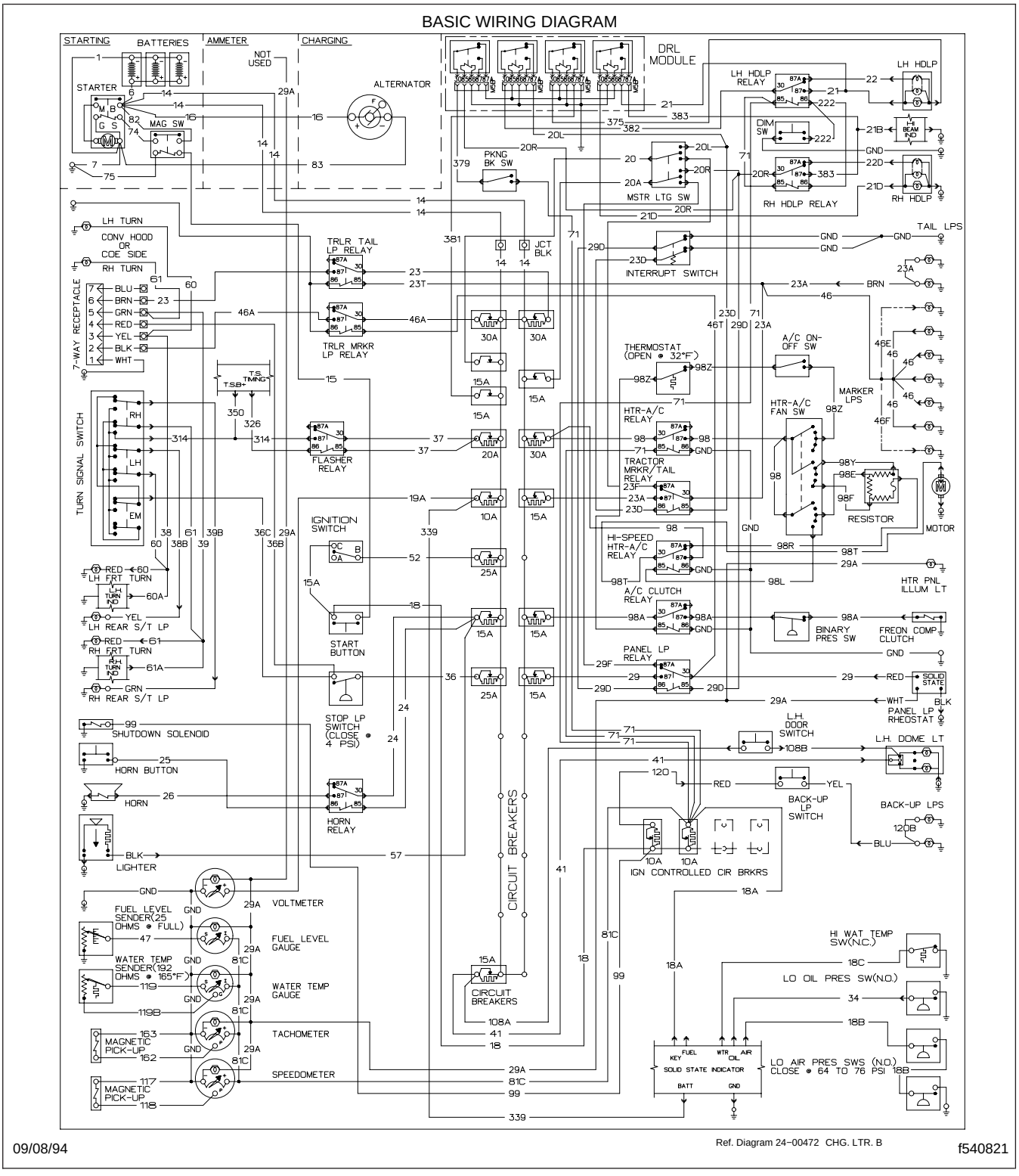


Fig. 3, Basic Wiring Diagram Used From October 26, 1990, for FLAs and FLDs Without Daytime Running Lights, and Without DDEC III



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Ref. Diagram 24−00472 CHG. LTR. B

f540821

Fig. 4, Basic Wiring Diagram for FLAs and FLDs With Daytime Running Lights, but Without DDEC III

Specifications

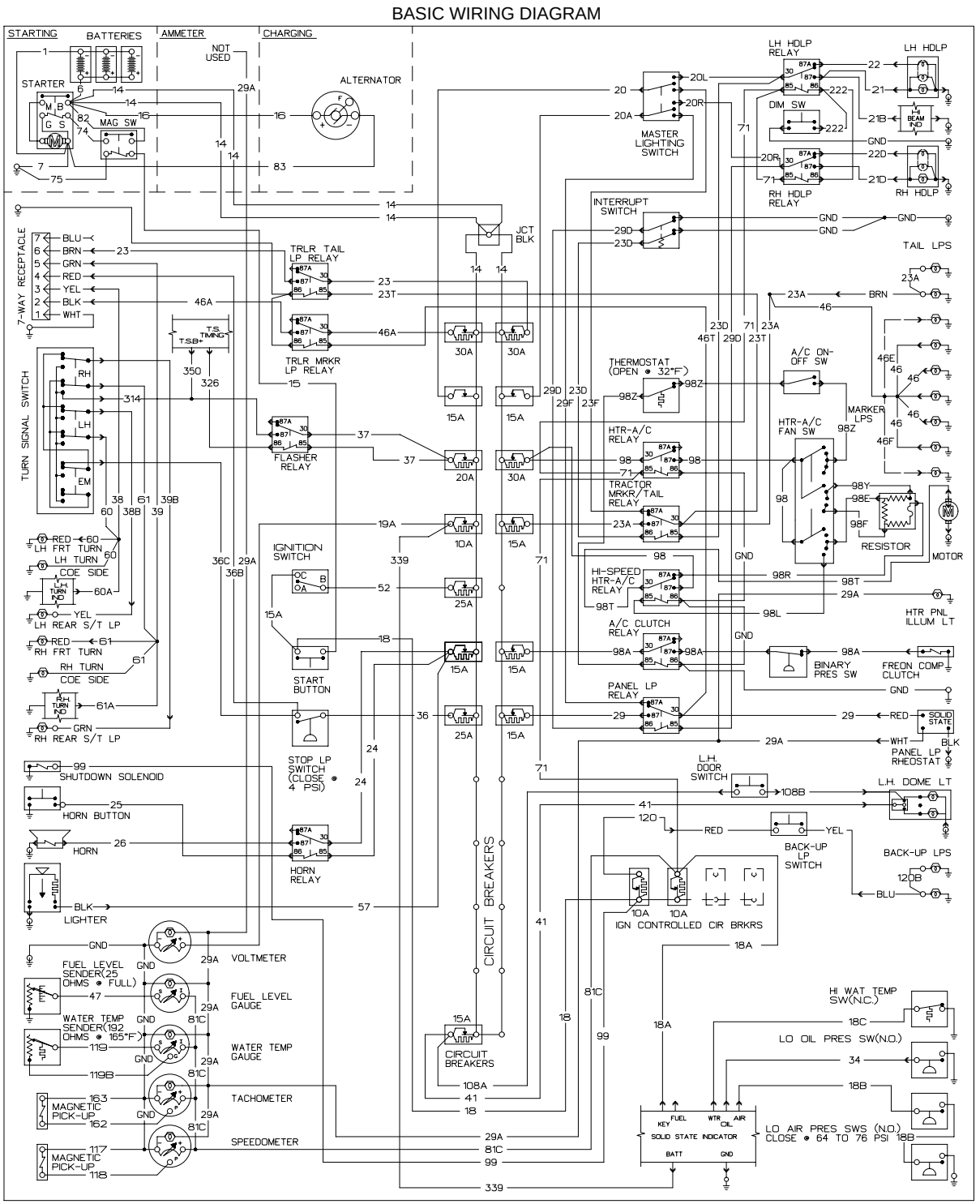


Fig. 5, Basic Wiring Diagram for FLBs Without Daytime Running Lights, and Without DDEC III

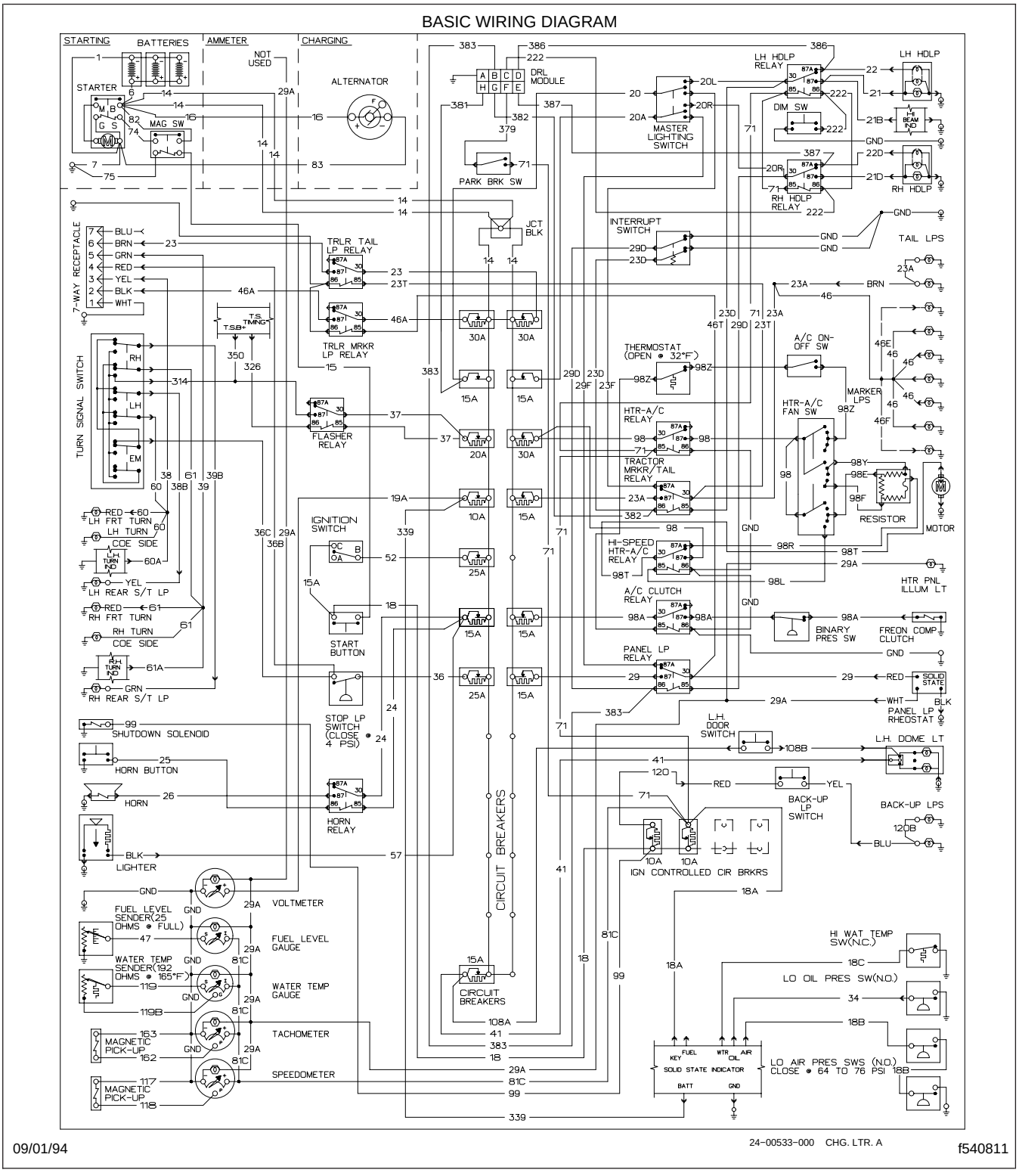


Fig. 6, Basic Wiring Diagram for FLBs With Daytime Running Lights, but Without DDEC III

Specifications

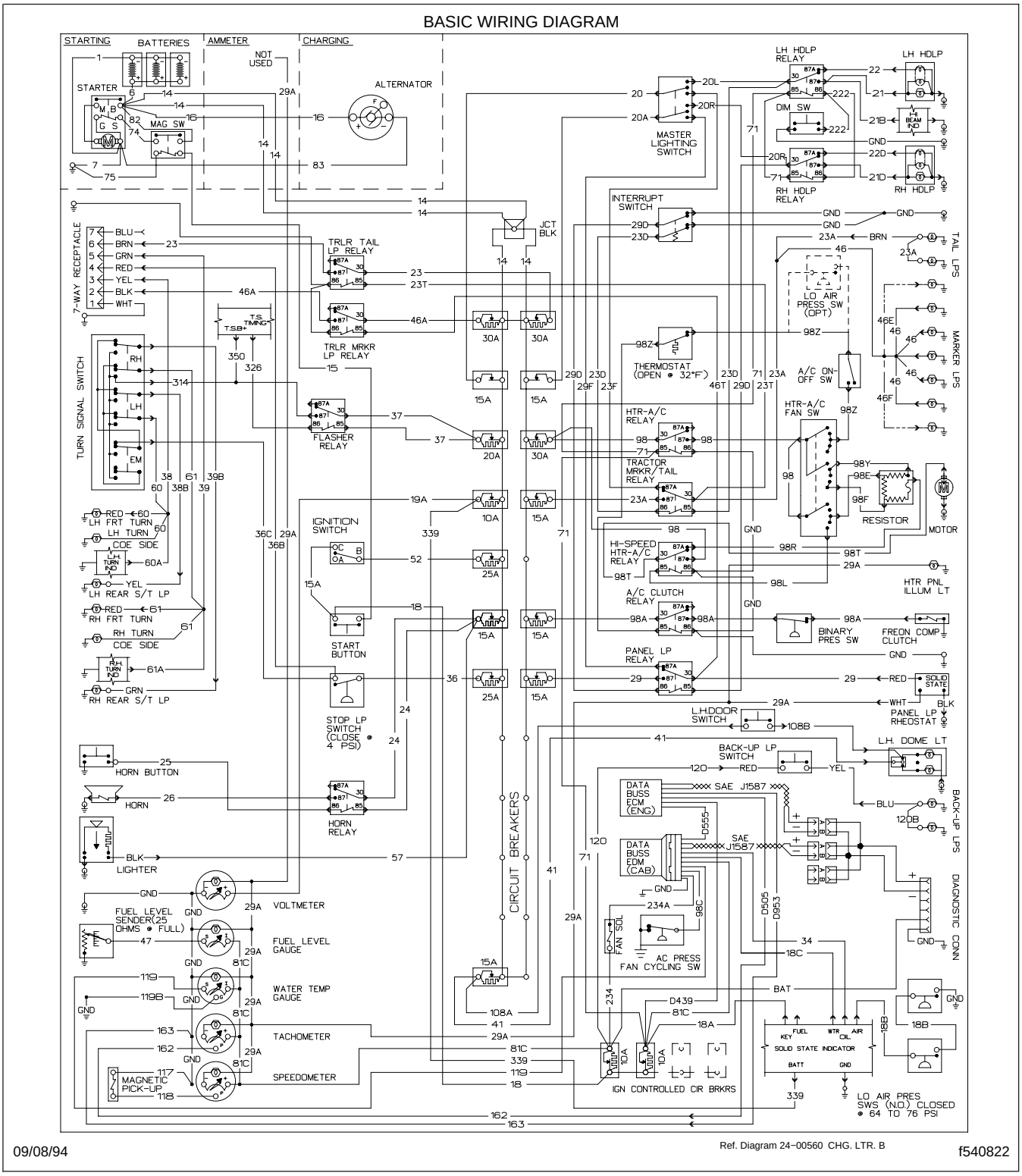
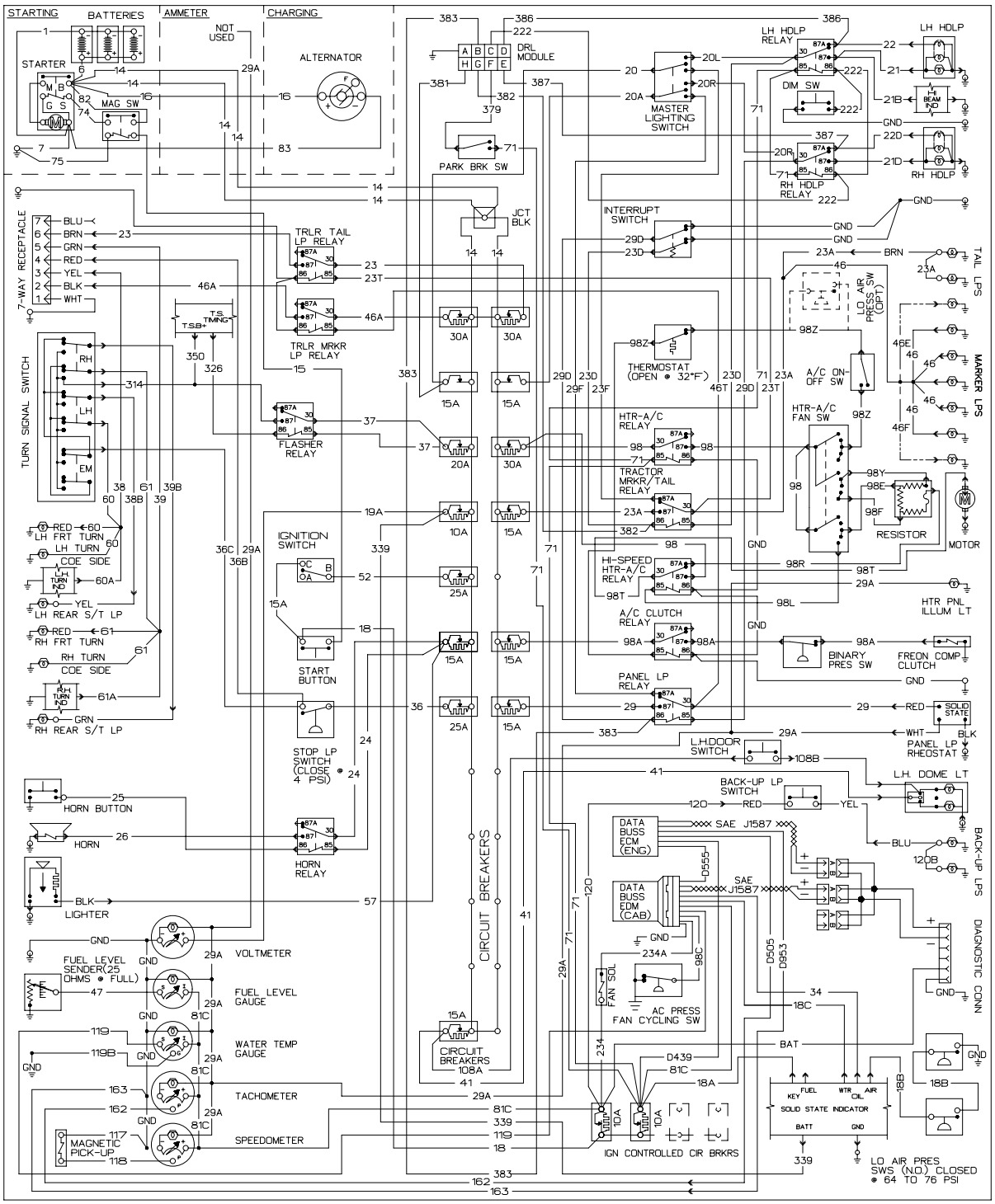


Fig. 7, Basic Wiring Diagram for FLBs With DDEC III (with an EDM), but Without Daytime Running Lights



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Ref. Diagram 24–00561 CHG. LTR. B

f540823

Fig. 8, Basic Wiring Diagram for FLBs With DDEC III (with an EDM), and With Daytime Running Lights

Specifications

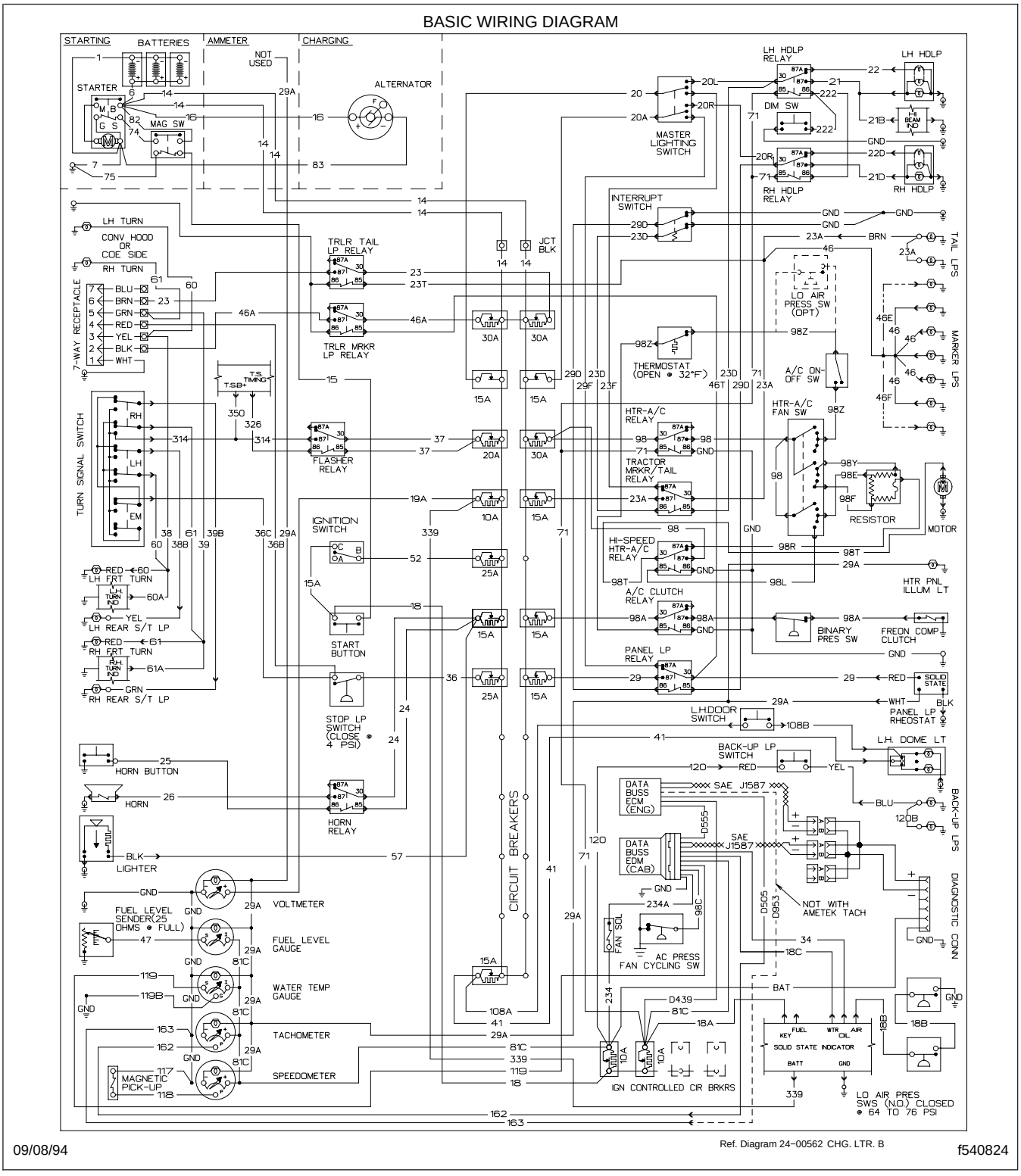


Fig. 9, Basic Wiring Diagram for FLDs with DDEC III (with an EDM), but Without Daytime Running Lights

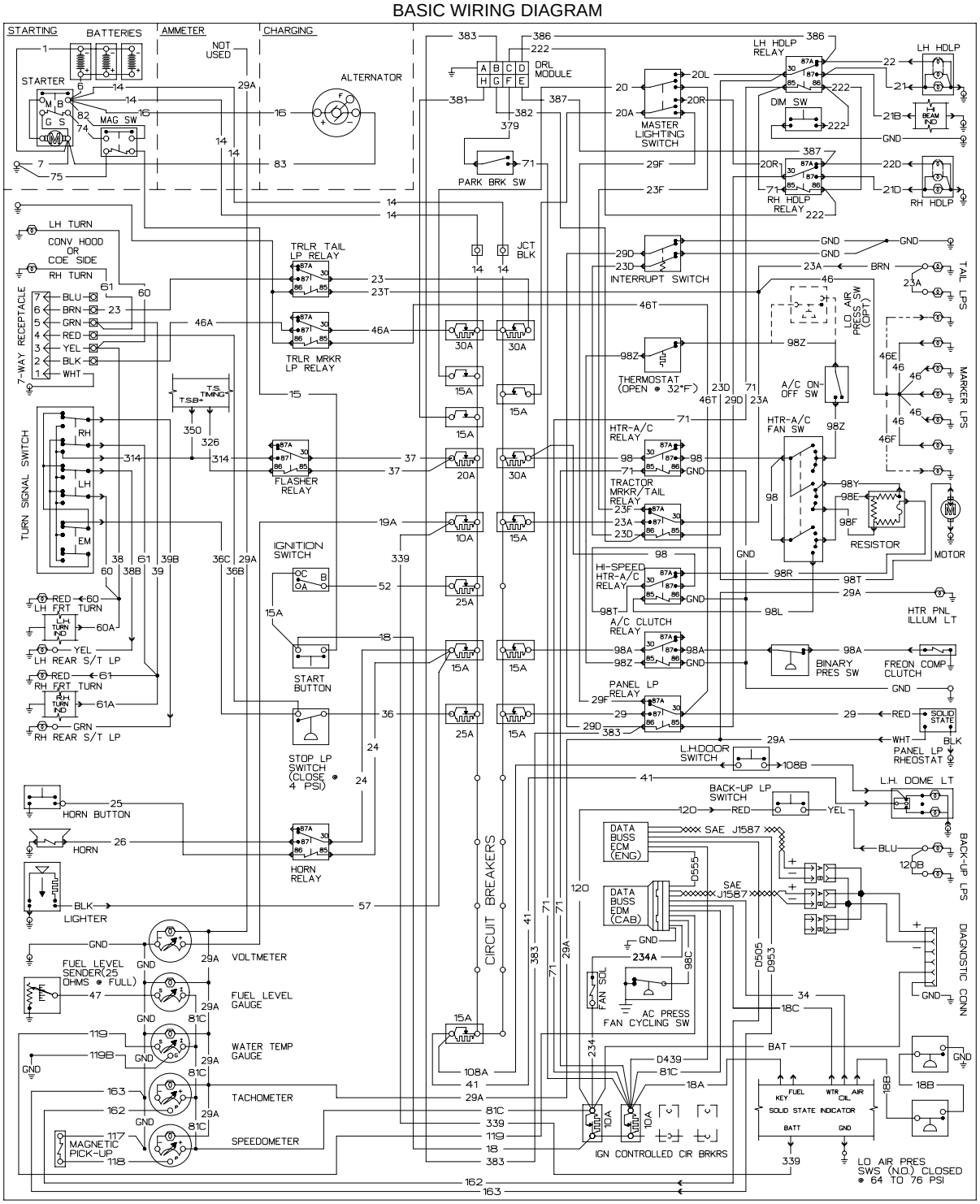
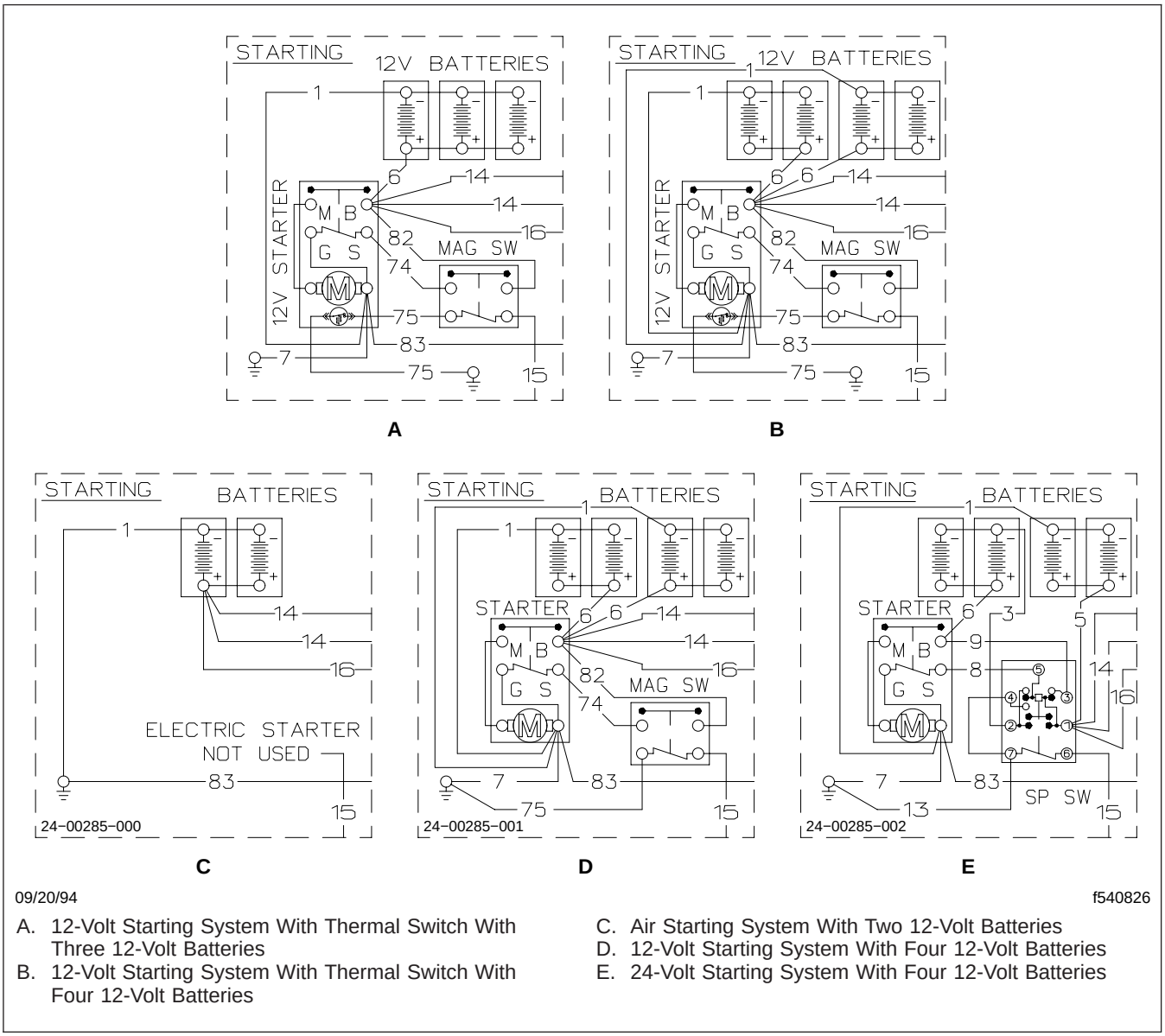


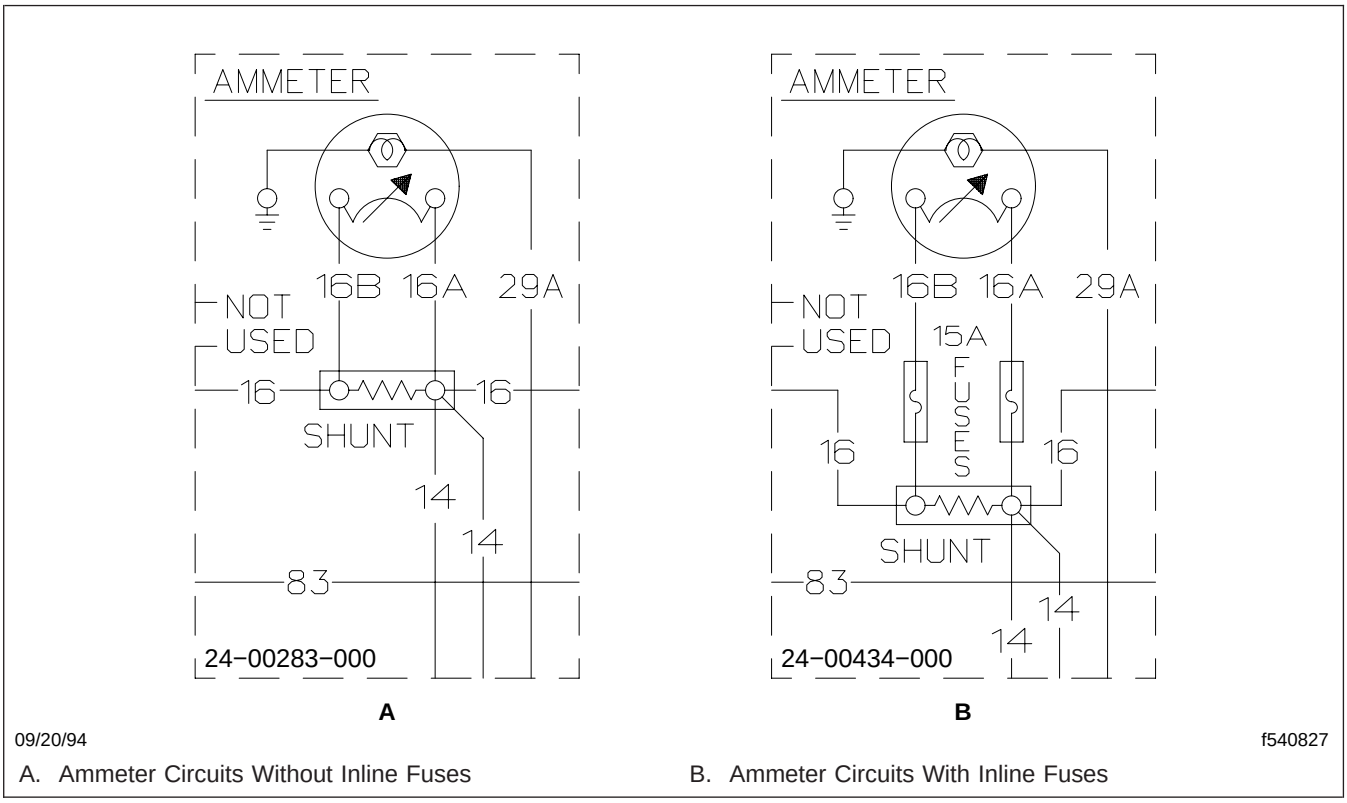
Fig. 10, Basic Wiring Diagram for FLDs with DDEC III (with an EDM), and With Daytime Running Lights

Specifications



A. 12-Volt Starting System With Thermal Switch With Three 12-Volt Batteries
B. 12-Volt Starting System With Thermal Switch With Four 12-Volt Batteries
C. Air Starting System With Two 12-Volt Batteries
D. 12-Volt Starting System With Four 12-Volt Batteries
E. 24-Volt Starting System With Four 12-Volt Batteries

Fig. 11, Starting Circuit Overlays



A. Ammeter Circuits Without Inline Fuses

B. Ammeter Circuits With Inline Fuses

Fig. 12, Ammeter Circuit Overlays

Circuits 1 through 47E

Circuit	Gauge	From	To
1	00	6V Battery (– Terminal)	12V Starter (Ground Terminal)
1	00	6V Battery (– Terminal)	24V Starter (Ground Terminal)
1	000	12V Battery (– Terminal)	12V Starter (Ground Terminal) (3-Battery System)
1	00	12V Battery (– Terminal)	12V Starter (Ground Terminal) (4-Battery System)
1	00	12V Battery (– Terminal)	24V Starter (Ground Terminal)
1	00	12V Battery (– Terminal)	Chassis Ground Stud (Air Starter)
2	00	6V Battery (+ Terminal)	6V Battery (– Terminal)
3	00	6V Battery (– Terminal)	Series-Parallel Switch (Terminal 1) (24V Starter)
3	00	12V Battery (– Terminal) (of 24V Battery Set)	Series-Parallel Switch (Terminal 1) (24V Starter)
3	00	12V Battery (– Terminal) (of 24V Battery Set)	12V Battery (+ Terminal) (of 12V Battery Set)
3	00	12V Battery (– Terminal)	12V Battery (+ Terminal) (T-R System)
5	00	6V Battery (+ Terminal)	Series-Parallel Switch (Terminal 2) (24V Starter)
5	00	12V Battery (+ Terminal) (of 24V Battery Set)	Series-Parallel Switch (Terminal 2) (24V Starter)
5	00	12V Battery (+ Terminal) (of 12V Battery Set)	12V Power Stud (T-R System)
5	—	12V Tap (24V Starter)	

Specifications

Circuit	Gauge	From	To
6	00	6V Battery (+ Terminal)	12V Starter (Battery Terminal)
6	00	6V Battery (+ Terminal)	24V Starter (Battery Terminal)
6	000	12V Battery (+ Terminal)	12V Starter (Battery Terminal) (3-Battery System)
6	00	12V Battery (+ Terminal)	12V Starter (Battery Terminal) (4-Battery System)
6	00	12V Battery (+ Terminal)	24V Starter (Battery Terminal)
6A	00	Starter (Battery Terminal)	Remote Jump Start Stud
7	00	Starter (Ground Terminal)	Chassis Ground Stud (12V or 24V Starter)
8	8	Starter (Battery Terminal)	Series-Parallel Switch (Terminal 5) (24V Starter)
9	10	Starter (Solenoid Switch Terminal)	Series-Parallel Switch (Terminal 4) (24V Starter)
13	10	Series-Parallel Switch (Terminal 6)	Ground Stud
14	2–No. 8	Starter (Battery Terminal)	Cab/Chassis Junction Block (12V Starter)
14	2–No. 8	Series-Parallel Switch (Terminal 2)	Cab/Chassis Junction Block (24V Starter)
14	2–No. 8	Battery (+ Terminal)	Cab/Chassis Junction Block (Air Starter)
14	2–No. 8	Cab/Chassis Junction Block	Bus Bar
14	—	Main Cab Feed	
14A	2–No. 8	Ignition-Controlled Magnetic Switch	Isolated Bus Bar
15	12	Start Button	Cab/Chassis Connector
15	12	Cab/Chassis Connector	Magnetic Switch (12V Starter)
15	12	Cab/Chassis Connector	Series-Parallel Switch (Terminal 7)
15	—	Starter Solenoid Coil Feed	
15A	12	Ignition Switch (Coil Terminal)	Start Button
15A	—	Start Button Switch Feed	
15B	14	Remote Control Junction Block	Remote Control Relay (Coil Terminal)
15C	14	Start Button (Cab)	Start Button (Sleeper Box)
15C	14	Start Button (Sleeper Box)	On/Off Switch (Sleeper Box)
15C	14	Start Button (Sleeper Box)	Transmission Neutral Switch
15D	14	Start Button (Cab)	Transmission Neutral Switch
15D	14	Transmission Neutral Switch	Starter Magnetic Switch
16	6	Alternator (Output Terminal)	12V Starter (Battery Terminal)
16	6	Alternator (Output Terminal)	Series-Parallel Switch (Terminal 2) (24V Starter)
16	6	Alternator (Output Terminal)	Battery (+ Terminal) (Air Starter)
16	6	Alternator (Output Terminal)	Ammeter Shunt (12V and 24V Starter)
16	6	Ammeter Shunt	12V Starter (Battery Terminal)
16	6	Ammeter Shunt	Series-Parallel Switch (Terminal 2) (24V Starter)
16	6	Ammeter Shunt	Battery (+ Terminal) (Air Starter)
16	—	Alternator Output	
16A	14	Ammeter Shunt (Alternator Output Side)	15 Amp Inline Fuse (COE)

Specifications

Circuit	Gauge	From	To
16A	14	15 Amp Inline Fuse	Ammeter Gauge (COE)
16A	16	15 Amp Inline Fuse	Ammeter Gauge (Conv)
16A	16	Ammeter Shunt (Alternator Output Side)	15 Amp Inline Fuse (Conv)
16B	14	Ammeter Shunt (Battery Side)	15 Amp Inline Fuse (COE)
16B	14	15 Amp Inline Fuse	Ammeter Gauge (COE)
16B	14	Ammeter Shunt (Series-Parallel Switch Side)	15 Amp Inline Fuse (COE)
16B	16	Ammeter Shunt (Battery Side)	15 Amp Inline Fuse (Conv)
16B	16	15 Amp Inline Fuse	Ammeter Gauge (Conv)
16B	16	Ammeter Shunt (Series-Parallel Switch Side)	15 Amp Inline Fuse (Conv)
16C	6	Auxiliary Battery Charge Circuit	Isolator Unit/Relay
16E	6	Isolator (12V Terminal)	Cab Power Stud
16F	6	Isolator (24V Terminal)	24V Starter (Terminal B)
18	12	Ignition Switch (Coil Terminal)	10 Amp Circuit Breaker
18A	16	10 Amp Circuit Breaker (Ignition-Controlled)	Lightbar (Pin D1)
18A	16	10 Amp Circuit Breaker	Buzzer/Quad-Diode
18B	16	Lightbar (Pin C14)	Low-Air-Pressure Sensor (Primary)
18B	16	Warning Light, Low-Air-Pressure	Buzzer/Quad-Diode
18B	16	Low-Air-Pressure Sensor (Primary)	Low-Air-Pressure Sensor (Secondary)
18B	16	Buzzer/Quad-Diode	Low-Air-Pressure Sensor
18B	—	Low-Air-Pressure Indicator Feed	
18C	16	Warning Light, High-Coolant-Temperature	Buzzer/Quad-Diode
18C	16	Lightbar (Pin C1)	Coolant Temperature Sensor
18C	16	Buzzer/Quad-Diode	Coolant Temperature Sensor
18C	—	High-Coolant-Temperature Indicator Feed	
18CA	14	Alarmstat Engine Temperature Switch	Circuit Breaker (Ignition-Controlled)
18CB	14/16	High-Coolant-Temperature Switch	High-Coolant-Temperature Warning Relay Signal
18D	16	Circuit Breaker (Ignition-Controlled)	Event Stylus (Argo Graph High-Coolant-Temperature)
18E	16	Murphy Switch Gauge	Buzzer/Quad-Diode
18F	16	Murphy Switch Gauge	Diode
18F	16	Diode	Control Module (Terminal S)
18G	12	Ignition Switch (Acc. Terminal)	10 Amp Circuit Breaker
19A	16	10 Amp Circuit Breaker	Voltmeter
19A	—	Voltmeter Feed	
20	14	15 Amp Circuit Breaker	Headlight (Taillight) Switch (Left Side)
20	14	Headlight Switch	Fog Light Switch (Canada)
20	—	Headlight Relay Coil Feed	

Specifications

Circuit	Gauge	From	To
20	—	Left Headlight Switch Supply	
20A	—	Headlight Relay	Power
20A	—	Right Headlight Switch Supply	
20A	14	Headlight Switch	Fog Light Switch (Canada)
20A	14	15 Amp Circuit Breaker	Headlight (Taillight) Switch (Right Side)
20L	14	Headlight (Taillight) Switch	Circuit 23D Splice
20L	14	Circuit 23D Splice	Left Headlight High/Low Relay (Terminal 30)
20L	—	Left Headlight Relay Feed	
20R	—	Right Headlight Relay Feed	
20R	14	Headlight (Taillight) Switch	Circuit 29D Splice
20R	14	Circuit 29D Splice	Right Headlight High/Low Relay (Terminal 30)
21	14	Left Headlight High/Low Relay (Terminal 87)	Circuit 21B Splice
21	14	Circuit 21B Splice	Left Headlight (High Beam)
21	—	Left Headlight (High Beam)	
21B	14	Circuit 21 Splice	High-Beam Indicator Light
21B	14	Left Headlight High/Low Relay (Terminal 87)	Lightbar (Pin C16)
21B	—	High-Beam Indicator Feed	
21D	14	Right Headlight High/Low Relay (Terminal 87)	Right Headlight (High Beam)
21D	14	Daytime Running Light Module	Right Headlight (High Beam)
21D	—	Right Headlight (High Beam)	
21H	16	Auxiliary High-Beam Flash Switch	High-Beam Flash Signal
22	14	Left Headlight High/Low Relay (Terminal 87A)	Left Headlight (Low Beam)
22	—	Left Headlight (Low Beam)	
22D	14	Right Headlight High/Low Relay (Terminal 87A)	Right Headlight (Low Beam)
22D	—	Right Headlight (Low Beam)	
23	10	30 Amp Circuit Breaker	Trailer Taillight Relay (Terminal 30)
23	10	Trailer Taillight Relay (Terminal 87)	7-Way Junction Block
23	—	Trailer Marker and Taillight Feed	
23A	—	Vehicle Taillight Feed	
23A	14	15 Amp Circuit Breaker	Tractor Marker/Taillight Relay (Terminal 87)
23A	14	Tractor Marker/Taillight Relay (Terminal 30)	Circuits 23T and 46 Splice
23A	14	Circuits 23T and 46 Splice	Tractor Taillights
23C	14	Taillight	License Plate Light
23D	—	Tractor Marker Light Control	
23D	14	Circuit 20L Splice	Tractor Marker/Taillight Relay (Terminal 85)
23D	14	Tractor Marker/Taillight Relay (Terminal 86)	Interrupt Switch
23F	14	Headlight (Taillight) Switch	Tractor Marker/Taillight Relay (Terminal 87A)

Circuit	Gauge	From	To
23F	14	Headlight Switch	Fog Light Switch (Canada)
23F	—	Tractor Marker Light Relay	
23T	—	Trailer Taillight Control	
23T	14	Circuits 23A and 46 Splice	Trailer Taillight Relay (Terminal 85)
23U	16	Marker Light Flash Switch	Marker Light Flash Signal
24	14	15 Amp Circuit Breaker	Horn Relay (Terminal 30)
24	14	15 Amp Circuit Breaker	Horn Relay (Terminal 85)
25	14	Horn Relay (Terminal 86)	Horn Button
25	—	Horn Button Feed	
26	—	Horn Feed	
26	14	Horn Relay (Terminal 87)	Horn
27	12	Right Fog Light Switch	Left Fog Light Switch
27	12	Left Fog Light Switch	Cab/Chassis Connector
27	12	Circuit 28 Splice	Cab/Chassis Connector
27	14	Cab/Chassis Connector	Right Fog Light
27	12	Circuit 28 Splice	Left Fog Light
27	14	Cab/Chassis Connector	Left Fog Light
27A	12	Circuit Breaker	Left Fog Light Switch
27A	12	Left Fog Light Switch	Left Fog Light
27B	12	Left Fog Light Switch	Left Inboard Fog Light Switch
27B	12	Left Inboard Fog Light Switch	Left Inboard Fog Light
Roadlights, Only with Low-Beam Headlights (Circuits 27C through 27E)			
27C	12	20 Amp Circuit Breaker	Fog Light Relay (Terminal 30)
27D	14	Fog Light Toggle Switch	Fog Light Relay (Terminal 85)
27E	14	Left Headlight Relay	Fog Light Toggle Switch
27E	14	Additional Fog Light Power	Switch/Relay
28	—	Fog Light Feed	
28	12	Fog Light Relay (Terminal 87)	Circuit 28 Splice
28	12	Circuit 28 Splice	Right Fog Light
28	12	Circuit Breaker	Right Fog Light Switch
28	12	Right Fog Light Switch	Cab/Chassis Connector
28	14	Cab/Chassis Connector	Right Fog Light
28	12	Fog Light Relay (Terminal 87)	Circuit 27 Splice (U.S.A.)
28	12	Circuit 27 Splice	Cab/Chassis Connector
28	14	Cab/Chassis Connector	Left Fog Light

Specifications

Circuit	Gauge	From	To
28	12	Fog Light Circuit Breaker	Fog Light Switch (Canada)
28	12	Fog Light Switch	Circuit 27 Splice (Canada)
28A	12	Right Fog Light Switch	Right Inboard Fog Light Switch
28A	12	Right Inboard Fog Light Switch	Right Inboard Fog Light
28B	12	High-Beam Relay (Coil Terminal)	Fog Light Relay (Coil Terminal)
28C	14	Fog Light Relay (Terminal 86)	Fog Light Switch (U.S.A.)
28C	14	Fog Light Switch	Left Headlight Relay (Terminal 87A) (U.S.A.)
28C	14	Driving Light Relay Signal	Switch
28D	12	Fog Light Circuit Breaker	Fog Light Relay (Terminal 30) (U.S.A.)
28D	14	Driving Light Relay Supply	Fuse/Breaker
28E	14	Driving Light Switch Supply	Low Beam Light/Taillight
28G	14	Rear Fog Light Relay Signal	Switch
28H	14	Rear Fog Light Power	Switch/Relay
29	14	15 Amp Circuit Breaker	Panel Light Relay (Terminal 87)
29	14	Panel Light Relay (Terminal 30)	Circuit 46T Splice
29	14	Circuit 46T Splice	Panel Light Rheostat
29	—	Instrument Light Switch Feed	
29A	16	Panel Light Rheostat	Panel Lights
29A	—	Instrument Light Feed	
29B	14	Circuit 29 at Panel Light Switch	Auxiliary Panel Light Switch
29D	14	Circuit 20R Splice	Panel Light Relay (Terminal 85)
29D	14	Panel Light Relay (Terminal 86)	Interrupt Switch
29D	—	Light Control Panel	
29F	—	Panel Light Relay (N.C.)	
29F	14	Panel Light Relay (Terminal 87A)	Headlight (Taillight) Switch
29F	14	Headlight Switch	Fog Light Switch (Canada)
29G	14	Warning Buzzer Power, Lights On	Door Switch/Relay/Light/Ignition
29H	14	Warning Signal, Lights On and Ignition On	Switch/Relay
30	16	Main Transmission Oil Temperature Gauge	Cab/Chassis Connector
30	14	Cab/Chassis Connector	Main Transmission Oil Temperature Sensor
30	—	Main Transmission Oil Temperature Gauge Feed	
31	16	Auxiliary Transmission Oil Temperature Gauge	Cab/Chassis Connector
31	14	Cab/Chassis Connector	Auxiliary Transmission Oil Temperature Sensor
32	14	20 Amp Circuit Breaker	Right Auxiliary Heater Switches
32A	14	Right Auxiliary Heater Switch No. 1	Right Auxiliary Heater (High)
32B	14	Right Auxiliary Heater Switch No. 1	Right Auxiliary Heater (Low)
32C	14	Right Auxiliary Heater Switch No. 2	Right Auxiliary Heater (High)

Specifications

Circuit	Gauge	From	To
32D	14	Right Auxiliary Heater Switch No. 2	Right Auxiliary Heater (Low)
33	14	20 Amp Circuit Breaker	Heater Switch
33A	14	Heater Switch (Terminal H)	Resistor (Terminal 1)
33A	14	Resistor (Terminal 1)	Heater Motor (High)
33B	16	Heater Switch (Terminal L)	Resistor (Terminal 2)
33B	16	Resistor (Terminal 2)	Heater Motor (Low)
33C	16	Heater Switch (Terminal M)	Resistor (Terminal 3)
33C	16	Resistor (Terminal 3)	Heater Motor (Medium)
34	16	Warning Light, Low Oil Pressure	Low-Oil-Pressure Sensor
34	16	Buzzer/Quad-Diode	Low-Oil-Pressure Sensor
34	16	Lightbar, Pin C4	Low-Oil-Pressure Sensor
34	—	Low-Oil-Pressure Indicator Feed	
34A	16	Buzzer/Quad-Diode	High-Oil-Pressure Switch
34A	16	High-Oil-Pressure Switch	Graph
34B	14	Indicator Light, Oil Pressure	High/Low-Oil-Pres. Switch (Cummins Big Cam III Engine)
34C	—	See Circuit 18E	
34D	—	See Circuit 18F	
35	16	Temperature Gauge (Engine Oil)	Engine Oil Temperature Sensor
35	—	Engine Oil Temperature Gauge Feed	
36	12	25 Amp Circuit Breaker	Stoplight Switch or Stoplight Relay
36	—	Stoplight Switch Feed	
36A	14	Stoplight Switch	Stoplights (End of Frame)
36B	12	Stoplight Switch	7-Way Junction Block
36B	—	Trailer Stoplight Feed	
36C	—	Turn Signal Stoplight Switch Feed	
36C	12	Stoplight Switch	Turn Signal Switch
36D	12	Stoplight Switch	Stoplights (Back of Cab)
36E	12	Stoplight Relay	Stoplights
36F	12	Spring Brake Stoplight Switch	Stoplight Relay (Coil Side) or Parking Brake Indicator Light
36G	14	Pressure Switch (Retarder Control Valve)	Stoplight Relay (Coil Terminal)
36H	16	VIGIL Flasher Override	Stoplight Switch
36H	16	Lightbar 4-Way-Flasher Override	Stoplight Switch
37	12	20 Amp Circuit Breaker	Turn Signal Switch (Brown Wire)
37	16	20 Amp Circuit Breaker	Flasher Relay (Terminal 85)
37	12	20 Amp Circuit Breaker	Flasher Relay (Terminal 30)

Specifications

Circuit	Gauge	From	To
37A	14	Turn Signal Flasher (Yellow Wire)	Remote Flasher Switch
38	14	Turn Signal Switch	7-Way Junction Block
38	—	Left-Turn Signal Light Feed	
38A	14	Turn Signal Switch	Left-Turn Signal Light (Amber) (End of Frame)
38B	12	Turn Signal Switch	Cab/Chassis Connector
38B	12	Cab/Chassis Connector	Left-Turn Signal Light (End of Frame)
38B	—	Left Stoplight and Turn Signal Feed	
38B	—	Trailer Stoplight Feed	
38C	14	Turn Signal Switch	Left-Turn Signal Light (Back of Cab)
39	14	Turn Signal Switch	7-Way Junction Block
39	—	Right-Turn Signal Light Feed (Trailer)	
39A	14	Turn Signal Switch	Right-Turn Signal Light (Back of Cab)
39B	12	Turn Signal Switch	Cab/Chassis Connector
39B	14	Cab/Chassis Connector	Right-Turn Signal Light (End of Frame)
39B	—	Right Stoplight and Turn Signal Feed	
39C	14	Turn Signal Switch	Right-Turn Signal Light (Amber) (End of Frame)
40	14	Circuit Breaker	Windshield Fan Switches
40A	14	Windshield Fan Switch	Left Windshield Fan (Low)
40B	14	Windshield Fan Switch	Left Windshield Fan (High)
40C	14	Windshield Fan Switch	Right Windshield Fan (Low)
40D	14	Windshield Fan Switch	Right Windshield Fan (High)
40E	14	Circuit Breaker	Windshield Fans Relay
40E	16	Windshield Fans Relay	Windshield Fan Switches
40F	14	Sleeper Box Fan Switch	Sleeper Box Fan
41	14	15 Amp Circuit Breaker	Cab Dome Light Switch
41	14	Cab Dome Light Switch	Cab Dome Light
41	—	Cab Dome Light Switch Feed	
41A	14	Circuit 41 Splice	Bunk Dome Light
41A	14	Bunk/Sleeper Dome Light Switch Power	Fuse/Breaker
41B	14	Circuit 41 Splice	Passenger Dome Light Switch
41B	14	Passenger Dome Light Switch	Passenger Dome Light
41C	16	Circuit 41 Splice	Driver Auxiliary Dome Light
41D	14	Circuit 41 Splice	Passenger Auxiliary Dome Light
41E	14	Circuit Breaker	3-Way Domelight Switch
41F	14	3-Way Dash Switch	Sleeper Box 3-Way Switch
41G	14	Sleeper Box 3-Way Switch	3-Way Dash Switch
41H	14	Sleeper Dome Light Power	Switch

Circuit	Gauge	From	To
41J	14	Sleeper Reading Light Power	Switch
41K	14	Upper Sleeper Flourescent Light Power	Switch
41L	14	Lower Sleeper Flourescent Light Power	Switch
42	16	Forward-Rear-Axle Oil Temperature Gauge	Cab/Chassis Connector
42	14	Cab/Chassis Connector	Forward-Rear-Axle Oil Temperature Sensor
42	—	Forward-Rear-Axle Oil Temperature Gauge Feed	
43	—	Rear-Axle Oil Temperature Gauge Feed	
43	16	Rearmost-Axle Oil Temperature Gauge	Cab/Chassis Connector
43	14	Cab/Chassis Connector	Rearmost-Axle Oil Temperature Sensor
44	14/16	Axle Oil Temperature Sensor	Center-Rear-Axle Oil Temperature Gauge (Signal)
45	12	Circuit Breaker	Trailer Circuit Auxiliary Switch
45	—	Auxiliary Trailer Feed	
45A	12	Trailer Circuit Auxiliary Switch	Trailer Receptacle (Auxiliary Circuit)
45A	12	Trailer Circuit Auxiliary Switch	Indicator Light (Auxiliary Circuit)
45B	14	Circuit Breaker	Trailer Circuit Auxiliary Switch
45C	14	Circuit Breaker	Trailer Circuit Auxiliary Relay (Terminal 30)
46	14	Circuits 23A and 23T Splice	Cab Marker and Identification Lights
46	—	Cab Marker Light Feed	
46A	10	30 Amp Circuit Breaker	Trailer Marker Lights Relay (Terminal 30)
46A	10	Trailer Marker Lights Relay (Terminal 87)	7-Way Junction Block
46E	14	Circuit 46 Splice	Left Side Marker Light (Cab)
46E	—	Left Side Marker Light Feed	
46F	14	Circuit 46 Splice	Right Side Marker Light (Cab)
46T	14	Circuit 29 Splice	Trailer Marker Lights Relay (Terminal 85)
47	16	Fuel Level Gauge	Cab/Chassis Connector
47	14	Cab/Chassis Connector	Fuel Level Sensor
47	—	Fuel Level Gauge Feed	
47A	14/16	Right Fuel Level Gauge	Right Fuel Level Sensor
47B	16	Combination Left and Right Fuel Gauge	Right and Left Selector Switch
47C	14/16	Low-Fuel-Level Sensor/Relay	Low-Fuel-Level Light
47C	14/16	Low-Fuel-Level Sensor	Low-Fuel-Level Relay Signal
47E	14	Fuel Level Sensor Power	Ignition Fuse/Circuit Breaker

Circuits 52 through 91H

Circuit	Gauge	From	To
52	12	20 Amp Circuit Breaker	Ignition Switch (Battery Terminal)

Specifications

Circuit	Gauge	From	To
52	—	Ignition Switch Feed (Battery)	
52B	14	Circuit Breaker	Engine Remote Control Switch
52C	10/12	Starter Batteries	Ignition Switch Breaker Power (Isolated)
54	16	Panel Light Rheostat	Speedograph and Tachograph
55	16	Circuit Breaker	Speedograph and Tachograph
57	14	15 Amp Circuit Breaker	Cigarette Lighter (Cab)
57	—	Cigarette Lighter Feed	
57A	14	12V Power Receptacle (Right Sleeper Bunk)	Circuit Breaker
57B	14	12V Power Receptacle (Right Sleeper Shelf)	Circuit Breaker
57S	14	15 Amp Circuit Breaker	Cigarette Lighter (Sleeper Box)
58	12	20 Amp Circuit Breaker	Left Auxiliary Heater Switch
58A	12	Left Auxiliary Heater Switch No. 1	Left Auxiliary Heater No. 1 (High)
58B	12	Left Auxiliary Heater Switch No. 1	Left Auxiliary Heater No. 1 (Low)
58C	12	Left Auxiliary Heater Switch No. 2	Left Auxiliary Heater No. 2 (High)
58D	12	Left Auxiliary Heater Switch No. 2	Left Auxiliary Heater No. 2 (Low)
60	14	Turn Signal Switch	Front Left-Turn Signal Light
60	—	Front Left-Turn Signal Light Feed	
60A	—	Left-Turn Signal Indicator Feed	
60A	14	Turn Signal Switch	Left-Turn Indicator Lamp
60A	16	Left-Turn Signal Switch	Lightbar (Pin C5)
60B	14	Left-Turn Signal Indicator Light	Remote Switch
60B	14	Front Left-Turn Signal Light	Remote Switch
60B	14	Trailer Left-Turn Signal Light	Remote Switch
60C	14	Rear Left-Turn Signal Light	Remote Flasher Switch
60D	14	Left- and Right-Turn Signal Alarm	Turn Signal Circuit Diodes
61	14	Turn Signal Switch	Front Right-Turn Signal Light
61	—	Front Right-Turn Signal Light Feed	
61A	16	Right-Turn Signal Switch	Right-Turn Indicator Lamp
61A	16	Right-Turn Signal Switch	Lightbar (Pin C15)
61B	14	Right-Turn Signal Indicator Light	Remote Switch
61B	14	Front Right-Turn Signal Light	Remote Switch
61B	14	Trailer Right-Turn Signal Light	Remote Switch
61B	—	Right-Turn Signal Indicator Feed	
61C	14	Rear Right-Turn Signal Light	Remote Flasher Switch
61D	14	Turn Signal Switch	Alarm (Right-Turn)
71	14	10 Amp Circuit Breaker	Ignition-Controlled Relays
71	—	Heater-A/C Control; High/Low Relay Control	

Circuit	Gauge	From	To
71	14	Circuit Breaker (Ignition-Controlled)	Alternator Excitation Circuit
71A	12	Ignition Switch (Acc. Terminal)	Relay (Coil Terminal) (Radio)
73	14	Circuit Breaker	Utility Light Switch
73A	14	Utility Light Switch	Indicator Light, Utility Light
73A	16	Utility Light Switch	Lightbar (Option Pin)
73B	14	Utility Light Switch	Utility Light
Fire Truck Flood Lamps (Circuits 73C through 73F)			
73C	12	25 Amp Circuit Breaker	Floodlight Switch
73C	12	Floodlight Switch	7-Way Junction Block
73D	12	Floodlight Switch	Panel Indicator Light
73E	14	15 Amp Circuit Breaker (Utility Lamp)	Utility Lamp Relay (Terminal 30)
73F	14	Circuit Breaker (Worklight, Military Vehicle)	Portable Worklight Receptacle
74	8	Starter Solenoid	Starter Magnetic Switch
74	—	Starter Solenoid Feed	
75	—	Starter Thermo Switch Feed	
75	14	Starter Magnetic Switch	Ground Stud
76	14	Mirror Heat Switch	Left Mirror Heat (High)
76	—	Left Heated Mirror Feed	
76A	14	Mirror Heat Switch	Left Mirror Heat (Low)
77	14	Mirror Heat Switch	Right Mirror Heat (High)
77	—	Right Heated Mirror Feed	
77A	14	Mirror Heat Switch	Right Mirror Heat (Low)
78	14	Circuit Breaker	Spotlight
78A	14	Spotlight Switch	Indicator Light, Spotlight
80	14	15 Amp Circuit Breaker	Mirror Heat Switch
80	—	Heated Mirror Switch Feed	
80A	14	Mirror Heat Switch	Indicator Light, Mirror Heat
80A	16	Mirror Heat Switch	Lightbar (Option Pin)
80A	—	Heated Mirror Indicator Feed	
80B	14	Mirror-Heater Timer Module, Power	Switch
80C	14	Mirror-Heater Timer Module, Signal	Relay/Switch
81C	—	Instrument Feed	
81C	16	10 Amp Circuit Breaker	Gauges and Indicator Lights
82	8	Starter (Battery Terminal)	Starter Magnetic Switch
82	—	Starter Control, Solenoid Feed	

Specifications

Circuit	Gauge	From	To
83	6	Alternator (Ground Terminal)	Starter (Ground Terminal)
84	14	Heat/Start Switch	Glo-Plug Solenoid (CAT Engine)
85	10	Starter (Battery Terminal) or Series-Parallel Switch	Glo-Plug Solenoid (CAT Engine)
86	14	Ignition Switch	Eaton Lockout Switch
87	16	Indicator Light, Interaxle	Cab/Chassis Connector
87	16	Cab/Chassis Connector	Interaxle Sensor
87	16	Lightbar (Option Pin)	Interaxle Sensor
87	14	Alarm, Buzzer	High-Range Warning Switch
87	16	Circuit Breaker (Ignition-Controlled)	Interaxle Sensor
87	16	Interaxle Switch	Indicator Light, Interaxle Lock
87	—	Indicator Light, Interaxle	
87A	16	Axle Lock Switch/Warning Buzzer	Ignition Fuse/Circuit-Breaker
87A	16	Ignition Fuse/Circuit-Breaker	Axle Lock Switch/Buzzer/Light Power
87B	14/16	Axle Lock No. 1 Switch	Indicator Light, Controlled Traction No. 1
87B	16	Traction Lock Switch	Indicator Light, Traction Lock No. 1
87C	16	Controlled Traction Switch	Indicator Light, Controlled Traction No. 1
87C	16	Traction Lock Switch	Indicator Light, Traction Lock No. 2
87D	14/16	Controlled Traction Switch	Indicator Light, Controlled Traction No. 2
87D	16	Traction Lock Switch	Indicator Light, Traction Lock No. 3
87E	14/16	Axle Lock No. 3 Switch	Indicator Light, Controlled Traction No. 3
87F	16	Automatic-Axle-Disengage Signal	Transmission-Activated Relay
88	14	Stoplight Switch	Multi-Luber Air Switch
88	16	Switch/Module Ignition Power	Ignition Fuse/Circuit-Breaker
88A	14	Multi-Luber Air Switch	Multi-Luber Connector
88A	16	Solenoid Valve Power, Auto-Luber	Switch/Module
88B	16	Switch/Module Constant Power	Fuse/Circuit-Breaker
90	14	15 Amp Circuit Breaker	Sander Switch
90A	14	Sander Switch	Sanders
90A	16	Sander Switch	Indicator Light, Sanders
91	14	Circuit Breaker	Engine Coolant Heater Switch
91	14	Engine Coolant Heater Switch	Engine Coolant Heater
91A	14	Engine Coolant Heater Switch	Indicator Light, Coolant Heater
91B	14	Block Heater Element (220 Volt)	16 Volt Transformer (Primary)
91C	14	16 Volt Transformer (Secondary)	Indicator Light, Block Heater
91D	14	Engine Coolant Heater Control Signal	Output Signal Switch
91E	14	Engine Coolant Heater Switch	Engine Coolant Heater
91F	14/16	Indicator Light Switch	Engine Coolant Heater Light

Circuit	Gauge	From	To
91G	14/16	Cab Fan Signal	Heater Unit
91H	10	Water Heater 12-Volt Supply	Battery (+ Terminal)

Circuits 94 Through 149C

Circuit	Gauge	From	To
Air Drier Heaters (Circuits 94 through 94B)			
94	14	Circuit Breaker	Purge Valve Heater Switch
94A	14	Purge Valve Heater Switch	Purge Valve Heater
94A	16	Purge Valve Heater Switch	Indicator Light, Purge Valve Heater
94B	16	Circuit Breaker	Electronic Module (Drain Valve)
94B	16	Electronic Module (Drain Valve)	Drain Valve (Racor)
Anchorlok Aftercooler (Circuit 94C)			
94C	14	10 Amp Circuit Breaker	Ignition-Controlled Relay (Terminal 30)
94C	14	Ignition-Controlled Relay (Terminal 87)	Air Drier/Heater
95	16	Radio (Left Front Speaker Power)	Left Front Speaker (+ Terminal)
95A	16	Radio (Right Front Speaker Power)	Right Front Speaker (+ Terminal)
95C	16	Radio or Fader (Left Rear Speaker Power)	Left Rear Speaker (+ Terminal)
95D	16	Radio or Fader (Right Rear Speaker Power)	Right Rear Speaker (+ Terminal)
95E	16	Cab Speaker Wiring (Left Side)	Sleeper Box Speaker Wiring (Left Side)
95F	16	Cab Speaker Wiring (Right Side)	Sleeper Box Speaker Wiring (Right Side)
95G	16	Radio Speaker Ground	All Speakers (– Terminal)
For Floating-Ground Speakers Only (Circuits 95J through 95M)			
95J	16	Radio Ground (Left Front Speaker)	Left Front Speaker (– Terminal)
95K	16	Radio Ground (Right Front Speaker)	Right Front Speaker (– Terminal)
95L	16	Radio Ground (Left Rear Speaker)	Left Rear Speaker (– Terminal)
95M	16	Radio Ground (Right Rear Speaker)	Right Rear Speaker (– Terminal)
Front Series-Connected Speakers (Circuits 95N and 95P)			
95N	16	Left First Speaker (– Terminal)	Left Second Speaker (+ Terminal)
95P	16	Right First Speaker (– Terminal)	Right Second Speaker (+ Terminal)
96	16	Circuit Breaker	Low-Oil-Level Indicator
Perry Low-Water-Level Alarm (Circuits 97 through 97C)			

Specifications

Circuit	Gauge	From	To
97	14	Circuit Breaker	Control Module (Brown Wire)
97A	16	Warning Light	Control Module (Red Wire)
97B	14	Start Button (Starter Side)	Control Module (Blue Wire)
97C	14	Low-Water-Level Sensor	Control Module (Yellow Wire)
98	12	20 Amp Circuit Breaker	Heater-A/C Relay (Terminal 30)
98	12	Heater-A/C Relay (Terminal 87)	Heater-A/C Fan Switch
98	12	Heater-A/C Jumper Switch	Heater-A/C Switch
98	12	30 Amp Circuit Breaker	Heater-A/C Relay (Terminal 30)
98	12	30 Amp Circuit Breaker	Heater-A/C High-Speed Relay (Terminal 87)
98	—	Heater-A/C Feed	
98A	—	Sleeper Box Heater-A/C Thermostat	Sleeper Box Heater-A/C Relay (Terminal 85)
98A	—	A/C Compressor Clutch and Receiver-Drier Feed	
98A	14	15 Amp Circuit Breaker	A/C Clutch Relay (Terminal 30)
98A	14	A/C Clutch Relay (Terminal 87)	Low-Refrigerant-Pressure Switch
98A	14	Low-Refrigerant-Pressure Switch	A/C Clutch
98B	14	Low-Refrigerant-Pressure Switch	Shutter Solenoid Valve
98D	12	Cab Heater-A/C Switch	Low-Speed Resistor
98D	—	Heater-A/C Fan Switch (Low-Speed)	
98E	12	Heater-A/C Fan Switch	Medium-Speed Resistor
98E	—	Heater-A/C Fan Switch Feed (Medium-Speed)	
98E	—	Heater-A/C Fan Motor (Medium-1)	
98F	—	Heater-A/C Fan Motor (High-Speed)	
98F	12	Heater-A/C Relay (Terminal 87)	Sleeper Box Fan Motor
98F	12	High-Speed Switch	Auxiliary Heater-A/C Fan Motor (Orange Wire)
98F	—	Heater-A/C Fan Motor (Medium-2)	
98F	12	Heater-A/C Fan Switch	Medium/High-Speed Resistor
98F	12	High-Speed Resistor	Heater-A/C Fan Motor
98F	12	Heater-A/C Control Box Relay (Terminal 7)	Heater-A/C Fan Motor (Sleeper Box)
98G	12	Auxiliary Control Panel Relay	Low-Speed Switch
98G	12	Low-Speed Switch	Auxiliary Heater-A/C Fan Motor (Red Wire)
98H	12	Heater-A/C Relay (Terminal 87A)	Refrigerant Solenoid Valve (Sleeper Box)
98H	14	Heater-A/C Control Box Relay (Terminal 9)	Refrigerant Solenoid Valve (Sleeper Box)
98L	12	Heater-A/C Fan Switch	High-Speed Resistor
98L	12	High-Speed Resistor	Heater-A/C Fan Motor
98L	12	Heater-A/C Switch	High-Speed Heater Relay (Terminal 85)
98L	—	High-Speed Fan Relay Control	

Specifications

Circuit	Gauge	From	To
98M	10	A/C Relay	Roof-Mounted A/C
98P	10	A/C Circuit Breaker	Roof-Mounted A/C Relay
98R	12	Output Terminal Resistor	High-Speed Heater-A/C Relay (Terminal 87)
98R	—	High-Speed Fan Relay	
98S	12	Booster Fan Switch	Booster Fan Motor (Sleeper Box)
98S	12	20 Amp Circuit Breaker	Heater-A/C Relay (Sleeper Box)
98S	12	Heater-A/C Relay (Terminal 87)	Sleeper Heater-A/C Relay (Terminal 30)
98S	12	Booster Fan Relay (Terminal 87)	Booster Fan On/Off Switch
98S	12	Heater-A/C Relay (Terminal 87)	Sleeper Box Heater-A/C
98S	12	20 Amp Circuit Breaker	Booster Fan Relay (Terminal 30)
98S	12	Booster Fan On/Off Switch	Booster Fan Motor
98T	10	Heater-A/C Relay (Terminal 30)	Heater-A/C Fan Motor
98T	—	Heater-A/C Fan Motor	
98Y	—	Heater-A/C Fan Motor, Low Speed	
98Y	14	Cab A/C Fan Switch	Low-Speed Resistor
98Z	12	Heater-A/C On/Off Switch	Thermostat Switch
98Z	12	Thermostat Switch	A/C Clutch Relay (Terminal 85)
98Z	12	Heater-A/C On/Off Switch	Heater-A/C Fan Switch
98Z	—	A/C Clutch Control; Shutter Control	
99	—	Fuel Solenoid Feed	
99	12	Ignition Switch (Coil Terminal)	Engine Shutdown Solenoid
99A	12	Ignition Switch (Battery Terminal)	Relay (Contact Terminal)
99A	12	Relay (Contact Terminal)	Engine Shutdown Solenoid
99B	12	Ignition Switch (Auxiliary Terminal)	On/Off Switch (Sleeper Box)
99C	12	Ignition Switch (Coil Terminal)	Start Button (Sleeper Box)
99D	14	Circuit Breaker (Ignition-Controlled)	Anti-Theft Switch
99D	14	Anti-Theft Switch	Second Fuel Solenoid Valve
99E	14	Ignition Switch (Coil Terminal)	Engine-Shutdown Module, or Relay (Terminal 30)
99F	12	Ignition-Power Relay (Terminal 86)	Auxiliary Stop Button
101	12	Bus Bar	Alternator Sensing Relay
102	16	Circuit Breaker	Parking Light Switch
102A	16	Parking Light Switch	Left Parking Light
103	16	Parking Light Switch	Right Parking Light
108	14	Circuit Breaker	Courtesy Light Switch
108A	14	Circuit Breaker	Left Door Switch
108B	14	Left Door Switch	Dome Light
108C	14	Left Door Switch	Left Courtesy Light

Specifications

Circuit	Gauge	From	To
109A	14	Circuit Breaker	Right Door Switch
109B	14	Right Door Switch	Dome Light
109C	14	Right Door Switch	Right Courtesy Light
113	16	5 Amp Circuit Breaker	Baggage Compartment Light Switch
113B	16	Baggage Compartment Light Switch	Left-Baggage-Compartment Light
113C	16	Baggage Compartment Light Switch	Right-Baggage-Compartment Light
113D	14	Baggage Compartment Light Switch	Baggage Compartment Light Circuit Breaker
116	6	Cab Ground Stud	Chassis Ground Stud
117	14	Transmission-Mounted Magnetic Pickup	Cab/Chassis Connector
117	16	Cab/Chassis Connector	Speedometer Gauge
117	—	Speedometer Sender Signal (Positive)	
117B	14	Dual-Lead Sensor (Second Pair)	VIGIL III Lightbar (Pin A04)
118	—	Speedometer Sender Signal (Negative)	
118	14	Transmission-Mounted Magnetic Pickup	Cab/Chassis Connector
118	16	Cab/Chassis Connector	Speedometer Gauge
118A	16	Speedometer	Dixon Trip Odometer (Blue Wire)
118B	14	Dual Lead Sensor (Second Pair)	VIGIL III Lightbar (Pin B04)
119	—	Coolant Temperature Gauge Feed	
119	16	Electric Coolant-Temperature Gauge	Cab/Chassis Connector
119	14	Cab/Chassis Connector	Coolant-Temperature Sensor
119A	14	Electric Coolant-Temperature Gauge (Remote)	Coolant Temperature Sensor
119B	16	Electric Coolant-Temperature Gauge (Ground)	Cab/Chassis Connector
119B	14	Cab/Chassis Connector	Coolant Temperature Sensor (Ground)
120	—	Back-Up Light Switch Feed	
120	14	10 Amp Circuit Breaker	Cab/Chassis Connector
120	14	Cab/Chassis Connector	Transmission Back-Up Light Switch (Red Wire)
120A	14	Transmission Back-Up Light Switch	Indicator Light, Transmission Back-Up Light
120B	14	Transmission Back-Up Light Switch (Yellow Wire)	Back-Up Lights
Jacobs or Cummins Engine Brake (Circuits 121 through 121E)			
121	14	10 Amp Circuit Breaker	Clutch Switch
121A	14	Clutch Switch	Throttle Switch
121A	—	See Circuit 121R	
121B	14	Throttle Switch	Engine Brake Selector Switch No. 1
121C	14	Engine Brake Selector Switch No. 1	Cylinders 3 and 4 (DDE and Cummins Inline)
121C	14	Engine Brake Selector Switch No. 1	Cylinders 1, 2, 3, and 4 (DDE and Cummins V-Engines)

Circuit	Gauge	From	To
121C	14	Engine Brake Selector Switch No. 1	Cylinders 1, 2, and 3 (CAT Inline)
121CA	14	Module (RPM O/R Input)	Engine Brake Selector Switch No. 1
121D	14	Engine Brake Selector Switch No. 2	Cylinders 1, 2, 5, and 6 (DDE and Cummins Inline)
121D	14	Engine Brake Selector Switch No. 2	Cylinders 5, 6, 7, and 8 (DDE and Cummins V-Engines)
121D	14	Engine Brake Selector Switch No. 2	Cylinders 4, 5, and 6 (CAT Inline)
121DA	14	Module (RPM O/R Input)	Engine Brake Selector Switch No. 2
121E	—	On/Off Switch	3–1–2 Selector Switch (B Terminal)
Jacobs Engine Brake (Canada Only) (Circuits 121F and 121G)			
121F	14	Clutch Switch	10 Amp Fuse
121G	14	10 Amp Fuse	Ignition Switch (Coil Terminal)
Jacobs Engine Brake; Ruan (Low-RPM Protection) (Circuits 121H through 121P)			
121H	14	Module (Black Wire)	Throttle Switch
121J	14	Module (Red Wire)	Clutch Switch
121K	14	10 Amp Circuit Breaker (Circuit 15)	Module (Yellow Wire)
121L	14	Low-Speed Module (White Wire)	Sensing Module
121M	14	Sensing Module	Low-Speed Module (White Wire)
121N	14	Throttle Switch	Time Delay Switch
121N	14	Time Delay Switch	Selector Switch and TCFM
121P	14	Throttle Switch	Time Delay Switch (+ Terminal)
Jacobs Engine Brake with Magnetically Operated Proximity Switch (Circuits 121A, and 121R through 121U)			
121A	14	Clutch Switch (Proximity Switch, Black Wire)	Throttle Switch
121R	14	10 Amp Circuit Breaker (Ignition-Controlled)	Relay
121Q	14	10 Amp Circuit Breaker	Clutch Switch (Canada)
121S	14	Relay (Terminal 30)	Relay (Terminal 85)
121T	14	Relay (Terminal 85)	Proximity Switch (Red Wire)
121U	14	Relay (Terminal 86)	Proximity Switch (White Wire)
Jacobs Engine Brake With DDEC (Circuits 121V through 121Z)			
121V	14	10 Amp Circuit Breaker (Ignition-Controlled)	Control Module (Red Wire)
121W	14	Control Module (White Wire)	Clutch Switch
121X	14	Control Module (Black Wire)	Clutch Switch
121Y	14	Throttle Switch	Cruise Control Switch

Specifications

Circuit	Gauge	From	To
121Z	14	Indicator Light, Engine Brake	Engine Brake Switch
122	14	Back-Up Light Switch	Back-Up Alarm
122	14	10 Amp Circuit Breaker (Ignition-Controlled)	Back-Up Alarm Switch
122A	14	Back-Up Alarm Switch	Back-Up Alarm
123	14	Leece-Neville Regulator (Field Terminal)	Alternator (Field Terminal)
123A	14	Alternator (Positive/Field Terminal)	Regulator, Alternator Voltage (Positive)
123B	14	Regulator, Alternator Voltage (Positive)	Regulator, Alternator Voltage (Field)
123C	14	Relay (Field Terminal)	Alternator (Field Terminal)
123D	14	Alternator (Negative)	Regulator, Alternator Voltage (Negative)
124	14	Leece-Neville Regulator (Ground Terminal)	Alternator (Ground Terminal)
125	16	Indicator Light (Parking Brake)	Parking Brake Sensor
125	16	Circuit Breaker (Ignition-Controlled)	Parking Light Sensor
125	16	Parking Light Sensor	Lightbar (Option Pin)
125A	16	Stoplight Switch (Spring Brake)	Stoplight Relay (Coil Terminal)
125B	14	Parking Brake Warning Buzzer	Parking Brake Switch (Output)
130	12	Transformer Rectifier Charger (– Terminal)	Alternator Output Terminal (+ Terminal)
130A	12	Transformer Rectifier Charger Phase Taps	Alternator Phase Taps
131	16	Warning Light, No-Charge	No-Charge Relay
131A	16	10 Amp Circuit Breaker (Ignition-Controlled)	No-Charge Relay
132	16	Ignition Switch	Warning Light, No-Charge
137	16	Alternator Phase Tap	No-Charge Light Relay
137	16	ADLO Relay	Warning Light, No-Charge (ADLO System)
138	14	Alternator Phase Tap	ADLO Relay
139	14	ADLO Relay	Starter Magnetic Switch
139A	14	10 Amp Circuit Breaker	ADLO Relay (Air Start)
139A	14	ADLO Relay (Air Start)	Air Start Lockout Solenoid
139B	16	Start Button	ADLO Relay
140	16	Electric Oil Pressure Gauge	Oil Pressure Sensor
141	14	Circuit Breaker (Ignition-Controlled)	ADLO Relay Contacts
141	14	ADLO Relay Contacts	ADLO Solenoid (Air Start)
147	16	10 Amp Circuit Breaker	Manual Override Switch (Thermatic Fan)
148	16	Manual Override Switch	Warning Light, Thermatic Fan
149	16	Manual Override Switch	Manual Override Solenoid
149A	14	Manual Override Switch	Lightbar (Pin C13)
149B	14	Circuit Breaker (Ignition-Controlled)	Manual Override Switch
149C	14	Engine, Fan-Switch/Relay	Parking Brake Switch

Circuits 150 Through 198

Circuit	Gauge	From	To
Kysor Engine Warning or Warning/Shutdown Systems (Circuits 150 through 150Y; also see Circuits 158 through 158L, and Circuit 173)			
150	14	Warning Light, Low-Oil-Pressure	Warning Bell (Low-Oil-Pressure Alarm)
150A	14	Kysor Control Module (Terminal 3)	Alarmstat (N.C. Terminal)
150B	14	Alarmstat (N.C. Terminal)	Engine Shutdown Solenoid
150C	14	Warning Bell	Alarmstat (N.O. Terminal)
150D	14	Alarmstat (N.O. Terminal)	Warning Light, High-Coolant-Temperature
150E	14	Circuit Breaker	Warning Bell (Low-Oil-Pressure)
150E	14	Warning Bell (Low-Oil-Pressure)	Low-Oil-Pressure Sending Unit
150F	14	Alarmstat (N.C. Terminal)	Manual Override Switch (Power Side)
150F	14	Alarmstat (N.C. Terminal)	Control Module (Terminal 1) (Kysor Auto Override)
150F	—	Alarmstat Shutdown Terminal Feed (N.C.)	
150G	14	Control Module (Terminal 3)	Warning Light, Low-Coolant-Level
150G	14	Control Module (Terminal 3)	Warning Bell
150H	14	Oil Pressure Switch	High-Temperature Switch (NYCAL)
150J	16	Tri-Diode (Female Terminal)	Warning Bell
150K	16	Tri-Diode (Male Terminal)	Pressurestat (N.C. Terminal)
150L	16	Tri-Diode (Male Terminal)	Alarmstat (N.O. Terminal)
150L	16	Warning Bell	Diode
150L	16	Diode	Alarmstat
150M	14	Alarmstat (C. Terminal)	Pressurestat (N.O. Terminal)
150M	—	Alarmstat to Pressurestat or Temperature Switch Ground	
150N	16	Pressurestat (N.O. Terminal)	Control Module (Terminal 3) (Kysor Auto Override)
150N	16	Pressurestat (N.O. Terminal)	Manual Override Pushbutton
150Q	14	10 Amp Circuit Breaker	4-Terminal Module (Terminal 1)
150Q	16	10 Amp Circuit Breaker	6-Terminal Module (Terminal 4)
150Q	16	10 Amp Circuit Breaker	Manual Override Switch
150Q	16	10 Amp Circuit Breaker (Ignition-Controlled)	Shutdown Relay (Terminal 30)
150Q	16	Shutdown Relay (Terminal 30)	Shutdown Relay (Terminal 85)
150R	14	Start Button	Control Module (Terminal 2)
150R	16	Start Button	Lightbar (Pin C8)
150S	16	Pressurestat (C. Terminal)	6-Terminal Control Module (Terminal 4)
150S	16	Pressure Switch	NYCAL Control Module (Terminal 4)
150T	14	Circuit Breaker	Warning Light, Low-Coolant-Level

Specifications

Circuit	Gauge	From	To
150X	16	10 Amp Circuit Breaker	Manual Override Switch (NYCAL)
150Y	16	Manual Override Switch	Engine Shutdown Solenoid
151	10	Circuit Breaker	110 Volt Inverter Input
153	14	Front Axle Declutch Switch	Solenoid Valve (Declutch)
153A	14	10 Amp Circuit Breaker	Front Axle Declutch Switch
154	14	Indicator Light, Air Lift	Air Lift Actuation Switch
155	14	Air Lift Actuation Switch	Solenoid Valve (Air Lift)
157	14	10 Amp Circuit Breaker	Power Mirror Switches
157A	14	Left Power Mirror Switch	Left Motor (In)
157B	14	Left Power Mirror Switch	Left Motor (Out)
157C	14	Right Power Mirror Switch	Right Motor (In)
157D	14	Right Power Mirror Switch	Right Motor (Out)
157E	14	Right Power Mirror Switch	Right Limiter Switch (Red Wire)
157F	14	Right Power Mirror Switch	Right Limiter Switch (Black Wire)
Kysor Engine Warning or Warning/Shutdown Systems (Circuits 158 through 158L; also see Circuits 150 through 150Y, and Circuit 173)			
158	14	6-Terminal Control Module (Terminal 3)	Engine Shutdown Solenoid
158B	16	Start Button	Warning Light, Low-Coolant-Level (ISSPRO Low-Coolant-Level Alarm)
158C	16	Pressurestat (N.O. Terminal)	Engine Shutdown Solenoid
158D	16	4-Terminal Control Module (Terminal 3)	Warning Light, Low-Coolant-Level
158D	16	4-Terminal Control Module (Terminal 3)	Low-Coolant Relay (Terminal B)
158E	16	Tri-Diode (Male Terminal)	Warning Light, Low-Coolant-Level
158F	16	4-Terminal Control Module (Terminal 1)	Warning Light, High-Coolant-Temperature
158F	16	4-Terminal Control Module (Terminal 1)	Warning Light, Low-Oil-Pressure
158F	16	4-Terminal Control Module (Terminal 1)	Warning Light, Low-Coolant-Level
158G	16	4-Terminal Control Module (Terminal 1)	Warning Bell
158H	16	Tri-Diode (Male Terminal)	Low-Coolant Relay (Terminal C)
158J	16	Warning Light, High-Coolant-Temperature	Kysor Alarmstat
158K	16	6-Terminal Control Module (Terminal 5)	Tri-Diode (Male Terminal)
158L	16	10 Amp Circuit Breaker	Relay Coil (Kysor Bell)
159	16	Indicator Light, Thermatic Fan	Thermatic Fan Sensor
160	14	Circuit Breaker	12 Volt to 110 Volt Inverter
162	16	Electronic Tachometer Gauge	Cab/Chassis Connector

Circuit	Gauge	From	To
162	14	Cab/Chassis Connector	Flywheel Magnetic Pickup
162	—	Electronic Tachometer (Sensor Signal +)	
163	16	Electronic Tachometer Gauge	Cab/Chassis Connector
163	14	Cab/Chassis Connector	Flywheel Magnetic Pickup
163	—	Electronic Tachometer (Sensor Signal –)	
164	16	Indicator Light, Front Axle Drive	Front Axle Drive Sensor
Ether Start Systems (Circuits 166 through 166F)			
166	12	Ignition Switch (Acc. Terminal)	Ether Start Switch
166	—	Ether Injection Pushbutton Feed	
166A	12	Ether Start Switch	Ether Cylinder Valve, or Thermostat Switch
166A	—	Ether Injection Solenoid Feed	
166A	12	Ether Cylinder Valve Solenoid	Thermostat Switch
166B	—	Ether Injection Thermostat Feed	
166C	12	Thermostat Switch	Ground
166C	14	Thermostat Signal Switch	Ether Solenoid Valve/Ground
166D	12	Circuit Breaker (Constant-Power)	Webb Ether Counter Module
166E	12	Webb Ether Counter Module	Ground
166F	12	Webb Ether Counter Module	Reset Switch
166F	12	Reset Switch	Ground
167	14	Ignition Switch (Acc. Terminal)	REN Oil Leveler
168	16	12-Volt Supply	Engine Hourmeter
168	16	Engine Hourmeter Power	Ignition Fuse/Circuit-Breaker or Switch
168	—	Engine Hourmeter Feed	
168A	16	Pressure Switch Supply	Ignition Fuse/Circuit-Breaker or Switch
170	16	Circuit Breaker (Ignition-Controlled)	Fifth Wheel Slide Sensor
170	16	Fifth Wheel Sensor	Lightbar (Option Pin)
170	—	Fifth Wheel Indicator Feed	
CAT BrakeSaver (Circuits 171 through 171H)			
171	14	Ignition Switch (Coil Terminal)	10 Amp Circuit Breaker (BrakeSaver)
171A	14	10 Amp Circuit Breaker	Selector Switch (Manual or Automatic)
171B	14	Selector Switch (Manual or Automatic)	Solenoid Valve
171C	14	Solenoid Valve	Clutch Switch
171D	14	Clutch Switch	Throttle Switch
171E	14	Toggle Switch (BrakeSaver)	10 Amp Fuse (Canada)

Specifications

Circuit	Gauge	From	To
171F	14	10 Amp Fuse (Canada)	Ignition Switch (Coil Terminal)
171G	14	Oil Temperature Sensor	Oil Temperature Gauge
171H	14	Circuit Breaker	Indicator Light
171H	14	Indicator Light	Pressure Switch (Ground Terminal)
172	16	Circuit Breaker	Electric Clock
172	—	Electric Clock or Tachograph Feed	
172A	16	Red Dot Clock	Alarm
172B	14	Circuit Breaker	Battery Cutoff Switch (Power Side)
Kysor Engine Warning or Warning/Shutdown Systems (Circuit 173; also see Circuits 158 through 158L and Circuits 150 through 150Y)			
173	14	Control Module	Low-Coolant-Level Probe
173	—	Low-Coolant-Level Probe	
Nycal Engine Warning System (Circuits 174 through 175)			
174	14	Control Module (Terminal 2)	Buzzer
174	14	Buzzer	Warning Light
174A	14	Control Module (Terminal 5)	Coolant Temperature Sensor
174B	14	Control Module (Terminal 3)	Buzzer
174B	14	Buzzer	Warning Light
174D	14	Control Module (Terminal 6)	Override Switch
175	14	Buzzer	Ignition Switch (Coil Terminal)
175	14	Control Module (Terminal 1)	Override Switch (Power Side)
Robert Shaw Engine Warning System (Circuits 177 through 177K)			
177	14	4 Amp Fuse	Low-Coolant-Level Probe
177A	14	Low-Coolant-Level Probe (Signal Terminal)	Warning Light, Low-Coolant-Level
177B	14	Low-Coolant-Level Probe (Test Terminal)	Test Switch
177C	14	Low-Coolant-Level Probe (Signal Terminal)	Tri-Diode
177E	16	Power Source	Relay Contact
177F	16	Relay Contact	Warning Light and Buzzer
177G	14	Tri-Diode	Low-Oil-Level Probe (Signal Terminal)
177G	14	Warning Light	Low-Oil-Level Probe (Signal Terminal)
177H	14	10 Amp Circuit Breaker	Low-Oil-Level Probe (+ Terminal)
177J	16	Start Button	Relay (Coil Side)
177K	14	Low-Oil-Level Probe (Test Terminal)	Relay (Power Side)

Specifications

Circuit	Gauge	From	To
Henke Delayed-Engine-Shutdown System (Circuits 178 through 178E; also see Circuits 195 and 195A)			
178	14	Ignition Switch (Battery Terminal)	Delayed-Shutdown Timer
178A	14	Shutdown Timer (Blue Wire)	Ignition Switch (Coil Terminal)
178B	14	Circuit Breaker	Shutdown Timer
178C	14	Shutdown Timer	Engine Fuel Solenoid
178D	12	Circuit Breaker (Ignition-Controlled)	Timer Relay (Power-In Terminal)
178D	12	Timer Relay (Power-Out Terminal)	Start Button (Ignition Side)
178E	14	Idle-Limit-Module Temperature Signal	Temperature Switch/Module
PSM 1000 (Circuits 179 through 179B)			
179	14	Ignition Switch	10 Amp Circuit Breaker
179A	14	10 Amp Circuit Breaker	On/Off Switch
179B	14	On/Off Switch	Glo-Plugs
Corning Glass Warning System (Circuits 180 through 180C)			
180	14	10 Amp Circuit Breaker	Converter Boxes
180A	14	Converter Box (Low-Fuel Terminal)	Warning Light, Low-Fuel
180B	14	Converter Box (Low-Oil Terminal)	Warning Light, Low-Oil
180C	14	Converter Box (Low-Coolant Terminal)	Warning Light, Low-Coolant
Fuel Pressure Sensor (Circuits 182 and 182A)			
182	16	10 Amp Circuit Breaker (Constant-Power)	Indicator Light
182A	16	Indicator Light	Pressure Switch (Fuel Line)
183A	16	Indicator Light (Air Cleaner)	Vacuum Switch
184	12	Ignition Switch (Coil Terminal)	Neutral Safety Switch (HT70 Transmission)
184A	12	Neutral Safety Switch (HT70 Transmission)	Air Solenoid Valve (Air Starter)
Superior 5608-20 Burglar Alarm (Circuits 185 through 185K; also see Circuits 211 through 211B)			
185	14	10 Amp Circuit Breaker (Constant-Power)	Burglar Alarm Unit
185A	14	Alarm Switch	Burglar Alarm Unit
185B	14	Right-Door Switch	Burglar Alarm Unit
185C	14	Left-Door Switch	Burglar Alarm Unit
185D	14	Cab-Mounted Switch	Burglar Alarm Unit
185E	14	Indicator Light	Burglar Alarm Unit
185F	14	Alarm Horn	Burglar Alarm Unit

Specifications

Circuit	Gauge	From	To
185G	14	Door Switch	Circuit Breaker (Constant-Power)
185H	14	Circuit Breaker (Constant-Power)	Indicator Light
185J	14	Circuit Breaker (Ignition Coil)	Burglar Alarm Unit
185K	12	Ignition Switch (Acc. Terminal)	Burglar Alarm Unit
186	—	See Circuit 140	
187	14	Ignition Switch (Coil Terminal)	Fan Switch (Horton)
188	14	Bus Bar	Circuit Breaker
188	14	Circuit Breaker	Antilock Power Relay
189	14	Antilock Power Relay	Warning Module
190	14	Circuit Breaker	Ejector Heater (Graham-White)
191	14	Circuit Breaker	Glo-Plug Switch (Cummins Engine)
191A	14	Glo-Plug Switch	Resistor (Cummins Engine)
191B	16	Glo-Plug Switch	Indicator Light, Glo-Plug (Cummins Engine)
191C	14	Resistor	Glo-Plug (Cummins Engine)
192	16	Indicator Light, Pusher Axle	Pusher Axle Sensor (Neway)
Electric Tilt Pump (Circuits 193 through 193C)			
193	14	10 Amp Circuit Breaker	Electric Tilt Pump Switch
193A	14	Electric Tilt Pump Switch	Solenoid (Coil Terminal)
193B	14	Battery	Solenoid (Contact)
193C	14	Solenoid (Contact)	Electric Tilt Pump Motor
194	—	See Circuit 203	
194A	—	See Circuit 203	
194B	—	See Circuit 203A	
194C	—	See Circuit 203B	
Henke Delayed-Engine-Shutdown System (Circuits 195 and 195A; also see Circuits 178 through 178E)			
195	14	Ignition Switch (Battery Terminal)	Engine Shutdown Timer
195A	14	Engine Shutdown Timer	Ignition Switch (Coil Terminal)
Fuel/Water Separator Heater (Circuits 196 through 196P)			
196	12	Circuit Breaker	Relay
196	12	Relay	Fuel Heater
196A	12	Toggle Switch	Fuel Heater Relay (Coil Terminal) and/or Indicator Light

Circuit	Gauge	From	To
196B	12	Ignition Switch (Acc. Terminal)	Circuit Breaker
196B	12	Circuit Breaker (Ignition-Controlled)	Fuel Heater Toggle Switch
196C	6	Battery	60 Amp Circuit Breaker
196C	6	60 Amp Circuit Breaker	Heavy-Duty Relay
196C	6	Heavy-Duty Relay	Fuel Heater
196E	10	30 Amp Circuit Breaker	Fuel Heater Timer Module
196F	10	Fuel Heater Timer Module	Fuel Heater Toggle Switch
196G	10	Fuel Heater Toggle Switch	Fuel Heater Timer Module
196H	10	Fuel Heater Timer Module	Fuel Heater Element
196J	10	Fuel Heater Timer Module	Indicator Light
196K	10	Circuit Breaker	Relay
196L	10	Fuel Heater Switch	Relay (Coil Terminal) and Indicator Light
196M	10	Relay	Fuel Heater
196N	10	Relay	Fuel Heater
196P	10	Fuel Heater Relay	Fuel Heater Temperature Switch
197	14	Indicator Light, Lockup	Pressure Switch (HT750 Automatic Transmission)
198	14	10 Amp Circuit Breaker	Two-Speed-Axle Pressure Switch
198	14	Two-Speed-Axle Pressure Switch	Speedometer Drive Joint

Circuits 200 Through 249B

Circuit	Gauge	From	To
Power Take Off (Circuits 200 through 200F; also see Circuit 238)			
200	14	PTO Switch	Indicator Light, PTO (No. 1)
200A	14	PTO Switch	Indicator Light, PTO (No. 2)
200B	14	PTO Switch	Indicator Light, PTO (No. 3)
200C	14	PTO Switch	Indicator Light, PTO (No. 4)
200D	14	10 Amp Circuit Breaker	Dash Switch
200E	14	Dash Switch	Transmission-Mounted Solenoid
200F	14	Back-Up Light Switch	PTO Pressure Switch
201	6	Battery	Circuit 14 Splice
202	—	Transformer Rectifier Output (24V Starter)	
202	6	30SI TR Output (Transformer Rectifier)	24V Starter (Battery Terminal)
Williams Exhaust Brake (Circuits 203 through 203E)			
203	14	Ignition Switch	3 Amp Fuse

Specifications

Circuit	Gauge	From	To
203	14	3 Amp Fuse	Dash Control Switch
203A	14	Exhaust Brake Switch/Relay	Exhaust Brake Supply Solenoid
203B	14	Throttle Switch	Exhaust Brake Return Solenoid
203C	14	Exhaust Brake Cut-Out Relay	Cruise Control On/Off Switch
203C	14	Cruise Control On/Off Switch	Ground
203D	14	Exhaust Brake Pressure Switch	Indicator Light
203E	16	Solenoid Valve Power Exhaust Brake Warm-Up	Switch/Starter Signal
204	16	Circuit Breaker	Seat Belt Warning Light and Buzzer
204A	16	Seat Belt Warning Light and Buzzer	Seat Belt Switch
205	14	Headlight Warning Relay	Headlight-On Alarm
205A	14	Trinary Switch	Air Fan Solenoid Valve
205A	—	Trinary Switch	Fan Clutch Solenoid Feed
206	16	Power Relay (Coil Terminal)	Low-Oil-Pressure Switch
206	16	Low-Oil-Pressure Switch	Ignition Switch (Coil Terminal)
206A	16	Power Relay (Power Out)	Heater-A/C Relay (Coil Terminal)
207	14	Circuit Breaker	Air Dryer Heater (See Circuit 94)
208	14	Ignition Switch	Solenoid (Neway Suspension—Triaxle with Pusher)
209	16	Circuit Breaker (Ignition-Controlled)	Pressure Switch
209	16	Pressure Switch (Two-Speed Axle)	Eaton 2-Speed Differential Adapter Solenoid
209A	16	Pressure Switch (Two-Speed Axle)	Speedometer (Auxiliary Terminal)
210	14	Circuit Breaker	Solenoid Switch (Cab Power)
210	14	Solenoid Switch	Circuit Breaker
210	14	Solenoid Switch	Solenoid (Coil Terminal)
Burglar Alarm (Circuits 211 through 211B; also see Circuits 185 through 185K)			
211	14	Circuit Breaker	Key Switch (Burglar Alarm, see Circuit 185)
211A	14	Key Switch	Siren Module (see Circuit 185A)
211B	14	Door Switch	Siren Module (see Circuits 185B and C)
212	14	Circuit Breaker	Refrigerator Switch
212A	14	Refrigerator Switch	Refrigerator
213	12	Converter (110V to 12V)	30 Amp Circuit Breaker (12V)
213A	14	12V Converter Charger	12V Battery (+ Terminal)
213B	12	110V Converter (12V Output)	Auxiliary Circuit Breaker
214	14	Auxiliary Generator Supply Voltage	

Circuit	Gauge	From	To
Webasto Heater (Circuits 215 through 215P)			
215	12	12V Battery (+ Terminal)	10 Amp Circuit Breaker
215A	12	10 Amp Circuit Breaker	Heater Control Unit (Terminal 4)
215B	14	Heater Control Unit (Terminal 6)	Indicator Light, Heater
215C	14	Indicator Light, Heater	Heater Control Unit (Terminal 3)
215D	14	Heater Control Unit (Terminal 1)	Heater On/Off Switch
215D	14	Heater On/Off Switch	10 Amp Circuit Breaker (Bus Bar)
215E	12	Heater Control Plug (Terminal 1)	Pump
215F	12	Heater Control Plug (Terminal 2)	Pump
215G	12	Heater Control Plug (Terminal 2)	Fuel Shutoff Solenoid
215H	12	Heater Control Plug (Terminal 5)	Fuel Shutoff Solenoid
215J	14	Preheat Nozzle	Heater Control Unit
215J	14	Heater Control Unit	Ground
215M	14	15 Amp Fuse	Cab/Chassis Connector
215M	8	Cab/Chassis Connector	Heater Relay
215N	14/16	Switch	Webasto Heater Unit
215P	14/16	Timer Control	Webasto Heater Unit
Sterling Idle Cycler (Circuits 216 through 216E)			
216	16	Ignition Switch	Air Switch (Spring Brakes)
216A	16	Air Switch (Spring Brakes)	Air Switch (Constant Air)
216B	16	Air Switch (Constant Air)	Sterling Engine Cycler (+ Terminal)
216C	16	Sterling Engine Cycler	Solenoid Switch (Positive Circuit)
216D	14	Sterling Engine Cycler	Hood Tilt Switch
216E	14	Hood Tilt Switch	Sterling Engine Cycler (Solenoid Wire)
217	10	Solenoid Switch	30 Amp Circuit Breaker
217C	10	Solenoid Switch	Synchro Start Solenoid
218	16	Ignition Switch	Digital Pyrometer (ISSPRO)
219	16	Turbocharger Pressure Gauge	Turbocharger Pressure Sensor
220	12	Ignition Switch (Acc. Terminal)	Accessory Relay
221	14	Circuit Breaker	Toggle Switch (Air Suspension Dump)
221A	14	Toggle Switch (Air Suspension Dump)	Solenoid Valve (Air Suspension Dump)
222	—	Headlight Dimmer Switch Feed	
222	16	Left Headlight Relay (Terminal 86)	Dimmer Switch
222	16	Right Headlight Relay (Terminal 86)	Dimmer Switch

Specifications

Circuit	Gauge	From	To
Transmission Shift Control (Circuits 223 through 224)			
223	16	Indicator Light, Shift Control	Transmission Shift Control
223A	14	Circuit Breaker (Ignition-Controlled)	Automatic Transmission Modulator Relay
223B	14	Automatic Transmission Modulator Relay	Solenoid Valve
223C	16	Ignition Fuse/Circuit-Breaker	Translator Module, Ignition Power
223H	16	Transmission Shift Control	Shift Control Solenoid
223H	16	Translator Module, Engine Output	Modulator Relay Signal
224	16	Transmission Shift Control	Indicator Lights (Rear)
225	16	Primary Air Gauge (Digital)	Primary Air Sensor
226	16	Secondary Air Gauge (Digital)	Secondary Air Sensor
227	16	Application Air Gauge (Digital)	Application Air Sensor
228	16	Oil Pressure Gauge (Digital)	Oil Pressure Sensor
Retarder (Circuits 229 through 230E)			
229	14	Hand Lever (Terminal C)	Relay Box (Terminal E)
229A	14	Hand Lever (Terminal 4)	Relay Box (Terminal 4)
229B	14	Hand Lever (Terminal 3)	Relay Box (Terminal 3)
229C	14	Hand Lever (Terminal 2)	Relay Box (Terminal 2)
229D	14	Hand Lever (Terminal 1)	Relay Box (Terminal 1)
229E	14	Hand Lever (Terminal 1)	Indicator Light (Retarder)
230	00	12V Starter (Battery Terminal)	Relay Box (+ Terminal)
230A	2–No. 6	Relay Box (Terminal 1)	Retarder
230B	2–No. 6	Relay Box (Terminal 2)	Retarder
230C	2–No. 6	Relay Box (Terminal 3)	Retarder
230D	2–No. 6	Relay Box (Terminal 4)	Retarder
230E	14	Relay Box (Terminal S)	Stoplight Switch (Terminal with 36A)
231	14	Circuit 25 Splice	Cab Tilt Alarm Relay
232	14	Transmission (Orange Wire) (Transmission Indexing)	12V Power (2 Amp Fused)
232A	14	Transmission (Green Wire) (Transmission Indexing)	Ground
233A	14	Ignition Switch	Teleflex Retarder (Allison Transmission)
233B	14	Teleflex Retarder	Indicator Light, Retarder (Allison Transmission)
233C	14	Teleflex Retarder Output Control	Valve Solenoid

Circuit	Gauge	From	To
234	14	Circuit Breaker (Ignition-Controlled)	Fan Clutch Thermal Switch
234	—	Fan Clutch Thermostat Control Feed	
234A	—	Fan Clutch Solenoid Feed	
234A	14	Fan Clutch Thermal Switch	Fan Clutch Solenoid
234B	14	Fan Clutch Solenoid	Multistat
234C	14	Manual Override Switch	Multistat (Ground Terminal)
234D	14	Shutter Override Solenoid	Multistat (Ground Terminal) (Manual Override)
234E	14	10 Amp Circuit Breaker (Ignition-Controlled)	Engine Shutter Thermostat
234E	14	Engine Shutter Thermostat	Shutter Solenoid
234F	14	Engine Fan Override Switch (Supply)	Circuit Breaker (Ignition-Controlled)
234G	16	Engine Fan Override Switch	Indicator Light, Engine Fan
Lenmar Speed Control (Circuits 235 through 235F)			
235	14	Ignition Switch (Coil Terminal)	Fuel Valve Pressure Switch (Green/Black Wire)
235A	14	Ignition Switch (Battery Terminal)	Valve Solenoid (White Wire)
235B	14	Verify Pushbutton Switch	Valve Solenoid (Red Wire)
235C	14	Electronic Speed Switch	Verify Pushbutton Switch (Black Ground Wire)
235D	14	Electronic Speed Switch	Verify Pushbutton Switch (Red Wire)
235E	14	Pulse Generator	Electronic Speed Switch
235F	14	Pulse Generator	Electronic Speed Switch
236	14	Indicator Light, Auxiliary Transmission	Aux. Transmission Switch (Neutral Position) (Fuller AT1202)
237	16	Ignition Switch	Dash Control Switch (Rockwell Elect. Auto. Interaxle Lock Sys.)
237	16	Dash Control Switch	Power Relay (Rockwell Elect. Auto. Interaxle Lock Sys.)
Power Take Off (Circuit 238; also see Circuits 200 through 200F)			
238	14	Ignition Switch	PTO Dash Switch (Chelsea Products, PTO Div., Dana)
238	14	PTO Dash Switch	PTO Valve Solenoid (Chelsea Products, PTO Div., Dana)
239	14	10 Amp Circuit Breaker	Power Relay (Term. E) (Rockwell Elect. Auto. Interaxle Lock Sys.)
240	14	Water Watcher Indicator	Fuel/Water Separator Bowl Probe (Chicago Rawhide)

Specifications

Circuit	Gauge	From	To
240A	14	Water Watcher Indicator (Ground Terminal)	Fuel/Water Separator Bowl Probe (Chicago Rawhide)
240B	14	Water Watcher Indicator	20 Amp Circuit Breaker
240C	16	Indicator Light, Water-In-Fuel	Control Module
240D	14/16	Water-In-Fuel Module	Water-In-Fuel Signal Relay
241	14	Warning Light, Low-Water-Pressure	Low-Water-Pressure Switch (Canada Safeway)
241A	14	Sangamo Tachograph	Low-Water-Pressure Switch (Canada Safeway)
241B	14	Sangamo Tachograph	Low-Oil-Pressure Switch (25 psi) (Canada Safeway Overspeed System)
242	14	Circuit Breaker	On/Off Switch (Seat Massage Unit)
243	12	Circuit Breaker	Microwave Oven Relay
243	12	Microwave Oven Relay	Inverter (Microwave Oven)
243	12	Inverter (Microwave Oven)	Microwave Oven
244	16	10 Amp Circuit Breaker (Ignition-Controlled)	Control Module (Hewitt Speed Alarm)
244A	14	Control Module (Red Wire)	Speed Sensor
244B	14	Control Module (Yellow Wire)	Speed Sensor
244C	14	Control Module (Brown Wire)	Fuel Control Valve
244D	14	Speed Alarm (Green Wire)	Shutdown Solenoid Valve (CAT Only)
245	16	Relay Box (Terminal A)	PNC/A22 Pressure Switch
245A	16	PNC/A22 Pressure Switch	PNC/P3 Buzzer
245B	16	Ignition Switch (Coil Terminal)	PNC/533 Relay Box (Terminal B)
Jerry Stugart P & N Company (Circuits 246 and 246A)			
246	14	Switch (Auxiliary Heater or Power)	Electric Fuel Pump
246	14	Circuit Breaker (Ignition-Controlled)	Electric Fuel Pump Switch
246A	14	Electric Fuel Pump Switch	Electric Fuel Pump
246A	14	Electric Fuel Pump Switch	Indicator Light, Fuel Pump
Cummins MVT Engine Timing Advance (Circuits 247 through 247B)			
247	14	Indicator Light	MVT Air Pressure Switch
247A	16	Relay (Contact Terminal)	Indicator Light
247B	14	Relay (Coil Terminal)	Extra Low-Air-Pressure Switch
Ulanet Watchdog ® Engine Shutdown System (Circuits 248 through 248D)			
248	14	Ignition Switch	Watchdog Module
248A	14	Watchdog Module	Sensors
248B	14	Watchdog Module	Shutdown Solenoid

Circuit	Gauge	From	To
248C	14	Module Override (Black Wire)	Override Switch
248C	16	Override Switch	Black Wire
248C	16	Black Wire	Module
248D	16	Module (Yellow Wire)	Warning Light
248D	16	Warning Light	Module
Webb Continuous Oil Change System (Circuits 249 through 249B)			
249	16	10 Amp Circuit Breaker (Ignition-Controlled)	Timer Module (White Wire)
249	16	10 Amp Circuit Breaker (Ignition-Controlled)	Oil Changer Solenoid
249A	16	10 Amp Circuit Breaker (Ignition-Controlled)	Timer Module (Red Wire)
249B	16	Timer Module (Yellow Wire)	Oil Changer Solenoid

Circuits 250 Through 303

Circuit	Gauge	From	To
Borg-Warner Cruise Control (Circuits 250 through 250T)			
250	16	Circuit Breaker	On/Off Switch
250	16	Circuit Breaker	Set/Resume Switch
250A	16	On/Off Switch	Indicator Light, Cruise Control
250B	16	On/Off Switch	Module (White/Green Wire)
250C	16	Set/Resume Switch	Module (White/Red Wire)
250D	16	Set/Resume Switch	Module (White/Yellow Wire)
250E	12	Brake Switch	Module (Orange Wire)
250F	16	Clutch Switch	Module (Blue Wire)
250F	16	Module (Violet Wire)	Clutch Switch
250G	16	Speedometer (+ Signal)	Module (Gray Wire)
250G	16	MPH Sensor (+ Signal)	Module (Gray Wire)
250H	16	Speedometer (– Signal)	Module Ground
250H	16	MPH Sensor (– Signal)	Module Ground
250J	16	Module (Black Wire)	Throttle Actuator (Black Wire)
250K	16	Module (White Wire)	Throttle Actuator (White Wire)
250L	16	Module (Red Wire)	Throttle Actuator (Red Wire)
250M	16	Module (Yellow Wire)	Air Supply Solenoid
250N	16	Module (Brown/Yellow Wire)	Air Exhaust Solenoid
250P	16	Module (Yellow/Green Wire)	Air Supply Solenoid
250Q	16	Module (Brown Wire)	Air Exhaust Solenoid
250T	16	CAT BrakeSaver Module (Green Wire)	Hand Valve Pressure Switch
250T	16	Hand Valve Pressure Switch	Ground

Specifications

Circuit	Gauge	From	To
Cummins Arrest System (Circuits 251 through 251M)			
251	14	Circuit Breaker	Overspeed Switch (C. Terminal)
251A	14	Overspeed Switch (C. Terminal)	Test Switch
251A	14	Test Switch	Overspeed Switch (N.O. Terminal)
251B	14	Overspeed Switch (N.O. Terminal)	Shutdown Solenoid
251C	14	MPH Sensor (+ Signal)	Overspeed Switch
251D	14	MPH Sensor (– Signal)	Overspeed Switch
251E	14	Test Switch	Circuit Breaker
251F	14	Test Switch	Shutdown Solenoid
251G	14	Shutdown Solenoid	Relay
251H	14	Relay	Overspeed Switch
251J	14	Relay	Circuit Breaker
251K	14	Manual Shutdown Switch	Overspeed Switch
251L	14	Solenoid Valve	Overspeed Switch
251M	14	Solenoid Valve	Overspeed Switch
Lenmar Engine Shutdown System (Circuits 252 through 252C)			
252	14	Indicator Light and Alarm	Oil Pressure Switch
252A	14	Ignition Switch (Coil Terminal)	Override Button
252B	14	Override Button	Fuel Bypass Solenoid
252C	14	Start Button	Fuel Bypass Solenoid
253	14	Ignition Switch	Indicator Light, Cab Tilt
254	14	Circuit Breaker	On/Off Switch, Revolving Emergency Light
254	10	30 Amp Circuit Breaker	Rotator Switch
254	14	On/Off Switch	Revolving Emergency Light
254A	14	On/Off Switch	Indicator Light, Revolving Emergency Light
254A	10	Rotator Switch	Panel Indicator Light
254B	10	Rotator Switch	Roof Wire
254C	10	Rotator Switch	7-Way Junction Block
255	14	Circuit Breaker	Switch (Advertising Light)
255	14	Switch	Advertising Light
255A	16	Switch	Indicator Light, Advertising Light
256	14	12V Supply to End of Frame	
257	16	Circuit Breaker	Delayed Wiper Control
257A	16	Delayed Wiper Control (Positive White Wire)	Right Control Solenoid

Circuit	Gauge	From	To
257B	16	Delayed Wiper Control (Positive White Wire)	Left Control Solenoid
257C	16	Delayed Wiper Control (Negative White Wire)	Right Control Solenoid
257D	16	Delayed Wiper Control (Negative White Wire)	Left Control Solenoid
258	18	Switch (Hydraulic Fifth Wheel)	Indicator Light (N.C. Position)
258A	18	Switch (Hydraulic Fifth Wheel)	Indicator Light (N.O. Position)
259	6	Alternator (Output Terminal)	DUVAC (Terminal 1)
259A	14	Alternator (Output Terminal)	Ammeter Shunt (Battery Side)
260	16	Power (Murphy Shutdown)	Starter Magnetic Switch
260A	16	Starter Magnetic Switch	Shutdown Solenoid
261	16	Controlled Differential Lockout	Indicator Light, Differential Lockout
Allison Automatic Transmission Retarder (Circuits 262 through 262G)			
262	14	Circuit Breaker (Ignition-Controlled)	Retarder Solenoid Valve
262A	14	Circuit Breaker	Toggle Switch
262B	14	Toggle Switch	Throttle Switch (DDE Buffer Switch)
262C	14	Throttle Switch (DDE Buffer Switch)	Indicator Light
262D	14	Throttle Switch (Output Relay)	Retarder Solenoid Valve
262D	14	Output Relay	Retarder Solenoid Valve
262E	14	Solenoid Valve (CAT and Cummins)	Pressure Switch
262F	14	High-Temperature Switch	Warning Light, Retarder Overheat
262G	14	Pressure Switch	Indicator Light, Retarder On
Sterling Technologies Engine Shutdown (Circuits 263 through 263H)			
263	14	Ignition Switch (Coil Terminal)	Module Power Wire (Terminal 1)
263A	14	Module (Terminal 4)	Low-Oil-Level Sensor
263B	14	Module (Terminal 3)	Low-Oil-Pressure Sensor
263C	14	Module (Terminal 2)	Run Solenoid (Engine)
263D	14	Module (Terminal 5)	High-Coolant-Temperature Sensor
263E	14	Module (Terminal 6)	Low-Coolant-Level Probe
263F	14	Module (Terminal 8)	Shutdown Test Button
263G	14	Module (Terminal 9)	Ground
263H	14	Oil Level Sensor	Indicator Light
264	14	10 Amp Circuit Breaker	Webb Low-Coolant Alarm Module
Webb Oil Monitor (Circuits 265 through 265C)			
265	14	Circuit Breaker	Warning Light, Webb Oil Monitor

Specifications

Circuit	Gauge	From	To
265A	14	Warning Light, Webb Oil Monitor	Probe No. 1
265B	14	Warning Light, Webb Oil Monitor	Probe No. 2
265C	14	Warning Light, Webb Oil Monitor	Probe No. 3
266	14	Circuit Breaker (Ignition-Controlled)	Indicator Light, PTO
266	14	Indicator Light (PTO)	PTO Transfer Case Switch
266	14	PTO Transfer Case Switch	Ground
268	14	Control Module (Terminal S, Murphy Switch Gauge)	Alarm (Murphy Switch Gauge)
268A	14	Alarm (Murphy Switch Gauge)	Circuit Breaker
Engler Electronic Speedometer and Tachometer (Circuits 269 through 270B)			
269	14	Pulse Generator (Red Wire)	Speedometer (Red Wire)
269A	14	Pulse Generator (Black Wire)	Speedometer (Black Wire)
269B	14	Pulse Generator (Green Wire)	Speedometer (Green Wire)
270	14	Pulse Generator (Red Wire)	Tachometer (Red Wire)
270A	14	Pulse Generator (Black Wire)	Tachometer (Black Wire)
270B	14	Pulse Generator (Green Wire)	Tachometer (Green Wire)
271	14	Electronic Gauge, Oil Pressure (Green Wire)	Electronic Sensor, Oil Pressure (Green Wire)
272	14	Circuit Breaker	Deep Reduction Pressure Switch
272	14	Deep Reduction Pressure Switch	Warning Light, Deep Reduction
273	14	Warning Light, High-Oil-Temperature (Rear Axle)	High-Oil-Temperature Switch (Rear Axle)
273	14	Circuit Breaker	Warning Light, High-Oil-Temperature (Rear Axle)
274	14	Circuit Breaker	Warning Light, High-Oil-Temperature (Transmission)
274	14	Warning Light, High-Oil-Temperature (Transmission)	High-Oil-Temperature Switch (Transmission)
275	14	10 Amp Circuit Breaker	Relay (Power Side) (TRW ETEC)
275A	14	10 Amp Circuit Breaker (Power In)	Relay (Coil Side) (TRW ETEC)
Webb Never Lo ® Oil Fill (Circuits 276 through 276H)			
276	14	Circuit Breaker (Ignition-Controlled)	Control Module
276	14	Control Module	Oil Fill Solenoid
276A	14	Oil Fill Solenoid	Control Module
276B	14	Oil Fill Sensor	Control Module
276C	14	Low-Oil-Level Warning Sensor	Control Module

Circuit	Gauge	From	To
276D	14	Control Module	Alarm
276D	14	Control Module	Ground
276E	14	Control Module	Low-Oil-Level Alarm
276F	14	Control Module	Warning Light, Add Oil
276G	14	12V Supply	Momentary Switch
276H	14	Momentary Switch	Solenoid
276H	14	Solenoid	Ground
Kysor Idlestop System (Circuits 277 through 277F)			
277	16	Idlestop Module (Load Terminal)	Relay (Coil Terminal)
277A	12	Ignition Switch (Coil Terminal)	Idlestop Module (Positive Terminal)
277B	12	Idlestop Module (Sensor Terminal)	Pressure Switch, or Relay (Parking Brake or Trans. Neutral)
277C	12	Idlestop Module (Ground Terminal)	Pressure Switch, or Relay (Parking Brake or Trans. Neutral)
277D	16	Idlestop Module (Battery Terminal)	Pushbutton Switch (N.C. Terminal)
277E	16	Pushbutton Switch (N.C. Terminal)	Ignition Switch (Battery Terminal)
277F	14	Parking Brake Switch or Trans. Neutral	Relay
Bosch Wiper Motors (Circuits 278 through 279E)			
278	14	Circuit Breaker	Right Wiper Motor Control
278A	14	Right Wiper Motor Control	Right Wiper Motor (Park Terminal)
278B	14	Right Wiper Motor Control	Right Wiper Motor (Low-Speed Terminal)
278C	14	Right Wiper Motor Control	Right Wiper Motor (High-Speed Terminal)
279	14	Circuit Breaker	Left Wiper Motor Control
279A	14	Left Wiper Motor Control	Left Wiper Motor (Park Terminal)
279B	14	Left Wiper Motor Control	Left Wiper Motor (Low-Speed Terminal)
279C	14	Left Wiper Motor Control	Left Wiper Motor (High-Speed Terminal)
279D	12	15 Amp Circuit Breaker (Electric Motor)	Electric Wiper Relay (Terminal 30)
279E	14	10 Amp Circuit Breaker (Ignition-Controlled)	Electric Wiper Relay (Terminal 85)
Hewitt Pyrometer Alarm (Circuits 280 through 280F)			
280	14	Circuit Breaker	Alarm Module (Black Wire)
280A	14	Alarm Module (Brown Wire)	Pyrometer (Negative Terminal)
280B	14	Alarm Module (Green Wire)	Pyrometer (Positive Terminal)
280C	14	Alarm Module (Blue Wire)	Pyrometer (Positive Term., Opposite Side of Circuit 280B)

Specifications

Circuit	Gauge	From	To
280D	14	Alarm Module (Orange Wire)	Pyrometer (Negative Term., Opposite Side of Circuit 280A)
280E	14	Alarm Module (Yellow Wire)	Shutdown Actuator Solenoid
280F	16	Alarm Module (Brown Wire)	Alarm
281	14	Circuit Breaker	Sensor Switch (Full-Flow Oil Filter)
281	14	Sensor Switch (Full-Flow Oil Filter)	Indicator Light, Filter Change
282	16	ISSPRO Engine Shutdown Control Module (White Wire)	Bar Alarm Gauges
282A	16	ISSPRO Shutdown Relay (N.O. Terminal)	Engine Shutdown Solenoid
Webb High Idle Cycler (Circuits 283 through 283C)			
283	14	Circuit Breaker (Ignition-Controlled)	Tilt Switch
283A	14	Spring Brake Switch	Module (+ Terminal, Red Wire)
283A	14	Module (Red Wire)	Solenoid
283B	14	Module (Blue Wire)	Solenoid
283C	14	Tilt Switch	Spring Brake Switch
284	14	Circuit Breaker (Ignition-Controlled)	Warning Light, Big Cam III Restricted Oil Filter
284	14	Warning Light, Big Cam III Restricted Oil Filter	Restricted Oil Filter Switch
284	14	Restricted Oil Filter Switch	Ground
285	14	Circuit Breaker	Air Suspension Pressure Switch
285	14	Air Suspension Switch	Indicator Light, Air Suspension
285A	14	Air Suspension Pressure Switch	Cab/Chassis Connector
285A	16	Cab/Chassis Connector	Indicator Light, Air Suspension
285A	16	Ignition Fuse/Circuit-Breaker	Air Suspension Switch Supply
285B	14	Air Suspension Pressure Switch	Cab/Chassis Connector
285B	16	Cab/Chassis Connector	Warning Buzzer (Air Suspension)
285C	14	Pressure Switch (Axle Lift)	Lightbar (Pin C13)
286	14	Water Sensor Box (Green Wire)	Rayco Fuel/Water Separator Bowl
287	14	Circuit Breaker	Oil Pressure Switch
287	14	Oil Pressure Switch	Sangamo Tachograph (White/Gray Wire)
Sterling Alarm System (Circuits 288 through 288C)			
288	14	Module (Yellow Wire)	Low-Oil-Pressure Switch
288A	14	Low-Oil-Pressure Switch	Warning Light, Low-Oil-Pressure
288B	14	Module (Green Wire)	High-Coolant-Temperature Switch

Circuit	Gauge	From	To
288C	14	High-Coolant-Temperature Switch	Warning Light, High-Coolant-Temperature
289	14	Circuit Breaker	Transmission Switch (Fuller)
289	14	Transmission Switch (Fuller)	Indicator Light, Neutral Position
Hewitt Alarm System (Circuits 290 through 290D)			
290	14	Warning Light, Low-Coolant-Level	Control Module (Brown Wire)
290A	14	Warning Light, Low-Oil-Pressure	Switch, Low-Oil-Pressure
290A	14	Warning Light, Low-Oil-Pressure	Module (Green Wire)
290B	14	Warning Light, High-Coolant-Temperature	Switch, High-Coolant-Temperature
290B	14	Warning Light, High-Coolant-Temperature	Module (Red Wire)
290C	14	Low-Coolant-Level Probe	Module (Yellow Wire)
290D	14	Warning Light, Low-Air-Pressure	Switch, Low-Air-Pressure
290D	14	Switch, Low-Air-Pressure	Module (Orange Wire)
Webb Oil and Coolant Level Monitor (Circuits 291 through 291G)			
291	14	Auxiliary Circuit Breaker	Control Module
291A	14	Control Module (Green Wire)	Low-Coolant-Level Probe
291B	14	Relay (Coil Side)	Oil Sensing Chamber (Probe No. 8)
291C	14	Relay (Power Output)	Indicator Light
291D	14	Control Module (Brown Wire)	Oil Sensing Chamber (Probe No. 2)
291E	14	Control Module (Yellow Wire)	Oil Sensing Chamber (Probe No. 4)
291F	14	Control Module (Purple Wire)	Oil Sensing Chamber (Probe No. 3)
291G	14	Control Module (Orange Wire)	Oil Sensing Chamber (Probe No. 1)
Flowscan or ARGO Fuel-Tach System (Circuits 292 through 292Z)			
292	16	Circuit Breaker (Ignition-Controlled)	Fuel-Tach Gauge
292A	16	Circuit Breaker (Ignition-Controlled)	Connector
292A	14	Connector	Fuel-Flow Meter
292B	16	Fuel-Tach Gauge	Connector
292B	14	Connector	Fuel-Flow Meter
292C	16	Fuel-Tach Gauge	Connector
292C	14	Connector	Transmission Speed Sensor (+ Lead)
292D	16	Fuel-Tach Gauge	Connector
292D	14	Connector	Transmission Speed Sensor (– Lead)
292E	14	Fuel-Flow Sensor (White Wire)	Fuel-Tach Gauge (Brown Wire)
292F	16	Circuit Breaker (Dome Light)	Relay (Power In)

Specifications

Circuit	Gauge	From	To
292F	16	Relay (Power Out)	Fuel-Tach Gauge (Red Wire)
292G	16	Circuit Breaker (Dome Light)	Switch
292G	16	Switch	Relay (Power Out)
292H	16	Circuit Breaker (Ignition-Controlled)	Relay (Coil Side)
292N	16	MPH Signal Coupler (Power)	ARGO FMS Monitor (Terminal 1, Power Out)
292N	16	MPH Signal Coupler (Power)	ARGO EDM Junction Block (Plug B)
292Q	16	Positive RPM Sensor (White Wire)	ARGO FMS Monitor (Terminal 2, Power In)
292R	16	Negative RPM Sensor (Black Wire)	ARGO FMS Monitor (Terminal 2, Ground)
292S	16	Positive MPH Sensor (White Wire)	ARGO FMS Monitor (Terminal 1, Power In)
292S	16	Positive MPH Sensor (White Wire)	ARGO EDM Junction Block (Plug B)
292T	16	Negative MPH Sensor (Black Wire)	ARGO FMS Monitor (Terminal 2, Ground)
292T	16	Negative RPM Sensor (Black Wire)	ARGO EDM Junction Block (Plug B)
292U	16	Flow Sensor, – Signal (Black Wire)	ARGO FMS Monitor (Terminal 3, Ground)
292U	16	Flow Sensor, – Signal (Black Wire)	ARGO EDM Junction Block (Plug A)
292W	16	Flow Sensor, + Signal (White Wire)	ARGO FMS Monitor (Terminal 3, Power In)
292W	16	Flow Sensor, + Signal (White Wire)	ARGO EDM Junction Block (Plug A)
292X	16	Flow Sensor, Power (Red Wire)	ARGO EDM Junction Block (Plug A)
292Y	16	RPM Signal Coupler (Red Wire)	ARGO FMS Monitor (Terminal 2, Power Out)
292Z	14	Fuel-Tach Reset Signal	Ground
Lubristart Ether Start System (Circuits 293 through 293C)			
293	12	Starter Solenoid	Magnetic Switch (Power In)
293A	12	Magnetic Switch (Power Out)	Ether Start System Valve
293B	14	Magnetic Switch (Power In)	Thermostat
293C	14	Thermostat	Magnetic Switch (Coil Side)
SAB Air Tank Automatic Drain Valve (Circuits 294 through 294B)			
294	14	Circuit Breaker	Relay (Power In)
294A	14	Brake Light Switch (Power Out)	Relay (Coil Side)
294B	14	Relay (Power Out)	Automatic Drain Valve
295A	12	Ignition Switch (Acc. Terminal)	Radio (Ignition-Controlled Power In)
295B	14	15 Amp Circuit Breaker	Radio (Constant Power In)
295C	14	15 Amp Circuit Breaker	CB Radio (Power In Lead)
295D	14	15 Amp Circuit Breaker	Access Panel (Radio, + Post)
295E	14	Remote Radio Amplifier (Power)	Circuit Breaker
296	16	10 Amp Circuit Breaker (Ignition-Controlled)	2 Amp Fuse

Circuit	Gauge	From	To
296	16	2 Amp Fuse	Dash Switch
296	16	Dash Switch	Indicator Light, Fuel Transfer
296A	14	Dash Switch	Fuel Transfer Pump
297A	14	Circuit Breaker	Buzzer Tri-Diode
297A	14	Buzzer Tri-Diode	Indicator Light
297B	14	Indicator Light	Buzzer Tri-Diode
297B	14	Buzzer Tri-Diode	Graph
298	14	Electric Fuel Pressure Sensor	Fuel Pressure Gauge
298A	16	Lightbar (Pin C3 or C7)	Fuel Pressure Switch
299	16	Outside Cab Air Temperature Probe	Cab/Chassis Connector
299	14	Cab/Chassis Connector	Air Temperature Gauge (Copper Terminal)
299A	16	Outside Cab Air Temperature Probe	Cab/Chassis Connector
299A	14	Cab/Chassis Connector	Air Temperature Gauge (Silver Terminal)
299D	16	Circuit Breaker	Outside Air Temperature Gauge
300	—	Radio Feed	
301	—	Alarm System Feed	
302	—	CB Radio Stud Feed	
303	—	Low Air Switch Jumper	

Circuits 304 Through 401B

Circuit	Gauge	From	To
304	—	Back-Up Light Feed	
305	—	Accessory Breaker Feed	
306	—	Ignition Breaker Feed	
306A	14	Option Ignition Run Power (Fused)	Ignition Fuse/Circuit-Breaker
307	—	Headlight Switch Feed (Head)	
308	—	Fifth Wheel Air Slide Switch Feed	
309	—	Parking Brake Switch Feed	
309	16	Relay/Module	Parking Brake Switch Signal
309A	14	Parking Brake Switch	Parking Brake Solenoid Valve Power
309B	14	Fuse/Circuit-Breaker/Parking Brake Switch	Parking Brake Switch Supply
309C	14	Fuse/Circuit-Breaker	Parking Brake Switch Supply
310	—	Axle Lock Switch Feed	
311	—	Option Block Feed Accessory	
312	—	Radio Power	Battery (+ Terminal)
313	—	Turn Signal Flasher Feed	
314	—	Turn Signal Switch Feed	

Specifications

Circuit	Gauge	From	To
314	12	Flasher Relay (Terminal 87)	Turn Signal Switch (Power In)
315	—	Wiper Switch Feed	
316	—	Wiper Motor (Low Speed)	
317	—	Wiper Motor (Park)	
318	—	Wiper Motor (High Speed)	
319	—	Wiper Motor Park	Battery (+ Terminal)
320	—	Wiper	Washer Motor
321	—	ICC Trailer Marker and Clearance Light Feed	
322	—	Headlight Switch Feed (Parking Lights)	
323	—	Odometer Output	
324	—	High-Coolant-Temperature Shutdown	
324	16	Lightbar (Pin C6)	Shutdown Switch, High-Coolant-Temperature
325	16	Lightbar (Pin C7)	Shutdown Switch, Low-Oil-Pressure
325	—	Low-Oil-Pressure Shutdown	
326	16	Flasher Relay (Coil Terminal 86)	Lightbar (Pin D13)
326	—	Turn Signal Flasher Timing (SSI Circuit)	
327	—	Engine Speed (Buffered Output)	
328	—	Road Speed (Buffered Output)	
329	—	Pyrometer Transducer (Positive Feed)	
330	—	Pyrometer Transducer (Negative Feed)	
331	—	Positive Data Link	
332	—	Negative Data Link	
333	—	Air Dryer Feed	
334	—	Dome Light Feed	
335	—	Cold Control Jumper	
336	—	Headlight Relay	Relay
337	—	Foglight Switch Feed	
338	—	Blower Motor Switch Feed	
339	—	Lightbar Feed	Battery
339	16	10 Amp Circuit Breaker	Lightbar (Pin D12)
340	—	Cold Control Switch Feed	
341	—	Marker Light	Trailer
342	—	Ammeter Feed	
343	—	Glow Plug Switch Feed	
344	—	Glow Plug Pressure Switch Feed	
345	—	Glow Plug Solenoid	Glow Plugs
346	—	Speaker Ground Circuit	

Circuit	Gauge	From	To
347	—	Shutter	Relay
348	—	Trinary Switch	Dual Temperature Switch (Shutters)
349	—	Shutter Solenoid	Dual Temperature Switch
350	—	Turn Signal Power Terminal	Lightbar
350	16	Flasher Relay (Terminal 87)	Lightbar (Pin D11)
351	—	Road Speed Fuel Solenoid	Lightbar
352	—	Circuit Breaker	Relay Contact (Delayed Shutdown)
353	—	Lightbar	Delay Shutdown Relay Coil
354	—	Shutter Solenoid	Transmission Temperature Switch
355	—	Fan Switch	Transmission Temperature Switch
356	—	Speed Control Power	
357	—	Fuel Solenoid Shutdown Delay Feed	
358	—	Trailer Relay Coil Feed	
359	—	Turn Signal Indicator Dimmer	
359	16	Headlight Switch (On)	Lightbar, Kysor VIP (Pin C9)
360	—	Lightbar	Engine Fan Power
360	16	Engine Fan Solenoid	Lightbar, Kysor VIP (Pin D3)
361	16	Engine Shutter Solenoid	Lightbar, Kysor VIP (Pin D4)
361	—	Lightbar	Radiator Shutter Power
362	—	Fuel/Water Separator Relay Coil Power	
363	—	Power Window Feed	
364	—	Power Window Up	
365	—	Power Window Down	
367	—	Lightbar	Water Temperature Gauge (B+ Terminal)
367	16	Lightbar, Kysor VIP (Pin D2)	Water Temperature Gauge (I Terminal)
368	16	Water Temperature Gauge (S Terminal)	Lightbar, Kysor VIP (Pin D10)
368	—	Lightbar	Water Temperature Gauge (Signal)
369	—	Lightbar	Water Temperature Gauge (Load)
369	16	Water Temperature Gauge (G Terminal)	Lightbar, Kysor VIP (Pin D9)
370	—	7-Way Auxiliary Feed	
371	—	Finder Minder Feed	
372	—	Trailer Heavy-Duty Power	
373	—	Fuel Solenoid Relay Coil Feed	
373	16	Fuel Solenoid Valve Relay (Terminal 86)	Lightbar, VIGIL II and Kysor VIP (Pin D6)
374	—	Starter Lock Relay	
375	—	Neutral	Daytime Running Lights
376	—	Antilock Power, Rockwell	

Specifications

Circuit	Gauge	From	To
377	—	Antilock Indicator, Rockwell/Bendix	
378	—	Antilock Solenoid, Rockwell/Bendix	
379	—	Parking Brake Switch	Daytime Running Light Module
379A	—	Daytime Running Light Parking Brake Switch	Alternating Headlight Switch
380	—	Daytime Running Lights Circuit Breaker Feed	
381	—	Daytime Running Lights	Battery Positive Terminal
382	—	Left Headlight High/Low Relay (Terminal 30)	Daytime Running Light Module
383	—	Right Headlight High/Low Relay (Terminal 87)	Daytime Running Light Module
384	—	Programming Enable	
385	—	Daytime Running Lights Control	
386	—	Left Headlight Low Beam	Daytime Running Lights
387	—	Right Headlight Low Beam	Daytime Running Lights
388	—	Hydraulic Brake Power	
389	—	Hydraulic Brake Battery (+ Terminal)	Relay Coil Feed
390	—	Hydraulic Brake Module Output	Brake Light Relay
391	—	Hydraulic Brake Relay Feed	
392	—	Hydraulic Brake Motor Pump Feed	
393	—	Flow Switch Input and Relay Coil Ground	
394	—	Hydraulic Brake Module Output	Parking Brake Light
394A	16	Ignition-Activated Relay	Parking Brake Switch Ground Supply
395	—	Hydraulic Brake Fluid Level Sensor	
396	—	Hydraulic Brake Module Output	Buzzer
397	—	Hydraulic Brake Door-Open Switch Signal	
398	—	Hydraulic Brake Coil Sense Signal	
399	14	Optional Circuit-Breaker/Fuse	Option Switch Supply
399A	14	Optional Switch	Option Switch Output
400	14	Optional Circuit-Breaker/Fuse	Option Switch Supply
400A	14	Optional Switch	Option Switch Output
401	14	Block Heater Switch (TCS Unit)	Engine Block Temperature Switch
401A	14	Engine Block Temperature Switch	Delay Timer (TCS Unit)
401B	14	TCS Unit (Blue Wire)	Trickle Charge Circuit Breaker (Electrical Panel)

Circuits 402 Through 419

Circuit	Gauge	From	To
Temp-A-Start (Circuits 402 through 402S3)			
402	12	25 Amp Circuit Breaker (Ignition-Controlled)	Module (Red Wire, Power In)
402A	12	Ignition Switch (Coil Terminal)	Module (Green Wire, Ignition On)

Circuit	Gauge	From	To
402B	12	Module (Blue Wire, Engine Run)	10 Amp Circuit Breaker (Ignition-Controlled)
402B	12	10 Amp Circuit Breaker (Ignition-Controlled)	Module (Yellow Wire, Auto. Start)
402C	12	Start Button	Module (Yellow Wire, Auto. Start)
402D	14	Module (Orange Wire, Oil Temperature)	Engine Oil-Temperature Sensor
402E	14	Module (White Wire, Oil Pressure)	Engine Oil-Pressure Switch
402G	12	Module (Black Wire, Ground)	Engine Ground
402H	12	Override Connector	Module (Purple Wire, Relay)
402J	14	Module (Brown Wire, Fast Idle)	Engine (Near the Fuel Solenoid)
402K	12	Module (Pink Wire, Battery/Key)	Ignition Switch (Battery Terminal)
402L1	14	Module (Gray Wire, Tilt 1)	Cab Tilt Switch
402L2	14	Cab Tilt Switch	Module (Gray Wire, Tilt 2)
402M	12	Ignition Switch (Battery Terminal)	Override Connector
402M	12	Override Connector	Master Relay (Terminal 87)
402M	14	Neutral Switch (N.C. Terminal)	Parking Brake Switch (N.C. Terminal)
402N	14	Tilt Switch (N.C. Terminal)	Neutral Switch (N.C. Terminal)
402N1	14	Module (Red Wire, Neutral 1)	Transmission Neutral Switch
402N2	14	Transmission Neutral Switch	Module (Brown Wire, Neutral 2)
402P	14	Module (Tan Interlock In)	Tilt Switch (N.C. Terminal)
402P1	14	Module (Tan Wire, Park 1)	Parking Brake Pressure Switch
402P2	14	Parking Brake Pressure Switch	Module (Tan Wire, Park 2)
402R	14	Master Relay (Terminal 86)	Module (Purple/White Wire, Key)
402S1	16	Bunk Thermostat (Temp-A-Start)	Control Module A
402S2	16	Bunk Thermostat (Temp-A-Start)	Control Module B
402S3	16	Bunk Thermostat (Temp-A-Start)	Control Module C
403	14	Circuit Breaker	Hewitt Elect. Fuel Restriction (Surveyor Four) Module (Red Wire)
403A	14	Hewitt Elect. Fuel Restriction (Surveyor Four) Module (Pink Wire)	Sensor (Engine-Mounted)
ARI Trip Recorder (Circuits 404 through 404S)			
404	16	Circuit Breaker (Ignition-Controlled)	Module (Green Wire)
404A	16	10 Amp Circuit Breaker	Module (Red Wire)
404B	14	Module (Blue Wire)	Front of Engine
404C	14	Module (Gray Wire)	Front of Engine
404D	14	Module (White/Blue Wire)	Rear of Transmission
404E	14	Module (White/Gray Wire)	Rear of Transmission
404F	14	Module (Yellow Wire)	Engine Thermostat Housing

Specifications

Circuit	Gauge	From	To
404G	14	Module (Black Wire)	Engine Block (Ahead of Bell Housing)
404H	14	Module (Brown Wire)	Engine (Rear of Fuel Pump)
404J	14	Module (Orange Wire)	PTO Switch
404K	14	Module (Yellow/Black Wire)	Two-Speed-Axle Switch
404L	16	Module (White Wire)	Stoplight Switch
404M	16	Trip Recorder G-Force Switch	Circuit Breaker
404N	16	Trip Recorder G-Force Input	G-Force Switch
404P	16	Trip Recorder Reset	Reset Switch
404R	16	Trip Recorder Reset Switch	Circuit Breaker
404S	16	Trip Recorder Alarm	Trip Recorder Module
Stemco Electronic Recorder (Circuits 405 through 405D)			
405	14	Transmission Sensor	Module (Yellow Wire)
405A	14	Transmission Sensor	Module (Brown Wire)
405B	14	RPM Sensor	Module (Violet Wire)
405C	14	RPM Sensor	Module (Green Wire)
405D	16	Module (Orange Wire)	Indicator Light
ARGO FMS 1330 Recorder (Circuits 405E through 405H)			
405E	14	Transmission Speed Sensor	ARGO Module
405F	14	Transmission Speed Sensor	ARGO Module
405G	14	Flywheel RPM Sensor	ARGO Module
405H	14	Flywheel RPM Sensor	ARGO Module
Fire Truck Equipment (Circuits 406 through 411B)			
406	14	15 Amp Circuit Breaker	Flashing Light Switch
406A	14	Flashing Light Switch	Alternating Flasher
406B	14	Flashing Light Switch	7-Way Junction Box
406C	14	Flashing Light Switch	Panel Indicator Light
406L	14	Alternating Flasher	Left Red Light (Above the Headlights)
406R	14	Alternating Flasher	Right Red Light (Above the Headlights)
407	14	15 Amp Circuit Breaker	Cross-Fire Light Switch
407	14	Cross-Fire Light Switch	Coiled-at-Grille Wire
407A	14	Cross-Fire Light Switch	Panel Indicator Light
408	14	15 Amp Circuit Breaker	Alley Light Switch
408A	14	Alley Light Switch	Panel Indicator Light
408L	14	Alley Light Switch	Left Roof Wire

Circuit	Gauge	From	To
408R	14	Alley Light Switch	Right Roof Wire
409	12	25 Amp Circuit Breaker	Bin Light Switch
409	12	Bin Light Switch	7-Way Junction Block
409A	12	Bin Light Switch	Panel Indicator Light
409B	14	7-Way Junction Block	Door Ajar Indicator Light
410	14	Roof Wire	Siren Speakers (Behind the Dash)
411	14	15 Amp Circuit Breaker	Canopy/Interior Light Switch
411A	14	Switch	Terminal Block (Right Side of Tunnel)
411A	14	Terminal Block (Right Side of Tunnel)	7-Way Junction Block
411B	14	Switch	Panel Indicator Light
412	16	Tachometer Gauge (Signal Terminal)	ISSPRO Module (Signal Terminal)
412A	16	ISSPRO Module (N.O. Terminal)	Buzzer/Quad-Diode (Input Terminal)
412B	16	ISSPRO Module (N.O. Terminal)	Indicator Light, or Buzzer/Quad-Diode
412C	16	Circuit Breaker (Ignition-Controlled)	ISSPRO Module (Common and Positive Terminals)
412D	16	Tachometer Gauge (Ground Terminal)	ISSPRO Module (Ground Terminal)
412E	16	Speedometer Gauge (Signal Terminal)	ISSPRO Module (Signal Terminal)
412F	16	Speedometer Gauge (Ground Terminal)	ISSPRO Module (Ground Terminal)
414	16	Circuit Breaker (Ignition-Controlled)	GEOSTAR Module
414A	16	Circuit Breaker (Constant-Power)	GEOSTAR Module
High Idle Governor (Circuits 415 through 415C)			
415	14	Governor Toggle Switch	Governor Solenoid Valve (Engine-Mounted)
415	14	Circuit Breaker (Ignition-Controlled)	Governor Solenoid Valve (Electrical Panel)
415A	14	Parking-Brake Pressure Switch	Toggle Switch
415B	14	Circuit Breaker (Ignition-Controlled)	Parking-Brake Pressure Switch
415C	14	Governor Solenoid Valve	Oil Pressure Switch, Turbo Conveyor
416	14	15 Amp Circuit Breaker	12V Television
416A	14	15 Amp Circuit Breaker	12V Refrigerator
417	16	10 Amp Circuit Breaker (Constant-Power)	Mobile Phone Harness (Red Wire)
417A	16	10 Amp Circuit Breaker (Ignition-Controlled)	Mobile Phone Harness (Green/Black Wire)
418	14	15 Amp Circuit Breaker	Left Toolbox Light
419	14	15 Amp Circuit Breaker	Right Toolbox Light

Specifications

Circuits 420A Through 505

Circuit	Gauge	From	To
Military Vehicle (Circuits 420A through 422C)			
420A	—	Blackout Light Switch (Pin A)	
420AA	12	Stoplight Switch (Supply)	Stoplight Circuit Breaker, Military Blackout Light
420B	—	Blackout Light Switch (Pin B)	Panel Light Dimmer (Bright Power)
420C	—	Blackout Light Switch (Pin C)	Stoplight/Dome-Light Switch (Power)
420D	—	Blackout Light Switch (Pin D)	Blackout Drive Light Control
420E	—	Blackout Light Switch (Pin E)	Blackout Tail/Marker Light Control
420F	—	25 Amp Circuit Breaker	Blackout Light Switch (Power)
420H	—	Blackout Light Switch (Pin H)	Tail/Marker Light Control
420J	—	Blackout Light Switch (Pin J)	Turn Signal Control Relay
420K	—	25 Amp Circuit Breaker	Blackout Power Switch (Pin C)
420L	—	25 Amp Circuit Breaker	Panel Light Dimmer (Dim Power)
420M	—	Blackout Light Switch (Pin M)	Headlight Power Relay (Coil)
420N	—	Blackout Light Switch (Pin N)	Blackout Stoplight Relay (Coil)
420P	—	15 Amp Circuit Breaker (24V)	24V Tail/Marker Light Supply Relay
420PA	—	24V Tail/Marker Light Supply Relay	24V Tail/Marker Light (Power)
420R	—	15 Amp Circuit Breaker (24V)	24V Blackout Drive Light Relay (Power)
420RA	—	Blackout Drive Light Relay (Power)	24V Blackout Drive Light (Power)
420S	—	15 Amp Circuit Breaker (24V)	24V Stoplight Relay (Power)
420SA	—	Stoplight Relay (Power)	24V Stoplight (Power)
420T	—	15 Amp Circuit Breaker (24V)	24V Turn Signal Light Relay (Power)
420TL	—	Left Turn Signal Relay	24V Left Turn Signal Light (Power)
420TR	—	Right Turn Signal Relay	24V Right Turn Signal Light (Power)
420V	—	15 Amp Circuit Breaker (24V)	Blackout Marker Light Relay (Supply)
420VA	—	Blackout Marker Light Relay	24V Blackout Marker Light (Power)
420W	—	15 Amp Circuit Breaker (24V)	24V Blackout Stoplight Relay (Supply)
420WA	—	24V Blackout Stoplight Relay (Supply)	Blackout Stoplight (Power)
421A	—	24V Blackout Marker Light Relay (Power)	Blackout Marker Light Receptacle (Pin A)
421AA	—	15 Amp Circuit Breaker (24V)	24V Blackout Marker Light Relay (Power)
421B	—	24V Left Flasher Relay	Left Turn Light Receptacle (Pin B)
421BA	—	15 Amp Circuit Breaker (24V)	24V Left Turn Relay (Power)
421C	—	24V Blackout Marker Light Relay	Blackout Marker Light Receptacle (Pin C)
421D	—	Vehicle Ground	Ground Receptacle (Pin D)
421D	—	12V On/Off Switch (Aux. Heater)	Fuel Pump (Aux. Heater)
421E	—	24V Auxiliary Heater	24V Indicator Light, Flame Detector
421E	—	24V Taillight Relay	Taillight Receptacle (Pin E)

Specifications

Circuit	Gauge	From	To
421EA	—	15 Amp Circuit Breaker (24V)	24V Taillight Relay (Power)
421F	—	24V Blackout Stoplight Relay (Power)	Blackout Stoplight Receptacle (Pin F)
421F	—	15 Amp Circuit Breaker (24V)	24V Blackout Stoplight Relay (Power)
421H	—	24V Blackout Taillight Relay	Blackout Taillight Receptacle (Pin H)
421J	—	24V Right Flasher Relay	Right Turn Light Receptacle (Pin J)
421JA	—	15 Amp Circuit Breaker (24V)	Right Turn Relay (Power)
421K	—	24V Blackout Drive Light Relay	Auxiliary Power Receptacle (Pin K)
421L	—	Vehicle Ground	Ground Receptacle (Pin L)
421M	—	24V Right Stoplight Relay	Right Stoplight Receptacle (Pin M)
421N	—	24V Left Stoplight Relay	Left Stoplight Receptacle (Pin N)
421P	—	24V Blackout Drive Light Relay	Blackout Drive Light (Power)
421PA	—	15 Amp Circuit Breaker (24V)	24V Blackout Drive Light Relay (Power)
422	—	12V On/Off Switch (Aux. Heater)	Select/Relay Coil Switch (Power)
422A	—	15 Amp Circuit Breaker (24V)	24V Auxiliary Heater (Constant Power)
422B	—	15 Amp Circuit Breaker (24V)	24V Auxiliary Heater (Run Power)
422C	—	15 Amp Circuit Breaker (24V)	24V Auxiliary Heater (High Power)
424	12	Headlight Wipe/Wash Switch	Circuit Breaker
424A	12	Headlight Wipe/Wash Motor Assembly	Headlight Wipe/Wash Switch
425	14	Battery Cutoff Switch Solenoid	Battery Cutoff Dash Switch
425A	12	Cutoff Switch Bypass, Constant Fuse Supply	12V Battery
425B	12	Constant 12V Cab Auxiliary Power	Battery Fuse
426	14	Inside/Outside-Air Indicator Light Switch	Circuit Breaker (Ignition-Controlled)
427	—	Satellite Tracking Unit Power	Circuit Breaker (Constant-Power)
427A	—	Satellite Tracking Unit Power	Circuit Breaker (Ignition-Controlled)
427B	—	Satellite Unit Stoplight Signal	Stoplight Switch Output
427C	16	Satellite Message Indicator Light Signal	Satellite Tracking Module
427D	16	Satellite Indicator Light Signal	Disable Switch
427E	16	Panic Switch Signal	Satellite Tracking Module
427F	16	Panic Switch Return	Satellite Tracking Module
428	14/16	Battery Isolator Relay Coil	Oil Pressure and Battery Boost Switch
428A	14	Battery Isolator Relay Coil	Power Supply
429	16	Indicator-Light/Buzzer (Pyro)	Alarm Output Gauge (Pyro)
430	14	Wiper Heater Switch (Supply)	Circuit Breaker (Ignition-Controlled)
430A	14	Wiper Heater Relay Coil (Supply)	Wiper Heater Switch
430B	14	Wiper Heater Relay (Supply)	Circuit Breaker (Constant-Power)
430C	14	Wiper Heater (Supply)	Switch/Relay

Specifications

Circuit	Gauge	From	To
431	—	Flame Start System	
431A	14/16	Alternator or Oil-Pressure Switch	Engine Run Signal to Module
431B	10	Control Module	Glow Plug Igniter (Power)
431C	16	Control Module	Indicator Light, Flame-Start
431D	14/16	Control Module	Fuel Solenoid Valve (Supply)
431E	14/16	Control Module	Engine Temperature Signal Sensor
431F	14/16	Ignition Switch Circuit	Ignition Signal to Module
431G	10	Circuit Breaker/Fuse	Module (Main 12V Supply)
431H	14/16	Ground	Module (Ground)
431J	14/16	Starter Circuit	Starter Signal to Module
431K	12/14	Circuit Breaker (Constant 12V Power)	Oil-Pressure Switch (Power)
432	12	Power Seat (Supply)	Fuse/Breaker/Relay
433	16	Fuse/Circuit-Breaker	Engine Data Display (Constant Power)
433A	16	Ignition Fuse/Circuit-Breaker	Engine Data Display (ignition Power)
433B	18	Logger Box	Data Hub, Transmit to PC
433C	18	Logger Box	Data Hub, Receive from PC
433D	18	Logger Box	Data Hub, Interface, ACTV
433E	18	Logger Box	Data Hub, Common Ref for RS232
433F	18	Logger Box	Data Bus RS485+
433G	18	Logger Box	Data Bus RS485–
433H	18	Logger Box	+12V Accessories Supply
433J	18	Logger Box	Accessories Common Ref
434	16	Fuse/Circuit-Breaker	ECAS ECU Power, Pin-1
434A	16	Stop Light Circuit	ECAS Service Brake Signal
434B	16	ECAS ECU	Indicator Light Signal, Failure, ECAS
434C	16	Switch	Indicator Light Signal, ECAS On/Off
434D	16	ECAS ECU	ECAS Hand Control Data Signal
434E	16	ECAS ECU	ECAS Hand Control Clock Signal
434F	16	ECAS ECU	ECAS Solenoid Valve, Pin-42
434G	16	ECAS ECU	ECAS Solenoid Valve, Pin-43
434H	16	ECAS ECU	ECAS Solenoid Valve, Pin-41
434J	16	Distance Sensor	ECAS Distance Signal
434K	16	ECAS Speed Sensor, Pin-1	ECAS Speed Signal, Pin-20
434L	16	ECAS Speed Sensor, Pin-2	ECAS Speed Signal, Pin-22
434M	16	ABS System	ECAS ATC Signal
434N	16	Switch	ECAS Load Transfer Switch Signal
435	16	Switch, Seat Belt	Indicator Light Signal, Seat Belt Warning

Circuit	Gauge	From	To
435A	16	Ignition Fuse/Circuit-Breaker	Indicator Light Power, Seat Belt Warning
436	16	Ignition Fuse/Circuit-Breaker	Camera/Monitor Supply
436A	16	Camera Switch Box	Right-Hand Turn Constant Power
436B	16	Backup Light/Right-Hand Turn Signal	Monitor On Signal
500	—	Brake Pedal Input	Hydraulic Brake Module
501	—	Buzzer	
502	—	Low-Cylinder-Level Sensor	Indicator
503	—	Temperature Switch	Glow Plug
504	—	Battery Charge Connector	
505	—	Sensor (Optional Gauge)	

Caterpillar Electronic Engines (Circuits C1 through C37)

Circuit	Gauge	From	To
C1	16	ECM (Parking Brake)	Parking Brake Switch
C2	14	Cruise Set/Resume Switch (Terminal E)	Cruise Set/Resume Switch (Terminal B)
C2	14	Cruise Set/Resume Switch (Terminal B)	Cruise On/Off Switch (Terminal C)
C2	14	Cruise On/Off Switch (Terminal C)	PEEC Ground Splice
C2	14	ECM, Speed Buffer	PEEC Ground Splice
C2	14	ECM, Throttle Sensor	PEEC Ground Splice
C2	14	ECM (Ground)	PEEC Ground Splice
C2	12	PEEC Ground Splice	Starter (Ground Terminal)
C3	14/12	PEEC Crank Relay	ECM, PEEC Crank Power
C3A	12/14	Circuit Breaker	PEEC Crank Power Supply Relay
C4	14	ECM, Vehicle Speed	Vehicle Speed Sensor Buffer
C5	14	ECM, Throttle Position	Throttle Position Sensor
C6	14/16	ECM, Cruise On	Cruise On/Off Switch
C7	14/16	ECM, Brake/Clutch	Service Brake Cutoff Switch
C7A	16	Brake/Retarder Switch	Clutch Switch
C7B	14/16	Jake Brake Switch (Forward Cylinder)	Jake Brake Switch (Aft Cylinder)
C7C	14/16	Brake Switch	Retarder Switch
C8	14/16	ECM, Cruise Resume/Coast	Cruise Set/Resume Switch (Terminal A)
C9	14/16	ECM, Cruise Set/Accelerate	Cruise Set/Resume Switch (Terminal B)
C21	14/16	Power Relay	ECM Power Splice
C21	14/16	ECM Power Splice	ECM, Throttle Sensor
C21	14/16	ECM Power Splice	ECM, Speed Buffer
C21	14/16	ECM Power Splice	ECM, Power Input
C32	14/16	ECM Ground	Check-Engine Switch

Specifications

Circuit	Gauge	From	To
C35	14/16	ECM, Select	Check-Engine Switch
C37	14/16	ECM, Diagnostic Light	Warning Light, Check-Engine

Detroit Diesel Electronic Engines (Circuits D115 Through D953C)

Circuit	Gauge	From	To
D115	18	ECM	Coolant Level Probe
D150	12/16	12V Battery (– Terminal)	ECM
D173	16/14	Coolant Level Probe	Control Module (Coolant Level)
D240	12	12V Battery (+ Terminal)	DDEC Fuse
D240A	12/16	DDEC Fuse	ECM
D241	12	12V Battery (+ Terminal)	DDEC Fuse
D241A	12/16	DDEC Fuse	ECM
D417	18	DDEC Throttle	ECM (Throttle Signal)
D419	16	Warning Light, Check-Engine	ECM (Check-Engine, Ground)
D439	12	Ignition Switch	ECM, Coolant Level Probe
D439A	16	Circuit Breaker (Ignition-Controlled)	Diagnostic Connector
D439B	16	Circuit Breaker (Ignition-Controlled)	Clutch Switch (Cruise Control)
D439C	16	Clutch Switch (Cruise Control)	Service Brake Switch (Cruise Control)
D439D	16	Service Brake Switch (Cruise Control)	Parking Brake Switch (Cruise Control)
D439E	16	Parking Brake Switch (Cruise Control)	Cutout Relay (Cruise Control)
D439F	16	Neutral Supply Switch	Parking Brake Switch
D439G	16	Relay Coil	Neutral Switch
D451	16	Diagnostic Connector Request Switch (Signal Terminal)	ECM, Diagnostic Request
D505	16/18	Diagnostic Connector	ECM Tachometer Drive (Signal Terminal)
D508	16/18	ECM, Idle Position (Ground Terminal)	Throttle Cutout Relay
D509	16	Warning Light (Engine Stop)	ECM, Engine Stop (Ground Terminal)
D510	16/18	ECM, PTO Control (Signal Terminal)	Parking Brake Switch
D510C	16	Parking Brake Switch	PTO/Fast Idle Switch
D510D	16	PTO/Fast Idle Switch	Potentiometer Resistor
D524	16/18	ECM Power-Control Timer (Signal Terminal)	Shutdown Relay/Switch
D524A	16	Circuit Breaker	Engine Timer Switch
D524B	16	Engine Timer Switch	Engine Timer Relay
D524C	16	Ignition Circuit Breaker Diode	Engine Timer Latch Relay
D524D	16	Oil Pressure Switch (Engine Timer)	Engine Timer Relay
D524E	16	Parking Brake Switch (Engine Timer)	Oil Pressure Switch (Engine Timer)
D528	16/18	Shutdown Override Switch	ECM, Shutdown Override (Signal Terminal)

Specifications

Circuit	Gauge	From	To
D531	16/18	Brake Switch (Cruise Control)	ECM, Brake/Clutch (On)
D531	16/18	Clutch Switch (Cruise Control)	ECM, Brake/Clutch (On)
D531	16/18	Cruise Control Relay	ECM, Brake/Clutch (On)
D541	16	Cruise Switch (Set/Coast)	ECM, Cruise Set/Coast (On)
D542	16	Cruise Switch (Set/Coast)	ECM, Cruise Set/Coast (Off)
D543	16/18	Brake Switch (Cruise Control)	ECM, Brake/Clutch (Off)
D543	16/18	Clutch Switch (Cruise Control)	ECM, Brake/Clutch (Off)
D543	16/18	Cruise Control Relay	ECM, Brake/Clutch (Off)
D544	16	Cruise Switch (Resume/Accelerate)	ECM, Resume/Accelerate (Off)
D545	16	Cruise Switch (Resume/Accelerate)	ECM, Resume/Accelerate (On)
D555	16	Indicator Light (Cruise On)	ECM, Cruise On (Ground)
D900	16/18	Diagnostic Connector	ECM, Data Link (+ Terminal)
D901	16/18	Diagnostic Connector	ECM, Data Link (– Terminal)
D902	16/18	Diagnostic Connector	ECM, Crank Position (+ Terminal)
D908	16/18	ECM, PWM Throttle (Signal Terminal)	ATEC Modulator Adapter Module
D916	18	ECM, 5V Throttle Sensor Supply	Throttle Pedal Sensor (Fast)
D952	18	ECM, Sensor Ground	Throttle Pedal Sensor (Idle)
D953	16	Misc. Elect. Ground Circuit	Battery Ground
D953A	16	Cruise-On Signal Ground	Cruise On/Off Switch
D953B	16	Cruise On/Off Switch Supply	Cruise Interrupt Relay
D953C	16	Engine Brake Dash Switch Input	Engine Brake Foot Switch Output

Allison Electronic Automatic Transmission (Circuits E02 Through E124)

Circuit	Gauge	From	To
E02	14	ATEC Power Relay	ECU Power (Off)
E02A	12	Ignition Switch (Power)	ATEC Power Relay Diode
E02B	14	Circuit Breaker	ATEC Power Relay
E02C	14	Ignition Power Diode	Relay, ATEC Power/Diode, Transmission Check
E03	14	Circuit Breaker	ECU, ATEC Power, and Oil Pressure Switch
E03A	14	ATEC Oil Pressure Diode Switch	Relay, Transmission Check Oil
E05	14/16	ECU, MPH Signal	Speedometer Gauge (Circuit No. 117)
E08	14/12	ECU Ground	Battery Ground
E09	14/16	ECU Ground	Battery Ground
E14	14/16	ECU Reverse (Ground Signal)	Backup Light Relay
E15	14/16	ECU, Transmission Check (Ground Signal)	Transmission Check Relay
E16	14/16	ECU, Test Mode	Transmission Check Button
E23	14/16	ECU, Special Power	ATEC Power Relay

Specifications

Circuit	Gauge	From	To
E25	14/16	ECU, Selector (Power)	ATEC Power Relay
E30	14/16	ECU, Selector (Ground)	12V Battery, (– Terminal)
E31	14/16	ECU, Neutral (Ground Signal)	Neutral Start Relay
E33	14/16	ECU, Selector (Dimmer)	Dash Panel Dimmer Light
E34	14/16	ECU, Selector (Ground)	12V Battery, (– Terminal)
E43	14/16	Transmission Check Relay	Warning Light, Transmission Check (Ground)
E104	16/18	ATEC Modulator Harness	DDEC II Adapter Module (Blue Wire)
E106	16/18	ATEC Modulator Harness	DDEC II Adapter Module (Black Wire)
E114	16	Auto Transmission Output Signal (Terminal 1) (Programmable)	World Transmission Electrical Control Unit
E124	16/18	ATEC Modulator Harness	DDEC II Adapter Module (Red Wire)
E124	16	Auto Transmission Retarder-On Signal	World Transmission Electrical Control Unit

Cummins Electronic Engines (Circuits N2 Through N27)

Circuit	Gauge	From	To
N2	18	ECM, Cruise On (Signal Terminal)	Cruise On/Off Switch
N3	18	ECM, Vehicle Speed Sensor (Input Terminal)	MPH Sensor
N4	18	ECM, Clutch Switch (Input Terminal)	Clutch Switch
N5	18	ECM, C-Brake (Input A Terminal)	2-Cylinder C-Brake Switch
N6	18	ECM, Throttle Switch (Input Terminal)	Throttle Switch
N7	18	ECM, Digital Vehicle Speed (Return)	MPH Sensor
N8	18	ECM, Data Link (Inverted)	Data Link Connector
N10	18	ECM, + 5 VDC Supply	Clutch Switch (Common)
N10	18	ECM, + 5 VDC Supply	Brake Pressure Switch (Common)
N10	18	ECM, + 5 VDC Supply	Throttle Switch (Common)
N10	18	ECM, + 5 VDC Supply	C-Brake Switch (Common)
N12	18	ECM, Cruise Set/Coast	Cruise Set/Coast Switch
N13	18	ECM, Brake Pressure (Input Terminal)	Brake Pressure Switch
N13A	18	ECM, Cruise Brake Switch Signal	Cruise Interrupt Relay
N14	18	ECM, Engine Position (Input Terminal)	Engine Position Sensor
N15	18	ECM, C-Brake (Input B)	4-Cylinder C-Brake Switch
N16	18	ECM, Stop Engine Light (Red)	Stop Engine Warning Light
N21	18	ECM, Diagnostic Test (Input)	Check Engine Switch
N22	18	ECM, Cruise Resume/Accelerate	Resume/Accelerate Switch
N23	18	ECM, Engine Position (Return)	Engine Position Sensor
N25	18	ECM, Check Engine Light (Yellow)	Check Engine Warning Light
N27	18	ECM, Data Link (Non-Inverted)	Data Link Connector

Rockwell WABCO Antilock Brake System (Circuits X1 Through XZS)

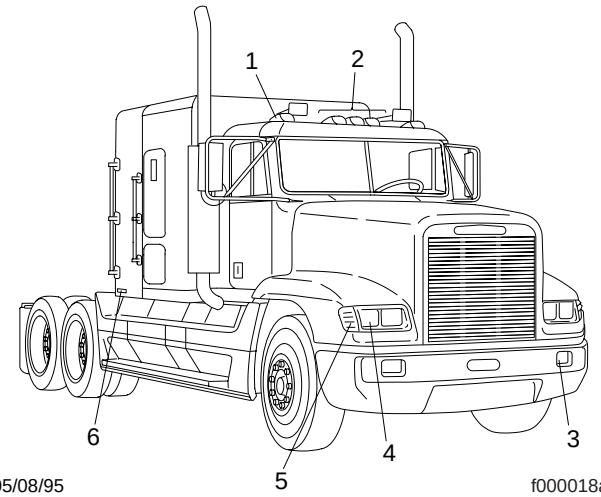
Circuit	Gauge	From	To
X1	14	ECU (Pin 1)	VR1 Relay (Pin 87)
X1B	14	Circuit X1	Engine Brake Relay (Pin 86)
X2	16	ECU (Pin 2)	Left Drive Slip Solenoid Valve
X3	18	ECU (Pin 3)	Right Front/Rear Solenoid Valve (Brown Wire)
X4	18	ECU (Pin 4)	Right Rear/Rear Solenoid Valve (Brown Wire)
X5	18	ECU (Pin 5)	Right Rear/Rear Solenoid Valve (Blue Wire)
X6	18	ECU (Pin 6)	Right Forward Solenoid Valve (Brown Wire)
X7	18	ECU (Pin 7)	Right Forward Solenoid Valve (Blue Wire)
X8	16	ECU (Pin 8)	VR1 Relay (Pin 86)
X8L	16	Circuit 8	Warning Light Relay (Pin 86)
X9	16	ECU (Pin 9)	5 Amp Circuit Breaker
X10	18	ECU (Pin 10)	Right Front/Rear Solenoid Valve (Blue Wire)
X11	18	ECU (Pin 11)	Engine Brake Relay (Pin 85)
X12	16	ECU (Pin 12)	Indicator Light, Wheel Slip
X13	18	ECU (Pin 13)	Right Front/Rear Sensor (Brown Wire)
X14	18	ECU (Pin 14)	Left Front/Rear Sensor (Black Wire)
X15	18	ECU (Pin 15)	Left Forward Sensor (Black Wire)
X16	18	ECU (Pin 16)	Right Rear/Rear Sensor (Brown Wire)
X17	18	ECU (Pin 17)	Right Forward Sensor (Brown Wire)
X18	18	ECU (Pin 18)	Left Rear/Rear Sensor (Black Wire)
X19	14	ECU (Pin 19)	VR2 Relay (Pin 87)
X20	16	ECU (Pin 20)	Right Drive Slip Solenoid Valve
X21	18	ECU (Pin 21)	Left Rear/Rear Solenoid Valve (Brown Wire)
X22	18	ECU (Pin 22)	Left Rear/Rear Solenoid Valve (Blue Wire)
X23	18	ECU (Pin 23)	Left Forward Solenoid Valve (Brown Wire)
X24	18	ECU (Pin 24)	Left Forward Solenoid Valve (Blue Wire)
X25	16	ECU (Pin 25)	VR2 Relay (Pin 86)
X26	16	ECU (Pin 26)	Warning Light Relay (Pin 30)
X26L	16	Circuit 26	Warning Light, Tractor ABS
X27	16	ECU (Pin 27)	Ground
X28	18	ECU (Pin 28)	Left Front/Rear Solenoid Valve (Brown Wire)
X29	18	ECU (Pin 29)	Left Front/Rear Solenoid Valve (Blue Wire)
X30	18	ECU (Pin 30)	Right Front/Rear Sensor (Black Wire)
X31	18	ECU (Pin 31)	Left Front/Rear Sensor (Brown Wire)
X32	18	ECU (Pin 32)	Left Forward Sensor (Brown Wire)
X33	18	ECU (Pin 33)	Right Rear/Rear Sensor (Black Wire)

Specifications

Circuit	Gauge	From	To
X34	18	ECU (Pin 34)	Right Forward Sensor (Black Wire)
X35	18	ECU (Pin 35)	Left Rear/Rear Sensor (Brown Wire)
X36B	14	Stoplight Switch	Trailer Stoplight Relay (Pin 85)
X36K	14	Circuits X36T and X36K	Trailer Stoplight Relay (Pin 87)
X36P	12	25 Amp Circuit Breaker	Trailer Stoplight Relay (Pin 30)
X36T	12	Circuits X36K and XAK	7-Way Junction Block (Stoplights)
X71	16	5 Amp Circuit Breaker	Relays (Pin 85)
X71D	16	Ignition Switch (Coil Terminal)	Lockout Relay (Pin 30)
X71P	16	Lockout Relay (Pin 87A)	5 Amp Circuit Breaker
X81C	16	10 Amp Circuit Breaker (Ignition-Controlled)	Warning Lights
X121	16	Engine Brake Inter-Tie	In-and-Out Relay
XAK	16	Information Module (Pin AK)	Circuits X36T and X36K
XBAT	8	30 Amp or 90 Amp Circuit Breaker	Circuit Breaker Bus
XGND	12	4-Way Junction Block	Main Ground
XIL	16	Information Module (Pin IL)	Warning Light, "No Trailer ABS"
XOV	16	Information Module (Pin OV)	Ground
XRK	12	Information Module (Pin RK)	Trailer Stoplights Relay (Pin 87A)
XR1	14	15 Amp Circuit Breaker	VR1 Relay (Pin 30)
XR2	14	15 Amp Circuit Breaker	VR2 Relay (Pin 30)
XT1	12	25 Amp Circuit Breaker	WABCO Trailer Receptacle No. 1
XT2	16	Information Module (Pin UA)	WABCO Trailer Receptacle No. 2
XT5	16	Warning Light, Trailer ABS	WABCO Trailer Receptacle No. 5
XUS	16	Information Module (Pin UES)	5 Amp Circuit Breaker
XZS	16	Information Module (Pin ZS)	5 Amp Circuit Breaker

General Information

Figure 1 shows the exterior lighting system of the 120 Conventional. **Figure 2** shows the exterior lighting system of the COE. In the front of the vehicle there are headlights, turn-signal lights, and side-marker lights.



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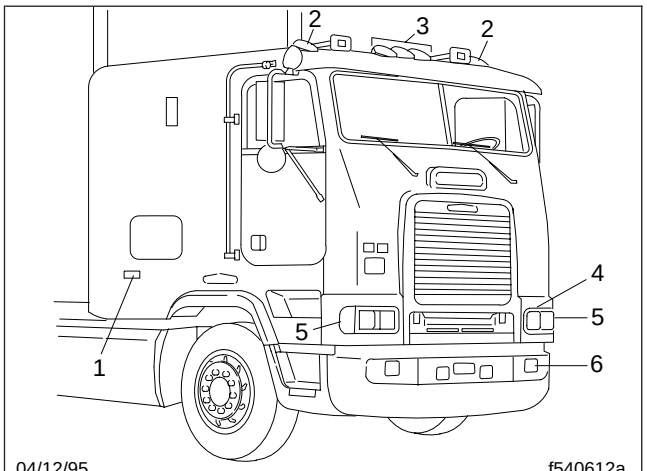
1. Clearance Light
2. Identification Lights
3. Road Light
4. Dual Headlights
5. Turn Signal/Side-Marker Lights
6. Intermediate Turn Signal Light

Fig. 1, 120 Conventional Lights

For vehicles built to operate in Canada, switching on the ignition and releasing the parking brakes automatically activates the headlight low beams (on later model vehicles) or high beams (on earlier models) at half voltage as daytime running lights. The daytime running lights will operate until the parking brakes are applied. Switching on the regular headlights will override the daytime running lights. The vehicle cannot be driven unless either the headlights or daytime running lights are activated.

Daytime running lights are optional on vehicles in the United States.

On the roof of the cab there are clearance and identification lights. At the rear of the vehicle there are taillights, stoplights with turn signals, and optional utility lights. Optional road (fog) lights are mounted in the front bumper.



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1. Side-Marker Light and Reflector
2. Clearance Light
3. Identification Lights
4. Dual Headlights
5. Turn Signal Light
6. Road Light

Fig. 2, COE Lights

NOTE: For vehicles built to operate in the United States, the low-beam headlights must be turned on before the road lights can be turned on. The road lights won't go on if the high-beam headlights are already on, and switching from low beams to high beams will switch off the road lights. For vehicles built to operate in Canada, as of June 29, 1990, the taillights and clearance lights must be on before the road lights can be turned on. Unless the headlight switch is all the way up (headlights, taillights, clearance lights, marker lights, and panel lights on) or down (taillights, clearance lights, marker lights, and panel lights on), the road light switch will not turn on the road lights.

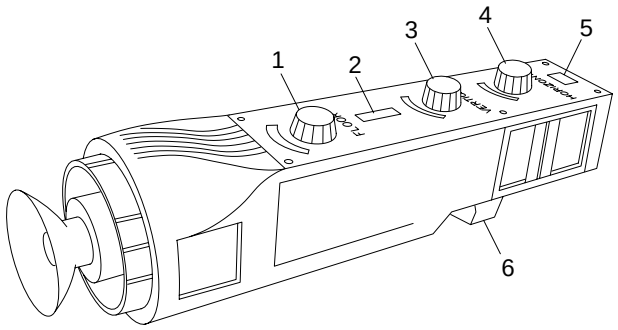
Inside the cab are dome lights with high-intensity reading lights, and an instrument panel that features fully lighted gauges and labels for switches and controls. The steering column-mounted turn-signal switch has the headlight dimmer switch built into it. In the bunk or sleeper are accessory lights and high-intensity reading lights. Baggage compartments may be equipped with accessory lights.

On the dash is a marker light interrupt switch designed to allow the driver of the vehicle to blink the

General Information

marker lights without turning off the headlights. When activated, the marker, taillight, front turn signal, and dash panel lights all blink. The marker light interrupter operates only with the headlights ON; it will not operate when only the parking lights are on.

Headlight aim can be checked and adjusted most easily, using the Hopkins mechanical aimer. The aimer attaches to the headlight with a vacuum cup activated by pushing the piston handle located on the base of the aimer. See **Fig. 3**.



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1. Floor Slope Dial
2. Level Vial
3. Vertical Dial
4. Horizontal Dial
5. Split Image View Port
6. Piston Handle

Fig. 3, Headlight Aimer

To adjust the horizontal aim, turn the horizontal adjusting screw on the headlight until the split image aligns in the split image view port. To adjust the vertical aim, turn the vertical adjusting screw on the headlight until the bubble is centered in the level vial.

Headlight Replacement

DUAL RECTANGULAR HEADLIGHT

(See Fig. 1 or Fig. 2)

1. Remove the headlight bezel retaining screws, and remove the bezel.

   On FLD Conventionals, disconnect the turn-signal wires, if necessary.

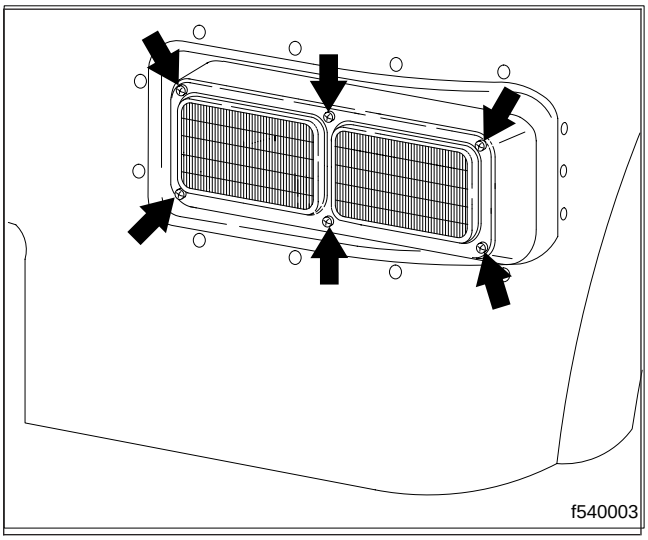


Fig. 1, Headlight Bezel Removal, COE

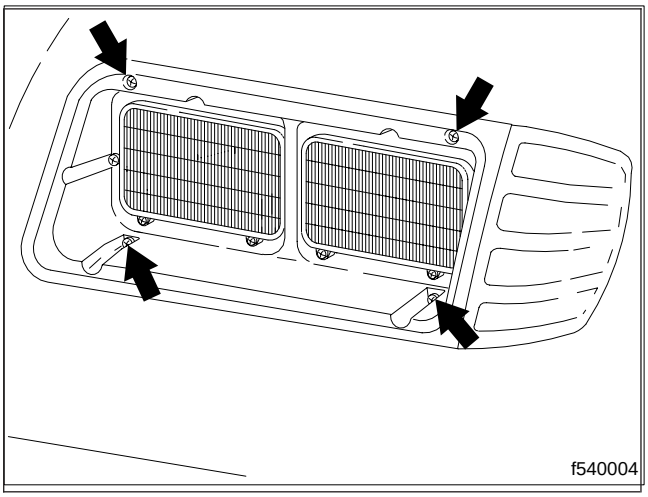


Fig. 2, Headlight Bezel Removal, FLD Conventional

2. Remove the retaining ring screws from one or both lamps.
3. Remove the retaining rings.
4. Remove the lamp from the housing; disconnect the wiring connector from the back of the lamp.
5. To provide corrosion protection, coat the prongs and base of the new lamp with dielectric grease. Refer to the approved electrical lubricants table in **Specifications 400.**
6. Push the wiring connector onto the prongs at the rear of the new lamp.
7. Place the new lamp in the headlight housing; position it so that the embossed number in the lamp lens is on the top.
8. Place the retaining ring over the lamp and install the retaining ring screws; tighten them securely.
9. Check and, if necessary, adjust the headlight aim as described in the electrical section in the vehicle maintenance manual.
10. Install the headlight bezel; secure it with the retaining screws. Connect the turn-signal wiring.

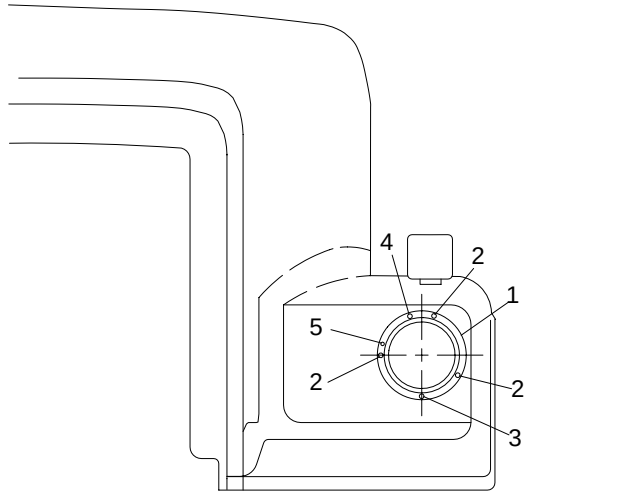
SINGLE ROUND HEADLIGHT

(See Fig. 3)

1. Remove the four screws holding the headlight bezel, and remove the bezel.

   On FLD 112 Conventionals, remove the one screw holding the headlight bezel; then remove the bezel.
2. Remove the three screws holding the retaining ring.
3. Remove the headlight and unplug the wiring connector from the back of the headlight.
4. To provide corrosion protection, coat the prongs and base of the new lamp with dielectric grease. Refer to the approved electrical lubricants table in **Specifications 400.**
5. Plug the wiring connector onto the headlight terminals.
6. Place the new headlight into the headlight bucket; then, place the retaining ring over the headlight.
7. Install the three retaining ring mounting screws.
8. Install the bezel; then, install the four bezel retaining screws.

Exterior Light Replacement



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1. Headlight Bezel
2. Retaining Ring Mounting Screw (3 qty.)
3. Bezel Retaining Screw
4. Headlight Aim Adjustment Screw, Vertical
5. Headlight Aim Adjustment, Horizontal

Fig. 3, Single Round Headlight, FLD 112 Conventional

On FLD 112 Conventionals, install the bezel; then install the one bezel retaining screw.

9. Check and, if necessary, adjust the headlight aim as described in the electrical section in the vehicle maintenance manual.

Turn/Side-Marker Light

1. On FLD Conventionals, remove the headlight bezel retaining screws. Disconnect the turn-signal wires, and remove the bezel.

   On COEs, remove the lens-to-housing attaching screws.

2. On FLD Conventionals, remove the socket from the turn-signal assembly. Remove the bulb from the socket.

   On COEs, remove the bulb from the socket.

3. To provide corrosion protection, coat the prongs and base of the new bulb with dielectric grease. Refer to the approved electrical lubricants table in **Specifications 400.**

4. Check for proper operation.

5. On COEs, install the lens and attaching screws.

   On FLD Conventionals, install the socket, connect the wiring, then install the headlight bezel; secure the bezel with the retaining screw(s).

Road Light Replacement

Road Light, Marchal

IMPORTANT: When replacing Marchal road light bulbs, avoid touching the glass part of the new bulb. Natural skin oils, present on even recently washed hands, will remain on the glass. This oil will prevent heat from dissipating. The increased heat inside the bulb will make the filament burn out prematurely.

1. Remove the two screws attaching the lens and reflector assembly to the light housing.

NOTE: Never remove the lens from the reflector. The reflector's aluminum inner surface would be seriously damaged by any dust or other contaminants. Wiping the reflector surface to clean it would also seriously reduce the road light's brightness.

2. A cloth-wrapped retaining wire holds the ceramic bulb socket into the back of the lens and reflector assembly. That wire is secured by two hooks on the back of the reflector. Remove the wire by unhooking it from the top hook.

3. Pull the ceramic bulb socket out of the lens and reflector housing.

4. Remove the bulb from the socket. The bulb is a "blade mount" style so pull the bulb off the mounting tab, then turn the bulb and remove it from the retaining pin.

5. Place the new bulb on the retaining pin; move the bulb over the mounting tab and snap it in place.

6. To ensure that no possible traces of skin oil are present on the bulb, wipe it with a clean, soft, lint-free cloth moistened with alcohol.

7. Test the light for proper operation.

8. If the light operates, install the ceramic bulb socket in the back of the lens and reflector housing, and secure it by fastening the retaining wire

across it. Make sure the retaining wire lies in the channel in the back of the ceramic socket and is securely fastened to both hooks on the back of the reflector.

9. Install the lens and reflector assembly on the light housing. Tighten the two screws to hold the assembly and the housing together.
10. Test the light for proper operation again.

Road Light, Per-Lux (See Fig. 4)

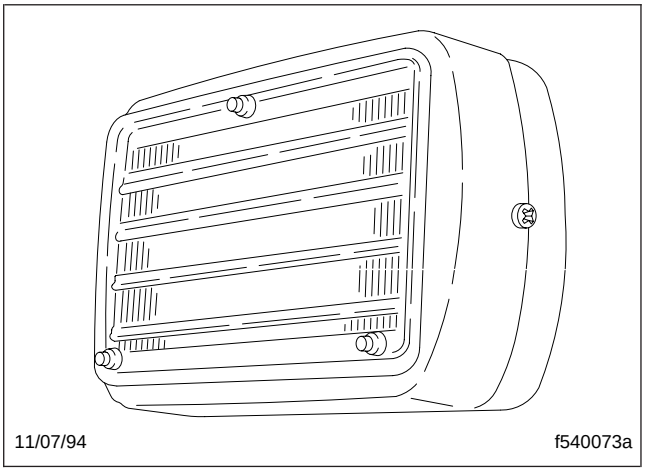


Fig. 4, Per-Lux Road Light

1. Gain access to the front of the light assembly by removing the mounting bracket locknut. Remove the light assembly from the mounting bracket.
2. Remove the crosshead screws from both sides of the lens retainer.
3. Separate the lens retainer and louver from the main housing. Pull the lamp from the housing, and disconnect the blade connectors from the blade terminals on the lamp. See **Fig. 5**.
4. To provide corrosion protection, coat the blade terminals on the new lamp with dielectric grease. For approved electrical lubricants, refer to the applicable table in **Specifications 400**.
5. Install the blade connectors on the terminals of the new lamp. Place the unit in the housing and test it for proper operation.
6. Place the louver over the lamp. Make sure the word "TOP" appears at the top. See **Fig. 6**. If not properly installed, the beam from the light will be directed upward instead of down.

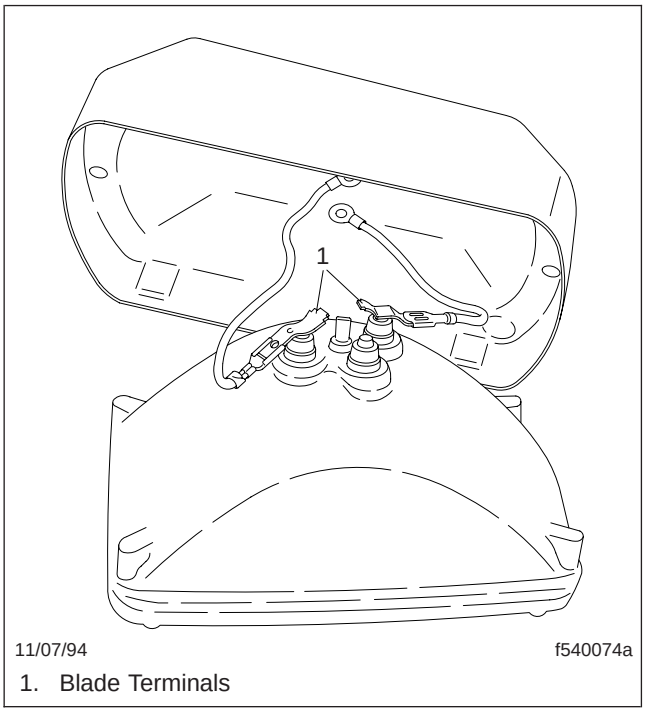


Fig. 5, Lamp Replacement, Per-Lux Road Light

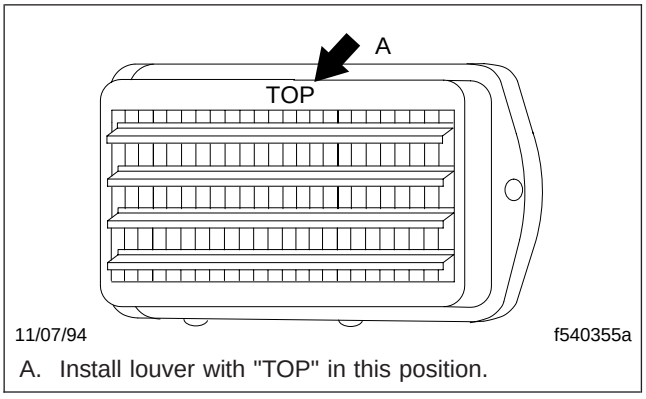


Fig. 6, Louver Installation, Per-Lux Road Light

7. Place the lens retainer over the louver. Install the crosshead screws.
8. Place the road light assembly in the mounting bracket and install the locknut. Make sure the light is aimed directly ahead; then tighten the locknut 75 lbf·ft (102 N·m).

Exterior Light Replacement

Stoplight and Taillight (See Fig. 7 and Fig. 8)

1. Remove the screws attaching the lens to the light housing; then remove the lens.
2. Press in on the bulb, then turn it counterclockwise to release it from the socket.
3. To provide corrosion protection, coat the prongs and base of the new bulb with dielectric grease. Refer to the approved electrical lubricants table in **Specifications, 400.**
4. Press the new bulb in the socket, and turn it clockwise to lock it in place. Test the bulb for proper operation.
5. Install the lens on the housing; fasten it in place with the attaching screws. Do not overtighten the screws or you will crack the lens.

Clearance/Identification Light Bulb

1. Using a screwdriver, unsnap the lens from the housing to gain access to the bulb.

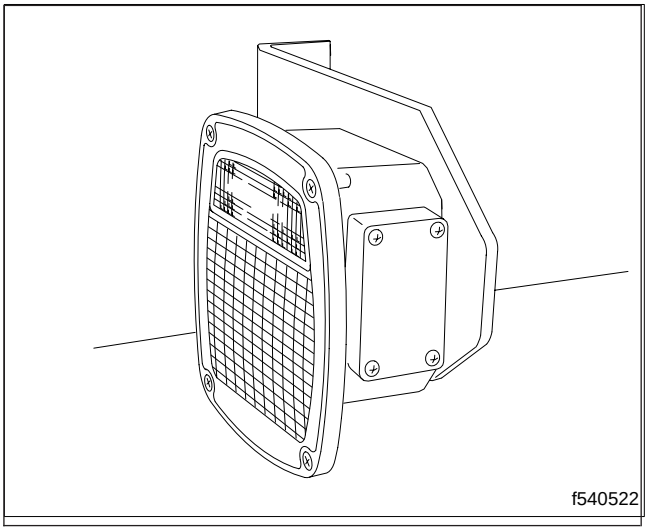
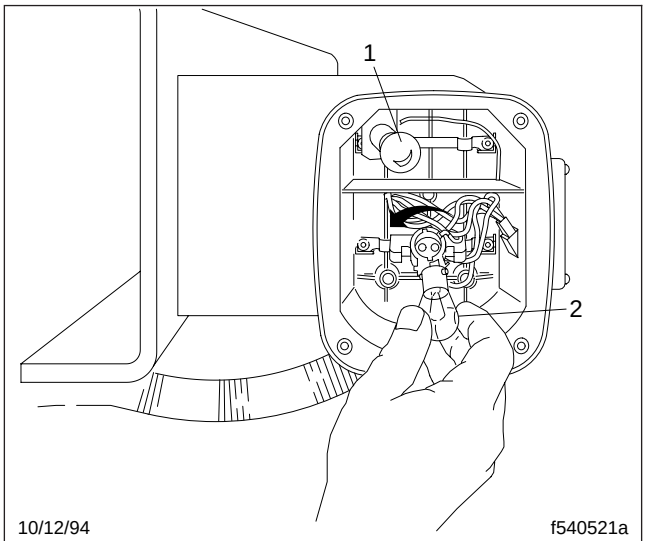


Fig. 7, Stoplight/Taillight Assembly

2. Pull out the bulb, then insert a new one.
3. Install the lens on the housing; make sure that it is fully seated.



1. Back-Up Light Bulb
2. Stoplight/Tailight Bulb

Fig. 8, Stoplight/Tailight Bulb Replacement

4. Test the bulb for operation.

Replacement

Instrument Panel Gauge Light

VDO and Stewart-Warner Gauges

1. Remove the screws that attach the gauge panel to the dash. See **Fig. 1**. Pull the panel out to reach the gauge light bulb.

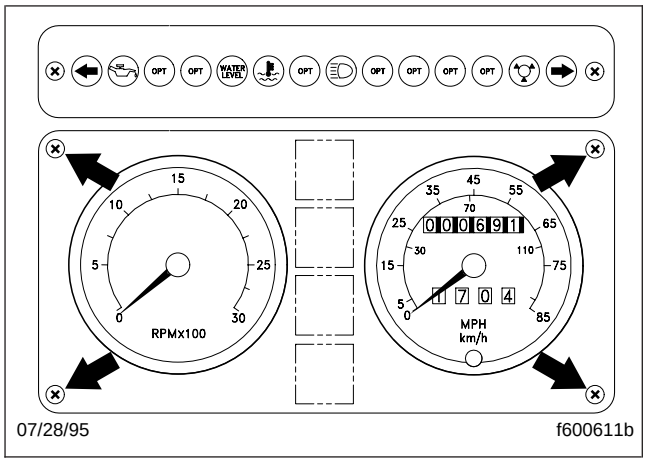


Fig. 1, Gauge Panel

2. Pull the light socket out of the back of the gauge. See **Fig. 2**. If the socket is firmly fixed, use a cloth or gloves to obtain a better grip. Carefully move the socket back and forth to loosen it—simply turning the socket will not loosen it.

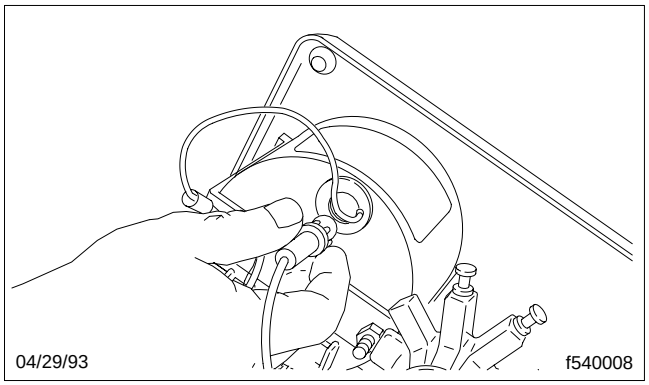


Fig. 2, Instrument Gauge Light Removal

3. Press in on the bulb, and turn it counterclockwise to release it from the socket.
4. Press the new bulb in the socket, and turn it clockwise to lock it in place. Test the bulb for proper operation.
5. Install the socket assembly in the gauge. Press the socket in until it snaps in place and is fully seated. Make sure that the green lens is installed over the bulb.
6. Place the gauge panel back in the dash, making sure that none of the wires are pinched, kinked, or otherwise incorrectly positioned. Install the screws.

Ametek Gauges

1. Remove the screws that attach the gauge panel to the dash. See **Fig. 1**. Pull the panel out to reach the light bulb socket (see **Fig. 3**) in the back of the gauge.

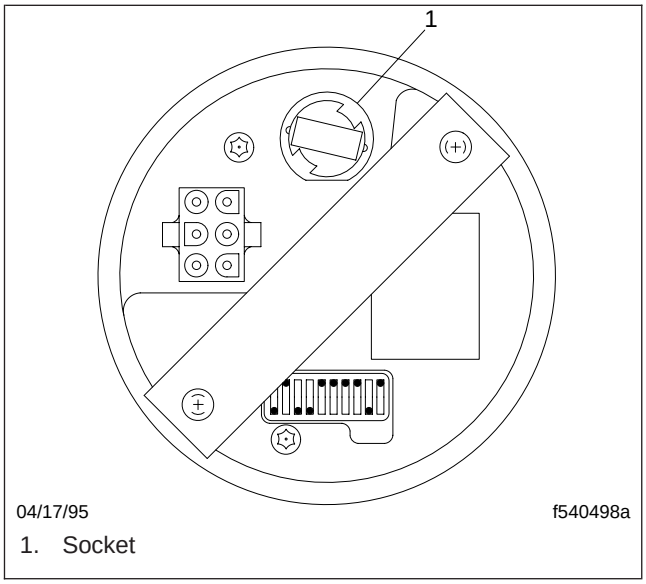
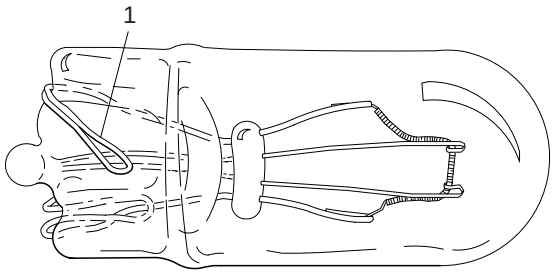


Fig. 3, Light Bulb Socket

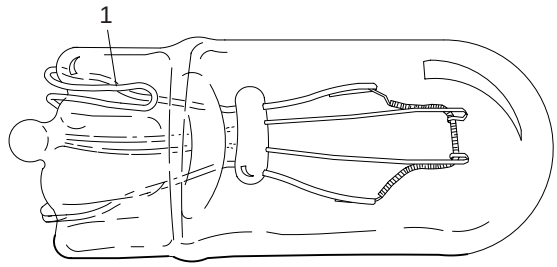
2. Turn the socket counterclockwise, and pull it out of the back of the gauge. Pull out, but don't twist, the light bulb.
3. If the filament or the bulb's contact wire is broken, replace the bulb.
4. If the contact wire is bent (see **Fig. 4**), straighten the wire (see **Fig. 5**).
5. Install the bulb by pushing it straight into the socket; don't move it up and down or twist it.

Interior Light Replacement



1. Incorrect Contact Wire

Fig. 4, Incorrect Contact Wire



1. Correct Contact Wire

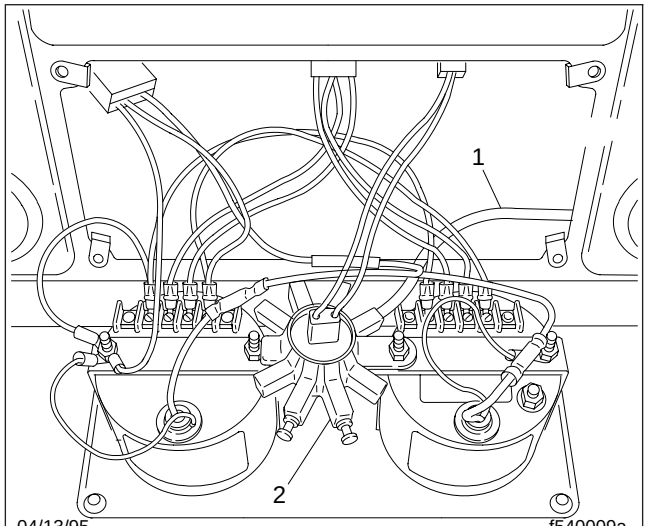
Fig. 5, Correct Contact Wire

Moving it up and down in the socket can bend the contact wires; twisting it can break the glass.

6. Install the socket in the back of the gauge and turn it clockwise one-eighth turn to lock it in place.
7. Test the bulb for correct operation. If it doesn't light up when the headlights are on, replace it.
8. Place the gauge panel back into the dash, making sure that none of the wires are pinched, kinked, or otherwise incorrectly positioned. Install the screws.

Bulb Replacement For Switch and Control Knob Labels

All of the switch and control-knob labels in the dash (except the heater/air-conditioner controls), are illuminated by means of fiber optics. The fiber optics light source contains a single bulb, and is attached by a nut to the back of the speedometer or tachometer mounting stud. See **Fig. 6**.



1. Fiber-Optic Strip
2. Fiber-Optic Light Source

Fig. 6, Fiber-Optic Light Assembly

1. Remove the screws that attach the speedometer and tachometer gauge panel to the dash. See **Fig. 1**.
2. Pull the panel out to reach the light-bulb socket in the back of the light source.
3. Turn the socket, and pull it out of the back of the light source. Pull out, but do not twist, the light bulb.
4. If the filament or the bulb's contact wire is broken, replace the bulb.

   If the contact wire is bent (see **Fig. 4**), straighten the wire (see **Fig. 5**), and install the bulb in its socket, as instructed in the next step. If it doesn't light up when the headlights are on, replace it.
5. Install the bulb by pushing it straight into the socket; do not move it up and down or twist it. Moving it up and down in the socket can bend the contact wires; twisting it can break the glass. Test the bulb for correct operation.
6. Install the socket in the back of the light source.
7. Place the gauge panel back in the dash, making sure that none of the wires are pinched or other-

wise abnormally positioned. Install the screws to lock the panel in place.

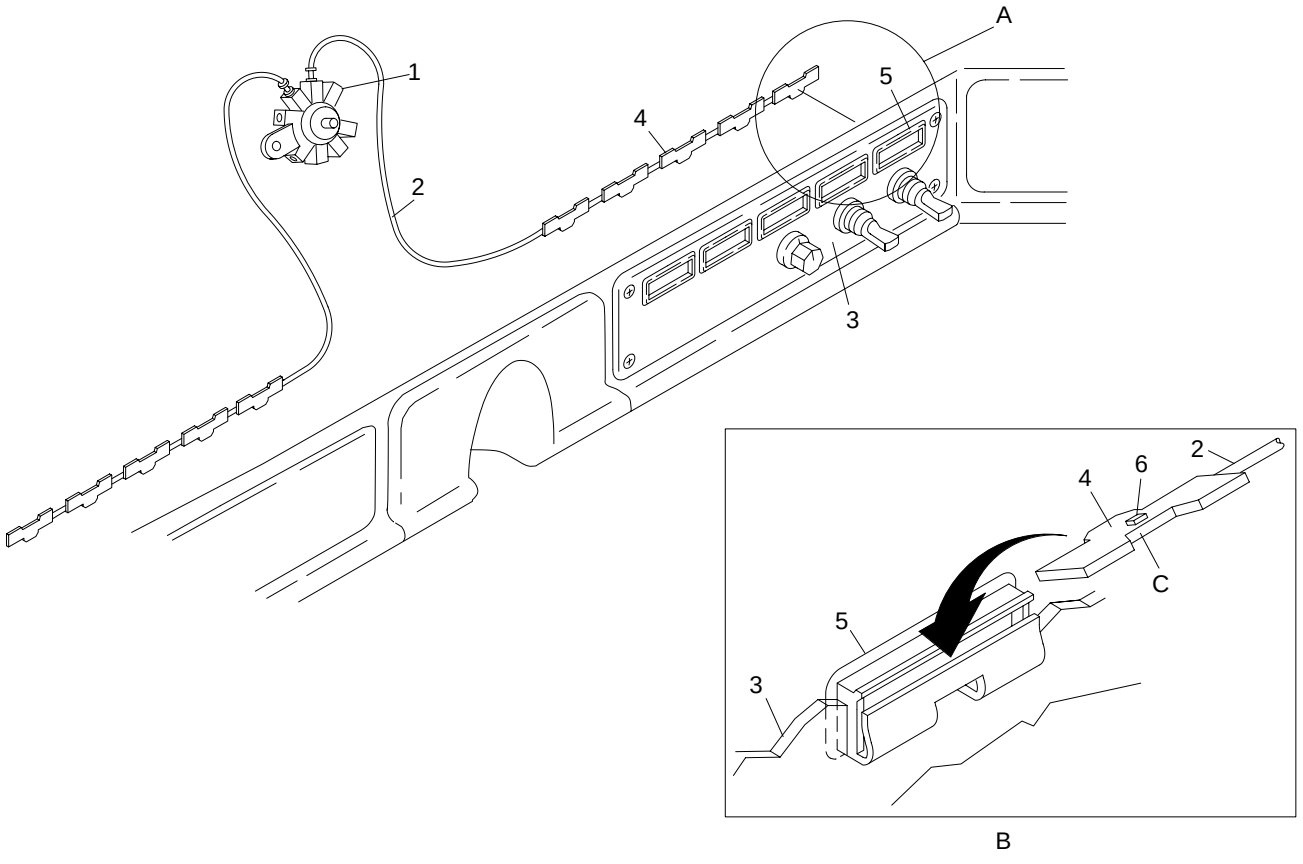
Fiber-Optic Strip Replacement For Switch and Control Knob Labels

If the labels of only one switch panel aren't lighted, the fiber-optic strip to that panel probably needs replacing. See **Fig. 7**.

1. Remove the fiber-optic strip.
   - 1.1 Access the fiber optic light source by removing the speedometer and tachometer gauge panel. See **Fig. 1** and **Fig. 6**.
   - 1.2 Remove the applicable switch panel, then find the fiber optic strip that feeds it.
   - 1.3 Pull the end of the fiber-optic strip out of the light source. See **Fig. 6**.
   - 1.4 Remove each label from the plastic bezel that holds it in the switch panel (see **Fig. 7**), then remove and discard the entire fiber-optic strip.

IMPORTANT: Don't discard the plastic bezels that hold the labels in the switch panel.

2. Check the new fiber optic strip; make sure the labels match the old one, and that it transmits light completely from one end to the other.



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1. Fiber-Optic Light Source
2. Fiber-Optic Strip
3. Switch Panel
4. Fiber-Optic Label
5. Plastic Benzel
6. Lip

Fig. 7, Fiber-Optic Strip Assembly

Interior Light Replacement

3. Install the fiber-optic strip.
   3.1 Insert the open end of the fiber optic strip into its hole in the light source, then feed the strip behind the applicable switch panel. Make sure the strip is routed clear of any studs or sharp edges.
   3.2 Install the labels in the switch panel by snapping each label into its bezel, while holding the bezel against the panel (see **Fig. 7**, Detail A). Carefully depress the small lip (Ref. 6) on the label so it snaps into the bezel.
4. Check that the labels are all lighted. If they're not, remove and replace the fiber-optic strip, following the instructions above.
5. Install the switch panel in the dash, making sure none of the wires are pinched. Install the screws to lock the panel in place.
6. Install the speedometer and tachometer gauge panel in the dash, making sure none of the wires are pinched or strained. Install the screws to lock the panel in place.

Warning or Indicator Light Bulb

The warning and indicator lightbar behind the bezel (see **Fig. 8**) is equipped with LEDs (light emitting diodes). If one of the LEDs no longer works, replace the lightbar assembly.

NOTE: From August 1994, a parking brake indicator light is added to the center gauge panel between the speedometer and the tachometer. Also, the WABCO anti-lock brake system light in the center panel is changed from the square Stewart-Warner light to a rectangular light manufactured by Grakon.

Headlight Dimmer and Turn-Signal Switch

NOTE: Before replacing the dimmer and turn-signal switch, make sure that the trouble is in the switch and not elsewhere in the circuit. Check that the circuit breaker and fuse are working, and inspect the signal light bulbs for broken filaments. Also, check the flasher relay, and replace it if necessary.

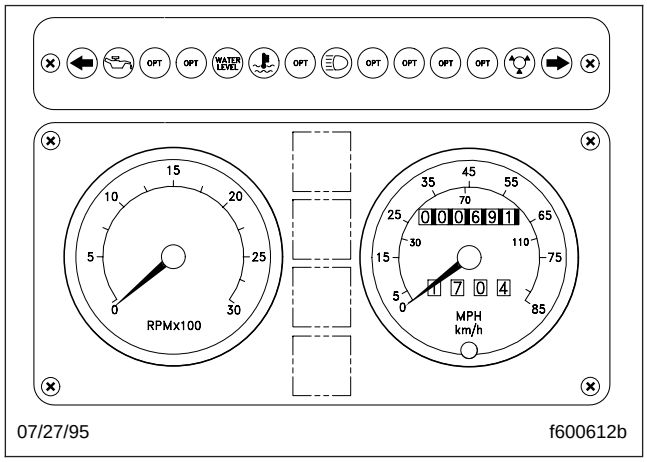


Fig. 8, Typical Gauge Panel (light bar above)

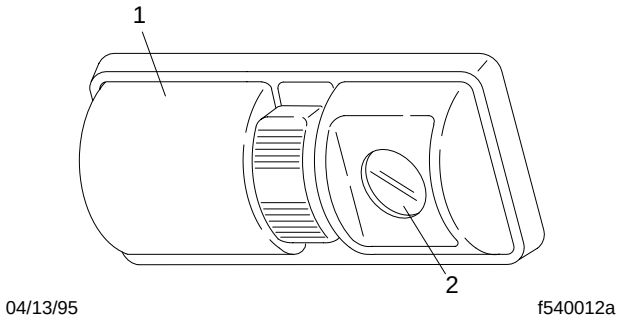
1. Loosen the clamp bolt on the switch mounting bracket. Remove the turn-signal switch mounting assembly from the steering column.
2. Unsnap the wiring connector from the turn-signal switch. Install a new switch, and fasten the wiring connector.
3. Place the turn-signal switch mounting assembly on the steering column. Align the switch so that it is pointing directly to the left, toward the driver's door; firmly tighten the clamp bolt.

Bulb Replacement For Heater/Air-Conditioner Switch and Control Knob Labels

1. Remove the screws from the heater/air-conditioner control panel. Pull the panel out.
2. Pull the socket out of the back of the panel. Press in on the bulb and turn it counterclockwise to release it from the socket.
3. Press the new bulb in the socket, and turn it clockwise to lock it in place. Test the bulb for proper operation.
4. Install the socket assembly in the back of the panel. Press the socket in until it snaps in place and is fully seated.
5. Place the control panel in position and install the screws.

Dome and Accessory Light

1. On domelights, unsnap the domelight or map-light lens (see **Fig. 9**) from the housing to gain access to the bulb; insert a screwdriver into the slots on the housing and gently push in on the lens. On accessory lights, remove the lens attachment screws. See **Fig. 10**.



1. Domelight
2. Map-Light Lens

Fig. 9, Domelight and Map-Light Assembly

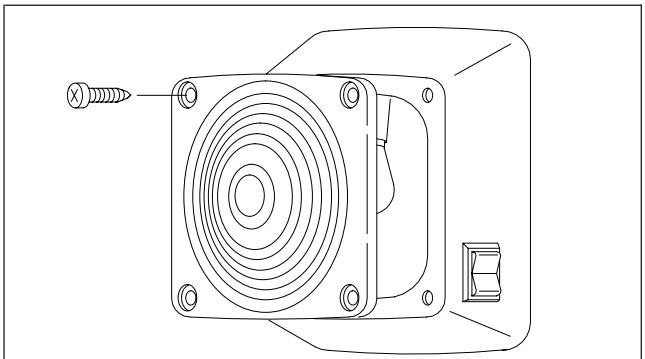


Fig. 10, Baggage Compartment Accessory Light

2. Press in on the accessory or map-light bulb; turn it counterclockwise to release it from the socket.

   On the domelight bulb, spread the spring-style contacts to remove the bulb from the housing base.

3. Press the new accessory or map-light bulb in the socket to snap it in place.

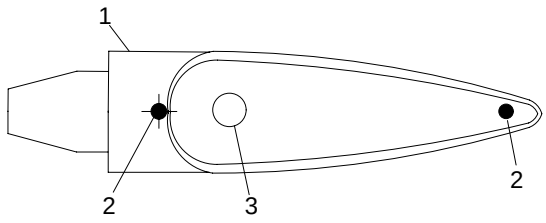
   Press the new domelight bulb into the housing base.

   Test the bulbs for correct operation.

4. Install the domelight or map-light lens on the housing; be sure that it is fully seated. Install the attaching screws on accessory lights; do not overtighten the screws or you will crack the lens.

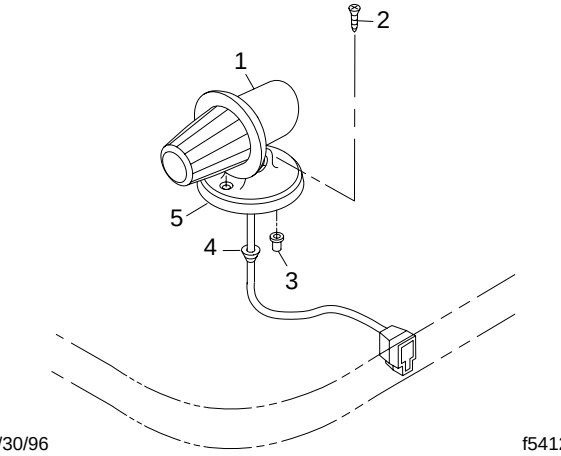
Cab Roof-Mounted Marker Lights (See Fig. 1 and Fig. 2)

There are several areas on cab roof-mounted marker lights that are vulnerable to water leaks into the cab. These areas include the front and rear mounting screws, the wiring and wire grommet, and around the full perimeter of the neoprene roof gasket. To eliminate a water leak, use the following procedure:



1. Marker Light
2. Mounting Screw
3. Wire Grommet

Fig. 1, Typical Bullet-Type Marker Light



1. Marker Light
2. Mounting Screw
3. Rivnut
4. Wire Grommet
5. Mounting Gasket

Fig. 2, Typical Pedestal-Mount Marker Light

1. Park the vehicle on level ground. Apply the parking brakes and chock the tires.
2. Remove the two screws that secure the marker light to the roof of the cab.
3. Remove the wire grommet from the cab roof; then disconnect the harness connector, and remove the marker light from the vehicle.
4. Thoroughly clean the area around the mounting gasket area to ensure a good seal.
5. Remove the old mounting gasket from the marker light.
6. Clean the gasket mounting surface on the marker light, then apply a light coating of sealant. See **Table 1** for a list of approved sealants.
7. Install a new gasket on the marker light, and set it aside.

NOTE: Allow the sealant to set up for at least 15 minutes before proceeding with the installation.

8. Apply a light coat of sealant to the cab-side of the mounting gasket. See **Table 1**.
9. Insert both mounting screws into the marker light and through the gasket; then apply sealant to the threads.
10. Connect the electrical connector to the cab wiring harness and guide the wiring into the cab.
11. Apply sealant around the wire grommet, and seat the grommet firmly into the cab roof.
12. Lower the marker light and gasket onto the roof; then hand-tighten the screws.

NOTE: Do not overtighten the screws. Overtightening the screws will distort the mounting gasket and cause water leaks.

13. After the screws are hand-tight, turn an additional 1/4 turn.
14. Allow the sealant to set up for at least 30 minutes, then test the cab for water leaks.
15. Remove the tire chocks.

Manufacturer	Item Number	Component to Seal
Dolchem	6060	Mounting Gasket

Water Sealing, Exterior Lights

Manufacturer	Item Number	Component to Seal
Dolchem	6068	Mounting Gasket
National Polymer Products	Perm Seal 1–A	Mounting Gasket
Mortite	–	Mounting Gasket
Dolchem	6100	Mounting Bolts Wire Grommets
Dolchem	6102	Mounting Bolts Wire Grommets
Dolchem	6076	Mounting Bolts Wire Grommets
3M	42 NF PLUS	Interior Roof Seal

Table 1, Approved Water Sealants for Exterior Lights

Headlight Aim Checking and Adjusting

Before checking or adjusting the headlight aim, do the following:

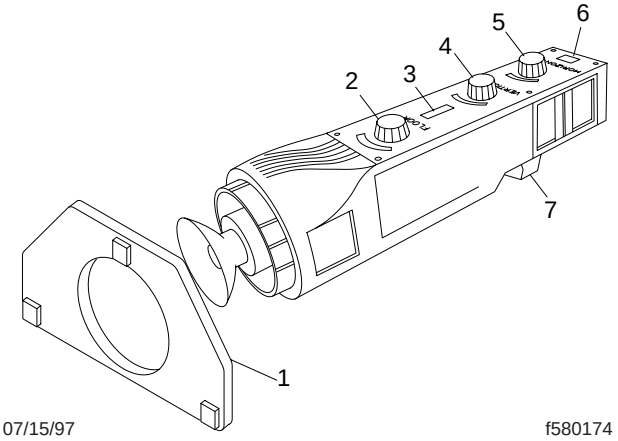
- Remove large amounts of mud or ice from the undersides of the fenders.
- Check the springs for sagging or broken leaves. Check the suspension for proper functioning of the leveling mechanism.
- Clean the headlight lenses and aiming pads.
- Check the bulbs for burnout and broken aiming pads. Switch the beams from low to high to make sure they switch properly.
- With the vehicle unloaded, check that the tires are inflated to the recommended air pressure. Clean the headlight lenses.

Checking

For a quick check to see if the headlights need aiming, do the following procedure.

1. Move the vehicle onto a flat surface that has been calibrated for slope. Shut down the engine, set the parking brake, and chock the tires.
2. Attach a headlight aimer to each headlight.

   2.1 Attach the mini-quad adaptor to the aimer. See **Fig. 1**.



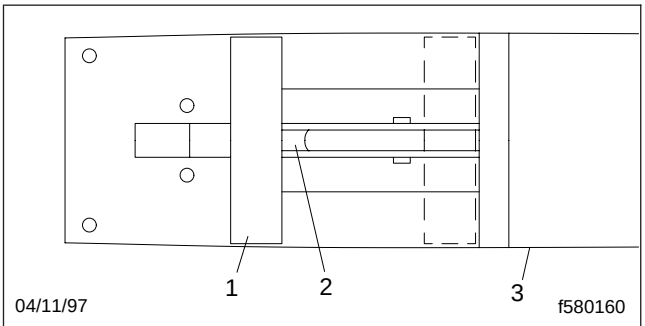
1. Mini-Quad Adaptor
2. Floor Slope Dial
3. Level Vial
4. Vertical Dial
5. Horizontal Dial
6. Split Image View Port
7. Piston Handle

Fig. 1, Mini-Quad Adaptor

NOTE: Use the seven-inch circular adaptor on vehicles with a single round headlight, like the FLD 112SD.

2.2 Align the adaptor with the aiming pads on the headlight lens.

2.3 Push the piston handle on the base of the aimer forward to engage the vacuum cup. Immediately pull the handle backward until it locks. See **Fig. 2**.



To attach, push the piston handle forward to engage the vacuum cup. Immediately pull the handle backward until it locks.
To remove, press the vacuum release button.

1. Piston Handle
2. Vacuum Release Button
3. Base of Aimer

Fig. 2, Aimer Attachment and Removal

2.4 Do the same procedure with the other aimer.

3. Check the floor slope dial for the correct setting. See **Fig. 3**.
4. Check the horizontal aim. See **Fig. 4**.

   4.1 Turn the horizontal dial until the split image is in alignment.

   4.2 If the horizontal dial scale on either aimer reads more than "4," re-aim the headlight.

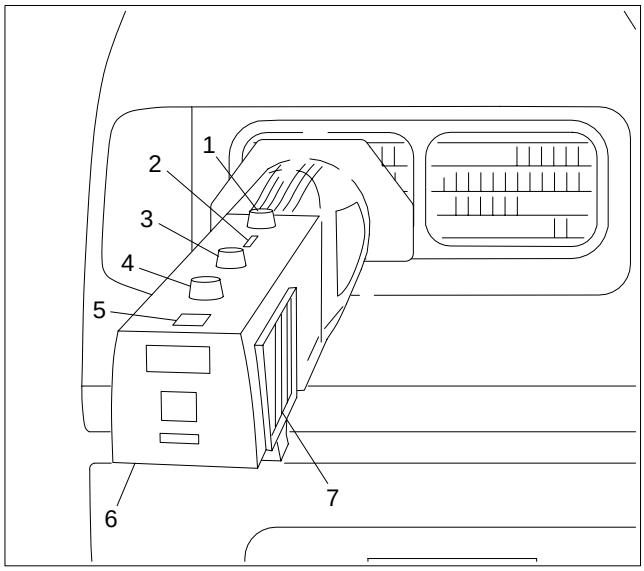
   NOTE: If adjustment is required, see the procedures under "Adjusting" below.

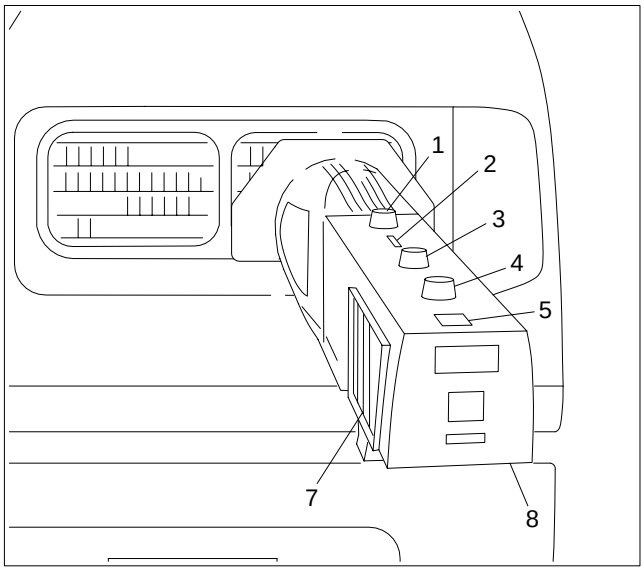
5. Check the vertical aim. See **Fig. 5**.

   5.1 Turn the vertical dial until the level vial is centered.

   5.2 If the vertical dial scale on either aimer reads more than "4," re-aim the headlight.

Headlight Aim Checking and Adjusting





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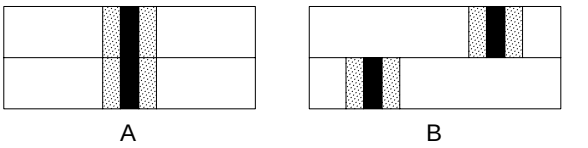
The sight openings must face each other.

1. Floor Slope Dial
2. Vertical Aim Level Vial
3. Vertical Dial
4. Horizontal Dial
5. Split Image View Port
6. Aimer (RH side)
7. Sight Opening
8. Aimer (LH side)

Fig. 3, Set-Up for Aiming



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View through the split image view port.

A. Split Image Aligned
B. Split Image Not Aligned

Fig. 4, Horizontal Aim Split Image

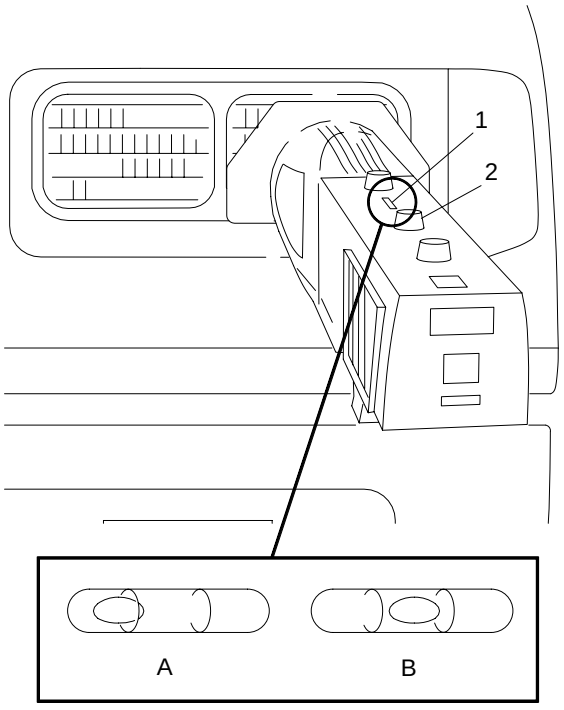
NOTE: If adjustment is required, see the procedures under "Adjusting" below.

6. Remove the two headlight aimers. Hold each aimer securely, and then press the vacuum release button.
7. Remove the chocks from the tires.

Adjusting

If the headlights need adjusting, do this procedure.

1. If not already there, move the vehicle onto a flat surface that has been calibrated for slope. Shut down the engine, set the parking brake, and chock the tires.
2. Attach a headlight aimer to each headlight. See the procedures above under "Checking" for detailed instructions.
3. Check the floor slope dial for the correct setting. See **Fig. 3**.
4. Adjust the horizontal aim. See **Fig. 4**.
   - 4.1 Set the horizontal dial to "0" (zero).
   - 4.2 Look in the viewing port for the split image target lines. If necessary, rotate either or both aimers until the lines are visible.
   - 4.3 Turn the horizontal adjustment screw as needed to make the split image appear as one solid line. See **Fig. 6**.



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Set the vertical dial to "0" (zero).

A. Bubble Not Centered
B. Bubble Centered
1. Level Vial
2. Vertical Dial

Fig. 5, Vertical Aim Level Vial

IMPORTANT: To avoid backlash, make the final adjustment by turning the screw clockwise.

4.4 Do the same procedure for the other headlight.

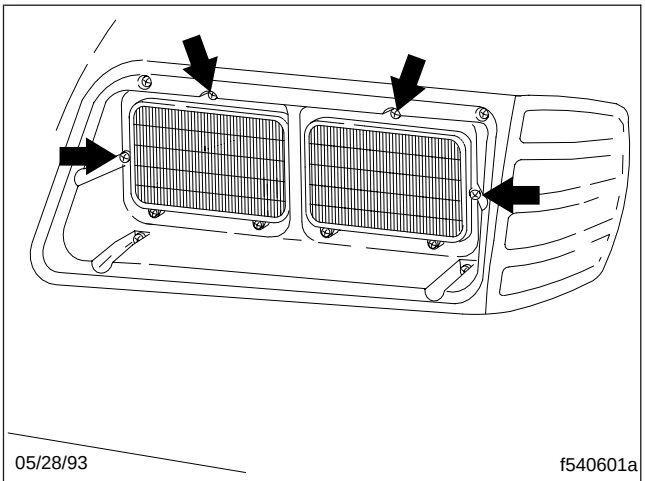
5. Adjust the vertical aim. See **Fig. 5**.

5.1 Set the vertical dial to "0" (zero).

5.2 Turn the vertical adjustment screw as needed to center the bubble.in the level vial between the lines. See **Fig. 6**.

IMPORTANT: To avoid backlash, make the final adjustment by turning the screw clockwise.

5.3 Do the same procedure for the other headlight.



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The vertical adjustment screws are on top of each bulb; the horizontal adjustment screws are on the side of each bulb.

Fig. 6, Headlight Adjustment Screws

6. Recheck the horizontal alignment on both aimers. Readjust if necessary.
7. Remove both headlight aimers. While holding the aimer securely, press the vacuum release button. See **Fig. 2**.
8. Remove the chocks from the tires.

See **Fig. 1** for a wiring diagram showing fog lights wired for operation in the United States. See **Fig. 2** for a wiring diagram showing fog lights wired for operation in Canada. See **Fig. 3** for a wiring diagram for daytime running lights.

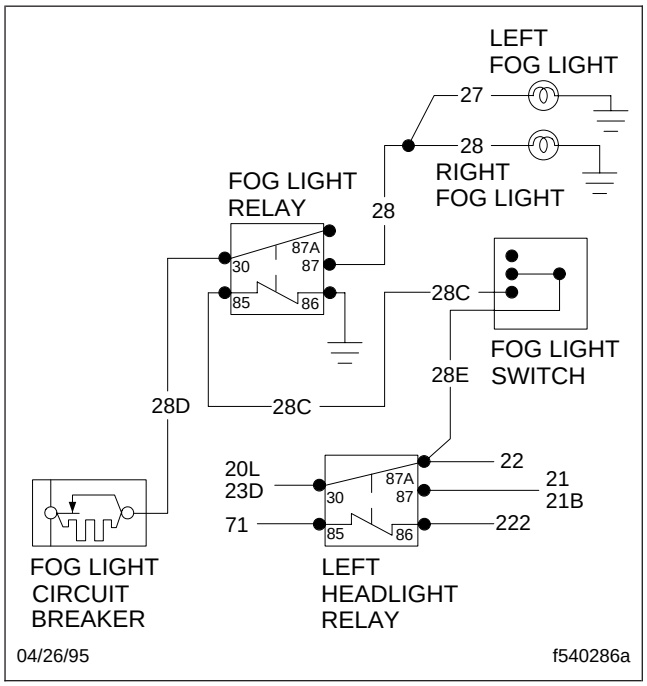


Fig. 1, Fog Lights Wired for Operation in the United States

Manufacturer	Lubricant or Part Number
Standard Oil Co.	White Vasoline
Shell Oil Co	No. 71032; No. 71306
Texaco, Inc.	No. 955
Quaker State	No. NYK-77

Table 1, Approved Electrical Lubricants

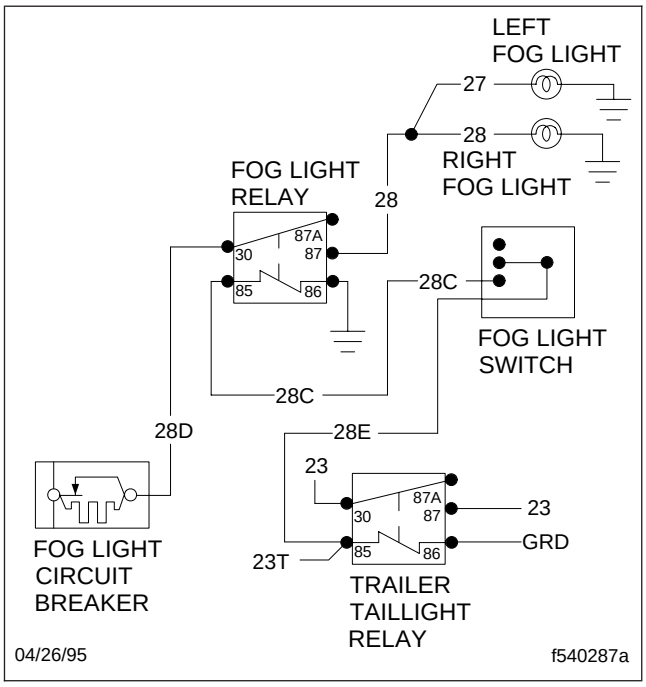


Fig. 2, Fog Lights Wired for Operation in Canada

Specifications

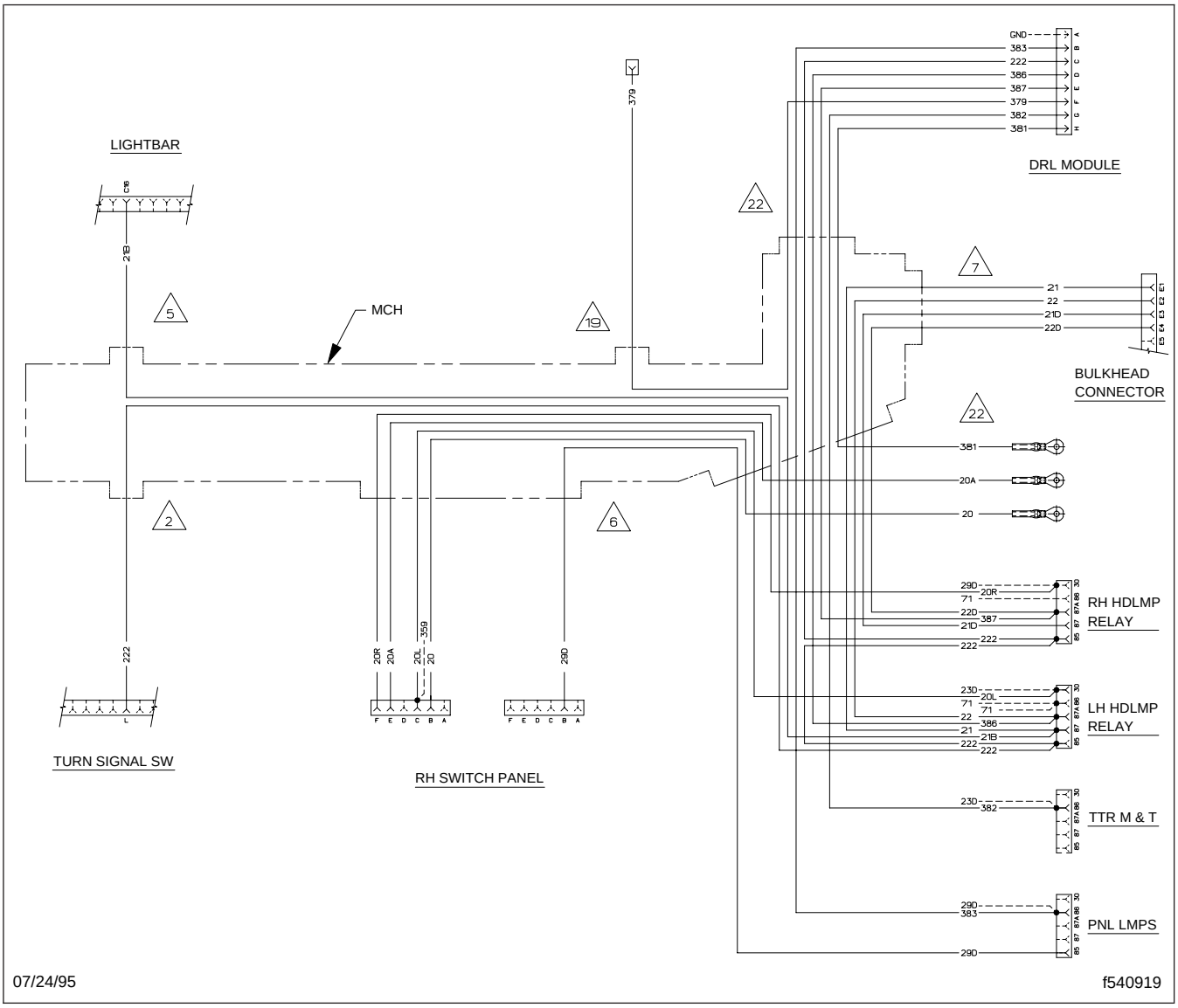


Fig. 3, Wiring Diagram for Daytime Running Lights

General Information

Lead-Acid Batteries

Batteries are electrochemical devices that store chemical energy. When the battery is connected to an external load, such as a starter, the chemical energy is converted into electrical energy and current flows through the circuit.

The battery has three functions:

- To supply power to start the engine.
- To stabilize the voltage in the electrical system. The battery filters high voltage transients and protects electronic components in the vehicle.
- To supply power when the vehicle's electrical load requirements go beyond what the charging system can supply or when the engine is not running.

All lead-acid batteries use plates made of two unlike metals held apart by separators. One of the metals becomes the positive plate, the other the negative plate. These plates are then grouped in pairs, alternating negative and positive. The groups are connected in series, and each plate group (cell) produces about two volts. Thus, a battery with six cells is a 12-volt battery.

In conventional liquid-electrolyte batteries (wet cells), each battery contains a group of plates immersed in a solution of electrolyte (dilute sulfuric acid).

Batteries may produce hydrogen gas when being charged. The vents allow the escape of gases produced in the battery.

NOTE: Liquid-electrolyte batteries must be kept in an upright position to prevent electrolyte leakage. Tipping a wet cell beyond a 45-degree angle in any direction can allow a small amount of electrolyte to leak out the vent holes.

Proper testing will indicate the battery condition. For more information, see **Troubleshooting 300**.

Absorbed Glass Mat (AGM) Batteries

Absorbed Glass Mat (AGM) batteries are lead-acid batteries in which the electrolyte is contained in a fiberglass mat. AGM batteries are physically similar to standard batteries. Carefully check the label on every battery to be certain it is AGM, and

AGM batteries are designed for high cranking amps and repeated cycle service to accommodate many of the auxiliary loads on vehicle electrical systems. They offer good protection against damage due to vibration, and are leak- and spill-proof, even if cracked or broken. Also, they self-discharge more slowly, and generate less heat when charging or discharging.

IMPORTANT: AGM batteries may be damaged or ruined by equipment designed for other types of batteries. AGM battery chargers must be regulated to a charge voltage less than 15.4 DCV; many chargers provide excessive voltage. To get full service from AGM batteries, carefully follow the battery manufacturer's instructions regarding charging rates and procedures.

Parasitic Battery Drain

Batteries are replenished each time the vehicle is driven with normal vehicle use. In long-term parking situations, however, parasitic drains may discharge the batteries enough that the starter will not be able to crank the engine.

A parasitic drain is an electrical load that draws current from the batteries when the ignition remains off.

A typical parasitic drain falls into the 25 to 325 mA (0.025 to 0.325 amps) range. Multiply the drain (in amps) by the time (in hours) the batteries sit without being recharged. The result is the amount of ampere-hours consumed by the parasitic drain. The actual drain may be small, but over time the batteries grow steadily weaker.

At warm temperature of 77°F (25°C), using approximately 40 percent of the total available ampere-hours will bring fully charged batteries to a no-start condition. In colder temperatures, the batteries will reach a no-start condition sooner.

General Safety Precautions

WARNING

Keep sparks, flames, burning cigarettes, etc. away from batteries. Batteries generate explosive gases, which could cause a battery to explode, causing serious personal injury, including blindness.

When charging the batteries, gas forms in each cell and escapes through the vent holes. In poorly ventilated areas, the gas lingers around the battery several hours after it has been charged. The gas is explosive around sparks, flame, or other intense heat; if ignited, it could cause the battery to explode. Follow these precautions when charging the batteries.

- Wear safety glasses or a face shield when working with batteries. When many batteries are handled, wear rubber gloves and an apron to protect clothing.
- Make sure that the area is well ventilated.
- Do not install any lead-acid battery in a sealed container or enclosure. Allow hydrogen gas caused by overcharging to escape. Exploding hydrogen gas can cause blindness or other bodily injury.
- Make sure that the charger cable leads are clean and making good connections. A poor connection could cause an electrical arc which could ignite the gas mixture and explode the battery.
- Do not break live circuits at the terminals because a spark usually occurs at the point where a live circuit is broken. Use care when connecting or disconnecting booster leads or cable clamps on chargers.
- Do not smoke near batteries that are being charged or have recently been charged. Keep the batteries away from open flames or sparks.
- If the battery is frozen, let it reach room temperature and completely thaw before trying to charge it. Check for leaks and cracks before charging the battery. Replace the battery if leaks or cracks are seen.
- Take care that tools or metal objects do not fall across the battery terminals.

WARNING

Do not install any lead-acid battery in a sealed container or enclosure. Allow hydrogen gas caused by overcharging to escape. Exploding hydrogen gas can cause blindness or other bodily injury.

CAUTION

If a metal object connects an ungrounded battery terminal to a nearby metal part of the vehicle which is grounded, it could short out the batteries, causing sparks and possible property damage.

Battery Electrolyte Safety Precautions

WARNING

Protect skin and eyes from battery electrolyte (acid). Electrolyte is corrosive and could result in serious personal injury if splashed on your skin or in your eyes.

If electrolyte is splashed on your skin or in your eye, force the eye open, rinse it with cool, clean water for about five minutes and call a doctor immediately. Do not add eye drops or other medication unless advised by the doctor.

If electrolyte is swallowed, drink several large glasses of milk or water. Follow with milk of magnesia, a beaten raw egg, or vegetable oil. Call a doctor immediately.

Use extreme care to avoid spilling or splashing electrolyte. Electrolyte spilled or splashed on your body or clothing should be neutralized with baking soda or household ammonia, then rinsed with clean water.

Electrolyte can also damage painted or unpainted metal vehicle parts. If electrolyte is spilled or splashed on any metal surface, neutralize and rinse it with clean water.

To prevent possible skin burns, do not wear watches, rings, or other jewelry while performing maintenance work on the batteries.

Battery Safety Precautions

⚠ WARNING

Do not apply pressure to the end walls of a plastic-case battery. This could cause electrolyte to squirt from the vents, possibly resulting in serious injury to skin or eyes.

When handling plastic-case batteries, use a battery carrier. If one is not available, lift these batteries with your hands placed at opposite corners of the battery.

Emergency Starting Using Booster Cables

WARNING

Before jump-starting a vehicle, read the instructions in Subject 100. Failure to follow the safety precautions could result in personal injury.

WARNING

Batteries release explosive gas. Do not smoke when working around batteries. Put out all flames and remove all sources of sparks or intense heat in the vicinity of the battery. Do not allow the vehicles to touch each other. Do not lean over the batteries when making connections, and keep all other persons away from the batteries. Failure to follow these precautions could lead to severe personal injury as a result of an explosion or acid burns.

NOTICE

Make sure both electrical systems are the same voltage. Electronic devices on both vehicles can be damaged when connected to a vehicle with a different operating voltage.

1. Apply the parking brakes and turn off all lights and other electrical devices. Ensure that the vehicles are not touching and both ignition switches are turned to the OFF position.

IMPORTANT: Do not attempt to jump start a damaged battery.

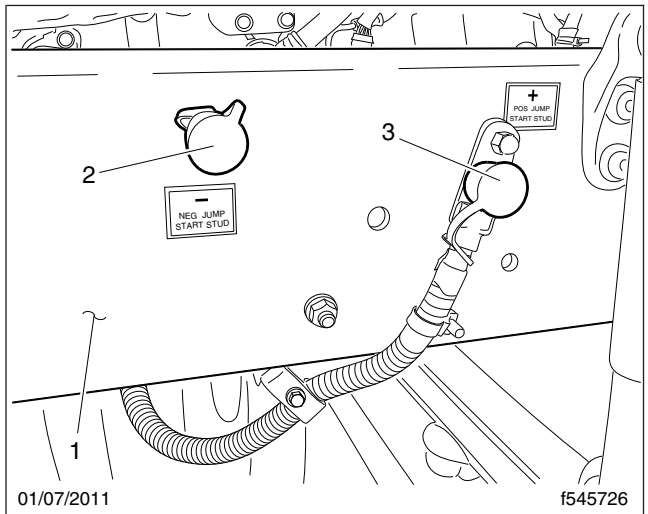
2. Remove the battery box cover.

NOTICE

Always connect the batteries and jumper cables correctly (positive-to-positive and negative-to-negative). Connecting a charging device backwards (positive-to-negative) can severely damage the vehicle electrical content and cause non-warrantable failures.

IMPORTANT: On vehicles equipped with optional jump start posts, connect to these posts instead of the battery terminals. Jump start posts may be installed in various locations on the vehicle. See Fig. 1.

3. Connect the positive (+) jumper cable to the positive terminal or jump start post on the discharged battery. See Fig. 2.



1. Frame Rail
2. Negative Jump Start Post
3. Positive Jump Start Post

Fig. 1, Possible Jump Start Post Location (passenger-side engine compartment)

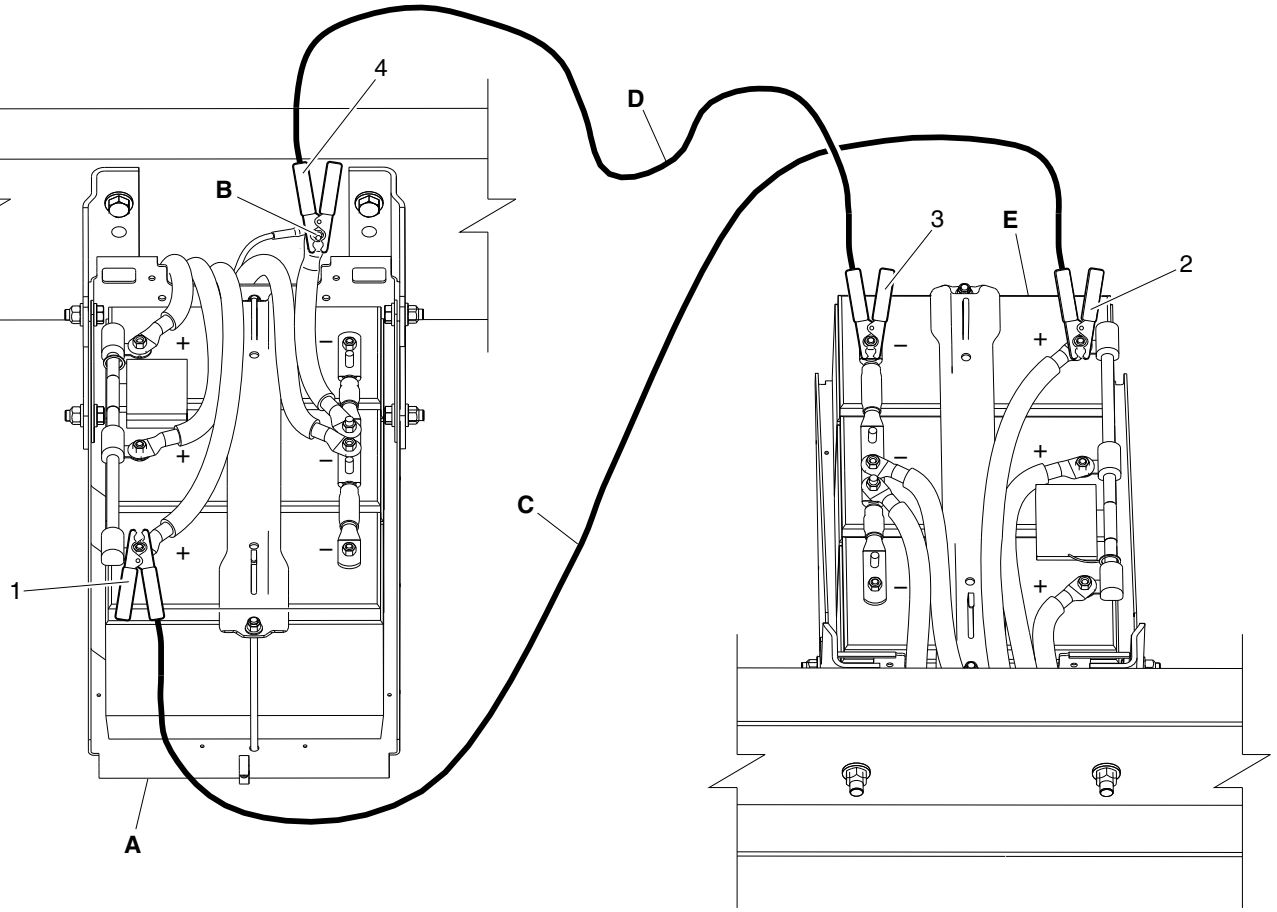
4. Connect the other end of the positive jumper cable to the positive terminal or jump start post on the booster battery providing the charge.

WARNING

Do the next step exactly as instructed and do not allow the clamps of one cable to touch the clamps of the other cable. Otherwise, a spark could occur near a battery, possibly resulting in severe personal injury from explosion and acid burns.

5. Connect the negative (-) jumper cable to the negative terminal or jump start post on the booster battery.
6. Connect the other end of the negative jumper cable to the negative ground stud on the vehicle requiring the jump start.
7. Start the engine of the vehicle providing the jump start and let the engine run a few minutes to charge the batteries of the other vehicle.

Emergency Starting Using Booster Cables



Disconnect jumper cables in the REVERSE order that they were connected.

A. Discharged Battery
B. Negative Ground Stud
C. Positive Jumper Cable
D. Negative Jumper Cable
E. Booster Battery

1. 1st Connection: Positive Jumper Cable to Discharged Battery
2. 2nd Connection: Positive Jumper Cable to Booster Battery
3. 3rd Connection: Negative Jumper Cable to Booster Battery
4. 4th Connection: Negative Jumper Cable to Negative Ground Stud (discharged battery)

Fig. 2, Jumper Connections

8. Attempt to start the engine of the vehicle receiving the jump. Do not operate the starter longer than 30 seconds, and wait at least two minutes between starting attempts to allow the starter to cool.
9. When the engine starts, let it idle a few minutes.

⚠ WARNING

Do the next step exactly as instructed and do not allow the clamps of one cable to touch the clamps of the other cable. Otherwise, a spark could occur near a battery, possibly resulting in severe personal injury from explosion and acid burns.

10. Disconnect the negative jumper cable from the negative cable stud on the jump-started vehicle.
11. Disconnect the negative jumper cable from the booster battery.
12. Disconnect the positive cable from the booster battery.
13. Disconnect the other end of the positive jumper cable from the jump-started vehicle.
14. Install the battery box cover; be sure it is positioned properly before fastening the latch.

WARNING

Before charging a battery, read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

When charging batteries, always wear eye protection. During charging, batteries give off explosive hydrogen gas. Exploding gas can cause blindness or other bodily injury.

WARNING

Before charging a battery, read the instructions in Subject 100. Failure to follow the safety precautions could result in personal injury.

When charging batteries, always wear eye protection. During charging, batteries give off explosive hydrogen gas. Exploding gas can cause blindness or other bodily injury.

Battery Charging

AGM batteries may be charged only with a charger that is specified for AGM batteries. Many older chargers operate at a voltage that is too high for AGM batteries and will cause permanent damage. Never combine AGM and flooded batteries together for charging or for use in a vehicle.

See **Table 1** for voltage to approximate battery state of charge for flooded batteries.

Voltage to Approximate Battery State of Charge for Flooded batteries		
Voltage		State of Charge
Flooded	AGM	
12.6	12.8	100%
12.4	12.6	75%
12.2	12.3	50%
12.0	12.0	25%
11.8	11.8	0%

Table 1, Voltage to Approximate Battery State of Charge for Flooded batteries

1. If the batteries are not installed in the vehicle, install the lead adapters on the battery positive and negative posts.
2. Connect the charger to the battery following the manufacturer's instructions. Slightly rock the charger's clamps to insure a complete connection.

IMPORTANT: If the battery feels hotter than 125°F (52°C) or if rapid gassing or spewing of electrolyte occurs, lower the charging rate or stop charging the battery and allow it to cool.

3. When finished, turn the charger off.

WARNING

Always turn the charger off before disconnecting it. Touching a charger lead when the circuit is live could create a spark and cause an explosion, resulting in personal injury.

Battery Removal, Cleaning and Inspection, and Installation

⚠ WARNING

Before doing any of the following procedures, read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

Removal

1. Before working on the battery box, make sure all electrical loads (lights, ignition, accessories) are turned off.
2. Remove the threaded fasteners that attach the air fairing panel (if equipped) in front of the battery box. Remove the air fairing panel.
3. Pull on the end of each hold-down latch until the end clears the cover-mounted catch. Pivot the latches out of the way, then lift off the battery box cover.
4. For assembly reference, note the locations of the battery positive and negative terminals in relation to surrounding components. Remove the battery cables.
5. Remove the battery retainer assembly. Remove the batteries from the carrier. See **Fig. 1**.

Cleaning and Inspection

1. Inspect all battery cables and interconnectors for wear, and replace them if necessary. Remove corrosion from cables, terminals, and battery posts with a wire brush and a solution of baking soda and water. Rinse thoroughly with clean water, and dry.
2. Clean and tighten the battery ground cable at the weld stud on the frame rail. Inspect and ensure that the nut is self-locking and that a flat washer is used. Do not use a split-lock washer or star washer. Torque the nut 15 to 18 lbf·ft (20 to 24 N·m). Seal the area with red dielectric enamel.
3. Inspect the retainer assembly and battery box. Replace worn or damaged parts. Remove any corrosion with a wire brush and wash with a weak solution of baking soda and water. Rinse with clean water and dry. To prevent rusting, paint the retainer assembly if needed.
4. Be sure foreign objects, such as stones, bolts, and nuts, are removed from the battery box.

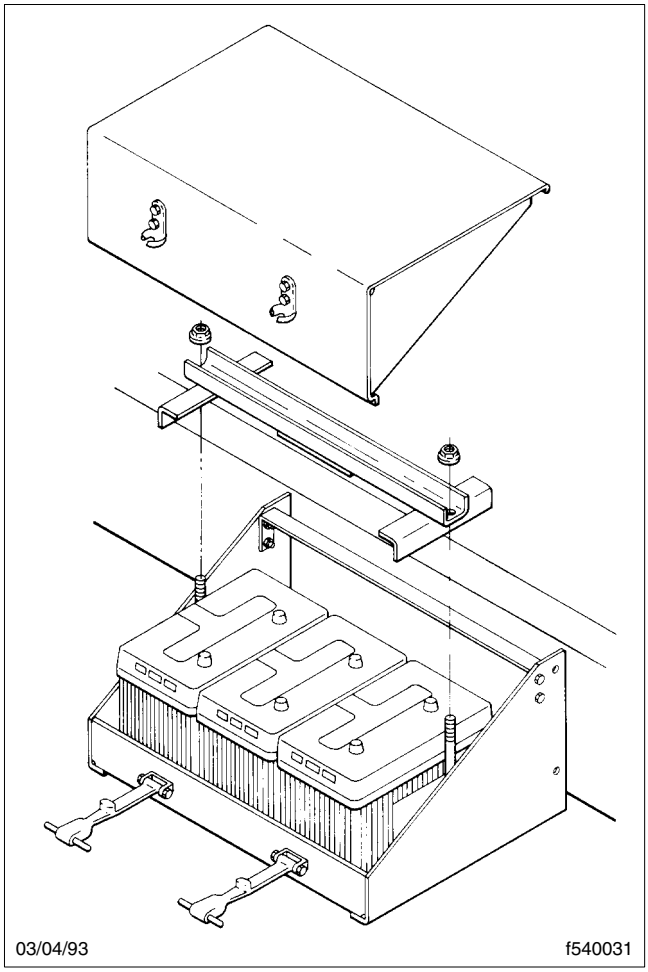


Fig. 1, Typical Battery Installation

Installation

1. Be sure that the battery to be installed has a sufficient capacity to cover the electrical needs of the vehicle.

⚠ CAUTION

Using an under-capacity battery will result in poor performance and premature battery failure, resulting in damage or reduced life of the starter.

2. Be sure the battery is at full charge when installed. If the battery has been in storage for some time, or if the installation is being made in subfreezing temperatures, give the battery a

Battery Removal, Cleaning and Inspection, and Installation

boost-charge before installing it. For instructions, see **Subject 120**.

3. Place the batteries in the carrier with the terminals in the proper position, as referenced earlier. The batteries should rest level in the carrier.
4. Install the battery retainer assembly, and tighten it until the batteries are secure. See **Fig. 1**.

CAUTION

Do not overtighten the battery retainer assembly. Overtightening could damage the batteries.

5. To provide corrosion protection, apply pumpable dielectric grease, part no. 48–02349–000, liberally to the terminal pads, then install the interconnectors. For a list of approved suppliers, see **Specifications 400**.

IMPORTANT: Many electrical components are located outside of the cab in areas subjected to harsh weather, road spray, etc. Some components also have exposed metal electrical terminals, which, when subjected to harsh conditions, may suffer corrosion at the electrical connection. Spray dielectric sealant on all exposed electrical terminals, and use dielectric grease on all covered terminals.

6. Connect the battery cables to the batteries; check for correct polarity with respect to the vehicle. Connect the ground cable last.

CAUTION

Reversed polarity may cause serious damage to the electrical system.

7. Tighten all battery connections to the torque specifications listed on the battery. Generally those are 10 to 15 lbf·ft (14 to 20 N·m). Proper torque is important for electrical system operation.
8. Start the engine, and check the operation of the charging system. If needed, adjust or repair the charging system to obtain the correct charging output. For instructions, see the appropriate section in **Group 15**.

CAUTION

Make sure all battery posts are covered with protective caps. Failure to do so could cause the battery box cover to short across the posts.

9. Install the battery box cover. Install the threaded fasteners that attach the air fairing panel (if equipped).

Troubleshooting

If the batteries pass testing, check for the following causes:

1. Accessories were left on overnight.
2. A slipping alternator belt, high resistance in the wiring, or a defective alternator is causing the batteries to discharge.
3. The electrical loads are exceeding the charging system capacity.
4. Wires in the electrical system are shorted or pinched.
5. There are loose or damaged battery cable-to-terminal connections.
6. The batteries are still connected in a vehicle that has been out of service. Small current drains of accessories that are connected all the time can discharge the batteries in a few days. Batteries left in a discharged condition are subject to freezing.

Electrical Drain and Parasitic Load

Batteries are replenished each time the vehicle is driven with normal vehicle use. In long-term parking situations, however, parasitic drains may discharge the batteries enough to cause a no-start condition.

A parasitic drain is an electrical load that draws current from the batteries when the ignition remains off. Some devices, such as the electronic control unit (ECU), the bulkhead module (BHM), the chassis module (CHM), the antilock braking system (ABS), and radio memory are intended to draw a very small current continuously. These draws are measured in milliamps (mA). Current draw should be less than 325 milliamps with no circuits active and the ECU, BHM, CHM, and ABS turned off.

Problem—The Batteries Are Undercharged

Problem—The Batteries Are Undercharged	
Possible Cause	**Remedy**
The drive belt is loose.	Check the drive belt and tensioner. Refer to the drive belt subject in the appropriate engine section in **Group 01** for instructions. If necessary, tighten to the manufacturer's specifications. Start the engine and check the alternator voltage and output. Refer to the troubleshooting subject in the alternator section in **Group 15** for instructions.
The drive belt is damaged or missing.	Check the drive pulleys for locked bearings. Repair or replace any damaged components. Replace the drive belt and start the engine. Check the alternator voltage and output. Refer to the troubleshooting subject in the alternator section in **Group 15** for instructions.
The batteries are undercharged.	Perform a battery test. Charge or replace batteries as needed. If the batteries were discharged, start the engine and check the alternator voltage and output. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The alternator or battery cables are undersized.	Perform a cable load drop test.
The alternator is malfunctioning.	Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The isolator relay is not operating correctly (optional battery isolator system only).	Refer to **Group 82, Subject 300** in this manual for instructions.

Battery Troubleshooting

1. .

   If equipped, set Load Disconnect Switch to "Off." With the DMM probes on the positive and negative posts of the battery pack, record the voltage. Due to differences in their design and operation, flooded cell and AGM batteries have different voltages at the same state of charge.

   Batteries should be fully charged before further testing. If batteries are not fully charged, they will draw current to recharge during testing, invalidating the troubleshooting test results. Fully charged batteries ensure reliable diagnosis.

   See **Table 1** for voltage as an approximate indicator of state of charge for AGM and flooded batteries.

   If the battery pack will not charge to 100% state of charge, there may be a shorted cell. Break the pack into individual batteries and test individually using an approved tester. Go to . After batteries have been tested individually, verify pack voltage once again.

Flooded	AGM	SoC
12.6	12.8	100%
12.4	12.6	80%
12.3	12.4	60%
12.1	12.2	40%
12	12	20%
11.8	11.8	0%

Table 1, Voltage to Approximate State of Charge (SoC)

2.

   Surface charge refers to a higher initial charge (volts), when discharging, in recently-charged batteries. This charge is a "shallow" charge, meaning that the charging-induced chemical reaction has mostly occurred at the surface of the lead plates, and has not equalized throughout the lead. Drawing current from the batteries before testing removes the surface charge, allowing for a better assessment of the "deep charge" state of the lead plates.

   After the surface charge is removed, the batteries need to be at least 80% SoC for further testing. See **Table 1** for voltage as an approximate indicator of state of charge.

3. .

   IMPORTANT: Batteries should only be tested individually.

   3.1 Remove the negative cables of the batteries first, and secure the leads out of the way before touching the positive cables. Remove the battery cables and clean the terminal pads with a wire brush. The adapters will not make sufficient contact with dirty or corroded contact pads.

   3.2 Connect the battery tester's positive and negative clamps to the lead base terminal pads at the positive and negative studs. See **Fig. 1**.

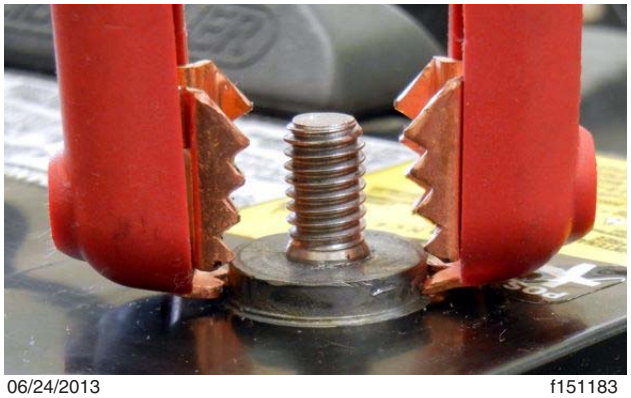


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Fig. 1, Tester Clamps Attached to the Post

The threaded portion of the battery posts are the right place to clip: the steel threads won't make a good connection. The base of the post, on the lead, is the best place to clip. Taking a few extra seconds to make sure the tester, DMM, and carbon pile clips are well-connected can be the difference between a useful and a useless test.

NOTE: If the lead base is too small to clamp to, only lead stud adapters should be used, never nuts. The lead stud adapters must be screwed down tight against the cleaned lead base using a hand tool. Lead adapters are available at most tool vendors.

Refer to the battery tester instruction manual for complete testing instructions.

If the battery tester requires the CCA rating of the battery, it should be on the battery label. See **Fig. 2**.

3.3 If the battery fails, enter the battery serial number and print out the result. The sensor windows on the tester and printer must be aligned to transmit the test results to the printer.

Fig. 2, Battery Label

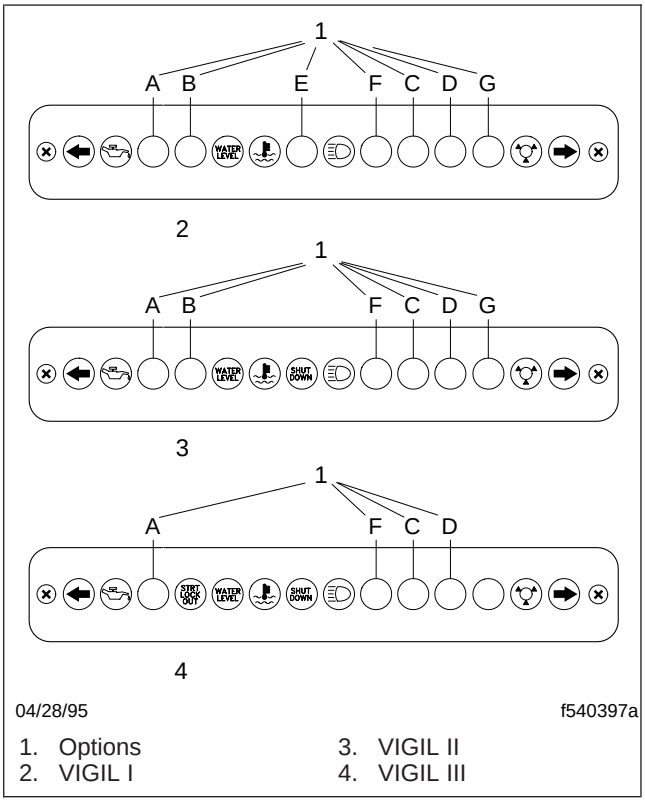
Specifications

See **Table 1** for recharge times. Refer to the commercial batteries page at **www.dekabatteries.com** for more information.

Recharge Time Using a Typical Charger (hours)						
Open Circuit Voltage		State of Charge	Charger Maximum Rate			
Flooded	AGM		50 Amps	30 Amps	20 Amps	10 Amps
12.6V	12.8V	100%				
12.4V	12.6V	75%	0.6	0.9	1.3	2.5
12.2V	12.3V	50%	1.2	1.9	2.7	5.1
12.0V	12.0V	25%	1.8	2.9	4.3	10.7
11.8V	11.8V	0%	2.5	4.0	5.7	10.7

Table 1, Recharge Time Using a Typical Charger

General Description (See Fig. 1)



1. Options
2. VIGIL I
3. VIGIL II
4. VIGIL III

Fig. 1, VIGIL Lightbar Models

The Freightliner VIGIL system consists of a solid-state lightbar located in the instrument panel above the speedometer and tachometer, and the wiring circuits needed to monitor vehicle operations. There are three models of VIGIL:

- VIGIL I
- VIGIL II
- VIGIL III

All models include the following functions:

- Turn Signal Indicators
- High Beam Indicator
- Low Oil Pressure Warning
- Low Air Pressure Warning
- Low Coolant Level Warning
- High Coolant Temperature Warning

VIGIL I activates a warning light and/or buzzer when any of the above impending engine or brake failure conditions occur, but VIGIL I does not shut down the engine.

VIGIL II activates a warning light and buzzer when an impending engine or brake failure condition occurs, and shuts down the engine by stopping fuel flow if the condition worsens. Earlier models of VIGIL II have DIP switches that allow the vehicle operator to cancel the automatic engine shutdown feature and use the lightbar as a warning system only.

VIGIL III includes the warning and engine shutdown features of VIGIL II, plus an automatic starter lockout to protect the starter from overheating and from being engaged into a running engine, a road speed governor to prevent the operator from driving above a pre-set speed, and an overspeed indicator light.

The overspeed indicator light serves two purposes. First, it indicates if the road speed governor or the speedometer sensor is malfunctioning or has been disconnected. If the vehicle is driven for two minutes at 5 mph (8 km/h) faster than the maximum speed allowed by the road speed governor, or if the engine maintains 1700 rpm for 15 minutes with no speedometer reading, the overspeed light will come on and stay on until the engine is shut down. Until it is cleared, the light will flash on for ten seconds each time the engine is started.

The light should not be cleared until the road speed governor and the speedometer sensor have been checked and repaired as needed. For instructions, see **Subject 115**.

The overspeed indicator light also comes on to indicate the vehicle is being driven faster than a preset speed. That speed can be less than, equal to, or greater than the maximum speed for the road speed governor. Once the vehicle slows to below the preset speed, the light goes out.

The engine shutdown feature on both VIGIL II and VIGIL III has an automatic override: if the vehicle must be moved to a safe place after shutdown, crank the engine and it will run for about 30 seconds before shutting down again.

In addition, VIGIL III has six outputs for driving the speedometer, odometer, trip recorders, fuel economy gauge, or satellite navigation device with vehicle speed information from the same transmission-mounted magnetic sensor.

General Information

Besides the standard warning, shutdown, and engine control features described above, the VIGIL systems may include indicator lights for the following optional features:

- Transmission Temperature
- Fifth Wheel Lock
- Utility Light
- Sludge Ejector
- Alternator No Charge
- Engine Heater
- Mirror Heater
- Sand
- Axle Temperature
- Parking Brake
- Cruise Control
- PTO

NOTE: Except for the high beam and turn signal indicators, none of the other lightbar lights stay on when the ignition is switched off. An operator will have to make sure that non-ignition controlled options such as heated mirrors and utility lights are shut off.

Identification (See Fig. 1)

To determine which VIGIL system is in a vehicle, first turn on the key. If the low air and low oil pressure warning lights and the buzzer come on until system air and oil pressures build to operating levels, the lightbar is VIGIL I.

If the lights and the buzzer come on for two one-second pulses, the system is VIGIL II or III. This is a self-check of the lightbar. The low air and oil pressure lights will stay on, but the buzzer will not come on again until the starter button is pressed. When the starter button is pressed, the low air and oil pressure lights and the buzzer will stay on until the system air and oil pressures build to operating levels. If this is the case, examine the lightbar. If it includes lights for the starter lock out or road speed governor the system is VIGIL III. If not, it's VIGIL II.

If there is a heavy frame around the lightbar face and the warning buzzer doesn't sound until the starter button is pressed, the system is a Kysor VIP. For more information, see **Section 54.06**.

Principles of Operation

The warning lights and buzzer in the Freightliner VIGIL system are activated by switches that control three types of circuit: floating-activated, ground-activated, or power-activated.

On a floating-activated circuit like the air pressure circuit, the switches are normally open. During operation, air pressure holds the switches closed and grounds the circuit. If the air pressure drops below a critical level, the switches return to their normally open state, the circuit loses ground, and the warning light and buzzer activate.

On ground-activated and power-activated circuits, the switches are normally closed. During operation, the switches open and respond to changes in vehicle operating conditions by returning to their normally closed positions. The ground-activated circuit grounds, while the power-activated circuit connects with a 12-volt power source. In either case, the warning light and buzzer activate.

ENGINE WARNING AND SHUTDOWN SYSTEMS

The low air pressure warning circuit is a floating-activated circuit controlled by two low-air-pressure switches, one in the primary air system and one in the secondary air system. Both switches are held closed by air pressure greater than 64 psi (440 kPa). If pressure in either the primary or secondary air system falls, the applicable switch opens, the circuit loses ground, and the warning light and buzzer come on.

The low oil pressure warning and shutdown systems use floating-activated circuits, like those for the low air pressure warning system. For this warning circuit, oil pressure holds a switch closed and grounds the circuit via wire 34. When oil pressure drops below a pre-set level, the switch opens, the circuit loses ground, and the warning light and buzzer come on.

If equipped with the shutdown feature, the engine will shut down when oil pressure drops further. A similar switch on wire 325 opens, the shutdown circuit loses ground, and the VIGIL system interrupts fuel delivery to the engine.

The coolant level sensor also controls a floating-activated circuit by grounding wire 173 through the engine coolant in the radiator. If the coolant level drops below the sensor, the circuit loses ground and activates the warning light and buzzer. To prevent a false alarm caused by sloshing coolant, the sensor must be exposed for five seconds before it activates the lightbar alarms. In VIGIL II or III, the engine will shut down if the sensor is exposed for 30 seconds.

The coolant temperature circuit in VIGIL I and II uses a different type of switch to ground its floating-activated circuit. This switch (alarmstat in VIGIL II) is normally closed, and opens as the coolant temperature rises above 215°F (101°C). The circuit loses ground, and the warning light and buzzer come on.

NOTE: On vehicles equipped with a Cummins M11 or N14, the coolant temperature switch opens at 220°F (104°C).

If equipped with the shutdown feature, the engine will shut down when coolant temperature reaches 220°F (104°C) and the switch that grounds wire 324 opens. Cummins M11 and N14 engines, however, are set to shut down when coolant temperature reaches 225°F (107°C).

The coolant temperature circuit in VIGIL III uses a thermistor (variable resistor) that changes resistance as the coolant around it changes temperature. The lightbar monitors the thermistor resistance, and uses that information to determine the coolant temperature. When the resistance indicates the coolant is above a predetermined temperature, the lightbar activates the coolant temperature warning light.

If thermistor resistance indicates the coolant temperature has continued to rise above a second predetermined temperature, the lightbar shuts down the engine.

The road speed governor in VIGIL III allows the vehicle's maximum speed to be set anywhere between 45 and 85 mph (72 and 137 km/h). This maximum speed is set at the factory according to the buyer's specifications, and the vehicle must be returned to a Freightliner dealer for resetting the road speed governor.

When the vehicle reaches the maximum speed, the lightbar activates the road speed governor relay through wire 351. The relay closes and activates the road speed governor solenoid through wire 251G. The solenoid constricts fuel delivery pressure from about 100 psi (690 kPa) to about 20 psi (140 kPa). Excess fuel is returned to the fuel tank through the fuel return line. There is a 2 mph (3 km/h) lag in the system, for example: if the maximum speed were set at 62 mph (100 km/h), the governor would cut fuel pressure at 62 mph (100 km/h) and return pressure to normal at 60 mph (97 km/h).

STARTER LOCK OUT (VIGIL III)

VIGIL III protects the starter by preventing cranking if any of the following conditions exist:

A. Voltage at the key switch is greater than 18 volts.

B. Voltage at the key switch is less than 9 volts before the starter button is pressed.

C. If the starter button has been pressed within two seconds (this prevents the starter cranking the engine as the engine is rocking back from a previous start attempt).

D. When engine speed exceeds 350 rpm (to prevent engaging the starter with the engine running).

E. If the starter has been cranking for a total of 30 seconds within a one-minute period. (The starter button is locked out for two minutes to allow the starter to cool).

NOTE: The starter lock-out warning light will be lit during the two-minute cooling period after 30 seconds of cranking; otherwise, it will light while the starter button is pushed within two seconds of a previous start attempt.

TURN SIGNALS

See **Fig. 2** for the turn signal circuits.

With a left turn selected, wire 314 is connected through the turn signal switch to wire 60, the tractor left front turn signal and trailer left turn signal, and to wire 38B, the tractor left rear turn signal.

Wire 350 connects with wire 314, so wire 350 is grounded through the turn signal bulbs. The lightbar gives a pulsing ground to wire 326. Wire 326 is grounded whenever the pulse is on.

The flasher relay already has voltage from wire 37, which comes from the battery via a 20-amp circuit breaker. When the flasher relay is grounded through wire 326 and the VIGIL lightbar, the flasher relay

General Information

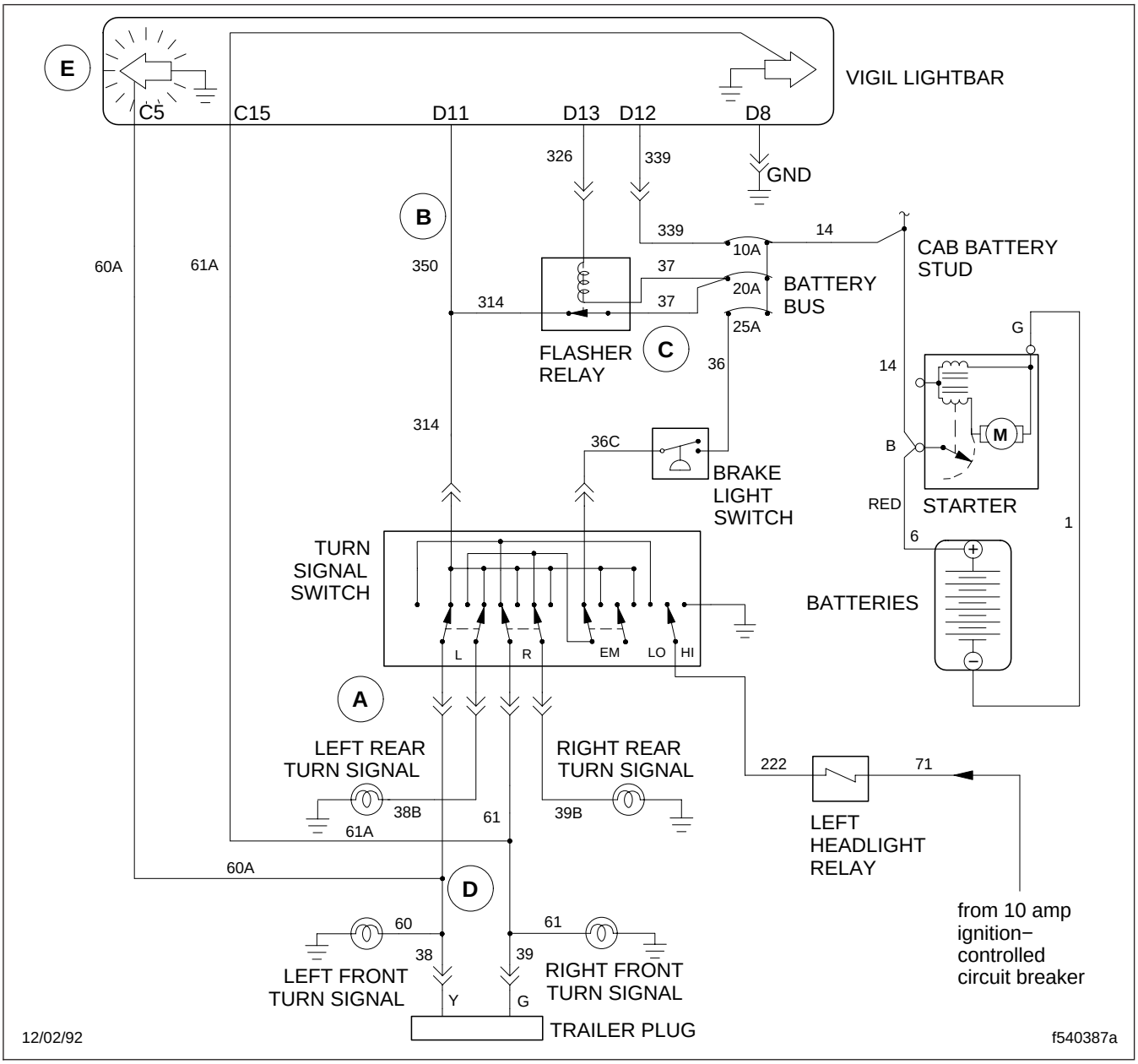


Fig. 2, Turn Signal Circuits

closes and connects wire 37 to wire 314, sending voltage to the signal bulbs.

The voltage in wire 60 that turns on the bulb also reaches wire 60A through the junction of those two wires. Through wire 60A, the voltage reaches the lightbar and causes the left turn indicator arrow in the lightbar to light up.

Wire 339, which is a battery circuit, also provides power to the lightbar. This allows the turn signals and four-way flashers to work even when the ignition is off.

Replacement

1. Remove the two screws on the lightbar bezel, then remove the bezel. **See Fig. 1**.

CAUTION

CAUTION: When removing the lightbar, the wiring harness may have to be loosened before the lightbar can be pulled free of the dash. To access the wiring harness, remove the gauge panel containing the tachometer and speedometer directly below the lightbar. Do not forcibly pull the lightbar from the dash; this may disconnect wires from the harness electrical connectors on the back of the lightbar.

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. Refer to the table in the electrical (wiring) section in this manual for information on special terminals and connectors, and on ordering tools for them.

2. Remove the lightbar and lens.
   - 2.1 Using a screwdriver, depress the four retaining tabs (**Fig. 2**).
   - 2.2 Slide the lightbar and lens assembly out of the dashboard.
   - 2.3 Disconnect the wiring connector(s), then remove the lightbar and lens assembly.
3. Install the new lightbar and lens.
   - 3.1 Connect the new lightbar to the wiring connector(s).
   - 3.2 If any optional function indicators are used, install the lenses for these functions from the old lightbar. See **Fig. 3**.
   - 3.3 Slide the new lightbar into the dashboard until the retaining tabs latch. Make sure the lightbar slips into the rear bracket and no wires are pinched in the bracket.
   - 3.4 Install the bezel and the two screws.
4. Test the operation of the new lightbar.

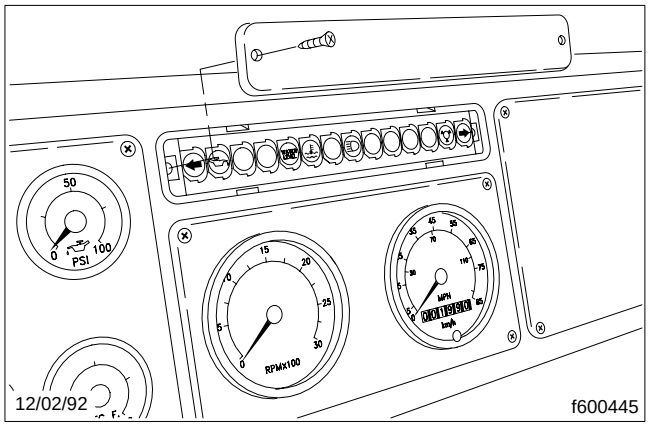


Fig. 1

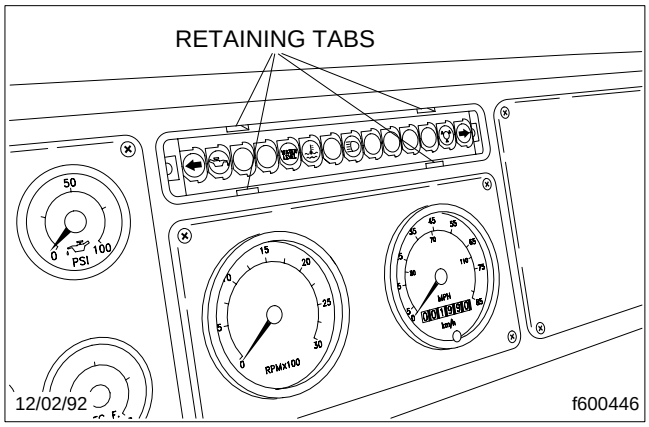


Fig. 2

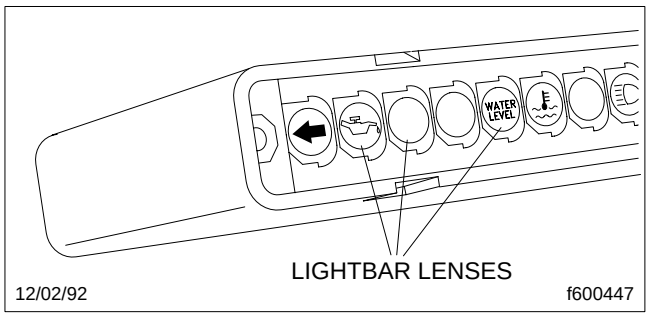


Fig. 3

Setting

⚠ CAUTION

CAUTION: When removing the lightbar, the wiring harness may have to be loosened before the lightbar can be pulled free of the dash. To access the wiring harness, remove the gauge panel containing the tachometer and speedometer directly below the lightbar. Do not forcibly pull the lightbar from the dash; this may disconnect wires from the harness electrical connectors on the back of the lightbar.

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. Refer to the table in the electrical (wiring) section in this manual for information on special terminals and connectors, and on ordering tools for them.

1. Remove the VIGIL II lightbar assembly from the dashboard.
   - 1.1 Remove the two screws on the lightbar bezel, then remove the bezel.
   - 1.2 Using a screwdriver, depress the four retaining tabs.
   - 1.3 Slide the lightbar and lens assembly out of the dashboard.
2. Looking down at the top of the lightbar, remove the tape that covers the access hole at the right front corner. **See Fig. 1**. DIP switch number 2 is located toward the center of the unit, DIP switch number 1 toward the edge. One side of the switch block is marked "open."
3. To turn off the shutdown features, move both the switches to the open position. Warning functions will still operate, but there will be no shutdown.
4. Move DIP switch 1 to the closed position to turn on the low oil pressure and high coolant temperature shutdown functions.
5. Move DIP switch 2 to the closed position to turn on the low coolant level shutdown function. Switch 2 has no effect if switch 1 is open.
6. Install the lightbar assembly in the dashboard.
   - 6.1 Slide the lightbar into the dashboard until the retaining tabs latch. Make sure the lightbar slips into the rear bracket and no wires are pinched in the bracket.
   - 6.2 Install the bezel and the two screws.
7. Test the lightbar operation.

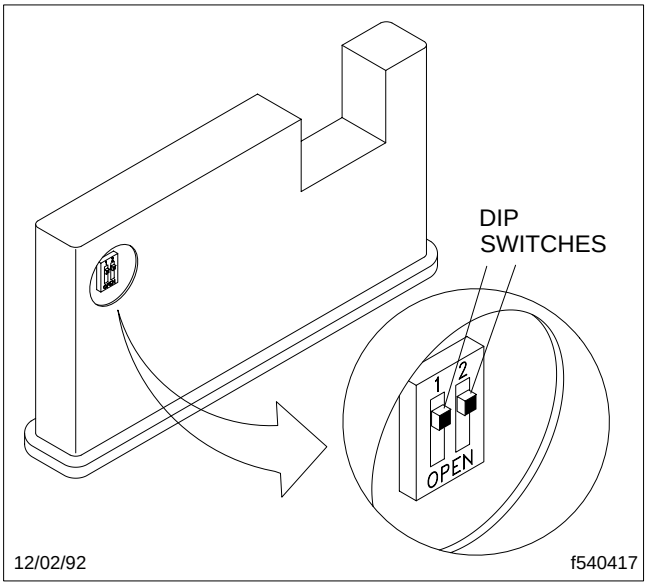


Fig. 1

Calibrating

VIGIL III speedometers and odometers are calibrated through the lightbar, not through the gauge head. The gauge head itself is not adjustable.

Use the procedure below to calibrate the speedometer and odometer.

To calibrate the speedometer and odometer, the vehicle must be driven over a measured mile so VIGIL III can count the number of pulses it receives from the transmission-mounted magnetic sensor. VIGIL III begins counting the pulses when the headlights are switched from low to high beams, and stops counting when the headlights are switched back to low beams.

1. Drive to a location with an accurate measured mile.
2. Remove the two screws on the lightbar bezel, then remove the bezel.
3. Turn on the key switch, and start the engine.

   Turn on the headlight low beams.

   Insert a blunt instrument, such as an open paper clip, in the small hole between the high coolant temperature light and the shutdown light until you feel a firm resistance. **See Fig. 1**.

   The amber light in the ninth position from the left will begin blinking and the buzzer will buzz for a moment.

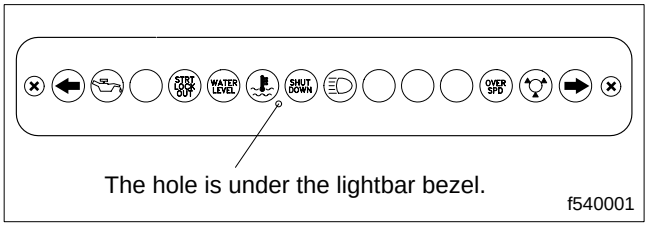


Fig. 1

4. Drive the vehicle into the measured mile at a minimum speed of 5 mph (8 km/h).

   Turn on the high beams at the beginning of the mile. Turn off the high beams at the end of the measured mile.

   Stop the vehicle at a convenient location, but leave the engine running.
5. Turn the high beams on again to check the accuracy of the current speedometer calibration. A speedometer reading of 45 mph (72 km/h) indicates the speedometer is calibrated correctly. Each 5 mph (8 km/h) increment above or below 45 mph (72 km/h) indicates a 1 mph (2 km/h) error in the speedometer reading when the vehicle is driven at 55 mph (88 km/h).

   For example: if the reading is 35 mph (56 km/h), the vehicle is traveling at 53 mph (85 km/h) when the speedometer reads 55 mph (88 km/h). If the reading is 55 mph (88 km/h), the vehicle is traveling at 57 mph (92 km/h) when the speedometer reads 55 mph (88 km/h).

   If the speedometer is accurate (the speedometer reads 45 mph), turn off the key switch to retain the existing calibration.
6. To calibrate the speedometer and odometer according to the new value obtained by running the measured mile, insert a blunt instrument in the calibration hole used in step three, and press until you feel firm resistance.

   Turning off the ignition at any point in this procedure cancels the recalibration and leaves the speedometer at the existing calibration.

NOTE: The speedometer can be recalibrated only within 15 percent above or below its original factory calibration. If making major rear axle or tire size changes, contact a Freightliner dealer or the Freightliner Parts Technical Department for information about recalibration outside the 15 percent range.

7. Install the lightbar bezel.

Setting and Clearing the Overspeed Indicator Light, VIGIL III

Setting

Use the following procedure to set the overspeed indicator light. The headlight dimmer pushbutton acts as a switch for changing the indicator light setting.

1. Remove the two screws on the lightbar bezel, then remove the bezel.
2. Turn on the ignition.

   Turn on the headlight low beams.

   Insert a blunt instrument, such as an open paper clip, in the small hole (see **Fig. 1**) between the high coolant temperature light and the shutdown light until you feel firm resistance.

   The amber light in the ninth position from the left will begin blinking and the buzzer will buzz for a moment. The speedometer will display the current overspeed setting.

   Turn on the high beams.

   The speedometer needle will begin to rise from the present overspeed setting to 85 mph (137 km/h). At 85 mph (137 km/h), the speedometer needle will drop quickly back to 40 mph (64 km/h) then rise again, slowly, to 85 mph (137 km/h). It will continue to rise and fall between 40 and 85 mph (64 and 137 km/h). When it reaches the desired overspeed setting, turn off the high beams.

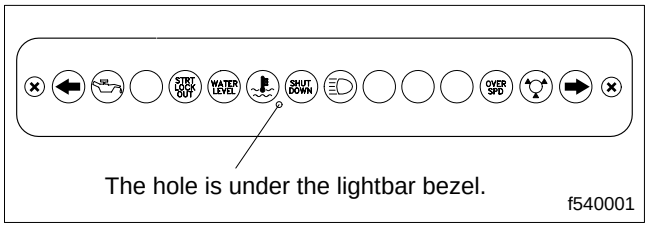


Fig. 1

3. To record the new overspeed setting, again insert the blunt instrument in the calibration hole, and press until you feel firm resistance.

NOTE: Turn off the ignition at any point in the resetting process to retain the existing setting.

4. Install the lightbar bezel.

Clearing

NOTE: If the overspeed indicator light flashes on for ten seconds each time the engine is started, the road speed governor or speedometer sensor is malfunctioning. Check and repair those components as necessary before clearing the indicator light.

1. Turn on the ignition to verify the overspeed light is activated.
2. Remove the two screws on the lightbar bezel; then remove the bezel.
3. Insert a blunt instrument, such as an open paper clip, in the small hole (see **Fig. 1**) between the high coolant temperature light and the shutdown light until you feel firm resistance.
4. Turn off the ignition.
5. Turn on the ignition to verify the overspeed light remains off.
6. Install the lightbar bezel.

Replacement

Later-model VIGIL I systems have buzzers that can be replaced in the field. These models can be identified by an orange sticker on the lightbar. Text on the sticker states that the buzzer is replaceable.

The buzzer should sound whenever the oil pressure is too low, the coolant temperature is too high, or the air pressure is too low. If the warning lamp for any of these conditions comes on, but the buzzer does not sound, the buzzer is probably malfunctioning. Other circuit failures could cause the buzzer not to sound, but they are much less likely to occur.

1. Remove the lightbar, as instructed in **Subject 100**.
2. Bend the lightbar housing enough to slide the circuit board out the front of the housing; or pry apart the top and bottom sections of the lightbar housing.
3. Pull the buzzer out of the lightbar. **See Fig. 1.**

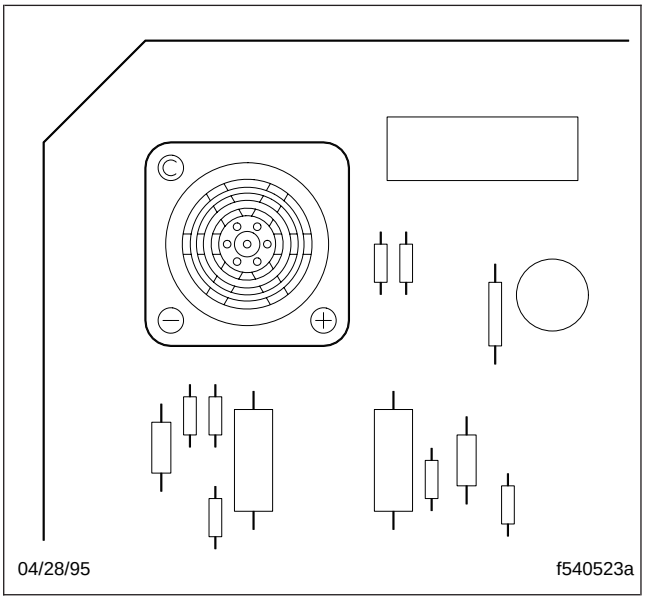


Fig. 1

4. Install the new buzzer in the lightbar, making sure that the positive (+) terminal symbol on the buzzer is on the same side as the positive symbol on the circuit board. **See Fig. 2.**

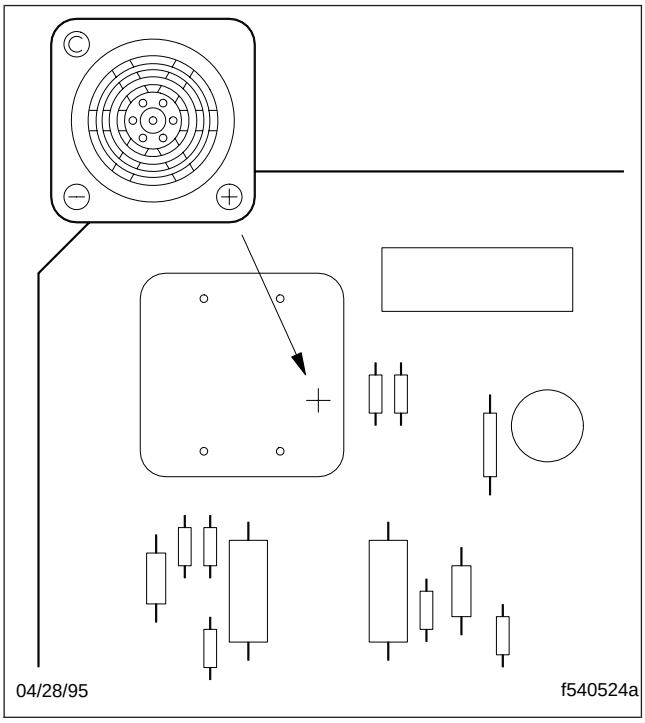


Fig. 2

5. Slide the circuit board back into the lightbar housing; or, if the housing was pried apart, snap the top and bottom sections of the housing together.
6. Install the lightbar, as instructed in **Subject 100**.

General Information

Use the table below to identify VIGIL problems and find the applicable troubleshooting flow chart for solving each problem. The troubleshooting guide for each function listed in the table includes a description of how the function works, a wiring schematic for the function, and flow charts for troubleshooting possible problems with the function.

The troubleshooting flow charts are designed to identify the cause of a problem in logical step-by-step tests. Each flow chart begins with the easiest tests and the most likely causes of each problem, and proceeds to more difficult tests and less likely causes. Before beginning any testing, read the following general troubleshooting guidelines:

1. If possible, replace the suspect lightbar with a lightbar of the same VIGIL model that is operating correctly. The new lightbar may solve the problem, but if it doesn't, you know the problem is not caused by the lightbar.

   However, if the new lightbar does appear to correct the problem, remove it, and install the old lightbar again. The action of removing and replacing the lightbar the first time may have corrected the problem.

2. When the ignition is turned on, VIGIL models II and III perform a self-check to test all indicator lights and the buzzer. If a function appears to be not working, turn the key off. Then, turn it on, and watch carefully to make sure the indicator light in question lights. If it doesn't, the LED may only be burned out.

3. Many of the troubleshooting tests use terminal D8 of the VIGIL wiring harness connector as a ground. Verify that terminal D8 is grounded by checking its continuity to a good ground, the electrical center mounting plate, for example.

4. Look at the cab harness side of the lightbar connector. Are all the wiring terminals fully seated? Are the terminals for the function in question installed in the right slots?

5. Look at the connector on the back of the lightbar. Are any of the pins bent, broken, or pushed back?

6. Review the description and the wiring schematic of how the circuit for the function in question works. Does an open input, a ground input, or a power input cause the lightbar reaction? Understand what conditions are necessary for the lightbar's reaction.

⚠ CAUTION

CAUTION: VIGIL troubleshooting may require removing the lightbar and inserting the leads of a voltmeter or ohmmeter in the wiring connectors for the VIGIL wiring harness. When removing the lightbar, the wiring harness may have to be loosened before the lightbar can be pulled free of the dash. To access the wiring harness, remove the gauge panel containing the tachometer and speedometer directly below the lightbar. Do not forcibly pull the lightbar from the dash; this may disconnect wires from the harness electrical connectors on the back of the lightbar.

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. Refer to the table in the electrical (wiring) section in this manual for information on special terminals and connectors, and on ordering tools for them.

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* Programmable option at the factory.
† To determine which option corresponds with which lightbar light, **see Fig. 1.**

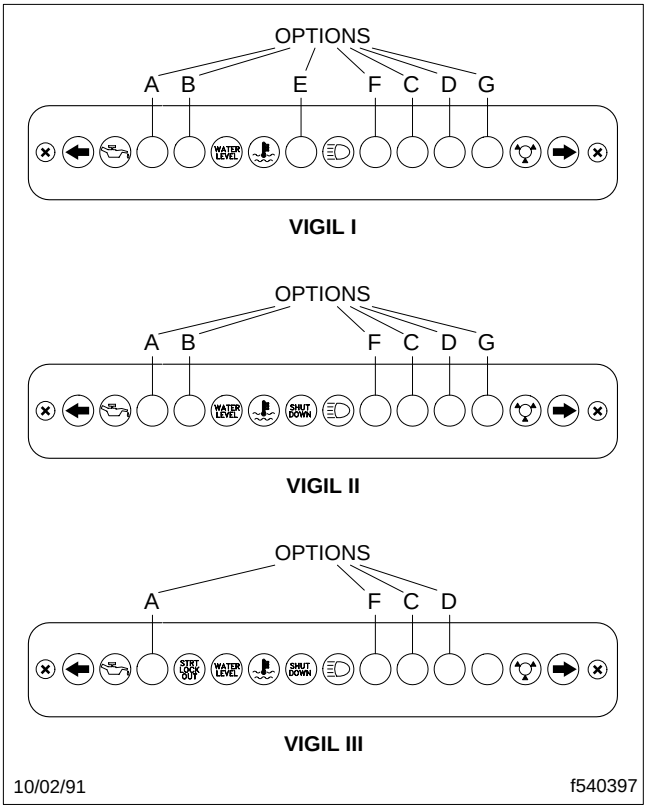


Fig. 1

Lightbar Overall

(See **Subject 400** for complete VIGIL wiring schematics)

On VIGIL I, when the ignition is switched on, the low air and oil pressure warning lights and the buzzer will come on and stay on until the air and oil pressures reach operating levels.

On VIGIL II and III, when the ignition is switched on, all the warning lights and the buzzer will come on for two one-second pulses. This is a self-check of the lightbar. The low air and oil pressure warning lights will stay on, but the buzzer will not sound again until the starter button is pressed. The low air and oil pressure warning lights and the buzzer will go off when the air and oil pressures reach operating levels.

Problem—Lightbar Dead (Few or No Functions Light When the Key Is Switched On)

See **Fig. 1** for troubleshooting procedures.

NOTE: All lightbars use constant battery power, ignition power (key on), and ground. If the battery power is missing, the turn signals will not work. If the ignition power is missing, most functions will not work. If the ground is missing, no functions will work.

Troubleshooting

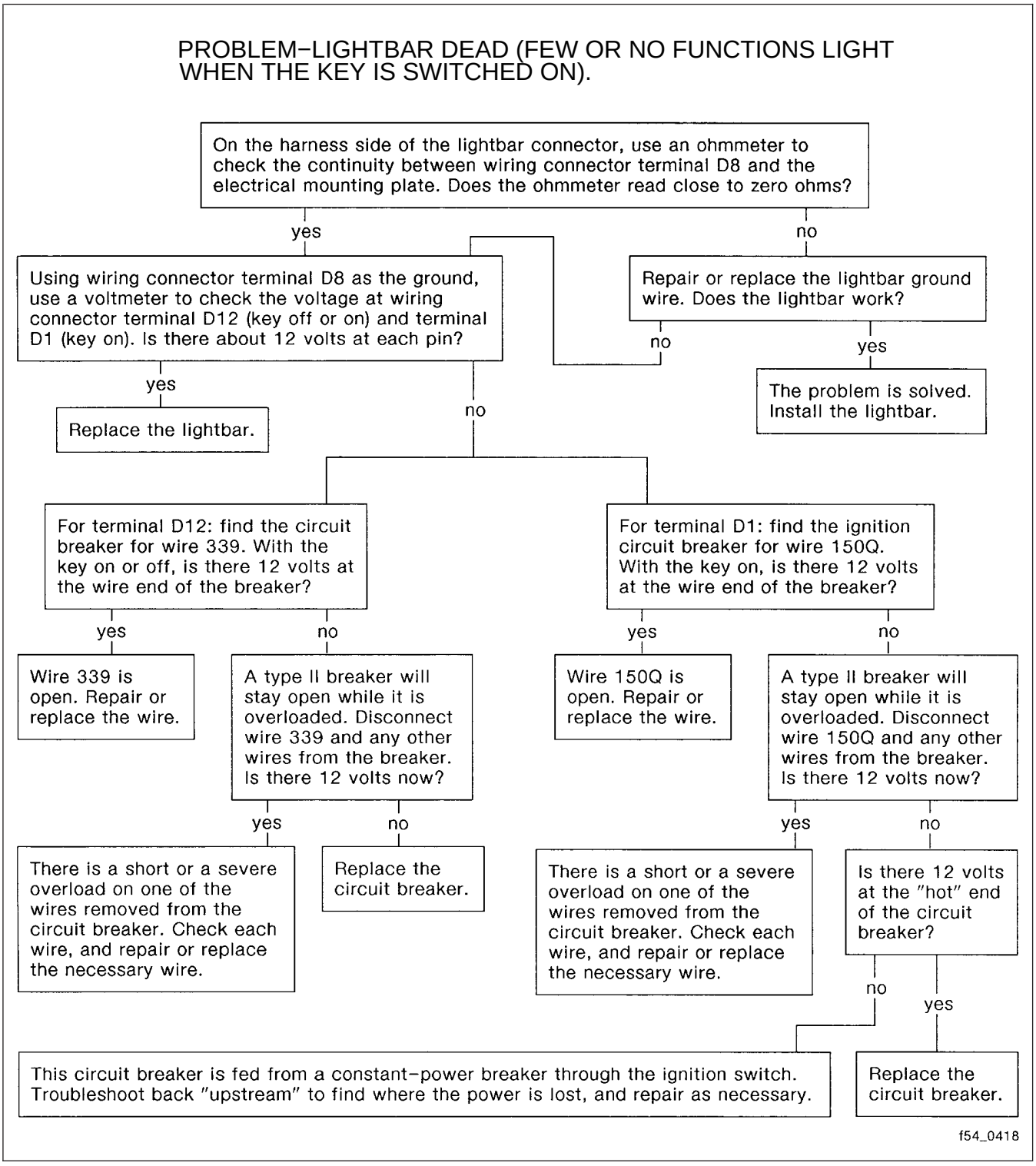
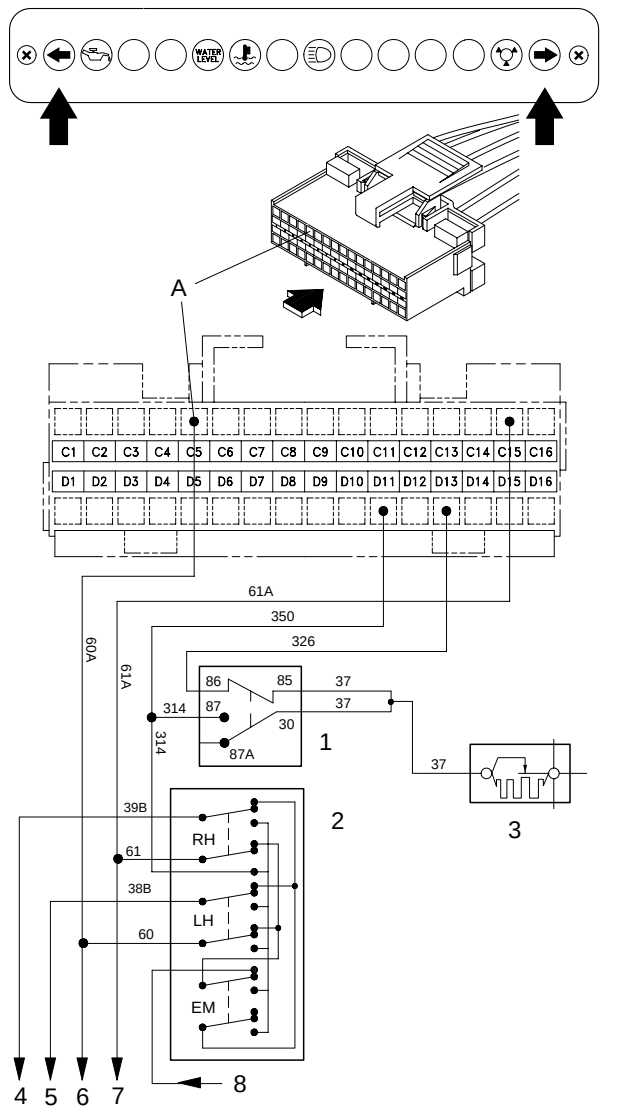


Fig. 1

Turn Signal Indicators (See Fig. 1)



A. Insert meter leads in outer holes for testing.
1. Flasher Relay
2. Turn Signal Switch
3. 20-Amp Circuit Breaker
4. To right-hand rear stop/turn signal lamps
5. To left-hand rear stop/turn signal lamps
6. To left-hand front turn signal lamps
7. To right-hand front turn signal lamps
8. From stop lamp switch

Fig. 1, Turn Signal/Emergency Flasher Circuits

Figure 1 shows the turn signal circuits. For a right turn, left turn, or for emergency flashers, only the turn signal switch contacts (RH, LH, EM) would change position.

With a left turn selected, terminal D11 of the lightbar is grounded through wire 350, wire 314, the turn signal switch LH contacts, wire 60, and the left turn signal bulbs.

Sensing this ground at terminal D11, the lightbar gives a pulsing ground at terminal D13. The pulsing ground reaches the flasher relay coil through wire 326, and causes the flasher relay contacts to cycle open and closed.

Each time the contacts cycle, the relay sends a pulse of power through wire 314, the turn signal switch, and wire 60 to the left turn signal bulbs and the left turn signal indicator.

Circuit operation is similar for a right turn. Terminal D11 of the lightbar is still grounded, but through wire 350, wire 314, the turn signal switch RH contacts, wire 61, and the right turn signal bulbs. The flasher relay cycles to operate the right turn signal bulbs and indicator.

When the emergency flashers are activated, the turn signal switch EM contacts connect both wire 60 and wire 61 to terminal D11, and the switch directs power to both the left and right hand turn signal bulbs and both turn signal indicators.

Problem — The Turn Signals Don't Work

See **Fig. 2** for troubleshooting procedures.

Troubleshooting

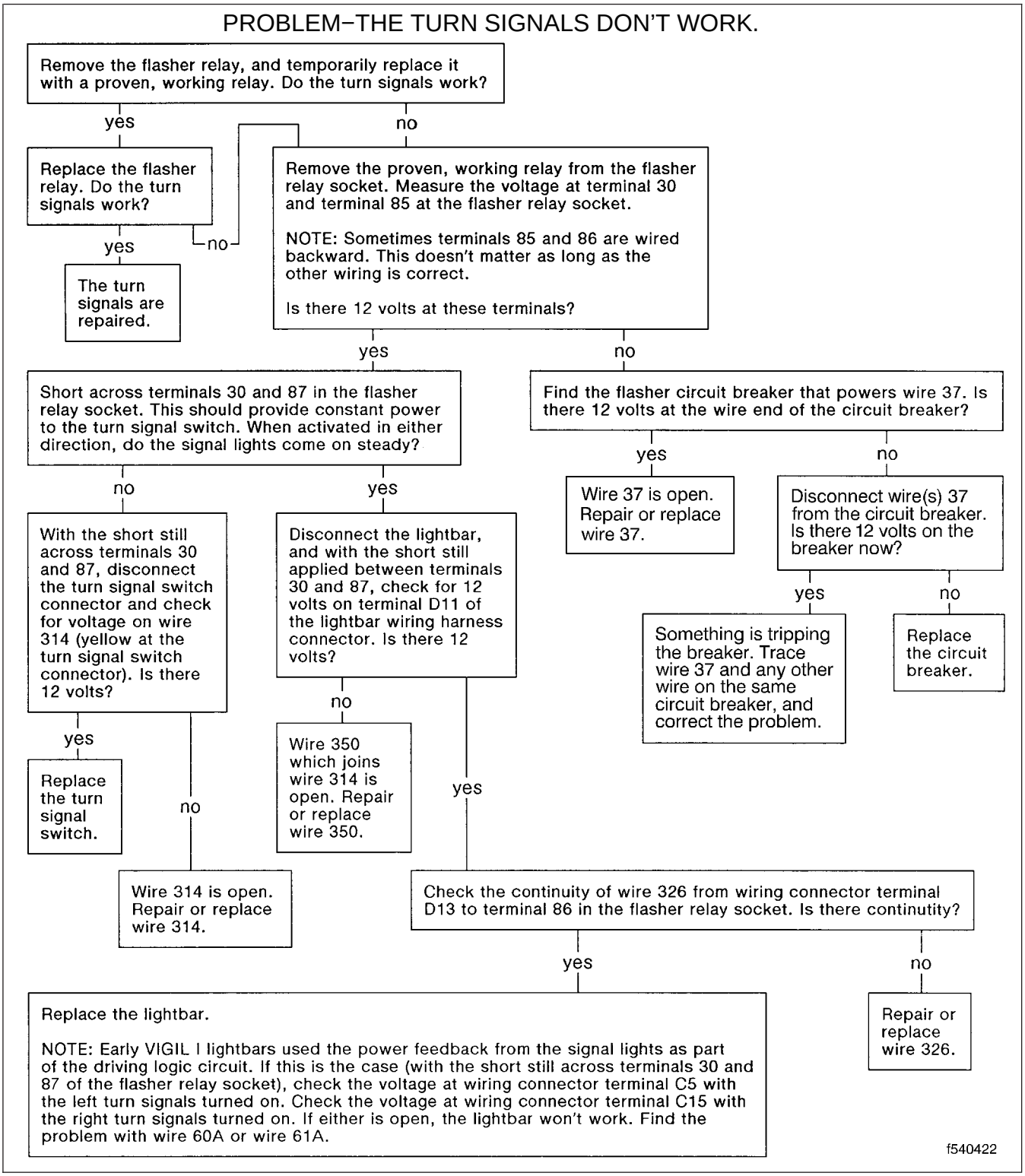


Fig. 2, Turn Signal/Emergency Flasher Troubleshooting

High Beam Indicator

(**See Fig. 1**)

The green function light in the center of the VIGIL lightbar indicates that the headlight high beams are on. This light comes on when the driver switches on the high beams, and goes off when the driver switches off the high beams.

When the high beams are on, the left headlight relay sends power through wire 21B to lightbar pin C16. This power tells the lightbar the headlight high beams are on, and the lightbar activates the high beam function light. When the headlights are switched to low beams or switched off, the power through wire 21B stops, and the high beam function light goes off.

Problem—The High Beam Indicator Light Doesn't Come On When the High Beams Are Activated

See Fig. 2 for troubleshooting procedures.

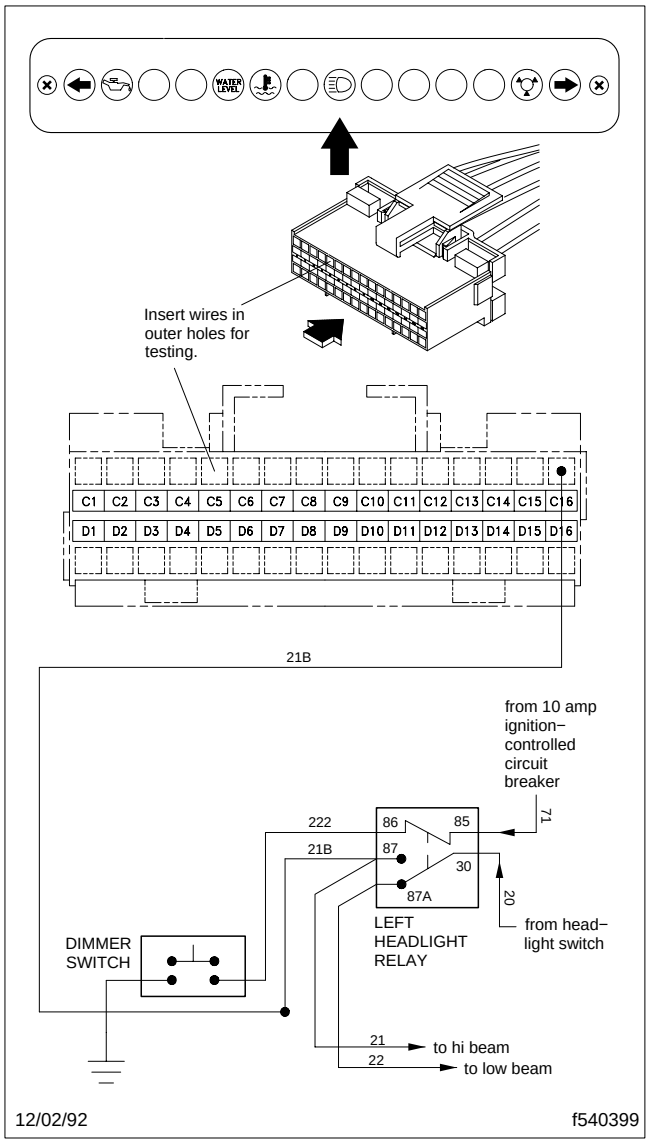


Fig. 1

Troubleshooting

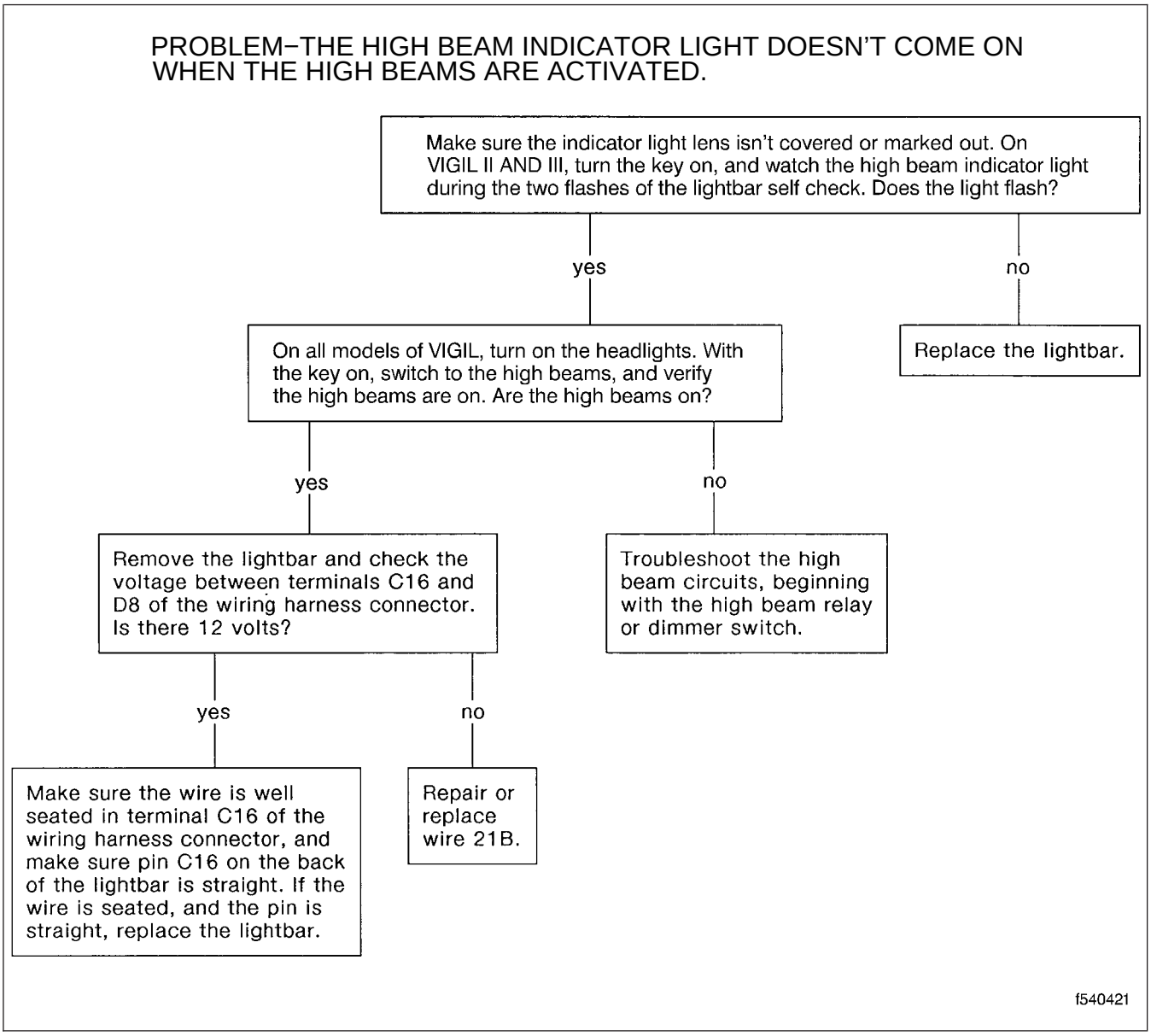


Fig. 2

Low-Oil-Pressure Warning and Shutdown (See Fig. 1)

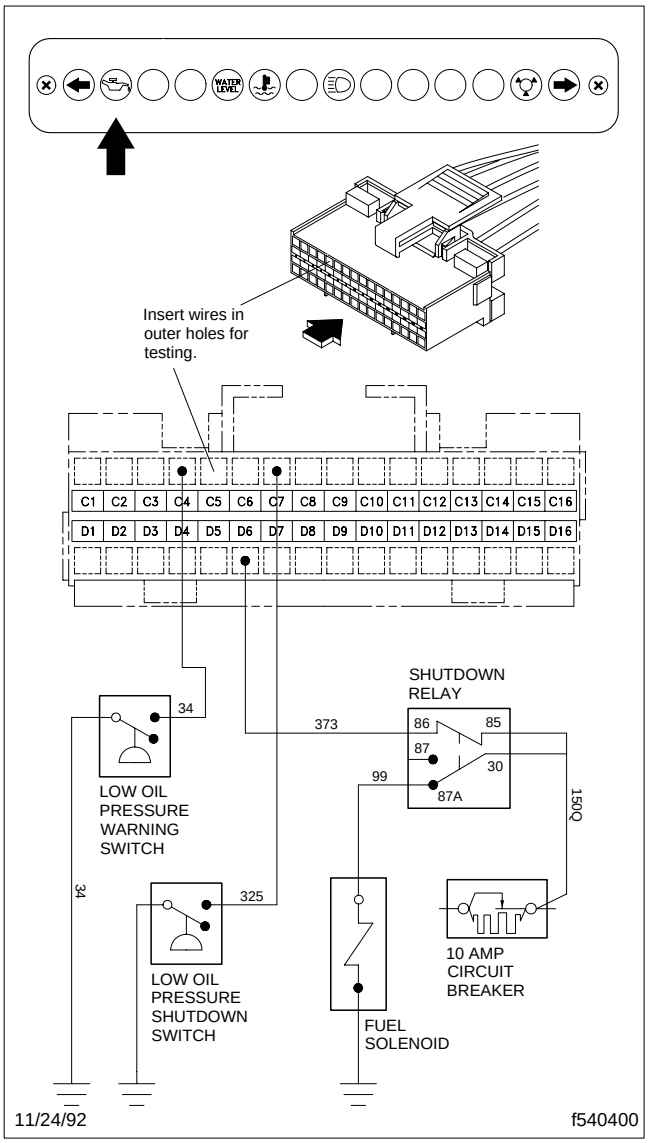


Fig. 1

The low-oil-pressure indicator alerts the driver to a problem with the engine oil pressure. There are two circuits associated with this feature: VIGIL I gives a warning only, VIGIL II and III give a warning and shut down the engine.

On VIGIL I, the low-oil-pressure light and buzzer come on when the ignition is switched on, and stop when the oil pressure reaches the operating level. On VIGIL II and III, the light and buzzer come on for two one-second pulses when the ignition is switched on. This is a self-check of all the circuits. The low-oil-pressure light stays on, but the buzzer doesn't sound again until the starter button is pressed. When the starter button is pressed, the light *and* buzzer will stay on while the oil pressure builds to the operating level.

Warning System (VIGILs I, II, and III)

A switch on the air/oil junction block activates the warning light and buzzer for the low-oil-pressure circuit. When the engine oil pressure drops below a predetermined point (see **Table 1**), the red lightbar warning light (second from the left) comes on and the buzzer sounds.

Engine	Oil Pressure in psi (kPa)	Switch Position	
		Engine Off	Engine On
Cummins	5–9 (34–62)	OPEN	CLOSED
CAT 3306/3176	5–9 (34–62)	OPEN	CLOSED
CAT 3406	13–17 (90–117)	OPEN	CLOSED
DDE SRS60	5–9 (34–62)	OPEN	CLOSED

Table 1

The low-oil-pressure warning switch controls a floating-active circuit: the switch is open when the engine isn't running. During normal engine operation, oil pressure holds the switch closed and grounds pin C4 on the VIGIL lightbar through wire 34. If the oil pressure drops below the predetermined point, the switch opens, lightbar pin C4 loses ground, and the warning light and buzzer come on.

Shutdown System (VIGILs II and III)

After the low-oil-pressure warning comes on, if engine oil pressure drops below a second predetermined point (see **Table 2**), the low-oil-pressure shutdown system shuts the engine down, and the red warning light (seventh from the left) comes on.

Troubleshooting

Engine	Oil Pressure in psi (kPa)	Switch Position	
		Engine Off	Engine On
Cummins	2-5 (14-35)	OPEN	CLOSED
CAT 3306/3176	2-5 (14-35)	OPEN	CLOSED
CAT 3406	8-12 (55-83)	OPEN	CLOSED
DDE SRS60	—	—	—

Table 2

NOTE: VIGIL III may be programmed at the factory to give only a warning.

Located in the air/oil junction block, the low-oil-pressure shutdown switch controls a floating-active circuit: the switch is open when the engine isn't running. During normal engine operation, oil pressure holds the switch closed and grounds pin C7 on the VIGIL lightbar through wire 325. If the oil pressure drops below a predetermined point, the switch opens, lightbar pin C7 loses ground, and thirty seconds later the shutdown light comes on. The lightbar energizes the shutdown relay, and the relay breaks the circuit to the fuel solenoid through wire 99.

Problem—The Low-Oil-Pressure Warning Light and the Buzzer Don't Come On When the Oil Pressure Is Low (See Fig. 2)

⚠ CAUTION

Before troubleshooting, check the engine oil level and pressure. Operating an engine without adequate oil can cause serious engine damage.

Problem—The Low-Oil-Pressure Warning Light and the Buzzer Come On When the Engine Is Running Normally (See Fig. 3)

⚠ CAUTION

Before troubleshooting, check the engine oil level and pressure. Operating an engine without adequate oil can cause serious engine damage.

Problem—The Low-Oil-Pressure Warning Light and the Buzzer Come On, and Thirty Seconds Later the Shutdown Light Comes On and the Engine Shuts Down; However, the Oil Pressure Reads Normal (See Fig. 4)

⚠ CAUTION

Before troubleshooting, check the engine oil level and pressure. Operating an engine without adequate oil can cause serious engine damage.

Problem—The Low-Oil-Pressure Warning Light and Shutdown Light Come On, But the Buzzer Doesn't and the Engine Doesn't Shut Down (See Fig. 5)

⚠ CAUTION

Before troubleshooting, check the engine oil level and pressure. Operating an engine without adequate oil can cause serious engine damage.

NOTE: This condition is a diagnostic aid in VIGIL II and III lightbars. It indicates the low oil pressure shutdown switch is opening before the low oil pressure warning switch.

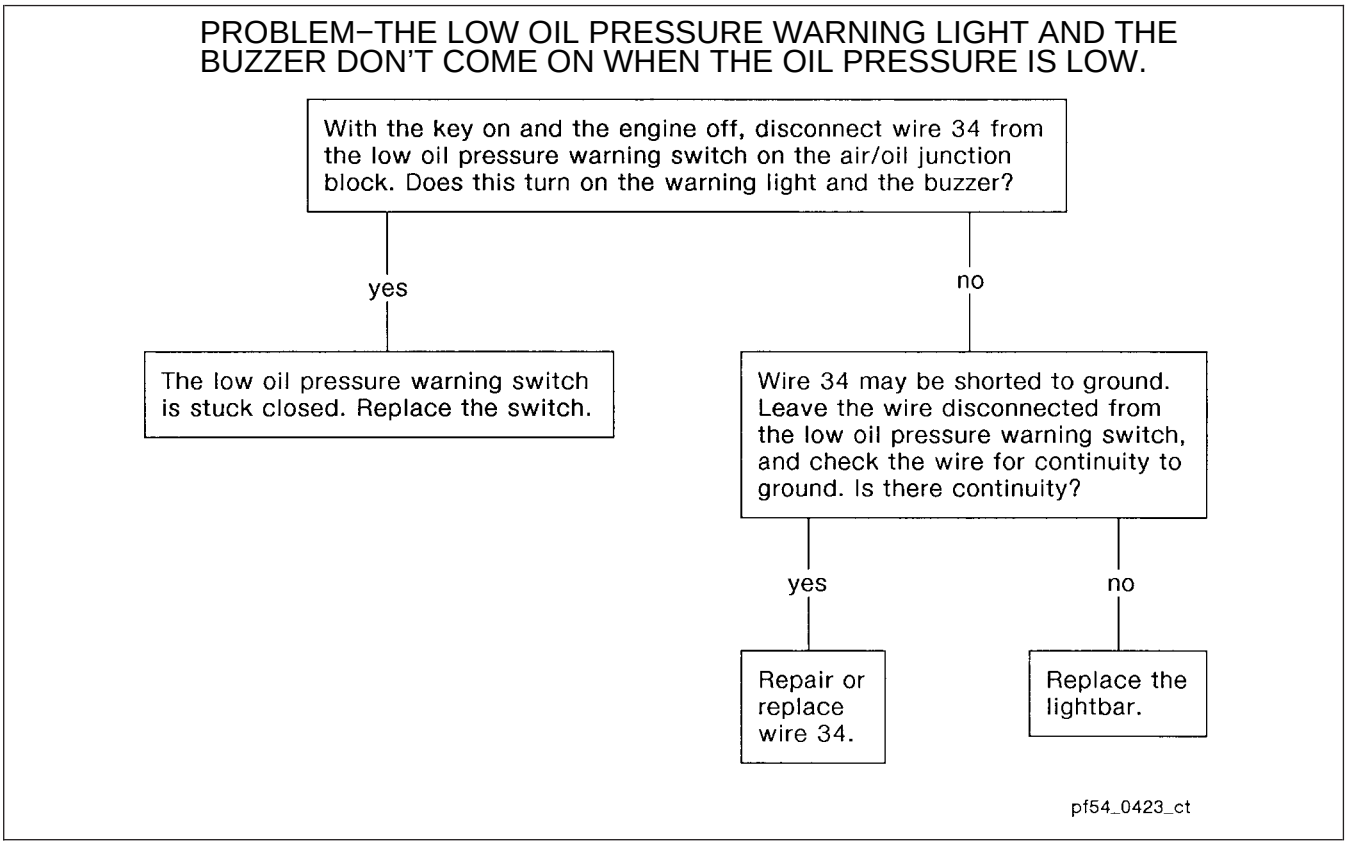

PROBLEM–THE LOW OIL PRESSURE WARNING LIGHT AND THE BUZZER DON'T COME ON WHEN THE OIL PRESSURE IS LOW.
With the key on and the engine off, disconnect wire 34 from the low oil pressure warning switch on the air/oil junction block. Does this turn on the warning light and the buzzer?
yes
no
The low oil pressure warning switch is stuck closed. Replace the switch.
Wire 34 may be shorted to ground. Leave the wire disconnected from the low oil pressure warning switch, and check the wire for continuity to ground. Is there continuity?
yes
no
Repair or replace wire 34.
Replace the lightbar.
pf54_0423_ct

Fig. 2

Troubleshooting

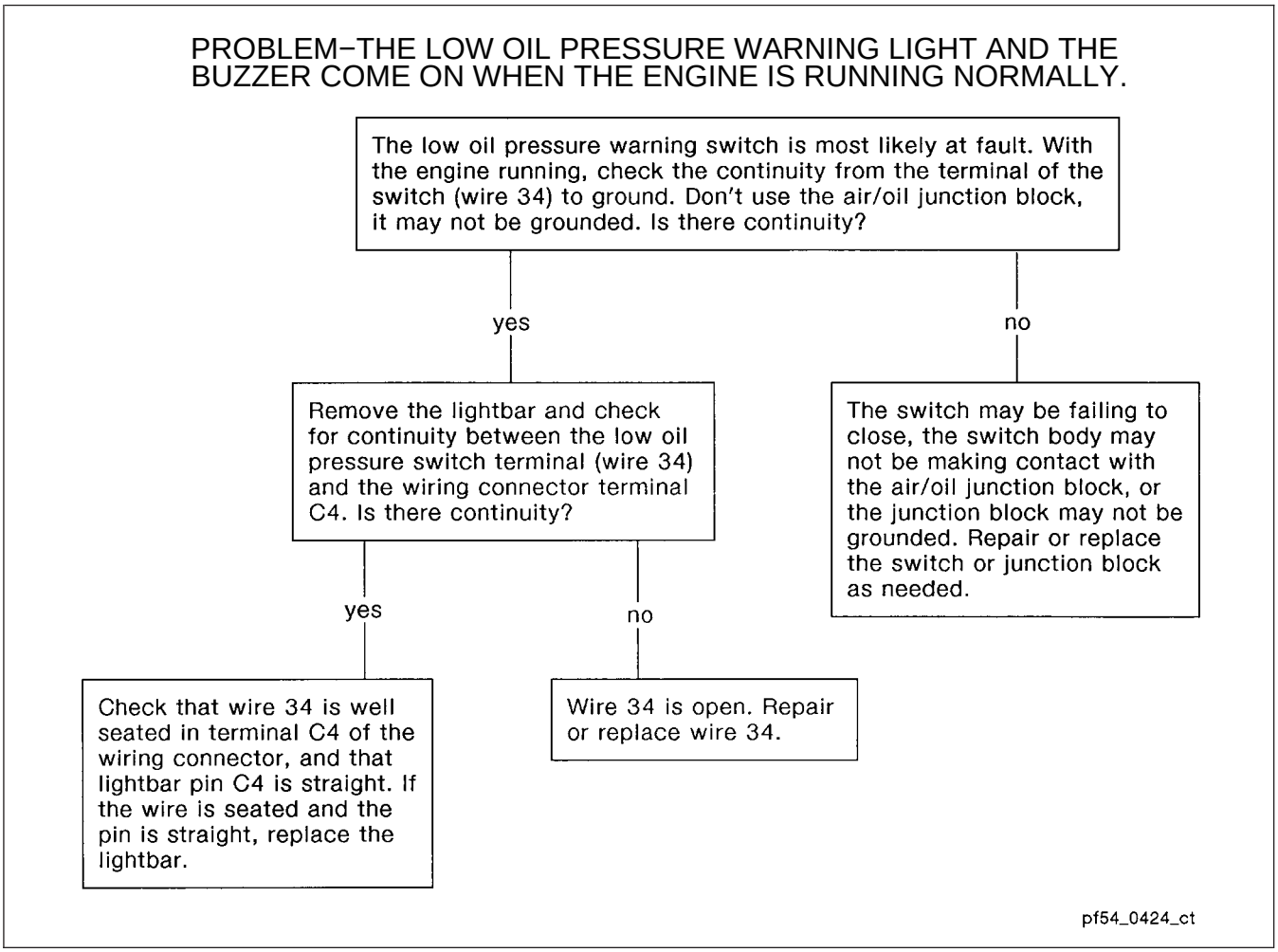


Fig. 3

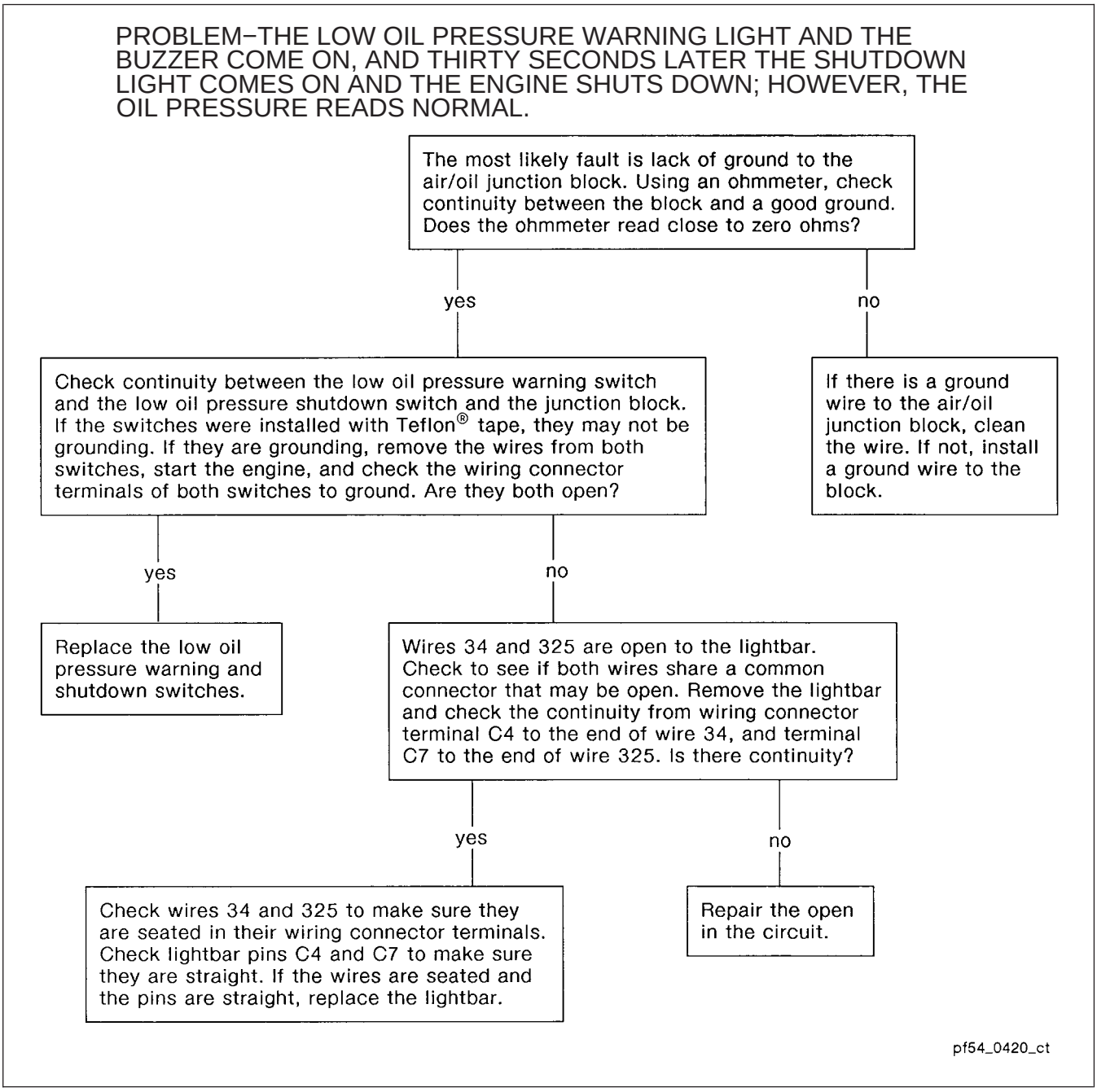

PROBLEM–THE LOW OIL PRESSURE WARNING LIGHT AND THE BUZZER COME ON, AND THIRTY SECONDS LATER THE SHUTDOWN LIGHT COMES ON AND THE ENGINE SHUTS DOWN; HOWEVER, THE OIL PRESSURE READS NORMAL.
The most likely fault is lack of ground to the air/oil junction block. Using an ohmmeter, check continuity between the block and a good ground. Does the ohmmeter read close to zero ohms?
yes
no
Check continuity between the low oil pressure warning switch and the low oil pressure shutdown switch and the junction block. If the switches were installed with Teflon® tape, they may not be grounding. If they are grounding, remove the wires from both switches, start the engine, and check the wiring connector terminals of both switches to ground. Are they both open?
If there is a ground wire to the air/oil junction block, clean the wire. If not, install a ground wire to the block.
yes
no
Replace the low oil pressure warning and shutdown switches.
Wires 34 and 325 are open to the lightbar. Check to see if both wires share a common connector that may be open. Remove the lightbar and check the continuity from wiring connector terminal C4 to the end of wire 34, and terminal C7 to the end of wire 325. Is there continuity?
yes
no
Check wires 34 and 325 to make sure they are seated in their wiring connector terminals. Check lightbar pins C4 and C7 to make sure they are straight. If the wires are seated and the pins are straight, replace the lightbar.
Repair the open in the circuit.
pf54_0420_ct

Fig. 4

Troubleshooting

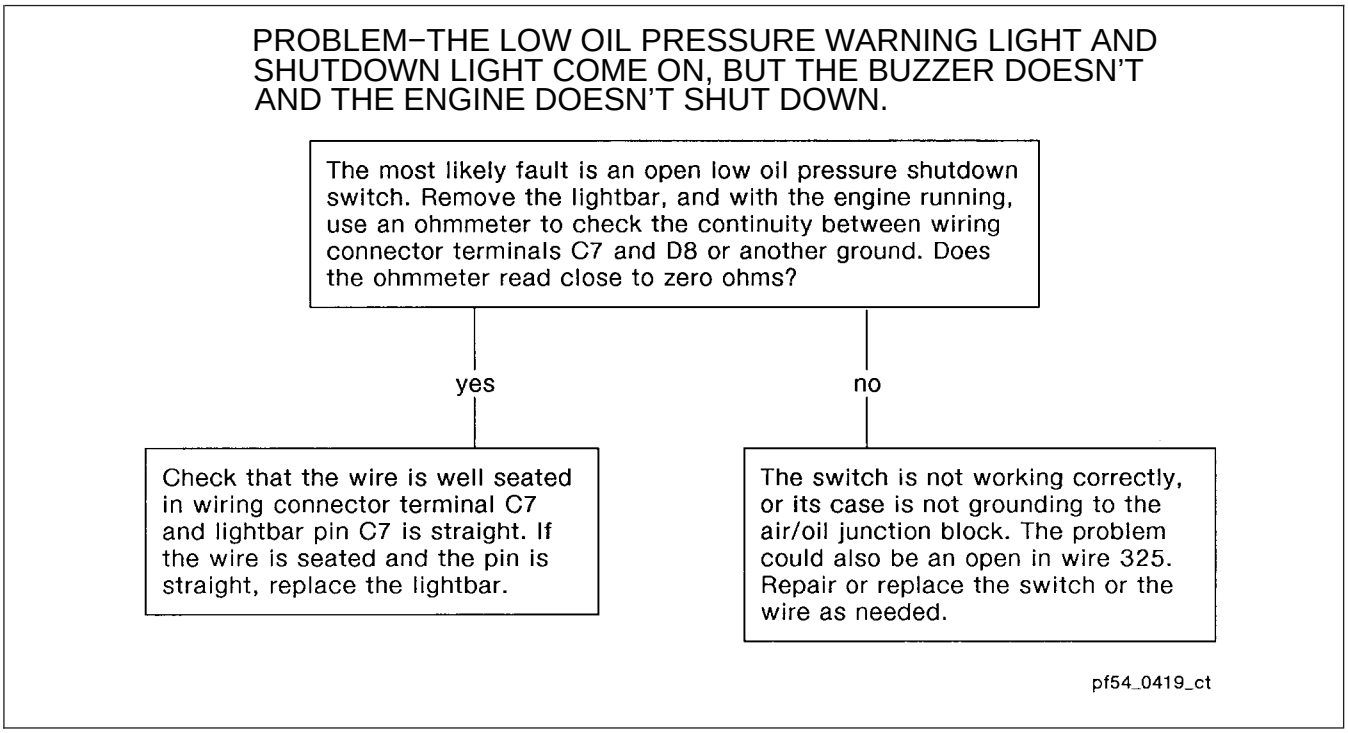


Fig. 5

Low Air Pressure Warning

(**See Fig. 1**)

The low air pressure indicator tells the driver when the brake system air pressure is low. All VIGIL models are equipped with the low air pressure warning system.

On VIGIL I, the low air pressure warning light and buzzer come on when the ignition is switched on and stop when the air pressure reaches the operating level. On VIGIL II and III, the warning light and buzzer come on for two one-second pulses when the ignition is switched on. This is a self-check of the VIGIL circuits. The low air pressure light stays on, but the buzzer doesn't sound again until the starter button is pressed. When the starter button is pressed, the light *and* buzzer will come on until air pressure builds to the operating level.

A switch in the primary air system and a switch in the secondary air system activate the warning light and buzzer for the low air pressure circuit. When air pressure in either system drops below 64 psi (441 kPa), the lightbar light (second from the right) comes on and the buzzer sounds.

The low air pressure warning switches control a floating-active circuit: the switches are open when brake system air pressure is below 64 psi (441 kPa). During normal vehicle operation, the air pressure holds the switches closed and grounds pin C14 on the VIGIL lightbar through wire 18B. If the air pressure drops below 64 psi (441 kPa), the switches open, lightbar pin C14 loses ground, and the warning light and buzzer come on.

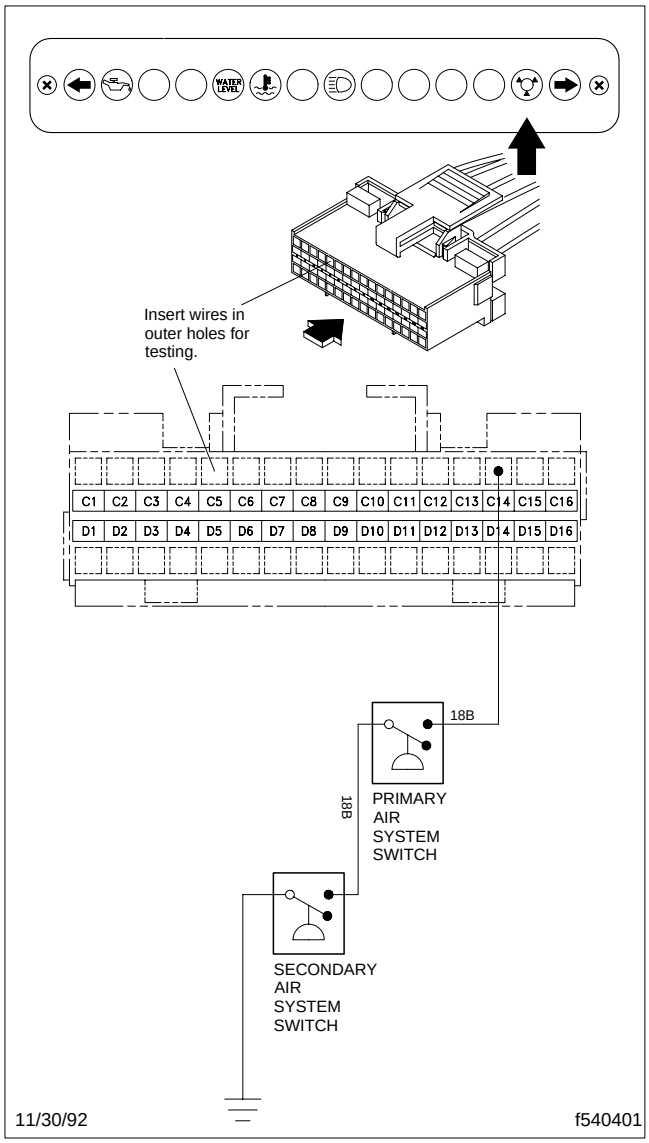


Fig. 1

Problem—The Low Air Pressure Warning Comes On When the Air Pressure Is Above 76 psi (524 kPa)

See Fig. 2.

NOTE: If the lightbar were working correctly, both the primary air system switch and the secondary air system switch would have to fail to cause this problem. Therefore, the lightbar is the more likely cause.

Problem—The Low Air Pressure Warning Doesn't Come On When the Air Pressure Is Below 64 psi (441 kPa)

See Fig. 3.

Troubleshooting

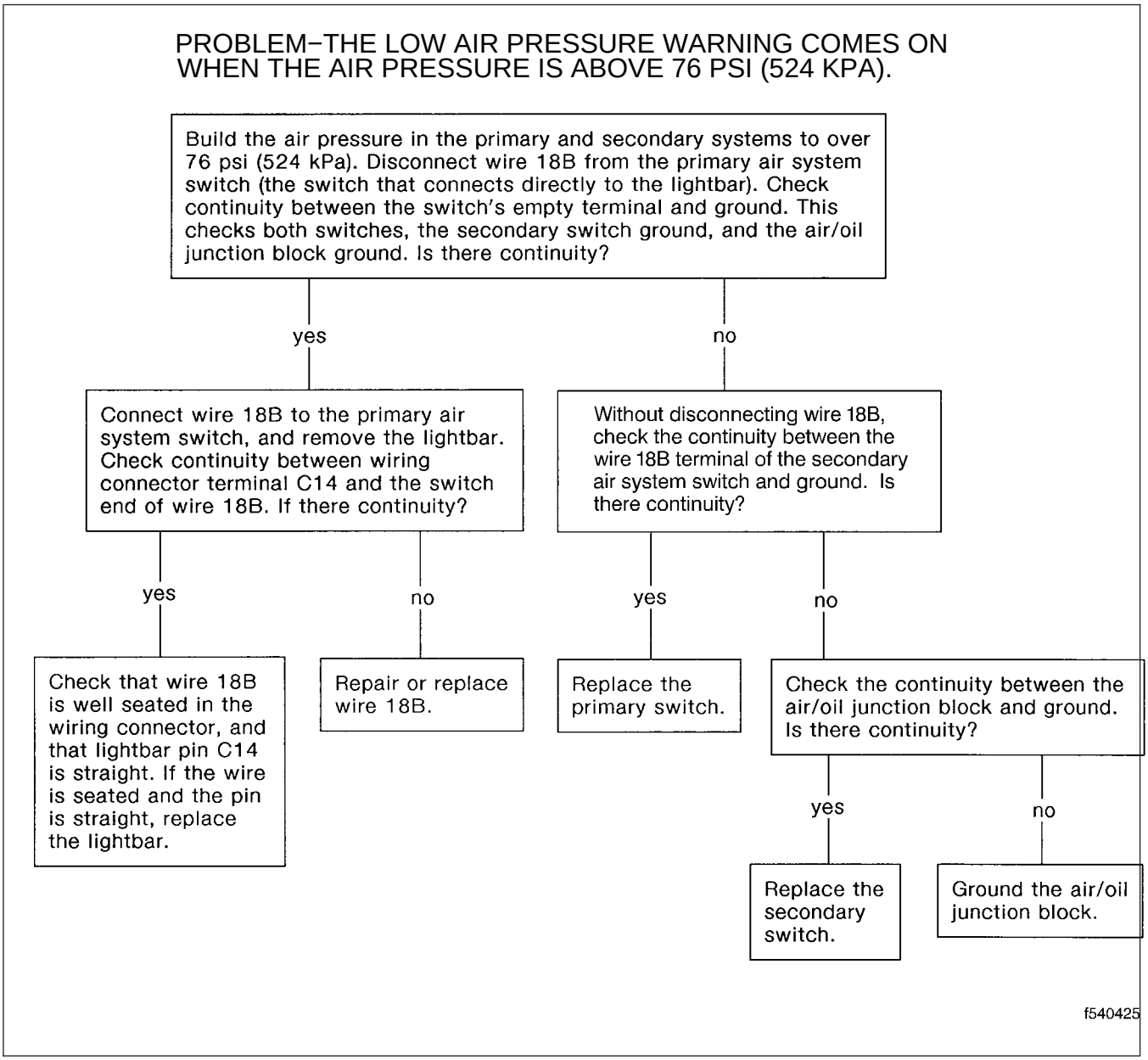


Fig. 2

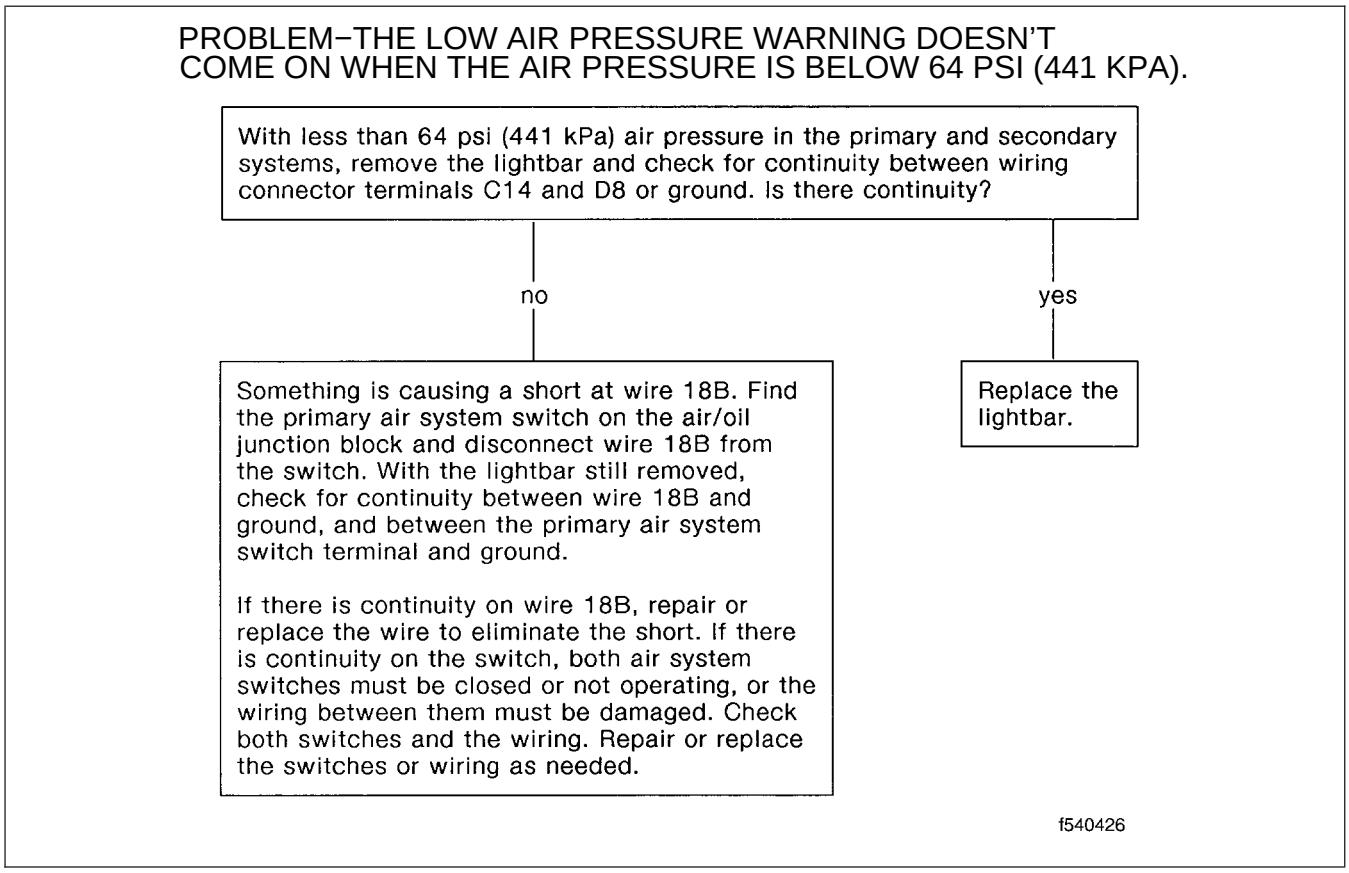

PROBLEM–THE LOW AIR PRESSURE WARNING DOESN'T COME ON WHEN THE AIR PRESSURE IS BELOW 64 PSI (441 KPA).
With less than 64 psi (441 kPa) air pressure in the primary and secondary systems, remove the lightbar and check for continuity between wiring connector terminals C14 and D8 or ground. Is there continuity?
no
yes
Something is causing a short at wire 18B. Find the primary air system switch on the air/oil junction block and disconnect wire 18B from the switch. With the lightbar still removed, check for continuity between wire 18B and ground, and between the primary air system switch terminal and ground.
If there is continuity on wire 18B, repair or replace the wire to eliminate the short. If there is continuity on the switch, both air system switches must be closed or not operating, or the wiring between them must be damaged. Check both switches and the wiring. Repair or replace the switches or wiring as needed.
Replace the lightbar.
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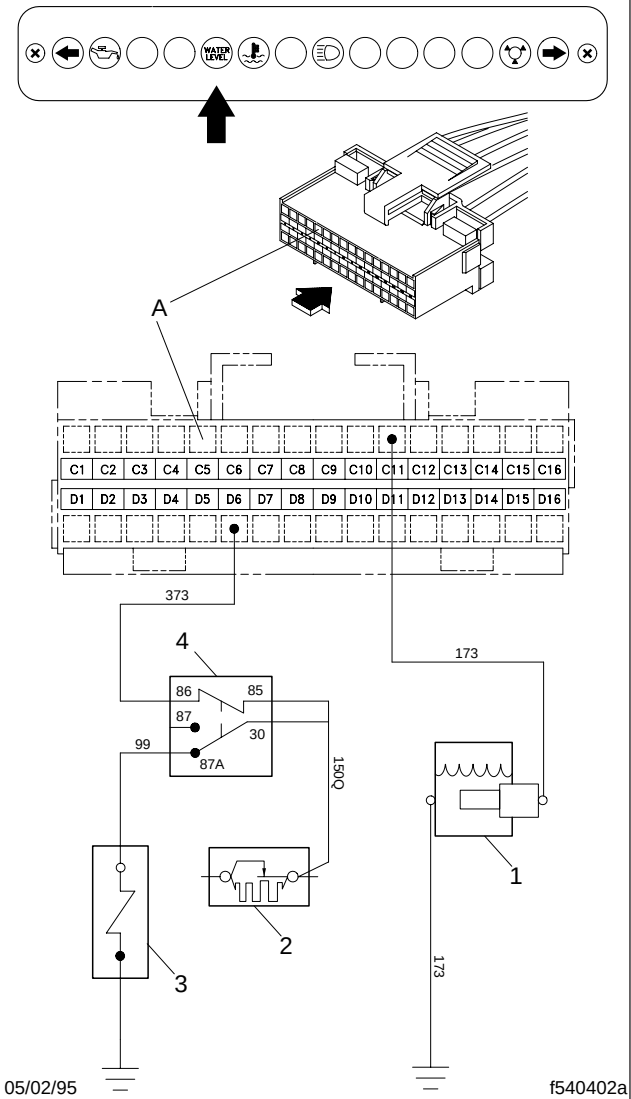
Fig. 3

Low Coolant Level Warning and Shutdown (See Fig. 1)



A. Insert wires in outer holes for testing.
1. Coolant Level Sensor
2. 10-Amp Circuit Breaker
3. Fuel Solenoid
4. Shutdown Relay (VIGIL II & III)

Fig. 1, Low Coolant Warning and Shutdown Circuits

The low coolant level indicator alerts the driver to low engine coolant. There are two circuits associated with this feature: VIGIL I gives a warning, VIGIL II and III give a warning and shut down the engine.

On VIGIL I, the low coolant level warning light will come on only when the coolant is low. On VIGIL II and III, the warning light will come on for two one-second pulses when the ignition is switched on.

Warning System (VIGIL I, II, and III)

A sensor in the radiator top tank activates the warning light for the low coolant level circuit. When the coolant level drops below the sensor for longer than five seconds, the lightbar warning light (fifth from the left) comes on.

The coolant level sensor controls a floating-active circuit: during normal engine operation, the circuit grounds lightbar pin C11 through wire 173, the coolant level sensor, and the coolant itself. If the coolant level drops below the sensor for more than five seconds, lightbar pin C11 loses ground, and the warning light comes on.

NOTE: Extremely cold coolant may prevent the coolant and sensor from grounding the low coolant level circuit.

Shutdown System (VIGIL II and III)

After the coolant level has dropped below the sensor for thirty seconds, the low coolant level shutdown system shuts down the engine by grounding lightbar pin D6 and wire 373. This energizes the shutdown relay, and the relay breaks the circuit to the fuel solenoid through wire 99.

NOTE: VIGIL III may be programmed at the factory to give only a warning.

Troubleshooting

Low Coolant Warning Troubleshooting

Low Coolant Warning Troubleshooting	
Problem	**Remedy**
The low coolant level warning light comes on when the coolant level is adequate.	Check the coolant level sensor and wire 173. See **Fig. 2**.
The low coolant level warning light does not come on when the coolant level is low.	Check the coolant level sensor and wire 173. See **Fig. 3**.
The low coolant level warning and shutdown lights come on and the engine shuts down when the coolant level is adequate.	Check the coolant level sensor and wire 173. See **Fig. 2**.
The low coolant level warning and shutdown lights don't come on when the coolant level is low.	Check the coolant level sensor and wire 173. See **Fig. 3**.

NOTE: On most electronic engines, the VIGIL lightbar does not use the low coolant level warning light; and wire 173 is grounded to prevent the light from coming on. If the low coolant level light does come on, lightbar pin C11 has lost ground, or the lightbar is not working properly. To isolate the fault, remove the lightbar and check for a good ground at terminal C11. If the ground is not OK, repair wire 173. If the ground is OK, check that the mating terminals at pin C11 are making good contact. If all are OK, Replace the lightbar.

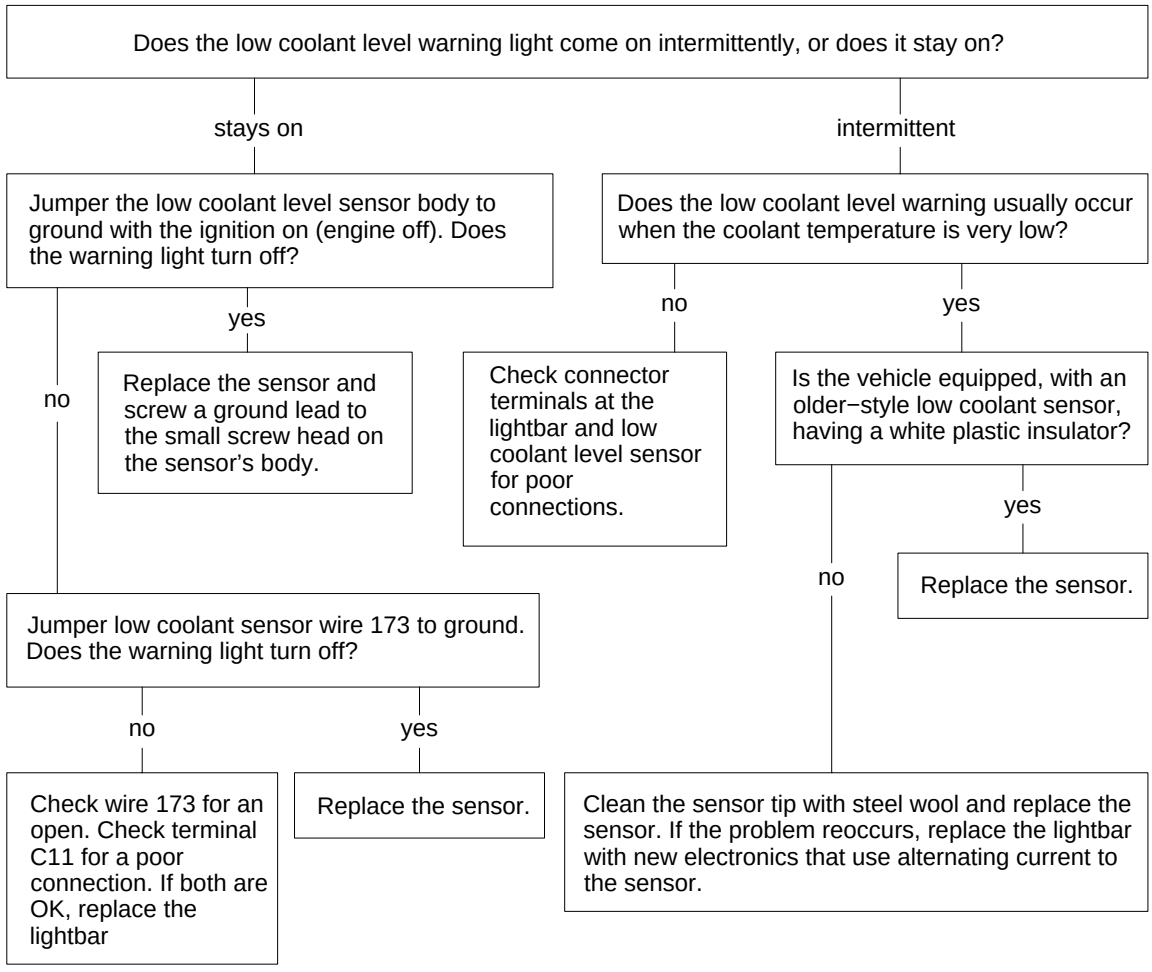


Fig. 2, The Low Coolant Level Warning Light Comes On When the Coolant Level is Adequate.

Troubleshooting

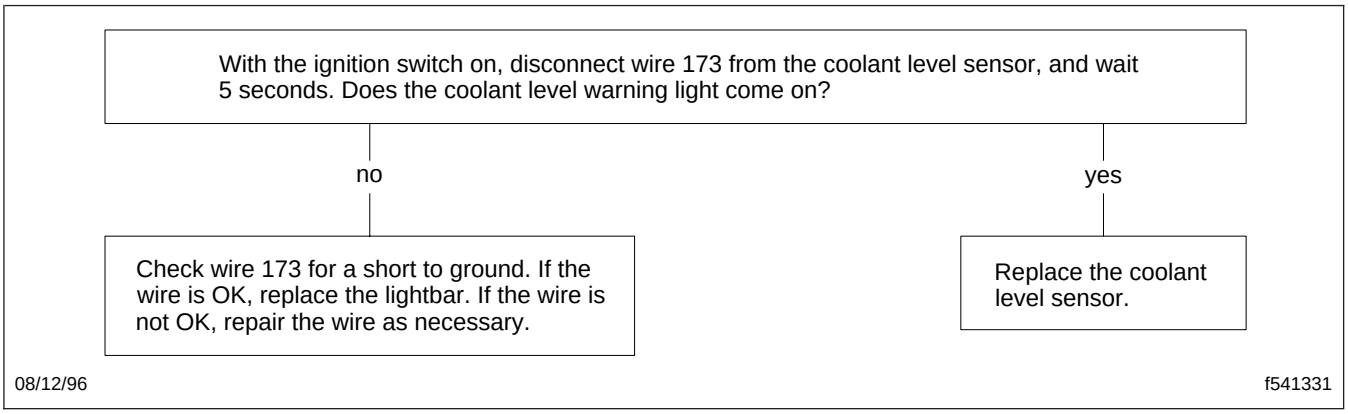
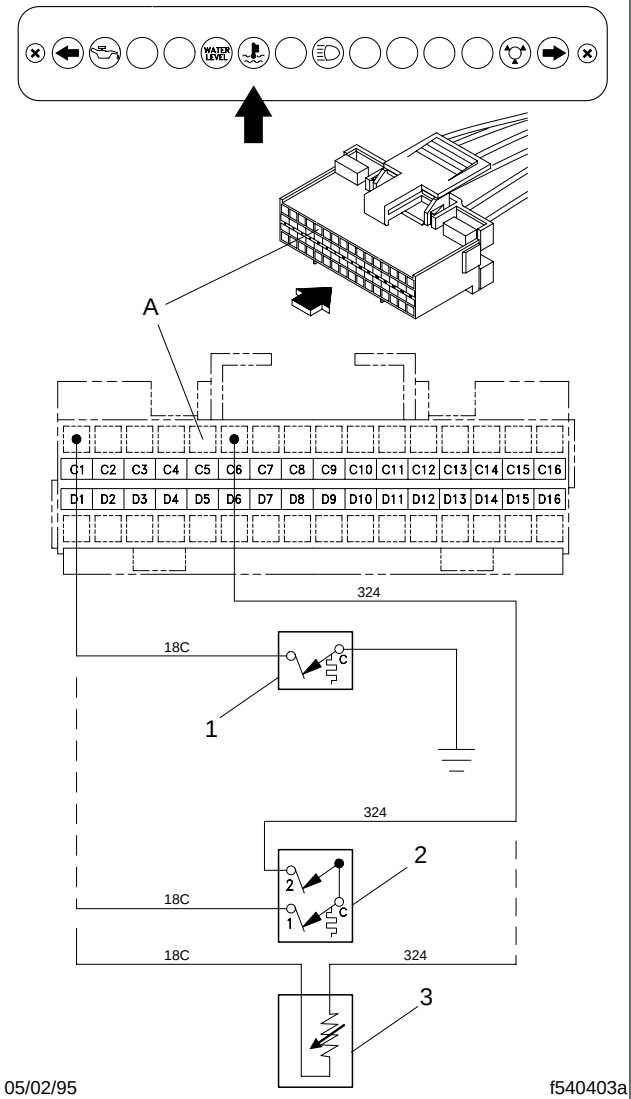


Fig. 3, The Low Coolant Level Warning Light Does Not Come On When the Coolant Level is Low.

High Coolant Temperature Warning and Shutdown (See Fig. 1)



A. Insert wires in outer holes for testing.
1. Coolant Temperature Switch (VIGIL I)
2. Coolant Temperature Switch (VIGIL II)
3. Coolant Temperature Switch (VIGIL III)

Fig. 1, Coolant Temperature Warning and Shutdown Circuits

The high coolant temperature indicator alerts the driver to an overheating engine. There are two circuits associated with this feature: VIGIL I gives a warning, VIGIL II and III give a warning and shut down the engine.

On VIGIL I, the high coolant temperature warning light will activate only when coolant is overheating. On VIGIL II and III, the warning light will come on for two one-second pulses when the ignition is switched on, and when the coolant is overheating.

Warning Function (VIGIL I, II, and III)

A switch (VIGIL I), alarmstat (VIGIL II), or a thermistor (VIGIL III) in the engine block activates the warning light for the high coolant temperature circuit. When the coolant temperature rises above a predetermined temperature, the lightbar warning light (sixth from the left) comes on.

On VIGIL I, the high coolant temperature switch controls a floating-active (normally-open) circuit. During engine operation, coolant temperature below 215°F (101°C) closes the switch and grounds lightbar pin C1 through wire 18C. If coolant temperature rises above 215°F (101°C), the switch opens, lightbar pin C1 loses ground, and the warning light comes on. On VIGIL II, the alarmstat works similarly.

NOTE: Cummins M11 and N14 engines activate the warning light at 220°F (104°C).

VIGIL III uses a thermistor (variable resistor) instead of a switch to monitor coolant temperature. The thermistor changes resistance with coolant temperature change (see **Table 1**). The lightbar monitors this resistance and when it indicates the coolant temperature has reached the critical temperature, the lightbar turns on the high coolant temperature warning light.

Thermistor Resistance	
Ohmmeter Reading (ohms)	**Coolant Temperature °F (°C)**
15K	33 (0.5)
7K	77 (25)
4.33K	105 (41)
2.2K	144 (62)
1.28K	175 (79)
778	204 (96)
600	219 (104)

Thermistor Resistance	
Ohmmeter Reading (ohms)	Coolant Temperature °F (°C)
333	253 (123)

Table 1, Thermistor Resistance

Shutdown Function (VIGIL II and III)

If the coolant temperature continues to rise, the high coolant temperature shutdown circuit shuts down the engine, and the red warning light (seventh from the left) comes on.

NOTE: VIGIL III may be programmed at the factory to give only a warning.

In the VIGIL II shutdown circuit, a switch in the engine block controls a floating-active circuit that grounds lightbar pin C6 through wire 18C. If the coolant rises above 220°F (104°C), the circuit loses ground, and the high coolant temperature shutdown circuit shuts down the engine by grounding lightbar pin D6 and wire 373. This energizes the shutdown relay, and the relay breaks the circuit to the fuel solenoid through wire 99.

NOTE: On late model vehicles equipped with a Cummins M11 or N14 engine, the coolant temperature switch opens at 225°F (107°C).

In the VIGIL III shutdown circuit, the thermistor continues to change resistance as the coolant temperature rises. If it rises above the critical temperature, the lightbar grounds pin D6 and wire 373. This energizes the shutdown relay, and the relay breaks the circuit to the fuel solenoid through wire 99.

Troubleshooting Chart

To use these troubleshooting charts, first determine which VIGIL system the vehicle is equipped with. For more information, see **Subject 050**. Select a symptom from the problem column, and follow the corresponding remedy.

Coolant Temperature Warning Troubleshooting

Coolant Temperature Warning Troubleshooting	
Problem	**Remedy**
The high coolant temperature warning light and the buzzer don't come on when the coolant temperature is high (VIGIL I, VIGIL II and VIGIL III).	Check the coolant temperature switch and wire 18C. For VIGIL I and VIGIL II, see **Fig. 2**. Check the coolant temperature switch and wires 18C and 324. For VIGIL III, see **Fig. 8**.
The high coolant temperature warning light and buzzer come on when the coolant temperature is normal (VIGIL I, VIGIL II and VIGIL III).	Check the coolant temperature switch and wire 18C. For VIGIL I, see **Fig. 4**. Check the coolant temperature switch and wire 18C. For VIGIL II, see **Fig. 3**.
The high coolant temperature warning light, the buzzer and the shutdown light don't come on when the coolant temperature is too high (VIGIL II and VIGIL III).	Check the coolant temperature switch. For VIGIL II, see **Fig. 5** . Check the coolant temperature switch and wires 18C and 324. For VIGIL III, see **Fig. 8**.
The engine shutdown light doesn't come on with the engine coolant temperature light on, and the engine temperature is too high (VIGIL II and VIGIL III).	Check the coolant temperature switch and wire 324. For VIGIL II, see **Fig. 6**. Check the coolant temperature switch and wires 18C and 324. For VIGIL III, see **Fig. 8**.

Coolant Temperature Warning Troubleshooting	
Problem	**Remedy**
The high coolant temperature warning light and the engine shutdown light come on when the coolant temperature is normal (VIGIL II and VIGIL III). The engine may or may not shutdown depending on the VIGIL lightbar programming.	Check the coolant temperature switch and wire 324. For VIGIL II, see **Fig. 7**. Check the coolant temperature switch and wires 18C and 324. For VIGIL III, see **Fig. 8**.
The high coolant temperature light and shutdown lights come on without the buzzer sounding (VIGIL II).	Check the coolant temperature switch and wires 18C and 324. See **Fig. 9**.
The high coolant temperature light comes on without the buzzer sounding (VIGIL II).	Check the coolant temperature switch and wires 18C and 324. See **Fig. 9**.
The high coolant temperature light comes on without the buzzer sounding (VIGIL I and VIGIL III).	Replace the VIGIL Lightbar.

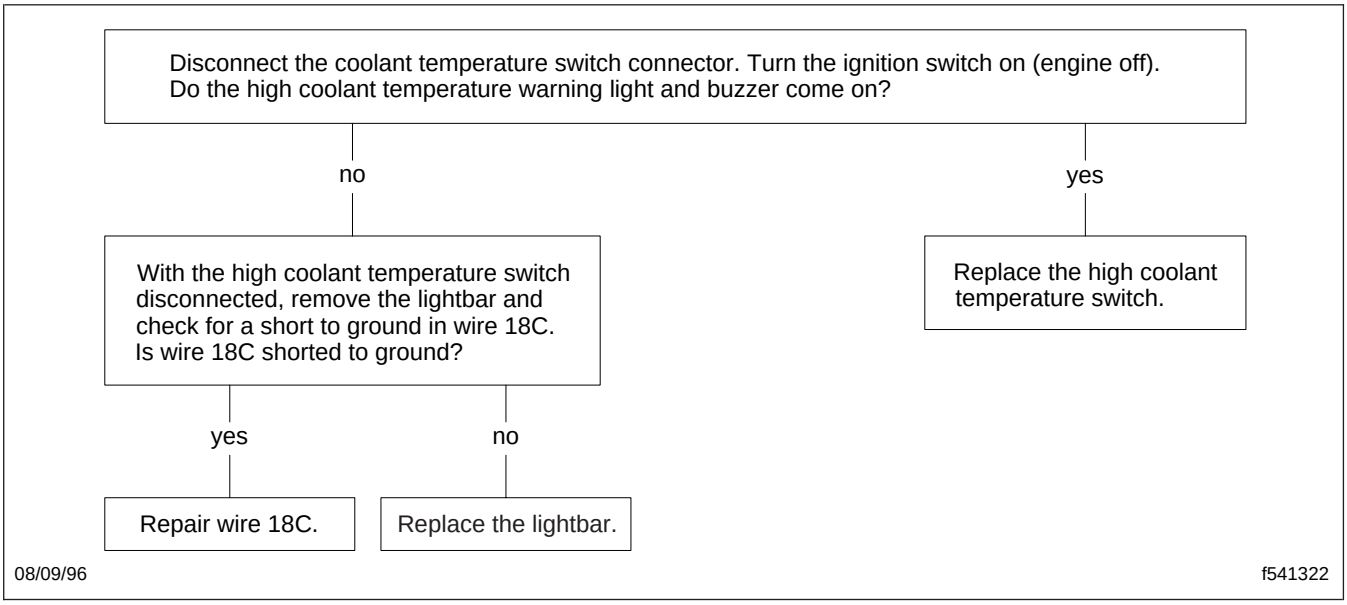


Fig. 2, The High Coolant Temperature Warning Light and the Buzzer Don't Come On When the Coolant Temperature is High (VIGIL I and VIGIL II).

Troubleshooting

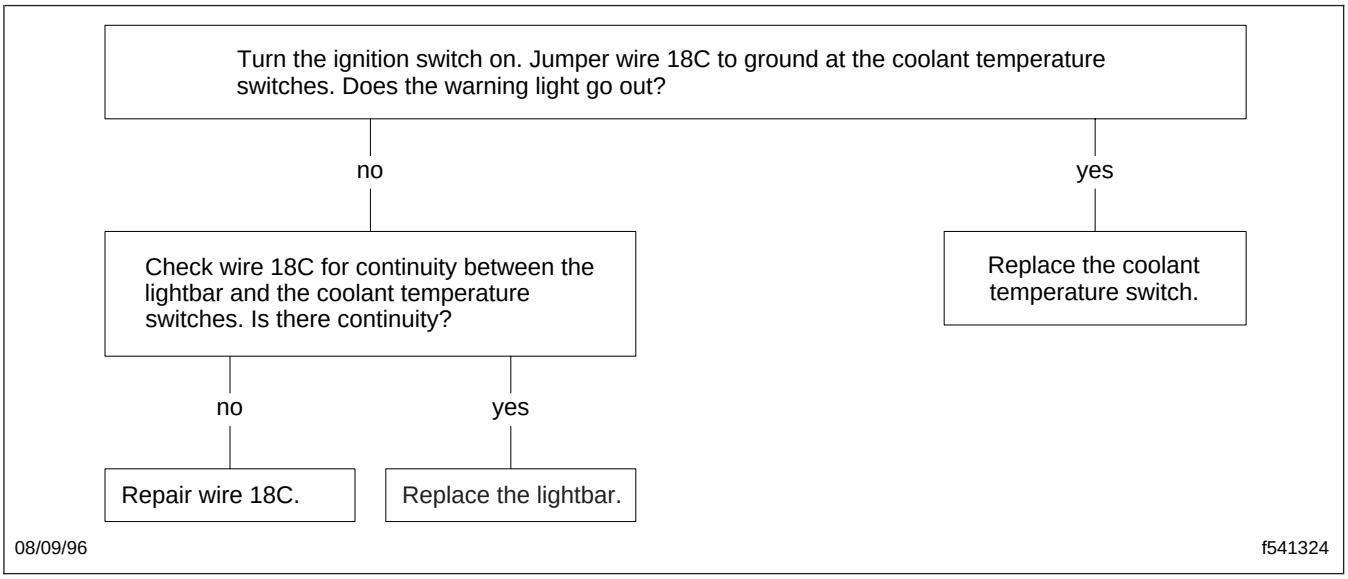


Fig. 3, The High Coolant Temperature Warning Light and the Shutdown Light Come On When the Coolant Temperature is Normal (VIGIL II).

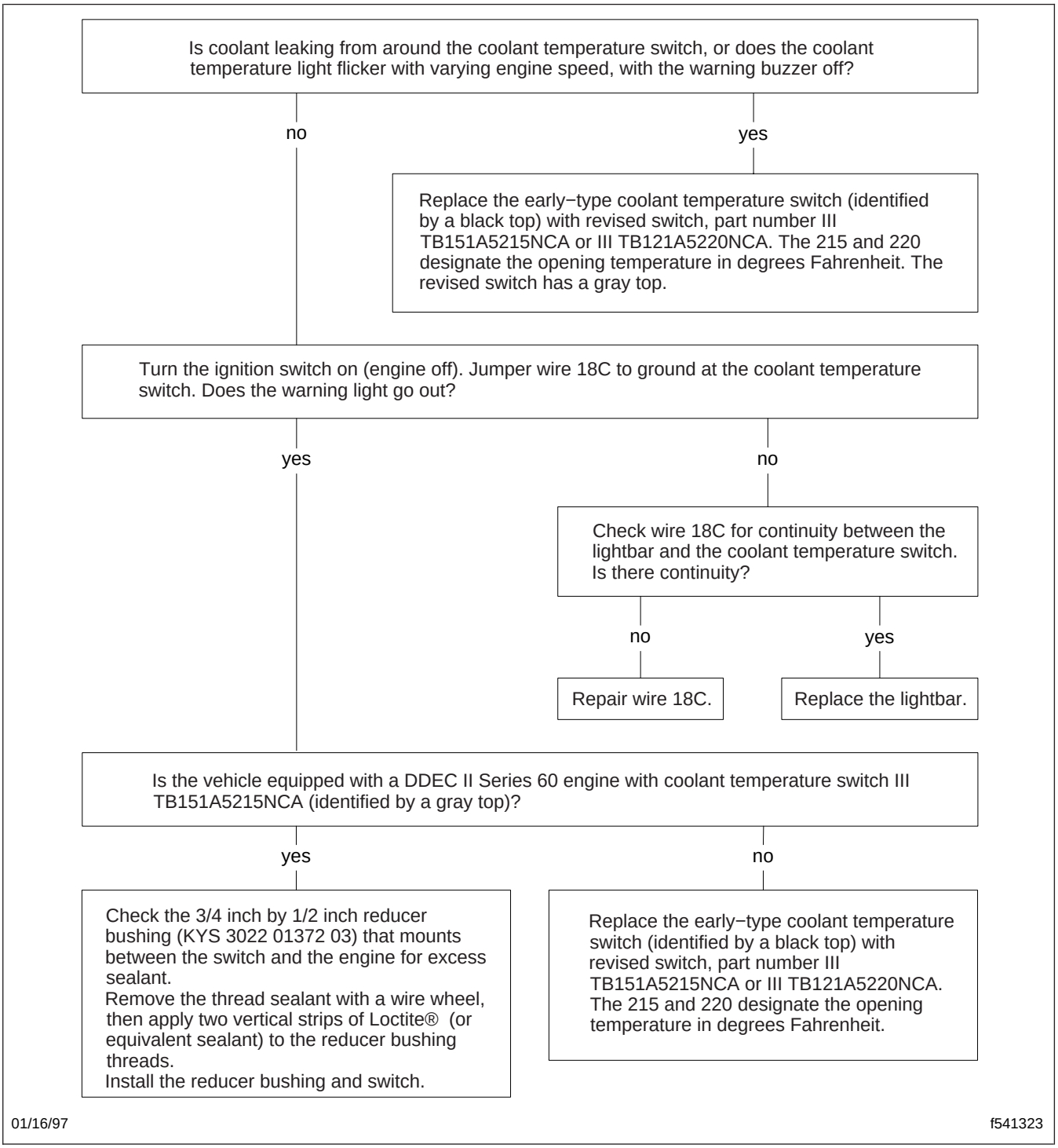


Fig. 4, The High Coolant Temperature Warning Light and the Shutdown Light Come On When the Coolant Temperature is Normal (VIGIL I).

Troubleshooting

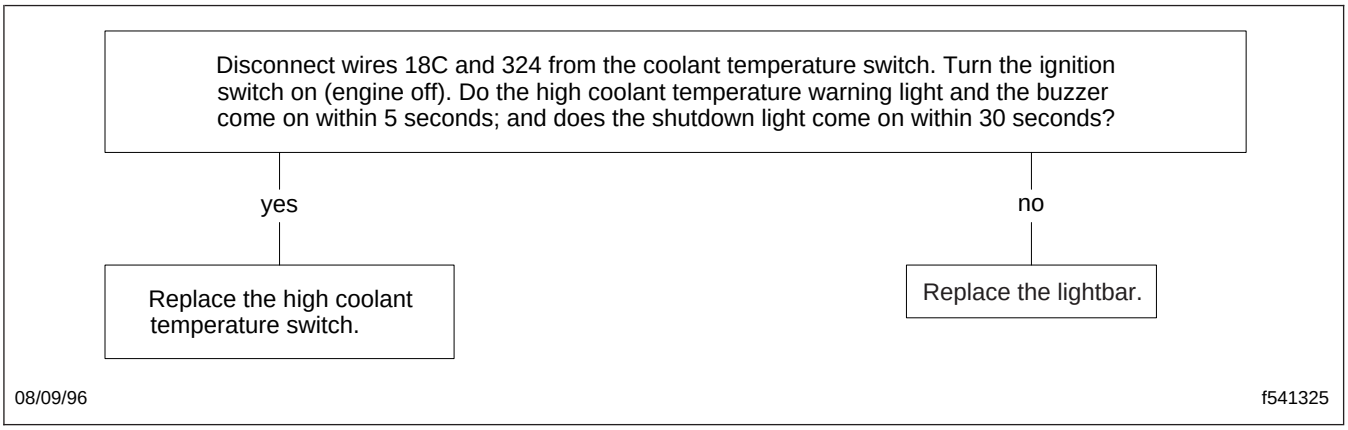


Fig. 5, The High Coolant Temperature Warning Light, the Buzzer and the Shutdown Light Don't Come On When the Coolant Temperature is Too High (VIGIL II).

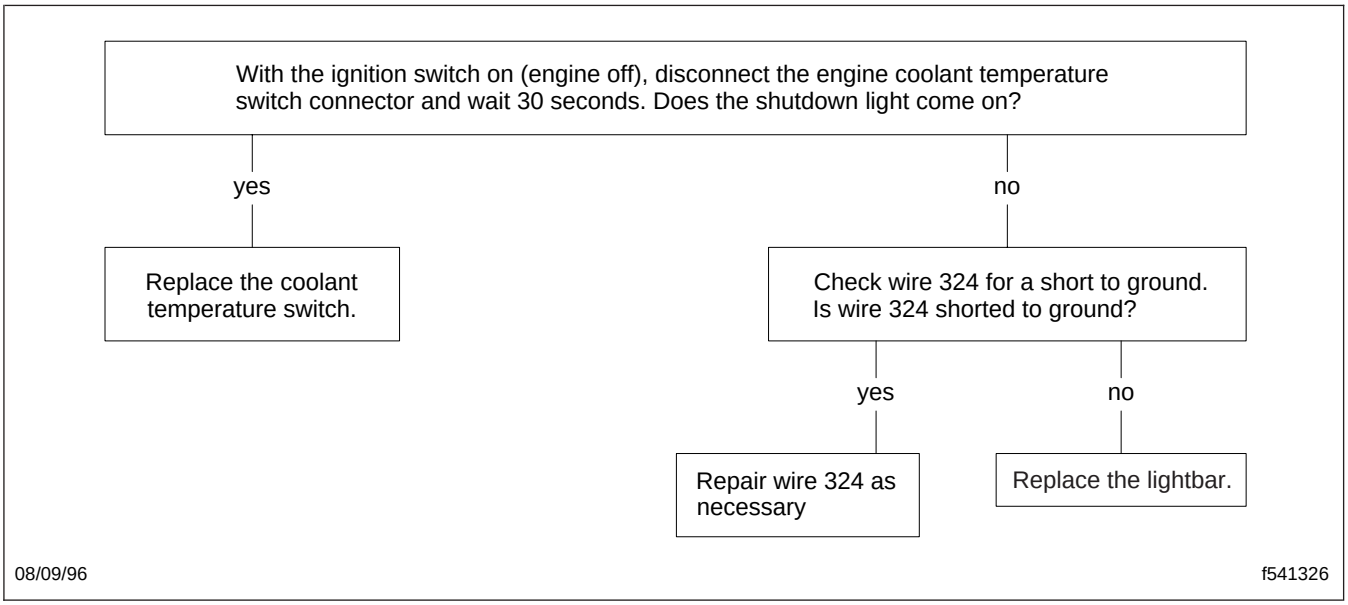


Fig. 6, The Engine Shutdown Light Doesn't Come On With the Engine Coolant Temperature Light On, and the Engine Temperature is Too High (VIGIL II).

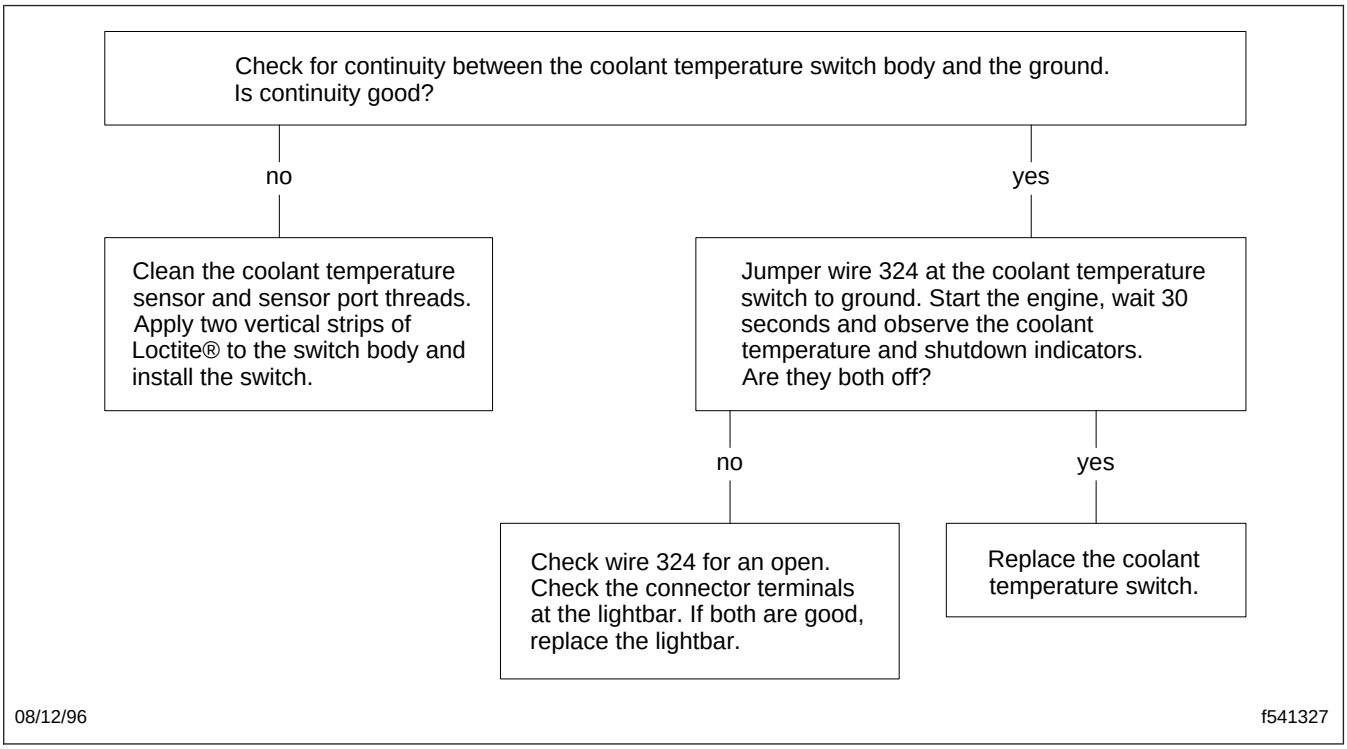


Fig. 7, The Engine Coolant Temperature Light and the Engine Shutdown Light Come On With the Engine Temperature Normal (VIGIL II).

Troubleshooting

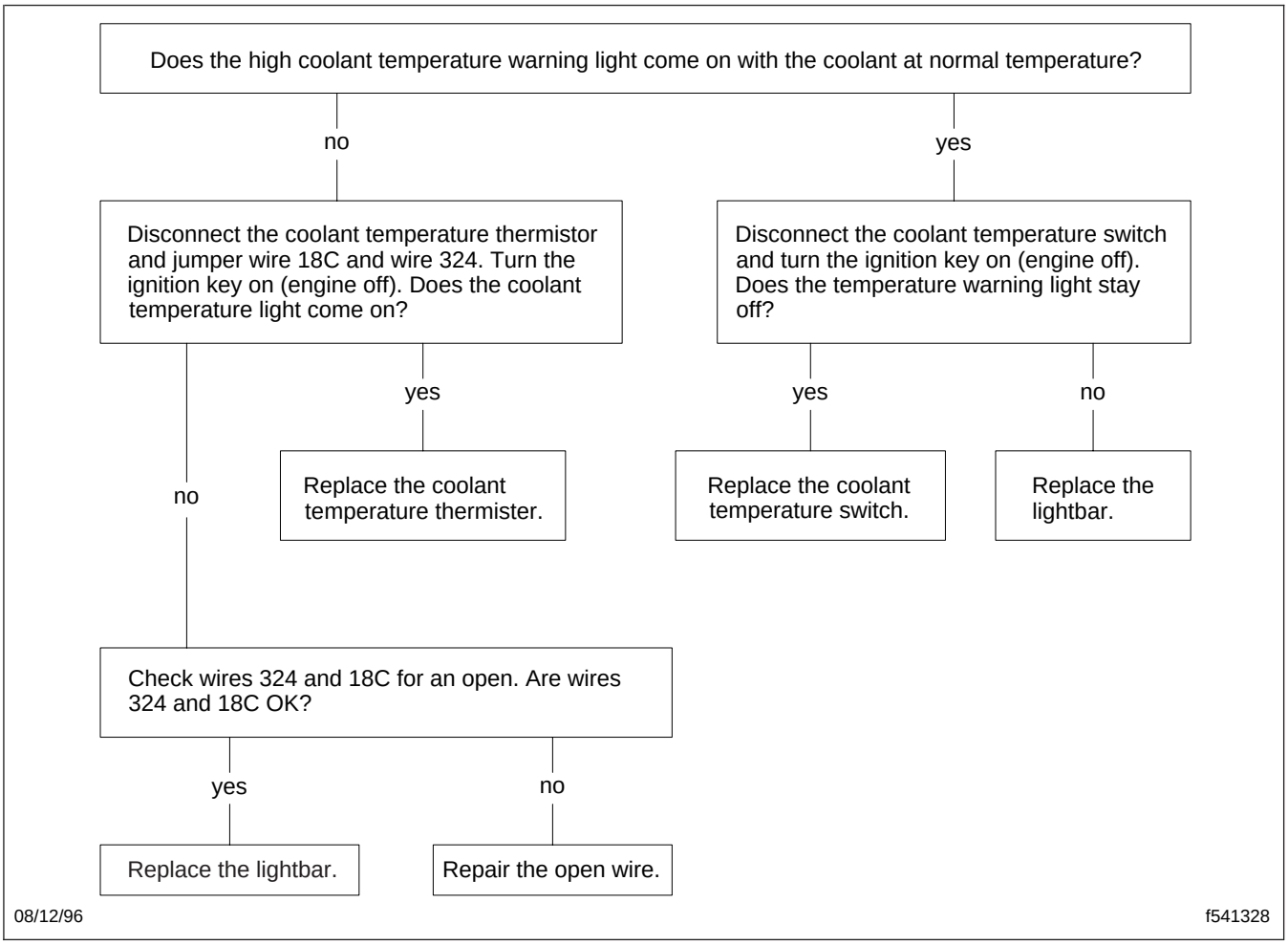


Fig. 8, The Engine Coolant Temperature Light, Engine Shutdown Light, and Buzzer Do Not Work Properly (VIGIL III).

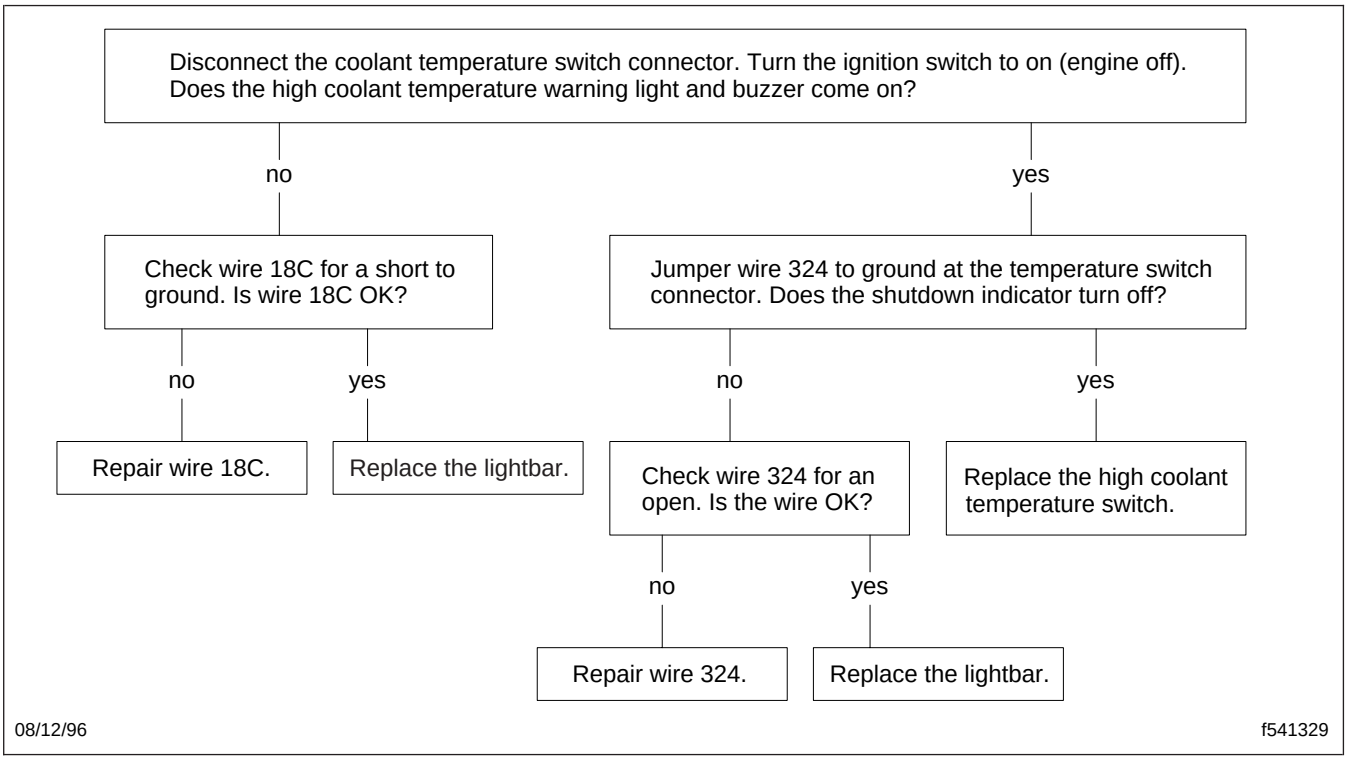


Fig. 9, The Shutdown Warning and/or High Coolant Temperature Lights Come On Without the Buzzer Sounding (VIGIL II).

Starter Lock Out (VIGIL III Only)

See Fig. 1

The starter lockout circuit prevents cranking the starter if any of the following conditions occur:

A. Voltage at the key switch is greater than 18 volts.

B. Voltage at the key switch is less than 9 volts before the starter button is pressed.

C. The starter button has been pressed within two seconds. (This prevents the starter cranking the engine as the engine is rocking back from a previous start attempt.)

D. Engine speed exceeds 350 rpm. (To prevent engaging the starter into a running engine.)

E. The starter has been cranking for a total of 30 seconds within a one-minute period. (The starter button is locked out for two minutes to allow the starter to cool.)

NOTE: The starter lock-out warning light will be lit during the two-minute cooling period after 30 seconds of cranking; otherwise, it will light while the starter button is pushed within two seconds of a previous start attempt.

When any of these conditions occur, the lightbar grounds wire 374 at lightbar pin A12. This energizes the starter lockout relay, which opens to break circuit 15 and prevent power from the starter button reaching the starter relay. Without power, the starter relay stays open and prevents battery power from reaching the starter.

NOTE: On vehicles equipped with starter lock out protection, there is a one-tenth second delay between the moment the driver pushes the starter button and the moment the starter motor activates. This is normal.

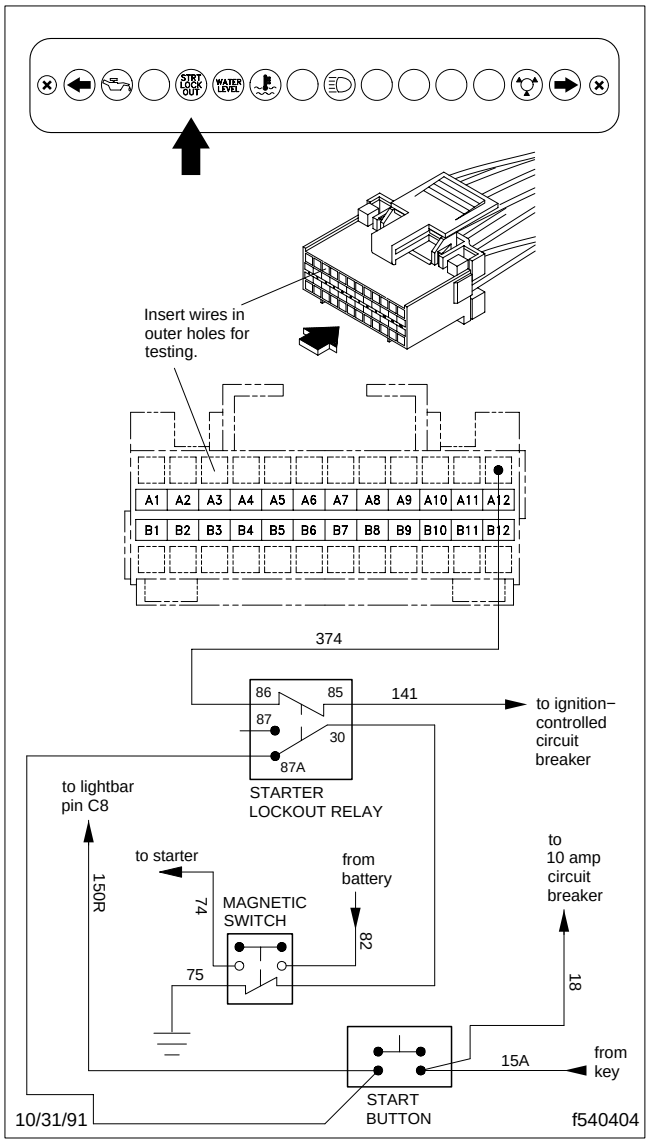


Fig. 1

Problem—The Starter Lockout Doesn't Work

See Fig. 2

NOTE: Check the fourth lightbar lens from the left to make sure the vehicle is programmed for the starter lockout feature. If the lense is blank or has something other than "Start Lock Out" printed on it, the vehicle doesn't have the lockout feature.

Problem—The Starter Doesn't Crank

See Fig. 3

NOTE: Check the fourth lightbar lense from the left to make sure the vehicle is programmed for

Troubleshooting

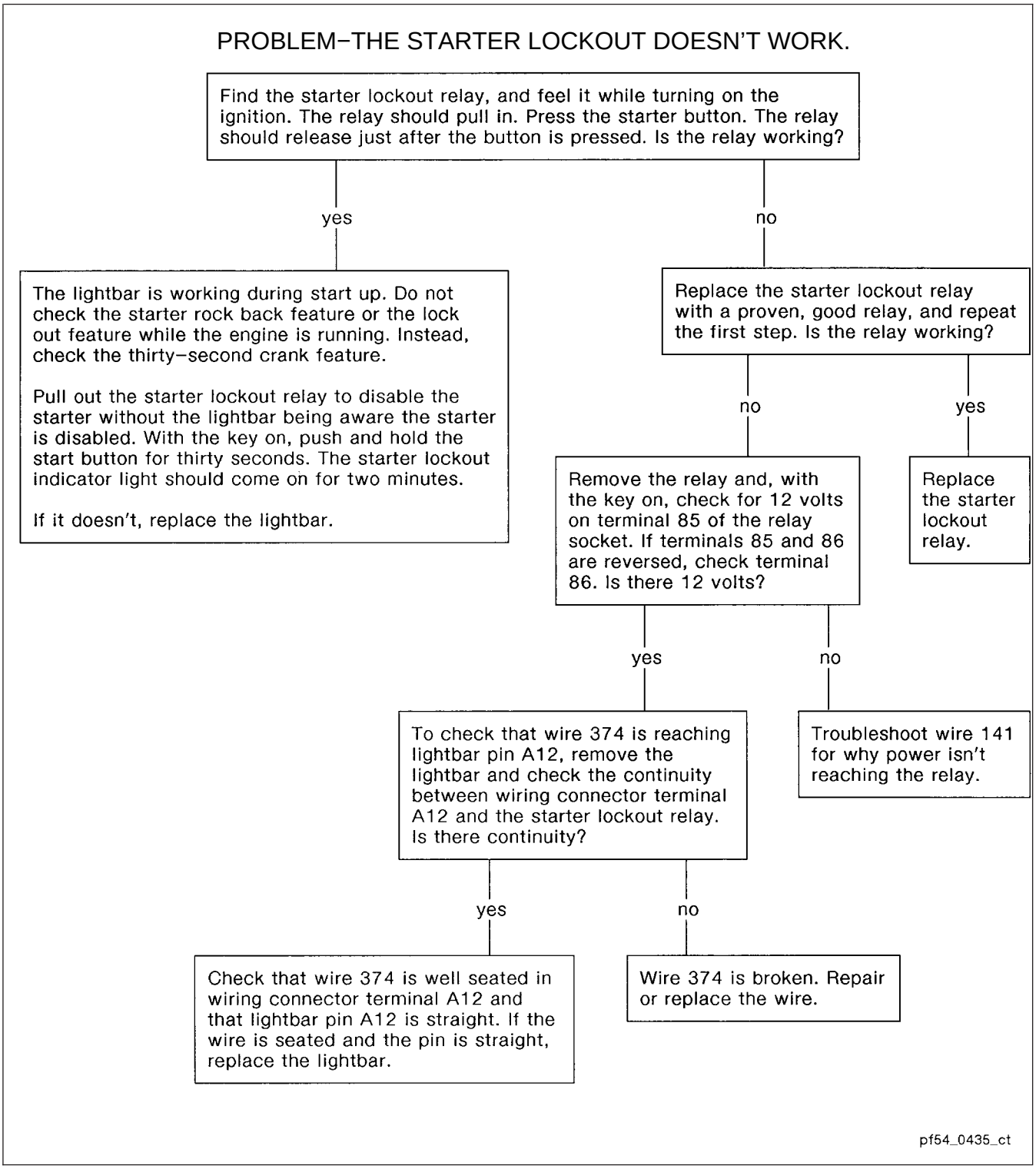


Fig. 2

the starter lockout feature. If the lense is blank or has something other than "Start Lock Out" printed on it, the vehicle doesn't have the lock-out feature.

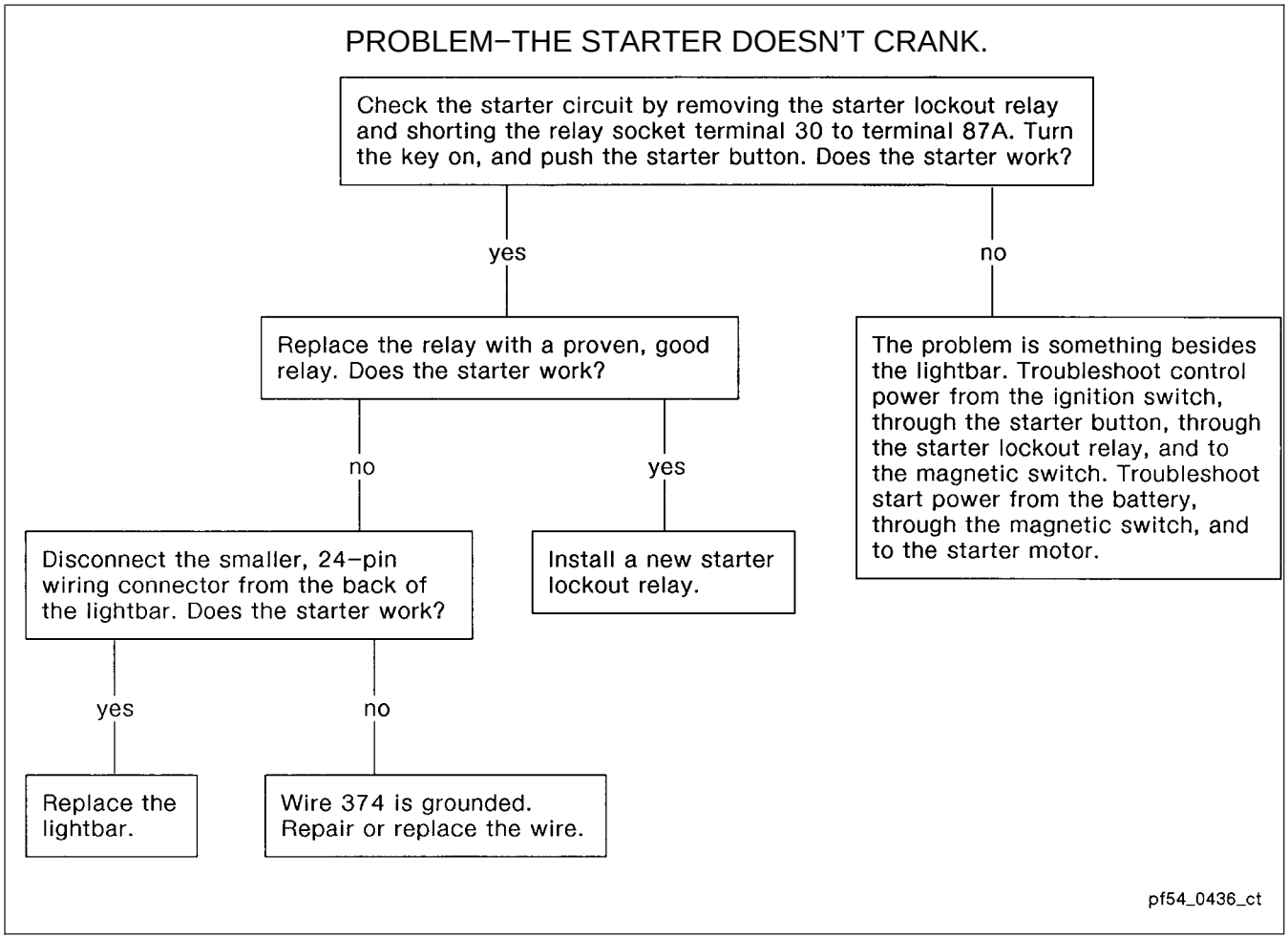


Fig. 3

Road Speed Governor (VIGIL III Only)

(**See Fig. 1**)

The road speed governor cuts fuel delivery to the engine when the vehicle travels faster than a predetermined speed. That speed, anywhere from 45 to 85 mph (72 to 137 km/h), is set at the factory according to owner specifications.

To cut the fuel delivery and control vehicle speed, the VIGIL III lightbar grounds wire 351 through lightbar pin D5. This energizes the road speed governor relay, and the relay grounds wire 251G, activating the road speed governor valve. The valve constricts fuel delivery pressure from about 100 psi (689 kPa) to about 20 psi (138 kPa). Excess fuel is returned to the fuel tank through the fuel return line.

There is a 2 mph (3 km/h) lag in the system, for example: if the maximum speed were set at 60 mph (97 km/h), the governor would cut fuel delivery pressure at 60 mph (97 km/h) and return pressure to normal at 58 mph (93 km/h).

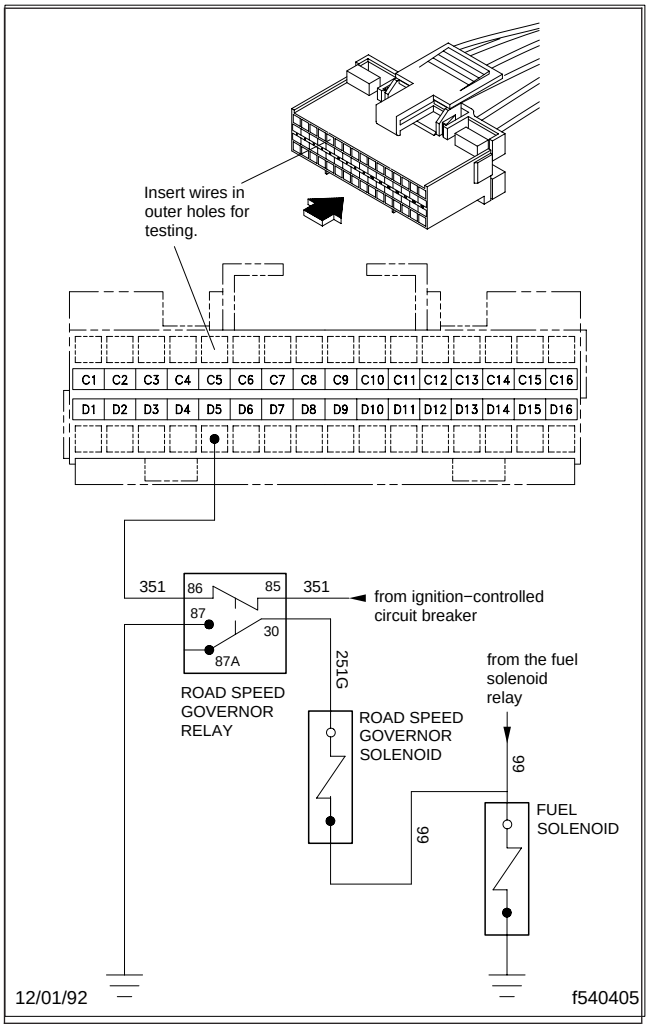


Fig. 1

Problem—The Road Speed Governor Doesn't Engage

See Fig. 2

Troubleshooting

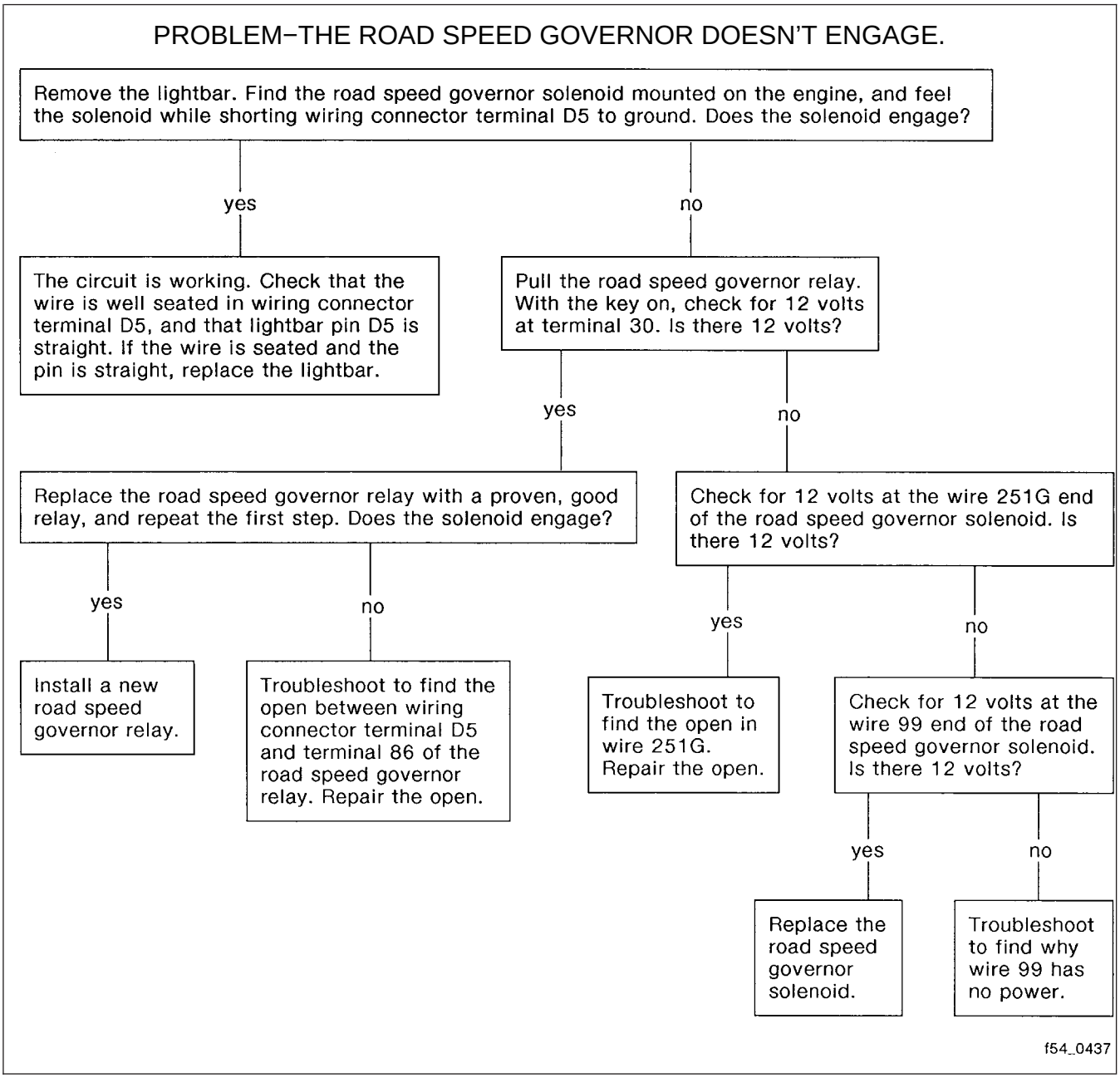


Fig. 2

Overspeed Indicator Light (VIGIL III Only) (See Fig. 1)

The overspeed indicator light can be programmed in the field to flash at any vehicle speed between 45 and 85 mph (72 and 137 km/h). Using the vehicle speed supplied by the speedometer sensor, VIGIL III activates the light as a warning to the driver whenever the vehicle travels over the programmed speed. Once the vehicle slows to below the programmed speed, the overspeed indicator light goes out.

The overspeed indicator light will also come on to show a problem with the road speed governor or the speedometer. The light comes on if either of the following conditions occur:

- The vehicle exceeds the top speed allowed by the road speed governor by 5 mph (7 km/h) for two minutes.
- There is no signal from the speedometer sensor for 15 minutes with the engine running above 1700 rpm.

If either condition occurs, the overspeed indicator light will come on and stay on until the engine is shut down. Until the problem with the governor or speedometer is repaired, the overspeed light will flash on each time the ignition is switched on. It will flash for ten seconds or until the starter is cranked.

Once the problem with the governor or speedometer is repaired, the overspeed light must be cleared so it no longer flashes on to indicate a problem. To clear the overspeed indicator light, or set it to flash on at a different vehicle speed, refer to **Subject 115**.

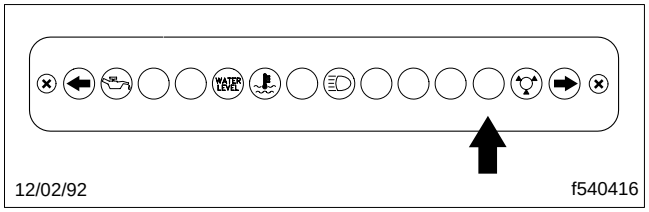


Fig. 1

Problem—The Overspeed Indicator Light Comes On for Ten Seconds When the Ignition Is Switched On

As noted in the description, this indicates a problem with the speedometer sensor or the road speed governor. Troubleshoot these areas, and solve the problem.

Bear in mind that the overspeed indicator light was designed to alert vehicle operators to the fact that someone may have tampered with the speedometer or road speed governor.

Option A (See Fig. 1)

Option A is a ground-activated circuit using the amber lightbar light (third from the left). As a ground-activated circuit, the option is controlled by a switch which stays open during normal vehicle operation.

When an unusual condition occurs (lack of alternator charge, high transmission temperature, etc.), the switch closes, and lightbar pin C3 grounds. The light-bar activates the warning light.

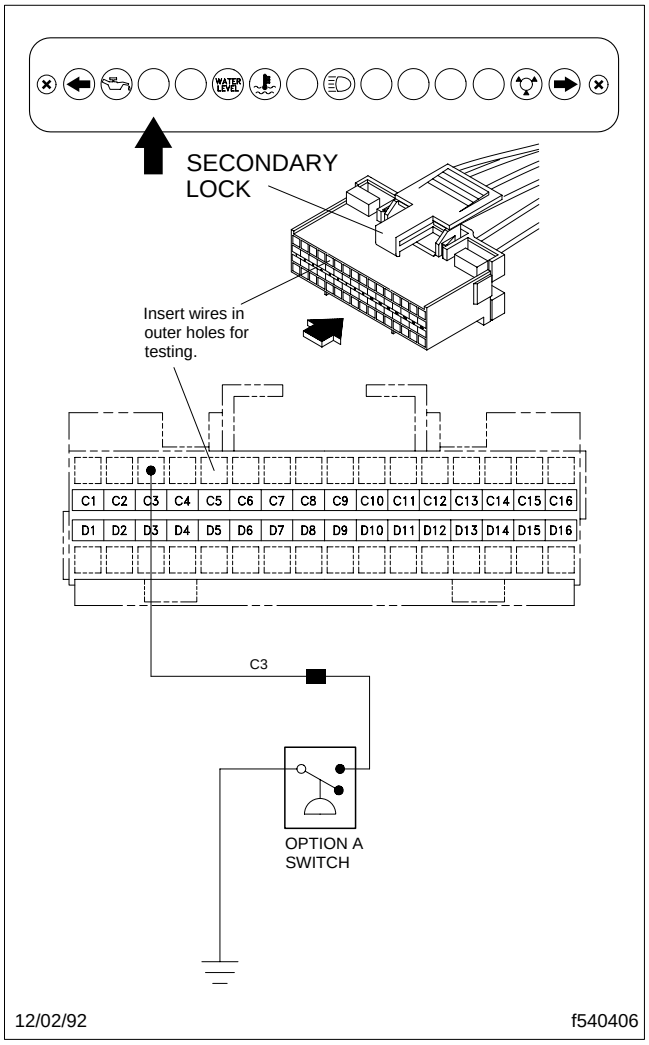


Fig. 1

Problem—The Option A Light Doesn't Come On When the Option Is Activated.

See Fig. 2

Troubleshooting

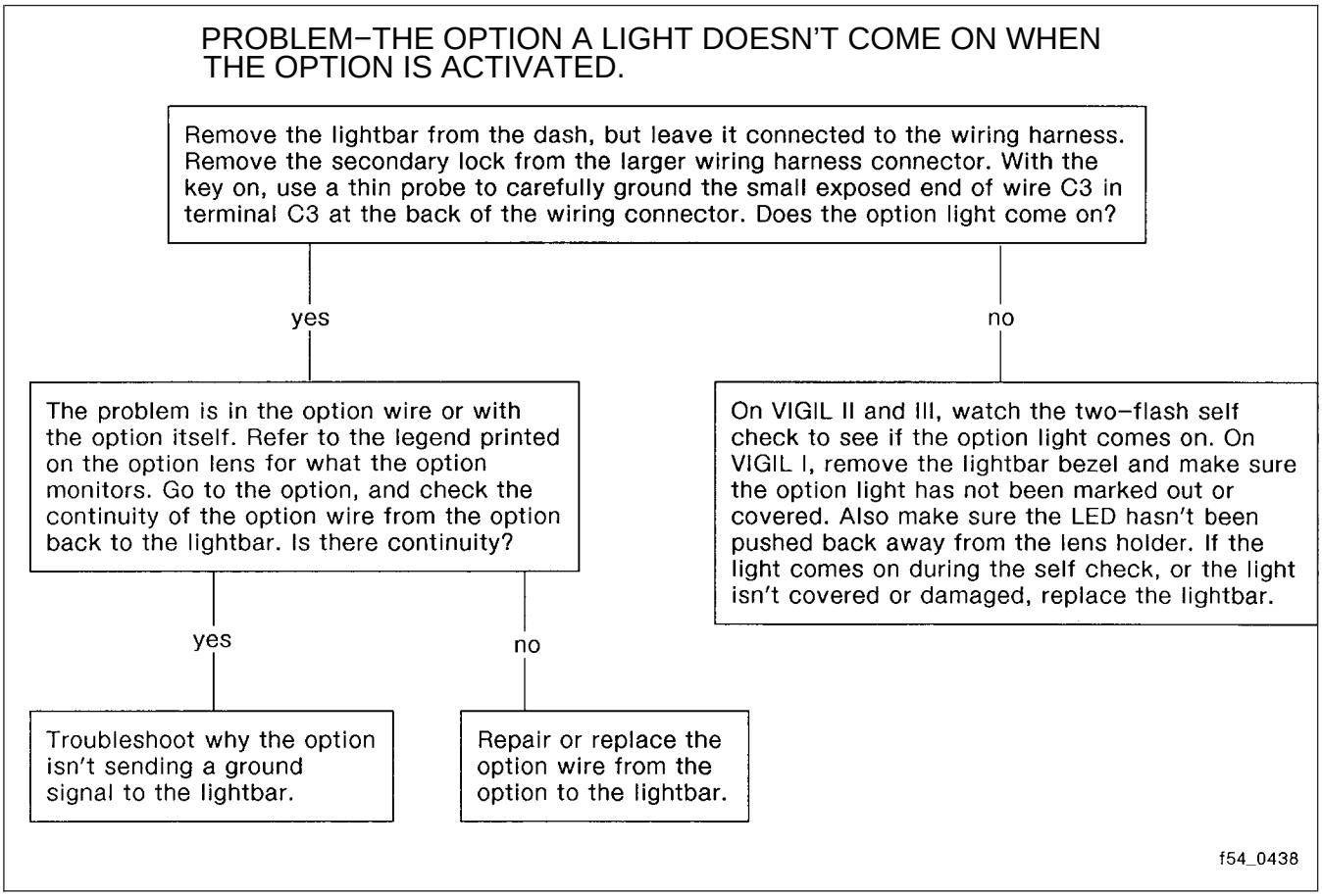


Fig. 2

Option B (See Fig. 1)

Option B can be either a ground-activated circuit or a power-activated circuit, and uses the red lightbar light fourth from the left. On VIGILs I and II, the part number sticker on the top of the lightbar is green if the option is ground-activated and white if power-activated. All VIGIL III lightbars use a ground-activated circuit for this option.

NOTE: VIGIL III may use this circuit for the starter lockout feature, if that feature is programmed at the factory.

In earlier models of VIGIL lightbars, as a power-activated circuit, option B is controlled through a switch or relay which connects the option with a 12-volt power source. The power activates the option and reaches lightbar pin C2 through the function wire and wire C2 to activate the function light.

In later models of VIGIL lightbars, as a ground-activated circuit, option B is controlled by a switch which stays open during normal vehicle operation.

When an unusual condition occurs (lack of alternator charge, high transmission temperature, etc.), the switch closes and grounds lightbar pin C2. The lightbar activates the function light.

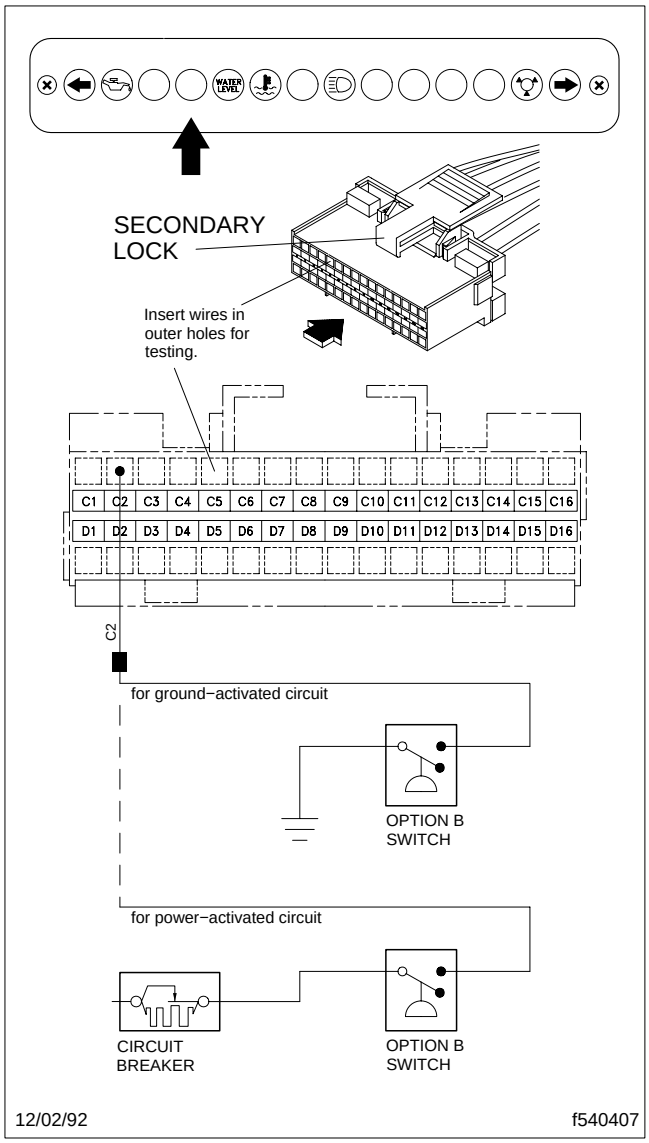


Fig. 1

Problem—The Option B Light Doesn't Come On When the Option Is Activated

NOTE: Option B can be either ground-activated or power-activated, refer to the applicable troubleshooting chart for the vehicle being serviced.

If the Option B is Ground-Activated, see **Fig. 2**.

If the Option B is Power-Activated, see **Fig. 3**.

Troubleshooting

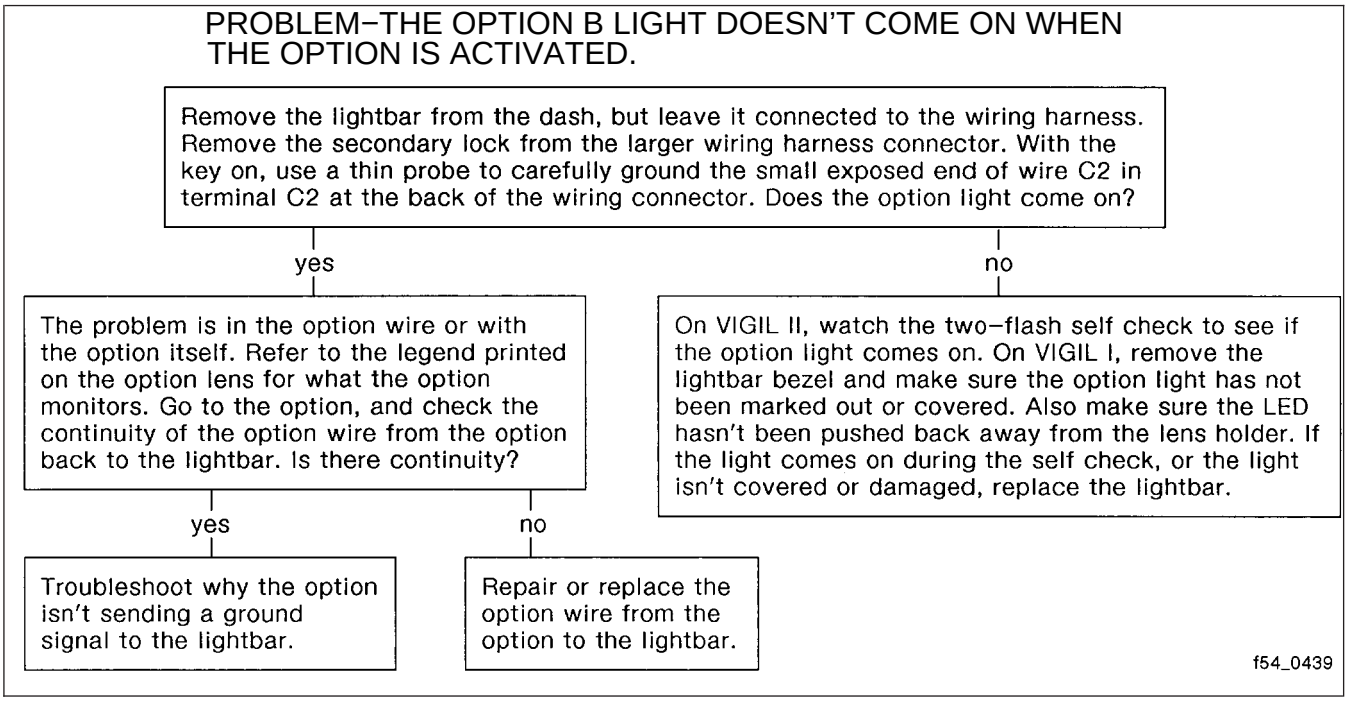


Fig. 2

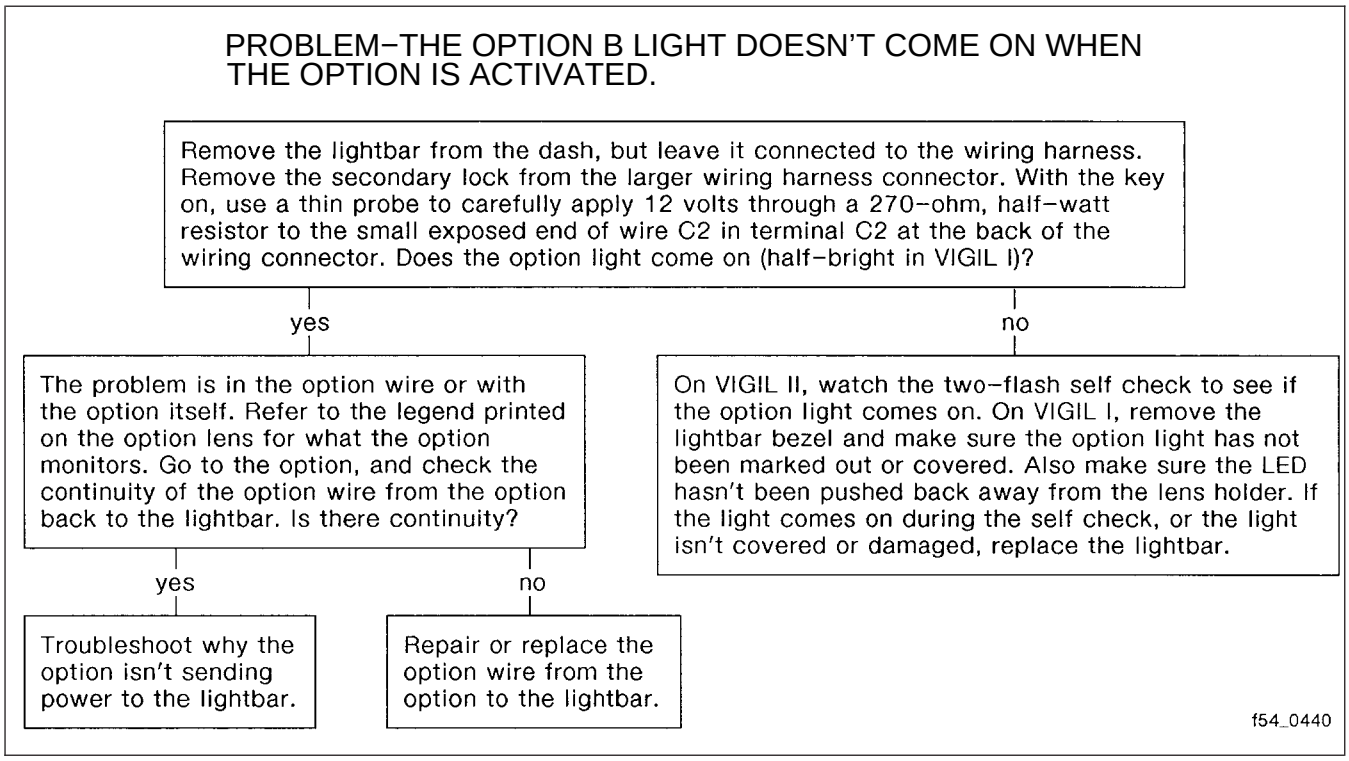

PROBLEM–THE OPTION B LIGHT DOESN'T COME ON WHEN THE OPTION IS ACTIVATED.
Remove the lightbar from the dash, but leave it connected to the wiring harness. Remove the secondary lock from the larger wiring harness connector. With the key on, use a thin probe to carefully apply 12 volts through a 270–ohm, half–watt resistor to the small exposed end of wire C2 in terminal C2 at the back of the wiring connector. Does the option light come on (half–bright in VIGIL I)?
yes
no
The problem is in the option wire or with the option itself. Refer to the legend printed on the option lens for what the option monitors. Go to the option, and check the continuity of the option wire from the option back to the lightbar. Is there continuity?
On VIGIL II, watch the two–flash self check to see if the option light comes on. On VIGIL I, remove the lightbar bezel and make sure the option light has not been marked out or covered. Also make sure the LED hasn't been pushed back away from the lens holder. If the light comes on during the self check, or the light isn't covered or damaged, replace the lightbar.
yes
no
Troubleshoot why the option isn't sending power to the lightbar.
Repair or replace the option wire from the option to the lightbar.
f54_0440

Fig. 3

Option C (See Fig. 1)

Option C is a power-activated circuit which uses the red (amber in later models) lightbar light tenth from the left.

As a power-activated circuit, option C is controlled by the driver through a switch which connects the option circuit with a 12-volt power source. When the driver wants the option (utility light, fifth wheel lock, sludge ejector, etc.) the driver throws the applicable switch, and the option C circuit connects to power. The power activates the option and reaches lightbar pin D15 through wire D15 to activate the function light.

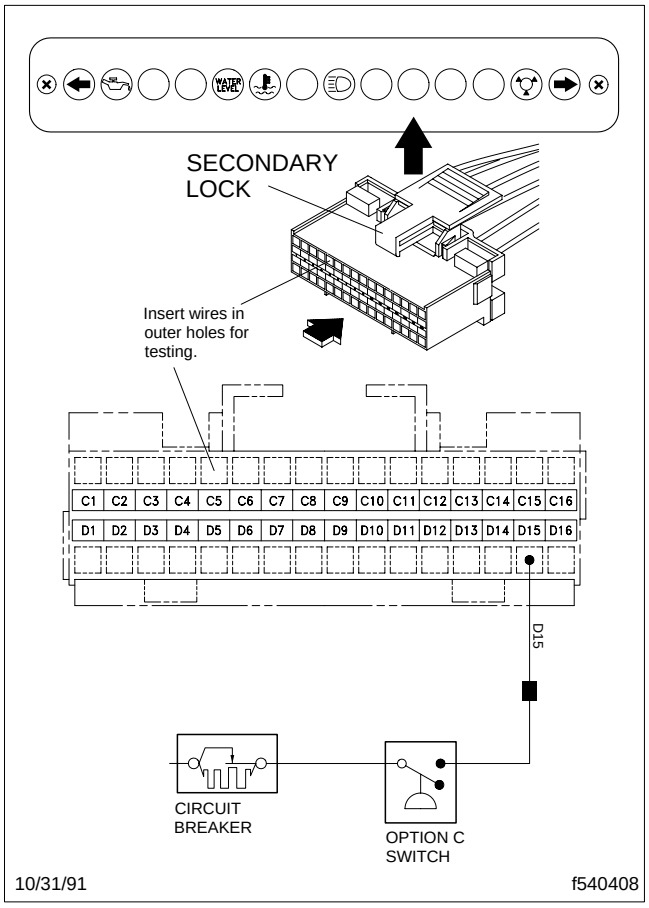


Fig. 1

Problem—The Option C Light Doesn't Come On When the Option Is Activated.

See Fig. 2

Troubleshooting

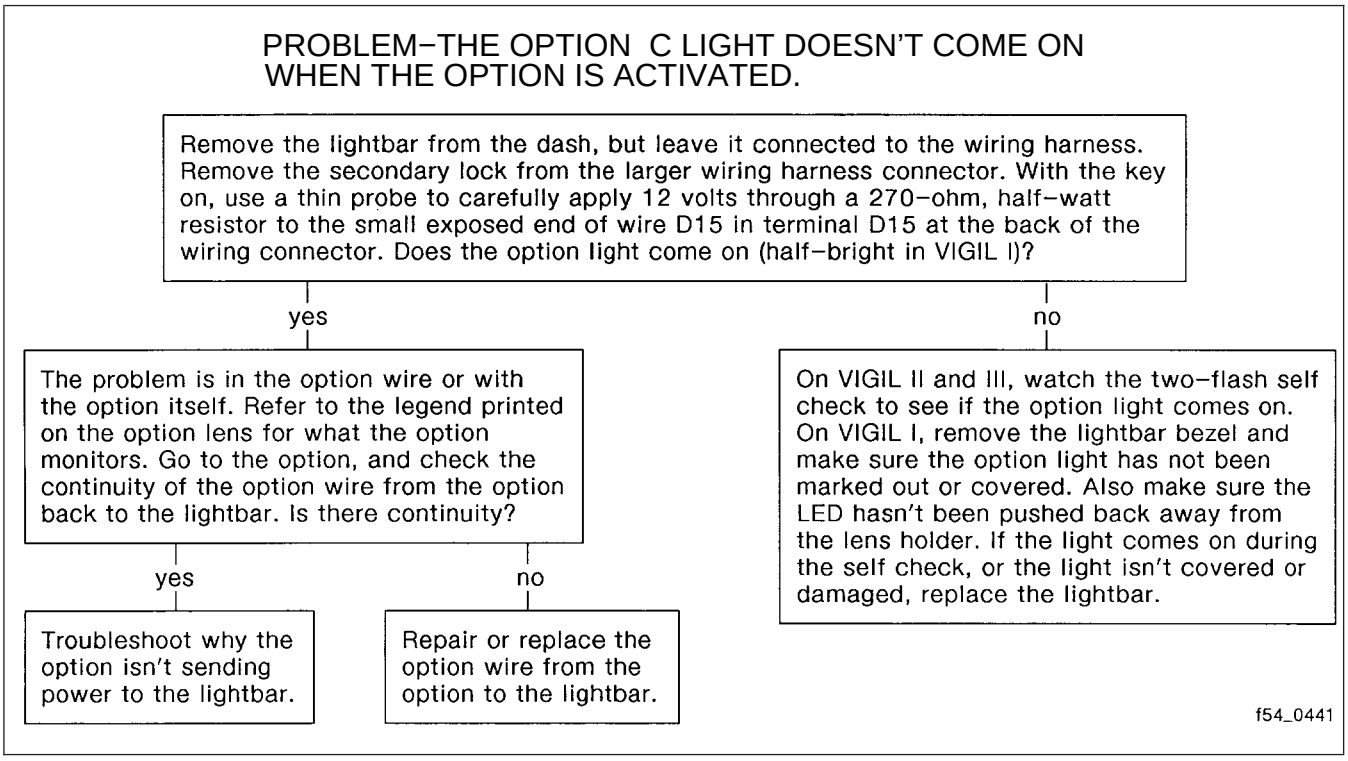


Fig. 2

Option D (See Fig. 1)

Option D is a power-activated circuit which uses the red (amber in later models) lightbar light eleventh from the left.

As a power-activated circuit, option D is controlled by the driver through a switch which connects the option circuit with a 12-volt power source. When the driver wants the option (utility light, fifth wheel lock, sludge ejector, etc.) the driver throws the applicable switch, and the option D circuit connects to power. The power activates the option and reaches lightbar pin D16 through wire D16 to activate the function light.

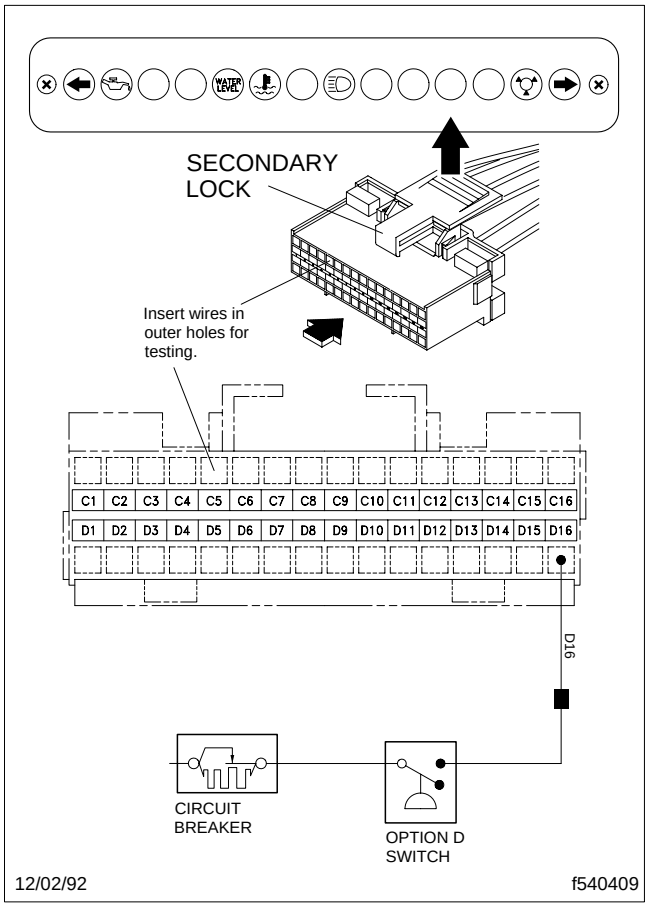


Fig. 1

Problem—The Option D Light Doesn't Come On When the Option Is Activated. .

See Fig. 2

Troubleshooting

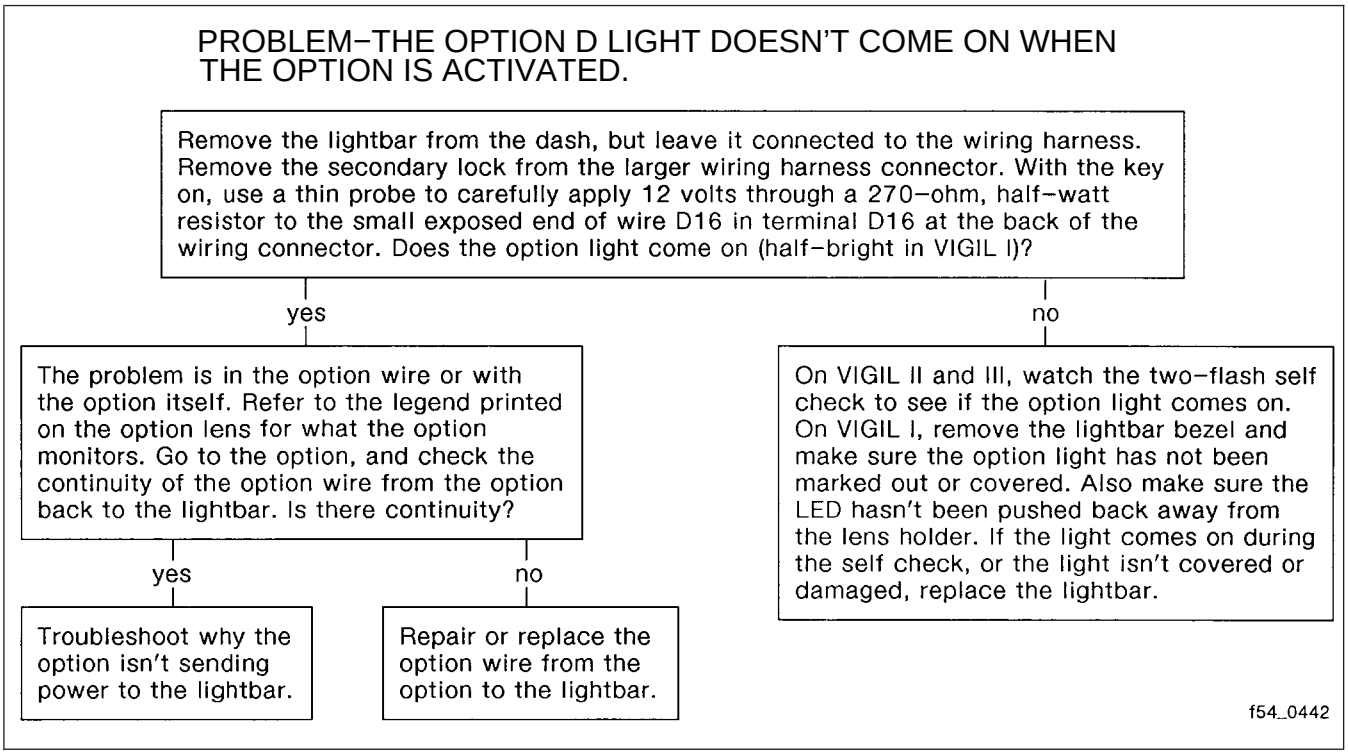


Fig. 2

Option E (See Fig. 1)

Option E is a ground-activated circuit using the red lightbar light seventh from the left. As a ground-activated circuit, the option is controlled by a switch which stays open during normal vehicle operation.

When an unusual condition occurs (lack of alternator charge, high transmission temperature, etc.), the switch closes and grounds lightbar pin C12. The lightbar activates the warning light.

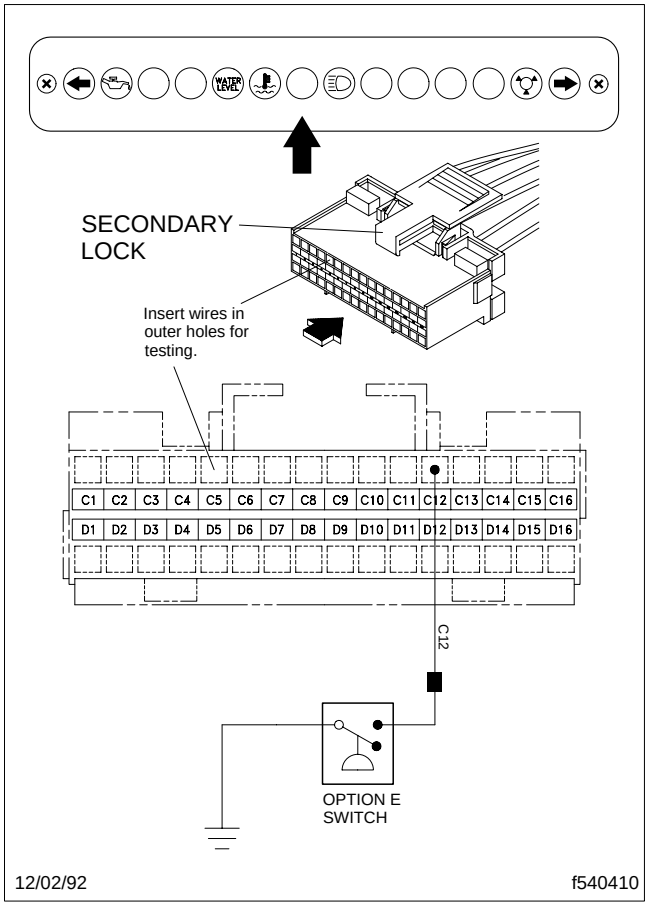


Fig. 1

Problem—The Option E Light Doesn't Come On When the Option Is Activated.

See Fig. 2

Troubleshooting

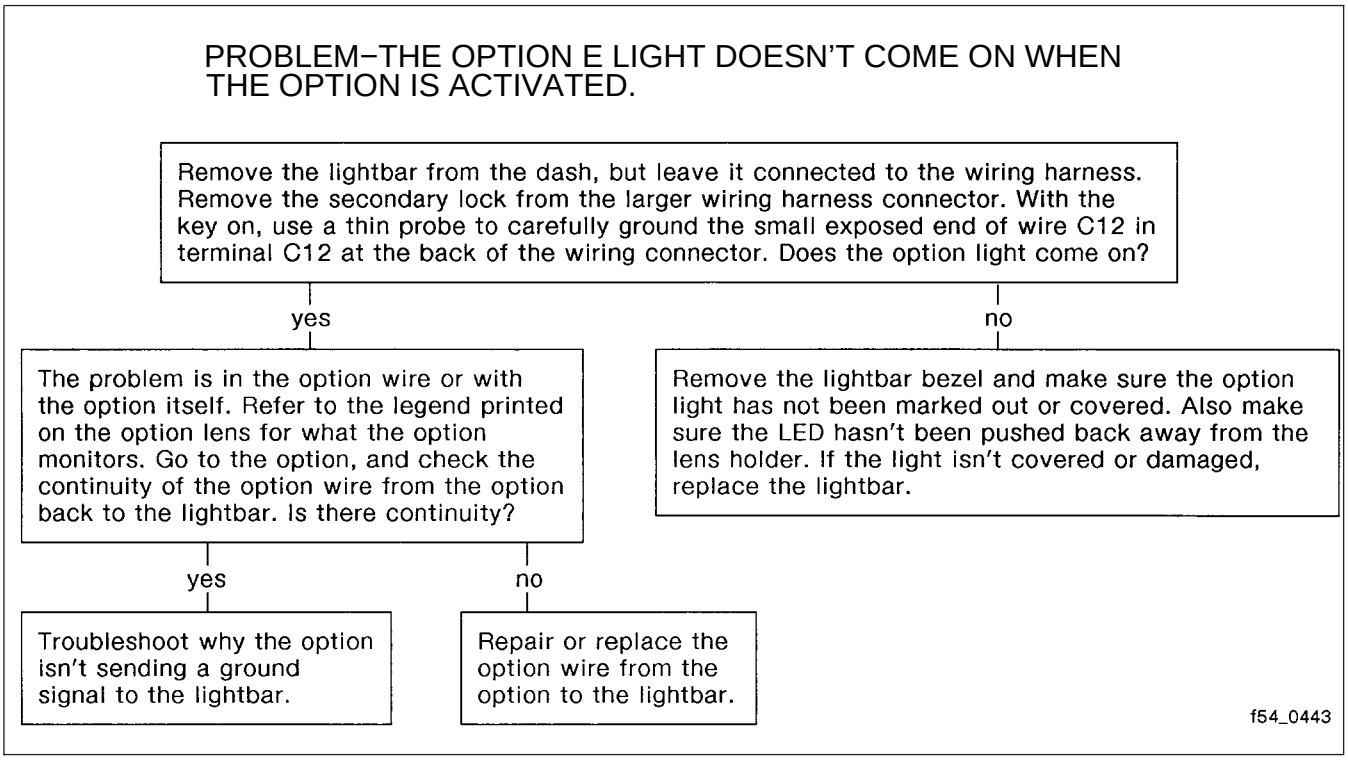


Fig. 2

Option F (See Fig. 1)

Option F is a power-activated circuit which uses the amber lightbar light ninth from the left.

As a power-activated circuit, option F is controlled by the driver through a switch which connects the option circuit with a 12-volt power source. When the driver wants the option (utility light, fifth wheel lock, sludge ejector, etc.) the driver throws the applicable switch, and the option F circuit connects to power. The power activates the option and reaches lightbar pin C13 through wire C13 to activate the function light.

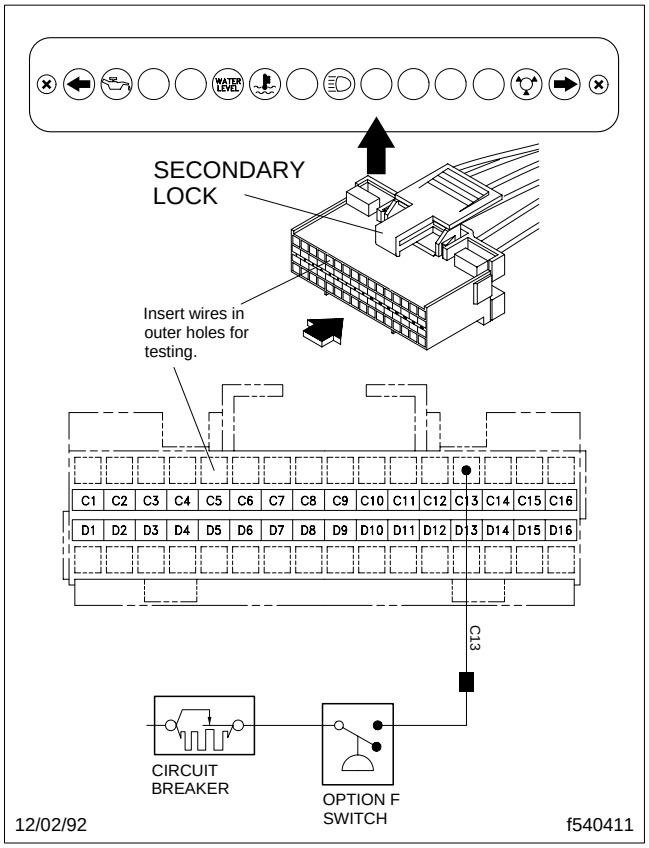


Fig. 1

Problem—The Option F Light Doesn't Come On When the Option Is Activated.

See Fig. 2

Troubleshooting

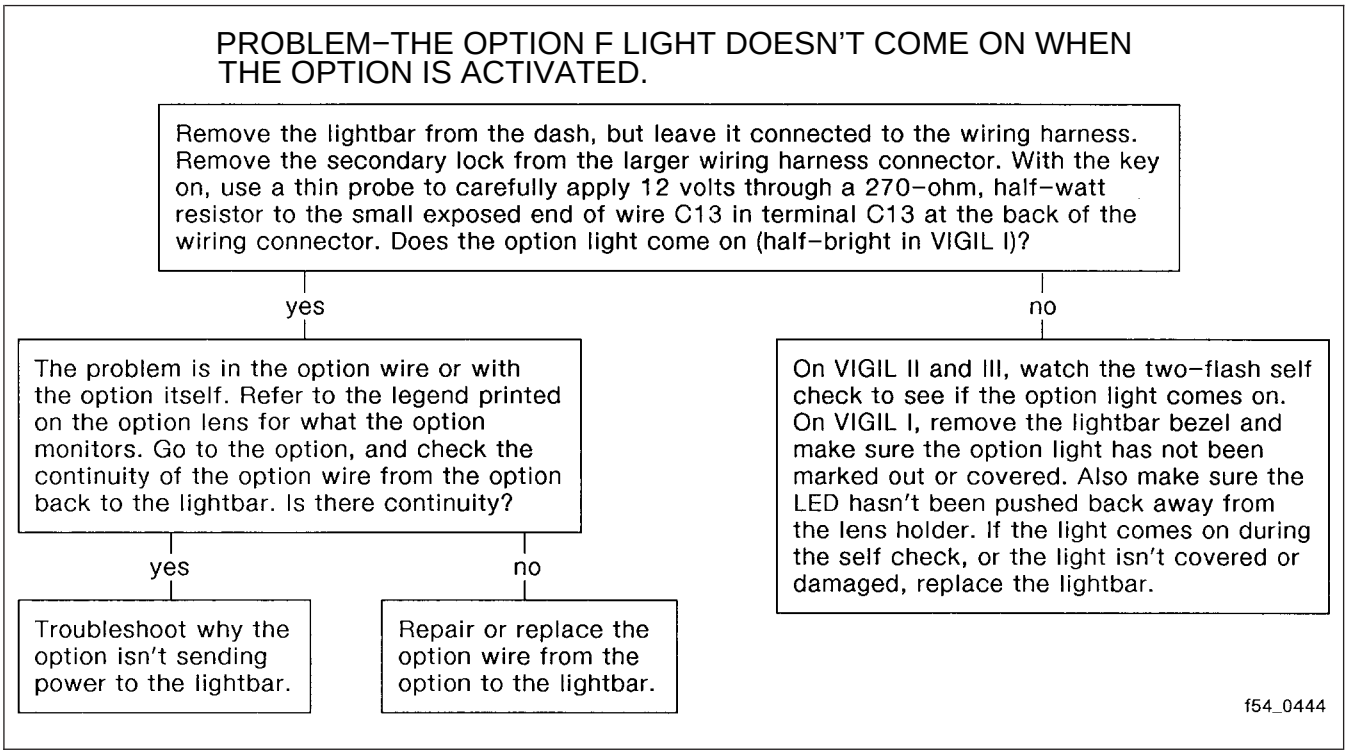


Fig. 2

Option G (See Fig. 1)

Option G is a power-activated circuit which uses the red lightbar light twelfth from the left.

NOTE: VIGIL III uses this lightbar light for the overspeed indicator light.

As a power-activated circuit, option G is controlled by the driver through a switch which connects the option circuit with a 12-volt power source. When the driver wants the option (utility light, fifth wheel lock, sludge ejector, etc.) the driver throws the applicable switch, and the option G circuit connects to power. The power activates the option and reaches lightbar pin D14 through wire D14 to activate the function light.

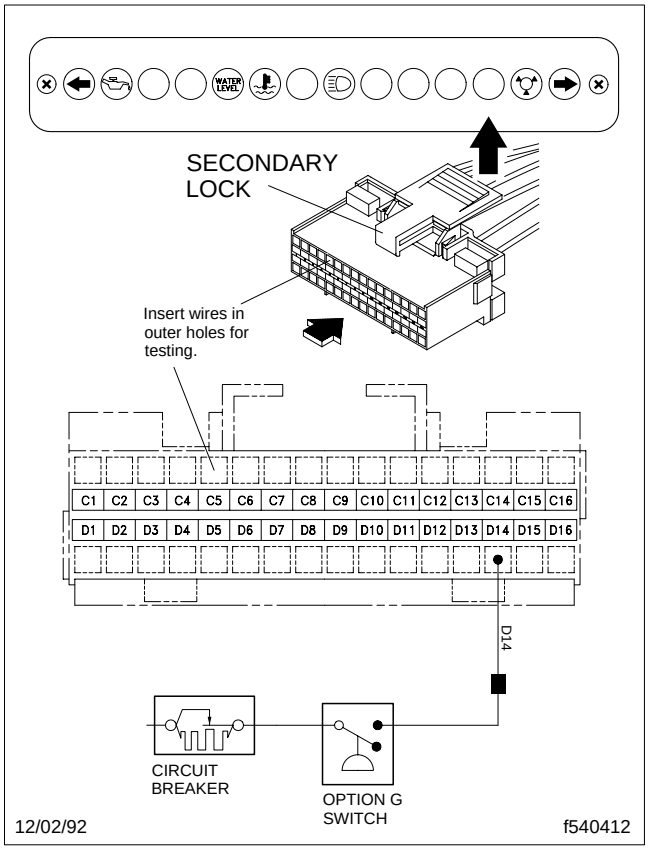


Fig. 1

Problem—The Option G Light Doesn't Come On When the Option Is Activated.

See **Fig. 2**.

Troubleshooting

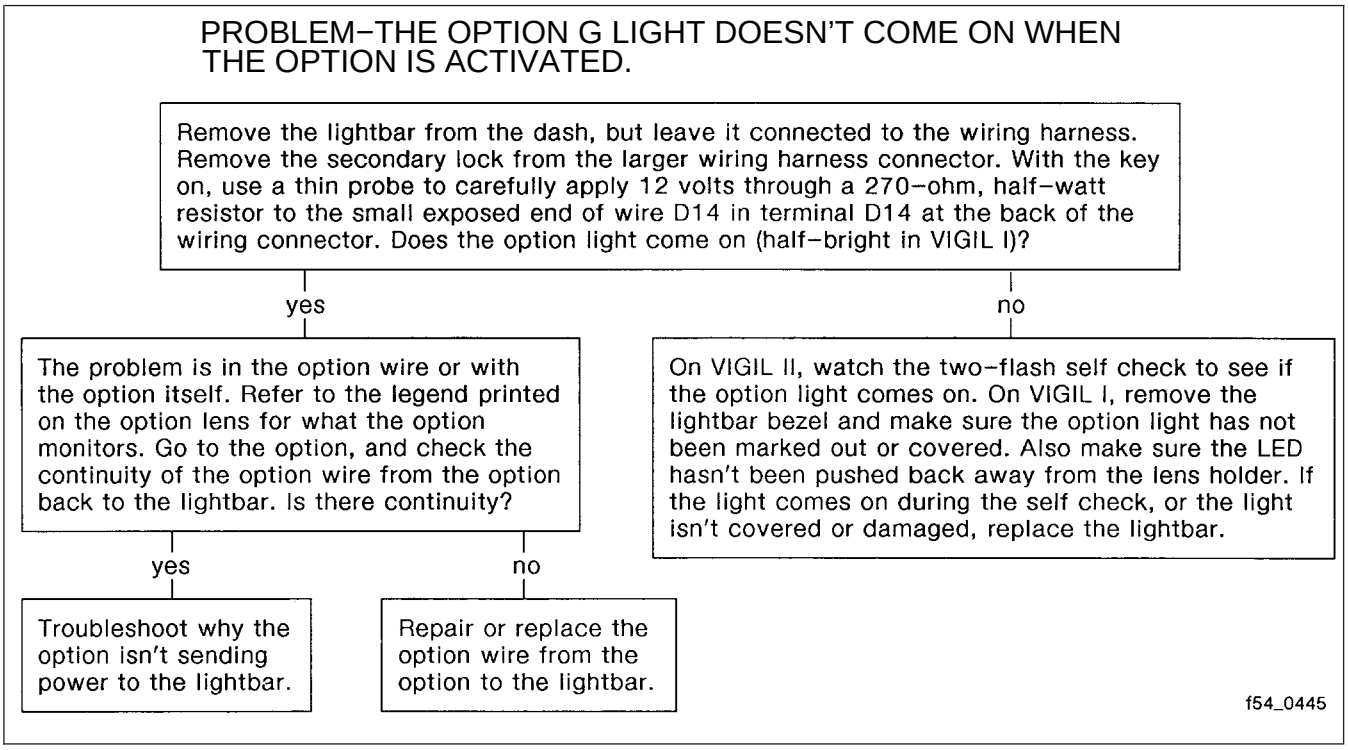


Fig. 2

Speedometer and Tachometer Control (VIGIL III Only) (See Fig. 1)

The VIGIL III lightbar counts signals from the speedometer and tachometer sensors and determines the vehicle speed and engine speed. The lightbar then sends this information to the tachometer and speedometer heads which only display the speeds.

All calibration for vehicle speed is done through the lightbar, not the speedometer head. For the calibration procedure, see **Subject 110**.

All calibration for engine speed is done at the factory, according to the type of engine installed in the vehicle. If changing engines, contact a Freightliner dealer or the Freightliner Parts Technical Department for information about tachometer recalibration.

The speedometer sensor is mounted on the transmission output, and is connected to the lightbar by wire 117 (to lightbar pin A4) and wire 118 (to lightbar pin B4). The speedometer head is connected to the lightbar by wire 328A (to lightbar pin A5). The VIGIL III lightbar has five additional vehicle speed circuits for driving options such as trip recorders, fuel economy gauges, and satellite navigation devices.

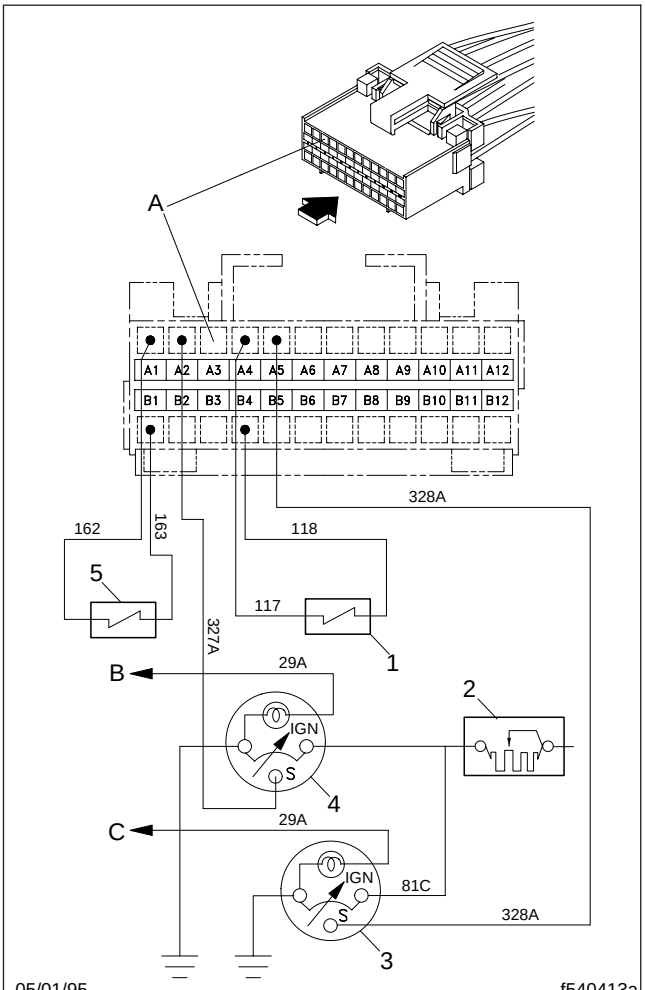
The tachometer sensor is mounted on the engine flywheel housing, and is connected to the lightbar by wire 162 (to lightbar pin A1) and wire 163 (to lightbar pin B1). The tachometer head is connected to the lightbar by wire 327A (to lightbar pin A2). The VIGIL III lightbar has one additional engine speed output.

Problem—The Speedometer Doesn't Work.

See **Fig. 2**.

Problem—The Tachometer Doesn't Work.

See **Fig. 3**.



A. Insert wires in outer holes for testing.
B. To Dash Lights
C. To Dash Lights

1. Speed Sensor
2. Circuit Breaker
3. Speedometer Head
4. Tachometer Head
5. RPM Sensor

Fig. 1, The VIGIL III Speedometer and Tachometer Control

Troubleshooting

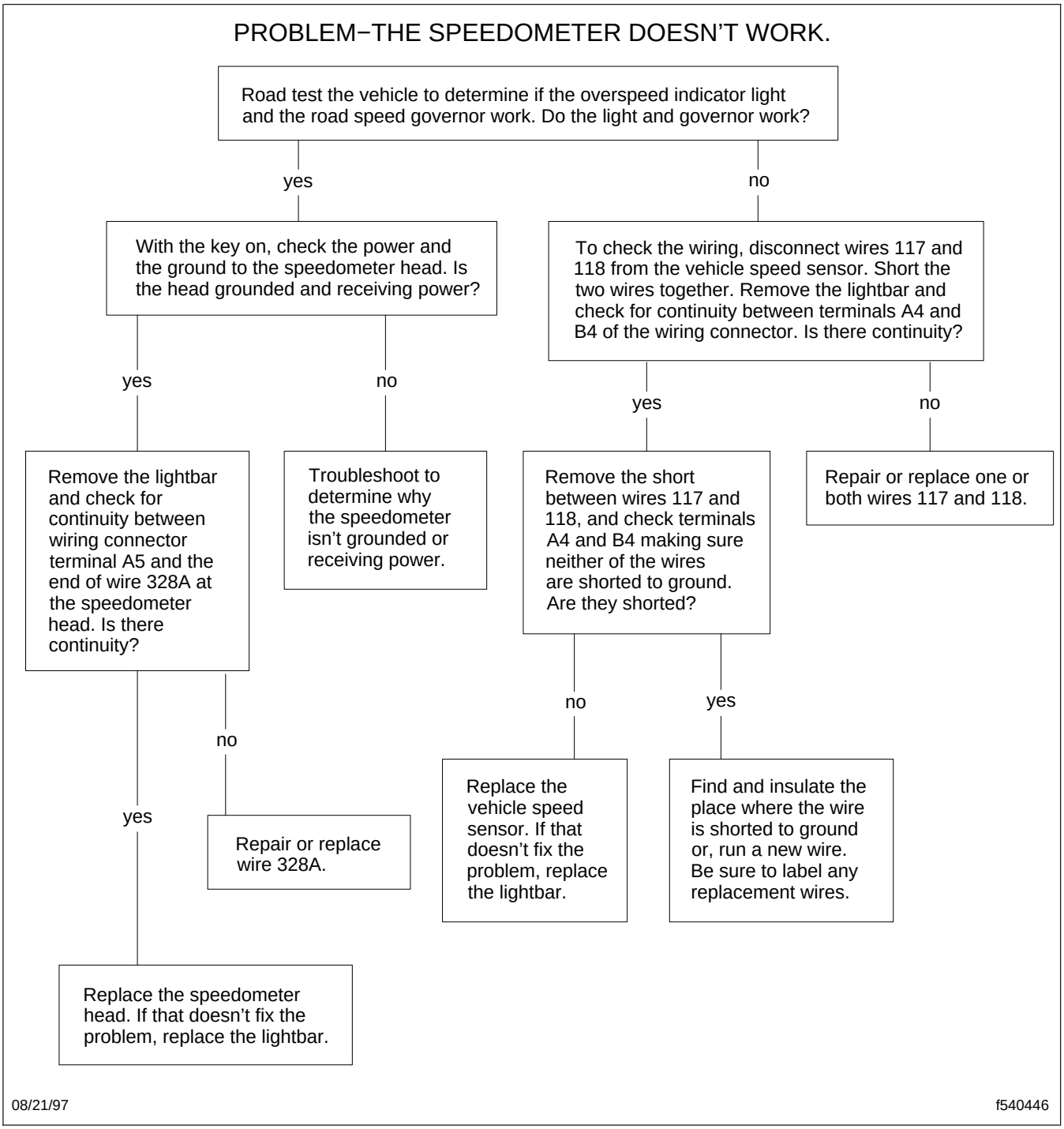


Fig. 2, Speedometer Troubleshooting

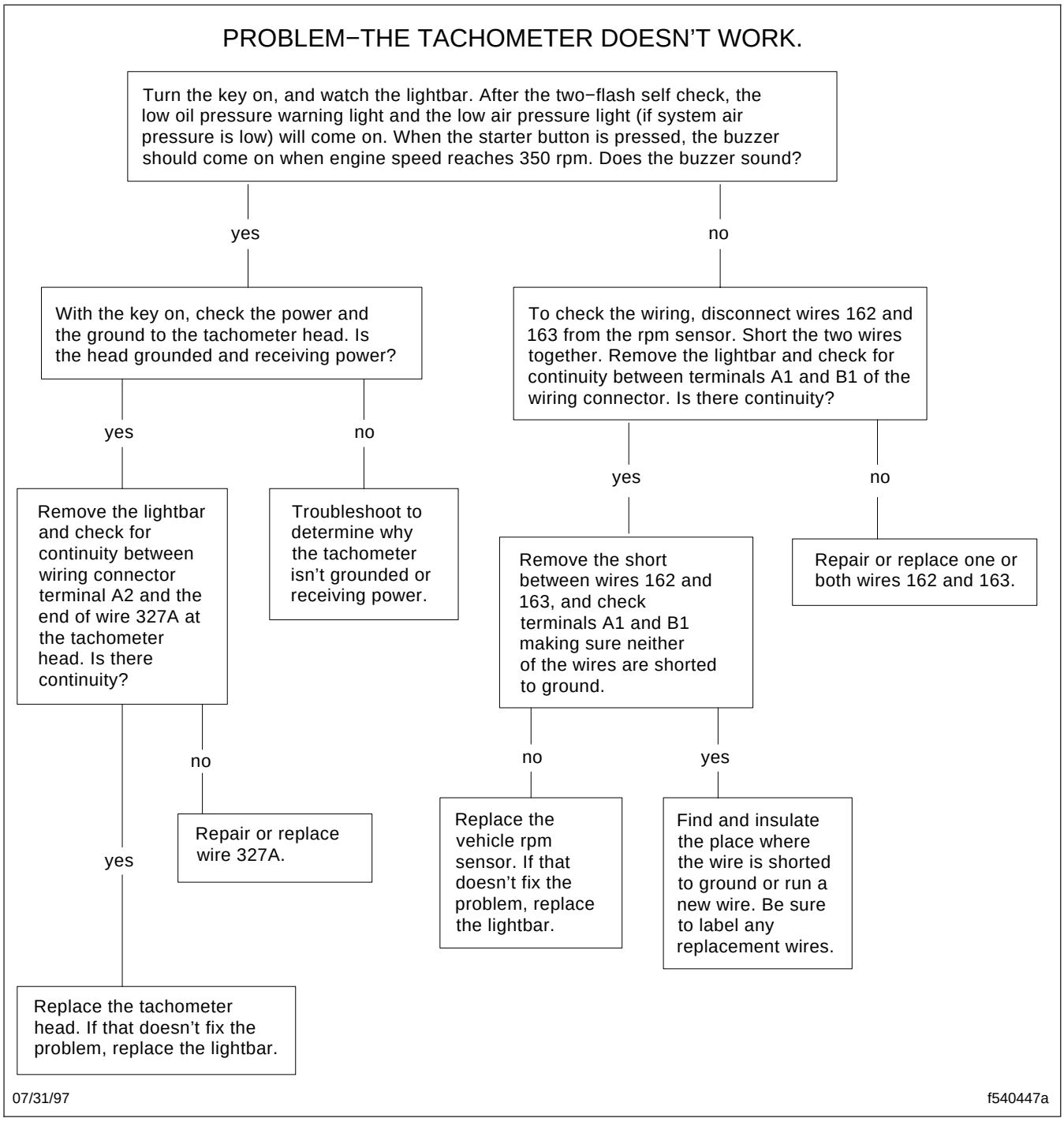


Fig. 3, Tachometer Troubleshooting

Engine Fan Control (VIGIL III Only) (See Fig. 1)

The VIGIL III lightbar uses one engine-mounted thermistor to monitor coolant temperature, to drive the coolant temperature gauge, and to start and stop the engine cooling fan as needed.

The thermistor is installed in the engine block and changes resistance as the coolant temperature changes, that is, the higher the coolant temperature, the lower the resistance. The VIGIL III lightbar monitors this resistance to determine coolant temperature, and the lightbar is programmed to turn the engine fan on and off at predetermined coolant temperatures. When thermistor resistance indicates the coolant is at either of those predetermined temperatures, the lightbar responds by activating or deactivating the fan.

To turn the fan on, the lightbar breaks the ground to lightbar pin D3 and wire 360. This shuts off the fan solenoid and turns on the fan. To turn the fan off, the lightbar grounds pin D3 and wire 360. This provides power to the fan solenoid, and turns off the fan.

NOTE: On most Freightliner vehicles, the engine fan runs when the fan solenoid receives power, and stops when power to the solenoid stops. On vehicles equipped with VIGIL III, the engine fan control is plumbed in reverse. On those vehicles, the engine fan runs when power to the fan solenoid stops, and the fan stops when the solenoid receives power. This "fail safe" installation provides continuous engine fan cooling if a failure in the circuit stops power to the fan solenoid.

NOTE: The air conditioning fan cycle switch used with VIGIL III is black with black wires; this switch is normally closed. Do not confuse this switch with the fan cycle switch used on vehicles without VIGIL III; this switch is black with white wires, and it is normally open.

Problem—The Fan (air-powered clutch) Doesn't Go Off.

See **Fig. 2**.

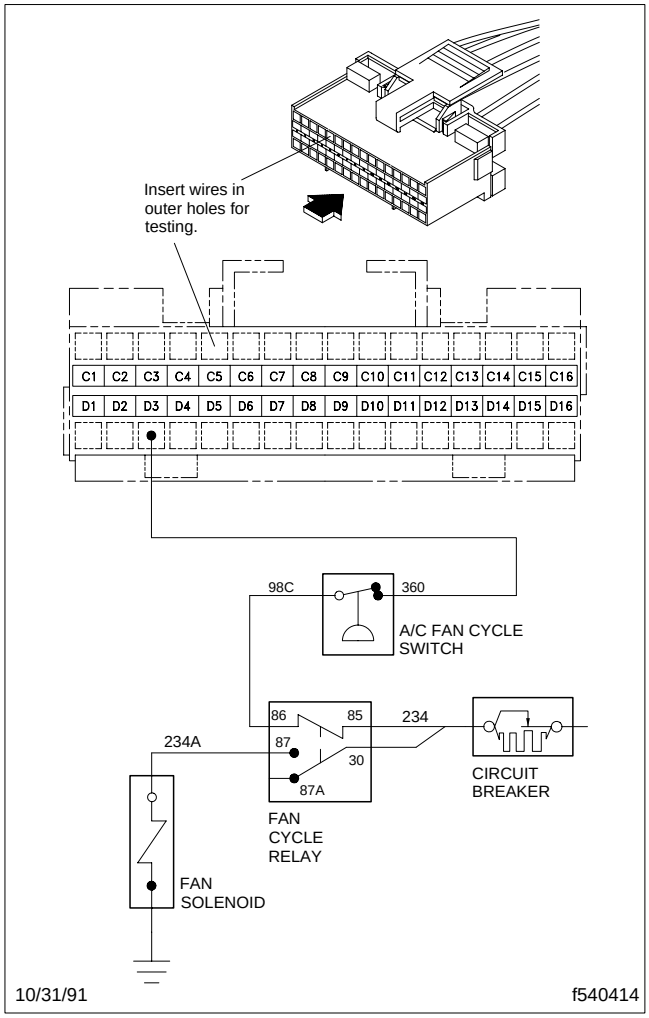


Fig. 1

Problem—The Fan (air-powered clutch) Doesn't Come On.

See **Fig. 3.**

Troubleshooting

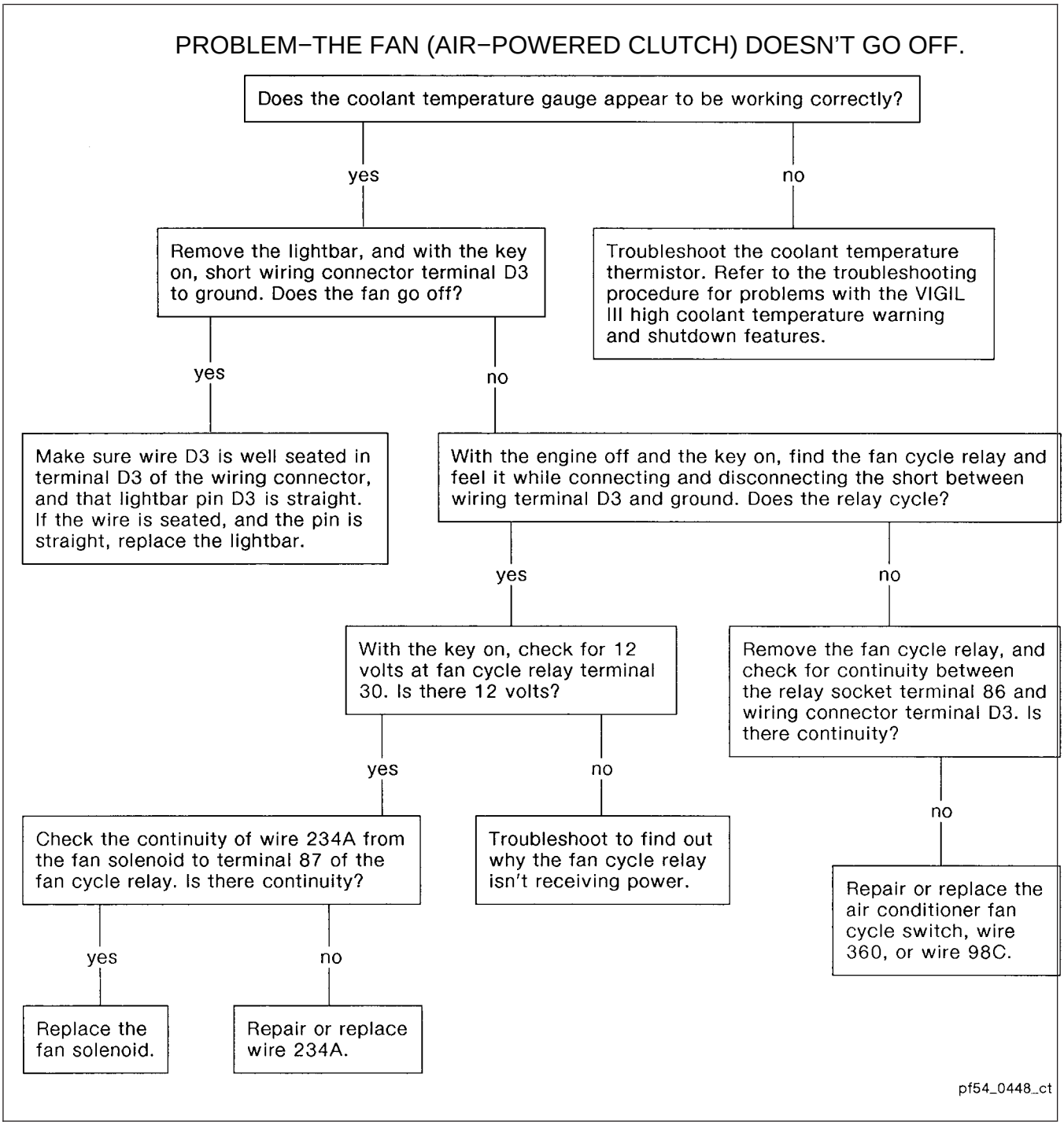


Fig. 2

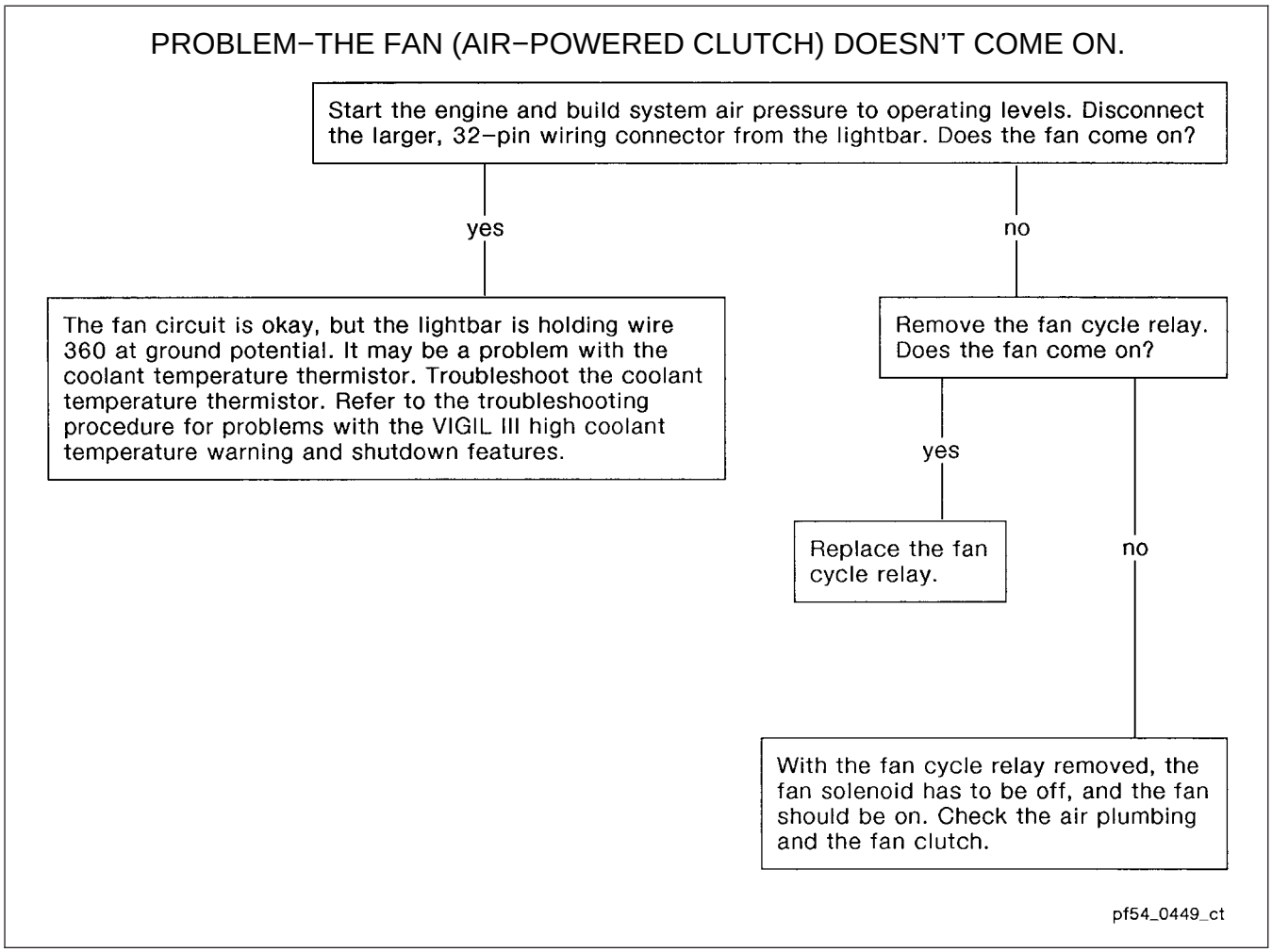

PROBLEM–THE FAN (AIR–POWERED CLUTCH) DOESN'T COME ON.
Start the engine and build system air pressure to operating levels. Disconnect the larger, 32–pin wiring connector from the lightbar. Does the fan come on?
yes
no
The fan circuit is okay, but the lightbar is holding wire 360 at ground potential. It may be a problem with the coolant temperature thermistor. Troubleshoot the coolant temperature thermistor. Refer to the troubleshooting procedure for problems with the VIGIL III high coolant temperature warning and shutdown features.
Remove the fan cycle relay. Does the fan come on?
yes
no
Replace the fan cycle relay.
With the fan cycle relay removed, the fan solenoid has to be off, and the fan should be on. Check the air plumbing and the fan clutch.
pf54_0449_ct

Fig. 3

Coolant Temperature Gauge Control (VIGIL III Only)

VIGIL III (see **Fig. 1**) uses a thermistor to measure coolant temperature. The thermistor is installed in the engine block and changes resistance as the coolant temperature changes, i.e., the higher the coolant temperature, the lower the resistance. See **Table 1**. The VIGIL III lightbar monitors this resistance to determine coolant temperature. The transducer is connected to the lightbar by wire 324 (to lightbar pin C6) and wire 18C (to lightbar pin C1).

Gauge Temperature: °F (°C)	Corresponding Resistance: ohms
105 (41)	502
144 (62)	228
175 (79)	127
204 (96)	81
219 (104)	66
253 (123)	43

Table 1

As the lightbar determines the coolant temperature, it displays it on the coolant temperature gauge. The gauge is connected to lightbar pin D10 by wire 368.

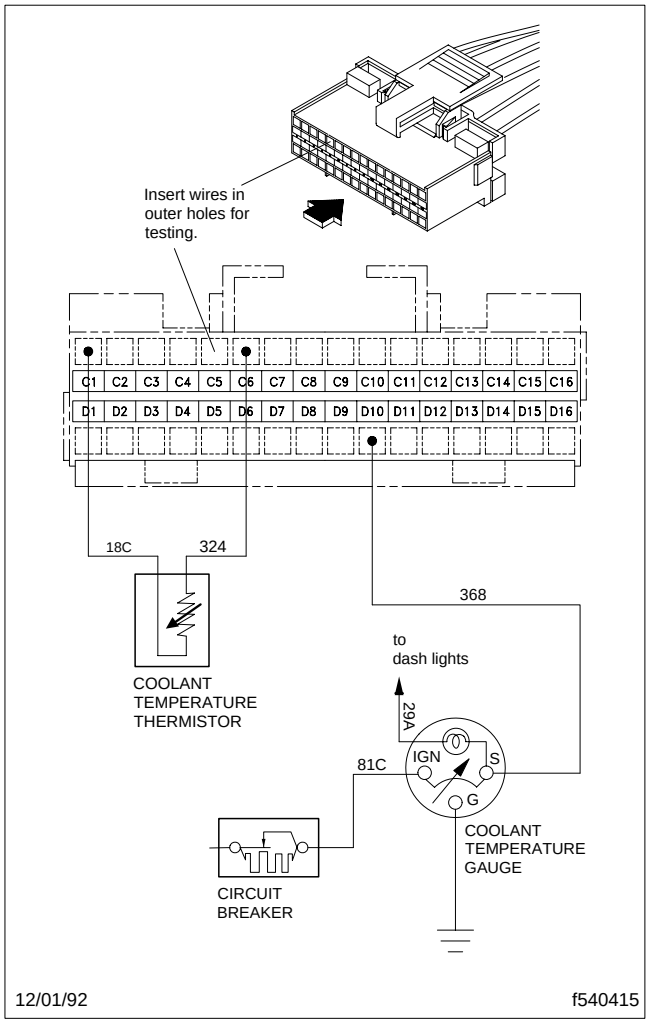


Fig. 1

Problem—The Coolant Temperature Gauge Doesn't Read Correctly.

See **Fig. 2**.

Troubleshooting

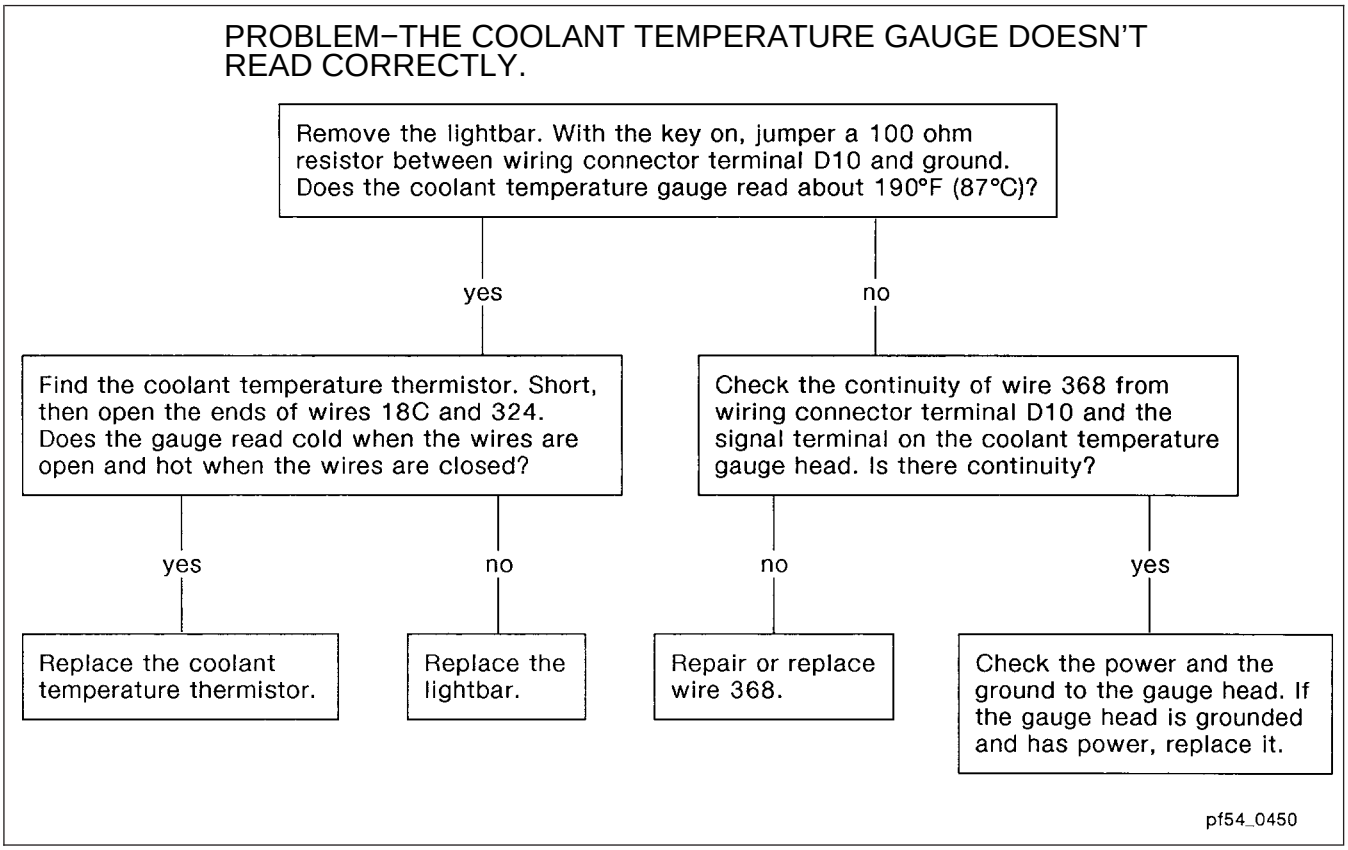


Fig. 2

For a standard VIGIL I wiring diagram, **see Fig. 1**.
For a VIGIL I wiring diagram modified to use with a Detroit Diesel DDEC electronic engine, **see Fig. 2**.

For a wiring diagram of the left turn signal circuits, **see Fig. 6**.

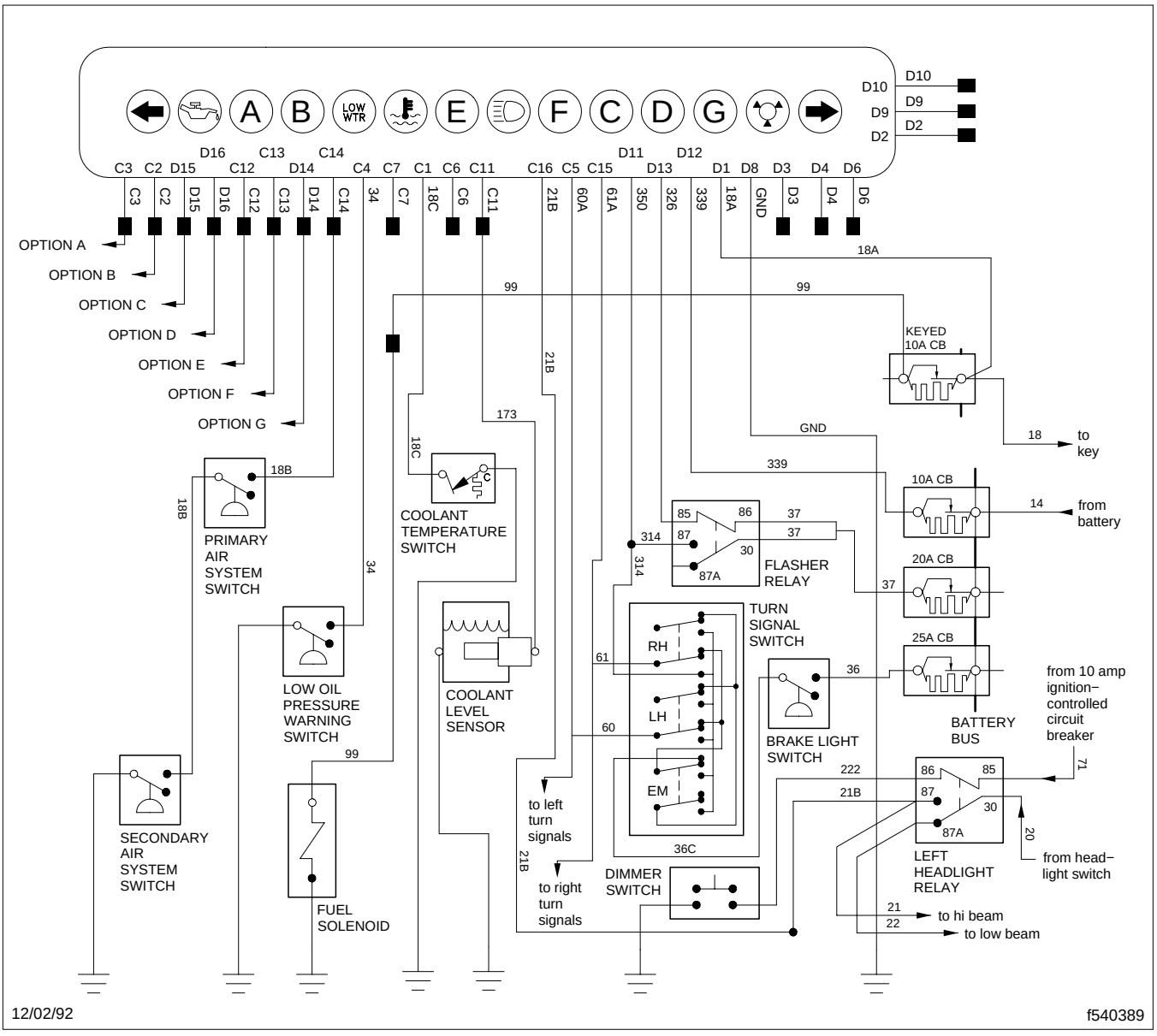


Fig. 1, Wiring Diagram, VIGIL I

For a standard VIGIL II wiring diagram, **see Fig. 3**.
For a VIGIL II wiring diagram modified to use with a Caterpillar PEEC electronic engine, **see Fig. 4**.

For a standard VIGIL III wiring diagram, **see Fig. 5**.

Specifications

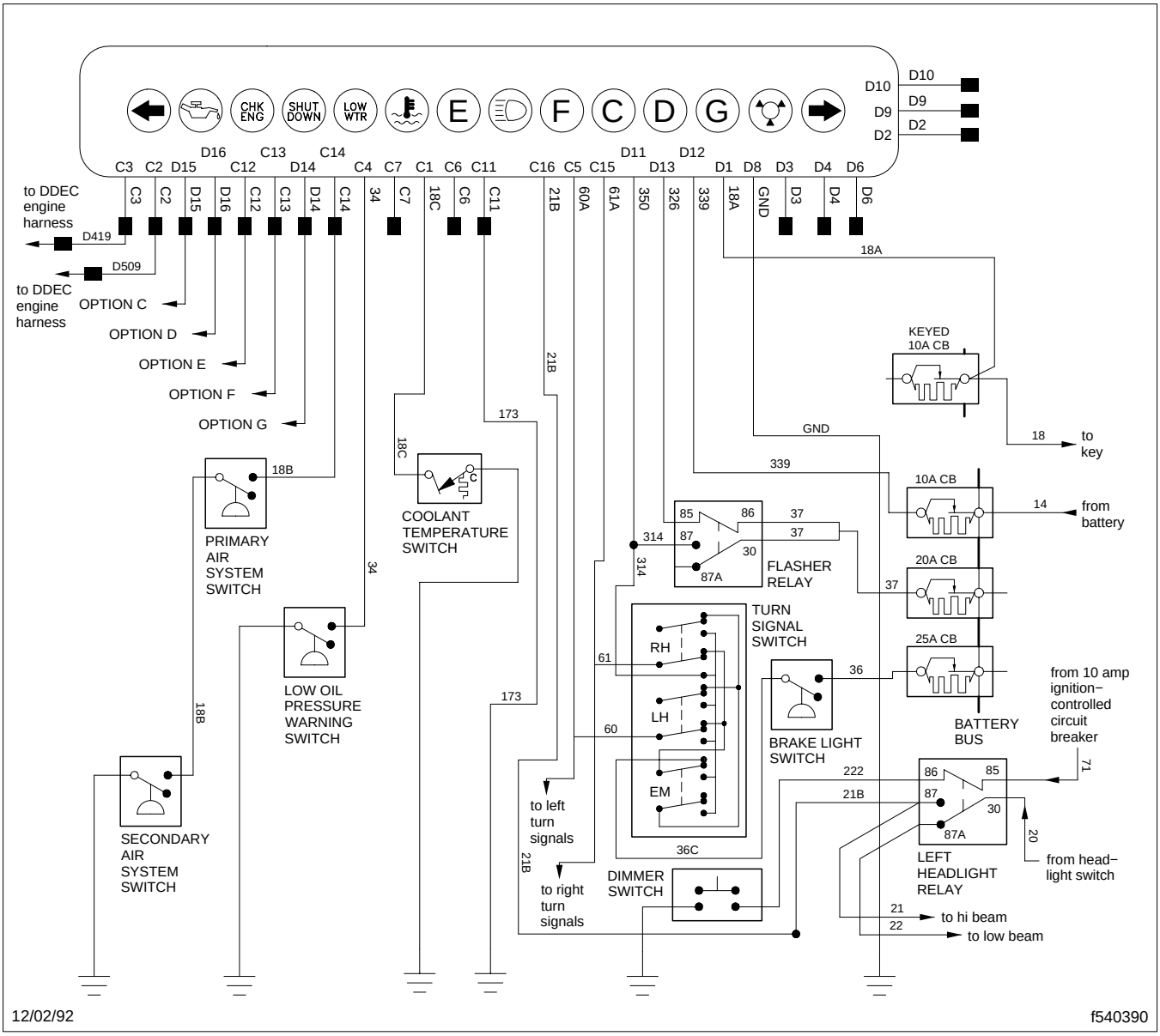


Fig. 2, Wiring Diagram, VIGIL I With Detroit DDEC Engine

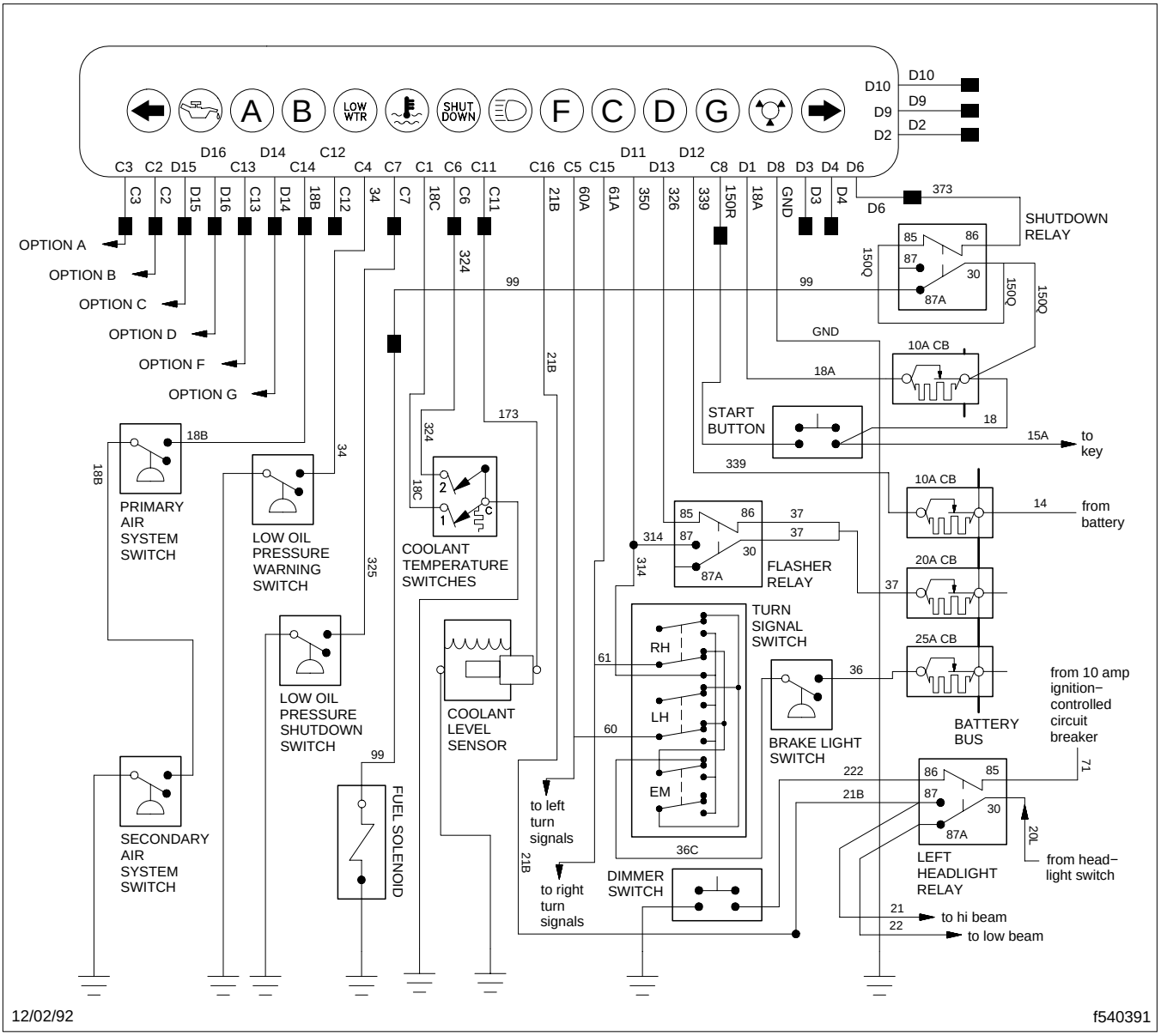


Fig. 3, Wiring Diagram, VIGIL II

Specifications

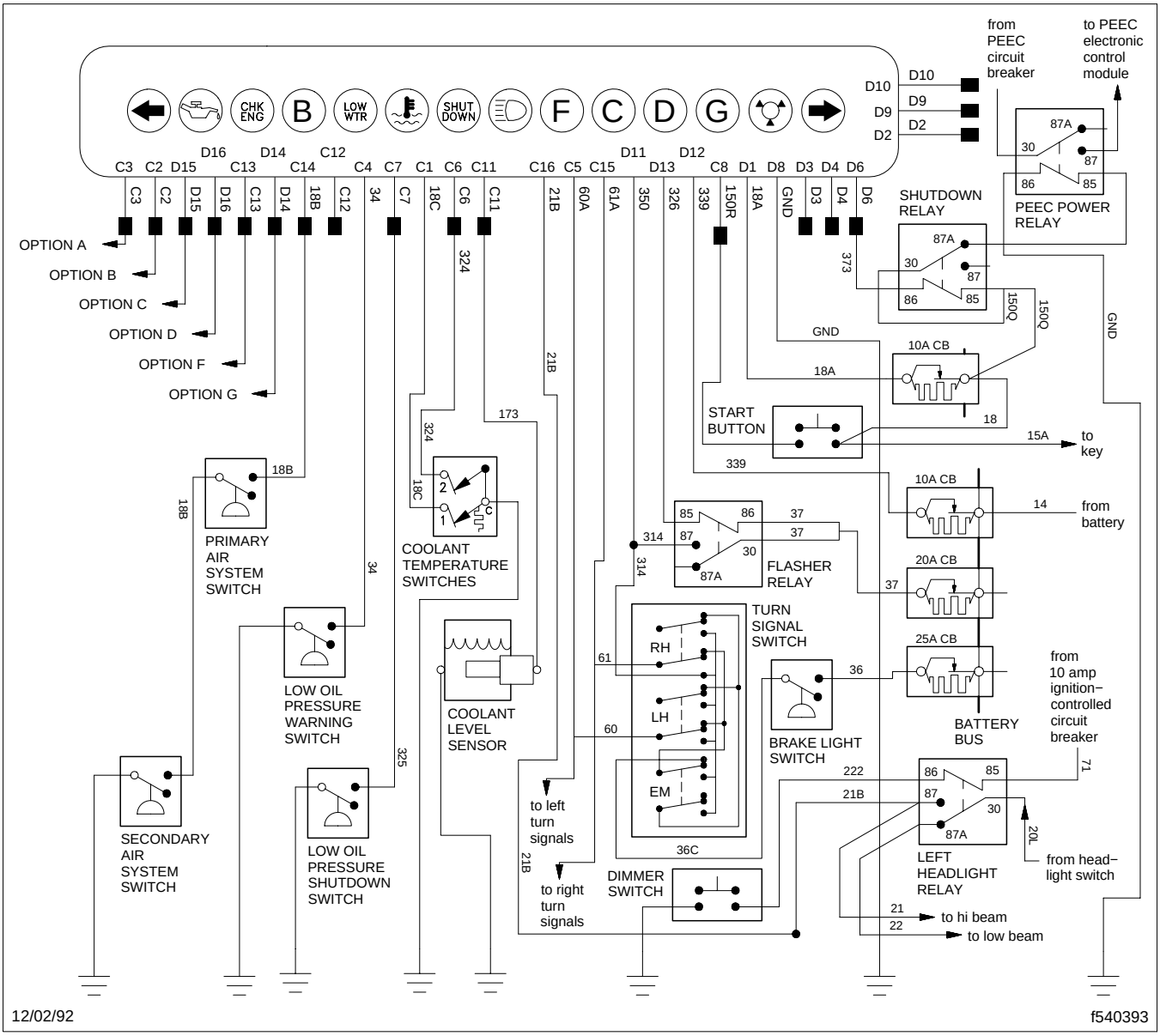


Fig. 4, Wiring Diagram, VIGIL II With Caterpillar PEEC Engine

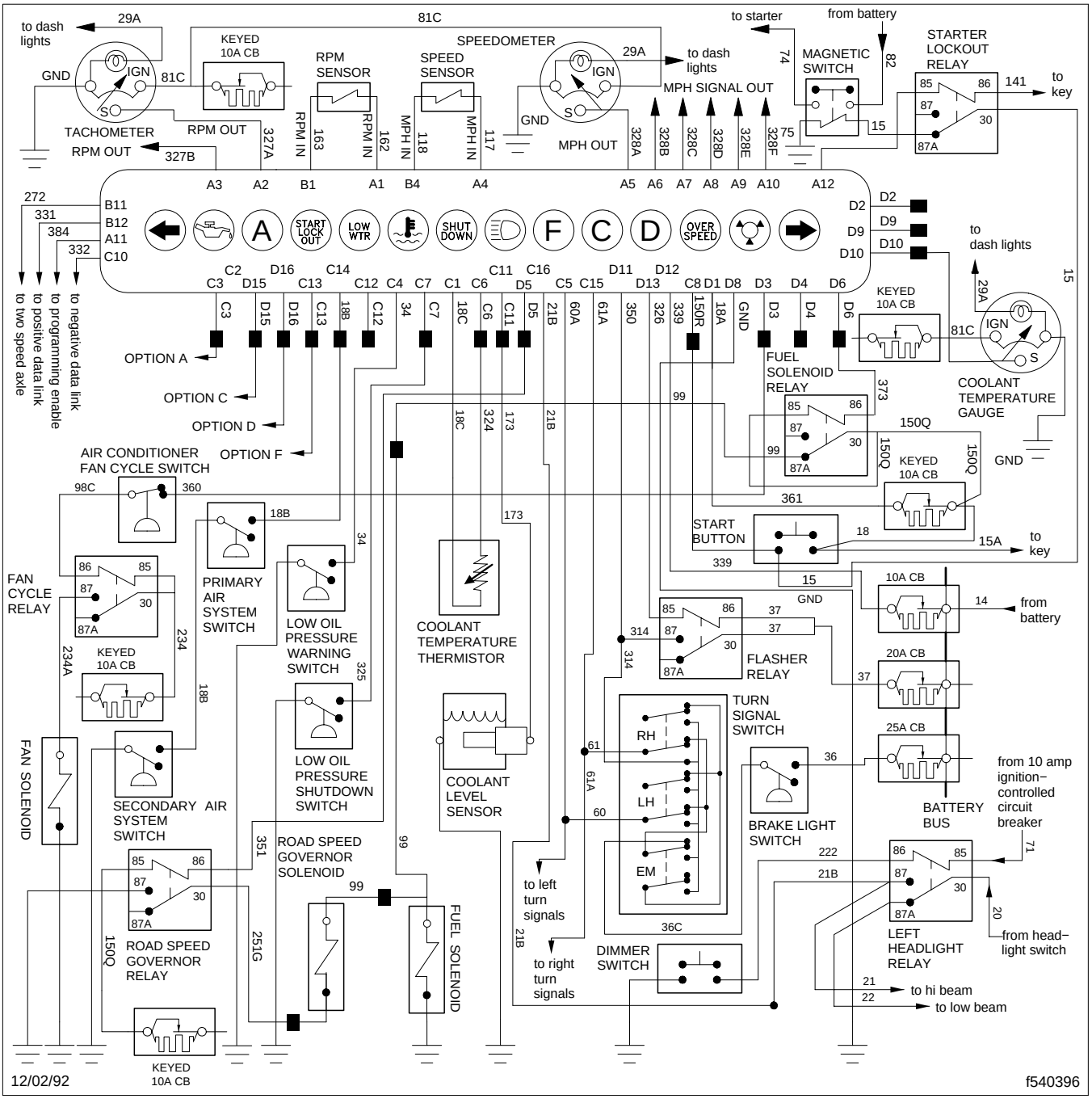


Fig. 5, Wiring Diagram, VIGIL III

Specifications

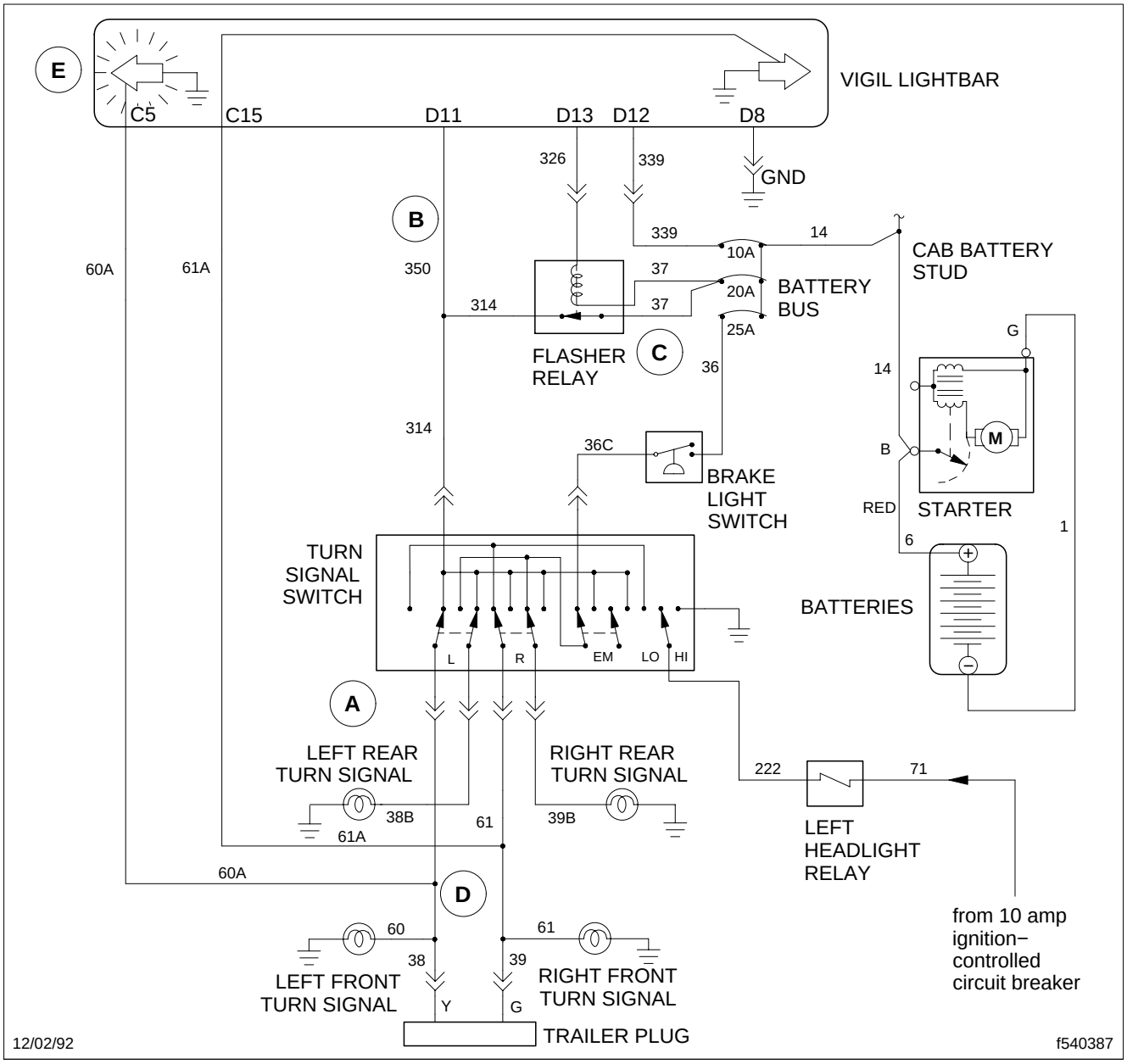
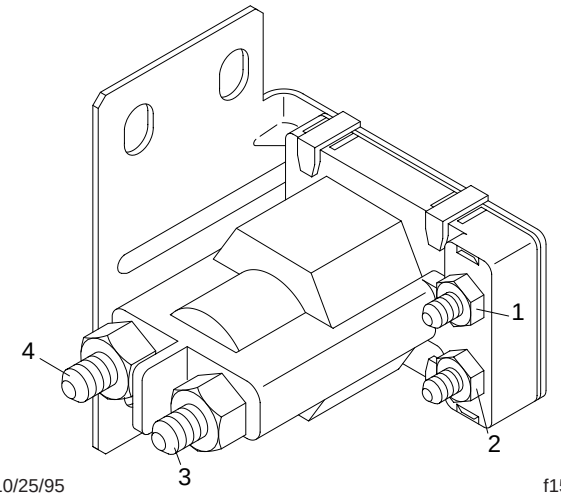


Fig. 6, Wiring Diagram, Turn Signals (left turn)

General Information

All 12-volt starting systems are equipped with a heavy-duty starter relay, or magnetic switch (see **Fig. 1**). On FLD Conventionals, the magnetic switch is attached near the windshield wiper motor on the driver's side. On COEs, the magnetic switch is attached to the left side of the front frame crossmember. When the ignition switch is held in the extreme clockwise (start) position, the magnetic switch closes, connecting electrical current to the starter solenoid, which engages the starter motor pinion with the engine flywheel ring gear, and then energizes the starter motor.



1. Coil Terminal (to ground)
2. Coil Terminal (to ignition switch)
3. Switch Terminal (to solenoid)
4. Switch Terminal (to starter BAT terminal)

Fig. 1, Magnetic Switch

The magnetic switch consists of a winding, mounted around a hollow cylinder containing a movable core or plunger, with a contact disk that is assembled onto the plunger.

When the winding is energized, plunger movement causes the contact disk to be held tightly against the two main switch terminals; this closes the circuit between these terminals, and activates the starting motor. When the winding is de-energized, a return spring causes the plunger to return to its original position, opening the circuit to the starter motor.

Magnetic Switch Replacement

Before replacing the magnetic switch, or repairing or replacing any of the starting and charging circuits, do the preliminary checks and the magnetic switch circuit test in **Troubleshooting, 300**.

Replacement

The magnetic switch cannot be disassembled. If the switch does not work, replace it.

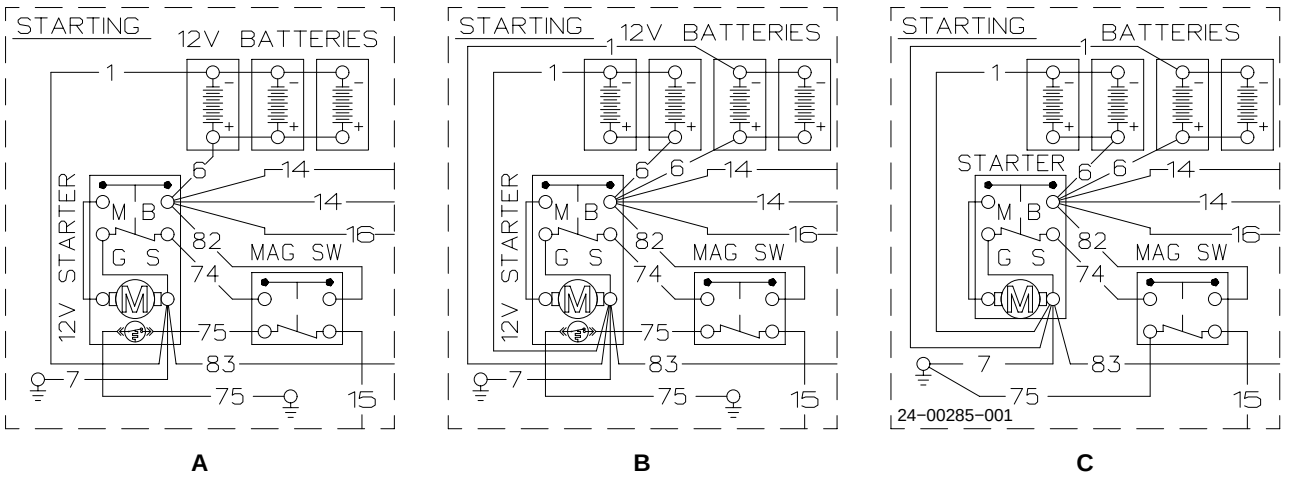
1. Apply the parking brakes, and chock the tires.
2. Disconnect the batteries and tilt the hood.
3. Mark the wires for later reference, then disconnect the wires that are attached to the magnetic switch. See **Fig. 1**.
4. Remove the magnetic switch.
   - 4.1 Remove the two mounting screws.
   - 4.2 Remove the two large terminal nuts.
   - 4.3 Disconnect the two-pin pigtail connector. Remove the magnetic switch.
5. Install the new magnetic switch.
   - 5.1 Tighten the mounting screws 84 lbf·in (940 N·cm).
   - 5.2 Connect the wires to the magnetic switch, using the marks made on removal. Tighten the terminal nuts securely.
   - 5.3 Connect the two-pin pigtail connector.
6. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

7. Connect the batteries and lower the hood.
8. Remove the chocks from the tires.

Magnetic Switch Replacement



04/22/96 f541276

A. 12-Volt Starting System With Thermal Switch and Three 12-Volt Batteries
B. 12-Volt Starting System With Thermal Switch and Four 12-Volt Batteries
C. 12-Volt Starting System With Four 12-Volt Batteries, No Thermal Switch

Fig. 1, Magnetic Switch Wiring

Preliminary Checks

Before replacing the magnetic switch, or repairing or replacing any of the starting and charging circuits, do these preliminary checks and the "Magnetic Switch Circuit Test."

1. Apply the parking brakes, and chock the tires.
2. Check the condition of the batteries. Follow the battery testing procedure in **Section 54.02, Subject 140**. Be sure the batteries are fully charged.

NOTE: The wiring, switches, and starter motor cannot be checked if the batteries are damaged or discharged.

3. Check the starting motor, ignition switch, and solenoid for damage or wear. Repair or replace the component(s), as needed.

Magnetic Switch Circuit Test

Before replacing the magnetic switch, or repairing or replacing any of the starting and charging circuits, do this test.

1. Apply the parking brakes, and chock the tires.
2. Check the condition of the batteries. Follow the battery testing procedure in **Section 54.02, Subject 140**. Be sure the batteries are fully charged.

NOTE: The wiring, switches, and starter motor cannot be checked if the batteries are damaged or discharged.

3. Check the starting motor, ignition switch, and solenoid for damage or wear. Repair or replace the component(s), as needed.
4. Check the wiring and the magnetic switch for wear or damage. See **Specifications, 400**.
5. Check the circuit between the magnetic switch and the starter "B" terminal (circuit 82) for correct voltage.
   - 5.1 Disconnect the circuit running from the starter "S" terminal to the magnetic switch (circuit 74).
   - 5.2 Connect a voltmeter to the magnetic switch terminal where the circuit from the starter "B" terminal is connected (circuit 82).
   - 5.3 If the voltmeter reading is 0 volt, check for an open circuit.

     If the voltmeter reading is less than 12.0 volts, check for corroded or loose connections.

     If the voltmeter reading is 12.0 volts or more, go to the next step.
   - 5.4 Repair or replace any damaged wires.
6. Check the magnetic switch ground circuit (circuit 75).
   - 6.1 Connect an ohmmeter between the magnetic switch ground terminal and a known good ground.
   - 6.2 If the ohmmeter reading is more than 0.5 ohm, check for corroded or loose connections.
   - 6.3 Repair or replace any damaged wires.
7. Check the magnetic switch ignition wiring (circuit 15) for correct voltage.

   NOTE: This check requires two persons.
   - 7.1 Have one person turn on the ignition keyswitch and hold in the start button.
   - 7.2 Have the other person connect a voltmeter between the magnetic switch terminal where the ignition circuit is connected (circuit 15) and a known good ground.
   - 7.3 If the voltmeter reading is 0 volt, check for an open in circuit 15.

     If the voltmeter reading is less than 11.0 volts, check for corroded or loose connections.

     If the voltmeter reading is 11.0 volts or more, go to the next step.
   - 7.4 Repair or replace any damaged wires, circuit breakers, or relays.
8. Check the circuit between the magnetic switch and the starter "S" terminal (circuit 74) for correct voltage.

   NOTE: This check requires two persons.
   - 8.1 Have one person turn on the ignition keyswitch and hold in the start button.

Troubleshooting

8.2 Have the other person connect a voltmeter between the magnetic switch terminal where the circuit from the starter "S" terminal is connected (circuit 74) and a known good ground.

8.3 If the voltmeter reading is less than 12.0 volts, replace the magnetic switch.

9. Check the voltage to the magnetic switch again. If the voltmeter reading is now 11.0 volts or more, disconnect the voltmeter, and remove the chocks from the tires. If the reading is still less than 11.0 volts, replace the magnetic switch. For instructions, see **Subject 100**.

Magnetic Switch Contactor Test

The cranking circuit includes the battery, starter solenoid, cranking motor, magnetic switch, and ignition keyswitch.

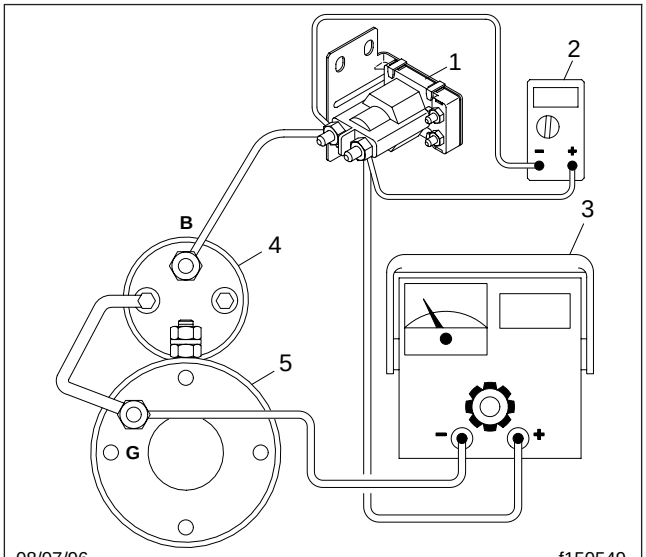
If there is excessive voltage loss in the cranking circuit, the starter may not engage the flywheel at all, or it may drop out too soon when battery voltage goes down. In this case, check the cranking circuit and starter solenoid for voltage loss. For instructions, see Section 15.00, **Troubleshooting, 300**.

If the magnetic switch closes during the cranking circuit test and the starter wiring test, also check the magnetic switch contactors for voltage loss.

1. Disconnect the lead from the magnetic switch to the "S" (solenoid) terminal on the starter (leave as in "Starter Wiring Test").
2. Connect this lead to the positive lead of a carbon pile tester. Connect the negative lead of the carbon pile to the starter "G" (ground) terminal (leave as in "Starter Wiring Test").
3. Set a digital voltmeter on the low scale and connect the positive lead to the magnetic switch terminal to which the carbon pile is already connected. Connect the negative lead to the other large terminal on the magnetic switch. See **Fig. 1**.
4. Start the engine and check the voltage.

   NOTE: This check requires two persons.

   4.1 Have one person turn on the ignition keyswitch and hold in the start button.



1. Magnetic Switch
2. Digital Voltmeter
3. Carbon Pile
4. Starter Solenoid
5. Cranking Motor

Fig. 1, Magnetic Switch Contactor Test

   4.2 Have the other person read the voltage on the voltmeter. It should read 0 volt.

5. Turn on the carbon pile and adjust it to a 100-amp load.

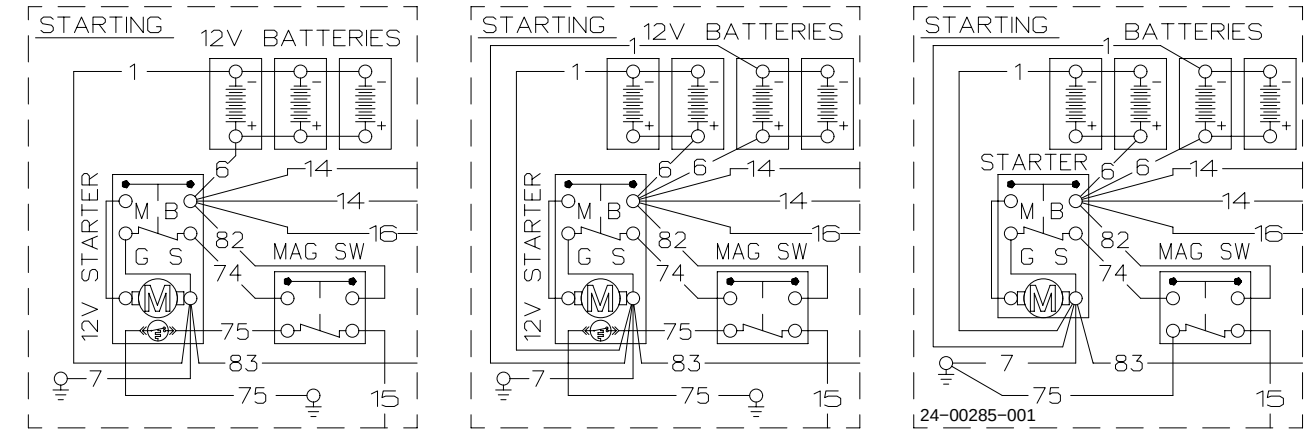
   5.1 Now read and record the voltage on the voltmeter. Turn off the carbon pile.

   5.2 If the voltage reads 11.8 volts or greater, the magnetic switch contactors are OK.

   If the voltage reads less than 11.8 volts, replace the magnetic switch.

Specifications

For typical magnetic switch wiring diagrams, see **Fig. 1**.



04/22/96 f541276

A. 12-Volt Starting System With Thermal Switch and Three 12-Volt Batteries
B. 12-Volt Starting System With Thermal Switch and Four 12-Volt Batteries
C. 12-Volt Starting System With Four 12-Volt Batteries, No Thermal Switch

Fig. 1, Magnetic Switch Wiring

General Information

The FloScan Fuel-Tach is an electronic monitoring system that records fuel consumption and displays average miles per gallon. It provides you with immediate feedback, showing a percentage difference between the current fuel consumption rate and the total trip miles per gallon average. The Fuel-Tach serves as a guide for shifting the transmission and for keeping the engine in the appropriate rpm range for better fuel efficiency. Information is displayed by either an analog gauge or an LED color bar graph. Both displays include a digital readout in miles per gallon.

The Fuel-Tach system allows you to select and receive average miles per gallon information for each new trip, for a series of trips, or for a specific period of time (up to six months). In addition, the Model DBS for electronic engines displays engine fault codes sent over the engine data bus, and maintains a "history" record of fault codes until the record is erased by the driver.

Principles of Operation

The Fuel-Tach system **(see Fig. 1)** is a microcomputer that processes and records vehicle speed and fuel consumption information. On vehicles with non-electronic engines, a fuel flow sensor **(see Fig. 2)**, that is installed in the fuel line, converts the fuel flow rate into electrical signals that are transmitted to the Fuel-Tach gauge. The vehicle speed signal is either received from a speed signal generator that is located at the mechanical drive tap in the transmission (for a mechanical speedometer), or received from a vehicle speed sensor installed in the transmission bearing retainer (for an electronic speedometer).

The system is driver-regulated by an "On-Ignition" switch **(see Fig. 3).**

The "Ignition" position allows the driver to receive average miles per gallon information for each new trip. In the "Ignition" position, once the engine is shut down, the Fuel-Tach system is off. The miles per gallon average of the just-completed trip is not maintained in the system's memory.

The "On" position allows the driver to receive average miles per gallon information for longer trips, or for specific time periods. In the "On" position, the Fuel-Tach system stays on and stores the average miles per gallon information in memory, even if the engine is shut down.

On vehicles with electronic engines, fuel flow and vehicle speed data are received from the engine data bus. The driver controls the system with a "Reset" switch. To reset the average miles per gallon and the engine fault code history, the driver pushes and holds the reset switch. The average miles per gallon figure will blink on and off for about ten seconds. The driver must continue to hold the reset switch until the blinking miles per gallon figure is replaced with a blinking "Er." If the switch is released before the display changes to a blinking "Er," the engine fault history will be displayed, and neither the average miles per gallon nor the fault history will be reset.

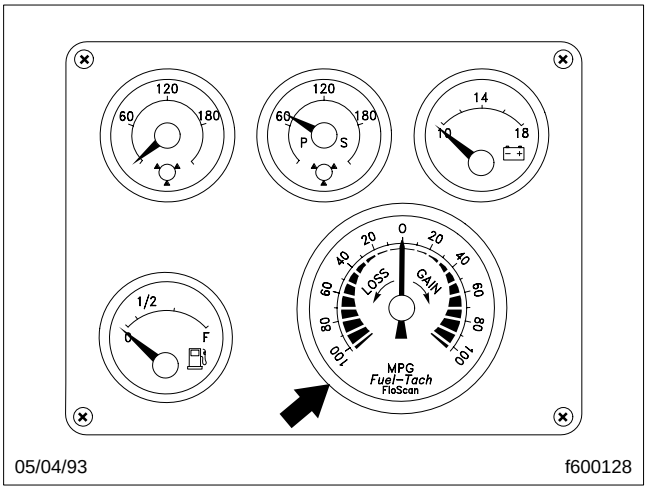


Fig. 1

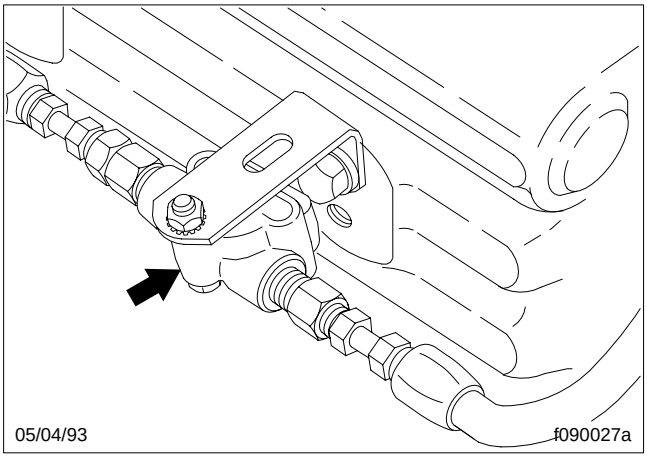


Fig. 2, Fuel Flow Sensor, Cummins Installation

General Information and Principles of Operation

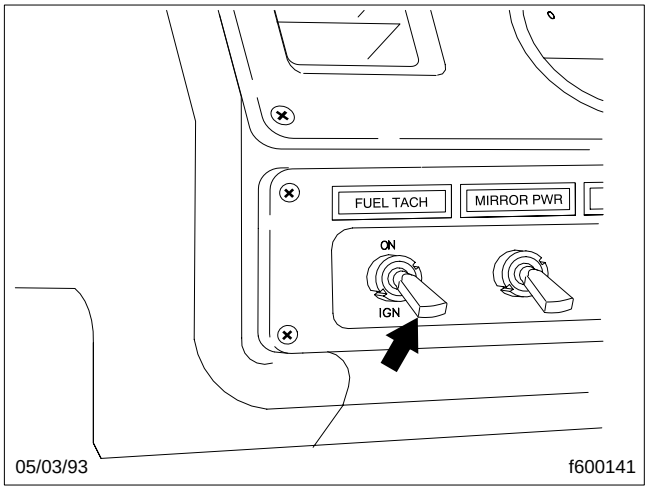


Fig. 3

Replacement

1. Apply the parking brakes.
2. Turn off the ignition switch.
3. Remove the screws that attach the Fuel-Tach gauge panel to the dash. Pull the panel out to gain access to the back of the gauge head.
4. Remove the wiring connector and the light bulb assembly from the back of the gauge.
5. Remove the nuts that attach the mounting bracket to the Fuel-Tach gauge, and remove the bracket. Remove the gauge from the front of the panel.
6. Install the new Fuel-Tach gauge using the instructions above, in reverse order.

Flow Sensor Replacement (Non-Electronic Engines Only)

Replacement

NOTE: Two flow sensors are used on Caterpillar **(see Fig. 1)** and Detroit Diesel engines.

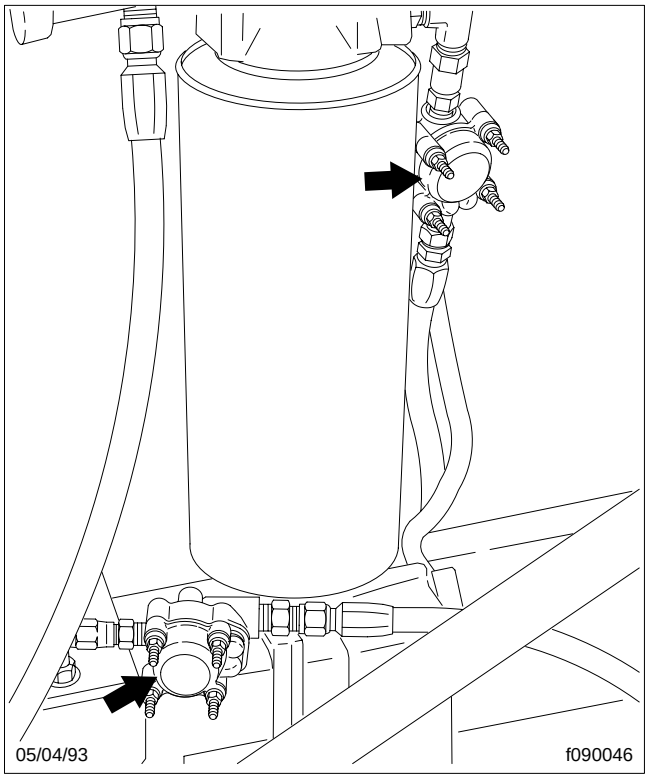


Fig. 1

1. Clean the area around the flow sensor to prevent contaminants from entering the fuel system. Use shop air to blow the area clean.
2. Disconnect the flow sensor wiring connector from the chassis wiring harness. Remove the tie straps as necessary.
3. On Cummins engines **(see Fig. 2)**, disconnect the fuel lines from the sensor. Remove the sensor from the mounting bracket.

   On Caterpillar and Detroit Diesel engines, disconnect the fuel lines from the sensor, then remove the sensor.

IMPORTANT: Collect fuel line drainage and cover the fuel line to prevent contaminants from entering the fuel system.

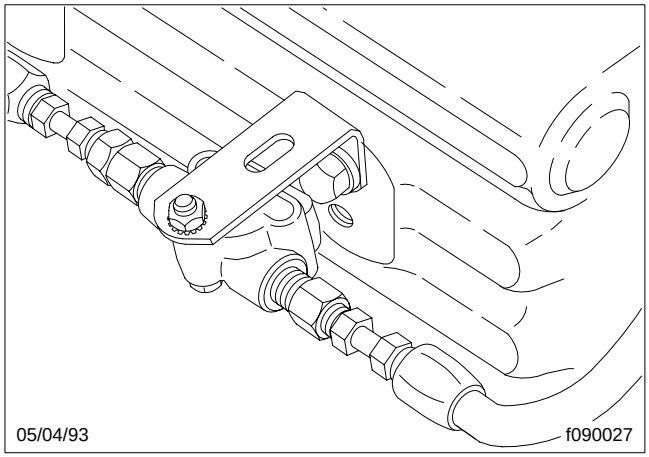


Fig. 2

⚠ WARNING

Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

4. If the sensor is used again, clean it with a carburetor cleaning fluid or a solvent.
5. Coat the fuel line pipe threads with Armite "Lead-Plate" no. 250 antiseize compound, or an equivalent.
6. On Cummins engines, install the flow sensor with the port marked "In" towards the fuel pump.

   On Caterpillar and Detroit Diesel engines, install one sensor in the fuel supply line and one sensor in the fuel return line.

   On all engines, make sure that the sensor wires point down (or in towards the engine), to prevent splash water from entering the sensor amplifier.
7. Tighten the fuel line fittings on each side of the flow sensor. On Cummins engines, install the mounting bracket capscrew and tighten the nut 108 lbf·in (1220 N·cm).
8. Connect the flow sensor wiring connector to the chassis wiring harness and secure as necessary with tie straps.

Fuel-Tach Gauge Calibration (Non-Electronic Engines Only)

Calibration

If a new Fuel-Tach gauge is installed, or if different tires are installed, calibrate the Fuel-Tach gauge.

NOTE: The procedures below are not listed in order of recommendation. The procedure chosen depends on the calibration equipment available.

ON-HIGHWAY CALIBRATION USING THE FUEL-TACH 911 CALIBRATOR

IMPORTANT: To ensure driving safety, a passenger must accompany the driver to operate and observe the Fuel-Tach gauge and calibration unit.

1. Remove the screws that attach the Fuel-Tach gauge panel to the dash. Pull the panel out and connect the 911 calibrator **as shown in Fig. 1.**
2. Move the calibrator toggle switch to the single-flow-sensor position for Cummins engines, or the dual-sensor position for all other engines.
3. On Cummins engines, enter the calibration factor in the calibration factor display.

NOTE: For Cummins engines, locate the Cummins fuel pump code number in **Specifications, 400.** The number to the right of the fuel pump code number is the calibration factor.

4. Press the calibrator reset button.
5. Accelerate the vehicle and maintain a constant speed.
6. Press the test button and maintain vehicle speed while the test light is on (about 10 seconds).
7. Multiply the vehicle speed by 0.1. For example, if the vehicle speed was maintained at 30 mph while the test light was on, multiply 30 by 0.1 to obtain the average-miles-per-gallon rating.
8. At the back of the gauge head, set the slide switch to a position that will provide the digital display reading that is closest to, but lower than, the average-miles-per-gallon rating. **See Fig. 2.**

   At the back of the gauge head, turn the rotary knob (if equipped), or insert a thin-bladed screwdriver into the slot and turn the calibration adjusting screw, until the digital display reads the average-miles-per-gallon rating obtained in the step above. **See Fig. 2.**
9. Disconnect the calibrator from the gauge head wiring connector. Connect the gauge head wiring connector to the chassis wiring harness.
10. Install the screws that attach the Fuel-Tach gauge panel to the dash.

IMPORTANT: Keep a record of actual average miles-per-gallon for a few tanks of fuel. If the Fuel-Tach digital display consistently differs from the actual average-miles-per-gallon performance, fine-tune the gauge by adjusting the digital display.

IN-SHOP CALIBRATION USING THE FUEL-TACH 911 CALIBRATOR AND THE 915 SPEED SIGNAL MODULE

1. Obtain the revolutions-per-mile value of the tire brand and model installed on the vehicle. The revolutions-per-mile value can be obtained from the tire dealer or manufacturer.
2. Obtain the vehicle axle ratio.

NOTE: The vehicle axle ratio is listed on the vehicle specification decal, and is also stamped on the axle housing.

3. If equipped with a Cummins engine, obtain the fuel pump code number and determine the calibration factor. See **Specifications, 400.**
4. Connect the 911 Calibrator and the 915 Speed Signal Module **as shown in Fig. 3.**
5. Move the calibrator toggle switch to the single-flow-sensor position for Cummins engines, or the dual-sensor position for all other engines.
6. On Cummins engine installations, enter the calibration factor in the calibration factor display.
7. Press the test button. The red test light will stay on about 10 seconds.
8. On vehicles equipped with electronic speedometers, make the following calculations:

   8.1 Multiply the revolutions-per-mile value of the tire brand, the rear axle ratio, and the vehicle speed sensor signal frequency

Fuel-Tach Gauge Calibration (Non-Electronic Engines Only)

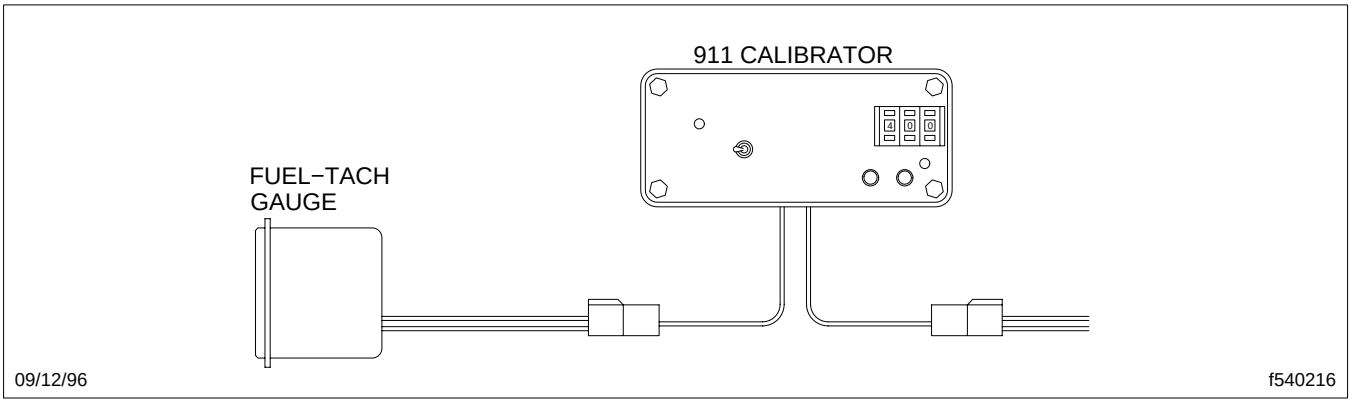


Fig. 1

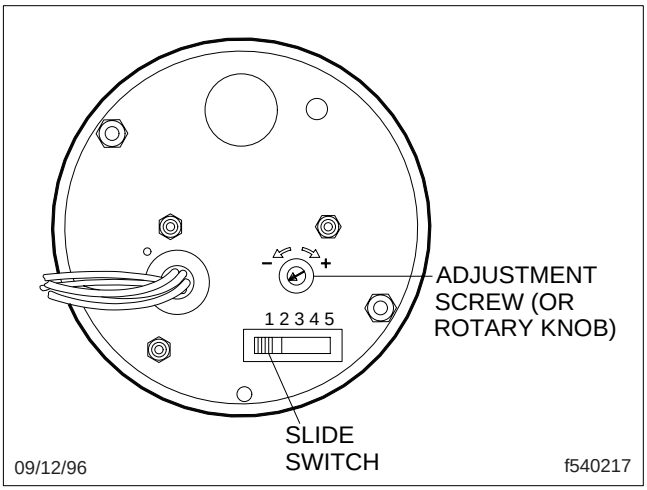


Fig. 2

(the standard speed sensor signal frequency is 16).

8.2 Divide 1,573,200 (the number of pulses generated per hour by the 915 Speed Signal Module) by the number obtained in the substep above.

8.3 Multiply the number obtained in the substep above by 0.1. Enter this number in the digital display using the slide switch and calibration adjusting screw (or rotary knob, if equipped), at the back of the gauge head.

Example (electronic speedometer installation):

470 (tire revolutions-per-mile value) x 5.86 (rear axle ratio) x 16 (vehicle speed sensor signal frequency) = 44,067.20

1,573,200 (915 Speed Signal Module pulse per hour rate) ÷ 44,067.20 = 35.7

35.7 x 0.1 = 3.6 (the average-miles-per-gallon rating).

At the back of the gauge head, set the slide switch to the position that will provide the digital display reading that is closest to, but less than the average-miles-per-gallon rating. **See Fig. 2.**

At the back of the gauge head, turn the rotary knob (if equipped), or insert a thin-bladed screwdriver into the slot and turn the calibration adjusting screw, until the digital display reads the average-miles-per-gallon rating. **See Fig. 2.**

9. On vehicles equipped with mechanical speedometers, the standard speed signal generator turns 1000 revolutions for every mile of vehicle travel. The only calculations required to calibrate the gauge head are these:

1,573,200 (915 Speed Signal Module pulse per hour rate) ÷ 8000 (mechanical speed signal generator frequency) = 197

197 x 0.1 = 19.7 (Enter 19.7 in the gauge digital display).

Fuel-Tach Gauge Calibration (Non-Electronic Engines Only)

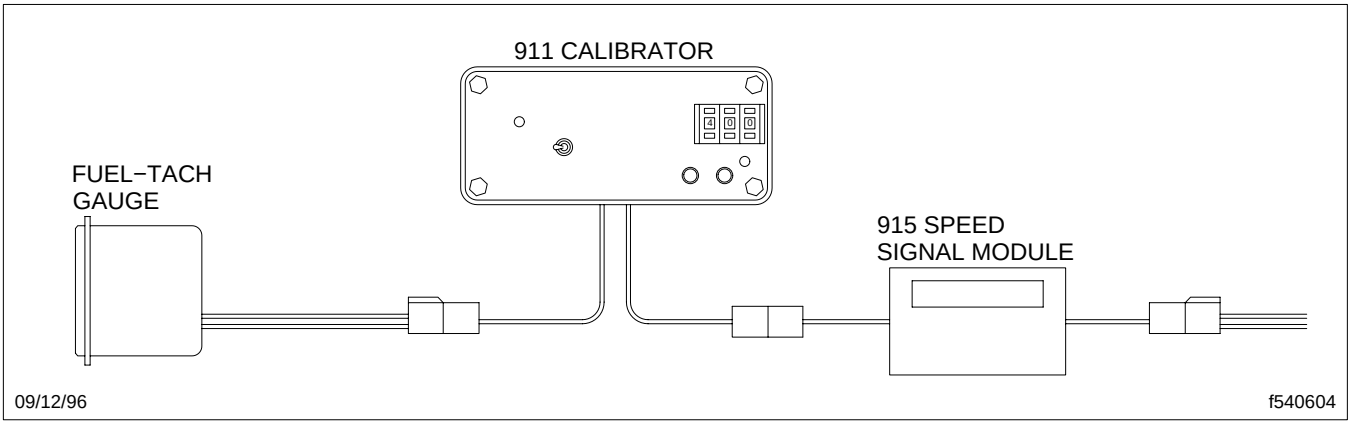


Fig. 3

AVERAGE-MILES-PER-GALLON METHOD

NOTE: Use this calibration method if the FloScan calibration equipment is not available. If this method is used, drive the vehicle with a full load. Also, this method requires that you calculate the average-miles-per-gallon rating by recording trip mileage and fuel consumption over at least two tanks of fuel.

IMPORTANT: If using this calibration method, always keep the Fuel-Tach switch in the "On" position.

1. Make sure that the digital reading is 0.0. If it is not, set the slide switch to 1, and turn the rotary knob (if equipped), or insert a thin-bladed screwdriver into the slot and turn counterclockwise until it stops.
2. Fill the fuel tank and record the vehicle mileage reading.
3. Drive the vehicle with a full load for 2 to 4 tanks of fuel.

NOTE: Try to refill the fuel tank to the same level as the previous fill.

4. Record the number of gallons used after each refill.
5. Subtract your mileage reading taken at the beginning of the trip from the end-of-trip mileage reading.
6. Divide the total miles traveled by the total number of gallons used for the trip. This is the average-miles-per-gallon rate.
7. At the back of the gauge head, set the slide switch to a position that will provide the digital display that is closest to, but lower than the average-miles-per-gallon rate.

   At the back of the gauge head, turn the rotary knob (if equipped), or insert a thin-bladed screwdriver into the slot and turn the calibrating adjusting screw, until the digital display reads the exact average-miles-per-gallon rate.

IMPORTANT: Keep a record of actual average miles-per-gallon for a few more tanks of fuel. If the Fuel-Tach digital display consistently differs from the actual average-miles-per-gallon performance, fine-tune the gauge by adjusting the digital display.

Fuel-Tach Gauge Operation Check (Non-Electronic Engines Only)

NOTE: This operation check requires using the Fuel-Tach 911 Calibrator and the 915 Speed Signal Module. These two instruments generate simulated fuel flow and vehicle speed signals that operate the Fuel-Tach gauge.

1. Connect the 911 Calibrator and the 915 Speed Signal Module. **See Fig. 1.**

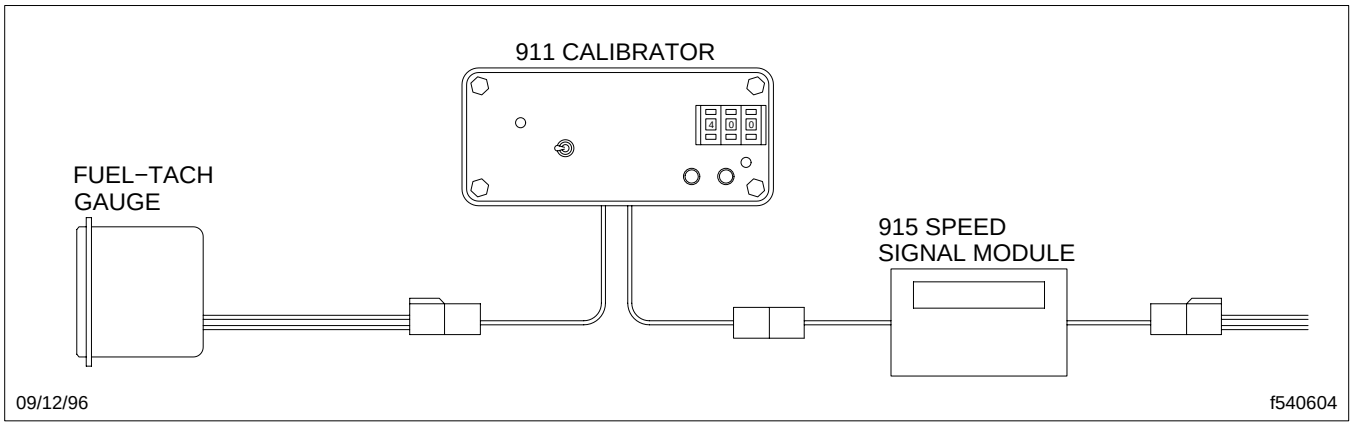


Fig. 1

2. At the back of the gauge head, set the slide switch to position number 2. **See Fig. 2.**

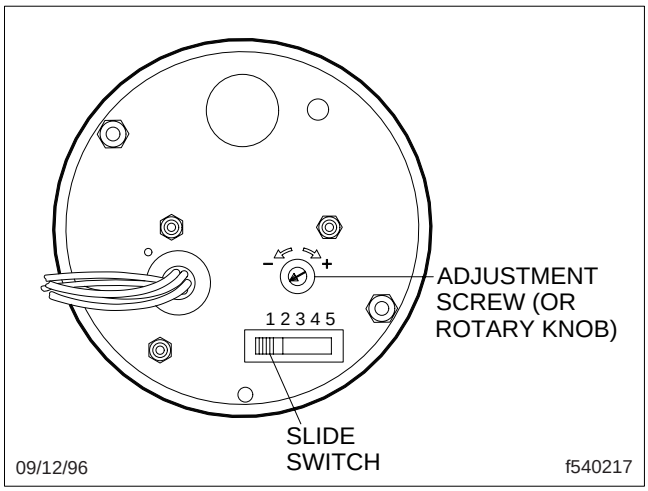


Fig. 2

3. At the back of the gauge head, turn the rotary knob, if equipped, or insert a thin-bladed screwdriver into the slot; turn clockwise until it stops.
4. Move the calibrator toggle switch to the single-sensor position. Set the calibration factor display to 400.
5. Turn the Fuel-Tach switch to the "On" position.
6. Press the calibrator reset button. The gauge digital display should read 18.8 for one second, and then 0.0. If there is no gauge digital display after pressing the reset button, refer to the "Trouble-shooting Chart" in this subject for fault diagnosis.
7. Press the calibrator test button so that the red test light is on. The gauge digital display should now read 1.5 or 1.6, and the gauge needle should point to 0.
8. Once the test light is off, press the test button again— the test light will come on again. The gauge digital display should read 1.5 or 1.6, and the gauge needle should point to 0.

   After the test light has been on about 4 seconds, flip the calibrator toggle switch to the dual-sensor position.

   The gauge needle should move to about a 60 to 70 percent reading in the green zone, and the gauge digital display should increase steadily until the test light goes off. Then the gauge needle should return to 0, and the digital display reading will stabilize.

9. Press the test button again. The gauge digital display should now read 6.3 or 6.4, and the gauge needle should point to 0.

   After about 4 seconds, flip the calibrator toggle switch to the single-sensor position. The gauge needle should move to about a 90 to 100 percent reading in the red zone, and the digital display should decrease steadily until the test light goes out. Then the gauge needle should return to 0, and the digital display reading will stabilize.

10. Press the test button again. The digital display should read 1.5 or 1.6.

    Move the gauge slide switch through the five switch positions. In each switch position the gauge digital display should read as shown in the table:

Guage Digital Display

Position 1	0.0
Position 2	1.5
Position 3	6.3
Position 4	19.9
Position 5	19.9

11. If the gauge operates as described above, it is working properly. If not, refer to the troubleshooting tables in this subject for further fault diagnosis procedures.

Flow Sensor Operation Check Using a DC Voltmeter (Non-Electronic Engines Only)

See Fig. 3.

⚠ WARNING

Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Remove the sensor(s) and clean it with a carburetor cleaning fluid or a solvent. Install the sensor. For instructions, **see Subject 110.**
2. Remove the screws that attach the Fuel-Tach gauge panel to the dash. Pull the panel out to gain access to the back of the gauge head.
3. Turn the Fuel-Tach switch to the "On" position.
4. Locate the Fuel-Tach wiring connector behind the gauge head and place the positive (red) probe of the voltmeter on the red wire. Place the negative (black) probe on the white wire (or brown wire if checking a return flow sensor).

   The voltmeter should read either 0 to 2 volts DC, or 9 to 13 volts DC.

5. Tap the sensor lightly. If the reading in the above step was 0 to 2 volts DC, the voltmeter should now read 9 to 13 volts DC. If the reading in the above step was 9 to 13 volts DC, the voltmeter should now read 0 to 2 volts DC.
6. Start the engine. The voltmeter should now read 5 to 7 volts DC. If the voltmeter reading remains unchanged at either 0 to 2 volts DC or 9 to 13 volts DC, replace the sensor.
7. Shut down the engine. Watch the voltmeter as the flow sensor rotor slows down and stops. The readings should change back and forth between the high (9 to 13 volts DC) and low (0 to 2 volts DC) levels until the rotor inside the sensor stops. If the voltmeter readings remain unchanged at either the high or low readings, replace the sensor.

Troubleshooting Chart (Non-Electronic Engines Only)

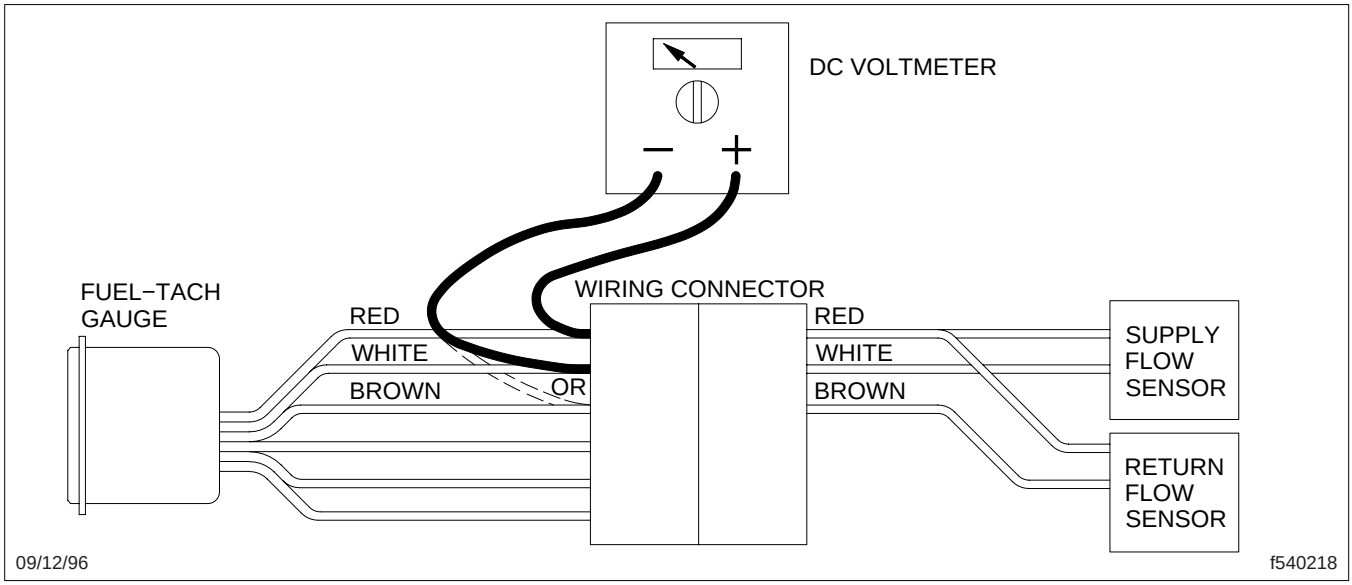


Fig. 3

Problem—The digital display is either missing digits, the decimal point, or displays nothing when the ignition is off and the Fuel-Tach switch is in the "On" position

Possible Cause	Remedy
The gauge is not receiving power. There must be a 12-volt DC reading between the red and black wires of the wiring connector behind the gauge head.	Check all wiring and wiring connectors for looseness or damage. Correct any problems.
	Make sure that each flow sensor is grounded to the engine.
	Check for an open circuit breaker, which may mean a short in the electrical circuit; repair as needed.
The Fuel-Tach on/ignition switch is not working.	Replace the switch if necessary.
The gauge is malfunctioning	Check the gauge with calibration units 911 and 915. See "Troubleshooting, 300." If this equipment is not available, replace the gauge.

Problem—If the vehicle is parked with the engine running, the gauge needle moves into the red or green zone and the digital display shows a number with the switch in positions 2 through 5 (this problem occurs on vehicles with electronic speedometers)

Possible Cause	Remedy
The vehicle speed sensor lead wire is not connected correctly to the speedometer head.	Check the wiring connection and correct if necessary.
The gauge is malfunctioning.	Check the gauge with calibration units 911 and 915. See "Troubleshooting, 300." If this equipment is not available, replace the gauge.

Troubleshooting

Problem—During calibration, the gauge needle reads 0 when the vehicle is traveling over 10 mph (16 km/h), and the digital display reads 0.0 in all five switch positions

Possible Cause	Remedy
The gauge is not receiving the vehicle signal (electronic speedometers only).	Check that the correct speed sensor is used and properly installed.
	Check that the black and green wire leads connect to the speed sensor terminals on the back of the speedometer head. Correct if necessary.
	Check the resistance of the speed sensor. Disconnect the wiring connector at the back of gauge and at the speed sensor. The resistance on the gauge side should be about 700 ohms. The resistance on the speed sensor side should be about 900 ohms. Repair or replace damaged wiring.
The gauge is not receiving the vehicle signal (mechanical speedometers only).	Check for an open or short circuit by disconnecting the signal generator leads. The resistance between the leads should measure between 30 and 50 ohms. Replace the sensor if necessary.
The gauge is malfunctioning.	Check the gauge with calibration units 911 and 915. see "Troubleshooting 300." If this equipment is not available, replace the gauge.

Problem—The gauge needle moves only in the green zone and the display reads 19.9, or increases to 19.9 in switch positions 2 through 5 (the vehicle is moving)

Possible Cause	Remedy
The fuel flow signal from the sensor(s) is low or nonexistent.	Clean the flow sensor(s). **See Subject 110.**
	Check that the wire leads are color matched across the wiring connector located behind the gauge head.
	Check that the wire leads are color matched across the harness connector located at the flow sensor. On vehicles with two flow sensors, the brown wire lead matches to the white wire lead.
	Make sure that each flow sensor is grounded to the engine. Check the resistance between the sensor and the engine block. The resistance should be about 0 ohms.
	Check that the sensor wires point down or in towards the engine. If necessary, redirect the wires to prevent splash water from shorting the sensor amplifier.
	Check that the sensor is operating properly. See "Troubleshooting, 300."
The gauge is malfunctioning.	Check the gauge with calibration units 911and 915. See "Troubleshooting, 300." If this equipment is not available, replace the gauge.

Problem—The gauge needle moves into the green zone as vehicle speed and throttle pressure increases (only on vehicles with two flow sensors)

Possible Cause	Remedy
The supply and return sensors are in stalled in the wrong fuel lines.	Check the sensors for proper installation. Correct if necessary.
The flow sensor wires are not matched correctly at the wiring connector.	Make sure that the white wire from the supply sensor is connected to the white wire at the wiring connector. Make sure that the white wire from the return sensor is connected to the brown wire lead at the wiring connector.

Problem—The gauge needle moves back and forth in the green and red zones (the vehicle is moving)

Possible Cause	Remedy
The flow sensor is installed backwards, or in the wrong fuel line.	Check each sensor for proper installation. Correct if necessary.

Problem—After calibration, the digital display reads higher or lower than actual performance

Possible Cause	Remedy
The Fuel-Tach gauge is calibrated wrong.	Recalibrate the gauge. **See Subject 120**.

Problem—The gauge needle moves back and forth in the green and red zones, and the display cannot be calibrated correctly

Possible Cause	Remedy
Intermittent power supply.	Check all wiring and wiring connections. Replace parts as necessary.
The gauge is malfunctioning.	Check the gauge with calibration units 911 and 915. Refer to "Troubleshooting, 300." If this equipment is not available, replace the gauge.

Problem—The gauge needle moves into the red and green zones, but not beyond the 20 to 40 percent range. The digital display reads low or cannot be calibrated to read consistently (only on vehicles with two flow sensors)

Possible Cause	Remedy
The gauge is not receiving the fuel flow signal from the return flow sensor.	Check that the wire leads are color matched across the wiring connector located behind the gauge head.
	Check that the wire leads are color matched across the wiring connector located at the flow sensor. On vehicles with two flow sensors, the brown wire lead matches to the white wire lead.
	Make sure that each flow sensor is grounded to the engine. Check the resistance between the sensor and the engine block. The resistance should be about 0 ohms.
	Check that the sensor is operating properly. See "Troubleshooting, 300."
The gauge is malfunctioning.	Check the gauge with calibration units 911 and 915. See "Troubleshooting 300." If this equipment is not available, replace the gauge.

Troubleshooting Chart (Electronic Engines Only)

The Model DBS Fuel-Tach displays error codes on the digital average-miles-per-gallon indicator whenever there is a system malfunction. See the Error Code Tables below for an explanation of the codes.

Error Code: oo

Possible Cause	Remedy
There is no power to the engine.	Check the vehicle wiring. Make sure there is power to the engine.
The data bus is not sending data.	Refer to the engine manufacturer's service literature for instructions.
The data leads are not connected.	Check that the data leads (brown and white wires) are properly connected. See the wiring diagrams in **Specifications, 400.** Correct any problems found.

Troubleshooting

Possible Cause	Remedy
One of the data leads is connected to ground or to +12 volts.	Check that the data leads (brown and white wires) are properly connected. See the wiring diagrams in **Specifications, 400.** Correct any problems found.

Error Code: LE

Possible Cause	Remedy
The data leads are reversed on the data bus.	Check that the data leads (brown and white wires) are properly connected. See the wiring diagrams in **Specifications, 400.** Correct any problems found.
One data lead is connected to the wrong polarity lead of the data bus, and the other lead is disconnected.	Check that the data leads (brown and white wires) are properly connected. See the wiring diagrams in **Specifications, 400.** Correct any problems found.

Error Code: oE

Possible Cause	Remedy
There is no vehicle speed or fuel flow information on the data bus.	Refer to the engine manufacturer's service literature for instructions.
DIP switches 1, 2, and 3 on the back of the Fuel-Tach are set for the wrong type of engine.	Set the DIP switches correctly. See the Figure in **Specifications, 400**, for settings.

Error Code: oF

Possible Cause	Remedy
There is vehicle speed information on the data bus, but no fuel flow information.	Refer to the engine manufacturer's service literature for instructions.
DIP switches 1, 2, and 3 on the back of the Fuel-Tach are set for the wrong type of engine.	Set the DIP switches correctly. See the Figure in **Specifications, 400**, for settings.

Error Code: oP

Possible Cause	Remedy
The data bus is sending out incomplete information.	Refer to the engine manufacturer's service literature for instructions.
The engine is not running, and a diagnostic or reprogramming tool is in use.	Refer to the engine manufacturer's service literature for instructions.

Error Code: o5

Possible Cause	Remedy
There is fuel flow information, but no vehicle speed information on the data bus.	Refer to the engine manufacturer's service literature for instructions.
DIP switches 1, 2, and 3 on the back of the Fuel-Tach are set for the wrong type of engine.	Set the DIP switches correctly. See the Figure in **Specifications, 400**, for settings.

Possible Cause	Remedy
The engine data bus is not programmed for vehicle speed information.	Refer to the engine manufacturer's service literature for instructions.

Specifications

NOTE: If the Cummins Fuel Pump Code Number is not listed in this section, call the FloScan Instrument Company toll-free at (800) 522-3610.

Cummins Fuel Pumps and Fuel-Tach Calibration Numbers

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
1501	367
1502	356
1953	476
1982	460
1983	452
2046	371
2134	432
2185	397
2242	439
2243	429
2248	437
2300	360
2322	474
2324	456
2344	462
2362	392
2368	431
2380	468
2410	411
2427	412
2433	427
2443	386
2462	515
2464	467
2466	453
2469	412
2480	453
2481	441
2488	396
2495	426
2501	405
2502	374
2512	398
2523	444
2530	360
2532	455
2534	419
2552	458
2589	511
2596	459
2603	462
2604	397
2613	409
2615	511
2616	512
2627	364
2628	374
2635	409
2640	453
2641	447
2650	395
2655	364
2662	489
2663	455
2665	458
2666	472
2680	450
2683	441
2689	429
2692	507
2693	498
2708	370
2718	392
2734	515
2735	443
2742	494

Specifications

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
2747	435
2761	403
2765	392
2769	461
2777	388
2780	464
2782	440
2789	427
2790	406
2796	461
2801	467
2805	456
2810	511
2812	498
2815	511
2819	468
2834	451
2838	472
2839	451
2842	376
2863	447
2864	431
2865	354
2867	357
2876	442
2878	457
2880	515
2881	409
2884	405
2885	455
2886	431
2899	461
2908	433
2912	429
2913	424
2914	357

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
2915	436
2916	369
2921	464
2922	447
2923	453
2929	464
2930	436
2931	424
2933	419
2937	401
2938	411
2943	455
2944	439
2945	459
2948	498
2949	427
2951	379
2953	351
2954	384
2955	372
2956	351
2958	378
2961	449
2968	479
2972	453
2975	429
2985	382
2992	421
2994	458
2995	406
3001	406
3003	502
3004	399
3005	434
3006	406
3008	456

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
3009	370
3014	406
3016	460
3019	339
3020	423
3021	423
3022	423
3023	392
3024	392
3025	397
3026	397
3027	426
3028	398
3029	395
3030	409
3033	347
3034	347
3035	376
3036	372
3037	378
3039	412
3040	382
3041	406
3042	406
3043	335
3046	399
3047	392
3048	402
3049	426
3055	427
3056	438
3057	437
3066	464
3069	357
3070	449
3071	446

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
3073	429
3080	532
3082	523
3087	447
3093	412
3111	396
3114	308
3116	310
3118	466
3121	466
3125	449
3126	462
3128	459
3132	387
3133	378
3160	329
3161	449
3162	453
3167	393
3171	314
3179	464
3190	289
3193	325
3199	332
3201	270
3203	332
3214	332
3218	457
3220	450
3227	455
3237	314
3239	239
3243	460
3247	303
3250	296
3251	304

Specifications

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
3253	480
3257	327
3262	332
3266	469
3275	471
3276	301
3278	463
3279	262
3280	468
3281	434
3287	462
3288	306
3289	329
3297	284
3300	292
3301	297
3302	269
3303	307
3304	331
3305	290
3306	302
3307	283
3308	296
3309	271
3310	387
3321	382
3322	399
3323	424
3329	298
3330	245
3331	292
3332	285
3333	268
3334	441
3335	280
3340	290

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
3341	298
3342	290
3343	332
3344	314
3345	303
3346	298
3349	332
3350	302
3351	329
3352	307
3353	311
3357	327
3359	271
3360	280
3361	278
3362	327
3364	275
3367	283
3368	284
3369	279
3372	297
3373	316
3374	315
3375	328
3376	261
3377	332
3378	268
3379	272
3383	314
3386	314
3395	452
3397	331
3398	426
3399	463
3400	322
3401	452

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
3402	288
3403	464
3404	310
3407	319
3408	297
3409	314
3410	332
3411	314
3412	332
3413	327
3414	289
3415	297
3416	302
3417	347
3418	347
3420	424
3423	332
3424	286
3425	345
3426	332
3428	274
3429	333
3430	336
3431	329
3432	307
3433	329
3434	307
3437	307
3438	316
3439	296
3440	324
3443	455
3445	450
3446	295
3447	443
3450	310

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
3467	289
3469	444
3477	335
3479	452
3480	425
3483	486
3484	316
3485	315
3490	330
3498	317
3499	406
3502	335
3505	399
3509	330
3511	401
3515	346
3516	375
3517	317
3518	293
3520	397
3521	443
3523	306
3526	446
3527	303
3530	376
3553	318
3554	330
3560	443
3570	274
3573	324
3574	314
3582	325
3585	344
3592	381
3593	359
3594	377

Specifications

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
3595	363
3596	368
3597	368
3607	314
3617	337
3618	299
3620	322
3621	315
3622	309
3623	300
3624	261
3625	289
3626	265
3627	314
3628	344
3630	347
3631	285
3632	289
3634	356
3635	315
3636	281
3638	337
3639	330
3640	344
3641	311
3643	337
3645	344
3650	306
3651	315
3653	396
3654	315
3657	412
3658	406
3665	417
3668	306
3671	324

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
3672	324
3673	278
3674	310
3675	351
3676	303
3677	305
3678	302
3679	314
3681	318
3683	374
3684	320
3687	368
3701	295
3720	365
3723	342
3724	413
3728	451
3729	289
3733	386
3735	363
3736	353
3741	295
3743	438
3744	330
3747	337
3749	317
3752	282
3753	269
3754	295
3755	263
3763	337
3766	476
3767	255
3768	267
3769	284
3771	327

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
3773	306
3775	310
3781	335
3791	419
3799	393
3800	351
3802	371
3803	372
3804	383
3805	403
3806	345
3809	364
3810	375
3811	373
3812	377
3813	366
3817	325
3822	279
3825	412
3826	348
3828	322
3829	315
3837	315
3851	390
3854	372
3865	407
3868	490
3873	367
3874	379
3878	316
3894	328
3896	286
3897	280
3900	321
3909	344
3910	317

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
3913	317
3914	332
3918	328
3922	308
3924	361
3928	379
3938	320
3943	367
3947	308
3960	314
3963	397
3965	331
3969	339
3970	340
3972	270
3973	279
3975	315
3976	441
3977	449
3979	399
3980	463
3983	404
3986	434
3997	375
3998	388
4001	376
4003	362
4006	329
4008	341
4010	290
4011	327
4016	370
4017	387
4021	332
4027	312
4028	325

Specifications

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
4034	331
4039	329
4040	313
4041	308
4042	321
4043	312
4044	344
4045	313
4046	307
4047	321
4048	306
4049	314
4050	303
4051	303
4052	317
4053	317
4054	313
4055	305
4058	307
4059	310
4060	311
4067	313
4068	321
4069	308
4073	313
4074	372
4075	382
4076	339
4078	295
4080	386
4086	307
4089	339
4090	395
4091	345
4092	323
4094	368

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
4095	363
4099	326
4100	319
4101	342
4102	324
4106	335
4108	321
4110	396
4111	321
4112	321
4113	311
4114	310
4115	378
4120	369
4124	346
4135	309
4136	319
4137	324
4138	325
4139	303
4140	326
4141	290
4143	384
4152	394
4153	316
4156	522
4157	329
4158	336
4159	344
4160	323
4161	344
4162	329
4163	341
4164	336
4166	514
4167	357

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
4170	341
4172	323
4174	312
4176	429
4178	335
4181	480
4182	434
4183	297
4184	316
4185	315
4187	312
4191	325
4192	373
4218	309
4219	323
4224	369
4226	292
4227	311
7975	310
7991	388
8875	314
9108	361
9214	381
9215	388
9225	323
9253	388
9262	381
X020	457
X022	423
X031	419
X032	444
X033	432
X045	435
X047	422
X048	421
X049	451

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
X050	408
X052	415
X053	407
X058	429
X062	404
X063	406
X064	400
X068	379
X069	418
X070	406
X071	392
X072	409
X073	415
X075	431
X076	379
X077	405
X078	426
X080	432
X081	371
X083	420
X084	400
X085	400
3355	304
3613	293
3619	344
3660	304
3690	451
3730	358
3740	320
3748	472
3751	472
3757	401
3760	361
3765	494
3778	372
3779	375

Specifications

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
3818	391
3823	315
3846	316
3847	324
3848	287
3870	398
3892	351
3895	361
3904	336
3919	324
3925	375
3926	372
3935	291
3940	422
3948	311
3949	277
3952	328
3954	444
3955	485
3959	344
3971	310
3978	395
3989	306
3991	266
3994	273
4022	336
4036	300
4064	322
4065	317
4066	307
4070	314
4072	283
4073	320
4084	307
4085	310
4105	312

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
4107	322
4116	306
4118	284
4121	291
4122	432
4123	435
4128	333
4144	360
4146	335
4168	275
4171	347
4212	391
4213	383
4220	293
4221	344
4222	323
4223	310
4228	429
4229	307
4230	310
4231	307
4232	310
4233	307
4234	307
4235	295
4236	312
4237	316
4240	311
4242	325
4244	290
4245	394
4246	287
4249	322
4250	322
4252	285
4258	269

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
4261	307
4263	311
4265	414
4267	382
4273	393
7900	447
7902	302
7903	302
7904	450
7905	253
7906	285
7908	245
7927	321
7928	299
7929	410
7934	324
7935	300
7936	344
7937	409
7938	344
7939	313
7940	406
7941	409
7942	311
7943	305
7945	315
7946	278
7947	472
7948	510
7949	279
7950	317
7952	322
7954	310
7957	332
7959	328
7960	291

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
7963	329
7964	273
7965	361
7966	306
7967	307
7968	305
7969	263
7970	362
7971	325
7972	310
7973	322
7974	339
7976	340
7977	284
7978	392
7980	329
7981	368
7982	363
7983	288
7984	310
7985	322
7986	422
7987	299
7988	323
7991	388
9017	361
9018	295
9026	310
9048	375
9058	391
9071	295
9081	403
9085	476
9093	351
9109	375
9110	391

Specifications

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
9124	322
9129	232
9132	332
9138	321
9141	372
9143	311
9145	291
9148	335
9159	328
9160	441
9166	442
9200	310
9201	317
9202	111
9203	317
9206	490
9209	332
9211	265
9212	376
9216	310
9217	307
9218	339
9219	340
9220	325
9221	322
9222	340
9223	395
9227	362
9229	307
9231	310
9234	322
9239	363
9240	310
9241	368
9243	322
9245	330

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
9254	360
9290	310
9375	321
X030	407
X086	429
X087	429
X088	407
X089	419
X090	444
X091	440
X093	435
X095	422
X096	421
X097	451
X098	408
X099	451
X100	407
X103	429
X107	404
X108	406
X109	400
X113	379
X114	418
X115	406
X116	392
X117	409
X118	415
X119	431
X120	379
X121	408
X122	426
X123	432
X124	371
X125	400
X126	420
X127	400

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
X128	400
X129	429
X132	423
X133	359
X134	376
X138	411
X139	444
X527	407
X528	434
X531	432
X546	402
X549	405
X552	408
X553	425
X557	437
X565	429
X567	410
X571	437
X572	433
X573	412
X578	451
X589	407
X590	434
X593	432
X600	402
X603	405
X606	408
X607	425
X611	437
X614	412
X615	420
X617	395
X618	429
X620	410
X624	437
X625	433

Cummins Fuel Pump Code Number	Fuel-Tach Calibration Factor
X626	412
X630	451
X613	437
X633	396
X634	396
X635	364
X636	364
X637	405
X639	405
X640	405
X647	405
X648	395
X649	423
X650	405
X652	432
X659	406
X660	420
X661	418

See Fig. 1 for the wiring diagram for an analog gauge with a Caterpillar or Detroit Diesel engine and an Ametek electronic speedometer.

See Fig. 2 for the wiring diagram for an analog gauge with a Cummins engine and an Ametek electronic speedometer.

See Fig. 3 for the wiring diagram for an analog gauge with a Caterpillar or Detroit Diesel engine and a Stewart-Warner electronic speedometer.

See Fig. 4 for the wiring diagram for an analog gauge with a Cummins engine and a Stewart-Warner electronic speedometer.

See Fig. 5 for the wiring diagram for an analog gauge with a Caterpillar or Detroit Diesel engine and a transmission-mounted vehicle speed sensor.

See Fig. 6 for the wiring diagram for an analog gauge with a Cummins engine and a transmission-mounted vehicle speed sensor.

See Fig. 7 for the wiring diagram for an analog gauge with a Caterpillar electronic engine.

Specifications

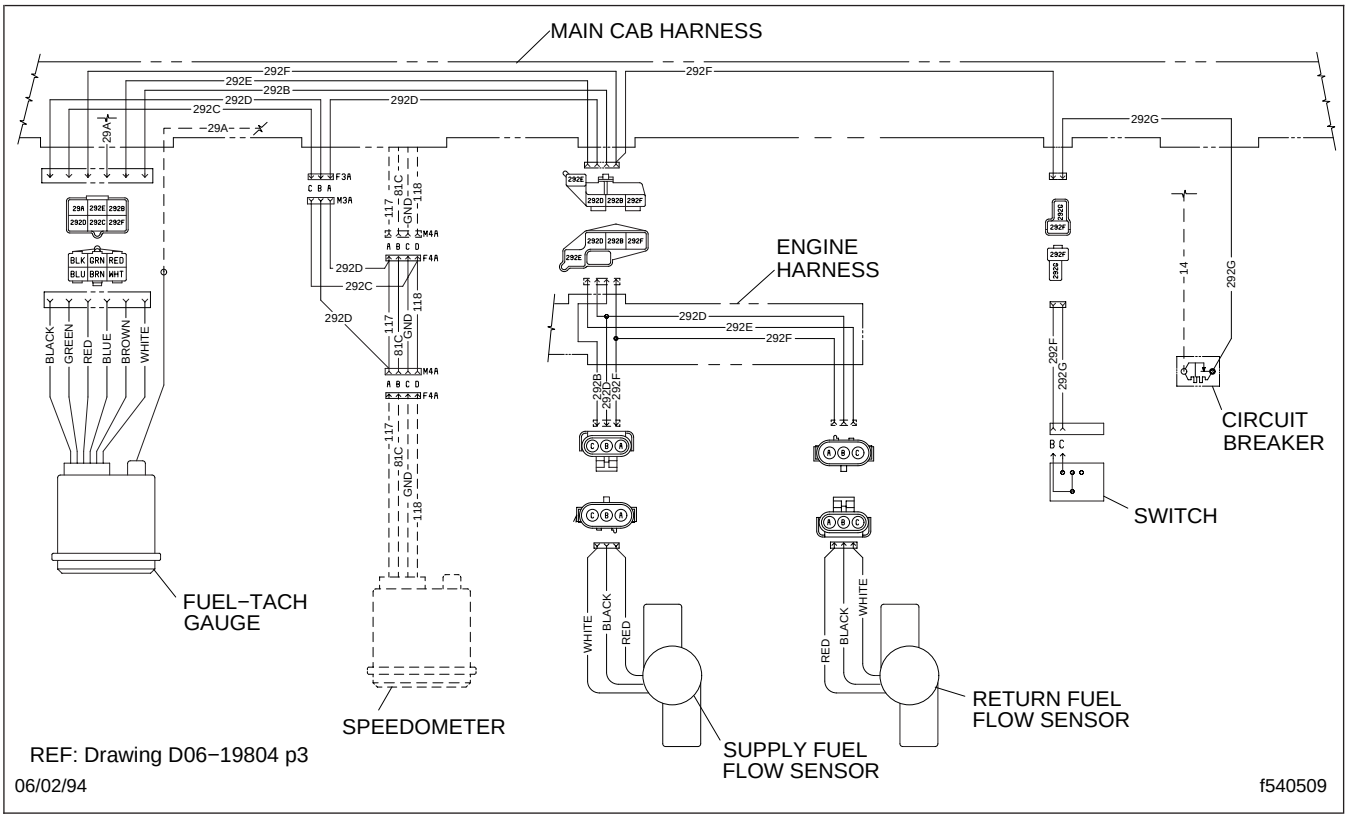


Fig. 1, Wiring Diagram for Analog Gauge With Caterpillar or Detroit Diesel Engine and Ametek Electronic Speedometer

See Fig. 8 for the wiring diagram for an analog gauge with a Cummins electronic engine.

See Fig. 9 for the wiring diagram for an analog gauge with a Detroit Diesel electronic engine.

See Fig. 10 for the wiring diagram for an LED Color Bar Graph with a Caterpillar electronic engine.

See Fig. 11 for the wiring diagram for an LED Color Bar Graph with a Cummins electronic engine.

See Fig. 12 for the wiring diagram for an LED Color Bar Graph with a Detroit Diesel electronic engine.

See Fig. 13 for electronic engine DIP switch settings (Fuel-Tach switches 1, 2, and 3).

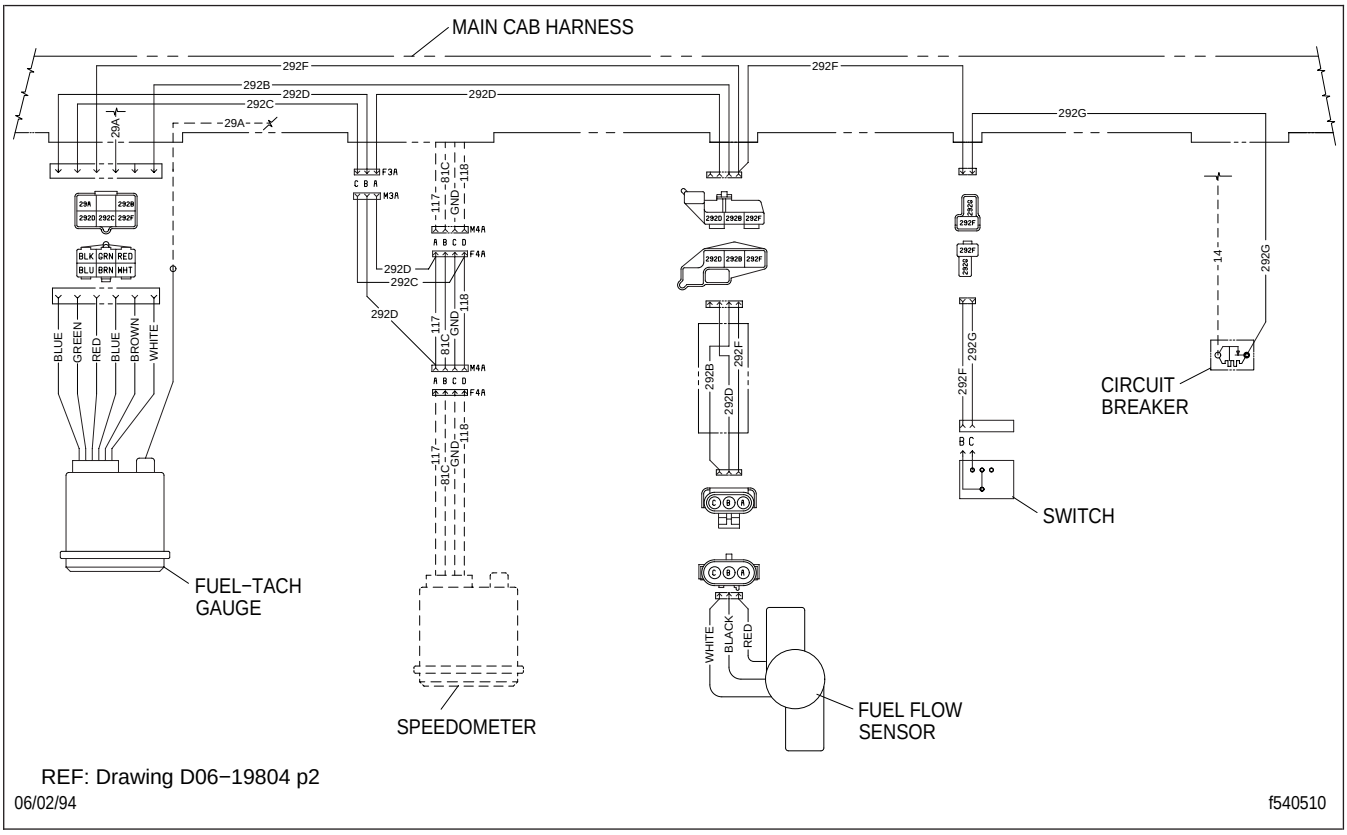


Fig. 2, Wiring Diagram for Analog Gauge With Cummins Engine and Ametek Electronic Speedometer

Specifications

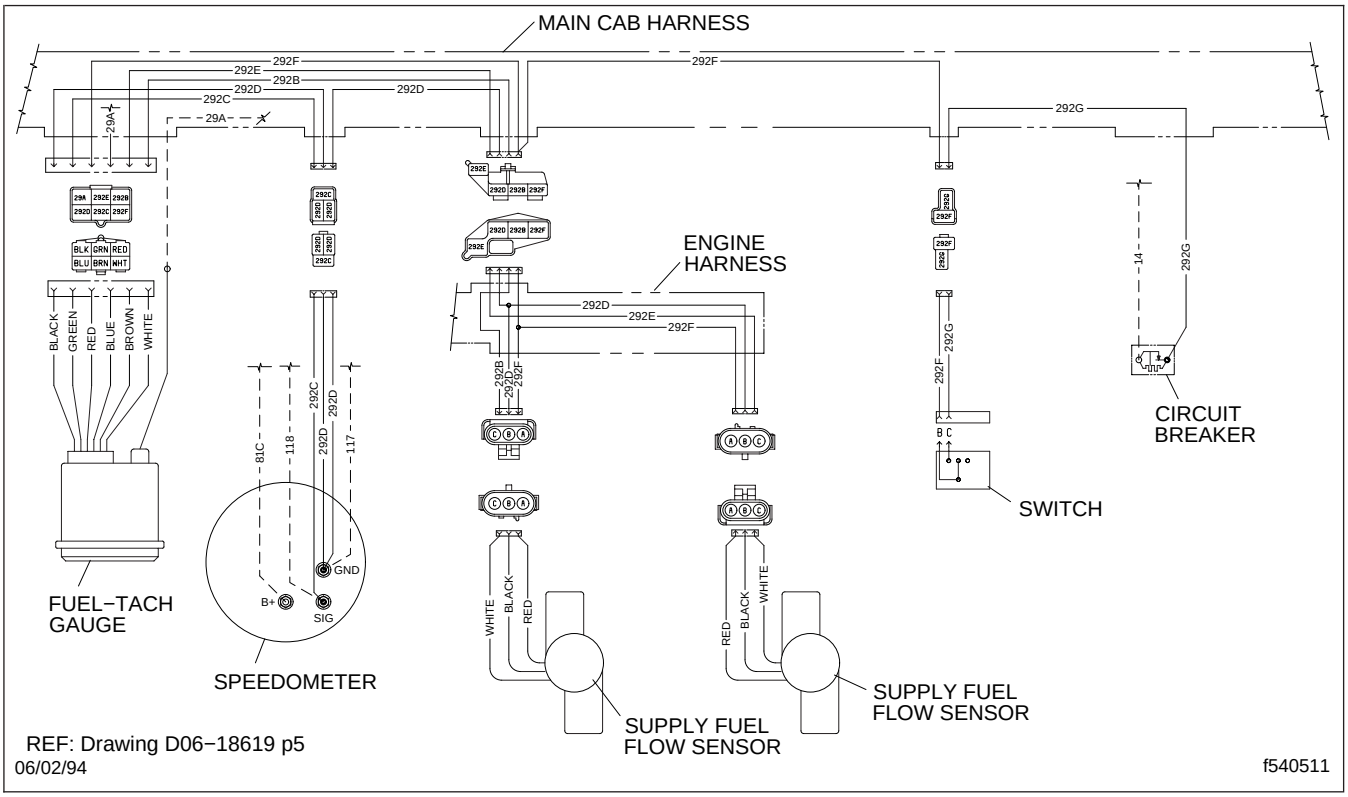


Fig. 3, Wiring Diagram for Analog Gauge With Caterpillar or Detroit Diesel Engine and Stewart-Warner Electronic Speedometer

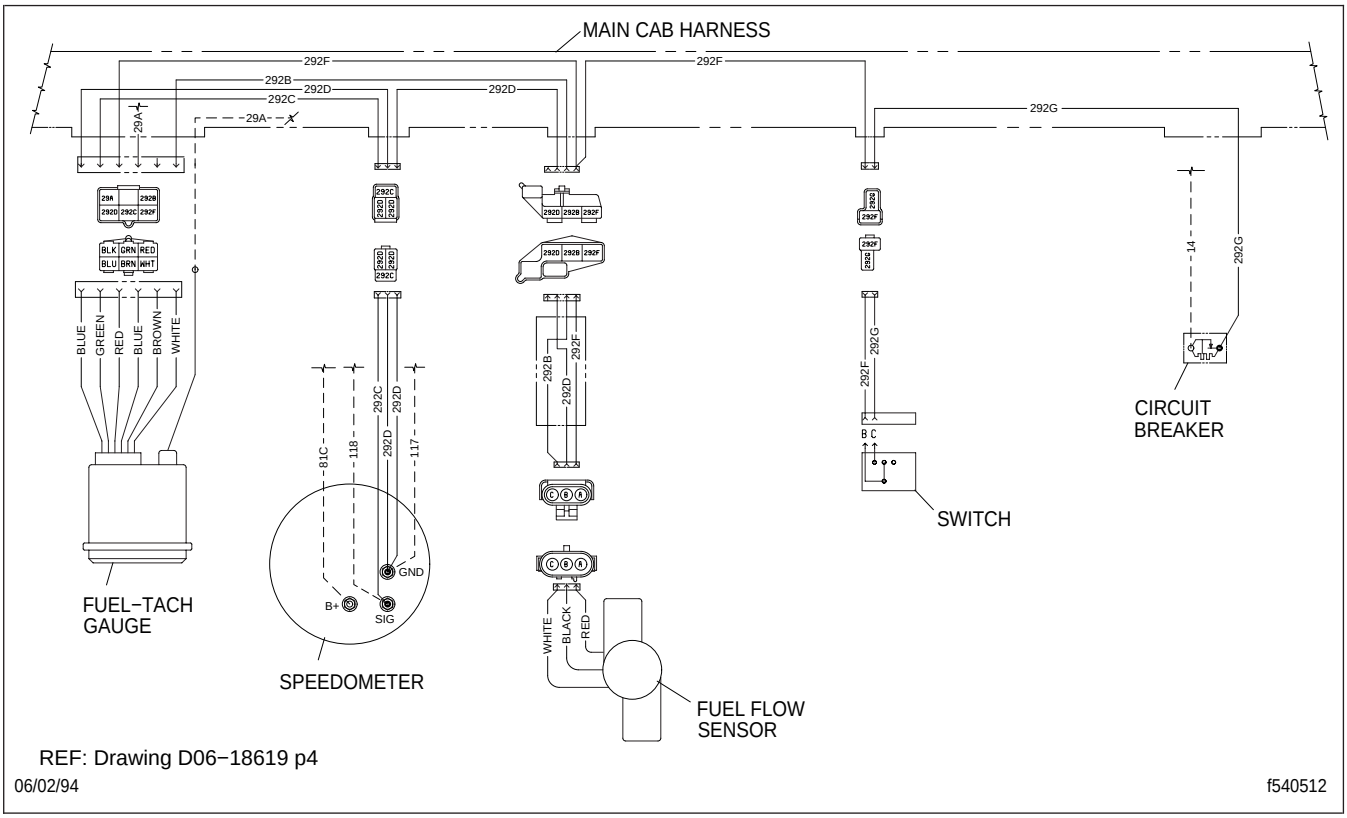


Fig. 4, Wiring Diagram for Analog Gauge With Cummins Engine and Stewart-Warner Electronic Speedometer

Specifications

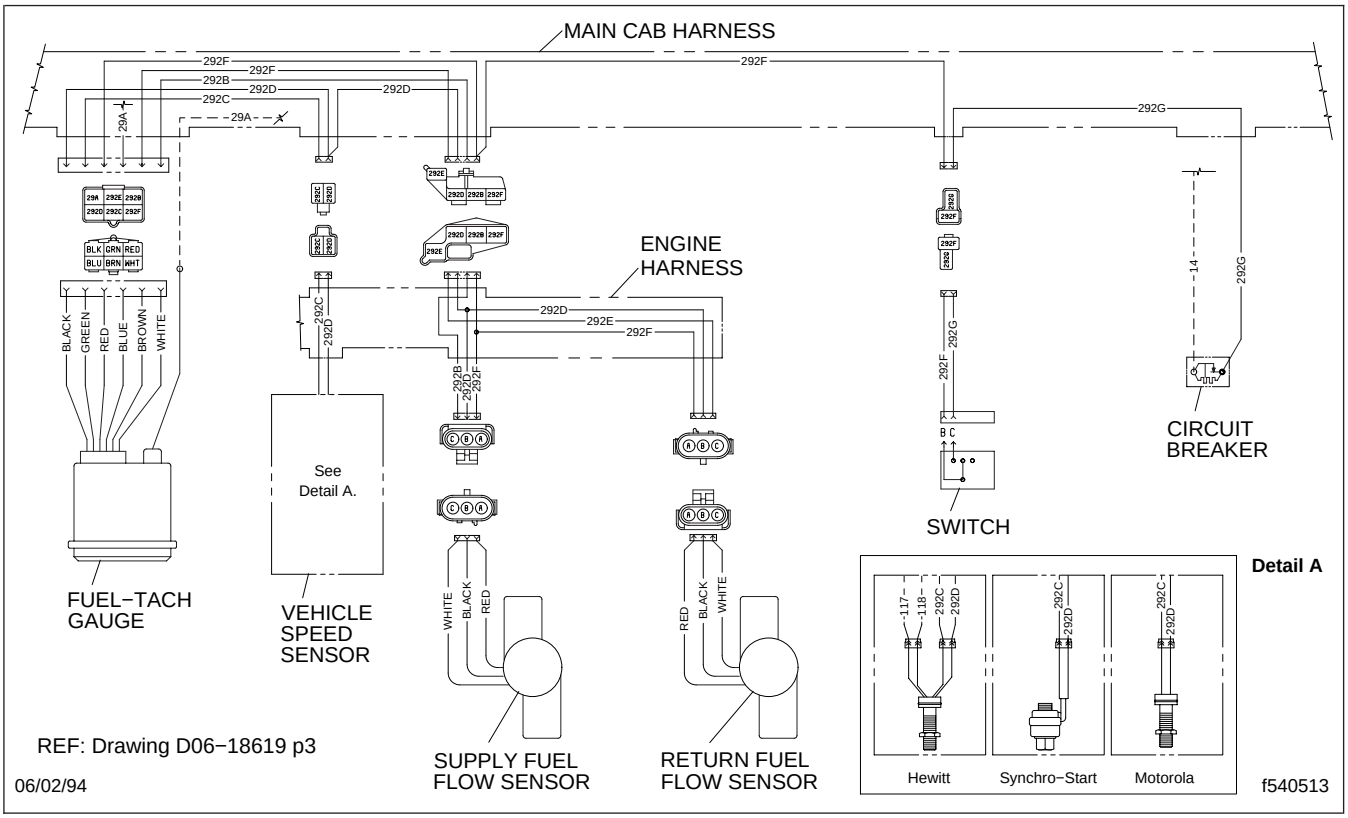


Fig. 5, Wiring Diagram for Analog Gauge With Caterpillar or Detroit Diesel Engine and Transmission-Mounted Vehicle Speed Sensor

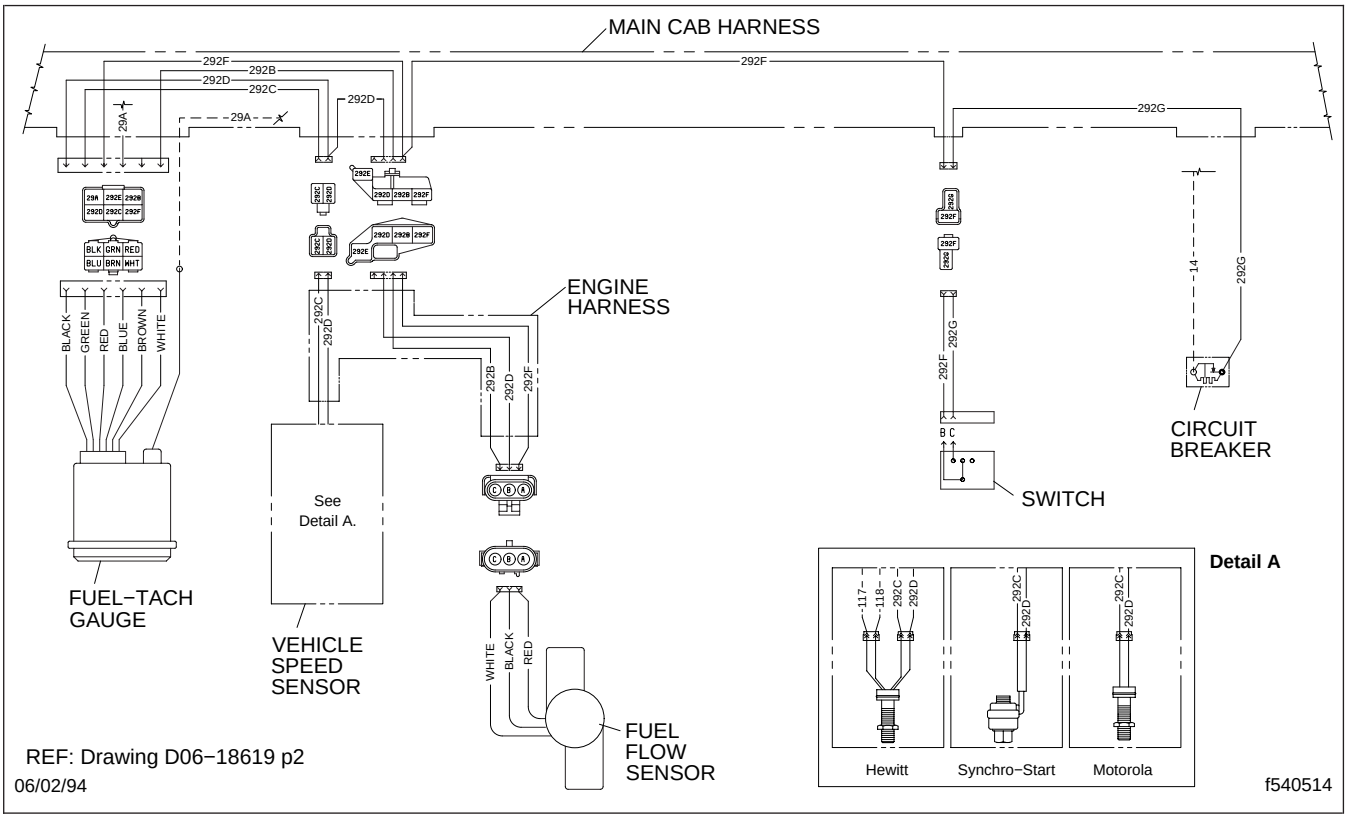


Fig. 6, Wiring Diagram for Analog Gauge With Cummins Engine and Transmission-Mounted Vehicle Speed Sensor

Specifications

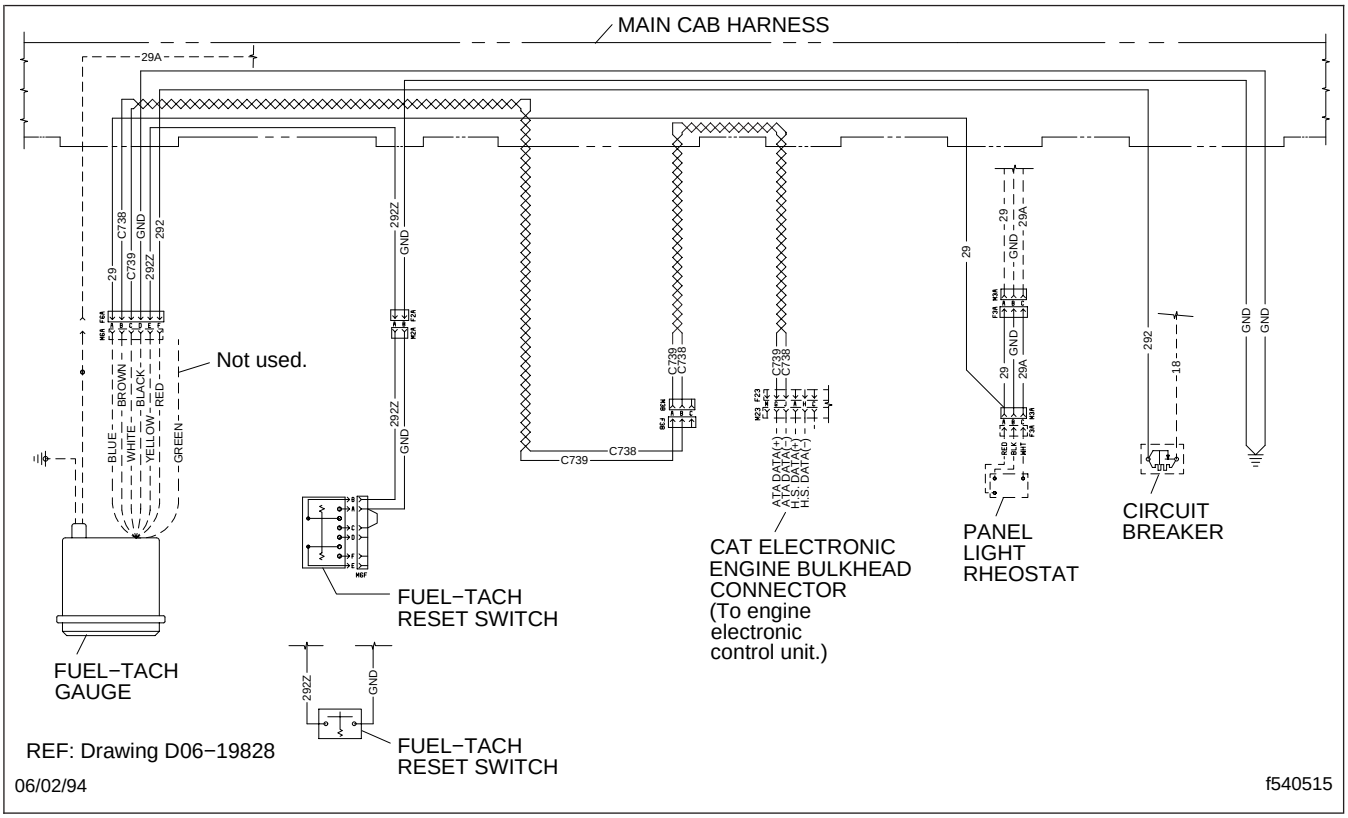


Fig. 7, Wiring Diagram for Analog Gauge With Caterpillar Electronic Engine

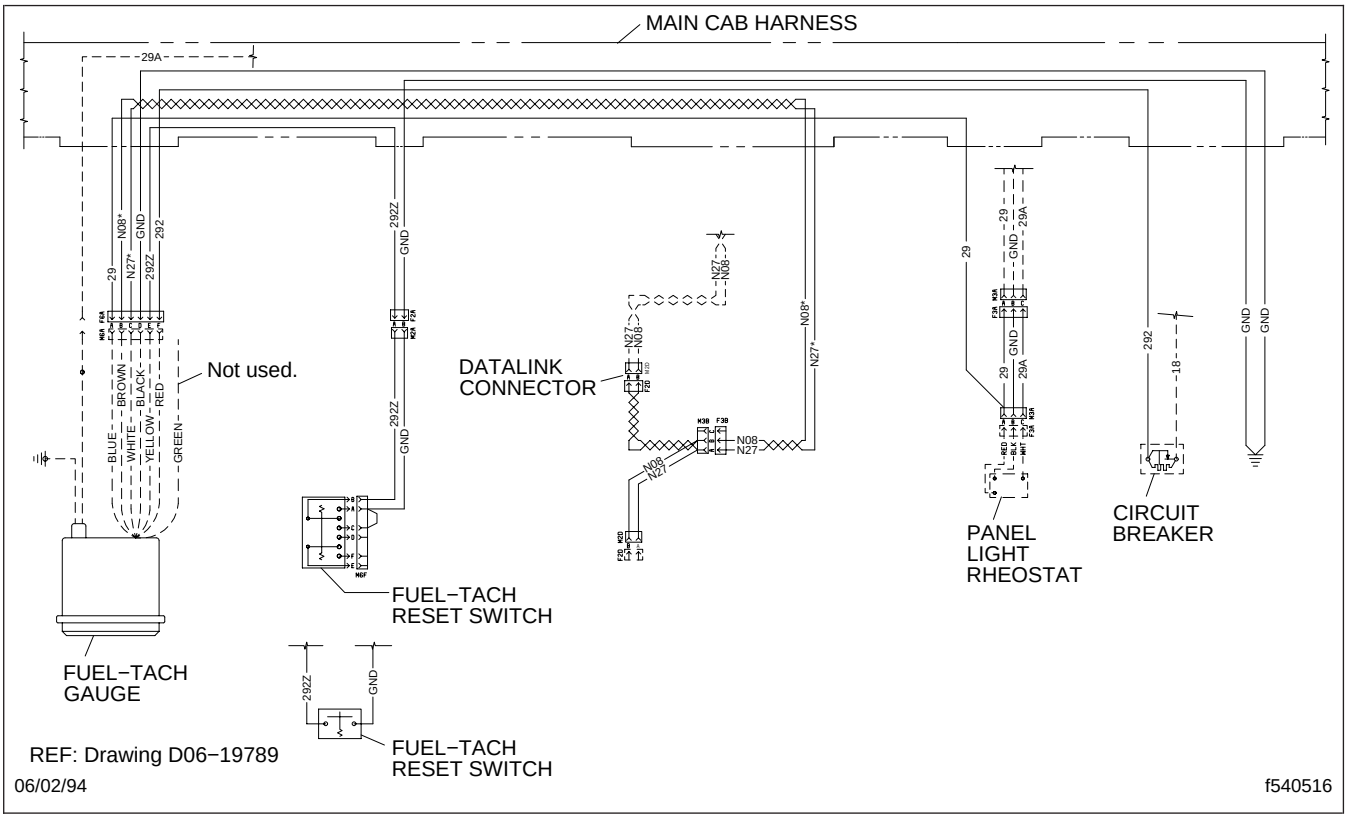


Fig. 8, Wiring Diagram for Analog Gauge With Cummins Electronic Engine

Specifications

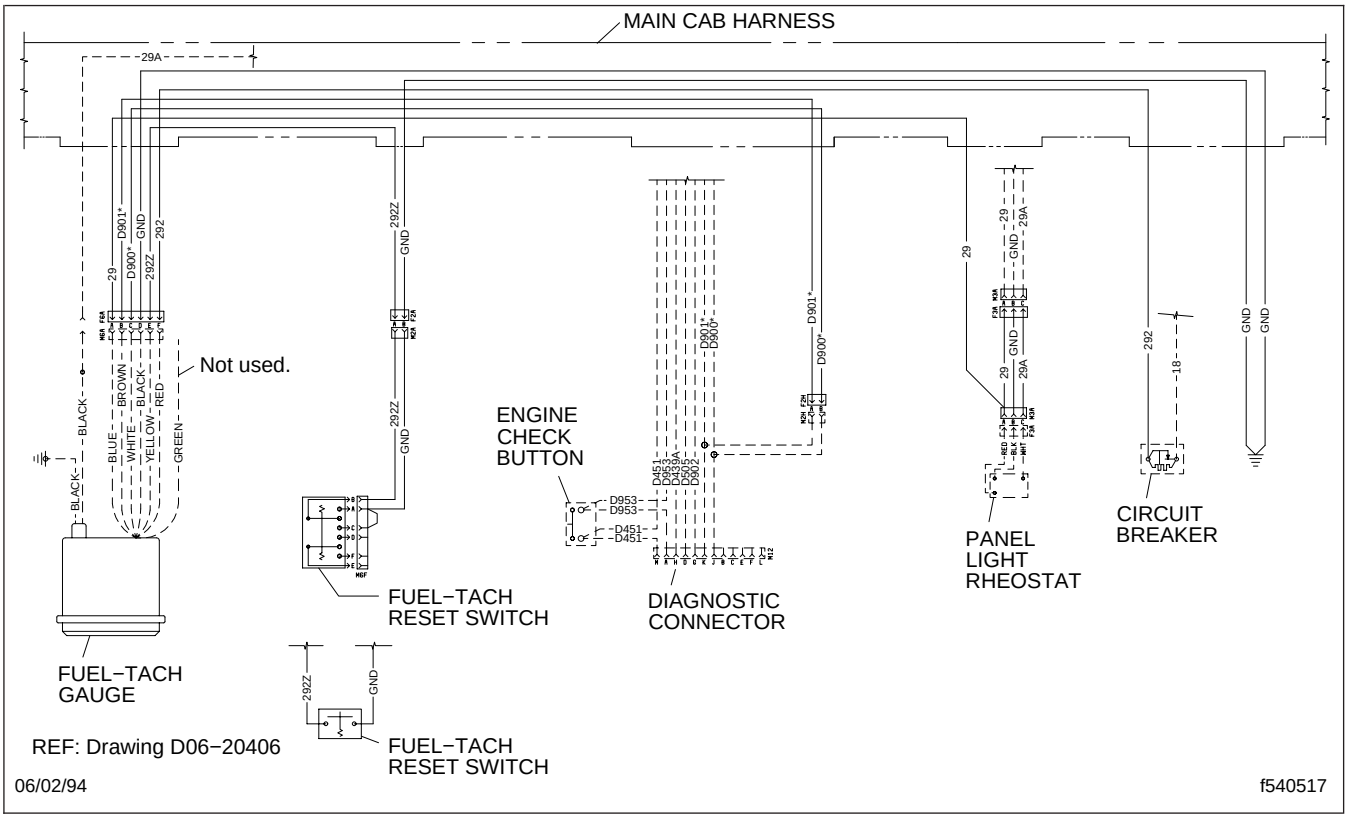


Fig. 9, Wiring Diagram for Analog Gauge With Detroit Diesel Electronic Engine

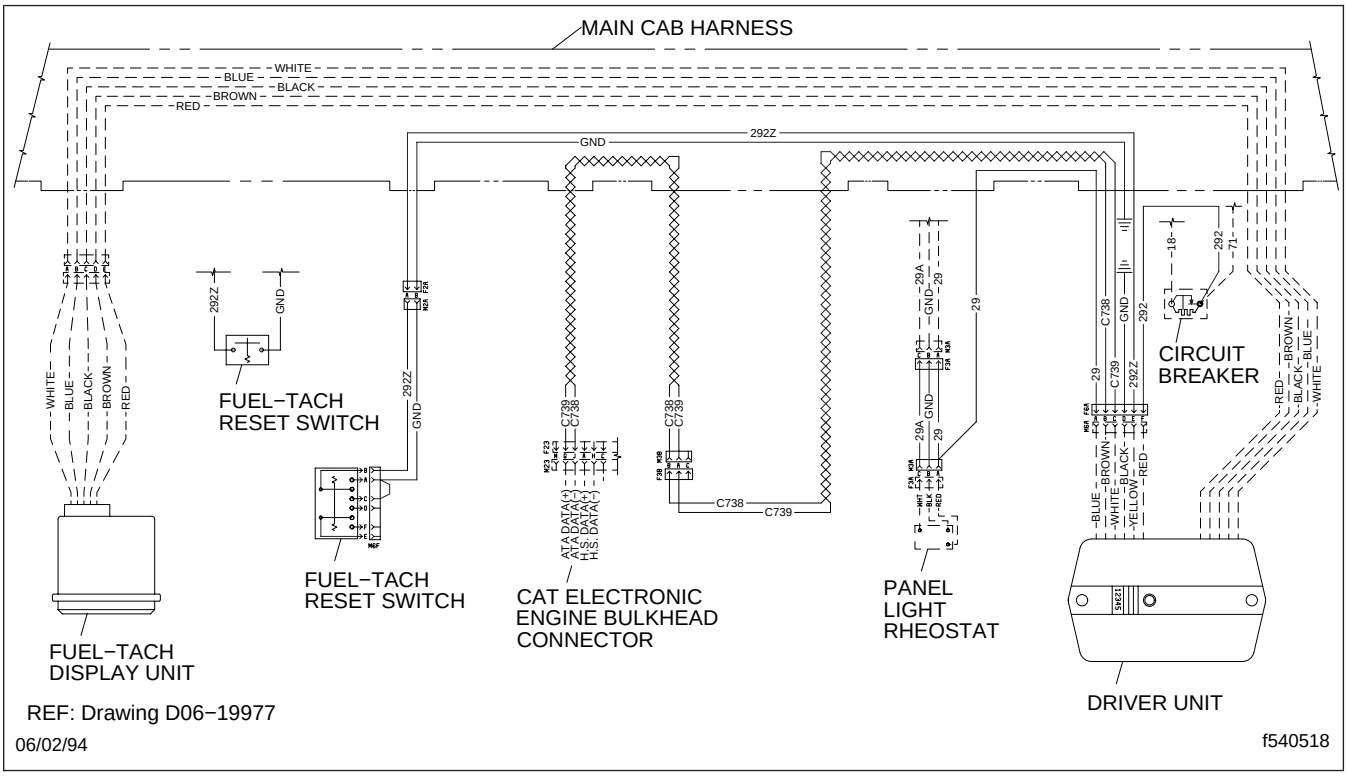


Fig. 10, Wiring Diagram for LED Color Bar Graph With Caterpillar Electronic Engine

Specifications

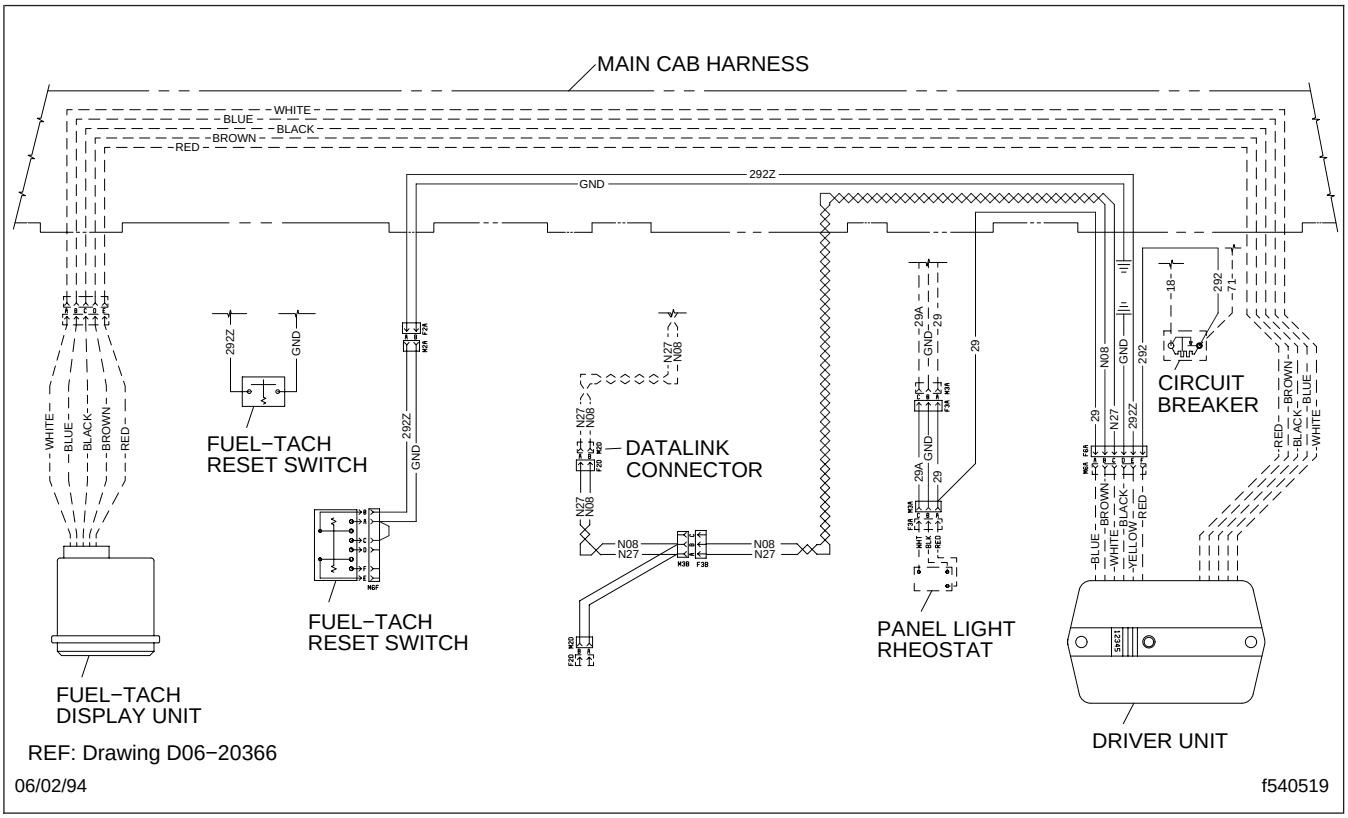


Fig. 11, Wiring Diagram for LED Color Bar Graph With Cummins Electronic Engine

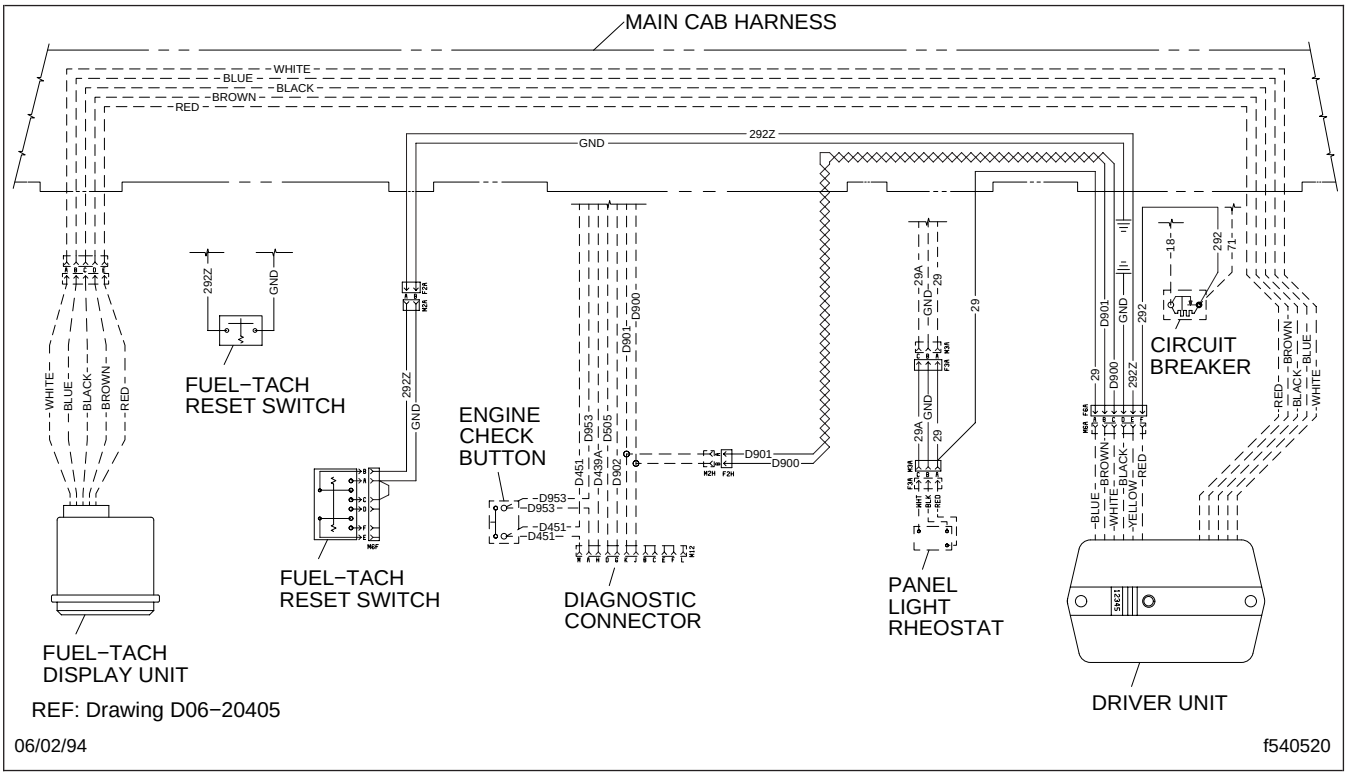


Fig. 12, Wiring Diagram for LED Color Bar Graph With Detroit Diesel Electronic Engine

Specifications

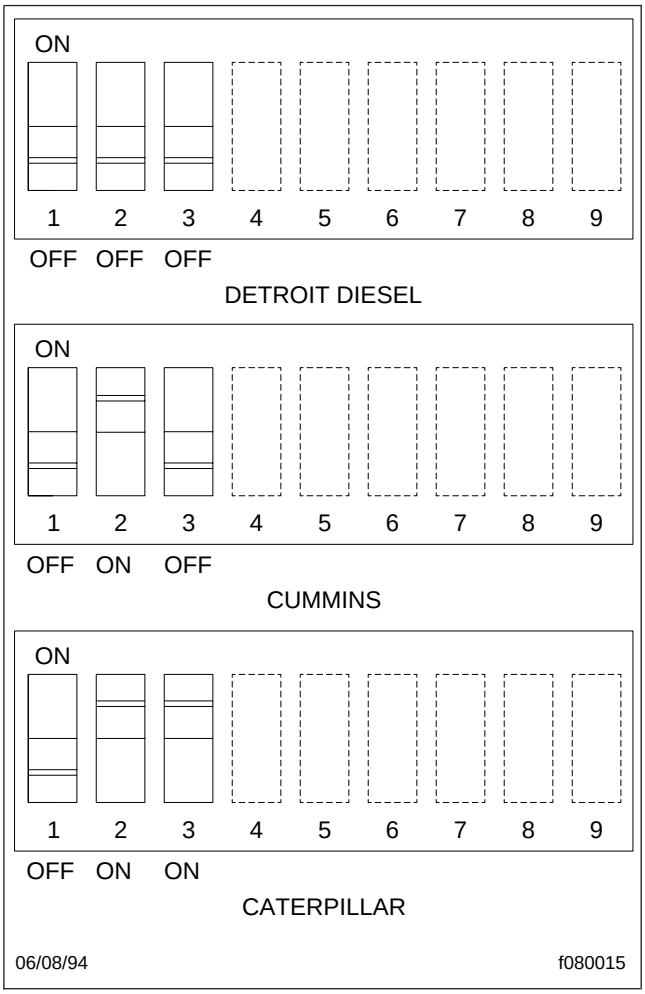


Fig. 13, Electronic Engine DIP Switch Settings (Fuel-Tach switches 1, 2, and 3)

General Information

The Kysor VIP is an electronically controlled warning and engine shutdown system. It also controls the turn signals and other standard and optional features. A solid-state lightbar in the instrument panel contains displays for the various functions.

The Kysor VIP monitors engine oil pressure, coolant temperature, and coolant level. If the oil pressure drops below a preset level, the low oil pressure light comes on, and a warning buzzer sounds. If the oil pressure drops to a preset critical level, the engine shutdown light comes on, and the voltage to the fuel control circuit is interrupted, shutting down the engine.

If the engine overheats, a warning light comes on, and a buzzer sounds. The temperature that triggers the warning light and buzzer varies with engine type. If the temperature continues to rise to critical levels, the engine shutdown light comes on, and the voltage to the fuel control circuit is interrupted, shutting down the engine.

If the coolant level drops below a sensor in the cooling system, the low water level light comes on, and a buzzer sounds. After 30 seconds the system shuts down the engine. The low coolant shutdown feature may be turned on or off by setting a DIP switch in the control module. All shutdown features have an automatic override: if it is necessary to move the vehicle to a safe location after a shutdown, just crank the engine—it will run for about 30 seconds and then shut down again.

The Kysor VIP provides a driver circuit for the temperature gauge. This circuit uses the same temperature sensor as the alarm and shutdown functions.

The system controls several other functions such as the headlight high beam indicator, low air pressure warning light and buzzer, dimming of the turn signal indicators when the headlights are turned on,and control of indicators for six optional features (see **Fig. 1**, Refs. A through G). The optional features can be any combination of the following:

- Transmission temperature
- Axle temperature
- Engine heater
- Alternator no charge
- Antilock
- Parking brake
- Sand
- Fifth wheel lock
- Mirror heater
- Utility lights
- Axle lock
- Sludge ejector
- or any six that are specially ordered.

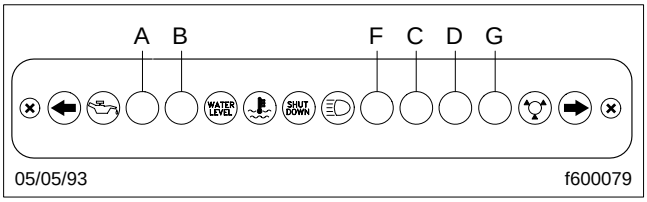


Fig. 1, Kysor Lightbar Optional Features

Three of the six optional indicators (Refs. B, C, and D) can trigger the warning buzzer. The buzzer feature can be activated at the factory or in the field by setting DIP switches on the control module.

When the ignition switch is turned on and the starter is engaged, all the LEDs in the lightbar light up as a check that they are working. When the starter is released, those LEDs not required to remain on by the corresponding circuit will turn off.

If the ignition switch is turned on and the engine is not cranked, there is no warning buzzer for any of the warning features. The warning buzzer is triggered by the start circuit. After the engine is cranked, releasing the start switch activates the buzzer. Therefore, during a normal start, the buzzer sounds after releasing the starter until the engine oil pressure and the air pressure reach normal operating values.

Circuit overload protection is built into the Kysor VIP. If an overload is detected on an output circuit (such as the fuel solenoid), that particular circuit shuts down. To restore full function, remove the overload; turn the ignition switch off, then back on. Intermittent shorts in the output circuits will cause intermittent false engine shutdown.

TURN SIGNALS

Figure 2 shows the circuit for a left turn. For a right turn or 4-way flashers, only the turn signal switch positions would change.

General Information

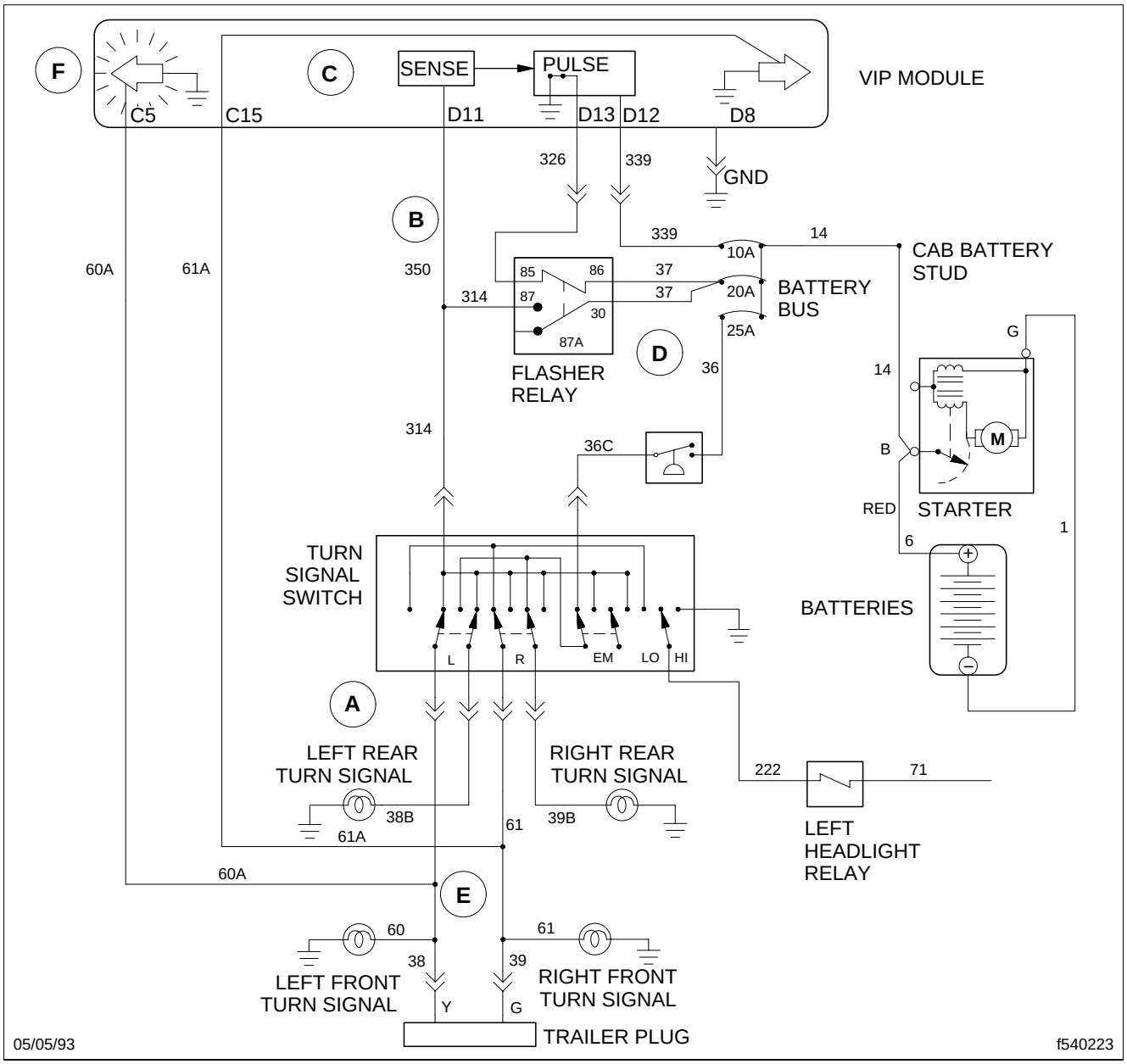


Fig. 2, Wiring Diagram: Turn Signal Functions

With a left turn selected, wire 314 is connected through the turn signal switch to wire 60 (tractor left front turn signal and trailer left turn signal) and to wire 38B (tractor left rear turn signal). See **Fig. 2**, Ref. A.

Wire 350 connects with wire 314, so wire 350 "sees" the ground in the turn signal bulbs. See Ref. B.

The sensor block in the Kysor VIP module (Ref. C) "sees" the ground in the turn signal bulbs. The sensor block directs the pulse block to give a pulsing ground to wire 326. Wire 326 is grounded whenever the pulse is on.

The relay coil (Ref. D) already has voltage from wire 37, which comes from the battery via a 20 amp cir-

cuit breaker. When the relay coil is grounded through wire 326 and the pulse block, the relay closes and connects wire 37 to wire 314, sending voltage to the signal bulbs.

The voltage in wire 60 that turns on the bulb also reaches wire 60A through the junction. See Ref. E.

Voltage in wire 60A reaches the Kysor VIP module and causes the left turn indicator arrow in the lightbar to light up. See Ref. F.

Power to the sensor and pulse blocks comes from wire 339, which is a battery circuit. The turn signals work even when the ignition is off.

OTHER FEATURES **(See Fig. 3)**

When the headlights are turned on, voltage in wire 359 from the headlight switch causes the system to dim the turn signal indicator arrows.

Loss of ground in wire 18B activates the low air pressure warning indicator and buzzer. The ground path is through wire 18B, through the primary switch, through the secondary switch, and through the ground wire on the secondary switch. These switches are normally open and are held closed by the air system pressure.

The A through G option wires may come from six different vehicle systems, selected by the customer. When one of these systems activates, voltage from the system enters the option wire, causing the Kysor VIP module to turn on the indicator for that system. If desired by the customer, activation of the option B, C, and D indicators may be accompanied by the warning buzzer. This is programmable through DIP switches in the Kysor VIP module, either at the factory or in the field.

The high beam indicator comes on when voltage is present in the high beam circuit (wire 21). Wire 21B joins with wire 21, and connects the Kysor VIP module.

General Information

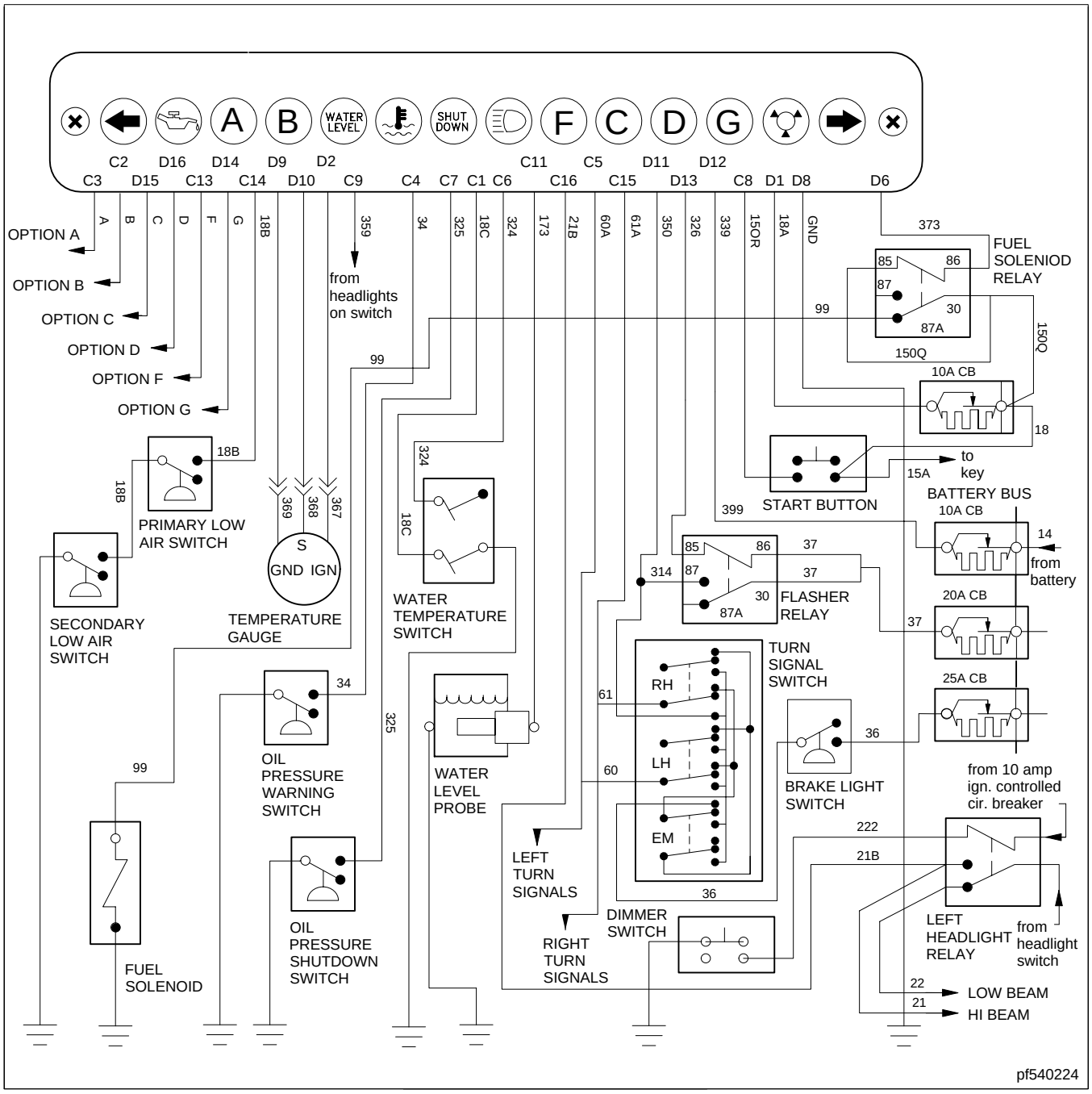


Fig. 3, Wiring Diagram: Engine Shutdown Functions

Lightbar Replacement

1. Remove the two screws on the lightbar lens, then remove the lens.
2. Using a screwdriver, depress the four retaining tabs.
3. Slide the lightbar out of the dashboard.
4. Disconnect the 32-pin wiring connector.
5. Remove the lightbar.
6. Connect the new lightbar to the 32-pin connector.
7. If any optional function indicators are used, remove the front panel from the new lightbar and install the symbols for these functions from the old lightbar.
8. Slide the new lightbar into the dashboard until the retaining tabs latch. Make sure that the lightbar slips into the rear bracket and that no wires are pinched in the bracket.
9. Install the lens and the two screws.
10. Test the new lightbar operation.

Setting the DIP Switches

1. Remove the Kysor VIP lightbar assembly from the dash.
2. Looking down at the top of the unit, remove the tape that covers the access hole at the right front corner. The DIP switches are numbered **as shown in Fig. 1**.
3. If all four switches are toward the faceplate, the warning buzzer will not sound with any of the optional features. Also, the low coolant level shutdown feature will be disengaged, but the low coolant level warning buzzer will sound.
4. Sliding the DIP switches toward the rear of the lightbar turns on the following features:
    - Switch 1—low coolant level shutdown
    - Switch 2—option D warning buzzer
    - Switch 3—option C warning buzzer
    - Switch 4—option B warning buzzer

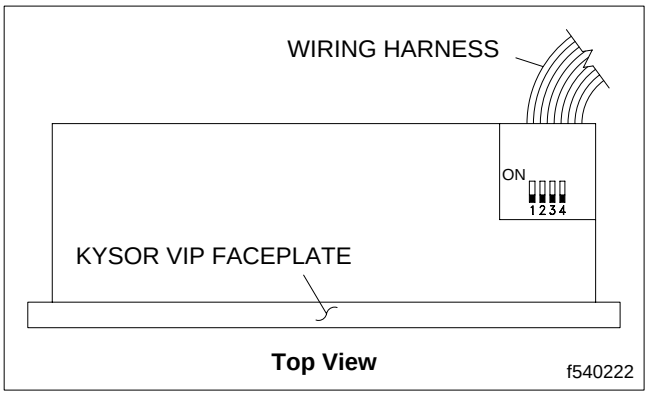


Fig. 1, DIP Switches

Turn Signal Flasher Relay Replacement

The Kysor VIP lightbar contains the circuitry used to operate the turn signals. For a general description and principles of operation, refer to **Subject 050**.

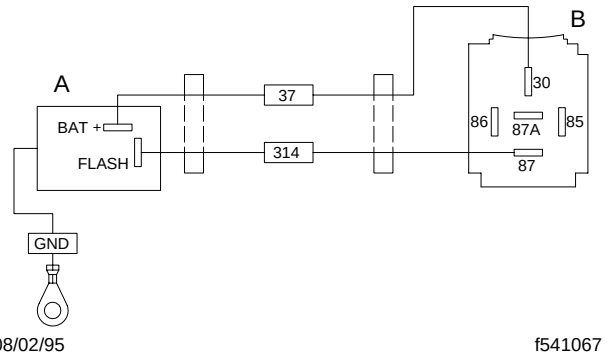
If diagnosis (refer to **Subject 300**) reveals that the turn signal flasher relay is the cause of inoperative turn signals, the relay can be replaced by simply unplugging the old relay from the vehicle electrical control panel (socket marked "flasher") and plugging in a new relay.

If, however, diagnosis reveals that the lightbar is the cause of inoperative turn signals, the turn signals may be repaired without replacing the lightbar *if the vehicle is out of warranty* by installing a solid state flasher relay.

If the vehicle is still under normal warranty and the lightbar is the cause of turn signal failure, replace the lightbar, following the instructions in **Subject 100**.

NOTE: The replacement solid state flasher must be remote-mounted near the vehicle electrical panel. It cannot be inserted directly into the flasher relay socket.

1. Remove the existing turn signal flasher relay, BSH 0 332 204 132, from the vehicle electrical panel. The turn signal flasher relay socket is marked "flasher."
2. Connect jumper harness A06–18781–000 to the flasher relay socket. **See Fig. 1.**



A. Replacement Flasher
B. Flasher Relay Socket in Electrical Panel

Fig. 1, Jumper Harness Circuit

   2.1 Install the male terminal of jumper harness wire 314 into terminal 87 of the flasher relay socket.

   2.2 Install the male terminal of jumper harness wire 37 into terminal 30 of the flasher relay socket.

3. Mount the replacement solid state flasher, KYS 1039 07732 01, at or near the vehicle electrical panel.

   3.1 Use the already-installed jumper harness wires to help choose a mounting location; the wires must reach the flasher location.

   3.2 The mounting location must provide a good ground for the mounting screw (thread the screw into cab metal).

   3.3 There is a wire marked "GND" attached to the replacement flasher. Insert the flasher mounting screw through the "GND" wire ring terminal when installing the flasher and tighten the screw securely.

4. Connect the jumper harness to the replacement flasher.

   4.1 Install the female terminal of jumper harness wire 314 onto the flasher terminal marked "FLASH."

   4.2 Install the female terminal of jumper harness wire 37 onto the flasher terminal marked "BAT +."

5. Test the turn signals.

Troubleshooting

ENGINE PROTECTION FEATURES

The Engine Run switch in the Kysor VIP module must be on for the fuel solenoid (or other fuel control) to turn on. The Engine Run switch is controlled by five separate inputs to the Kysor VIP. The test procedure for each input and an explanation of how each functions are presented below.

1. *Ignition Switch On* — Connect a voltmeter to the fuel solenoid wire 99, and turn on the ignition switch. The voltmeter should register at least 12 volts for 20 to 40 seconds; then, the voltage should drop to zero.

2. *Starter Engage* — Turn on the ignition key and measure the voltage as above. After the voltage drops to zero, briefly engage the starter. There should be 12 volts at the fuel solenoid again for 20 to 40 seconds. Then, the voltage should drop to zero. This feature is operated by voltage in wire 150R, which has voltage only when the engine is being cranked.

3. *Coolant Level Sensing* — Disconnect wire 173 from the coolant level probe in the radiator tank. Start the engine. The WATER LEVEL indicator and the warning buzzer should be on. If the DIP switch is set for low coolant shutdown, the engine should shut down 20 to 40 seconds after it starts and the SHUT DOWN indicator should come on at the same time.

   Reconnect wire 173 to the coolant level probe.

   This circuit sends a current through wire 173 to the coolant level probe. If the circuit is grounded through the coolant, the system interprets this as a normal condition. Coolant loss uncovers the probe and breaks the ground. This causes the VIP module to turn on the low coolant warning and, if the DIP switch is so set, to shut down the engine. An open circuit in wire 173 causes a false low coolant warning and shutdown. If wire 173 shorts to ground, the protection feature doesn't operate.

4. *Coolant Temperature Sensing* — Disconnect wire 18C from the coolant temperature switch. Start the engine. The overheat indicator should turn on and the warning buzzer should sound. The engine should shut down 20 to 40 seconds after starting, and the SHUT DOWN indicator should come on at the same time.

   This circuit monitors the temperature switch continuity through wires 324 and 18C. If wire 324 shorts to ground, the high temperature alarm and shutdown features won't work. The engine could overheat and be damaged.

IMPORTANT: Perform the temperature sensing test at every scheduled vehicle service to ensure that there are no problems with circuit 324. Reconnect wires 18C and 324 to the temperature switch.

5. *Low Oil Pressure Sensing* —

   5.1 Warning Indicator

   Disconnect wire 34 from the oil pressure warning switch. Start the engine. The low oil pressure warning indicator should turn on and the warning buzzer should sound. Circuit 34 is ground-seeking at the warning switch, which is normally open, but closes when oil pressure reaches a setpoint. The warning switch opens and interrupts the ground to wire 34 if oil pressure falls below the switch setpoint. When wire 34 loses ground, the oil pressure warning turns on, so an open circuit in wire 34 would cause a false low oil pressure warning. A short to ground in wire 34 would prevent the low oil pressure warning from working. This would be noticeable when the ignition switch is first turned on: the low oil pressure indicator would not light until the starter is engaged. During normal start up, the low oil pressure indicator should light when the key is turned on, but the buzzer should sound only after the starter is engaged.

   5.2 Engine Shutdown

   Leave wire 34 disconnected from the oil pressure warning switch. Disconnect wire 325 from the oil pressure shutdown switch. Start the engine. The low oil pressure indicator and the buzzer should be on. The SHUT DOWN light should come on 20 to 40 seconds after start up, and the engine should shut down at the same time. Circuit 325 is similar to 34 in that it seeks ground through the normally open

shutdown switch; if that ground is lost due to low oil pressure or an open circuit, the Kysor VIP shuts down the engine. If circuit 325 shorts to ground, the low oil pressure shutdown feature will not work.

HIGH BEAM INDICATOR, TURN SIGNAL INDICATOR DIMMER, AND OPTIONS A THROUGH G

If these functions fail to operate, check for voltage in the corresponding wires at the Kysor VIP module connectors:

- High beam indicator — wire 21B
- Turn signal indicator dimmer — wire 359
- Options A through G — wires A through G

If any function will not turn off, check the corresponding wire for voltage that shouldn't be there. If there is voltage, find the source (a short circuit) and correct the problem. If the wiring checks out, replace the Kysor VIP control module.

Troubleshooting Chart: Engine Protection Features

Problem — The engine cranks but will not start. The shutdown indicator stays on during cranking and after the starter switch is released

Possible Cause	Remedy
Poor ground on GND wire (pin D8) at Kysor VIP module.	Make sure GND wire is adequately grounded.
Low ignition switch voltage to Kysor VIP module. The voltage at wire 18A should measure 9 volts or higher while cranking the engine.	This is not a VIP problem. Find the reason for the low voltage and correct the problem.
No start signal to Kysor VIP module. The voltage at wire 150R should measure 9 volts or higher while cranking the engine.	This is not a VIP problem. Find the reason for the low voltage and correct the problem.
The fuel solenoid or wire 99 is shorted to ground. Unplug the 32-pin connector at the Kysor module. Using a digital ohmmeter, measure the resistance between the chassis end of wire 99 and ground. Resistance less than 6.3 ohms indicates shorts in wire 99 or in the fuel solenoid.	Correct the short in the fuel solenoid or wire 99. If the short cannot be corrected, replace the shorted solenoid or wire.

Problem — The engine cranks but will not start. The shutdown indicator is on while the starter is cranking but goes off when the starter switch is released

Possible Cause	Remedy
The fuel solenoid is malfunctioning or there are other engine problems if there is 9 volts at the fuel solenoid while cranking the starter.	Consult the engine manufacturer for troubleshooting procedures.
Wire 99 may be broken or loose if there is less than 9 volts at the fuel solenoid while cranking the starter.	Repair or replace wire 99.
The Kysor VIP module is malfunctioning if there is less than 9 volts at the fuel solenoid while cranking the starter, but wire 99 is not broken or loose.	Replace the module.

Problem — The engine runs, then shuts down; the warning indicator and buzzer are not on; the shutdown indicator is not on as the engine begins to lose RPM

Possible Cause	Remedy
Wire 99 or the fuel solenoid have intermittent open connections.	Repair the intermittent open connections.
Wire 18A or 373 from the ignition switch to the Kysor VIP module to ground have intermittent open connections.	Repair the intermittent open connections.
The Kysor VIP module is malfunctioning.	Replace the module.

Problem — The low oil pressure warning indicator, buzzer, and the shutdown indicator are on, but the engine runs normally

Possible Cause	Remedy
Wire 34 or 325 in the oil pressure shutdown circuit is broken or intermittently open if the problem doesn't disappear when the switch end of wire 325 is jumped to ground.	Correct the open circuit or replace wire 34 or 325.
The oil pressure shutdown switch is malfunctioning if the problem disappears when the switch end of wire 325 is jumped to ground.	Replace the switch.
The Kysor VIP module is malfunctioning.	Replace the module.

Problem — The engine runs, then shuts down with the coolant level indicator, the warning buzzer, and the shutdown indicator on

Possible Cause	Remedy
The coolant level is low.	Fill the cooling system to the proper level.
Wire 173 is broken or intermittently open.	Correct the open circuit or replace wire 173.
The radiator is not grounded.	Make sure the radiator is grounded to the chassis.
The coolant probe is covered with oil or other electrical insulating material.	Clean the probe. If the cooling system is contaminated, flush and fill the cooling system.

Problem — The engine shuts down with the overheat indicator, the warning buzzer, and the shutdown indicator on

Possible Cause	Remedy
The engine is overheating.	Locate and correct the cause of overheating.
Wire 324 or 18C is broken or intermittently open.	Correct the open circuit or replace wire 324 or 18C.
The temperature switch is malfunctioning.	Replace the temperature switch.

Troubleshooting

Problem — The engine shuts down with the low oil pressure indicator, the warning buzzer, and the shutdown indicator on

Possible Cause	Remedy
The engine oil pressure is low.	Check the engine manufacturer's manual for diagnostic and corrective measures.
The wrong oil pressure warning and shutdown switches are installed.	Install the correct switches for the engine.

Problem — The warning buzzer doesn't work

Possible Cause	Remedy
The Kysor VIP battery circuit (wire 339) is open. If this happens, the turn signal will not operate either.	Repair the battery circuit (wire 339).
The warning buzzer is malfunctioning.	Repair the warning buzzer.

Troubleshooting Chart: Low Air Pressure Warning

Problem — The low air pressure warning is on constantly when the air pressure is above 64 to 76 psi (441 to 524 kPa). **See Fig. 1.**

Problem — There is no warning when the air pressure is below 64 to 76 psi (441 to 524 kPa). **See Fig. 2.**

Troubleshooting Chart: Turn Signals

Problem — The turn signals don't work. **See Fig. 3.**

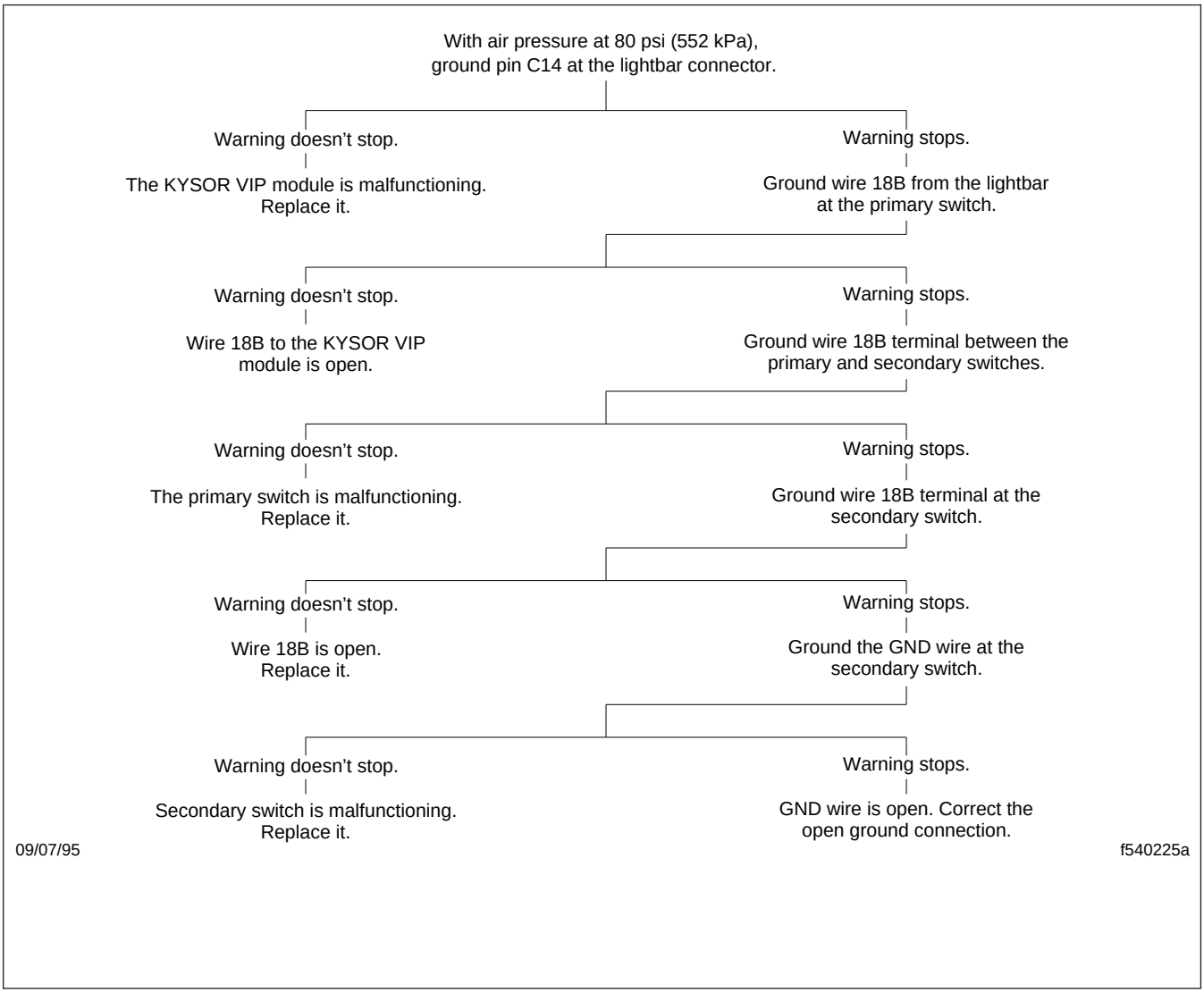


Fig. 1, Problem — The low air pressure warning is on constantly when the air pressure is above 64 to 76 psi (441 to 524 kPa).

Troubleshooting

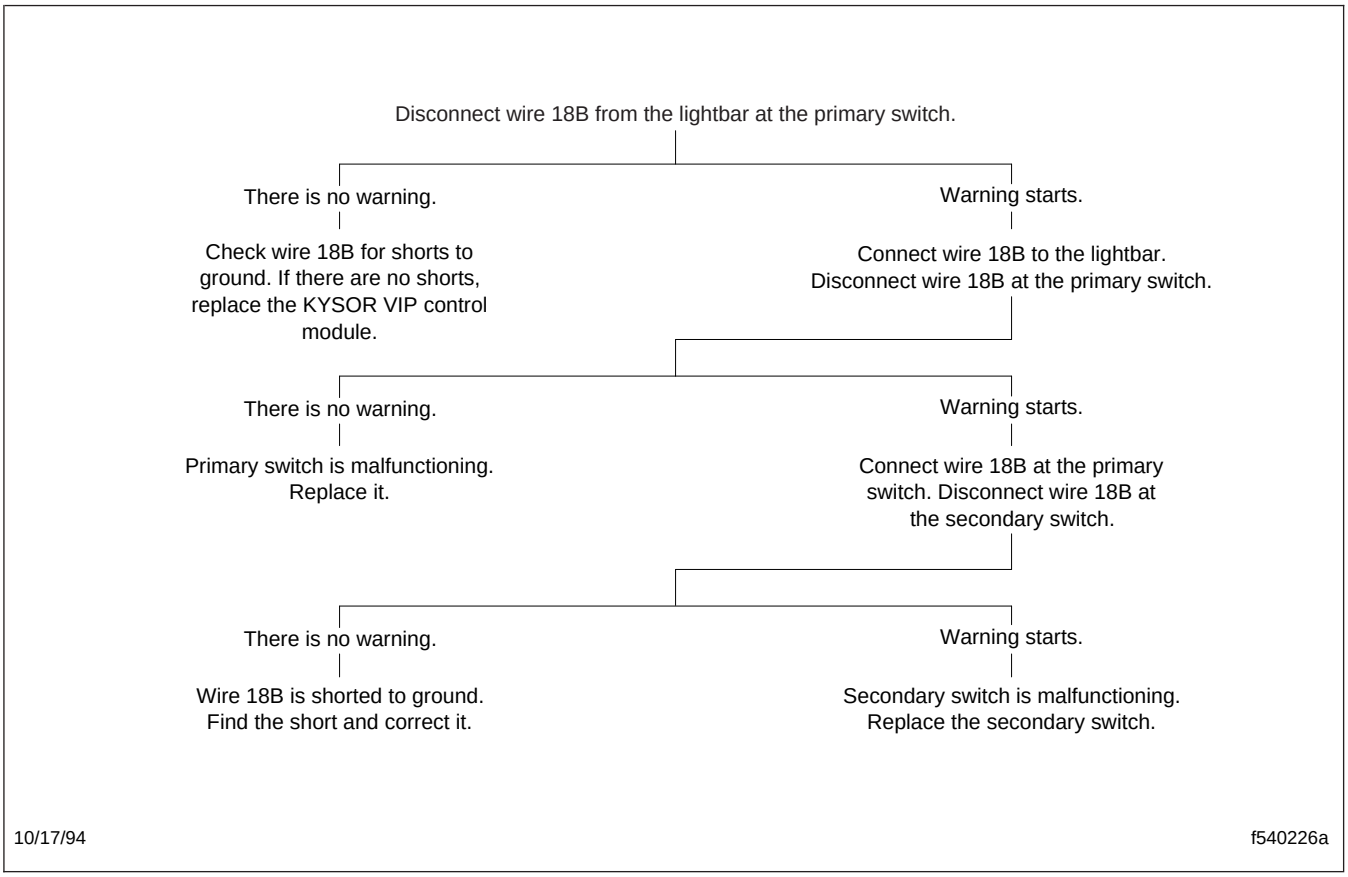


Fig. 2, Problem — There is no warning when the air pressure is below 64 to 76 psi (441 to 524 kPa).

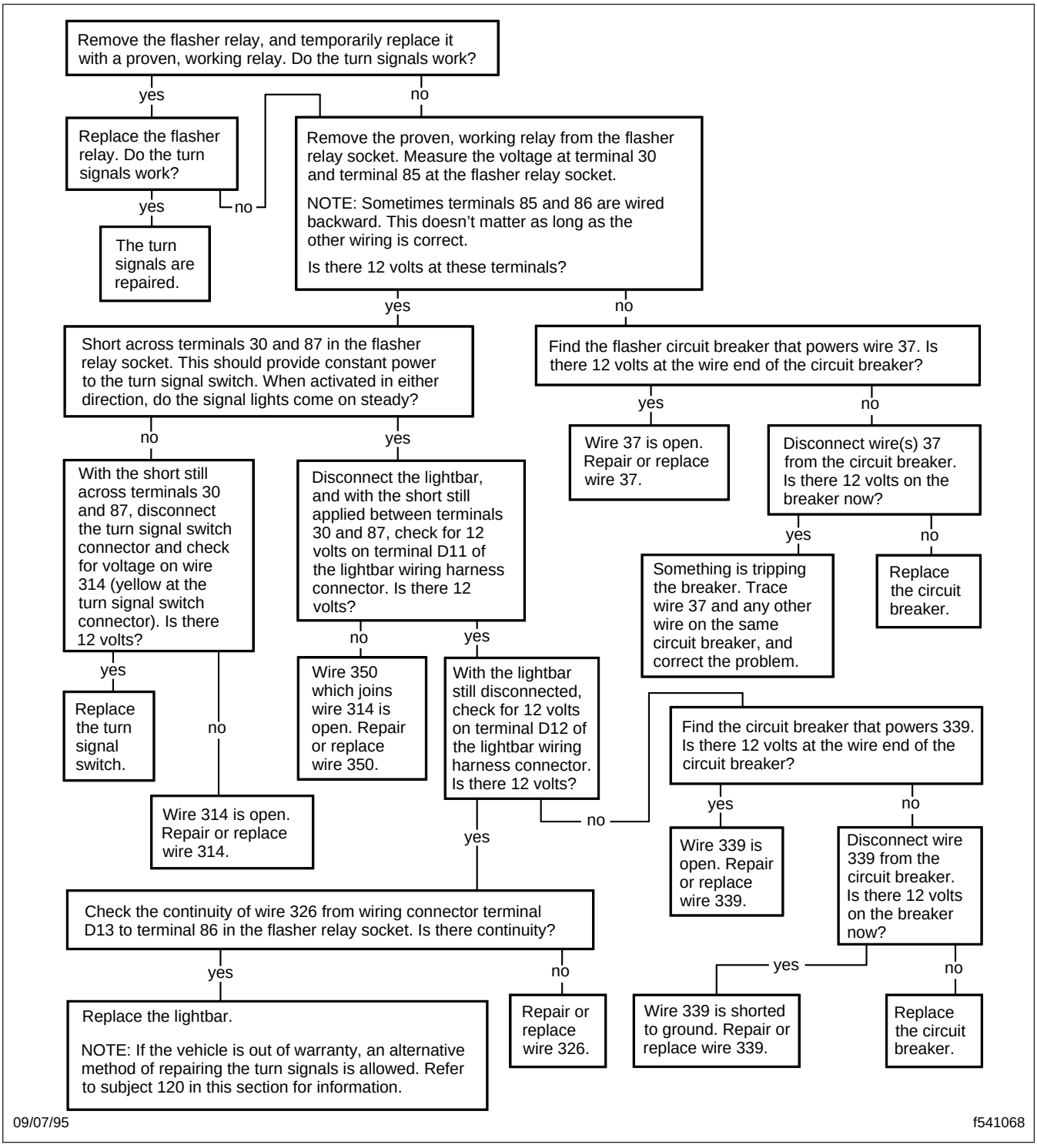


Fig. 3, Problem — The turn signals don't work.

General Description

Engine speeds are shown in revolutions-per-minute (rpm) by the electronic tachometer (**Fig. 1**). The tachometer is used as a guide for shifting, and to keep the engine speed in the proper rpm range.

The electronic tachometer consists of a gauge, magnetic sensor (**Fig. 2**), and the electrical wires that complete the circuit between the two components.

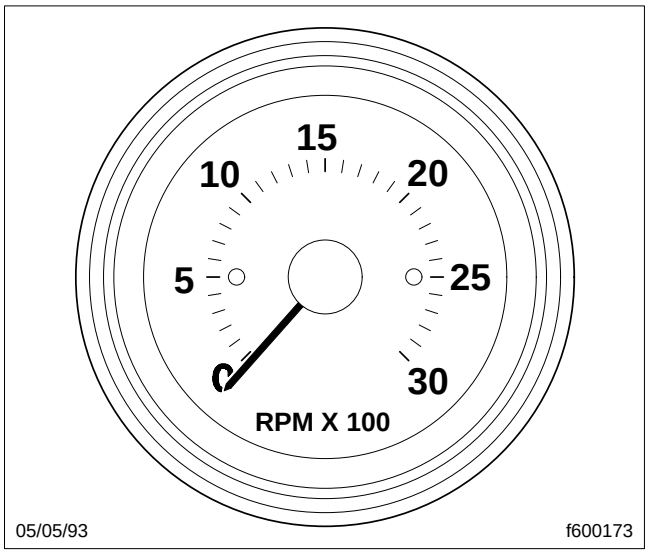


Fig. 1

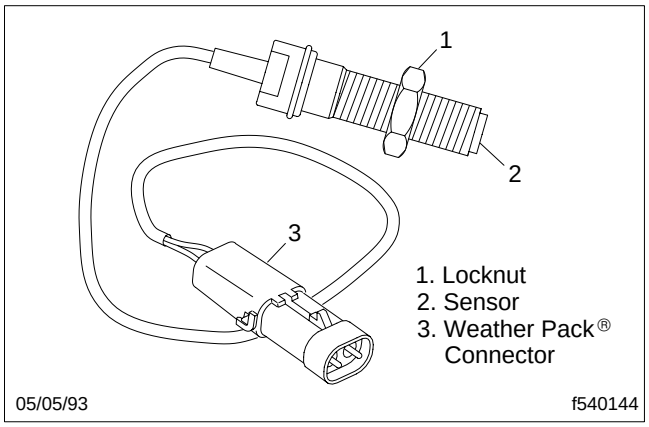


Fig. 2, Magnetic Sensor Assembly

The electronic tachometer receives signals from the magnetic sensor, which extends through a threaded bore in the flywheel housing (**Fig. 3**). When the vehicle is moving, the teeth of the turning flywheel generate electrical pulses in the sensor's magnetic field. These pulses are transmitted to the tachometer head, which converts the signals to an rpm reading.

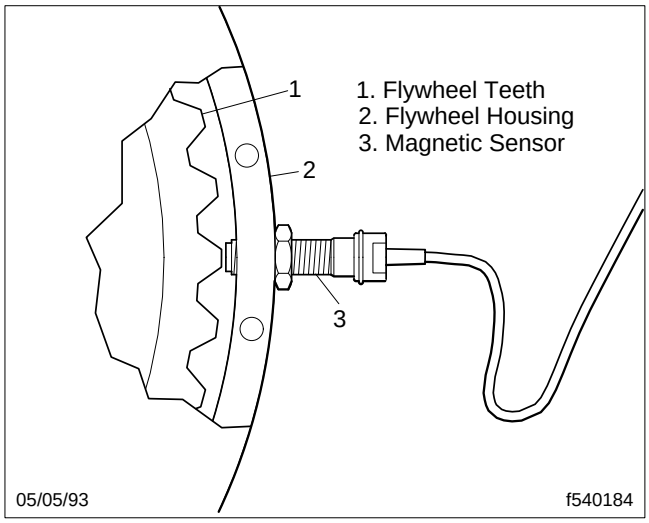


Fig. 3

Replacement

1. Apply the parking brakes.
2. Turn off the ignition.
3. Remove the screws that attach the tachometer/speedometer panel to the dash. Pull the panel out to gain access to the back of the tachometer head. **See Fig. 1**.
4. Unplug the electrical wiring connectors from the tachometer head.
5. Remove the nuts that attach the mounting bracket to the tachometer head, and remove the bracket. Remove the tachometer head by pulling it out from the front of the panel.
6. Calibrate the new tachometer head to the vehicle's engine. For instructions, **refer to Subject 120.**
7. Place the new tachometer head in the dash panel. Attach the mounting bracket to the tachometer head, then tighten the nuts.
8. Connect the electrical wiring connectors to the tachometer head.
9. Position the panel, then install the screws that attach the tachometer/speedometer panel to the dash.

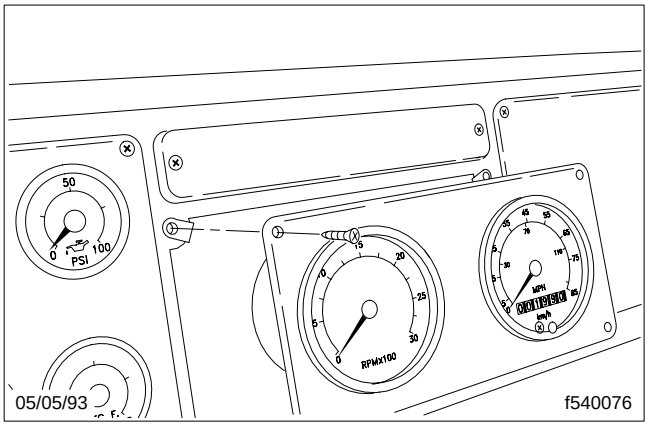


Fig. 1

Replacement and Adjustment

1. Disconnect the Weather Pack® connector. **See Fig. 1.**
2. Loosen the magnetic sensor locknut. Remove the sensor from the flywheel housing.
3. Screw the new magnetic sensor into the flywheel housing until it bottoms out on the gear teeth. Back off the sensor one-half turn. **See Fig. 2**.

IMPORTANT: The tachometer reading will be wrong if the correct adjustment is not maintained.

4. Hold the magnetic sensor in place to keep it from turning. Tighten the locknut 18 lbf·ft (25 N·m).
5. Connect the Weather Pack connector.
6. Test drive the vehicle and check that the tachometer is operating. If there is no tachometer reading, the magnetic sensor was probably not adjusted correctly; readjust the sensor.

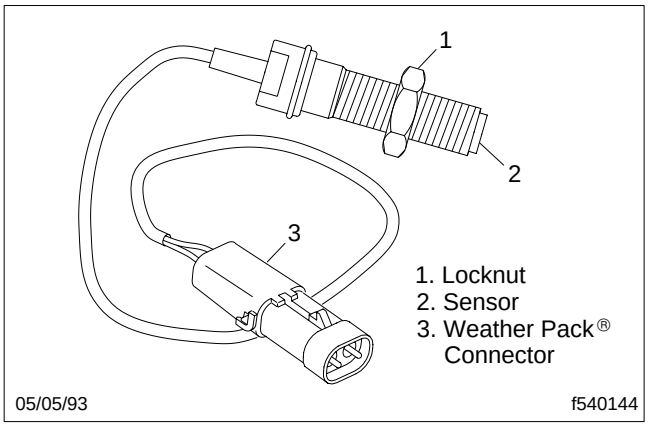


Fig. 1, Magnetic Sensor Assembly

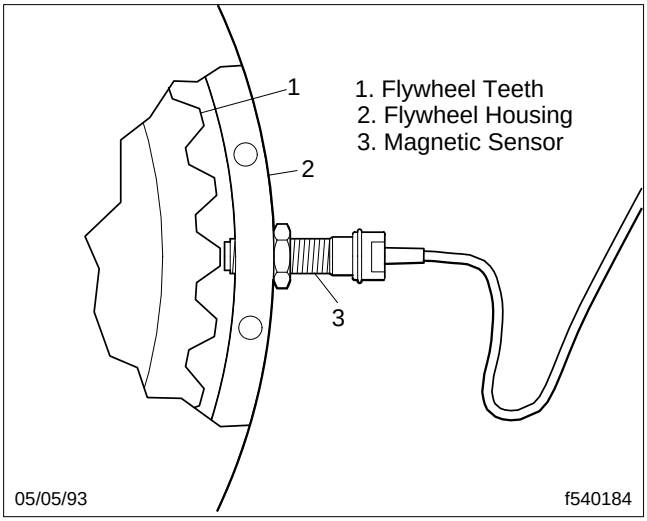


Fig. 2

Calibrating the Tachometer Head

If a new tachometer head is installed, or if a new engine is installed, you must also recalibrate the tachometer head.

The Stewart-Warner tachometer is calibrated by setting eight DIP switches at the back of the tachometer head. **See Fig. 1**. The DIP switches are set according to the engine model used in the vehicle. Determine the tachometer calibration setting as follows:

1. Adjust the magnetic sensor. For instructions, **refer to Subject 110**.
2. Obtain the calibration code from the table listing codes **in Specifications, 400.**
3. Remove the tachometer head from the panel. For instructions, **refer to Subject 100.**
4. Remove the plastic cover from the DIP switch panel at the back of the tachometer head. Calibrate the tachometer by moving DOWN each switch that corresponds to the 0 (zero) positions of the calibration code. **See Fig. 2**.

   Move UP each switch that corresponds to the 1 (one) positions of the calibration code. **See Fig. 2**.
5. Install the plastic cover on the DIP switch panel.
6. Install the tachometer head in the panel. For instructions, **refer to Subject 100**.

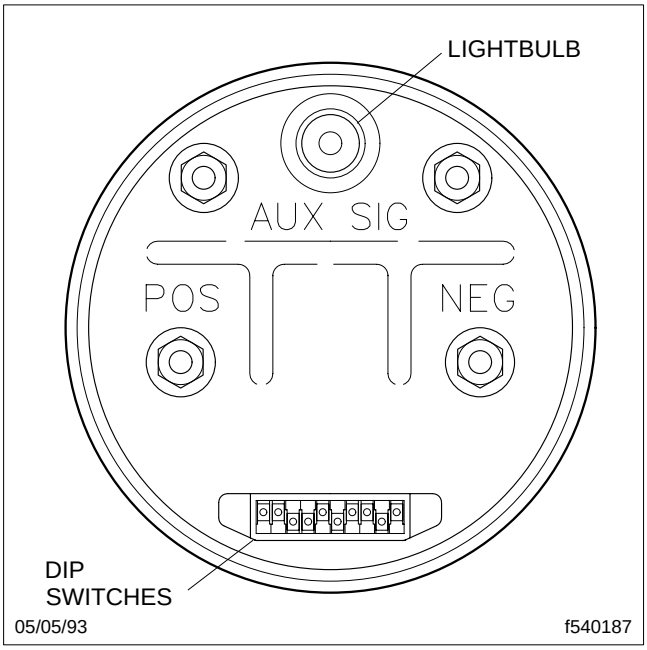


Fig. 1

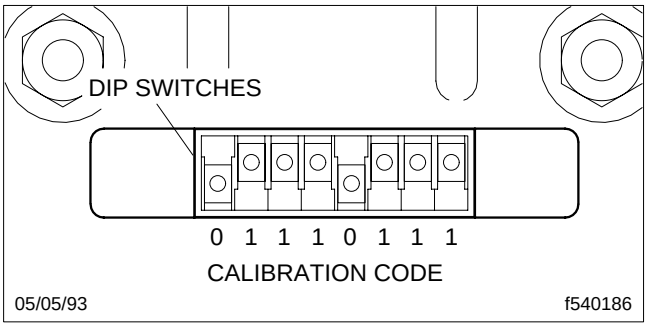


Fig. 2

Troubleshooting

The following is a troubleshooting process requiring the use of a voltmeter and an ohmmeter. Make the checks in the order listed below.

Incorrect tachometer head readings may occur whenever a new tachometer head or engine is installed. In each case, calibrate the tachometer head using the procedure in this section.

Inaccurate readings will also occur if the magnetic sensor is not adjusted correctly. Before troubleshooting the system, make sure the magnetic sensor is correctly adjusted. For instructions, **see Subject 110**. Also, make sure the batteries are fully charged.

MAGNETIC SENSOR VOLTAGE CHECK

NOTE: To receive an accurate tachometer reading, a minimum of one volt AC output is needed from the magnetic sensor.

1. Disconnect the electrical connector from the sensor. Make sure the sensor terminals are free of corrosion and moisture.
2. Connect an AC voltmeter to the terminals of the magnetic sensor.
3. Run the engine at idle speed, and check the voltage output from the sensor. If the voltage is less than one volt, refer to the "Troubleshooting Chart" for possible causes and corrections.
4. Turn off the engine and disconnect the voltmeter.

MAGNETIC SENSOR RESISTANCE CHECK USING AN OHMMETER

Connect the ohmmeter leads to the terminals of the magnetic sensor. The resistance should measure 876 ohms. Readings between 788 and 963 ohms are acceptable.

If the resistance is acceptable, then inaccurate tachometer readings are caused by either the wiring to the tachometer head or by the tachometer head itself. Go to "Wiring Check: Magnetic Sensor to Tachometer Head."

If the resistance is outside the acceptable range, replace the sensor with a new one. For instructions, **see Subject 110**.

WIRING CHECK: MAGNETIC SENSOR TO TACHOMETER HEAD

1. Remove the screws that attach the tachometer/speedometer panel to the dash. Pull the panel out to gain access to the back of the tachometer head.
2. Unplug the electrical wiring connector from the tachometer head.
3. Check for an open or short circuit by disconnecting the magnetic sensor leads, circuit numbers 162 and 163. Connect the ohmmeter to the leads of circuit numbers 162 and 163. The resistance should measure 876 ohms. A reading between 788 and 963 ohms is acceptable.

   If the above reading is not obtained, and the magnetic sensor is operative, the problem is in the wiring between the magnetic sensor and the tachometer head. Repair or replace the damaged wiring.

   If the reading is between 788 and 963 ohms, connect the magnetic sensor leads to the tachometer head. Go to "Battery Voltage Check Using a DC Voltmeter."

BATTERY VOLTAGE CHECK USING A DC VOLTMETER

1. With the ignition switch off, attach the probes of the DC voltmeter across the positive and negative terminals of the tachometer head.

NOTE: Attach the negative (black) probe to the yellow wire terminal and the positive (red) probe to the red wire terminal.

2. Turn on the ignition switch. The voltmeter should read 9 to 16 volts DC.

   If the voltage is between 9 and 16 volts DC, but the tachometer meter readings are inaccurate, then the tachometer head, not the wiring is causing inaccurate readings. Turn off the ignition switch, and disconnect the voltmeter probes. Replace the tachometer head. For instructions, **see Subject 100**.

   If the voltage is not between 9 and 16 volts DC, check the wiring between the ignition switch and the tachometer head. Turn off the ignition switch,

and disconnect the voltmeter probes. Repair or replace the damaged wiring.

3. Place the panel in the dash; install and tighten the screws.

Troubleshooting Chart

Problem—Less Than One Volt Reading from the Magnetic Sensor

Possible Cause	Remedy
Magnetic sensor gap is not properly adjusted.	Adjust the magnetic sensor.
The magnetic sensor is damaged.	Replace the magnetic sensor.

Problem—Tachometer Head Will Not Register

Possible Cause	Remedy
Magnetic sensor gap is not properly adjusted.	Adjust the magnetic sensor.
The magnetic sensor is damaged.	Replace the magnetic sensor.
The tachometer head is damaged internally.	Replace only after checking all other possible causes.
Loose or corroded terminals, broken contacts, broken wires, shorting, or frayed wires are causing an incomplete circuit.	Replace the damaged component(s), as necessary.

Problem—Inaccurate Tachometer Readings

Possible Cause	Remedy
Magnetic sensor gap is not properly adjusted.	Adjust the magnetic sensor.
Shorts are occurring in the magnetic sensor.	Check the resistance of the magnetic sensor. Replace the sensor, if necessary.
The tachometer head is incorrectly calibrated.	Recalibrate the tachometer head.
Erratic readings are resulting from loose electrical connections.	Check all the wiring in the tachometer system. Tighten all loose connections.

Calibration codes by engine for Stewart–Warner electronic tachometers.

Engine Manufacturer	Engine Model	Calibration Code
Detroit	All	01110111
Caterpillar	3306	10010111
	3406 and 3176	01110001
Cummins	NTC Big Cam III & IV	01100011
	L10	

Table 1

General Description

This speedometer system includes a magnetic sensor (**Fig. 1**) mounted on the transmission bearing cover near the output shaft. See **Fig. 2**. The magnetic sensor uses pulse feedback from a standard 16-tooth spacer gear located under the bearing cover on the inboard end of the transmission output shaft. The magnetic end of the sensor extends through a threaded bore in the bearing cover and stops within a few hundredths of an inch from the teeth of the spacer gear.

When the vehicle is moving, the teeth of the turning spacer gear generate electrical pulses in the sensor's magnetic field. These pulses are transmitted to the speedometer head, which amplifies and interprets the pulses as vehicle speed and distance traveled.

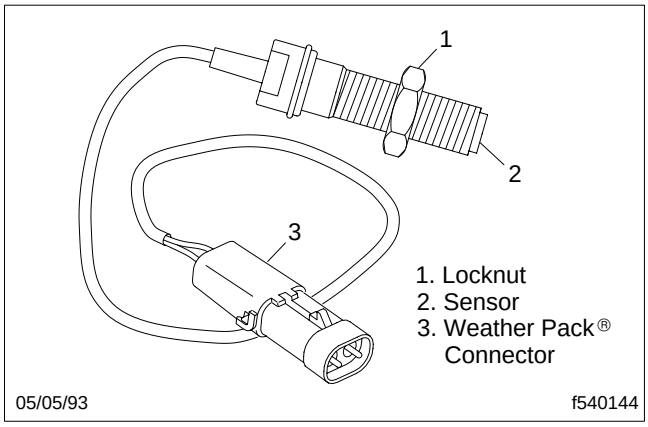


Fig. 1, Magnetic Sensor Assembly

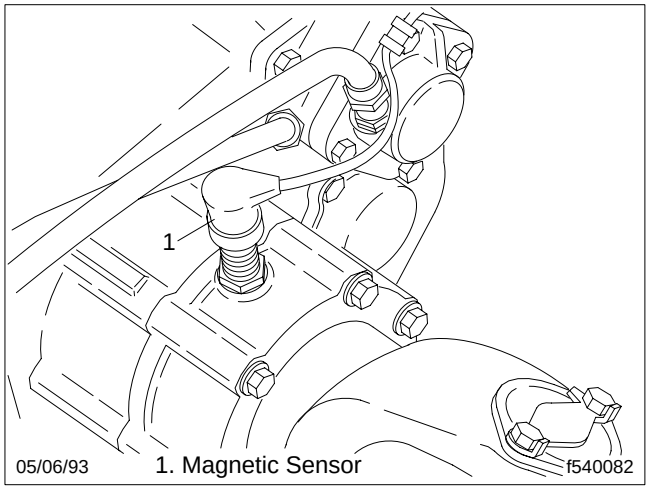


Fig. 2, Magnetic Sensor Installation

Replacement

1. Apply the parking brakes.
2. Turn off the ignition.
3. Remove the screws that attach the tachometer/speedometer panel to the dash. Pull the panel out to gain access to the back of the speedometer head. **See Fig. 1**.
4. Unplug the electrical wiring connectors from the speedometer head.
5. Remove the nuts that attach the mounting bracket to the speedometer head, and remove the bracket. Remove the speedometer head by pulling it out from the front of the panel.
6. Place the speedometer head in the dash panel. Attach the mounting bracket to the speedometer head, then tighten the nuts.
7. Connect the electrical wiring at the speedometer head.
8. Position the panel, then install the screws that attach the tachometer/speedometer panel to the dash.

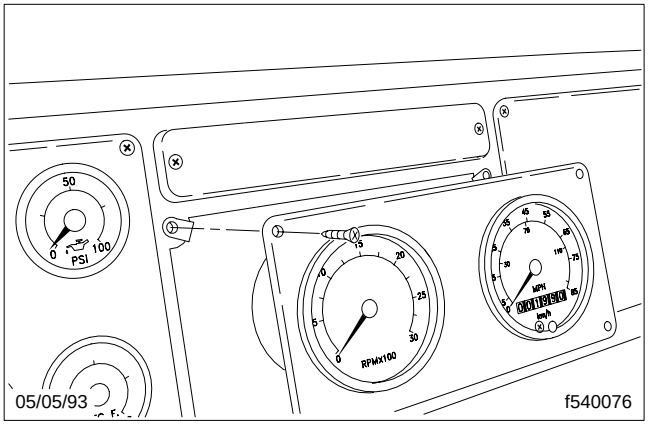


Fig. 1

Replacement and Adjustment

1. Disconnect the Weather Pack® connector. **See Fig. 1**.
2. Loosen the magnetic sensor locknut. Remove the sensor from the transmission housing.
3. Screw the new magnetic sensor into the transmission housing until it bottoms out on the gear teeth. Back off the sensor one-half turn.

IMPORTANT: The speedometer reading will be wrong if a correct adjustment is not maintained.

4. Hold the magnetic sensor in place to keep it from turning. Tighten the locknut 18 lbf·ft (24 N·m).
5. Connect the Weather Pack connector.
6. Test drive the vehicle and check that the speedometer is operating correctly. If there is no speedometer reading, the magnetic sensor was probably not adjusted correctly; readjust the sensor.

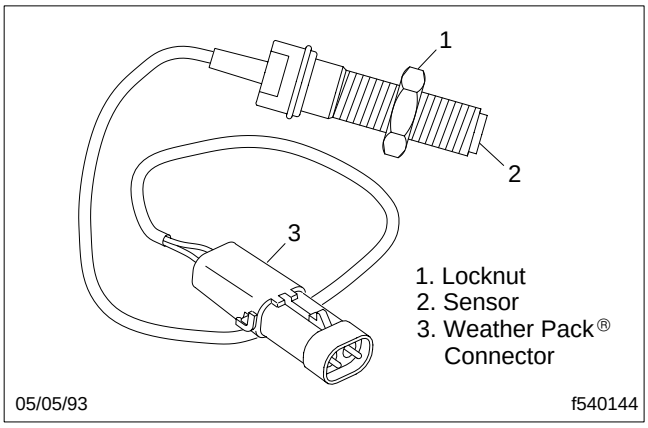


Fig. 1, Magnetic Sensor Assembly

Calibrating the Speedometer Head

If a new speedometer head is installed, or if different tires are installed, you must recalibrate the speedometer head.

The Stewart-Warner speedometer is calibrated by setting ten DIP switches at the back of the speedometer head. **See Fig. 1**. The DIP switches are set according to the specifications of a calibration code. Determine the speedometer calibration setting as follows:

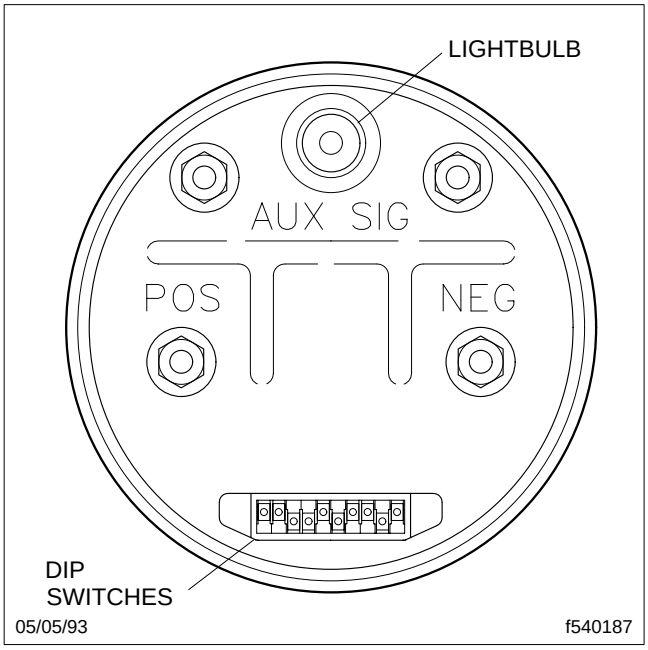


Fig. 1

1. Obtain the revolutions-per-mile (rpm), or revolutions-per-kilometer (rpkm) value of the tire brand and model installed on the vehicle. The rpm or rpkm value can be obtained from the tire dealer or manufacturer.
2. Obtain the vehicle axle ratio (ar) from the vehicle specification decal.

NOTE: The vehicle axle ratio (ar) is also stamped on the axle housing.

3. Determine the speedometer pulses-per-mile (ppm) as follows:

   3.1 Multiply the revolutions-per-mile (rpm) value of the tire brand by the vehicle axle ratio (ar).

   NOTE: To convert from revolutions-per-kilometer (rpkm) to revolutions-per-mile (rpm), multiply the rpkm value by 0.62137.

   3.2 Multiply the number obtained in the substep above by the total number of teeth (n) on the transmission spacer gear. A 16-tooth spacer gear is standard.

   Example:

   486 (rpm) x 4.63 (ar) x 16 (n) = 36 002.8 (ppm)

4. In the table **in Specifications, 400,** find the ppm value obtained in the previous step (or the value closest to it). In the example above, 36 000 is the closest ppm value to 36 002.8.

   The number to the right of the applicable ppm value is the speedometer calibration code. In this example, the calibration code is 0011010010.

5. Remove the speedometer head from the panel. For instructions, see **Subject 100**.
6. Remove the plastic cover from the DIP switch panel at the back of the speedometer head. Calibrate the speedometer by moving UP each switch that corresponds to the 0 (zero) positions of the calibration code. **See Fig. 2**.

   Move DOWN each switch that corresponds to the 1 (one) positions of the calibration code. **See Fig. 2**.

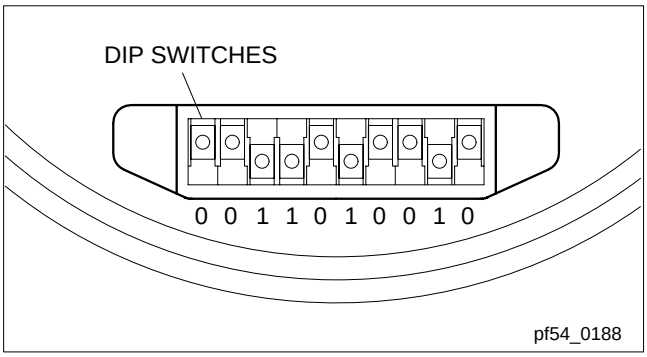


Fig. 2

7. Install the plastic cover on the DIP switch panel.

Calibrating the Speedometer Head

8. Install the speedometer head in the panel. For instructions, see **Subject 100**.

Troubleshooting

The following is a troubleshooting process requiring the use of a voltmeter and an ohmmeter. Make the checks in the order listed below.

Incorrect speedometer head readings may occur whenever a new speedometer head or different tires are installed. In each case, calibrate the speedometer head using the procedure in this section.

Inaccurate readings will also occur if the magnetic sensor is not adjusted correctly. Before troubleshooting the system, make sure the magnetic sensor is correctly adjusted. For instructions, **see Subject 110**.

Also, make sure the batteries are fully charged.

SPEEDOMETER HEAD ACCURACY TEST

Testing the accuracy of speedometer head readings is best performed by commercial services specializing in such tests. If these commercial services are not available, do the odometer reading test below.

ODOMETER READING TEST

To check the accuracy of the odometer, drive the vehicle over a measured mile. An inaccurate odometer reading indicates incorrect speedometer head calibration. Calibrate the speedometer head. For instructions, **see Subject 120**.

If inaccurate odometer readings continue after calibration, go to "Magnetic Sensor Resistance Check Using an Ohmmeter."

MAGNETIC SENSOR RESISTANCE CHECK USING AN OHMMETER

1. Disconnect the Weather Pack® connector from the sensor. Make sure the sensor terminals and wires are free of corrosion and moisture.
2. Connect the ohmmeter leads to the terminals of the magnetic sensor. The resistance should measure 876 ohms. Readings between 788 and 963 ohms are acceptable.

   If the resistance is acceptable, then inaccurate speedometer readings are caused by either the wiring to the speedometer head or by the speedometer head itself. Go to "Wiring Check: Magnetic Sensor to Speedometer Head."

   If the resistance is outside the acceptable range, replace the sensor with a new one. For instructions, **see Subject 110**.

WIRING CHECK: MAGNETIC SENSOR TO SPEEDOMETER HEAD

1. Remove the screws that attach the tachometer/speedometer panel to the dash. Pull the panel out to gain access to the back of the speedometer head.
2. Unplug the electrical wiring connector from the speedometer head.
3. Check for an open or short circuit by disconnecting the magnetic sensor leads, circuit numbers 117 and 118. Connect the ohmmeter to the leads of circuit numbers 117 and 118. The resistance should measure 876 ohms. A reading between 788 and 963 ohms is acceptable.

   If the above reading is not obtained, and the magnetic sensor is operative, the problem is in the wiring between the magnetic sensor and the speedometer head. Repair or replace the damaged wiring.

   If the reading is between 788 and 963 ohms, connect the magnetic sensor leads to the speedometer head. Go to "Battery Voltage Check Using a DC Voltmeter."

BATTERY VOLTAGE CHECK USING A DC VOLTMETER

1. With the ignition switch off, attach the probes of the DC voltmeter across the positive and negative terminals of the speedometer head.

NOTE: Attach the negative (black) probe to the yellow wire terminal and the positive (red) probe to the red wire terminal.

2. Turn on the ignition switch. The voltmeter should read 9 to 16 volts DC.

   If the voltage is between 9 and 16 volts DC, but the speedometer and odometer readings are inaccurate, then the speedometer head is causing inaccurate readings. Turn off the ignition switch, and disconnect the voltmeter probes. Replace the speedometer head. For instructions, **see Subject 100**.

Troubleshooting

If the voltage is not between 9 and 16 volts DC, check the wiring between the ignition switch and the speedometer head. Turn the ignition switch off, and disconnect the voltmeter probes. Repair or replace the damaged wiring.

3. Place the panel in the dash; install and tighten the screws.

Troubleshooting Chart

Problem—Speedometer Head Will Not Register

Possible Cause	Remedy
Magnetic sensor gap is not properly adjusted.	Adjust the magnetic sensor.
Loose or corroded terminals, broken contacts, broken wires, shorting, or frayed wires are causing an incomplete circuit.	Replace the damaged component(s), as necessary.
The magnetic sensor is damaged.	Replace the magnetic sensor.
The speedometer head is damaged internally.	Replace only after checking all other possible causes.

Problem—Inaccurate Speedometer Readings

Possible Cause	Remedy
Magnetic sensor gap is not properly adjusted.	Adjust the magnetic sensor.
Shorts are occurring in the magnetic sensor.	Check the resistance of the magnetic sensor. Replace the sensor, if necessary.
The speedometer head is incorrectly calibrated.	Recalibrate.
Erratic readings are resulting from loose electrical connections.	Check all the wiring in the speedometer system. Tighten all loose connections.

Pulses-per-mile (ppm) and calibration codes.

Pulses-Per-Mile (ppm)	Calibration Code
6960	0101110000
7080	1101110000
7200	0011110000
7320	1011110000
7440	0111110000
7560	1111110000
7680	0000001000
7800	1000001000
7920	0100001000
8040	1100001000
8160	0010001000
8280	1010001000
8400	0110001000
8520	1110001000
8640	0001001000
8760	1001001000
8880	0101001000
9000	1101001000
9120	0011001000
9240	1011001000
9360	0111001000
9480	1111001000
9600	0000101000
9720	1000101000
9840	0100101000
9960	1100101000
10080	0010101000
10200	1010101000
10320	0110101000
10440	1110101000
10560	0001101000
10680	1001101000
10800	0101101000
10920	1101101000
11040	0011101000
11160	1011101000
11280	0111101000
11400	1111101000
11520	0000011000
11640	1000011000
11760	0100011000
11880	1100011000
12000	0010011000
12120	1010011000
12240	0110011000
12360	1110011000
12480	0001011000
12600	1001011000
12720	0101011000
12840	1101011000
12960	0011011000
13080	1011011000
13200	0111011000
13320	1111011000
13440	0000111000
13560	1000111000
13680	0100111000
13800	1100111000
13920	0010111000
14040	1010111000
14160	0110111000
14280	1110111000
14400	0001111000
14520	1001111000
14640	0101111000
14760	1101111000
14880	0011111000
15000	1011111000
15120	0111111000
15240	1111111000
15360	0000000100
15480	1000000100

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
15600	0100000100
15720	1100000100
15840	0010000100
15960	1010000100
16080	0110000100
16200	1110000100
16320	0001000100
16440	1001000100
16560	0101000100
16680	1101000100
16800	0011000100
16920	1011000100
17040	0111000100
17160	1111000100
17280	0000100100
17400	1000100100
17520	0100100100
17640	1100100100
17760	0010100100
17880	1010100100
18000	0110100100
18120	1110100100
18240	0001100100
18360	1001100100
18480	0101100100
18600	1101100100
18720	0011100100
18840	1011100100
18960	0111100100
19080	1111100100
19200	0000010100
19320	1000010100
19440	0100010100
19560	1100010100
19680	0010010100
19800	1010010100

Pulses-Per-Mile (ppm)	Calibration Code
19920	0110010100
20040	1110010100
20160	0001010100
20280	1001010100
20400	0101010100
20520	1101010100
20640	0011010100
20760	1011010100
20880	0111010100
21000	1111010100
21120	0000110100
21240	1000110100
21360	0100110100
21480	1100110100
21600	0010110100
21720	1010110100
21840	0110110100
21960	1110110100
22080	0001110100
22200	1001110100
22320	0101110100
22440	1101110100
22560	0011110100
22680	1011110100
22800	0111110100
22920	1111110100
23040	0000001100
23160	1000001100
23280	0100001100
23400	1100001100
23520	0010001100
23640	1010001100
23760	0110001100
23880	1110001100
24000	0001001100
24120	1001001100

Pulses-Per-Mile (ppm)	Calibration Code
24240	0101001100
24360	1101001100
24480	0011001100
24600	1011001100
24720	0111001100
24840	1111001100
24960	0000101100
25080	1000101100
25200	0100101100
25320	1100101100
25440	0010101100
25560	1010101100
25680	0110101100
25800	1110101100
25920	0001101100
26040	1001101100
26160	0101101100
26280	1101101100
26400	0011101100
26520	1011101100
26640	0111101100
26760	1111101100
26880	0000011100
27000	1000011100
27120	0100011100
27240	1100011100
27360	0010011100
27480	1010011100
27600	0110011100
27720	1110011100
27840	0001011100
27960	1001011100
28080	0101011100
28200	1101011100
28320	0011011100
28440	1011011100

Pulses-Per-Mile (ppm)	Calibration Code
28560	0111011100
28680	1111011100
28800	0000111100
28920	1000111100
29040	0100111100
29160	1100111100
29280	0010111100
29400	1010111100
29520	0110111100
29640	1110111100
29760	0001111100
29880	1001111100
30000	0101111100
30120	1101111100
30240	0011111100
30360	1011111100
30480	0111111100
30600	1111111100
30720	0000000010
30840	1000000010
30960	0100000010
31080	1100000010
31200	0010000010
31320	1010000010
31440	0110000010
31560	1110000010
31680	0001000010
31800	1001000010
31920	0101000010
32040	1101000010
32160	0011000010
32280	1011000010
32400	0111000010
32520	1111000010
32640	0000100010
32760	1000100010

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
32880	0100100010
33000	1100100010
33120	0010100010
33240	1010100010
33360	0110100010
33480	1110100010
33600	0001100010
33720	1001100010
33840	0101100010
33960	1101100010
34080	0011100010
34200	1011100010
34320	0111100010
34440	1111100010
34560	0000010010
34680	1000010010
34800	0100010010
34920	1100010010
35040	0010010010
35160	1010010010
35280	0110010010
35400	1110010010
35520	0001010010
35640	1001010010
35760	0101010010
35880	1101010010
36000	0011010010
36120	1011010010
36240	0111010010
36360	1111010010
36480	0000110010
36600	1000110010
36720	0100110010
36840	1100110010
36960	0010110010
37080	1010110010

Pulses-Per-Mile (ppm)	Calibration Code
37200	0110110010
37320	1110110010
37440	0001110010
37560	1001110010
37680	0101110010
37800	1101110010
37920	0011110010
38040	1011110010
38160	0111110010
38280	1111110010
38400	0000001010
38520	1000001010
38640	0100001010
38760	1100001010
38880	0010001010
39000	1010001010
39120	0110001010
39240	1110001010
39360	0001001010
39480	1001001010
39600	0101001010
39720	1101001010
39840	0011001010
39960	1011001010
40080	0111001010
40200	1111001010
40320	0000101010
40440	1000101010
40560	0100101010
40680	1100101010
40800	0010101010
40920	1010101010
41040	0110101010
41160	1110101010
41280	0001101010
41400	1001101010

Pulses-Per-Mile (ppm)	Calibration Code
41520	0101101010
41640	1101101010
41760	0011101010
41880	1011101010
42000	0111101010
42120	1111101010
42240	0000011010
42360	1000011010
42480	0100011010
42600	1100011010
42720	0010011010
42840	1010011010
42960	0110011010
43080	1110011010
43200	0001011010
43320	1001011010
43440	0101011010
43560	1101011010
43680	0011011010
43800	1011011010
43920	0111011010
44040	1111011010
44160	0000111010
44280	1000111010
44400	0100111010
44520	1100111010
44640	0010111010
44760	1010111010
44880	0110111010
45000	1110111010
45120	0001111010
45240	1001111010
45360	0101111010
45480	1101111010
45600	0011111010
45720	1011111010

Pulses-Per-Mile (ppm)	Calibration Code
45840	0111111010
45960	1111111010
46080	0000000110
46200	1000000110
46320	0100000110
46440	1100000110
46560	0010000110
46680	1010000110
46800	0110000110
46920	1110000110
47040	0001000110
47160	1001000110
47280	0101000110
47400	1101000110
47520	0011000110
47640	1011000110
47760	0111000110
47880	1111000110
48000	0000100110
48120	1000100110
48240	0100100110
48360	1100100110
48480	0010100110
48600	1010100110
48720	0110100110
48840	1110100110
48960	0001100110
49080	1001100110
49200	0101100110
49320	1101100110
49440	0011100110
49560	1011100110
49680	0111100110
49800	1111100110
49920	0000010110
50040	1000010110

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
50160	0100010110
50280	1100010110
50400	0010010110
50520	1010010110
50640	0110010110
50760	1110010110
50880	0001010110
51000	1001010110
51120	0101010110
51240	1101010110
51360	0011010110
51480	1011010110
51600	0111010110
51720	1111010110
51840	0000110110
51960	1000110110
52080	0100110110
52200	1100110110
52320	0010110110
52440	1010110110
52560	0110110110
52680	1110110110
52800	0001110110
52920	1001110110
53040	0101110110
53160	1101110110
53280	0011110110
53400	1011110110
53520	0111110110
53640	1111110110
53760	0000001110
53880	1000001110
54000	0100001110
54120	1100001110
54240	0010001110
54360	1010001110

Pulses-Per-Mile (ppm)	Calibration Code
54480	0110001110
54600	1110001110
54720	0001001110
54840	1001001110
54960	0101001110
55080	1101001110
55200	0011001110
55320	1011001110
55440	0111001110
55560	1111001110
55680	0000101110
55800	1000101110
55920	0100101110
56040	1100101110
56160	0010101110
56280	1010101110
56400	0110101110
56520	1110101110
56640	0001101110
56760	1001101110
56880	0101101110
57000	1101101110
57120	0011101110
57240	1011101110
57360	0111101110
57480	1111101110
57600	0000011110
57720	1000011110
57840	0100011110
57960	1100011110
58080	0010011110
58200	1010011110
58320	0110011110
58440	1110011110
58560	0001011110
58680	1001011110

Pulses-Per-Mile (ppm)	Calibration Code
58800	0101011110
58920	1101011110
59040	0011011110
59160	1011011110
59280	0111011110
59400	1111011110
59520	0000111110
59640	1000111110
59760	0100111110
59880	1100111110
60000	0010111110
60120	1010111110
60240	0110111110
60360	1110111110
60480	0001111110
60600	1001111110
60720	0101111110
60840	1101111110
60960	0011111110
61080	1011111110
61200	0111111110
61320	1111111110
61440	0000000001
61560	1000000001
61680	0100000001
61800	1100000001
61920	0010000001
62040	1010000001
62160	0110000001
62280	1110000001
62400	0001000001
62520	1001000001
62640	0101000001
62760	1101000001
62880	0011000001
63000	1011000001

Pulses-Per-Mile (ppm)	Calibration Code
63120	0111000001
63240	1111000001
63360	0000100001
63480	1000100001
63600	0100100001
63720	1100100001
63840	0010100001
63960	1010100001
64080	0110100001
64200	1110100001
64320	0001100001
64440	1001100001
64560	0101100001
64680	1101100001
64800	0011100001
64920	1011100001
65040	0111100001
65160	1111100001
65280	0000010001
65400	1000010001
65520	0100010001
65640	1100010001
65760	0010010001
65880	1010010001
66000	0110010001
66120	1110010001
66240	0001010001
66360	1001010001
66480	0101010001
66600	1101010001
66720	0011010001
66840	1011010001
66960	0111010001
67080	1111010001
67200	0000110001
67320	1000110001

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
67440	0100110001
67560	1100110001
67680	0010110001
67800	1010110001
67920	0110110001
68040	1110110001
68160	0001110001
68280	1001110001
68400	0101110001
68520	1101110001
68640	0011110001
68760	1011110001
68880	0111110001
69000	1111110001
69120	0000001001
69240	1000001001
69360	0100001001
69480	1100001001
69600	0010001001
69720	1010001001
69840	0110001001
69960	1110001001
70080	0001001001
70200	1001001001
70320	0101001001
70440	1101001001
70560	0011001001
70680	1011001001
70800	0111001001
70920	1111001001
71040	0000101001
71160	1000101001
71280	0100101001
71400	1100101001
71520	0010101001
71640	1010101001

Pulses-Per-Mile (ppm)	Calibration Code
71760	0110101001
71880	1110101001
72000	0001101001
72120	1001101001
72240	0101101001
72360	1101101001
72480	0011101001
72600	1011101001
72720	0111101001
72840	1111101001
72960	0000011001
73080	1000011001
73200	0100011001
73320	1100011001
73440	0010011001
73560	1010011001
73680	0110011001
73800	1110011001
73920	0001011001
74040	1001011001
74160	0101011001
74280	1101011001
74400	0011011001
74520	1011011001
74640	0111011001
74760	1111011001
74880	0000111001
75000	1000111001
75120	0100111001
75240	1100111001
75360	0010111001
75480	1010111001
75600	0110111001
75720	1110111001
75840	0001111001
75960	1001111001

Pulses-Per-Mile (ppm)	Calibration Code
76080	0101111001
76200	1101111001
76320	0011111001
76440	1011111001
76560	0111111001
76680	1111111001
76800	0000000101
76920	1000000101
77040	0100000101
77160	1100000101
77280	0010000101
77400	1010000101
77520	0110000101
77640	1110000101
77760	0001000101
77880	1001000101
78000	0101000101
78120	1101000101
78240	0011000101
78360	1011000101
78480	0111000101
78600	1111000101
78720	0000100101
78840	1000100101
78960	0100100101
79080	1100100101
79200	0010100101
79320	1010100101
79440	0110100101
79560	1110100101
79680	0001100101
79800	1001100101
79920	0101100101
80040	1101100101
80160	0011100101
80280	1011100101

Pulses-Per-Mile (ppm)	Calibration Code
80400	0111100101
80520	1111100101
80640	0000010101
80760	1000010101
80880	0100010101
81000	1100010101
81120	0010010101
81240	1010010101
81360	0110010101
81480	1110010101
81600	0001010101
81720	1001010101
81840	0101010101
81960	1101010101
82080	0011010101
82200	1011010101
82320	0111010101
82440	1111010101
82560	0000110101
82680	1000110101
82800	0100110101
82920	1100110101
83040	0010110101
83160	1010110101
83280	0110110101
83400	1110110101
83520	0001110101
83640	1001110101
83760	0101110101
83880	1101110101
84000	0011110101
84120	1011110101
84240	0111110101
84360	1111110101
84480	0000001101
84600	1000001101

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
84720	0100001101
84840	1100001101
84960	0010001101
85080	1010001101
85200	0110001101
85320	1110001101
85440	0001001101
85560	1001001101
85680	0101001101
85800	1101001101
85920	0011001101
86040	1011001101
86160	0111001101
86280	1111001101
86400	0000101101
86520	1000101101
86640	0100101101
86760	1100101101
86880	0010101101
87000	1010101101
87120	0110101101
87240	1110101101
87360	0001101101
87480	1001101101
87600	0101101101
87720	1101101101
87840	0011101101
87960	1011101101
88080	0111101101
88200	1111101101
88320	0000011101
88440	1000011101
88560	0100011101
88680	1100011101
88800	0010011101
88920	1010011101

Pulses-Per-Mile (ppm)	Calibration Code
89040	0110011101
89160	1110011101
89280	0001011101
89400	1001011101
89520	0101011101
89640	1101011101
89760	0011011101
89880	1011011101
90000	0111011101
90120	1111011101
90240	0000111101
90360	1000111101
90480	0100111101
90600	1100111101
90720	0010111101
90840	1010111101
90960	0110111101
91080	1110111101
91200	0001111101
91320	1001111101
91440	0101111101
91560	1101111101
91680	0011111101
91800	1011111101
91920	0111111101
92040	1111111101
92160	0000000011
92280	1000000011
92400	0100000011
92520	1100000011
92640	0010000011
92760	1010000011
92880	0110000011
93000	1110000011
93120	0001000011
93240	1001000011

Pulses-Per-Mile (ppm)	Calibration Code
93360	0101000011
93480	1101000011
93600	0011000011
93720	1011000011
93840	0111000011
93960	1111000011
94080	0000100011
94200	1000100011
94320	0100100011
94440	1100100011
94560	0010100011
94680	1010100011
94800	0110100011
94920	1110100011
95040	0001100011
95160	1001100011
95280	0101100011
95400	1101100011
95520	0011100011
95640	1011100011
95760	0111100011
95880	1111100011
96000	0000010011
96120	1000010011
96240	0100010011
96360	1100010011
96480	0010010011
96600	1010010011
96720	0110010011
96840	1110010011
96960	0001010011
97080	1001010011
97200	0101010011
97320	1101010011
97440	0011010011
97560	1011010011

Pulses-Per-Mile (ppm)	Calibration Code
97680	0111010011
97800	1111010011
97920	0000110011
98040	1000110011
98160	0100110011
98280	1100110011
98400	0010110011
98520	1010110011
98640	0110110011
98760	1110110011
98880	0001110011
99000	1001110011
99120	0101110011
99240	1101110011
99360	0011110011
99480	1011110011
99600	0111110011
99720	1111110011
99840	0000001011
99960	1000001011
100080	0100001011
100200	1100001011
100320	0010001011
100440	1010001011
100560	0110001011
100680	1110001011
100800	0001001011
100920	1001001011
101040	0101001011
101160	1101001011
101280	0011001011
101400	1011001011
101520	0111001011
101640	1111001011
101760	0000101011
101880	1000101011

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
102000	0100101011
102120	1100101011
102240	0010101011
102360	1010101011
102480	0110101011
102600	1110101011
102720	0001101011
102840	1001101011
102960	0101101011
103080	1101101011
103200	0011101011
103320	1011101011
103440	0111101011
103560	1111101011
103680	0000011011
103800	1000011011
103920	0100011011
104040	1100011011
104160	0010011011
104280	1010011011
104400	0110011011
104520	1110011011
104640	0001011011
104760	1001011011
104880	0101011011
105000	1101011011
105120	0011011011
105240	1011011011
105360	0111011011
105480	1111011011
105600	0000111011
105720	1000111011
105840	0100111011
105960	1100111011
106080	0010111011
106200	1010111011

Pulses-Per-Mile (ppm)	Calibration Code
106320	0110111011
106440	1110111011
106560	0001111011
106680	1001111011
106800	0101111011
106920	1101111011
107040	0011111011
107160	1011111011
107280	0111111011
107400	1111111011
107520	0000000111
107640	1000000111
107760	0100000111
107880	1100000111
108000	0010000111
108120	1010000111
108240	0110000111
108360	1110000111
108480	0001000111
108600	1001000111
108720	0101000111
108840	1101000111
108960	0011000111
109080	1011000111
109200	0111000111
109320	1111000111
109440	0000100111
109560	1000100111
109680	0100100111
109800	1100100111
109920	0010100111
110040	1010100111
110160	0110100111
110280	1110100111
110400	0001100111
110520	1001100111

Pulses-Per-Mile (ppm)	Calibration Code
110640	0101100111
110760	1101100111
110880	0011100111
111000	1011100111
111120	0111100111
111240	1111100111
111360	0000010111
111480	1000010111
111600	0100010111
111720	1100010111
111840	0010010111
111960	1010010111
112080	0110010111
112200	1110010111
112320	0001010111
112440	1001010111
112560	0101010111
112680	1101010111
112800	0011010111
112920	1011010111
113040	0111010111
113160	1111010111
113280	0000110111
113400	1000110111
113520	0100110111
113640	1100110111
113760	0010110111
113880	1010110111
114000	0110110111
114120	1110110111
114240	0001110111
114360	1001110111
114480	0101110111
114600	1101110111
114720	0011110111
114840	1011110111

Pulses-Per-Mile (ppm)	Calibration Code
114960	0111110111
115080	1111110111
115200	0000001111
115320	1000001111
115440	0100001111
115560	1100001111
115680	0010001111
115800	1010001111
115920	0110001111
116040	1110001111
116160	0001001111
116280	1001001111
116400	0101001111
116520	1101001111
116640	0011001111
116760	1011001111
116880	0111001111
117000	1111001111
117120	0000101111
117240	1000101111
117360	0100101111
117480	1100101111
117600	0010101111
117720	1010101111
117840	0110101111
117960	1110101111
118080	0001101111
118200	1001101111
118320	0101101111
118440	1101101111
118560	0011101111
118680	1011101111
118800	0111101111
118920	1111101111
119040	0000011111
119160	1000011111

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
119280	0100011111
119400	1100011111
119520	0010011111
119640	1010011111
119760	0110011111
119880	1110011111
120000	0001011111
120120	1001011111
120240	0101011111
120360	1101011111
120480	0011011111
120600	1011011111
120720	0111011111
120840	1111011111
120960	0000111111
121080	1000111111
121200	0100111111
121320	1100111111
121440	0010111111
121560	1010111111
121680	0110111111
121800	1110111111
121920	0001111111
122040	1001111111
122160	0101111111
122280	1101111111
122400	0011111111
122520	1011111111
122640	0111111111
122760	1111111111

General Information

An air restriction gauge (**Fig. 1**) indicates how much air filter capacity has been used and how much remains. It registers the actual maximum restriction of the filter element (or elements, if two air cleaners are installed) when the engine is operating at full load. The yellow indicator inside the air restriction gauge retains the reading so that the remaining capacity can be read even after the engine is shut down.

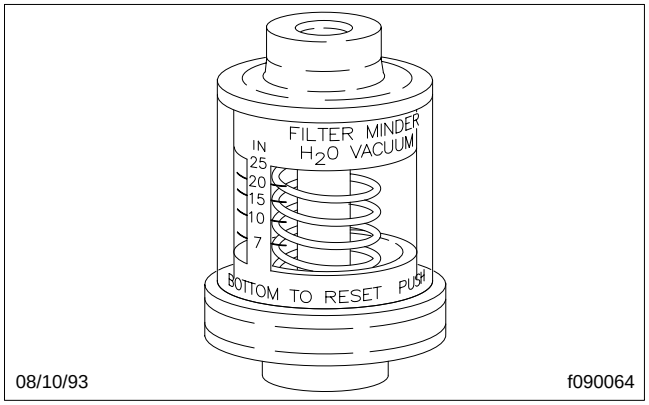


Fig. 1, Air Restriction Gauge (air cleaner-mounted type shown)

The air restriction gauge and tap fittings sometimes become plugged from moisture or engine vapors, possibly causing an incorrect reading.

IMPORTANT: Most engine degreasers are harmful to polycarbonate (Lexan) plastics that are used in air restriction gauges. When cleaning an engine or other components, avoid getting degreaser on these plastic parts.

The air restriction gauge is mounted on the air cleaner intake piping (**see Fig. 2**), or in the dash panel (**see Fig. 3**). A gauge mounted on the air cleaner or intake piping has a push-type reset button located at the end opposite the mounting fitting; only one gauge is used even when two air cleaners are installed. The reset button on the dash panel-mounted gauge is in the face of the gauge.

NOTE: Avoid opening the air cleaner and disturbing the seals or filter element until the yellow indicator shows maximum restriction ("red line") (**see Fig. 4**). When this occurs, the air cleaner(s) needs to be serviced; however, immediate engine shutdown is not necessary.

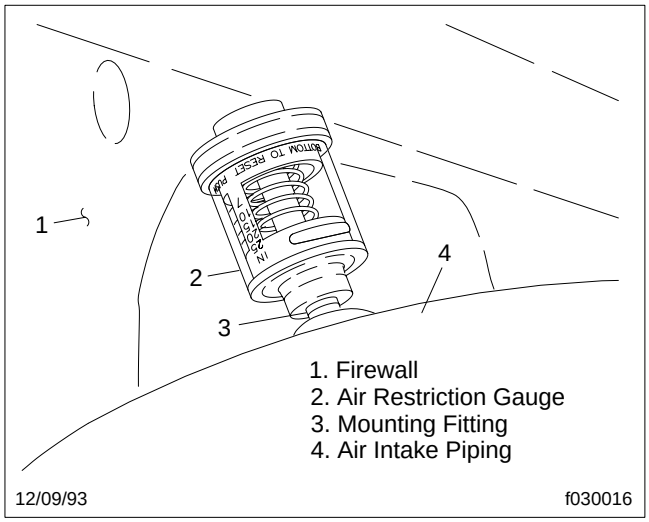


Fig. 2, Air Restriction Gauge Mounted on the Intake Piping

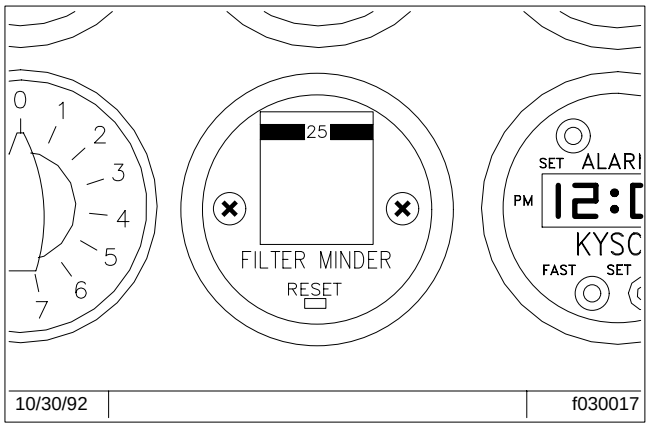


Fig. 3, Air Restriction Gauge Mounted in the Dash Panel

General Information

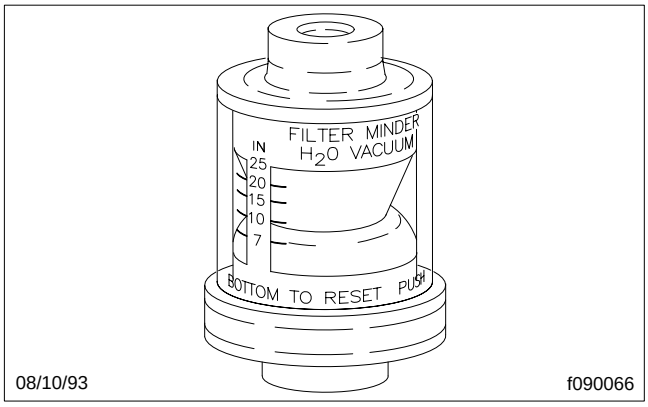


Fig. 4, Maximum Restriction

Replacement

DASH-MOUNTED

1. Apply the parking brakes.
2. Turn off the ignition switch.
3. Remove the two screws that attach the air restriction gauge to the panel. Remove the four panel screws and pull out the panel to gain access to the back of the gauge. Disconnect the air line.
4. Remove the gauge.
5. Install the new air restriction gauge using the instructions above, in reverse order.

AIR INTAKE PIPE MOUNTED

1. Chock the tires, then tilt the hood or cab. For cab-tilting instructions, see **Group 60**.
2. Using a wrench, unscrew the gauge from the air intake piping.
3. Install the new air restriction gauge using the instructions above, in reverse order.

NOTE: The fitting in the intake pipe is a special fitting incorporating an orifice and a filter. Be sure that the correct fitting is installed.

Troubleshooting

Problem—No Restriction Reading

Possible Cause	Remedy
The gauge leaks.	Remove the air restriction gauge. Apply a vacuum to the gauge until the yellow indicator reaches the red line. With your thumb on the mounting fitting, close the end of the gauge airtight. Hold in the reset button. The yellow indicator will drop slightly and then not move unless the gauge has a leak. If the gauge is functioning properly, install it and press the reset button. If the yellow indicator continues to move, replace the air restriction gauge. Repeat the troubleshooting procedure to verify that the new gauge does not leak. When the gauge is functioning properly, install it and press the reset button.
The air cleaner or intake pipe fitting or vacuum hose (dash-panel mounted gauge) is plugged.	Remove the air restriction gauge. Apply a vacuum to the gauge until the yellow indicator reaches the red line. Connect the gauge to the air cleaner or intake pipe fitting or yellow hose (as appropriate), and hold in the reset button. The yellow indicator will fully return to zero unless the fitting or vacuum hose line is plugged. (A slow return is normal due to the safety filter in the fitting.) If the gauge is functioning properly, press the reset button. On dash-panel mounted gauges, return the gauge to its mounting. If the yellow indicator does not fully return to zero, clear the fitting or vacuum hose line and repeat the procedure.
The vacuum hose line leaks (dash-panel mounted gauge).	Disconnect both ends of the vacuum hose line. Apply vacuum to the gauge until the indicator reaches the red line. Connect the gauge to the vacuum hose line and close the other end of the line airtight. Hold the reset button. The yellow indicator will drop slightly and then not move unless the vacuum hose line has a leak. If the gauge is functioning properly, install the vacuum hose line and return the gauge to the dash mounting; press the reset button. If the yellow indicator continues to move, replace the vacuum hose line. Repeat the troubleshooting procedure to verify that the new line does not also leak. When the gauge functions properly, install the vacuum hose line and return the gauge to the dash mounting; press the reset button.
Engine airflow is too low to generate a reading.	Turbocharged engines must be at full load to pull full engine airflow. Restrictions can be simulated by gradually closing off air intake. If there is still no restriction reading, check for leaks in the gauge or vacuum hose, as appropriate, and take corrective action.

Problem—High Restriction Readings

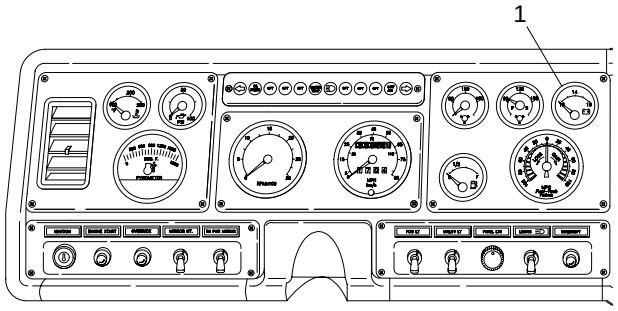
Possible Cause	Remedy
The element(s) is plugged or poorly cleaned.	Ultra-fine particles are difficult to remove, and cleaning may not sufficiently lower the restriction. Carefully attempt to unplug or clean the element(s); if unsuccessful, install a new filter element(s).
The safety filter is plugged (if equipped).	Do not clean the safety filter. Replace it with a new one.
The air cleaner(s) is undersized.	The air cleaner may be too small if a larger engine has been installed. Replace the undersized unit(s) with properly sized air cleaner.
The air restriction gauge is too close to the intake of an engine blower or turbo.	Under certain circumstances, air turbulence near the blower intakes may cause a high vacuum reading. locate the gauge away from the blower intake by at least 1-1/2 times the diameter of the intake tube.

Troubleshooting

Possible Cause	Remedy
The intake screens or ducts are plugged.	Check the system upstream from the air restriction gauge and remove any debris. Check for damage or improper installation, and take any necessary corrective action.
Heavy snow or rain.	Temporary high restriction can occur during a rain or snow storm and disappear after drying out. However, the cold air may be so dense that high restriction may not reduce the engine power before the element(s) is damaged. If the gauge reads maximum restriction (red line), check the element(s) for damage and replace if necessary.

General Description

The voltmeter, located on the upper right dash panel (**see Fig. 1**), indicates overall system voltage. Normally, the gauge shows about 12 volts, with the ignition on or off. It will show slightly less when the engine is started, and more when the alternator is recharging the batteries.



12/09/93 f600463a

1. Voltmeter

Fig. 1

Removal

See Fig. 1

1. Disconnect the batteries at the negative terminals.
2. Remove the upper right dash panel, then tilt it down to access the voltmeter.
3. Remove the voltmeter from the dash panel.
   - 3.1 Pull the light bulb and its plug (Ref. 7) from the back of the voltmeter.
   - 3.2 Disconnect the three-pin wiring connector (Ref. 5) from the back of the gauge.
   - 3.3 Remove the two nylon stopnuts (Ref. 4) from the studs at the back of the gauge, then remove the U-bracket (Ref. 3) from the studs.
   - 3.4 Remove the voltmeter from the dash panel.

Installation

1. Install the voltmeter in the dash panel.
   - 1.1 Install the voltmeter in the panel hole, making sure the tab (Ref. 6) at the bottom of the voltmeter lines up with the slot in the dash panel hole.
   - 1.2 Install the metal U-bracket over the studs at the back of the voltmeter, then install the nylon stopnuts on the studs. Tighten them so the U-bracket holds the voltmeter securely in the dash panel.
   - 1.3 Connect the three-pin electrical connector to the back of the voltmeter.
   - 1.4 Install the light bulb and plug into the back of the voltmeter.
2. Install the dash panel; tighten the screws firmly.
3. Connect the batteries at the negative terminals.

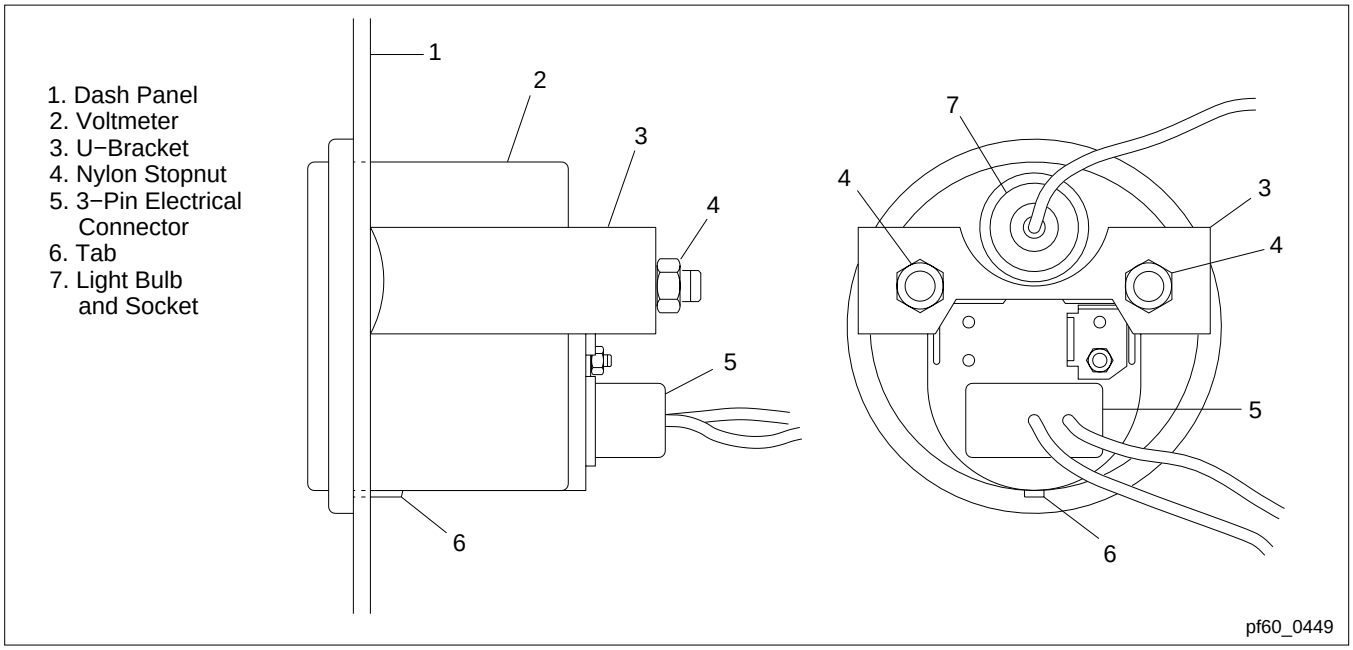


Fig. 1

See **Fig. 1** for a full view of the PEEC wiring diagram. See **Fig. 2**, **Fig. 3**, or **Fig. 4** for partial (detailed) views of the PEEC wiring diagram.

See **Fig. 5** for the PEEC wiring diagram, engine harness.

See **Fig. 6** for the PEEC Jake Brake wiring diagram.

See **Fig. 7** for a full view of the PEEC III wiring diagram. See **Fig. 8**, or **Fig. 9** for partial (detailed) views of the PEEC III wiring diagram.

See **Fig. 10** for the PEEC III Jake Brake wiring diagram, COE.

Fig. 11 for the PEEC III Jake Brake wiring diagram, Conventional.

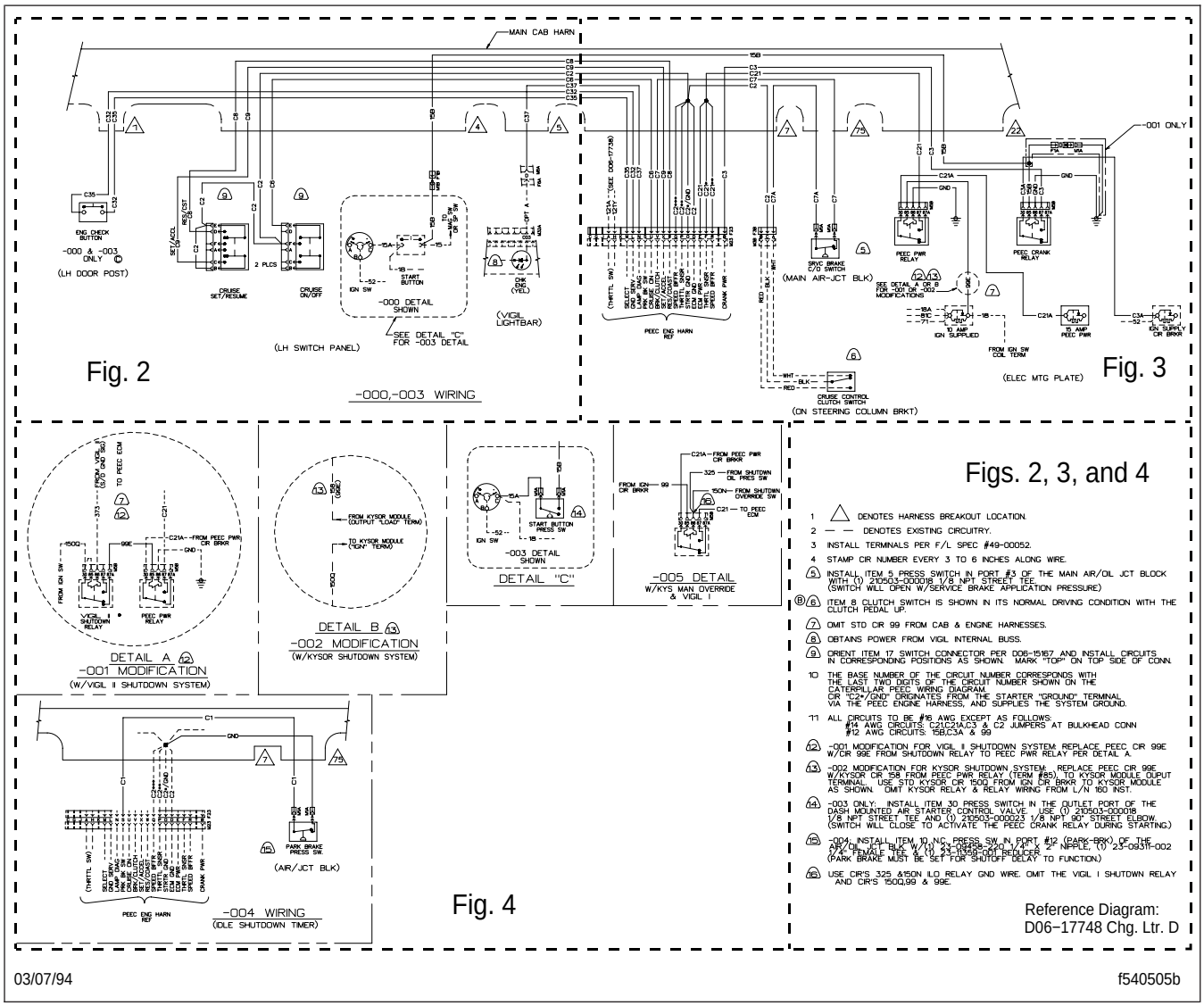


Fig. 1, PEEC Wiring Diagram

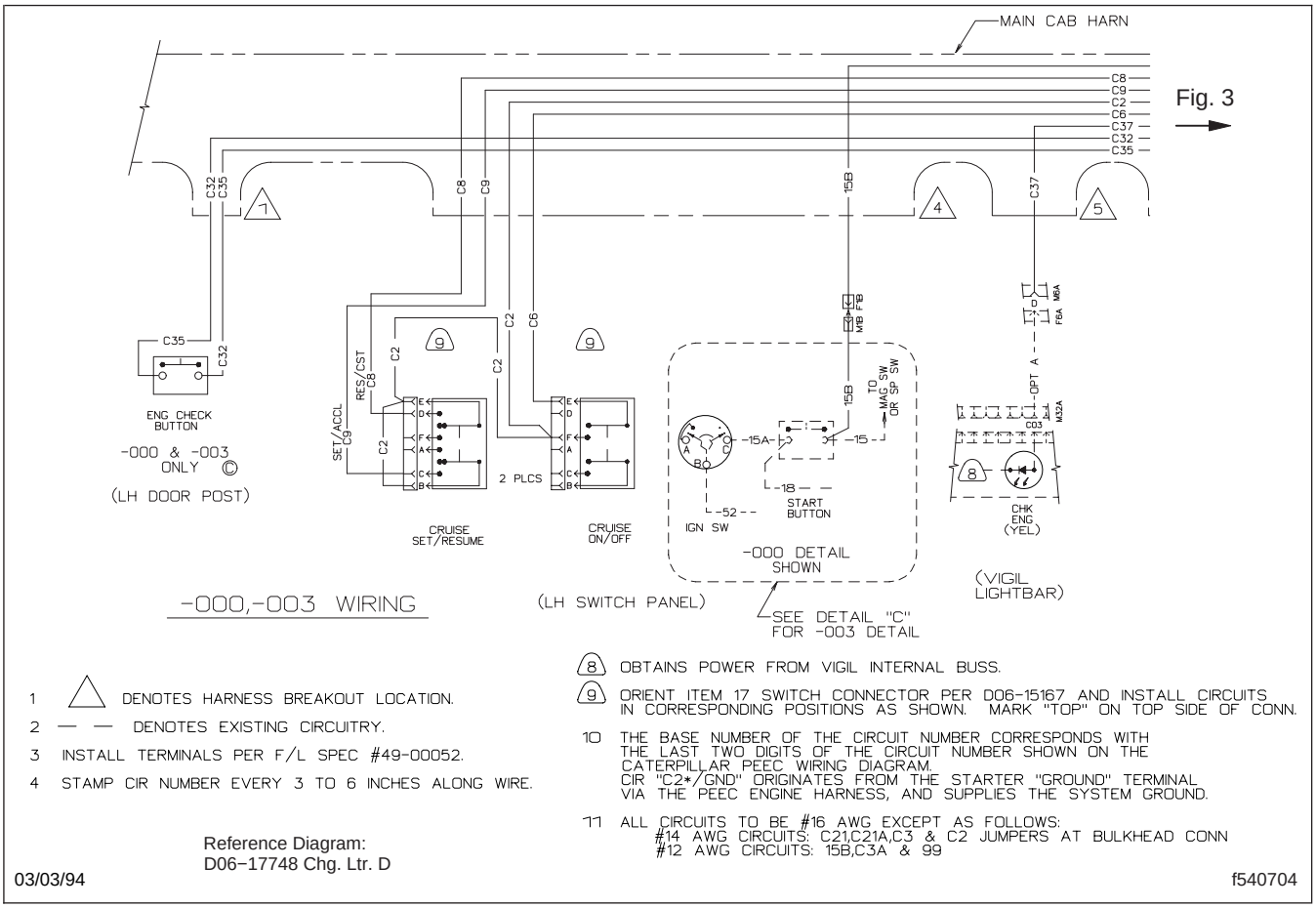
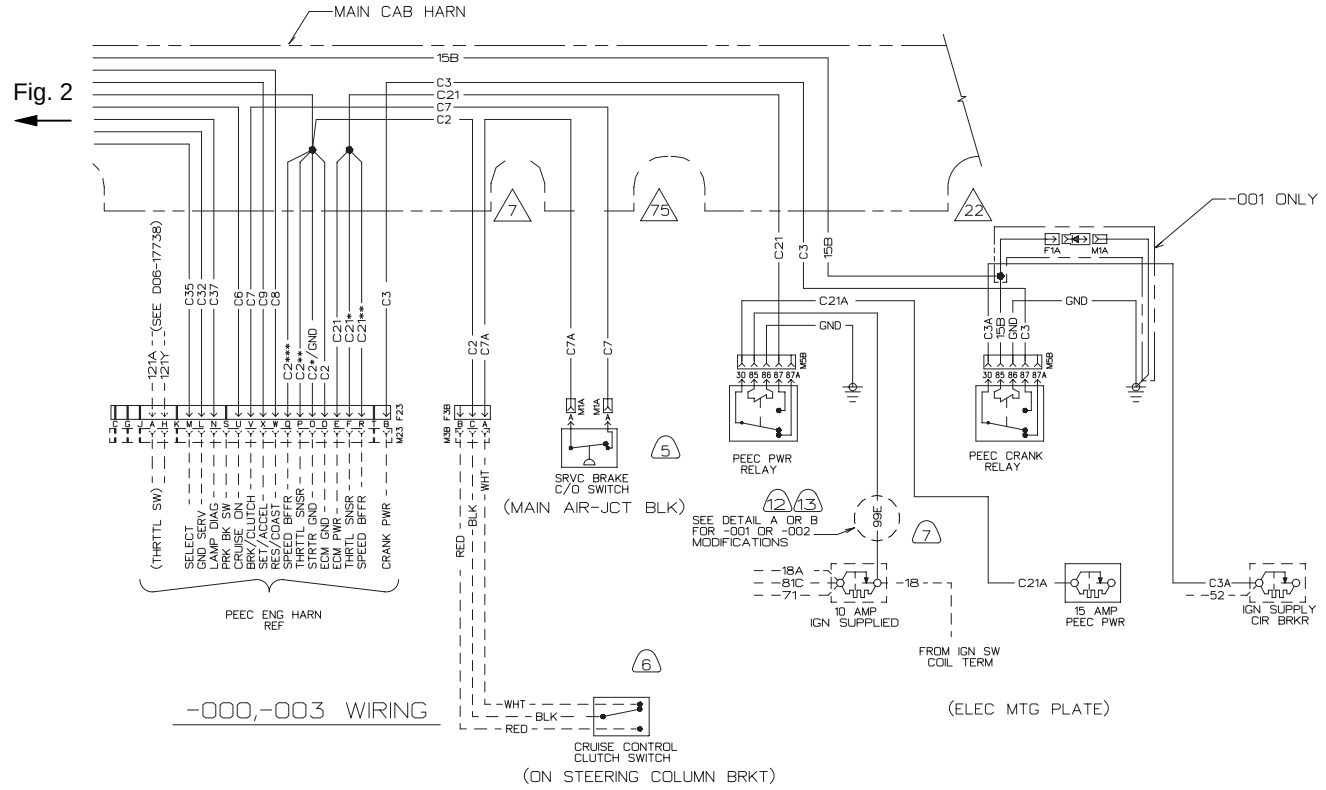

MAIN CAB HARN
C8
C9
C2
C6
C37
C32
C35
Fig. 3
C32
C35
1
C8
C9
15B
4
C37
5
C35
C32
ENG CHECK BUTTON
-000 & -003 ONLY ©
(LH DOOR POST)
SET/ACCL
C9
RES/CST
C8
C2
9
C2
C6
9
2 PLCS
CRUISE SET/RESUME
CRUISE ON/OFF
MEB F18
15B
TO MAG SW OR SP SW
-15A-
-15-
-18-
START BUTTON
-52-
IGN SW
-000 DETAIL SHOWN
SEE DETAIL "C" FOR -003 DETAIL
(LH SWITCH PANEL)
D
F6A
M6A
-OPT A-
C3
M32A
8
CHK ENG (YEL)
(VIGIL LIGHTBAR)
-000,-003 WIRING
1 DENOTES HARNESS BREAKOUT LOCATION.
2 — — DENOTES EXISTING CIRCUITRY.
3 INSTALL TERMINALS PER F/L SPEC #49-00052.
4 STAMP CIR NUMBER EVERY 3 TO 6 INCHES ALONG WIRE.
8 OBTAINS POWER FROM VIGIL INTERNAL BUSS.
9 ORIENT ITEM 17 SWITCH CONNECTOR PER D06-15167 AND INSTALL CIRCUITS IN CORRESPONDING POSITIONS AS SHOWN. MARK "TOP" ON TOP SIDE OF CONN.
10 THE BASE NUMBER OF THE CIRCUIT NUMBER CORRESPONDS WITH THE LAST TWO DIGITS OF THE CIRCUIT NUMBER SHOWN ON THE CATERPILLAR PEEC WIRING DIAGRAM. CIR "C2*/GND" ORIGINATES FROM THE STARTER "GROUND" TERMINAL VIA THE PEEC ENGINE HARNESS, AND SUPPLIES THE SYSTEM GROUND.
11 ALL CIRCUITS TO BE #16 AWG EXCEPT AS FOLLOWS:
#14 AWG CIRCUITS: C21,C21A,C3 & C2 JUMPERS AT BULKHEAD CONN
#12 AWG CIRCUITS: 15B,C3A & 99
Reference Diagram:
D06-17748 Chg. Ltr. D
03/03/94
f540704

Fig. 2

Fig. 2



1 △ DENOTES HARNESS BREAKOUT LOCATION.

2 — — DENOTES EXISTING CIRCUITRY.

3 INSTALL TERMINALS PER F/L SPEC #49-00052.

4 STAMP CIR NUMBER EVERY 3 TO 6 INCHES ALONG WIRE.

5 INSTALL ITEM 5 PRESS SWITCH IN PORT #3 OF THE MAIN AIR/OIL JCT BLOCK WITH (1) 210503-000018 1/8 NPT STREET TEE. (SWITCH WILL OPEN W/SERVICE BRAKE APPLICATION PRESSURE)

B 6 ITEM 8 CLUTCH SWITCH IS SHOWN IN ITS NORMAL DRIVING CONDITION WITH THE CLUTCH PEDAL UP.

7 OMIT STD CIR 99 FROM CAB & ENGINE HARNESSES.

10 THE BASE NUMBER OF THE CIRCUIT NUMBER CORRESPONDS WITH THE LAST TWO DIGITS OF THE CIRCUIT NUMBER SHOWN ON THE CATERPILLAR PEEC WIRING DIAGRAM. CIR "C2*/GND" ORIGINATES FROM THE STARTER "GROUND" TERMINAL VIA THE PEEC ENGINE HARNESS, AND SUPPLIES THE SYSTEM GROUND.

11 ALL CIRCUITS TO BE #16 AWG EXCEPT AS FOLLOWS:
#14 AWG CIRCUITS: C21,C21A,C3 & C2 JUMPERS AT BULKHEAD CONN
#12 AWG CIRCUITS: 15B,C3A & 99

12 -001 MODIFICATION FOR VIGIL II SHUTDOWN SYSTEM: REPLACE PEEC CIR 99E W/CIR 99E FROM SHUTDOWN RELAY TO PEEC PWR RELAY PER DETAIL A.

13 -002 MODIFICATION FOR KYSOR SHUTDOWN SYSTEM: REPLACE PEEC CIR 99E W/KYSOR CIR 158 FROM PEEC PWR RELAY (TERM #85), TO KYSOR MODULE OUPUT TERMINAL. USE STD KYSOR CIR 150Q FROM IGN CIR BRKR TO KYSOR MODULE AS SHOWN. OMIT KYSOR RELAY & RELAY WIRING FROM L/N 160 INST.

Reference Diagram:
D06−17748 Chg. Ltr. D

03/03/94

f540705

Fig. 3

Specifications

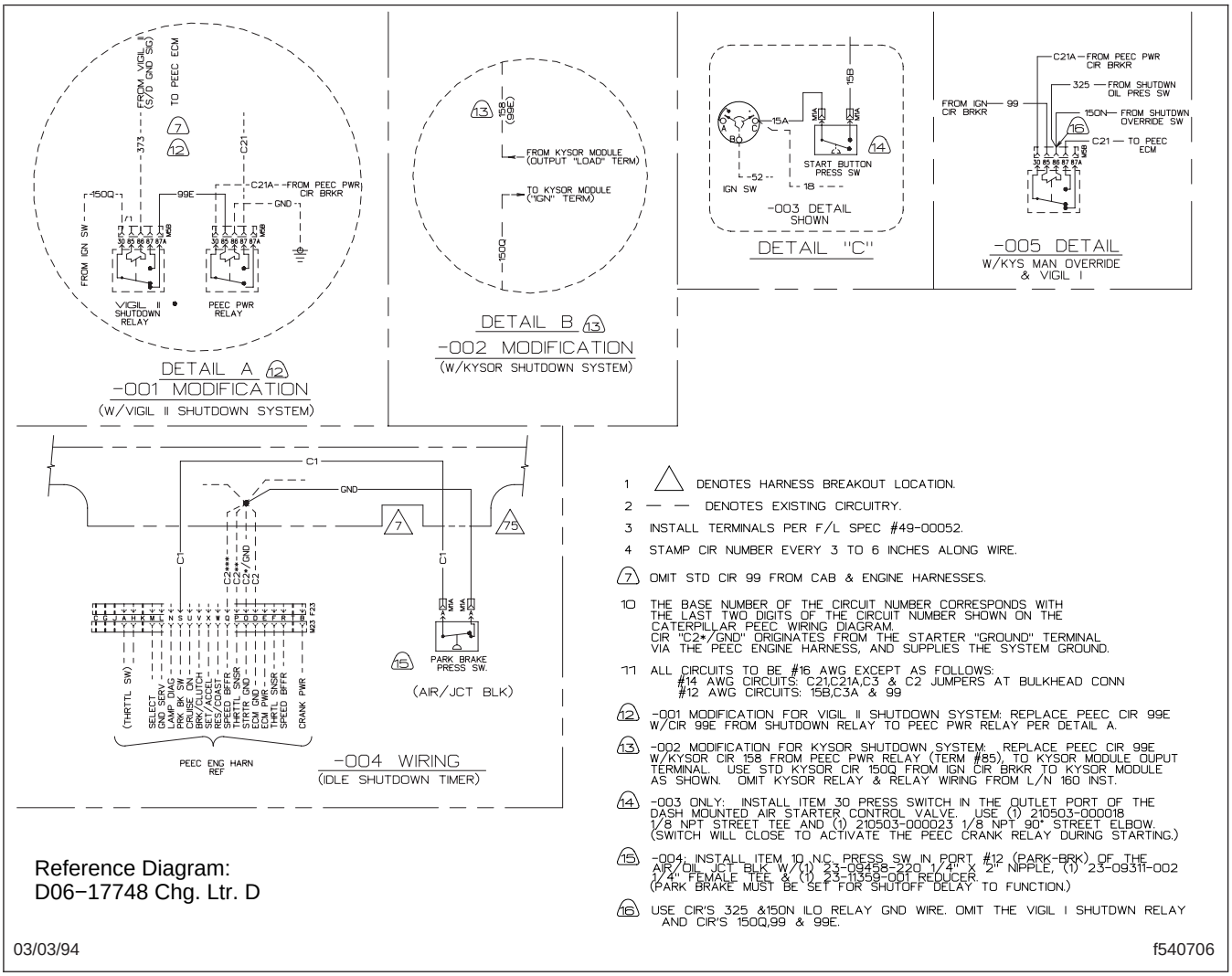


Fig. 4

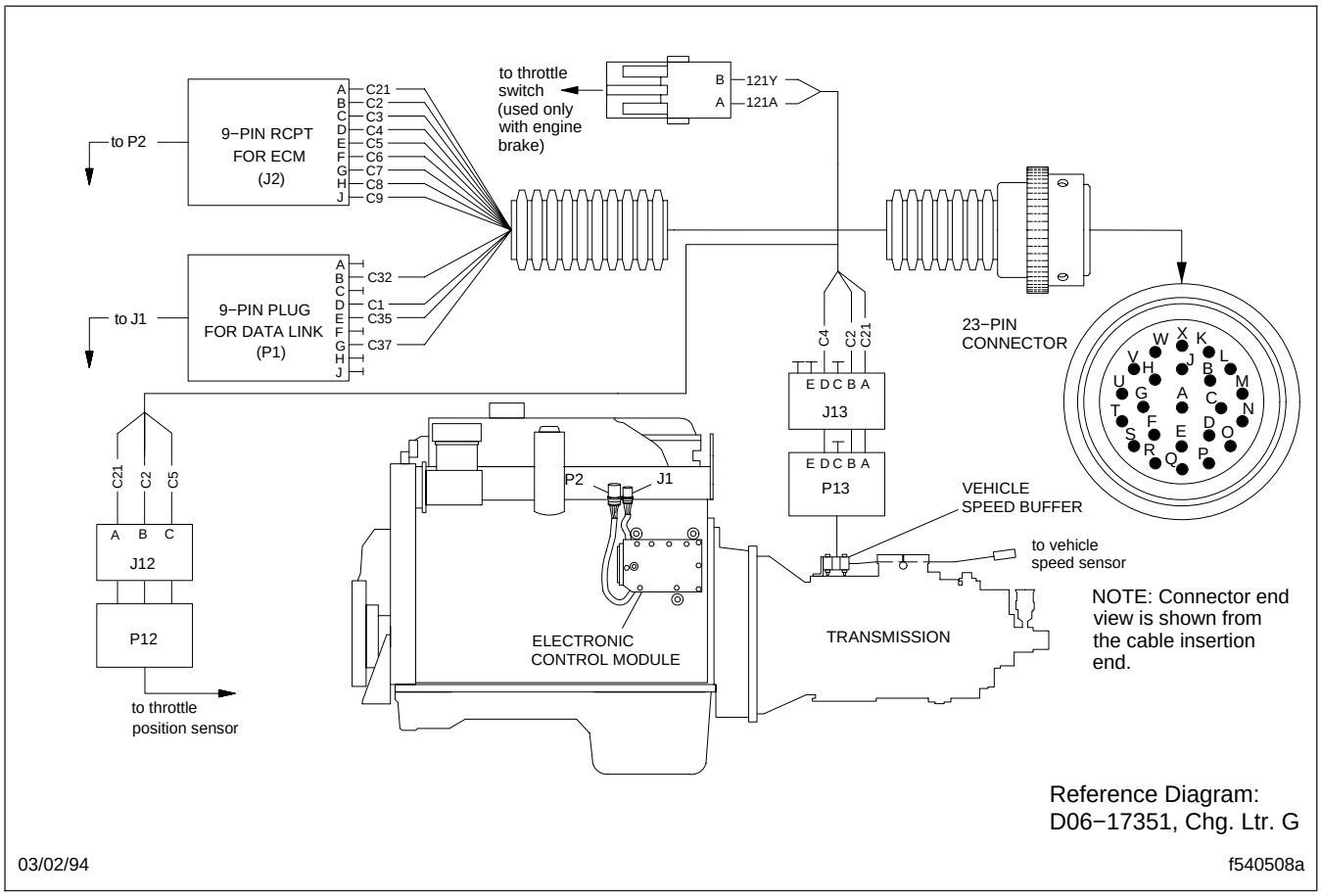


Fig. 5, PEEC Wiring Diagram, Engine Harness

Specifications

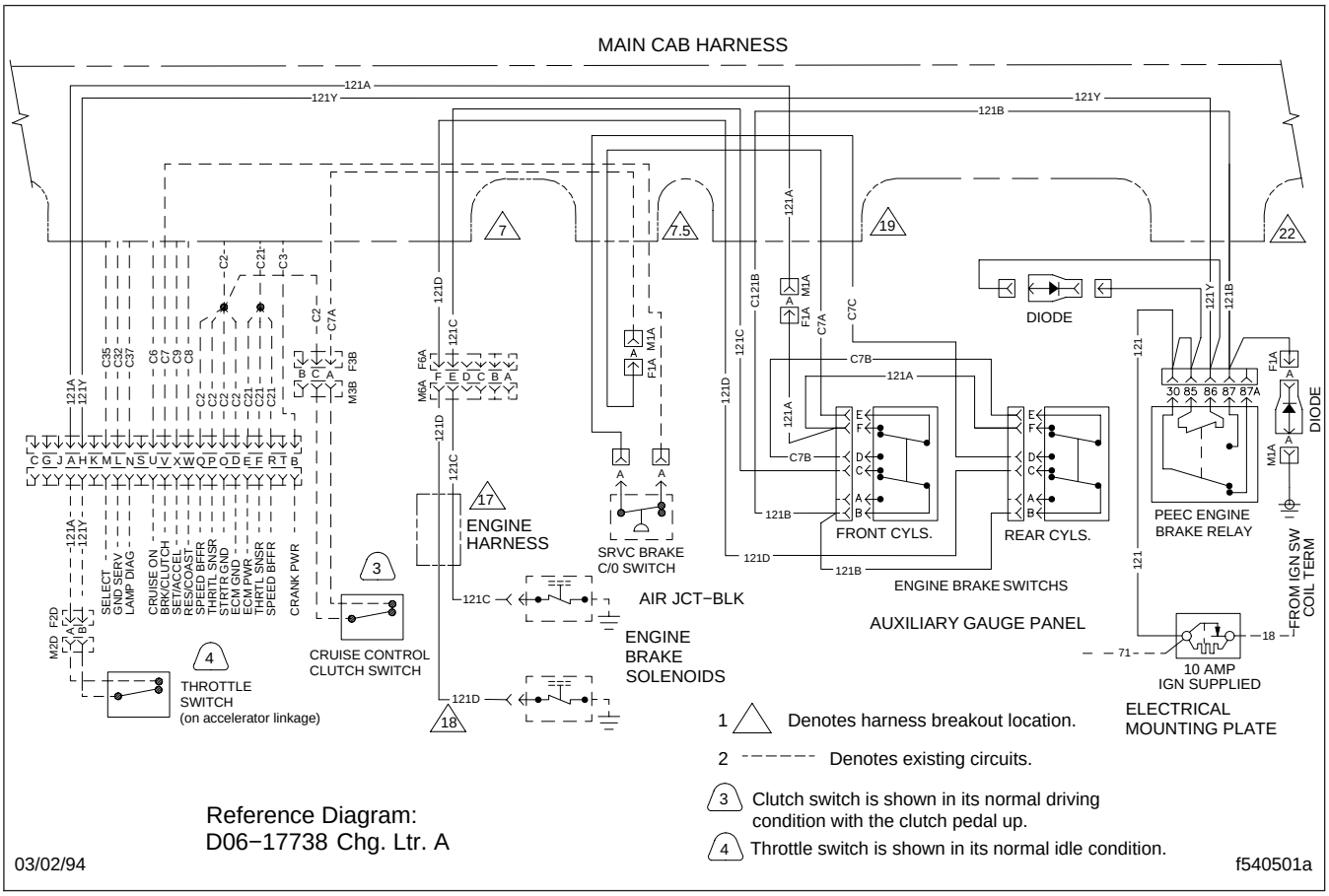


Fig. 6, PEEC Jake Brake Wiring Diagram

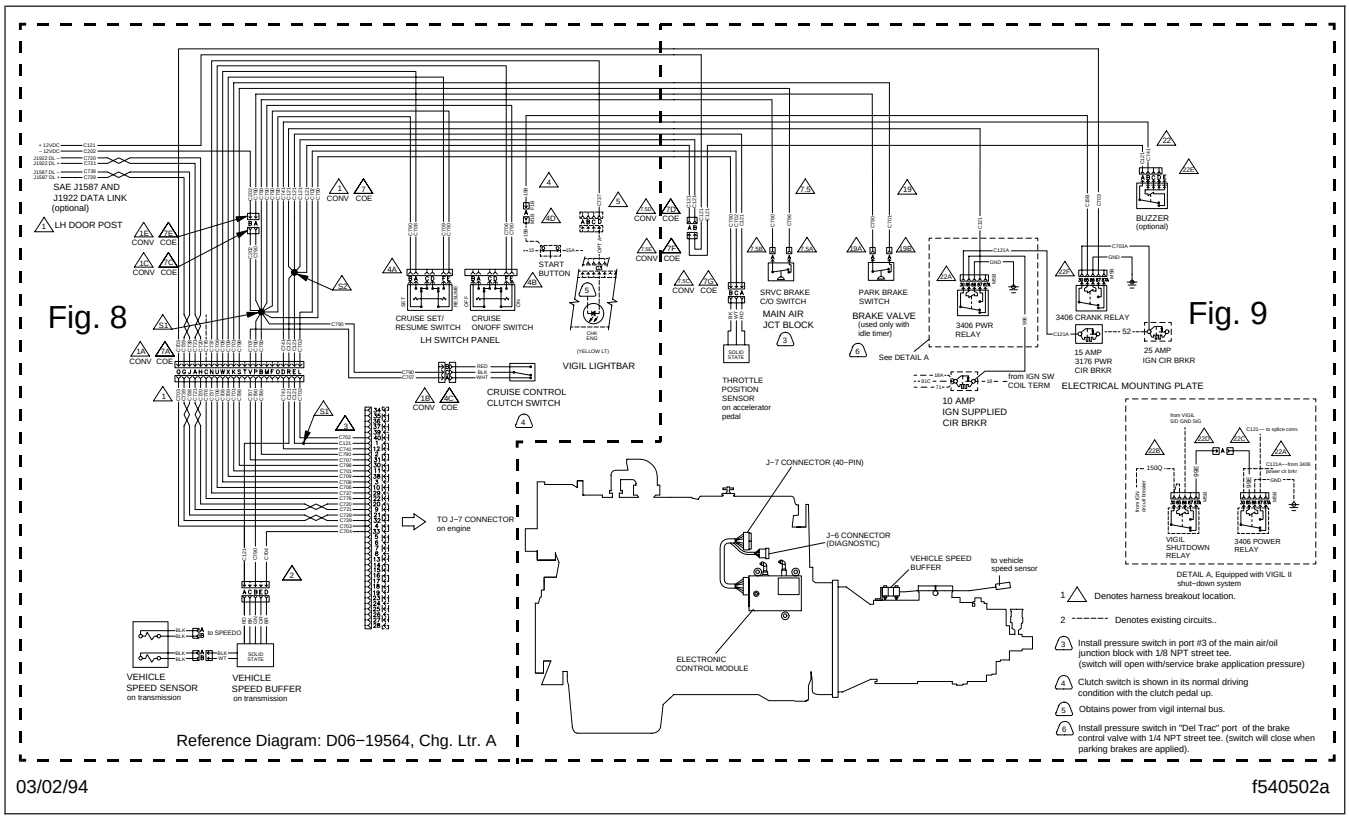


Fig. 7, PEEC III Wiring Diagram

Specifications

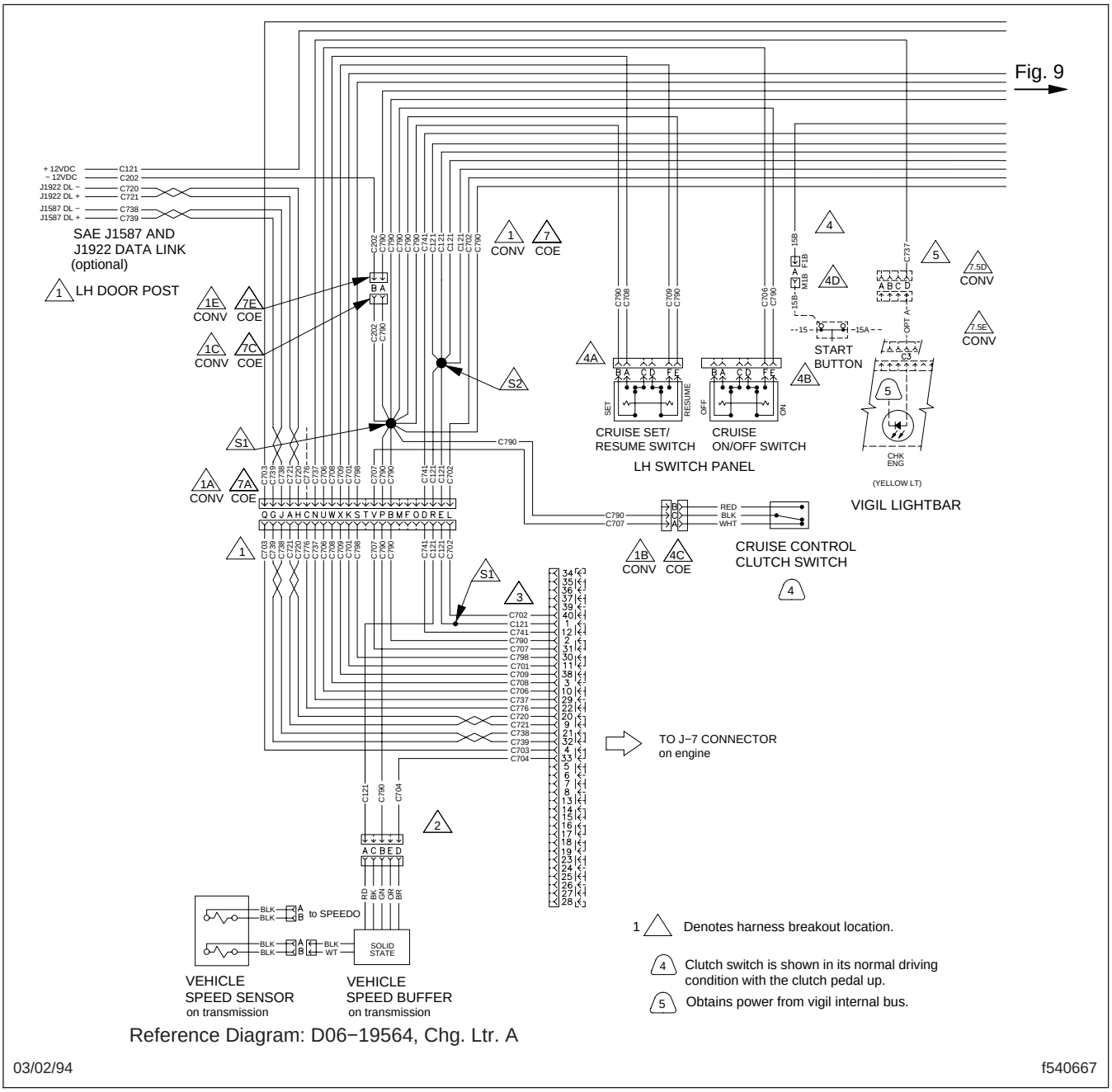


Fig. 8

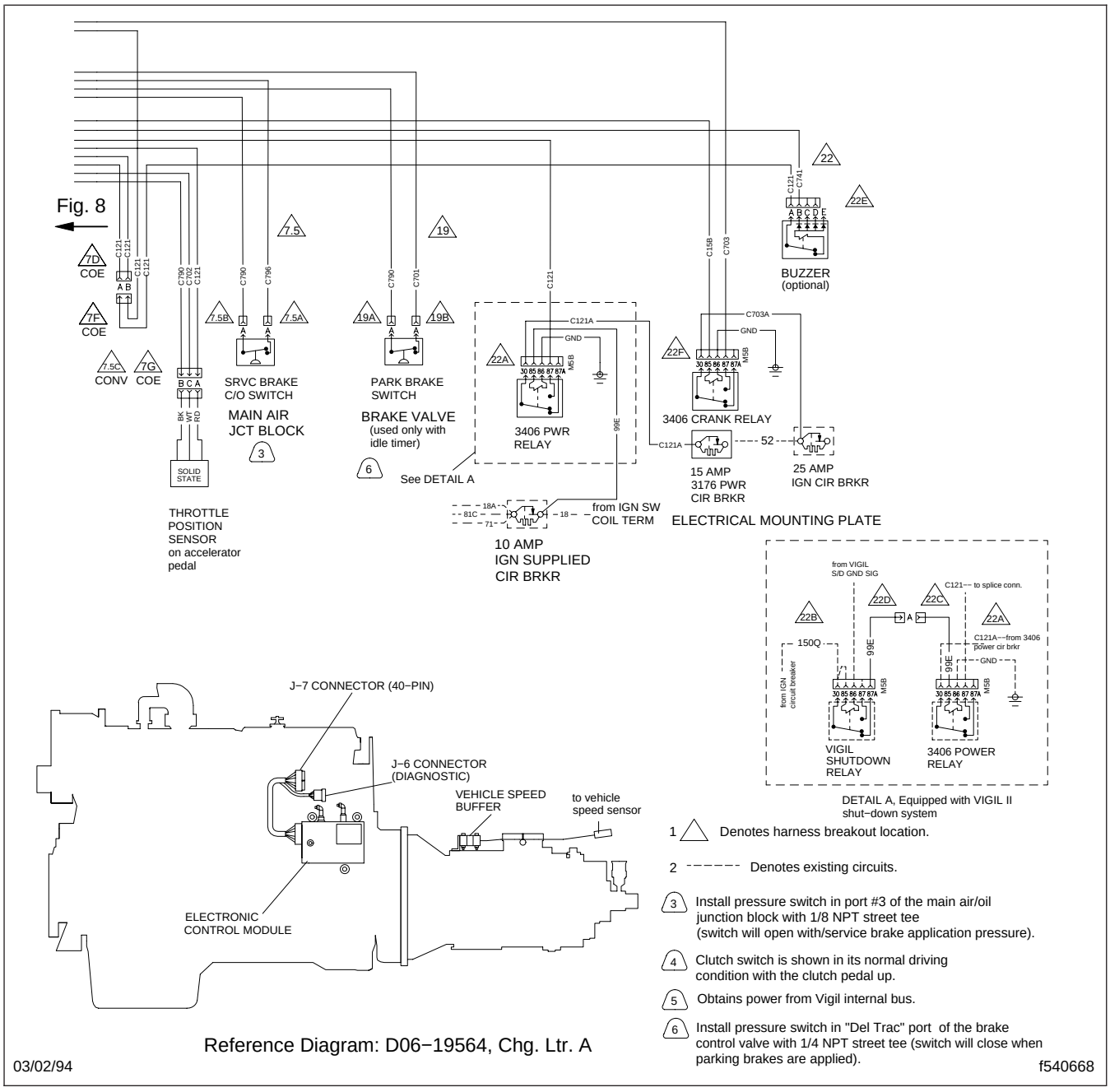


Fig. 8
7D COE
7F COE
7.5C CONV
7G COE
7.5
7.5B
7.5A
19
19A
19B
22
22E
BUZZER (optional)
SRVC BRAKE C/O SWITCH
PARK BRAKE SWITCH
MAIN AIR JCT BLOCK
BRAKE VALVE (used only with idle timer)
3406 PWR RELAY
3406 CRANK RELAY
15 AMP 3176 PWR CIR BRKR
25 AMP IGN CIR BRKR
ELECTRICAL MOUNTING PLATE
THROTTLE POSITION SENSOR on accelerator pedal
See DETAIL A
from IGN SW COIL TERM
10 AMP IGN SUPPLIED CIR BRKR
J−7 CONNECTOR (40−PIN)
J−6 CONNECTOR (DIAGNOSTIC)
VEHICLE SPEED BUFFER
to vehicle speed sensor
ELECTRONIC CONTROL MODULE
from VIGIL S/D GND SIG
C121 to splice conn.
C121A from 3406 power cir brkr
150Q
from IGN circuit breaker
VIGIL SHUTDOWN RELAY
3406 POWER RELAY
DETAIL A, Equipped with VIGIL II shut−down system
1 Denotes harness breakout location.
2 Denotes existing circuits.
3 Install pressure switch in port #3 of the main air/oil junction block with 1/8 NPT street tee (switch will open with/service brake application pressure).
4 Clutch switch is shown in its normal driving condition with the clutch pedal up.
5 Obtains power from Vigil internal bus.
6 Install pressure switch in "Del Trac" port of the brake control valve with 1/4 NPT street tee (switch will close when parking brakes are applied).
Reference Diagram: D06−19564, Chg. Ltr. A
03/02/94
f540668

Fig. 9

Specifications

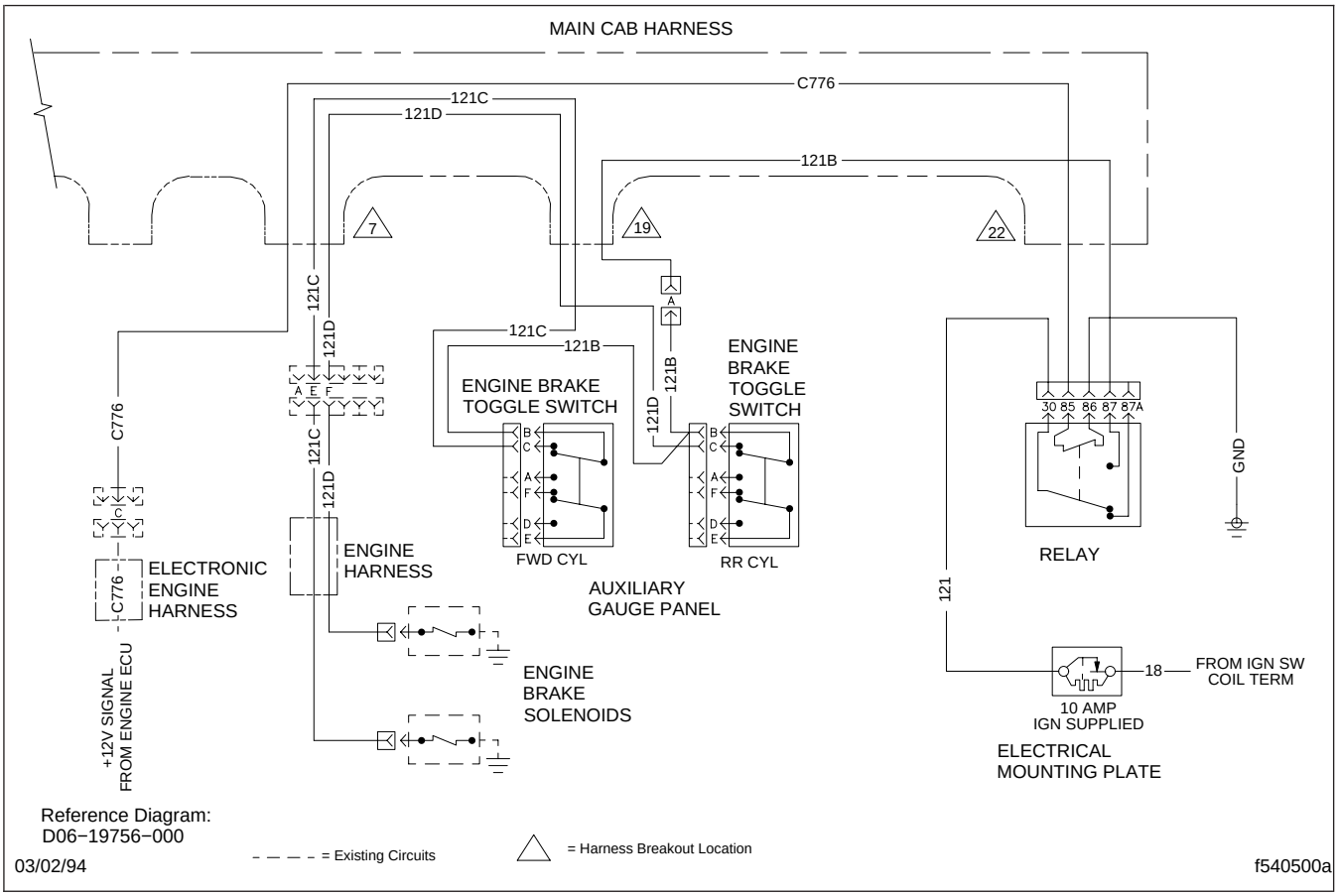


Fig. 10, PEEC III Jake Brake Wiring Diagram, COE

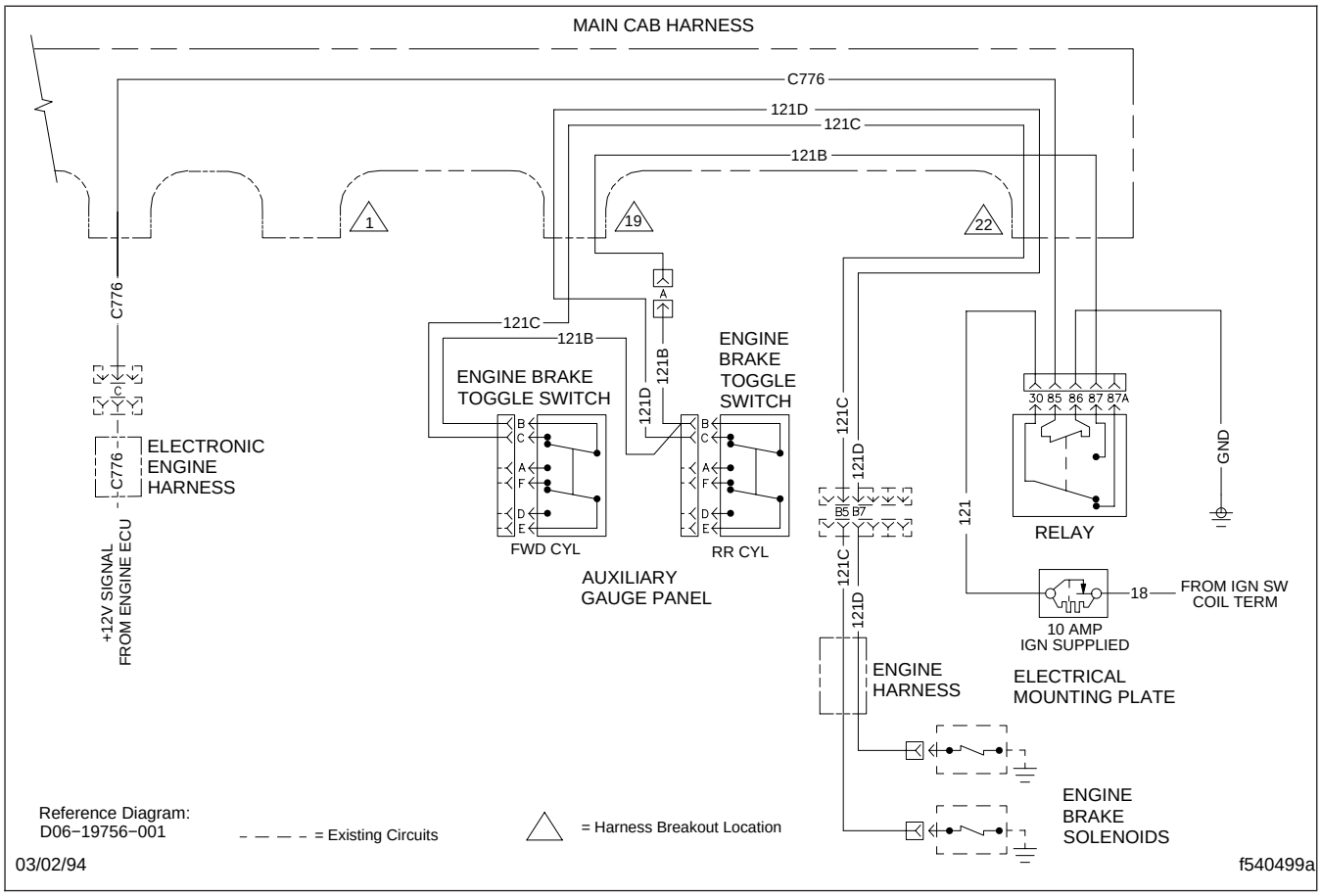


Fig. 11, PEEC III Jake Brake Wiring Diagram, Conventional

General Information

In general, the wiring diagrams **in "Specifications, 400"** show only those wiring circuits installed by Freightliner at the factory. For detailed engine wiring, refer to the applicable Caterpillar service manual.

To determine which 3176 version an engine is, check the serial number on the electronic control module (refer to the appropriate figure in **"Specifications, 400"**). Pre-1991 version engines have "2YG" before the serial number, and 1991 versions have "7LG" before the serial number.

Specifications

See Fig. 1 for a full view of the 3176 wiring diagram, 2YG version. **See Fig. 2**, or **Fig. 3** for partial (detailed) views of the 3176 wiring diagram, 2YG version.

See Fig. 4 for the 3176 Jake Brake wiring diagram, COE (2YG version)

See Fig. 5 for the 3176 Jake Brake wiring diagram, Conventional (2YG version)

See Fig. 6 for a full view of the 3176 wiring diagram, 7LG version (without engine monitoring system). **See Fig. 7**, or **Fig. 8** for partial (detailed) views of the 3176 wiring diagram, 7LG version (without engine monitoring system).

See Fig. 9 for a full view of the 3176 wiring diagram, 7LG version (with engine monitoring system). **See Fig. 10**, or **Fig. 11** for partial (detailed) views of the 3176 wiring diagram, 7LG version (with engine monitoring system).

See Fig. 12 for the 3176 Jake Brake wiring diagram, COE (7LG version).

See Fig. 13 for the 3176 Jake Brake wiring diagram, Conventional (7LG version).

Specifications

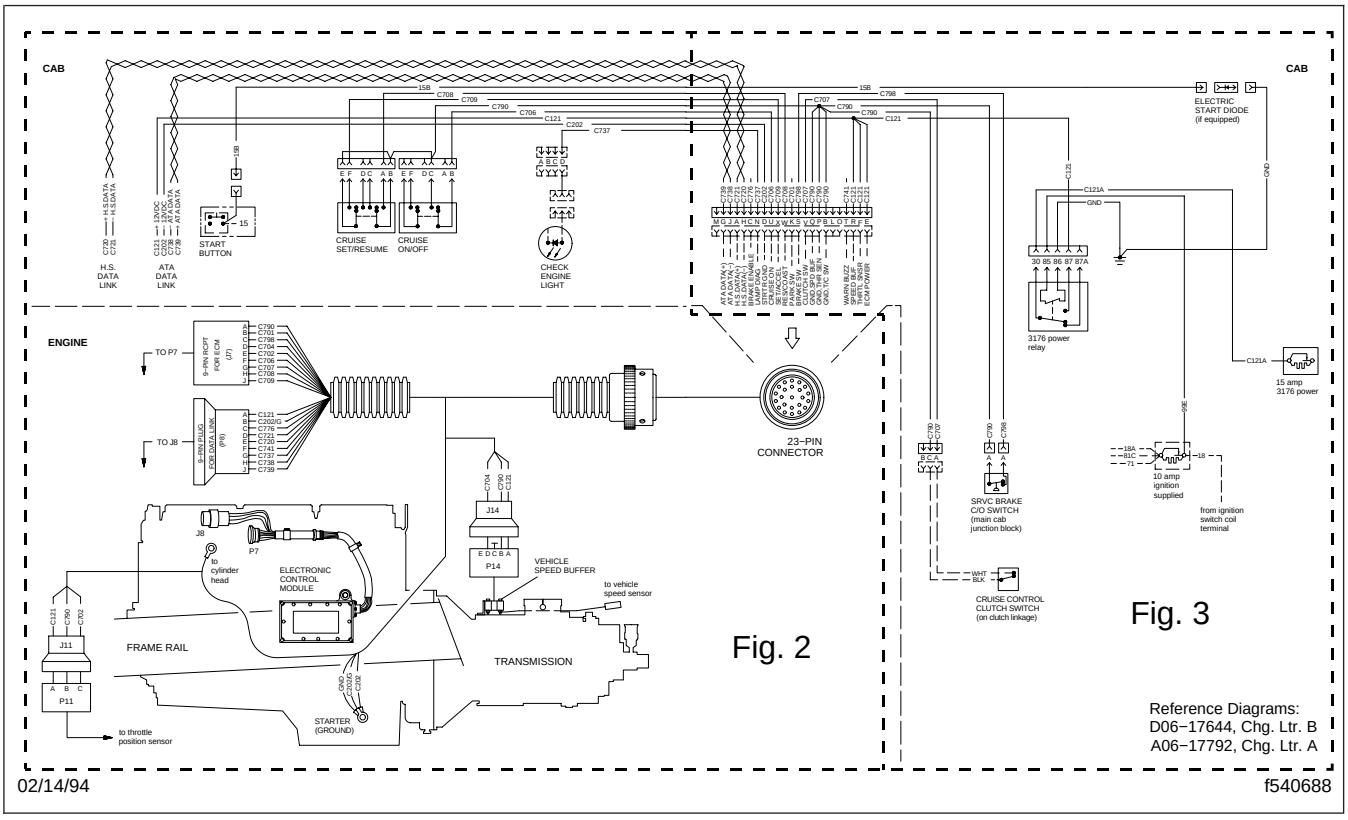


Fig. 1, 3176 Wiring Diagram, 2YG Version

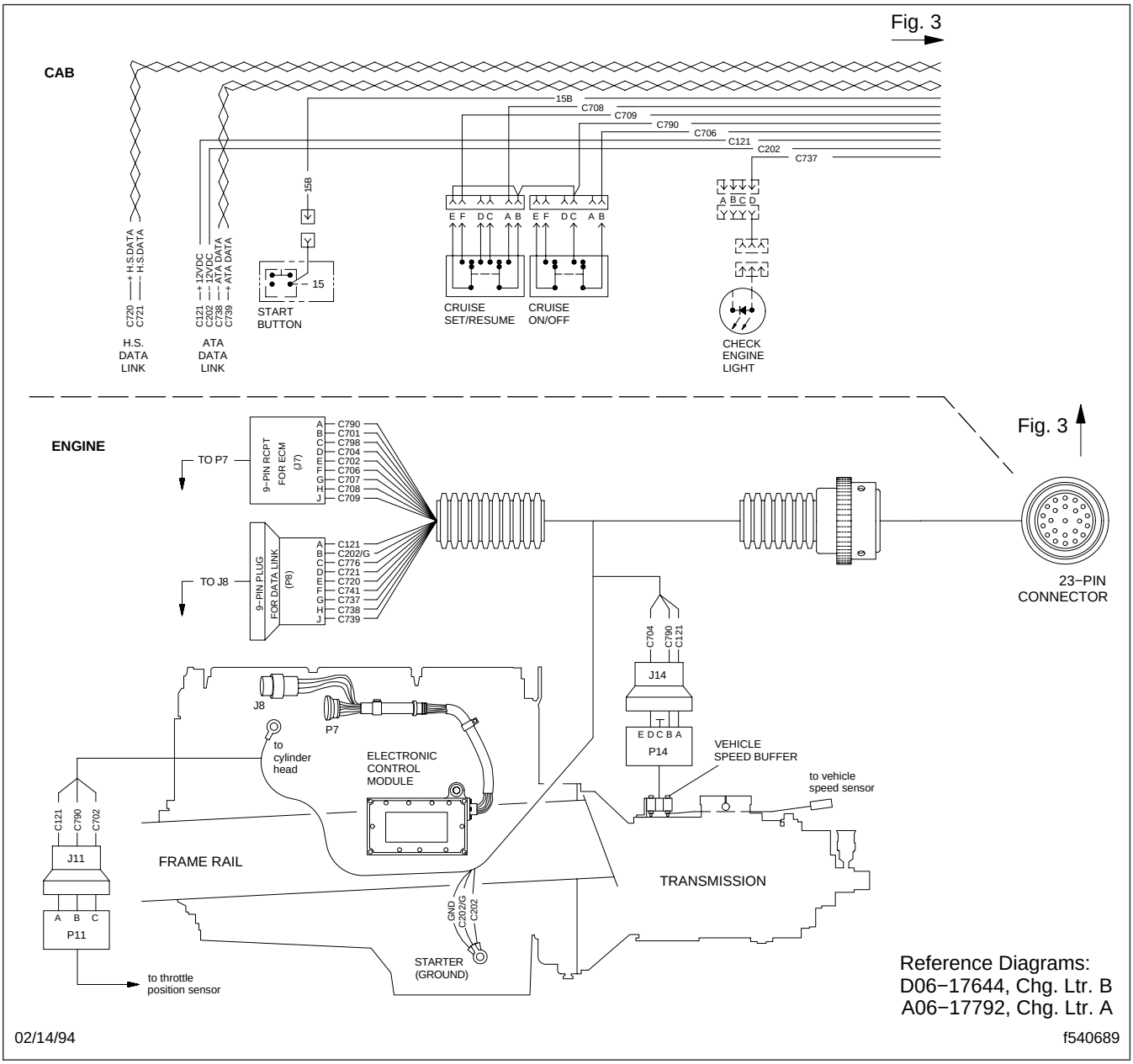


Fig. 3
CAB
15B
C708
C709
C790
C706
C121
C202
C737
C720
C721
H.S.DATA
H.S.DATA
C121
C202
C738
C739
12VDC
12VDC
ATA DATA
ATA DATA
15
START BUTTON
E F D C A B
CRUISE SET/RESUME
CRUISE ON/OFF
A B C D
CHECK ENGINE LIGHT
H.S. DATA LINK
ATA DATA LINK
Fig. 3
ENGINE
TO P7
9−PIN RCPT FOR ECM (J7)
C790
C701
C798
C704
C702
C706
C707
C708
C709
TO J8
9−PIN PLUG FOR DATA LINK (P8)
C121
C202/G
C776
C721
C720
C741
C737
C738
C739
23−PIN CONNECTOR
J8
P7
to cylinder head
ELECTRONIC CONTROL MODULE
C704
C790
C121
J14
E D C B A
P14
VEHICLE SPEED BUFFER
to vehicle speed sensor
C121
C790
C702
J11
A B C
P11
FRAME RAIL
TRANSMISSION
GND
C202/G
C202
STARTER (GROUND)
to throttle position sensor
Reference Diagrams:
D06−17644, Chg. Ltr. B
A06−17792, Chg. Ltr. A
02/14/94
f540689

Fig. 2

Specifications

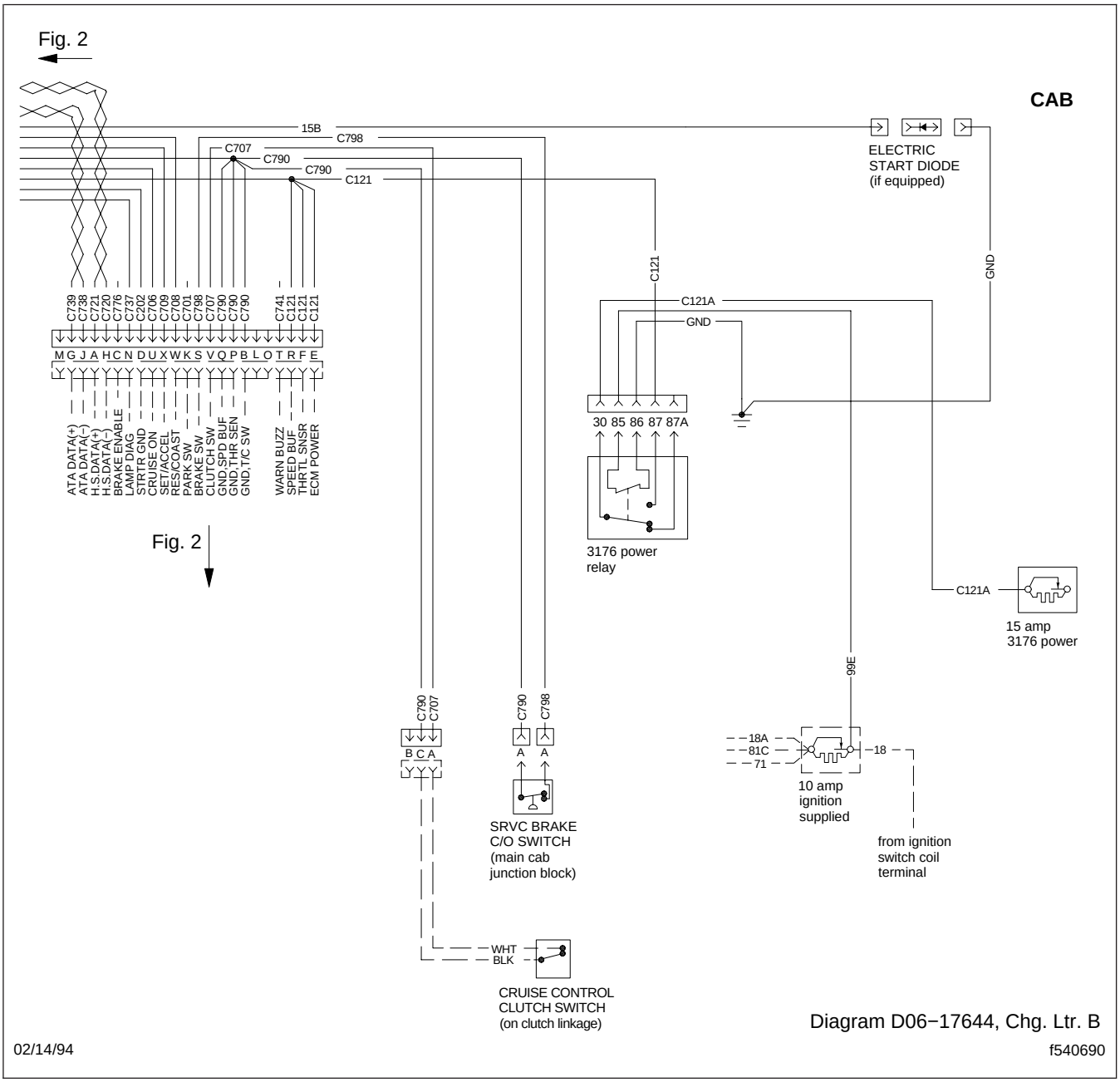


Fig. 3

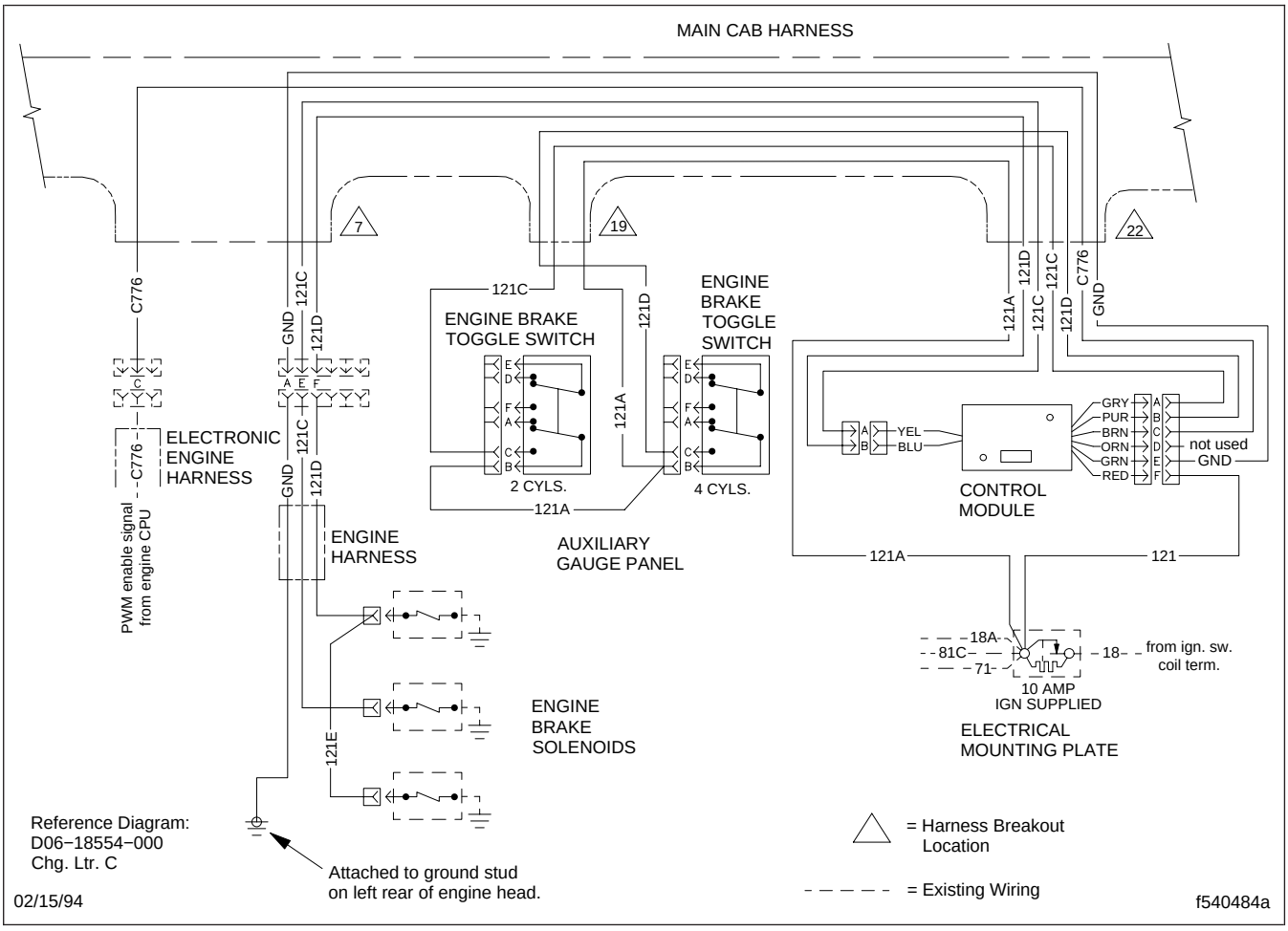


Fig. 4, 3176 Jake Brake Wiring Diagram, COE (2YG Version)

Specifications

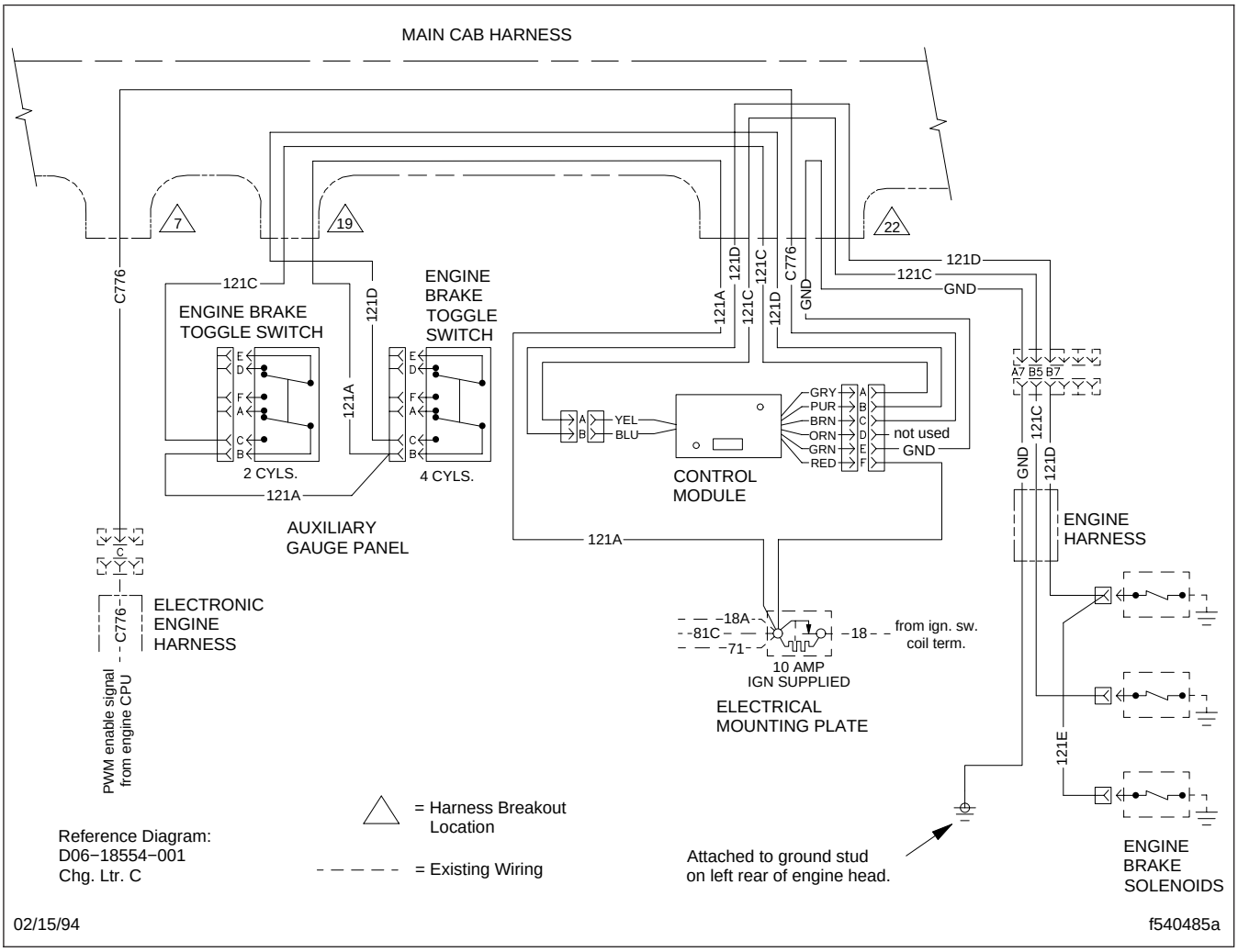


Fig. 5, 3176 Jake Brake Wiring Diagram, Conventional (2YG Version)

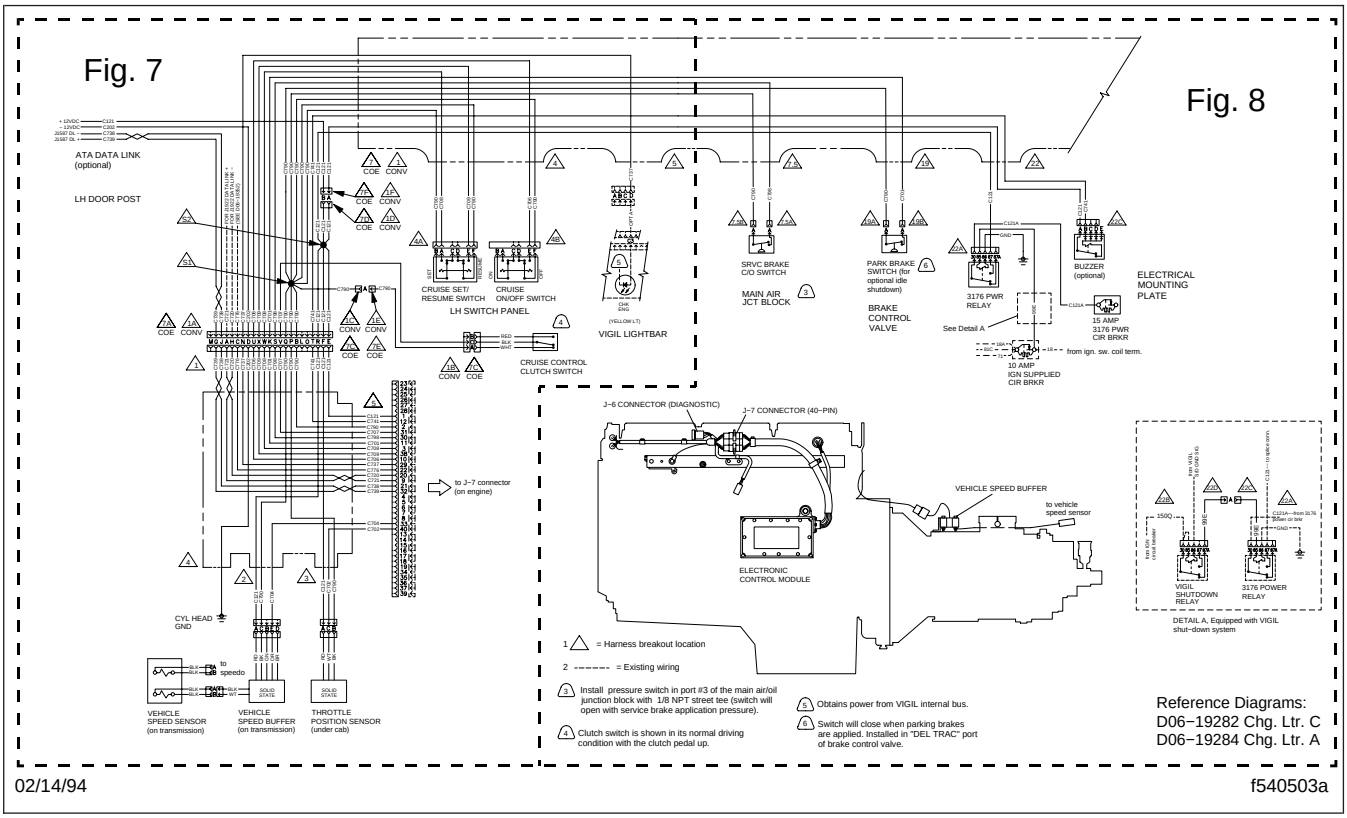


Fig. 6, 3176 Wiring Diagram, 7LG Version (without engine monitoring system)

Specifications

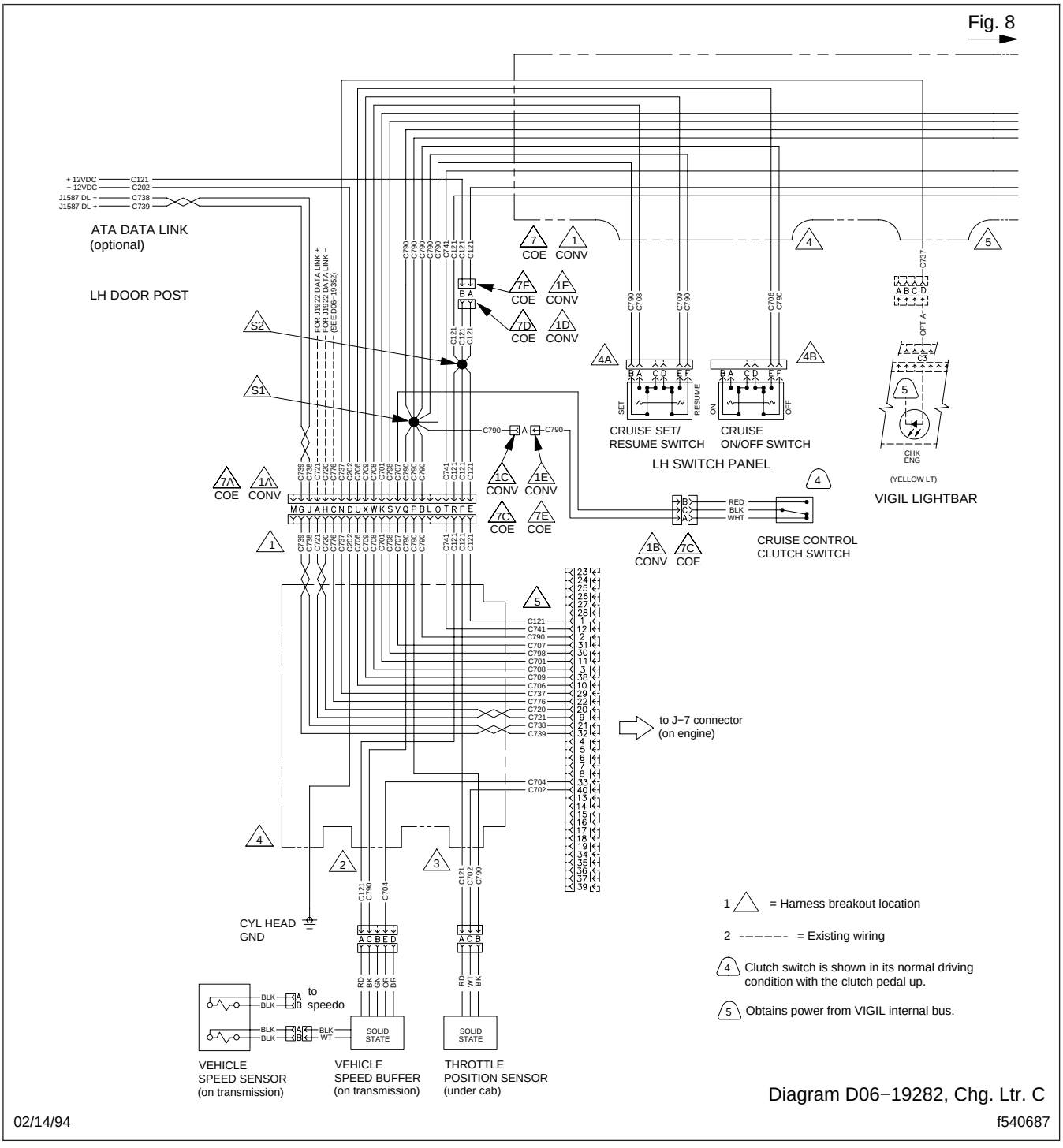


Fig. 7

Fig. 7

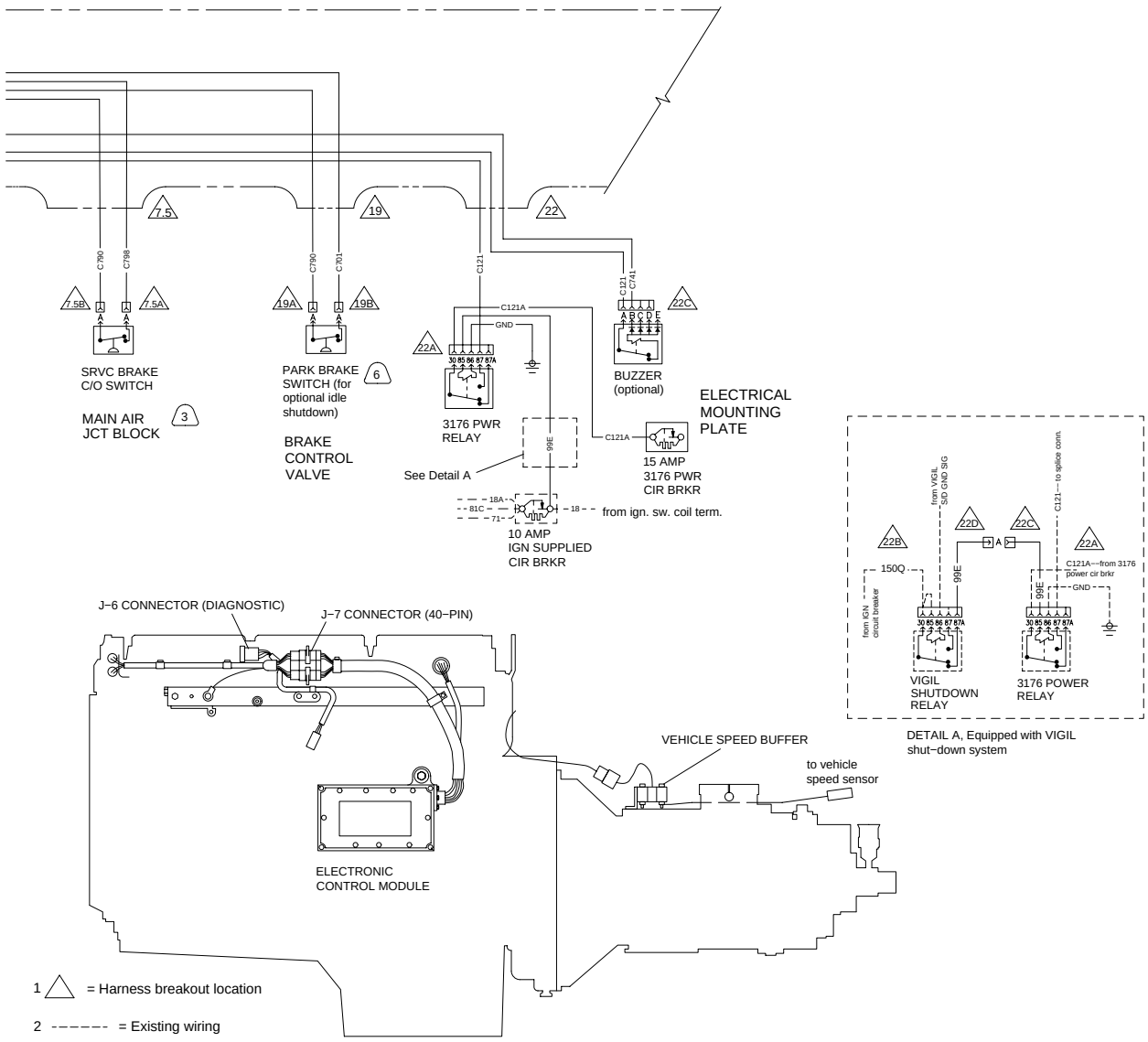

7.5
19
22
C790
C788
C790
C701
C121
C121
C741
7.5B
7.5A
19A
19B
22C
C121A
GND
22A
SRVC BRAKE
C/O SWITCH
MAIN AIR
JCT BLOCK
3
PARK BRAKE
SWITCH (for
optional idle
shutdown)
6
BRAKE
CONTROL
VALVE
3176 PWR
RELAY
See Detail A
BUZZER
(optional)
ELECTRICAL
MOUNTING
PLATE
15 AMP
3176 PWR
CIR BRKR
18A
81C
71
18
from ign. sw. coil term.
10 AMP
IGN SUPPLIED
CIR BRKR
J−6 CONNECTOR (DIAGNOSTIC)
J−7 CONNECTOR (40−PIN)
VEHICLE SPEED BUFFER
to vehicle
speed sensor
ELECTRONIC
CONTROL MODULE
from VIGIL
SHD GND SIG
C121 − to splice conn
22B
22D
22C
22A
150Q
from IGN
circuit breaker
C121A − from 3176
power cir brkr
GND
VIGIL
SHUTDOWN
RELAY
3176 POWER
RELAY
DETAIL A, Equipped with VIGIL
shut−down system
1 = Harness breakout location
2 = Existing wiring
3 Install pressure switch in port #3 of the main air/oil junction block with 1/8 NPT street tee (switch will open with service brake application pressure).
6 Switch will close when parking brakes are applied. Installed in "DEL TRAC" port of brake control valve.
Reference Diagrams:
D06−19282, Chg. Ltr. C
D06−19284, Chg. Ltr. A
02/14/94
f540692

Fig. 8

Specifications

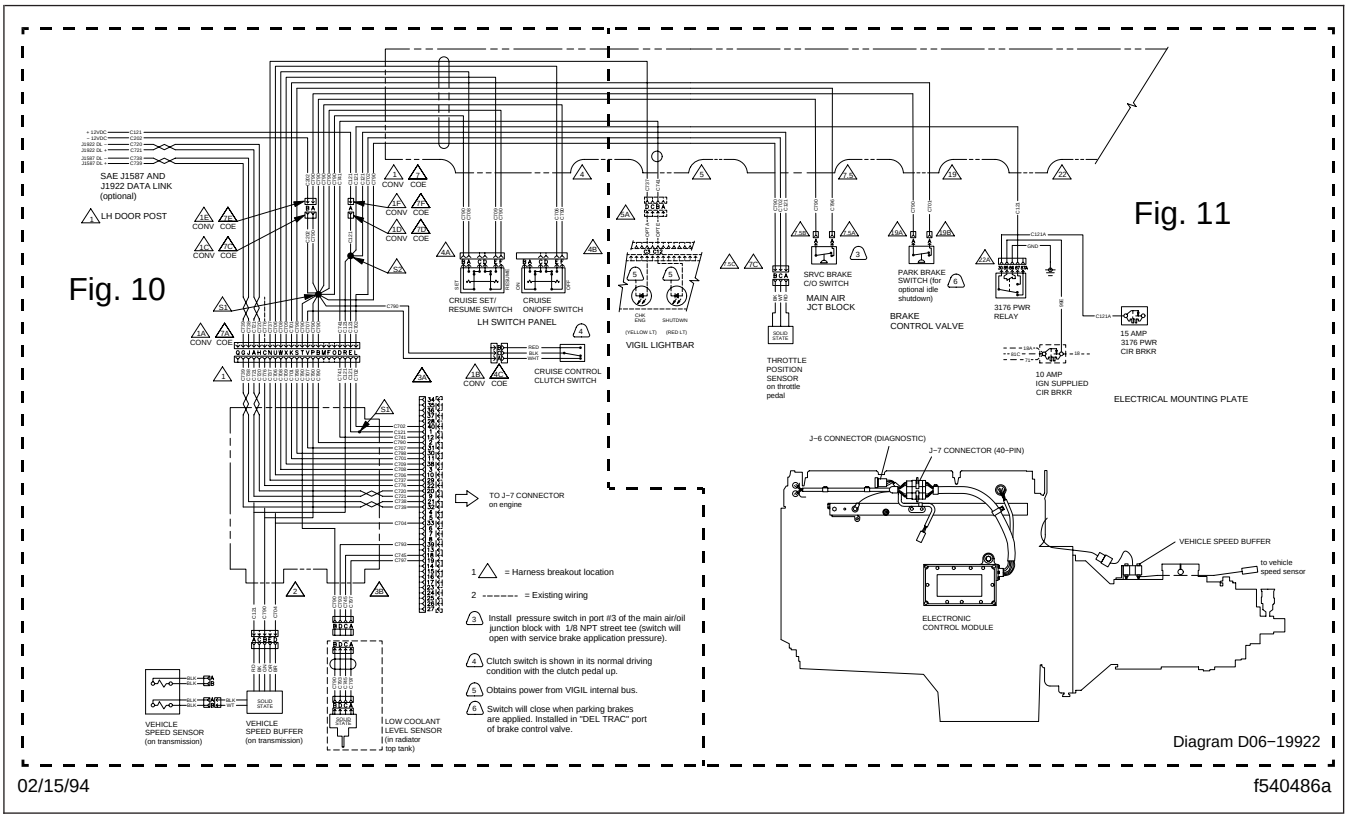


Fig. 9, 3176 Wiring Diagram, 7LG Version (with engine monitoring system)

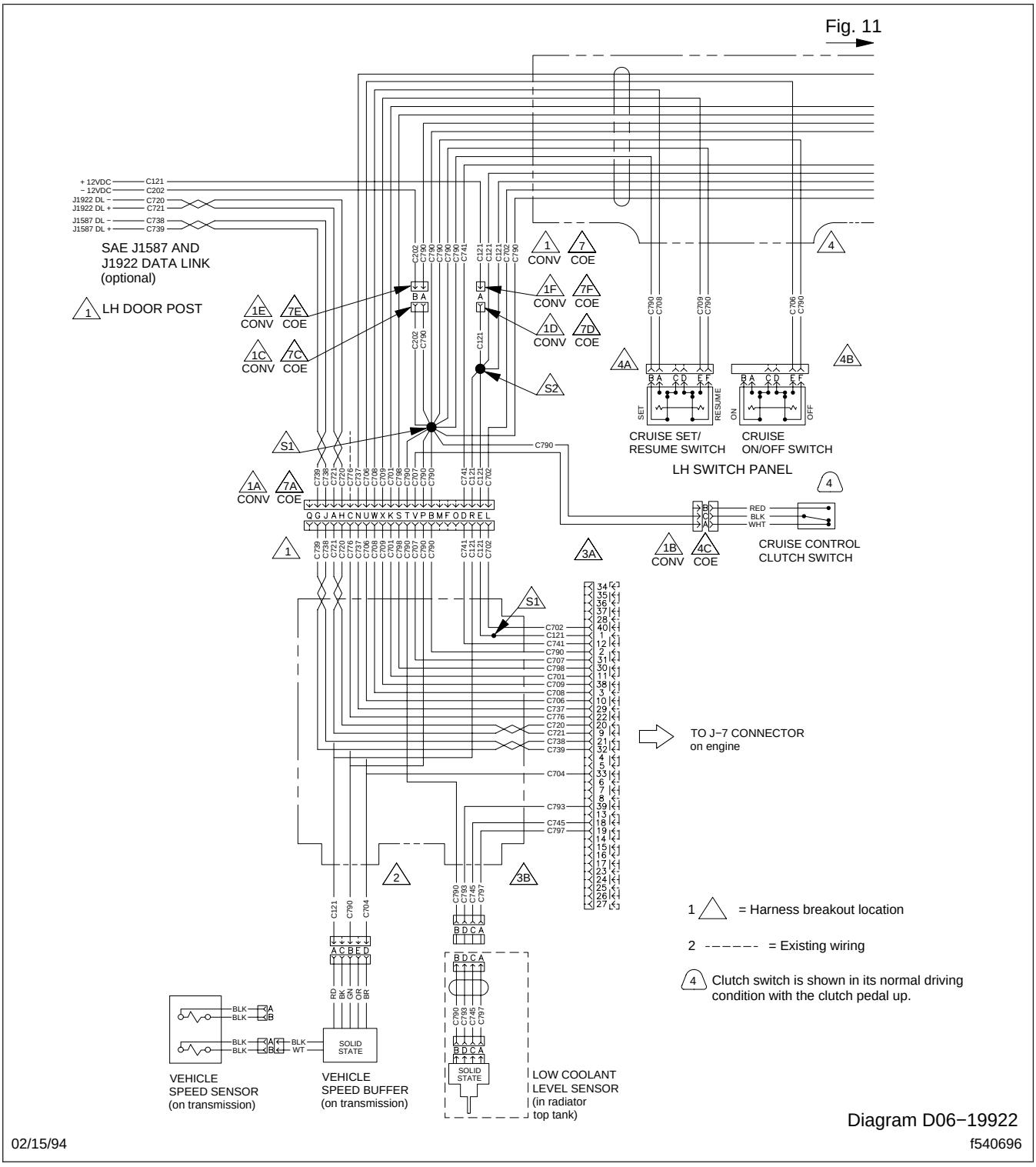


Fig. 11
+ 12VDC C121
− 12VDC C202
J1922 DL − C720
J1922 DL + C721
J1587 DL − C738
J1587 DL + C739
SAE J1587 AND
J1922 DATA LINK
(optional)
1 LH DOOR POST
1E CONV 7E COE
1C CONV 7C COE
1 CONV 7 COE
1F CONV 7F COE
1D CONV 7D COE
S2
S1
1A CONV 7A COE
4A
4B
SET
RESUME
ON
OFF
CRUISE SET/
RESUME SWITCH
CRUISE
ON/OFF SWITCH
LH SWITCH PANEL
RED
BLK
WHT
CRUISE CONTROL
CLUTCH SWITCH
1B CONV 4C COE
3A
3B
TO J−7 CONNECTOR
on engine
1 = Harness breakout location
2 = Existing wiring
4 Clutch switch is shown in its normal driving condition with the clutch pedal up.
VEHICLE
SPEED SENSOR
(on transmission)
VEHICLE
SPEED BUFFER
(on transmission)
SOLID
STATE
LOW COOLANT
LEVEL SENSOR
(in radiator
top tank)
Diagram D06−19922
02/15/94
f540696

Fig. 10

Specifications

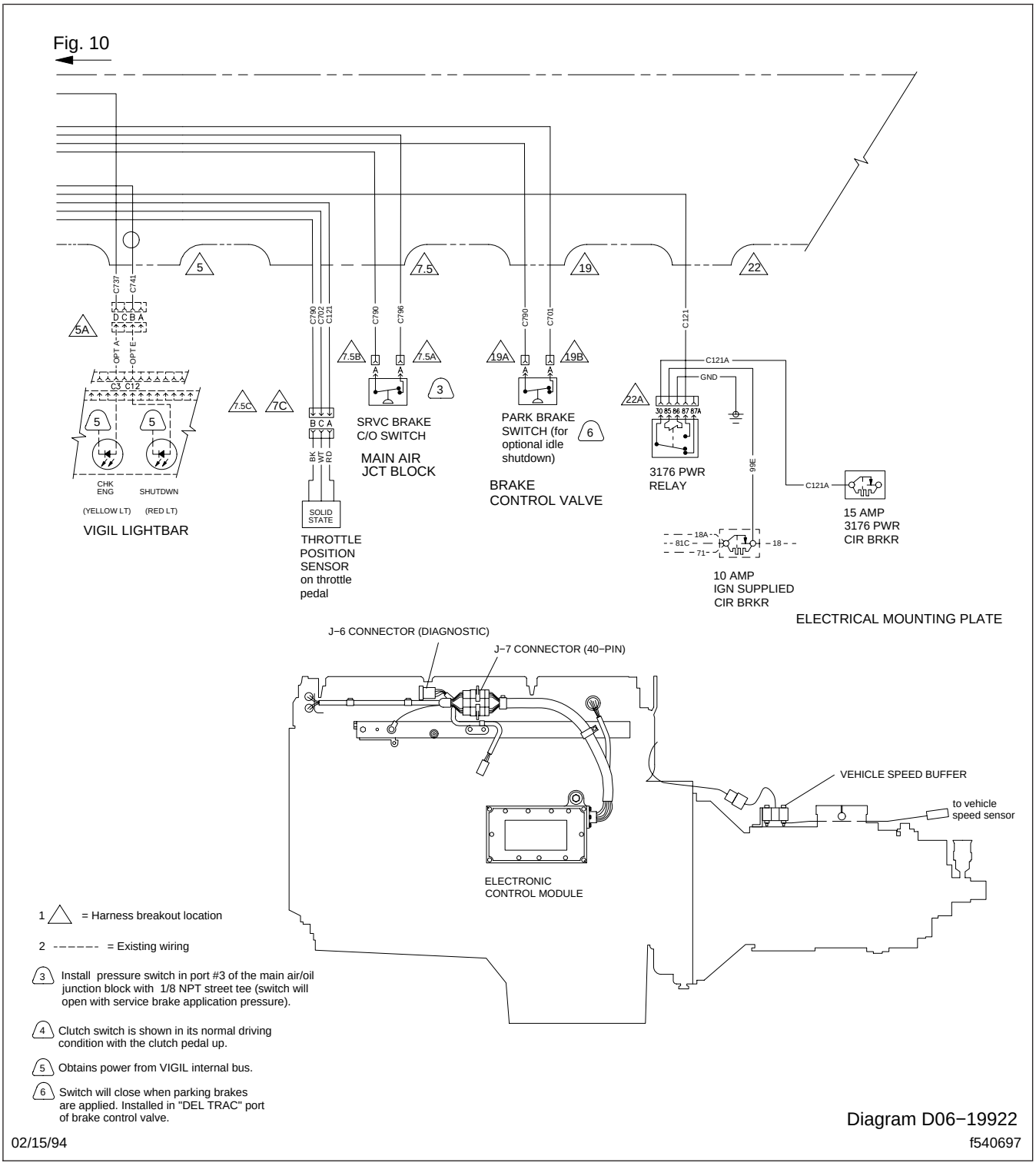


Fig. 11

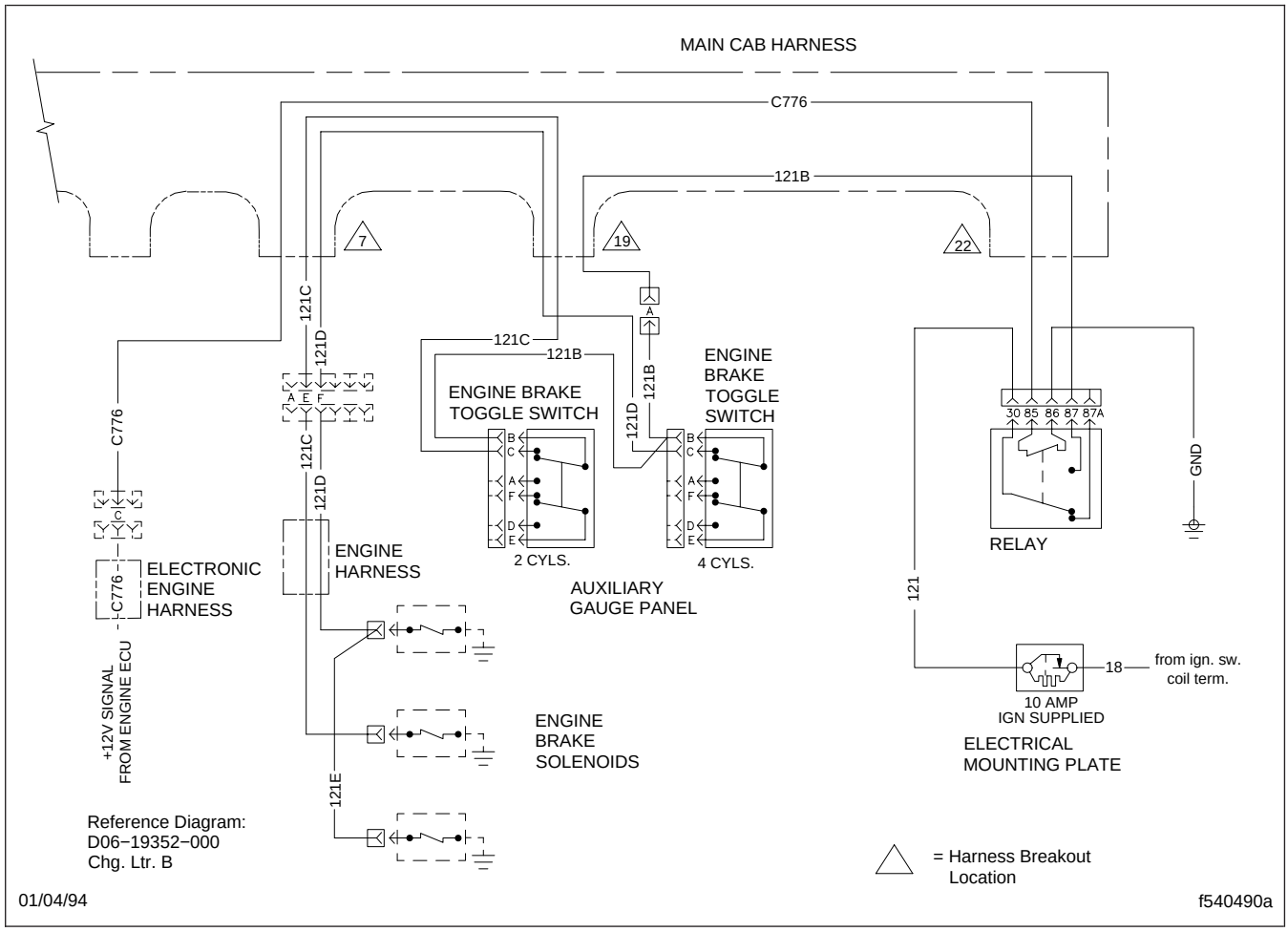


Fig. 12, 3176 Jake Brake Wiring Diagram, COE (7LG Version)

Specifications

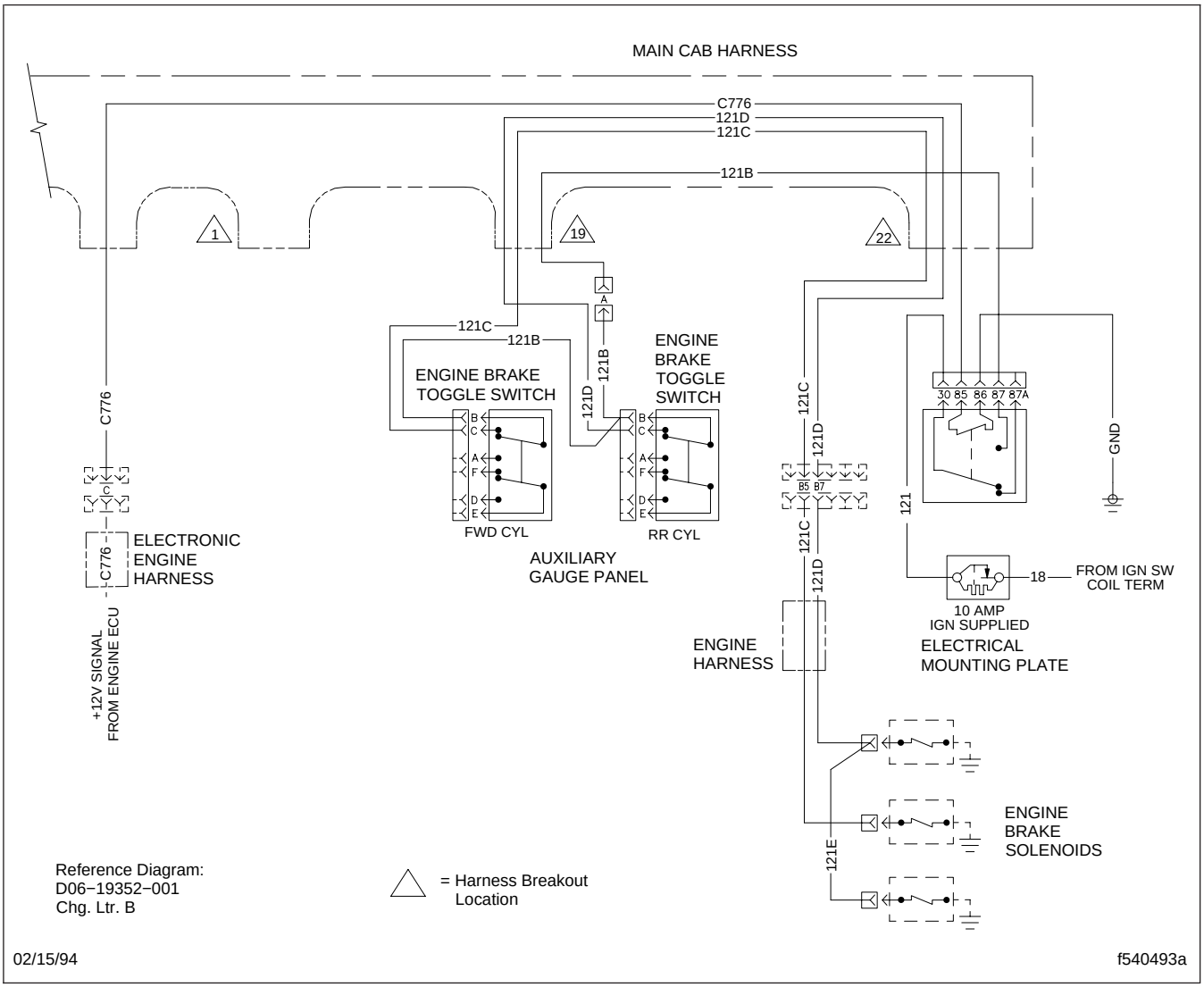


Fig. 13, 3176 Jake Brake Wiring Diagram, Conventional (7LG Version)

See Fig. 1 for a full view of the Caterpillar 3406C wiring diagram. **See Fig. 2**, or **Fig. 3** for partial (detailed) views of the Caterpillar 3406C wiring diagram.

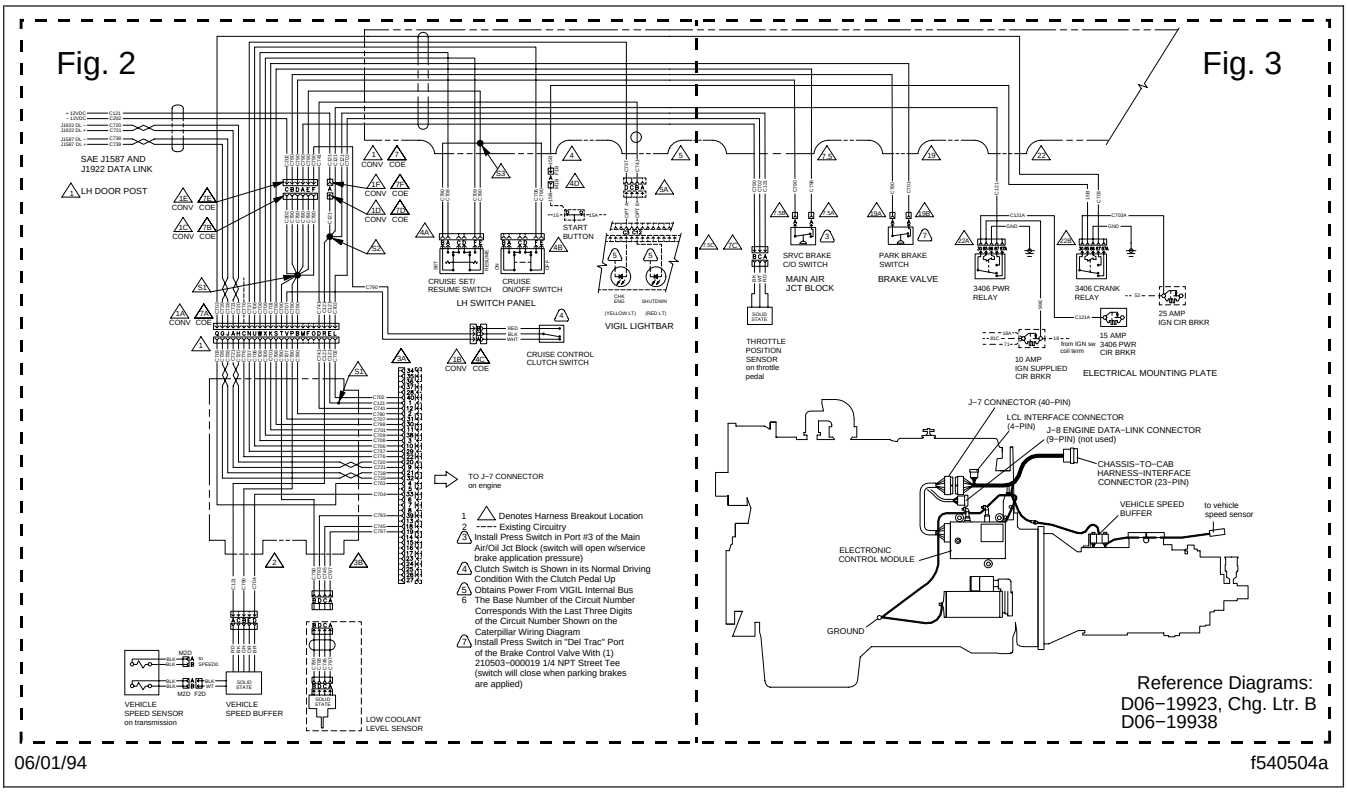


Fig. 1, Caterpillar 3406C Wiring Diagram

Specifications

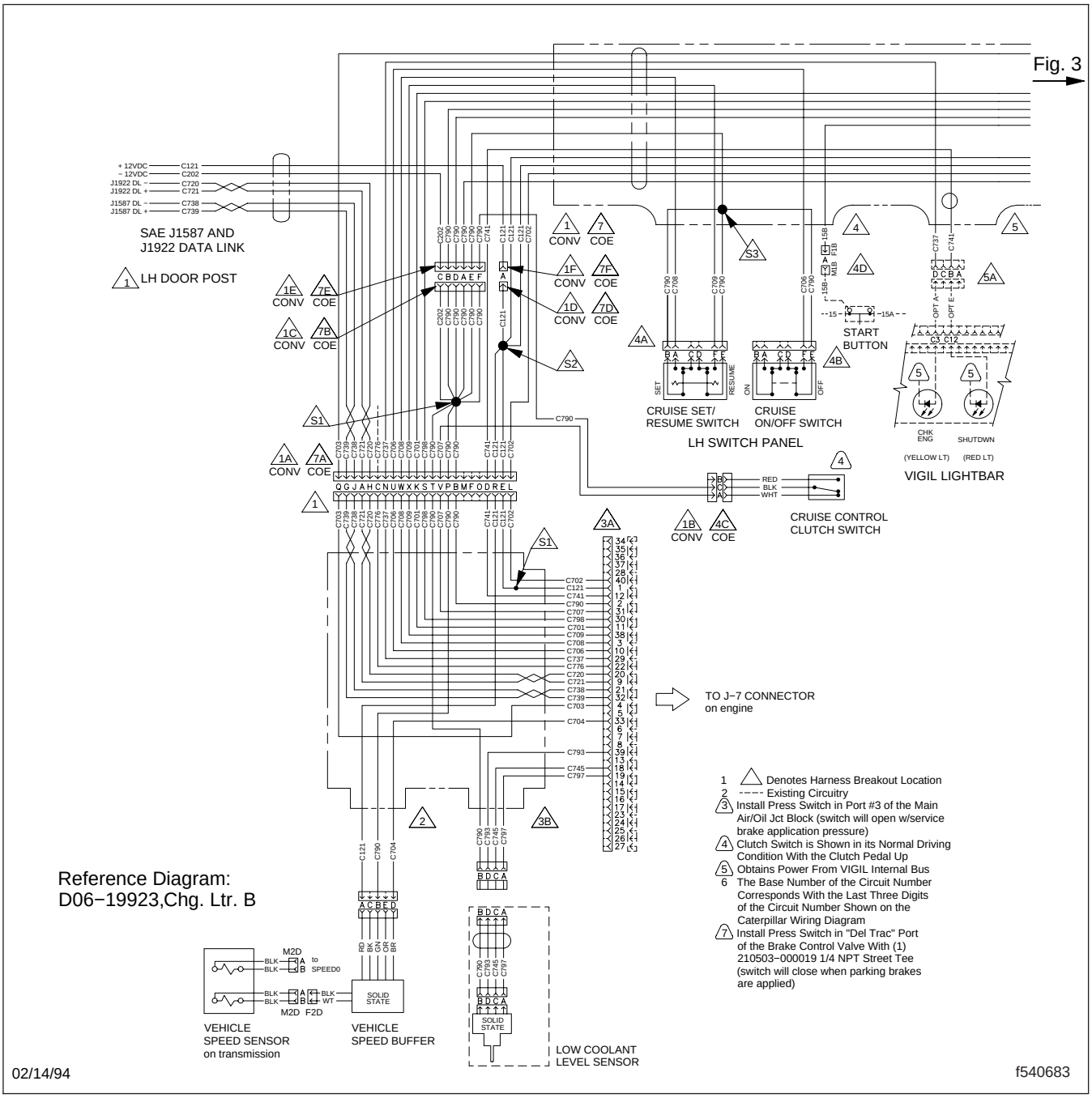


Fig. 2

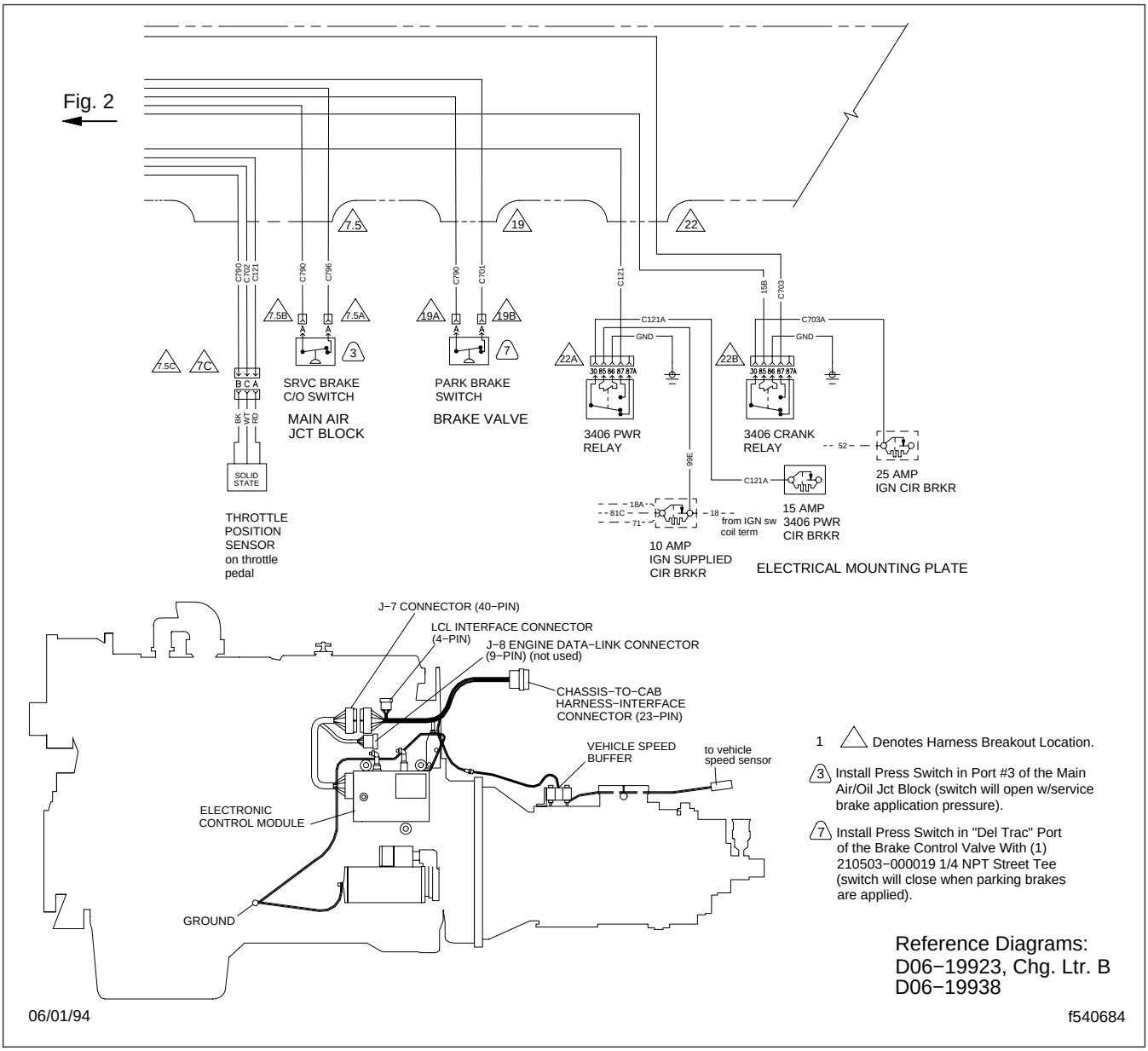


Fig. 2
7.5
19
22
C790
C702
C121
C790
C796
C790
C701
C121
15B
C703
7.5B
7.5A
19A
19B
C121A
GND
C703A
GND
7.5C
7C
3
7
22A
22B
B C A
BK
WT
RD
SRVC BRAKE
C/O SWITCH
PARK BRAKE
SWITCH
MAIN AIR
JCT BLOCK
BRAKE VALVE
3406 PWR
RELAY
3406 CRANK
RELAY
52
25 AMP
IGN CIR BRKR
99E
C121A
SOLID
STATE
18A
81C
71
18
from IGN sw
coil term
15 AMP
3406 PWR
CIR BRKR
THROTTLE
POSITION
SENSOR
on throttle
pedal
10 AMP
IGN SUPPLIED
CIR BRKR
ELECTRICAL MOUNTING PLATE
J−7 CONNECTOR (40−PIN)
LCL INTERFACE CONNECTOR
(4−PIN)
J−8 ENGINE DATA−LINK CONNECTOR
(9−PIN) (not used)
CHASSIS−TO−CAB
HARNESS−INTERFACE
CONNECTOR (23−PIN)
VEHICLE SPEED
BUFFER
to vehicle
speed sensor
ELECTRONIC
CONTROL MODULE
GROUND
1 Denotes Harness Breakout Location.
3 Install Press Switch in Port #3 of the Main Air/Oil Jct Block (switch will open w/service brake application pressure).
7 Install Press Switch in "Del Trac" Port of the Brake Control Valve With (1) 210503−000019 1/4 NPT Street Tee (switch will close when parking brakes are applied).
Reference Diagrams:
D06−19923, Chg. Ltr. B
D06−19938
06/01/94
f540684

Fig. 3

CELECT™ Plus

The Cummins CELECT Plus electronic engine controls replace the earlier CELECT controls.

Freightliner supplies two principal wiring harnesses to each engine. The 12-volt (12V) engine harness supplies power to the starter and various appliances. The electronic engine harness communicates data between the electronic control module (ECM), various data-gathering devices, and the cab information systems. In addition, a power harness supplies battery power to the engine ECM.

For a schematic of the CELECT Plus cab wiring, see **Fig. 1**. For detailed (partial) views of the cab wiring, see **Fig. 2** and **Fig. 3**.

For a schematic of the engine compartment wiring, see **Fig. 4**. For a detailed view of the power harness and engine ECM end of the electronic engine harness, see **Fig. 5**. For a detailed view of the frontwall connector end of the electronic engine harness, see **Fig. 6**.

For a view of the harness routing for the FLB, see **Fig. 7**.

For a view of the harness routing for the FLD, see **Fig. 8**.

For a drawing of the power harness, see **Fig. 9**.

For a drawing of the FLB electronic engine harness, see **Fig. 10**.

For a drawing of the FLD electronic engine harness, see **Fig. 11**.

For a drawing of the M11+ 12V engine harness for the FLB, see **Fig. 12**.

For a drawing of the N14+ 12V engine harness for the FLB, see **Fig. 13**.

For a drawing of the M11+ 12V engine harness for the FLD, see **Fig. 14**.

For a drawing of the N14+ 12V engine harness for the FLD, see **Fig. 15**.

CELECT™

See **Fig. 16** for a schematic of the Cummins CELECT™ engine wiring. See **Fig. 17** and **Fig. 18** for detailed (partial) views of the Cummins CELECT engine wiring. See **Fig. 19** for a detailed view of the vehicle harness connector.

Specifications

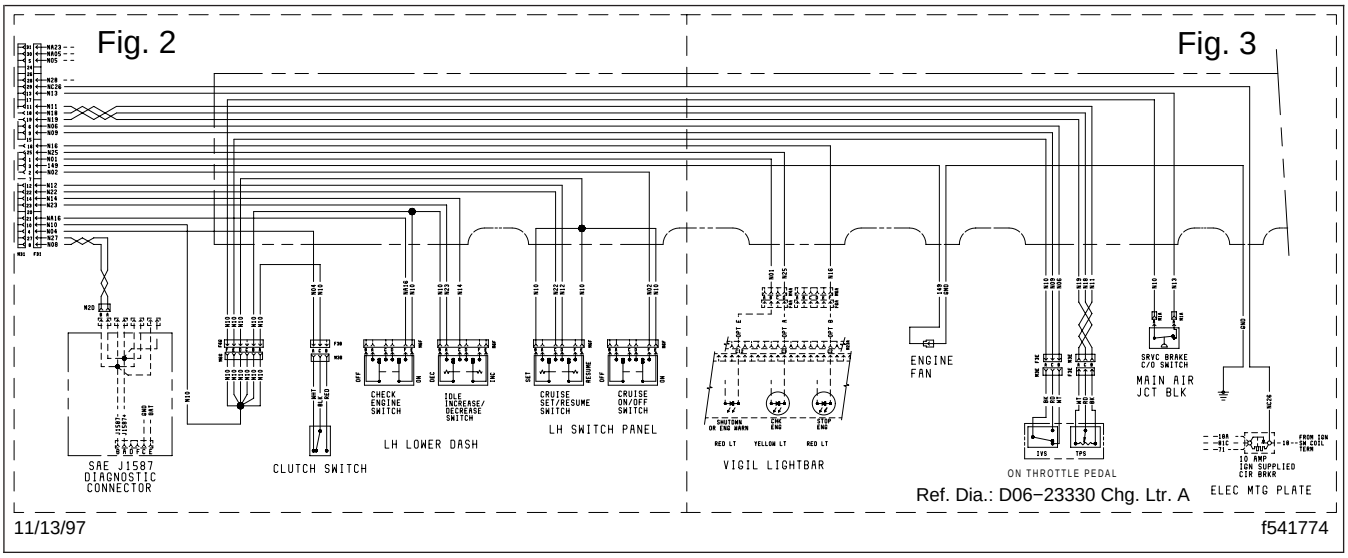


Fig. 1, CELECT Plus Wiring Schematic, Cab

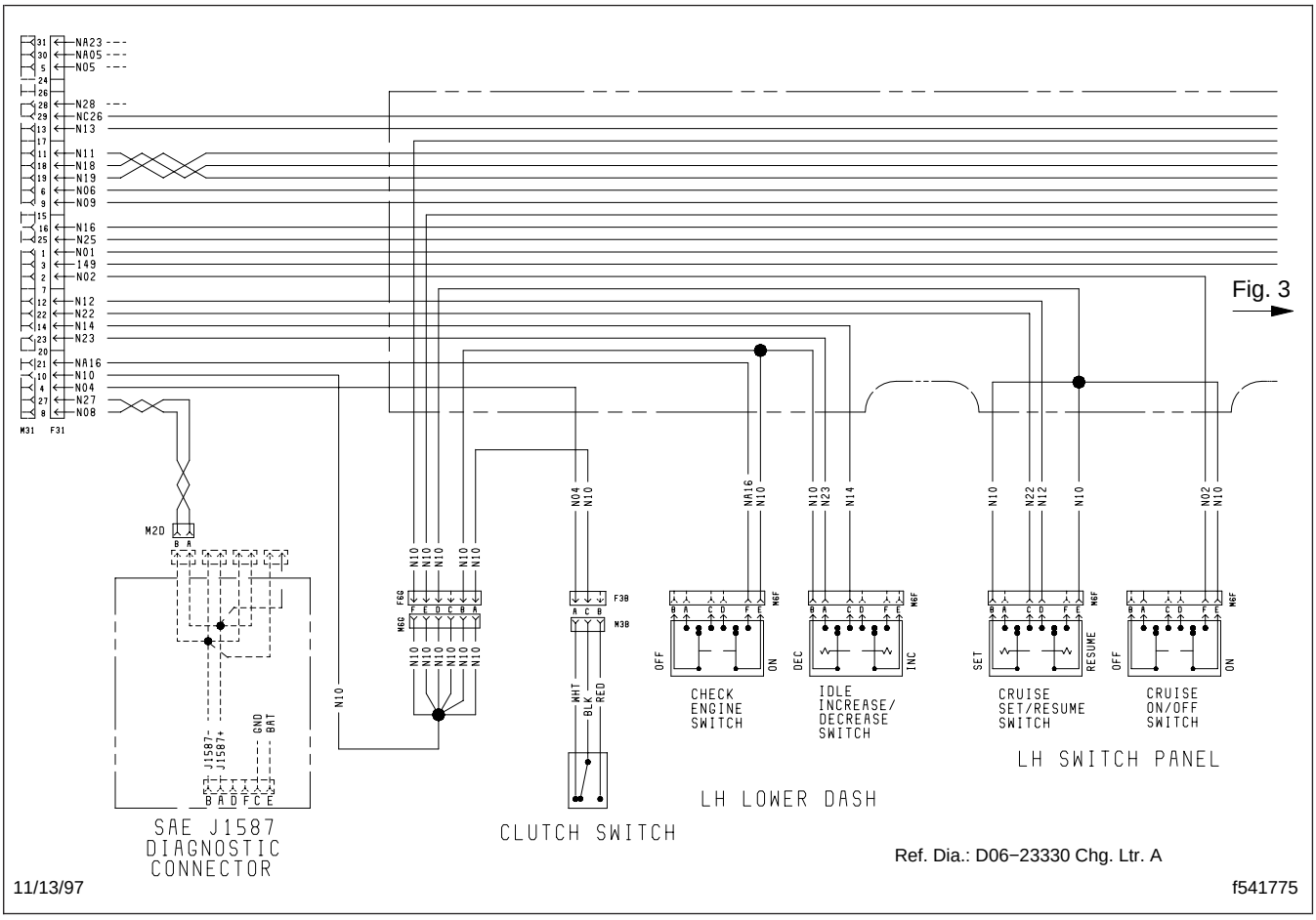


Fig. 2, CELECT Plus Wiring Schematic, Cab (detailed view)

Specifications

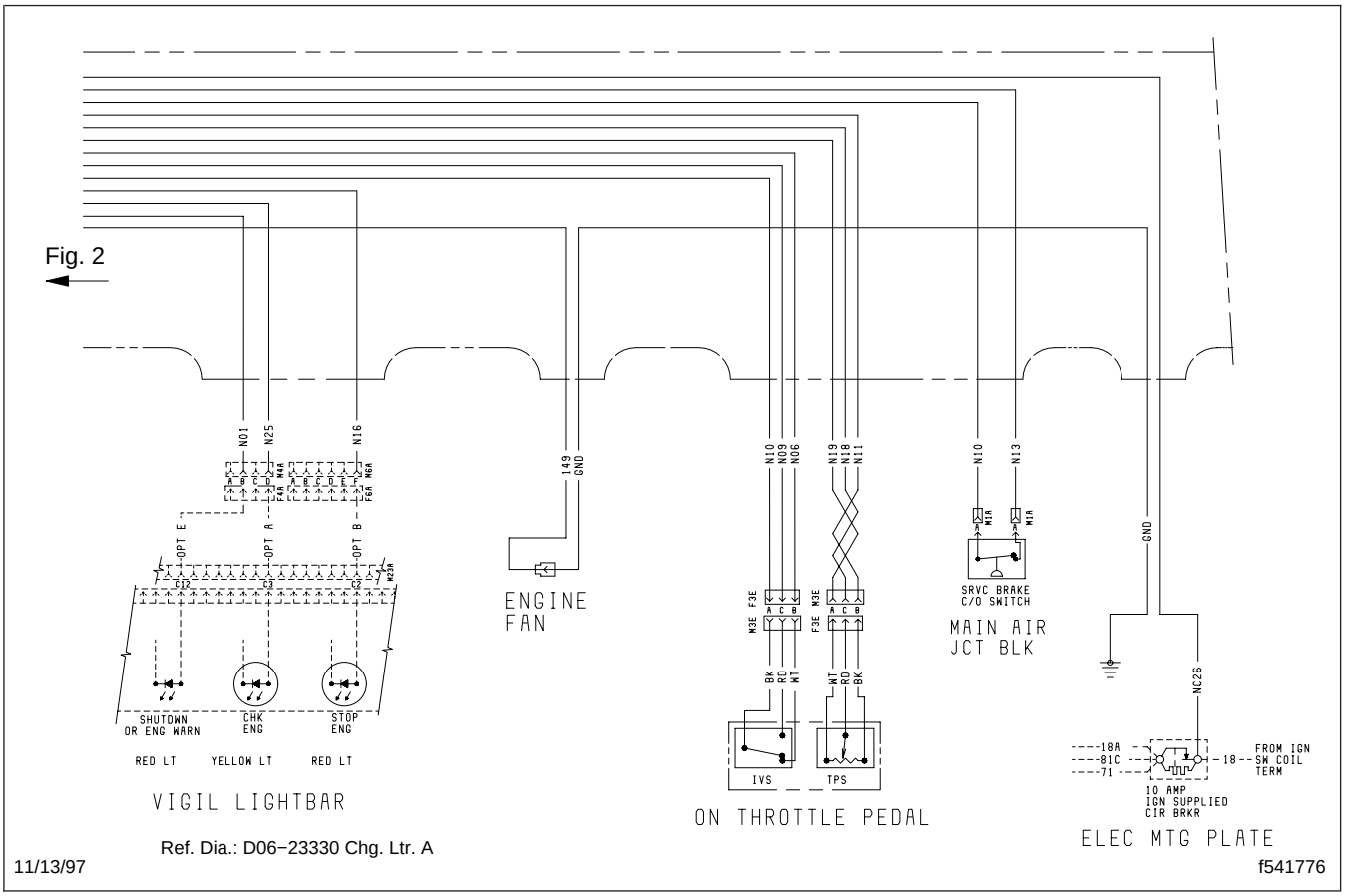


Fig. 3, CELECT Plus Wiring Schematic, Cab (detailed view)

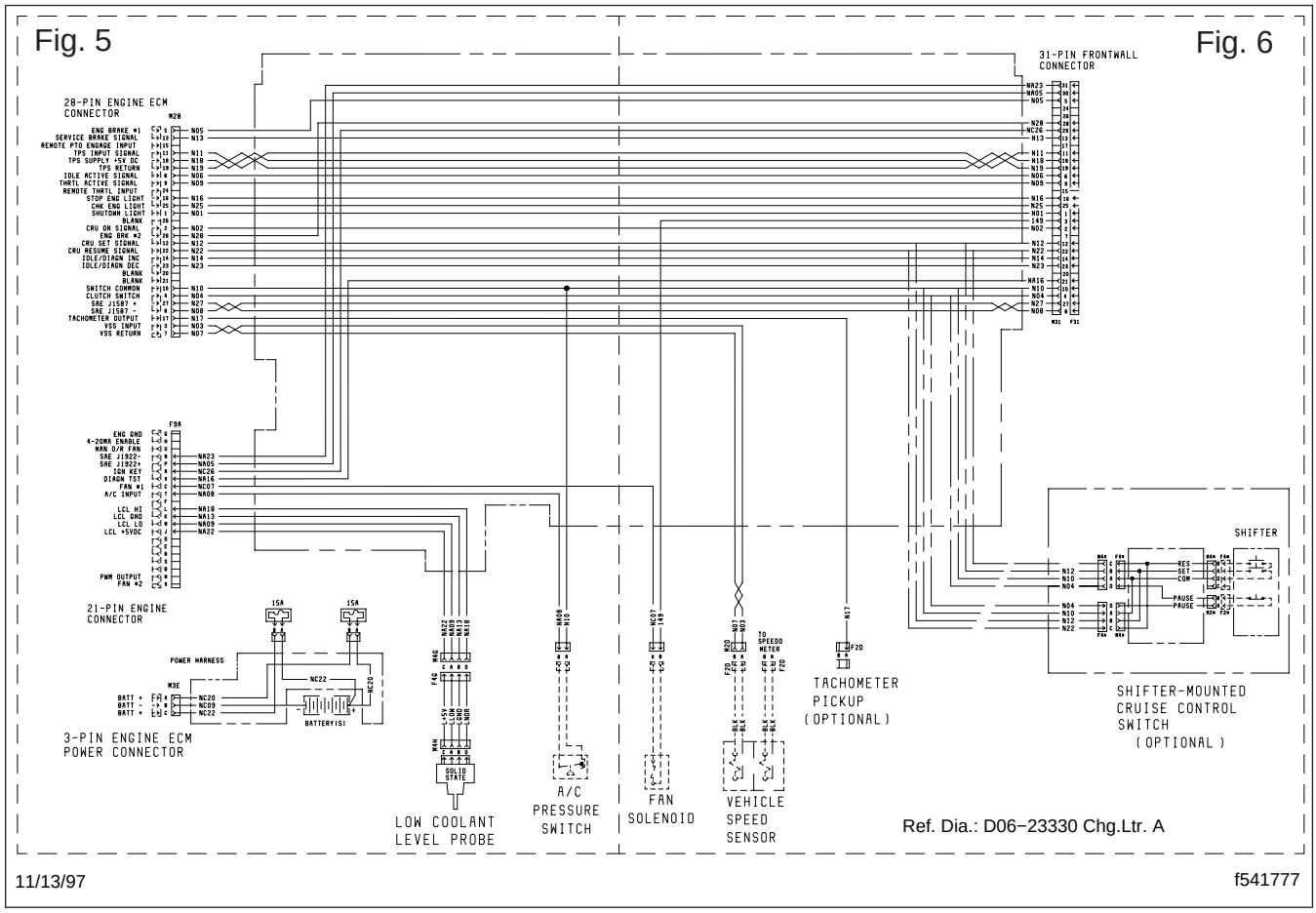


Fig. 4, CELECT Plus Wiring Schematic, Engine Compartment

Specifications

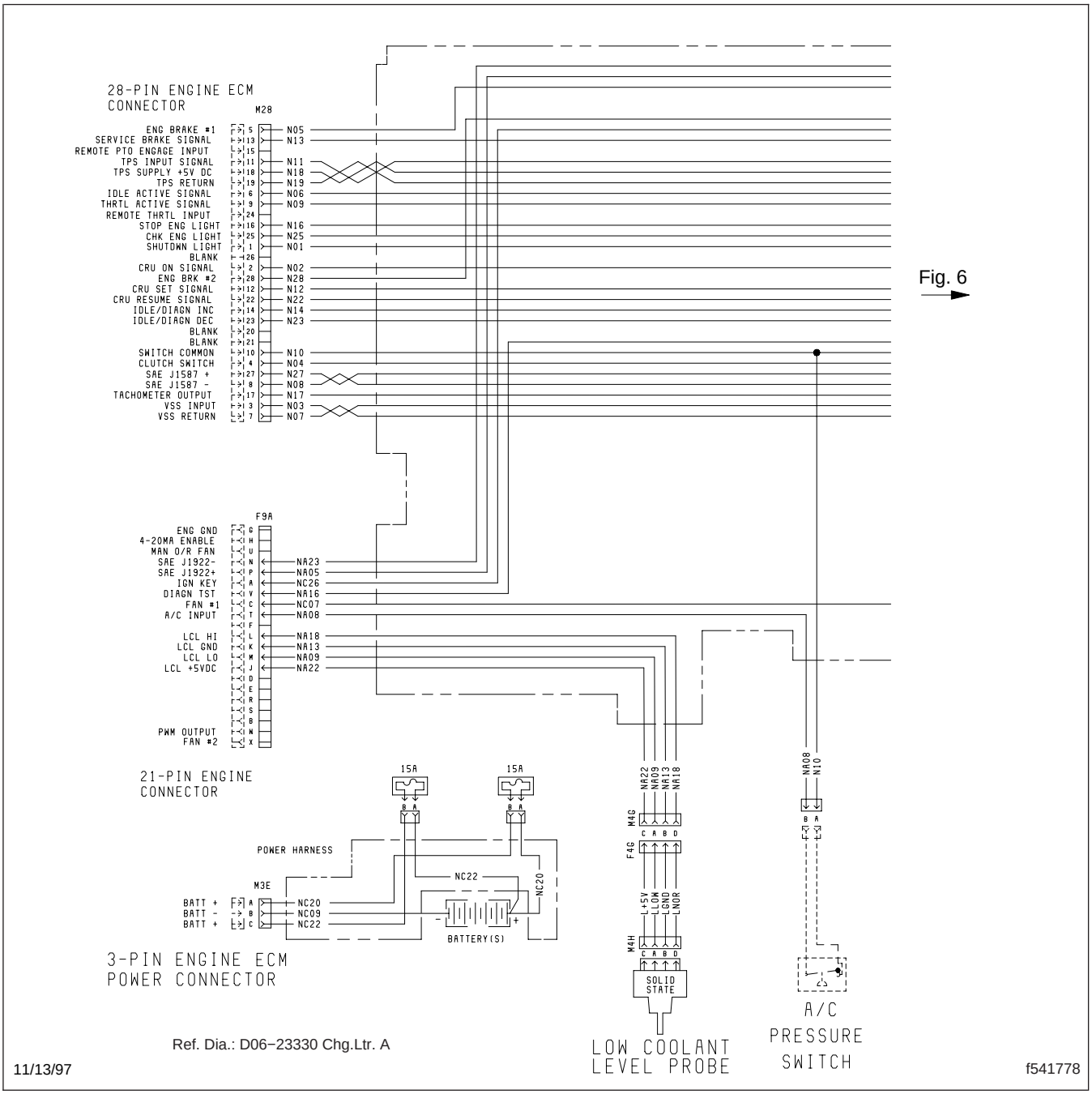


Fig. 6

Fig. 5, CELECT Plus Wiring Schematic, Engine ECM Connector End

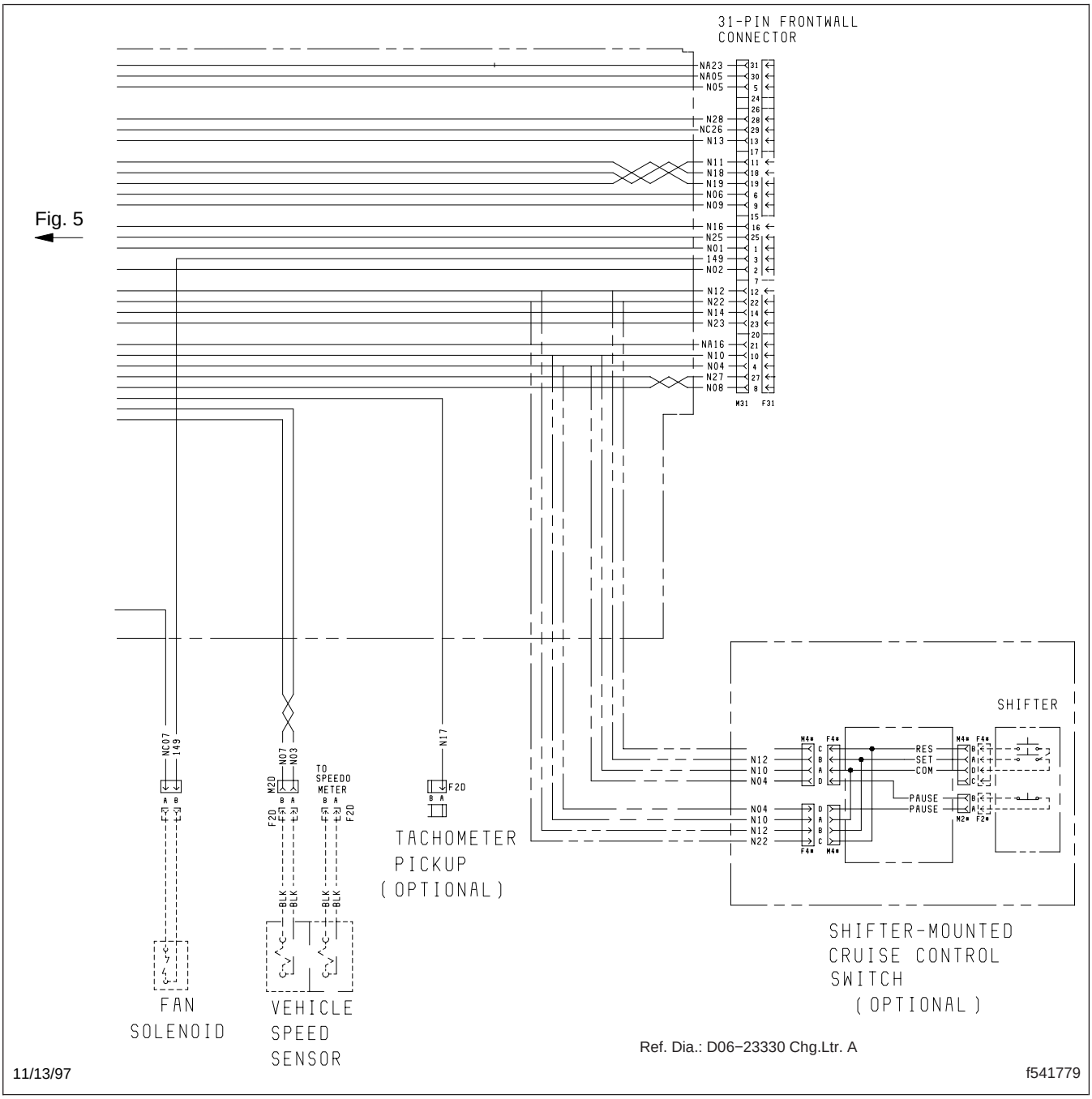
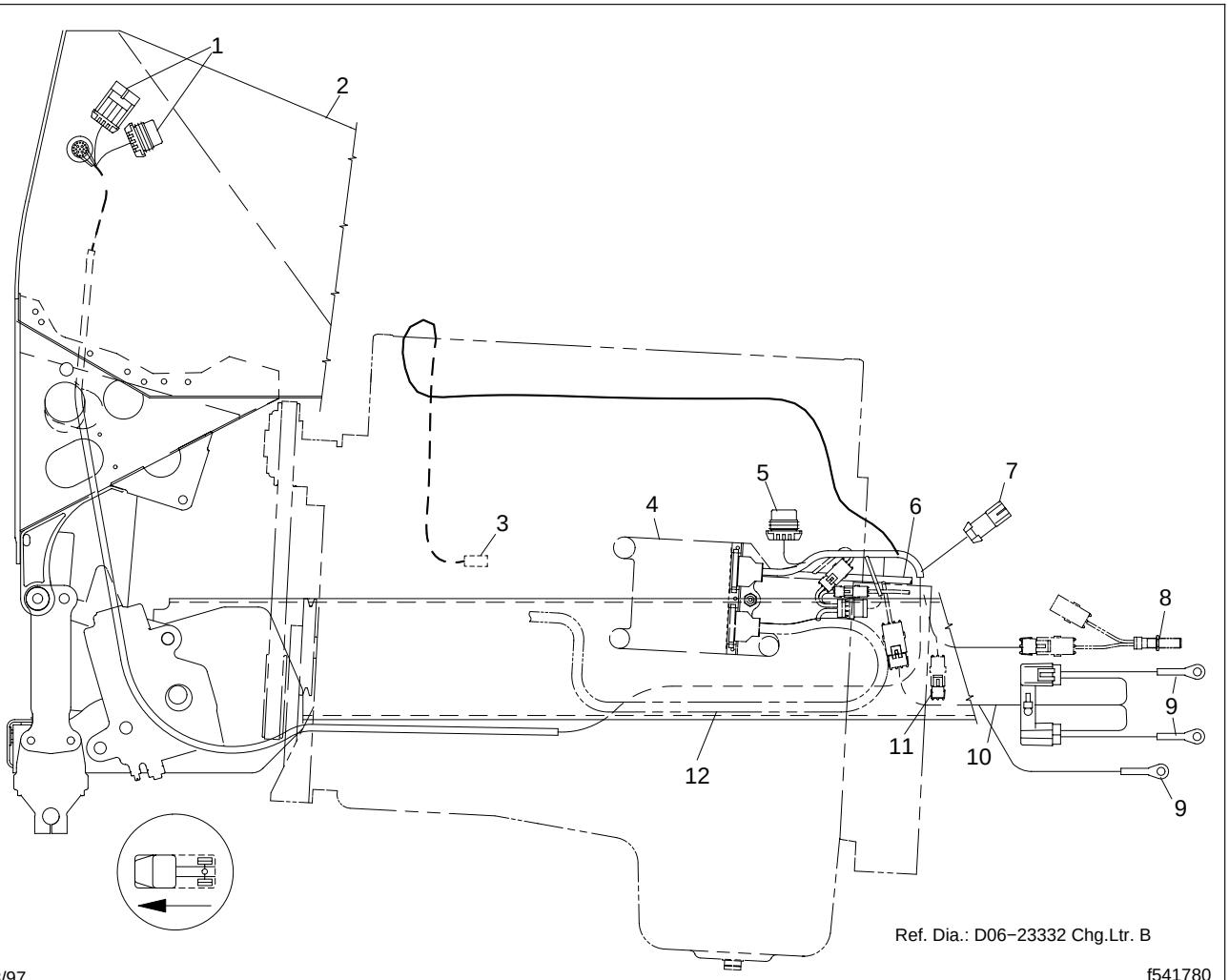


Fig. 6, CELECT Plus Wiring Schematic, Frontwall Connector End

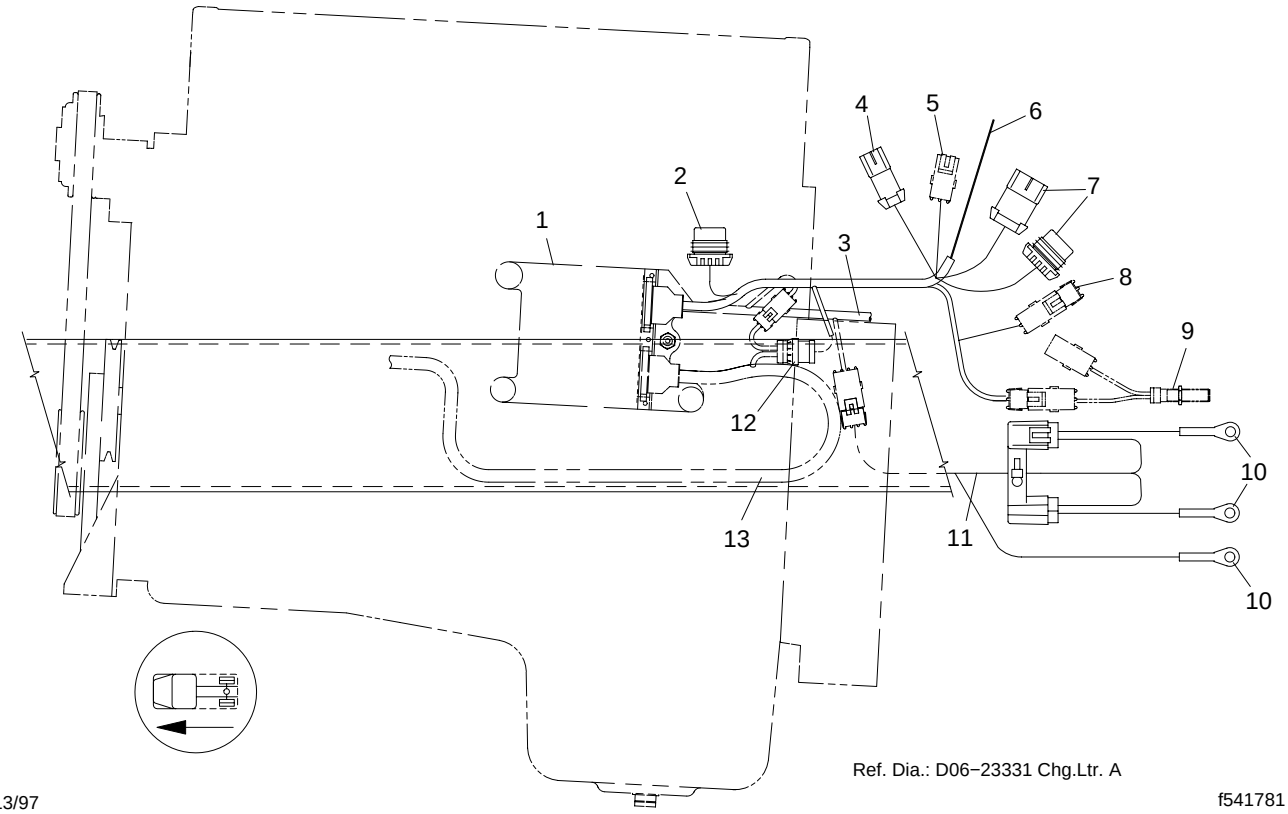
Specifications



NOTE: Engine shown in side view.

1. Shifter-Mounted Cruise Control Interface (optional)
2. Tunnel
3. A/C Pressure Switch Connector
4. Engine ECM
5. Low Coolant Level Harness Connector
6. Electronic Engine Harness
7. Fan Solenoid Connector
8. Speedometer Sensor (VSS) Connector
9. Battery Ring Terminal(s)
10. Power Harness
11. Tachometer Output (optional)
12. 12V Engine Harness

Fig. 7, CELECT Plus Harness Routing, FLB

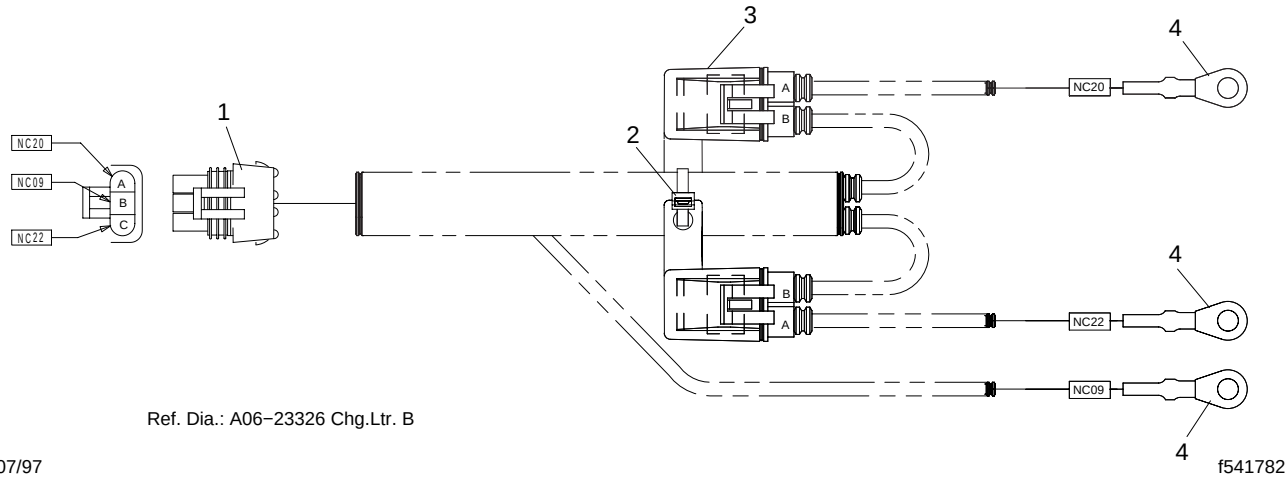


NOTE: Engine shown in side view.

1. Engine ECM
2. Low Coolant Level Harness Connector
3. Actuator Harness (supplied by CUM)
4. Fan Solenoid Connector
5. A/C Pressure Switch Connector
6. Electronic Engine Harness
7. Shifter-Mounted Cruise Control Interface (optional)
8. Tachometer Output (optional)
9. Speedometer Sensor (VSS) Connector
10. Battery Ring Terminal(s)
11. Power Harness
12. 21-Pin Deutsch Connector
13. 12V Engine Harness

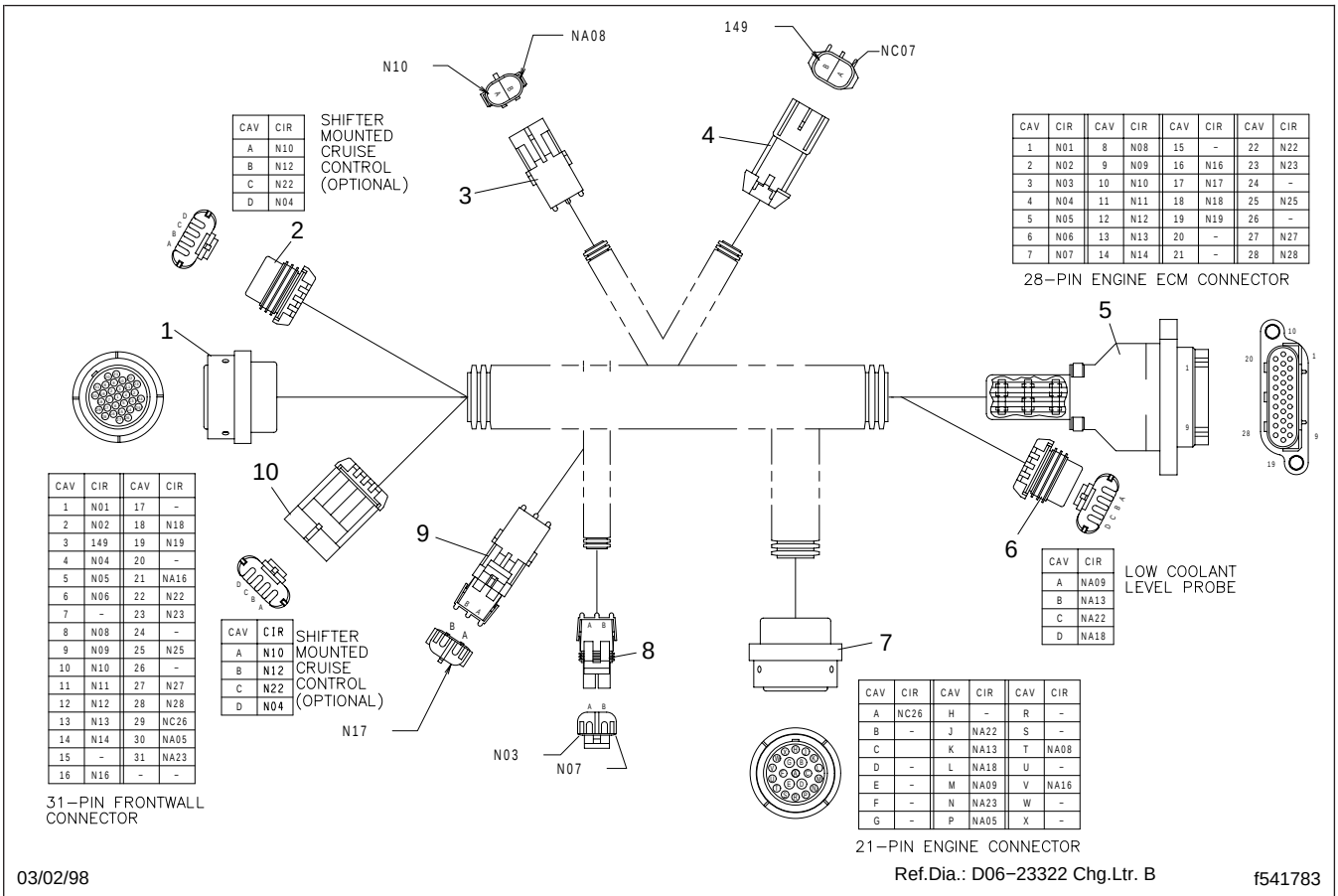
Fig. 8, CELECT Plus Harness Routing, FLD

Specifications



1. 3-Pin Engine ECM Connector
2. Tie Strap
3. 15-Amp Fuse
4. Battery Ring Terminal(s)

Fig. 9, CELECT Plus Power Harness



CAV	CIR
A	N10
B	N12
C	N22
D	N04

CAV	CIR	CAV	CIR	CAV	CIR	CAV	CIR
1	N01	8	N08	15	–	22	N22
2	N02	9	N09	16	N16	23	N23
3	N03	10	N10	17	N17	24	–
4	N04	11	N11	18	N18	25	N25
5	N05	12	N12	19	N19	26	–
6	N06	13	N13	20	–	27	N27
7	N07	14	N14	21	–	28	N28

CAV	CIR	CAV	CIR
1	N01	17	–
2	N02	18	N18
3	149	19	N19
4	N04	20	–
5	N05	21	NA16
6	N06	22	N22
7	–	23	N23
8	N08	24	–
9	N09	25	N25
10	N10	26	–
11	N11	27	N27
12	N12	28	N28
13	N13	29	NC26
14	N14	30	NA05
15	–	31	NA23
16	N16	–	–

CAV	CIR
A	N10
B	N12
C	N22
D	N04

CAV	CIR
A	NA09
B	NA13
C	NA22
D	NA18

CAV	CIR	CAV	CIR	CAV	CIR
A	NC26	H	–	R	–
B	–	J	NA22	S	–
C		K	NA13	T	NA08
D	–	L	NA18	U	–
E	–	M	NA09	V	NA16
F	–	N	NA23	W	–
G	–	P	NA05	X	–

03/02/98

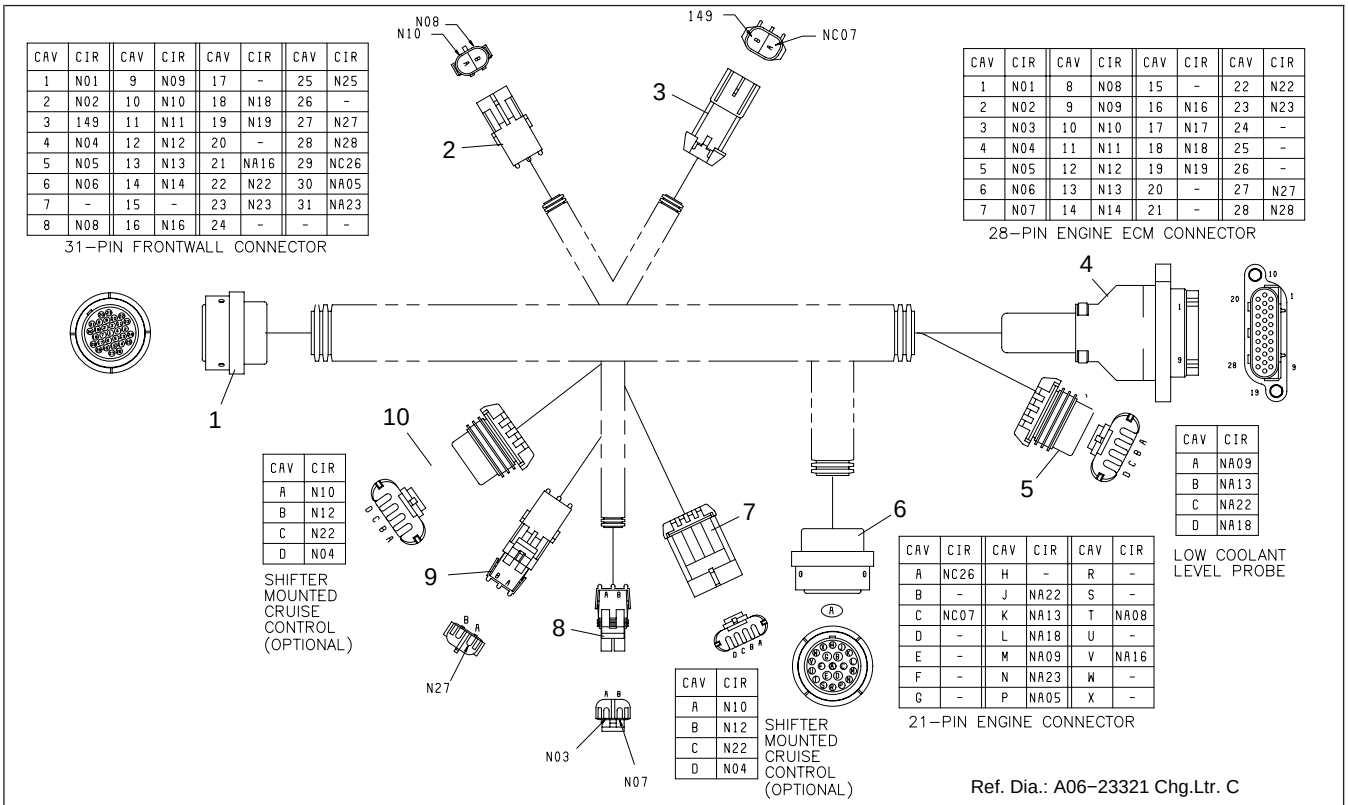
Ref.Dia.: D06–23322 Chg.Ltr. B

f541783

1. 31-Pin Frontwall Connector
2. Shifter-Mounted Cruise Control Connector #1 (optional)
3. A/C Pressure Switch Connector
4. Fan Solenoid Connector
5. 28-Pin Engine ECM Connector
6. Low Coolant Level Harness Connector
7. 21-Pin Engine Connector
8. Speedometer Sensor (VSS) Connector
9. Tachometer Output (optional)
10. Shifter-Mounted Cruise Control Connector #2 (optional)

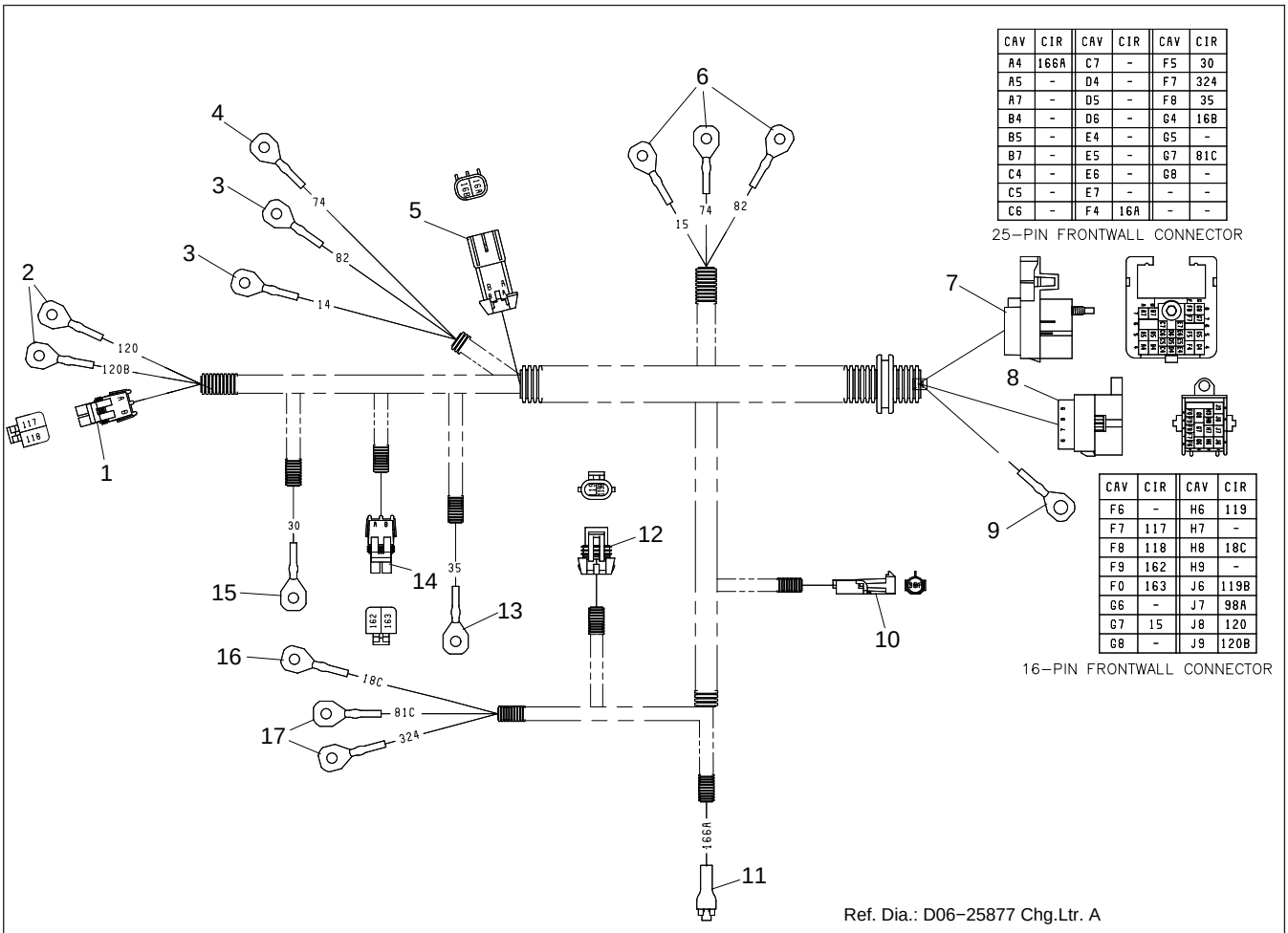
Fig. 10, CELECT Plus Electronic Engine Harness, FLB

Specifications



1. 31-Pin Frontwall Connector
2. A/C Pressure Switch Connector
3. Fan Solenoid Connector
4. 28-Pin Engine ECM Connector
5. Low Coolant Level Harness Connector
6. 21-Pin Engine Connector
7. Shifter-Mounted Cruise Control Connector #2 (optional)
8. Speedometer Sensor (VSS) Connector
9. Tachometer Output (optional)
10. Shifter-Mounted Cruise Control Connector #1 (optional)

Fig. 11, CELECT Plus Electronic Engine Harness, FLD



CAV	CIR	CAV	CIR	CAV	CIR
A4	166A	C7	-	F5	30
A5	-	D4	-	F7	324
A7	-	D5	-	F8	35
B4	-	D6	-	G4	16B
B5	-	E4	-	G5	-
B7	-	E5	-	G7	81C
C4	-	E6	-	G8	-
C5	-	E7	-	-	-
C6	-	F4	16A	-	-

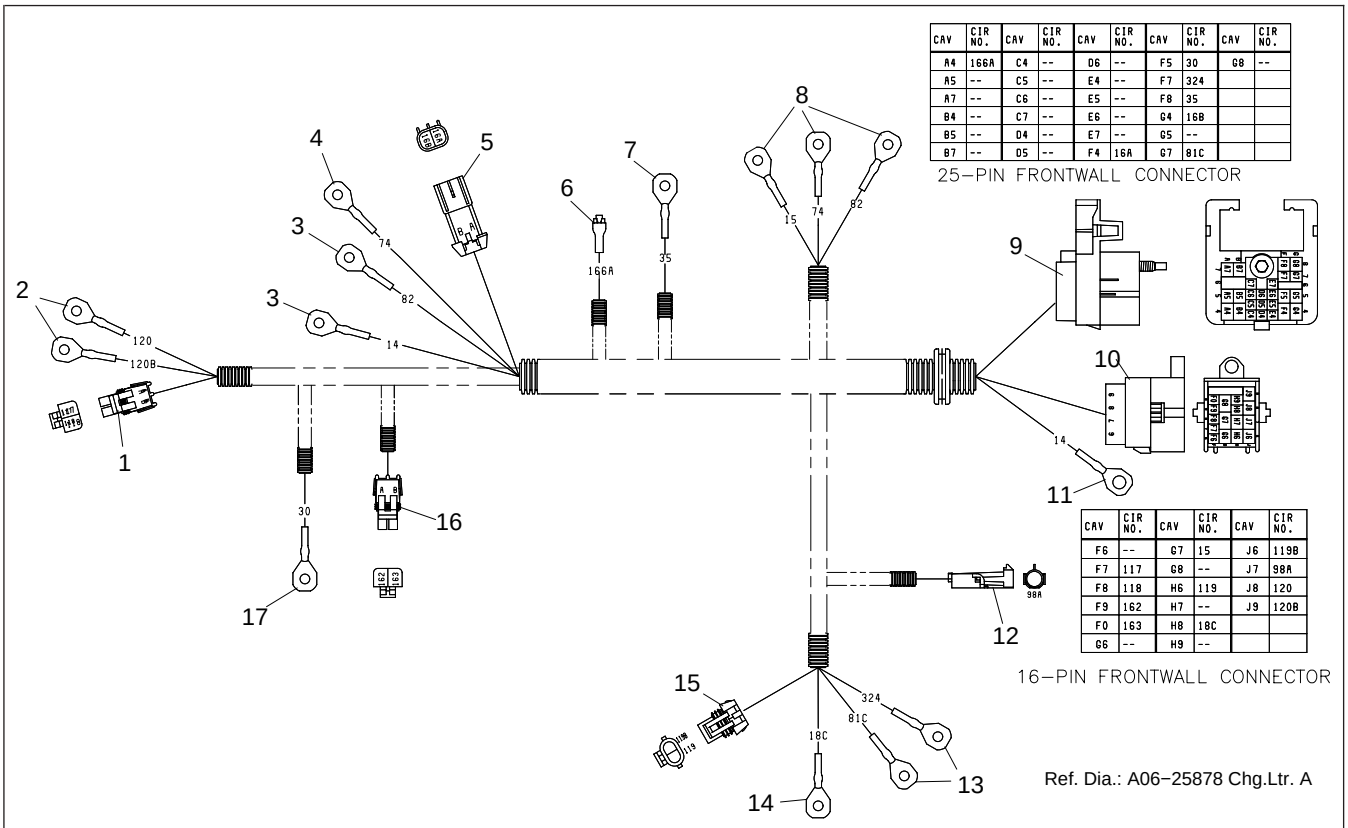
CAV	CIR	CAV	CIR
F6	-	H6	119
F7	117	H7	-
F8	118	H8	18C
F9	162	H9	-
F0	163	J6	119B
G6	-	J7	98A
G7	15	J8	120
G8	-	J9	120B

Where possible, connectors are identified by component name.

1. Speedometer Sensor (VSS)
2. Back-Up Light Switch
3. Starter Solenoid
4. Starter (BAT terminal)
5. Ammeter Shunt (optional)
6. Magnetic Switch
7. 25-Pin Frontwall Connector
8. 16-Pin Frontwall Connector
9. Power Stud
10. A/C Compressor Clutch
11. Ether Start Sensor
12. Coolant Temperature Sensor
13. Engine Oil Temperature Sensor
14. Tachometer Pickup (optional)
15. Transmission Fluid Temperature Sensor
16. High Coolant Temperature Warning Switch
17. High Coolant Temperature Shutdown Switch

Fig. 12, M11+ 12V Engine Harness, FLB

Specifications



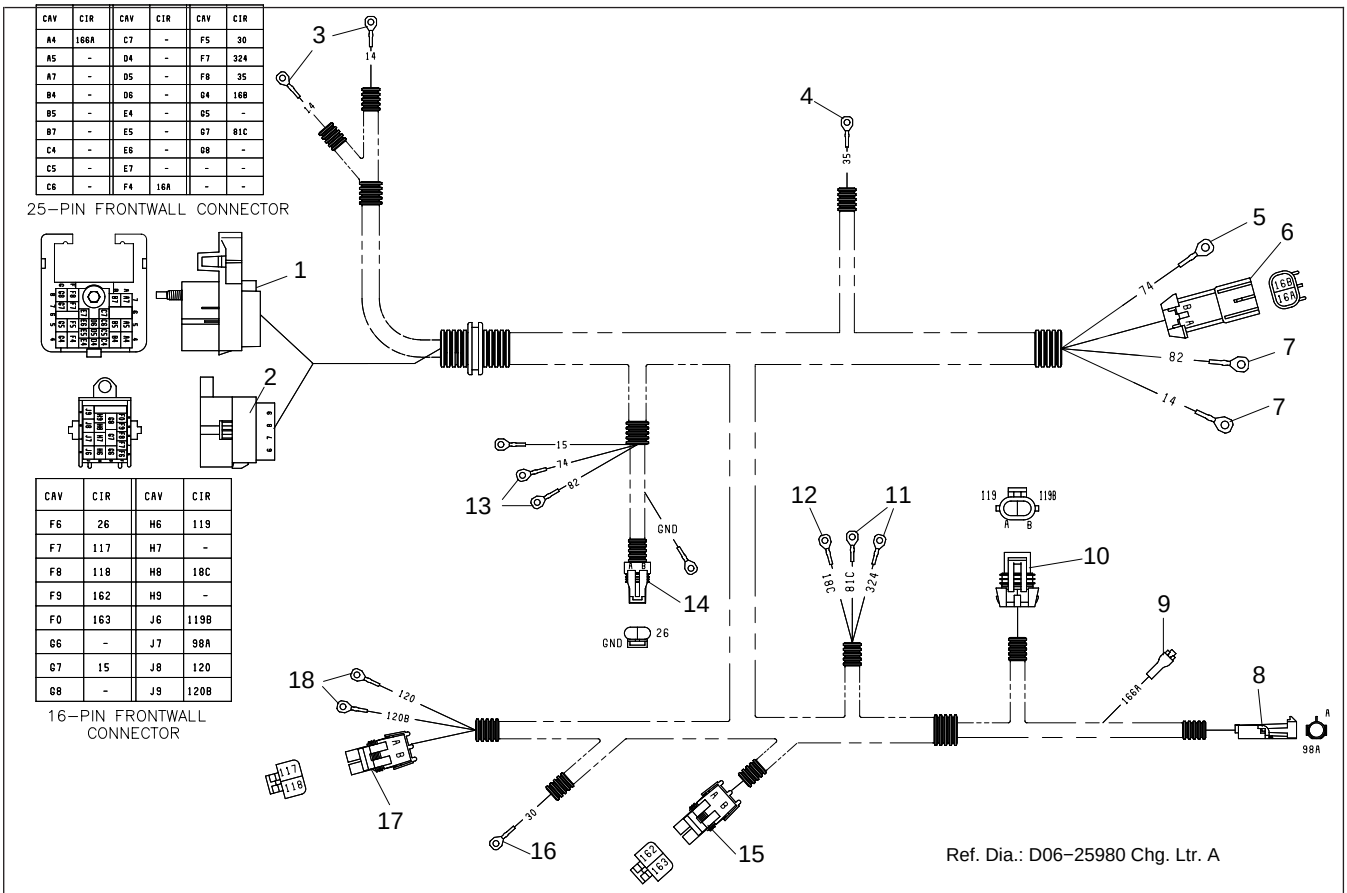
CAV	CIR NO.	CAV	CIR NO.	CAV	CIR NO.	CAV	CIR NO.	CAV	CIR NO.
A4	166A	C4	--	D6	--	F5	30	G8	--
A5	--	C5	--	E4	--	F7	324		
A7	--	C6	--	E5	--	F8	35		
B4	--	C7	--	E6	--	G4	16B		
B5	--	D4	--	E7	--	G5	--		
B7	--	D5	--	F4	16A	G7	81C		

CAV	CIR NO.	CAV	CIR NO.	CAV	CIR NO.
F6	--	G7	15	J6	119B
F7	117	G8	--	J7	98A
F8	118	H6	119	J8	120
F9	162	H7	--	J9	120B
F0	163	H8	18C		
G6	--	H9	--		

Where possible, connectors are identified by component name.

1. Speedometer Sensor (VSS)
2. Back-Up Light Switch
3. Starter Solenoid
4. Starter (BAT terminal)
5. Ammeter Shunt (optional)
6. Ether Start Sensor
7. Engine Oil Temperature Sensor
8. Magnetic Switch
9. 25-Pin Frontwall Connector
10. 16-Pin Frontwall Connector
11. Power Stud
12. A/C Compressor Clutch
13. High Coolant Temperature Shutdown Switch
14. High Coolant Temperature Warning Switch
15. Coolant Temperature Sensor
16. Tachometer Pickup (optional)
17. Transmission Fluid Temperature Sensor

Fig. 13, N14+ 12V Engine Harness, FLB

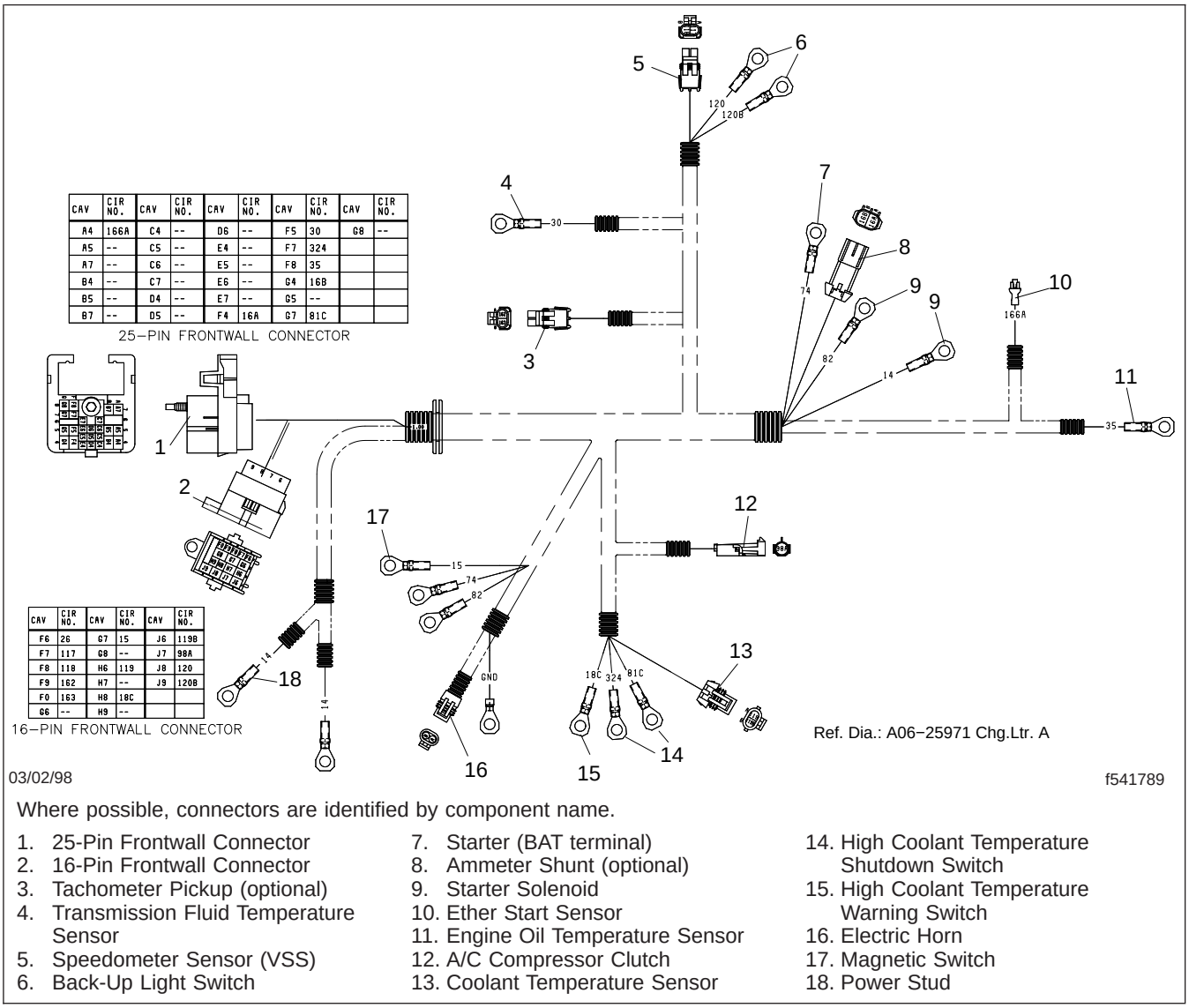


Where possible, connectors are identified by component name.

1. 25-Pin Frontwall Connector
2. 16-Pin Frontwall Connector
3. Power Stud
4. Engine Oil Temperature Sensor
5. Starter (BAT terminal)
6. Ammeter Shunt (optional)
7. Starter Solenoid
8. A/C Compressor Clutch
9. Ether Start Sensor
10. Coolant Temperature Sensor
11. High Coolant Temperature Shutdown Switch
12. High Coolant Temperature Warning Switch
13. Magnetic Switch
14. Electric Horn
15. Tachometer Pickup (optional)
16. Transmission Fluid Temperature Sensor
17. Speedometer Sensor (VSS)
18. Back-Up Light Switch

Fig. 14, M11+ 12V Engine Harness, FLD

Specifications



CAV	CIR NO.	CAV	CIR NO.	CAV	CIR NO.	CAV	CIR NO.	CAV	CIR NO.
A4	166A	C4	--	D6	--	F5	30	G8	--
A5	--	C5	--	E4	--	F7	324		
A7	--	C6	--	E5	--	F8	35		
B4	--	C7	--	E6	--	G4	16B		
B5	--	D4	--	E7	--	G5	--		
B7	--	D5	--	F4	16A	G7	81C		

CAV	CIR NO.	CAV	CIR NO.	CAV	CIR NO.
F6	26	G7	15	J6	119B
F7	117	G8	--	J7	98A
F8	118	H6	119	J8	120
F9	162	H7	--	J9	120B
F0	163	H8	18C		
G6	--	H9	--		

Where possible, connectors are identified by component name.

1. 25-Pin Frontwall Connector
2. 16-Pin Frontwall Connector
3. Tachometer Pickup (optional)
4. Transmission Fluid Temperature Sensor
5. Speedometer Sensor (VSS)
6. Back-Up Light Switch
7. Starter (BAT terminal)
8. Ammeter Shunt (optional)
9. Starter Solenoid
10. Ether Start Sensor
11. Engine Oil Temperature Sensor
12. A/C Compressor Clutch
13. Coolant Temperature Sensor
14. High Coolant Temperature Shutdown Switch
15. High Coolant Temperature Warning Switch
16. Electric Horn
17. Magnetic Switch
18. Power Stud

Fig. 15, N14+ 12V Engine Harness, FLD

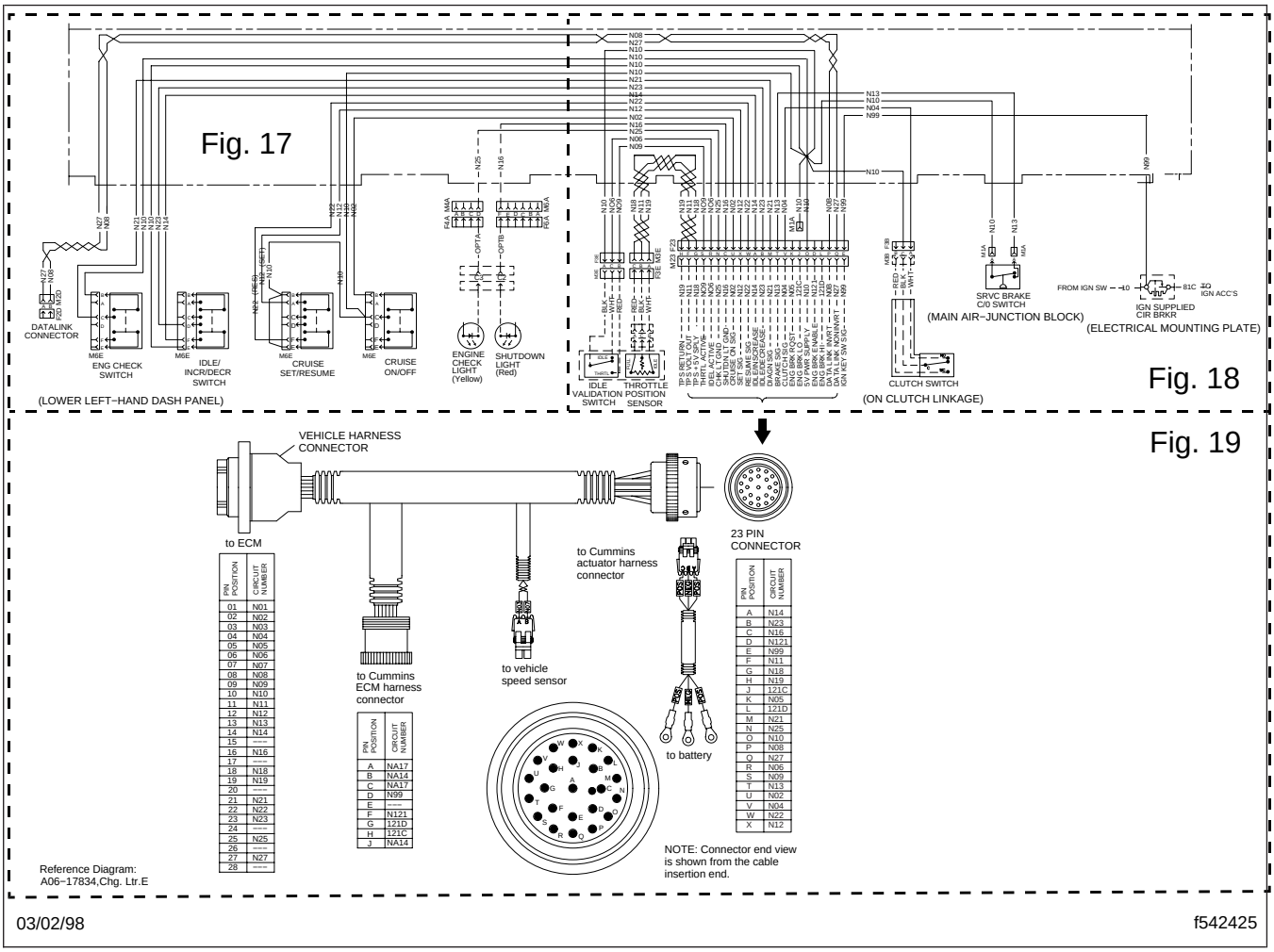


Fig. 16, Cummins CELECT Engine Wiring

Specifications

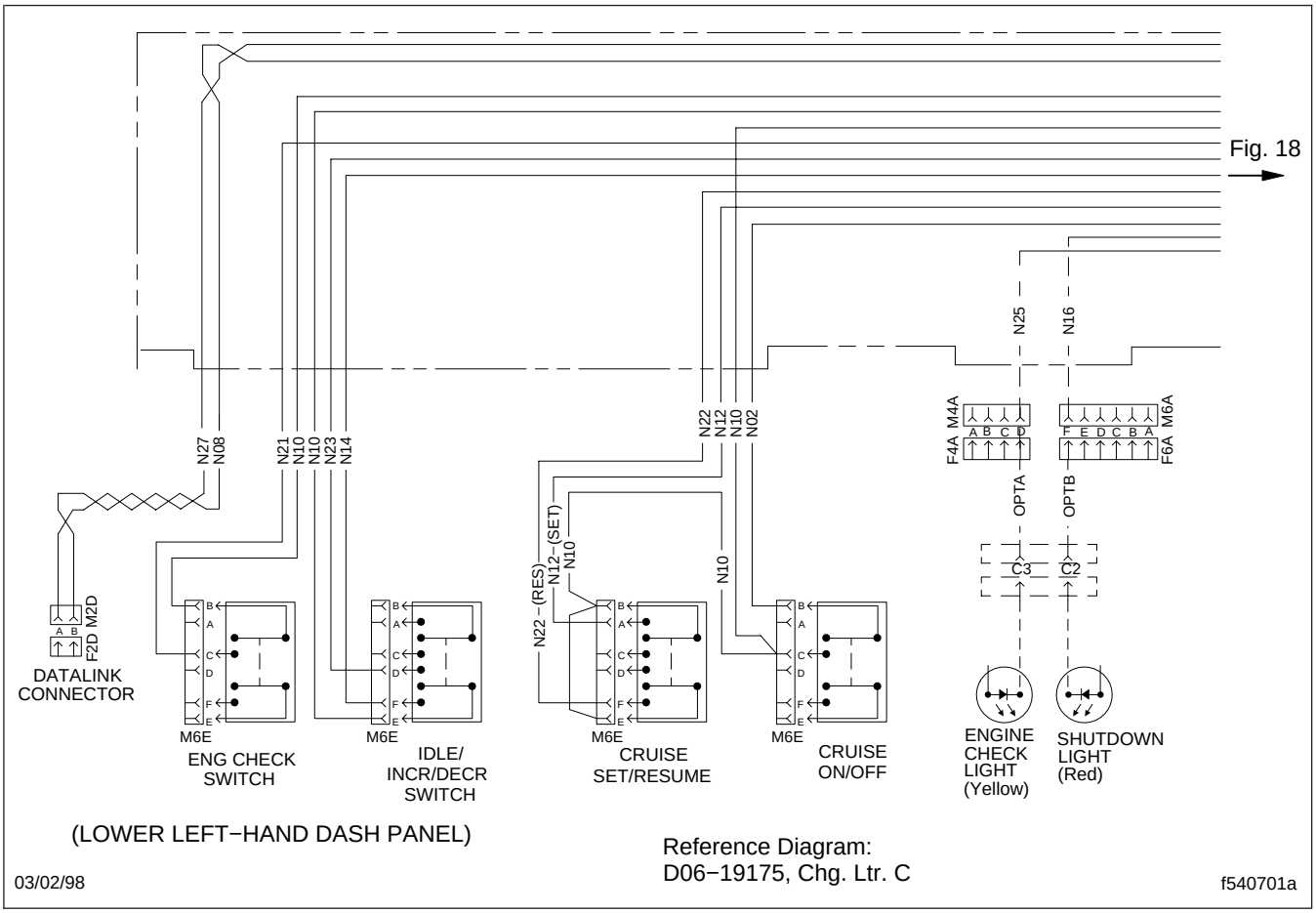


Fig. 17, Cummins CELECT Engine Wiring (detailed view)

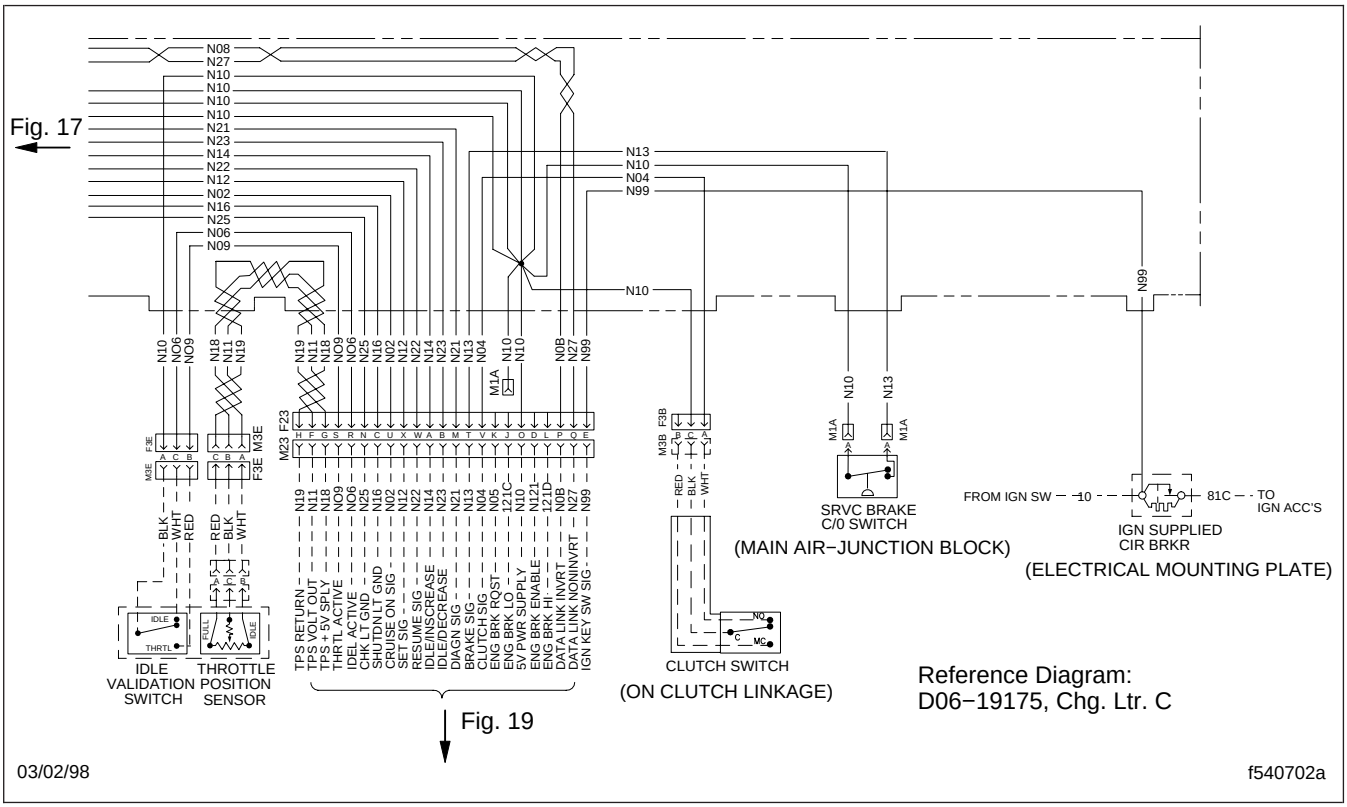
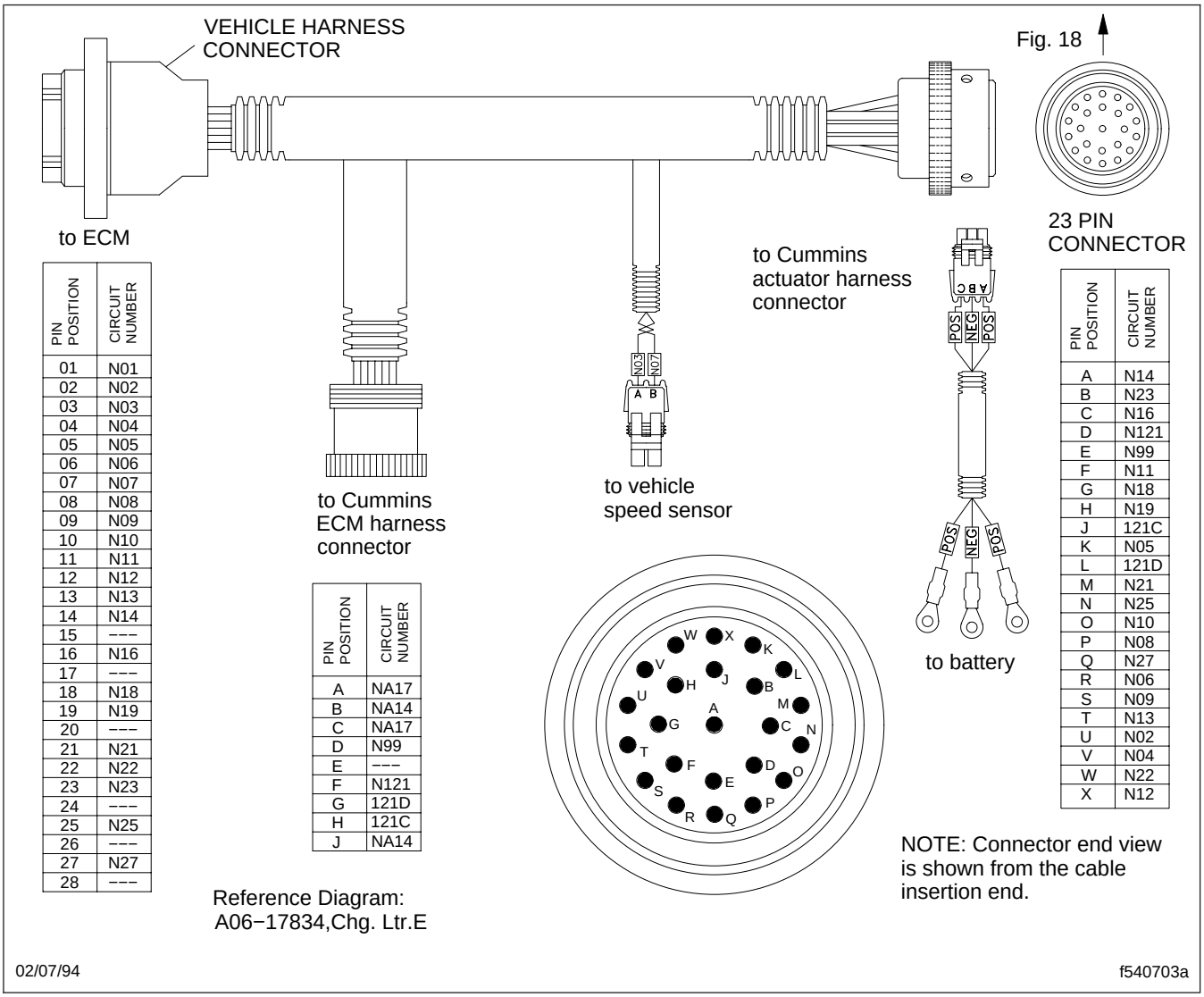


Fig. 18, Cummins CELECT Engine Wiring (detailed view)

Specifications



PIN POSITION	CIRCUIT NUMBER
01	N01
02	N02
03	N03
04	N04
05	N05
06	N06
07	N07
08	N08
09	N09
10	N10
11	N11
12	N12
13	N13
14	N14
15	–––
16	N16
17	–––
18	N18
19	N19
20	–––
21	N21
22	N22
23	N23
24	–––
25	N25
26	–––
27	N27
28	–––

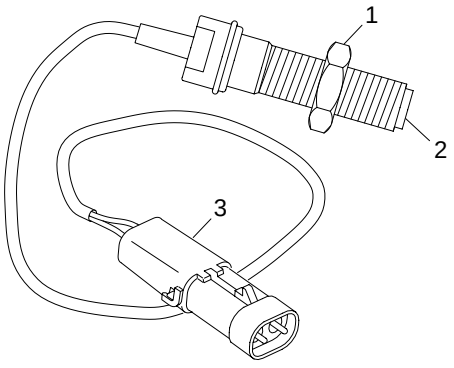
PIN POSITION	CIRCUIT NUMBER
A	NA17
B	NA14
C	NA17
D	N99
E	–––
F	N121
G	121D
H	121C
J	NA14

PIN POSITION	CIRCUIT NUMBER
A	N14
B	N23
C	N16
D	N121
E	N99
F	N11
G	N18
H	N19
J	121C
K	N05
L	121D
M	N21
N	N25
O	N10
P	N08
Q	N27
R	N06
S	N09
T	N13
U	N02
V	N04
W	N22
X	N12

Fig. 19, Cummins CELECT Vehicle Harness Connector

General Description

The Dixson 700 series speedometer uses a magnetic sensor (**Fig. 1**) mounted on the transmission bearing cover near the output shaft. **See Fig. 2**. The magnetic sensor uses feedback from a standard 16-tooth pulse wheel located under the bearing cover on the inboard end of the transmission output shaft. The magnetic end of the sensor extends through a threaded bore in the bearing cover. It is tightened down to the pulse wheel, and then backed off 1 to 1-1/2 turns, creating an air gap. For reference purposes, the gap should approach 0.050 inches (1.27 mm).



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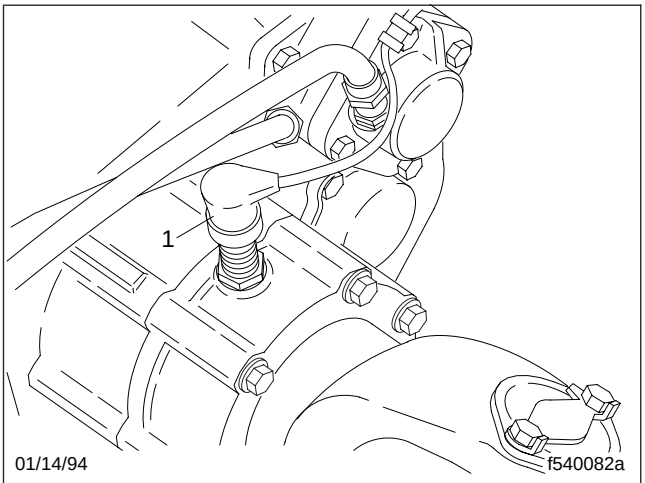
1. Jam Nut
2. Sensor
3. Weather Pack® Connector

Fig. 1, Magnetic Sensor Assembly

When the vehicle is moving, the teeth of the turning pulse wheel generate electrical pulses in the sensor's magnetic field. These pulses are transmitted to the speedometer head, which amplifies and interprets the pulses as vehicle speed and distance traveled.



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1. Magnetic Sensor

Fig. 2, Magnetic Sensor Installation

Calibrating the Speedometer Head

To calibrate a Dixson 700 Series speedometer, use the formula and tables given below.

First, determine the full scale frequency (FSF) using this formula:

$$\text{FSF (Hz)} = \frac{\text{R/mi x RAR x T x 80 MPH}}{\text{3600 seconds}}$$

Explanation of abbreviations:

- R/mi = Tire revolutions per mile
- RAR = rear axle ratio
- T = number of pulse wheel teeth

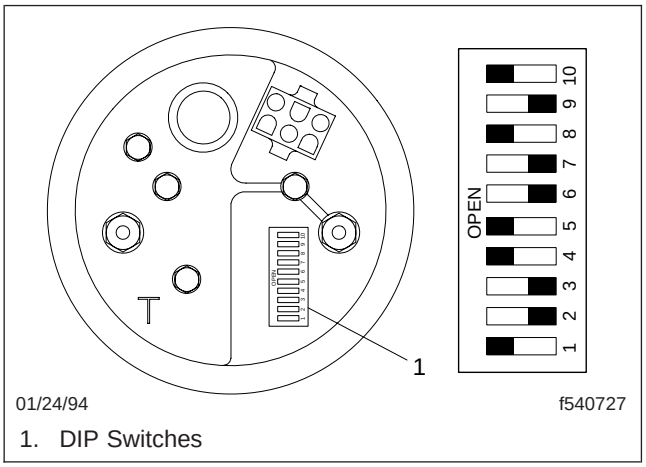
NOTE: The number of pulse wheel teeth is normally 16.

Then, find the frequency in the table in **"Specifications."** The table indicates which DIP switches on the back of the speedometer head to close. **See Fig. 1** for the location of the DIP switches.

For example, with a rear axle ratio of 4.10 and tires having 500 revolutions per mile, the calculations would be as follows:

$$\frac{\text{500 x 4.10 x 16 x 80}}{\text{3600}} = \text{729 Hz}$$

Referring to the table in **"Specifications,"** find 729 Hz. Close switches 2, 3, 6, 7, and 9.



1. DIP Switches

Fig. 1, DIP Switch Location

Speedometer Calibration Codes and DIP Switch Settings

Full Scale Frequency (Hz)	DIP Switches Closed
450	3,4,5,6,7,8,10
451	3,4,5,6,7,8,10
452	3,4,5,6,7,8,9
453	3,4,5,6,7,8,9
454	3,4,5,6,7,8,9,10
455	3,4,5,6,7,8,9,10
456	2
457	2,10
458	2,10
459	2,9
460	2,9
461	2,9,10
462	2,9,10
463	2,8
464	2,8,10
465	2,8,10
466	2,8,9
467	2,8,9
468	2,8,9,10
469	2,8,9,10
470	2,7
471	2,7
472	2,7,10
473	2,7,9
474	2,7,9
475	2,7,9,10
476	2,7,9,10
477	2,7,8
478	2,7,8
479	2,7,8,10
480	2,7,8,9
481	2,7,8,9
482	2,7,8,9,10
483	2,7,8,9,10
484	2,6
485	2,6
486	2,6,10
487	2,6,10
488	2,6,9
489	2,6,9,10
490	2,6,9,10
491	2,6,8
492	2,6,8
493	2,6,8,10
494	2,6,8,10
495	2,6,8,9
496	2,6,8,9,10
497	2,6,8,9,10
498	2,6,7
499	2,6,7
500	2,6,7,10
501	2,6,7,10
502	2,6,7,9
503	2,6,7,9
504	2,6,7,9,10
505	2,6,7,8
506	2,6,7,8
507	2,6,7,8,10
508	2,6,7,8,10
509	2,6,7,8,9
510	2,6,7,8,9
511	2,6,7,8,9,10
512	2,5
513	2,5
514	2,5,10
515	2,5,10
516	2,5,9
517	2,5,9
518	2,5,9,10
519	2,5,9,10

Specifications

Full Scale Frequency (Hz)	DIP Switches Closed
520	2,5,8
521	2,5,8,10
522	2,5,8,10
523	2,5,8,9
524	2,5,8,9
525	2,5,8,9,10
526	2,5,8,9,10
527	2,5,7
528	2,5,7,10
529	2,5,7,10
530	2,5,7,9
531	2,5,7,9
532	2,5,7,9,10
533	2,5,7,9,10
534	2,5,7,8
535	2,5,7,8
536	2,5,7,8,10
537	2,5,7,8,9
538	2,5,7,8,9
539	2,5,7,8,9,10
540	2,5,7,8,9,10
541	2,5,6
542	2,5,6
543	2,5,6,10
544	2,5,6,9
545	2,5,6,9
546	2,5,6,9,10
547	2,5,6,9,10
548	2,5,6,8
549	2,5,6,8
550	2,5,6,8,10
551	2,5,6,8,10
552	2,5,6,8,9
553	2,5,6,8,9,10
554	2,5,6,8,9,10
555	2,5,6,7

Full Scale Frequency (Hz)	DIP Switches Closed
556	2,5,6,7
557	2,5,6,7,10
558	2,5,6,7,10
559	2,5,6,7,9
560	2,5,6,7,9,10
561	2,5,6,7,9,10
562	2,5,6,7,8
563	2,5,6,7,8
564	2,5,6,7,8,10
565	2,5,6,7,8,10
566	2,5,6,7,8,9
567	2,5,6,7,8,9
568	2,5,6,7,8,9,10
569	2,4
570	2,4
571	2,4,10
572	2,4,10
573	2,4,9
574	2,4,9
575	2,4,9,10
576	2,4,8
577	2,4,8
578	2,4,8,10
579	2,4,8,10
580	2,4,8,9
581	2,4,8,9
582	2,4,8,9,10
583	2,4,8,9,10
584	2,4,7
585	2,4,7,10
586	2,4,7,10
587	2,4,7,9
588	2,4,7,9
589	2,4,7,9,10
590	2,4,7,9,10
591	2,4,7,8

Full Scale Frequency (Hz)	DIP Switches Closed
592	2,4,7,8,10
593	2,4,7,8,10
594	2,4,7,8,9
595	2,4,7,8,9
596	2,4,7,8,9,10
597	2,4,7,8,9,10
598	2,4,6
599	2,4,6
600	2,4,6,10
601	2,4,6,9
602	2,4,6,9
603	2,4,6,9,10
604	2,4,6,9,10
605	2,4,6,8
606	2,4,6,8
607	2,4,6,8,10
608	2,4,6,8,9
609	2,4,6,8,9
610	2,4,6,8,9,10
611	2,4,6,8,9,10
612	2,4,6,7
613	2,4,6,7
614	2,4,6,7,10
615	2,4,6,7,10
616	2,4,6,7,9
617	2,4,6,7,9,10
618	2,4,6,7,9,10
619	2,4,6,7,8
620	2,4,6,7,8
621	2,4,6,7,8,10
622	2,4,6,7,8,10
623	2,4,6,7,8,9
624	2,4,6,7,8,9,10
625	2,4,6,7,8,9,10
626	2,4,5
627	2,4,5

Full Scale Frequency (Hz)	DIP Switches Closed
628	2,4,5,10
629	2,4,5,10
630	2,4,5,9
631	2,4,5,9
632	2,4,5,9,10
633	2,4,5,8
634	2,4,5,8
635	2,4,5,8,10
636	2,4,5,8,10
637	2,4,5,8,9
638	2,4,5,8,9
639	2,4,5,8,9,10
640	2,4,5,7
641	2,4,5,7
642	2,4,5,7,10
643	2,4,5,7,10
644	2,4,5,7,9
645	2,4,5,7,9
646	2,4,5,7,9,10
647	2,4,5,7,9,10
648	2,4,5,7,8
649	2,4,5,7,8,10
650	2,4,5,7,8,10
651	2,4,5,7,8,9
652	2,4,5,7,8,9
653	2,4,5,7,8,9,10
654	2,4,5,7,8,9,10
655	2,4,5,6
656	2,4,5,6,10
657	2,4,5,6,10
658	2,4,5,6,9
659	2,4,5,6,9
660	2,4,5,6,9,10
661	2,4,5,6,9,10
662	2,4,5,6,8
663	2,4,5,6,8

Specifications

Full Scale Frequency (Hz)	DIP Switches Closed
664	2,4,5,6,8,10
665	2,4,5,6,8,9
666	2,4,5,6,8,9
667	2,4,5,6,8,9,10
668	2,4,5,6,8,9,10
669	2,4,5,6,7
670	2,4,5,6,7
671	2,4,5,6,7,10
672	2,4,5,6,7,9
673	2,4,5,6,7,9
674	2,4,5,6,7,9,10
675	2,4,5,6,7,9,10
676	2,4,5,6,7,8
677	2,4,5,6,7,8
678	2,4,5,6,7,8,10
679	2,4,5,6,7,8,10
680	2,4,5,6,7,8,9
681	2,4,5,6,7,8,9,10
682	2,4,5,6,7,8,9,10
683	2,3
684	2,3
685	2,3,10
686	2,3,10
687	2,3,9
688	2,3,9,10
689	2,3,9,10
690	2,3,8
691	2,3,8
692	2,3,8,10
693	2,3,8,10
694	2,3,8,9
695	2,3,8,9
696	2,3,8,9,10
697	2,3,7
698	2,3,7
699	2,3,7,10

Full Scale Frequency (Hz)	DIP Switches Closed
700	2,3,7,10
701	2,3,7,9
702	2,3,7,9
703	2,3,7,9,10
704	2,3,7,8
705	2,3,7,8
706	2,3,7,8,10
707	2,3,7,8,10
708	2,3,7,8,9
709	2,3,7,8,9
710	2,3,7,8,9,10
711	2,3,7,8,9,10
712	2,3,6
713	2,3,6,10
714	2,3,6,10
715	2,3,6,9
716	2,3,6,9
717	2,3,6,9,10
718	2,3,6,9,10
719	2,3,6,8
720	2,3,6,8,10
721	2,3,6,8,10
722	2,3,6,8,9
723	2,3,6,8,9
724	2,3,6,8,9,10
725	2,3,6,8,9,10
726	2,3,6,7
727	2,3,6,7
728	2,3,6,7,10
729	2,3,6,7,9
730	2,3,6,7,9
731	2,3,6,7,9,10
732	2,3,6,7,9,10
733	2,3,6,7,8
734	2,3,6,7,8
735	2,3,6,7,8,10

Full Scale Frequency (Hz)	DIP Switches Closed
736	2,3,6,7,8,9
737	2,3,6,7,8,9
738	2,3,6,7,8,9,10
739	2,3,6,7,8,9,10
740	2,3,5
741	2,3,5
742	2,3,5,10
743	2,3,5,10
744	2,3,5,9
745	2,3,5,9,10
746	2,3,5,9,10
747	2,3,5,8
748	2,3,5,8
749	2,3,5,8,10
750	2,3,5,8,10
751	2,3,5,8,9
752	2,3,5,8,9,10
753	2,3,5,8,9,10
754	2,3,5,7
755	2,3,5,7
756	2,3,5,7,10
757	2,3,5,7,10
758	2,3,5,7,9
759	2,3,5,7,9
760	2,3,5,7,9,10
761	2,3,5,7,8
762	2,3,5,7,8
763	2,3,5,7,8,10
764	2,3,5,7,8,10
765	2,3,5,7,8,9
766	2,3,5,7,8,9
767	2,3,5,7,8,9,10
768	2,3,5,6
769	2,3,5,6
770	2,3,5,6,10
771	2,3,5,6,10

Full Scale Frequency (Hz)	DIP Switches Closed
772	2,3,5,6,9
773	2,3,5,6,9
774	2,3,5,6,9,10
775	2,3,5,6,9,10
776	2,3,5,6,8
777	2,3,5,6,8,10
778	2,3,5,6,8,10
779	2,3,5,6,8,9
780	2,3,5,6,8,9
781	2,3,5,6,8,9,10
782	2,3,5,6,8,9,10
783	2,3,5,6,7
784	2,3,5,6,7,10
785	2,3,5,6,7,10
786	2,3,5,6,7,9
787	2,3,5,6,7,9
788	2,3,5,6,7,9,10
789	2,3,5,6,7,9,10
790	2,3,5,6,7,8
791	2,3,5,6,7,8
792	2,3,5,6,7,8,10
793	2,3,5,6,7,8,9
794	2,3,5,6,7,8,9
795	2,3,5,6,7,8,9,10
796	2,3,5,6,7,8,9,10
797	2,3,4
798	2,3,4
799	2,3,4,10
800	2,3,4,9
801	2,3,4,9
802	2,3,4,9,10
803	2,3,4,9,10
804	2,3,4,8
805	2,3,4,8
806	2,3,4,8,10
807	2,3,4,8,10

Specifications

Full Scale Frequency (Hz)	DIP Switches Closed
808	2,3,4,8,9
809	2,3,4,8,9,10
810	2,3,4,8,9,10
811	2,3,4,7
812	2,3,4,7
813	2,3,4,7,10
814	2,3,4,7,10
815	2,3,4,7,9
816	2,3,4,7,9,10
817	2,3,4,7,9,10
818	2,3,4,7,8
819	2,3,4,7,8
820	2,3,4,7,8,10
821	2,3,4,7,8,10
822	2,3,4,7,8,9
823	2,3,4,7,8,9
824	2,3,4,7,8,9,10
825	2,3,4,6
826	2,3,4,6
827	2,3,4,6,10
828	2,3,4,6,10
829	2,3,4,6,9
830	2,3,4,6,9
831	2,3,4,6,9,10
832	2,3,4,6,8
833	2,3,4,6,8
834	2,3,4,6,8,10
835	2,3,4,6,8,10
836	2,3,4,6,8,9
837	2,3,4,6,8,9
838	2,3,4,6,8,9,10
839	2,3,4,6,8,9,10
840	2,3,4,6,7
841	2,3,4,6,7,10
842	2,3,4,6,7,10
843	2,3,4,6,7,9

Full Scale Frequency (Hz)	DIP Switches Closed
844	2,3,4,6,7,9
845	2,3,4,6,7,9,10
846	2,3,4,6,7,9,10
847	2,3,4,6,7,8
848	2,3,4,6,7,8,10
849	2,3,4,6,7,8,10
850	2,3,4,6,7,8,9
851	2,3,4,6,7,8,9
852	2,3,4,6,7,8,9,10
853	2,3,4,6,7,8,9,10
854	2,3,4,5
855	2,3,4,5
856	2,3,4,5,10
857	2,3,4,5,9
858	2,3,4,5,9
859	2,3,4,5,9,10
860	2,3,4,5,9,10
861	2,3,4,5,8
862	2,3,4,5,8
863	2,3,4,5,8,10
864	2,3,4,5,9
865	2,3,4,5,9
866	2,3,4,5,8,9,10
867	2,3,4,5,8,9,10
868	2,3,4,5,7
869	2,3,4,5,7
870	2,3,4,5,7,10
871	2,3,4,5,7,10
872	2,3,4,5,7,9
873	2,3,4,5,7,9,10
874	2,3,4,5,7,9,10
875	2,3,4,5,7,8
876	2,3,4,5,7,8
877	2,3,4,5,7,8,10
878	2,3,4,5,7,8,10
879	2,3,4,5,7,8,9

Full Scale Frequency (Hz)	DIP Switches Closed
880	2,3,4,5,7,8,9,10
881	2,3,4,5,7,8,9,10
882	2,3,4,5,6
883	2,3,4,5,6
884	2,3,4,5,6,10
885	2,3,4,5,6,10
886	2,3,4,5,6,9
887	2,3,4,5,6,9
888	2,3,4,5,6,9,10
889	2,3,4,5,6,8
890	2,3,4,5,6,8
891	2,3,4,5,6,8,10
892	2,3,4,5,6,8,10
893	2,3,4,5,6,8,9
894	2,3,4,5,6,8,9
895	2,3,4,5,6,8,9,10
896	2,3,4,5,6,7
897	2,3,4,5,6,7
898	2,3,4,5,6,7,10
899	2,3,4,5,6,7,10
900	2,3,4,5,6,7,9
901	2,3,4,5,6,7,9
902	2,3,4,5,6,7,9,10
903	2,3,4,5,6,7,9,10
904	2,3,4,5,6,7,8
905	2,3,4,5,6,7,8,10
906	2,3,4,5,6,7,8,10
907	2,3,4,5,6,7,8,9
908	2,3,4,5,6,7,8,9
909	2,3,4,5,6,7,8,9,10
910	2,3,4,5,6,7,8,9,10
911	1
912	1,10
913	1,10
914	1,9
915	1,9

Full Scale Frequency (Hz)	DIP Switches Closed
916	1,9,10
917	1,9,10
918	1,8
919	1,8
920	1,8,10
921	1,8,9
922	1,8,9
923	1,8,9,10
924	1,8,9,10
925	1,7
926	1,7
927	1,7,10
928	1,7,9
929	1,7,9
930	1,7,9,10
931	1,7,9,10
932	1,7,8
933	1,7,8
934	1,7,8,10
935	1,7,8,10
936	1,7,8,9
937	1,7,8,9,10
938	1,7,8,9,10
939	1,6
940	1,6
941	1,6,10
942	1,6,10
943	1,6,9
944	1,6,9,10
945	1,6,9,10
946	1,6,8
947	1,6,8
948	1,6,8,10
949	1,6,8,10
950	1,6,8,9
951	1,6,8,9

Specifications

Full Scale Frequency (Hz)	DIP Switches Closed
952	1,6,8,9,10
953	1,6,7
954	1,6,7
955	1,6,7,10
956	1,6,7,10
957	1,6,7,9
958	1,6,7,9
959	1,6,7,9,10
960	1,6,7,8
961	1,6,7,8
962	1,6,7,8,10
963	1,6,7,8,10
964	1,6,7,8,9
965	1,6,7,8,9
966	1,6,7,8,9,10
967	1,6,7,8,9,10
968	1,5
969	1,5,10
970	1,5,10
971	1,5,9
972	1,5,9
973	1,5,9,10
974	1,5,9,10
975	1,5,8
976	1,5,8,10
977	1,5,8,10
978	1,5,8,9
979	1,5,8,9
980	1,5,8,9,10
981	1,5,8,9,10
982	1,5,7
983	1,5,7
984	1,5,7,10
985	1,5,7,9
986	1,5,7,9
987	1,5,7,9,10

Full Scale Frequency (Hz)	DIP Switches Closed
988	1,5,7,9,10
989	1,5,7,8
990	1,5,7,8
991	1,5,7,8,10
992	1,5,7,8,9
993	1,5,7,8,9
994	1,5,7,8,9,10
995	1,5,7,8,9,10
996	1,5,6
997	1,5,6
998	1,5,6,10
999	1,5,6,10
1000	1,5,6,9
1001	1,5,6,9,10
1002	1,5,6,9,10
1003	1,5,6,8
1004	1,5,6,8
1005	1,5,6,8,10
1006	1,5,6,8,10
1007	1,5,6,8,9
1008	1,5,6,8,9,10
1009	1,5,6,8,9,10
1010	1,5,6,7
1011	1,5,6,7
1012	1,5,6,7,10
1013	1,5,6,7,10
1014	1,5,6,7,9
1015	1,5,6,7,9
1016	1,5,6,7,9,10
1017	1,5,6,7,8
1018	1,5,6,7,8
1019	1,5,6,7,8,10
1020	1,5,6,7,8,10
1021	1,5,6,7,8,9
1022	1,5,6,7,8,9
1023	1,5,6,7,8,9,10

Full Scale Frequency (Hz)	DIP Switches Closed
1024	1,4
1025	1,4
1026	1,4,10
1027	1,4,10
1028	1,4,9
1029	1,4,9
1030	1,4,9,10
1031	1,4,9,10
1032	1,4,8
1033	1,4,8,10
1034	1,4,8,10
1035	1,4,8,9
1036	1,4,8,9
1037	1,4,8,9,10
1038	1,4,8,9,10
1039	1,4,7
1040	1,4,7,10
1041	1,4,7,10
1042	1,4,7,9
1043	1,4,7,9
1044	1,4,7,9,10
1045	1,4,7,9,10
1046	1,4,7,8
1047	1,4,7,8
1048	1,4,7,8,10
1049	1,4,7,8,9
1050	1,4,7,8,9
1051	1,4,7,8,9,10
1052	1,4,7,8,9,10
1053	1,4,6
1054	1,4,6
1055	1,4,6,10
1056	1,4,6,9
1057	1,4,6,9
1058	1,4,6,9,10
1059	1,4,6,9,10

Full Scale Frequency (Hz)	DIP Switches Closed
1060	1,4,6,8
1061	1,4,6,8
1062	1,4,6,8,10
1063	1,4,6,8,10
1064	1,4,6,8,9
1065	1,4,6,8,9,10
1066	1,4,6,8,9,10
1067	1,4,6,7
1068	1,4,6,7
1069	1,4,6,7,10
1070	1,4,6,7,10
1071	1,4,6,7,9
1072	1,4,6,7,9,10
1073	1,4,6,7,9,10
1074	1,4,6,7,8
1075	1,4,6,7,8
1076	1,4,6,7,8,10
1077	1,4,6,7,8,10
1078	1,4,6,7,8,9
1079	1,4,6,7,8,9
1080	1,4,6,7,8,9,10
1081	1,4,5
1082	1,4,5
1083	1,4,5,10
1084	1,4,5,10
1085	1,4,5,9
1086	1,4,5,9
1087	1,4,5,9,10
1088	1,4,5,8
1089	1,4,5,8
1090	1,4,5,8,10
1091	1,4,5,8,10
1092	1,4,5,8,9
1093	1,4,5,8,9
1094	1,4,5,8,9,10
1095	1,4,5,8,9,10

Specifications

Full Scale Frequency (Hz)	DIP Switches Closed
1096	1,4,5,7
1097	1,4,5,7,10
1098	1,4,5,7,10
1099	1,4,5,7,9
1100	1,4,5,7,9
1101	1,4,5,7,9,10
1102	1,4,5,7,9,10
1103	1,4,5,7,8
1104	1,4,5,7,8,10
1105	1,4,5,7,8,10
1106	1,4,5,7,8,9
1107	1,4,5,7,8,9
1108	1,4,5,7,8,9,10
1109	1,4,5,7,8,9,10
1110	1,4,5,6
1111	1,4,5,6
1112	1,4,5,6,10
1113	1,4,5,6,9
1114	1,4,5,6,9
1115	1,4,5,6,9,10
1116	1,4,5,6,9,10
1117	1,4,5,6,8
1118	1,4,5,6,8
1119	1,4,5,6,8,10
1120	1,4,5,6,8,9
1121	1,4,5,6,8,9
1122	1,4,5,6,8,9,10
1123	1,4,5,6,8,9,10
1124	1,4,5,6,7
1125	1,4,5,6,7
1126	1,4,5,6,7,10
1127	1,4,5,6,7,10
1128	1,4,5,6,7,9
1129	1,4,5,6,7,9,10
1130	1,4,5,6,7,9,10
1131	1,4,5,6,7,8

Full Scale Frequency (Hz)	DIP Switches Closed
1132	1,4,5,6,7,8
1133	1,4,5,6,7,8,10
1134	1,4,5,6,7,8,10
1135	1,4,5,6,7,8,9
1136	1,4,5,6,7,8,9,10
1137	1,4,5,6,7,8,9,10
1138	1,3
1139	1,3
1140	1,3,10
1141	1,3,10
1142	1,3,9
1143	1,3,9
1144	1,3,9,10
1145	1,3,8
1146	1,3,8
1147	1,3,8,10
1148	1,3,8,10
1149	1,3,8,9
1150	1,3,8,9
1151	1,3,8,9,10
1152	1,3,7
1153	1,3,7
1154	1,3,7,10
1155	1,3,7,10
1156	1,3,7,9
1157	1,3,7,9
1158	1,3,7,9,10
1159	1,3,7,9,10
1160	1,3,7,8
1161	1,3,7,8,10
1162	1,3,7,8,10
1163	1,3,7,8,9
1164	1,3,7,8,9
1165	1,3,7,8,9,10
1166	1,3,7,8,9,10
1167	1,3,6

Full Scale Frequency (Hz)	DIP Switches Closed
1168	1,3,6,10
1169	1,3,6,10
1170	1,3,6,9
1171	1,3,6,9
1172	1,3,6,9,10
1173	1,3,6,9,10
1174	1,3,6,8
1175	1,3,6,8
1176	1,3,6,8,10
1177	1,3,6,8,9
1178	1,3,6,8,9
1179	1,3,6,8,9,10
1180	1,3,6,8,9,10
1181	1,3,6,7
1182	1,3,6,7
1183	1,3,6,7,10
1184	1,3,6,7,9
1185	1,3,6,7,9
1186	1,3,6,7,9,10
1187	1,3,6,7,9,10
1188	1,3,6,7,8
1189	1,3,6,7,8
1190	1,3,6,7,8,10
1191	1,3,6,7,8,10
1192	1,3,6,7,8,9
1193	1,3,6,7,8,9,10
1194	1,3,6,7,8,9,10
1195	1,3,5
1196	1,3,5
1197	1,3,5,10
1198	1,3,5,10
1199	1,3,5,9
1200	1,3,5,9,10
1201	1,3,5,9,10
1202	1,3,5,8
1203	1,3,5,8

Full Scale Frequency (Hz)	DIP Switches Closed
1204	1,3,5,8,10
1205	1,3,5,8,10
1206	1,3,5,8,9
1207	1,3,5,8,9
1208	1,3,5,8,9,10
1209	1,3,5,7
1210	1,3,5,7
1211	1,3,5,7,10
1212	1,3,5,7,10
1213	1,3,5,7,9
1214	1,3,5,7,9
1215	1,3,5,7,9,10
1216	1,3,5,7,8
1217	1,3,5,7,8
1218	1,3,5,7,8,10
1219	1,3,5,7,8,10
1220	1,3,5,7,8,9
1221	1,3,5,7,8,9
1222	1,3,5,7,8,9,10
1223	1,3,5,7,8,9,10
1224	1,3,5,6
1225	1,3,5,6,10
1226	1,3,5,6,10
1227	1,3,5,6,9
1228	1,3,5,6,9
1229	1,3,5,6,9,10
1230	1,3,5,6,9,10
1231	1,3,5,6,8
1232	1,3,5,6,8,10
1233	1,3,5,6,8,10
1234	1,3,5,6,8,9
1235	1,3,5,6,8,9
1236	1,3,5,6,8,9,10
1237	1,3,5,6,8,9,10
1238	1,3,5,6,7
1239	1,3,5,6,7

Specifications

Full Scale Frequency (Hz)	DIP Switches Closed
1240	1,3,5,6,7,10
1241	1,3,5,6,7,9
1242	1,3,5,6,7,9
1243	1,3,5,6,7,10
1244	1,3,5,6,7,10
1245	1,3,5,6,7,8
1246	1,3,5,6,7,8
1247	1,3,5,6,7,8,10
1248	1,3,5,6,7,8,9
1249	1,3,5,6,7,8,9
1250	1,3,5,6,7,8,9,10
1251	1,3,5,6,7,8,9,10
1252	1,3,4
1253	1,3,4
1254	1,3,4,10
1255	1,3,4,10
1256	1,3,4,9
1257	1,3,4,9,10
1258	1,3,4,9,10
1259	1,3,4,8
1260	1,3,4,8
1261	1,3,4,8,10
1262	1,3,4,8,10
1263	1,3,4,8,9
1264	1,3,4,8,9,10
1265	1,3,4,8,9,10
1266	1,3,4,7
1267	1,3,4,7
1268	1,3,4,7,10
1269	1,3,4,7,10
1270	1,3,4,7,9
1271	1,3,4,7,9
1272	1,3,4,7,9,10
1273	1,3,4,7,8
1274	1,3,4,7,8
1275	1,3,4,7,8,10

Full Scale Frequency (Hz)	DIP Switches Closed
1276	1,3,4,7,8,10
1277	1,3,4,7,8,9
1278	1,3,4,7,8,9
1279	1,3,4,7,8,9,10
1280	1,3,4,6
1281	1,3,4,6
1282	1,3,4,6,10
1283	1,3,4,6,10
1284	1,3,4,6,9
1285	1,3,4,6,9
1286	1,3,4,6,9,10
1287	1,3,4,6,9,10
1288	1,3,4,6,8
1289	1,3,4,6,8,10
1290	1,3,4,6,8,10
1291	1,3,4,6,8,9
1292	1,3,4,6,8,9
1293	1,3,4,6,8,9,10
1294	1,3,4,6,8,9,10
1295	1,3,4,6,7
1296	1,3,4,6,7,10
1297	1,3,4,6,7,10
1298	1,3,4,6,7,9
1299	1,3,4,6,7,9
1300	1,3,4,6,7,9,10
1301	1,3,4,6,7,9,10
1302	1,3,4,6,7,8
1303	1,3,4,6,7,8
1304	1,3,4,6,7,8,10
1305	1,3,4,6,7,8,9
1306	1,3,4,6,7,8,9
1307	1,3,4,6,7,8,9,10
1308	1,3,4,6,7,8,9,10
1309	1,3,4,5
1310	1,3,4,5
1311	1,3,4,5,10

Full Scale Frequency (Hz)	DIP Switches Closed
1312	1,3,4,5,9
1313	1,3,4,5,9
1314	1,3,4,5,9,10
1315	1,3,4,5,9,10
1316	1,3,4,5,8
1317	1,3,4,5,8
1318	1,3,4,5,8,10
1319	1,3,4,5,8,10
1320	1,3,4,5,8,9
1321	1,3,4,5,8,9,10
1322	1,3,4,5,8,9,10
1323	1,3,4,5,7
1324	1,3,4,5,7
1325	1,3,4,5,7,10
1326	1,3,4,5,7,10
1327	1,3,4,5,7,9
1328	1,3,4,5,7,9,10
1329	1,3,4,5,7,9,10
1330	1,3,4,5,7,8
1331	1,3,4,5,7,8
1332	1,3,4,5,7,8,10
1333	1,3,4,5,7,8,10
1334	1,3,4,5,7,8,9
1335	1,3,4,5,7,8,9
1336	1,3,4,5,7,8,9,10
1337	1,3,4,5,6
1338	1,3,4,5,6
1339	1,3,4,5,6,10
1340	1,3,4,5,6,10
1341	1,3,4,5,6,9
1342	1,3,4,5,6,9
1343	1,3,4,5,6,9,10
1344	1,3,4,5,6,8
1345	1,3,4,5,6,8
1346	1,3,4,5,6,8,10
1347	1,3,4,5,6,8,10

Full Scale Frequency (Hz)	DIP Switches Closed
1348	1,3,4,5,6,8,9
1349	1,3,4,5,6,8,9
1350	1,3,4,5,6,8,9,10
1351	1,3,4,5,6,8,9,10
1352	1,3,4,5,6,7
1353	1,3,4,5,6,7,10
1354	1,3,4,5,6,7,10
1355	1,3,4,5,6,7,9
1356	1,3,4,5,6,7,9
1357	1,3,4,5,6,7,9,10
1358	1,3,4,5,6,7,9,10
1359	1,3,4,5,6,7,8
1360	1,3,4,5,6,7,8,10
1361	1,3,4,5,6,7,8,10
1362	1,3,4,5,6,7,8,9
1363	1,3,4,5,6,7,8,9
1364	1,3,4,5,6,7,8,9,10
1365	1,3,4,5,6,7,8,9,10
1366	1,2
1367	1,2
1368	1,2,10
1369	1,2,9
1370	1,2,9
1371	1,2,9,10
1372	1,2,9,10
1373	1,2,8
1374	1,2,8
1375	1,2,8,10
1376	1,2,8,9
1377	1,2,8,9
1378	1,2,8,9,10
1379	1,2,8,9,10
1380	1,2,7
1381	1,2,7
1382	1,2,7,10
1383	1,2,7,10

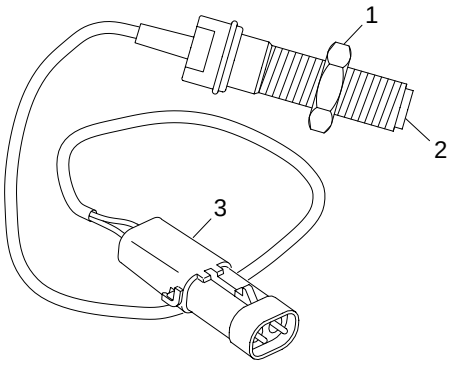
Specifications

Full Scale Frequency (Hz)	DIP Switches Closed
1384	1,2,7,9
1385	1,2,7,9,10
1386	1,2,7,9,10
1387	1,2,7,8
1388	1,2,7,8
1389	1,2,7,8,10
1390	1,2,7,8,10
1391	1,2,7,8,9
1392	1,2,7,8,9,10
1393	1,2,7,8,9,10
1394	1,2,6
1395	1,2,6
1396	1,2,6,10
1397	1,2,6,10
1398	1,2,6,9
1399	1,2,6,9
1400	1,2,6,9,10
1401	1,2,6,8
1402	1,2,6,8
1403	1,2,6,8,10
1404	1,2,6,8,10
1405	1,2,6,8,9
1406	1,2,6,8,9
1407	1,2,6,8,9,10
1408	1,2,6,7
1409	1,2,6,7
1410	1,2,6,7,10
1411	1,2,6,7,10
1412	1,2,6,7,9
1413	1,2,6,7,9
1414	1,2,6,7,9,10
1415	1,2,6,7,9,10
1416	1,2,6,7,8
1417	1,2,6,7,8,10
1418	1,2,6,7,8,10
1419	1,2,6,7,8,9

Full Scale Frequency (Hz)	DIP Switches Closed
1420	1,2,6,7,8,9
1421	1,2,6,7,8,9,10
1422	1,2,6,7,8,9,10
1423	1,2,5
1424	1,2,5,10
1425	1,2,5,10
1426	1,2,5,9
1427	1,2,5,9
1428	1,2,5,9,10
1429	1,2,5,9,10
1430	1,2,5,8
1431	1,2,5,8
1432	1,2,5,8,10
1433	1,2,5,8,9
1434	1,2,5,8,9
1435	1,2,5,8,9,10
1436	1,2,5,8,9,10
1437	1,2,5,7
1438	1,2,5,7
1439	1,2,5,7,10
1440	1,2,5,7,9
1441	1,2,5,7,9
1442	1,2,5,7,9,10
1443	1,2,5,7,9,10
1444	1,2,5,7,8
1445	1,2,5,7,8
1446	1,2,5,7,8,10
1447	1,2,5,7,8,10
1448	1,2,5,7,8,9
1449	1,2,5,7,8,9,10
1450	1,2,5,7,8,9,10

General Description

The ISSPRO programmable speedometer uses a magnetic sensor (**Fig. 1**) mounted on the transmission bearing cover near the output shaft. **See Fig. 2**. The magnetic sensor uses feedback from a standard 16-tooth pulse wheel located under the bearing cover on the inboard end of the transmission output shaft. The magnetic end of the sensor extends through a threaded bore in the bearing cover. It is tightened down to the pulse wheel, and then backed off 1 to 1-1/2 turns, creating an air gap. For reference purposes, the gap should approach 0.050 inches (1.27 mm).

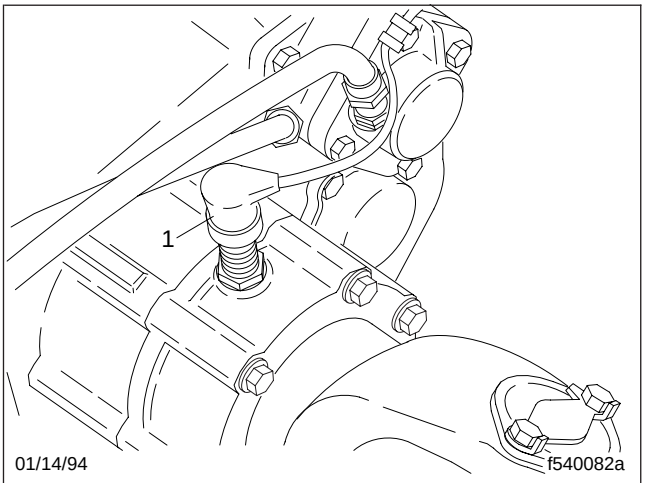


01/14/94 f540144a

1. Jam Nut
2. Sensor
3. Weather Pack® Connector

Fig. 1, Magnetic Sensor Assembly

When the vehicle is moving, the teeth of the turning pulse wheel generate electrical pulses in the sensor's magnetic field. These pulses are transmitted to the speedometer head, which amplifies and interprets the pulses as vehicle speed and distance traveled.



01/14/94 f540082a

1. Magnetic Sensor

Fig. 2, Magnetic Sensor Installation

Calibrating the Speedometer Head

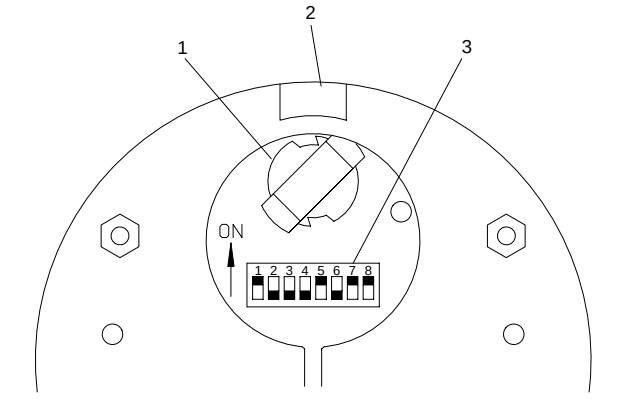
To calibrate an ISSPRO programmable speedometer, use the formula and table given below.

First, determine the calibration number using this formula:

Calibration Number = tire revs/mi x rear axle ratio x number of pulse wheel teeth.

NOTE: The number of pulse wheel teeth is normally 16.

Then, find the calibration number in the table in **"Specifications."** The table indicates which DIP switches on the back of the speedometer head need to be set to the "ON" position. **See Fig. 1** for the location on the DIP switches.



1. Lamp and Socket
2. Slot
3. DIP Switches

Fig. 1

For example, with a rear axle ratio of 4.10 and tires having 500 revolutions per mile, the calculations would be as follows:

500 x 4.10 x 16 = 32800

Referring to the table in **"Specifications,"** find 32800. Since 32800 falls in the range 32457-32826, set switches 1, 5, 7, and 8 to the "ON" position. To set the switch in the "ON" position, slide it upward.

Speedometer Calibration Codes and DIP Switch Settings

Calibration Number	DIP Switches ON
67784–69378	1,2,3,4,5,6,7,8
66226–67783	2,3,4,5,6,7,8
64739–66225	1,3,4,5,6,7,8
63314–64738	3,4,5,6,7,8
61950–63313	1,2,4,5,6,7,8
60646–61949	2,4,5,6,7,8
59397–60645	1,4,5,6,7,8
58195–59396	4,5,6,7,8
57040–58194	1,2,3,5,6,7,8
55934–57039	2,3,5,6,7,8
54869–55933	1,3,5,6,7,8
53842–54868	3,5,6,7,8
52852–53841	1,2,5,6,7,8
51901–52851	2,5,6,7,8
50983–51900	1,5,6,7,8
50054–50982	5,6,7,8
49157–50053	1,2,3,4,6,7,8
48333–49156	2,3,4,6,7,8
47536–48332	1,3,4,6,7,8
46763–47535	3,4,6,7,8
46015–46762	1,2,4,6,7,8
45292–46014	2,4,6,7,8
44591–45291	1,4,6,7,8
43911–44590	4,6,7,8
43250–43910	1,2,3,6,7,8
42611–43249	2,3,6,7,8
41990–42610	1,3,6,7,8
41386–41989	3,6,7,8
40799–41385	1,2,6,7,8
40230–40798	2,6,7,8
39676–40229	1,6,7,8
39099–39675	6,7,8
38537–39098	1,2,3,4,5,7,8
38029–38536	2,3,4,5,7,8
37534–38028	1,3,4,5,7,8
37050–37533	3,4,5,7,8
36579–37049	1,2,4,5,7,8
36121–36578	2,4,5,7,8
35674–36120	1,4,5,7,8
35237–35673	4,5,7,8
34810–35236	1,2,3,5,7,8
34395–34809	2,3,5,7,8
33989–34394	1,3,5,7,8
33592–33988	3,5,7,8
33205–33591	1,2,5,7,8
32827–33204	2,5,7,8
32457–32826	1,5,7,8
32078–32456	5,7,8
31707–32077	1,2,3,4,7,8
31363–31706	2,3,4,7,8
31025–31362	1,3,4,7,8
30694–31024	3,4,7,8
30370–30693	1,2,4,7,8
30053–30369	2,4,7,8
29743–30052	1,4,7,8
29439–29742	4,7,8
29140–29438	1,2,3,7,8
28849–29139	2,3,7,8
28563–28848	1,3,7,8
28282–28562	3,7,8
28007–28281	1,2,7,8
27737–28006	2,7,8
27473–27736	1,7,8
27147–27472	7,8
26827–27146	1,2,3,4,5,6,8
26580–26826	2,3,4,5,6,8
26337–26579	1,3,4,5,6,8
26098–26336	3,4,5,6,8
25863–26097	1,2,4,5,6,8
25633–25862	2,4,5,6,8
25408–25632	1,4,5,6,8

Specifications

Calibration Number	DIP Switches ON
25185–25407	4,5,6,8
24966–25184	1,2,3,5,6,8
24752–24965	2,3,5,6,8
24541–24751	1,3,5,6,8
24334–24540	3,5,6,8
24130–24333	1,2,5,6,8
23929–24129	2,5,6,8
23732–23928	1,5,6,8
23529–23731	5,6,8
23329–23528	1,2,3,4,6,8
23142–23328	2,3,4,6,8
22958–23141	1,3,4,6,8
22776–22957	3,4,6,8
22597–22775	1,2,4,6,8
22421–22596	2,4,6,8
22248–22420	1,4,6,8
22077–22247	4,6,8
21909–22076	1,2,3,6,8
21744–21908	2,3,6,8
21581–21743	1,3,6,8
21421–21580	3,6,8
21262–21420	1,2,6,8
21107–21261	2,6,8
20953–21106	1,6,8
20791–20952	6,8
20631–20790	1,2,3,4,5,8
20485–20630	2,3,4,5,8
20340–20484	1,3,4,5,8
20197–20339	3,4,5,8
20056–20196	1,2,4,5,8
19918–20055	2,4,5,8
19781–19917	1,4,5,8
19646–19780	4,5,8
19513–19645	1,2,3,5,8
19382–19512	2,3,5,8
19252–19381	1,3,5,8

Calibration Number	DIP Switches ON
19124–19251	3,5,8
18998–19123	1,2,5,8
18874–18997	2,5,8
18751–18873	1,5,8
18624–18750	5,8
18498–18623	1,2,3,4,8
18380–18497	2,3,4,8
18264–18379	1,3,4,8
18149–18263	3,4,8
18035–18148	1,2,4,8
17923–18034	2,4,8
17812–17922	1,4,8
17702–17811	4,8
17594–17701	1,2,3,8
17487–17593	2,3,8
17382–17486	1,3,8
17278–17381	3,8
17174–17277	1,2,8
17073–17173	2,8
16972–17072	1,8
16847–16971	8
16724–16846	1,2,3,4,5,6,7
16627–16723	2,3,4,5,6,7
16532–16626	1,3,4,5,6,7
16437–16531	3,4,5,6,7
16344–16436	1,2,4,5,6,7
16252–16343	2,4,5,6,7
16161–16251	1,4,5,6,7
16070–16160	4,5,6,7
15981–16069	1,2,3,5,6,7
15893–15980	2,3,5,6,7
15806–15892	1,3,5,6,7
15720–15805	3,5,6,7
15634–15719	1,2,5,6,7
15550–15633	2,5,6,7
15466–15549	1,5,6,7

Calibration Number	DIP Switches ON
15380–15465	5,6,7
15294–15379	1,2,3,4,6,7
15213–15293	2,3,4,6,7
15134–15212	1,3,4,6,7
15054–15133	3,4,6,7
14976–15053	1,2,4,6,7
14899–14975	2,4,6,7
14822–14898	1,4,6,7
14746–14821	4,6,7
14671–14745	1,2,3,6,7
14597–14670	2,3,6,7
14523–14596	1,3,6,7
14450–14522	3,6,7
14378–14449	1,2,6,7
14307–14377	2,6,7
14236–14306	1,6,7
14161–14235	6,7
14087–14160	1,2,3,4,5,7
14018–14086	2,3,4,5,7
13950–14017	1,3,4,5,7
13883–13949	3,4,5,7
13816–13882	1,2,4,5,7
13750–13815	2,4,5,7
13685–13749	1,4,5,7
13620–13684	4,5,7
13556–13619	1,2,3,5,7
13493–13555	2,3,5,7
13430–13492	1,3,5,7
13367–13429	3,5,7
13306–13366	1,2,5,7
13244–13305	2,5,7
13184–13243	1,5,7
13121–13183	5,7
13059–13120	1,2,3,4,7
13000–13058	2,3,4,7
12941–12999	1,3,4,7

Calibration Number	DIP Switches ON
12883–12940	3,4,7
12826–12882	1,2,4,7
12769–12825	2,4,7
12713–12768	1,4,7
12657–12712	4,7
12601–12656	1,2,3,7
12547–12600	2,3,7
12492–12546	1,3,7
12438–12491	3,7
12385–12437	1,2,7
12332–12384	2,7
12279–12331	1,7
12214–12278	7
12149–12213	1,2,3,4,5,6
12098–12148	2,3,4,5,6
12047–12097	1,3,4,5,6
11997–12046	3,4,5,6
11947–11996	1,2,4,5,6
11898–11946	2,4,5,6
11849–11897	1,4,5,6
11800–11848	4,5,6
11752–11799	1,2,3,5,6
11704–11751	2,3,5,6
11657–11703	1,3,5,6
11610–11656	3,5,6
11563–11609	1,2,5,6
11517–11562	2,5,6
11471–11516	1,5,6
11424–11470	5,6
11376–11423	1,2,3,4,6
11332–11375	2,3,4,6
11287–11331	1,3,4,6
11243–11286	3,4,6
11199–11242	1,2,4,6
11156–11198	2,4,6
11113–11155	1,4,6

Specifications

Calibration Number	DIP Switches ON
11070–11112	4,6
11028–11069	1,2,3,6
10986–11027	2,3,6
10944–10985	1,3,6
10903–10943	3,6
10861–10902	1,2,6
10821–10860	2,6
10780–10820	1,6
10737–10779	6
10694–10736	1,2,3,4,5
10655–10693	2,3,4,5
10616–10654	1,3,4,5
10577–10615	3,4,5
10538–10576	1,2,4,5
10499–10537	2,4,5
10461–10498	1,4,5
10423–10460	4,5
10386–10422	1,2,3,5
10349–10385	2,3,5
10312–10348	1,3,5
10275–10311	3,5
10238–10274	1,2,5
10202–10237	2,5
10166–10201	1,5
10128–10165	5
10091–10127	1,2,3,4
10056–e 10090	2,3,4
10021–10055	1,3,4
9986–10020	3,4
9952–9985	1,2,4
9918–9951	2,4
9884–9917	1,4
9850–9883	4
9816–9849	1,2,3
9783–9815	2,3
9750–9782	1,3

Calibration Number	DIP Switches ON
9717–9749	3
9684–9716	1,2
9652–9683	2
9620–9651	1
9531–9619	none

See **Fig. 1** for a full view of the Detroit Diesel Electronic Controls (DDEC) II wiring diagram. See **Fig. 2** and **Fig. 3** for partial (detailed) views of the full view of the DDEC II wiring diagram. See **Fig. 4** for a full view of the DDEC III wiring diagram (the engine side). See **Fig. 5** and **Fig. 6** for partial (detailed) views of the full view of the DDEC III wiring diagram (the engine side). See **Fig. 7** for a full view of the DDEC III wiring diagram (the cab side). See **Fig. 8** and **Fig. 9** for partial (detailed) views of the full view of the DDEC III wiring diagram (the cab side). See **Fig. 10** for a full view of the Electronic Data Monitor (EDM) wiring diagram. See **Fig. 11** and **Fig. 12** for partial (detailed) views of the full view of the EDM wiring diagram. See **Fig. 13** for the Jake brake as used with DDEC III wiring diagram.

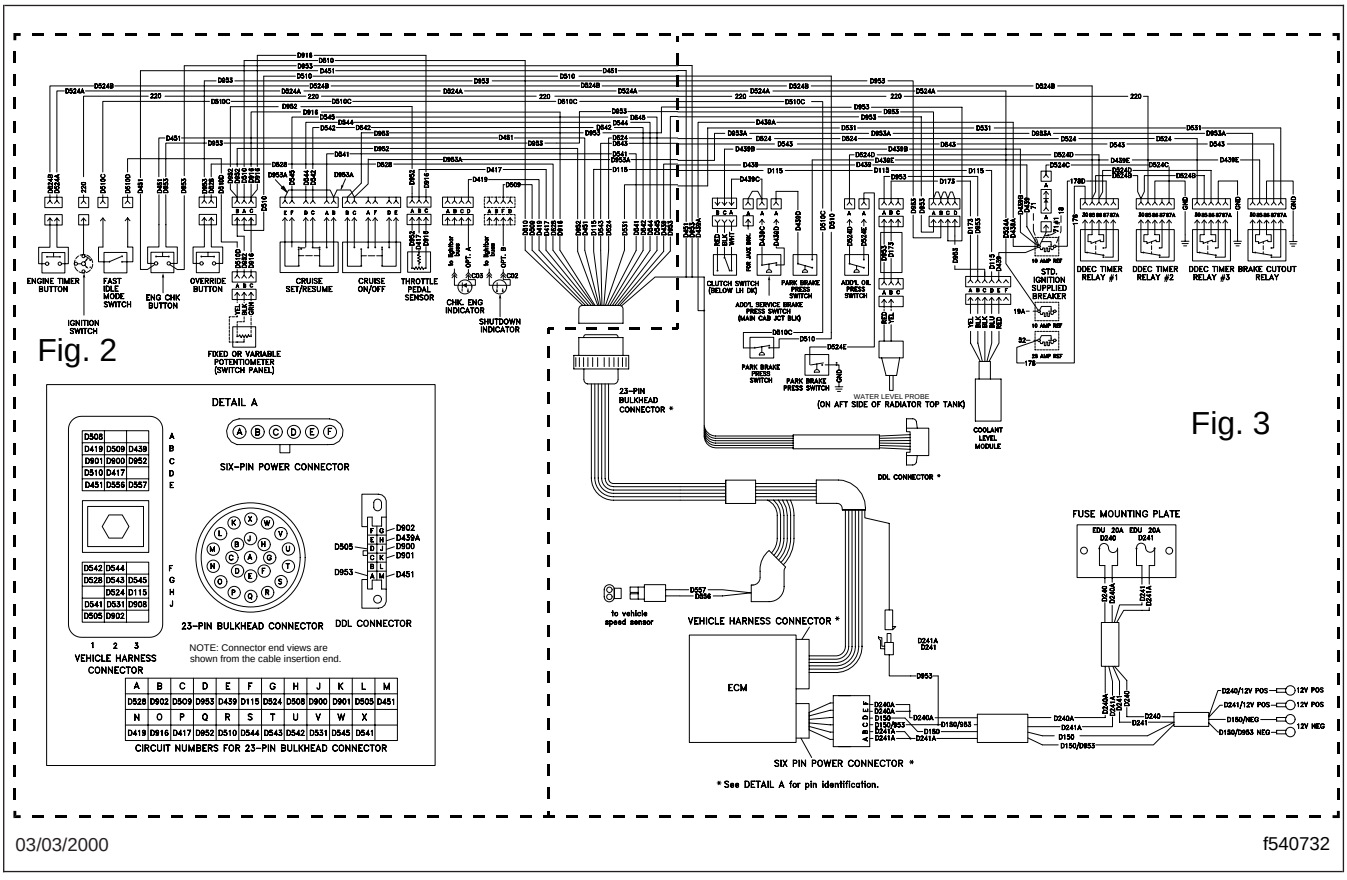


Fig. 1, DDEC II Wiring Diagram

Specifications

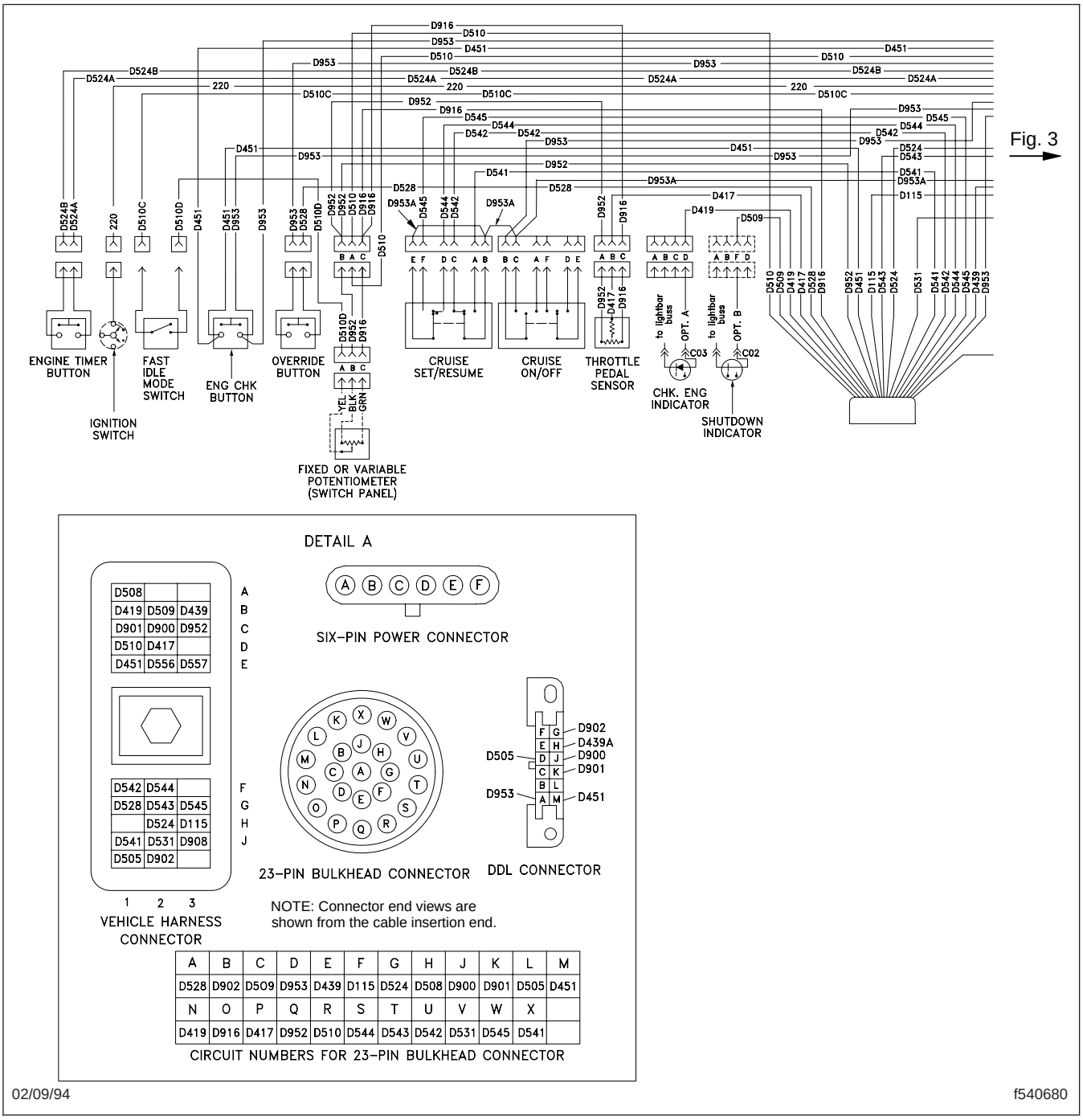


Fig. 2, DDEC II Wiring Diagram (enlarged portion of Figure 1)

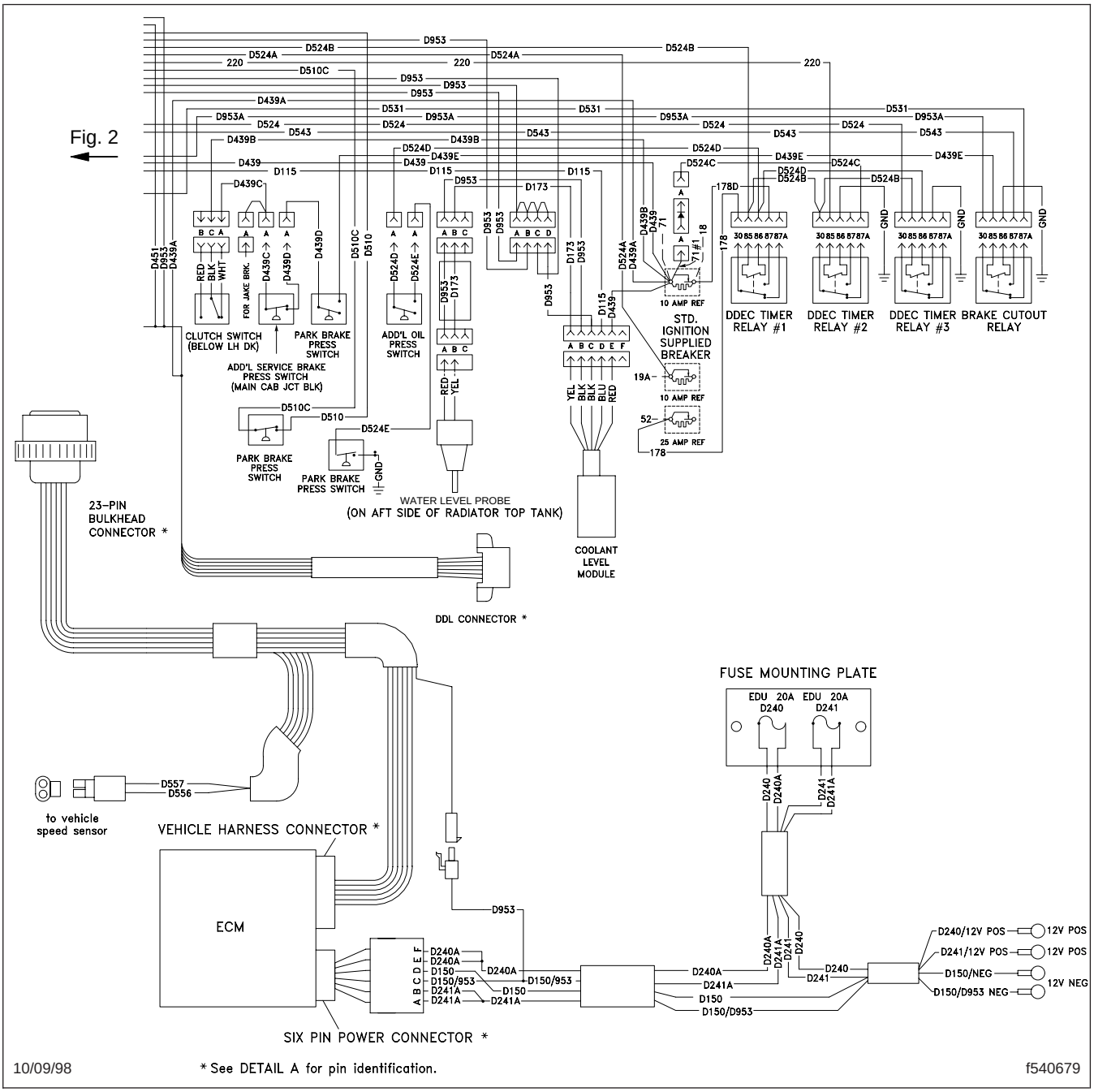


Fig. 3, DDEC II Wiring Diagram (enlarged portion of Figure 1)

Specifications

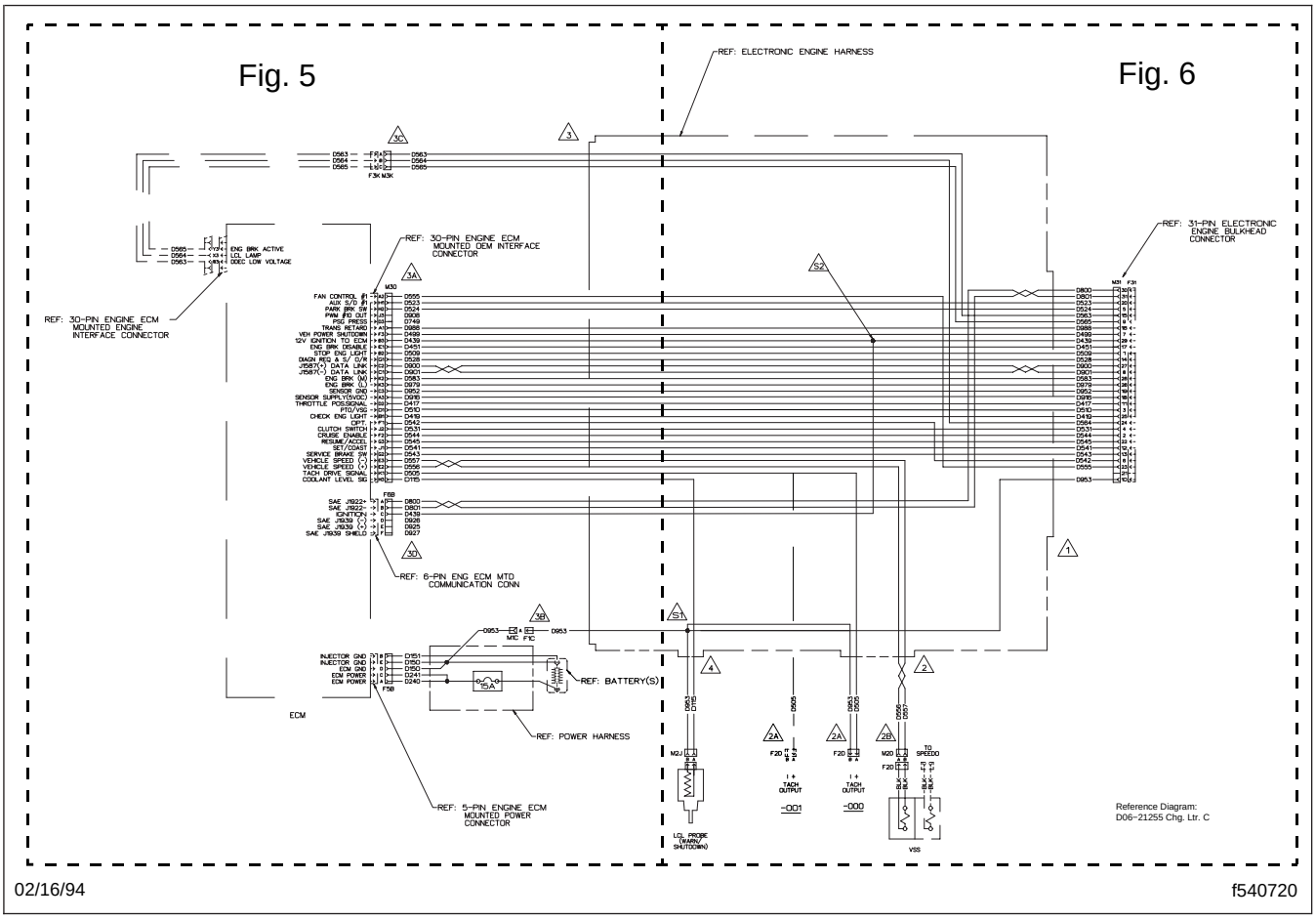


Fig. 4, Detroit Diesel Series 50 and 60 Engines With DDEC III Wiring Diagram (engine-harness side)

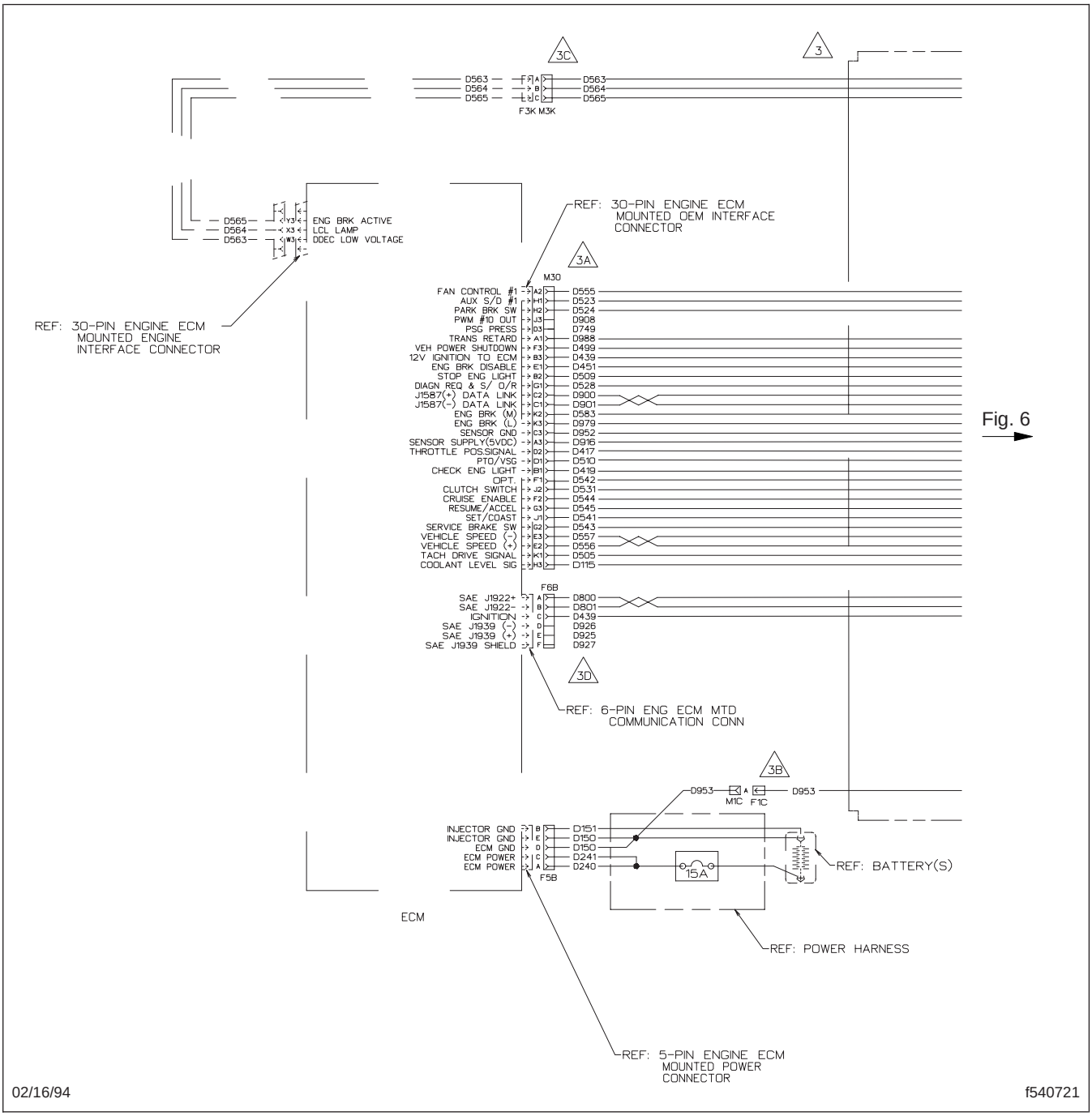


Fig. 6

Fig. 5, Detroit Diesel Series 50 and 60 Engines With DDEC III Wiring Diagram (enlarged portion of Figure 4)

Specifications

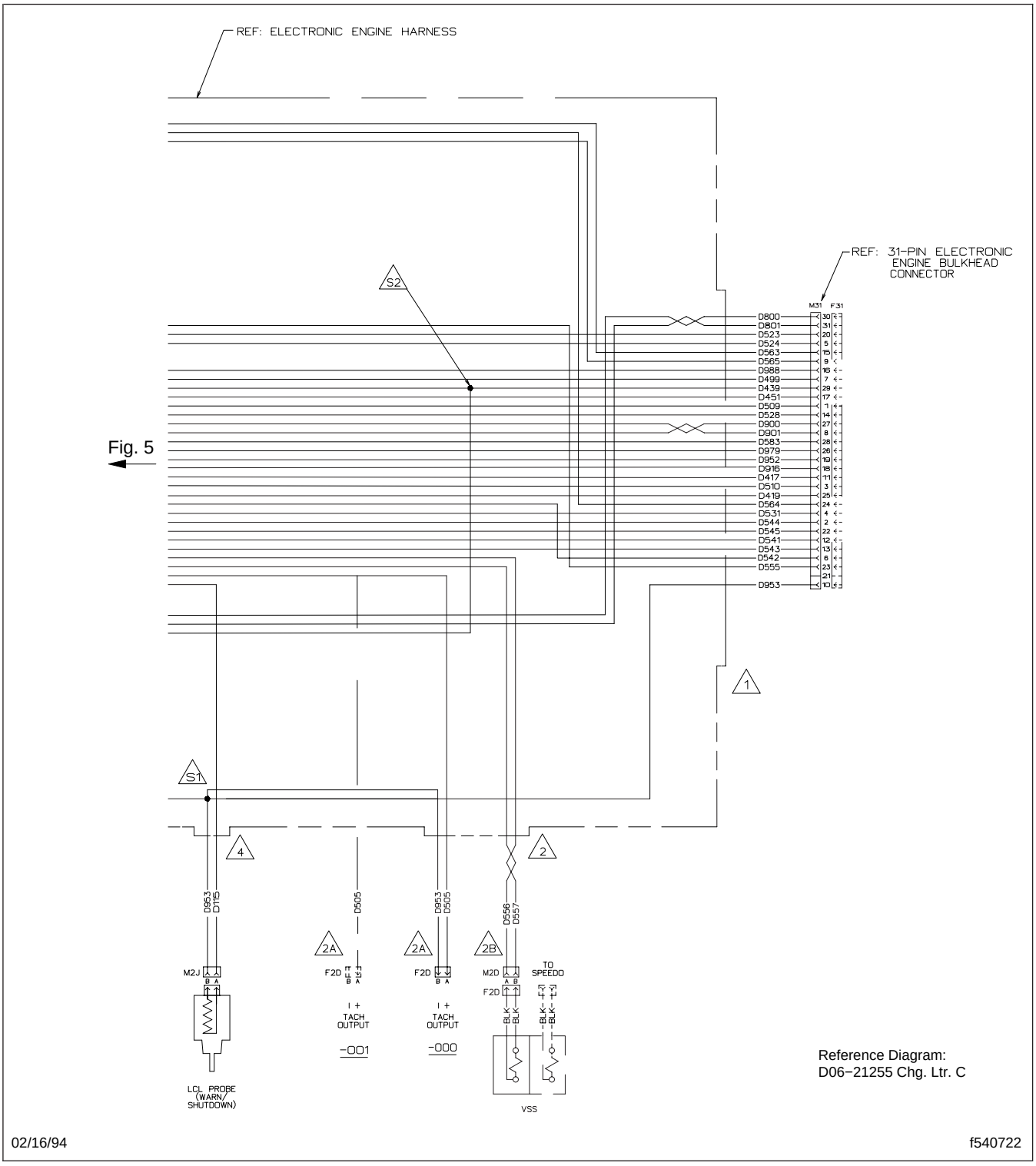


Fig. 5

Fig. 6, Detroit Diesel Series 50 and 60 Engines With DDEC III Wiring Diagram (enlarged portion of Figure 4)

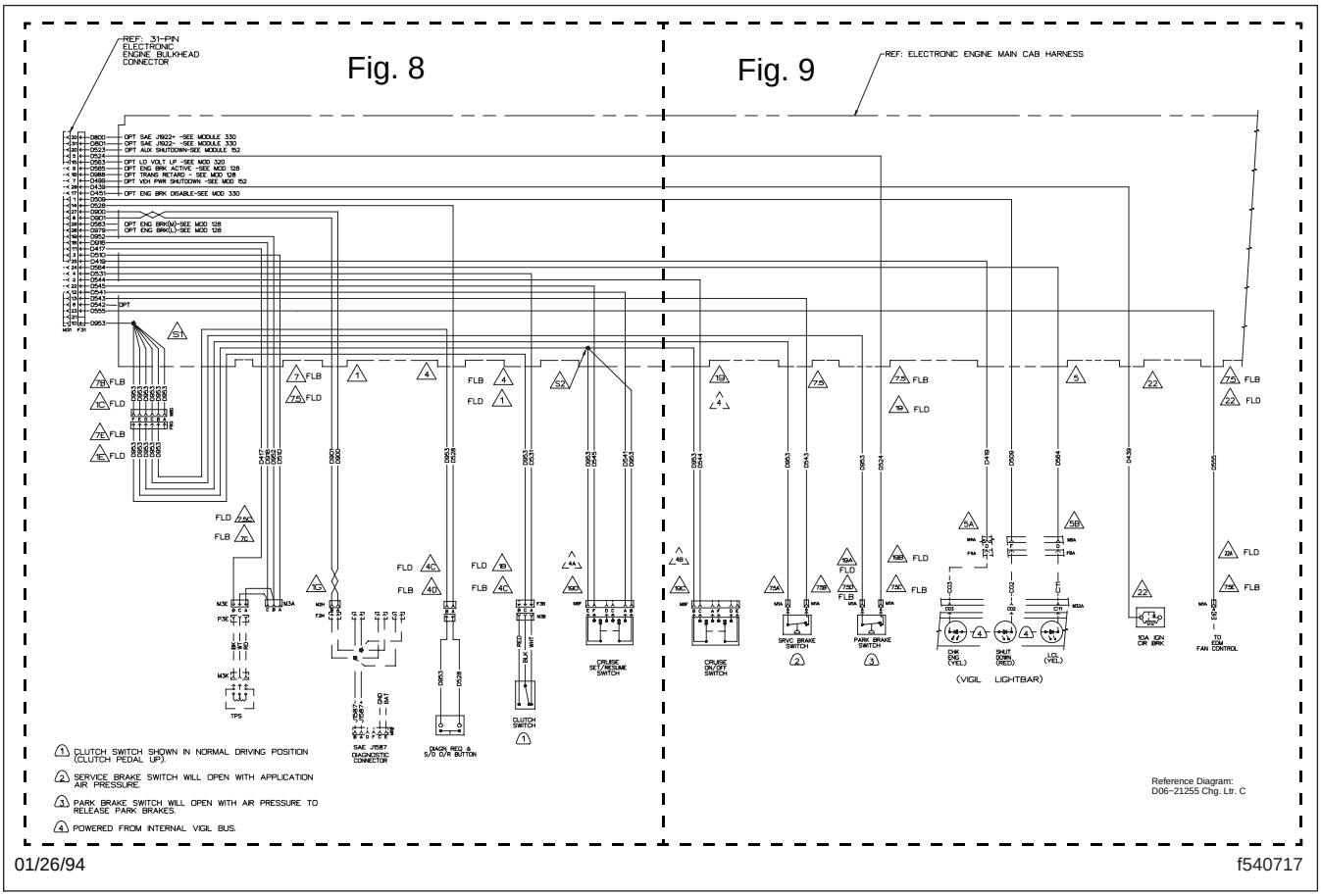


Fig. 7, Detroit Diesel Series 50 and 60 Engines With DDEC III Wiring Diagram (cab-harness side)

Specifications

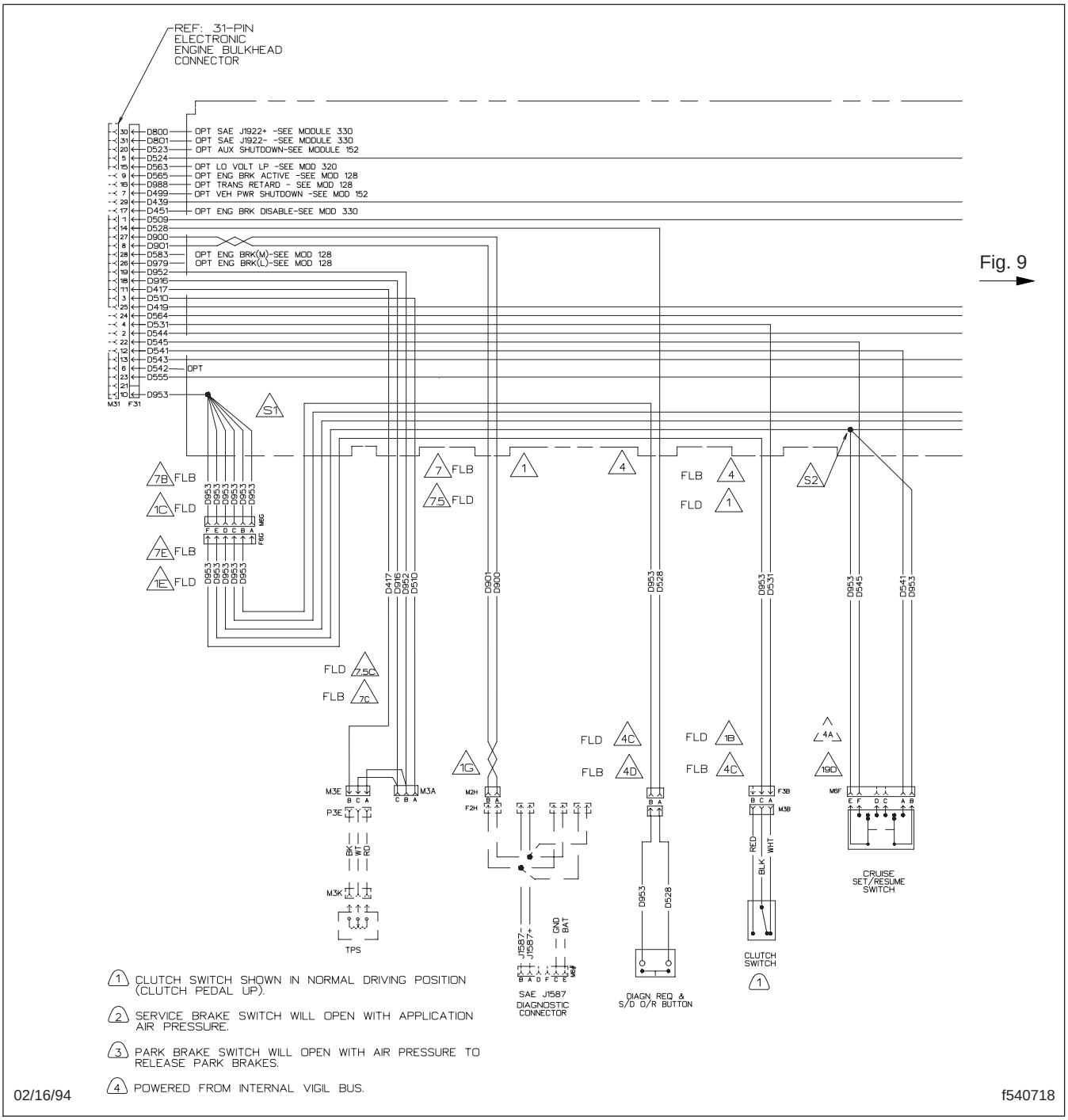


Fig. 9

Fig. 8, Detroit Diesel Series 50 and 60 Engines With DDEC III Wiring Diagram (enlarged portion of Figure 7)

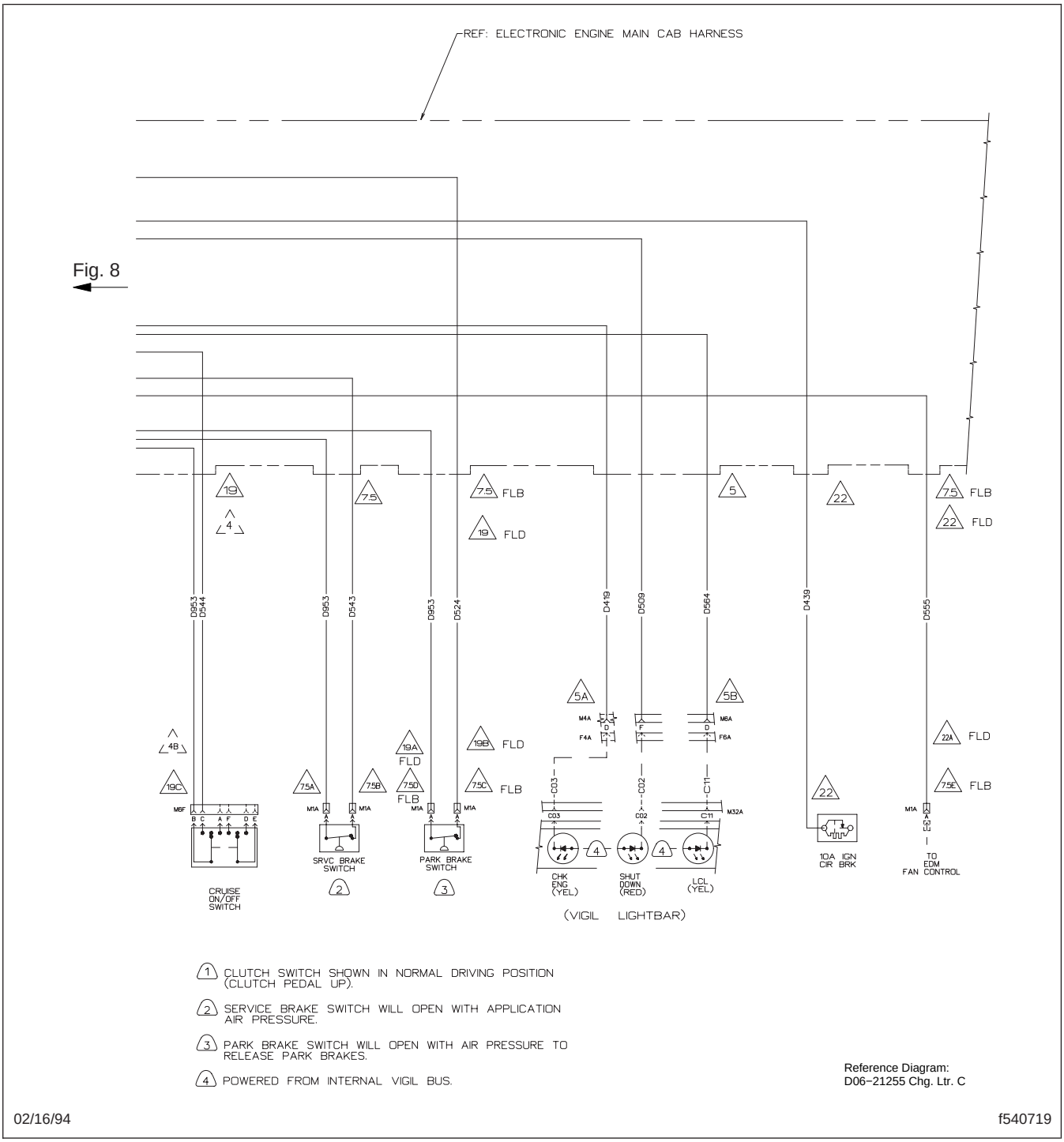


Fig. 9, Detroit Diesel Series 50 and 60 Engines With DDEC III Wiring Diagram (enlarged portion of Figure 7)

Specifications

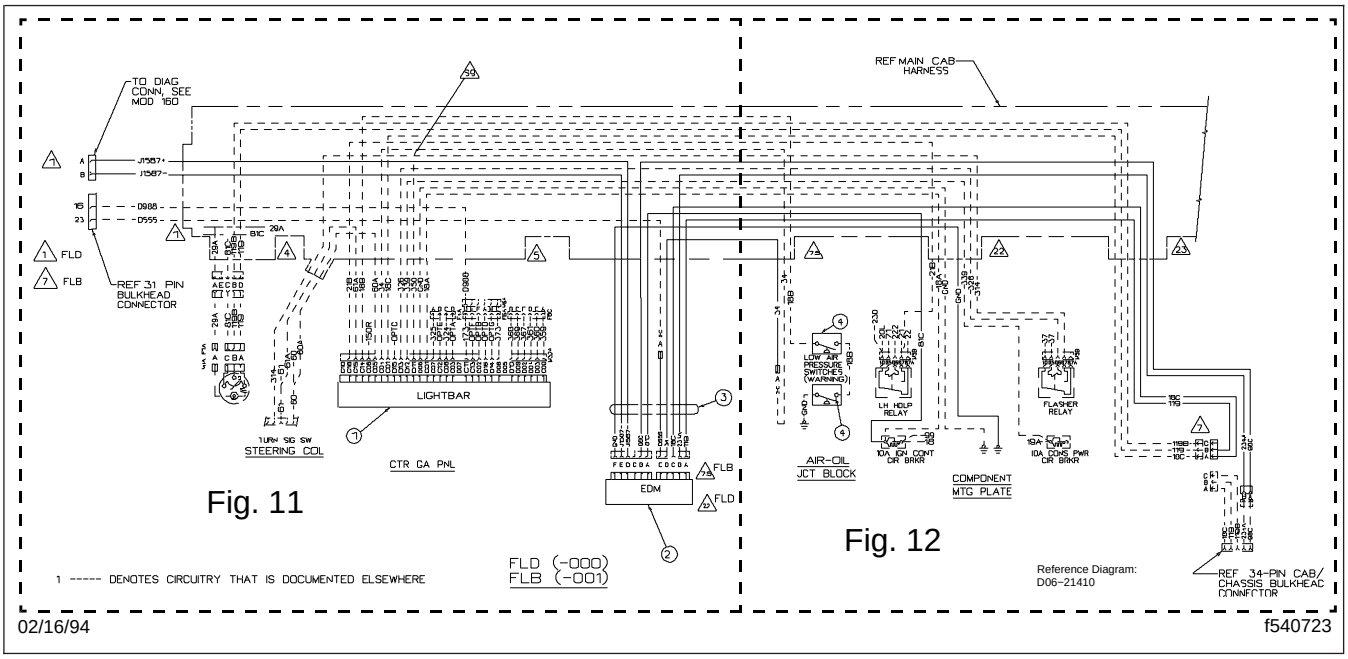


Fig. 10, Electronic Data Monitor (EDM) Wiring Diagram, Detroit Diesel Series 50 and 60 Engines With DDEC III

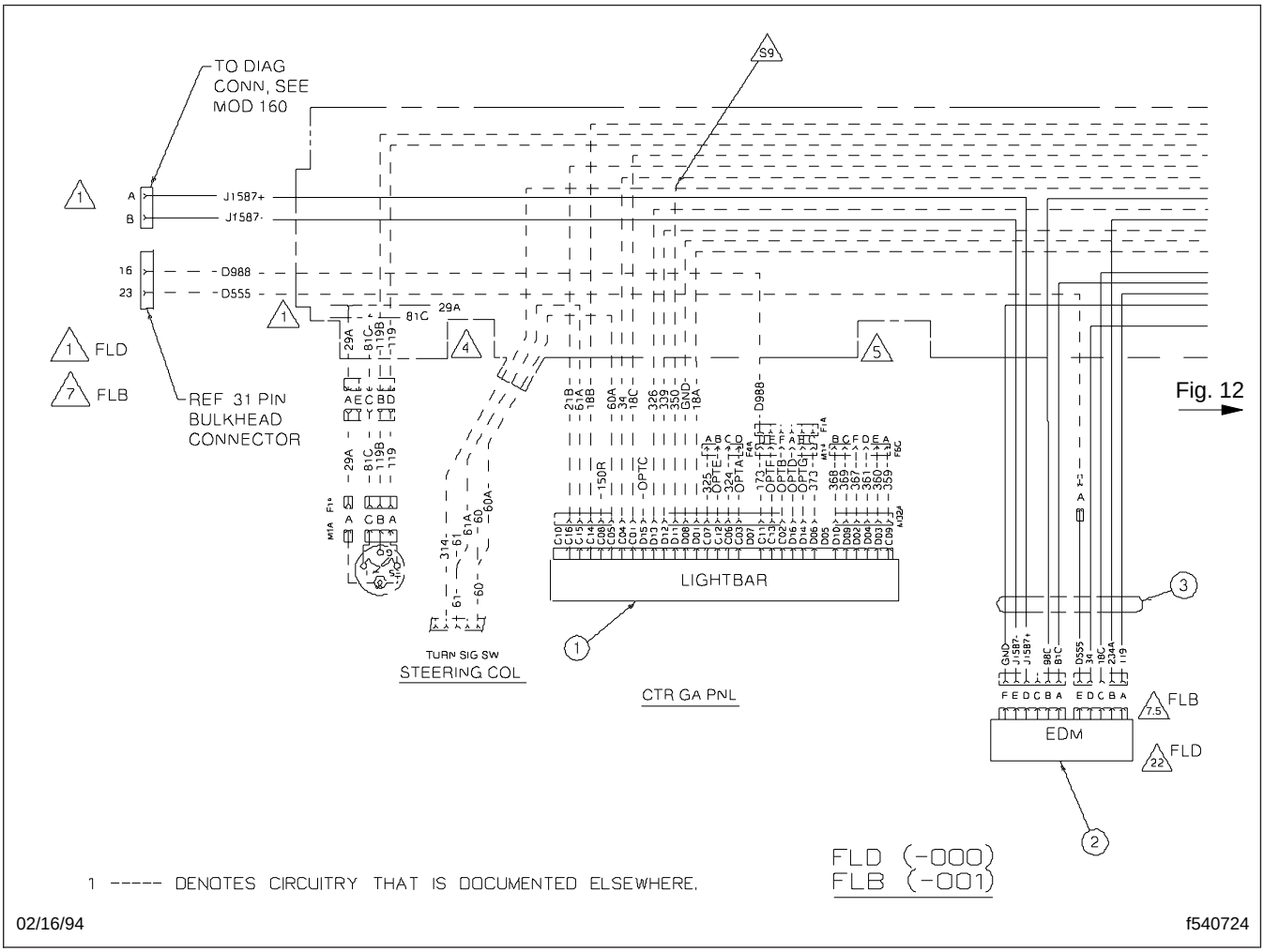


Fig. 11, Electronic Data Monitor (EDM) Wiring Diagram, Detroit Diesel Series 50 and 60 Engines With DDEC III (enlarged portion of Figure 10)

Specifications

Fig. 11

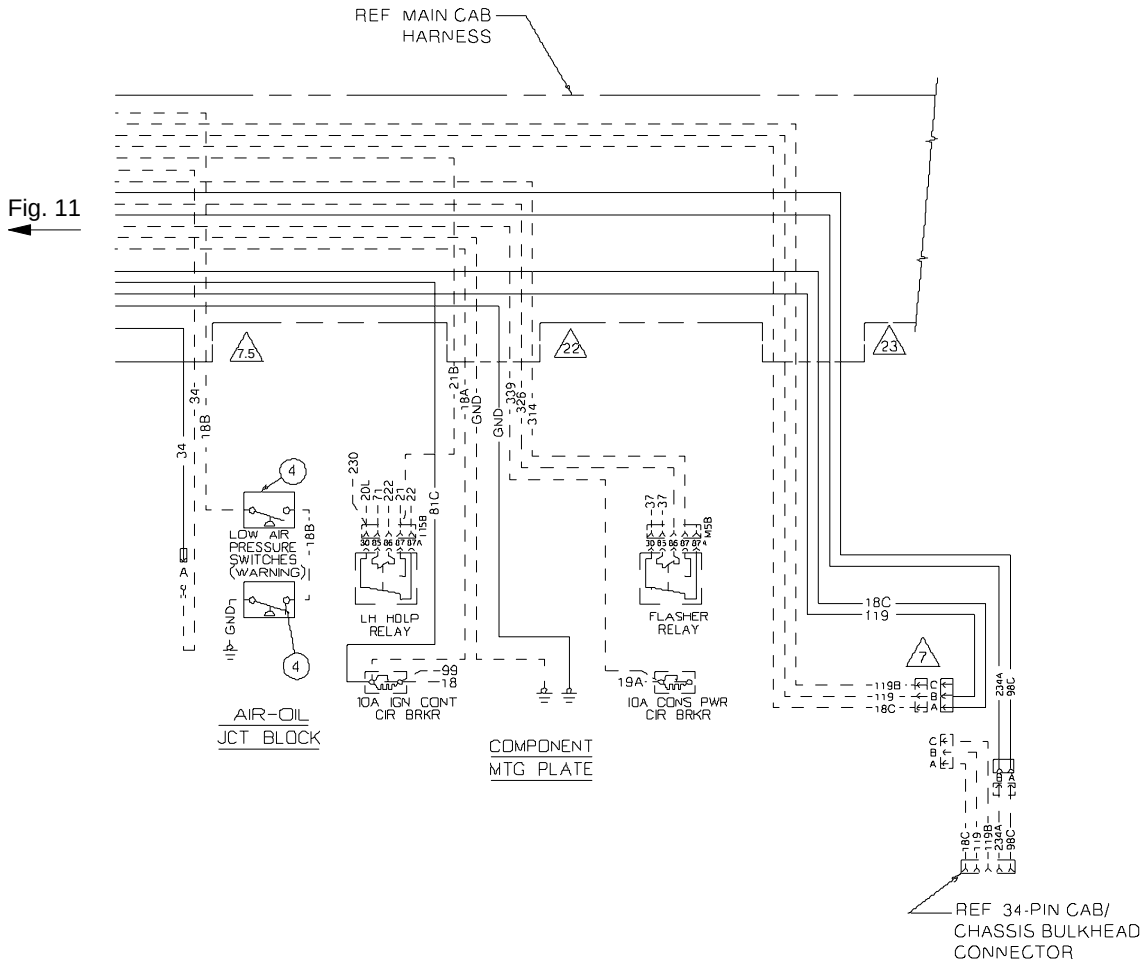


Fig. 12, Electronic Data Monitor (EDM) Wiring Diagram, Detroit Diesel Series 50 and 60 Engines With DDEC III (enlarged portion of Figure 10)

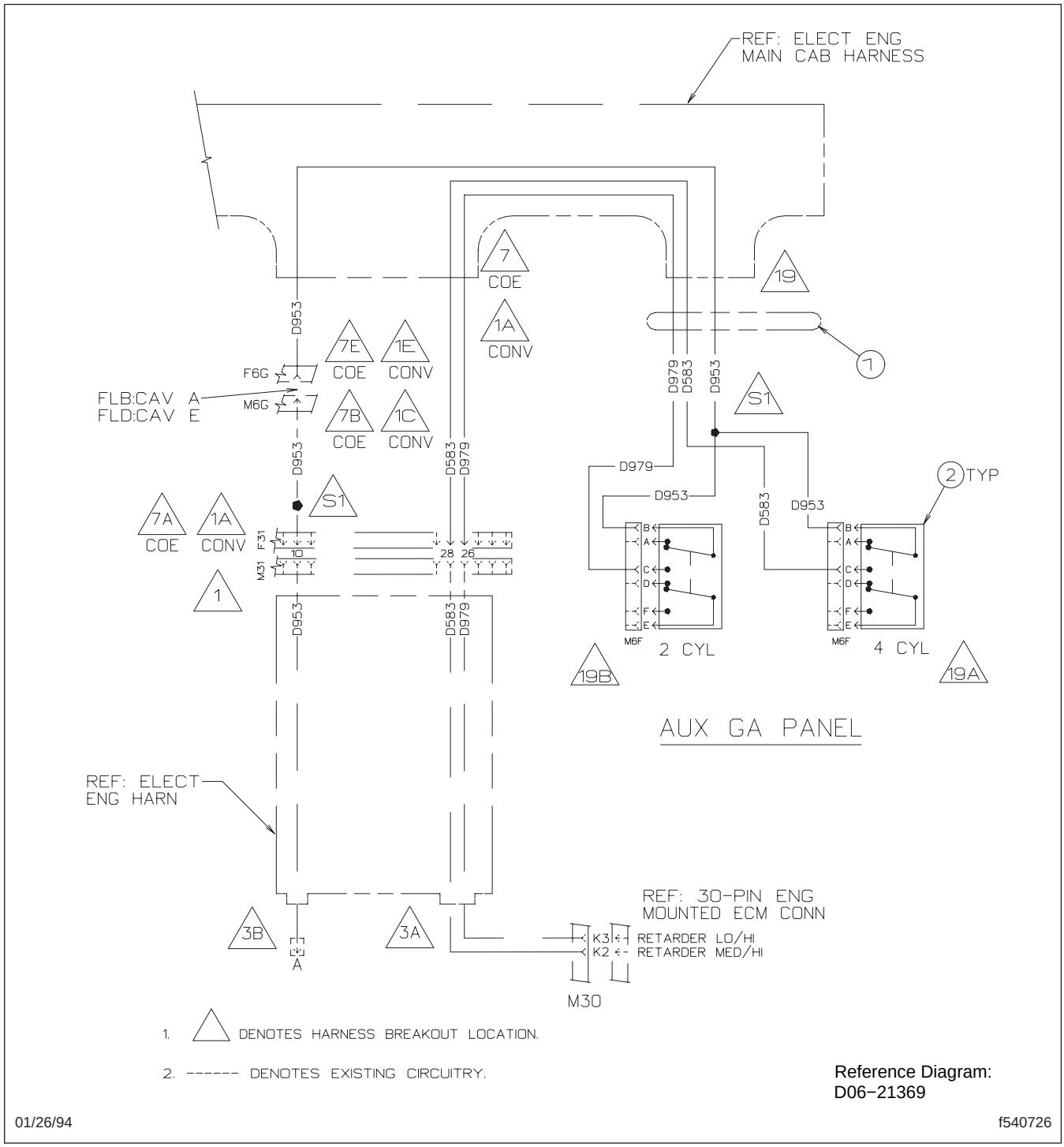
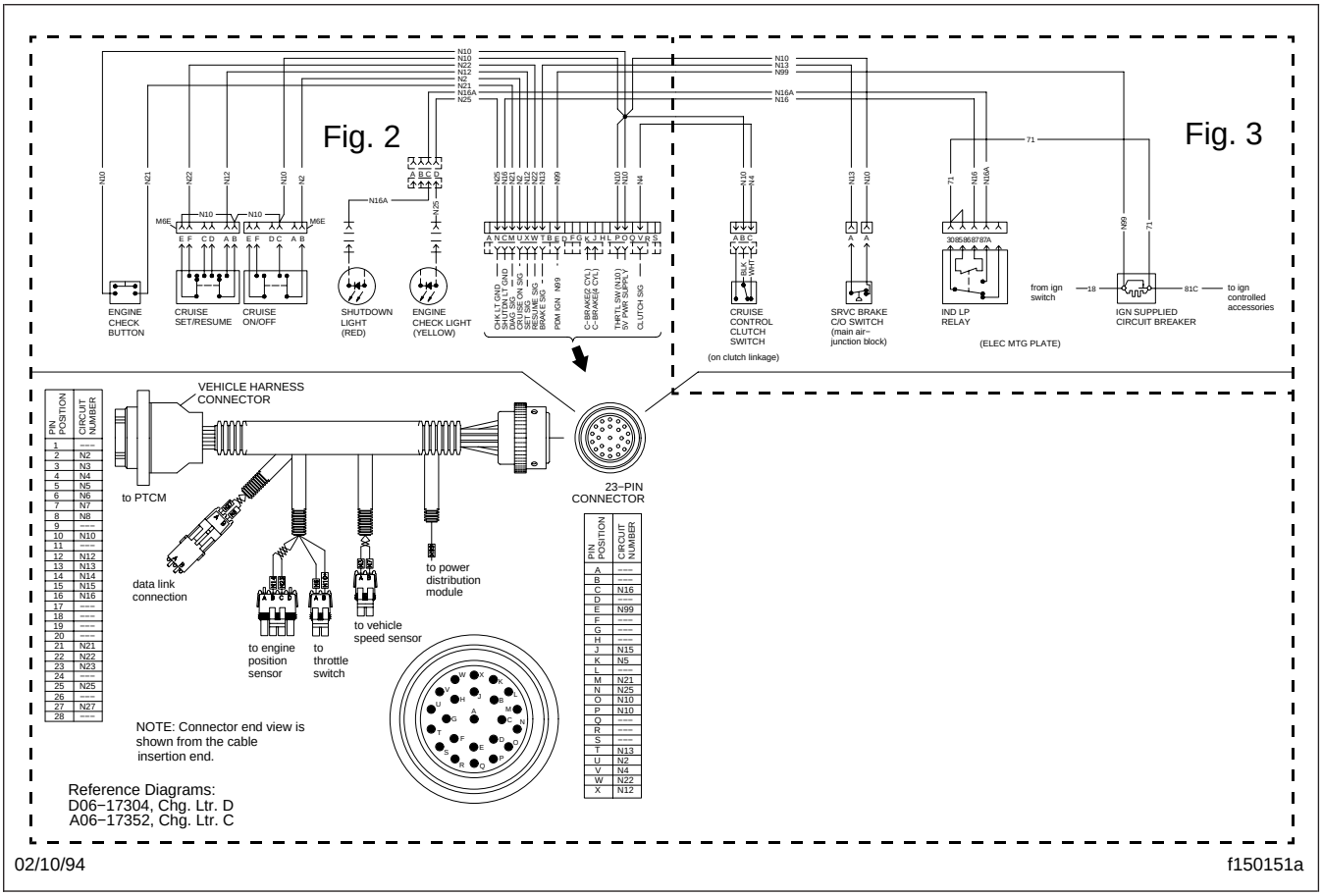


Fig. 13, Jake Brake Wiring Diagram, Detroit Diesel Engine With DDEC III

See **Fig. 1** for a full view of the Cummins PACE™ engine wiring diagram.



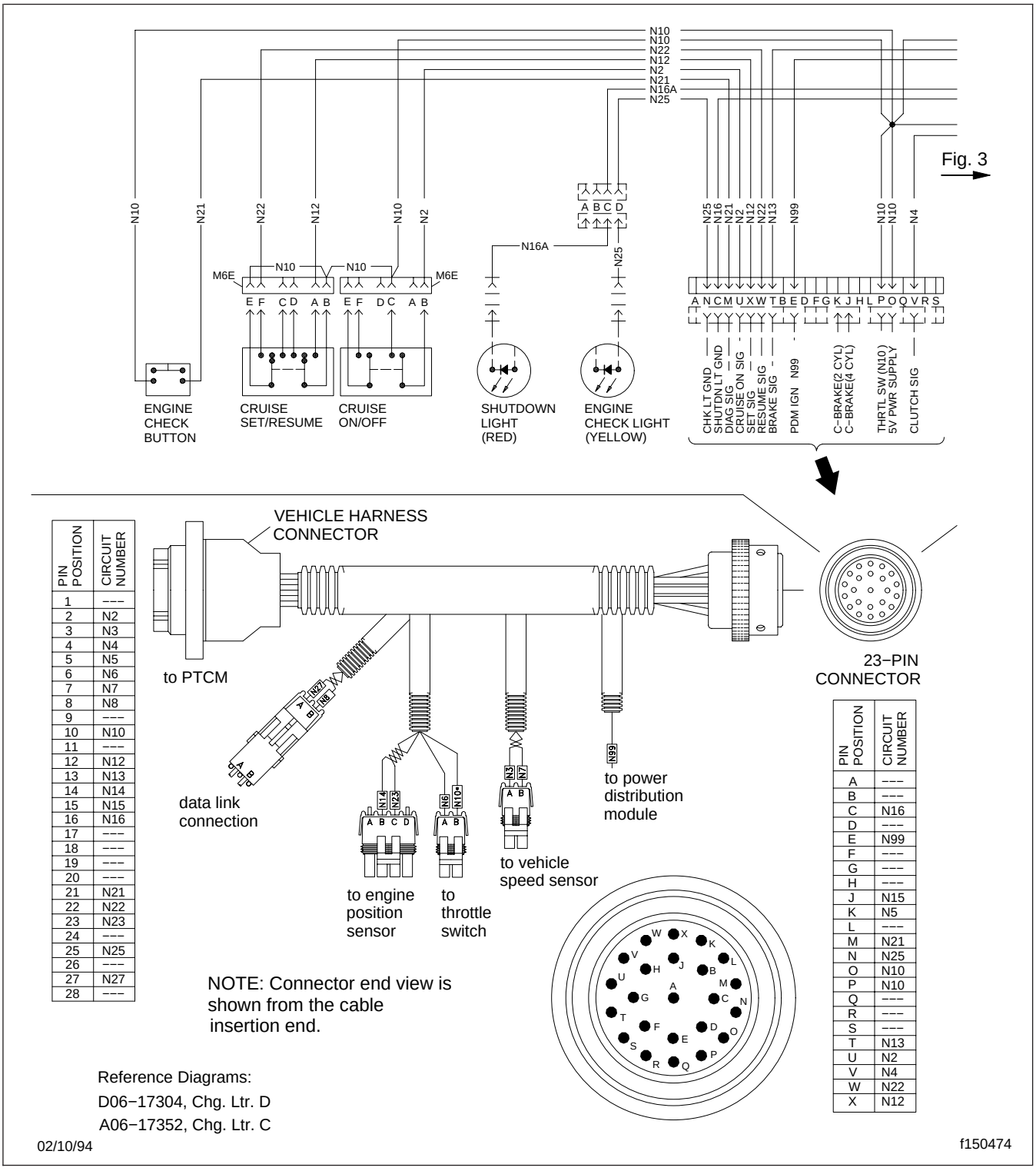
PIN POSITION	CIRCUIT NUMBER
1	----
2	N2
3	N3
4	N4
5	N5
6	N6
7	N7
8	N8
9	----
10	N10
11	----
12	N12
13	N13
14	N14
15	N15
16	N16
17	----
18	----
19	----
20	----
21	N21
22	N22
23	N23
24	----
25	N25
26	----
27	N27
28	----

PIN POSITION	CIRCUIT NUMBER
A	----
B	----
C	N16
D	----
E	N99
F	----
G	----
H	----
J	N15
K	N5
L	----
M	N21
N	N25
O	N10
P	N10
Q	----
R	----
S	----
T	N13
U	N2
V	N4
W	N22
X	N12

Fig. 1, Cummins PACE Electronic Engine Wiring Diagram

See **Fig. 2** and **Fig. 3** for partial (detailed) views of the Cummins PACE™ engine wiring diagram.

Specifications



PIN POSITION	CIRCUIT NUMBER
1	–––
2	N2
3	N3
4	N4
5	N5
6	N6
7	N7
8	N8
9	–––
10	N10
11	–––
12	N12
13	N13
14	N14
15	N15
16	N16
17	–––
18	–––
19	–––
20	–––
21	N21
22	N22
23	N23
24	–––
25	N25
26	–––
27	N27
28	–––

PIN POSITION	CIRCUIT NUMBER
A	–––
B	–––
C	N16
D	–––
E	N99
F	–––
G	–––
H	–––
J	N15
K	N5
L	–––
M	N21
N	N25
O	N10
P	N10
Q	–––
R	–––
S	–––
T	N13
U	N2
V	N4
W	N22
X	N12

Fig. 2, Cummins PACE Electronic Engine Wiring Diagram (Enlarged Portion of Figure 1)

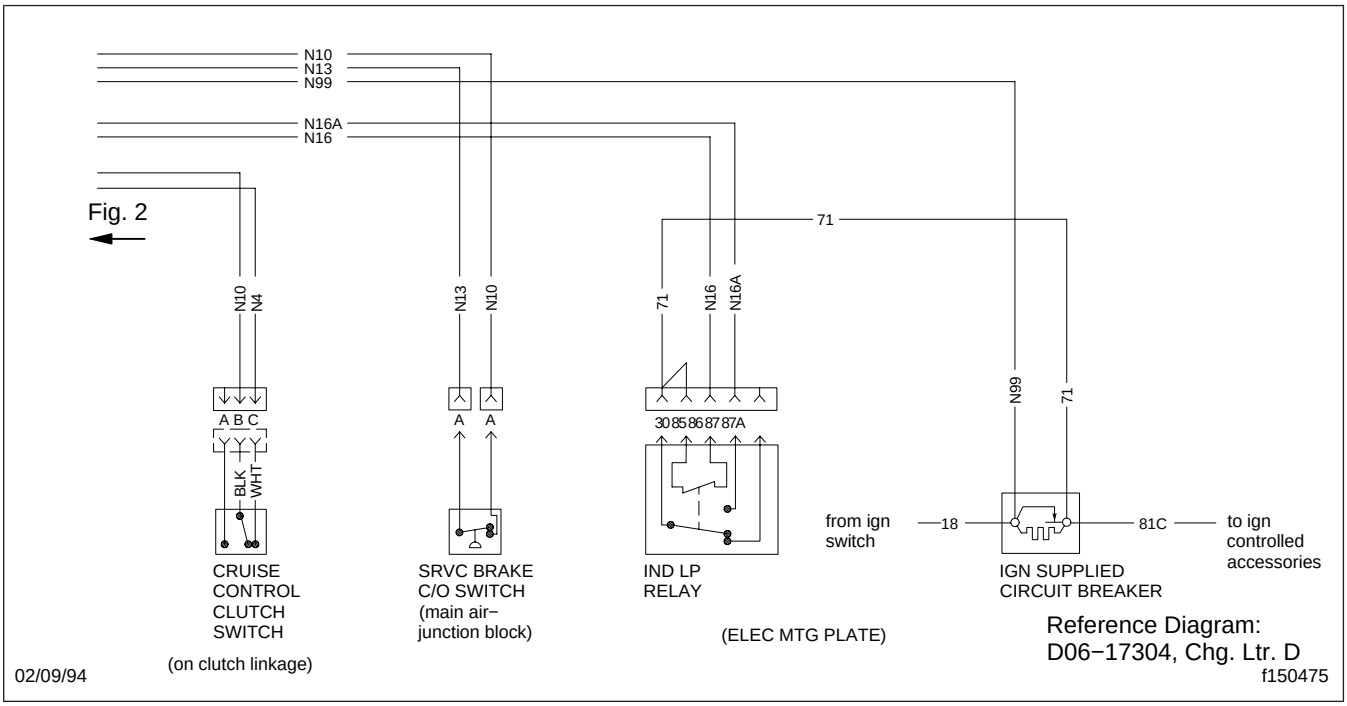


Fig. 3, Cummins PACE Electronic Engine Wiring Diagram (Enlarged Portion of Figure 1)

General Information

In general, the wiring diagrams in **Specifications, 400** show only those wiring circuits installed by Freightliner at the factory. For detailed engine wiring, refer to the applicable Caterpillar service manual.

To determine which version an engine is, check the serial number on the engine control plate (refer to the appropriate figure in **Specifications, 400**). The 1994-model 3176B engines have a "9CK" serial number; the 3406E engines have a "5EK" serial number.

See Fig. 1 for a full view of the Caterpillar 3176B and 3406E engine wiring diagram, including cab and engine switch circuits. For partial (detailed) views of the Caterpillar 3176B and 3406E engine wiring diagram, **See Fig. 2**, **see Fig. 3** and **see Fig. 4**. **See Fig. 5**for the Caterpillar 3176B and 3406E engine brake wiring diagram.

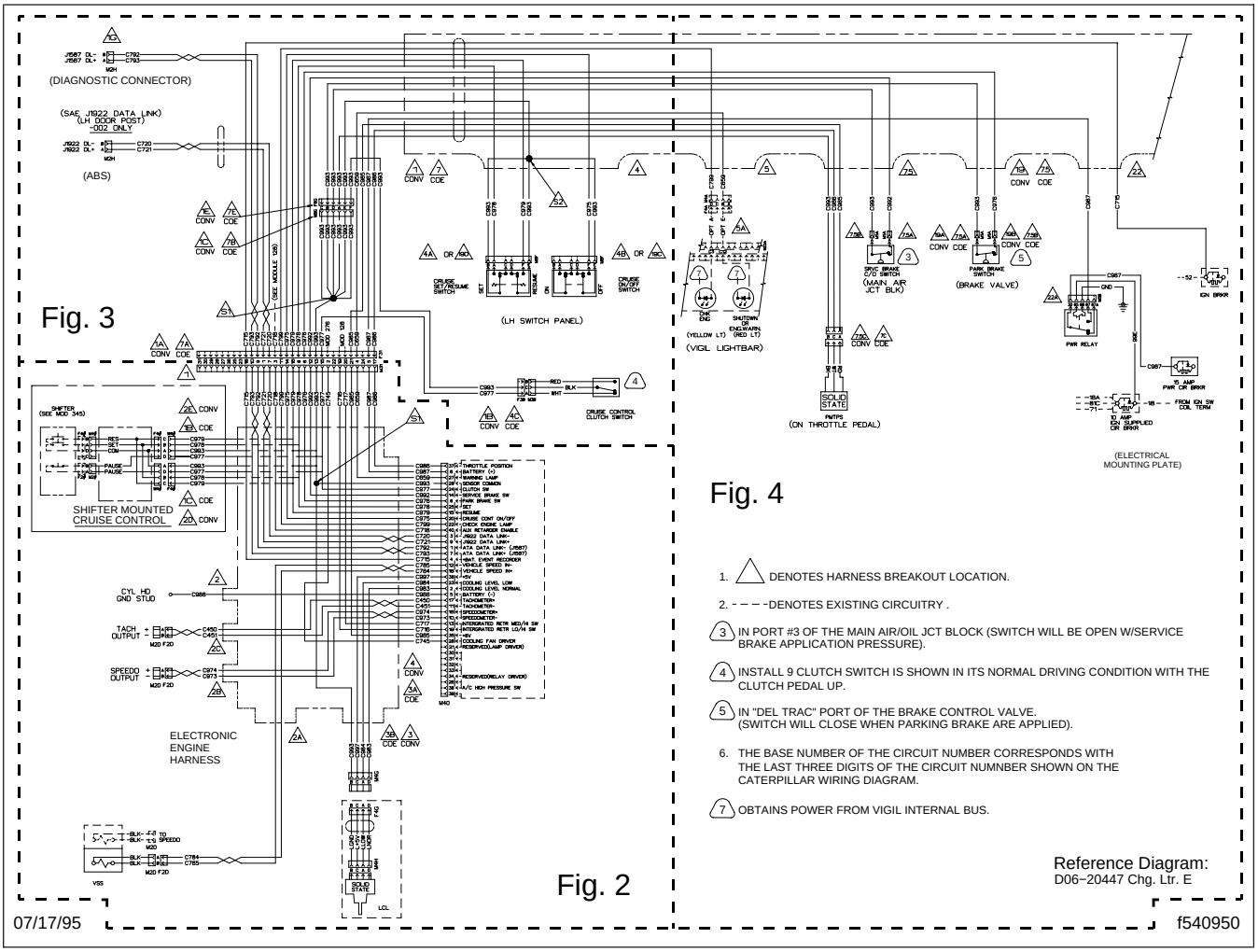


Fig. 1, Caterpillar 3176B and 3406E Wiring Diagram (cab and engine switch circuits)

Specifications

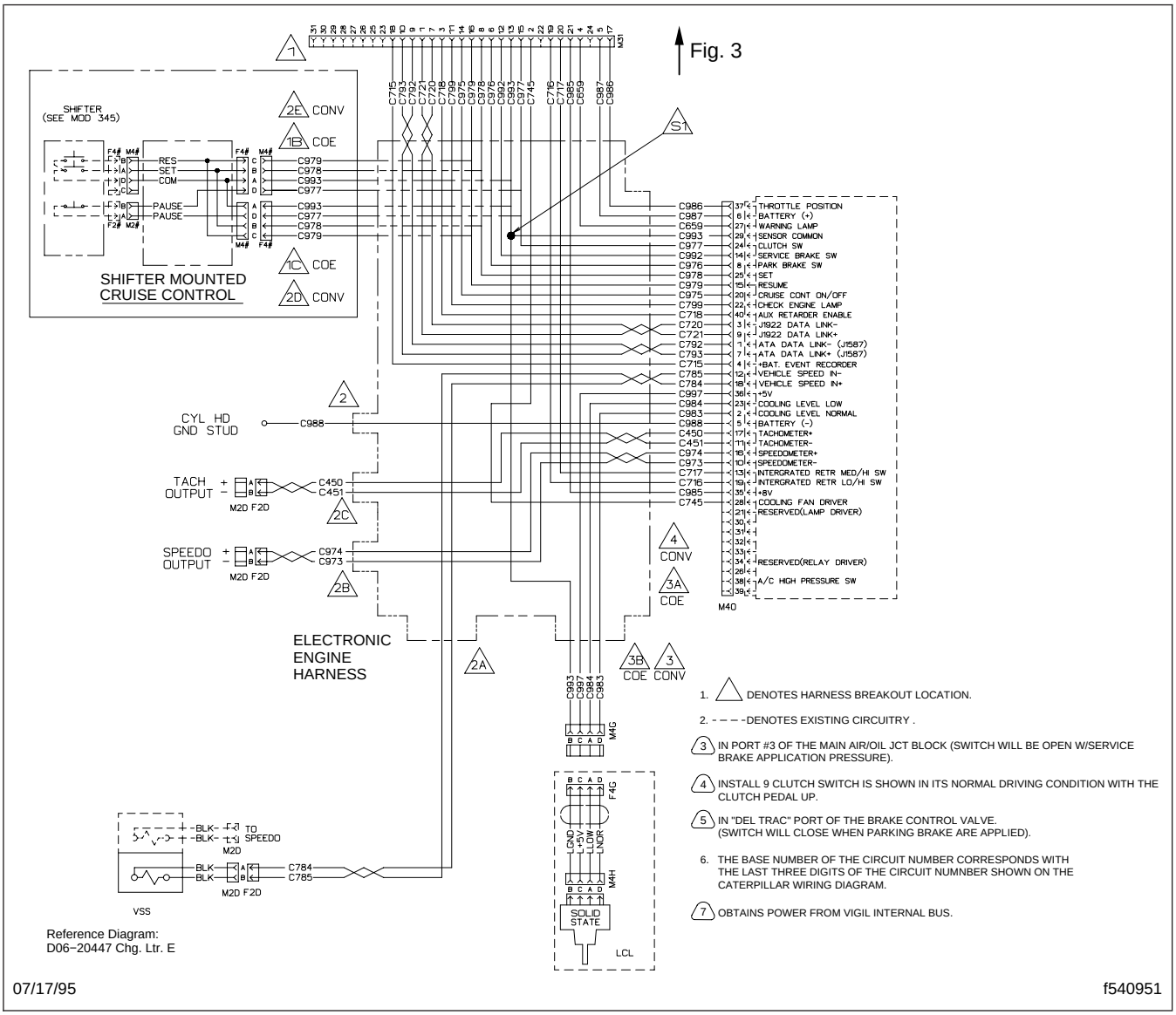


Fig. 2, Caterpillar 3176B and 3406E Wiring Diagram (detail)

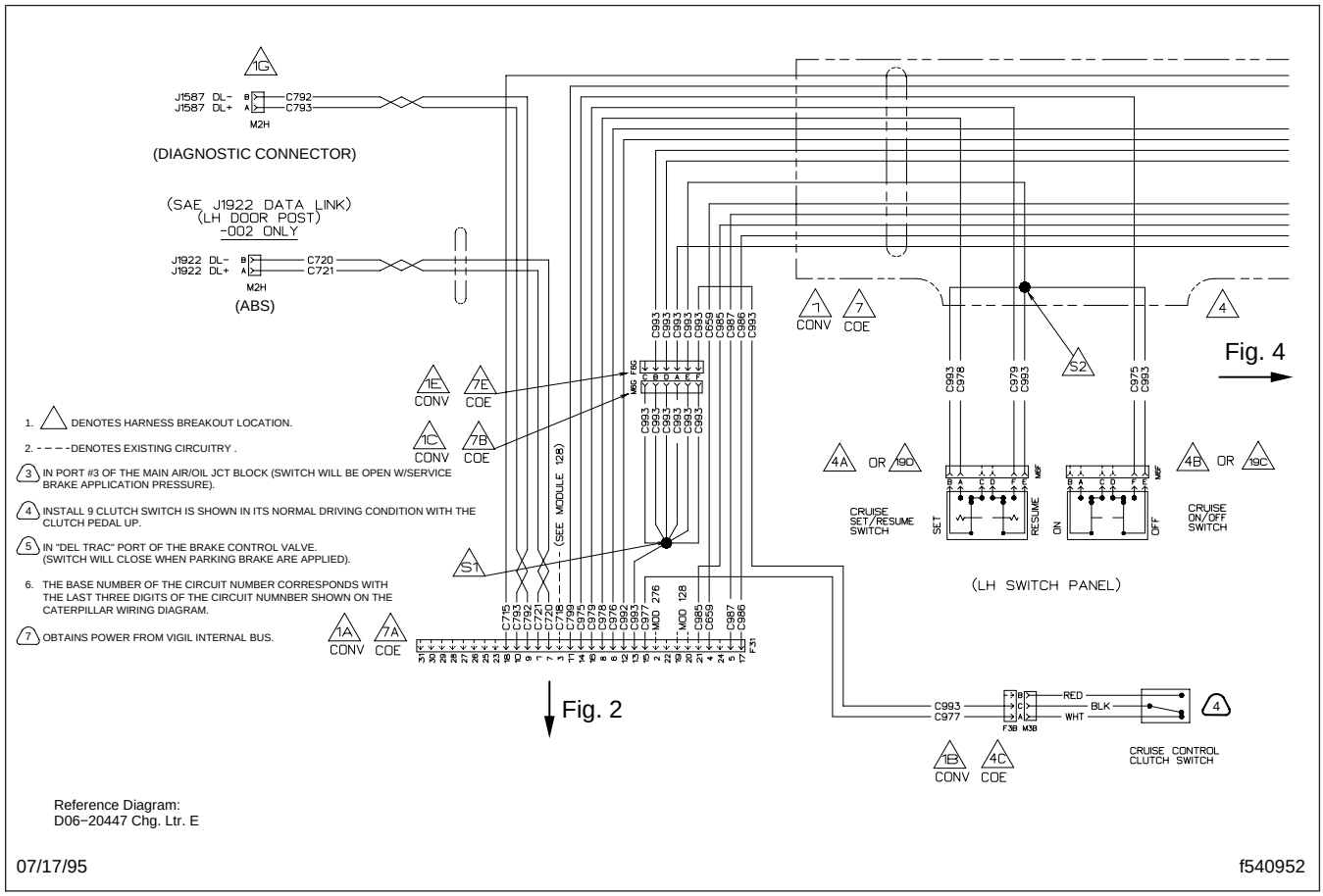


Fig. 3, Caterpillar 3176B and 3406E Wiring Diagram (detail)

Specifications

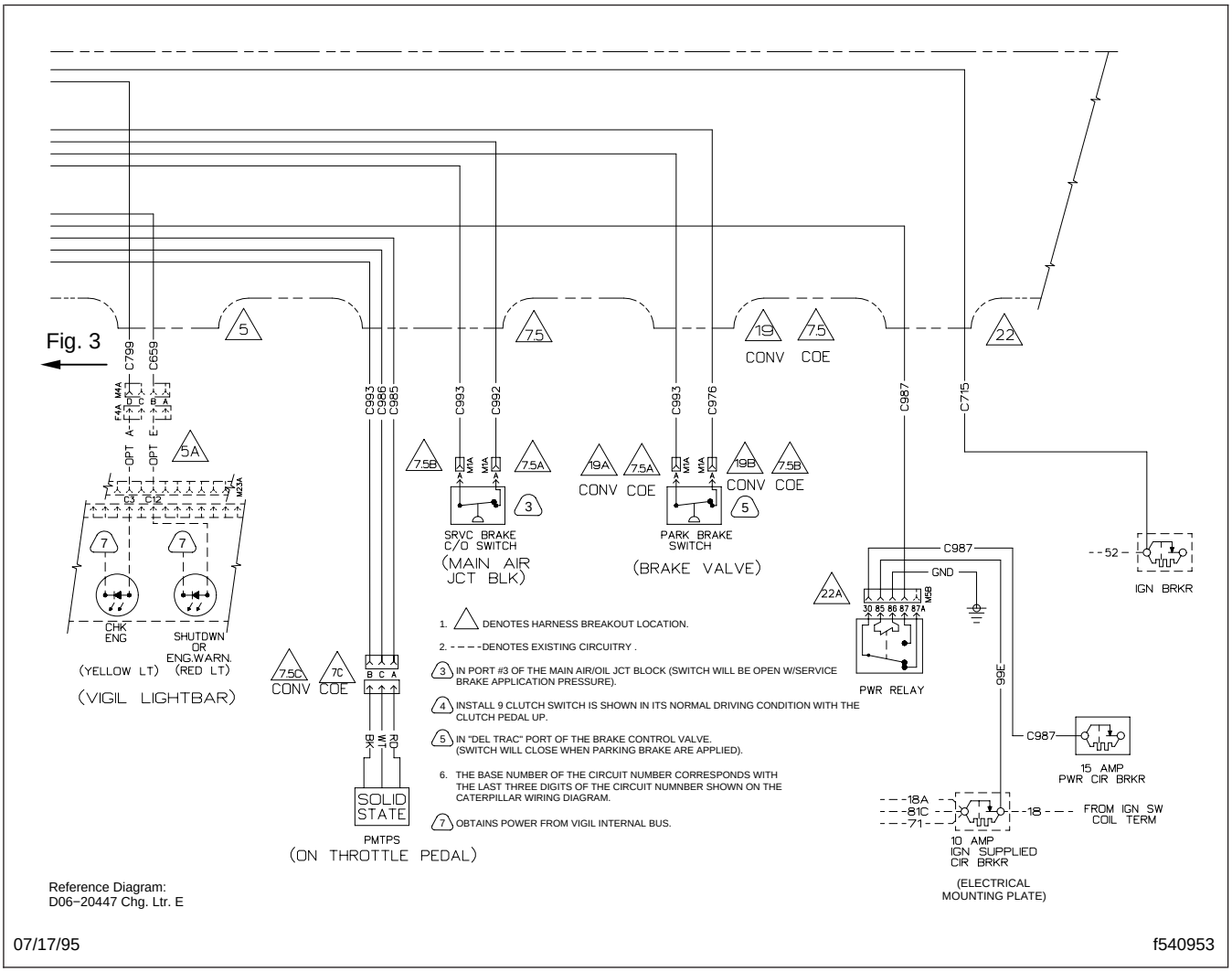


Fig. 4, Caterpillar 3176B and 3406E Wiring Diagram (detail)

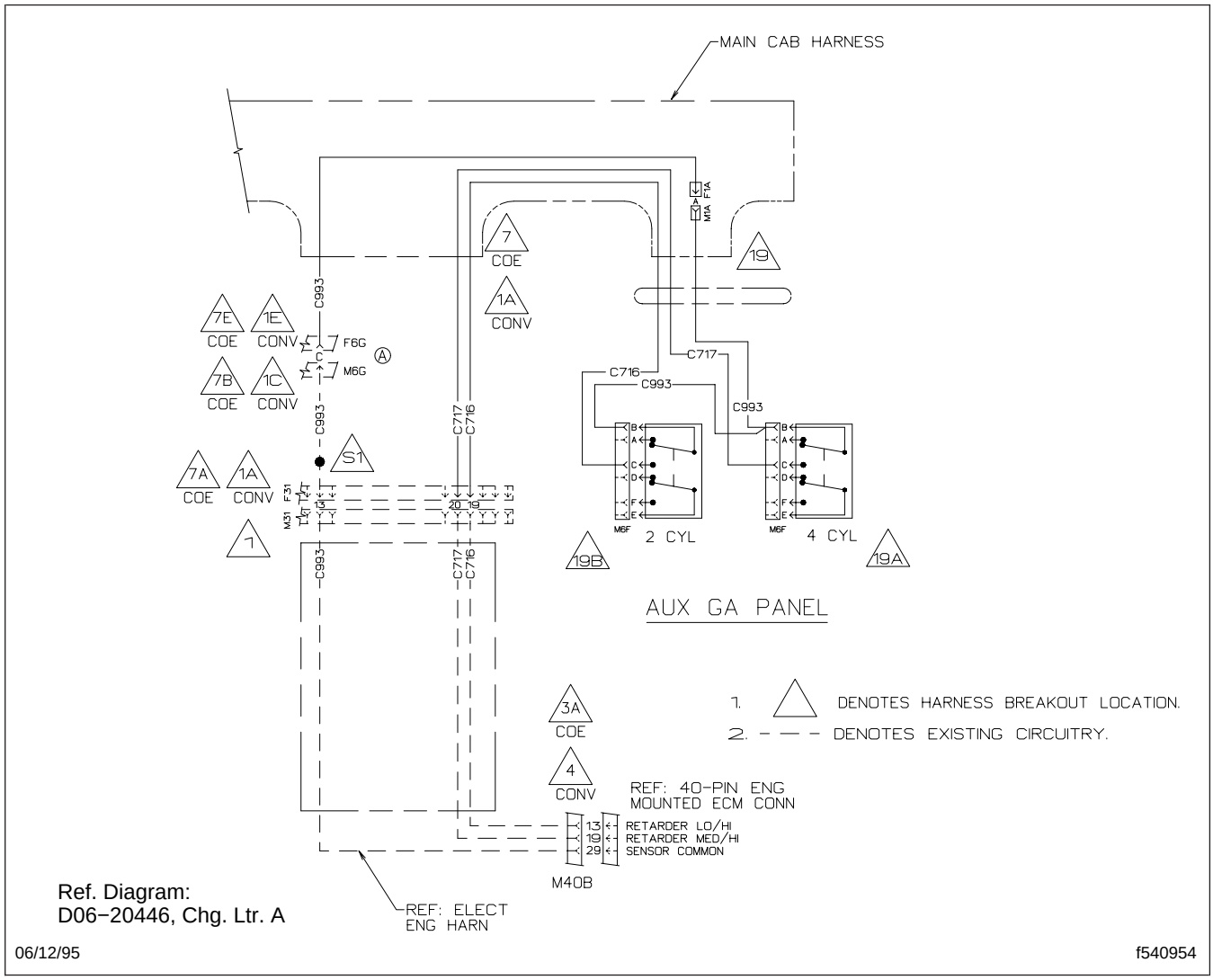


Fig. 5, Caterpillar 3176B and 3406E Engine Brake Wiring Diagram

General Information

The Ametek electronic speedometer consists of a dash-mounted gauge (speedometer head), a transmission-mounted magnetic sensor (vehicle speed sensor), and the electrical wires that complete the circuits between the system's components.

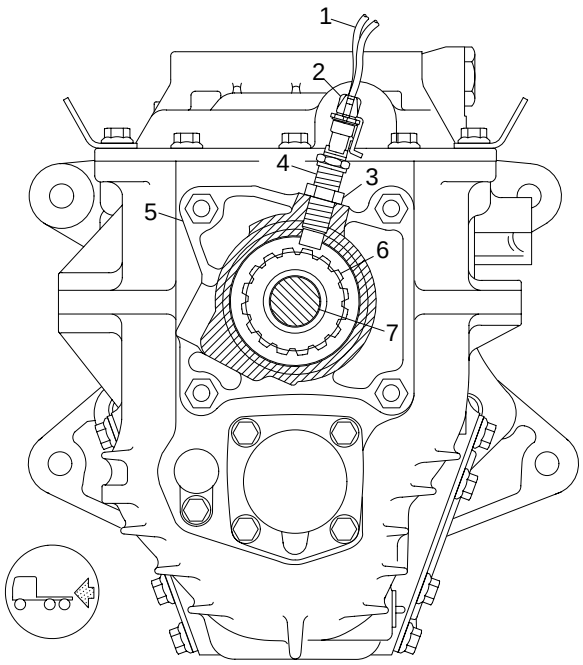
A vehicle built for use in the U.S.A. has a speedometer head that registers vehicle speed in miles per hour (mph) on its outer, or major scale, and in kilometers per hour (km/h) on its inner, or minor scale. It records the total distance traveled in miles on a 7-wheel odometer. The speedometer head installed on vehicles built for use outside the United States registers vehicle speed in km/h on the outer scale (and mph on the inner scale), and has a 7-wheel odometer that records distance in kilometers.

The magnetic sensor is mounted with its magnetic end extending through a threaded bore in the transmission case. It stops a little over one millimeter from the teeth of a standard 16-tooth spacer gear. It is located under the cover, on the inboard end of the transmission output shaft. See **Fig. 1**.

The magnetic sensor is an inductive type made with a magnet and a coil of wire. Electronic engines have two coils. An inductive sensor generates an AC voltage whenever the sensor's magnetic field is moved. When the vehicle is moving, each tooth of the transmission spacer gear in the transmission attracts the sensor's magnetic field. When this happens the sensor generates a pulsing signal. The gear-driven speedometer counts the pulses generated by the magnetic sensor and calculates the vehicle speed. For the speedometer head to correctly interpret the signal generated, the speedometer head must be calibrated for the specific drivetrain on the vehicle.

At the back of the speedometer head are 10 DIP switches. See **Fig. 2**. The speedometer is calibrated by setting the DIP switches on or off to correspond to a specific calibration code. The axle ratio, the number of teeth on the spacer gear, and the tire size (tire revolutions per mile) are all factors used to determine the specific speedometer calibration code. For each possible drivetrain combination, there is a different calibration code.

Recalibrate the speedometer on gear-driven speedometers only if it is new or if the vehicle has had new tires installed that differ in size from the original tires. An exception to this are vehicles equipped with the



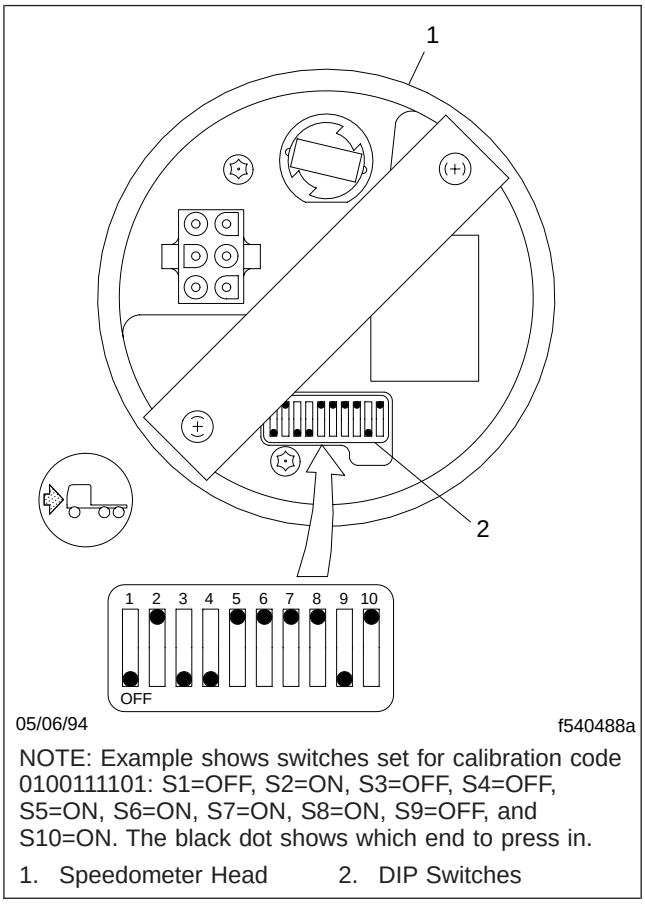
NOTE: Eaton FS4005 series transmission shown

1. Speedometer Wiring
2. Connector
3. Sensor Jam Nut
4. Magnetic Sensor
5. Transmission Bearing Cover
6. Transmission Spacer Gear
7. Transmission Output Shaft

Fig. 1, Cutaway View of an Installed Magnetic Sensor (typical)

VIGIL® III system. These vehicles are calibrated at the factory and should never require recalibration. If a speedometer appears to be inaccurate on a vehicle with VIGIL III, calibrate the lightbar, not the speedometer. The Vigil section contains further information on calibration procedures. See **Section 54.03**.

General Information



NOTE: Example shows switches set for calibration code 0100111101: S1=OFF, S2=ON, S3=OFF, S4=OFF, S5=ON, S6=ON, S7=ON, S8=ON, S9=OFF, and S10=ON. The black dot shows which end to press in.

1. Speedometer Head 2. DIP Switches

Fig. 2, Rear View of the Speedometer Head

Speedometer Head Removal and Installation

Removal

1. Shut down the engine, apply the parking brake and chock the tires.
2. Remove the screws that attach the tachometer/speedometer panel to the dash. Pull the panel out to gain access to the back of the speedometer head. See **Fig. 1**.

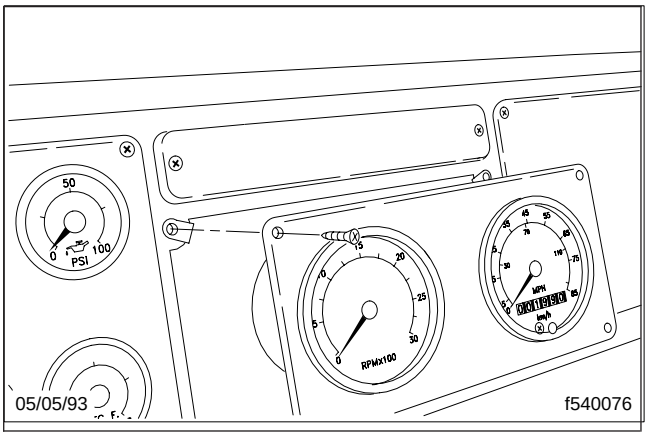


Fig. 1, Speedometer/Tachometer Panel Removal

3. Unplug the electrical wiring harness connector from the back of the speedometer head.
4. Remove the Torx®-head screws that attach the mounting bracket to the speedometer head, and remove the bracket.
5. Remove the speedometer head from the speedometer/tachometer panel by pulling the speedometer head out from the front of the panel.

Installation

1. Place the speedometer head in the panel. Attach the mounting bracket to the speedometer head, then install and tighten the Torx-head screws.
2. Connect the wiring harness connector to the speedometer head.
3. Position the panel, then install and tighten the screws that attach the tachometer/speedometer panel to the dash.
4. Remove the chocks from the tires.

Calibration

Always calibrate a new speedometer head before installing it. For the speedometer to correctly interpret the signal generated by the magnetic speed sensor, calibrate the speedometer head for the specific drivetrain on the vehicle. Also, calibrate the speedometer head whenever different tires (brand, size, or tread design) are installed.

NOTE: Speedometer heads used in conjunction with the VIGIL III system are calibrated at the factory and should never require recalibration. If a speedometer is suspected of being inaccurate, or if the tires are being changed on a vehicle with VIGIL® III, the lightbar module must be recalibrated. See **Section 54.03** for further information on VIGIL lightbar calibration procedures.

1. Determine the pulses per mile (PPM) by using the following formula:

   Pulses per mile (PPM) = Tire revolutions per mile × Axle ratio × Number of teeth on the speedometer spacer gear.

   1.1 Look on the sidewall of the tires to find their size, manufacturer, and tread design. Contact the tire dealer or manufacturer to get the revolutions per mile, or revolutions per kilometer for those tires. To convert revolutions per kilometer to revolutions per mile multiply the revolutions per kilometer value by 1.609.

   1.2 Find the rear axle ratio on the vehicle specification decal, or on the identification plate attached to the axle housing.

   1.3 Calculate the number of pulses per mile (PPM) that are being sent to the speedometer. First, multiply the tire revolutions per mile by the rear axle ratio.

   Then, multiply the answer by the number of teeth on the speedometer spacer gear.

   Example: Suppose the tire revolutions per mile are 491, the axle ratio is 4.11, and the speedometer spacer gear has 16 teeth. The pulses per mile (PPM) would be:

   491 × 4.11 × 16 = 32288.16 PPM

   NOTE: Most transmissions have 16 teeth on the transmission's speedometer spacer gear.

2. Determine the calibration number for the speedometer head by using the following formula:

   Calibration number = Pulses per mile (PPM) ÷ 120

   Use the example from the previous step: 32288.16 (PPM) ÷ 120 = 269.068 or 269. Since the result of the calculation is rounded to the nearest whole number, the speedometer calibration number would be 269. For the speedometer calibration number, see the PPM/120 column in the calibration tables.

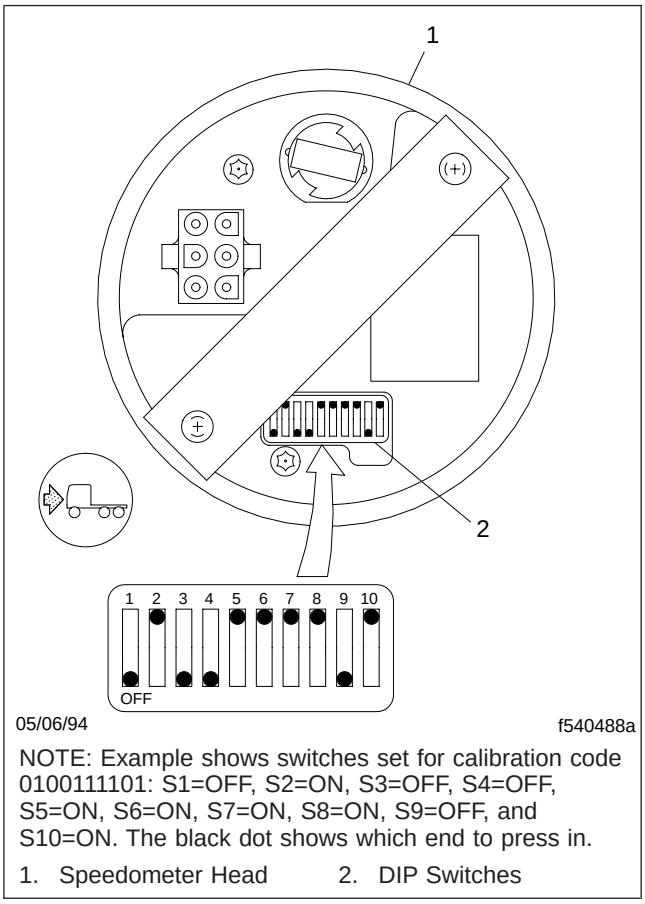
3. Once the speedometer calibration number has been calculated, use the speedometer calibration tables to determine the speedometer DIP switch settings. See **Specifications, 400**.

4. Remove the speedometer head from the dash; see **Subject 100** for instructions.

5. Set the positions of the ten rocker (DIP) switches to ON or OFF as indicated by the calibration code. The individual switches are set by depressing the appropriate end of the switch with a suitable tool that isn't likely to break off inside the speedometer (such as a small screwdriver). Pressing in at the top of the switch turns the DIP switch ON. Pressing in at the bottom turns the DIP switch OFF. See **Fig. 1**.

6. Install the speedometer head; see **Subject 100**.

Speedometer Head Calibration



NOTE: Example shows switches set for calibration code 0100111101: S1=OFF, S2=ON, S3=OFF, S4=OFF, S5=ON, S6=ON, S7=ON, S8=ON, S9=OFF, and S10=ON. The black dot shows which end to press in.

1. Speedometer Head 2. DIP Switches

Fig. 1, Rear View of Speedometer Head

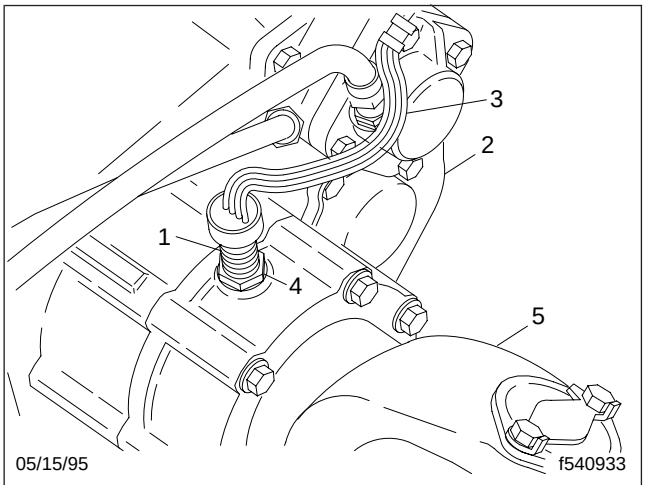
Magnetic Sensor Replacement and Adjustment

Replacement and Adjustment

1. Apply the parking brakes, shut down the engine, and chock the tires.
2. Remove the magnetic sensor.
   - 2.1 Disconnect the electrical connector from the magnetic sensor.
   - 2.2 Loosen the magnetic sensor jam nut. Turn the magnetic sensor out of the transmission bearing cover. If not removed with the sensor, also remove the O-ring from the bearing cover.
3. On Rockwell transmissions, install a new O-ring on the magnetic sensor. If installing a new sensor, leave the plastic cap on the end of the sensor. The cap serves as a gap gauge when installing the sensor. See **Fig. 1**.
   - 3.1 With the jam nut backed off to the outboard end of the new magnetic sensor, turn the sensor by hand into the transmission bearing cover until it bottoms out on the gear teeth.
   - 3.2 If the magnetic sensor is installed without the plastic shim (gap gauge) back out the sensor three-quarters of a turn to adjust the gap.
4. Adjust the sensor
   - 4.1 Back off the jam nut.
   - 4.2 Turn the sensor into the bearing cover.
   - 4.3 Back the sensor out.

   NOTE: If the sensor was installed with the plastic cap (gap gauge), do not back out the sensor three-quarters of a turn since the gap has been set by the plastic cap.
5. Install the sensor. See **Fig. 1**.
   - 5.1 Holding the sensor in place to keep it from turning, tighten the jam nut 18 lbf·ft (25 N·m).

   IMPORTANT: Maintain the correct sensor adjustment, or the speedometer reading will not be correct.
   - 5.2 Connect the wiring harness connector to the sensor and be sure it is locked in place.
6. Remove the chocks from the tires.
7. Test drive the vehicle and check that the speedometer is operating correctly. If there is no speedometer reading, it may mean that the magnetic sensor was not adjusted correctly. Readjust the sensor.



1. Magnetic Speed Sensor
2. Transmission Housing
3. Sensor Wiring
4. Sensor Jam Nut
5. Drive Yoke

Fig. 1, View of an Installed Magnetic Sensor

Troubleshooting Procedures

NOTE: If the vehicle is equipped with the VIGIL® III system, see troubleshooting information in **Section 54.03**.

Speedometer malfunctions are usually one of two types: the speedometer/odometer readings are incorrect, or the speedometer does not operate at all.

INACCURATE SPEEDOMETER

If an inaccurate speedometer is suspected, drive the vehicle over a measured mile to confirm the amount of inaccuracy.

An inaccurate odometer reading over a measured mile indicates a problem in the speedometer system, but it does not isolate the cause of the inaccuracy. Inaccurate speedometer/odometer readings may occur when a new speedometer head or new tires are installed. In each case, calibrate the speedometer head using the procedure in **Subject 110**.

NOTE: Testing the accuracy of speedometer head readings is best done by commercial services specializing in such tests. If these commercial services are not available, do the odometer reading test over a measured mile.

Another cause of an inaccurate speedometer reading is an incorrect magnetic sensor-to-gear clearance (gap). Make sure the magnetic sensor is correctly adjusted. For instructions on how to adjust the magnetic sensor, see **Subject 120**.

SPEEDOMETER DOES NOT OPERATE

Do the following steps to check for malfunctions that would cause a totally inoperative speedometer.

1. Check for an open or shorted magnetic sensor.
2. Check for open or shorted wire.
3. Check for a faulty speedometer head.

To isolate the cause of an inoperative speedometer, follow the troubleshooting procedures in the order given.

1. Check for an open or shorted magnetic sensor by measuring the resistance of the sensor.

   1.1 There are two connectors for the magnetic sensor. One connector for the speedometer, and one for the engine control module. The speedometer connector contains the wiring for circuit 117 and 118.

   1.2 Disconnect the harness connector for circuit 117 and 118, located at the passenger side firewall.

   1.3 Make sure that both halves of the connection are free of corrosion and moisture.

   1.4 Connect the leads of an ohmmeter to the pins on the magnetic sensor side of the harness connector. The resistance measured should fall within the range given in **Table 1**.

   1.5 If the resistance is above or below the acceptable range, replace the sensor; see **Subject 120**. If the resistance is in the acceptable range, go to the next step.

Magnetic Sensor Resistance	
Engine	**Magnetic Sensor Resistance in Ohms**
Caterpillar	824 to 1006
Detroit Diesel	824 to 1006
Cummins (white and green sensor wires)	756 to 924
Cummins (red and black sensor wires)	1188 to 1452

Table 1, Magnetic Sensor Resistance

2. Check that the magnetic sensor is not shorted to ground by measuring the sensor's resistance to ground.

   2.1 Connect the red ohmmeter lead to a pin on the bad magnetic sensor. Touch the black ohmmeter lead to any ground point. The resistance should read infinite ohms.

   2.2 If the resistance measured is less than infinite, the magnetic sensor is grounded and must be replaced; see **Subject 120**. If the resistance reading was acceptable, reconnect the magnetic sensor connector and then go to the next step.

3. Check the wiring between the magnetic sensor and the speedometer head for an open circuit.

Troubleshooting

3.1 Remove the speedometer head from the dash and disconnect the wiring harness from the speedometer head; see **Subject 100**.

3.2 Check for an open circuit by connecting the ohmmeter leads to the speedometer harness connector, terminals 5 and 1 (wiring circuit numbers 117 and 118, respectively). See **Fig. 1**. The resistance measured should fall within the range given in **Table 1**.

3.3 If the resistance is above the acceptable range, there is more resistance in the wiring between the speedometer head and the magnetic sensor. If the resistance is below the acceptable range, a short between the wires 117 and 118 has occurred. Repair or replace the damaged wiring. Then install the speedometer head; see **Subject 100**. If the measured resistance is in the acceptable range, go to the next step.

4. Check the wiring between the magnetic sensor and the speedometer head for a short circuit to ground.

4.1 Remove the speedometer head from the dash panel. Disconnect the six–pin connector from the speedometer.

4.2 Connect the positive lead from an ohmmeter to terminal 5, circuit 117, and connect the negative lead to a good ground source. If there is no short to ground, the ohmmeter should read infinite ohms. If there is a short to ground, the ohmmeter should read low ohms. See **Fig. 1**.

4.3 Connect the positive lead from an ohmmeter to terminal 1, circuit 118, and connect the negative lead to a good ground source. If there is no short to ground, the ohmmeter should read infinite ohms. If there is a short to ground, the ohmmeter should read low ohms.

4.4 If the resistance measured was less than infinite ohms in either of the measurements, repair the short to ground in the respective circuit wiring. If the measurements were acceptable, go to the next step.

5. Check the ground circuit wiring between the speedometer head and ground for an open circuit.

5.1 Connect the red ohmmeter lead to the speedometer harness connector terminal 3. Touch the black ohmmeter lead to any ground point. See **Fig. 1**. A measurement of 3 ohms or less is acceptable.

5.2 If the resistance measured is more than 3 ohms, repair the open circuit in the wire. If the resistance reading was acceptable, go to the next step.

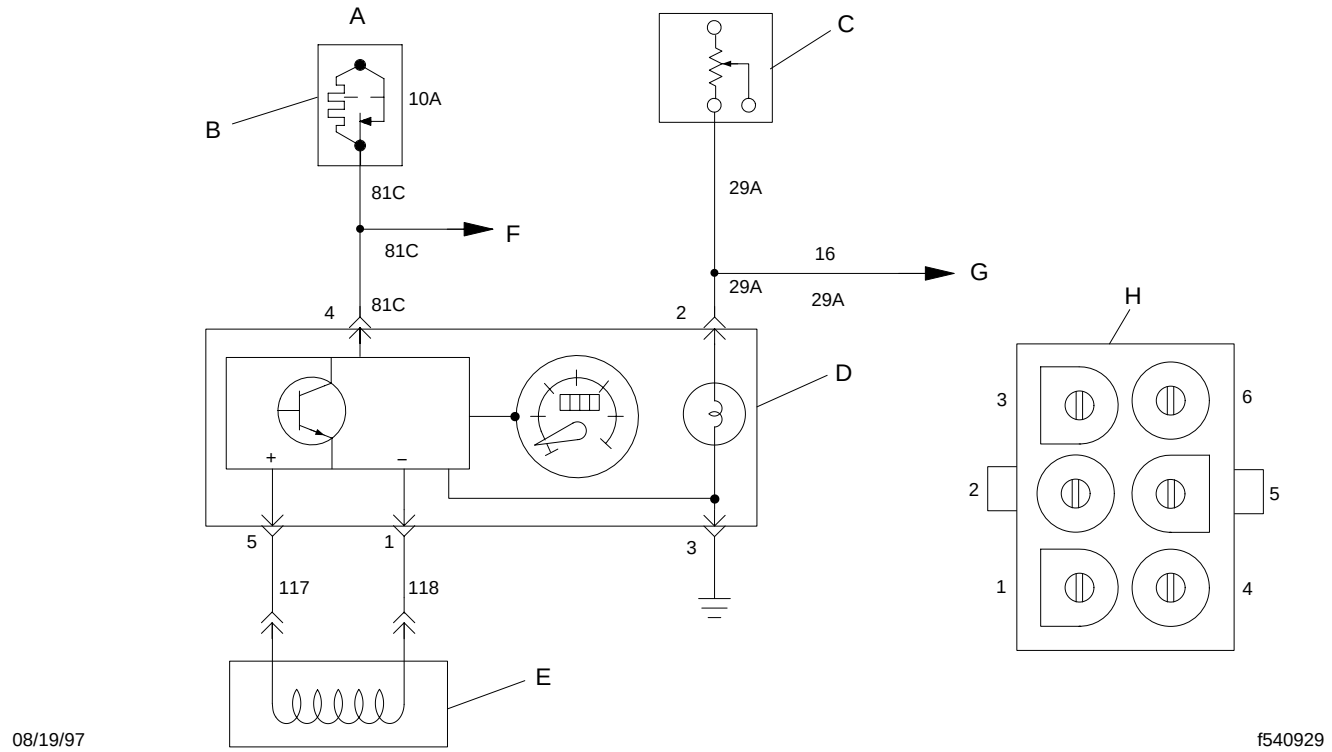
6. Check for battery voltage at the speedometer head connector.

6.1 Connect the positive lead of a voltmeter to terminal 4. Connect the negative lead to terminal 3. Check that the voltmeter is set to DC volts. See **Fig. 1**.

6.2 Turn the ignition switch on, and check that there is 11 to 13 volts.

6.3 If the voltage is not between 11 and 13 volts, check the voltage at the circuit breaker. The voltage should be 11 to 13 volts ±1 volt. Check the wiring between the circuit breaker and the speedometer head. Repair any damaged wiring and then install the speedometer head; see **Subject 100**. If the voltage is between 11 and 13 volts DC, the speedometer head is malfunctioning and must be replaced.

Troubleshooting Tables



A. Ignition Powered Circuit Breaker
B. Ignition Circuit Breaker Panel
C. Panel Lamp Rheostat (solid state)
D. Speedometer Head
E. Magnetic Sensor
F. To Fuel Gauge
G. To Instrument Panel Lamps
H. Speedometer Connector (harness side)

Fig. 1, Speedometer Wiring Schematic

Problem—Speedometer Head Will Not Register

Problem—Speedometer Head Will Not Register	
Possible Cause	**Remedy**
The magnetic sensor gap is incorrectly adjusted.	Adjust the magnetic sensor.
The magnetic sensor is damaged.	Replace the magnetic sensor.
Loose or corroded terminals, broken terminal connections, broken wires, shorting, grounded, or frayed wires are causing an incomplete circuit.	Replace the damaged wiring component(s) as necessary.
The speedometer head is damaged internally.	Replace the speedometer head only after checking all other possible causes.

Troubleshooting

Problem—Inaccurate or Erratic Speedometer Readings

Problem—Inaccurate or Erratic Speedometer Readings	
Possible Cause	**Remedy**
The magnetic sensor gap is incorrectly adjusted.	Adjust the magnetic sensor.
The speedometer head is incorrectly calibrated.	Calibrate the speedometer head.
Loose electrical connections or intermittent open or short circuits in the speedometer wiring.	Check all the wiring in the speedometer system. Tighten all connections.

Ametek Speedometer Calibration Codes, 58 to 92										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
58 =	ON	OFF	ON	OFF	OFF	OFF	ON	ON	ON	ON
59 =	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	ON	ON
60 =	ON	ON	OFF	OFF	OFF	OFF	ON	ON	ON	ON
61 =	OFF	ON	OFF	OFF	OFF	OFF	ON	ON	ON	ON
62 =	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON
63 =	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON
64 =	ON	ON	ON	ON	ON	ON	OFF	ON	ON	ON
65 =	OFF	ON	ON	ON	ON	ON	OFF	ON	ON	ON
66 =	ON	OFF	ON	ON	ON	ON	OFF	ON	ON	ON
67 =	OFF	OFF	ON	ON	ON	ON	OFF	ON	ON	ON
68 =	ON	ON	OFF	ON	ON	ON	OFF	ON	ON	ON
69 =	OFF	ON	OFF	ON	ON	ON	OFF	ON	ON	ON
70 =	ON	OFF	OFF	ON	ON	ON	OFF	ON	ON	ON
71 =	OFF	OFF	OFF	ON	ON	ON	OFF	ON	ON	ON
72 =	ON	ON	ON	OFF	ON	ON	OFF	ON	ON	ON
73 =	OFF	ON	ON	OFF	ON	ON	OFF	ON	ON	ON
74 =	ON	OFF	ON	OFF	ON	ON	OFF	ON	ON	ON
75 =	OFF	OFF	ON	OFF	ON	ON	OFF	ON	ON	ON
76 =	ON	ON	OFF	OFF	ON	ON	OFF	ON	ON	ON
77 =	OFF	ON	OFF	OFF	ON	ON	OFF	ON	ON	ON
78 =	ON	OFF	OFF	OFF	ON	ON	OFF	ON	ON	ON
79 =	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	ON	ON
80 =	ON	ON	ON	ON	OFF	ON	OFF	ON	ON	ON
81 =	OFF	ON	ON	ON	OFF	ON	OFF	ON	ON	ON
82 =	ON	OFF	ON	ON	OFF	ON	OFF	ON	ON	ON
83 =	OFF	OFF	ON	ON	OFF	ON	OFF	ON	ON	ON
84 =	ON	ON	OFF	ON	OFF	ON	OFF	ON	ON	ON
85 =	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	ON	ON
86 =	ON	OFF	OFF	ON	OFF	ON	OFF	ON	ON	ON
87 =	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	ON	ON
88 =	ON	ON	ON	OFF	OFF	ON	OFF	ON	ON	ON
89 =	OFF	ON	ON	OFF	OFF	ON	OFF	ON	ON	ON
90 =	ON	OFF	ON	OFF	OFF	ON	OFF	ON	ON	ON
91 =	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	ON	ON
92 =	ON	ON	OFF	OFF	OFF	ON	OFF	ON	ON	ON

Table 1, Ametek Speedometer Calibration Codes, 58 to 92

Specifications

Ametek Speedometer Calibration Codes, 93 to 129										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
93 =	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	ON	ON
94 =	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	ON	ON
95 =	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	ON	ON
96 =	ON	ON	ON	ON	ON	OFF	OFF	ON	ON	ON
97 =	OFF	ON	ON	ON	ON	OFF	OFF	ON	ON	ON
98 =	ON	OFF	ON	ON	ON	OFF	OFF	ON	ON	ON
99 =	OFF	OFF	ON	ON	ON	OFF	OFF	ON	ON	ON
100 =	ON	ON	OFF	ON	ON	OFF	OFF	ON	ON	ON
101 =	OFF	ON	OFF	ON	ON	OFF	OFF	ON	ON	ON
102 =	ON	OFF	OFF	ON	ON	OFF	OFF	ON	ON	ON
103 =	OFF	OFF	OFF	ON	ON	OFF	OFF	ON	ON	ON
104 =	ON	ON	ON	OFF	ON	OFF	OFF	ON	ON	ON
105 =	OFF	ON	ON	OFF	ON	OFF	OFF	ON	ON	ON
106 =	ON	OFF	ON	OFF	ON	OFF	OFF	ON	ON	ON
107 =	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	ON	ON
108 =	ON	ON	OFF	OFF	ON	OFF	OFF	ON	ON	ON
109 =	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	ON	ON
110 =	ON	OFF	OFF	OFF	ON	OFF	OFF	ON	ON	ON
111 =	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	ON	ON
112 =	ON	ON	ON	ON	OFF	OFF	OFF	ON	ON	ON
113 =	OFF	ON	ON	ON	OFF	OFF	OFF	ON	ON	ON
114 =	ON	OFF	ON	ON	OFF	OFF	OFF	ON	ON	ON
115 =	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	ON	ON
116 =	ON	ON	OFF	ON	OFF	OFF	OFF	ON	ON	ON
117 =	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	ON	ON
118 =	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	ON
119 =	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	ON
120 =	ON	ON	ON	OFF	OFF	OFF	OFF	ON	ON	ON
121 =	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	ON	ON
122 =	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	ON	ON
123 =	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON	ON	ON
124 =	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	ON
125 =	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	ON
126 =	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON
127 =	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON
128 =	ON	ON	ON	ON	ON	ON	ON	OFF	ON	ON

Ametek Speedometer Calibration Codes, 93 to 129										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
129 =	OFF	ON	ON	ON	ON	ON	ON	OFF	ON	ON

Table 2, Ametek Speedometer Calibration Codes, 93 to 129

Ametek Speedometer Calibration Codes, 130 to 166										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
130 =	ON	OFF	ON	ON	ON	ON	ON	OFF	ON	ON
131 =	OFF	OFF	ON	ON	ON	ON	ON	OFF	ON	ON
132 =	ON	ON	OFF	ON	ON	ON	ON	OFF	ON	ON
133 =	OFF	ON	OFF	ON	ON	ON	ON	OFF	ON	ON
134 =	ON	OFF	OFF	ON	ON	ON	ON	OFF	ON	ON
135 =	OFF	OFF	OFF	ON	ON	ON	ON	OFF	ON	ON
136 =	ON	ON	ON	OFF	ON	ON	ON	OFF	ON	ON
137 =	OFF	ON	ON	OFF	ON	ON	ON	OFF	ON	ON
138 =	ON	OFF	ON	OFF	ON	ON	ON	OFF	ON	ON
139 =	OFF	OFF	ON	OFF	ON	ON	ON	OFF	ON	ON
140 =	ON	ON	OFF	OFF	ON	ON	ON	OFF	ON	ON
141 =	OFF	ON	OFF	OFF	ON	ON	ON	OFF	ON	ON
142 =	ON	OFF	OFF	OFF	ON	ON	ON	OFF	ON	ON
143 =	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	ON	ON
144 =	ON	ON	ON	ON	OFF	ON	ON	OFF	ON	ON
145 =	OFF	ON	ON	ON	OFF	ON	ON	OFF	ON	ON
146 =	ON	OFF	ON	ON	OFF	ON	ON	OFF	ON	ON
147 =	OFF	OFF	ON	ON	OFF	ON	ON	OFF	ON	ON
148 =	ON	ON	OFF	ON	OFF	ON	ON	OFF	ON	ON
149 =	OFF	ON	OFF	ON	OFF	ON	ON	OFF	ON	ON
150 =	ON	OFF	OFF	ON	OFF	ON	ON	OFF	ON	ON
151 =	OFF	OFF	OFF	ON	OFF	ON	ON	OFF	ON	ON
152 =	ON	ON	ON	OFF	OFF	ON	ON	OFF	ON	ON
153 =	OFF	ON	ON	OFF	OFF	ON	ON	OFF	ON	ON
154 =	ON	OFF	ON	OFF	OFF	ON	ON	OFF	ON	ON
155 =	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	ON	ON
156 =	ON	ON	OFF	OFF	OFF	ON	ON	OFF	ON	ON
157 =	OFF	ON	OFF	OFF	OFF	ON	ON	OFF	ON	ON
158 =	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	ON
159 =	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	ON
160 =	ON	ON	ON	ON	ON	OFF	ON	OFF	ON	ON

Specifications

Ametek Speedometer Calibration Codes, 130 to 166										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
161 =	OFF	ON	ON	ON	ON	OFF	ON	OFF	ON	ON
162 =	ON	OFF	ON	ON	ON	OFF	ON	OFF	ON	ON
163 =	OFF	OFF	ON	ON	ON	OFF	ON	OFF	ON	ON
164 =	ON	ON	OFF	ON	ON	OFF	ON	OFF	ON	ON
165 =	OFF	ON	OFF	ON	ON	OFF	ON	OFF	ON	ON
166 =	ON	OFF	OFF	ON	ON	OFF	ON	OFF	ON	ON

Table 3, Ametek Speedometer Calibration Codes, 130 to 166

Ametek Speedometer Calibration Codes, 167 to 203										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
167 =	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	ON	ON
168 =	ON	ON	ON	OFF	ON	OFF	ON	OFF	ON	ON
169 =	OFF	ON	ON	OFF	ON	OFF	ON	OFF	ON	ON
170 =	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	ON
171 =	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	ON	ON
172 =	ON	ON	OFF	OFF	ON	OFF	ON	OFF	ON	ON
173 =	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	ON	ON
174 =	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	ON
175 =	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	ON
176 =	ON	ON	ON	ON	OFF	OFF	ON	OFF	ON	ON
177 =	OFF	ON	ON	ON	OFF	OFF	ON	OFF	ON	ON
178 =	ON	OFF	ON	ON	OFF	OFF	ON	OFF	ON	ON
179 =	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	ON	ON
180 =	ON	ON	OFF	ON	OFF	OFF	ON	OFF	ON	ON
181 =	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	ON	ON
182 =	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	ON
183 =	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	ON
184 =	ON	ON	ON	OFF	OFF	OFF	ON	OFF	ON	ON
185 =	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	ON	ON
186 =	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	ON
187 =	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	ON
188 =	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	ON
189 =	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	ON
190 =	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	ON
191 =	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	ON
192 =	ON	ON	ON	ON	ON	ON	OFF	OFF	ON	ON

Ametek Speedometer Calibration Codes, 167 to 203										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
193 =	OFF	ON	ON	ON	ON	ON	OFF	OFF	ON	ON
194 =	ON	OFF	ON	ON	ON	ON	OFF	OFF	ON	ON
195 =	OFF	OFF	ON	ON	ON	ON	OFF	OFF	ON	ON
196 =	ON	ON	OFF	ON	ON	ON	OFF	OFF	ON	ON
197 =	OFF	ON	OFF	ON	ON	ON	OFF	OFF	ON	ON
198 =	ON	OFF	OFF	ON	ON	ON	OFF	OFF	ON	ON
199 =	OFF	OFF	OFF	ON	ON	ON	OFF	OFF	ON	ON
200 =	ON	ON	ON	OFF	ON	ON	OFF	OFF	ON	ON
201 =	OFF	ON	ON	OFF	ON	ON	OFF	OFF	ON	ON
202 =	ON	OFF	ON	OFF	ON	ON	OFF	OFF	ON	ON
203 =	OFF	OFF	ON	OFF	ON	ON	OFF	OFF	ON	ON

Table 4, Ametek Speedometer Calibration Codes, 167 to 203

Ametek Speedometer Calibration Codes, 204 to 240										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
204 =	ON	ON	OFF	OFF	ON	ON	OFF	OFF	ON	ON
205 =	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	ON	ON
206 =	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	ON	ON
207 =	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	ON	ON
208 =	ON	ON	ON	ON	OFF	ON	OFF	OFF	ON	ON
209 =	OFF	ON	ON	ON	OFF	ON	OFF	OFF	ON	ON
210 =	ON	OFF	ON	ON	OFF	ON	OFF	OFF	ON	ON
211 =	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	ON	ON
212 =	ON	ON	OFF	ON	OFF	ON	OFF	OFF	ON	ON
213 =	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	ON	ON
214 =	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	ON
215 =	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	ON
216 =	ON	ON	ON	OFF	OFF	ON	OFF	OFF	ON	ON
217 =	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	ON	ON
218 =	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	ON
219 =	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	ON
220 =	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	ON	ON
221 =	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	ON	ON
222 =	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	ON
223 =	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	ON
224 =	ON	ON	ON	ON	ON	OFF	OFF	OFF	ON	ON

Specifications

Ametek Speedometer Calibration Codes, 204 to 240										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
225 =	OFF	ON	ON	ON	ON	OFF	OFF	OFF	ON	ON
226 =	ON	OFF	ON	ON	ON	OFF	OFF	OFF	ON	ON
227 =	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	ON	ON
228 =	ON	ON	OFF	ON	ON	OFF	OFF	OFF	ON	ON
229 =	OFF	ON	OFF	ON	ON	OFF	OFF	OFF	ON	ON
230 =	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	ON
231 =	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	ON
232 =	ON	ON	ON	OFF	ON	OFF	OFF	OFF	ON	ON
233 =	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	ON	ON
234 =	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	ON
235 =	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	ON
236 =	ON	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	ON
237 =	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	ON
238 =	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	ON
239 =	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	ON
240 =	ON	ON	ON	ON	OFF	OFF	OFF	OFF	ON	ON

Table 5, Ametek Speedometer Calibration Codes, 204 to 240

Ametek Speedometer Calibration Codes, 241 to 277										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
241 =	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	ON	ON
242 =	ON	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	ON
243 =	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	ON
244 =	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	ON
245 =	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	ON
246 =	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON	ON
247 =	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON	ON
248 =	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	ON
249 =	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	ON
250 =	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	ON
251 =	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	ON
252 =	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON
253 =	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON
254 =	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON
255 =	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON
256 =	ON	ON	ON	ON	ON	ON	ON	ON	OFF	ON

Ametek Speedometer Calibration Codes, 241 to 277										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
257 =	OFF	ON	ON	ON	ON	ON	ON	ON	OFF	ON
258 =	ON	OFF	ON	ON	ON	ON	ON	ON	OFF	ON
259 =	OFF	OFF	ON	ON	ON	ON	ON	ON	OFF	ON
260 =	ON	ON	OFF	ON	ON	ON	ON	ON	OFF	ON
261 =	OFF	ON	OFF	ON	ON	ON	ON	ON	OFF	ON
262 =	ON	OFF	OFF	ON	ON	ON	ON	ON	OFF	ON
263 =	OFF	OFF	OFF	ON	ON	ON	ON	ON	OFF	ON
264 =	ON	ON	ON	OFF	ON	ON	ON	ON	OFF	ON
265 =	OFF	ON	ON	OFF	ON	ON	ON	ON	OFF	ON
266 =	ON	OFF	ON	OFF	ON	ON	ON	ON	OFF	ON
267 =	OFF	OFF	ON	OFF	ON	ON	ON	ON	OFF	ON
268 =	ON	ON	OFF	OFF	ON	ON	ON	ON	OFF	ON
269 =	OFF	ON	OFF	OFF	ON	ON	ON	ON	OFF	ON
270 =	ON	OFF	OFF	OFF	ON	ON	ON	ON	OFF	ON
271 =	OFF	OFF	OFF	OFF	ON	ON	ON	ON	OFF	ON
272 =	ON	ON	ON	ON	OFF	ON	ON	ON	OFF	ON
273 =	OFF	ON	ON	ON	OFF	ON	ON	ON	OFF	ON
274 =	ON	OFF	ON	ON	OFF	ON	ON	ON	OFF	ON
275 =	OFF	OFF	ON	ON	OFF	ON	ON	ON	OFF	ON
276 =	ON	ON	OFF	ON	OFF	ON	ON	ON	OFF	ON
277 =	OFF	ON	OFF	ON	OFF	ON	ON	ON	OFF	ON

Table 6, Ametek Speedometer Calibration Codes, 241 to 277

Ametek Speedometer Calibration Codes, 278 to 314										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
278 =	ON	OFF	OFF	ON	OFF	ON	ON	ON	OFF	ON
279 =	OFF	OFF	OFF	ON	OFF	ON	ON	ON	OFF	ON
280 =	ON	ON	ON	OFF	OFF	ON	ON	ON	OFF	ON
281 =	OFF	ON	ON	OFF	OFF	ON	ON	ON	OFF	ON
282 =	ON	OFF	ON	OFF	OFF	ON	ON	ON	OFF	ON
283 =	OFF	OFF	ON	OFF	OFF	ON	ON	ON	OFF	ON
284 =	ON	ON	OFF	OFF	OFF	ON	ON	ON	OFF	ON
285 =	OFF	ON	OFF	OFF	OFF	ON	ON	ON	OFF	ON
286 =	ON	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	ON
287 =	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	ON
288 =	ON	ON	ON	ON	ON	OFF	ON	ON	OFF	ON

Specifications

Ametek Speedometer Calibration Codes, 278 to 314										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
289 =	OFF	ON	ON	ON	ON	OFF	ON	ON	OFF	ON
290 =	ON	OFF	ON	ON	ON	OFF	ON	ON	OFF	ON
291 =	OFF	OFF	ON	ON	ON	OFF	ON	ON	OFF	ON
292 =	ON	ON	OFF	ON	ON	OFF	ON	ON	OFF	ON
293 =	OFF	ON	OFF	ON	ON	OFF	ON	ON	OFF	ON
294 =	ON	OFF	OFF	ON	ON	OFF	ON	ON	OFF	ON
295 =	OFF	OFF	OFF	ON	ON	OFF	ON	ON	OFF	ON
296 =	ON	ON	ON	OFF	ON	OFF	ON	ON	OFF	ON
297 =	OFF	ON	ON	OFF	ON	OFF	ON	ON	OFF	ON
298 =	ON	OFF	ON	OFF	ON	OFF	ON	ON	OFF	ON
299 =	OFF	OFF	ON	OFF	ON	OFF	ON	ON	OFF	ON
300 =	ON	ON	OFF	OFF	ON	OFF	ON	ON	OFF	ON
301 =	OFF	ON	OFF	OFF	ON	OFF	ON	ON	OFF	ON
302 =	ON	OFF	OFF	OFF	ON	OFF	ON	ON	OFF	ON
303 =	OFF	OFF	OFF	OFF	ON	OFF	ON	ON	OFF	ON
304 =	ON	ON	ON	ON	OFF	OFF	ON	ON	OFF	ON
305 =	OFF	ON	ON	ON	OFF	OFF	ON	ON	OFF	ON
306 =	ON	OFF	ON	ON	OFF	OFF	ON	ON	OFF	ON
307 =	OFF	OFF	ON	ON	OFF	OFF	ON	ON	OFF	ON
308 =	ON	ON	OFF	ON	OFF	OFF	ON	ON	OFF	ON
309 =	OFF	ON	OFF	ON	OFF	OFF	ON	ON	OFF	ON
310 =	ON	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	ON
311 =	OFF	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	ON
312 =	ON	ON	ON	OFF	OFF	OFF	ON	ON	OFF	ON
313 =	OFF	ON	ON	OFF	OFF	OFF	ON	ON	OFF	ON
314 =	ON	OFF	ON	OFF	OFF	OFF	ON	ON	OFF	ON

Table 7, Ametek Speedometer Calibration Codes, 278 to 314

Ametek Speedometer Calibration Codes, 315 to 351										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
315 =	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	OFF	ON
316 =	ON	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	ON
317 =	OFF	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	ON
318 =	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	ON
319 =	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	ON
320 =	ON	ON	ON	ON	ON	ON	OFF	ON	OFF	ON

Ametek Speedometer Calibration Codes, 315 to 351										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
321 =	OFF	ON	ON	ON	ON	ON	OFF	ON	OFF	ON
322 =	ON	OFF	ON	ON	ON	ON	OFF	ON	OFF	ON
323 =	OFF	OFF	ON	ON	ON	ON	OFF	ON	OFF	ON
324 =	ON	ON	OFF	ON	ON	ON	OFF	ON	OFF	ON
325 =	OFF	ON	OFF	ON	ON	ON	OFF	ON	OFF	ON
326 =	ON	OFF	OFF	ON	ON	ON	OFF	ON	OFF	ON
327 =	OFF	OFF	OFF	ON	ON	ON	OFF	ON	OFF	ON
328 =	ON	ON	ON	OFF	ON	ON	OFF	ON	OFF	ON
329 =	OFF	ON	ON	OFF	ON	ON	OFF	ON	OFF	ON
330 =	ON	OFF	ON	OFF	ON	ON	OFF	ON	OFF	ON
331 =	OFF	OFF	ON	OFF	ON	ON	OFF	ON	OFF	ON
332 =	ON	ON	OFF	OFF	ON	ON	OFF	ON	OFF	ON
333 =	OFF	ON	OFF	OFF	ON	ON	OFF	ON	OFF	ON
334 =	ON	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	ON
335 =	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	ON
336 =	ON	ON	ON	ON	OFF	ON	OFF	ON	OFF	ON
337 =	OFF	ON	ON	ON	OFF	ON	OFF	ON	OFF	ON
338 =	ON	OFF	ON	ON	OFF	ON	OFF	ON	OFF	ON
339 =	OFF	OFF	ON	ON	OFF	ON	OFF	ON	OFF	ON
340 =	ON	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON
341 =	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON
342 =	ON	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	ON
343 =	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	ON
344 =	ON	ON	ON	OFF	OFF	ON	OFF	ON	OFF	ON
345 =	OFF	ON	ON	OFF	OFF	ON	OFF	ON	OFF	ON
346 =	ON	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	ON
347 =	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	ON
348 =	ON	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	ON
349 =	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	ON
350 =	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	ON
351 =	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	ON

Table 8, Ametek Speedometer Calibration Codes, 315 to 351

Ametek Speedometer Calibration Codes, 352 to 388										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
352 =	ON	ON	ON	ON	ON	OFF	OFF	ON	OFF	ON

Specifications

Ametek Speedometer Calibration Codes, 352 to 388										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
353 =	OFF	ON	ON	ON	ON	OFF	OFF	ON	OFF	ON
354 =	ON	OFF	ON	ON	ON	OFF	OFF	ON	OFF	ON
355 =	OFF	OFF	ON	ON	ON	OFF	OFF	ON	OFF	ON
356 =	ON	ON	OFF	ON	ON	OFF	OFF	ON	OFF	ON
357 =	OFF	ON	OFF	ON	ON	OFF	OFF	ON	OFF	ON
358 =	ON	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	ON
359 =	OFF	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	ON
360 =	ON	ON	ON	OFF	ON	OFF	OFF	ON	OFF	ON
361 =	OFF	ON	ON	OFF	ON	OFF	OFF	ON	OFF	ON
362 =	ON	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	ON
363 =	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	ON
364 =	ON	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	ON
365 =	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	ON
366 =	ON	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	ON
367 =	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	ON
368 =	ON	ON	ON	ON	OFF	OFF	OFF	ON	OFF	ON
369 =	OFF	ON	ON	ON	OFF	OFF	OFF	ON	OFF	ON
370 =	ON	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	ON
371 =	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	ON
372 =	ON	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	ON
373 =	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	ON
374 =	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	ON
375 =	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	ON
376 =	ON	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	ON
377 =	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	ON
378 =	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	ON
379 =	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	ON
380 =	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON
381 =	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON
382 =	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON
383 =	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON
384 =	ON	ON	ON	ON	ON	ON	ON	OFF	OFF	ON
385 =	OFF	ON	ON	ON	ON	ON	ON	OFF	OFF	ON
386 =	ON	OFF	ON	ON	ON	ON	ON	OFF	OFF	ON
387 =	OFF	OFF	ON	ON	ON	ON	ON	OFF	OFF	ON

Ametek Speedometer Calibration Codes, 352 to 388										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
388 =	ON	ON	OFF	ON	ON	ON	ON	OFF	OFF	ON

Table 9, Ametek Speedometer Calibration Codes, 352 to 388

Ametek Speedometer Calibration Codes, 389 to 425										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
389 =	OFF	ON	OFF	ON	ON	ON	ON	OFF	OFF	ON
390 =	ON	OFF	OFF	ON	ON	ON	ON	OFF	OFF	ON
391 =	OFF	OFF	OFF	ON	ON	ON	ON	OFF	OFF	ON
392 =	ON	ON	ON	OFF	ON	ON	ON	OFF	OFF	ON
393 =	OFF	ON	ON	OFF	ON	ON	ON	OFF	OFF	ON
394 =	ON	OFF	ON	OFF	ON	ON	ON	OFF	OFF	ON
395 =	OFF	OFF	ON	OFF	ON	ON	ON	OFF	OFF	ON
396 =	ON	ON	OFF	OFF	ON	ON	ON	OFF	OFF	ON
397 =	OFF	ON	OFF	OFF	ON	ON	ON	OFF	OFF	ON
398 =	ON	OFF	OFF	OFF	ON	ON	ON	OFF	OFF	ON
399 =	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	OFF	ON
400 =	ON	ON	ON	ON	OFF	ON	ON	OFF	OFF	ON
401 =	OFF	ON	ON	ON	OFF	ON	ON	OFF	OFF	ON
402 =	ON	OFF	ON	ON	OFF	ON	ON	OFF	OFF	ON
403 =	OFF	OFF	ON	ON	OFF	ON	ON	OFF	OFF	ON
404 =	ON	ON	OFF	ON	OFF	ON	ON	OFF	OFF	ON
405 =	OFF	ON	OFF	ON	OFF	ON	ON	OFF	OFF	ON
406 =	ON	OFF	OFF	ON	OFF	ON	ON	OFF	OFF	ON
407 =	OFF	OFF	OFF	ON	OFF	ON	ON	OFF	OFF	ON
408 =	ON	ON	ON	OFF	OFF	ON	ON	OFF	OFF	ON
409 =	OFF	ON	ON	OFF	OFF	ON	ON	OFF	OFF	ON
410 =	ON	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	ON
411 =	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	ON
412 =	ON	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	ON
413 =	OFF	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	ON
414 =	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	ON
415 =	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	ON
416 =	ON	ON	ON	ON	ON	OFF	ON	OFF	OFF	ON
417 =	OFF	ON	ON	ON	ON	OFF	ON	OFF	OFF	ON
418 =	ON	OFF	ON	ON	ON	OFF	ON	OFF	OFF	ON
419 =	OFF	OFF	ON	ON	ON	OFF	ON	OFF	OFF	ON

Specifications

Ametek Speedometer Calibration Codes, 389 to 425										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
420 =	ON	ON	OFF	ON	ON	OFF	ON	OFF	OFF	ON
421 =	OFF	ON	OFF	ON	ON	OFF	ON	OFF	OFF	ON
422 =	ON	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	ON
423 =	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	ON
424 =	ON	ON	ON	OFF	ON	OFF	ON	OFF	OFF	ON
425 =	OFF	ON	ON	OFF	ON	OFF	ON	OFF	OFF	ON

Table 10, Ametek Speedometer Calibration Codes, 389 to 425

Ametek Speedometer Calibration Codes, 426 to 462										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
426 =	ON	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	ON
427 =	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	ON
428 =	ON	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	ON
429 =	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	ON
430 =	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	ON
431 =	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	ON
432 =	ON	ON	ON	ON	OFF	OFF	ON	OFF	OFF	ON
433 =	OFF	ON	ON	ON	OFF	OFF	ON	OFF	OFF	ON
434 =	ON	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	ON
435 =	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	ON
436 =	ON	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	ON
437 =	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	ON
438 =	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON
439 =	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON
440 =	ON	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	ON
441 =	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	ON
442 =	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	ON
443 =	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	ON
444 =	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON
445 =	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON
446 =	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON
447 =	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON
448 =	ON	ON	ON	ON	ON	ON	OFF	OFF	OFF	ON
449 =	OFF	ON	ON	ON	ON	ON	OFF	OFF	OFF	ON
450 =	ON	OFF	ON	ON	ON	ON	OFF	OFF	OFF	ON
451 =	OFF	OFF	ON	ON	ON	ON	OFF	OFF	OFF	ON

Ametek Speedometer Calibration Codes, 426 to 462										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
452 =	ON	ON	OFF	ON	ON	ON	OFF	OFF	OFF	ON
453 =	OFF	ON	OFF	ON	ON	ON	OFF	OFF	OFF	ON
454 =	ON	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	ON
455 =	OFF	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	ON
456 =	ON	ON	ON	OFF	ON	ON	OFF	OFF	OFF	ON
457 =	OFF	ON	ON	OFF	ON	ON	OFF	OFF	OFF	ON
458 =	ON	OFF	ON	OFF	ON	ON	OFF	OFF	OFF	ON
459 =	OFF	OFF	ON	OFF	ON	ON	OFF	OFF	OFF	ON
460 =	ON	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	ON
461 =	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	ON
462 =	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	ON

Table 11, Ametek Speedometer Calibration Codes, 426 to 462

Ametek Speedometer Calibration Codes, 463 to 499										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
463 =	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	ON
464 =	ON	ON	ON	ON	OFF	ON	OFF	OFF	OFF	ON
465 =	OFF	ON	ON	ON	OFF	ON	OFF	OFF	OFF	ON
466 =	ON	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	ON
467 =	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	ON
468 =	ON	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	ON
469 =	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	ON
470 =	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	ON
471 =	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	ON
472 =	ON	ON	ON	OFF	OFF	ON	OFF	OFF	OFF	ON
473 =	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	OFF	ON
474 =	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	ON
475 =	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	ON
476 =	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON
477 =	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON
478 =	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON
479 =	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON
480 =	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF	ON
481 =	OFF	ON	ON	ON	ON	OFF	OFF	OFF	OFF	ON
482 =	ON	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	ON
483 =	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	ON

Specifications

Ametek Speedometer Calibration Codes, 463 to 499										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
484 =	ON	ON	OFF	ON	ON	OFF	OFF	OFF	OFF	ON
485 =	OFF	ON	OFF	ON	ON	OFF	OFF	OFF	OFF	ON
486 =	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	ON
487 =	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	ON
488 =	ON	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	ON
489 =	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	ON
490 =	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	ON
491 =	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	ON
492 =	ON	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON
493 =	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON
494 =	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON
495 =	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON
496 =	ON	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	ON
497 =	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	ON
498 =	ON	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	ON
499 =	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	ON

Table 12, Ametek Speedometer Calibration Codes, 463 to 499

Ametek Speedometer Calibration Codes, 500 to 536										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
500 =	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON
501 =	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON
502 =	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON
503 =	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON
504 =	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON
505 =	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON
506 =	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON
507 =	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON
508 =	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON
509 =	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON
510 =	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON
511 =	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON
512 =	ON	ON	ON	ON	ON	ON	ON	ON	ON	OFF
513 =	OFF	ON	ON	ON	ON	ON	ON	ON	ON	OFF
514 =	ON	OFF	ON	ON	ON	ON	ON	ON	ON	OFF
515 =	OFF	OFF	ON	ON	ON	ON	ON	ON	ON	OFF

Ametek Speedometer Calibration Codes, 500 to 536										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
516 =	ON	ON	OFF	ON	ON	ON	ON	ON	ON	OFF
517 =	OFF	ON	OFF	ON	ON	ON	ON	ON	ON	OFF
518 =	ON	OFF	OFF	ON	ON	ON	ON	ON	ON	OFF
519 =	OFF	OFF	OFF	ON	ON	ON	ON	ON	ON	OFF
520 =	ON	ON	ON	OFF	ON	ON	ON	ON	ON	OFF
521 =	OFF	ON	ON	OFF	ON	ON	ON	ON	ON	OFF
522 =	ON	OFF	ON	OFF	ON	ON	ON	ON	ON	OFF
523 =	OFF	OFF	ON	OFF	ON	ON	ON	ON	ON	OFF
524 =	ON	ON	OFF	OFF	ON	ON	ON	ON	ON	OFF
525 =	OFF	ON	OFF	OFF	ON	ON	ON	ON	ON	OFF
526 =	ON	OFF	OFF	OFF	ON	ON	ON	ON	ON	OFF
527 =	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	OFF
528 =	ON	ON	ON	ON	OFF	ON	ON	ON	ON	OFF
529 =	OFF	ON	ON	ON	OFF	ON	ON	ON	ON	OFF
530 =	ON	OFF	ON	ON	OFF	ON	ON	ON	ON	OFF
531 =	OFF	OFF	ON	ON	OFF	ON	ON	ON	ON	OFF
532 =	ON	ON	OFF	ON	OFF	ON	ON	ON	ON	OFF
533 =	OFF	ON	OFF	ON	OFF	ON	ON	ON	ON	OFF
534 =	ON	OFF	OFF	ON	OFF	ON	ON	ON	ON	OFF
535 =	OFF	OFF	OFF	ON	OFF	ON	ON	ON	ON	OFF
536 =	ON	ON	ON	OFF	OFF	ON	ON	ON	ON	OFF

Table 13, Ametek Speedometer Calibration Codes, 500 to 536

Ametek Speedometer Calibration Codes, 537 to 573										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
537 =	OFF	ON	ON	OFF	OFF	ON	ON	ON	ON	OFF
538 =	ON	OFF	ON	OFF	OFF	ON	ON	ON	ON	OFF
539 =	OFF	OFF	ON	OFF	OFF	ON	ON	ON	ON	OFF
540 =	ON	ON	OFF	OFF	OFF	ON	ON	ON	ON	OFF
541 =	OFF	ON	OFF	OFF	OFF	ON	ON	ON	ON	OFF
542 =	ON	OFF	OFF	OFF	OFF	ON	ON	ON	ON	OFF
543 =	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON	OFF
544 =	ON	ON	ON	ON	ON	OFF	ON	ON	ON	OFF
545 =	OFF	ON	ON	ON	ON	OFF	ON	ON	ON	OFF
546 =	ON	OFF	ON	ON	ON	OFF	ON	ON	ON	OFF
547 =	OFF	OFF	ON	ON	ON	OFF	ON	ON	ON	OFF

Specifications

Ametek Speedometer Calibration Codes, 537 to 573										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
548 =	ON	ON	OFF	ON	ON	OFF	ON	ON	ON	OFF
549 =	OFF	ON	OFF	ON	ON	OFF	ON	ON	ON	OFF
550 =	ON	OFF	OFF	ON	ON	OFF	ON	ON	ON	OFF
551 =	OFF	OFF	OFF	ON	ON	OFF	ON	ON	ON	OFF
552 =	ON	ON	ON	OFF	ON	OFF	ON	ON	ON	OFF
553 =	OFF	ON	ON	OFF	ON	OFF	ON	ON	ON	OFF
554 =	ON	OFF	ON	OFF	ON	OFF	ON	ON	ON	OFF
555 =	OFF	OFF	ON	OFF	ON	OFF	ON	ON	ON	OFF
556 =	ON	ON	OFF	OFF	ON	OFF	ON	ON	ON	OFF
557 =	OFF	ON	OFF	OFF	ON	OFF	ON	ON	ON	OFF
558 =	ON	OFF	OFF	OFF	ON	OFF	ON	ON	ON	OFF
559 =	OFF	OFF	OFF	OFF	ON	OFF	ON	ON	ON	OFF
560 =	ON	ON	ON	ON	OFF	OFF	ON	ON	ON	OFF
561 =	OFF	ON	ON	ON	OFF	OFF	ON	ON	ON	OFF
562 =	ON	OFF	ON	ON	OFF	OFF	ON	ON	ON	OFF
563 =	OFF	OFF	ON	ON	OFF	OFF	ON	ON	ON	OFF
564 =	ON	ON	OFF	ON	OFF	OFF	ON	ON	ON	OFF
565 =	OFF	ON	OFF	ON	OFF	OFF	ON	ON	ON	OFF
566 =	ON	OFF	OFF	ON	OFF	OFF	ON	ON	ON	OFF
567 =	OFF	OFF	OFF	ON	OFF	OFF	ON	ON	ON	OFF
568 =	ON	ON	ON	OFF	OFF	OFF	ON	ON	ON	OFF
569 =	OFF	ON	ON	OFF	OFF	OFF	ON	ON	ON	OFF
570 =	ON	OFF	ON	OFF	OFF	OFF	ON	ON	ON	OFF
571 =	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	ON	OFF
572 =	ON	ON	OFF	OFF	OFF	OFF	ON	ON	ON	OFF
573 =	OFF	ON	OFF	OFF	OFF	OFF	ON	ON	ON	OFF

Table 14, Ametek Speedometer Calibration Codes, 537 to 573

Ametek Speedometer Calibration Codes, 574 to 610										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
574 =	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	OFF
575 =	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	OFF
576 =	ON	ON	ON	ON	ON	ON	OFF	ON	ON	OFF
577 =	OFF	ON	ON	ON	ON	ON	OFF	ON	ON	OFF
578 =	ON	OFF	ON	ON	ON	ON	OFF	ON	ON	OFF
579 =	OFF	OFF	ON	ON	ON	ON	OFF	ON	ON	OFF

Ametek Speedometer Calibration Codes, 574 to 610										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
580 =	ON	ON	OFF	ON	ON	ON	OFF	ON	ON	OFF
581 =	OFF	ON	OFF	ON	ON	ON	OFF	ON	ON	OFF
582 =	ON	OFF	OFF	ON	ON	ON	OFF	ON	ON	OFF
583 =	OFF	OFF	OFF	ON	ON	ON	OFF	ON	ON	OFF
584 =	ON	ON	ON	OFF	ON	ON	OFF	ON	ON	OFF
585 =	OFF	ON	ON	OFF	ON	ON	OFF	ON	ON	OFF
586 =	ON	OFF	ON	OFF	ON	ON	OFF	ON	ON	OFF
587 =	OFF	OFF	ON	OFF	ON	ON	OFF	ON	ON	OFF
588 =	ON	ON	OFF	OFF	ON	ON	OFF	ON	ON	OFF
589 =	OFF	ON	OFF	OFF	ON	ON	OFF	ON	ON	OFF
590 =	ON	OFF	OFF	OFF	ON	ON	OFF	ON	ON	OFF
591 =	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	ON	OFF
592 =	ON	ON	ON	ON	OFF	ON	OFF	ON	ON	OFF
593 =	OFF	ON	ON	ON	OFF	ON	OFF	ON	ON	OFF
594 =	ON	OFF	ON	ON	OFF	ON	OFF	ON	ON	OFF
595 =	OFF	OFF	ON	ON	OFF	ON	OFF	ON	ON	OFF
596 =	ON	ON	OFF	ON	OFF	ON	OFF	ON	ON	OFF
597 =	OFF	ON	OFF	ON	OFF	ON	OFF	ON	ON	OFF
598 =	ON	OFF	OFF	ON	OFF	ON	OFF	ON	ON	OFF
599 =	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	ON	OFF
600 =	ON	ON	ON	OFF	OFF	ON	OFF	ON	ON	OFF
601 =	OFF	ON	ON	OFF	OFF	ON	OFF	ON	ON	OFF
602 =	ON	OFF	ON	OFF	OFF	ON	OFF	ON	ON	OFF
603 =	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	ON	OFF
604 =	ON	ON	OFF	OFF	OFF	ON	OFF	ON	ON	OFF
605 =	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	ON	OFF
606 =	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	ON	OFF
607 =	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	ON	OFF
608 =	ON	ON	ON	ON	ON	OFF	OFF	ON	ON	OFF
609 =	OFF	ON	ON	ON	ON	OFF	OFF	ON	ON	OFF
610 =	ON	OFF	ON	ON	ON	OFF	OFF	ON	ON	OFF

Table 15, Ametek Speedometer Calibration Codes, 574 to 610

Ametek Speedometer Calibration Codes, 611 to 647										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
611 =	OFF	OFF	ON	ON	ON	OFF	OFF	ON	ON	OFF

Specifications

Ametek Speedometer Calibration Codes, 611 to 647										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
612 =	ON	ON	OFF	ON	ON	OFF	OFF	ON	ON	OFF
613 =	OFF	ON	OFF	ON	ON	OFF	OFF	ON	ON	OFF
614 =	ON	OFF	OFF	ON	ON	OFF	OFF	ON	ON	OFF
615 =	OFF	OFF	OFF	ON	ON	OFF	OFF	ON	ON	OFF
616 =	ON	ON	ON	OFF	ON	OFF	OFF	ON	ON	OFF
617 =	OFF	ON	ON	OFF	ON	OFF	OFF	ON	ON	OFF
618 =	ON	OFF	ON	OFF	ON	OFF	OFF	ON	ON	OFF
619 =	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	ON	OFF
620 =	ON	ON	OFF	OFF	ON	OFF	OFF	ON	ON	OFF
621 =	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	ON	OFF
622 =	ON	OFF	OFF	OFF	ON	OFF	OFF	ON	ON	OFF
623 =	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	ON	OFF
624 =	ON	ON	ON	ON	OFF	OFF	OFF	ON	ON	OFF
625 =	OFF	ON	ON	ON	OFF	OFF	OFF	ON	ON	OFF
626 =	ON	OFF	ON	ON	OFF	OFF	OFF	ON	ON	OFF
627 =	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	ON	OFF
628 =	ON	ON	OFF	ON	OFF	OFF	OFF	ON	ON	OFF
629 =	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	ON	OFF
630 =	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	OFF
631 =	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	OFF
632 =	ON	ON	ON	OFF	OFF	OFF	OFF	ON	ON	OFF
633 =	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	ON	OFF
634 =	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	ON	OFF
635 =	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON	ON	OFF
636 =	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF
637 =	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF
638 =	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF
639 =	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF
640 =	ON	ON	ON	ON	ON	ON	ON	OFF	ON	OFF
641 =	OFF	ON	ON	ON	ON	ON	ON	OFF	ON	OFF
642 =	ON	OFF	ON	ON	ON	ON	ON	OFF	ON	OFF
643 =	OFF	OFF	ON	ON	ON	ON	ON	OFF	ON	OFF
644 =	ON	ON	OFF	ON	ON	ON	ON	OFF	ON	OFF
645 =	OFF	ON	OFF	ON	ON	ON	ON	OFF	ON	OFF
646 =	ON	OFF	OFF	ON	ON	ON	ON	OFF	ON	OFF

Ametek Speedometer Calibration Codes, 611 to 647										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
647 =	OFF	OFF	OFF	ON	ON	ON	ON	OFF	ON	OFF

Table 16, Ametek Speedometer Calibration Codes, 611 to 647

Ametek Speedometer Calibration Codes, 648 to 684										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
648 =	ON	ON	ON	OFF	ON	ON	ON	OFF	ON	OFF
649 =	OFF	ON	ON	OFF	ON	ON	ON	OFF	ON	OFF
650 =	ON	OFF	ON	OFF	ON	ON	ON	OFF	ON	OFF
651 =	OFF	OFF	ON	OFF	ON	ON	ON	OFF	ON	OFF
652 =	ON	ON	OFF	OFF	ON	ON	ON	OFF	ON	OFF
653 =	OFF	ON	OFF	OFF	ON	ON	ON	OFF	ON	OFF
654 =	ON	OFF	OFF	OFF	ON	ON	ON	OFF	ON	OFF
655 =	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	ON	OFF
656 =	ON	ON	ON	ON	OFF	ON	ON	OFF	ON	OFF
657 =	OFF	ON	ON	ON	OFF	ON	ON	OFF	ON	OFF
658 =	ON	OFF	ON	ON	OFF	ON	ON	OFF	ON	OFF
659 =	OFF	OFF	ON	ON	OFF	ON	ON	OFF	ON	OFF
660 =	ON	ON	OFF	ON	OFF	ON	ON	OFF	ON	OFF
661 =	OFF	ON	OFF	ON	OFF	ON	ON	OFF	ON	OFF
662 =	ON	OFF	OFF	ON	OFF	ON	ON	OFF	ON	OFF
663 =	OFF	OFF	OFF	ON	OFF	ON	ON	OFF	ON	OFF
664 =	ON	ON	ON	OFF	OFF	ON	ON	OFF	ON	OFF
665 =	OFF	ON	ON	OFF	OFF	ON	ON	OFF	ON	OFF
666 =	ON	OFF	ON	OFF	OFF	ON	ON	OFF	ON	OFF
667 =	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	ON	OFF
668 =	ON	ON	OFF	OFF	OFF	ON	ON	OFF	ON	OFF
669 =	OFF	ON	OFF	OFF	OFF	ON	ON	OFF	ON	OFF
670 =	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	OFF
671 =	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	OFF
672 =	ON	ON	ON	ON	ON	OFF	ON	OFF	ON	OFF
673 =	OFF	ON	ON	ON	ON	OFF	ON	OFF	ON	OFF
674 =	ON	OFF	ON	ON	ON	OFF	ON	OFF	ON	OFF
675 =	OFF	OFF	ON	ON	ON	OFF	ON	OFF	ON	OFF
676 =	ON	ON	OFF	ON	ON	OFF	ON	OFF	ON	OFF
677 =	OFF	ON	OFF	ON	ON	OFF	ON	OFF	ON	OFF
678 =	ON	OFF	OFF	ON	ON	OFF	ON	OFF	ON	OFF

Specifications

Ametek Speedometer Calibration Codes, 648 to 684										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
679 =	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	ON	OFF
680 =	ON	ON	ON	OFF	ON	OFF	ON	OFF	ON	OFF
681 =	OFF	ON	ON	OFF	ON	OFF	ON	OFF	ON	OFF
682 =	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF
683 =	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF
684 =	ON	ON	OFF	OFF	ON	OFF	ON	OFF	ON	OFF

Table 17, Ametek Speedometer Calibration Codes, 648 to 684

Ametek Speedometer Calibration Codes, 685 to 721										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
685 =	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	ON	OFF
686 =	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	OFF
687 =	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	OFF
688 =	ON	ON	ON	ON	OFF	OFF	ON	OFF	ON	OFF
689 =	OFF	ON	ON	ON	OFF	OFF	ON	OFF	ON	OFF
690 =	ON	OFF	ON	ON	OFF	OFF	ON	OFF	ON	OFF
691 =	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	ON	OFF
692 =	ON	ON	OFF	ON	OFF	OFF	ON	OFF	ON	OFF
693 =	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	ON	OFF
694 =	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	OFF
695 =	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	OFF
696 =	ON	ON	ON	OFF	OFF	OFF	ON	OFF	ON	OFF
697 =	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	ON	OFF
698 =	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	OFF
699 =	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	OFF
700 =	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF
701 =	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF
702 =	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF
703 =	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF
704 =	ON	ON	ON	ON	ON	ON	OFF	OFF	ON	OFF
705 =	OFF	ON	ON	ON	ON	ON	OFF	OFF	ON	OFF
706 =	ON	OFF	ON	ON	ON	ON	OFF	OFF	ON	OFF
707 =	OFF	OFF	ON	ON	ON	ON	OFF	OFF	ON	OFF
708 =	ON	ON	OFF	ON	ON	ON	OFF	OFF	ON	OFF
709 =	OFF	ON	OFF	ON	ON	ON	OFF	OFF	ON	OFF
710 =	ON	OFF	OFF	ON	ON	ON	OFF	OFF	ON	OFF

Ametek Speedometer Calibration Codes, 685 to 721										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
711 =	OFF	OFF	OFF	ON	ON	ON	OFF	OFF	ON	OFF
712 =	ON	ON	ON	OFF	ON	ON	OFF	OFF	ON	OFF
713 =	OFF	ON	ON	OFF	ON	ON	OFF	OFF	ON	OFF
714 =	ON	OFF	ON	OFF	ON	ON	OFF	OFF	ON	OFF
715 =	OFF	OFF	ON	OFF	ON	ON	OFF	OFF	ON	OFF
716 =	ON	ON	OFF	OFF	ON	ON	OFF	OFF	ON	OFF
717 =	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	ON	OFF
718 =	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	ON	OFF
719 =	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	ON	OFF
720 =	ON	ON	ON	ON	OFF	ON	OFF	OFF	ON	OFF
721 =	OFF	ON	ON	ON	OFF	ON	OFF	OFF	ON	OFF

Table 18, Ametek Speedometer Calibration Codes, 685 to 721

Ametek Speedometer Calibration Codes, 722 to 758										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
722 =	ON	OFF	ON	ON	OFF	ON	OFF	OFF	ON	OFF
723 =	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	ON	OFF
724 =	ON	ON	OFF	ON	OFF	ON	OFF	OFF	ON	OFF
725 =	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	ON	OFF
726 =	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	OFF
727 =	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	OFF
728 =	ON	ON	ON	OFF	OFF	ON	OFF	OFF	ON	OFF
729 =	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	ON	OFF
730 =	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	OFF
731 =	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	OFF
732 =	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF
733 =	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF
734 =	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF
735 =	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF
736 =	ON	ON	ON	ON	ON	OFF	OFF	OFF	ON	OFF
737 =	OFF	ON	ON	ON	ON	OFF	OFF	OFF	ON	OFF
738 =	ON	OFF	ON	ON	ON	OFF	OFF	OFF	ON	OFF
739 =	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	ON	OFF
740 =	ON	ON	OFF	ON	ON	OFF	OFF	OFF	ON	OFF
741 =	OFF	ON	OFF	ON	ON	OFF	OFF	OFF	ON	OFF
742 =	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	OFF

Specifications

Ametek Speedometer Calibration Codes, 722 to 758										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
743 =	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	OFF
744 =	ON	ON	ON	OFF	ON	OFF	OFF	OFF	ON	OFF
745 =	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	ON	OFF
746 =	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	OFF
747 =	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	OFF
748 =	ON	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF
749 =	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF
750 =	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF
751 =	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF
752 =	ON	ON	ON	ON	OFF	OFF	OFF	OFF	ON	OFF
753 =	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	ON	OFF
754 =	ON	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	OFF
755 =	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	OFF
756 =	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF
757 =	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF
758 =	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF

Table 19, Ametek Speedometer Calibration Codes, 722 to 758

Ametek Speedometer Calibration Codes, 759 to 795										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
759 =	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF
760 =	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF
761 =	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF
762 =	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF
763 =	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF
764 =	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF
765 =	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF
766 =	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF
767 =	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF
768 =	ON	ON	ON	ON	ON	ON	ON	ON	OFF	OFF
769 =	OFF	ON	ON	ON	ON	ON	ON	ON	OFF	OFF
770 =	ON	OFF	ON	ON	ON	ON	ON	ON	OFF	OFF
771 =	OFF	OFF	ON	ON	ON	ON	ON	ON	OFF	OFF
772 =	ON	ON	OFF	ON	ON	ON	ON	ON	OFF	OFF
773 =	OFF	ON	OFF	ON	ON	ON	ON	ON	OFF	OFF
774 =	ON	OFF	OFF	ON	ON	ON	ON	ON	OFF	OFF

Ametek Speedometer Calibration Codes, 759 to 795										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
775 =	OFF	OFF	OFF	ON	ON	ON	ON	ON	OFF	OFF
776 =	ON	ON	ON	OFF	ON	ON	ON	ON	OFF	OFF
777 =	OFF	ON	ON	OFF	ON	ON	ON	ON	OFF	OFF
778 =	ON	OFF	ON	OFF	ON	ON	ON	ON	OFF	OFF
779 =	OFF	OFF	ON	OFF	ON	ON	ON	ON	OFF	OFF
780 =	ON	ON	OFF	OFF	ON	ON	ON	ON	OFF	OFF
781 =	OFF	ON	OFF	OFF	ON	ON	ON	ON	OFF	OFF
782 =	ON	OFF	OFF	OFF	ON	ON	ON	ON	OFF	OFF
783 =	OFF	OFF	OFF	OFF	ON	ON	ON	ON	OFF	OFF
784 =	ON	ON	ON	ON	OFF	ON	ON	ON	OFF	OFF
785 =	OFF	ON	ON	ON	OFF	ON	ON	ON	OFF	OFF
786 =	ON	OFF	ON	ON	OFF	ON	ON	ON	OFF	OFF
787 =	OFF	OFF	ON	ON	OFF	ON	ON	ON	OFF	OFF
788 =	ON	ON	OFF	ON	OFF	ON	ON	ON	OFF	OFF
789 =	OFF	ON	OFF	ON	OFF	ON	ON	ON	OFF	OFF
790 =	ON	OFF	OFF	ON	OFF	ON	ON	ON	OFF	OFF
791 =	OFF	OFF	OFF	ON	OFF	ON	ON	ON	OFF	OFF
792 =	ON	ON	ON	OFF	OFF	ON	ON	ON	OFF	OFF
793 =	OFF	ON	ON	OFF	OFF	ON	ON	ON	OFF	OFF
794 =	ON	OFF	ON	OFF	OFF	ON	ON	ON	OFF	OFF
795 =	OFF	OFF	ON	OFF	OFF	ON	ON	ON	OFF	OFF

Table 20, Ametek Speedometer Calibration Codes, 759 to 795

Ametek Speedometer Calibration Codes, 796 to 832										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
796 =	ON	ON	OFF	OFF	OFF	ON	ON	ON	OFF	OFF
797 =	OFF	ON	OFF	OFF	OFF	ON	ON	ON	OFF	OFF
798 =	ON	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	OFF
799 =	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	OFF
800 =	ON	ON	ON	ON	ON	OFF	ON	ON	OFF	OFF
801 =	OFF	ON	ON	ON	ON	OFF	ON	ON	OFF	OFF
802 =	ON	OFF	ON	ON	ON	OFF	ON	ON	OFF	OFF
803 =	OFF	OFF	ON	ON	ON	OFF	ON	ON	OFF	OFF
804 =	ON	ON	OFF	ON	ON	OFF	ON	ON	OFF	OFF
805 =	OFF	ON	OFF	ON	ON	OFF	ON	ON	OFF	OFF
806 =	ON	OFF	OFF	ON	ON	OFF	ON	ON	OFF	OFF

Specifications

Ametek Speedometer Calibration Codes, 796 to 832										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
807 =	OFF	OFF	OFF	ON	ON	OFF	ON	ON	OFF	OFF
808 =	ON	ON	ON	OFF	ON	OFF	ON	ON	OFF	OFF
809 =	OFF	ON	ON	OFF	ON	OFF	ON	ON	OFF	OFF
810 =	ON	OFF	ON	OFF	ON	OFF	ON	ON	OFF	OFF
811 =	OFF	OFF	ON	OFF	ON	OFF	ON	ON	OFF	OFF
812 =	ON	ON	OFF	OFF	ON	OFF	ON	ON	OFF	OFF
813 =	OFF	ON	OFF	OFF	ON	OFF	ON	ON	OFF	OFF
814 =	ON	OFF	OFF	OFF	ON	OFF	ON	ON	OFF	OFF
815 =	OFF	OFF	OFF	OFF	ON	OFF	ON	ON	OFF	OFF
816 =	ON	ON	ON	ON	OFF	OFF	ON	ON	OFF	OFF
817 =	OFF	ON	ON	ON	OFF	OFF	ON	ON	OFF	OFF
818 =	ON	OFF	ON	ON	OFF	OFF	ON	ON	OFF	OFF
819 =	OFF	OFF	ON	ON	OFF	OFF	ON	ON	OFF	OFF
820 =	ON	ON	OFF	ON	OFF	OFF	ON	ON	OFF	OFF
821 =	OFF	ON	OFF	ON	OFF	OFF	ON	ON	OFF	OFF
822 =	ON	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	OFF
823 =	OFF	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	OFF
824 =	ON	ON	ON	OFF	OFF	OFF	ON	ON	OFF	OFF
825 =	OFF	ON	ON	OFF	OFF	OFF	ON	ON	OFF	OFF
826 =	ON	OFF	ON	OFF	OFF	OFF	ON	ON	OFF	OFF
827 =	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	OFF	OFF
828 =	ON	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF
829 =	OFF	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF
830 =	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF
831 =	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF
832 =	ON	ON	ON	ON	ON	ON	OFF	ON	OFF	OFF

Table 21, Ametek Speedometer Calibration Codes, 796 to 832

Ametek Speedometer Calibration Codes, 833 to 869										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
833 =	OFF	ON	ON	ON	ON	ON	OFF	ON	OFF	OFF
834 =	ON	OFF	ON	ON	ON	ON	OFF	ON	OFF	OFF
835 =	OFF	OFF	ON	ON	ON	ON	OFF	ON	OFF	OFF
836 =	ON	ON	OFF	ON	ON	ON	OFF	ON	OFF	OFF
837 =	OFF	ON	OFF	ON	ON	ON	OFF	ON	OFF	OFF
838 =	ON	OFF	OFF	ON	ON	ON	OFF	ON	OFF	OFF

Ametek Speedometer Calibration Codes, 833 to 869										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
839 =	OFF	OFF	OFF	ON	ON	ON	OFF	ON	OFF	OFF
840 =	ON	ON	ON	OFF	ON	ON	OFF	ON	OFF	OFF
841 =	OFF	ON	ON	OFF	ON	ON	OFF	ON	OFF	OFF
842 =	ON	OFF	ON	OFF	ON	ON	OFF	ON	OFF	OFF
843 =	OFF	OFF	ON	OFF	ON	ON	OFF	ON	OFF	OFF
844 =	ON	ON	OFF	OFF	ON	ON	OFF	ON	OFF	OFF
845 =	OFF	ON	OFF	OFF	ON	ON	OFF	ON	OFF	OFF
846 =	ON	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	OFF
847 =	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	OFF
848 =	ON	ON	ON	ON	OFF	ON	OFF	ON	OFF	OFF
849 =	OFF	ON	ON	ON	OFF	ON	OFF	ON	OFF	OFF
850 =	ON	OFF	ON	ON	OFF	ON	OFF	ON	OFF	OFF
851 =	OFF	OFF	ON	ON	OFF	ON	OFF	ON	OFF	OFF
852 =	ON	ON	OFF	ON	OFF	ON	OFF	ON	OFF	OFF
853 =	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	OFF
854 =	ON	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	OFF
855 =	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	OFF
856 =	ON	ON	ON	OFF	OFF	ON	OFF	ON	OFF	OFF
857 =	OFF	ON	ON	OFF	OFF	ON	OFF	ON	OFF	OFF
858 =	ON	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	OFF
859 =	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	OFF
860 =	ON	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF
861 =	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF
862 =	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF
863 =	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF
864 =	ON	ON	ON	ON	ON	OFF	OFF	ON	OFF	OFF
865 =	OFF	ON	ON	ON	ON	OFF	OFF	ON	OFF	OFF
866 =	ON	OFF	ON	ON	ON	OFF	OFF	ON	OFF	OFF
867 =	OFF	OFF	ON	ON	ON	OFF	OFF	ON	OFF	OFF
868 =	ON	ON	OFF	ON	ON	OFF	OFF	ON	OFF	OFF
869 =	OFF	ON	OFF	ON	ON	OFF	OFF	ON	OFF	OFF

Table 22, Ametek Speedometer Calibration Codes, 833 to 869

Ametek Speedometer Calibration Codes, 870 to 906										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
870 =	ON	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	OFF

Specifications

Ametek Speedometer Calibration Codes, 870 to 906										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
871 =	OFF	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	OFF
872 =	ON	ON	ON	OFF	ON	OFF	OFF	ON	OFF	OFF
873 =	OFF	ON	ON	OFF	ON	OFF	OFF	ON	OFF	OFF
874 =	ON	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	OFF
875 =	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	OFF
876 =	ON	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF
877 =	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF
878 =	ON	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF
879 =	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF
880 =	ON	ON	ON	ON	OFF	OFF	OFF	ON	OFF	OFF
881 =	OFF	ON	ON	ON	OFF	OFF	OFF	ON	OFF	OFF
882 =	ON	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	OFF
883 =	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	OFF
884 =	ON	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF
885 =	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF
886 =	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF
887 =	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF
888 =	ON	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF
889 =	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF
890 =	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF
891 =	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF
892 =	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF
893 =	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF
894 =	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF
895 =	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF
896 =	ON	ON	ON	ON	ON	ON	ON	OFF	OFF	OFF
897 =	OFF	ON	ON	ON	ON	ON	ON	OFF	OFF	OFF
898 =	ON	OFF	ON	ON	ON	ON	ON	OFF	OFF	OFF
899 =	OFF	OFF	ON	ON	ON	ON	ON	OFF	OFF	OFF
900 =	ON	ON	OFF	ON	ON	ON	ON	OFF	OFF	OFF
901 =	OFF	ON	OFF	ON	ON	ON	ON	OFF	OFF	OFF
902 =	ON	OFF	OFF	ON	ON	ON	ON	OFF	OFF	OFF
903 =	OFF	OFF	OFF	ON	ON	ON	ON	OFF	OFF	OFF
904 =	ON	ON	ON	OFF	ON	ON	ON	OFF	OFF	OFF
905 =	OFF	ON	ON	OFF	ON	ON	ON	OFF	OFF	OFF

Ametek Speedometer Calibration Codes, 870 to 906										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
906 =	ON	OFF	ON	OFF	ON	ON	ON	OFF	OFF	OFF

Table 23, Ametek Speedometer Calibration Codes, 870 to 906

Ametek Speedometer Calibration Codes, 907 to 943										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
907 =	OFF	OFF	ON	OFF	ON	ON	ON	OFF	OFF	OFF
908 =	ON	ON	OFF	OFF	ON	ON	ON	OFF	OFF	OFF
909 =	OFF	ON	OFF	OFF	ON	ON	ON	OFF	OFF	OFF
910 =	ON	OFF	OFF	OFF	ON	ON	ON	OFF	OFF	OFF
911 =	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	OFF	OFF
912 =	ON	ON	ON	ON	OFF	ON	ON	OFF	OFF	OFF
913 =	OFF	ON	ON	ON	OFF	ON	ON	OFF	OFF	OFF
914 =	ON	OFF	ON	ON	OFF	ON	ON	OFF	OFF	OFF
915 =	OFF	OFF	ON	ON	OFF	ON	ON	OFF	OFF	OFF
916 =	ON	ON	OFF	ON	OFF	ON	ON	OFF	OFF	OFF
917 =	OFF	ON	OFF	ON	OFF	ON	ON	OFF	OFF	OFF
918 =	ON	OFF	OFF	ON	OFF	ON	ON	OFF	OFF	OFF
919 =	OFF	OFF	OFF	ON	OFF	ON	ON	OFF	OFF	OFF
920 =	ON	ON	ON	OFF	OFF	ON	ON	OFF	OFF	OFF
921 =	OFF	ON	ON	OFF	OFF	ON	ON	OFF	OFF	OFF
922 =	ON	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	OFF
923 =	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	OFF
924 =	ON	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF
925 =	OFF	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF
926 =	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF
927 =	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF
928 =	ON	ON	ON	ON	ON	OFF	ON	OFF	OFF	OFF
929 =	OFF	ON	ON	ON	ON	OFF	ON	OFF	OFF	OFF
930 =	ON	OFF	ON	ON	ON	OFF	ON	OFF	OFF	OFF
931 =	OFF	OFF	ON	ON	ON	OFF	ON	OFF	OFF	OFF
932 =	ON	ON	OFF	ON	ON	OFF	ON	OFF	OFF	OFF
933 =	OFF	ON	OFF	ON	ON	OFF	ON	OFF	OFF	OFF
934 =	ON	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	OFF
935 =	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	OFF
936 =	ON	ON	ON	OFF	ON	OFF	ON	OFF	OFF	OFF
937 =	OFF	ON	ON	OFF	ON	OFF	ON	OFF	OFF	OFF

Specifications

Ametek Speedometer Calibration Codes, 907 to 943										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
938 =	ON	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	OFF
939 =	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	OFF
940 =	ON	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF
941 =	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF
942 =	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF
943 =	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF

Table 24, Ametek Speedometer Calibration Codes, 907 to 943

Ametek Speedometer Calibration Codes, 944 to 980										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
944 =	ON	ON	ON	ON	OFF	OFF	ON	OFF	OFF	OFF
945 =	OFF	ON	ON	ON	OFF	OFF	ON	OFF	OFF	OFF
946 =	ON	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	OFF
947 =	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	OFF
948 =	ON	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF
949 =	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF
950 =	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF
951 =	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF
952 =	ON	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF
953 =	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF
954 =	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF
955 =	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF
956 =	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF
957 =	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF
958 =	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF
959 =	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF
960 =	ON	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF
961 =	OFF	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF
962 =	ON	OFF	ON	ON	ON	ON	OFF	OFF	OFF	OFF
963 =	OFF	OFF	ON	ON	ON	ON	OFF	OFF	OFF	OFF
964 =	ON	ON	OFF	ON	ON	ON	OFF	OFF	OFF	OFF
965 =	OFF	ON	OFF	ON	ON	ON	OFF	OFF	OFF	OFF
966 =	ON	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	OFF
967 =	OFF	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	OFF
968 =	ON	ON	ON	OFF	ON	ON	OFF	OFF	OFF	OFF
969 =	OFF	ON	ON	OFF	ON	ON	OFF	OFF	OFF	OFF

Ametek Speedometer Calibration Codes, 944 to 980										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
970 =	ON	OFF	ON	OFF	ON	ON	OFF	OFF	OFF	OFF
971 =	OFF	OFF	ON	OFF	ON	ON	OFF	OFF	OFF	OFF
972 =	ON	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF
973 =	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF
974 =	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF
975 =	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF
976 =	ON	ON	ON	ON	OFF	ON	OFF	OFF	OFF	OFF
977 =	OFF	ON	ON	ON	OFF	ON	OFF	OFF	OFF	OFF
978 =	ON	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	OFF
979 =	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	OFF
980 =	ON	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF

Table 25, Ametek Speedometer Calibration Codes, 944 to 980

Ametek Speedometer Calibration Codes, 981 to 1023										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
981 =	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF
982 =	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF
983 =	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF
984 =	ON	ON	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF
985 =	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF
986 =	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF
987 =	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF
988 =	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF
989 =	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF
990 =	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF
991 =	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF
992 =	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF	OFF
993 =	OFF	ON	ON	ON	ON	OFF	OFF	OFF	OFF	OFF
994 =	ON	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	OFF
995 =	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	OFF
996 =	ON	ON	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF
997 =	OFF	ON	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF
998 =	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF
999 =	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF
1000 =	ON	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF
1001 =	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF

Specifications

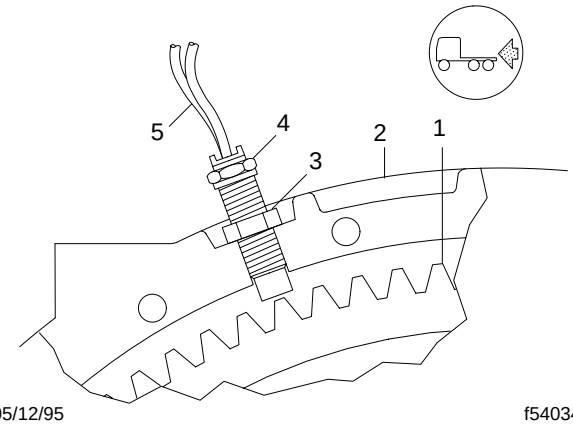
Ametek Speedometer Calibration Codes, 981 to 1023										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
1002 =	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF
1003 =	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF
1004 =	ON	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF
1005 =	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF
1006 =	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF
1007 =	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF
1008 =	ON	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF
1009 =	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF
1010 =	ON	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF
1011 =	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF
1012 =	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF
1013 =	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF
1014 =	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF
1015 =	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF
1016 =	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF
1017 =	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF
1018 =	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF
1019 =	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF
1020 =	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
1021 =	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
1022 =	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
1023 =	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF

Table 26, Ametek Speedometer Calibration Codes, 981 to 1023

General Information

The Ametek electronic tachometer consists of a dash-mounted gauge, a magnetic sensor mounted on the flywheel housing, and the necessary electrical wiring. An optional model is equipped with a 7-wheel hourmeter that records the total hours of engine operation.

The magnetic sensor is mounted through a threaded bore in the flywheel cover. The sensor, when installed and adjusted correctly, is 1/32 inch (1 mm) away from the teeth of the flywheel. See **Fig. 1**.



1. Flywheel Ring Gear
2. Flywheel Housing
3. Magnetic Sensor Jam Nut
4 Tachometer Magnetic Sensor
5 Magnetic Sensor Wiring

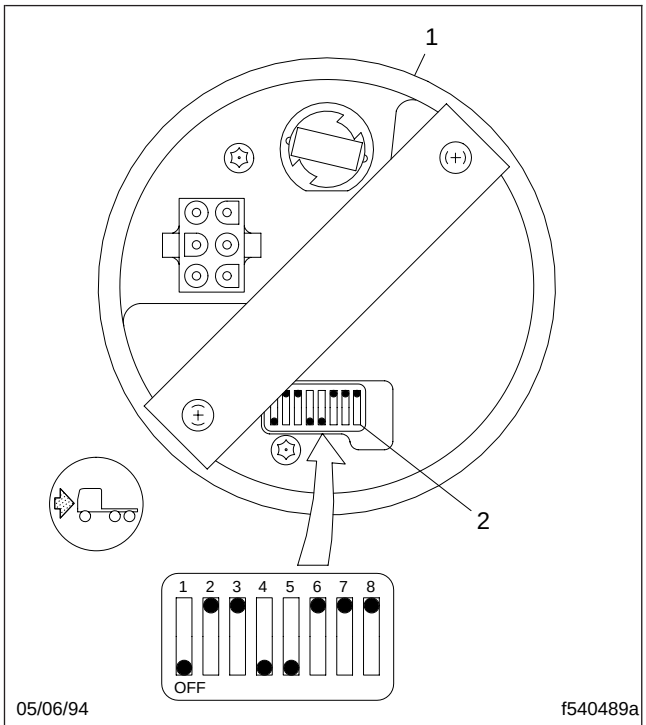
Fig. 1, Cutaway View of the Tachometer Magnetic Sensor

The magnetic sensor is an inductive sensor made with a magnet and a coil of wire. An inductive sensor generates an AC voltage whenever the sensor's magnetic field is moved. When the engine is running, the teeth of the turning flywheel attracts the sensor's magnetic field and the sensor generates a pulsing signal. The tachometer head counts the pulses generated by the magnetic sensor and calculates the engine speed (rpm).

For the tachometer to correctly interpret the signal generated by the sensor, the tachometer must be calibrated for the specific number of flywheel teeth on the vehicle. This applies to all flywheel-driven tachometers.

At the back of the tachometer are 8 DIP switches. See **Fig. 2**. The tachometer is calibrated by setting the DIP switches on or off to correspond to a specific calibration code. Generally, the number of teeth on the flywheel is used to determine the tachometer calibration code.

NOTE: Vehicles equipped with the VIGIL® III system and all Cummins and Caterpillar electronic engines do not have magnetic sensors on the flywheels. On these vehicles, the lightbar module or the engine control module provides the signal to the tachometer instead of the magnetic sensor.



NOTE: Example shows switches set for calibration code 01100111: S1=OFF, S2=ON, S3=ON, S4=OFF, S5=OFF, S6=ON, S7=ON, and S8=ON. The black dot shows which end to press in.

1. Tachometer Head
2. DIP Switches

Fig. 2, Rear View of the Tachometer

Tachometer Head Removal and Installation

Removal

1. Apply the parking brake, shut down the engine, and chock the tires.
2. Remove the screws that attach the tachometer/speedometer panel to the dash. Pull the panel out to gain access to the back of the tachometer head. See **Fig. 1**.

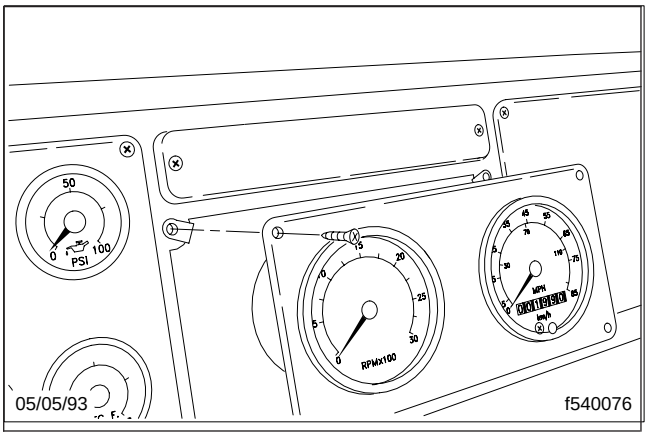


Fig. 1, Tachometer/Speedometer Panel Removal

3. Unplug the electrical wiring harness connectors from the back of the tachometer head.
4. Remove the Torx®-head screws that attach the mounting bracket to the tachometer head, and remove the bracket.
5. Carefully remove the spider from the back of the tachometer.
6. Remove the tachometer head from the speedometer/tachometer panel by pulling the tachometer head out from the front of the panel.

Installation

1. Place the tachometer head in the panel. Attach the mounting bracket to the tachometer head, then install and tighten the Torx-head screws.
2. Carefully reattach the spider to the back of the tachometer.
3. Connect the wiring harness connectors to the speedometer and tachometer heads.
4. Position the panel, then install and tighten the screws that attach the tachometer/speedometer panel to the dash.
5. Remove the chocks from the tires.

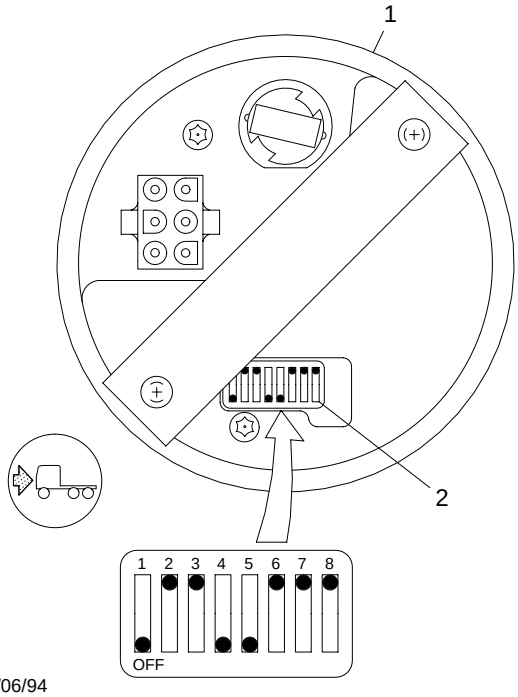
Calibration

Always calibrate a new tachometer head before installing it.

1. See **Table 1** to determine the tachometer calibration setting. If the engine application is not listed in the table, determine the number of teeth on the engine flywheel and then consult the tachometer calibration tables for the calibration code. See **Specifications, 400** for the tachometer calibration tables.
2. Set the positions of the eight DIP switches to ON or OFF as indicated by the calibration code. See **Fig. 1**.

   Using a scribe, an awl, or a straightened paper clip, depress the top of the rocker switch to set it to ON; depress the bottom to set it to OFF.

   For example, to match the calibration code for an engine with 103 teeth on the flywheel, the number 1 DIP switch is OFF (bottom is depressed), the number 2 switch is ON (top is depressed), number switch 3 is ON, switches 4 and 5 are OFF, switches 6, 7, and 8 are ON, as shown in **Fig. 1**.
3. Install the new calibrated tachometer; see **Subject 100**.



NOTE: Example shows switches set for calibration code: S1=OFF, S2=ON, S3=ON, S4=OFF, S5=OFF, S6=ON, S7=ON, and S8=ON. The black dot shows which end to press in.

1. Tachometer Head
2. DIP Switches

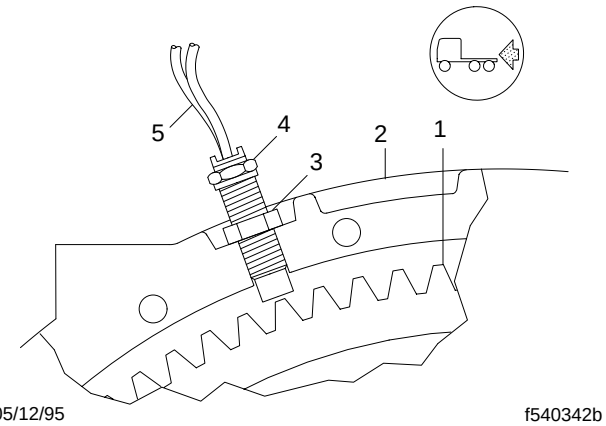
Fig. 1, Tachometer Head, Rear View

Common Tachometer Calibration Codes									
Engine	**Flywheel Teeth**	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**
All with VIGIL® III	N/A	Off	Off	Off	Off	On	On	Off	Off
Caterpillar 3176 and 3406	113	Off	On	On	On	Off	Off	Off	On
Caterpillar 3306	156	On	Off	Off	On	On	On	Off	Off
Cummins without Allison 700 transmission	103	Off	On	On	Off	Off	On	On	On
Cummins with Allison 700 transmission	118	Off	On	On	On	Off	On	On	Off
Cummins C Series	138	On	Off	Off	Off	On	Off	On	Off
Detroit Diesel Series 60 (except ECU driven)	118	Off	On	On	On	Off	On	On	Off
Detroit Diesel Series 50 or 60 (DDEC II or III; ECU driven)	118	Off	Off	Off	Off	On	On	Off	Off

Table 1, Common Tachometer Calibration Codes

Replacement and Adjustment

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the rear wheels.
2. Remove the magnetic sensor.
   - 2.1 Disconnect the harness connector from the magnetic sensor.
   - 2.2 Loosen the magnetic sensor jam nut. Turn the magnetic sensor out of the flywheel housing. See **Fig. 1**.
3. Install the new sensor. See **Fig. 1** .
   - 3.1 With the jam nut backed off to the outboard end of the new magnetic sensor, turn the sensor by hand into the flywheel housing until it bottoms out on the teeth of the flywheel ring gear.



1. Flywheel Ring Gear
2. Flywheel Housing
3. Magnetic Sensor Jam Nut
4. Tachometer Magnetic Sensor
5. Magnetic Sensor Wiring

Fig. 1, Cutaway View of Magnetic Sensor Installation (rear view)

- 3.2 Back out the sensor one-half of a turn. See **Fig. 1**.
- 3.3 Holding the sensor in place to keep it from turning, tighten the jam nut 18 lbf·ft (25 N·m).
- 3.4 Connect the wiring to the sensor and be sure it is locked in place.

4. Adjust the new sensor. First, start the engine and allow it to idle. Check that the tachometer is operating at idle; increase engine speed and check that the tachometer increases with throttle activation. If there is no tachometer reading, proceed to troubleshooting section for diagnosis and repair.

IMPORTANT: Maintain the correct sensor adjustment, or the tachometer reading will not be correct.

Troubleshooting Procedures

NOTE: Do not use the following troubleshooting procedures if the vehicle is equipped with VIGIL® III, DDEC II, or DDEC III.

Tachometer malfunctions are usually one of two types: the tachometer does not operate at all, or the tachometer readings are inaccurate.

Inaccurate Tachometer

Incorrect tachometer readings may occur whenever a new tachometer head is installed. Calibrate the tachometer head using the procedure in **Subject 110**.

Inaccurate readings may also occur if the magnetic sensor is not adjusted correctly. Before troubleshooting the system, make sure the magnetic sensor is correctly adjusted. For instructions, see **Subject 120**.

Tachometer Does Not Operate

1. Test the magnetic sensor's output voltage.

   NOTE: To receive an accurate tachometer reading, a minimum of one volt AC output is needed from the magnetic sensor.

   1.1 Disconnect the connector from the magnetic sensor. Inspect both halves of the connector for evidence of corrosion or moisture. Clean and repair the connector if necessary.

   1.2 Connect the leads of an AC voltmeter to the pins of the magnetic sensor.

   1.3 Run the engine at idle speed, and check the voltage output from the sensor. Then shut down the engine.

   1.4 If the voltage is less than one volt, and the sensor was correctly adjusted before troubleshooting the system, the magnetic sensor is damaged; replace it.

   If the voltage is at least one volt, go to the next step.

2. Check for an open or shorted magnetic sensor by measuring the resistance of the sensor.

   2.1 Connect the leads of an ohmmeter to the pins of the magnetic sensor. The resistance should measure 876 ± 88 ohms.

   2.2 If the resistance is outside the acceptable range, replace the sensor; see **Subject 120**.

   If the resistance is in the acceptable range, go to the next step.

3. Check that the magnetic sensor is not shorted to ground, by measuring the sensor's continuity to ground.

   3.1 Connect the positive ohmmeter lead to a pin on the magnetic sensor. Touch the negative ohmmeter lead to a good ground source. The ohmmeter should read infinite ohms.

   3.2 If the resistance measured is less than infinite, the magnetic sensor is grounded and must be replaced.

   If the resistance reading was acceptable, reconnect the magnetic sensor connector and go to the next step.

4. Check the wiring between the magnetic sensor and the tachometer for an open circuit.

   4.1 Remove the tachometer/speedometer panel from the dash and disconnect the harness connector from the tachometer; see **Subject 100**.

   4.2 Check for an open circuit by connecting the ohmmeter leads to the tachometer harness connector terminals 5 and 1 (wiring circuit numbers 162 and 163, respectively). See **Fig. 1**. The resistance should measure 876 ± 88 ohms.

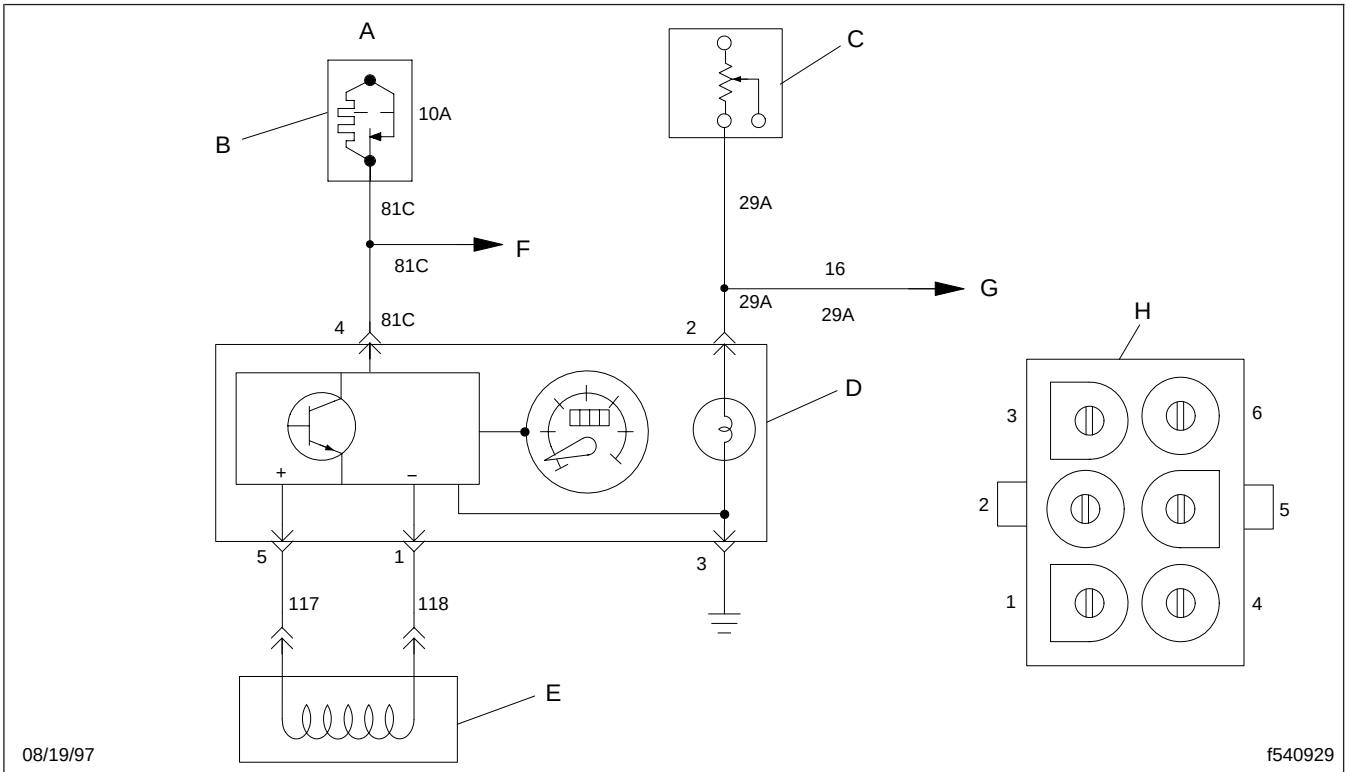
   4.3 If the resistance is above the acceptable range, there is resistance in the wiring between the tachometer and the magnetic sensor. If the resistance is below the acceptable range, there is a short between wire 162 and wire 163. Repair or replace the damaged wiring. Then install the tachometer; see **Subject 100**.

   If the measured resistance is in the acceptable range, go to the next step.

5. Check the wiring between the magnetic sensor and the tachometer for a short circuit to ground.

   5.1 Disconnect the harness connector from the tachometer head. Connect the positive lead from an ohmmeter to terminal five

Troubleshooting



A. Ignition Fed Circuit Breaker
B. Ignition Circuit Breaker Panel
C. Relay
D. Panel Lamp Rheostat (solid state)
E. Tachometer Head
F. Magnetic Sensor
G. To Fuel Gauge
H. To Instrument Panel Lamps

Fig. 1, Tachometer Wiring Schematic

(circuit 162), and the negative lead to a good ground source. If the circuit is shorted to ground, a reading of low ohms will be present.

If there is no short to ground, the circuit will read infinite ohms. See **Fig. 1**.

5.2 Connect the positive lead from an ohmmeter to terminal one (circuit 163) at the same connector, and the negative lead to a good ground source. If the circuit is shorted to ground, a reading of low ohms will be present.

If there is no short to ground, the circuit will read infinite ohms.

5.3 If the resistance measured was less than infinite ohms in either of the measurements, repair the short to ground in the respective circuit wiring.

If the measurement was acceptable go to the next step.

6. Check the ground circuit wiring between the tachometer and ground for an open circuit.

6.1 Connect the positive lead from an ohmmeter to the tachometer harness connector (terminal 3). Connect the negative lead to a good ground source. See **Fig. 1**. A measurement of 3 ohms or less is acceptable.

6.2 If the resistance measured is more than 3 ohms, repair the wire.

If the resistance reading was acceptable, go to the next step.

7. Check for battery voltage at the tachometer connector.

7.1 Connect the positive lead from a voltmeter to terminal four at the tachometer head

connector. Connect the negative lead to terminal three. Check that the voltmeter is set to DC volts. See **Fig. 1**.

7.2 Turn the ignition switch on. The voltmeter should read 11 to 13 volts.

7.3 If the voltage is not between 11 and 13 volts, check the voltage at the circuit breaker. Voltage at the circuit breaker should be approximately 11 to 13 volts ± 1 volt. Then check the wiring between the circuit breaker and the tachometer. Repair the damaged wiring and then install the tachometer; see **Subject 100**.

If the voltage is between 11 and 13 volts, the tachometer is malfunctioning and must be replaced.

Troubleshooting Tables

Problem—Less Than One Volt Reading from Magnetic Sensor

Problem—Less Than One Volt Reading from Magnetic Sensor	
Possible Cause	**Remedy**
The magnetic sensor gap is incorrectly adjusted.	Adjust the magnetic sensor.
The magnetic sensor is damaged.	Replace the magnetic sensor.

Problem—Tachometer Head Will Not Register

Problem—Tachometer Head Will Not Register	
Possible Cause	**Remedy**
The magnetic sensor gap is incorrectly adjusted.	Adjust the magnetic sensor.
The magnetic sensor is damaged.	Replace the magnetic sensor.
Loose or corroded terminals, broken terminal connections, broken wires, shorting, grounded, or frayed wires are causing an incomplete circuit.	Replace the damaged wiring component(s) as necessary.
The tachometer head is damaged internally.	Replace the tachometer head only after checking all other possible causes.

Problem—Inaccurate Tachometer Readings

Problem—Inaccurate Tachometer Readings	
Possible Cause	**Remedy**
The magnetic sensor gap is incorrectly adjusted.	Adjust the magnetic sensor.
Shorts, or opens are occurring in the magnetic sensor.	Check the resistance of the magnetic sensor. Replace the sensor if necessary.
The tachometer head is incorrectly calibrated.	Calibrate the tachometer head.
Erratic readings are resulting from loose electrical connections, or intermittent short/open in wiring.	Check all the wiring in the tachometer system. Tighten all loose connections.

Ametek Tachometer Calibration Codes

FLYWHEEL TEETH	S1	S2	S3	S4	S5	S6	S7	S8
85	OFF	ON	OFF	ON	OFF	ON	OFF	ON
86	OFF	ON	OFF	ON	OFF	ON	ON	OFF
87	OFF	ON	OFF	ON	OFF	ON	ON	ON
88	OFF	ON	OFF	ON	ON	OFF	OFF	OFF
89	OFF	ON	OFF	ON	ON	OFF	OFF	ON
90	OFF	ON	OFF	ON	ON	OFF	ON	OFF
91	OFF	ON	OFF	ON	ON	OFF	ON	ON
92	OFF	ON	OFF	ON	ON	ON	OFF	OFF
93	OFF	ON	OFF	ON	ON	ON	OFF	ON
94	OFF	ON	OFF	ON	ON	ON	ON	OFF
95	OFF	ON	OFF	ON	ON	ON	ON	ON
96	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF
97	OFF	ON	ON	OFF	OFF	OFF	OFF	ON
98	OFF	ON	ON	OFF	OFF	OFF	ON	OFF
99	OFF	ON	ON	OFF	OFF	OFF	ON	ON
100	OFF	ON	ON	OFF	OFF	ON	OFF	OFF
101	OFF	ON	ON	OFF	OFF	ON	OFF	ON
102	OFF	ON	ON	OFF	OFF	ON	ON	OFF
103	OFF	ON	ON	OFF	OFF	ON	ON	ON
104	OFF	ON	ON	OFF	ON	OFF	OFF	OFF
105	OFF	ON	ON	OFF	ON	OFF	OFF	ON
106	OFF	ON	ON	OFF	ON	OFF	ON	OFF
107	OFF	ON	ON	OFF	ON	OFF	ON	ON
108	OFF	ON	ON	OFF	ON	ON	OFF	OFF
109	OFF	ON	ON	OFF	ON	ON	OFF	ON
110	OFF	ON	ON	OFF	ON	ON	ON	OFF
111	OFF	ON	ON	OFF	ON	ON	ON	ON
112	OFF	ON	ON	ON	OFF	OFF	OFF	OFF
113	OFF	ON	ON	ON	OFF	OFF	OFF	ON
114	OFF	ON	ON	ON	OFF	OFF	ON	OFF
115	OFF	ON	ON	ON	OFF	OFF	ON	ON
116	OFF	ON	ON	ON	OFF	ON	OFF	OFF
117	OFF	ON	ON	ON	OFF	ON	OFF	ON
118	OFF	ON	ON	ON	OFF	ON	ON	OFF
119	OFF	ON	ON	ON	OFF	ON	ON	ON
120	OFF	ON	ON	ON	ON	OFF	OFF	OFF

Specifications

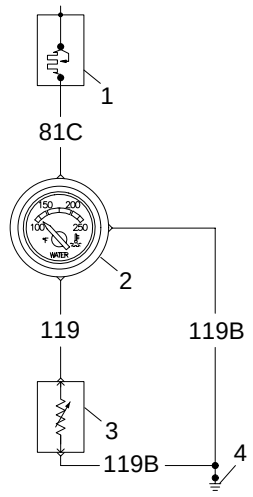
FLYWHEEL TEETH	S1	S2	S3	S4	S5	S6	S7	S8
121	OFF	ON	ON	ON	ON	OFF	OFF	ON
122	OFF	ON	ON	ON	ON	OFF	ON	OFF
123	OFF	ON	ON	ON	ON	OFF	ON	ON
124	OFF	ON	ON	ON	ON	ON	OFF	OFF
125	OFF	ON	ON	ON	ON	ON	OFF	ON
126	OFF	ON	ON	ON	ON	ON	ON	OFF
127	OFF	ON	ON	ON	ON	ON	ON	ON
128	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF
129	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON
130	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF
131	ON	OFF	OFF	OFF	OFF	OFF	ON	ON
132	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF
133	ON	OFF	OFF	OFF	OFF	ON	OFF	ON
134	ON	OFF	OFF	OFF	OFF	ON	ON	OFF
135	ON	OFF	OFF	OFF	OFF	ON	ON	ON
136	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF
137	ON	OFF	OFF	OFF	ON	OFF	OFF	ON
138	ON	OFF	OFF	OFF	ON	OFF	ON	OFF
139	ON	OFF	OFF	OFF	ON	OFF	ON	ON
140	ON	OFF	OFF	OFF	ON	ON	OFF	OFF
141	ON	OFF	OFF	OFF	ON	ON	OFF	ON
142	ON	OFF	OFF	OFF	ON	ON	ON	OFF
143	ON	OFF	OFF	OFF	ON	ON	ON	ON
144	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF
145	ON	OFF	OFF	ON	OFF	OFF	OFF	ON
146	ON	OFF	OFF	ON	OFF	OFF	ON	OFF
147	ON	OFF	OFF	ON	OFF	OFF	ON	ON
148	ON	OFF	OFF	ON	OFF	ON	OFF	OFF
149	ON	OFF	OFF	ON	OFF	ON	OFF	ON
150	ON	OFF	OFF	ON	OFF	ON	ON	OFF
151	ON	OFF	OFF	ON	OFF	ON	ON	ON
152	ON	OFF	OFF	ON	ON	OFF	OFF	OFF
153	ON	OFF	OFF	ON	ON	OFF	OFF	ON
154	ON	OFF	OFF	ON	ON	OFF	ON	OFF
155	ON	OFF	OFF	ON	ON	OFF	ON	ON
156	ON	OFF	OFF	ON	ON	ON	OFF	OFF

FLYWHEEL TEETH	S1	S2	S3	S4	S5	S6	S7	S8
157	ON	OFF	OFF	ON	ON	ON	OFF	ON
158	ON	OFF	OFF	ON	ON	ON	ON	OFF
159	ON	OFF	OFF	ON	ON	ON	ON	ON
160	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF
161	ON	OFF	ON	OFF	OFF	OFF	OFF	ON
162	ON	OFF	ON	OFF	OFF	OFF	ON	OFF
163	ON	OFF	ON	OFF	OFF	OFF	ON	ON
164	ON	OFF	ON	OFF	OFF	ON	OFF	OFF
165	ON	OFF	ON	OFF	OFF	ON	OFF	ON
166	ON	OFF	ON	OFF	OFF	ON	ON	OFF
167	ON	OFF	ON	OFF	OFF	ON	ON	ON
168	ON	OFF	ON	OFF	ON	OFF	OFF	OFF
169	ON	OFF	ON	OFF	ON	OFF	OFF	ON
170	ON	OFF	ON	OFF	ON	OFF	ON	OFF

Table 1, Ametek Tachometer Calibration Codes

General Information

The Ametek coolant temperature gauge system is standard equipment on vehicles equipped with non-electronic engines. The system consists of a dash-mounted gauge (electrical type), an engine-mounted temperature sender, and the electrical wires that connect these components. See **Fig. 1**.



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1. Power Supply Circuit Breaker
2. Coolant Temperature Gauge
3. Coolant Temperature Sender
4. Ground Point

Fig. 1, Engine Coolant Temperature Gauge System, Non-Electronic Engine, Without VIGIL III or KYSOR VIP System

On vehicles equipped with the optional VIGIL III® or KYSOR VIP® engine monitoring systems, the lightbar or VIP module is also part of the coolant temperature gauge system. See the applicable section in this group for information about these systems.

The coolant temperature gauge is a cross-coil electric gauge with a 90-degree sweep and has a light bulb for illumination.

Vehicles built for use in North America have a gauge that registers coolant temperature in degrees Fahrenheit (°F). Vehicles built for export out of North America have a gauge that registers coolant temperature in degrees Celsius (°C).

The coolant temperature sender (see **Fig. 2**) is threaded into a fitting on the engine, where its tip comes in direct contact with engine coolant. The specific location varies according to engine manufacturer and model, but is usually near the thermostat.

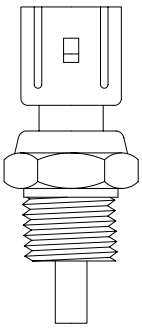

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Fig. 2, Coolant Temperature Sender, Two-Terminal Type

The coolant temperature sender is a temperature sensitive resistor (thermistor) whose electrical resistance decreases as coolant temperature increases. In other words, the resistance across the sensor terminals is high when the engine is cold (about 400 ohms) and drops as the engine warms up (resistance is about 50 ohms when the engine is hot).

Coolant Temperature Gauge Removal and Installation

Removal

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the batteries.
3. Remove the screws that attach the dash panel containing the coolant temperature gauge. **See Fig. 1.** Pull the panel out to gain access to the back of the coolant temperature gauge.

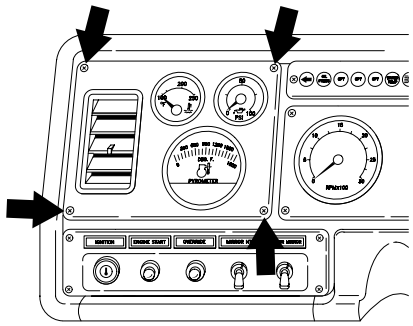
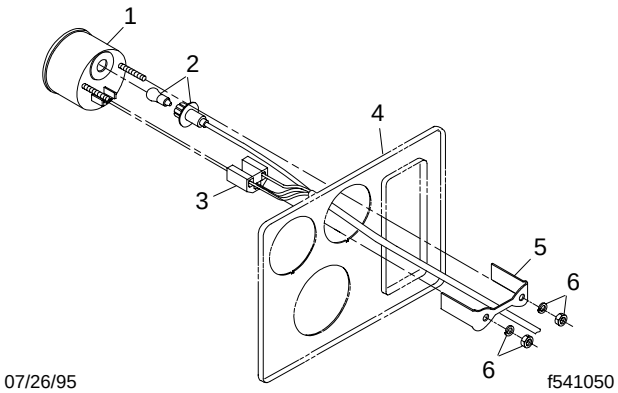


Fig. 1, Dash Panel With Coolant Temperature Gauge

4. Pull the gauge illumination bulb socket from the back of the temperature gauge. **See Fig. 2.**



1. Coolant Temperature Gauge
2. Illumination Bulb and Socket
3. Electrical Connector
4. Gauge Panel
5. Mounting Bracket
6. Mounting Nuts and Lockwashers

Fig. 2, Coolant Temperature Gauge Installation View

5. Disconnect the electrical wiring connector from the back of the coolant temperature gauge.
6. Remove the nuts that attach the mounting bracket to the gauge, and remove the bracket.
7. Remove the gauge from the panel by pulling the gauge out from the front of the panel.

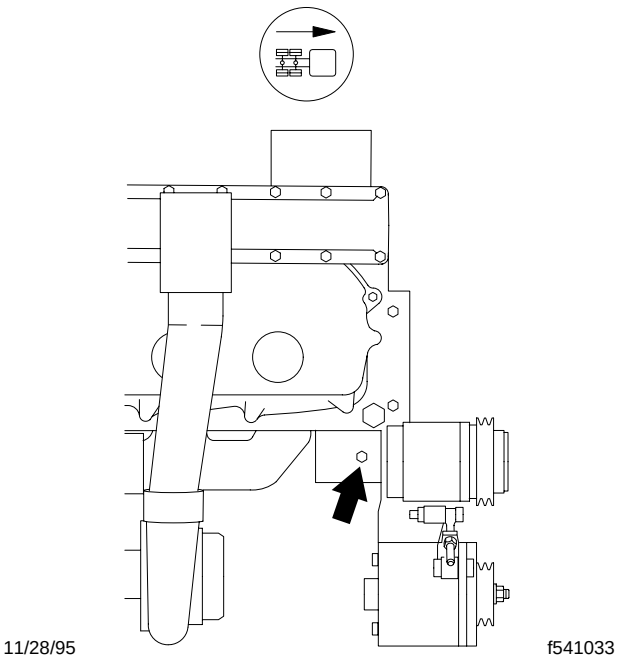
Installation

1. Place the coolant temperature gauge in the panel and attach the mounting bracket to the gauge.
2. Install the mounting bracket lock washers and retaining nuts. Tighten the nuts 10 lbf·in (110 N·cm).
3. Connect the electrical wiring connector to the coolant temperature gauge.
4. Insert the gauge illumination bulb and socket into the hole in the back of the gauge.
5. Position the panel over the dash opening and lower it into place, making sure that no gauge wires are trapped between the panel and the dash. Then, install and tighten the screws that attach the panel to the dash.
6. Connect the batteries.
7. Start the engine and verify that the coolant temperature gauge is operating properly.
8. Remove the chocks from the tires.

Coolant Temperature Sender Removal and Installation

Removal

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Open the hood and locate the coolant temperature sender. Sender location varies according to engine manufacturer and model, but the gauge sender circuits are always marked "119" and "119B" directly on the wires. **See Fig. 1**, **Fig. 2**, **Fig. 3**, **Fig. 4**, **Fig. 5**, **Fig. 6**, **and Fig. 7.**



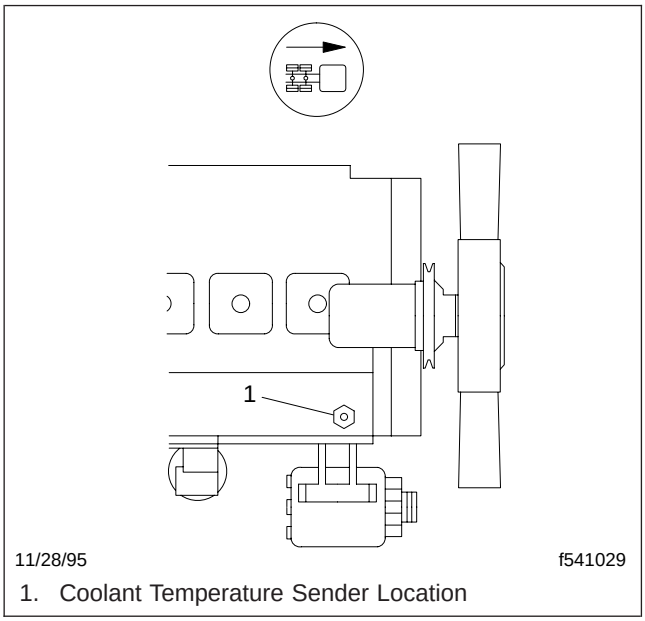
1. Coolant Temperature Sender Location

Fig. 1, Coolant Temperature Gauge Sender Location, Caterpillar 3406 Engine

WARNING

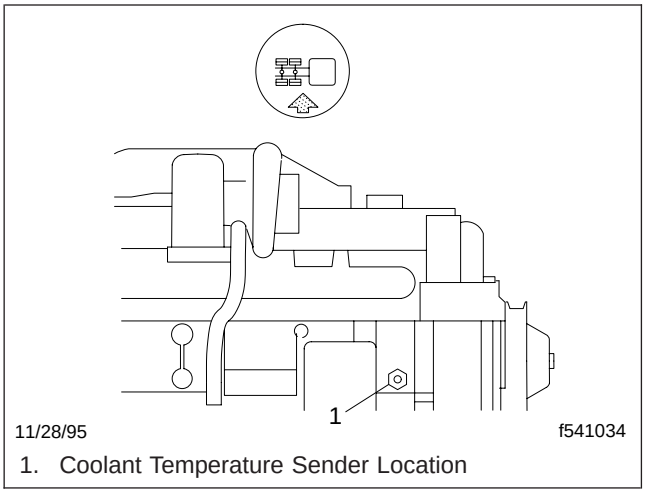
WARNING: Don't drain the cooling system while the engine is hot. To avoid personal injury from scalding coolant, wait until the engine has cooled down before draining the system.

3. Drain coolant from the system until the coolant level drops below the coolant temperature gauge sender location.



1. Coolant Temperature Sender Location

Fig. 2, Coolant Temperature Gauge Sender Location, Cummins B Series Engine



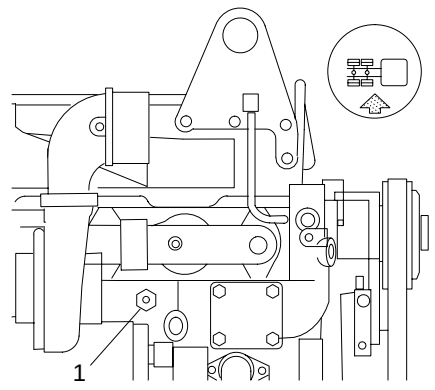
1. Coolant Temperature Sender Location

Fig. 3, Coolant Temperature Gauge Sender Location, Cummins C Series Engine

3.1 With the engine cool, loosen the radiator cap to release pressure from the radiator, then tighten the cap.

3.2 Place a clean drain pan under the drain plug or petcock located at the bottom of the radiator left end-tank. **See Fig. 8.** Remove the drain plug or open the petcock. If necessary, use a deflector to channel

Coolant Temperature Sender Removal and Installation



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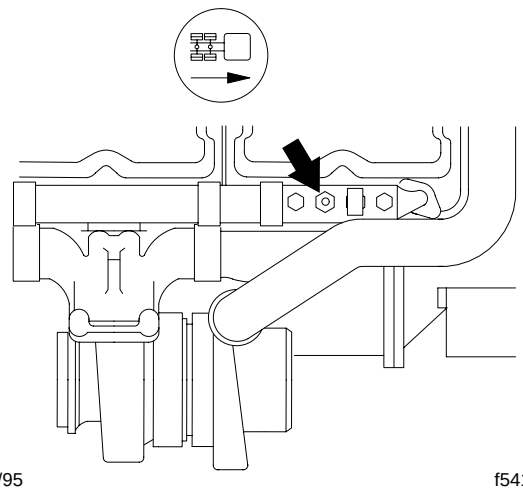
1. Coolant Temperature Sender Location

Fig. 4, Coolant Temperature Gauge Sender Location, Cummins M11 Engine



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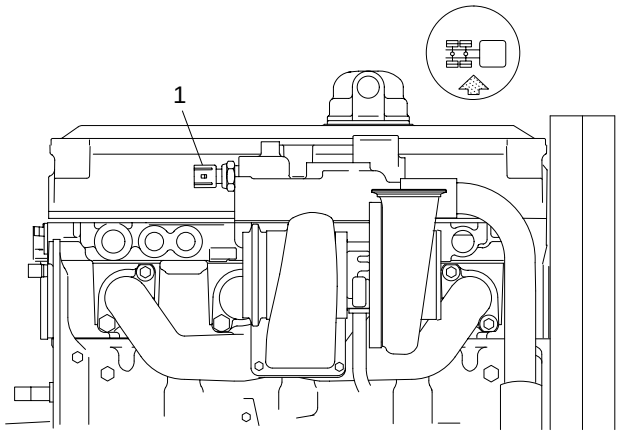
1. Coolant Temperature Sender Location

Fig. 5, Coolant Temperature Gauge Sender Location, Cummins NTC Engine

coolant away from the front springs and into the drain pan.

On some Caterpillar and Detroit Diesel Engines, the radiator drain plug is located on the forward end of the coolant outlet pipe. **See Fig. 9.** On these vehicles, remove the aerodynamic cover to access the drain plug.



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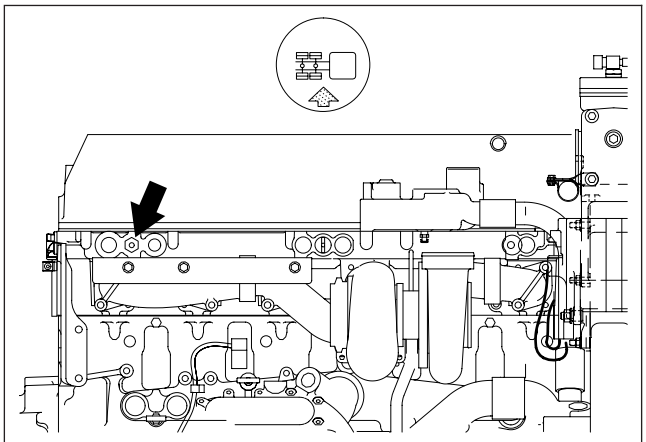
1. Coolant Temperature Sender Location

Fig. 6, Coolant Temperature Gauge Sender Location, Detroit Diesel 50 Series Engine



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1. Coolant Temperature Sender Location

Fig. 7, Coolant Temperature Gauge Sender Location, Detroit Diesel 60 Series Engine

3.3 Install the drain plug or tighten the petcock.

4. Unplug the wiring harness connector from the coolant temperature sender, and remove the sender from the engine.

Coolant Temperature Sender Removal and Installation

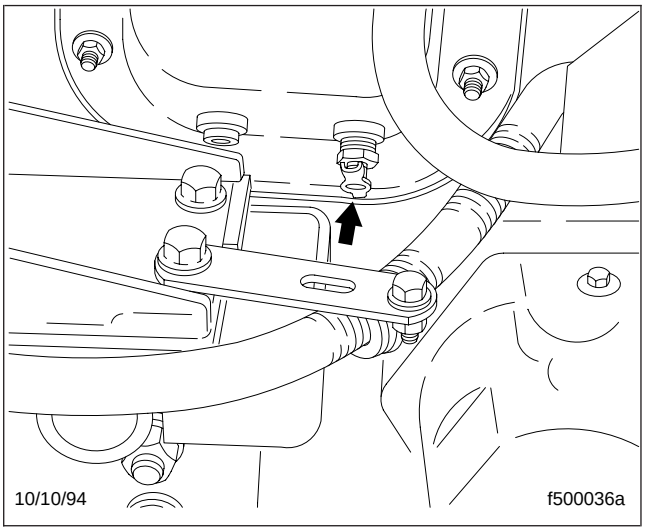


Fig. 8, Radiator Drain Location, Typical

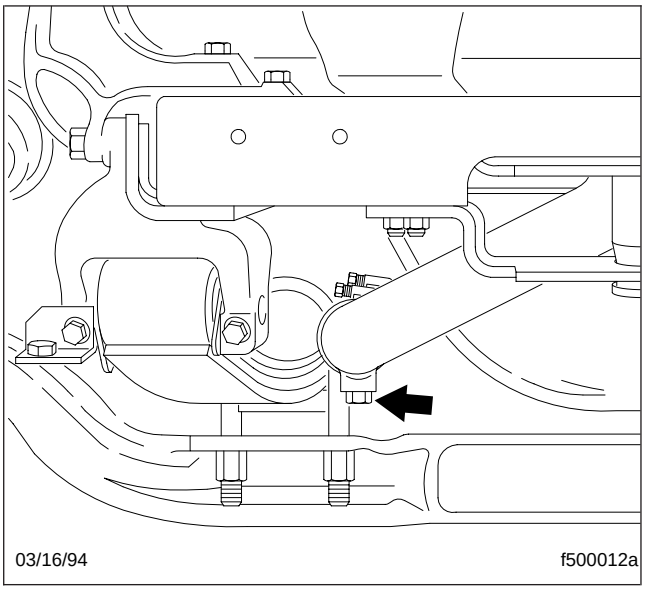


Fig. 9, Radiator Drain Location, Some Caterpillar and Detroit Diesel Engines

Installation

1. Clean old sealant residue from the threads of the coolant temperature sender opening.
2. Apply pipe thread sealant to the threads of the new coolant temperature sender, and install the sender in the engine opening. Tighten the sender until it is snug.
3. Connect the vehicle wiring harness to the sender.
4. Fill the cooling system.
5. Start the engine, check for leaks, and check that the coolant temperature gauge is operating properly.
6. Remove the chocks from the tires.

Troubleshooting Procedures

NOTE: If the vehicle is equipped with the VIGIL III® or KYSOR VIP® engine protection system, see the applicable section in this group for coolant temperature gauge troubleshooting information.

Coolant temperature gauge malfunctions are usually one of two types: the gauge does not operate at all (always shows that the engine is cold), or the coolant temperature indicated by the gauge is believed to be incorrect.

Before proceeding with any troubleshooting when an inaccurate gauge or sender is suspected, confirm that the coolant level is correct and the engine thermostat and fan clutch are operating properly. Simply removing the radiator cap and inserting a thermometer may reveal that the problem is not in the gauge system, but in the cooling system itself. For cooling system troubleshooting, see **Group 20**.

Malfunctions that would cause a totally inoperative coolant temperature gauge include open circuits in the gauge, sender, or wiring. To isolate the cause of an inoperative coolant temperature gauge, follow the troubleshooting procedures in the order given.

1. Switch off the ignition and unplug the wiring harness connector from the coolant temperature gauge sender.
2. Switch on the ignition and observe the gauge needle; it should remain at the left end of the scale (low temperature indicated).
3. Switch off the ignition and, using a jumper wire, connect the sender wiring harness terminal to ground (if a one-terminal sender is used) or short the sender wiring harness terminals together (if a two-terminal sender is used).
4. Switch on the ignition again and watch the gauge needle; it should move immediately to the extreme right or "hot" end of the scale.
5. If the gauge operates as described in the previous steps, it is functioning properly and the wiring to the gauge is okay. The problem is in the sender; replace it following the instructions in **Subject 110** and verify that the gauge operates properly.

   If the gauge does not function as described previously, continue troubleshooting with the following steps:
6. Switch off the ignition, unground (or remove the jumper wire from) the wiring harness connector and reconnect it to the coolant temperature gauge sender.
7. Remove the screws that attach the dash panel containing the coolant temperature gauge. Then, carefully pull the panel out to access the back of the gauge. If necessary, refer to **Subject 100**.
8. Unplug the wiring harness connector from the back of the coolant temperature gauge. See **Fig. 1**.
9. Check the coolant temperature gauge ground circuit wiring for an open circuit.

   9.1 With the ignition switch turned off, connect the leads of an ohmmeter between the cab metal (an unpainted bolt or screw attached directly to cab structure works well) and the ground circuit (wire marked "119B") in the wiring harness connector. See **Fig. 1**.

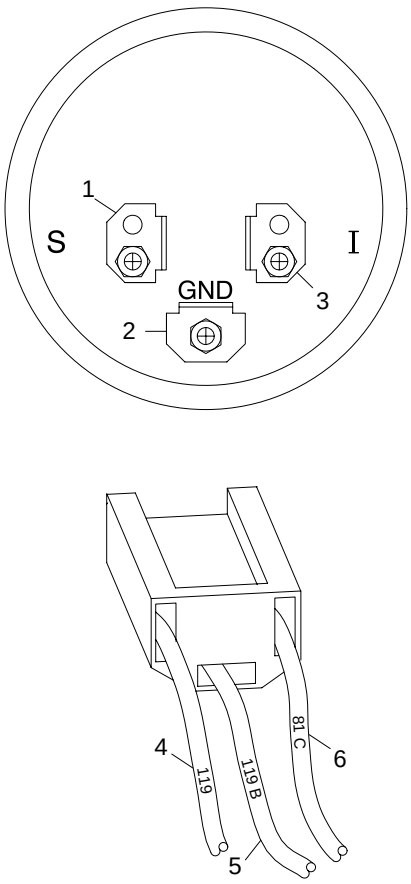
   9.2 Resistance should be less than one ohm. If it is, go to the next step. If resistance is higher than one ohm, verify that you have good connections at both the wiring harness connector and the cab metal.

   9.3 If the connections are good, but resistance is still greater than one ohm, locate the damaged section of wiring between the connector and ground. Repair the damage by splicing in a length of replacement wiring following the instructions in this group.
10. Check the signal and ground circuits between the coolant temperature gauge and sender.

    10.1 With the wiring harness connector unplugged from the gauge, connect one ohmmeter lead to the harness connector sender signal circuit (wire marked "119") and the other lead to the harness connector ground circuit (wire marked "119B"). See **Fig. 1**.

    10.2 If the harness and sender are good, resistance will depend upon engine temperature and should be, approximately,

Troubleshooting



1. Sender Signal Terminal
2. Ground Terminal
3. Ignition Power Terminal
4. Sender Signal Circuit
5. Ground Circuit
6. Ignition Power Circuit

Fig. 1, Coolant Temperature Gauge Connection

no more than 400 ohms for a cold engine and at least 50 ohms for a hot engine.

NOTE: The resistance values above are approximations only. Test the sensor in place, on the engine. For the purpose of the resistance test, a cold engine is one which has been sitting overnight, or for a minimum of two hours. A hot engine is one which has reached operating temperature, a minimum of 180°F (82°C).

10.3 If resistance is within specifications, go to the next step. If resistance is too low, temporarily unplug the sender and recheck resistance. If resistance is still too low, find and repair the short to ground in circuit 119. If resistance is too high, unplug the sender, connect a jumper wire across the harness connector terminals, and recheck resistance. If resistance is still too high, find and repair the poor connection or damaged wire in circuit 119 or 119B.

11. Check for battery voltage at the coolant temperature gauge wiring harness connector.

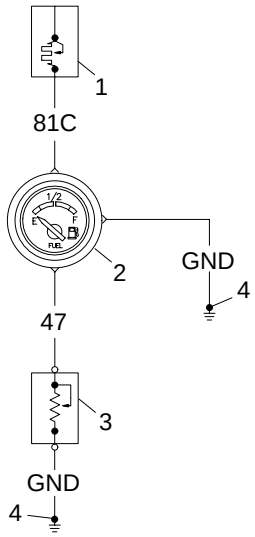
    11.1 Turn the ignition switch on.

    11.2 Connect a voltmeter (set on 20 volt scale, DC voltage for a 12 volt system or 50 volt scale, DC volts for a 24 volt system) to the gauge wiring harness connector as follows; positive (red) probe to the ignition power circuit (wire marked "81C") and the negative (black) probe to the ground circuit (wire marked "119B"). See **Fig. 1**. The voltmeter should read between 9 and 16 volts DC on a 12 volt system or between 21 and 27 volts DC on a 24 volt system.

    11.3 If voltage is between 9 and 16 volts DC in a 12 volt system or between 21 and 27 volts in a 24 volt system, the gauge itself is malfunctioning, and must be replaced. For instructions, refer to **Subject 100**. If the voltage reading is not within the limits mentioned above, check the circuit breaker that supplies power to the gauge. If the circuit breaker is okay, locate and repair the damage to the power circuit. General wire repair information can be found elsewhere in this group.

General Information

The Ametek fuel level gauge system consists of a dash-mounted gauge (electrical type), a fuel tank-mounted fuel level sender, and the electrical wires that connect these components. See **Fig. 1**.



1. Power Supply Circuit Breaker
2. Fuel Level Gauge
3. Fuel Level Sender
4. Ground Point

Fig. 1, Fuel Level Gauge System

The fuel level gauge is a cross-coil electric gauge with a 90 degree sweep and has a light bulb for illumination.

The fuel level sender (see **Fig. 2**) is mounted inside the left hand fuel tank and is serviced by removing a plate fitted to the top of the tank.

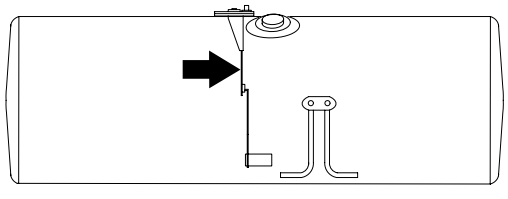


Fig. 2, Fuel Level Sender

The fuel level sender consists of a float and arm fitted to a variable resistor; the float rests on the fuel surface and, as the fuel level drops, the float drops with it. When the fuel tank is full, fuel level sender resistance is about 30 ohms. When the fuel tank is about half full, resistance is about 100 ohms. When the tank is empty, resistance is about 245 ohms.

Fuel Level Gauge Removal and Installation

Removal

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the batteries.
3. Remove the screws that attach the dash panel containing the fuel level gauge. See **Fig. 1**. Pull the panel out to gain access to the back of the fuel level gauge.

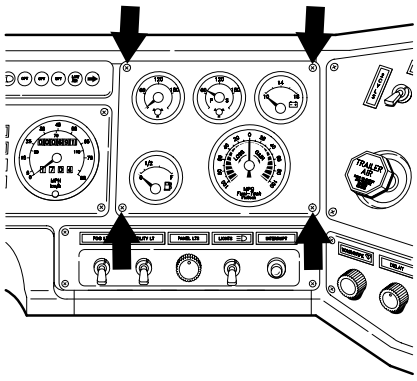
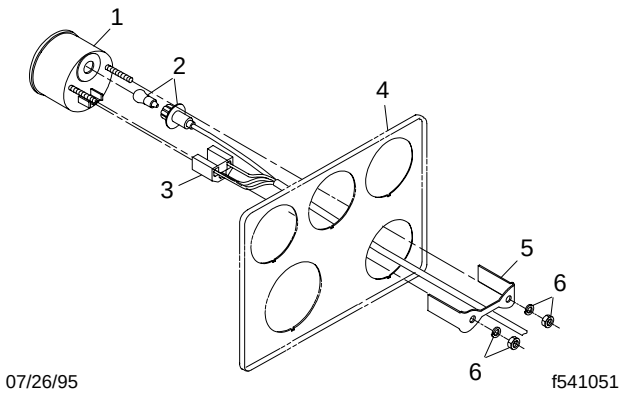


Fig. 1, Dash Panel With Fuel Level Gauge

4. Pull the gauge illumination bulb socket from the back of the fuel gauge. See **Fig. 2**.



1. Fuel Level Gauge
2. Illumination Bulb and Socket
3. Electrical Connector
4. Gauge Panel
5. Mounting Bracket
6. Mounting Nuts and Lockwashers

Fig. 2, Fuel Level Gauge Installation View

5. Disconnect the electrical wiring connector from the back of the fuel level gauge.
6. Remove the nuts that attach the mounting bracket to the gauge, and remove the bracket.
7. Remove the gauge from the panel by pulling the gauge out from the front of the panel.

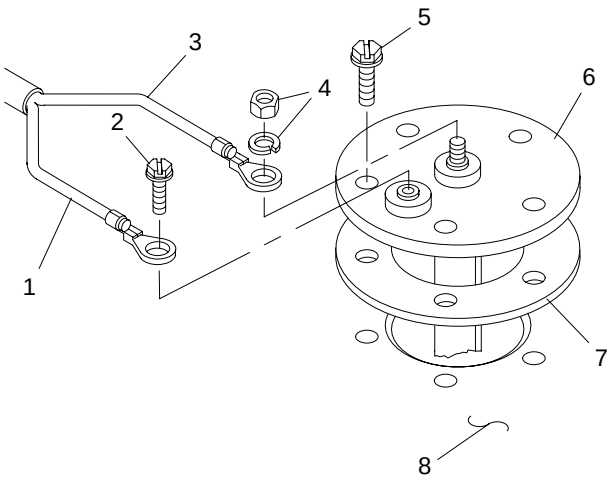
Installation

1. Place the fuel level gauge in the panel and attach the mounting bracket to the gauge.
2. Install the mounting bracket lock washers and retaining nuts. Tighten the nuts 10 lbf·in (110 N·cm).
3. Connect the electrical wiring connector to the fuel level gauge.
4. Insert the gauge illumination bulb and socket into the hole in the back of the gauge.
5. Position the panel over the dash opening and lower it into place, making sure that no gauge wires are trapped between the panel and the dash. Then, install and tighten the screws that attach the panel to the dash.
6. Connect the batteries.
7. Start the engine and verify that the fuel level gauge is operating properly.
8. Remove the chocks from the tires.

Fuel Level Sender Removal and Installation

Removal

1. Shut down the engine, apply the parking brake, and chock the tires.
2. If necessary, remove any fairings or skirts blocking access to the top of the left hand fuel tank.
3. Use masking tape and a felt-tipped marker to label the fuel sender wires; this will ease reassembly.
4. Remove the screws securing the fuel level signal and ground wires to the fuel level sender and disconnect the wires from the sender. **See Fig. 1.**



1. Ground Wire
2. 10-24 Machine Screw
3. Circuit 47
4. 10-32 Hexnut and Split Lockwasher
5. 10-32 Machine Screw
6. Fuel Level Sender
7. Gasket
8. Fuel Tank

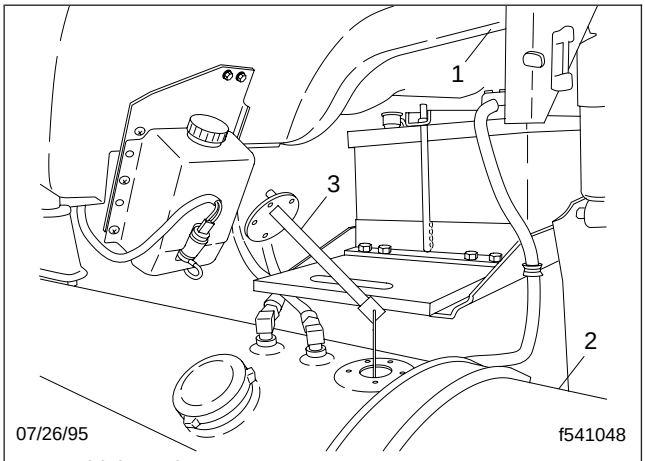
Fig. 1, Fuel Level Sender Mounting

5. Using a felt-tipped permanent marker, make alignment marks on both the fuel level sender plate and the fuel tank to simplify the assembly process.

WARNING

WARNING: Do not service the fuel system in the presence of sparks, open flames, or intense heat. These could ignite the fuel, possibly causing severe burns.

6. Remove the screws securing the fuel level sender to the fuel tank and carefully withdraw the sender and gasket from the tank. **See Fig. 2.** Be careful to avoid bending the float arm or damaging the float itself. The sender assembly *can* be removed from the tank opening without being damaged by tilting and rotating the sender as it is being withdrawn.



1. Vehicle Cab
2. Fuel Tank
3. Fuel Level Sender

Fig. 2, Fuel Level Sender Removal/Installation

Installation

NOTE: If the fuel level sender is being replaced with a new unit, be sure to "transfer" the sender alignment mark from the old sender to the new sender.

1. Make sure the gasket is in place on the fuel sender assembly and insert the fuel level sender into the fuel tank, being careful to avoid damage to the float or float arm.
2. Rotate the sender assembly as necessary to line up the alignment marks made earlier, install the sender mounting screws, and tighten them. **See Fig. 1.**

Fuel Level Sender Removal and Installation

3. Connect the vehicle wiring harness to the sender. Circuit 47 ("47" marked directly on the wire) must be connected to the insulated post at the center of the sender plate. The ground wire (marked "GND") must be connected to the remaining terminal post. **See Fig. 1.**
4. Start the engine, check for leaks, and check that the fuel level gauge is operating properly.
5. Install any side skirts or fairings that were removed to access the fuel level sender.
6. Remove the chocks from the tires.

Troubleshooting Procedures

Fuel level gauge malfunctions are usually one of two types: the gauge does not operate at all (always shows that the tank is empty), or the fuel level indicated by the gauge is believed to be incorrect.

Before proceeding with any troubleshooting when an inaccurate gauge or sender is suspected, confirm the actual fuel level using a clean dipstick in the left-hand fuel tank, since this tank contains the sender.

If the vehicle is equipped with dual fuel tanks, check to see that the fuel level is approximately the same in both tanks. If the levels are different, check for problems with the fuel equalizing line and/or valve (non-EquiFlo vehicles) or EquiFlo suction and return lines (EquiFlo-equipped vehicles). For fuel tank and line information, refer to **Group 47**.

Malfunctions that would cause a totally inoperative fuel level gauge include open circuits in the gauge, sender, or wiring. To isolate the cause of an inoperative fuel level gauge, follow the troubleshooting procedures in the order given.

1. Switch off the ignition and disconnect the fuel level signal circuit from the fuel level sender.

   1.1 Remove side skirts or fairings, if necessary, to access the top of the left hand fuel tank.

   1.2 Remove the screw securing the signal wire (marked "47") to the insulated center terminal of the fuel level sender. **See Fig. 1.**

   1.3 Disconnect the wire from the center terminal and bend the wire or prop it up so it cannot touch the sender or the tank itself.

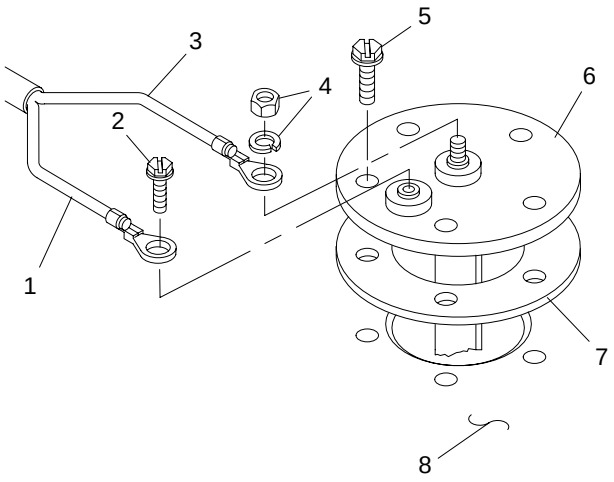
2. Switch on the ignition and observe the gauge needle; it should remain at the left end of the scale (empty tank indicated).

3. Switch off the ignition and, using a jumper wire, connect the wiring harness signal wire (circuit 47) to the sender ground terminal.

4. Switch on the ignition again and watch the gauge needle; it should move immediately to the extreme right or "full" end of the scale.

5. If the gauge operates as described in the above steps, it is functioning properly and the wiring to the gauge is okay. The problem is in the sender; replace it following the instructions in **Subject 110** and verify that the gauge operates properly.

   If the gauge does not function as described above, continue troubleshooting with the following steps:



1. Ground Wire
2. 10-24 Machine Screw
3. Circuit 47 Wire
4. 10-32 Hexnut and Split Lockwasher
5. 10-32 Machine Screw
6. Fuel Level Sender
7. Gasket
8. Fuel Tank

Fig. 1, Fuel Level Sender Connections

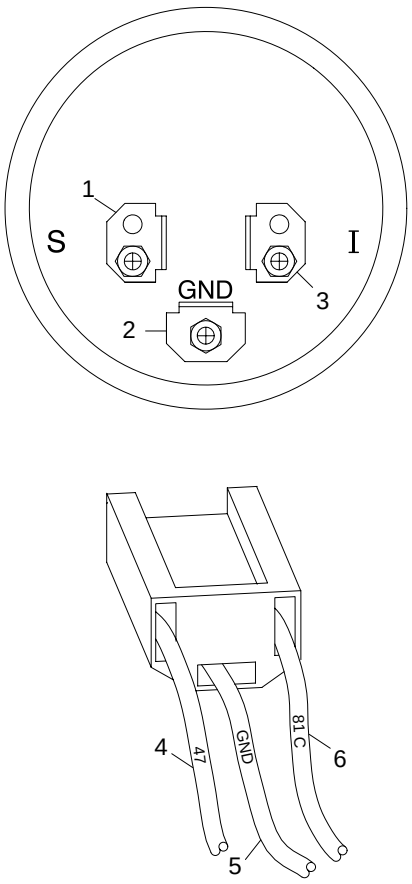
6. Check the fuel level sender ground circuit. Switch off the ignition and disconnect the jumper previously installed between the sender signal and ground wires. Connect one lead of an ohmmeter to an exposed part of the frame, and connect the remaining lead to the sender ground terminal (wire still connected to the terminal). Resistance should be very low—less than 5 ohms. Higher resistance indicates a problem in the ground circuit. Look for a loose wire, corrosion at the terminal, or a damaged wire. If the sender ground circuit checks out, leave the signal wire disconnected at the sender and continue with the following steps.

7. Remove the screws that attach the dash panel containing the fuel level gauge. Then, carefully

Troubleshooting

pull the panel out to access the back of the gauge. If necessary, refer to **Subject 100**.

8. Unplug the wiring harness connector from the back of the fuel level gauge. **See Fig. 2.**



1. Sender Signal Terminal
2. Ground Terminal
3. Ignition Power Terminal
4. Sender Signal Circuit
5. Ground Circuit
6. Ignition Power Circuit

Fig. 2, Fuel Level Gauge Connection

9. Check the fuel level gauge ground circuit wiring for an open circuit.

   9.1 With the ignition switch turned off, connect the leads of an ohmmeter between the cab metal (an unpainted bolt or screw attached directly to cab structure works well) and the ground circuit (wire marked "GND") in the wiring harness connector. **See Fig. 1.**

   9.2 Resistance should be very low—less than 5 ohms. If it is, go to the next step. If resistance is higher than 5 ohms, verify that you have good connections at both the wiring harness connector and the cab metal.

   9.3 If the connections are good, but resistance is still greater than 5 ohms, locate the damaged section of wiring between the connector and ground. Repair the damage by splicing in a length of replacement wiring following the instructions in this manual.

10. Check the signal circuit between the fuel level gauge and sender.

    10.1 With the wiring harness connector still unplugged from the gauge, connect one ohmmeter lead to the harness connector signal circuit (wire marked "47") and the other lead to the harness connector signal wire (still disconnected) at the fuel tank. **See Fig. 1** and **Fig. 2**.

    10.2 Resistance should be very low—less than 5 ohms. If it is, continue troubleshooting. If resistance is too high, locate and repair the loose connection or damaged section of wire between the fuel level gauge and the sender.

    10.3 Check the sender signal wire for a short to ground. Check resistance between the gauge connector signal wire (gauge still disconnected) and a good ground. The ohmmeter should indicate infinite resistance. Any other reading means that the signal wire is shorted to ground. Look for a pinched, chafed or otherwise damaged circuit 47 between the gauge and the sender.

11. Check for battery voltage at the fuel gauge wiring harness connector.

    11.1 Turn the ignition switch on.

    11.2 Connect a voltmeter (set on 20 volt scale, DC voltage) to the gauge wiring harness connector as follows; positive (red) probe to the ignition power circuit (wire marked

"81C") and the negative (black) probe to the ground circuit (wire marked "GND"). **See Fig. 1.** The voltmeter should read between 9 and 16 volts DC.

11.3 If voltage is between 9 and 16 volts DC, the gauge itself is malfunctioning, and must be replaced. For instructions, refer to **Subject 100**. If the voltage reading is not between 9 and 16 volts DC, check the circuit breaker that supplies power to the gauge. If the circuit breaker is okay, locate and repair the damage to the power circuit. General wire repair information can be found elsewhere in this manual.

12. Reconnect the fuel level gauge and sender wires and reinstall the fuel gauge panel. Make sure that the gauge is now operating properly.

General Information

The HighwayMaster® mobile communications system combines phone and satellite capabilities. It includes the following components, as shown in **Fig. 1**:

- A control unit for processing all vehicle communications, mounted in the cab (see **Fig. 2**);
- A cellular telephone handset and cradle, mounted below the dash console (see **Fig. 3**);
- A text display unit for satellite communications, mounted on top of the dash console (see **Fig. 4**);
- A hands-free microphone, mounted underneath the display unit (see **Fig. 4**);
- A speaker, mounted below the dash console next to the handset (see **Fig. 5**);
- A cellular antenna for telephone communications, normally mounted on the back of the cab (see **Fig. 6** for factory installations and **Fig. 7** for aftermarket installations);
- A GPS (global positioning system) antenna for satellite communications, normally mounted on the back of the cab next to the cellular antenna (see **Fig. 6** for factory installations and **Fig. 7** for aftermarket installations);
- The cables necessary to connect the various components together.

Each of these components can be replaced separately. See the appropriate subject for replacement procedures.

- For control unit replacement, see **Subject 100**.
- For handset replacement, see **Subject 110**.
- For display unit replacement, see **Subject 120**.
- For microphone replacement, see **Subject 130**.
- For speaker replacement, see **Subject 140**.
- For cellular antenna replacement, see **Subject 150**.
- For GPS antenna replacement, see **Subject 160**.

Before use, the control unit must be activated to receive data through the cellular and satellite networks. Also, the system must receive an authorization from Customer Care, HighwayMaster's technical support facility, that a system module has been assigned and that the information about it has been stored in ACUS, a database maintained by AT & T.

NOTE: When replacing a control unit, make sure the new unit has been activated before turning it on for the first time.

To operate successfully, the information must be accurate, and include the following:

1. TIN (Truck Identification Number)—a number generated by HighwayMaster for billing purposes;
2. CID (Customer Identification Number)—a number generated by HighwayMaster for customer reporting and tracking;
3. MIN (Mobile Identification Number)—the phone number of the cellular modem, which is found on a decal on the side of the control unit;
4. ESN (Electronic Serial Number)—an electronically encoded serial number in the control unit, which is also found on the decal on the side of the control unit;
5. Tractor Number—the vehicle ID number;
6. System Module Serial Number—the serial number of the control unit, which is also found on the decal on the side of the control unit;
7. Text Display Serial Number—the serial number of the display unit, which is found on a decal on the back of the display unit;
8. Handset Serial Number—the serial number of the handset, which is found on on a metal tag on the back of the handset.

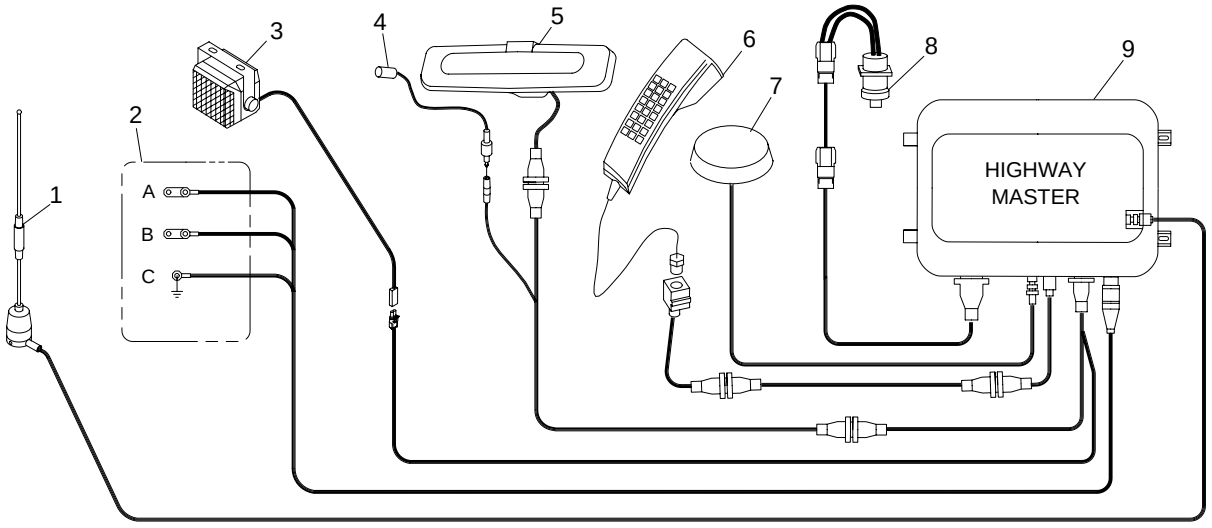
Principles of Operation

START-UP CYCLE

Each time the engine is started, the HighwayMaster system goes into its start-up cycle. When the system is functioning properly, it goes through the following steps:

1. The display shows the underline prompt (_).
2. The display reads "Checking Cellular Service" and then changes to "Registering Unit for Service."

General Information



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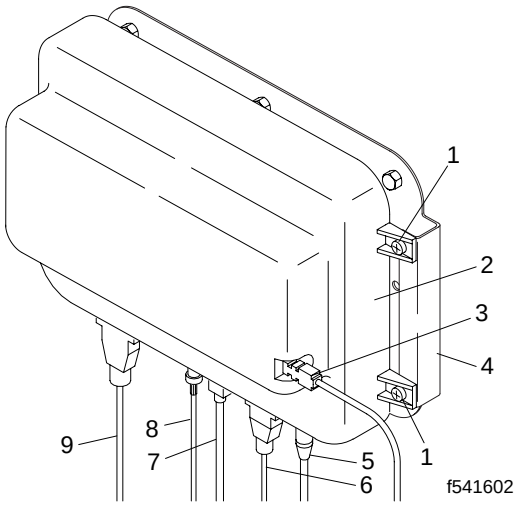
A. IGN Circuit Breaker
B. BAT Circuit Breaker
C. Ground
1. Cellular Antenna
2. Electrical Power Center
3. Speaker
4. Microphone
5. Display Unit
6. Handset
7. GPS Antenna
8. Datalink Connector
9. Control Unit

Fig. 1, HighwayMaster System Components



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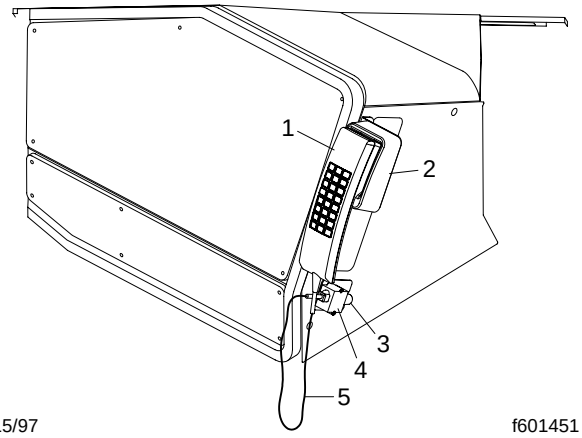
1. SEM Screw
2. Control Unit
3. Cellular Antenna Cable
4. Mounting Plate
5. Power Cable
6. Display Cable
7. Phone Cable
8. GPS Antenna Cable
9. Datalink Cable

Fig. 2, Control Unit and Cables



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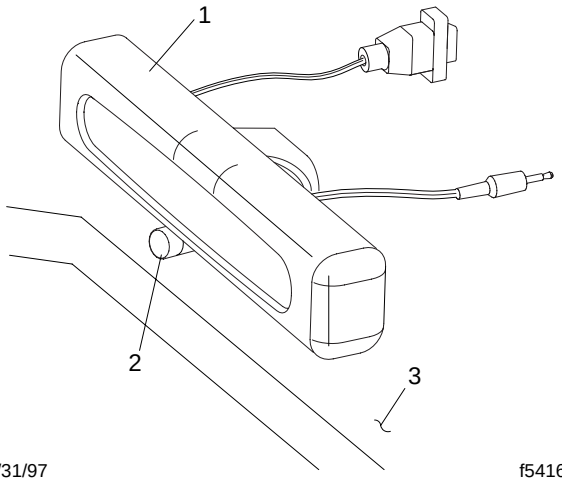
1. Handset
2. Cradle
3. Phone Cable Connector
4. Pickup
5. Handset Cord

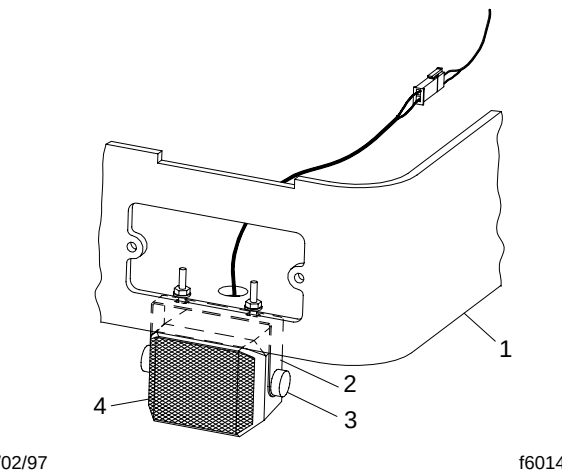
Fig. 3, Handset

3. Once the unit has been registered, the display reads either "HighwayMaster Service Area" (if you are in an area where HighwayMaster provides cellular coverage) or "HighwayMaster" (if you are out of the coverage area).



1. Display Unit
2. Microphone
3. Dash Console

Fig. 4, Display Unit and Microphone

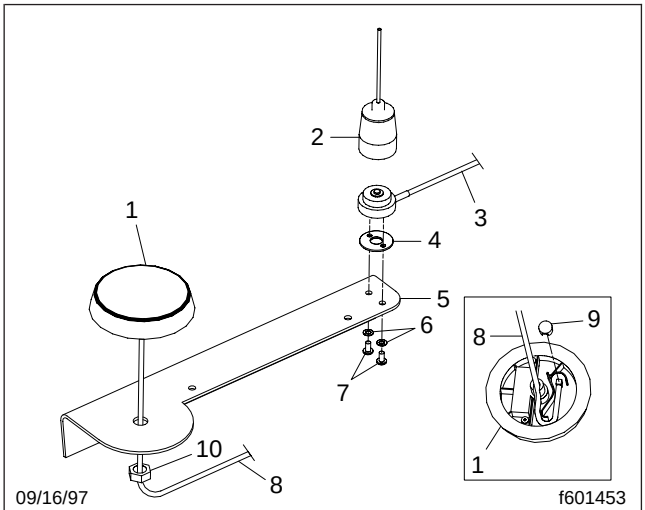


1. Dash Panel
2. Mounting Bracket
3. Knob
4. Speaker

Fig. 5, Speaker

4. When fully operational, the handset is illuminated and the display shows from three to seven bars.

The screen saver timer is a feature that allows the display to go blank if the system has not been used for a programmable number of minutes. The timer can be set to anywhere from 1 to 240 minutes in 1-minute intervals.



1. GPS Antenna
2. Cellular Antenna
3. Cellular Antenna Cable
4. Spacer
5. Mounting Bracket
6. #10 Washers
7. 10–32 Machine Screws
8. GPS Antenna Cable
9. Rubber Cable Cap
10. M12 Nylon Hexnut

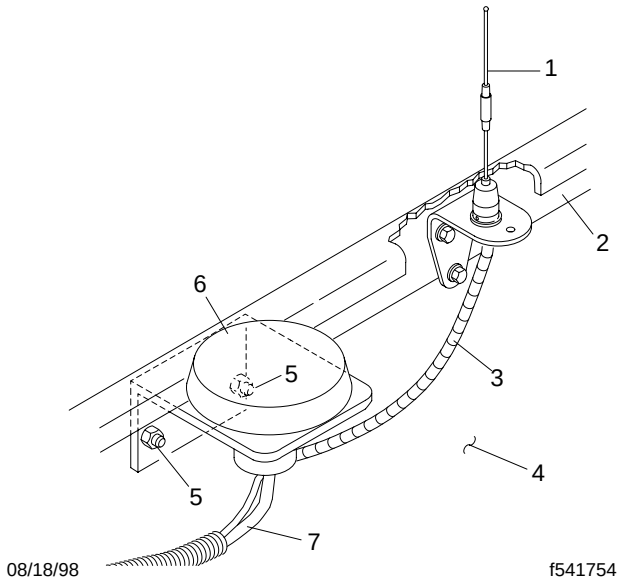
Fig. 6, Cellular and GPS Antenna (factory installation)

HANDSET KEYPAD

In addition to having all the features of a telephone, the handset also functions as a keypad for programming the HighwayMaster system. The function keys on the handset also allow access to the memory functions of the system. The up and down keys allow scrolling through the information stored in memory.

- The SND (Send) key is used to start a call and to transmit information. Pressing SND when receiving a call activates the hands-free microphone and the voice recognition system.
- The END key is used to end a hands-free call and get the system ready to receive new information.
- The PWR (Power) key turns the system on and off.
- The CHK (Check) key is used to check information, such as NAV status.
- The RCL (Recall) key is used to recall information stored in memory.

General Information



1. Cellular Antenna
2. Raised Roof Rib
3. Cellular Antenna Cable
4. Back of Cab
5. Mounting Stud
6. GPS Antenna
7. Dual Antenna Cable

Fig. 7, Cellular and GPS Antenna (aftermarket installation)

- The STO (Store) key is used to store information in memory, including telephone numbers and programming codes.
- The F (Function) key calls up the programming menu, allowing you to set functions such as the screen saver timer.
- The CLR (Clear) key is used to clear information from the display.

VOICE RECOGNITION

For greater driver convenience, the system can be operated by voice commands, using the hands-free microphone and the voice recognition system.

The control unit contains the voice recognition system which allows the speaker to respond to voice commands. To test the voice recognition system, press the END key on the handset. If the speaker says "Ready," the voice recognition system is working.

POWER OFF DELAY

Power off delay is a feature that allows the HighwayMaster system to remain in operation for a programmable number of hours after the vehicle is shut off. The delay can be set to anywhere from 0 to 12 hours in 1-hour intervals.

PERSONAL AND AUTHORIZED CALLING

The personal calling feature allows drivers, at their own expense, to use the HighwayMaster system to make personal calls, providing they have an AT & T TrueChoice ^{SM} calling card.

Both personal and authorized phone numbers can be stored in memory for easier dialing.

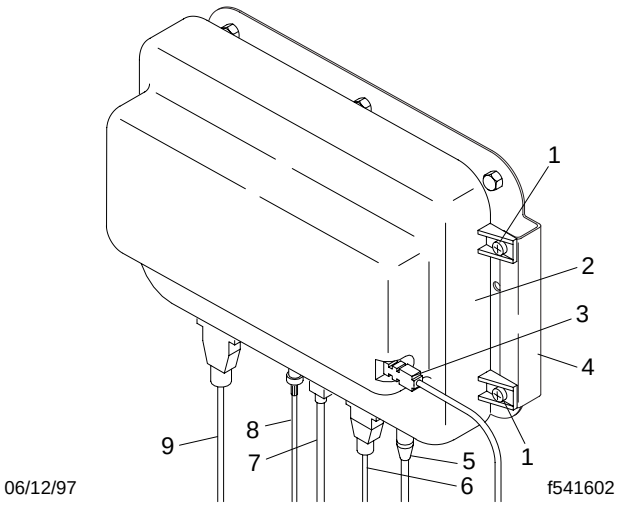
Authorized numbers are used for company business. They are stored in memory by the trucking company using special codes, allowing the driver to call dispatchers, terminals, and customers at company expense.

Replacement

The HighwayMaster® control unit is normally mounted on a mounting plate attached to the cab deck in the right-hand baggage compartment. On day cabs, and in other cases where space does not permit it to be mounted in this location, the control unit is mounted with its mounting plate attached directly to the rear wall.

IMPORTANT: Before attempting to install a new control unit, fax the serial number, electronic serial number, and mobile identification number of the unit to HighwayMaster at 1–214–930–7244. These numbers are found on the decal on the side of the control unit.

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Gain access to the control unit. Normally it is installed under the bunk on the right-hand side of the cab.
3. Remove the cables attached to the control unit. See **Fig. 1**.



1. SEM Screw
2. Control Unit
3. Cellular Antenna Cable
4. Mounting Plate
5. Power Cable
6. Display Cable
7. Phone Cable
8. GPS Antenna Cable
9. Datalink Cable

Fig. 1, Control Unit and Cables

3.1 Remove the round 1-pin connector on the cellular antenna cable from the plug on the side of the front casing.

3.2 Remove the round 3-pin connector on the power cable from the plug on the bottom of the case.

3.3 Remove the 9-pin connector on the display cable from the plug on the bottom of the case.

3.4 Remove the connector on the phone cable from the phone plug on the bottom of the case.

3.5 Remove the round 1-pin connector on the GPS antenna cable from the plug on the bottom of the case.

3.6 Remove the 15-pin connector on the datalink cable from the plug on the bottom of the case.

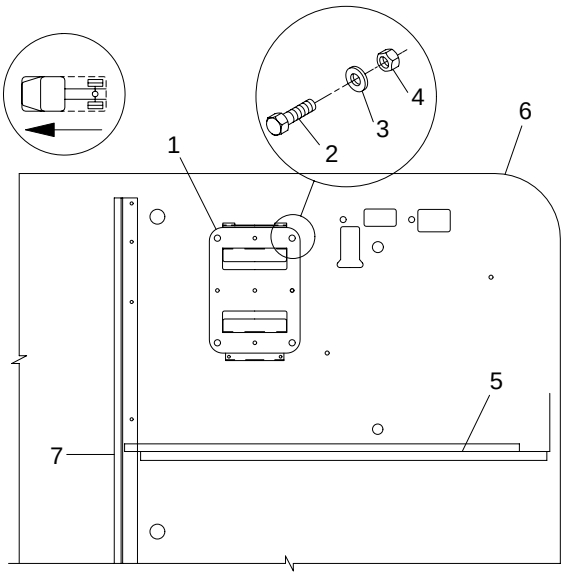
4. Remove the two SEM screws attaching the control unit to the mounting plate and lift the two lugs on the other end of the control unit out of the slots provided on the mounting plate.

NOTE: It is not necessary to remove the mounting plate to replace the control unit. Do the following step only if it is necessary to replace the mounting plate or to change the mounting of the control unit.

5. Remove the 1/4–20 capscrews (3/4-inch long), washers, and locknuts attaching the mounting plate to the cab deck (or rear wall). See **Fig. 2**.
6. If removed, attach the mounting plate to the cab deck (or wall).
7. Insert the lugs in the control unit into the slots in the mounting plate. Install the SEM screws and tighten them until snug.
8. Connect the display, phone, and both antenna cables to the control unit, as removed. Check all cables for good connections at both ends.
9. Connect the datalink cable to the control unit, as removed. Check the cable for good connections at both ends. See **Fig. 3**.
10. Connect the batteries.

IMPORTANT: Do not connect the power cable until battery power has been restored. Before

Control Unit Replacement



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1. Mounting Plate
2. 1/4–20 Capscrew
3. 1/4-Inch Flatwasher
4. 1/4–20 Locknut
5. R/H Baggage Compartment Partition
6. Cab Deck
7. Forward Bunk Partition

Fig. 2, Mounting Plate Removal

connecting power to the unit, call HighwayMaster Customer Care at 1–800–647–6693 to confirm the unit has been initialized from the host.

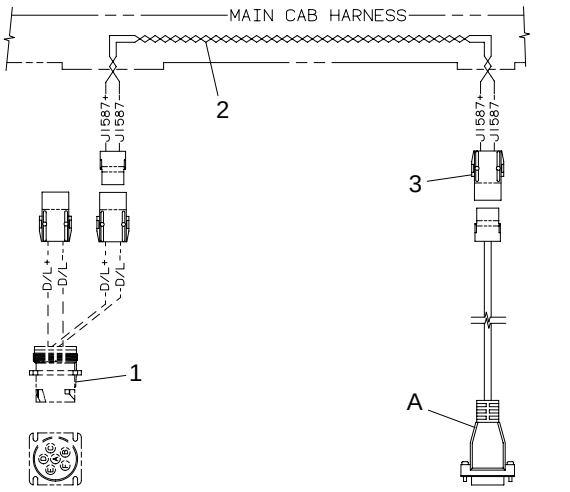
11. With battery power restored, connect the power cable to the control unit, as removed. Check the cable for good connections at both ends. See **Fig. 4** and **Fig. 5**.

12. Initialize the control unit.

    12.1 On the handset, press the following sequence of keys:

    - "STO," "9," "9," "SND"
    - "STO," "0," "1," "SND"

    NOTE: If the display does not read "TRANSMISSION SUCCESSFUL," first press the key sequence "STO," "0," "1," "SND" again. If that does not work, call HighwayMaster Customer Care at 1–800–647–6693 and follow their instructions.



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A. To Control Unit
1. Diagnostic Connector
2. Datalink Harness
3. Harness Connector

Fig. 3, Datalink Cable

    12.2 When the display reads "TRANSMISSION SUCCESSFUL," type in this key sequence:

    - "5," "9," "8," "2," "0," "0," "CHK"

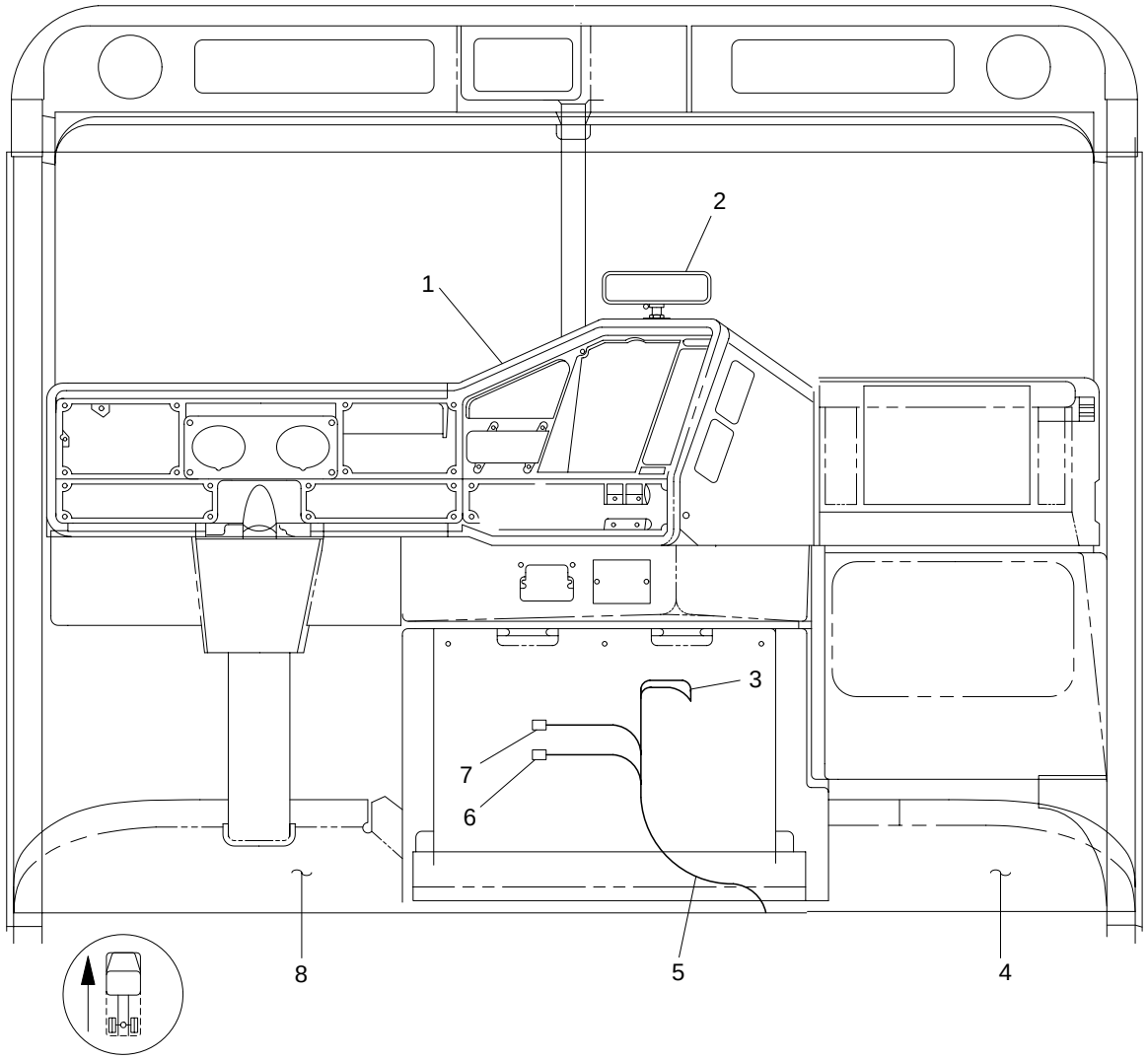
    12.3 When the display reads "GPS HAS REACHED NAV STATUS," the system is ready to operate.

    If the display does not read "GPS HAS REACHED NAV STATUS," see **Troubleshooting, 300**.

13. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.

14. Ask Customer Care to issue a returned materials authorization number (RMA). Enter this number on a "Service Record/Installation Acknowledgment" form and send the form back to HighwayMaster along with the old control unit.

15. Return the old control unit to HighwayMaster, using the address label provided. Send it to the following address: HighwayMaster Repair Depot,



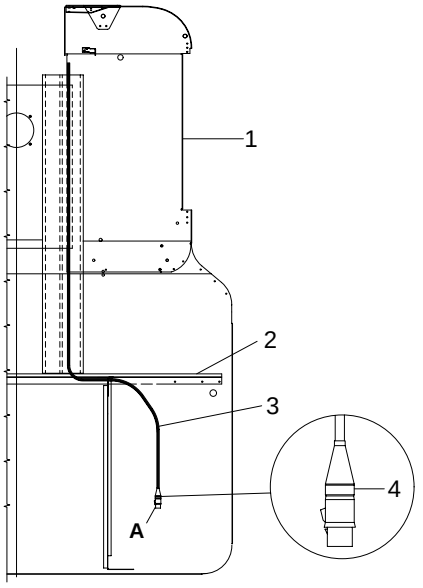
1. Dash Console
2. Display Unit
3. Ground
4. R/H Footwell
5. Power Cable
6. White Wire (IGN bus)
7. Red Wire (BAT bus)
8. L/H Footwell

Fig. 4, Power Cable Routing (dash)

ATTN: Roy Moultrie, 2300 Highway 79 South,
Guntersville AL 35976.

16. Restore the cab to normal operating condition.
17. Remove the chocks from the tires.

Control Unit Replacement



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A. To Control Unit
1. R/H Cab Deck
2. Forward Bunk Partition
3. Power Cable
4. 3-Pin Connector

Fig. 5, Power Cable Routing (cab)

Replacement

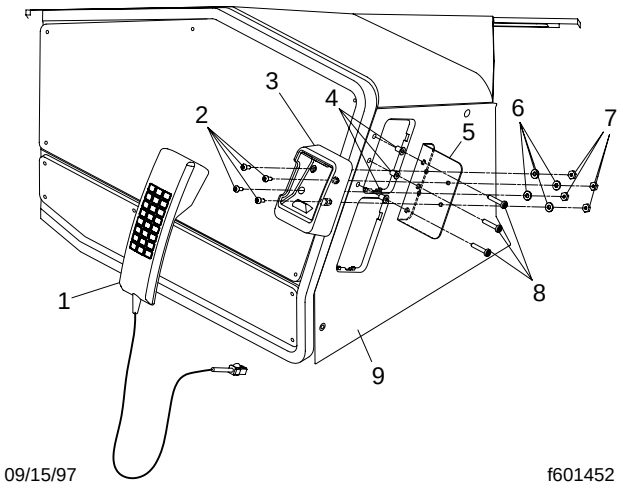
The HighwayMaster® handset and cradle are normally mounted on the side of the dash console.

IMPORTANT: Before attempting to install a new handset, fax the serial number of the unit to HighwayMaster at 1–214–930–7244. The serial number is found on a metal tag on the back side of the handset.

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the handset cord from the pickup (mounted behind the speaker).

NOTE: It is not necessary to remove the cradle or the pickup to replace the handset. Do the following step only if it is necessary to replace the cradle, replace the pickup, or to change the mounting of the handset. See **Fig. 1**.

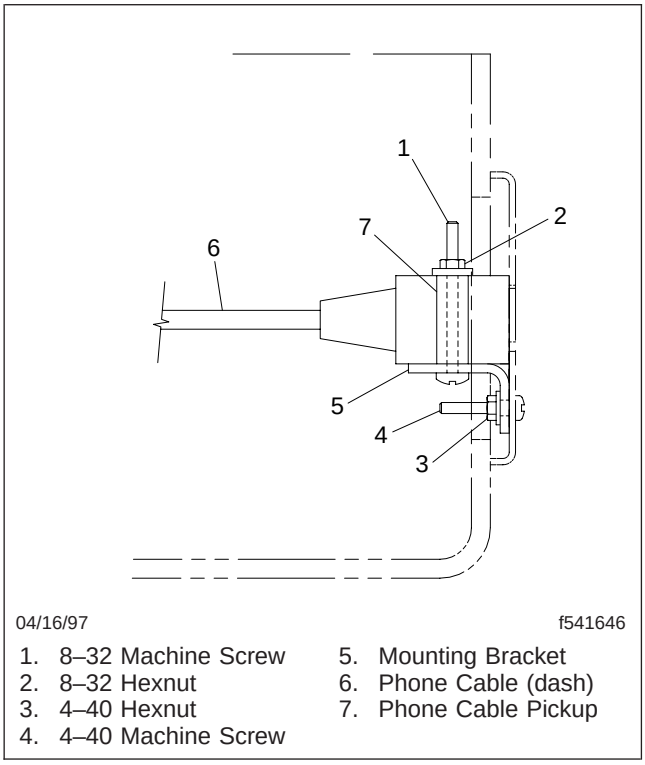
3. Remove the cradle from the dash. Remove the four 6–32 machine screws, locknuts and #6 washers that attach the cradle to the dash.



1. Handset
2. 6–32 Machine Screws
3. Cradle
4. Rivnuts
5. Mounting Bracket
6. #6 Washers
7. 6–32 Locknuts
8. 10–32 Machine Screws
9. Console Side Panel

Fig. 1, Handset and Cradle Installation

4. Remove the phone cable pickup from the dash. See **Fig. 2**.



1. 8–32 Machine Screw
2. 8–32 Hexnut
3. 4–40 Hexnut
4. 4–40 Machine Screw
5. Mounting Bracket
6. Phone Cable (dash)
7. Phone Cable Pickup

Fig. 2, Pickup Installation

4.1 Remove the two 4–40 machine screws that attach the phone cable pickup mounting bracket to the dash.

4.2 Remove the two 8–32 machine screws that attach the pickup to the mounting bracket.

4.3 Disconnect the phone cable (dash) from the plug on the back of the pickup.

4.4 Remove the round 1-pin connector on the phone cable from the plug on the bottom of the case.

5. Install the phone cable pickup.

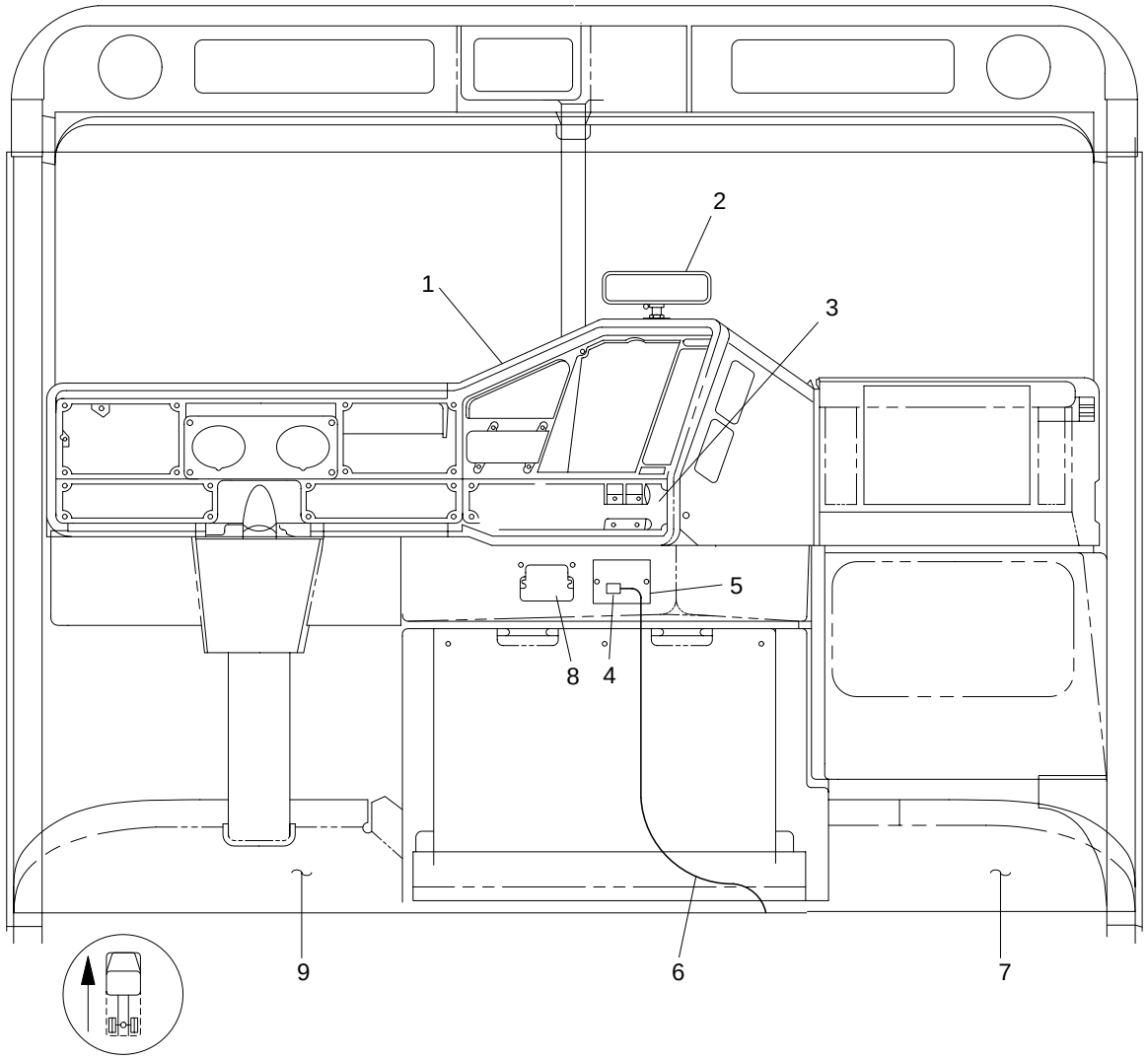
5.1 Install the two 8–32 machine screws that attach the pickup to the mounting bracket.

5.2 Connect the round 1-pin phone cable connector to the plug on the bottom of the pickup.

Handset Replacement

5.3 Install the two 4–40 machine screws that attach the phone cable pickup mounting bracket to the dash.

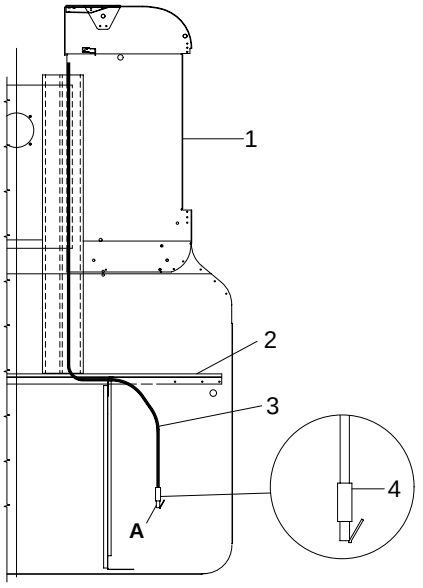
6. Attach the cradle to the four 1/4-inch (6 mm) holes, as removed.
7. Insert the cord of the new handset into the pickup.
8. Check all the phone cable connections, as shown in **Fig. 3** and **Fig. 4**. Check all three cables, dash, door, and cab, for good connections at both ends.
9. Connect the batteries.
10. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.
11. Remove the chocks from the tires.



1. Dash Console
2. Display Unit
3. HVAC Panel
4. R/H Footwell
5. Speaker
6. Phone Cable
7. Phone Plug
8. Handset Cradle
9. L/H Footwell

Fig. 3, Phone Cable Routing (dash)

Handset Replacement



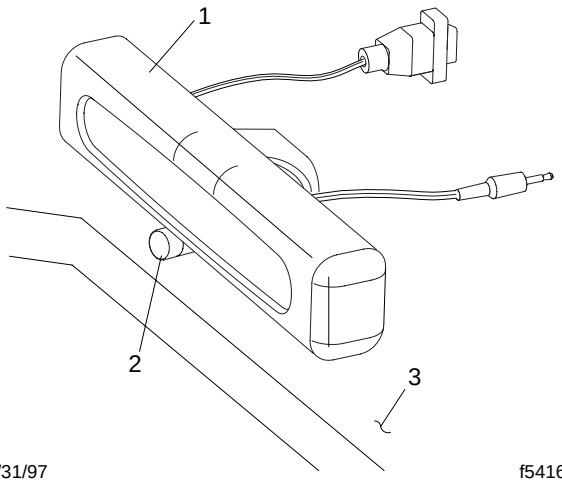
04/16/97 f541644

A. To Control Unit
1. R/H Cab Deck
2. Forward Bunk Partition
3. Phone Cable
4. Phone Connector

Fig. 4, Phone Cable Routing (cab)

Replacement

The HighwayMaster® display unit is normally mounted above the dash console. See **Fig. 1**.

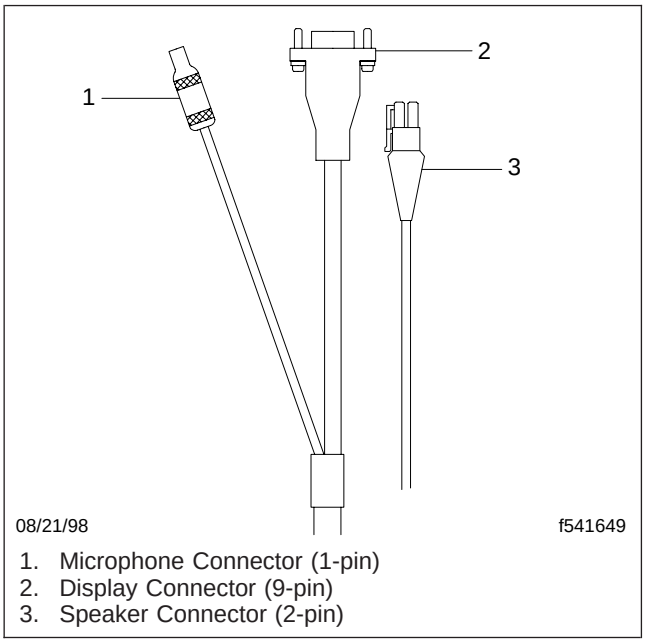


1. Display Unit
2. Microphone
3. Dash Console

Fig. 1, Display Unit and Microphone

IMPORTANT: Before attempting to install a new display unit, fax the serial number of the unit to HighwayMaster at 1–214–930–7244. The serial number is found on the decal on the back side of the control unit.

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Unclip the microphone from the microphone bracket. If the bracket is damaged, remove the two speed clips attaching it to the dash console and replace the bracket.
3. Remove the 10–32 machine screw from the prong of the display bracket. Remove the locknuts and washers from the studs on the back of the display unit.
4. Remove the display bracket, with the display unit attached, from the dash. Pull the two wires (display unit and microphone) out of the dash. When the connectors are sufficiently exposed, disconnect the wires and mark them for later assembly. See **Fig. 2**.



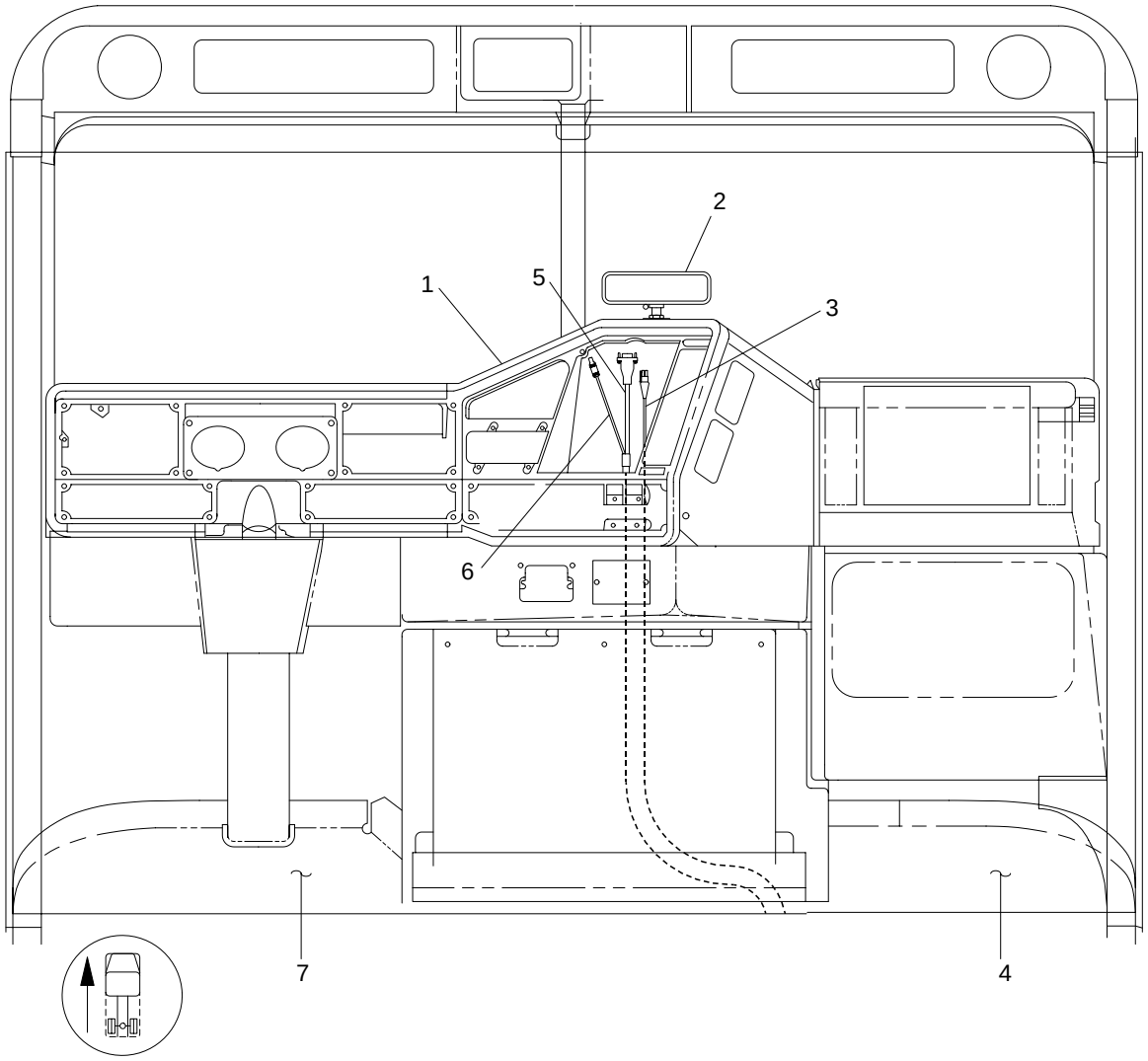
1. Microphone Connector (1-pin)
2. Display Connector (9-pin)
3. Speaker Connector (2-pin)

Fig. 2, Display Cable Connectors

NOTE: If necessary, reach under the dash to disconnect the display and microphone wires.

5. Remove the four 10–32 machine screws attaching the display bracket to the display unit.
6. Attach the electrical connectors to the display unit and microphone, as removed.
7. Install the new display unit on the display bracket, using the four 10–32 machine screws.
8. Position the display bracket on the top of the dash console. Make sure the studs on the back of the display bracket pass through the fastener holes on the front of the dash console.
9. Attach the #10 washers and 10–24 locknuts to the studs. Attach the display bracket to the dash with 10–32 machine screw.
10. Install a new microphone bracket, if removed. Clip the microphone to the microphone bracket.
11. Check the display cable for good connections at both ends. See **Fig. 3** and **Fig. 4**.
12. Connect the batteries and restore the cab to normal operating condition.
13. Place a voice call. Test the system for correct operation, including the hands-free microphone,

Display Unit Replacement

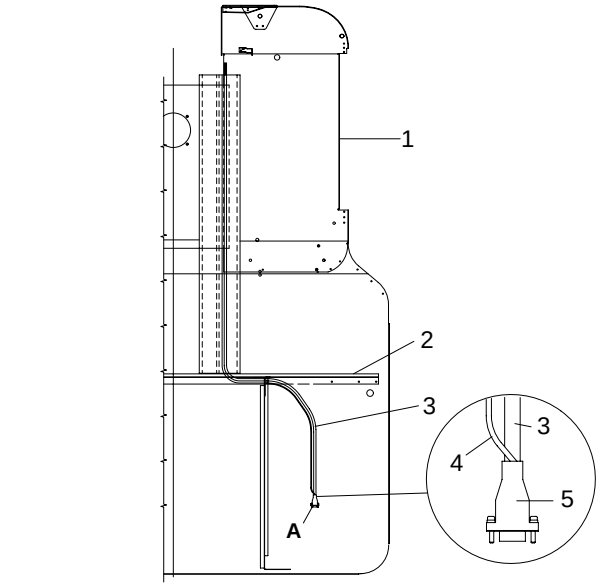


1. Dash Console
2. Display Unit
3. Speaker Cable
4. R/H Footwell
5. Display Cable
6. Microphone Cable
7. L/H Footwell

Fig. 3, Display and Microphone Cable Routing (dash)

volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.

14. Remove the chocks from the tires.



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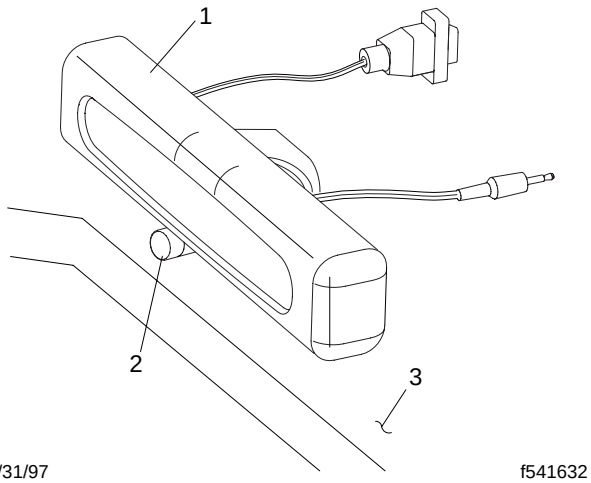
A. To Control Unit
1. R/H Cab Deck
2. Forward Bunk Partition
3. Display Cable
4. Speaker Cable
5. 9-Pin Connector

Fig. 4, Display and Speaker Cable Routing (cab)

Replacement

The HighwayMaster® hands-free microphone is normally clipped to a small bracket attached to the display unit. See **Fig. 1**.



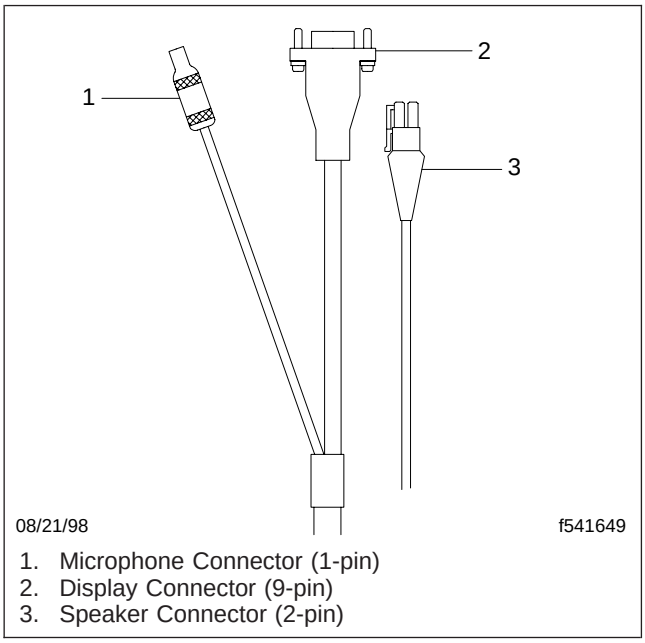
1. Display Unit
2. Microphone
3. Dash Console

Fig. 1, Display Unit and Microphone

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Unclip the microphone from the microphone bracket.
3. Remove the 10–32 machine screw from the prong of the display bracket. For more information, see **Subject 120**.
4. Remove the display bracket, with the display unit attached, from the dash. Pull the two wires (display unit and microphone) out of the dash. When the microphone connector is sufficiently exposed, disconnect the wire. See **Fig. 2**.

NOTE: If necessary, loosen the dash console and reach behind it to disconnect the display and microphone wires.

5. Attach the electrical connector to the new microphone, as removed.
6. Install the display bracket, using the 10–32 machine screw to fasten the prong of the bracket to the dash console.

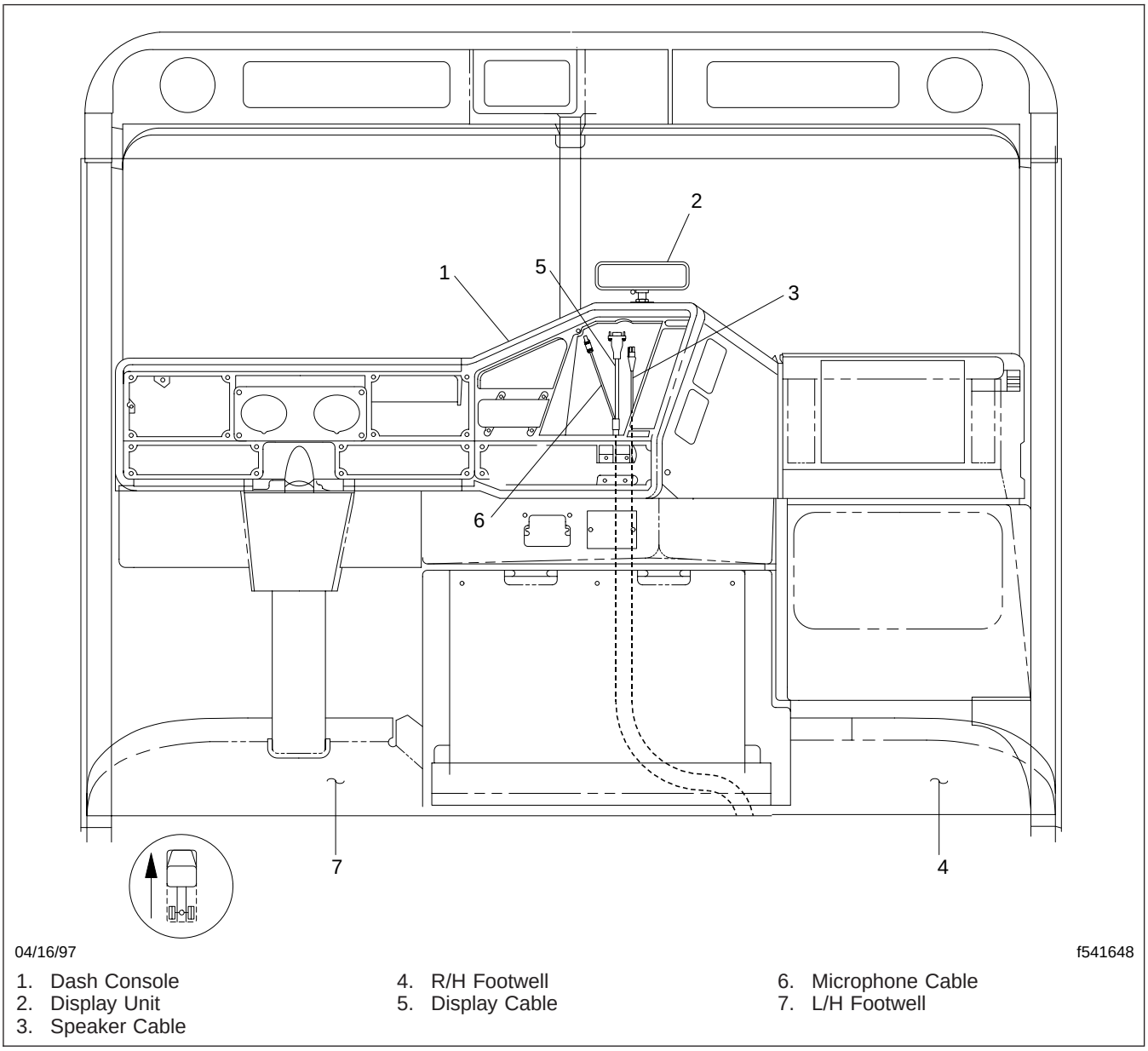


1. Microphone Connector (1-pin)
2. Display Connector (9-pin)
3. Speaker Connector (2-pin)

Fig. 2, Display Cable Connectors

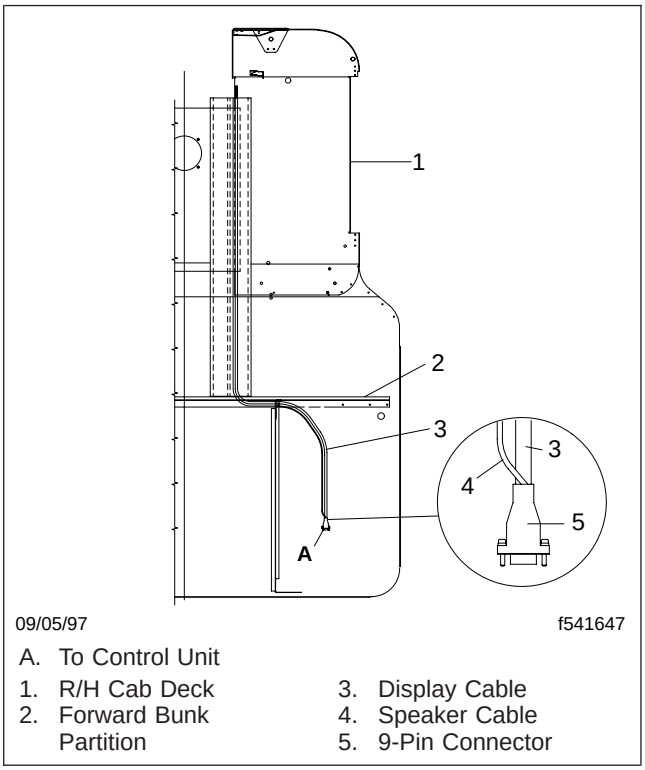
7. Clip the new microphone to the microphone bracket.
8. Check the door display cable for good connections at both ends. See **Fig. 3**.
9. Check the cab display cable for good connections at both ends. See **Fig. 4**.
10. Connect the batteries and restore the cab to normal operating condition.
11. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.
12. Remove the chocks from the tires.

Microphone Replacement



1. Dash Console
2. Display Unit
3. Speaker Cable
4. R/H Footwell
5. Display Cable
6. Microphone Cable
7. L/H Footwell

Fig. 3, Display and Microphone Cable Routing (dash)



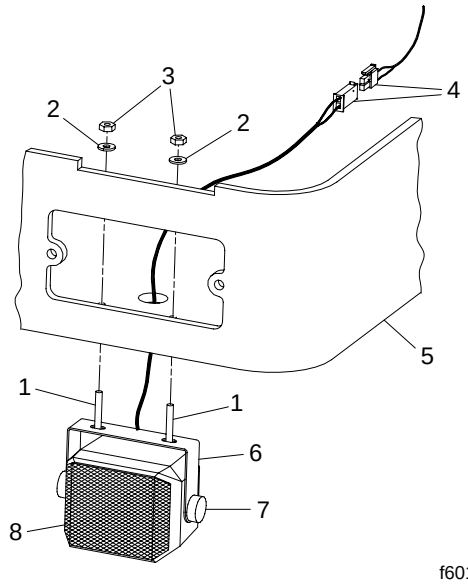
A. To Control Unit
1. R/H Cab Deck
2. Forward Bunk Partition
3. Display Cable
4. Speaker Cable
5. 9-Pin Connector

Fig. 4, Display and Speaker Cable Routing (cab)

Replacement

The HighwayMaster® speaker is normally installed on the lower dash below the ATC panel.

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the speaker from the speaker bracket. See **Fig. 1**.



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1. 8–32 Machine Screw
2. #8 Washer
3. 8–32 Locknuts
4. Speaker Cable Connectors
5. Dash
6. Speaker Bracket
7. Knob
8. Speaker

Fig. 1, Speaker Mounting

2.1 Loosen the knobs on each side of the speaker and remove the speaker from the speaker bracket.

2.2 Pull the speaker cable wire and connector out through the hole in the dash panel. If necessary, remove or loosen the panel.

NOTE: Do the next step if necessary to change the mounting or replace any of the mounting hardware.

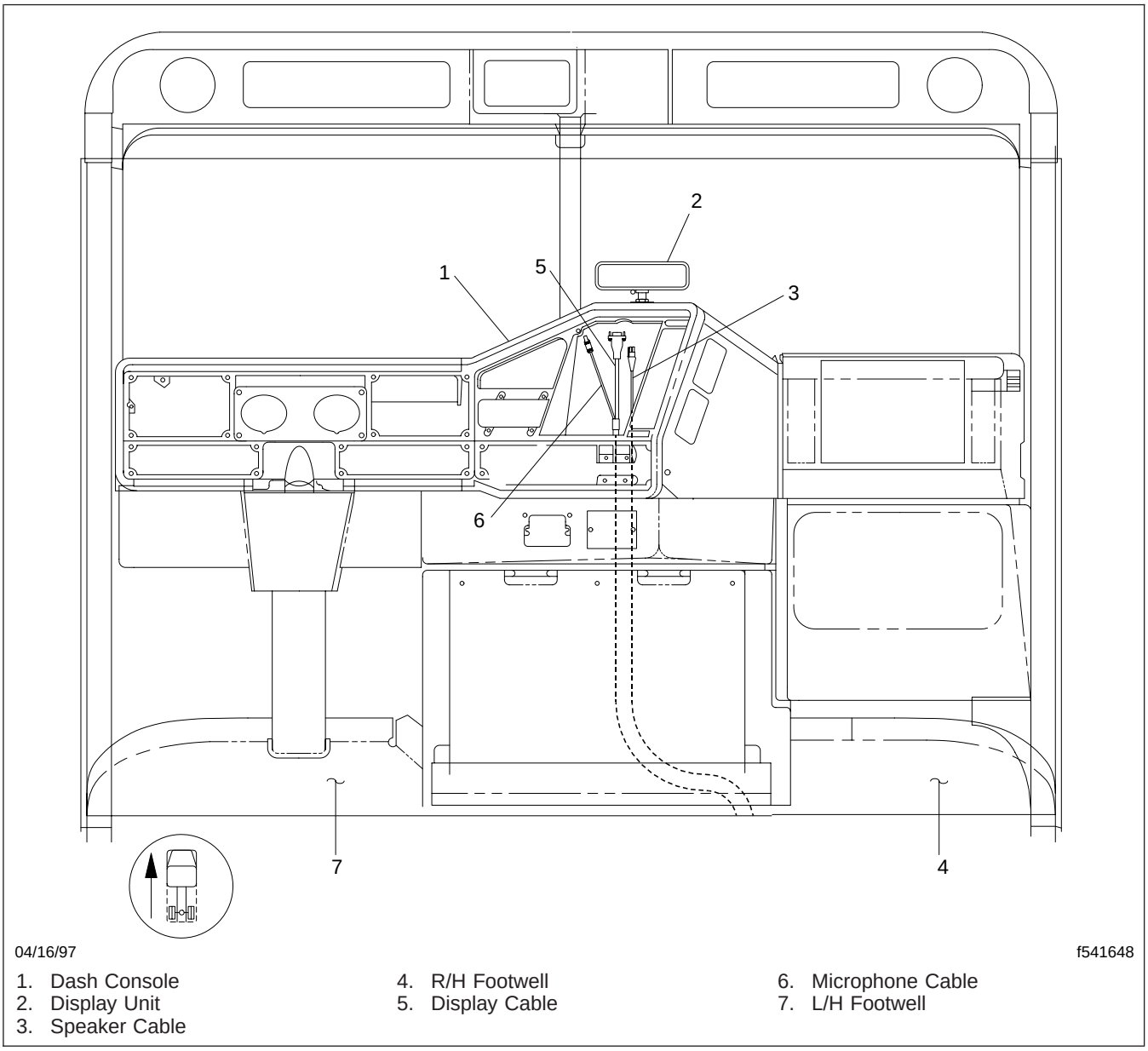
3. Remove the speaker mounting. Remove the two 8–32 machine screws attaching the speaker bracket to the dash panel.
4. If removed, install the speaker bracket. Use the removed fasteners.
5. Install the speaker.

   5.1 Insert the knobs on each side of the new speaker into the slots in the speaker bracket.

   5.2 Route the new speaker cable through the drill hole and connect it to the electrical connector on the end of the cab speaker cable.

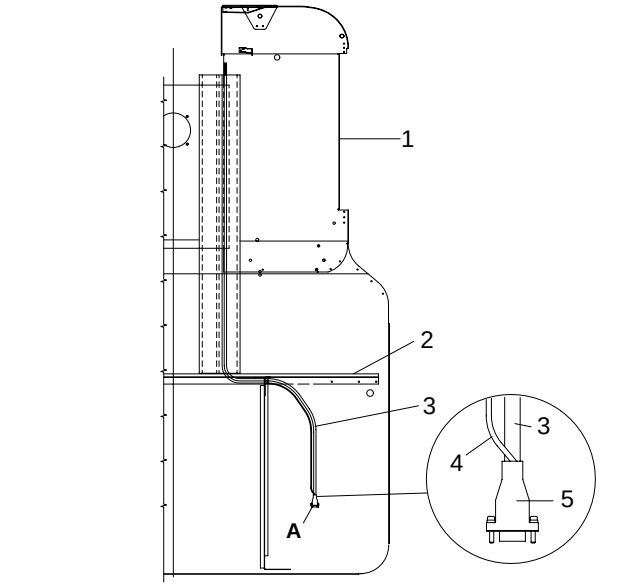
   5.3 When the cable has been properly routed and connected, tighten the knobs on the speaker until firm and tight.
6. Check the dash speaker cable for good connections at both ends. See **Fig. 2**.
7. Check the cab speaker cable for good connections at both ends. See **Fig. 3**.
8. Connect the batteries and restore the cab to normal operating condition.
9. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.
10. Remove the chocks from the tires.

Speaker Replacement



1. Dash Console
2. Display Unit
3. Speaker Cable
4. R/H Footwell
5. Display Cable
6. Microphone Cable
7. L/H Footwell

Fig. 2, Display and Speaker Cable Routing (dash)

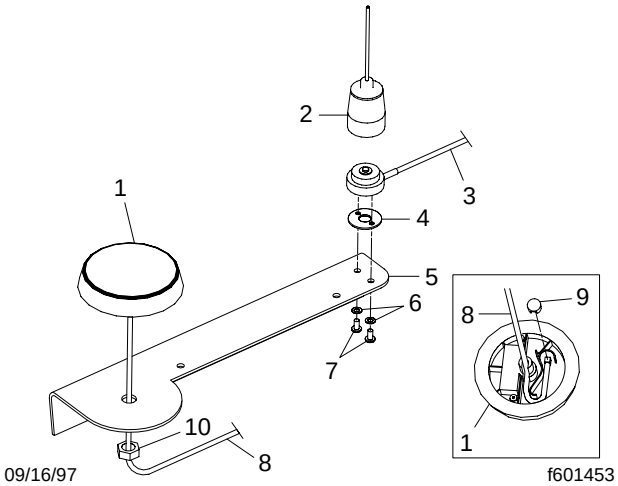


A. To Control Unit
1. R/H Cab Deck
2. Forward Bunk Partition
3. Display Cable
4. Speaker Cable
5. 9-Pin Connector

Fig. 3, Display and Speaker Cable Routing (cab)

Replacement

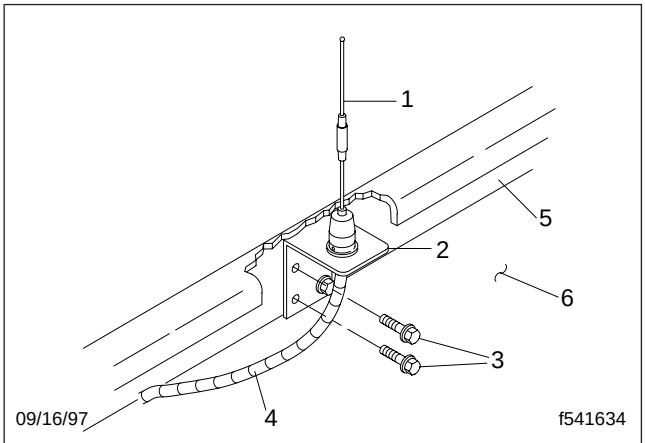
The HighwayMaster® cellular antenna is normally installed on the back of the cab. On factory installations, it is on the rear cab wall on a shared bracket with GPS antenna (see **Fig. 1**); on aftermarket installations, it is on the raised roof rib (see **Fig. 2**).



1. GPS Antenna
2. Cellular Antenna
3. Cellular Antenna Cable
4. Spacer
5. Mounting Bracket
6. #10 Washers
7. 10–32 Machine Screws
8. GPS Antenna Cable
9. Rubber Cable Cap
10. M12 Nylon Hexnut

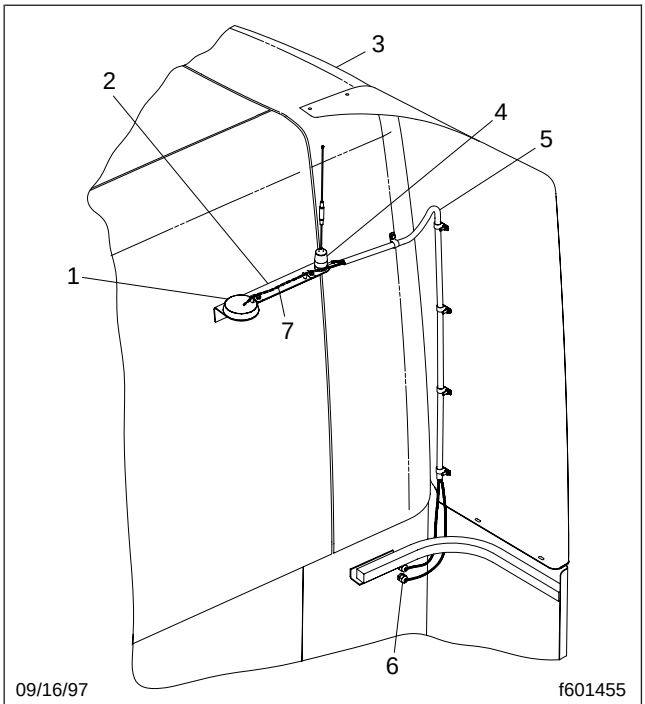
Fig. 1, Cellular Antenna (factory installation)

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Remove the two 10–32 machine screws and washers from the cellular antenna bracket. Remove the antenna, base and spacer.
3. Install the new antenna, base, and spacer. Use the removed fasteners.
4. Check the cellular antenna cable for good connections at both ends. See **Fig. 3**.
5. Check the through-skin fittings for tightness and proper fit. See **Fig. 4**.



1. Cellular Antenna
2. Mounting Bracket
3. Mounting Bolts
4. Antenna Cable
5. Raised Roof Rib
6. Back of Cab

Fig. 2, Cellular Antenna (aftermarket installation)

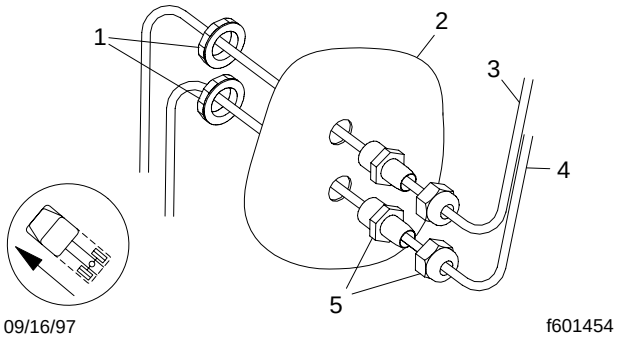


Factory installation is shown.

1. GPS Antenna
2. Mounting Bracket
3. Roof Cap
4. Cellular Antenna
5. Dual Antenna Cable
6. Through-Skin Fittings
7. GPS Cable

Fig. 3, Antenna Cable Routing

Cellular Antenna Replacement



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Factory installation is shown.

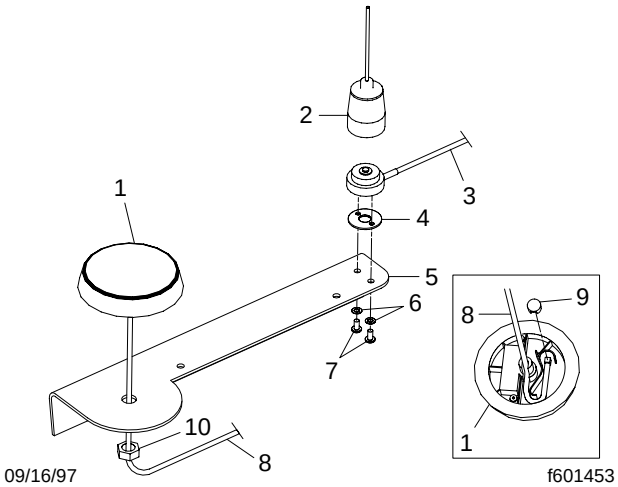
1. Cable Nuts
2. Cab Skin
3. GPS Cable
4. Cellular Cable
5. Through-Skin Fittings

Fig. 4, Back of Cab Cable Pass-Through

6. Connect the batteries and restore the cab to normal operating condition.
7. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.
8. Remove the chocks from the tires.

Replacement

The HighwayMaster® GPS (global positioning system) antenna is normally installed on the back of the cab. On factory installations, it is on the rear cab wall on a shared bracket with GPS antenna (see **Fig. 1**); on aftermarket installations, it is on the raised roof rib (see **Fig. 2**).

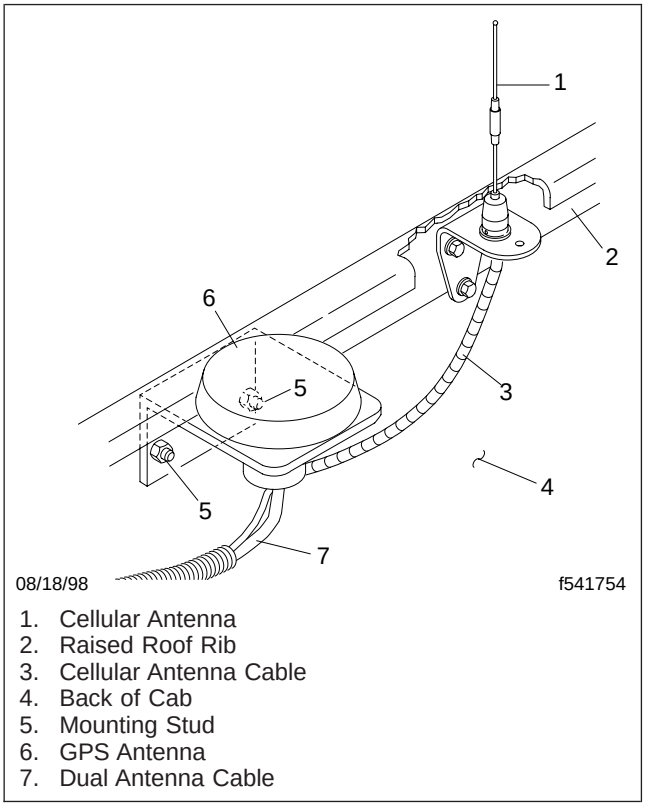


NOTE: The insert shows a bottom view of the antenna.

1. GPS Antenna
2. Cellular Antenna
3. Cellular Antenna Cable
4. Spacer
5. Mounting Bracket
6. #10 Washers
7. 10–32 Machine Screws
8. GPS Cable
9. Rubber Cable Cap
10. M12 Nylon Hexnut

Fig. 1, GPS Antenna (factory installation)

1. Set the parking brake, chock the tires, and disconnect the batteries.
2. Loosen the M12 nylon hexnut from the GPS antenna bracket. Remove the antenna.
3. Turn over the new antenna and install the rubber cable cap on end of the GPS antenna cable.
4. Install the new antenna. Make sure the M12 nylon hexnut is firm and tight.



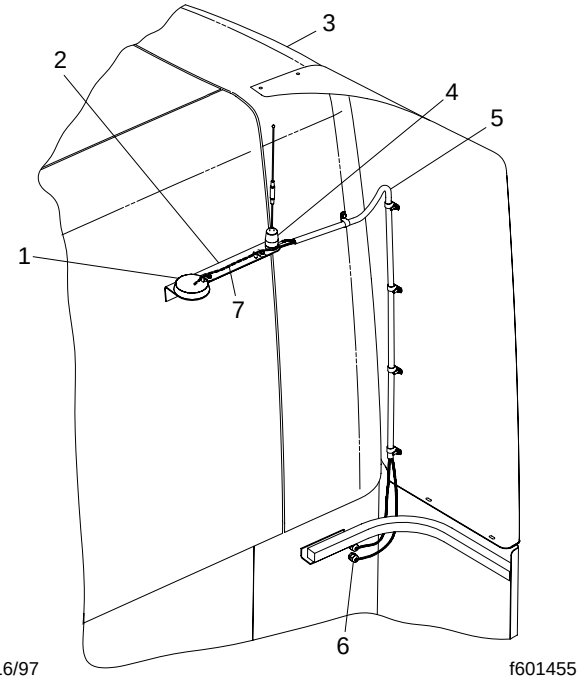
1. Cellular Antenna
2. Raised Roof Rib
3. Cellular Antenna Cable
4. Back of Cab
5. Mounting Stud
6. GPS Antenna
7. Dual Antenna Cable

Fig. 2, GPS Antenna (aftermarket installation)

IMPORTANT: Check the cable insulation for signs of heat damage and rout it away from the stacks if necessary.

5. Check the cellular antenna cable for good connections at both ends. See **Fig. 3**.
6. Check the through-skin fittings for tightness and proper fit. See **Fig. 4**.
7. Connect the batteries and restore the cab to normal operating condition.
8. Place a voice call. Test the system for correct operation, including the hands-free microphone, volume control, and voice recognition, and make adjustments as needed. For more information, see **Troubleshooting, 300**.
9. Remove the chocks from the tires.

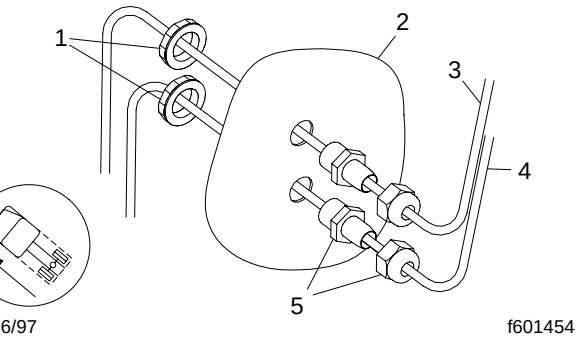
GPS Antenna Replacement



Factory installation is shown.

1. GPS Antenna
2. Mounting Bracket
3. Roof Cap
4. Cellular Antenna
5. Dual Antenna Cable
6. Through-Skin Fittings
7. GPS Cable

Fig. 3, Antenna Cable Routing



Factory installation is shown.

1. Cable Nuts
2. Cab Skin
3. GPS Cable
4. Cellular Cable
5. Through-Skin Fittings

Fig. 4, Back of Cab Cable Pass-Through

Troubleshooting

When the engine is started, the HighwayMaster system goes into its start-up cycle. When the system is functioning properly, it goes through the following steps:

1. The display shows the underline prompt (_).
2. The display reads "Checking Cellular Service" and then changes to "Registering Unit for Service."
3. Once the unit has been registered, the display reads either "HighwayMaster Service Area" (if you are in an area where HighwayMaster provides cellular coverage) or "HighwayMaster" (if you are out of the coverage area).
4. When fully operational, the handset is illuminated and the display shows from three to seven bars.

Use this cycle as a diagnostic check. If the system does not go through all of these steps, see the appropriate troubleshooting table below.

Problem—The HighwayMaster System Has No Power

Problem—The HighwayMaster System Has No Power	
Possible Cause	**Remedy**
The vehicle is not running.	With the transmission in neutral and the parking brake set, start the engine and check to see if the system goes through the complete start-up cycle.
The circuit breaker is blown or missing.	Check the 10-amp circuit breaker in the electrical power center connected to the white wire in the power cable. Replace any damaged components.
There are loose connections.	Carefully check all of the connections on the power, phone, display, speaker, and both antenna cables. Connect as necessary.
The power cable needs replacing.	Disconnect the power cable from the electrical power center. Then disconnect the power cable from the control unit. With the power cable reconnected to the electrical power center, turn the ignition keyswitch on. See **Fig. 1** and **Fig. 2**. Now insert the negative lead of a digital voltmeter into the right-hand cavity on the connector. Insert the positive lead into another cavity, and check for voltage. When finished, check the other end of the cable. If the voltage at either end reads less than 11 volts, or more than 13.5 volts, replace the power cable.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The HighwayMaster System Has Intermittent Power

Problem—The HighwayMaster System Has Intermittent Power	
Possible Cause	**Remedy**
The circuit breaker is loose or defective.	Check the 10-amp circuit breaker in the electrical power center connected to the white wire in the power cable. Replace any damaged components.
There are loose connections.	Carefully check all of the connections on the power, phone, display, speaker, and both antenna cables. Repair/replace as necessary.
The power cable needs replacing.	Disconnect the power cable from the electrical power center. Then disconnect the power cable from the control unit. With the power cable reconnected to the electrical power center, turn the ignition keyswitch on. See **Fig. 1** and **Fig. 2**. Now insert the negative lead of a digital voltmeter into the right-hand cavity on the connector. Insert the positive lead into another cavity, and check for voltage. When finished, check the other end of the cable. If the voltage at either end reads less than 11 volts, or more than 13.5 volts, replace the power cable.

Troubleshooting

Problem—The HighwayMaster System Has Intermittent Power	
Possible Cause	**Remedy**
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—When the Ignition Keyswitch Is Turned Off, the HighwayMaster System Also Turns Off

Problem—When the Ignition Keyswitch Is Turned Off, the HighwayMaster System Also Turns Off	
Possible Cause	**Remedy**
The power off delay is not set or is set to 0.	Call the host operator to set the delay to the desired time, from 1 to 12 hours.
There are loose connections in the phone cables.	Disconnect the power cable from the electrical power center. Now disconnect and reconnect the phone cables, making sure the connectors seat properly. See **Fig. 3** and **Fig. 4**. Reconnect the power cable to the electrical power center.
The power plug is installed incorrectly.	Check the installation of the power plug and reposition it if necessary.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The Handset Does Not Illuminate

Problem—The Handset Does Not Illuminate	
Possible Cause	**Remedy**
The handset is not correctly connected to the pickup.	Turn the unit off. Check the connection of the handset cord to the pickup and turn the unit back on.
There are loose connections in the phone cables.	Disconnect the power cable from the electrical power center. Now disconnect and reconnect the phone cables, making sure the connectors seat properly. See **Fig. 3** and **Fig. 4**. Reconnect the power cable to the electrical power center.
The handset is broken.	Turn the unit off. Replace the handset with a spare handset and turn the unit back on. If the handset now illuminates, replace the handset. See **Subject 110** for detailed instructions.
The phone cable assembly needs replacing.	Disconnect the power cable from the electrical power center. Now connect a spare phone cable assembly, making sure the connectors seat properly. See **Fig. 3** and **Fig. 4**. Reconnect the power cable to the electrical power center. If the handset now illuminates, replace the phone cable assembly.

Problem—The Keypad on the Handset Does Not Function

Problem—The Keypad on the Handset Does Not Function	
Possible Cause	**Remedy**
The handset is damaged.	Check the handset for physical damage, disconnected wires, and broken seals.
There are sticky keys in the keypad.	Try several keys to see if any key responds. If some keys respond but others do not, clean the keypad. Turn the unit off. Spray on some contact cleaner and wipe off the keypad until it is dry. Turn the unit back on and check the keys again. Repeat if necessary.

Problem—The Keypad on the Handset Does Not Function	
Possible Cause	**Remedy**
The handset is broken.	Turn the power off. Replace the handset with a spare handset and turn the power back on. If the handset now illuminates, replace the handset. See **Subject 110** for detailed instructions.
The phone cable assembly needs replacing.	Disconnect the power cable from the electrical power center. Now connect a spare phone cable assembly, making sure the connectors seat properly. See **Fig. 3** and **Fig. 4**. Reconnect the power cable to the electrical power center. If the handset now illuminates, replace the phone cable assembly.

Problem—The Display Is Blank, but the Handset and Control Unit Have Power

Problem—The Display Is Blank, but the Handset and Control Unit Have Power	
Possible Cause	**Remedy**
The screen saver is set to a short period of time.	On the handset, press "F" (function) and "Send." Use the arrow key to move down the menu to get to "Set Screen Saver Timer." Enter any number from 1 to 240 to change the number of minutes before the display goes blank.
There are loose connections in the display cables.	Disconnect the power cable from the electrical power center. Now disconnect and reconnect the display cables, making sure the connectors seat properly. See **Fig. 5** and **Fig. 6**. Reconnect the power cable to the electrical power center.
The display cable assembly needs replacing.	Disconnect the circuit breaker. Now connect a spare display cable, making sure the connectors seat properly. See **Fig. 5** and **Fig. 6**. Reconnect the circuit breaker. If the display now works, replace the display cable assembly.
The display unit is broken.	Replace the display unit. See **Subject 120** for detailed instructions.

Problem—The Display Shows Only the Underline Prompt (_)

Problem—The Display Shows Only the Underline Prompt (_)	
Possible Cause	**Remedy**
The screen saver is set to a short period of time.	On the handset, press "F" (function) and "Send." Use the arrow key to move down the menu to get to "Set Screen Saver Timer." Enter any number from 1 to 240 to change the number of minutes before the display goes blank.
There are loose connections in the display cables.	Disconnect the circuit breaker. Now disconnect and reconnect the display cables, making sure the connectors seat properly. See **Fig. 5** and **Fig. 6**. Reconnect the circuit breaker.
The display unit is broken.	Replace the display unit. See **Subject 120** for detailed instructions.
The display cable assembly needs replacing.	Disconnect the circuit breaker. Now connect a spare display cable, making sure the connectors seat properly. See **Fig. 5** and **Fig. 6**. Reconnect the circuit breaker. If the display now works, replace the display cable assembly.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Troubleshooting

Problem—The Display Shows Only the "HighwayMaster" Message

Problem—The Display Shows Only the "HighwayMaster" Message	
Possible Cause	**Remedy**
The vehicle is outside the coverage area.	The display is functioning correctly. Move the vehicle to a covered area and the message will change to "HighwayMaster Service Area."
The cellular antenna is missing.	Replace the cellular antenna, making sure the tab is bent down enough to make contact with the antenna base. See **Subject 150** for detailed instructions.
The cellular antenna connector is broken.	Inspect the connector (at the control unit) for damage. Replace the connector, and check the display again. See **Fig. 7**. If the display is still not correct, ask Customer Care (1–800–647–6693) to download a SID table.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The Display Gives Scrambled Information

Problem—The Display Gives Scrambled Information	
Possible Cause	**Remedy**
The system needs to be restarted.	Call Customer Care at 1–800–647–6693 and request a remote restart. Remove power from the system for one minute. Reconnect the power and reinitialize the control unit. See **Subject 100** for detailed instructions.

Problem—The Microphone Does Not Work, Or Broadcasts Noise

Problem—The Microphone Does Not Work, Or Broadcasts Noise	
Possible Cause	**Remedy**
There is interference from wind, or other electrical sources.	Check the microphone with the window rolled up and all electrical appliances off.
The connection with the display cable is bad.	Check the connection with the display cable and make sure it is properly connected. For a more secure connection, wrap electrical tape around the connector.
The microphone wire is damaged.	Check the microphone wire for damage. Replace the microphone if any is found. See **Subject 130** for detailed instructions. Test the system again with the new microphone installed.
The display cable assembly needs replacing.	Disconnect the circuit breaker. Now connect a spare display cable, making sure the connectors seat properly. See **Fig. 5** and **Fig. 6**. Reconnect the circuit breaker. If the display now works, replace the display cable assembly.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The Speaker Does Not Work

Problem—The Speaker Does Not Work	
Possible Cause	**Remedy**
The handset is not properly seated in the cradle.	Check that the handset is seated properly. Turn the power on, and press the "End" button. If the speaker is operating, it will respond by saying "Ready."

Problem—The Speaker Does Not Work	
Possible Cause	**Remedy**
The display unit is broken.	Disconnect the circuit breaker. Now connect a spare display unit. Reconnect the circuit breaker, and press the "End" button. If the speaker now operates, replace the display unit. See **Subject 120** for detailed instructions.
The display cable assembly needs replacing.	Disconnect the circuit breaker. Now connect a spare display cable, making sure the connectors seat properly. See **Fig. 5** and **Fig. 6**. Reconnect the circuit breaker, and press the "End" button. If the speaker now operates, replace the display cable assembly.
The voice recognition system in the control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The GPS (Satellite) System Does Not Provide Actual Position Data, or Provides It Infrequently

Problem—The GPS (Satellite) System Does Not Provide Actual Position Data, or Provides It Infrequently	
Possible Cause	**Remedy**
The system has not reached "NAV" status.	On the handset keypad, enter "589200," followed by "CHK." When the display reads "GPS HAS REACHED NAV STATUS," call the host operator and ask for an actual position on the vehicle. If the operator still does not have an actual, ask for an **immediate data exchange (F2)** to download the data.
There are loose connections on the GPS antenna.	Check all of the antenna connections for condition. See **Fig. 8**. Repair/replace as necessary.
The GPS antenna and/or cable is damaged.	Check the GPS antenna and cable for damage. Repair or replace any damaged parts as necessary. On the handset keypad, enter "589200," followed by "CHK." When the display reads "GPS Has Reached NAV Status," call the host operator and ask for an actual position on the vehicle. If the operator still does not have an actual, ask for an **immediate data exchange (F2)** to download the data.
The HighwayMaster system is not registered properly.	Call Customer Care at 1–800–647–6693 to check the registration status of the system.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The HighwayMaster System Does Not Receive Status Codes or Authorized Numbers

Problem—The HighwayMaster System Does Not Receive Status Codes or Authorized Numbers	
Possible Cause	**Remedy**
The registration codes were never entered.	On the handset keypad, enter "STO," "99," and "SEND." When the display reads "HighwayMaster Service Area," enter "STO," and "01." Keep repeating this step until the Display reads "Transmission Successful." Check the status codes by entering "STO" "01," and the up arrow (↑) to scroll through the codes. Similarly, check the authorization numbers by entering "RCL," "#," "01," and the up arrow (↑) to scroll through the numbers.
The control unit has not been initialized.	Call the host operator to request initialization and repeat the procedure above.

Troubleshooting

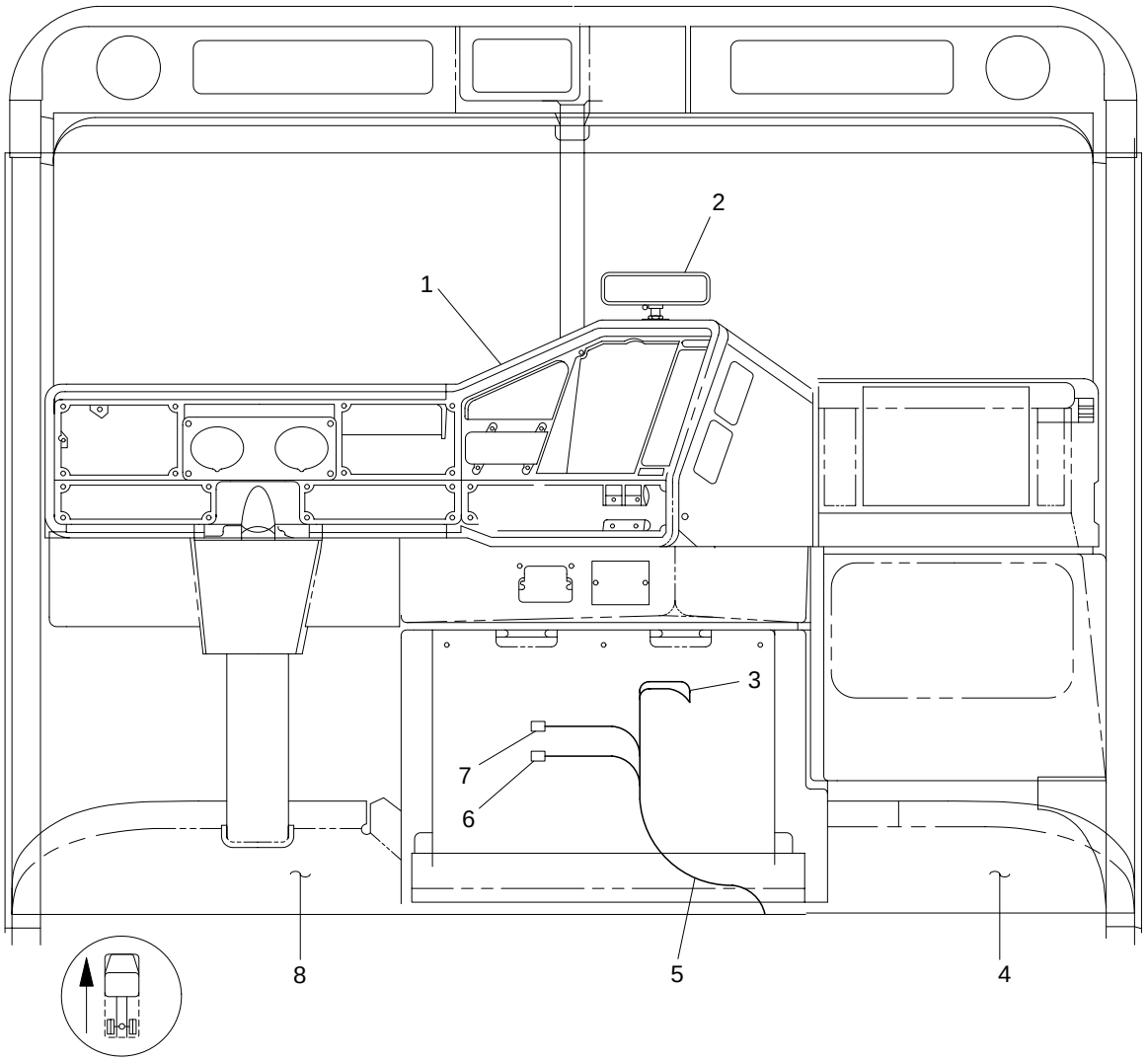
Problem—The HighwayMaster System Does Not Receive Status Codes or Authorized Numbers	
Possible Cause	**Remedy**
The HighwayMaster system is not registered properly.	Call Customer Care at 1–800–647–6693 to check the registration status of the system.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The HighwayMaster System Will Not Power Off

Problem—The HighwayMaster System Will Not Power Off	
Possible Cause	**Remedy**
The power off delay has been set.	Call the host operator to reset the delay.
The electrical connections are not in the correct place.	Check all the electrical connections from the auxiliary power distribution module to the control unit. Repair/ replace as necessary.
The control unit is broken.	Replace the control unit. See **Subject 100** for detailed instructions.

Problem—The Driver Is Unable To Call Personal Numbers

Problem—The Driver Is Unable To Call Personal Numbers	
Possible Cause	**Remedy**
The driver does not have a valid AT & T calling card.	Ask the driver to call AT & T to obtain a valid calling card.
The personal calling feature is not active.	Call Customer Care at 1–800–647–6693 and ask them to active the personal calling feature.



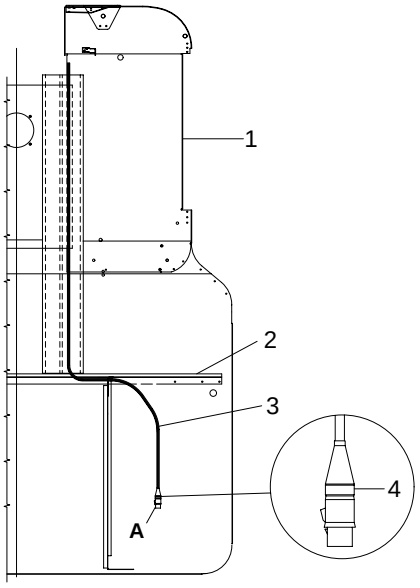
09/16/97

f541642

1. Dash Console
2. Display Unit
3. Ground
4. R/H Footwell
5. Power Cable
6. White Wire (IGN bus)
7. Red Wire (BAT bus)
8. L/H Footwell

Fig. 1, Power Cable Routing (dash)

Troubleshooting



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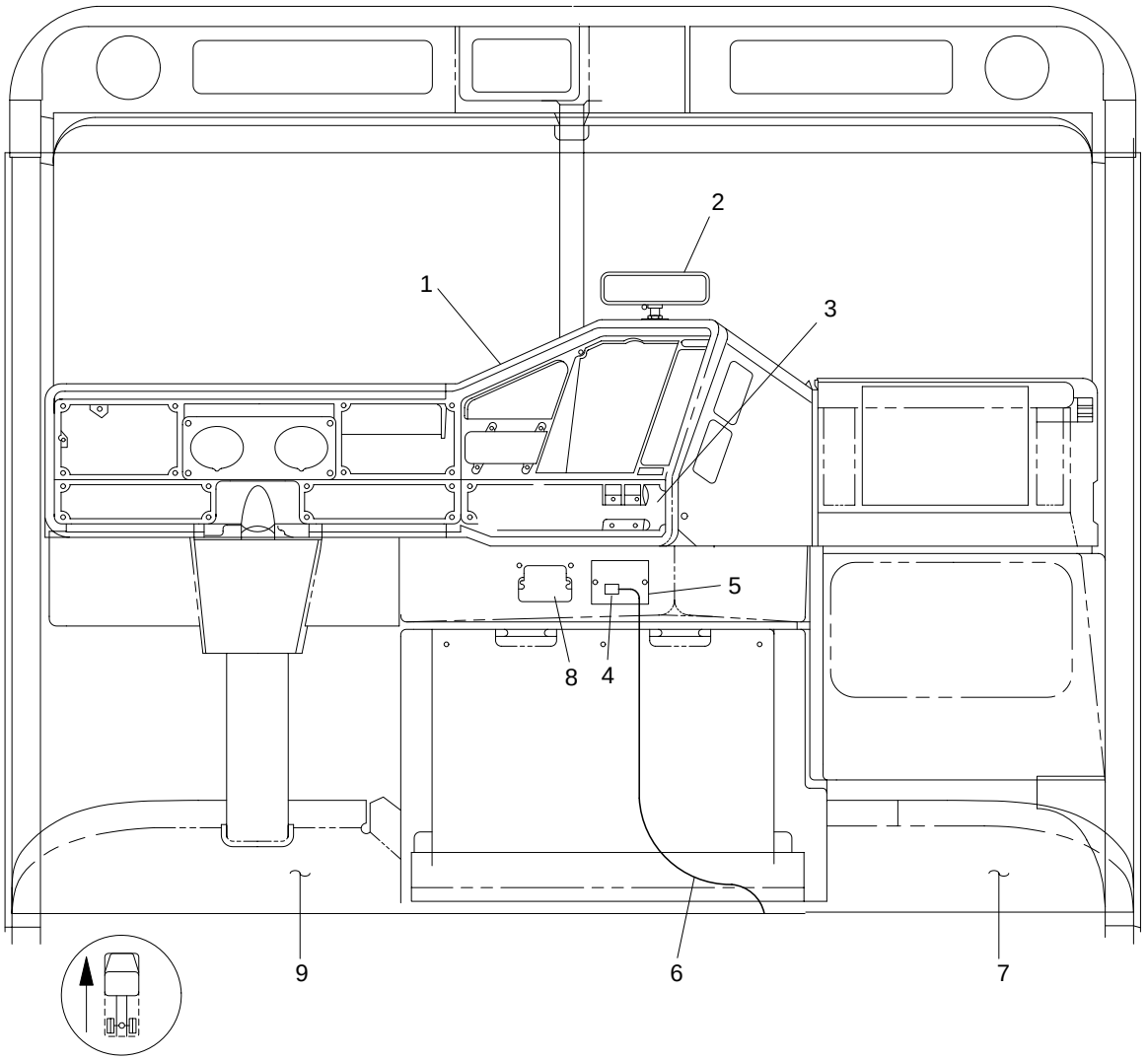
A. To Control Unit

1. R/H Cab Deck
2. Forward Bunk Partition
3. Power Cable
4. 3-Pin Connector

Fig. 2, Power Cable Routing (cab)



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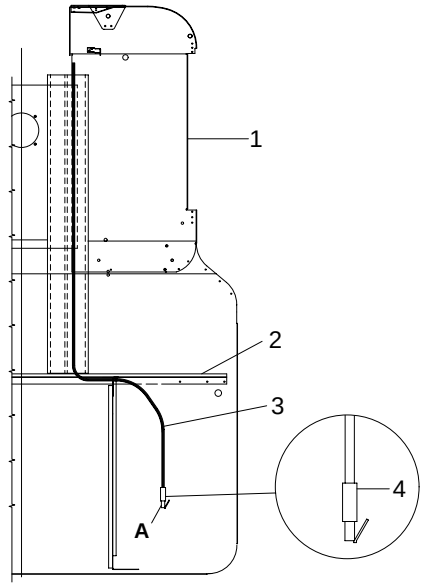
1. Dash Console
2. Display Unit
3. HVAC Panel
4. R/H Footwell
5. Speaker
6. Phone Cable
7. Phone Plug
8. Handset Cradle
9. L/H Footwell

Fig. 3, Phone Cable Routing (dash)

Troubleshooting

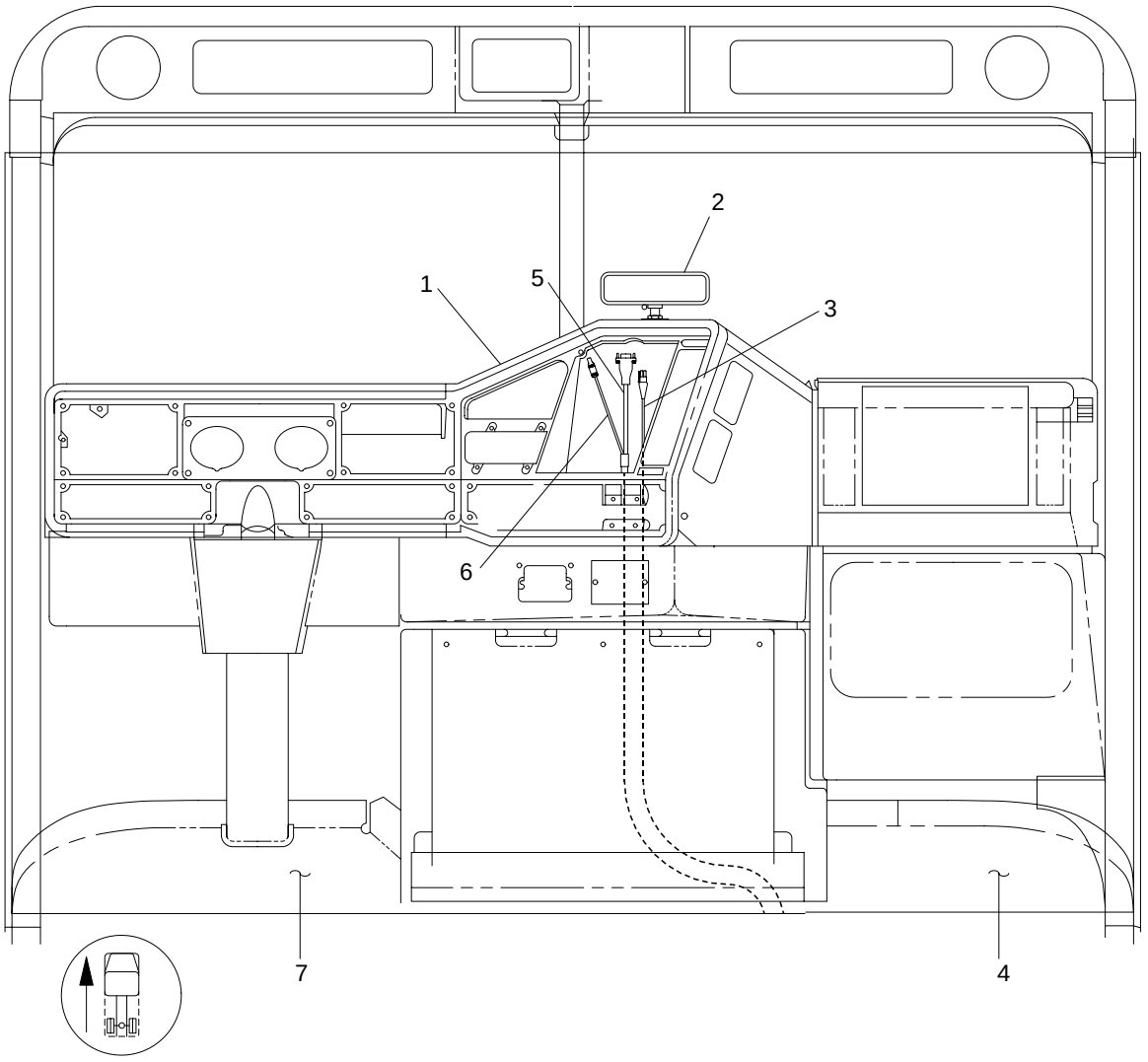


04/16/97 f541644

A. To Control Unit

1. R/H Cab Deck
2. Forward Bunk Partition
3. Phone Cable
4. Phone Connector

Fig. 4, Phone Cable Routing (cab)



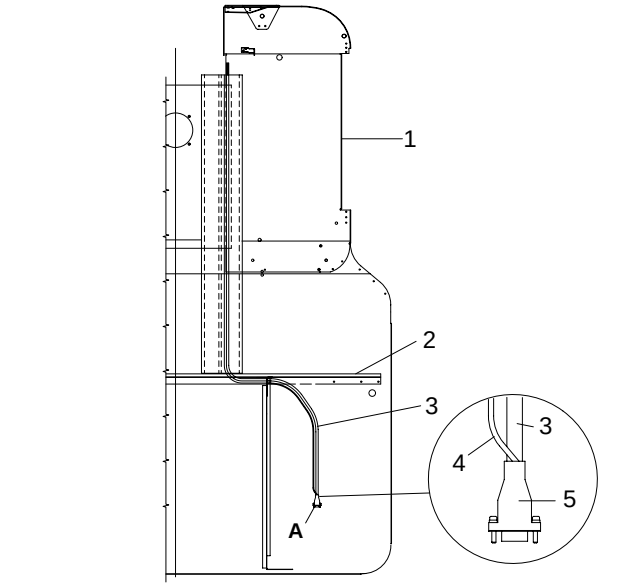
04/16/97

f541648

1. Dash Console
2. Display Unit
3. Speaker Cable
4. R/H Footwell
5. Display Cable
6. Microphone Cable
7. L/H Footwell

Fig. 5, Display and Microphone Cable Routing (dash)

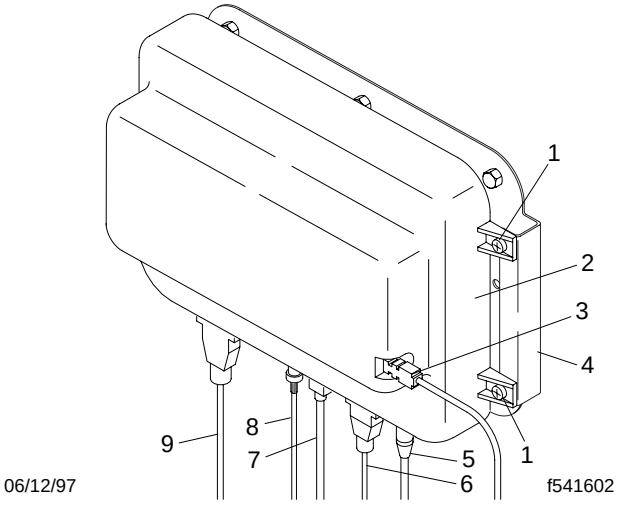
Troubleshooting



A. To Control Unit

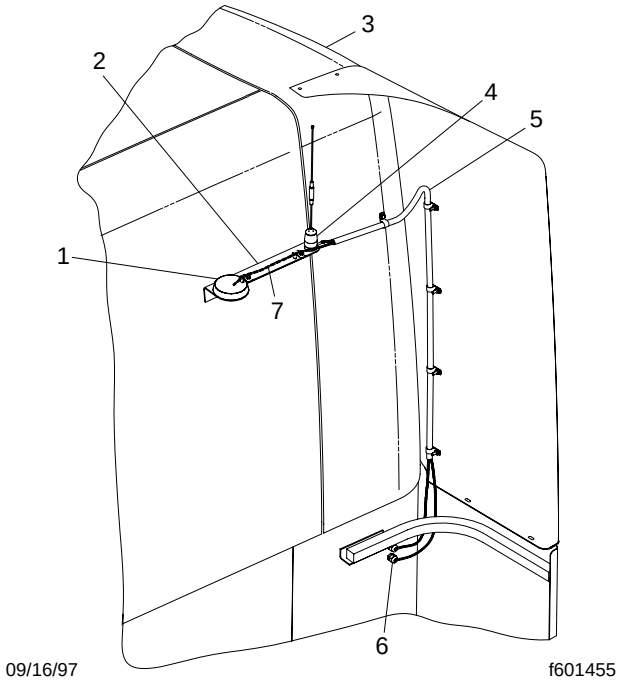
1. R/H Cab Deck
2. Forward Bunk Partition
3. Display Cable
4. Speaker Cable
5. 9-Pin Connector

Fig. 6, Display and Speaker Cable Routing (cab)



1. SEM Screw
2. Control Unit
3. Cellular Antenna Cable
4. Mounting Plate
5. Power Cable
6. Display Cable
7. Phone Cable
8. GPS Antenna Cable
9. Datalink Cable

Fig. 7, Control Unit Cable Connections



Factory installation is shown.

1. GPS Antenna
2. Mounting Bracket
3. Roof Cap
4. Cellular Antenna
5. Dual Antenna Cable
6. Through-Skin Fittings
7. GPS Cable

Fig. 8, Antenna Cable Connections

For a drawing of the power cable, see **Fig. 1**.

For a schematic of the power cable wiring, see **Fig. 2**.

For a drawing of the phone cable, see **Fig. 3**.

For a drawing of the display cable, see **Fig. 4**.

For a schematic of the datalink cable, see **Fig. 5**.

For a schematic of the HighwayMaster system wiring, see **Fig. 6**.

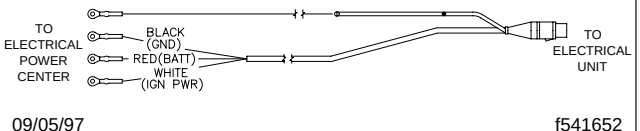


Fig. 1, HighwayMaster Power Cable

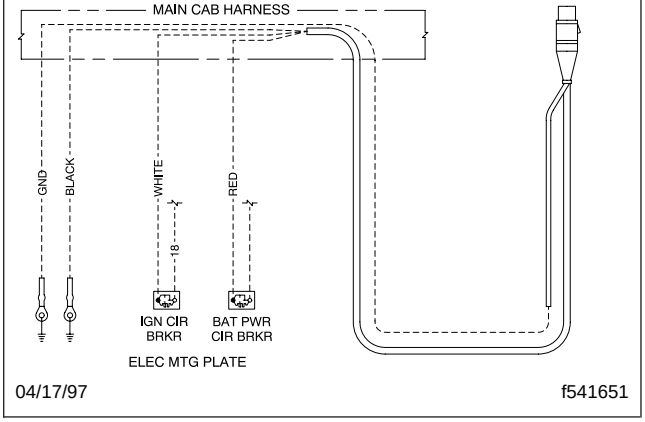
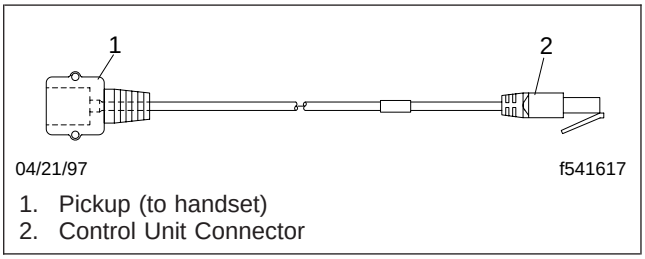
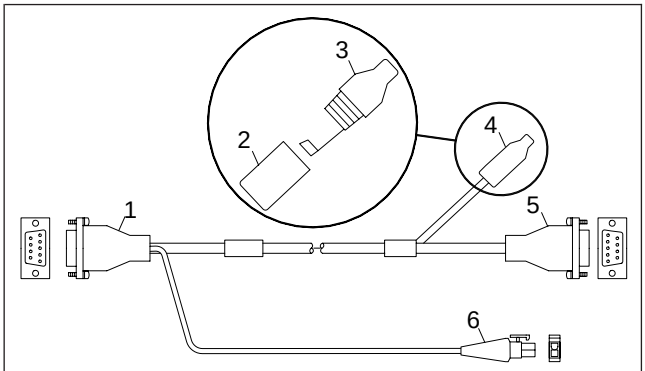


Fig. 2, HighwayMaster Power Cable Wiring Schematic



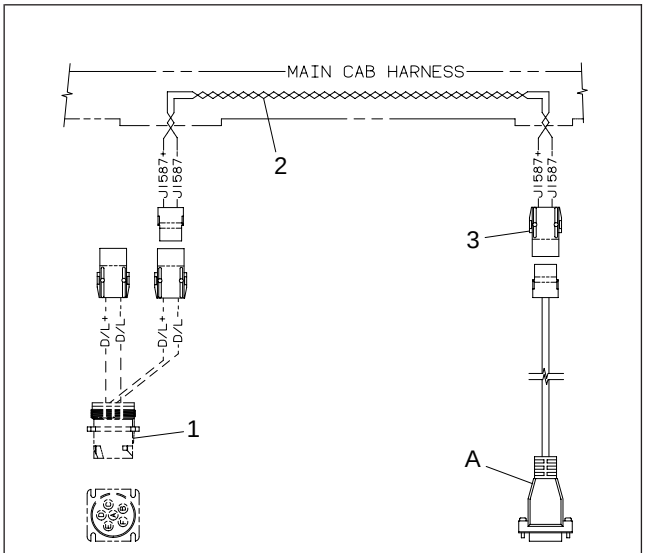
1. Pickup (to handset)
2. Control Unit Connector

Fig. 3, HighwayMaster Phone Cable



1. Control Unit Connector
2. Sleeve
3. Sleeve Terminal
4. Microphone Connector
5. Display Unit Connector
6. Speaker Connector

Fig. 4, HighwayMaster Display Cable



A. To Control Unit
1. Diagnostic Connector
2. Datalink Harness
3. Harness Connector

Fig. 5, HighwayMaster Datalink Cable

Specifications

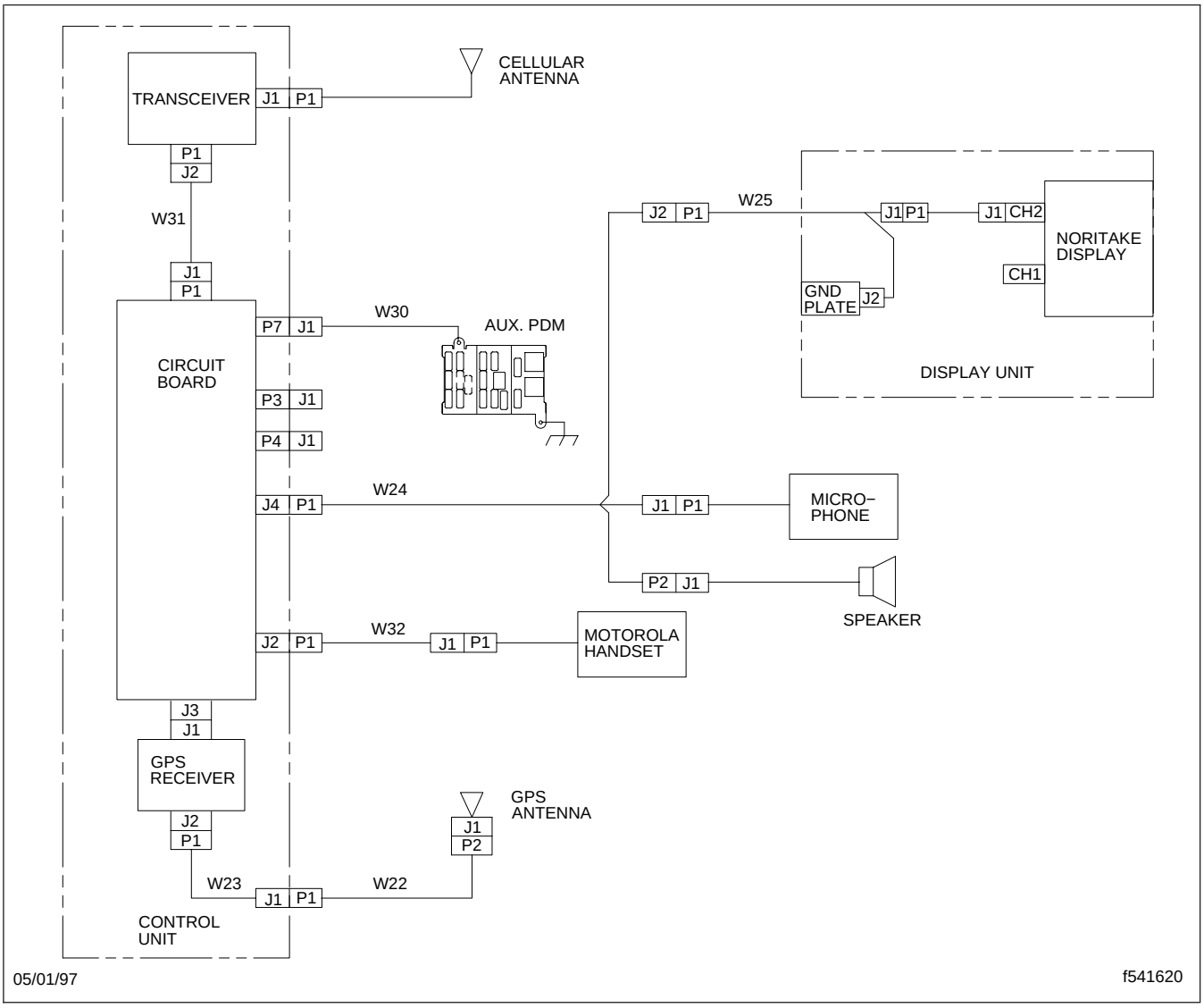
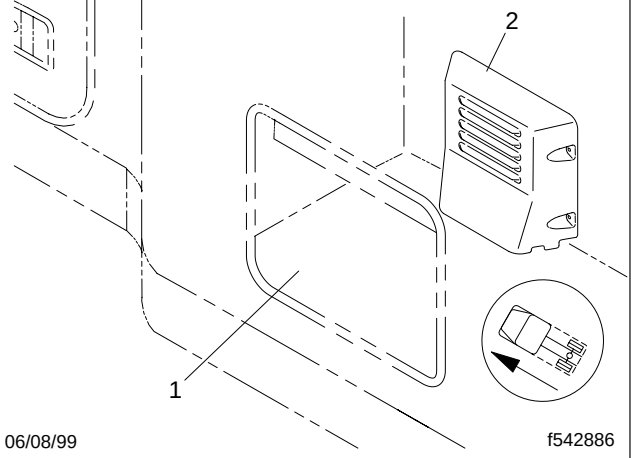


Fig. 6, HighwayMaster Wiring Schematic

General Information

The optional low voltage disconnect (LVD) module is mounted inside the driver's side exterior baggage compartment, against the back wall. The module is protected by a molded plastic cover. See **Fig. 1**.



1. Baggage Compartment Door Opening
2. Low Voltage Disconnect Cover

Fig. 1, Low Voltage Disconnect Mounting

The low voltage disconnect module monitors battery voltage levels. If battery voltage falls below 12.3 volts, the LVD module will sound a warning buzzer for one minute. If no action is taken within that time, the LVD module will remove power to predetermined cab and sleeper circuits and an LED indicator on the module will be illuminated.

The LVD module will turn off power to the following main cab circuits (if installed):

- CB power (circuit 295C)
- Cigar lighter (circuit 5)
- Dome, reading and map lights (circuits 41, 108A, and 109A)
- Extra dash switches (circuit Opt.)
- Locating and positioning system (circuit 427A)
- Mirror heat and power (circuit 80 and 157)
- Power windows (circuit 363R and 363L)
- Radio power (circuit 295B)
- Road lights (circuit 28D)
- Utility lights (circuit 73)

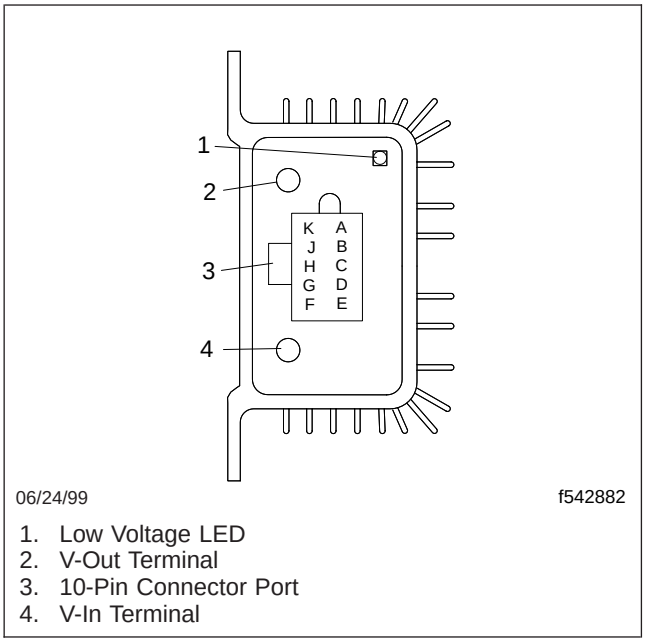
The LVD module will turn off power to the following sleeper circuits:

- Baggage compartment lights (circuit 113)
- Dome and reading lights (circuit 41/41J)
- Power receptacles (circuits 57A, 57B, 57S, and 416)
- Refrigerator/cooler power (circuit 57B)

Once battery voltage reaches 13 volts, or if the vehicle is started, the LVD module will automatically reconnect power to the predetermined circuits.

The LVD module incorporates a 60-second time delay to prevent false triggering and is equipped with internal short circuit protection, over current protection, transient voltage suppression, and thermal protection.

The LVD module has two terminal post connections, a 10-pin connector port, and an LED indicator, all mounted on the side of the module. See **Fig. 2**.



1. Low Voltage LED
2. V-Out Terminal
3. 10-Pin Connector Port
4. V-In Terminal

Fig. 2, Low Voltage Disconnect Module (side view)

The two terminal post connections are V-in and V-out. The V-in terminal (circuit 447) is the voltage supply input from the circuit breaker/relay panel, and protects the LVD module by passing through a 50-amp circuit breaker. The V-out terminal (circuit 447H)

General Information

is the controlled voltage output from the LVD module to the ISO bus power input terminal of the circuit breaker/relay panel (predetermined cab and sleeper circuits). It also supplies power to the warning buzzer (circuit 447J).

The 10-pin connector contains circuit 447B, which is connected to the battery, and is used by the LVD module to monitor the level of battery voltage. It contains the module's ground circuit (GND), also connected to the battery; and it contains the warning buzzer circuit (447G), which sounds the warning buzzer when the LVD module detects low voltage.

Low Voltage Disconnect Module Removal and Installation

Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the tires.
2. Disconnect the batteries.
3. Open the exterior baggage compartment door on the left hand side, aft of the door. The low voltage disconnect module is located behind the protective plastic cover mounted on the back wall. See **Fig. 1**.
4. Unfasten the four Torx® head fasteners and remove the protective plastic cover.

CAUTION

To prevent damage to the low voltage disconnect module, remove the ground wire from the ground terminal last.

5. Remove the low voltage disconnect module.
   - 5.1 Note the position of the wiring on the terminals and remove the wiring from the screw terminals on the side of the low voltage disconnect module. See **Fig. 2**.
   - 5.2 Remove the six mounting fasteners, three above and three below the module, from the baggage compartment backwall, and remove the low voltage disconnect module.

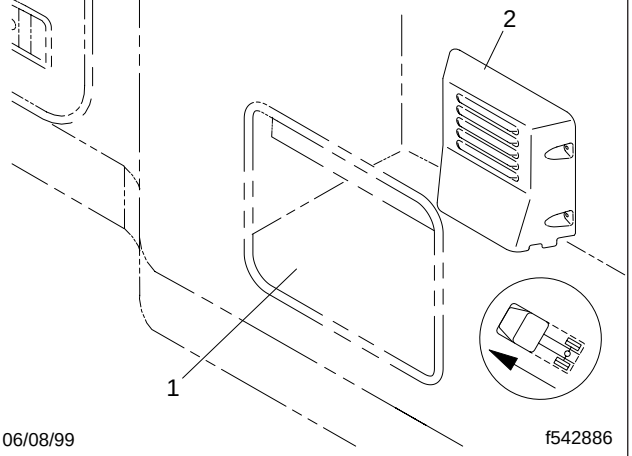
Installation

1. Install the low voltage disconnect module inside the left-hand exterior baggage compartment, against the backwall.
   - 1.1 Place the module against the backwall and install the six Torx-head fasteners. Tighten them firmly.

CAUTION

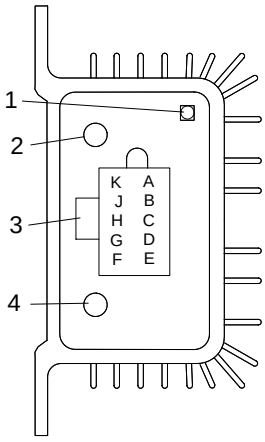
To prevent damage to the low voltage disconnect module, connect the ground wire to the ground terminal first.

   - 1.2 Install the wiring to the terminals on the top of the low voltage disconnect module. See **Fig. 2**.
2. Attach the protective plastic cover to the backwall with four Torx-head fasteners.
3. Close the baggage compartment door.
4. Connect the batteries.
5. Remove the chocks from the tires.



1. Baggage Compartment Door Opening
2. Low Voltage Disconnect Cover

Fig. 1, Low Voltage Disconnect Mounting



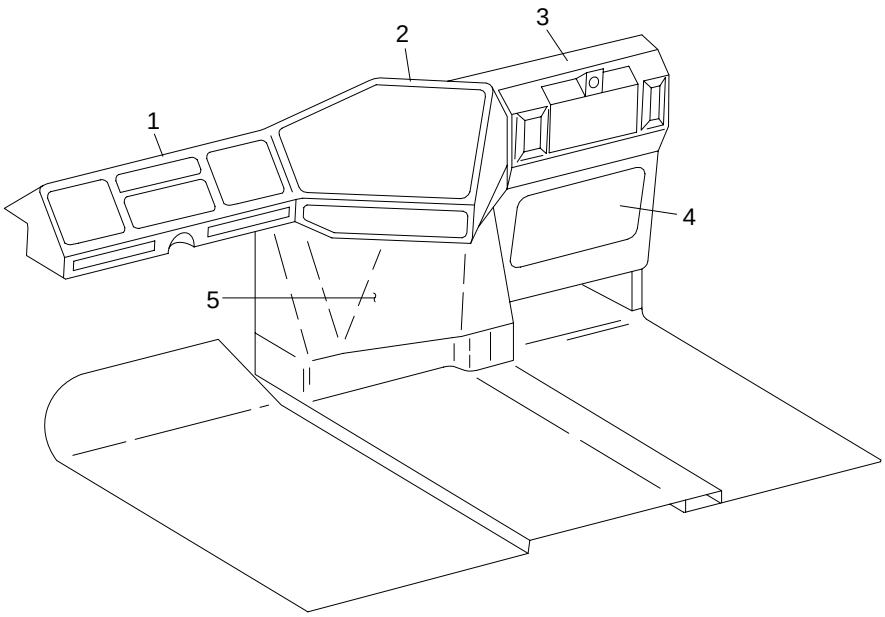
1. Low Voltage LED
2. V-Out Terminal
3. 10-Pin Connector Port
4. V-In Terminal

Fig. 2, Low Voltage Disconnect Module (side view)

Low Voltage Disconnect Warning Buzzer Removal and Installation

Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the tires.
2. Disconnect the batteries.
3. Remove the electrical center cover. See **Fig. 1**.



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1. Driver's Instrument Panel
2. Center Dash Panel
3. Glove Compartment
4. Heater–A/C Cover
5. Electrical Center Cover

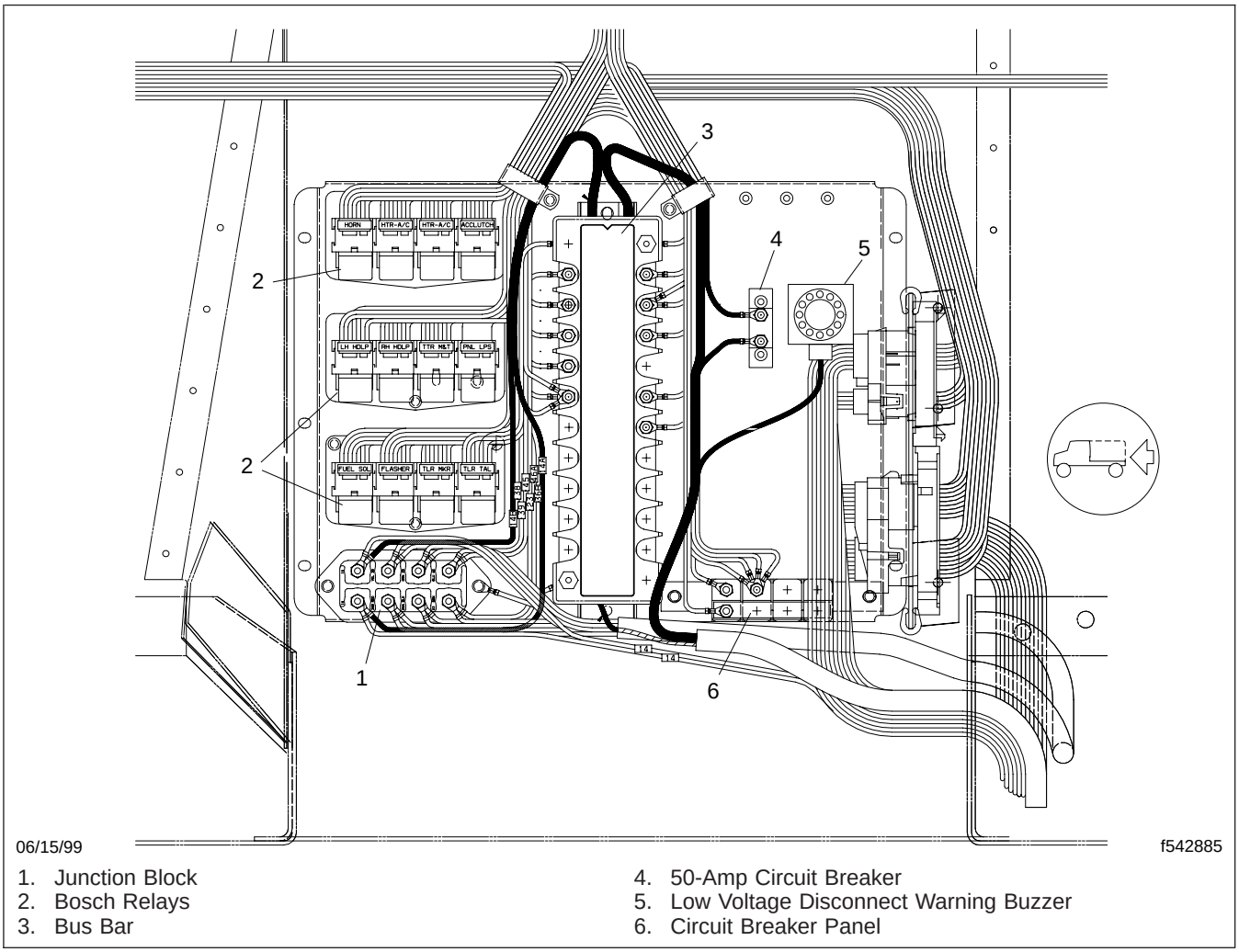
Fig. 1, Dash Panel

4. Remove from the circuit breaker/relay panel the two mounting fasteners that hold the low voltage disconnect warning buzzer, and remove the buzzer. The buzzer can be mounted anywhere on the panel. See **Fig. 2**.
5. Remove the electrical connector from the low voltage disconnect warning buzzer.

Installation

1. Attach the electrical connector to the low voltage disconnect warning buzzer.
2. Install the warning buzzer in the space available on the circuit breaker/relay panel, using two standard hardware fasteners. See **Fig. 2**. Tighten the fasteners firmly.
3. Attach the electrical center cover. See **Fig. 1**.
4. Connect the batteries and remove the chocks from the tires.

Low Voltage Disconnect Warning Buzzer Removal and Installation



1. Junction Block
2. Bosch Relays
3. Bus Bar
4. 50-Amp Circuit Breaker
5. Low Voltage Disconnect Warning Buzzer
6. Circuit Breaker Panel

Fig. 2, Circuit Breaker Relay Panel

Functional Test

NOTE: If the LVD deactivates (removes power to the cab/sleeper loads), it needs to be reset prior to performing a functional test. If the batteries are discharged below 12.3 volts, charge the batteries before performing any troubleshooting procedures. The LVD can be reset by starting the engine. Once the LVD senses 13.1 volts or more, it resets automatically.

1. Shut down the engine.
2. Unplug the 10-position connector from the LVD.
3. Remove wire 447B from cavity E on the connector, and wrap a small piece of electrical tape around the exposed wire.
4. Insert the plug into the LVD with wire 447B still removed.

NOTE: The red LED indicator light on the LVD should turn ON when the connector is inserted.

5. Insert a metal conducting probe into cavity E of the connector, making sure contact is made between the metal probe and pin E on the LVD.
6. Connect a jumper wire between the terminal on wire 447B and the test probe inserted in cavity E.

NOTE: The electrical loads such as dome lights will remain OFF even though an electrical connection exists between circuit 447B and pin E. The LVD needs to be reset after removing the plug from the LVD.

7. Reset the LVD by starting the engine. The dome lights should come back ON, and the red LED indicator light on the LVD should turn OFF.
8. Shut down the engine.
9. Remove the metal test probe from cavity E.

NOTE: After removing the test probe, there will be a delay before the LVD disconnects the cab/sleeper loads. If equipped with the optional warning buzzer, it will sound for 60 seconds. After the time delay, the cab/sleeper loads (dome lights, for example) will shut OFF, and the optional warning buzzer will shut OFF.

10. Disconnect the jumper wire from 447B.
11. Remove the 10-position connector from the LVD.
12. Insert wire 447B into cavity E of the connector.
13. Insert the connector into the LVD.
14. Start the engine to reset the LVD.
15. If the LVD does not operate properly after performing the functional test, perform the troubleshooting procedures in this subject.

Troubleshooting Table

Low Voltage Disconnect System

Refer to **Table 1** to troubleshoot the low voltage disconnect system.

NOTE: The warning alarm is an option that is not present on all vehicles. Verify that the vehicle has the warning alarm option. Some LVD modules are designed to disconnect at 12.3 volts. Check the option code to find out which model is under test.

Low Voltage Disconnect System Malfunctions	
Possible Cause	**Remedy**
Voltage goes below 12.1 volts without the LVD disconnecting.	See **Table 2**.
The LVD system is always activated – no power on the ISO terminal of the Electrical Center.	See **Table 3**.
LVD System Cuts Power to Accessories when the Key is in the OFF Position.	See **Table 4**.
No warning alarm operation when LVD activates.	See **Table 5**.

Table 1, Low Voltage Disconnect System Malfunctions

Troubleshooting

Voltage Goes Below 12.1 Volts Without the LVD Disconnecting			
Step	**Test Procedure**	**Test Result**	**Action**
1	Test the voltage at the BATT terminal on the Electrical Center. Is the voltage at or below 12.1 volts?	Yes	Go to step 2.
		No	Without starting the engine, turn the headlights on, and as many electrical loads as manageable, to draw the batteries down. As the voltage drops to/below 12.1 volts, go to step 2.
2	Is the LED on the LVD module illuminated steady or flashing?	Flashing	Monitor the voltage at the ISO terminal of the PDM for the next two minutes. If the LVD is also equipped with an audible alarm, it will begin to beep after the LED flashes for one minute. Go to step 3.
		Illuminated	When the light is on steady, the LVD has disconnected voltage. Measure the voltage at the ISO terminal of the Electrical Center. If there is still battery voltage at the ISO terminal of the main PDM, replace the defective LVD module. If battery voltage is not present at the ISO terminal, the LVD has properly disconnected power. There is no problem per the reported symptom.
		Steady	The module is not recognizing a low voltage situation. If battery voltage goes below 12.0 volts with no activity from the LVD, replace the LVD.
3	The alarm beeps slowly for 30 seconds then rapidly for 30 seconds. After the LED flashes for two minutes and is at the end of the alarm cycle, the LVD disconnects the output to the ISO terminal of the PDM and the LED illuminates steadily. Measure the voltage on the ISO terminal of the PDM. Is battery voltage present?	Yes	If the LED continues to flash for more than two minutes or if it is on steady, the module is not disconnecting power. Replace the LVD.
		No	The LVD disconnects power. There is no problem per the reported symptom. Reset the system by starting the engine. When system voltage is greater than 12.8 volts, the LVD will reconnect power to the ISO circuit.

Table 2, Voltage Goes Below 12.1 Volts Without the LVD Disconnecting

LVD System Always Activated			
Step	**Test Procedure**	**Test Result**	**Action**
1	Measure the voltage at the BAT terminal on the PDM. Is the voltage at or close to 0 volts?	Yes	Go to step 3.
		No	Measure the voltage on the ISO terminal of the Electrical Center. If the voltage is at or close to 0 volts, go to step 2. Otherwise, go to step 3.

LVD System Always Activated			
Step	**Test Procedure**	**Test Result**	**Action**
2	Start the engine and measure the voltage on the BAT terminal of the PDM. When the voltage is above 12.8 volts, the LVD should reconnect power to the ISO terminal. If the voltage on the BAT terminal does not go above 12.8 volts, go to step 3. Otherwise, when it does, measure the voltage on the ISO terminal. Is battery voltage present?	Yes	The LVD is reconnecting power correctly. No further action is necessary.
		No	Check the 50-amp in-line fuse located in the Electrical Center. If the fuse is open, determine the cause of the short; it could be the LVD module, or the wiring before or after it. Also, check the circuit breakers.
3	Measure the voltage at the batteries. Is battery voltage close to 12 volts?	Yes	Locate and repair an open circuit feeding the Electrical Center.
		No	Recharge the vehicle batteries then repeat this testing.

Table 3, LVD System Always Activated

LVD System Cuts Power to Accessories when the Key is in the OFF Position			
Step	**Test Procedure**	**Test Result**	**Action**
1	Measure the voltage at the batteries. Is the voltage above 12.4 volts?	Yes	Check the wiring at the LVD. Make sure circuit 14D is connected to the LVD V_In terminal, and that circuit 14BS is connected to the V_Out terminal. If not, switch the circuits.
		No	The LVD is working properly.

Table 4, LVD System Cuts Power to Accessories when the Key is in the OFF Position

No Warning Alarm Operation When LVD Activates			
Step	**Test Procedure**	**Test Result**	**Action**
1	Measure the voltage at the BAT terminal. Is the voltage at or above 12.4 volts?	Yes	Without starting the engine, turn the headlights and as many electrical loads as manageable on to draw the batteries down. As the voltage drops to/below 12.1 volts, go to step 2.
		No	Reset the LVD by starting the engine to bring system voltage above the disconnect threshold. When power is reconnected, repeat this test.
2	When the system voltage drops to the cut off threshold, the LED on the LVD module will begin to flash. After one minute of flashing, the alarm will begin to beep slowly if the LVD is equipped with alarm option. Does the alarm beep?	Yes	The system is working normally.
		No	The alarm is internal to the LVD and is not serviceable separately. Replace the LVD module.

Table 5, No Warning Alarm Operation When LVD Activates

The following equipment will be required to perform the test procedures:

- digital multimeter
- gas or propane torch
- test leads
- alligator clips
- pliers

Thermocouple Test Procedure

In-Vehicle Test Procedure

IMPORTANT: Do not use ohms as judgement criteria. A thermocouple, by nature, is a short of less than 1.5 ohms.

1. On a digital multimeter, turn the SELECT button to millivolt (mV) scale. Attach the positive lead from the multimeter onto the yellow wire on the thermocouple, and the negative lead from the multimeter onto the red wire on the thermocouple. Once this is completed, check the meter reading at engine idle. The multimeter should read between 3 to 15 mVs. If this is not the case, the thermocouple is defective and should be returned. If, however, the multimeter reading is correct, proceed to the next step.
2. Disconnect the probe terminals/connectors from the lead wire terminals/connectors. Using a light grade sand paper, make sure the metal contacts are free of corrosion and oxidation. Reconnect the probe to the lead wire and repeat the above step. If the meter reading is still erratic or incorrect, proceed to the section titled *Out-of-Vehicle Test Procedure*.

Out-of-Vehicle Test Procedure

1. Remove the thermocouple from the vehicle. Attach the positive lead from the multimeter to the yellow wire on the thermocouple, and the negative lead from the multimeter to the red wire on the thermocouple.
2. Light the torch. Place pliers on the hex nut of the thermocouple so that the tip of the thermocouple can be moved to the center of the flame. Watch the multimeter display as it rises. Continue to heat the thermocouple until the multimeter reads between 12 and 15 mVs.
3. Remove the thermocouple from the flame and watch the multimeter display. It should drop slowly as the thermocouple cools.
4. As the probe cools, hold the thermocouple on the hex nut with the pliers. Then, slightly twist and flex the wire of the thermocouple (up, down, left, and right). While flexing the wire, watch the multimeter display for one of the following to occur:
   - Multimeter reading of 0.0 mV.
   - Multimeter reading exceeds 50 mV.
   - Multimeter is reading the same millivolts regardless of the amount of heat applied.
   - Multimeter reading is erratic and does not fall smoothly as the probe cools.

If any of the above occur, the thermocouple is defective.

5. If the unit tests satisfactory, look elsewhere in the system for faults.

Gauge Testing Procedure

If there were no problems found with the thermocouple, follow steps below to test the pyrometer gauge.

1. Connect the thermocouple to the lead wire.
2. Connect the multimeter test leads to the lead wire connection on the back of the gauge. Use a gas torch to heat the probe tip while measuring the millivolts. The millivolt reading should increase as heat is applied.

   If millivolt reading does not increase or is erratic, lead wire is defective.
3. Connect multimeter test leads to probe, positive lead to yellow and negative lead to red. Use the gas torch to heat thermocouple until it reaches reasonable millivolt levels (less than 20 mV) specified below. the temperature reading on gauge and millivolt readings should corresponded to those specified in **Table 1** and **Table 2**.

Troubleshooting

Low Temperature Type "J" Thermocouple	
Degrees F° (C°)	**Millivolt Reading at Thermocouple**
68 (20)	0
100 (38)	0.9
200 (93)	3.9
300 (149)	6.9
400 (204)	10.0
500 (260)	13.1
600 (316)	16.2

Table 1, Low Temperature Type "J" Thermocouple

High Temperature Type "K" thermocouple	
Degrees F° (C°)	**Millivolt Reading at Thermocouple**
68 (20)	0
300 (149)	5.3
600 (316)	12.9
900 (482)	19.1
1200 (650)	26.2
1500 (816)	33.1

Table 2, High Temperature Type "K" thermocouple

Air Horn Valve Removal and Installation

Removal

1. Park the vehicle. Set the parking brake. Shut down the engine and chock the tires.
2. Drain the air supply, and disconnect the batteries.
3. Remove the driver's sun visor.
4. Remove the fasteners attaching the left-side and front sections of the headliner and overhead console to the cab.
5. Remove the left side of the overhead console.
6. At the air horn valve, disconnect the antenna cable, and move it aside.
7. Disconnect the air hoses attached to the air horn valve. Mark the hoses for later reference.
8. Remove the fasteners that attach the air horn valve to the mounting bracket.
9. Disconnect the air horn control cable from the headliner, if attached, and from the air horn valve.
10. Remove the air horn valve.

Installation

1. Position the air horn valve.
2. Connect the air horn valve control cable to the air horn valve and to the headliner, if necessary.
3. Mount the valve on its brackets and secure it with the fasteners.
4. Connect the air hoses to the air horn valve.

⚠ CAUTION

CAUTION: Do not overtighten the air hose fittings. Hand-tighten the fittings 1/2-turn after tightening begins.

5. Connect the antenna cable.
6. Install the left-side overhead console.
7. Install the headliner and the sun visor.
8. Connect the batteries.
9. Remove the chocks from the tires. Start the engine, and refill the air supply.
10. Test the horn.

General Description

COE and 120 Conventional cabs have a two-section flat glass windshield and a one-piece windshield seal. **See Fig. 1.** Either of the wind-shield glass sections may be replaced without removing the other one. However, to replace the seal, both glass sections must be removed. Refer to **Specifications, 400** for tools that will make windshield removal and installation easier.

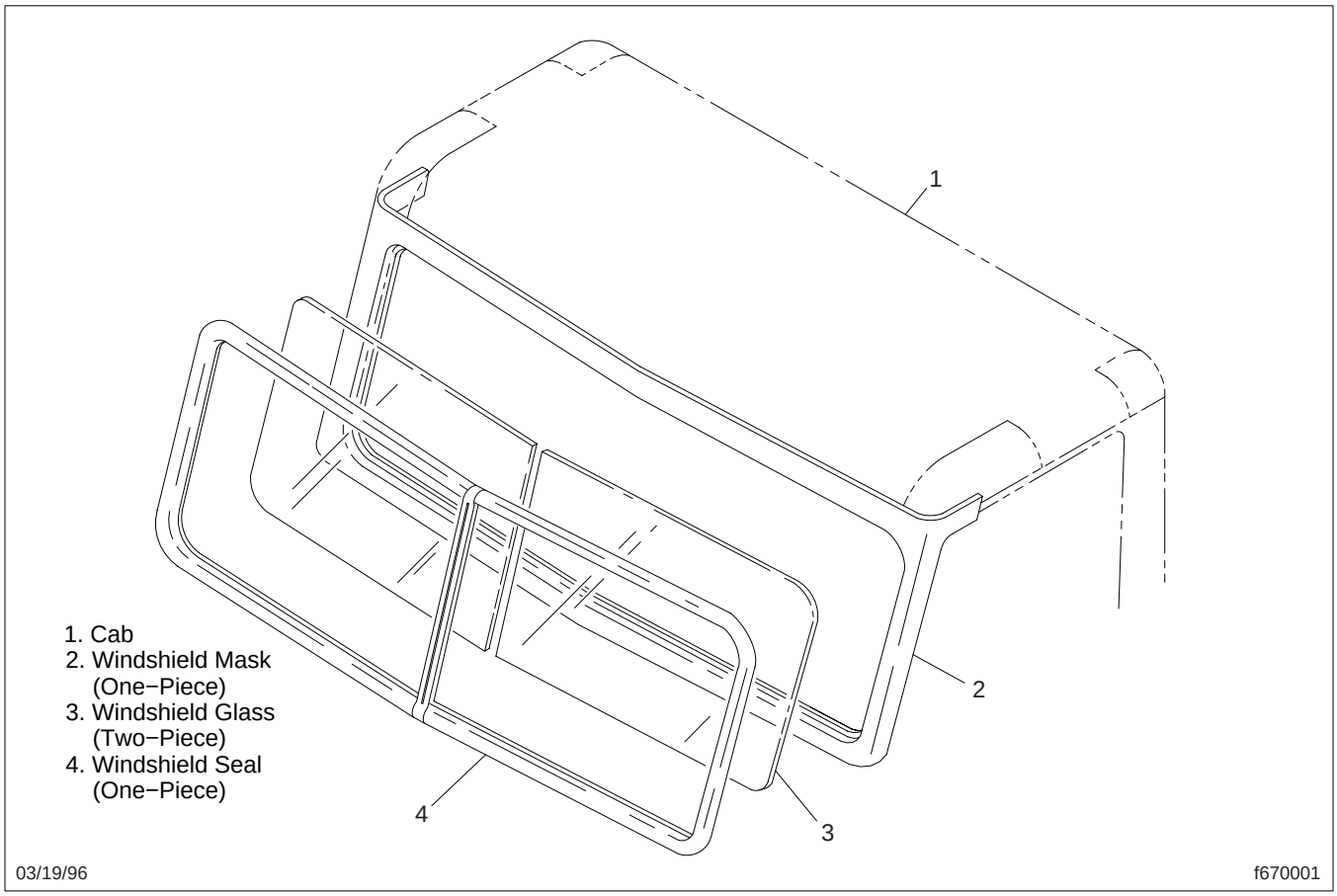


Fig. 1

Windshield Removal

If a windshield is cracked, carefully inspect the glass, seal, and flange to determine the cause. Correct the cause before installing a new windshield.

CAUTION

CAUTION: Failure to correct the cause of a windshield crack may cause the replacement windshield to crack when exposed to high winds, pressure, temperature extremes, or vehicle motion.

1. Remove the windshield wiper arm(s).

NOTE: At least two people are needed to remove a windshield.

2. Protect the paint finish and instrument panel by taping paper around the windshield opening, and laying a protective tarp over the hood and fenders. Before removing the windshield, mark the location of the crack on the windshield seal and flange.

WARNING

WARNING: When handling windshield glass, wear protective gloves to protect your hands from sharp edges and to allow a better grip. Not wearing protective gloves when handling glass could result in personal injury.

3. Using a windshield pick (**Fig. 1**), remove the lockstrip (**Fig. 2**).
4. *If replacing the windshield glass only, do the following:*
   - 4.1 Apply pressure to the edge of the glass from the inside. At the same time, use a windshield pick to lift the glass out of the seal. Remove the windshield.
   - 4.2 Check inside the seal for high spots or obstructions that could have caused the glass to crack. Check for wear, nicks, or cuts. Replace the seal if necessary.
5. *If replacing the windshield seal only, do the following:*
   - 5.1 Remove the interior trim pieces covering the top and bottom of the center windshield support.
   - 5.2 Remove the eight Phillips-head machine screws from the center windshield support. **See Fig. 3.** Move the center support out of the way. **See Fig. 4.**

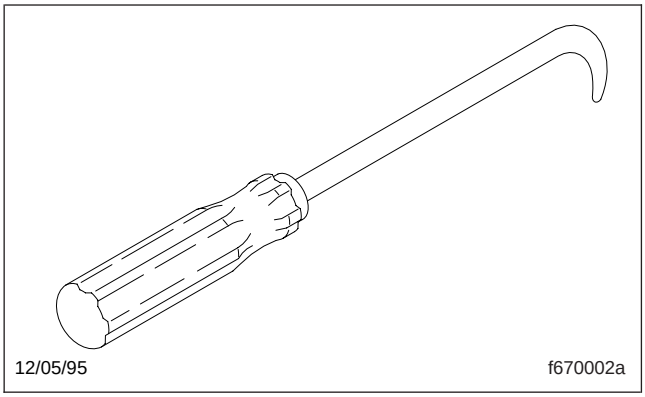


Fig. 1, Typical Windshield Pick

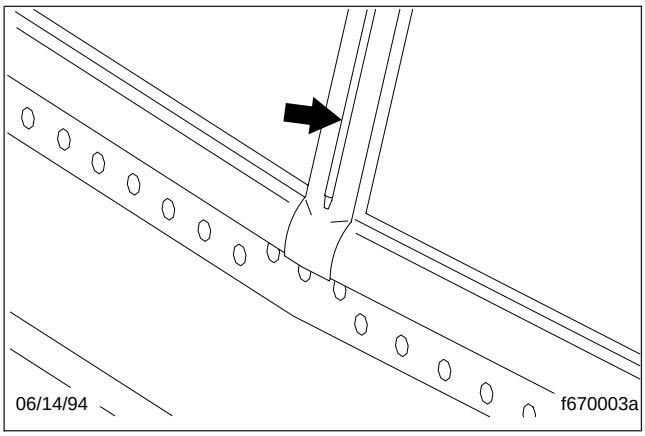


Fig. 2, Lockstrip

   - 5.3 Inside the cab, cut away the portion of the seal that is molded around the flange of the cab. **See Fig. 5.**
   - 5.4 Carefully remove the glass and seal. Separate the seal from the glass.
6. Check the windshield opening:
   - 6.1 Clean the windshield opening to remove any dirt or other foreign matter from the flange.

Windshield Removal and Installation

6.2 Check for the following conditions at the point where the windshield cracked:

- Chipped edges on the removed glass. This could indicate a high spot on the windshield flange.
- High spots or obstructions on the flange and surrounding surfaces.

6.3 Mark any problem areas on the flange, and correct as necessary.

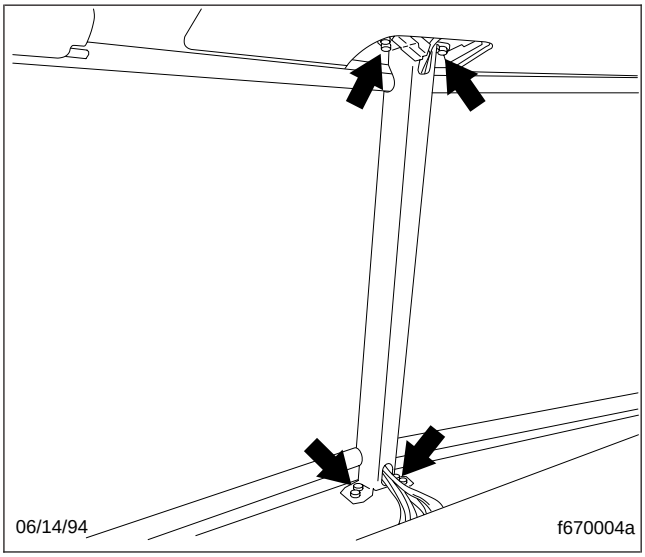


Fig. 3, Center Support Screws

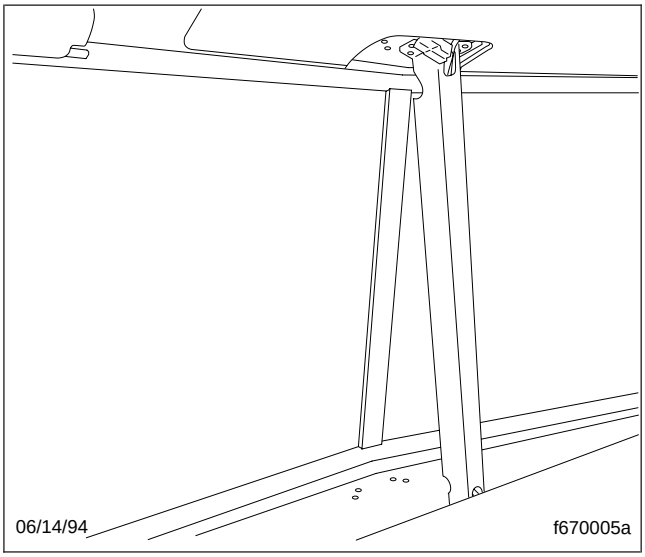
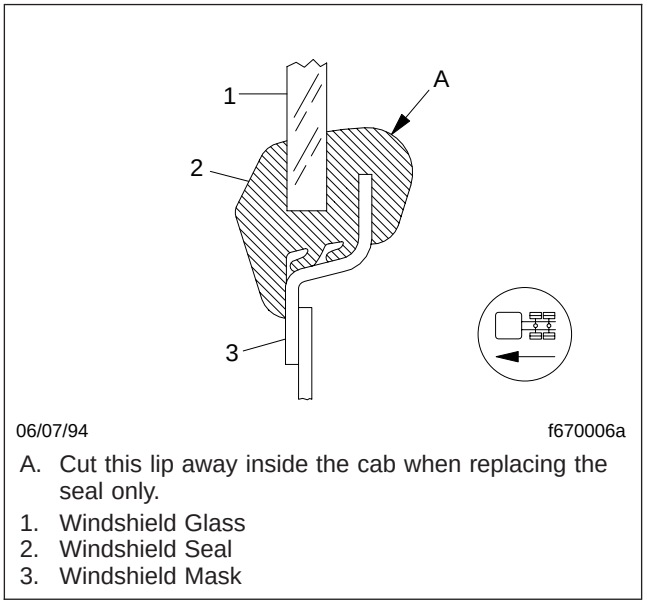


Fig. 4



A. Cut this lip away inside the cab when replacing the seal only.
1. Windshield Glass
2. Windshield Seal
3. Windshield Mask

Fig. 5

Windshield Installation

WARNING

WARNING: When handling windshield glass, wear protective gloves to protect your hands from sharp edges and to allow a better grip. Not wearing protective gloves when handling glass could result in personal injury.

CAUTION

CAUTION: When handling the windshield glass, be careful not to nick or splinter the edges of the glass. Chipped edges could cause cracking later on.

NOTE: Two people are needed to install a windshield.

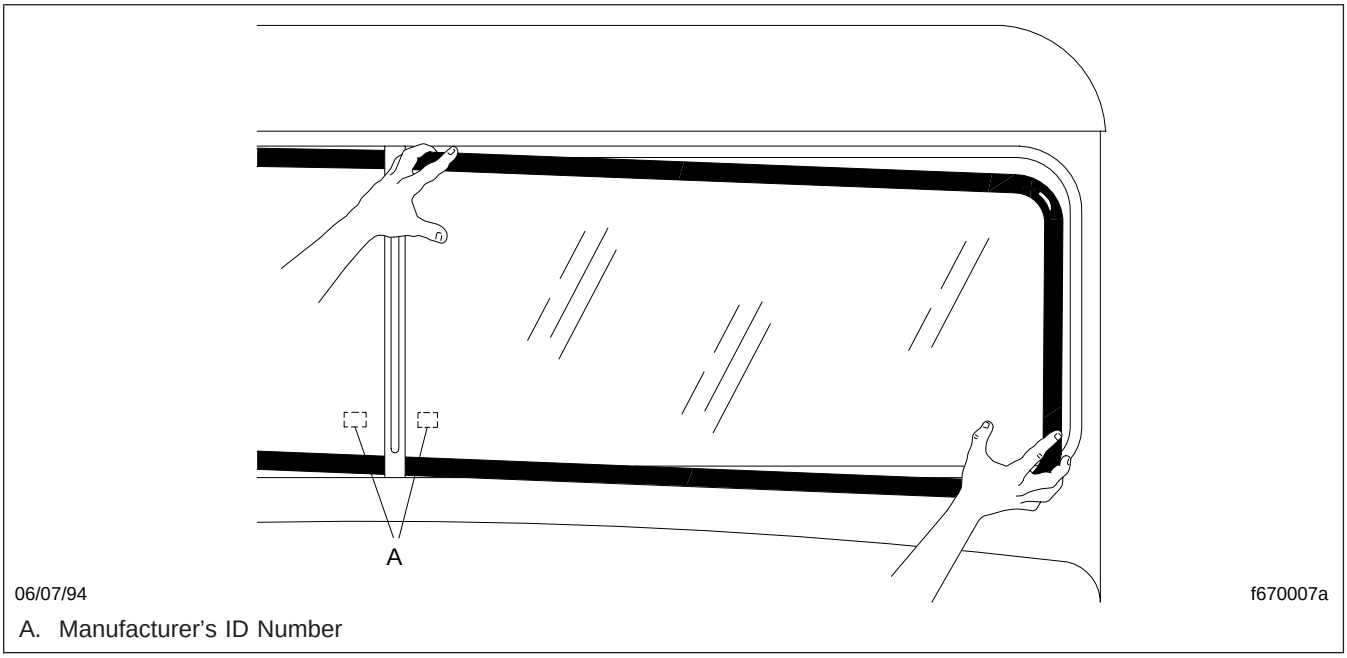
1. *If installing the windshield glass only, do the following:*

   1.1 Lubricate the seal with a soap-and-water solution.

   1.2 Slide the glass into the seal channel as far as it will go without forcing it. **See Fig. 6.**

NOTE: The manufacturer's ID number must be at the lower center corner of the glass, when installed.

1.3 Stretch the rubber seal around the outside edge of the glass, with the glass in its seal groove.



A. Manufacturer's ID Number

Fig. 6, Positioning the Glass in the Seal

1.4 Using the windshield pick, and alternating between the top and bottom flanges, work the seal over the metal flange of the windshield mask.

1.5 With one person pushing lightly on the glass from the outside, finish working the seal over the flange from inside the cab.

1.6 Using a sandbag, finish seating the glass by tapping on the windshield until the glass and seal are correctly positioned.

2. *If installing the glass sections and seal, do the following:*

2.1 Install the seal on both pieces of windshield glass. Work the glass into the seal channel (**see Fig. 5**) by sliding it from the outside towards the center strip as far as it will go without forcing it. Using a windshield pick, work the seal lip over the glass until it bottoms in the channel.

NOTE: The seal is installed on the glass without lubricants or sealants.

NOTE: The manufacturer's ID numbers must be located in the lower center corners when the glass is installed on the cab. **See Fig. 6.**

2.2 Install two cords in the outside seal groove (**Fig. 7**) as shown in **Fig. 8**. Leave the loose ends at the outside edges of the windshield assembly.

NOTE: The cord should be a braided cotton cord (trade size number 5 minimum to number 8 maximum) with a reinforced core.

2.3 Lubricate the cord channel with a soap-and-water solution; then wet the cab skin with clear water just before installing the windshield assembly.

2.4 Place the glass sections and seal assembly into the windshield opening.

2.5 With one person pushing lightly on the outside of the windshield at the center

Windshield Removal and Installation

bottom, have another person inside the cab pull one rope around the lower corner on one side of the assembly, then on the other side. The person on the outside then pushes in on the windshield at the center top while the person on the inside pulls the loose ends of the cord over the top left corner, then the top right corner. The person on the outside now applies even pressure to the center of the windshield while the person on the inside alternately pulls the ropes toward the center of the windshield assembly. When the rope ends are within a few inches of each other, pull on both rope ends at the same time to pull the last of the seal over the flange.

NOTE: If the rope binds or starts to tear the seal, use the safety loop at the center, and pull back towards the point where the rope is bound. If the loop is not needed, it simply pulls out when the final portion of the seal is pulled over the flange.

2.6 Using a sandbag, finish seating the glass by tapping on the glass until the glass and seal are correctly positioned.

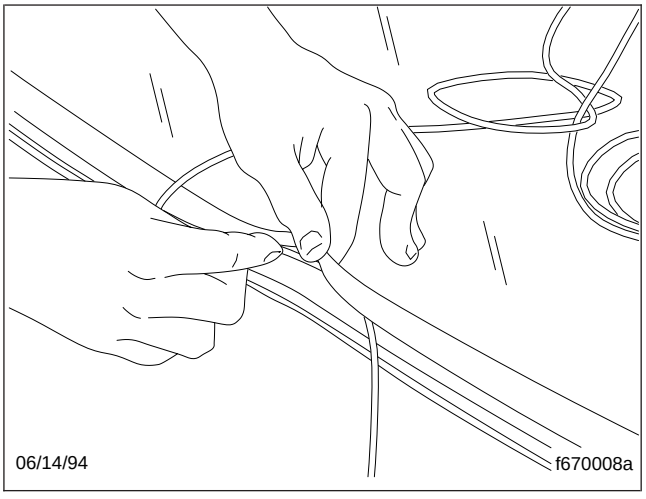


Fig. 7

3. Insert the bead spreader (**Fig. 9**) into the lockstrip channel at the bottom. Then insert the lockstrip into the eye of the spreading tool. Move the bead spreader in the channel, working toward the top, while feeding the lockstrip into the channel. **See Fig. 10.** Do not let the lockstrip twist: it should lay flat in the channel. Cut off any excess lockstrip and tuck the end into the channel.
4. Install the windshield wiper arm(s).
5. Remove the protective tape, paper, and tarp.

Windshield Removal and Installation

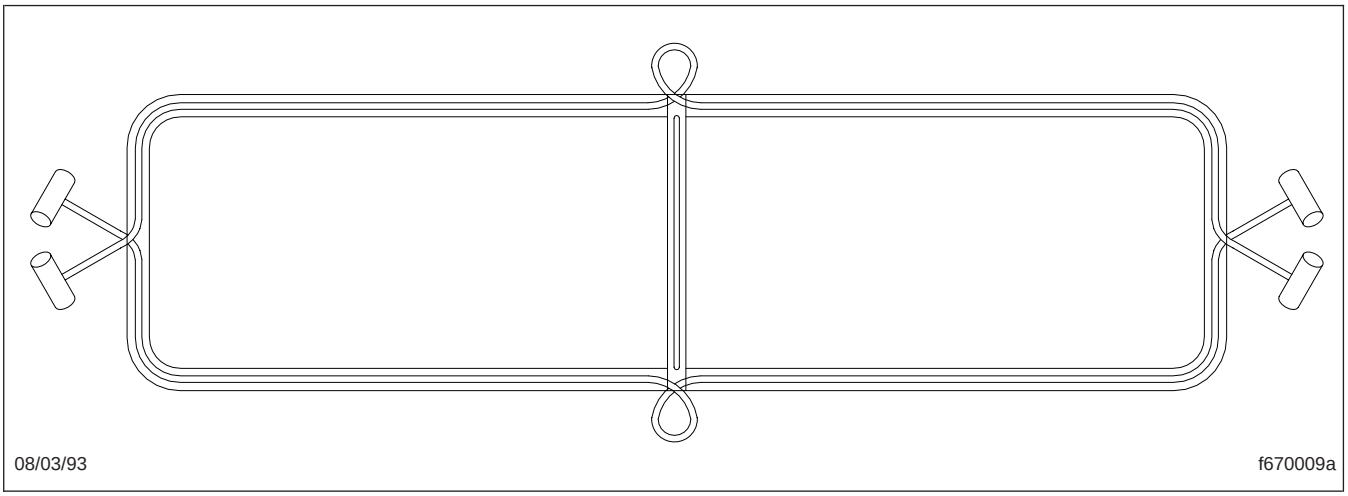


Fig. 8

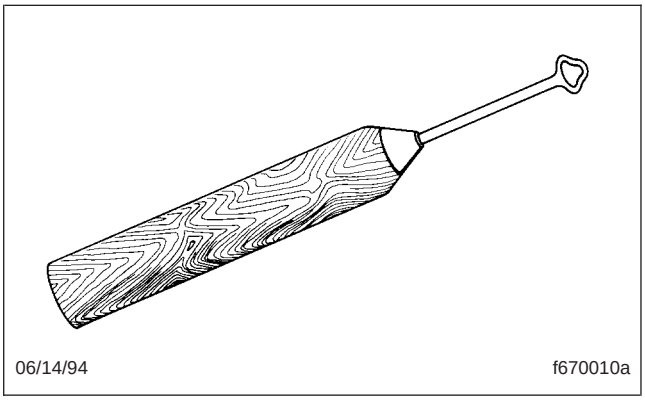


Fig. 9, Typical Bead Spreader

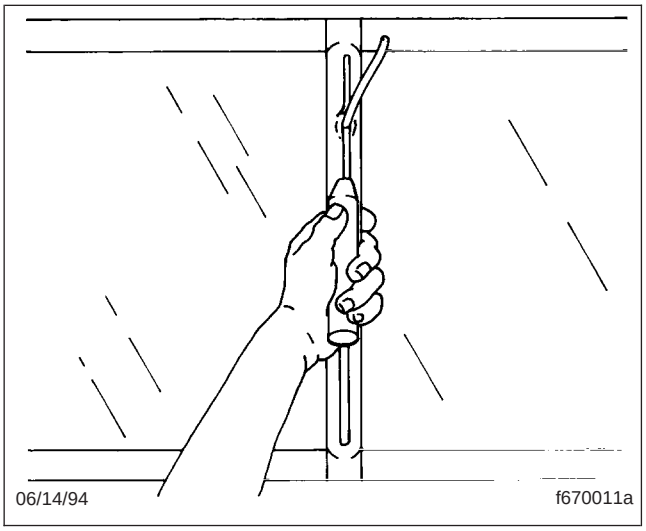


Fig. 10, Feeding the Lockstrip into the Channel

The tools in **Fig. 1**, and others, can be purchased from the following distributors:

Sommer & Maca
5501 West Ogden Avenue
Chicago, IL 606501–800–323–9200
C.R. Laurence Co., Inc.
P.O. Box 21345
Los Angeles, CA 90021-03451–800–421–6144

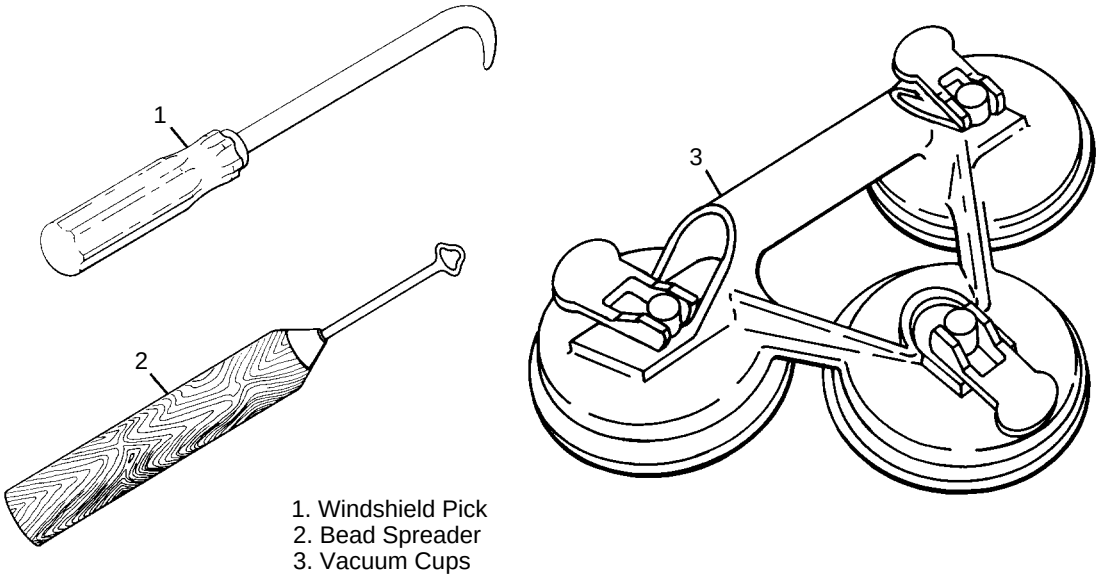


Fig. 1, Windshield Tools

General Information

Cab rear air-suspension systems absorb road shocks better than solid-mount systems, and thus provide a smoother ride for cab occupants and cab-mounted equipment.

The Conventional cab's optional air-suspension system consists of two air springs, a height-control valve, a cab-mount stop assembly, two shock absorbers, and a vertical linkage; see **Fig. 1**, **Fig. 2**, **Fig. 3**, and **Fig. 4.** Vehicles built from October, 1991 also have a lateral control rod to limit side-to-side movement of the cab.

Air Springs

The top of each air spring is mounted to a cab-mount angle under the rearmost edge of the cab, and the bottom is mounted to the frame rail crossmember. Together with the height-control valve, the air springs compensate for changes in cab load by maintaining the correct cab height at the rear of the cab.

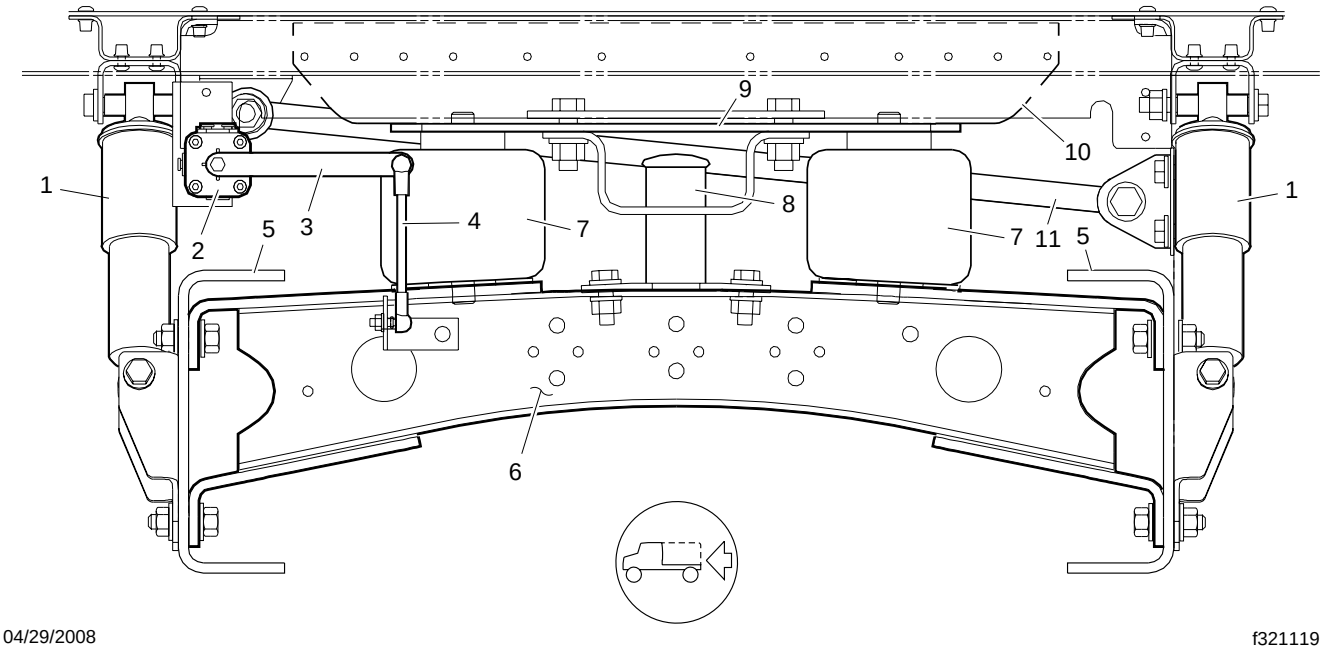
Height-Control Valve

NOTE: If a leak occurs in the cab air-suspension system, a pressure protection valve (located in the air supply line to the height-control valve) will maintain a minimum pressure of about 65 psi (450 kPa) in the vehicle secondary air system.

All of the air in the cab air-suspension system is admitted through or exhausted from the height-control valve (also called a leveling valve), which is attached to a bracket under the rear edge of the cab. The height-control valve has a horizontal control lever, the outboard end of which is connected to a vertical linkage. The lower end of the vertical linkage is attached to a frame crossmember.

Vehicles have either a Barksdale, WABCO, or Neway height-control valve; see **Fig. 5.**

When the load on the cab increases, the dimension between the cab and the crossmember decreases,



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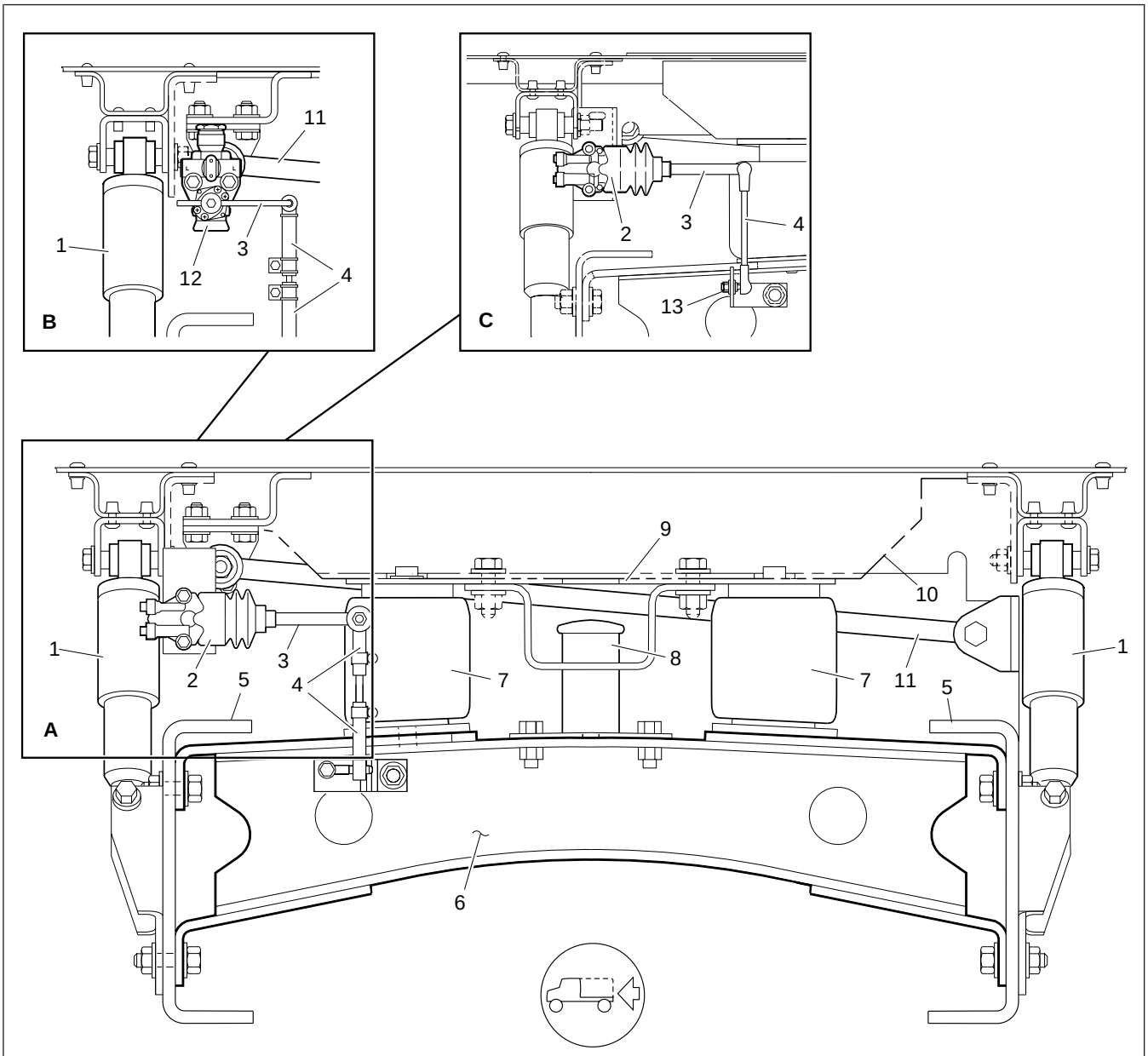
1. Shock Absorber
2. Barksdale Height-Control Valve
3. Horizontal Control Lever
4. Vertical Linkage
5. Frame Rail
6. Frame Crossmember
7. Air Spring
8. Lower Cab-Mount Stop
9. Upper Cab-Mount Stop
10. Cab Rear-Deck Angle
11. Lateral Control Rod

Fig. 1, Cab Rear Air-Suspension Installation, Vehicles with Barksdale Height-Control Valve

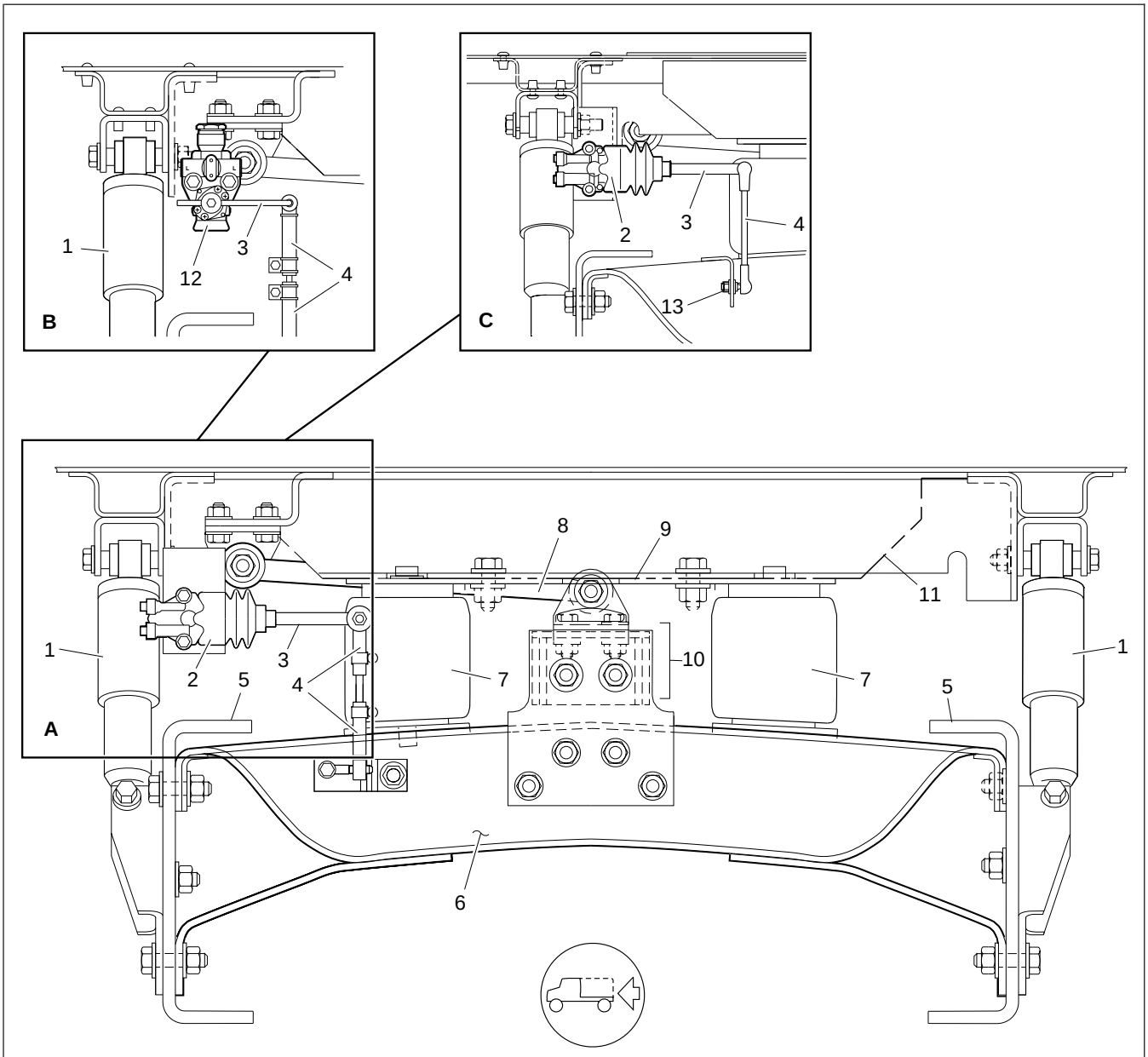
General Information



A. Vehicles Built from November 5, 1993 to May 17, 1997
B. Vehicles Built from April 5, 1991 to November 5, 1993
C. Vehicles Built after May 17, 1997

1. Shock Absorber
2. WABCO Height-Control Valve, Vehicles Built from November 5, 1993 (plastic valve housing)
3. Horizontal Control Lever
4. Vertical Linkage
5. Frame Rail
6. Frame Crossmember
7. Air Spring
8. Lower Cab-Mount Stop
9. Upper Cab-Mount Stop
10. Cab Rear-Deck Angle
11. Lateral Control Rod Assembly
12. WABCO Height-Control Valve, Vehicles Built from April 5, 1991 to November 5, 1993 (aluminum valve housing)
13. Adjustment Bolt

Fig. 2, Cab Rear Air-Suspension Installation, SleeperCab with WABCO Height-Control Valve

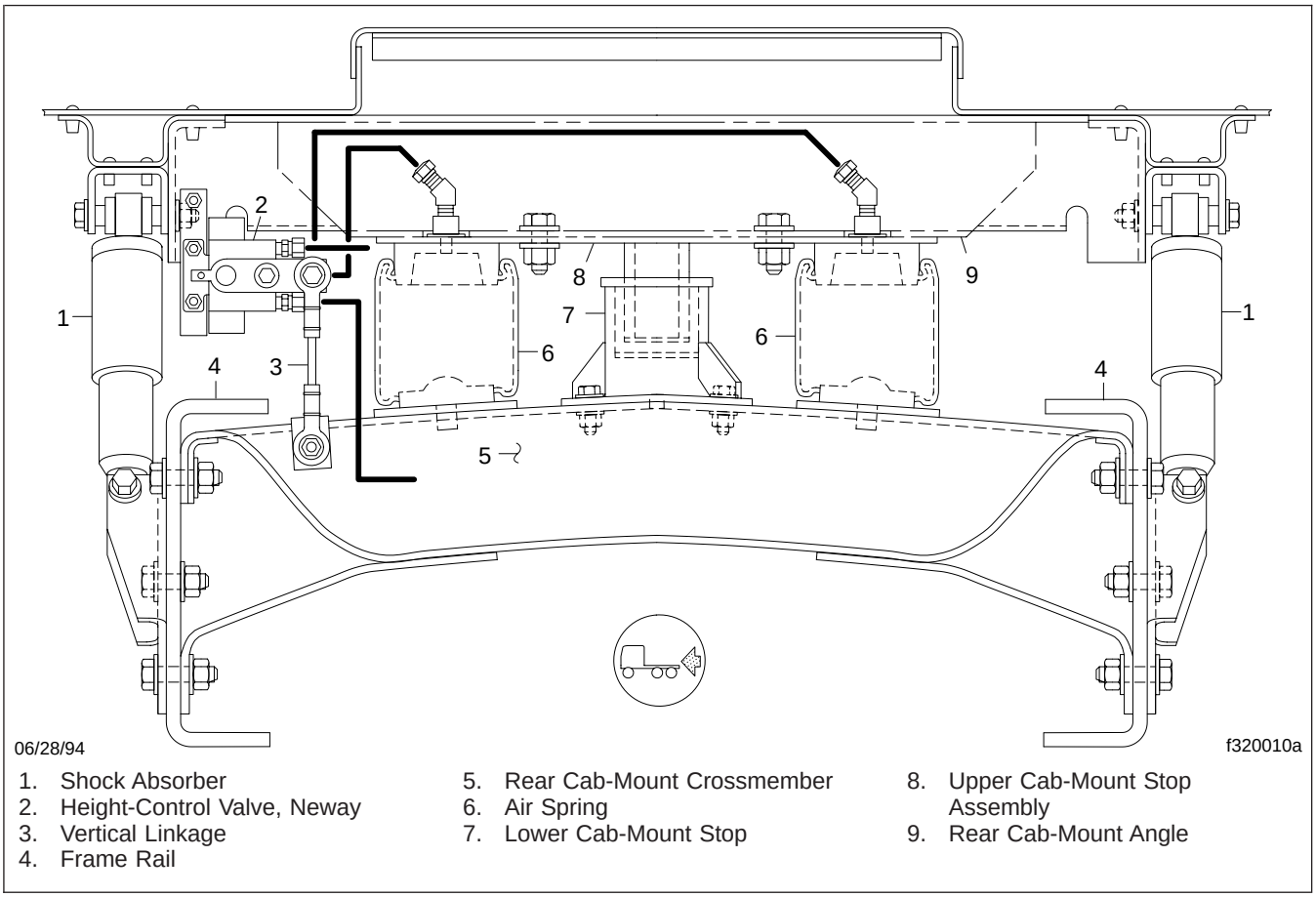


A. Vehicles Built from November 5, 1993 to May 17, 1997
B. Vehicles Built from April 5, 1991 to November 5, 1993
C. Vehicles Built from May 17, 1997

1. Shock Absorber
2. WABCO Height-Control Valve, Vehicles Built from November 5, 1993 (plastic valve housing)
3. Horizontal Control Lever
4. Vertical Linkage
5. Frame Rail
6. Frame Crossmember
7. Air Spring
8. Lateral Control Rod Assembly
9. Upper Cab-Mount Stop
10. Lower Cab-Mount Stop
11. Cab Rear-Deck Angle
12. WABCO Height-Control Valve, Vehicles Built from April 5, 1991 to November 5, 1993 (aluminum valve housing)
13. Adjustment Bolt

Fig. 3, Cab Rear Air-Suspension Installation, Non-SleeperCab with WABCO Height-Control Valve

General Information



1. Shock Absorber
2. Height-Control Valve, Neway
3. Vertical Linkage
4. Frame Rail
5. Rear Cab-Mount Crossmember
6. Air Spring
7. Lower Cab-Mount Stop
8. Upper Cab-Mount Stop Assembly
9. Rear Cab-Mount Angle

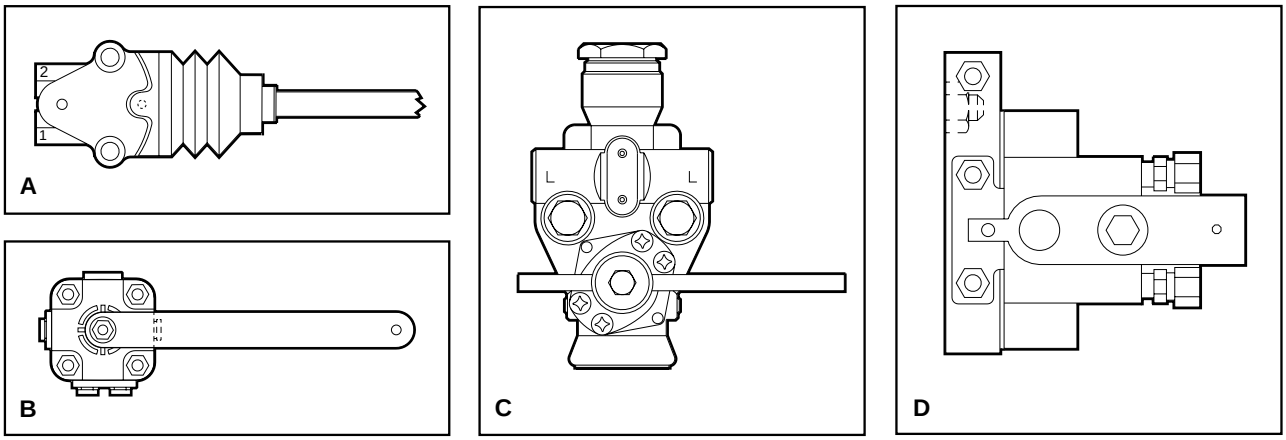
Fig. 4, Cab Rear Air-Suspension Installation, Vehicles Built From January 1990 to April 1991 (without lateral control rod)

causing the vertical linkage to push upward on the end of the horizontal control lever. This turns the height-control valve shaft, which activates the height-control valve. Air flows through the valve and into the air springs until the pressure in the springs raises the cab to the correct height. At this height, the control lever and the control shaft are returned to their neutral positions, closing the intake air supply.

When the load on the cab decreases, the rear of the cab rises, causing the vertical linkage to pull down on the end of the horizontal control lever. Turning the height-control valve shaft in this direction activates an exhaust port in the valve. This allows air pressure in the air springs to decrease until the cab is lowered to the correct height. Again, the control lever and control shaft are returned to their neutral positions, and air flow is stopped.

When the vehicle is in motion, small and abrupt movements of the cab will occur, resulting in small or abrupt movements of the control lever. These movements of the control lever do not activate the height-control valve to correct the cab ride height.

Changes in load that occur when occupants or heavy items are added to or removed from the cab will activate the height-control valve to correct the cab ride height. Also, when the vehicle is moving forward at high speed or in a high headwind, a major change in load occurs from the downforce applied to an optional air shield or air fairing. When these changes in load occur, the cab air-suspension system will correct the cab ride height at the rear of the cab.



A. WABCO Valve, Plastic Valve Housing
B. Barksdale Valve
C. WABCO Valve, Aluminum Valve Housing
D. Neway Valve

Fig. 5, Height-Control Valves

Cab-Mount Stop Assembly

The cab-mount stop assembly attaches to the cab-mount angle and the crossmember, between the air springs. It limits the side-to-side and downward motion of the rear of the cab. If a leak occurs in the cab air-suspension system, the cab-mount stop will support the rear of the cab until a repair can be made.

Lateral Control Rod

On vehicles built from October 1991, the lateral control rod limits the side-to-side motion of the rear of the cab.

Shock Absorbers

The shock absorbers are mounted to the rear of the cab, and to the outboard edge of each frame rail. The shock absorbers control the air spring and cab suspension movement, and reduce the amount of oscillation in the cab suspension system.

Cab Height Adjustment, Barksdale

The vertical linkage on Barksdale height-control valves is not adjustable.

Cab Height Adjustment, WABCO

NOTE: There are two types of WABCO height-control valves; plastic housing or aluminum housing; see **Fig. 1**. The procedure for adjusting the cab height is slightly different for each type. Determine which type of WABCO height-control valve is present, then use the applicable procedure below to adjust the cab height.

WABCO Height-Control Valve with Plastic Housing

1. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa). Turn off the engine and wait 5 to 10 minutes for the system to equalize.

IMPORTANT: If the rubber cap (**Fig. 1**, Item 6) is missing from the lower cab-mount stop, replace it before measuring the cab height.

3. Measure the distance from the bottom of the upper cab-mount stop to the top of the lower cab-mount stop (Ref. B). The distance should be 7/8 to 1-1/4 inches (22 to 32 mm). If the distance is not correct, go to the next step.
4. Place a 1-inch (25-mm) thick block between the upper and lower cab-mount stops. If necessary, raise the cab so the block will fit, then lower the cab onto the block.
5. Disconnect the horizontal control lever (**Fig. 1**, Item 2) from the vertical linkage (Item 3).
6. Lock the height-control valve in the neutral position, as follows.
   - 6.1 Pull back the flap on the rubber boot to expose the hole in the valve body; see **Fig. 2**.
   - 6.2 Move the horizontal control lever up or down slightly to align the hole in the valve body with the hole in the plastic pivot assembly underneath. To hold the control lever in the neutral (horizontal) position, insert a 5/32-inch (4-mm) pin or drill bit into the holes.
7. Adjust the length of the vertical linkage.

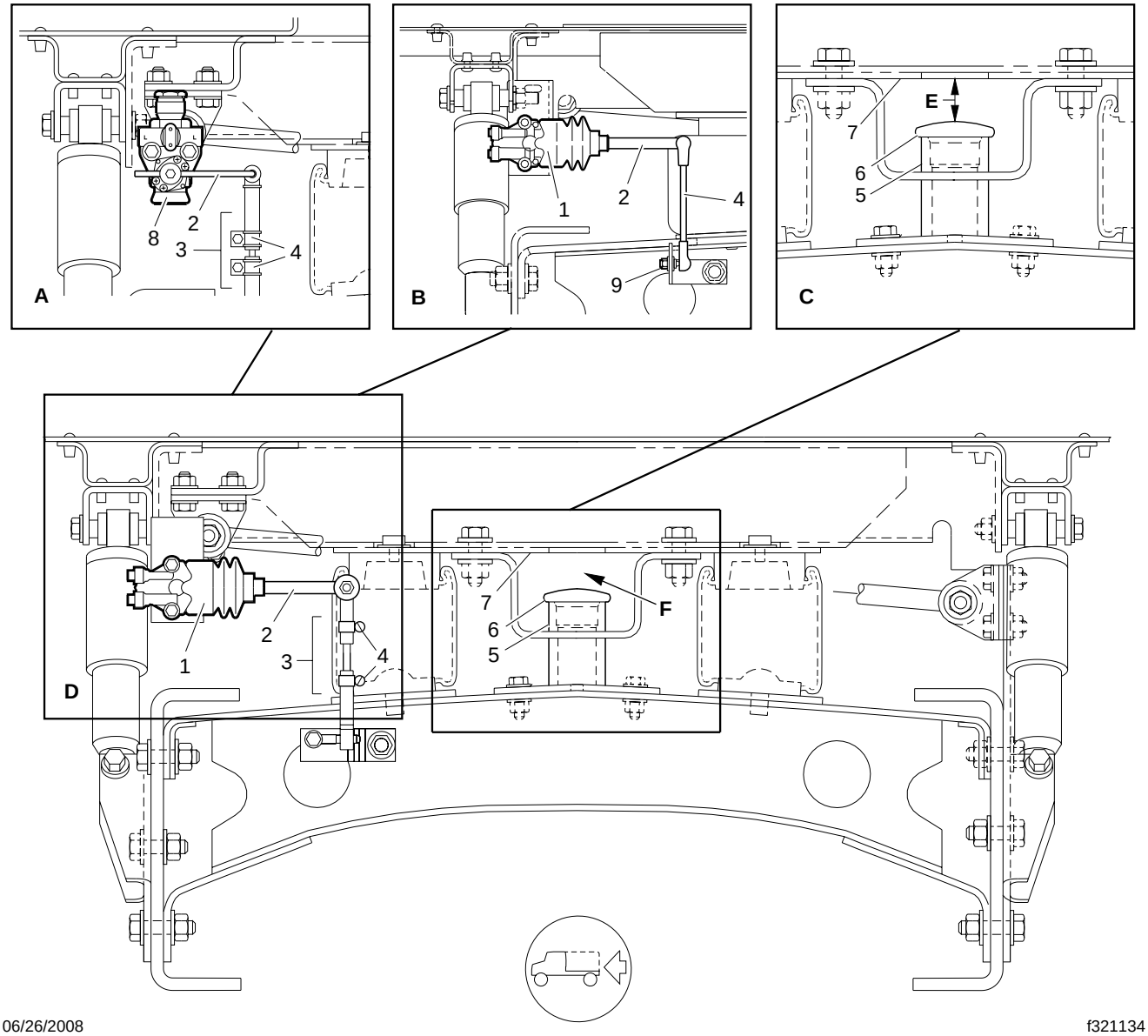
   For vehicles built to May 17, 1997: Loosen the vertical linkage clamps (**Fig. 1**, Item 4), and lengthen or shorten the vertical linkage rod as necessary until the upper hole in the linkage aligns with the hole in the horizontal control lever. Tighten the linkage clamps.

   For vehicles built after May 17, 1997: Loosen the adjustment bolt at the lower end of the vertical linkage, then move it vertically in the slot until the upper hole in the linkage aligns with the hole in the horizontal control lever; see **Fig. 1** (Item 8) and **Fig. 3** (Item 4). Tighten the adjustment bolt.
8. Remove the pin or drill bit previously inserted in the height-control valve.
9. Raise the horizontal control lever, and hold it there until the weight of the cab is off the block, then remove the block.
10. Push down on the horizontal control lever, and hold it down until all the air is exhausted from the air springs.
11. Connect the vertical linkage to the horizontal control lever. Tighten the fasteners firmly.
12. Let the height-control valve return to the neutral position, then measure the distance between the upper and lower cab-mount stops. It should be 7/8 to 1-1/4 inches (22 to 32 mm).
13. If needed, make a minor adjustment to the vertical linkage.

WABCO Height-Control Valve with Aluminum Housing

1. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa). Turn off the engine and wait 5 to 10 minutes for the system to equalize.
3. Check the length of the horizontal control lever between its pivot points; see **Fig. 4**. The length

Cab Height Adjustment



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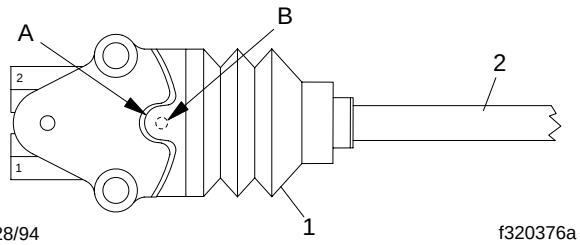
A. Vehicles Built from November 5, 1993 to May 17, 1997
B. Vehicles Built from April 5, 1991 to November 5, 1993
C. Vehicles Built after May 17, 1997
D. 7/8 to 1-1/4 Inches (22 to 32 mm)
F. Place block here.

1. WABCO Height-Control Valve, Plastic Housing
2. Horizontal Control Lever
3. Vertical Linkage
4. Vertical Linkage Clamps
5. Lower Cab-Mount Stop
6. Rubber Cap
7. Upper Cab-Mount Stop
8. WABCO Height-Control Valve, Aluminum Housing
9. Adjustment Bolt

Fig. 1, Cab Rear Air-Suspension Installation, SleeperCab With WABCO Height-Control Valve



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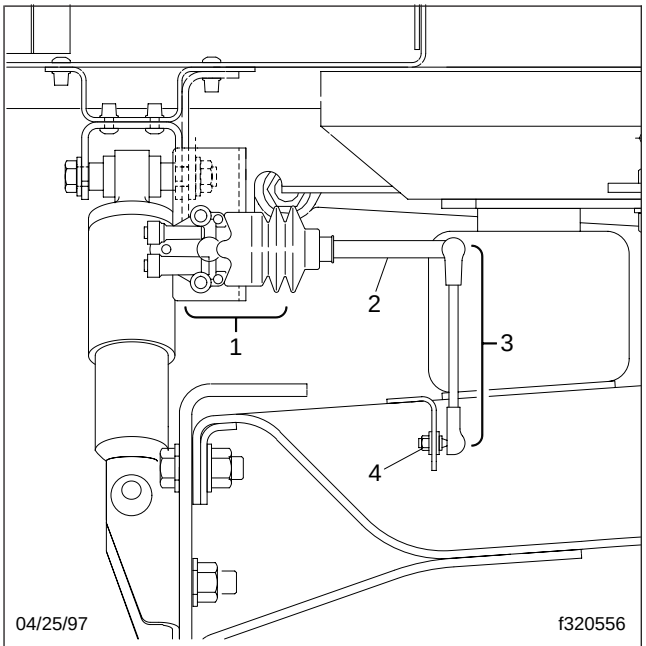
A. Lift flap.
B. Install 5/32-inch (4-mm) pin or drill bit here.

1. Rubber Boot
2. Horizontal Control Lever

Fig. 2, WABCO Height-Control Valve with Plastic Housing



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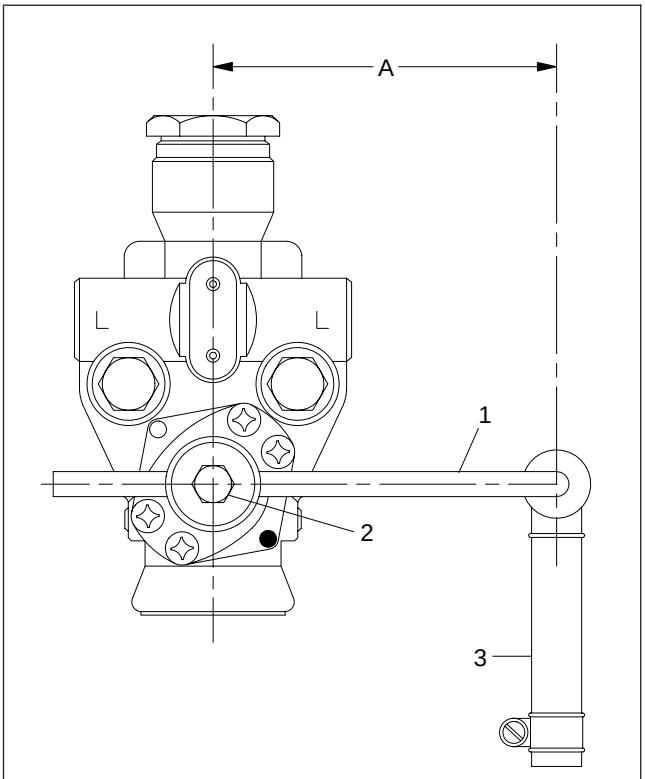
1. Height-Control Valve
2. Horizontal Control Lever
3. Vertical Linkage
4. Adjustment Bolt

Fig. 3, Non-SleeperCab WABCO Height-Control Valve (vehicles built after May 17, 1997)

should be 3-1/4 inches (83 mm). If it isn't, adjust the length of the control lever, as follows.

3.1 Loosen the adjustment locknut on the horizontal control lever shaft.



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A. 3-1/4 inches (83 mm)

1. Horizontal Control Lever
2. Adjustment Locknut
3. Vertical Linkage

Fig. 4, Horizontal Control Lever Length Checking

3.2 Slide the horizontal control lever to the left or right, as needed, until its length between its pivot points is 3-1/4 inches (83 mm).

3.3 Tighten the adjustment locknut 62 lbf·in (700 N·cm).

IMPORTANT: If the rubber cap (**Fig. 1**, item 6) is missing from the lower cab-mount stop, replace it before measuring the cab height.

4. Measure the distance from the bottom of the upper cab-mount stop to the top of the lower cab-mount stop (**Fig. 1**, Ref. B). The distance should be 7/8 to 1-1/4 inches (22 to 32 mm). If the distance isn't correct, determine the difference, using 1 inch (25 mm) as a reference. For example, if the measured distance is 1-3/4

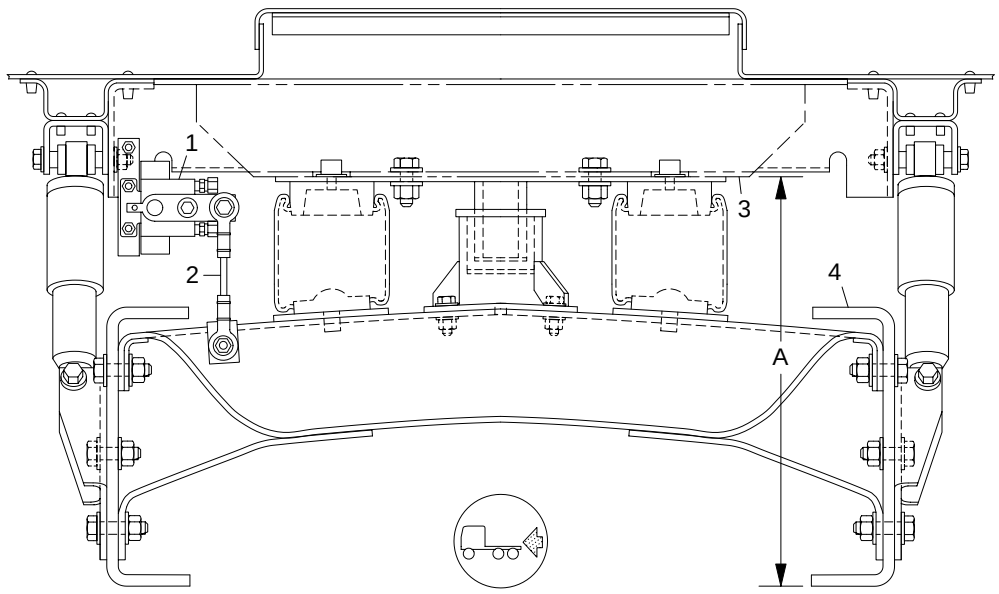
Cab Height Adjustment

inches (44 mm), the difference would be 3/4 inch (19 mm). Write down this value.

5. Place a 1-inch (25-mm) thick block between the upper and lower cab-mount stops. If necessary, raise the cab so the block will fit, then lower the cab onto the block.
6. Disconnect the horizontal control lever (**Fig. 1**, item 2) from the vertical linkage (item 3).
7. Adjust the length of the vertical linkage, as follows.
   - 7.1 Loosen the vertical linkage clamps (**Fig. 1**, item 4).
   - 7.2 Lengthen or shorten the vertical linkage rod by the amount previously determined (the difference between the measured distance and 1 inch or 25 mm).
   - 7.3 Tighten the linkage clamps.
8. Lift the horizontal control lever, and raise the cab enough to remove the block from between the upper and lower cab-mount stops.
9. Push down on the horizontal control lever, and hold it down until all the air is exhausted from the air springs.
10. Connect the vertical linkage to the horizontal control lever. Tighten the fasteners firmly.
11. Let the horizontal control lever return to the neutral position; then measure the distance between the upper and lower cab-mount stops. It should be 7/8 to 1-1/4 inches (22 to 32 mm).
12. If needed, make a minor adjustment to the vertical linkage.

Cab Height Adjustment, Neway

1. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa). Turn off the engine and wait 5 to 10 minutes for the system to equalize.
3. Measure the distance from the bottom of the cab rear deck angle to the bottom surface of the frame rail lower flange (**Fig. 5**, Ref. A). The distance should be 15-1/8 inches (384 mm). If the distance is correct, no adjustment is needed. If it's not correct, go to the next step.
4. Disconnect the vertical linkage from the horizontal control lever (**Fig. 6**, items 16 and 11). If necessary, move the horizontal control lever upward and hold it there until the distance between the bottom of the cab rear deck angle and the bottom surface of the frame rail lower flange is *just over* 15-1/8 inches (384 mm).
5. Block the cab by placing a 1-inch (25-mm) wooden block between the upper and lower cab-mount stop assemblies.
6. Move the horizontal control lever down, and hold it there until all air is exhausted from the air springs.
7. Loosen the adjustment locknut (**Fig. 6**, item 12). Put a 3/16-inch (5-mm) diameter pin or drill bit into the hole at the back of the nylon block, and through the hole (item 7) in the valve mounting bracket. Move the horizontal control lever until the nylon block stud (item 10) is centered in the lever adjustment slot (item 9). Hold the horizontal control lever there while tightening the adjustment locknut 60 lbf·in (680 N·cm).
8. Loosen the nuts on the top two mounting bolts that attach the height-control valve plate to the rear cab-mount Z-angle. Loosen them just enough to allow the plate to pivot on the center bolt. The upper hole in the height-control valve plate is horizontally slotted.
9. Pivot the height-control valve and plate, until the hole in the inboard end of the horizontal control lever is aligned with the hole in the vertical linkage. Install the linkage fasteners, then tighten the height-control valve plate fasteners 108 lbf·in (1220 N·cm).
10. Remove the 3/16-inch (5-mm) diameter pin or drill bit. Disconnect the vertical linkage from the horizontal control lever. Move the horizontal control lever upward, and hold it there until the weight of the cab is removed from the block. Remove the block.
11. Move the horizontal lever down, and hold it there until all air is exhausted from the air springs. Connect the vertical linkage to the horizontal control lever, and let the air springs fill until the valve shuts off.
12. Measure the vertical distance from the bottom of the cab rear deck angle to the bottom surface of the frame rail lower flange (**Fig. 5**, Ref. A).



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A. 15-1/8 inches (384 mm)

1. Height-Control Valve (Neway)
2. Vertical Linkage
3. Cab Rear Deck Angle
4. Right Frame Rail

Fig. 5, Cab Ride-Height Measurement, Neway Height-Control Valve

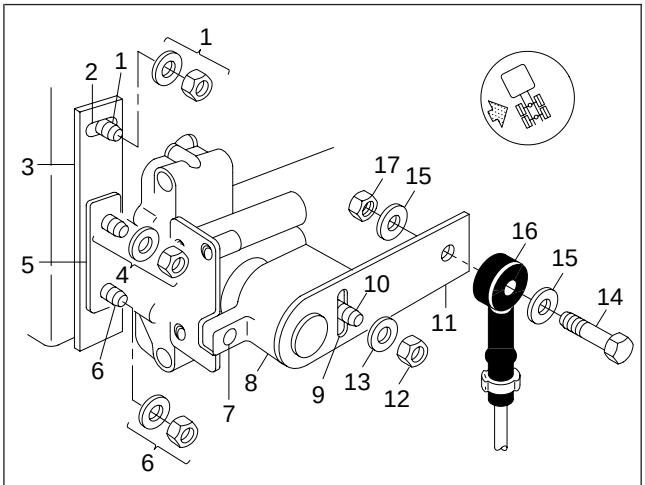
If the distance is not 15-1/8 inches (384 mm), slightly loosen the top two valve-plate mounting bolts. Pivot the height-control valve until the distance is correct.

When the distance is correct, tighten the height-control valve plate fasteners 108 lbf·in (1220 N·cm). Disconnect the vertical linkage from the horizontal control lever, then check the distance again, using the applicable previous steps.

IMPORTANT: Because of a built-in delay in the height-control valve, two to six seconds are required after making adjustments before the air spring height changes.

13. When the distance is 15 inches (381 mm), loosen the adjustment locknut, and move the nylon block in relation to the horizontal control lever, to make the final adjustment to 15-1/8 inches (384 mm). Tighten the adjustment locknut 60 lbf·in (680 N·cm).
14. Remove the wooden block from between the upper and lower cab-mount stop assemblies.

Cab Height Adjustment



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1. Height-Control Valve Plate Upper Mounting Fasteners
2. Slotted Hole
3. Height-Control Valve Plate
4. Center Mounting Fasteners
5. Height-Control Valve Bracket
6. Lower Mounting Fasteners
7. 3/16-Inch Diameter Hole
8. Nylon Block
9. Lever Adjustment Slot
10. Nylon Block Stud
11. Horizontal Control Lever
12. Adjustment Locknut
13. Hardened Washer
14. Height-Control Valve Linkage Bolt
15. Hardened Washer
16. Vertical Linkage
17. Locknut

Fig. 6, Neway Height-Control Valve Installation

Height-Control Valve Checking

It is normal to hear air leaking from the height-control valve for as much as five minutes after getting out of the vehicle. This air leakage is just the height-control valve exhausting air from the cab suspension air spring to reach the neutral position.

Vehicles have a Barksdale, WABCO, or Neway valve; see **Fig. 1**. Two methods are available to check the operation of the Barksdale height-control valves. A leak in the valve may be discovered without using a test kit, but a test kit is necessary to determine if the valve has an unacceptable rate of leakage. The WABCO and Neway valves can only be checked without a test kit.

Some Barksdale height-control valves have been returned for warranty because the four bolts in the valve housing were overtightened, often, enough to crack the valve housing. These bolts should not be loose, and should not normally require tightening, as there are no serviceable parts in the valve.

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing if you detect leaks in the housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

NOTICE

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

Checking the Height-Control Valve Without Using a Test Kit

WARNING

Keep your hands and all objects away from the area under and around the cab when removing the pressure from the air system. Parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.

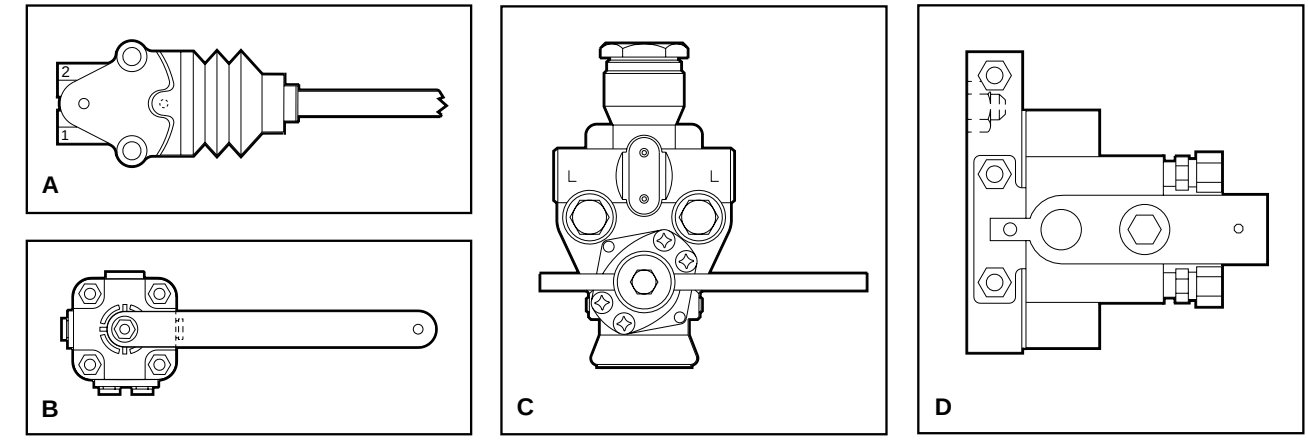
1. With the vehicle parked on a level surface, run the engine to build vehicle air pressure to at least 100 psi (690 kPa), then shut off the engine, apply the parking brakes, and chock the tires.
2. Wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

3. Disconnect the vertical linkage from the control lever; see **Fig. 2**, **Fig. 3**, or **Fig. 4**.
4. Push the control lever down about 45 degrees for 6 to 8 seconds. If air passes through the valve, that section of the valve is okay.
5. Return the control lever to the neutral position.
6. Pull the control lever up about 45 degrees for 6 to 8 seconds. If the air spring inflates, that section of the valve is okay.
7. Return the control lever to the neutral position. If the air stops again in the neutral position, the valve is working correctly.

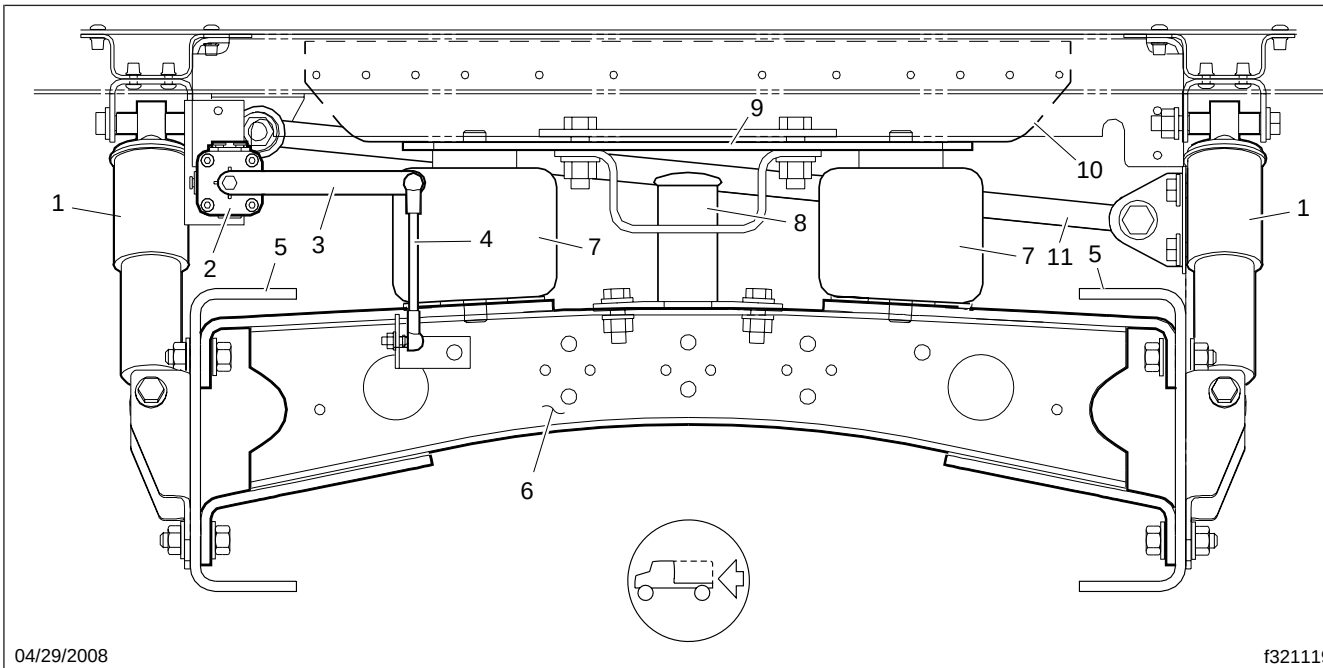
NOTE: If a leak is detected on a Barksdale height-control valve, go to "Checking a Barksdale Height-Control Valve Using a Test Kit". Barksdale valves have an acceptable leak rate of 3 cubic inches (50 cc) per minute. You can determine if a leak is acceptable only by using the Barksdale test kit.

Height-Control Valve Checking



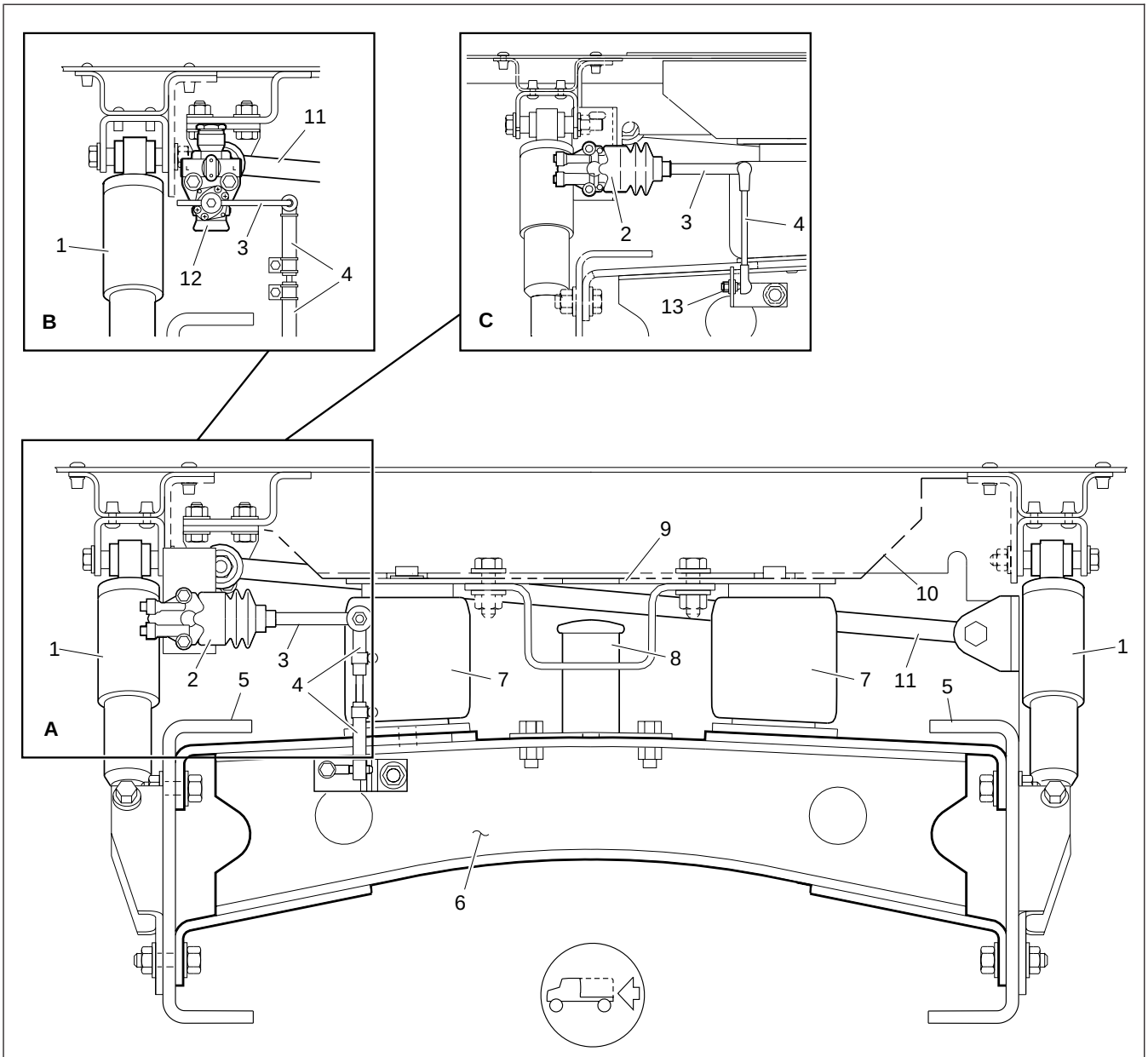
A. WABCO Valve, Plastic Valve Housing
B. Barksdale Valve
C. WABCO Valve, Aluminum Valve Housing
D. Neway Valve

Fig. 1, Height-Control Valves



1. Shock Absorber
2. Barksdale Height-Control Valve
3. Horizontal Control Lever
4. Vertical Linkage
5. Frame Rail
6. Frame Crossmember
7. Air Spring
8. Lower Cab-Mount Stop
9. Upper Cab-Mount Stop
10. Cab Rear-Deck Angle
11. Lateral Control Rod Assembly

Fig. 2, Barksdale Height-Control Valve Installation



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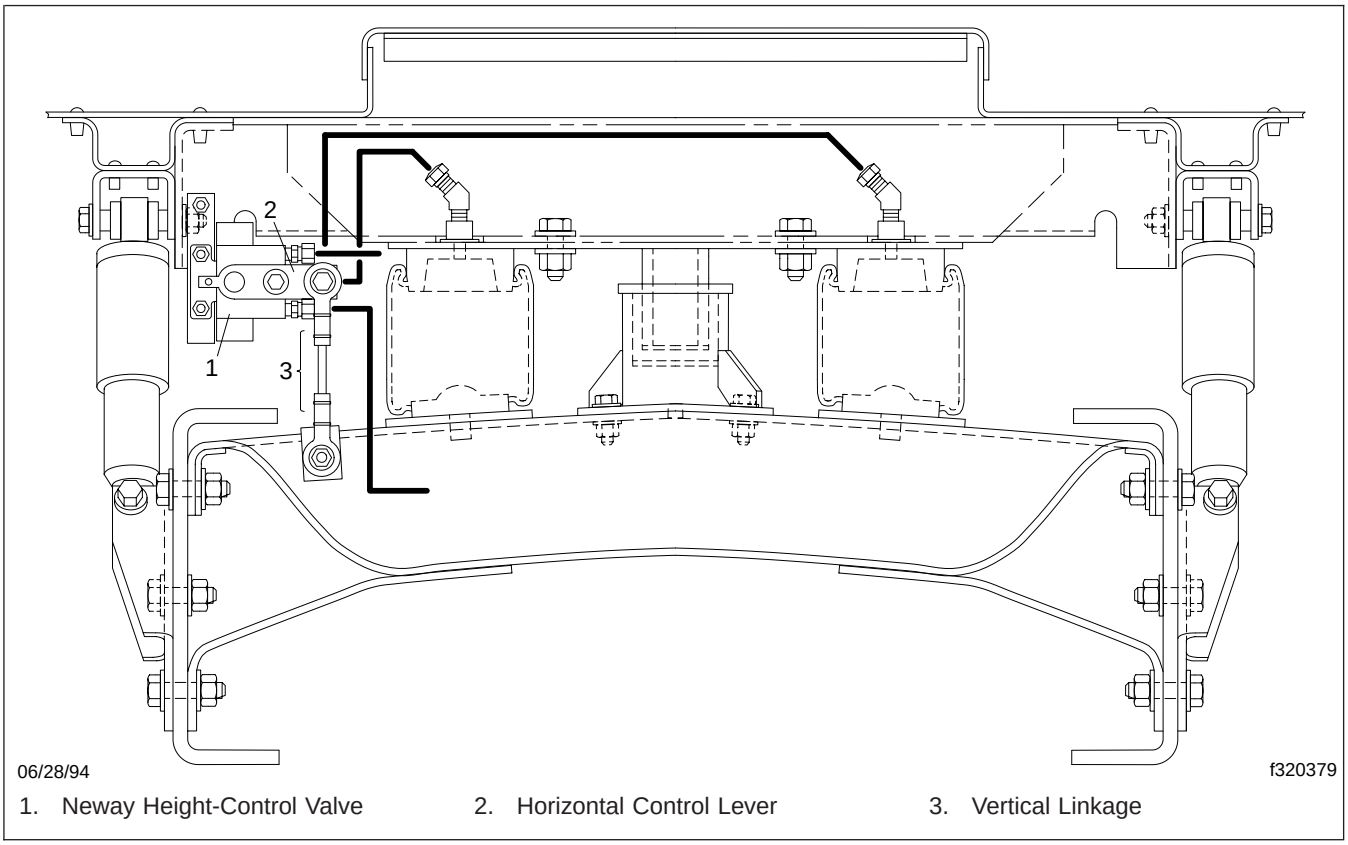
A. Vehicles Built from November 5, 1993 to May 17, 1997
B. Vehicles Built from April 5, 1991 to November 5, 1993
C. Vehicles Built after May 17, 1997

1. Shock Absorber
2. WABCO Height-Control Valve, Vehicles Built from November 5, 1993 (plastic valve housing)
3. Horizontal Control Lever
4. Vertical Linkage
5. Frame Rail
6. Frame Crossmember
7. Air Spring
8. Lower Cab-Mount Stop
9. Upper Cab-Mount Stop
10. Cab Rear-Deck Angle
11. Lateral Control Rod Assembly
12. WABCO Height-Control Valve, Vehicles Built from April 5, 1991 to November 5, 1993 (aluminum valve housing)
13. Adjustment Bolt

Fig. 3, WABCO Height-Control Valve Installation

Height-Control Valve Checking



1. Neway Height-Control Valve
2. Horizontal Control Lever
3. Vertical Linkage

Fig. 4, Neway Height-Control Valve Installation

If a leak is detected at the exhaust port on a WABCO or Neway height-control valve, the valve is defective. Replace it, following the procedure in **Subject 120**.

8. Connect the vertical linkage to the control lever, then tighten the linkage nut.

   If needed, adjust the cab ride height or replace the height-control valve. For adjustment of the cab ride height, see **Subject 100**. For replacement of the height-control valve, see **Subject 120**.

NOTE: For some vehicle applications, the cab ride height is preset in the factory, and is not adjustable.

Checking the Barksdale Height-Control Valve Using a Test Kit

IMPORTANT: The procedure described below is for use on Barksdale height-control valves only.

⚠ WARNING

Keep your hands and all objects away from the area under and around the cab when removing the pressure from the air system. Parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.

NOTE: The Barksdale field test kit is designed to be used with the height-control valve installed on the vehicle. Refer to **Specifications 400** for

information on ordering the Barksdale height-control valve test kit KD2264.

1. If not already done, park the vehicle on a level surface and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. Check the rubber exhaust flapper at the back of the valve housing for leaks. Use a soapy solution.
5. Disconnect the vertical linkage from the control lever; see **Fig. 2**.
6. Rotate and hold the control lever down at about 45 degrees to exhaust air from the air springs.
7. Disconnect the air lines from the air spring ports on the height-control valve. Leave the elbow fittings (if equipped) in place. Install a Parker plug into each air spring port (or elbow fitting); see **Fig. 5**.
8. If a flapper is present on the exhaust port of the height-control valve, remove it using needlenose pliers.
9. Clean the surface around the exhaust port, then install the test fitting into the exhaust port. The centering pin on the fitting must align with the slot on the exhaust port. Rotate the test fitting 45 degrees clockwise to lock it in place; see **Fig. 5**.
10. Connect one end of the air hose from the kit to the test connector on the exhaust port, and the other end to the test gauge.
11. Check the height-control valve in the fill mode, as follows.

    11.1 Rotate the valve control lever up 45 degrees from the horizontal to the fill position.

    11.2 Press the reset button on the test gauge.

    11.3 Observe the test gauge for 30 seconds. Refer to **Fig. 6** for the maximum allowable exhaust pressure change versus inlet pressure.

    The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

    If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

12. Check the height-control valve in the exhaust mode, as follows.

    12.1 Rotate the valve control lever down 45 degrees from the horizontal to the exhaust position.

    12.2 Press the reset button on the test gauge.

    12.3 Observe the test gauge for 30 seconds. Refer to **Fig. 6** for the maximum allowable exhaust pressure change versus inlet pressure.

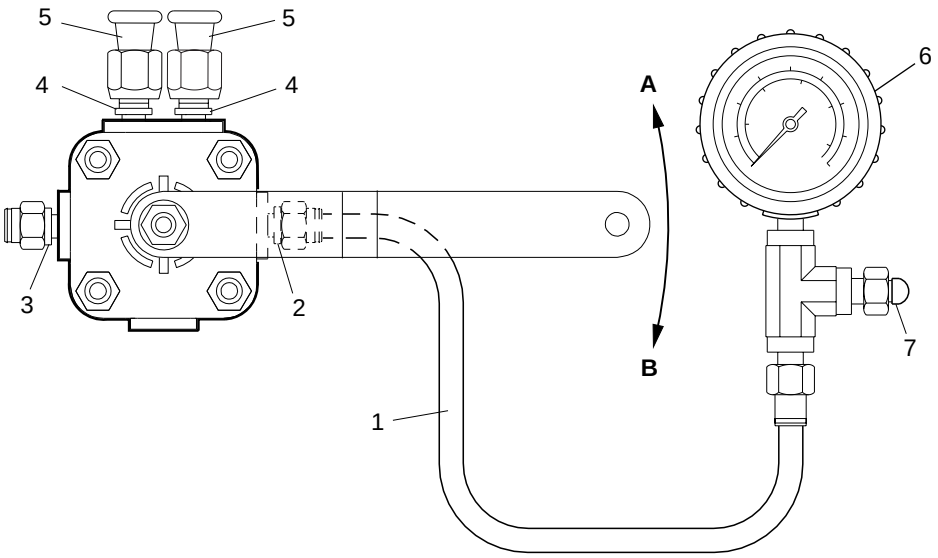
    The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

    If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

13. Disconnect the test gauge and connector from the valve exhaust port.
14. If the height-control valve is defective, replace it; see **Subject 120**.
15. Install the flapper on the exhaust port by pressing it into place.
16. Remove the two Parker plugs from the air spring ports, and connect the air lines to the air spring ports (or elbow fittings). Connect the vertical linkage to the height-control valve control lever. The ride height will automatically return to the correct position.

Height-Control Valve Checking



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A. Fill
B. Exhaust

1. Air Line
2. Exhaust Port Test Fitting
3. Air Intake Port
4. Air Spring Port
5. Parker Plug
6. Test Gauge Assembly
7. Reset Button

Fig. 5, Test Connections

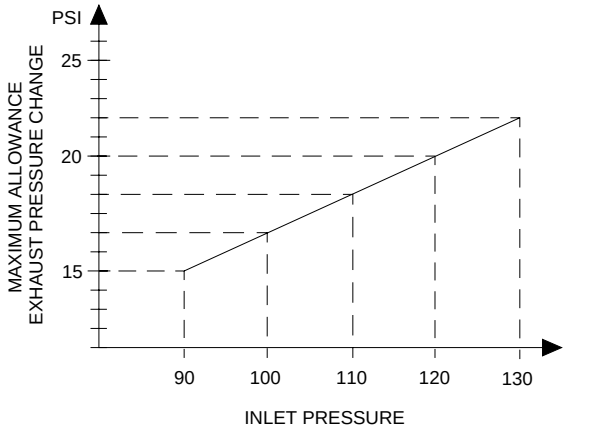

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Fig. 6, Inlet Pressure vs. Exhaust Pressure Change in 30 Seconds

IMPORTANT: Before replacing the height-control valve, do the steps in **Subject 110** to see if the valve is actually damaged or just out of adjustment.

Height-Control Valve Replacement, Barksdale

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.

⚠ WARNING

Do not disconnect any air lines in the cab suspension system without first blocking the cab securely. If the cab isn't securely blocked, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.

2. Place blocks between the frame and the bottom of the cab, or use jack stands to keep the cab in position when the air springs are deflated.
3. Drain all air from the air tanks.

⚠ WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

4. Remove the nut and washer that attaches the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1**.
5. Rotate and hold the horizontal control lever down until all air is exhausted from the air spring.
6. Mark the air tubing to the height-control valve for later reference, then disconnect the tubing.

NOTICE

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

7. While holding the height-control valve mounting studs in place with an Allen wrench, remove the nuts and washers that attach the valve to the mounting bracket. Remove the height-control valve.
8. Position the new height-control valve on the height-control bracket. While holding the height-control valve mounting studs in place with an Allen wrench, install the nuts and washers, and tighten the nuts 95 lbf·in (1100 N·cm). Do not overtighten.
9. Connect the air tubing to the height-control valve.
10. Align the vertical linkage with the horizontal control lever and install the washer and nut.
11. Start the engine and run it until air pressure builds to at least 100 psi (690 kPa).
12. Check all air tubing and fittings for leaks.
13. Remove the cab supports.

Height-Control Valve Replacement, WABCO

NOTE: Vehicles built before November 5, 1993, are equipped with a different model WABCO height control valve than later vehicles; see **Fig. 2**. The replacement procedure is basically the same for both models.

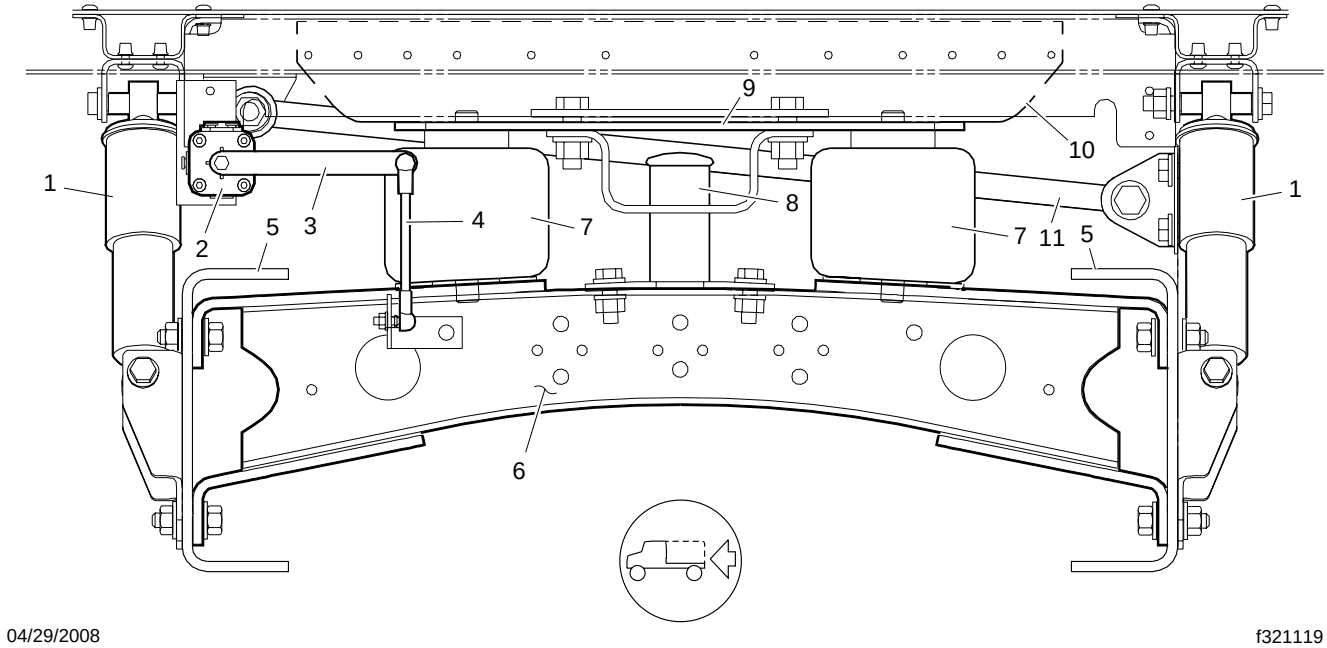
1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.

⚠ WARNING

Do not disconnect any air lines in the cab suspension system without first blocking the cab securely. If the cab isn't securely blocked, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.

2. Block the cab at normal ride height, by placing a wooden block between the top of the lower cab-mount stop and the bottom of the upper cab-mount stop assembly; see **Fig. 2**.

Height-Control Valve Replacement



1. Shock Absorber
2. Barksdale Height-Control Valve
3. Horizontal Control Lever
4. Vertical Linkage
5. Frame Rail
6. Frame Crossmember
7. Air Spring
8. Lower Cab-Mount Stop
9. Upper Cab-Mount Stop
10. Cab Rear-Deck Angle
11. Lateral Control Rod

Fig. 1, Barksdale Height-Control Valve Installation

3. Drain all air from the air tanks.

⚠ WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

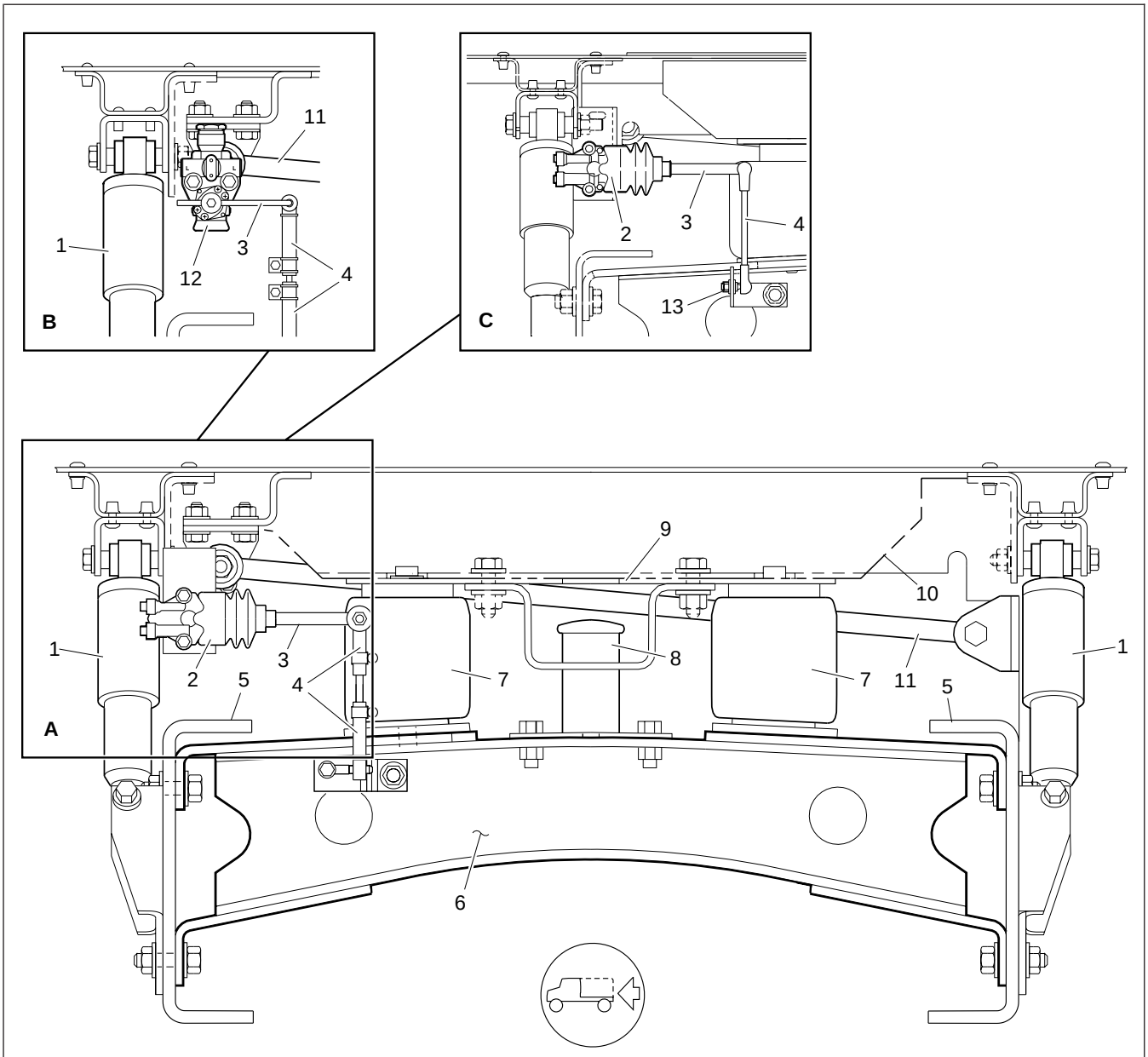
4. Disconnect the vertical linkage from the horizontal control lever. Move the lever down, and hold it there until all air is exhausted from the air springs.
5. Mark the air lines to the height-control valve for later reference, then disconnect them.

   For vehicles built before November 5, 1993: Remove the air line and the fitting from each of the height-control valve ports.

   For vehicles built from November 5, 1993: Push down on the brass collar on the push-to-seat fitting at one port, then remove the air line from the fitting. Repeat for the other port.
6. Remove the mounting fasteners from the height-control valve, then remove the height-control valve from the vehicle.
7. Position the new height-control valve on the mounting plate, then install the fasteners and tighten them 180 lbf·ft (244 N·m).
8. Remove the covers from the air lines. As marked earlier, connect the air lines to the height-control valve.

   For vehicles built before November 5, 1993: Install the air lines and the fittings into the height-control valve ports. Tighten the fitting nuts finger-tight, then tighten them two more turns, or until no threads show on the fitting body.

   For vehicles built from November 5, 1993: Install the air lines into the fittings until they seat completely. Tug on the lines to make sure they are completely seated.



A. Vehicles Built from November 5, 1993 to May 17, 1997
B. Vehicles Built from April 5, 1991 to November 5, 1993
C. Vehicles Built after May 17, 1997

1. Shock Absorber
2. WABCO Height-Control Valve, Vehicles Built from November 5, 1993 (plastic valve housing)
3. Horizontal Control Lever
4. Vertical Linkage
5. Frame Rail
6. Frame Crossmember
7. Air Spring
8. Lower Cab-Mount Stop
9. Upper Cab-Mount Stop
10. Cab Rear-Deck Angle
11. Lateral Control Rod Assembly
12. WABCO Height-Control Valve, Vehicles Built from April 5, 1991 to November 5, 1993 (aluminum valve housing)
13. Adjustment Bolt

Fig. 2, WABCO Height-Control Valve Installation

Height-Control Valve Replacement

9. Close the drain cocks on all air reservoirs.
10. Connect the vertical linkage to the horizontal control lever.
11. Start the engine and run it until air pressure builds to at least 100 psi (690 kPa).
12. Check the operation of the new height-control valve; see **Subject 110**.
13. Check all air lines and connections for leaks; eliminate all leaks.
14. Remove the cab support.
15. Adjust the height-control valve; see **Subject 100**.

Height-Control Valve Replacement, Neway

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.

⚠ WARNING

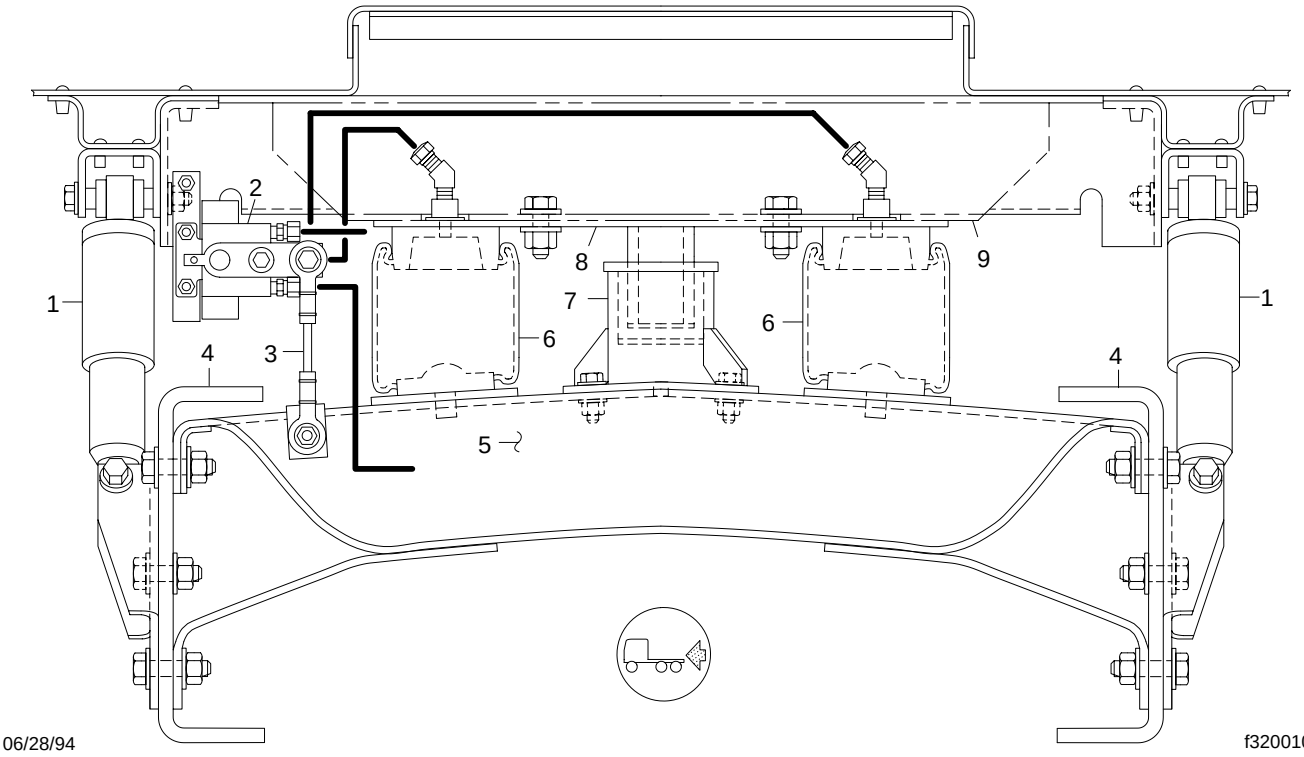
Do not disconnect any air lines in the cab suspension system without first blocking the cab securely. If the cab isn't securely blocked, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.

2. Block the cab at normal ride height, by placing a wooden block between the top of the lower cab-mount stop and the bottom of the upper cab-mount stop assembly; see **Fig. 3**.
3. Drain all air from the air tanks.

⚠ WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

4. Disconnect the vertical linkage from the horizontal control lever; see **Fig. 4**. Move the lever down, and hold it there until all air is exhausted from the air springs.
5. Remove the adjustment locknut and washer (**Fig. 4**, items 12 and 13) from the nylon block stud. Remove the horizontal control lever, and save it for installation on the new valve.
6. Disconnect the air lines from the fittings in the bottom and center ports of the height-control valve (**Fig. 5**, items 9 and 15). Do not disconnect the exhaust tube (item 13). Mark the lines for assembly reference. Cover the open ends of the air lines to prevent dirt or other foreign material from entering.
7. Remove the tee (**Fig. 5**, item 14) from the center the new height-control valve.
8. Remove the height-control valve mounting fasteners (**Fig. 4**, items 4 and 6), and remove the valve from the height-control valve plate (item 3).
9. Install the tee (**Fig. 5**, item 14) in the center port of the new height-control valve, and position it so the leg of the tee will point up and forward at a 45-degree angle when the height-control valve is installed on the vehicle.
10. Install the new exhaust fitting and exhaust tube (**Fig. 5**, items 7 and 13) in the top port of the height-control valve.
11. Install a new nylon tube fitting (**Fig. 5**, item 8) in the bottom port of the height-control valve.
12. Install a 3/16-inch diameter pin (**Fig. 3**, item 16) in the hole in the nylon block and height-control valve bracket (item 7).
13. Install the horizontal control lever on the height-control valve, and position it so the nylon block stud (**Fig. 3**, item 10) is centered in the lever adjustment slot (item 9). Install the adjustment locknut and hardened washer, and tighten the locknut 60 lbf·in (680 N·cm). Remove the pin from the nylon block and the bracket.
14. Attach the new height-control valve to the height-control valve plate. Tighten only the lower valve mounting nut (**Fig. 4**, item 6) 108 lbf·in (1220 N·cm).
15. Remove the covers from the air lines, and install new fitting nuts and brass sleeves (**Fig. 3**, items 11 and 12) on the lines. Connect the air lines to the height-control valve, as marked earlier, or as shown in **Specifications, 400**. Tighten the fitting nuts finger-tight, then tighten them two more turns, or until no threads show on the fitting body.
16. Close the drain cocks on all air reservoirs.
17. Start the engine and run it until air pressure builds to at least 100 psi (690 kPa).

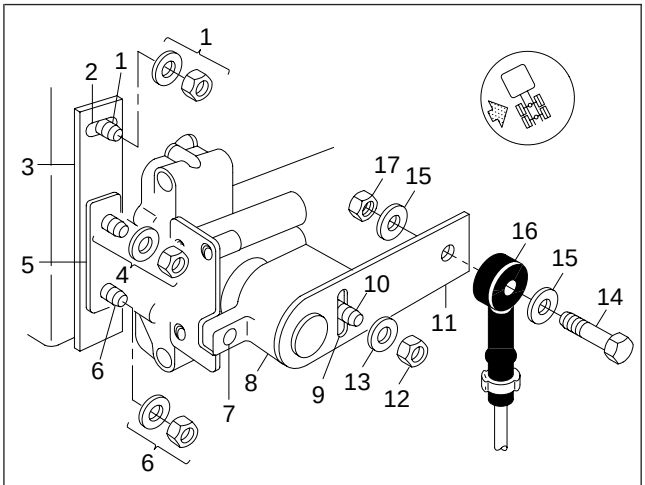


1. Shock Absorber
2. Height-Control Valve, Neway
3. Vertical Linkage
4. Frame Rail
5. Rear Cab-Mount Crossmember
6. Air Spring
7. Lower Cab-Mount Stop
8. Upper Cab-Mount Stop Assembly
9. Rear Cab-Mount Angle

Fig. 3, Cab Rear Air-Suspension Installation, Vehicles Built from January 1990 to April 1991 (without lateral control rod)

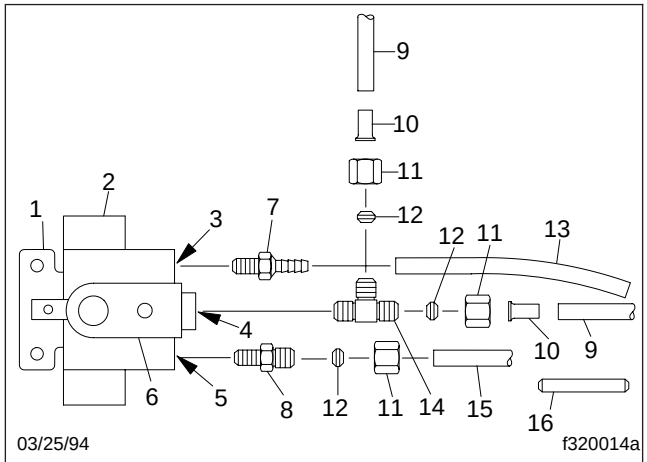
18. Check the operation of the new height-control valve; see **Subject 110**.
19. Check all air lines and connections for leaks; eliminate all leaks.
20. Remove the cab support.
21. Adjust the height-control valve; see **Subject 100**.

Height-Control Valve Replacement



1. Height-Control Valve Plate Upper Mounting Fasteners
2. Slotted Hole
3. Height-Control Valve Plate
4. Center Mounting Fasteners
5. Height-Control Valve Bracket
6. Lower Mounting Fasteners
7. 3/16-Inch Diameter Hole
8. Nylon Block
9. Lever Adjustment Slot
10. Nylon Block Stud
11. Horizontal Control Lever
12. Adjustment Locknut
13. Hardened Washer
14. Vertical Linkage Bolt
15. Hardened Washer
16. Vertical Linkage
17. Locknut

Fig. 4, Neway Height-Control Valve Installation

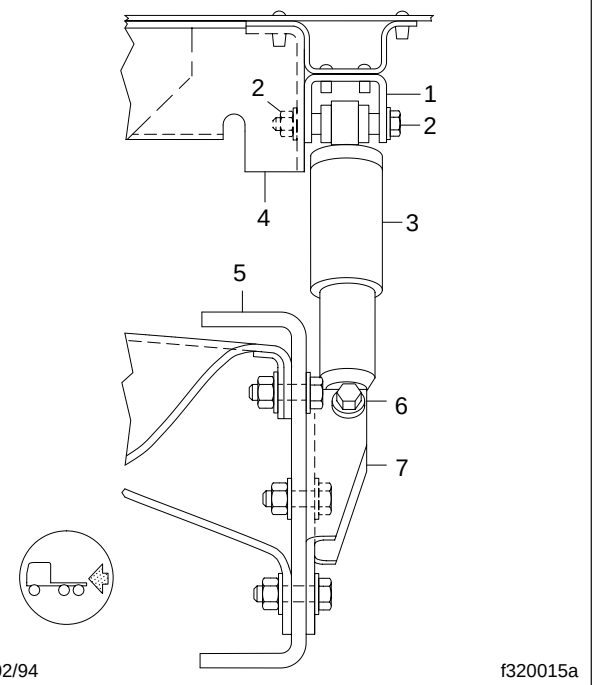


1. Height-Control Valve Bracket
2. Height-Control Valve Body
3. Top Port
4. Center Port
5. Bottom Port
6. Nylon Block
7. Exhaust Fitting
8. Fitting (with filter)
9. Air-Spring Supply Air Line
10. Brass Insert
11. Fitting Nut
12. Brass Sleeve
13. Exhaust Tube
14. Tee
15. Height-Control Valve Supply Air Line
16. 3/16-Inch Diameter Pin

Fig. 5, Neway Height-Control Valve Assembly

Replacement

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.
2. Place blocks between the frame and the bottom of the cab, or use jack stands to keep the cab in position when the shock is removed.
3. Remove the locknuts and hardened washers from the shock absorber upper and lower mounting bolts; see **Fig. 1**. Remove the bolts. Pull the shock absorber out of the mounting brackets.
4. Install the new shock absorber in the mounting brackets, and secure it using the bolts, washers, and locknuts. Tighten the locknuts 70 lbf·ft (95 N·m).



NOTE: Right-hand side, shown from the rear.

1. Upper Mounting Bracket
2. Upper Mounting Fastener
3. Shock Absorber
4. Rear Cab-Mount Z-Angle
5. Frame Rail
6. Lower Mounting Fastener
7. Lower Mounting Bracket

Fig. 1, Shock Absorber Installation

5. Remove the cab supports.

Replacement

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.

⚠ WARNING

Do not disconnect any air lines in the cab suspension system without first blocking the cab securely. If the cab isn't securely blocked, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.

2. Jack up the cab, and block it at about 1 inch (25 mm) higher than its normal ride height. Block the cab between the frame rail and the bottom of the cab deck.
3. Drain all air from the air tanks.

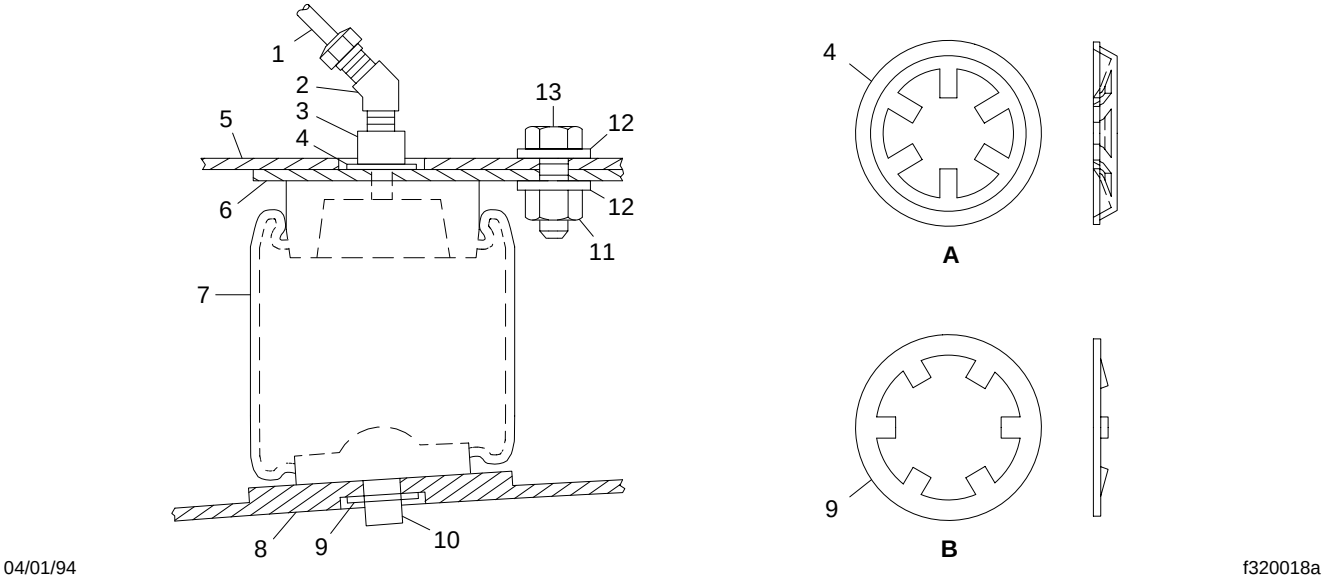
⚠ WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

4. Disconnect both air-spring supply air lines at the height-control valve tee, or the height-control valve ports, if there is no tee. For plumbing diagrams, see **Specifications 400**. Cover the open ends of the air lines and the tee (or height-control valve ports) to prevent dirt or other foreign material from entering.
5. Using a hammer and a small chisel, remove the circular push-on from the bottom boss of each air spring; see **Fig. 1**, items 9 and 10. Discard the push-ons.
6. Remove the fasteners that attach the lower cab-mount stop to the frame crossmember; see **Fig. 2**, **Fig. 3**, or **Fig. 4**.
7. Remove the fasteners that attach the upper cab-mount stop assembly to the rear cab-mount angle; see **Fig. 2**, **Fig. 3**, or **Fig. 4**.

   *For non-SleeperCabs with a WABCO height-control valve (**Fig. 3**):* Remove all eight lower cab-mount fasteners, then remove the two tie-rod bracket fasteners (item 11).
8. Work the 45-degree elbows and air lines out of the holes in the rear cab-mount angle (see **Fig. 1**), by collapsing the air bags while pushing the upper cab-mount stop assembly toward the passenger's side.
9. Remove the bottom boss of both air springs from the rear frame crossmember. Tape the lower cab-mount stop to the upper stop assembly.
10. Pull forward on the upper cab-mount stop assembly, and remove the upper cab-mount stop assembly, lower cab-mount stop, and the air springs, as an assembly.
11. As an assembly, remove the air line and 45-degree elbow from the air spring that is being replaced. Cover the open end of the elbow.
12. Using a hammer and a small chisel, remove the reinforced circular push-on (**Fig. 1**, item 4) from the upper boss of the air spring that is being replaced. Remove the air spring from the upper stop assembly. Discard the reinforced circular push-on.
13. Install a new air spring in the upper stop assembly, and press a new reinforced circular push-on all the way onto the upper boss of the air spring.
14. Remove the cover from the 45-degree elbow, and install the elbow in the upper boss. Tighten it finger-tight, then one turn more. If needed, further tighten it until the elbow points in the same direction as the 45-degree elbow in the other air spring.
15. As an assembly, install the upper cab-mount stop assembly, air springs, and lower cab-mount stop, between the rear frame crossmember and the rear cab-mount angle. The 45-degree elbows on the air springs must point toward the driver's side. Route the air lines up through the air spring mounting holes in the rear cab-mount angle. Remove the tape from the lower cab-mount stop.
16. Collapse the air springs, and work the 45-degree elbows and the air spring upper bosses through the holes in the rear cab-mount angle. Install the bolts, hardened washers, and locknuts that attach the upper cab-mount stop assembly to the angle; see **Fig. 2**, **Fig. 3**, or **Fig. 4**. Tighten the locknuts 180 lbf·ft (244 N·m).
17. Position the lower boss of each air spring in the rear frame crossmember. Press a new circular push-on (**Fig. 1**, item 9) all the way onto each boss.

Air Spring Replacement



A. Detail of Reinforced Circular Push-On
B. Detail of Circular Push-On

1. Left Air-Spring Supply
2. 45-Degree Elbow
3. Air Bag Top Boss
4. Reinforced Circular Push-On
5. Rear Cab-Mount Angle
6. Upper Cab-Mount Stop Assembly
7. Air Spring (left side shown)
8. Rear Cab-Mount Crossmember
9. Circular Push-On
10. Air Spring Bottom Boss
11. Locknut
12. Hardened Washer
13. Hexhead Bolt

Fig. 1, Air Spring Installation

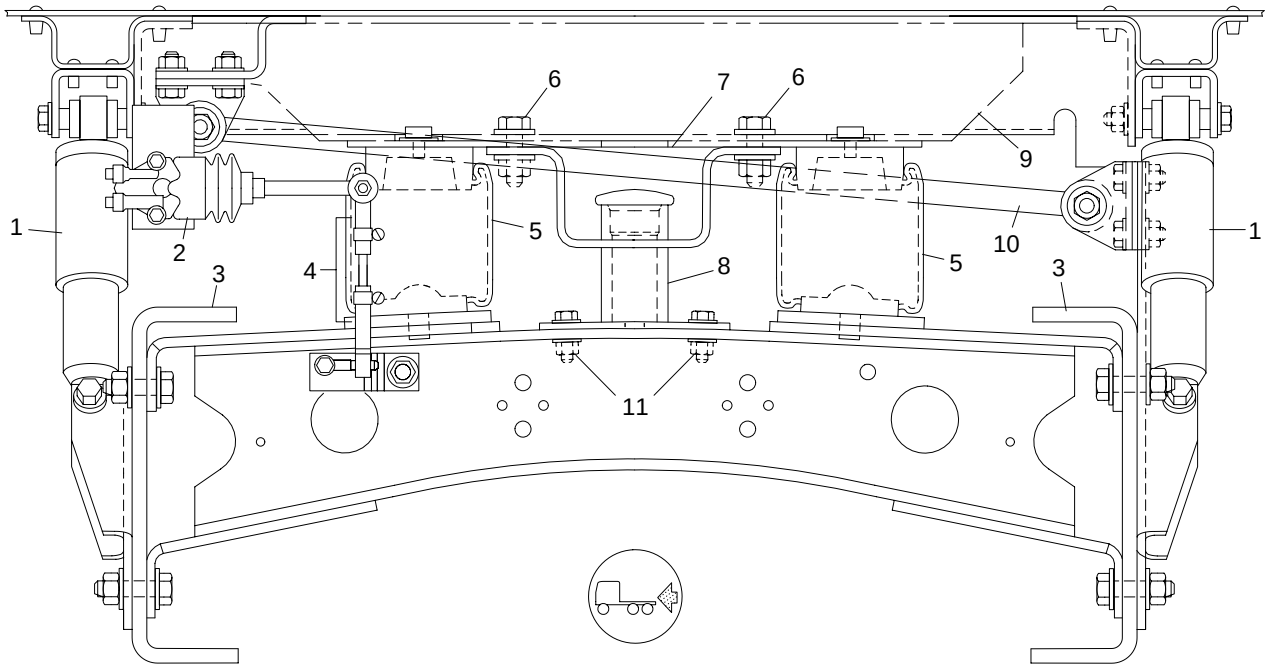
18. Install the bolts, hardened washers, and locknuts that attach the lower cab-mount stop to the rear frame crossmember.

    For non-SleeperCabs with WABCO height-control valves (**Fig. 3**): Install the eight lower cab-mount fasteners; then install the two lateral control rod bracket fasteners (item 11).

    For all applications, tighten the locknuts 91 lbf·ft (123 N·m).

19. Remove the cover from the tee on the height-control valve (or from the height-control valve ports) and from the air-spring supply air lines. Install a new sleeve in each of the fitting nuts. Attach the air lines to the tee or to the height-control valve ports, as applicable. Tighten each nut finger-tight, then tighten it two more turns, or until no threads show on the tee or height-control valve.
20. Jack up the cab, and remove the block.
21. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).

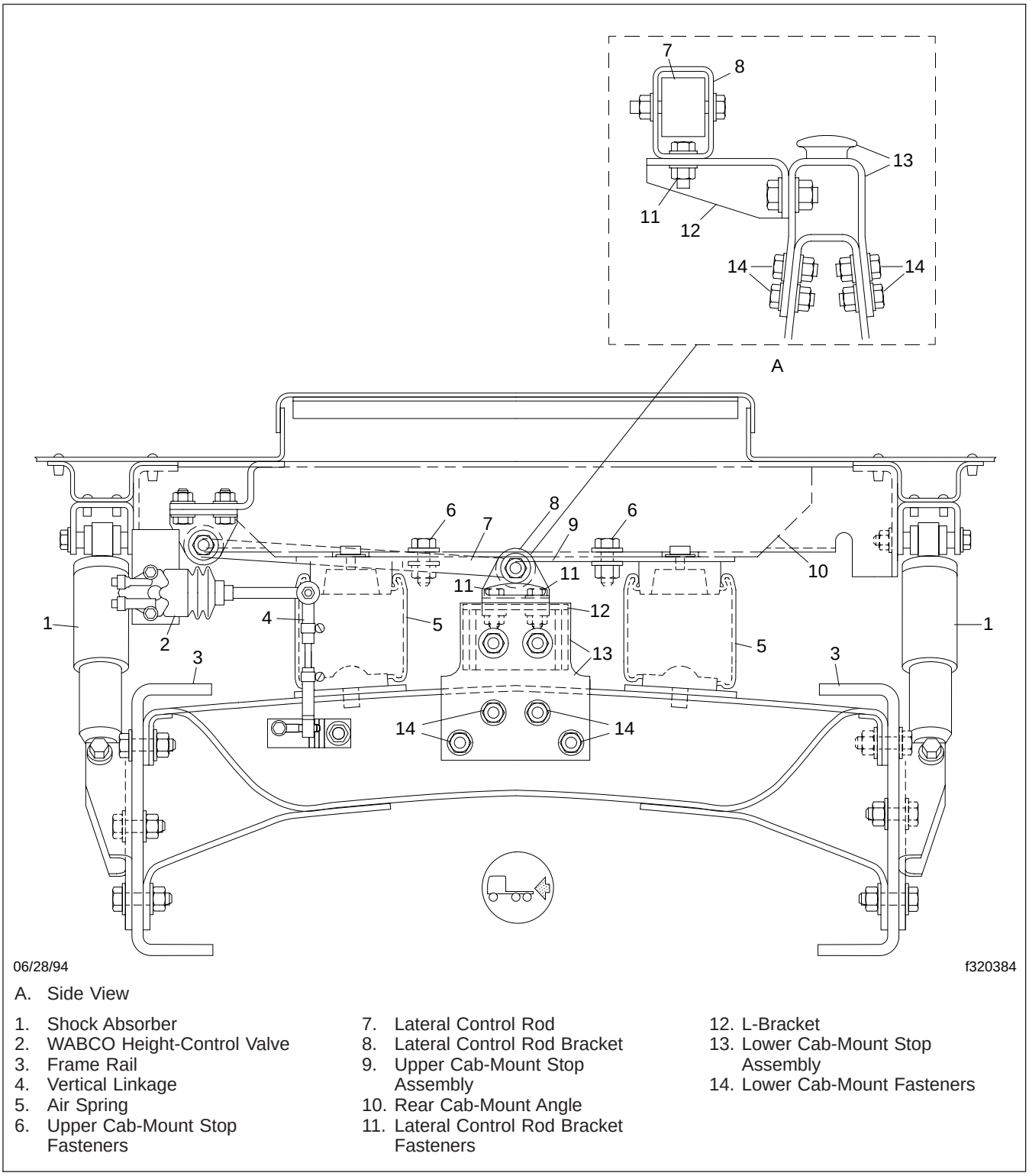
    Check for air leaks at the air springs and at the height-control valve. Tighten the fittings or replace the parts, as needed.



1. Shock Absorber
2. WABCO Height-Control Valve
3. Frame Rail
4. Vertical Linkage
5. Air Spring
6. Upper Cab-Mount Stop Fasteners
7. Upper Cab-Mount Stop Assembly
8. Lower Cab-Mount Stop Assembly
9. Rear Cab-Mount Angle
10. Lateral Control Rod Assembly
11. Lower Cab-Mount Stop Fasteners

Fig. 2, Cab Rear Air-Suspension Installation, SleeperCab

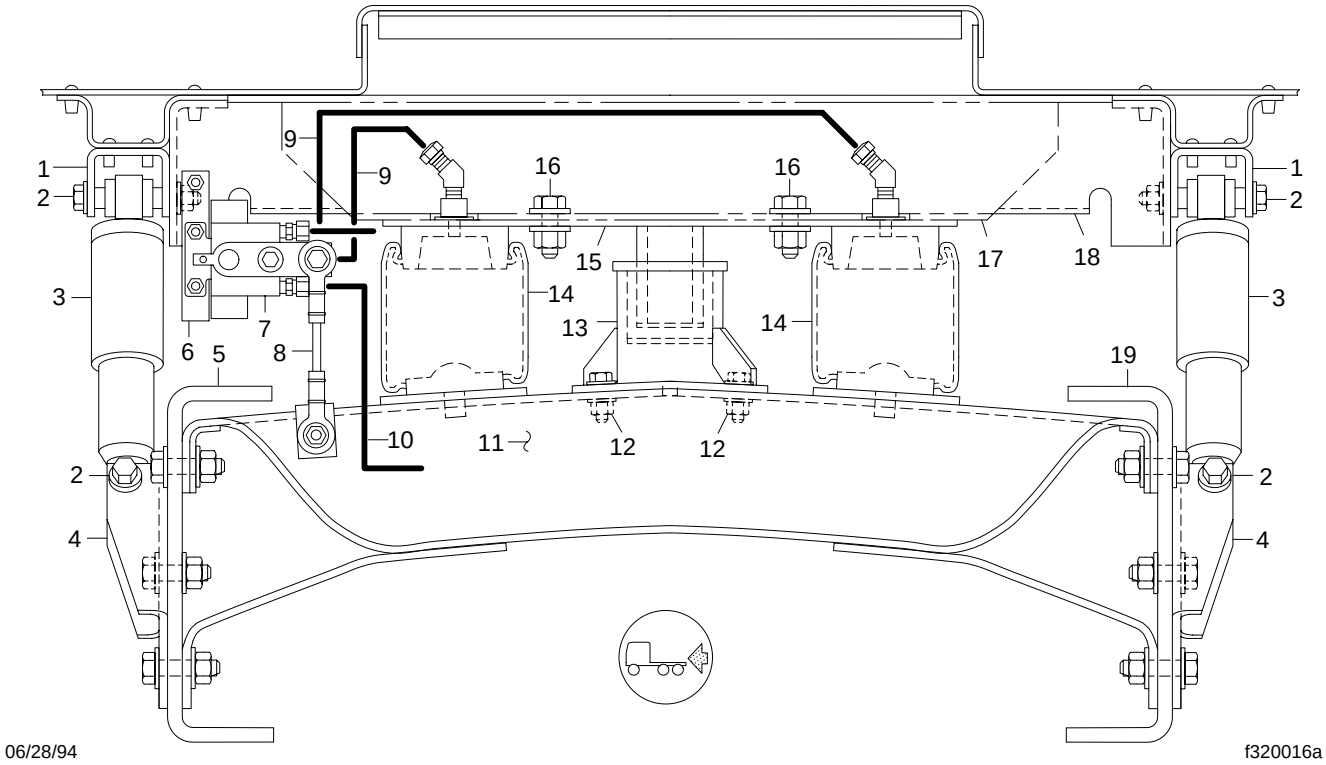
Air Spring Replacement



A. Side View

1. Shock Absorber
2. WABCO Height-Control Valve
3. Frame Rail
4. Vertical Linkage
5. Air Spring
6. Upper Cab-Mount Stop Fasteners
7. Lateral Control Rod
8. Lateral Control Rod Bracket
9. Upper Cab-Mount Stop Assembly
10. Rear Cab-Mount Angle
11. Lateral Control Rod Bracket Fasteners
12. L-Bracket
13. Lower Cab-Mount Stop Assembly
14. Lower Cab-Mount Fasteners

Fig. 3, Cab Rear Air-Suspension Installation, Non-SleeperCab



1. Shock Absorber Upper Mounting Bracket
2. Shock Absorber Mounting Fasteners
3. Shock Absorber
4. Shock Absorber Lower Mounting Bracket
5. Left Frame Rail
6. Height-Control Valve Plate
7. Neway Height-Control Valve
8. Vertical Linkage
9. Air-Spring Supply Air Line
10. Height-Control Valve Supply Air Line
11. Rear Cab-Mount Crossmember
12. Lower Cab-Mount Stop Fasteners
13. Lower Cab-Mount Stop
14. Air Spring
15. Upper Cab-Mount Stop Assembly
16. Upper Cab-Mount Assembly Fasteners
17. Rear Cab-Mount Angle
18. Rear Cab-Mount Z-Angle
19. Right Frame Rail

Fig. 4, Cab Rear Air-Suspension Installation, Vehicles With Neway Height-Control Valve

Troubleshooting Tables

Problem—Both Air Springs Are Flat

Possible Cause	Remedy
Low air pressure in the secondary air system.	Check the air pressure gauge on the instrument panel. If secondary air pressure is low, run the engine until at least 70 psi (482 kPa) is indicated.
Air is leaking from the cab air-suspension system.	Check for leakage from fittings, air lines, air springs, and the height-control valve. Tighten loose fittings to stop leakage; replace worn or damaged parts.
The height-control valve is out of adjustment.	Adjust the height-control valve; see **Subject 100**.
The height-control valve is inoperative.	If upward movement of the horizontal control lever on a properly adjusted valve fails to inflate the air springs, replace the height-control valve; see **Subject 120**.
The vertical linkage is damaged.	Check for damage to the vertical linkage and the horizontal control lever. Repair or replace damaged linkage parts.

Problem—Air Springs Deflate Rapidly When the Engine Is Not Running

Possible Cause	Remedy
Air is leaking from the cab air-suspension system.	Check for leakage from fittings, air lines, air springs, and the height-control valve. Tighten loose fittings to stop leakage; replace worn or damaged parts.

Problem—Rear of Cab Rides Too High or Too Low

Possible Cause	Remedy
The height-control valve is out of adjustment.	Adjust the height-control valve; see **Subject 100**.

Problem—Collapsed Air Spring

Possible Cause	Remedy
An air spring is punctured.	Locate leaks by listening for escaping air, or by applying a soap and water solution to the air spring and watching for bubbles. Repair punctures and cuts that are less than 1/8 inch (3 mm). Replace the air spring if damage is greater. Check the area around the damaged air spring for contact with other components. Correct the problem areas as needed.
The air spring is continually or repeatedly over-extended.	Check the suspension height. Make sure the correct height is maintained. Adjust if needed. See **Subject 100** for the correct height and adjustment procedures. Check for a broken shock absorber or shock bracket; replace if broken.

Troubleshooting Procedures

Checking the Cab Height-Control System for Air Leaks

⚠ WARNING

Keep your hands and all objects away from the area under and around the cab when removing the pressure from the air system. Parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing if you detect leaks in the housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

NOTICE

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

1. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa). Turn off the engine and wait 5 to 10 minutes for the system to equalize.

   NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal and does not indicate a damaged valve.
3. Apply a soap-and-water solution to the outside of the air fittings on the height-control valve and on the suspension air springs. Look for bubbles indicating an air leak.
4. If bubbles are seen, check that the air tubing is installed correctly into the fitting.

   If no bubbles are seen, check the height-control valve for air leaks; see **Subject 110**.

Diagnostics and Testing

Air Spring

Inspect the exterior surfaces of the air spring, looking for wear. With the air spring fully inflated, check to see if there is sufficient clearance around the air spring to prevent lines or objects from rubbing against the air spring. Air tubing or cab components that rub against the air spring will cause damage to the air spring. If the air spring is not capable of lifting the cab to its proper ride height, check to see if the shock absorber is damaged. A binding shock absorber will limit the air spring's ability to extend. To clean the air spring, use soap and water.

NOTE: Do not use organic solvents, abrasives, or pressurized steam cleaners to clean the air spring.

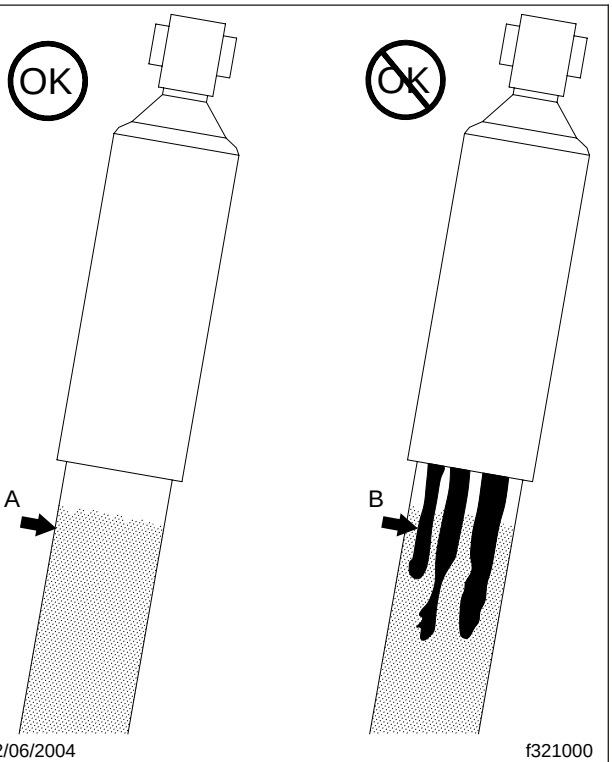
Shock Absorber

Inspect the shock body for damage such as bends or dents in the piston. Bends or dents in the shock body will negatively affect the operation of the shock. Inspect the shock body for signs of leaking fluid. Normal operation of the shock will result in some misting of the hydraulic fluid onto the exterior shock body. Large streams of fluid indicate a leak, and the shock should be replaced; see **Fig. 1**.

To test the operation of a shock absorber, hold the shock in an upright position and cycle the piston at least five times by pushing the piston up and down. The piston should move evenly throughout each section of the cycle. If the shock does not move evenly when pushed down or pulled up, the shock should be replaced.

Noises such as squeaks, which may be intermittent, may be caused by the valves used to regulate the internal hydraulic fluid. This problem is not repairable, and the shock will need to be replaced. Noises from the shock, such as knocking or rattling, may be due to movement between the bushings and mounting brackets. Inspect the bushings or mounting brackets for wear. Repair worn components as necessary. Check the torque of the shock absorber mounting nuts and tighten if necessary.

NOTE: The shock absorber bushings do not require any type of lubrication. Do not attempt to stop bushing noise by lubricating them; grease and mineral-oil-base lubricants will deteriorate the bushing rubber.



A. Dust covered mist (normal).
B. Hydraulic fluid streaks indicating an actual leak.

Fig. 1, Differences Between Misting and Leaking

Torque Specifications

Unless listed in **Table 1**, tighten all fasteners using the torque specifications found in **Section 00.06**.

Description	Size	Torque
Neway Height-Control Valve Adjustment Locknut	1/4–20	60 lbf·in (680 N·cm)
Neway Height-Control Valve Mounting Locknuts	1/4–20*	10 lbf·ft (14 N·m)
WABCO Height-Control Valve Mounting Locknuts	5/16–18	15 lbf·ft (20 N·m)
Barksdale Height-Control Valve Housing Bolts†	1/4–20	45 lbf·in (500 N·cm)
Barksdale Height-Control Valve Mounting Locknuts†	1/4–20*	95 lbf·in (1100 N·cm)
Shock Absorber Locknuts	1/2–13*	91 lbf·ft (123 N·m)
Upper Cab-Mount Stop Assembly Mounting Locknuts	5/8–11*	180 lbf·ft (244 N·m)
Lower Cab-Mount Stop Mounting Locknuts	1/2–13*	91 lbf·ft (123 N·m)
Lateral Control Rod Bracket Locknuts	1/2–13*	91 lbf·ft (123 N·m)

* Grade 8 bolts with phosphate- and oil-coated threads, and cadmium-plated, wax-coated grade C locknuts; both used with hardened washers.

† See the cautionary statements below.

Table 1, Torque Values

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

NOTICE

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

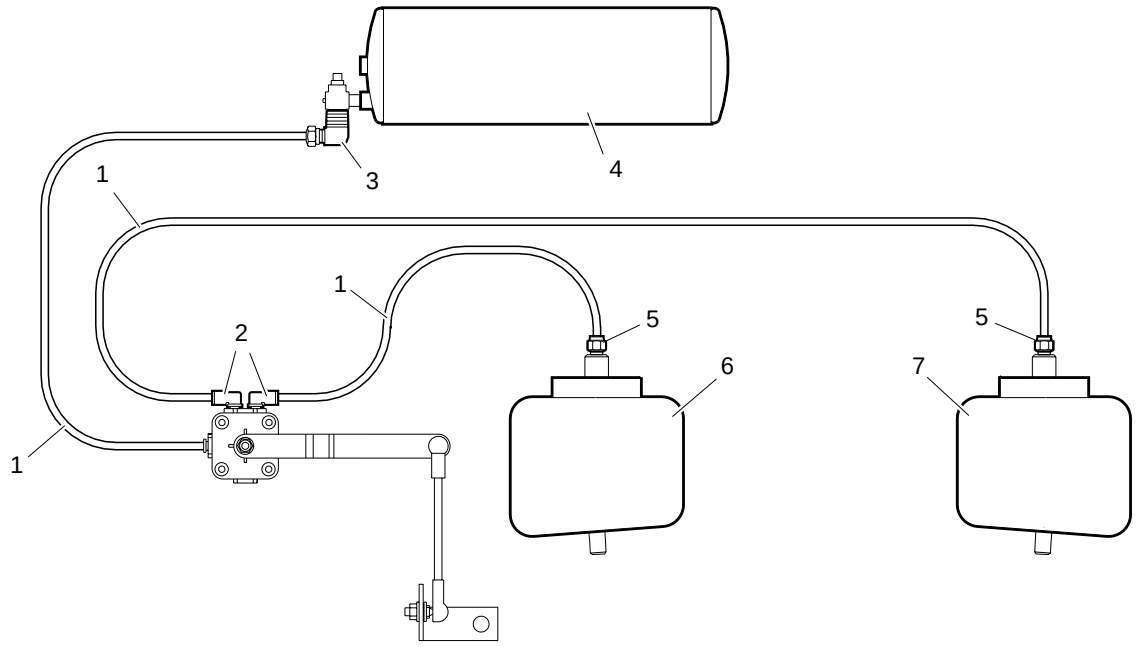
Plumbing Diagrams

For cab air suspension plumbing diagrams, see **Fig. 1**, **Fig. 2**, and **Fig. 3**.

Special Tools

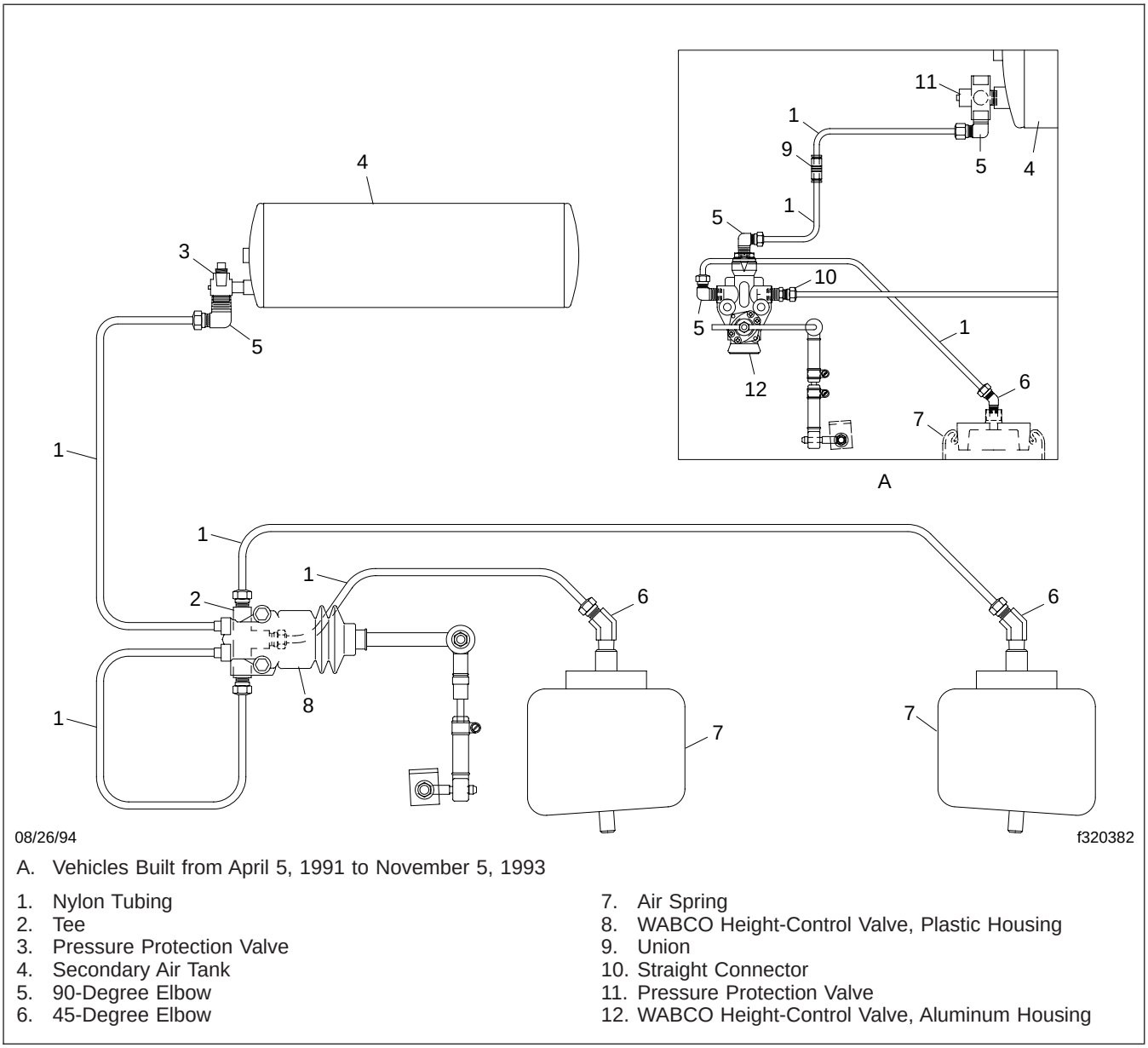
Use the kit shown in **Fig. 4** to test a Barksdale height-control valve. Test kit BKS KD2264 is available via the Direct Ship program in paragon.

Specifications



1. Nylon Tube
2. 90-Degree Fittings
3. 90-Degree Elbow
4. Secondary Air Tank
5. Connector
6. Air Spring, LH
7. Air Spring, RH

Fig. 1, Plumbing Diagram, Barksdale Height-Control Valve

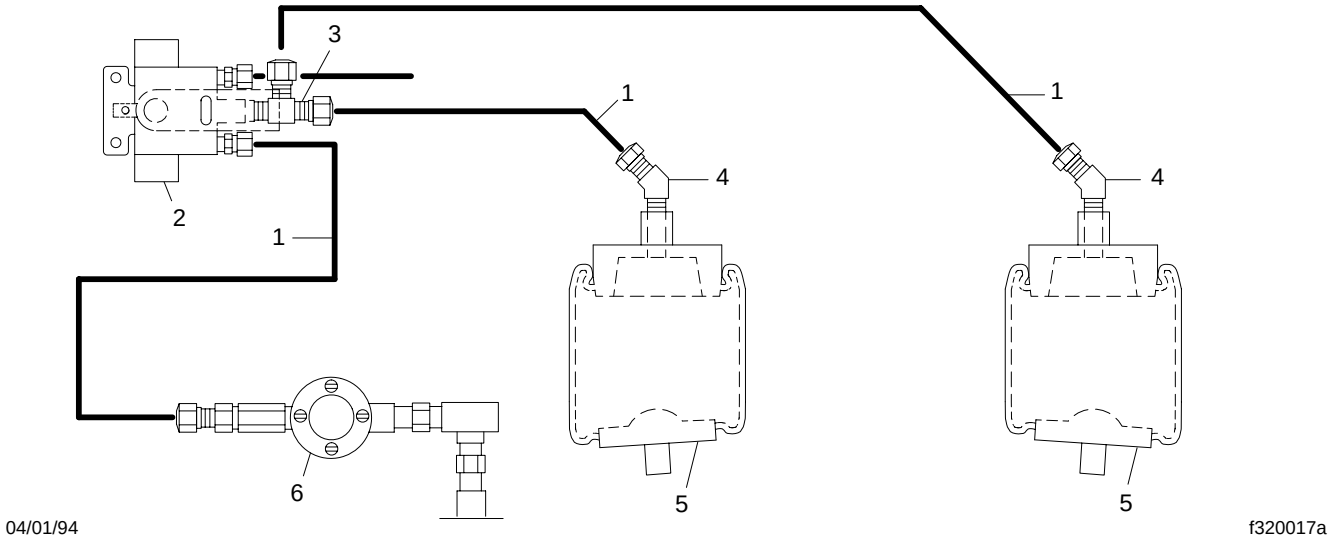


A. Vehicles Built from April 5, 1991 to November 5, 1993

1. Nylon Tubing
2. Tee
3. Pressure Protection Valve
4. Secondary Air Tank
5. 90-Degree Elbow
6. 45-Degree Elbow
7. Air Spring
8. WABCO Height-Control Valve, Plastic Housing
9. Union
10. Straight Connector
11. Pressure Protection Valve
12. WABCO Height-Control Valve, Aluminum Housing

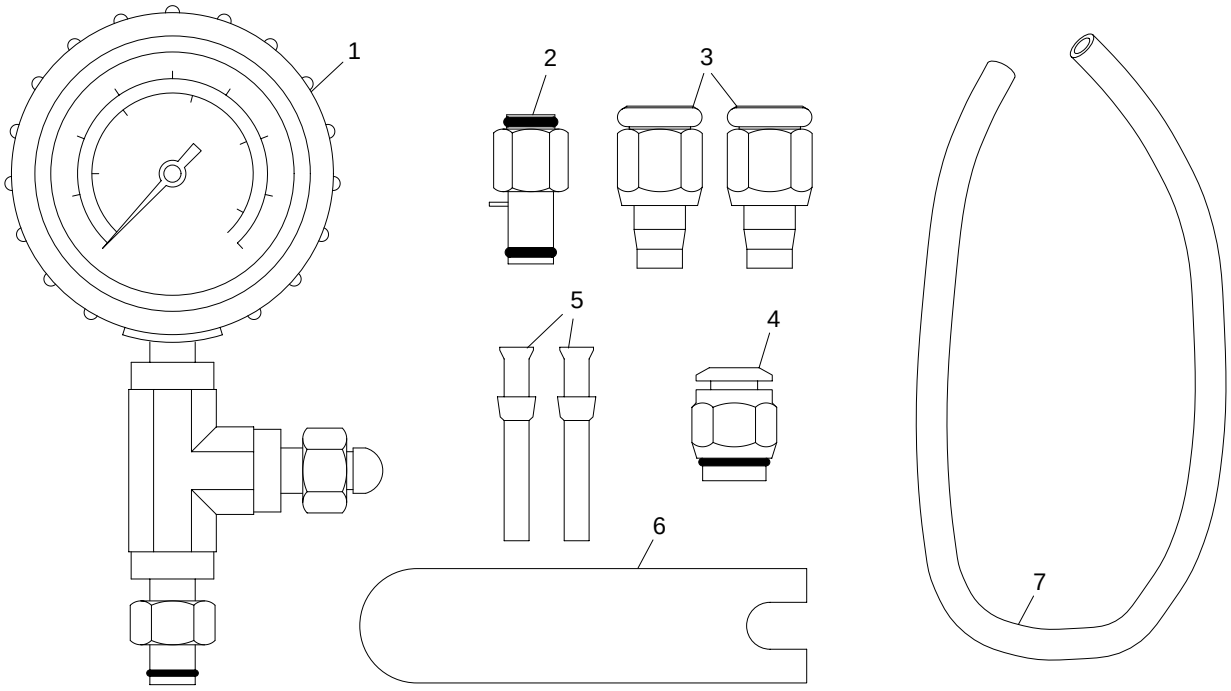
Fig. 2, Plumbing Diagram, WABCO Height-Control Valve

Specifications



1. Nylon Tube
2. Height-Control Valve
3. Tee
4. 45-Degree Elbow
5. Air Spring
6. Pressure Protection Valve (on transmission)

Fig. 3, Plumbing Diagram, Neway Height-Control Valve



1. Test Gauge Assembly with Reset Button
2. Exhaust Port Test Connector for Cab Suspension Valve
3. Parker Plugs
4. Exhaust Port Test Connector for Chassis Suspension Valve
5. Test Plugs for Cab Suspension Valve
6. Special Tool for Disconnecting Air Line
7. Air Line

Fig. 4, Barksdale Height-Control Valve Test Kit BKS KD2264

General Information and Principles of Operation

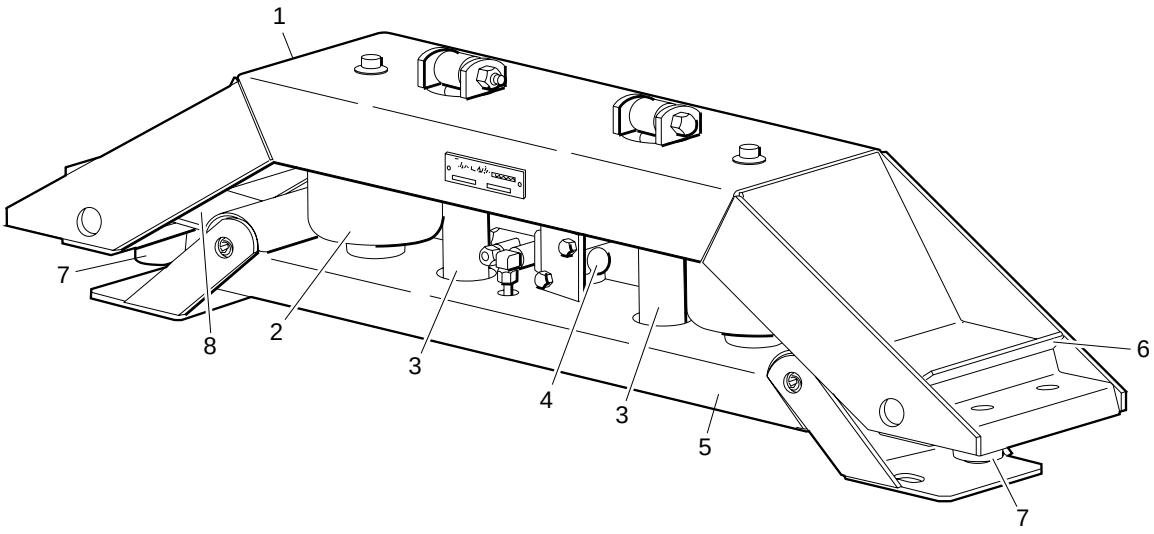
The Link Cabmate cab rear air-suspension system is standard equipment on the longer COEs. It is an option on shorter COE cabs. Model FRT285–AV (**Fig. 1**) is used on 96-inch and 104-inch FLA COEs. Model FRT46–2P–A (**Fig. 2**) is used on 90-inch, 100-inch, and 110-inch FLB COEs.

The cab air-suspension system absorbs road shocks and compensates for changing cab loads. Both models have the same basic parts: two air springs, a leveling valve, two shock absorbers, two transverse torque arms, and top and bottom units. See **Fig. 1** and **Fig. 2**.

AIR SPRINGS

The tops of both air springs are mounted on the top unit(s) and the bottoms are mounted on the bottom unit(s). Two transverse torque arms provide side-to-side location of the top unit in relation to the bottom unit.

Together with the leveling valve, the air springs compensate for changes in cab load by maintaining the correct distance between the rear of the cab and the frame rails.



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1. Top Unit
2. Air Spring
3. Shock Absorber
4. Leveling Valve
5. Bottom Unit
6. Cab Latch
7. Rubber Bumper
8. Transverse Torque Arm

Fig. 1, Model FRT285-AV Cab Rear Air Suspension Unit

TOP AND BOTTOM UNITS

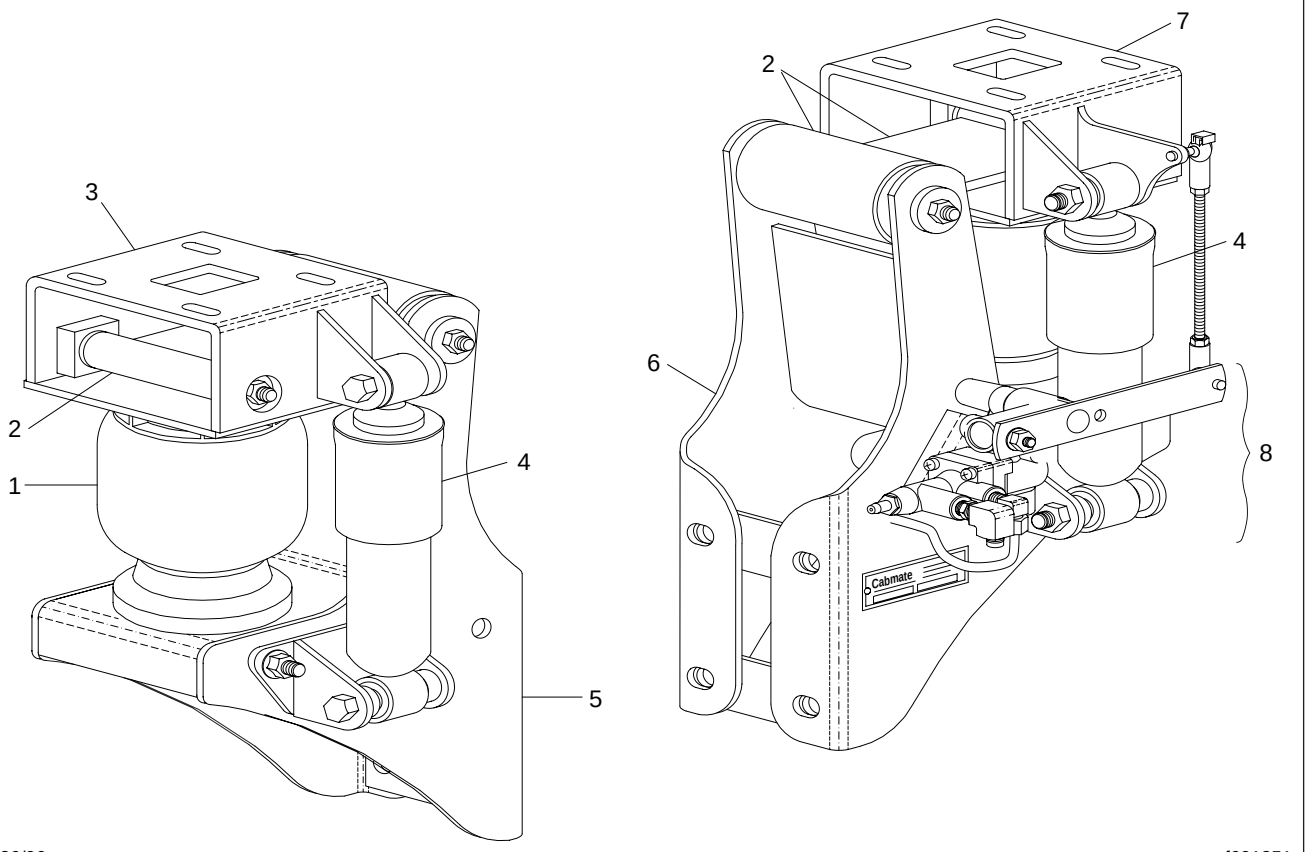
Model FRT285–AV (**Fig. 1**) has one top and one bottom unit. The top unit has built-in cab latches, and partially covers the bottom unit. The bottom unit is mounted to the frame rails.

Model FRT46–2P–A (**Fig. 2**) has two separate top and bottom units, one pair on each side of the vehicle. The bottom units are mounted on the frame rails, and the top units have separate, hydraulic cab latches attached to them.

LEVELING VALVE

All of the air in the cab air-suspension system is admitted through or exhausted from the leveling valve (**Fig. 1**, Ref. 4; and **Fig. 2**, Ref. 8). It mounts on a bracket attached to the bottom unit. A horizontal lever connects the leveling valve control shaft to the vertical linkage attached to the top unit.

General Information and Principles of Operation



1. Air Spring
2. Transverse Torque Arm
3. Top Unit, Passenger's Side
4. Shock Absorber
5. Bottom Unit, Passenger's Side
6. Bottom Unit, Driver's Side
7. Top Unit, Driver's Side
8. Leveling Valve, Arm, and Linkage

Fig. 2, Model FRT46-2P-A Cab Rear Air Suspension Unit

When the load on the cab increases, the distance between the top and bottom units decreases, causing the vertical linkage to push down on one end of the horizontal lever. This turns the leveling valve control shaft, which activates an intake valve core inside the leveling valve. Air flows through the valve and into the air springs until the pressure in the springs raises the cab to the correct height. At this height, the horizontal lever and the control shaft are returned to their neutral positions, closing the intake valve core.

When the load on the cab decreases, the rear of the cab rises, causing the vertical linkage to pull up on the end of the horizontal lever. Turning the leveling valve control shaft in this direction activates an exhaust valve core. This exhausts air from the air springs until the cab is lowered to the correct height. Again, the horizontal lever and control shaft are returned to their neutral positions, and air flow is stopped.

When the vehicle is in motion, small and abrupt movements of the cab will occur, resulting in similar movements of the horizontal lever. Small movements of the lever do not activate the leveling valve because of a built-in free-travel range: a gap between the leveling valve control shaft and both of the valve cores (intake and exhaust). Abrupt movements do not activate the leveling valve because it is filled with a silicone fluid, which delays the opening of one

valve core for as long as five seconds after the closing of the other.

Changes in load which result in larger movements of the horizontal lever (beyond the free-travel range) for more than five seconds will activate the leveling valve. Such changes in load occur when occupants or heavy items are added to or removed from the cab. Also, when the vehicle is moving forward at high speed or in a strong headwind, a major change in load occurs from the downward force applied to an optional air shield or air fairing. When these changes in load occur, the cab air-suspension system will adjust the height at the rear of the cab.

CAB-MOUNT STOP ASSEMBLY (Model FRT285–AV only)

The cab-mount stop assembly consists of two rubber bumpers (**Fig. 1,** Ref. 7) attached to the top unit. They limit downward movement of the cab. If a leak occurs in the cab air-suspension system, the bumpers support the cab until the system can be repaired.

NOTE: If a leak occurs in the cab air-suspension system, a pressure protection valve (located in the air supply line to the leveling valve) will maintain at least 65 psi (450 kPa) in the vehicle secondary air system.

SHOCK ABSORBERS

The shock absorbers attach to the top and bottom units. In addition to damping cab oscillations, the shock absorbers limit upward movement of the rear of the cab.

Adjustment

1. Chock the tires. Build up vehicle air pressure to at least 100 psi (690 kPa).
2. Check the leveling valve adjustment.
   - 2.1 *For model FRT285–AV:*

     Measure the distance from the bottom unit flange to the bottom of the rubber bumper. It should be 1/2 to 3/4 inch (13 to 19 mm). See **Fig. 1**.

     For model FRT46–2P–A:

     Measure the distance from the bottom of the top unit to the top of the bottom unit. It should be 5-3/4 inches (146 mm). See **Fig. 2**.
   - 2.2 If the measured distance is correct, no adjustment is needed.

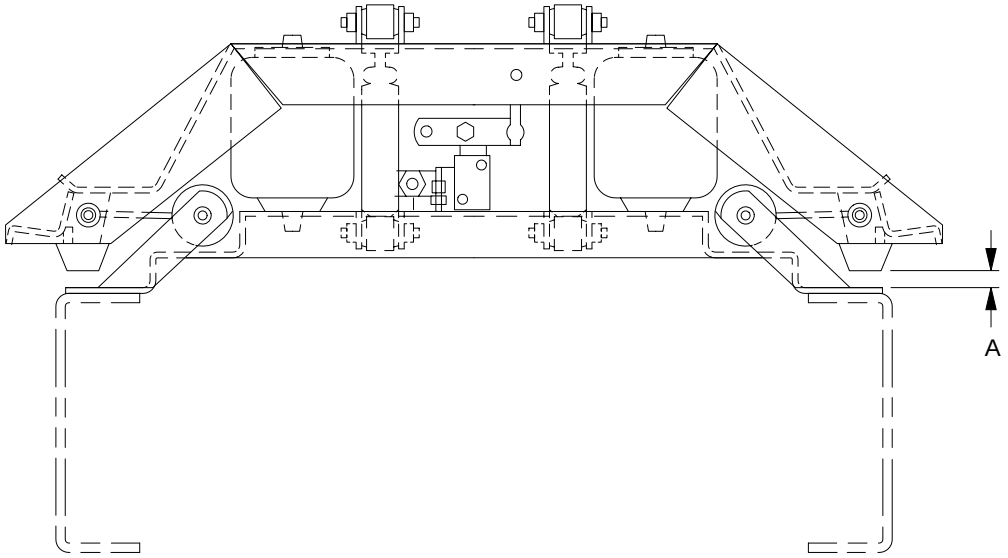
     If the required adjustment is 1/4 inch (6 mm) or *greater*, go to the coarse adjustment step.

     If the required adjustment is *less* than 1/4 inch (6 mm), go to the fine adjustment step.
3. The leveling valve *coarse* adjustment should be performed when the required adjustment is 1/4 in (6 mm) or greater.
   - 3.1 Loosen the horizontal lever retaining nut. See **Fig. 3**.
   - 3.2 Pivot the lever until the distance is within 1/4 inch (6 mm) of the desired measurement.
   - 3.3 Tighten the retaining nut 84 lbf·in (940 N·cm). Go to the next step.
4. The leveling valve *fine* adjustment should be performed when the required adjustment is less than 1/4 inch (6 mm).
   - 4.1 Loosen the jam nut at the vertical linkage lower ball socket and back-off the nut several turns.
   - 4.2 Using a small screwdriver, carefully unlatch the clip on bottom of the vertical linkage ball socket; then, pry the ball socket off the horizontal lever.
   - 4.3 Turn the ball socket clockwise to shorten the vertical linkage, or counterclockwise to lengthen it.
   - 4.4 Connect the linkage and measure the flange-to-bumper distance (model FRT286-AV) or top unit-to-bottom unit distance (model FRT46–2P–A). Make any corrections as needed.

IMPORTANT: Because of a built-in delay in the leveling valve, it may take as long as five seconds after making adjustments before the air spring height changes.

   - 4.5 When the leveling valve is properly adjusted, latch the clip on bottom of the vertical linkage ball socket and tighten the jam nut.

Leveling Valve Adjustment



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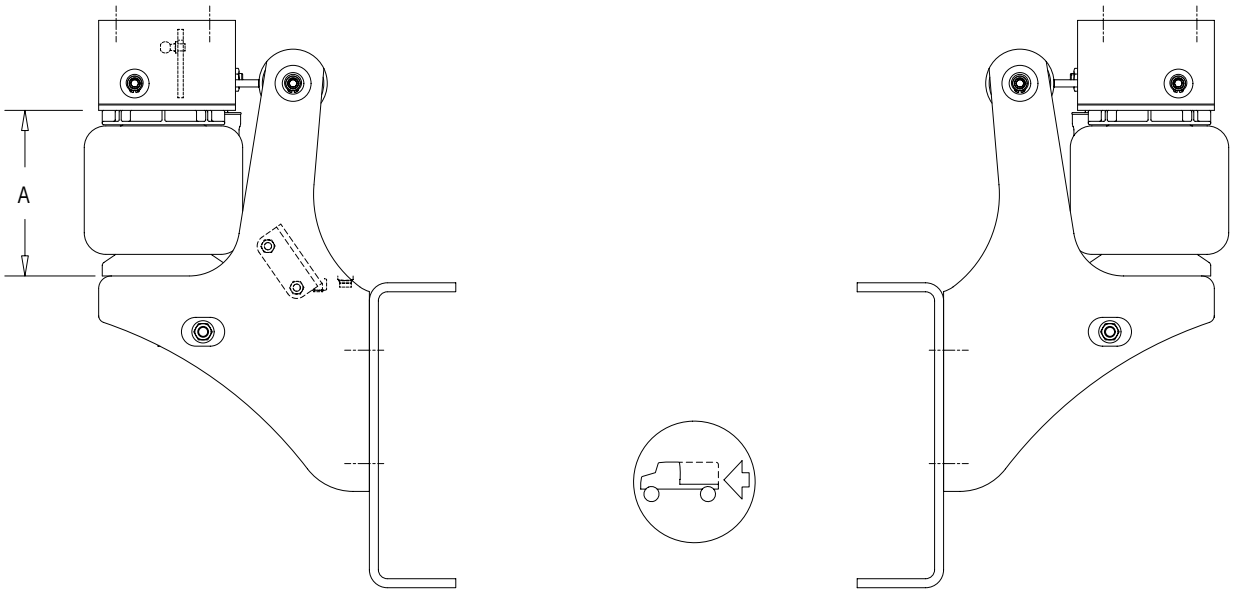
A. 1/2 to 3/4 inch (13 to 19 mm)

Fig. 1, Top Unit-to-Bottom Unit Spacing, Model FRT285-AV



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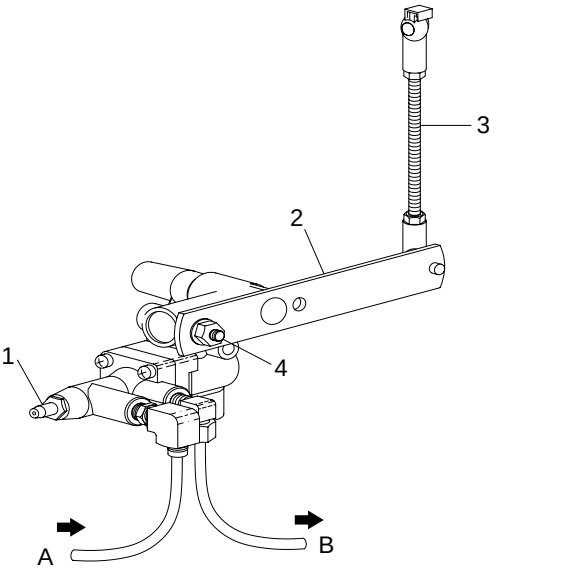
A. 5-3/4 inches (146 mm)

Fig. 2, Top Unit-to-Bottom Unit Spacing, Model FRT46-2P-A



A. from air supply
B. to air springs
1. Exhaust Port
2. Horizontal Arm
3. Vertical Linkage
4. Retaining Nut

Fig. 3, Leveling Valve Connections

Checks

To keep the cab air-suspension system operating reliably, the air system must be kept free of oil, moisture, and other foreign material. Regularly inspect and maintain the vehicle air system components. Refer to the brake section in the vehicle maintenance manual.

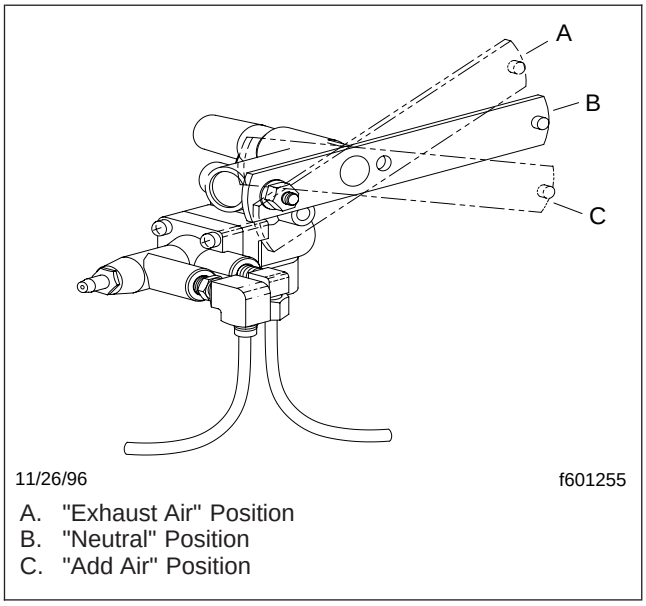
⚠ CAUTION

Failure to take precautions against the entry of oil, moisture, and other foreign material into the cab air-suspension system could eventually lead to sludge forming in the air system. Sludge could adversely affect the operation of the cab air-suspension system and other air system components.

Before replacing the leveling valve, do the following steps to see if the valve is actually damaged, or is merely out of adjustment.

1. Chock the tires. Run the engine to build up vehicle air pressure to at least 100 psi (690 kPa).
2. Using a screwdriver, snap the vertical linkage off the horizontal lever attached to the leveling valve.
3. Push the lever down about 45 degrees for 6 to 8 seconds. See **Fig. 1**, Ref. C. If air passes through the valve and inflates the air springs,that section of the valve is okay.
4. Return the lever to the neutral position. See **Fig. 1**, Ref. B. Air should stop flowing. If so, that section of the valve is okay.
5. Pull the lever up about 45 degrees for 6 to 8 seconds. See **Fig. 1**, Ref. A. If air exhausts from the valve, that section of the valve is okay.
6. Return the lever to the neutral position. If the air stops again in the neutral position, the valve is working correctly.
7. If the valve works as stated in all of the above steps, no further checking is needed. Connect the vertical linkage to the horizontal lever.

   If the valve doesn't work as stated in all of the above steps, replace it. See **Subject 120**.
8. If adjustment of the leveling valve is needed, see **Subject 100**.



A. "Exhaust Air" Position
B. "Neutral" Position
C. "Add Air" Position

Fig. 1, Leveling Valve Check Positions

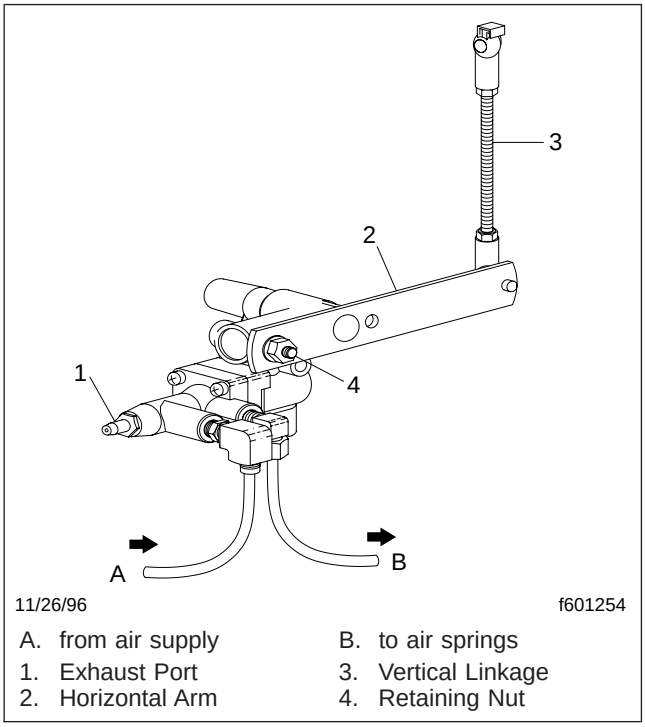
Replacement

DANGER

Before doing the work below, review the cab tilting information under the cab tilt section. Failure to read the warnings and to be aware of the dangers of tilting and lowering the cab could result in serious injury or death.

NOTE: Before replacing the leveling valve, do the steps in **Subject 110** to see if the valve is actually damaged, or is merely out of adjustment.

1. Chock the tires and tilt the cab. See **Section 60.04** for instructions.
2. Drain the air system.
3. Remove the leveling valve.
   - 3.1 Using a screwdriver, disconnect the vertical linkage from the leveling valve horizontal lever. See **Fig. 1**. Move the lever down, and hold it there to exhaust all air from the air springs.
   - 3.2 Remove the retaining nut and washer that attaches the horizontal lever to the stud on the leveling valve. Remove the horizontal lever, and save it for installation on the new valve.
   - 3.3 Disconnect the air lines from the fittings at the leveling valve ports. Mark the lines for assembly reference. Cover the open ends of the air lines to prevent dirt or other foreign material from entering.
   - 3.4 Remove the leveling valve mounting fasteners; then, remove the valve from its mounting plate.
4. Install the new leveling valve.
   - 4.1 Mount the new valve on the plate. Tighten the hexhead capscrews 96 lbf·in (1080 N·cm).
   - 4.2 Mount the horizontal lever on the leveling valve. Tighten the locknut 84 lbf·in (940 N·cm).
   - 4.3 Remove the covers from the air lines. Connect the air lines to the leveling valve as marked earlier or as shown in **Specifications, 400**. Tighten the fitting nuts finger-tight; then, tighten them two more turns or until no threads show on the fitting body.
5. Lower the cab and latch it. See **Section 60.04** for instructions.
6. Close the drain cocks on all air reservoirs. Run the engine to build up vehicle air pressure to at least 100 psi (690 kPa).
7. Check the operation of the new leveling valve. For instructions, see **Subject 110**.
8. Check all air lines and connections for leaks; eliminate any found.
9. Adjust the leveling valve. For instructions, see **Subject 100**.



A. from air supply
B. to air springs
1. Exhaust Port
2. Horizontal Arm
3. Vertical Linkage
4. Retaining Nut

Fig. 1, Leveling Valve Connections

Replacement

1. Remove the locknuts from the shock absorber upper and lower mounting bolts. Remove the bolts. Pull the shock absorber out of the mounting brackets.
2. Install the replacement shock absorber in the mounting brackets, and secure it with the bolts and locknuts.

NOTE: The longer bolts go in the lower mounting brackets.

3. Tighten the locknuts 50 lbf·ft (68 N·m).

Replacement, Model FRT285–AV

⚠ DANGER

Before doing the work below, review the cab tilting information under the cab tilt section. Failure to read the warnings and to be aware of the dangers of tilting and lowering the cab could result in serious injury or death.

1. Chock the tires.
2. Tilt the cab. See **Section 60.04** for instructions.
3. Drain the vehicle air system.
4. Remove the air spring. See **Fig. 1**.
   - 4.1 Using a screwdriver, disconnect the vertical linkage from the leveling valve horizontal lever. Move the lever up to exhaust all air from the air springs.
   - 4.2 Disconnect the air spring air supply hose fitting at the 90-degree elbow (Ref. 14).
   - 4.3 Remove the elbow from the air spring being replaced.
   - 4.4 Remove and discard the push-on retainer rings (Refs. 2 and 17) from the air spring upper and lower mounting bosses.
   - 4.5 Remove the air spring.
5. Install a new air spring.
   - 5.1 With the new air spring in its installed position, install push-on retainer rings all the way onto the upper and lower air spring mounting bosses.

   NOTE: The larger diameter retainer ring goes on the lower boss.

   - 5.2 Install the 90-degree elbow in the air spring. Tighten it finger-tight plus one turn. If needed, further tighten it until it lines up with the tee (Ref. 16). Do not use Teflon® tape.
   - 5.3 Remove the cover from the air spring supply line. Attach the air lines to the 90-degree elbow. Tighten each nut finger-tight plus two turns or until no threads show on the elbow.
6. Lower the cab and latch it. See **Section 60.04** for instructions.
7. Start the engine and build vehicle air pressure to at least 100 psi (690 kPa).
8. Check for air leaks at the air springs and at the leveling valve. Tighten the fittings or replace the parts as needed.

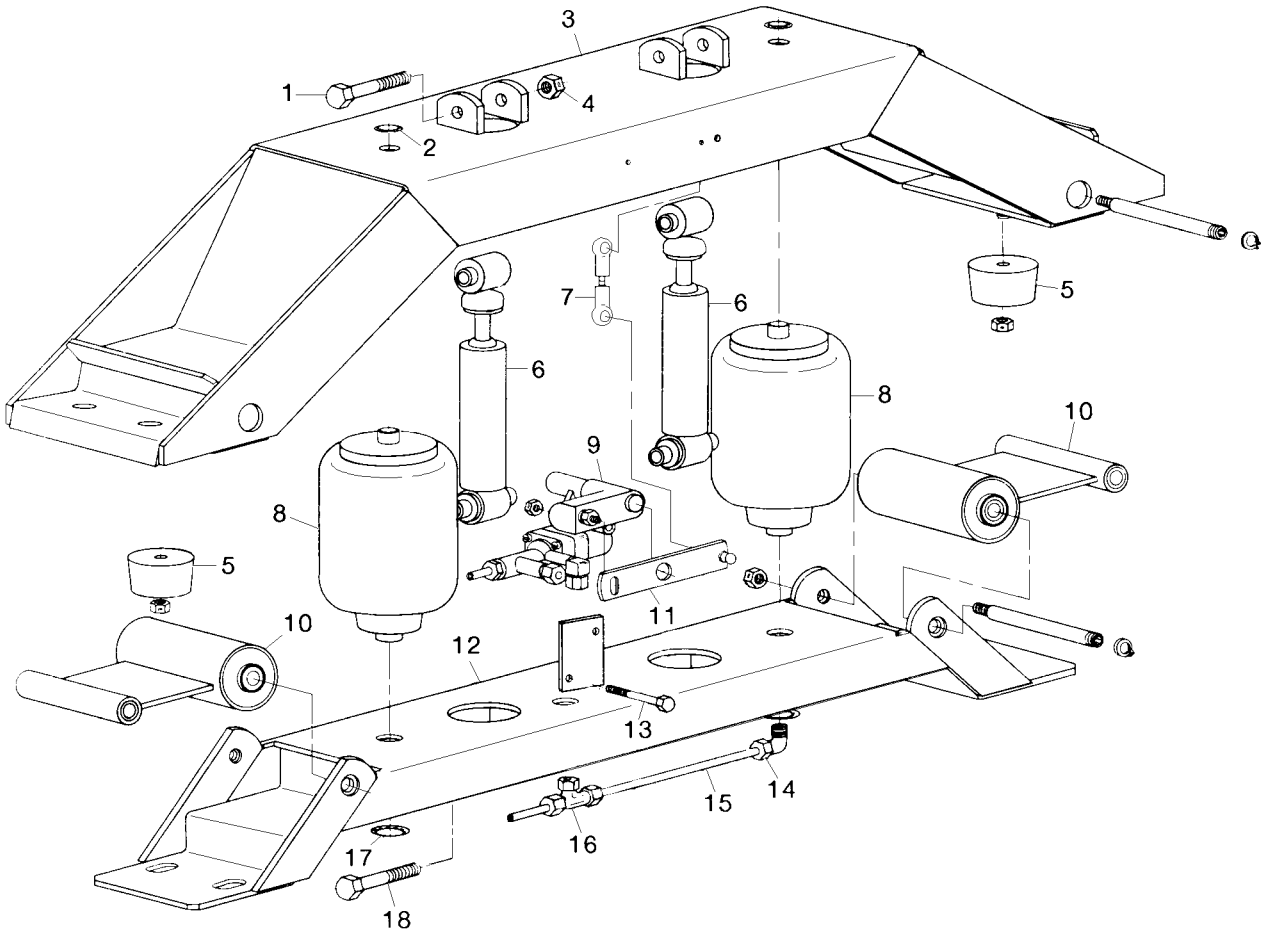
Replacement, Model FRT46–2P–A

⚠ DANGER

Before doing the work below, review the cab tilting information under the cab tilt section. Failure to read the warnings and to be aware of the dangers of tilting and lowering the cab could result in serious injury or death.

1. Chock the tires.
2. Tilt the cab. See **Section 60.04** for instructions.
3. Drain the vehicle air system.
4. Remove the air spring. See **Fig. 2**.
   - 4.1 Using a screwdriver, disconnect the vertical linkage from the leveling valve horizontal lever. Move the lever up to exhaust all air from the air springs.
   - 4.2 Disconnect the air fitting from the air spring being replaced. See **Fig. 2**.
   - 4.3 Remove the transverse torque arm from the top unit.
   - 4.4 Remove the nut from the end of one of the torque-arm bolts (Ref. 4).
   - 4.5 Using a drift or punch, drive out the torque-arm bolt.
   - 4.6 Repeat the procedure for the other torque-arm bolt; then remove the transverse torque arm from the top unit.
   - 4.7 Remove the push-on retainer ring (Ref. 7) and the retainer nut (Ref. 17) from the air spring upper and lower mounting bosses; discard the push-on retainer.
   - 4.8 Remove the air spring.

Air Spring Replacement



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1. Shock Absorber Upper Mounting Bolt
2. Retainer Ring (1/2-inch)
3. Top Unit
4. Locknut
5. Rubber Bumper
6. Shock Absorber
7. Leveling Valve Vertical Linkage
8. Air Spring
9. Leveling Valve
10. Transverse Torque Arm
11. Horizontal Lever
12. Bottom Unit
13. Leveling Valve Mounting Bolt
14. 90-Degree Elbow
15. Air Line (1/4-inch)
16. Tee
17. Retainer Ring (3/4-inch)
18. Shock Absorber Lower Mounting Bolt

Fig. 1, Model FRT285-AV Link Cabmate Cab Rear Air Suspension (exploded view)

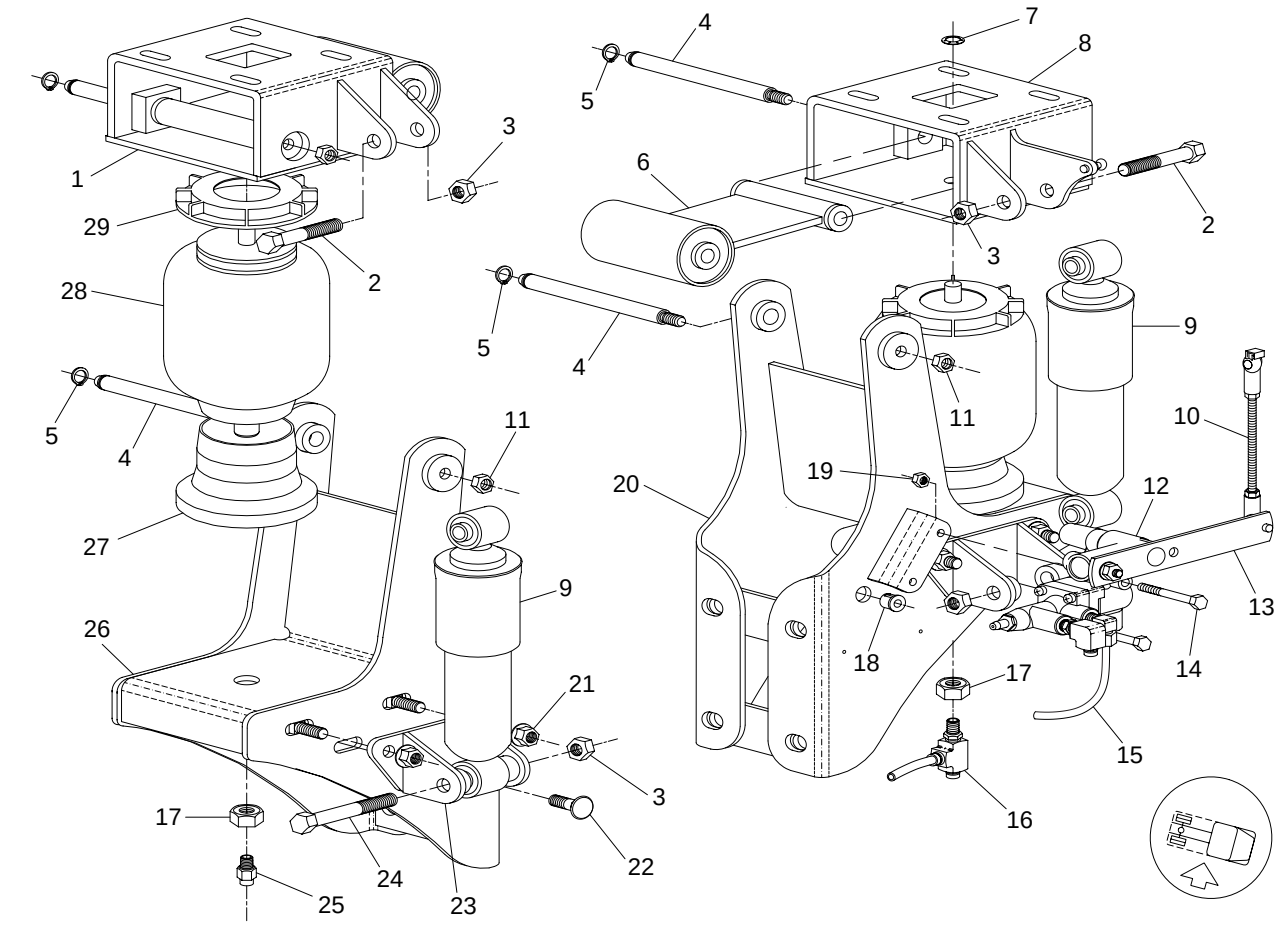
5. Install the new air spring.

   5.1 Place a new air spring between the top and bottom units.

   5.2 Install a new push-on retainer ring all the way onto the air-spring upper mounting boss. Install the retainer nut on the air-spring lower mounting boss.

   5.3 Position the transverse torque arm in the top unit so the holes line up with those of the top unit. Make sure the end with the large cylinder is facing inboard, as shown in **Fig. 2**.

   5.4 Install the torque-arm bolts, then the nuts on the ends of the bolts.



1. Top Unit, Passenger's Side
2. 7/16 x 2-1/4-inch Hexbolt
3. 7/16-inch Locknut
4. Torque Arm Bolt
5. Snap Ring
6. Torque Arm
7. 1/2-inch Retainer Ring
8. Top Unit, Driver's Side
9. Shock Absorber
10. Leveling Valve Linkage
11. 3/8-inch Locknut
12. Leveling Valve
13. Leveling Valve Arm
14. 1/4 x 2-inch Hexbolt
15. 1/4-inch Air Line
16. Tee
17. 3/4-inch Retainer Nut
18. Air Line Grommet
19. 1/4-inch Locknut
20. Bottom Unit, Driver's Side
21. 3/8-inch Flanged Locknut
22. 3/8 x 1-inch Carriage Bolt
23. Bottom Shock Absorber Mount
24. 7/16 x 3-inch Bolt
25. 1/8 NPT Connector
26. Bottom Unit, Passenger's Side
27. Lower Accessory Piston
28. Air Spring
29. Upper Accessory Piston

Fig. 2, Model FRT46-2P-A Link Cabmate Cab Rear Air Suspension (exploded view)

5.5 Connect the air line to the air spring. Tighten it finger-tight plus one turn. Do not use Teflon® tape.

6. Lower the cab and latch it. See **Section 60.04** for instructions.

7. Start the engine and build vehicle air pressure to at least 100 psi (690 kPa).

8. Check for air leaks at the air springs and at the leveling valve. Tighten the fittings or replace the parts as needed.

Problem—Both Air Springs Are Flat

Problem—Both Air Springs Are Flat	
Possible Cause	**Remedy**
Low air pressure in the secondary air system.	Check the air pressure gauge on the instrument panel. If secondary air pressure is low, run the engine until at least 70 psi (482 kPa) is indicated.
Air is leaking from the cab air-suspension system.	Check for leakage from fittings, air lines, air springs, and the leveling valve. Tighten loose fittings to stop leakage; replace worn or damaged parts. Do not use Teflon tape on fittings.
The leveling valve is out of adjustment.	Adjust the leveling valve.
The leveling valve is inoperative.	If upward movement of the lever on a properly adjusted valve fails to inflate the air springs, replace the leveling valve.
The leveling valve linkage is damaged.	Check for damage to the leveling valve linkage and the lever. Repair or replace damaged linkage parts.

Problem—Air Bags Deflate Rapidly When the Engine Is Not Running

Problem—Air Bags Deflate Rapidly When the Engine Is Not Running	
Possible Cause	**Remedy**
Air is leaking from the cab air-suspension system.	Check for leakage from fittings, air lines, air springs, and the leveling valve. Tighten loose fittings to stop leakage; replace worn or damaged parts. Do not use Teflon tape on fittings.

Problem—Rear of Cab Rides Too High or Too Low

Problem—Rear of Cab Rides Too High or Too Low	
Possible Cause	**Remedy**
The leveling valve is out of adjustment.	Adjust the leveling valve.

Problem—Collapsed Air Spring

Problem—Collapsed Air Spring</ENTRY	
Possible Cause	**Remedy**
An air spring is punctured.	Replace the air spring. Check the area around the damaged air spring for contact with other components. Correct the problem areas as needed.
The air spring is continually or repeatedly over-extended.	Check the height of the air spring. Make sure the correct height is maintained. Adjust if needed. Check for a broken shock absorber or shock bracket; replace if broken.

Problem—Bouncy Ride

Problem—Bouncy Ride	
Possible Cause	**Remedy**
The cab air suspension shock absorbers are leaking or worn out.	Replace the shock absorbers.

Specifications

Tightening Torques		
Description	**Size**	**Torque**
Leveling Valve Mounting Bolts	1/4 x 2 UNC	96 lbf·in (1080 N·cm)
Horizontal Lever Retaining Nut	1/4 UNC	84 lbf·in (940 N·cm)
Shock Absorber Mounting Bolts		
Upper	7/16 x 2-1/4 UNF	50 lbf·ft (68 N·m)
Lower	7/16 x 3 UNF	50 lbf·ft (68 N·m)
Air Line Fitting Nuts	—	finger-tight + two turns
Air Line Elbow	—	finger-tight + one turn

Table 1, Tightening Torques

General Description

The Power-Packer® cab-tilt system has four major parts (**Fig. 1**):

- A hydraulic pump consisting of a pump body, a reservoir, and a pump control lever.
- Two hydraulic tilt cylinders that raise and lower the cab.
- A shift-disconnect cylinder that allows the shift tube to extend during cab tilting.
- A tilt strut on the right-side tilt cylinder, which must be used when working under a cab that has not been fully tilted.

The optional air/hydraulic system has the same major parts as the hydraulic-only system, but has an additional air motor assembly attached to the tilt pump. See **Fig. 2**. The air motor normally operates the tilt pump in place of the manual pump control lever. If for any reason the air motor isn't working, the tilt pump can be operated with the manual pump lever.

On FLB COEs, the cab latches are hydraulic, and are plumbed into the cab-tilt system.

The tilt cylinders are connected to the pump by flexible high-pressure lines. Velocity fuses are built into the tilt cylinder ports. They act as check valves to prevent the cab from free falling in case of hydraulic system damage, such as a ruptured line.

Principles of Operation

There are two hydraulic circuits in the Power-Packer system: the *push* circuit raises the cab from the lowered position to the desired tilt position, and the *pull* circuit brings the cab from a fully tilted position up and over center. See **Fig. 3**.

Placing the control lever in the "Raise" position opens the *push* circuit in the hydraulic system. When the mechanical cab hold-down latches are released and the pump is operated, hydraulic pressure builds up in the tilt cylinders and the shift-disconnect cylinder. If equipped with hydraulic cab latches, hydraulic pressure releases the latches. As pressure increases, the shift-disconnect cylinder releases to allow the shift tube to telescope out. Then the tilt cylinder piston rods extend, raising the cab. When the cab goes over center, it falls at a controlled rate to the full-tilt position, automatically relieving hydraulic system pressure.

When the control lever is placed in the "Lower" position, the *pull* circuit in the hydraulic system opens. When the pump is operated, hydraulic pressure forces the cab back up and over top-dead-center. The cab then falls at a controlled rate until it settles onto the rear mounts.

NOTE: Whenever raising or lowering the cab, stop working the pump once the cab goes over center. The cab falls at a controlled rate and continued pumping could lock up the tilt cylinders.

HYDRAULIC LOCK-UP

Hydraulic lock-up can occur for the following reasons:

- Very cold weather
- Use of the wrong hydraulic fluid
- Air in the system
- Sudden cab movement
- A ruptured hydraulic line

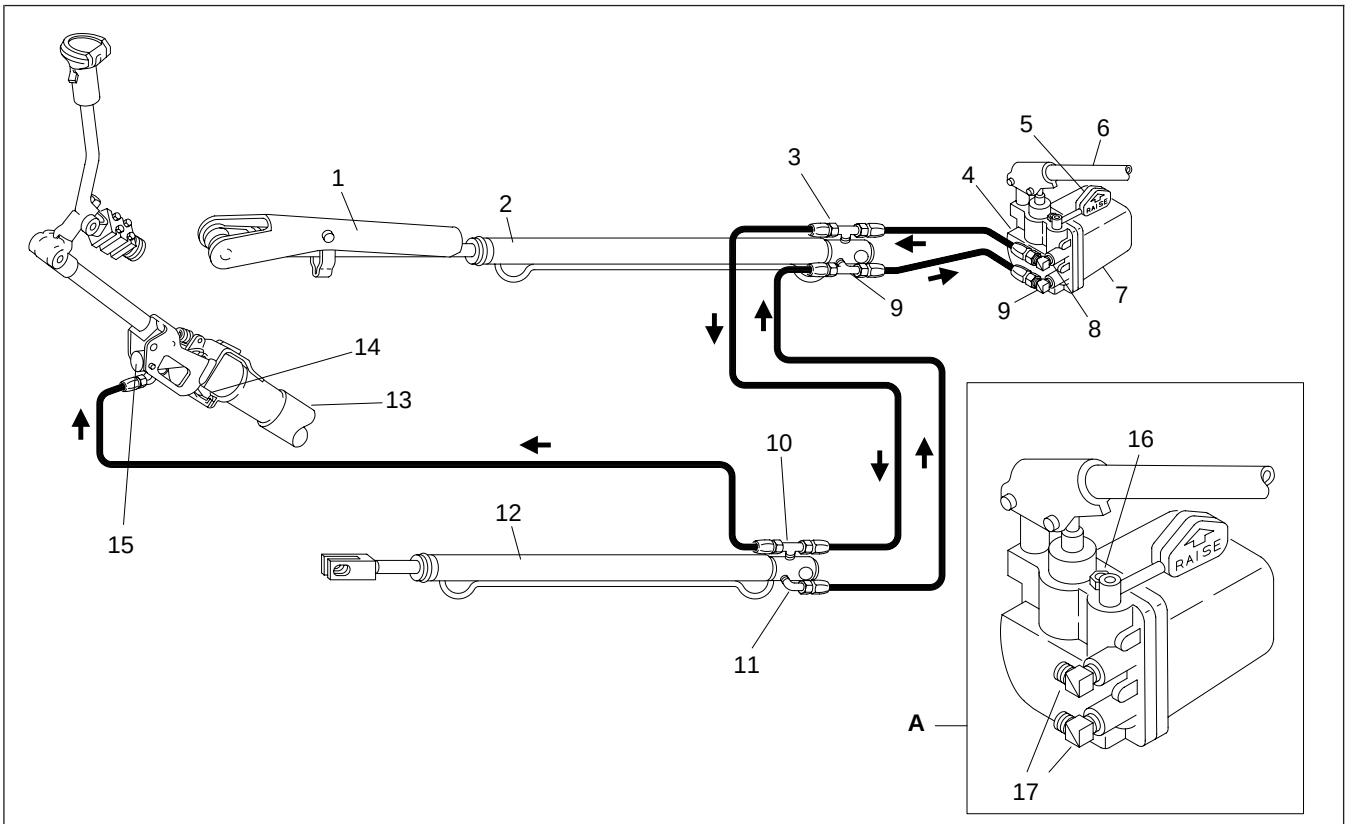
Any of the above situations will cause the velocity fuses to function as safety check valves, and lock up the tilt cylinders. To unlock the cylinders, the cab must be moved in the opposite direction of travel (back toward the 45-degree position).

IMPORTANT: If the tilt cylinders lock up, check for a major problem (such as a ruptured line or leaking fitting) before trying to unlock the tilt cylinders. If such a problem is found, make any necessary repairs before unlocking the cylinder.

For example, if the cab is moving toward the full-tilt position when the lock-up occurs, move the control lever to "Lower," and work the pump a few strokes. This will unlock the cylinders. Move the control lever to "Raise," and allow the cab to descend to a full-tilt position.

If the cab is moving toward the lowered (operating) position when the lock-up occurs, move the control lever to "Raise," and work the pump a few strokes. This will unlock the cylinders. Move the control lever to "Lower," and allow the cab to descend to the operating position.

General Information and Principles of Operation



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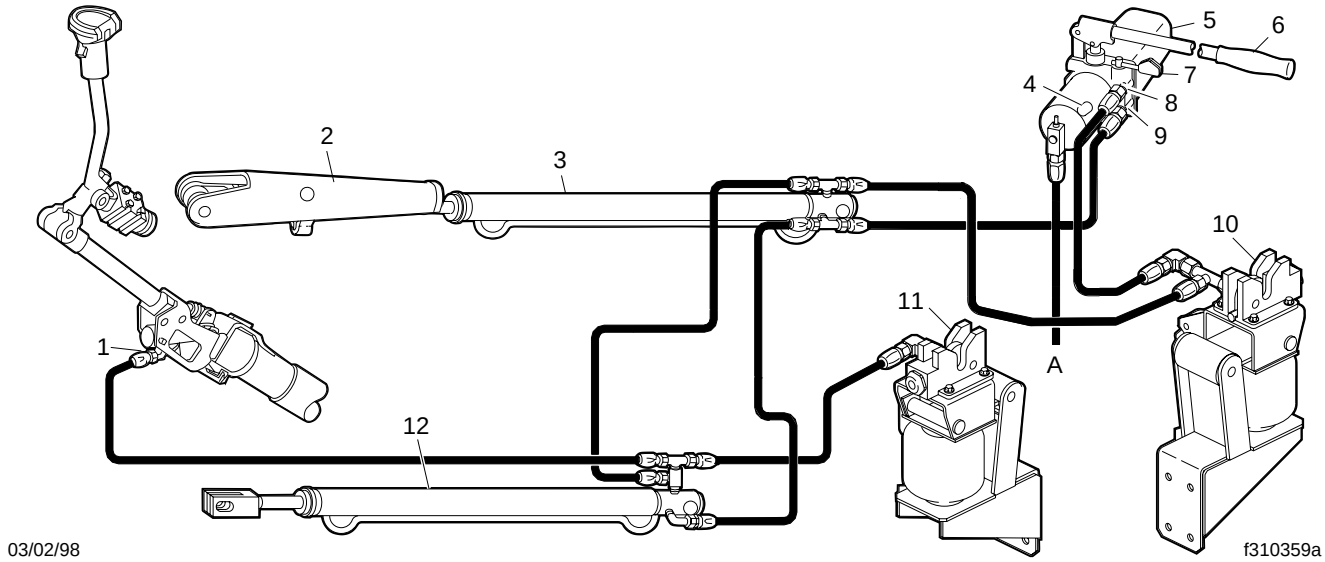
A. Tilt Pump Enlargement

1. Tilt Strut
2. Right Tilt Cylinder
3. "Push" Port Fitting
4. Pump Body
5. Pump Control Lever
6. Pump Lever
7. Reservoir
8. "Push" Port Fitting
9. "Pull" Port Fitting
10. "Push" Port Fitting
11. "Pull" Port Fitting
12. Left Tilt Cylinder
13. Shift Tube
14. Shift Tube Latch Mechanism
15. Shift-Disconnect Cylinder
16. Fill Plug
17. Fittings

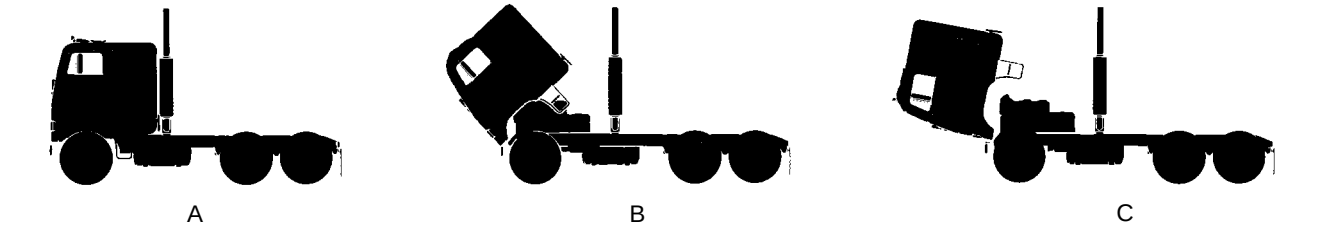
Fig. 1, Hydraulic-Only System, Equipped With Mechanical Cab Latches



A. Air supply connects here.

1. Shift-Disconnect Cylinder
2. Tilt Strut
3. Right Tilt Cylinder
4. Air Motor Assembly and Button
5. Reservoir
6. Manual Pump Lever
7. Pump Control Lever
8. "Push" Port
9. "Pull" Port
10. Right Hydraulic Cab Latch
11. Left Hydraulic Cab Latch
12. Left Tilt Cylinder

Fig. 2, Air/Hydraulic System, and Equipped With Hydraulic Cab Latches and Cab Air Suspension



A. Lowered or in Operating Position
B. 45-Degree Tilted Position
C. Full-Tilt Position (80 Degrees)

Fig. 3, Cab Positions

Tilting the FLB Cab

CAUTION

CAUTION: Before tilting the cab, make sure the vehicle is parked on level ground, both side-to-side and front-to-rear. Tilting the cab while the vehicle is parked on unlevel ground (such as a sloping highway shoulder) may damage the cab mounts and prevent you from returning the cab to the operating position.

1. Apply the parking brakes. Place the transmission shift lever in neutral. Shut down the engine if it is running.

WARNING

WARNING: Before tilting the cab, make sure there is adequate clearance in front of the vehicle, and that the area is free of people and all objects.

Do not tilt the cab with the engine running. Tilting the cab could engage the transmission. If the engine is running, the vehicle can move, causing an accident that could result in personal injury or property damage.

2. Secure all loose articles in the cab and bunk, and make sure the doors are securely latched.

WARNING

WARNING: Objects falling in the cab, or a door flying open, could damage the vehicle or cause personal injury.

3. Move the pump control lever to "Raise."
4. Operate the pump (using the manual pump handle or the air control button, if so equipped) to disengage the hold-down latches.

IMPORTANT: Check the indicator pin on each cab latch. The latches have disengaged if the pins are out. **See Fig. 1.**

If air is present in the hydraulic tilt system, pump operation will seem "spongy" or ineffective. If this happens, bleed the air from the system. For instructions, see **Subject 100**.

If the cab stops moving while it is being raised, do not force it to move with the tilt pump. The velocity fuses have locked up the tilt cylinder. To unlock them, see **Subject 050**.

WARNING

WARNING: Make sure the tilt strut is pushed down onto the right tilt cylinder rod. If the tilt strut is not engaged, and the cab drops, the result could be serious injury or death.

5. When the cab reaches a 30-degree angle, stop operating the pump. Push the free end of the tilt strut down onto the right tilt-cylinder rod. **See Fig. 2.** The tilt strut prevents the cab from accidently dropping below this position.

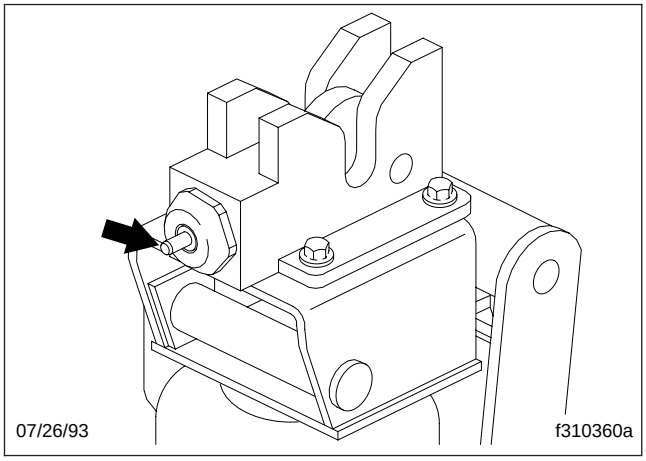


Fig. 1, Cab Latch Indicator Pin

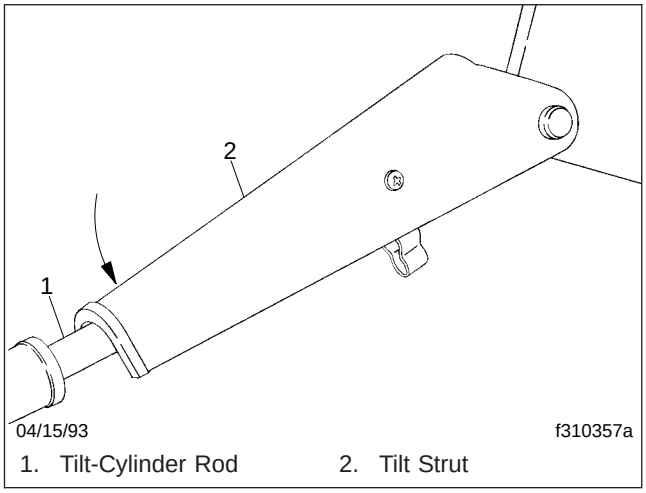


Fig. 2, Tilt Strut Positioning

Cab Tilting

6. To tilt the cab all the way, continue working the pump until the cab nears a 45-degree angle. Reduce pumping speed. Once the cab goes beyond 45 degrees, stop working the pump. The cab will gently descend to a full-tilt position. To stop the cab at any position between 45-degrees and full-tilt, move the control lever to "Lower."

IMPORTANT: If the cab unintentionally stops after it has gone beyond 45 degrees, do not force it down with the tilt pump. The velocity fuses have locked the tilt cylinders. To unlock them, see **Subject 050**.

Returning the FLB Cab From a Tilted Position

DANGER

Stay completely clear of the cab's travel path at all times. Once the tilt strut has been released, do not lean over the frame rails, the engine, or the transmission for any reason. To do so could result in serious injury or death.

1. Move the tilt strut away from the right tilt-cylinder rod, and lock it in the spring catch.

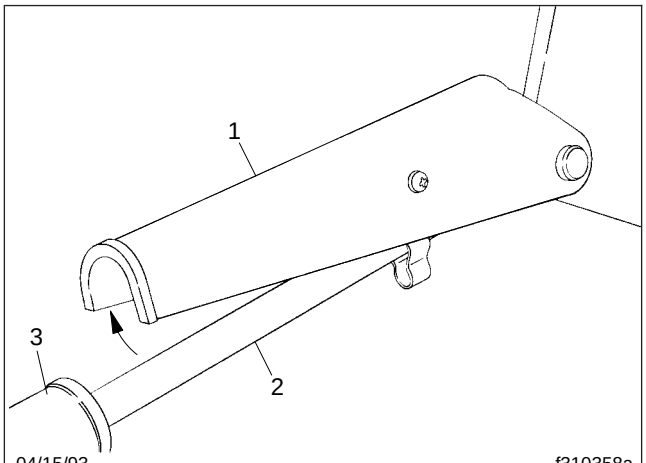
   If the cab was tilted less than 45 degrees, raise it enough to release the tilt strut. Move the tilt strut away from the tilt-cylinder rod, and lock it in the spring catch before lowering the cab. **See Fig. 3.**

2. Set the pump control lever at "Lower," and work the pump until the cab nears a 45-degree angle. Reduce pumping speed. Once the cab goes over center, stop working the pump. The cab will gently descend to the operating position.

   To stop the cab at any position between 45 degrees and 30 degrees, move the control lever to "Raise," and push the tilt strut down onto the right tilt-cylinder rod.

IMPORTANT: If the cab unintentionally stops after it has gone beyond 45 degrees, do not force it down with the tilt pump. The tilt strut is in the locked position, or the velocity fuses have locked the tilt cylinders. Release the tilt strut, or, to unlock the velocity fuses, see **Subject 050**.

3. When the cab is lowered all the way, make sure the pump control lever is set at "Lower."



1. Tilt Strut
2. Tilt-Cylinder Rod
3. Tilt Cylinder

Fig. 3, Releasing the Tilt Strut

4. Check the indicator pin on each cab latch. **See Fig. 1.** The latches are locked when the pins have moved back into the piston and cylinder spring assembly.

5. Push the transmission shift lever forward to lock the shift tube latch mechanism.

NOTE: Maintain the hydraulic fluid level at the oil fill plug. Add fluid only when the cab is in the operating position. Use only Freightliner-approved hydraulic fluid, as indicated in **Subject 400**.

Tilting the FLA Cab

CAUTION

CAUTION: Before tilting the cab, make sure the vehicle is parked on level ground, both side-to-side and front-to-rear. Tilting the cab while the vehicle is parked on unlevel ground (such as a sloping highway shoulder) may damage the cab mounts and prevent you from returning the cab to the operating position.

1. Apply the parking brakes. Place the transmission shift lever in neutral. Shut down the engine if it is running.

⚠ WARNING

WARNING: Before tilting the cab, make sure there is adequate clearance in front of the vehicle, and that the area is free of people and all objects.

Do not tilt the cab with the engine running. Tilting the cab could engage the transmission. If the engine is running, the vehicle can move, causing an accident that could result in personal injury or property damage.

2. Remove the pump handle from the baggage compartment, and insert it into the pump shank.
3. Secure all loose articles in the cab and bunk, and make sure the doors are securely latched.

⚠ WARNING

WARNING: Objects falling in the cab, or a door flying open, could damage the vehicle or cause personal injury.

4. Move the pump control lever to "Raise."
5. Unlock the back-of-cab latch handles **(Fig. 4)** by pulling them outward. **See Fig. 5.**

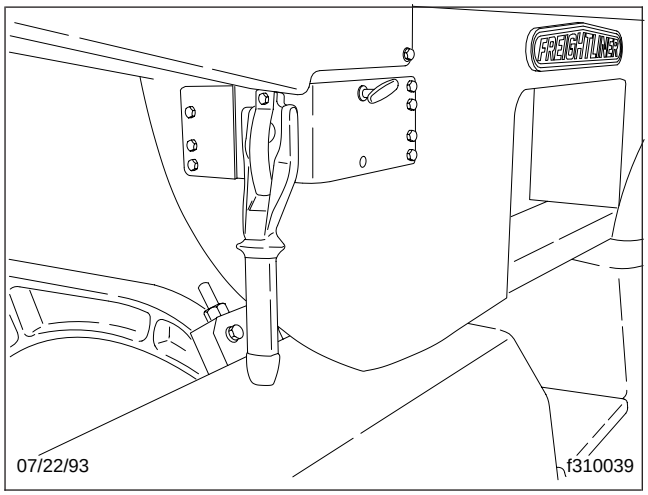


Fig. 4, Latch Handle (Locked Position)

⚠ CAUTION

CAUTION: Do not work the tilt pump while the cab latches are locked. Doing this causes stress in the back of the cab, which could cause rivet and cab-skin damage.

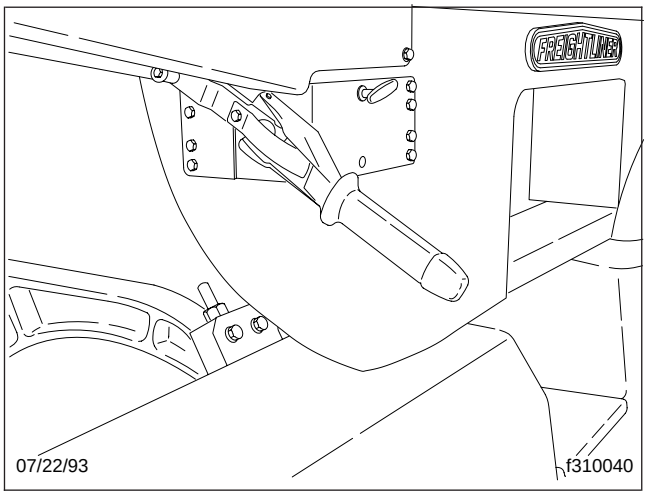


Fig. 5, Latch Handle (Unlocked Position)

6. Pull the safety hook release handle **(Fig. 6)** while working the hydraulic pump. If the cab does not begin to raise during the first 10 to 15 strokes, stop what you are doing. Make sure the shift tube latch mechanism has released.

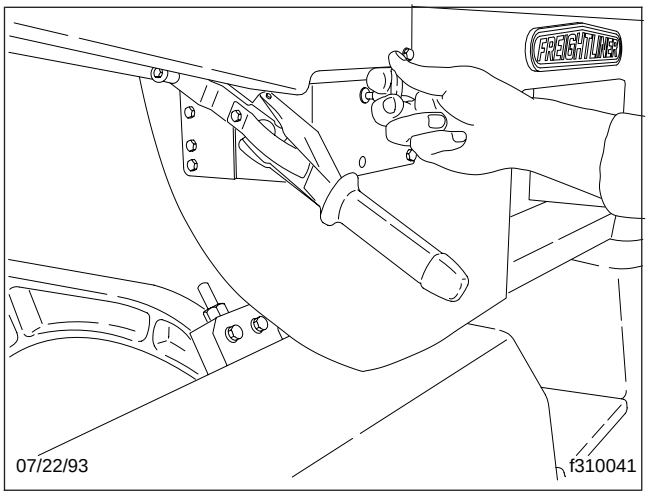


Fig. 6, Releasing the Safety Hooks

⚠ CAUTION

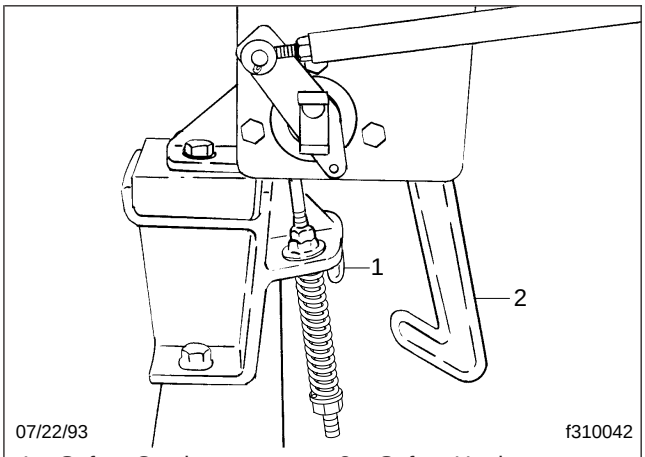
CAUTION: Continued application of force to tilt the cab when the shift tube latch mechanism has not released could result in transmission or shift tube damage.

NOTE: If air is present in the hydraulic tilt system, pump operation will seem "spongy" or inef-

fective. If this happens, bleed the air from the system. For instruction, see **Subject 100**.

If the cab stops moving while it is being raised, do not force it to move with the tilt pump. The velocity fuses have locked up the tilt cylinders. To unlock them, see **Subject 050**.

7. After the safety hook has been raised above the safety catch **(Fig. 7)**, let go of the release handle. Tilt the cab to a 30-degree angle.



1. Safety Catch 2. Safety Hook

Fig. 7, Safety Catch Mechanism

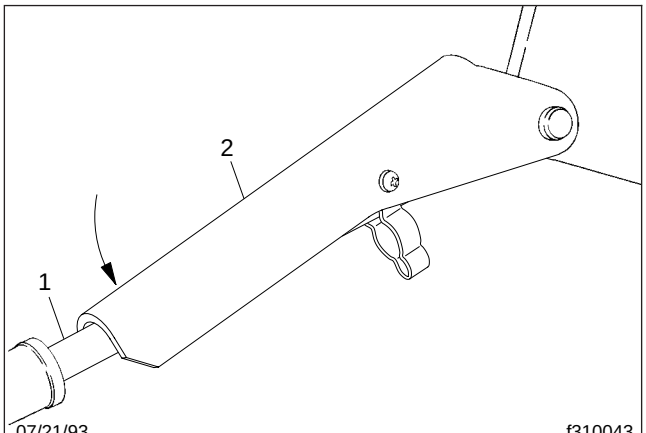
WARNING

WARNING: Make sure the tilt strut is pushed down onto the right tilt cylinder rod. If the tilt strut is not engaged, and the cab drops, the result could be serious injury or death.

8. When the cab reaches a 30-degree angle, push the free end of the tilt strut down onto the right tilt-cylinder rod. **See Fig. 8.** The tilt strut prevents the cab from accidently dropping below this position.

9. To tilt the cab all the way, continue working the pump until the cab nears a 45-degree angle. Reduce pumping speed. Once the cab goes beyond 45 degrees, stop pumping. The cab will gently descend to a full-tilt position. To stop the cab at any position between 45-degrees and full-tilt, move the control lever to "Lower."

IMPORTANT: If the cab unintentionally stops after it has gone beyond 45 degrees, do not force it down with the tilt pump. The velocity fuses have locked the tilt cylinders. To unlock them, see **Subject 050**.



1. Tilt-Cylinder Rod 2. Tilt Strut

Fig. 8, Tilt Strut Positioning

Returning the FLA Cab From a Tilted Position

DANGER

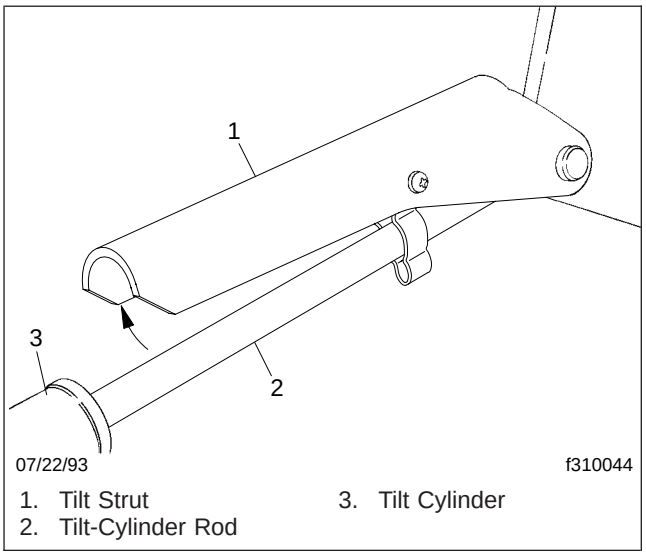
Stay completely clear of the cab's travel path at all times. Once the tilt strut has been released, do not lean over the frame rails, the engine, or the transmission for any reason. To do so could result in serious injury or death.

1. Move the tilt strut away from the right tilt-cylinder rod, and lock it in the spring catch.

   If the cab was tilted less than 45 degrees, raise it enough to release the tilt strut. Move the tilt strut away from the tilt-cylinder rod, and lock it in the spring catch before lowering the cab. **See Fig. 9.**

2. Set the pump control lever at "Lower," and work the pump until the cab nears a 45-degree angle. Reduce pumping speed. Once the cab goes over center, stop pumping. The cab will gently descend to the operating position.

   To stop the cab at any position between 45 degrees and 30 degrees, move the control lever to "Raise," and push the tilt strut down onto the right tilt-cylinder rod.



1. Tilt Strut
2. Tilt-Cylinder Rod
3. Tilt Cylinder

Fig. 9, Releasing the Tilt Strut

IMPORTANT: If the cab unintentionally stops after it has gone beyond 45 degrees, do not force it down with the tilt pump. The tilt strut is in the locked position, or the velocity fuses have locked the tilt cylinders. Release the tilt strut, or, to unlock the velocity fuses, see **Subject 050**.

3. When the cab is lowered all the way, make sure the pump control lever is set at "Lower."
4. Lock the cab latch handles. **See Fig. 4.** Make sure the cab latch hooks have engaged the U-bolts on the cab mounts, and that each latch handle lockpin is engaged.
5. Remove the pump handle from the pump shank. Mount the handle in the baggage compartment.
6. Push the transmission shift lever forward to lock the shift tube latch mechanism.

NOTE: Maintain the hydraulic fluid level at the oil fill plug. Add fluid only when the cab is in the operating position. Use only Freightliner-approved hydraulic fluid, as indicated in **Subject 400**.

Bleeding the System

A "spongy" feeling (cylinders do not move when the pump handle is operated) indicates air in the cab-tilt system. Use the following procedures to remove the air from the cab-tilt system:

IMPORTANT: With the exception of bleeding the *pull* port fittings on the tilt cylinders, and the hydraulic cab latches, never bleed any part of the system while the cab is tilted.

BLEEDING THE TILT CYLINDERS

⚠ DANGER

Before doing the work below, review the cab tilting information under Subject 060. Failure to read the warnings and to be aware of the dangers of tilting and lowering the cab could result in serious injury or death.

1. With the cab completely lowered and the tilt cylinders retracted, loosen the *push* port fitting on each tilt cylinder. See **Fig. 1**. Do not disconnect the hose from the fitting. Place the control lever in the "Raise" position, and operate the tilt pump until a bubble-free stream of hydraulic fluid flows from the *push* ports on the tilt cylinders.
2. Tighten the *push* port fitting on each tilt cylinder.
3. Tilt the cab to the full-tilt position. Refer to **Subject 060** for cab tilting instructions.
4. Loosen the *pull* port fitting on each tilt cylinder. See **Fig. 1**. Place the control lever in the "Lower" position, and operate the tilt pump until a bubble-free stream of hydraulic fluid flows from the *pull* port fitting on each cylinder.
5. Tighten the *pull* port fitting on each tilt cylinder.

⚠ DANGER

Stay completely clear of the cab's travel path at all times. Once the tilt strut has been released, do not lean over the frame rails, the engine, or the transmission for any reason. To do so could result in serious injury or death.

6. Lower the cab to the operating position. For instructions, refer to **Subject 060**.
7. Fill the tilt pump reservoir until hydraulic fluid appears in the fill port. Install and tighten the fill plug. Refer to **Specifications, 400** for the specified hydraulic fluid. Do not use engine oil, brake fluid, or automatic transmission fluid.
8. Tilt the cab fully and return it to the lowered position. Refer to **Subject 060** for instructions. Fill the tilt pump reservoir until hydraulic fluid appears in the fill port. Use only specified hydraulic fluid. Install and tighten the fill plug.

BLEEDING THE SHIFT-DISCONNECT CYLINDER

Since this cylinder is mounted at the highest point in the system (on the shifter mechanism under the tunnel), air going to the top of it will not discharge to the reservoir.

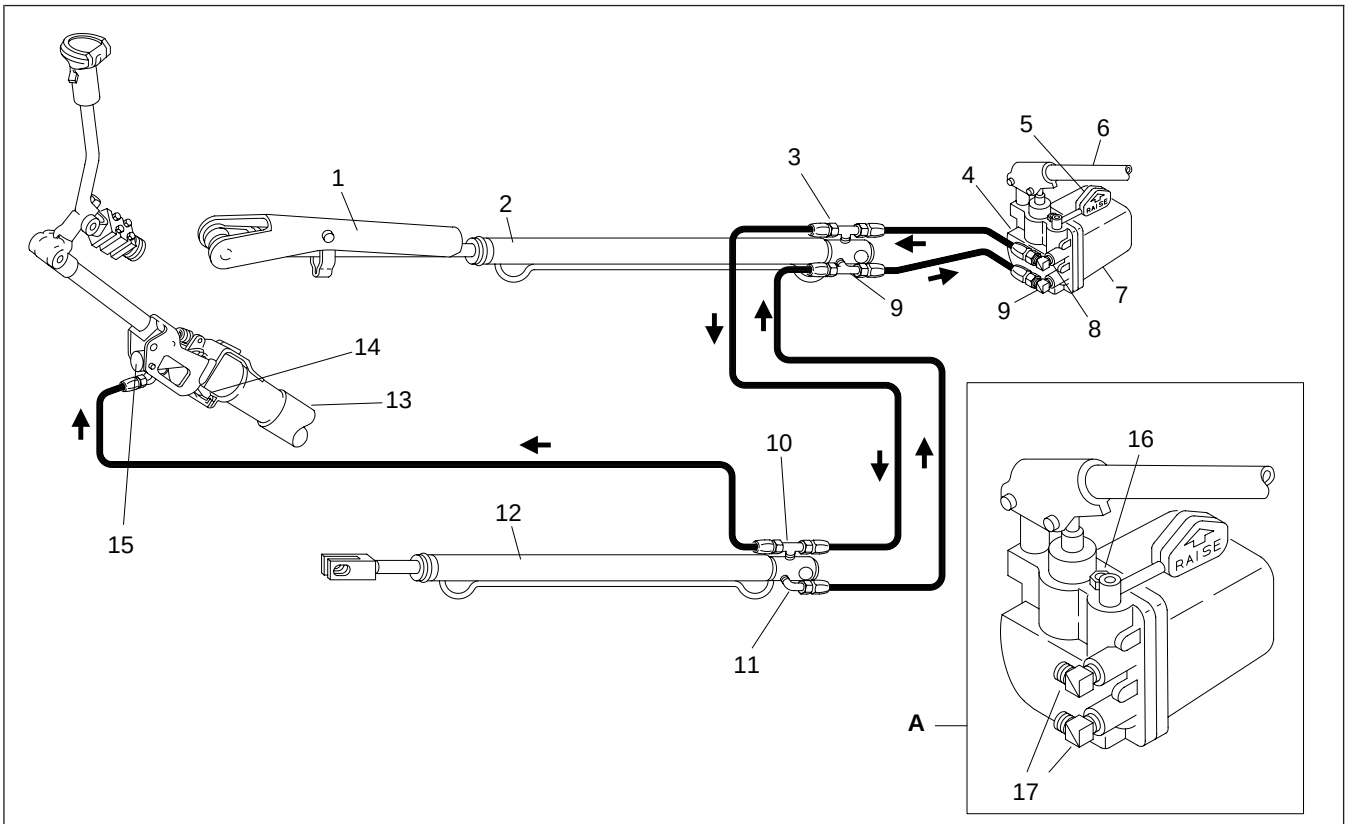
1. With the shift-disconnect cylinder fully collapsed, and the cab in the lowered (operating) position, loosen the fitting on the cylinder. See **Fig. 1**. Place the control lever in the "Raise" position, and operate the tilt pump until a bubble-free stream of hydraulic fluid flows from the fitting. Pump until about 2 fl oz (60 mL) of hydraulic fluid flows from the fitting to ensure that the entire line is free of air.
2. Tighten the fitting and refill the tilt pump until hydraulic fluid appears in the fill port. Refer to **Specifications, 400** for the specified hydraulic fluid. Do not use engine oil, brake fluid, or automatic transmission fluid. Install and tighten the fill plug.

BLEEDING THE HYDRAULIC CAB LATCHES

⚠ DANGER

Before doing the work below, review the cab tilting information under Subject 060. Failure to read the warnings and to be aware of the dangers of tilting and lowering the cab could result in serious injury or death.

Bleeding the System



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A. Tilt Pump Enlargement

1. Tilt Strut
2. Right Tilt Cylinder
3. "Push" Port Fitting
4. Pump Body
5. Pump Control Lever
6. Pump Lever
7. Reservoir
8. "Push Port Fitting
9. "Pull" Port Fitting
10. "Push" Port Fitting
11. "Pull" Port Fitting
12. Left Tilt Cylinder
13. Shift Tube
14. Shift Tube Latch Mechanism
15. Shift-Disconnect Cylinder
16. Fill Plug
17. Fittings

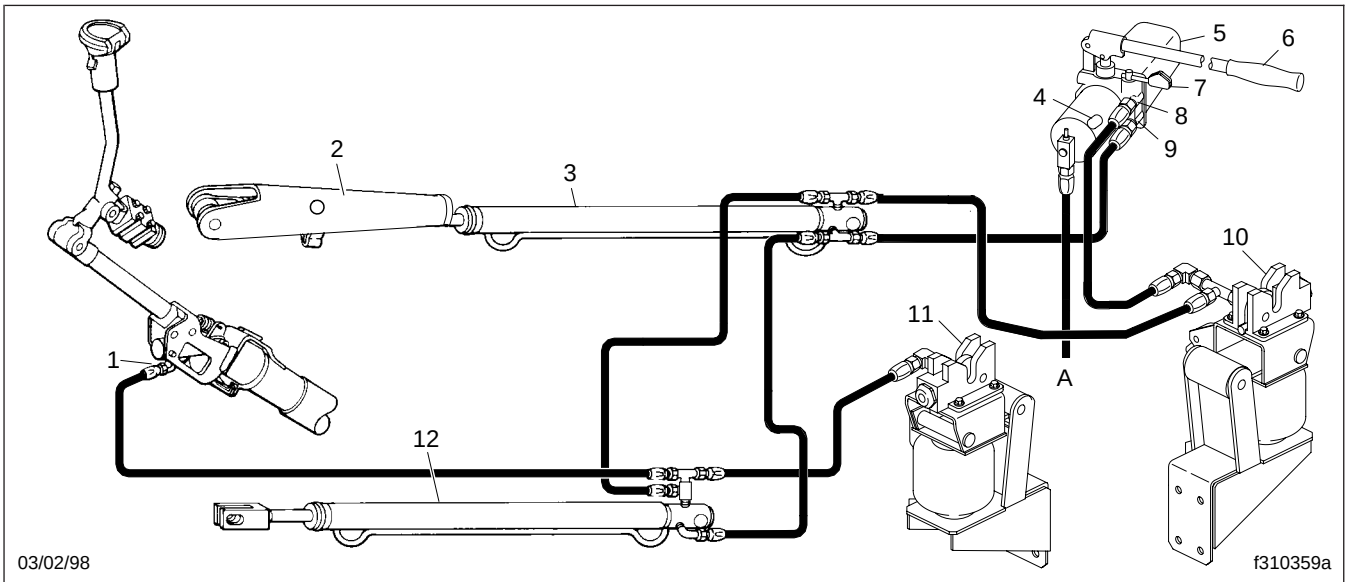
Fig. 1, Hydraulic-Only System, Equipped With Mechanical Cab Latches

Since the hydraulic cab latches are mounted higher in the system than the tilt pump, air going to them will not discharge to the reservoir. See **Fig. 2**.

1. Tilt the cab to the full-tilt position. Refer to **Subject 060** for cab tilting instructions.
2. Push the free end of the tilt strut down onto the rod of the right tilt cylinder.
3. Put the pump control lever into the "Lower" position. Operate the tilt pump until the cab goes over-center. Let the cab settle onto the tilt strut.
4. Loosen the hydraulic fitting on the right cab latch.
5. Put the pump control lever in the "Raise" position; then operate the tilt pump (using either the air motor or the pump lever) until a bubble-free stream of fluid flows from the fitting. Pump until about 2 fl oz (60 mL) of fluid flows from the fitting to ensure the entire line is free of air.
6. Tighten the cab latch fitting.
7. Put the pump lever in the "Lower" position.
8. Loosen the fitting on the left cab latch.
9. Put the pump control lever in the "Raise" position; then operate the tilt pump (using either the air motor or the pump lever) until a bubble-free

stream of fluid flows from the fitting. Pump until about 2 fl oz (60 mL) of fluid flows from the fitting to ensure the entire line is free of air.

10. Tighten the cab latch fitting.
11. With the pump control lever still in the "Raise" position, operate the tilt pump just enough to take the weight off the tilt strut; then release the tilt strut, and lock it in the spring catch.
12. Lower the cab. For instructions, refer to **Subject 060**.



A. Air supply connects here.
1. Shift-Disconnect Cylinder
2. Tilt Strut
3. Right Tilt Cylinder
4. Air Motor Assembly and Button
5. Reservoir
6. Manual Pump Lever
7. Pump Control Lever
8. "Push" Port
9. "Pull" Port
10. Right Hydraulic Cab Latch
11. Left Hydraulic Cab Latch
12. Left Tilt Cylinder

Fig. 2, Air/Hydraulic System, and Equipped With Hydraulic Cab Latches and Cab Air Suspension

13. Fill the tilt pump until hydraulic fluid appears in the fill port. Refer to **Specifications 400** for specified hydraulic fluid. Don't use engine oil, brake fluid, or automatic transmission fluid.
14. Install the fill plug and tighten it firmly.

Tilt Cylinder Removal, Disassembly, Assembly, and Installation

Removal

NOTE: Remove the tilt cylinder assemblies from the vehicle only when the cab is in the lowered (operating) position.

1. Release the hydraulic pressure by alternately moving the control lever on the tilt pump to the "Raise" and "Lower" positions. Hold the control lever in each position for a few seconds. Allow enough time for the shift-disconnect cylinder to empty. Return the control lever to the "Lower" position before proceeding.
2. Disconnect the hydraulic lines from both tilt cylinders. Cover the ends of the lines to prevent dirt from entering the system.

If the hydraulic fluid is discolored, drain the cab-tilt system by placing a container under the tilt pump reservoir, then removing it. Install the reservoir; then add new, approved fluid. See **Specifications, 400** for approved fluids.

3. Disconnect the right tilt cylinder at the clevis end by removing the cotter pin (**Fig. 1**, Ref. 5), and the clevis pin (Ref. 6).
4. Remove the tilt strut by removing the locknut (Ref. 3) and the machine screw (Ref. 1), then the tilt strut spring (Ref. 4).

   If the tilt-strut spring is installed with rivets and a retainer, squeeze the legs of the tilt-strut spring together; then remove the rivets from each side of the tilt strut. Remove the tilt strut spring and the tilt strut. Discard the rivets, and the retainer that is inside the tilt strut.
5. Loosen and remove the 5/8–11 bolt (Ref. 8) that holds the lower end of the tilt cylinder to the end spacer (Ref. 12) on the right-side frame rail.
6. Remove the right tilt cylinder from the vehicle.
7. Repeat the procedure for the left tilt cylinder.

NOTE: There is no tilt strut on the left tilt cylinder.

Disassembly

IMPORTANT: Even a small amount of dirt in a hydraulic system can impair its function; therefore, always work under the cleanest possible conditions.

1. Clean both tilt cylinder assemblies with solvent before disassembling them. Clean them with the piston rods retracted.

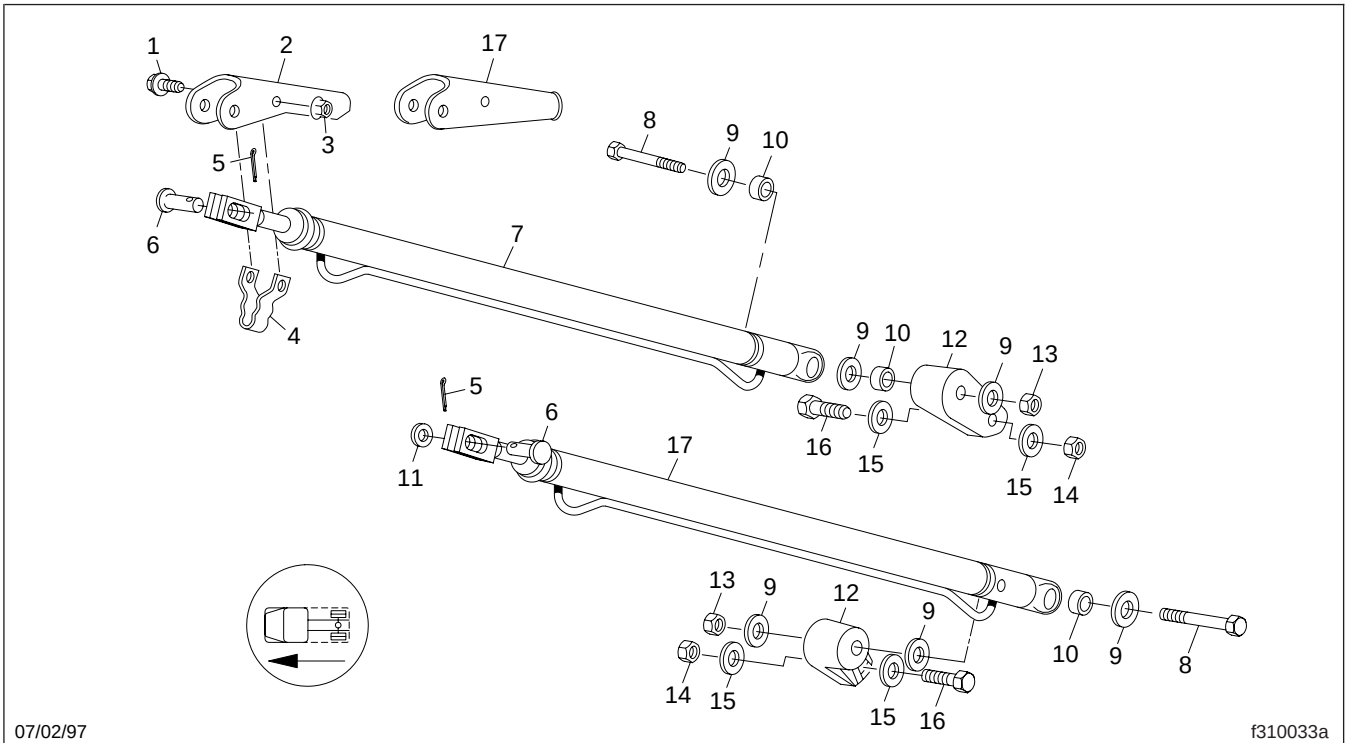
⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

2. Remove the piston rod assembly from the cylinder (see **Fig. 2**):
   - 2.1 Using a brass drift, tap the gland (Ref. 7) down into the cylinder until the retaining ring (Ref. 3) is lined up with the 1/8-inch hole at the end of the cylinder tube; then remove the retaining ring, using the hole as an aid.
   - 2.2 Gently pull the piston rod assembly from the cylinder tube.
3. Unscrew the piston from the piston rod assembly. If the piston was staked to the rod, inspect the internal threads for damage and replace the piston if necessary.
4. If the piston is to be used again, remove and discard the O-ring and seal (Refs. 11 and 10) from the piston.
5. Remove and discard the small O-ring (Ref. 2) from the threaded portion of the piston rod.
6. Remove the gland (Ref. 7) from the piston rod.
7. Remove the wiper, back-up ring, and the O-ring (Refs. 4, 5, and 6) from inside the gland.
8. Check the piston rod, gland, piston, and the cylinder tube for wear and damage. Clean them.
9. Repeat the procedure for the left-side tilt cylinder.

NOTE: Do not re-use or try to straighten a bent piston rod. Replace the rod even if the bend is slight.

Tilt Cylinder Removal, Disassembly, Assembly, and Installation



1. Machine Screw
2. Old-Style (FLA) Tilt Strut
3. Nylon-Threaded Locknut
4. Tilt Strut Spring
5. Cotter Pin (2 qty.)
6. Clevis Pin (2 qty.)
7. Tilt Cylinder
8. 5/8–11 Bolt (2 qty.)
9. 5/8" Hardened Washer
10. Mounting Bushing
11. 5/8" Washer
12. End Spacer (2 qty.)
13. 5/8–11 Nut (2 qty.)
14. 1/2–13 Nut (2 qty.)
15. 1/2" Hardened Washer (4 qty.)
16. 1/2–13 Bolt (2 qty.)
17. New-Style (FLB) Tilt Strut

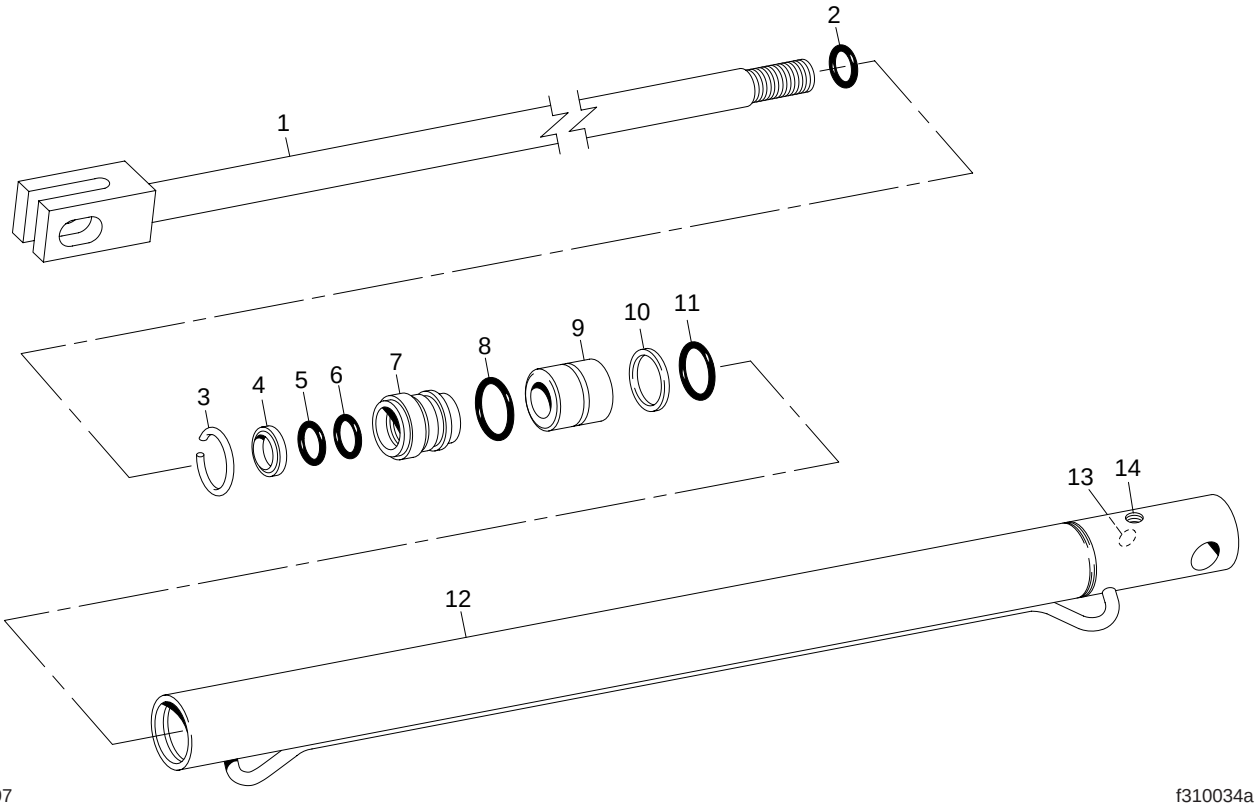
Fig. 1

Assembly

NOTE: Use the Cylinder Seal Kit. Refer to the Freightliner *Parts Book* for the correct part number.

1. Install the new wiper, back-up ring, and O-ring inside the gland of one of the tilt cylinders.
2. Lubricate the inside of the gland with hydraulic fluid, and put it back on the piston rod. See **Fig. 2**.
3. Wipe a thin coat of hydraulic fluid on the piston rod.
4. Install the new small O-ring on the threaded portion of the piston rod. See **Fig. 2**.
5. Screw the piston onto the piston rod, using Loctite® sealant on the threads. Stake the piston threads in two places, 180 degrees apart.
6. Install the new seal (Ref. 10) and O-ring (Ref. 11) on the piston.
7. Make sure the cylinder bore is clean, and pour a small amount of hydraulic fluid into it. Rotate the cylinder tube to spread the fluid evenly throughout the bore.
8. Install the piston rod assembly in the cylinder. Lightly tap the gland to position it, and install the retaining ring (Ref. 3).
9. Repeat the procedure for the other tilt cylinder.
10. Check both pistons for smooth action in the cylinders. Make sure that they don't bind.

Tilt Cylinder Removal, Disassembly, Assembly, and Installation



1. Piston Rod
2. O-Ring
3. Retaining Ring
4. Wiper
5. Back-Up Ring
6. O-Ring
7. Gland
8. O-Ring
9. Piston
10. Seal
11. O-Ring
12. Cylinder
13. Pull Port
14. Push Port

Fig. 2, Tilt Cylinder Components

11. Push the piston rod assemblies into the cylinders as far as possible. Fill both cylinders at the *pull* ports (**Fig. 2**, Ref.13) with the specified hydraulic fluid. See **Specifications, 400** for the specified hydraulic fluid.

Installation

1. Install the right tilt cylinder assembly on the vehicle (see **Fig. 1**):

   1.1 Place the tilt strut (Ref. 2) over the clevis of the tilt cylinder, making sure the holes in both parts are aligned.

   1.2 Place the tilt cylinder clevis and tilt strut on the mounting flange of the cab, and insert the clevis pin through the aligned holes of all three parts.

   1.3 Place the washer over the end of the clevis pin, and install the cotter pin into the clevis pin hole. Lock the cotter pin.

   1.4 Install the tilt-strut spring (**Fig. 1**, Ref. 4).

   Place the tilt-strut spring (**Fig. 1**, Ref. 4) over the piston rod; then install it onto the tilt strut, using the machine screw and nylon locknut (Refs. 1 and 3).

NOTE: If the tilt-strut spring was installed with rivets, replace them with two 10–24 machine screws (3/4-inch long) and nylon locknuts.

Tilt Cylinder Removal, Disassembly, Assembly, and Installation

1.5 Line up the mounting hole at the bottom end of the tilt cylinder with that on the right-side end spacer. See **Fig. 1**.

1.6 Coat the outside of the mounting bushing (Ref. 10) with Never-Seez®; then install the 5/8–11 bolt and nut, and mounting bushing as shown in **Fig. 1**.

1.7 Tighten the 5/8–11 bolt 135 lbf·ft (183 N·m).

1.8 Check the end spacer mounting bolt (Ref. 16) for tightness, and tighten it 95 lbf·ft (129 N·m) if necessary.

2. Repeat the procedure for the left tilt cylinder. Note that there is no tilt strut on the left tilt cylinder.
3. Connect the hydraulic lines to the cylinder port fittings, but do not tighten them.
4. Bleed the hydraulic system as described in **Subject 100**.

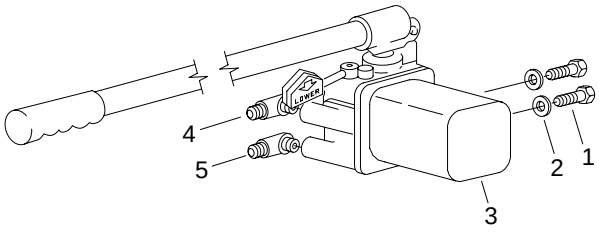
Tilt Pump Removal, Disassembly, Assembly, and Installation

Removal

1. Release the hydraulic pressure in the lines, tilt cylinders, and the shift-disconnect cylinder by alternately moving the pump control lever to the "Raise" and "Lower" positions. Hold the control lever in each position for a few seconds. Allow enough time for the shift-disconnect cylinder to empty. Return the control lever to the "Lower" position.
2. On air/hydraulic systems, drain the air tanks; then disconnect the air supply line from the air motor. Leave the air motor assembly attached to the tilt pump.
3. Mark the hydraulic lines and disconnect them at the *push* and *pull* ports on the tilt pump assembly. Place a container under the ends of the disconnected lines to catch any fluid remaining in them.
4. Cover the ends of the hydraulic lines to prevent the entry of dirt into the system.
5. Remove the two tilt pump mounting capscrews and washers. **See Fig. 1.**
6. Remove the tilt pump assembly from the vehicle.

Disassembly (See Fig. 2)

1. Clean the exterior of the pump before disassembly.
2. Place the tilt pump assembly over a container and remove the four capscrews (Ref. 30) that attach the reservoir to the tilt pump body.
3. Remove the reservoir from the tilt pump body, allowing the hydraulic fluid to drain into the container.
4. Remove and discard the O-ring (Ref. 28) from the groove in the edge of the tilt pump reservoir.
5. Remove the right angle fittings, if present, from the *push* and *pull* ports on the tilt pump body. **See Fig. 1**, Refs. 4 and 5.
6. Check the screens (**Fig. 2**, Ref. 40) in each port for dirt particles and damage. Carefully clean the screens; if they are very clogged or damaged, remove them by releasing the retaining rings (Ref. 41).
7. Remove the plunger (Ref. 8) as follows:



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1. 3/8" Capscrew (2 qty.)
2. 3/8" Washer (2 qty.)
3. Tilt Pump Assembly
4. Push Port Fitting
5. Pull Port Fitting

Fig. 1, Hydraulic-Only System Shown

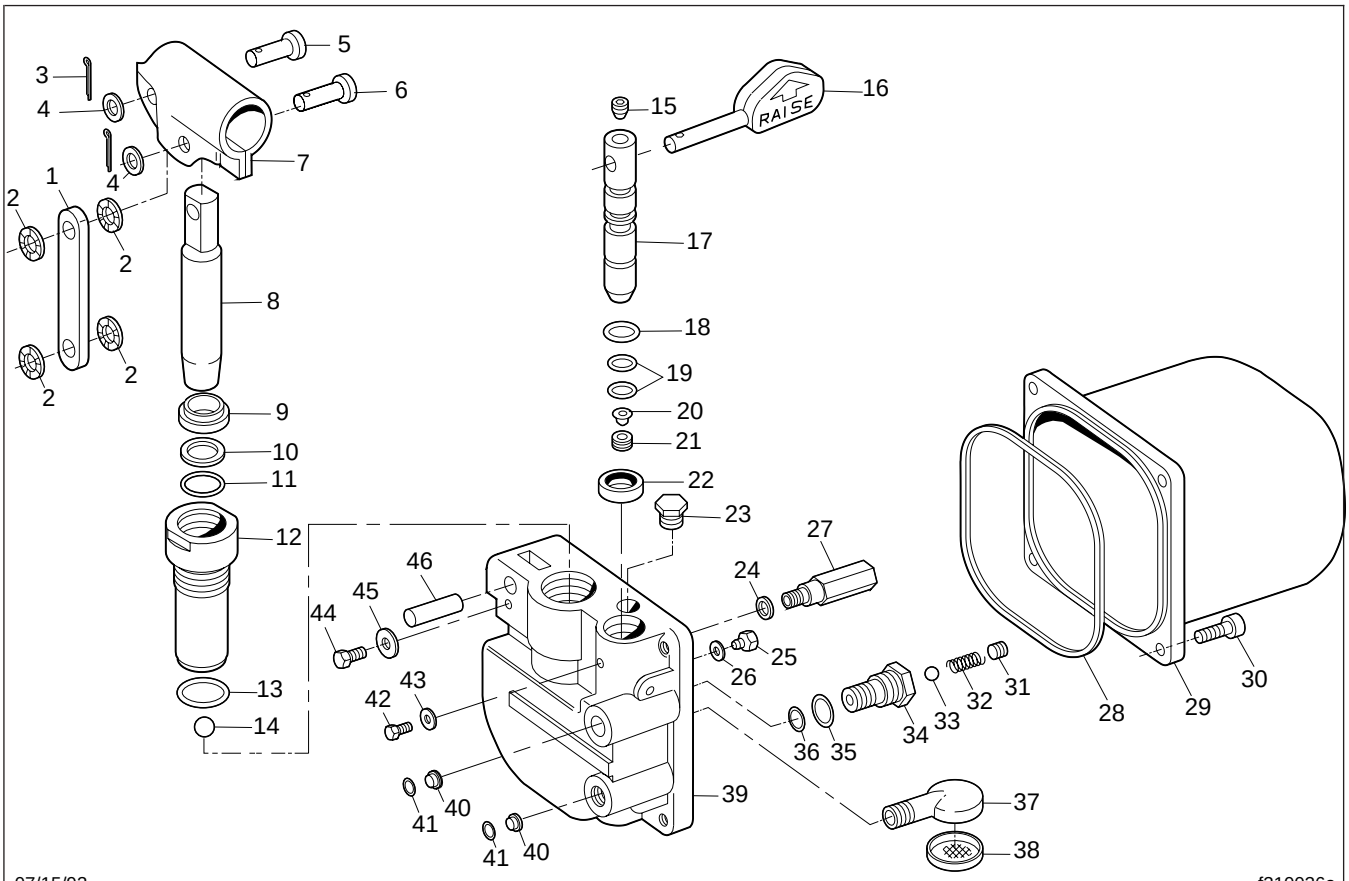
7.1 Remove the cotter pin, washers, and wave washers (Refs. 3, 4, and 2) from the upper beam link pin (Ref. 5).

7.2 Remove the upper beam link pin, and disconnect the beam link from the beam (Ref. 7).

7.3 Pull straight up on the beam to remove the plunger (Ref. 8) from the cylinder (Ref. 12).

8. If replacing the plunger (Ref. 8), remove the cotter pin, washer, and lower beam link pin (Ref. 6); then remove the beam from the plunger.
9. Using a small screwdriver, carefully pry the wiper (Ref. 9), the back-up ring (Ref. 10), and the O-ring (Ref. 11) from inside the cylinder.
10. Remove the cylinder (Ref. 12) by unscrewing it from the tilt pump body.
11. Remove and discard the O-ring (Ref. 13) from the cylinder.
12. Remove the capscrew (Ref. 42) and the gasket from the tilt pump body.
13. Pull up on the control lever (Ref. 16) and the spool (Ref. 17), and remove the spool from the tilt pump body.
14. Remove and discard the black O-ring (Ref. 18) and the two clear O-rings (Ref. 19) from the spool.
15. Remove the orifice screw (Ref. 21) from the bottom of the spool, and make sure that it is free of dirt particles.

Tilt Pump Removal, Disassembly, Assembly, and Installation



1. Beam Link
2. Wave Washer (4 qty.)
3. Cotter Pin (2 qty)
4. Washer (2 qty.)
5. Upper Beam Link Pin
6. Lower Beam Link Pin
7. Beam
8. Plunger
9. Wiper
10. Back-Up Ring
11. O-Ring
12. Cylinder
13. O-Ring
14. 1/4" Ball
15. Setscrew
16. Control Lever
17. Spool
18. Black O-Ring
19. Clear O-Ring (2 qty.)
20. Screen
21. Orifice Screw
22. Wiper
23. Fill Plug
24. Gasket
25. Plug
26. Gasket
27. Relief Valve
28. Reservoir O-Ring
29. Reservoir
30. Capscrew (4 qty.)
31. Plug
32. Spring
33. 3/16" Ball
34. Outlet Seat
35. O-Ring
36. O-Ring
37. Inlet Adapter
38. Screen
39. Tilt Pump Body
40. Screen
41. Retaining Ring (2 qty.)
42. Capscrew
43. Gasket
44. Screw
45. Washer
46. Pin

Fig. 2, Hydraulic-Only Tilt Pump Shown

16. Remove the screen (Ref. 20), if present, and check it for dirt particles. Clean it, if needed; if it's damaged, replace it.

17. Loosen the setscrew (Ref. 15) at the top of the spool, and remove the control lever from the spool.

Tilt Pump Removal, Disassembly, Assembly, and Installation

18. Pry the wiper (Ref. 22) from the hole in the tilt pump body, and discard it.
19. Remove the plug (Ref. 25) from the tilt pump body. Turn the tilt pump body upside down and remove the 1/4-inch ball (Ref. 14) from the bottom of the bore where the cylinder (Ref. 12) was installed.
20. Remove the outlet seat (Ref. 34) from the tilt pump body, and remove the two O-rings (Refs. 35 and 36) from the outlet seat.
21. Remove the plug (Ref. 31) from the top of the outlet seat, and remove the spring and the 3/16-inch ball (Refs. 32 and 33).
22. Remove the inlet adapter (Ref. 37) from the body of the tilt pump.
23. Inspect and clean the screen (Ref. 38) at the bottom of the inlet adapter. Remove and discard the screen if it is damaged or completely clogged.

Assembly (See Fig. 2)

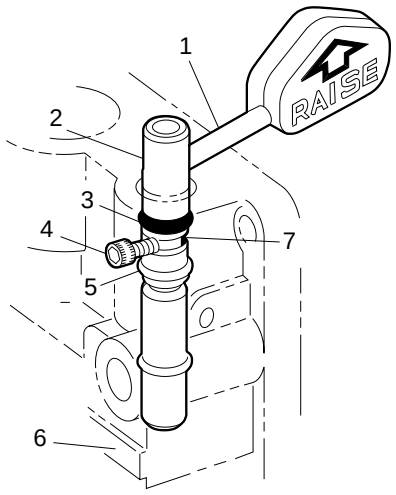
Before beginning, make sure that all of the tilt pump components are as clean as possible. Any particles of dirt or foreign matter in the system will affect its efficiency. Always work in as clean an environment as possible.

Use the Tilt Pump Seal Kit for the new O-rings, wipers, 1/4-inch ball, 3/16-inch ball, and copper seals. Refer to the Freightliner *Parts Book* for the correct part number.

⚠ CAUTION

CAUTION: Do not use any type of Teflon® tape on the threaded components (such as bolts, plugs, and valves) that are to be installed on the tilt pump. Small particles of tape may eventually work their way into the hydraulic system, impairing its efficiency.

1. Insert the 1/4-inch ball (Ref. 14) into the cylinder bore.
2. Install and tighten the plug (Ref. 25) and the new gasket (Ref. 26).
3. Install the O-ring (Ref. 13) on the cylinder (Ref. 12), and install the cylinder into the tilt pump body. Tighten the cylinder 80 lbf·ft (108 N·m).
4. Lightly coat the back-up ring (Ref. 10), the O-ring (Ref. 11), and the wiper (Ref. 9) with hydraulic fluid, and install them into the cylinder.
5. If the beam (Ref. 7) was removed from the plunger, connect the two together, using the lower beam pin (Ref. 6), washer, and cotter pin.
6. Carefully insert the plunger into the cylinder and push it down as far as it will go. Do not damage the wiper or O-ring.
7. Line up the holes in the beam (Ref. 7) and the beam link (Ref. 1), and install the wave washers (Ref. 2), the upper beam link pin (Ref. 5), washer (Ref. 4), and the cotter pin (Ref. 3).
8. Install the two small, clear O-rings (Ref. 19) and the black O-ring (Ref. 18) on the spool (Ref. 17).
9. Install the screen (Ref. 20).
10. Install and tighten the orifice screw (Ref. 21) on the bottom of the spool.
11. Apply a light coat of hydraulic fluid on the spool. Find the wide groove on the spool just below the black O-ring. **See Fig. 3.** The capscrew (Ref. 4) seats in this groove when the spool is properly installed in the tilt pump body.



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1. Control Lever
2. Spool
3. Black O-Ring
4. Capscrew
5. Clear O-Ring
6. Tilt Pump Body
7. Groove for Capscrew

Fig. 3

Tilt Pump Removal, Disassembly, Assembly, and Installation

12. Install the spool into the bore on the tilt pump body.

IMPORTANT: Install the spool in the bore far enough for the wide groove to align with the capscrew hole. **See Fig. 3.**

13. If replacing the gasket (Ref. 43), insert a new gasket into the tilt pump body.
14. Install the capscrew (Ref. 42) into the hole in the tilt pump body. Make sure it seats in the spool groove, **as shown in Fig. 3**. If the capscrew does not seat firmly on its gasket, then it is not in the groove on the spool.
15. Slide the new wiper (Ref. 22) over the top of the spool. Place a 1/2-inch (13-mm) socket (1/2-inch drive) over the spool, and drive the wiper into position.
16. Install the control lever (Ref.16) in the spool. Make sure that it is correctly lined up.
17. Install the setscrew (Ref. 15) on top of the spool, and tighten it firmly.
18. If the relief valve (Ref. 27) was removed, install it, along with a new gasket (Ref. 24). Tighten the relief valve 60 lbf·in (680 N·cm).
19. Install the clear O-ring (Ref. 36) and the black O-ring (Ref. 35) on the outlet seat (Ref. 34).
20. Install the outlet seat into the tilt pump body. Tighten the outlet seat 19 to 21 lbf·ft (26 to 28 N·m).
21. Install the 3/16-inch ball (Ref. 33), the spring (Ref. 32), and the plug (Ref. 31) into the outlet seat. Tighten the plug firmly.
22. If the screen (Ref. 38) was removed, insert it into the inlet adapter (Ref. 37), and install the inlet adapter into the tilt pump body.
23. If the screens (Ref. 40) in the *push* and *pull* ports were removed, insert new screens, and install the retaining rings (Ref. 41).
24. Apply a small amount of white grease to the reservoir O-ring (Ref. 28), and insert it into the groove in the reservoir (Ref. 29).
25. Install the reservoir on the tilt pump body.
26. Install and tighten the four capscrews (Ref. 28) 96 lbf·in (1080 N·cm).
27. Install the fittings on the *push* and *pull* ports. Tighten them 96 lbf·in (1080 N·cm).

Installation

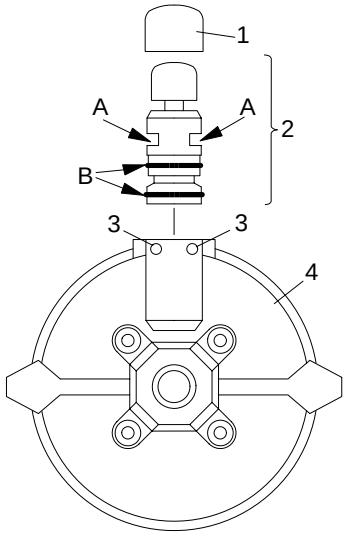
1. Using the two mounting capscrews and washers, install the assembled tilt pump on the vehicle. **See Fig. 1**, Refs. 2 and 3. Tighten the capscrews 23 lbf·ft (31 N·m).
2. Connect the hydraulic lines to the *push* and *pull* ports on the tilt pump assembly. Do not tighten the lines on the fittings until the system has been bled.
3. Fill the reservoir with the specified hydraulic fluid, and install and tighten the fill plug. Refer to **Specifications, 400** for the specified hydraulic fluid. Do not use engine oil, brake fluid, or automatic transmission fluid.
4. Bleed the entire system. Refer to **Subject 100**. Tighten the hydraulic lines firmly.

Air Button Assembly Replacement

Replacement

If the air button is sticking, and affecting the operation of the air motor, replace the air button assembly using this procedure.

1. Drain the air tanks.
2. Disconnect the air supply line from the air motor.
3. Remove the old air button assembly.
   - 3.1 Remove the rubber boot from the air button.
   - 3.2 Using a suitable punch, drive out the two roll pins holding the air button in place. **See Fig. 1.**



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A. Roll pins fit into these grooves.
B. Lubricate these O-rings.
1. Rubber Boot
2. Air Button Assembly
3. Roll Pins
4. Air Motor Assembly

Fig. 1

   - 3.3 Using a twisting motion, pull the old air button assembly out of the air motor housing.
4. Clean out the cavity in the air motor housing.
5. Install the new air button assembly.
   - 5.1 Using clean motor oil or Lubri-Plate®, lubricate the O-rings on the new air button assembly. **See Fig. 1.**
   - 5.2 Using a slight twisting motion, push the new air button assembly into the air motor housing. If it doesn't go in correctly, remove it and lubricate the O-rings again.
   - 5.3 Turn the air button assembly so that the grooves in it are lined up with the holes for the roll pins. **See Fig. 1.**
   - 5.4 Install the roll pins. Make sure they are flush with the air motor housing.
   - 5.5 Install a new rubber boot over the button.
6. Connect the air supply line to the air motor assembly.
7. Build up the system air pressure; then check for air leaks around the button and the supply line.
8. Test the operation of the new air button.

   If there are still problems with the operation of the air motor, replace the entire air motor assembly, following the instructions **in Subject 132**.

Replacement

DANGER

Before doing the work below, review the cab tilting information under Subject 060. Failure to read the warnings and to be aware of the dangers of tilting and lowering the cab could result in serious injury or death.

CAUTION

CAUTION: Drain the air tanks before removing the air motor. Failure to do so could result in damage to the vehicle or the tilt system parts.

NOTE: The air motor can be removed from the hydraulic tilt pump without removing the tilt pump from the vehicle.

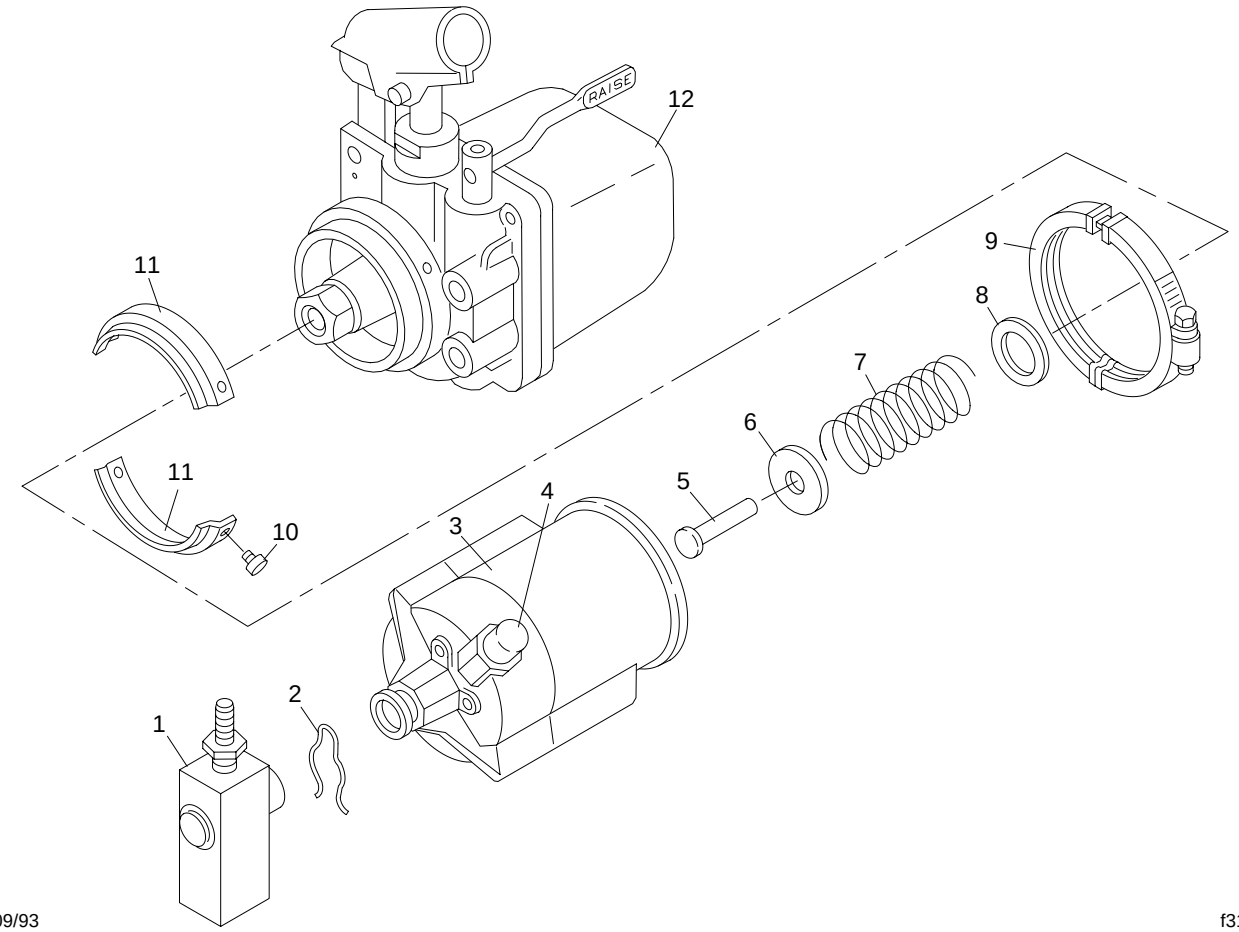
1. Tilt the cab. Refer to **Subject 060** for instructions.
2. Drain the air tanks.

WARNING

WARNING: Hold the air motor housing firmly while you are removing it from the tilt pump. The spring inside the air motor could eject the air motor housing and other parts from the tilt pump, which could cause personal injury or parts damage.

3. Remove the air motor from the tilt pump. **See Fig. 1.**
   - 3.1 Remove the retaining clip (Ref. 2) from the air inlet assembly (Ref. 1). It isn't necessary to disconnect the air line from the air inlet assembly.
   - 3.2 While holding the air motor housing (Ref. 3) firmly, loosen the mounting clamp (Ref. 9 or 11) holding the air motor to the tilt pump.
   - 3.3 Slowly and carefully remove the air motor from the tilt pump. Hold on to the piston, spring, spool, and washer (Refs. 5, 7, 6, and 8), and save them for the installation of the new air body.
4. Check the piston, spring, spool, and washer. If they're not damaged or worn, use them on the new air motor; otherwise, replace them.
5. Remove the rubber boot from the air button (Ref. 4). If the boot isn't damaged, use it on the new air motor; otherwise, replace it.
6. Clean all the parts.
7. Install the new air motor onto the tilt pump.
   - 7.1 Install the rubber boot on the air button.
   - 7.2 Place the piston, spool, spring, and washer inside the new air motor housing, **as shown in Fig. 1**.
   - 7.3 Align the new air motor with the tilt pump, then push it in place.
   - 7.4 While holding the air motor in place, install and tighten the mounting clamp. Make sure the clamp is securely tightened before you let go of the air motor.
   - 7.5 Push the air inlet assembly onto the end of the air motor; then install the retaining clip.
8. Start the engine to build the air pressure.
9. When the air pressure is 120 psi (827 kPa), test the air motor by lowering the cab to the operating position. Refer to **Subject 060** for complete instructions on lowering the cab.

Air Motor Replacement



1. Air Inlet Assembly
2. Retaining Clip
3. Air Motor Housing
4. Air Button
5. Piston
6. Spool
7. Spring
8. Washer
9. New-Style Mounting Clamp
10. Screw
11. Old-Style Mounting
12. Tilt Pump

Fig. 1

Troubleshooting

Problem—Cab Fails to Tilt or Fails to Return from Tilt When Using Manual Pump Lever, but Hydraulic Pressure Builds In System

Possible Cause	Remedy
Cab latch binding or failing to unlatch.	Check the cab latch release mechanism (either mechanical or hydraulic latches).
Plugged orifice at the bottom of the spool in the tilt pump.	Replace or rebuild the tilt pump.
Control lever in the wrong position.	Put the control lever in the correct position.
Worn seals or O-rings in the tilt pump.	Replace or rebuild the tilt pump.
Hoses blocked.	Replace the hoses.
Shift tube latch assembly not disconnecting.	Manually disconnect the shift tube latch mechanism; then repair latch, hose, or both.
Push and *pull* lines crossed.	Check for correct installation.
Internal leak in tilt pump.	Repair or replace the tilt pump.
Internal leak in tilt cylinder.	Repair or replace the tilt cylinder.
External leak.	Repair or replace the leaking part.
Air in hydraulic system.	Bleed the hydraulic system.

Problem—Cab Fails to Tilt or Fails to Return from Tilt When Using Air Motor, but System Works When Using Manual Pump Lever

Possible Cause	Remedy
Insufficient air supply to air motor.	Build air system pressure, or repair/replace air system parts as needed.
The air motor is not working.	Repair or replace the air motor.
The air button assembly is not working.	Replace the air button assembly.

Problem—Cab Stops Moving When in Controlled Fall

Possible Cause	Remedy
Velocity fuses locked up.	Reverse the pump direction with the control lever, and operate the pump to unlock.
Plugged orifice.	Inspect, and clean or replace.
Tilt strut left engaged.	Disengage the tilt strut.

Problem—Cylinder Velocity Fuses Are Locked Up

Possible Cause	Remedy
Controlled fall rate is too fast.	Inspect the orifice in bottom of spool valve; replace or rebuild the tilt pump, if needed.
Air in the system.	Bleed the system.
Ruptured hydraulic line.	Replace the hydraulic line.

Troubleshooting

Problem—Hydraulic Fluid Leaking at Hand Pump Plunger or Around Spool Valve

Possible Cause	Remedy
Worn seals and O-rings.	Replace or rebuild the tilt pump.

Problem—Hydraulic Fluid Leaking at Air Motor Exhaust, and/or Between Air Motor and Tilt Pump

Possible Cause	Remedy
Seals between air motor and tilt pump leaking.	Replace the tilt pump, and the air motor plunger, spring and spool, if needed.

Problem—Hydraulic Fluid Leak at the Tilt-Cylinder Gland

Possible Cause	Remedy
Worn seal on the gland.	Replace or rebuild the tilt cylinder.

Problem—Tilt Pump Leaks Between the Pump Base and the Reservoir

Possible Cause	Remedy
Worn O-ring on the reservoir.	Replace the O-ring on the reservoir.
O-ring on the reservoir pinched.	Replace the O-ring, making sure it is properly positioned.

Problem—Cab Drifts When in the Half-Raised Position

Possible Cause	Remedy
Worn spool valve seals.	Replace the spool valve seals or rebuild the tilt pump.
Worn piston seals inside the tilt cylinders.	Replace the piston seals or rebuild the tilt cylinders.
Control lever not all the way in the correct position.	Place the control lever in the correct position.

Specifications

Torque Values				
Description	Size	Grade	Torque	
			lbf·in (N·cm)	lbf·ft (N·m)
Tilt Cylinder Mounting Bolts	5/8–11	8	—	135 (183)
End Spacer Mounting Bolts, 2 inches	1/2–13	8	—	95 (129)
Tilt Pump Cylinder	—	—	—	80 (108)
Tilt Pump Relief Valve	—	—	60 (680)	—
Tilt Pump Outlet Seat	—	—	—	19–21 (26–28)
Tilt Pump Reservoir Socket-Head Capscrews	1/4–20	7	96 (1080)	—
Push and Pull Port Fittings	—	—	96 (1080)	—
Tilt Pump Mounting Capscrews	3/8–16	5	—	23 (31)

Table 1, Torque Values

Hydraulic Fluid Types		
Component or Usage		Fluid Type
Tilt Pump Hydraulic Fluid	All Temperatures	Freightliner Tilt System Hydraulic Fluid * (part number 48-02207-200) (MIL-H-5606 equivalent)

* The following vendor lubricants are approved: Texaco 1537 Aircraft Hydraulic Oil 15; Union Arctic Low Pour (-65) Hydraulic Fluid 04617; Filmite 530 Hydraulic Oil

Table 2, Hydraulic Fluid Types

General Information

On COE sleeper cabs and Conventionals with sleeper boxes, baggage doors are located on either side of the vehicle, to allow access to the storage compartments under the sleeper bunk. COEs have varying sizes of baggage doors, and may have single doors at each side, or dual doors at each side, depending on the cab size and the installation of various options. **See Fig. 1**. Conventionals have a 22-inch-wide by 18-inch-high door on each side of the sleeper box. **See Fig. 2**.

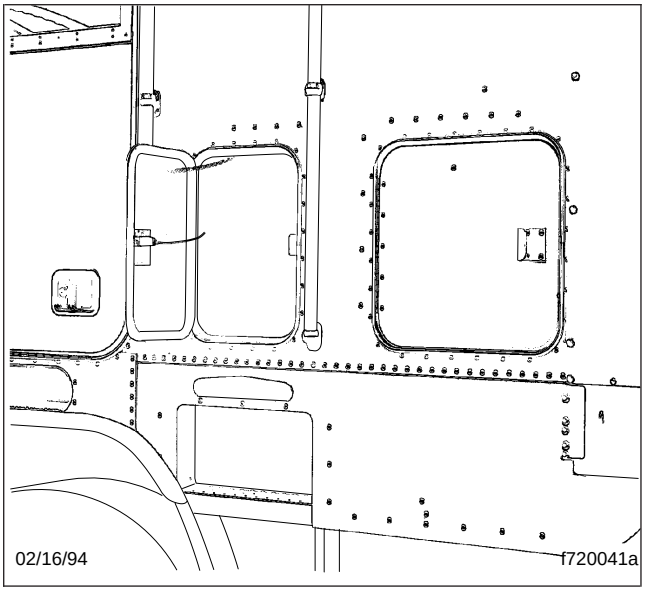


Fig. 1

The baggage doors on COE sleeper cabs and Conventional sleeper boxes have rounded corners, single-panel construction, a piano-style hinge, and a one-piece extruded aluminum door-openingframe. The baggage door panel is slightly recessed in the door-opening frame, and the door-opening frame features a full-circumference integral drip molding. A neoprene sponge bulb seal is glued to the inner perimeter of the door panel. A door stop chain limits opening the door beyond approximately 105 degrees. **See Fig. 1** or **Fig. 2**.

Each of the COE single baggage doors or forward baggage doors (of dual doors) is held closed by a pull latch that is opened by a remote-cable in the driver's compartment. Rear door latches (of dual doors) are opened by remote cables in the forward baggage compartments.

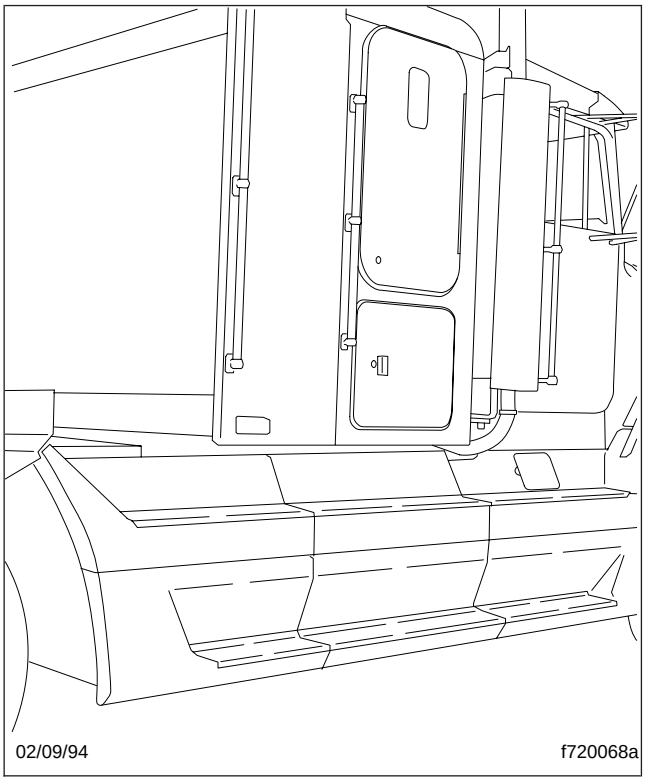


Fig. 2

Baggage doors on current-model FLB COEs also have a keyed lock cylinder. These doors can be opened from either the inside, using the remote cable, or from the outside, using the lock cylinder.

Some early-model FLB COEs have top-hinged baggage doors equipped with a gas spring, and a keyed, paddle-handle type of latch. Refer elsewhere in this group for information and service procedures for this type of baggage door.

Each of the Conventional baggage doors is held closed by a rotary latch that is opened by a keyed lock cylinder.

Access to the COE sleeper compartment is provided by the opening from the driver's compartment, with no access from outside the cab.

Access to Conventional sleeper boxes is provided by a 22-inch-wide by 37-inch-high access door, in addition to the walk-through opening at the back of the cab. The access door is on the curb-side of the sleeper on all sizes of sleeper boxes, with an additional street-side 22-inch by 37-inch door available as an option on 40-inch sleeper boxes.

General Information

The sleeper box access door is a rounded-corner bulkhead-style door, similar to the bulkhead-style cab doors on COEs and Conventionals.

The door opening frame has a full-circumference integral drip molding, and the surface of the access door is flush with the outermost edge of the drip molding. A push-on neoprene sponge bulb seal fits over the inner flange of the door opening frame. A door check strap prevents the door from opening too far. **See Fig. 2**.

A lever handle releases the access door from inside the sleeper box. A keyed lock cylinder actuates the rotary latch from the outside.

On Conventionals and FLB COEs, the same key used for the cab doors and ignition is used for the baggage doors and access door(s).

Baggage Door Seal Replacement

Replacement

1. Using a putty knife, separate one end of the baggage door seal, at the seal seam located at the center of the bottom of the door panel. See **Fig. 1** or **Fig. 2**. Gripping that end of the seal, pull the entire length of the seal off of the door panel.

⚠ WARNING

WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

2. Using a solvent (such as chlorothane or methylene-chloride), thoroughly clean and dry the seal application area of the door panel. Remove any rust, grease, dirt, or old adhesive from the surface.
3. If not already done, cut a length of new door seal that is slightly longer than the total perimeter of the baggage door.
4. Apply HBF/SC-1112 contact cement (manufactured by the H.B. Fuller Company), or an equivalent adhesive, to the door seal at the areas **shown in Fig. 3**. Apply the adhesive to the inside edges of the door panel at the areas **shown in Fig. 3**. Apply extra adhesive to the seal area of the hinge-leaf-to-panel overlap, **as shown in Fig. 1**

   Allow the adhesive to dry, as specified by the manufacturer.
5. Beginning with one (squared off) end of the seal at the center of the bottom inside edge of the door panel, install the door seal, making sure that the contour of the seal is fitted to the curved lip of the door panel all the way around its perimeter, except at the hinge. **See Fig. 3.** To avoid pulling the seal away from the corners of the panel, do not stretch the seal.
6. Just prior to complete seating of the door seal, cut off (square) the excess length of the seal so that the two ends will form a hairline seam (butt joint) at the center of the bottom of the door panel. Apply HBF/ SC-1112 contact cement, or an equivalent adhesive, to both ends of the seal.

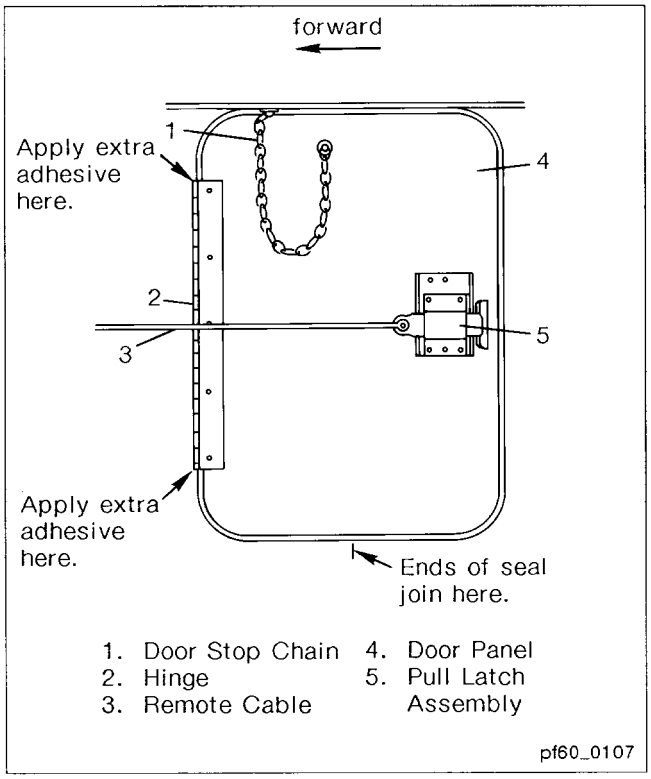


Fig. 1, COE Baggage Door (as viewed from inside)

   Allow the adhesive to dry, as specified by the manufacturer, then complete the door seal installation, and press the seal ends together.
7. Test the door for ease of opening and closing, and adjust the latch mechanism if necessary.

Baggage Door Seal Replacement

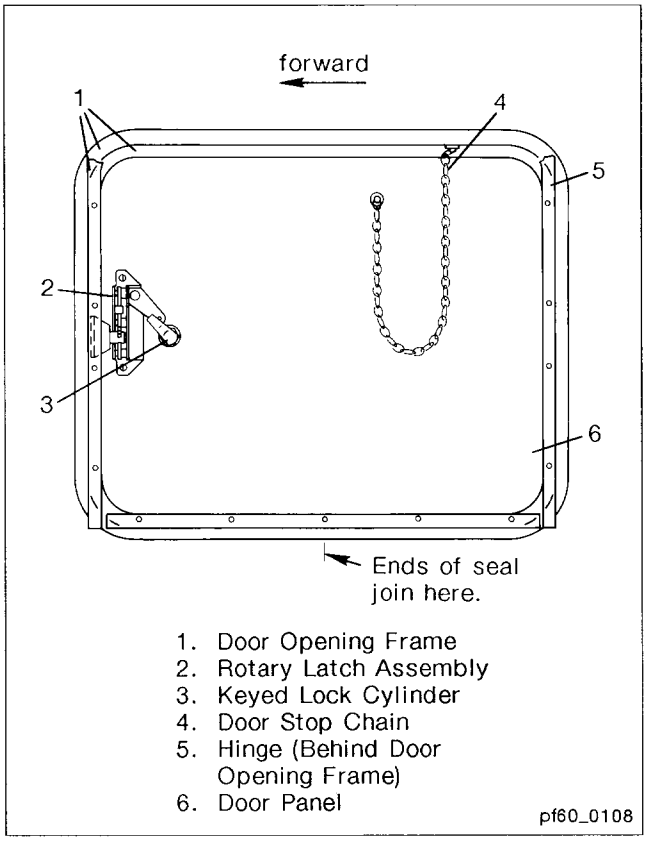


Fig. 2, Conventional Baggage Door (as viewed from inside)

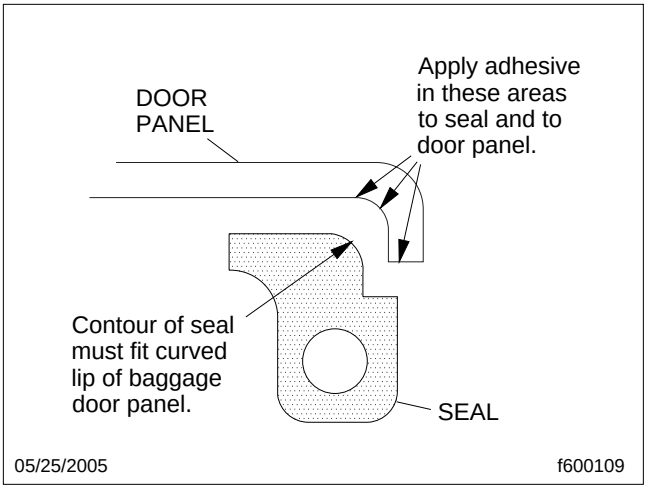


Fig. 3, Baggage Door Seal

Adjustment

If the baggage door is difficult to open or close, or if there are wind or water leaks at the door opening frame (when the door seal is correctly installed and is in good condition), adjust the baggage door latch, using the applicable procedure below.

CONVENTIONAL (See Fig. 1)

NOTE: The mounting holes in the striker assembly are horizontally slotted to allow in and out movement. The matching holes in the baggage door latch reinforcement are vertically slotted to allow up and down movement of the striker assembly.

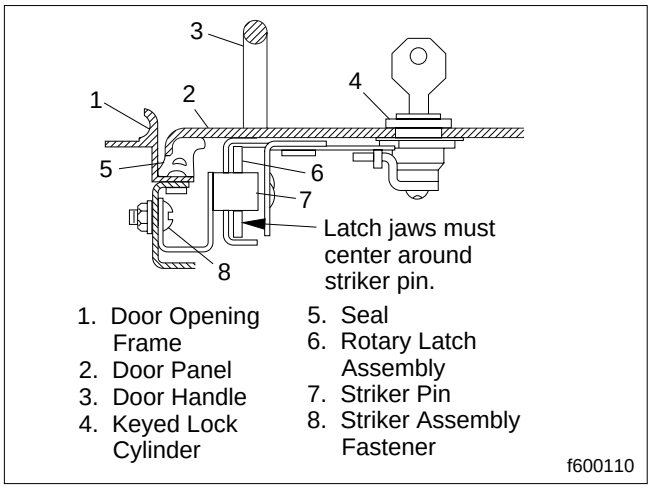


Fig. 1, Conventional Baggage Door Latch

1. Loosen the fasteners that hold the striker assembly in position, but do not loosen them any further than what is needed to allow movement of the striker assembly.
2. Partially close the baggage door to about 1 inch (50 mm) of the latched position, and see if the latch jaws will be centered around the striker pin when the door is closed. Move the striker assembly up or down as necessary.
3. Adjust the in and out position of the striker assembly as needed. If the baggage door was difficult to open or close, move the striker assembly outboard a slight amount; if wind or water leaks were a problem, move the striker assembly inboard.
4. Tighten the fasteners, then check the adjustment of the latch by opening and closing the door several times. Readjust if necessary.

COE (See Fig. 2)

NOTE: The mounting holes in the striker plate are horizontally slotted to allow in and out adjustment. Because of the design of the COE baggage door latch, up and down adjustment is not required.

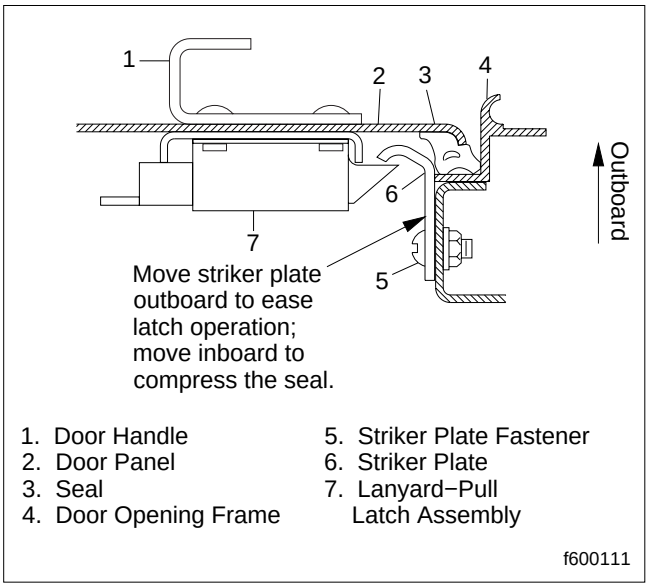


Fig. 2, COE Baggage Door Latch

1. Loosen the fasteners that hold the striker plate in position, but do not loosen them any further than what is needed to allow movement of the striker plate.
2. Move the striker plate outboard if the baggage door was difficult to open or close, or move it inboard if wind or water leaks were a problem.
3. Tighten the fasteners, then check the adjustment of the latch by opening and closing the door several times. Readjust if necessary.

Sleeper Box Access Door Seal Replacement

Replacement

1. Using a putty knife, separate one end of the access door seal, at the seal seam. Gripping that end of the seal, pull the entire length of the seal off of the door opening frame, by pulling toward the center of the opening.
2. Remove any rust, grease, or dirt from the seal flange.
3. Install the new seal on the door opening frame and seal flange bracket, so the bulb-portion of the seal will be facing the door when it is closed. **See Fig. 1.** The ends of the seal should be located at the bottom of the door. **See Fig. 2.**
4. Just prior to complete seating of the door seal, cut off (square) any excess length of the seal so that the two ends will form a hairline seam (butt joint).
5. Test the door for ease of opening and closing, and adjust the latch mechanism or door hinge if necessary.

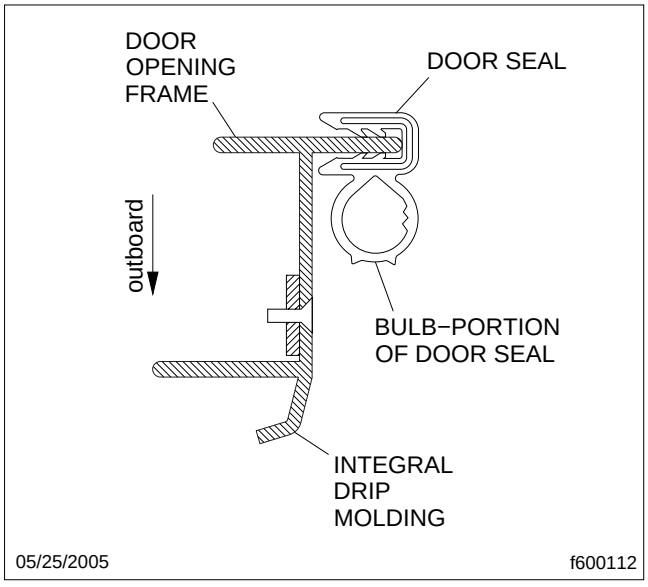


Fig. 1, Sleeper Box Access Door Seal

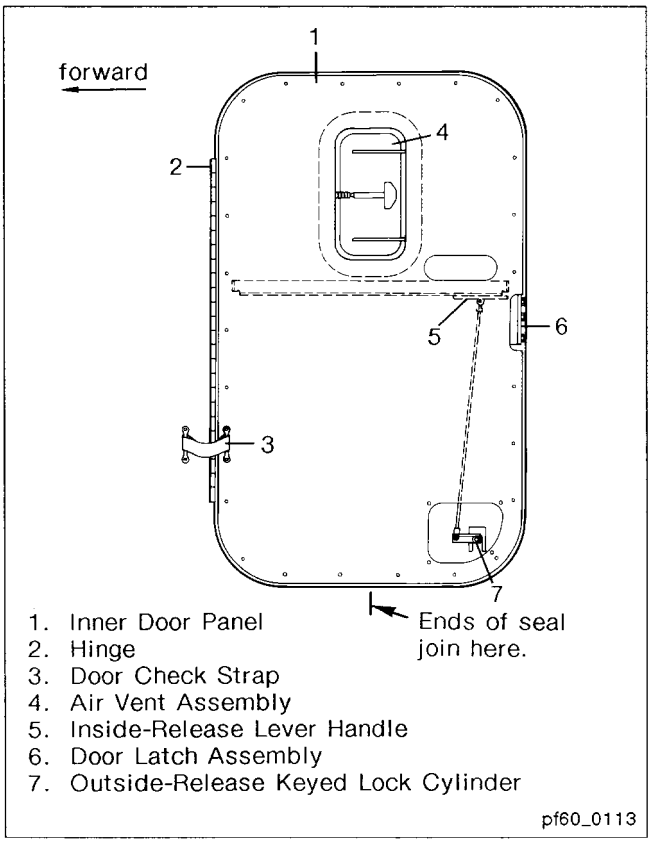


Fig. 2, Conventional Sleeper Box Access Door (as viewed from inside)

Adjustment

If the sleeper box access door is difficult to open or close, or the door seal is wearing prematurely, or if there are wind or water leaks at the door opening frame (when the door seal is correctly installed and is in good condition) check and adjust the access door.

1. With the access door closed and latched, check the vertical space between the access door and the closest point on the door opening frame, at the top center and bottom center of the door.

   If the space is not the same, adjust the height of the door in the door opening frame, as follows:

   1.1 Open the door to the 90-degree position.

   1.2 Loosen all of the hinge-attachment bolts (**Fig. 1**), but do not loosen them any further than what is needed to allow movement of the access door.

   1.3 Move the door straight up or down until the spaces at the top and bottom are equal. Hold the door in position, and tighten the hinge-attachment bolts.

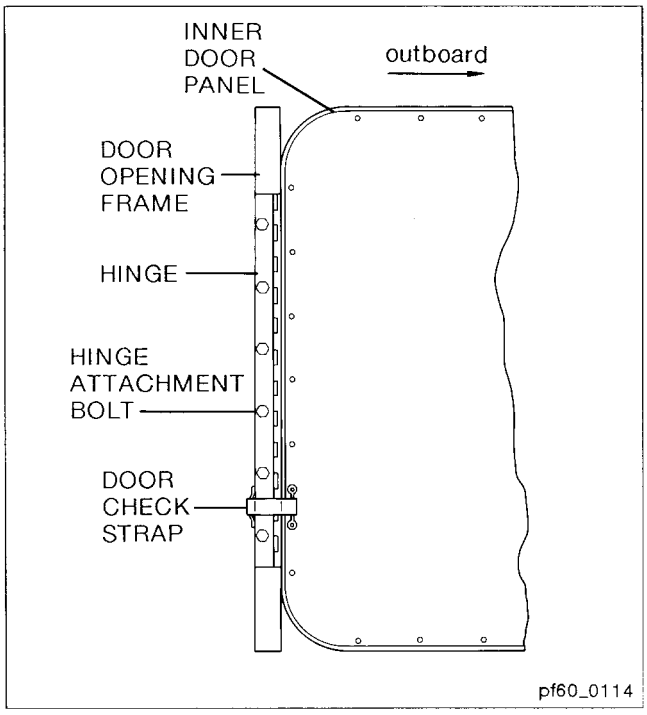


Fig. 1

2. Partially close the access door to about 1 inch (50 mm) of the latched position, and see if the latch jaws will be centered around the outer sleeve of the striker pin (see **Fig. 2**) when the door is closed.

   If not, adjust the striker pin, as follows:

   2.1 Open the access door. Using a no. 50 Torx® recess driver, loosen the striker pin. See **Fig. 3**.

   2.2 If the latch jaws are not closing around the outer sleeve, but are hitting the head of the striker pin, or the inner sleeve or coned washer, remove the striker pin, then add or remove shims (as needed) between the coned washer and the door opening frame. See **Fig. 2**. Reinstall the striker pin.

   NOTE: Add only enough shims to allow proper engagement of the latch jaws around the striker pin's outer sleeve; too many shims will cause interference between the striker pin and the backing plate of the latch assembly.

   2.3 Move the striker pin up or down as needed, to align it with the latch jaws.

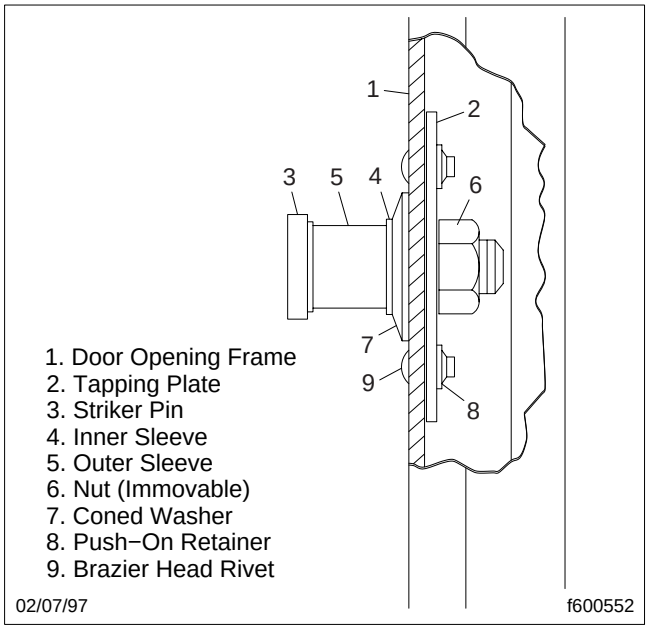


Fig. 2, Striker Pin Assembly

Sleeper Box Access Door Adjustment

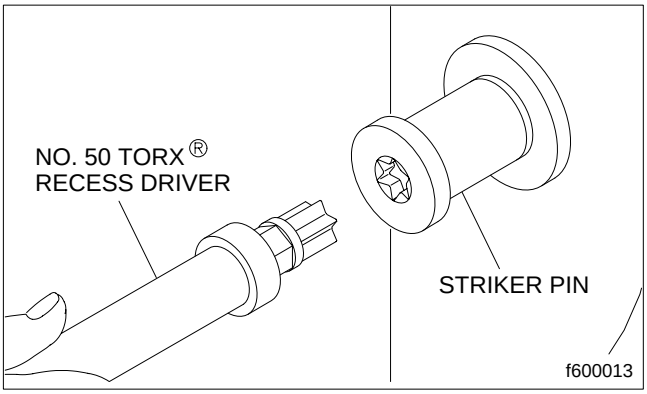


Fig. 3, Striker Pin Tool

2.4 Using the Torx driver, tighten the striker pin enough to prevent its movement.

3. Close and latch the access door. Check for flushness between the outer surface of the access door and the door opening frame's integral drip molding, at the hinged edge of the access door (the hinge will not be flush).

   If the door surface is not flush with the molding, adjust the hinged edge inward or outward, as follows:

   3.1 Open the door to the 90-degree position.

   3.2 Loosen, but do not remove, all but the uppermost and lowermost hinge-attachment bolts. See **Fig. 1**.

   3.3 Adjust the in and out position of the top of the door by loosening the upper bolt, moving the top of the door as needed, then tightening the upper bolt enough to resist movement.

   3.4 Adjust the bottom of the door by loosening the lower bolt, moving the bottom of the door as needed, then tightening the lower bolt enough to resist movement.

   3.5 Close the door, and check the adjustment. Readjust if necessary.

4. Close and latch the access door. Check for flushness between the outer surface of the access door and the door opening frame's integral drip molding, at the latched edge of the access door.

   If the door surface is not flush with the molding, adjust it inward or outward at the latch, as follows:

   4.1 Open the access door. Using a no. 50 Torx recess driver, loosen the striker pin. See **Fig. 3**.

   4.2 Without moving the striker pin vertically, move the striker pin in or out of the opening, as needed.

   4.3 Using the Torx driver, tighten the striker pin enough to prevent its movement, then close the door, and check its adjustment. Readjust if necessary.

5. Make a final check of all of the above adjustments, including checking that the door opens and closes properly. Readjust if needed.

6. Open the door, and tighten all of the hinge-attachment bolts 32 lbf·in (360 N·cm). See **Fig. 1**.

   Using the no. 50 Torx recess driver, tighten the striker pin 50 lbf·ft (68 N·m). See **Fig. 3**.

Specifications

Description	Torque
Sleeper Box Access Door: Hinge Attachment Bolts Striker Pin	32 lbf·in (360 N·cm)

Table 1, Torque Values

General Information

The overlapping skin panels on the Freightliner cab are fastened together with aluminum alloy rivets. The rivets share the load of the stressed skin panels.

A rivet is a fastening device and as such, it must have two ends (or heads) to hold the material together. One of these heads is preformed by the manufacturer, and is referred to as the "manufactured head." The other end of the rivet is formed after the rivet has been driven through the material that is to be fastened together. This head is referred to as the "bucked head" and is formed (or shaped) when driven against a bucking bar. **See Fig. 1.**

A rivet set connects to an air-driven rivet gun, and when the proper size rivet set is positioned on the rivet, the rivet gun delivers hammer-like blows which upsets the rivet shank and forms the bucked head when it is backed up against a bucking bar. **See Fig. 2.**

The following information provides general guidelines for the proper methods and procedures for riveting the skin panels of the Freightliner cab. Included are types of rivets used, proper rivet sets, rivet gun operation, bucking bars, removal of rivets, and a troubleshooting section on improperly installed rivets.

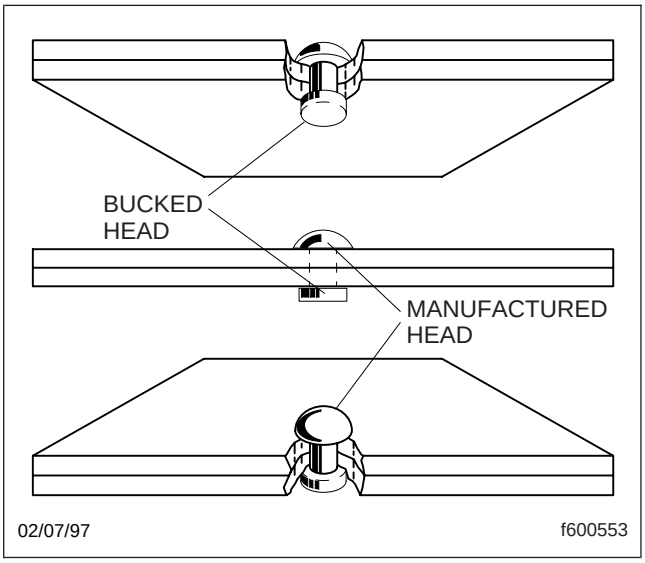


Fig. 1

TYPES OF RIVETS

Freightliner uses two types of aluminum alloy rivets. One type is the brazier head rivet. **See Fig. 3.** The rivet set used to drive the brazier head rivet is cupped to fit the round head of the rivet.

The other type of rivet used is the flush type, or 78-degree countersunk rivet. **See Fig. 4**. Its name is derived from the angle between the shoulders of the rivet. This rivet requires the use of a "mushroom" flush type rivet set.

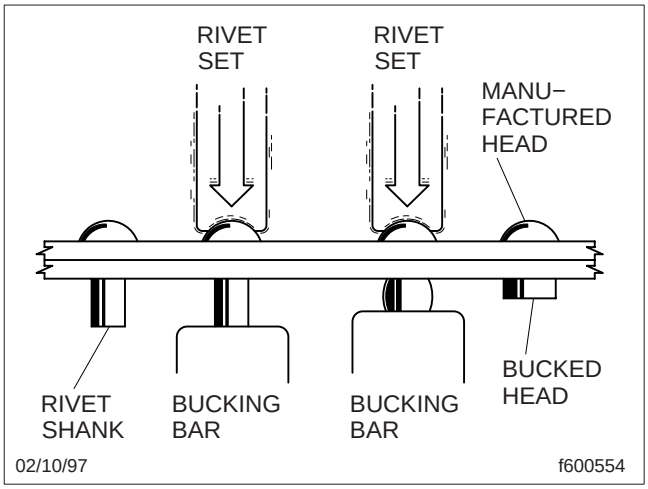


Fig. 2, Riveting Operation

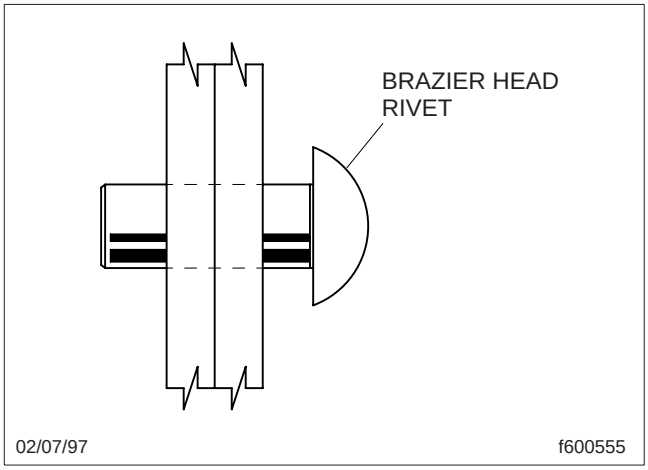


Fig. 3, Brazier Head Rivet

General Information

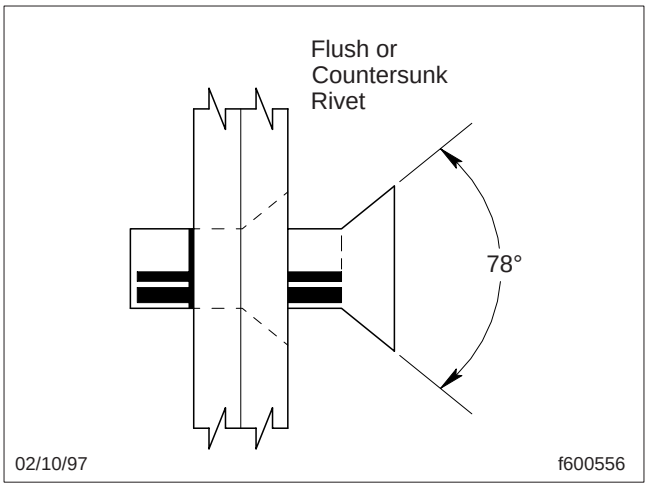


Fig. 4, Flush Type, or 78-Degree Countersunk Rivet

RIVET SETS

The rivet set is the link that transmits the power of the blow from the rivet gun to the rivet head. The following describes a few of the common types of rivet sets.

- Two types of rivet sets are the straight rivet set (**Fig. 5**), and the offset rivet set (**Fig. 6**). The offset rivet set is used when the operation cannot be properly performed with a straight rivet set because of the location of the rivet.
- A straight or offset rivet set with a cupped end (**Fig. 5**) is used on brazier head rivets.
- A straight or offset rivet set with a flat end is used on the flush, or 78-degree countersunk rivet. This flat ended rivet set is referred to as the "mushroom" type (**see Fig. 7**), and must be positioned flush against the work in order to drive the rivet correctly.

NOTE: The rivet set end must fit the manufactured head of the rivet at all times. **See Fig. 8.** If the size of the rivet and the rivet set are not identical to each other, damage to the rivet or the material being fastened can result. The rivet set has the size of the rivet that it is to be used for stamped on the rivet set, **as shown in Fig. 9**.

RIVET GUN **(See Fig. 10)**

The air-driven rivet gun provides the force needed for riveting. Rivet guns are made in varying sizes. Each

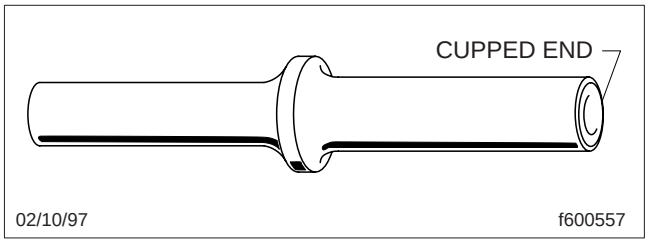


Fig. 5, Straight Rivet Set, Cupped End

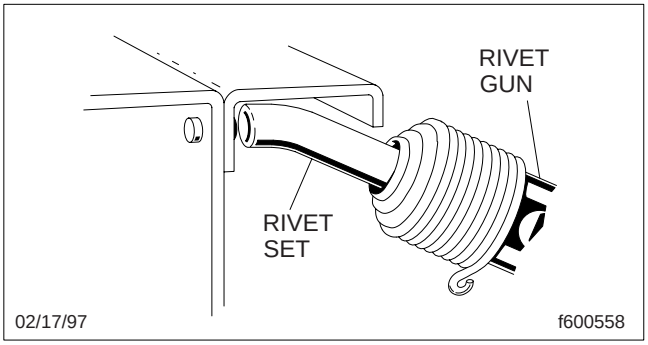


Fig. 6, Offset Rivet Set, Cupped End

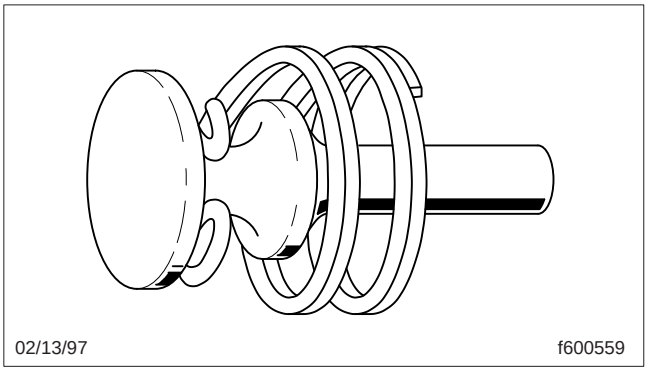


Fig. 7, Mushroom Type Rivet Set End

rivet gun size has a definite range of rivet sizes that it can drive. The gun sizes are identified as follows: 2X, 3X, 4X, 5X, 9X, and so on. The larger the number, the larger the size rivet it will handle. In general, rivets 3/16-inch (4.8-mm) diameter or less can be driven with any one of the following gun sizes: 2X, 3X, or 4X.

The air connector attaches the air line to the rivet gun. The air regulator adjusts the volume of air pressure to the desired hitting power of the rivet gun.

The retainer spring on the rivet gun is a safety feature that prevents the rivet set from flying out of the gun during operation.

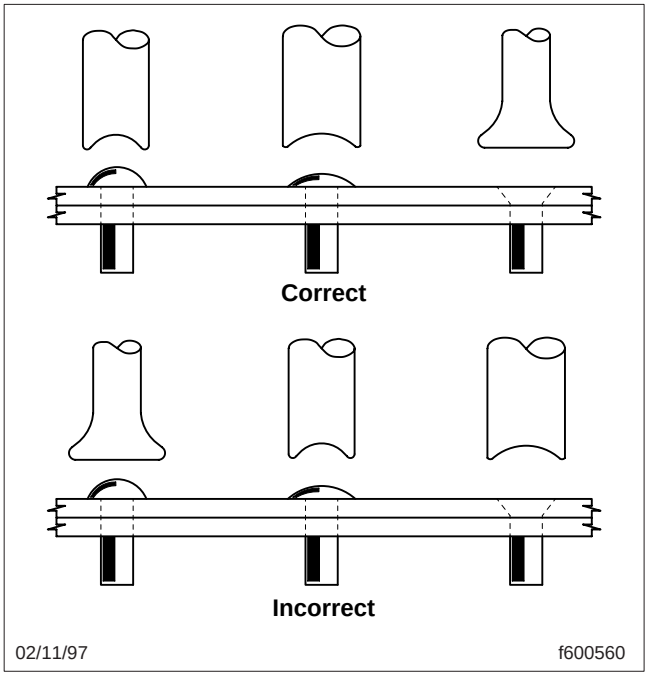


Fig. 8, Rivet Set and Rivet Head Sizing

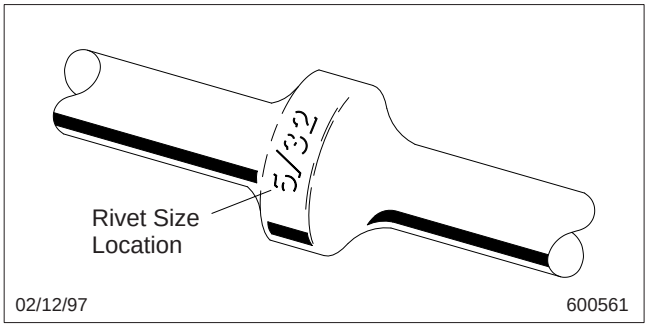


Fig. 9, Rivet Size Identification

BUCKING BARS

Bucking bars are made of steel, and vary in size and shape. **See Fig. 11.** Various shapes are required for "hard to get" rivets.

The proper weight of a bucking bar depends on the size, strength, and position of the rivet being used. Bucking bars vary in weight from approximately 1 to 15 lb (0.45 to 6.75 kg).

The polished surface (or end) of the bucking bar is called the "face." **See Fig. 12.** The "face" of the bucking bar is positioned against the rivet shank and

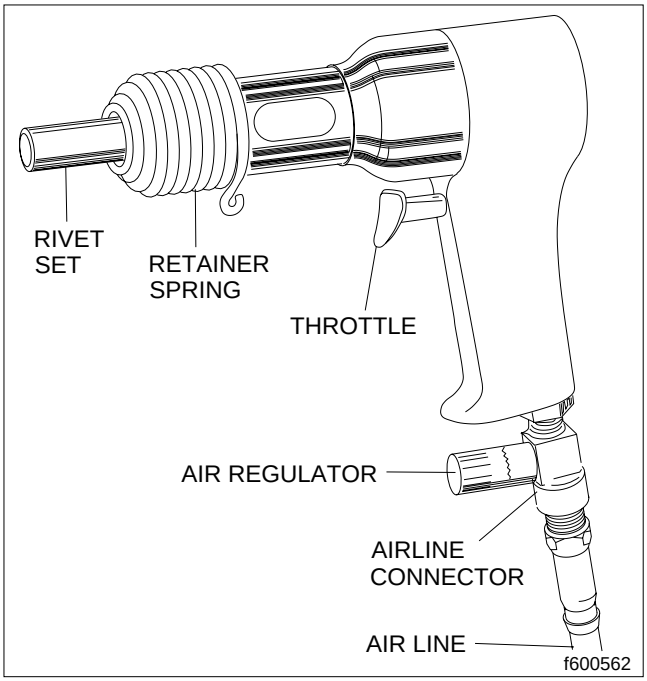


Fig. 10, Typical Rivet Gun (Rivet Set Installed)

parallel to the panels being fastened when the rivet is being "shot." This forms the bucked head of the rivet.

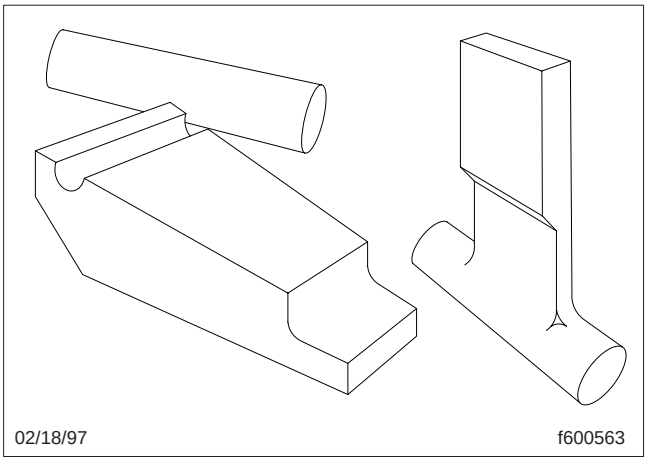


Fig. 11, Typical Bucking Bars

General Information

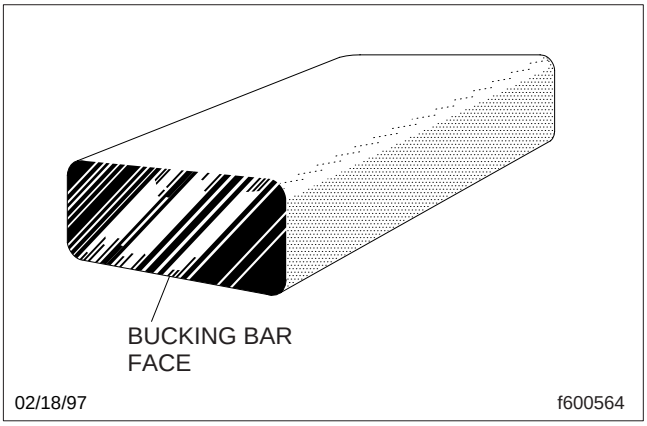


Fig. 12, Bucking Bar

Guidelines for Proper Riveting

CAUTION

CAUTION: All rivets must be driven and bucked properly. Failure to do so can result in damage to the cab skin panels or rivet(s). Failure of one rivet in a row of rivets will place additional clamping loads on the remaining rivets, reducing rivet strength and causing possible rivet failure.

NOTE: If the rivet holes need to be drilled, the table in **Specifications, 400** for the proper drill size to use for each rivet size.

1. Remove the retainer spring from the rivet gun by turning the spring in a counterclockwise direction. See **Fig. 1.**
2. Place the desired size and type rivet set in the rivet gun. See **Fig. 2.**

CAUTION

CAUTION: The size of the rivet set must be the same size as the rivet. See Fig. 3. An incorrect size will damage either the rivet or the skin panels. Too large a rivet set will flatten the rivet head and mar the skin panels.

3. Install the retainer spring over the rivet set and on the rivet gun. Secure the rivet set by turning the retainer spring in a clockwise direction. See **Fig. 4.**
4. Connect the air line to the rivet gun. Adjust the air regulator to obtain the desired hitting power. Turn the regulator clockwise to reduce the hitting power of the rivet gun. See **Fig. 5.** Turn the air regulator counterclockwise to increase the hitting power of the rivet gun.
5. Check the hitting power by pressing the rivet set against a block of wood and opening the throttle of the gun. See **Fig. 6.** Adjust to the desired hitting power.
6. Place the rivet in the rivet holes of the panels to be fastened. As a general rule, the projection of the rivet shank, before driving, should be about 1-1/2 "D" wide, with "D" being the original diameter of the rivet shank. See **Fig. 7.**
7. Align the rivet set and rivet gun, rivet, and bucking bar as shown in **Fig. 8**. Be sure to keep the line of pressure in a straight line with the manufactured rivet head. Be sure that the "face" of the bucking bar is kept parallel to the skin panels when the rivet is being "shot," as this will form the bucked head of the rivet properly.

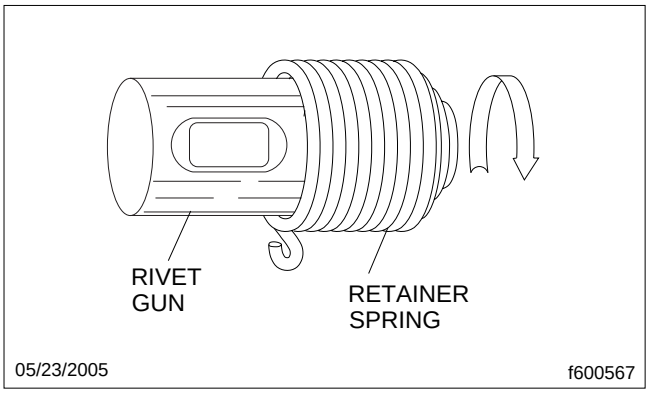


Fig. 1, Retainer Spring Removal

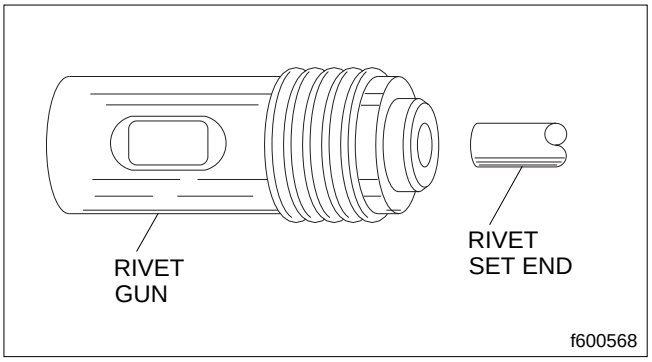


Fig. 2, Rivet Set Installation into Rivet Gun

CAUTION

CAUTION: If the "face" of the bucking bar is not parallel to the skin panels, damage to the skin panels and an improperly formed bucked head can result. See Fig. 9.

8. Drive the rivet through by opening the throttle of the rivet gun.

IMPORTANT: The manufactured heads of the rivets must be driven carefully to avoid dimpling of the skin panels and "eye-browing" of the heads. These conditions will blemish the overall appearance of the vehicle, as they are highly visible after painting.

9. Inspect the rivet. The bucked head of the rivet should be 1-1/2 "D" wide, and 1/2 "D" thick, with

Guidelines for Proper Riveting

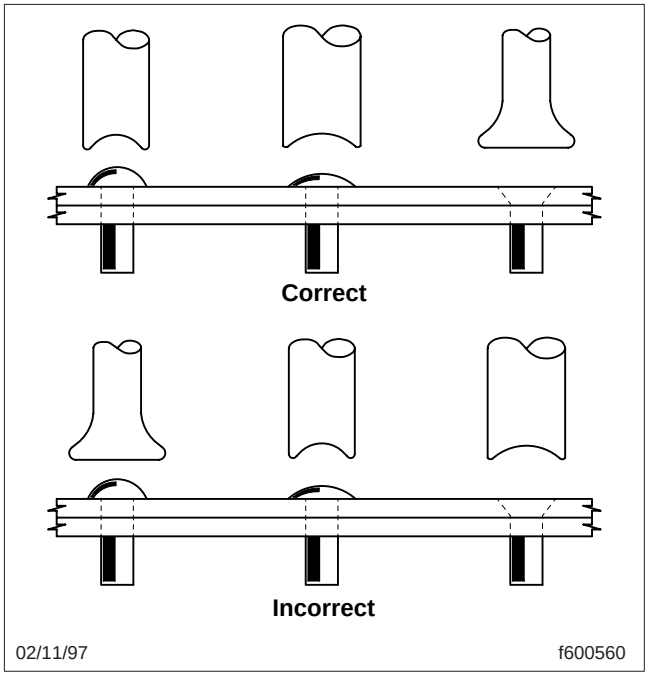


Fig. 3, Rivet Set and Rivet Head Sizing

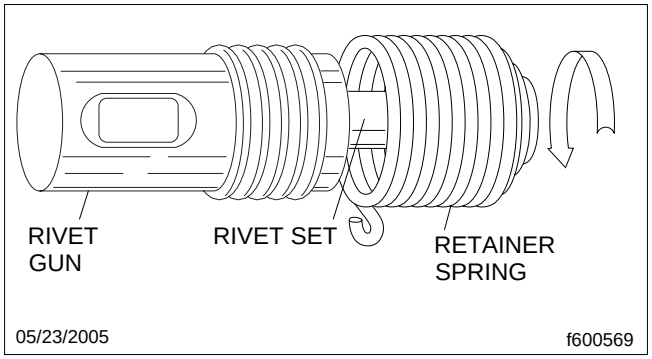


Fig. 4, Retainer Spring Installation

"D" being the original diameter of the rivet shank. See **Fig. 10.** If there are any imperfections, refer to **Troubleshooting Rivet Imperfections, 300**, for possible causes and corrections.

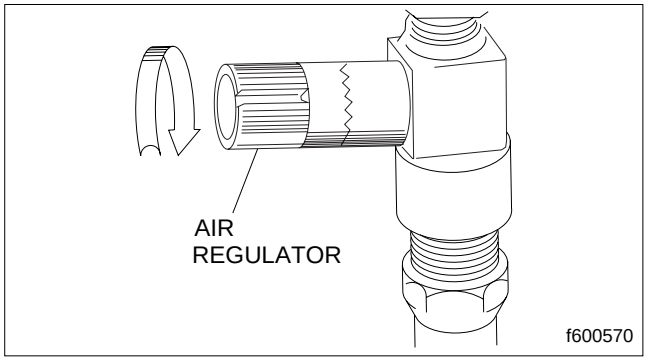


Fig. 5

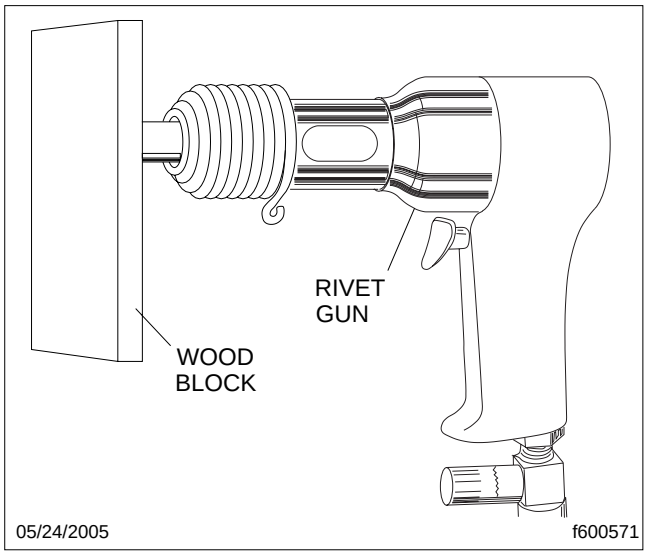


Fig. 6, Testing the Rivet Gun

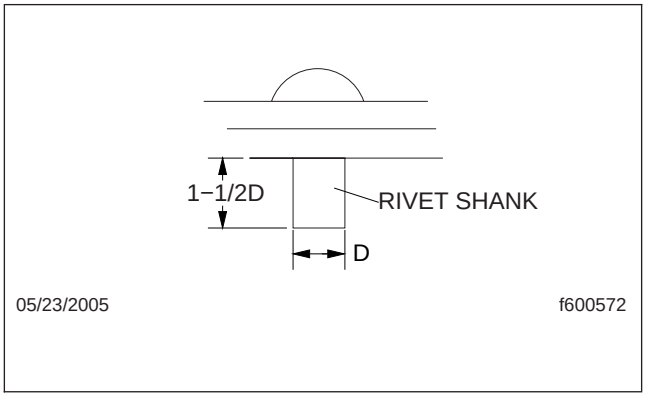


Fig. 7, Correct Rivet Shank Length

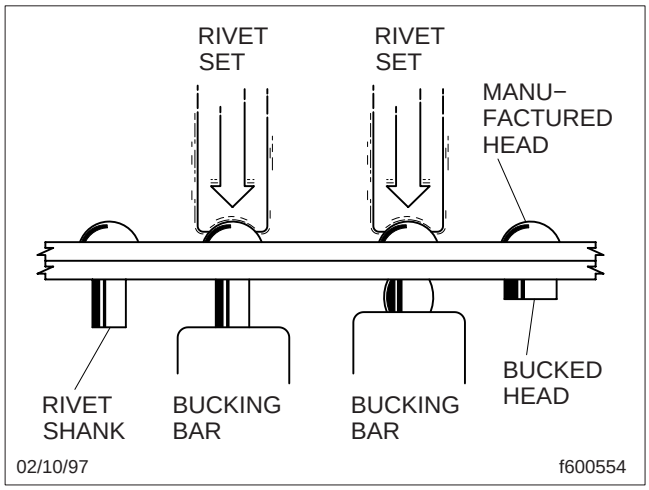


Fig. 8, Riveting Operation

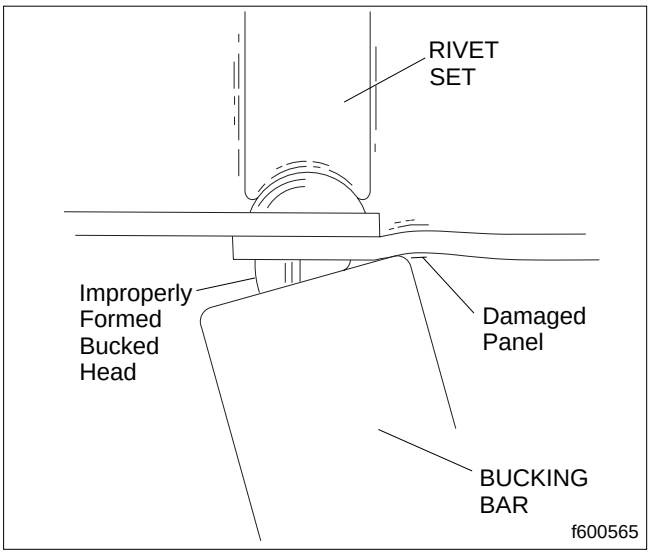


Fig. 9, Improperly Positioned Bucking Bar

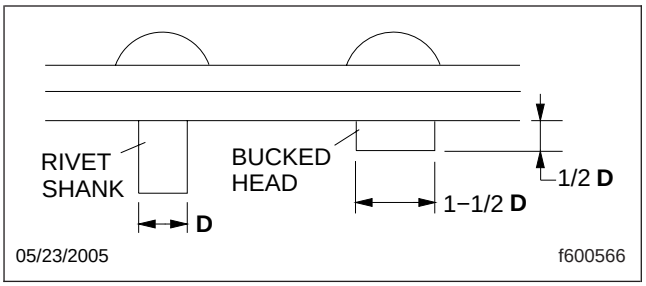


Fig. 10, Correct Bucked Head Size

Removing Rivets

If a drill is not available, a chisel can be used to cut off the manufactured head of the rivet. See **Fig. 1.** Take care not to damage the surrounding material.

1. Using a drill bit that has the same diameter as the rivet shank to be removed (see **Fig. 2**), drill into the exact center of the manufactured head (see **Fig. 3**) to the depth shown in **Fig. 4**.

NOTE: A smaller size drill bit can be used.

2. Using a drill punch, pry off the rivet head. See **Fig. 5.**
3. Drive out the shank with the drill punch. See **Fig. 6.**

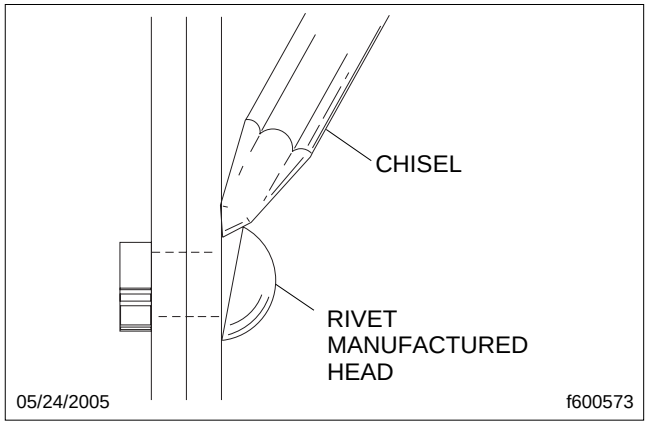


Fig. 1

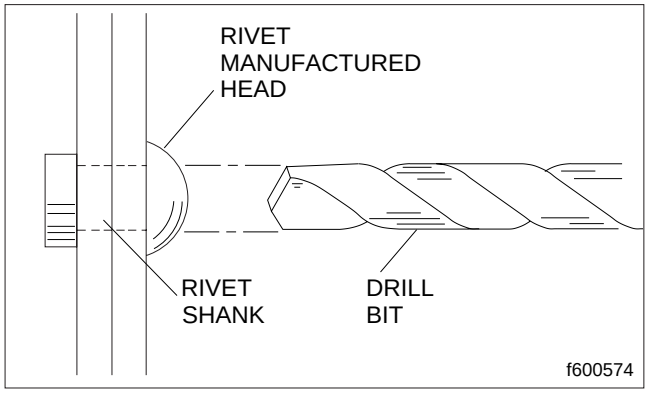


Fig. 2

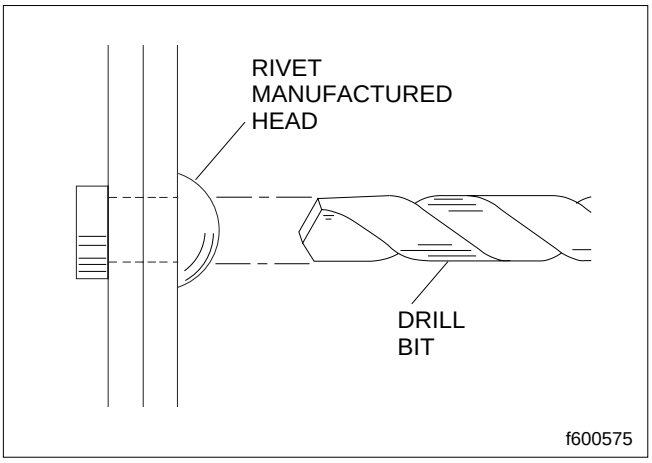


Fig. 3

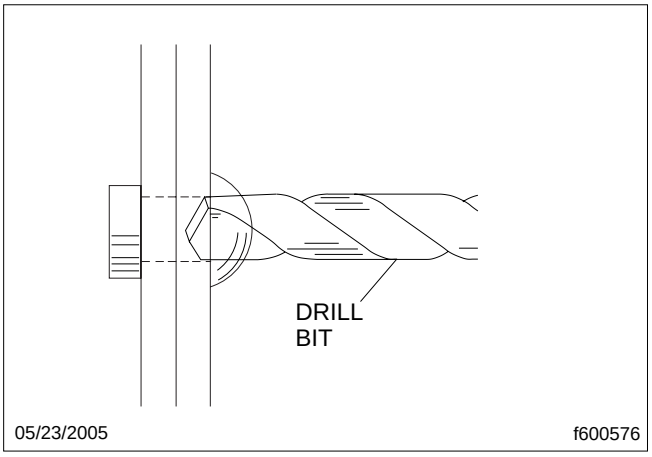


Fig. 4

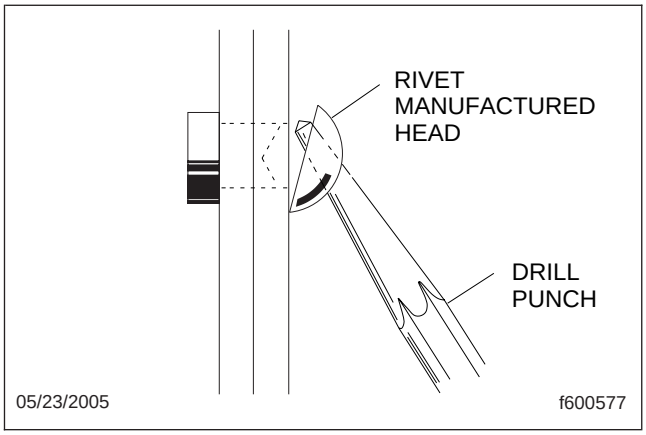


Fig. 5

Removing Rivets

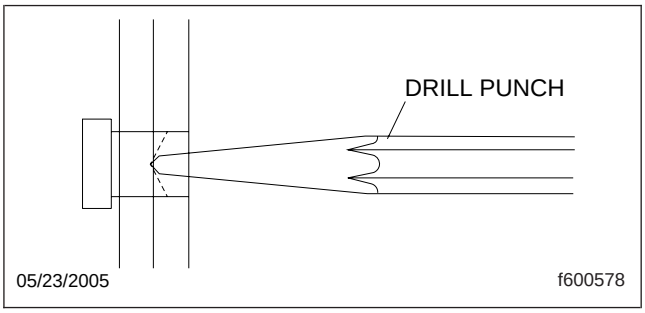


Fig. 6

Troubleshooting Rivet Imperfections

The following troubleshooting information should be used as an aid in correcting rivet imperfections that can result from improper riveting operations. See **Fig. 1** and **Fig. 2**.

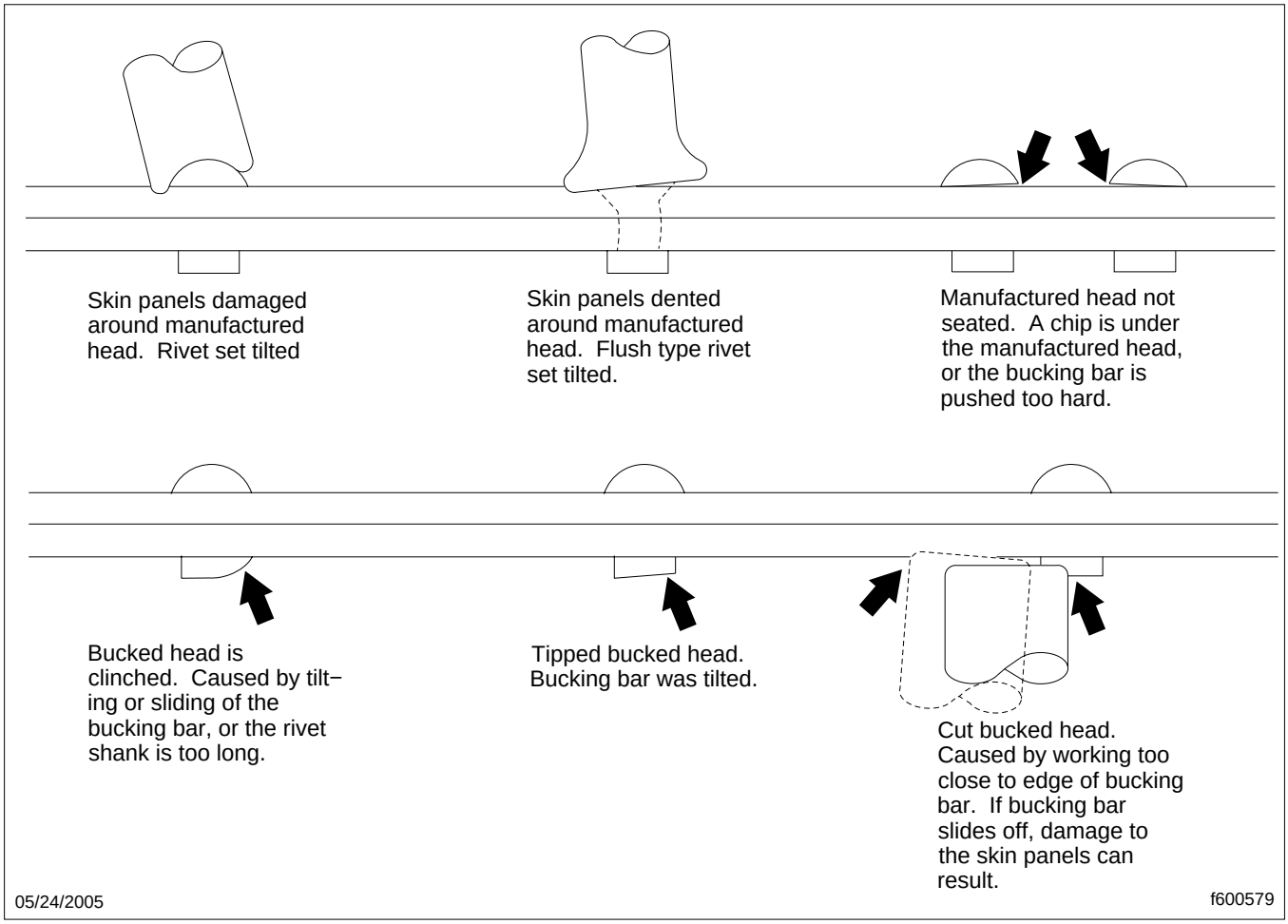


Fig. 1

Troubleshooting Rivet Imperfections

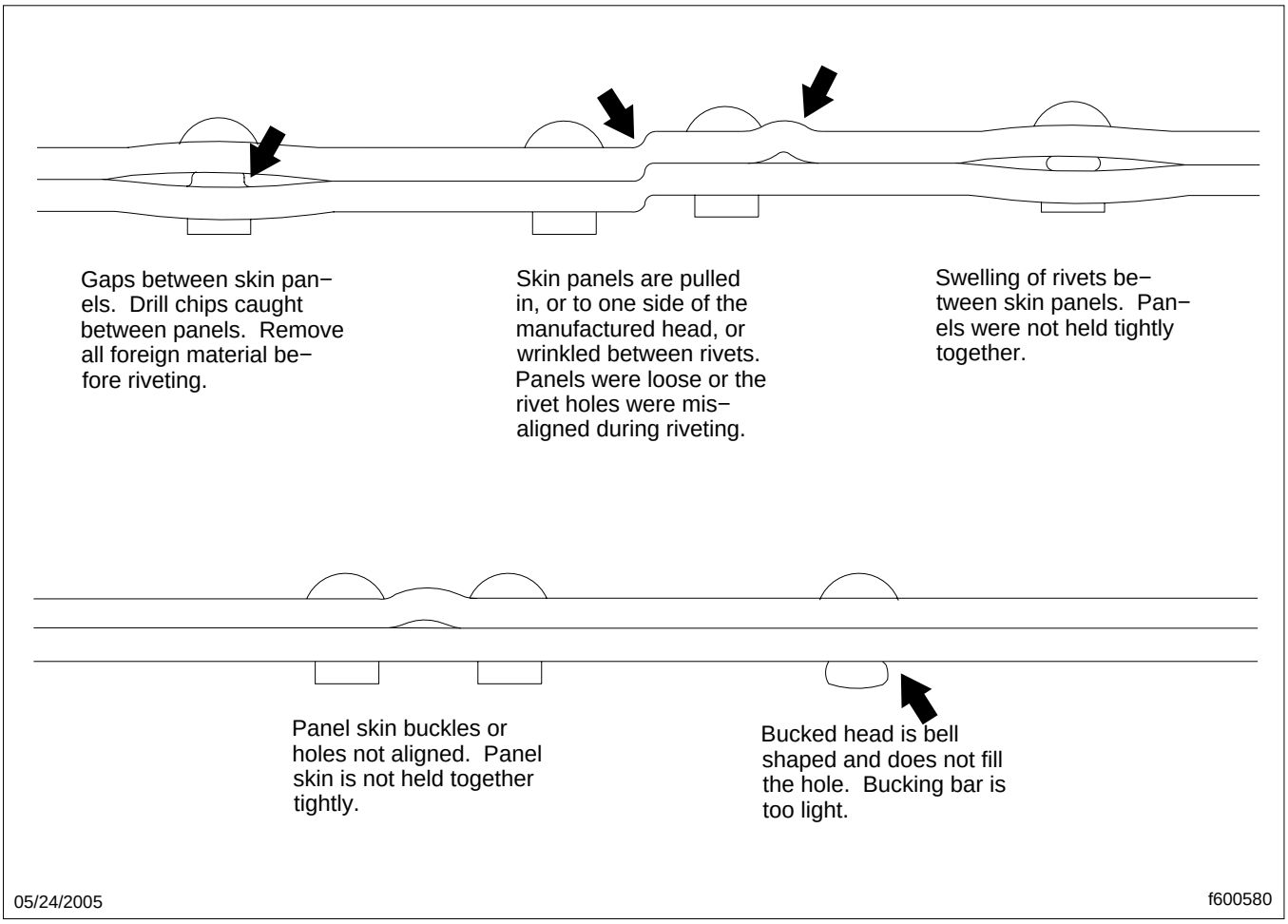


Fig. 2

Specifications

Shank Diameter	Length	Drill Size	Part Number
3/16"	5/16"	No. 11	23–9367–605
	3/8"		23–9367–606
	7/16"		23–9367–607
	1/2"		23–9367–608
	9/16"		23–9367–609
	5/8"		23–9367–610
	3/4"		23–9367–612

Table 1, 3/16-Inch Brazier Head Rivets

Shank Diameter	Length	Drill Size	Part Number
3/16"	3/8"	No. 11	23–9368–606
	7/16"		23–9368–607
	1/2"		23–9368–608

Table 2, 3/16-Inch Brazier Head Soft Rivets

Shank Diameter	Length	Drill Size	Part Number
3/16"	3/8"	No. 11	23–9366–606
	7/16"		23–9366–607
	1/2"		23–9366–608
	9/16"		23–9366–609
	5/8"		23–9366–610
	3/4"		23–9366–612
	1"		23–9366–616
	1 1/4"		23–9366–620

Table 3, 3/16-Inch Countersunk Rivets

Shank Diameter	Length	Drill Size	Part Number
1/4"	3/8"	F	23–11634–806
	7/16"		23–11634–807
	1/2"		23–11634–808
	9/16"		23–11634–809
	5/8"		23–11634–810
	3/4"		23–11634–812

Table 4, 1/4-Inch Brazier Head Rivets

Specifications

Shank Diameter	Drill Size	Drill Size Decimal Equivalent
1/8-inch	No. 30	0.129 inch
5/32-inch	No. 21	0.159 inch
3/16-inch	No. 11	0.191 inch
1/4-inch	F	0.257 inch

Table 5, Drill Size for Rivet Holes

General Information

The cab latch assembly consists of two locking devices which allow a controlled amount of looseness before stopping the upward motion of the back of the cab. The looseness serves as a means of relieving possible stresses in the cab due to the normal motions of the frame during vehicle operation. The cab latch prevents the possibility of the cab tilting during vehicle operation, and the unwanted separation of the engine air intake duct where applicable.

Two styles of cab support mounts are used on COEs. **Figure 1** shows the frame-top mounted inboard mount used on the longer length and sleeper cab models. Where the mounting of other assemblies interferes with the mounting of the inboard mount, or when the short cab models are used, the outboard cab support mount (**Fig. 2**) which bolts to the side of the frame, is used.

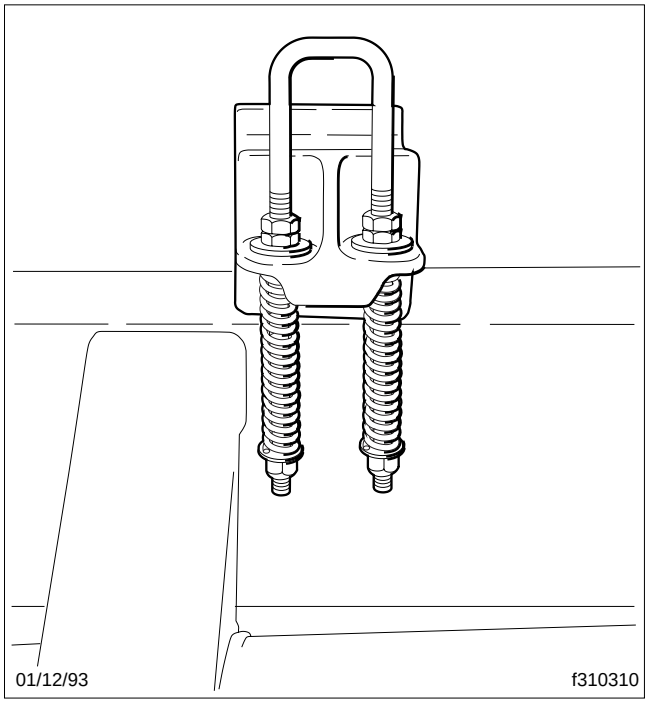


Fig. 1, Inboard Mount

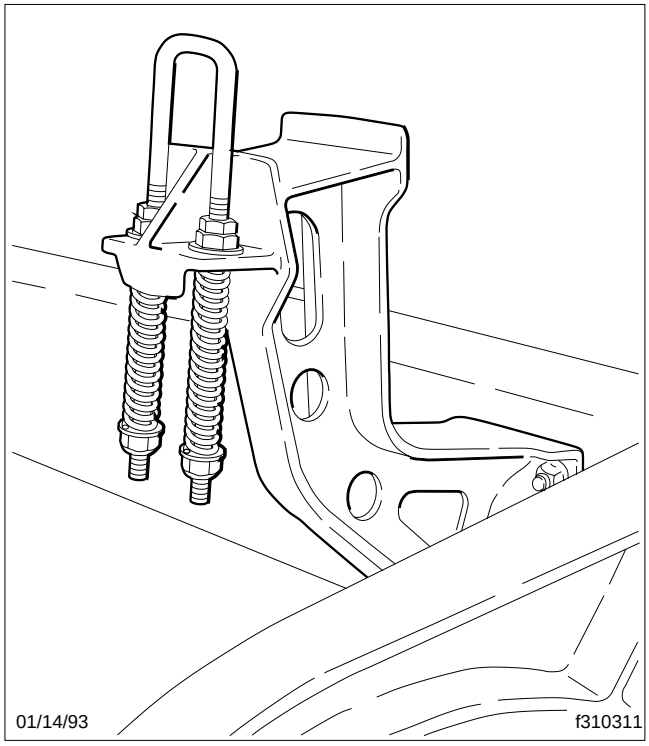


Fig. 2, Outboard Mount

Latch Adjustment

See **Fig. 1** for the following procedure. All adjustments or measurements in **Fig. 1** apply to both types of cab support mounts.

1. Unlock and tilt the cab until all pressure is released from the U-bolt assembly. The spacing between the bottom edge of the U-bolt arch and the U-bolt retainer should be 4-1/4 inches (108 mm).
2. Slowly lower the cab. Adjust the cab latch handle linkage (Ref. 1) so that as the cab is lowered,

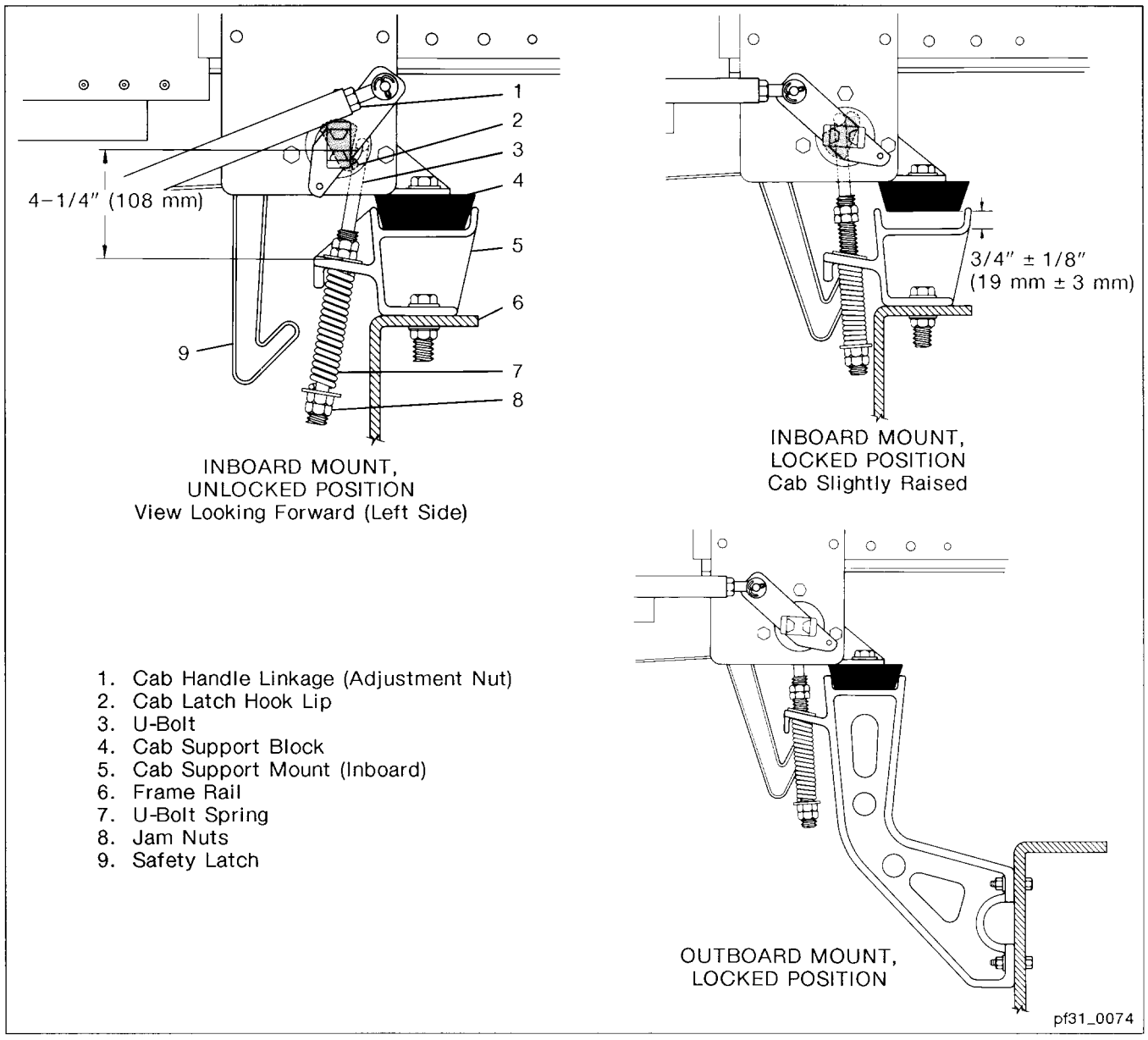


Fig. 1, Cab Latch Assembly

Latch Adjustment

and the cab latch hook lip (Ref. 2) nudges the U-bolt arch.

3. Lock the cab latch handle with the cab in the upright (operating) position. As the cab latch hook (Ref. 2) rotates, be sure it lifts the U-bolt to the over-center position causing a locking action. With the cab in this locked position:

   3.1 Eliminate any cab-to-frame looseness by attempting to raise the cab, until the U-bolt springs are fully compressed. See **Fig. 1**, locked position.

   3.2 Measure the spacing between the cab support block and the cab mount plate. This measurement should be 3/4-inch ±1/8-inch (19 mm ±3 mm). Tighten or loosen the jam nuts (Ref. 8) to maintain this measurement.

4. Unlock the cab latch. Slowly raise the cab and observe that the safety-catch securely stops the upward motion of the cab.

⚠ WARNING

Do not operate the vehicle with either one or both of the cab latch handles unlocked, or with an inoperative cab latch. Failure to secure the cab could allow it to tilt during a brake application. This would result in a loss of vehicle control by the driver and pose a danger to the driver and persons in the area.

General Information

On FLB COEs, top-hinged baggage doors are located on both sides of the vehicle. There is a single door on each side of the cab. Freightliner 110-inch cabs may have either single or double doors on each side. The baggage doors are of single-panel construction. They have rounded corners, a piano-style hinge, a one-piece extruded aluminum door opening frame, a gas spring, an interior light, and a self-latching, key-operated latch with a paddle-type handle. **See Fig. 1** and **Fig. 2**. The same key used for the cab doors and ignition is used for the baggage doors.

A neoprene rubber seal fits over the edge of the door opening frame; the lip on the seal contacts the inside surface of the door when it's closed. A gas strut holds the door open and prevents it from opening too far. An interior light is activated when the baggage door is open.

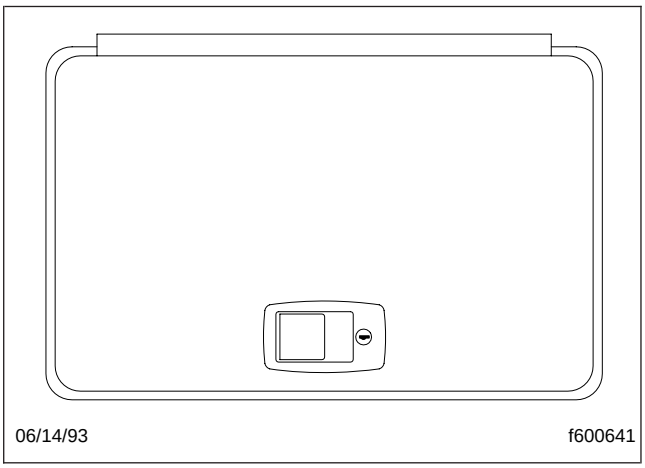


Fig. 1

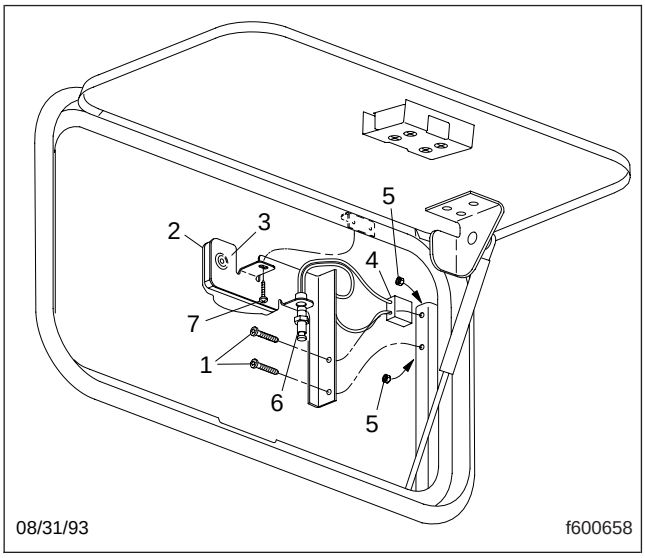


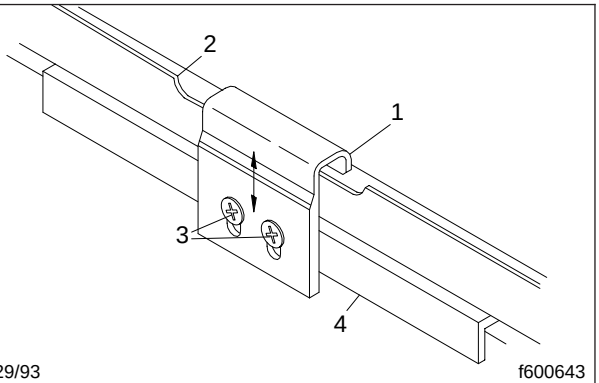
Fig. 2

Adjustment

If the baggage door is hard to open or close, and the seal is in good condition, adjust the latch by moving the striker plate up or down, following the procedure below.

NOTE: This procedure is only for up-and-down adjustments; the rubber seal compensates for any in-and-out play.

1. Loosen the two screws that hold the striker plate to the mounting bracket. Loosen them just enough to move the striker plate. **See Fig. 1.**
2. Move the striker plate up or down; then tighten the screws.
3. Close the door and check for correct latching.
4. If needed, loosen the screws and move the striker plate up or down again; then tighten them, and close the door. Repeat until the door latches correctly.
5. When the door latches correctly, make sure the screws are firmly tightened.



1. Striker Plate
2. Baggage Door Frame
3. Screws
4. Mounting Bracket

Fig. 1, Inside View (seal not shown)

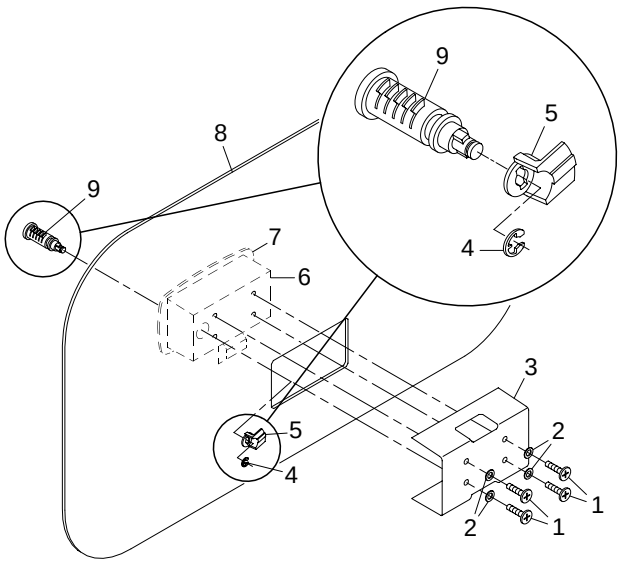
6. Close the baggage door.

Latch and Lock Cylinder Replacement

Replacement

NOTE: If the baggage door latch doesn't work, replace it; it is not serviceable. If you are going to use the same key with the new latch assembly, remove the lock cylinder and cam from the old latch, and install them in the new latch assembly.

1. Open the baggage door; then, from inside the door, remove the four screws and washers holding the mounting bracket to the latch assembly. **See Fig. 1.**
2. Remove the mounting bracket, then lift out the latch assembly and the rubber gasket through the hole in the baggage door.
3. Remove the lock cylinder and the cam from the old latch assembly.
   - 3.1 Remove the retaining ring (Ref. 4) from the end of the lock cylinder. Save the retaining ring.
   - 3.2 Remove the cam (Ref. 5) from the end of the lock cylinder.
   - 3.3 Put the key into the lock and turn it; then remove the lock cylinder (Ref. 9) from the latch assembly.
4. Install the old lock cylinder and cam (unless it's being replaced with a new one).
   - 4.1 Put the key in the lock and turn it to depress the tumblers; then insert the lock cylinder into the new latch, **as shown in Fig. 1**.
   - 4.2 Install the cam onto the end of the lock cylinder so that it's facing inboard, toward the center of the latch.
   - 4.3 Install the retaining ring.
5. Place the new latch assembly and gasket into the hole in the baggage door, making sure the key hole is facing toward the front of the vehicle.
6. From inside the baggage door, attach the mounting bracket to the latch assembly, using the four mounting screws and washers. Tighten the screws firmly.
7. Close the baggage door; then check the adjustment of the latch. If needed, adjust the latch assembly up-and-down, following the instructions in **Subject 100**.



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1. Mounting Screws
2. Washers
3. Mounting Bracket
4. Retaining Ring
5. Cam
6. Latch Assembly
7. Rubber Gasket
8. Baggage Door
9. Lock Cylinder

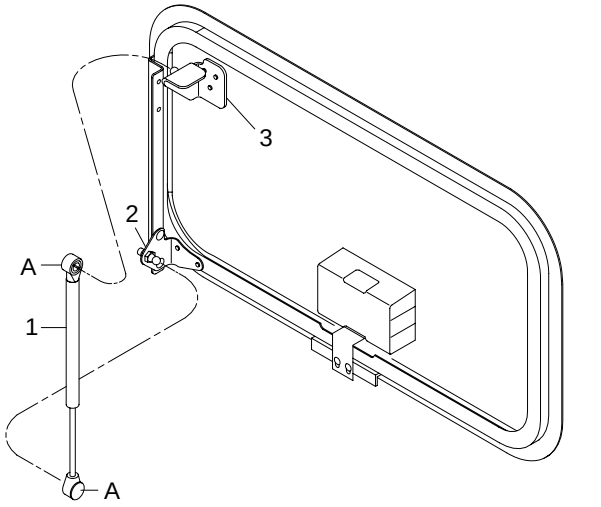
Fig. 1

Replacement

1. Open the baggage door.
2. Pry the plastic caps off both ends of the gas spring. **See Fig. 1.**
3. Pull the sockets out of the ball joints on the upper and lower mounting brackets; then remove the gas spring.

IMPORTANT: Install a new gas spring with the rod end *down*, **as shown in Fig. 1.**

4. Snap the sockets of the gas spring onto the ball joints on the top and bottom mounting brackets.
5. Install the plastic caps over the sockets.
6. Close the baggage door, then open it to test the gas spring.



A. Pry off these caps.
1. Gas Spring
2. Lower Mounting Bracket and Ball Joint
3. Upper Mounting Bracket and Ball Joint

Fig. 1, Inside View

Interior Light Replacement

Replacement

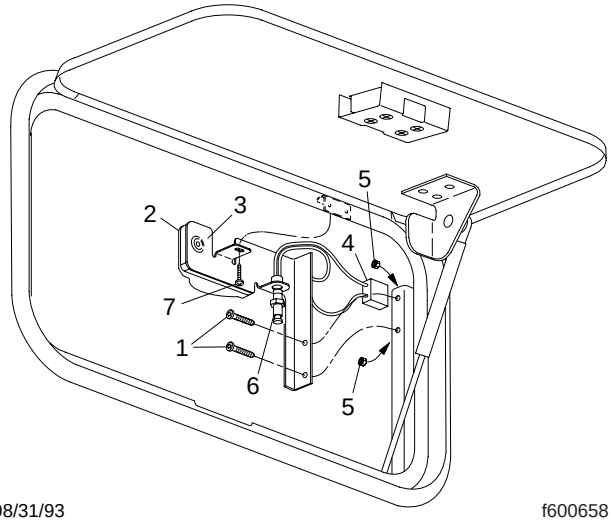
The interior light assembly for the baggage door is controlled by a switch activated automatically when the baggage door is opened. The switch and light are mounted on a common bracket. **See Fig. 1.**

NOTE: This procedure is for replacing the entire interior light assembly; to replace just the light bulb, remove the lens only.

To replace just the switch, disconnect the batteries at the negative terminals; then disconnect the wiring from the switch to the light. Remove the switch from the mounting bracket.

IMPORTANT: The light switch is self-adjusting. When first installed, the switch is fully extended, and may seem too long. When the baggage door is first closed, the switch is permanently compressed to the correct length.

1. Disconnect the batteries at the negative terminals.
2. Open the baggage door.
3. Disconnect the light assembly wiring from the harness inside the baggage compartment. **See Fig. 1.**
4. Remove the tapping screw (Ref. 7) holding the light assembly to the mounting angle at the top of the door frame; then remove the two machine screws and kep nuts (Refs. 1 and 5) holding the light assembly to the mounting angle at the side of the door frame. Remove the light assembly.
5. Install a new light assembly on the angles inside the doorway, using the two machine screws and kep nuts, and the tapping screw removed previously.
6. Connect the light wiring to the harness.
7. Close the baggage door firmly to adjust the length of the light switch.
8. Connect the batteries.
9. Open the baggage door to test the light. If there is a problem, check the light bulb, then the switch. If the problem persists, check the wiring harness to the light.



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1. Machine Screws
2. Interior Light Assembly
3. Mounting Bracket
4. Wiring Connector
5. Kep Nut
6. Switch
7. Tapping Screw

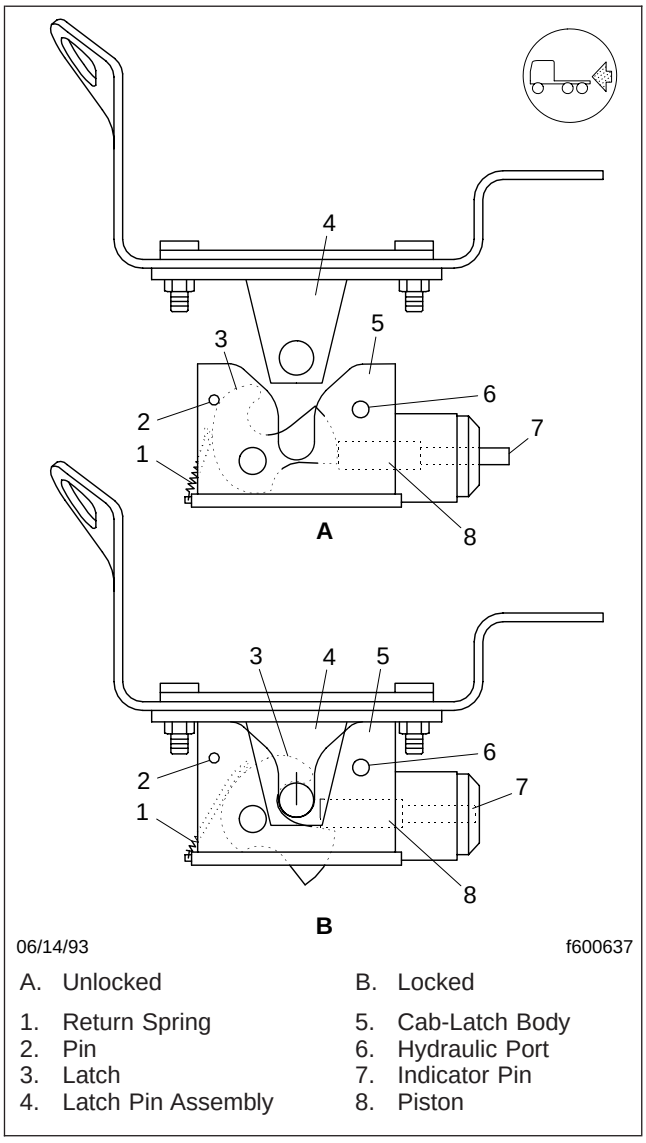
Fig. 1

General Information

A hydraulic cab latch assembly (see **Fig. 1**) is located on each side of the cab, and is mounted to the cab suspension. The latches keep the cab secured to the frame and prevent any shifting or unwanted movement. When the latches are released (unlocked) the cab can be tilted. A latch pin (Ref. 4), mounted to the underside of the cab, fits into each cab latch assembly. The latch assembly consists of a body (Ref. 5), a latch (Ref. 3), a return spring (Ref. 1), a piston (Ref. 8), a piston spring (not shown), and an indicator pin (Ref. 7).

The cab latches are plumbed into the cab-tilt hydraulic system. They automatically open when the cab is tilted, and close and lock when the cab is lowered.

When the cab is latched, a spring inside the housing keeps the piston (Ref. 8) pushed up against the cam part of the latch (Ref. 3), preventing the latch from releasing. When the cab is tilted, hydraulic pressure moves the piston (Ref. 8) outward, which allows the latch to be pulled up by the return spring (Ref. 1), releasing the latch pin (Ref. 4). The cab is then free to tilt. As the cab is lowered, hydraulic pressure is released, and the latch pin pushes on the cam part of the latch. The latch swings around, captures the pin, and the spring inside the housing pushes the cylinder back out and against the cam part of the latch. This locks the latch in place, securing the cab. Indicator pins (Ref. 7) let the driver know whether or not the latches are locked. If the pins are flush with the latch housing ends, the latches are locked; if they're sticking out, the latches are not locked. See **Fig. 1.**



A. Unlocked
B. Locked

1. Return Spring
2. Pin
3. Latch
4. Latch Pin Assembly
5. Cab-Latch Body
6. Hydraulic Port
7. Indicator Pin
8. Piston

Fig. 1

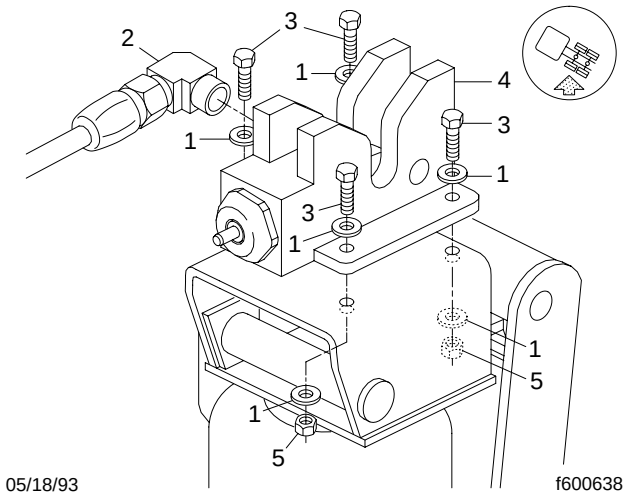
Replacement

DANGER

Before doing the work below, review the cab tilting information under the cab tilt section. Failure to read the warnings and to be aware of the dangers of tilting and lowering the cab could result in serious injury or death.

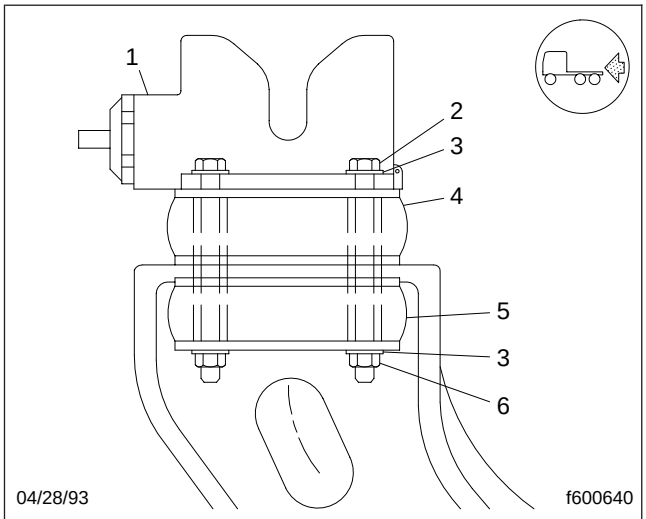
1. Tilt the cab. Refer to the **Subject 060** in the section "Cab Tilt System" for instructions. Make sure the tilt strut is pushed down over the right tilt-cylinder rod.
2. Put the tilt pump selector on "Lower."
3. Using a container to catch any hydraulic fluid, disconnect the hydraulic lines from the lower cab latch assemblies.
4. Loosen and remove the capscrews, washers, and locknuts that attach the latches to the cab suspension, then remove the hydraulic cab latch from the vehicle. **See Fig. 1** or **Fig. 2**.

   On vehicles with a non-air cab suspension, remove the upper and lower cab isolators.



1. 3/8" Hardened Washer
2. Hydraulic Line
3. 3/8–16 Capscrew
4. Cab Latch Assembly
5. 3/8–16 Locknut

Fig. 1



1. Cab Latch Assembly
2. 3/8–16 Capscrew
3. Hardened Washer
4. Upper Cab Isolator
5. Lower Cab Isolator
6. 3/8–16 Locknut

Fig. 2

IMPORTANT: Mark the position of the upper and lower isolators.

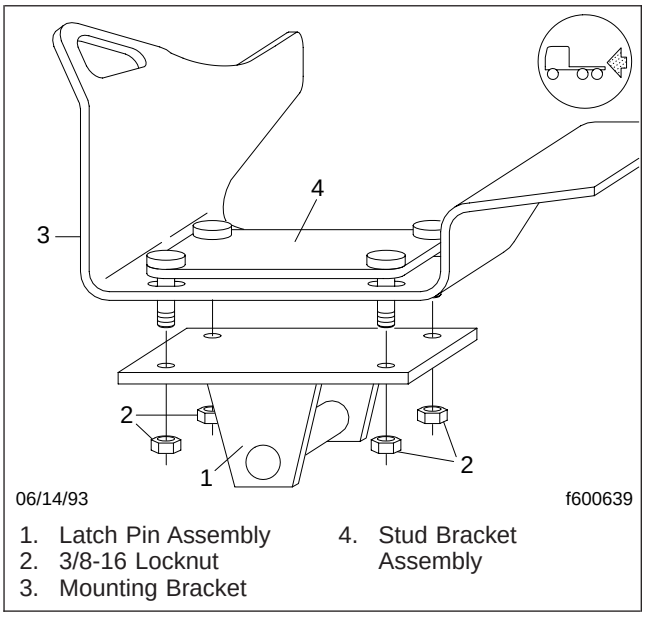
5. Install the hydraulic cab latch in place on the cab suspension bracket.
   - 5.1 If the vehicle is equipped with a non-air cab suspension, install the upper and lower isolators.
   - 5.2 Install the capscrews, hardened washers, and locknuts. Tighten the nuts 28 lbf·ft (38 N·m).
6. Connect the hydraulic lines to each cab latch.
7. Bleed the cab-tilt system, following the instructions in **Subject 100** in the section "Cab Tilt System".

Replacement

DANGER

Before doing the work below, review the cab tilting information under the cab tilt section. Failure to read the warnings and to be aware of the dangers of tilting and lowering the cab could result in serious injury or death.

1. Tilt the cab. Refer to **Subject 060** in the section "Cab-Tilt System" for instructions.
2. Remove the locknuts that attach the latch pin assembly to the underside of the cab; then remove the latch pin assembly. **See Fig. 1.**



1. Latch Pin Assembly
2. 3/8-16 Locknut
3. Mounting Bracket
4. Stud Bracket Assembly

Fig. 1

3. Install the new latch pin assembly onto the studs on the underside of the cab.
4. Install the locknuts very loosely on the studs. Make sure the latch pin assembly can move from side-to-side.
5. Lower the cab. Refer to **Subject 060** in the section "Cab-Tilt System" for instructions. The latch pins will align with the cab latches and seat into place on the cab mounting brackets.
6. Tighten one nut firmly on each latch pin to hold it in place.
7. Following the instructions in **Subject 060** in the section "Cab-Tilt System," tilt the cab far enough to engage the tilt strut.
8. Tighten all the locknuts 28 lbf·ft (38 N·m).
9. Lower the cab, following the instructions in **Subject 060** in the section "Cab-Tilt System."

General Information

The Moto Mirro is an electrically heated, remote-controlled mirror. Using a switch that is mounted in the dash, a driver can adjust the mirror though a 60-degree range to increase visibility range. The mirror is rotated by a high-torque electric motor working through a planetary-gear transmission. This produces 14 lbf·ft (19 N·m) torque at the mirror housing to break ice and road sludge. A self-regulating, 70-watt polyester film heater heats the mirror surface to remove moisture and ice. An indicator light in the optional VIGIL™ or Kysor® VIP system can be used to alert the driver that the mirror heater is on.

Moto Mirror Removal and Installation

Removal

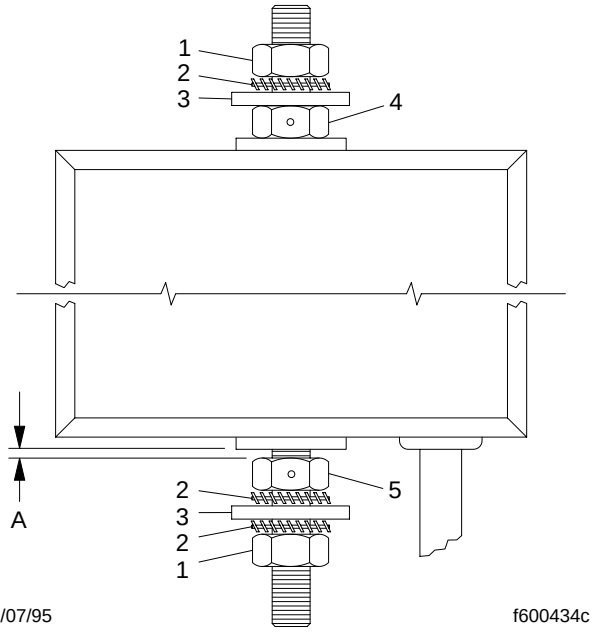
1. Turn off the ignition switch.
2. Disconnect the electrical wiring from the mirror.
   - 2.1 On new-style mirrors (identified by a grey plastic strain relief where the wiring enters the bottom of the mirror), pry the strain relief from the mirror, pull all four wires from the mirror case until the snap connectors are about 4 inches (100 mm) from the case, and disconnect the snap connectors.
   - 2.2 On older-style mirrors (identified by a black plastic strain relief where the wiring enters enters the bottom of the mirror), disconnect the mirror wiring at the connector behind the left hand side of the instrument panel and feed it through the door jamb boot and door.
3. If a convex mirror is mounted on the Moto Mirror bottom shaft, remove it.
4. Remove the hexnuts from the mirror top and bottom shaft. **See Fig. 1**, Ref. 1.
5. Loosen the nuts securing the L-brackets to the C-bracket and remove the Moto Mirror.

Installation

1. Insert the mirror top and bottom shafts through the holes in the L-brackets. **See Fig. 2**. Install the hexnuts and lockwashers, making sure they are positioned correctly. **See Fig. 1**.
2. Tighten the hexnuts on the top and bottom shafts 15 lbf·ft (20 N·m).

IMPORTANT: Do not use an impact wrench; it could cause overtightening of the nuts.

3. Tighten the nuts holding the L-brackets to the C-bracket 10 lbf·ft (14 N·m).
4. If a convex mirror was installed, mount it on the C-bracket to A-bracket bolts, where it doesn't interfere with the full range of movement of the Moto Mirror. Do not mount the convex mirror to the Moto Mirror shaft.



NOTE: On older installations, Ref. 5 may not be pinned. Be sure to maintain the minimum clearance of 1/8" (3 mm).

A. Minimum 1/8" (3 mm)

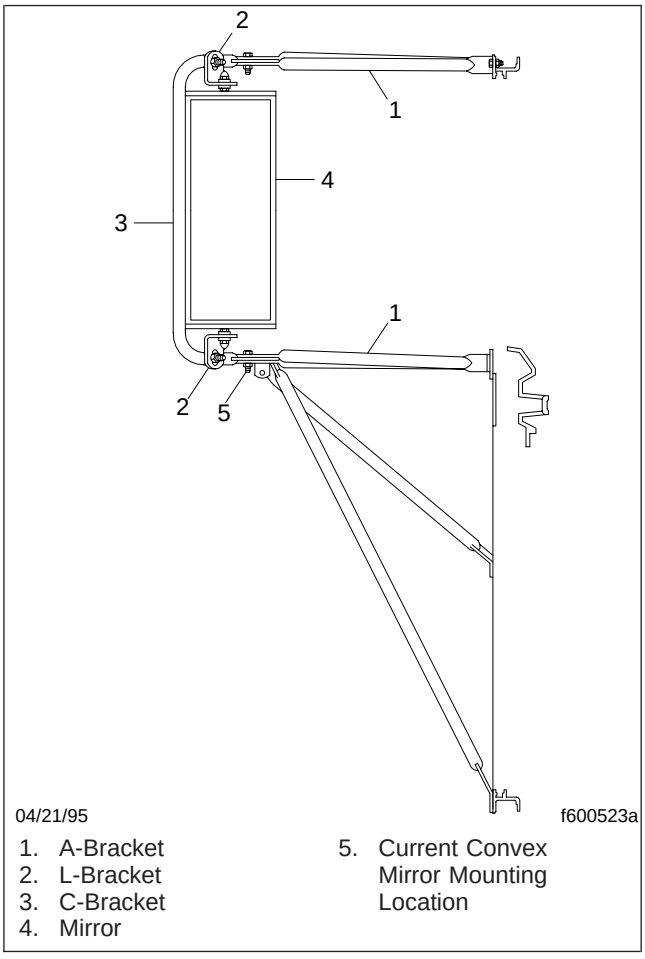
1. Hexnut
2. Star Washer
3. L-Bracket
4. Upper Pinned Hexnut
5. Lower Pinned Hexnut

Fig. 1, Moto Mirror Installation

NOTE: If the convex mirror bracket is installed between the two nuts that clamp the Moto Mirror to the L-bracket, the nuts will eventually loosen.

5. Position the C-bracket at the correct angle to allow the full range of mirror movement. On the passenger side, the C-bracket should be positioned at 90 degrees to the cab door. On the driver side, the C-bracket should be positioned at 60 degrees to the cab door (30 degrees aft of perpendicular to the door). **See Fig. 3.** Tighten the fasteners at the connections between the C-bracket and the A-bracket 25-30 lbf·ft (34-40 N·m). This will prevent the C-bracket from moving out of position easily, yet it will allow the mirror to swing away on impact.
6. Connect the electrical wiring to the mirror.

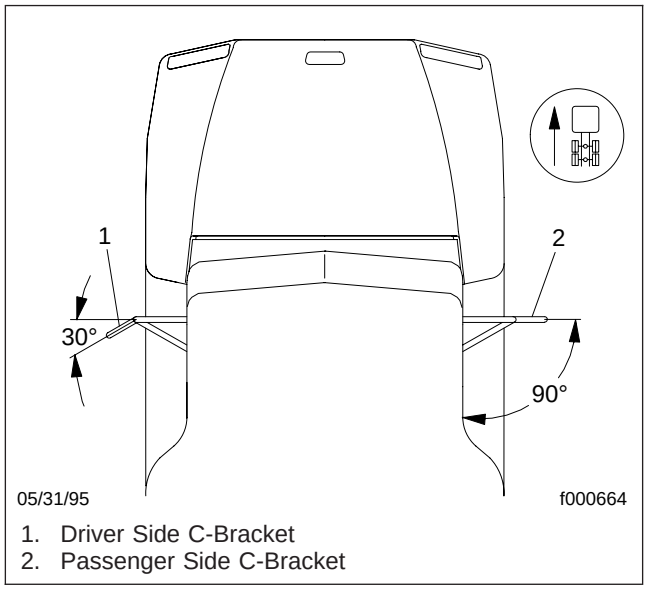
Moto Mirror Removal and Installation



1. A-Bracket
2. L-Bracket
3. C-Bracket
4. Mirror
5. Current Convex Mirror Mounting Location

Fig. 2, Mirror Brackets

7. Check that the mirror is rotating correctly. Turn on the ignition and the mirror heater switch. Feel the mirror glass after 5 minutes to make sure it is heating.



1. Driver Side C-Bracket
2. Passenger Side C-Bracket

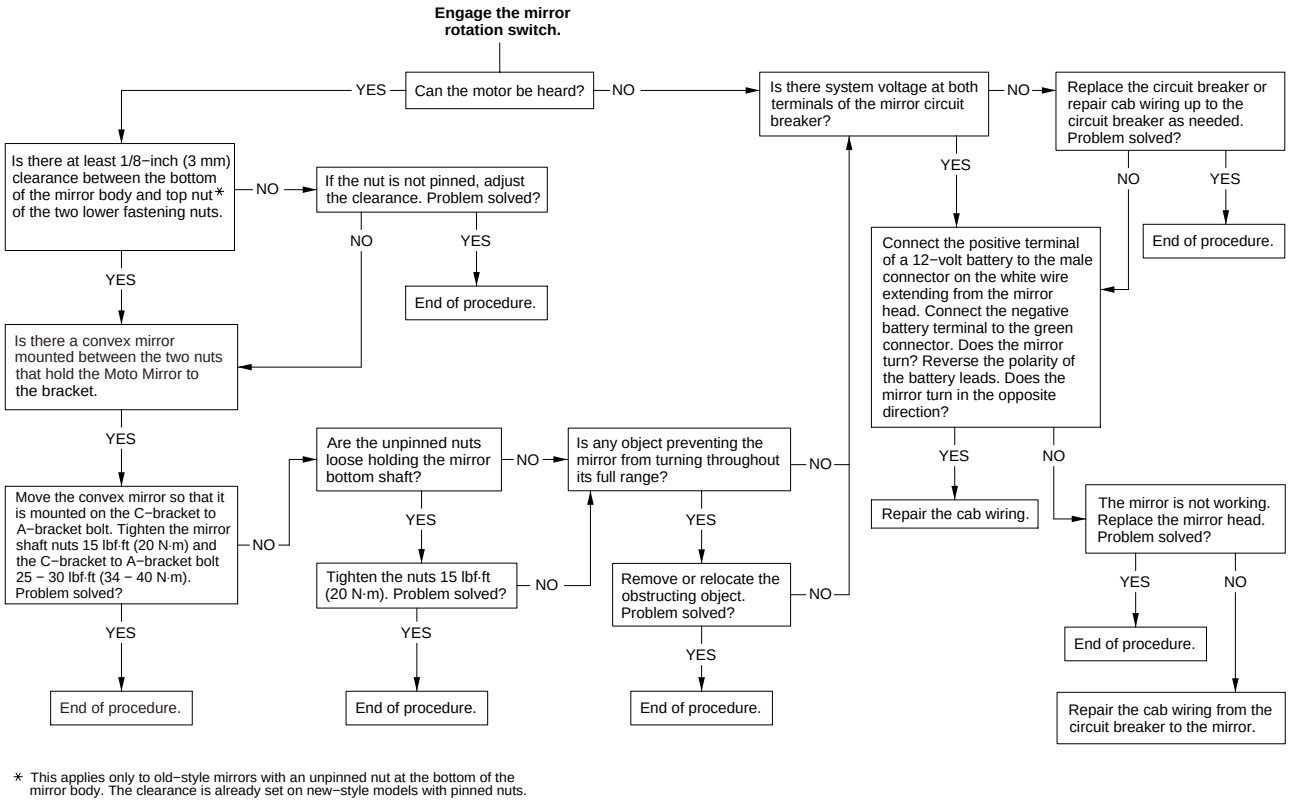
Fig. 3, C-Bracket Positions

Troubleshooting

For troubleshooting mirror rotation problems, **see Fig. 1** and **Fig. 2.** For mirror heating problems, **see Fig. 3.**

The following troubleshooting steps can be done with the mirror on the vehicle.

NOTE: Older−style Moto Mirrors are hard−wired, and the wires must be disconnected behind the dash for electrical troubleshooting. New−style Moto Mirrors have wire snap connectors inside the mirror case, rather than hard wiring. These models can be identified by grey plastic strain reliefs at the bottom of the mirror. Hard−wired mirrors have black strain reliefs.
To access the wiring for newer−style Moto Mirrors, remove the grey strain relief and pull all four snap connectors about 4 inches (100 mm) from the mirror case. Disconnect the snap connectors.



* This applies only to old−style mirrors with an unpinned nut at the bottom of the mirror body. The clearance is already set on new−style models with pinned nuts.

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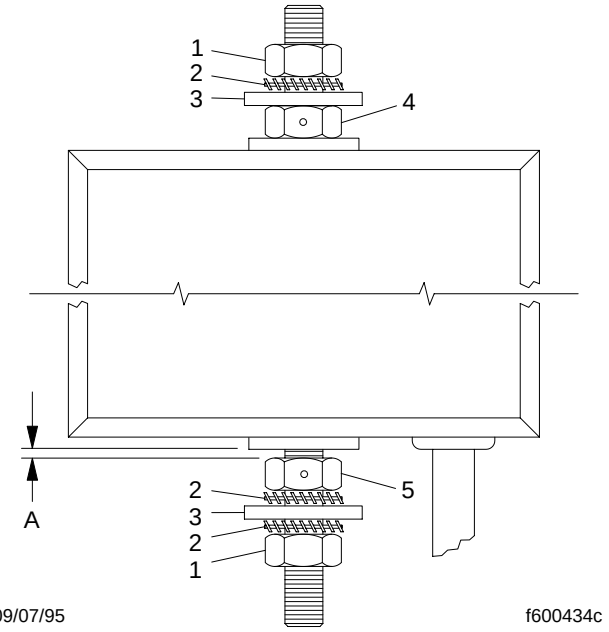
Fig. 1, Mirror Rotation Problem

Troubleshooting



On older installations, Ref. 5 may not be pinned. Be sure to maintain the minimum clearance of 1/8" (3 mm).

A. Minimum 1/8" (3 mm)

1. Hexnut
2. Star Washer
3. L-Bracket
4. Upper Pinned Hexnut
5. Lower Pinned Hexnut

Fig. 2, Moto Mirror Installation

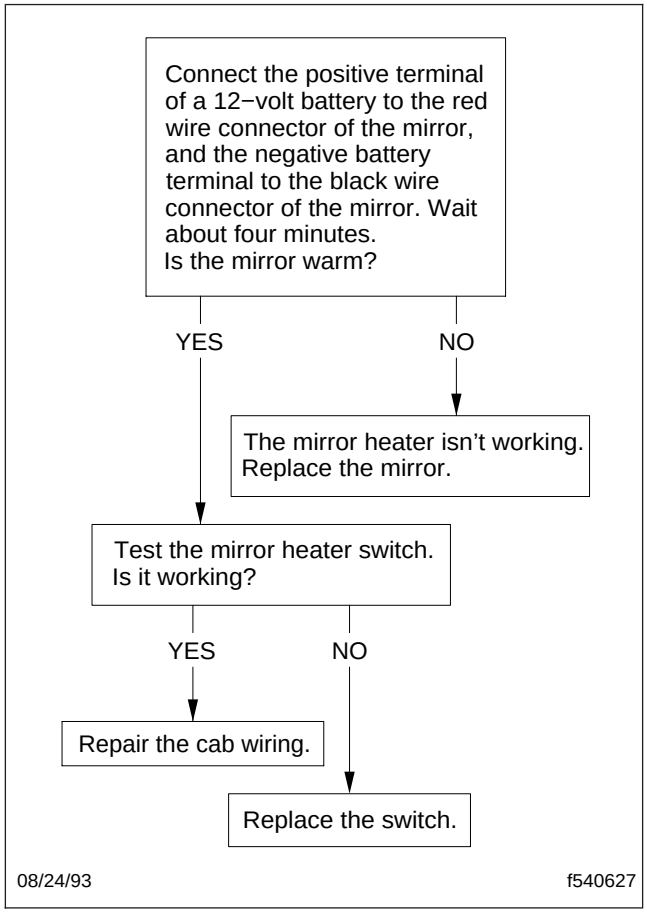


Fig. 3, Mirror Heat Problem

See **Table 1** below for torque values.

Description	Torque lbf·ft (N·m)
Mirror Top and Bottom Shaft Nuts	15 (20)
C-Bracket to A-Bracket Nuts	25–30 (34–40)
L-Bracket to C-Bracket Nuts	10 (14)

Table 1, Torque Values

See **Fig. 1** for the wiring for heated mirrors with indicator light. See **Fig. 2**for the wiring for remote control, heated mirrors. See **Fig. 3**for the wiring for right-side only remote control mirror.

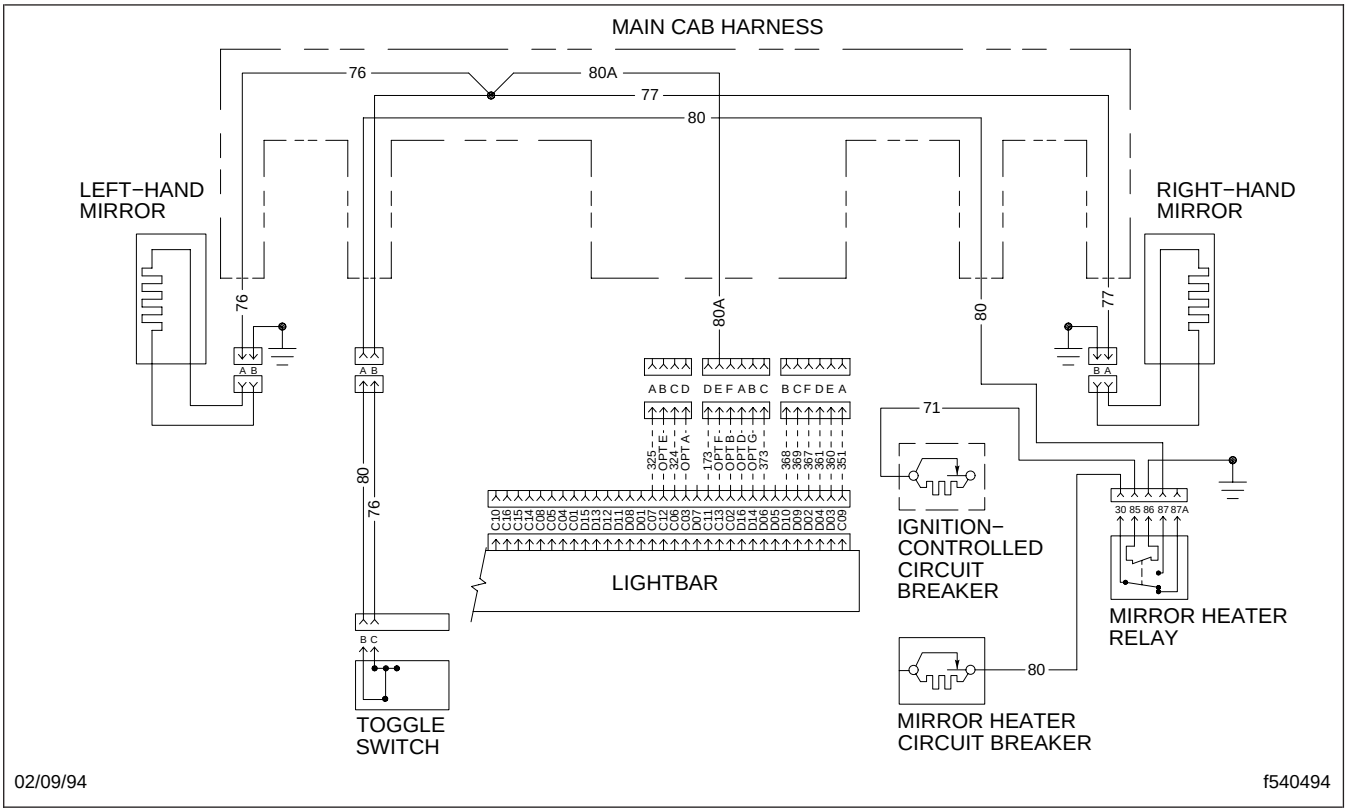


Fig. 1, Wiring for Heated Mirrors with Indicator Light

Specifications

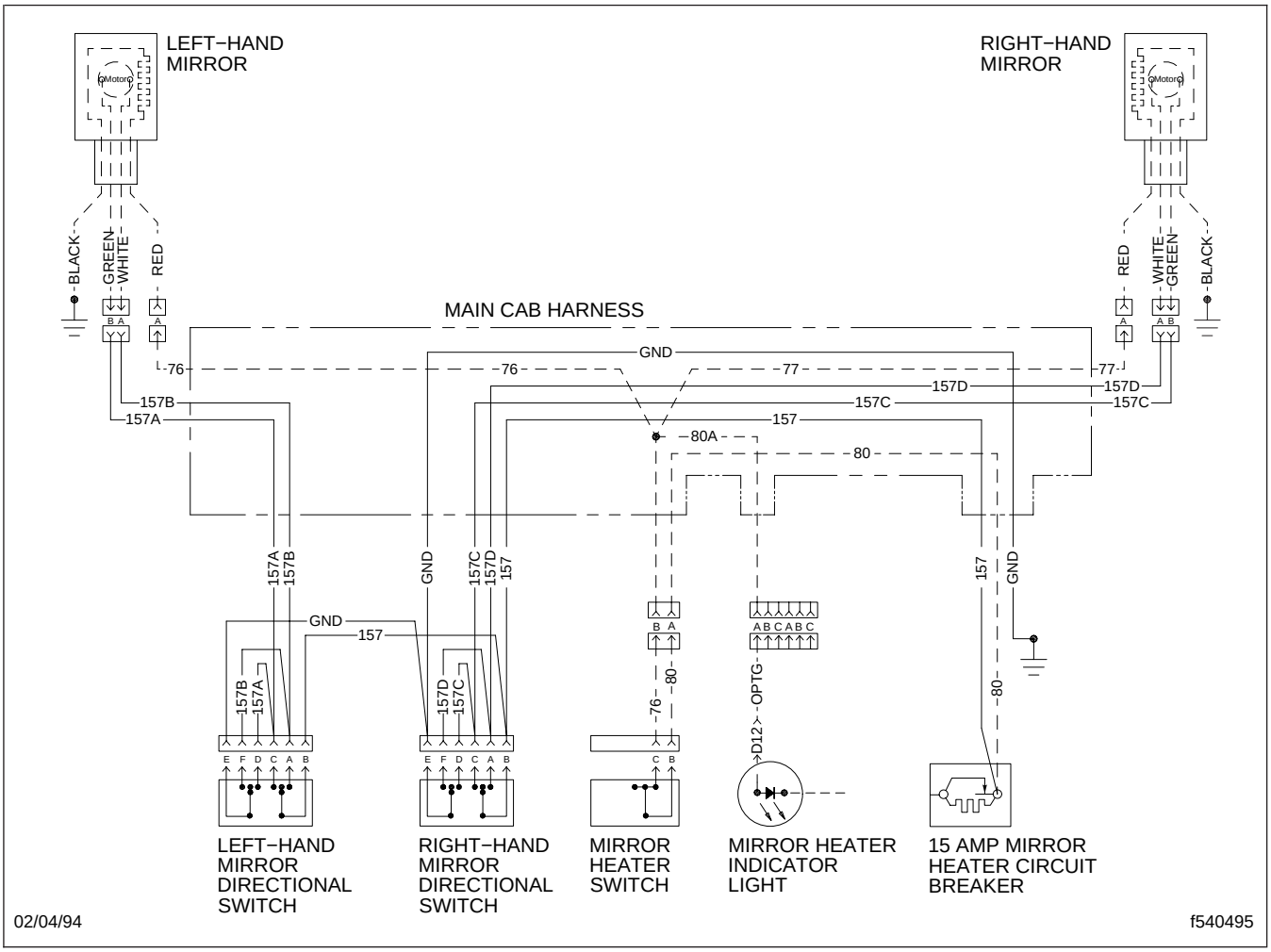


Fig. 2, Wiring for Remote Control, Heated Mirrors

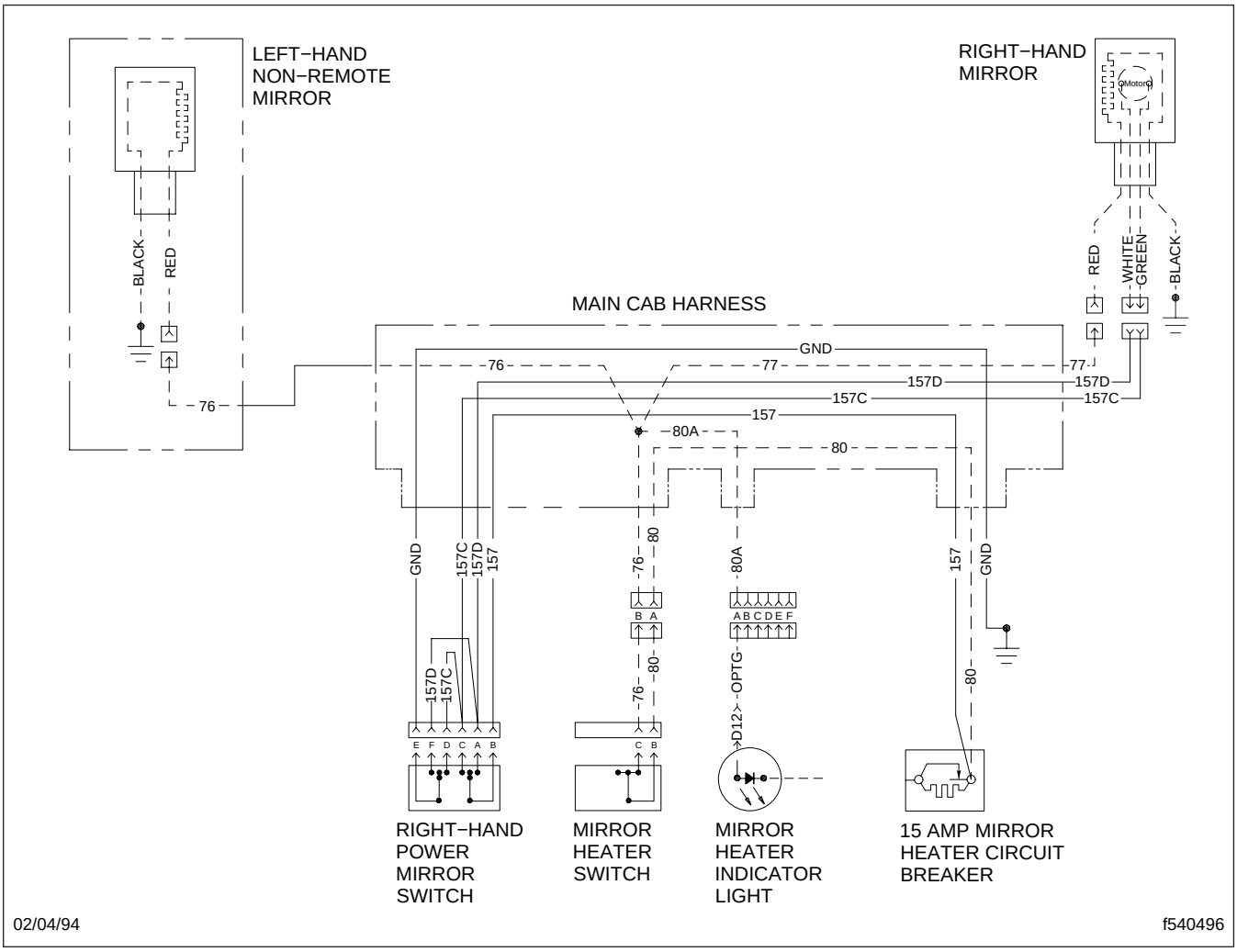


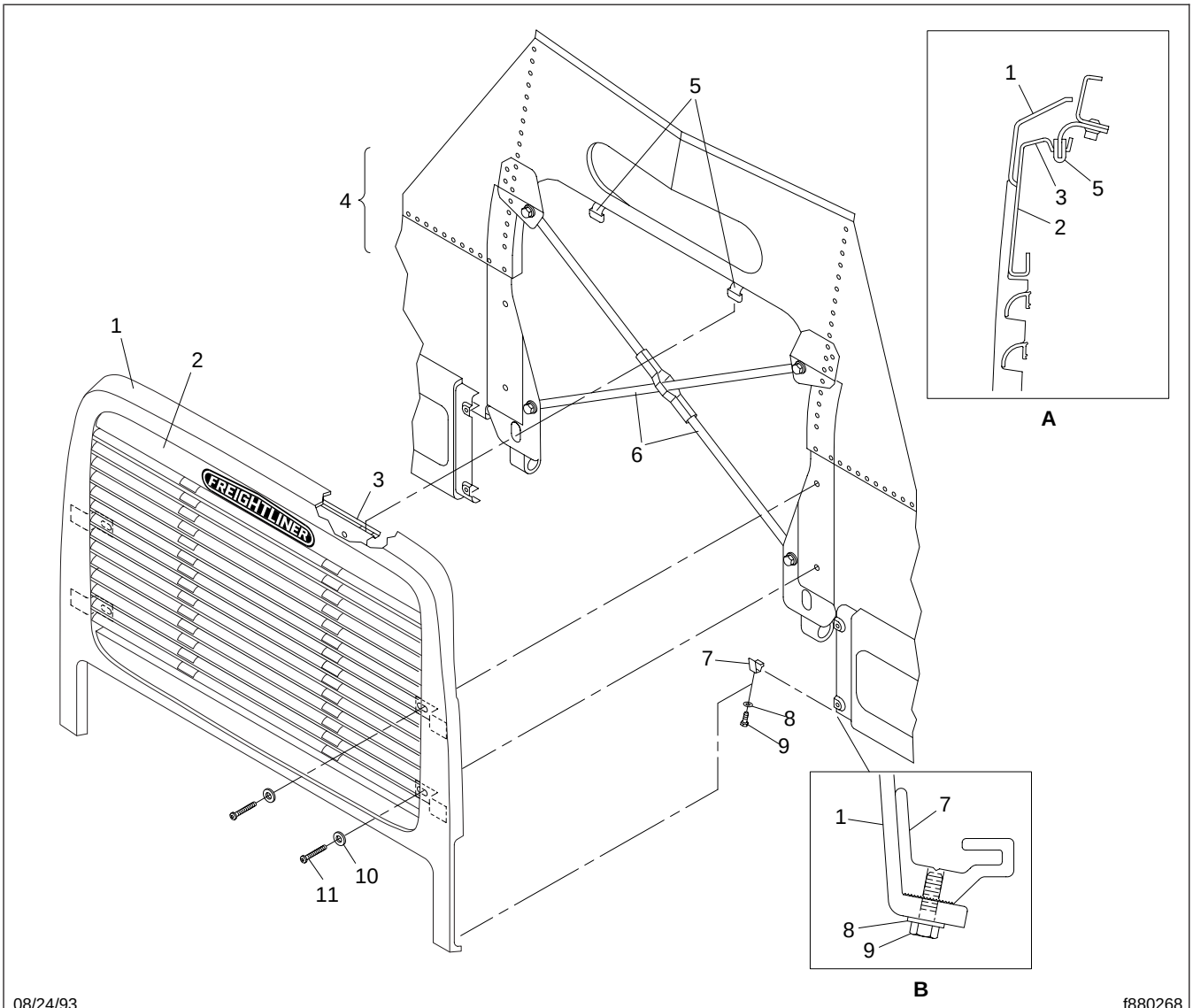
Fig. 3, Wiring for Right-Side Only, Remote Control Mirror

Grille and Tunnel Cross-Brace Removal and Installation

Removal

1. Remove the grille and the grille-surround assembly from the cab. See **Fig. 1**.

1.1 Remove the four Torx®-head machine screws and washers (Refs. 11 and 10) that hold the grille and grille-surround assembly to the cab front-wall (Ref. 4).



A. Side View, Installed

B. Side View, Installed

1. Grille-Surround Assembly
2. Grille
3. Top Lip
4. Cab Front-Wall
5. Upper Restraint Bracket
6. Cross Braces
7. Lower Restraint Bracket (2 qty.)
8. Washer, 1/2" (2 qty.)
9. 1/4–20 Capscrew (2 qty.)
10. Washer, 5/16"
11. Torx®-Head Machine Screw (4 qty.)

Fig. 1

Grille and Tunnel Cross-Brace Removal and Installation

1.2 Remove the two screws (Ref. 9) that attach the bottom legs of the grill-surround assembly to the lower restraint brackets (Ref. 7).

1.3 Pull out the bottom of the grille and grille-surround assembly, then tilt the assembly up to unhook the top lip of the grille (Ref. 3) from the two upper restraint brackets (Ref. 5) at the top of the cab front-wall.

1.4 Remove the grille and grille-surround assembly .

2. If removing the tunnel cross-braces, remove the 1/2–13 capscrews, nuts, and washers that hold the braces to the cab front-wall brackets. See **Fig. 2**.

3. If you are replacing the grille or the grille-surround, separate them. See **Fig. 3**.

3.1 Remove nine (of the 14) 1/4–20 nuts and washers (Refs. 4 and 3) holding the grille-surround assembly to the top and sides of the grille.

3.2 Remove the remaining 1/4–20 nuts, capscrews and washers (Refs. 4, 5, and 3) holding the grille-surround assembly to the bottom of the grille.

3.3 Separate the two parts.

Installation

1. If the tunnel cross-braces were removed, install them. See **Fig. 2** . Tighten the 1/2–13 nuts 68 lbf·ft (92 N·m).

2. If the grille and grille-surround assembly were separated, assemble them. See **Fig. 3**.

2.1 Align the two parts so the studs (Ref. 2) on the grille-surround assembly fit into the holes in the grille.

2.2 Install the nine washers and 1/4–20 nuts onto the studs. Tighten them 60 lbf·in (680 N·cm).

2.3 Install the five 1/4–20 capscrews, washers, and nuts onto the bottom of the grille and the grille-surround. Tighten them 60 lbf·in (680 N·cm).

3. Install the grille and grille-surround assembly onto the cab front-wall.

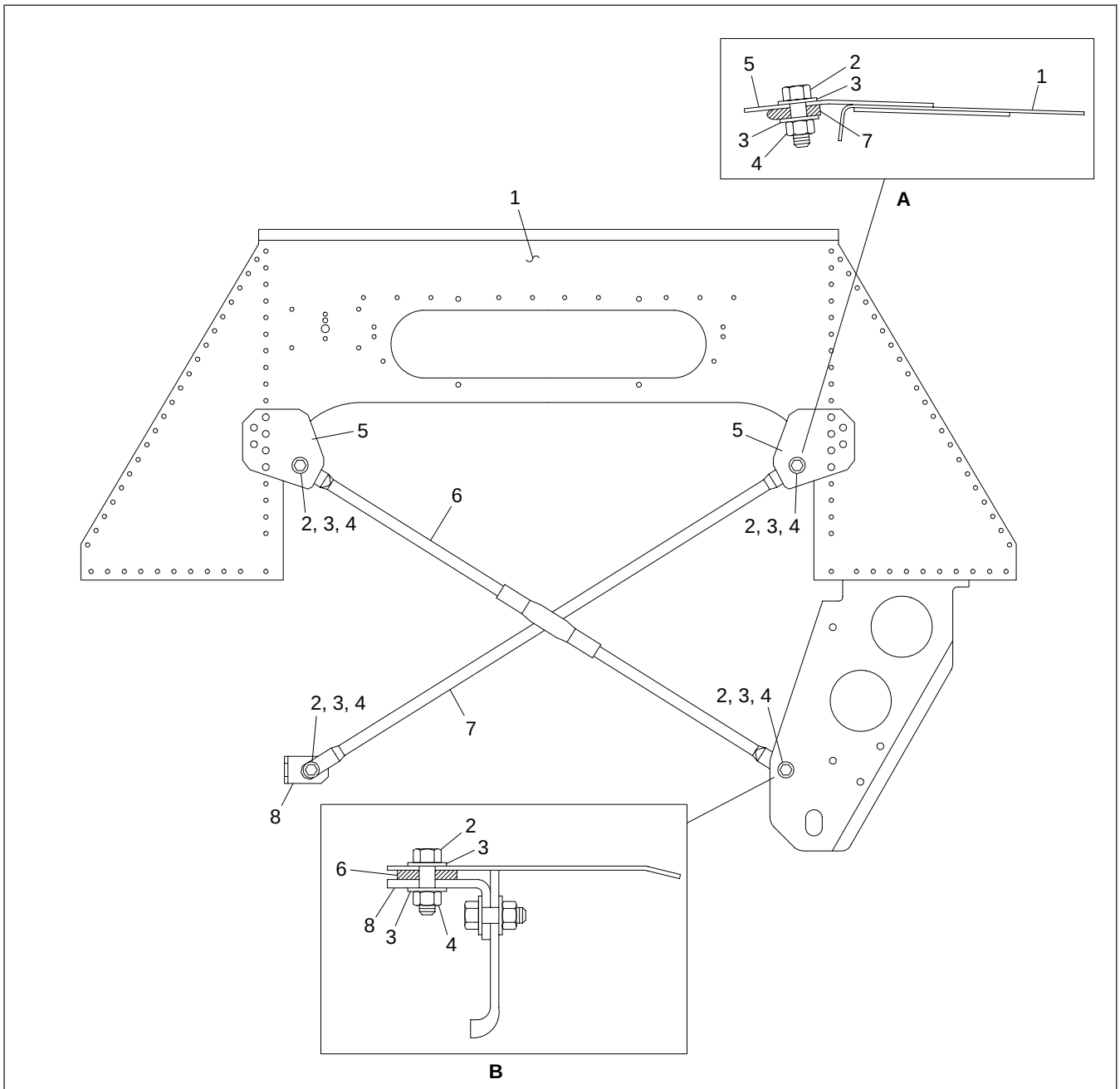
3.1 Tilt the grille and grille-surround assembly up, then hook the top lip of the grille (**Fig. 1,** Ref. 3) onto the two restraint brackets (Ref. 5) at the top of the cab front-wall. See Ref. A.

3.2 Align the grille and grille-surround assembly on the cab front-wall so the holes in the four grille brackets are aligned with those in the cab front-wall.

3.3 Install the four Torx-head machine screws and washers (Refs. 11 and 10). Tighten them 10 lbf·ft (14 N·m).

3.4 Install the two screws and the washers that attach the bottom legs of the grille-surround to the lower restraint brackets. Tighten them 10 lbf·ft (14 N·m).

Grille and Tunnel Cross-Brace Removal and Installation

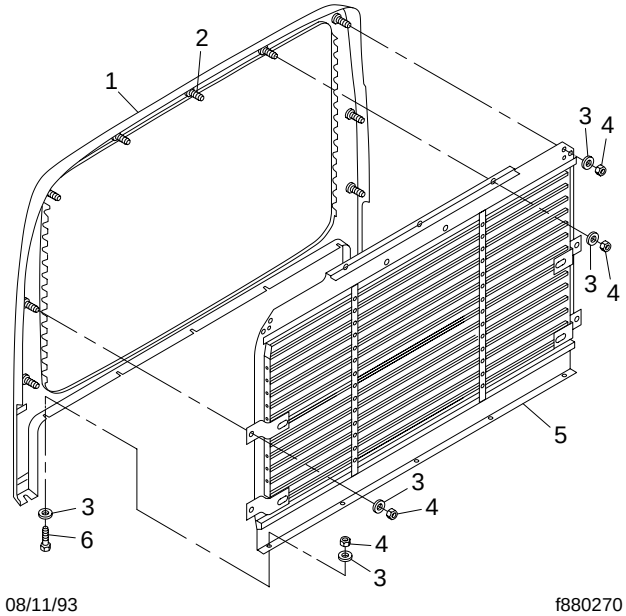


A. Bottom View
B. Bottom View

1. Cab Front-Wall
2. Capscrew, 1/2–13
3. Washer
4. Locknut, 1/2–13
5. Upper Bracket
6. Brace Rod
7. Brace Rod
8. Lower Bracket

Fig. 2

Grille and Tunnel Cross-Brace Removal and Installation



1. Grille-Surround Assembly
2. Stud (9 qty.)
3. Washer (14 qty.)
4. Nut, 1/4–20 (14 qty.)
5. Capscrew, 1/4–20 (5 qty.)

Fig. 3

Panel and Cabinet Manufacture

Raised roof cap panels and cabinets are made of glass fiber reinforced plastic (FRP) materials. FRP panels and cabinets are manufactured using both male and female molds. The steel molds are maintained at temperatures ranging between 120° and 150°F.

Initially, the mold halves are coated with a release agent to permit part removal after the resin hardens. Next, the glass reinforcing fabric is attached to the female mold half. Now the resin is catalyzed and poured into the female mold half. The mold halves are then nested together, but with a gap between them in order to produce the specified thickness in the finished panel.

The resin is allowed to harden in the mold. After the resin hardens, the mold is separated and the part removed. This process produces parts with uniform wall thickness and smooth inner and outer walls.

Roof Cap Construction

The roof cap is assembled in the following manner:

1. All molded parts are cut to their finished edge profile and all holes and cutouts are added.
2. All parts are cleaned and then sanded.
3. Mating flanges are wiped with solvents to ensure proper bonding.
4. A two-part urethane adhesive is applied to the mating surfaces.
5. The left and right rear cabinets are pre-assembled, as are the outer cap panels.
6. The front cabinets and rear panel reinforcements are then bonded to the outer cap subassembly.
7. Finally, the rear cabinet subassemblies are bonded to the outer cap, completing the roof cap assembly. After assembly, the interior cabinets provide structural reinforcement to the outer cap panels.

If it is damaged, the cap can be repaired by following the procedures specified in **Subject 100**. If the cap is so badly damaged that the major subassemblies described above need to be replaced, remove the entire roof cap and replace it with a service cap available through the Freightliner Parts Distribution Centers.

Repair Safety Precautions

Before performing any fiberglass repairs, read the following precautions. Observe any additional precautions given by the manufacturers of the repair materials used.

1. All of the raw materials used in repairing fiberglass are harmful to the eyes and could cause blindness. Wear goggles or other protective eye shields to reduce the chances of splash contacting your eyes.
2. Wear protective gloves, as some people may have skin sensitivity to resin. Also, don't allow the hardener to contact your skin; the hardener can be a skin irritant.

IMPORTANT: In case the hardener or resin contacts your skin, wash with soap and water. If the hardener or resin should contact your eyes, rinse with plenty of water (15 minutes), and call a doctor.

3. When working with fiberglass materials, wear old clothing, since the resin may damage the cloth. Wash the clothing before wearing it again.
4. Most of the liquids involved in fiberglass repair and cleanup (especially when using acetone as a solvent) are flammable; some are also toxic. Don't perform repairs in areas where exposed (or stored) flammable liquids may contact an open flame or any burning material, such as a cigarette. Don't perform repairs in areas that are not well ventilated.

⚠ WARNING

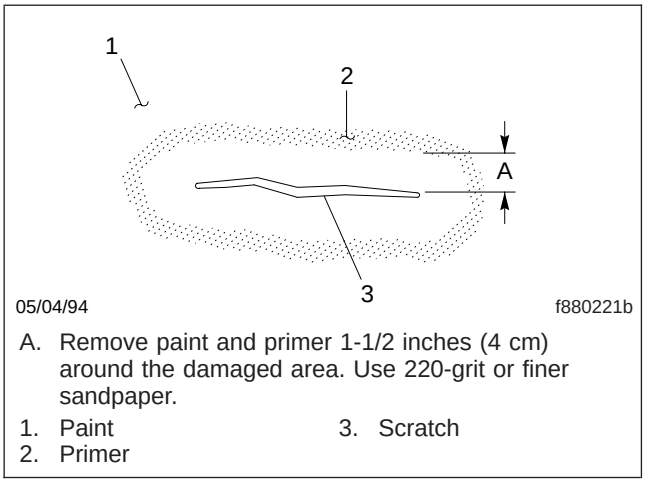
WARNING: Failure to ensure that fiberglass repairs are done in a safe workshop area could result in severe personal injury due to explosion of flammable liquids or breathing of toxic fumes.

5. Do not use electric tools when the fumes of flammable solvents are present. The heat or sparks generated by the tools could create a fire hazard.
6. When grinding or sanding fiberglass surfaces, wear goggles or other protective eye shields, and also an air-purifying respirator, either a throw-away type or one with a replaceable particulate filter(s). Don't breathe grinding dust or particles, otherwise irritation may occur. Also, during grinding and sanding operations, wear a disposable (paper) shop coat to keep dust and fiber slivers off your clothing.
7. Because fiberglass dust can shorten the life of electrical units, air-powered tools are preferred (for frequent use).
8. Unless fiberglass repairs are done on a regular (daily) basis, don't save leftover liquids. If liquids must be saved, store them in cool, dark areas, away from direct sunlight.

Surface Damage Repair

Surface damage refers to scratches, chips, or nicks on the outer surface of the roof skin or interior cabinet panels. To repair surface damage, do the following steps:

1. Locate the damaged area. If there are cracks, see if they go all the way through the panel. If they do, refer to "Structural Damage Repair" for instructions.
2. Clean the area with xylene or an equivalent grease- and wax-removing solvent. Inspect the area closely.
3. Using 220-grit or finer sandpaper, remove all of the paint around the damaged area to a distance of about 1-1/2 inches (4 cm). See **Fig. 1**.



A. Remove paint and primer 1-1/2 inches (4 cm) around the damaged area. Use 220-grit or finer sandpaper.

1. Paint
2. Primer
3. Scratch

Fig. 1, Damaged Area With Paint Removed

4. Using an air nozzle, blow off all dust.

Raised Roof Cab Repairs

5. Use filler (Ashland Pliogrip 7775L self-leveling urethane) over the non-coated area, and spread a thin layer using a squeegee applicator. Cover the entire damaged area, overlapping onto the painted surface. Leave a crowned excess of filler, slightly higher than the painted surface.

NOTE: When using Ashland Pliogrip 7775L, dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.

6. After the filler dries (in about five minutes), sand it with a hand-held disc pad. Use 320-grit or finer sandpaper. Feather the edges of the fill so there are no visible sharp edges.
7. Clean the area with compressed air. Mask the area, then spot prime and paint it. Use Sherwin Williams BB-11 black conductive primer. See **Group 98** for spot-painting instructions.

Structural Damage Repair

The raised roof cap assembly consists of several parts, including roof skin, window surround panels, halo panels, overhead and side cabinets, plus supports and reinforcements, all of which are bonded together with a structural bonding agent. See **Fig. 2**. If the roof structure is damaged, determine which parts are affected.

If there is damage at any joint between two parts, the damage is not repairable. For example, if the roof skin is damaged so badly that the internal cabinet bonded to the roof skin is also damaged, replace the entire roof cap assembly.

If a joint between two parts has separated and there is no damage at the joint area, the parts can be rebonded. Or, if a part is damaged and its adjoining parts are not damaged, the damaged part can be separated from the roof and new or used parts can be bonded in place. A section of a part can be replaced as long as the section does not include a joint between two parts. Roof skin, panels, and cabinets are available as replacement parts or for use in section replacements.

⚠ CAUTION

CAUTION: As noted above, the cabinets serve as structural reinforcement for the outer panels. Removing the larger cabinets may cause the outer panels to deform, making reassembly impossible.

If the damage is such that the parts cannot be replaced, or a section replacement cannot be done, replace the entire roof cap assembly.

For damage in the form of a small crack or hole, refer to "Crack or Small Hole Repair."

For larger damaged areas, refer to "Section Replacement (Repair of Punctures and Large Fractures)."

For replacing or rebonding parts, refer to "Roof Cap Assembly Rebonding."

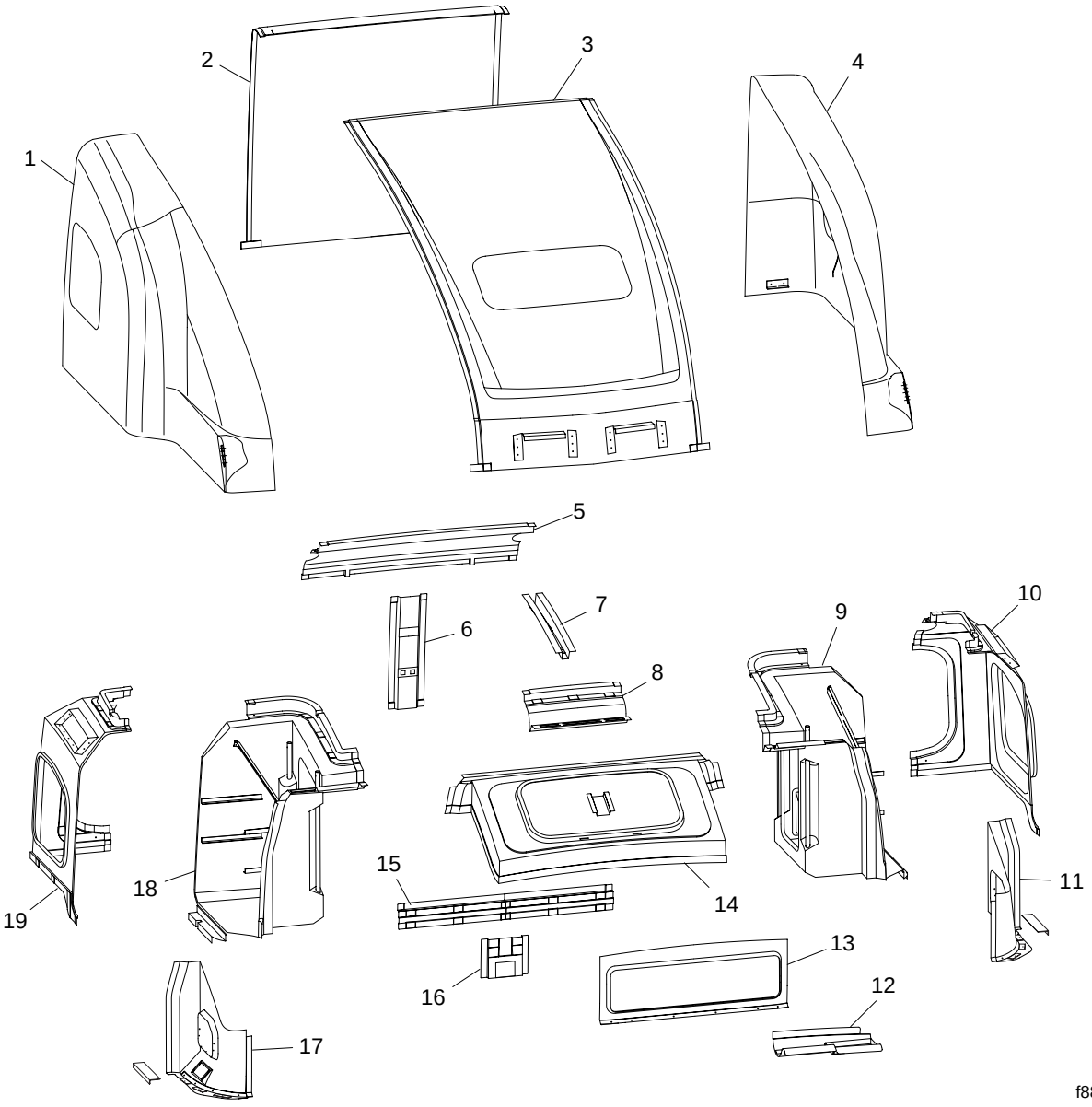
CRACK OR SMALL HOLE REPAIR

A crack (fracture) or small hole through the laminate requires repair with a fiberglass reinforced patch.

1. Examine the damage to the roof cap assembly. Apply hand pressure all around the damaged area to check for any concealed damage.
2. If upholstery and/or thermal insulating material is present in the damaged area, remove the material to provide an adequate working area.
3. Clean the area with xylene, acetone, or an equivalent grease- and wax-removing solvent. Inspect the area closely. All dirt, water, grease, and oils must be removed.
4. If repairing a crack, use a 1/8-inch diameter bit to drill a hole completely through the uncracked laminate 1/8 inch (3 mm) from each end of the crack, to prevent the crack from lengthening. See **Fig. 3**.
5. On the inner surface of the roof or cabinet, use a router bit (on a grinder or a drill) to grind away a shallow recess one-quarter the depth of the roof panel and 1/2 inch (13 mm) outward from all sides of the damage. Taper the outside edge of the ground area. See **Fig. 4**.

   If repairing a crack, grind outward to the drilled hole at the end of the crack, but not beyond. See **Fig. 5**.
6. Use 80- to 220-grit sandpaper to scuff an area at least 1 inch (25 mm) away from the fracture on

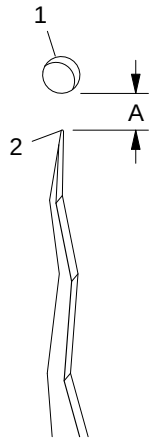
Raised Roof Cab Repairs



1. Right-Hand Side Skin
2. Center Rear Skin
3. Center Front Skin (with Skylight)
4. Left-Hand Side Skin
5. Upper Rear Panel
6. Center Rear Vertical Reinforcement
7. Rear Roof Trim Reinforcement
8. Center Rear Halo Support
9. Left-Hand Side Cabinet
10. Left-Hand Window Surround Panel
11. Front Overhead Cabinet, Left-Hand Side
12. Front Towel Support
13. Front Overhead Cabinet, Center
14. Front Halo Panel (with Skylight) including Front Roof Trim Support
15. Lower Rear Reinforcement, Horizontal
16. Lower Rear Reinforcement, Vertical
17. Front Overhead Cabinet, Right-Hand Side
18. Right-Hand Side Cabinet
19. Right-Hand Window Surround Panel

Fig. 2, Roof Cap Assembly Components

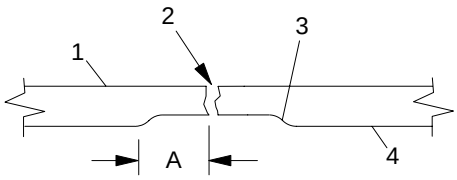
Raised Roof Cab Repairs



05/04/94 f880222b

A. Drill a 1/8-inch hole, 1/8 inch (3 mm) away from the end of a crack.
1. 1/8-Inch Hole
2. End of Crack

Fig. 3, Preventing Crack Lengthening



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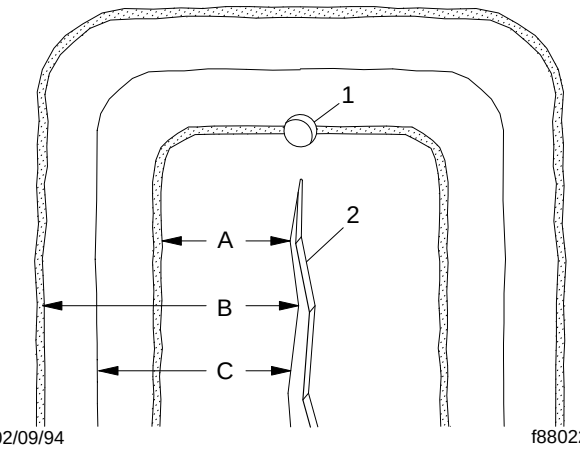
A. Grind a shallow recess one-quarter the depth of the roof panel and 1/2 inch (13 mm) outward in all directions from the damaged area.
1. Roof Panel
2. Crack
3. Slight Taper
4. Underside of Panel

Fig. 4, Recessed Area (cross-sectional view)

all sides. Be sure to scuff thoroughly, since this will give the patch a surface to which it can stick. See **Fig. 5**.

7. Blow the dust away with compressed air and wipe the area with a clean cloth.
8. If necessary, align the panel sections on both sides of the crack, using weights or clamps to re-establish the original panel profile.
9. With a razor-blade knife, cut a section of woven fiberglass cloth to fully cover the crack and to overlay about 3/4 inch (19 mm). See **Fig. 5**.



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A. Use a router to grind away a shallow recess one-quarter the depth of the roof panel and 1/2 inch (13 mm) outward from the damage. If repairing a crack, don't grind past the hole drilled at the end of the crack.
B. Use 80- to 220-grit sandpaper to scuff the area one inch (25 mm) around the damage.
C. Cut the fiberglass cloth to fully cover the damage, and overlay about 3/4 inch (19 mm).
1. Hole
2. Crack

Fig. 5, Preparing the Damaged Area on the Inner Side of the Roof Panel

10. To bond the fiberglass cloth to the damaged panel, choose one of the following bonding agents:
    - Magnolia Magnabond 58 epoxy resin
    - Ashland Pliogrip® 7773 urethane adhesive

IMPORTANT: Do not mix epoxy and urethane.

When using Magnolia Magnabond 58: Measuring the volumes with a spoon, and using a wooden stir stick, mix equal parts of Magnolia Magnabond 58 A and B epoxy resins on a clean sheet of glass, metal, or a section of scrap laminate. Mix for fifteen seconds to ensure a good blend.

IMPORTANT: With Magnolia Magnabond 58, it is critical to measure the A:B ratio accurately. Also, make sure the two components are adequately mixed.

When using Ashland Pliogrip 7773: Dispense the required adhesive from the cartridge in a

continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.

11. Use a plastic or metal device to spread a thin layer of the bonding agent over the scuffed area.
12. Lay the cut section of fiberglass cloth on the repair area, centered over the damage. Using a fiberglass roller, press the cloth down firmly into the layer of bonding agent to completely soak the glass fibers.
13. Apply another layer of bonding agent over the glass cloth. Spread the agent evenly using the fiberglass roller.
14. After two to five minutes, the bonding agent will start to jell. It may take more time when cool, less when warm.

IMPORTANT: To avoid pre-jelling or skin-over, mate the FRP parts to be bonded within one to four minutes after extruding and applying the bonding agent.

NOTE: To get a smoother surface, press a piece of masking tape, wider than the repair, directly over the wet bonding agent and smooth it before it hardens. The tape can be removed after fifteen minutes when the agent has set.

15. The patch should be hard enough in fifteen minutes to allow sanding to a smooth flat surface if required.
16. Repair the damage on the outside surface of the panel and paint the surface on both sides, using the instructions in "Surface Damage Repair."

PUNCTURE AND LARGE FRACTURE REPAIR (SECTION REPLACEMENT)

On very large damaged areas (for example, structural damage on the roof cap covering an area of a square foot or more) it may be easier to do a section replacement rather than make a patch. Cabinets and roof reinforcements may be used in section replacements. Also, another damaged roof with the needed section intact may be available as scrap.

IMPORTANT: A piece of FRP laminate from a roof or hood must be used for section replacement. Use of any other material may not allow the necessary bonding for the repair.

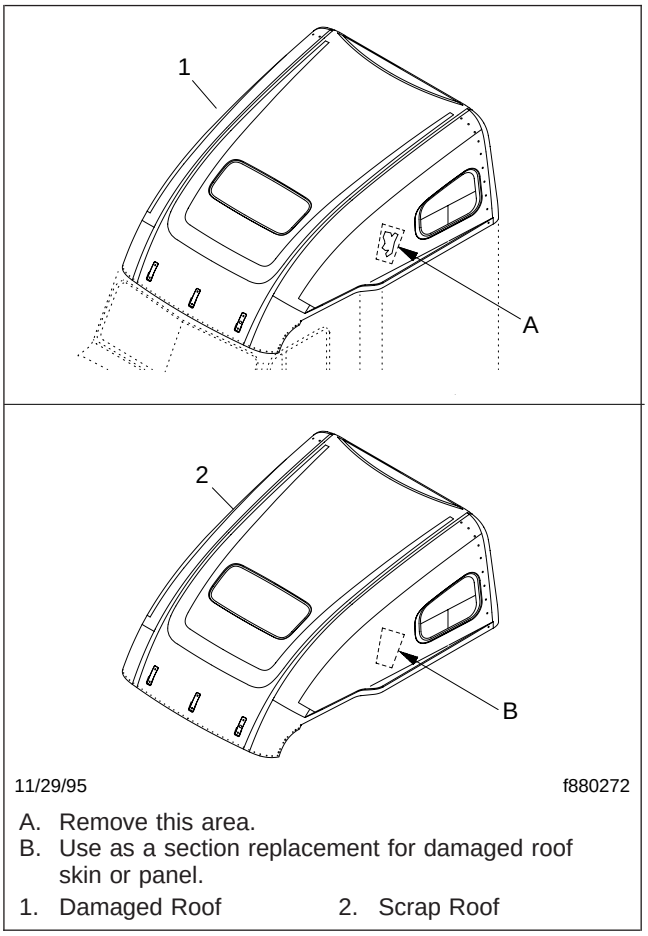
1. Push in on the area immediately surrounding and underneath the damaged area to determine the extent of the damage.
2. If upholstery and/or thermal insulating material is present in the damaged area, remove the material to provide an adequate working area.
3. Clean the area with xylene, acetone, or an equivalent grease- and wax-removing solvent. Inspect the area closely. All dirt, water, grease, and oils must be removed.
4. Using a saber saw, cut out a large, straight-sided panel containing the damaged area. Refer to the example in **Fig. 6**, Ref. A. If the damage extends to a joint where the part is bonded to another, first separate the bonded portion of the damaged section with a heat gun and putty knife before cutting.

⚠ WARNING

WARNING: Wear goggles and an air purifying respirator when grinding, cutting, or sanding during all fiberglass repairs. The ground dust and particles could cause temporary or permanent damage to your eyes and, if inhaled, could cause throat or lung irritation.

5. From the scrap roof panel, hood, or new part, cut a section replacement panel from the same area, only slightly larger than the original cutout. Refer to the example in **Fig. 6**, Ref. B. Then, trim the section replacement to fit both the size and contour of the original cutout.
6. After the trimming is completed, sand the edges to allow a 1/16- to 1/8-inch (about 2- to 3-mm) gap around the cutout.
7. On the inner side of the panel, use a router bit (on a grinder or drill) to grind away a shallow recess one-quarter the depth of the roof panel, 1/2 inch (13 mm) outward from all sides of the cutout area. See **Fig. 7**. Also, grind 1/2 inch (13 mm) inward from all sides of the section replacement. See **Fig. 7**. Slightly taper the outside edge of the ground area on the roof panel and the inside edge of the ground area on the section replacement. See **Fig. 8**.

Raised Roof Cab Repairs



A. Remove this area.
B. Use as a section replacement for damaged roof skin or panel.
1. Damaged Roof
2. Scrap Roof

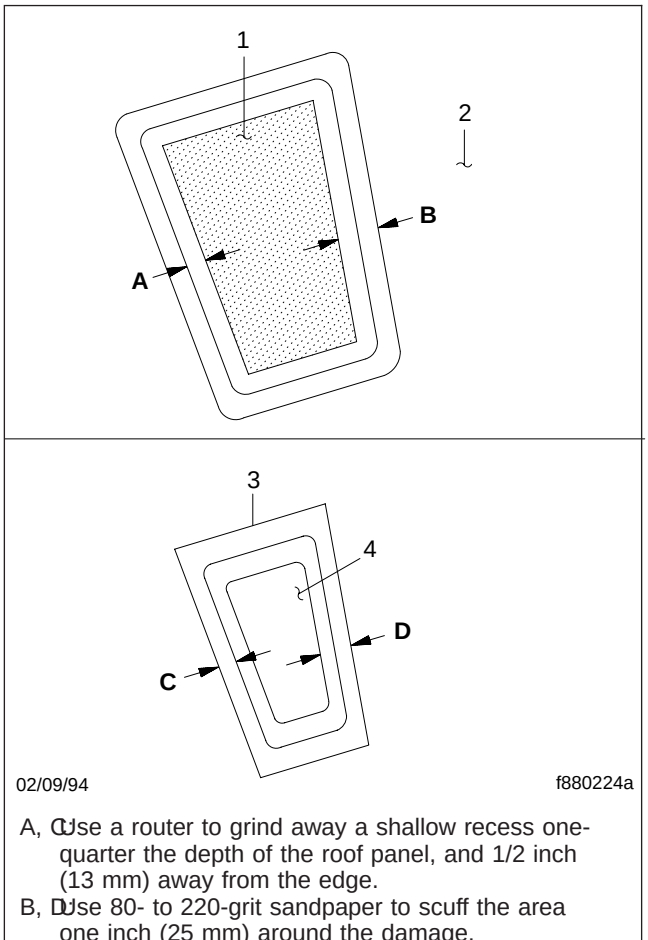
Fig. 6, Section Replacement of a Damaged Fiberglass Roof

8. Use 80- to 220-grit sandpaper to scuff an area at least 1 inch (25 mm) out from all sides of the cutout area. See **Fig. 7**.

   Also, scuff at least 1 inch (25 mm) in from all sides of the section replacement. See **Fig. 7**. Be sure to scuff thoroughly, since this will give the section replacement a surface to which it can stick. Be sure to completely sand off any undercoating sprayed on these areas.

9. On the outer sides of both the cutout and the section replacement, bevel the edges about 45 degrees. See **Fig. 9**.

10. Gently feather the outer painted surfaces back about 1/2 inch (13 mm) beyond the edges of the repair areas (on both the cutout and the section replacement), using 220-grit or finer sandpaper.



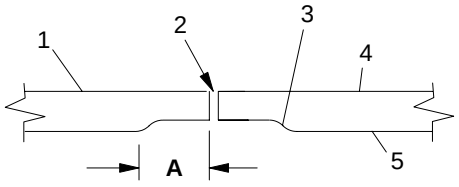
A, C. Use a router to grind away a shallow recess one-quarter the depth of the roof panel, and 1/2 inch (13 mm) away from the edge.
B, D. Use 80- to 220-grit sandpaper to scuff the area one inch (25 mm) around the damage.
1. Cutout Hole
2. Underside of Roof
3. Section Replacement
4. Underside of Section Replacement

Fig. 7, Preparing the Section Replacement and Roof Panel Cutout on the Unexposed Side

11. Blow the dust away with compressed air and wipe the area with a clean cloth.

12. If the section replacement is close enough to an edge, use clamps to temporarily secure it during the repair. If the replacement is too far from an edge to use clamps, use bond strips as shown in **Fig. 10**.

    12.1 Cut some scrap FRP into strips. Make enough strips to hold the section replacement in position, about one every six inches (15 cm). If the surface of the replacement panel is contoured or curved,



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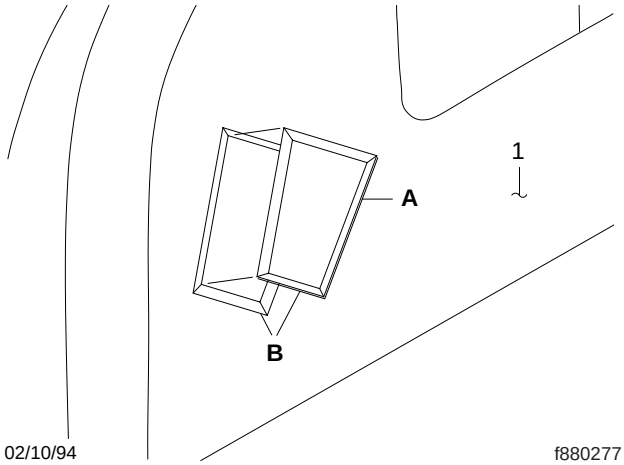
A. Grind a shallow recess one-quarter the depth of the roof panel and 1/2 inch (13 mm) outward in all directions from the damaged area.

1. Section Replacement
2. Gap
3. Slight Taper
4. Roof Panel
5. Underside of Roof

Fig. 8, Cutout Area (cross-sectional view)



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A. Insert section replacement.
B. Bevel outer surface edges on all sides.

1. Exposed Side of Roof

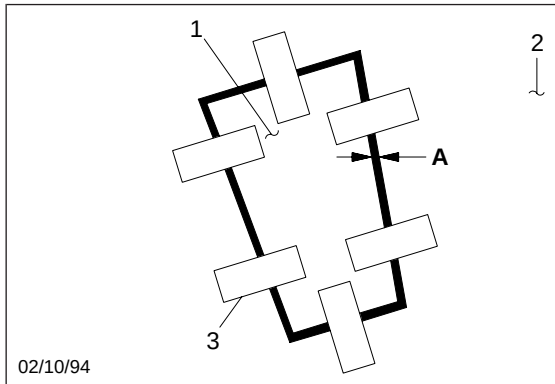
Fig. 9, Areas to be Beveled

use many small bond strips. Larger strips could deform the curves.

12.2 On the inner side of the repair, use 80- to 220-grit sandpaper to scuff sand the areas on the roof and section replacement panels where you plan to bond the strips.

12.3 If a joint between parts was separated for the repair, rebond the joint. Refer to "Roof Cap Assembly Rebonding" for instructions.

12.4 Holding the section replacement in position, bond the strips to both roof and replacement panels in the area already scuffed. Use Lord F Fusor® 320/322 or Ashland Pliogrip 7773 to bond the strips.



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A. Gap of 1/16 inch to 1/8 inch (2 to 3 mm)

1. Section Replacement
2. Underside of Roof
3. Bond Strip

Fig. 10, Securing the Section Replacement to the Roof Panel Using Bond Strips

12.5 If Fusor 320/322 is used, apply light pressure and heat from a heat gun to the area for three to five minutes.

12.6 After the bonding agent has hardened, use 80- to 220-grit sandpaper to scuff the bond strips.

12.7 Blow the dust away with compressed air and wipe the area with a clean cloth.

13. With a razor-blade knife, cut sections of woven fiberglass cloth to fully cover the gap between the cutout and the section replacement, all the way around the damaged area. The cloth should overlay about 3/4 inch (19 mm) on both sides of the gap. See **Fig. 11**.

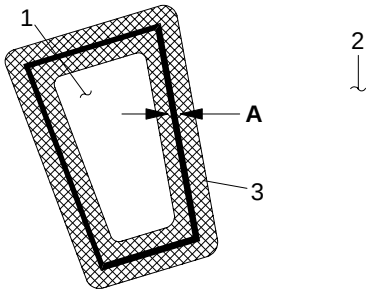
14. To bond the fiberglass cloth to the damaged panel, choose one of the following bonding agents:

    - Magnolia Magnabond 58 epoxy resin
    - Ashland Pliogrip 7773 urethane adhesive

IMPORTANT: Do not mix epoxy and urethane.

When using Magnolia Magnabond 58: Measuring the volumes with a spoon, and using a wooden stir stick, mix equal parts of Magnolia Magnabond 58 A and B epoxy resins on a clean

Raised Roof Cab Repairs



NOTE: The fiberglass cloth should overlay about 3/4 inch (19 mm) on both sides of the gap.

A. Gap of 1/16 inch to 1/8 inch (2 to 3 mm)
1. Section Replacement
2. Underside of Roof
3. Fiberglass Cloth

Fig. 11, Overlaying Fiberglass Cloth

sheet of glass, metal, or a section of scrap laminate. Mix for fifteen seconds to ensure a good blend.

IMPORTANT: With Magnolia Magnabond 58, it is critical to measure the A:B ratio accurately. Also, make sure the two components are adequately mixed.

When using Ashland Pliogrip 7773: Dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.

15. Use a plastic or metal device to spread a thin layer of the bonding agent over the scuffed area.
16. Lay the cut sections of fiberglass cloth on the repair area, centered over the damage. Using a fiberglass roller, press the cloth down firmly into the layer of bonding agent to completely soak the glass fibers.
17. Apply another layer of bonding agent over the glass cloth. Spread the agent evenly using the fiberglass roller.
18. After two to five minutes, the bonding agent will start to jell. It may take more time when cool, less when warm.

IMPORTANT: To avoid pre-jelling or skin-over, mate the FRP parts to be bonded within one to four minutes after extruding and applying the bonding agent.

NOTE: To get a smoother surface, press a piece of masking tape, wider than the repair, directly over the wet bonding agent and smooth it before it hardens. The tape can be removed after fifteen minutes when the bonding agent has set.

19. Repair the damage on both inner and outer surfaces of the roof, and paint the surface on both sides, using the instructions in "Surface Damage Repair." Surfaces on the inside of the roof cap that will be covered with insulation and upholstery panels do not require paint.

ROOF CAP ASSEMBLY REBONDING

1. If rebonding a joint that has separated, or if replacing a damaged part, completely separate each part using a heat gun and putty knife. Remove as much of the old adhesive as possible. The heat gun will soften the adhesive and allow it to be peeled off the FRP roof cap subassemblies.

   If the parts cannot be separated, work folded medium-grit sandpaper or a section of a steel hacksaw blade between the two surfaces to remove the old adhesive.
2. Scuff the surfaces with 80- to 220-grit sandpaper.
3. Clean the surfaces to be bonded with Ashland 6036 primer or methylene chloride. Inspect the area closely to be sure all of the old adhesive, dirt, water, grease, and oils are removed.
4. If replacing a large part, such as an outer panel, align the part on the roof cap assembly and clamp it in place. Drill holes through the bonding surfaces and install clamping bolts in the holes. Use two washers, one on each side of the joint. See **Fig. 12**. There should be enough clamping bolts to hold the panel in place and keep the bonding surfaces together, or at least one bolt every 12 to 18 inches (30 to 45 cm). Remove the part for application of bonding agent.
5. Using the manufacturer's instructions, mix enough bonding agent to bond the parts together. Choose one of the following bonding agents:
   - Magnolia Magnabond 58-2 or Lord F Fusor 320/322

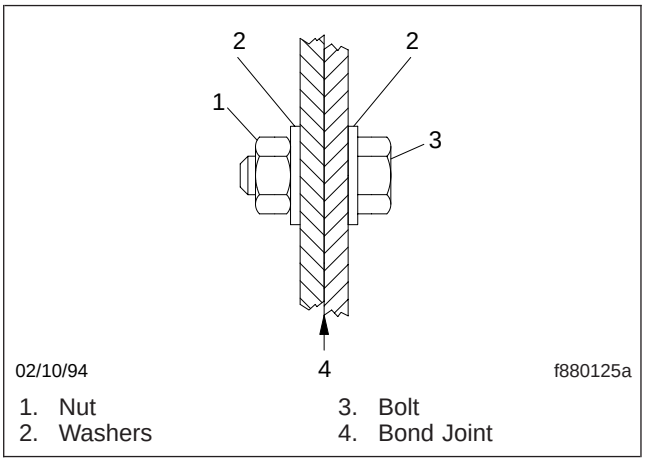


Fig. 12, Clamping Bolt at Bond Joint

- Ashland Pliogrip urethane cartridge materials 7773 or 7779 or equivalents

IMPORTANT: Do not mix epoxy and urethane.

When using Magnolia Magnabond 58-2 or Lord F Fusor 320/322: Put the bonding agent in a standard caulking gun. Cut the nozzle to dispense a 3/8-inch (10 mm) diameter bead. If the parts can't be completely separated, cut the nozzle so the agent can be injected between the surfaces.

When using Ashland Pliogrip 7773 or 7779: Dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.

6. Within four minutes after applying the bead, align the part on the roof assembly and clamp it firmly in place. If it is a large part, install the clamping bolts. Tighten the clamps or clamping bolts just enough to ensure that a uniform amount of pressure is applied along the seam. Ideally, the bonding agent should be compressed to form a bond line one inch (25 mm) wide and 0.030 inch (0.76 mm) thick. This thickness can be ensured by sprinkling 0.030 inch glass beads into the bonding agent before mating the parts.
7. Before it cures, within seven to 10 minutes, remove any excess bonding agent that squeezes out the edges of the bond.
8. If a heat gun is used, remove the clamps when the bonded FRP parts are cool to the touch; in about one hour. If no heat is applied, leave the bonded parts clamped together for twenty-four hours.

NOTE: Do not use a heat gun when working with Ashland Pliogrip adhesive.

9. If holes were drilled for clamping bolts, repair them using the instructions under "Crack or Small Hole Repair."
10. If necessary, prime and paint the repair area using the instructions under "Surface Damage Repair."

Replacement

⚠ WARNING

WARNING: When handling glass, wear protective gloves to protect your hands from sharp edges and to allow a better grip. Not wearing protective gloves when handling glass could result in personal injury.

1. Park the vehicle on a flat surface. Shut down the engine, set the parking brake, and chock the tires.
2. Inside the cab, attach a suction device onto the skylight window glass surface. See **Fig. 1**.

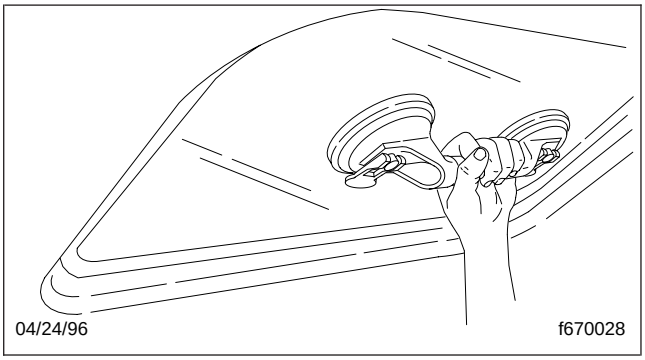


Fig. 1, Attaching the Suction Device to Skylight Window Glass

3. Use a utility knife to cut the rubber seal from around the skylight window glass.
4. Remove the cut seal from the glass.

⚠ CAUTION

CAUTION: When handling the skylight window glass, be careful not to nick or splinter the edges of the glass. Chipped edges could cause cracking later on.

NOTE: When removing the skylight window glass be sure to note the location of the manufacturer's ID on the lower left corner of the inside surface of the glass. The glass must be replaced in the same position.

5. Remove the skylight window glass from the opening, and remove the rubber seal remaining on the glass.
6. Clean the surface of the skylight window opening with a cleaning solvent.
7. Check for rough spots, and sand and prime as necessary.
8. Move the skylight window glass from the inside of the cab to a workbench, and install a new rubber seal.
   - 8.1 Clean the edges of the glass.
   - 8.2 Apply a 1/8-inch (3 mm) bead of sealant to the inside channel of the seal.
   - 8.3 Stretch the rubber seal around the edge of the glass, seating the glass in the groove. See **Fig. 2**.

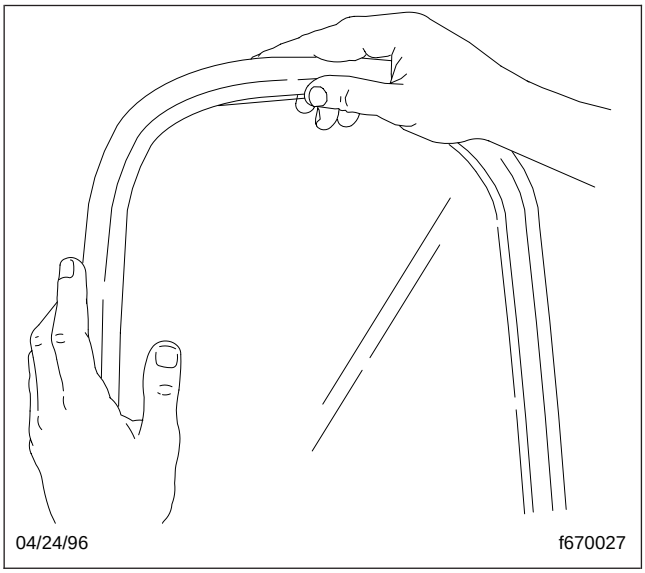


Fig. 2, Attaching Rubber Seal to Skylight Window Glass

   - 8.4 Check the location of the manufacturer's ID on the glass.
9. Return the assembly to the cab.
10. Spray a soap-and-water solution onto the roof edge and the inside of the seal now attached to the skylight window glass.
11. Using a windshield pick (see **Fig. 3**) and holding the glass in position with the suction device, begin to set the rubber seal onto the edge of the opening. If needed, the suction device can be moved to specific areas of the glass to assist in setting the seal.

Skylight Seal Replacement

12. Using a bead spreader (see **Fig. 4**), install the rubber locking strip into the skylight window glass seal.

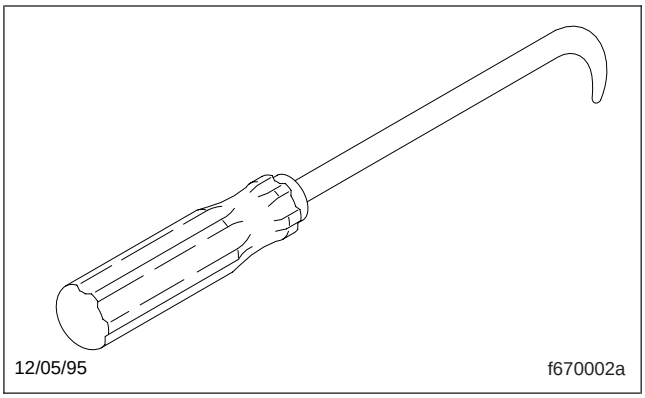


Fig. 3, Typical Windshield Pick

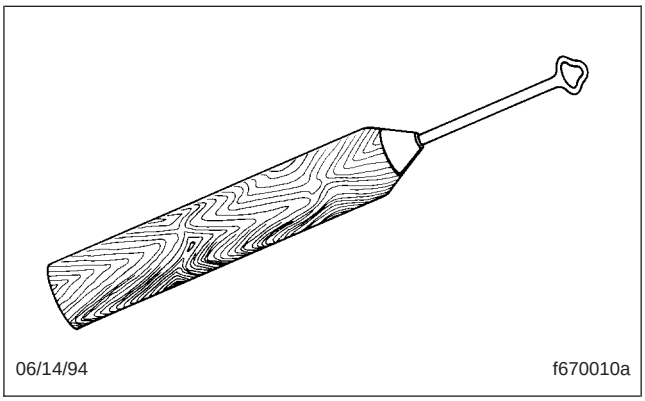


Fig. 4, Typical Bead Spreader

12.1 Insert the bead spreader into the lockstrip channel at the bottom of the rubber seal.

12.2 Insert the lockstrip into the eye of the spreading tool.

12.3 Move the bead spreader in the channel, working toward the top, while feeding the lockstrip into the channel.

12.4 Do not allow the lockstrip to twist. It should lie flat in the channel.

12.5 Cut away any excess lockstrip and tuck the end into the channel.

12.6 Use more soap-and-water solution, if necessary.

13. Remove the suction device, and clean the glass and the area surrounding the skylight window.

Roof Cap Manufacture

Mid-roof caps are made of glass fiber reinforced plastic (FRP) materials. Depending on size and place of manufacture, roof caps are either Spray-up or RTM. Tools will be either epoxy or nickle shell, and either female only or female/male. Interior reinforcements are epoxy tooled RTM (male/female).

Initially, the mold halves are coated with a release agent to permit part removal after the resin hardens. Next, the glass reinforcing fabric is attached to the female mold half. Now the resin is catalyzed and poured into the female mold half. The mold halves are then nested together, but with a gap between them in order to produce the specified thickness in the finished panel.

The resin is allowed to harden in the mold. After the resin hardens, the mold is separated and the part removed. This process produces parts with uniform wall thickness and smooth inner and outer walls.

Spray-up caps are made using the "contact molding" technique. They are easily recognized by their rough inner surface. Contact molding is done with an open mold, or a female configuration, which controls external shape and finish. A gel coating is first sprayed onto the mold. The gel coating eventually becomes the smooth outer surface of the roof cap. It provides impact and abrasion resistance to the laminate underneath. In addition, it readily accepts a coating of paint. A laminate of fiberglass reinforcement and resin is then built up by use of a special chopper/spray gun, which directs short glass fibers and catalyzed resin onto the mold (gelled) surface. The glass fibers are rapidly "chopped" from a feeder roll of continuous strand roving, which consists of numerous, untwisted fiberglass strands wound into a cylindrical package.

The resin used in this process is air-inhibited; that is, it will not completely cure, or harden, when the laminate is exposed to air. All portions not directly exposed to air (including those portions of the laminate contacting the gel), dry instantly. As a result, no matter how many "passes" are made with the roving fiberglass chopper/spray gun in a particular area, the final structure will have only one layer of fiberglass (that is, distinct layers of fiberglass will not be present when using this process).

Upon completion of this phase in the manufacture of a fiberglass roof cap, major stress areas are reinforced by hand. During "hand lay-up," fiberglass reinforcement in the form of woven roving, which is a heavy, drapable fabric, is manually built up, with air-inhibited resin added as needed.

Roof Cap Repairs

If it is damaged, the cap can be repaired by following the procedures specified in **Subject 100**. If the cap is so badly damaged that it must be replaced, remove the entire roof cap and replace it with a service cap available through the Freightliner Parts Distribution Centers.

Repair Safety Precautions

Before performing any fiberglass repairs, read the following precautions. Observe any additional precautions given by the manufacturers of the repair materials used.

1. All of the raw materials used in repairing fiberglass are harmful to the eyes and could cause blindness. Wear goggles or other protective eye shields to reduce the chances of splash contacting your eyes.
2. Wear protective gloves, as some people may have skin sensitivity to resin. Also, don't allow the hardener to contact your skin; the hardener can be a skin irritant.

IMPORTANT: In case the hardener or resin contacts your skin, wash with soap and water. If the hardener or resin should contact your eyes, rinse with plenty of water (15 minutes), and call a doctor.

3. When working with fiberglass materials, wear old clothing, since the resin may damage the cloth. Wash the clothing before wearing it again.
4. Most of the liquids involved in fiberglass repair and cleanup (especially when using acetone as a solvent) are flammable; some are also toxic. Don't perform repairs in areas where exposed (or stored) flammable liquids may contact an open flame or any burning material, such as a cigarette. Don't perform repairs in areas that are not well ventilated.

⚠ WARNING

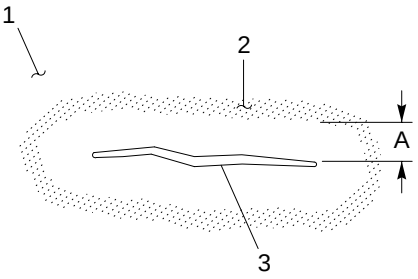
WARNING: Ensure that fiberglass repairs are done in a safe workshop area. Failure to do so could result in severe personal injury due to explosion of flammable liquids or breathing of toxic fumes.

5. Do not use electric tools when the fumes of flammable solvents are present. The heat or sparks generated by the tools could create a fire hazard.
6. When grinding or sanding fiberglass surfaces, wear goggles or other protective eye shields, and also an air-purifying respirator, either a throw-away type or one with a replaceable particulate filter(s). Don't breathe grinding dust or particles, otherwise irritation may occur. Also, during grinding and sanding operations, wear a disposable (paper) shop coat to keep dust and fiber slivers off your clothing.
7. Because fiberglass dust can shorten the life of electrical units, air-powered tools are preferred (for frequent use).
8. Unless fiberglass repairs are done on a regular (daily) basis, don't save leftover liquids. If liquids must be saved, store them in cool, dark areas, away from direct sunlight.

Surface Damage Repair

Surface damage refers to scratches, chips, or nicks on the outer surface of the roof skin or interior cabinet panels. To repair surface damage, do the following steps:

1. Locate the damaged area. If there are cracks, see if they go all the way through the cap. If they do, refer to "Structural Damage Repair" for instructions.
2. Clean the area with xylene or an equivalent grease- and wax-removing solvent. Inspect the area closely.
3. Using 220-grit or finer sandpaper, remove all of the paint around the damaged area to a distance of about 1-1/2 inches (4 cm). See **Fig. 1**.



A. Remove paint and primer 1-1/2 inches (4 cm) around the damaged area. Use 220-grit or finer sandpaper.

1. Paint
2. Primer
3. Scratch

Fig. 1, Damaged Area With Paint Removed

4. Using an air nozzle, blow off all dust.

Mid-Roof Cab Repairs

5. Use filler (Ashland Pliogrip 7775L self-leveling urethane) over the non-coated area, and spread a thin layer using a squeegee applicator. Cover the entire damaged area, overlapping onto the painted surface. Leave a crowned excess of filler, slightly higher than the painted surface.

NOTE: When using Ashland Pliogrip 7775L, dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.

6. After the filler dries (about five minutes), sand it with a hand-held disc pad. Use 320-grit or finer sandpaper. Feather the edges of the fill so there are no visible sharp edges.
7. Clean the area with compressed air. Mask the area, then spot prime and paint it. Use Sherwin Williams BB-11 black conductive primer. See **Group 98** for spot-painting instructions.

Structural Damage Repair

The mid-roof cap assembly consists of a single, molded skin with bonded internal reinforcement. See **Fig. 2**.

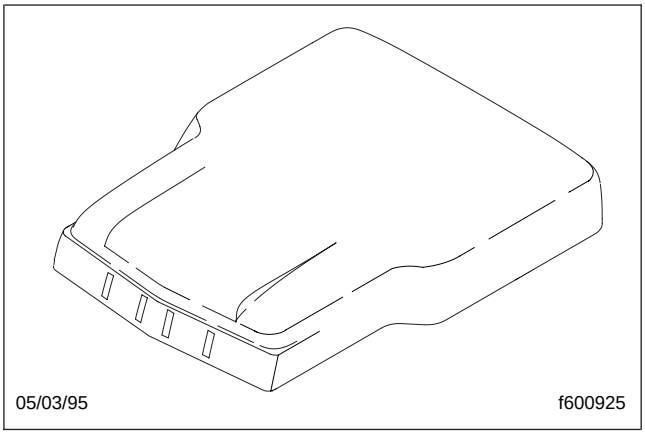


Fig. 2, Mid-Roof Cap

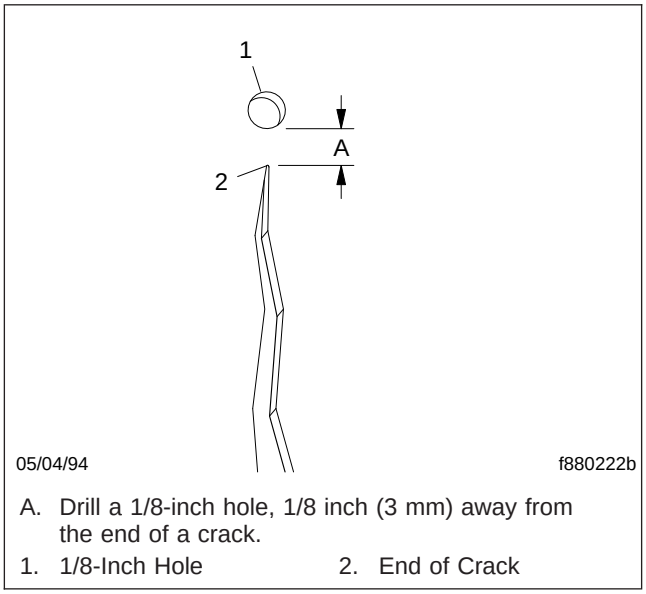
For damage in the form of a small crack or hole, refer to "Crack or Small Hole Repair."

For larger damaged areas, refer to "Section Replacement (Repair of Punctures and Large Fractures)."

CRACK OR SMALL HOLE REPAIR

A crack (fracture) or small hole through the laminate requires repair with a fiberglass reinforced patch.

1. Examine the damage to the roof cap assembly. Apply hand pressure all around the damaged area to check for any concealed damage.
2. If upholstery and/or thermal insulating material is present in the damaged area, remove the material to provide an adequate working area.
3. Clean the area with xylene, acetone, or an equivalent grease- and wax-removing solvent. Inspect the area closely. All dirt, water, grease, and oils must be removed.
4. If repairing a crack, use a 1/8-inch diameter bit to drill a hole completely through the uncracked laminate 1/8 inch (3 mm) from each end of the crack, to prevent the crack from lengthening. See **Fig. 3**.

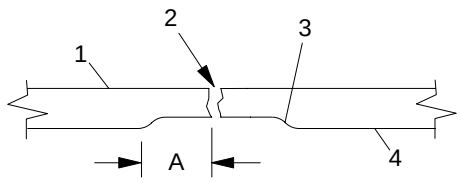


A. Drill a 1/8-inch hole, 1/8 inch (3 mm) away from the end of a crack.
1. 1/8-Inch Hole
2. End of Crack

Fig. 3, Repair Area

5. On the inner surface of the roof cap, use a router bit (on a grinder or a drill) to grind away a shallow recess one-quarter the depth of the roof panel and 1/2 inch (13 mm) outward from all sides of the damage. Taper the outside edge of the ground area. See **Fig. 4**.

If repairing a crack, grind outward to the drilled hole at the end of the crack, but not beyond. See **Fig. 5**.



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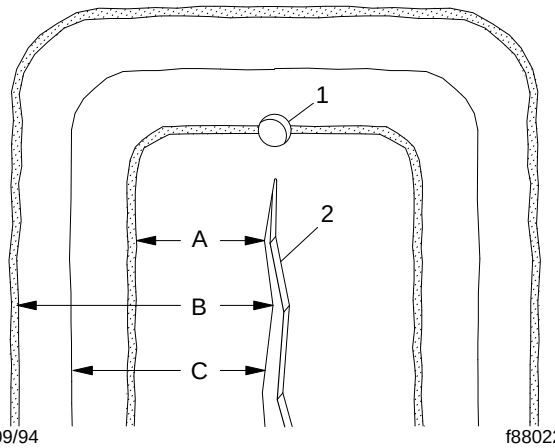
A. Grind a shallow recess one-quarter the depth of the roof cap and 1/2 inch (13 mm) outward in all directions from the damaged area.

1. Roof Cap
2. Crack
3. Slight Taper
4. Underside of Cap

Fig. 4, Recessed Area (cross-sectional view)



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A. Use a router to grind away a shallow recess one-quarter the depth of the roof cap and 1/2 inch (13 mm) outward from the damage. If repairing a crack, don't grind past the hole drilled at the end of the crack.
B. Use 80- to 220-grit sandpaper to scuff the area one inch (25 mm) around the damage.
C. Cut the fiberglass cloth to fully cover the damage, and overlay about 3/4 inch (19 mm).

1. Hole
2. Crack

Fig. 5, Preparing the Damaged Area on the Inner Side of the Roof Cap

6. Use 80- to 220-grit sandpaper to scuff an area at least 1 inch (25 mm) away from the fracture on all sides. Be sure to scuff thoroughly, since this will give the patch a surface to which it can stick. See **Fig. 5**.
7. Blow the dust away with compressed air and wipe the area with a clean cloth.
8. If necessary, align the panel sections on both sides of the crack, using weights or clamps to re-establish the original panel profile.
9. With a razor-blade knife, cut a section of woven fiberglass cloth to fully cover the crack and to overlay about 3/4 inch (19 mm). See **Fig. 5**.
10. To bond the fiberglass cloth to the damaged panel, choose one of the following bonding agents:
    - Magnolia Magnabond 58 epoxy resin
    - Ashland Pliogrip® 7773 urethane adhesive

IMPORTANT: Do not mix epoxy and urethane.

When using Magnolia Magnabond 58: Measuring the volumes with a spoon, and using a wooden stir stick, mix equal parts of Magnolia Magnabond 58 A and B epoxy resins on a clean sheet of glass, metal, or a section of scrap laminate. Mix for fifteen seconds to ensure a good blend.

IMPORTANT: With Magnolia Magnabond 58, it is critical to measure the A:B ratio accurately. Also, make sure the two components are adequately mixed.

When using Ashland Pliogrip 7773: Dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.

11. Use a plastic or metal device to spread a thin layer of the bonding agent over the scuffed area.
12. Lay the cut section of fiberglass cloth on the repair area, centered over the damage. Using a fiberglass roller, press the cloth down firmly into the layer of bonding agent to completely soak the glass fibers.
13. Apply another layer of bonding agent over the glass cloth. Spread the agent evenly using the fiberglass roller.

Mid-Roof Cab Repairs

14. After two to five minutes, the bonding agent will start to jell. It may take more time when cool, less when warm.

IMPORTANT: To avoid pre-jelling or skin-over, mate the FRP parts to be bonded within one to four minutes after extruding and applying the bonding agent.

NOTE: To get a smoother surface, press a piece of masking tape, wider than the repair, directly over the wet bonding agent and smooth it before it hardens. The tape can be removed after fifteen minutes when the agent has set.

15. The patch should be hard enough in fifteen minutes to allow sanding to a smooth flat surface if required.

16. Repair the damage on the outside surface of the panel and paint the surface on both sides, using the instructions in "Surface Damage Repair."

PUNCTURE AND LARGE FRACTURE REPAIR

On very large damaged areas (for example, structural damage on the roof cap covering an area of a square foot or more) it may be easier to do a section replacement rather than make a patch. Another damaged roof with the needed section intact may be available as scrap.

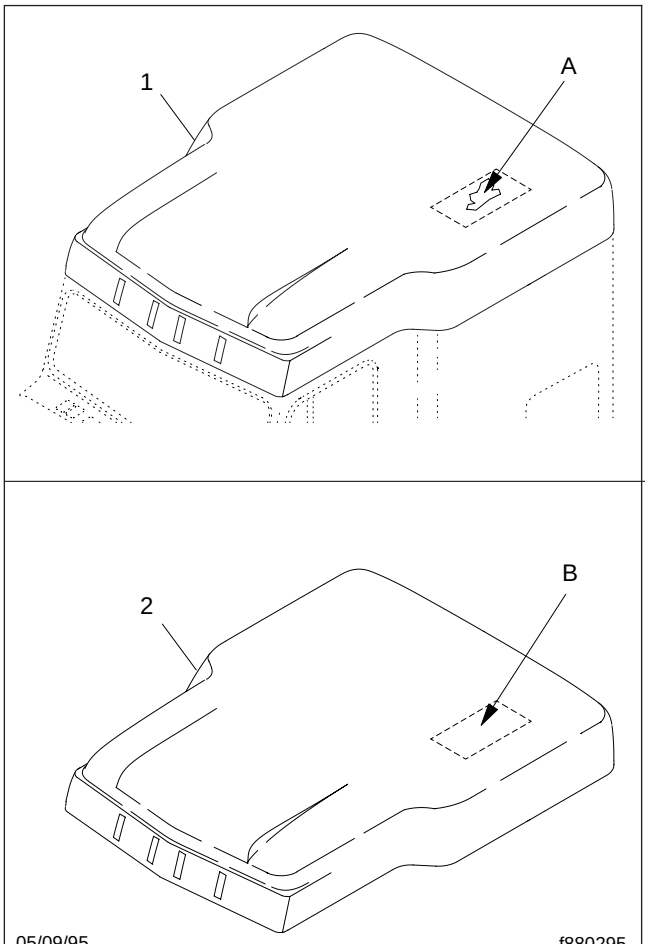
IMPORTANT: A piece of FRP laminate from a roof or hood must be used for section replacement. Use of any other material may not allow the necessary bonding for the repair.

1. Push in on the area immediately surrounding and underneath the damaged area to determine the extent of the damage.

2. If upholstery and/or thermal insulating material is present in the damaged area, remove the material to provide an adequate working area.

3. Clean the area with xylene, acetone, or an equivalent grease- and wax-removing solvent. Inspect the area closely. All dirt, water, grease, and oils must be removed.

4. Using a saber saw, cut out a large, straight-sided panel containing the damaged area. See the example in **Fig. 6**.



A. Remove this area.
B. Use as a section replacement for damaged roof skin.
1. Damaged Roof
2. Scrap Roof

Fig. 6, Section Replacement of a Damaged Fiberglass Roof

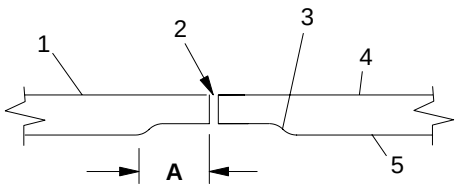
WARNING

WARNING: Wear goggles and an air purifying respirator when grinding, cutting, or sanding during all fiberglass repairs. The ground dust and particles could cause temporary or permanent damage to your eyes and, if inhaled, could cause throat or lung irritation.

5. From the scrap roof, cut a section replacement panel from the same area, only slightly larger than the original cutout. See the example in

Fig. 6, Ref. B. Then, trim the section replacement to fit both the size and contour of the original cutout.

6. After the trimming is completed, sand the edges to allow a 1/16- to 1/8-inch (about 2- to 3-mm) gap around the cutout.
7. On the inner side of the panel, use a router bit (on a grinder or drill) to grind away a shallow recess one-quarter the depth of the roof cap, 1/2 inch (13 mm) outward from all sides of the cutout area. Also, grind 1/2 inch (13 mm) inward from all sides of the section replacement. Slightly taper the outside edge of the ground area on the roof panel and the inside edge of the ground area on the section replacement. See Fig. 7.



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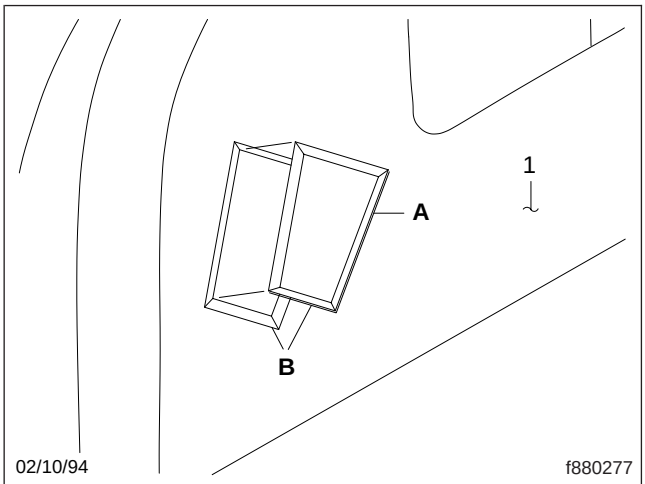
A. Grind a shallow recess one-quarter the depth of the roof cap and 1/2 inch (13 mm) outward in all directions from the damaged area.
1. Section Replacement
2. Gap
3. Slight Taper
4. Roof Panel
5. Underside of Roof

Fig. 7, Cutout Area (cross-sectional view)

8. Use 80- to 220-grit sandpaper to scuff an area at least 1 inch (25 mm) out from all sides of the cutout area.

   Also, scuff at least 1 inch (25 mm) in from all sides of the section replacement. Be sure to scuff thoroughly, since this will give the section replacement a surface to which it can stick. Be sure to completely sand off any undercoating sprayed on these areas.
9. On the outer sides of both the cutout and the section replacement, bevel the edges about 45 degrees. See Fig. 8.
10. Gently feather the outer painted surfaces back about 1/2 inch (13 mm) beyond the edges of the repair areas (on both the cutout and the section replacement), using 220-grit or finer sandpaper.



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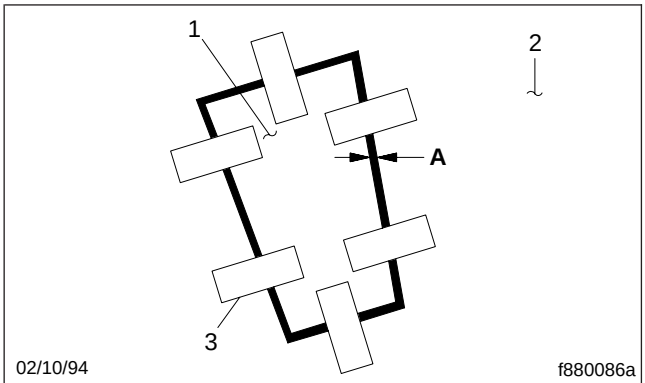
A. Insert section replacement.
B. Bevel outer surface edges on all sides.
1. Exposed Side of Roof

Fig. 8, Areas to be Beveled

11. Blow the dust away with compressed air and wipe the area with a clean cloth.
12. If the section replacement is close enough to an edge, use clamps to temporarily secure it during the repair. If the replacement is too far from an edge to use clamps, use bond strips as shown in Fig. 9.



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A. Gap of 1/16 inch to 1/8 inch (2 to 3 mm)
1. Section Replacement
2. Underside of Roof
3. Bond Strip

Fig. 9, Securing the Section Replacement to the Roof Cap Using Bond Strips

12.1 Cut some scrap FRP into strips. Make enough strips to hold the section replacement in position, about one every six

Mid-Roof Cab Repairs

inches (15 cm). If the surface of the replacement panel is contoured or curved, use many small bond strips. Larger strips could deform the curves.

12.2 On the inner side of the repair, use 80- to 220-grit sandpaper to scuff sand the areas on the roof where you plan to bond the strips.

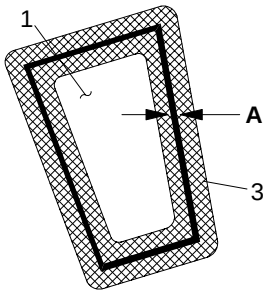
12.3 Holding the section replacement in position, bond the strips to both roof and replacement panels in the area already scuffed. Use Lord F Fusor® 320/322 or Ashland Pliogrip 7773 to bond the strips.

12.4 If Fusor 320/322 is used, apply light pressure and heat from a heat gun to the area for three to five minutes.

12.5 After the bonding agent has hardened, use 80- to 220-grit sandpaper to scuff the bond strips.

12.6 Blow the dust away with compressed air and wipe the area with a clean cloth.

13. With a razor-blade knife, cut sections of woven fiberglass cloth to fully cover the gap between the cutout and the section replacement, all the way around the damaged area. The cloth should overlay about 3/4 inch (19 mm) on both sides of the gap. See **Fig. 10**.



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NOTE: The fiberglass cloth should overlay about 3/4 inch (19 mm) on both sides of the gap.

A. Gap of 1/16 inch to 1/8 inch (2 to 3 mm)
1. Section Replacement
2. Underside of Roof
3. Fiberglass Cloth

Fig. 10, Fiberglass Cloth Overlay

14. To bond the fiberglass cloth to the damaged area, choose one of the following bonding agents:

- Magnolia Magnabond 58 epoxy resin
- Ashland Pliogrip 7773 urethane adhesive

IMPORTANT: Do not mix epoxy and urethane.

When using Magnolia Magnabond 58: Measuring the volumes with a spoon, and using a wooden stir stick, mix equal parts of Magnolia Magnabond 58 A and B epoxy resins on a clean sheet of glass, metal, or a section of scrap laminate. Mix for fifteen seconds to ensure a good blend.

IMPORTANT: With Magnolia Magnabond 58, it is critical to measure the A:B ratio accurately. Also, make sure the two components are adequately mixed.

When using Ashland Pliogrip 7773: Dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.

15. Use a plastic or metal device to spread a thin layer of the bonding agent over the scuffed area.

16. Lay the cut sections of fiberglass cloth on the repair area, centered over the damage. Using a fiberglass roller, press the cloth down firmly into the layer of bonding agent to completely soak the glass fibers.

17. Apply another layer of bonding agent over the glass cloth. Spread the agent evenly using the fiberglass roller.

18. After two to five minutes, the bonding agent will start to jell. It may take more time when cool, less when warm.

IMPORTANT: To avoid pre-jelling or skin-over, mate the FRP parts to be bonded within one to four minutes after extruding and applying the bonding agent.

NOTE: To get a smoother surface, press a piece of masking tape, wider than the repair, directly over the wet bonding agent and smooth it before it hardens. The tape can be removed after fifteen minutes when the bonding agent has set.

Repair

Dashboards and consoles are made of injection-molded thermoplastics. Damage such as cracks, tears, splits, or holes can be repaired, and painted surfaces can be touched-up in damaged areas.

Before any service or repair is done on areas made of this structural foam, clean the surfaces with soapy water or a mild nonabrasive cleaner.

CAUTION

CAUTION: Do not use protectant treatments. Some cleaners contain noncompatable chemicals which can initiate stress-crazing and cracking of the structural foam.

In some instances, the structural foam panel may need to be removed for service.

IMPORTANT: If service is required on particular sections (see **Fig. 1** or **Fig. 2**) of the dash, the individual gauge and control panels can be removed to gain access to the area needing repair. Remove the screws attaching the control panel to the dash, then move the panel away from the dash. On COE vehicles, to remove Panel C (see **Fig. 2**), first remove the accessory panel located on the lower left corner of Panel C, then disconnect the spring that secures the panel to the cab (see **Fig. 3**). Remove the screws that attach Panel C to Panel D, then remove Panel C.

Small Scratches or Scrapes

Minor scratches and scrapes can be refinished by first removing any burrs with a razor knife and then by painting, using the instructions given under "Touch-Up Painting."

Gouges, Chips, or Deep Scratches

Gouges, chips, or deep scratches can be filled with one of the following filler compounds:

- Sherwin-Williams D61–A–21;
- Pettit Paint Polyester Mender;
- Fiberglass-Evencoat, Brightwhite Formula 27;
- Linkoloid Spackling Paste, or an equivalent plastic spackling compound.

Follow these instructions to repair gouges, or chipped or deeply scratched areas:

1. Use a razor knife to scrape the scratch or gouge clean. Take care not to damage the surrounding paint.
2. Mix the filler compound, if being used, following the manufacturer's instructions.
3. Fill the damaged area with the filler compound and smooth the filled area with a flexible, non-scratching tool, such as a plastic spatula. While the compound is still soft, use a clean, damp cloth to wipe off the excess compound from the surrounding area and the painted surfaces.

NOTE: If using spackling paste, fill the damaged area slightly higher than the surface. Spackling paste will shrink as it drys.

4. After the compound is dry, sand the filled area with 400-grit (or finer) sandpaper.
5. Paint over the area. For instructions, see "Touch-Up Painting."
6. Allow 12 to 24 hours to dry. Then, if necessary, use very fine steel wool to buff and blend in the gloss with the rest of the area.

Cracks, Tears, or Splits

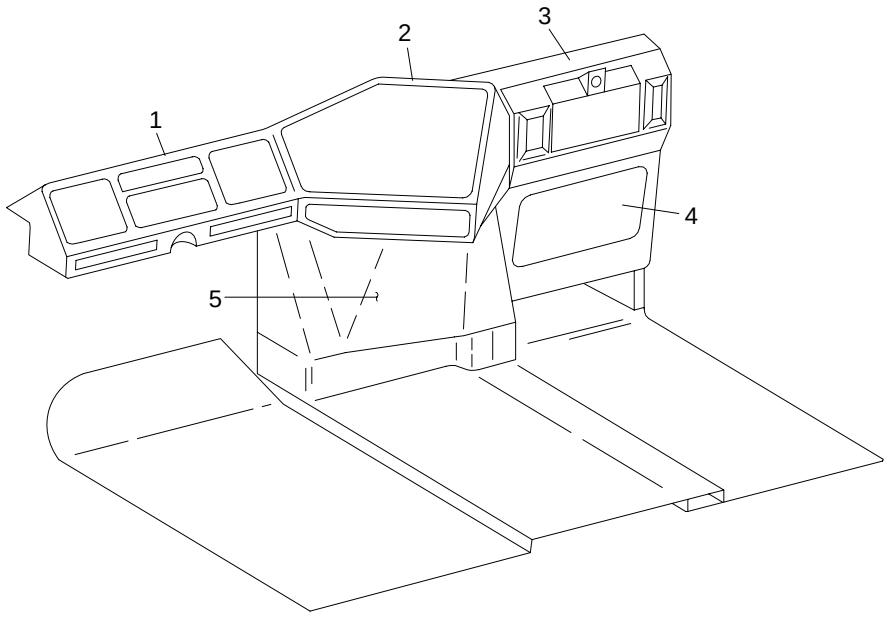
IMPORTANT: The following pertains only to bonding structural foam to itself. Do not attempt to join other materials using this method.

1. Apply SC125 acrylic cement, methylene chloride, or MEK to the surfaces to be bonded together.
2. Join the surfaces together and apply a light pressure until an initial bond strength is achieved.

NOTE: If bonding a crack, apply light pressure to open up the crack so that the cement penetrates all the way through to the back. Additional cement can be applied on the back of the crack.

3. Allow to dry for at least 12 hours before applying any stress to the repaired areas.

Panel Repair



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1. Panel A
2. Panel B
3. Panel C
4. Panel D
5. Panel E

Fig. 1, Conventional Dash

Holes, 1/4-inch (6 mm) Or Smaller

NOTE: Gain access to the back side of the hole.

1. Cut a piece of scrap structural foam, enough to make a snug fit in the hole.
2. Apply a flat piece of steel or aluminum against the rear of the hole. This will "pull away" the heat, preventing distortion in the surrounding material. Using a soldering iron, insert the tip into the hole until the foam along the edges of the hole begins to melt.

⚠ CAUTION

CAUTION: Discontinue heating when the foam along the edges of the hole has melted. Overheating will cause the surrounding area to melt. This will result in disfigurement of the hole and the possibility of bubbles forming on the surface of the surrounding area.

3. Remove any excess material with a razor knife.

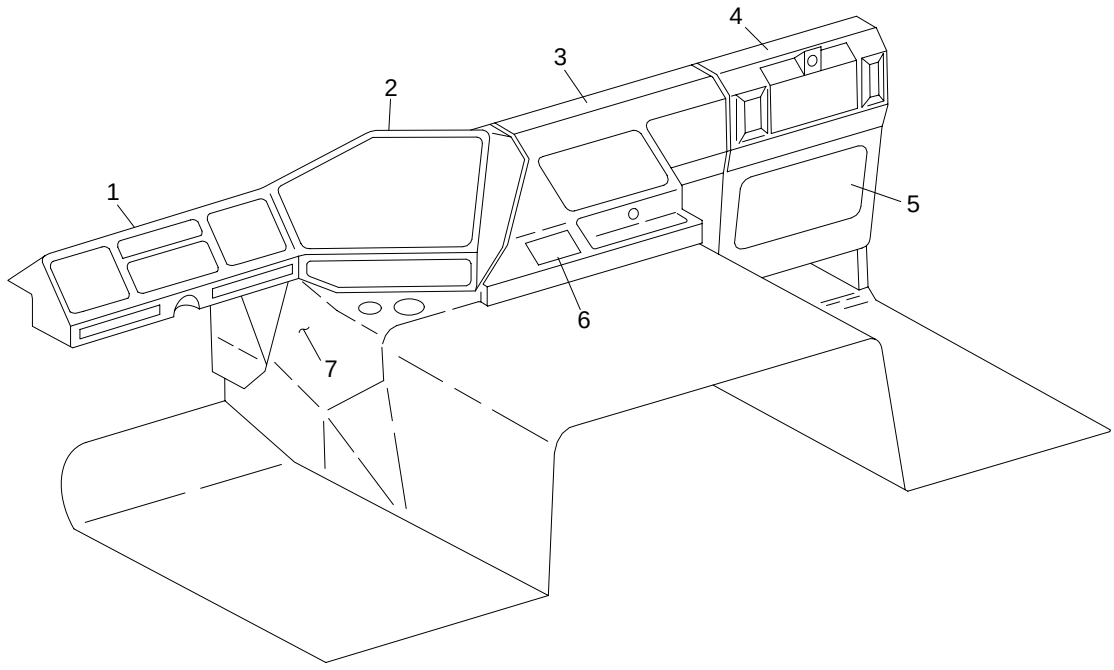
Holes, Larger Than 1/4-inch (6 mm)

NOTE: Gain access to the back side of the hole.

1. Fill the hole with strips of fiberglass cloth from the back side. Bond the fiberglass with fiberglass resin.
2. Mix the filler compound, if used, following the manufacturer's instructions. For recommended filler compounds, see "Gouges, Chips, Or Deep Scratches." Apply the compound to the fiberglass and allow it to dry.

NOTE: If using spackling paste, fill the damaged area slightly higher than the surface. Spackling paste will shrink as it drys.

3. After the compound is dry, sand the filled area with 400 grit (or finer) sandpaper. Wipe the area clean with a damp cloth.
4. Paint over the area. For instructions, see "Touch-Up Painting."



1. Panel A
2. Panel B
3. Panel C
4. Panel D
5. Panel E
6. Accessory Panel
7. Panel F

Fig. 2, COE Dash

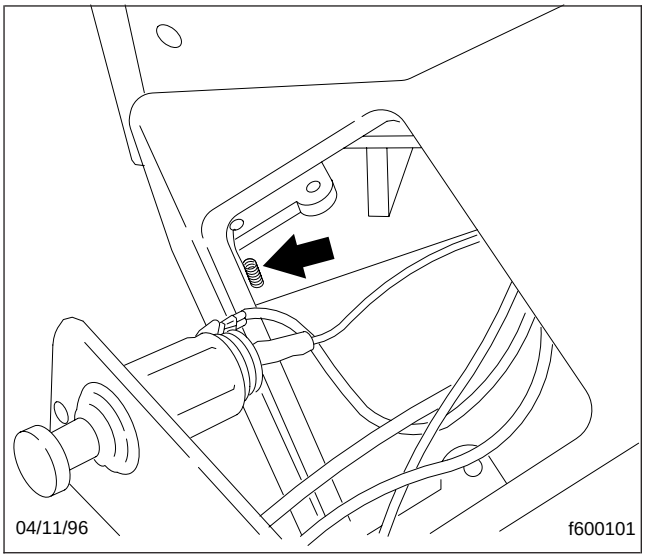


Fig. 3, Spring to be Disconnected

5. Allow 12 to 24 hours to dry. Then, if necessary, use very fine steel wool to buff and blend in the gloss with the rest of the area.

Touch-Up Painting

For saddle-colored structural foam sections, use Dupont Lucite H7909L paint or Sherwin Williams Polane T No. Z99NY17 paint. For black-colored structural foam sections, use Dupont Lucite H7911L paint or Sherwin Williams Polane T No. Z99BY4 paint.

1. If using Dupont Lucite H7909L saddle-colored paint, mix the paint and tint according to the applicable mixing formula given in **Table 1**.

   If using Dupont Lucite H7911L black-colored paint, mix the paint and tint according to the applicable mixing formula given in **Table 2**.

   If using Sherwin Williams Polane T Z99NY17 saddle-colored paint, or Sherwin Williams Polane T Z99BY4 black-colored paint, mix the paint, catalyst, and reducer for one minute, using the

ratio of: six units paint, one unit catalyst, and four units reducer.

Dupont Lucite H7909L Saddle-Color Tint and Paint Mixing Formula		
Tint	**Ounces Tint/1 Ounce Paint**	**Grams Tint/ 1 mL Paint**
453L	0.184	0.175
428L	0.308	0.295
406L	0.352	0.337
402L	0.369	0.353
465L	0.845	0.811
4528S	0.981	0.940

Table 1, Dupont Lucite H7909L Saddle-Color Tint and Paint Mixing Formula

Dupont Lucite H7911L Black-Color Tint and Paint Mixing Formula		
Tint	**Ounces Tint/1 Ounce Paint**	**Grams Tint/ 1 mL Paint**
406L	0.369	0.354
465L	0.857	0.822
4528S	0.964	0.925

Table 2, Dupont Lucite H7911L Black-Color Tint and Paint Mixing Formula

IMPORTANT: After one minute of mixing, Polane T paint must be used within the next five minutes. If this time is exceeded, add two units of reducer, and use within one minute.

2. An air brush or camel hair brush can be used to apply the paint to the structural foam. A small applicator, such as a toothpick, can also be used to apply paint in a small area.

NOTE: If possible, paint only in the damaged area as the surface texture is difficult to reproduce.

3. If using an air brush, spray the paint lightly over the damaged area until a slight gloss appears. Allow the solvent to flash off, then lightly spray a second coat and feather out around the damaged area. Keep within 1-1/2 inches (38 mm) of the damaged area.

   If using a camel hair brush, apply paint quickly and directly over the area. Do not continue brushing. Let the work stand for at least 30 minutes before applying a second coat. Allow two hours before handling.

NOTE: If too much paint is applied, pat the area with a soft sponge. Excess paint can be scraped off with a razor knife.

4. To texture a large area (for appearance), use a piece of material with a textured surface (a small piece of sponge or terry cloth) and dab the paint over the area.
5. Clean all tools immediately after painting. These paints have now catalyzed. They cannot be removed with solvent after they dry.

Repair

Some Freightliner interior cab linings and upholstery panels are formed from ABS plastic sheets. Damage such as cracks, tears, splits, or holes can be repaired by bonding using an ABS plastic pipe cement that meets ASTM (American Society for Testing and Materials) specification D–2235.

Before any service or repair is done on areas made of ABS plastic, thoroughly clean the surfaces with soapy water or a mild non-abrasive cleaner and allow the work to dry completely.

⚠ CAUTION

Do not use lacquer thinner to clean the ABS surfaces. It can cause stress lines in the ABS plastic.

IMPORTANT: This procedure is intended only for bonding ABS plastic to itself. Do not attempt to join different materials to each other by this method.

Gain access to the back side (smooth side) of the ABS section to be repaired. By removing some attaching fasteners, most ABS panels can be lifted enough to provide access to the back side of the panel to bond a reinforcement. If necessary, remove the panel and perform the repairs on a workbench.

Cut and form a scrap piece of ABS plastic for use as a reinforcement on the back side of the repair. Apply the ABS plastic cement to the surfaces you are bonding. Join the surfaces together and the hardening of the cement will form the bond.

Cracks, Tears, or Splits

1. Cut out a reinforcement piece from some scrap ABS with tinsnips or heavy-duty scissors. The reinforcement must overlap the cracked area on all sides to properly support the repair. If available, cut a reinforcement piece from an identical scrapped ABS section.

NOTE: If an identical piece is not available, form a piece by heating and bending it. Place the piece on the edge of a workbench, heat it with a heat gun, and bend it to form the desired angle.

2. Apply a moderate, even coat (avoid excess) of ABS plastic cement to the cracked surfaces, the back side of the cracked panel, and the reinforcement piece. Work rapidly since the cement hardens quickly.
3. Join the cracked surfaces and apply the reinforcement piece to the back side of the panel. Apply light pressure for approximately 30 seconds, until an initial bond strength is achieved.
4. Clamp the bonded area, if possible, for at least 30 minutes. Do not flex the repaired area for at least 30 minutes after bonding. Allow the work to set for eight to 12 hours.

Holes, 1/4-inch (6 mm) Or Smaller

NOTE: The damaged area must be in a horizontal position to prevent the ABS plastic cement from dripping when the hole is filled.

1. Cut out a reinforcement piece from some scrap ABS with tinsnips or heavy-duty scissors. The reinforcement piece must be larger in circumferance than the hole to properly support the repaired area. If available, cut a reinforcement piece from an identical scrapped ABS section.

NOTE: If an identical piece is not available, form a piece by heating and bending it. Place the piece on the edge of a workbench, heat it with a heat gun, and bend it to form the desired angle.

2. Apply a moderate, even coat (avoid excess) of ABS plastic cement to the reinforcement piece and the surrounding back side of the hole. Work rapidly since the cement hardens quickly.
3. Apply the reinforcement piece to the back side of the panel. Apply light pressure for approximately 30 seconds, until an initial bond strength is achieved.
4. Make enough shavings to fill the hole by filing a piece of scrap ABS plastic.
5. Mix the shavings with ABS plastic cement, then fill the hole with the mixed shavings and cement. Before the cement hardens, pat the filled hole with a piece of cloth having a rough surface (such as the back of a piece of scrap carpet) to create a texture. Allow the work to set for eight to 12 hours.

Upholstery Panel and Cab Lining Repair

Holes, Larger Than 1/4-inch (6 mm)

1. Shave the edges of the hole or section so that they are smooth and even.
2. Cut a piece of scrap ABS plastic the size and shape of the hole, using tinsnips or heavy-duty scissors. Insert and fill the hole with this piece. Cut a reinforcement piece larger in circumference than the hole to properly support the repaired area. If available, cut a reinforcement piece from an identical scrapped ABS section.

NOTE: Size the filler piece by placing the scrap ABS plastic piece on the back side of the hole, then outline the shape of the hole with a pencil. If an identical piece is not available, form a piece by heating and bending it. Place the piece on the edge of a workbench, heat it with a heat gun, and bend it to form the desired angle.

3. Apply a moderate, even coat (avoid excess) of ABS plastic cement to the reinforcement piece, the surrounding back side of the hole, and the back side of the fitted piece. Bond the reinforcement piece and the fitted piece together, then attach the assembly to the back side of the hole so that the fitted piece fits into the hole. Work rapidly since the cement hardens quickly.
4. Clamp the bonded area, if possible, for at least 30 minutes. Do not flex the area for at least 30 minutes after bonding. Allow the work to set for eight to 12 hours.

Repair of Stress Lines

Stress lines generally result from the severe bending or impacting of ABS plastic and produce a whitened appearance in a localized area. Gradually heat an area showing stress lines with a heat gun. Allow it to cool, and the ABS plastic will return to its original color and condition.

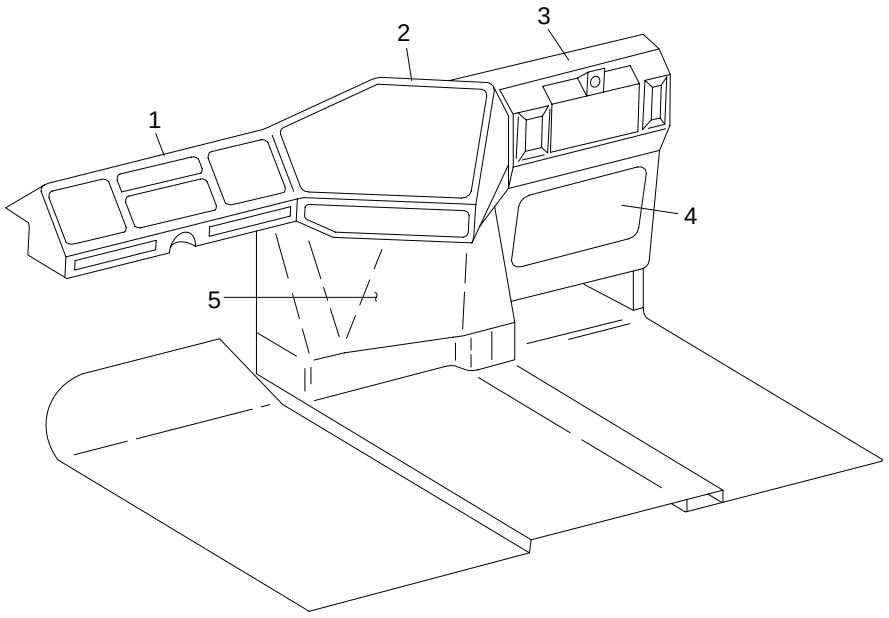
⚠ CAUTION

Use care not to overheat ABS plastic. If overheated, the material will become too soft and lose its original shape. Hold a moist cloth against the back side of the material during heating to minimize the softening of the plastic.

FLD Conventional Dash Removal and Installation

Removal

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Disconnect the batteries. Refer to **Group 54** in this manual for instructions.
3. Remove the steering wheel. Refer to **Group 46** in this manual for instructions.
4. Remove the electrical center cover. See **Fig. 1**, Ref. 5.
9. Remove the plastic cover in the driver's knee area. Mark and disconnect the electrical connectors and, if equipped, the switches.
10. Remove the fasteners from the bottom surface of the lower dash cover. Remove the lower dash cover from the center dash panel.
11. Remove the top covers from the dash on the driver's side of the vehicle.
12. Open the glove compartment on the passenger's side of the vehicle. Remove the fasteners inside the glove compartment, and remove the glove compartment from the vehicle.



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1. Driver's Instrument Panel
2. Center Dash Panel
3. Glove Compartment
4. Heater-A/C Cover
5. Electrical Center Cover

Fig. 1, Dash Panel

5. Mark and disconnect the main cab power feeds from the junction stud (circuit 14).
6. Disconnect the trailer 7-way cable from the ring terminal junction block.
7. Mark and disconnect the engine and chassis harness bulkhead connectors from the mounting plate. See **Fig. 2**.
8. Remove the lower plastic covers on the right and left sides of the electrical center.
13. Remove the heater-A/C cover.

NOTE: If the heater-A/C unit is to be removed, drain the coolant and evacuate the refrigerant.

14. Mark and disconnect the heater-A/C wires.
15. With tilt steering column equipped vehicles, tilt the column to the furthest aft tilt position and fully collapse the column.
16. Remove the turn signal switch and trailer brake controls from the steering column.

FLD Conventional Dash Removal and Installation

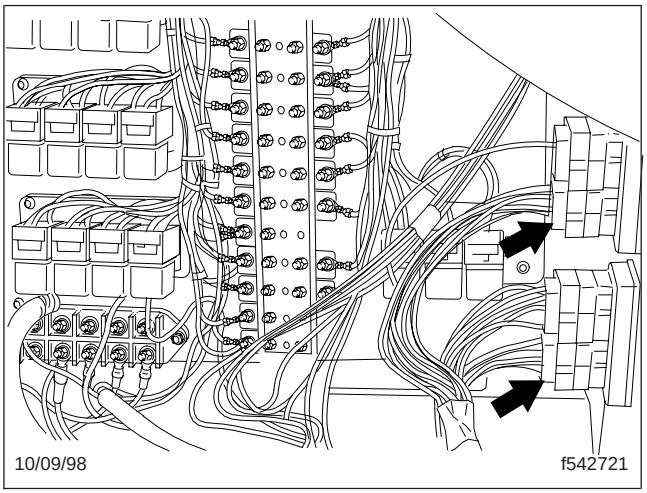


Fig. 2, Main Cab Power Feeds

17. Remove the fixed steering column from the support bracket, if equipped.
18. Remove the electrical center mounting screws and bulkhead connector mounting bracket screws from the interior frontwall.

⚠ CAUTION

Do not let the hood free-fall to the full-open position. To do so could cause damage to the hood, or the stop cables or hood straps, as equipped.

19. Open the hood. See **Fig. 3**.
20. On the exterior frontwall, unplug the electronic engine harness connector.
21. Remove the electronic engine harness bulkhead connector on the exterior frontwall and carefully push the connector in to the cab interior. Use care not to bend the connector pins.
22. Disconnect the windshield wiper air lines and/or the electrical connectors and washer lines. Refer to **Group 82** for instructions. If the vehicle is equipped with intermittent wiper controls or is electrically powered, the wipers will need to be removed from the cab harness side connectors to permit the wires to be passed back into the cab. Mark the wires to permit correct assembly.
23. Disconnect all air lines from the junction block, located beneath the steering column. Mark the lines and the junction block for correct assembly.

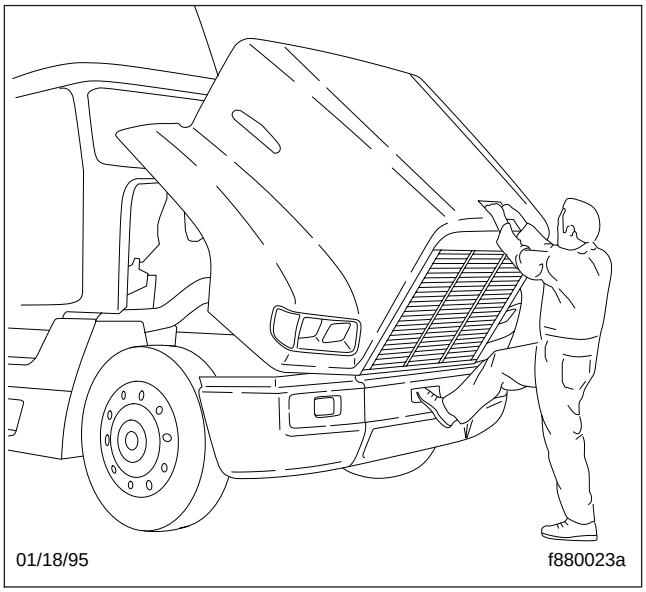


Fig. 3, Opening the Hood

24. If possible, remove all air lines that are routed to the anchor couplings on the far left side of the interior frontwall. If access from the inside of the cab does not permit removal, the air lines must be removed from the engine side and then the anchor couplings passed into the cab interior.
25. Remove the air ducts located on the left lower side of the dash.
26. Mark and disconnect the electrical connectors that route to the doors and/or to the cab mounted mirrors. Some of the cab side connectors may have to be removed from the wires to permit the wires to be passed to the cab interior.
27. Remove the center windshield post and its plastic end covers. Disconnect the electrical connectors in the overhead console and place the wires on the dash.
28. On raised roof SleeperCabs with a floor harness, mark and disconnect the wires that are routed in the floor harness.
29. Remove the fasteners that attach the dash to the lower steel support brackets at both sides of the center interior frontwall.
30. Remove the fasteners that attach the dash to the nosebeam at the top of the dash.

NOTE: Only center steel support fasteners need to be loosened.

31. Remove the dash.

Installation

1. Position the dash in the vehicle.
2. Install the fasteners that attach the dash to the nosebeam at the top of the dash.
3. Install the fasteners that attach the dash to the lower steel support brackets at both sides of the center frontwall.
4. If working on a raised roof SleeperCab, connect the wires that are routed in the floor harness.
5. Connect the two electrical connectors in the overhead console at the windshield post. Position the center windshield post and the plastic covers on the windshield, and install the fasteners.
6. Connect the electrical wires that route to the doors.
7. Install the air ducts located on the left lower sides of the dash.
8. If removed, install the air lines that are routed to the anchor couplings on the left side of the frontwall.
9. Connect the air lines to the junction block.
10. Connect the windshield wiper assembly. Refer to **Group 82** in this manual for instructions.
11. Insert the harness bulkhead connector to the interior frontwall. Install the retaining nut, and tighten securely.
12. On the exterior frontwall, plug in the electronic engine harness.
13. Close the hood.
14. If equipped, install the fixed steering column on the support bracket.
15. Install the turn signal switch and the trailer brake controls to the steering column.
16. Connect the wires to the heater-A/C unit.
17. Position the glove compartment on the passenger's side of the vehicle, and install the fasteners.
18. Install the top covers on the driver's side dash.
19. Install the heater-A/C cover.
20. Attach the lower dash cover to the center dash section.
21. Install the plastic cover on the driver's knee area.
22. Install the lower plastic cover on the left and right sides of the electrical center.
23. Connect the engine and chassis harness bulkhead connectors to the mounting plate.
24. Connect the trailer 7-way cable to the ring terminal junction block.
25. Connect the main cab power feeds to the junction stud (circuit 14).
26. Install the electrical center cover.
27. Install the steering wheel. Refer to **Group 46** in this manual for instructions.
28. Connect the batteries.
29. Charge the A/C system, and fill the radiator with coolant.
30. Remove the chocks from the tires.

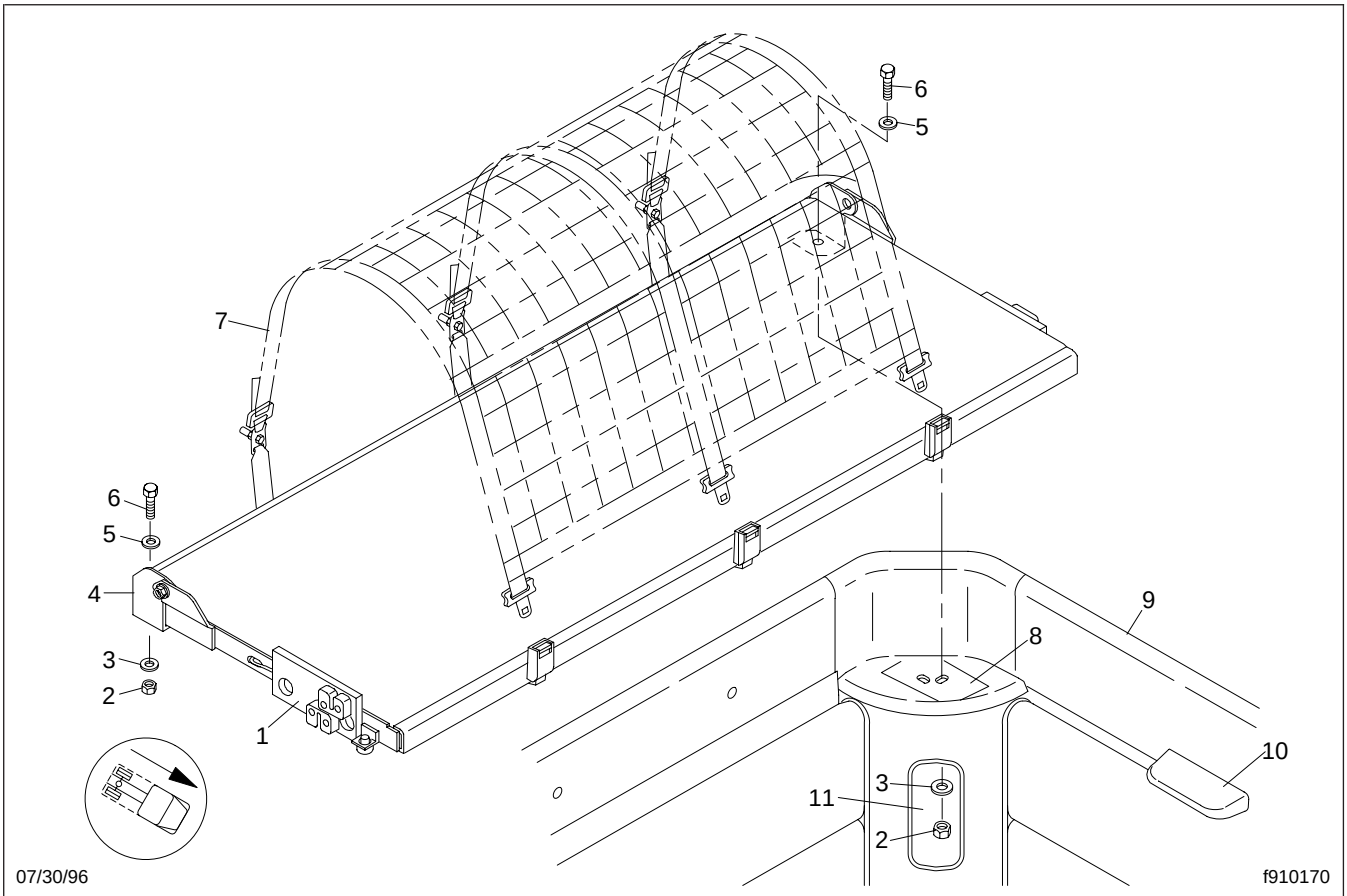
Dymetrol Upper Bunk Removal and Installation

Removal

1. Park the vehicle and apply the parking brake.
2. Chock the tires.
3. Remove the bunk. See **Fig. 1.**

⚠ WARNING

WARNING: Support the bunk assembly before removing the mounting bolts. If not supported, the bunk could fall on you, which could result in



1. Latch Mounting Bracket
2. Nut
3. Washer
4. Bunk Assembly
5. Washer
6. Bolt
7. Bunk Restraint
8. Bunk Mount
9. Cab Sidewall
10. Bunk Support
11. Control Panel

Fig. 1, Upper Bunk Structure

3.1 Raise the bunk and make sure it is securely latched .

3.2 Remove the sleeper bunk control panel to gain access to the left-side bunk mounting bolt and nut.

personal injury.

3.3 Support the bunk assembly, then remove the nut, bolt, and washers from each of the two bunk mounts.

Dymetrol Upper Bunk Removal and Installation

3.4 With the aid of a helper, remove the bunk assembly from the vehicle.

Installation

1. Install the bunk. See **Fig. 1.**

   1.1 With the aid of a helper, set the bunk in its raised position onto the mounts. Support the bunk securely.

⚠ WARNING

WARNING: Support the bunk assembly while installing the mounting bolts. If not supported, the bunk could fall on you, which could result in personal injury.

   1.2 On each side, install the mounting bolt and washers and tighten the nut.

   1.3 Install the sleeper bunk control panel at the left rear of the bunk.

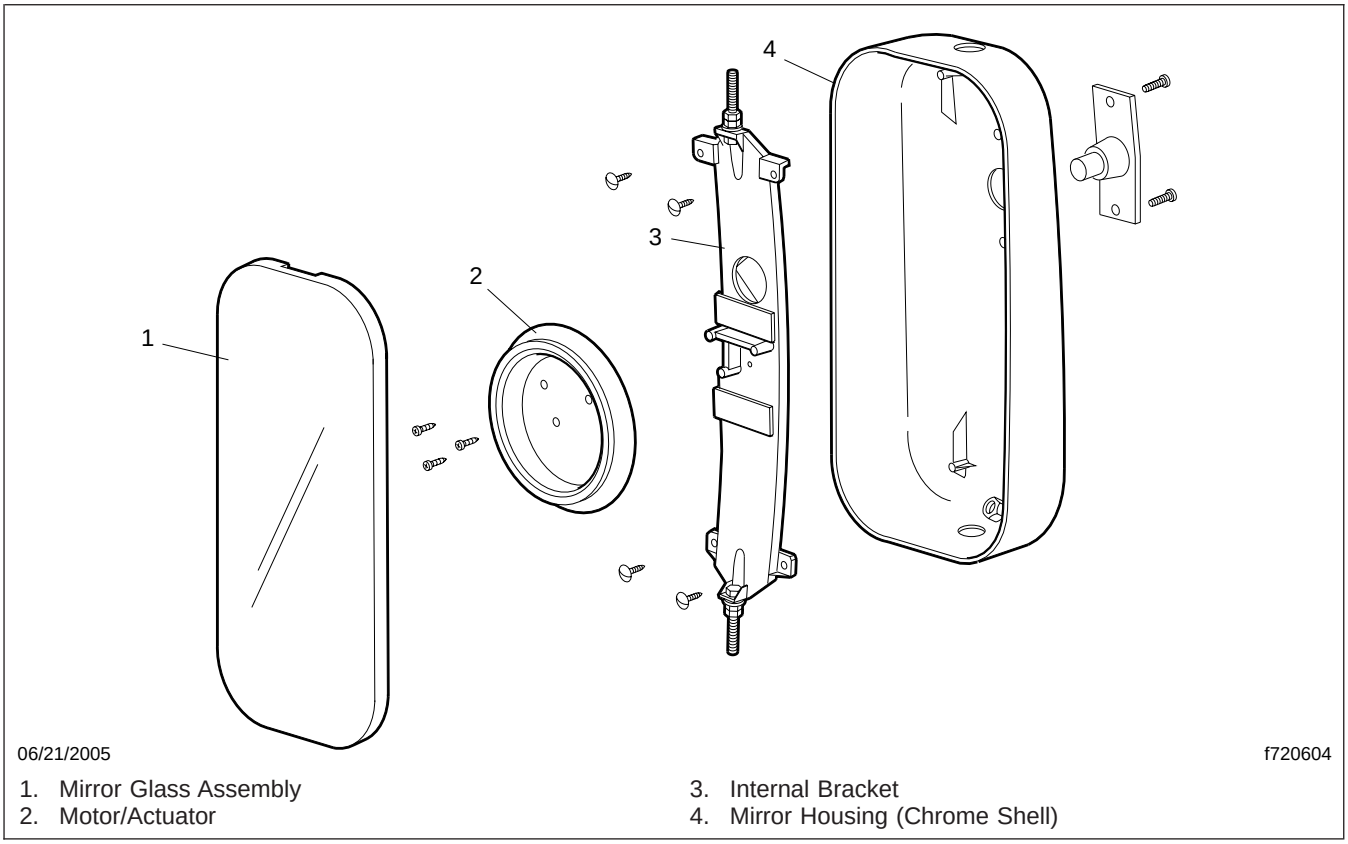
   1.4 Lower the bunk.

2. Remove the chocks from the tires.

General Information

The Hadley 4WAY mirror (**Fig. 1**) is manually adjustable. When adjusting the mirror, only the glass moves, not the entire mirror housing as in traditional single-axis-movement mirrors. Whether the mirror is motorized or not, its position may be changed by simply pushing on the mirror glass, without causing drive system damage.

Both the mirror glass assembly and the motor/actuator are fully replaceable in the field.



1. Mirror Glass Assembly
2. Motor/Actuator
3. Internal Bracket
4. Mirror Housing (Chrome Shell)

Fig. 1, Hadley 4WAY Mirror Assembly

Removal

1. Rotate the mirror fully to the right.
2. Find the small lever near the center of the left edge of the mirror glass. Push the lever down while holding on to the mirror glass. Pull the mirror glass assembly out of the mirror housing.
3. Disconnect the heater wire connections at the bottom of the mirror glass assembly.

Installation

1. Connect the heater wire connections to the mirror glass assembly.

NOTE: Each heater wire can be connected to either heater terminal, since the heater is not polarity-sensitive.

2. Push the mirror lever fully down, then position the mirror glass assembly on the motor/actuator. Ensure that the mirror glass assembly is fully engaged on the motor/actuator, and while holding it in place, move the lever up to lock it in place.

Motor/Actuator Replacement

1. Remove the mirror glass assembly as described in **Subject 100**.
2. Locate the wires that are routed from the harness to the motor/actuator, and remove the electrical tape. Cut the green, yellow, and white wires just below the connection to the motor/actuator wires.
3. Using a T15 Torx® driver, remove the three motor/actuator retaining screws, and set them aside. Remove the motor/actuator from the housing.
4. Strip approximately 1/4 inch (6 mm) of the insulation from the harness wires.
5. Connect the harness wires to the new motor/actuator wires, matching the colors as shown in **Table 1**.

Wire Color Matching	
Harness Wire Colors	**Motor/Actuator Wire Colors**
Green	Blue
Yellow	Black
White	Yellow and White

Table 1, Wire Color Matching

6. Ensure that the two black motor/actuator mounting pads are still in place on the bracket before installing the motor/actuator. Place the motor/actuator on the mounting points, and attach it with the three screws. Do not over-tighten the screws.
7. Install the mirror glass assembly as described in **Subject 100**.

Troubleshooting Tables

Problem—Mirror Glass Will Not Move When Activating Mirror Switch

Problem—Mirror Glass Will Not Move When Activating Mirror Switch	
Possible Cause	**Remedy**
The mirror head is not motorized.	Confirm that the mirror head is a motorized head by removing the glass and checking if there are wires attached to the motor/actuator.
The fuse or circuit breaker is open.	Replace the fuse or reset the circuit breaker.
An obstruction in the mirror head is preventing the mirror glass from moving.	Have an assistant listen to the motor/actuator as you activate the mirror switch. If the motor is attempting to move the mirror glass, check for any possible obstructions that may keep the mirror glass from moving.
The motor/actuator is not working.	Find and disconnect the mirror harness connector from the truck cab connector. Using the mirror operation tables in **Specifications 400**, supply power to the motor/actuator from an external power source. If the motor/actuator still does not work, replace it. If it does work, check the mirror switch and wiring.

Problem—The Mirror Will Not Stay Adjusted, Moves at High Speed, or Vibrates

Problem—The Mirror Will Not Stay Adjusted, Moves at High Speed, or Vibrates	
Possible Cause	**Remedy**
The mirror bracket is loose.	Check all mirror bracket fasteners. Tighten any that are loose.
The mirror head is loose.	Check the mirror-head mounting nuts. Tightening any that are loose.
The motor/actuator is loose.	Check the motor/actuator screws. Tighten any that are loose, using a T15 Torx driver.
The mirror has broken or worn parts.	Check for broken or worn parts. Check the mirror glass assembly, the motor/actuator mounting ring, and the internal bracket. Replace them, if necessary. NOTE: If there is noticeable wear on the motor/actuator or the mirror glass assembly, replace both components.

Problem—The Mirror Heater Does Not Work

Problem—The Mirror Heater Does Not Work	
Possible Cause	**Remedy**
The fuse or circuit breaker is open.	Replace the fuse or reset the circuit breaker.
The heater switch connections are loose.	Check the heater switch connections. Reconnect loose wires, if necessary.

Troubleshooting

Problem—The Mirror Heater Does Not Work	
Possible Cause	**Remedy**
The heater element does not work.	Remove the mirror glass assembly. Carefully disconnect the heater element wires from the heater element terminals. Place the mirror heater switch in the "On" position. With a voltage meter, check the heater element wires for the presence of 12 volts (or the battery source voltage). If the source voltage is present, replace the mirror glass assembly. If the voltage is not present, check and repair the wiring and connectors.
The wiring is damaged or disconnected.	NOTE: The heater element can also be checked by applying 12 volts directly from a battery or a power supply to the heater element terminals. Since the heater element is not polarity-sensitive, each power lead can be connected to either terminal. The heater should draw 2 to 5 amps, depending on the ambient temperature at the time of the test. Allow two minutes for the glass to become warm to the touch.

See **Table 1** and **Table 2** for the Hadley 4WAY mirror wire function and motor/actuator operation information.

Mirror Wire Harness	
Wire Color	**Wire Function**
Blue	Light (Positive)
Red	Heat (Positive)
Black	Heat (Ground)
Yellow	Motor—Y Axis
White	Motor—Common
Green	Motor—X Axis

Table 1, Mirror Wire Harness

Motor/Actuator Operation		
Apply Positive (+) Voltage	**Apply Negative (-) Ground**	**Motor Movement**
Yellow	White	Up
White	Yellow	Down
White	Green	Left
Green	White	Right

Table 2, Motor/Actuator Operation

General Information

The Velvac mirror is an 8 by 16 inch (20 by 40 cm) electrically heated, remote-controlled mirror with marker lights. Using switches that mount in the cab, a driver can remotely adjust the position of each mirror. The mirror is rotated by an electric motor mounted to a slip clutch. The slip clutch allows for manual adjustment of the mirrors without damage to the electric motor or drive gears. A temperature-controlled heater heats the mirror surface to remove moisture and ice and the marker lights on the mirrors signal the widest points of the vehicle to oncoming traffic.

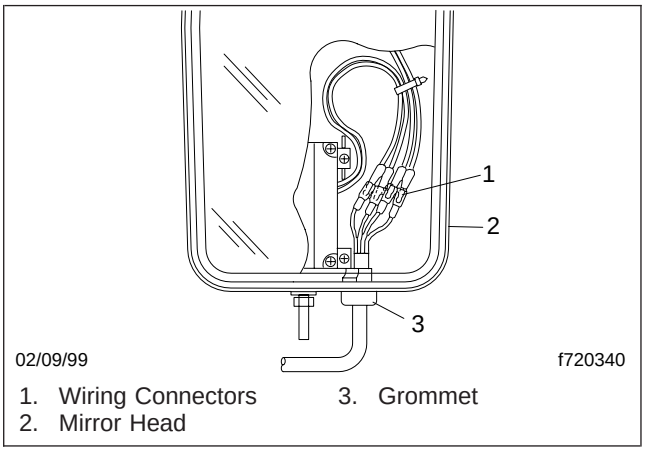
Velvac Mirror Removal and Installation

Removal

1. Apply the parking brake, turn the keyswitch to the OFF position and chock the tires.
2. Disconnect the batteries.

NOTE: Most repairs to the Velvac mirrors can be made with the mirror head still mounted to the brackets on the vehicle.

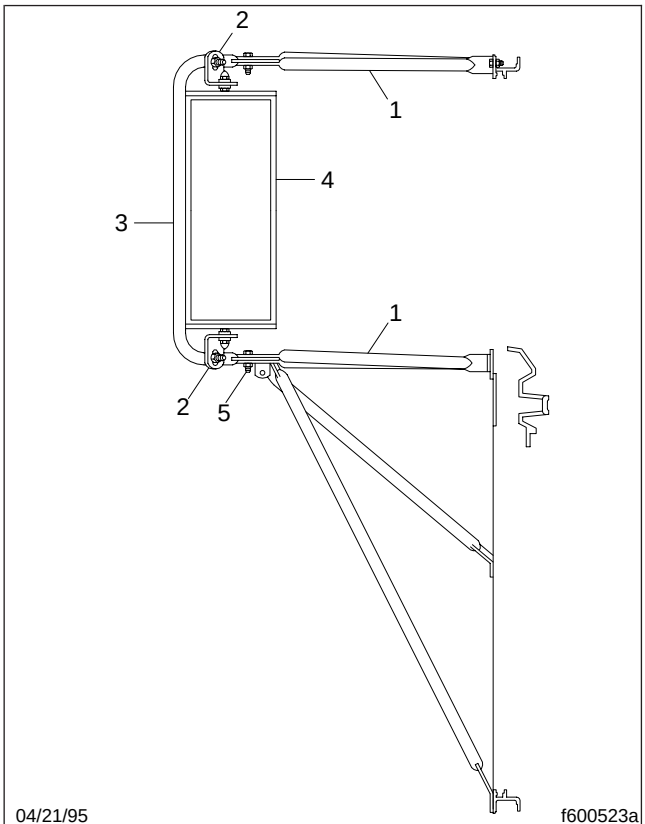
3. Using pliers or a grommet tool, depress the grommet tab and remove the plastic grommet for the mirror wiring harness from the bottom of the mirror head. See **Fig. 1**.



1. Wiring Connectors
2. Mirror Head
3. Grommet

Fig. 1, Disconnecting the Wiring

4. Pull the wires through the hole for the grommet so that the wire connectors are outside the mirror head. Disconnect all the electrical connectors at the mirror.
5. If a convex mirror is mounted on the bottom shaft of the Velvac mirror, remove the convex mirror.
6. Remove the nuts securing the L-brackets to the C-bracket and remove the Velvac mirror from the vehicle. See **Fig. 2**.
7. Using a 1/2 inch backup wrench to prevent the jam nuts at the top of the mirror head from turning on the shaft, remove the locknut from the top shaft. Remove the washers and L-bracket from the top shaft.
8. Using a 9/16 inch backup wrench to prevent the nut at the bottom of the mirror head from turning, remove the locknut from the bottom shaft. Remove the washers and L-bracket from the bottom shaft. See **Fig. 3**.



1. A-Bracket
2. L-Bracket
3. C-Bracket
4. Velvac Mirror
5. Mount for Convex Mirror

Fig. 2, Typical Mirror Mounting Arrangement

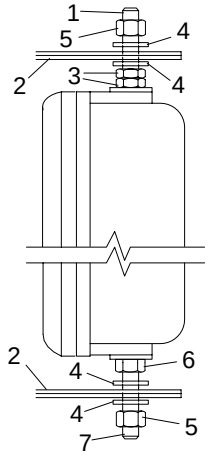
IMPORTANT: Do not allow the lower nut next to the mirror head to turn on the bottom shaft when removing the locknut. The torque on this nut is set at the factory.

Installation

1. Install a flatwasher on top of the two jam nuts on the top shaft of the mirror head. Install the top L-bracket and another flatwasher. Install a hexnut with a split lockwasher onto the top shaft.

IMPORTANT: Use a backup wrench on the jam nuts to prevent the jam nuts from turning the top shaft of the mirror. These jam nuts have been

Velvac Mirror Removal and Installation



1. 5/16–18 Thread
2. Clamp
3. Jam Nuts
4. Flatwasher
5. Locknut
6. Large Nut
7. Motor Shaft

Fig. 3, Typical Mirror Mounting Arrangement

tightened at the factory and must not rotate when tightening the top L-bracket locknut. The top shaft must be free to rotate on the mirror head.

2. With a backup wrench on the jam nuts to prevent turning, tighten the locknut that holds the L-bracket on the top shaft to 60 to 80 lbf·in (680 to 900 N·cm) for the non-motorized mirrors. Tighten the hexnut to 125 to 200 lbf·in (1410 to 2260 N·cm) for the motorized mirrors.
3. Install a flatwasher on the bottom shaft of the mirror head. Install the bottom L-bracket and another flatwasher. Install the hexnut with a split lockwasher onto the bottom shaft.

IMPORTANT: Use a backup wrench on the nut next to the mirror head to prevent the nut from turning on the bottom shaft of the mirror. The nut was tightened at the factory and must not rotate when tightening the bottom L-bracket locknut. If the nut has loosened, tighten it only until the bottom shaft starts turning with the nut.

4. With a backup wrench on the nut next to the mirror head to prevent turning, tighten the locknut that holds the L-bracket on the bottom shaft 14 lbf·ft (19 N·m).
5. Connect the wires from the mirror to the wiring harness according to the color code chart in **Table 1**.

Mirror Wiring Color Code	
Mirror Head	**Harness**
Red (heater +)	Red
Black (heater, light –)	Black
Blue (light +)	Blue
White (motor)	White
Green (motor)	Green

Table 1, Mirror Wiring Color Code

6. Slide the plastic grommet to its original position on the jacket of the mirror harness. Using pliers or a grommet tool, push the grommet and harness into the hole in the bottom of the mirror head. Make sure that the grommet tab locks the grommet in place.
7. Install the convex mirror (if removed) on the end of the lower A-bracket.

⚠ WARNING

Grab only the mirror head when turning the mirror by hand. Do not apply force to the mirror glass or the glass could break and cause injury.

8. Rotate the mirror head by hand to make sure that there is clearance.
9. Connect the batteries.
10. Test the operation of all the mirror functions using the switches inside the cab. The mirror should be warm to the touch within 5 minutes of starting the mirror heater.
11. Remove the chocks from the tires.

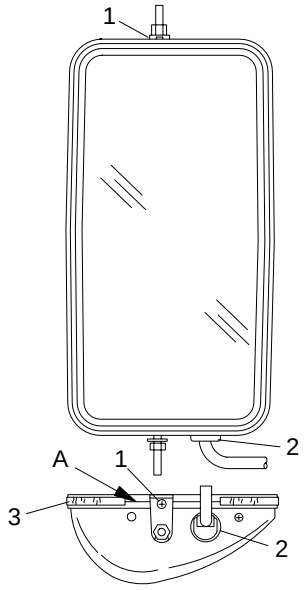
Velvac Mirror Motor Replacement

Removal

1. Apply the parking brake, turn the keyswitch to the OFF position, and chock the tires.
2. Disconnect the batteries.

NOTE: The motor in the Velvac mirror can be replaced with the mirror head still mounted to the brackets on the vehicle.

3. Remove any tape from the perimeter of the bezel. Remove the two screws on both the top and the bottom of the mirror head. See **Fig. 1**.



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A. Separate bezel/mirror head here.
1. Bezel Screws
2. Grommet
3. Tape

Fig. 1, Velvac Mirror Disassembly

CAUTION

Avoid putting force on the glass or using sharp tools to separate the glass from the mirror housing. The glass can easily break and the housing can be scratched by the use of sharp tools.

4. Use your hands to carefully separate the bezel and glass assembly from the mirror housing. The plastic bezel is held in the housing by six Tinnerman® clips in the internal groove along the rear edge of the mirror housing.
5. Remove the wire connectors from the heater element on the back of the mirror glass. Put the mirror glass and heater element is a safe place.
6. Cut the tie strap and remove the wires to the mirror motor.
7. Remove the lower L-bracket from the A-bracket. Remove the locknut, L-bracket, and flatwashers from the motor shaft at the lower bracket.
8. Install two jam nuts on the motor shaft and tighten against each other. Hold a backup wrench on the outer jam nut to prevent the motor shaft from turning. Remove the large nut from the motor shaft.

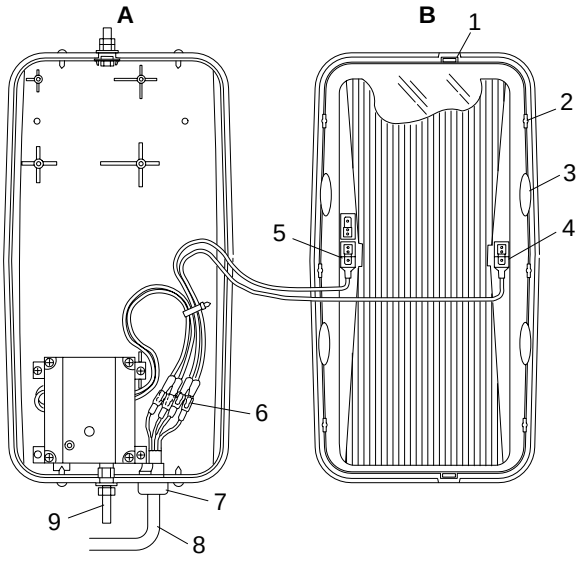
NOTE: The nut on the motor shaft uses thread sealant to help it stay in position.

9. Using a Phillips screwdriver, remove the four screws that hold the motor to the housing. Lift the motor from the mirror housing.

Installation

1. Install the shaft of the new motor into its hole in the housing.
2. Install and carefully tighten the four screws that hold the motor to the housing.
3. Apply Loctite® 271 to the threads of the motor shaft nut and install it on the shaft. Tighten the nut until the shaft begins to turn.
4. Install a flatwasher, the lower L-bracket, another flatwasher, and a new nylon-insert locknut, but do not tighten the locknut.
5. Fasten the lower L-bracket to the A-bracket. Use a 9/16 inch backup wrench to prevent the shaft nut from turning and tighten the locknut on the end of the motor shaft.
6. Connect the wires from the motor to the wires of the same color in the harness. Install a tie strap in the same location as before.
7. Remove any Tinnerman clips left in the groove in the housing or on the bezel. Install new clips in the six locations on the bezel shown in **Fig. 2**.
8. Connect the black wire and the blue wire to the two terminals on the ground side of the heating element. Connect the red wire to the terminal on the other side of the element.

Velvac Mirror Motor Replacement



A. Mirror Head
B. Glass/Heating Element and Bezel
1. Alignment Tab
2. Tinnerman Clips
3. Factory-applied Silicone
4. Heating Element Power Connection
5. Heating Element Ground Connection
6. Wire Connectors
7. Grommet
8. Wire Harness
9. Motor Shaft

Fig. 2, Velvac Mirror Assembly

9. Align the tabs on the top and bottom of the bezel with the slots in the housing. Carefully and evenly press the glass and bezel assembly into the groove in the housing so that the clips firmly hold the bezel assembly in place.
10. Carefully press the glass and bezel assembly against the housing while installing the bezel mounting screws into the housing. Push down on the screwdriver while turning the screws, but do not over-tighten the screws into the plastic mirror housing.
11. Apply the tape, that was removed earlier, around the perimeter of the bezel.
12. Connect the batteries and test the mirror operation.
13. Remove the chocks from the tires.

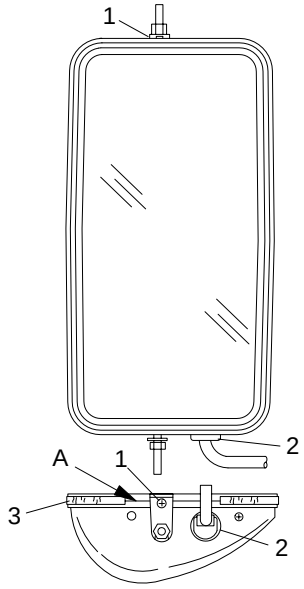
Velvac Mirror Glass and Heating Element Removal and Installation

Removal

1. Apply the parking brake, turn the keyswitch to the OFF position, and chock the tires.
2. Disconnect the batteries.

NOTE: The heating element in the Velvac mirror can be replaced with the mirror head still mounted to the brackets on the vehicle.

3. Remove and discard any tape from the perimeter of the bezel. Remove the screws on the top and the bottom that hold the bezel to the mirror head. See **Fig. 1**.



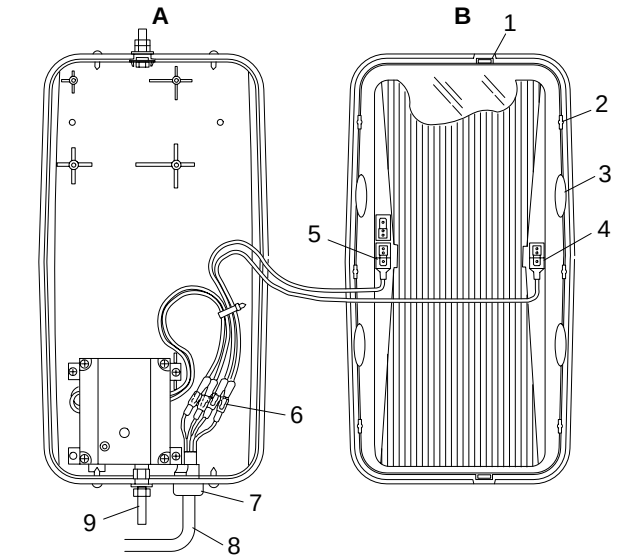
A. Separate bezel/mirror head here.
1. Bezel Screws
2. Grommet
3. Tape

Fig. 1, Removing the Bezel

CAUTION

Avoid putting force on the glass or using sharp tools to separate the glass from the mirror housing. The glass can easily break and the housing can be scratched by the use of sharp tools.

4. Use your hands to carefully separate the bezel and glass assembly from the mirror housing. The plastic bezel is held in the housing by six Tinnerman® clips in the internal groove along the rear edge of the mirror housing. See **Fig. 2**.



A. Mirror Head
B. Glass/Heating Element and Bezel
1. Alignment Tab
2. Tinnerman Clips
3. Factory-applied Silicone
4. Heating Element Power Connection
5. Heating Element Ground Connection
6. Wire Connectors
7. Grommet
8. Wire Harness
9. Motor Shaft

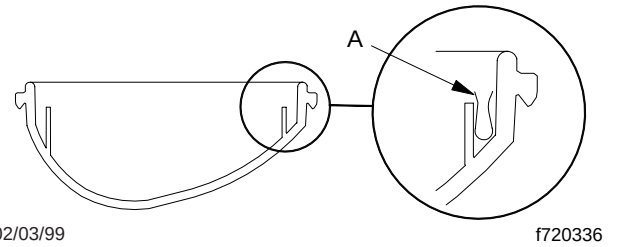
Fig. 2, Velvac Mirror Assembly

5. Remove the wire connectors from the heater element on the back of the mirror glass.
6. Peel the silicon from the bezel and remove the mirror glass and heating element.

Installation

1. Remove any Tinnerman clips left in the groove in the housing or on the bezel. See **Fig. 3**. Install new clips in the six locations on the bezel shown in **Fig. 2**.
2. Install the glass and heater element into the bezel. Apply silicon sealer four places along the glass perimeter to hold the glass to the bezel.

Velvac Mirror Glass and Heating Element Removal and Installation



A. Remove the clips from the groove in the housing.

Fig. 3, Removing the Clips

3. Connect the black wire and the blue wire to the two terminals on one side of the heating element. Connect the red wire to the terminal on the other side of the element.
4. Align the tabs on the top and bottom of the bezel with the slots in the housing. Carefully and evenly press the glass and bezel assembly into the groove in the housing so that the clips firmly hold the bezel assembly in place.
5. Carefully press the glass and bezel assembly against the housing while installing the bezel mounting screws into the housing. Push down on the screwdriver while turning the screws, but do not over-tighten the screws into the plastic mirror housing.
6. Connect the batteries and test the mirror operation.
7. Remove the chocks from the tires.

Troubleshooting

Use the information in the following troubleshooting tables to determine the possible causes and remedies of problems with the Velvac mirrors. To test the mirror components, go to the appropriate heading in this subject.

Problem—The Mirror Will Not Rotate When the Switch Is Closed

Problem—The Mirror Will Not Rotate When the Switch Is Closed	
Possible Cause	**Remedy**
An obstruction is in the path of the mirror.	Remove the obstruction.
The motor switch does not have power.	Turn the power on.
The fuse or circuit breaker is open.	Replace the fuse or reset the circuit breaker.
The switch is not working.	Test the switch. Replace it, if necessary.
The wiring is damaged.	Check and repair the wiring.
The motor is worn.	Test the motor. Go to "Testing the Electric Motor" in this subject.

Problem—The Heater Does Not Work

Problem—The Heater Does Not Work	
Possible Cause	**Remedy**
There is no power to the heater switch.	Turn the power on.
The fuse or circuit breaker is open.	Replace the fuse or reset the circuit breaker.
The switch is not working.	Test the switch. Replace it, if necessary.
The wiring is damaged.	Check and repair the wiring.
The heating element is not working.	Test the element. Go to "Testing the Heater" in this subject.

Problem—The Mirror Will Not Stay Adjusted, Moves at High Speed, or Vibrates

Problem—The Mirror Will Not Stay Adjusted, Moves at High Speed, or Vibrates	
Possible Cause	**Remedy**
The fasteners are not tight.	Tighten the mirror mounting hardware.
The slip clutch is worn.	Test the slip clutch. Go to "Testing the Slip Clutch" in this subject.

Problem—The Glass Is Broken

Problem—The Glass Is Broken	
Possible Cause	**Remedy**
An object has struck the glass.	Replace the glass. For instructions, go to **Subject 120**.

Troubleshooting

Problem—The Glass Surface Has Scratches

Problem—The Glass Surface Has Scratches	
Possible Cause	**Remedy**
The glass was cleaned incorrectly.	Replace the glass, if necesary. Use only non-abrasive cleaners and soft cloths to clean the glass surface.

Problem—The Glass Is Distorted

Problem—The Glass Is Distorted	
Possible Cause	**Remedy**
The mounting brackets are misaligned causing the head to flex.	Align the mounting brackets.
The mirror hits an obstruction during its rotation.	Remove the obstruction.

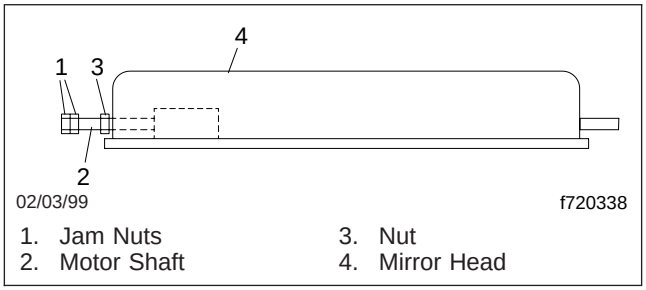
Problem—The Marker Light Does Not Illuminate

Problem—The Marker Light Does Not Illuminate	
Possible Cause	**Remedy**
The bulb is burnt.	Replace the bulb.
The switch is not working.	Test the switch. Replace it, if necessary.
The wiring is damaged.	Check and repair the wiring.
The fuse or circuit breaker is open.	Replace the fuse or reset the circuit breaker.

TESTING THE SLIP CLUTCH

The Velvac mirror slip clutch allows the mirror head to be positioned manually without damaging the motor gear assembly. The slip clutch resistance to rotation keeps the mirror from moving unintentionally. To test the torque needed to rotate the mirror head in relation to the motor shaft, use the following procedure.

1. Apply the parking brake, turn the keyswitch to the OFF position and chock the tires.
2. Disconnect the batteries.
3. Remove the Velvac mirror head from the vehicle. See **Subject 100** for the instructions.
4. Install two 5/16–18 jam nuts on the motor shaft of the mirror head. Using a backup wrench on one of the jam nuts, tighten the other jam nut against the first. See **Fig. 1**.



1. Jam Nuts
2. Motor Shaft
3. Nut
4. Mirror Head

Fig. 1, Testing the Slip Clutch

5. Use a beam-type or dial-type torque wrench on the outer jam nut. Hold the mirror head from rotating and note the reading on the torque wrench while rotating the jam nuts and motor shaft.
6. The torque required to turn the motor shaft in relation to the motor head must be between 60 and 110 lbf·in (680 to 1230 N·cm).
7. Replace the motor assembly if the torque needed to rotate the shaft is more than 110 lbf·in (1230 N·cm). For instructions, see **Subject 110**. If the motor shaft begins to turn at a torque value

of less than 60 lbf·in (680 N·cm), tighten the large nut on the motor shaft just until the shaft begins to turn with the nut. Check the rotating torque again. Replace the motor assembly if the torque needed to turn the shaft is still not correct.

TESTING THE ELECTRIC MOTOR

To test the electric motor that rotates the mirror head, use the following procedure.

1. Apply the parking brake, turn the keyswitch to the OFF position and chock the tires.
2. Disconnect the batteries.

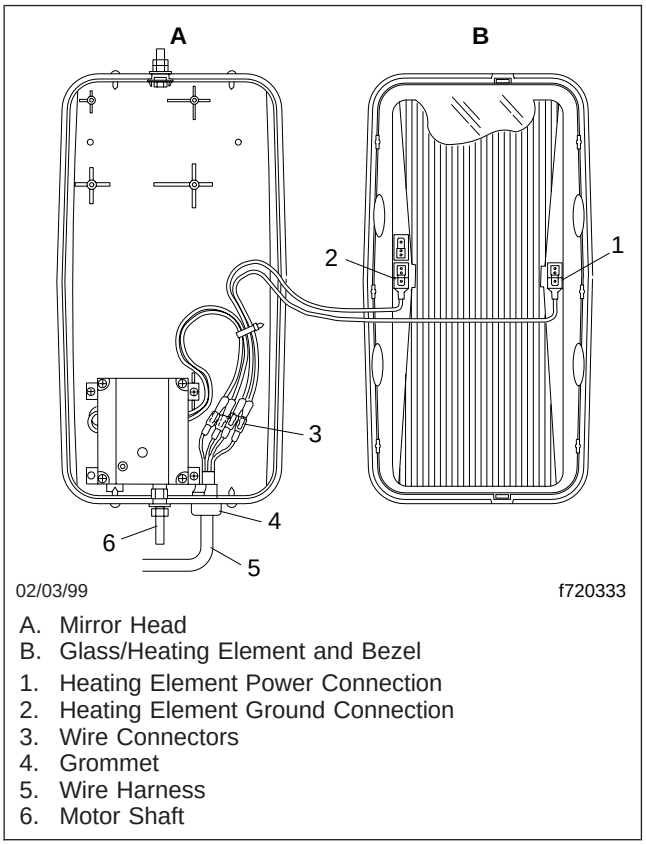
NOTE: Most repairs to the Velvac mirrors can be made with the mirror head still mounted to the brackets on the vehicle.

3. Using pliers or a grommet tool, depress the grommet tab and remove the plastic grommet for the mirror wiring harness from the bottom of the mirror head. See **Fig. 2**.
4. Pull the mirror wires through the hole for the grommet so that the wire connectors are outside the mirror head. Disconnect the electrical connectors for the white and the green wires.
5. Connect a jumper wire from the battery negative post (or a good ground) to the white wire in the mirror head.

⚠ CAUTION

The mirror head will immediately start rotating when you complete the temporary circuit. Make sure that your hands and all objects are out of the way of the mirror head before starting this test. Disconnect the wires before the mirror head can hit any object. Failure to do so could cause personal injury or damage to the mirror.

6. Temporarily touch a jumper wire from the battery positive post to the green wire in the mirror head. The motor should immediately start turning the mirror head in a clockwise direction (looking from the top).
7. Disconnect the white wire from the jumper wire connected to the battery negative post (or ground). Connect the grounded jumper to the green wire in the mirror.



A. Mirror Head
B. Glass/Heating Element and Bezel
1. Heating Element Power Connection
2. Heating Element Ground Connection
3. Wire Connectors
4. Grommet
5. Wire Harness
6. Motor Shaft

Fig. 2, Velvac Mirror Assembly

8. With your hands away from the mirror head, temporarily touch a jumper wire from the battery positive post to the white wire in the mirror head. The motor should immediately start turning the mirror head in a counter-clockwise direction (looking from the top).
9. Replace the motor if it does not operate as stated above. See **Subject 110** for the motor replacement procedure.
10. Remove the jumper wires and connect the batteries.
11. Remove the chocks from the tires.

TESTING THE HEATER

To test the electric heating element in the mirror head, use the following procedure.

1. Apply the parking brake, turn the keyswitch to the OFF position, and chock the tires.

Troubleshooting

2. Disconnect the batteries.
3. Using pliers or a grommet tool, depress the grommet tab and remove the plastic grommet for the mirror wiring harness from the bottom of the mirror head. See **Fig. 2**.
4. Pull the mirror wires through the hole for the grommet so that the wire connectors are outside the mirror head. Disconnect the electrical connectors for the black and the red wires.
5. Test for continuity in the heater circuit by connecting one probe of an ohmmeter to the black wire from the mirror and the other probe to the red wire. The ohmmeter must indicate continuity. Replace the mirror glass/heating element if the ohmmeter indicates an open circuit.
6. Connect a jumper wire from the battery negative post (or a good ground) to the black wire in the mirror head.
7. Connect a jumper wire from the battery positive post to the red wire in the mirror head. The heating element will make the mirror glass warm to the touch within 5 minutes.
8. Replace the mirror glass and heating element assembly if it does not operate as stated above. See **Subject 120** for the heating element replacement procedure.
9. Remove the jumper wires and connect the batteries.
10. Remove the chocks from the tires.

General Information

The aluminum cab is a semi-monocoque design, which means that the outer skin panels are load-bearing as is the internal framework. This type of construction requires less framework than standard cab construction, and results in a very strong, yet lightweight cab.

There are seven basic cab configurations: day cab, SleeperCab, mid-roof SleeperCab, raised-roof SleeperCab, sleeper box, raised-roof sleeper box, and Hi Style sleeper box.

The major cab parts are the front-wall assembly, right and left door-frame assemblies, right and left side-wall assemblies, back-wall assembly, front and rear roof cap assemblies (for mid-roof SleeperCabs), and the cab deck assembly. Day cabs have one roof-cap assembly. Mid-roof SleeperCabs have one glass-fiber-reinforced plastic (FRP) roof assembly. Raised-roof SleeperCabs have roof cap panels and cabinets made of glass-fiber-reinforced plastic (FRP) bonded together.

The over-lapping aluminum side-wall panels are joined with rivets, and reinforced with steel in high-stress areas. The steel front wall is assembled with Huckbolt® fasteners. The side cowl panels are made of fiberglass.

The cab deck consists of a framework of longitudinal sills and transverse crossmembers, with forward and rear deck plates fastened to them. Non-SleeperCabs have one deck plate.

When any repairs are done to the cab, it is necessary to check the frame rails for correct alignment and squaring. Then the cab must be leveled and squared. If the cab is repaired without straightening the frame rails, undue stress could be put on the cab, which could weaken it. Also, it may be impossible to square the cab.

Cab Water-Leak Detection

Use the following procedure to locate areas where water may intrude into the cab.

1. Park the vehicle, apply the parking brakes, and chock the front and rear tires.
2. Prepare a wash solution of at least one-quarter cup of soap to one gallon of water in a spray bottle.
3. Place tape over the cab exhausters.
4. Close all doors, windows, and vents.
5. With the HVAC system in "Fresh Air" mode, turn the fan blower motor on high.

NOTE: Perform the leak detection test with the HVAC system in the "Fresh Air" mode only. Do not set the system in the "Recirculation" mode.

6. Spray the cab, and sleeper if so equipped, with the wash solution, and look for bubbles. See **Fig. 1**. Inspect all applicable areas listed below:
   - windshield perimeter and center post
   - visor brackets
   - air horns and marker lights (if so equipped)
   - roof deflector mounts (if so equipped)
   - cab and sleeper roof seams (if present)
   - sleeper boot (if so equipped)
   - sleeper roof side windows (if present)
   - skylight window
7. Mark areas of suspected leaks.

NOTE: This method of leak detection may also identify areas that will not leak water, even though those areas produce bubbles. Bubbles around door seals, baggage doors, and along the vehicle side walls will likely not cause water intrusion issues.

If small bubbles are found in an area that is not suspected to leak, a repair may not be necessary.

8. Rinse the wash solution off the vehicle with water.
9. Turn off the fan blower motor.

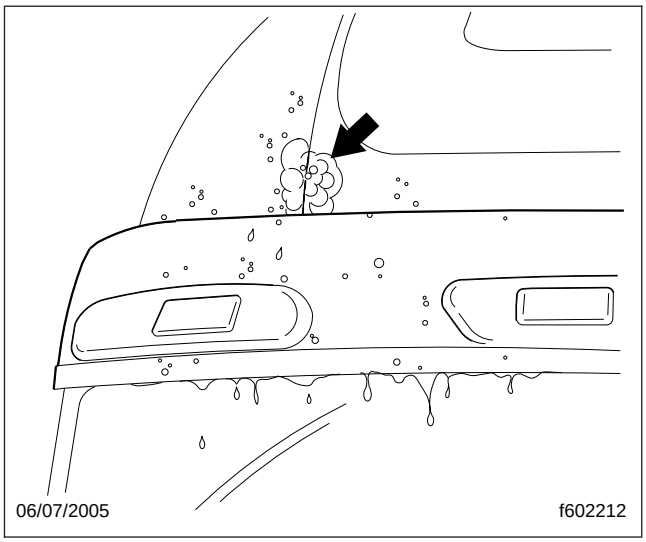


Fig. 1, Cab Water-Leak Detection with Wash Solution

10. Remove the tape from the cab exhausters.
11. Remove the chocks from the tires.

Cab Water-Leak Repair

If a leak is found, the repair method will depend on the area and type of leak. It may be necessary to remove some components, though most leaks should be repairable by sealing the area of the leak with silicone sealant.

Leaks in the Windshield or Skylight Sealant

Repair leaks in the windshield or skylight sealant using the approved method and adhesive. Refer to **Section 60.01** for instructions on windshield repair.

Leaks Caused by Structural Damage to a Roof Cap

Repair leaks caused by structural damage to a roof cap by using the procedures outlined in the applicable sections in this manual. Use the repair method appropriate to the material used in the roof cap construction.

To repair small leaks, clean with shop air and a clean rag, then seal with a silicone sealant.

General Description

The bulkhead-style cab door (**Fig. 1**) features two one-piece aluminum extrusions with welded ends: one for the door frame, and the other for the door opening frame. The cab seal is mounted on the door.

The "bulkhead" description refers to the manner in which the door, when closed, seats inside the door opening frame; the outer panel surface of the door is then flush with the outermost edge of the drip molding.

The door opening frame has an integral drip molding, which is riveted to the cab skin, deck plate, windshield mask, and roof. Both the door opening frame and the drip molding are painted the predominant color of the cab exterior.

The door frame is the foundation of the door assembly (**Fig. 2**), serving as:

- the mount for the outer panel of the door
- the window sill mount
- the channel support for the window glass
- the hinge support
- the ventilator window mount
- the door latch mount

A sector gear-and-arm window regulator assembly (**Fig. 2**, Ref. 15), raises and lowers the window on standard door assemblies. Optional air-powered windows use compressed air from the vehicle's air system to raise and lower the window.

The wiring harness for the turn signals, heated mirrors, and CB/radio antenna is routed along the inner portion of the hinge and is not visible with the door closed.

Most of the door parts are replaceable, with the exception of the outer panel (the exterior door skin). The outer panel is crimped to and bonded with structural adhesive to the door frame flange. If damaged, the outer panel and door frame assembly must be replaced as one assembly.

⚠ CAUTION

CAUTION: Do not attempt to replace the outer panel if it is structurally damaged. The entire portion of the panel that is crimped around the door frame is also bonded with a high-strength structural adhesive. In order to weaken this adhesive, a temperature of 400°F (204°C) is needed. If the aluminum door frame is heated to temperatures approaching 400°F (204°C), the door frame can crack or warp; accelerated aging of the metal may also occur.

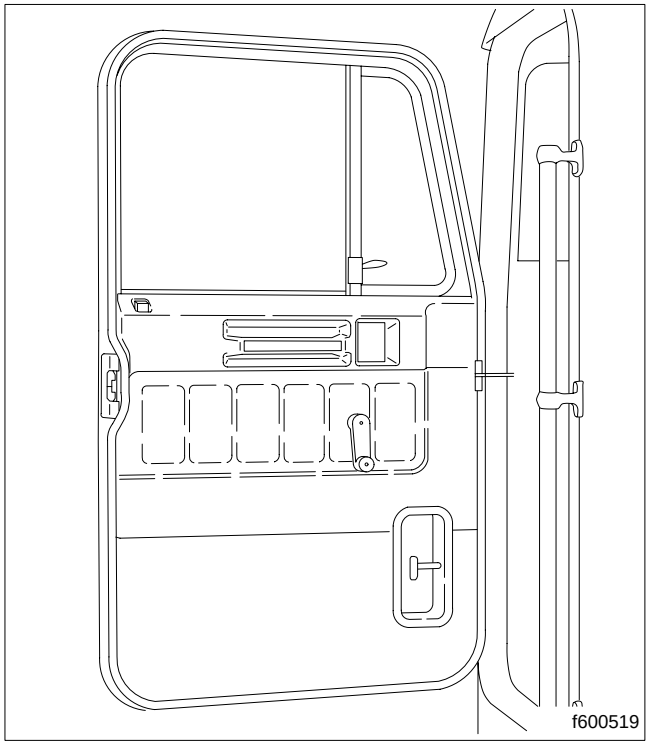


Fig. 1, Bulkhead-Style Cab Door

Unless otherwise noted, all service operations can be done with the door attached to the vehicle. To reduce work time, don't remove the door unless told to do so.

General Description

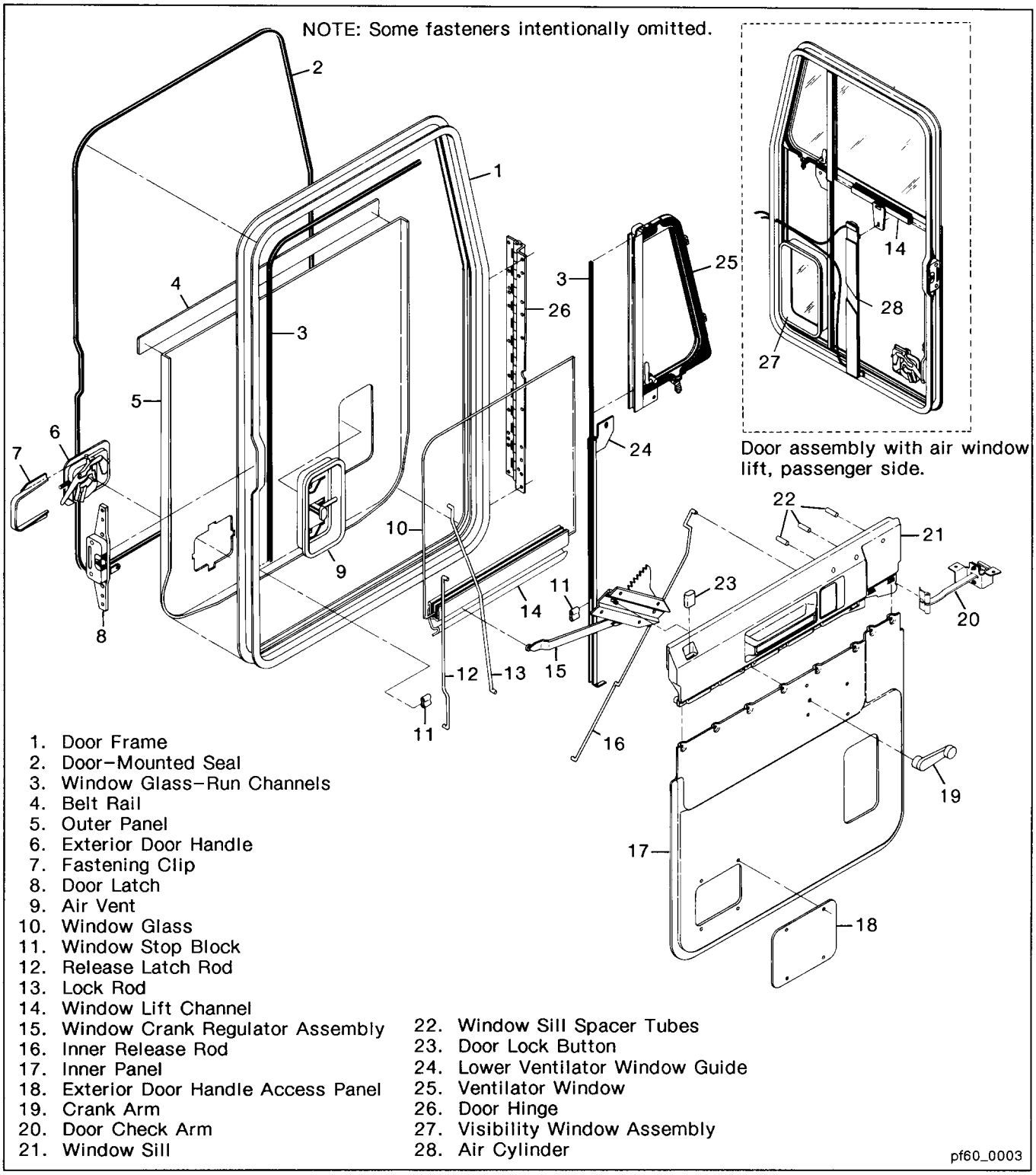
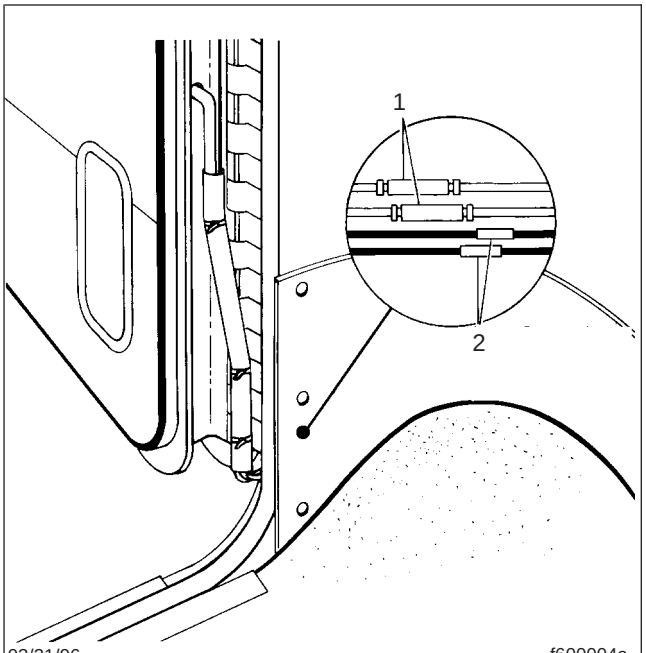


Fig. 2, Cab Door Assembly, Exploded View (Driver's Side)

Door Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Lower the window. When the door is equipped with an air window, it is not necessary to drain the air system reservoirs if the air lines are disconnected at the fittings, as described in the applicable step below.
3. Turn off the ignition switch.
4. Remove the kick panel. Locate the wire splices for the cab door. Mark the wires for later assembly reference, then disconnect them at the splices. See **Fig. 1**.
5. If the vehicle has an air window, disconnect the air lines at the fittings located near the wire splices described in the step above. The lines are disconnected by pulling back the cover ring from the fitting, then pushing in the center of the fitting while pulling back on the air line. See **Fig. 2**.



1. Air Line Fittings
2. Electrical Wire Butt Splices

Fig. 1, Cab Door Electrical Wire/Air Line Disconnect Locations

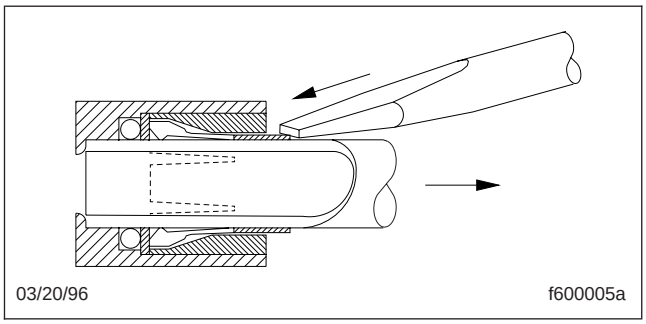


Fig. 2, Disconnecting Air Lines With a Screwdriver

6. Disconnect the CB/radio antenna cable at the base of the antenna, if so equipped. Unwind the cable from around the outside mirror bracket.
7. Remove the Allen-head bolt that attaches the door check arm to the door frame. See **Fig. 3**. Use care not to let the door swing open too far during removal. (Normally, the door check arm would prevent this.)

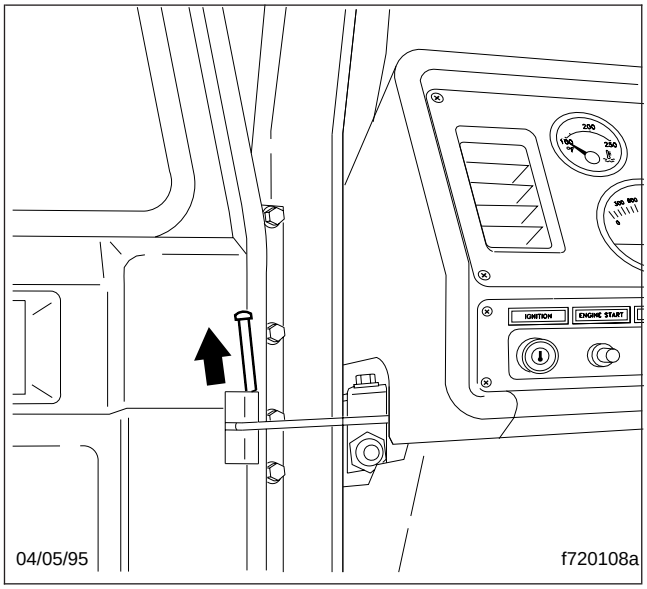
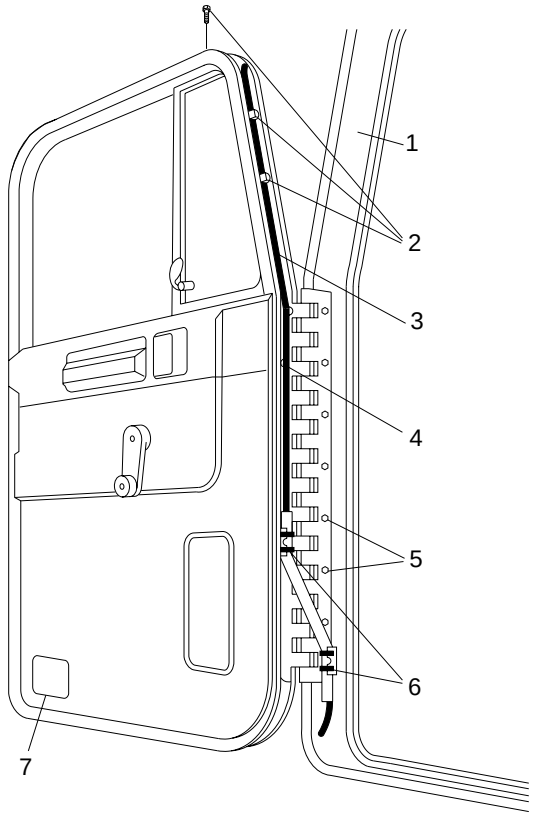


Fig. 3, Removing the Door Check Arm Allen-Head Bolt

8. Snip off all of the plastic spot ties that bundle the electrical wires, the antenna cable, and, if applicable, the air lines along the inner door hinge area. See **Fig. 4**. Unhook the wires and air lines.
9. Pull the disconnected end of the antenna cable through the grommeted hole in the top portion of the door frame assembly. If the cable is clamped to the door frame, loosen or remove the two pan-

Door Removal, Installation, and Adjustment



1. Door Opening Frame
2. Panhead Screws
3. Antenna Cable
4. Lockbolt (Huckbolt®) Assemblies
5. Hinge Self-Tapping Screws
6. Spot Ties
7. Exterior Door Handle Access Cover

Fig. 4, Cab Door

head screws (and lockwashers) that partially attach the ventilator window assembly to the side of the door frame (the panhead screws also fasten the clamps to the frame). See **Fig. 4**. Remove the cable from the clamps. Lay the cable on the cab floor where it will not be stepped on or tripped over.

10. Carefully pull the disconnected wires and, if so equipped, the air lines through the grommeted holes in the bottom portion of the door opening frame. Bundle the loose wires and air lines, then temporarily tape them to the door.

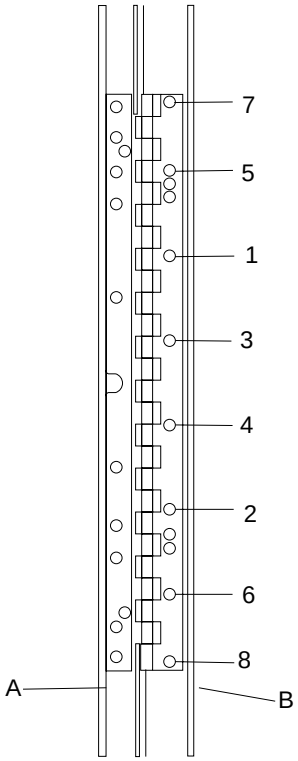
⚠ WARNING

Do not leave disconnected wires or air lines dangling from the door. They could be tripped over as the door is removed, resulting in personal injury or property damage. Temporarily attach loose wires and air lines to the door with tape.

11. Using a door support or another person, support the door frame from its bottom to prevent it from falling or tipping during removal. With the door open and supported, loosen all of the self-tapping screws that attach the hinge to the cab door opening frame.
12. Remove the self-tapping screws. Then remove the door from the door opening frame.

Door Installation

1. If the door seal has been damaged or is weathered, replace it. For instructions, refer to **Subject 110**.
2. With the tires chocked, and using a door support or another person, support the door from its bottom to prevent it from falling or tipping during installation. Place the door in the opening frame and align it so that the hinge can be fastened down.
3. Install the hinge adjusting screws (**Fig. 5**, items 1 and 2). Tighten the screws finger-tight. Then adjust the door in the door opening frame using the instructions under "Door Adjustment."
4. Unfasten the previously tied and bundled wires and, if applicable, air lines. Thread the wires and air lines through the grommeted holes in the bottom portion of the door opening frame and into the cab.
5. If applicable, connect the air window lines at the fittings located just inside the cab, near the door opening frame. See **Fig. 1**. The lines automatically lock in place when they're inserted and seated in the fittings.
6. As marked earlier, connect all electrical wiring to the door. The wires should be connected at the butt splices located just inside the cab, near the door opening frame.
7. Using the previously removed upholstery screws, attach the kick panel to the cab floor/door-opening frame area.



For door adjustment, tighten only screws 1 and 2.

NOTE: Some parts intentionally omitted. Door shown open 180 degrees.

A. Door Frame B. Door Opening Frame

Fig. 5, Hinge Self-Tapping Screws Tightening Sequence

8. Install new plastic spot ties to hold the wiring harness and air lines in place. See **Fig. 4**.
9. If applicable, clamp the antenna cable to the inner portion of the door frame, and tighten the previously loosened or removed panhead screws and lockwashers that partially attach the ventilator window assembly to the door frame.
10. Align the door check arm, then insert the Allen-head bolt that attaches the door check arm to the door frame.
11. If applicable, thread the antenna cable through the grommeted hole in the top portion of the door frame assembly. Wind the cable around the outside mirror bracket until most of the slack is eliminated. Attach the CB/radio antenna cable to the base of the antenna.
12. Make sure the door electrical components and the air window are operating correctly.

Door Adjustment

Do not begin door adjustment until you review and understand all of the information below.

When a door assembly is newly installed on a vehicle, it must be adjusted for correct up-and-down, and in-and-out positioning, relative to the door opening frame. The door assembly should also be adjusted whenever one or more of the following conditions exist (providing the door seal is correctly installed and is in good condition; for more information, refer to **Subject 110**):

- wind or water leaks at the door opening frame
- premature wear of the door seal
- hard closing or opening of the door

The hinge is horizontally slotted, and when the self-tapping screws (**Fig. 5**) are loosened, the door can be moved in or out of the door opening frame. The vertically slotted holes along the hinge area of the door opening frame allow for up-and-down adjustment of the door.

The self-tapping screws of the hinge, when installed in the order shown in **Fig. 5**, tap into a loosely riveted metal plate. The metal plate is riveted—using countersunk rivets and pushnuts—to the internal side of the door opening frame. The plate is therefore out of view.

Design considerations of the door assembly and the door opening frame require that all but two of the self-tapping screws along the hinge be loose during door adjustment. The only screws that should be tightened during door adjustment are the third one up from the bottom and the third one down from the top (**Fig. 5**, items 1 and 2). After the door is adjusted to specifications, the remaining screws must be tightened in the order shown in **Fig. 5**.

IMPORTANT: Do not try to adjust the door using any of the self-tapping screws except the third one up from the bottom and the third one down from the top (**Fig. 5**, items 1 and 2). These screws are closest to the rivet/pushnut fasteners that attach the tapping plate to the internal por-

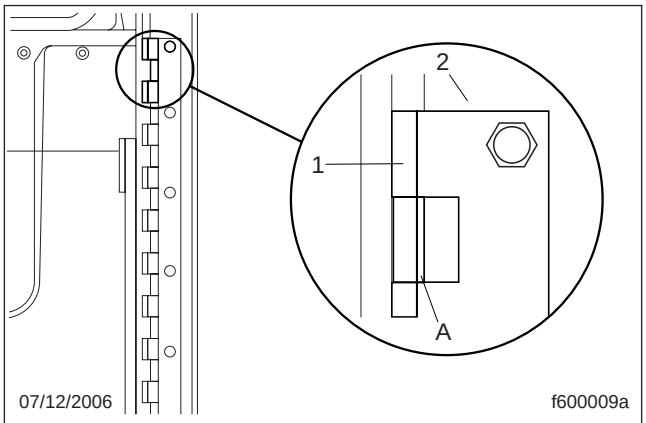
Door Removal, Installation, and Adjustment

tion of the door opening frame. Because of their closeness to the fasteners the screws are certain to tap into the tapping plate and hold the door in the desired position. If any of the other screws are used during door adjustment, it may not be possible to tighten them after the door has been positioned.

Up-and-Down, In-and-Out Adjustment

1. With the tires chocked, and the door installed in the door opening frame, remove or loosen all but two of the self-tapping screws. The third screw up from the bottom of the hinge and the third screw down from the top of the hinge should be used to hold the door in the desired position. See **Fig. 5**.
2. Adjust the door in the door opening frame to an estimated correct position.
   - 2.1 Carefully close the door. See if the top and bottom edges of the door are evenly gapped from the drip molding. Adjust if necessary.
   - 2.2 Remove the door-check bolt and open the door about 90 degrees. If there is no sunlight, place a source of light in back of the door.
   - 2.3 Look at the hinge and the visible edges of the drip molding in back of the hinge (from the vantage point of the striker pin). A broken, hairline thread of light should extend down the hinge. See **Fig. 6**. The "thread" should not widen at either end. Adjust if necessary.
3. From inside the cab, with the door closed or nearly closed, measure for specific up-and-down positioning of the door, and adjust as necessary.

   The distance between the inner flange of the door frame and the door opening frame, measured vertically at the top and bottom edges of the door, must be equal, within 3/32 inch (2 mm), at the top and bottom edges of the door.
4. Close the door to the fully latched position (second click). From outside the cab, check the in-and-out positioning of the door, and adjust as necessary.



NOTE: Door shown open 90 degrees.

A. Light should be visible here.

1. Hinge
2. Door Opening Frame (Drip Molding)

Fig. 6, Gap Between Door and Drip Molding

NOTE: Doors made before June 10, 1991, have two aligned rows of rivets in the trim belt rail under the window. See **Fig. 7**. The rivets are all the same size. Door made from June 10, 1991, have two staggered rows of rivets in the trim belt rail, and the rivets in the lower row are larger than those in the upper row. See **Fig. 7**. These doors also have larger hinges than the previous-style doors.

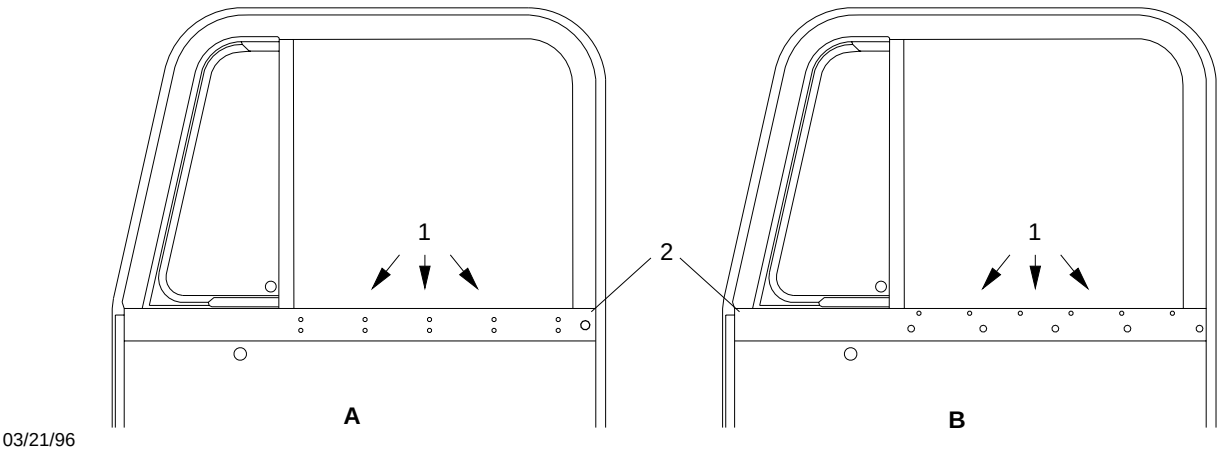
- 4.1 Adjust the top of the door, just below the radius, (see **Fig. 8**).

  On previous-style doors, the door should be recessed 1/16 inch (2 mm). It may be recessed as much as 3/16 inch (5 mm).

  On current-style doors, the door should be recessed 1/16 inch (2 mm). However, it may be recessed as much as 1/8 inch (3 mm), or as little as 1/32 inch (1 mm).

  The gap along the top of the door must be parallel to the door opening frame.

  At the door latch, the door should be flush, but may protrude as much as 1/8 inch (3 mm). It must not be recessed. The gap along the back of the door must be parallel to the door opening frame.



A. Doors Made Before June 10, 1991
B. Doors Made From June 10, 1991
1. Rivets
2. Trim Belt Rail

Fig. 7, Door Trim Belt Rail Rivets

4.2 Adjust the bottom of the door, just above the radius (see **Fig. 8**).

On previous-style doors, the door should be flush; however it may be recessed as much as 1/8 inch (3 mm).

On current-style doors, the door should be flush; however it may protrude or be recessed as much as 1/16 inch (2 mm).

The gap along the bottom of the door must be parallel to the door opening frame.

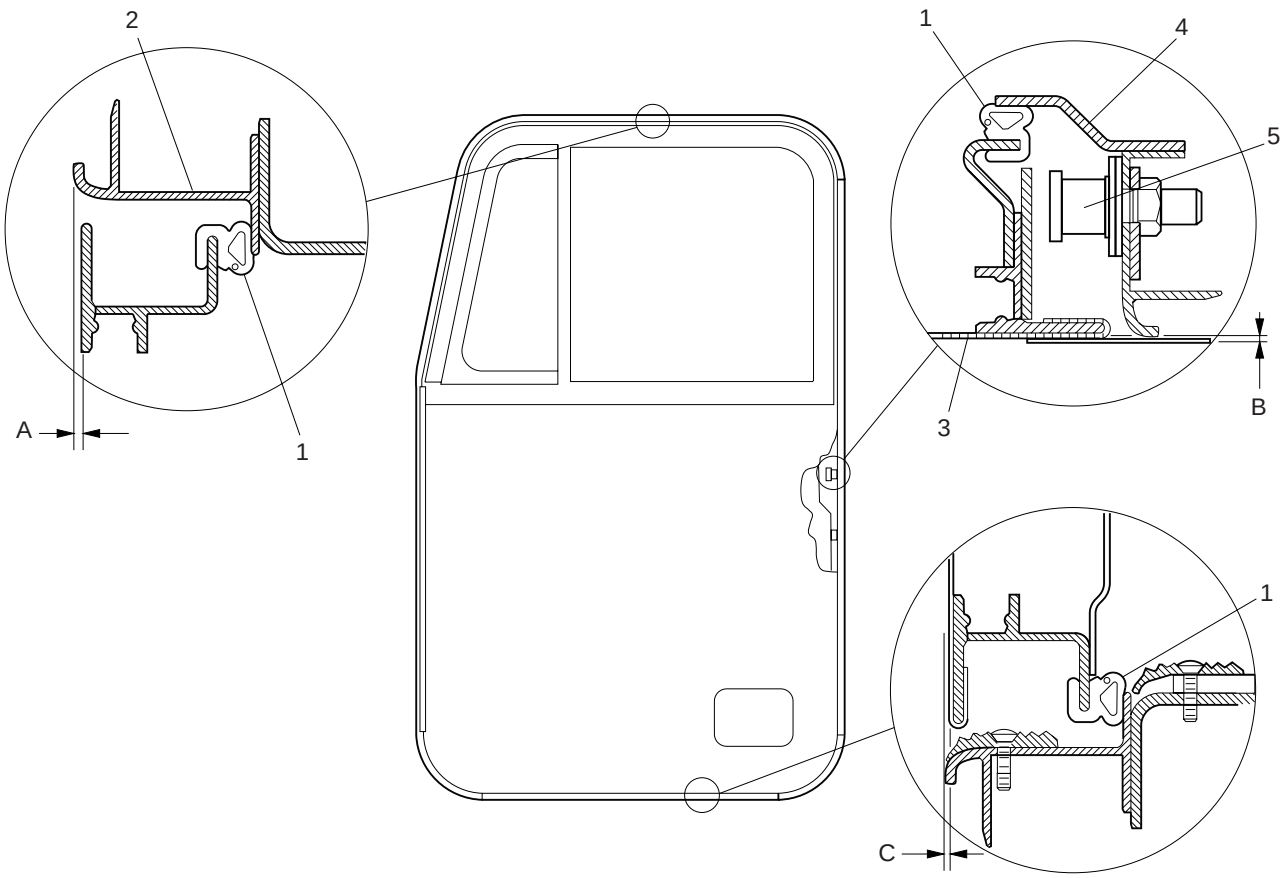
5. Tighten the adjusting screws to a final torque of 120 lbf·in (1360 N·cm). Tighten the remaining self-tapping screws to the same torque; they should be tightened in the order shown in **Fig. 5**.
6. Test the striker pin adjustment, as described in this subject.

Striker Pin Adjustment

1. From outside the cab, with the tires chocked, partially close the door until the latch jaws are about 1 to 2 inches (2.5 to 5.0 cm) from the striker pin. See **Fig. 9**.
2. See if the latch jaws will be centered around the striker pin's outer sleeve (**Fig. 10**) when the door is closed. If necessary, reposition the striker pin after loosening it with a no. 50 Torx® recess driver. See **Fig. 11**. If needed, add shims between the conical washer and the door opening frame.

   Add only enough shims to allow correct engagement of the latch jaws around the striker pin's outer sleeve; too many shims will cause interference between the striker pin and the backing plate of the latch assembly.
3. Repeat the previous two steps above. If the striker pin appears to be correctly positioned, and two or more conical washers are used, tighten it 18 to 22 lbf·ft (24 to 30 N·m). If only one conical washer is used, tighten the striker pin 9 to 11 lbf·ft (12 to 15 N·m).
4. Carefully close the door to the fully latched position (second click). From outside the cab, check the in-and-out positioning of the door. See "Up-and-Down, In-and-Out Adjustment."
5. Remove the chocks from the tires.

Door Removal, Installation, and Adjustment



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A = 1/16 inch (2 mm), + 1/8 inch (3 mm), - 0 inch (0 mm) for Doors Made Before 6/10/1991
A = 1/16 inch (2 mm), + 1/16 inch (2 mm), - 3/64 inch (1 mm) for Doors Made From 6/10/1991

B = 0 inch (0 mm), + 1/8 inch (3 mm), - 0 inch (0 mm)

C = 0 inch (0 mm), + 0 inch (0 mm), - 1/8 inch (3 mm) for Doors Made Before 6/10/1991
C = 0 inch (0 mm), ± 1/16 inch (2 mm) for Doors Made From 6/10/1991

1. Door Seal
2. Door Opening Frame
3. Door Skin
4. Seal Flange Bracket
5. Striker Pin

Fig. 8, In-and-Out Positioning of the Door

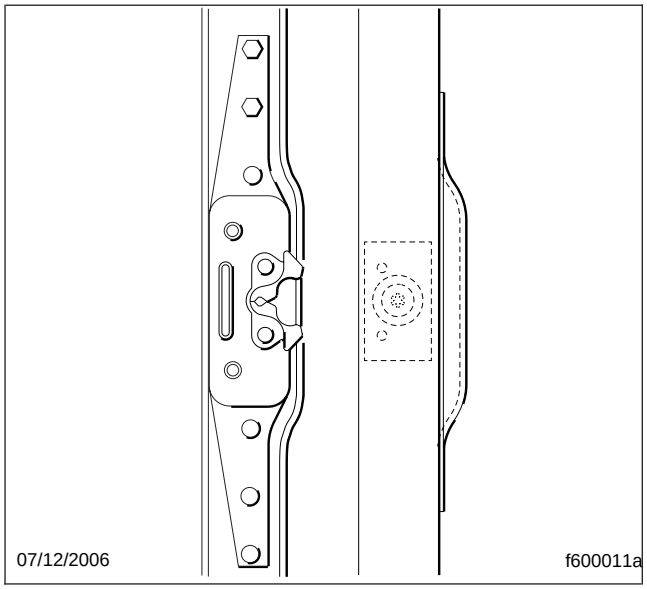


Fig. 9, Door Latch Mechanism

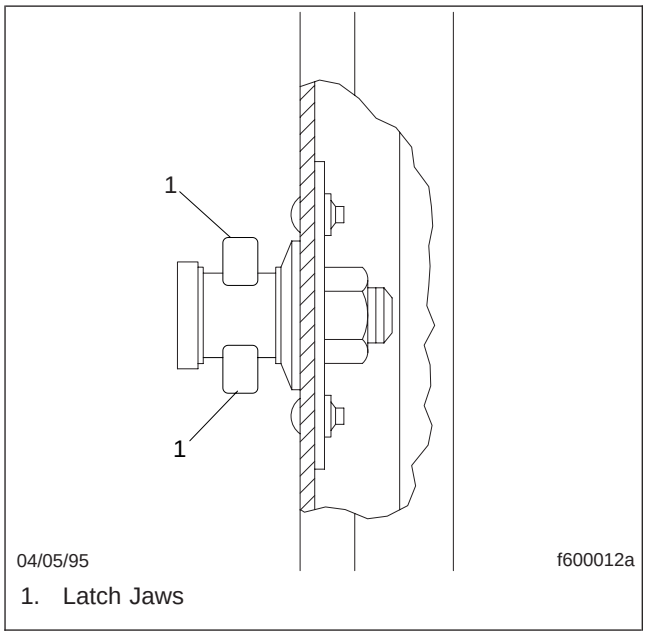


Fig. 10, Latch Jaws

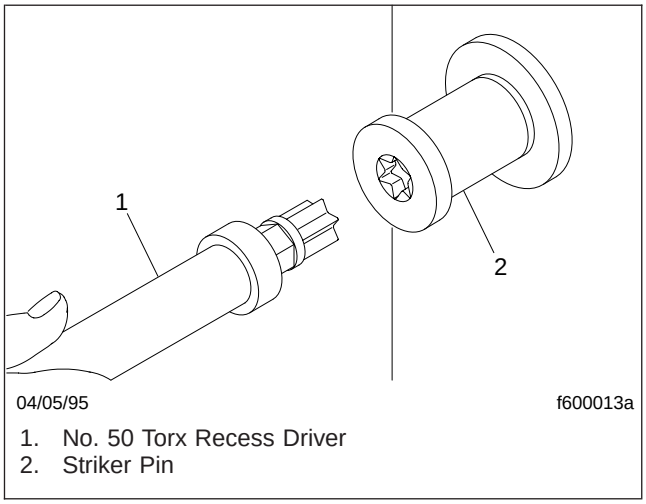


Fig. 11, Striker Pin Tool

Door Seal Replacement

1. Pull the entire length of the seal from the inner door flange.
2. Install the new door seal by pushing it firmly onto the inner door flange, with the ends of the seal meeting about 12 inches (30 cm) above the bottom of the door, along the front hinge. **See Fig. 1.** Trim to length as needed. Make sure the seal is pushed completely onto the flange all around the door. There should be no creases or buckles on the sealing surface.

⚠ CAUTION

CAUTION: Do not stretch the door seal during installation. To do so may reduce its sealing ability, which could result in water leaks.

3. Check the door adjustments using the instructions in **Subject 100**.

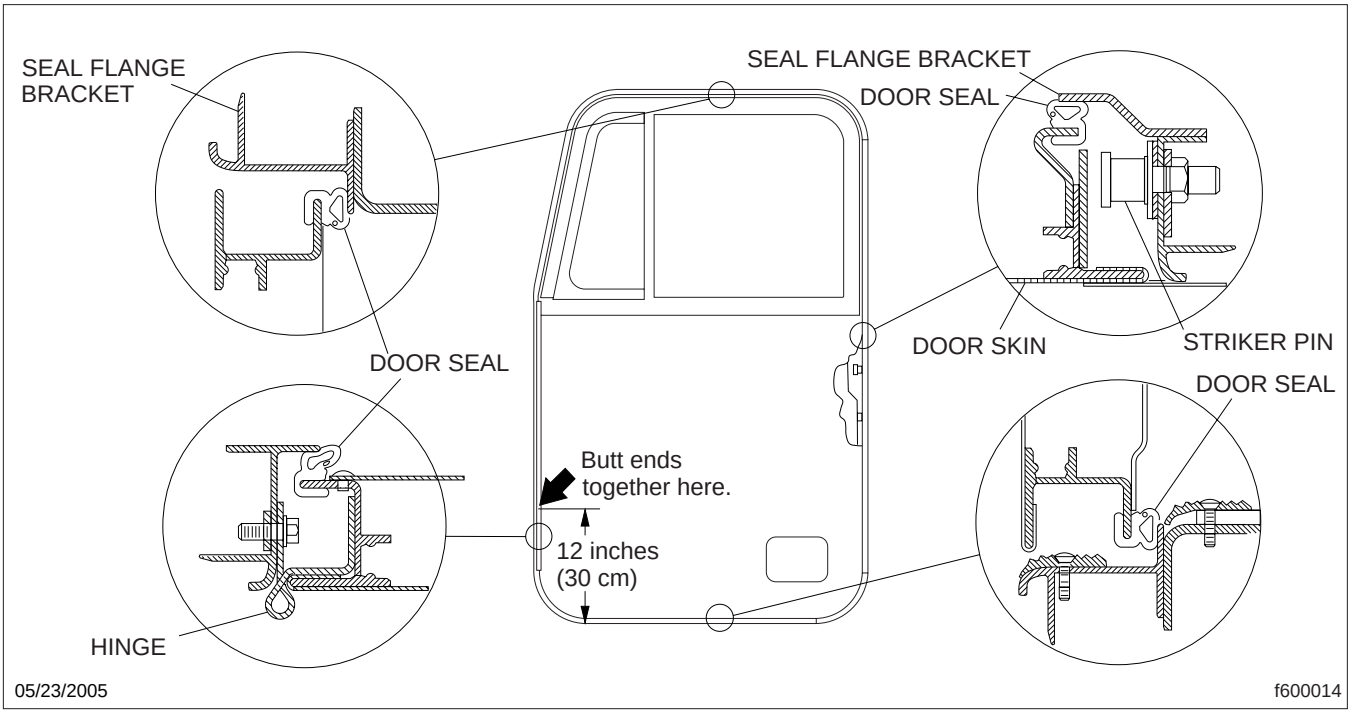


Fig. 1, Door Seal Installation

Window Glass Removal

⚠ WARNING

WARNING: Use care when working around or handling glass. Wear protective gloves to eliminate the possibility of personal injury resulting from accidentally breaking or splintering the glass.

1. Apply the parking brakes. Lower the window glass.
2. Mark the three socket-head capscrews that partially attach the outside mirror mounting bracket to the door, for later assembly reference. Using an allen wrench, remove the capscrews, nuts, and washers. **See Fig. 1.** If the three window sill spacer tubes and washers can be easily pushed out, they also should be referenced and removed.
3. For hand crank windows, remove the crank arm from the regulator assembly mounting spindle.
4. Remove the screws that attach the inner panel to the window sill. **See Fig. 2.** On custom interiors, first remove the velour and carpet inserts. **See Fig. 3.**
5. If the door is equipped with an air window, also remove the two screws that attach the air cylinder to the window sill. **See Fig. 4.**
6. Remove the upper three hexhead capscrews located on the hinge side of the door. **See Fig. 5.** Remove the allen-head bolt that attaches the door check arm to the door frame. **See Fig. 6.** Use care not to let the door swing open too far during repair. (Normally, the door check arm would prevent this.)
7. Remove the two hexhead capscrews located on the opposite side of the door (above the door latch assembly). **See Fig. 7.**
8. Carefully remove the window sill as follows:

   IMPORTANT: The window sill is not completely unfastened from the door at this point. The rod that connects to the window sill release handle inside the door must first be disconnected.

   8.1 Gripping the window sill door handle, lean the top of the window sill away from the door so that it clears the ventilator window seal. With steady, upward movement, pull the window sill until the entire bottom portion unseats from the edge of the inner panel. **See Fig. 8.** The window sill will resist this movement, but will seem unsprung after it is unseated.

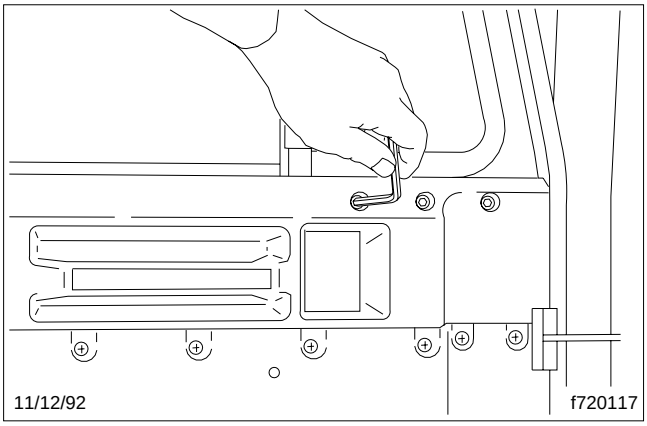


Fig. 1, Window Sill Capscrew Removal/Installation

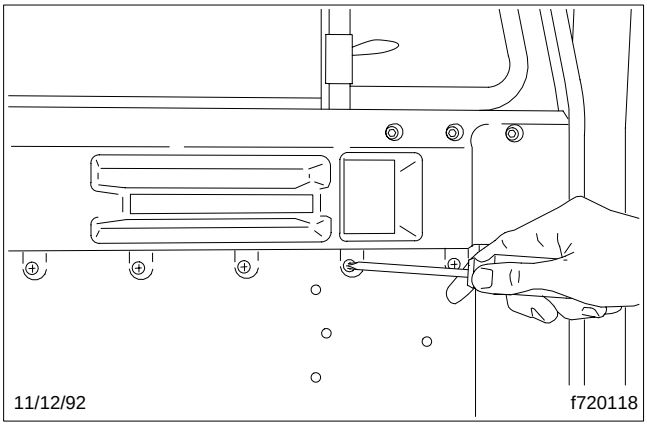


Fig. 2, Inner Panel Screw Removal/Installation

IMPORTANT: Do not attempt to completely separate the window sill from the door.

8.2 Lean the top of the window sill away from the door after pushing the door lock button free. **See Fig. 9.** Then disconnect the release handle rod plastic keeper from the rod. **See Fig. 10.** Remove the window sill.

Window Glass Removal and Installation

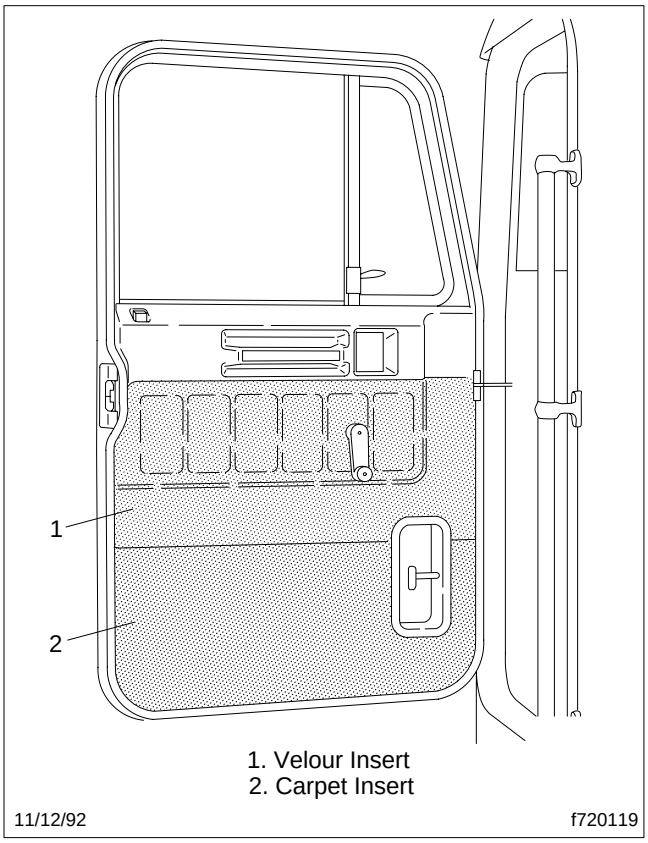


Fig. 3, Custom Interior Door

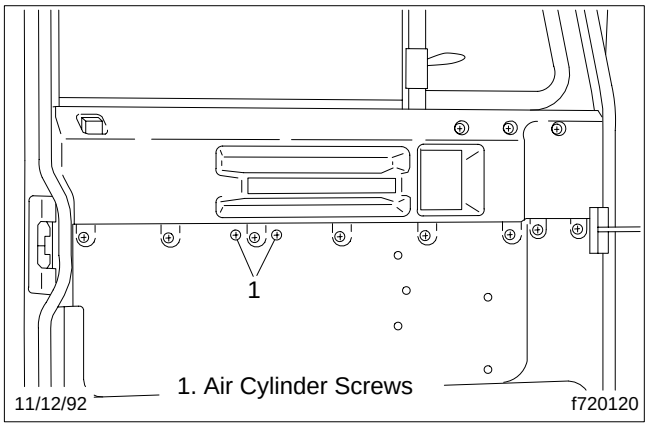


Fig. 4

NOTE: As the window sill is pulled away, if not previously removed, be careful not to let the three window sill spacer tubes (**see Fig. 11**) and washers drop into the door.

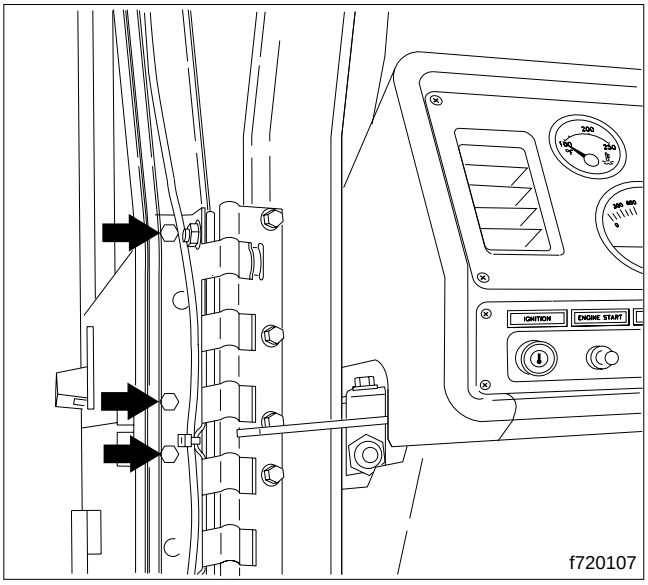


Fig. 5

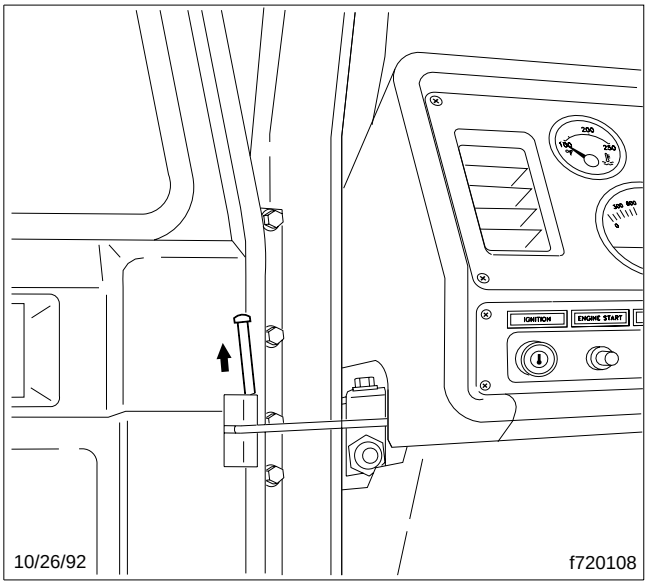


Fig. 6

During removal, keep the window sill tilted, as shown in **Fig. 9**.

8.3 If applicable, reference the window sill spacer tubes and remove them (and the washers) from the window sill. **See Fig. 11.**

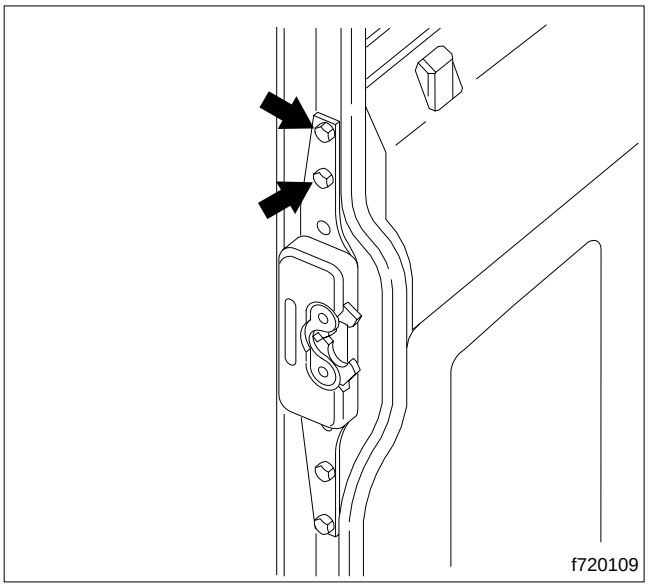


Fig. 7

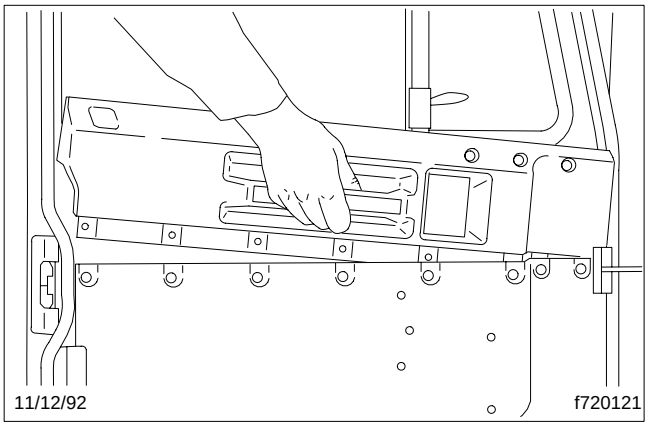


Fig. 8

9. If the door is equipped with an air window, go to the step after the next.

   For hand crank windows, remove the fasteners and lockwashers that attach the window crank regulator assembly to the inner panel.

10. Pull the inner panel away from the door so that the crank arm mounting spindle (of the regulator assembly) clears the inner panel. **See Fig. 12.** Disengage the regulator arm roller from the window lift channel by rolling it out of one end of the window lift channel.

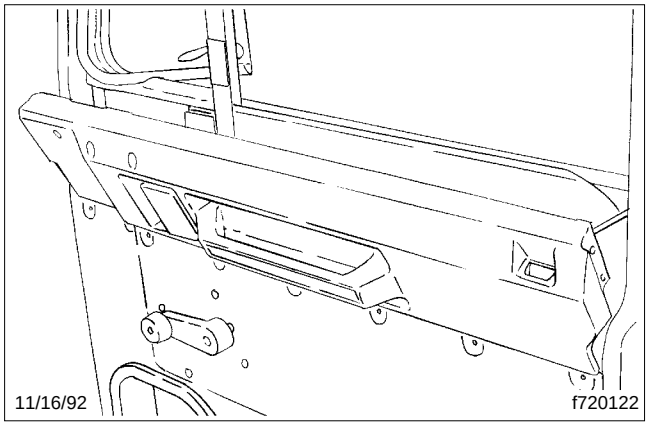


Fig. 9

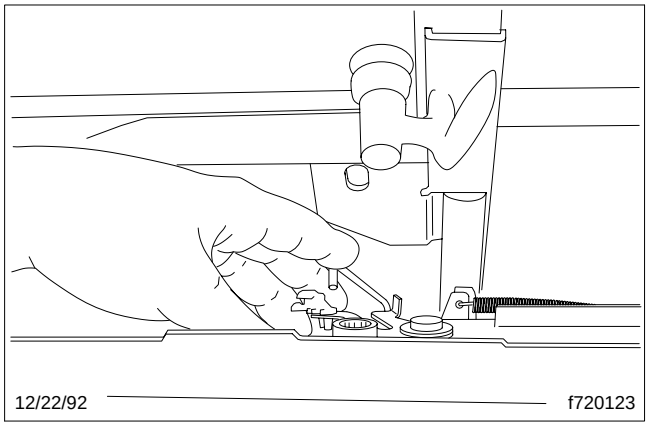


Fig. 10, Disconnecting/Connecting the Release Handle Rod from the Window Sill

   Remove the window crank regulator assembly from the door. Go to the step after the next.

11. Disengage the window glass assembly from the air cylinder as follows:

    11.1 Remove the exterior door handle access cover from the inner panel. **See Fig. 13.**

    11.2 Because the window is in the lowered position, the pin that connects the window lift channel to the air cylinder (**see Fig. 14**) can be removed by reaching in through the access hole of the exterior door handle. If the pin cannot be reached, the work space can be increased by removing the exterior door handle, following the instructions in **Subject 140**.

Window Glass Removal and Installation

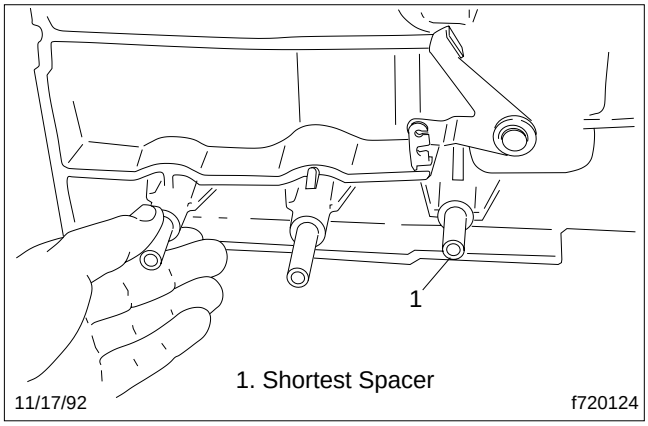


Fig. 11, Window Sill Spacers (unseated)

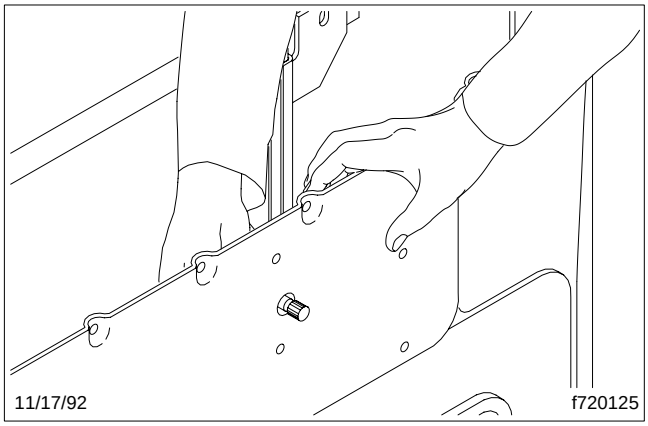


Fig. 12, Regulator Assembly Removal/Installation

11.3 After removing the pin, unseat the window lift channel from the air cylinder.

12. Tilt the lower ventilator window guide toward the hinge. **See Fig. 15.**

13. If the window glass has been shattered, go to the next step.

IMPORTANT: Wear rubber gripper gloves during the removal of the window glass to ensure a secure grip on the glass.

14. If the window glass is not shattered, carefully unseat the bottom portion (on the latch side of the door) off of the window stop block and out of the glass-run channel. **See Fig. 16.** This can be done by slowly lifting up on the top (hinge side) corner of the window glass. Then, unseat the opposite (hinge side) corner of the window glass off the stop block.

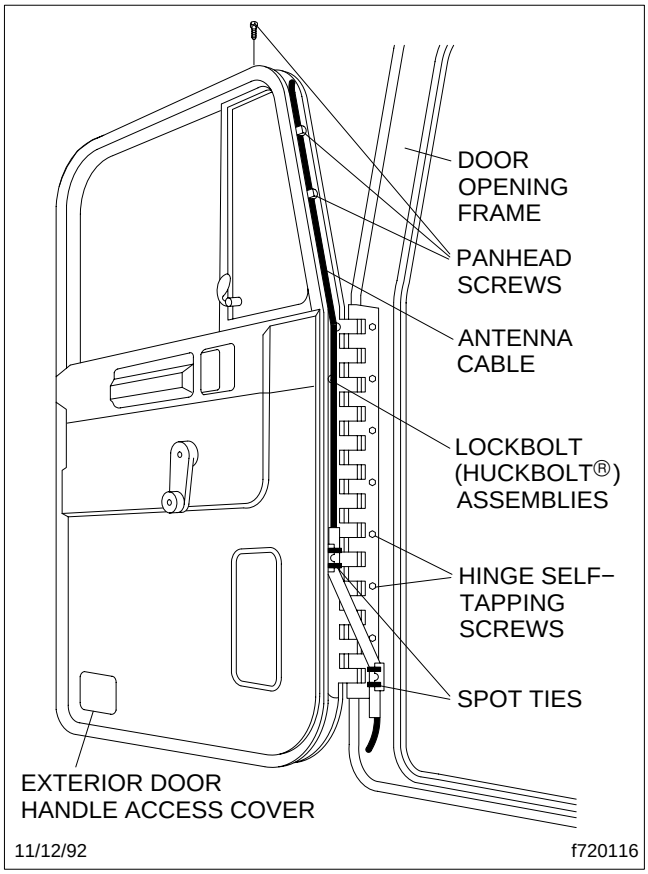


Fig. 13, Cab Door

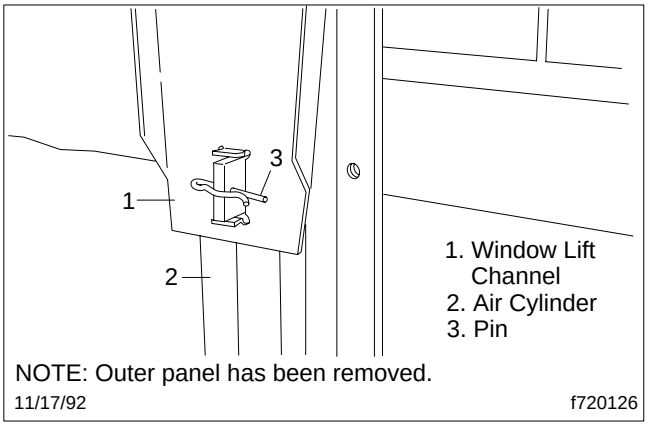


Fig. 14, Air Cylinder/Window Lift Channel

Lean the window glass so that it is outside the window channel of the ventilator window mounting bracket, then carefully lift out the window glass assembly. Go to the next step.

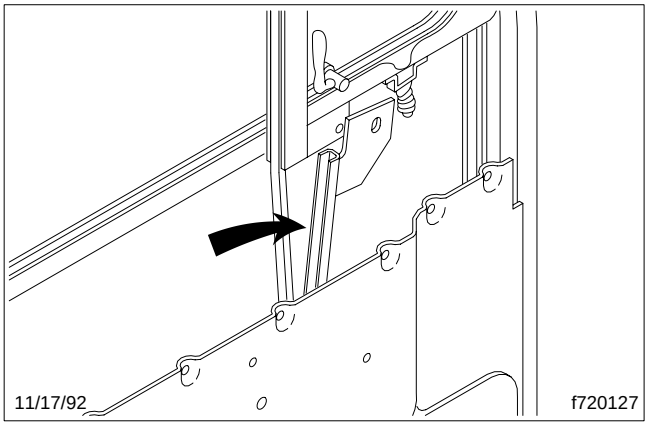


Fig. 15, Tilting the Lower Ventilator Window Guide

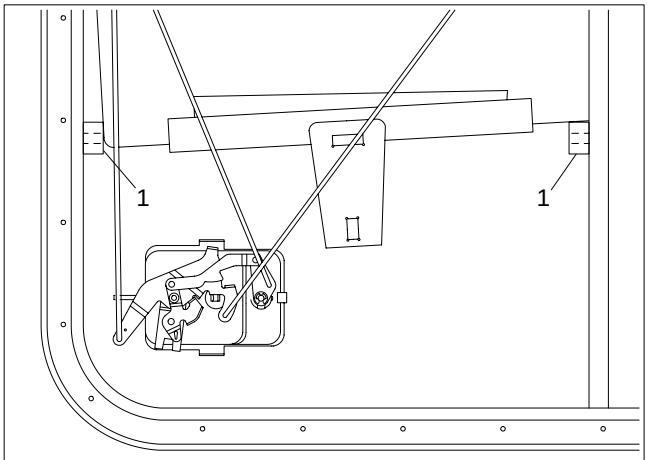


Fig. 16, Unseating or Partially-Seating the Window Glass Assembly

15. Wearing protective gloves, remove all accessible shattered glass. Then, if applicable, remove the window lift channel.

    Remove the exterior door handle. For instructions, refer to **Subject 140**. Using a narrow extension accessory, vacuum out small glass fragments that may have fallen to the bottom of the door frame through the space behind the exterior door handle access cover attached to the inner panel. **See Fig. 13.** Failure to remove the glass fragments could cause plugged drain holes at the bottom of the door frame.

16. If necessary, remove the window glass-run channels. **See Fig. 17.** If the window glass was shattered, inspect the glass-run channels for cuts. Replace the glass-run channels, if damaged.

17. If the ventilator window assembly must be replaced, remove the three panhead screws and lockwashers that attach the window assembly to the door frame. **See Fig. 13.** Remove the window glass-run channel from the ventilator window. Remove the ventilator assembly.

Window Glass Installation

IMPORTANT: If the ventilator window assembly has been removed, follow the first two steps below carefully. Proper installation of the ventilator window seal will prevent problems arising during window sill installation. Also, proper installation of the ventilator window seal will prevent water leaks from occurring when the vehicle is later placed in service.

If the ventilator window assembly has not been removed, skip the first two steps below.

1. Seat the ventilator window assembly in the door frame. Tilt the lower ventilator window guide toward the hinge. Make sure that the bottom seal flap on the outside of the door overlaps the belt rail (**Fig. 18**). The flap does not go under the belt rail.

2. Make sure that the flaps of the ventilator window side seal overlap onto the outside and inside surfaces of the door frame. If the seal flaps come between the door frame and the ventilator window mounting bracket, the holes for the panhead screws will not line up.

   Install the lockwashers and panhead screws. Check the position (squareness) of the ventilator window in the door frame. The window channels should be parallel to one another, or binding of the window glass will occur as the window is raised. If necessary, adjust the position of the ventilator window. Tighten the panhead screws securely.

3. If the window glass-run channels have been removed, install them. Make sure the glass-run channels are fully seated in the window channels.

Window Glass Removal and Installation

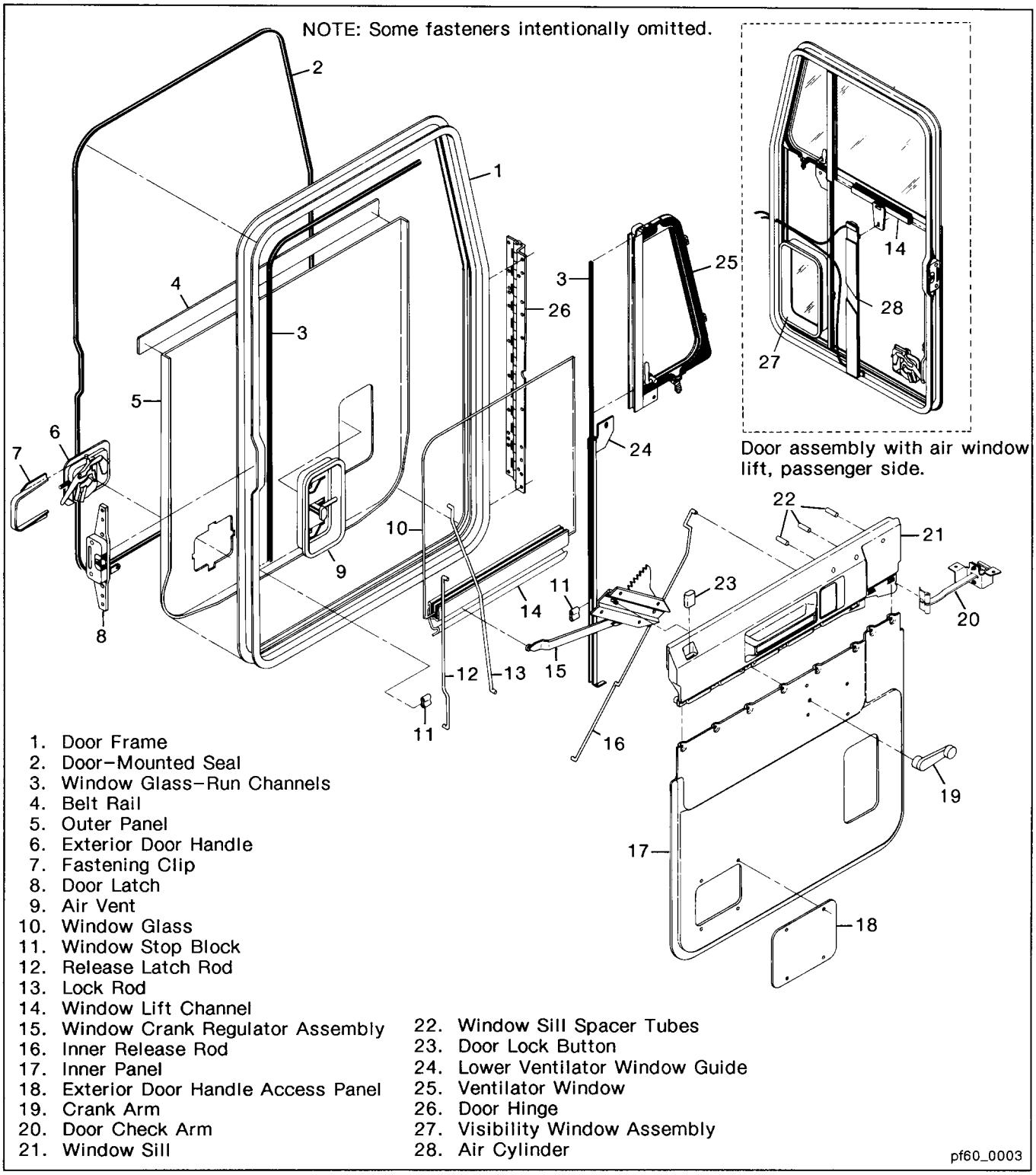


Fig. 17, Cab Door Assembly, Exploded View (Driver's Side)

CAUTION

CAUTION: Failure to wear rubber gripper gloves while installing the window glass in the door could result in the glass slipping out of your hands and breaking.

IMPORTANT: Wear rubber gripper gloves when installing the window glass. Usually, service operations performed on the door will be done while the door is in a vertical position (that is, attached to the vehicle). Because of this, you will need a secure grip when handling the glass.

4. Carefully place the window glass assembly inside the door. If applicable, make sure the window lift channel will be facing toward the inner panel.
5. Make sure that the lower ventilator window guide is tilted toward the hinge. Install the window glass assembly in the window channel as follows:
   - 5.1 Position the bottom (hinge side) corner of the window glass on the window stop block. **See Fig. 16.**
   - 5.2 Position the top (hinge side) area of the window glass so that it is inside the window channel of the ventilator window mounting bracket. **See Fig. 19.**
   - 5.3 Pull up on the top (latch side) corner of the window glass. **See Fig. 19.** As the top edge of the window is pulled up into a horizontal position, the bottom (latch side) corner of the window will clear the window stop block and seat in the channel, as shown in **Fig. 20**.
   - 5.4 Tilt the lower ventilator window guide back to the vertical position. *Make sure that the guide remains in the vertical position.*
6. If the door is equipped with an air window, skip the next three steps below and proceed to the step that begins "Attach the window lift channel...".

   For hand crank windows, engage the regulator arm roller of the window crank regulator assembly to the window lift channel. If necessary, pull the window glass up in order to ease installing the regulator arm roller in one end of the window lift channel.

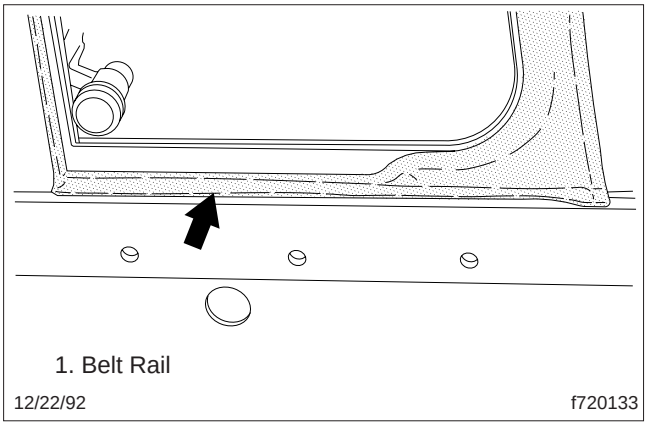


Fig. 18, Bottom Seal of the Ventilator Window Assembly

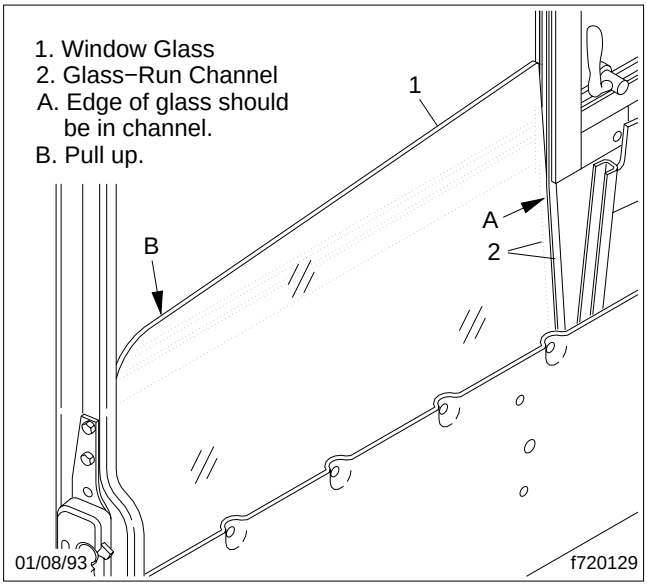


Fig. 19, Window Glass Installation

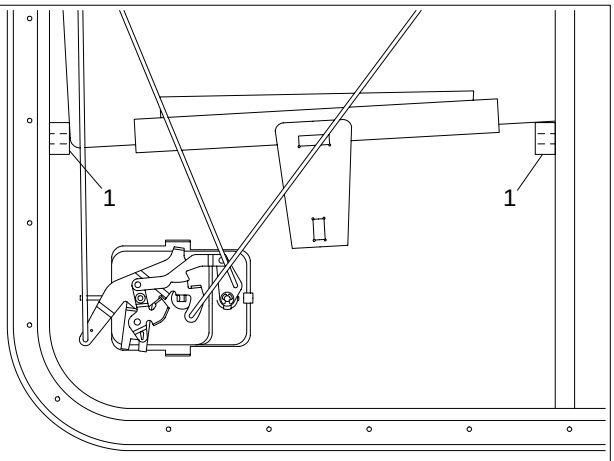
IMPORTANT: (If not already done, install the exterior door handle, using the instructions in **Subject 140**.) Before concluding the installation of the window crank regulator assembly, make sure the release handle rod (the "loose" rod that tends to interfere with service operations) leans on top of the regulator assembly and not below it. Also, make sure that it is not placed on the roller side of the regulator.

Window Glass Removal and Installation

7. Install the regulator assembly so that the crank arm mounting spindle protrudes through the inner panel. This requires that the inner panel be pulled away from the door until a gap exists that is wide enough to allow the installation of the regulator assembly. **See Fig. 12.**

8. Install the lockwashers and fasteners that attach the window glass, as needed to align the inner panel holes with the regulator assembly holes. (A second person may be needed to assist during this procedure.) Tighten the fasteners 96 lbf·in (1080 N·cm).

9. Attach the crank arm to the regulator assembly mounting spindle. Then, install the allen-head capscrew. Test the window for up-and-down movement. Hard rolling usually means the window glass-run channels are not seated properly. Inspect the glass-run channels for seating. Go to the step after the next.



1. Stop Block

NOTE: Some components intentionally removed.

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Fig. 20, Correctly Seated Window Glass Assembly

10. Attach the window lift channel to the air cylinder as follows:

    10.1 Seat the window lift channel in the air cylinder mounting bracket; access the components through the exterior door handle access hole on the inner panel. **See Fig. 13.**

    10.2 Install the pin that prevents the window lift channel from slipping out of the air cylinder mounting bracket. **See Fig. 14.** Then, if the exterior door handle was removed from the door, install it, using the instructions in **Subject 140**.

    10.3 Attach the exterior door handle access cover to the inner panel. Then proceed to the next step.

11. Install the window sill as follows:

    11.1 Place the window sill in its approximate installation position, with the bottom edge tucked under the inner panel. Use care not to dislodge the Tinnerman clip from the mounting angle of the window sill. Insert the door lock button through the hole in the window sill.

    11.2 Connect the release handle rod in the plastic keeper attached to the window sill. **See Fig. 10.** vMake sure the rod is locked in place.

    11.3 Push the window sill approximately in place; allow about a 1/2 inch (13 mm) or less gap to exist directly under the ventilator window assembly. Open the ventilator window. Then, using a flat, blunt instrument, work out the ventilator window seal flap (in the bottom corner nearest the hinge) so that the flap overlaps the window sill. The flap does not go under the window sill. After this has been done, the remaining portion of the ventilator window seal flap can be manually worked out without the use of a tool. See **Fig. 21** and **Fig. 22**.

    11.4 Push the window sill in place, snug against the door frame. Install the two longest window sill spacer tubes (as referenced earlier) and washers in the window sill.

12. Install the last window sill spacer tube through the window sill hole. The spacer should be completely seated. If it does not seat, remove it, then see if the lower ventilator window guide is tilted out of place. **See Fig. 23.** Using the tip of a small screwdriver through the spacer hole from outside the door, lever the window guide back to

a vertical position. At the same time, push the spacer in place. Then install the washer.

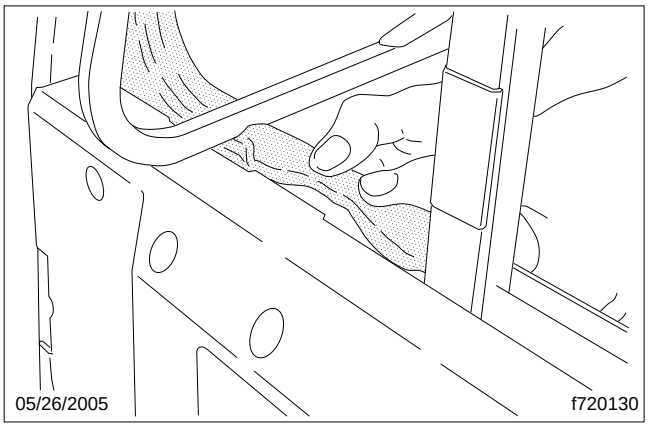


Fig. 21

13. Install the allen-head bolt that attaches the door check arm to the window sill and door frame. **See Fig. 6.** Install the three hexhead capscrews on the hinge side of the door frame. **See Fig. 5.** If equipped with 1/4–20 SAE grade 5 capscrews, tighten them 60 to 84 lbf·in (680 to 940 N·cm); if equipped with 1/4–28 SAE grade 8 capscrews, tighten them 120 lbf·in (1360 N·cm).

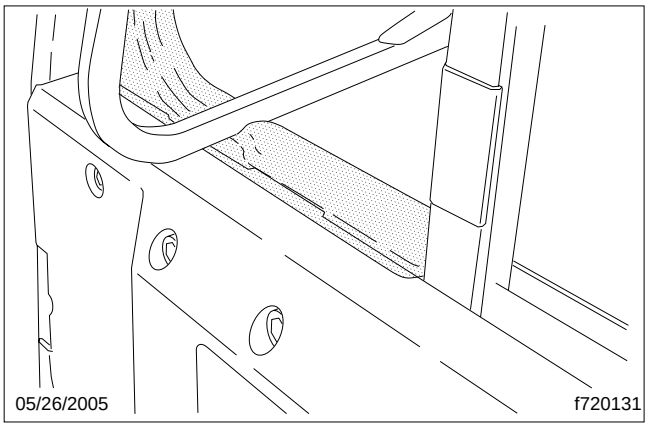


Fig. 22, Correctly Installed Window Seal

⚠ CAUTION

CAUTION: Don't force a capscrew in place. If the capscrew seems to be going in crooked, the holes in the spline unit (which is pressed into the window sill) and the door frame are not properly aligned. The spline nut could be pushed out of the window sill if too much force is applied to the capscrew. If the holes are misaligned, the probable cause is an improperly installed ventilator window seal (weather-strip). Refer to the applicable steps under this heading for information on the proper installation of the ventilator window seal.

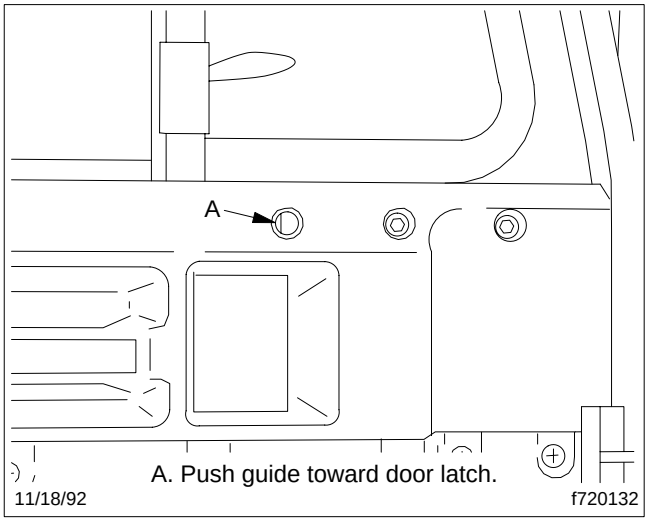


Fig. 23, Lower Ventilator Window Guide Tilted Out of Place

14. Install the two hexhead capscrews on the opposite side of the door frame (above the door latch assembly), as shown in **Fig. 7**. Note the CAUTION in the previous step above. If equipped with 1/4–20 SAE grade 5 capscrews, tighten them 60 to 84 lbf·in (680 to 940 N·cm); if equipped with 1/4–28 SAE grade 8 capscrews, tighten them 120 lbf·in (1360 N·cm).
15. Install the screws that attach the inner panel to the window sill (the longest screw is installed at the door latch end of the panel). **See Fig. 2**. Also, if applicable, install the two screws that attach the air cylinder to the window sill. **See Fig. 4.**
16. On custom interiors, install the velour and carpet inserts. **See Fig. 3.** This requires that the previously installed window crank arm, if so equipped, be removed again. Install the crank arm after the door panel and inserts have been attached.
17. As referenced earlier, install the three capscrews (using an allen wrench), nuts, and washers, that partially attach the outside mirror mounting

Window Glass Removal and Installation

bracket to the door. **See Fig. 1.** Tighten the cap-screws 120 lbf·in (1360 N·cm).

Ventilator Window Removal and Installation

Ventilator Window Removal

NOTE: The ventilator window glass can be "pulled" out of the mounting bracket assembly without having to disassemble the components. A special tool, usually available through automotive glass shops, is required.

1. Lower the window.
2. Pull out the window glass-run channel that is seated in the side of the ventilator window mounting bracket.
3. Remove the allen-head capscrew and the outside nuts and washer above the release handle on the window sill. **See Fig. 1.** Using an allen wrench, push out the spacer and washer from the outside hole in the door.
4. Loosen, but don't remove, the other two window sill allen-head capscrews and nuts that partially fasten the outside mirror to the door. **See Fig. 1.**
5. Remove the three panhead screws and lockwashers that attach the ventilator window assembly to the door frame. **See Fig. 2.**

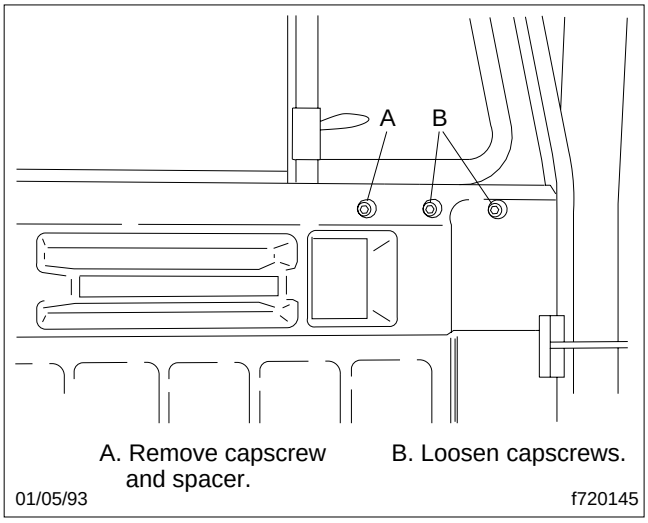


Fig. 1

6. Tilt the top of the ventilator window assembly toward the door latch. Remove the ventilator window assembly.

Ventilator Window Installation

1. Seat the ventilator window assembly in the door. All portions (the inside and outside "flaps") of the seal must overlap the door, frame, the exterior door belt rail (**Fig. 3**), and the window sill (**Fig. 4**).

⚠ CAUTION

CAUTION: Failure to ensure correct installation of the seal could eventually result in cab water leaks.

2. Install the three panhead screws and lockwashers that attach the ventilator window assembly to the door frame. **See Fig. 2.** Check the position (squareness) of the ventilator window in the door frame. The door window channels must be parallel to each other, or the window glass will bind as it is raised. Adjust the position of the ventilator window, if necessary. Tighten the panhead screws securely.
3. Using an allen wrench, tighten the two previously loosened window sill capscrews and nuts 120 lbf·in (1360 N·cm).
4. Install the previously removed window sill spacer through the window sill hole. The spacer should be completely seated. If it doesn't seat, the lower ventilator window guide is tilted out of place. **See Fig. 5.**

   Using the tip of a small screwdriver through the spacer hole from outside the door, lever the window guide back to a vertical position. At the same time, push the spacer in place.
5. Install the allen-head capscrew, nuts, and washers that partially attach the outside mirror bracket to the door. Tighten the capscrew 120 lbf·in (1360 N·cm).
6. Seat the window glass-run channel along the side of the ventilator window.
7. Test the window for up-and-down movement. Hard rolling means that the previously removed window glass-run channel was not seated correctly. Seat the glass-run channel completely.

Ventilator Window Removal and Installation

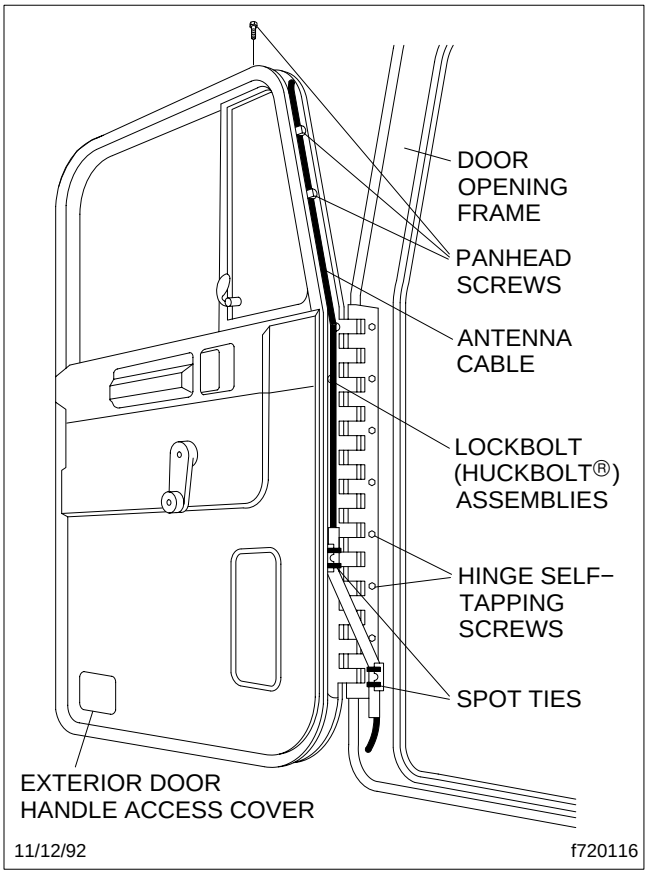


Fig. 2, Cab Door

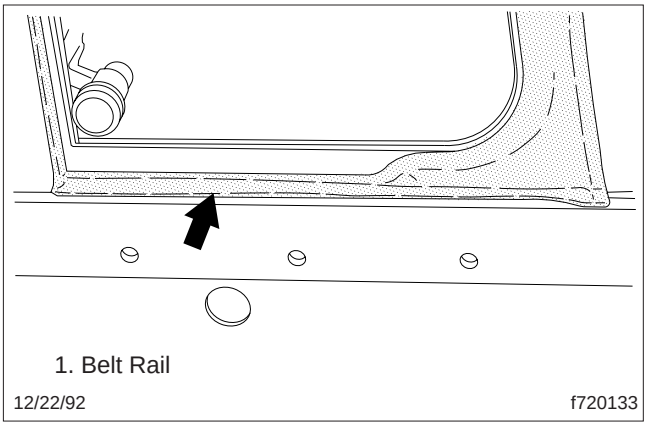


Fig. 3, Bottom Seal of the Ventilator Window Assembly

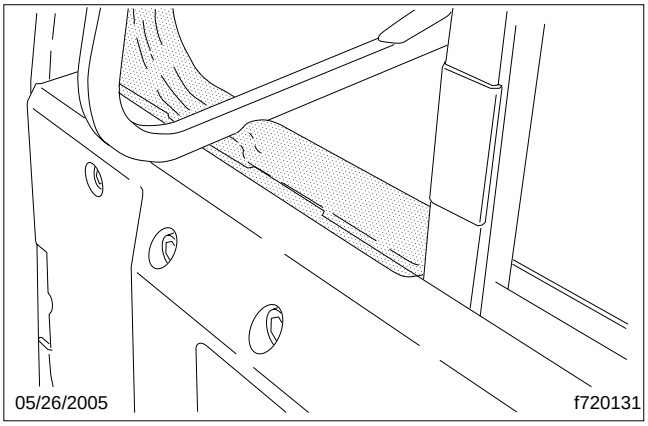


Fig. 4, Correctly Installed Ventilator Window Seal

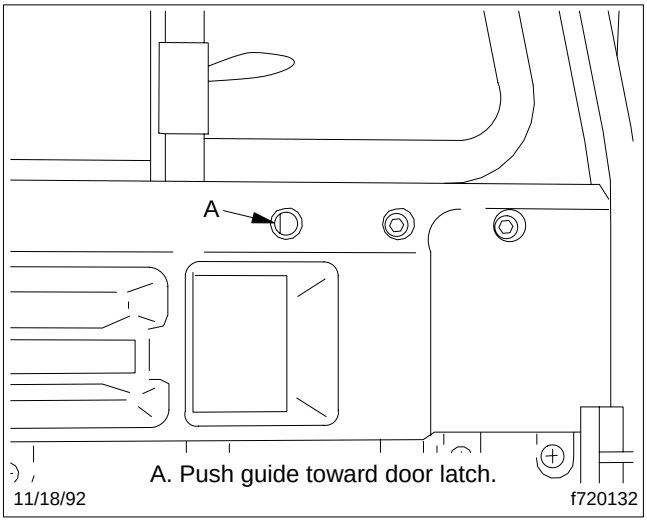


Fig. 5, Lower Ventilator Window Guide Tilted Out of Place

Exterior Door Handle and Rods Replacement

Replacement

1. On custom interiors equipped with hand crank windows, remove the crank arm from the window crank regulator assembly. On all custom door interiors, first remove the interior door panel. See **Fig. 1.**
2. Remove the exterior door handle access cover from the inner door skin panel. See **Fig. 2.**
3. Reference the three rods (inner release rod, release latch rod, and lock rod; see **Fig. 3**) attached to the door handle assembly. Release the rods from the plastic keepers, as shown in **Fig. 3**.
4. Remove the retaining nut that secures the fastening clip to the door handle assembly. See **Fig. 4.**
5. Using a pry, such as a screwdriver, push the fastening clip to the side until it clears the door handle bolt. See **Fig. 4.** Be careful not to let the door handle assembly drop as the fastening clip is pushed out of place. Remove the door handle assembly.

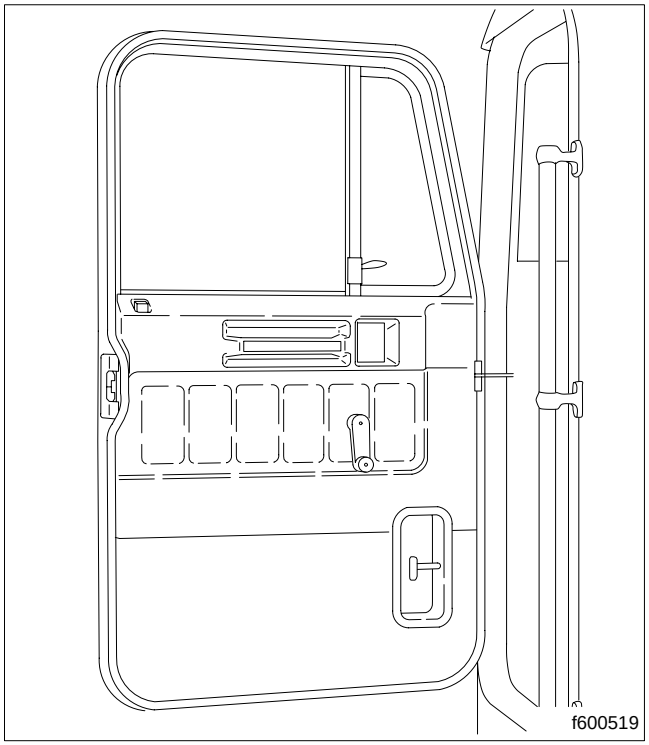


Fig. 1, Custom Interior Door

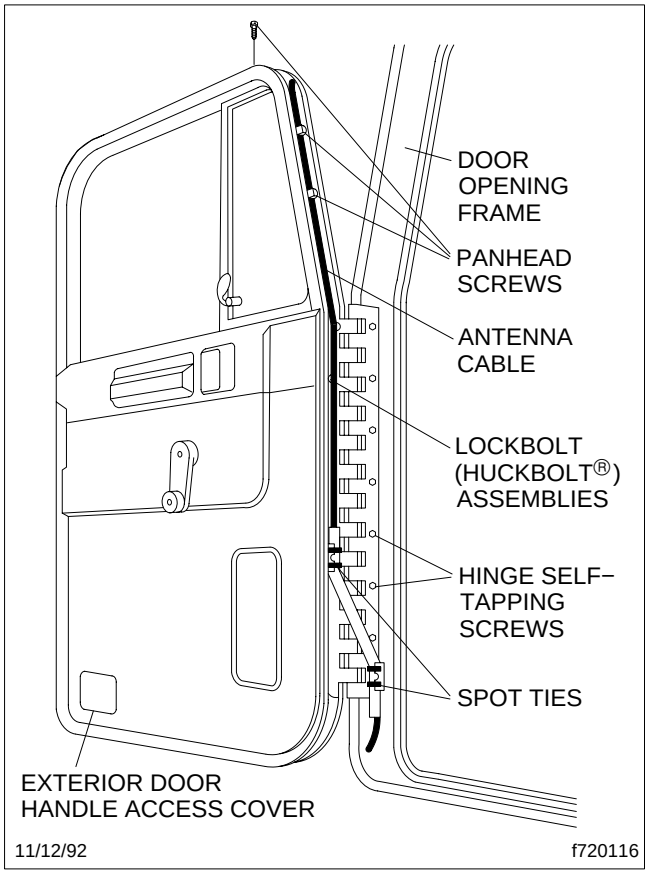


Fig. 2, Cab Door

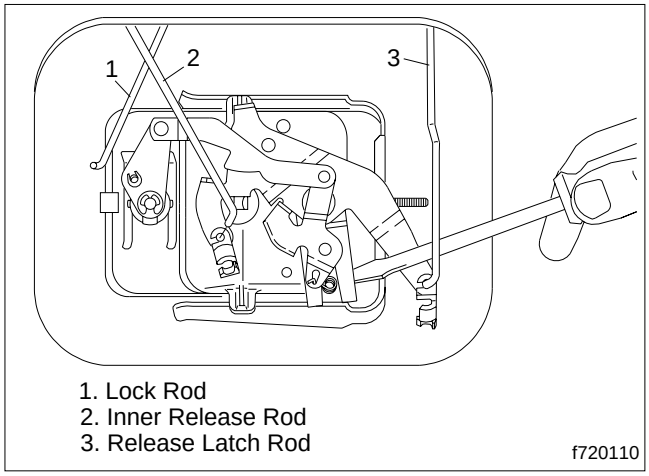


Fig. 3, Releasing the Rods from the Exterior Door Handle

Exterior Door Handle and Rods Replacement

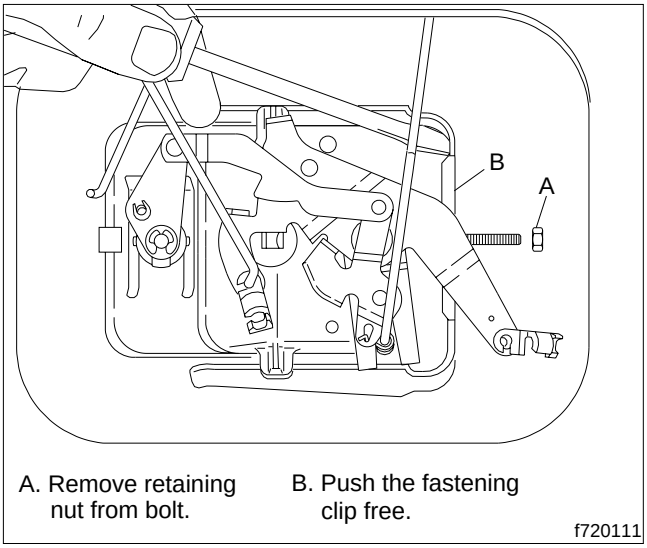


Fig. 4, Removing the Exterior Door Handle Fastening Clip

6. Position the new door handle assembly in the door, then slide the fastening clip in place (reverse the procedure used to remove it).
7. Install the retaining nut that secures the fastening clip to the door handle assembly. See **Fig. 4**. Tighten the nut securely.
8. As referenced earlier, attach the three rods to the door handle assembly. Make sure the plastic keepers are locked in place.
9. Make sure that the three rods have been correctly installed by doing the following tests: Close the latch jaws until they lock in place. Depress the lock button on the interior side of the door. Attempt to open the locked jaws using the exterior door handle. The jaws should not open. Attempt to open the locked jaws using the interior door handle. The jaws should open and the lock button should release.
10. With the cab door closed and unlocked, gradually pull on the paddle of the exterior door handle while measuring its travel. The paddle should move at least 3/8 inch (9.5 mm) before the door latch opens. See **Fig. 5**.

    If the door latch opens correctly, go to the next step.

    If the door latch opens too soon, do the following:

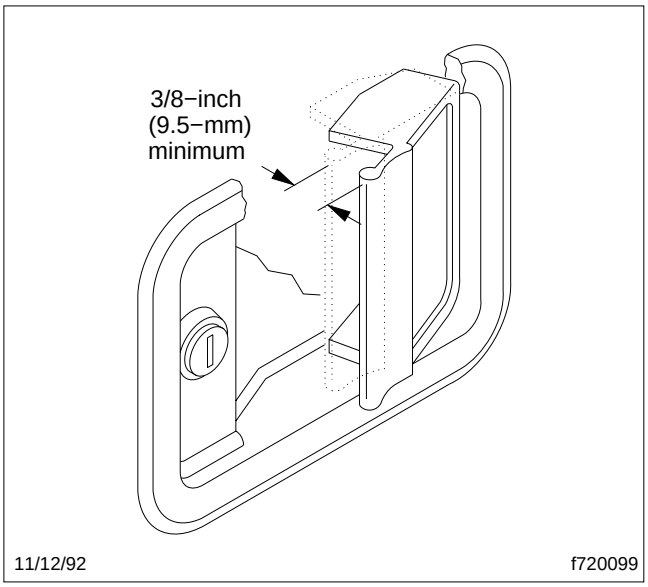


Fig. 5

10.1 Remove the latch release rod from the plastic keeper in the handle assembly.

10.2 Move the latch release rod to the top of its travel and then pull it down slowly until the first resistance is felt. This is its free-travel range. The end of the rod should fit into the plastic keeper in the hole somewhere within this range. If it does, connect the latch release rod, and go to the next step.

If the latch release rod cannot be inserted into the keeper without moving it beyond the free-travel range (preloading the rod), remove the plastic keeper from the handle assembly.

10.3 Using a size B bit, drill a hole at the prepunched pilot hole in the handle assembly. See **Fig. 6**.

10.4 Install the plastic keeper in the handle assembly.

10.5 Attach the latch release rod to the door handle assembly. Make sure the plastic keeper is locked in place.

11. Attach the exterior door handle access cover to the inner panel of the door.
12. If applicable, attach the interior door panel inserts to the inner door skin panel. Attach the

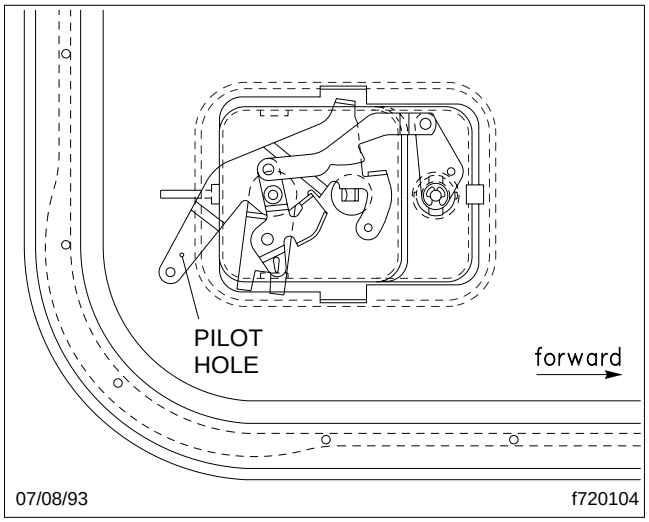


Fig. 6

crank arm to the window crank regulator assembly. Install and tighten the allen-head capscrew.

Door Lock Rod Replacement

1. Remove the window crank; then the interior door panel from the inner door skin panel. See **Fig. 1**.
2. Remove the exterior door handle access cover. See **Fig. 2**.
3. Remove the lock rod from the door.
   - 3.1 Disconnect the inner release rod and the lock rod from the plastic keepers. See **Fig. 3.**
   - 3.2 Disconnect the spring (not shown) that attaches the lock rod to the release latch rod.
   - 3.3 Remove the lock rod from the door by pulling the bottom end down and out through the access opening, together with the door lock button, which is attached at the top end.
4. Install the door lock button on the new lock rod.
5. Install the lock rod in the door.
   - 5.1 Pass the end of the lock rod with the door lock button in through the access opening and up through the slit in the top of the window sill.
   - 5.2 Connect the opposite end of the lock rod to the plastic keeper. See **Fig. 3.**
   - 5.3 Install the spring between the lock rod and the release latch rod.
   - 5.4 Connect the inner release rod to the plastic keeper. See **Fig. 3.**
6. Install the exterior door access panel; then the interior door panel and the window crank. See **Fig. 1** and **Fig. 2**.

Release Latch Rod and Inner Release Rod Replacement

1. Remove the window crank; then the interior door panel from the inner door skin. See **Fig. 1.**
2. Remove the exterior door handle access cover from the inner panel. See **Fig. 2.**
3. Disconnect the bottom ends of the rods.
   - 3.1 Disconnect the release latch rod, the inner release rod, and the lock rod from the plastic keepers. See **Fig. 3.**
   - 3.2 Disconnect the spring (not shown) between the release rod and the lock rod.
4. Remove the window sill.
   - 4.1 Remove the three bolts at the top of the window sill; then the eight screws at the bottom. See **Fig. 7.**
   - 4.2 Remove the allen-head bolt that attaches the door check arm to the door frame (**Fig. 8**); then the upper three hexhead capscrews located on the hinge side of the door (**Fig. 9**).
   - 4.3 Remove the two hexhead capscrews located on the opposite side of the door (above the door latch assembly). See **Fig. 10.**
   - 4.4 Remove the window sill with the inner release rod attached.
   - 4.5 Remove the inner release rod from the sill by disconnecting the plastic keeper.
5. Remove the two remaining rods.
   - 5.1 Remove the lock rod with the door lock button.

Exterior Door Handle and Rods Replacement

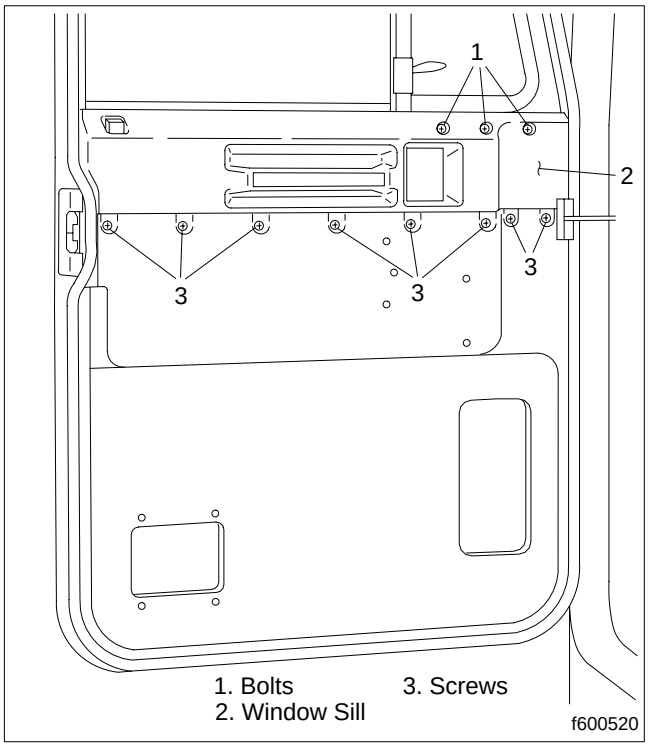


Fig. 7

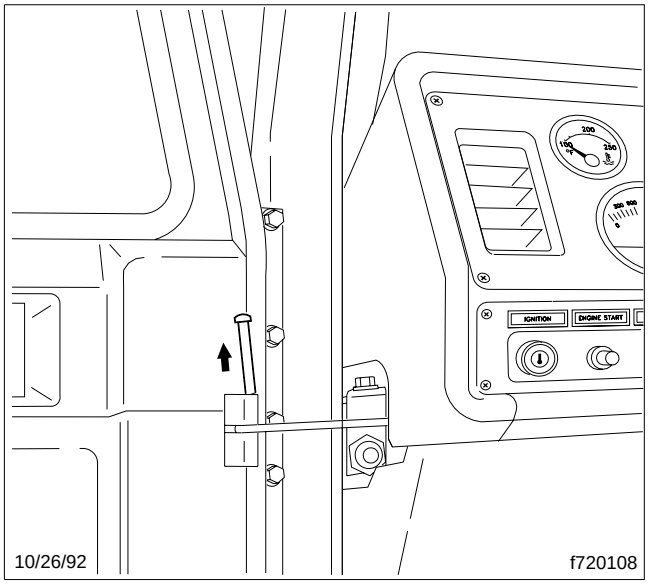


Fig. 8

5.2 Remove the release latch rod by disconnecting the top end from the plastic keeper.

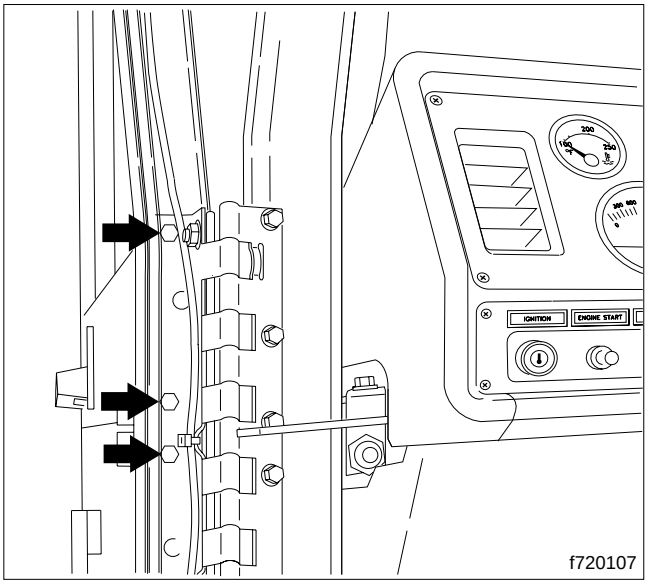


Fig. 9

6. Install the window sill and the rods.

   6.1 Connect the top end of the new release latch rod to the plastic keeper before installing the window sill.

   6.2 With the top end of the new inner release rod attached, install the window sill and its fasteners (bolts and screws), following, in reverse order, the procedure above; then attach the door check arm and the allen-head bolt to the door frame (**Fig. 8**).

   6.3 Connect the bottom end of the release latch rod to the plastic keeper. See **Fig. 3.**

   6.4 Pass the end of the lock rod with the door lock button up through the slit in the top of the window sill; then connect the other end to the plastic keeper.

   6.5 Connect the bottom end of the new inner release rod to the plastic keeper; then install the spring between the release latch rod and the lock rod.

7. Install the exterior door handle access panel; then the interior door panel and the window crank. See **Fig. 1** and **Fig. 2**.

Exterior Door Handle and Rods Replacement

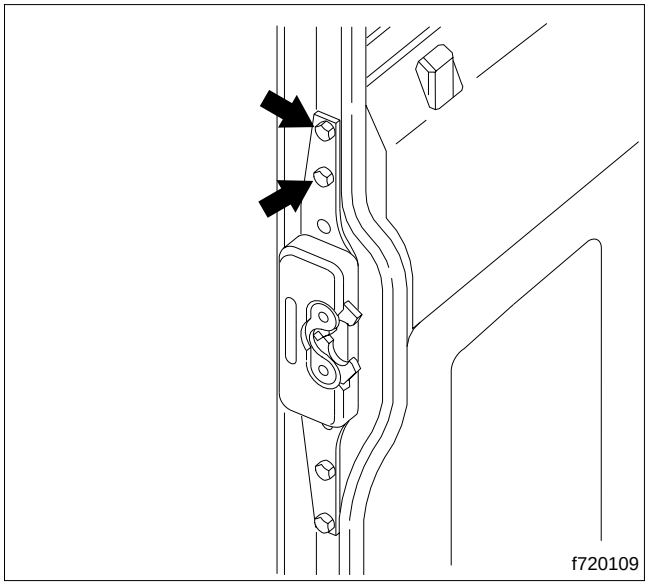


Fig. 10

Visibility Window Glass Replacement

Special tools are not needed to remove and install the visibility window glass. A regular screwdriver (a small one) and a thin, flat tool, such as a putty knife, can be used if a special corkscrew instrument (utilized in major body shops for window glass replacement) is not available.

⚠ WARNING

WARNING: Use care when working around or handling glass. Wear protective gloves to eliminate the possibility of personal injury resulting from accidentally breaking or splintering the glass.

1. From the outside of the door, locate the seam where the visibility window glass rubber extrusion ends. Then, carefully using a tool such as a small screwdriver, unseat the rubber extrusion lockstrip. See **Fig. 1.**
2. Using the screwdriver, carefully unseat the entire length of the lockstrip. If desired, the lockstrip can be worked out without using the screwdriver; this will lessen the chances of blemishing the rubber extrusion.
3. After the lockstrip is completely unseated, push out the visibility glass from inside the door.

NOTE: If the lockstrip is completely unseated, little pressure is needed to push out the glass. When pushing out the glass, wear heavy protective gloves if the glass is blemished with fine, hairline scratches or if it is cracked.

4. Replace the rubber extrusion, if necessary, as follows:
   - 4.1 Without using sealant, start at the center of the rear edge and work the deep, narrow slot of the rubber extrusion onto the door skin lip. Work the rubber extrusion as far as possible onto the door skin, keeping it tight into the corners. See **Fig. 2.**
   - 4.2 Overlap the ends of the extrusion and cut the overlap to 1/2 inch (13 mm). See **Fig. 3.** Coat one end with weather-strip adhesive and butt the ends together (**Fig. 4**).

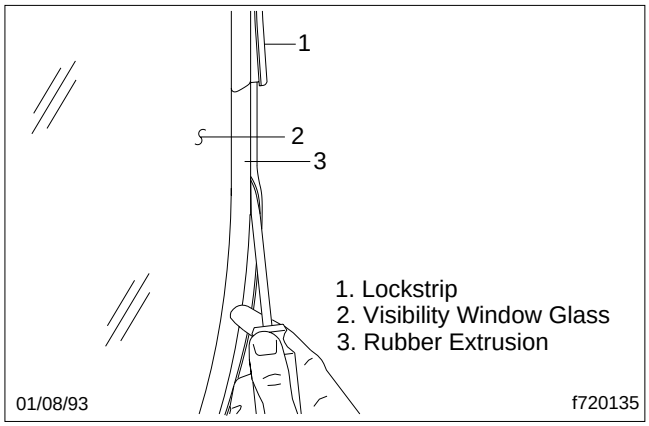


Fig. 1, Unseating the Visibility Rubber Extrusion Lockstrip

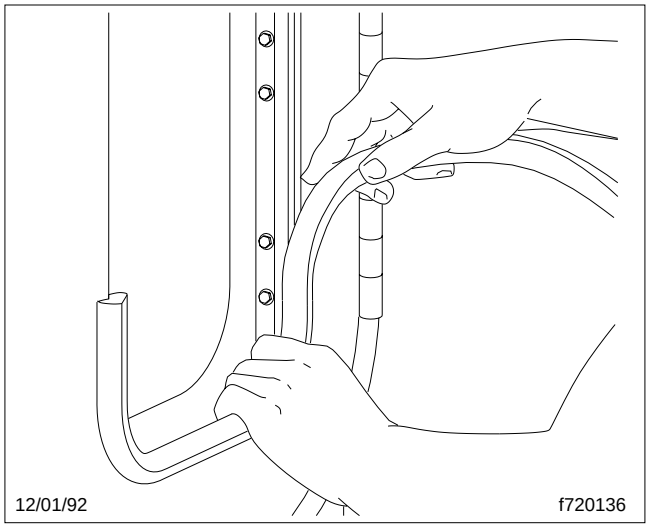


Fig. 2

5. Lubricate the rubber with soap and water (**Fig. 5**), and seat as much of the new window glass (without using tools) as possible. See **Fig. 6.** Then using a small screwdriver, work the edges of the extruded rubber over the edge of the glass. See **Fig. 7.** Be sure the glass is seated properly with the rubber extrusion flaps overlapping the inner and outer surfaces of the glass.
6. If possible, begin at the rubber extrusion seam and tuck the lockstrip end in place. By lifting up the rubber extrusion using a putty knife, the lockstrip can be worked in using your fingers, as shown in **Fig. 8**.

Visibility Window Glass Replacement

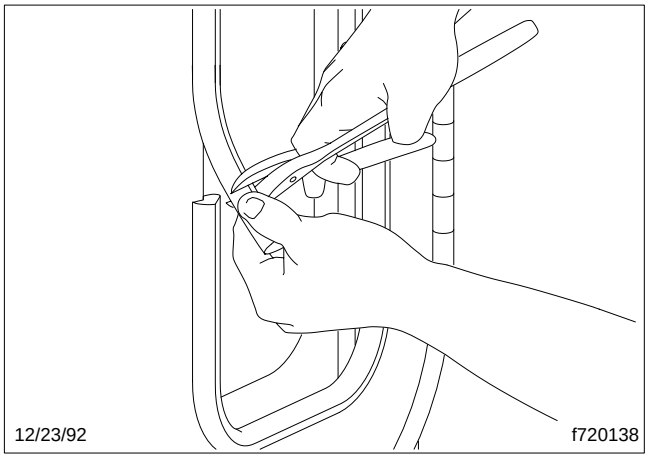


Fig. 3

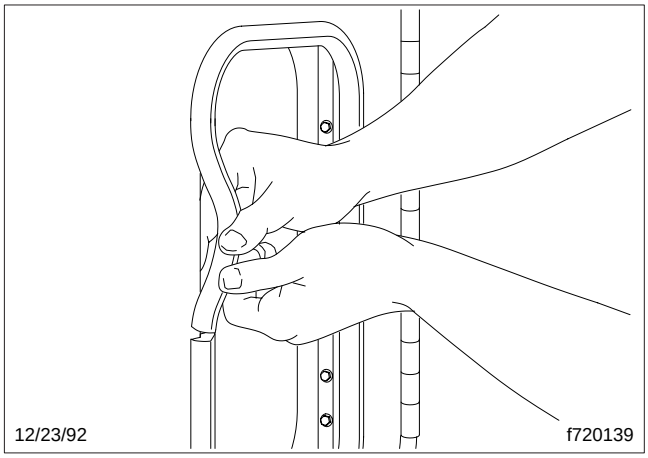


Fig. 4

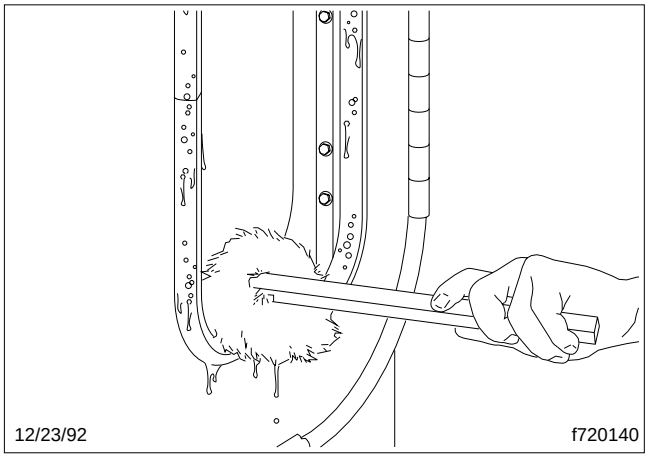


Fig. 5

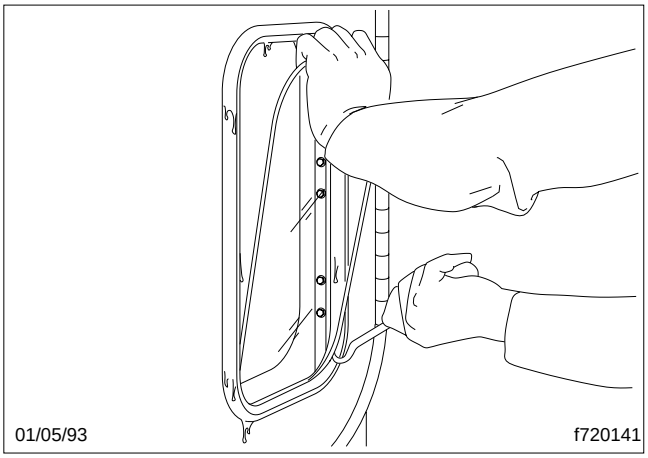


Fig. 6

7. Seat about 80 percent of the lockstrip around the border of the rubber extrusion. As you work, frequently and gently push down on the glass in order to seat it in the door. Except for the rounded portions of the work area, most of the seating of the lockstrip can be done without using the putty knife.
8. After about 80 percent of the lockstrip length has been seated, gently use the putty knife to tuck in the flap of the rubber extrusion, so that the glass is completely seated. Push down on the glass until it is

   level with the outer panel of the door; only slight pressure is needed to seat the glass. Then, using the putty knife, seat the remaining portion of the lockstrip. See **Fig. 9.**

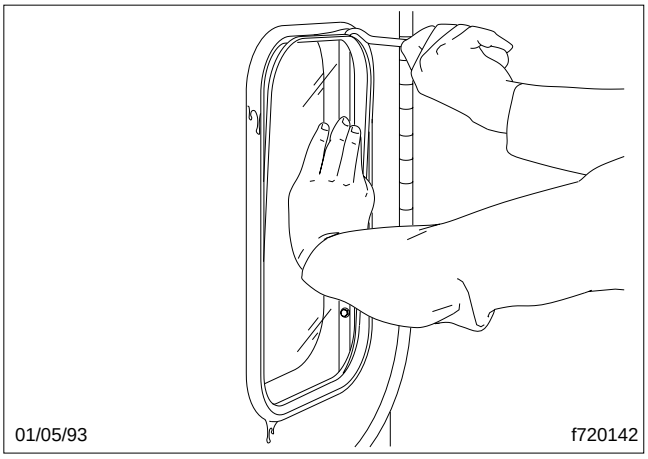


Fig. 7

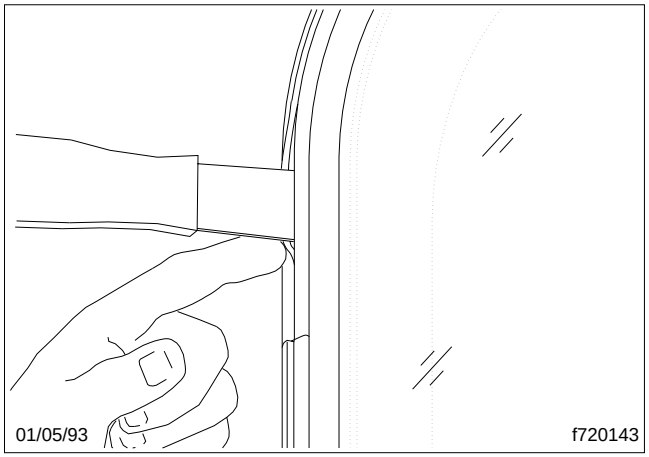


Fig. 8

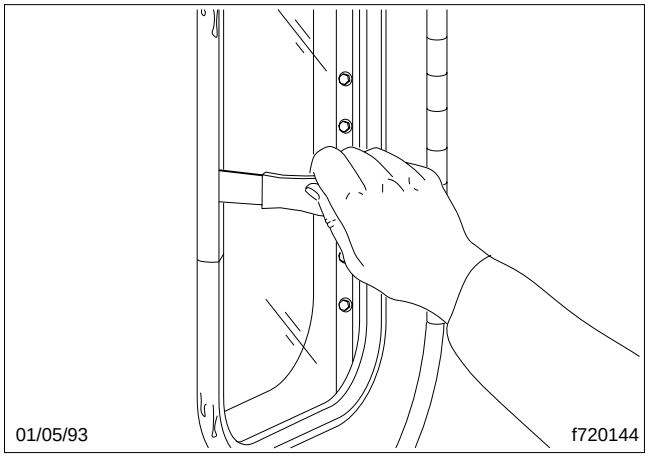


Fig. 9

⚠ CAUTION

CAUTION: Use care when sliding the putty knife blade along the edge of the glass. Small splinters of glass will break off if the work is done carelessly.

IMPORTANT: To prevent cab water leaks, the rubber extrusion should lay flat against the outer panel and should not crease at any point, especially around the corners of the visibility window. Reinstall the visibility window if the rubber extrusion creases; make sure that the glass is completely seated in the door.

Air Vent Removal (See Fig. 1)

1. Do steps 1 through 5 in **Subject 170**, "Removal."
2. Centerpunch the rivets that attach the air vent assembly to the outer panel of the door. Using a no. 11 (0.191-inch) drill bit, drill out the rivets. Do not enlarge the original holes. Remove any debris that falls inside the door.
3. Remove the air vent assembly.

Air Vent Installation (See Fig. 1)

1. Line the replacement air vent assembly with sealant tape as follows:
   - 1.1 On the entire inboard lip of the air vent assembly (the portion facing the inner panel), attach vinyl foam tape 48–00016–805.
   - 1.2 On the outboard face of the air vent assembly (the portion touching the outer panel), attach vinyl foam tape 48–00050–206.
2. Using 3/16-inch rivets (5/16-inch long), attach the air vent assembly to the outer panel.
3. Do steps 3 through 9 in **Subject 170**, "Installation."

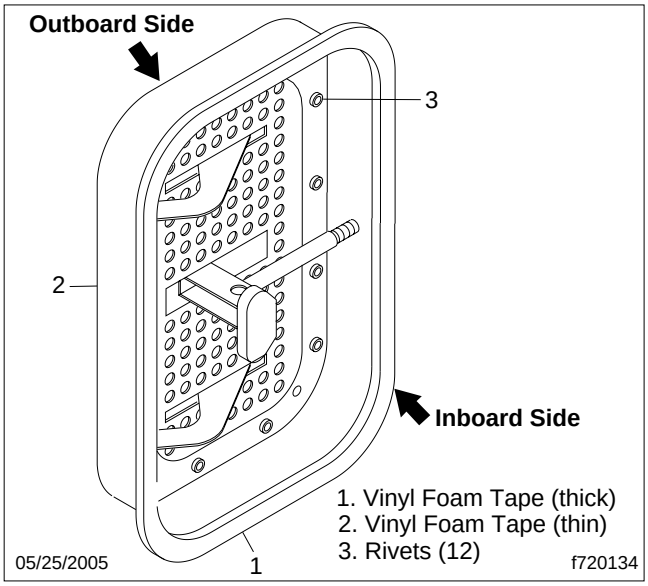


Fig. 1, Air Vent Assembly

Door Hinge Removal

1. Remove the door from the vehicle. For instructions, see **Subject 100**.
2. Remove the window sill from the door. For instructions, see **Subject 120**.
3. If applicable, remove the capscrew, nuts, and washer that partially attach the outside mirror mounting bracket to the door frame and hinge assembly.
4. Remove the panhead screws that attach the inner panel to the hinge side of the door frame.
5. Centerpunch the rivets that attach the inner panel to the door frame. Using a no. 11 (0.191-inch) drill bit, drill out the rivets. Do not enlarge the original holes.

IMPORTANT: On doors equipped with visibility windows, it is possible to replace the hinge without removing the rivets from the inner panel/door frame assembly. After removing the visibility window trim ring (see **Fig. 1**), the applicable service operations below can be performed utilizing the temporary access space.

6. Remove the inner panel assembly from the door frame. For doors equipped with hand cranked windows, disengage the regulator arm roller from the window lift channel as the inner panel is pulled away.
7. Centerpunch the lockbolt (Huckbolt®) assemblies that attach the hinge to the door frame. See **Fig. 2.** Carefully drill out the fasteners using a 1/4-inch drill bit. Do not enlarge the original holes. Remove any debris that falls inside the door.
8. Remove the hinge.

Door Hinge Installation

1. If necessary, replace the rubber sealant tape on the inner side edges of the inner panel (does not include the window sill edge).
2. Depending on the availability of tools, attach the new hinge to the door frame using one of the following methods:

   1/4-inch, mild steel, pin and collar lockbolt assemblies A23–09988–005.

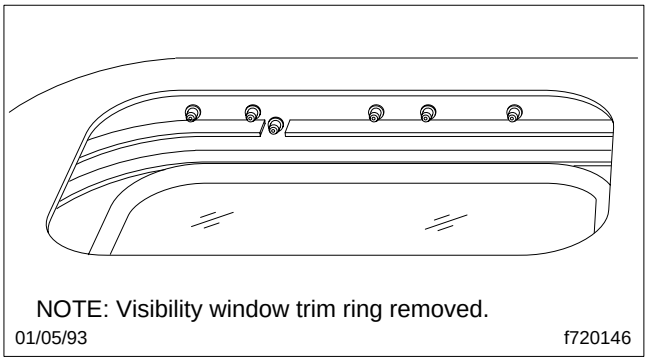


Fig. 1, Access Space to the Lockbolt Assemblies

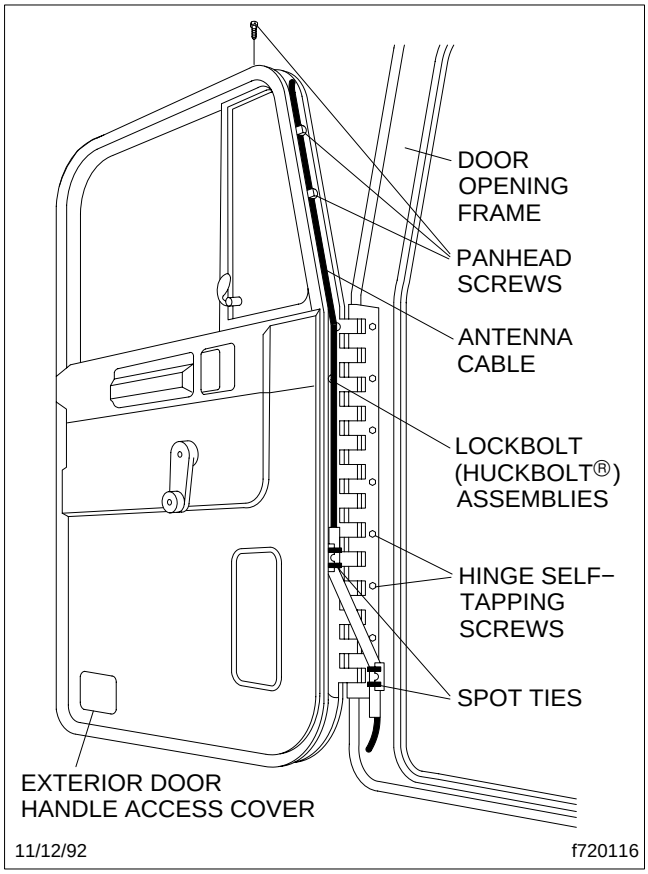


Fig. 2, Cab Door

   1/4–20, grade 5, 1-inch bolts used in combination with either pre-assembled nut and lockwasher assemblies (kep nuts) 23–10340–125, or standard hexnuts and lockwashers.

3. Position the inner panel assembly on the door frame. For doors equipped with crank-style win-

Door Hinge Removal and Installation

dows, engage the regulator arm roller of the window crank regulator assembly in the window lift channel as the inner panel is installed.

4. Using 3/16-inch rivets, attach the inner panel to the door frame. Do not attempt to rivet the portion in the hinge area.
5. Install the panhead screws that attach the inner panel to the remaining portion of the door frame.
6. If applicable, install the visibility window trim ring and countersunk screws.
7. If applicable, install the capscrews, nuts, and washers that partially attach the outside mirror mounting bracket to the door frame and hinge assembly. Tighten the capscrews 120 lbf·in (1360 N·cm).
8. Install the window sill on the door. For instructions, see **Subject 120**.
9. Install and adjust the door on the vehicle. For instructions, see **Subject 100**.
10. Spray a light coating of silicone lubricant, such as WD-40® or an equivalent, along the entire length of the hinge.

Door Latch Removal

1. Remove the door, the window sill, mirror bracket fasteners, and inner panel screws; then drill out the door inner panel rivets. For instructions, see "Door Hinge Removal" in **Subject 170**.
2. Unfasten the latch release rod from the plastic keeper on the latch assembly.
3. Centerpunch the lockbolt (Huckbolt®) assemblies that attach the door latch assembly to the door frame. Carefully drill out the fasteners using a 1/4-inch drill bit. Do not enlarge the original holes. Remove all the debris that falls inside the door.
4. Remove the door latch assembly.

Door Latch Installation

1. To ease installation of the window sill, ream the top two (window sill) capscrew holes of the door latch 5/16 inch (7.9 mm).
2. Depending on the availability of tools, attach the new door latch assembly to the door frame using one of the following methods:

   1/4-inch, mild steel, pin and collar lockbolt assemblies A23–09988–005.

   1/4–20, grade 5, 1-inch bolts used in combination with either pre-assembled nut and lockwasher assemblies (kep nuts) 23–10340–125 , or standard hexnuts and lockwashers. Tighten the nuts 60 to 84 lbf·in (680 to 940 N·cm).
3. Attach the latch release rod to the plastic keeper on the latch assembly.
4. Attach the inner door panel, outside mirror bracket, and window sill, following the instructions under "Door Hinge Installation" in **Subject 170**.
5. Test the latch for correct operation as follows:

   Close one jaw of the latch until it locks in place. Release the jaw (repeatedly) using the interior door handle and the exterior door handle. There should be a crisp release.

   Repeat the test using the opposite jaw.

   Replace the latch assembly if binding occurs.
6. Install and adjust the door on the vehicle, following the instructions in **Subject 100**.

Door Check Removal

DRIVER-SIDE

1. Disconnect the batteries at the negative terminal.
2. On COEs, remove the six screws securing the dash skirt panel, and remove it. See **Fig. 1.** Remove the Z-bracket at the same time.

   On Conventionals, remove the five screws securing the dash skirt panel, and remove it. Remove the Z-bracket at the same time.
3. Remove the rubber boot (see **Fig. 2**) from the doorjamb interior light switch by peeling it over the switch contact pin.
4. Remove the jam nut and withdraw the switch from the bracket. See **Fig. 3.**
5. Remove the allen-head bolt attaching the door check to the cab door. See **Fig. 4.** Use care not to let the door swing open too far during removal. (Normally, the door check arm would prevent this.)

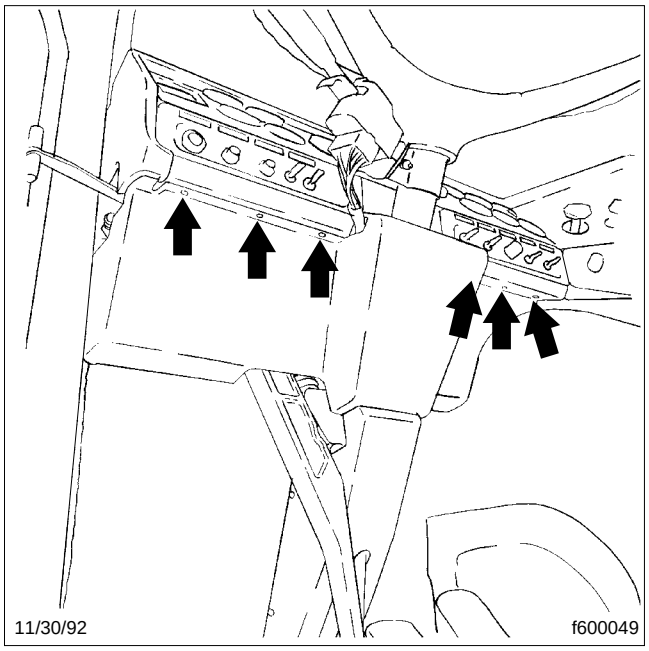


Fig. 1

6. Remove the three locknuts and flatwashers from the door check arm bracket. Remove the three bolts and flatwashers. The doorjamb interior light switch bracket will come loose with the door check bracket.

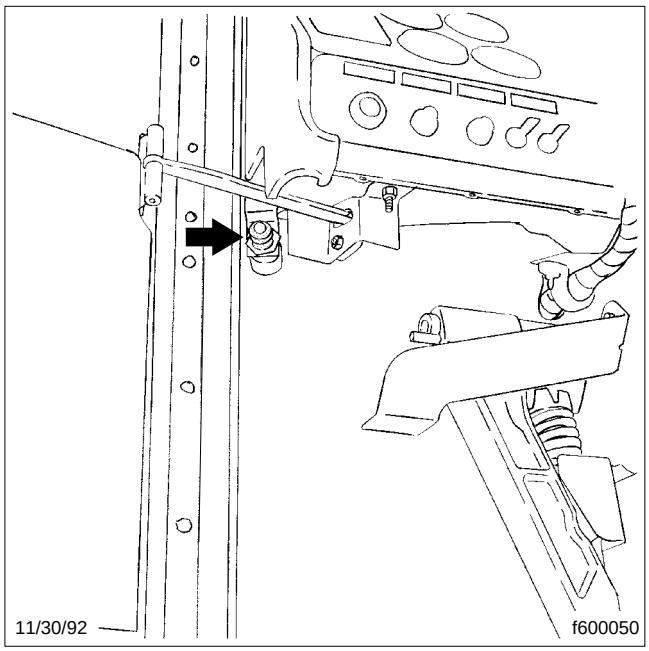


Fig. 2

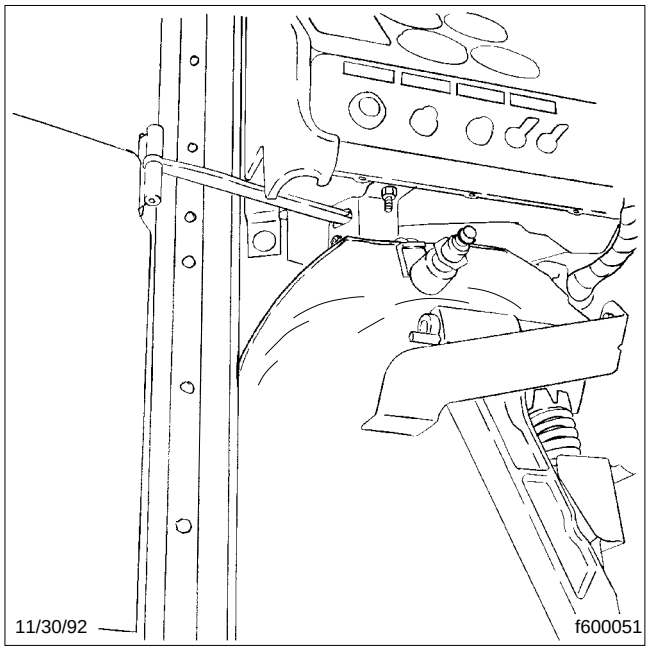


Fig. 3

Door Check Removal and Installation

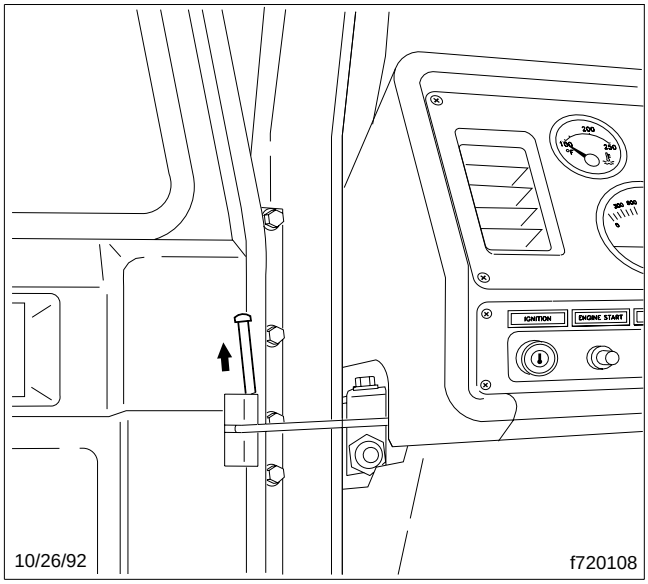


Fig. 4

PASSENGER-SIDE

1. Remove the allen-head bolt attaching the door check arm to the cab door. Use care not to let the door swing open too far during removal. (Normally, the door check arm would prevent this.)
2. On COEs, remove the eight screws securing the dash skirt panel. See **Fig. 5.**

   On Conventionals, remove the nine screws securing the dash skirt panel. See **Fig. 6.**
3. On COEs, remove the two panhead screws from the top of the right dash. Then, remove the three locknuts and springwashers from the back of the glove box and the one panhead screw from the floor of the glove box.

   On Conventionals, remove the three locknuts and springwashers from the back of the glove box.
4. Pull the right dash toward the back of the cab enough to be able to access the two locknuts on the door check bracket.
5. Remove the two locknuts and flatwashers from the door check arm bracket. Remove the two bolts and flatwashers and remove the door check bracket.

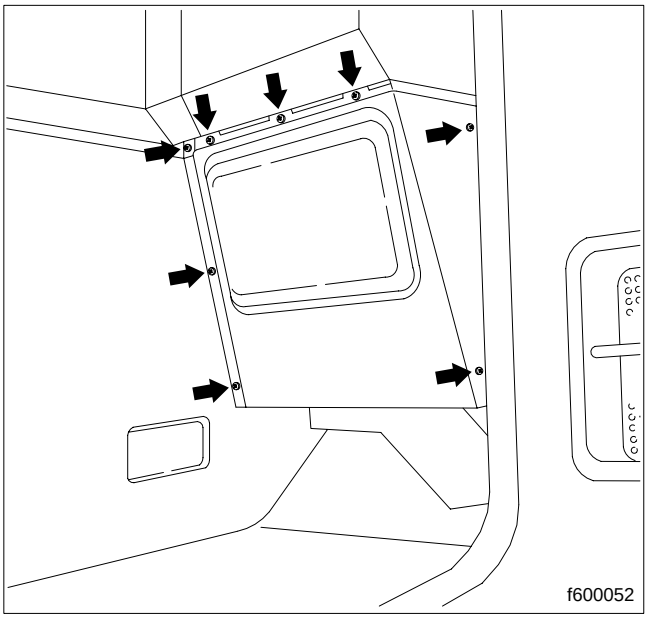


Fig. 5

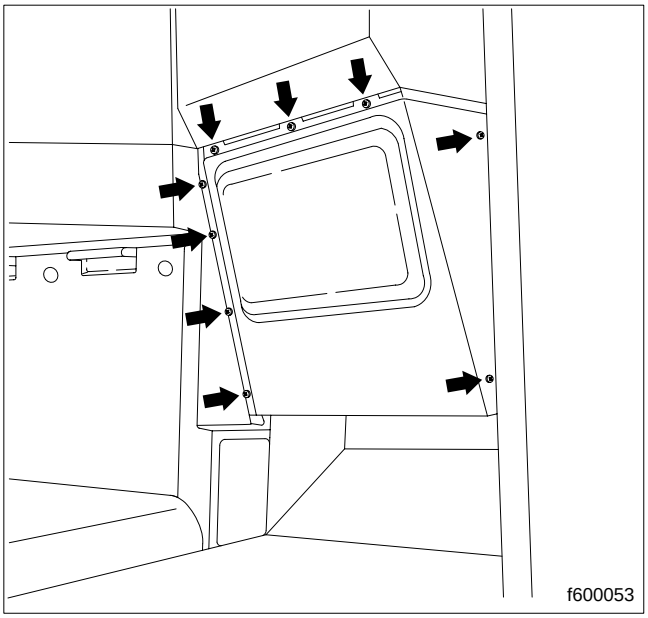


Fig. 6

Door Check Installation

DRIVER-SIDE

1. Position the door check bracket and insert the aft-inboard bolt and washer. Install the flatwasher and locknut.
2. Position the doorjamb interior light switch bracket and install the other two bolts, flatwashers, and locknuts.
3. Tighten all three locknuts securely.
4. Install the interior light switch in the hole in the bracket, and using the adjustment nut and jam nut, adjust the depth of the switch so the door will contact it when closed. Tighten the jam nut securely.
5. Install the rubber boot.
6. Install the Z-bracket and dash skirt panel.
7. Install the allen-head bolt that attaches the door check arm to the cab door.
8. Connect the batteries. Test the doorjamb light switch to be sure the interior light will come on when the door is opened, and will shut off when the door is closed.

PASSENGER-SIDE

1. Position the door check bracket, and insert the two bolts and flatwashers. Install the flatwashers and locknuts. Tighten the locknuts securely.
2. On COEs, install the right dash using the three springwashers and nuts on the studs in the back of the glove box, and the one panhead screw in the floor of the glove box. Install the two pan-head screws in the top of the right dash. Tighten the locknuts securely.

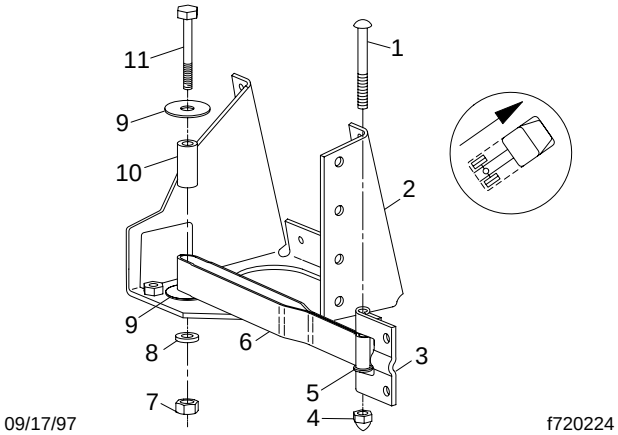
   On Conventionals, install the right dash using the three springwashers and nuts on the studs in the back of the glove box. Tighten the locknuts securely.
3. Install the dash skirt panel.
4. Install the allen-head bolt that attaches the door check arm to the cab door.

Door Check Removal and Installation, FLB RH DR

Removal

RIGHT-HAND (DRIVER'S) SIDE

1. Using a 1/4-inch Allen wrench, remove the check plate shoulder bolt, crown nut, and #12 washer. See **Fig. 1**.



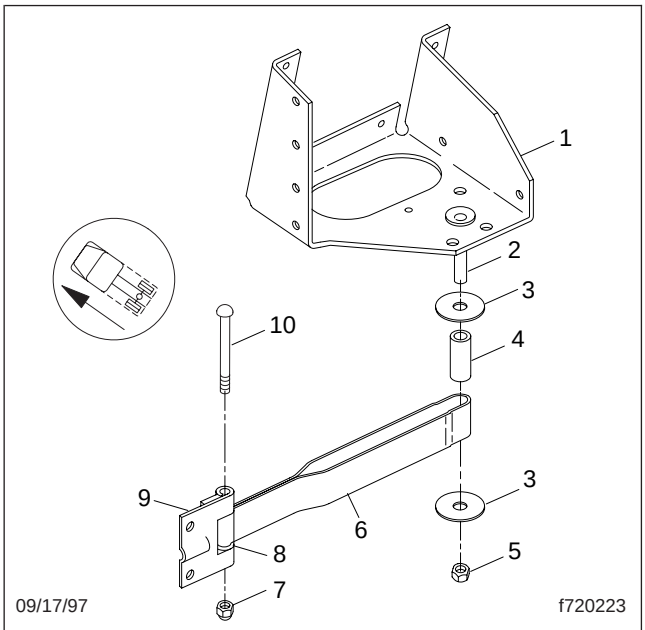
1. #12 Shoulder Bolt
2. Nosebeam End Bracket, RH
3. Check Plate
4. Crown Nut
5. #12 Washer
6. Check Arm
7. 1/4–20 Locknut
8. 1/4-Inch Washer
9. Extra-Wide Washer (1/4-inch i.d.)
10. Roller
11. 1/4–20 Capscrew

Fig. 1, Door Check Arm (right-hand side)

2. Remove the two T20 machine screws attaching the right-hand dash skirt panel to the dash.
3. Remove the HVAC ducting directly over the door check arm as needed to gain access to the capscrew holding the check arm in place.
4. Using a 7/16-inch wrench, remove the 1/4–20 locknut, washers, roller, and 1/4–20 capscrew from the end of the door check arm.
5. Remove the door check arm.

LEFT-HAND (PASSENGER'S) SIDE

1. Using a 1/4-inch Allen wrench, remove the check plate shoulder bolt, crown nut, and #12 washer. See **Fig. 2**.
2. Remove the six T20 machine screws attaching the left-hand dash skirt panel to the dash.



1. Nosebeam End Bracket, LH
2. Hanging Stud
3. Extra-Wide Washer (5/16-inch i.d.)
4. Latch Bearing
5. 5/16–18 Locknut
6. Check Arm
7. Crown Nut
8. #12 Washer
9. Check Plate
10. #12 Shoulder Bolt

Fig. 2, Door Check Arm (left-hand side)

3. Using a 1/2-inch wrench, remove the 5/16–18 locknut, washers, and latch bearing from the stud on the nosebeam end bracket.
4. Remove the door check arm.

Installation

RIGHT-HAND (DRIVER'S) SIDE

1. Position the door check arm in the check plate, making sure that the seam is facing forward (towards the front of the vehicle).
2. Install the check plate shoulder bolt, crown nut, and #12 washer. Tighten until firm.
3. Position the other end of the door check arm on the right-hand nosebeam end bracket, with one extra-wide washer (1/4-inch inside diameter) underneath it. Insert the roller into it.
4. Insert the 1/4–20 capscrew and the other extra-wide washer through the check arm and roller.

Door Check Removal and Installation, FLB RH DR

Install the 1/4–20 locknut and the narrow washer (1/4-inch inside diameter) onto the capscrew. Tighten the locknut 84 lbf·in (940 N·cm).

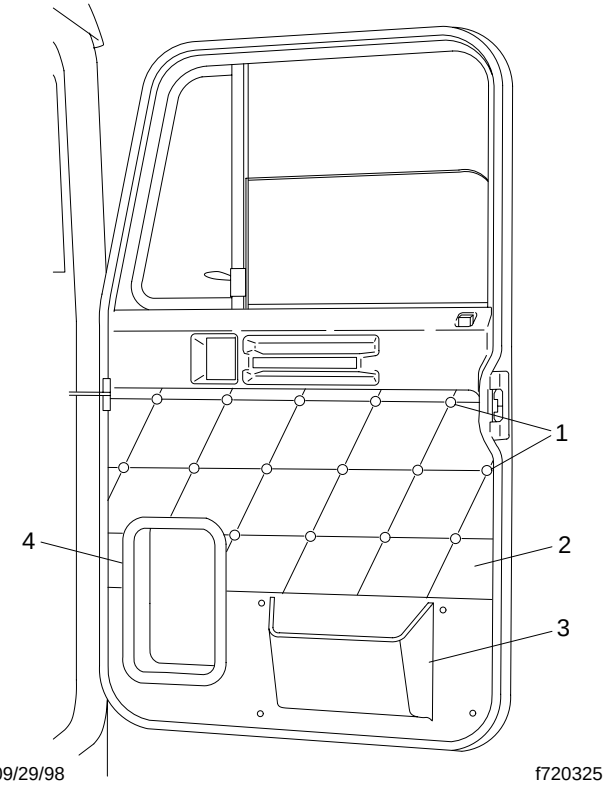
5. Install the HVAC ducting, as removed.
6. Install the right-hand dash skirt panel on the dash, using the two T20 machine screws, as removed.

LEFT-HAND (PASSENGER'S) SIDE

1. Position the door check arm in the check plate, making sure that the seam is facing forward (towards the front of the vehicle).
2. Install the check plate shoulder bolt, crown nut, and #12 washer. Tighten until firm.
3. Slip the other end of the door check arm onto the stud attached to the bottom of the left-hand nosebeam end bracket.
4. Install the latch bearing, 2 extra-wide washers (5/16-inch inside diameter), and the 5/16–18 locknut onto the stud. Tighten the locknut 15 lbf·ft (20 N·m).
5. Install the left-hand dash skirt panel on the dash, using the six T20 machine screws, as removed.

Regulator Replacement

1. Lower the window halfway down and secure it in place.
2. If the vehicle is equipped with a visibility window, remove the Torx®-head fasteners that attach the visibility window frame to the door panel and remove the window frame. See **Fig. 1**.



1. Upholstery Buttons
2. Inner Door Trim Panel
3. Pocket
4. Visibility Window

Fig. 1, Right-Hand Door, Conventional Shown

3. Remove the Torx®-head fasteners around the pocket on the inner door trim panel. See **Fig. 1**.

NOTE: On Conventionals, there are four Torx®-head fasteners around the pocket. On COEs, there is one Torx®-head fastener on each side of the pocket.

4. Remove the inner door trim panel.

4.1 If the inner door trim panel has upholstery buttons, remove the upholstery buttons along the upper edge of the inner door trim panel. On Conventionals, the upholstery button near the door latch on the second row of buttons will also need to be removed. See **Fig. 1**. Remove the screws that were covered by the upholstery buttons.

4.2 Gently insert a pry bar or a straight-blade screwdriver under a corner of the inner door trim panel, and lift the panel to pull the first plastic fastener out of the door. See **Fig. 2**. Use care not to damage the inner door trim panel.

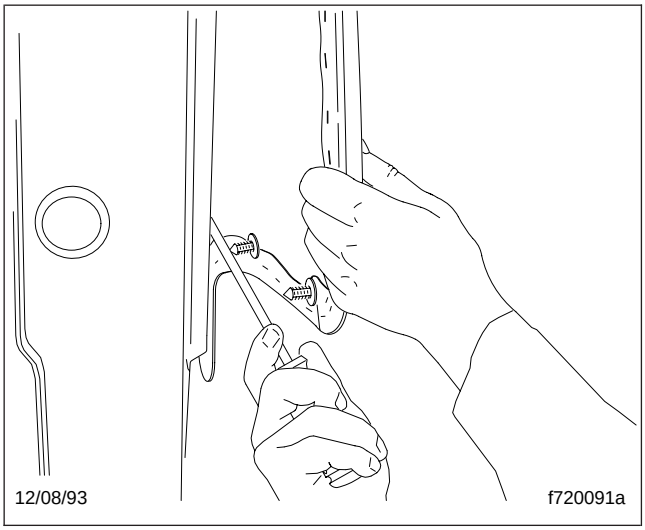


Fig. 2, Removing the Door Trim Panel

4.3 Working around the edge of the panel, pull out each of the plastic fasteners one at a time. If any of the plastic fasteners are damaged, replace them by inserting the head of the new fastener in the backing-board hole.

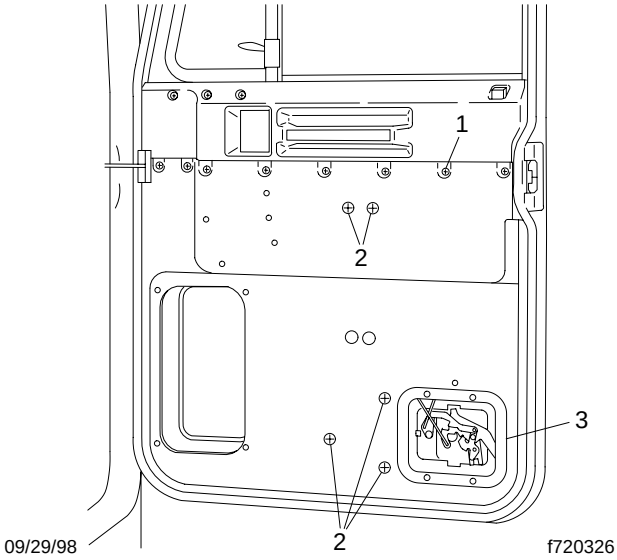
5. Remove the door panel.

5.1 Loosen the screw above the access panel. See **Fig. 3**.

5.2 Remove the Torx®-head fasteners that attach the door panel to the door.

5.3 Remove the five screws that attach the regulator to the door. See **Fig. 3**.

Power Window Regulator Replacement

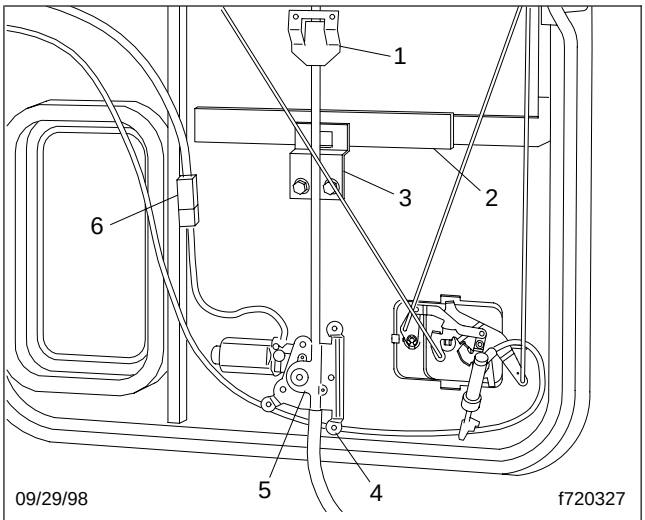


1. Torx®-Head Fastener
2. Regulator Mounting Screws
3. Access Panel

Fig. 3, Right-Hand Door Panel

6. Remove the regulator.

   6.1 Disconnect the wire harness from the regulator. See **Fig. 4**.



1. Upper Bracket
2. Lift Channel
3. Cursor
4. Lower Bracket
5. Regulator
6. Wire Harness

Fig. 4, Power Window Regulator

   6.2 Remove the two screws that attach the regulator to the lift channel.

7. Place the new regulator inside the door. Using two screws, attach the cursor on the regulator to the lift channel. See **Fig. 4**. Tighten the screws securely.
8. Attach the wire harness to the regulator.
9. Place the door panel on the door. Line up the holes in the door panel with the mounting holes on the upper and lower brackets of the regulator. Attach the regulator to the door panel using five Torx®-head fasteners. See **Fig. 4**. Tighten the fasteners 80 to 90 lbf·in (904 to 1017 N·cm).
10. Check that the window closes completely and moves smoothly.
11. Using Torx®-head fasteners, attach the door panel to the door. Tighten the fasteners securely.
12. Tighten the Torx®-head fastener above the access panel.
13. Install the inner door trim panel.

    13.1 Attach the inner door trim panel to the door panel only at the top of the panel by pushing in each of the plastic fasteners one at a time.

    13.2 If the inner door trim panel has upholstery buttons, attach the Torx®-head fasteners to the inner door trim panel along the upper edge of the panel. Tighten the fasteners securely.

    13.3 Press the remaining plastic fasteners into the door panel.

    13.4 If the inner door trim panel has upholstery buttons, attach the upholstery buttons to the heads of the Torx®-head fasteners.

14. Attach the Torx®-head fasteners to the door trim panel around the pocket.
15. If the vehicle is equipped with a visibility window, use Torx®-head fasteners to attach the window frame to the visibility window. Tighten the fasteners securely.

Window Regulator

To field test a power window regulator, follow the procedure in **Table 1**.

NOTE: Power window regulators are equipped with automatic reset internal thermal protection to prevent motor damage from electrical failure or overuse. Depending on the air temperature, window load, and amount of use, the protection may trip after two or three window cycles. This is normal and is not considered to be a defect. Allow the motor to cool at least 10 minutes to reset the thermal protection before testing.

To field test a manual window regulator, follow the procedure in **Table 2**.

Power Window Regulator Not Working			
Step	**Test Procedure**	**Test Result**	**Action**
1	Check the fuse for the window regulators. Is it open?	Yes	Replace the fuse. Continue troubleshooting for a short in the system.
		No	Go to **step 2**.
2	Check the battery. Is it fully charged?	Yes	Go to **step 3**.
		No	Charge the battery.
3	Remove the interior door panel. Check for battery voltage at the window regulator terminals. With the window rocker switch in the neutral position, connect a voltmeter to the two terminals where the wiring harness connects to the window regulator motor. Is voltage present?	Yes	A shorted switch may have caused the internal circuit protection in the motor to trip. Correct the problem, allow the motor to cool for 10 minutes, then check for voltage again.
		No	Go to **step 4**.
4	With the window rocker switch pushed to the "DOWN" position, check the voltage at the regulator terminals. Also check the voltage with the rocker switch pushed to the "UP" position. What is the voltage reading?	11–15 volts	Go to **step 5**.
		Below 11 or above 15 volts	Check the battery for a full charge, then check the rocker switch for excessive resistance. Repair or replace the switch as needed.
		No voltage	Check the rocker switch for proper function. Replace as needed.
5	Remove the screws that attach the glass to the regulator. Is the glass free to move up and down within the run channels without binding?	Yes	Go to **step 6**.
		No	Adjust the glass run channels, or correct the binding condition. Go to **step 6**.
6	Attach the glass to the regulator, leaving the screws loose so that the glass is free to move slightly from side to side. Test the regulator. Does the regulator work properly with the glass mounting screws loosened?	Yes	Check the regulator mounting alignment, adjust if needed, then tighten the screws. Repeat as necessary.
		No	Go to **step 7**.
7	Test the regulator operation. Does it work properly?	Yes	Troubleshooting is completed.
		No	Replace the window regulator.

Table 1, Power Window Regulator Not Working

Troubleshooting

Manual Window Regulator Not Working or Noisy, Window Glass Binding			
Step	**Test Procedure**	**Test Result**	**Action**
1	Remove the interior door panel to gain access to the window regulator.	—	—
2	Are the regulator mounting screws tight, and is the glass secured to the regulator.	Yes	Go to **step 3**.
		No	Correct any problems and retest.
3	Disconnect the glass from the regulator. Is the glass free to move up and down within the run channels without binding?	Yes	Check that the glass attachment point of the regulator moves when the handle is cranked. If it does not, replace the regulator. Otherwise, go to **step 4**.
		No	Adjust the glass run channels, or correct the binding condition. Go to **step 4**.
4	Connect the glass to the regulator, leaving the screws loose so that the glass is free to move slightly from side to side. Crank the handle. Does the regulator work properly with the glass mounting screws loosened?	Yes	Raise and lower the glass completely, then tighten the glass mounting screws.
		No	Loosen the regulator mounting screws and try to adjust the regulator alignment for proper operation. The glass also may need to realigned after any adjustments to the regulator.
5	Test the regulator operation. Does it work properly?	Yes	Troubleshooting is completed.
		No	Replace the window regulator.

Table 2, Manual Window Regulator Not Working or Noisy, Window Glass Binding

Specifications

For fastener torque values, see **Table 1**.

Description		Grade	Size	Torque
FLB RH DR Door Check Arm Locknut, Left-Hand		2 (nylon insert)	5/16–18	15 lbf·ft (20 N·m)
FLB RH DR Door Check Arm Locknut, Right-Hand		2 (nylon insert)	1/4–20	84 lbf·in (940 N·cm)
Hinge Self-Tapping Screws		8	1/4–20	120 lbf·in (1360 N·cm)
Door-Latch/Window-Sill Hexhead Capscrews		5	1/4–20	60–84 lbf·in (680–940 N·cm)
		8	1/4–28	120 lbf·in (1360 N·cm)
Hinge/Door-Frame/Window-Sill Hexhead Capscrews		5	1/4–20	60–84 lbf·in (680–940 N·cm)
		8	1/4–28	120 lbf·in (1360 N·cm)
Window Sill Allen-Head Capscrews		—	1/4–20	60 lbf·in (680 N·cm)
Striker Pin	With One Conical Washer	8	7/16–14	9–11 lbf·ft (12–15 N·m)
	With Two or More Conical Washers	8	7/16–14	18–22 lbf·ft (24–30 N·m)
Inner Panel to Window Sill	Sheet Metal Screws	—	Type A, #10	30 lbf·in (340 N·cm)
	Machine Screws	—	10–24	60 lbf·in (680 N·cm)

Table 1, Torque Values

General Description

Sprague HP-100 series wiper motors are powered by air from the vehicle's accessory air system. Control knobs on the dash panel control the starting, stopping, and speed of the wipers, by regulating the amount of air pressure going to the wiper motors. On COEs (see **Fig. 1**), the right control knob controls the right wiper motor; the left control knob controls the left wiper motor and the windshield washers. On Conventionals (**see Fig. 2**), one knob controls both the wipers and the windshield washers. As an option, an intermittent (delay) wiper control regulates wiper sweep during light rain or mist. See **Fig. 3.**

The washer reservoir regulating (purge) valve automatically clears the lines to the nozzles, before and after each wash cycle, to prevent freezing and clogging of the lines and nozzles. Washer fluid is supplied by a hose that runs from the reservoir, through the cab skin (COEs) or firewall (Conventionals), and up the center of the wiper arm, connecting with the nozzle directly behind where the wiper blade attaches. A 360-degree adjustable nozzle is attached to each wiper arm by the same bolt that holds the wiper blade in place.

On COEs, the left wiper motor is mounted on the left nose-skin, under the dash. The right wiper motor is mounted behind the center noseskin and can be reached from the tunnel.

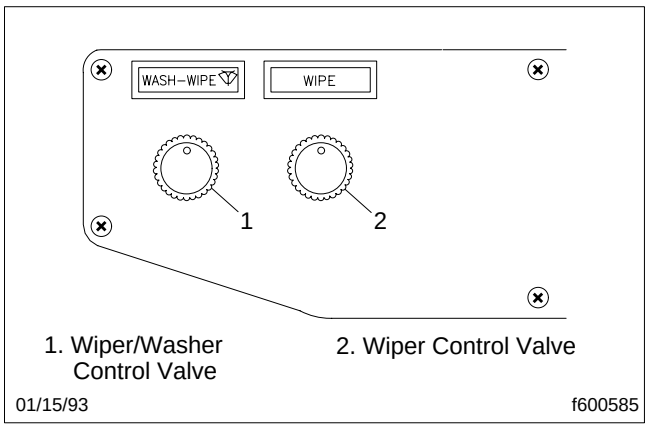


Fig. 1

On Conventionals, a single wiper motor operates both wiper arms. The wiper motor is located on the left firewall, under the cowl, and can be reached by tilting the hood. See **Fig. 4.** The passenger wiper arm, bracket, and linkage are located on the right firewall. See **Fig. 5.**

The wiper motor is a sealed unit. As such, there are no replacement parts. If the wiper motor doesn't operate correctly, troubleshoot the wiper/washer system (see **Troubleshooting, 300**) and if necessary, replace the wiper motor.

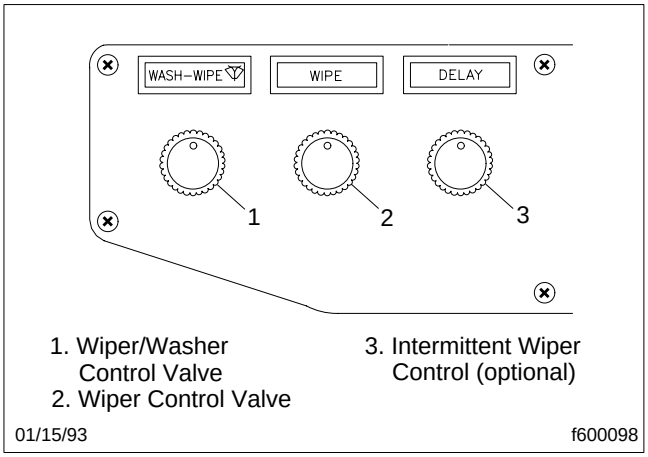


Fig. 2

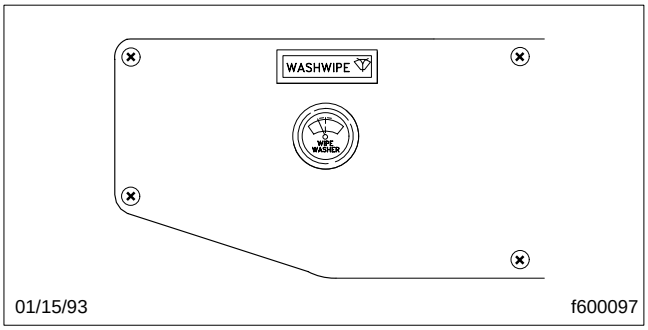


Fig. 3

Principles of Operation

NOTE: Refer to the applicable Freightliner driver's manual for complete instructions on how to use the wiper and washer systems.

When the control knob is turned clockwise more than one-eighth turn, pressurized air flows from the "Out" port of the control valve to the "In" port of the wiper motor. The wiper motor starts, and will increase in speed as the knob is turned to its clockwise limit.

When a wiper control knob is turned to its extreme counterclockwise position, pressurized air flows from

General Description and Principles of Operation

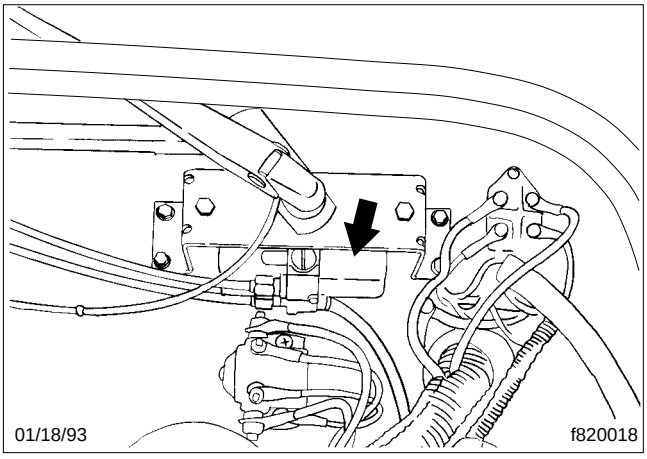


Fig. 4, Conventional Wiper Motor Location

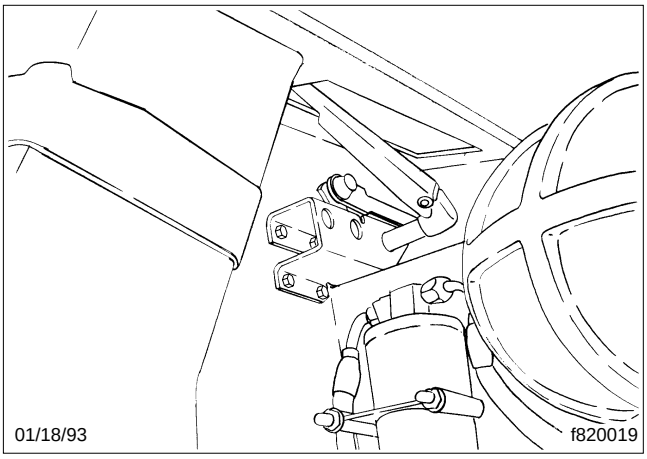


Fig. 5, Conventional Wiper Arm Bracket Assembly

both the "Out" and "Park" ports of the control valve. Both ports of the motor valve receive air, and the wiper motor parks the wiper blade.

If the system is equipped with an intermittent (delay) wiper control, all pressurized air flows through an electronic solenoid before flowing to the wiper motor. The solenoid delays the passage of pressurized air to the motors for zero to 10 seconds, depending on the setting of the intermittent control knob.

The washer system is activated when the knob on the wiper/washer control valve is pushed in. This allows pressurized air to flow from the washer port of the control valve to the washer reservoir regulating (purge) valve. If the knob is held in, air pressure holds the washer regulating valve open, and forces a stream of fluid from the reservoir to the windshield. If the knob is pushed in and released, air pressure causes the spring-loaded regulating valve diaphragm to surge until the compressed air is exhausted; this directs a broken stream of fluid to the windshield.

Wiper or Wiper/Washer Control Valve Replacement (See Fig. 1)

1. Apply the parking brakes and drain the air system.
2. Using a 5/64-inch allen wrench, loosen the setscrew in the control valve knob and remove the knob.
3. Pull the knobs off the heater/air-conditioner lever slide controls.
4. Remove the six screws attaching the control panel to the dash. **See Fig. 2.** Move the panel away from the dash enough to service it.
5. If equipped with washer control, disconnect the hose that attaches to the wiper/washer control valve from the reservoir regulating (purge) valve.
6. To prevent twisting of the tubing, use two wrenches to disconnect the "Park," "In," and "Out" air lines from the male couplings at the back of the valve. For later reference, mark the air lines.

NOTE: All control valve ports are labeled with "Park," "In," or "Out." Use these references when connecting or disconnecting air lines.

7. Remove the retaining nut from the valve, and remove the valve.
8. Remove the fittings from the back of the control valve.
9. Coat the male threads on the fittings with Loctite® 242, or an equivalent sealant; install them in the back of the new valve.
10. Insert the control valve through the panel and install the retaining nut. Tighten the nut securely.
11. As previously marked, or referring to **Fig. 3** or **Fig. 4**, connect the air lines to the ports on the valve body by inserting the end of the line into the fitting until it bottoms. Tighten the nut finger-tight. Then, using two wrenches, tighten the nut at least two turns or until no threads show on the fitting body.
12. If so equipped, connect the hose that runs from the washer reservoir control (purge) valve to the wiper/washer control valve.
13. Start the engine and build up air pressure to the cutoff point. Test the wiper valve to be sure it is connected properly, and check that there is no leakage at the fittings. Correct any problems. Shut down the engine.
14. Place the control panel in the dash, and install the six screws.
15. Using a 5/64-inch allen wrench, install the control valve knob and tighten the setscrew.
16. Push the knobs onto the heater/air-conditioner lever slide controls.

Valve Replacement

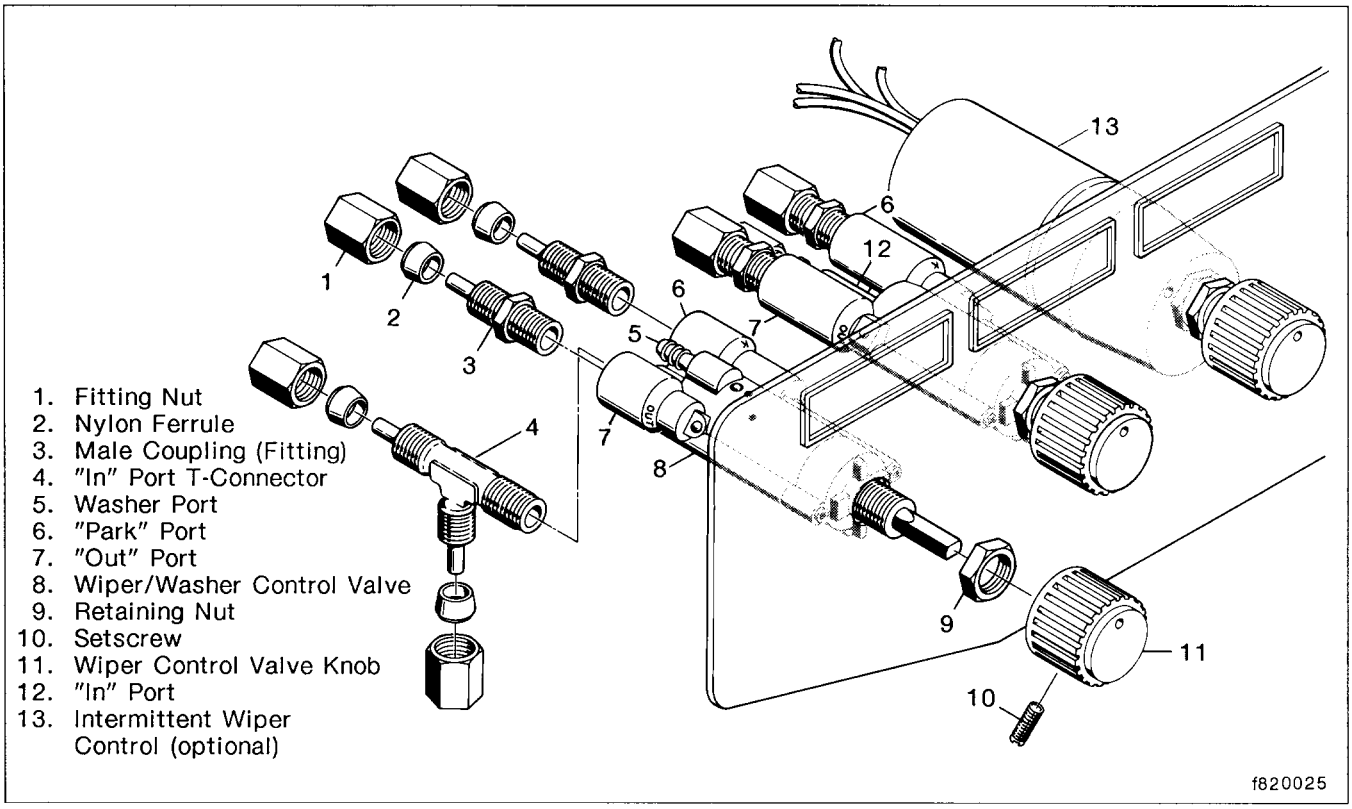


Fig. 1, Wiper and Wiper/Washer Control Valves

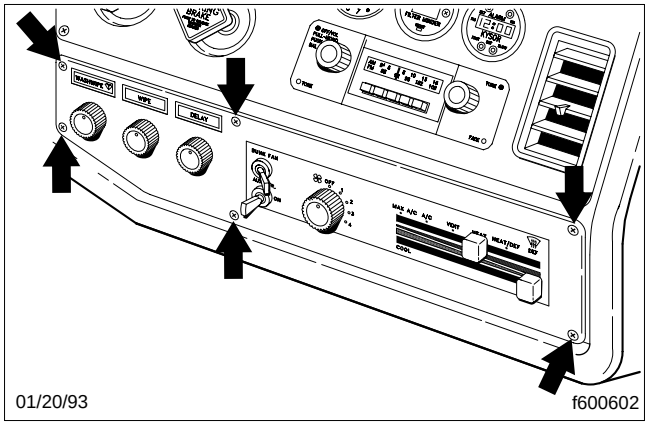


Fig. 2, Control Panel Screws

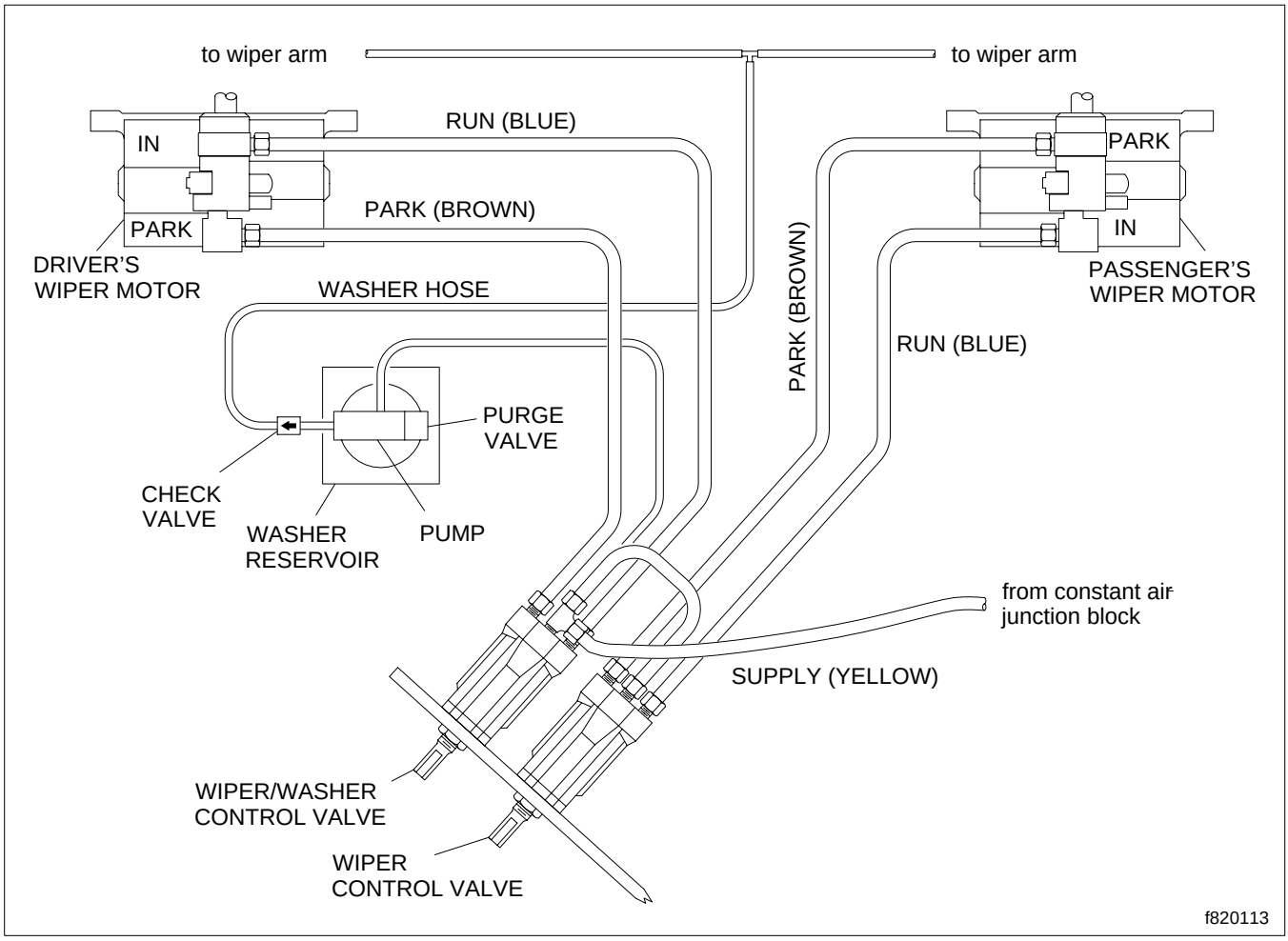


Fig. 3, COE Wiper/Washer System

Valve Replacement

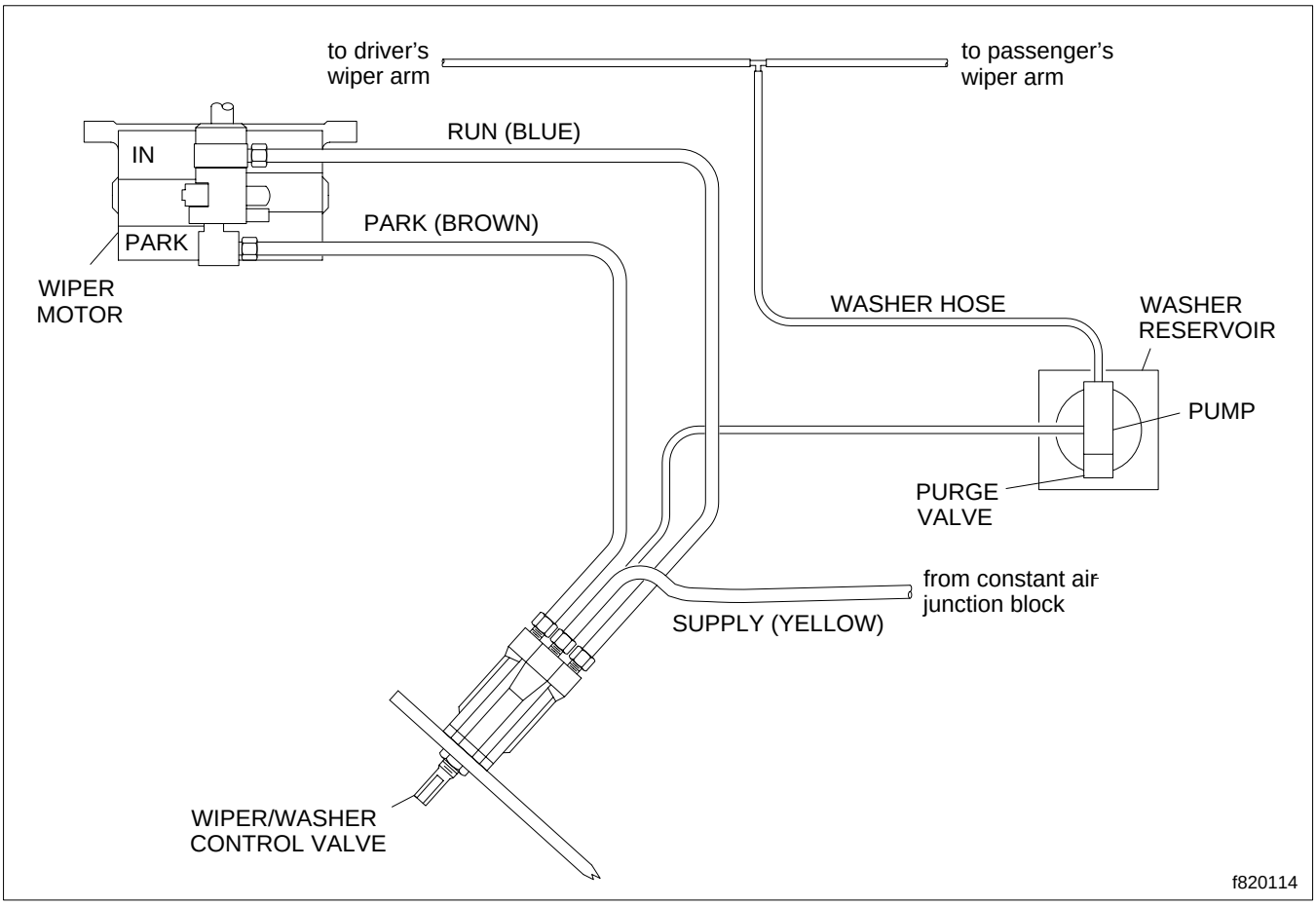


Fig. 4, Conventional Wiper/Washer System

Replacement

IMPORTANT: Before replacing the control unit, be sure that the fuse, located in the red (power) wire going to the back of the control unit, isn't burned out. If necessary, replace the fuse with a new 1-amp fuse.

Also, after operating or servicing the intermittent wiper control, make sure the control knob is turned off. If left on, it will continue to cycle, and continual cycling will shorten the life of the intermittent wiper control.

1. Make sure the ignition key is off.
2. Using a 5/64-inch allen wrench, loosen the set-screws in the intermittent wiper control knob and remove the knob.
3. Pull the knobs off the lever slide controls for the heater/air-conditioner.
4. Remove the six screws attaching the control panel to the dash. Move the panel away from the dash enough to service it.
5. Remove the adjustment and jam nuts from the valve.
6. For later reference, mark the wiper control wires. Disconnect the wires and remove the control.
7. Install a new intermittent wiper control in the dash panel, using the adjustment and jam nuts.
8. As previously marked, or referring to **Fig. 1** or **Fig. 2** connect the wiper control wires.
9. Place the control panel in the dash, and install the six screws.
10. Using a 5/64-inch allen wrench, install the control valve knob and tighten the setscrew.
11. Push the knobs onto the control levers for the heater/air-conditioner panel.

Intermittent Wiper Control Replacement

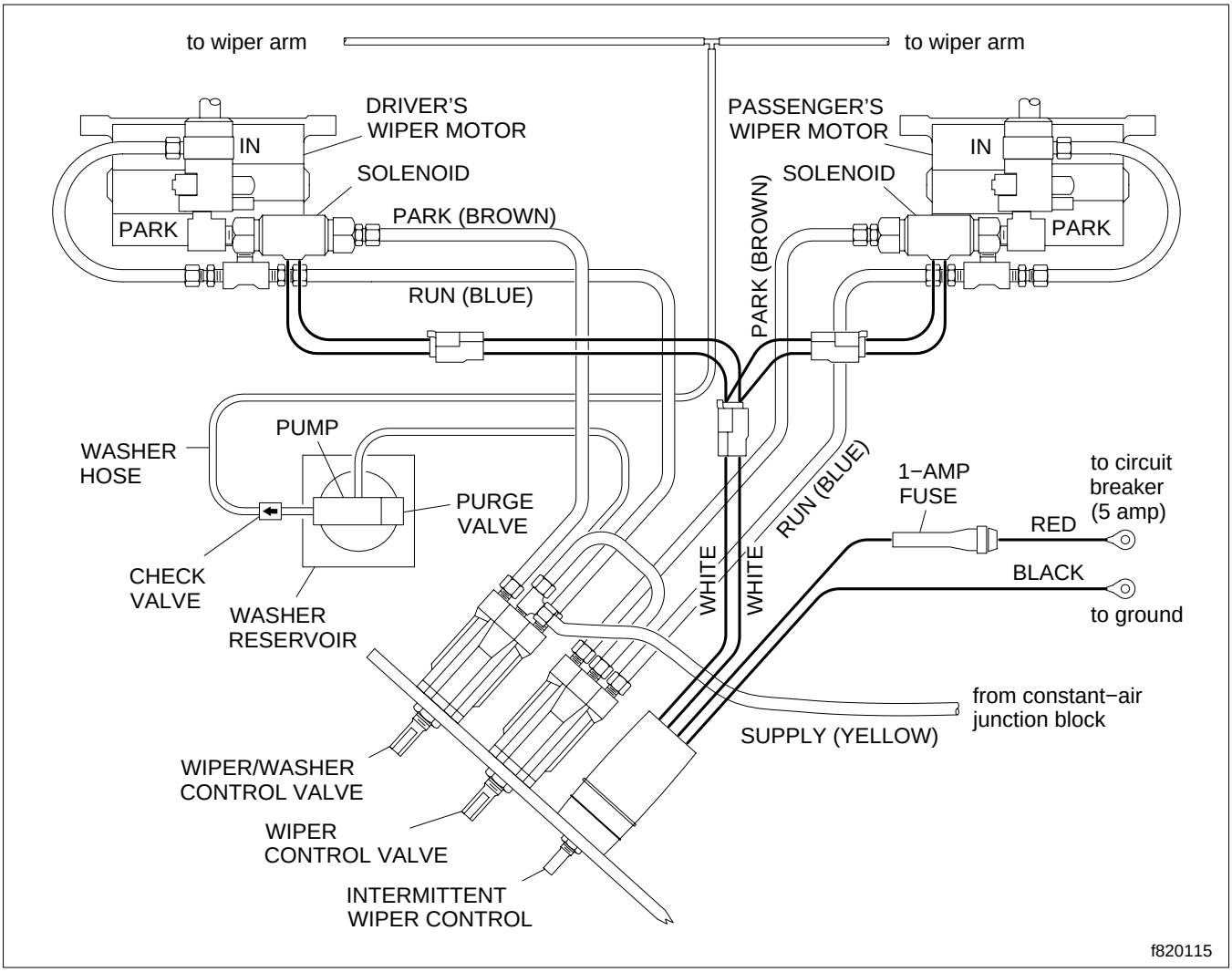


Fig. 1, COE Wiper/Washer System With Intermittent Control

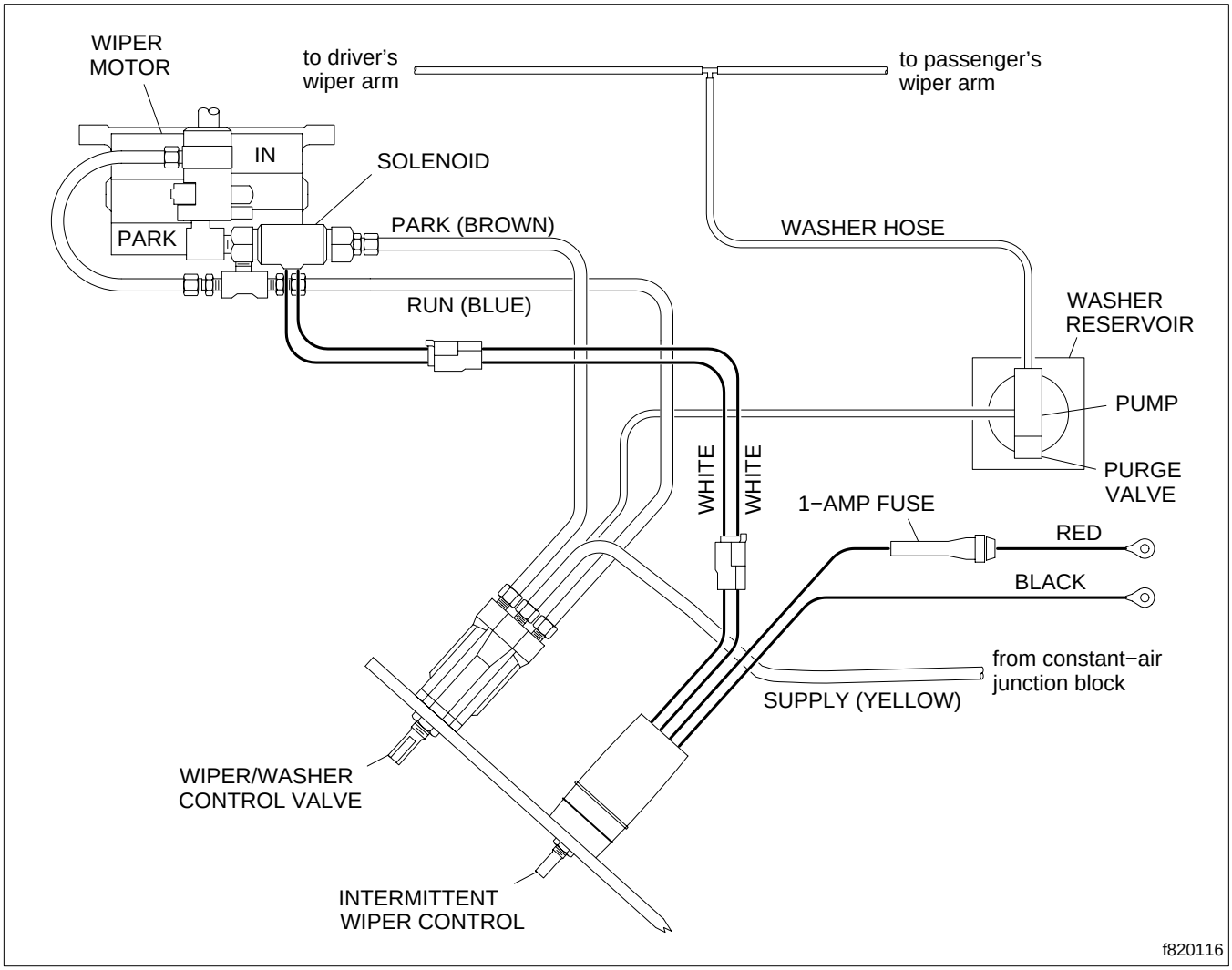
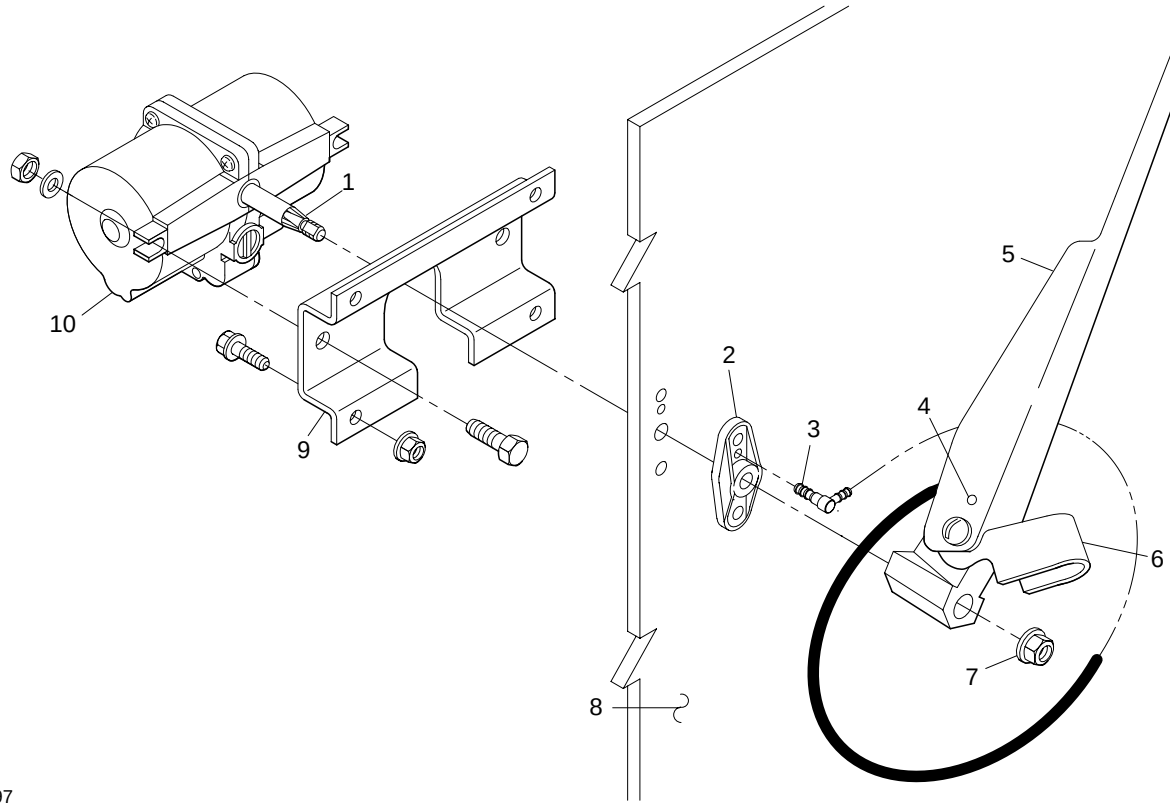


Fig. 2, Conventional Wiper/Washer System With Intermittent Control

Wiper Motor Removal and Installation, FLA COE (See Fig. 1)



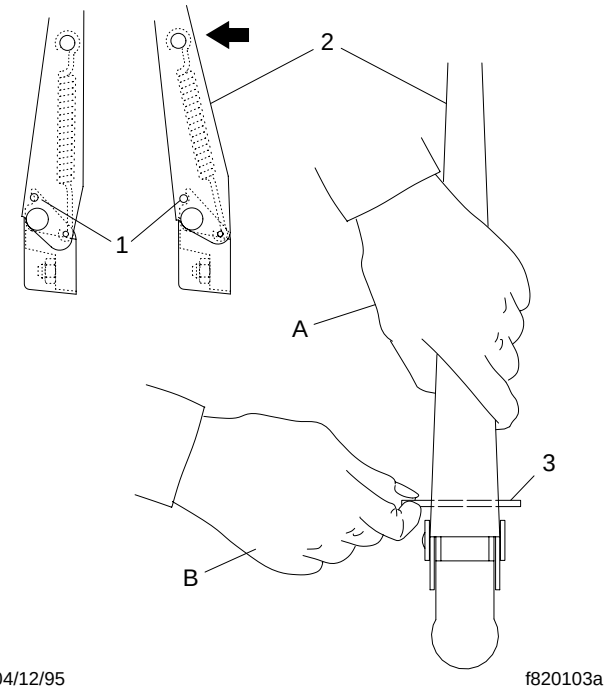
1. Transmission Shaft
2. Outer Bearing
3. Hose Barb
4. Pin Hole
5. Wiper Arm
6. Cover
7. Wiper Arm Nut
8. Cab Nose-Skin
9. Wiper Motor Mounting Bracket
10. Wiper Motor

Fig. 1, Wiper Motor and Wiper Arm Attachment

DRIVER-SIDE WIPER MOTOR REMOVAL

1. Gently lift the wiper off the windshield until a pin or drill bit, 1/8 inch (3.2 mm) in diameter by 1-1/2 inches (38 mm) long, can be inserted through the pin hole at the base of the arm. See **Fig. 2**. This will relieve the wiper arm tension against the windshield, and keep the arm away from the windshield.
2. Lift the cover and remove the wiper arm nut.
3. Disconnect the washer hose from the hose barb.
4. Remove the wiper arm from the wiper motor transmission shaft.
5. Remove the two screws from the outer bearing, then remove it.
6. Remove the kick panel.
7. Remove the six screws from the dash skirt, then remove it.
8. For later reference, mark and disconnect the air lines from the ports marked "In" and "Park." Disconnect the air hose from the exhaust port.
9. Remove the two locknuts, flatwashers, and bolts. Then remove the wiper motor.

Wiper Motor Removal and Installation, FLA COE



A. Lift gently to stretch spring.
B. Insert pin for removal and installation.

1. Pin Hole
2. Wiper Arm
3. Pin

Fig. 2, Position the Wiper Arm

NOTE: If replacing the wiper motor, remove the fittings from the "In" and "Park" ports of the old motor and install them on the new wiper motor.

DRIVER-SIDE WIPER MOTOR INSTALLATION

1. Place the wiper motor on the wiper motor bracket. Install the two bolts, flatwashers, and locknuts. Tighten the locknuts 15 lbf·ft (20 N·m).
2. As previously marked, or referring to **Fig. 3** or **Fig. 4**, connect the air lines to the "In" and "Park" ports on the wiper motor by inserting the end of the line into the fitting until it bottoms. Tighten the nut finger-tight. Using two wrenches, tighten the nut at least two turns or until no threads show on the fitting body. Connect the exhaust port air line.
3. Using the six screws, install the dash skirt.
4. Install the kick panel.
5. Using the two screws, install the wiper motor transmission shaft outer bearing.
6. Install the wiper arm.

   6.1 For an existing wiper blade:

   Place the wiper arm on the wiper motor transmission shaft, engaging the grooves on the arm with the splines on the shaft. Make sure the blade is in the correct park position, as shown in **Fig. 5**. Install the wiper arm nut, and tighten it 14 lbf·ft (19 N·m).

⚠ CAUTION

If you have to reposition the wiper blade to the correct park position, make sure the splines of the wiper motor transmission shaft are still aligned with the grooves in the wiper arm; otherwise tightening the wiper arm nut will strip out the grooves in the wiper arm.

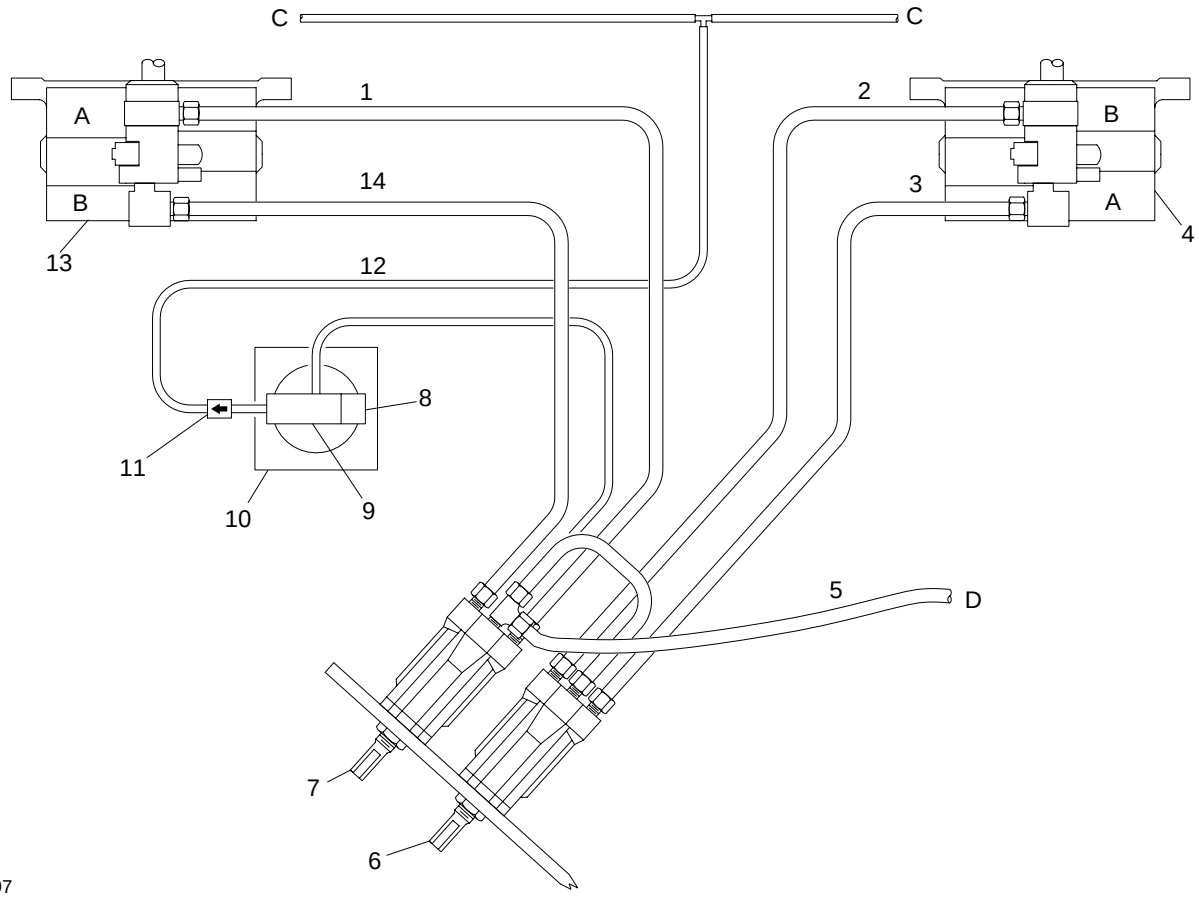
   6.2 For a new wiper blade:

   Place the wiper arm on the wiper motor transmission shaft, aligning the blade in the park position, as shown in **Fig. 5**. Install the wiper arm nut, and tighten it 14 lbf·ft (19 N·m). The splines on the shaft will cut grooves in the new wiper arm.

   6.3 Remove the pin from the hole in the wiper arm by gently pulling the blade up and away from the windshield until tension is off the pin. If the pin doesn't fall free, it should be loose enough to pull out.

   6.4 Check that the wiper blade doesn't touch the windshield seal. If it does, remove the wiper arm, then reposition it so that the blade doesn't touch the windshield seal. Install the wiper arm again, keeping the grooves in the arm aligned with the splines on the motor shaft. If the wiper arm can't be installed as shown in **Fig. 5**, replace it with a new one.

7. Connect the windshield washer hose to the hose barb. Make sure the washer hose doesn't rest on the nose-skin.



A. In
B. Park
C. To Wiper Arm
D. From Constant-Air Junction Block

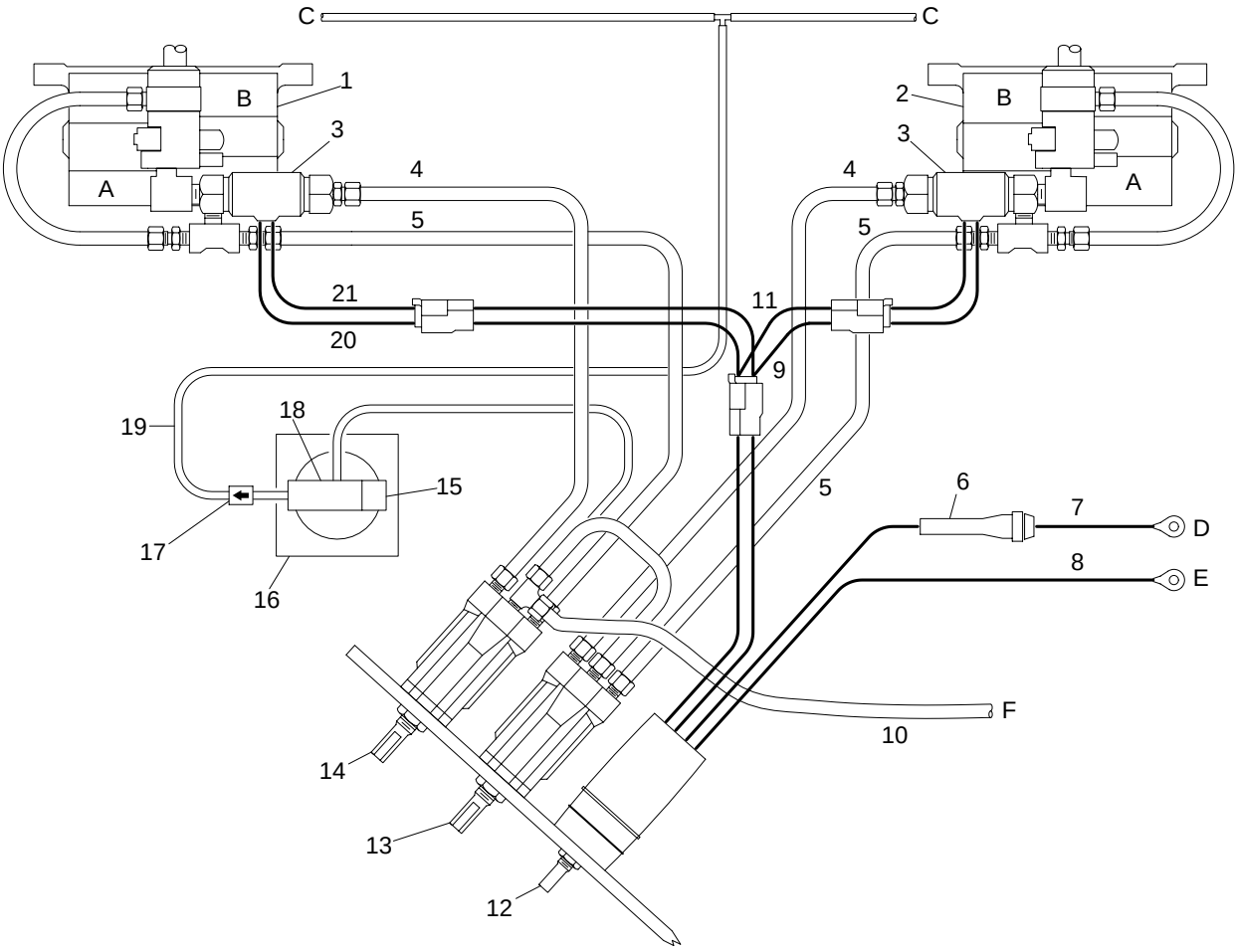
1. Run (blue)
2. Park (brown)
3. Run (blue)
4. Passenger's Wiper Motor
5. Supply (yellow)
6. Wiper Control Valve
7. Wiper/Washer Control Valve
8. Purge Valve
9. Pump
10. Washer Reservoir
11. Check Valve
12. Washer Hose
13. Driver's Wiper Motor
14. Park (brown)

Fig. 3, Wiper/Washer System

PASSENGER-SIDE WIPER MOTOR REMOVAL

1. Gently lift the wiper off the windshield until a pin or drill bit, 1/8 inch (3.2 mm) in diameter by 1-1/2 inches (38 mm) long, can be inserted through the hole at the base of the arm. See **Fig. 2**. This will relieve the wiper arm tension against the windshield, and keep the arm away from the windshield.
2. Lift the cover and remove the wiper arm nut.
3. Disconnect the washer hose from the hose barb.
4. Remove the wiper arm from the wiper motor transmission shaft.

Wiper Motor Removal and Installation, FLA COE



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A. Park
B. In
C. To Wiper Arm
D. To Circuit Breaker (5 amps)
E. To Ground
F. From Constant-Air Junction Block

1. Driver's Wiper Motor
2. Passenger's Wiper Motor
3. Solenoid
4. Park (brown)
5. Run (blue)
6. 1-Amp Fuse
7. Red Wire (257)
8. Black Wire (GND)
9. White Wire (257A)
10. Supply (yellow)
11. White Wire (257C)
12. Intermittent Wiper Control
13. Wiper Control Valve
14. Wiper/Washer Control Valve
15. Purge Valve
16. Washer Reservoir
17. Check Valve
18. Pump
19. Washer Hose
20. White Wire (257D)
21. White Wire (257B)

Fig. 4, Intermittent Wiper/Washer System

5. Remove the four capnuts from the front grille and remove it.

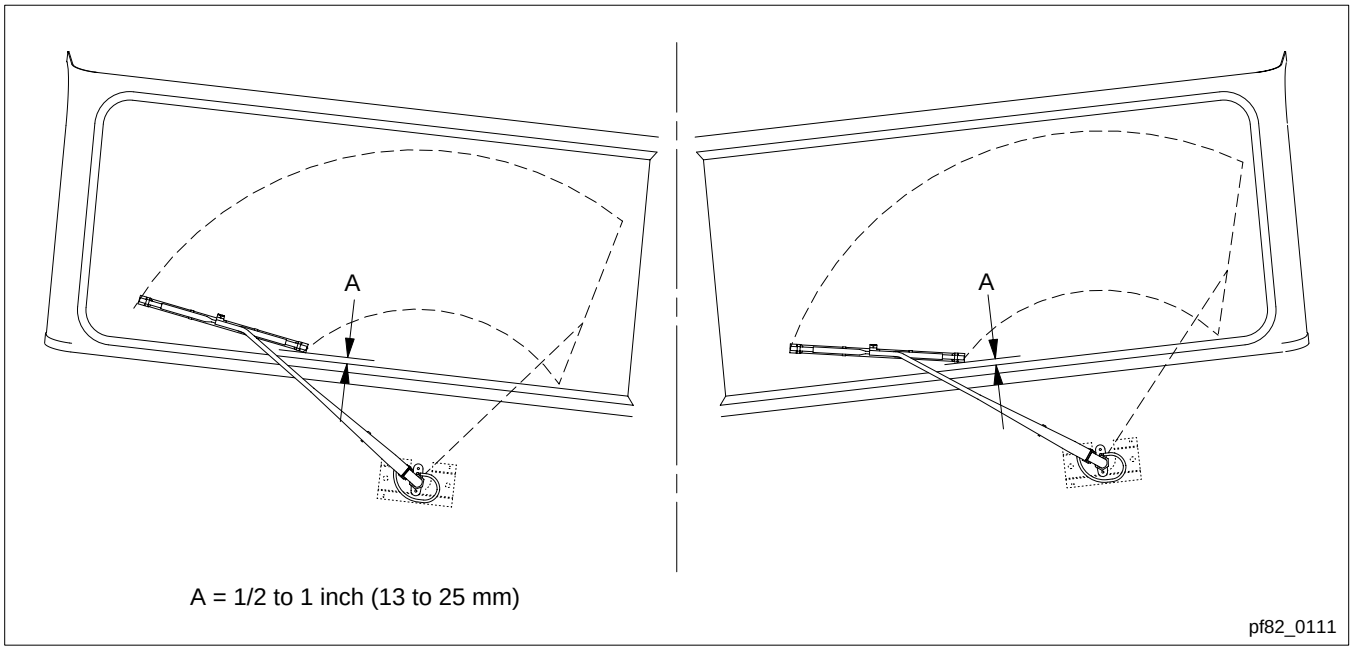


Fig. 5, Wiper Sweep Pattern & Park Position

6. Tilt the cab enough to access the wiper motor. Refer to the vehicle driver's manual, for instructions.
7. For later reference, mark and disconnect the air lines from the ports marked "In" and "Park."
8. Remove the two locknuts, flatwashers, and bolts. See **Fig. 6**. Then remove the wiper motor.

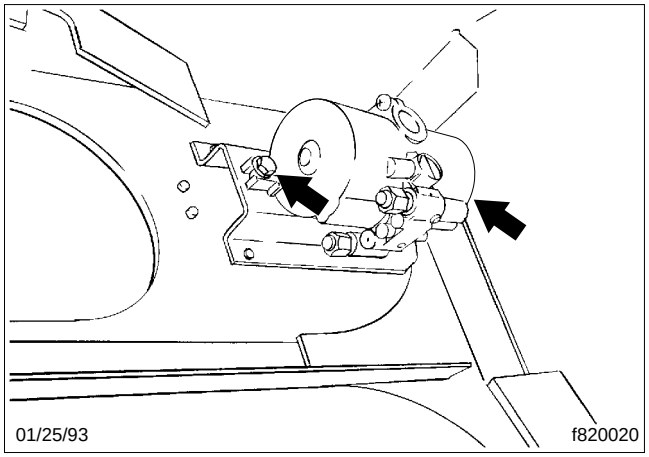


Fig. 6, Remove the Fastening Bolts

NOTE: If replacing the wiper motor, remove the fittings from the "In" and "Park" ports of the old motor and install them on the new wiper motor.

PASSENGER-SIDE WIPER MOTOR INSTALLATION

1. Place the wiper motor on the wiper motor bracket. Install the two bolts, flatwashers, and locknuts. Tighten the locknuts 15 lbf·ft (20 N·m).
2. As previously marked, or referring to **Fig. 3** or **Fig. 4**, connect the air lines to the "In" and "Park" ports on the wiper motor by inserting the end of the line into the fitting until it bottoms. Tighten the nut finger-tight. Using two wrenches, tighten the nut at least two turns or until no threads show on the fitting body.
3. Return the cab to the driving position. Refer to the vehicle driver's manual, for instructions.
4. Using the four capnuts, install the front grille.
5. Install the wiper arm.

   5.1 For an existing wiper blade:

   Place the wiper arm on the wiper motor transmission shaft, engaging the grooves

Wiper Motor Removal and Installation, FLA COE

on the arm with the splines on the shaft. Make sure the blade is in the correct park position, as shown in **Fig. 5**. Install the wiper arm nut, and tighten it 14 lbf·ft (19 N·m).

CAUTION

If you have to reposition the wiper blade to the correct park position, make sure the splines of the wiper motor transmission shaft are still aligned with the grooves in the wiper arm; otherwise tightening the wiper arm nut will strip out the grooves in the wiper arm.

5.2 For a new wiper blade:

Place the wiper arm on the wiper motor transmission shaft, aligning the blade in the park position, as shown in **Fig. 5**. Install the wiper arm nut, and tighten it 14 lbf·ft (19 N·m). The splines on the shaft will cut grooves in the new wiper arm.

5.3 Remove the pin from the hole in the wiper arm by gently pulling the blade up and away from the windshield until tension is off the pin. If the pin doesn't fall free, it should be loose enough to pull out.

5.4 Check that the wiper blade doesn't touch the windshield seal. If it does, remove the wiper arm, then reposition it so that the blade doesn't touch the windshield seal. Install the wiper arm again, keeping the grooves in the arm aligned with the splines on the motor shaft. If the wiper arm can't be installed as shown in **Fig. 5**, replace it with a new one.

6. Connect the windshield washer hose to the hose barb. Make sure the washer hose doesn't rest on the nose-skin.

Wiper Motor Removal and Installation, Conventional

Wiper Motor Removal (See Fig. 1)

1. Tilt the hood.
2. Gently lift the wiper off the windshield until a pin or nail 1/8 inch (3.2 mm) in diameter by 1-1/2 inches (38 mm) long can be inserted through the hole at the base of the arm. See **Fig. 2**. This will relieve the wiper arm tension against the windshield, and keep the arm away from the windshield.
3. Remove the wiper arm nut.
4. Disconnect the washer hose from the wiper arm.
5. Remove the wiper arm from the wiper motor transmission shaft.
6. Remove the large nut securing the drive bar to the wiper motor transmission shaft.
7. For later reference, mark and disconnect the air lines from the ports marked "In" and "Park." Disconnect the air hose from the exhaust port.
8. Remove the two locknuts, flatwashers, and bolts from the wiper motor bracket. Remove the wiper motor.

NOTE: If replacing the wiper motor, remove the fittings from the "In" and "Park" ports of the old motor and install them on the new wiper motor.

Wiper Motor Installation

1. Place the wiper motor on the wiper motor bracket. Install the two bolts, flatwashers, and locknuts. Tighten the locknuts 15 lbf·ft (20 N·m).
2. As previously marked, or referring to **Fig. 3** or **Fig. 4**, connect the air lines to the "In" and "Park" ports on the wiper motor by inserting the end of the line into the fitting until it bottoms. Tighten the nut finger-tight. Using two wrenches, tighten the nut at least two turns or until no threads show on the fitting body. Connect the exhaust port air line.
3. Install the drive bar and secure it with the large nut. Tighten the nut 20 to 25 lbf·ft (27 to 34 N·m).
4. Install the wiper arm as follows:

   4.1 *For an existing wiper blade:*

   Place the wiper arm on the wiper motor transmission shaft, engaging the grooves on the arm with the splines on the shaft. Make sure the blade is in the correct park position as shown in **Fig. 5**. Install the wiper arm nut, and tighten it 14 lbf·ft (19 N·m).

   For a new wiper blade:

   Place the wiper arm on the wiper motor transmission shaft, aligning the blade in the park position as shown in **Fig. 5**. Install the wiper arm nut, and tighten it 14 lbf·ft (19 N·m). The splines on the shaft will cut grooves in the new wiper arm.

CAUTION

CAUTION: If you have to reposition the wiper blade to the correct park position, make sure the splines of the wiper motor transmission shaft are still aligned with the grooves in the wiper arm; otherwise tightening the wiper arm nut will strip out the grooves in the wiper arm.

   4.2 Remove the pin from the hole in the wiper arm by gently pulling the blade up and away from the windshield until tension is off the pin. If the pin doesn't fall free, it should be loose enough to pull out.

   4.3 Check that the wiper blade doesn't touch the windshield seal. If it does, remove the wiper arm, then reposition it so that the blade doesn't touch the windshield seal. Install the wiper arm again, keeping the grooves in the arm aligned with the splines on the motor shaft. If the wiper arm can't be installed as shown in **Fig. 5**, replace it with a new one.

5. Connect the windshield washer hose to the wiper arm.
6. Return the hood to the operating position, and latch it.

Linkage Removal and Installation

1. Tilt the hood.
2. Find the ball joint clips (if so equipped) at each end of the wiper linkage. See **Fig. 6**. Remove each one by prying it up until the tab on the clip clears the ball joint socket.

Wiper Motor Removal and Installation, Conventional

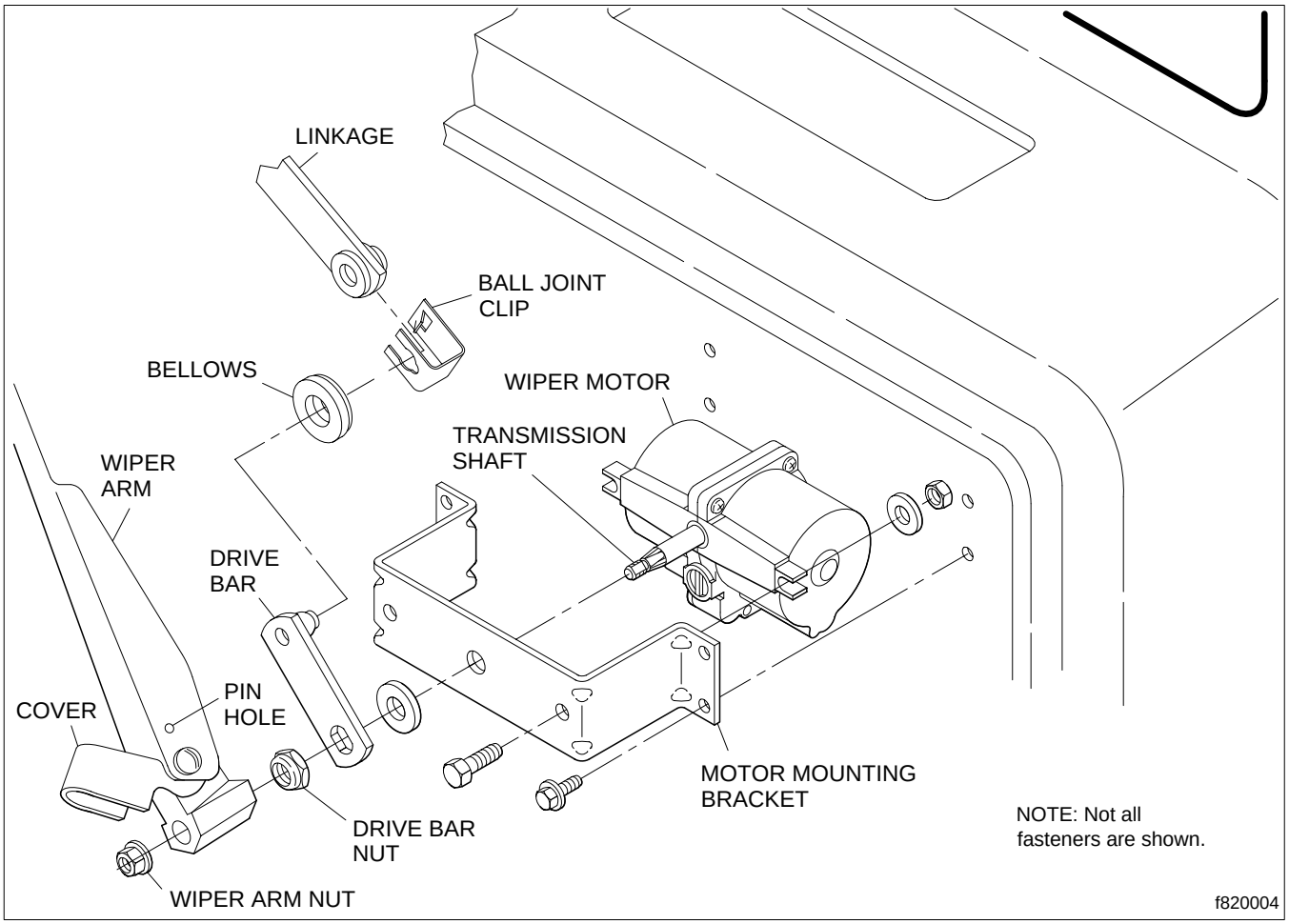


Fig. 1, Wiper Motor and Wiper Arm Attachment, Conventional

3. Using a large screwdriver, pry the linkage arm ball socket from the drive bar assembly. Pry the ball socket from the other end of the linkage arm (**Fig. 7**), and remove it.
4. Place the new linkage arm near the balls on the wiper motor drive bar and the wiper arm drive bar on the passenger side. Using a pair of channel-lock pliers, squeeze the ball joints onto the balls on the wiper motor drive bar and the wiper arm drive bar. See **Fig. 8**.

NOTE: If there were no ball-joint clips present, install a new pair; otherwise install the existing clips.

5. Install the ball joint clip on the passenger-side wiper linkage as follows:

5.1 Move the wiper arm until it is vertical on the windshield.

⚠ CAUTION

CAUTION: Use care not to let the prongs of the retaining clip tear the rubber bellows. If the prongs damage the bellows, replace the bellows.

5.2 Hold the clip so the prongs are toward the windshield, and insert the prongs between the rubber bellows and the end of the wiper linkage. See **Fig. 6** and **Fig. 9**.

NOTE: If the rubber bellows are missing or damaged, replace them.

Wiper Motor Removal and Installation, Conventional

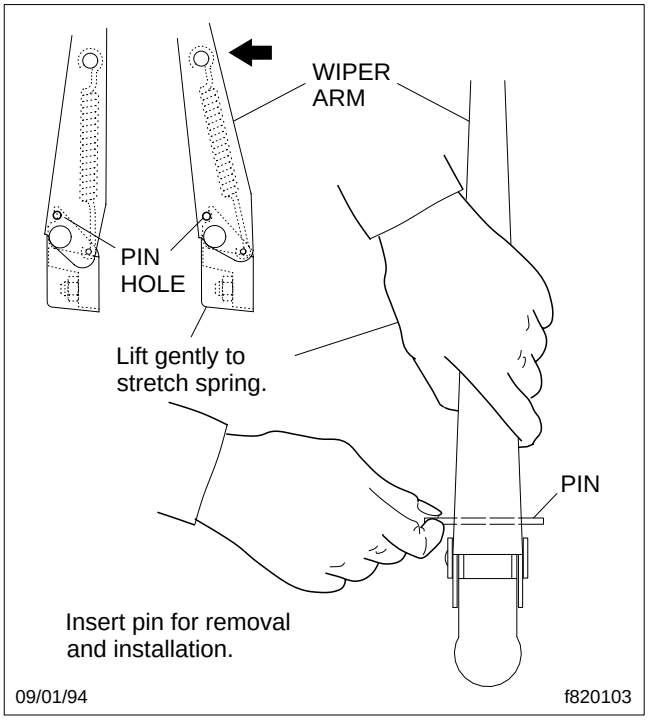


Fig. 2

5.3 Slide the clip onto the ball joint until the tab snaps down over the far side of the socket cap.

6. Install the ball joint clip over the driver-side wiper linkage as follows:

6.1 Move the wiper arm to the park position.

CAUTION

CAUTION: Use care not to let the prongs of the retaining clip tear the rubber bellows. If the prongs damage the bellows, replace the bellows.

6.2 Hold the clip with the prongs away from the windshield, and insert the prongs between the rubber bellows and the end of the wiper linkage. See **Fig. 6** and **Fig. 10**.

NOTE: If the rubber bellows are missing or damaged, replace them.

6.3 Slide the clip onto the ball joint until the tab snaps down over the far side of the socket cap.

7. Wet the windshield and run the wipers to ensure the clips are securely installed.

8. Return the hood to the operating position, and latch it.

Wiper Motor Removal and Installation, Conventional

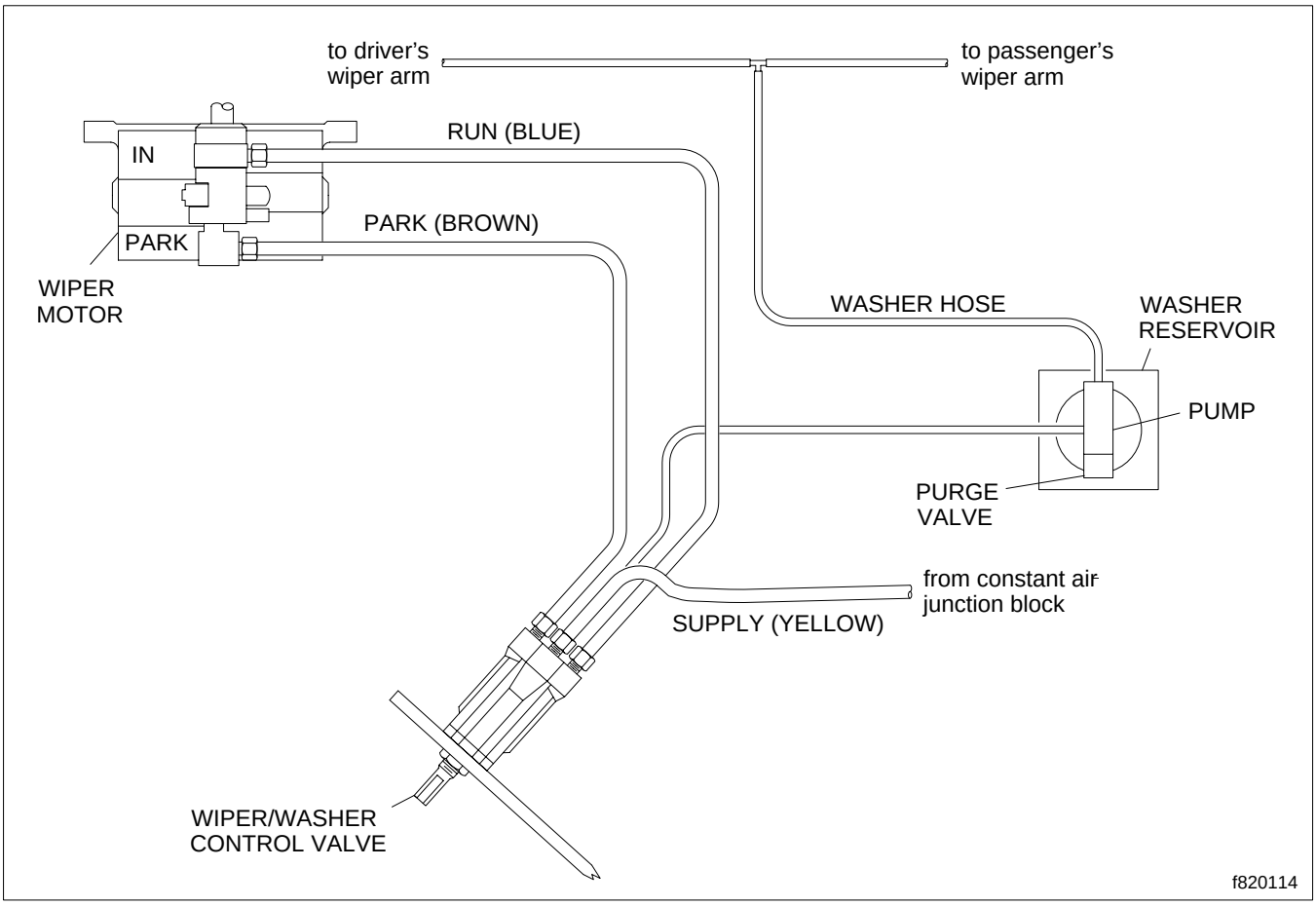


Fig. 3, Conventional Wiper/Washer System

Wiper Motor Removal and Installation, Conventional

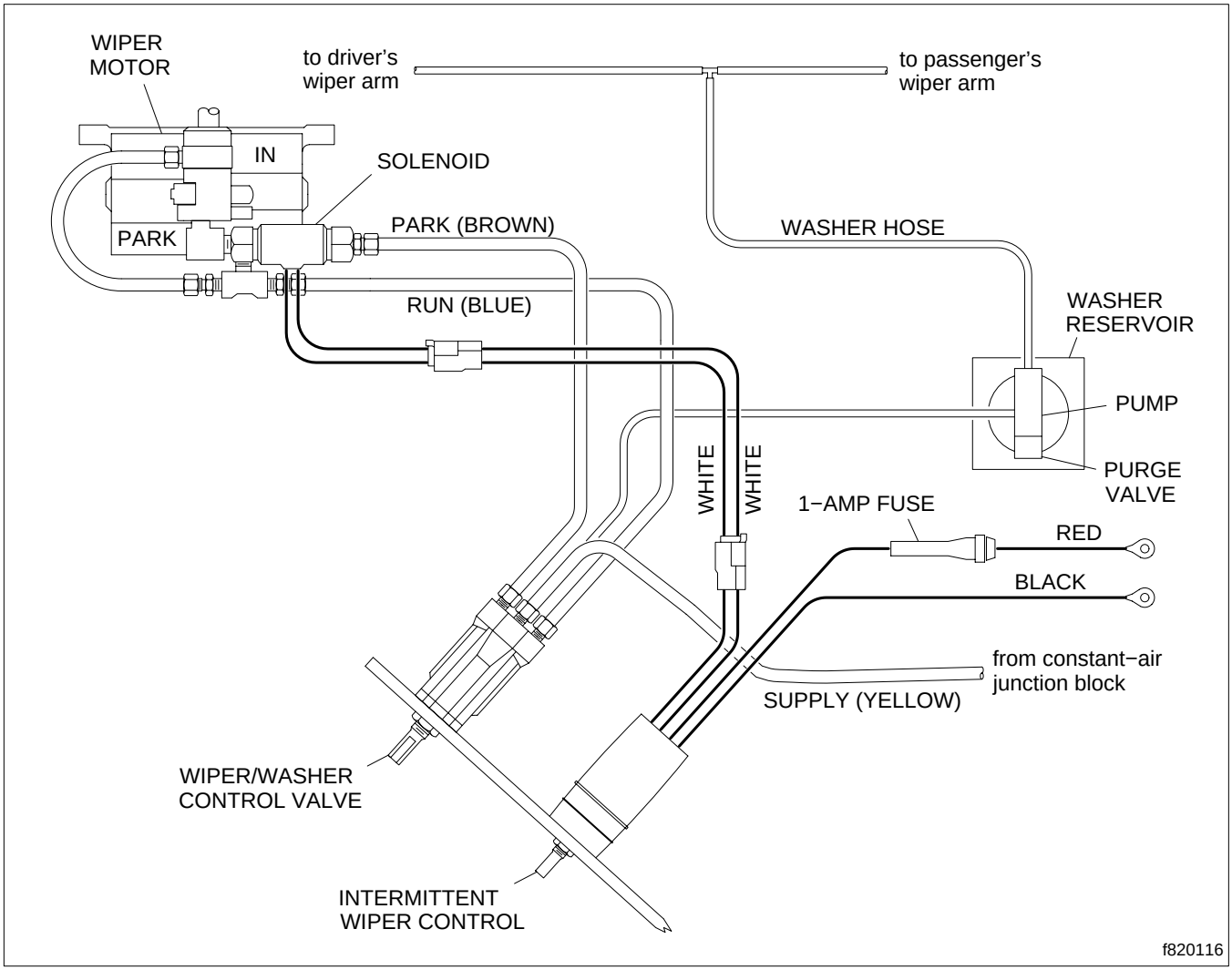


Fig. 4, Conventional Wiper/Washer System With Intermittent Control

Wiper Motor Removal and Installation, Conventional

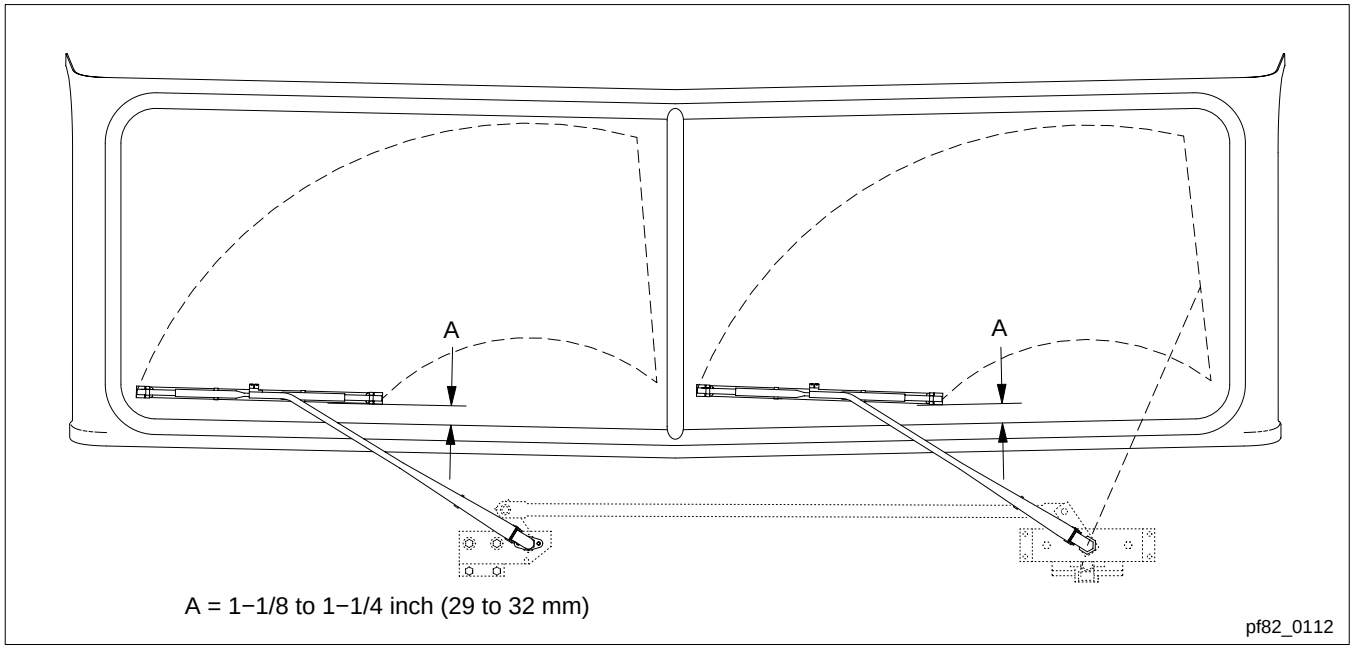


Fig. 5, Wiper Sweep Pattern and Park Position, Conventional

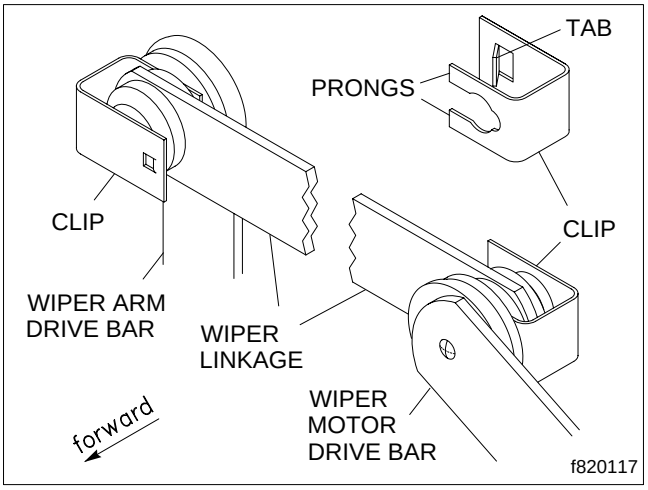


Fig. 6

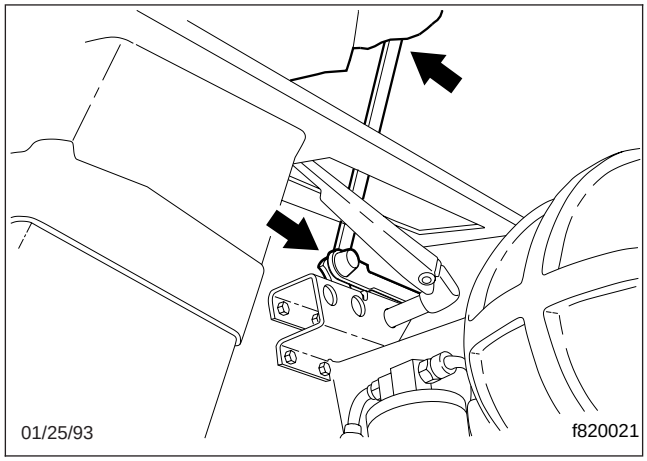


Fig. 7, Separating Linkage

Wiper Motor Removal and Installation, Conventional

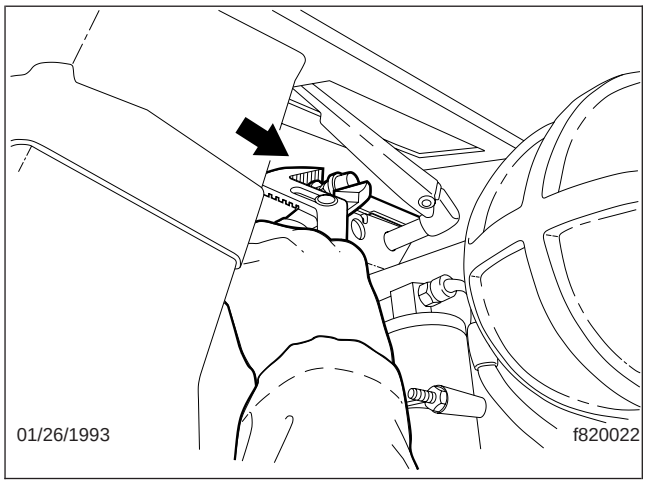


Fig. 8, Connecting Linkage

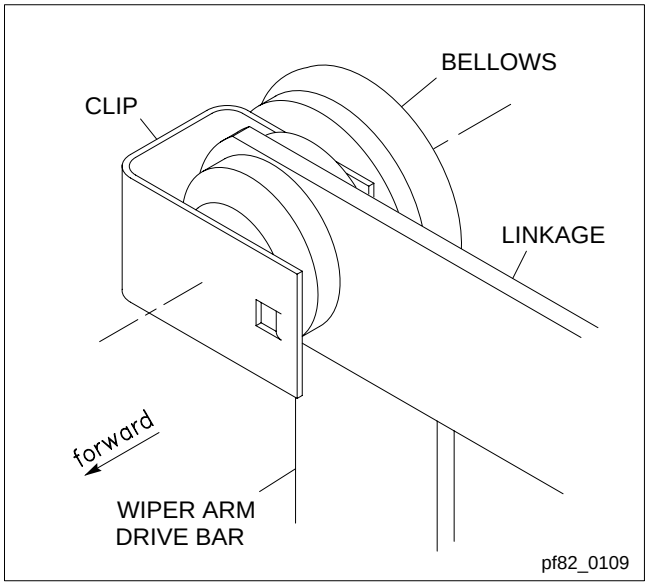


Fig. 9, Clip Installed on Passenger-Side Wiper Assembly

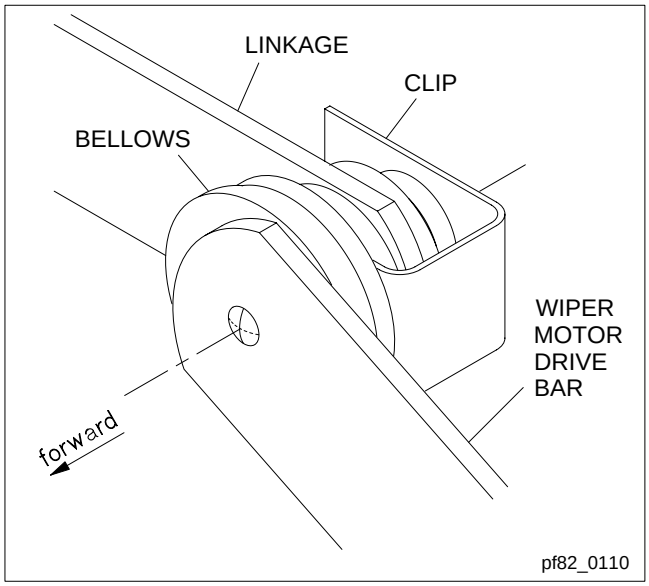
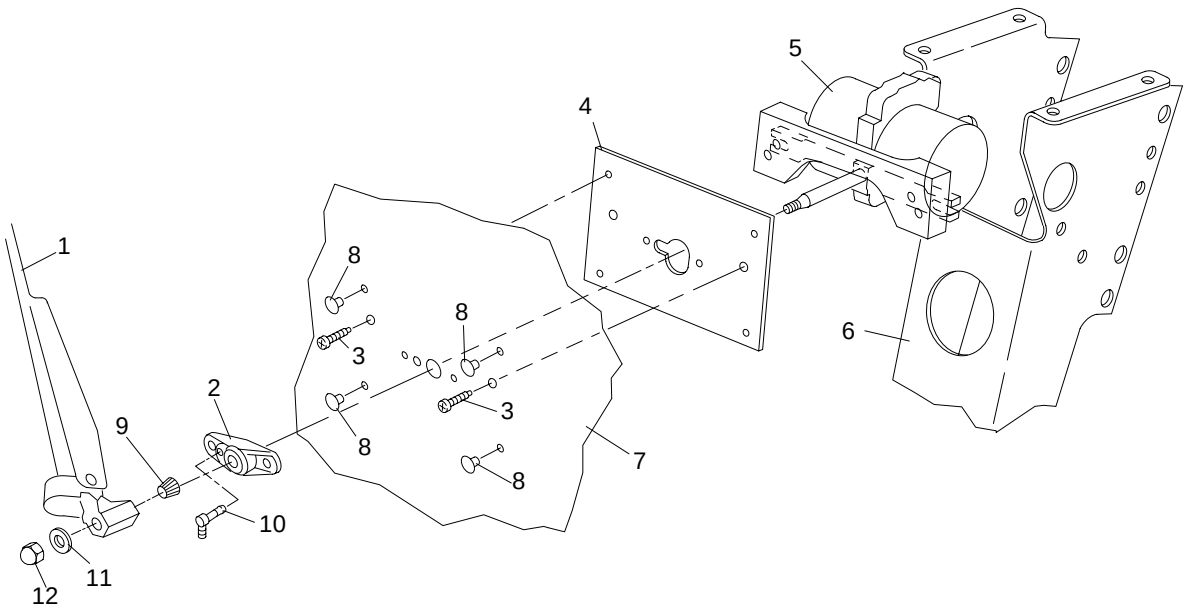


Fig. 10, Clip Installed on Driver-Side Wiper Assembly

Wiper Motor Removal and Installation, FLB COE

DRIVER-SIDE WIPER MOTOR REMOVAL (See Fig. 1)

6. Remove the two screws from the outer bearing, then remove it.
7. From inside the cab, Remove the six screws from the under-dash cover, then remove it.
8. Mark and remove the toggle switches (if present)



1. Wiper Arm
2. Outer Bearing
3. 1/4–20 Machine Screw
4. Stiffener Plate
5. Wiper Motor Assembly
6. Steering Column Bracket
7. Cab Nose-Skin
8. Aluminum Rivet
9. Serrated Arm Driver
10. Hose Barb
11. Lockwasher
12. Drive Nut

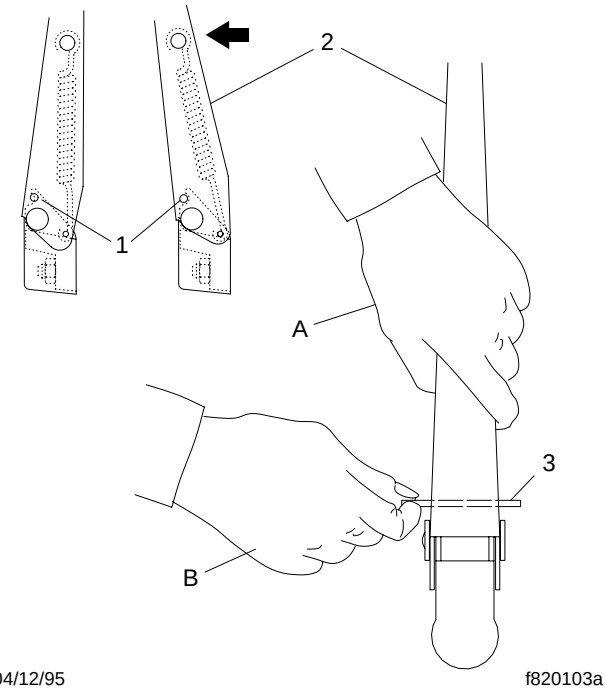
Fig. 1, Driver-Side Wiper Assembly

1. Gently lift the wiper off the windshield until a pin or drill bit, 1/8 inch (3.2 mm) in diameter by 1-1/2 inches (38 mm) long, can be inserted through the pin hole at the base of the arm. See **Fig. 2**. This will relieve the wiper arm tension against the windshield, and keep the arm away from the windshield.
2. Lift the cover and remove the drive nut and lockwasher from the wiper driveshaft.
3. Disconnect the washer hose from the hose barb.
4. Remove the wiper arm from the driveshaft.
5. Remove the serrated arm driver.

from the cover.

9. If there is a Deutsch® diagnostic connector on the bottom of the cover, remove it.
   - 9.1 Remove the four screws holding the diagnostic connector in place.
   - 9.2 Separate the two halves of the connector by twisting one of them counterclockwise one half turn.
10. Remove the HVAC duct sections from underneath the left side of the dash. See **Fig. 3**.

Wiper Motor Removal and Installation, FLB COE



A. Lift gently to stretch spring.
B. Insert pin for removal and installation.

1. Pin Hole
2. Wiper Arm
3. Pin

Fig. 2, Position the Wiper Arm

10.1 Remove the grab handle from the front edge of the doorway.

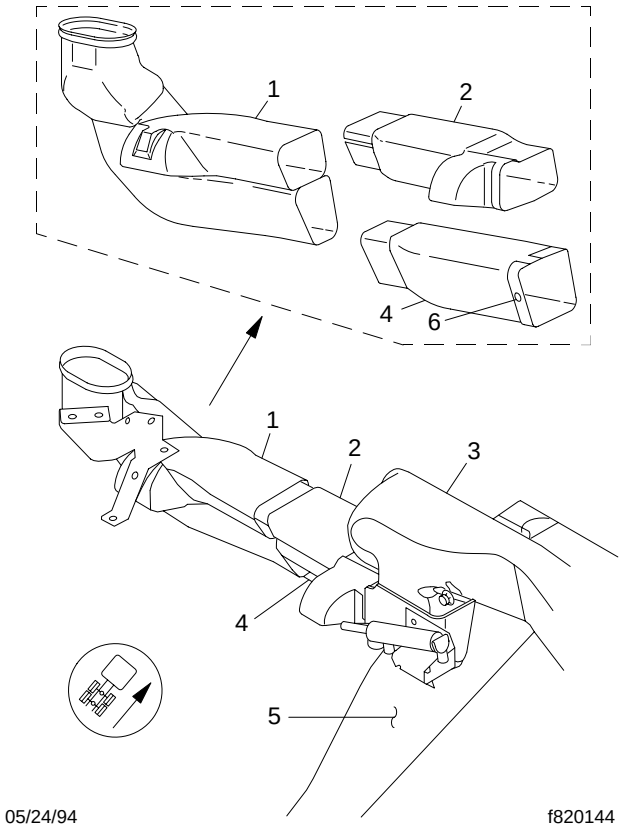
10.2 Remove the lower steering column cover.

10.3 Pull back the upholstery panel to gain access to the HVAC ducting.

10.4 On the left side, near the door, remove the nut that holds the left section of the HVAC duct to the underside of the dash. Remove the section.

10.5 On the right side of the steering column, find and remove the screw that holds the two center HVAC duct sections to the right HVAC duct section.

10.6 Remove the lower, then the upper center HVAC duct section.



1. Left Section of the HVAC Duct
2. Upper Center HVAC Section
3. Right Section
4. Lower Center Section
5. Tunnel
6. Screw Hole

Fig. 3, HVAC Duct Sections

NOTE: There may be an additional fastener holding the lower center HVAC duct section to the nose-skin.

11. From under the dash, disconnect the air lines from the wiper motor.

11.1 For later reference, mark the air lines from the ports marked "In" and "Park."

11.2 Disconnect the air lines from the "In" and "Park" ports.

11.3 Disconnect the air hose from the exhaust port.

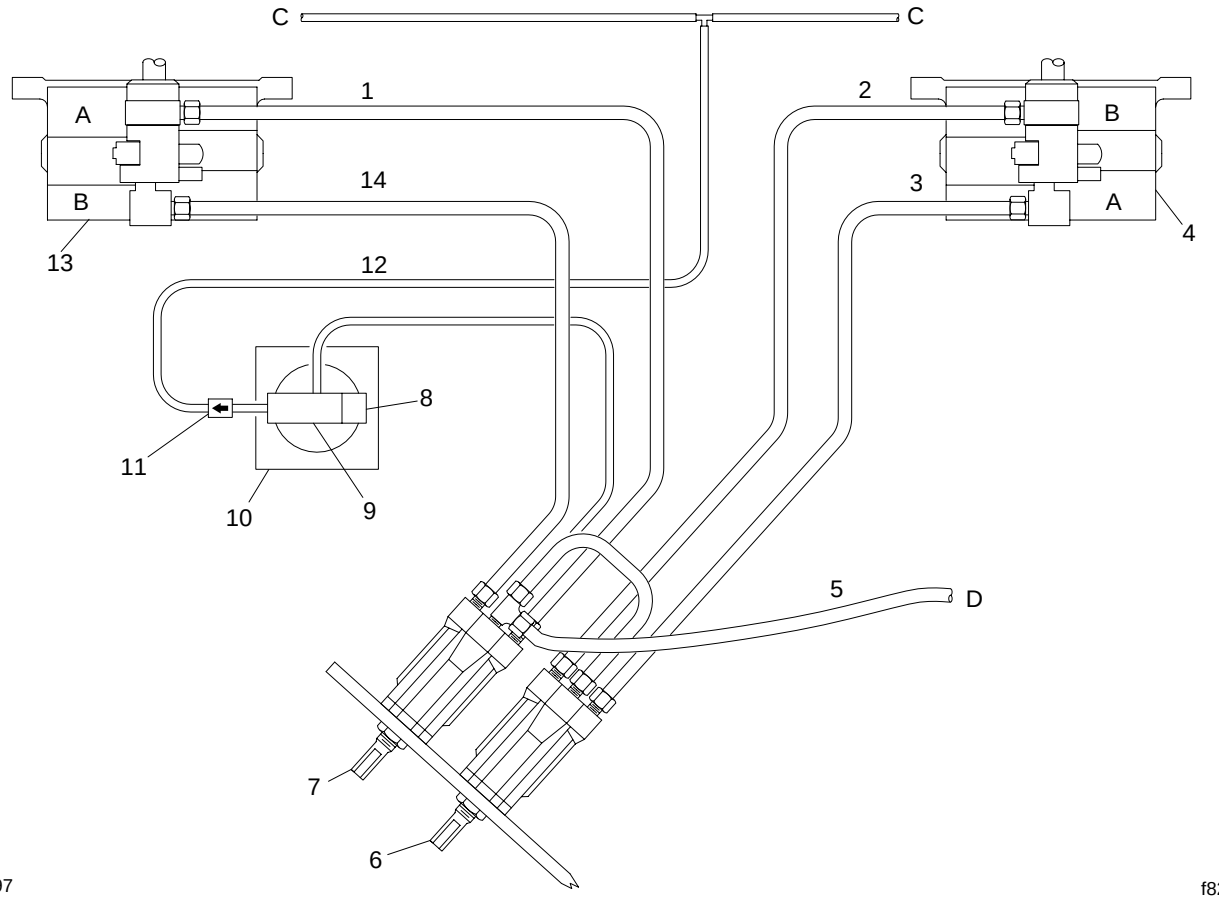
12. From inside the cab and under the dash, hold the wiper motor in place. Then, have someone from outside the cab, remove the two Torx®-head machine screws from the upper nose-skin (near the drivers wiper arm mounting location). These machine screws (**Fig. 1** Ref. 3) attach the wiper assembly to the stiffener plate and nose-skin.
13. Remove the wiper motor from between the stiffener plate and steering column bracket.
    - 13.1 Move the wiper motor away from the stiffener plate until the driveshaft clears the outer bearing mounting hole.
    - 13.2 Move the wiper motor to the left (toward the driver's door); then slide it down toward the floor, and out from underneath the dash.

NOTE: If replacing the wiper motor, remove the fittings from the "In" and "Park" ports of the old motor and install them on the new wiper motor.

DRIVER-SIDE WIPER MOTOR INSTALLATION **(See Fig. 1)**

1. Attach the wiper motor.
    - 1.1 From inside the cab and under the dash, slide the wiper motor up between the stiffener plate and steering column bracket.
    - 1.2 Insert the wiper motor driveshaft through the outer bearing mounting hole.
    - 1.3 While aligning the two mounting holes of the motor assembly with the two holes in the nose-skin, push the wiper motor flush against the stiffener plate. Hold the wiper motor in this position.
    - 1.4 Then, have someone from outside the cab install and tighten snugly the two Torx®-head machine screws. To engage with the wiper motor mounting holes, the machine screws must pass through the upper nose-skin (near the driver's wiper arm mounting location), the stiffener plate, and through to the wiper motor (**Fig. 1** Ref. 3).
2. From outside the cab, tighten the two Torx®-head machine screws to a torque of 40 ±10 lbf·in (442 ±113 N·cm).
3. From under the dash, connect the air lines (as previously marked, or referring to **Fig. 4** or **Fig. 5**) to the "In" and "Park" ports on the wiper motor by inserting the end of the line into the fitting until it bottoms. Tighten the nut finger-tight. Using two wrenches, tighten the nut at least two turns or until no threads show on the fitting body. Connect the exhaust port air line.
4. Attach the HVAC duct sections to the lower left side of the dash. See **Fig. 3**.
    - 4.1 Install the upper center section, then the lower center section of the HVAC duct.
    - 4.2 Install the left section of the HVAC duct. Then, tighten the nut firmly on the stud.
    - 4.3 Install the upholstery panel.
    - 4.4 Install the grab handle.
    - 4.5 Install the lower steering column panel.
5. If so equipped, install the Deutsch® diagnostic connector onto the bottom of the under-dash cover; then install the toggle switches.
6. Using the six screws, install the under-dash cover.
7. From outside the cab, using the two screws, install the wiper motor driveshaft outer bearing.
8. Install the serrated arm driver over the driveshaft.
9. Install the wiper arm.
    - 9.1 Place the wiper arm on the wiper motor driveshaft, engaging the grooves on the arm with the splines on the serrated arm driver. Make sure the blade is in the correct park position, as shown in **Fig. 6**. Install the lockwasher and drive nut, and tighten the drive nut 14 lbf·ft (19 N·m).
    - 9.2 Remove the pin from the hole in the wiper arm by gently pulling the blade up and away from the windshield until tension is off the pin. If the pin doesn't fall free, it should be loose enough to pull out.
    - 9.3 Check that the wiper blade doesn't touch the windshield seal. If it does, remove the wiper arm, then reposition it so that the blade doesn't touch the windshield seal. Install the wiper arm again.
10. Connect the windshield washer hose to the hose barb. Make sure the washer hose doesn't rest on the nose-skin.

Wiper Motor Removal and Installation, FLB COE



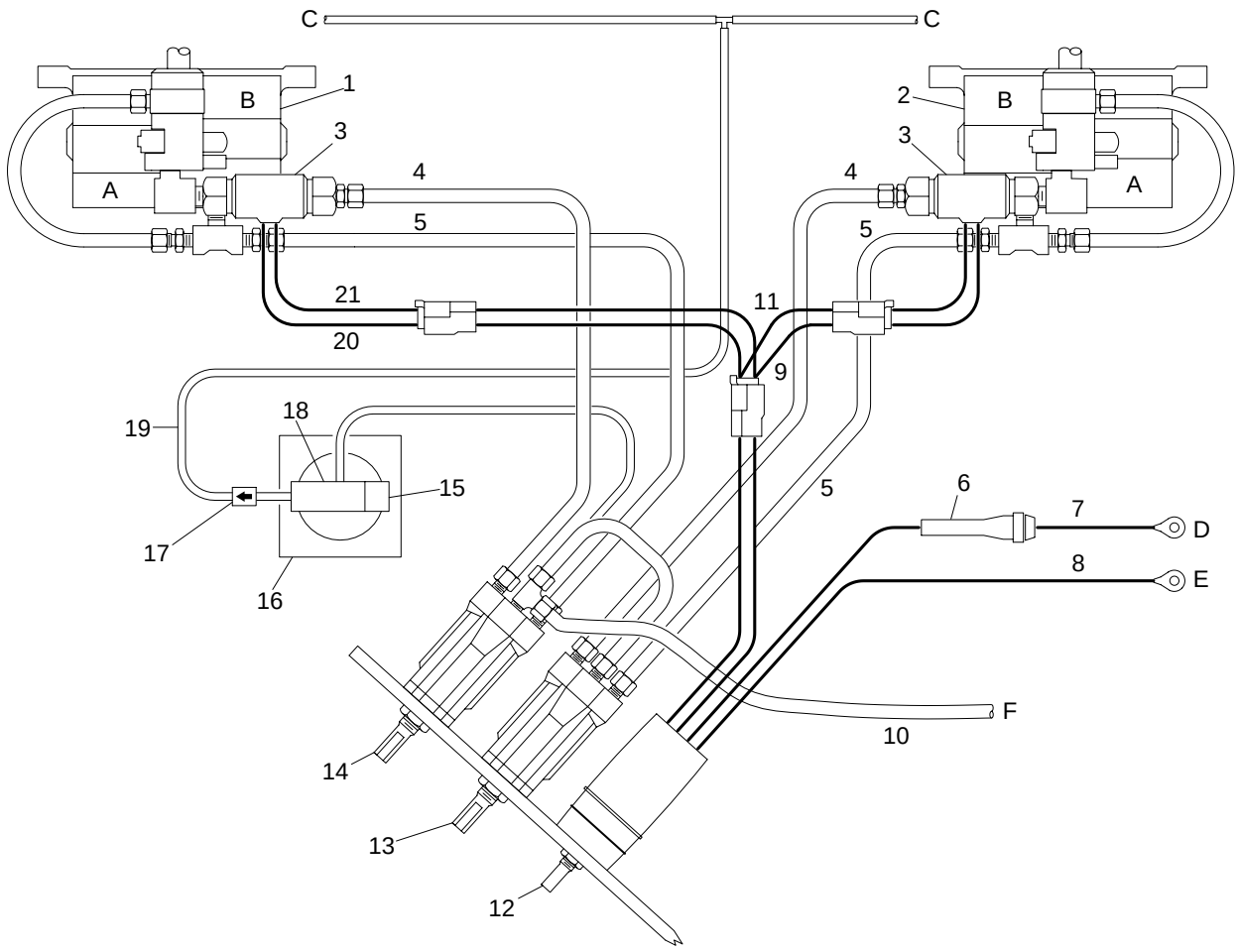
A. In
B. Park
C. To Wiper Arm
D. From Constant-Air Junction Block

1. Run (blue)
2. Park (brown)
3. Run (blue)
4. Passenger's Wiper Motor
5. Supply (yellow)
6. Wiper Control Valve
7. Wiper/Washer Control Valve
8. Purge Valve
9. Pump
10. Washer Reservoir
11. Check Valve
12. Washer Hose
13. Driver's Wiper Motor
14. Park (brown)

Fig. 4, Wiper/Washer System

PASSENGER-SIDE WIPER MOTOR REMOVAL (See Fig. 7)

1. Gently lift the wiper off the windshield until a pin or drill bit, 1/8 inch (3.2 mm) in diameter by 1-1/2 inches (38 mm) long, can be inserted through the hole at the base of the arm. See **Fig. 2**. This will relieve the wiper arm tension against the windshield, and keep the arm away from the windshield.
2. Lift the cover and remove the drive nut and lockwasher.
3. Disconnect the washer hose from the hose barb.
4. Remove the wiper arm from the driveshaft.
5. Remove the serrated arm driver.



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A. Park
B. In
C. To Wiper Arm
D. To Circuit Breaker (5 amps)
E. To Ground
F. From Constant-Air Junction Block

1. Driver's Wiper Motor
2. Passenger's Wiper Motor
3. Solenoid
4. Park (brown)
5. Run (blue)
6. 1-Amp Fuse
7. Red Wire (257)
8. Black Wire (GND)
9. White Wire (257A)
10. Supply (yellow)
11. White Wire (257C)
12. Intermittent Wiper Control
13. Wiper Control Valve
14. Wiper/Washer Control Valve
15. Purge Valve
16. Washer Reservoir
17. Check Valve
18. Pump
19. Washer Hose
20. White Wire (257D)
21. White Wire (257B)

Fig. 5, Intermittent Wiper/Washer System

6. Remove the four capnuts from the front grille and remove it.

Wiper Motor Removal and Installation, FLB COE

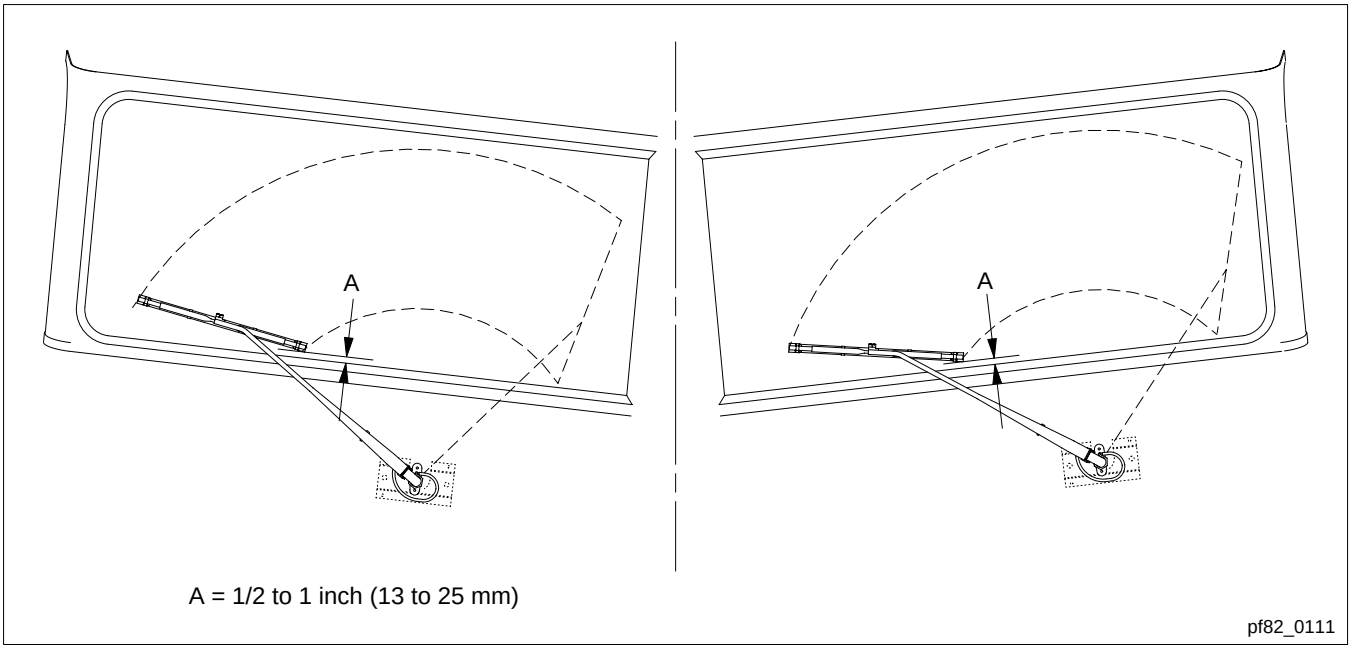


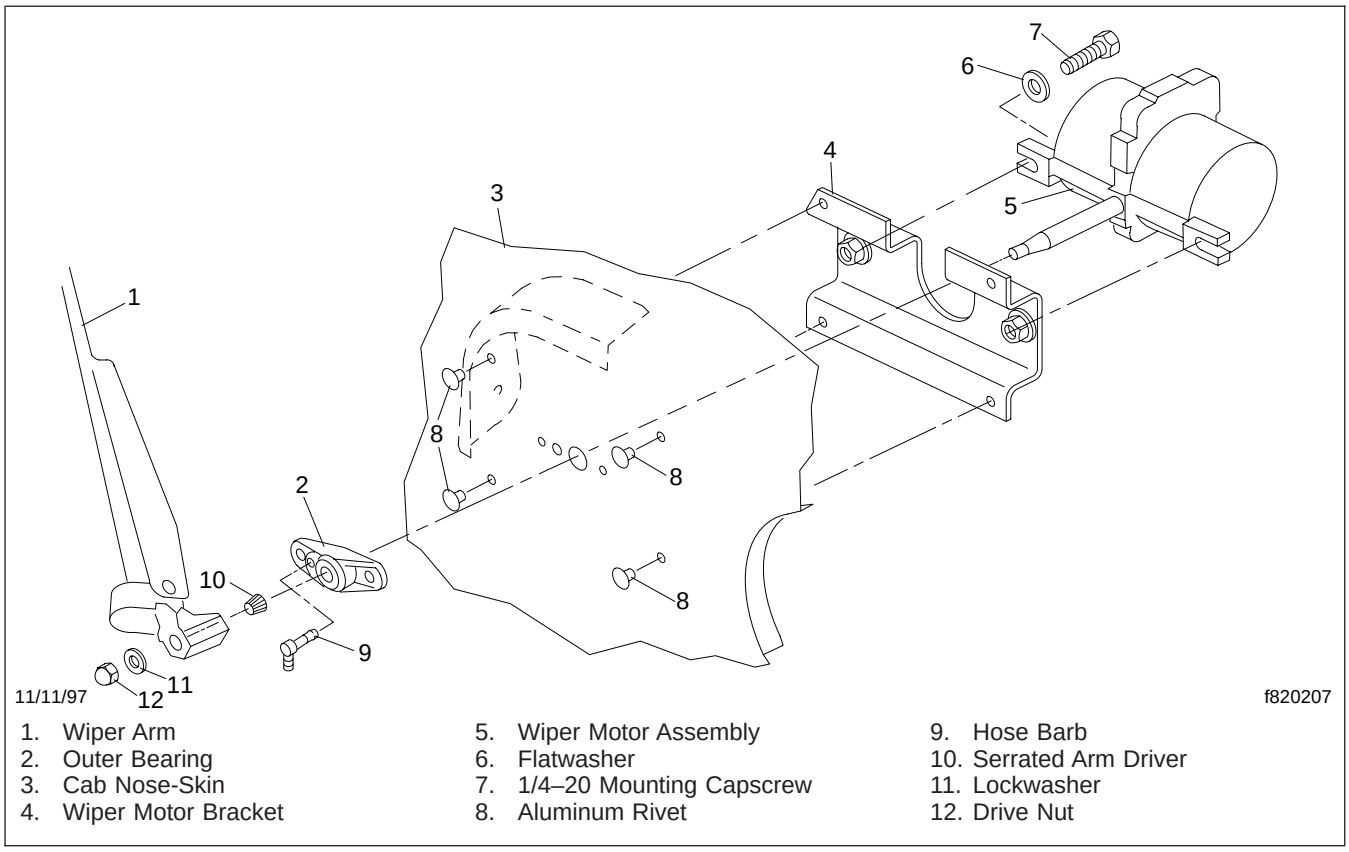
Fig. 6, Wiper Sweep Pattern and Park Position, COE

7. Tilt the cab enough to access the wiper motor. See Chapter 3 of the *FLB COE Driver's Manual* for instructions.
8. For later reference, mark and disconnect the air lines from the ports marked "In" and "Park."
9. Remove the two capscrews and flatwashers from the wiper motor mounting bracket. See **Fig. 8**. Then remove the wiper motor.

NOTE: If replacing the wiper motor, remove the fittings from the "In" and "Park" ports of the old motor and install them on the new wiper motor.

PASSENGER-SIDE WIPER MOTOR INSTALLATION **(See Fig. 7)**

1. Insert the wiper motor driveshaft through both the nose-skin and outer bearing. Push the wiper motor housing flush against the bracket. Install the two capscrews and flatwashers into the mounting holes. Tighten the capscrews 15 lbf·ft (20 N·m).
2. As previously marked, or referring to **Fig. 4** or **Fig. 5**, connect the air lines to the "In" and "Park" ports on the wiper motor by inserting the end of the line into the fitting until it bottoms. Tighten the nut finger-tight. Using two wrenches, tighten the nut at least two turns or until no threads show on the fitting body.
3. Return the cab to the driving position. See Chapter 3 of the *FLB COE Driver's Manual* for instructions.
4. Using the four capnuts, install the front grille.
5. Install the serrated driver.
6. Install the wiper arm.
   - 6.1 Place the wiper arm on the wiper motor driveshaft, engaging the grooves on the arm with the splines on the serrated arm driver. Make sure the blade is in the correct park position, as shown in **Fig. 6**. Install the lockwasher and drive nut, and tighten the drive nut 14 lbf·ft (19 N·m).
   - 6.2 Remove the pin from the hole in the wiper arm by gently pulling the blade up and away from the windshield until tension is off the pin. If the pin doesn't fall free, it should be loose enough to pull out.
   - 6.3 Check that the wiper blade doesn't touch the windshield seal. If it does, remove the wiper arm, then reposition it so that the



1. Wiper Arm
2. Outer Bearing
3. Cab Nose-Skin
4. Wiper Motor Bracket
5. Wiper Motor Assembly
6. Flatwasher
7. 1/4–20 Mounting Capscrew
8. Aluminum Rivet
9. Hose Barb
10. Serrated Arm Driver
11. Lockwasher
12. Drive Nut

Fig. 7, Passenger-Side Wiper Assembly

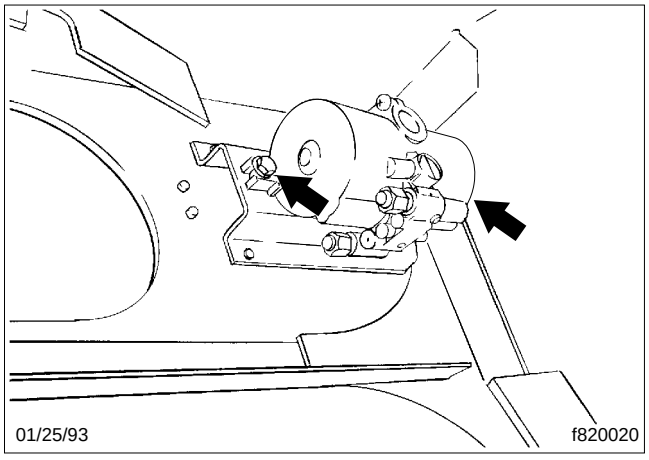


Fig. 8, Remove Capscrews

blade doesn't touch the windshield seal. Install the wiper arm again.

7. Connect the windshield washer hose to the hose barb. Make sure the washer hose doesn't rest on the nose-skin.

Troubleshooting

PRELIMINARY CHECKS

Before attempting to isolate the cause(s) of a wiper/washer system problem, check the operation of the windshield wiper motor(s) and the washer, to determine which parts of the system don't have to be checked.

NOTE: Use the troubleshooting charts at the end of this section before doing the test procedures below.

WIPER CONTROL VALVE TESTING

1. Start the engine to build up the air system pressure.
2. Pull the knobs off the heater/air-conditioner lever slide controls.
3. Remove the six screws attaching the control panel to the dash. **See Fig. 1.** Move the panel away from the dash enough to service it.

NOTE: All control valve ports are labeled with "Park," "In," or "Out." Use these references when connecting or disconnecting air lines.

⚠ WARNING

WARNING: Wear safety goggles when draining the air system, loosening an air line, or working around open air ports, because dirt or sludge could fly out at high speeds. Don't direct the air streams at other people. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

4. To prevent twisting of the tubing, use two wrenches to disconnect the air lines from the "Park" and "Out" male couplings at the back of the valve. Mark the air lines for later reference.
5. Turn the wiper control knob clockwise at least one-quarter turn. Air should flow from the "Out" port only. If air doesn't flow from the "Out" port, check for a plugged port. If needed, unplug the port and lubricate the valve, using 1/4 to 1/2 oz. (7 to 14 mL) of Dow Corning 200 Fluid, 200 viscosity. If air flows from both the "Out" and the "Park" ports, replace the control valve.

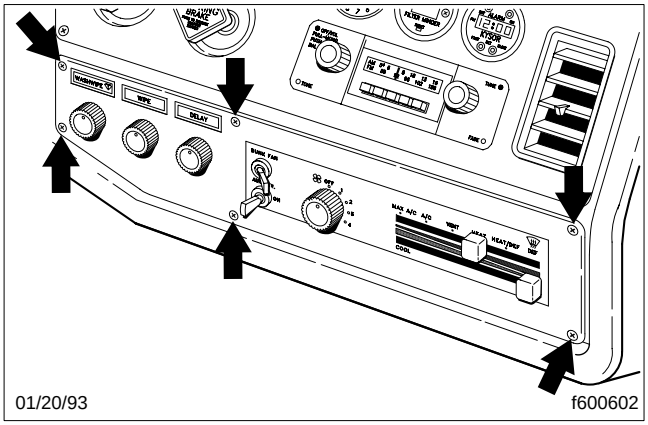


Fig. 1, Control Panel Screws

6. Test the wiper park function by turning the control valve knob to the counterclockwise position. You should feel the switch click as the off detent is reached. Continue to turn the knob past the off position and hold it there; air should flow from both the "Out" and "Park" ports. If not, check for plugged ports. If needed, unplug the port(s).
7. If needed, test the control valve input pressure as follows:
   - 7.1 Shut down the engine, then drain the air system.
   - 7.2 Using two wrenches to avoid twisting the tubing, disconnect the air supply line from the control valve "In" port.
   - 7.3 Connect a pressure gauge to the air supply line. Start the engine to build up pressure in the air system.
   - 7.4 When the air compressor shuts off, check the pressure reading on the gauge. It should be 90 to 130 psi (621 to 896 kPa). See the system specifications table in **Specifications, 400**. If the pressure is less, troubleshoot the air system following the instructions in the brake section.
   - 7.5 Shut down the engine. Drain the air system. Remove the pressure gauge from the air supply line. Connect the air line to the "In" port of the control valve, using two wrenches. Tighten the fittings firmly.

8. If needed, test the control valve output pressure as follows:
   - 8.1 Start the engine to build up the air system pressure. The system pressure should be about 120 psi (689 kPa). If the pressure doesn't get that high, troubleshoot the air system, following the instructions in the brake section.
   - 8.2 Connect a pressure gauge to the "Out" port on the control valve.
   - 8.3 Turn the wiper control knob clockwise one-quarter turn.
   - 8.4 Check the reading on the pressure gauge. It should be 90 to 110 psi (621 to 758 kPa). See the system specifications table in **Specifications, 400**. If it isn't, replace the control valve; otherwise go to the next step.
9. As previously marked, connect the air lines to the "Out" and "Park" ports on the valve body by inserting the end of the line into the fitting until it bottoms. Tighten the nut finger-tight. Then, using two wrenches, tighten the nut at least two turns or until no threads show on the fitting body.
10. Place the control panel in the dash, and install the six screws.
11. Push the knobs onto the heater/air conditioner lever slide controls.

INTERMITTENT CONTROLLER TESTING

IMPORTANT: After operating or servicing the intermittent wiper control, make sure the control knob is turned off. If left on, it will continue to cycle, and continual cycling will shorten the life of the intermittent wiper control.

1. Connect a voltmeter to the controller output (white) wires. Put the voltmeter selector on "DC Volts."
2. Turn the wiper control knob to high.
3. Turn the intermittent control knob at least one-quarter turn clockwise.
4. Check the reading on the voltmeter. It should be 9 to 15 volts DC. The wipers should be parked.
5. The voltage should drop to 0, and the wipers should sweep through one cycle. The voltage should then come back up. Check the duration of the voltage drop. It should be 0.7 to 1.1 seconds. See the Intermittent Controller Specifications table in **Specifications, 400**. If the duration is different, replace the intermittent controller.

WIPER CYCLE TESTING

1. Start the engine, and let the air pressure build to 120 psi (827 kPa). The compressor should shut off at this point.
2. Make sure the exhaust port on the motor is not blocked.
3. Using a spray bottle (*not* the windshield washer), wet the windshield.
4. Turn on the wiper switch all the way. Make sure the intermittent switch (if so equipped) is off.

⚠ CAUTION

CAUTION: Keep the windshield constantly wet while doing this test. Running the wipers on dry windshield will not produce accurate test results, and may scratch the windshield. Don't use the windshield washers to wet the windshield.

5. Using a spray bottle, keep the windshield wet by spraying it after each wiper pass.
6. Let the wipers cycle for about three or four times, then count the number of complete sweep cycles in a 30 second period. Multiply this number by 2 to get cycles per minute (cpm).
7. If the wiper speed is less than that shown in the wiper System Specifications table in **Specifications, 400**, go to "Problem—Wiper Motor Works Too Slowly," in the troubleshooting charts.

Troubleshooting Charts

TROUBLESHOOTING: WIPER MOTORS, VALVES, AND LINKAGE

Problem—Wiper Motor Won't Start

Possible Cause	Remedy
The wiper blade is stuck to the windshield.	Wet the windshield glass, then carefully pull the wiper away from the glass.
The wiper linkage is binding, or it is worn.	Free the linkage, or replace it if needed.
The air compressor isn't working.	Repair or replace the air compressor.
The vehicle air system is low.	Referring to **Specifications, 400**, build up the air pressure.
An air line is blocked, leaking, or broken.	Unplug, tighten, or replace the air line, as needed.
The control valve is contaminated.	Clean and lubricate the control valve.
The motor valve is contaminated.	Clean and lubricate the motor valve. Lubricate the valve by adding 1/4 to 1/2 oz. (7 to 14 mL) of Dow Corning 200 Fluid, 200 viscosity, to the motor. Then let the motor run for 15 to 20 seconds.
The wiper motor isn't working.	Replace the wiper motor.
The control valve isn't working.	Test the valve. Replace it if needed.

Problem—Wiper Motor and Shaft Work, But Wiper Arm Won't Move

Possible Cause	Remedy
The wiper arm is loose.	Tighten the wiper arm nut 14 lbf·ft (19 N·m).
The wiper arm splines are stripped.	Replace the wiper arm.
The splines on the motor shaft or the wiper arm driver are stripped.	Replace the wiper motor or the wiper arm driver, and the wiper arm.
The wiper arm driver is loose or cracked.	Tighten or replace, as needed.

Problem—Wiper Motor Works Too Slowly (Refer to the system specifications table in Specifications, 400.)

Possible Cause	Remedy
An air line (including the exhaust line) is leaking, plugged, or broken.	Tighten, unplug, or replace the air line, as needed.
The control valve is contaminated.	Clean and lubricate the control valve.
The motor valve is contaminated.	Clean and lubricate the motor valve. Lubricate the valve by adding 1/4 to 1/2 oz. (7 to 14 mL) of Dow Corning 200 Fluid, 200 viscosity, to the motor. Then let the motor run for 15 to 20 seconds.
The wiper motor is leaking air.	Replace the wiper motor.
The control valve isn't working.	Test the control valve. Replace it if needed.
The wiper motor isn't working.	Replace the wiper motor.

Problem—Wiper Motor Action Is Erratic

Possible Cause	Remedy
The motor is sticking.	Lubricate the motor by adding 1/4 to 1/2 oz. (7 to 14 mL) of Dow Corning 200 Fluid, 200 viscosity, to the motor. Then let the motor run for 15 to 20 seconds. If the problem persists, replace the motor.
The motor exhaust port is plugged.	Unplug the motor exhaust port.

Troubleshooting

Possible Cause	Remedy
The motor valve is not working.	Replace the motor.
The motor is leaking internally.	Replace the motor.

Problem—Wipers Jerk at End of Travel (Slam-Action Operation)

Possible Cause	Remedy
A wiper motor or control valve air port is plugged.	Unplug the air port.
The wiper motor valve isn't working.	Replace the wiper motor.
The wiper motor is leaking internally.	Replace the wiper motor.

Problem—Wipers Have Short Sweep

Possible Cause	Remedy
The wiper motor valve is not working.	Replace the wiper motor.
The wiper motor is leaking internally.	Replace the wiper motor.

Problem—Wipers Oversweeping

Possible Cause	Remedy
A wiper arm is loose.	Tighten the wiper arm nut.
The wiper arm splines are worn.	Replace the wiper arm.
The wiper arm driver is loose.	Tighten the wiper arm driver.
The wiper arm driver is worn.	Replace the wiper arm driver.
The wiper motor is not working.	Replace the wiper motor.

Problem—The Wipers Don't Return to Park Position

Possible Cause	Remedy
The wiper motor exhaust port is plugged.	Unplug the wiper motor exhaust port.
The control valve is contaminated.	Clean and lubricate the control valve.
The control valve doesn't work.	Test the control valve. Replace it if needed.
The wiper motor valve is contaminated.	Clean and lubricate the wiper motor control valve.
The wiper arm motor valve isn't working.	Replace the wiper motor.

TROUBLESHOOTING: INTERMITTENT CONTROL SYSTEM

Problem—Wiper Motor Won't Start

Possible Cause	Remedy
The wiper control valve isn't fully on.	Turn the control valve clockwise to the end of its travel.
The intermittent controller isn't engaged.	Make sure the controller is engaged at least one-quarter turn.
There isn't enough voltage to the controller.	Check the controller circuit for loose or corroded connections, disconnected terminals, an open circuit, or incorrect wiring. Check for a blown fuse along the red (power) wire going to the controller. Replace it with a new 1-amp fuse if needed.
The solenoid doesn't work.	Replace the solenoid.
The intermittent controller doesn't work.	Test the intermittent controller, and replace it if needed.

Problem—Wiper Arm Sweeps Too Short

Possible Cause	Remedy
The wiper control valve isn't on fully.	Turn the control valve knob clockwise to the end of its travel.
The wiper motor is too slow.	Go to "Troubleshooting: Wiper Motors, Valves, and Linkage; Problem - Wiper Motor Works Too Slowly."
The controller doesn't work.	Test the intermittent controller, and replace it if needed.

TROUBLESHOOTING: WINDSHIELD WASHER

Problem—Windshield Washer Doesn't Squirt Fluid

Possible Cause	Remedy
The reservoir is empty.	Fill the reservoir.
The washer fluid is frozen.	Thaw the system. Purge the system, then fill it with a low temperature solution.
The valves are incorrectly plumbed.	Plumb the system correctly. Refer to the applicable figure in **Specifications, 400**.
Tubing, nozzles, or other system parts are plugged.	Unplug and lubricate the system parts as needed. If a part is too plugged, replace it.
The tubing is kinked or disconnected.	Remove the kink, or connect the tubing. If needed, replace the tubing.
The tubing is damaged.	Replace the damaged section of tubing.
The vehicle air system is low.	Let the air pressure build.
The control valve outlet pressure is low.	Test the control valve. Replace it if needed.
The washer pump is damaged.	Replace the washer pump.

Problem—Washer Fluid Comes Out Weakly, or Too Little Washer Fluid Comes Out

Possible Cause	Remedy
The wrong kind of solution is in the reservoir.	Replace the fluid in the reservoir with windshield washer fluid.
The tubing is damaged.	Replace the damaged section of tubing.
The tubing is kinked.	Remove the kink.

Troubleshooting

Possible Cause	Remedy
The tubing, nozzles, or other system parts are contaminated.	Clean and lubricate the applicable parts, or replace them if needed.
The control valve washer port pressure is too low.	Check the washer port pressure on the control valve. Replace the control valve if needed.
The washer pump is damaged.	Replace the washer pump.

Problem—Washer Fluid Misdirected

Possible Cause	Remedy
The nozzles are incorrectly adjusted.	Adjust the nozzles.

TROUBLESHOOTING: AIR LINES

Problem—Air Line Blows Off Fitting, or Ruptures

Possible Cause	Remedy
The tubing is damaged.	Replace the damaged section of tubing.
The control valve outlet pressure is too high.	Test the control valve. Replace it if needed.

Refer to the figures in this subject as follows:

- **Fig. 1**, COE Wiper/Washer System
- **Fig. 2**, Conventional Wiper/Washer System
- **Fig. 3**, COE Wiper/Washer System With Intermittent Control
- **Fig. 4**, Conventional Wiper/Washer System With Intermittent Control
- **Fig. 5**, Wiper Sweep Pattern and Park Position, COE
- **Fig. 6**, Wiper Sweep Pattern and Park Position, Conventional

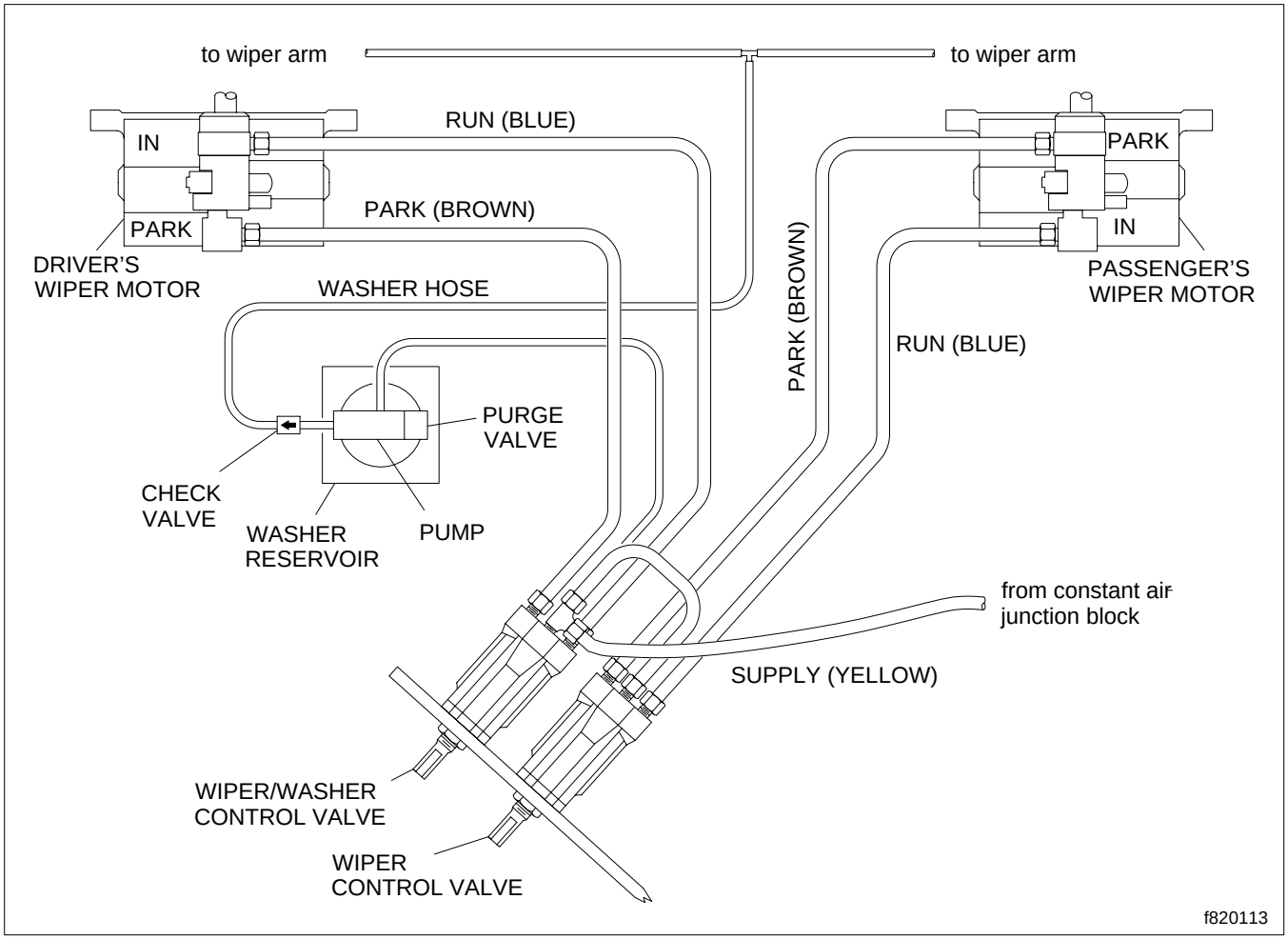


Fig. 1, COE Wiper/Washer System

Specifications

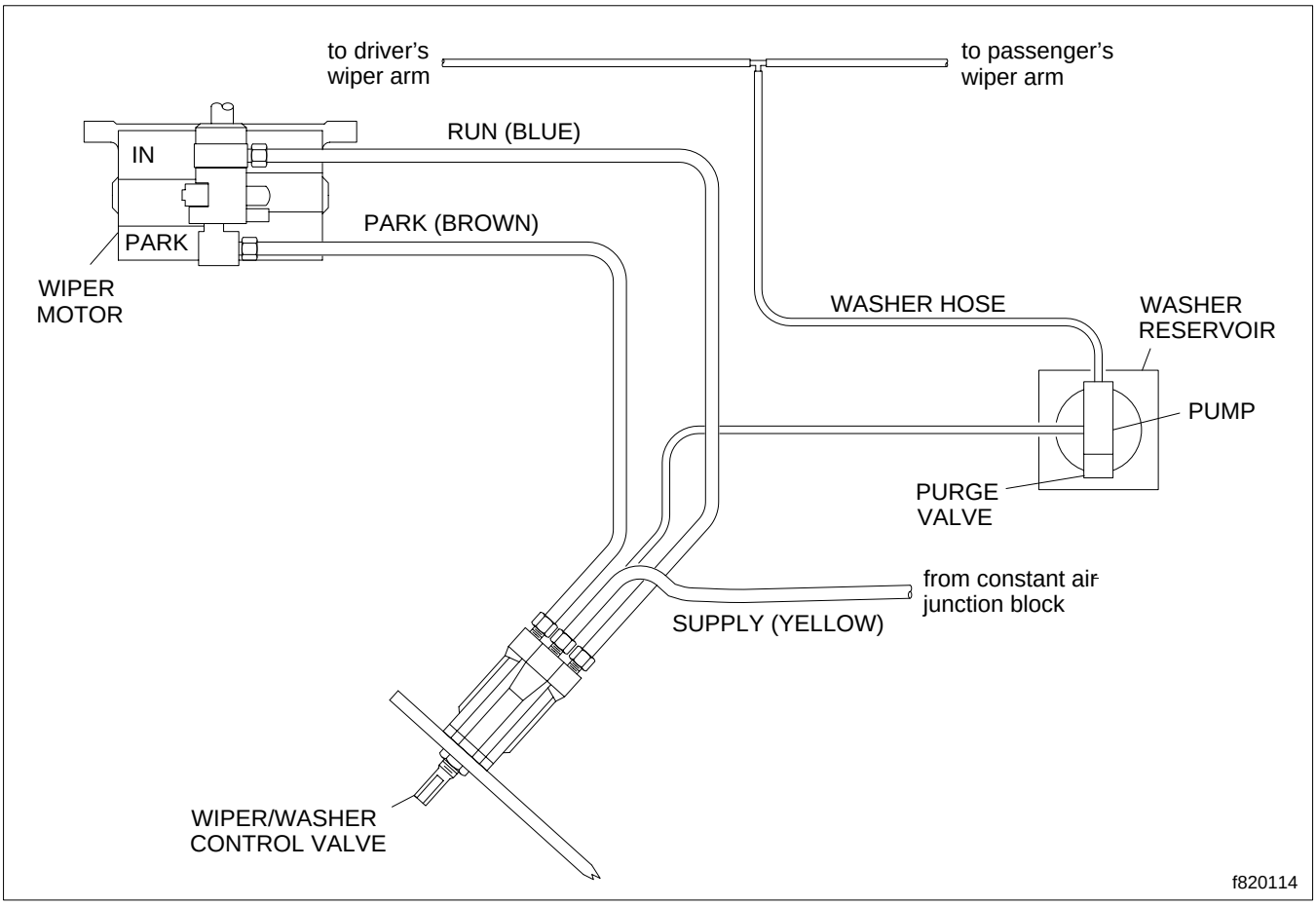


Fig. 2, Conventional Wiper/Washer System

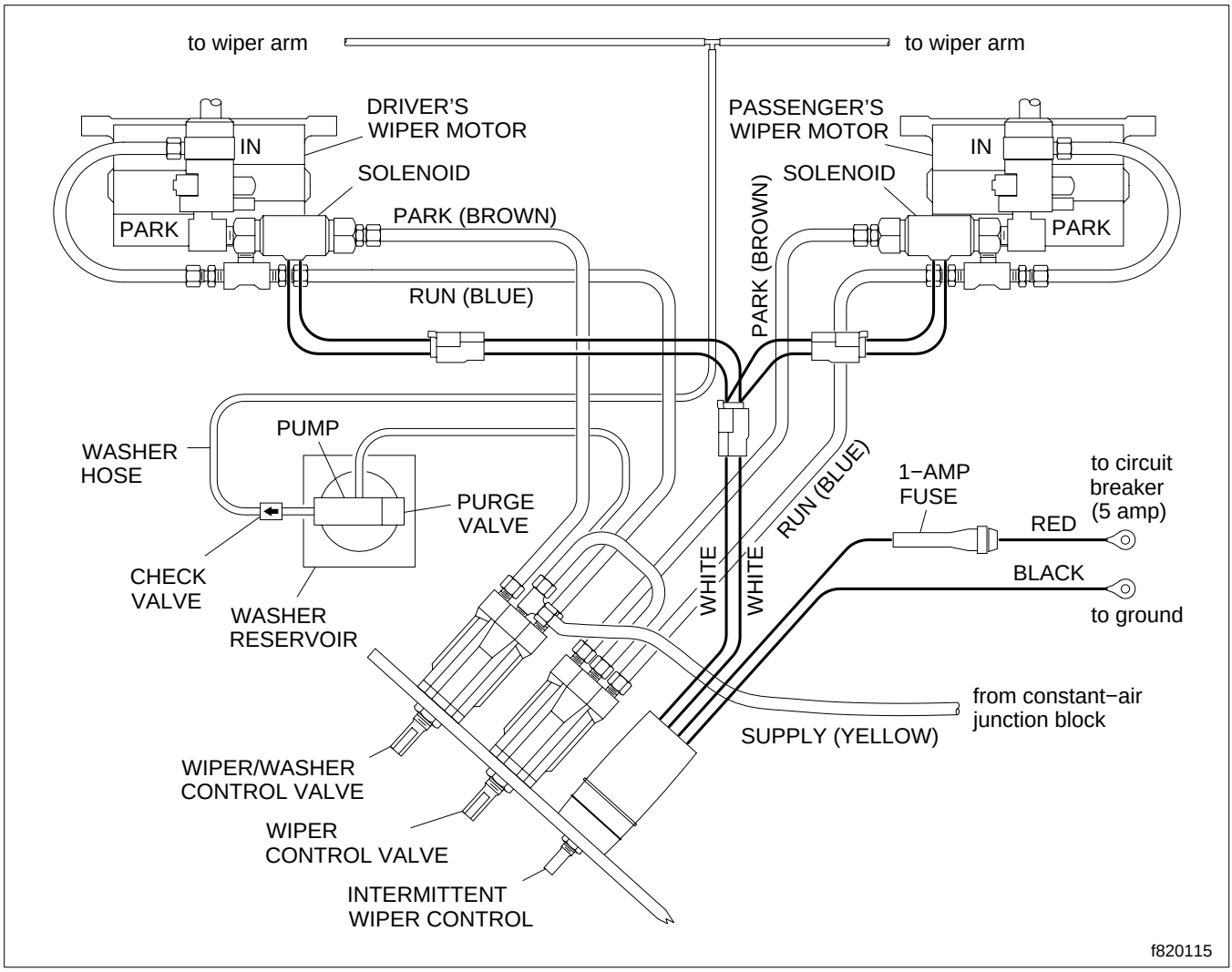


Fig. 3, COE Wiper/Washer System With Intermittent Control

Specifications

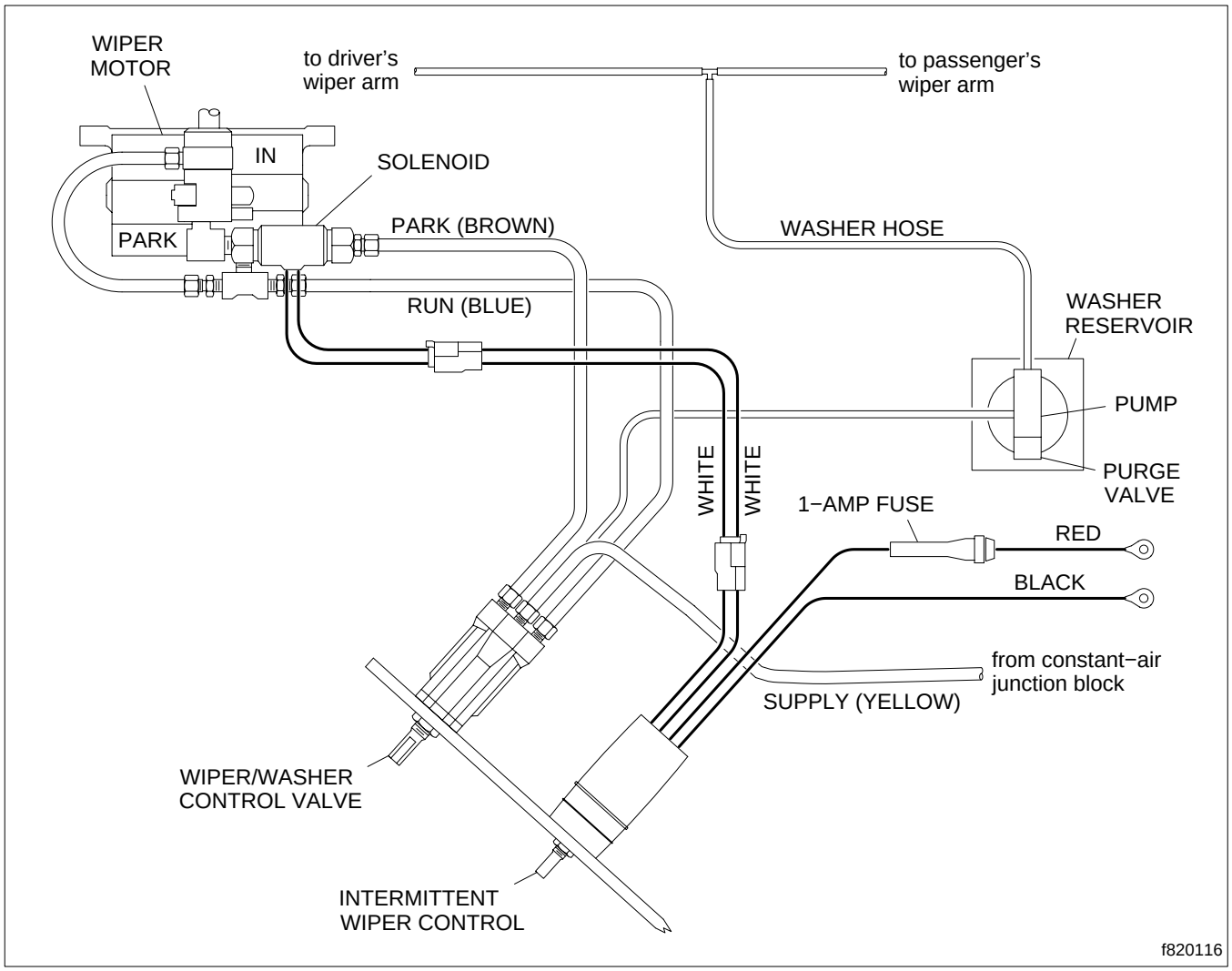


Fig. 4, Conventional Wiper/Washer System With Intermittent Control

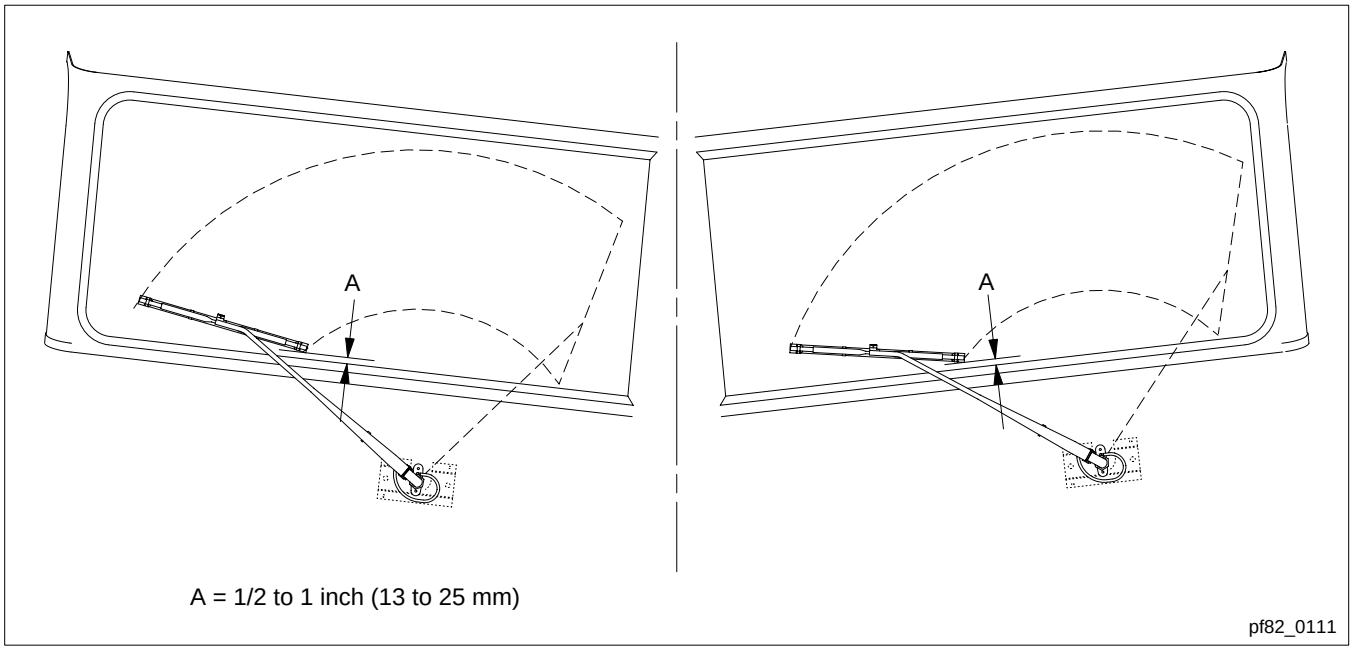


Fig. 5, Wiper Sweep Pattern and Park Position, COE

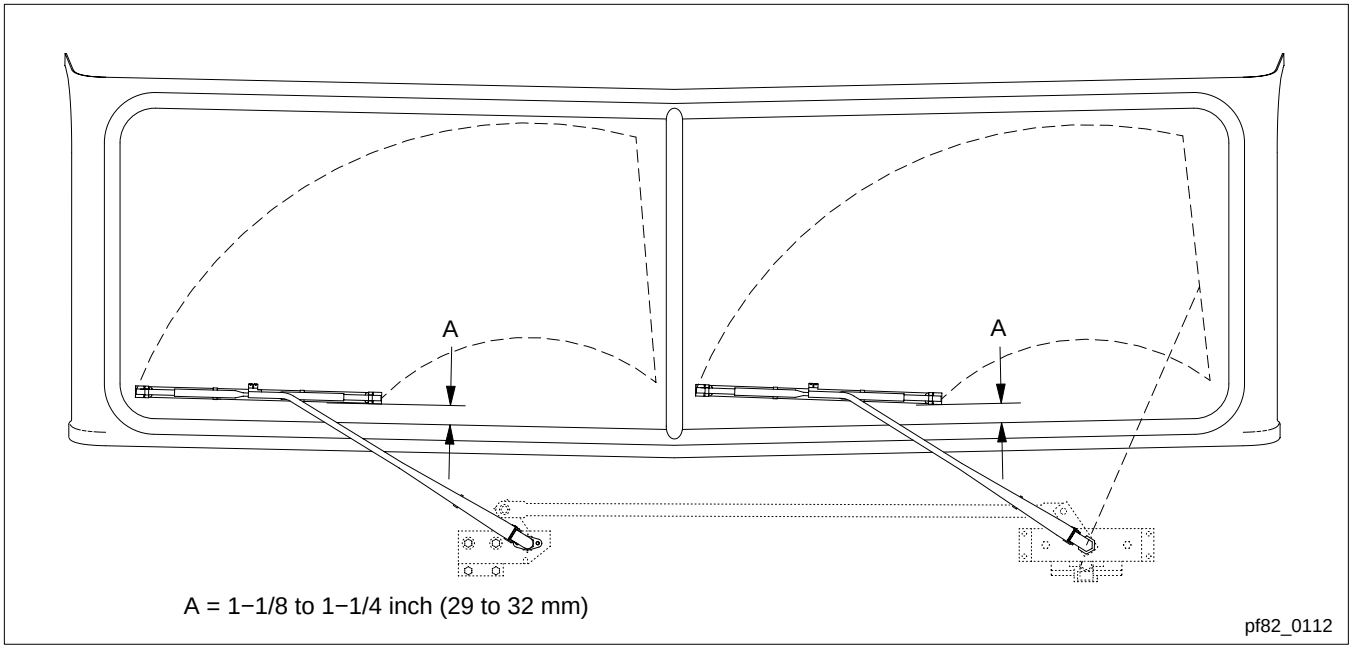


Fig. 6, Wiper Sweep Pattern and Park Position, Conventional

Specifications

Wiper Motor Model	Maximum Wiper Speed (cycles/min) *	Control Valve		Washer Control Output Pressure † psi (kPa)	Washer Pump Delivery Volume Per Cycle
		Input Pressure psi (kPa)	Output Pressure ‡ psi (kPa)		
HP 130 (FLA)	60–70	90–130 (621–896) (equal to correct air compressor output)	90–110 (621–758)	40–50 (276–345)	120 mL (4 oz) (minimum)
HP 135 (FLD)	58–68				

* Measured at 120 psi (827 kPa) control valve input pressure, with wet glass.

† At 100 psi (689 kPa) input pressure.

‡ At 120 psi (827 kPa) input pressure.

Table 1, Standard Wiper System Specifications

Voltage (DC)	Cycle Duration *
9–15	0.7–1.1 seconds

* Controller is normally on, and cycles off to allow motor operation.

Table 2, Intermittent Controller Specifications

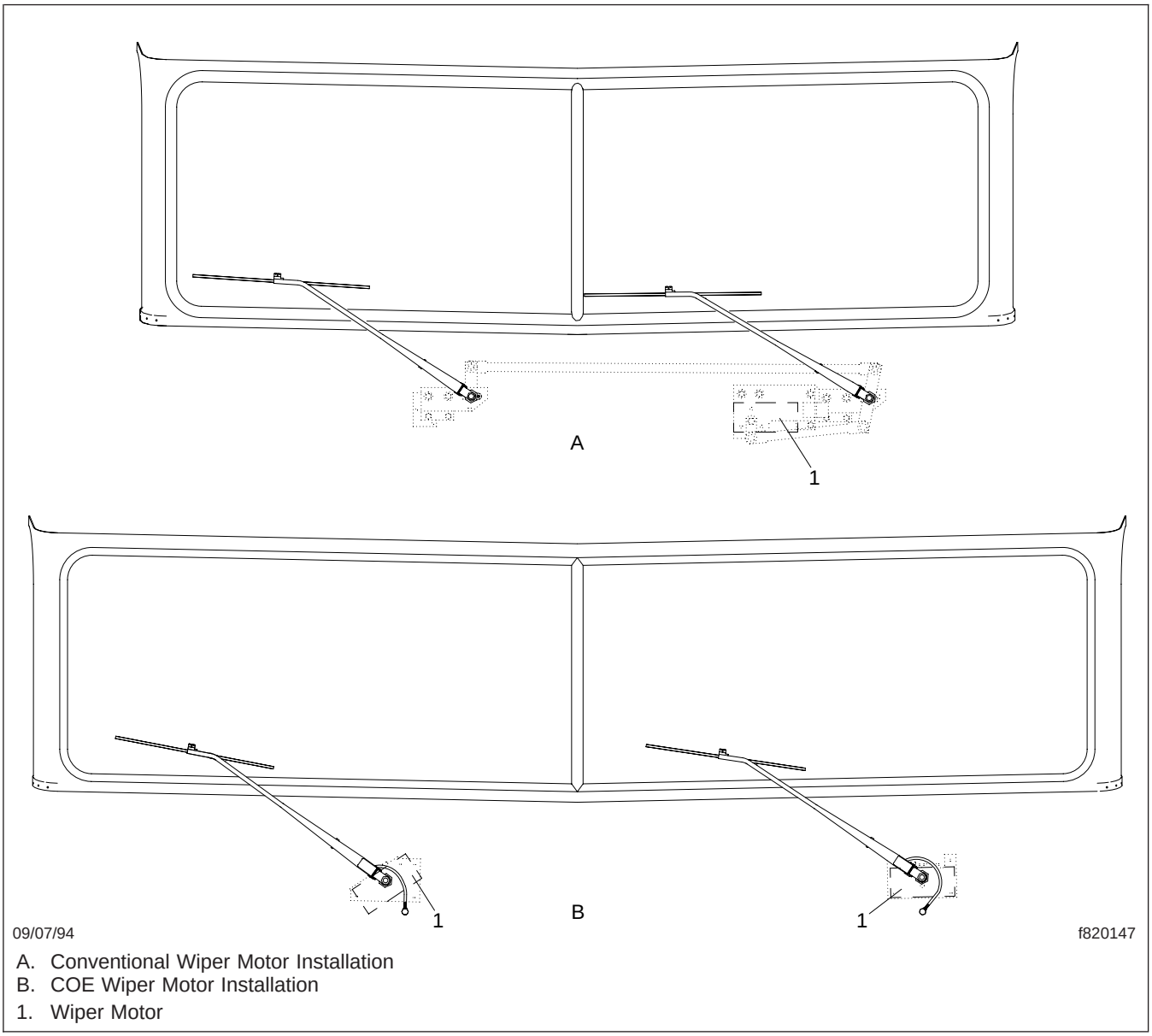
General Information

Sprague electric windshield wipers and washers are operated by a control knob mounted on the dash. The knob controls the speed of the wipers as well as activating the washers. The speed of the wipers is regulated by turning the control knob clockwise (increased speed) or counterclockwise (decreased speed). The delay feature (if so equipped) is integrated with the speed control knob, between the stop and the low speed positions. On COEs, separate knobs operate the wipers for the left and right sides; the left-hand (driver's-side) knob controls both washers.

On Conventionals, a single wiper motor, mounted on the left side of the firewall, powers both wipers. **See Fig. 1.** On COEs, there is one wiper motor for each side; both are mounted on the nose-skin. **See Fig. 1.** The electric wiper motors are sealed units; they are not serviceable. If a wiper motor doesn't work because of internal problems, replace it.

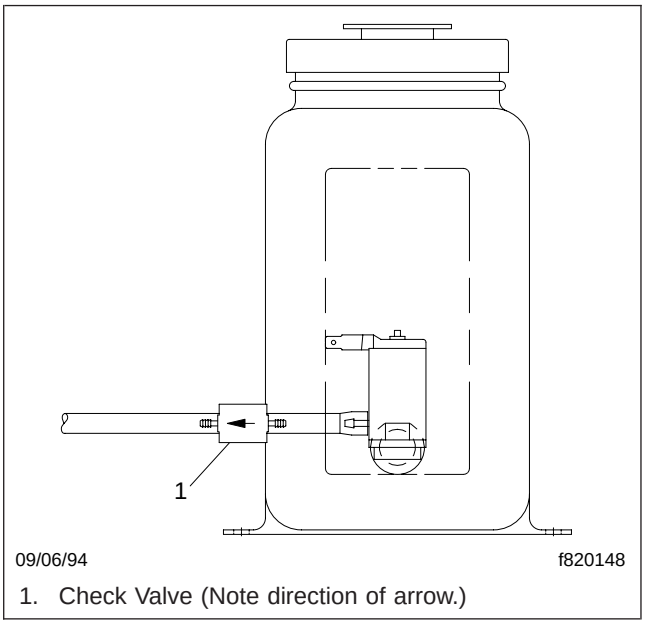
The windshield washer reservoir is located inside the right-side baggage compartment, or behind the passenger seat in 63-inch FLA COEs. **See Fig. 2.** Fluid is pumped from the reservoir to nozzles in each arm ("wet blades"). A purge mechanism empties the lines after use to prevent fluid from freezing in the lines during cold weather. On COEs, a check valve in the outlet of the reservoir prevents fluid from draining when the cab is tilted.

General Information



A. Conventional Wiper Motor Installation
B. COE Wiper Motor Installation
1. Wiper Motor

Fig. 1



1. Check Valve (Note direction of arrow.)

Fig. 2

Wiper Motor Removal and Installation, COE

DRIVER-SIDE WIPER MOTOR REMOVAL

1. Park the vehicle on a smooth, level surface. Apply the parking brakes and chock the rear tires.
2. Drain the air system.
3. Disconnect the batteries.

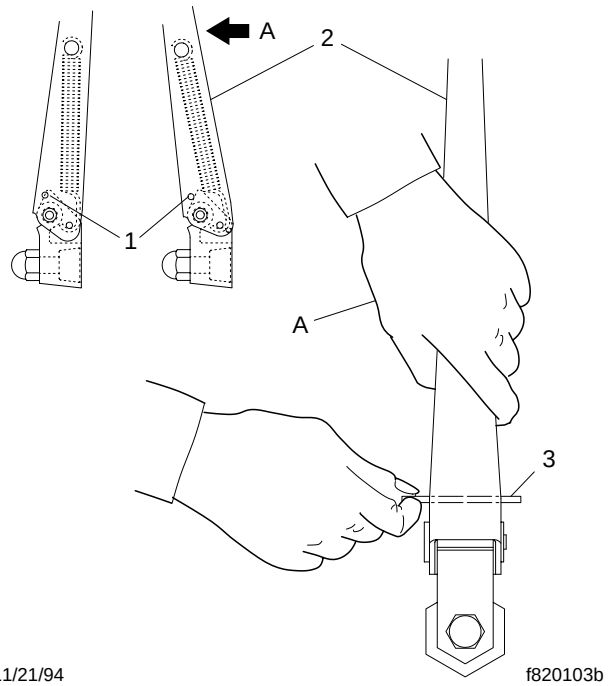
⚠ WARNING

WARNING: Disconnect the batteries before working on the wiper motor. Otherwise, the motor could cycle if the driveshaft is forced out of the parked position, which could result in personal injury.

4. Gently lift the wiper arm off the windshield until a pin or nail 1/8 inch (3.2 mm) in diameter by 1-1/2 inches (40 mm) long can be inserted through the pin hole at the base of the arm. **See Fig. 1.** This will relieve the wiper arm tension, and keep the arm away from the windshield.
5. Disconnect the washer fluid hose from the hose barb.
6. Remove the acorn nut and star washer; then remove the wiper arm. **See Fig. 2.**
7. Remove the splined arm driver, the weather seal cover, the drive nut, the flat washer, and the gasket. **See Fig. 2.**
8. Inside the cab: If there are toggle switches in the lower panel beneath the steering wheel, mark and remove the toggle switches. Remove the lower panel.

⚠ WARNING

WARNING: Wear safety goggles when loosening an air line, because dirt or sludge could fly out at high speeds. Don't direct the airstream at anyone. Don't disconnect pressurized hoses, since they may whip when air escapes. Failure to take all necessary precautions could result in personal injury.

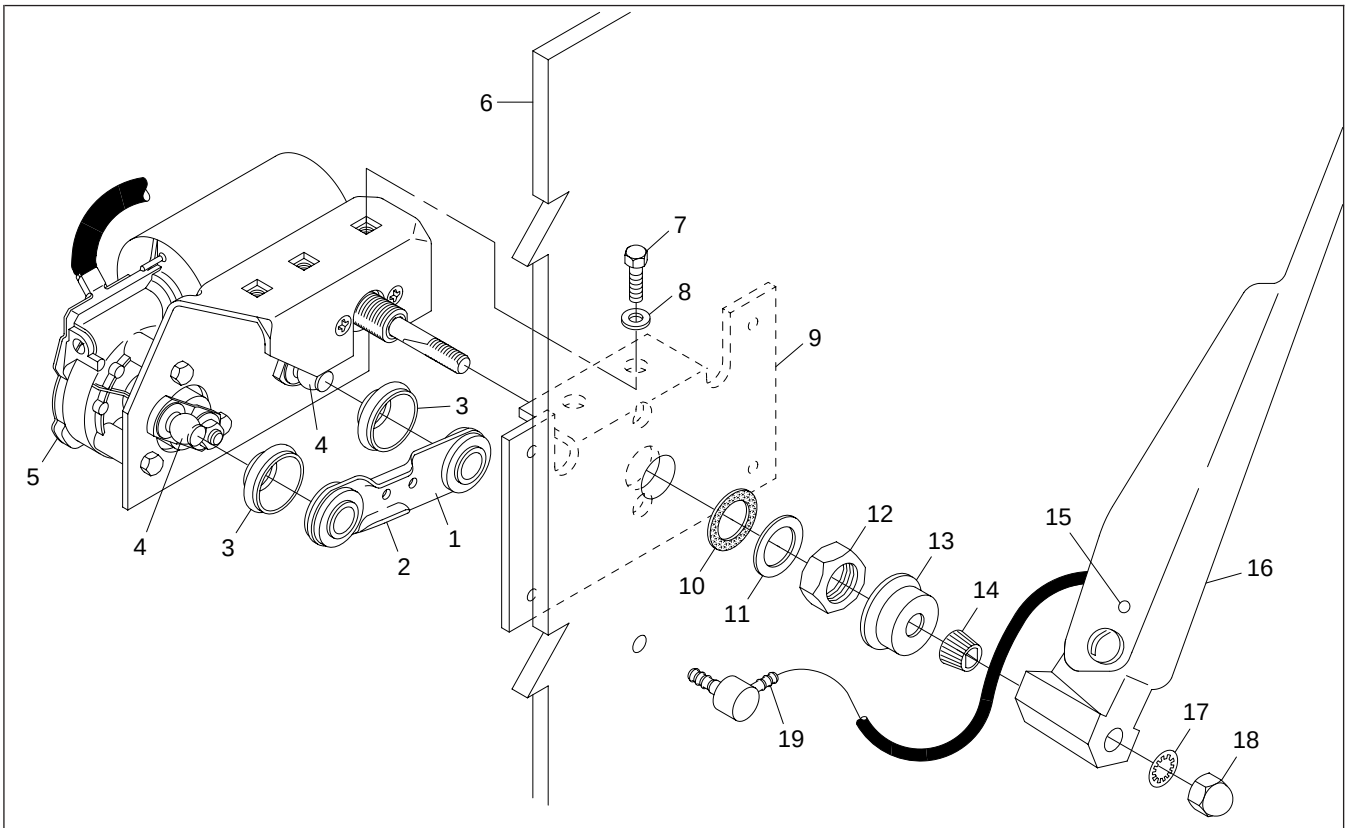


A. Lift gently to stretch spring.
1. Pin Hole
2. Wiper Arm
3. Pin

Fig. 1

9. Disconnect the air line from the HVAC air cylinder. **See Fig. 3.**
10. Remove the heater/air conditioner duct:
    - 10.1 Remove the mounting nuts and washers from the duct.
    - 10.2 Pull the duct down and twist it to disconnect the top joint.
    - 10.3 Remove the duct.
11. Remove the speedometer/tachometer panel from the dash, to gain better access to the wiper motor wiring.
12. Disconnect the two electrical connectors from the wiper motor.
13. Remove the wiper motor.
    - 13.1 Remove the two mounting capscrews and washers from the wiper motor mount.

Wiper Motor Removal and Installation, COE



1. Connecting Link
2. Flange (Connecting Link)
3. Bellows
4. Ball Pin
5. Wiper Motor
6. Nose-Skin
7. Mounting Capscrew (2 qty.)
8. Washer (2 qty.)
9. Wiper Motor Mounting Bracket
10. Gasket
11. Flatwasher
12. Drive Nut
13. Weather Seal Cover
14. Serrated Arm Driver
15. Pin Hole
16. Wiper Arm
17. Star Washer
18. Acorn Nut
19. Hose Barb

Fig. 2

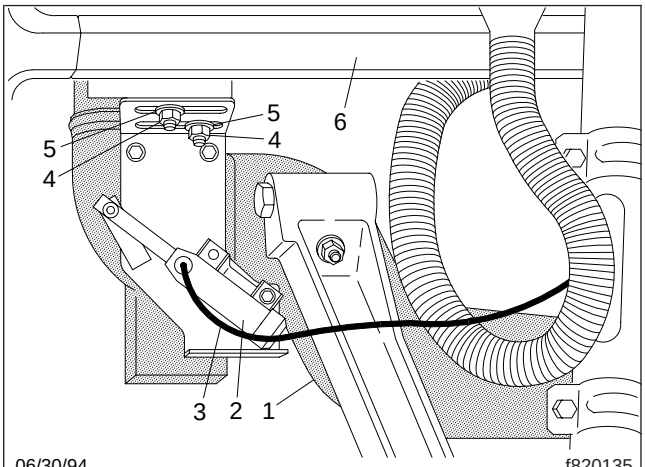
13.2 Hold on to the wiper motor with both hands. Tilt the motor slightly back toward yourself; then rotate it clockwise about 90 degrees. **See Fig. 4.**

13.3 Tilt the motor back more until the wiper driveshaft clears the hole in the nose-skin.

13.4 Rotate the motor back counterclockwise (to where it was originally); then, keeping the wiper driveshaft pointing up, slide the wiper motor to your left, along the nose-skin. Move any wires or air lines out of the way, then remove the wiper motor from under the dash.

DRIVER-SIDE WIPER MOTOR INSTALLATION

1. Hold the wiper motor so that the driveshaft is pointing up. Feed the wires in first; then slide the motor into position from the left side of the lower dash. When the driveshaft is near the hole in the nose-skin, rotate the motor clockwise about 90 degrees.



1. Heater/Air Conditioner Duct
2. Air Cylinder
3. Air Line
4. Nut
5. Washer
6. Dash

Fig. 3

2. Tilt the motor forward until the driveshaft fits through the hole in the nose-skin; then rotate the motor back counterclockwise, and tilt it forward so the driveshaft goes all the way into the hole.
3. Install the two mounting bolts in the wiper motor mount. Tighten the mounting bolts 15 lbf·ft (20 N·m).
4. Connect the wiring to the wiper motor.
5. Install the heater/air conditioner duct beneath the dash.
6. Connect the air line at the heater/air conditioner duct air cylinder.
7. Install the speedometer/tachometer panel in the dash.
8. Install any toggle switches removed earlier. Install the panel beneath the steering wheel.
9. Install the gasket, the flat washer, and the drive nut onto the wiper motor shaft. Tighten the drive nut 180 to 220 lbf·in (2040 to 2480 N·cm).
10. Install the weather seal and the splined arm driver over the shaft. Install the wiper arm. Install the star washer and the acorn nut. **See Fig. 2.** Tighten the acorn nut 90 to 110 lbf·in (1020 to 1240 N·cm).
11. Attach the washer fluid hose to the hose barb.
12. Connect the batteries. Check the function of the wipers on both sides.
13. Remove the chocks from the rear tires.

PASSENGER-SIDE WIPER MOTOR REMOVAL

1. Gently lift the wiper arm off the windshield until a pin or nail 1/8 inch (3.2 mm) in diameter by 1-1/2 inches (40 mm) long can be inserted through the pin hole at the base of the arm. **See Fig. 1.** This will relieve the wiper arm tension, and keep the arm away from the windshield.
2. If not already done, disconnect the batteries.

⚠ WARNING

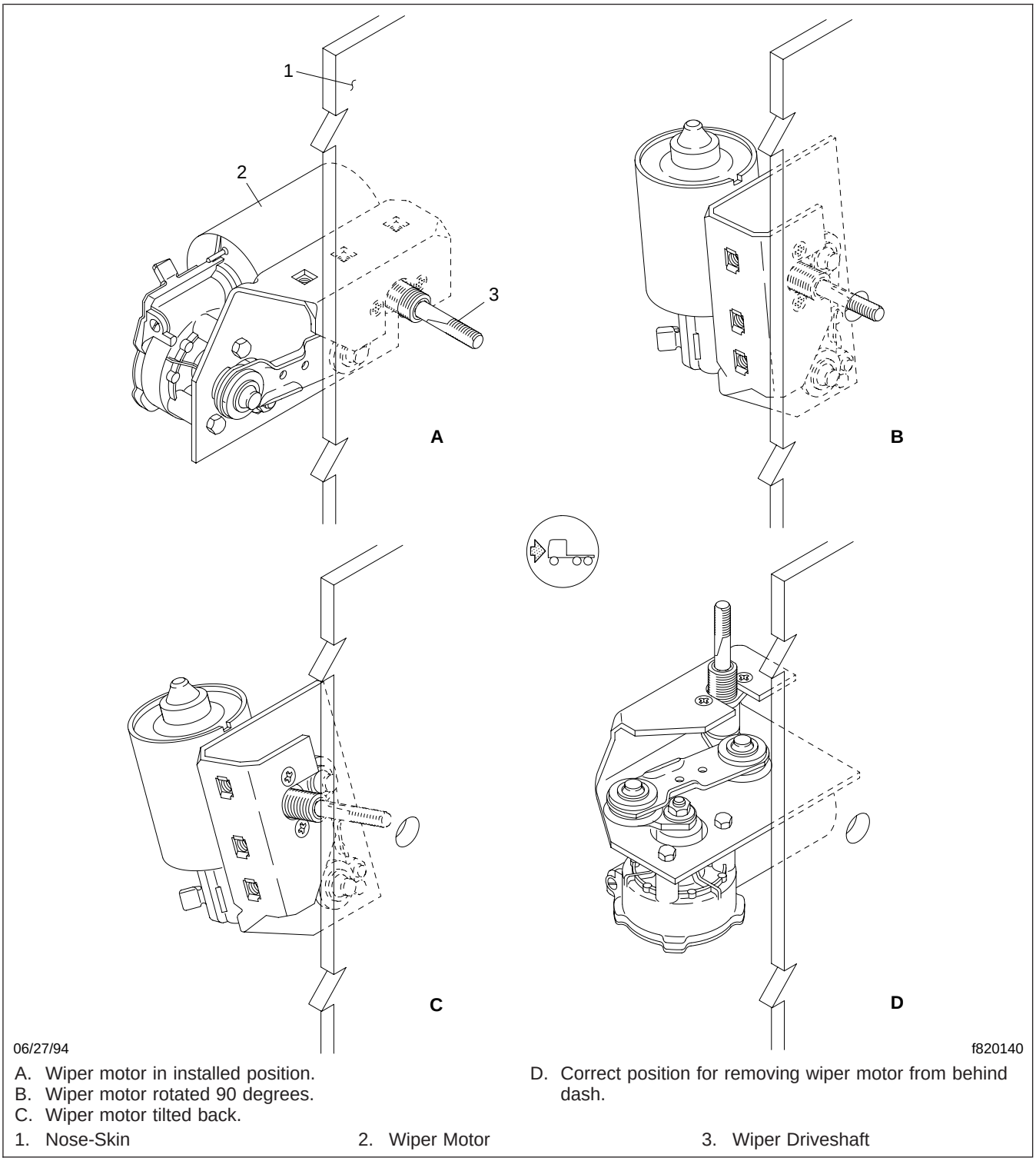
WARNING: If the batteries aren't disconnected before working on the wiper motor, the motor could cycle if the driveshaft is forced out of the parked position. This could result in personal injury.

3. Disconnect the washer fluid hose from the hose barb.
4. Remove the acorn nut and star washer; then remove the wiper arm. **See Fig. 2.**
5. Remove the splined arm driver, the weather seal cover, the drive nut, the flatwasher, and the gasket. **See Fig. 2.**
6. Remove the four nuts from the grille. Remove the grille.
7. Tilt the cab enough to gain access to the wiper motor through the grille opening (approximately 45 degrees). See **Group 60** for instructions on tilting the cab.
8. Disconnect the two electrical connectors from the wiper motor.
9. Remove the two mounting capscrews from the wiper motor mount. Remove the wiper motor.

PASSENGER-SIDE WIPER MOTOR INSTALLATION

1. With the cab tilted, position the motor through the noseskin. Install the two mounting bolts in

Wiper Motor Removal and Installation, COE



A. Wiper motor in installed position.
B. Wiper motor rotated 90 degrees.
C. Wiper motor tilted back.
D. Correct position for removing wiper motor from behind dash.

1. Nose-Skin
2. Wiper Motor
3. Wiper Driveshaft

Fig. 4

the wiper motor mount. Tighten the mounting bolts 15 lbf·ft (20 N·m).

2. Connect the two electrical connectors to the wiper motor.
3. Lower and secure the cab according to the instructions in **Group 60**.
4. Install the grille. Tighten the four mounting nuts securely.
5. Install the gasket, the flatwasher, and the drive nut on the wiper motor shaft. Tighten the drive nut 180 to 220 lbf·in (2020 to 2480 N·cm).
6. Install the weather seal and the splined arm driver over the shaft. Install the wiper arm. Install the star washer and the acorn nut. **See Fig. 2.** Tighten the acorn nut 90 to 110 lbf·in (1020 to 1240 N·cm).
7. Attach the washer fluid hose to the hose barb.

Wiper Motor and Linkage Removal and Installation, Conventional

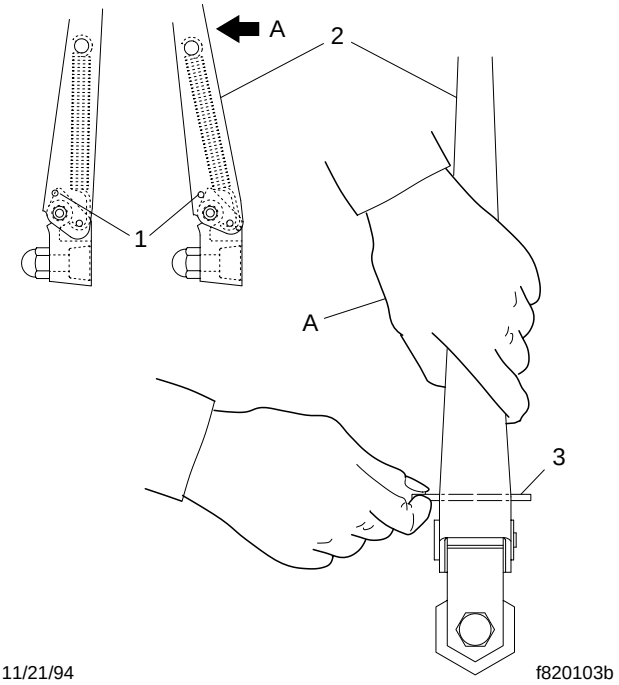
Wiper Motor Removal

1. Park the vehicle on a level surface. Apply the parking brakes; then chock the rear tires.
2. Make sure the wiper blades are parked. If needed, park them by turning them on, then off.
3. Tilt the hood. For instructions, see the vehicle driver's manual.
4. Disconnect the batteries.

⚠ WARNING

WARNING: Disconnect the batteries before working on the wiper motor. Otherwise, the motor could cycle if the driveshaft is forced out of the parked position, which could result in personal injury.

5. Remove the driver-side wiper arm.
   - 5.1 Gently lift the wiper arm off the windshield until a pin or nail 1/8 inch (3.2 mm) in diameter and 1-1/2 inches (40 mm) long can be installed throught the pin hole at the base of the arm. **See Fig. 1.** This will relieve the wiper arm tension, and keep the arm away from the windshield.
   - 5.2 Disconnect the washer hose from the wiper arm.
   - 5.3 Remove flanged locknut holding the driver-side wiper arm to the wiper arm shaft; then remove the wiper arm.
6. Disconnect the conlink assembly from the linkage pivot bar. **See Fig. 2.**
   - 6.1 Remove the retaining ring from the pivot bar ball stud.
   - 6.2 Remove the steel washer.
   - 6.3 Remove the rubber bellows and spacer; then lift the conlink off the pivot bar stud.
   - 6.4 Remove the second rubber bellows and spacer.
7. Disconnect the wiper motor wiring.
8. Remove the four locknuts and washers, and the one capscrew and washer holding the motor-and-linkage bracket in place. **See Fig. 2.**



A. Lift gently to stretch spring.
1. Pin Hole
2. Wiper Arm
3. Pin

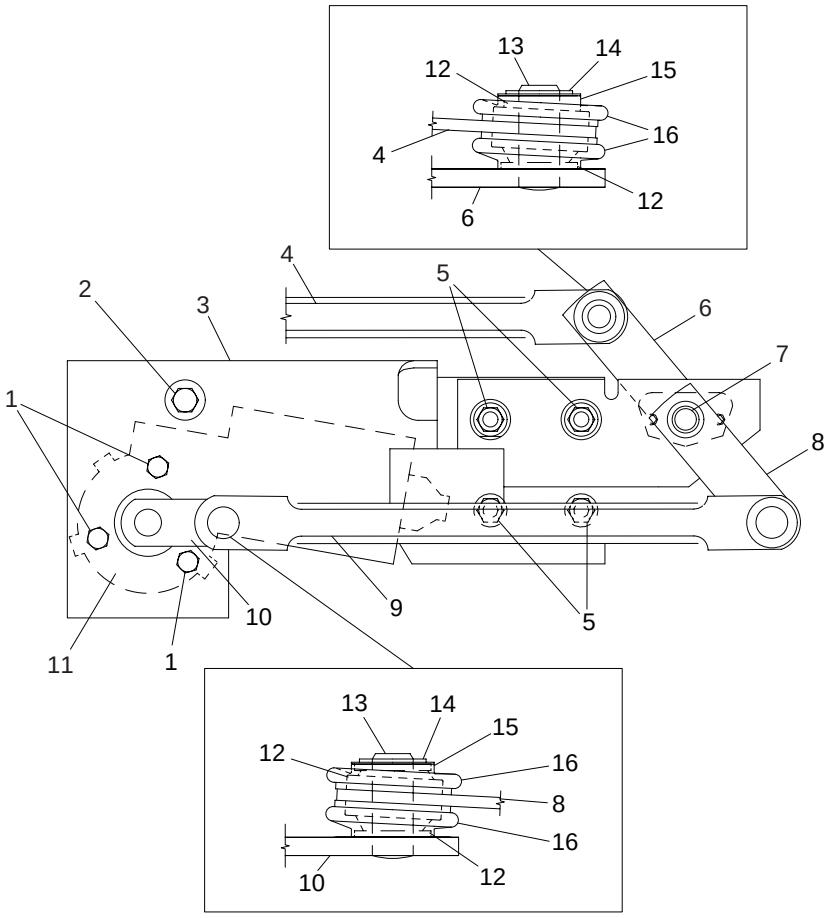
Fig. 1

9. Remove the motor-and-linkage bracket.
10. If replacing the wiper motor:
    - 10.1 Disconnect the short linkage bar from the drive crank (**see Fig. 2**), using the same procedure as for disconnecting the conlink.
    - 10.2 Remove the three capscrews and washers holding the wiper motor to the bracket assembly; then remove the motor and the drive crank.

Wiper Motor Installation

1. If replacing the wiper motor:
   - 1.1 Place the new motor and drive crank in the bracket assembly; then install the three mounting capscrews. Tighten them firmly.

Wiper Motor and Linkage Removal and Installation, Conventional



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1. Wiper Motor Mounting Capscrews
2. 1/4–20 Hexbolt and Washer
3. Motor and Linkage Bracket
4. Conlink
5. 1/4–20 Nut and Washer
6. Linkage Pivot Bar
7. Wiper Shaft (wiper removed)
8. Wiper Pivot Bar
9. Short Linkage Bar
10. Drive Crank
11. Wiper Motor
12. Spacer
13. Ball Stud
14. Retaining Ring
15. Steel Washer
16. Rubber Bellows

Fig. 2

1.2 Connect the short linkage bar to the drive crank. Fill one of the rubber bellows with grease, then install a spacer inside it. Install the bellows on the drive crank ball stud, then install the short linkage bar. Fill the second rubber bellows with grease, put a spacer in it, then install them on the ball stud. Install the steel washer, then the retaining ring.

2. Install the wiper motor and bracket assembly on the firewall, using the fasteners previously removed. Tighten the fasteners 60 to 84 lbf·in (680 to 940 N·cm).

3. Connect the wiper motor wiring.

4. Connect the conlink assembly to the linkage pivot bar.

   4.1 Install a rubber bellows and spacer onto the pivot bar stud

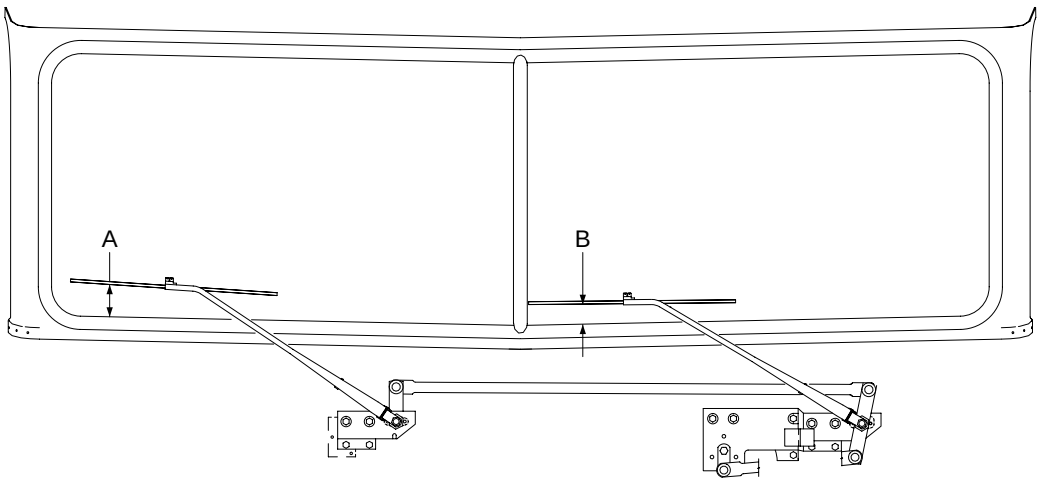
   4.2 Fill the bellows with grease.

4.3 Install the end of the conlink onto the pivot bar stud.

4.4 Assemble a second spacer and bellows, fill the bellow with grease, then install them onto the stud.

4.5 Install the steel washer, then the retaining ring.

5. Install the wiper arm. Make sure it is in the correct park position. Tighten the flanged locknut 90 to 110 lbf·in (1020 to1240 N·cm).
6. Connect the washer hose to the wiper arm.
7. Gently lift the wiper and remove the pin previously installed to keep the blade off the windshield.
8. Connect the batteries.
9. Test the wiper motor and washers. Make sure the wiper blades park correctly. **See Fig. 3.** If needed, remove the wiper arm and install it again.



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A. 2 to 2-1/2 " (51 to 64 mm)
B. 1-1/4 to 1-3/4 " (32 to 44 mm)

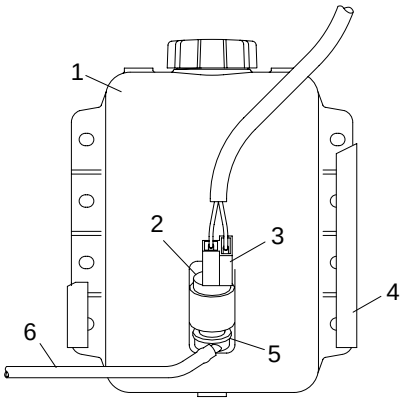
Fig. 3

10. Close the hood.
11. Remove the chocks from the tires.

Replacement

To avoid losing washer fluid from the reservoir, you can remove the reservoir and empty it before starting this procedure, or you can place a clean bowl under it before pulling out the washer pump.

1. Park the vehicle on level ground. Set the parking brake and chock the tires.
2. Disconnect the electrical connections and washer fluid tubing from the washer pump. See **Fig. 1**.



1. Washer Fluid Reservoir
2. Washer Pump
3. Washer Pump Connector
4. Washer Fluid Reservoir Bracket
5. Rubber Grommet
6. Washer Fluid Tube

Fig. 1, Washer Fluid Pump Mounted on Reservoir (typical installation)

3. Unsnap the pump from the grip of the reservoir body and pull it from the washer fluid reservoir.
4. Remove the rubber grommet.
5. Install the new washer pump and a new rubber grommet.
6. Connect the electrical connections and washer fluid tube.
7. Fill the washer fluid reservoir.
8. Test the operation of the pump.
9. Remove the chocks from the tires.

Problem—Wipers and Washer Not Working

Possible Cause	Remedy
The wiring is loose.	Check for and tighten any loose wiring connections.
An open or short circuit.	Check circuit 279 (and 278 for right-side COE motor), the ignition circuit breaker, and (if equipped) the ignition-powered relay. See the applicable figure in **Specifications, 400**.
	Tighten loose wiring connection(s).
	Check and replace the switch.
	Check and replace broken wire(s).
The system is binding.	Free or replace the linkage.
	Free or replace the arm or blade.
The motor does not work.	Replace the motor.

Problem—The Wiper Motor Shaft Turns, But the Wiper Arms Do Not Move (Conventionals)

Possible Cause	Remedy
The drive crank is loose or disconnected.	Check the drive crank. If it's loose at the wiper motor drive shaft, clean the drive shaft splines. Replace the crank if necessary. If the crank is disconnected from the short linkage bar, connect it. If the problem persists, replace or repair parts as needed.
The linkage is loose or disconnected.	Check the all the linkage connections. Repair or replace parts as needed.

Problem—Wiper Motor High Speed Not Working

Possible Cause	Remedy
An open circuit.	Check circuit 279C (and 278C for right-side COE motor). Check the system wiring and the switch wiring (white wire). See the applicable figure in **Specifications, 400**.

Problem—Wiper Motor Low Speed Not Working

Possible Cause	Remedy
An open circuit	Check circuit 279B (and 278B for right-side COE motor) for continuity. Check the system wiring and the switch wiring (yellow wire). See the applicable figure in **Specifications, 400**.

Problem—Washers Not Working

Possible Cause	Remedy
Washer tubing disconnected.	Check the washer tubing between the washer pump and the wipers.
An open circuit.	Check circuit 424A. Also check the brown wire on the switch. See the applicable figure in **Specifications, 400**.

Troubleshooting

Problem—Circuit Breaker Keeps Tripping

Possible Cause	Remedy
Incorrect circuit breaker installed.	Make sure correct amperage circuit breaker is installed. See the applicable figure in **Specifications, 400**.
Wiring is shorted to ground.	Check the wiring and the motor(s) for shorts to ground. See the applicable figure in **Specifications, 400**.
The wiper linkage is binding.	Check the linkage.

Problem—Wipers Do Not Park

Possible Cause	Remedy
The park circuit is not working	Check circuit 279 (and 278 for right-side COE motor) for continuity. Also check circuit 279A (and 278A for right-side COE motor) for continuity. Check blue wire (GND) on switch. See the applicable figure in **Specifications, 400**.

Problem—Intermittent (Delay) Feature Not Working; High and Low Speeds are O.K.

Possible Cause	Remedy
The wiper switch ground circuit is open.	Check the ground circuit (black wire) on the switch. See the applicable figure in **Specifications, 400**.

Problem—Wipers Oversweeping

Possible Cause	Remedy
Worn or broken linkage component.	Replace linkage components as required.
Worn or broken pivot assembly.	Replace the pivot assembly.
Worn or broken wiper arm.	Replace the wiper arm.
The motor assembly is loose.	Secure the motor assembly.
Vehicle voltage too high.	Repair the vehicle electrical system.

See **Fig. 1** for the wiring diagram for FLDs without the intermittent feature.

See **Fig. 2** for the wiring diagram for FLDs equipped with the intermittent feature.

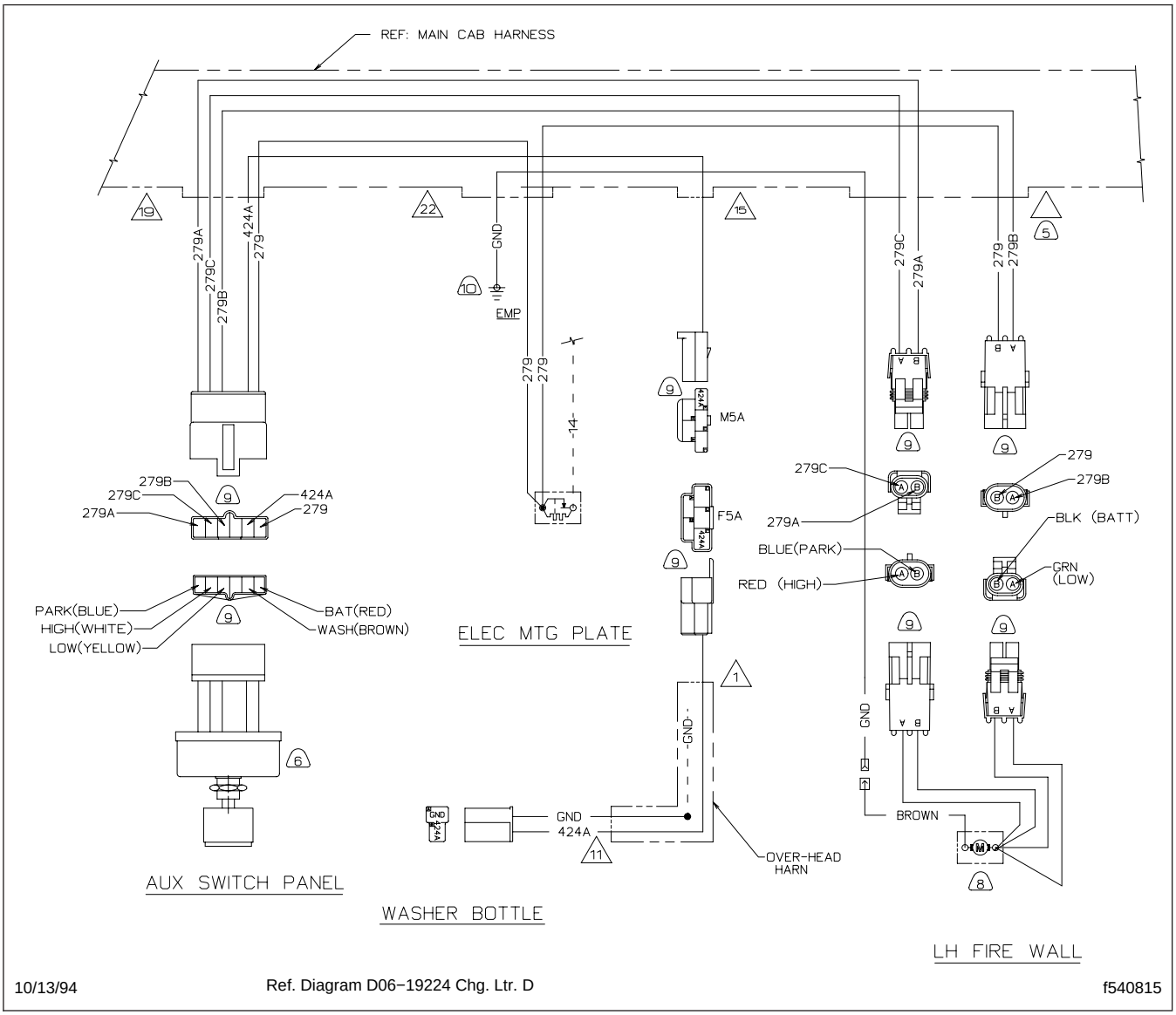
See **Fig. 3** for the wiring diagram for FLAs without the intermittent feature.

See **Fig. 4** for the wiring diagram for FLAs with the intermittent feature.

See **Fig. 5** for the FLD wiper park position.

See **Fig. 6** for the FLA wiper park position.

Specifications



10/13/94 Ref. Diagram D06−19224 Chg. Ltr. D f540815

Fig. 1, Wiring Diagram, FLDs Without Intermittent Feature

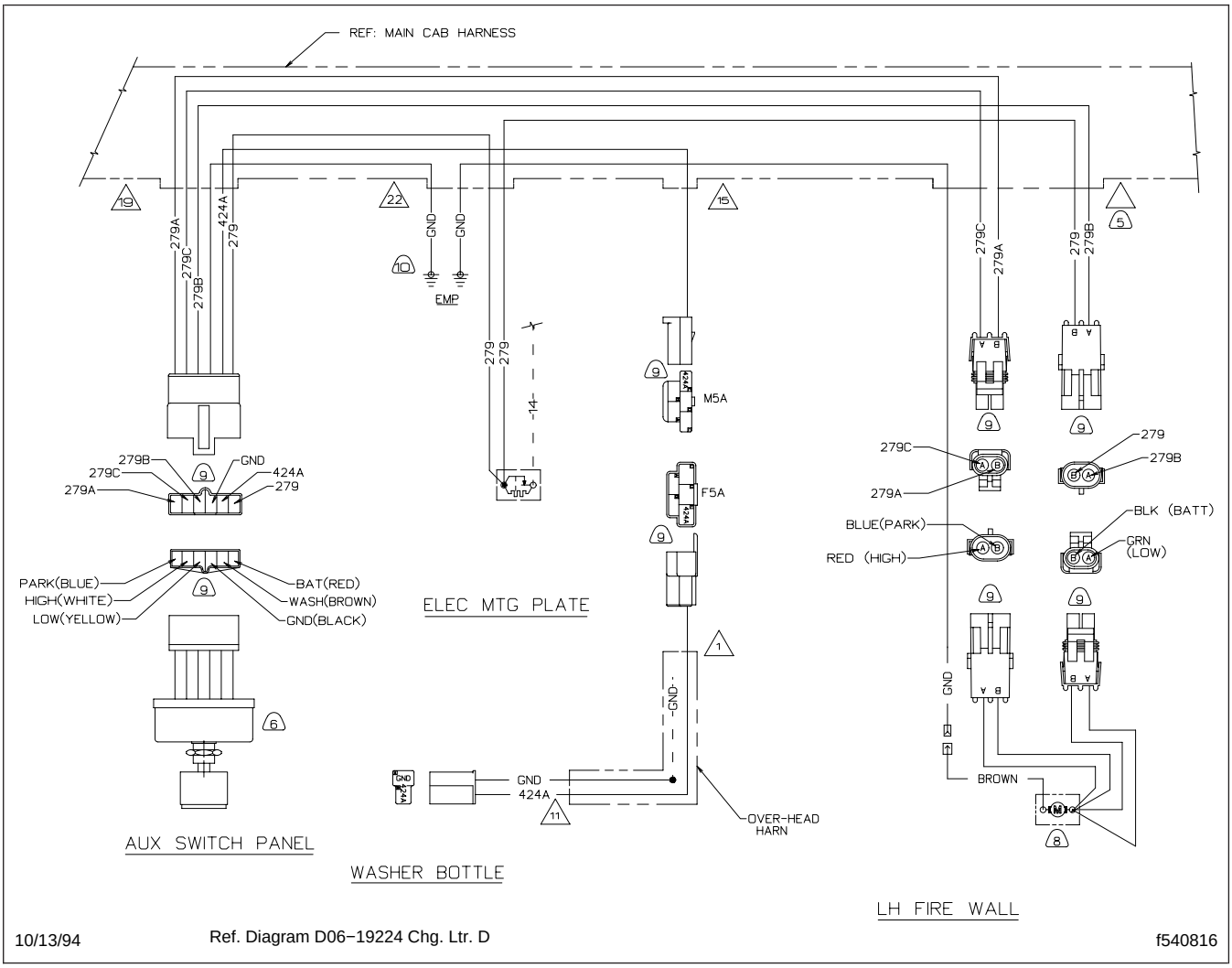


Fig. 2, Wiring Diagram, FLDs With Intermittent Feature

Specifications

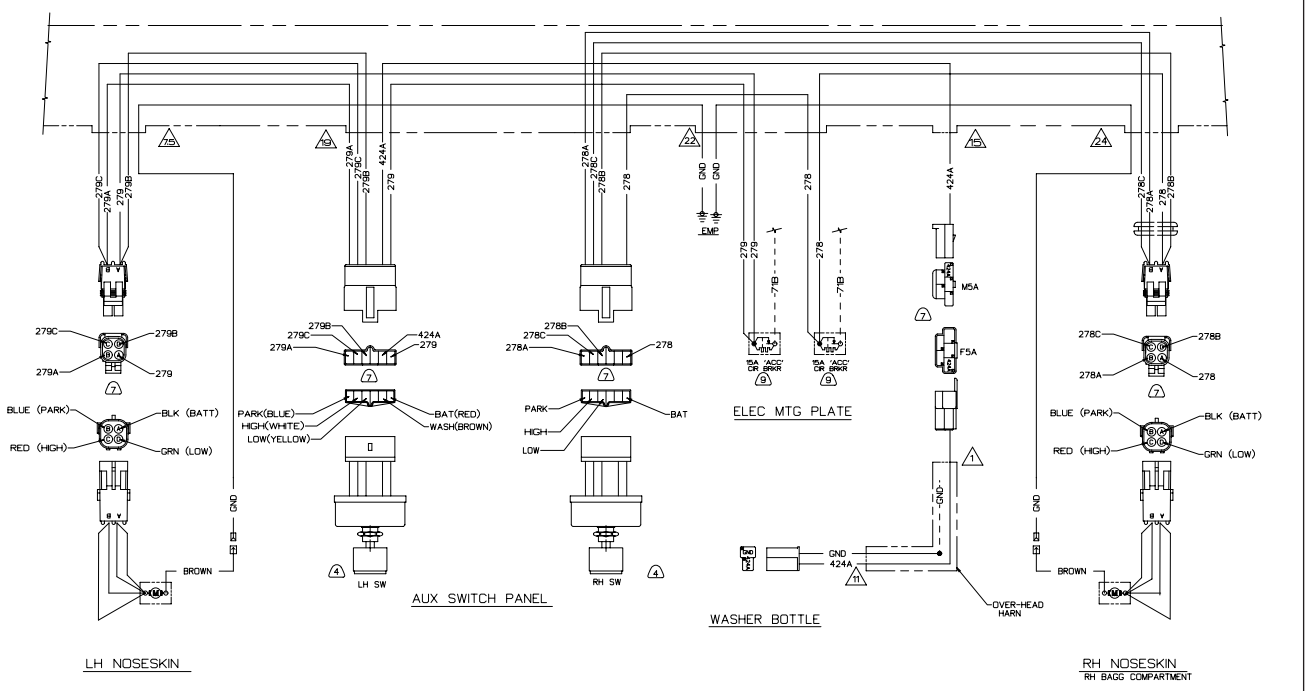


Fig. 3, Wiring Diagram, FLAs Without Intermittent Feature

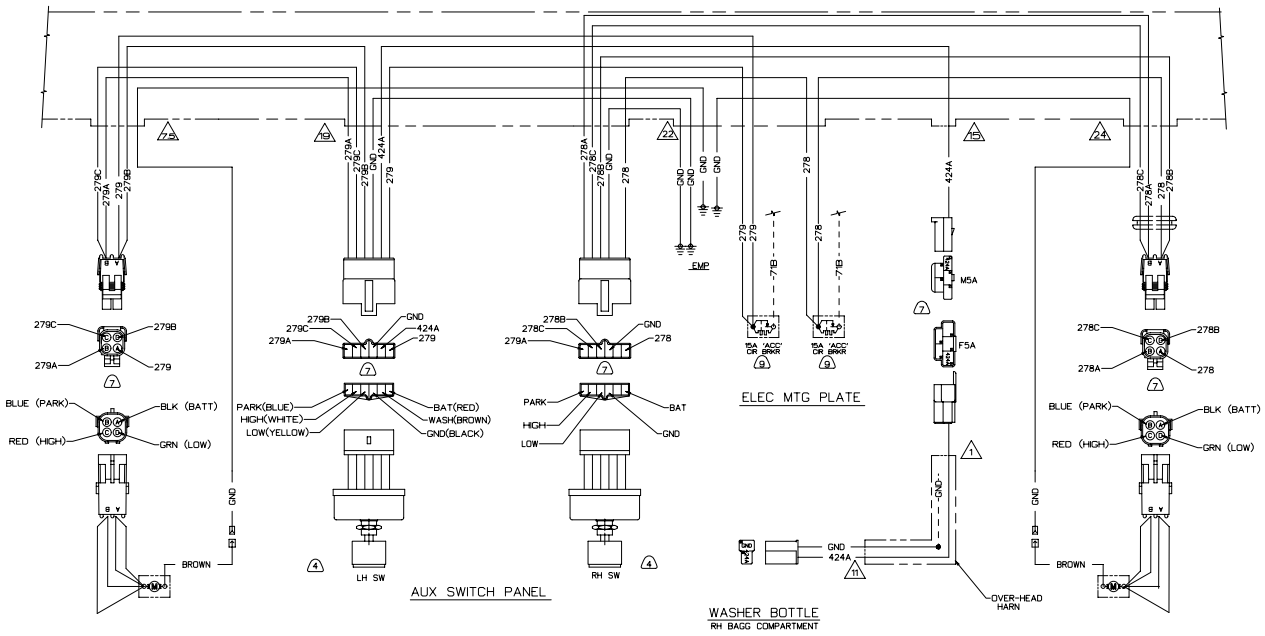


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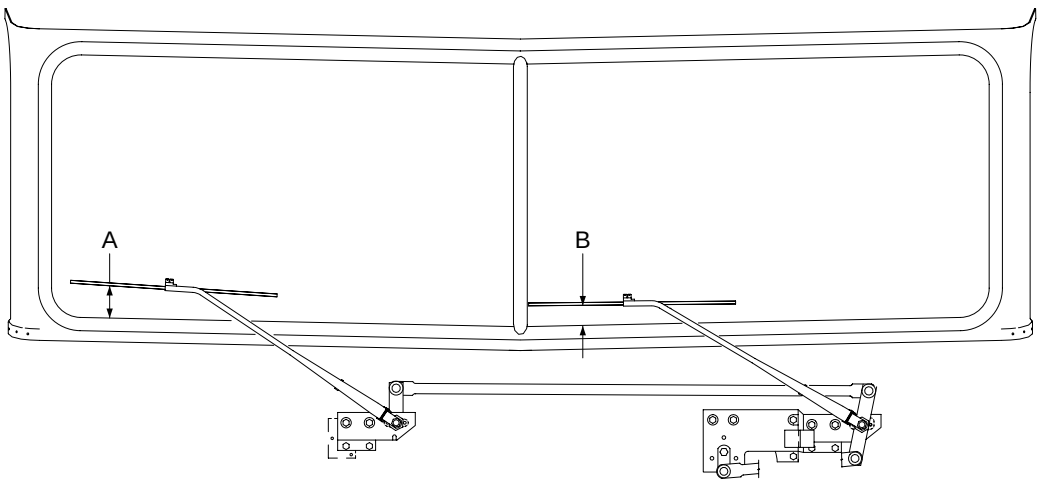
Fig. 4, Wiring Diagram, FLAs With Intermittent Feature



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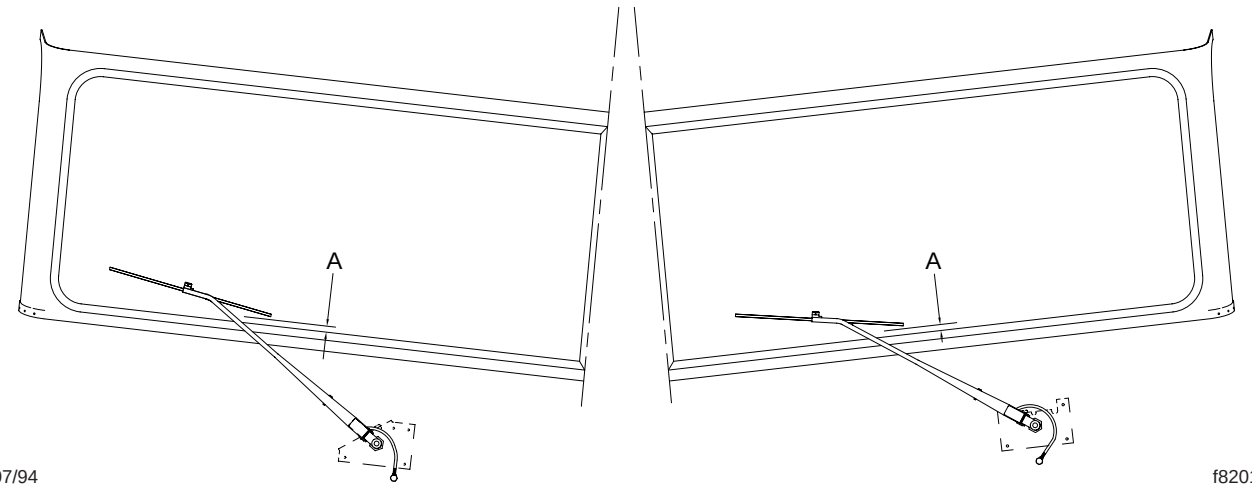
A. 2 to 2-1/2" (51 to 64 mm)
B. 1-14 to 1-3/4" (32 to 44 mm)

Fig. 5, Windshield Wiper Park Position, FLDs

Specifications



A. 1 to 1-1/4" (25 to 32 mm)

Fig. 6, Windshield Wiper Park Position, FLAs

General Information

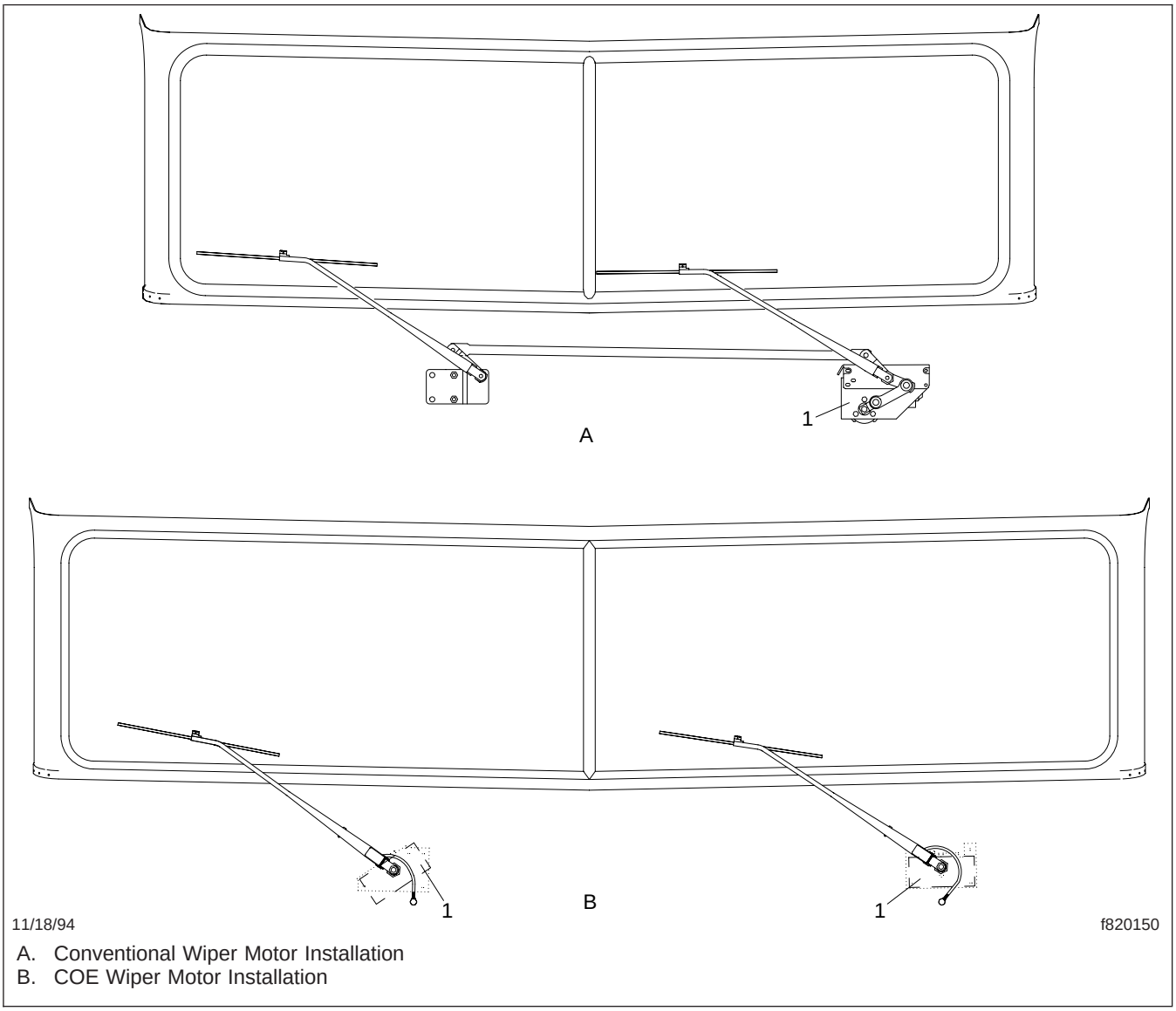
FLB COEs with electric windshield wipers are equipped with United Technologies electric wipers, as are FLD Conventionals built from January 7, 1994.

The wipers are operated by a dash-mounted control knob. The knob regulates the speed of the wipers and activates the washers. Turning the control knob clockwise increases speed, and counterclockwise decreases speed. The delay feature (if so equipped) is integrated with the speed control knob, between the stop and the low- speed positions. On COEs, separate knobs operate the wipers for the left and right sides; the left-hand (driver's-side) knob controls both washers.

On Conventionals, a single wiper motor, mounted on the left side of the firewall, powers both wipers. See **Fig. 1**. On COEs, there is one wiper motor for each side; both are mounted on the nose-skin. See **Fig. 1**. The electric wiper motors are sealed units; they are not serviceable. If a wiper motor doesn't work because of internal problems, replace it.

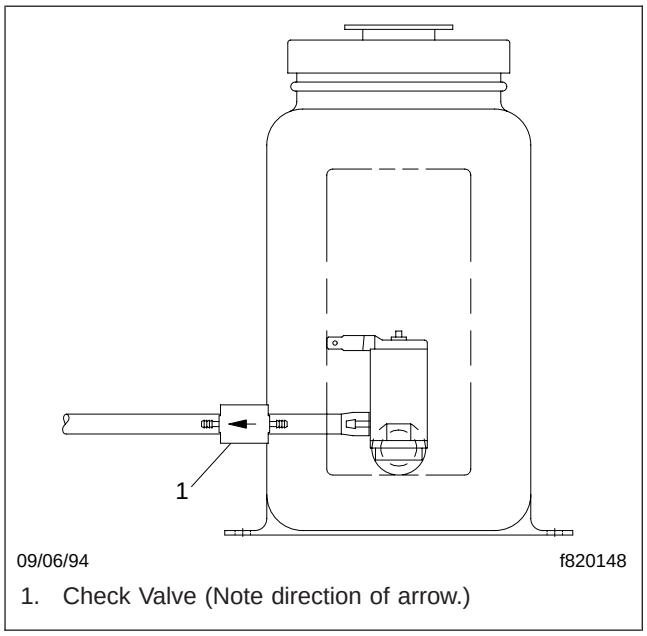
The windshield washer reservoir (see **Fig. 2**) is located inside the right-side baggage compartment, or behind the passenger seat in 63-inch FLA COEs. Fluid is pumped from the reservoir to nozzles in each blade ("wet blades"). A purge mechanism empties the lines after use to prevent fluid from freezing in the lines during cold weather. On COEs, a check valve in the outlet of the reservoir prevents fluid from draining when the cab is tilted.

General Information



A. Conventional Wiper Motor Installation
B. COE Wiper Motor Installation

Fig. 1



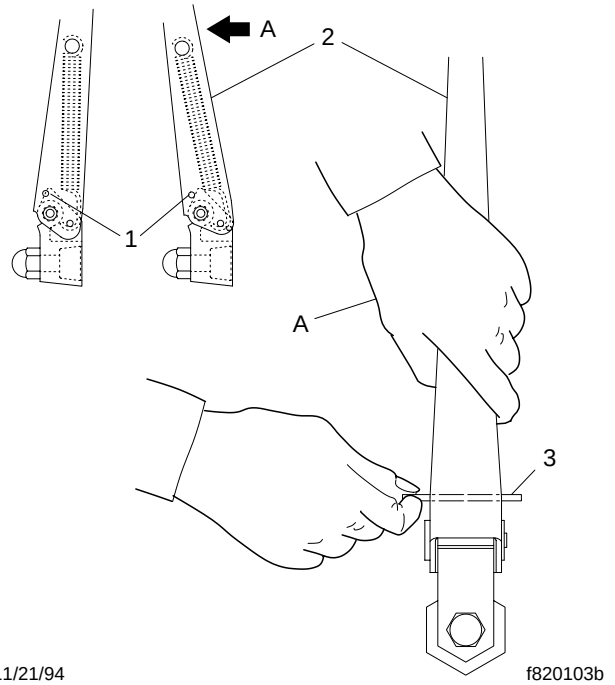
1. Check Valve (Note direction of arrow.)

Fig. 2

Driver-Side Wiper Motor Removal and Installation

REMOVAL

1. Park the vehicle on a smooth, level surface. Apply the parking brakes and chock the rear tires.
2. Disconnect the batteries.
3. Gently lift the wiper arm off the windshield until a pin or drill bit, 1/8 inch (3.2 mm) in diameter by 1-1/2 inches (40 mm) long, can be inserted through the pin hole at the base of the arm. See **Fig. 1**. This will relieve the wiper arm tension, and keep the arm away from the windshield.



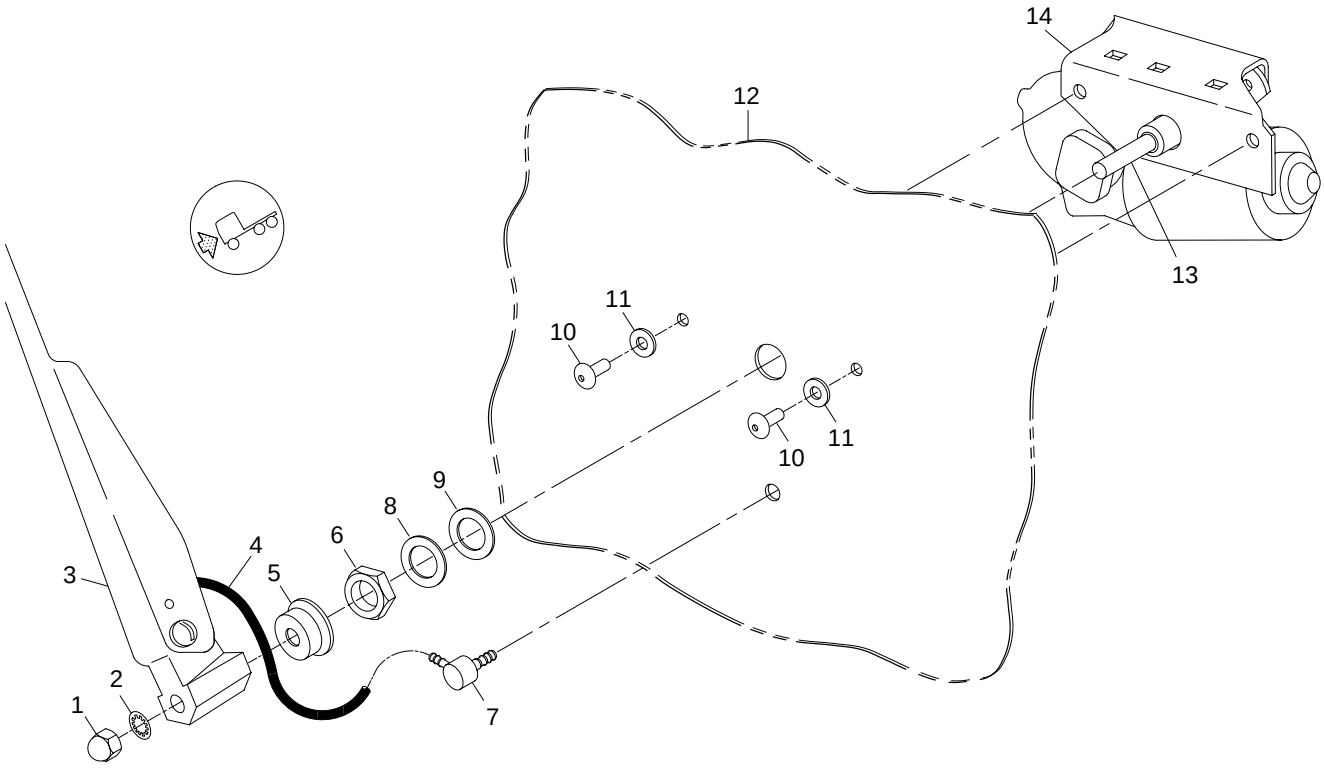
A. Lift gently to stretch spring.
1. Pin Hole
2. Wiper Arm
3. Pin

Fig. 1, Relieving the Tension on the Wiper Arm

4. Remove the acorn nut (crown nut) and star washer from the wiper driveshaft; then remove the wiper arm. See **Fig. 2**.
5. Remove the weather seal from the wiper driveshaft.
6. Remove the two Torx®-head mounting screws and washers from the nose-skin.
7. Disconnect the washer hose from the hose barb.
8. Remove the nut holding the washer hose barb to the nose-skin; then remove the hose barb.
9. From inside the cab, remove the lower dash skirt panel (E-panel).
10. Mark and remove the toggle switches (if present) from the cover.
11. If there is a Deutsch® diagnostic connector on the bottom of the panel, remove it.
    - 11.1 Remove the four screws holding the diagnostic connector in place.
    - 11.2 Separate the two halves of the connector by twisting one of them counterclockwise one-half turn.
12. On vehicles with left-hand drive (LH DR), remove the HVAC duct sections from underneath the left side of the dash. See **Fig. 3**.
    - 12.1 Remove the grab handle from the front edge of the doorway.
    - 12.2 Remove the lower steering column cover.
    - 12.3 Pull back the upholstery panel to gain access to the HVAC ducting.
    - 12.4 On the left side, near the door, remove the nut that holds the left section of the HVAC duct to the underside of the dash. Remove the section.
    - 12.5 On the right side of the steering column, find and remove the screw that holds the two center HVAC duct sections to the right HVAC duct section.
    - 12.6 Remove the lower, then the upper center HVAC duct section.

    NOTE: There may be an additional fastener holding the lower center HVAC duct section to the nose-skin.
13. On vehicles with right-hand drive (RH DR), loosen the steering column assembly enough to allow removal of the wiper motor. For instructions, see the appropriate steering column section in **Group 46**.

Wiper Motor Removal and Installation, FLB COE



1. Acorn Nut
2. Star Washer
3. Wiper Arm
4. Washer Hose
5. Weather Seal
6. Large Drive Nut
7. Hose Barb
8. Brass Washer
9. Rubber Seal Ring
10. Torx-Head Screw
11. Washer
12. Nose-Skin
13. Wiper Driveshaft
14. Wiper Motor and Mounting Bracket Assembly

Fig. 2, Wiper Drive Assembly

14. From outside the cab, remove the large drive nut, brass washer, and rubber seal ring from the wiper driveshaft. See **Fig. 2**.

15. From inside the cab, remove the wiper motor.

    15.1 Reach up underneath the dash, and disconnect the 2-pin electrical connector from the wiper motor wiring.

    15.2 Move the motor away from the nose-skin until the driveshaft clears the mounting hole.

    15.3 Tilt the motor back toward yourself so the driveshaft is pointing up; then slide the motor out from behind the clutch pedal.

    15.4 If necessary, move the motor outboard (toward the driver's door); then slide it down toward the floor, and out from underneath the dash.

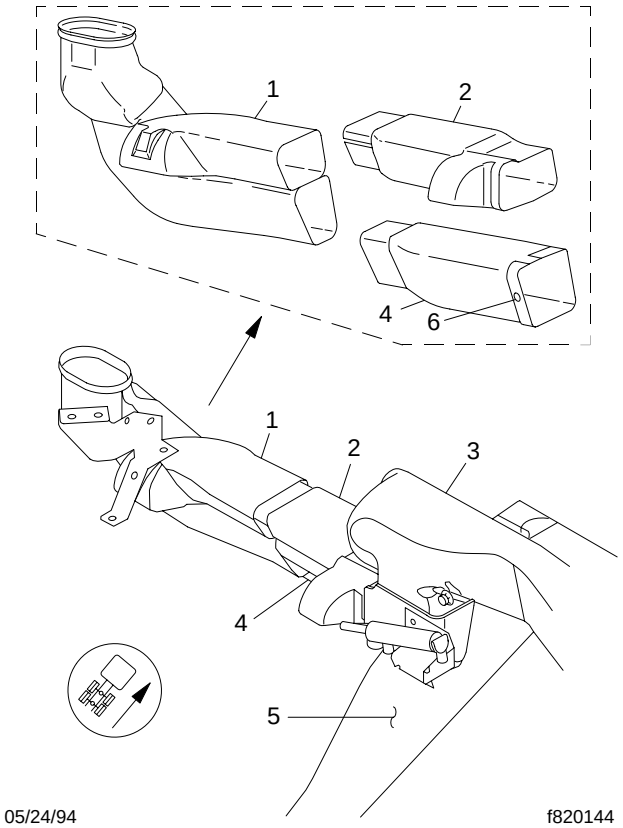
INSTALLATION

1. Feed the wiper motor wiring in behind the clutch pedal; then slide the wiper motor—with the driveshaft pointing up—along the nose-skin to the mounting hole.

2. Connect the wiring.

3. Tilt the motor forward, and insert the wiper driveshaft into the mounting hole on the nose-skin.

4. Hold the wiper motor in place; then have someone from outside the cab install the rubber seal



1. Left Section of HVAC Duct
2. Upper Center HVAC Section
3. Right Section
4. Lower Center Section
5. Tunnel
6. Hole for Screw Connecting Center Sections to Right Section

Fig. 3, Left-Hand Drive HVAC Ducts

ring, brass washer, and drive nut on the wiper driveshaft. See **Fig. 2**. Tighten the nut just enough to hold the motor in place.

5. Position the motor so its two mounting holes line up with the two holes in the nose-skin; then install the two Torx-head screws. Don't tighten them all the way.
6. On RH DR vehicles, tighten any loosened fasteners on the steering column assembly. For instructions, see the appropriate steering column section in **Group 46**.
7. On LH DR, install the HVAC duct sections, as removed.
   - 7.1 Install the upper, then the lower center section of the HVAC duct.
   - 7.2 Install the left section of the HVAC duct. Tighten the nut firmly on the stud.
   - 7.3 Install the upholstery panel.
   - 7.4 Install the grab handle.
   - 7.5 Install the lower steering column cover panel.
8. If so equipped, install the Deutsch diagnostic connector onto the bottom of the lower dash cover; then install the toggle switches.
9. Install the lower dash skirt panel (E-panel).
10. Firmly tighten the two Torx-head mounting screws 72 lbf·in (820 N·cm).
11. Install the wiper drive assembly. See **Fig. 2**.
    - 11.1 Install the weather seal over the wiper driveshaft.
    - 11.2 Install the wiper arm onto the splines of the driveshaft.
    - 11.3 Install the star washer.
    - 11.4 Install the acorn nut; tighten it 100 lbf·in (1120 N·cm). Hold it for several seconds to let the parts seat.
    - 11.5 Remove the 1/8-inch (3.2-mm) pin or drill bit from the wiper arm.
12. Install the hose barb in the nose-skin. Secure it with the nut and tighten the nut 9 lbf·ft (12 N·m).
13. Connect the washer hose to the hose barb.

NOTE: Twist the washer hose approximately 1/4-turn clockwise before pushing it onto the barb, so the hose will not rest on the nose-skin.

14. Connect the batteries.
15. Run the wipers several times through full travel, then turn them off.
16. Tighten the acorn nut again to 100 lbf·in (1120 N·cm).
17. Remove the chocks from the rear tires.

Wiper Motor Removal and Installation, FLB COE

Passenger-Side Wiper Motor Removal and Installation

REMOVAL

1. Park the vehicle on a smooth, level surface. Apply the parking brakes and chock the rear tires.
2. Disconnect the batteries.
3. Gently lift the wiper arm off the windshield until a pin or drill bit, 1/8 inch (3.2 mm) in diameter by 1-1/2 inches (40 mm) long, can be inserted through the pin hole at the base of the arm. See **Fig. 1**. This will relieve the wiper arm tension, and keep the arm away from the windshield.
4. Disconnect the washer fluid hose from the hose barb.
5. Remove the wiper arm acorn nut and star washer; then remove the wiper arm. See **Fig. 2**.
6. Remove the weather seal, the drive nut, the brass washer, and the rubber seal ring. See **Fig. 2**.
7. Remove the four nuts from the grille. Remove the grille.
8. Tilt the cab enough to gain access to the wiper motor through the grille opening (approximately 45 degrees). See **Group 60** for instructions on tilting the cab.
9. Disconnect the two electrical connectors from the wiper motor.
10. Remove the two mounting capscrews from the wiper motor mount. Remove the wiper motor.

INSTALLATION

1. With the cab tilted, position the motor through the nose-skin. Install the two mounting bolts in the wiper motor mount. Tighten the mounting bolts 15 lbf·ft (20 N·m).
2. Connect the two electrical connectors to the wiper motor.
3. Lower and secure the cab according to the instructions in **Group 60**.
4. Install the grille. Tighten the four mounting nuts securely.
5. Install the rubber seal ring, the brass washer, and the drive nut on the wiper motor shaft. Tighten the drive nut 11 lbf·ft (15 N·m).
6. Install the wiper drive assembly. See **Fig. 2**.
   - 6.1 Install the weather seal over the wiper driveshaft.
   - 6.2 Install the wiper arm onto the splines of the driveshaft.
   - 6.3 Install the star washer.
   - 6.4 Install the acorn nut; tighten it 100 lbf·in (1120 N·cm). Hold it for several seconds to let the parts seat.
7. Connect the washer fluid hose to the hose barb.

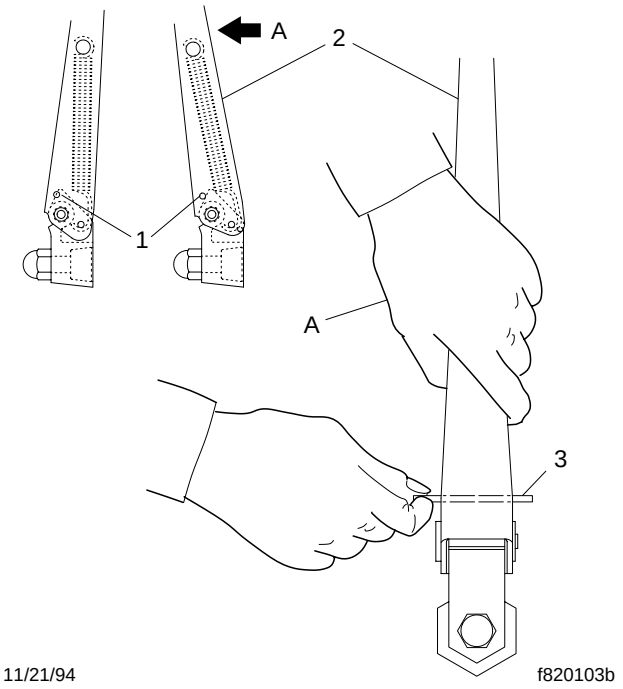
NOTE: Twist the washer fluid hose approximately 1/4-turn clockwise before pushing it onto the barb, so the hose will not rest on the nose-skin.

8. Remove the 1/8-inch (3.2-mm) pin or drill bit from the hole in the wiper arm.
9. Connect the batteries.
10. Run the wipers several times through full travel, then turn them off.
11. Tighten the acorn nut again to 100 lbf·in (1120 N·cm.
12. Remove the chocks from the rear tires.

Wiper Motor and Linkage Removal and Installation, Conventional

Wiper Motor Removal

1. Park the vehicle on a level surface. Apply the parking brakes; then chock the rear tires.
2. Make sure the wiper blades are parked. If necessary, park them by turning them on, then off.
3. Tilt the hood. For instructions, see the vehicle driver's manual.
4. Disconnect the batteries.
5. Remove the driver-side wiper arm.
   - 5.1 Gently lift the wiper arm off the windshield until a pin or nail 1/8 inch (3.2 mm) in diameter and 1-1/2 inches (40 mm) long can be inserted throught the pin hole at the base of the arm. **See Fig. 1.** This will relieve the wiper arm tension, and keep the arm away from the windshield.
   - 5.2 Disconnect the washer hose from the wiper arm.
   - 5.3 Remove nut holding the driver-side wiper arm to the wiper arm shaft; then remove the wiper arm.
6. Using a screwdriver, pry the conlink off the linkage pivot bar. **See Fig. 2.** Remove the rubber seal from the ball joint.
7. Disconnect the wiper motor wiring.
8. Remove the fasteners holding the motor-and-linkage bracket in place. **See Fig. 2.**
9. Remove the motor-and-linkage bracket.
10. If replacing the wiper motor:
    - 10.1 Disconnect the short linkage bar from the wiper motor drive crank (**see Fig. 3**), using the same procedure as for disconnecting the conlink.
    - 10.2 Remove the three capscrews and washers holding the wiper motor to the bracket assembly; then remove the motor and the drive crank.



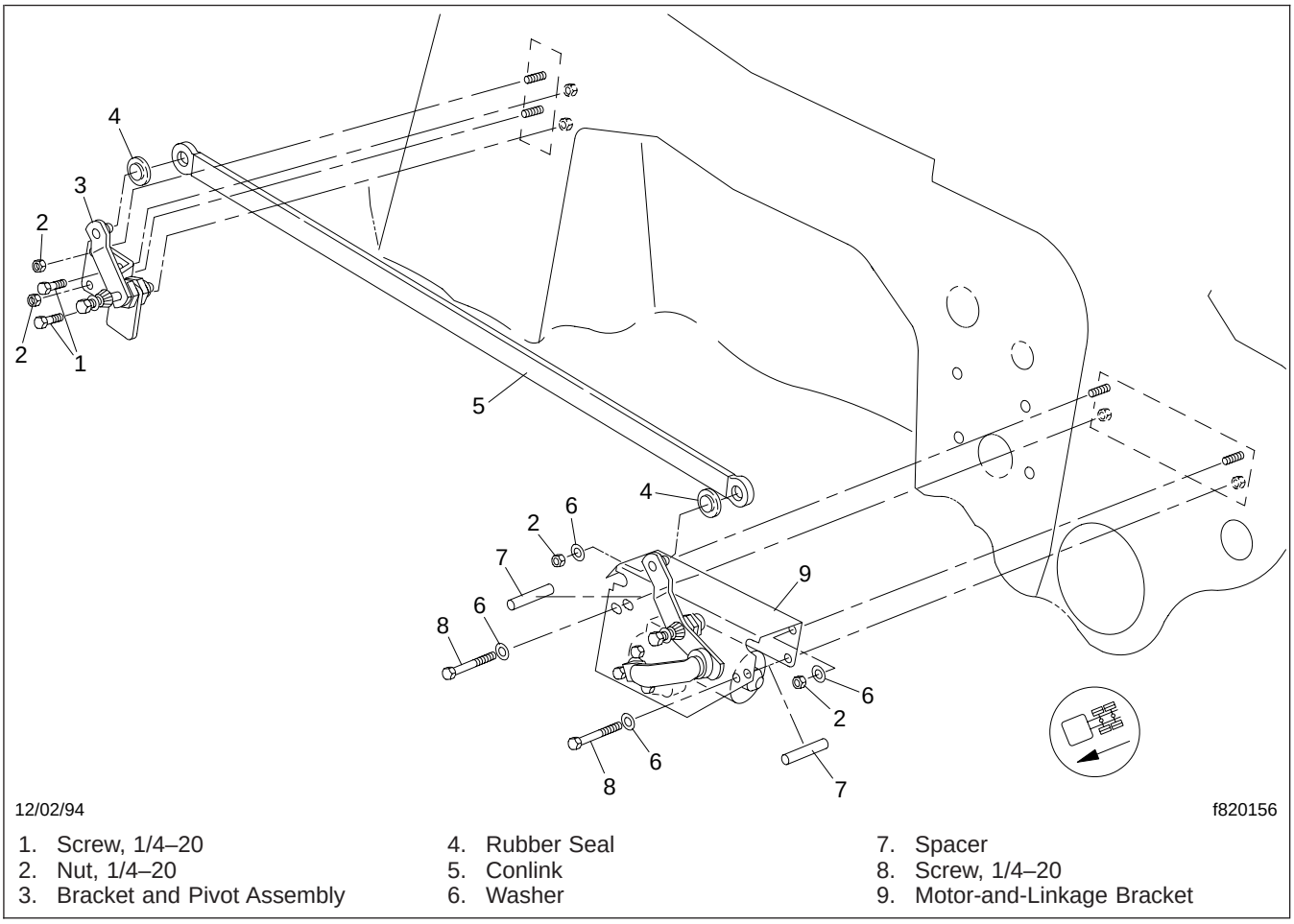
A. Lift gently to stretch spring.
1. Pin Hole
2. Wiper Arm
3. Pin

Fig. 1

Wiper Motor Installation

1. If replacing the wiper motor:
   - 1.1 Place the new motor and drive crank in the bracket assembly; then install the three mounting capscrews. Tighten them 55 lbf·in (620 N·cm).
   - 1.2 Install the rubber seal on the shaft of the linkage bar, with the open end of the seal facing up. Press the short linkage bar onto the drive crank, using pliers.
2. Install the wiper motor and bracket assembly on the firewall, using the fasteners previously removed. Tighten the fasteners 60 to 84 lbf ·in (680 to 940 N·cm).
3. Connect the wiper motor wiring.
4. Connect the conlink assembly to the linkage pivot bar.
   - 4.1 Install the rubber seal onto the linkage pivot bar ball joint, with the open end of the seal facing up.

Wiper Motor and Linkage Removal and Installation, Conventional



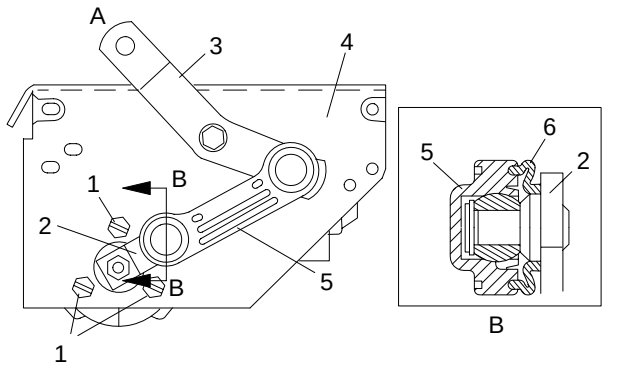
1. Screw, 1/4–20
2. Nut, 1/4–20
3. Bracket and Pivot Assembly
4. Rubber Seal
5. Conlink
6. Washer
7. Spacer
8. Screw, 1/4–20
9. Motor-and-Linkage Bracket

Fig. 2

4.2 Using pliers, press the conlink onto the linkage pivot bar.

5. Install the wiper arm. Make sure it is in the correct park position. Tighten the wiper arm nut 100 lbf·in (1020 N·cm). Hold for several seconds to let the parts seat.
6. Connect the washer hose to the wiper arm.
7. Gently lift the wiper and remove the pin previously installed to keep the blade off the windshield.
8. Connect the batteries.
9. Run the wipers several times through full travel, then turn them off.
10. Tighten the wiper arm nut again to 100 lbf·in (1020 N·cm).
11. Close the hood.
12. Remove the chocks from the tires.

Wiper Motor and Linkage Removal and Installation, Conventional



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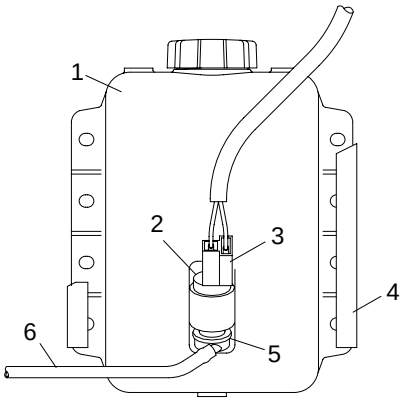
A. to conlink
B. Cross-Section View
1. Mounting Screws
2. Drive Crank
3. Linkage Pivot Bar
4. Motor-and-Linkage Bracket
5. Short Linkage Bar

Fig. 3

Replacement

To avoid losing washer fluid from the reservoir, you can remove the reservoir and empty it before starting this procedure, or you can place a clean bowl under it before pulling out the washer pump.

1. Park the vehicle on level ground. Set the parking brake and chock the tires.
2. Disconnect the electrical connections and washer fluid tubing from the washer pump. See **Fig. 1**.



1. Washer Fluid Reservoir
2. Washer Pump
3. Washer Pump Connector
4. Washer Fluid Reservoir Bracket
5. Rubber Grommet
6. Washer Fluid Tube

Fig. 1, Washer Fluid Pump Mounted on Reservoir (typical installation)

3. Unsnap the pump from the grip of the reservoir body and pull it from the washer fluid reservoir.
4. Remove the rubber grommet.
5. Install the new washer pump and a new rubber grommet.
6. Connect the electrical connections and washer fluid tube.
7. Fill the washer fluid reservoir.
8. Test the operation of the pump.
9. Remove the chocks from the tires.

Problem—Wipers and Washer Not Working

Possible Cause	Remedy
The wiring is loose.	Check for and tighten any loose wiring connections.
An open or short circuit.	Check circuit 279 (and 278 for right-side COE motor), the ignition circuit breaker, and (if equipped) the ignition-powered relay. See the applicable figure in **Specifications, 400**.
	Tighten loose wiring connection(s).
	Check and replace the switch.
	Check and replace broken wire(s).
The system is binding.	Free or replace the linkage.
	Free or replace the arm or blade.
The motor does not work.	Replace the motor.

Problem—The Wiper Motor Shaft Turns, But the Wiper Arms Do Not Move (Conventionals)

Possible Cause	Remedy
The drive crank is loose or disconnected.	Check the drive crank. If it's loose at the wiper motor drive shaft, clean the drive shaft splines. Replace the crank if necessary. If the crank is disconnected from the short linkage bar, connect it. If the problem persists, replace or repair parts as needed.
The linkage is loose or disconnected.	Check the all the linkage connections. Repair or replace parts as needed.

Problem—Wiper Motor High Speed Not Working

Possible Cause	Remedy
An open circuit.	Check circuit 279C (and 278C for right-side COE motor). Check the system wiring and the switch wiring (white wire). See the applicable figure in **Specifications, 400**.

Problem—Wiper Motor Low Speed Not Working

Possible Cause	Remedy
An open circuit	Check circuit 279B (and 278B for right-side COE motor) for continuity. Check the system wiring and the switch wiring (yellow wire). See the applicable figure in **Specifications, 400**.

Problem—Washers Not Working

Possible Cause	Remedy
Washer tubing disconnected.	Check the washer tubing between the washer pump and the wipers.
An open circuit.	Check circuit 424A. Also check the brown wire on the switch. See the applicable figure in **Specifications, 400**.

Troubleshooting

Problem—Circuit Breaker Keeps Tripping

Possible Cause	Remedy
Incorrect circuit breaker installed.	Make sure correct amperage circuit breaker is installed. See the applicable figure in **Specifications, 400**.
Wiring is shorted to ground.	Check the wiring and the motor(s) for shorts to ground. See the applicable figure in **Specifications, 400**.
The wiper linkage is binding.	Check the linkage.

Problem—Wipers Do Not Park

Possible Cause	Remedy
The park circuit is not working	Check circuit 279 (and 278 for right-side COE motor) for continuity. Also check circuit 279A (and 278A for right-side COE motor) for continuity. Check blue wire (GND) on switch. See the applicable figure in **Specifications, 400**.

Problem—Intermittent (Delay) Feature Not Working; High and Low Speeds are O.K.

Possible Cause	Remedy
The wiper switch ground circuit is open.	Check the ground circuit (black wire) on the switch. See the applicable figure in **Specifications, 400**.

Problem—Wipers Oversweeping

Possible Cause	Remedy
Worn or broken linkage component.	Replace linkage components as required.
Worn or broken pivot assembly.	Replace the pivot assembly.
Worn or broken wiper arm.	Replace the wiper arm.
The motor assembly is loose.	Secure the motor assembly.
Vehicle voltage too high.	Repair the vehicle electrical system.

See **Fig. 1** for the wiring diagram for FLD Sleeper-Cabs without the intermittent feature.

See **Fig. 2** for the wiring diagram for FLD Sleeper-Cabs with the intermittent feature.

See **Fig. 3** for the wiring diagram for FLD non-sleepers without the intermittent feature.

See **Fig. 4** for the wiring diagram for FLD non-sleepers with the intermittent feature.

See **Fig. 5** for the wiring diagram for FLBs without the intermittent feature.

See **Fig. 6** for the wiring diagram for FLBs with the intermittent feature.

See **Fig. 7** for the FLD wiper park position.

See **Fig. 8** for the FLB LH DR wiper park position.

See **Fig. 9** for the FLB RH DR wiper park position.

Wiper Cycle Speeds *	
Wiper Motor Speed	**Cycles Per Minute**
Low	40–42
High	65–70

* Wiper speeds are affected by ambient temperature.

Table 1, Wiper Cycle Speeds

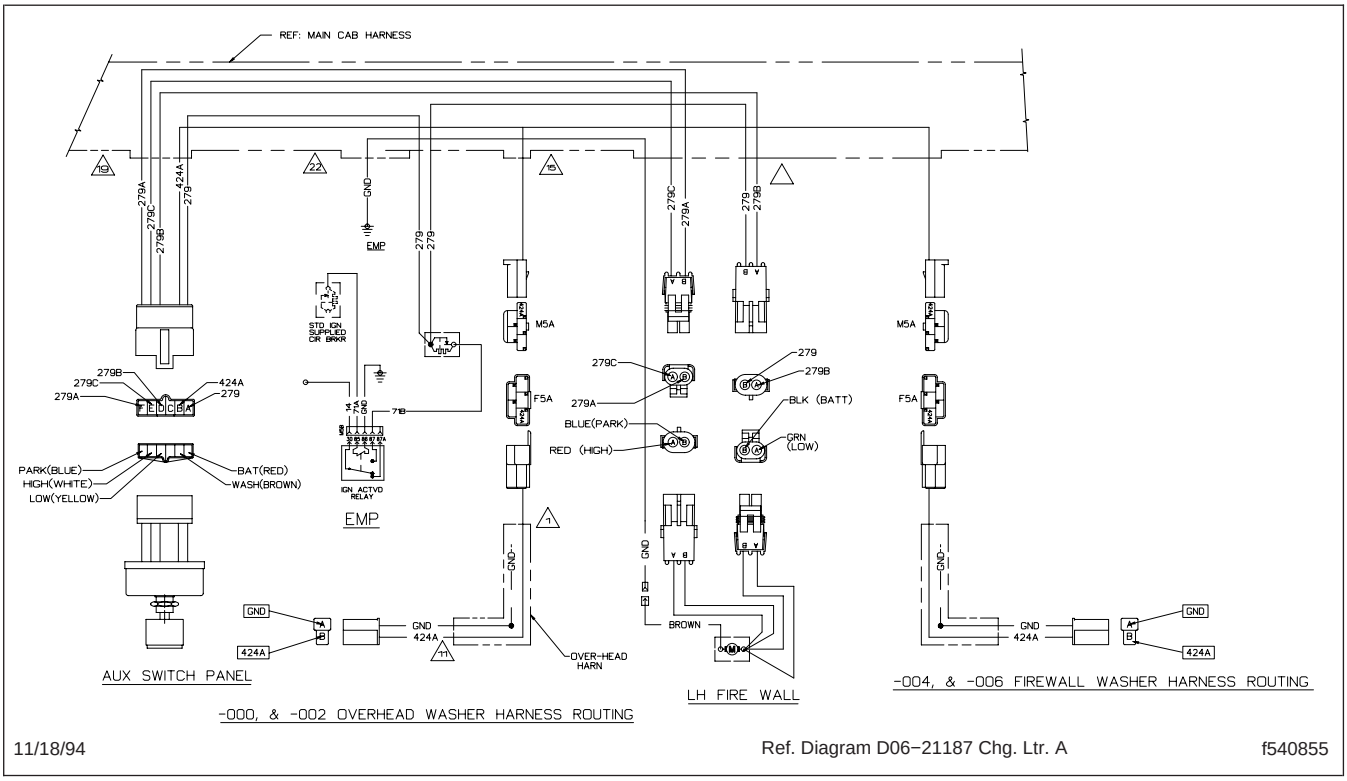


Fig. 1, Wiring Diagram, FLD SleeperCab Without Intermittent Feature

Specifications

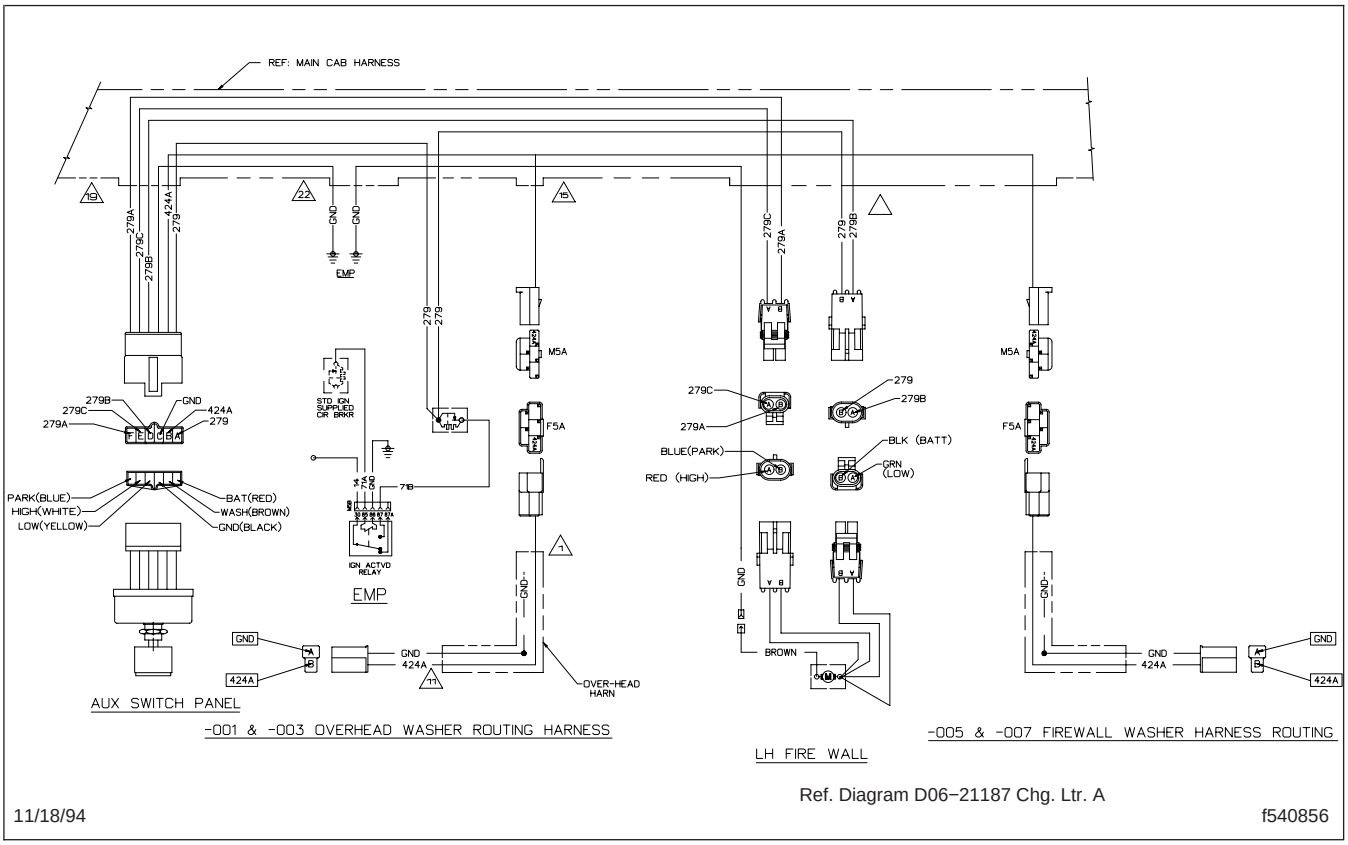


Fig. 2, Wiring Diagram, FLD SleeperCab With Intermittent Feature

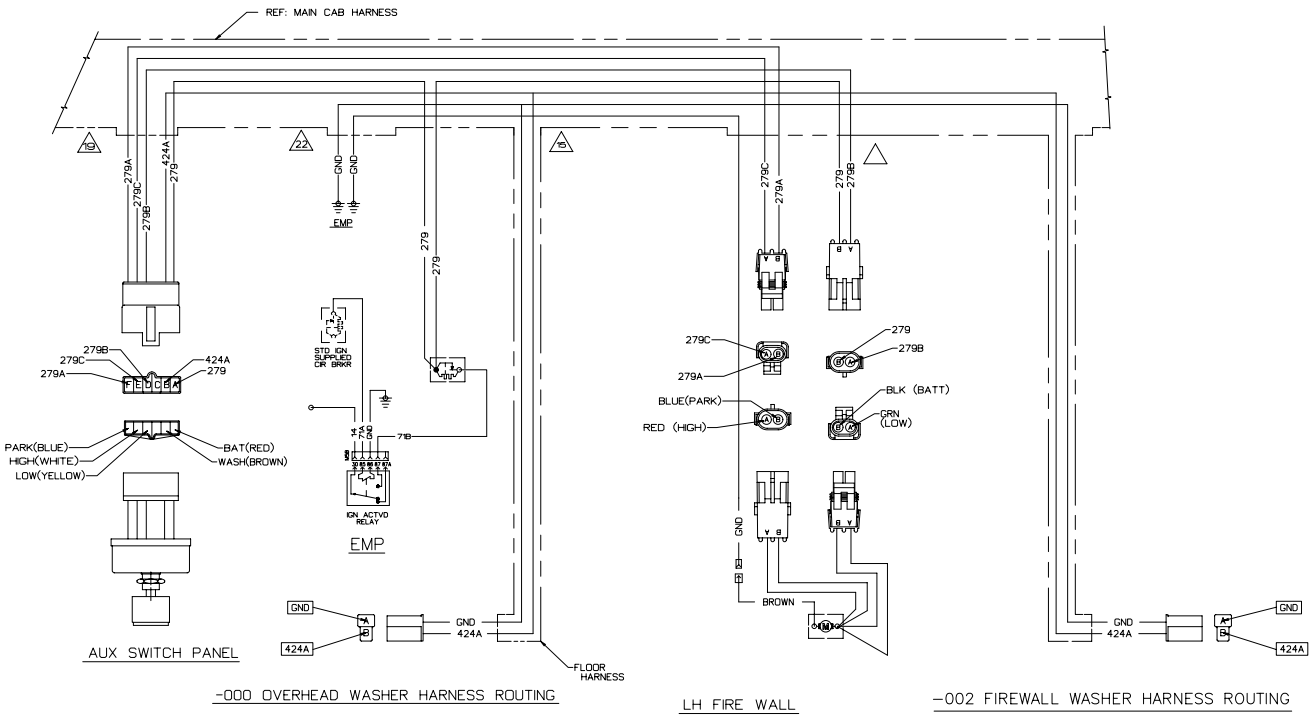


Fig. 3, Wiring Diagram, FLD Non-Sleeper Without Intermittent Feature

Specifications

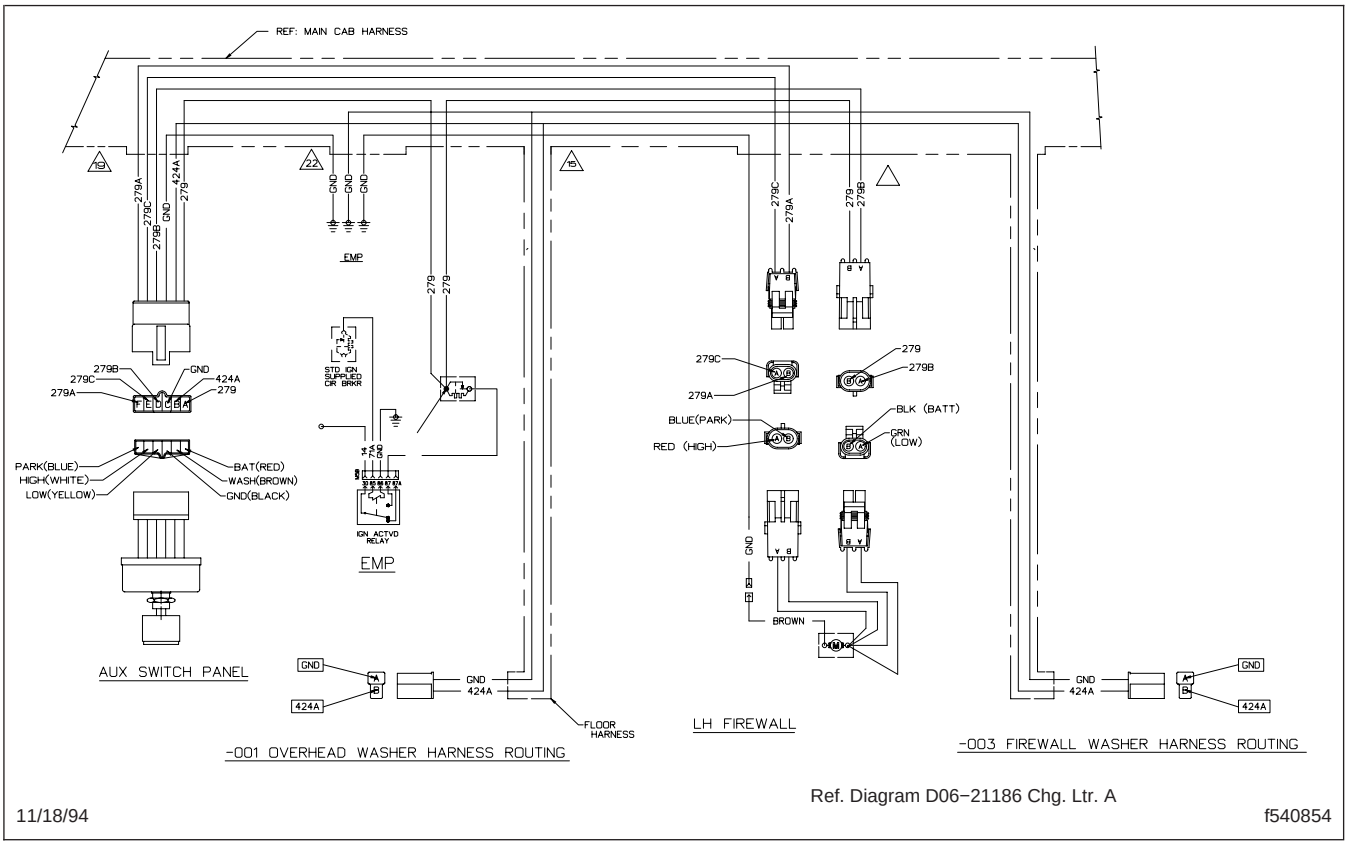


Fig. 4, Wiring Diagram, FLD Non-Sleeper With Intermittent Feature

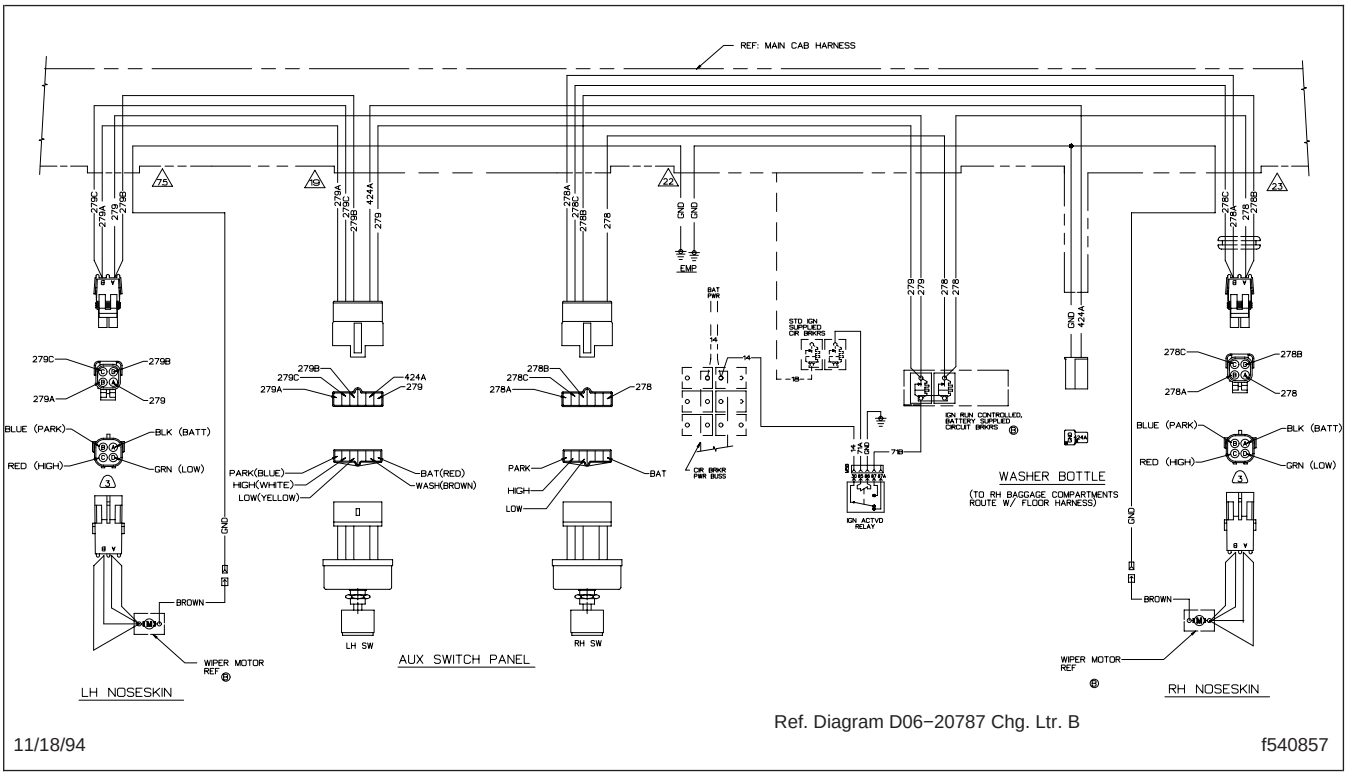


Fig. 5, Wiring Diagram, FLB Without Intermittent Feature

Specifications

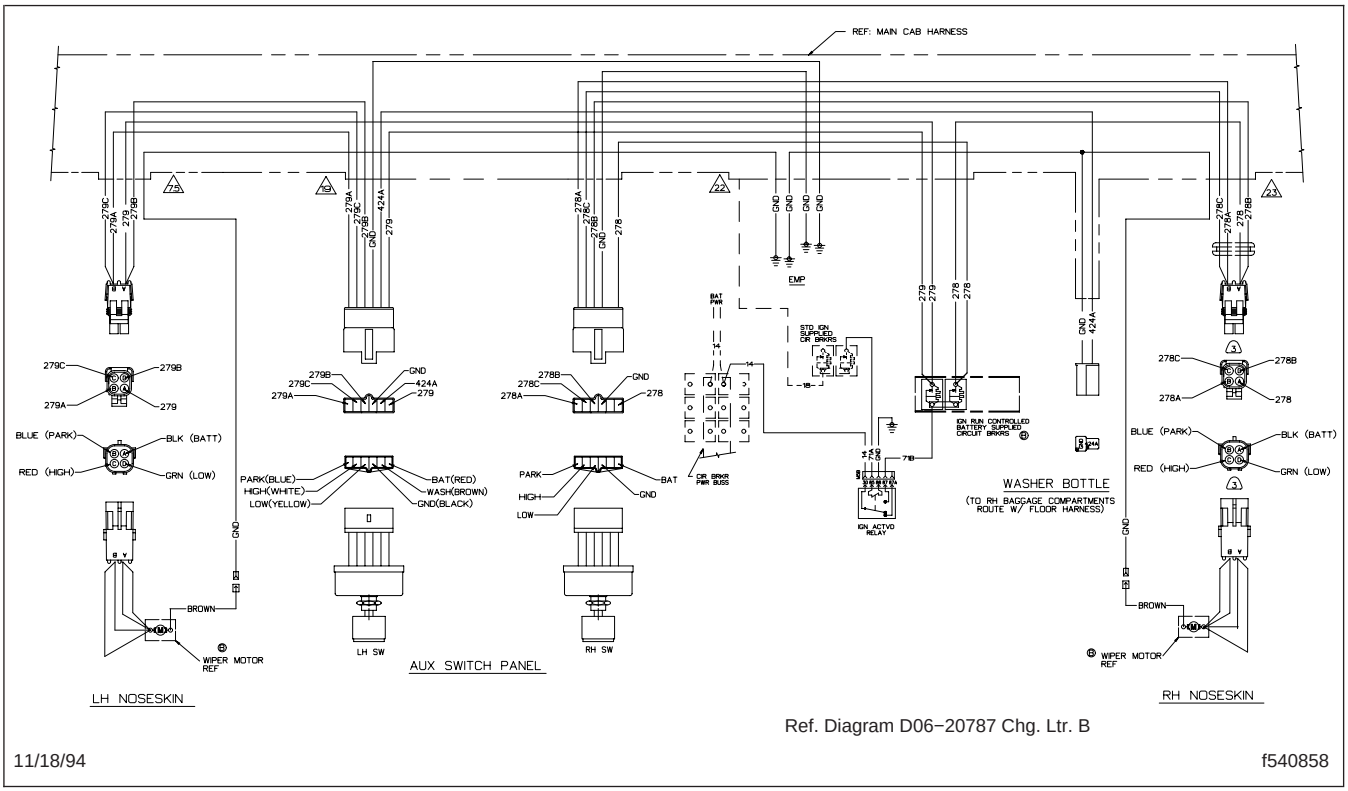
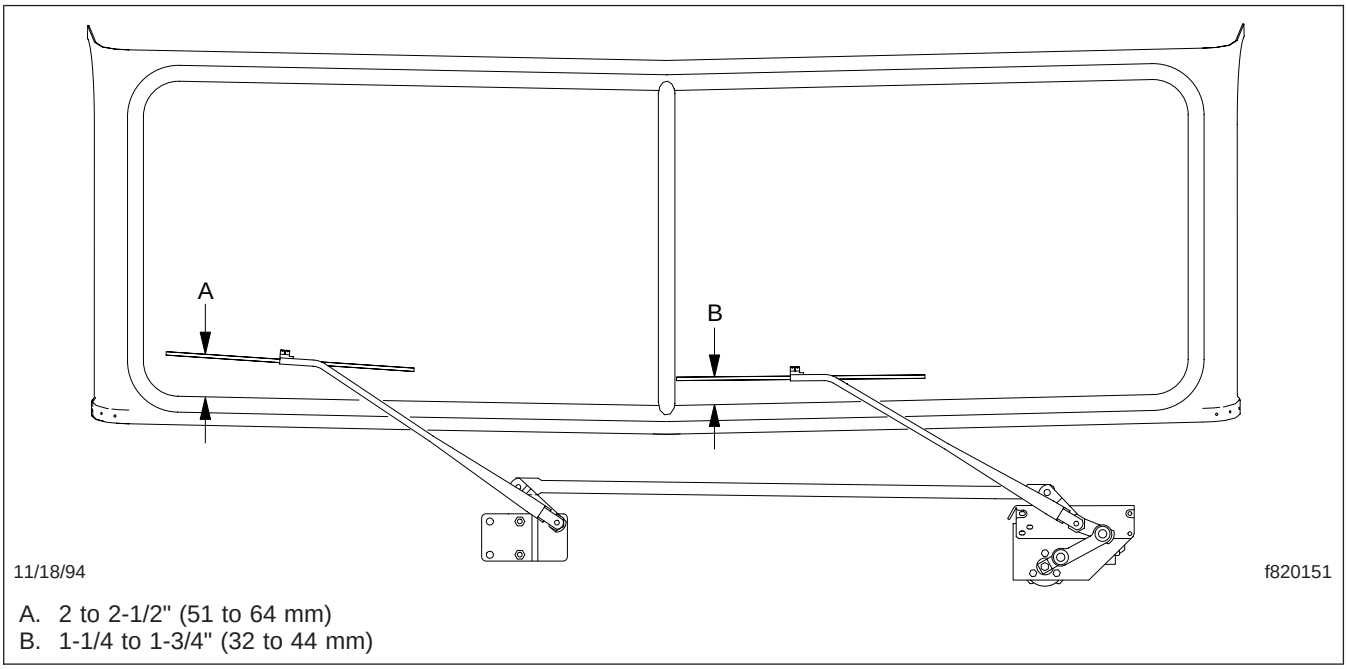
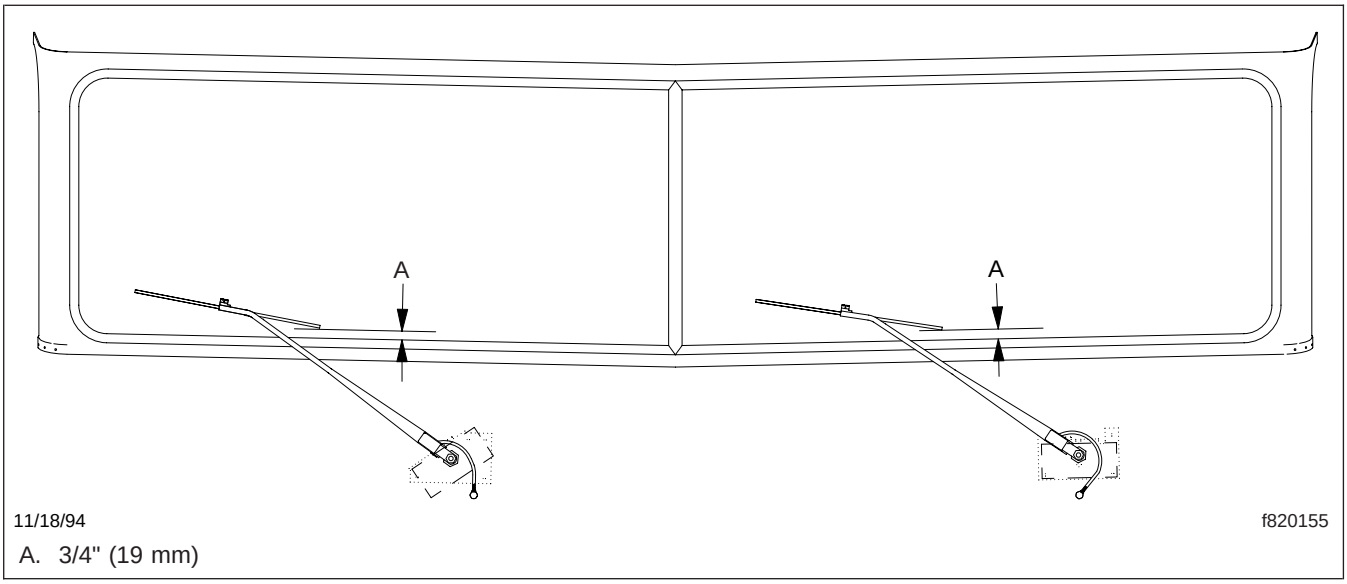


Fig. 6, Wiring Diagram, FLB With Intermittent Feature



A. 2 to 2-1/2" (51 to 64 mm)
B. 1-1/4 to 1-3/4" (32 to 44 mm)

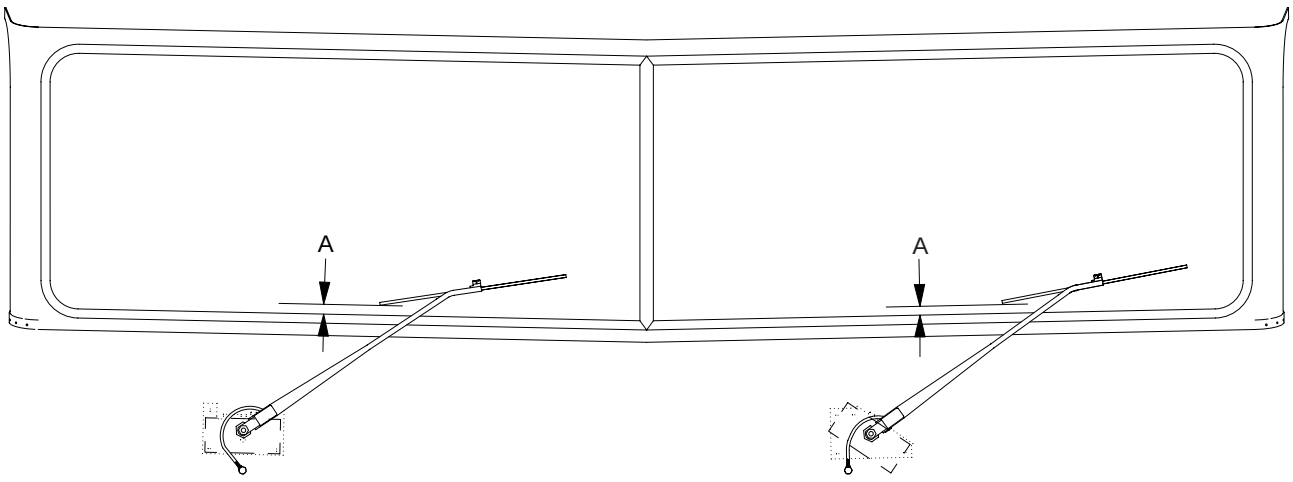
Fig. 7, Windshield Wiper Park Position, FLDs



A. 3/4" (19 mm)

Fig. 8, Windshield Wiper Park Position, Left-Hand-Drive FLBs

Specifications



A. 3/4" (19 mm)

Fig. 9, Windshield Wiper Park Position, Right-Hand-Drive FLBs

General Information

The heating and air conditioning unit is mounted under the glove compartment. It is a single unit consisting of a heater core, evaporator coil, blower motor, control valves, and air ducts. The system is turned on by the four-speed blower switch, which also controls the air flow rate. By controlling the coolant flow through the heater core, and by controlling the air flow through the heater core and evaporator coil, an even cab temperature is maintained. Refer to the vehicle driver's manual for heater/air-conditioner operating instructions.

The front ducting system allows you to control all of the air outlets from a single lever. In COEs, ducting provides heat and air conditioning to the defrost outlets, foot wells, and bunk. The bunk duct also contains a booster fan, controlled by a toggle switch on the dash, for greater air flow in the bunk. See **Fig. 1** for the air duct system in COEs.

Conventionals are equipped with a ducting system similar to that in COEs. See **Fig. 2.**

Description of Components

Refrigerant

Refrigerant is a substance that is used to absorb heat from the air in the cab and release it to the air outside the cab. In an open container, refrigerant boils at minus 21.6°F (minus 30°C); sealing and pressurizing refrigerant in the air conditioning system raises its boiling-point temperature.

During compressor operation, refrigerant constantly changes from a gas to a liquid, and back to a gas, depending on whether it is absorbing heat (boiling) in the low-pressure evaporator coils, or releasing absorbed heat in the high-pressure condenser.

Expansion Valve

(See **Fig. 3** and **Fig. 4**)

An expansion valve is a dividing point between the high-and low-pressure parts of the refrigerant system. High-pressure liquid refrigerant from the receiver-drier passes through the expansion valve and moves into the low-pressure area of the evaporator coil.

An expansion valve controls the flow rate of refrigerant in proportion to the rate of evaporation in the evaporator. If the amount of liquid in the evaporator drops off, the temperature of the gas going to the compressor rises. This causes a diaphragm in the expansion valve to react to opposing pressures on both of its sides, which causes an orifice in the valve to open or close. See **Fig. 4.** Through the orifice, liquid refrigerant is metered into the evaporator, as needed.

Evaporator Coil

Because the evaporator coil is an area of low pressure in the system, the boiling point of refrigerant lowers, which causes it to absorb heat from the tubing walls and fins of the coils. As it absorbs heat, liquid refrigerant quickly boils and turns into a gas.

As heat is absorbed from the outside surfaces of the evaporator coil, air passing over the unit loses its heat to these cooler surfaces. Moisture in the air condenses on the outside of the coil and drains off as water (the air becomes dehumidified).

Refrigerant Compressor

(See **Fig. 5**)

"Heat" in the low-pressure gas of the evaporator coils is not heat that can be noticed by touch, because liquid refrigerant boils at a temperature much lower than the temperature at which water turns to ice. By touch, the "heated" gas in the coils is very cold. As a result, there is the problem of how to remove heat from subfreezing gas using outside air that may be higher than 100°F (38°C).

With a refrigerant compressor, low-pressure gas from the evaporator can be squeezed into a much smaller space. When the gas is compressed, the heat it contains becomes concentrated. In this way, the gas is made hotter than the outside air, without adding heat.

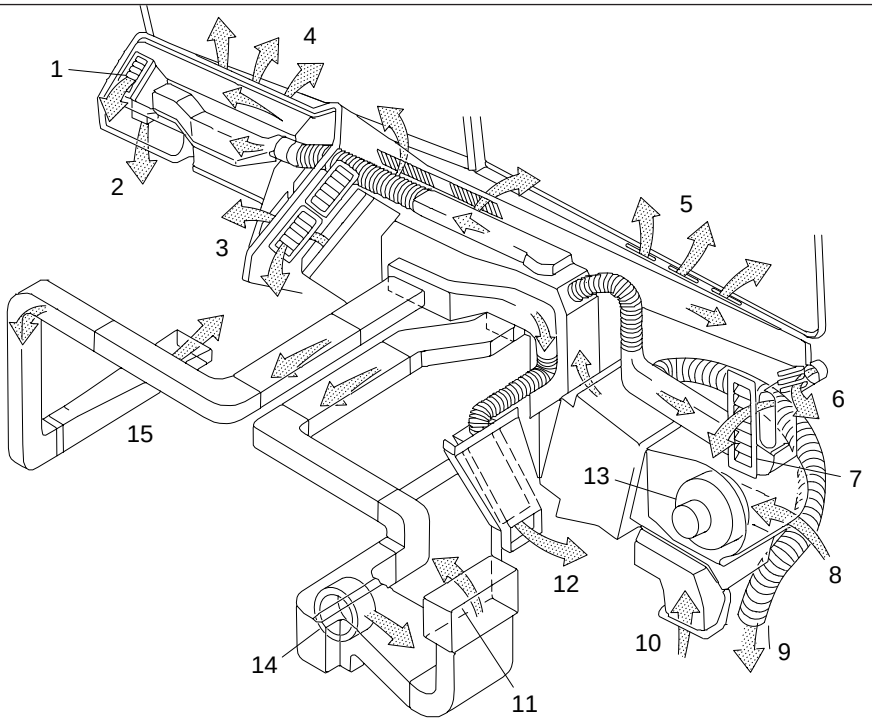
A secondary purpose of the compressor is to move refrigerant through the system.

Condenser

(See **Fig. 6**)

A condenser turns hot refrigerant gas, coming from the compressor, into liquid. Mounted in front of the radiator, it is made up of a coiled tube and a series of fins. Because of its location, the condenser transfers heat to air that is drawn in by the engine fan and by air that is forced into the engine compartment as the vehicle moves forward (ram air).

General Information and Principles of Operation



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1. Dash Face Outlet (Driver's Door Window Defrost Outlet)
2. Floor Outlet
3. Dash Face Outlets
4. Windshield Defrost Outlets
5. Windshield Defrost Outlets
6. Passenger's Door Window Defrost Outlet
7. Dash Face Outlet
8. Recirculated Air Inlet
9. Floor Outlet
10. Fresh Air Inlet
11. Bunk Outlet
12. Passenger's Floor Outlet
13. Blower Motor
14. Bunk Fan
15. Driver's Floor Outlet

Fig. 1, COE Air Duct System

Receiver-Drier

(See **Fig. 7**)

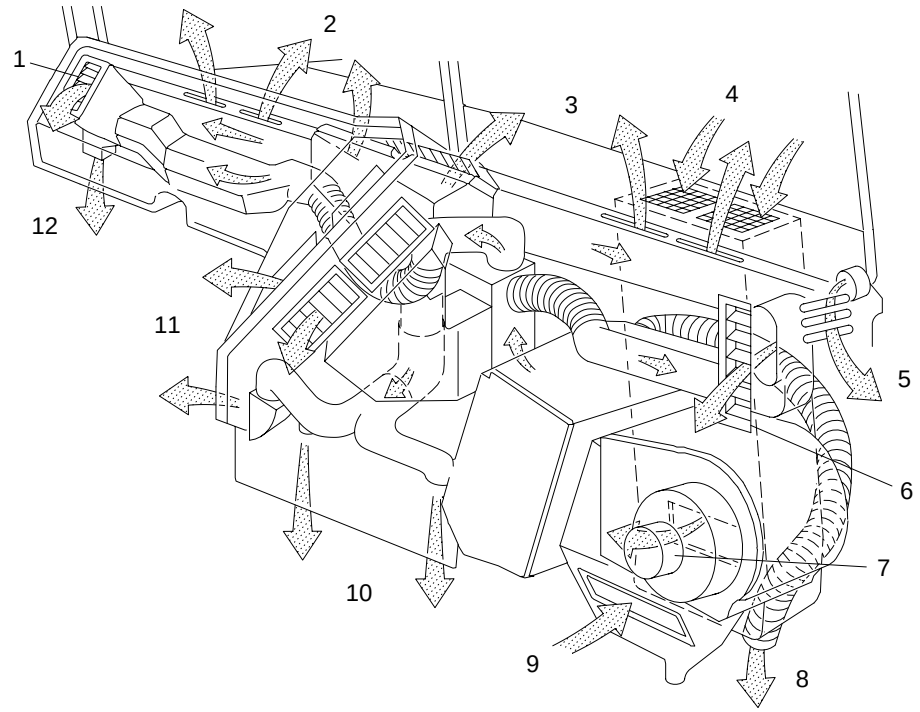
The receiver-drier is a reservoir and filter for liquid refrigerant. It also removes water and acids from the refrigerant. The water-absorbing material (desiccant) in the unit helps stop blockages from forming in the expansion valve and other parts of the system. If the system pressure should ever rise above 525 ± 75 psi (3620 ± 517 kPa), a pop-off plug will blow out of the receiver-drier causing the system pressure to drop below 7± 3 psi (48 ± 21 kPa), thereby disengaging the refrigerant compressor clutch.

A moisture indicator shows the amount of water in the refrigerant system. A sight glass on the unit contains a specially treated element (litmus paper) that changes color depending on the amount of water in the refrigerant. The indicator changes from a deep cobalt blue (dry) to light greyish-blue (wet) to lilac, lavender, and finally pink (very wet). Any color other than cobalt blue is considered wet. Any time the system is evacuated (dehydrated), replace the receiver-drier.

NOTE: Check the moisture indicator while the system is at operating temperature.

Thermostatic Switch

A thermostatic switch engages and disengages the refrigerant compressor. See **Fig. 8.** From the thermostatic switch, a sensing tube extends to the evaporator coil where it monitors the temperature near the coil tubes. As air passes through the evaporator coil,



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1. Dash Face Outlet (Driver's Door Window Defrost Outlet)
2. Windshield Defrost Outlets
3. Windshield Defrost Outlets
4. Fresh Air Inlet
5. Passenger's Door Window Defrost Outlet
6. Dash Face Outlet
7. Blower Motor
8. Floor Outlet
9. Recirculated Air Inlet
10. Floor Outlets
11. Dash Face Outlets
12. Floor Outlet

Fig. 2, 120 Conventional Air Duct System

water vapor can condense and freeze on the coil, blocking airflow. If this happens, the thermostatic switch disengages the refrigerant compressor clutch until all ice has melted.

Fan Cycle Switch (On-Off Fan Only)

Located on the receiver-drier, the fan cycle switch activates a solenoid to turn the fan on when refrigerant pressure is greater than 260 ± 10 psi (1800 kPa). It turns the fan off when pressure drops below 174 ± 10 psi (1200 kPa).

Heater Core

The heater core is a series of fins through which tubing is routed. When the heating system is on, engine coolant flows through the heater core tubes, heating the tubes and fins. The heat is absorbed by air that is forced through the heater core by the blower motor.

Water Regulating Valve (See Fig. 9)

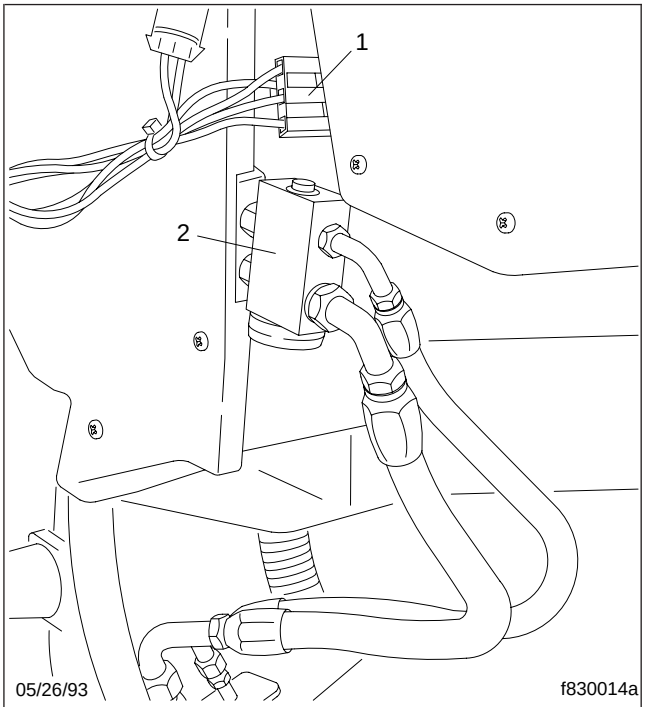
The water regulating valve is controlled by a temperature slide lever on the dash panel. A cable from the lever opens and closes the valve, regulating the amount of engine coolant flowing through the heater core.

Blower Motor Resistor Block Assembly

(See **Fig. 3**)

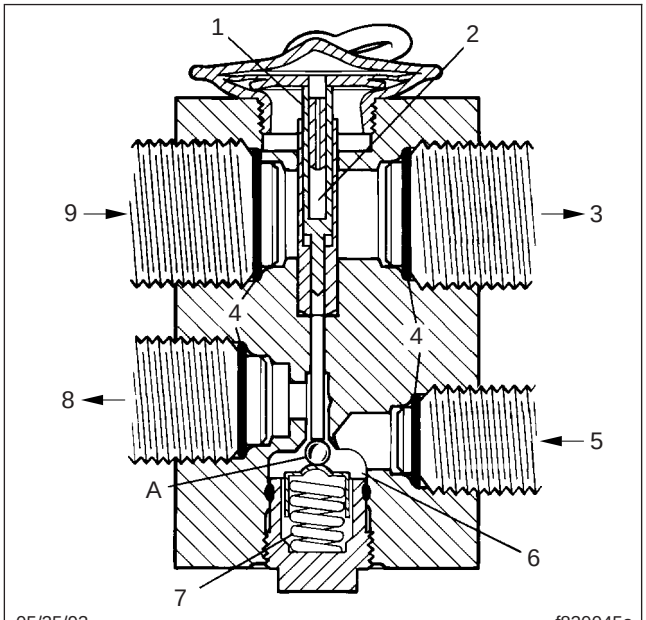
The blower motor draws air over the evaporator coils and forces it through the heater core and into the

General Information and Principles of Operation



1. Resistor Block
2. Expansion Valve

Fig. 3, Resistor Block Installation



1. Internal Equalization Passage
2. Temperature Sensor
3. to compressor
4. O-Rings
5. from receiver-drier
6. Metering Orifice
7. Ball and Spring
8. to evaporator
9. from evaporator
A. Bleed at ball seat.

Fig. 4, Expansion Valve

cab. The resistor block assembly controls the speed of the blower motor. The resistor assembly has a thermal cutout which shuts off current to the blower motor if the motor overheats.

Binary Switch

A binary switch disengages the refrigerant compressor to protect it from harmful operating conditions. It performs two functions:

A. If refrigerant is lost or the outside temperature is too low, the binary switch will keep the compressor from operating. The switch disengages the compressor when falling pressure goes below 26 to 31 psig (179 to 214 kPa); normal compressor operation resumes when rising pressure reaches 0.1 to 3 psig (0.6 to 21 kPa) above shut-off pressure.

B. If the compressor cylinder head pressure increases to unsafe levels above 356 to 413 psig (2454 to 2847 kPa), the binary switch shuts off the compressor. Too much pressure may be caused by blocked air flow through the condenser, a plugged expansion valve or receiver-drier, or too much refrigerant in the system. When pressure falls back 57 to 11 psig (393 to

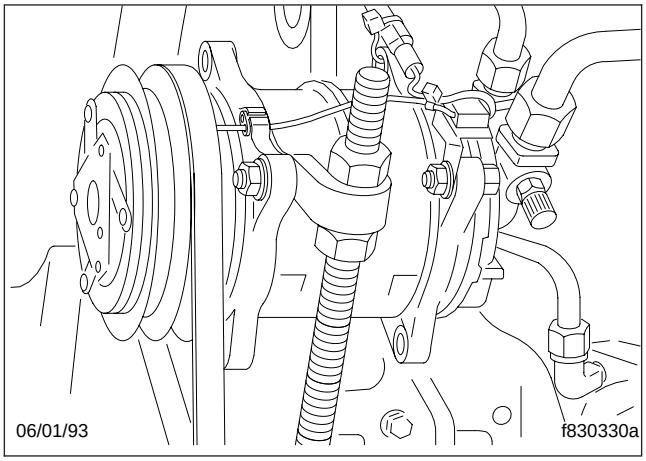


Fig. 5, Refrigerant Compressor

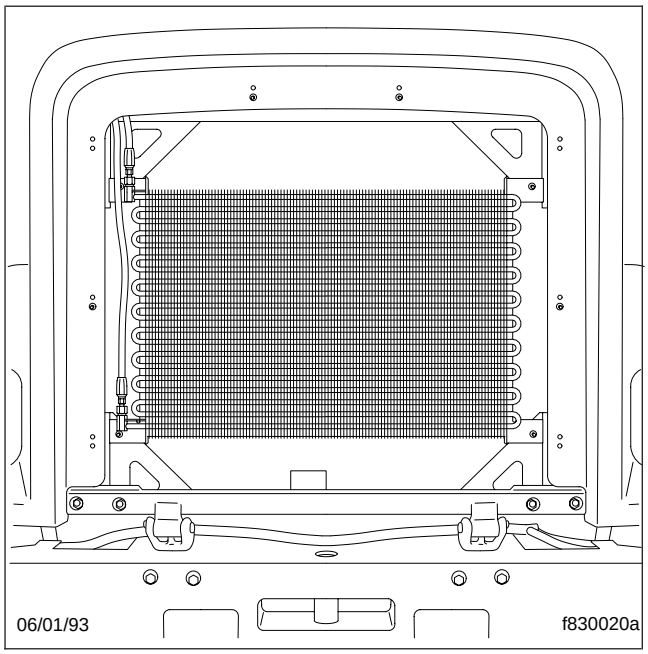


Fig. 6, Condenser (Grille Removed)

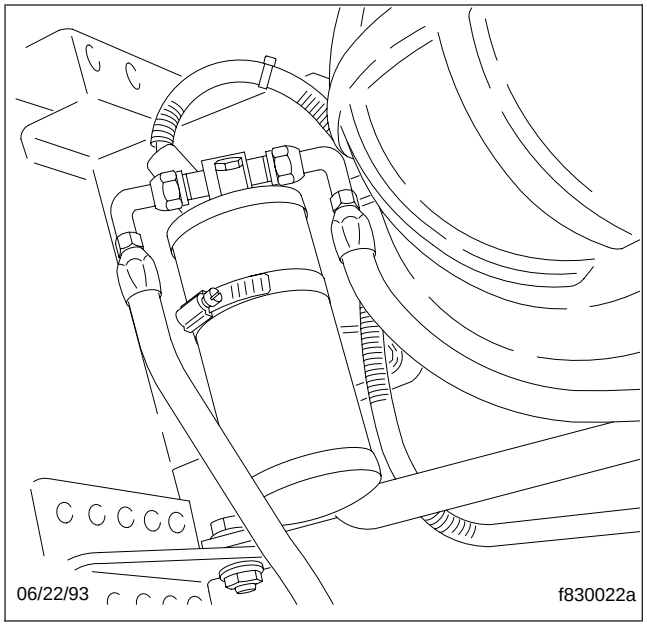


Fig. 7, Receiver-Drier

786 kPa) from shut-off pressure, the compressor resumes operation.

Definition of Terms

Refer to the following terms for a better understanding of the heater/air-conditioning system.

Air Conditioner A device used to control the temperature, humidity, cleanness, and movement of air.

Air Cylinder An air-operated device used to open or close a vent through which fresh air is drawn into the cab by the blower.

Air Pressure The pressure exerted in every direction at any given point. Normal atmospheric pressure (that is, the pressure caused by the weight of the atmosphere) at sea level is 14.696 psia (101.60 kPa).

Ambient Air Temperature The temperature of air around an object; the outside temperature.

Blower A motor and fan used to draw air through the evaporators, and force it through the heater core and into the cab.

Blower Resistor Block Assembly Inline resistors that control the amount of voltage going to the blower motor. By controlling the voltage, you can control the fan speed.

Boiling Point The temperature at which a liquid changes to a gas, at a certain pressure.

Bulk Charging Use of large containers of refrigerant for charging a refrigerant system. Normally used for charging empty systems.

Carbon Dioxide A colorless, odorless, dry, inert gas.

CFM Cubic feet per minute

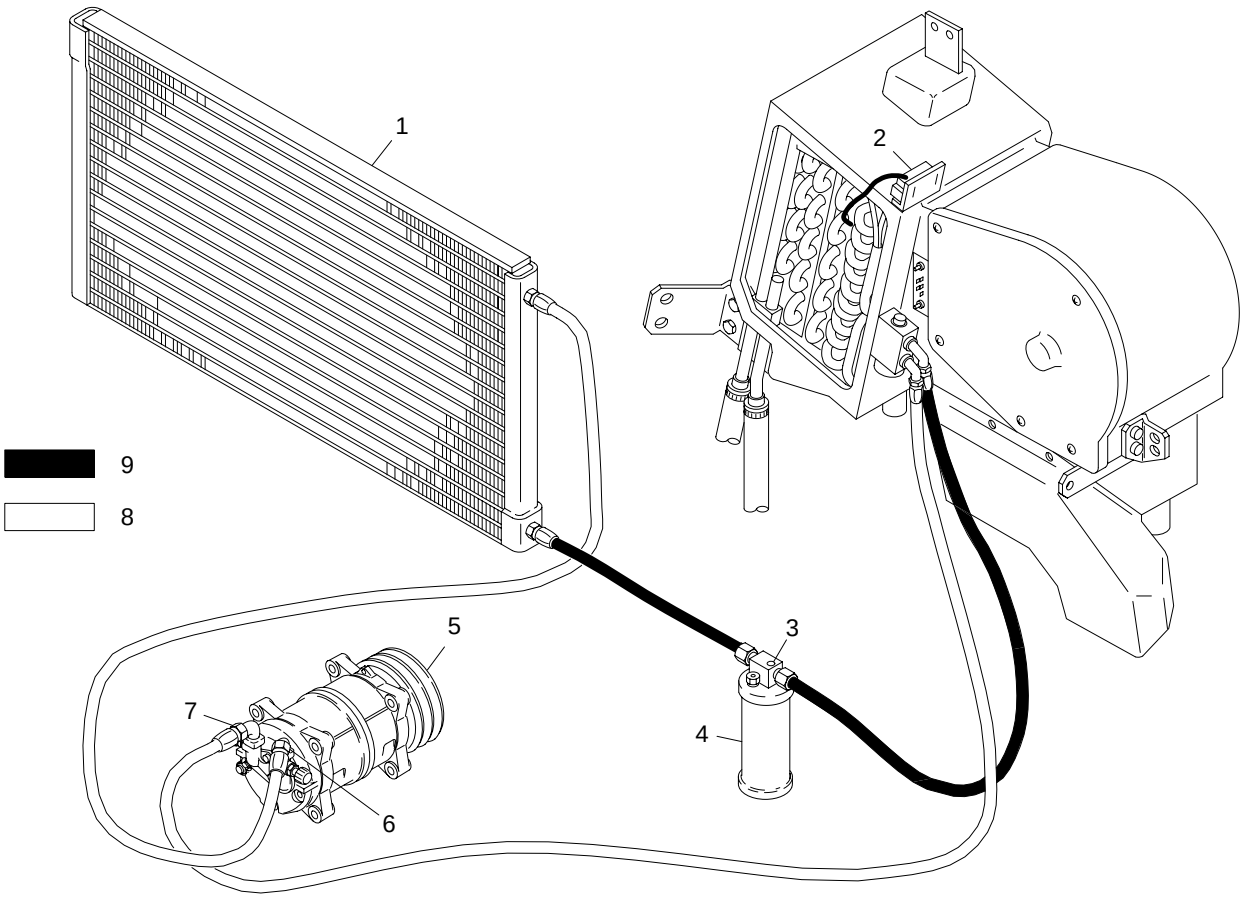
Charge A specific amount of refrigerant or oil by volume or weight. Also, the act of placing an amount of refrigerant or oil in the air conditioning system.

Clutch Cycling Switch Engages or disengages the compressor depending on changes in system pressure or evaporator temperature.

Cold The absence of heat. (The lowest possible temperature is thought to be –459°F [–273°C].)

Compressor A unit used to draw low-pressure refrigerant gas from the evaporator and squeeze it into a high-temperature, high-pressure gas. This causes the refrigerant to have a higher temperature than the surrounding air, allowing the condenser to change

General Information and Principles of Operation



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1. Condenser
2. Thermostatic Switch
3. Sight Glass
4. Receiver-Drier
5. Refrigerant Compressor
6. Discharge Side
7. Suction Side
8. Vapor
9. Liquid

Fig. 8, Air Conditioning System

the gas back into a liquid. A secondary purpose of the compressor is to move refrigerant through the system.

Condensate Water, taken from the air, which forms on the outer surface of the evaporator.

Condenser A heat exchanger that is used to remove heat from refrigerant, changing it from a high-pressure hot gas to a high-pressure warm liquid.

Condensing Pressure Pressure, as read from the gauge at the discharge service valve; pressure from the discharge side of the compressor into the condenser; high-side pressure; discharge pressure.

Contaminants Anything other than refrigerant or refrigerant oil in the system. Usually means water in the system: when water and refrigerant mix, corrosive hydrochloric acid forms.

Cycling Clutch System A system which controls compressor clutch operation in order to raise or lower the temperature in the cab.

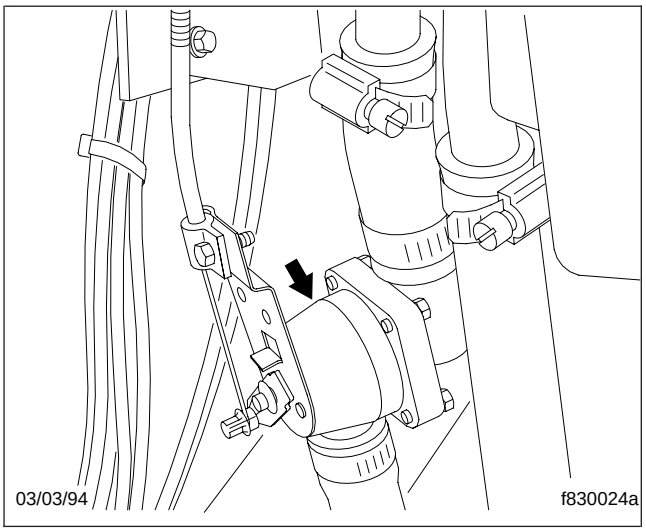


Fig. 9, Water Regulating Valve

Dehumidify To remove water from the air, at the evaporator coil.

Dehydrate To remove all traces of wet air from the refrigerant system. Normally called evacuation.

Desiccant A drying agent used in the refrigerant system (in the receiver-drier) to remove water and create an extremely dry condition.

Dichlorodifluoromethane The chemical name of refrigerant.

Discharge To bleed some or all of the refrigerant from a system by opening a valve or hose connection and recovering the refrigerant from the system.

Discharge Line Connects the refrigerant compressor outlet to the condenser inlet.

Discharge Pressure Pressure of the refrigerant being discharged from the compressor; high-side pressure; condensing pressure.

Discharge Service Valve A device that is attached to the discharge side of the compressor; it allows high-side pressure to be checked and other service operations to be performed.

Drive Pulley A V-pulley attached to the front of the engine crankshaft. It drives the compressor clutch pulley with a belt.

Drying Agent See "Desiccant."

Duct A passageway for the transfer of air from one point to another.

Evacuate Evacuation places a high vacuum in the refrigeration system and dehydrates or removes all traces of wet air.

Evaporate A change of state from a liquid to a gas.

Evaporator Coil A component in which liquid refrigerant changes to a gas after it absorbs heat from the air. Also removes some water from the air.

Expansion Valve A device that causes a pressure-drop of the refrigerant and also regulates its flow.

Flooding A condition caused by too much liquid refrigerant going into the evaporator; usually caused by an expansion valve that is stuck open.

Flushing A process of placing liquid R-12 in a refrigerant part to flow out dirt and water from the part. R-12 removes heavy contamination, such as gritty dirt and large dirt build-up.

Foaming Bubbles of oil and refrigerant caused by a rapid boiling out of refrigerant dissolved in the oil when the pressure is suddenly reduced. Foam in the sight glass means a very low refrigerant charge.

Freeze-Up Failure of a unit to operate properly because of ice forming at the expansion valve orifice or on the evaporator coils and fins.

Head Pressure Refrigerant pressure from the discharge side of the compressor to the condenser and expansion valves. See "Discharge Pressure."

Heater Core A part of the heating system in which hot engine coolant flows to provide heat to the cab or to adjust the temperature produced by the air conditioner.

Humidity The amount of water vapor in the air.

Hydraulic Lock The return of liquid refrigerant to the compressor, which could destroy the unit.

Hydrochloric Acid A highly caustic substance that forms when water and refrigerant mix in a refrigerant system.

Hydrofluorocarbon The chemical name for R-134a.

Leak Detector Any device used to detect refrigerant leaks in a refrigerant system.

Low-Air Pressure Switch An air operated electrical switch that is normally open, but closes when the system air pressure rises to 65 to 75 psi (448 to 517 kPa). Its purpose is to prevent the refrigerant com-

pressor from turning on if the vehicle's air system pressure is too low to activate the cooling fan.

Low Suction Pressure Low-side pressure that is lower than normal due to a system problem.

Magnetic Clutch An electrical coupling device used to engage or disengage the compressor.

Manifold Designed to control refrigerant flow for system test purposes; used with manifold gauges.

Manifold Gauge A calibrated instrument used for measuring system pressures.

Manifold Gauge Set A manifold that is complete with gauges and charging hoses and is used to measure or test pressure.

Micron A metric measurement of mercury; one-tenth of an inch of mercury equals 2540 microns. Measurement in microns is the only accurate way to determine the amount of pressure that is left in a refrigerant system by a high vacuum pump.

Moisture Indicator Litmus paper in a sight glass receiver-drier; shows how much water is in the system.

Nitrogen A colorless, odorless, dry, inert gas.

Opacity A condition that is used to describe contamination of refrigerant oil in the compressor. Fresh refrigerant oil is clear; when contaminated, it appears cloudy or may have fine particles held in suspension.

Overcharge Too much refrigerant or oil in the system.

Phosgene Fumes Poisonous gas produced when refrigerant contacts an open flame or some other source of intense heat.

psia Pounds per square inch, absolute pressure.

psig Pounds per square inch, gauge pressure.

Receiver-Drier A combination desiccant, filter, and storage container for liquid refrigerant.

Refrigerant-12 (R-12) The cooling agent used in automotive air conditioning systems. See "Dichlorodifluoromethane."

Refrigeration Cycle The complete circulation of refrigerant through an air conditioning system, accompanied by changes in temperature and pressure.

Refrigerant Oil Highly refined oil that is free of contaminants.

Relative Humidity The actual water content of the air in relation to the total water the air can hold at a given temperature.

Resistor A voltage-dropping device, usually wire-wound, for controlling fan speed.

Schrader Valve A spring-loaded valve (similar to but not interchangeable with a tire valve) located inside the compressor service valve fitting to hold refrigerant in the system. Special adapters must be used with the gauge hose to get into the system.

Sensor A temperature-sensing unit that is used to sense air temperatures and provide a control voltage for operation of automatic temperature control units.

Sight Glass A window in the receiver-drier (moisture indicator) used to check the refrigerant charge.

Suction Line The line connecting the evaporator outlet to the compressor inlet.

Suction Pressure Compressor inlet pressure (the system's low-side pressure).

Suction Service Valve A device located on the suction side of the compressor that allows low-side pressure to be checked and other service operations to be performed.

Suction Side The low-pressure area of the system, extending from the expansion valve to the compressor inlet.

Thermistor A temperature-sensing resistor that is used to measure (in microns) internal system vacuum levels during evacuation.

Thermostatic Vacuum Gauge A high-vacuum gauge sensitive to pressures ranging from atmospheric pressure to less than 1 micron, with scales reading from 25,000 microns to 1 micron.

Thermostatic Switch A temperature-sensitive switch used to control system temperature and prevent evaporator freeze-up; it does this by cycling the compressor's operation.

Vacuum Refers to pressure that is less than atmospheric pressure.

Vacuum Pump A mechanical device used to evacuate and place a high vacuum in the refrigerant system.

Vacuum Pump Oil Water soluble oil used in some vacuum pumps to absorb water from the refrigerant system.

Vapor The gaseous state of a material.

Water Regulating Valve A valve, mechanically operated, for controlling the flow of hot coolant to the heater core.

Principles of Operation

Air Conditioner

(See **Fig. 8**)

When the refrigerant compressor is on, a rotating swash plate actuates the pistons and cylinders, drawing in and compressing the gas. The motion of the swash plate drives three double-ended pistons that squeeze the refrigerant into a high-pressure, high-temperature gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid. After it is compressed, refrigerant gas moves out of the discharge port of the compressor, and on to the condenser.

At the condenser, air passing over the coil's fins absorbs heat from the hot refrigerant gas, and causes it to change into a liquid. The liquid moves to the receiver-drier, which filters it and removes traces of water and acids, and then stores the refrigerant until it is needed by the system.

From the receiver-drier, liquid refrigerant moves to the expansion valve, which meters the flow into the evaporator coil, and acts as a boundary between the high-and low-pressure sides of the system. The metered release of the expansion valve greatly drops the liquid's pressure, causing it to expand. The pressure drop lowers the boiling point of the refrigerant, and causes it to quickly evaporate as it absorbs heat from air passing over the coil. The resulting cool air is forced into the cab by the blower; the heated refrigerant gas is drawn back into the compressor, where the cycle is repeated.

Heater

Moving the temperature slide lever from "COOL" to "WARM" opens the water regulating valve, which allows engine-heated coolant to flow through the heater core. Heat absorbed by the air passing over the heater core fins is forced through ducts and into the cab.

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold refrigerant, you must discharge, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the air conditioning system has been discharged to a refrigerant recovery unit through the service valves on the compressor.

Refrigerants are safe when used under the right conditions. Always wear safety goggles and non-leather gloves while discharging, purging, flushing, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

WARNING: Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should first be treated with a few drops of sterile mineral oil in the eyes, and then rinsed with a weak boric acid solution. Do not rub the eyes. Call a doctor right away.

Refrigerant splashed on the skin should be treated the same as for frostbite: gently pour cool water on the area, but do not rub the skin. Keep the skin warm with layers of soft, sterile cloth. Call a doctor right away.

Even though refrigerant does not burn, when it contacts extreme heat or flame, poisonous phosgene gas is created. This gas also is produced when an open flame leak detector is used. Phosgene fumes have an acrid (bitter) smell.

⚠ WARNING

WARNING: Do not work in an area where refrigerant may contact an open flame or any burning material, such as a cigarette. When it contacts extreme heat, refrigerant breaks down into poisonous phosgene gas which, if breathed, causes severe respiratory irritation. Do not breathe the fumes from an open flame leak detector.

You must work in an area where there is a constant flow of fresh air when the system is discharged, flushed, charged, and leak tested using an open flame leak detector.

Changes in both federal and state laws will affect the way dealerships service air-conditioning systems. Under current federal laws, refrigerant must be recovered and recycled by all users to protect the environment, and not released into the atmosphere. Many service operations not directly involving the air-conditioning system require the release of the refrigerant charge. Under the new regulations, dealerships not having the required recovery and recycling equipment (and properly trained and certified personnel) will not be allowed to do any of this service work.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant cans from exploding, never expose them to temperatures higher than 125°F (52°C). Never leave refrigerant cans in the sun, and do not store them in sun-exposed areas where heat can build up, such as in gloveboxes, automobile trunks, etc.

Heater and Air Conditioner Removal and Installation

Removal (See Fig. 1)

IMPORTANT: Before replacing any refrigerant parts, read **Subject 250**. If the system is contaminated, purge or flush it before you install replacement parts.

Whenever a refrigerant line is disconnected, replace the rubber O-ring (**Fig. 2**). Lubricate the new O-ring with refrigerant oil and apply Loctite® 242 or 592 to the male fitting threads before connecting the lines.

Do not disconnect or connect refrigerant fittings using only one wrench. Hold one fitting in place using a wrench, and turn the other fitting using a second wrench.

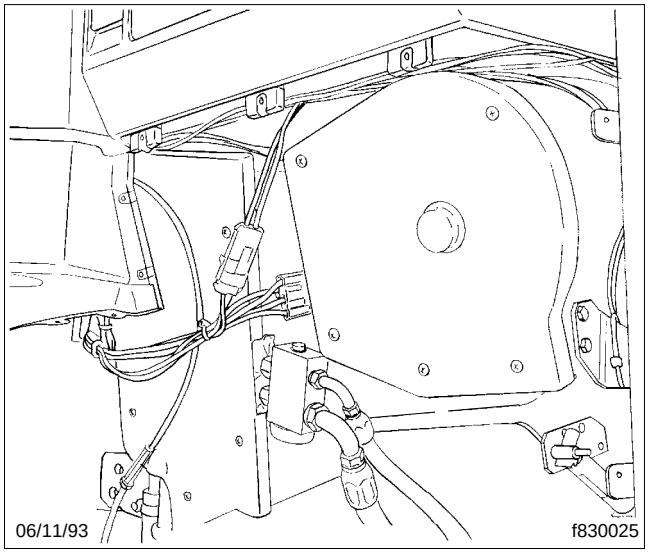


Fig. 1, Behr Heater/Air-Conditioner

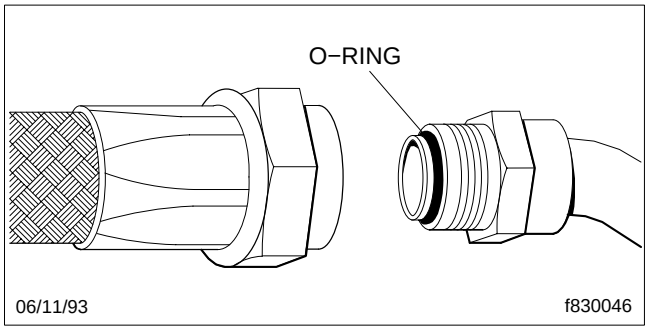


Fig. 2

1. Disconnect the batteries.

WARNING

WARNING: Do not drain the cooling system while the engine is hot. To avoid personal injury from scalding coolant, wait until the engine has cooled before draining the system.

2. Move the temperature slide lever to "WARM." With the engine cold, remove the cooling system drain plug, and drain the coolant into a clean container.
3. On COEs, remove the ten screws securing the dash skirt panels (**Fig. 3**) on the right side of the cab.

   On 120 Conventionals, remove the five screws securing the electrical access panel, the nine screws securing the dash skirt panels (**Fig. 4**) on the right side of the cab, and the twelve screws securing the lower center dash. Allow the dash to hang from its wire connections.
4. Protect the carpeting with a shop towel, and loosen the hose clamps. Disconnect the heater core inlet and outlet hoses. See **Fig. 5.**
5. Unplug the connectors for the blower motor, resistor block, and the thermostatic switch.

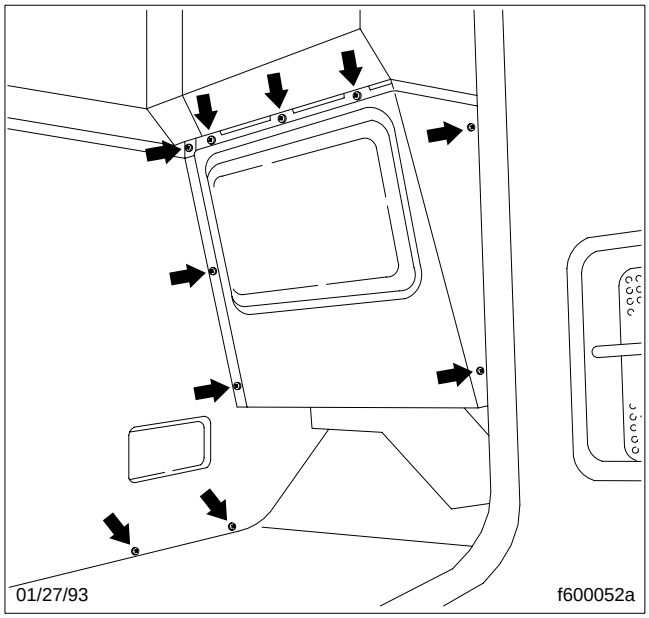


Fig. 3, COE Heater/Air-Conditioner Dash Skirt Panels

6. Review the information under **Safety Precautions, 100**.

Heater and Air Conditioner Removal and Installation

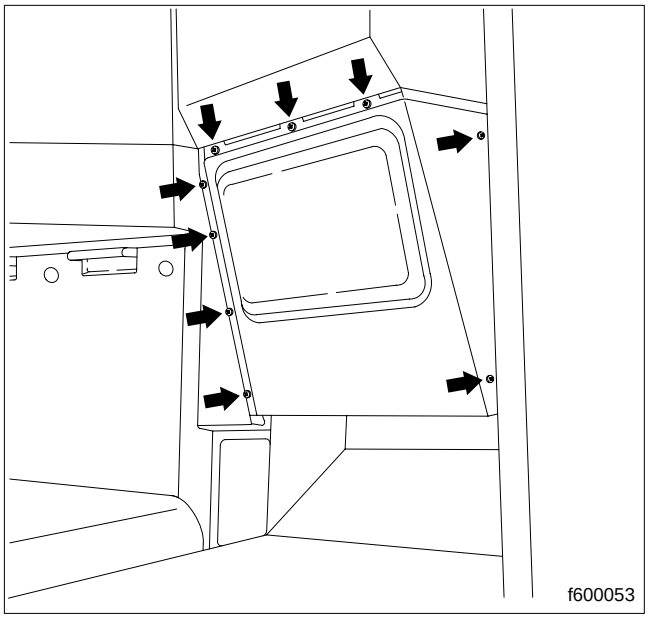


Fig. 4, 120 Conventional Heater/Air-Conditioner Dash Skirt Panels

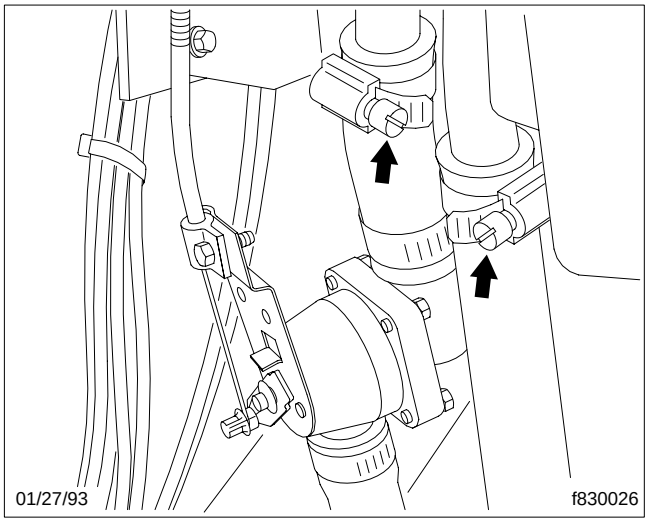


Fig. 5, Heater Core Inlet and Outlet Hose Connections

WARNING

WARNING: Failure to review the safety precautions, and to be aware of the dangers involved when working with refrigerant, could result in serious personal injury.

7. Wearing protective goggles and gloves, discharge the refrigerant system. For instructions, refer to **Subject 250**.
8. Remove the mastic insulating tape from around the expansion valve.
9. Using two wrenches to avoid twisting the tubing, disconnect the refrigerant lines from the expansion valve.

CAUTION

CAUTION: Water and dirt can damage the refrigerant system. Five minutes of not being capped is the limit for any hose or component. Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

10. On COEs, remove the four screws and the nut from the air recirculation duct, and disconnect the duct.
11. Disconnect the air line from the air recirculation door air cylinder and move it out of the way. See **Fig. 6.**

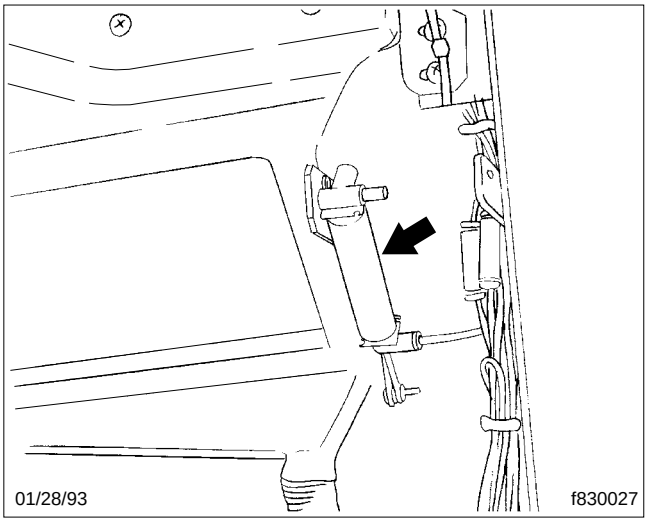


Fig. 6, Air Cylinder

12. Remove the six capscrews that hold the heater/air-conditioner unit in place. Access the top two capscrews by removing the right dash ash tray.

NOTE: Heater/air-conditioner installation is easier with the right dash removed.

13. Lift the unit out of the truck, withdrawing the drain tubes from the floorboard as the unit is removed.

Installation

1. Feed the drain tubes through the floorboard as the unit is installed.
2. Install the six capscrews that secure the heater/air-conditioner. Tighten them 48 lbf·in (540 N·cm).
3. Position the air recirculation duct and install the four screws and one nut.
4. Connect the air line to the air recirculation door air cylinder.
5. Remove the plugs from the refrigerant lines and the expansion valve. Install new O-rings and lubricate them with refrigerant oil. Apply Loctite 242 or 592 to the male fitting threads and connect the refrigerant lines to the expansion valve. Using two wrenches to avoid twisting the lines, tighten the connections to the value in **Table 1**.
6. Evacuate and charge the system with R-12. Refer to **Subject 250** for instructions. Be sure to add refrigerant oil to the compressor, to replace that which is lost when the system is discharged. Refer to the refrigerant compressor section elsewhere in this group.
7. Wipe clean the expansion valve and refrigerant lines, and wrap them with mastic insulating tape.
8. Connect the wire connectors to the blower motor resistor block and the thermostatic switch.
9. Connect the heater inlet and outlet hoses. Tighten the clamps securely.
10. On 120 Conventionals, install the lower center dash.
11. Install the radiator drain plug and fill the cooling system.
12. Connect the batteries.
13. Start the engine. When the engine thermostat(s) opens, air will be forced from the heater core as the coolant circulates. Check the coolant level again and fill as needed.
14. Install the dash skirt panels.

Outside Diameter for Metal Tube (in inches)	Torque for Steel Tubes * lbf·ft (N·m)	Torque for Aluminum or Copper Tubes lbf·ft (N·m)
1/4	10–15 (14–20)	5–7 (7–9)
3/8	30–35 (41–47)	11–13 (15–18)
1/2	30–35 (41–47)	15–20 (20–27)
5/8	30–35 (41–47)	21–27 (28–37)
3/4	30–35 (41–47)	28–33 (38–45)

* When tightening fittings, always use the torque reading for the softer metal when unlike metals are used.

Table 1, Refrigerant Line Torque Specifications

Heater Core Removal and Installation

Removal

1. Move the temperature slide lever to "WARM."

⚠ WARNING

WARNING: Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

2. With the engine cold, remove the cooling system drain plug, and drain the coolant into a clean container.
3. Disconnect the batteries.
4. On COEs, remove the ten screws securing the dash skirt panels on the right side of the cab. See **Fig. 1.**

   On 120 Conventionals:

   4.1 Remove the five screws securing the electrical access panel, and the nine screws (see **Fig. 2**) securing the dash skirt panels on the right side of the cab.

   4.2 Remove the twelve capscrews that secure the lower center dash. Allow the dash to hang from its wire connections.

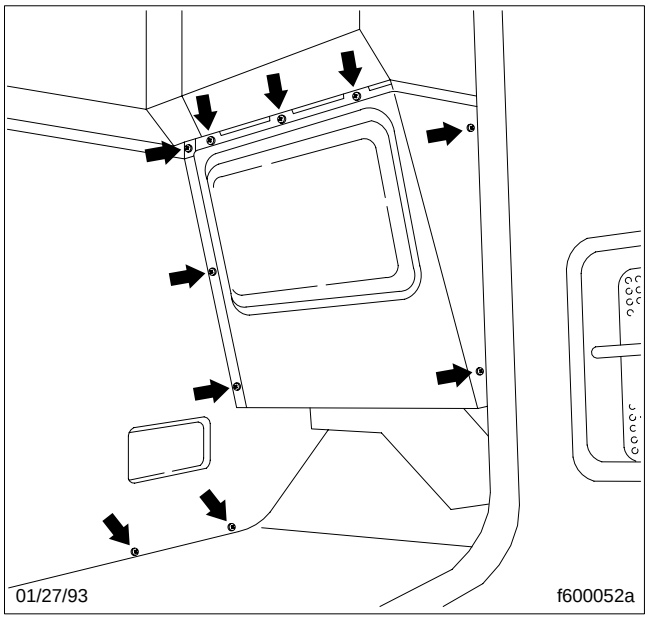


Fig. 1, COE Heater/Air-Conditioner Dash Skirt Panel Screws

5. Protect the carpeting with a shop towel, and loosen the clamps attaching the heater hoses to the heater core pipe elbows. See **Fig. 3.** Disconnect the heater inlet and outlet hoses.
6. If the thermostat sensor tube is present on the heater core cover (see **Fig. 4**), remove the mounting bracket (Ref. 3). Using a felt-tipped pen, mark the tube where it goes into the heater core, then carefully pull the tube out of the rubber grommet on the heater core cover.
7. Remove the five screws from the heater/ air-conditioner core cover. Remove the cover.

⚠ WARNING

WARNING: Failure to wear protective gloves could result in serious skin cuts due to the sharp edges on the heater core fins.

8. Wearing protective gloves, slide the heater core up and out, and remove it from the housing. See **Fig. 5.**

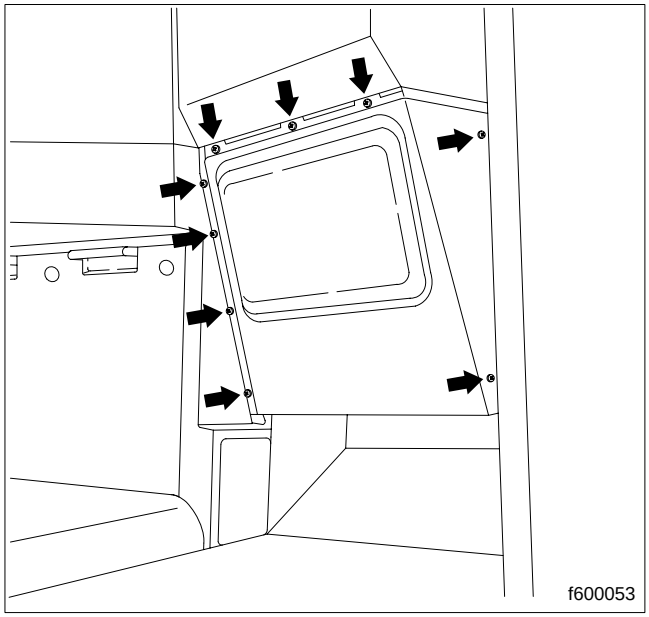


Fig. 2, 120 Conventional Heater/Air-Conditioner Dash Skirt Panel Screws

Installation

1. Wearing protective gloves, slide the heater core into the housing.

Heater Core Removal and Installation

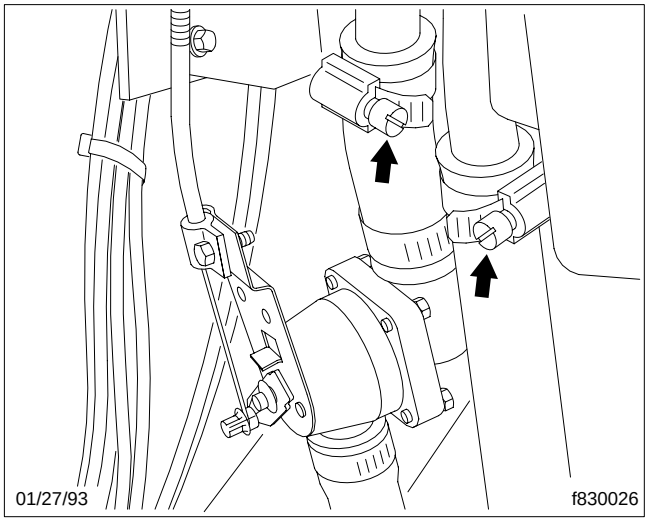
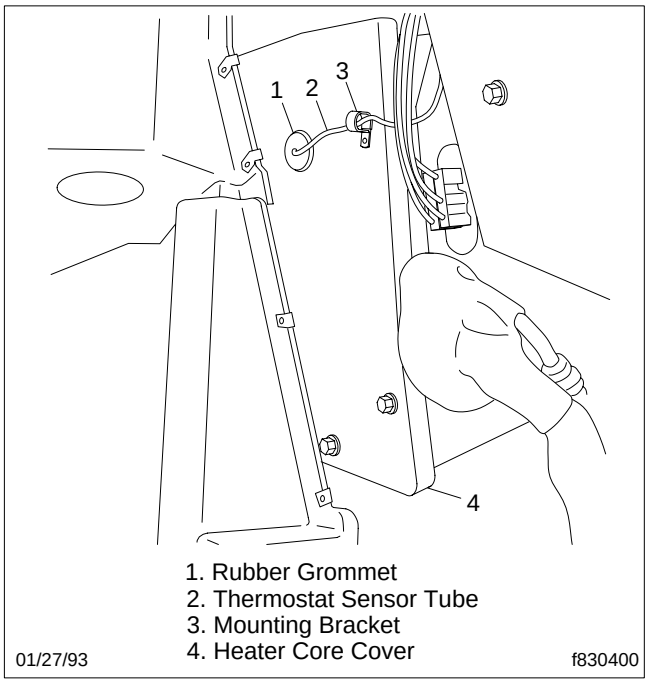


Fig. 3, Heater Core Inlet and Outlet Hose Connections



1. Rubber Grommet
2. Thermostat Sensor Tube
3. Mounting Bracket
4. Heater Core Cover

Fig. 4

⚠ CAUTION

CAUTION: Be careful when installing the thermostat sensor tube. Using too much force will bend the tube, which could damage it.

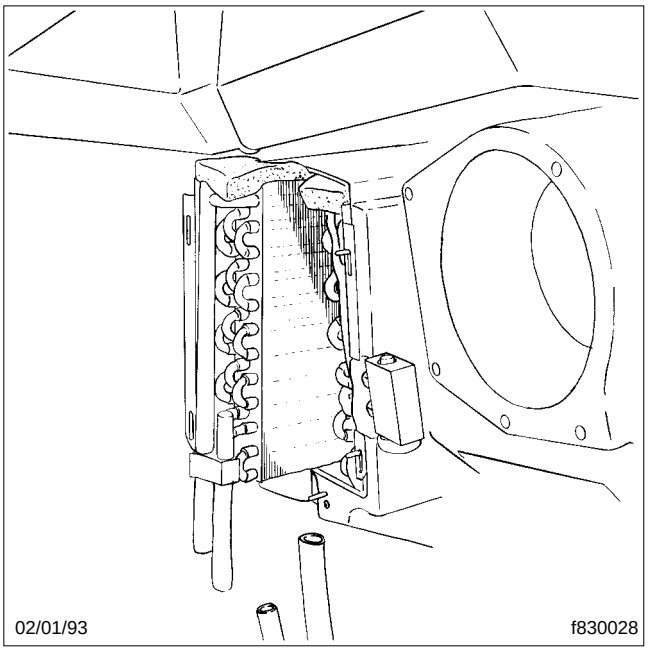


Fig. 5, Heater Core Partially Removed

If the thermostat sensor tube was routed through the heater core cover, carefully insert the sensor tube through the rubber grommet in the cover, then push the tube about 1 inch (25 mm) into the evaporator coil. While holding the heater core cover in place, insert the sensor tube into the evaporator coil—about 3 inches (76 mm), or at least as far as the felt-tip pen mark made during removal.

2. Install the heater core cover using the five screws removed earlier. Tighten the screws securely.

   On Conventionals, position the lower center dash and install the twelve capscrews. Tighten them firmly.
3. Connect the batteries.
4. Connect the heater inlet and outlet hoses to the heater core pipe elbows. Tighten the clamps securely.
5. Install the cooling system drain plug and fill the cooling system.
6. Start the engine. When the engine thermostat(s) opens, air will be forced from the heater core as the coolant circulates. Check the coolant level again and fill as needed.

7. On COEs, install the dash skirt panels.

   On Conventionals, install the center electrical panel access cover and the right dash skirt panels.

Blower Motor Removal and Installation

Removal

1. Turn off the ignition switch.

⚠ WARNING

WARNING: Failure to turn off the ignition switch could allow the blower motor to operate during repairs. This could result in personal injury or electrical shock.

2. On COEs, remove the eight screws securing the dash skirt panel on the right side of the cab. See **Fig. 1**.

   On 120 Conventionals, remove the nine screws securing the dash skirt panel on the right side of the cab. See **Fig. 2**.

3. Remove the five phillips-head machine screws from the blower motor cover. Then remove the cover. See **Fig. 3**.
4. Disconnect the blower motor wires.
5. Remove the three locknuts and washers (**Fig. 4**) from the studs on the blower motor bracket.
6. Lift the blower motor out of the housing by hand. See **Fig. 5**.

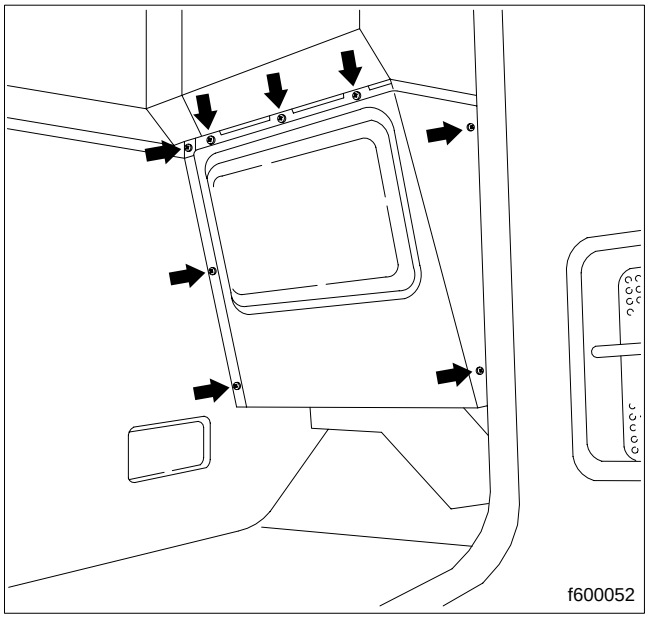


Fig. 1, COE Heater/Air-Conditioner Dash Skirt Panel Screws

Installation

1. Position the blower motor on the mounting bracket in the housing. Install the locknuts and flatwashers. Tighten the locknuts 30 lbf·in (340 N·cm).

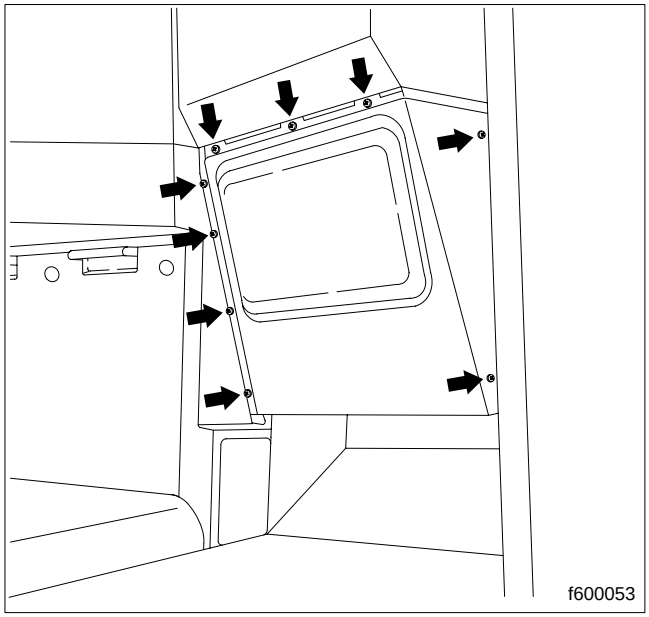


Fig. 2, 120 Conventional Heater/Air-Conditioner Dash Skirt Panel Screws

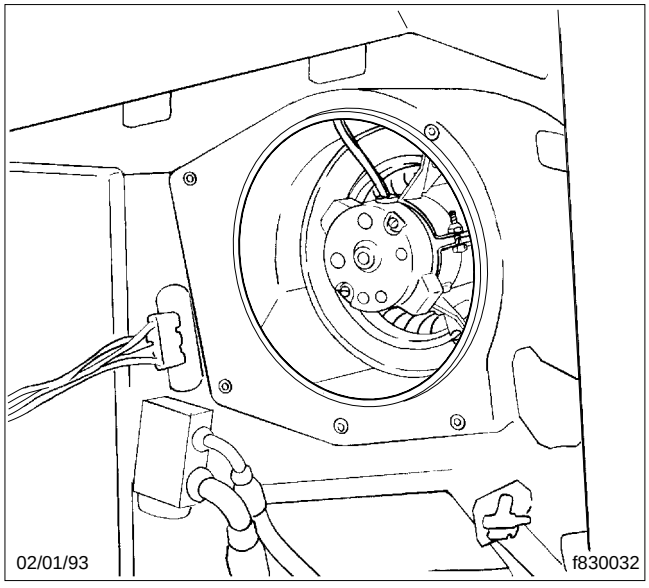


Fig. 3

Blower Motor Removal and Installation

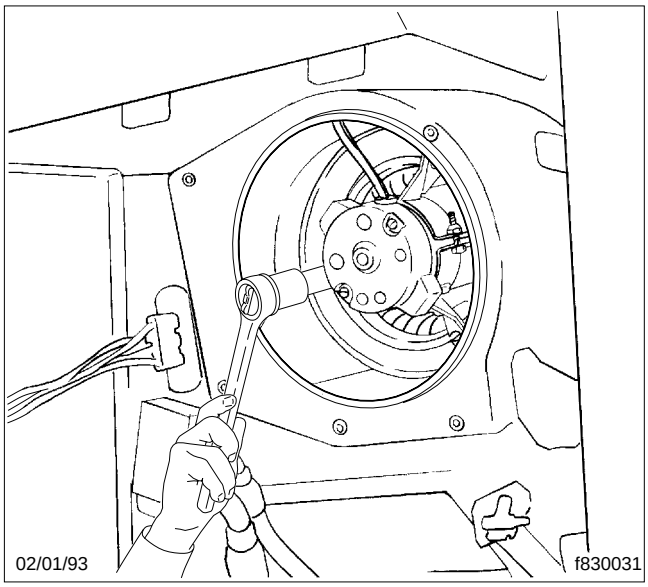


Fig. 4, Removing Locknuts

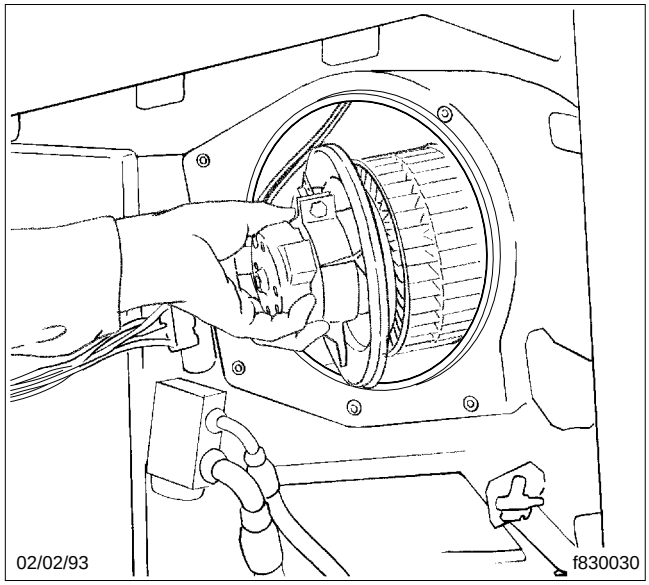


Fig. 5, Removing Blower Motor

2. Connect the blower motor wires.
3. Install the blower motor cover and secure it with the five phillips-head machine screws. Tighten the screws securely.
4. Turn on the ignition key and test the blower motor.
5. Install the dash skirt panel.

Bunk Blower Motor Removal and Installation, COE

Removal

1. Turn off the ignition switch.

⚠ WARNING

WARNING: Failure to turn off the ignition switch could allow the blower motor to operate during repairs. This could result in personal injury or electrical shock.

2. Open the right side baggage compartment door. Remove the three phillips-head machine screws, and the two clips, from the bunk blower motor access cover located in the bottom of the air duct. See **Fig. 1**. Remove the cover.
3. Remove the two locknuts, washers, and bolts from the blower motor support bracket. See **Fig. 2**. Remove the blower motor and bracket from the duct work.
4. Disconnect the blower motor wires.

Installation

1. Connect the wires to the bunk blower motor.
2. Position the blower motor and mounting brackets in the bunk duct. Install the nuts and flatwashers. Tighten the nuts 30 lbf·in (340 N·cm).
3. Install the blower motor cover using the two clips and three phillips-head machine screws. Tighten the screws securely.
4. Turn on the ignition switch and test the blower motor.

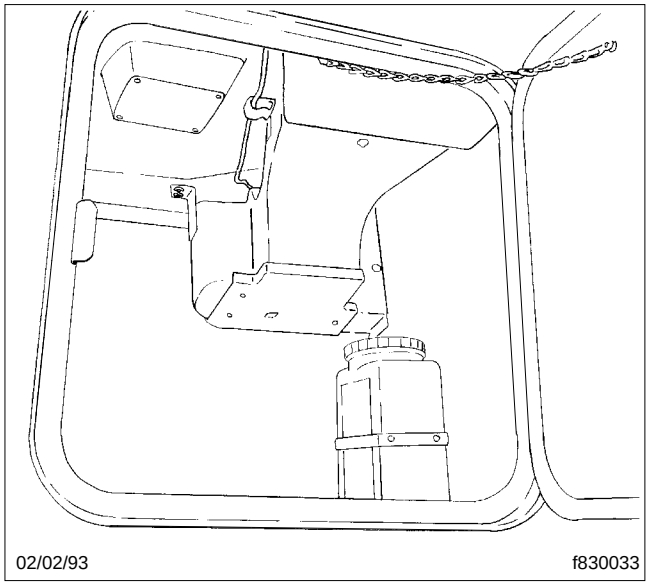


Fig. 1

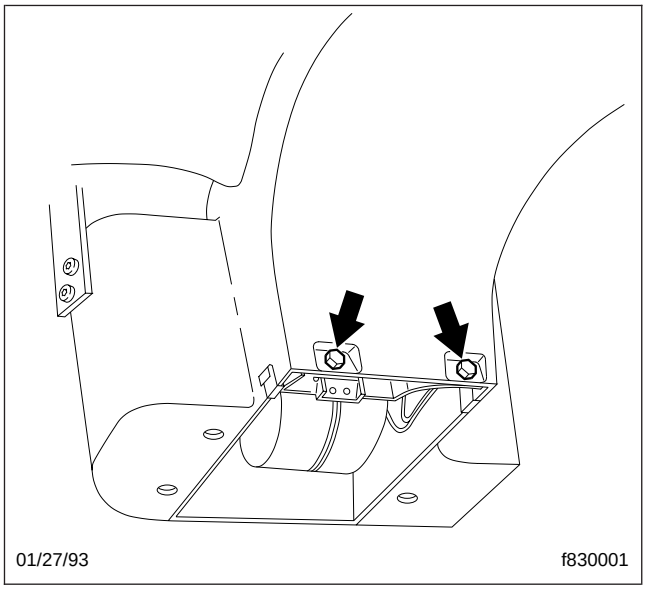


Fig. 2

Resistor Block Replacement

Replacement

CAUTION

CAUTION: Never try to bypass the fuse in the blower motor resistor block. To do so could cause the blower motor to overheat, resulting in serious damage to the heater/air-conditioning system.

1. Turn off the ignition switch.

WARNING

WARNING: Failure to turn off the ignition switch could allow the blower motor to operate during repairs. This could result in personal injury or electrical shock.

2. On COEs, remove the eight screws securing the dash skirt panel on the right side of the cab. See **Fig. 1.**

   On 120 Conventionals, remove the nine screws securing the dash skirt panel on the right side of the cab. See **Fig. 2**.
3. Disconnect the harness from the resistor block.
4. Remove the two locknuts from the studs, and lift out the resistor block. See **Fig. 3.**
5. Position the new resistor block on the mounting studs, and install the locknuts. Tighten the locknuts 30 lbf·in (340 N·cm).
6. Connect the wire harness.
7. Turn on the ignition key and test the blower motor.
8. Install the dash skirt panel.

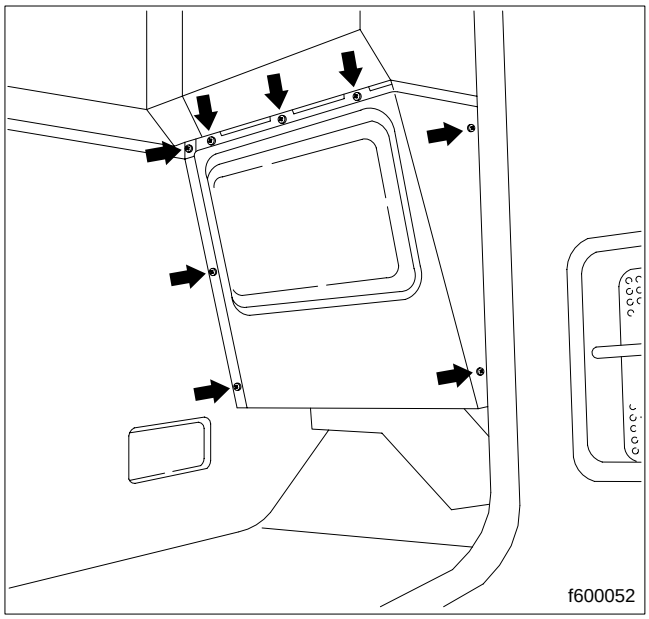


Fig. 1, COE Heater/Air-Conditioner Dash Skirt Panel Screws

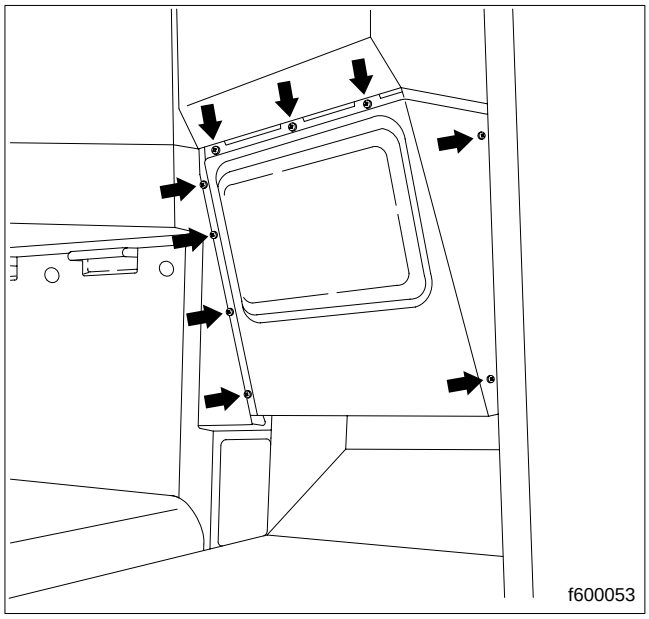


Fig. 2, 120 Conventional Heater/Air-Conditioner Dash Skirt Panel Screws

Resistor Block Replacement

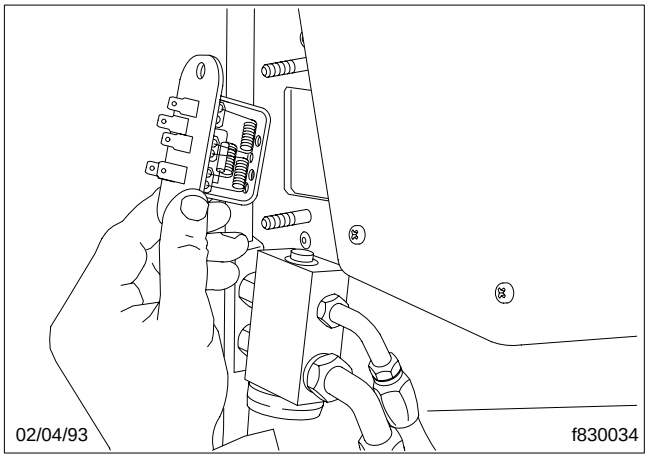


Fig. 3, Removing Resistor Block

Removal and Installation

FRESH AIR RECIRCULATION FLAP AIR CYLINDER

Removal

1. Move the slide lever to "DEF." This will cut off air pressure to the air cylinder.
2. On COEs, remove the eight screws securing the dash skirt panel on the right side of the cab. See **Fig. 1.**

   On 120 Conventionals, remove the nine screws securing the dash skirt panel on the right side of the cab. See **Fig. 2.**
3. Disconnect the air line from the air cylinder by pushing in the cover ring; then pull out the air line. See **Fig. 3.**
4. Remove one locknut or retainer clip from the upper rod, and the other locknut or retainer clip, from the recirculation flap rod. Remove the air cylinder by sliding it off the mounting rods. See **Fig. 4.**

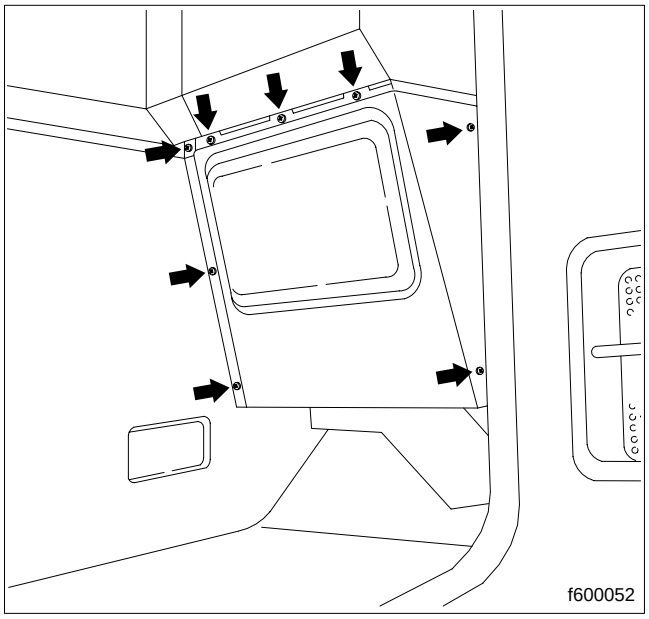


Fig. 1, COE Heater/Air-Conditioner Dash Skirt Panel

Installation

1. Place the air cylinder on the mounting rods, and install the locknuts or retainer clips. If so equipped, tighten the locknuts 30 lbf·in (340 N·cm).
2. Connect the air line to the air cylinder by pushing the air line into the fitting as far as it will go and then gently pulling the air line back to lock it in place.
3. Test the air cylinder by moving the slide lever from "DEF" to "MAX A/C." Be sure the flap works freely, has full movement, and seals completely.

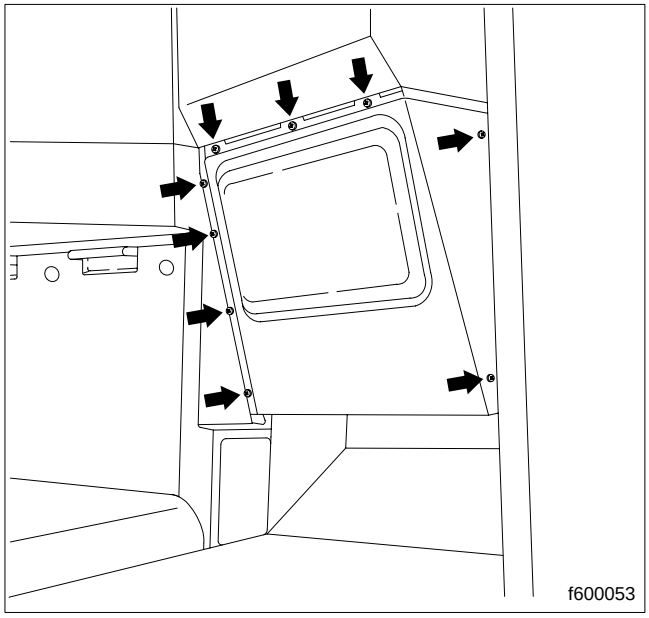


Fig. 2, 120 Conventional Heater/Air-Conditioner Dash Skirt Panel

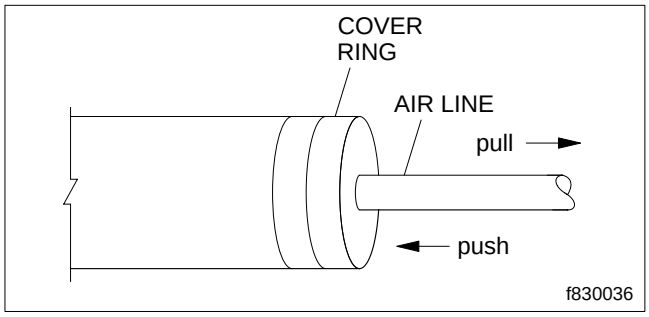


Fig. 3

4. Install the dash skirt panel.

Air Cylinder Removal and Installation

FACE-DUCT AIR CYLINDER (COE) (See Fig. 5)

Removal

1. Mark the two louvers and bezels (**Fig. 6**) on the right side of the instrument panel so they can be installed in the same position. Using a short, thin, flat-bladed screwdriver, remove the two louvers by gently prying the tabs that hold them in the bezels. Push the louvers into the duct, then rotate them to remove them from the bezel.

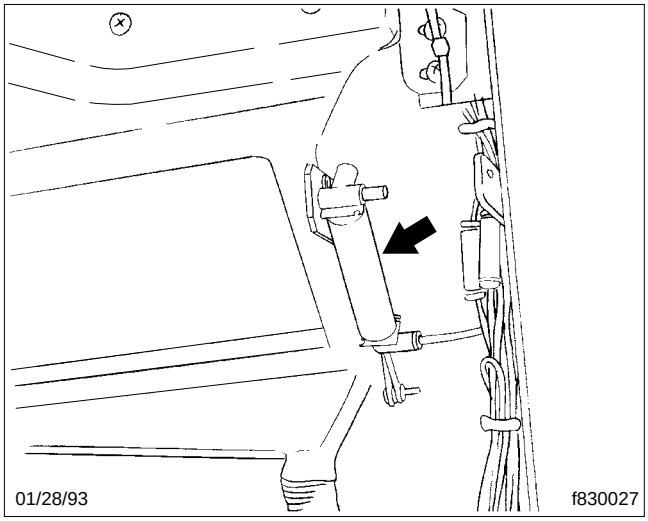


Fig. 4, Air Cylinder

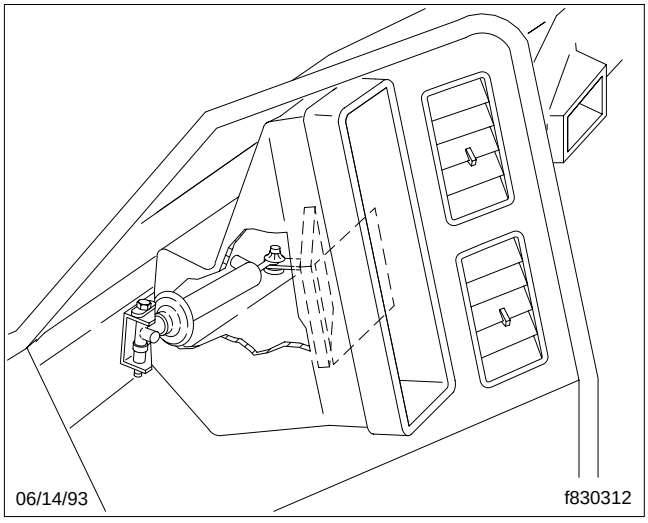


Fig. 5

2. Remove the B-section dash cover (**Fig. 7**) by removing the seven fasteners (either Torx or Phillips screws) and lifting the cover off the dash.
3. Move the slide lever to "DEF." This will cut off air pressure to the air cylinder.

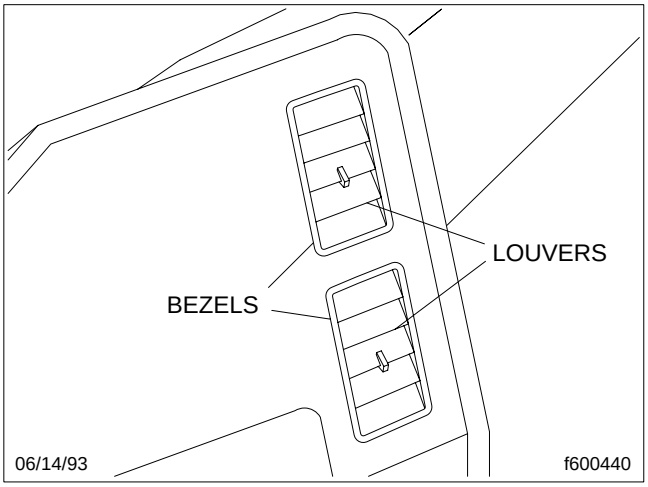


Fig. 6

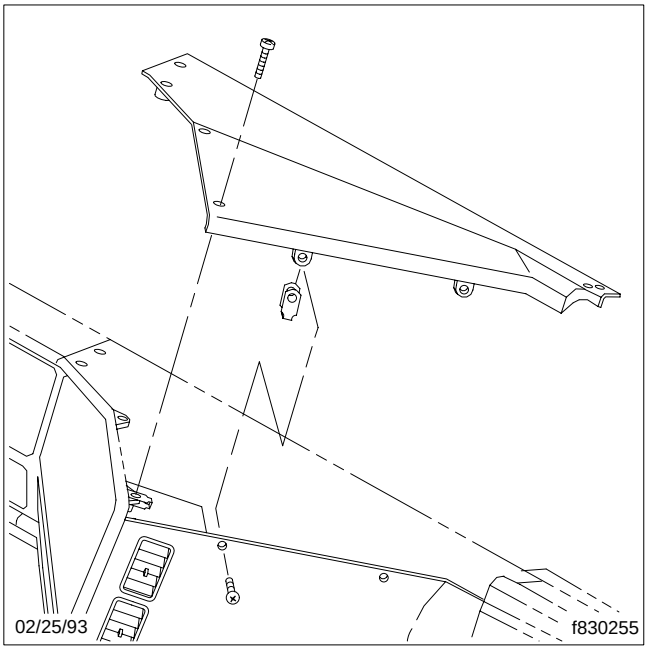


Fig. 7, Dash Cover

4. Using a long, flat-bladed screwdriver and a flashlight, reach into the duct and gently pry the push nut up and off the door rod end of the air cylinder. See **Fig. 8.**

5. To prevent the spacer that is below the air cylinder mounting boss from falling down into the dash, either tape the spacer or hold it by reaching down through the upper dash opening. Remove the bolt that attaches the left end of the cylinder to the mounting bracket. Remove the spacer. See **Fig. 8.**

NOTE: The cylinder is preloaded and will pop in slightly when the bolt is removed.

6. While holding the grommet in place with your right hand, gently remove the cylinder with your left hand by pulling it out of the duct to the left with a twisting motion.
7. Remove the air line from the cylinder by pushing in the blue cover ring and pulling out the line. See **Fig. 3.**

Installation

1. While holding on to the grommet, insert a new air cylinder through the grommet.

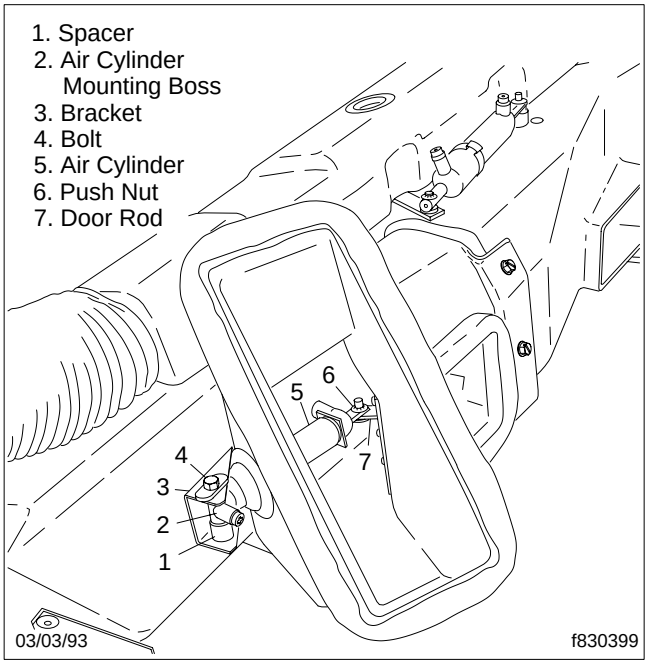


Fig. 8

2. Supply shop air to the cylinder to extend the piston rod. Then, hook the piston rod end onto the door pivot. Install a new push nut on the pivot.
3. Install the mounting bolt and spacer(s).
4. Connect the air line to the air cylinder by pushing the air line into the fitting as far as it will go and then gently pulling the air line back to lock it in place.
5. Test the air cylinder by moving the slide lever from "DEF" to "MAX A/C." Be sure the flaps work freely, have full movement, and seal completely.
6. Install the dash covers.
7. Install the louvers by inserting them in the duct and positioning them in the bezel as marked earlier. Then, pull them toward you to snap them in place.

OTHER AIR CYLINDERS

Removal

1. Move the slide lever to "DEF." This will cut off air pressure to the air cylinders.
2. Remove the center dash cover and locate the air cylinders. See **Fig. 9** and **Fig. 10**.
3. Disconnect the air lines from the air cylinders by pushing in the cover ring; then pull out the air line. See **Fig. 3.**

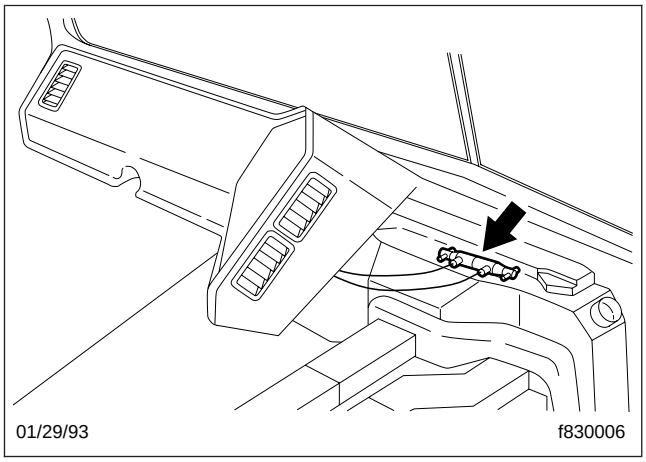


Fig. 9, Air Cylinder Location, COE

4. Remove the retainer clips from the stud and the flap rod. Remove the air cylinder by sliding it off the mounting rods.

Installation

1. Place the air cylinder on the mounting rods, and install the retainer clips.

Air Cylinder Removal and Installation

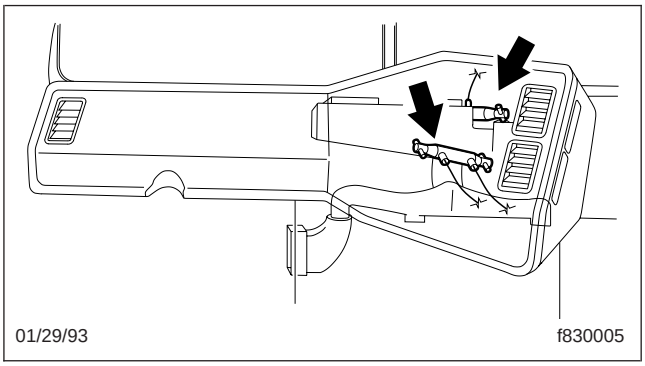


Fig. 10, Air Cylinder Location, Conventional

2. Connect the air lines to the air cylinders by pushing the air line into the fitting as far as it will go and then gently pulling the air line back to lock it in place.
3. Test the air cylinders by moving the slide lever from "DEF" to "MAX A/C." Be sure the flaps work freely, have full movement, and seal completely.
4. Install the center dash covers.

Water Regulating Valve Removal and Installation

Removal

1. Move the temperature slide lever to "WARM."

⚠ WARNING

WARNING: Do not drain the cooling system while the engine is hot. To avoid personal injury from scalding coolant, wait until the engine has cooled before draining the system.

2. With the engine cold, remove the cooling system drain plug, and drain the coolant into a clean container.
3. On COEs, remove the five screws securing the dash skirt panel on the right side of the tunnel. See **Fig. 1.**

   On 120 Conventionals, remove the five screws securing the electrical panel access panel and the four screws (**Fig. 2**) securing the dash skirt corner piece.
4. Protect the carpeting with a shop towel, and loosen the clamps attaching the heater hoses to the water regulating valve. See **Fig. 3.** Disconnect the hoses from the valve.
5. Loosen the temperature slide lever cable clamp. See **Fig. 4.**
6. Loosen the keeper (see **Fig. 4**) that attaches the control cable to the water regulating valve rod. Then slip the cable off the end of the rod.
7. Remove the valve.

Installation

1. Connect the heater hoses to the water regulating valve. Don't tighten the clamps at this time.
2. Feed the water regulating valve cable through the clamp and slip the end of the cable over the rod. Using the keeper, secure the end and tighten the cable clamp securely.
3. Tighten the hose clamps securely.
4. Move the temperature slide lever to "COOL." The water regulating valve should close completely. Slide the lever to "WARM." The valve should open. The travel of the lever should be smooth, and should travel the full distance on the control panel. If it doesn't, turn the adjustment turnbuckle (**Fig. 5**) in the direction necessary to get full travel.
5. Install the cooling system drain plug and fill the cooling system.

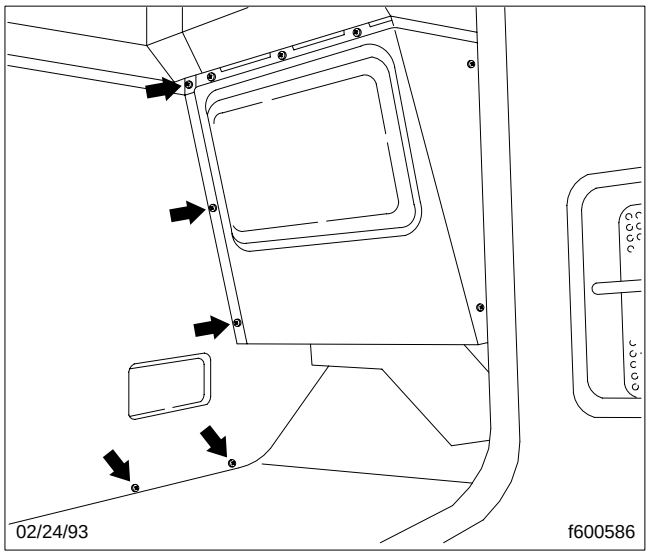


Fig. 1, Remove Dash Skirt Panel Screws, COE

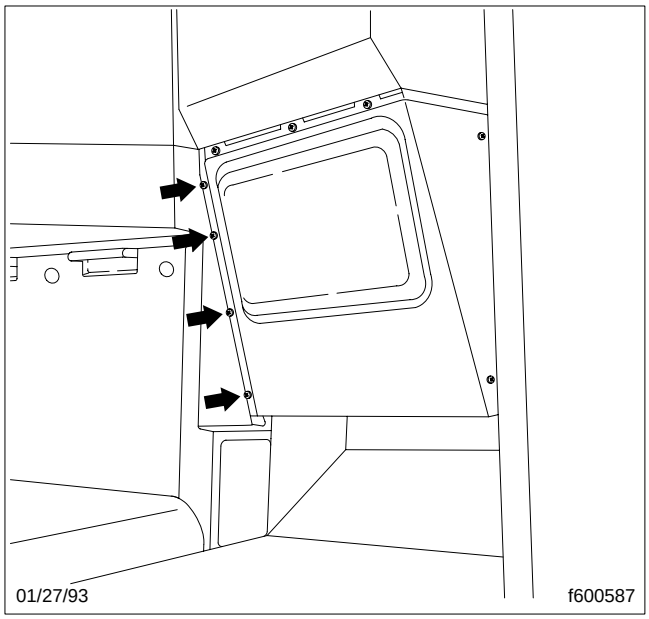


Fig. 2, Remove Dash Skirt Panel Screws, 120 Conventional

Water Regulating Valve Removal and Installation

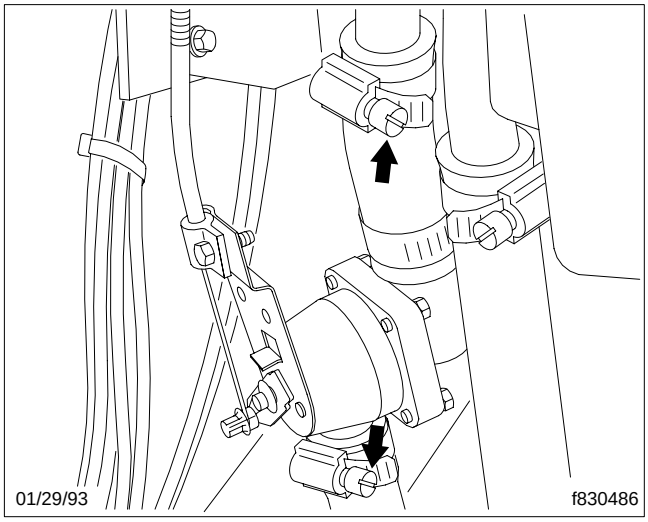


Fig. 3, Loosen Hose Clamps

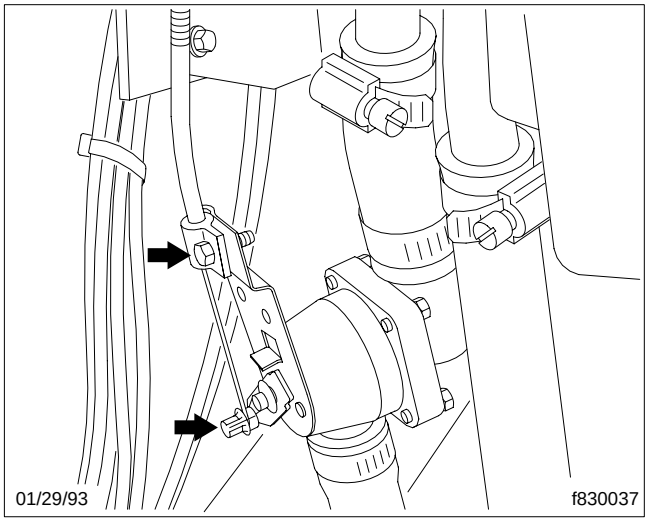


Fig. 4

6. Start the engine. When the engine thermostat(s) opens, air will be forced from the heater core as the coolant circulates. Check the coolant level again and fill again as needed.
7. Check for leaks around the water regulating valve and correct the cause.
8. Install the dash skirt panel.

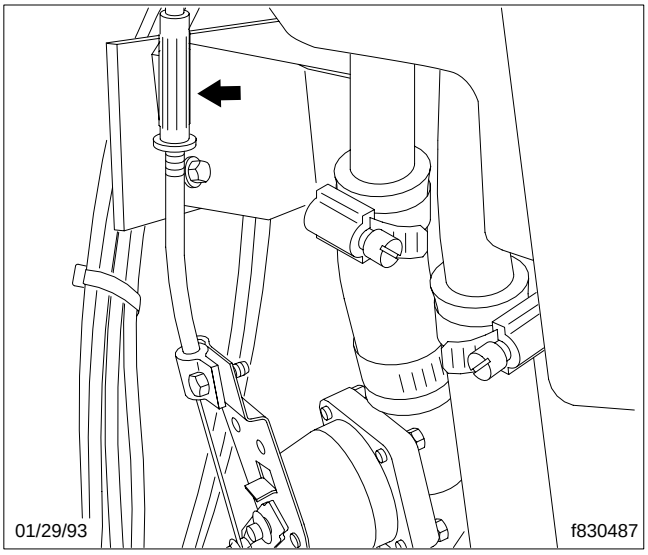


Fig. 5, Water Regulating Valve Cable Turnbuckle

Water Regulating Valve Cable Replacement

Replacement

1. Pull off the slide lever control knobs.
2. Remove the six screws attaching the control panel to the dash. See **Fig. 1.** Move the panel away from the dash.
3. Remove the four machine screws attaching the slide lever controls. See **Fig. 2.** Slide the unit to the side and pull it out of the dash as far as the cable will permit.

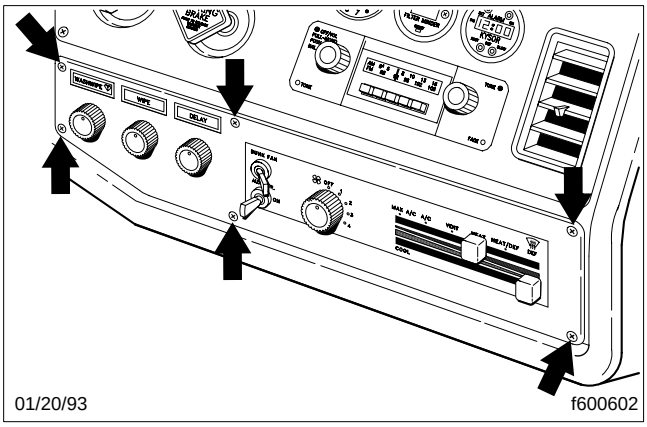


Fig. 1, Remove Control Panel Screws

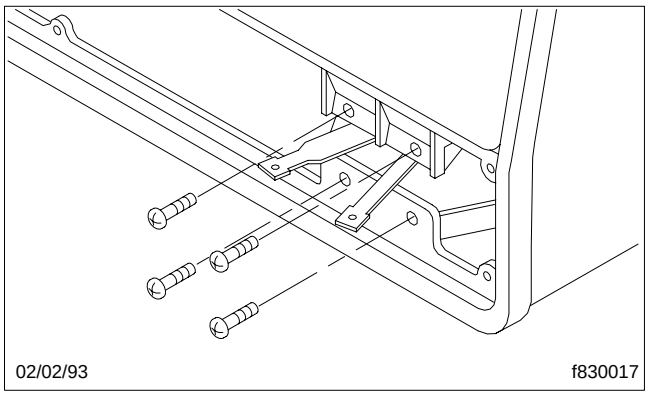


Fig. 2

4. Loosen the cable clamp screw (**Fig. 3**), then detach the cable from the slide lever.
5. On COEs, remove the five screws securing the dash skirt panel on the right side of the tunnel. See **Fig. 4.**

   On 120 Conventionals, remove the five screws securing the electrical panel access panel and the four screws securing the dash skirt corner piece. See **Fig. 5.**

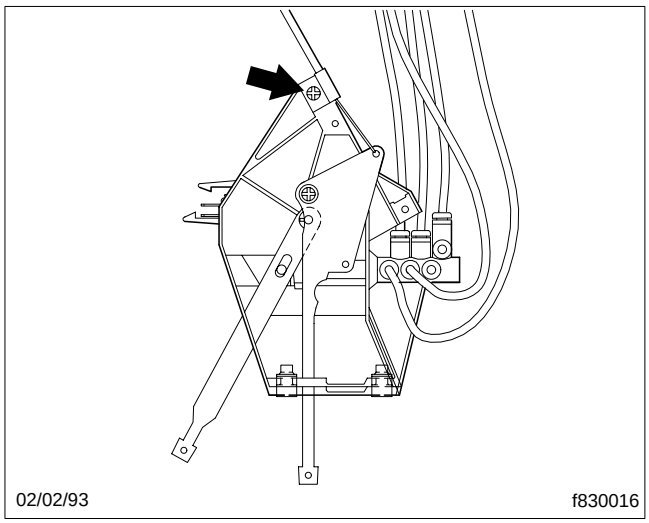


Fig. 3

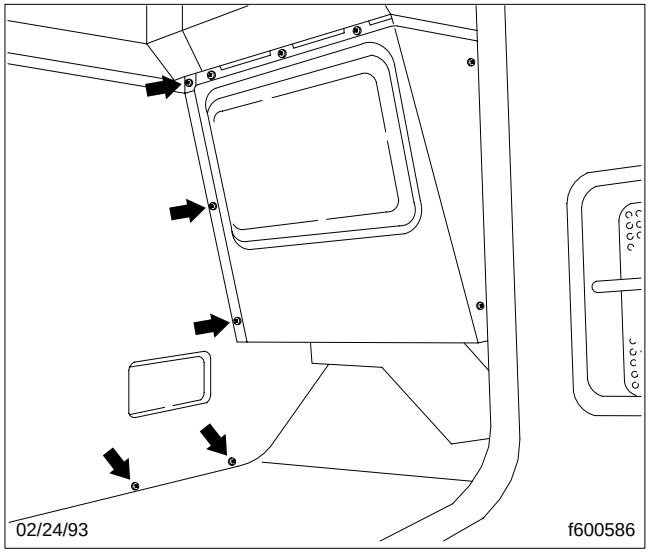


Fig. 4, Remove Dash Skirt Panel Screws, COE

6. Loosen the control cable clamp (**Fig. 6**).
7. Loosen the keeper (see **Fig. 6**) that attaches the cable to the water regulating valve rod. Slip the cable off the end of the rod.
8. Pull the cable out of the dash.
9. Feed the replacement cable through the dash and through the clamp. Slip the end of the cable

Water Regulating Valve Cable Replacement

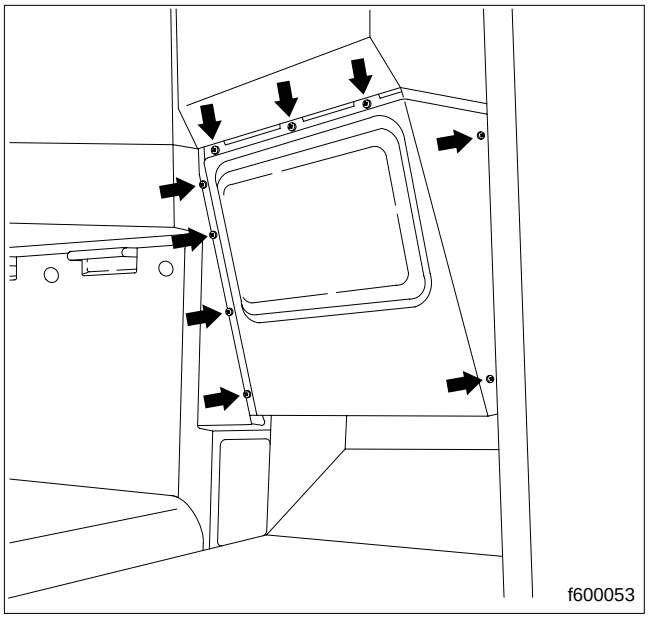


Fig. 5, Remove Dash Skirt Panel Screws, 120 Conventional

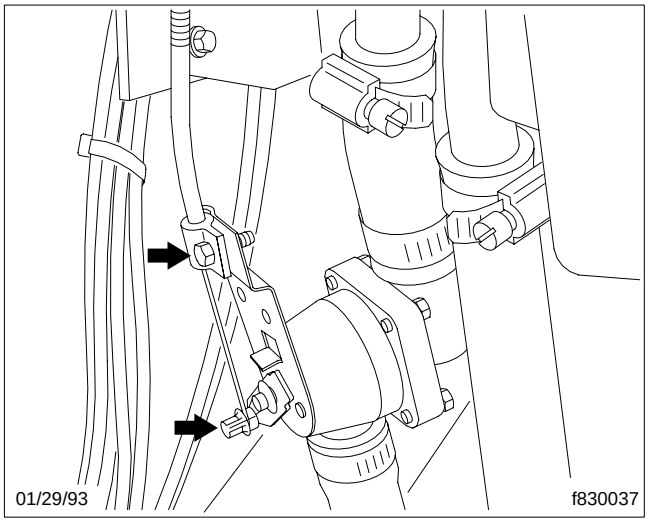


Fig. 6

over the water regulating valve rod. Secure the end using the keeper and tighten the cable clamp securely.

10. At the other end of the cable, feed the end of the cable through the cable clamp and hook the end on the slide lever. Tighten the cable clamp securely.
11. Using the four machine screws, install the slide lever control unit.
12. Using the six screws, install the control panel.
13. Install the slide lever control knobs.
14. Move the temperature slide lever to "COOL." The water valve should close completely. Slide the control lever to "WARM." The valve should open. The travel of the slide lever should be smooth and should travel the full distance on the control panel. If it doesn't, turn the adjustment turnbuckle (**Fig. 7**) in the direction necessary to get full travel.
15. Install the dash skirt panel.

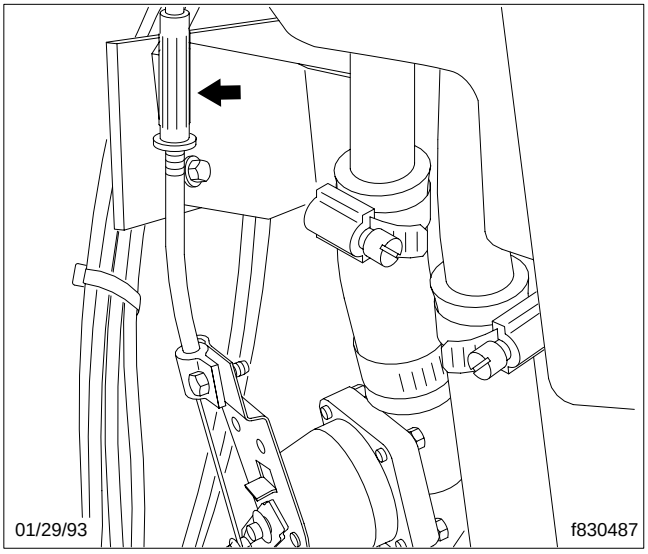


Fig. 7, Water Regulating Valve Cover Turnbuckle

Evaporator Coil Removal and Installation

Removal

IMPORTANT: Before replacing any refrigerant parts, read **Subject 250**. If the system is contaminated, purge or flush it before you install replacement parts.

NOTE: Whenever a refrigerant line is disconnected, replace the rubber O-ring. Lubricate the new O-ring with refrigerant oil and apply Loctite® 242 or 592 to the male fitting threads before connecting the lines.

Do not disconnect or connect refrigerant fittings using only one wrench. Hold one fitting in place using a wrench, and turn the other fitting using a second wrench.

1. Disconnect the batteries.
2. On COEs, remove the ten screws securing the dash skirt panels on the right side of the cab. See **Fig. 1.**

   On 120 Conventionals:

   2.1 Remove the five screws securing the electrical access panel and the nine screws (see **Fig. 2**) securing the dash skirt panels on the right side of the cab.

   2.2 Remove the twelve phillips-head capscrews securing the lower center dash. Allow the dash to hang from its wire connections.
3. Remove the five screws from the heater/air-conditioner core cover. Remove the cover. See **Fig. 3.**
4. Remove the mastic insulating tape from around the expansion valve.
5. Review the information under **Safety Precautions, 100**.

⚠ WARNING

WARNING: Failure to review the safety precautions, and to be aware of the dangers involved when working with refrigerant, could result in serious personal injury.

6. Wearing protective goggles and gloves, discharge the refrigerant system. For instructions, refer to **Subject 250**.
7. Using two wrenches to avoid twisting the tubing, disconnect the evaporator coil lines from the expansion valve. Install plugs in the lines and the expansion valve ports.

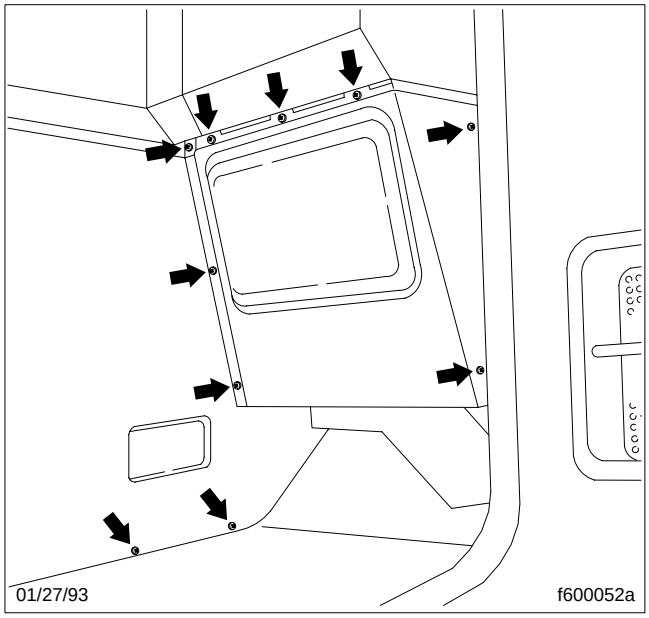


Fig. 1, COE Heater/Air-Conditioner Dash Skirt Panel Screws

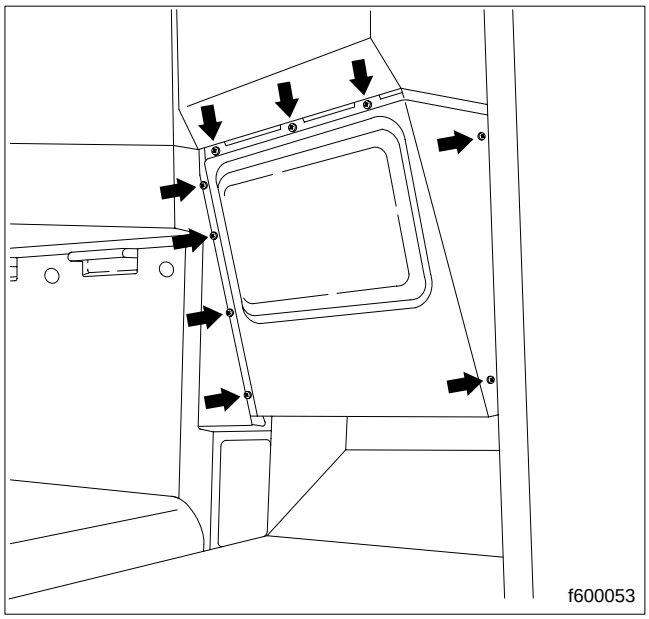


Fig. 2, 120 Conventional Heater/Air-Conditioner Dash Skirt Panel Screws

Evaporator Coil Removal and Installation

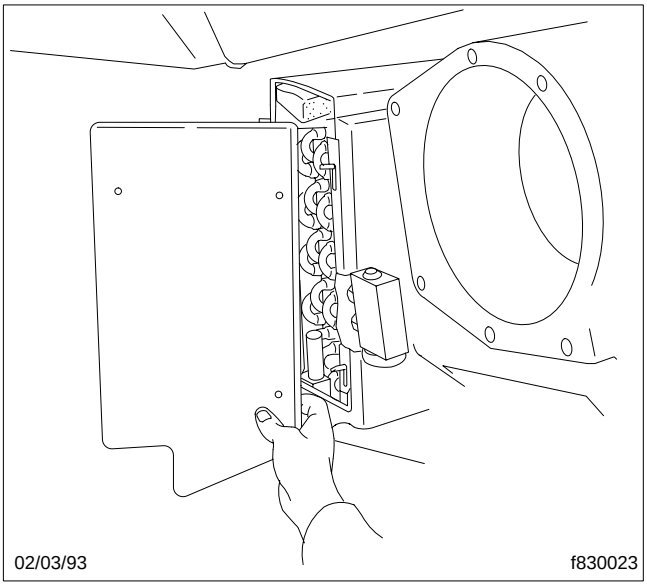


Fig. 3, Removing the Cover

CAUTION

CAUTION: Water and dirt can damage the refrigerant system. Five minutes of not being capped is the limit for any hose or component. Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

8. Remove the thermostatic switch sensor tube from the evaporator coil.

WARNING

WARNING: Failure to wear protective gloves could result in serious skin cuts due to the sharp edges on the evaporator coil fins.

9. Wearing protective gloves, slide the evaporator coil up and out of the housing.

Installation

1. Wearing protective gloves, slide the evaporator coil into the housing.
2. Insert the thermostatic switch sensor tube into the same hole from which it was removed. The tip of the sensor tube must be in direct contact with a fin and be inserted at least 4 inches (10 cm) into the evaporator.
3. Remove the plugs from the evaporator coil lines and the expansion valve. Install new O-rings and apply refrigerant oil to the threads and O-rings, and connect the lines to the expansion valve. Using two wrenches to avoid twisting the tubing, tighten the evaporator hoses 18 lbf·ft (24 N·m). Tighten the large hose to the compressor 24 lbf·ft (33 N·m); and tighten the small hose from the receiver-drier 12 lbf·ft (17 N·m).
4. Evacuate and charge the system with refrigerant. Refer to **Subject 250** for instructions. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is discharged; refer to the refrigerant compressor section elsewhere in this group.
5. Wipe the expansion valve and refrigerant line connections clean, and wrap them with mastic insulating tape.
6. On COEs, install the heater and air conditioner core cover and secure it with the five screws. Tighten the screws securely.

   On Conventionals:

   6.1 Install the heater/air-conditioner core cover and secure it with the five screws. Tighten the screws securely.

   6.2 Position the lower center dash and install the twelve capscrews. Tighten the capscrews securely.
7. On COEs, install the dash skirts.

   On Conventionals, install the electrical access panel and the right dash skirt panels.
8. Connect the batteries.

Expansion Valve Removal and Installation

Removal

IMPORTANT: Before replacing any refrigerant parts, read **Subject 250**. If the system is contaminated, purge or flush it before you install replacement parts.

NOTE: Whenever a refrigerant line is disconnected, replace the rubber O-ring. Lubricate the new O-ring with refrigerant oil and apply Loctite® 242 or 592 to the male fitting threads before connecting the lines.

Do not disconnect or connect refrigerant fittings using only one wrench. Hold one fitting in place using a wrench, and turn the other fitting with a second wrench.

1. On COEs, remove the eight screws securing the dash skirt panel on the right side of the cab. See **Fig. 1**.

   On 120 Conventionals, remove the nine screws securing the dash skirt panel on the right side of the cab. See **Fig. 2**.

2. Review the information under **Safety Precautions, 100**.

⚠ WARNING

WARNING: Failure to review the safety precautions, and to be aware of the dangers involved when working with refrigerant, could result in serious personal injury.

3. Wearing protective goggles and gloves, discharge the refrigerant system. For instructions, refer to **Subject 250**.
4. Remove the mastic insulating tape from around the expansion valve.
5. Using two wrenches, to avoid twisting the tubing, disconnect the refrigerant lines and the evaporator coil inlet and outlet lines from the expansion valve. Install plugs in the refrigerant lines. Remove the expansion valve.

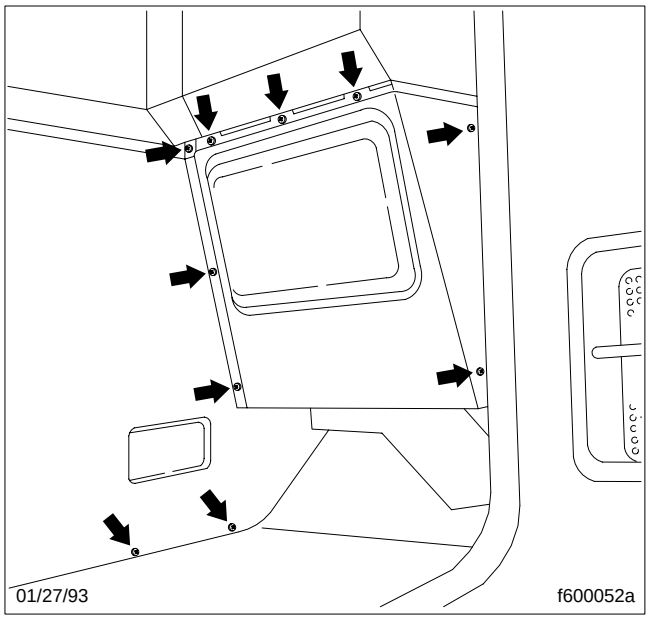


Fig. 1, COE Heater/Air-Conditioner Dash Skirt Panel Screws

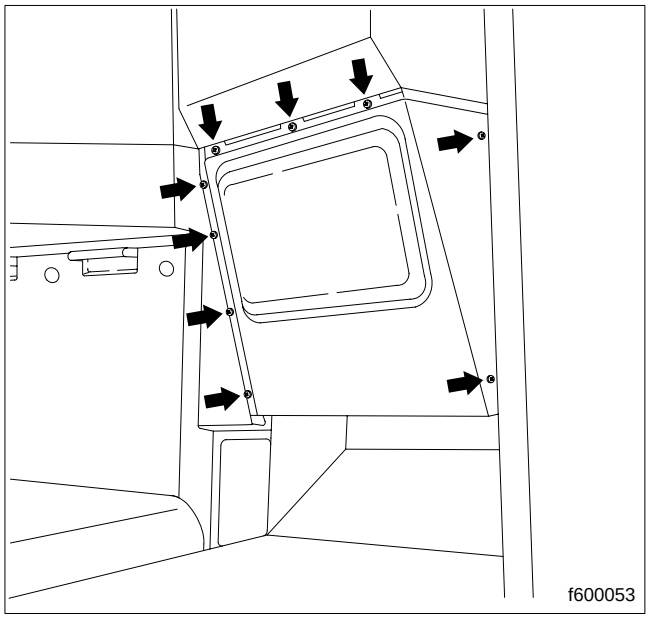


Fig. 2, 120 Conventional Heater/Air-Conditioner Dash Skirt Panel Screws

⚠ CAUTION

CAUTION: Water and dirt can damage the refrigerant system. Five minutes of not being capped is the limit for any hose or component. Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

Expansion Valve Removal and Installation

Installation

1. Remove the plugs from the refrigerant lines and the new expansion valve. Install new

   O-rings and lubricate them with refrigerant oil. Apply Loctite 242 or 592 to the male fitting threads and connect the refrigerant lines to the expansion valve. Using two wrenches to avoid twisting the tubing, tighten the evaporator lines 18 lbf·ft (24 N·m). Tighten the large hose to the compressor 24 lbf·ft (33 N·m); tighten the small hose from the receiver-drier 12 lbf·ft (17 N·m).
2. Evacuate and charge the system with refrigerant. Refer to **Subject 250** for instructions. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is discharged; refer to the refrigerant compressor section in this manual.
3. Wipe the expansion valve and refrigerant line connections clean, and wrap them with mastic insulating tape.
4. Install the dash skirt panel.

Receiver-Drier Removal and Installation

Removal

IMPORTANT: Before replacing any refrigerant parts, read **Subject 250**. If the system is contaminated, purge or flush it before you install replacement parts.

NOTE: Whenever a refrigerant line is disconnected, replace the rubber O-ring. Lubricate the new O-ring with refrigerant oil and apply Loctite® 242 or 592 to the male fitting threads before connecting the lines.

Do not disconnect or connect refrigerant fittings using only one wrench. Hold one fitting in place using a wrench, and turn the other fitting with a second wrench.

The receiver-drier and moisture indicator are one unit, and cannot be replaced separately.

1. On COEs, tilt the cab. Refer to the vehicle driver's manual for instructions. On 120 Conventionals, tilt the hood.
2. Review the information under **Safety Precautions, 100**.

⚠ WARNING

WARNING: Failure to review the safety precautions, and to be aware of the dangers involved when working with refrigerant, could result in serious personal injury.

3. Wearing protective goggles and gloves, discharge the refrigerant system. For instructions, refer to **Subject 250**.
4. After the system is completely discharged, disconnect the refrigerant lines from the receiver-drier, using two wrenches to avoid twisting the tubing. Install plugs in the refrigerant lines.

⚠ CAUTION

CAUTION: Water and dirt can damage the refrigerant system. Five minutes of not being capped is the limit for any hose or component. Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

IMPORTANT: If the desiccant cartridge inside the receiver-drier has fallen apart, flush the entire system and replace the expansion valve and the refrigerant compressor (desiccant matter can't be removed from these parts). A cartridge may fall apart from too much water in the system, because of poor evacuation of the system, or lack of maintenance.

5. If equipped with a fan cycle switch, disconnect the harness connectors and unscrew the switch from the Schrader valve on the receiver-drier. Save the switch for later use.
6. Loosen the hose clamp assembly (see **Fig. 1**) attaching the receiver-drier to the mounting bracket; and remove the receiver-drier.

Installation

1. Position the receiver-drier in the mounting bracket. Tighten the hose clamp securely.
2. Remove the plugs from the refrigerant lines and the line ports on the new receiver-drier. Install new O-rings and apply refrigerant oil to them. Apply Loctite 242 or 592 to the male fitting threads and connect the refrigerant lines to the receiver-drier. Using two wrenches to avoid twisting the tubing, tighten the connections to the value in **Table 1**.

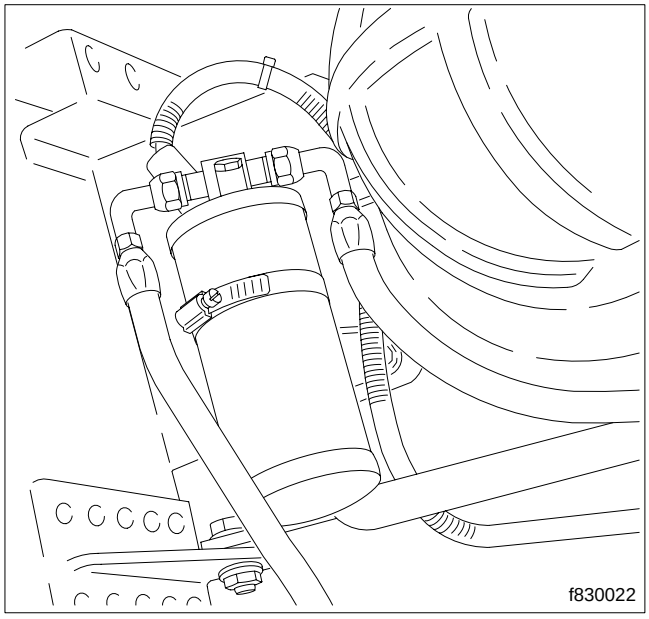


Fig. 1, Receiver-Drier

Receiver-Drier Removal and Installation

3. If equipped with a fan cycle switch, apply Loctite 242 or 592 to the male threads of the Schrader valve. Install the fan cycle switch, and tighten it 108 lbf·in (1220 N·cm) or one-eighth turn past hand-tight. Connect the wiring harness to the switch.
4. Charge the system with refrigerant. Refer to **Subject 250** for instructions. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is discharged; refer to the refrigerant compressor section in this manual.
5. Lower the cab or hood to the operating position. Refer to the vehicle driver's manual for instructions.

Outside Diameter for Metal Tube (in inches)	Torque for Steel Tubes * lbf·ft (N·m)	Torque for Aluminum or Copper Tubes lbf·ft (N·m)
1/4	10–15 (14–20)	5–7 (7–9)
3/8	30–35 (41–47)	11–13 (15–18)
1/2	30–35 (41–47)	15–20 (20–27)
5/8	30–35 (41–47)	21–27 (28–37)
3/4	30–35 (41–47)	28–33 (38–45)

* When tightening fittings, always use the torque reading for the softer metal when unlike metals are used.

Table 1, Refrigerant Line Torque Specifications

Fan Cycling Switch Removal and Installation

Removal

IMPORTANT: Before replacing any refrigerant parts, refer to **Subject 250**. If the system is contaminated, purge or flush it before you install replacement parts.

1. On COEs , tilt the cab. Refer to the vehicle driver's manual for instructions.

   On 120 Conventionals, tilt the hood.

2. Review the information under **Safety Precautions, 100**.

⚠ WARNING

WARNING: Failure to review the safety precautions, and to be aware of the dangers involved when working with refrigerant, could result in serious personal injury.

3. Disconnect the harness connectors and unscrew the switch from the Schrader valve on the receiver-drier. **See Fig. 1.** Save the switch for later use.

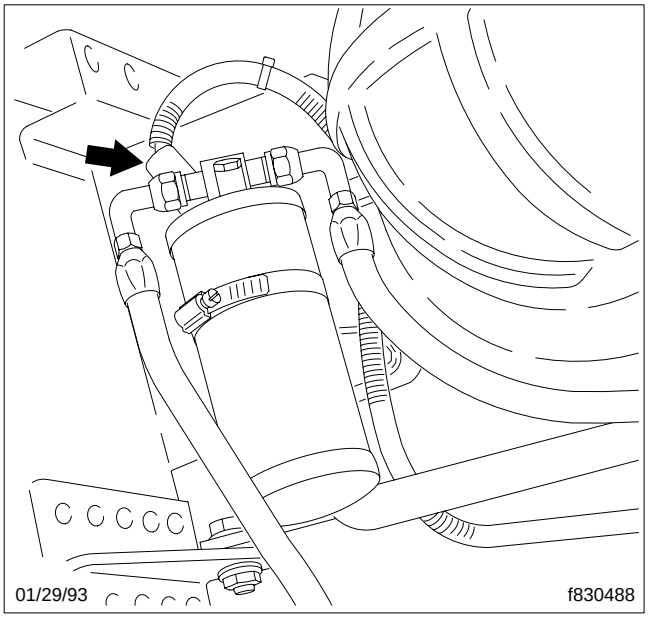


Fig. 1, Fan Cycling Switch

Installation

1. Coat the male threads of the fan cycling switch with Loctite® 242 or 592. Install the fan cycling switch on the Schrader valve on the receiver-drier. Tighten the switch 108 lbf·in (1220 N·cm).
2. Connect the wiring harness to the switch.
3. Check the system charge and charge the system with R-12 if needed. Refer to **Subject 250** for instructions.
4. On COEs, return the cab to the operating position. Refer to the vehicle driver's manual for instructions.

   On 120 Conventionals, return the hood to the operating position.

Condenser Removal and Installation

Removal (See Fig. 1 and Fig. 2)

1. Tilt the cab assembly or hood. Refer to the vehicle driver's manual for instructions.
2. Review the information under **Safety Precautions, 100**.

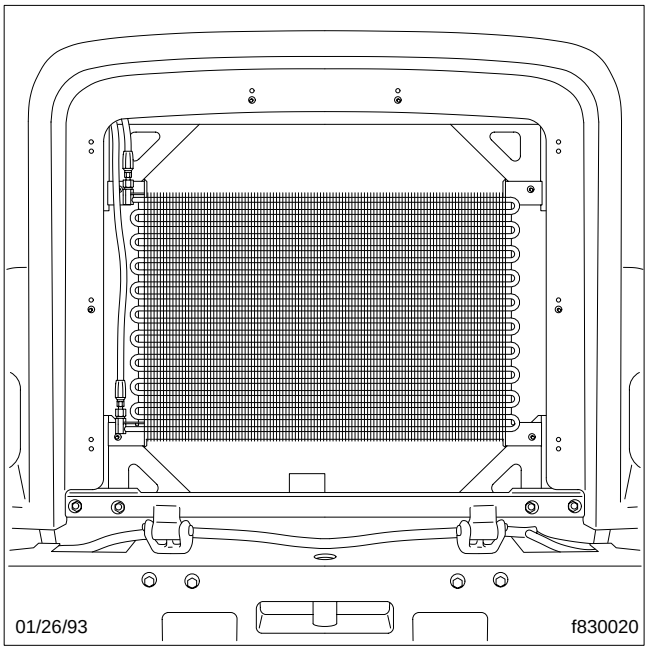


Fig. 1, Condenser

⚠ WARNING

WARNING: Failure to review the safety precautions, and to be aware of the dangers involved when working with refrigerant, could result in serious personal injury.

3. Wearing protective goggles and gloves, discharge the refrigerant system. For instructions, refer to **Subject 250**.
4. After the system is completely discharged, disconnect the refrigerant lines at the condenser; use two wrenches to avoid twisting the lines. Install plugs in the refrigerant lines and the condenser parts.

⚠ CAUTION

CAUTION: Water and dirt can damage the refrigerant system. Five minutes of not being capped

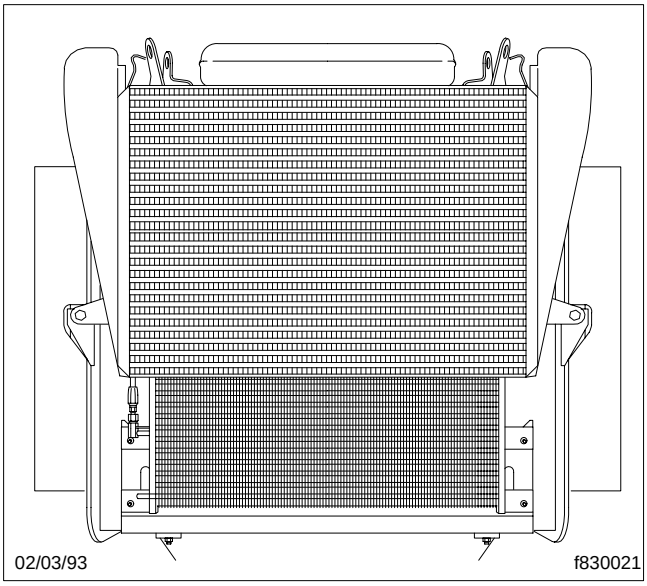


Fig. 2, Condenser and Air-to-Air Aftercooler

is the limit for any hose or component. Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

5. Remove the capscrews attaching the condenser to the radiator, and remove the condenser.

Installation

1. Place the condenser on the radiator. Install and tighten the capscrews 108 lbf·in (1220 N·cm).
2. Remove the plugs from the refrigerant lines and the condenser. Install new O-rings and apply refrigerant oil to them. Apply Loctite® 242 or 592 to the male fitting threads and connect the refrigerant lines to the condenser. Using two wrenches to avoid twisting the tubing, tighten the connections to the values in **Table 1**.
3. Charge the system with refrigerant. Refer to **Subject 250** for instructions.
4. Add refrigerant oil to the compressor to replace that which is lost in the old condenser. Refer to the refrigerant compressor section in this manual.

Condenser Removal and Installation

Outside Diameter for Metal Tube (in inches)	Torque for Steel Tubes * lbf·ft (N·m)	Torque for Aluminum or Copper Tubes lbf·ft (N·m)
1/4	10–15 (14–20)	5–7 (7–9)
3/8	30–35 (41–47)	11–13 (15–18)
1/2	30–35 (41–47)	15–20 (20–27)
5/8	30–35 (41–47)	21–27 (28–37)
3/4	30–35 (41–47)	28–33 (38–45)

* When tightening fittings, always use the torque reading for the softer metal when unlike metals are used.

Table 1, Refrigerant Line Torque Specifications

Low Pressure Switch Removal and Installation

Removal

IMPORTANT: Before replacing any refrigerant parts, refer to **Subject 250**. If the system is contaminated, purge or flush it before you install replacement parts.

1. On COEs, tilt the cab. Refer to the vehicle driver's manual for instructions.

   On 120 Conventionals, tilt the hood.

2. Review the information under **Safety Precautions, 100**.

⚠ WARNING

WARNING: Failure to review the safety precautions, and to be aware of the dangers involved when working with refrigerant, could result in serious personal injury.

3. Disconnect the harness connectors and unscrew the switch from the Schrader valve on the service port suction side of the refrigerant compressor. **See Fig. 1.** Save the switch for later use.

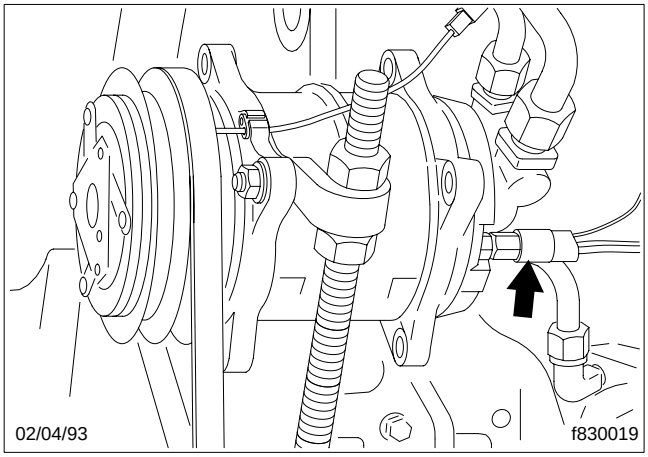


Fig. 1, Low Pressure Switch

Installation

1. Coat the male threads of the low pressure switch with Loctite® 242 or 592. Install the low pressure switch on the Schrader valve on the service port on the suction side of the refrigerant compressor. Tighten the switch 108 lbf·in (1220 N·cm).
2. Connect the wiring harness to the switch.
3. Check the system charge and charge the system with R-12 if needed. Refer to **Subject 250** for instructions.
4. On COEs, return the cab to the operating position. Refer to the vehicle driver's manual for instructions.

   On 120 Conventionals, return the hood to the operating position.

Thermostatic Switch Removal and Installation

Removal

1. Turn off the ignition switch.

⚠ WARNING

WARNING: Failure to turn off the ignition switch could result in personal injury or electrical shock.

2. On COEs, remove the eight screws securing the dash skirt panel on the right side of the cab. **See Fig. 1 .**

   On Conventionals, remove the nine screws securing the dash skirt panel on the right side of the cab. **See Fig. 2.**

3. Disconnect the harness from the thermostatic switch. **See Fig. 3.**

4. On COEs, remove the five screws from the heater/air-conditioner core cover.

   On Conventionals, remove the three outboard screws from the heater/air-conditioner core cover.

5. Carefully withdraw the thermostatic switch sensor tube from the evaporator coil.

   If the thermostat sensor tube is routed through the heater core cover (**Fig. 4**), remove the mounting bracket (Ref. 3). Using a felt-tipped pen, mark the tube where it goes into the heater core cover, then carefully pull the tube out of the rubber grommet.

6. Remove the two screws attaching the thermostatic switch to the housing. Remove the switch.

Installation

1. Install the new thermostatic switch using the two screws removed earlier.

⚠ CAUTION

CAUTION: Be careful when installing the thermostat sensor tube. Using too much force will bend the tube, which could damage it.

2. Carefully insert the thermostatic switch sensor tube into the same hole from which it was removed. The tip of the sensor tube must be in direct contact with an evaporator coil fin and be inserted at least 4 inches (10 cm) into the evaporator.

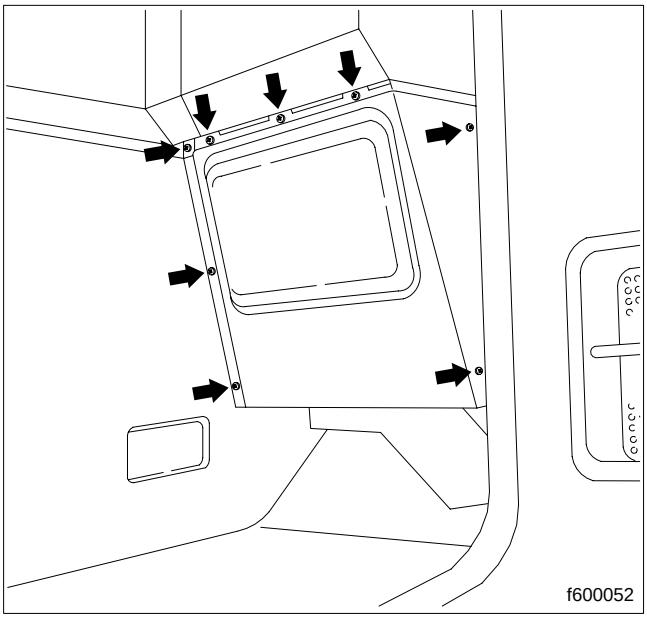


Fig. 1, COE Heater/Air-Conditioner Dash Skirt Panel Screws

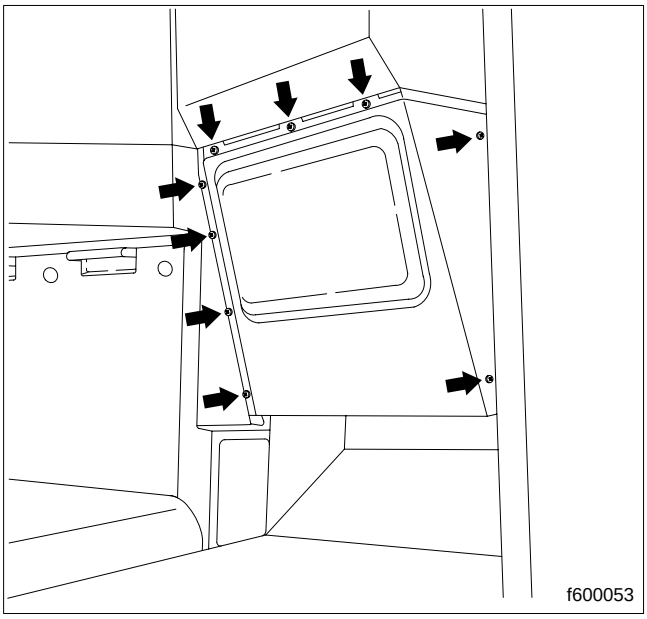


Fig. 2, 120 Conventional Heater/Air-Conditioner Dash Skirt Panel Screws

Thermostatic Switch Removal and Installation

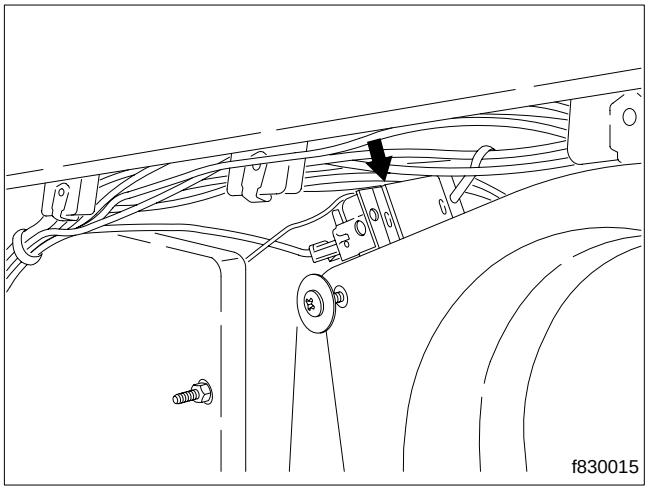


Fig. 3, Thermostatic Switch

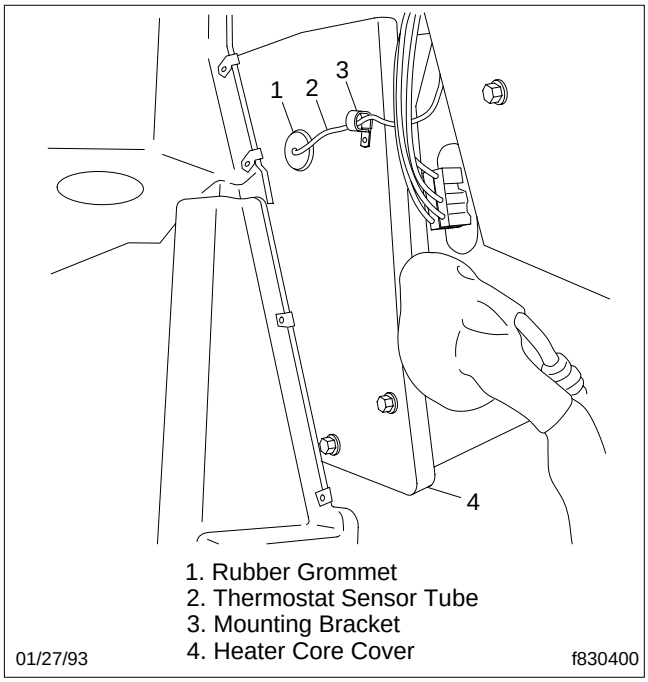


Fig. 4

If the thermostat sensor tube was routed through the heater core cover (**Fig. 4**), hold the cover in place and carefully insert the sensor tube through the cover into the evaporator coil—about 3 inches (76 mm), or at least as far as the felt-tipped pen mark made earlier.

3. On COEs, install the heater/air-conditioner core cover and secure it with the five screws. Tighten the screws securely.

   On Conventionals, install the three outboard screws and tighten them securely.

4. Connect the wire harness to the thermostatic switch.

5. Install the dash skirt panel.

Blower Motor Switch

1. Turn off the ignition switch.

⚠ WARNING

WARNING: Failure to turn off the ignition switch could allow the control panel to short during repairs. This could result in damage to the electrical system or an injury due to electrical shock.

2. Pull off the knobs from the slide lever controls.
3. Remove the six screws attaching the control panel to the dash. **See Fig. 1.** Move the panel away from the dash enough to service it.
4. Remove a switch as follows:
   - 4.1 Pull the knob off of the control shaft.
   - 4.2 For later reference, mark the wires on the back of the switch, then disconnect them.
   - 4.3 Using a wrench, remove the nut from the switch and remove the switch.
5. Install a switch as follows:
   - 5.1 Insert the switch through the hole in the panel. Using a wrench, tighten the nut securely.
   - 5.2 Connect the wires to the back of the switch.

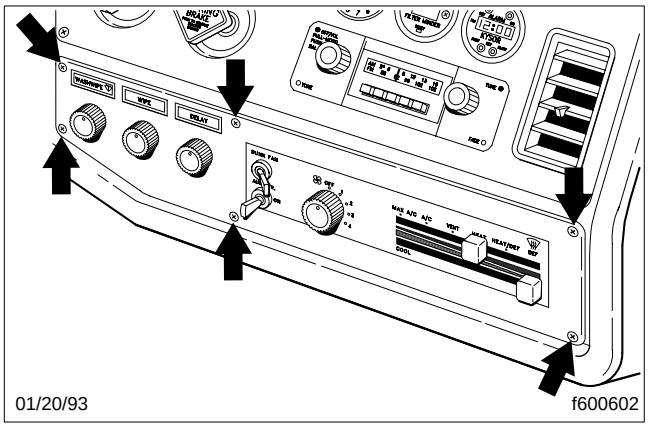


Fig. 1, Remove Control Panel Screws

   - 5.3 Push the control knob onto the shaft.
6. Using the six screws, install the control panel.
7. Push the knobs onto the slide control levers.
8. Turn on the ignition switch and test the blower motor.

Slide Lever Controls

1. Pull off the knobs from the slide lever controls.
2. Remove the six screws attaching the control panel to the dash. **See Fig. 1.** Move the panel away from the dash enough to service it.
3. Remove the four machine screws attaching the slide lever controls. **See Fig. 2.** Slide the unit to the side and pull it out of the dash as far as the cable will permit.
4. Loosen the water regulator valve cable clamp screw (**Fig. 3**), then detach the cable from the slide lever.

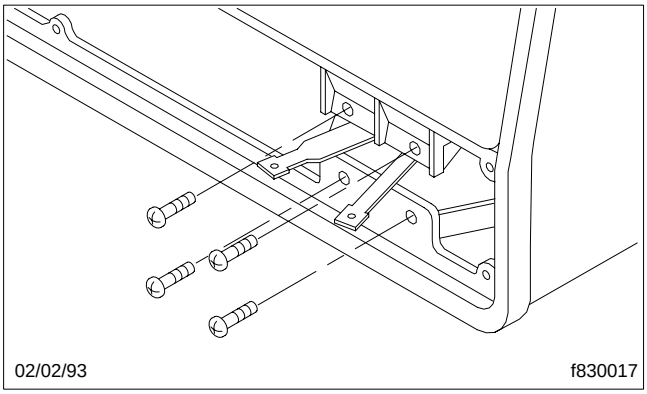


Fig. 2, Remove Machine Screws

5. Mark the air lines for assembly reference, or note the color of each line and where it attaches. Disconnect the air lines from the control unit by pushing in the cover ring; then pull out the air line. **See Fig. 4.**
6. Disconnect the wires from the microswitch.
7. Remove the unit from the dash.
8. Connect the wires to the microswitch.
9. Connect the air lines to the replacement unit by pushing them into the fitting as far as they will go, then give the air line a slight tug so the line will lock into place.

Control Panel Switch Replacement

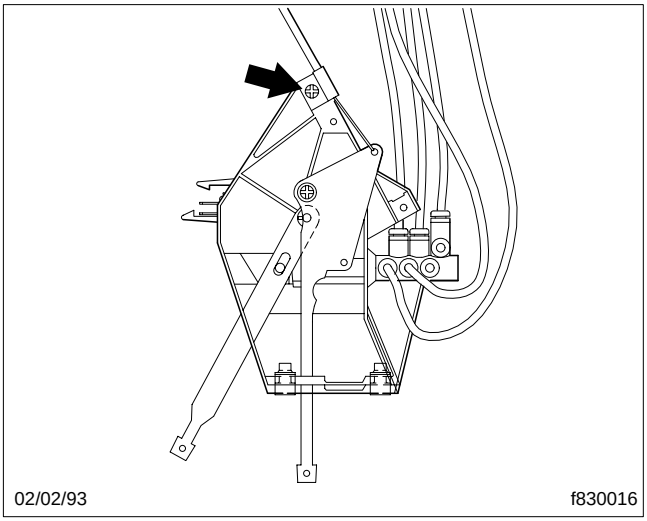


Fig. 3, Loosen Cable Clamp

10. Hook the end of the water regulating valve control cable onto the slide lever. Tighten the clamp securely.
11. Using the four machine screws, install the slide lever control unit.
12. Using the six screws, install the control panel.
13. Push the knobs onto the slide lever controls.
14. Move the temperature slide lever to "COOL." The water regulating valve should close completely. Slide the control lever to "WARM." The valve should open. The travel of the slide lever should be smooth and it should travel the full distance on the control panel. If it doesn't, turn the turnbuckle in the direction necessary to get full travel. Refer to **Subject 185** for instructions.

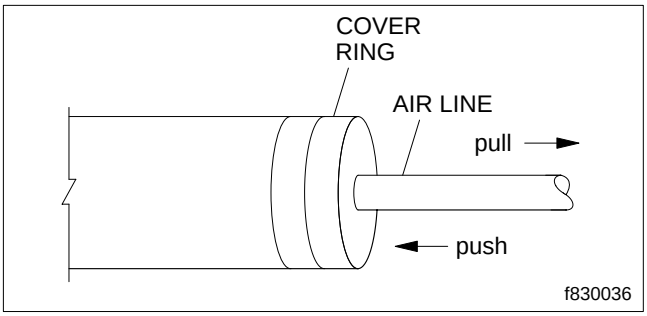


Fig. 4

15. Move the slide lever control to each of the positions and check for correct air flow from the appropriate vents. Refer to **Specifications, 400** for air line identification.

Replacement (See Fig. 1)

NOTE: A Schrader valve in the receiver-drier prevents loss of refrigerant when removing the binary switch.

1. Tilt the hood.
2. Disconnect the electrical leads from the binary switch.
3. Unscrew the binary switch from the receiver-drier.
4. Screw the new binary switch into the receiver-drier. Tighten the switch 108 lbf·in (1220 N·cm) or one-eighth turn past hand-tight. Connect the electrical leads to the switch.
5. Check the operation of the air-conditioning system.
6. Lower the hood.

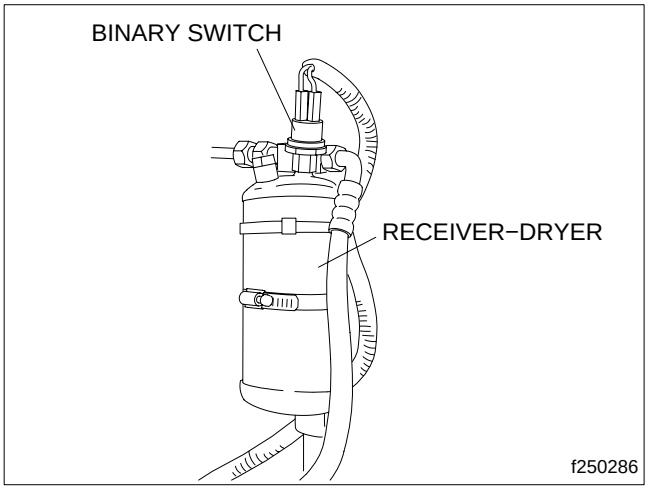


Fig. 1

Discharging

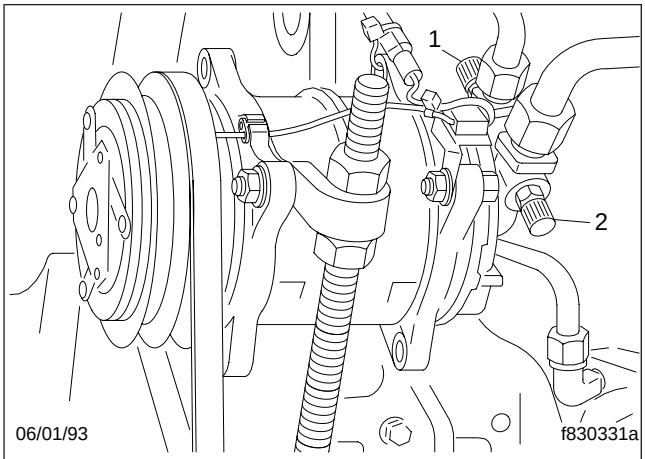
Discharging the air conditioning system removes most of the refrigerant charge in the system.

1. Tilt the hood or cab. See the vehicle driver's manual for instructions.

⚠ WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

2. Remove the caps from the compressor suction and discharge (labeled "D") service valves. See **Fig. 1**.



1. Discharge Service Valve
2. Suction Service Valve

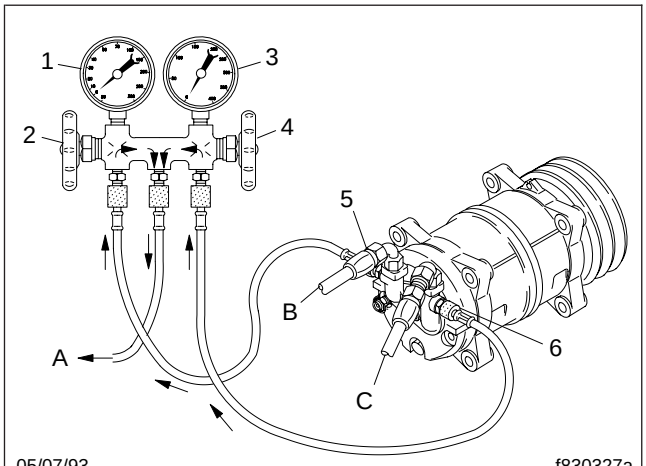
Fig. 1, Service Valves

IMPORTANT: The suction and discharge service valves have Schrader valves, which are similar to but not the same as tire valves. Be sure the manifold gauge set has a valve core depressor on the end of each hose.

3. Wearing protective goggles and nonleather gloves, attach a manifold gauge set to the valves as follows. See **Fig. 2**.

   3.1 Close both manifold valves.

   3.2 Connect the manifold high-side hose to the compressor discharge service valve.



A. To recycling station
B. From expansion valve
C. To condenser

1. Low-Side Gauge
2. Manifold Suction Hand Valve (open)
3. High-Side Gauge
4. Manifold Discharge Hand Valve (open)
5. Suction Service Valve
6. Discharge Service Valve

Fig. 2, Discharging Hookup

   3.3 Connect the manifold low-side hose to the compressor suction service valve.

   3.4 Connect the manifold center hose to an Underwriters Laboratories (U.L.) approved recovery/recycling station.

4. Follow the recovery/recycling station manufacturer's instructions and recover all of the refrigerant from the system.

IMPORTANT: Always comply with all local regulations regarding R–12 disposal. You may be subject to substantial penalties for improper disposal.

5. Measure the oil in the recovery and recycling equipment. The compressor will have to be refilled with the same quantity of new refrigerant oil.

   If the system is contaminated, all of the compressor oil must be replaced with clean oil after purging and flushing the system. If the system is heavily contaminated with desiccant or grit, re-

place the compressor, expansion valve, and receiver-drier.

Flushing

General Information

⚠ WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

Flushing removes heavy contamination, such as gritty oil and large dirt buildup. When a part is flushed, liquid refrigerant is forced through it. The liquid picks up the contaminants and flushes them out.

Whether to flush a part depends on how much contamination there is as described above.

Normally the system always has pressure in it. Some loss of refrigerant from one season to the next is normal and does not mean that the system is dirty. If refrigerant has leaked until the system is nearly empty or if refrigerant parts show signs of internal corrosion and grit, the system is contaminated.

If the system is contaminated with moisture, flush all sections of the system. Then change the oil in the compressor and replace the receiver-drier prior to evacuating and charging the system.

If the system is heavily contaminated or if desiccant has circulated through the system, replace the receiver-drier, expansion valve, and compressor.

Do not flush the receiver-drier or the compressor.

Flush the system in segments to lessen the chance of blowing deposits against a port.

Flush the system in the opposite direction of refrigerant flow (in other words, backflush the sections).

Flushing parts with refrigerant requires a recovery/recycling station.

Flushing Procedure

Method 1

NOTE: Use this method when the recovery and charging machine is equipped with a flush cycle.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), receiver-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter and follow the instructions from the manufacturer of the recovery and charging machine to perform the flush. When flushing the entire system, use an adaptor that fits where the compressor was located, and backflush.
4. Remove the adaptors and bypass devices and install the expansion device(s), the compressor, and a new receiver-drier.
5. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
6. Charge the system with refrigerant and check the system performance.

Method 2

NOTE: Use this method when two recovery and charging machines are available.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), receiver-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter. When flushing the entire system, use an adaptor

that fits where the compressor was located, and backflush.

4. Charge the part with 2 pounds (0.9 kg) of refrigerant or the system with 5 pounds (2.3 kg) of refrigerant, then recover the refrigerant with a second machine. It is desirable to start the recovery slightly before the charge cycle is done, since this helps to push fluid through the system. Repeat the process several times until you think that all the oil has been removed.
5. Remove the adaptors and bypass devices and install the expansion device(s), the compressor(s), and a new receiver-drier.
6. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
7. Charge the system with refrigerant and check the system performance.

Evacuating (dehydration)

General Information

Moisture in a Refrigerant System

Moisture damages air conditioning systems in three ways.

First, water forms ice crystals at the thermostatic expansion valve. Ice crystals retard or stop the flow of refrigerant, causing a reduction or complete loss of cooling. As the expansion valve warms due to the lack of refrigerant, the ice melts and passes through the expansion valve. Then refrigerant will flow again until the ice crystals re-form. The result is intermittent cooling.

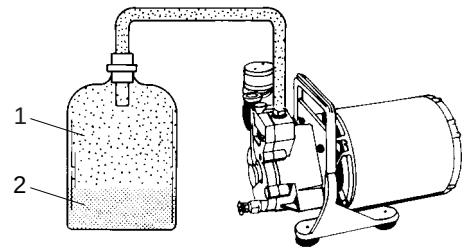
Second, water causes corrosion. Refrigerants may contain chlorine, which combined with water forms hydrochloric acid. This acid corrodes steel and copper plating.

Third, water mixes with refrigerant oil forming sludge. This reduces the lubricating ability of the oil and can plug the condenser, evaporator and thermostatic expansion valve.

Effects of Pressure on the Boiling Points of Water

Water boils at 212°F (100°C) at an atmospheric pressure of 14.7 psi (101 kPa) (sea level). At higher elevations the atmospheric pressure is lower which allows water to boil at lower temperatures. See **Table 1** for boiling temperatures of water at converted pressures.

Similarly we can boil and remove water from the air conditioning system by lowering the system pressure to a vacuum to cause the moisture to boil at normal ambient temperatures. A vacuum pump can reduce the pressure in the system. Since the pressure is the lowest at the pump, water vapor is pulled out of the system. See **Fig. 3**. This process is called evacuation or dehydration.



1. Vapor
2. Water

Fig. 3, Water to Vapor

Vacuum Pump Selection

The purpose of a high-vacuum pump is to reduce and hold a vacuum in the air conditioner system so moisture can be boiled at ambient temperature. For example, a vacuum pump capable of pulling a vacuum of 28.89 inHg (733.8 mmHg), is able to boil water at 80°F (27°C). There are various types of vacuum pumps available. Only some types are recommended for truck air conditioning evacuation.

Refrigerant Service Operations

Boiling Temperatures of Water at Converted Pressures		
Boiling Temperature of Water °F (°C)	Absolute Pressure psi (microns)	Vacuum inHg (mmHg)
212 (100)	14.696 (759993.4)	0 (0)
205 (96)	12.770 (660400.0)	3.92 (99.6)
194 (90)	10.169 (523881.6)	9.22 (234.2)
176 (80)	6.8699 (355269.8)	15.93 (404.6)
158 (70)	4.5207 (233786.7)	20.72 (526.3)
140 (60)	2.8900 (14958.7)	24.04 (610.6)
122 (50)	1.7987 (92555.1)	26.28 (667.5)
104 (40)	1.0700 (55336.4)	27.74 (704.6)
86 (30)	0.61540 (31826.2)	28.67 (728.2)
80 (27)	0.57010 (26220.4)	28.89 (733.8)
76 (24)	0.44435 (22979.9)	29.02 (737.1)
72 (22)	0.38856 (20094.7)	29.13 (739.9)
69 (21)	0.35084 (18143.7)	29.21 (741.9)
64 (18)	0.29505 (15258.5)	29.32 (744.7)
59 (15)	0.24720 (12783.8)	29.42 (747.3)
53 (12)	0.19888 (10285.0)	29.52 (749.8)
45 (7)	0.14746 (7625.8)	29.62 (752.3)
32 (0)	0.08858 (4579.6)	29.74 (755.4)
21 (–6)	0.05293 (2738.1)	29.81 (757.2)
6 (–14)	0.02521 (1304.0)	29.87 (758.7)
–24 (–31)	0.004905 (253.7)	29.911 (759.74)
–35 (–37)	0.002544 (131.6)	29.915 (759.84)
–60 (–51)	0.0004972 (25.7)	29.9200 (759.968)
–70 (–57)	0.0002443 (12.6)	29.92050 (759.9807)
–90 (–68)	0.0000526 (2.72)	29.92089 (759.9906)

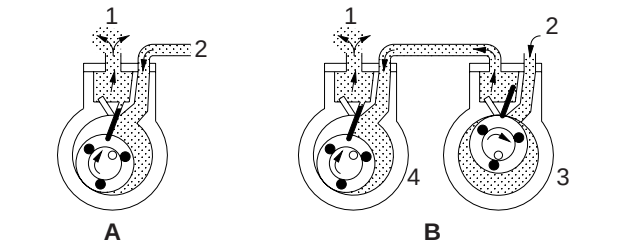
Table 1, Boiling Temperatures of Water at Converted Pressures

Air pump-type vacuum pumps are designed to remove large volumes of air but do not develop high vacuum. They cannot pull more than 28 inHg (711 mmHg) which boils water at 100°F (38°C).

Compressor-type vacuum pumps come in two designs: piston-type and rotary-vane type. A piston-type compressor can typically pull a vacuum of 28.2 inHg (716.3 mmHg) which boils water at 96°F (36°C). A rotary-vane type compressor may pull a vacuum of 29.82 inHg (757.4 mmHg) which boils water at 21°F (–6°C), but it is limited to pumping 0.4 to 0.8 cfm, which is too slow to handle truck air conditioners.

High-vacuum pumps are available in single-stage and two-stage models. A single-stage model is adequate, but a two-stage model is recommended to save time and assure complete evacuation. See **Fig. 4**.

Most single-stage high-vacuum pumps with a gas ballast will pull down to about 29.88 inHg (758.95 mmHg) which boils water at 4°F (–16°C).



A. Single-Stage Pump
1. Exhaust
2. Intake

B. Two-Stage Pump
3. First Pump
4. Second Pump

Fig. 4, Vacuum Pumps

A two-stage high-vacuum pump features a second pump to reach a higher vacuum than a single-stage pump. In a two-stage pump, the exhaust of the first pump discharges into the intake of the second pump. The second stage pumps at a lower pressure and therefore pulls a higher vacuum on the system than the first pump can by itself.

Two-stage high-vacuum pumps are capable of pulling down to 29.9192 inHg (759.95 mmHg) of vacuum for prolonged periods, which boils water at –60°F (–51°C).

The discharge line restriction is a factor affecting pump-down time. Pump-down time can be significantly reduced by use of larger diameter hoses, as short in length as possible.

Pumping capacity affects pump-down time. It is perfectly acceptable to use a large vacuum pump on a small system. Using too small of a pump on a large system could cause premature pump wear, or require excessive time to pull a vacuum, even though the pump may be able to draw adequate vacuum.

The suggested minimum cfm for pumps on different size air conditioners are listed in **Table 2**.

Minimum CFM for Pumps on Different Size Air Conditioners	
System Size	**Suggested High-Vacuum Pump Size**
Panel Trucks Large Window Units	2.2 cfm
Tractor/Trailers, Buses Rooftop A/C Systems	3.0 cfm
Refrigeration Van	15.0 cfm

Table 2, Minimum CFM for Pumps on Different Size Air Conditioners

Measuring Vacuum

Gauges

Vacuum can be measured with:

- A standard compound gauge;
- A closed-end manometer;
- An electronic thermistor vacuum gauge.

A standard compound gauge reads low pressures in inches of mercury. It is not suitable for measuring high vacuum.

A closed-end U-tube mercury manometer can be read with good accuracy. High vacuum readings can only be read from laboratory-style U-tube manometers.

Electronic thermistor vacuum gauges are designed for use with high vacuum pumps and can accurately read as low as 100 microns. This gauge can use an analog scale or a digital (LED) display.

Procedure

The location of the vacuum gauge will affect the reading. The closer to the vacuum source, the lower will be the reading.

Isolate the vacuum pump with a good vacuum valve and allow the pressure in the system to stabilize before taking a final reading.

If the pressure will not stabilize, it is an indication of a leak. If it does stabilize at a vacuum which is too high (for example, 1500 microns), it is an indication of moisture and more evacuation is required.

Maintaining the Vacuum Pump

Maintenance is important for high-vacuum pumps. The oil must be changed at regular intervals to prevent moisture buildup which will cause eventual pump failure.

Pumping down for extremely wet air conditioning systems can completely saturate the pump oil.

CAUTION

Flush the vacuum pump every fourth time it is used, and before storing for long periods of time. Acid will form and corrode the pump, if water-laden oil remains in the pump for an extended period.

Vacuum pump oil is water soluble. This aids the pump in reaching a high vacuum by absorbing water and sealing the pump.

Only vacuum pump oil should be used as a flushing agent and lubricant. Do not use any solvent or any other oil. Clean oil should be run through the pump until it runs out clear. Oil should be added to the fill level indicated on the pump. Check the oil level before each use.

Evacuation Procedure

1. The system must be discharged and, if contaminated, flushed and the compressor filled with the correct amount of refrigerant oil. Replace the receiver-drier if the system is opened.
2. Close both manifold hand valves on the manifold gauge set. See **Fig. 5**.
3. If using a thermistor vacuum gauge, connect the gauge between the manifold center service hose and the vacuum pump.
4. Connect the manifold discharge line to the discharge service valve on the compressor.
5. Connect the manifold suction line to the suction service valve on the compressor.
6. Connect the center manifold line to the vacuum pump.
7. Open the manifold hand valves.
8. Turn on the vacuum pump, and open the pump control valve.
9. If using a thermistor gauge, open the thermistor gauge valve.
10. Allow the pump to draw to at least 29.90 inHg (759.5 mmHg).
11. Close the pump valves, and turn off the pump.
12. Allow the system to stabilize for five minutes.
13. If not using a thermistor gauge, go to the next step. If using a thermistor gauge, proceed as follows:
    - 13.1 If the thermistor gauge reading does not rise above 29.85 inHg (758.2 mmHg), the system is OK. Proceed to "Charging."
    - 13.2 If the thermistor gauge reading rises above 29.85 inHg (758.2 mmHg) and stops, there is moisture in the system. Repeat the previous five steps and this step.
    - 13.3 If the thermistor gauge reading rises above 29.85 inHg (758.2 mmHg) and continues to rise, add a partial charge of refrigerant and leak test the system. Repair any leaks and reevacuate the system. Refer to "Leak Testing" for instructions.
14. If not using a thermistor gauge, proceed as follows:
    - 14.1 Note the low pressure gauge needle position.
    - 14.2 Wait 15 minutes, then check the low pressure gauge needle position again.
    - 14.3 If the needle has not moved, turn on the vacuum pump and open the pump control valve. Let the pump run for one hour. Go to "Charging."

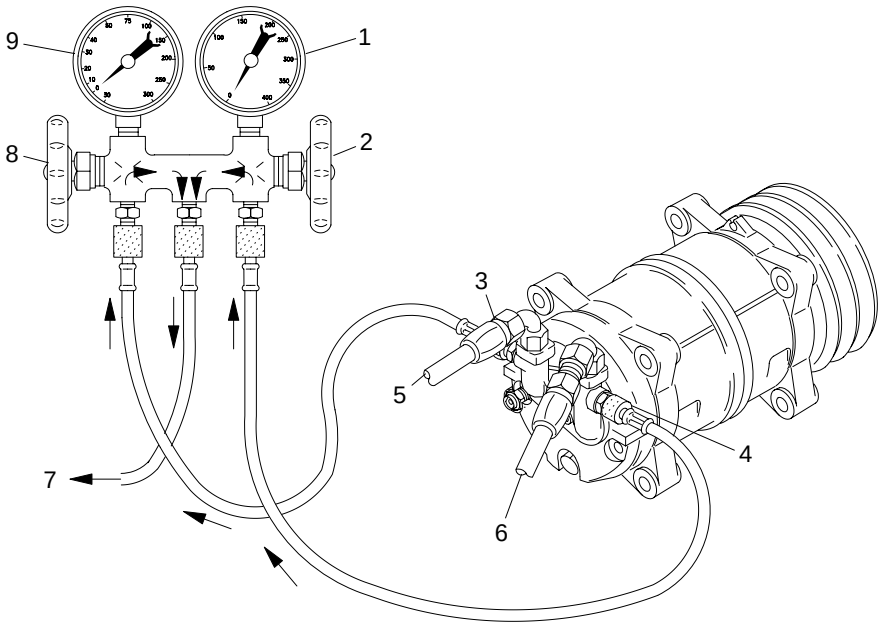
    IMPORTANT: A gauge reading of over 29.85 inHg (758.2 mmHg) indicates that there is still water in the system.
    - 14.4 If the needle has moved, add a partial charge of refrigerant and leak test the system. Repair any leaks and reevacuate the system. See "Leak Testing" for instructions.

Charging

General Information

WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.



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1. High-Side Gauge
2. Manifold Discharge Hand Valve (open)
3. Suction Service Valve
4. Discharge Service Valve
5. From Expansion Valve
6. To Condenser
7. To Vacuum Pump
8. Manifold Suction Hand Valve (open)
9. Low-Side Gauge

Fig. 5, Evacuation Hookup

The recommended way of charging a system is by adding refrigerant as a gas. High-side liquid charging may cause liquid refrigerant to enter the compressor. If this happens, it may cause a hydraulic lock in the compressor and destruction of the unit.

If a charging cylinder is used—one that heats refrigerant and allows the worker to make exact refrigerant measurements—follow the instructions of the equipment manufacturer.

Gas Charging Procedure

NOTE: The system must be evacuated with the manifold gauge set connected to the compressor before a full charge can be added to the system.

1. Obtain enough refrigerant to fully charge the system. See the refrigerant capacity table in **Specifications 400**.

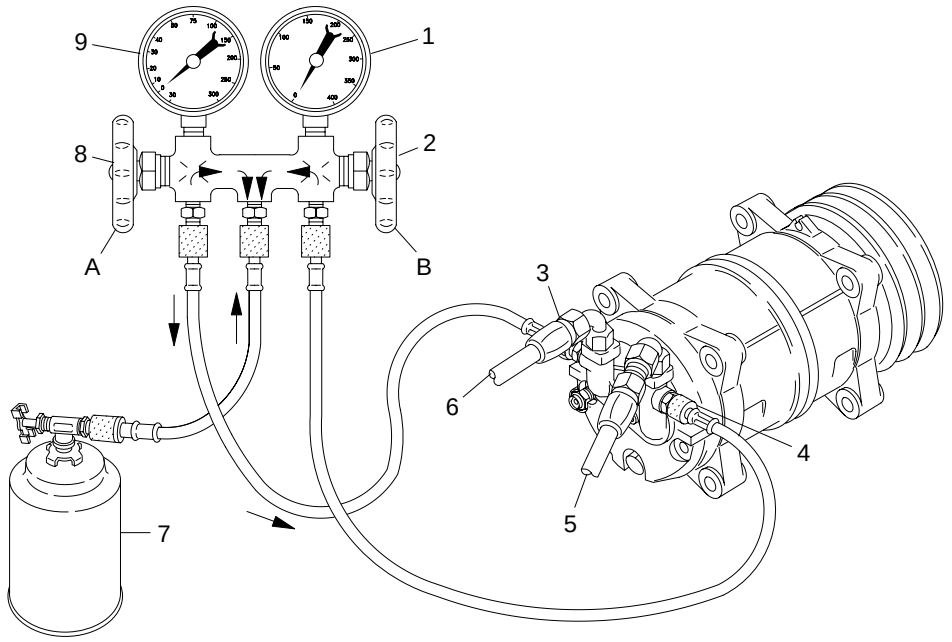
   If a tank (bulk quantities) is used, it should be set on a scale and its weight noted so that the correct amount of refrigerant enters the system. This prevents overcharging, which could damage the compressor.

   If one-pound (454-gram) cans of refrigerant are used, obtain enough to fully charge the system.

   NOTE: Each one-pound can actually holds 14 ounces (397 grams) of refrigerant.

2. Close the manifold hand valves.
3. Connect the manifold center service hose to the refrigerant can as shown in **Fig. 6**. Do not release the refrigerant at this time. Place the can in an upright position so that refrigerant enters the system as a gas. **Do not allow liquid refrigerant to enter the compressor by tipping the refrigerant can.**

Refrigerant Service Operations



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A. Low-Side Hand Valve
B. High-Side Hand Valve

1. High-Side Gauge
2. Manifold Discharge Hand Valve (closed)
3. Suction Service Valve
4. Discharge Service Valve
5. To Condenser
6. From Expansion Valve
7. R–12
8. Manifold Suction Hand Valve (open)
9. Low-Side Gauge

Fig. 6, Gas Charging Hookup

⚠ CAUTION

If the refrigerant can is tilted during service operations, liquid refrigerant could enter the compressor through its suction port, which may damage the unit once it is turned on.

4. With the engine off, open the manifold low-side hand valve. Do not open the manifold high-side hand valve.
5. Open the valve on the refrigerant can to allow the refrigerant vapor to enter the system.

IMPORTANT: On bulk quantity tanks, larger hoses are used. These hoses alone may carry 8 ounces (227 grams) or more of refrigerant.

6. Close the valve on the refrigerant can. If a full charge did not enter the system, the rest will be added while the compressor is on.

⚠ WARNING

Any other way of warming refrigerant, such as using a torch, is dangerous and should never be tried. Using extreme heat on an refrigerant can could cause an explosion and serious bodily injury.

7. Start the engine and run it at 1500 rpm. Set the cab air conditioner controls at maximum cooling and fan speed. The refrigerant compressor must engage. Open the valve on the refrigerant can. Leave the valve open until a full charge of refrigerant has entered the system. Close the valve on the refrigerant can.

   To know when a one-pound can is empty, tap it on the bottom. A hollow ringing will be heard. **Do not tip the refrigerant can.**

NOTE: If refrigerant is slow to enter the system because of low outside temperatures, vaporization can be quickened by placing the refrigerant can in a tub of warm water no warmer than 125°F (52°C).

8. When enough refrigerant has entered the system, look at the sight glass. No frothing or bubbles should appear when the compressor is on. If frothing occurs, leak test the system.
9. While the compressor is engaged, check the operating pressures at the suction and discharge ports. See the applicable compressor section in this manual. If the operating pressures are not acceptable, refer to **Troubleshooting 300** for possible causes.
10. Shut down the engine. Close both manifold hand valves.
11. All of the manifold gauge hoses are under pressure. Disconnect them from the compressor and the refrigerant can. Install the caps on the compressor service valves.

Liquid Charging Procedure

NOTE: Before charging, the system must be recovered and evacuated with the recovery/recycling station connected to the service and discharge port connections.

1. Obtain enough refrigerant to fully charge the system. See the refrigerant capacity table in **Specifications 400**.

   If a tank (bulk quantity) is used, it should be set on a scale and its weight noted so that the correct amount of refrigerant enters the system. This prevents overcharging, which could damage the compressor.

   If one-pound cans of refrigerant are used, obtain enough to fully charge the system.

NOTE: Most one-pound cans actually hold 14 ounces (397 grams) of refrigerant.

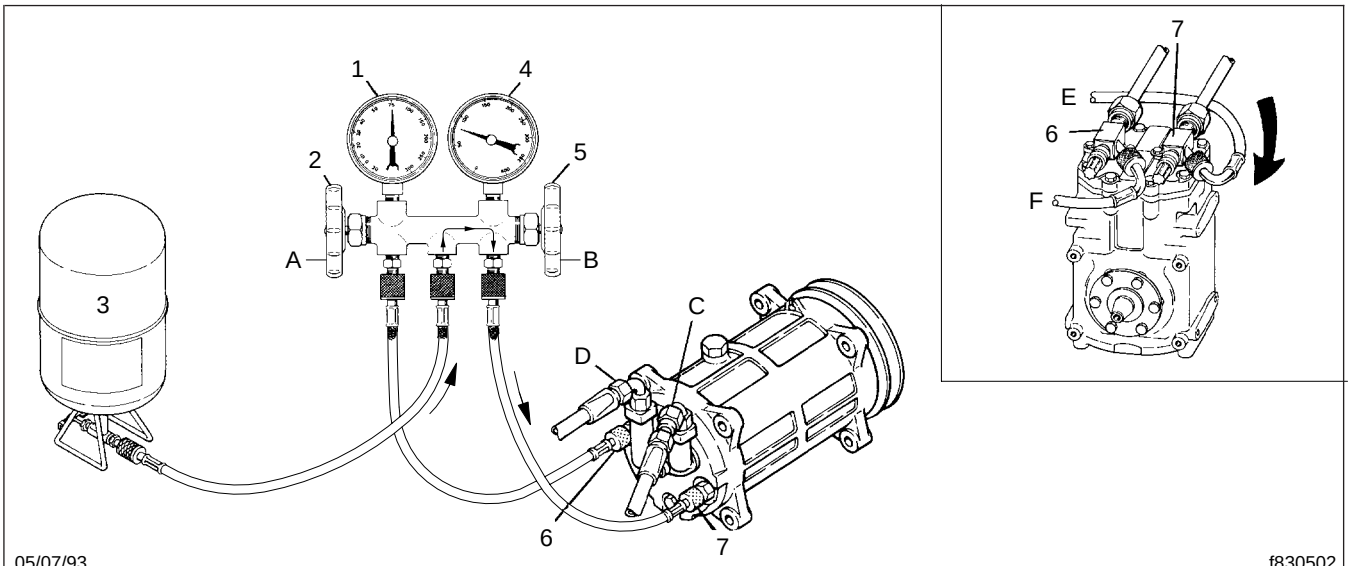
2. Close the manifold hand valves.
3. Disconnect the vacuum pump. Connect the manifold center service hose to the refrigerant container and purge the air from the hose.
4. With the engine off, open the manifold high-side hand valve. **Do not** open the manifold low-side hand valve. See **Fig. 7**
5. If charging from a tank (bulk quantity), turn the tank upside down. Open the valve on the refrigerant container to allow the refrigerant liquid to enter the system.

NOTE: If refrigerant is slow to enter the system because of low outside temperatures, vaporization can be quickened by placing the refrigerant tank in a tub of warm water no warmer than 125°F (52°C).

6. Close the high-side hand valve. If a full charge did not enter the system, the rest will be added while the compressor is on.
7. Start the engine and run it at 1500 rpm. Set the cab air conditioner controls at maximum cooling and fan speed. The refrigerant compressor must engage. If charging from a tank (bulk quantity), place the tank in the upright position. Open the low-side hand valve. Leave the valve open until a full charge of refrigerant has entered the system. Close the valve on the refrigerant container. Close the low-side hand valve. Disconnect the hoses.
8. When enough refrigerant has entered the system, look at the sight glass. No frothing or bubbles should appear when the compressor is on. If frothing occurs, leak test the system.
9. While the compressor is engaged, check the operating pressures at the suction and discharge ports. See the applicable compressor section in this manual. If the operating pressures are not acceptable, refer to **Troubleshooting 300** for possible causes.
10. Shut down the engine.
11. On swashplate and piston-type compressors with Schrader valves, disconnect the manifold set.

    Disconnect the hoses from the refrigerant compressor. Install the caps on the service valves.

Refrigerant Service Operations



A. Low -Side Hand Valve
B. High-Side Hand Valve
C. To Condenser
D. From Expansion Valve
E. To High-Side Gauge
F. To Low-Side Gauge

1. Low-Side Gauge
2. Closed Manifold Suction Hand Valve
3. R–12 Bulk Container
4. High-Side Gauge
5. Open Manifold Discharge Hand Valve
6. Suction Service Valve
7. Discharge Service Valve

Fig. 7, Liquid Charging Hookup

Charge Checking

WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

In a system that is fully charged, some bubbles will show as the compressor cycles. Very high outside temperatures may cause occasional bubbles when the compressor is running. This is normal. For additional information, see "Refrigerant Check" in Troubleshooting 300.

Leak Testing

General Information

WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

Refrigerant is odorless. As a result, all of it may leak away and not be noticed until the system stops cooling. All vehicle refrigerant systems lose some refrigerant, depending on the condition of the system. Higher loss rates signal a need to locate and repair the leaks.

Leaks are most often found at the compressor hose connections and at the various fittings and joints in the system. Refrigerant can be lost through hose permeation. Leaks can also be traced to pinholes in

the evaporator caused by acid, which forms when water and refrigerant mix.

Leak Detection

There are three ways of finding the locations of leaks:

- sight detection
- flame-type propane leak detection
- electronic leak detection

The electronic leak detection method is the recommended method and the most precise method of detecting leaks.

The sight detection method may be used to find large leaks. Many large leaks will cause oil to escape along with refrigerant at the point of the leak. A deposit of oil may be a sign of a leak. Verification of leaks must be done using the electronic leak detection method.

The flame-type detection method is done with a small torch. This method presents a fire hazard and gives off poisonous phosgene gas. Therefore, this method of detection is **not recommended**.

Freightliner recommends using only the Heated Diode type of electronic leak detector. This type of detector can be identified by its construction and power supply. It has a heated element which requires periodic replacement and uses either a 12V DC or 120V AC power supply, or has a rechargeable battery. The Heated Diode type detector is sensitive only to gases containing halogen, such as R–12 and R–134a refrigerants. It will not detect other substances and is more likely to detect all of the leaks in a system. This type has both visual and audio indicators and self-tests to confirm operation.

Recommended electronic Heated Diode type leak detectors are available from their manufacturers. See **Table 3**.

Another type of detector, the Corona Discharge type, is the kind most commonly found in service and repair shops. This detector requires very little power and can operate on as few as four AA alkaline batteries. The Corona Discharge detector is not sufficiently sensitive and will create false alarms by detecting moisture and antifreeze or solvent vapors. This type of detector is specifically **not recommended**.

Electronic Leak Detectors		
Designation	**Manufacturer**	**Comments**
D-TEK	Leybold Inficon 2 Technology Place East Syracuse NY 13057 (315) 434–1144	• Rechargeable battery • Hand-held design • Simple to operate
H–10 Professional	Bacharach Inc. c/o Yokogawa Corp. of America 2 Dart Road Newnan GA 30265 (800) 850–0044	• Rechargeable battery • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Most sensitive available
J 39400	SPX Kent-Moore 28635 Mound Road Warren MI 48092–3499 (800) 328–6657	• 12V DC or 120V AC • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Manual balance control

Table 3, Electronic Leak Detectors

Refrigerant Service Operations

When checking for leaks, always focus your attention on the lowest portion of the fitting or part being tested. Refrigerant is heavier than air and will collect at the low point. Oil will also flow toward the low point.

NOTE: Do not try to use a leak tester right after connecting or disconnecting service hoses. Traces of refrigerant at the fittings can falsely signal a leak.

Use the following procedures to locate A/C system refrigerant gas leaks using a heated diode type electronic leak detector.

1. Operate the electronic leak detector in accordance with the manufacturer's instructions.
2. Leak test with the engine turned off.
3. Charge the air conditioning system with sufficient refrigerant to indicate a gauge pressure of at least 50 psi (340 kPa) with the system not operating. It may not be possible to produce this amount of pressure and measure leakage if the ambient temperature is less than 59°F (15°C).
4. Be careful not to contaminate the detector probe tip if the part being tested is not clean. Wipe the part off with a dry shop towel or blow it off with shop air. Do not use cleaners or solvents as many detectors are sensitive to their chemical ingredients.
5. Visually inspect the entire refrigerant system. Look for air conditioning lubricant leakage and corrosion or damage to lines, hoses, and all other components. Inspect each questionable location carefully with the detector probe. Check all fittings, couplings, refrigerant controls, service ports (with caps installed), brazed or welded areas, and areas around attachment points and hold-downs.
6. Follow the path of the refrigerant system methodically so that no leaks are missed. If a leak is found, continue to test the rest of the system.
7. Inspect an area of possible leakage slowly and close to the part, moving completely around the part. Move the probe no faster than one to two inches (25 to 50 mm) per second and no farther away than 1/4 inch (6.4 mm) from the part.
8. If a large leak is present in either the system being serviced or the service equipment, the surrounding air will be saturated with refrigerant gas. In this situation the leak detector operates erratically and will indicate leakage without being near a possible leak source. Place a large fan so that a light breeze blows through the work area. Verify a leak by blowing shop air into the area and repeating the inspection. Pinpoint a large leak by blowing out the area often.
9. You may test the evaporator core while it is in its housing. Turn on the blower motor for a minimum of 15 seconds. Shut off the blower and wait for refrigerant gas to accumulate in the housing. Follow the detector instructions for the specific length of time to wait for the gas to accumulate. Insert the detector probe into the blower resistor block, or condensate drain hole if no water is present. If this is not possible insert the probe into the closest opening to the evaporator, such as a heater or vent duct.
10. Leak test the front seal area of the compressor. Blow shop air into the cavities in and around the clutch for at least 15 seconds. Let the compressor stand for one minute and then test for leakage. Inspect rotary type compressors (Sanden or Sel-Tec) by placing the probe near the holes at the front of the clutch. Inspect two-cylinder reciprocating type compressors (Climate Control) by placing the probe between the clutch coil and the compressor.

IMPORTANT: Be careful not to damage the clutch bearing seal with high pressure shop air.

11. Leak test repaired areas of the system after repairs have been performed. Leak test the service ports (with caps installed) after any service which disturbs the refrigerant system.

Preliminary Checks

Before testing the operation of the air conditioning system, make the following checks.

1. Make sure the refrigerant compressor's drive belt is not damaged and is correctly tensioned. Also check the compressor mountings for tightness. for instructions and other information, refer to the refrigerant compressor section elsewhere in this group.
2. Using a feeler gauge, check for correct refrigerant compressor clutch clearance. For instructions, refer to the refrigerant compressor section elsewhere in this group.
3. Check for broken, burst, or cut hoses; also check for loose fittings on all parts.
4. Check for road debris build-up on the condenser coil fins. Using air pressure and a whiskbroom or a soapy spray of water, carefully clean off the condenser; be careful not to bend the fins.
5. Check the moisture indicator sight glass for the moisture content of the refrigerant and the state of the charge. The air conditioner should be on when checking the indicator; you should make this check at the end of a day's run. Replace the charge if it is wet. If there are bubbles in the sight glass, the refrigerant charge could be low; add more R-12 to the system. Refer to **Subject 250** for instructions.
6. If there is not enough airflow, make sure that leaves or other debris has not entered the fresh air ports under the windshield. If debris has entered, it could clog the fins of the evaporator coils, and block airflow.

   Also, be sure that all ducts are connected to the dash louvers and that the air-control flaps in the heater housing are moving properly (this requires removal of the right and center dash panel).

Performance Tests

Following is a brief description of symptoms or conditions that will exist if something goes wrong in a refrigerant part.

Cooling Check

When outside temperature and humidity are high, it will take longer to cool the cab, especially if the fresh air vents are left open.

To determine if the air conditioner is cooling enough:

1. Set the engine speed at 1500 rpm.
2. Close the doors and windows.
3. Turn on the air conditioner; set the controls at maximum cooling (recirculated air) and blower speed. The compressor must be engaged during this test.
4. Make sure the auxiliary air conditioning is off.
5. Allow the system to run for at least 10 minutes (longer on hot and humid days).
6. Place a thermometer inside the louver or air duct; make sure the controls are set so that air flows out of the duct being tested.
7. Compare the measured temperature readings to the readings in temperature/pressure table in **Specifications, 400**. If the duct's air temperature is higher than normal readings, the system isn't cooling enough. For possible causes, refer to the troubleshooting chart.

Refrigerant Check

There are four conditions to look for when checking refrigerant in the sight glass.

1. Bubbles normally show only when the system is started and then disappear after a few seconds. If these bubbles *continue all the time* the system is running, the system is merely low on (not completely out of) refrigerant. Only an occasional bubble should be seen during normal operation.
2. A clear sight glass means that the system has enough refrigerant to work properly, that it is completely out of refrigerant, or that it is overcharged.
3. A cloudy sight glass means that dirt or broken-down bits of desiccant are flowing through the system. This is a serious condition that requires a complete flushing out of the system, installation of a new receiver-drier, expansion valve, and, if the desiccant cartridge of the receiver-drier has fallen apart, installation of a new refrigerant compressor.

4. Oil streaks in the sight glass mean low refrigerant or too much oil in the system.

Receiver-Drier

The receiver-drier is normally at outside temperature. To the touch, the entire length of the unit should be the same temperature. If noticeable cool spots exist, replace the receiver-drier.

A blockage at the inlet of the unit will cause high head pressures; outlet blockages will cause low head pressures and little or no cooling.

If the moisture indicator isn't blue, the receiver-drier is saturated with water and acid, and must be replaced.

Cooling System

Although they are not physically connected, there is a close tie between a vehicle's air conditioner and its cooling system. Poor air conditioner cooling can be the result of a problem in the cooling system.

If the cooling system does not work correctly, the heat of the engine will rise to abnormal levels. The added heat will transfer to the air conditioner, other underhood parts, and maybe make its way into the cab. The added heat makes it necessary for the air conditioner to work harder and, at the same time, it reduces the air conditioner's ability to cool down the air in the cab.

Refer to the engine cooling section for cooling system troubleshooting and to the engine manufacturer's service manual for other details about cooling system problems.

Expansion Valve

Problems that start in the expansion valve show up as follows: when stuck closed, the evaporator coil and the expansion valve will be at outside temperature; when stuck open, both the coil and the valve will be extremely cold with frost or ice build-up.

Because the expansion valve is very sensitive to contamination, blockages in the system tend to be found here. Usually, the contaminant is water; less than a drop of water is all it takes to make the valve inoperative. When water reaches the valve, the extreme cold that results from the pressure drop freezes the water, forming a block of ice in the valve. After the system shuts down and the valve warms up, the ice melts, and the valve operates again, only to freeze up when the water returns.

On-and-off operation of the expansion valve means that the receiver-drier is not removing water and acids from the system. These contaminants should cause the moisture indicator's element to turn pink or white.

Refrigerant Compressor

Compressor problems usually show in one of four ways: abnormal noise; seizure; leakage; or low suction and discharge pressures.

Resonant compressor noises are not causes for alarm; irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch and see if the drive plate can be turned. If it won't turn, the compressor has seized.

Low discharge pressure may be caused by not enough refrigerant, not enough belt tension, or a blockage somewhere in the system. These things should be checked before servicing the compressor.

Evaporator

The evaporator coils are basically trouble-free when airflow over the fins is not blocked. External or, less often, internal blockages will cause low suction pressure as well as little or no cooling.

If hydrochloric acid has formed in the system (the result when refrigerant mixes with water), it may cause pinholes to form in the evaporator coil. If a leak exists in the system, and it cannot be traced to other parts or fittings, suspect damage to one of the evaporator coils.

Condenser

The condenser is also usually trouble-free when road debris, such as leaves or dirt buildup, is removed. If debris cakes up, airflow over the condenser fins is blocked; air is not able to absorb enough heat to turn the hot refrigerant gas into a liquid. High head pressures will result. In these cases, carefully clean off the outer surfaces of the condenser with compressed air or a soap and water solution; be careful not to bend the fins.

High head pressures will also occur if the condenser's tubing is abnormally bent, blocking the flow of refrigerant.

Less common internal blockages (bits of foreign material or metallic grit build-up) will stop the flow of refrigerant.

A quick test to check that poor system performance is caused by the condenser is to direct a spray of water onto the condenser while the system is running. If the air conditioner cools better because of the assist provided by the water, it is a sign that the condenser is not working.

When troubleshooting a suspected condenser problem, remember that the problem may be caused by the cooling system transferring high levels of heat to the condenser. Refer to the engine cooling section in this manual for cooling system troubleshooting and to the engine manufacturer's service manual for other details about cooling system problems.

Thermostatic Switch

Before troubleshooting the thermostatic switch, be sure there is a full charge of refrigerant in the system. The compressor will not operate, or will cycle too often, if there is not enough refrigerant in the system.

Quick or delayed cycling of the compressor may be caused by a thermostatic switch that is working, but is out of adjustment. If, after doing the tests below, the switch seems to be out of adjustment, replace it (the thermostatic switch cannot be recalibrated).

1. Be sure the compressor clutch is operating correctly. Refer to the refrigerant compressor section elsewhere in this group.
2. Expose the evaporator coil. Refer to **Subject 190** for instructions.
3. Connect the batteries and start the engine. Place the air conditioner control at its coldest setting; turn on the air conditioner and the fan.
4. Place an accurate thermometer in contact with a tube on the evaporator coil. Be sure the thermometer is in good contact with the tube, or you will get a wrong reading.

   When the temperature drops below 31° to 36°F (–1° to 2°C), the compressor clutch should disengage and remain this way until the temperature rises to 39° to 44°F (4° to 7°C).
5. If the compressor did not engage when the temperature was above the accepted high range, do the following test:

   5.1 Connect a voltmeter or a test light from one of the terminals on the thermostatic switch to ground. Repeat this test with the other terminal on the switch.

   5.2 With the engine running and the air conditioner and blower on, both terminals will show voltage when the compressor should be engaged; one terminal will show voltage when the compressor should be disengaged.

   If there is no voltage, there is a problem in the electrical system from the batteries to the thermostatic switch. Check all circuits for the cause, and repair or replace the wiring or parts.

   In all other cases where the compressor is not engaging and disengaging properly, the thermostatic switch is the cause. Replace it with a new switch.
6. Shut down the engine and, to prevent accidental electric shock or shorting during dash assembling, disconnect the batteries.
7. Assemble the dash; refer to **Subject 190** for instructions.

Line Restrictions

A restricted suction line causes low suction pressure at the compressor and little or not cooling. A restriction in a line between the compressor and the expansion valve can cause high discharge and low suction pressure, and insufficient cooling.

Usually, areas of ice or frost build-up mean a blockage. Parts that often freeze up are probably corroded or inoperative and should be replaced. Parts (such as the expansion valve) that freeze up once in a while may do so because of water in the system, which will cause the moisture indicator's element to turn pink; if this happens, replace the receiver-drier, purge or flush the lines and parts, and install a new charge.

Troubleshooting Tables

Troubleshooting

Problem—Little or No Airflow

Possible Cause	Remedy
The blower is not operating.	Check for an open circuit breaker. An open circuit indicates a short in the electrical system, which must be located and repaired.
	Check the air conditioner relays for operation. Replace, as necessary.
	Make sure the blower motor switch is working. Replace, if necessary.
	Check the wiring to the blower motor. If any connections are loose, securely tighten them. Make sure the wiring conforms to the applicable diagram under **Specifications, 400**.
	Check the blower motor for operation. Replace if sticking or otherwise inoperative.
	Check the resistor block. Replace, if necessary. **CAUTION:** Never try to by pass the fuse in the resistor block. To do so could cause the blower motor to overheat, resulting in serious damage to the heater/air-conditioning system.
There are restrictions or leaks in the air ducts.	Examine all air ducts and remove any blockages. Stop any leaks or replace any portion where the leaks cannot be stopped.
Ice has formed on the evaporator coil.	Defrost the evaporator coil before resuming operation of the air conditioner. Review "Performance Tests" in this subject for possible causes and corrective action.

Problem—Warm Airflow When the Air Conditioner Is On

Possible Cause	Remedy
There is no refrigerant charge in the system.	Perform a leak test. Repair any leaks, purge the system, replace the receiver-drier, and add a full charge of refrigerant.
Moisture in the system.	If moisture is in the system, ice crystals may form at the expansion valve, blocking the flow of refrigerant (off and on). Discharge the refrigerant charge, purge the system, replace the receiver-drier, and add a full charge of refrigerant.
The refrigerant compressor is not operating.	If the refrigerant charge is low, charge and leak test the system. Repair any leaks.
	The refrigerant compressor clutch or drive belt needs repair or replacement. For instructions, refer to the refrigerant compressor section elsewhere in this group.
The air-conditioner microswitch is not working.	Replace the microswitch.
Ice has formed on the evaporator coil.	Defrost the evaporator coil before resuming operation of the air conditioner. Review "Performance Tests" in this subject for possible causes and corrective action.

Problem—Foaming in the Receiver-Drier Sight Glass

Possible Cause	Remedy
There is an insufficient refrigerant charge in the system.	Add refrigerant.
There are leaks in the system.	Perform a leak test. Stop all leaks, exhaust the old refrigerant from the system, and add a new charge.
Restriction in the line between the condenser and the receiver-drier is slowing refrigerant flow.	Remove the restrictions from the line. If water or corrosion is present, purge or flush the system, replace the receiver-drier, and add a full charge of refrigerant.

Problem—Low Evaporator Coil Outlet Pressure (Low Compressor Suction Pressure)

Possible Cause	Remedy
The expansion valve is not working.	Replace the expansion valve. If moisture or corrosion is present, purge or flush the system, replace the receiver-drier, and add a full charge of refrigerant.
There are restrictions in the line to the expansion valve.	Remove the line restrictions. If moisture or corrosion is present, purge or flush the system, replace the receiver-drier, and add a full charge of refrigerant.
There is an insufficient refrigerant charge in the system.	Add refrigerant.

Problem—High Compressor Discharge Pressure

Possible Cause	Remedy
The shutters are not opening.	Replace the shutter solenoid valve, fan cycling switch, or both.
Airflow through the condenser is restricted.	Remove the debris from the condenser.
There is an internal restriction in the condenser. (The return tube bends should all be the same temperature).	Replace the condenser. If water or corrosion is present, evacuate the system, replace the receiver-drier, and add a full charge of refrigerant.
Air is present in the system.	Perform a leak test. Repair any leaks, evacuate the system, and add a full charge of refrigerant.
The system has too much refrigerant.	Drain some of the refrigerant charge at the compressor discharge service valve.
Heavy frosting on the suction line suggests that the evaporator coil is flooded.	Defrost the evaporator coil before resuming operation of the air conditioner. If the problem recurs, there is probably moisture (ice crystals) blocking the expansion valve. Exhaust the refrigerant charge, purge the system, replace the receiver-drier, and add a full charge of refrigerant.
The engine is over-heated.	Refer to the engine manufacturer's operations manual for corrective measures.
Restriction in the compressor discharge line.	Repair or replace the line.

Problem—Evaporator Outlet Air Temperature Increases as the Compressor Discharge Pressure Drops

Possible Cause	Remedy
There are leaks in the system.	Leak test the system. Repair any leaks, exhaust the old refrigerant, and add a full charge of refrigerant.

Troubleshooting

Possible Cause	Remedy
The expansion valve setting is too low.	Replace the expansion valve. Add a full charge of refrigerant.
Too much oil is in the system. An indication of this is clutch or belt slippage at governed engine speed.	Check and remove excess refrigerant oil. For instructions, refer to the refrigerant compressor section elsewhere in this group.

Problem—Compressor Operates Too Often or Continuously

Possible Cause	Remedy
There is too little refrigerant in the sytem.	Perform a leak test. Repair any leaks, and add a full charge of refrigerant.
Ice has formed on the evaporator coil.	Defrost the evaporator coil before resuming operation of the air conditioner. Check the operation of the thermostatic switch, and replace as necessary.
There is a restriction in the refrigerant system.	Remove the restriction from the line. If water or corrosion is present, purge or flush the system, replace the receiver-drier, and add a full charge of refrigerant.
Dirt and debris are clogging the condenser fins.	Remove all dirt and debris from the condenser fins.
The thermostatic switch isn't working.	Replace the thermostatic switch.

Problem—Quick or Delayed Cycling of the Compressor

Possible Cause	Remedy
The thermostatic switch operates, but is out of adjustment.	Repace the thermostatic switch. Do not attempt to adjust it.
Loss of refrigerant is causing a delayed cycling of the compressor.	Leak test and add a full charge of refrigerant.

Problem—Temperature in the Cab Too Low or No Heat

Possible Cause	Remedy
The water regulating valve is not opened.	Slide the temperature lever slide control toward "warm."
The water regulating valve is not opening all the way.	Adjust the water regulating valve cable.
The water regulating valve isn't working.	Replace the water regulating valve.
A heater hose is pinched or twisted.	Repair or replace the heater hose.
Coolant is leaking from the system.	Check for leakage at the heater core, and at all hose connections from the heater core to the engine. Check the radiator coolant level, as instructed in the vehicle driver's manual, and add coolant, if necessary. Check and repair any leaks at the radiator.
Dust or dirt is clogging the heater core fins.	Remove and clean the heater core.

Problem—Condensed Water Is Leaking from the Air Conditioner

Possible Cause	Remedy
The drain tubes are plugged.	Clean the drain holes and drain tubes.

Fault Analysis Flow Chart

(See Fig. 1)

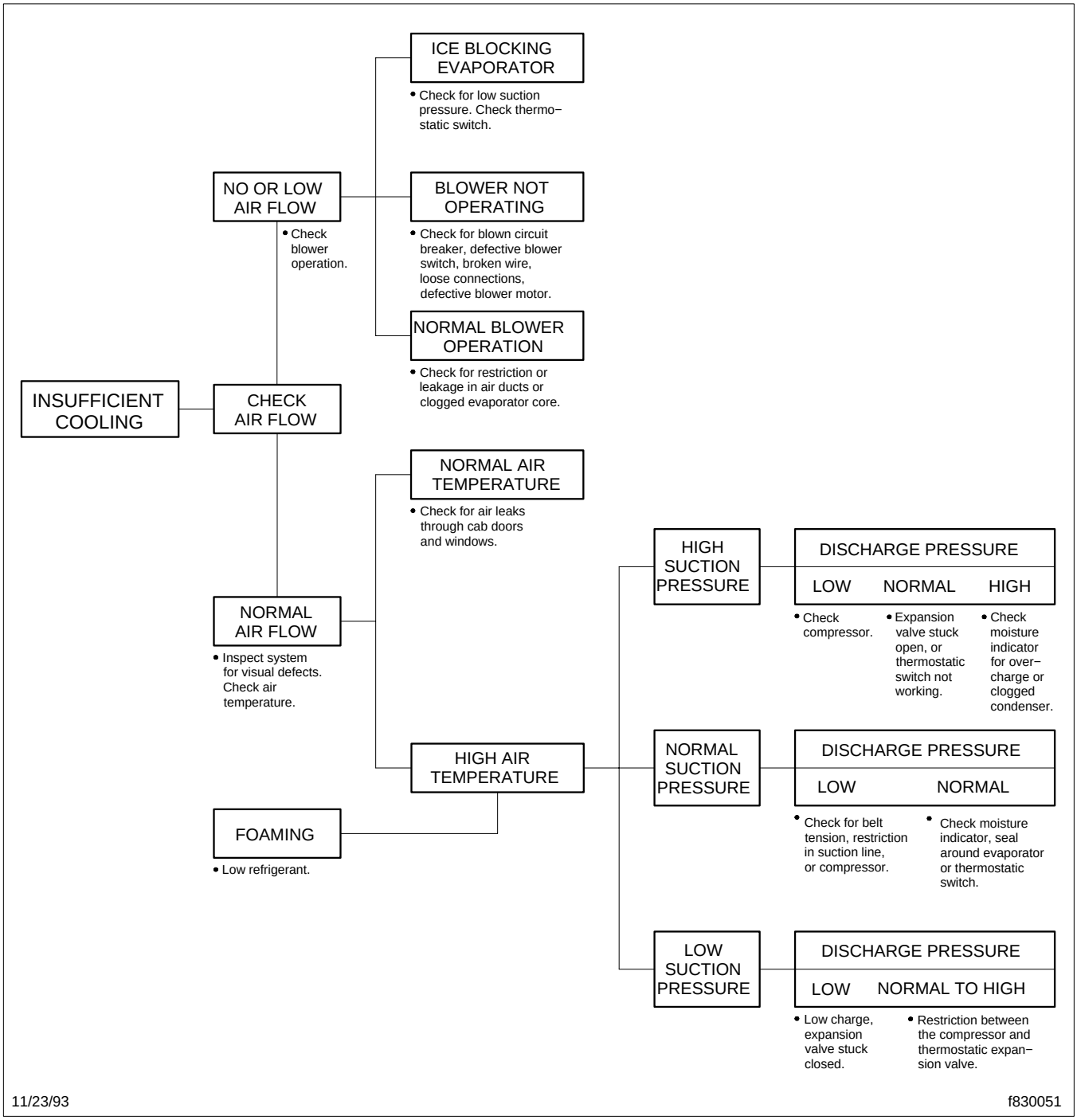


Fig. 1

Specifications

See **Fig. 1** for heater-A/C wiring with viscous fan. See **Fig. 2** for heater-A/C wiring with on-off fan. See **Fig. 3** for heater-A/C system components with viscous fan. See **Fig. 4** for heater-A/C system components with on-off fan. See **Fig. 5** for heater plumbing on DDE 60 engines (vehicles built after June 1, 1990). See **Fig. 6** for heater plumbing on CAT 3176 engines (vehicles built after June 1, 1990). See **Fig. 7** for heater plumbing on CAT 3406 engines (vehicles built after June 1, 1990). See **Fig. 8** for heater plumbing on Cummins L10 engines (vehicles built after June 1, 1990). See **Fig. 9** for heater plumbing on Cummins NTC engines (vehicles built after June 1, 1990). See **Fig. 10** for control panel plumbing diagram.

Air Tubing Fitting Torque Specifications				
Fitting Size	Tube (inches)	Additional Turns (using a wrench) Required to Seal from Finger-Tight		
		Compression	Threaded Sleeve	SAE 45-Degree Flare
2	1/8	1–1/4	1–1/2	1/6 Do Not Overtighten
3	3/16			
4	1/4			
5	5/16	1–3/4		
6	3/8	2–1/4		
8	1/2			
10	5/8			
12	3/4			
16	1			
20	1–1/4			

Table 1, Air Tubing Fitting Torque Specifications

Refrigerant Line Torque Specifications *		
Outside Diameter for Metal Tube (inch)	Torque for Steel Tubes † lbf·ft (N·m)	Torque for Aluminum or Copper Tubes †
1/4	10–15 (14–20)	60–80 lbf·in (680–940 N·cm)
3/8	30–35 (41–47)	11–13 lbf·ft (15–18 N·m)
1/2	30–35 (41–47)	15–20 lbf·ft (20–27 N·m)
5/8	30–35 (41–47)	21–27 lbf·ft (28–37 N·m)

Specifications

Refrigerant Line Torque Specifications *		
Outside Diameter for Metal Tube (inch)	Torque for Steel Tubes † lbf·ft (N·m)	Torque for Aluminum or Copper Tubes †
3/4	30–35 (41–47)	28–33 lbf·ft (38–45 N·m)

* Use two wrenches, one on each side of each fitting. Replace O-ring and lubricate with oil. Apply Loctite® 242 or 592 to the male portion of the fitting threads.
† When tightening fittings, always use the torque reading for the softer metal when unlike metals are used.

Table 2, Refrigerant Line Torque Specifications

Compressor Fitting Torque Specifications		
Ports	Aluminum Valve Body lbf·ft (N·m)	Iron Valve Body lbf·ft (N·m)
No. 10 Suction	14–18 (19–24)	26–31 (35–42)
No. 8 Discharge	14–18 (19–24)	26–29 (33–39)

Table 3, Compressor Fitting Torque Specifications

System Full-Charge Refrigerant Capacity Specifications		
Air Conditioner Installation	With Sleeper A/C	Refrigerant Capacity oz (kg)
FLA COE With Radiator-Mounted Condenser	No	51 (1.45)
	Yes	64 (1.82)
FLD Conventional With Radiator-Mounted Condenser	No	50 (1.42)
	Yes	63 (1.79)

Table 4, System Full-Charge Refrigerant Capacity Specifications

Temperature/ Pressure Specifications				
Relative Humidity	Outside Air Temperature °F (°C)	Maximum Center Console Outlet Temperature °F (°C)	With Compressor Running	
			Low Pressure psi (kPa)	High Pressure psi (kPa)
Low 30% (60% through Medium)	75 (24)	55 (13)	9–25 (62–172)	160 (1103)
	85 (29)	58 (14)	9–30 (62–207)	180 (1241)
	100 (38)	62 (17)	9–35 (62–241)	220 (1517)

Temperature/ Pressure Specifications				
Relative Humidity	Outside Air Temperature °F (°C)	Maximum Center Console Outlet Temperature °F (°C)	With Compressor Running	
			Low Pressure psi (kPa)	High Pressure psi (kPa)
High (90%)	75 (24)	57 (14)	9–25 (62–172)	170 (1172)
	85 (29)	60 (16)	9–35 (62–241)	190 (1310)
	100 (38)	64 (18)	9–40 (62–276)	260 (1793)

Table 5, Temperature/Pressure Specifications

Air Line Identification					
Lever Position	Line Color/ Function				
	Yellow Supply	Green Heat/ Def	Red Heat	Blue Vent	White Recirc Cylinder
	Air Pressure				
DEF	Yes	No	No	No	No
HEAT/DEF	Yes	Yes	No	No	No
HEAT	Yes	Yes	Yes	No	No
VENT	Yes	Yes	Yes	Yes	No
A/C	Yes	Yes	Yes	Yes	No
MAX A/C	Yes	Yes	Yes	Yes	Yes

Table 6, Air Line Identification

3/4- and 5/8-Inch Heater Hose Clamp Torque Values	
Description	Torque lbf·in (N·cm)
Standard Hose Clamp	40 (452)
Worm-Gear Hose Clamp	40 (452)
Breeze Constant-Torque Hose Clamp	40 (452)
Oetiker Constant-Torque Hose Clamp	18 (203)

Table 7, 3/4- and 5/8-Inch Heater Hose Clamp Torque Values

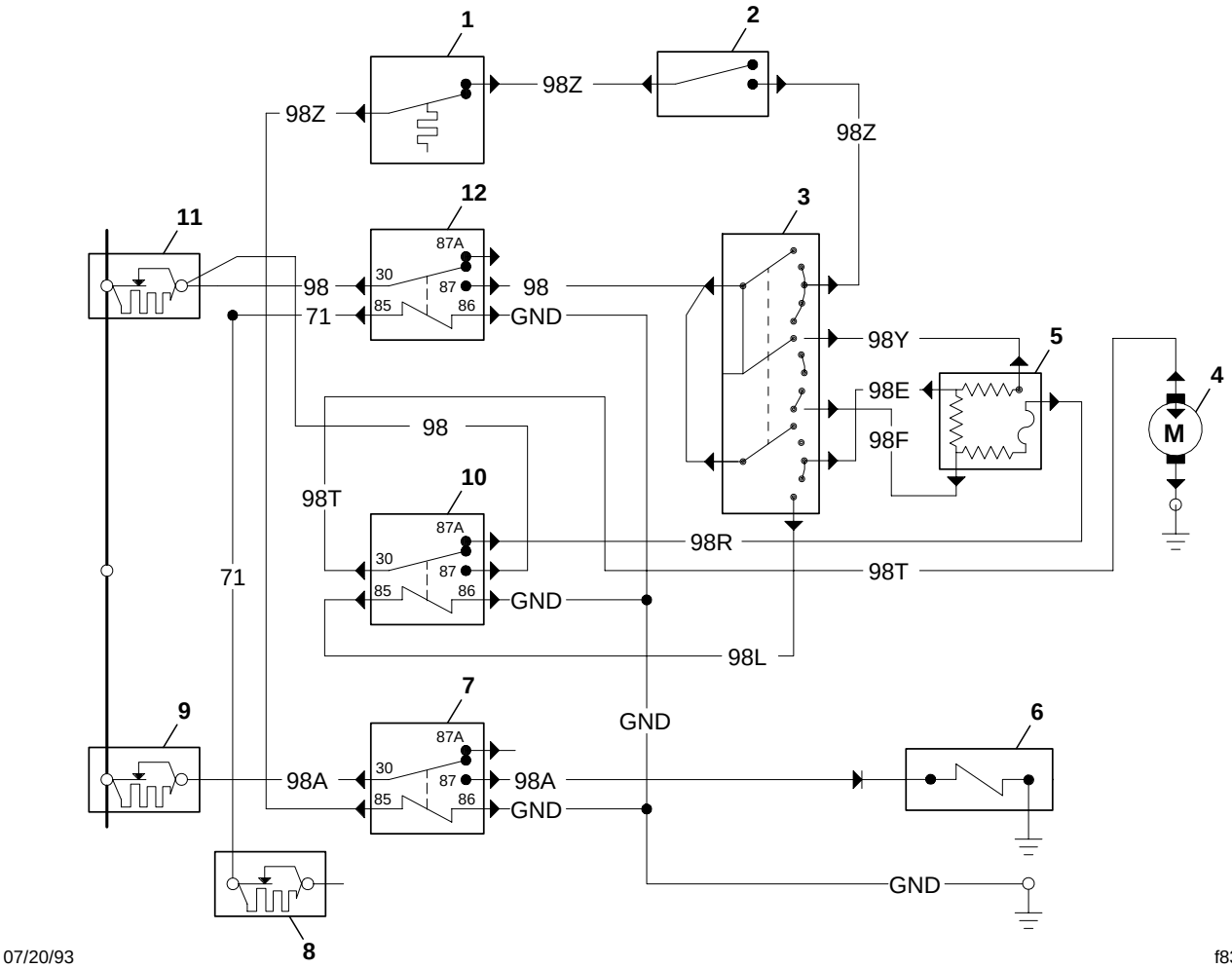
Specifications

Electronic Leak Detectors		
Designation	**Manufacturer**	**Comments**
D-TEK	Leybold Inficon 2 Technology Place East Syracuse, NY 13057 (315) 434–1144	• Rechargeable battery • Hand-held design • Simple to operate
H–10 Professional	Yokogawa Corp. of America 2 Dart Road Newnan, GA 30265 (800) 258–2552	• Rechargeable battery • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Most sensitive available
J 39400	Kent-Moore 29784 Little Mack Roseville, MI 48066–2298 (810) 578–7285	• 12V DC or 120V AC • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Manual balance control

Table 8, Electronic Leak Detectors

⚠ CAUTION

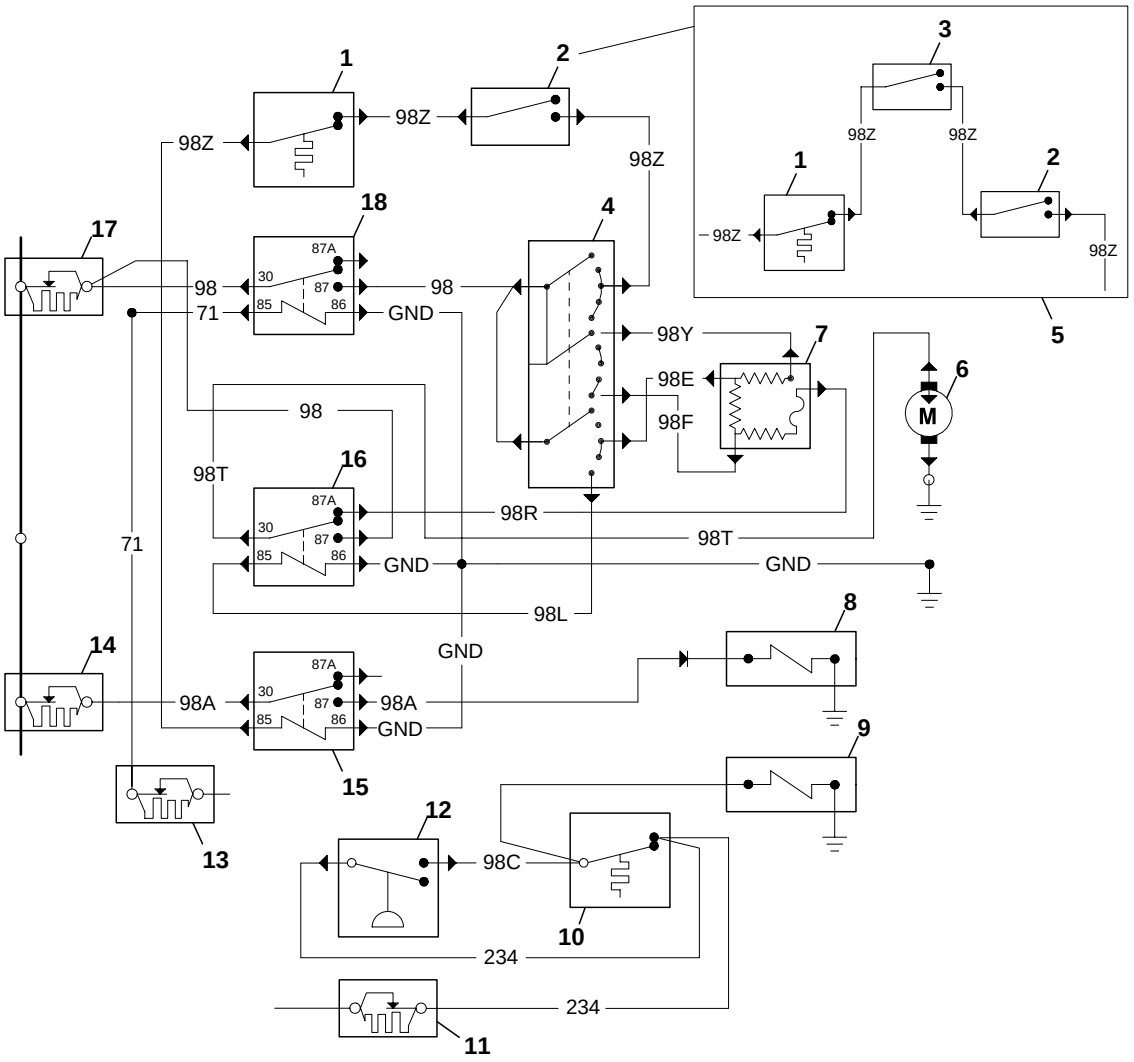
Never try to bypass the fuse in the blower motor resistor block. To do so could cause the blower motor to overheat, resulting in serious damage to the heater/air-conditioning system.



1. Thermostat (Open 32°F)
2. Air Conditioner On-Off Switch
3. Heater/Air-Conditioner Fan Switch
4. Motor
5. Resistor
6. Refrigerant Compressor Clutch
7. Air Conditioner Clutch Relay
8. 10A Keyed Circuit Breaker
9. 15A
10. Heater/Air-Conditioner Relay
11. 30A
12. Heater/Air-Conditioner Relay

Fig. 1, Heater/Air-Conditioning Wiring, Viscous Fan

Specifications



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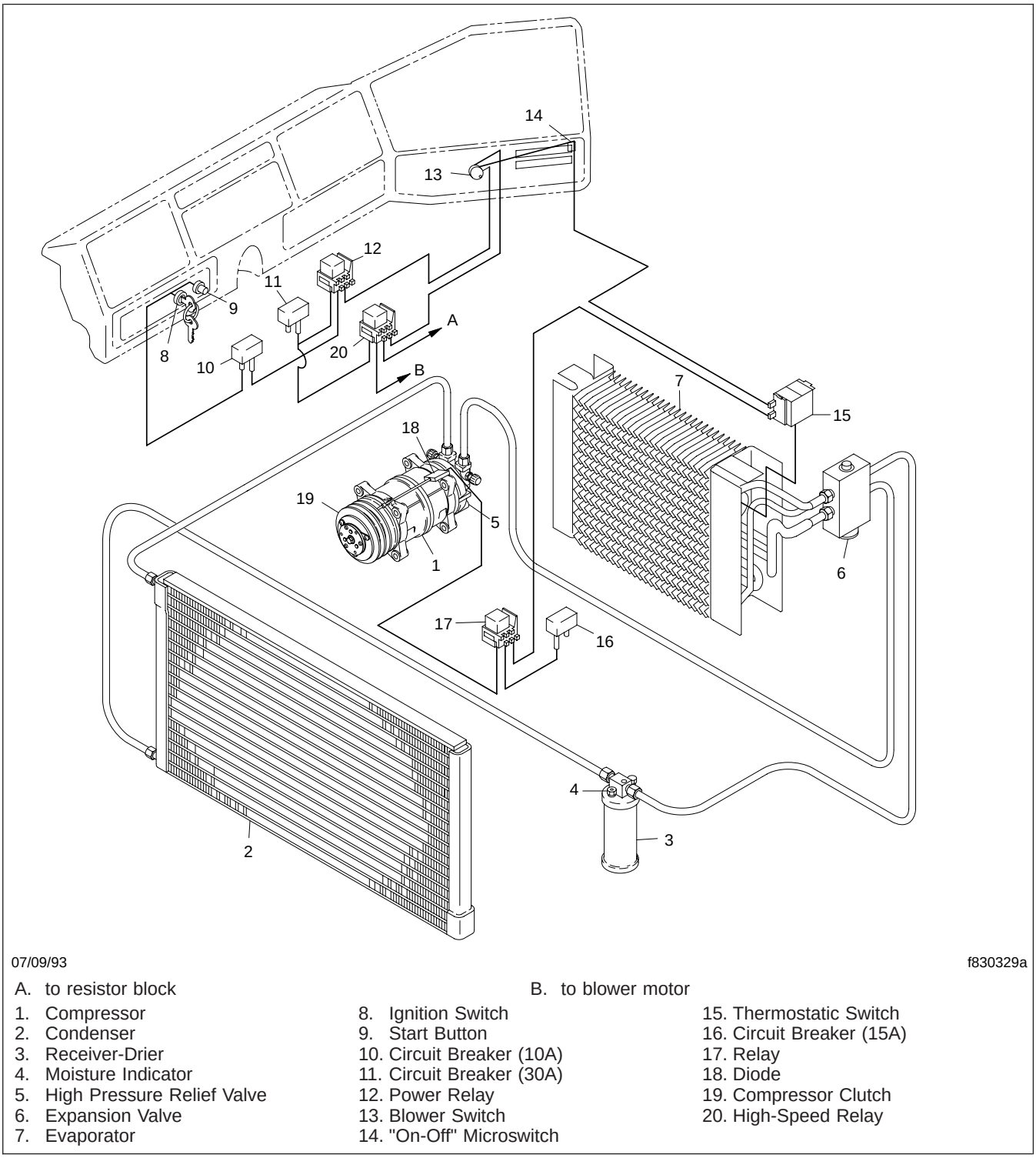
1. Thermostat (Open 32°F)
2. Air Conditioner On-Off Switch
3. Low-Air Pressure Switch (on constant-air junction block)
4. Heater/Air-Conditioner Fan Switch
5. Vehicles Equipped With Low-Air Pressure Switch (built from 01/19/90)
6. Motor
7. Resistor
8. Refrigerant Compressor Clutch
9. Fan Clutch Solenoid
10. Fan Clutch Thermal Switch
11. 10A Auxiliary Keyed Circuit Breaker
12. Fan Cycle Switch
13. 10A Keyed Circuit Breaker
14. 15A
15. Air Conditioner Clutch Relay
16. Heater/Air-Conditioner Relay
17. 30A
18. Heater/Air-Conditioner Relay

Fig. 2, Heater/Air-Conditioning Wiring, On-Off Fan

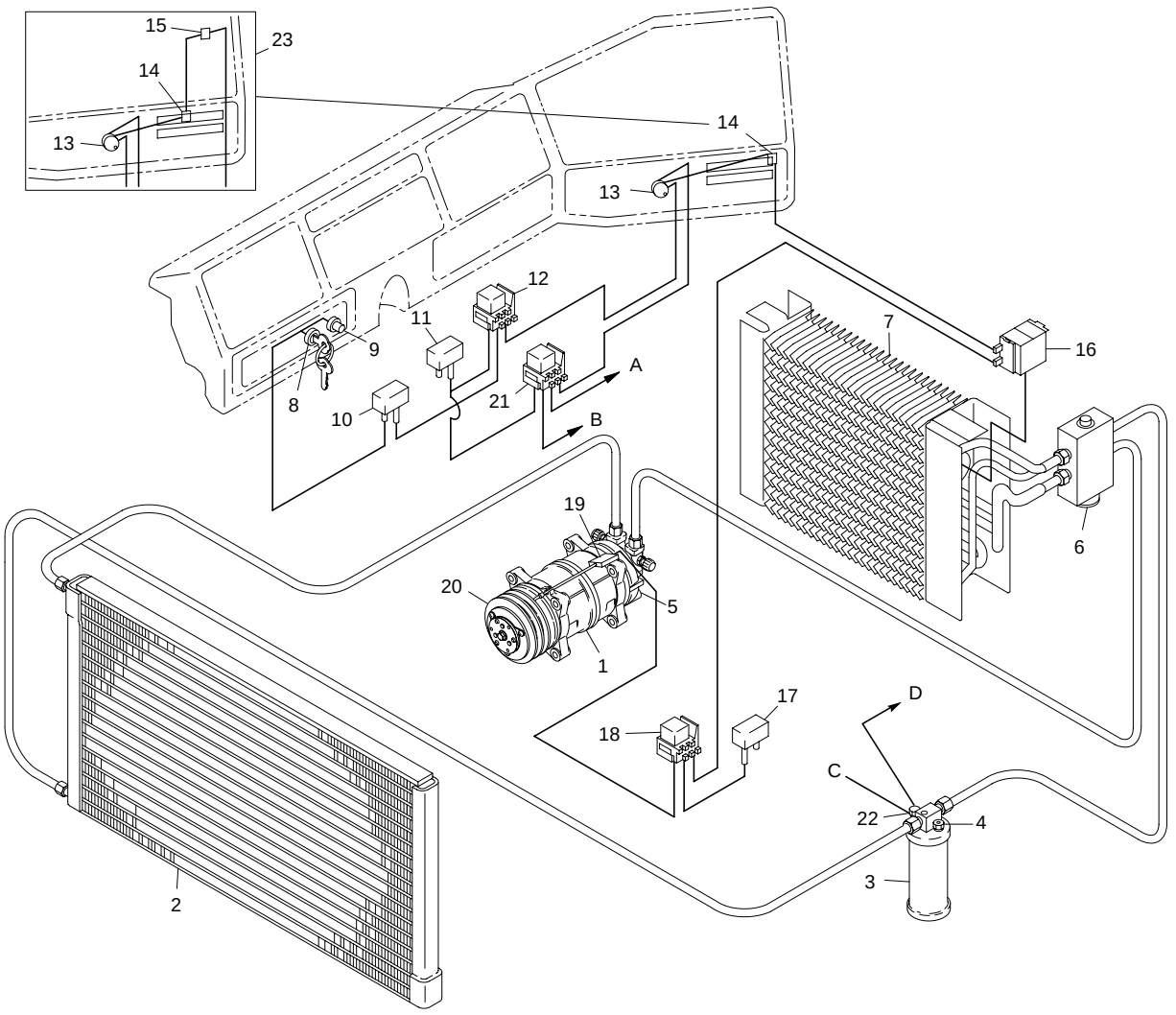


A. to resistor block
B. to blower motor

1. Compressor
2. Condenser
3. Receiver-Drier
4. Moisture Indicator
5. High Pressure Relief Valve
6. Expansion Valve
7. Evaporator
8. Ignition Switch
9. Start Button
10. Circuit Breaker (10A)
11. Circuit Breaker (30A)
12. Power Relay
13. Blower Switch
14. "On-Off" Microswitch
15. Thermostatic Switch
16. Circuit Breaker (15A)
17. Relay
18. Diode
19. Compressor Clutch
20. High-Speed Relay

Fig. 3, FLA COE and FLD Conventional Air Conditioning System (With Viscous Fan)

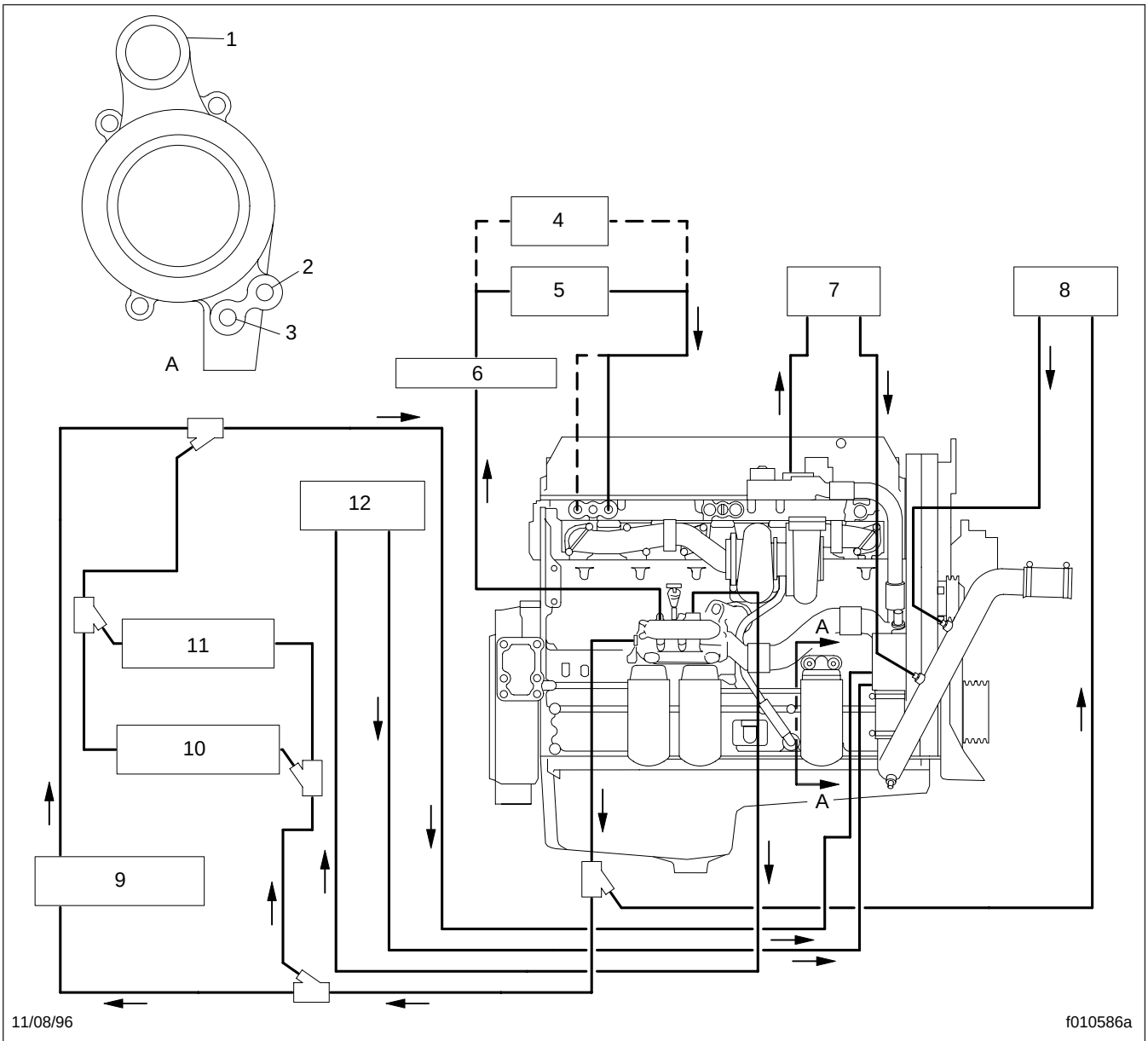
Specifications



A. to resistor block
B. to blower motor
C. from engine fan thermal switch
D. to engine fan thermal switch

1. Compressor
2. Condenser
3. Receiver-Drier
4. Moisture Indicator
5. High Pressure Relief Valve
6. Expansion Valve
7. Evaporator
8. Ignition Switch
9. Start Button
10. Circuit Breaker (10A)
11. Circuit Breaker (30A)
12. Power Relay
13. Blower Switch
14. "On-Off" Microswitch
15. Low-Air Pressure Switch
16. Thermostatic Switch
17. Circuit Breaker (15A)
18. Relay
19. Diode
20. Compressor Clutch
21. High-Speed Relay
22. Fan Cycling Switch
23. Vehicles Equipped With a Low-Air Pressure Switch (built from 01/19/90)

Fig. 4, FLA COE and FLD Conventional Air Conditioning System (With On-Off Fan)



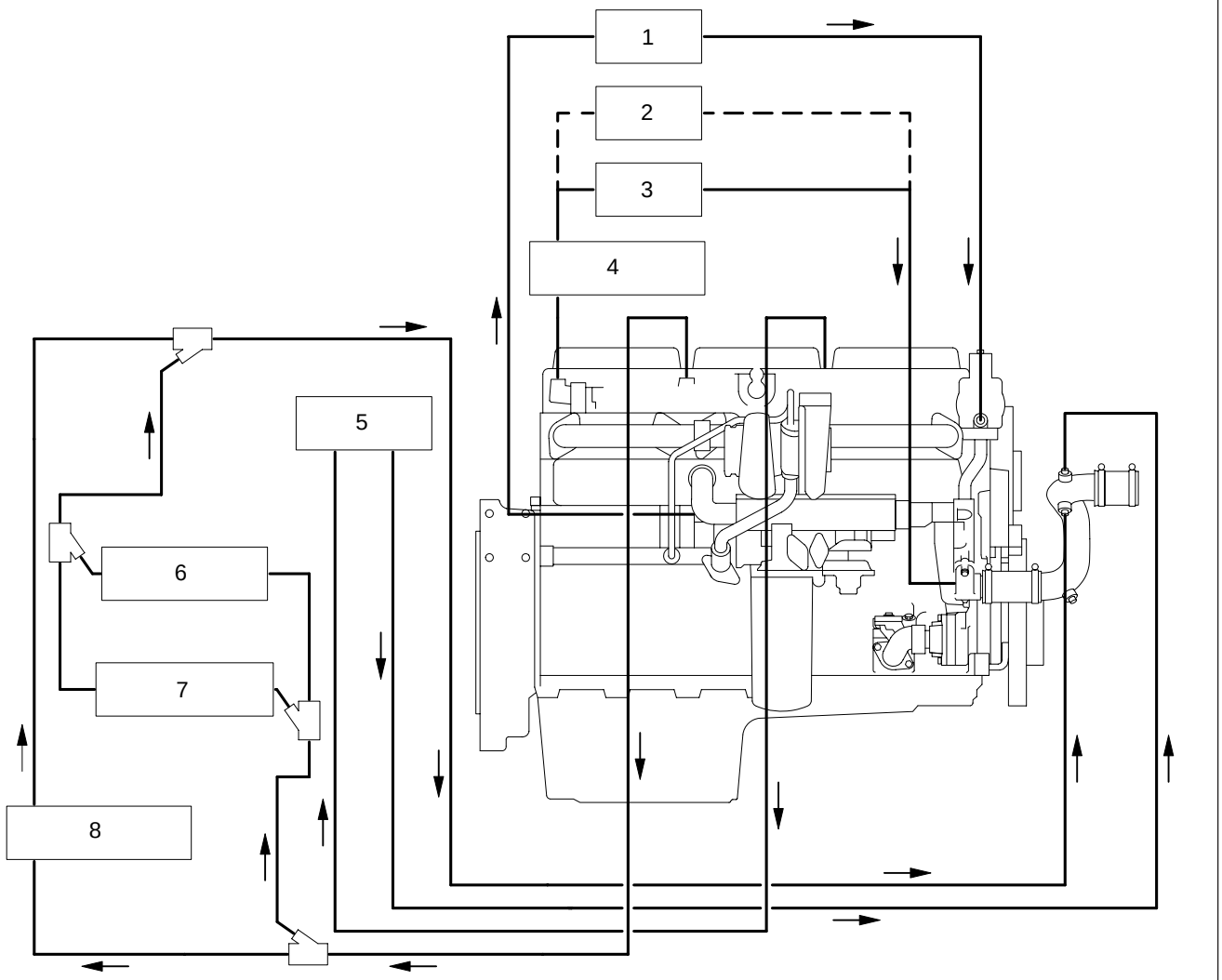
NOTE: Depending on vehicle options, and often for ease of installation, different supply and return ports can be used.

A. **View A-A**

1. Water Pump Outlet
2. Main Heater Return Port
3. Aux Heaters Return Port
4. Fuel Heater
5. Fuel Heater
6. Thermostat
7. Water Filter
8. Trailer Heater
9. Sleeper Bunk Heater
10. Passenger's Aux Heater
11. Driver's Aux Heater
12. Main Cab Heater

Fig. 5, Heater Plumbing for DDE Series 60 Engines (Vehicles Built After June 1, 1990)

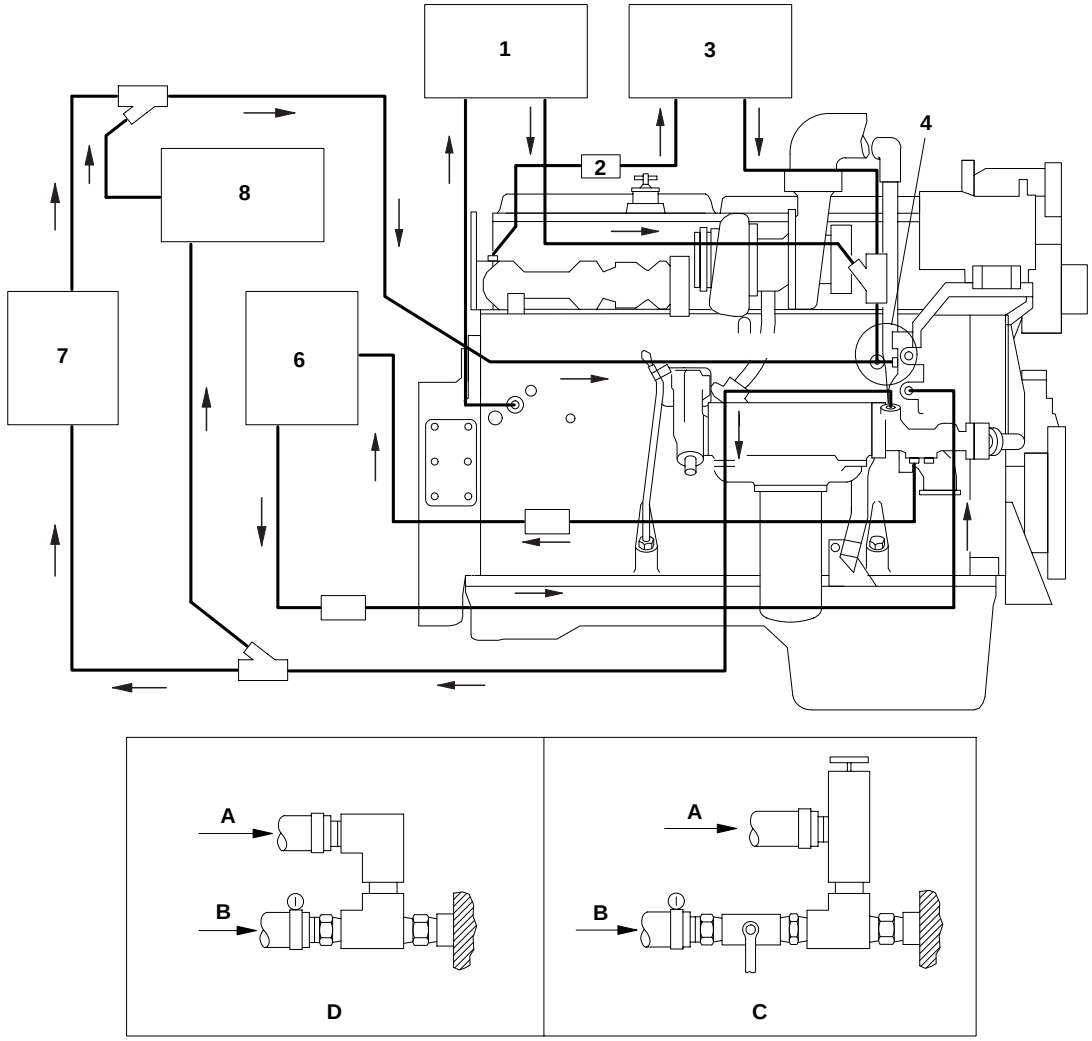
Specifications



NOTE: Depending on vehicle options, and often for ease of installation, different supply and return ports can be used.

1. Water Filter
2. Fuel Heater
3. Fuel Heater
4. Thermostat
5. Main Cab Heater
6. Driver's Aux Heater
7. Passenger's Aux Heater
8. Sleeper Bunk Heater

Fig. 6, Heater Plumbing for Caterpillar 3176 Engines (Vehicles Built After June 1, 1990)



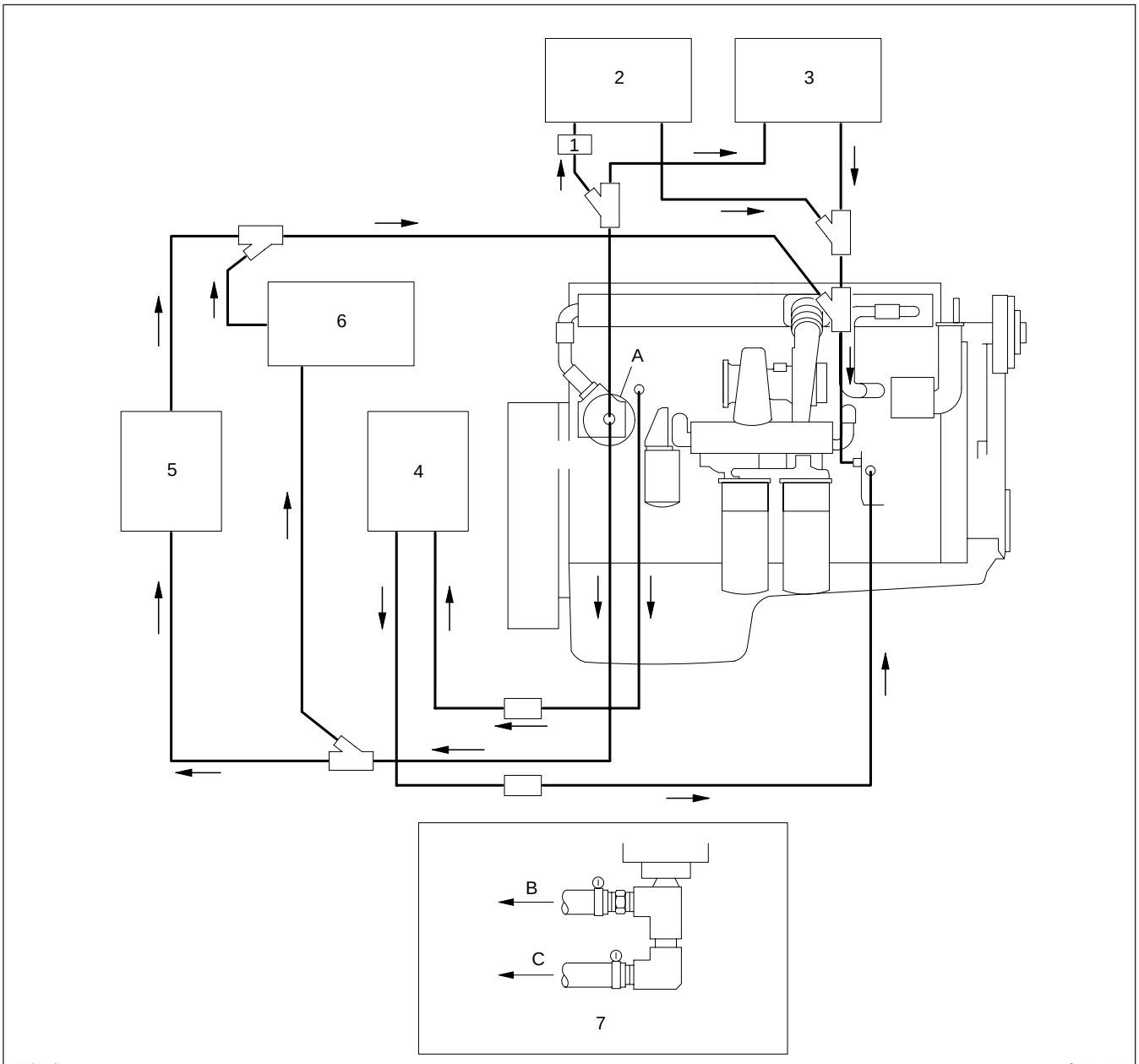
NOTE: Depending on vehicle options, and often for ease of installation, different supply and return ports can be used.

A. from fuel heater and water filter
B. from auxiliary heater(s)
C. With Shutoff Valve(s)
D. Without Shutoff Valve(s)

1. Water Filter
2. Thermostat
3. Fuel Heater
4. See Detail A
5. Detail A (side view)
6. Main Cab Heater
7. Sleeper Heater
8. Driver-Side Auxiliary Heater

Fig. 7, Heater Plumbing for Caterpillar 3406 Engines (Vehicles Built After June 1, 1990)

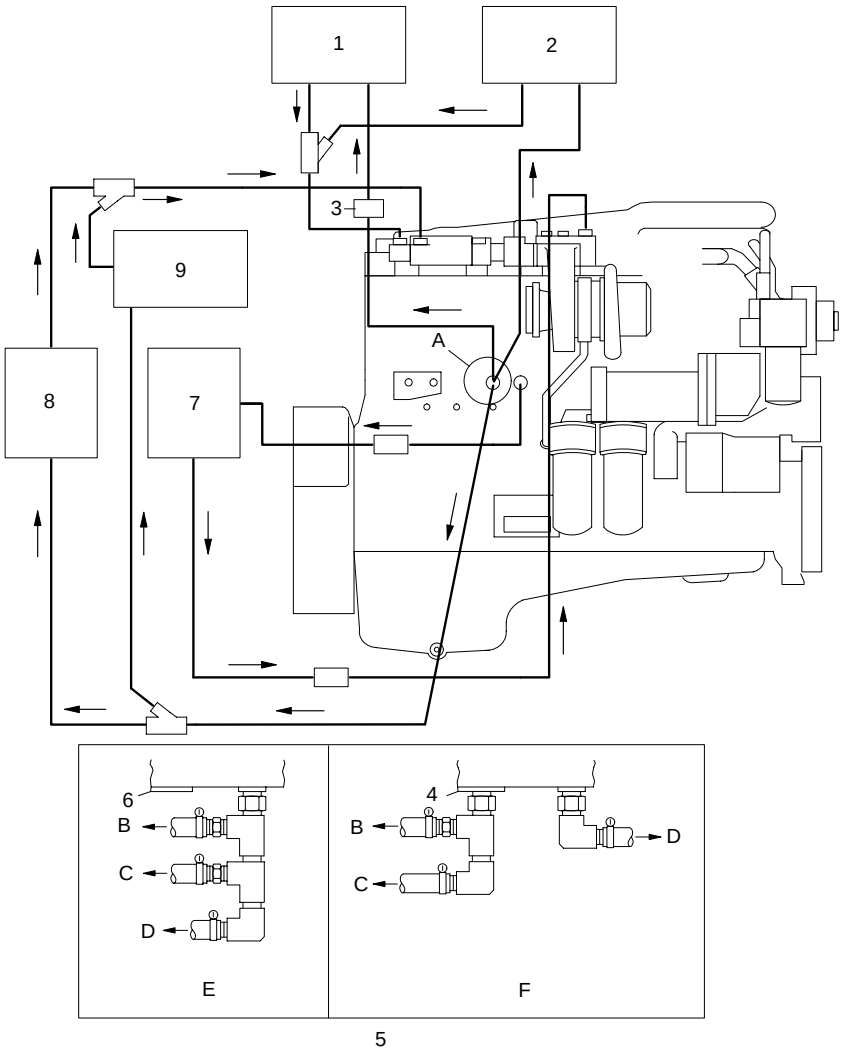
Specifications



NOTE: Depending on vehicle options, and often for ease of installation, different supply and return ports can be used.

A. See Detail A
B. to fuel heater and water filters
C. to auxiliary heater(s)
D. Detail A (top view)
1. Thermostat
2. Fuel Heater
3. Water Filter
4. Main Cab Heater
5. Sleeper Heater
6. Driver-Side Auxiliary Heater

Fig. 8, Heater Plumbing for Cummins L10 Engines (Vehicles Built After June 1, 1990)



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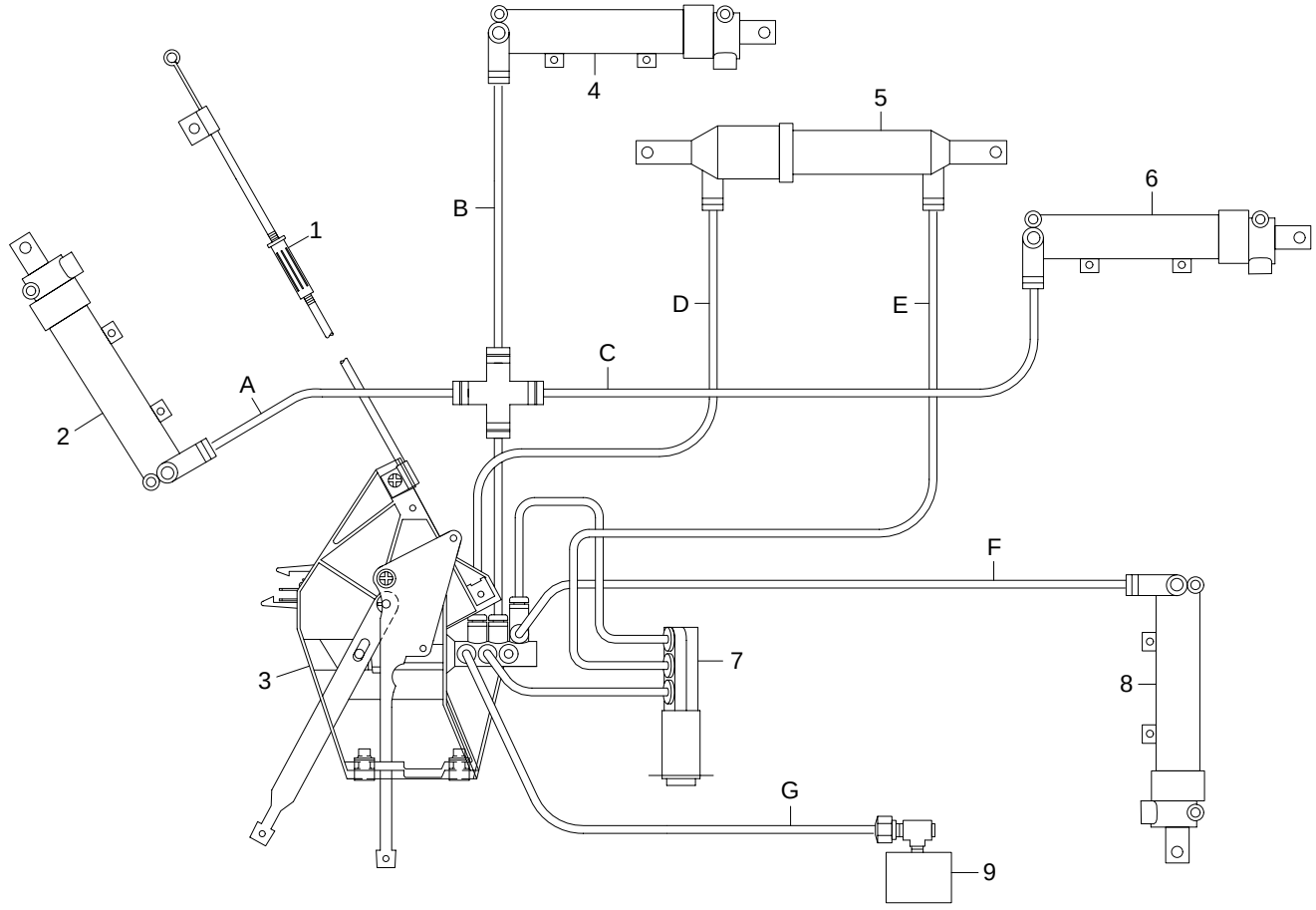
NOTE: Depending on vehicle options, and often for ease of installation, different supply and return ports can be used.

A. See Detail A
B. to water filter
C. to fuel heater
D. to auxiliary heaters
E. Supply Port Covered by Block Heater
F. Supply Port Available

1. Fuel Heater
2. Water Filter
3. Thermostat
4. Block Heater or Cover Plate
5. Detail A (top view)
6. Block Heater
7. Main Cab Heater
8. Sleeper Heater
9. Driver-Side Auxiliary Heater

Fig. 9, Heater Plumbing for Cummins NTC Engines (Vehicles Built After June 1, 1990)

Specifications



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A. Vent/Blue
B. Vent/Blue
C. Vent/Blue
D. Heat/Defrost-Green
E. Heat/Red
F. Recirc/White
G. Supply/Yellow

1. Water Regulator Valve Cable
2. Left-Side Diverter Air Cylinder
3. Slide Lever Control
4. Face Duct Air Cylinder
5. Heat/Defrost Duct Air Cylinder
6. Right-Side Diverter Air Cylinder
7. Fresh-Air Recirculation Valve
8. Recirculation Air Cylinder
9. Constant Air Junction Block

Fig. 10, Control Panel Plumbing (vehicle equipped with a heater/air-conditioner, and a fresh-air recirculation valve)

General Information

The main purpose of the refrigerant compressor (**Fig. 1**) is to draw refrigerant gas from the evaporator and squeeze it into high-pressure gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid so that it can be used for cooling again. A second purpose of the compressor is to move refrigerant through the air conditioner system.

The compressor is cycled by a thermostatic switch, which is located on the blower motor housing in the cab. See **Fig. 2.** When the cab is cool enough, the switch breaks the circuit to the compressor's clutch. When the clutch is disengaged, its pulley free-wheels and the compressor shaft stops turning. When the clutch engages, it causes the pulley to turn the compressor shaft.

Refer to the cab air conditioner section for other information.

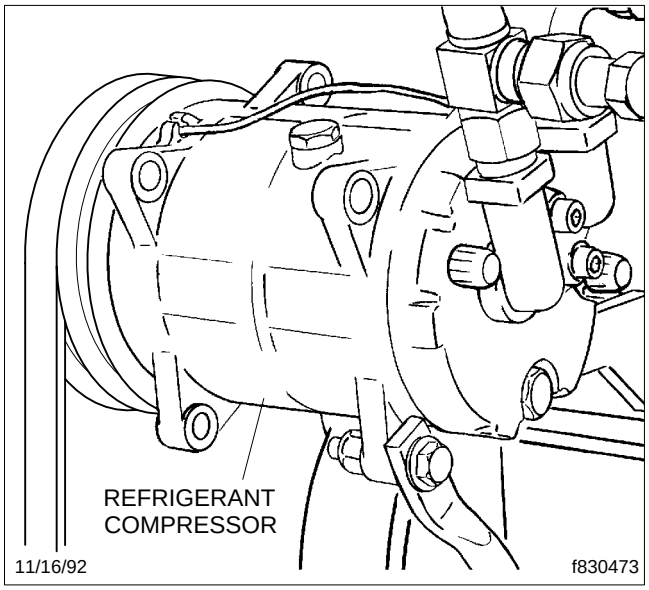


Fig. 1

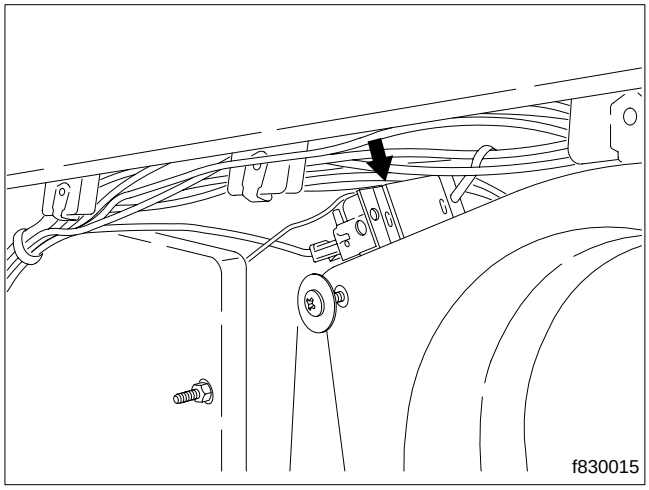


Fig. 2

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold refrigerant, you must discharge, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure. You should disconnect them only after the air conditioning system has been discharged to a refrigerant recovery unit through the service valves.

Refrigerants are safe when used under the right conditions. Always wear safety goggles and non-leather gloves while discharging, purging, flushing, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

WARNING: Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should first be treated with a few drops of sterile mineral oil in the eyes, and then rinsed with a weak boric acid solution. Do not rub the eyes. Call a doctor right away.

Refrigerant splashed on the skin should be treated the same as for frostbite: gently pour cool water on the area, but do not rub the skin. Keep the skin warm with layers of soft, sterile cloth. Call a doctor right away.

⚠ WARNING

When the engine is running and the air conditioning compressor is engaged, stay clear of the high-pressure relief valve (Fig. 1). If the system pressure were to exceed the relief valve setting, refrigerant would be released suddenly under high pressure, possibly causing serious injury on contact with skin or eye tissue.

Even though refrigerant does not burn, when it contacts extreme heat or flame, poisonous gas is created.

⚠ WARNING

WARNING: Do not work in an area where refrigerant may contact an open flame or any burning material, such as a cigarette. When it contacts extreme heat, refrigerant breaks down into poisonous gas which, if breathed, causes severe respiratory irritation. If an open flame leak detector is used, follow the manufacturer's safety precautions.

If a refrigerant recovery and recycling station is available, discharge the air conditioning system into the station. Refer to the manufacturer's operating instructions.

If a refrigerant recovery and recycling station is not available, check local regulations for disposal methods.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant cans from exploding, never expose them to temperatures higher than 52°C (125°F). Never leave refrigerant cans in the sun, and do not store them in sun-exposed areas where heat can build up, such as in glove boxes, automobile trunks, etc.

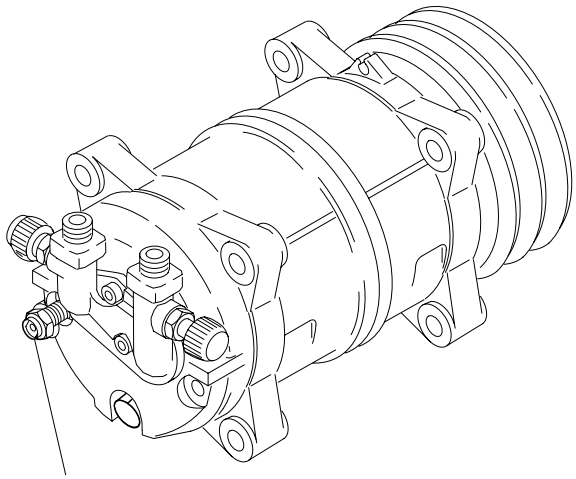


Fig. 1

Pre-Service Checks

WARNING

WARNING: Before doing any work, read the information under "Safety Precautions, 100." Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

Some special tools are needed for doing repair work on the compressor. Tool kits can be bought from the distributors listed in **Specifications, 400**.

The checks below should be made whenever the air conditioner system is not cooling enough and the causes are unknown.

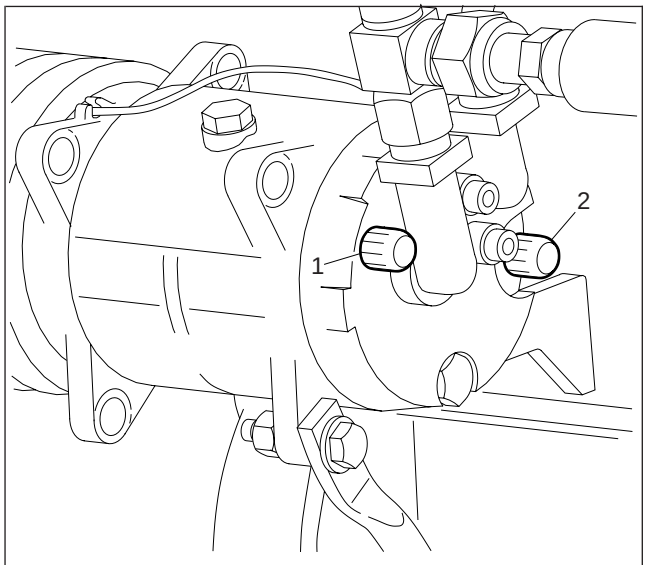
1. Be sure to check the moisture indicator, to see if water is the cause of the problems. The air conditioner should be on when checking the indicator; it is better to check it at the end of a day's run.
2. Check the drive belt and mounting as follows:
   - 2.1 On the drive belt, look for wear, damage, or oil. If worn, damaged, or oil-soaked, remove it and install a new one.
   - 2.2 Check the compressor mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners to the torque value using the applicable torque table under **Specifications, 400**. Repair or replace cracked or damaged brackets.
   - 2.3 Check the tension of the compressor drive belt, using a belt tension gauge. Adjust the belt, as needed. Refer to the engine section in this manual for information.
3. Check the wiring and connections to the compressor clutch. Replace damaged wiring and tighten loose connections.
4. Check for road debris build-up on the condenser coil fins. Using air pressure and a whiskbroom or a solution of soap and water, carefully clean the condenser; be careful not to bend the fins.
5. Check the refrigerant charge in the air conditioner system; for instructions, refer to the cab air conditioner section in this group.
6. Check the suction pressure and discharge pressure of the refrigerant compressor; refer to **Subject 130**.

NOTE: For other possible causes of air conditioner problems, refer to the cab air conditioner section in this group.

Compressor Suction and Discharge Pressure Checking

Procedures

1. Read the information under **Safety Precautions, 100**.
2. Attach a manifold gauge set to the compressor service ports. Equip the manifold gauge set with a valve core depressor.
   - 2.1 Remove the protector caps from the suction and discharge ports. See **Fig. 1.**
   - 2.2 Close both of the valves on the manifold gauge set. Cap the manifold center hose.
   - 2.3 Connect the high-side hose to the discharge service port. The connection should be finger-tight.
   - 2.4 Open the high-side manifold valve one turn. Open the low-side manifold valve just enough to allow refrigerant gas to slowly escape from the low-side hose. Allow gas to escape for three seconds, then close both manifold valves.
   - 2.5 Quickly connect the low-side hose to the suction service port. The connection should be finger tight.



1. Suction Service Valve
2. Discharge Service Valve

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Fig. 1

3. Start the engine and set it to run at 1500 rpm.
4. Turn the blower on high, and set the air conditioner controls to MAX A/C, so that the compressor is operating. If the outside temperature is cooler than 70°F (21°C), *partially* block the air to the condenser.
5. Look at the manifold suction and discharge pressure gauges. The pressure on the gauges should be within the range in the temperature/pressure specifications table in **Specifications, 400**.
   - 5.1 If the suction pressure is normal and the discharge pressure is too high, proceed to the next step.
   - 5.2 If the suction and discharge pressures are both too high, there is air in the system, too much R-12 in the system, or the condenser is clogged with debris. Clean the condenser and check the charge. For instructions, refer to the cab air conditioner section in this group.
   - 5.3 If the suction pressure is too high and the discharge pressure is normal, check whether the expansion valve is stuck open. Refer to the cab air conditioner section in this group.
   - 5.4 If the suction pressure is too low and the discharge pressure is normal or too low, check for passage of air through the evaporator coils. If airflow is blocked, remove the blockage. If airflow is satisfactory, check for blockages in the line to the suction side of the compressor.
   - 5.5 If the suction pressure is normal or too high and the discharge pressure is too low, proceed to the step after the next.
6. If the suction pressure is normal and the discharge pressure is too high, airflow through the condenser may not be enough to carry away the heat.

   Do the following:

   - 6.1 Place a large fan in front of the radiator; place it so that the airflow goes through the condenser. After two minutes of operating the air conditioner and the fan at the same time, look at the manifold pressure gauges again. (One other procedure is to direct a spray of water onto the condenser while the system is running.)

Compressor Suction and Discharge Pressure Checking

6.2 If the discharge pressure is still too high, the lines between the compressor and the receiver-drier are restricted, or the condenser is restricted internally. Discharge, flush, evacuate, charge, and leak test the system. If the restriction can't be removed by flushing, replace the affected line or condenser. After flushing and before placing a vacuum on the system, *be sure to add the correct amount of refrigerant oil to the compressor*. For instructions, refer to **Subject 150** or **Subject 155**.

7. If the suction pressure is normal or too high and the discharge pressure is too low, check for a slipping clutch or wrong-sized clutch pulley or accessory drive pulley. Replace parts as needed.

   If the suction pressure is still normal or too high and the discharge pressure is still too low, the compressor is the problem. Repair or replace the compressor.

Compressor Removal and Installation

Removal

WARNING

Before doing any work, read the information in Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

1. Turn off the engine, apply the brakes, and chock the tires.
2. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.04**, Subject 250.
3. Remove the compressor drive belt. If the shaft seal assembly or the entire compressor is being replaced, remove the magnetic clutch assembly. For instructions, see **Subject 160** or **Subject 165**.
4. Clean the compressor around the refrigerant line connections. Disconnect the refrigerant lines from the compressor. Quickly cap the discharge and suction ports and the refrigerant lines.

IMPORTANT: Under no circumstances should the ports on the compressor or the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

5. Remove the nuts and bolts that attach the compressor to the mounting bracket. Remove the compressor.

Installation

IMPORTANT: A new compressor is filled with refrigerant oil and nitrogen gas. On CH series compressors the quantity is printed on the label attached to the compressor. When installing a new compressor on the vehicle, do all of the steps below. If installing a used compressor, disregard the first step.

1. Prepare a new compressor.
   - 1.1 Gently release nitrogen from the discharge side of the compressor. Be careful not to let the oil flow out.
   - 1.2 Turn the compressor shaft several times by hand to distribute oil which has settled in the cylinder.
2. If installing a new compressor, adjust the refrigerant oil level in the new compressor. For instructions see, **Section 83.06**, Subject 130.
3. Using bolts and nuts, install the refrigerant compressor on the mounting bracket. Torque the bolts 33 lbf·ft (45 N·m).
4. Install the magnetic clutch assembly if it was removed. For instructions, see **Subject 160** or **Subject 165**.
5. Install the compressor drive belt. Refer to the engine section in this manual for compressor drive belt tension adjustment.
6. Uncap the discharge and suction ports and the refrigerant lines. Check the refrigerant lines and the discharge and suction ports. They must be clean and free of nicks, gasket residue, and other foreign material.
7. On refrigerant line connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On refrigerant line connections that have Mini Stat-O-Seals, replace the seals. **Do not** lubricate Mini Stat-O-Seals prior to installation. Use only a Mini Stat-O-Seal on a Mini Stat-O-Seal assembly.
8. Connect the refrigerant lines to the compressor.

   On refrigerant line connections that have threaded fittings, torque the fittings 33 lbf·ft (45 N·m).

   On refrigerant line connections that have a Mini Stat-O-Seal assembly, torque the bolt on the Mini Stat-O-Seal assembly 11 to 15 lbf·ft (15 to 20 N·m).
9. If installing a new compressor or if the system was without any refrigerant pressure before repairs were started, replace the receiver-drier. For instructions, see **Section 83.04**, Subject 210.

   If the compressor is not being replaced, check the moisture indicator on the receiver-drier. If it is not blue, replace the receiver-drier. For instructions, see **Section 83.04**, Subject 210.

Compressor Removal and Installation

10. Evacuate, charge, and leak test the refrigerant system. For instructions, see **Section 83.04**, Subject 250.
11. Remove the chocks from the tires.

Oil Check and Adding Oil to the Compressor, DKS-15BH

Procedure

IMPORTANT: New compressors are factory-charged with 6.8 fl oz (200 mL) of refrigerant oil, which does not require periodic checking. Refrigerant oil is circulated through the system with the refrigerant, and cannot leave the system except through a leak, when the system is discharged for service, and when a refrigerant part is replaced.

Add only refrigerant compressor oil "Suniso 5GS," "FREOL DS-38P," or refrigerant oil of viscosity SUS 500/100°F. Oil must be from a container that has not been opened, or that has been tightly sealed since its last use. Tubing, funnels, or other equipment used to transfer the oil should be very clean and dry.

IMPORTANT: Add the same amount of oil that is removed when the system is discharged, or when a system part is replaced.

When discharging the system or replacing system parts, add enough oil to replace that which is lost with the refrigerant charge and the discarded part. The oil quantities listed below are approximate refill amounts.

A. *Refrigerant charge*—0.7 fl oz (20 mL): This amount of oil must be added to the compressor each time the system loses its charge, due to routine discharging or due to a slow leak; no other parts of the system have been purged, flushed, or replaced.

   IMPORTANT: The remaining items below list oil quantities that include the amounts that are lost during discharging. Do not add an additional 0.7 fl oz (20 mL)—the amount described in the item above—to the quantities listed.

B. *Receiver-drier*—2.7 fl oz (80 mL);

   IMPORTANT: A new receiver-drier may contain 3.4 fl oz (100 mL) of refrigerant oil, eliminating the need to add oil before installation. Confirm the oil level in a new receiver-drier; don't add any oil if it already contains 3.4 fl oz (100 mL).

C. *Condenser*—1.0 fl oz (30 mL);

D. *Evaporator coil*—0.7 fl oz (20 mL) each;

E. *Entire system*—10.2 fl oz (300 mL) without auxiliary heater/air-conditioner, 12.2 fl oz (360 mL) with auxiliary heater/air-conditioner: Add this amount of oil to the compressor if the entire system (including the compressor) has been discharged of refrigerant and oil, and all parts and hoses have been flushed.

When handling refrigerant oil:

- The oil should be free of water, dust, metal powder, and other foreign substances.
- Do not mix refrigerant oil with other types or viscosities of oil.
- Refrigerant oil absorbs water when exposed to the air for short periods. After use, quickly seal the oil container.

During normal operation, part of the oil recirculates with the refrigerant in the system. When checking the amount of oil in the system, first run the compressor to return the oil to the compressor.

1. Turn on the air conditioner (compressor must be engaged), and set the cab blower fan at high speed.
2. Run the compressor for at least 20 minutes, between 800 and 1200 rpm.
3. After turning off the engine, remove the compressor from the vehicle.
4. Remove the oil drain plug, and drain the oil into a clean container. See **Fig. 1.**
5. Measure the drained oil with a measuring cylinder.
6. Check the oil for contamination. Compressor oil is different from engine oil in that no cleaning agent is added to it. Even if the compressor is run for an entire season, the oil should never become cloudy, as long as there is nothing wrong with the compressor or the method in which it is used. Inspect the extracted oil for any of the following conditions:

   6.1 Cloudiness;

   6.2 Color change to red;

   6.3 Presence of foreign particles (metal powder, etc.) in the oil.

   If the oil taken from the compressor shows any of the above problems, flush all parts of the system and replace the receiver-drier. For instructions, refer to the applicable sections in this group.

Oil Check and Adding Oil to the Compressor, DKS-15BH

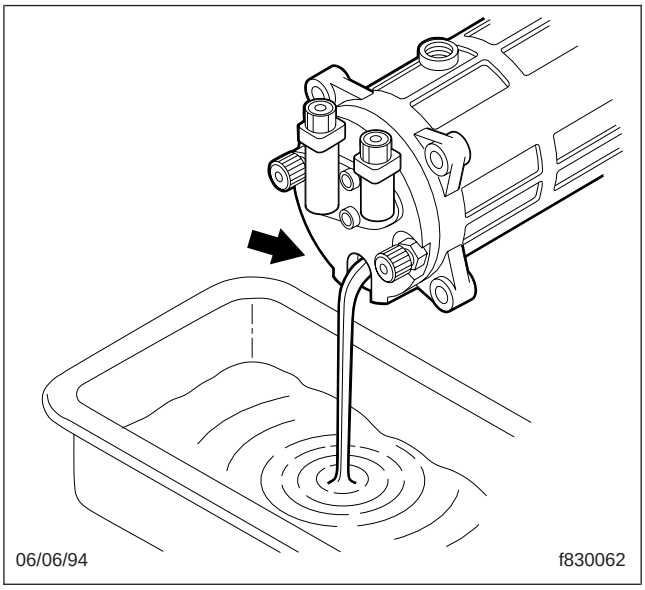


Fig. 1

7. Install the drain plug and a new O-ring lightly coated with clean compressor oil. Tighten the plug 96 lbf·in (1080 N·cm).
8. Remove the oil filler plug, and add oil. See **Fig. 2.** The charging amount is listed in **Table 1**.

Charging Amounts	
Collected Amount	**Charging Amount**
More than 3.0 fl oz. (90 mL)	Same as collected amount; do not exceed 12.2 fl oz (360 mL) in a system with an auxiliary heater/air-conditioner or 10.2 fl oz (300 mL) in a system without one.
Less than 3.0 fl oz (90 mL)	3.0 fl oz (90 mL)

Table 1, Charging Amounts

9. If an oil return operation (the first two steps above) could not be done and the amount of extracted oil was higher than 3.0 fl oz (90 mL), add the same amount of oil to the compressor to be installed. If the amount of oil extracted is less than 3.0 fl oz (90 mL), recheck the compressor oil as follows:

   9.1 Add 1.7 fl oz (50 mL) of oil to the compressor and install it on the vehicle. Place a refrigerant charge in the system.

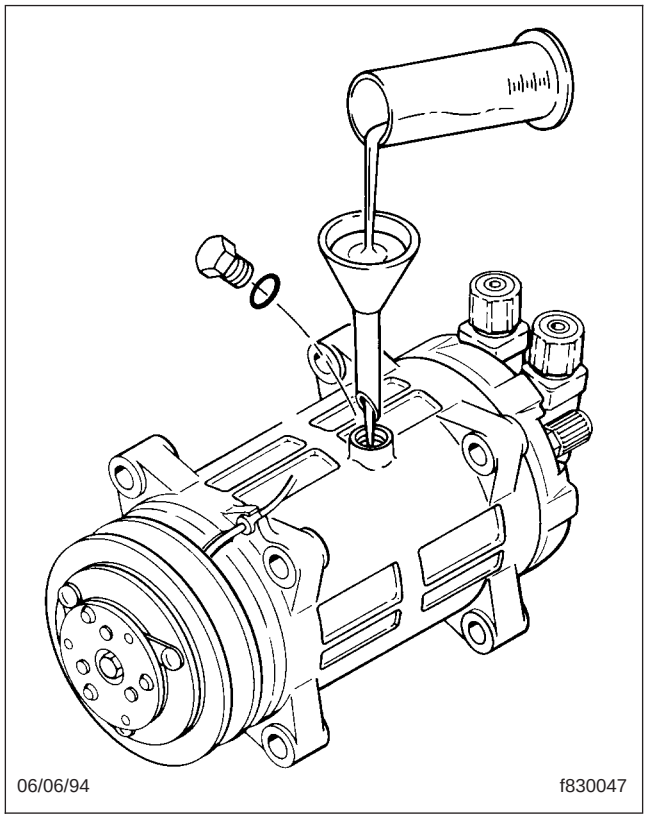


Fig. 2

   9.2 Perform another oil return operation.

   9.3 Remove the compressor and check the amount of oil. Add oil as listed in **Table 2**.

Oil Amounts	
Collected Amount	**Charging Amount**
More than 2.4 fl oz (70 mL)	2.4 fl oz (70 mL)
Less than 2.4 fl oz (70 mL)	3.0 fl oz (90 mL)

Table 2, Oil Amounts

10. Install the filler plug and a new O-ring. Tighten the plug 96 lbf·in (1080 N·cm).

Oil Check and Adding Oil to the Compressor, DKS-15CH

Procedure

IMPORTANT: New compressors are factory-charged with 6.8 fl oz (200 mL) refrigerant oil, which does not require periodic checking. Some refrigerant oil is circulated through the system with the refrigerant, and cannot leave the system except through a leak, when the system is discharged for service, or when a system part is replaced.

Add only FREOL DS-83P refrigerant compressor oil. Oil must be from a container that has not been opened, or that has been tightly sealed since its last use. Tubing, funnels, or other equipment used to transfer the oil should be very clean and dry.

IMPORTANT: Add the same amount of oil that is removed when the system is discharged, or when a system part is replaced.

When discharging the system or replacing system parts, add enough oil to replace that which is lost with the refrigerant charge and the discarded part. The oil quantities listed below are approximate refill amounts.

A. *Refrigerant charge*—0.7 fl oz (20 mL): This amount of oil must be added to the compressor each time the system loses its charge, due to routine discharging or due to a slow leak; no other parts of the system have been purged, flushed, or replaced.

B. *Receiver-drier*—2.7 fl oz (80 mL);

   IMPORTANT: A new receiver-drier may contain 3.4 fl oz (100 mL) of refrigerant oil, eliminating the need to add oil before installation. Confirm the oil level in a new receiver-drier; don't add any oil if it already contains 3.4 fl oz (100 mL).

C. *Condenser*—1.0 fl oz (30 mL);

D. *Evaporator coil*—0.7 fl oz (20 mL) each;

E. *Entire system*—10.2 fl oz (300 mL) without auxiliary heater/air-conditioner, 12.2 fl oz (360 mL) with auxiliary heater/air-conditioner: Add this amount of oil to the compressor if the entire system (including the compressor) has been discharged of refrigerant and oil, and all parts and hoses have been flushed.

IMPORTANT: The last four items above list oil quantities that include the amounts that are lost during discharging. Do not add an additional 0.7 fl oz (20 mL)—the amount described in for the first item above—to the quantities listed.

When handling refrigerant oil:

- The oil should be free of water, dust, metal powder, and other foreign substances.
- Do not mix refrigerant oil with other types or viscosities of oil.
- Refrigerant oil absorbs water when exposed to the air for short periods. After use, quickly seal the oil container.

During normal operation, part of the oil recirculates with the refrigerant in the system. When checking the amount of oil in the system, first run the compressor to return the oil to the compressor.

1. Turn on the air conditioner (the compressor must be engaged), and set the cab blower fan at high speed.
2. Run the compressor for at least 20 minutes, between 800 and 1200 rpm.
3. After turning off the engine, remove the compressor from the vehicle.
4. Remove the drain plug; then, drain the compressor oil into a clean container. See **Fig. 1.** Rotate the drive plate several times by hand to extract the remaining oil through the discharge-side port. About 1.0 fl oz (30 mL) of oil will remain in the compressor and cannot be removed without disassembling it.
5. Measure the drained oil with a measuring cylinder.
6. Check the oil for contamination. Unlike engine oil, compressor oil contains no added cleaning agent. Even after an entire season of use the oil should not become cloudy, as long as there is nothing wrong with the compressor or the way it is used. Inspect the drained oil for any of the following conditions:

   6.1 Cloudiness;

   6.2 Color change to red;

   6.3 Presence of foreign particles (metal powder, etc.) in the oil.

Oil Check and Adding Oil to the Compressor, DKS-15CH

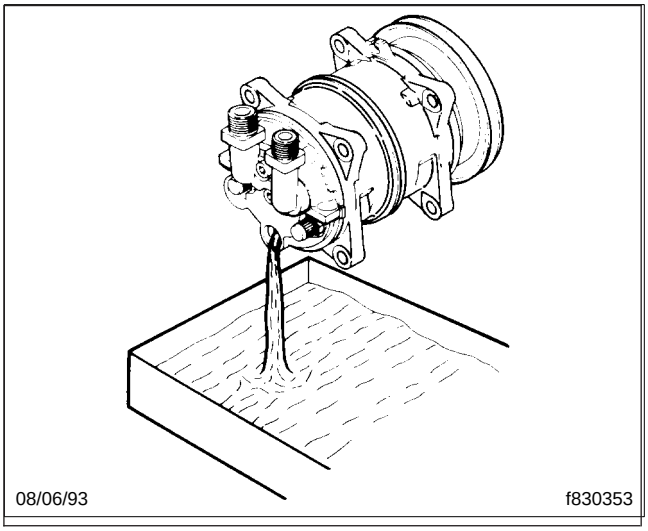


Fig. 1

If the oil drained from the compressor shows any of the above problems, flush all parts of the system and replace the receiver-drier. For instructions, refer to the applicable sections in this group.

7. Install the drain plug and a new O-ring lightly coated with clean compressor oil. Tighten the plug 113 to 130 lbf·in (1280 to 1460 N·cm).
8. Fill the compressor with oil through the suction-side hose fitting. See **Fig. 2.** Refer to **Table 1** for the charging amount.
9. If an oil return operation (the first two steps above) could not be done, check the compressor oil as follows:
   - 9.1 Remove the damaged compressor from the vehicle.
   - 9.2 Remove the drain plug, and drain the oil.
   - 9.3 Using a measuring cylinder, measure the drained oil.
   - 9.4 Check the oil for contamination.
   - 9.5 Fill the new compressor with oil through the suction-side connector. Refer to **Table 1** for the correct amount of oil.
   - 9.6 Install the new compressor on the vehicle.

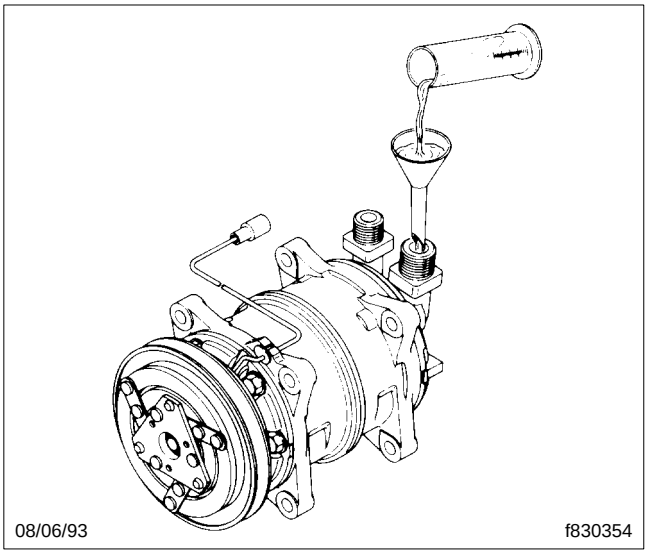


Fig. 2

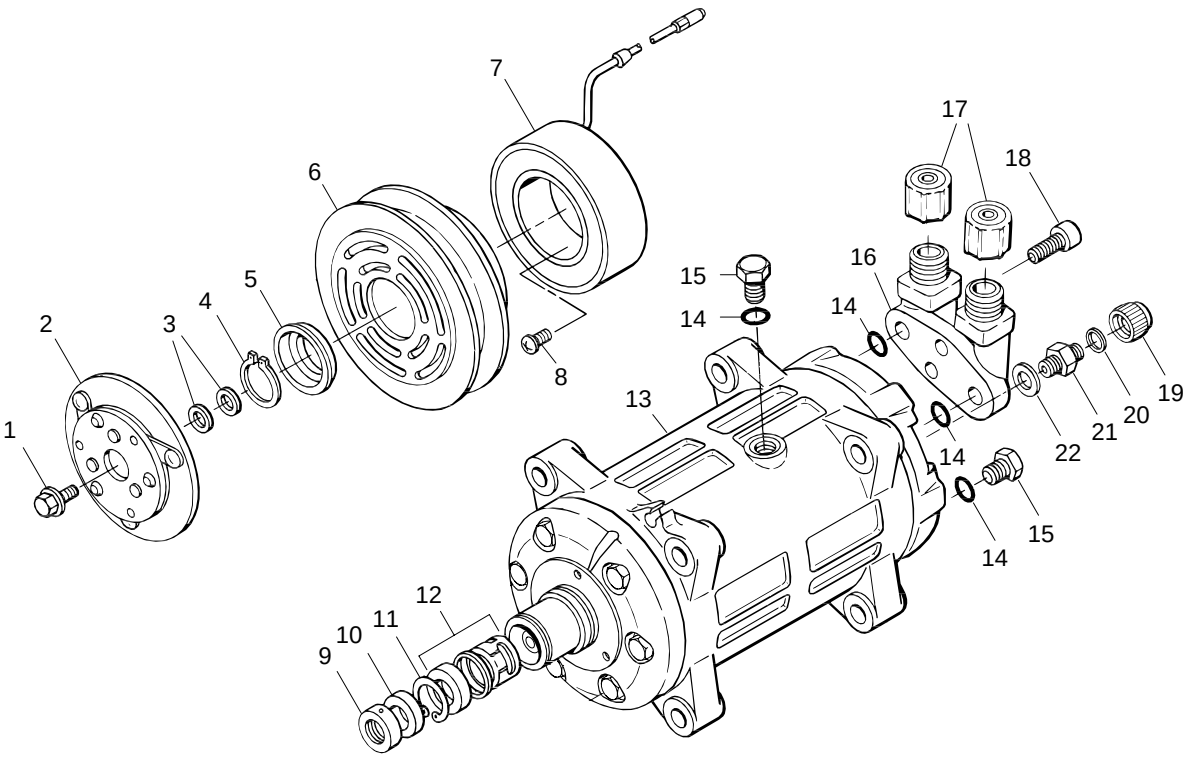
Collected Amount	Charging Amount
More than 4.1 fl oz. (120 mL)	Same as collected amount; do not exceed 12.2 fl oz (360 mL) in a system with an auxiliary heater/air-conditioner or 10.2 fl oz (300 mL) in a system without one.
Less than 4.1 fl oz (120 mL)	4.1 fl oz (120 mL)

Table 1

   - 9.7 Perform the oil return operation.
   - 9.8 Remove the compressor and check the amount of oil again.
   - 9.9 Fill the compressor with oil again. Refer to **Table 1** for the correct amount of oil.

Magnetic Clutch Assembly Removal, Inspection, and Installation, DKS-15BH

Removal (See Fig. 1)



1. Bolt
2. Drive Plate
3. Shim
4. Snap Ring
5. Cover
6. Pulley
7. Field Coil
8. Screw
9. Retainer
10. Felt
11. Snap Ring
12. Shaft Seal Assembly
13. Cylinder Head
14. O−Ring
15. Plug
16. Connector
17. Connector Caps
18. Socket Head Bolt
19. Cap
20. O−Ring
21. Valve Assembly
22. Gasket

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Fig. 1

NOTE: The special tools available from independent suppliers may look different from those shown in the figures below. They are functionally identical, though. Refer to **Specifications, 400** for suppliers of the special tools.

1. Remove the compressor from the vehicle. For instructions, refer to **Subject 140**.
2. Remove the center bolt using a clutch holder and a 10 mm locknut socket. See **Fig. 2.**
3. Remove the drive plate using a drive-plate remover and thrust-bolt and shim-gauge guide. See **Fig. 3.** Remove the shims from the compressor driveshaft or drive plate.
4. Remove the snap ring with external snap-ring pliers; remove the cover.
5. Remove the pulley assembly using a shaft-protector pilot and a pulley puller. See **Fig. 4.**

IMPORTANT: When removing the pulley assembly, be sure not to deform the clutch face.

Magnetic Clutch Assembly Removal, Inspection, and Installation, DKS-15BH

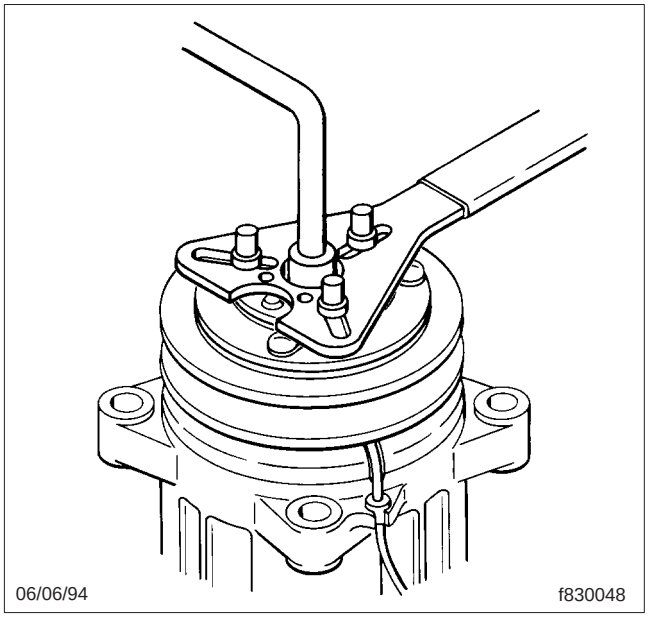


Fig. 2

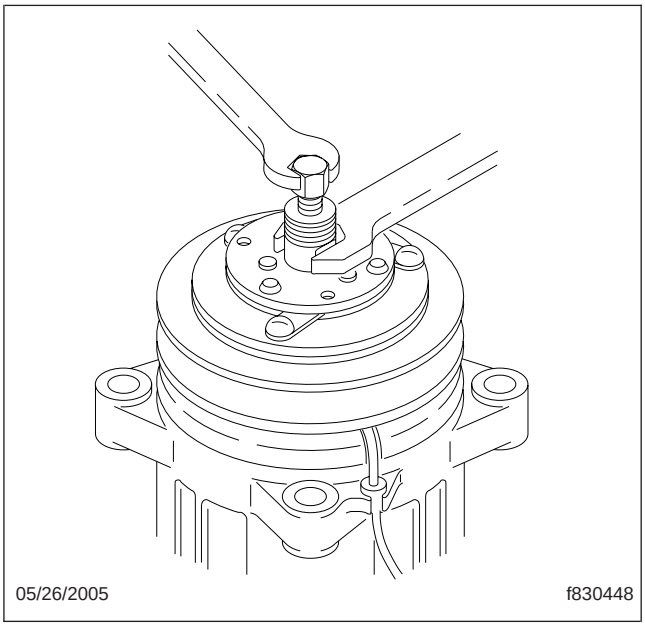


Fig. 3

6. Remove the coil lead wire and coil by removing the three screws.

Inspection

1. Inspect the drive plate. If the frictional surface shows signs of damage due to too much heat, replace the drive plate and pulley assembly.

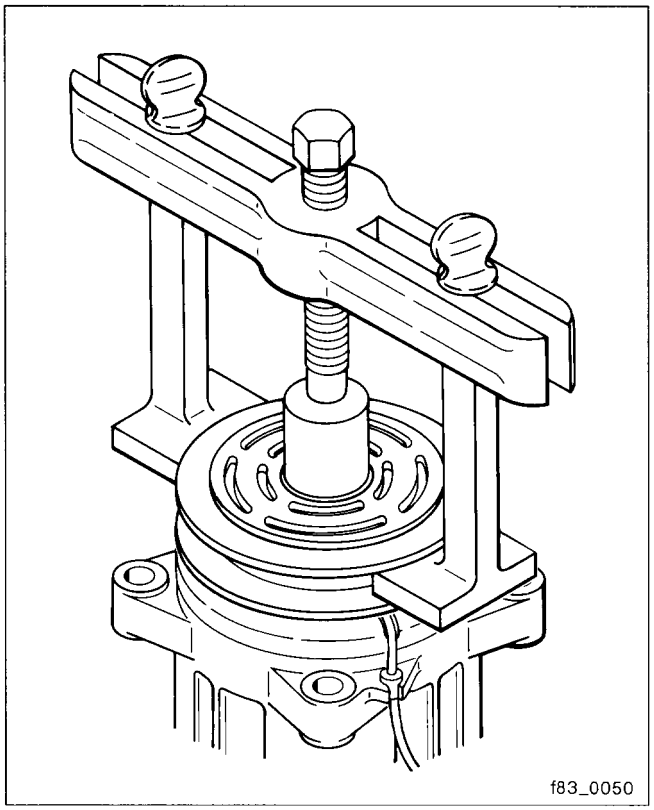


Fig. 4

2. Check the appearance of the pulley assembly. If the frictional surface of the pulley shows signs of too much grooving due to slippage, replace both the pulley and drive plate. Clean the frictional surfaces of the pulley assembly before installing it.
3. Check the coil for a loose connector and for cracked insulation. Replace it, if necessary.

Installation (See Fig. 1)

1. Install the coil on the compressor (lead wire up), and tighten the mounting screws 48 lbf·in (540 N·cm).

Magnetic Clutch Assembly Removal, Inspection, and Installation, DKS-15BH

2. Install the lead wire into the hole with the rubber holder.
3. Install the pulley assembly with a clutch bearing and assembly installer, then install the bearing cover and snap ring.
4. Position the original shims on the driveshaft. See **Fig. 5.**
5. Lining up the spline in the drive plate, use a clutch plate installer to install the drive plate on the compressor driveshaft. See **Fig. 6.**
6. Install the center bolt, using the clutch holder to prevent drive-plate rotation. Tighten the bolt 135 lbf·in (1520 N·cm).

NOTE: After tightening the bolt, check that the pulley turns smoothly.

7. Using a feeler gauge, check that the clutch clearance is between 0.01 to 0.02 inch (0.3 to 0.6 mm). See **Fig. 7.** Adjust the clearance using shims, as necessary. Adjusting shims are available in the following thicknesses: 0.1 mm; 0.3 mm; 0.5 mm; 0.8 mm; and 2.2 mm.
8. Install the compressor on the vehicle. For instructions, refer to **Subject 140**.
9. Perform a running-in operation on the clutch. For instructions, refer to **Subject 190**.

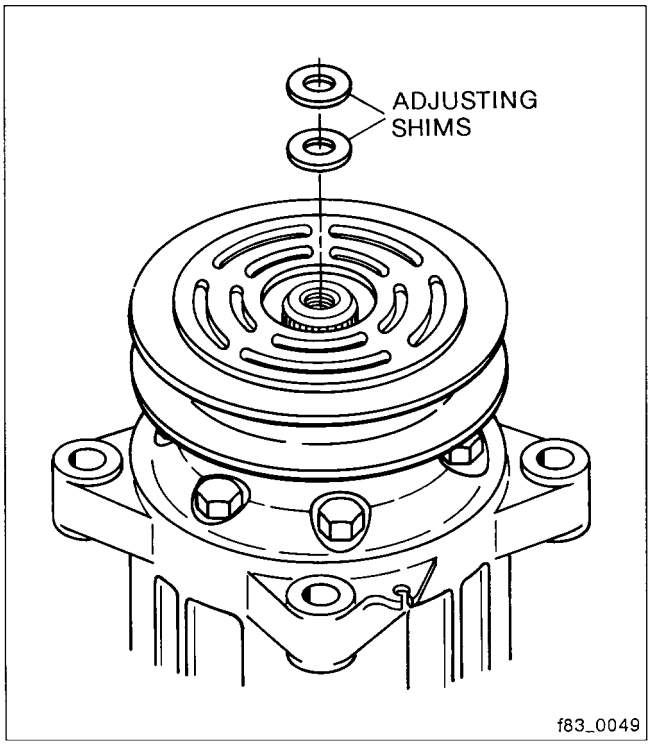


Fig. 5

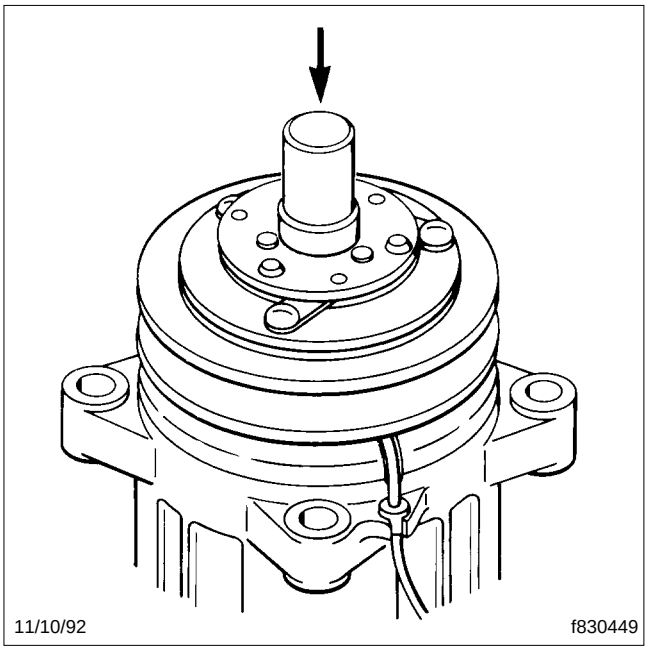


Fig. 6

Magnetic Clutch Assembly Removal, Inspection, and Installation, DKS-15BH

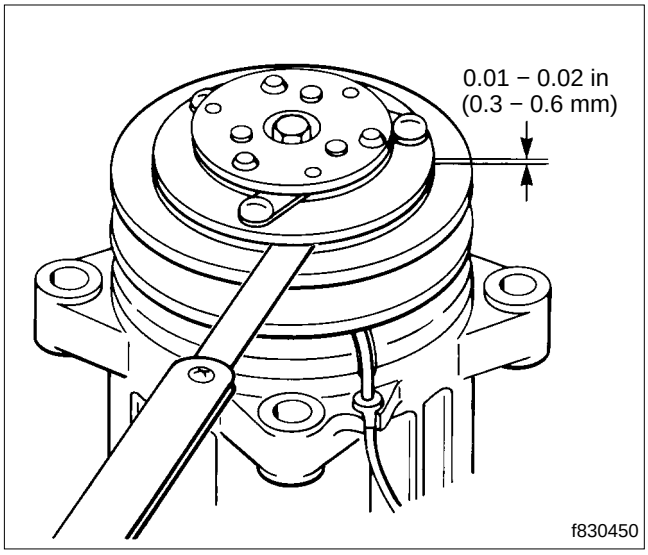


Fig. 7

Magnetic Clutch Assembly Removal, Inspection, and Installation, DKS-15CH

Removal (See Fig. 1)

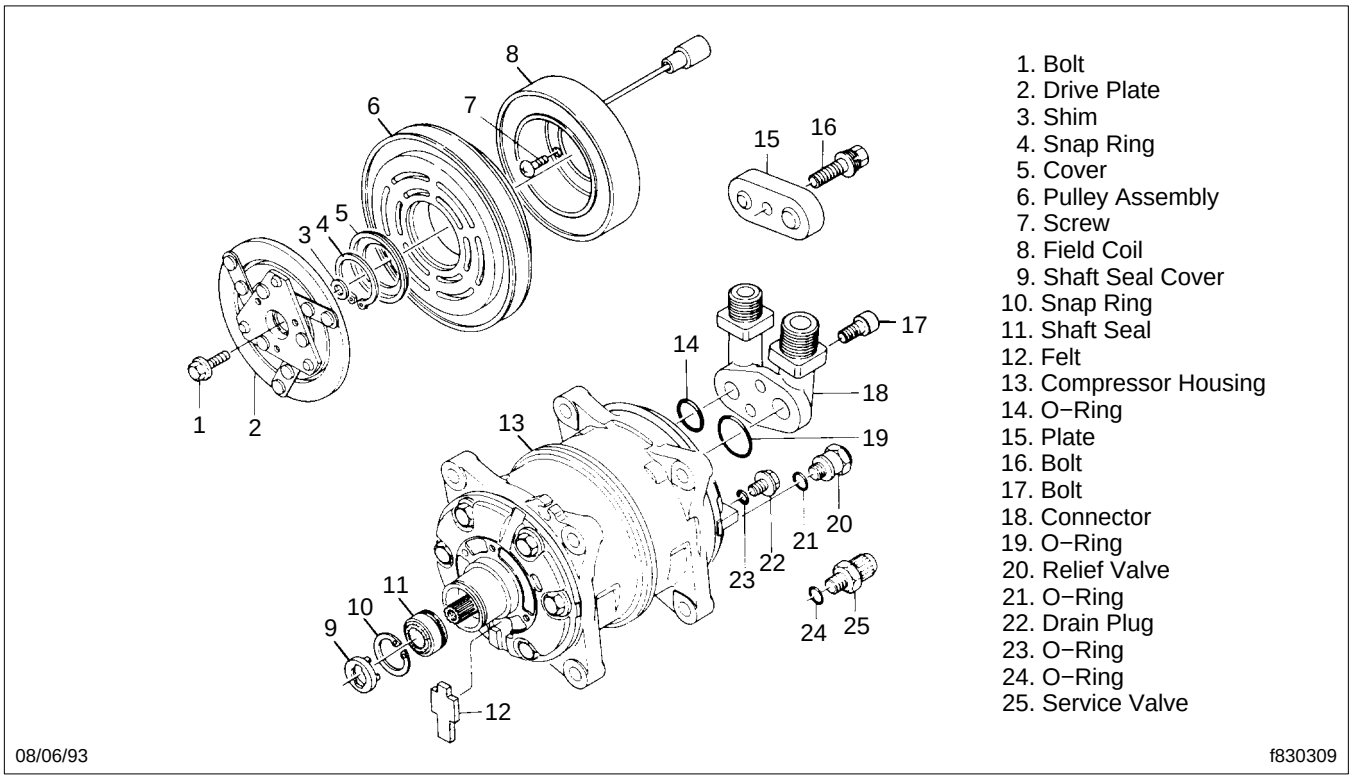


Fig. 1

NOTE: The special tools available from independent suppliers may look different from those shown in the figures below. They are functionally identical, though. Refer to **Specifications, 400** for suppliers of the special tools.

1. Remove the compressor from the vehicle. For instructions, refer to **Subject 140**.
2. Remove the center bolt using the drive plate holder to prevent drive-plate rotation. See **Fig. 2.**
3. Using the drive-plate puller, remove the drive plate. See **Fig. 3.** Then, remove the shims from either the driveshaft or the drive plate.
4. Using external snap-ring pliers, remove the snap ring; then, remove the cover. See **Fig. 4.**
5. Using the pulley puller and the spacer positioned on the cylinder head hub, remove the pulley assembly. See **Fig. 5.**

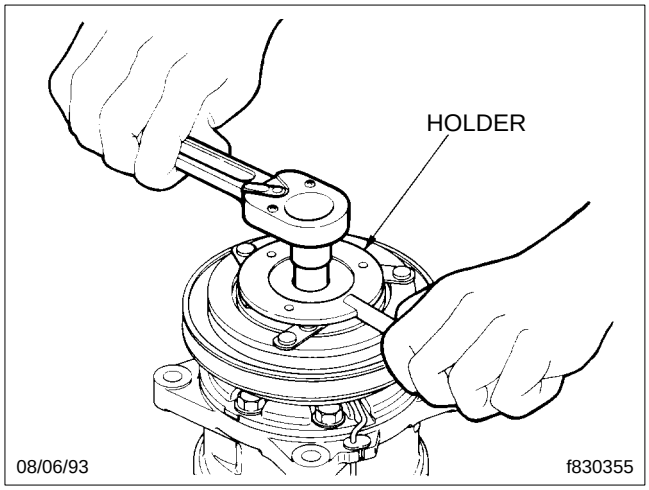


Fig. 2

NOTE: To avoid damaging the pulley groove, the puller claws should be hooked into (not under) the pulley groove.

Magnetic Clutch Assembly Removal, Inspection, and Installation, DKS-15CH

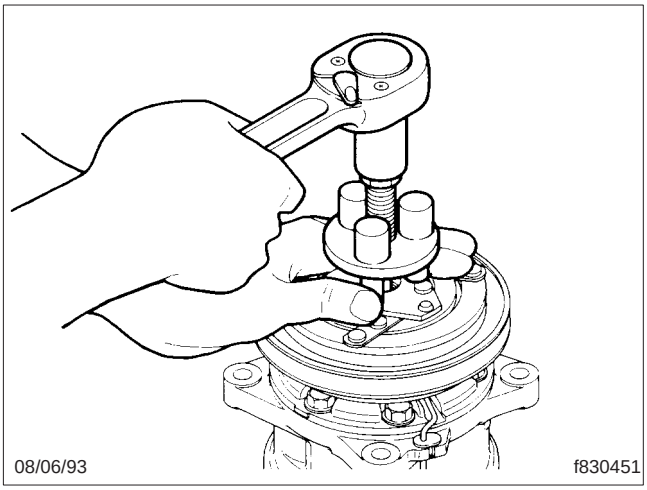


Fig. 3

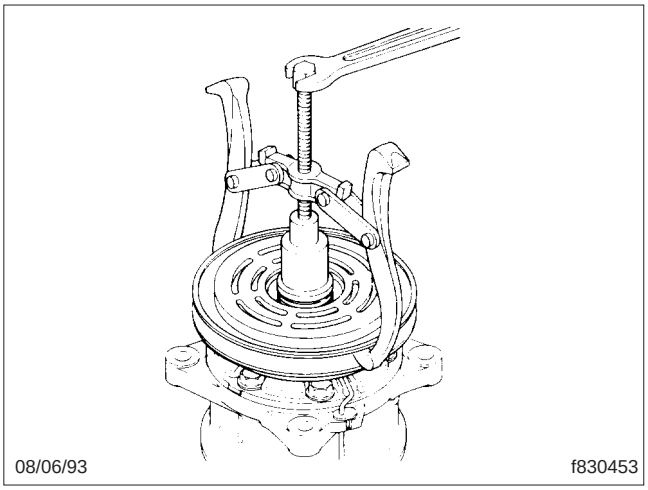


Fig. 5

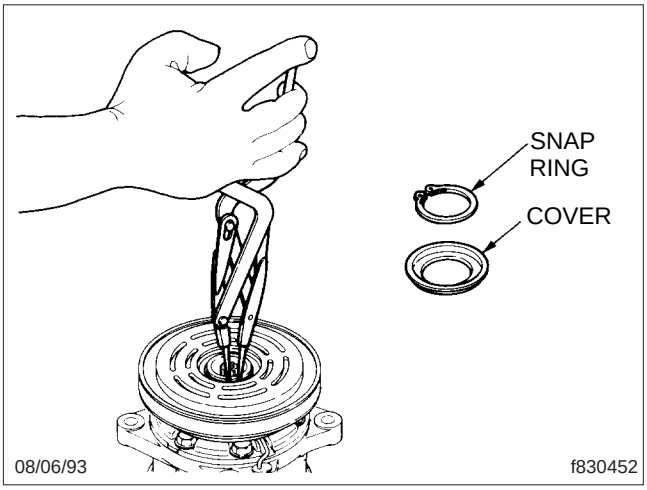


Fig. 4

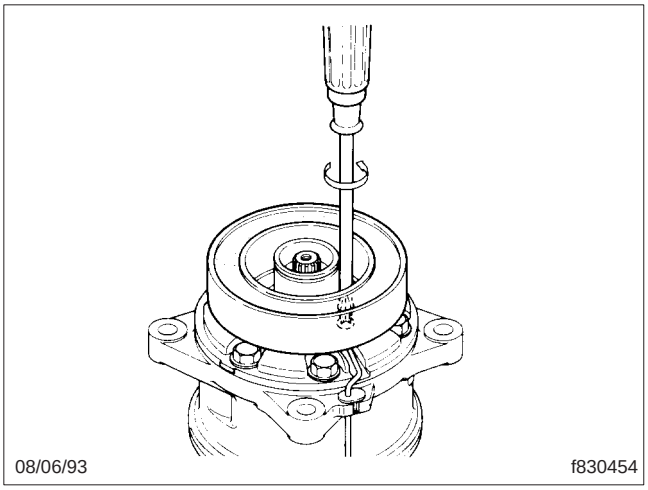


Fig. 6

6. Remove the coil's lead wire from the wire holder on the compressor; then, remove the three screws and the coil. See **Fig. 6.**

⚠ CAUTION

CAUTION: Do not hold the coil by the lead wire. This could damage the coil.

Inspection (See Fig. 7)

1. Inspect the drive plate. If the frictional surface shows signs of damage due to too much heat, replace the drive plate and pulley assembly.

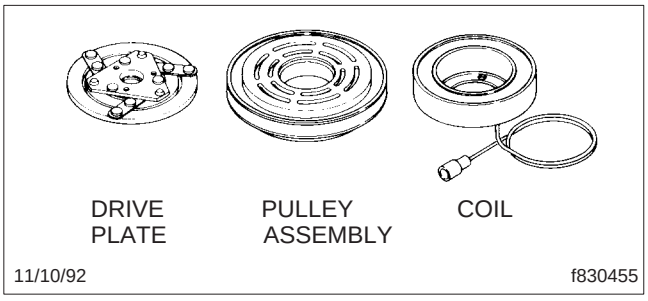


Fig. 7

2. Check the appearance of the pulley assembly. If the frictional surface of the pulley shows signs of too much grooving due to slippage, replace both

the pulley and drive plate. Clean the frictional surfaces of the pulley assembly before installing it.

3. Check the coil for a loose connector and for cracked insulation. Replace it if necessary.

Installation

1. Make sure the felt is installed on the front cylinder head. See **Fig. 8.**

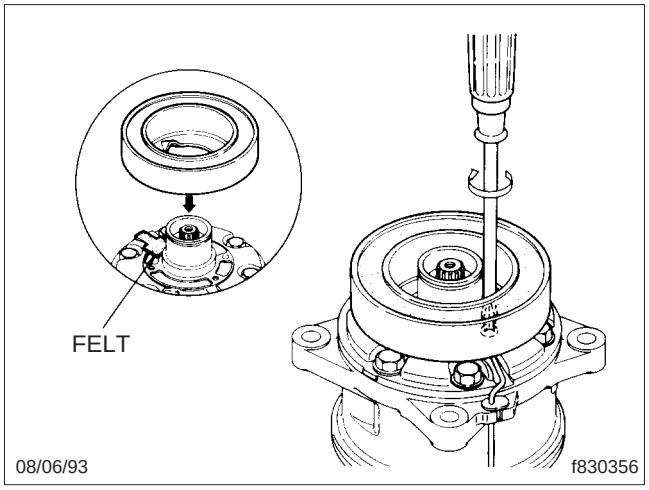


Fig. 8

2. Install the coil on the compressor (lead wire on top).
3. Make sure the concave portion of the coil is aligned with the felt; then, tighten the mounting screws 35 to 52 lbf·in (400 to 580 N·cm). See **Fig. 8.**
4. Install the lead wire in the wire holder on the compressor.
5. Using the installation tool and a hand press, install the pulley assembly. See **Fig. 9.** Install the bearing cover and the snap ring. See **Fig. 10.**

NOTE: The chamfered edge of the snap ring should face upward.

6. Install the drive plate on the compressor driveshaft, together with the original shim(s). See **Fig. 11.** Press the drive plate down by hand.

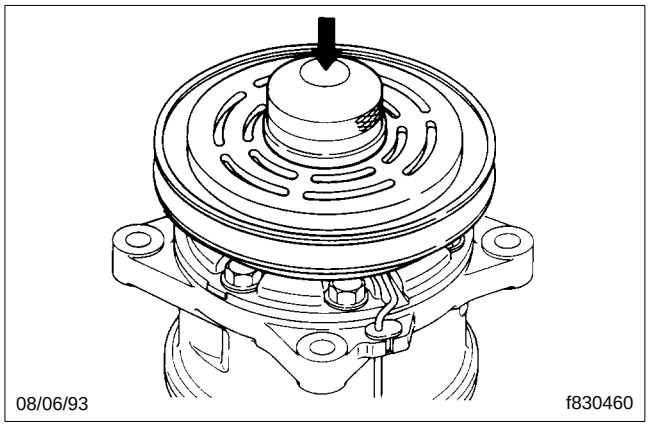


Fig. 9

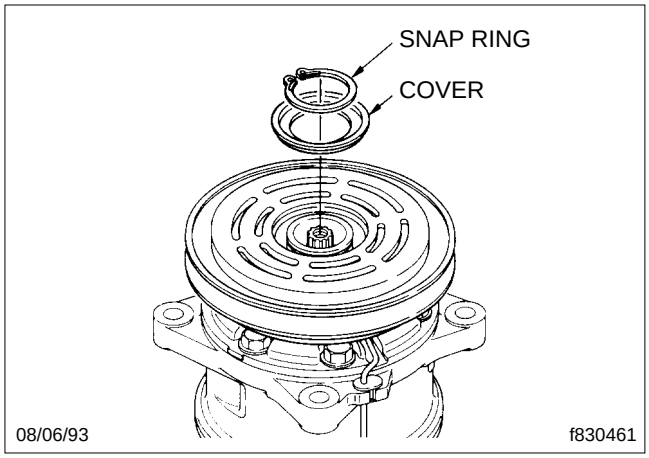


Fig. 10

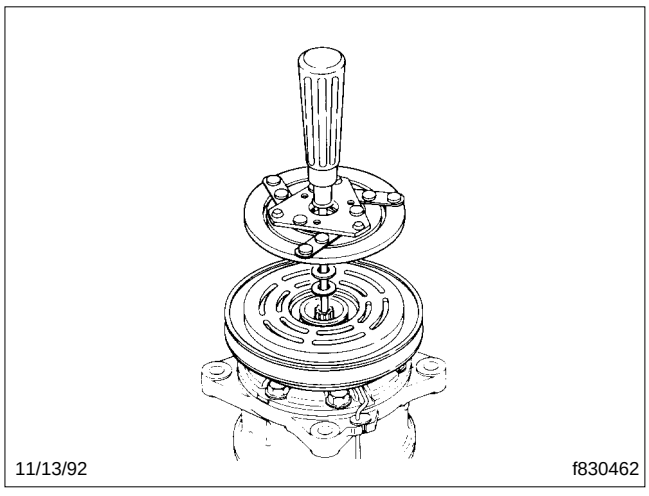


Fig. 11

Magnetic Clutch Assembly Removal, Inspection, and Installation, DKS-15CH

7. Using the clutch holder to prevent drive-plate rotation, tighten the bolt 104 to 121 lbf·in (1180 to 1360 N·cm).

NOTE: After tightening the bolt, check that the pulley turns smoothly.

8. Using a feeler gauge, check that the clutch clearance is 0.01 to 0.02 inch (0.3 to 0.6 mm). See **Fig. 12.** Adjust the clearance using shims, as necessary. Adjusting shims are available in the following thicknesses: 0.1 mm; 0.3 mm; 0.5 mm; 0.8 mm; and 2.2 mm.

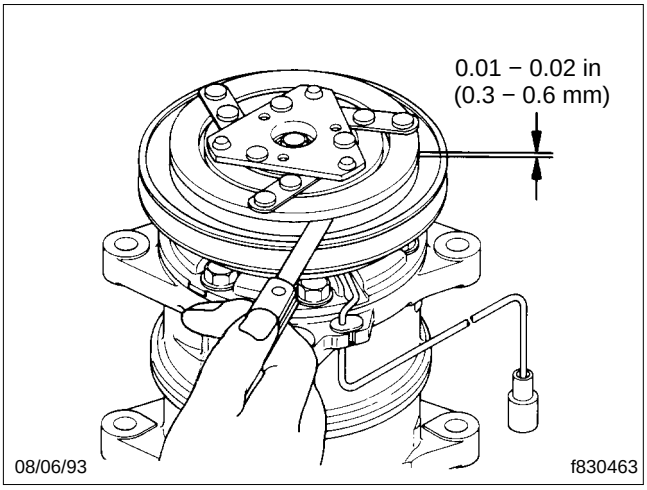


Fig. 12

9. Install the compressor on the vehicle. For instructions refer to **Subject 140**.

10. Perform a break-in operation on the clutch. For instructions, refer to **Subject 190**.

Shaft Seal Replacement, DKS-15BH

Procedure

NOTE: The special tools available from independent suppliers may look different from those shown in the figures below. They are functionally identical, though. Refer to **Specifications, 400** for suppliers of the special tools.

The shaft seal assembly is precision machined, with its critical parts finished to extremely close tolerances and, as such, must be handled with caution. Its slip-face demands very careful handling.

1. Remove the magnetic clutch assembly, as outlined in **Subject 160**.
2. Using a felt-ring remover, remove and discard the felt-cover assembly. **See Fig. 1.**
3. Using internal snap-ring pliers, remove the seal seat-to-compressor snap ring. **See Fig. 2.**
4. Using a seal-seat remover and installer, remove and discard the seal seat. **See Fig. 3.**
5. Using a felt-ring remover, remove the O-ring in the inside groove of the shaft seal housing. **See Fig. 4.** Discard the O-ring.

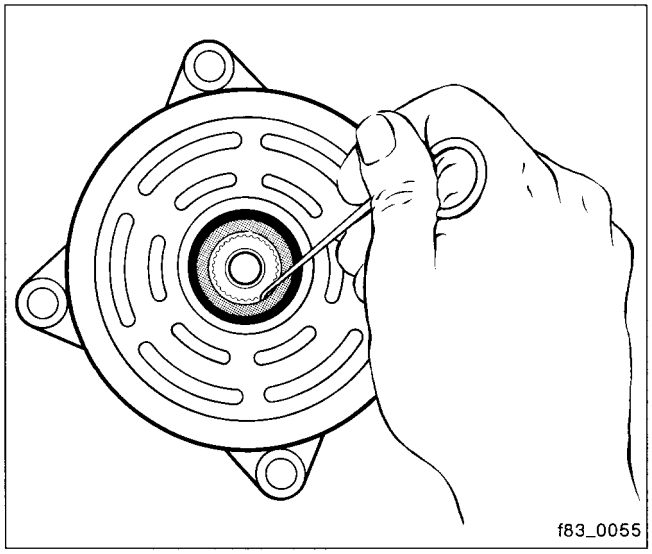


Fig. 1

6. Using a seal remover and installer, remove the shaft seal as follows:

   6.1 Insert the seal remover and press down. **See Fig. 5.**

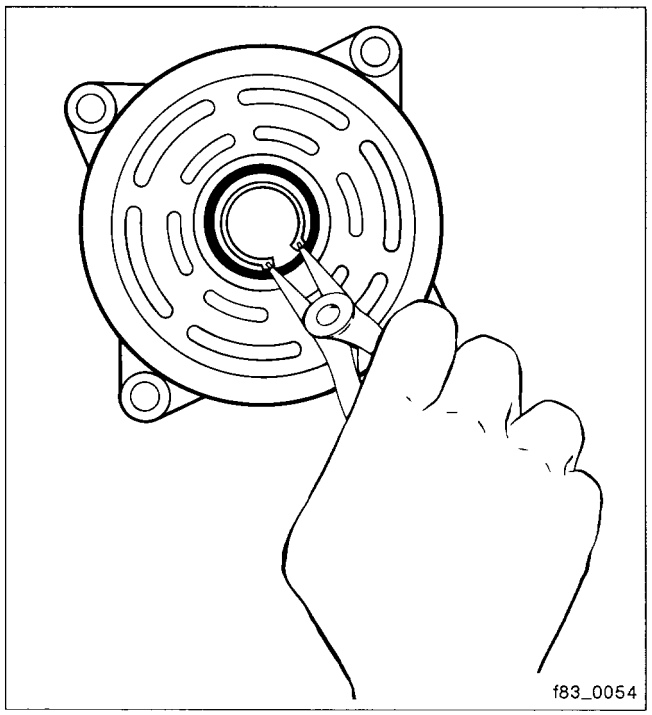


Fig. 2

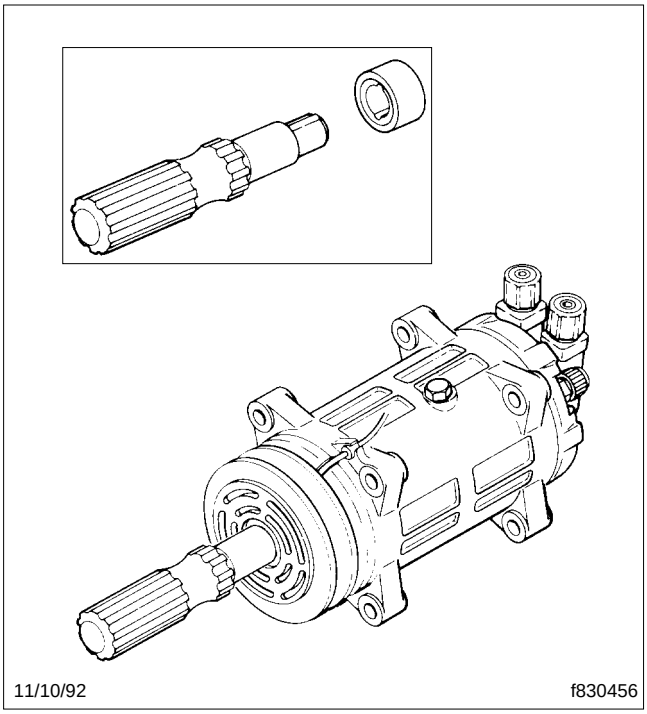


Fig. 3

Shaft Seal Replacement, DKS-15BH

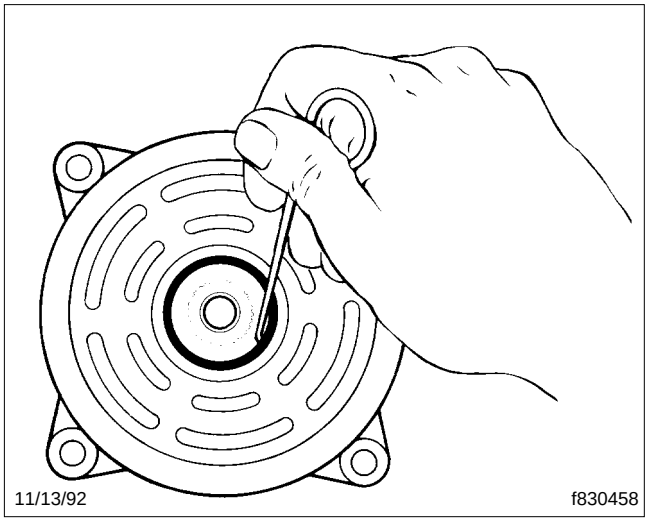


Fig. 4

6.2 With a clockwise motion, hitch the remover hook to the shaft seal hook. **See Fig. 5.**

6.3 Slowly draw out the seal. **See Fig. 6.** Discard the shaft seal.

7. Check the shaft and the inside of the compressor neck for dirt or foreign particles; be sure these are clean before installing the new shaft seal.

NOTE: The shaft seal assembly should not be re-used. Always use a new seal kit, even on rebuilt compressors. Be very careful that the face of the shaft seal to be installed is not scratched or damaged. Make sure that the seal seat and the shaft seal are free of lint and dirt that could damage the shaft seal surface.

8. Clean the sealed section of the compressor.
9. Apply clean refrigerant oil to the new shaft seal and the driveshaft. If the slip faces are dirty, clean them with thinner and, after drying the cleaned face, apply clean refrigerant oil to them.
10. Install the new shaft seal on the driveshaft, using a seal remover and installer, matching the chamfered portion of the shaft seal retainer to the corresponding chamfered part of the driveshaft. **See Fig. 7.** Use the shaft cover to prevent damage.
11. Install a new O-ring in the groove inside of the compressor neck.

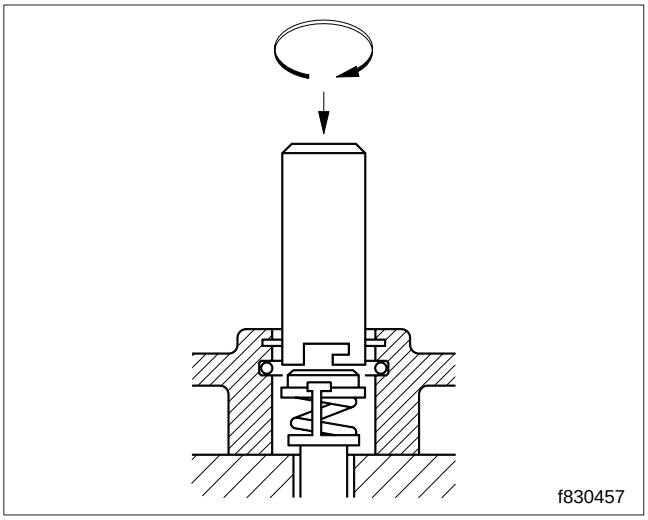


Fig. 5

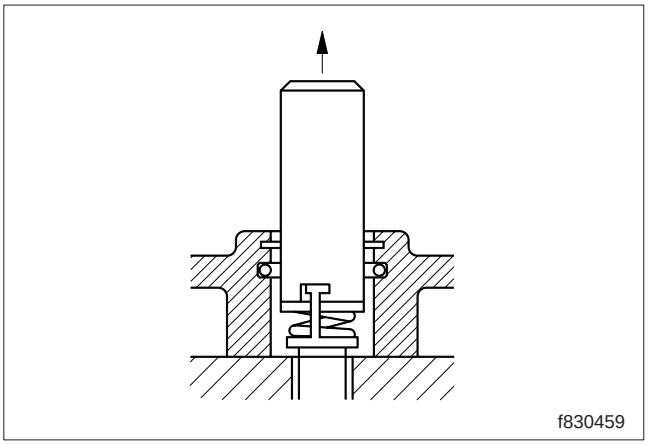


Fig. 6

12. Apply clean refrigerant oil to the seal seat.
13. Install the seal seat using a seal-seat remover and installer.
14. Using internal snap-ring pliers, install the compressor snap ring on the seal seat.
15. Install the felt-ring assembly, using a felt-and retaining-ring installer.
16. Install the magnetic clutch assembly. For instructions, refer to **Subject 160**.
17. Perform a running-in operation and leak test. For instructions, refer to **Subject 190**.

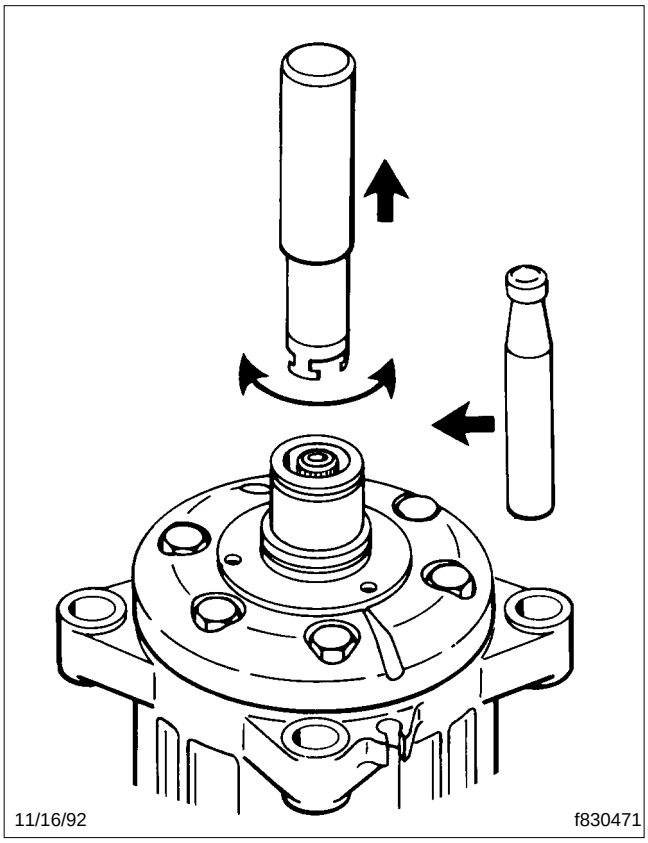


Fig. 7

Shaft Seal Replacement, DKS-15CH

Procedure

NOTE: The special tools available from independent suppliers may look different than those shown in the figures below. They are functionally identical, though. Refer to **Specifications, 400** for suppliers of the special tools.

1. Remove the magnetic clutch assembly, as described in **Subject 165**.
2. Remove the felt. **See Fig. 1.**
3. Using the remover, remove the shaft seal cover by engaging the hook on the remover with the hook on the shaft seal cover and slowly drawing out the cover. **See Fig. 1.** Discard the shaft seal cover.
4. Using internal snap-ring pliers, remove the snap ring. **See Fig. 2.**
5. Using the remover, remove the shaft seal by engaging the hook on the remover with the hook on the shaft seal and slowly drawing out the shaft seal. **See Fig. 3.**

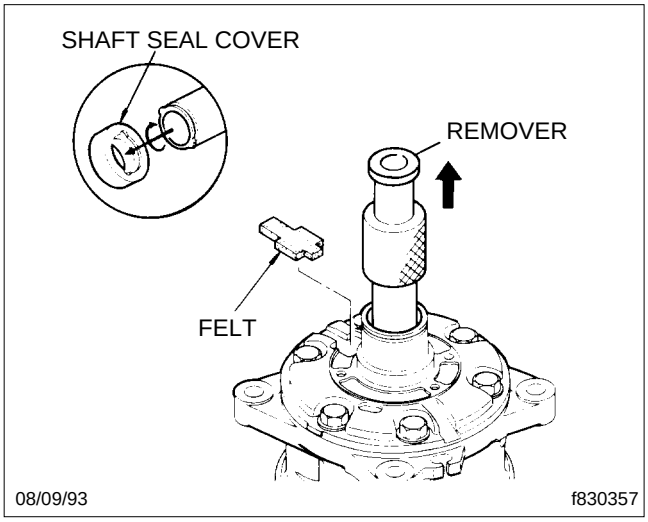


Fig. 1

NOTE: The shaft seal and shaft seal cover should not be re-used. Always use a new seal kit. Be very careful that the lip of the shaft seal to be installed is not scratched or damaged in any way. Make sure the shaft seal is free of lint and dirt, which could damage the shaft seal surface.

6. Clean the sealed section of the front cylinder head.
7. Apply clean compressor oil to the new shaft seal and to the front cylinder head. If the slip faces are dirty, clean them with thinner, dry them, and apply clean compressor oil to them.
8. Install the guide onto the end of the driveshaft. **See Fig. 4.**
9. Insert the shaft seal over the guide into the front cylinder head. **See Fig. 5.**

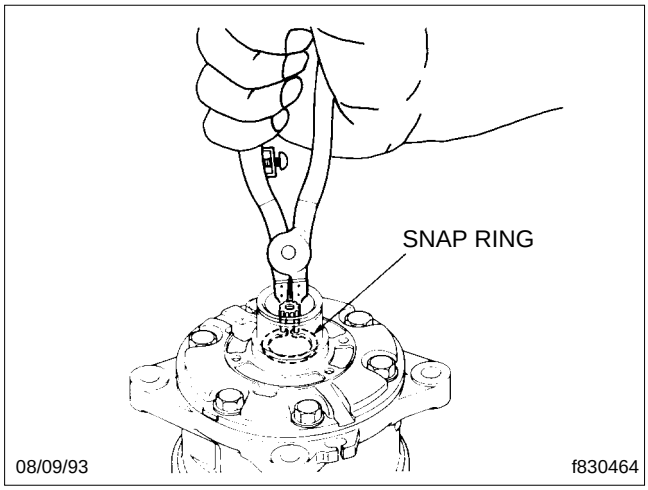


Fig. 2

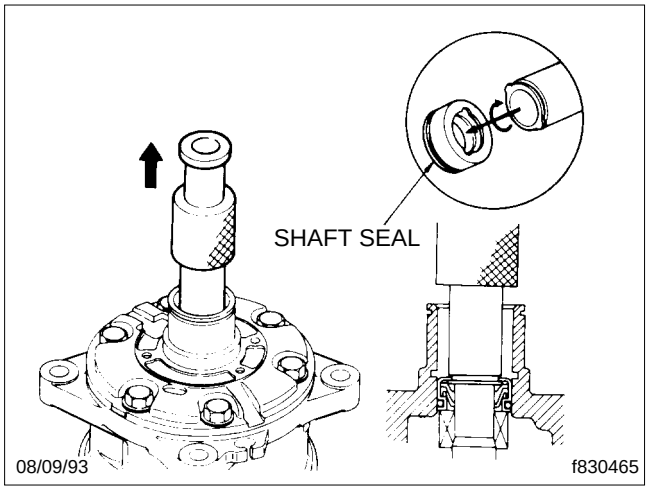


Fig. 3

10. Using the installing end of the remover, install the shaft seal as far as possible into the front cylinder head. **See Fig. 6.** Remove the guide

Shaft Seal Replacement, DKS-15CH

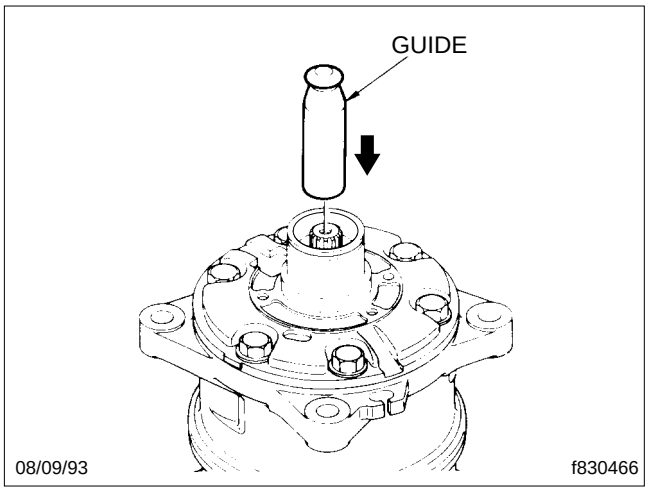


Fig. 4

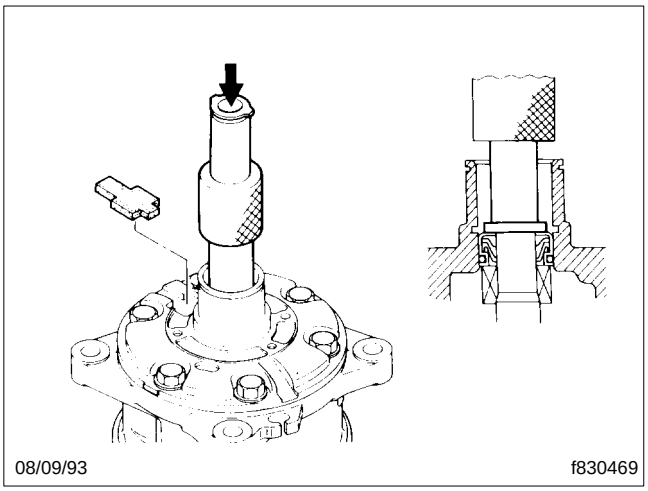


Fig. 6

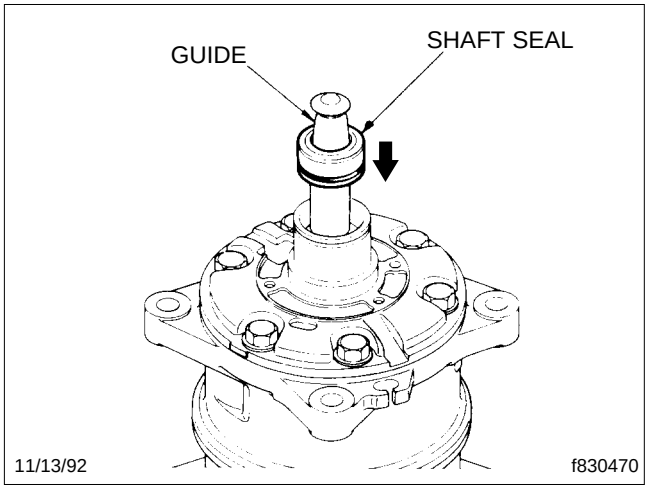


Fig. 5

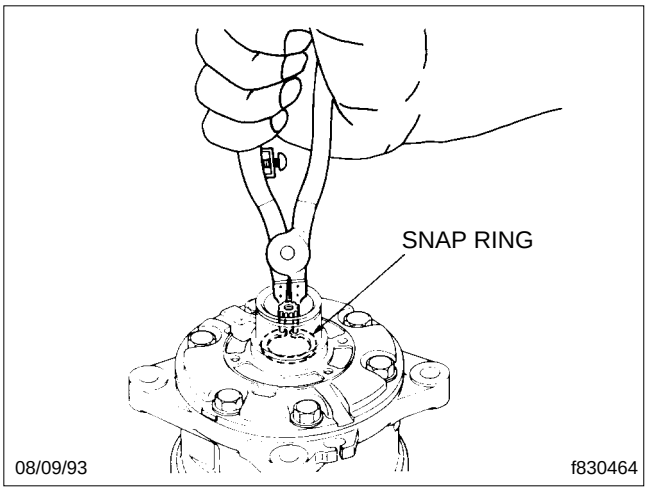


Fig. 7

previously installed in the step above from the driveshaft.

11. Using internal snap-ring pliers, install the snap ring. **See Fig. 7.** Press the snap ring using the installing end of the remover until a click is heard.

NOTE: When installing the snap ring, the round edge of the snap ring must face downward, **as shown in Fig. 8.**

12. Fit the guide onto the end of the driveshaft. **See Fig. 9.** Using the installing end of the remover, install the shaft seal cover.

NOTE: The installation position of the shaft seal cover is **shown in Fig. 10.**

13. Install a new felt. **See Fig. 10.**

14. Install the magnetic clutch assembly, as described in **Subject 165**.

Shaft Seal Replacement, DKS-15CH

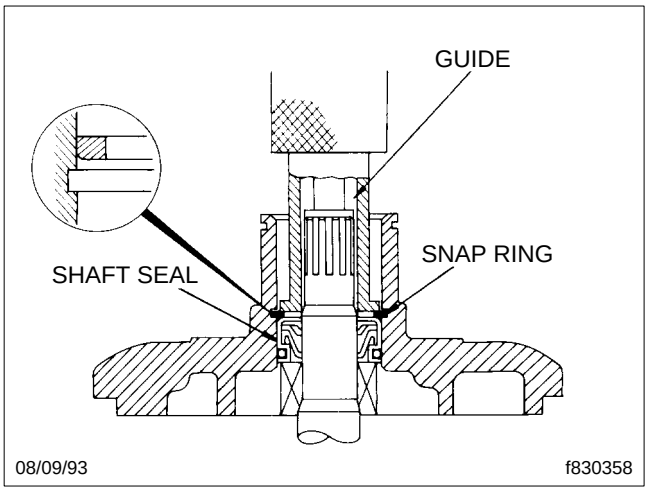


Fig. 8

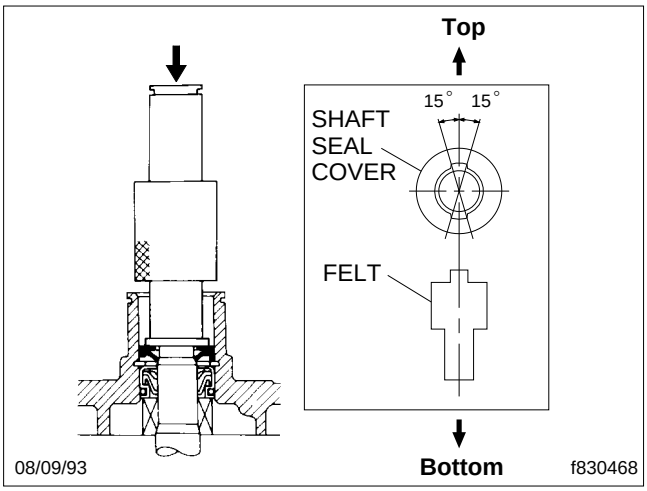


Fig. 10

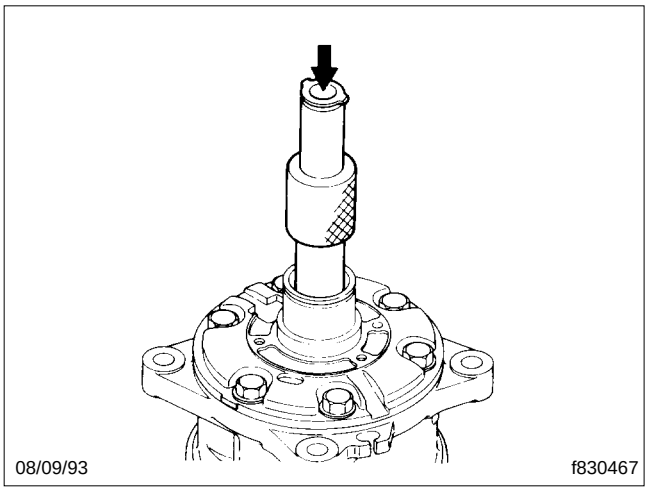


Fig. 9

Leak Test

Check the compressor for refrigerant leaks after it is repaired, as follows:

1. Install blanking caps in the suction and discharge fittings on the compressor.
2. Connect a manifold gauge set to the compressor's service ports. Close the discharge hand valve on the manifold. Fill refrigerant gas through the service port on the suction side fitting, raising the pressure to at least 70 psi (482 kPa).
3. Check the compressor for leakage using a leak detector.
4. Slowly release the refrigerant from the compressor. Remove the caps just before connecting the hoses to the compressor.

Magnetic Clutch Running-In

1. Install the compressor on the vehicle, and charge the system with refrigerant.
2. Turn the compressor eight to ten times by hand to remove any liquid in the cylinders. This will prevent hydraulic lock.
3. Turn on the engine and the air conditioner. Keep the compressor's speed at 500 rpm.
4. Cycle the clutch on and off at least 30 times by placing the air conditioner temperature control at the coolest setting, turning on the fan, and operating the air conditioner switch on the climate control panel (on for 10 seconds; off for 10 seconds).

Storing a Repaired Compressor

Procedure

If it is necessary to store a repaired compressor for some time before installation, evacuate the compressor and fill refrigerant gas through the service port on the suction side fitting to raise the pressure to 70 psi (482 kPa).

Specifications

Special tools can be purchased from the following independent suppliers:

Classic Tool Design
31 Walnut St.
New Windsor, NY 12550(914) 562-8700

Mastercool USA Inc.
216 Route 10, Bldg. 3
Randolph, NJ 07869(201) 366-1101

Application	Torque: lbf·in (N·cm)	Torque: lbf·ft (N·m)
Adjusting Rod Lower and Upper Jam Nuts	—	130 (176)
Compressor Mounting Nuts	—	33 (45)
Compressor Clutch Coil Mounting Screws	35–52 (400–580)	—
Clutch Assembly Bolt	120–144 (1360–1620)	—
Oil Fill Plug	84–108 (940–1220)	—
Oil Drain Plug	84–108 (940–1220)	—

Table 1, Torque Values, DKS-15BH

Application	Torque: lbf·in (N·cm)	Torque: lbf·ft (N·m)
Adjusting Rod Lower and Upper Jam Nuts	—	130 (176)
Compressor Mounting Nuts	—	33 (45)
Compressor Clutch Coil Mounting Screws	35–52 (400–580)	—
Clutch Assembly Bolt	104–121 (1180–1360)	—
Oil Drain Plug	113–130 (1280–1460)	—

Table 2, Torque Values, DKS-15CH

Relative Humidity	Outside Air Temperature °F (°C)	Maximum Center Console Outlet Temperature °F (°C)	With Compressor Running	
			Low Pressure psig (kPa)	High Pressure psig (kPa)
Low (30%) through Medium (60%)	75 (24)	55 (13)	9–25 (62–172)	160 (1103)
	85 (29)	58 (14)	9–30 (62–207)	180 (1241)
	100 (38)	62 (17)	9–35 (62–241)	220 (1517)
High (90%)	75 (24)	57 (14)	9–25 (62–172)	170 (1172)
	85 (29)	60 (16)	9–35 (62–241)	190 (1310)
	100 (38)	64 (18)	9–40 (62–276)	260 (1793)

Table 3, Temperature/Pressure Specifications

Model	Refrigerant Oil
DKS-15BH	Suniso 5GS, FREOL DS-83P (or refrigerant oil of viscosity SUS 500/100°F)
DKS-15CH	FREOL DS-83P

Table 4, Refrigerant Oil Specifications

General Information

The main purpose of the refrigerant compressor is to draw refrigerant gas from the evaporator and squeeze it into high-pressure gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid so that it can be used for cooling again. A second purpose of the compressor is to move refrigerant through the air conditioner system.

The compressor is cycled by a thermostatic switch, which is located on the blower motor housing in the cab. **See Fig. 1.** When there is enough of a temperature drop in the cab, the switch breaks the circuit to the compressor's magnetic clutch. When the clutch is disengaged, its pulley is free-wheeling and the compressor shaft is not turning. When the clutch is engaged, it holds to the pulley, and the turning of the pulley causes the compressor shaft to turn.

The Climate Control compressor is a two-piston design. The pistons are driven by a crankshaft and connecting rods.

Refer to the applicable cab air conditioner section in this group for other information.

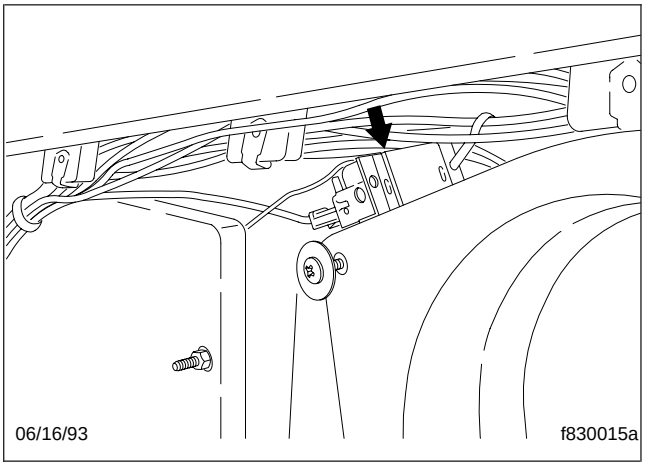


Fig. 1

Safety Precautions

CAUTION

CAUTION: Different refrigerant oils are used in compressors on R–12 and R–134a air conditioning systems. Always use the correct refrigerant oil and never mix oils. If the wrong oil is used, or if oils are mixed, the compressor could seize due to improper lubrication.

Refrigerant R–134a Air Conditioning Systems

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

WARNING

WARNING: Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

WARNING

R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion that could cause personal injury or property damage.

You must work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R-134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG), or polyol ester (POE) oil is used in the compressor. When handling these oils, observe the following:

- keep the oil free of contaminants
- do not expose the a/c system or the oil container to air for long periods of time; PAG and POE oils have a high moisture absorption capacity
- use care when handling: painted surfaces, plastic parts, and other components (drive belts) could be damaged if the oil is spilled on them
- never mix the oils with other types of refrigerant oil

Safety Precautions

Refrigerant R–12 Air Conditioning Systems

Whenever repairs are made to any air conditioner parts that hold refrigerant, you must discharge, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the air conditioning system has been discharged to a refrigerant recovery unit through the service valves on the compressor.

Refrigerants are safe when used under the right conditions. Always wear safety goggles and non-leather gloves while discharging, purging, flushing, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

WARNING: Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should first be treated with a few drops of sterile mineral oil in the eyes, and then rinsed with a weak boric acid solution. Do not rub the eyes. Call a doctor right away.

Refrigerant splashed on the skin should be treated the same as for frostbite: gently pour cool water on the area, but do not rub the skin. Keep the skin warm with layers of soft, sterile cloth. Call a doctor right away.

Even though refrigerant does not burn, when it contacts extreme heat or flame, poisonous phosgene gas is created. This gas also is produced when an open flame leak detector is used. Phosgene fumes have an acrid (bitter) smell.

⚠ WARNING

WARNING: Do not work in an area where refrigerant may contact an open flame or any burning material, such as a cigarette. When it contacts extreme heat, refrigerant breaks down into poisonous phosgene gas which, if breathed, causes severe respiratory irritation. Do not breathe the fumes from an open flame leak detector.

You must work in an area where there is a constant flow of fresh air when the system is discharged, flushed, charged, and leak tested using an open flame leak detector.

Changes in both federal and state laws will affect the way dealerships service air-conditioning systems. Under current federal laws, refrigerant R–12 must be recovered and recycled by all users to protect the environment, and not released into the atmosphere. Many service operations not directly involving the air-conditioning system require the release of the refrigerant charge. Under the new regulations, dealerships not having the required recovery and recycling equipment (and properly trained and certified personnel) will not be allowed to do any of this service work.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant cans from exploding, never expose them to temperatures higher than 125°F (52°C). Never leave refrigerant cans in the sun, and do not store them in sun-exposed areas where heat can build up, such as in gloveboxes, automobile trunks, etc.

Pre-Service Checks

WARNING

WARNING: Before doing any work, read the information under Safety Precautions, 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

CAUTION

CAUTION: Determine if the air conditioning system is charged with refrigerant R–134a or R–12. Check the label on the radiator shroud (the side the compressor is on), the compressor identification tag, and the caution labels on system components, for verification. Service procedures are different for these refrigerant systems. Failure to properly identify the refrigerant system prior to servicing could cause component malfunction and system contamination.

Some special tools are needed for doing repair work on the compressor. Refer to the special tools table in **Specifications 400.** Tool kits can be bought from the distributor listed under the special tools table in **Specifications 400.**

NOTE: Compressor problems usually show in one of four ways: abnormal noise; seizure; leakage; or low suction and discharge pressures. Resonant compressor noises are not causes for alarm; irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch and see if the drive plate can be turned. If it won't turn, the compressor has seized.

Do the following checks whenever the air conditioner system is not cooling enough and the causes are unknown.

1. Be sure to check the moisture indicator, to see if moisture is the cause of the problems. The air conditioner should be on when checking the indicator; it is better to check it at the end of a day's run.
2. Check the drive belt and mounting:
   - 2.1 On the drive belt, look for wear, damage, or oil. If worn, oil-soaked, or damaged, remove it and install a new one. Refer to the drive belt section in **Group 01** of this manual for instructions.
   - 2.2 Check the compressor mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners to the torque value in the torque specifications table under **Specifications 400.** Repair or replace cracked or damaged brackets.
   - 2.3 Check the tension of the compressor drive belt. Refer to the drive belt section in **Group 01** of this manual for instructions.
   - 2.4 Check the compressor oil level. Refer to **Subject 140** for instructions.
3. Check the wiring and connections to the compressor clutch. Replace damaged wiring and tighten loose connections.
4. Check for road debris build-up on the condenser coil fins. Using air pressure and a whiskbroom or a solution of soap and water, carefully clean the condenser; be careful not to bend the fins.
5. Check the refrigerant charge in the air conditioner system; for instructions, refer to the applicable heater and air conditioner section in this group.
6. Check the valve plate and cylinder gasket (**Subject 170**), and the shaft seal (**Subject 160**) for damage. Replace as needed.

NOTE: For other possible causes of air conditioner problems, refer to the applicable heater and air conditioner section in this group and to the applicable fan clutch section in **Group 20** of this manual.

Compressor Suction and Discharge Pressure Checking, R–12 Systems

Checking

⚠ WARNING

WARNING: Before doing any of the work below, read the information under Safety Precautions, 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

IMPORTANT: This subject applies to R–12 only. Temperature/pressure specifications for R–134a systems have not been developed at this time.

1. Attach a manifold gauge set to the service ports. Make sure that the manifold gauge set is equipped with a valve core depressor.
   - 1.1 Remove the protector caps from the service valve ports on the compressor.
   - 1.2 Make sure that the valves on the recovery and recycling station are closed. Cap the manifold center hose.
   - 1.3 Connect the red high-side hose to the discharge service valve, and the blue low-side hose to the suction service valve.
2. Start the engine and set it to run at 1500 rpm.
3. Turn on the heater-air conditioner blower, and set the air conditioner controls to the coldest setting, so that the compressor is operating. If the outside temperature is cooler than 70°F (21°C), *partially* block the air to the condenser.
4. Look at the manifold suction and discharge pressure gauges. The pressure on the gauges should be within the range in the temperature/pressure specifications table in **Specifications 400.**
   - 4.1 If the suction and discharge pressures are both too high, there is air in the refrigerant, or too much refrigerant in the system; check the charge; for instructions, refer to the applicable heater and air conditioner section in this group.
   - 4.2 If the suction pressure is too high and the discharge pressure is normal, check the wiring to the thermostatic switch on the blower motor housing; repair or replace the wiring, as needed. If the wiring is correct and there is power to the switch, check that the probe of the thermostatic switch is correctly installed in the evaporator coil. Refer to the applicable heater and air conditioner section in this group for instructions. If everything checks out okay, but the problem persists, replace the thermostatic switch at the climate control panel.
   - 4.3 If the suction pressure is too low and the discharge pressure is normal or too low, check for passage of air through the evaporator coils. If airflow is blocked, remove the blockage. If airflow is satisfactory, check for blockages in the line to the suction side of the compressor.
5. If the suction pressure is normal and the discharge pressure is too high, airflow through the condenser may not be enough to carry away the heat.
   - 5.1 Place a large fan in front of the radiator, so that the airflow goes through the condenser. After two minutes of operating the air conditioner and the fan at the same time, look at the manifold pressure gauges again. (One other procedure is to direct a spray of water onto the condenser while the system is running.)
   - 5.2 If the discharge pressure is still too high, the lines between the compressor and the receiver-drier are blocked, or the condenser is blocked internally. Discharge, flush, evacuate, charge, and leak test the system. If the blockage can't be removed by flushing, replace the blocked line or blocked condenser. After flushing and before placing a vacuum in the system, *be sure to add the correct amount of refrigerant oil to the compressor.* For instructions, refer to **Subject 140**.
6. If the suction pressure is normal or too high and the discharge pressure is too low, check for a slipping clutch or wrong-sized clutch pulley or accessory drive pulley. Replace parts as needed.

   If the suction pressure is still normal or too high and the discharge pressure is still too low, the compressor is the problem. Repair or replace the compressor.

Compressor Removal and Installation

Removal

WARNING

Before doing any work, read the information in Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

1. Turn off the engine, apply the brakes, and chock the tires.
2. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.04**, Subject 250.
3. Remove the compressor drive belt. If the shaft seal assembly or the entire compressor is being replaced, remove the magnetic clutch assembly. For instructions, see **Subject 150**.
4. Clean the compressor around the refrigerant line connections. Disconnect the refrigerant lines from the compressor. Quickly cap the discharge and suction ports and the refrigerant lines.

IMPORTANT: Under no circumstances should the ports on the compressor or the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

5. Remove the nuts and bolts that attach the compressor to the mounting bracket. Remove the compressor.

Installation

IMPORTANT: A new compressor is filled with refrigerant oil and nitrogen gas. The quantity is printed on a label attached to the compressor. When installing a new compressor on the vehicle, do all of the steps below. If installing a used compressor, disregard the first step.

1. Prepare a new compressor.
   - 1.1 Gently release the nitrogen gas from the discharge side of the compressor. Be careful not to let the oil flow out.
   - 1.2 Turn the compressor shaft several times by hand to distribute oil which has settled in the cylinder.
2. If installing a new compressor, adjust the refrigerant oil level in the new compressor. For instructions see, **Section 83.06**, Subject 130.
3. Using bolts and nuts, install the refrigerant compressor on the mounting bracket. Torque the bolts 35 lbf·ft (47 N·m).
4. Install the magnetic clutch assembly if it was removed. For instructions, see **Subject 150**.
5. Install the compressor drive belt. Refer to the engine section for compressor drive belt tension adjustment.
6. Uncap the discharge and suction ports and the refrigerant lines. Check the refrigerant lines and the discharge and suction ports. They must be clean and free of nicks, gasket residue, and other foreign material.
7. On refrigerant line connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On refrigerant line connections that have Mini Stat-O-Seals, replace the seals. **Do not** lubricate Mini Stat-O-Seals prior to installation. Use only a Mini Stat-O-Seal on a Mini Stat-O-Seal assembly.
8. Connect the refrigerant lines to the compressor.

   On refrigerant line connections that have threaded fittings, torque the fittings 33 lbf·ft (45 N·m).

   On refrigerant line connections that have Mini Stat-O-Seal assemblies, torque the bolts on the Mini Stat-O-Seal assemblies 11 to 15 lbf·ft (15 to 20 N·m).
9. If installing a new compressor or if the system was without any refrigerant pressure before repairs were started, replace the receiver-drier. For instructions, see **Section 83.04**, Subject 210.

   If the compressor is not being replaced, check the moisture indicator on the receiver-drier. If it is not blue, replace the receiver-drier. For instructions, see **Section 83.04**, Subject 210.

Compressor Removal and Installation

10. Evacuate, charge, and leak test the air conditioning system. For instructions, see **Section 83.04**, Subject 250.
11. Remove the chocks from the tires.

Oil Check and Adding Oil to the Compressor

General Information

⚠ CAUTION

Different refrigerant oils are used in compressors on R–12 and R–134a air conditioning systems. Always use the correct refrigerant oil and never mix oils. If the wrong oil is used, or if oils are mixed, the compressor could seize due to improper lubrication.

IMPORTANT: On R–12 air conditioning systems, new compressors are factory-charged with about 12.2 fl oz (360 mL) of refrigerant oil. On R–134a air conditioning systems, new compressors are factory-charged with about 14 fl oz (414 mL) of refrigerant oil. Some refrigerant oil is circulated through the system with the refrigerant, and cannot leave the system except through a leak, when the system is discharged or recovered, or when a system part is replaced.

Oil must be from a container that has not been opened, or that has been tightly sealed since its last use. Check the labelling on the compressor to determine the recommended refrigerant oil. Tubing, funnels, or other equipment used to transfer the oil should be very clean and dry.

IMPORTANT: Add the same amount of oil that is removed when the system is discharged or recovered, or when a system part is replaced. The two lists below are approximate refill amounts for R–12 and R–134a air conditioning systems. Make sure you use the correct list.

The following is for R–12 air conditioning systems only:

A. Refrigerant charge—0.7 fl oz (20 mL): This amount of oil may be removed from the system each time the system loses its charge, due to routine discharging or due to a slow leak; no other parts of the system have been purged, flushed, or replaced.

IMPORTANT: The items below list oil quantities that include the amounts that are lost during discharging. Do not add an additional 0.7 fl oz (20 mL)—the amount described in the item above—to the quantities listed.

B. Receiver-drier—2.7 fl oz (80 mL);

IMPORTANT: A new receiver-drier may contain 3.4 fl oz (100 mL) of refrigerant oil, eliminating the need to add oil before installation. Confirm the oil level in a new receiver-drier; don't add any oil if it already contains 3.4 fl oz (100 mL).

C. Condenser—1.0 fl oz (30 mL);

D. Evaporator coil—0.7 fl oz (20 mL);

E. Entire system—15 fl oz (450 mL) with or without an auxiliary heater/air-conditioner. Add this amount of oil to the compressor if the entire system (including the compressor) has been discharged of refrigerant and oil, and all parts and hoses have been flushed.

The following is for R–134a air conditioning systems only:

A. Oil charge—the entire system should have *about* 14 fl oz (414 mL) of refrigerant oil. There should be 10 fl oz (296 mL) in the compressor. Each major component has *about* 2.0 fl oz (59 mL) of oil (this amount has been rounded off for ease of adding oil to the compressor). Therefore, additional oil must be added to the compressor when a major component is replaced.

NOTE: As an example, if the condenser and the receiver-drier are to be replaced, first check the oil level of the compressor. The compressor should have 10 fl oz (296 mL). Add oil if needed. Then, after replacing the condenser and the receiver-drier, add an additional 4.0 fl oz (118 mL) of oil to the compressor. The entire system should then have about 14 fl oz (414 mL).

When handling refrigerant oil:

- The oil should be free of water, dust, metal powder, and other foreign substances.
- Don't mix refrigerant oil with other types or viscosities of oil.
- Refrigerant oil absorbs moisture when exposed to the air for any period of time. After use, quickly seal the oil container.

IMPORTANT: Replacing only the amount of oil that is removed during evacuation may result in the wrong oil charge because the oil charge may have been incorrect prior to evacuation.

Oil Check and Adding Oil to the Compressor

The only way to ensure the proper oil charge is to check the oil level of the compressor with a dipstick.

B. Receiver-drier—when the receiver-drier is replaced, *about* 2.0 fl oz (59 mL) must be added to the compressor in addition to the 10 fl oz (296 mL) that the compressor requires.

IMPORTANT: A new receiver-drier does not contain any refrigerant oil.

C. Condenser—when the condenser is replaced, *about* 2.0 fl oz (59 mL) must be added to the compressor in addition to the 10 fl oz (296 mL) that the compressor requires.

D. Evaporator coil—when the evaporator coil is replaced, *about* 2.0 fl oz (59 mL) must be added to the compressor in addition to the 10 fl oz (296 mL) that the compressor requires.

IMPORTANT: Check the compressor oil level whenever the system has been opened.

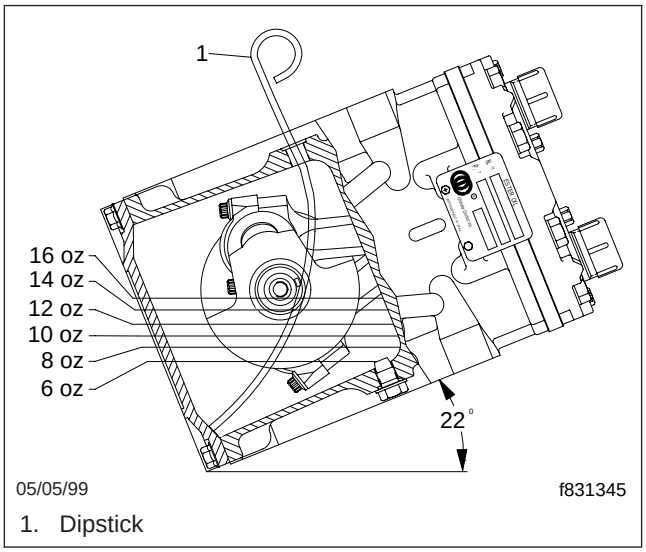
⚠ WARNING

Don't remove the oil fill plug without first recovering or discharging the system. Failure to recover or discharge the system could cause uncontrolled release of high-pressure refrigerant, which can freeze skin and eye tissue causing serious injury or blindness.

1. Remove the oil fill plug and O-ring.
2. Check the oil level with the dipstick. When the compressor is mounted vertically, use either plug; when mounted in any other orientation, use the upper plug. **Figure 1** shows the oil level with the refrigerant compressor mounted at 22 degrees. **Figure 2** shows the oil level with the refrigerant compressor mounted at 45 degrees.

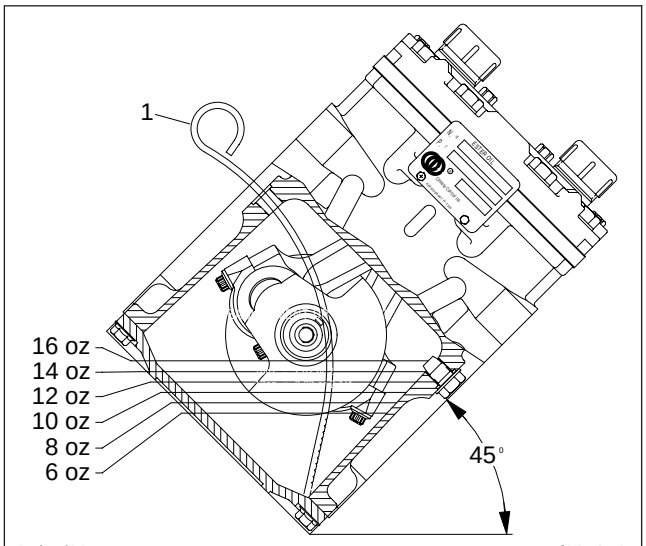
   If the dipstick bottoms out before going in more than 3 inches (75 mm), it is hitting the compressor crankshaft. Rotate the drive plate by hand and insert the dipstick again until it contacts the bottom of the sump. See **Table 1** to determine the oil quantity. Add or remove oil from the compressor so that the oil charge is 10 fl oz (296 mL).

NOTE: A dipstick can be made locally or purchased from a special tools supplier. Refer to the special tools table in **Specifications 400**. If made locally, it can be formed from 1/8-inch diameter by 8-5/16 inch long stock. See **Fig. 3**. Use a nonferrous material that is not subject to corrosion. Notching the end makes it easier to see the oil depth.



1. Dipstick

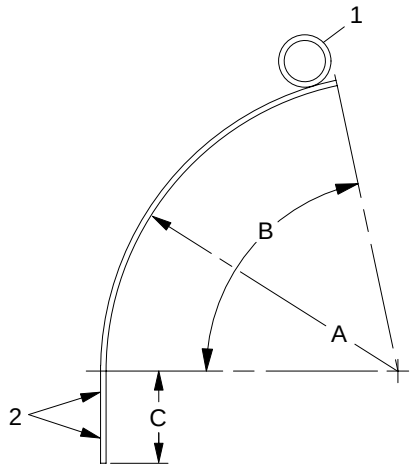
Fig. 1, Oil Level With Refrigerant Compressor Mounted at 22 Degrees



1. Dipstick

Fig. 2, Oil Level With Refrigerant Compressor Mounted at 45 Degrees

3. Being careful not to twist the O-ring, slip it over the oil fill plug threads. Insert the plug in the oil fill opening and tighten it until snug. If the plug leaks, don't attempt to stop the leak by overtightening. Leaks may be caused by dirt under the O-ring, dirt on the seat, a broken O-ring, or a damaged seat on the oil fill plug or opening. Correct the problem and install a new O-ring.



NOTE: Left-Hand Mounting: Check oil when shaft key is down. Right-Hand Mounting: Check oil when shaft key is up.

A. 4-3/4 Inches (121 mm) Radius
B. 78°
C. 1-1/2 (38 mm) Inches
1. Finger Ring
2. 12 Notches, 1/8 Inch (3.2 mm) Apart

Fig. 3, Dipstick Specifications

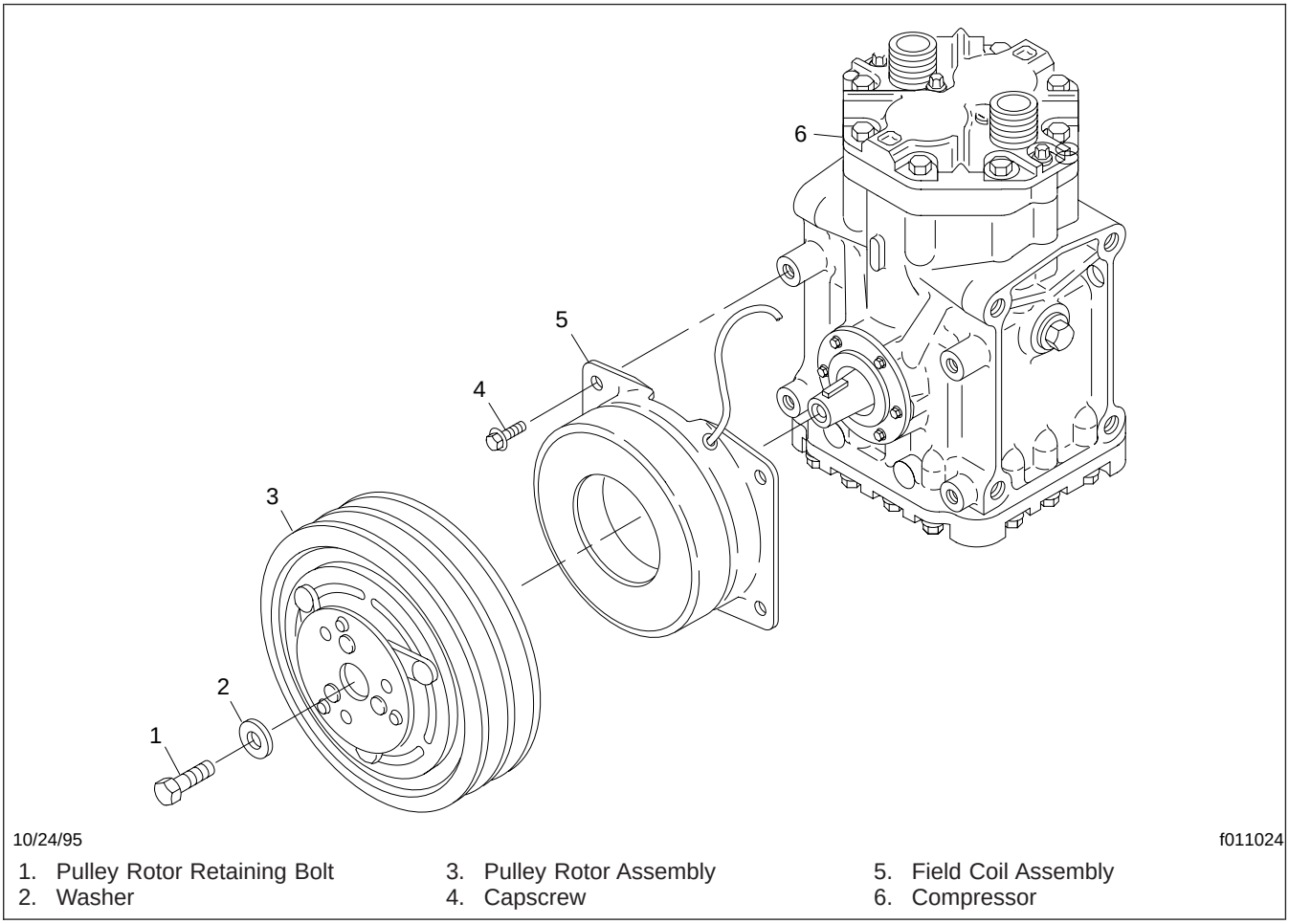
Oil Quantity at Various Dipstick Depths				
Dipstick Depth				Oil Quantity fl oz (mL)
0-Degree Mount (horizontal) inches (mm)	22-Degree Mount inches (mm)	45-Degree Mount inches (mm)	90-Degree Mount (vertical) inches (mm)	
13/16 (20.6)	1-3/4 (44.5)	1-5/8 (41.3)	7/8 (22.2)	6 (177)
1 (25.4)	2-1/16 (52.4)	1-13/16 (46)	1 (25.4)	8 (237)
1-3/16 (30.2)	2-5/16 (58.7)	2 (50.8)	1-1/8 (28.6)	10 (296)
1-5/8 (41.3)	2-9/16 (65.1)	2-1/4 (57.2)	1-7/16 (36.5)	12 (355)
1-13/16 (46)	2-7/8 (73)	2-7/16 (61.9)	1-11/16 (43)	14 (414)
1-15/16 (49.2)	3-1/8 (79.4)	2-5/8 (66.7)	1-7/8 (47.6)	16 (473)

Table 1, Oil Quantity at Various Dipstick Depths

Magnetic Clutch Assembly Removal, Inspection, and Installation

Removal (See Fig. 1)

1. Remove the 5/16-inch pulley rotor retaining bolt from the center of the pulley rotor.
5. Remove the four 1/4–20 capscrews holding the field coil assembly to the compressor housing.
6. Remove the field coil assembly.



1. Pulley Rotor Retaining Bolt
2. Washer
3. Pulley Rotor Assembly
4. Capscrew
5. Field Coil Assembly
6. Compressor

Fig. 1, Pulley Rotor and Field Coil Assemblies

2. Install a 5/8–11 capscrew in the hub of the pulley rotor assembly.
3. Tighten the screw to pull the pulley rotor assembly off the compressor shaft.

CAUTION

CAUTION: Do not try to remove the pulley rotor assembly by prying or hammering. This can damage the assembly.

4. Disconnect the field coil electrical lead wire.

Inspection

1. Inspect the drive plate. If the friction surface shows signs of damage due to too much heat, replace the drive plate and pulley assembly.
2. Check the appearance of the pulley assembly. If the frictional surface of the pulley shows signs of too much grooving due to slippage, replace both the pulley and drive plate. Clean the friction surfaces of the pulley assembly before installing it.

Magnetic Clutch Assembly Removal, Inspection, and Installation

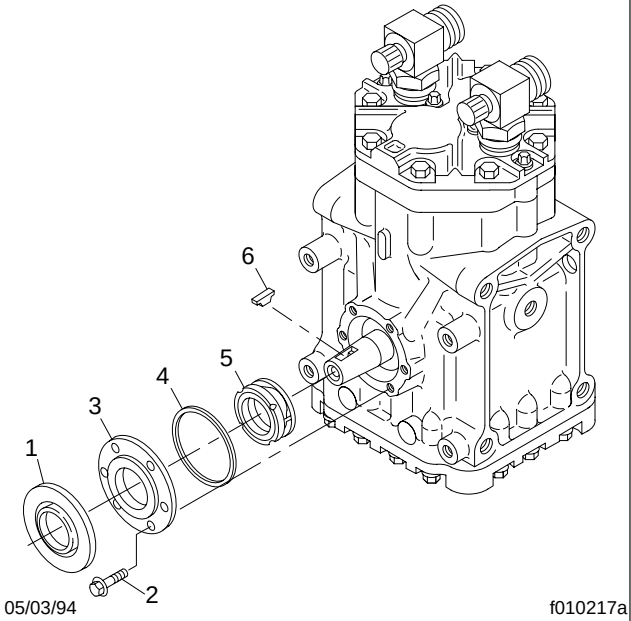
3. Check the coil for a loose connector and for cracked insulation. Replace it, if necessary.

Installation

1. Position the field coil assembly on the compressor housing with the four screw mounting holes aligned with the bosses on the housing.
2. Apply Loctite® 262 or 680 to the four 1/4–20 capscrews (on those threads that do not already have dry Loctite on them).
3. Install the capscrews and gradually tighten them to align the coil assembly. Final torque should be 15 lbf·ft (20 N·m).
4. Taking care to properly align and seat the shaft and hub keyways, attach the pulley rotor assembly to the compressor shaft.
5. Install the 5/16–24 center bolt and washer. Tighten the bolt about 20 lbf·ft (27 N·m).
6. Turn the pulley rotor assembly by hand to make sure it moves freely without interference with the field coil assembly.
7. Connect the lead wire from the field coil to the vehicle electrical circuit.
8. Engage and disengage the clutch several times to check for correct operation.

Replacement (See Fig. 1)

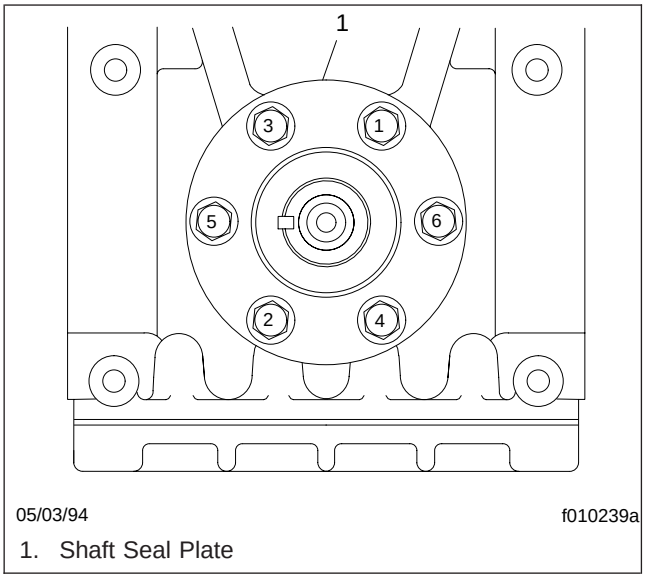
1. Remove the compressor from the vehicle. For instructions refer to **Subject 130.**



1. Dust Cover
2. Capscrew
3. Seal Cover Plate
4. O-Ring
5. Seal Gland
6. Shaft Key

Fig. 1

2. Using the clutch center jacking bolt, remove the clutch.
3. Remove the dust cover if present.
4. Remove the seal cover plate. Using the seal puller, pull out and discard the seal gland. Do not use a screwdriver to pry the seal gland from the compressor shaft; this could damage the shaft. Discard all seal parts including the O-ring.
5. Clean the shaft and seal cavity with a clean lint-free cloth.
6. Dip the new seal gland in refrigerant oil.
7. Push the seal assembly (**see Fig. 1**), minus the carbon ring (inside the seal gland), over the end of the shaft with the carbon ring retainer facing out. Use the seal installer tool to move the seal assembly into position on the shaft.
8. Place the carbon ring in the ring retainer so the lapped surface is facing out. The notches in the outside edge of the carbon ring must engage the driving lugs and be firmly seated in the retainer.
9. Coat a new O-ring with refrigerant oil so it will stick; then, install it in the seal cover plate groove.
10. Install the seal cover plate so there is equal clearance around the shaft. Install the cap-screws, and tighten them 60 to 84 lbf·in (680 to 940 N·cm) in sequence. **See Fig. 2.**



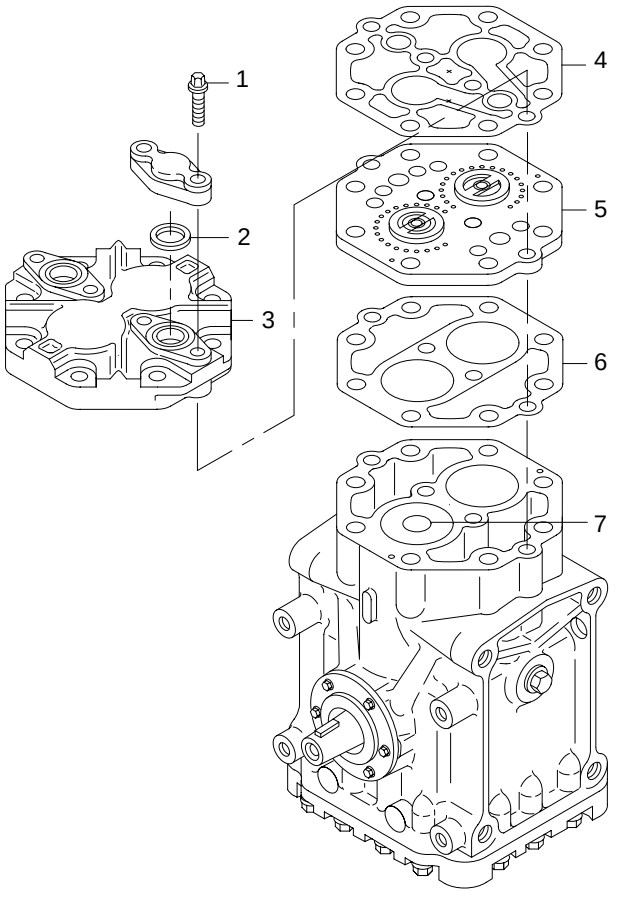
1. Shaft Seal Plate

Fig. 2, Tightening Sequence

11. Place the dust cover on the shaft before inserting the shaft key. As the clutch bolt is tightened, the dust cover will be drawn into the proper position.

Head and Valve Plate Removal and Installation

Removal (See Fig. 1)



1. Capscrew
2. O-Ring
3. Cylinder Head
4. Cylinder Head Gasket
5. Valve Plate
6. Cylinder Gasket
7. Piston

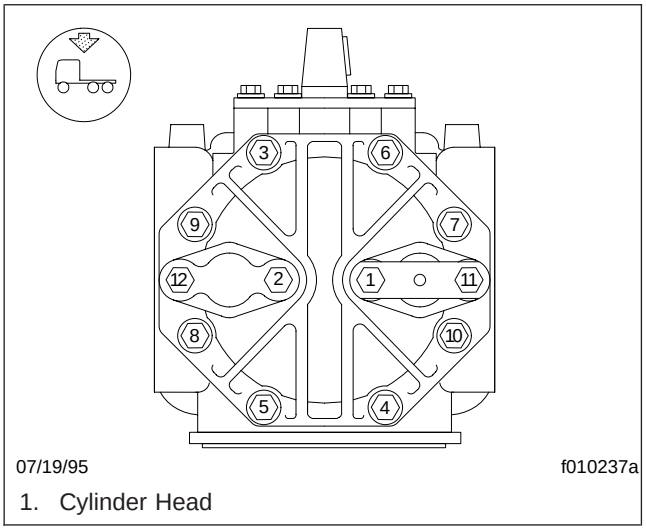
Fig. 1

NOTE: Before doing any work on the head and valve plate, open both service valves to release any gas pressure in the compressor. The cylinder head is made of aluminum; be careful when removing it not to damage the sealing surfaces.

1. Remove the screws from the service valves. **See Fig. 2**, Refs. 1, 2, 11, and 12.

   If equipped with flanged-type service valves, these four screws are longer than the remaining head screws.

   If equipped with Rotalock or Tube-O type valves, remove them by loosening the hexnuts which are part of the valve assembly.



1. Cylinder Head

Fig. 2, Cylinder Head Capscrew Tightening Sequence

2. Remove the remaining screws from the head.
3. Remove the valve plate and head from the cylinder by prying or tapping under the ears extending from the valve plate. If the head and valve plate adhere, hold the head and tap the valve plate ears away from the head with a soft hammer.

CAUTION

CAUTION: Do not hit or tap the head to separate it from the valve plate. Damage to the head may result.

4. Being careful not to scratch or nick the machined sealing surfaces, remove all gasket material adhering to the head, valve plate, or cylinder.

Installation

NOTE: Valves and valve plates are furnished only as a complete assembly.

Head and Valve Plate Removal and Installation

⚠ CAUTION

CAUTION: Different refrigerant oils are used in compressors on R–12 and R–134a air conditioning systems. Always use the correct refrigerant oil and never mix oils. If the wrong oil is used, or if oils are mixed, the compressor could seize due to improper lubrication.

1. Apply a thin film of clean refrigerant oil to the area of the crankcase to be covered by the cylinder gasket. Place the cylinder gasket in position on the cylinder so the dowel pins in the crankcase pass through the dowel pin holes in the cylinder gasket.
2. Apply a thin film of clean refrigerant oil to the top and bottom valve plate areas to be covered by gaskets. Place the valve plate in position on the cylinder gasket so the discharge valve assemblies are facing up and the locating dowel pins go through the dowel pin holes in the valve plate. The discharge valve assemblies are the smaller diameter ones with the restrainer over the valve reed.
3. Place the head gasket in position on the valve plate so the dowel pins go through the dowel pin holes in the gasket.
4. Apply a light film of clean refrigerant oil to the machined surface of the cylinder head which contacts the head gasket. Place the head on the cylinder head gasket so the dowel pins go into the dowel pin holes in the head.
5. Apply a thin film of clean refrigerant oil to the service valve flanges. Place a service valve gasket in position on the cylinder head service valve flanges. Place the service valves in position on the proper service valve ports (suction or discharge) and insert the four longer screws through the service valve mounting pads, the head, the valve plate, and into the crankcase.

   If equipped with Rotalock or Tube-O type valves, insert the longer screws on the inside of the service valve ports and the shorter screws on the outside.

   Insert the remaining head screws and tighten all the screws until the heads make contact.
6. Tighten the head and service valve screws 17 to 25 lbf·ft (23 to 34 N·m) in sequence. **See Fig. 2.**

Pistons, Connecting Rods, Crankshaft, and Bearing Removal and Installation

Piston and Connecting Rod Removal

The pistons and connecting rods are easily accessible after removing the head, valve plate assembly, and base plate. If the connecting rods will be reused, mark the rod, cap and crankshaft throw so the rod can be installed in exactly the same position on the crank pin.

Crankshaft and Bearing Removal

NOTE: When replacing the crankshaft, both the front (seal end) and rear main bearings should also be replaced since they may be damaged during removal.

1. Remove the four screws from the rear bearing cover plate.
2. Remove the cover plate by gently prying it loose from the crankcase, being careful that the housing is pulled parallel to the bearing surface.
3. Remove all components down to the crankcase, crankshaft, and seal end main bearing assembly.
4. Wash this assembly in a solvent, that meets or exceeds OSHA guidelines, to remove all traces of oil and grease. Allow it to dry.
5. Heat the assembly in an oven set to 300°F (150°C).

⚠ CAUTION

CAUTION: Heat the complete assembly evenly in an oven. Localized heating may crack the crankcase.

6. Remove the crankshaft and ball bearing assembly from the crankcase.
7. If the crankshaft is reusable, remove the ball bearing assembly. Hold the crankshaft vertically in a vise with the flywheel end up, gripping the shaft at the unmachined center throw. Using two large screwdrivers as a pry under the bearing race, force the bearing upward and remove it from the shaft.

Crankshaft and Bearing Installation

1. Press the rear ball bearing onto the crankshaft by exerting pressure on the bearing inner race.
2. Make sure that the shaft, bearing, and recess in the crankcase are clean and free of burrs.
3. Heat the crankcase in an oven set to 300°F (150°C).

⚠ CAUTION

CAUTION: Heat the complete assembly evenly in an oven. Localized heating may crack the crankcase.

4. Using the opening in the bottom of the crankcase as a point of entry, place the seal end bearing in the recess. If necessary, apply force to the outer race to be sure that it is seated in the bottom of the recess.
5. Allow the crankcase to cool. Install the crankshaft through the rear bearing cover plate opening, and guide the flywheel end through the inner race of the ball bearing.
6. Place the crankcase so that it is completely supported on the ball bearing inner race. Then, press the shaft into place until the shaft boss contacts the inner bearing race.

⚠ CAUTION

CAUTION: If the housing is not completely supported by the inner bearing race, the bearing may be destroyed.

7. Install the rear bearing cover plate with the O-ring in the crankcase. A slight force may be required due to the small clearances between the outer race of the ball bearing and the bearing cover plate recess.
8. Install the four capscrews and tighten them 10 to 16 lbf·ft (14 to 22 N·m) in sequence. **See Fig. 1.**

Pistons, Connecting Rods, Crankshaft, and Bearing Removal and Installation

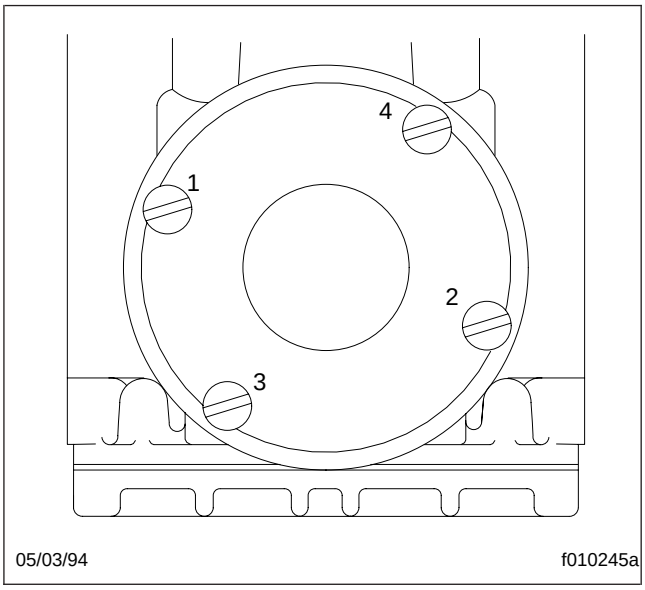


Fig. 1, Rear Bearing Cover Plate Capscrew Tightening Sequence

Piston and Connecting Rod Installation

CAUTION

CAUTION: Different refrigerant oils are used in compressors on R–12 and R–134a air conditioning systems. Always use the correct refrigerant oil and never mix oils. If the wrong oil is used, or if oils are mixed, the compressor could seize due to improper lubrication.

NOTE: When installing either the original or a new piston and connecting rod assembly, coat all bearing surfaces with clean oil of the same brand used in the crankcase.

When installing the assembly into the cylinder, the wrist pin roll pin must be positioned toward the center of the compressor. If positioned toward the outside, the roll pin may hit the crankshaft when the piston is at bottom dead center.

When installing a used connecting rod, match up the marks made during removal. When installing a new connecting rod, the dowel pins in the bearing cap must be positioned to enter the holes in the rod.

1. Install the piston and connecting rod assemblies.
2. Install the connecting rod capscrews and tighten them 12 to 16 lbf·ft (16 to 22 N·m).
3. Wipe all parts with a lint free cloth to make sure they are clean.
4. Install the base plate. Tighten the capscrews 10 to 16 lbf·ft (14 to 22 N·m) in sequence. **See Fig. 2.**

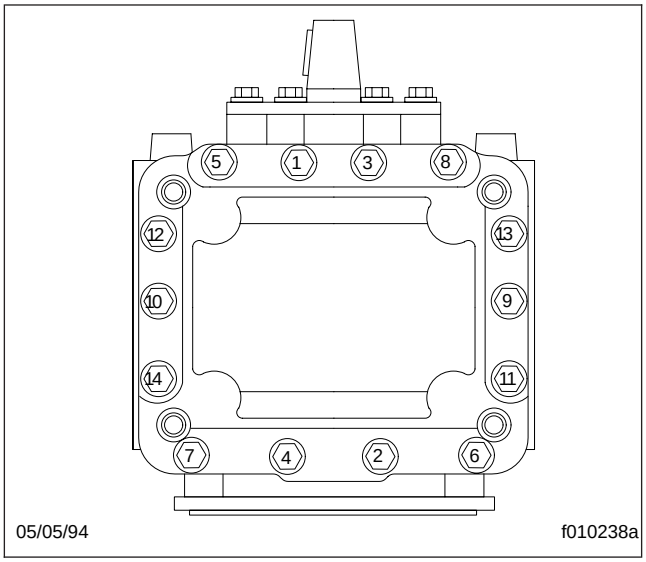


Fig. 2, Baseplate Capscrew Tightening Sequence

5. Install the head and valve plate assembly. For instructions, refer to **Subject 170.**
6. Check the labelling on the compressor to determine the recommended refrigerant oil. Fill the crankcase with the recommended oil.
7. Close all openings to prevent the entrance of foreign material.

Specifications

Special tools can be ordered from your local tool supplier.

Torque Specifications				
Location	Thread	Head Type	Torque	
			lbf·ft (N·m)	lbf·in (N·cm)
Base Plate	1/4–20	Hex	10–16 (14–22)	—
Connecting Rod	1/4–20	12 point	12–16 (16–22)	—
Rear Bearing Cover Plate	1/4–20	Flat	10–16 (14–22)	—
Cylinder Head	5/16–18	Hex	17–25 (23–34)	—
Seal Plate	10–24	Hex	—	60–84 (680–940)
Flange Valve	5/16–18	Hex	17–25 (23–34)	—
Tube-O Valve	1–14	Hex	35–40 (47–54)	—
Rotalock Valve	1–14	Hex	35–40 (47–54)	—
Mounting Screw	3/8–16	Hex	35 (47)	—
Oil Fill Plug	3/8–24	Hex	—	60–120 (680–1360)
Clutch Bolt	5/16–24	Hex	20 (27)	—

Table 1, Torque Specifications

Temperature/Pressure Specifications for R-12 Air Conditioning System		
Ambient Temperature	System Pressure	
	Suction Side psi (kPa)	Discharge Side psi (kPa)
60 to 80°F (15 to 27°C)	8 to 15 (55 to 103)	140 to 180 (965 to 1240)
80 to 90°F (27 to 32°C)	12 to 15 (83 to 103)	180 to 200 (1240 to 1378)
90° (32°C) or higher	15 to 20 (103 to 138)	200 to 220 (1378 to 1516)

Table 2, Temperature/Pressure Specifications for R-12 Air Conditioning System

Recommended Refrigerant Oils, R-134a Systems*		
Description	Part Number	Compressor Manufacture Date
Polyalkylene Glycol (PAG)	ABP N83 326055	Prior to May 5, 1995, and from July 2002
Polyol Ester (POE)	ABP N83 326008	May 5, 1995, through July 2002

* Look at the identification tag on the refrigerant compressor to determine the type of refrigerant oil that should be used in the air conditioning system. If the type of oil is not specified on the identification tag, use the compressor manufacture date to determine the type of oil to use.

Table 3, Recommended Refrigerant Oils, R-134a Systems

General Information and Principles of Operation

Sleeper heater and air conditioner units (**Fig. 1** and **Fig. 2**) are installed in Conventional sleeper boxes, and in the sleeper compartments of 96-inch and all 104-inch COEs. These units are self-contained, and include the heater core, evaporator coil, blower, and control valves. They are mounted either in the baggage compartment or under the lower bunk, depending on the cab model.

The sleeper heater is plumbed directly to the engine, independent of the cab heater. The sleeper air conditioner is dependent on the cab's air conditioning system, sharing the same refrigerant and compressor.

For air conditioner general information and principles of operation, refer to the cab heater and air conditioner section in this group.

The sleeper unit's climate control panel (**Fig. 3**, **Fig. 4**, or **Fig. 5**) is installed in various locations in the sleeper, depending on the sleeper size and vehicle type. Refer to the vehicle driver's manual for operating instructions.

Opening of the water shutoff valve (see **Fig. 1**, **Fig. 6**, and **Fig. 7**) allows engine-heated coolant to flow through the heater core. Heat is absorbed by air passing over the heater core fins.

The blower forces the heated air through the ducts and into the sleeper.

Depending on the type of temperature control, the water shutoff valve opens when:

- *Electronic Thermostat Control*—The water temperature toggle switch (on the sleeper control panel) is moved to HOT (**Fig. 3**, Ref. 2).
- *Manual Cable Control*—The temperature control cable handle (**Fig. 6**, Ref. 2) (attached to the outlet duct at the foot of the bunk) is pulled up.
- *Constant Temperature Control (C.T.C.)*—The rotary temperature control knob (**Fig. 8**, Ref. 12) is turned clockwise to HEAT.

If equipped with an electronic thermostat control system, the operating mode is determined by the settings of the mode toggle switch and the mode switch relay, which are wired into the system after the thermostat. See **Fig. 3** and **Fig. 9**.

With the mode switch set at HEAT, the thermostat (in connection with the mode switch relay) sends power to the sleeper unit fan when the sleeper temperature is lower than the thermostat setting. The thermostat (in connection with the relay) interrupts power to the fan when the temperature is at or higher than the thermostat setting.

With the mode switch set at A/C, the relay sends power to the fan and refrigerant solenoid valve when the temperature is higher than the thermostat setting, and the thermostat and relay interrupt power when the temperature is at or below the setting.

If the mode switch relay cycles in either operating mode, the thermostat is working correctly.

The maximum temperature to which the thermostat can be set (by turning the temperature control knob clockwise all the way) is 85° ± 2°F (29.5° ± 1°C). If the sleeper temperature is above 85° ± 2°F (29.5° ± 1°C), the thermostat won't send power to the mode switch relay; if the mode switch is at HEAT, the fan won't run.

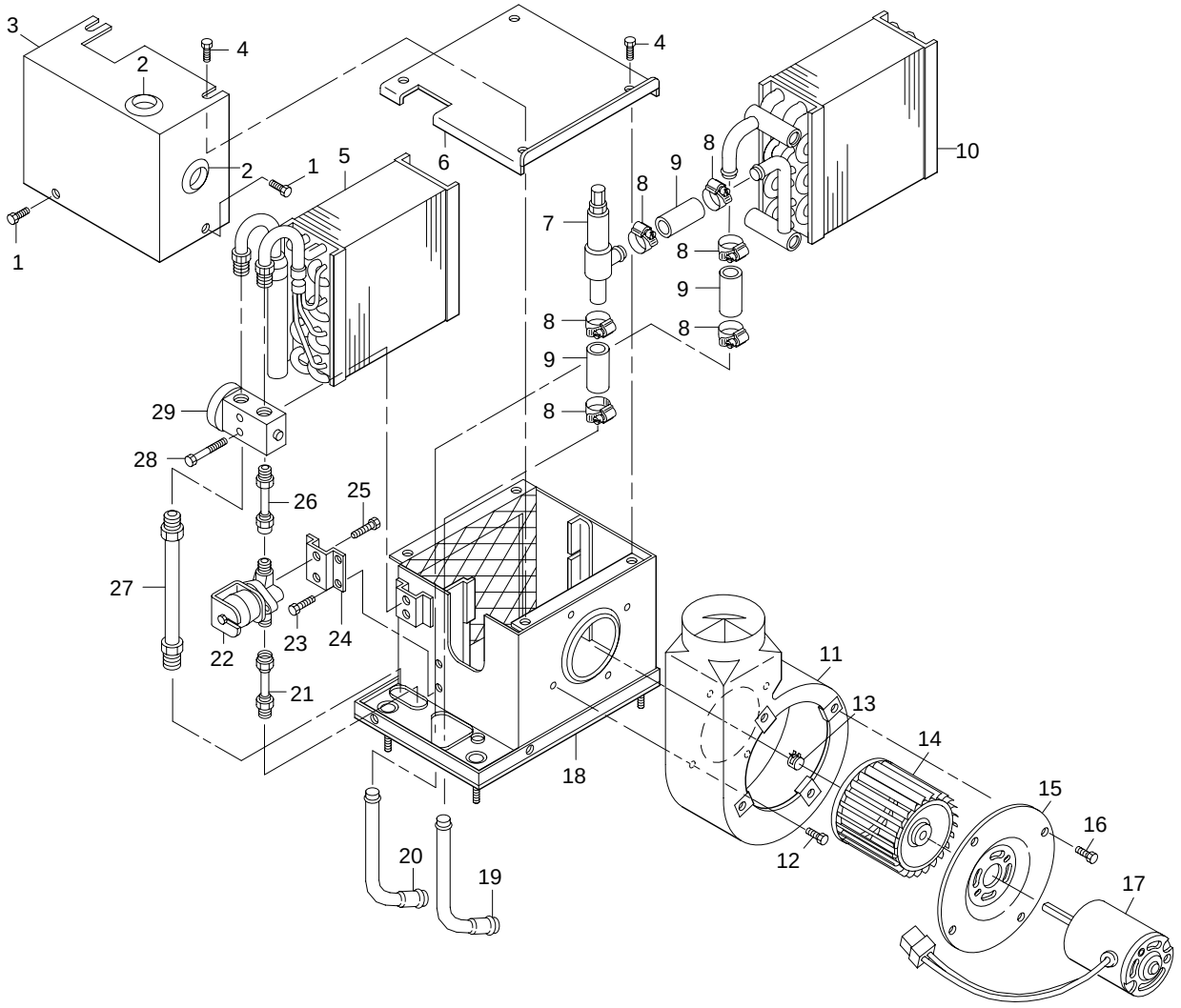
The minimum temperature to which the thermostat can be set (by turning the knob counterclockwise all the way) is 65° ± 2°F (18° ± 1°C). If the sleeper temperature is below 65° ± 2°F (18° ± 1°C), the thermostat will send power to the mode switch relay; if the mode switch is at A/C, the fan won't run and the refrigerant solenoid won't operate.

The electronic thermostat has a 6°F (3.5°C) "dead band." This means that once the heater warms up the sleeper to the thermostat setting, the fan will turn off, and won't turn on again until the temperature drops 6°F (3.5°C) below the thermostat setting. Likewise, once the air conditioner cools down the sleeper to the thermostat setting, the fan (and refrigerant solenoid) will turn off, and won't turn on again until the temperature rises 6°F (3.5°C) above the thermostat setting. The dead band prevents the sleeper heater and air conditioner from cycling too often, yet maintains the temperature within a reasonable range of the thermostat setting.

The C.T.C. system has four major components:

- Controllable Circuit Board Assembly (**Fig. 7**, Ref. 4)
  - – Supplies power to the variable resistor (**Fig. 8**, Ref. 8) and the water supply solenoid.
  - – Monitors air output temperature.

General Information and Principles of Operation



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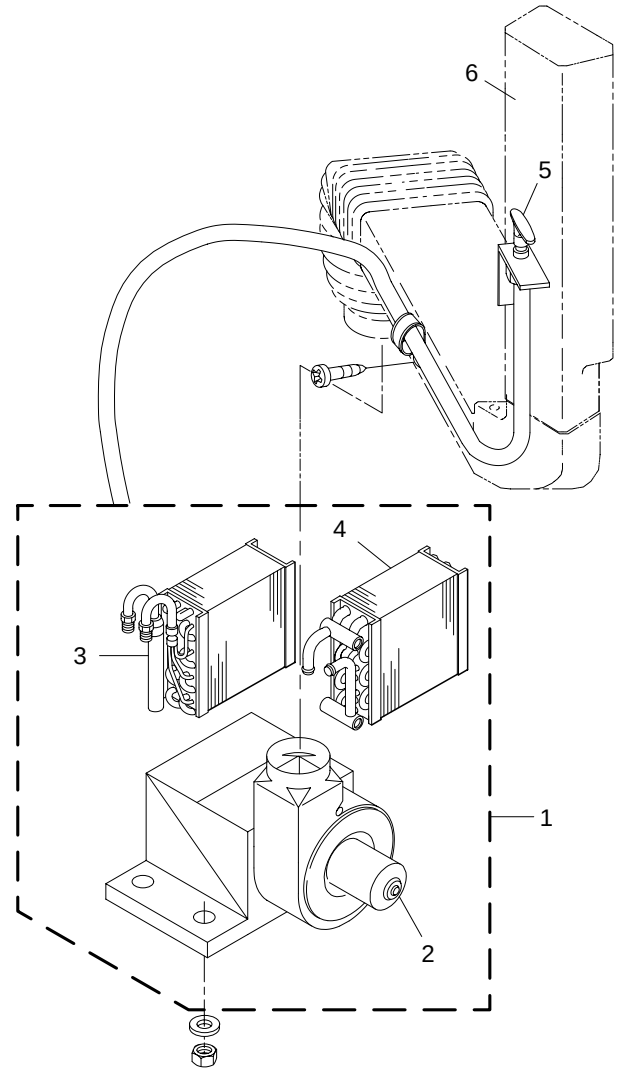
1. Capscrew
2. Grommet
3. Valve Cover
4. Capscrew
5. Evaporator Coil
6. Cover
7. Water Shutoff Valve
8. Hose Clamp
9. Hose
10. Heater Core
11. Blower Housing
12. Capscrew
13. Retainer Clip
14. Blower Wheel
15. Motor Mount
16. Capscrew
17. Blower Motor
18. Housing
19. Water Inlet Tube
20. Water Outlet Tube
21. Refrigerant Inlet Tube
22. Solenoid Valve
23. Capscrew
24. Bracket
25. Capscrew
26. Refrigerant Inlet Tube
27. Refrigerant Outlet Tube
28. Capscrew
29. Expansion Valve

Fig. 1, Sleeper Heater and Air Conditioner Assembly (With Electronic Thermostat Control)

- Variable Resistor (**Fig. 8**, Ref. 8)



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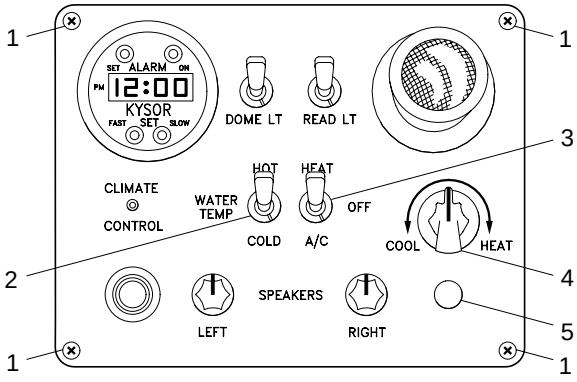
1. Heater/AC Unit
2. Blower Motor
3. Evaporator Coil Assembly
4. Heater Core Assembly
5. Cable Control for Manual Temperature Control
6. Transfer Duct

Fig. 2, Heater and Air Conditioner Assembly (With Manual Temperature Control Cable)

– Used with the temperature control knob (Ref. 12) to select the desired temperature.



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1. Control Panel Screw
2. Water Temperature Switch
3. Mode Switch
4. Temperature Control Knob
5. Temperature Sensor

Fig. 3, Control Panel for Electronic Thermostat Control System

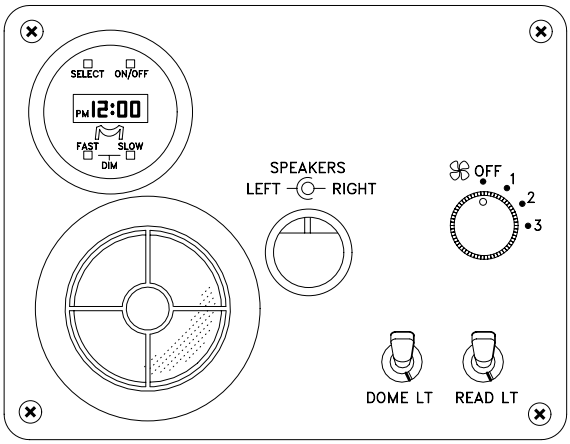

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Fig. 4, Control Panel for Manual Temperature Control Cable System

– Converts the desired temperature into a control voltage for the circuit board.

- Air-Operated Water Shutoff Valve (**Fig. 7**, Ref. 8)

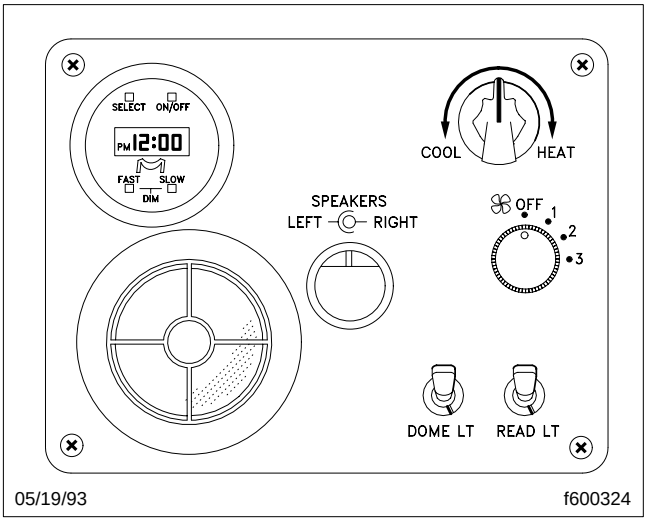


Fig. 5, Control Panel for Constant Temperature Control (CTC™) System

  - The valve is opened and closed by air pressure which is controlled by the water supply solenoid valve.

- Water Supply Solenoid Valve (**Fig. 7**, Ref. 9)
  - Receives power from the circuit board.
  - Controls the air supply to the water shutoff valve.

If equipped with a constant temperature control system (C.T.C.), a preselected temperature is maintained by pulsating the flow of hot water through the heater core.

Once the operator adjusts the temperature control knob (**Fig. 8**, Ref. 12), the air output temperature is monitored at the sleeper heater and air conditioner unit. Any change in output temperature activates the circuit board, energizing or de-energizing the water supply solenoid valve. This controls the air supply that opens or closes the water shutoff valve.

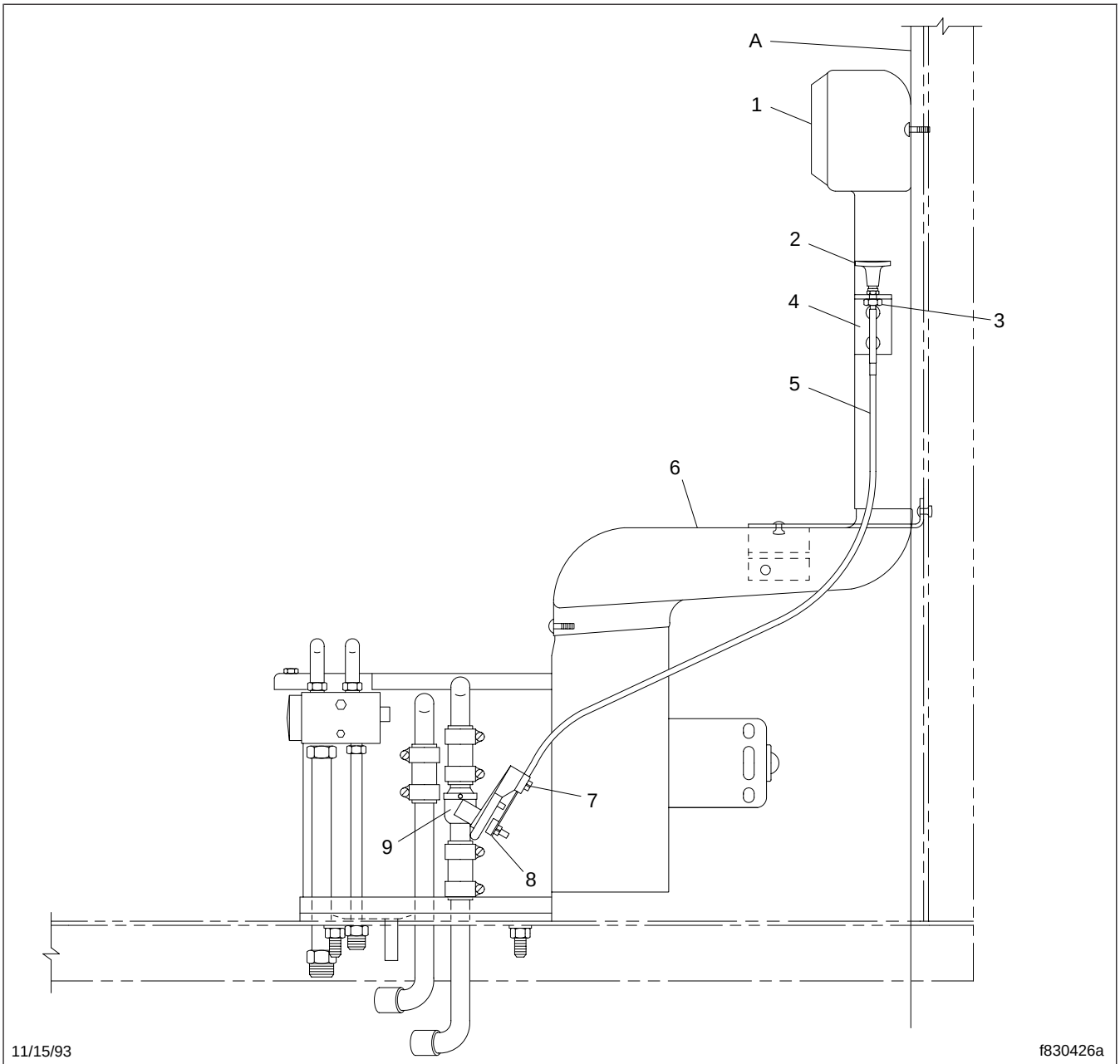
If the air is colder than the selected temperature, hot water is allowed to flow through the water shutoff valve into the heater core. As the output temperature reaches the desired setting, the water shutoff valve is closed, preventing hot water from entering the heater core, until air output temperature becomes too cool again. Then the process starts over.

NOTE: Whenever the refrigerant compressor is operating, the fan will always run at a very low speed, even with the fan control knob turned off. This prevents ice from forming on the evaporator, especially during humid weather.

If equipped with a manual temperature control cable system (**Fig. 2**), outlet air temperature is manually controlled by moving the temperature control cable. Depending on the control panel settings in the cab, moving the cable regulates the water shutoff valve and can provide a full range of warm to hot air (heat mode), or cool to cold air (A/C mode).

A fan control knob (see **Fig. 4**) controls a three-speed blower motor and allows the operator to choose the amount of air flow in the sleeper.

NOTE: Whenever the refrigerant compressor is operating, the fan will always run at a very low speed, even with the fan control knob turned off. This prevents ice from forming on the evaporator, especially during humid weather.

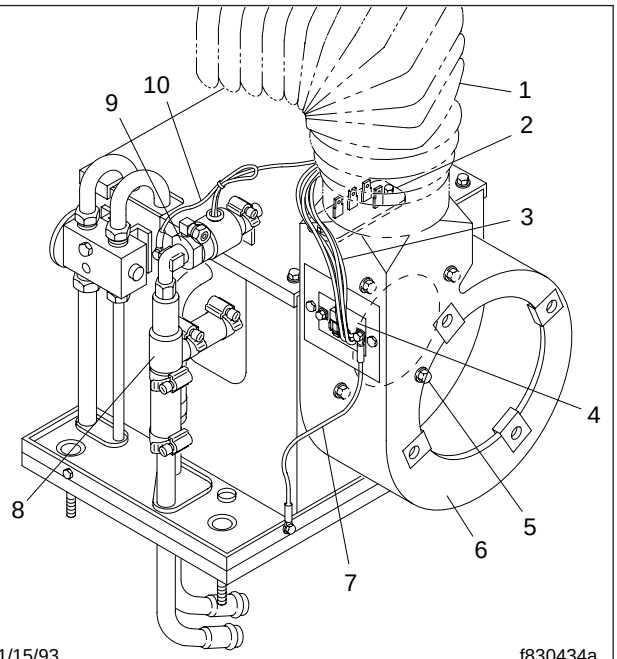


A. Upholstery Reference

1. Louver Assembly
2. Cable Handle
3. Cable Nut
4. Cable Bracket
5. Temperature Control Cable
6. Duct Assembly
7. Cable Clamp
8. Cable End Loop
9. Water Shutoff Valve

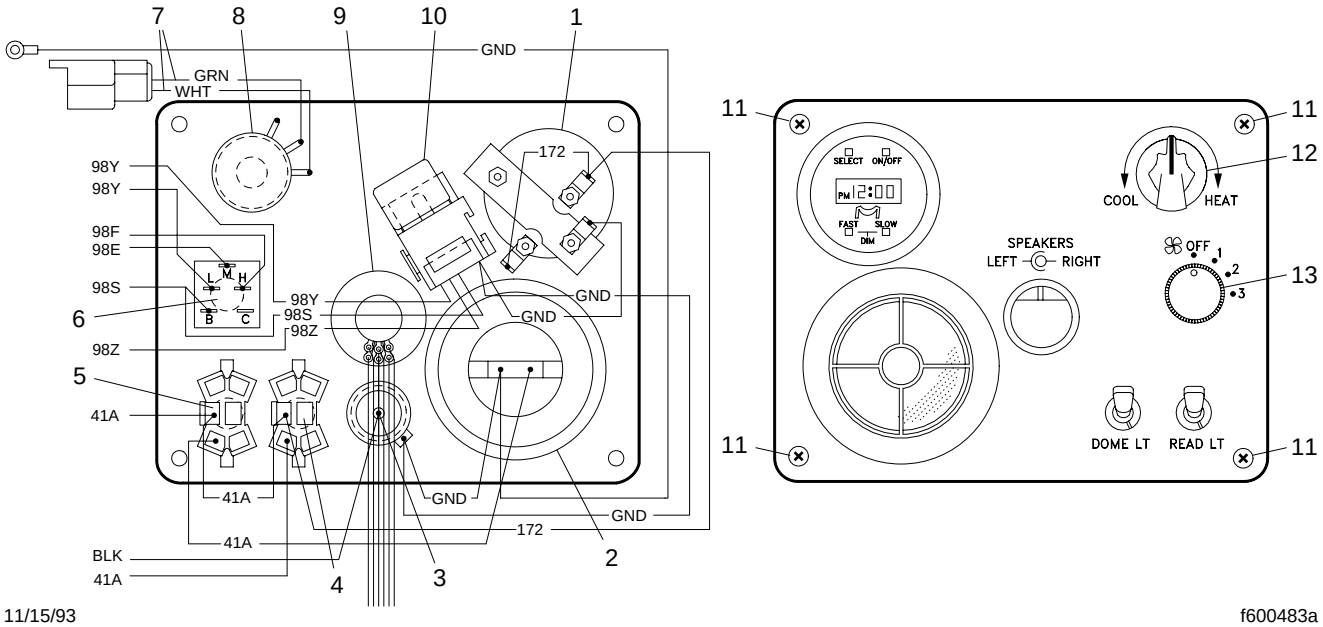
Fig. 6, Manual Temperature Control Cable

General Information and Principles of Operation



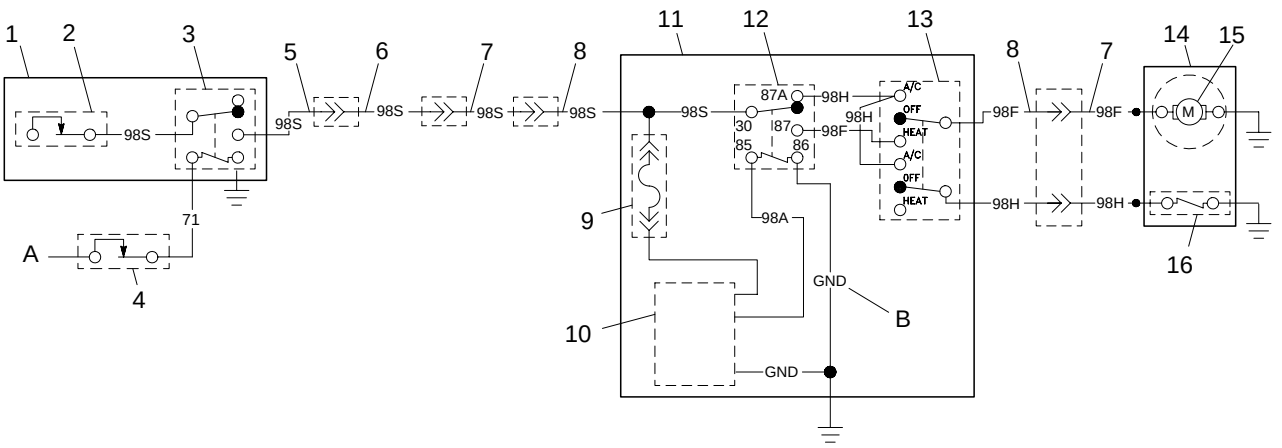
1. Duct
2. Blower Resistor
3. C.T.C. Wiring Harness
4. C.T.C. Circuit Board
5. Capscrew
6. Blower Housing
7. C.T.C. Ground Wire
8. Water Shutoff Valve
9. Water Supply Solenoid Valve
10. Solenoid Ground Wire

Fig. 7, Sleeper Heater and Air Conditioner With C.T.C.



1. Clock
2. Reading Light
3. Cigarette Lighter
4. Dome Light Switch
5. Reading Light Switch
6. Fan Control Knob and Switch
7. C.T.C. Green and White Wires
8. C.T.C. Knob and Variable Resistor Assembly
9. Fader Control
10. Relay
11. Mounting Screws
12. Temperature Control Knob
13. Fan Control Knob

Fig. 8, C.T.C. Control Panel and Parts



A. from the ignition switch

B. Ground

1. Component Mounting Plate
2. Circuit Breaker, 20A
3. Sleeper Heater-A/C Relay
4. Circuit Breaker, 10A
5. Main Cab Wiring Harness
6. Floor Harness
7. Sleeper Harness
8. Control Panel Harness
9. Fuse
10. Electronic Thermostat
11. Sleeper Control Panel
12. Mode Switch Relay
13. Mode (Heat-Off-A/C) Switch
14. Heater and Air Conditioner Unit
15. Blower Motor (Fan)
16. Refrigerant Solenoid Valve

Fig. 9, Electronic Thermostat Control System Wiring Diagram

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold refrigerant, you must discharge, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure. You should disconnect them only after the air conditioning system has been discharged to a refrigerant recovery unit through the service valves.

Refrigerants are safe when used under the right conditions. Always wear safety goggles and non-leather gloves while discharging, purging, flushing, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

WARNING: Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should first be treated with a few drops of sterile mineral oil in the eyes, and then rinsed with a weak boric acid solution. Do not rub the eyes. Call a doctor right away.

Refrigerant splashed on the skin should be treated the same as for frostbite: gently pour cool water on the area, but do not rub the skin. Keep the skin warm with layers of soft, sterile cloth. Call a doctor right away.

Even though refrigerant does not burn, when it contacts extreme heat or flame, poisonous gas is created.

⚠ WARNING

WARNING: Do not work in an area where refrigerant may contact an open flame or any burning material, such as a cigarette. When it contacts extreme heat, refrigerant breaks down into poisonous gas which, if breathed, causes severe respiratory irritation. If an open flame leak detector is used, follow the manufacturer's safety precautions.

If a refrigerant recovery and recycling station is available, discharge the air conditioning system into the station. Refer to the manufacturer's operating instructions.

If a refrigerant recovery and recycling station is not available, check local regulations for disposal methods.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant cans from exploding, never expose them to temperatures higher than 52°C (125°F). Never leave refrigerant cans in the sun, and do not store them in sun-exposed areas where heat can build up, such as in glove boxes, automobile trunks, etc.

Toggle Switch Replacement

WARNING

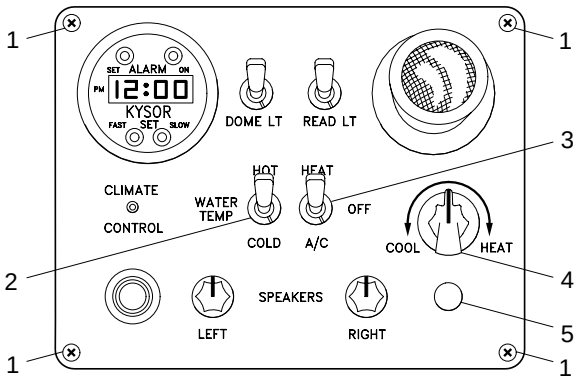
WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

1. Disconnect the batteries. Drain the air system if the heater water-temperature toggle switch will be replaced.
2. Remove the four screws (**Fig. 1**, Ref. 1) attaching the control panel to the sleeper compartment wall, and pull the panel away from the wall.
3. Mark the wires or air tubes connected to the switch (**Fig. 2**, Ref. 2) for later reference. Disconnect the wires or tubes from the switch. To disconnect an air tube, push in on the collar at the fitting and pull out the tube.
4. Remove the switch (**Fig. 1**, Ref. 2 or 3) from the control panel by unscrewing the jam nut on the outside of the panel. Install the new switch on the control panel. Tighten the jam nut firmly.
5. For electrical switches, connect the wires as previously marked. See **Fig. 3** for the wiring diagram.

   For air switches, connect the air tubes as marked. To connect an air tube, push the tube into the fitting until it bottoms.
6. Install the control panel on the wall. Tighten the screws firmly.
7. Connect the batteries.

Thermostat Replacement

1. Disconnect the batteries.
2. Remove the four screws (**Fig. 1**, Ref. 1) attaching the control panel to the sleeper compartment wall, and pull the panel away from the wall.
3. Remove the knob from the thermostat control shaft by loosening the setscrew that holds the knob on the shaft and pulling the knob off.



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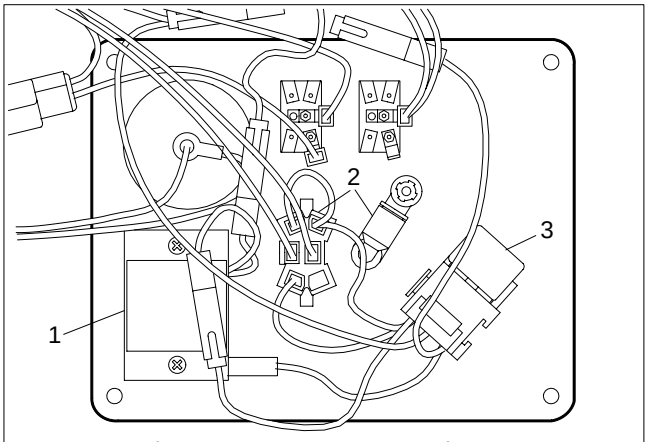
1. Control Panel Screw
2. Water Temperature Switch
3. Mode Switch
4. Temperature Control Knob
5. Temperature Sensor

Fig. 1, Control Panel for Electronic Thermostat Control System



1. Thermostat
2. Toggle Switches
3. Relay

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Fig. 2, Control Panel Parts for Electronic Thermostat Control System

4. Mark the wires for later reference, and disconnect them from the thermostat. See **Fig. 2**, Ref. 1.
5. Remove the thermostat from the control panel by unscrewing the jam nut on the outside of the panel and removing the thermostat from the panel.

6. Install the new thermostat on the control panel. Tighten the jam nut firmly.
7. Connect the wires to the thermostat as marked. See **Fig. 3** for the wiring diagram.
8. Install the knob on the thermostat control shaft. Tighten the setscrew firmly.
9. Install the control panel on the sleeper compartment wall. Tighten the four screws firmly.
10. Connect the batteries.

Relay Replacement

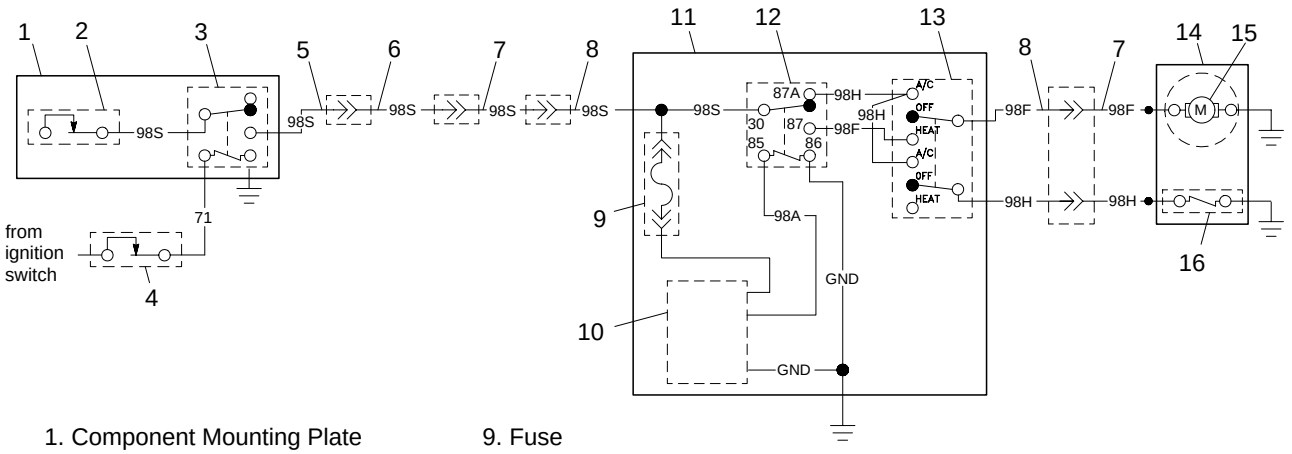
1. Disconnect the batteries.
2. Remove the four screws attaching the control panel to the sleeper compartment wall, and pull the panel away from the wall.
3. Remove the relay (**Fig. 2**, Ref. 3, or **Fig. 4**, Ref. 10) from the control panel and install a new relay in its place.
4. Install the control panel on the sleeper compartment wall. Tighten the four screws firmly.
5. Connect the batteries.

C.T.C. Knob and Resistor Replacement

1. Disconnect the batteries.
2. Remove the four screws (**Fig. 4**, Ref. 11) attaching the control panel to the sleeper compartment wall, and pull the panel away from the wall.
3. Mark the green and white wires connected to the C.T.C. variable resistor (Refs. 7 and 8) for later reference. Unplug the green and white wires from the wiring harness.
4. Using an Allen wrench, remove the setscrew and temperature control knob (Ref. 12). Remove the nut, and pull the resistor assembly (Ref. 8) out of the back of the panel.
5. Install the new resistor assembly and replace the nut. Replace the temperature control knob, and insert and tighten the setscrew.
6. Plug in the previously marked green and white wires to the wiring harness.
7. Install the control panel on the wall. Tighten the four screws firmly.
8. Connect the batteries.

Fan Control Switch Replacement

1. Disconnect the batteries.
2. Remove the four screws (**Fig. 4**, Ref. 11) attaching the control panel to the sleeper compartment wall, and pull the panel away from the wall.
3. Mark the four wires connected to the fan control switch (Ref. 6) and note where each one goes. Unplug the connectors from the switch.
4. Using an Allen wrench, remove the setscrew and fan control knob (Ref. 13). Remove the nut, and pull the switch (Ref. 6) out of the back of the panel.
5. Install the new fan control switch and replace the nut. Replace the knob, and insert and tighten the setscrew.
6. Plug in the wiring connectors to the switch, making sure the wires are connected in the proper pattern.
7. Install the control panel on the wall. Tighten the four screws firmly.
8. Connect the batteries.



1. Component Mounting Plate
2. Circuit Breaker, 20A
3. Sleeper Heater−A/C Relay
4. Circuit Breaker, 10A
5. Main Cab Wiring Harness
6. Floor Harness
7. Sleeper Harness
8. Control Panel Harness
9. Fuse
10. Electronic Thermostat
11. Sleeper Control Panel
12. Mode Switch Relay
13. Mode (Heat−Off−A/C) Switch
14. Heater and Air Conditioner Unit
15. Blower Motor (Fan)
16. Refrigerant Solenoid Valve

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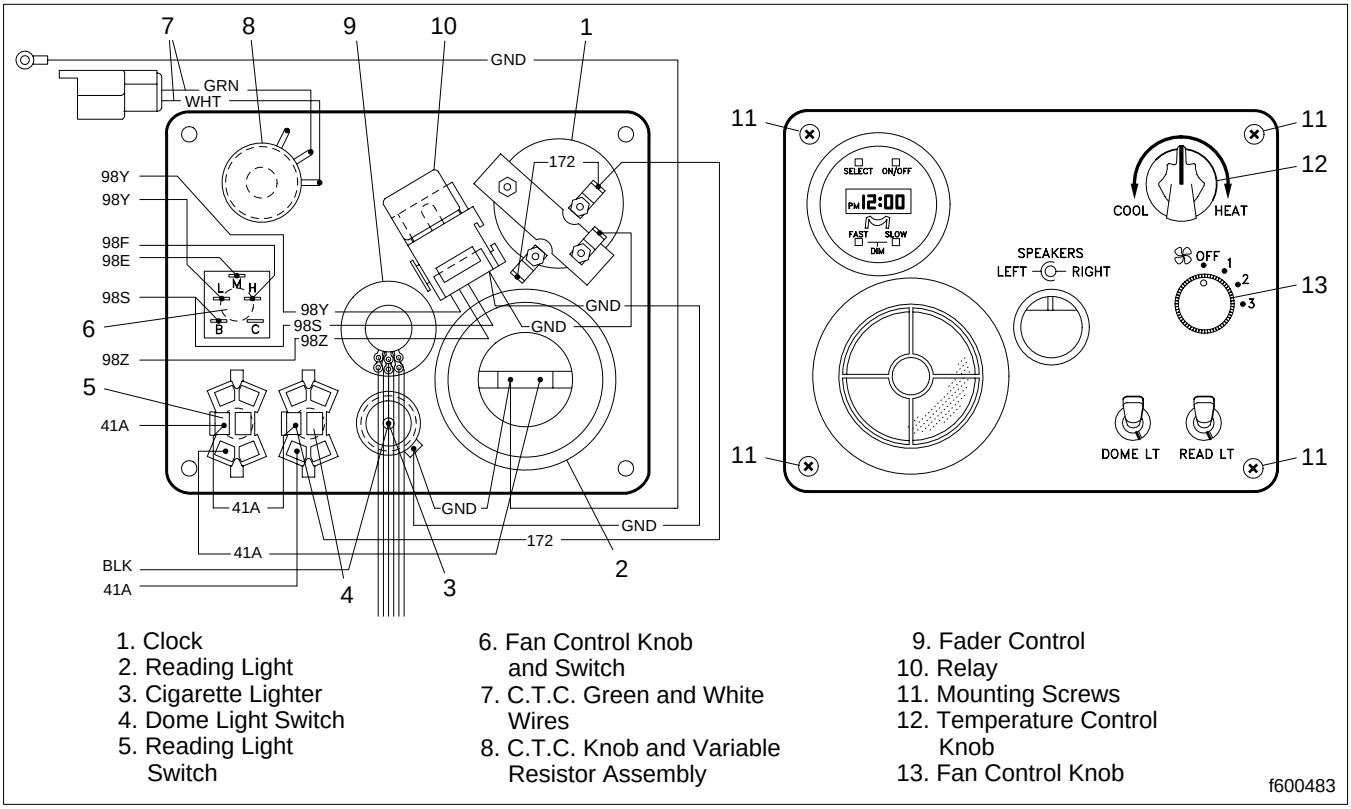
Fig. 3, Sleeper Heater and Air Conditioner Wiring Diagram, Electronic Thermostat System

Control Panel Component Replacement



1. Clock
2. Reading Light
3. Cigarette Lighter
4. Dome Light Switch
5. Reading Light Switch
6. Fan Control Knob and Switch
7. C.T.C. Green and White Wires
8. C.T.C. Knob and Variable Resistor Assembly
9. Fader Control
10. Relay
11. Mounting Screws
12. Temperature Control Knob
13. Fan Control Knob

Fig. 4, C.T.C. Control Panel and Parts

Removal

1. Review the information under **Safety Precautions, 100**.

⚠ WARNING

Failure to review the safety precautions, and to be aware of the danger involved when working with refrigerant, could result in serious personal injury.

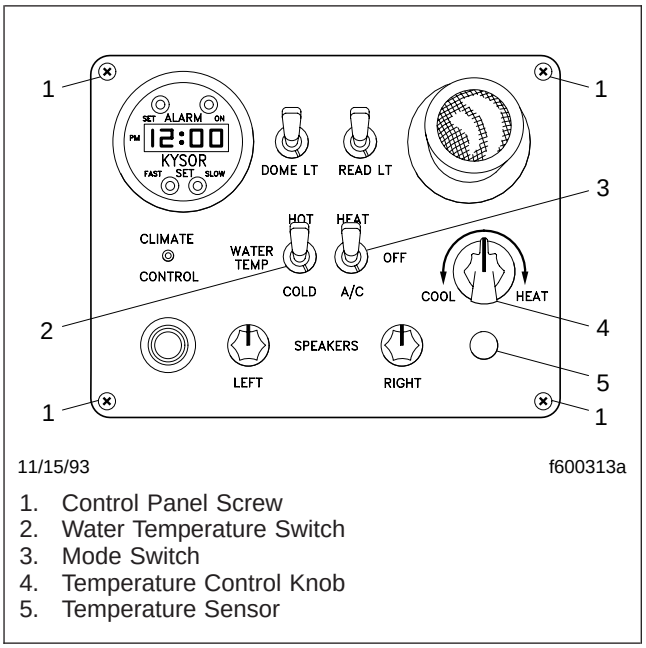
2. Depending on the type of temperature control, open the water shutoff valve.

   If equipped with a toggle switch control, set the heater water-temperature toggle switch to HOT (**Fig. 1**). When in this position, there is no air pressure to the water shutoff valve.

   If equipped with a cable control, pull the temperature control cable up (**Fig. 2**).

   If equipped with C.T.C., turn the temperature control knob clockwise to HEAT (**Fig. 3**).

3. Disconnect the batteries.



1. Control Panel Screw
2. Water Temperature Switch
3. Mode Switch
4. Temperature Control Knob
5. Temperature Sensor

Fig. 1, Control Panel for Electronic Thermostat Control System

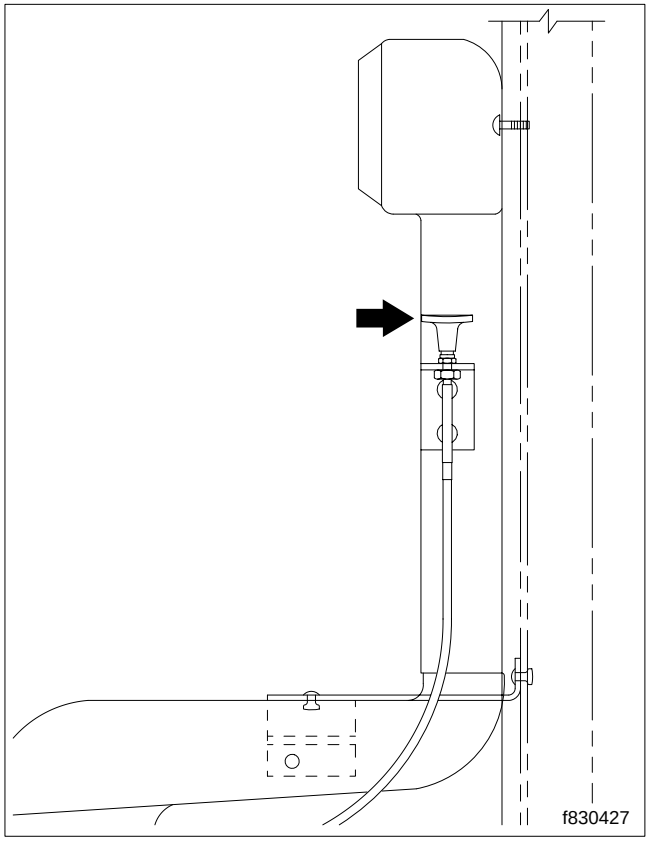


Fig. 2, Manual Temperature Control Cable Handle

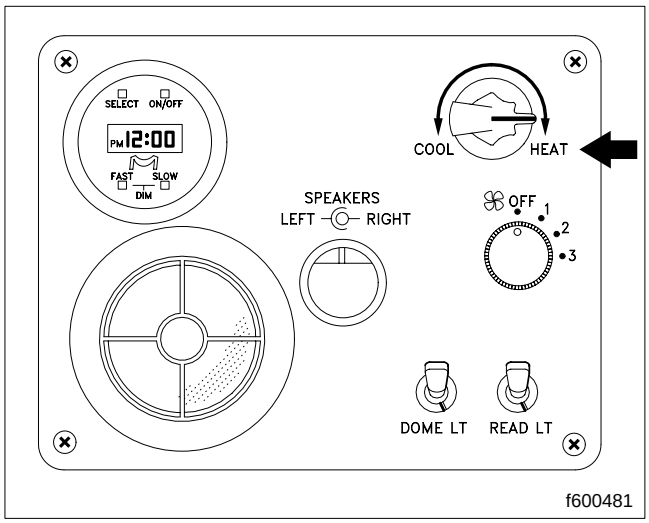


Fig. 3, Temperature Control Knob for C.T.C. System

Heater and Air Conditioner Removal and Installation

WARNING

Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

4. Drain the air system.
5. Wearing protective goggles and gloves, discharge the refrigerant from the system. For instructions, refer to the cab air conditioner section in this group.
6. Access the sleeper heater and air conditioner unit.

   On Conventionals with sleeper boxes, either remove the sleeper box mattress and bunk panel or, open the right-side baggage compartment door.

   On SleeperCabs, raise the mattress and bunk panel to their locked position.

   On COEs, open the right-or left-side baggage compartment door.

WARNING

Drain the heater core only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

7. For proper draining procedures, refer to the cab heater and air conditioner section in this group. Drain the cooling system by opening the radiator drain.
8. Under the sleeper, remove the standoff bracket (if equipped) separating the two heater hoses. Mark the heater hoses for later reference and drain the heater core by disconnecting the heater hoses from the heater core elbows (**Fig. 4**, Ref. 3).
9. Under the sleeper, mark the refrigerant lines for later reference. Using two wrenches to avoid twisting the lines, disconnect the refrigerant hoses at the air conditioner ports. See **Fig. 4**, Ref. 1. Place caps on the refrigerant hoses, and plug the air conditioner ports.

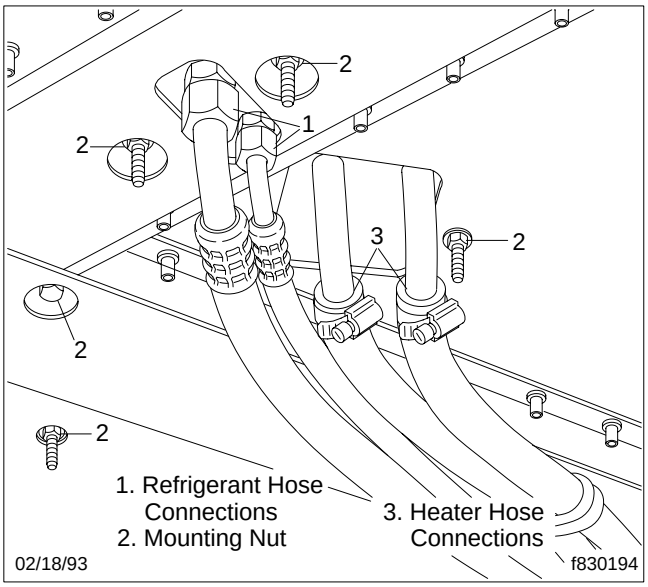


Fig. 4, Mounting Nuts and Hose Connections Under the Sleeper

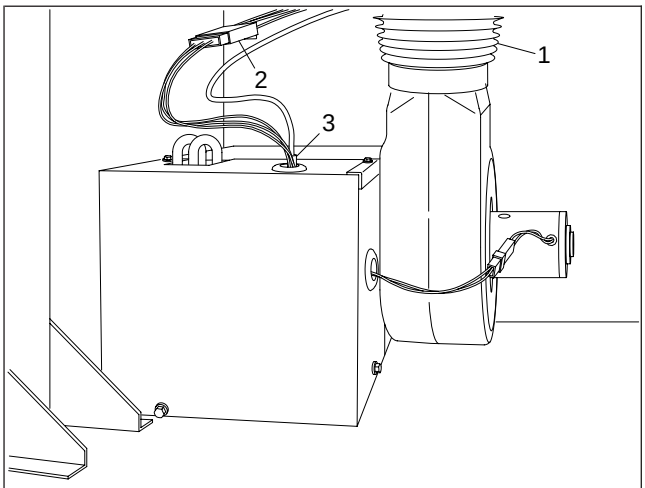
CAUTION

Water and dirt can damage the refrigerant system. Five minutes of not being capped is the limit for any hose or component. Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

10. From under the sleeper, remove the six locknuts and washers holding the heater and air conditioner unit in place. See **Fig. 4**, Ref. 2.
11. Inside the sleeper, disconnect the air duct (**Fig. 5**, Ref. 1) from the blower housing.
12. Disconnect the wires from the sleeper heater and air conditioner. See **Fig. 5**, Ref. 2.
13. Disconnect the water shutoff valve.

    If equipped with a mode switch control, disconnect the air tube that leads to the water valve from the top of the unit. See **Fig. 5**, Ref. 3. To disconnect the tube, push in the collar at the fitting and pull out the tube.

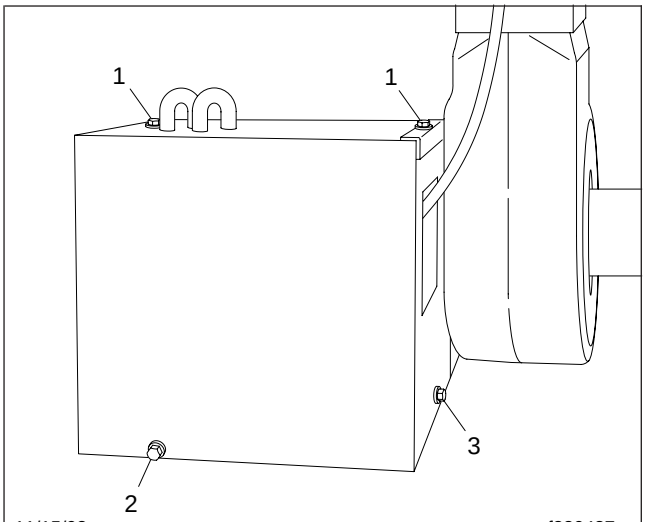
    If equipped with a cable control, remove the water shutoff valve cover (**Fig. 6**). Loosen the top and bottom capscrews and remove the side capscrew. Remove the cover. Loosen the cable clamp (**Fig. 7**, Ref. 7) and disconnect the cable from the water shutoff valve.



1. Air Duct
2. Wire Connector
3. Air-Tube to Water-Valve Connection

Fig. 5, Heater and Air Conditioner Installed in a Conventional 40-Inch Sleeper (Electronic ThermostatControl System)

If equipped with C.T.C., disconnect the air tube from the water supply solenoid by unscrewing the fitting (**Fig. 8**, Ref. 2).



1. Top Capscrew
2. Bottom Capscrew
3. Side Capscrew

Fig. 6, Water Shutoff Valve Cover

14. Lift the sleeper heater and air conditioner until it clears the sleeper deck, and then remove it. Be sure not to damage the water drain tube or heater core while lifting the unit out of the sleeper compartment.

Installation

1. Position the sleeper heater and air conditioner on the deck. Make sure the heater core elbows, refrigerant lines, water drain tube, and mounting studs protrude through the floor.
2. Connect the water shutoff valve.

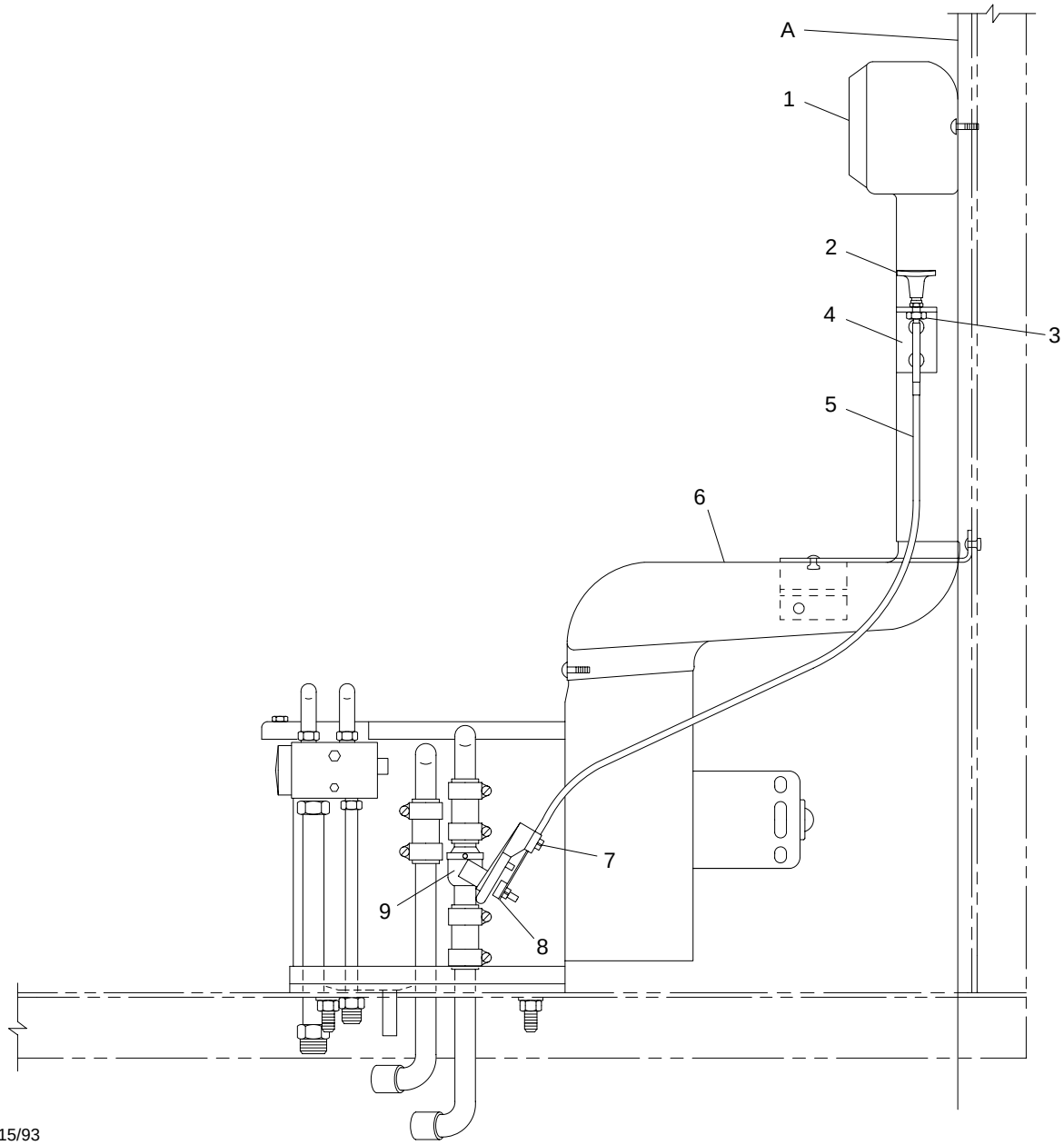
   If equipped a with mode switch control, connect the air tube to the water shutoff valve by pushing the tube into the fitting until it stops (**Fig. 5**, Ref. 3).

   If equipped with a cable control, position the cable end loop and clamp the cable to the water shutoff valve (**Fig. 7**, Refs. 7 and 8). Install the valve cover on the sleeper heater and air conditioner (**Fig. 6**). Tighten the capscrews 28 to 32 lbf·in (320 to 360 N·cm).

   If equipped with C.T.C., connect the air tube to the water supply solenoid by screwing on the fitting (**Fig. 8**, Ref. 2).
3. Connect the wires leading to the unit.
4. Connect the air duct to the blower housing.
5. Underneath the cab, install the six flatwashers and locknuts on the mounting studs. Tighten the nuts 13 lbf·ft (18 N·m).
6. Remove the plugs from the air conditioner ports and the caps from the refrigerant lines. Install new O-rings. Apply refrigerant oil to the O-rings. See **Fig. 9**. Apply refrigerant oil to the male portion of the fitting threads. Attach the refrigerant lines to the air conditioner fittings as previously marked.

   Using two wrenches to avoid twisting the lines, tighten the #6 inlet fitting 11 lbf·ft (15 N·m). Tighten the #10 outlet fitting 21 lbf·ft (28 N·m).
7. Install the standoff bracket (if equipped) that separates the two heater hoses. Attach the heater hoses to the heater core elbows as marked. Tighten the clamps 30 to 35 lbf·in (340 to 400 N·cm).

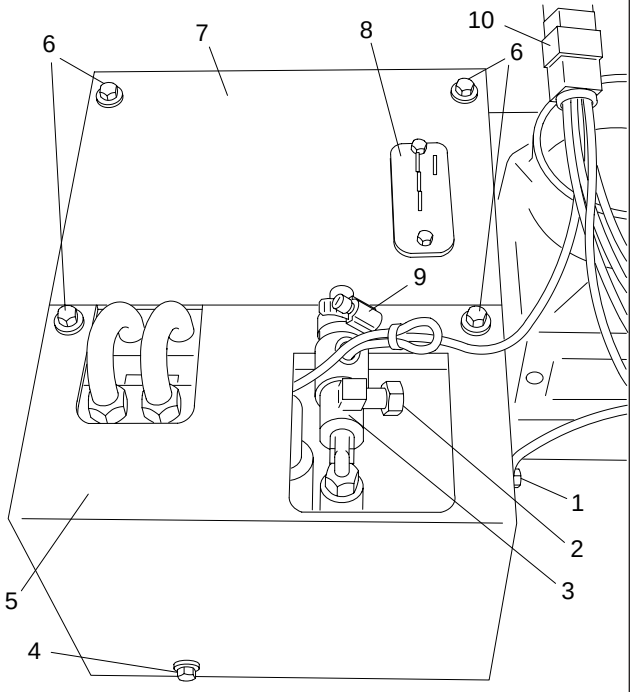
Heater and Air Conditioner Removal and Installation



A. Upholstery Reference

1. Louver Assembly
2. Cable Handle
3. Cable Nut
4. Cable Bracket
5. Temperature Control Cable
6. Duct Assembly
7. Cable Clamp
8. Cable End Loop
9. Water Shutoff Valve

Fig. 7, Manual Temperature Control Cable



1. Side Capscrew
2. Solenoid Air Tube Fitting
3. Water Supply Solenoid
4. Bottom Capscrew
5. Water Shutoff Valve Cover
6. Top Capscrew
7. Heater Core Cover
8. Blower Resistor
9. Solenoid Clamp
10. Power Connector

Fig. 8

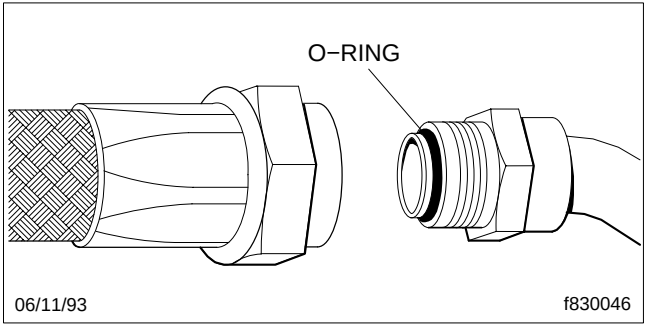


Fig. 9

8. Evacuate and charge the air conditioning system. For instructions, refer to the cab air conditioner section in this group.
9. Fill the cooling system with coolant. For coolant specifications, refer to the vehicle maintenance manual.

⚠ CAUTION

Coolant must be filled to the bottom of the radiator filler neck. Low coolant could cause engine overheating, which could damage the engine.

10. Start the engine, let it run for 20 to 30 seconds, and then shut it off. Install a pressure tester, test the cooling system at 10 psi (69 kPa), and then inspect for leaks. If leaks are found, tighten the hose clamps 30 to 35 lbf·in (340 to 400 N·cm) or replace the hoses as needed. Check the coolant level, and add coolant if needed.
11. Open the water shutoff valve.

    If equipped with a mode switch control, set the heater water-temperature toggle switch to HOT. When in this position, there is no air pressure to the water shutoff valve.

    If equipped with a cable control, pull the temperature control cable up.

    If equipped with C.T.C., turn the temperature control knob clockwise to HEAT.
12. Start the engine. When the radiator thermostat opens, air will be forced from the heater core as the coolant circulates. Check the coolant level again and add coolant if needed.
13. On Conventionals, reposition the sleeper mattress and wooden bunk panel.
14. Connect the batteries.

Replacement

1. Disconnect the batteries.
2. Access the sleeper heater and air conditioner unit.

   On Conventionals with sleeper boxes, either remove the sleeper box mattress and bunk panel or open the right-side baggage compartment door.

   On SleeperCabs, raise the mattress and bunk panel to their locked position.

   On COEs, open the right- or left-side baggage compartment door.
3. Disconnect the wires from the blower motor to the heater and air conditioner. See **Fig. 1**, Ref. 3.
4. Remove the four capscrews (**Fig. 1**, Ref. 4) that attach the blower motor to the blower housing. Remove the blower motor from the housing.
5. Using pliers or an Allen wrench, remove the retainer clip (**Fig. 2**) or setscrew that holds the blower wheel on the shaft. Pull the blower wheel off the shaft.

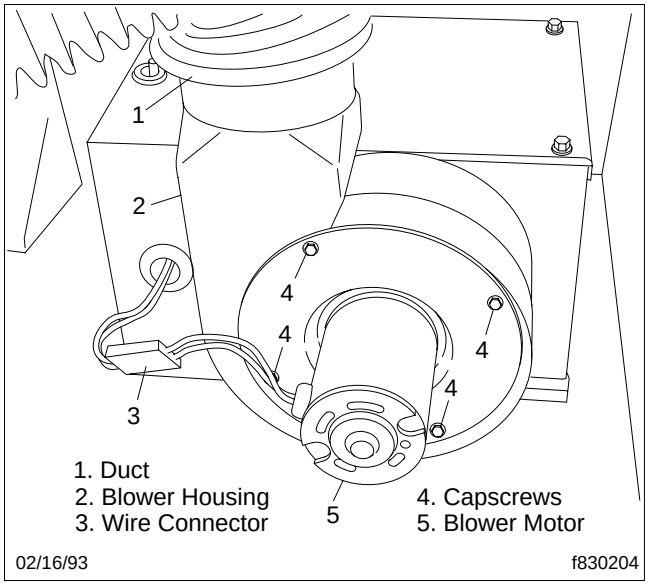


Fig. 1, Blower Assembly, Installed in a 40-Inch Conventional Sleeper

6. Remove the blower motor from the motor mount (**Fig. 3**, Ref. 1) by removing the two nuts and lockwashers.

   If replacing the blower housing, go to the next step; otherwise go to the step after the next.
7. Replace the blower housing (**Fig. 4**, Ref. 6).

   7.1 Disconnect the housing from the air duct (Ref. 1).

   7.2 On C.T.C. models, remove the two screws that attach the C.T.C. circuit board and ground wire (Refs. 4 and 7) to the blower housing.

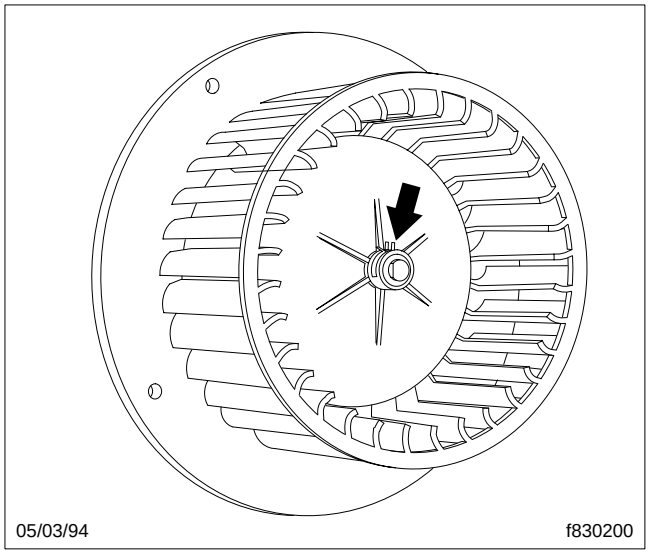


Fig. 2, Blower Wheel Retainer Clip

   7.3 Remove the four capscrews (Ref. 5) that attach the blower housing to the heater and air conditioner.

   7.4 Remove the housing and install a new housing.

   7.5 Attach the blower housing to the heater and air conditioner and tighten the capscrews firmly.

   7.6 On C.T.C. models, attach the circuit board to the new blower housing. Connect the ground wire to the top of the circuit board as you replace the two capscrews.

   7.7 Attach the air duct to the blower housing.
8. Position a new blower motor on the motor mount. Install the lockwashers and nuts. Tighten the nuts firmly.

Blower Motor and Housing Replacement

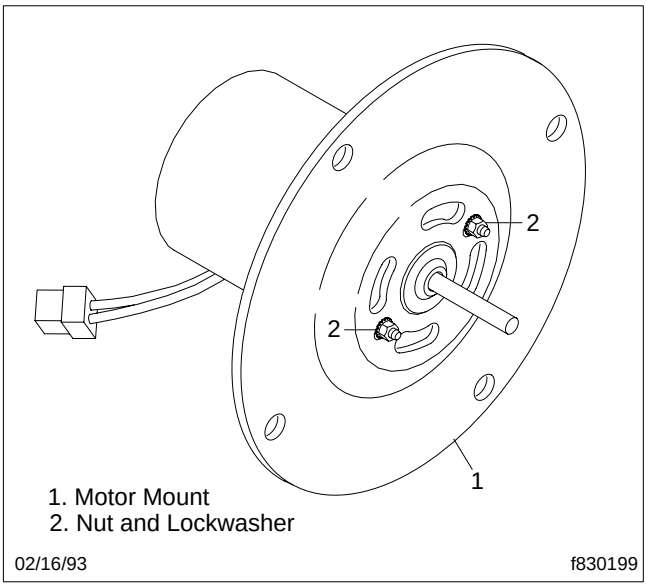


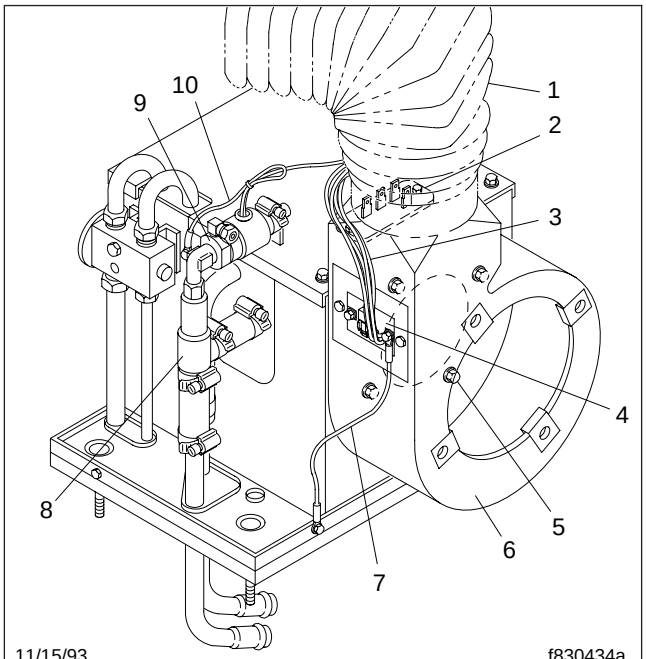
Fig. 3, Blower Motor Mount and Fasteners

9. Place the blower wheel on the blower motor shaft. Position the wheel so the edge of the wheel is 1/4 inch (6 mm) from the motor mount. See **Fig. 5.** Install the retainer clip or setscrew. Make sure the blower wheel is installed on the shaft so it won't touch the blower housing.

⚠ CAUTION

CAUTION: If the blower wheel doesn't spin freely at installation, blower motor drag will result and can lead to permanent damage to the motor.

10. Install the blower motor assembly on the blower housing. Tighten the capscrews 28 to 32 lbf·in (320 to 360 N·cm).
11. Connect the wires to the blower motor.
12. On Conventionals, reposition the sleeper mattress and wooden bunk panel.
13. Connect the batteries.



1. Duct
2. Blower Resistor
3. C.T.C. Wiring Harness
4. C.T.C. Circuit Board
5. Capscrew
6. Blower Housing
7. C.T.C. Ground Wire
8. Water Shutoff Valve
9. Water Supply Solenoid Valve
10. Solenoid Ground Wire

Fig. 4, Sleeper Heater and Air Conditioner With C.T.C.

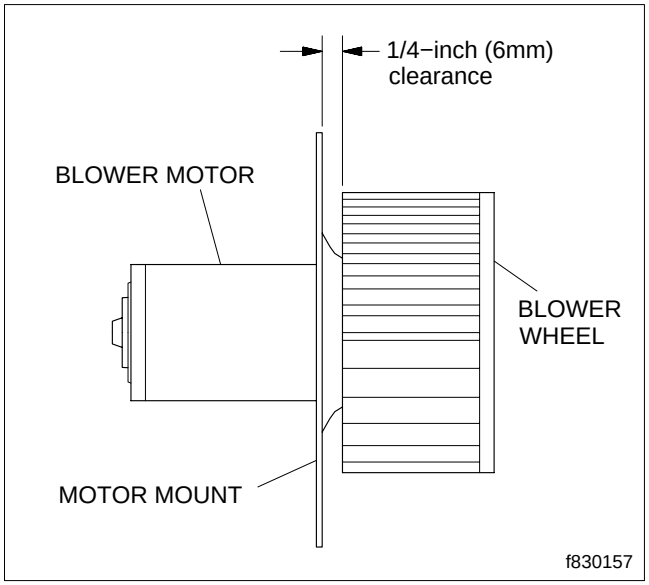

1/4−inch (6mm)
clearance
BLOWER MOTOR
BLOWER
WHEEL
MOTOR MOUNT
f830157

Fig. 5

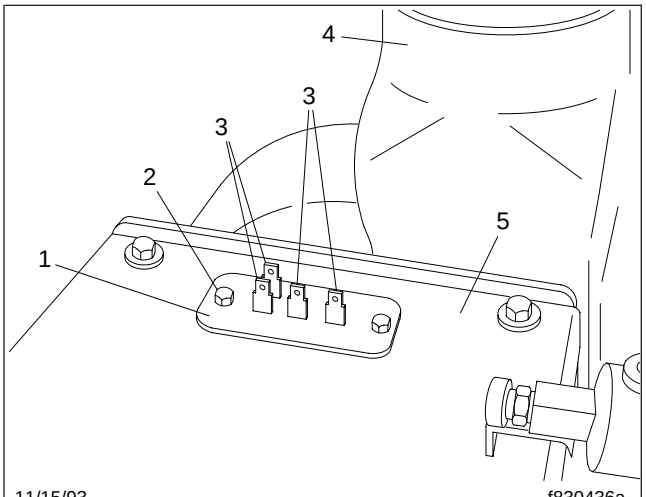
Replacement

1. Turn off the ignition switch and apply the parking brakes.
2. Access the sleeper heater and air conditioner unit.

   On Conventionals with sleeper boxes, either remove the sleeper box mattress and bunk panel or open the right-side baggage compartment door.

   On SleeperCabs, raise the mattress and bunk panel to their locked position.

   On COEs, open the right-or left-side baggage compartment door.
3. Disconnect the wiring connector(s) from the resistor terminals (**Fig. 1**, Ref. 3).
4. Remove the two capscrews (Ref. 2).
5. Remove and replace the blower resistor (Ref. 1).
6. Replace the capscrews.
7. Connect the wiring connector(s) to the resistor terminals.
8. On Conventionals, reposition the wooden bunk panel and the sleeper mattress.



1. Blower Resistor
2. Capscrew
3. Terminals
4. Blower Housing
5. Heater Core Cover

Fig. 1, Blower Resistor

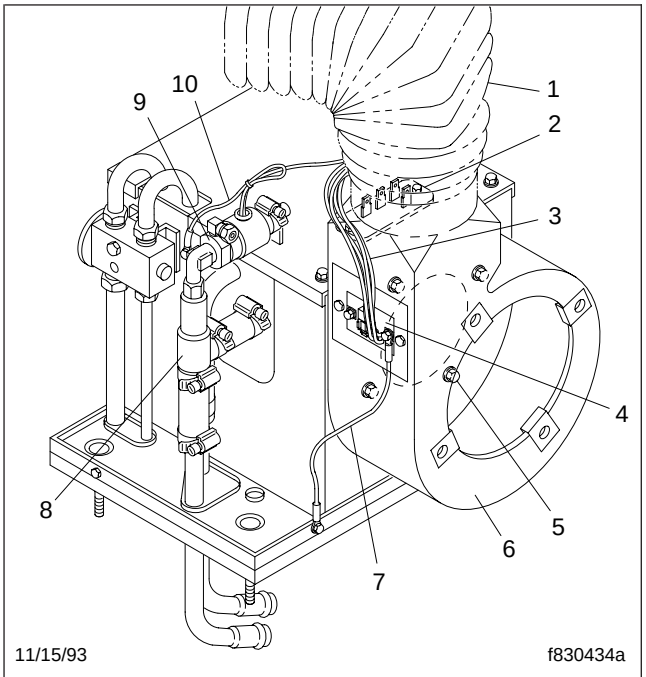
Replacement

1. Turn off the ignition switch, apply the parking brakes, and disconnect the batteries.
2. Access the sleeper heater and air conditioner unit.

   On Conventionals with sleeper boxes, either remove the sleeper box mattress and bunk panel or open the right-side baggage compartment door.

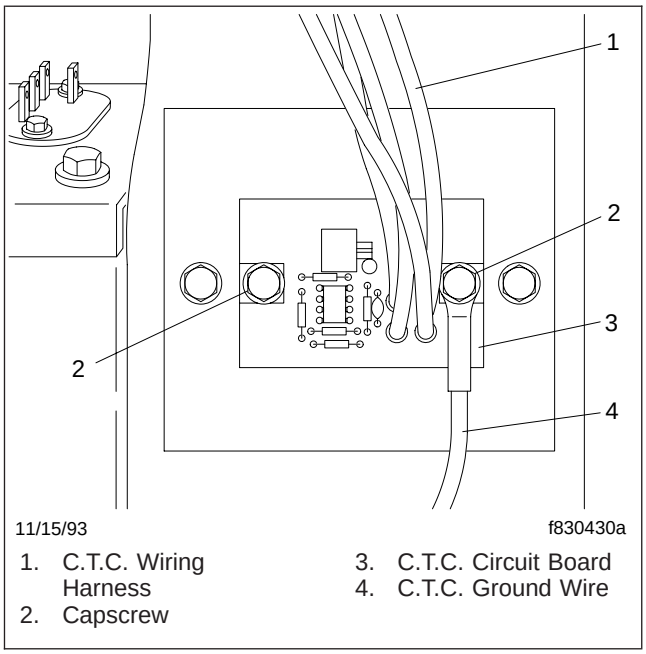
   On SleeperCabs, raise the mattress and bunk panel to their locked position.

   On COEs, open the right-or left-side baggage compartment door.
3. Disconnect the C.T.C. wiring harness (**Fig. 1**, Ref. 3 and **Fig. 2**, Ref. 1).



1. Duct
2. Blower Resistor
3. C.T.C. Wiring Harness
4. C.T.C. Circuit Board
5. Capscrew
6. Blower Housing
7. C.T.C. Ground Wire
8. Water Shutoff Valve
9. Water Supply Solenoid Valve
10. Solenoid Ground Wire

Fig. 1, Sleeper Heater and Air Conditioner With C.T.C.



1. C.T.C. Wiring Harness
2. Capscrew
3. C.T.C. Circuit Board
4. C.T.C. Ground Wire

Fig. 2, C.T.C. Circuit Board

4. Remove the two capscrews (**Fig. 2**, Ref. 2) holding the C.T.C. circuit board (Ref. 3) and the ground wire (Ref. 4) to the blower housing.
5. Replace the C.T.C. circuit board. Connect the ground wire to the top of the circuit board as you replace the two capscrews.
6. Connect the C.T.C. wiring harness.
7. On Conventionals, reposition the wooden bunk panel and the sleeper mattress.
8. Connect the batteries.

Replacement

1. Apply the parking brakes.

⚠ WARNING

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

2. For C.T.C. models, drain the air system.
3. Access the sleeper heater/air-conditioner unit.

   On Conventionals with sleeper boxes, either remove the sleeper box mattress and bunk panel or open the right-side baggage compartment door.

   On SleeperCabs, raise the mattress and bunk panel to their locked position.

   On COEs, open the right-or left-side baggage compartment door.
4. Depending on the type of temperature control, open the water shutoff valve.

   If equipped with a mode switch control, set the heater water-temperature toggle switch to HOT (**Fig. 1**). When in this position, there is no air pressure to the water shutoff valve.

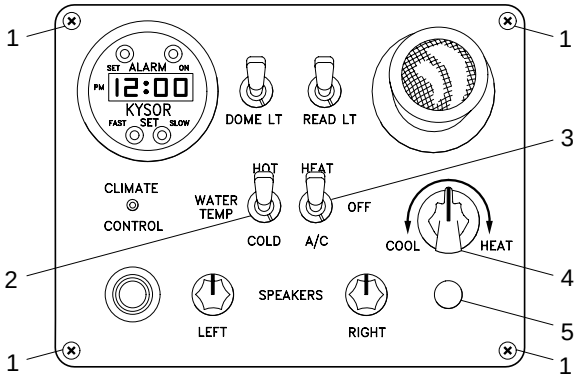
   If equipped with a cable control, pull the temperature control cable up (**Fig. 2**).

   If equipped with C.T.C., turn the temperature control knob clockwise to HEAT (**Fig. 3**).

⚠ WARNING

WARNING: Drain the heater core only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

5. For proper draining procedures, refer to the cab heater and air conditioner section in this group. Drain the cooling system by opening the radiator drain.
6. Remove the water shutoff valve cover (if equipped).



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1. Control Panel Screw
2. Water Temperature Switch
3. Mode Switch
4. Temperature Control Knob
5. Temperature Sensor

Fig. 1, Control Panel for Electronic Thermostat Control System

   If equipped with toggle switch control, disconnect the electrical wires (**Fig. 4**, Ref. 1) leading away from the sleeper heater and air conditioner.

   Disconnect the air tube from the water shutoff valve by pressing down on the collar at the fitting (Ref. 2), and pulling out the air tube.

   Remove the two capscrews (**Fig. 5**, Ref. 5) at the base of the valve cover (Ref. 4). Loosen the two capscrews (Refs. 1 and 3) that hold the top of the cover in place. Slide the cover off the unit.

   If equipped with cable control or C.T.C., loosen the top and bottom capscrews (**Fig. 6**, Refs. 4 and 6) and remove the side capscrew (Ref. 1). Remove the valve cover.
7. Disconnect the temperature control cable or water supply solenoid.

   If equipped with a cable control, loosen the clamp and disconnect the cable (**Fig. 7**, Refs. 7 and 8) from the water shutoff valve.

   If equipped with C.T.C., remove the solenoid clamp (**Fig. 8**, Ref. 8) holding the water supply solenoid to the heater core cover.
8. Remove the water shutoff valve by loosening the hose clamps and disconnecting the coolant hoses. See **Fig. 9 .**

Water Shutoff Valve Replacement

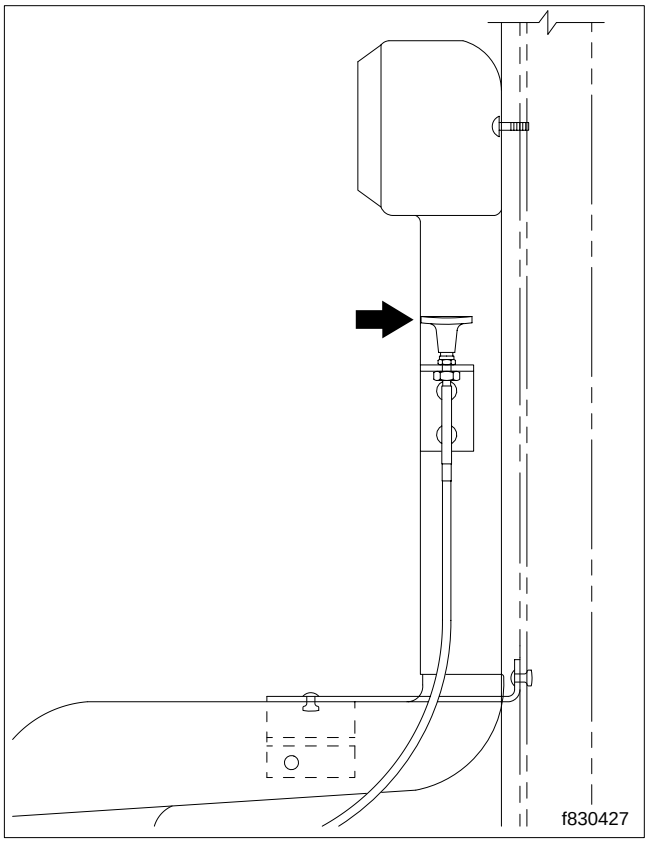


Fig. 2, Manual Temperature Control Cable Handle

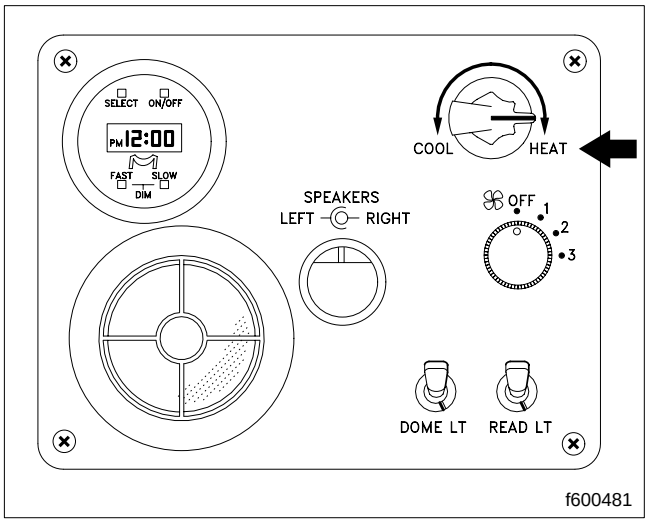
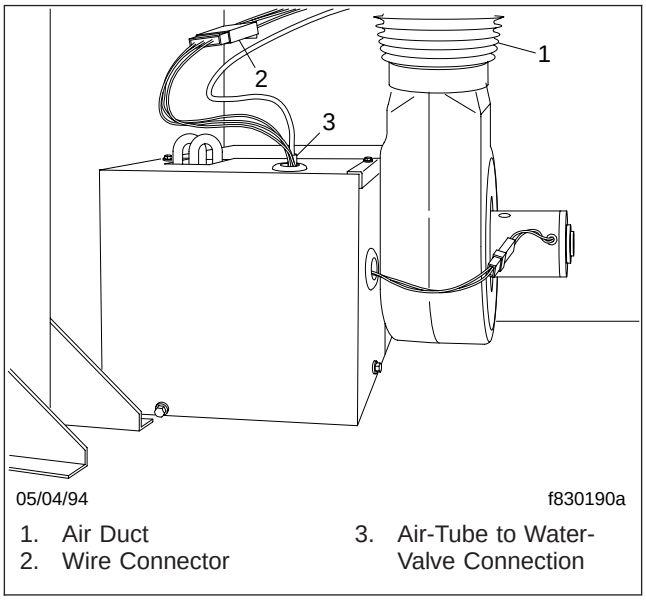


Fig. 3, Temperature Control Knob for C.T.C. System

On C.T.C. models, disconnect the solenoid air line, the solenoid ground wire and hot wire at the



1. Air Duct
2. Wire Connector
3. Air-Tube to Water-Valve Connection

Fig. 4, Heater and Air Conditioner Installed in a Conventional 40-Inch Sleeper

connector, loosen the hose clamps and disconnect the coolant hoses, and then unscrew the water shutoff valve (**Fig. 8**, Ref. 4) from the water supply solenoid.

9. On C.T.C. models, apply liquid Teflon® sealant between the solenoid fitting and the water shutoff valve (**Fig. 10**). Screw the new water shutoff valve into the water supply solenoid before connecting the hoses and tightening the clamps.

   Install the new water shutoff valve. Connect the coolant hoses and tighten the hose clamps 30 to 35 lbf·in (340 to 400 N·cm).

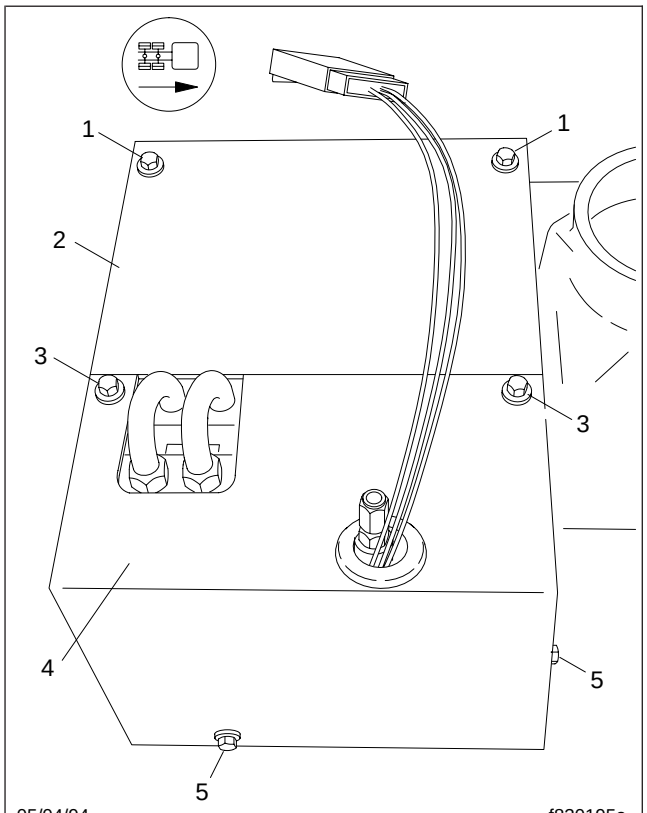
10. Connect the air tube, temperature control cable or water supply solenoid.

    If equipped with a toggle switch control, push the air tube into the fitting until it bottoms.

    If equipped with a cable control, connect the cable to the water shutoff valve and tighten the clamp.

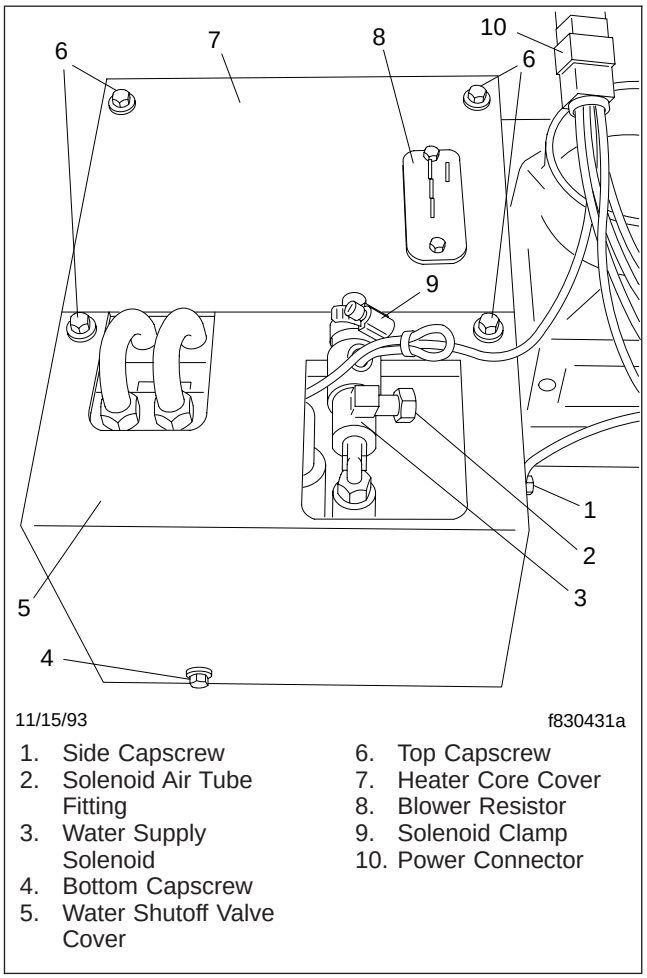
    If equipped with C.T.C, fasten the solenoid clamp, connect the ground and hot wires to the power connector, and connect the solenoid air line.

11. Close the drain on the radiator, and fill the cooling system with coolant to the level of the bottom



1. Top Capscrew, Left Side
2. Heater Core Cover
3. Top Capscrew, Right Side
4. Valve Cover
5. Bottom Capscrew

Fig. 5



1. Side Capscrew
2. Solenoid Air Tube Fitting
3. Water Supply Solenoid
4. Bottom Capscrew
5. Water Shutoff Valve Cover
6. Top Capscrew
7. Heater Core Cover
8. Blower Resistor
9. Solenoid Clamp
10. Power Connector

Fig. 6

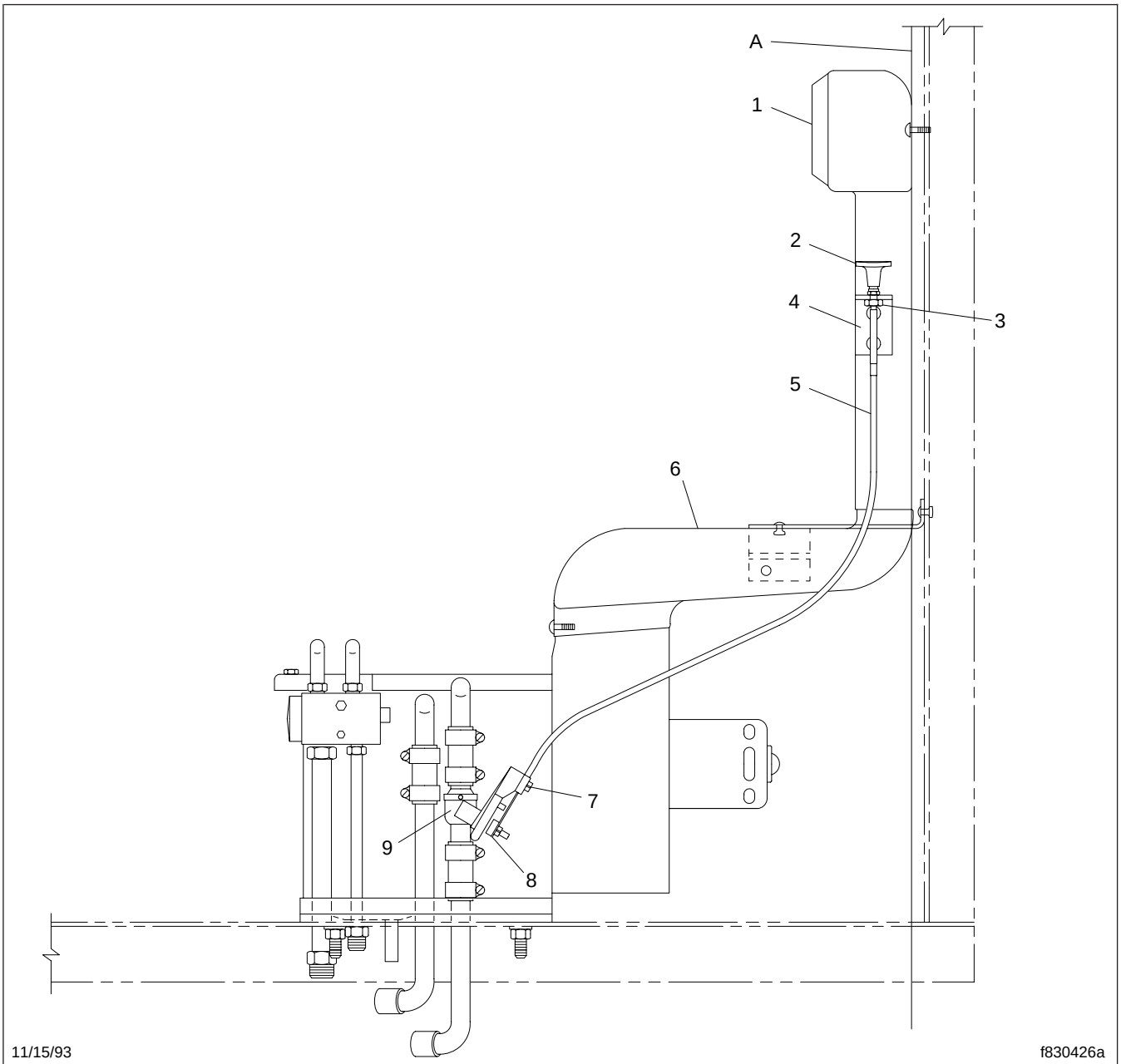
of the radiator filler neck. Don't install the radiator cap. For coolant specifications, refer to the vehicle maintenance manual.

⚠ CAUTION

CAUTION: Coolant must be filled to the bottom of the radiator filler neck. Low coolant could cause engine overheating, which could damage the engine.

12. Start the engine, and check the hose connections at the valve for coolant leaks. Turn off the engine. If leaks are found, tighten the hose connections or replace the hoses as needed. Check the coolant level, and add coolant as needed.
13. Install the valve cover on the sleeper heater/air-conditioner. Tighten the capscrews 28 to 32 lbf·in (320 to 360 N·cm). For C.T.C. models, remember to connect the C.T.C. ground wire to the side of the valve cover (**Fig. 6**, Ref. 1).
14. If necessary, connect the electrical wires to the sleeper heater and air conditioner.
15. On Conventionals, reposition the wooden bunk panel and the sleeper mattress.

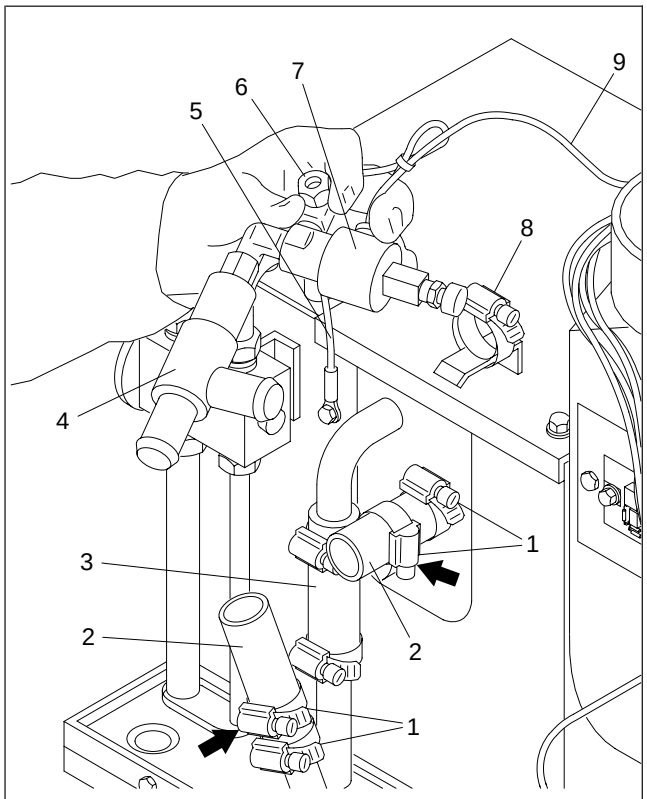
Water Shutoff Valve Replacement



A. Upholstery Reference

1. Louver Assembly
2. Cable Handle
3. Cable Nut
4. Cable Bracket
5. Temperature Control Cable
6. Duct Assembly
7. Cable Clamp
8. Cable End Loop
9. Water Shutoff Valve

Fig. 7, Manual Temperature Control Cable



1. Clamps
2. Inlet Hose
3. Outlet Hose
4. Water Shutoff Valve
5. Solenoid Ground Wire
6. Solenoid Air Tube Fitting
7. Water Supply Solenoid
8. Solenoid Clamp
9. Solenoid Wiring and Connector

Fig. 8, C.T.C. Water Shutoff Valve and Solenoid

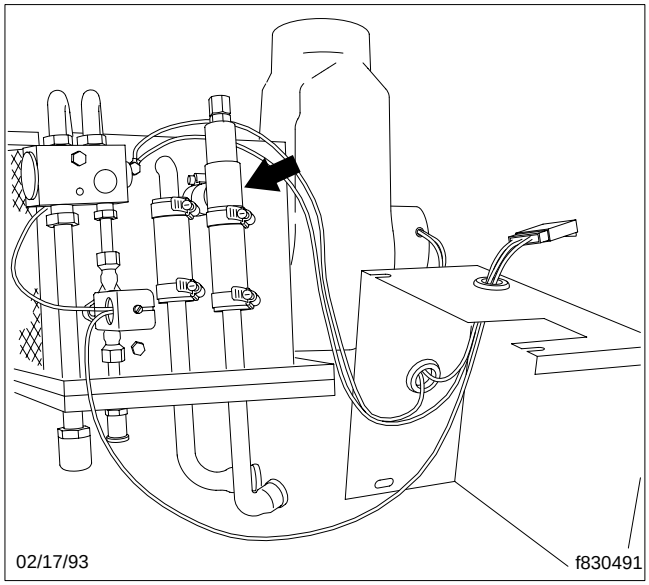


Fig. 9, Water Shutoff Valve

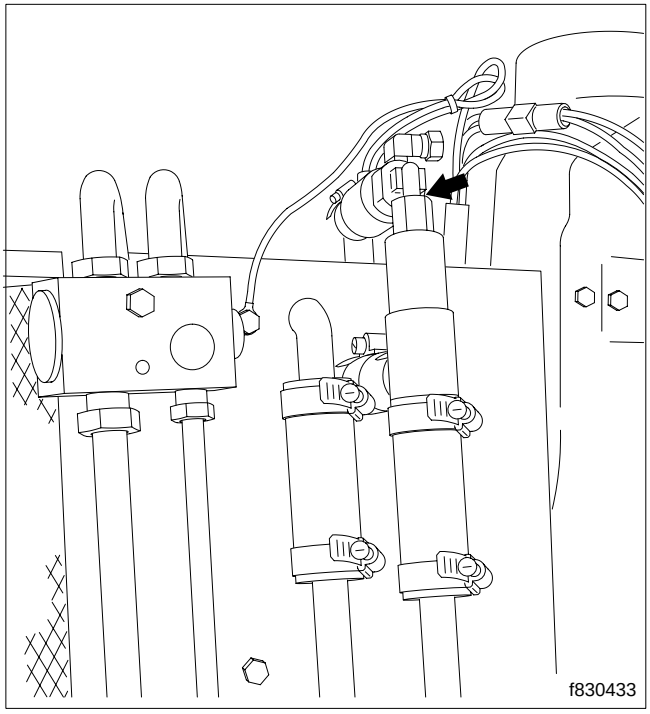


Fig. 10, Assembled C.T.C. Water Shutoff Valve and Solenoid

C.T.C. Water Supply Solenoid Valve Replacement

Replacement

1. Apply the parking brakes.

⚠ WARNING

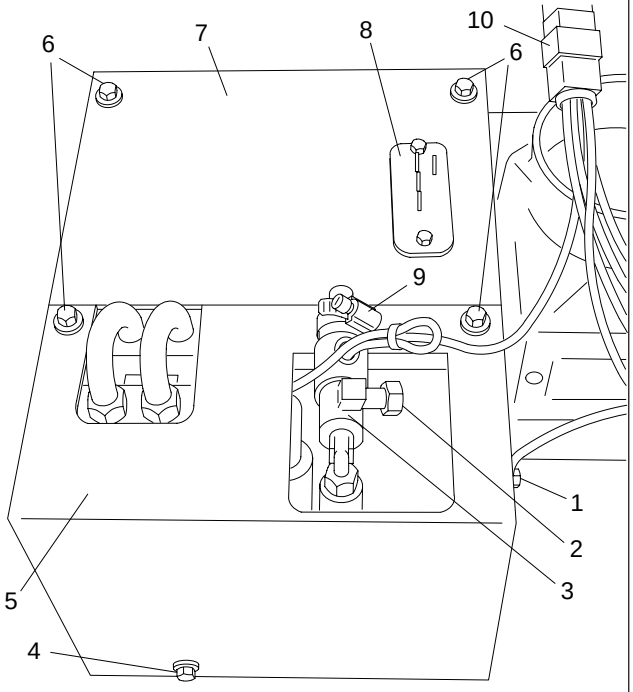
WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

2. Drain the air system.
3. Access the sleeper heater/air-conditioner unit.

   On Conventionals with sleeper boxes, either remove the sleeper box mattress and bunk panel or open the right-side baggage compartment door.

   On SleeperCabs, raise the mattress and bunk panel to their locked position.

   On COEs, open the right-or left-side baggage compartment door.
4. Remove the water shutoff valve cover (**Fig. 1**, Ref. 5). Loosen the top and bottom capscrews (Refs. 4 and 6) and remove the side capscrew (Ref. 1) that holds the C.T.C. ground wire to the valve cover. Remove the valve cover.
5. Disconnect the solenoid air line by unscrewing the fitting (Ref. 2).
6. Unplug the solenoid power connector (Ref. 10). Disconnect the solenoid ground wire (**Fig. 2**, Ref. 5).
7. Remove the solenoid clamp (**Fig. 3**, Ref. 8).
8. Hold the water shutoff valve (Ref. 3) with a wrench and unscrew the water supply solenoid (Ref. 6).
9. Transfer the two solenoid fittings (Refs. 5 and 7) to the new solenoid. Apply liquid Teflon® sealant between the fitting (Ref. 5) and the water shutoff valve, and between the solenoid and both solenoid fittings (Refs. 5 and 7). Install the new solenoid.
10. Clamp the solenoid to the sleeper heater/ air-conditioner housing.

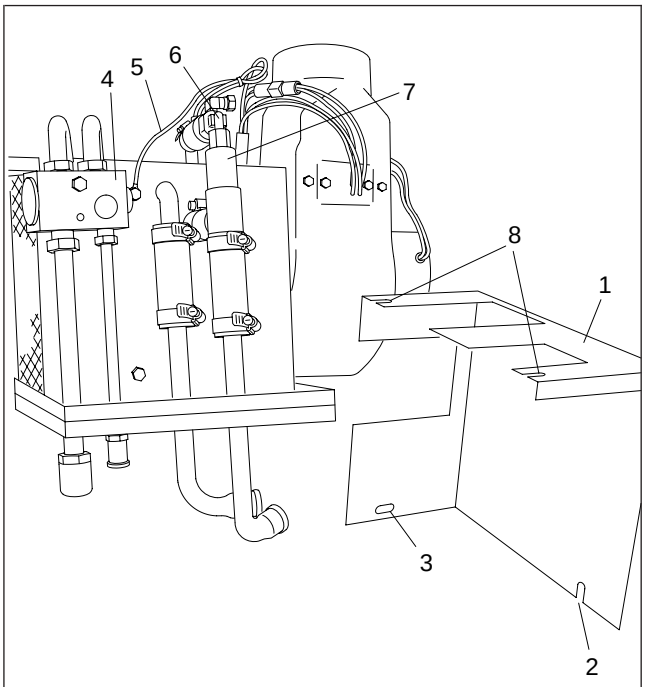


1. Side Capscrew
2. Solenoid Air Tube Fitting
3. Water Supply Solenoid
4. Bottom Capscrew
5. Water Shutoff Valve Cover
6. Top Capscrew
7. Heater Core Cover
8. Blower Resistor
9. Solenoid Clamp
10. Power Connector

Fig. 1

11. Connect the solenoid ground wire to the sleeper heater and air conditioner housing. Plug in the power connector.
12. Connect the solenoid air line to the new solenoid.
13. Put on the water shutoff valve cover and remember to connect the C.T.C. ground wire as you install the side capscrew (**Fig. 1**, Ref. 1).
14. On Conventionals, reposition the wooden bunk panel and the sleeper mattress.

C.T.C. Water Supply Solenoid Valve Replacement



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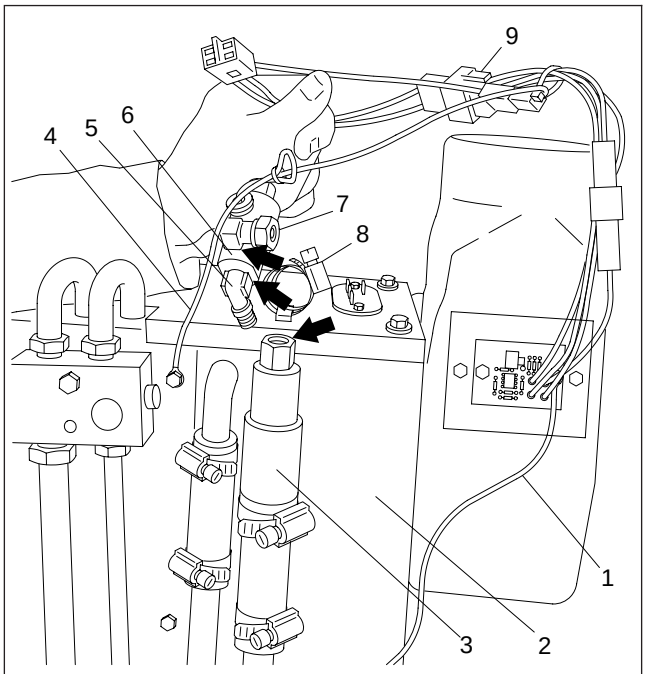
1. Water Shutoff Valve Cover
2. Bottom Slot
3. Side Slot
4. Expansion Valve
5. Solenoid Ground Wire
6. Water Supply Solenoid
7. Water Shutoff Valve
8. Top Slots

Fig. 2, C.T.C. Sleeper Heater/AC Without Valve Cover



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1. CTC Ground Wire
2. Sleeper Heater/AC Housing
3. Water Shutoff Valve
4. Solenoid Ground Wire
5. Solenoid Fitting
6. Water Supply Solenoid
7. Solenoid Air Tube Fitting
8. Solenoid Clamp
9. Power Connector

Fig. 3, C.T.C. Water Supply Solenoid

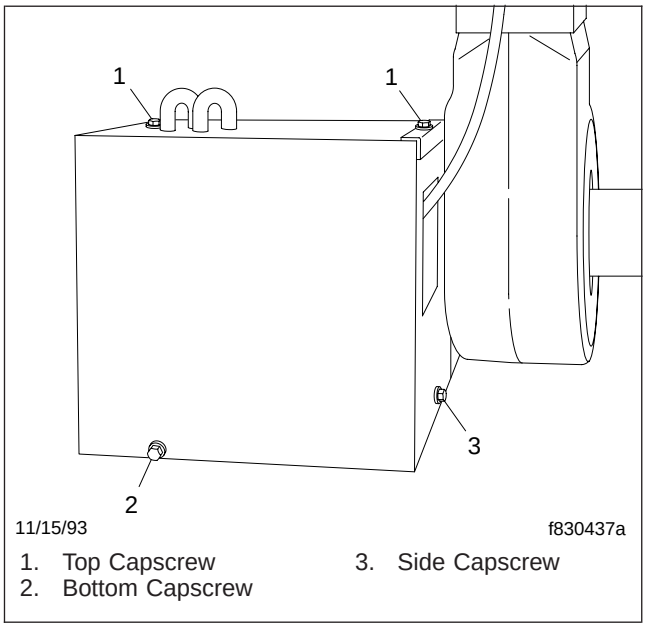
Replacement

1. Apply the parking brakes.
2. Access the sleeper heater/air-conditioner unit.

   On Conventionals with sleeper boxes, either remove the sleeper box mattress and bunk panel or open the right-side baggage compartment door.

   On SleeperCabs, raise the mattress and bunk panel to their locked position.

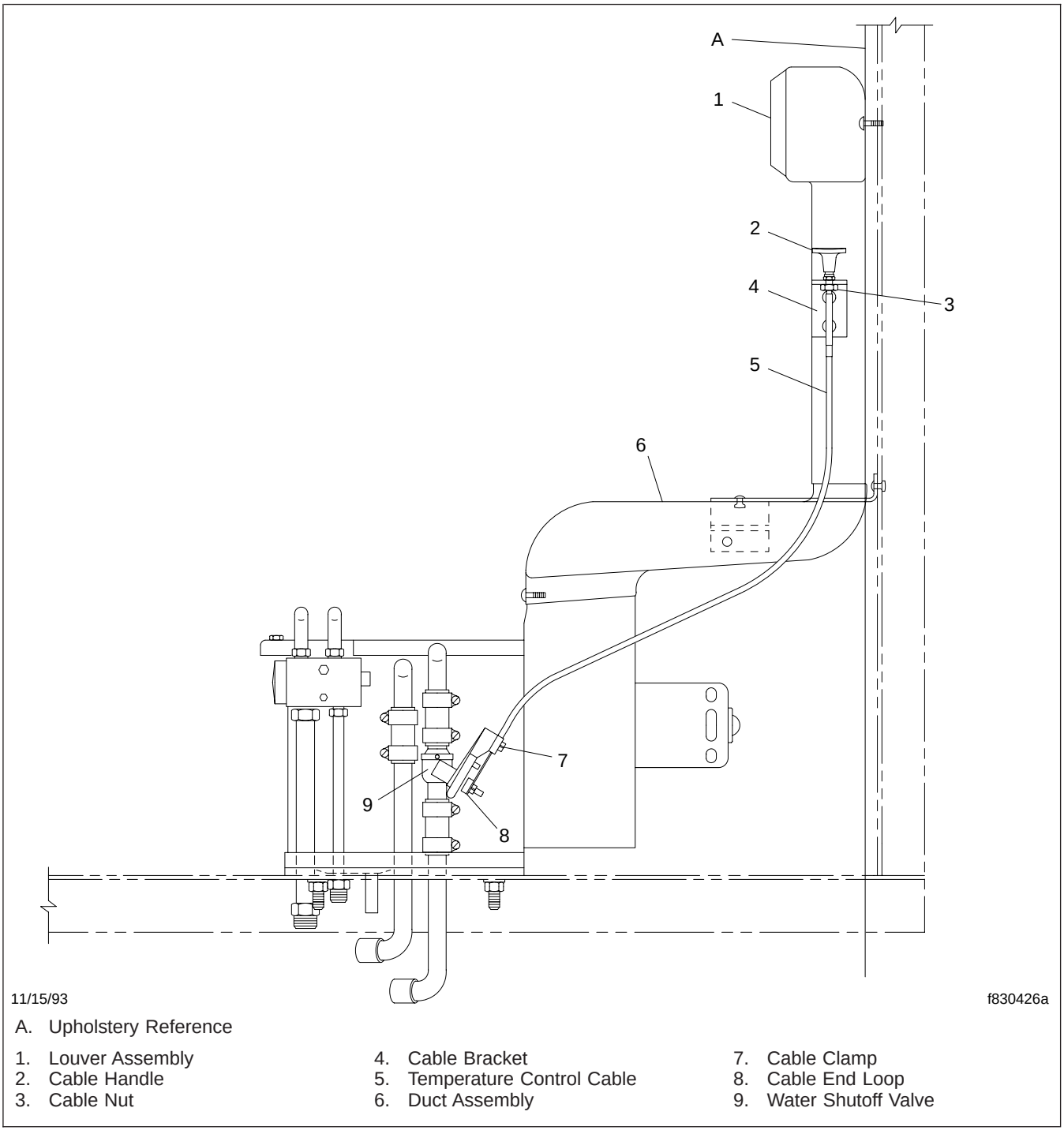
   On COEs, open the right-or left-side baggage compartment door.
3. Remove the water shutoff valve cover by loosening the top and bottom capscrews (**Fig. 1**, Refs. 1 and 2) and removing the side capscrew (Ref. 3).
4. Loosen the cable clamp and disconnect the cable assembly (**Fig. 2**, Refs. 7 and 8) from the water shutoff valve (Ref. 9).
5. At the cable handle, loosen the cable nut (Ref. 3), slide the cable out of the bracket slot, and pull out the cable assembly.
6. Position the new temperature control cable handle (Ref. 2) in the bracket slot and loosely fasten the cable nut.
7. Route the cable down to the water shutoff valve. Position the cable end loop and clamp it to the water shutoff valve (Refs. 7 and 8).
8. Tighten the cable nut.
9. Check that the water shutoff valve opens when the cable is pulled up.
10. Install the water shutoff valve cover.
11. On Conventionals, reposition the wooden bunk panel and the sleeper mattress.



1. Top Capscrew
2. Bottom Capscrew
3. Side Capscrew

Fig. 1, Water Shutoff Valve Cover

Manual Temperature Control Cable Replacement



A. Upholstery Reference

1. Louver Assembly
2. Cable Handle
3. Cable Nut
4. Cable Bracket
5. Temperature Control Cable
6. Duct Assembly
7. Cable Clamp
8. Cable End Loop
9. Water Shutoff Valve

Fig. 2, Manual Temperature Control Cable

Expansion Valve and Solenoid Valve Replacement

Replacement

1. Apply the parking brakes.
2. Review the information under **"Safety Precautions, 100."**

WARNING

WARNING: Failure to review the safety precautions, and to be aware of the dangers involved when working with refrigerant, could result in serious personal injury.

3. Wearing protective goggles and gloves, discharge the refrigerant from the system. Refer to the cab air conditioner section in this group for instructions.
4. Access the sleeper heater and air conditioner unit.

   On Conventionals with sleeper boxes, either remove the sleeper box mattress and bunk panel or open the right-side baggage compartment door.

   On SleeperCabs, raise the mattress and bunk panel to their locked position.

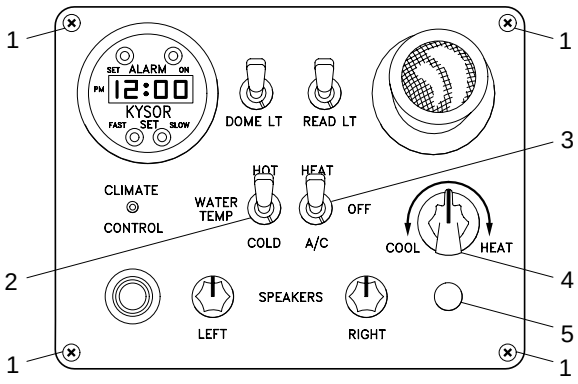
   On COEs, open the right- or left-side baggage compartment door.
5. For mode switch-controlled models, set the heater water-temperature toggle switch to HOT (**Fig. 1**). When in this position, there is no air pressure to the water shutoff valve.
6. Remove the water shutoff valve cover (if equipped).

   If equipped with mode switch control, disconnect the electrical wires (**Fig. 2**, Ref. 1) leading away from the sleeper heater and air conditioner.

   Disconnect the air tube from the water shutoff valve by pressing down on the collar at the fitting (Ref. 2), and pulling out the air tube.

   Remove the two capscrews (**Fig. 3**, Ref. 5) at the base of the valve cover (Ref. 4). Loosen the two capscrews (Refs. 1 and 3) that hold the top of the cover in place. Slide the cover off the unit.

   If equipped with a cable control or C.T.C., loosen the top and bottom capscrews (**Fig. 4**, Refs. 4 and 6) and remove the side capscrew (Ref. 1). Remove the valve cover.



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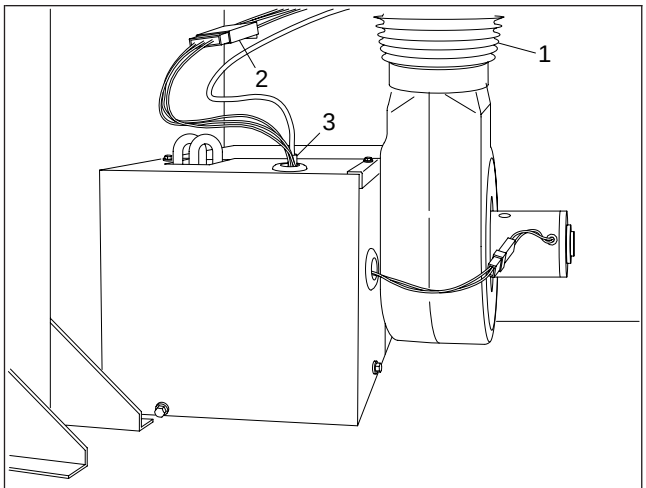
1. Control Panel Screw
2. Water Temperature Switch
3. Mode Switch
4. Temperature Control Knob
5. Temperature Sensor

Fig. 1, Control Panel for Electronic Thermostat Control System



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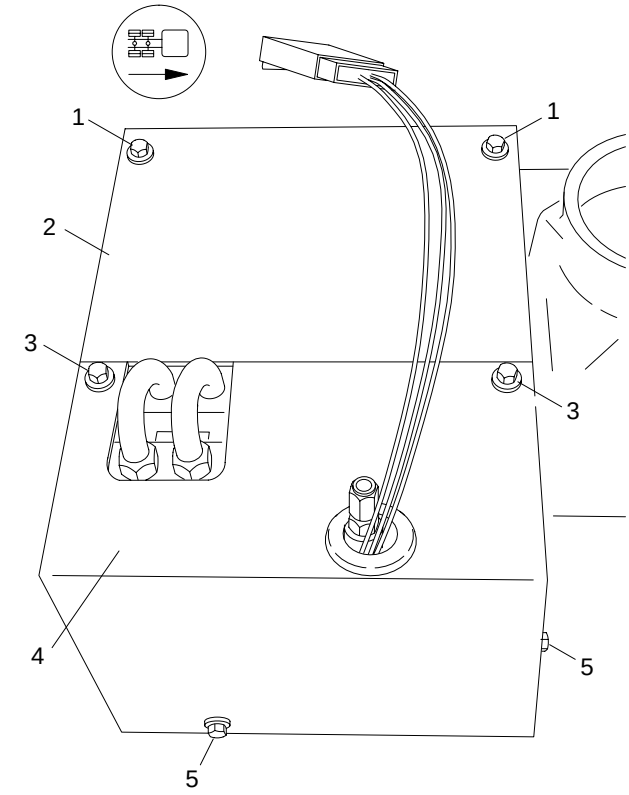
1. Air Duct
2. Wire Connector
3. Air-Tube to Water-Valve Connection

Fig. 2, Heater and Air Conditioner Installed in a Conventional 40-Inch Sleeper

7. Replace the expansion valve (**Fig. 5**, Ref. 4, or **Fig. 6**, Ref. 1).

Expansion Valve and Solenoid Valve Replacement



1. Top Capscrew, Left Side
2. Heater Core Cover
3. Top Capscrew, Right Side
4. Valve Cover
5. Bottom Capscrew

Fig. 3

CAUTION

CAUTION: Water and dirt can damage the refrigerant system. Five minutes of not being capped is the limit for any disconnected hose or component. Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

7.1 Disconnect the two refrigerant lines from the expansion valve, then remove the expansion valve from the evaporator coil. Remove the valve-mounting capscrew. If needed, lift the evaporator coil as you remove the valve. Put caps on the ends of the lines until you install the new expansion valve.

7.2 Remove the caps from the refrigerant lines. Install new O-rings on the fittings. See **Fig. 7.** Apply refrigerant oil to the male portion of the fitting threads. Attach the expansion valve to the evaporator coil. Attach the fittings to the expansion valve refrigerant lines, but don't tighten them at this time.

7.3 Install the new expansion valve to its bracket. Tighten the capscrew 15 to 18 lbf·in (160 to 200 N·cm).

7.4 Tighten the refrigerant line fittings.

#6 inlet side—11 lbf·ft (15 N·m)

#10 outlet side—21 lbf·ft (28 N·m)

On cable control or C.T.C., tighten these additional fittings.

#8 expansion valve, top—15 lbf·ft (20 N·m)

8. Replace the solenoid valve (**Fig. 6**, Ref. 2).

8.1 Disconnect the solenoid ground wire from the sleeper heater and air conditioner housing.

8.2 Remove the solenoid wire from the connector.

CAUTION

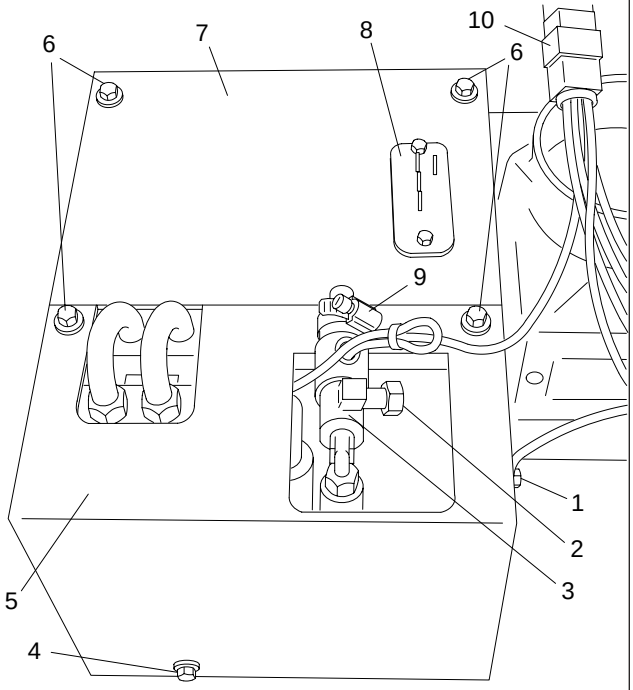
CAUTION: Water and dirt can damage the refrigerant system. Five minutes of not being capped is the limit for any disconnected hose or component. Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

8.3 Disconnect the refrigerant lines from the solenoid valve. Unscrew the two capscrews holding the solenoid valve bracket to the heater and air conditioner housing. Remove the solenoid valve and bracket. Cap the ends of the refrigerant lines until you can install a new solenoid valve.

8.4 Remove the solenoid valve from the bracket. Install a new solenoid valve on the bracket. Tighten the two screws firmly.

8.5 Remove the caps from the refrigerant lines. Install new O-rings. Apply refrigerant oil to the O-rings on the fittings. See **Fig. 7.** Apply refrigerant oil to the male

Expansion Valve and Solenoid Valve Replacement



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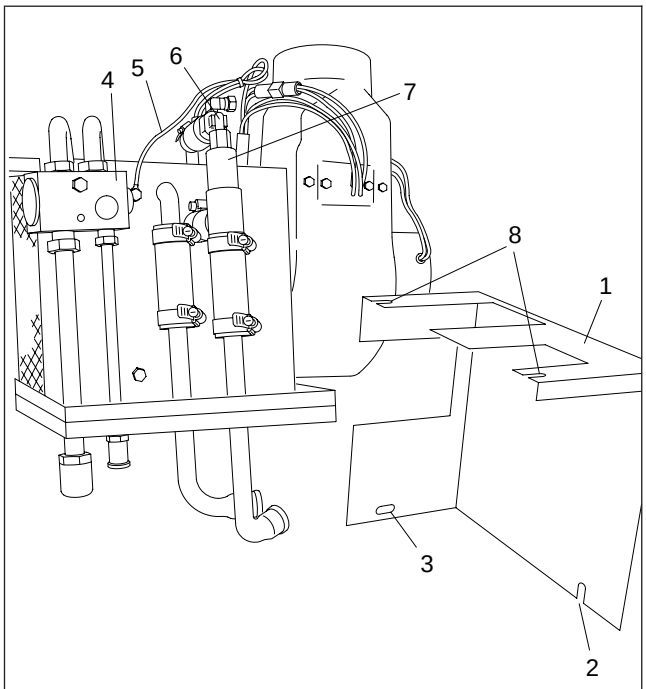
1. Side Capscrew
2. Solenoid Air Tube Fitting
3. Water Supply Solenoid
4. Bottom Capscrew
5. Water Shutoff Valve Cover
6. Top Capscrew
7. Heater Core Cover
8. Blower Resistor
9. Solenoid Clamp
10. Power Connector

Fig. 4

portion of the fitting threads. Connect the refrigerant lines to the freon solenoid valve.

9. Install the valve cover on the sleeper heater/ air-conditioner. For C.T.C. models, remember to connect the C.T.C. ground wire to the side of the valve cover (**Fig. 4**, Ref. 1). Tighten the capscrews 28 to 32 lbf·in (320 to 360 N·cm).
10. For mode switch-controlled models, connect the electrical wires to the sleeper heater/air-conditioner. Connect the air tube to the water shutoff valve by pushing the tube into the fitting until it stops.

    Start the engine, set the temperature control switch to COLD, and check for air leaks at the tube connection.



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1. Water Shutoff Valve Cover
2. Bottom Slot
3. Side Slot
4. Expansion Valve
5. Solenoid Ground Wire
6. Water Supply Solenoid
7. Water Shutoff Valve
8. Top Slots

Fig. 5, C.T.C. Sleeper Heater/AC Without Valve Cover

11. On Conventionals, reposition the wooden bunk panel and the sleeper mattress.
12. Evacuate and charge the system. For instructions, refer to the cab air conditioner section in this group.

Expansion Valve and Solenoid Valve Replacement

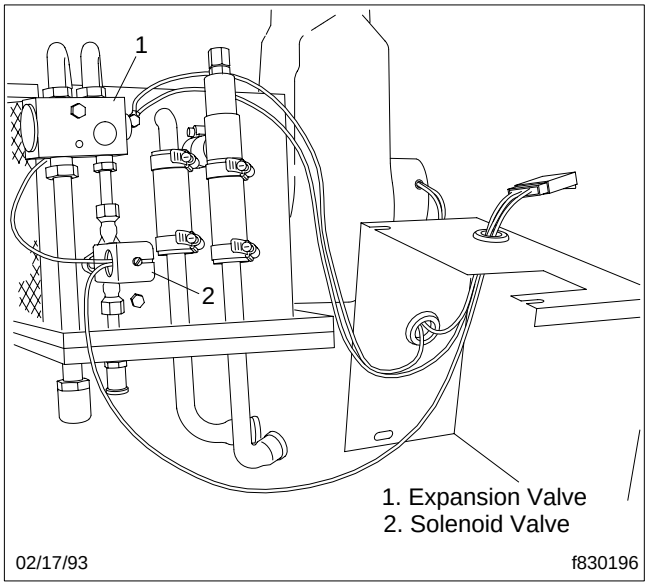


Fig. 6, Sleeper Heater/AC for Electronic Thermostat Control System

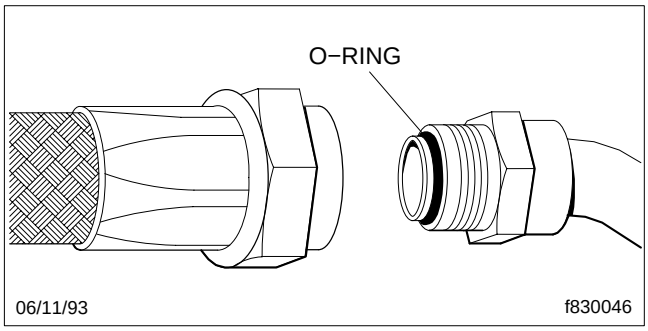


Fig. 7

Replacement

1. Apply the parking brakes.
2. Access the sleeper heater and air conditioner unit.

   On Conventionals with sleeper boxes, either remove the sleeper box mattress and bunk panel or open the right-side baggage compartment door.

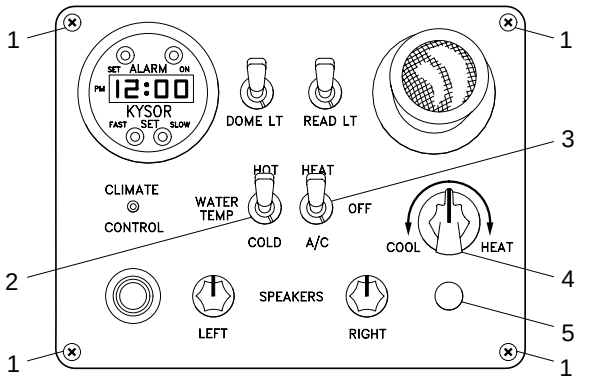
   On SleeperCabs, raise the mattress and bunk panel to their locked position.

   On COEs, open the right-or left-side baggage compartment door.
3. Depending on the type of temperature control, open the water shutoff valve.

   If equipped with a mode switch control, set the heater water-temperature switch to HOT (**Fig. 1**). When in this position, there is no compressed air to the water shutoff valve.

   If equipped with a cable control, pull the temperature control handle up (**Fig. 2**).

   If equipped with C.T.C., turn the temperature control knob clockwise to HEAT (**Fig. 3**).



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1. Control Panel Screw
2. Water Temperature Switch
3. Mode Switch
4. Temperature Control Knob
5. Temperature Sensor

Fig. 1, Control Panel for Electronic Thermostat Control System

WARNING

WARNING: Drain the heater core only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

4. For proper draining procedures, refer to the cab heater and air conditioner section in this group. Drain the cooling system by opening the radiator drain.
5. Remove the water shutoff valve cover (if equipped).

   If equipped with a mode switch control, disconnect the electrical wires (**Fig. 4**, Ref. 1) leading away from the sleeper heater and air conditioner.

   Disconnect the air tube from the water shutoff valve by pressing down on the collar at the fitting (Ref. 2), and pulling out the air tube.

   Remove the two capscrews (**Fig. 5**, Ref. 5) at the base of the valve cover (Ref. 4). Loosen the two capscrews (Refs. 1 and 3) that hold the top of the cover in place. Slide the cover off the unit.

   If equipped with a cable control or C.T.C., disconnect the electrical connector from the blower resistor (**Fig. 6**, Ref. 8). On C.T.C. models, also remove the solenoid clamp (Ref. 9). Remove the valve cover.
6. Remove the heater core cover (**Fig. 5**, Ref. 2 or **Fig. 6**, Ref. 7) from the sleeper heater and air conditioner unit by removing the two capscrews (**Fig. 5**, Refs. 1 and 3).
7. Loosen the two clamps and disconnect the hoses from the heater core inlet and outlet. **See Fig. 7** or **Fig. 8**. For C.T.C. models, set the water supply solenoid and the water shutoff valve out of the way.
8. Lift the heater core (**Fig. 9**) out of the housing. If necessary, clean up any spilled coolant from the inside of the housing before installing the new heater core. Insert the new heater core in the housing.
9. Connect the hoses to the heater core. Tighten the hose clamps 30 to 35 lbf·in (340 to 400 N·cm).
10. Close the drain on the radiator, and fill the cooling system with coolant. For coolant specifica-

Heater Core Replacement

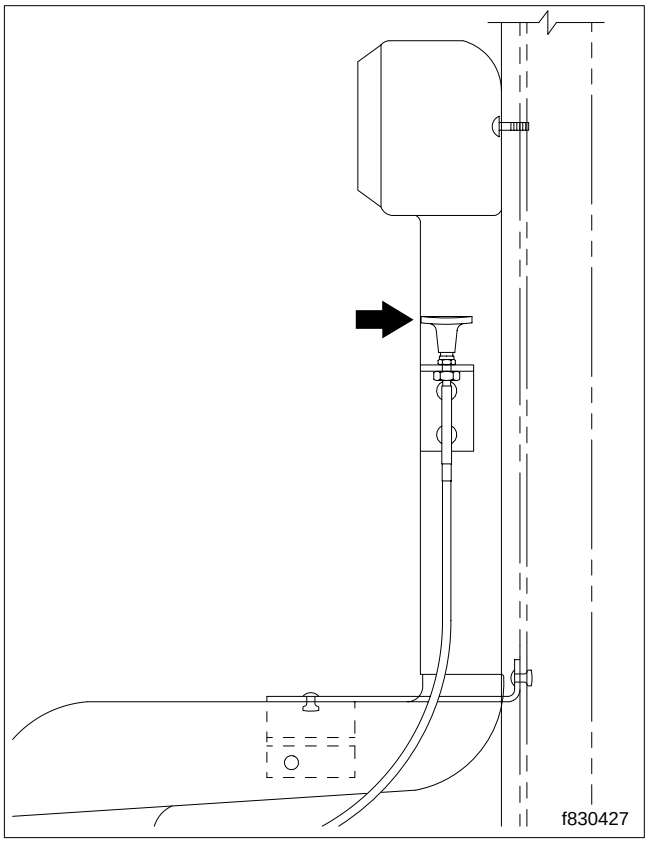


Fig. 2, Manual Temperature Control Cable Handle

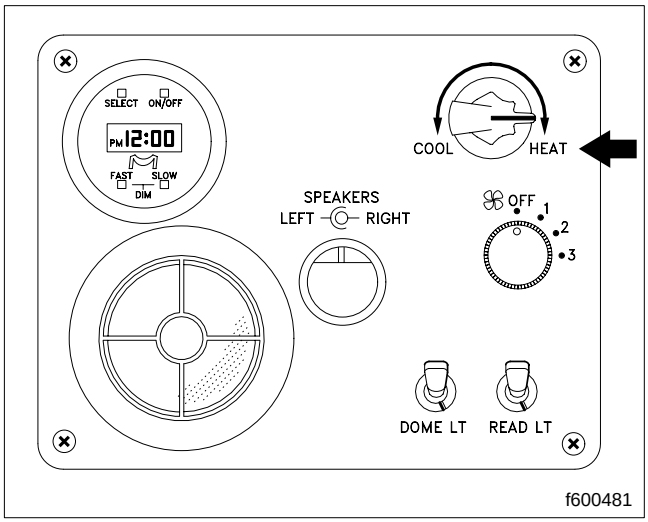
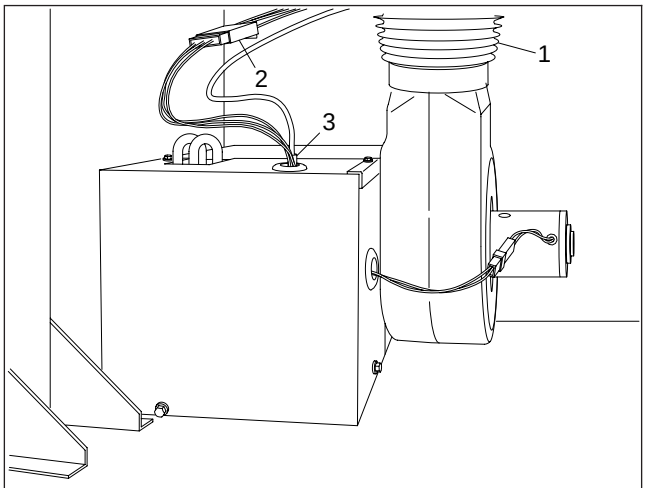


Fig. 3, Temperature Control Knob for C.T.C. System

tions, refer to the vehicle maintenance manual. Don't install the radiator cap.



1. Air Duct
2. Wire Connector
3. Air-Tube to Water-Valve Connection

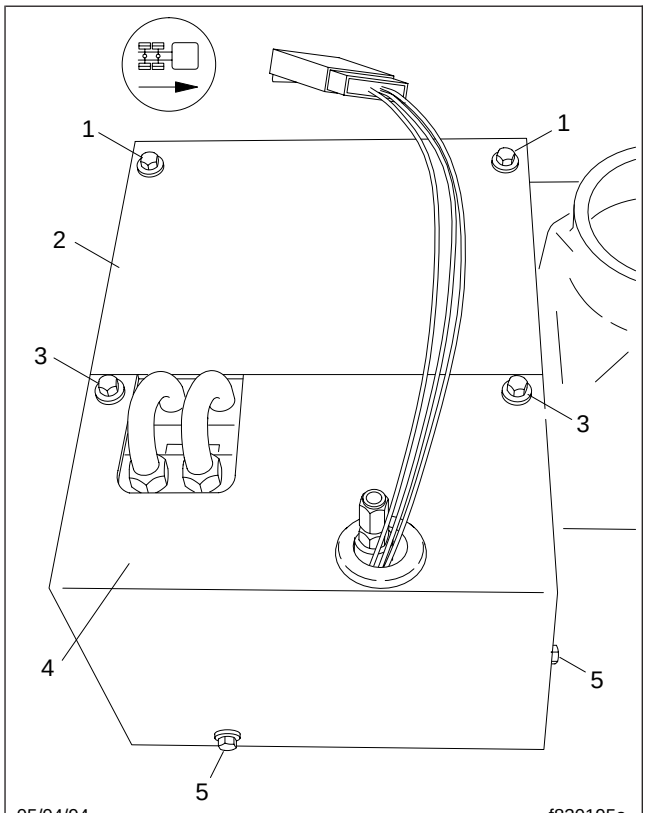
Fig. 4, Heater and Air Conditioner Installed in a Conventional 40-Inch Sleeper

⚠ CAUTION

CAUTION: Coolant must be filled to the bottom of the radiator filler neck. Low coolant could cause engine overheating, which could damage the engine.

11. Start the engine, let it run for 20 to 30 seconds, and then shut it off. Install a pressure tester, test the cooling system at 10 psi (68 kPa), and then inspect for leaks. If leaks are found, tighten the hose clamps 30 to 35 lbf·in (340 to 400 N·cm) or replace the hoses as needed. Check the coolant level, and add coolant if needed.
12. Install the heater core cover and water shutoff valve cover on the sleeper heater and air conditioner. For C.T.C. models, remember to connect the C.T.C. ground wire to the side of the valve cover (**Fig. 6**, Ref. 1). Tighten the capscrews 28 to 32 lbf·in (320 to 360 N·cm).
13. Connect the air tube, temperature control cable, water supply solenoid and wiring.

    13.1 If equipped with a mode switch control, push the air tube into the fitting until it stops. Connect the wiring to the heater core cover.



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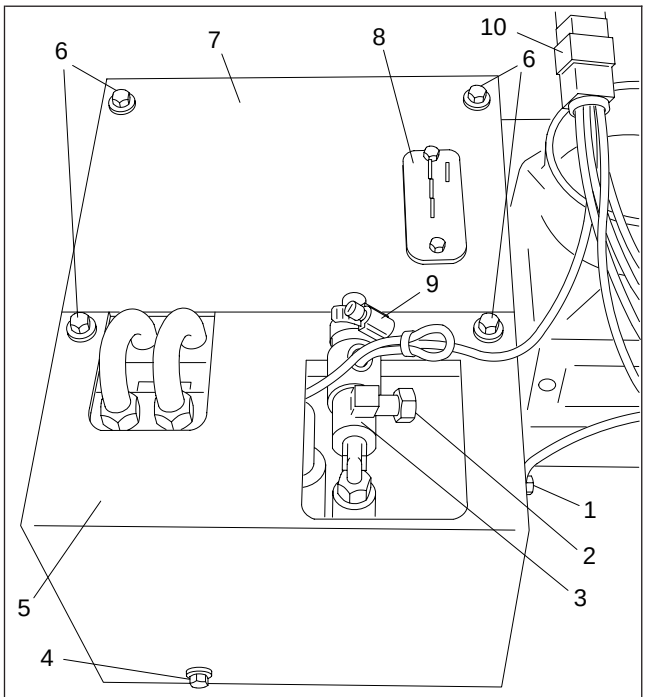
1. Top Capscrew, Left Side
2. Heater Core Cover
3. Top Capscrew, Right Side
4. Valve Cover
5. Bottom Capscrew

Fig. 5



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1. Side Capscrew
2. Solenoid Air Tube Fitting
3. Water Supply Solenoid
4. Bottom Capscrew
5. Water Shutoff Valve Cover
6. Top Capscrew
7. Heater Core Cover
8. Blower Resistor
9. Solenoid Clamp
10. Power Connector

Fig. 6

13.2 If equipped with a cable control, connect the cable to the water shutoff valve and tighten the clamp. Connect the wiring to the blower resistor (**Fig. 6**, Ref. 8).

13.3 If equipped with C.T.C, fasten the solenoid clamp (**Fig. 6**, Ref. 9), and connect the wiring to the blower resistor (Ref. 8).

14. For mode switch-controlled models, start the engine, set the temperature control to COLD, and check for air leaks at the air tube connection.

15. On Conventionals, reposition the wooden bunk panel and the sleeper mattress.

Heater Core Replacement

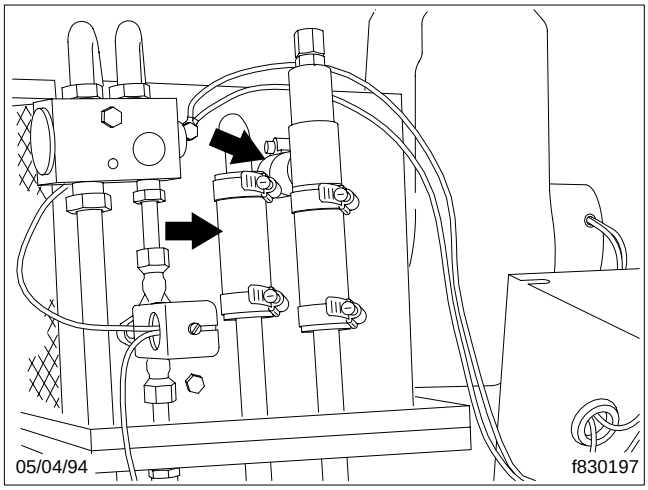
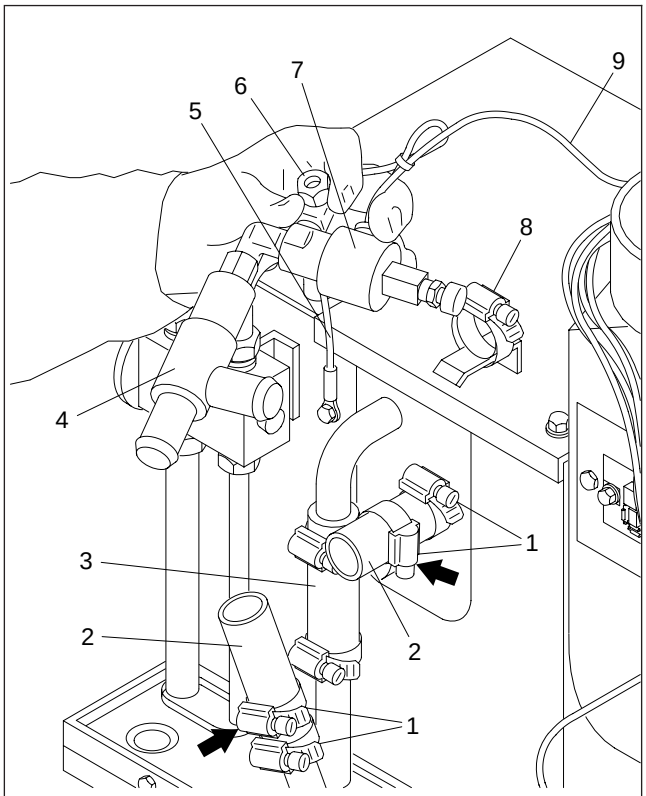


Fig. 7, Heater Core Inlet and Outlet Hoses



1. Clamps
2. Inlet Hose
3. Outlet Hose
4. Water Shutoff Valve
5. Solenoid Ground Wire
6. Solenoid Air Tube Fitting
7. Water Supply Solenoid
8. Solenoid Clamp
9. Solenoid Wiring and Connector

Fig. 8, C.T.C. Water Shutoff Valve and Solenoid

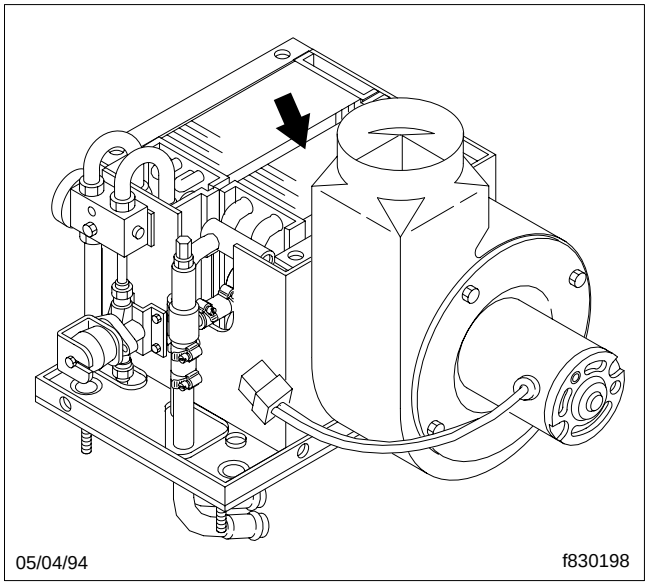


Fig. 9, Heater Core

Replacement

1. Apply the parking brakes.
2. Review the information under **"Safety Precautions, 100."**

WARNING

WARNING: Failure to review the safety precautions, and to be aware of the dangers involved when working with refrigerant, could result in serious personal injury.

3. Wearing protective goggles and gloves, discharge the refrigerant from the system. Refer to the cab air conditioner section in this group for instructions.
4. Access the sleeper heater and air conditioner unit.

   On Conventionals with sleeper boxes, either remove the sleeper box mattress and bunk panel or open the right-side baggage compartment door.

   On SleeperCabs, raise the mattress and bunk panel to their locked position.

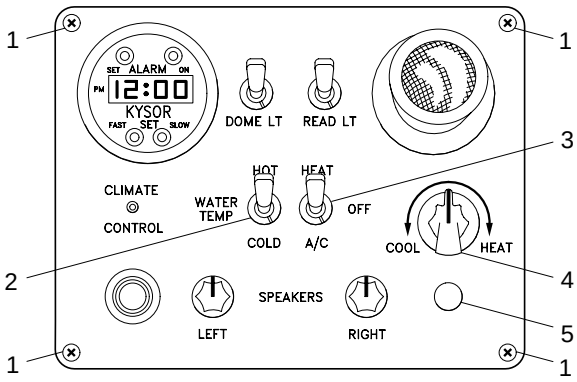
   On COEs, open the right-or left-side baggage compartment door.
5. For mode switch-controlled models, set the heater water-temperature switch to HOT (**Fig. 1**). When in this position, there is no air pressure to the water shutoff valve.
6. Remove the water shutoff valve cover (if equipped).

   If equipped with a mode switch control, disconnect the electrical wires (**Fig. 2**, Ref. 1) leading away from the sleeper heater and air conditioner.

   Disconnect the air tube from the water shutoff valve by pressing down on the collar at the fitting (Ref. 2), and pulling out the air tube.

   Remove the two capscrews (**Fig. 3**, Ref. 5) at the base of the valve cover (Ref. 4). Loosen the two capscrews (Refs. 1 and 3) that hold the top of the cover in place. Slide the cover off the unit.

   If equipped with a cable control or C.T.C., disconnect the electrical connectors from the blower resistor (**Fig. 4**, Ref. 8). Loosen the top and bottom capscrews (Refs. 4 and 6) and remove the side capscrew (Ref. 1). On C.T.C. models, remove the solenoid clamp (Ref. 9). Remove the valve cover.



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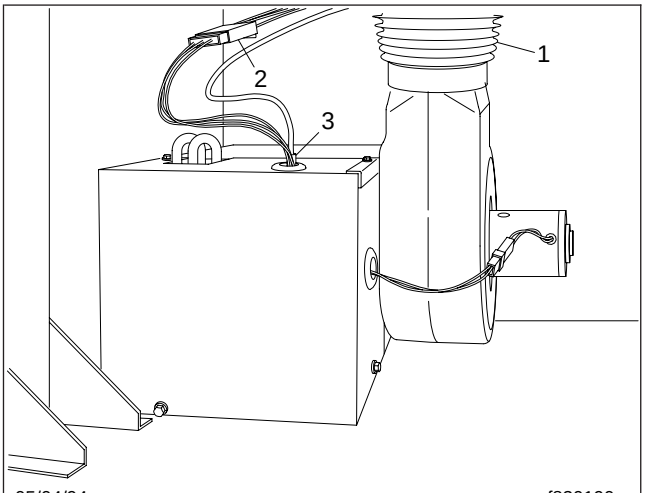
1. Control Panel Screw
2. Water Temperature Switch
3. Mode Switch
4. Temperature Control Knob
5. Temperature Sensor

Fig. 1, Control Panel for Electronic Thermostat Control System



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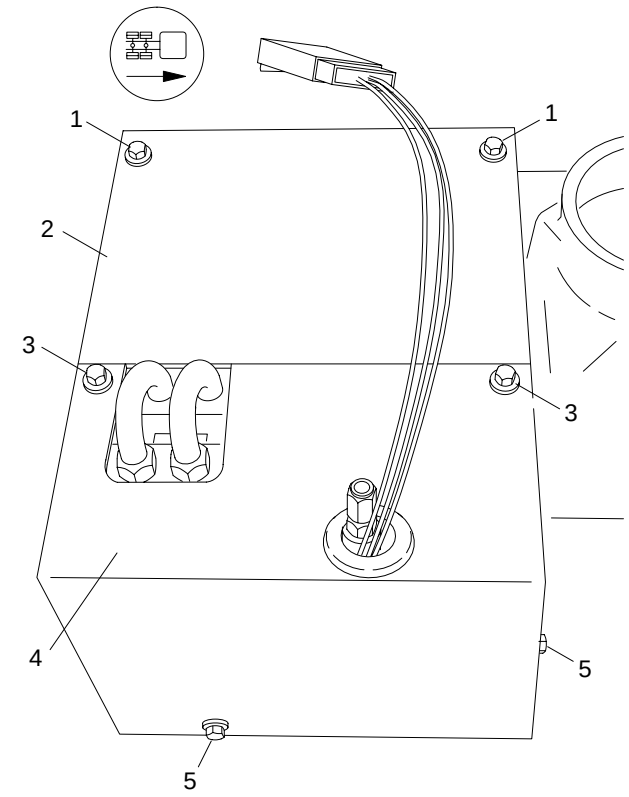
1. Air Duct
2. Wire Connector
3. Air-Tube to Water-Valve Connection

Fig. 2, Heater and Air Conditioner Installed in a Conventional 40-Inch Sleeper

Evaporator Coil Replacement



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1. Top Capscrew, Left Side
2. Heater Core Cover
3. Top Capscrew, Right Side
4. Valve Cover
5. Bottom Capscrew

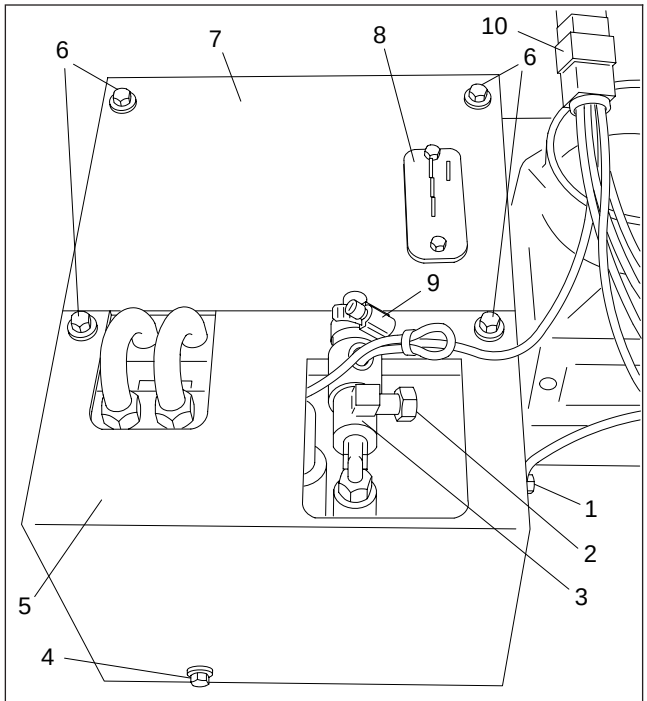
Fig. 3

7. Remove the heater core cover (**Fig. 3**, Ref. 2 or **Fig. 4**, Ref. 7) from the sleeper heater and air conditioner by removing the two capscrews (**Fig. 3**, Refs. 1 and 3).

CAUTION

CAUTION: Water and dirt can damage the refrigerant system. Five minutes of not being capped is the limit for any disconnected hose or component. Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

8. Disconnect the connections between the evaporator coil and the expansion valve. See **Fig. 5.** Lift the evaporator coil (**Fig. 6**) out of the housing. If necessary, clean up any spilled refrigerant oil from the inside of the housing before installing the new evaporator coil. Cap the expansion valve ports until you can install a new evaporator coil.
9. Install new O-rings on the new evaporator coil fittings and apply refrigerant oil to the O-rings. See **Fig. 7.** Apply refrigerant oil to the male portion of the fitting threads.
10. Remove the caps from the expansion valve ports. Install the evaporator coil in the housing. Connect the expansion valve to the evaporator coil.



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1. Side Capscrew
2. Solenoid Air Tube Fitting
3. Water Supply Solenoid
4. Bottom Capscrew
5. Water Shutoff Valve Cover
6. Top Capscrew
7. Heater Core Cover
8. Blower Resistor
9. Solenoid Clamp
10. Power Connector

Fig. 4

11. Tighten the evaporator coil inlet side fitting 11 to 13 lbf·ft (15 to 18 N·m). Tighten the outlet side fitting 21 to 27 lbf·ft (28 to 37 N·m).

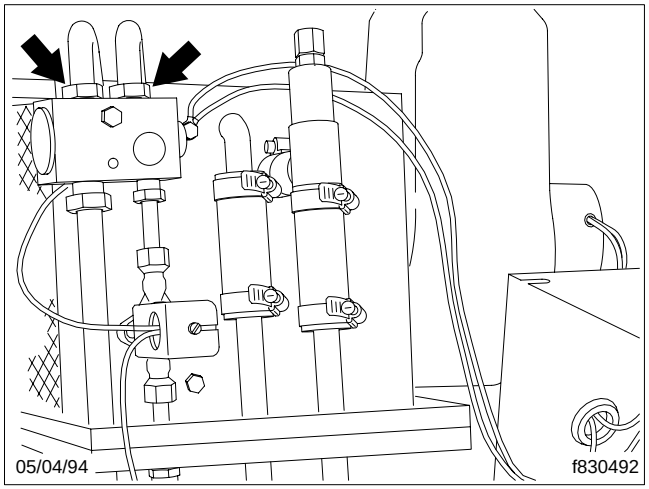


Fig. 5, Evaporator-Coil to Expansion-Valve Connections

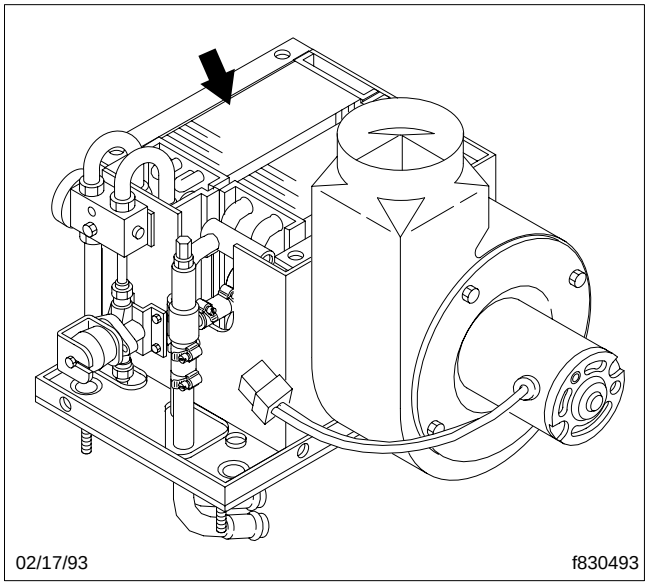


Fig. 6, Evaporator Coil

12. Install the covers on the sleeper heater and air conditioner. Tighten the capscrews 28 to 32 lbf·in (320 to 360 N·cm).
13. Connect the air tube, water supply solenoid, or wiring.

    If equipped with a mode switch control, connect the air tube to the water shutoff valve by pushing the air tube into the fitting until it stops.

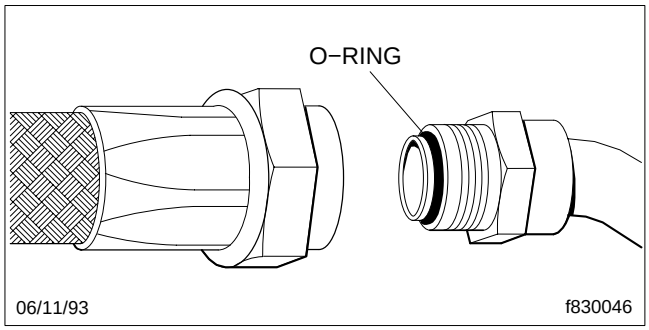


Fig. 7

    Connect the electrical wires to the heater core cover.

    If equipped with a cable control, connect the cable to the water shutoff valve and tighten the clamp.

    Connect the wiring to the blower resistor (**Fig. 4**, Ref. 8).

    If equipped with C.T.C., install the solenoid clamp (**Fig. 4**, Ref. 9).

    Connect the wiring to the blower resistor (Ref. 8), and the C.T.C. ground wire to the side of the valve cover (Ref. 1).

14. For mode (toggle) switch-controlled models, start the engine, set the temperature control to COLD, and check for air leaks at the air tube connection.
15. On Conventionals, reposition the wooden bunk panel and the sleeper mattress.
16. Evacuate and charge the system. For instructions, refer to the cab air conditioner section in this group.

Replacement

For instructions covering replacement of the receiver-drier, condenser, and compressor, refer to the cab air conditioner section and the refrigerant compressor section in this group.

Troubleshooting

SLEEPER AIR CONDITIONER

Since the sleeper air conditioner and the cab air conditioner have several components in common, refer to the cab heater and air conditioner section in this group for general troubleshooting instructions.

ELECTRONIC THERMOSTAT SYSTEM

To test the electronic thermostat for proper cycling of the sleeper unit, place a sensitive thermometer (preferably electronic) near the front of the sleeper unit control panel, as close to the thermostat sensor as possible. If the air temperature is below 75°F (24°C), operate the sleeper heater. If the air temperature is above 75°F (24°C), operate the sleeper air-conditioner. Operate the engine, and set the controls of the cab heater/air-conditioner for the same mode as the sleeper. This is especially important in the air conditioning mode, since the sleeper unit is a slave to the main unit. Set the temperature control knob so the sleeper unit will change the temperature by at least 6°F (3.5°C) from ambient.

If the sleeper unit will not operate in the selected mode, operate the cab and sleeper units in the other mode. If, in either mode, the sleeper unit begins to cycle on and off with an approximate 6°F (3.5°C) temperature difference, the thermostat is operating properly. If the sleeper unit cycles properly in one mode and will not operate in the other, the problem is not the thermostat; check for a problem with the mode switch, the relay, or the wiring. See **Fig. 1**.

CONSTANT TEMPERATURE CONTROL (C.T.C. SYSTEM)

On vehicles equipped with the Constant Temperature Control (C.T.C.) system, the following problems may occur:

- Warm air output with the temperature control knob in the cold position;
- Cold air output with the temperature control knob in the hot position.

The following procedure requires the use of a multimeter. See **Fig. 2**.

NOTE: If using the C.T.C. analyzer (which is available from the Red Dot Corporation) to troubleshoot the C.T.C. system, follow the instructions that come with the analyzer.

To properly diagnose problems affecting the system, the vehicle must be operating at normal coolant temperature, air pressure, and voltage output.

PROBLEM: AIR OUTPUT IS WARM WITH TEMPERATURE CONTROL KNOB IN THE "COLD" POSITION

1. Cycle the temperature control knob from HOT to COLD. If you *can* hear or feel the water supply solenoid valve cycling, do the next two steps. If you *can't* hear or feel the water solenoid valve cycling, skip the next two steps and go to the last step.
2. Check the water supply shutoff valve.

   Disconnect the air line from the water supply solenoid. If the air supply turns off and on as the control knob is cycled, replace the water shutoff valve.
3. Check the water supply solenoid valve (with power on).

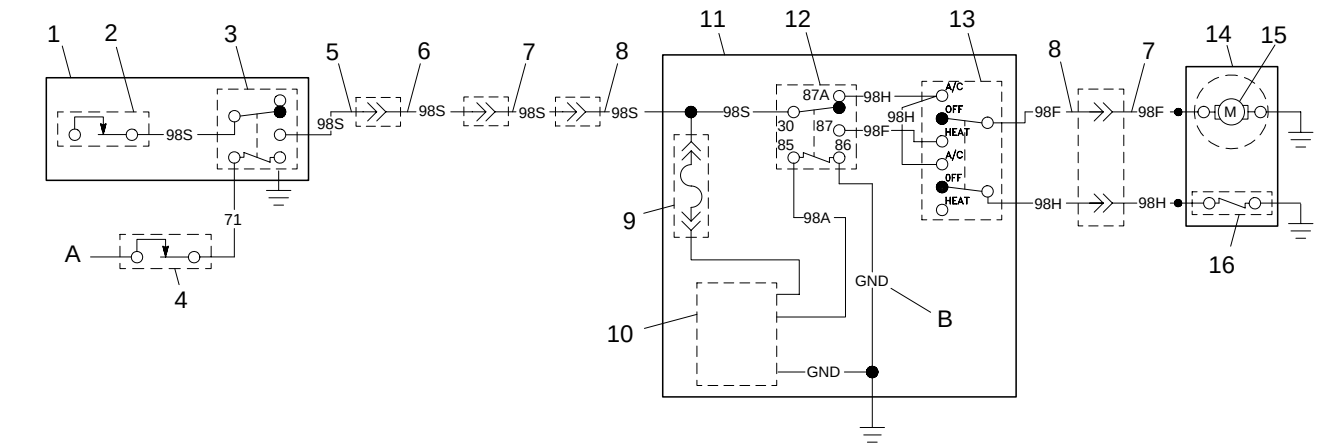
   3.1 Check the voltage at the circuit board; it should be 12 to 14 volts. If there is no voltage, check the vehicle electrical system. Repair as needed.

   3.2 Check the solenoid ground, the inline fuse, and the air supply to the solenoid. Repair or replace as needed.

   3.3 Check the solenoid draw. The solenoid should draw 0.5 amp as it is cycled. If the reading is over 0.75 amp, replace the solenoid.

   3.4 Check the voltage at the solenoid with the temperature control knob at HOT, then at COLD. If the voltage is 0 to 4 volts with the control knob at HOT, and 8.5 to 11.0 volts with the knob at COLD, replace the solenoid.
4. Check the variable resistor in the control panel.

Troubleshooting



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A. from the ignition switch

B. Ground

1. Component Mounting Plate
2. Circuit Breaker, 20A
3. Sleeper Heater-A/C Relay
4. Circuit Breaker, 10A
5. Main Cab Wiring Harness
6. Floor Harness
7. Sleeper Harness
8. Control Panel Harness
9. Fuse
10. Electronic Thermostat
11. Sleeper Control Panel
12. Mode Switch Relay
13. Mode (Heat-Off-A/C) Switch
14. Heater and Air Conditioner Unit
15. Blower Motor (Fan)
16. Refrigerant Solenoid Valve

Fig. 1, Sleeper Heater and Air Conditioner Wiring Diagram, Electronic Thermostat System

4.1 Voltage at the wiring connector (purple wire) should be 8.5 to 12.0 volts. If there is no power, check the connector. If the connector is good, replace the circuit board (**Fig. 3**, Ref. 4).

4.2 With the temperature control knob at COLD, the voltage should be 0 to 4.0 volts. With the control knob at HOT, the voltage should be 8 to 11 volts.

If there is no voltage, check for damaged wiring. Repair or replace as needed. If the wiring is OK, replace the variable resistor assembly (**Fig. 4**, Ref. 8).

PROBLEM: AIR OUTPUT IS COLD WITH TEMPERATURE CONTROL KNOB IN THE "HOT" POSITION

1. With the power on, disconnect the circuit board from the wiring harness.

   If the Water supply solenoid cycles and the air output becomes hot, replace the circuit board.

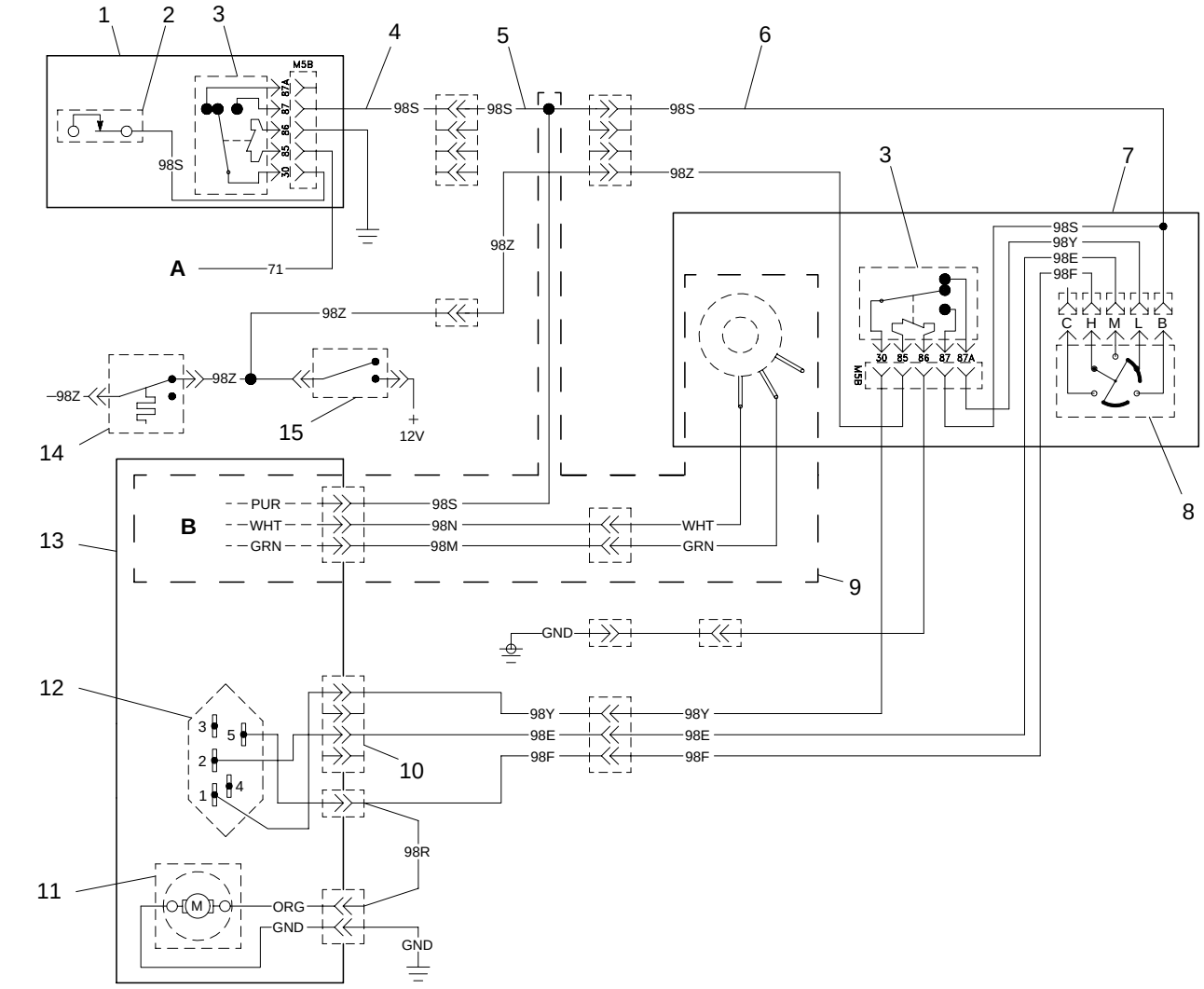
   If the solenoid does not cycle, check the water supply solenoid valve and the water shutoff valve. (See the first three steps under "Problem: Air output is Warm.") If they're OK, replace the circuit board.

2. Check the voltage at the wiring connector with the temperature control knob at HOT, then at COLD. If the voltage is 0 to 4 volts with the control knob at HOT, and 8.5 to 11.0 volts with the knob at COLD, replace the circuit board.

3. If the voltage at the wiring connector reads 10 to 13 volts and remains unchanged as the control knob is turned from HOT to COLD, the variable resistor in the sleeper control panel may be shorted out.

4. If the voltage at the wiring connector reads 10 to 13 volts and changes only a volt or two when the control knob is turned from HOT to COLD, the circuit board is not properly grounded.

   4.1 Turn off the ignition switch.



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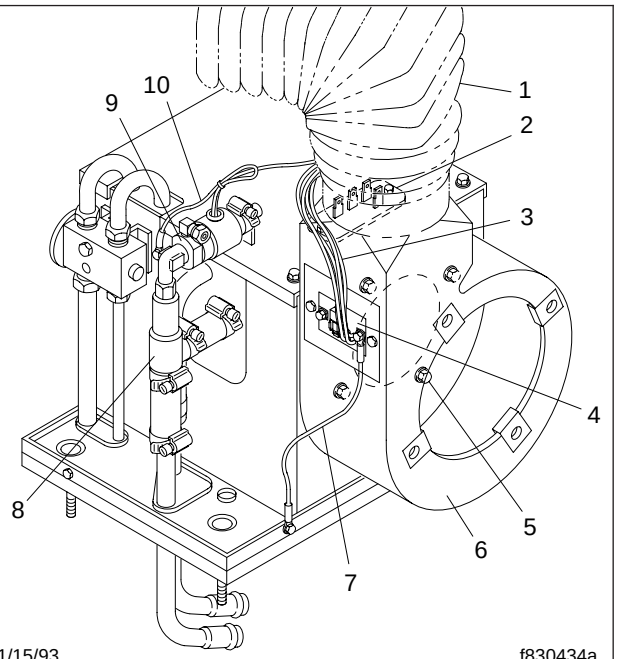
A. from the ignition switch
B. to the C.T.C. board

1. Component Mounting Plate
2. Circuit Breaker, 20 Amp (15 amp if diode is installed in circuit 98Y)
3. Relay
4. Main Cab Wiring Harness
5. Overhead Harness
6. Sleep Control Panel Wiring Harness
7. Control Panel
8. Fan Speed Switch
9. C.T.C. Variable Resistor Assembly
10. Connection from Sleeper Control Panel to Resistor
11. Blower Motor
12. Resistor
13. Red Dot Sleeper Heater/Air Conditioner Unit
14. Main Combination Thermostat
15. A/C On-Off Switch

Fig. 2, Sleeper Heater and Air Conditioner Wiring Diagram, Constant Temperature Control (C.T.C.) System

4.2 Remove the circuit board and the ground wire from the blower housing. See **Fig. 3**.

Troubleshooting

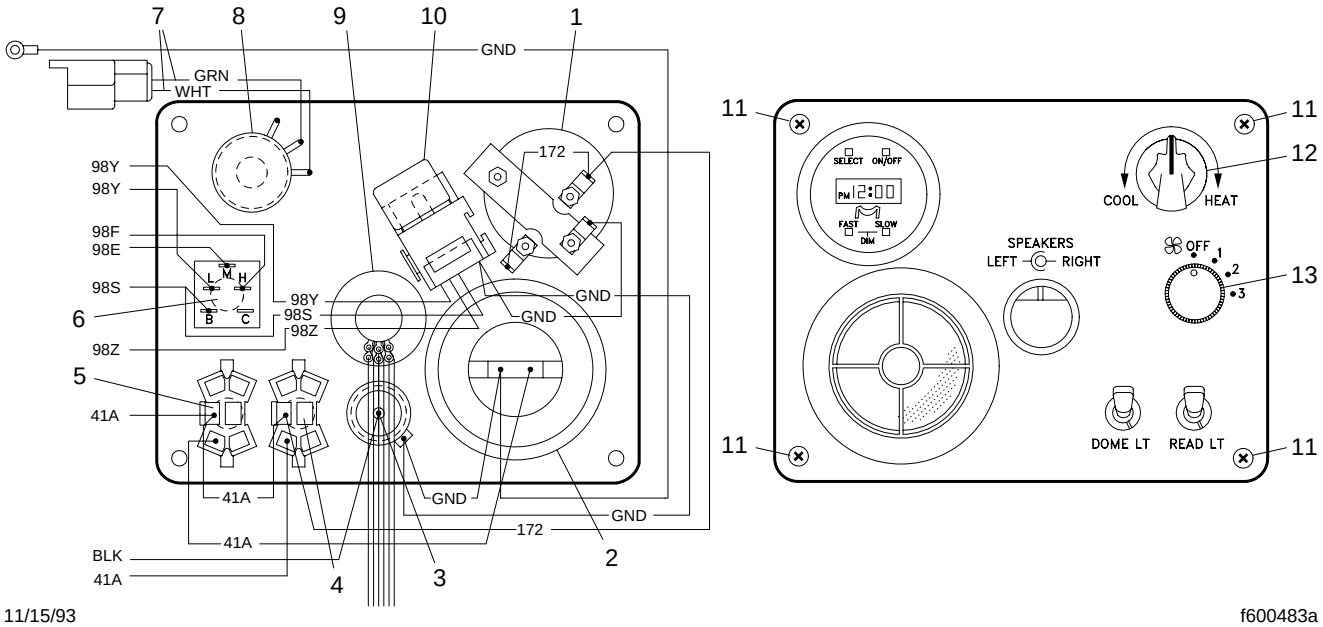


1. Duct
2. Blower Resistor
3. C.T.C. Wiring Harness
4. C.T.C. Circuit Board
5. Capscrew
6. Blower Housing
7. C.T.C. Ground Wire
8. Water Shutoff Valve
9. Water Supply Solenoid Valve
10. Solenoid Ground Wire

Fig. 3, Sleeper Heater and Air Conditioner With C.T.C.

4.3 Clean the area around the two hold-down screws on he circuit board and blower housing.

4.4 Install the circuit board and C.T.C. ground wire, and tighten the screws.



1. Clock
2. Reading Light
3. Cigarette Lighter
4. Dome Light Switch
5. Reading Light Switch
6. Fan Control Knob and Switch
7. C.T.C. Green and White Wires
8. C.T.C. Knob and Variable Resistor Assembly
9. Fader Control
10. Relay
11. Mounting Screws
12. Temperature Control Knob
13. Fan Control Knob

Fig. 4, C.T.C. Control Panel

See **Fig. 1** for the wiring diagram if equipped with the "Electronic Thermostat System."

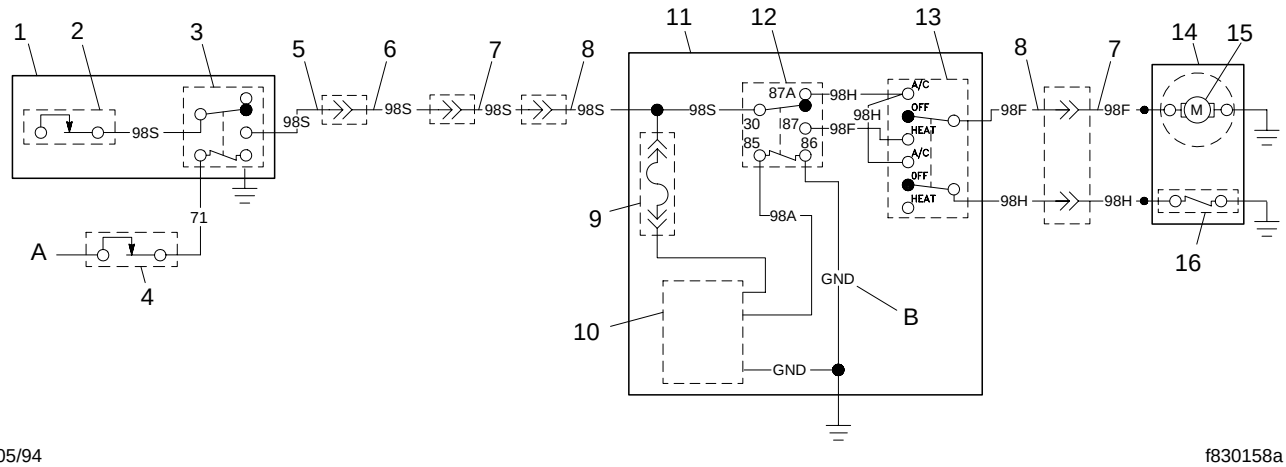
See **Fig. 2** for the wiring diagram if equipped with the "Manual Cable Control System."

See **Fig. 3** for the wiring diagram if equipped with the "Constant Temperature Control (C.T.C.) System."

Fastener Torques		
Description	**Torque**	
	lbf·in (N·cm)	**lbf·ft (N·m)**
Heater and Air Conditioner Mounting Locknuts	—	13 (18)
Heater Hose Clamps	30–35 (340–400)	—
Refrigerant Line (Inlet Side) No. 6 Fitting *	—	11 (15)
Refrigerant Line (Expansion Valve Top) No. 8 Fitting *	—	15 (20)
Refrigerant Line (Outlet Side) No. 10 Fitting *	—	21 (28)
Blower Motor Mounting Capscrews	28–32 (320–360)	—
Heater and Air Conditioner Cover Capscrews	28–32 (320–360)	—
Expansion Valve and Solenoid Valve Mounting Capscrews	15–18 (160–200)	—

* Use two wrenches, one on each side of the fitting. Replace the O-ring and lubricate it with refrigerant oil. Apply refrigerant oil to the male portion of the fitting threads. If equipped with aluminum fittings, apply Molykote M Gear Guard to the male portion of the fitting threads.

Table 1, Fastener Torques



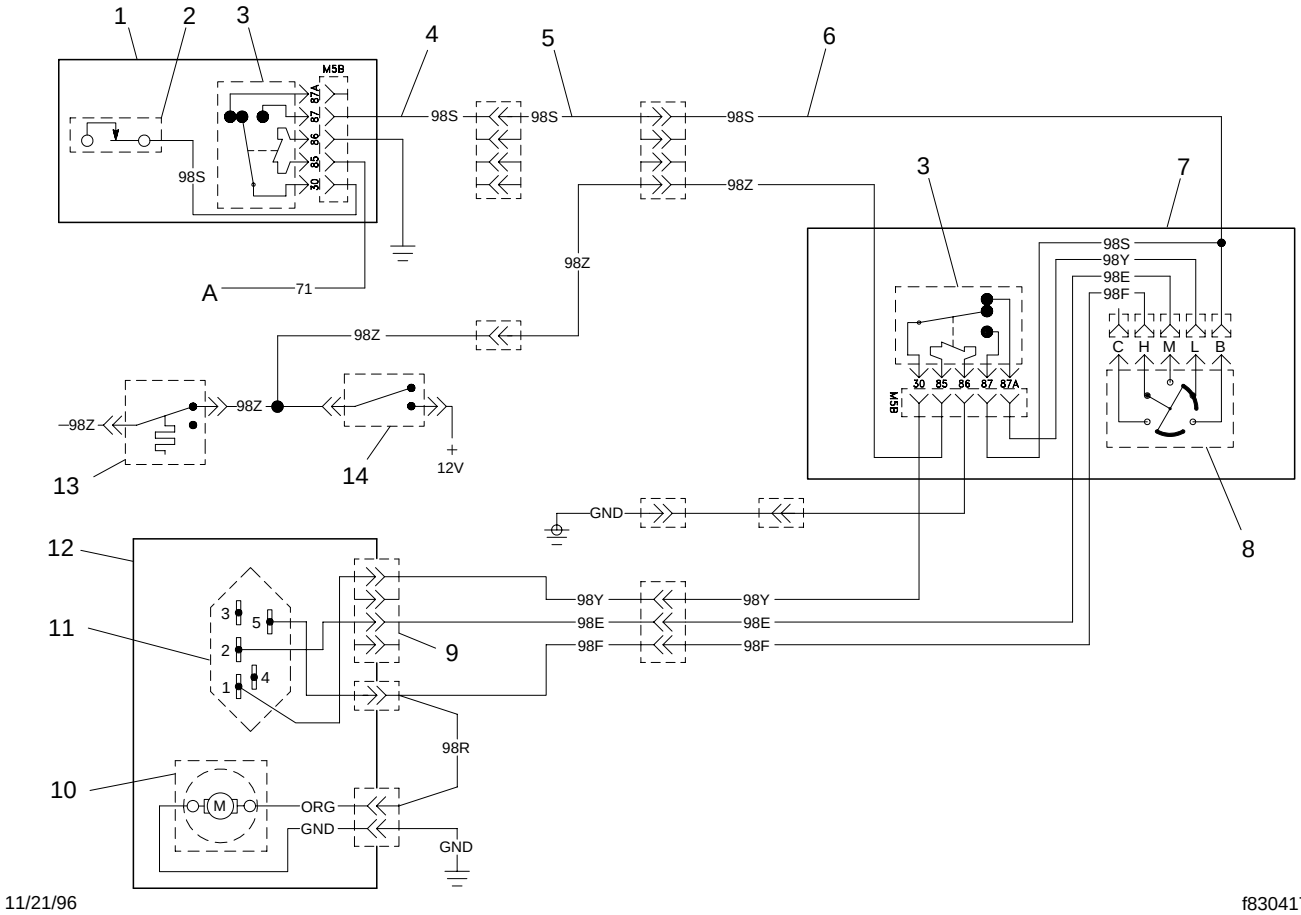
A. from the ignition switch

B. Ground

1. Component Mounting Plate
2. Circuit Breaker, 20A
3. Sleeper Heater-A/C Relay
4. Circuit Breaker, 10A
5. Main Cab Wiring Harness
6. Floor Harness
7. Sleeper Harness
8. Control Panel Harness
9. Fuse
10. Electronic Thermostat
11. Sleeper Control Panel
12. Mode Switch Relay
13. Mode (Heat-Off-A/C) Switch
14. Heater and Air Conditioner Unit
15. Blower Motor (Fan)
16. Refrigerant Solenoid Valve

Fig. 1, Sleeper Heater and Air Conditioner Wiring Diagram, Electronic Thermostat System

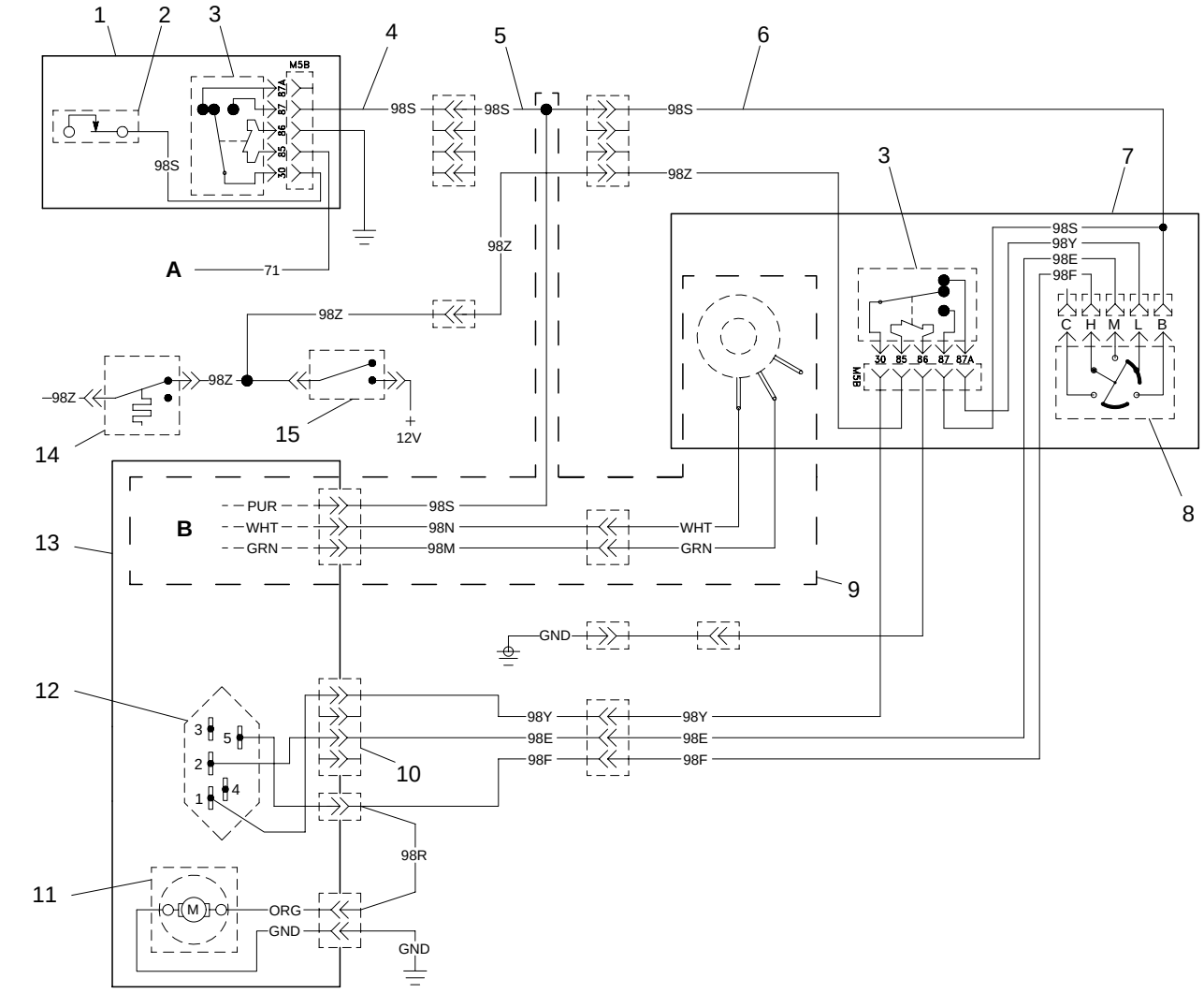
Specifications



A. from the ignition switch

1. Component Mounting Plate
2. Circuit Breaker, 20 Amp (15 amp if diode is installed in circuit 98Y)
3. Relay
4. Main Cab Wiring Harness
5. Overhead Harness
6. Sleeper Control Panel Wiring Harness
7. Control Panel
8. Fan Speed Switch
9. Connection from Sleeper Control Panel to Resistor
10. Blower Motor
11. Resistor
12. Red Dot Sleeper Heater/Air Conditioner Unit
13. Main Combination Thermostat
14. A/C On-Off Switch

Fig. 2, Sleeper Heater and Air Conditioner Wiring Diagram, Manual Cable Control System



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A. from the ignition switch
B. to the C.T.C. board

1. Component Mounting Plate
2. Circuit Breaker, 20 Amp (15 amp if diode is installed in circuit 98Y)
3. Relay
4. Main Cab Wiring Harness
5. Overhead Harness
6. Sleeper Control Panel Wiring Harness
7. Control Panel
8. Fan Speed Switch
9. C.T.C. Variable Resistor Assembly
10. Connection from Sleeper Control Panel to Resistor
11. Blower Motor
12. Resistor
13. Red Dot Sleeper Heater/Air Conditioner Unit
14. Main Combination Thermostat
15. A/C On-Off Switch

Fig. 3, Sleeper Heater and Air Conditioner Wiring Diagram, Constant Temperature Control (C.T.C.) System

General Description

The heating and air conditioning unit is mounted behind the dashboard. It consists of a heater core, evaporator, blower motor, control valves, and air ducts. Controlling the coolant flow through the heater core and refrigerant flow through the evaporator allows the driver to set cab temperature.

Thermodynamic Principles

Air conditioning is done by refrigerating, dehumidifying, and circulating the air in the passenger compartment. The process of refrigeration works due to three thermodynamic principles:

- Heat Transfer
- Latent Heat of Vaporization
- Effects of Pressure on Vaporization and Condensation

How they apply to vehicular air conditioning is described below.

Heat Transfer

If a hot object is placed close to a cold object, the heat in the warmer object will always travel to the cooler one, until they are the same temperature.

For example, a block of ice does not transfer its coldness to a nearby warm container. Instead, the heat in the warm container flows to the ice.

The British Thermal Unit (BTU) is a measure used to determine the amount of heat transferred from one object to another. One BTU is the amount of heat required to raise the temperature of 1 pound (0.45 kg) of water 1°F (0.55°C).

For example, to raise the temperature of 1 pound (0.45 kg) of water from 32°F to 212°F (0°C to 100°C), one BTU must be added for 1°F (0.55°C) rise in temperature, or a total of 180 BTUs. Conversely, in order to lower the temperature of 1 pound (0.45 kg) of water from 212°F to 32°F (100°C to 0°C), 180 BTUs must be removed from the water.

Latent Heat of Vaporization

When a liquid boils, it absorbs heat and passes the heat off in the vapor it gives off. The vapor leaves the liquid at the boiling point, but can go no higher. When the gas condenses, changing back to a liquid, it gives off heat without reducing the temperature of the resulting liquid.

For example, when 1 pound (0.45 kg) of water at 32°F (0°C) is heated over a flame, the temperature of the water rises 1°F (0.55°C) with each BTU that the water absorbs from the flame. Thus, after it has absorbed 180 BTUs, the water reaches a temperature of 212°F (100°C) and boils.

Though the flame continues to heat the water, the temperature of the water will not exceed 212°F (100°C). The water, however, starts to change from a liquid to a gaseous state. It continues to boil until the water has passed off into the atmosphere as vapor. If this vapor were checked with a thermometer, it also would show a temperature of 212°F (100°C).

In other words, there was a rise of only 180°F (from 32°F to 212°F or 0°C to 100°C) in the water and vapor temperature, even though the flame applied many more than 180 BTUs. In this case, the heat is absorbed by the liquid in the process of boiling, and dissipates in the vapor. As the vapor contacts the relatively cool air, the hidden heat flows into the cooler air and the vapor condenses back to water. Scientists refer to this principle as the latent (hidden) heat of vaporization.

Water has a latent heat of vaporization of 970 BTUs and a boiling point of 212°F (100°C). This means that 1 pound (0.45 kg) of water at 212°F (100°C), will absorb 970 BTUs when changing to vapor at 212°F (100°C). Conversely, the vapor will give off 970 BTUs when condensing back to water at 212°F (100°C).

This heat transfer, occurring when a liquid boils or a vapor condenses, forms the basic principle of all conventional refrigerant systems.

For a liquid to be a refrigerant, it must also have a low boiling point. That is, the temperature at which it boils must be lower than the substance to be cooled.

R–134a is a non-CFC refrigerant. Its temperature/pressure relationship makes it suitable for mobile air conditioning systems.

Effect of Pressure on Boiling or Condensation

As refrigerant passes through an air conditioning system, it flows under high-pressure conditions, first as a high-pressure vapor between the refrigerant com-

pressor and the condenser, then as a high-pressure liquid between the condenser and the evaporator orifice. It expands to a low-pressure vapor between the evaporator orifice and the refrigerant return port in the refrigerant compressor. As pressures in the closed refrigerant circuit vary, temperatures will also vary. As pressure increases, temperatures also increase; as the pressure decreases, temperatures also decrease. The refrigerant flow diagram highlights the changes that take place. See **Fig. 1**.

Description of Components

Air Conditioning Protection and Diagnostics System (APADS™)

The APADS control and diagnostics system is designed to increase the life of the air conditioning system components, reduce air conditioning maintenance, and aid the diagnosis of system faults. The APADS control system consists of an electronic control module, high- and low-pressure switches, and an evaporator thermostat. The electronic control module actively monitors system conditions and controls the operation of the refrigerant compressor and the on/off fan drive. Refer to Principles of Operation for more information on this system.

On a conventional vehicle, the electronic control module is located under the hood on the right side of the frontwall. See **Fig. 2**. On a COE, the electronic control module is located on the right frame rail near the receiver-drier. See **Fig. 3**. The electronic control module registers fault codes that warn of existing or impending problems in the air conditioning system. Diagnostic information and system status are communicated by red and green light emitting diodes (LEDs) built into the electronic control module. Since only one blink code can be displayed, the fault code of highest priority takes precedence. For more information on fault codes, see **Troubleshooting 300**.

APADS Evaporator Thermostat

The evaporator thermostat is the main air conditioning system control. The evaporator thermostat is wired in series with the air conditioning system on/off switch. It opens at 32°F (0°C) or below, and closes at 38°F (3°C) or above.

APADS High Pressure Switch

Located on the discharge side of the refrigerant compressor, the high pressure switch signals the electronic control module to turn the fan on and to prevent operation of the refrigerant compressor in the event of a high pressure condition. When the pressure increases above 290 to 310 psi (2000 to 2137 kPa) on vehicles built before December 11, 1998 or 340 to 375 psi (2344 to 2586 kPa) on vehicles built from December 11, 1998 the electronic control module shuts down the refrigerant compressor if necessary, and turns the fan on. When the pressure returns to 250 to 270 psi (1724 to 1862 kPa), the compressor resumes normal operation and the electronic control module turns the fan off.

APADS Low Pressure Switch

Located on the suction side of the refrigerant compressor, the low pressure switch signals the electronic control module to shut down the refrigerant compressor in extremely cold temperatures or if there is a loss of charge. When the pressure falls below 10 psi (69 kPa) the electronic control module shuts down the refrigerant compressor. When the pressure is above 34 psi (234 kPa) the compressor resumes normal operation.

Binary Switch

A binary switch disengages the refrigerant compressor to protect it from harmful operating conditions. It performs two functions:

- If refrigerant is lost or the outside temperature is too low, the binary switch will keep the compressor from operating. The switch disengages the compressor when falling pressure goes below 28 psig (195 kPa). Normal compressor operation resumes when rising pressure reaches 30 psig (205 kPa).
- If the compressor cylinder head pressure increases to unsafe levels above 385 psig (2655 kPa), the binary switch shuts off the compressor. Too much pressure may be caused by blocked air flow through the condenser, a plugged expansion valve or receiver-drier, or too much refrigerant in the system. When pressure falls back to 300 psig (2070 kPa), the compressor resumes operation.

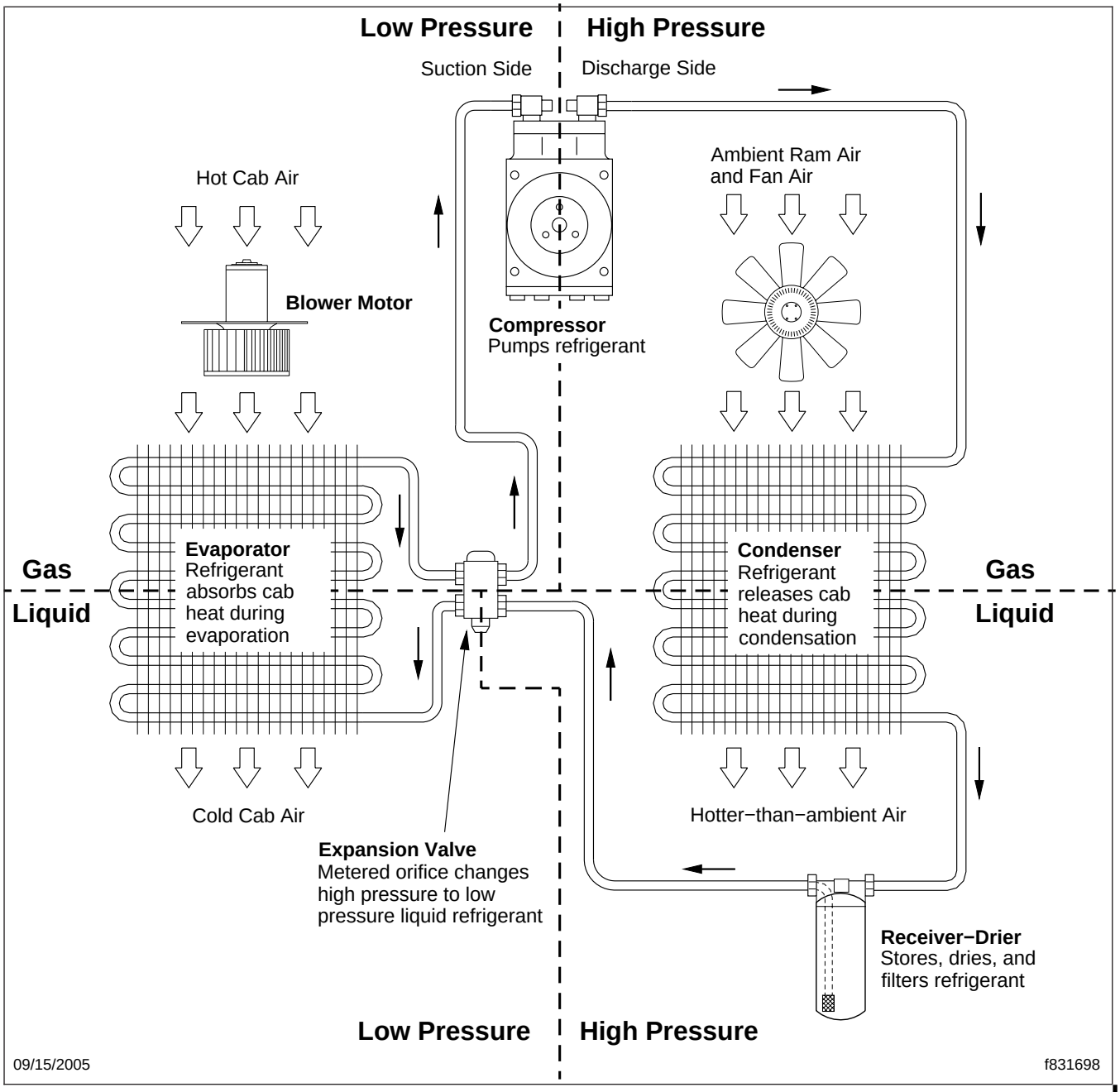


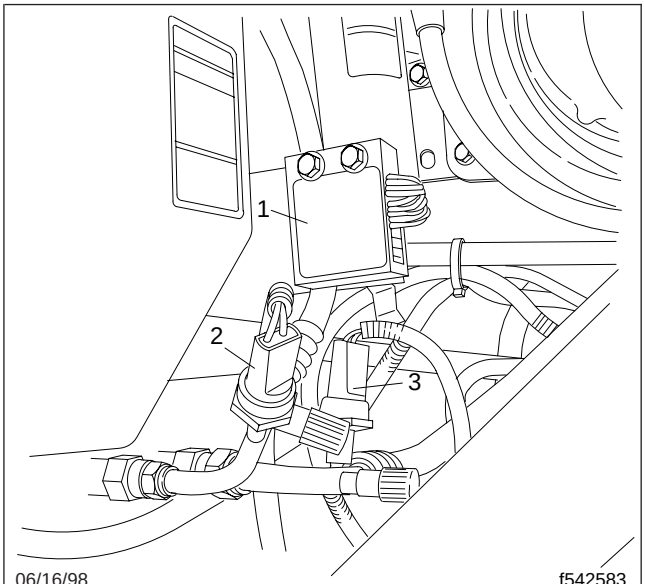
Fig. 1, Refrigerant Flow Diagram

Blower Motor Resistor Block Assembly

The blower motor draws air over the evaporator and forces it through the heater core and into the cab.

The resistor block assembly controls the speed of the blower motor. The resistor assembly has a thermal cutout which shuts off current to the blower motor if the circuit overheats.

General Information



1. Electronic Control Module
2. High Pressure Switch
3. Low Pressure Switch

Fig. 2, APADS Control Module and Pressure Switches, Conventional

Condenser

A condenser turns hot refrigerant gas, coming from the compressor, into liquid. Mounted in front of the radiator, it is made up of a coiled tube and a series of fins. Because of its location, the condenser transfers heat to air that is drawn in by the engine fan, and to air that is forced through it as the vehicle moves forward (ram air).

Evaporator

Because the evaporator is an area of low pressure in the system, the boiling point of the refrigerant drops, which causes it to absorb heat from the coiled tubing walls and fins. As it absorbs heat, the liquid refrigerant quickly boils and vaporizes into a gas.

As heat is absorbed from the outside surfaces of the evaporator, which cools it from the inside, air passing through the unit transfers its heat to these cooler surfaces. Moisture in the air condenses on the outside of the evaporator and drains off as water. This dehumidifies the air circulating through the evaporator and the passenger compartment.

Expansion Valve

An expansion valve divides the high- and low-pressure parts of the refrigerant system. High-pressure liquid refrigerant from the receiver-drier passes through the expansion valve and moves into the low-pressure area of the evaporator. See **Fig. 4** and **Fig. 5**.

An expansion valve controls the flow rate of refrigerant in proportion to the rate of evaporation in the evaporator. If the amount of liquid in the evaporator falls, the temperature of the gas going to the compressor rises. This causes a sensor tube in the expansion valve to react to the temperature changes, which causes an orifice in the valve to open or close. Through the orifice, liquid refrigerant is metered into the evaporator.

Fan Cycle Switch

Located on the receiver-drier, the fan cycle switch (on-off fan only) activates a solenoid to turn the fan on or off, depending on refrigerant pressure.

On vehicles built before November 1994, the fan will come on if refrigerant pressure is greater than 260 ± 10 psi (1800 kPa). The fan turns off when pressure drops below 174 ± 10 psi (1200 kPa).

On vehicles built from November 1994, the fan will come on if the refrigerant pressure is greater than 300 ± 10 psi (2068 kPa). The fan turns off when the pressure drops below 250 ± 10 psi (1724 kPa).

Heater Core

The heater core is a coiled tube covered with heat transfer fins. When the heating system is on, engine coolant flows through the heater core tube, heating the tube and fins. The heat is absorbed by air that is forced through the heater core by the blower motor.

Receiver-Drier

The receiver-drier is a reservoir and filter for liquid refrigerant. It also removes water and acids from the refrigerant. The water-absorbing material (desiccant) in the unit helps stop blockages caused by moisture forming in the expansion valve and other parts of the system.

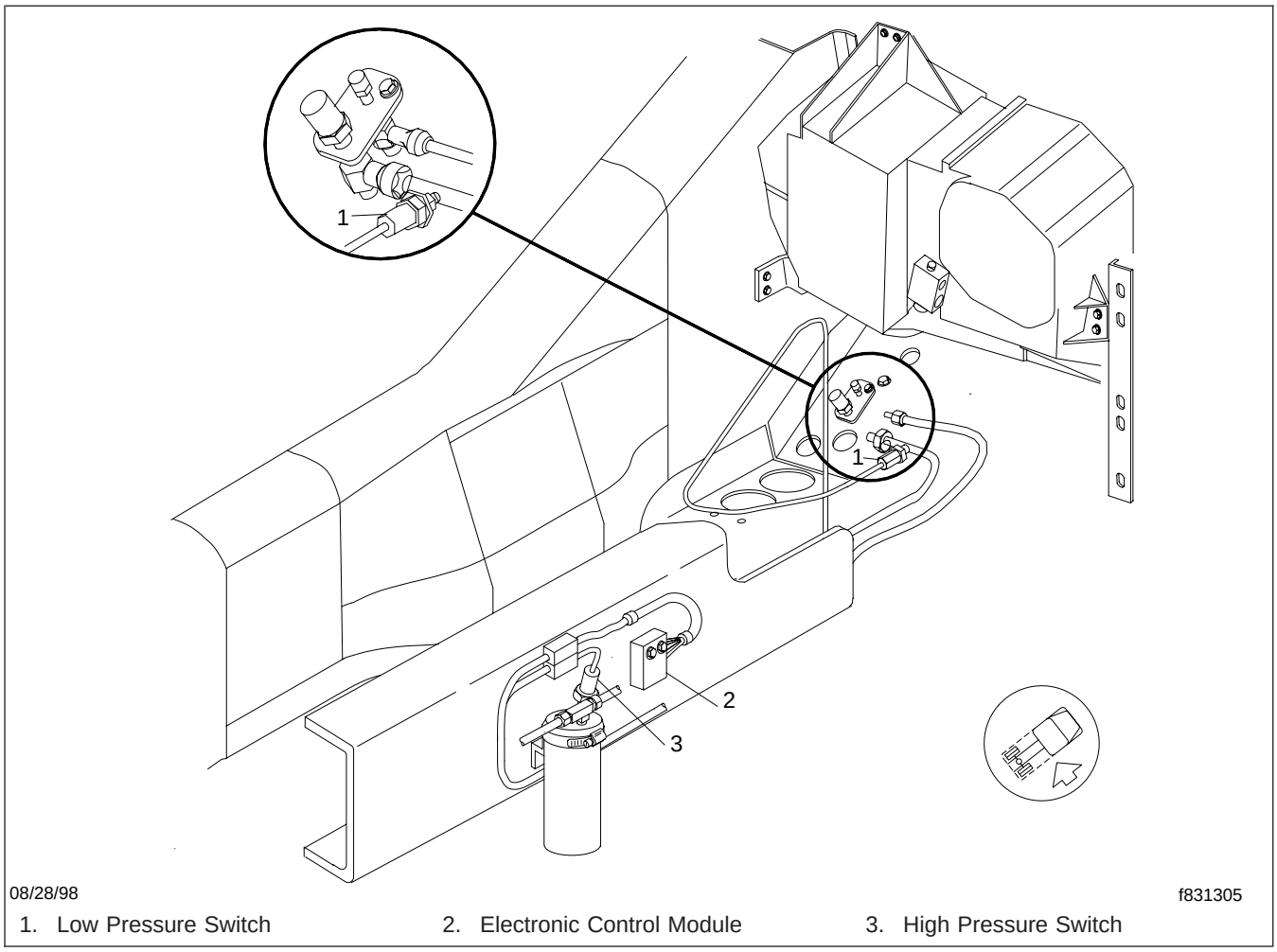


Fig. 3, APADS Control Module and Pressure Switches, COE

Refrigerant

Refrigerant is a substance that is used to absorb heat from the air in the cab and release it to the air outside the cab.

During compressor operation, refrigerant constantly changes from a gas to a liquid, then back to a gas. It absorbs heat in the low pressure evaporator under the dashboard. It releases heat from the high pressure condensor, mounted in front of the radiator.

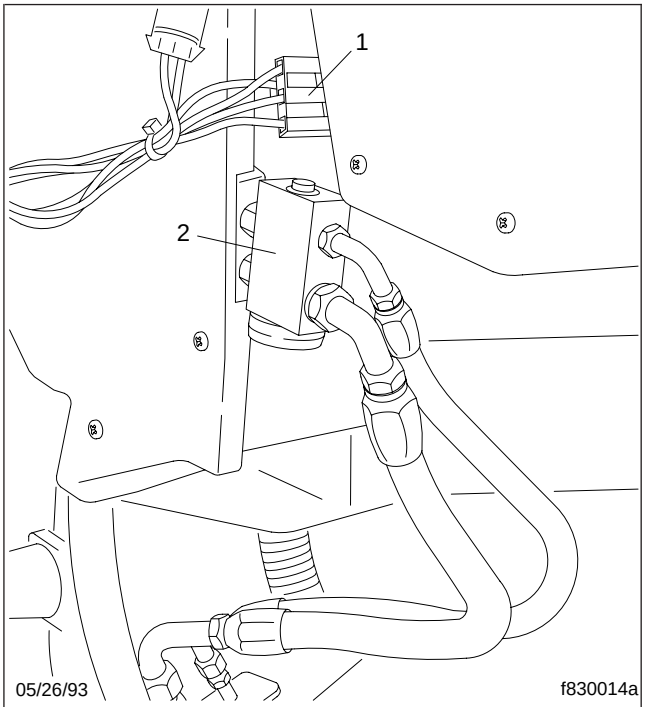
Refrigerant Compressor

"Heat" in the low-pressure gas of the evaporator does not feel hot to the touch, because liquid refrigerant boils at a temperature much lower than the temperature at which water turns to ice. To the touch, the "heated" gas in the coils feels very cold. As a result, there is the problem of how to remove heat from subfreezing gas using outside air that may be higher than 100°F (38°C).

With a refrigerant compressor, low-pressure gas from the evaporator can be squeezed into a much smaller space. When the gas is compressed, the heat it contains becomes concentrated. This makes the gas hotter than the outside air, without adding heat.

If the system pressure rises above 550 ± 50 psi (3792 ± 345 kPa), a pressure relief valve will vent, disengaging the compressor clutch until the pressure drops to 400 psi (2758 kPa).

General Information



1. Resistor Block
2. Expansion Valve

Fig. 4, Expansion Valve and Resistor Block

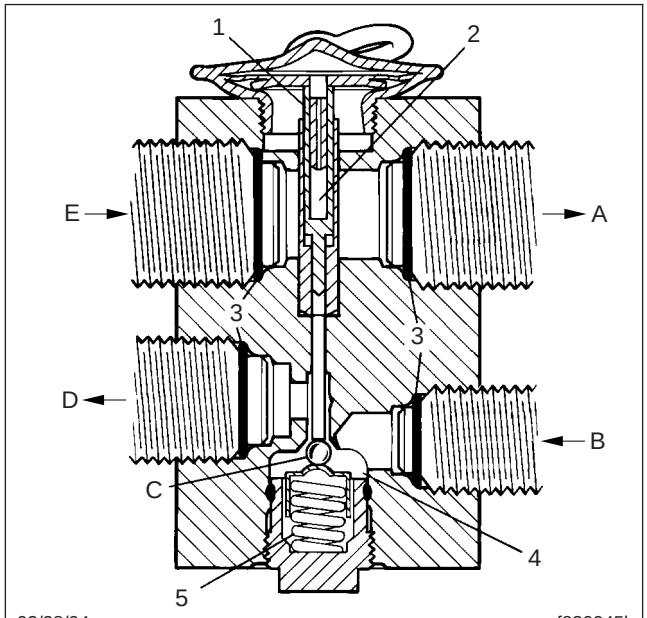
By compressing the refrigerant, the compressor circulates it through the system.

Thermostatic Switch

A thermostatic switch engages and disengages the refrigerant compressor. See **Fig. 6**. From the thermostatic switch, a sensing tube extends to the evaporator where it monitors the temperature near the coiled tube. As air containing water vapor passes through the evaporator, the water vapor can condense and freeze on the evaporator, blocking airflow. If the evaporator temperature drops too low, the thermostatic switch disengages the refrigerant compressor clutch until a temperature just above freezing is reached to thaw the ice.

Water Regulating Valve

The water regulating valve is controlled by a temperature slide lever on the dash panel. A cable from the lever opens and closes the valve, regulating the amount of engine coolant flowing through the heater core.



A. To the compressor
B. From the receiver-drier
C. Bleed at the ball seat.
D. To the evaporator
E. From the evaporator
1. Internal Equalization Passage
2. Temperature Sensor
3. O-Ring
4. Metering Orifice
5. Ball and Spring

Fig. 5, Expansion Valve Operation

Definition of Terms

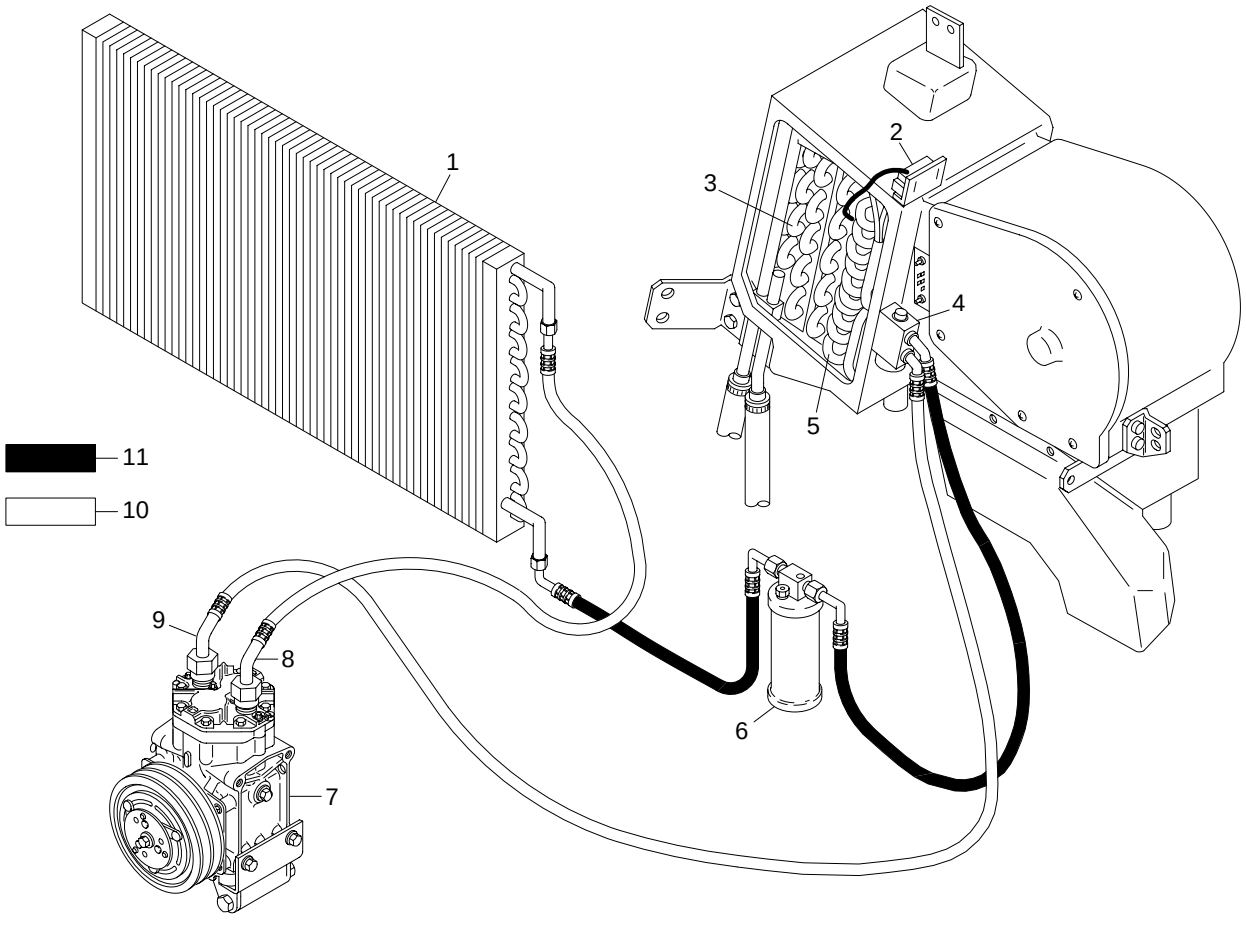
The following terms are defined according to their air conditioning context.

Air Conditioner A system used to control the temperature, humidity, and movement of air in the cab.

Air Cylinder An air-operated device used to open or close vents through which air is pushed into the cab by the blower.

Ambient Air Temperature The temperature of air around an object or the outside temperature.

Air Conditioning Protection Unit (ACPU) A system that monitors heater and air conditioner conditions (such as low or high refrigerant charge) and controls the refrigerant compressor and the on-off fan drive. Impending or existing problems are registered as



1. Condenser
2. Thermostatic Switch
3. Heater Core
4. Expansion Valve
5. Evaporator
6. Receiver-Drier
7. Refrigerant Compressor
8. Discharge Side
9. Suction Side
10. Vapor
11. Liquid

Fig. 6, System Temperature Control

fault codes through the Instrumentation Control Unit. The ACPU was installed on vehicles built before April 16, 1999.

Binary Switch This switch disengages the refrigerant compressor clutch to protect the compressor from harmful operating conditions.

Blower Motor A blower motor forces air through the HVAC assembly, and through the duct work.

Blower Resistor Block Assembly Inline resistors that control the amount of voltage going to the blower motor. The fan speed is regulated by controlling the voltage to the blower motor.

Boiling Point The temperature at which a liquid changes to a gas. The boiling point varies with pressure.

Bulk Charging Use of large containers of refrigerant for charging a refrigerant system. Normally used for charging empty systems.

Charge A specific amount of refrigerant or oil by volume or weight. Also the act of placing an amount of refrigerant or oil into the air conditioning system.

General Information

Cycling Clutch System A system that controls compressor clutch operation in order to raise or lower the temperature in the cab.

Condensate Water formed from the vapor in the air, which forms on the outer surface of the evaporator.

Condenser A heat exchanger that is used to remove heat from refrigerant, changing it from a high pressure hot gas, to a high pressure warm liquid. Typically the condenser is mounted in front of the radiator.

Contaminants Usually means water, dirt, or air in the system, but anything other than refrigerant, or refrigerant oil in the system is considered a contaminant.

Dehumidify To remove water from the air at the evaporator.

Dehydrate To remove all traces of moisture from the refrigerant system. This process occurs during evacuation.

Desiccant A drying agent used in the receiver-drier to remove moisture and create an extremely dry condition.

Discharge Line Connects the refrigerant compressor outlet to the condenser inlet.

Discharge Pressure High-side pressure, or condensing pressure of the refrigerant being discharged from the compressor.

Discharge Service Valve The valve through which high-side pressure can be checked, and other service operations can be performed. This valve is located between the receiver-drier and the expansion valve.

Drive Pulley The pulley attached to the front of the engine crankshaft which drives the compressor clutch pulley with a belt.

Duct A passageway for the transfer of air from one point to another.

Evacuate To create a high vacuum in the refrigeration system, to remove air and dehydrate or remove traces of moisture.

Evaporate A change of state from a liquid to a gas.

Evaporator A component in which liquid refrigerant changes to a gas after it absorbs heat from the air. It also removes some moisture from the cab air.

Expansion Valve A device that causes a pressure drop of the refrigerant and regulates its flow.

Flooding The condition of too much liquid refrigerant going into the evaporator. Usually caused by an expansion valve that is stuck open.

Flushing Passing liquid refrigerant through an air conditioner component, to remove dirt and water from the part. Liquid refrigerant removes heavy contamination, such as gritty dirt and large dirt buildup.

Freeze-Up Failure of a unit to operate properly because of ice forming at the expansion valve orifice, or on the evaporator.

Heater Core A finned, coiled tube in the heating system through which hot engine coolant flows to provide heat to the cab, or to adjust the temperature produced by the air conditioner.

High-Pressure Switch (Air Conditioning Protection Unit) Located on the discharge side of the service ports (small refrigerant line), this switch signals the electronic control module to turn the fan on or off, depending on refrigerant pressure. Additionally, if the high pressure condition does not return to normal within a programmed period of time, the control module will turn off the compressor.

Humidity The amount of water vapor in the air.

Hydraulic Lock The return of liquid refrigerant to the compressor, which could destroy the unit.

Leak Detector Any device used to detect refrigerant leaks in a refrigerant system.

Liquid Line High pressure liquid refrigerant is carried back to the evaporator from the condenser by the liquid line, to repeat the evaporation/condensation cycle.

Liquid Pressure Pressure of refrigerant in the liquid line from the condenser to the expansion device.

Low Head Pressure High-side pressure that is lower than normal, due to a system problem.

Low-Pressure Switch (Air Conditioning Protection Unit) Located on the suction side of the service ports (large refrigerant line), this switch signals the electronic control module to disengage the refrigerant compressor to protect it from harmful operating conditions.

Low Suction Pressure Low-side pressure that is lower than normal due to a system problem.

Magnetic Clutch An electrical coupling device used to engage or disengage the compressor.

Manifold Designed to control refrigerant flow for system test purposes. It is used with manifold gauges.

Manifold Gauge A calibrated instrument used for measuring system pressures.

Manifold Gauge Set A manifold that is complete with gauges and charging hoses and is used to measure or test pressure.

Micron A metric unit of length equal to one-millionth of a meter. This unit of measure is used to measure vacuum drawn from a refrigerant system by a vacuum pump.

Nitrogen A colorless, odorless, dry, inert gas that can be used to remove light contaminants, such as dust, from air conditioner parts.

Opacity A measure of contamination of refrigerant oil in the compressor. Fresh refrigerant oil is clear, but when contaminated, it appears cloudy or may have fine particles held in suspension.

Overcharge Too much refrigerant or oil in the system.

Polyalkylene Glycol (PAG) A highly refined synthetic oil, used in R–134a air conditioning systems.

Polyol Ester (POE) A highly refined synthetic oil, used in R–134a air conditioning systems.

Purge To remove damp air, traces of refrigerant, and loose dirt from a system or part by flushing with a dry, inert gas, such as nitrogen.

psia Pounds per square inch, absolute pressure. Pressure exerted by the air at sea level. Atmospheric pressure is usually measured with a mercury barometer.

psig PSIG, or gauge pressure, measures pressure relative to the local atmosphere. At sea level, 0 PSIG is about 14.7 PSIA, but in Denver, which is at about 5000 feet altitude, 0 PSIG is about 12.5 PSIA. A PSIG reading below 0 indicates a vacuum.

Receiver-Drier A combination desiccant, filter, and storage container for liquid refrigerant.

Recovery Removal of the refrigerant from the air conditioning system.

Recycling Removal of contaminants and moisture from R–134a using a recovery and recycling station.

Refrigerant–134a (R–134a) The cooling agent used in automotive air conditioning systems. The chemical name for R–134a is tetrafluoroethane.

Refrigerant Compressor A device used to draw low-pressure refrigerant gas from the evaporator and squeeze it into a high-temperature, high-pressure gas. Another function of the compressor is to move refrigerant through the system.

Refrigeration Cycle The complete circulation of refrigerant through an air conditioning system, accompanied by changes in temperature and pressure.

Relative Humidity The actual water content of the air in relation to the total water the air can hold at a given temperature.

Resistor A voltage-dropping device, usually wire wound, for controlling fan speed.

Sensor A temperature- or pressure-sensing unit that is used to sense air temperatures or pressures, and provide a control voltage for operation of automatic temperature control units.

Suction Line The line connecting the evaporator outlet to the compressor inlet.

Suction Pressure Compressor inlet pressure or the system's low-side pressure.

Suction Service Valve A device that allows low-side pressure to be checked and other service operations to be performed. This valve is located between the evaporator and the compressor.

Suction Side The low-pressure area of the system extending from the expansion valve to the compressor inlet.

Thermistor A vacuum pressure sensor that is used to measure, in microns of mercury, the internal system vacuum level after evacuation.

Thermostatic Vacuum Gauge A high-vacuum gauge sensitive to pressures ranging from atmospheric pressure to less than 1 micron of mercury, with scales reading from 25,000 microns to 1 micron of mercury.

Thermostatic Switch A temperature-sensitive switch used to control system temperature and prevent evaporator freeze-up. It does this by controlling the compressor's clutch operation.

Undercharge A system low on refrigerant resulting in lack of cooling and possible compressor damage.

General Information

Vacuum Refers to pressure that is less than atmospheric pressure.

Vacuum Pump A mechanical device used to evacuate and create a high vacuum in the refrigerant system.

Vacuum Pump Oil Water soluble oil used in some vacuum pumps to absorb moisture from the refrigerant system.

Vapor The gaseous state of a material.

Water Regulating Valve A mechanically or electronically controlled valve used for controlling the flow of coolant to the heater core.

Principles of Operation

Air Conditioner

When the refrigerant compressor is on, a crankshaft actuates the pistons and connecting rods, drawing in and compressing the gas. The pistons squeeze the refrigerant into a high-pressure, high-temperature gas.

After it is compressed, refrigerant gas moves out of the discharge port of the compressor, and on to the condenser. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid.

At the condenser, air passing over the coil's fins absorbs heat from the hot refrigerant gas, and causes it to change into a liquid. The liquid moves to the receiver-drier, which filters it and removes traces of moisture and acids, then stores the refrigerant until it is needed by the system.

From the receiver-drier, liquid refrigerant moves to the expansion valve, which meters the flow into the evaporator, and acts as a boundary between the high- and low-pressure sides of the system. The metered release of the expansion valve greatly drops the liquid's pressure, causing it to expand. The pressure drop lowers the boiling point of the refrigerant and causes it to evaporate quickly as it absorbs heat from air passing through the evaporator. Because the air passing through the evaporator has lost its heat, it is cool. The blower forces the cool air into the cab, where it cools the passenger compartment. Then, the heated refrigerant gas is drawn back into the compressor to repeat the cycle.

Air Conditioning Protection and Diagnostics System (APADS)

After the engine is started, the electronic control module prevents operation of the refrigerant compressor for 15 seconds. After the 15 second delay, the compressor comes on for about 15 seconds. The control module makes the start-up cycle happen, ignoring input from the thermostat. Engaging the compressor circulates its lubricant. This benefits the system, especially when it is not used frequently. If the high or low pressure switches indicate out of bound or fault conditions, the compressor is turned off.

The evaporator thermostat is the primary control of the air conditioning system. The refrigerant compressor will cycle at the frequency governed by the thermostat, but is limited to a maximum of one cycle per 15 seconds.

When the high pressure switch signals a high pressure condition, the refrigerant compressor is allowed to stay on for a variable period limited to 10 seconds, before shutting off. The compressor is allowed to turn on again after the high pressure switch resets, and the maximum cycle rate of the compressor is limited to once every 15 seconds, as governed by the control logic.

When the low pressure switch signals a low pressure condition, the refrigerant compressor is turned off. The compressor is allowed to turn on after the low pressure switch resets, and the maximum cycle rate of the compressor is limited to once every 15 seconds, as governed by the control logic.

If system supply voltage falls below 11 volts, APADS automatically shuts down the refrigerant compressor. When system supply voltage rises, APADS allows the compressor to turn back on.

The refrigerant compressor is shut down until the next ignition cycle, if any of the following faults occur:

- high pressure
- open clutch
- shorted clutch

Heater

Moving the temperature slide lever from COOL to WARM opens the water regulating valve, which allows engine-heated coolant to flow through the

heater core. The blower motor forces air through the heater core fins and ducts to warm the cab.

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

WARNING: Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

⚠ WARNING

WARNING: R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion, which could cause personal injury or property damage. R–134a may be safely pressured with dry nitrogen.

You must work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R-134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG), or polyol ester (POE) oil is used in the compressor. When handling these oils, observe the following:

- keep the oil free of contaminants
- do not expose the a/c system or the oil container to air for long periods of time; PAG and POE oils absorb moisture quickly
- use care when handling: painted surfaces, plastic parts, and other components (drive belts) could be damaged if the oil is spilled on them
- never mix the oils with other types of refrigerant oil

Heater and Air Conditioner Removal and Installation

Removal (See Fig. 1)

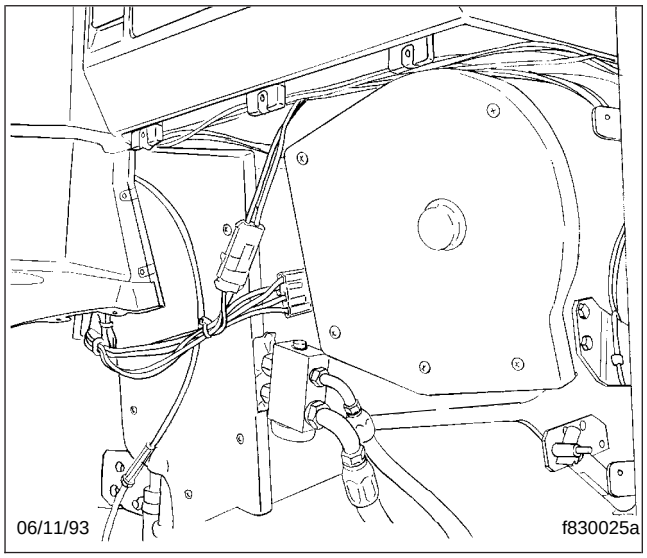


Fig. 1, Behr Heater/Air-Conditioner

⚠ WARNING

Before doing any of the work below, read the safety precautions in Subject 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

Whenever a refrigerant line is disconnected, replace the rubber O-ring (see **Fig. 2**). Lubricate the new O-ring with mineral oil and apply Loctite® 565 or 592 to the male fitting threads before connecting the lines.

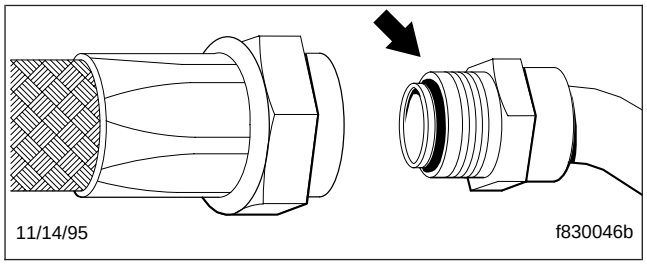


Fig. 2, Replace the Rubber O-Ring

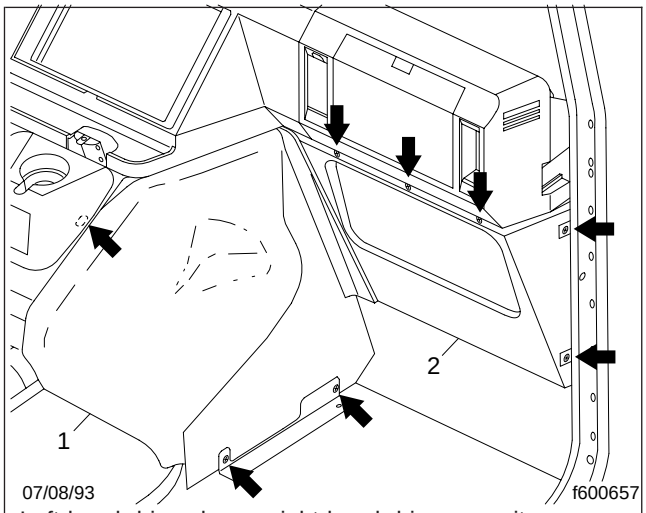
1. Disconnect the batteries.

⚠ WARNING

Do not drain the cooling system while the engine is hot. To avoid personal injury from scalding coolant, wait until the engine has cooled before draining the system.

2. Move the temperature slide lever to "WARM." With the engine cold, remove the cooling system drain plug, and drain the coolant into a clean container.
3. On COEs, remove the screws securing the dash skirt panels (see **Fig. 3**) on the passenger's side of the cab.

   On Conventionals, remove the screws securing the dash skirt panels (see **Fig. 4**) on the passenger's side of the cab. Remove the five fasteners that attach the two panels on the passenger's side of the electrical access panel, then remove the panels. Loosen the quarter-turn screws and remove the electrical access panel.



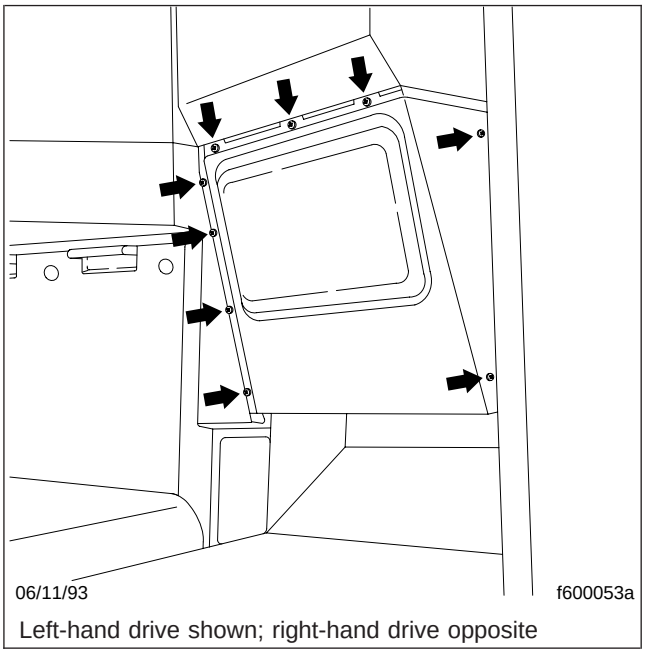
Left-hand drive shown; right-hand drive opposite

1. Passenger-Side Tunnel Cover
2. Passenger-Side Dash Skirt Panel

Fig. 3, COE Heater/Air-Conditioner Dash Skirt Panels

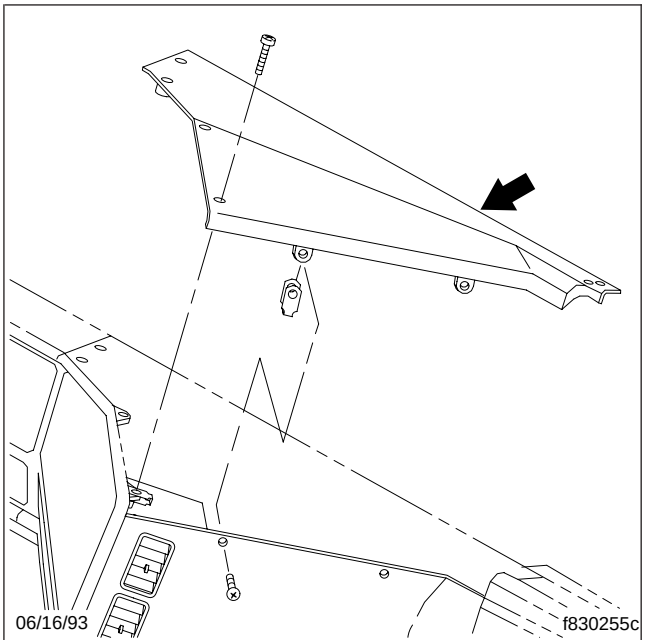
4. On right-hand drive (RH DR) FLBs, remove the door check arm. For detailed instructions, see Section 72.00, **Subject 192**.
5. On Conventionals, remove the B-section dash cover (see **Fig. 5**) by removing the seven fasteners and lifting the cover off the dash.

Heater and Air Conditioner Removal and Installation



Left-hand drive shown; right-hand drive opposite

Fig. 4, 120 Conventional Heater/Air-Conditioner Dash Skirt Panels

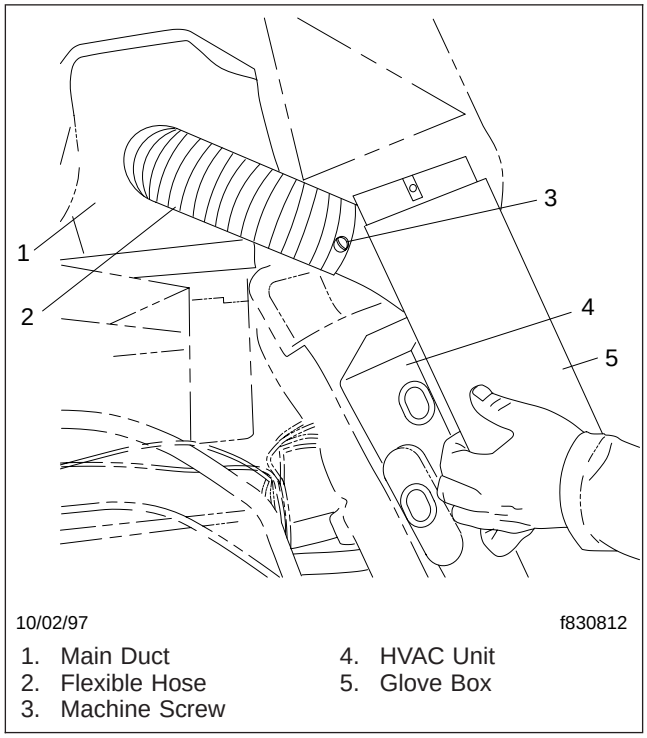


Left-hand drive shown; right-hand drive opposite

Fig. 5, Dash Cover

6. Remove the glove box.

6.1 On COEs, remove the three nuts and spring washers inside the box. Remove the three screws (four T30 torx-head machine screws on RH DR FLBs) from the passenger-side dash skirt panel. Remove the two machine screws attaching the passenger-side dash outlet flex hose to the duct on the back of the glove box assembly. Disconnect the flex hose. See **Fig. 6**.



1. Main Duct
2. Flexible Hose
3. Machine Screw
4. HVAC Unit
5. Glove Box

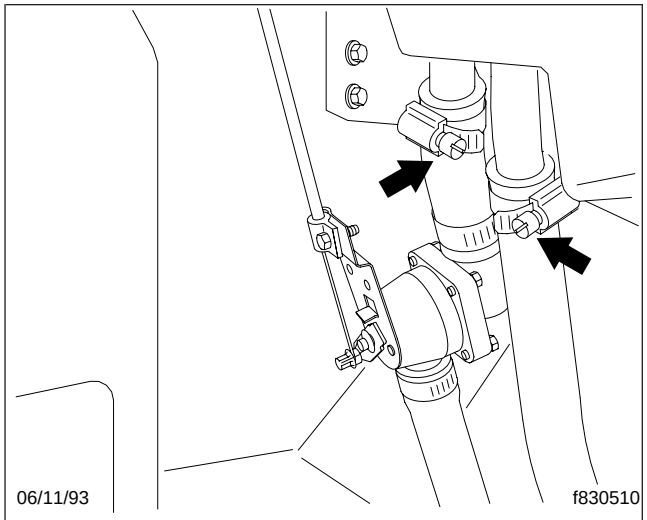
Fig. 6, Removing the Flex Hose

6.2 On Conventionals, remove two screws inside the glove box and remove the top panel from the assembly. Remove the three nuts and spring washers inside the box. Disconnect the two flex hoses from the ducts at the back of the glove box.

Disconnect the blue air line from the air cylinder at the back of the glove box.

NOTE: Pushing up on the upper inboard corner of the assembly, then swinging the lower outboard corner out, may ease removal of the glove box assembly.

7. Protect the carpeting with a shop towel, and loosen the hose clamps. Disconnect the heater core inlet and outlet hoses. See **Fig. 7**.



Left-hand drive shown; right-hand drive similar

Fig. 7, Heater Core Inlet and Outlet Hose Connections

8. Unplug the connectors for the blower motor, resistor block, and the thermostatic switch.
9. Remove the sealant from the drain tube(s) that pass through the cab deck.
10. Wearing protective goggles and gloves, recover the refrigerant from the system. For instructions, see **Subject 250**.
11. Remove the mastic insulating tape from around the expansion valve.
12. Using a wrench, disconnect the two refrigerant lines from the expansion valve.

CAUTION

Water and dirt can damage the refrigerant system. Five minutes of not being capped is the limit for any hose or component. Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

13. On Conventionals, remove the six capscrews that attach the fresh air inlet duct on the engine side of the cab frontwall. Remove the silicone sealant from the duct and push the rubber boot inside the cab.
14. Disconnect the air line from the air recirculation door air cylinder and move it out of the way. See **Fig. 8**.

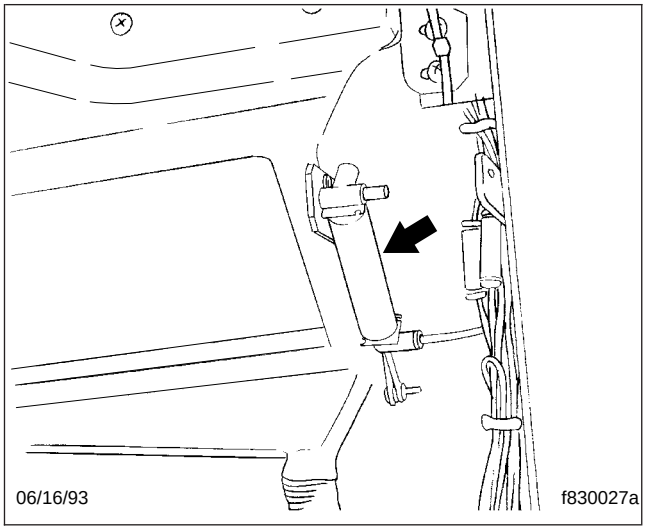


Fig. 8, Air Cylinder

15. Using a 7/16-inch wrench, remove the six capscrews that hold the heater/air-conditioner unit in place.
16. Lift the unit out of the truck, withdrawing the drain tubes from the floorboard as the unit is removed.

NOTE: On Conventionals, pull out the lower outboard side of the unit first. If needed, remove the drain tubes and the grab handle to assist in removal of the unit.

Installation

1. Feed the drain tubes through the floorboard as the unit is installed (if the drain tubes were removed, make sure that they are fastened securely to the unit). Also, make sure that the flex hoses for the air ducts are positioned behind the unit.

   On Conventionals, pull the rubber boot through the frontwall from the engine side. Install the six capscrews that attach the fresh air inlet duct on the engine side of the frontwall. Tighten the capscrews securely. Using RTV silicone, seal the area around the rubber boot.

Heater and Air Conditioner Removal and Installation

2. Install the six capscrews that secure the heater/air-conditioner. Tighten them 48 lbf·in (540 N·cm). Using RTV silicone, seal the area around the drain tubes and cab floor.
3. On Conventionals, install the grab handle (if removed).
4. Connect the air line to the air recirculation door air cylinder.
5. Remove the plugs from the refrigerant lines and the expansion valve. Install new O-rings and lubricate them with mineral oil. Apply Loctite 565 or 592 to the male fitting threads and connect the refrigerant lines to the expansion valve. Using a wrench, tighten the connections to the correct value as shown in **Table 1**.

Refrigerant Line Torque Specifications		
Metal Tube Outside Diameter (in inches)	**Steel Tube Torque * in lbf·ft (N·m)**	**Aluminum or Copper Tube Torque in lbf·ft (N·m)**
1/4	10–15 (14–20)	5–7 (7–9)
3/8	30–35 (41–47)	11–13 (15–18)
1/2	30–35 (41–47)	15–20 (20–27)
5/8	30–35 (41–47)	21–27 (28–37)
3/4	30–35 (41–47)	28–33 (38–45)

* When tightening fittings, always use the torque reading for the softer metal (when unlike metals are used).

Table 1, Refrigerant Line Torque Specifications

6. Evacuate and charge the system with refrigerant. See **Subject 250** for instructions. Be sure to add refrigerant oil to the compressor, to replace that which is lost when the system is discharged. See the refrigerant compressor section elsewhere in this group.
7. Wipe clean the expansion valve and refrigerant lines, and wrap them with mastic insulating tape.
8. Connect the wire connectors to the blower motor resistor block and the thermostatic switch.
9. Connect the heater inlet and outlet hoses. Tighten the clamps securely.
10. Install the glove box.

    10.1 On Conventionals, connect the flex hoses to the ducts at the back of the glove box assembly. Make sure that the hoses are not twisted. Connect the blue air line to the air cylinder at the back of the glove box. Install the glove box in the dash. Tighten the fasteners until snug.

    Install the top cover on the glove box assembly.

    10.2 On COEs, connect the passenger-side dash outlet flex hose to the duct at the back of the glove box assembly. Make sure that the flex hose is not twisted. Install the glove box in the dash. Tighten the fasteners until snug.
11. On right-hand drive (RH DR) FLBs, install the door check arm, as removed. For detailed instructions, see Section 72.00, **Subject 192**.
12. On Conventionals, install the B-section dash cover. Tighten the fasteners until snug.
13. On Conventionals, install the electrical access panel. On COEs and Conventionals, install the dash skirt panels on the passenger's side of the cab.
14. Install the radiator drain plug and fill the cooling system.
15. Connect the batteries.
16. Start the engine. When the engine thermostat(s) opens, air will be forced from the heater core as the coolant circulates. Check the coolant level again and fill as needed.

Removal

1. Move the temperature slide lever to "WARM."

⚠ WARNING

WARNING: Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

2. With the engine cold, remove the cooling system drain plug, and drain the coolant into a clean container.
3. Disconnect the batteries.
4. Remove the dash skirt panels.

   4.1 On COEs, remove the screws securing the dash skirt panels on the right side of the cab. See **Fig. 1.**

   4.2 On Conventionals, remove the screws securing the dash skirt panels (**Fig. 2**) on the right side of the cab. Remove the five fasteners that attach the two panels on the right side of the electrical access panel, then remove the panels. Remove the three fasteners that attach the panel on the left side of the electrical access panel, then remove the panel. Loosen the quarter-turn screws and remove the electrical access panel.

   Remove the six fasteners that attach the electrical access panel support bracket to the cab tunnel, then remove the bracket.

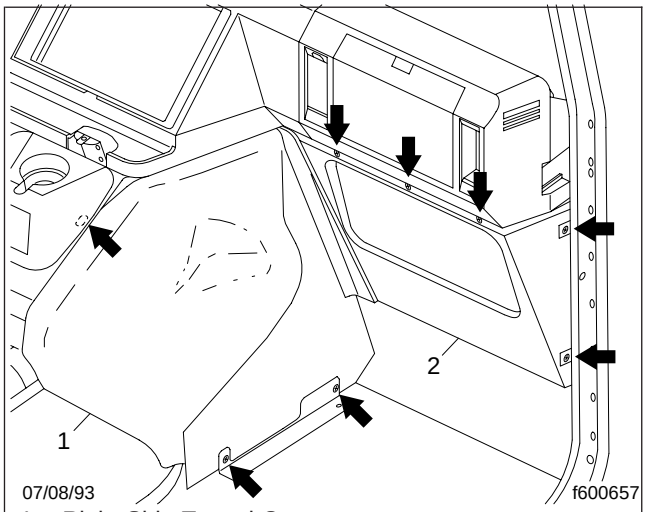
5. On Conventionals, remove these additional dash panels.

   5.1 Remove three capscrews under the center dash console (above the electrical access panel).

   5.2 Remove the three screws that attach the kick panel located just to the right of the accelearator pedal. Remove the panel.

   Move the wiring as needed to access and remove the screw that secures the under dash cover.

   5.3 Remove the two bottom screws that attach the heater and air conditioner control panel to the dash.



1. Right-Side Tunnel Cover
2. Right-Side Dash Skirt Panel

Fig. 1, COE Heater/Air-Conditioner Dash Skirt Panel Screws

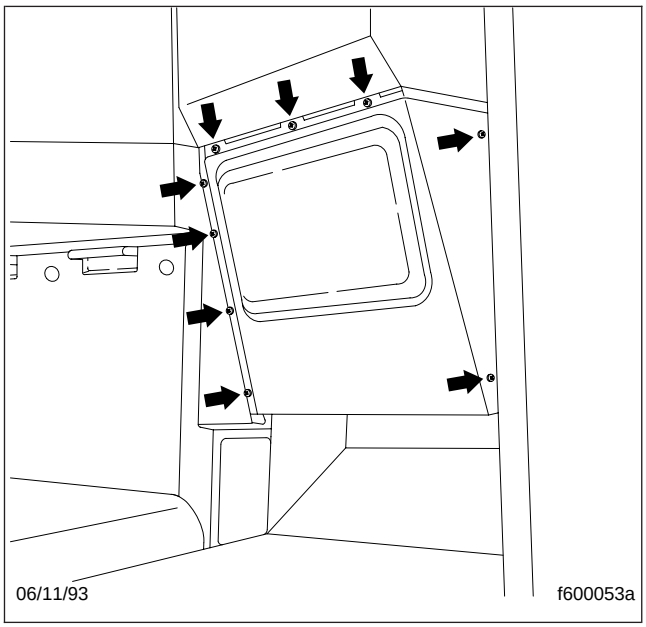


Fig. 2, 120 Conventional Heater/Air-Conditioner Dash Skirt Panel Screws

   5.4 Move the under dash panel to allow access to the heater core cover.

   5.5 Remove two screws inside the glove box and remove the top panel from the assembly. Remove the three nuts and spring

Heater Core Removal and Installation

washers inside the box. Disconnect the two flex hoses from the ducts at the back of the glove box.

Disconnect the blue air line from the air cylinder at the back of the glove box. Remove the glove box.

6. Protect the carpeting with a shop towel, and loosen the clamps attaching the heater hoses to the heater core pipe elbows. See **Fig. 3.** Disconnect the heater inlet and outlet hoses.

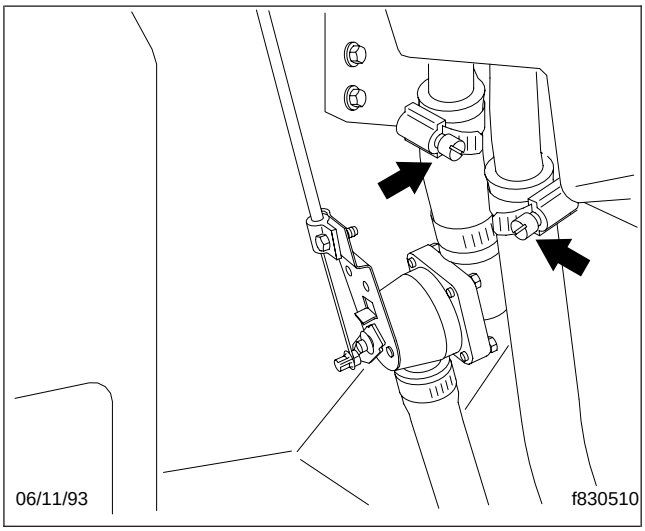


Fig. 3, Heater Core Inlet and Outlet Hose Connections

7. Remove the screws from the heater/air-conditioner core cover. See **Fig. 4.** Remove the cover.

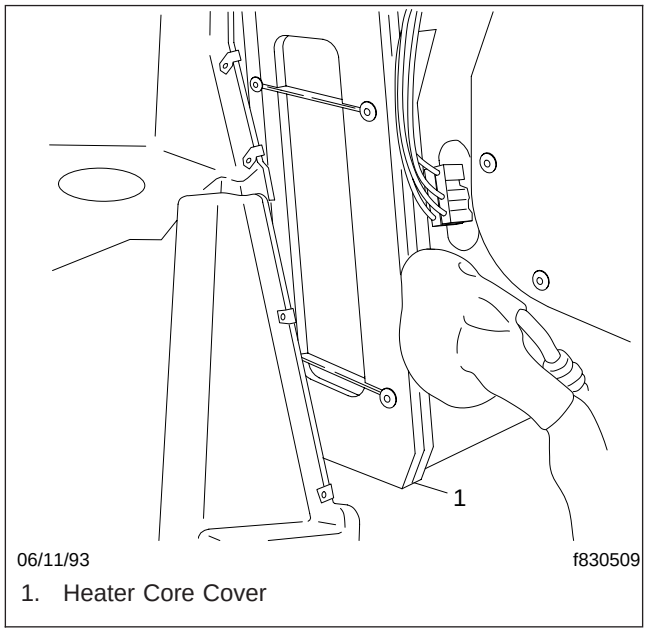
⚠ WARNING

WARNING: Failure to wear protective gloves could result in serious skin cuts due to the sharp edges on the heater core fins.

8. Wearing protective gloves, slide the heater core up and out, and remove it from the housing. See **Fig. 5**.

Installation

1. Wearing protective gloves, slide the heater core into the housing. Connect the heater inlet and outlet hoses to the heater core pipe elbows. Tighten the clamps securely.



1. Heater Core Cover

Fig. 4

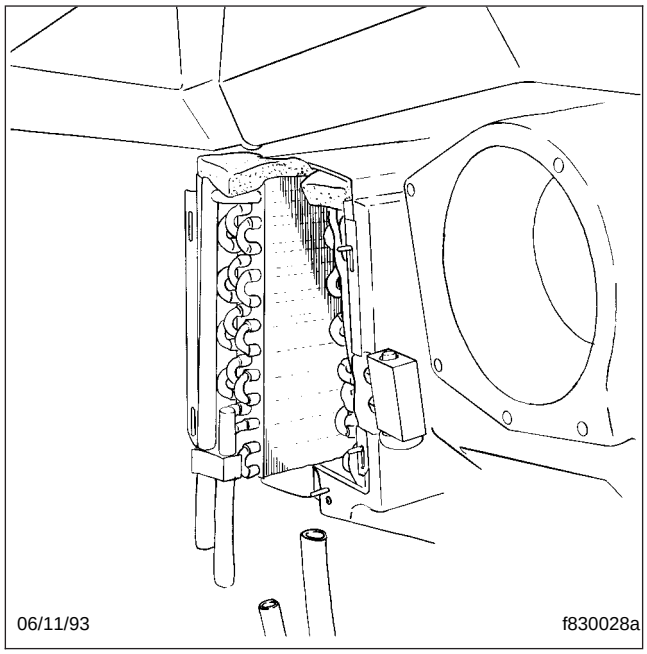


Fig. 5, Heater Core Partially Removed

2. Install the heater core cover, and tighten the screws securely.
3. Install the dash skirt panels.

3.1 On COEs, install the screws securing the dash skirt panels on the right side of the cab.

3.2 On Conventionals, position the electrical access panel support bracket on the cab tunnel, then install the six fasteners that attach the bracket to the tunnel.

Position the two panels on the right side of the electrical access panel, then install the five fasteners that attach the panels. Position the panel on the left side of the electrical access panel, then install the three fasteners that attach the panel. Position the electrical access panel, then tighten the quarter-turn screws.

4. On Conventionals, install these additional dash panels.

4.1 Connect the flex hoses to the ducts at the back of the glove box assembly. Make sure that the hoses are not twisted. Connect the blue air line to the air cylinder at the back of the glove box. Install the glove box in the dash. Tighten the fasteners until snug.

Install the top cover on the glove box assembly.

4.2 Install the dash skirt panel on the right side of the cab (below the glove box).

4.3 Install the two bottom screws that attach the heater and air conditioner control panel to the dash.

4.4 Move the wiring as needed to install the screw that secures the under dash cover.

Position the kick panel located just to the right of the accelearator pedal, then install and tighten the three screws.

4.5 Install the three capscrews under the center dash console (above the electrical access panel).

5. Connect the batteries.

6. Install the cooling system drain plug and fill the cooling system.

7. Start the engine. When the engine thermostat(s) opens, air will be forced from the heater core as the coolant circulates. Check the coolant level again and fill as needed.

Blower Motor Removal and Installation

Removal

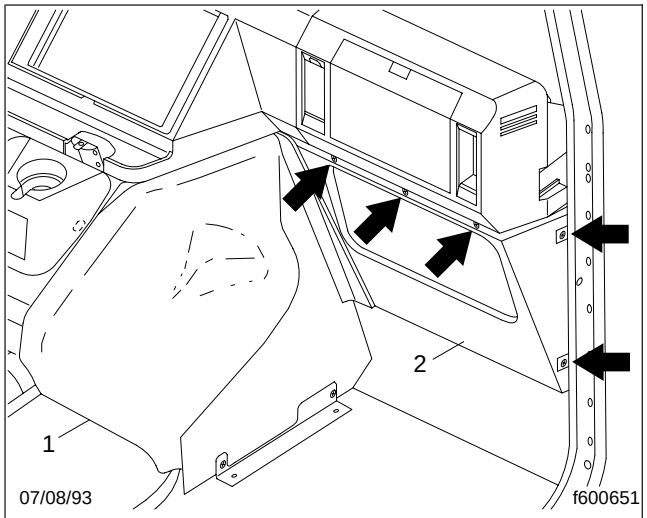
1. Turn off the ignition switch.

⚠ WARNING

WARNING: Failure to turn off the ignition switch could allow the blower motor to operate during repairs. This could result in personal injury or electrical shock.

2. On COEs, remove the screws securing the dash skirt panel on the right side of the cab. See **Fig. 1.**

   On 120 Conventionals, remove the screws securing the dash skirt panel on the right side of the cab. See **Fig. 2.**



1. Right-Side Tunnel Cover
2. Right-Side Dash Skirt Panel

Fig. 1, COE Heater/Air-Conditioner Dash Skirt Panel Screws

3. Remove the five torx-head screws from the blower motor cover (**Fig. 3**). Then remove the cover.
4. Disconnect the blower motor wires.
5. Remove the three screws from the blower motor bracket, then lift the blower motor out of the housing by hand.

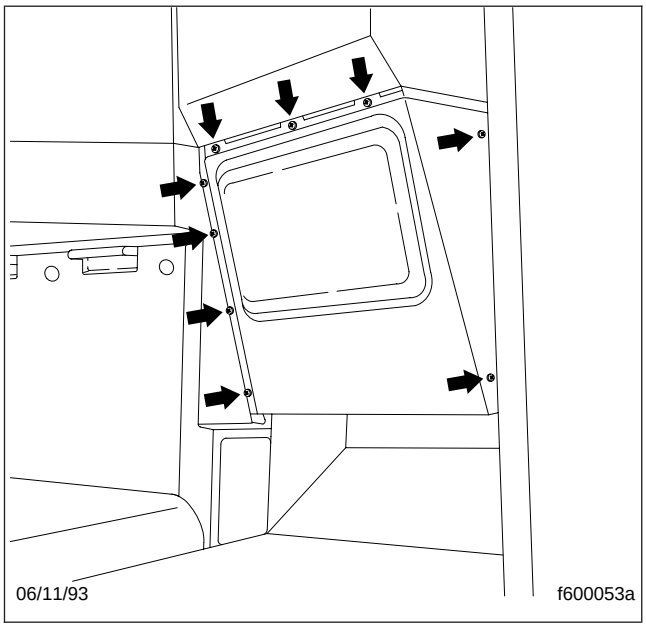


Fig. 2, 120 Conventional Heater/Air-Conditioner Dash Skirt Panel Screws

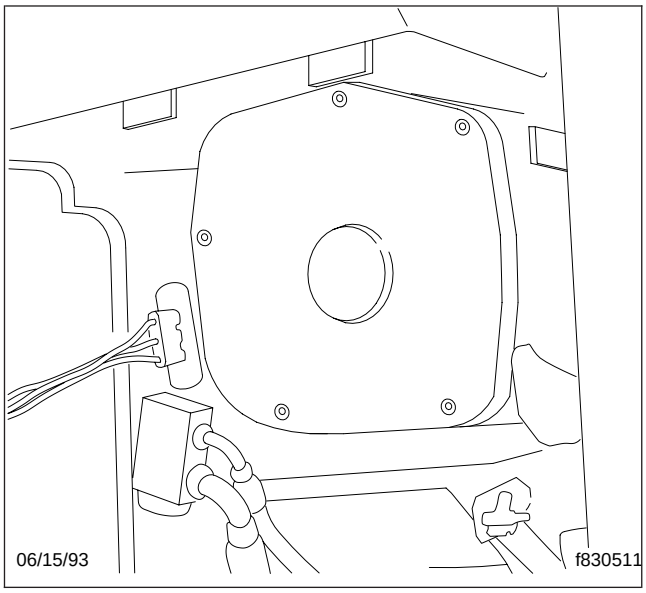


Fig. 3

Installation

1. Position the blower motor on the mounting bracket in the housing. Install the screws and tighten them securely.

Blower Motor Removal and Installation

2. Connect the blower motor wires.
3. Install the blower motor cover and secure it with the five torx-head screws. Tighten the screws securely.
4. Turn on the ignition key and test the blower motor.
5. Install the dash skirt panel.

Bunk Blower Motor Removal and Installation, COE

Removal

1. Turn off the ignition switch.

⚠ WARNING

WARNING: Failure to turn off the ignition switch could allow the blower motor to operate during repairs. This could result in personal injury or electrical shock.

2. Open the right side baggage compartment door. Remove the three phillips-head machine screws, and the two clips, from the bunk blower motor access cover located in the bottom of the air duct. **See Fig. 1**. Remove the cover.

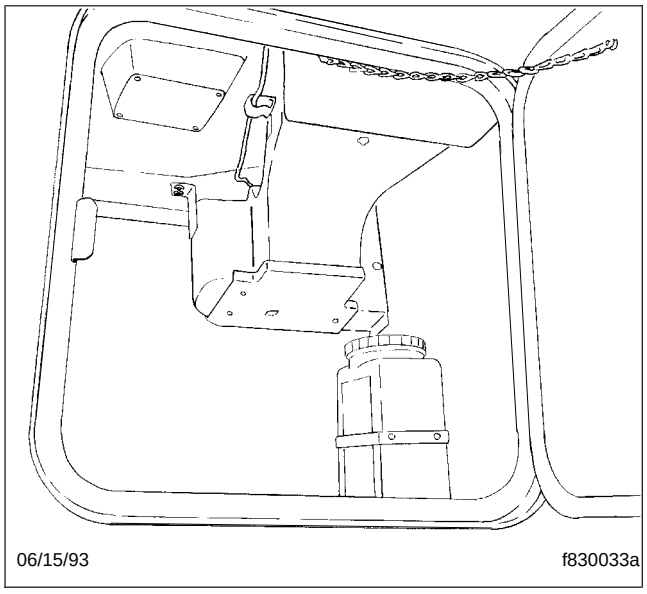


Fig. 1

3. Remove the two locknuts, washers, and bolts from the blower motor support bracket. **See Fig. 2**. Remove the blower motor and bracket from the duct work.
4. Disconnect the blower motor wires.

Installation

1. Connect the wires to the bunk blower motor.
2. Position the blower motor and mounting brackets in the bunk duct. Install the nuts and flatwashers. Tighten the nuts 30 lbf·in (340 N·cm).

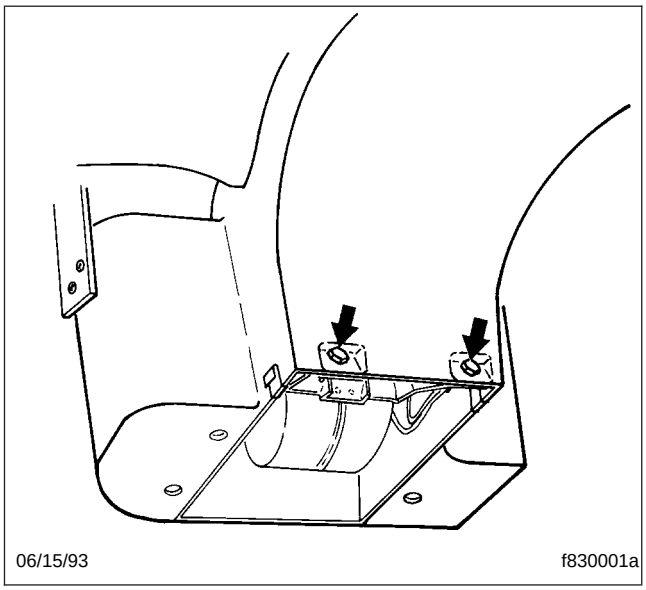


Fig. 2

3. Install the blower motor cover using the two clips and three phillips-head machine screws. Tighten the screws securely.
4. Turn on the ignition switch and test the blower motor.

Replacement

CAUTION

Never try to bypass the fuse in the blower motor resistor block. To do so could cause the blower motor to overheat, resulting in serious damage to the heater/air-conditioning system.

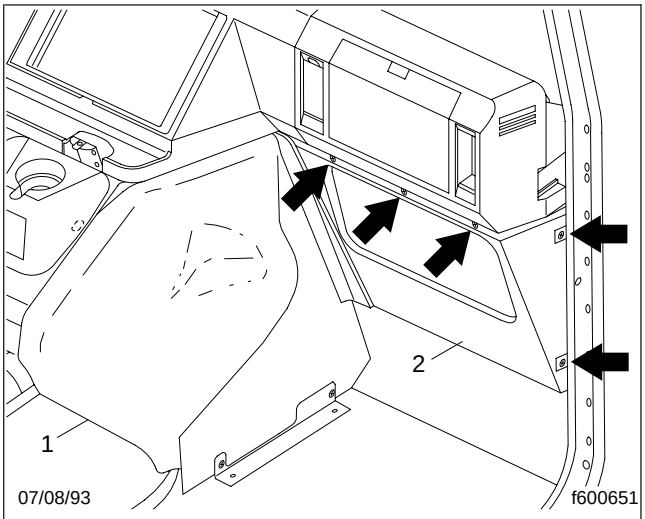
1. Turn off the ignition switch.

WARNING

Failure to turn off the ignition switch could allow the blower motor to operate during repairs. This could result in personal injury or electrical shock.

2. On COEs, remove the screws securing the dash skirt panel on the right side of the cab. See **Fig. 1**.

   On 120 Conventionals, remove the screws securing the dash skirt panel on the right side of the cab. See **Fig. 2**.



1. Right-Side Tunnel Cover
2. Right-Side Dash Skirt Panel

Fig. 1, COE Heater/Air-Conditioner Dash Skirt Panel Screws

3. Disconnect the harness from the resistor block.
4. Remove the two locknuts from the studs, and lift out the resistor block. See **Fig. 3**.

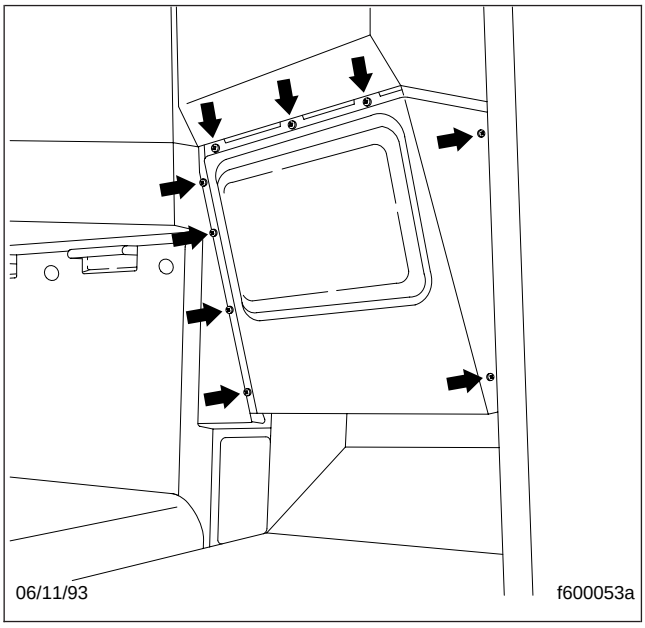


Fig. 2, 120 Conventional Heater/Air-Conditioner Dash Skirt Panel Screws

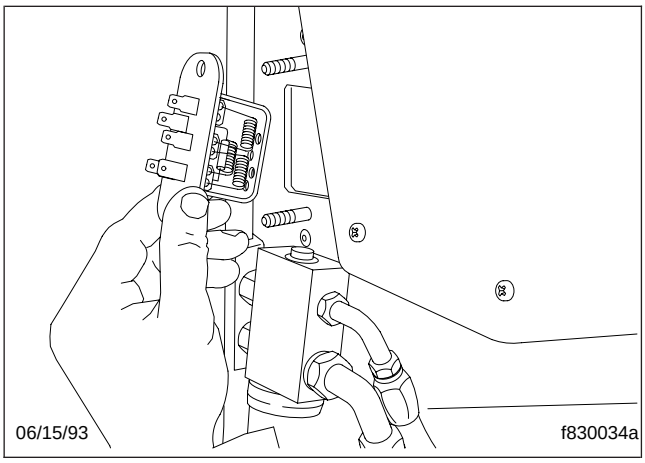


Fig. 3, Removing Resistor Block

5. Position the new resistor block on the mounting studs, and install the locknuts. Tighten the locknuts 30 lbf·in (340 N·cm).
6. Connect the wire harness.
7. Turn on the ignition key and test the blower motor.
8. Install the dash skirt panel.

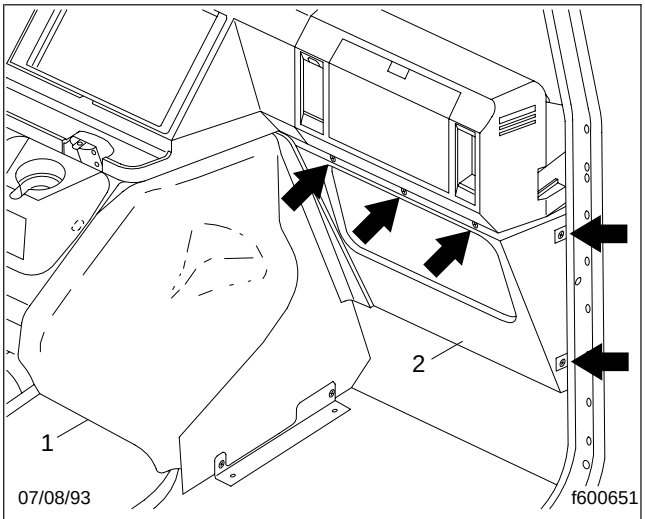
Removal and Installation

FRESH AIR RECIRCULATION FLAP AIR CYLINDER

Removal

1. Move the slide lever to "DEF." This will cut off air pressure to the air cylinder.
2. On COEs, remove the screws securing the dash skirt panel on the right side of the cab. **See Fig. 1**.

   On 120 Conventionals, remove the screws securing the dash skirt panel on the right side of the cab. **See Fig. 2**.



1. Right-Side Tunnel Cover
2. Right-Side Dash Skirt Panel

Fig. 1, COE Heater/Air-Conditioner Dash Skirt Panel

3. Disconnect the air line from the air cylinder by pushing in the cover ring; then pull out the air line. **See Fig. 3**.
4. Remove one locknut or retainer clip from the upper rod, and the other locknut or retainer clip, from the recirculation flap rod. Remove the air cylinder by sliding it off the mounting rods. **See Fig. 4**.

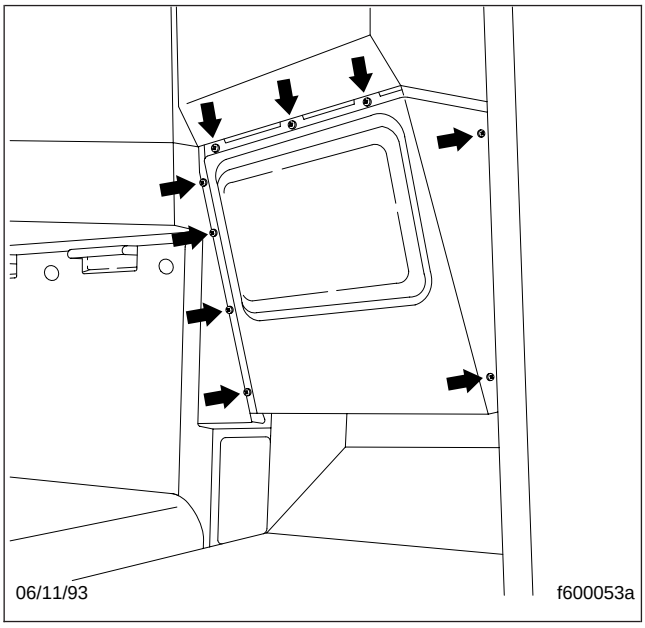
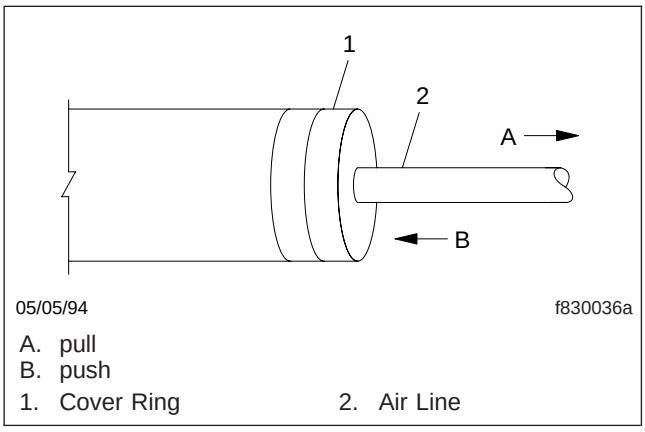


Fig. 2, 120 Conventional Heater/Air-Conditioner Dash Skirt Panel



A. pull
B. push
1. Cover Ring
2. Air Line

Fig. 3

Installation

1. Place the air cylinder on the mounting rods, and install the locknuts or retainer clips. If so equipped, tighten the locknuts 30 lbf·in (340 N·cm).
2. Connect the air line to the air cylinder by pushing the air line into the fitting as far as it will go and then gently pulling the air line back to lock it in place.

Air Cylinder Removal and Installation

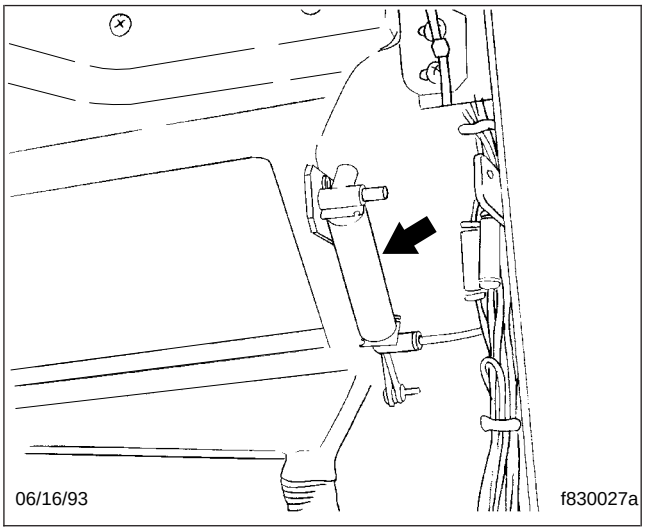


Fig. 4, Air Cylinder

3. Test the air cylinder by moving the slide lever from "DEF" to "MAX A/C." Be sure the flap works freely, has full movement, and seals completely.
4. Install the dash skirt panel.

FACE-DUCT AIR CYLINDER (COE)

(See Fig. 5)

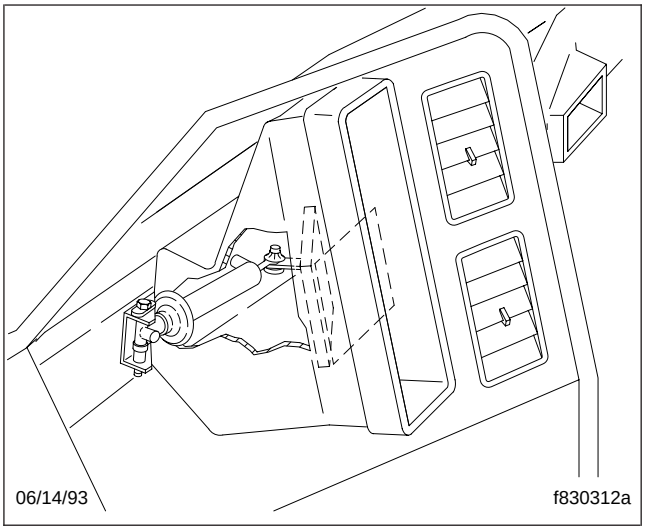
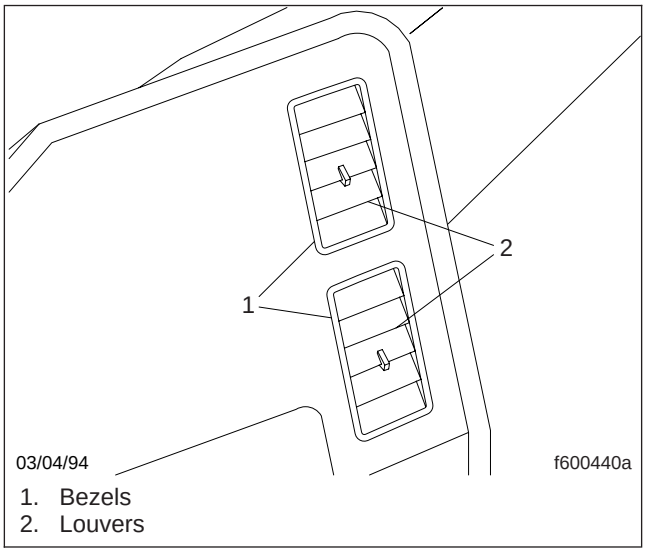


Fig. 5

Removal

1. Mark the two louvers and bezels (**Fig. 6**) on the right side of the instrument panel so they can be installed in the same position. Using a short, thin, flat-bladed screwdriver, remove the two louvers by gently prying the tabs that hold them in the bezels. Push the louvers into the duct, then rotate them to remove them from the bezel.



1. Bezels
2. Louvers

Fig. 6

2. Remove the B-section dash cover (**Fig. 7**) by removing the seven fasteners (either Torx or Phillips screws) and lifting the cover off the dash.
3. Move the slide lever to "DEF." This will cut off air pressure to the air cylinder.
4. Using a long, flat-bladed screwdriver and a flashlight, reach into the duct and gently pry the push nut up and off the door rod end of the air cylinder. **See Fig. 8**.
5. To prevent the spacer that is below the air cylinder mounting boss from falling down into the dash, either tape the spacer or hold it by reaching down through the upper dash opening. Remove the bolt that attaches the left end of the cylinder to the mounting bracket. Remove the spacer. **See Fig. 8**.

NOTE: The cylinder is preloaded and will pop in slightly when the bolt is removed.

6. While holding the grommet in place with your right hand, gently remove the cylinder with your left hand by pulling it out of the duct to the left with a twisting motion.

Air Cylinder Removal and Installation

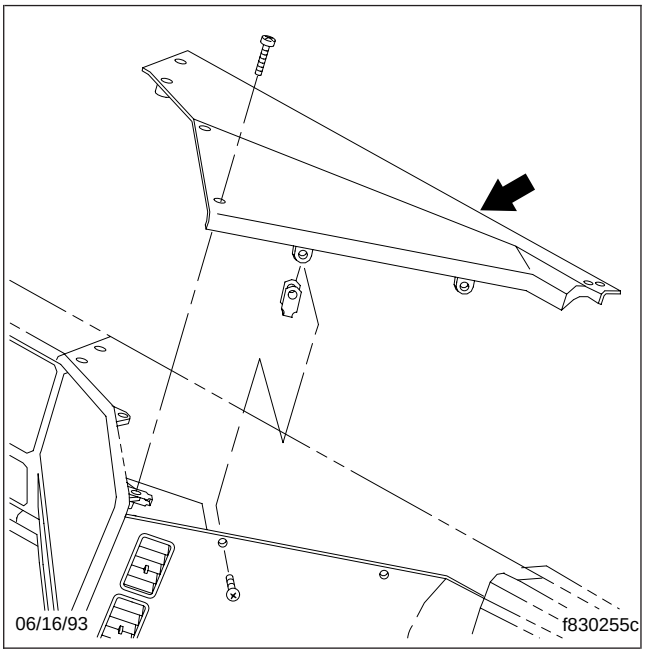
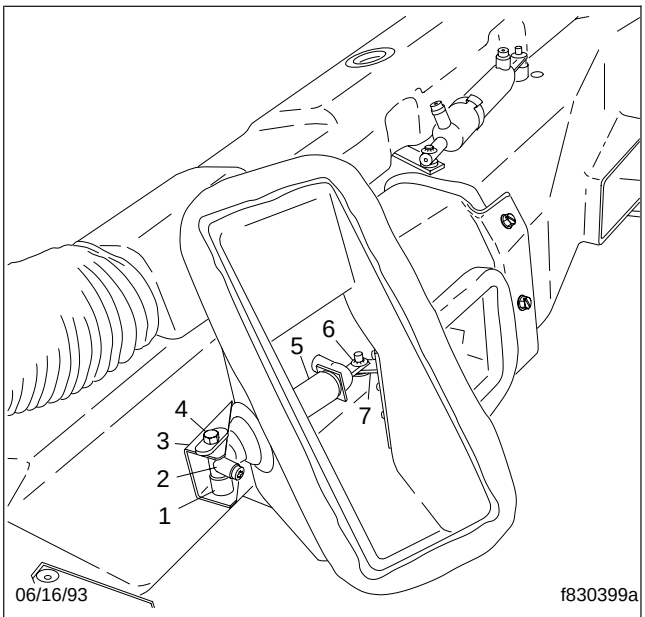


Fig. 7, Dash Cover



1. Spacer
2. Air Cylinder Mounting Boss
3. Bracket
4. Bolt
5. Air Cylinder
6. Push Nut
7. Door Rod

Fig. 8

7. Remove the air line from the cylinder by pushing in the blue cover ring and pulling out the line. **See Fig. 3**.

Installation

1. While holding on to the grommet, insert a new air cylinder through the grommet.
2. Supply shop air to the cylinder to extend the piston rod. Then, hook the piston rod end onto the door pivot. Install a new push nut on the pivot.
3. Install the mounting bolt and spacer(s).
4. Connect the air line to the air cylinder by pushing the air line into the fitting as far as it will go and then gently pulling the air line back to lock it in place.
5. Test the air cylinder by moving the slide lever from "DEF" to "MAX A/C." Be sure the flaps work freely, have full movement, and seal completely.
6. Install the dash covers.
7. Install the louvers by inserting them in the duct and positioning them in the bezel as marked earlier. Then, pull them toward you to snap them in place.

Other Air Cylinders

Removal

1. Move the slide lever to "DEF." This will cut off air pressure to the air cylinders.
2. Remove the center dash cover and locate the air cylinders. **See Fig. 9** and **Fig. 10**.
3. Disconnect the air lines from the air cylinders by pushing in the cover ring; then pull out the air line. **See Fig. 3**.
4. Remove the retainer clips from the stud and the flap rod. Remove the air cylinder by sliding it off the mounting rods.

Installation

1. Place the air cylinder on the mounting rods, and install the retainer clips.
2. Connect the air lines to the air cylinders by pushing the air line into the fitting as far as it will go and then gently pulling the air line back to lock it in place.

Air Cylinder Removal and Installation

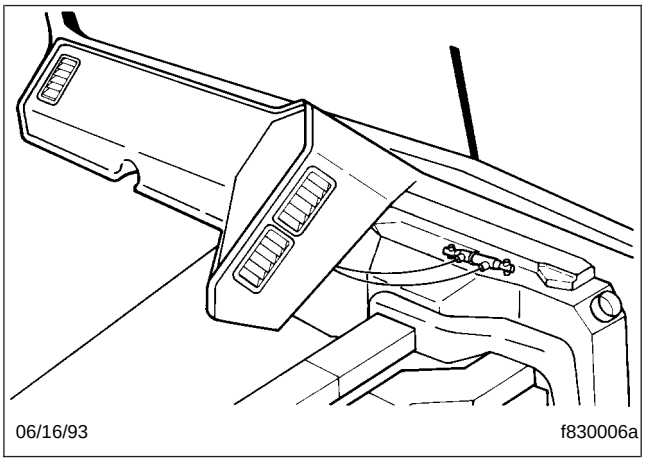


Fig. 9, Air Cylinder Location, COE

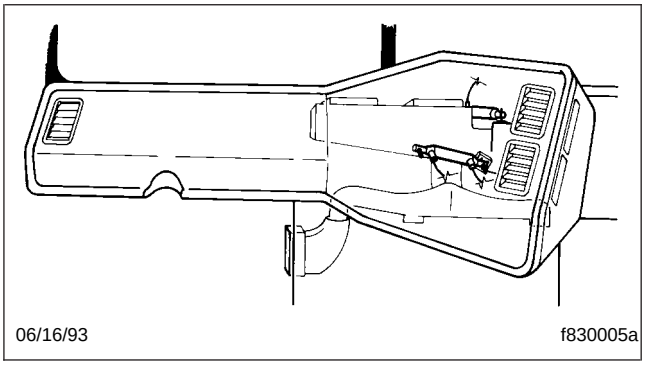


Fig. 10, Air Cylinder Location, Conventional

3. Test the air cylinders by moving the slide lever from "DEF" to "MAX A/C." Be sure the flaps work freely, have full movement, and seal completely.
4. Install the center dash covers.

Removal

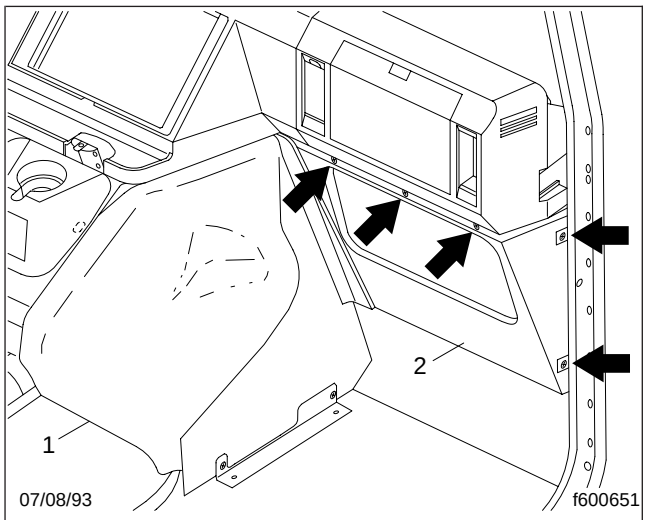
1. Move the temperature slide lever to "WARM."

⚠ WARNING

WARNING: Do not drain the cooling system while the engine is hot. To avoid personal injury from scalding coolant, wait until the engine has cooled before draining the system.

2. With the engine cold, remove the cooling system drain plug, and drain the coolant into a clean container.
3. On COEs, remove the screws securing the dash skirt panel on the right side of the tunnel. See **Fig. 1**.

   On 120 Conventionals, remove the screws securing the dash skirt panels (**Fig. 2**) on the right side of the cab; loosen the quarter-turn screws and remove the electrical access panel.



1. Right-Side Tunnel Cover
2. Right-Side Dash Skirt Panel

Fig. 1, Remove Dash Skirt Panel Screws, COE

4. Protect the carpeting with a shop towel, and loosen the clamps attaching the heater hoses to the water regulating valve. See **Fig. 3**. Disconnect the hoses from the valve.
5. Loosen the temperature slide lever cable clamp. See **Fig. 4**.

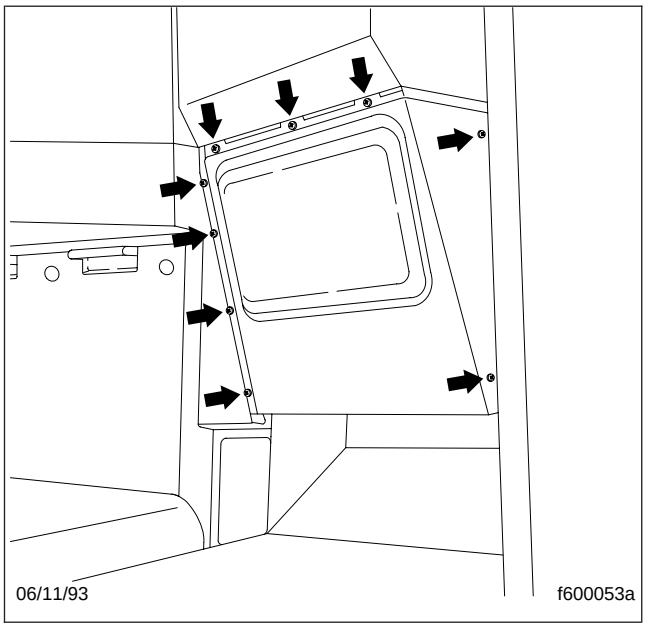


Fig. 2, Remove Dash Skirt Panel Screws, 120 Conventional

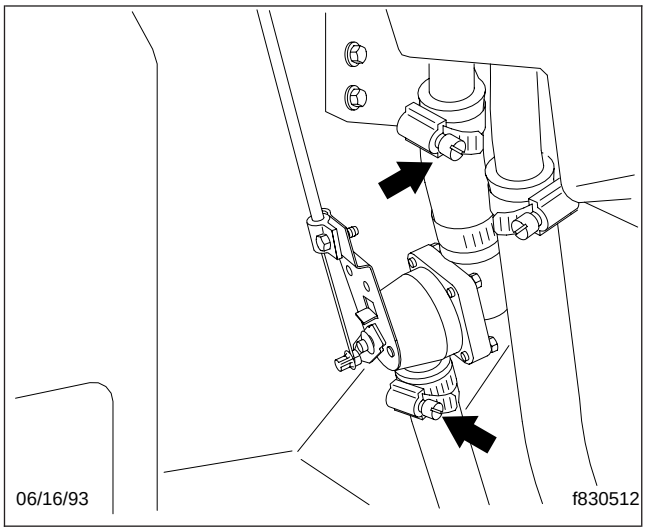


Fig. 3, Loosen Hose Clamps

6. Loosen the keeper (**Fig. 4**) that attaches the control cable to the water regulating valve rod. Then slip the cable off the end of the rod.
7. Remove the valve.

Water Regulating Valve Removal and Installation

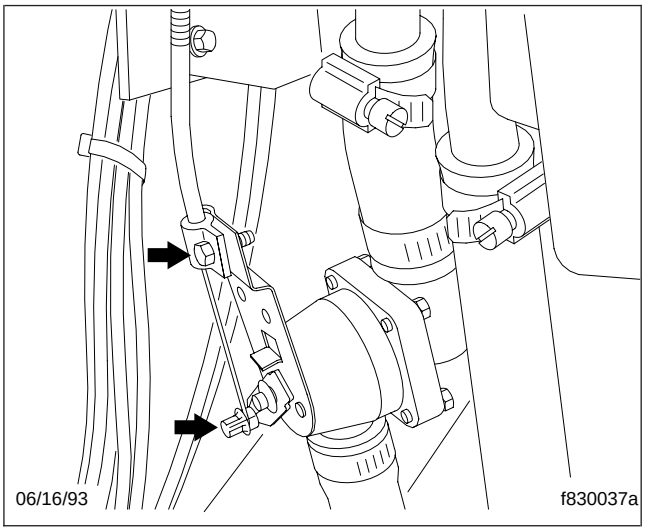


Fig. 4

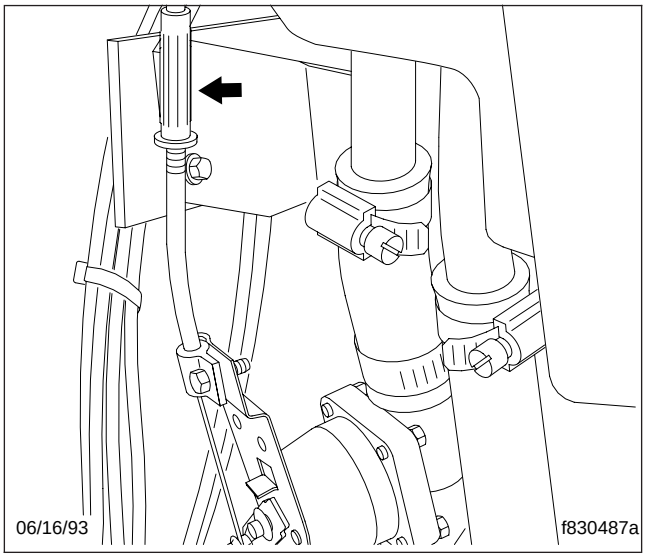


Fig. 5, Water Regulating Valve Cable Turnbuckle

Installation

1. Connect the heater hoses to the water regulating valve. Don't tighten the clamps at this time.
2. Feed the water regulating valve cable through the clamp and slip the end of the cable over the rod. Using the keeper, secure the end and tighten the cable clamp securely.
3. Tighten the hose clamps securely.
4. Move the temperature slide lever to "COOL." The water regulating valve should close completely. Slide the lever to "WARM." The valve should open. The travel of the lever should be smooth, and should travel the full distance on the control panel. If it doesn't, turn the adjustment turnbuckle (**Fig. 5**) in the direction necessary to get full travel.
5. Install the cooling system drain plug and fill the cooling system.
6. Start the engine. When the engine thermostat(s) opens, air will be forced from the heater core as the coolant circulates. Check the coolant level again and fill again as needed.
7. Check for leaks around the water regulating valve and correct the cause.
8. Install the dash skirt panels and the electrical access panel (on Conventionals).

Water Regulating Valve Cable Replacement

Replacement

1. Pull off the slide lever control knobs.
2. Remove the six screws attaching the control panel to the dash. See **Fig. 1**. Move the panel away from the dash.

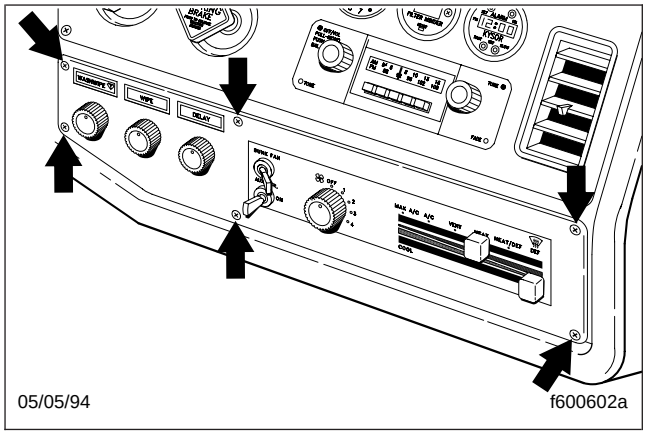


Fig. 1, Remove Control Panel Screws

3. Remove the four machine screws attaching the slide lever controls. See **Fig. 2**. Slide the unit to the side and pull it out of the dash as far as the cable will permit.

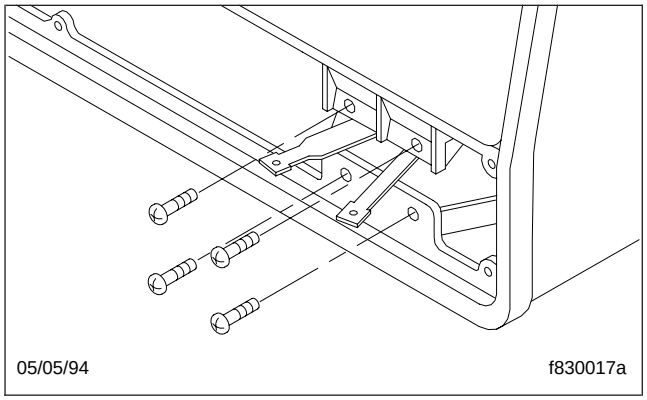


Fig. 2

4. Loosen the cable clamp screw (**Fig. 3**), then detach the cable from the slide lever.
5. On COEs, remove the screws securing the dash skirt panel on the right side of the tunnel. See **Fig. 4**.

   On 120 Conventionals, remove the screws securing the dash skirt panels (**Fig. 5**) on the right side of the cab; loosen the quarter-turn screws and remove the electrical access panel.

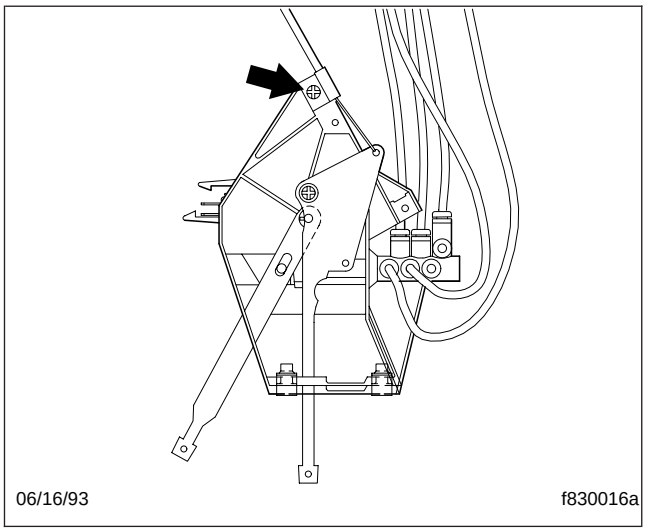
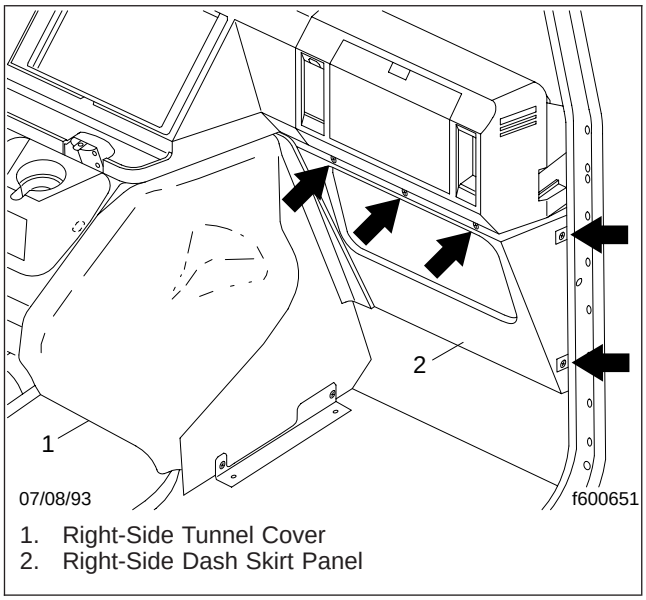


Fig. 3



1. Right-Side Tunnel Cover
2. Right-Side Dash Skirt Panel

Fig. 4, Remove Dash Skirt Panel Screws, COE

6. Loosen the control cable clamp (**Fig. 6**).
7. Loosen the keeper (see **Fig. 6**) that attaches the cable to the water regulating valve rod. Slip the cable off the end of the rod.
8. Pull the cable out of the dash.

Water Regulating Valve Cable Replacement

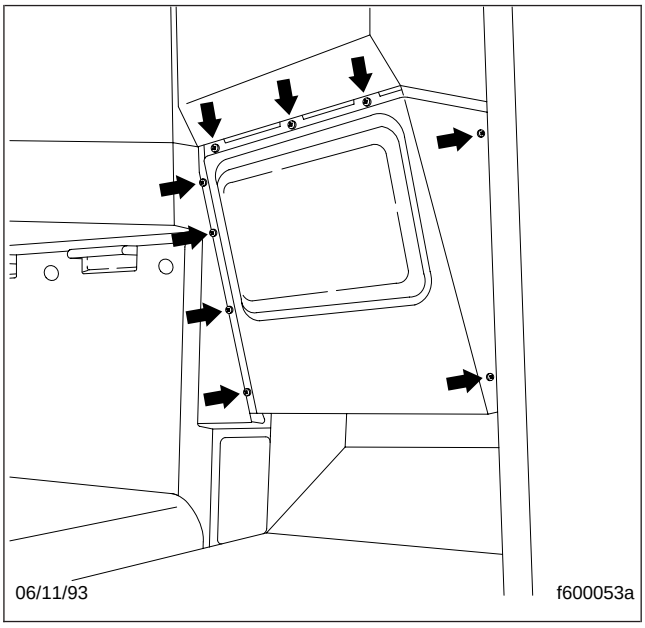


Fig. 5, Remove Dash Skirt Panel Screws, 120 Conventional

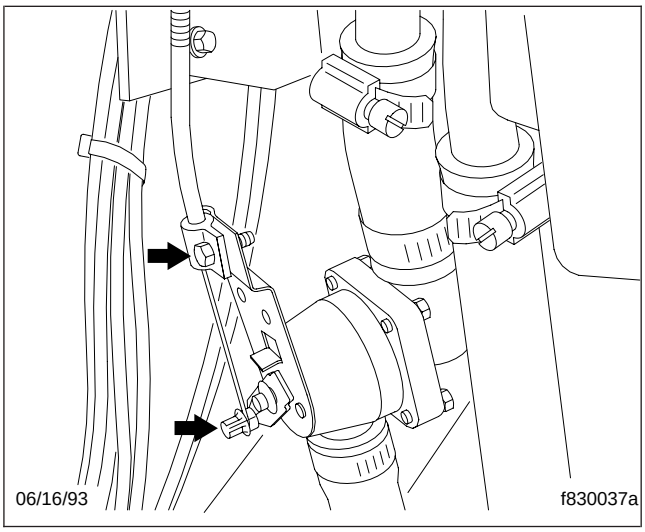


Fig. 6

9. Feed the replacement cable through the dash and through the clamp. Slip the end of the cable over the water regulating valve rod. Secure the end using the keeper and tighten the cable clamp securely.
10. At the other end of the cable, feed the end of the cable through the cable clamp and hook the end on the slide lever. Tighten the cable clamp securely.
11. Using the four machine screws, install the slide lever control unit.
12. Using the six screws, install the control panel.
13. Install the slide lever control knobs.
14. Move the temperature slide lever to "COOL." The water valve should close completely. Slide the control lever to "WARM." The valve should open. The travel of the slide lever should be smooth and should travel the full distance on the control panel. If it doesn't, turn the adjustment turnbuckle (**Fig. 7**) in the direction necessary to get full travel.

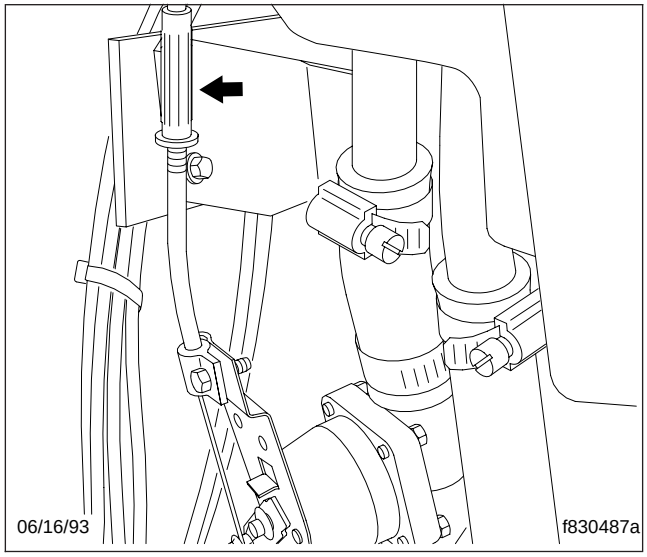


Fig. 7, Water Regulating Valve Cover Turnbuckle

15. Install the dash skirt panels and the electrical access panel (on Conventionals).

Evaporator Coil Removal and Installation

Removal

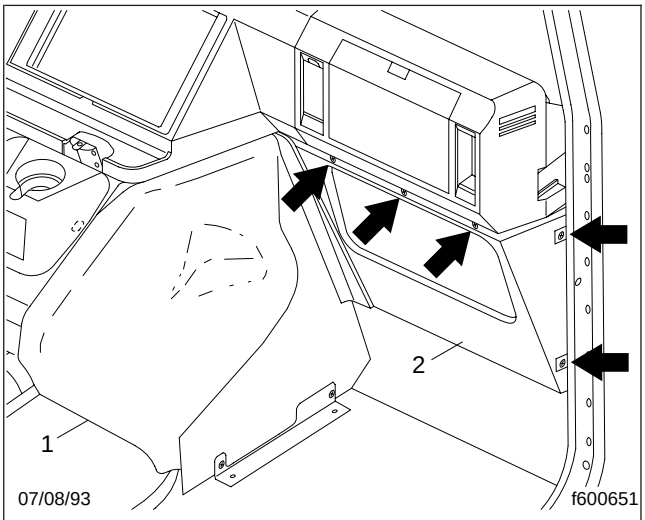
⚠ WARNING

WARNING: Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

Whenever a refrigerant line is disconnected, replace the rubber O-ring. Lubricate the new O-ring with mineral oil and apply Loctite® 242 or 592 to the male fitting threads before connecting the lines.

1. Disconnect the batteries.
2. Remove the dash skirt panels.

   2.1 On COEs, remove the screws securing the dash skirt panels on the right side of the cab. See Fig. 1.



1. Right-Side Tunnel Cover
2. Right-Side Dash Skirt Panel

Fig. 1, COE Heater/Air-Conditioner Dash Skirt Panel Screws

   2.2 On Conventionals, remove the screws securing the dash skirt panels (Fig. 2) on the right side of the cab. Remove the five fasteners that attach the two panels on the right side of the electrical access panel, then remove the panels. Remove the three fasteners that attach the panel on the left side of the electrical access panel, then remove the panel. Loosen the quarter-turn screws and remove the electrical access panel.

   Remove the six fasteners that attach the electrical access panel support bracket to the cab tunnel, then remove the bracket.

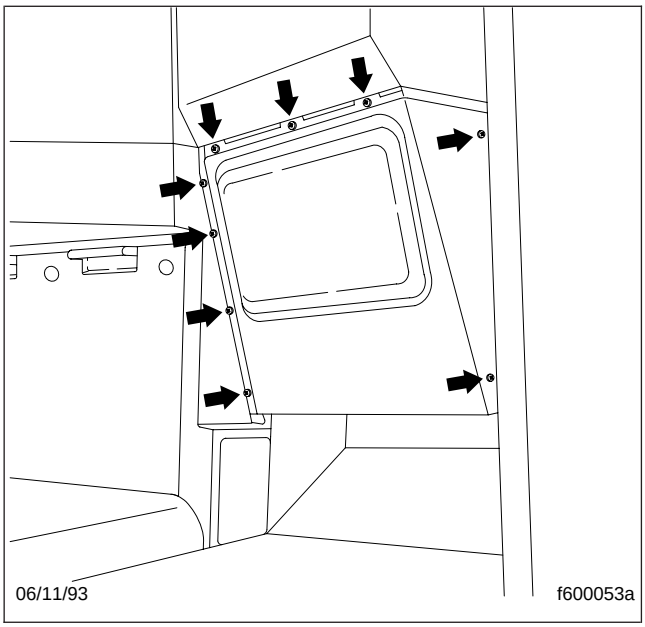


Fig. 2, 120 Conventional Heater/Air-Conditioner Dash Skirt Panel Screws

3. On Conventionals, remove these additional dash panels.

   3.1 Remove three capscrews under the center dash console (above the electrical access panel).

   3.2 Remove the three screws that attach the kick panel located just to the right of the accelearator pedal. Remove the panel.

   Move the wiring as needed to access and remove the screw that secures the under dash cover.

   3.3 Remove the two bottom screws that attach the heater and air conditioner control panel to the dash.

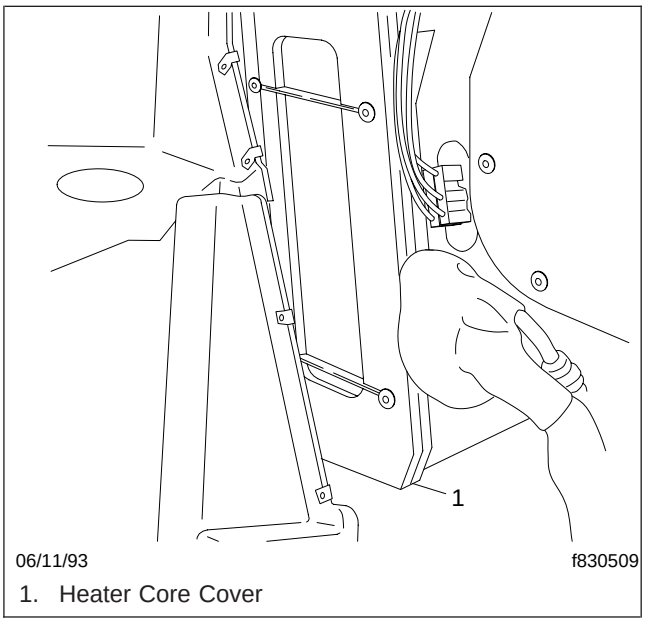
   3.4 Move the under dash panel to allow access to the heater core cover.

Evaporator Coil Removal and Installation

3.5 Remove two screws inside the glove box and remove the top panel from the assembly. Remove the three nuts and spring washers inside the box. Disconnect the two flex hoses from the ducts at the back of the glove box.

Disconnect the blue air line from the air cylinder at the back of the glove box. Remove the glove box.

4. Remove the screws from the heater/air-conditioner core cover. Remove the cover. **See Fig. 3.**



1. Heater Core Cover

Fig. 3, Remove the Screws from the Heater Core Cover

5. Remove the mastic insulating tape from around the expansion valve.
6. Wearing protective goggles and gloves, recover the refrigerant from the system. For instructions, refer to **Subject 250.**
7. Using a wrench, disconnect the evaporator coil lines from the expansion valve. Install plugs in the lines and the expansion valve ports.

⚠ CAUTION

CAUTION: Water and dirt can damage the refrigerant system. Five minutes of not being capped is the limit for any hose or component. Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

8. Remove the thermostatic switch and sensor tube from the evaporator coil.

⚠ WARNING

WARNING: Failure to wear protective gloves could result in serious skin cuts due to the sharp edges on the evaporator coil fins.

9. Wearing protective gloves, slide the evaporator coil up and out of the housing.

Installation

1. Wearing protective gloves, slide the evaporator coil into the housing.
2. Insert the thermostatic switch and sensor tube. The tip of the sensor tube must be in direct contact with a fin and be inserted at least 4 inches (10 cm) into the evaporator.
3. Remove the plugs from the evaporator coil lines and the expansion valve. Install new O-rings and apply mineral oil to the threads and O-rings, and connect the lines to the expansion valve. Using a wrench, tighten the evaporator hoses 18 lbf·ft (24 N·m). Tighten the large hose to the compressor 24 lbf·ft (33 N·m); and tighten the small hose from the receiver-drIer 12 lbf·ft (16 N·m).
4. Evacuate and charge the system with refrigerant. Refer to **Subject 250** for instructions. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is discharged; refer to the applicable refrigerant compressor section elsewhere in this group.
5. Wipe the expansion valve and refrigerant line connections clean, and wrap them with mastic insulating tape.
6. Install the heater core cover, and tighten the screws securely.
7. Install the dash skirt panels.

   7.1 On COEs, install the screws securing the dash skirt panels on the right side of the cab.

   7.2 On Conventionals, position the electrical access panel support bracket on the cab

tunnel, then install the six fasteners that attach the bracket to the tunnel.

Position the two panels on the right side of the electrical access panel, then install the five fasteners that attach the panels. Position the panel on the left side of the electrical access panel, then install the three fasteners that attach the panel. Position the electrical access panel, then tighten the quarter-turn screws.

8. On Conventionals, install these additional dash panels.

   8.1 Connect the flex hoses to the ducts at the back of the glove box assembly. Make sure that the hoses are not twisted. Connect the blue air line to the air cylinder at the back of the glove box. Install the glove box in the dash. Tighten the fasteners until snug.

   Install the top cover on the glove box assembly.

   8.2 Install the dash skirt panel on the right side of the cab (below the glove box).

   8.3 Install the two bottom screws that attach the heater and air conditioner control panel to the dash.

   8.4 Move the wiring as needed to install the screw that secures the under dash cover.

   Position the kick panel located just to the right of the accelearator pedal, then install and tighten the three screws.

   8.5 Install the three capscrews under the center dash console (above the electrical access panel).

9. Connect the batteries.

Expansion Valve Removal and Installation

Removal

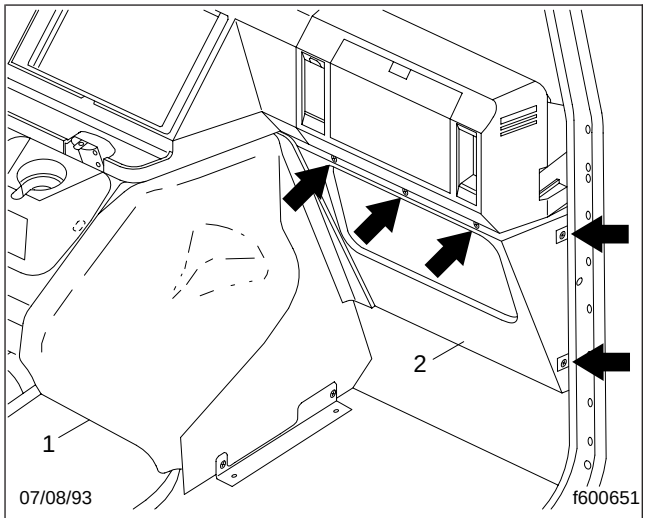
WARNING

WARNING: Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

Whenever a refrigerant line is disconnected, replace the rubber O-ring. Lubricate the new O-ring with mineral oil and apply Loctite® 242 or 592 to the male fitting threads before connecting the lines.

1. On COEs, remove the screws securing the dash skirt panel on the right side of the cab. See **Fig. 1.**

   On Conventionals, remove the screws securing the dash skirt panel on the right side of the cab. See **Fig. 2.**



1. Right-Side Tunnel Cover
2. Right-Side Dash Skirt Panel

Fig. 1, COE Heater/Air-Conditioner Dash Skirt Panel Screws

2. Wearing protective goggles and gloves, discharge the refrigerant system. For instructions, refer to **Subject 250.**
3. Remove the mastic insulating tape from around the expansion valve.

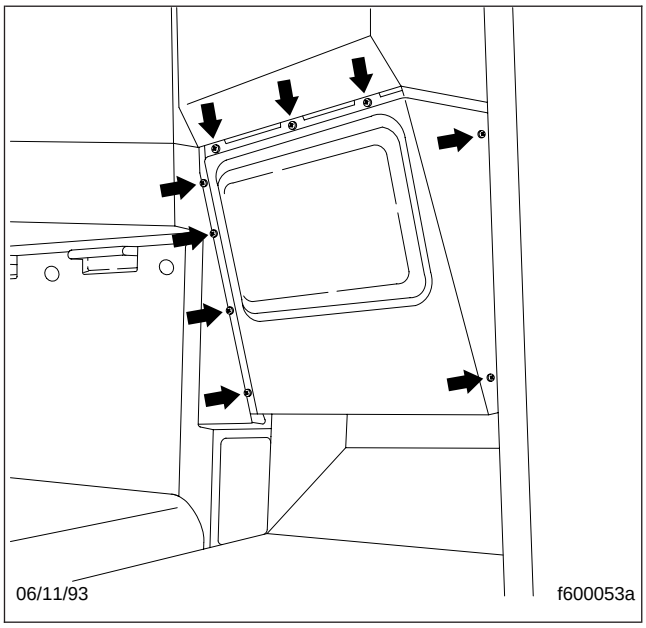


Fig. 2, 120 Conventional Heater/Air-Conditioner Dash Skirt Panel Screws

4. Using a wrench, disconnect the refrigerant lines and the evaporator coil inlet and outlet lines from the expansion valve. Install plugs in the refrigerant lines. Remove the expansion valve.

CAUTION

CAUTION: Water and dirt can damage the refrigerant system. Five minutes of not being capped is the limit for any hose or component. Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

Installation

1. Remove the plugs from the refrigerant lines and the new expansion valve. Install new O-rings and lubricate them with mineral oil. Apply Loctite 242 or 592 to the male fitting threads and connect the refrigerant lines to the expansion valve. Using a wrench, tighten the evaporator lines 18 lbf·ft (24 N·m). Tighten the large hose to the compressor 24 lbf·ft (33 N·m); tighten the small hose from the receiver-drier 12 lbf·ft (16 N·m).
2. Evacuate and charge the system with refrigerant. Refer to **Subject 250** for instructions. Be sure to add refrigerant oil to the compressor to replace

Expansion Valve Removal and Installation

that which is lost when the system is discharged; refer to the applicable refrigerant compressor section in this manual.

3. Wipe the expansion valve and refrigerant line connections clean, and wrap them with mastic insulating tape.
4. Install the dash skirt panel.

Receiver-Drier Removal and Installation

Removal

⚠ WARNING

WARNING: Before doing any of the work below, read the information under Safety Precautions, 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

Whenever a refrigerant line is disconnected, replace the rubber O-ring. Lubricate the new O-ring with mineral oil and apply Loctite® 242 or 592 to the male fitting threads before connecting the lines.

Do not disconnect or connect refrigerant fittings using only one wrench. Hold one fitting in place using a wrench, and turn the other fitting with a second wrench.

The receiver-drier and moisture indicator are one unit, and cannot be replaced separately.

1. Tilt the hood or cab. For cab-tilting instructions, refer to **Group 60** in this manual.
2. Wearing protective goggles and gloves, recover the refrigerant system. For instructions, refer to **Subject 250.**
3. After the system is completely recovered, disconnect the refrigerant lines from the receiver-drier, using two wrenches to avoid twisting the tubing. Install plugs in the refrigerant lines.

⚠ CAUTION

CAUTION: Water and dirt can damage the refrigerant system. Five minutes of not being capped is the limit for any hose or component. Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

IMPORTANT: If the desiccant cartridge inside the receiver-drier has fallen apart, evacuate the system and replace the expansion valve and the refrigerant compressor (desiccant matter can't be removed from these parts). A cartridge may fall apart from too much moisture in the system, because of poor evacuation of the system, or lack of maintenance.

4. If equipped with a fan cycle switch, disconnect the harness connectors and unscrew the switch from its' coupling on the receiver-drier. Save the switch for later use.
5. Unscrew the binary switch from its coupling on the receiver-drier.
6. Loosen the hose clamp assembly **(Fig. 1)** attaching the receiver-drier to the mounting bracket; and remove the receiver-drier.

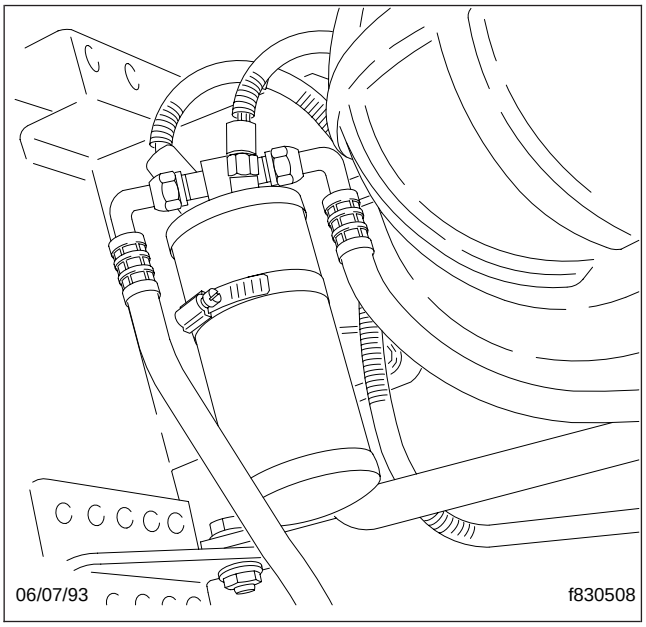


Fig. 1, Receiver-Drier

Installation

1. Position the receiver-drier in the mounting bracket. Tighten the hose clamp securely.
2. Remove the plugs from the refrigerant lines and the line ports on the new receiver-drier. Install new O-rings and apply mineral oil to them. Apply Loctite 242 or 592 to the male fitting threads and connect the refrigerant lines to the receiver-drier. Using two wrenches to avoid twisting the tubing, tighten the connections to the value in **Table 1.**
3. If equipped with a fan cycle switch:

   On vehicles built before November 1994, apply Loctite 242 or 592 to the male threads of the coupling. Install the fan cycle switch, and tighten

Receiver-Drier Removal and Installation

it 108 lbf·in (1220 N·cm) or one-eighth turn past hand-tight.

On vehicles built from November 1994, lubricate a new O-ring with mineral oil, then install it over the male threads of the receiver-drier coupling. Install the fan cycle switch and tighten it 20 to 25 lbf·ft (27 to 34 N·m).

Connect the wiring harness to the switch.

4. On vehicles built before November 1994, apply Loctite 242 or 592 to the male threads of the binary switch coupling. Install the binary switch, and tighten it 108 lbf·in (1220 N·cm) or one-eighth turn past hand-tight.

   On vehicles built since November 1994, lubricate a new O-ring with mineral oil, then install it over the male threads of the receiver-drier coupling. Install the binary switch and tighten it 20 to 25 lbf·ft (27 to 34 N·m).

   Connect the wiring harness to the switch.

5. Charge the system with refrigerant. Refer to **Subject 250** for instructions. Be sure to add refrigerant oil to the compressor to replace that which is lost when the system is recovered; refer to the applicable refrigerant compressor section in this manual.

6. Return the cab or hood to the operating position. For cab lowering instructions, see **Group 60** in this manual.

Outside Diameter for Metal Tube (in inches)	Torque for Steel Tubes * lbf·ft (N·m)	Torque for Aluminum or Copper Tubes lbf·ft (N·m)
1/4	10–15 (14–20)	5–7 (7–9)
3/8	30–35 (41–47)	11–13 (15–18)
1/2	30–35 (41–47)	15–20 (20–27)
5/8	30–35 (41–47)	21–27 (28–37)
3/4	30–35 (41–47)	28–33 (38–45)

* When tightening fittings, always use the torque reading for the softer metal when unlike metals are used.

Table 1, Refrigerant Line Torque Specifications

Fan Cycling Switch Removal and Installation

Removal

WARNING

WARNING: Before doing any of the work below, read the information under Safety Precautions, 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

1. Tilt the hood or cab. For cab-tilting instructions, refer to **Group 60** in this manual.
2. Disconnect the harness connectors and unscrew the switch from its coupling on the receiver-drier. **See Fig. 1.** Save the switch for later use.

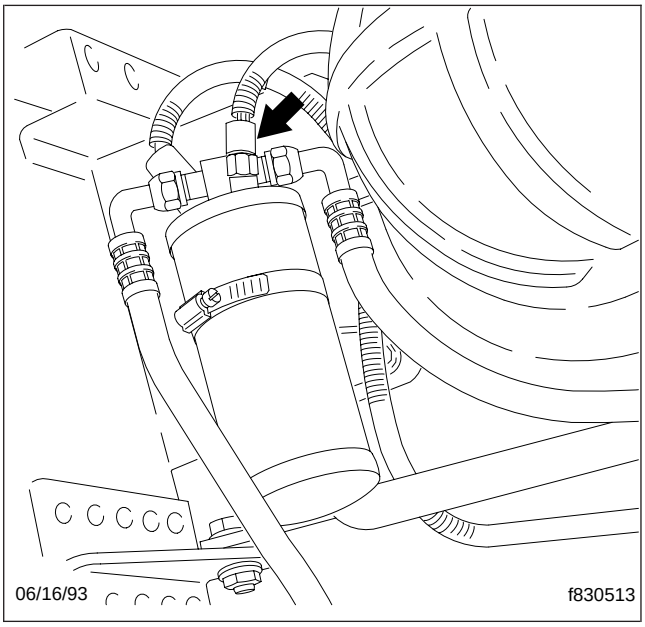


Fig. 1, Fan Cycling Switch

Installation

1. On vehicles built before November 1994, apply Loctite 242 or 592 to the male threads of the coupling. Install the fan cycle switch, and tighten it 108 lbf·in (1220 N·cm) or one-eighth turn past hand-tight.

   On vehicles built from November 1994, lubricate a new O-ring with mineral oil, then install it over the male threads of the receiver-drier coupling. Install the fan cycle switch and tighten it 20 to 25 lbf·ft (27 to 34 N·m).
2. Connect the wiring harness to the switch.
3. Check the system charge and charge the system with refrigerant if needed. Refer to **Subject 250** for instructions.
4. Return the hood or cab to the operating position. For cab lowering instructions, refer to **Group 60** in this manual.

Condenser Removal and Installation

Removal

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

1. Open the hood or tilt the cab. For cab tilt instructions, see **Group 60**.
2. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 250**.
3. Disconnect the refrigerant lines from the condenser. Quickly cap the condenser inlet and outlet ports if the condenser will be reinstalled, and cap the refrigerant lines.

IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through the refrigerant lines since shop air is wet (humid).

4. Remove the fasteners that attach the condenser to the radiator. Remove the condenser.

Installation

1. Using fasteners, install the condenser on the radiator. Torque the fasteners 108 lbf·in (1220 N·cm).
2. Uncap the inlet and outlet ports on the condenser and uncap the refrigerant lines.
3. On refrigerant line connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On refrigerant line connections that have Mini Stat-O-Seals, replace the seals. **Do not** lubricate Mini Stat-O-Seals prior to installation. Use only a Mini Stat-O-Seal on a Mini Stat-O-Seal assembly.
4. Connect the refrigerant lines to the condenser.

   On refrigerant line connections that have threaded fittings, tighten the fittings to the appropriate torque specification in **Table 1**.

   On refrigerant line connections that have a Mini Stat-O-Seal assembly, torque the bolt on the Mini Stat-O-Seal assembly 11 to 15 lbf·ft (15 to 20 N·m).

A/C Threaded Fitting Torque Specifications *	
Refrigerant Line Size	**Torque lbf·ft (N·m)**
#6	20 to 25 (27 to 34)
#8	30 to 35 (41 to 47)
#10 and #12	35 to 40 (47 to 54)

* One-inch fittings on the A/C compressor need to be torqued 21 to 27 lbf·ft (28 to 37 N·m) regardless of refrigerant line size.

Table 1, A/C Threaded Fitting Torque Specifications

5. Evacuate and charge the air conditioning system with refrigerant. For instructions, see **Subject 250**.
6. Add refrigerant oil to the compressor to replace that which is lost in the old condenser. For instructions, see **Section 83.06**, Subject 130.
7. Return the hood or cab to the operating position. For cab tilt instructions, see **Group 60**.

Thermostatic Switch Removal and Installation

Removal

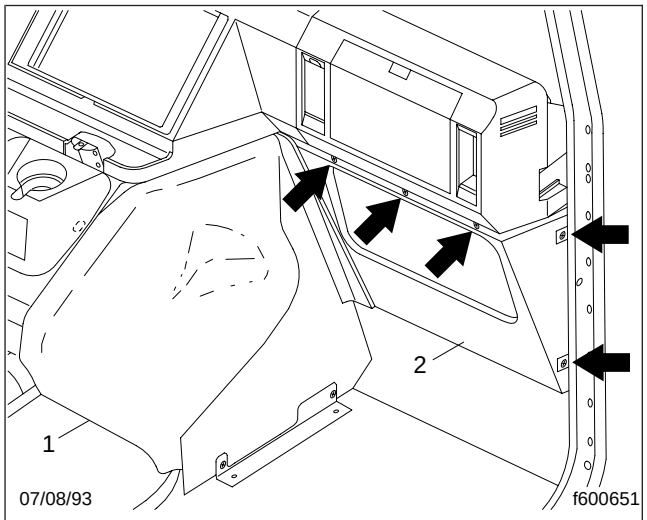
1. Turn off the ignition switch.

⚠ WARNING

WARNING: Failure to turn off the ignition switch could result in personal injury or electrical shock.

2. On COEs, remove the screws securing the dash skirt panel on the right side of the cab. See **Fig. 1.**

   On Conventionals, remove the screws securing the dash skirt panel on the right side of the cab. See **Fig. 2.**



1. Right-Side Tunnel Cover
2. Right-Side Dash Skirt Panel

Fig. 1, COE Heater/Air-Conditioner Dash Skirt Panel Screws

3. Disconnect the harness from the thermostatic switch. See **Fig. 3.**
4. On COEs, remove the four screws from the heater/air-conditioner core cover.

   On Conventionals, remove the three outboard screws from the heater/air-conditioner core cover.
5. Remove the two screws attaching the thermostatic switch to the housing. Remove the switch and the sensor tube.

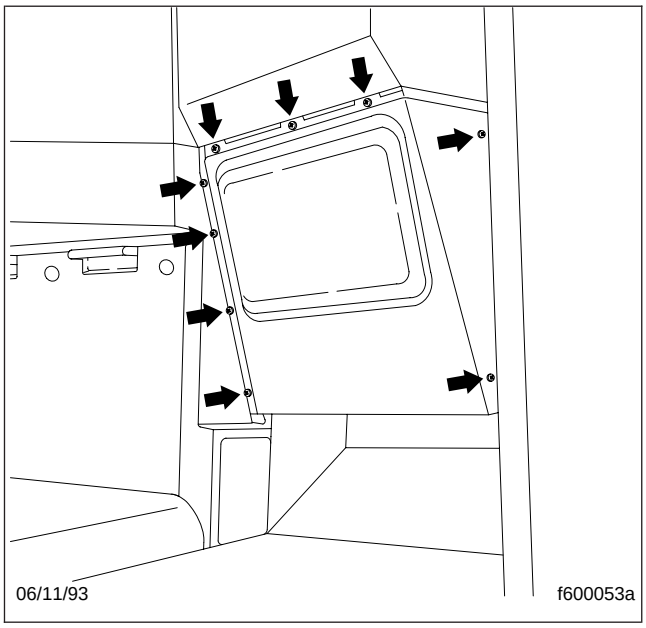


Fig. 2, 120 Conventional Heater/Air-Conditioner Dash Skirt Panel Screws

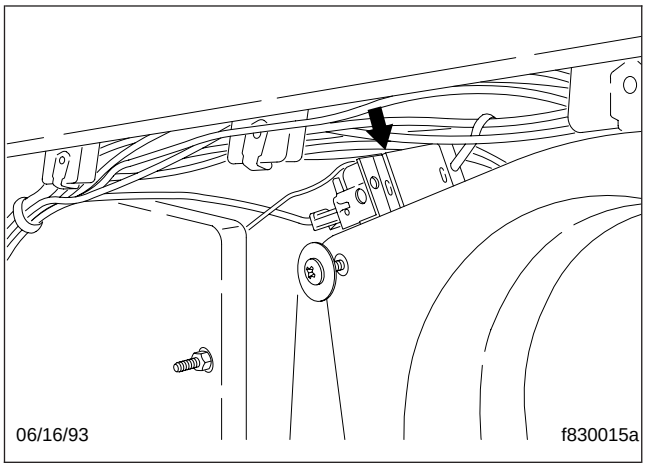


Fig. 3, Thermostatic Switch

Installation

1. Using the two screws removed previously, install the new thermostatic switch.

⚠ CAUTION

CAUTION: Be careful when installing the thermostat sensor tube. Using too much force will bend the tube, which could damage it.

Thermostatic Switch Removal and Installation

2. Carefully insert the thermostatic switch sensor tube into the same hole from which it was removed. The tip of the sensor tube must be in direct contact with an evaporator coil fin and be inserted at least 4 inches (10 cm) into the evaporator.
3. On COEs, install the heater/air-conditioner core cover and secure it with the four screws. Tighten the screws securely.

   On Conventionals, install the three outboard screws and tighten them securely.
4. Connect the wire harness to the thermostatic switch.
5. Install the dash skirt panel.

Blower Motor Switch

1. Turn off the ignition switch.

⚠ WARNING

WARNING: Failure to turn off the ignition switch could allow the control panel to short during repairs. This could result in damage to the electrical system or an injury due to electrical shock.

2. Pull off the knobs from the slide lever controls.
3. Remove the six screws attaching the control panel to the dash. See **Fig. 1**. Move the panel away from the dash enough to service it.

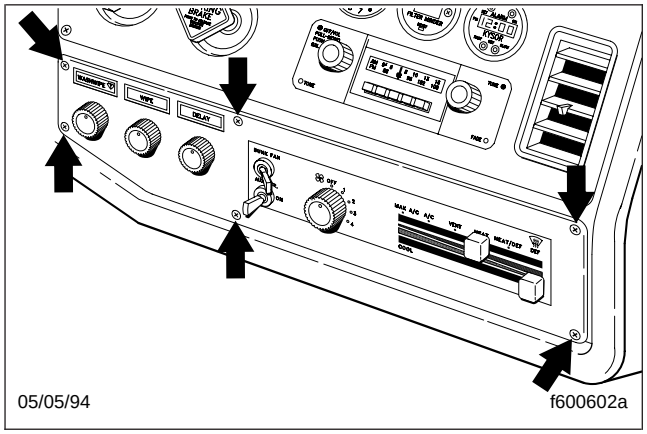


Fig. 1, Remove Control Panel Screws

4. Remove a switch as follows:
   - 4.1 Pull the knob off of the control shaft.
   - 4.2 For later reference, mark the wires on the back of the switch, then disconnect them.
   - 4.3 Using a wrench, remove the nut from the switch and remove the switch.
5. Install a switch as follows:
   - 5.1 Insert the switch through the hole in the panel. Using a wrench, tighten the nut securely.
   - 5.2 Connect the wires to the back of the switch.
   - 5.3 Push the control knob onto the shaft.
6. Using the six screws, install the control panel.
7. Push the knobs onto the slide control levers.
8. Turn on the ignition switch and test the blower motor.

Slide Lever Controls

1. Pull off the knobs from the slide lever controls.
2. Remove the six screws attaching the control panel to the dash. See **Fig. 1**. Move the panel away from the dash enough to service it.
3. Remove the four machine screws attaching the slide lever controls. See **Fig. 2**. Slide the unit to the side and pull it out of the dash as far as the cable will permit.

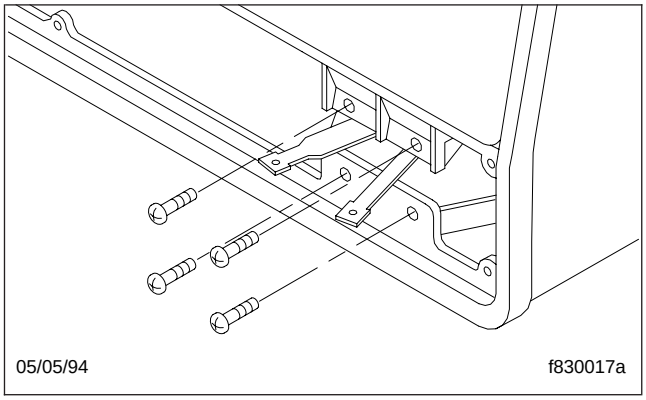


Fig. 2, Remove Machine Screws

4. Loosen the water regulator valve cable clamp screw (**Fig. 3**), then detach the cable from the slide lever.
5. Mark the air lines for assembly reference, or note the color of each line and where it attaches. Disconnect the air lines from the control unit by pushing in the cover ring; then pull out the air line. See **Fig. 4**.
6. Disconnect the wires from the microswitch.
7. Remove the unit from the dash.
8. Connect the wires to the microswitch.
9. Connect the air lines to the replacement unit by pushing them into the fitting as far as they will go, then give the air line a slight tug so the line will lock into place.
10. Hook the end of the water regulating valve control cable onto the slide lever. Tighten the clamp securely.

Control Panel Switch Replacement

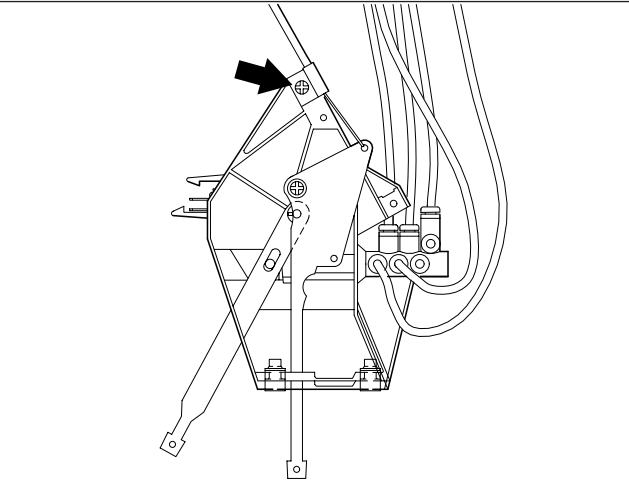
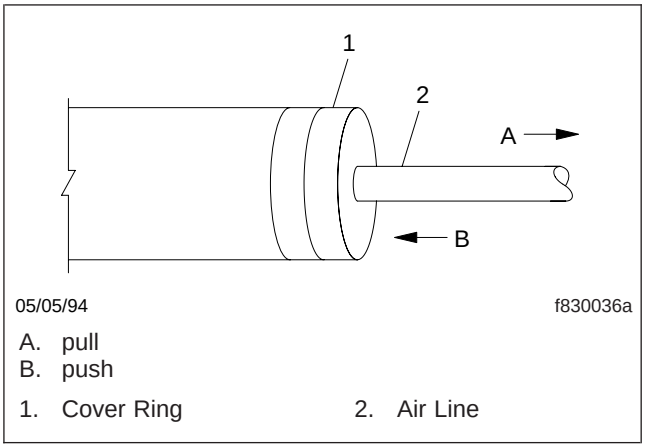


Fig. 3, Loosen Cable Clamp



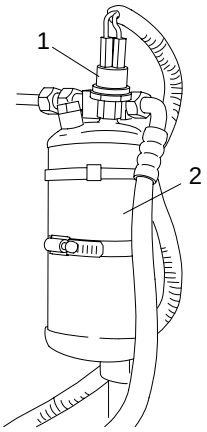
A. pull
B. push

1. Cover Ring
2. Air Line

Fig. 4

11. Using the four machine screws, install the slide lever control unit.
12. Using the six screws, install the control panel.
13. Push the knobs onto the slide lever controls.
14. Move the temperature slide lever to "COOL." The water regulating valve should close completely. Slide the control lever to "WARM." The valve should open. The travel of the slide lever should be smooth and it should travel the full distance on the control panel. If it doesn't, turn the turnbuckle in the direction necessary to get full travel. Refer to **Subject 185** for instructions.
15. Move the slide lever control to each of the positions and check for correct air flow from the appropriate vents. Refer to the air line identification table in **Specifications, 400**.

Replacement (See Fig. 1)



1. Binary Switch
2. Receiver-Drier

Fig. 1, Receiver-Drier Installation

1. Tilt the hood or cab. For cab-tilting instructions, refer to **Group 60** in this manual.
2. Disconnect the electrical leads from the binary switch.
3. Unscrew the binary switch from the receiver-drier.
4. On vehicles built before November 1994, apply Loctite® 242 or 592 to the male threads of the binary switch coupling. Install the binary switch, and tighten it 108 lbf·in (1220 N·cm) or one-eighth turn past hand-tight.

   On vehicles built from November 1994, lubricate a new O-ring with mineral oil, then install it over the male threads of the receiver-drier coupling. Install the binary switch and tighten it 20 to 25 lbf·ft (27 to 34 N·m).
5. Check the operation of the air-conditioning system.
6. Return the hood or cab to the operating position. For cab lowering instructions, refer to **Group 60** in this manual.

Recovery

⚠ WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

The recovery process removes most of the refrigerant charge in the system.

1. Tilt the hood or cab. For instructions, see **Group 60**.
2. If equipped with a swashplate-type compressor, start the engine and run the air conditioning system for 5 minutes. Shut down the engine.
3. Remove the caps from the suction and discharge service valves. On Conventionals, these valves are located at the frontwall on the passenger side of the vehicle; on FLB COEs, the valves are located in the passenger side wheel well. See **Fig. 1**.
4. Wearing protective goggles and nonleather gloves, attach the recovery/recycling station hoses to the valves.

   IMPORTANT: Push down firmly on the hose connectors until they click into engagement. This will ensure that the coupler is locked.

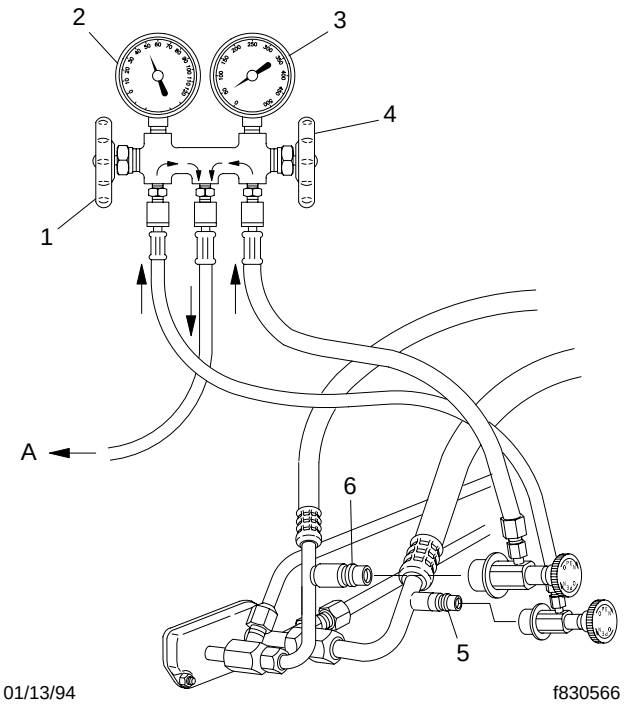
   4.1 Make sure that the recovery and recycling station valves are closed.

   4.2 Connect the red high-side hose to the discharge service valve.

   4.3 Connect the blue low-side hose to the suction service valve.

   4.4 Turn the knob clockwise on each coupler to open the Schrader valves.
5. Follow the recovery and recycling station manufacturer's instructions, and recover all of the refrigerant from the system.

IMPORTANT: Always comply with all local regulations regarding refrigerant disposal. You may be subject to substantial penalties for improper disposal.



A. To Recovery Station

1. Manifold Suction Hand Valve (Open)
2. Low-Side Gauge
3. High-Side Gauge
4. Manifold Discharge Hand Valve (Open)
5. Suction Service Valve
6. Discharge Service Valve

Fig. 1, Recovery Hookup (FLD Conventional service valves shown)

6. Measure the oil recovered during this procedure. The compressor will have to be refilled with the same quantity of new refrigerant oil.

   If the system is contaminated with moisture, all of the compressor oil must be replaced with clean oil. If the system is heavily contaminated with desiccant or grit, replace the compressor, expansion valve, and receiver-drier.

Evacuating (Recycling)

General Information

Moisture in a Refrigerant System

NOTE: Refrigerating system PAG oil is very hygroscopic; it absorbs large amounts of water very readily from the moisture in the air. Any PAG oil to be used in a refrigeration system should be carefully guarded from exposure to the atmosphere. PAG oil in an open container quickly becomes useless.

Water inside the refrigeration system forms ice crystals at the thermostatic expansion valve. Ice crystals retard or stop the flow of refrigerant, causing a reduction, or complete loss of cooling. As the expansion valve warms due to the lack of refrigerant, the ice melts and passes through the expansion valve. Then refrigerant will flow again until the ice crystals re-form. The result is intermittent cooling.

Refrigerant oil has an extremely high moisture absorption capacity. Absorbing large amounts of water reduces the lubricating ability of the oil, which can cause damage to the compressor and other system components.

Effects of Pressure on the Boiling Points of Water

Water boils at 212°F (100°C) at an atmospheric pressure of 14.7 psi (sea level). At higher elevations the atmospheric pressure is lower, and that lowers the boiling point of water. For example, water boils at a lower temperature at the top of a mountain than it does on the sea coast. See **Table 1** for boiling temperatures of water at converted pressures.

Creating a vacuum in the air conditioner system allows any water in it to boil and vaporize at normal ambient temperatures. A vacuum pump reduces the pressure in the system; since the pressure is the lowest at the pump, water vapor is removed from the system at the vacuum pump. See **Fig. 2**. This process is called evacuation or dehydration. Most recovery and recycling stations automatically recycle refrigerant during this process, to ensure the system will be charged with the cleanest refrigerant possible.

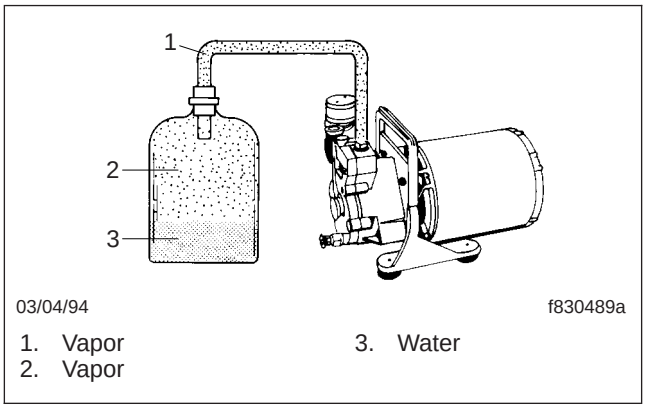


Fig. 2, Water to Vapor

Vacuum Pump Selection

The purpose of a high-vacuum pump is to reduce and hold a vacuum in the air conditioner system so the refrigerant will boil at ambient temperature. For example, if a vacuum pump is capable of creating a vacuum of 28.89 inHg (733.8 mmHg), it creates the condition where water boils at 80°F (27°C), instead of the sea level pressure boiling point of 212°F (100°C). There are many types of vacuum pumps available, but only specific types are recommended for truck air conditioning.

Air pump type vacuum pumps are designed to remove large volumes of air, but do not develop high vacuum. They cannot pull more than 28 inHg (711.2 mmHg). At that pressure, water boils at 100°F (38°C).

Compressor-type vacuum pumps come in two designs: piston-type and rotary-vane type. A piston-type compressor can typically create a 28.2 inHg (716.3 mmHg) vacuum. At that pressure, water boils at 96°F (36°C). A rotary-vane type compressor may pull a vacuum of 29.82 inHg (757.4 mmHg) which allows water to boil at 21°F (–6°C), but it is limited to pumping 0.4 to 0.8 cfm which is too slow to work on truck air conditioners.

High-vacuum pumps are available in single and two-stage models. A single-stage pump is adequate, but a two-stage pump is recommended to save time and ensure complete evacuation. See **Fig. 3**.

Most single-stage high-vacuum pumps with a gas ballast will pull down to about 29.88 inHg (758.95 mmHg). At that vacuum, water boils at 4°F (–16°C).

Boiling Temperatures of Water at Converted Pressures		
Boiling Temperature of Water: °F (°C)	**Absolute Pressure: psi (microns)**	**Vacuum: inHg (mmHg)**
212 (100)	14.696 (759993.4)	0 (0)
205 (96)	12.770 (660400.0)	3.92 (99.6)
194 (90)	10.169 (523881.6)	9.22 (234.2)
176 (80)	6.8699 (355269.8)	15.93 (404.6)
158 (70)	4.5207 (233786.7)	20.72 (526.3)
140 (60)	2.8900 (14958.7)	24.04 (610.6)
122 (50)	1.7987 (92555.1)	26.28 (667.5)
104 (40)	1.0700 (55336.4)	27.74 (704.6)
89 (30)	0.61540 (31826.2)	28.67 (728.2)
86 (27)	0.57010 (26220.4)	28.89 (733.8)
76 (24)	0.44435 (22979.9)	29.02 (737.1)
72 (22)	0.38856 (20094.7)	29.13 (739.9)
69 (21)	0.35084 (18143.7)	29.21 (741.9)
64 (18)	0.29505 (15258.5)	29.32 (744.7)
59 (15)	0.24720 (12783.8)	29.42 (747.3)
53 (12)	0.19888 (10285.0)	29.52 (749.8)
45 (7)	0.14746 (7625.8)	29.62 (752.3)
32 (0)	0.08858 (4579.6)	29.74 (755.4)
21 (–6)	0.05293 (2738.1)	29.81 (757.2)
6 (–14)	0.02521 (1304.0)	29.87 (758.7)
–24 (–31)	0.004905 (253.7)	29.911 (759.74)
–35 (–37)	0.002544 (131.6)	29.915 (759.84)
–60 (–51)	0.0004972 (25.7)	29.9200 (759.968)
–70 (–57)	0.0002443 (12.69)	29.92050 (759.9807)
–90 (–68)	0.0000526 (2.72)	29.92089 (759.9906)

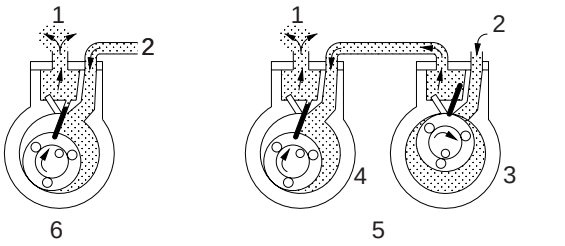
Table 1, Boiling Temperatures of Water at Converted Pressures

A two-stage high-vacuum pump features a second pump to reach a higher vacuum than a single-stage pump. In a two-stage pump, the exhaust of the first pump discharges into the intake of the second pump. The second stage pumps at a lower pressure and therefore pulls a higher vacuum on the system than the first pump can by itself.

Two stage high-vacuum pumps are capable of pulling down to 29.9192 inHg (759.95 mmHg) of vacuum for prolonged periods, at which pressure water boils at –60°F (–51°C).

Discharge line restriction is a factor affecting pump-down time. Pump-down time can be significantly reduced by use of larger diameter hoses, as short in length as possible.

Pumping capacity affects pump-down time. It is perfectly acceptable to use a large vacuum pump on a small system. Using too small of a pump on a large system could cause premature pump wear or require



1. Exhaust
2. Intake
3. First Pump
4. Second Pump
5. Two-Stage Pump
6. Single-Stage Pump

Fig. 3, Single- and Two-Stage Vacuum Pumps

excessive time to pull a vacuum, even though the pump may be able to draw adequate vacuum.

The suggested *minimum* cfm for pumps on different size air conditioners are listed in **Table 2**.

Minimum CFM for Pumps on Different Size Air Conditioners	
System Size	**Suggested High-Vacuum Pump Size**
Panel Trucks Large Window Units	2.2 cfm
Tractor/Trailers, Buses Rooftop A/C Systems	3.0 cfm
Refrigeration Van	15.0 cfm

Table 2, Minimum CFMs for Pumps on Different Size Air Conditioners

Measuring Vacuum

Gauges

Vacuum can be measured with:

- a standard compound gauge;
- a closed end manometer;
- an electronic thermistor vacuum gauge.

A standard compound gauge reads low pressures in inches of mercury. It is not suitable for measuring high vacuum.

A closed end U-tube mercury manometer can be read with good accuracy. High vacuum readings can only be read from laboratory-style U-tube manometers, which are not practical for service shops.

An electronic thermistor vacuum gauge is designed for use with high vacuum pumps and can accurately read as low as 100 microns. This gauge can use an analog scale, or a digital LED display.

Procedure

The location of the vacuum gauge will affect the reading. The closer to the vacuum source, the lower will be the reading.

Isolate the vacuum pump with a good vacuum valve and allow the pressure in the system to stabilize before taking a final reading.

If the pressure will not stabilize, it is an indication of a leak. If it does stabilize at a vacuum which is too high (for example, 1500 microns), it is an indication of moisture and more evacuation is required.

Maintaining the Vacuum Pump

Maintenance is important for high-vacuum pumps. The oil must be changed at regular intervals to prevent moisture buildup which will cause eventual pump failure.

Pumping down for extremely wet air conditioning systems can completely saturate the pump oil.

⚠ CAUTION

Flush the vacuum pump every fourth time it is used, and before storing for long periods of time. Acid will form and corrode the pump, if water-laden oil remains in the pump for an extended period.

Vacuum pump oil is water soluble. This aids the pump in reaching a high vacuum by absorbing water and sealing the pump.

Only vacuum pump oil should be used as a lubricant. Do not use any solvent or any other oil. Clean oil should be run through the pump until it runs out clear. Oil should be added to the fill level indicated on the pump. Check the oil level before each use.

Evacuation Procedure

1. The system must have been recovered and the compressor filled with the correct amount of refrigerant oil. Replace the receiver-drier if the system is opened.

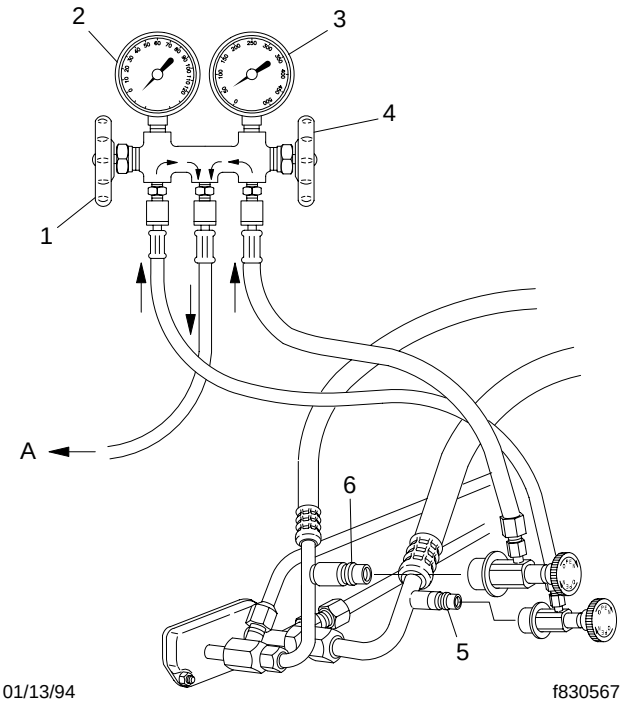
2. Wearing protective goggles and nonleather gloves, attach the recovery/recycling station hoses to the valves. See **Fig. 4**.

   IMPORTANT: Push down firmly on the hose connectors until they click into engagement, to ensure the coupler is locked.

   2.1 Make sure that the recovery and recycling station valves are closed.

   2.2 Connect the red high-side hose to the discharge service valve.

   2.3 Connect the blue low-side hose to the suction service valve.



A. To Vacuum Pump

1. Manifold Suction Hand Valve (open)
2. Low-Side Gauge
3. High-Side Gauge
4. Manifold Discharge Hand Valve (open)
5. Suction Service Valve
6. Discharge Service Valve

Fig. 4, Evacuation Hookup (FLD Conventional service valves shown)

   2.4 Turn the knob clockwise on each coupler to open the Schrader valves.

3. Follow the recovery and recycling station manufacturer's instructions and evacuate/recycle the refrigerant system.

Flushing

WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

Flushing removes moisture-laden oil and some contamination, such as dirty oil and some particles. When a part is flushed, liquid refrigerant is forced through it. The liquid picks up the contaminants and flushes them out.

Whether to flush or replace a part depends on how much contamination there is, as previously described.

Normally, the system always has pressure in it. Some loss of refrigerant from one season to the next is normal, and does not mean that the system is dirty. If refrigerant parts show signs of internal corrosion and grit, the system is contaminated.

If the system is contaminated with moisture, flush all sections of the system. Then change the oil in the compressor, and replace the receiver-drier prior to evacuating and charging the system.

If the system is heavily contaminated or if desiccant has circulated through the system, replace the receiver-drier, expansion valve(s), and inspect the compressor.

Flush the system in segments to lessen the chance of blowing deposits against a port.

Flush the system in the opposite direction of refrigerant flow.

Flushing parts with refrigerant, requires a refrigerant recovery and charging machine.

Flushing Procedure

Method 1

NOTE: Use this method when the recovery and charging machine is equipped with a flush cycle.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), receiver-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter and follow the instructions from the manufacturer of the recovery and charging machine to perform the flush. When flushing the entire system, use an adaptor that fits where the compressor was located, and backflush.
4. Remove the adaptors and bypass devices and install the expansion device(s), the compressor, and a new receiver-drier.
5. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
6. Charge the system with refrigerant and check the system performance.

Method 2

NOTE: Use this method when two recovery and charging machines are available.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), receiver-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter. When flushing the entire system, use an adaptor that fits where the compressor was located, and backflush.
4. Charge the part with 2 pounds (0.9 kg) of refrigerant or the system with 5 pounds (2.3 kg) of refrigerant, then recover the refrigerant with a second machine. It is desirable to start the recovery slightly before the charge cycle is done, since this helps to push fluid through the system. Repeat the process several times until you think that all the oil has been removed.
5. Remove the adaptors and bypass devices and install the expansion device(s), the compressor(s), and a new receiver-drier.
6. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
7. Charge the system with refrigerant and check the system performance.

Charging

WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

NOTE: Before charging, the system must be recovered and evacuated with the recovery and recycling station connected to the service and discharge port connections.

1. Obtain enough refrigerant to fully charge the system. See **Specifications 400**.

   Set the tank on a scale and weigh it so that the correct amount of refrigerant enters the system. This prevents overcharging, which could damage the compressor.

2. Charge the refrigerant system.

   NOTE: If equipped with a recovery, recycling, and recharging station, charge the system on the high side following the manufacturer's instructions. If charging from a bulk container, do the following.

2.1 Turn the tank (bulk container) upside down. With the engine off, open the high-side hand valve. **Do not** open the low-side hand valve.

2.2 Allow refrigerant to enter the system until the correct charge (by weight) has entered. Then close the high-side hand valve.

2.3 Start the engine and run it at 1500 rpm. Set the cab air conditioner controls at maximum cooling and fan speed. The refrigerant compressor must engage.

2.4 If a full charge did not enter the system, place the tank (bulk container) in the upright position, then open the *low-side valve* to draw vapor into the system. Leave the valve open until the correct weight of refrigerant has entered the system, then close the low-side valve.

NOTE: If refrigerant is slow to enter the system because of low outside temperatures, vaporization can be quickened by placing the refrigerant tank in a tub of warm water no warmer than 125°F (52°C).

3. While the compressor is engaged, check the operating pressures at the suction and discharge ports. See the applicable compressor section in this manual. If the operating pressures are not acceptable, see **Troubleshooting 300** for possible causes.
4. Disconnect the high-side hose. With the engine running, open the low-side and high-side hose valves to recover the refrigerant from the lines.
5. Shut down the engine.

Leak Testing

General Information

WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

Refrigerant is odorless; as a result, all of it may leak away and not be noticed until the system stops cooling. All vehicle refrigerant systems lose some refrigerant, depending on the condition of the system. Higher loss rates signal a need to locate and repair the leaks.

Leaks are most often found at the compressor hose connections and at the various fittings and joints in the system. If unapproved replacement hoses are installed, refrigerant can be lost through hose permeation.

Leak Detection

When checking for leaks, move the probe all the way around the fitting or the suspected leak.

NOTE: Do not try to use a leak tester right after connecting or disconnecting service hoses. Traces of refrigerant at the fittings can falsely signal a leak. Always verify a leak by blowing shop air in to the area of the suspected leak and checking the area again.

Freightliner recommends using only the Heated Diode type of electronic leak detector. This type of detector can be identified by its construction and power supply. It has a heated element which requires periodic replacement and uses either a 12V DC or 120V AC power supply, or has a rechargeable battery. The Heated Diode type detector is sensitive only to gases containing halogen, such as R–134a and R–12 refrigerants. It will not detect other substances and is more likely to detect all of the leaks in a system. This type has both visual and audio indicators and self-tests to confirm operation.

Recommended electronic Heated Diode type leak detectors are available from their manufacturers. See **Table 3**.

Another type of detector, the Corona Discharge type, is the kind most commonly found in service and repair shops. This detector requires very little power and can operate on as few as four AA alkaline batteries. The Corona Discharge detector is not sufficiently sensitive and will create false alarms by detecting moisture and antifreeze or solvent vapors. This type of detector is specifically **not recommended**.

Use the following procedures to locate A/C system refrigerant gas leaks using a heated diode type electronic leak detector.

Refrigerant Service Operations

Electronic Leak Detectors		
Designation	**Manufacturer**	**Comments**
D-TEK	Leybold Inficon 2 Technology Place East Syracuse, NY 13057 (315) 434–1144	• Rechargeable battery • Hand-held design • Simple to operate
H–10 Professional	Bacharach Inc. c/o Yokogawa Corp. of America 2 Dart Road Newnan, GA 30265 (800) 850–0044	• Rechargeable battery • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Most sensitive available
J 39400	Kent-Moore 29784 Little Mack Roseville, MI 48066–2298 (810) 578–7285	• 12V DC or 120V AC • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Manual balance control

Table 3, Electronic Leak Detectors

1. Operate the electronic leak detector in accordance with the manufacturer's instructions.
2. Leak test with the engine turned off.
3. Charge the air conditioning system with sufficient refrigerant to indicate a gauge pressure of at least 50 psi (340 kPa) with the system not operating. It may not be possible to produce this amount of pressure and measure leakage if the ambient temperature is less than 59°F (15°C).
4. Be careful not to contaminate the detector probe tip if the part being tested is not clean. Wipe the part off with a dry shop towel or blow it off with shop air. Do not use cleaners or solvents as many detectors are sensitive to their chemical ingredients.
5. Visually inspect the entire refrigerant system. Look for air conditioning lubricant leakage and corrosion or damage to lines, hoses, and all other components. Inspect each questionable location carefully with the detector probe. Check all fittings, couplings, refrigerant controls, service ports (with caps installed), brazed or welded areas, and areas around attachment points and hold-downs.
6. Follow the path of the refrigerant system methodically so that no leaks are missed. If a leak is found, continue to test the rest of the system.
7. Inspect an area of possible leakage slowly and close to the part, moving completely around the part. Move the probe no faster than one to two inches (25 to 50 mm) per second and no farther away than 1/4 inch (6.4 mm) from the part.
8. If a large leak is present in either the system being serviced or the service equipment, the surrounding air will be saturated with refrigerant gas. In this situation the leak detector operates erratically and will indicate leakage without being near a possible leak source. Place a large fan so that a light breeze blows through the work area. Verify a leak by blowing shop air into the area and repeating the inspection. Pinpoint a large leak by blowing out the area often.
9. You may test the evaporator core while it is in its housing. Turn on the blower motor for a minimum of 15 seconds. Shut off the blower and wait for refrigerant gas to accumulate in the housing. Follow the detector instructions for the specific length of time to wait for the gas to accumulate. Insert the detector probe into the blower resistor

block or condensate drain tube if no water is present. If this is not possible insert the probe into the closest opening to the evaporator, such as a heater or vent duct.

NOTE: The presence of water in the condensate drain tube can be determined by inserting the eraser end of a pencil in the drain tube. Inserting the pencil will break the surface tension of any water near the opening of the drain tube and allow the water to drain out before inserting the probe tip. It is only necessary to break the plane of the drain tube with the probe tip. It doesn't need to be inserted far into the tube.

10. Leak test the front seal area of the compressor. Blow shop air into the cavities in and around the clutch for at least 15 seconds. Let the compressor stand for one minute and then test for leakage. Inspect axial-type compressors (Sanden or Sel-Tec) by placing the probe near the holes at the front of the clutch. Inspect two-cylinder reciprocating type compressors (Climate Control) by placing the probe between the clutch coil and the compressor.

IMPORTANT: Be careful not to damage the clutch bearing seal with high pressure shop air.

11. Leak test repaired areas of the system after repairs have been performed. Leak test the service ports (with caps installed) after any service which disturbs the refrigerant system.

Preliminary Checks

Before testing the operation of the air conditioning system, make the following checks:

1. Make sure the refrigerant compressor's drive belt is not damaged and is correctly tensioned. Also check the compressor mountings for tightness. For instructions and other information, see the refrigerant compressor section elsewhere in this group.
2. Using a feeler gauge, check for correct refrigerant compressor clutch clearance. For instructions, see the refrigerant compressor section elsewhere in this group.
3. Check for broken, burst, or cut hoses; also check for loose fittings on all parts.
4. Check for road debris buildup on the condenser coil fins. Using air pressure and a whiskbroom or a soapy spray of water, carefully clean off the condenser; be careful not to bend the fins
5. Check the color of the moisture indicator sight glass. If the color is a deep cobalt blue, the refrigerant charge is dry. If the indicator is *not* blue, the system is contaminated with moisture; recover the refrigerant, evacuate the system, replace the receiver-drier, and add a full refrigerant charge.
6. If there is not enough airflow, make sure that leaves or other debris has not entered the fresh air ports under the windshield. If debris has entered, it could clog the fins of the evaporator core, and block airflow.

   Also, be sure that all ducts are connected to the dash louvers and that the air-control flaps in the heater housing are moving properly (this requires removal of the right and center dash panel).

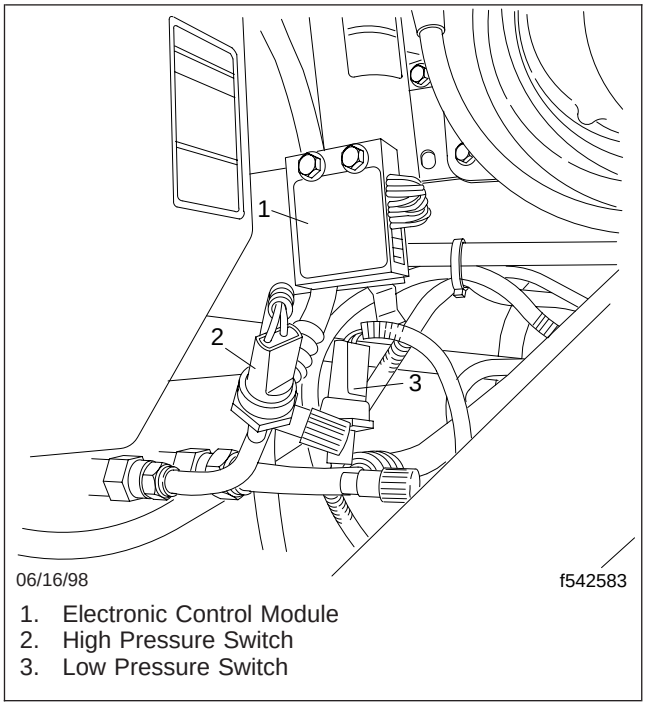
Performance Tests

Following is a brief description of symptoms or conditions that could exist if something goes wrong with a refrigerant part.

Air Conditioning Protection and Diagnostics System (APADS™)

The Air Conditioning Protection and Diagnostics System consists of an electronic control module, high and low pressure switches, and an evaporator thermostat. The electronic control module actively monitors system conditions and controls the operation of the refrigerant compressor and the on/off fan drive.

On Conventionals, the electronic control module is located under the hood on the right-hand side of the frontwall. See **Fig. 1**. On COEs, the electronic control module is located on the right-hand frame rail near the receiver-drier. See **Fig. 2**.



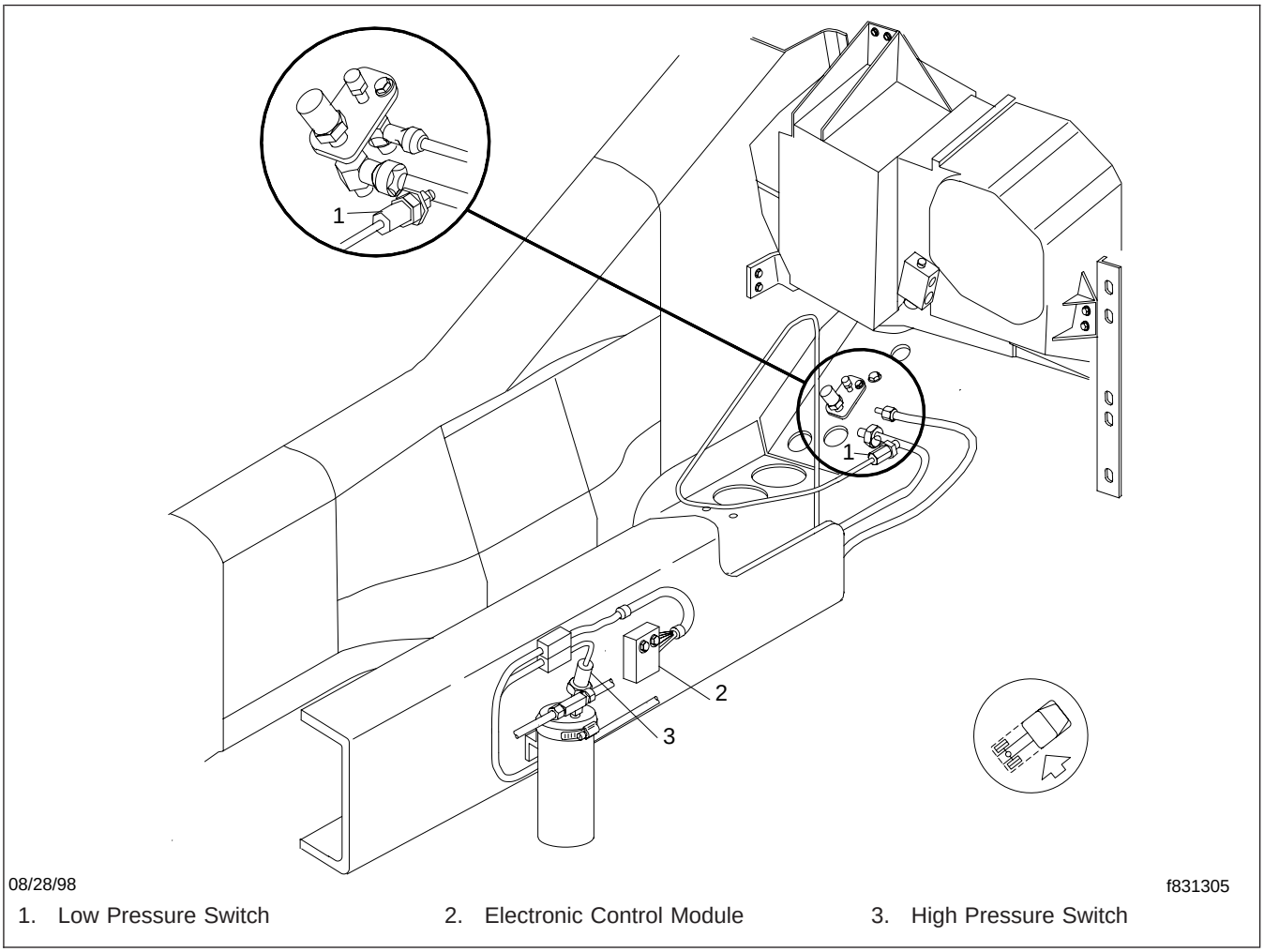
1. Electronic Control Module
2. High Pressure Switch
3. Low Pressure Switch

Fig. 1, APADS Control Module and Pressure Switches, Conventional

The electronic control module registers fault codes that warn of existing or impending problems in the air conditioning system. Diagnostic information is provided by a blinking red LED (light emitting diode) built into the electronic control module. Since only one blink code can be displayed, the fault code of highest priority takes precedence. See **Table 1** for the fault code order of priority. Only the highest priority fault code is held in memory. Once the fault code is cleared, a new fault must occur to initiate a new blink code.

A "blink" is approximately 1/4 second in duration. Once the number of blinks has been broadcast, there

Troubleshooting



1. Low Pressure Switch
2. Electronic Control Module
3. High Pressure Switch

Fig. 2, APADS Control Module and Pressure Switches, COE

is a delay time of two seconds before the blink code is repeated. See **Table 2** for a description of blink codes.

The blink code is cleared by two methods:

- Cycle the ignition switch—one second on, one second off—for four consecutive cycles.
- Self-clearing based on the persistence of the fault. If a fault condition occurs once and does not repeat, the fault code is held for an extended period of time and then cleared. If the fault is repetitive, it will always be retained in memory until the problem is fixed.

For APADS™ troubleshooting information, see **Table 3**.

APADS™ Fault Code Order of Priority			
Priority	**Fault Code Name**	**Fault Description**	**LED Blinks**
1	Static low pressure	Full loss of charge	1
2	Dynamic low pressure	Partial loss of charge	1

APADS™ Fault Code Order of Priority			
Priority	**Fault Code Name**	**Fault Description**	**LED Blinks**
3	High pressure	Overcharge, blocked condenser	2
4	Open clutch	Clutch wire open	3
5	Shorted clutch	Shorted clutch coil	3
6	Low pressure switch open	Cut wire to low pressure switch	4
7	High pressure switch open	Cut wire to high pressure switch	4
8	Low voltage	Low battery voltage	Rapid Green
9	No faults	No faults, module functional	Red off, Green slow blink

Table 1, APADS Fault Code Order of Priority

APADS™ Blink Codes	
Condition	**Description**
Slow Green	Unit is functioning properly
Fast Green	Low system voltage
One Red Blink	Loss of refrigerant
Two Red Blinks	Fan failure or external condenser blockage
Three Red Blinks	Voltage drop out, open or shorted wire to compressor clutch
Four Red Blinks	Open wire in pressure switch circuit

Table 2, APADS Blink Codes

APADS™ Troubleshooting Table			
Condition	**Definition**	**Possible Cause**	**Action**
Slow flashing green light.	Two seconds on, 1/2 second off	Unit is functioning properly.	No action is needed.
Rapid flashing green light.	Low system voltage, indicates low supply voltage condition. Voltage has dropped below 11.0 volts.	Possibly caused by a defective alternator, discharged batteries, poor ground, or an excessive electrical load.	Check voltage at the control harness by probing pins 4 (ground) and 2 (power). If voltage is less than 11.0 volts, start checking for voltage drops or a poor ground.
Ignition on, LEDs not flashing on control module or no lights on module.	Control module not receiving battery voltage.	Fuse or circuit breaker is blown	Repair fuse or reset circuit breaker.
		Broken power or ground wire to control module.	Repair wiring.
		Damaged control module.	Replace the APADS™ electronic control module, or retrofit the APADS with a binary switch. For instructions, see Service Bulletin 83–74.

Troubleshooting

APADS™ Troubleshooting Table			
Condition	**Definition**	**Possible Cause**	**Action**
Red light flashing one blink in sequence.	Low pressure fault. This is detected by monitoring the ambient temperature and switching activity of the low pressure switch.	Partial or total loss of refrigerant.	Install service gauges and check system for leaks.
		A damaged low pressure switch.	Disconnect the low-side pressure switch connector and measure the resistance value of the switch. If the resistance shows 2.49k ohms, the switch is operating properly. If the resistance shows less than 5 ohms, replace the switch. NOTE: This check must be done with the switch installed on the vehicle, and the ignition in the off position and proper charge.
Red light flashing two blinks in sequence.	High pressure fault. The system is exhibiting abnormal high pressure activity.	Fan drive failure.	Inspect proper operation of solenoid valve, relay, and/or related components.
		Blocked air flow through condenser.	Remove restriction from condenser.
Red light flashing three blinks in sequence.	Open wire to A/C clutch. Detected by inadequate current through the compressor clutch. If no current is sensed when the A/C drive is turned on, an open connection to the clutch coil is indicated.	A break in the wiring between the control module and the A/C compressor clutch or a break in the clutch coil.	With the use of an ohmmeter, check the resistance of the clutch coil. If the reading is less than 2.8 ohms, replace the clutch.
	Shorted wire or shorted A/C clutch. Detected by excessive current through the compressor clutch.	This indicates either a shorted clutch coil or shorted wiring to the clutch.	Locate and repair shorted or frayed wiring between the control module and the A/C clutch.
	Fluctuating battery voltage.	Fluctuation of greater than one volt caused by a damaged voltage regulator.	Replace the alternator.
Red light flashing four blinks in sequence.	Opening in wiring harness to high or low pressure switches.	Unseated connector.	Check connectors at the module and the pressure switch for loose pins.
		Break between wiring harness and pressure switch.	Using an ohmmeter, probe the yellow and yellow/black pins of the module harness. Resistance should read less than 5 ohms.
		Moisture intrusion into the connectors or switch.	Check seals and inspect wires for continuity.
		The use of a non-Index pressure switch.	Install the correct pressure switch.

APADS™ Troubleshooting Table			
Condition	**Definition**	**Possible Cause**	**Action**
A/C clutch is not engaging during the first 15 seconds after the ignition is turned on.	—	Unit is functionally properly. Regardless of A/C system state at start-up, the A/C clutch is disengaged for the first 15 seconds.	—
At ignition, turn on, with A/C controls set to the on position, compressor is off for 15 seconds, on for 15 seconds, then remains off indefinitely.	No voltage going to A/C compressor clutch.	Incorrect A/C input signal.	Check for a break in the wiring between A/C clutch and the A/C controls.
			Check for a bad A/C on/off control switch.
			Check for a bad A/C relay.
At start-up, after 15 seconds, compressor clutch doesn't engage, but engine fan engages.	Control module sensing an open in the high pressure switch circuit.	High-side pressure switch failure.	Check switch by measuring the resistance value across the leads. If the resistance shows less than 1k ohms, the switch is functioning properly. If resistance is greater than 100 ohms, replace the switch.
Slow flashing green, compressor is on for a short period of time, off for 15 seconds in a repetitive sequence.	Indicates that the system is exhibiting abnormal high or low pressure activity.	Blockage on the high side of the system or in the condenser.	Repair the restriction.
		Partial loss of refrigerant.	Check system for loss of refrigerant.
Slow flashing green light, not engaging in defrost mode or in cold weather.	—	The unit is more than likely functioning correctly. If the ambient temperature is too low, the compressor clutch is not allowed to engage because of low system pressure.	—
Slow flashing green, clutch is engaged, A/C is not cooling.	—	Inoperative blower motor.	Check for proper operation of the blower motors.
		Loose or broken compressor belts.	Tighten or replace compressor belts.

Table 3, APADS Troubleshooting Table

Receiver-Drier

The receiver-drier is normally at outside temperature. To the touch, the entire length of the unit should be the same temperature. If noticeable cool spots exist, replace the receiver-drier.

A blockage at the inlet of the unit will cause high head pressures; outlet blockages will cause low head pressures and little or no cooling.

If the moisture indicator is pink or white (showing that the system is wet), the receiver-drier is saturated with moisture and must be replaced.

Cooling System

Although they are not physically connected, there is a close tie between a vehicle's air conditioner and its cooling system. Poor air conditioner cooling can be the result of a problem in the cooling system.

Troubleshooting

If the cooling system does not work correctly, the heat of the engine will rise to abnormal levels. The added heat will transfer to the air conditioner, other underhood parts, and maybe make its way into the cab. The added heat makes it necessary for the air conditioner to work harder and, at the same time, it reduces the air conditioner's ability to cool down the air in the cab. Also, if the water regulating valve isn't closing all the way, heat will enter the cab, giving the impression that the air conditioning system is not working.

See **Group 20** for cooling system troubleshooting and see the engine manufacturer's service manual for other details about cooling system problems.

Expansion Valve

Problems that start in the expansion valve show up as follows: when stuck closed, the evaporator coil and the expansion valve will be at outside temperature; when stuck open, both the coil and the valve will be extremely cold with frost or ice buildup.

Because the expansion valve channels are very small, blockages in the system tend to be found here (the valve is very sensitive to contamination). Usually, the contaminant is water; less than a drop of water is all it takes to make the valve inoperative. When water reaches the valve, the extreme cold that results from the pressure drop freezes the water, forming a block of ice in the valve. After the system shuts down and the valve warms up, the ice melts, and the valve operates again, only to freeze up when the moisture returns.

On-and-off operation of the expansion valve means that the receiver-drier is not removing moisture from the system. These contaminants should cause the moisture indicator's element to turn white and then pink.

Refrigerant Compressor

Compressor problems usually show in one of four ways: abnormal noise; seizure; leakage; or low suction and discharge pressures.

Resonant compressor noises are not causes for alarm; irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch and see if the drive plate can be turned. If it won't turn, the compressor has seized.

Low discharge pressure may be caused by not enough refrigerant, not enough belt tension, or a blockage somewhere in the system. These things should be checked before servicing the compressor.

Evaporator

The evaporator coils are basically trouble-free when airflow over the fins is not blocked. External or, less often, internal blockages will cause low suction pressure as well as little or no cooling.

If a leak exists in the system, and it cannot be traced to other parts or fittings, suspect damage to one of the evaporator coils.

Condenser

The condenser is usually trouble-free. Normally, the temperature of the condenser outlet line is noticeably cooler than the inlet line. However, when road debris (such as leaves or dirt buildup) cakes up, airflow over the condenser fins is blocked; air is not able to absorb enough heat to turn the hot refrigerant gas into a liquid. High head pressures will result. In these cases, carefully clean off the outer surfaces of the condenser with compressed air or a soap and water solution; be careful not to bend the fins.

High head pressures will also occur if the condenser's tubing is abnormally bent, blocking the flow of refrigerant. Frost will appear at the point where the flow is restricted.

Less common internal blockages (bits of foreign material or metallic grit buildup) will stop the flow of refrigerant.

A quick test to check that poor system performance is caused by the condenser is to direct a spray of water onto the condenser while the system is running. If the air conditioner cools better because of the assist provided by the water, it is a sign that the condenser is not working.

When troubleshooting a suspected condenser problem, remember that the problem may be caused by the radiator transferring high levels of heat to the condenser. See **Group 20** for cooling system troubleshooting and see the engine manufacturer's service manual for other details about cooling system problems.

Thermostatic Switch

IMPORTANT: Before troubleshooting the thermostatic switch, be sure there is a full charge of refrigerant in the system. The compressor will not operate, or will cycle too often, if there is not enough refrigerant in the system.

Quick or delayed cycling of the compressor may be caused by a thermostatic switch that is working, but is out of adjustment. If, after doing the tests below, the switch seems to be out of adjustment, replace it (the thermostatic switch cannot be recalibrated).

1. Be sure the compressor clutch is operating correctly. See the refrigerant compressor section elsewhere in this group.
2. Expose the evaporator coil. See **Subject 190** for instructions.
3. Start the engine. Place the air conditioner control at its coldest setting. Turn on the air conditioner and the fan.
4. Place an accurate thermometer in contact with a tube on the evaporator coil. Be sure the thermometer is in good contact with the tube, or you will get a wrong reading.

   When the temperature drops below 31 to 36°F (–1 to 2°C), the compressor clutch should disengage and remain this way until the temperature rises to 39 to 44°F (4 to 7°C).
5. If the compressor did not engage when the temperature was above the accepted high range, do the following test:

   5.1 Connect a voltmeter or a test light from one of the terminals on the thermostatic switch to ground. Repeat this test with the other terminal on the switch.

   5.2 With the engine running and the air conditioner and blower on, both terminals will show voltage when the compressor should be engaged; one terminal will show voltage when the compressor should be disengaged.

   If there is no voltage, there is a problem in the electrical system from the batteries to the thermostatic switch. Check all circuits for the cause, and repair or replace the wiring or parts.

   In all other cases where the compressor is not engaging and disengaging properly, the thermostatic switch is the cause. Replace it with a new switch.
6. Shut down the engine and, to prevent accidental electric shock or shorting during dash assembling, disconnect the batteries.
7. Assemble the dash. See **Subject 190** for instructions.

Line Restrictions

A restricted suction line causes low suction pressure at the compressor and little or no cooling. A restriction in a line between the compressor and the expansion valve can cause high discharge and low suction pressure, and insufficient cooling.

Usually, areas of ice or frost buildup mean a blockage. Parts that often freeze up are probably corroded or inoperative and should be replaced. Parts (such as the expansion valve) that freeze up once in a while may do so because of moisture in the system, which will cause the moisture indicator's element to turn white or pink; if this happens, recover the refrigerant charge, evacuate/recycle the system refrigerant, replace the receiver-drier, and install a new charge.

Troubleshooting Tables

Troubleshooting

Problem—Little or No Airflow

Problem—Little or No Airflow	
Possible Cause	**Remedy**
The blower is not operating.	Check for an open circuit breaker. An open circuit indicates a short in the electrical system, which must be located and repaired.
	Check the air conditioner relays for operation. Replace, as necessary.
	Make sure the blower motor switch is working. Replace, if necessary.
	Check the wiring to the blower motor. If any connections are loose, securely tighten them. Make sure the wiring conforms to the applicable diagram under **Specifications, 400**.
	Check the blower motor for operation. Replace if sticking or otherwise inoperative.
	Check the resistor block. Replace, if necessary. **CAUTION** **Never try to by pass the fuse in the resistor block. To do so could cause the blower motor to overheat, resulting in serious damage to the heater/ air-conditioning system.**
There are restrictions or leaks in the air ducts.	Examine all air ducts and remove any blockages. Stop any leaks or replace any portion where the leaks cannot be stopped.
Ice has formed on the evaporator coil.	Defrost the evaporator coil before resuming operation of the air conditioner. Review "Performance Tests" in this subject for possible causes and corrective action.

Problem—Warm Airflow When the Air Conditioner Is On

Problem—Warm Airflow When the Air Conditioner Is On	
Possible Cause	**Remedy**
There is no refrigerant charge in the system.	Perform a leak test. Repair any leaks, evacuate the system, replace the receiver-drier, and add a full charge of refrigerant.
Moisture in the system.	If moisture is in the system, ice crystals may form at the expansion valve, blocking the flow of refrigerant (off and on). Recover the refrigerant charge, replace the receiver-drier, evacuate the system, and add a full charge of refrigerant.
The refrigerant compressor is not operating.	If the refrigerant charge is low, charge and leak test the system. Repair any leaks.
	The refrigerant compressor clutch or drive belt needs repair or replacement. For instructions, see the refrigerant compressor section elsewhere in this group.
The air-conditioner microswitch is not working.	Replace the microswitch.
Ice has formed on the evaporator coil.	Defrost the evaporator coil before resuming operation of the air conditioner. Review "Performance Tests" in this subject for possible causes and corrective action.

Problem—Low Evaporator Coil Outlet Pressure (Low Compressor Suction Pressure)

Problem—Low Evaporator Coil Outlet Pressure (Low Compressor Suction Pressure)	
Possible Cause	**Remedy**
The expansion valve is not working.	Replace the expansion valve.
There are restrictions in the line to the expansion valve.	Remove the line restrictions.
There is an insufficient refrigerant charge in the system.	Locate the leak. Recover the charge, replace the receiver-drier, and add a full refrigerant charge.

Problem—High Compressor Discharge Pressure

Problem—High Compressor Discharge Pressure	
Possible Cause	**Remedy**
The shutters are not opening.	Replace the shutter solenoid valve, fan cycling switch, or both.
Airflow through the condenser is restricted.	Remove the debris from the condenser.
There is an internal restriction in the condenser. (Ice buildup on the condenser or a cool spot on the line from the condenser to the receiver-drier.	Replace the condenser.
Air is present in the system.	Perform a leak test. Repair any leaks, evacuate the system, and add a full charge of refrigerant.
Heavy frosting on the suction line suggests that the evaporator coil is flooded.	Defrost the evaporator coil before resuming operation of the air conditioner.
The engine is over-heated.	See the engine manufacturer's operations manual for corrective measures.
Restriction in the compressor discharge line.	Repair or replace the line.

Problem—Evaporator Outlet Air Temperature Increases as the Compressor Discharge Pressure Drops

Problem—Evaporator Outlet Air Temperature Increases as the Compressor Discharge Pressure Drops	
Possible Cause	**Remedy**
There are leaks in the system.	Leak test the system.
The expansion valve setting is too low.	Replace the expansion valve. Add a full charge of refrigerant.
Too much oil is in the system. An indication of this is clutch or belt slippage at governed engine speed.	Check and remove excess refrigerant oil. For instructions, see the refrigerant compressor section elsewhere in this group.

Problem—Compressor Operates Too Often or Continuously

Problem—Compressor Operates Too Often or Continuously	
Possible Cause	**Remedy**
There is too little refrigerant in the system.	Perform a leak test. Repair any leaks, and add a full charge of refrigerant.
Ice has formed on the evaporator coil.	Defrost the evaporator coil before resuming operation of the air conditioner. Check the operation of the thermostatic switch, and replace as necessary.

Troubleshooting

Problem—Compressor Operates Too Often or Continuously	
Possible Cause	**Remedy**
There is a restriction in the refrigerant system.	Remove the restriction from the line.
Dirt and debris are clogging the condenser fins.	Remove all dirt and debris from the condenser fins.
The thermostatic switch isn't working.	Replace the thermostatic switch.

Problem—Quick or Delayed Cycling of the Compressor

Problem—Quick or Delayed Cycling of the Compressor	
Possible Cause	**Remedy**
The thermostatic switch operates, but is out of adjustment.	Replace the thermostatic switch. Do not attempt to adjust it.
Loss of refrigerant is causing a delayed cycling of the compressor.	Leak test and add a full charge of refrigerant.

Problem—Temperature in the Cab Too Low or No Heat

Problem—Temperature in the Cab Too Low or No Heat	
Possible Cause	**Remedy**
The water regulating valve is not opened.	Slide the temperature lever slide control toward "warm."
The water regulating valve is not opening all the way.	Adjust the water regulating valve cable.
The water regulating valve isn't working.	Replace the water regulating valve.
A heater hose is pinched or twisted.	Repair or replace the heater hose.
Coolant is leaking from the system.	Check for leakage at the heater core, and at all hose connections from the heater core to the engine. Check the radiator coolant level, as instructed in the vehicle driver's manual, and add coolant, if necessary. Check and repair any leaks at the radiator.
Dust or dirt is clogging the heater core fins.	Remove and clean the heater core.

Problem—Condensed Water Is Leaking from the Air Conditioner

Problem—Condensed Water Is Leaking from the Air Conditioner	
Possible Cause	**Remedy**
The drain tubes are plugged.	Clean the drain holes and drain tubes.

Fault Analysis Flow Chart

(See Fig. 3)

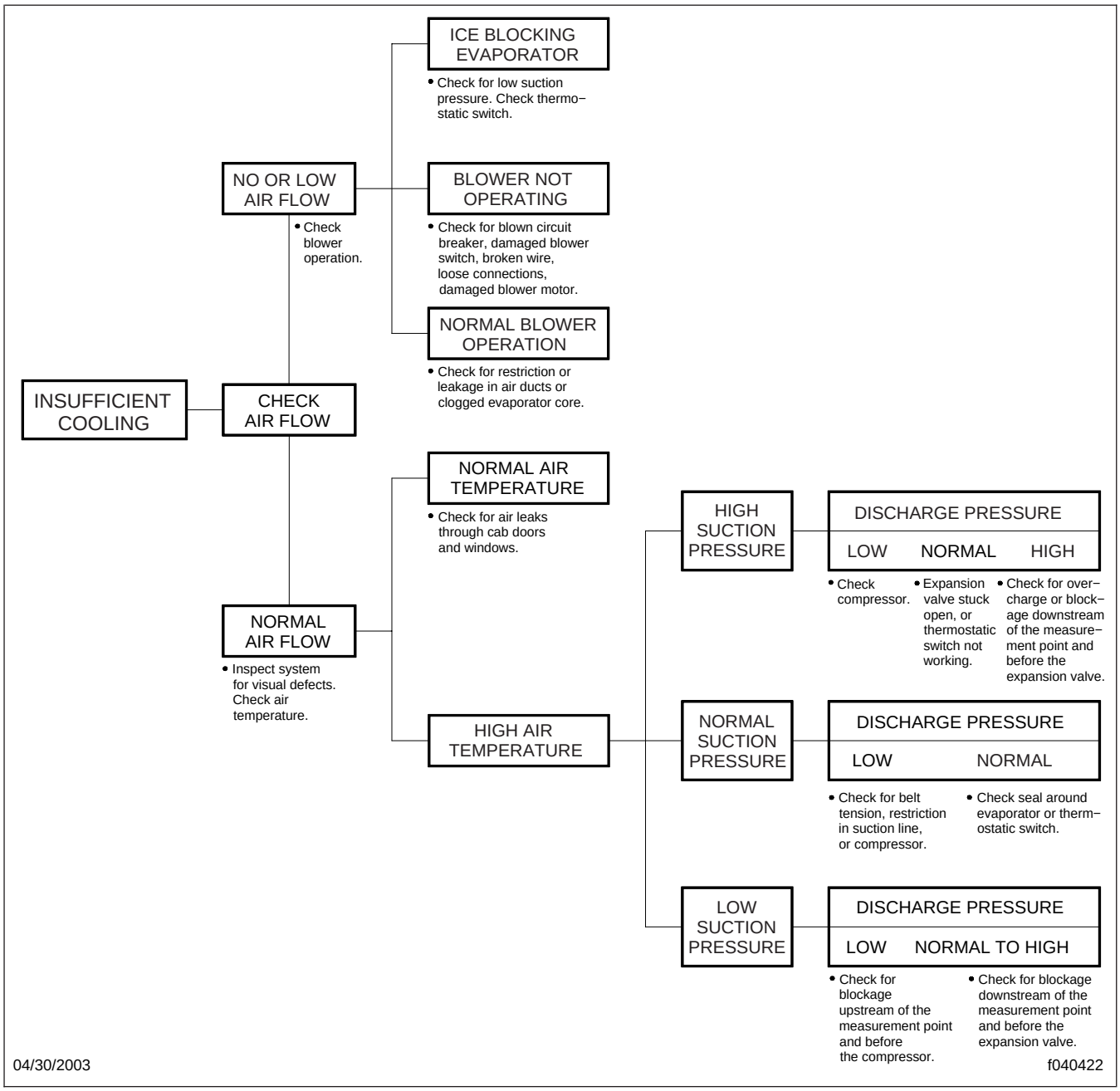


Fig. 3, Fault Analysis Flow Chart

Specifications

See **Fig. 1** for heater-A/C wiring.

See **Fig. 2** for heater-A/C system components.

See **Fig. 3** for heater plumbing on DDE 60 engines (vehicles built after June 1, 1990).

See **Fig. 4** for heater plumbing on CAT™ 3176 engines (vehicles built after June 1, 1990).

See **Fig. 5** for heater plumbing on CAT™ 3406 engines (vehicles built after June 1, 1990).

See **Fig. 6** for heater plumbing on Cummins L10 engines (vehicles built after June 1, 1990).

See **Fig. 7** for heater plumbing on Cummins NTC engines (vehicles built after June 1, 1990).

See **Fig. 8** for control panel plumbing diagram.

See **Fig. 9** for APADS™ electronic control module wiring diagram.

See **Fig. 10** for COE with DDEC® III engine and APADS™ schematic.

See **Fig. 11** for FLD with Caterpillar™ electronic engine and APADS™ schematic.

See **Fig. 12** for FLD with DDEC® III engine and APADS™ schematic.

See **Fig. 13** for FLD with Cummins electronic engine and APADS™ schematic.

CAUTION

Never try to bypass the fuse in the blower motor resistor block. To do so could cause the blower motor to overheat, resulting in serious damage to the heater-A/C system.

Air Tubing Fitting Torque Specifications				
Fitting Size	Tube (inches)	Additional Turns (using a wrench) Required to Seal from Finger-Tight		
		Compression	Threaded Sleeve	SAE 45-Degree Flare
2	1/8	1-1/4	1-1/2	1/6 Do Not Overtighten
3	3/16			
4	1/4			
5	5/16	1-3/4		
6	3/8	2-1/4		
8	1/2			
10	5/8			
12	3/4			
16	1			
20	1-1/4			

Table 1, Air Tubing Fitting Torque Specifications

A/C Fitting Torque Specifications*	
Hose Size	Torque
#6	20–25 lbf·ft (27–34 N·m)
#8	30–35 lbf·ft (41–47 N·m)

Specifications

A/C Fitting Torque Specifications*	
Hose Size	**Torque**
#10 and #12	35–40 lbf·ft (47–54 N·m)

* One-inch fittings on the A/C compressor need to be torqued 21 to 27 lbf·ft (28 to 37 N·m) regardless of hose size.

Table 2, A/C Fitting Torque Specifications

Refrigerant Charge Specifications		
Condenser Make	**Type of Cab**	**Refrigerant Amount**
Behr	Day Cab	2.875 lb or 2 lb 14 oz (1.30 kg)
	SleeperCab	3.438 lb or 3 lb 7 oz (1.56 kg)
Modine	Day Cab	3.50 lb or 3 lb 8 oz (1.59 kg)
	SleeperCab	3.88 lb or 3 lb 14 oz (1.76 kg)

Table 3, Refrigerant Charge Specifications

Air Line Identification					
Lever Position	**Line Color/Function**				
	Yellow Supply	**Green Heat/ Def**	**Red Heat**	**Blue Vent**	**White Recirc Cylinder**
	Air Pressure				
DEF	Yes	No	No	No	No
HEAT/DEF	Yes	Yes	No	No	No
HEAT	Yes	Yes	Yes	No	No
VENT	Yes	Yes	Yes	Yes	No
A/C	Yes	Yes	Yes	Yes	No
MAX A/C	Yes	Yes	Yes	Yes	Yes

Table 4, Air Line Identification

3/4- and 5/8-Inch Heater Hose Clamp Torque Values	
Description	**Torque lbf·in (N·cm)**
Standard Hose Clamp	40 (452)
Worm-Gear Hose Clamp	
Breeze Constant-Torque Hose Clamp	
Oetiker Constant-Torque Hose Clamp	18 (203)

Table 5, 3/4- and 5/8-Inch Heater Hose Clamp Torque Values

Specifications

Electronic Leak Detectors		
Designation	**Manufacturer**	**Comments**
D-TEK, D-Tek Select, TekMate	Leybold Inficon 2 Technology Place East Syracuse, NY 13057 (315) 434–1144	• Rechargeable battery • Hand-held design • Simple to operate
H–10 Professional	Yokogawa Corp. of America 2 Dart Road Newnan, GA 30265 (800) 258–2552	• Rechargeable battery • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Most sensitive available
J 39400	SPX Kent-Moore 28635 Mound Road Warren, MI 48092 (800) 328–6657	• 12V DC or 120V AC • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Manual balance control

Table 6, Electronic Leak Detectors

APADS™ Parametric Specifications*				
Parameter	**Minimum**	**Typical**	**Maximum**	**Units†**
Supply Voltage‡	10.0	13.5	16.0	Volts
Supply Voltage§			24.0	Volts
Supply Current (no load)			50.0	mAmps
Load (AC clutch drive)	3.0	4.0		Ohms
Load (AC clutch drive)		0.1	0.20	Henries
Load Energy ½LI^2			1.5	Joules
Relay Contact Voltage Drop		0.04	0.10	Volts
Load (fan actuator circuit)	13.0			Ohms
Load (fan actuator circuit)			80.0	mHenries
Input Debounce Delay	0.3		1.1	Seconds
Open Clutch Sense Current	0.15	0.5	1.27	Amps
Shorted Clutch Cut Out Resistance	1.7		2.4	Ohms
Voltage Cut Out Off Threshold	10.8	11.0	11.2	Volts
Evaporator Thermostat On Range	5.0		VIGN	Volts

Specifications

APADS™ Parametric Specifications*				
Parameter	**Minimum**	**Typical**	**Maximum**	**Units†**
Evaporator Thermostat Off Range	0		1.0	Volts

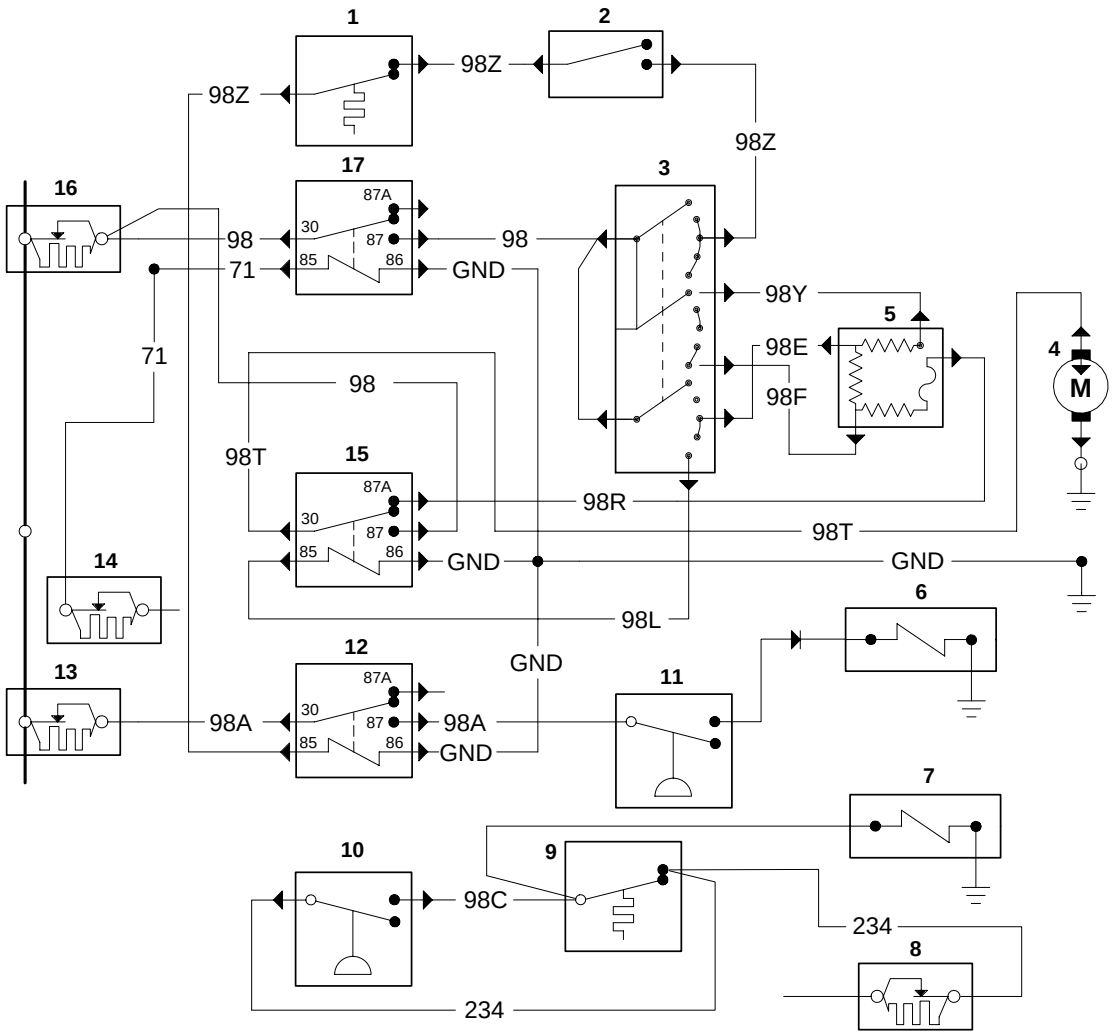
* Applicable over the full operating range: –40° to 212°F (–40° to 100°C)

† All voltages referenced are to ground lead of the device.

‡ Continuous operation.

§ Absolute maximum; two minute duration.

Table 7, APADS™ Parametric Specifications



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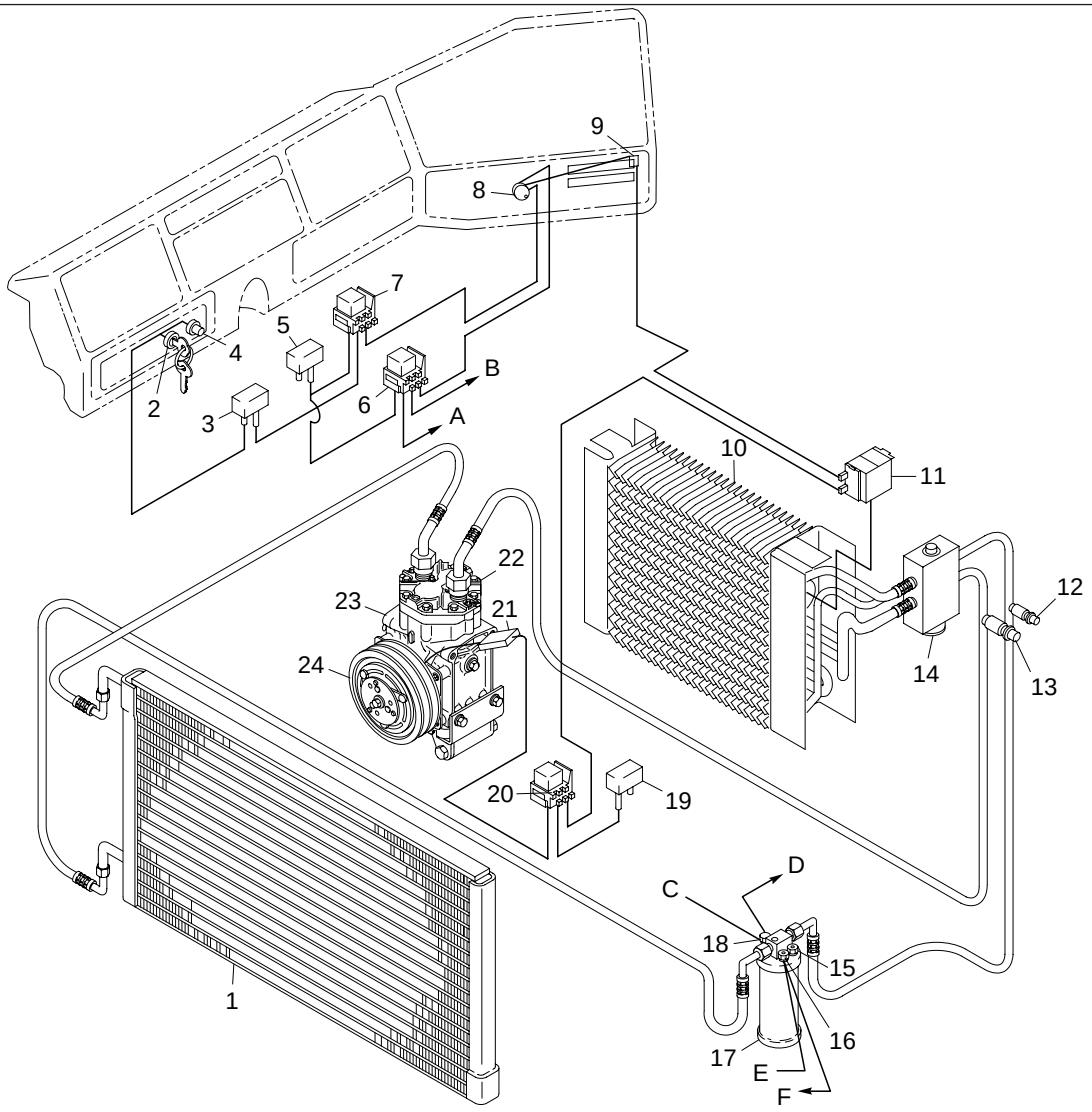
1. Thermostat (Open 32°F)
2. Air Conditioner On-Off Switch
3. Heater-Air Conditioner Fan Switch
4. Motor
5. Resistor
6. Refrigerant Compressor Clutch
7. Fan Clutch Solenoid
8. 10 Amp Auxiliary Keyed Circuit Breaker
9. Fan Clutch Thermal Switch
10. Fan Cycle Switch
11. Binary Pressure Switch
12. Air Conditioner Clutch Relay
13. 15 Amp
14. 10 Amp Keyed Circuit Breaker
15. Heater-Air Conditioner Relay
16. 30 Amp
17. Heater-Air Conditioner Relay

Fig. 1, Heater/Air-Conditioning Wiring

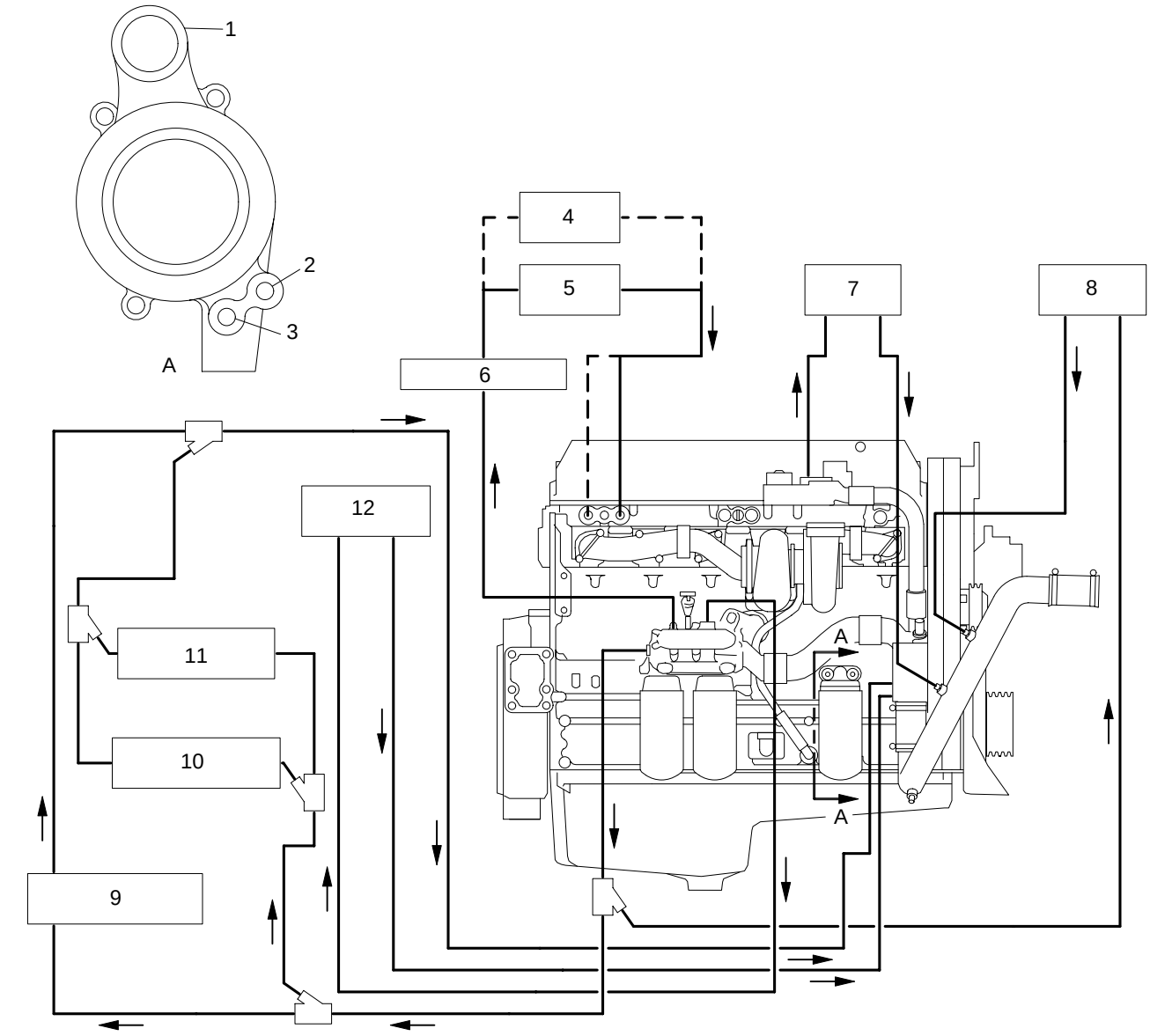
Specifications



A. to resistor block
B. to blower motor
C. from engine fan thermal switch
D. to engine fan thermal switch
E. from a/c clutch relay
F. to compressor clutch

1. Condenser
2. Ignition Switch
3. Circuit Breaker (10A)
4. Start Button
5. Circuit Breaker (30A)
6. High-Speed Relay
7. Power Relay
8. Blower Switch
9. "On-Off" Microswitch
10. Evaporator
11. Thermostatic Switch
12. Suction Service Valve
13. Discharge Service Valve
14. Expansion Valve
15. Moisture Indicator
16. Binary Switch
17. Receiver-Drier
18. Fan Cycling Switch
19. Circuit Breaker (15A)
20. A/C Clutch Relay
21. Diode
22. High Pressure Relief Valve
23. Compressor
24. Compressor Clutch

Fig. 2, FLB COE and FLD Conventional Air Conditioning System



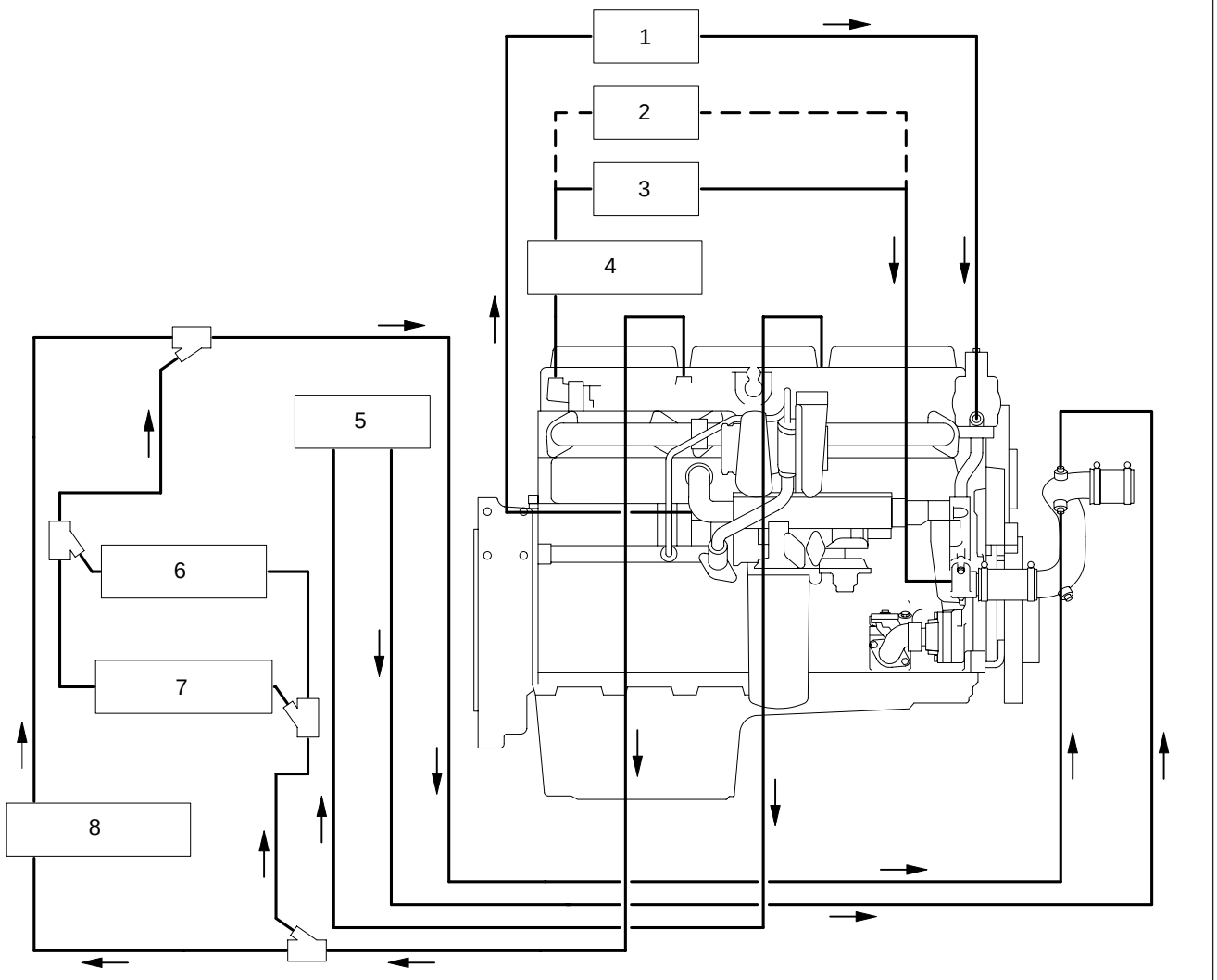
NOTE: Depending on vehicle options, and often for ease of installation, different supply and return ports can be used.

A. **View A-A**

1. Water Pump Outlet
2. Main Heater Return Port
3. Aux Heaters Return Port
4. Fuel Heater
5. Fuel Heater
6. Thermostat
7. Water Filter
8. Trailer Heater
9. Sleeper Bunk Heater
10. Passenger's Aux Heater
11. Driver's Aux Heater
12. Main Cab Heater

Fig. 3, Heater Plumbing for DDE Series 60 Engines (Vehicles Built After June 1, 1990)

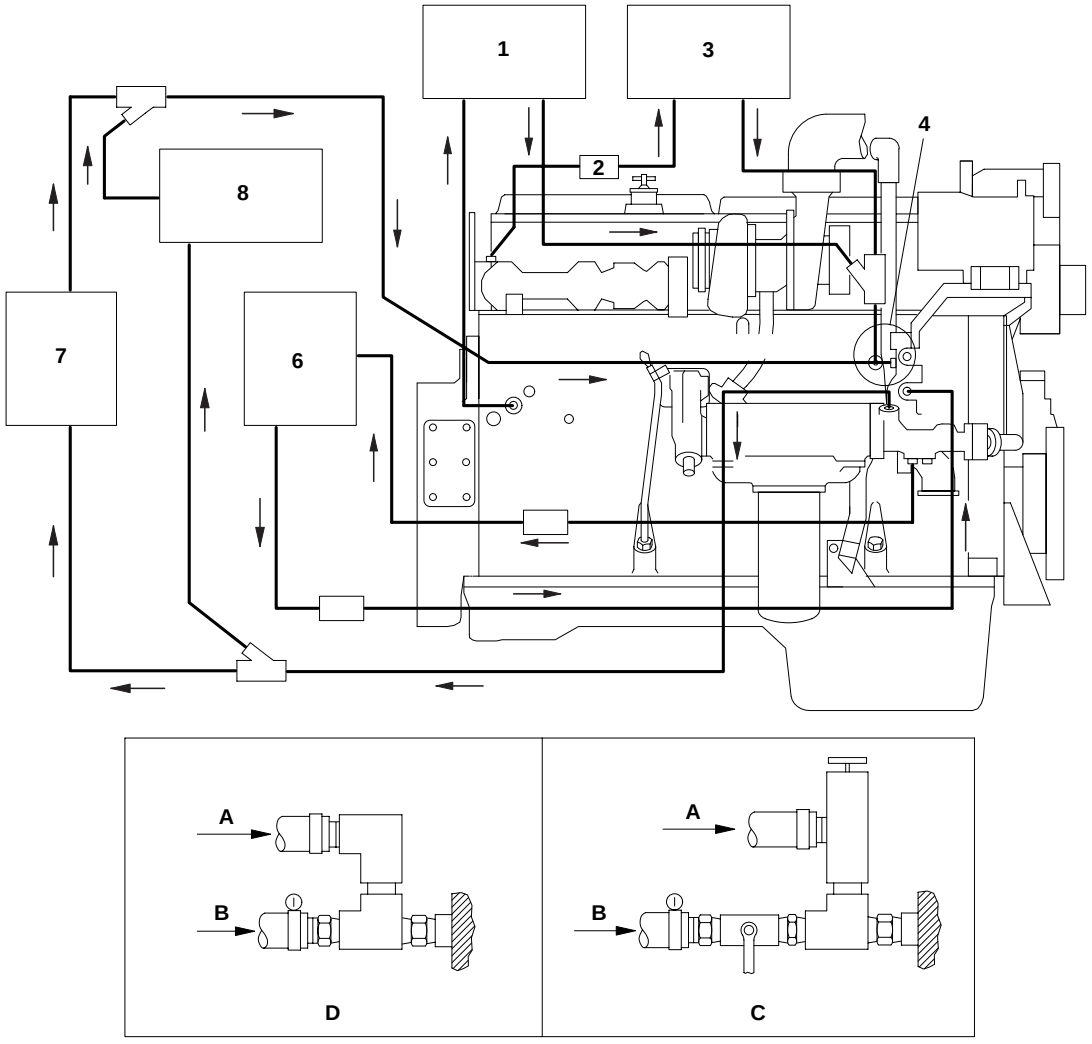
Specifications



NOTE: Depending on vehicle options, and often for ease of installation, different supply and return ports can be used.

1. Water Filter
2. Fuel Heater
3. Fuel Heater
4. Thermostat
5. Main Cab Heater
6. Driver's Aux Heater
7. Passenger's Aux Heater
8. Sleeper Bunk Heater

Fig. 4, Heater Plumbing for Caterpillar 3176 Engines (Vehicles Built After June 1, 1990)



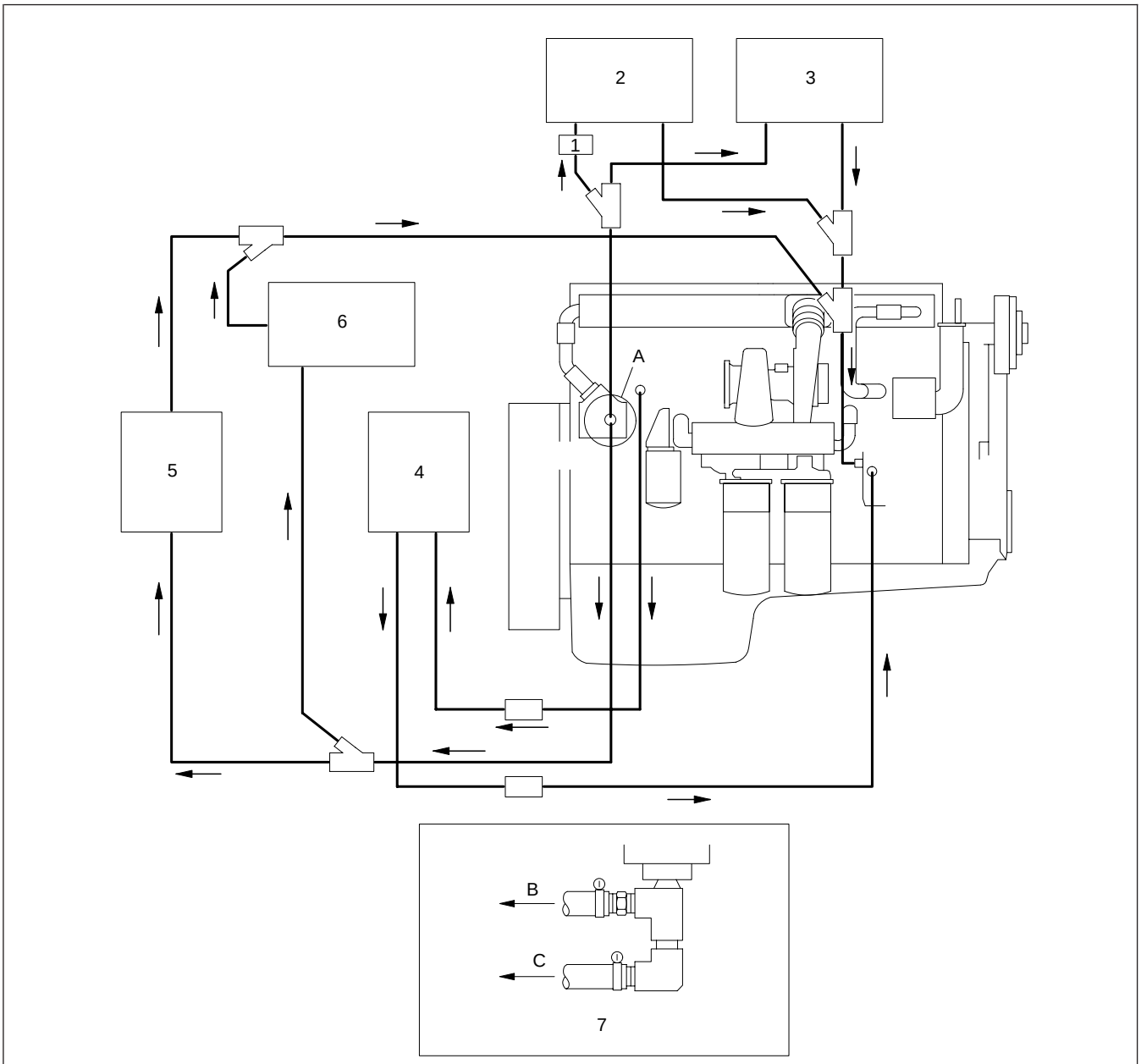
NOTE: Depending on vehicle options, and often for ease of installation, different supply and return ports can be used.

A. from fuel heater and water filter
B. from auxiliary heater(s)
C. With Shutoff Valve(s)
D. Without Shutoff Valve(s)

1. Water Filter
2. Thermostat
3. Fuel Heater
4. See Detail A
5. Detail A (side view)
6. Main Cab Heater
7. Sleeper Heater
8. Driver-Side Auxiliary Heater

Fig. 5, Heater Plumbing for Caterpillar 3406 Engines (Vehicles Built After June 1, 1990)

Specifications

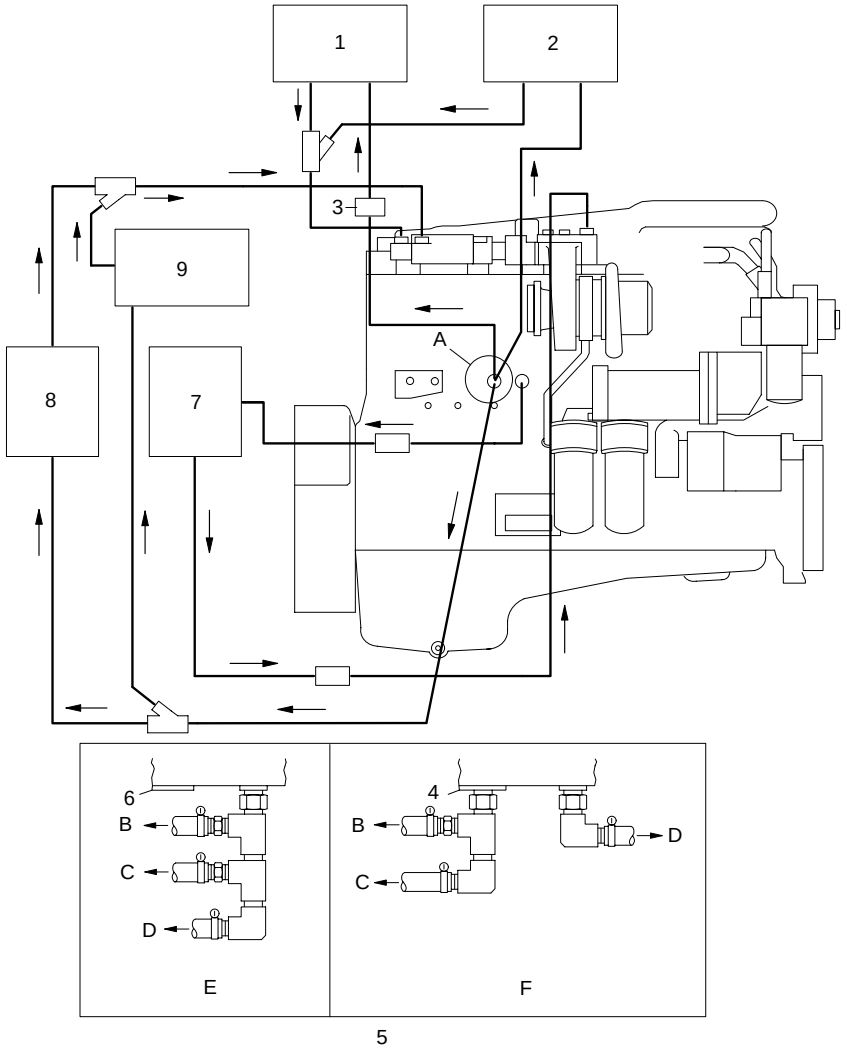


NOTE: Depending on vehicle options, and often for ease of installation, different supply and return ports can be used.

A. See Detail A
B. to fuel heater and water filters
C. to auxiliary heater(s)

1. Thermostat
2. Fuel Heater
3. Water Filter
4. Main Cab Heater
5. Sleeper Heater
6. Driver-Side Auxiliary Heater
7. Detail A (top view)

Fig. 6, Heater Plumbing for Cummins L10 Engines (Vehicles Built After June 1, 1990)



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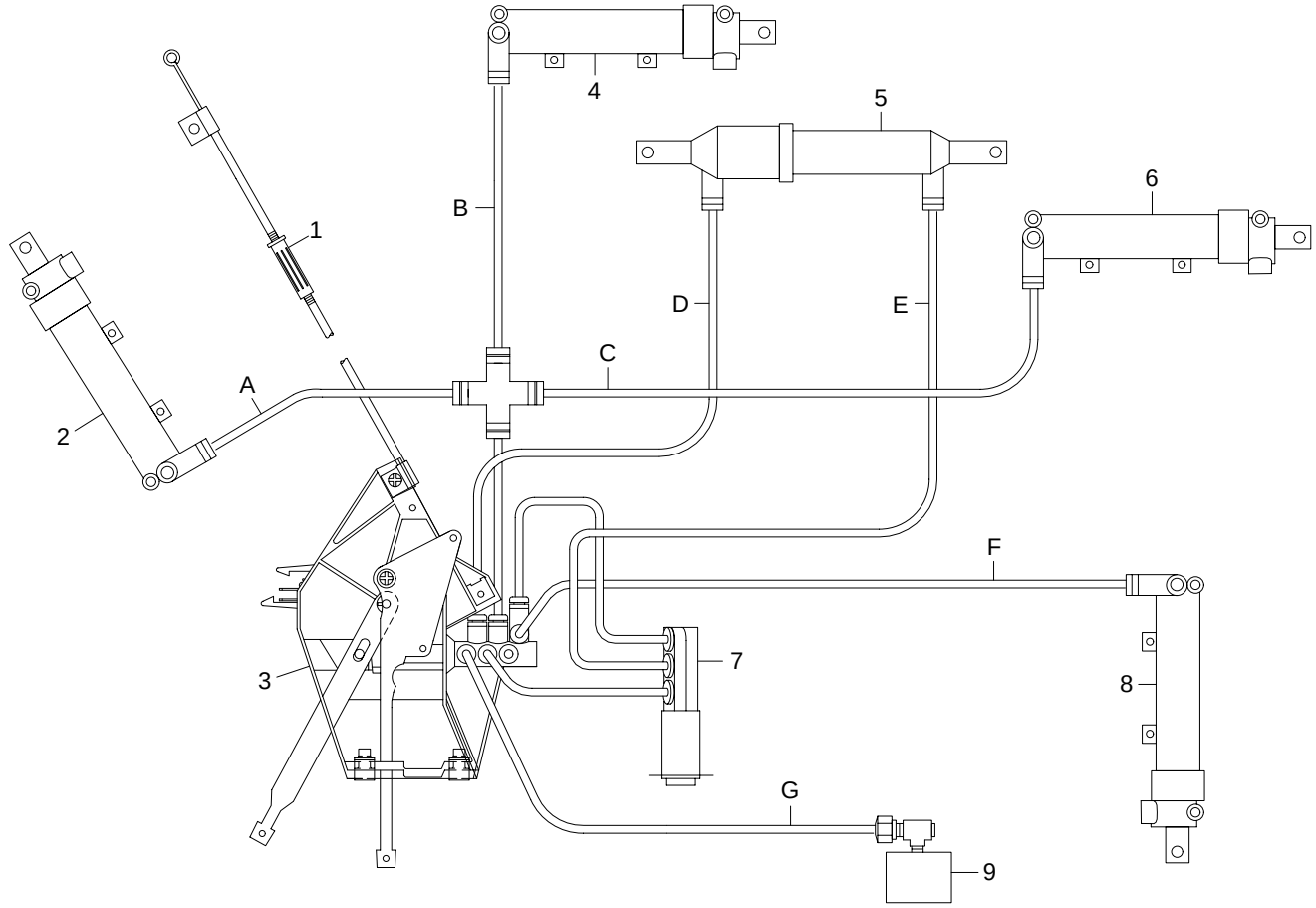
NOTE: Depending on vehicle options, and often for ease of installation, different supply and return ports can be used.

A. See Detail A
B. to water filter
C. to fuel heater
D. to auxiliary heaters
E. Supply Port Covered by Block Heater
F. Supply Port Available

1. Fuel Heater
2. Water Filter
3. Thermostat
4. Block Heater or Cover Plate
5. Detail A (top view)
6. Block Heater
7. Main Cab Heater
8. Sleeper Heater
9. Driver-Side Auxiliary Heater

Fig. 7, Heater Plumbing for Cummins NTC Engines (Vehicles Built After June 1, 1990)

Specifications



A. Vent/Blue
B. Vent/Blue
C. Vent/Blue
D. Heat/Defrost-Green
E. Heat/Red
F. Recirc/White
G. Supply/Yellow

1. Water Regulator Valve Cable
2. Left-Side Diverter Air Cylinder
3. Slide Lever Control
4. Face Duct Air Cylinder
5. Heat/Defrost Duct Air Cylinder
6. Right-Side Diverter Air Cylinder
7. Fresh-Air Recirculation Valve
8. Recirculation Air Cylinder
9. Constant Air Junction Block

Fig. 8, Control Panel Plumbing (vehicle equipped with heater and air conditioner, and a fresh-air recirculation valve)

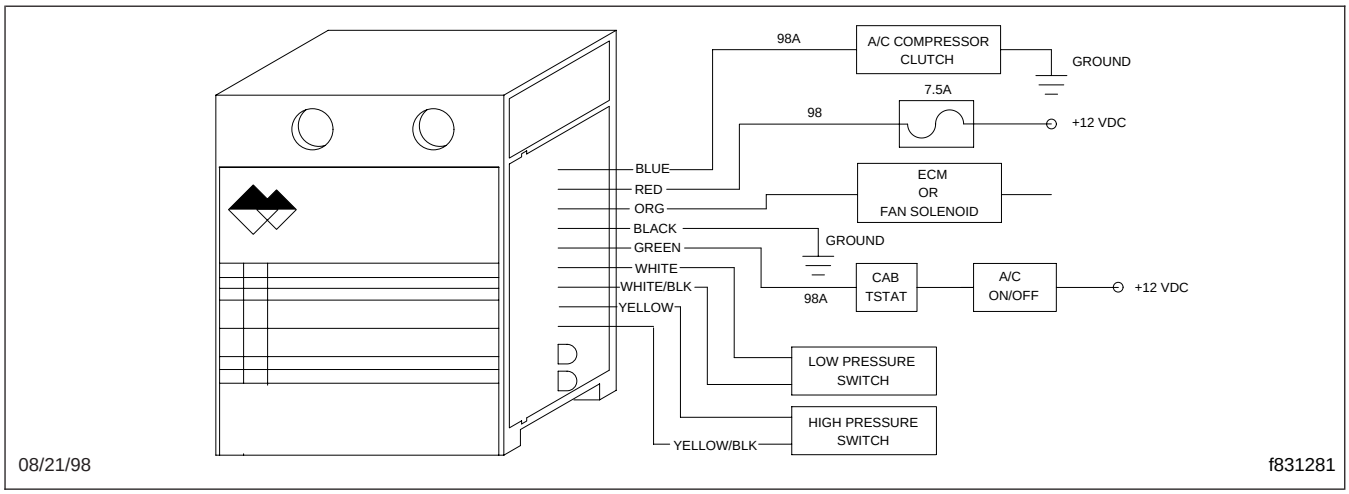


Fig. 9, APADS™ Electronic Control Module Wiring Diagram

Specifications

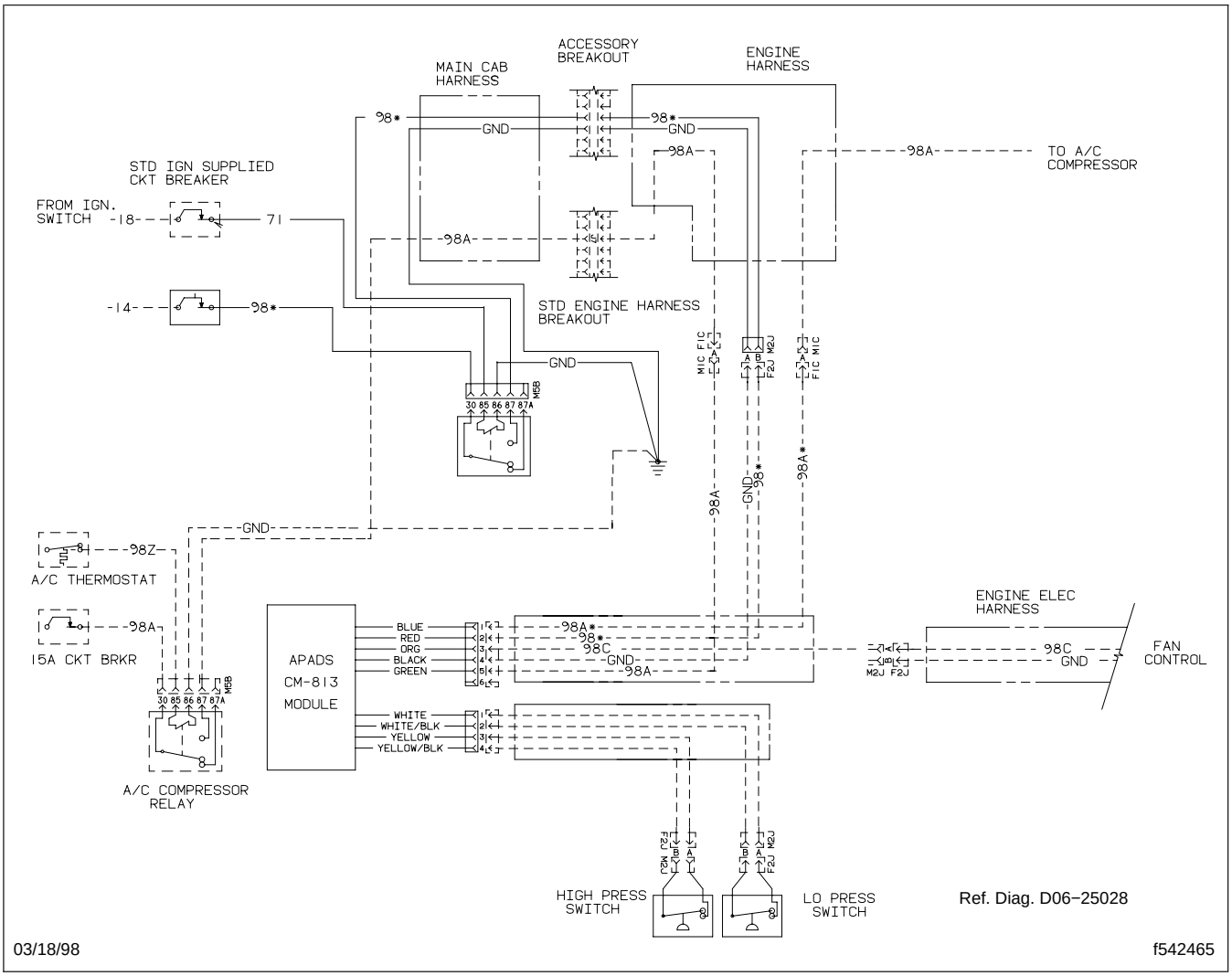


Fig. 10, COE With DDEC® III Engine and APADS™ Schematic

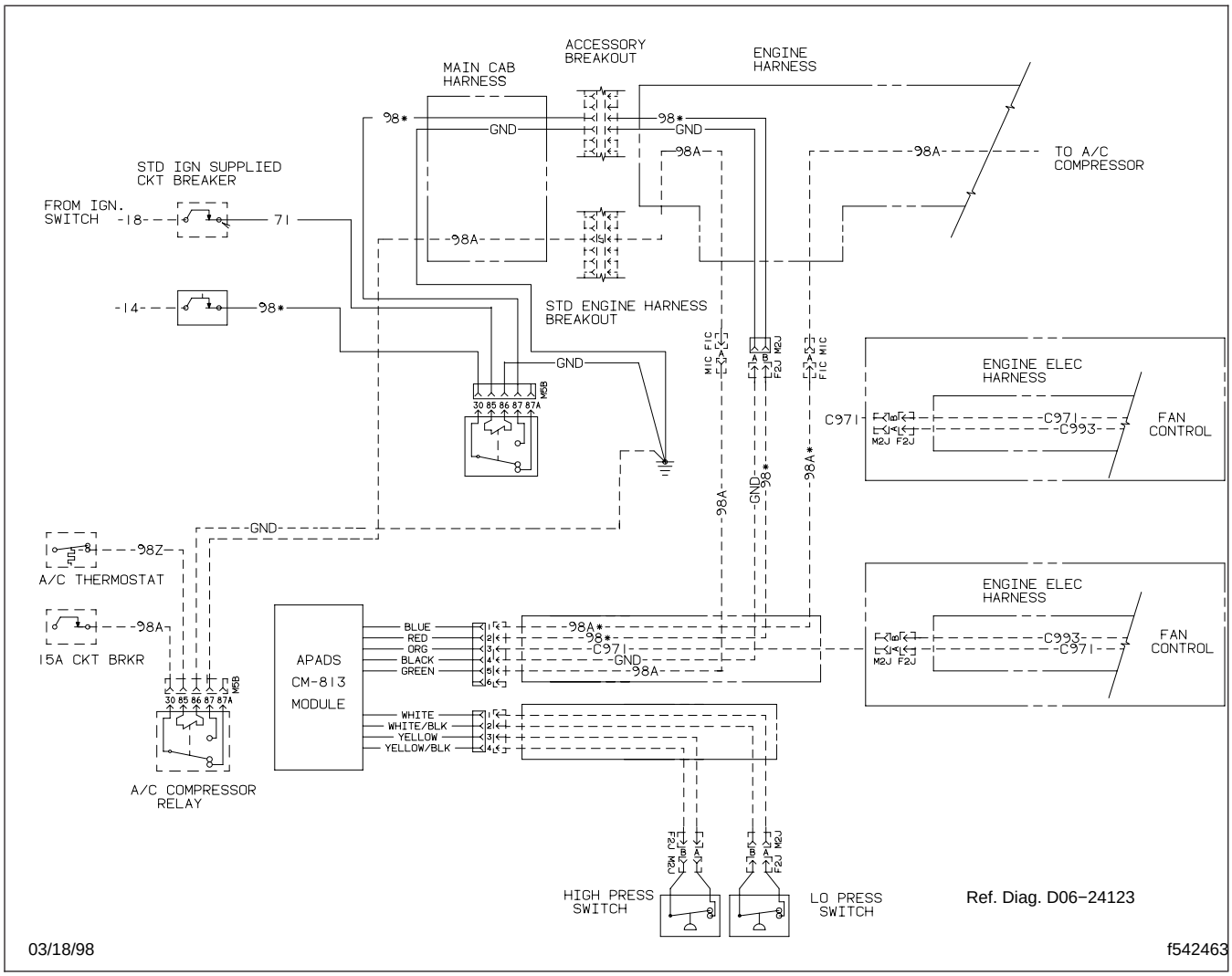


Fig. 11, FLD With Caterpillar™ Electronic Engine and APADS™ Schematic

Specifications

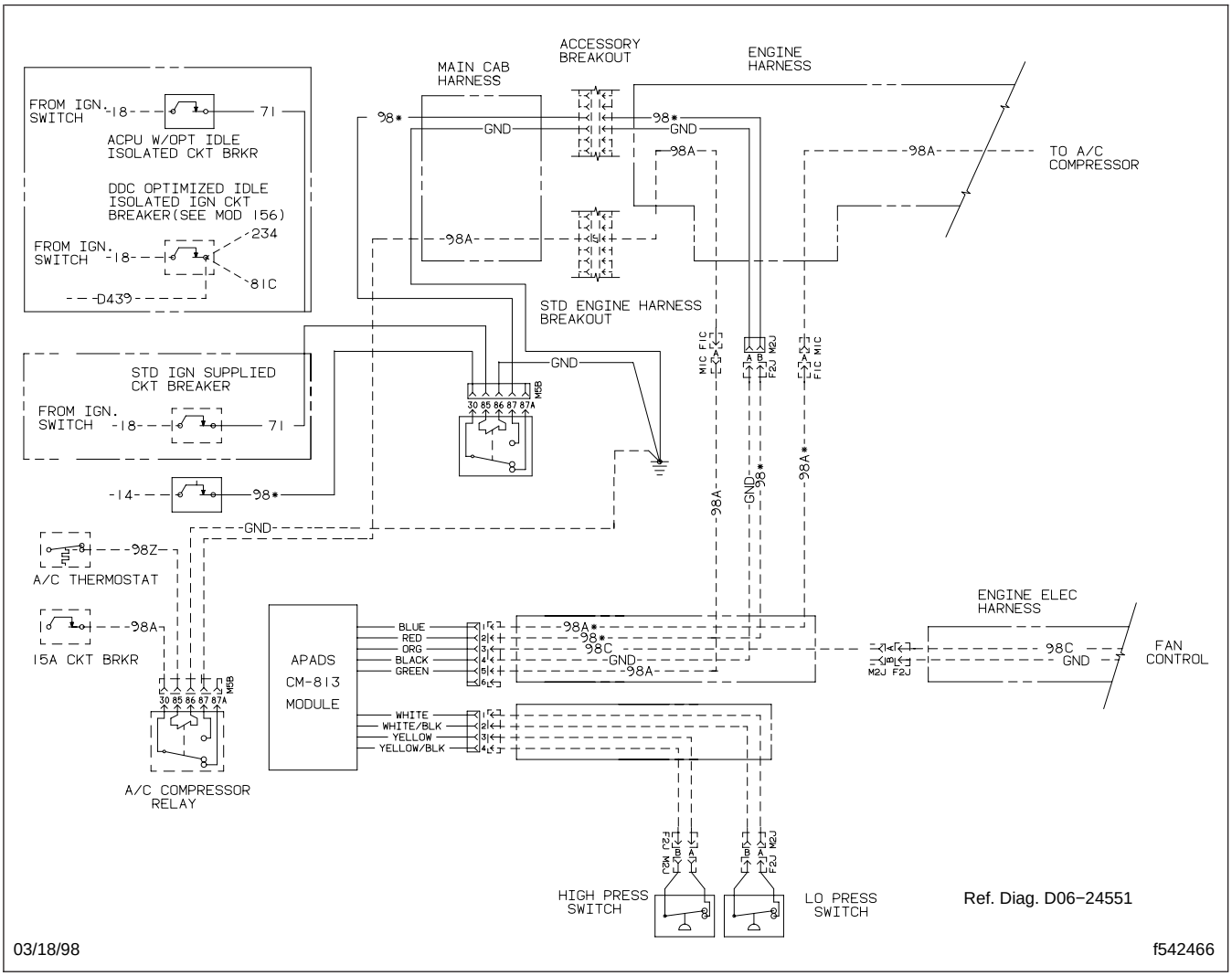


Fig. 12, FLD With DDEC® III Engine and APADS™ Schematic

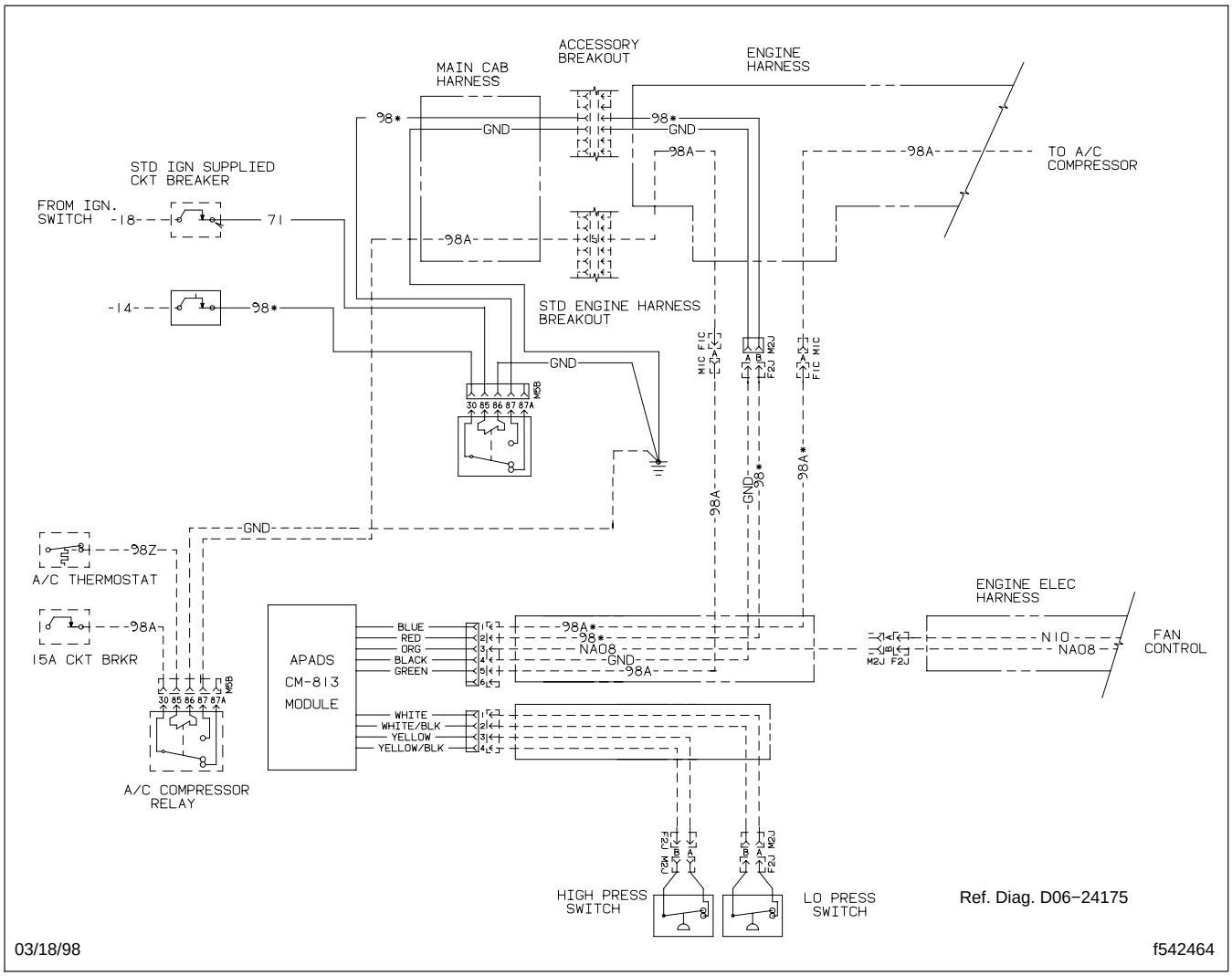


Fig. 13, FLD With Cummins Electronic Engine and APADS™ Schematic

General Information and Principles of Operation

Sleeper heater and air conditioner units **(Fig. 1** and **Fig. 2)** are self-contained, and include the heater core/evaporator coil, blower motor, and control valves. They are mounted either in the baggage compartment or under the lower bunk, depending on the cab model.

The sleeper heater is plumbed directly to the engine, independent of the cab heater. The sleeper air conditioner is dependent on the cab's air conditioning system, sharing the same refrigerant and compressor.

For air conditioner general information and principles of operation, refer to the applicable heater and air conditioner section in this group.

The sleeper unit's climate control panel **(Fig. 3** or **Fig. 4)** is installed in various locations in the sleeper, depending on the sleeper size and vehicle type. Refer to the vehicle driver's manual for operating instructions.

Opening of the water shutoff valve **(Fig. 1** or **Fig. 2)** allows engine-heated coolant to flow through the heater core. Heat is absorbed by air passing over the heater core fins.

The blower forces the heated air through the ducts and into the sleeper.

Depending on the type of temperature control, the water shutoff valve opens when:

- *Manual Cable Control*—The temperature control cable handle attached to the outlet duct at the foot of the bunk, is pulled up.
- *Automatic Temperature Control (A.T.C.)*—The rotary temperature control knob **(Fig. 4)** is turned clockwise to HEAT.

The A.T.C. system has four major components:

- A.T.C Module

  —Supplies power to the water supply solenoid.

  —Monitors air output temperature.

  —Used with the temperature control knob to select the desired temperature.

- Air-Operated Water Shutoff Valve

  —The valve is opened and closed by air pressure which is controlled by the water supply solenoid valve.

- Water Supply Solenoid Valve

  —Receives power from the A.T.C. module.

  —Controls the air supply to the water shutoff valve.

- Air Temperature Sensor

  —Monitors air output temperature.

If equipped with an automatic temperature control system (A.T.C.), a preselected temperature is maintained by pulsating the flow of hot water through the heater core.

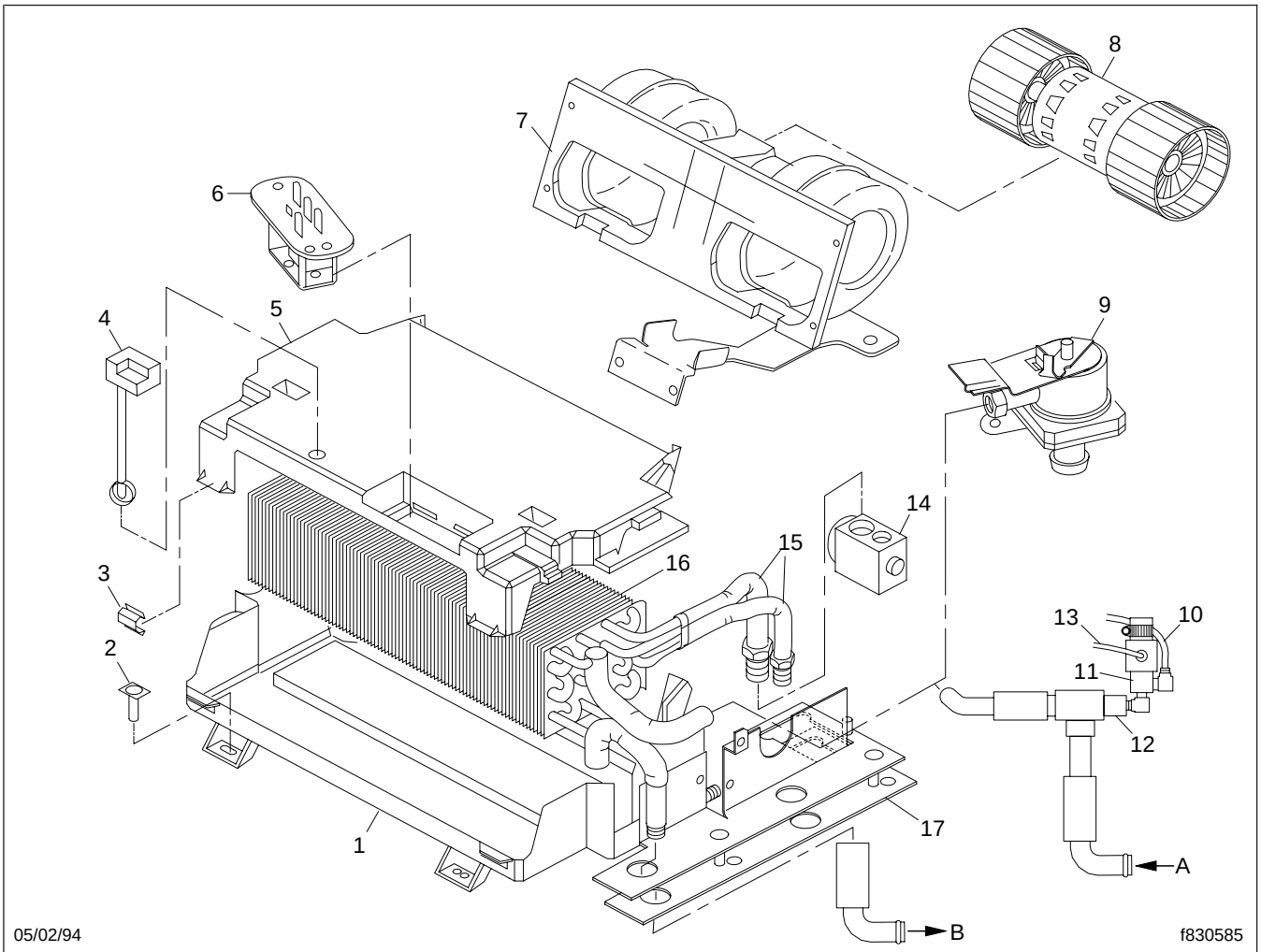
Once the operator adjusts the temperature control knob, the air output temperature is monitored by an air temperature sensor at the sleeper heater and air conditioner unit. Any change in output temperature activates the A.T.C. module, energizing or de-energizing the water supply solenoid valve. This controls the air supply that opens or closes the water shutoff valve.

If the air is colder than the selected temperature, hot water is allowed to flow through the water shutoff valve into the heater core. As the output temperature reaches the desired setting, the water shutoff valve is closed, preventing hot water from entering the heater core, until air output temperature becomes too cool again. Then the process starts over.

If equipped with a manual temperature control cable system, outlet air temperature is manually controlled by moving the temperature control cable. Depending on the control panel settings in the cab, moving the cable regulates the water shutoff valve and can provide a full range of warm to hot air (heat mode), or cool to cold air (A/C mode).

A fan control knob controls a three-speed blower motor and allows the operator to choose the amount of air flow in the sleeper.

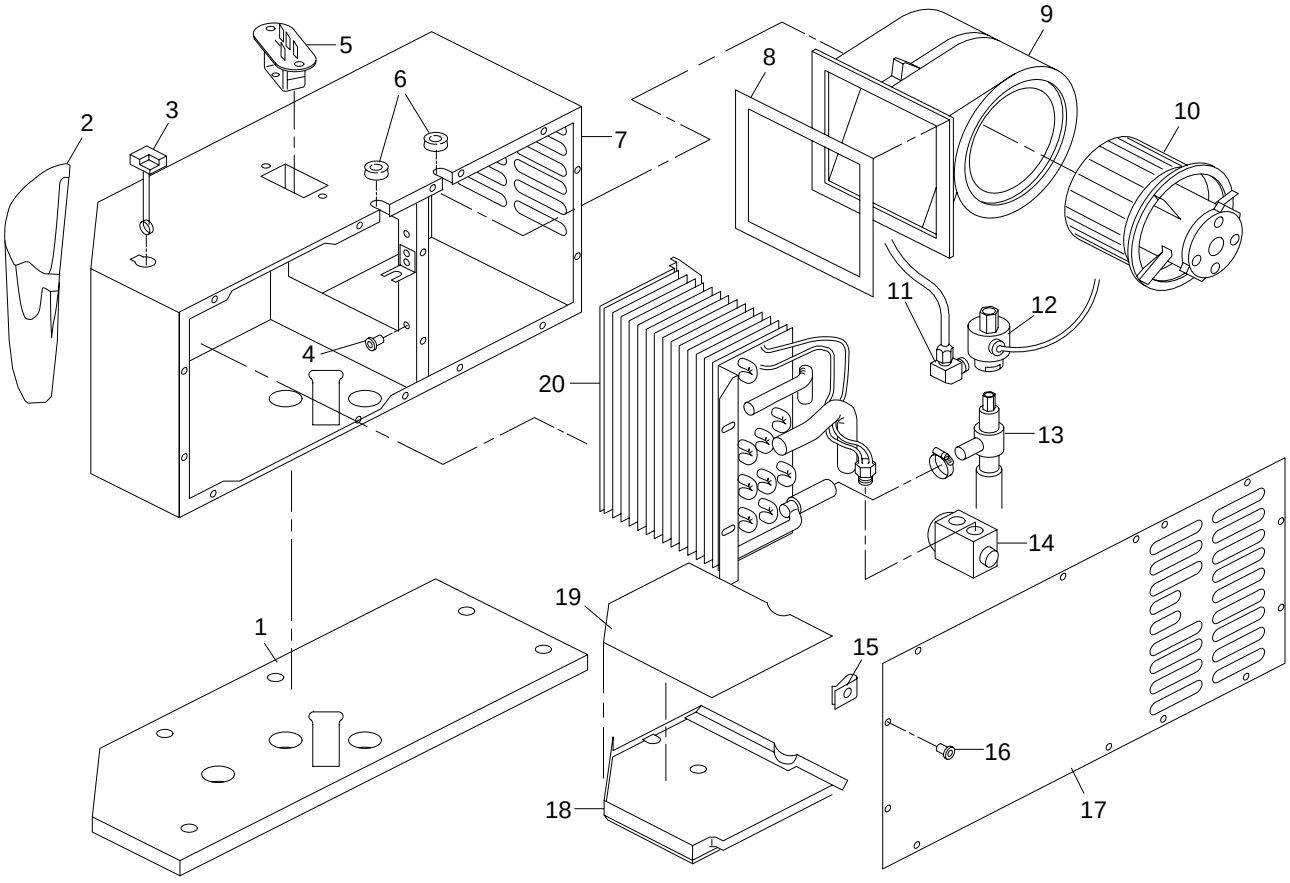
General Information and Principles of Operation



A. Water Supply
B. Water Outlet

1. Deck Plate
2. Mounting Fastener (2 qty.)
3. Top-Cover Clip
4. Temperature Sensor (A.T.C. only)
5. Top Cover
6. Resistor
7. Blower Motor Housing
8. Blower Motor
9. Water Supply Valve (cable control only)
10. Air Line
11. Water Supply Solenoid Valve (A.T.C. only)
12. Water Shutoff Valve
13. Solenoid Wiring
14. Expansion Valve
15. Refrigerant Lines
16. Evaporator/Heater Core Assembly
17. Deck Seal

Fig. 1, FLD Conventional Sleeper Heater and Air Conditioner Assembly



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1. Housing Gasket
2. Discharge Air Duct
3. Sensor
4. Rivet, 3/16 x 1/4 inch
5. Resistor
6. Grommet
7. Housing Assembly
8. Blower Motor Seal
9. Blower Motor Housing
10. Blower Motor Assembly
11. 90° Elbow
12. Water Supply Solenoid Valve
13. Water Shutoff Valve
14. Expansion Valve
15. U-Clip
16. Screw, 11–16 x 3/4 inch
17. Front Cover
18. Drain Baffle
19. Drain Plate
20. Evaporator/Heater Core Assembly

Fig. 2, FLB COE Sleeper Heater and Air Conditioner Assembly

General Information and Principles of Operation

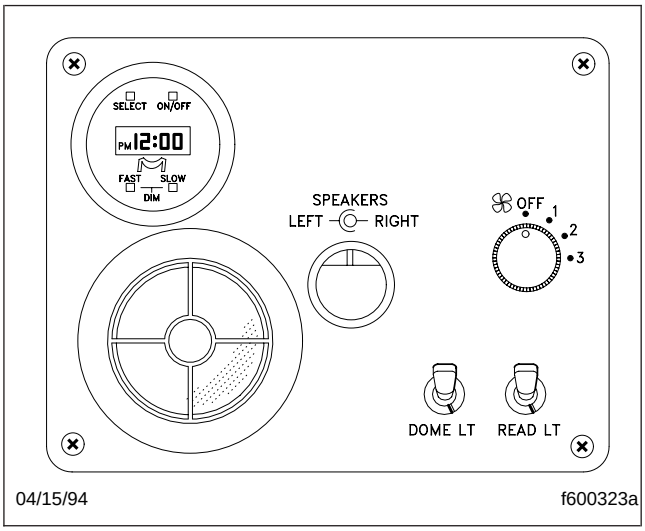


Fig. 3, Control Panel for Manual Temperature Control Cable System

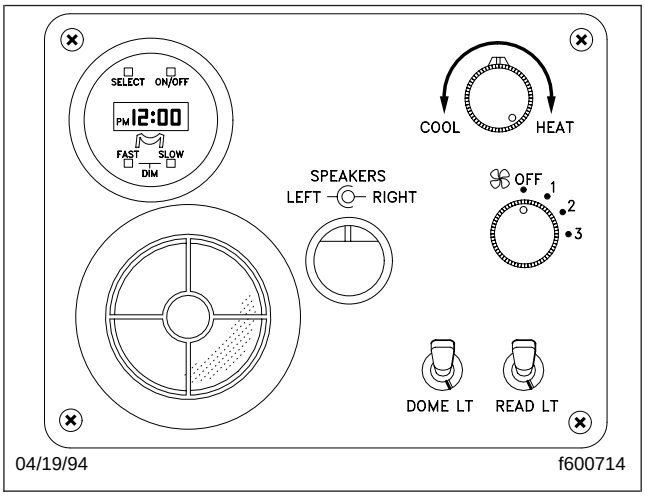


Fig. 4, Control Panel for Automatic Temperature Control (A.T.C.) System

Safety Precautions

Refrigerant R–134a Air Conditioning Systems

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

WARNING: Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

⚠ WARNING

WARNING: R–134a air conditioning systems should not be pressure tested or leak tested with compressed air (R–134a may be safely pressured with dry nitrogen). Combustible mixtures of air and R–134a may form, resulting in a fire or explosion, which could cause personal injury or property damage.

You must work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG) oil is used in the compressor. When handling PAG oil, observe the following:

- keep the oil free of contaminants
- do not expose the AC system or the PAG oil container to air for long periods of time; PAG oil has a high moisture absorption capacity
- use care when handling: painted surfaces, plastic parts, and other components (drive belts) could be damaged if PAG oil is spilled on them
- never mix PAG oil with other types of refrigerant oil

Refrigerant R–12 Air Conditioning Systems

Whenever repairs are made to any air conditioner parts that hold refrigerant, you must discharge, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the air conditioning system has been discharged to a refrigerant recovery unit through the service valves on the compressor.

Refrigerants are safe when used under the right conditions. Always wear safety goggles and non-leather

gloves while discharging, purging, flushing, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

WARNING: Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should first be treated with a few drops of sterile mineral oil in the eyes, and then rinsed with a weak boric acid solution. Do not rub the eyes. Call a doctor right away.

Refrigerant splashed on the skin should be treated the same as for frostbite: gently pour cool water on the area, but do not rub the skin. Keep the skin warm with layers of soft, sterile cloth. Call a doctor right away.

Even though refrigerant does not burn, when it contacts extreme heat or flame, poisonous phosgene gas is created. This gas also is produced when an open flame leak detector is used. Phosgene fumes have an acrid (bitter) smell.

⚠ WARNING

WARNING: Do not work in an area where refrigerant may contact an open flame or any burning material, such as a cigarette. When it contacts extreme heat, refrigerant breaks down into poisonous phosgene gas which, if breathed, causes severe respiratory irritation. Do not breathe the fumes from an open flame leak detector.

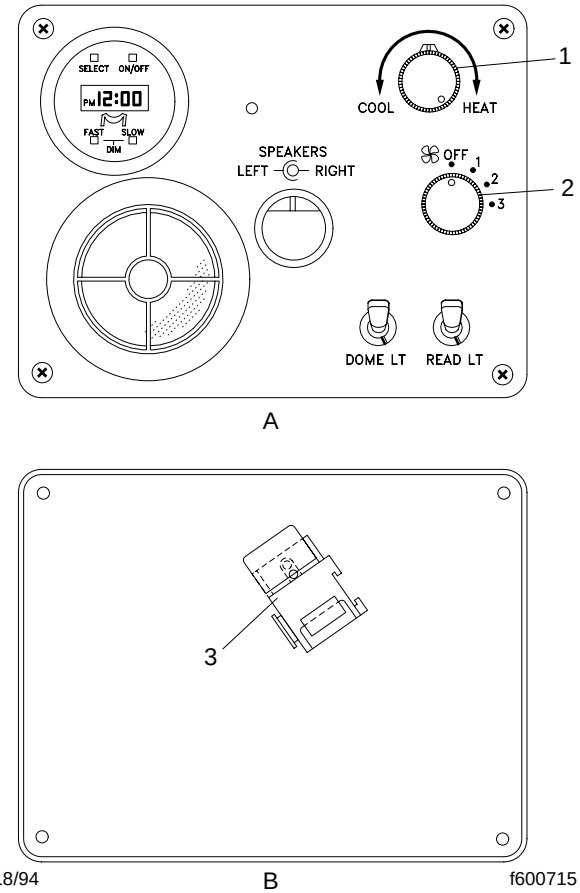
You must work in an area where there is a constant flow of fresh air when the system is discharged, flushed, charged, and leak tested using an open flame leak detector.

IMPORTANT: Changes in both federal and state laws will affect the way dealerships service air-conditioning systems. Under current federal laws, refrigerant R–12 must be recovered and recycled by all users to protect the environment, and not released into the atmosphere. Many service operations not directly involving the air-conditioning system require the release of the refrigerant charge. Under the new regulations, dealerships not having the required recovery and recycling equipment (and properly trained and certified personnel) will not be allowed to do any of this service work.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant cans from exploding, never expose them to temperatures higher than 125°F (52°C). Never leave refrigerant cans in the sun, and do not store them in sun-exposed areas where heat can build up, such as in gloveboxes, automobile trunks, etc.

Relay Replacement

1. Disconnect the batteries.
2. Remove the four screws attaching the control panel to the sleeper compartment wall, and pull the panel away from the wall.
3. Remove the relay **(Fig. 1)** from the control panel and install a new relay in its place.



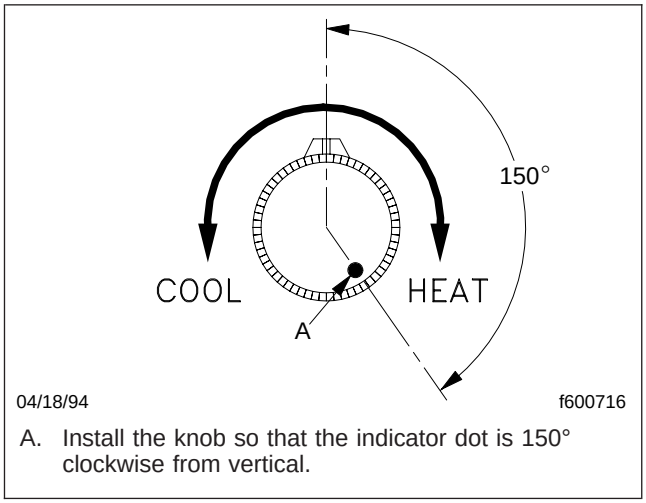
A. Panel Front View
B. Panel Rear View
1. A.T.C. Control Knob
2. Fan Control Knob
3. Relay

Fig. 1, A.T.C. Control Panel

4. Install the control panel on the sleeper compartment wall. Tighten the four screws firmly.
5. Connect the batteries.

A.T.C. Module and Temperature Control Knob Replacement

1. Disconnect the batteries.
2. Remove the four screws attaching the control panel to the sleeper compartment wall, and pull the panel away from the wall.
3. Unplug the wiring connectors at the A.T.C. module.
4. Using an Allen wrench, remove the setscrew and temperature control knob. Remove the nut, and pull the module out of the back of the panel.
5. Make sure that the slotted shaft on the module is turned fully clockwise; then, install the new module and replace the nut. Replace the temperature control knob. **See Fig. 2.**



A. Install the knob so that the indicator dot is 150° clockwise from vertical.

Fig. 2

6. Connect the wiring connectors at the A.T.C. module.
7. Install the control panel on the wall. Tighten the four screws firmly.
8. Connect the batteries.

Fan Control Switch Replacement

1. Disconnect the batteries.

Control Panel Component Replacement

2. Remove the four screws attaching the control panel to the sleeper compartment wall, and pull the panel away from the wall.
3. Mark the four wires connected to the fan control switch and note where each one goes. Unplug the connectors from the switch.
4. Using an Allen wrench, remove the setscrew and fan control knob. Remove the nut, and pull the switch out of the back of the panel.
5. Install the new fan control switch and replace the nut. Position the knob so that the indicating dot aligns with OFF. Insert and tighten the setscrew.
6. Plug in the wiring connectors to the switch, making sure the wires are connected in the proper pattern.
7. Install the control panel on the wall. Tighten the four screws firmly.
8. Connect the batteries.

Removal

1. Review the information under **Safety Precautions 100.**

⚠ WARNING

WARNING: Failure to review the safety precautions, and to be aware of the danger involved when working with refrigerant, could result in serious personal injury.

2. Depending on the type of temperature control, open the water shutoff valve.

   If equipped with a cable control, pull the temperature control cable up **(Fig. 1).**

   If equipped with A.T.C., turn the temperature control knob clockwise to HEAT **(Fig. 2).**

3. Disconnect the batteries.

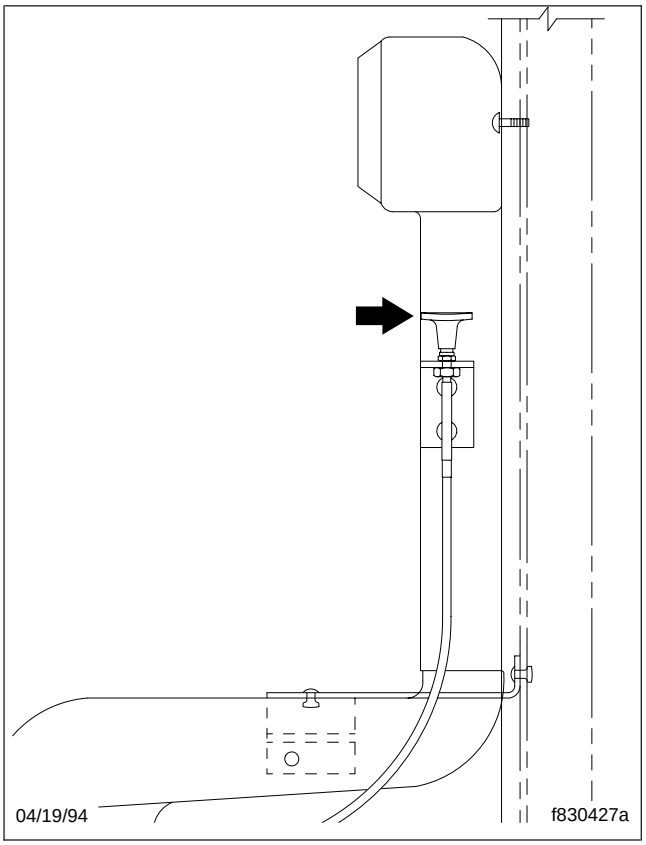


Fig. 1, Manual Temperature Control Cable Handle

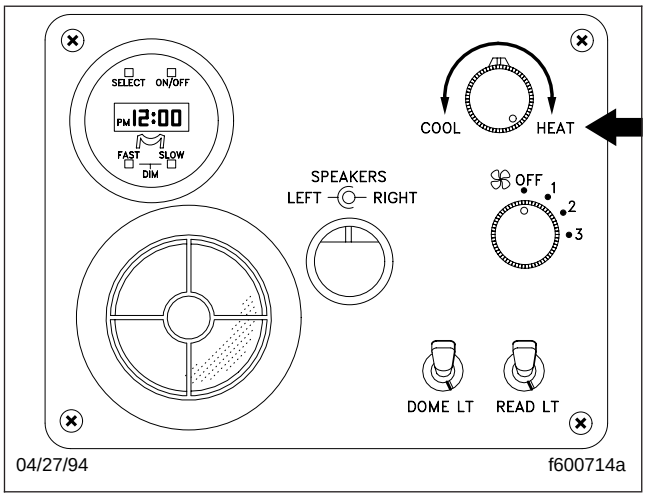


Fig. 2, Temperature Control Knob for A.T.C. System

⚠ WARNING

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

4. Drain the air system.
5. Wearing protective goggles and gloves, discharge the refrigerant from the system. For instructions, refer to the cab air conditioner section in this group.
6. Access the sleeper heater and air conditioner unit.

   On Conventionals with sleeper boxes, either remove the sleeper box mattress and bunk panel or, open the right-side baggage compartment door.

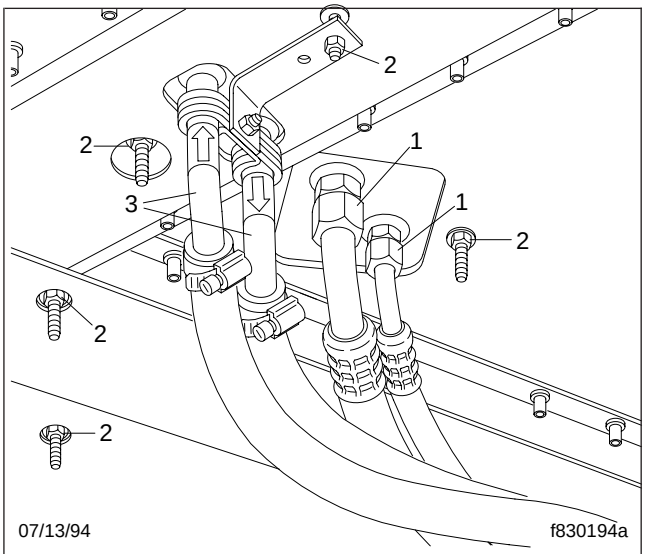
   On SleeperCabs, raise the mattress and bunk panel to their locked position.

   On COEs, open the right-side baggage compartment door.
7. Under the sleeper, remove the standoff bracket (if equipped) separating the two heater hoses. Mark the heater hoses for later reference and drain the heater core by disconnecting the heater hoses from the heater core elbows (**Fig. 3**, Ref. 3).

Heater and Air Conditioner Removal and Installation

Clamp off the hoses to prevent coolant loss.

8. Under the sleeper, mark the refrigerant lines for later reference. Using two wrenches to avoid twisting the lines, disconnect the refrigerant hoses at the expansion valve ports. **See Fig. 3**, Ref. 1. Place caps on the refrigerant hoses, and plug the expansion valve ports.



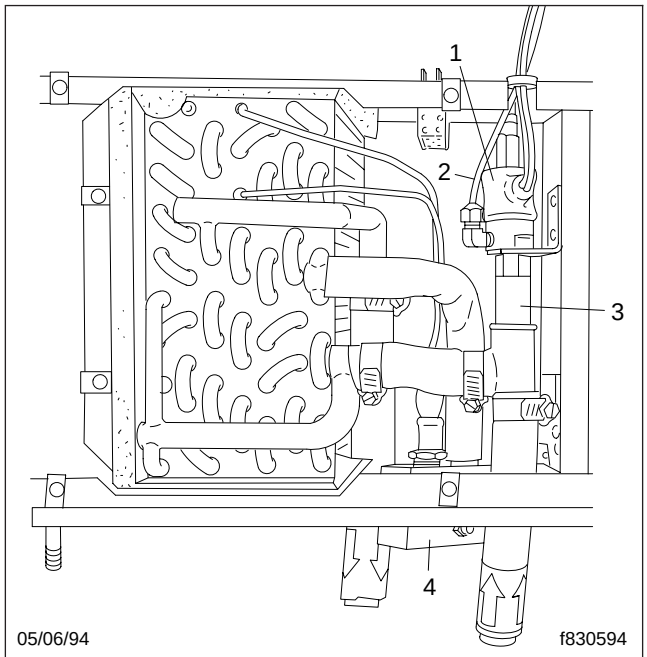
1. Refrigerant Hose Connections
2. Mounting Nut
3. Heater Hose Connections

Fig. 3, Mounting Nuts and Hose Connections Under the Sleeper (Conventional shown)

⚠ CAUTION

CAUTION: Water and dirt can damage the refrigerant system. Five minutes of not being capped is the limit for any hose or component. Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

9. From under the sleeper, remove the locknuts and washers holding the heater and air conditioner unit in place. **See Fig. 3**, Ref. 2.
10. Inside the sleeper, disconnect the air duct from the blower housing.
11. Disconnect the wiring connectors from the sleeper heater and air conditioner.
12. Disconnect the water shutoff valve.



1. Water Supply Solenoid Valve
2. Air Line
3. Water Shutoff Valve
4. Expansion Valve

Fig. 4, Sleeper Heater and Air Conditioner (FLB shown)

If equipped with a cable control, remove the water shutoff valve cover. Loosen the top and bottom capscrews and remove the side capscrew. Remove the cover. Loosen the cable clamp and disconnect the cable from the water shutoff valve.

If equipped with A.T.C., disconnect the air line from the water supply solenoid by unscrewing the fitting (**Fig. 4).**

13. Lift the sleeper heater and air conditioner until it clears the sleeper deck, and then remove it. Be sure not to damage the water drain tube(s) or heater core while lifting the unit out of the sleeper compartment.

Installation

1. Position the sleeper heater and air conditioner on the deck. Make sure the heater core elbows, expansion valve, water drain tube(s), and mounting studs protrude through the floor.

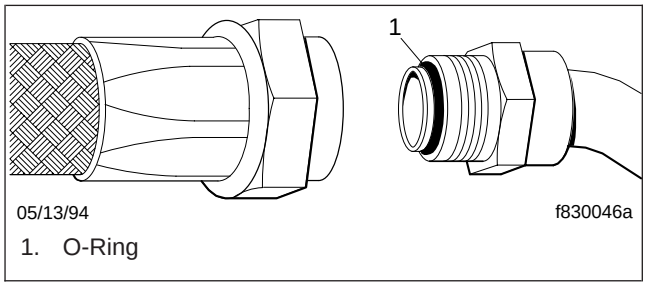
2. Connect the water shutoff valve.

   If equipped with a cable control, position the cable end loop and clamp the cable to the water shutoff valve. Install the valve cover on the sleeper heater and air conditioner. Tighten the capscrews 28 to 32 lbf·in (320 to 360 N·cm).

   If equipped with A.T.C., connect the air tube to the water supply solenoid by screwing on the fitting.

3. Connect the wires leading to the unit.
4. Connect the air duct to the blower housing.
5. Underneath the cab, install the flatwashers and locknuts on the mounting studs. Tighten the nuts 13 lbf·ft (18 N·m).
6. Remove the plugs from the expansion valve ports and the caps from the refrigerant lines. Install new O-rings. Apply refrigerant oil to the O-rings. **See Fig. 5.** Apply refrigerant oil to the male portion of the fitting threads. Attach the refrigerant lines to the air conditioner fittings as previously marked.

   Using two wrenches to avoid twisting the lines, tighten the 6 inlet fitting 11 lbf·ft (15 N·m). Tighten the 10 outlet fitting 21 lbf·ft (28 N·m).



1. O-Ring

Fig. 5

7. Install the standoff bracket (if equipped) that separates the two heater hoses. Attach the heater hoses to the heater core elbows as marked. Tighten the clamps 30 to 35 lbf·in (340 to 400 N·cm).
8. Evacuate and charge the air conditioning system. For instructions, refer to the cab air conditioner section in this group.
9. Fill the cooling system with coolant. For coolant specifications, refer to the vehicle maintenance manual.

⚠ CAUTION

CAUTION: Coolant must be filled to the bottom of the radiator filler neck. Low coolant could cause engine overheating, which could damage the engine.

10. Start the engine, let it run for 20 to 30 seconds, and then shut it off. Install a pressure tester, test the cooling system at 10 psi (69 kPa), and then inspect for leaks. If leaks are found, tighten the hose clamps 30 to 35 lbf·in (340 to 400 N·cm) or replace the hoses as needed. Check the coolant level, and add coolant if needed.
11. Open the water shutoff valve.

    If equipped with a cable control, pull the temperature control cable up.

    If equipped with A.T.C., turn the temperature control knob clockwise to HEAT.

12. Start the engine. When the radiator thermostat opens, air will be forced from the heater core as the coolant circulates. Check the coolant level again and add coolant if needed.
13. On Conventionals, reposition the sleeper mattress and wooden bunk panel.
14. Connect the batteries.

Blower Motor and Wheel Assembly Replacement

Replacement

1. Disconnect the batteries.
2. Access the sleeper heater and air conditioner unit.

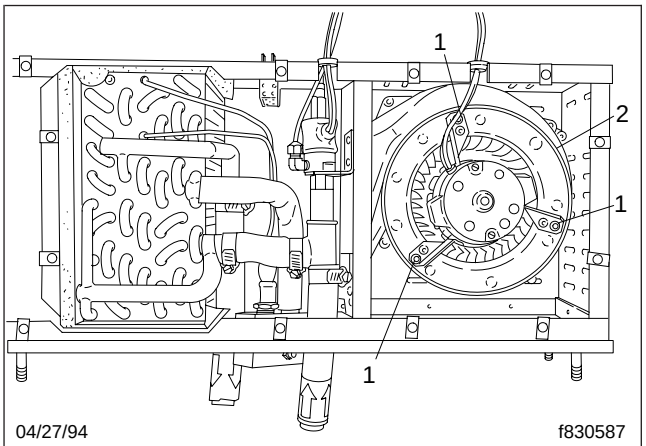
   On Conventionals with sleeper boxes, either remove the sleeper box mattress and bunk panel or open the right-side baggage compartment door.

   On SleeperCabs, raise the mattress and bunk panel to their locked position.

   On COEs, open the right side baggage compartment door.
3. Disconnect the blower motor wiring connector.
4. On COEs, remove the blower motor assembly.

   4.1 Remove the fasteners that attach the front cover to the housing. Remove the cover.

   4.2 Remove the mounting fasteners that attach the blower motor to the blower housing. **See Fig. 1.** Remove the blower motor assembly from the housing.



1. Blower Motor Mounting Fasteners
2. Blower Motor Assembly

Fig. 1, Blower Assembly (FLB shown)

5. On Conventionals, remove the blower motor and wheel assembly.

   5.1 Remove the top cover retainer clips.

   5.2 Slide the blower motor housing out of the heater and air conditioner unit.

   5.3 Remove the two screws from the motor mount band that secure the assembly to the housing. **See Fig. 2.**

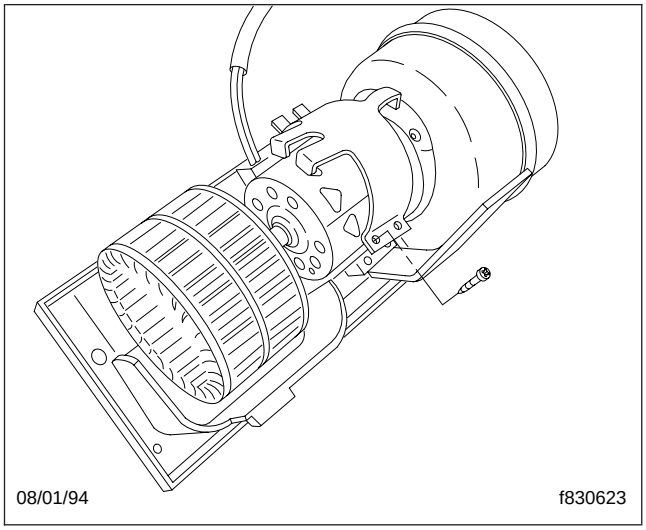


Fig. 2

   5.4 Using a screwdriver, unsnap the four half shells that fit over the blower wheels.

   5.5 Remove the blower motor and wheel assembly.

6. Install a new blower motor and wheel assembly.

   On COEs, install the fasteners that attach the blower motor and wheel assembly to the housing. **See Fig. 1.** Tighten the fasteners firmly. Install the front cover.

   On Conventionals, position the new assembly and install the four half shells that fit over the blower wheels. Using two screws, install the motor mount band. Tighten the screws firmly. Slide the unit into place in the heater and air conditioner assembly. Install the top cover with the retainer clips.
7. Connect the wires to the blower motor.
8. On Conventionals, reposition the sleeper mattress and wooden bunk panel.
9. Connect the batteries.

Replacement

1. Turn off the ignition switch and apply the parking brakes.
2. Access the sleeper heater and air conditioner unit.

   On Conventionals with sleeper boxes, either remove the sleeper box mattress and bunk panel or open the right-side baggage compartment door.

   On SleeperCabs, raise the mattress and bunk panel to their locked position.

   On COEs, open the right-side baggage compartment door.
3. Disconnect the wiring connector(s) from the resistor terminals **(Fig. 1)**.

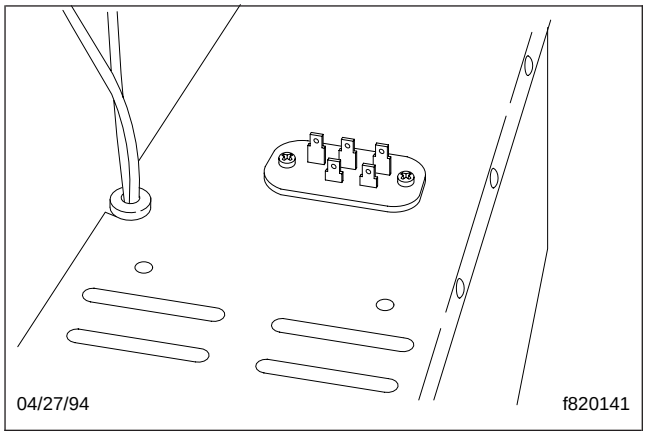


Fig. 1, Blower Resistor (FLB COE shown)

4. Remove the capscrews.
5. Remove and replace the blower resistor.
6. Replace the capscrews.
7. Connect the wiring connector(s) to the resistor terminals.
8. On Conventionals, reposition the wooden bunk panel and the sleeper mattress.

Replacement

1. Apply the parking brakes.

⚠ WARNING

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

2. For A.T.C. models, drain the air system.
3. Access the sleeper heater/air-conditioner unit.

   On Conventionals with sleeper boxes, either remove the sleeper box mattress and bunk panel or open the right-side baggage compartment door.

   On SleeperCabs, raise the mattress and bunk panel to their locked position.

   On COEs, open the right side baggage compartment door.
4. Depending on the type of temperature control, open the water shutoff valve.

   If equipped with a cable control, pull the temperature control cable up **(Fig. 1).**

   If equipped with A.T.C., turn the temperature control knob clockwise to HEAT **(Fig. 2).**
5. On COEs, remove the front cover from the unit.
6. Loosen the hose clamps and disconnect the coolant hoses from the shutoff valve. **See Fig. 3** or **Fig. 4.**

   If equipped with a cable control, loosen the clamp and disconnect the cable from the water shutoff valve.

   If equipped with A.T.C., remove the bracket **(Fig. 3)** holding the water supply solenoid valve to the heater core cover.
7. On A.T.C. models, disconnect the solenoid air line, and the solenoid electrical connector. Loosen the hose clamp (if equipped), and then unscrew the water shutoff valve from the water supply solenoid.

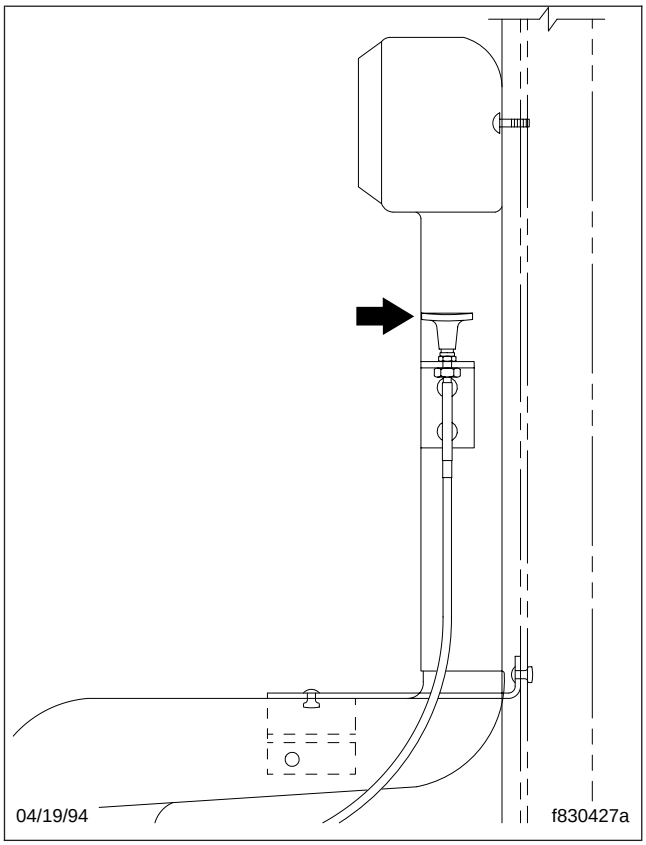


Fig. 1, Manual Temperature Control Cable Handle

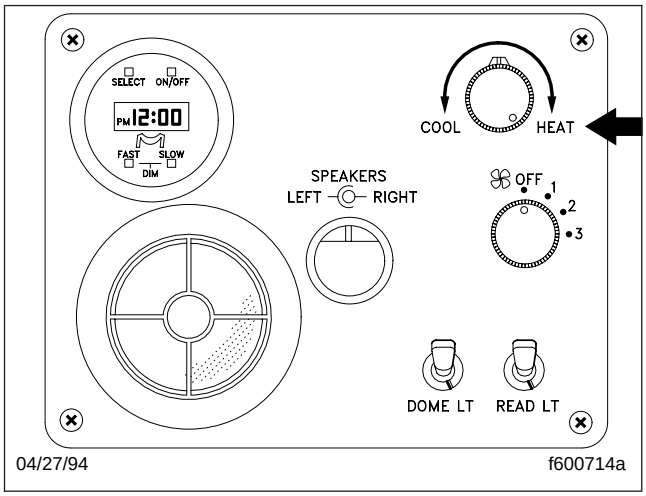
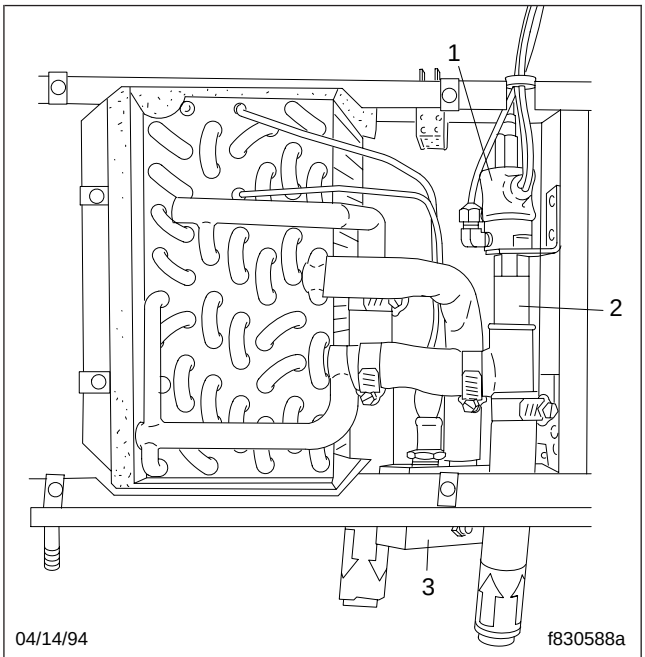


Fig. 2, Temperature Control Knob for A.T.C. System

8. On A.T.C. models, apply liquid Teflon® sealant between the solenoid fitting and the water shutoff valve. Screw the new water shutoff valve into the

Water Shutoff Valve Replacement



1. Water Supply Solenoid Valve
2. Water Shutoff Valve
3. Expansion Valve

Fig. 3, A.T.C. Water Shutoff Valve, Water Supply Solenoid Valve, and Expansion Valve (FLB shown)

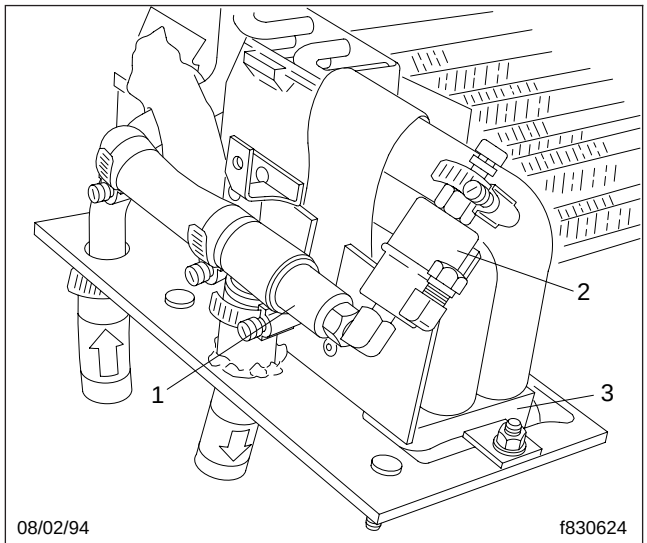
water supply solenoid before connecting the hoses and tightening the clamps.

Install the new water shutoff valve. Connect the coolant hoses and tighten the hose clamps 30 to 35 lbf·in (340 to 400 N·cm).

9. If equipped with a cable control, connect the cable to the water shutoff valve and tighten the clamp.

   If equipped with A.T.C, fasten the solenoid clamp (if equipped), connect the wiring, and the solenoid air line.

10. Fill the cooling system with coolant to the level of the bottom of the radiator filler neck. Don't install the radiator cap. For coolant specifications, refer to the vehicle maintenance manual.



1. Water Shutoff Valve
2. Water Supply Solenoid Valve
3. Expansion Valve

Fig. 4, A.T.C. Water Shutoff Valve, Water Supply Solenoid Valve, and Expansion Valve (Conventional shown)

⚠ CAUTION

CAUTION: Coolant must be filled to the bottom of the radiator filler neck. Low coolant could cause engine overheating, which could damage the engine.

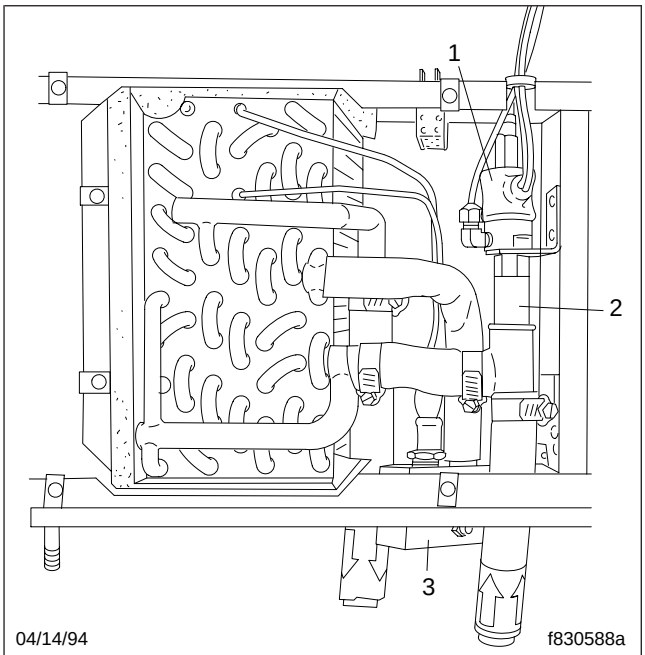
11. Start the engine, and check the hose connections at the valve for coolant leaks. Turn off the engine. If leaks are found, tighten the hose connections or replace the hoses as needed. Check the coolant level, and add coolant as needed.

12. On COEs, install the front cover on the sleeper heater/air-conditioner.

13. On Conventionals, reposition the wooden bunk panel and the sleeper mattress.

A.T.C. Water Supply Solenoid Valve Replacement

Replacement (See Fig. 1 or Fig. 2)



1. Water Supply Solenoid Valve
2. Water Shutoff Valve
3. Expansion Valve

Fig. 1, A.T.C. Water Shutoff Valve, Water Supply Solenoid Valve, and Expansion Valve (FLB shown)

1. Apply the parking brakes.

WARNING

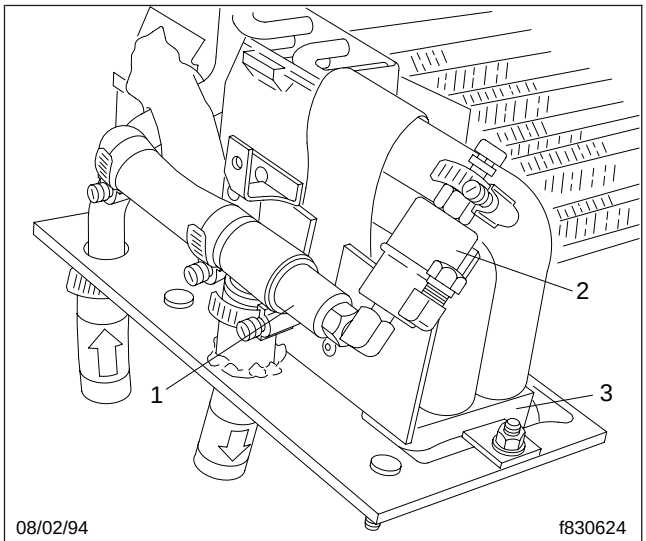
WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

2. Drain the air system.
3. Access the sleeper heater/air-conditioner unit.

   On Conventionals with sleeper boxes, either remove the sleeper box mattress and bunk panel or open the right-side baggage compartment door.

   On SleeperCabs, raise the mattress and bunk panel to their locked position.

   On COEs, open the right side baggage compartment door. Remove the front cover from the unit.
4. Disconnect the solenoid air line by unscrewing the fitting.
5. Disconnect the solenoid valve wiring (if equipped).
6. Remove the solenoid clamp (if equipped).
7. On Conventionals, remove the coolant hoses from the water shutoff valve. **See Fig. 2.**



1. Water Shutoff Valve
2. Water Supply Solenoid Valve
3. Expansion Valve

Fig. 2, A.T.C. Water Shutoff Valve, Water Supply Solenoid Valve, and Expansion Valve (Conventional shown)

8. Hold the water shutoff valve with a wrench and unscrew the water supply solenoid.
9. Transfer the solenoid fittings to the new solenoid. Apply liquid Teflon® sealant between the fitting and the water shutoff valve, and between the solenoid and the solenoid fittings. Install the new solenoid.
10. On Conventionals, clamp the solenoid to the mounting bracket and connect the coolant hose to the water shutoff valve.
11. Connect the solenoid valve wiring and the solenoid air line.
12. On COEs, install the front cover.

A.T.C. Water Supply Solenoid Valve Replacement

13. On Conventionals, reposition the wooden bunk panel and the sleeper mattress.

Manual Temperature Control Cable Replacement

Replacement

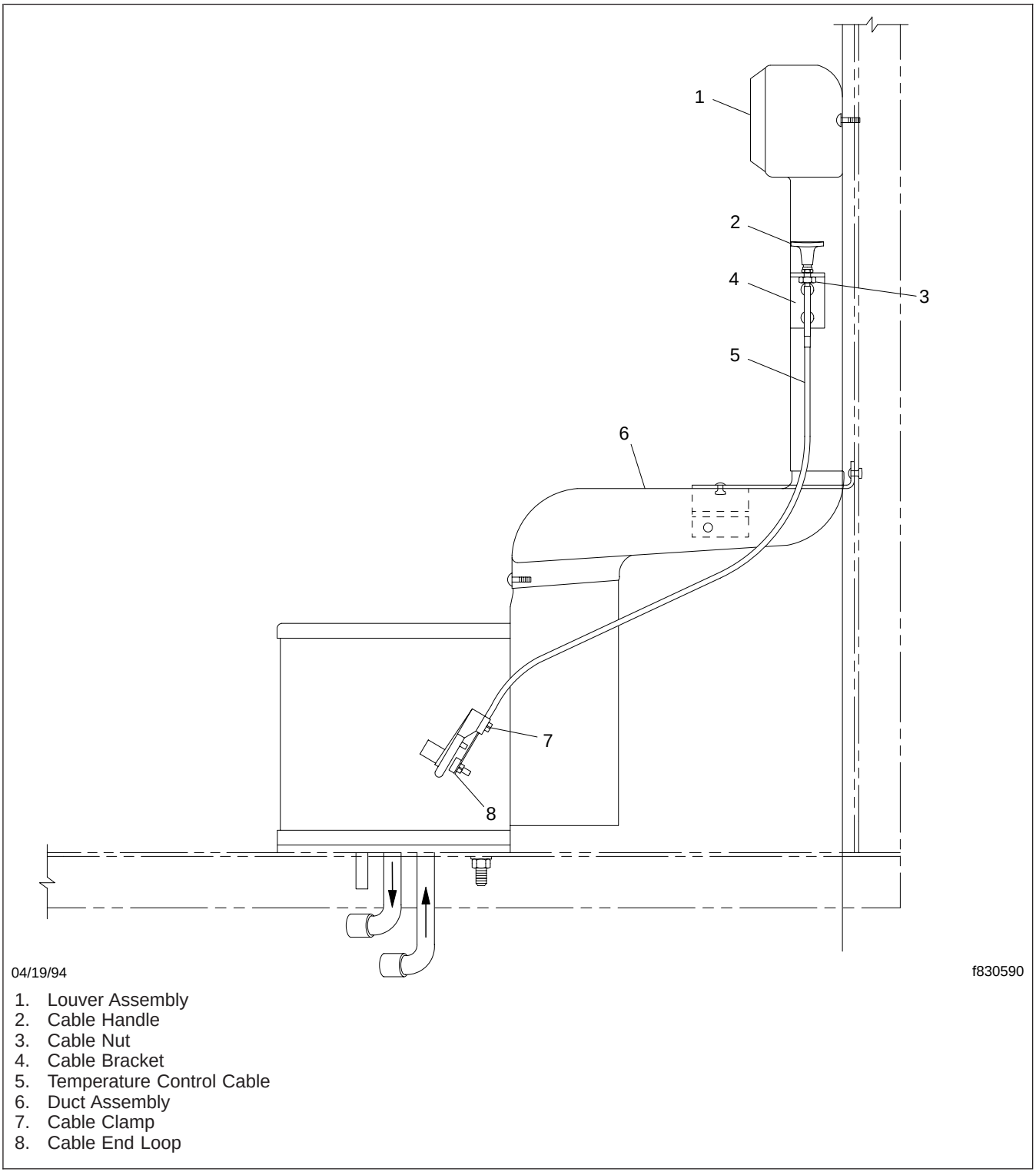
1. Apply the parking brakes.
2. Access the sleeper heater/air-conditioner unit.

   On Conventionals with sleeper boxes, either remove the sleeper box mattress and bunk panel or open the right-side baggage compartment door.

   On SleeperCabs, raise the mattress and bunk panel to their locked position.

   On COEs, open the right side baggage compartment door. Remove the front cover from the heater and air conditioner unit.
3. Remove the water shutoff valve cover by loosening the top and bottom capscrews and removing the side capscrew.
4. Loosen the cable clamp and disconnect the cable assembly **(Fig. 1)** from the water shutoff valve.
5. At the cable handle, loosen the cable nut, slide the cable out of the bracket slot, and pull out the cable assembly.
6. Position the new temperature control cable handle in the bracket slot and loosely fasten the cable nut.
7. Route the cable down to the water shutoff valve. Position the cable end loop and clamp it to the water shutoff valve.
8. Tighten the cable nut.
9. Check that the water shutoff valve opens when the cable is pulled up.
10. On COEs, install the front cover on the heater and air conditioner unit.
11. On Conventionals, reposition the wooden bunk panel and the sleeper mattress.

Manual Temperature Control Cable Replacement



1. Louver Assembly
2. Cable Handle
3. Cable Nut
4. Cable Bracket
5. Temperature Control Cable
6. Duct Assembly
7. Cable Clamp
8. Cable End Loop

Fig. 1, Manual Temperature Control Cable

Replacement

1. Apply the parking brakes.
2. Review the information under **Safety Precautions 100.**

⚠ WARNING

WARNING: Failure to review the safety precautions, and to be aware of the dangers involved when working with refrigerant, could result in serious personal injury.

3. Wearing protective goggles and gloves, discharge the refrigerant from the system. Refer to the cab air conditioner section in this group for instructions.
4. Access the sleeper heater and air conditioner unit.

   On Conventionals with sleeper boxes, either remove the sleeper box mattress and bunk panel or open the right-side baggage compartment door.

   On SleeperCabs, raise the mattress and bunk panel to their locked position.

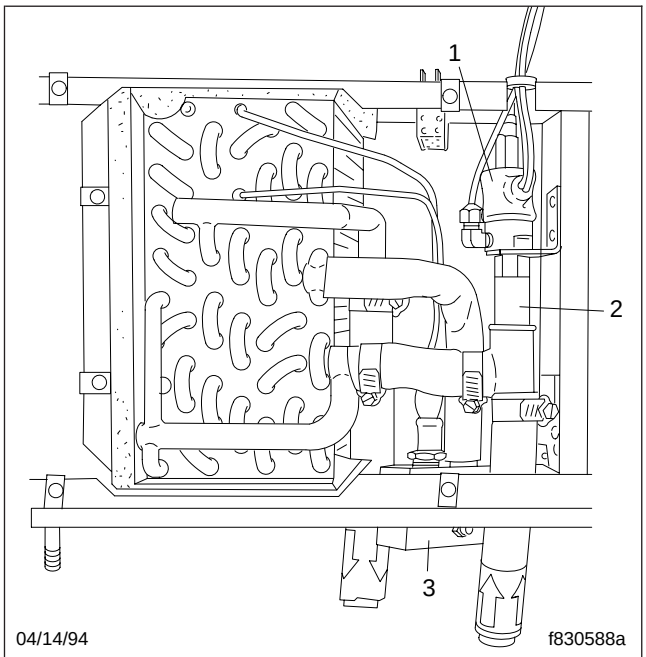
   On COEs, open the right side baggage compartment door. Remove the front cover from the heater and air conditioner unit.
5. Replace the expansion valve. **See Fig. 1** or **Fig. 2.**

⚠ CAUTION

CAUTION: Water and dirt can damage the refrigerant system. Five minutes of not being capped is the limit for any disconnected hose or component. Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

5.1 Disconnect the two refrigerant lines from the expansion valve. Remove the valve-mounting capscrew, then remove the valve. Put caps on the ends of the lines until you install the new expansion valve.

5.2 Remove the caps from the refrigerant lines. Install new O-rings on the fittings. **See Fig. 3.** Apply refrigerant oil to the male portion of the fitting threads. Attach the fittings to the expansion valve refrigerant lines, but don't tighten them at this time.



1. Water Supply Solenoid Valve
2. Water Shutoff Valve
3. Expansion Valve

Fig. 1, A.T.C. Water Shutoff Valve, Water Supply Solenoid Valve, and Expansion Valve (FLB shown)

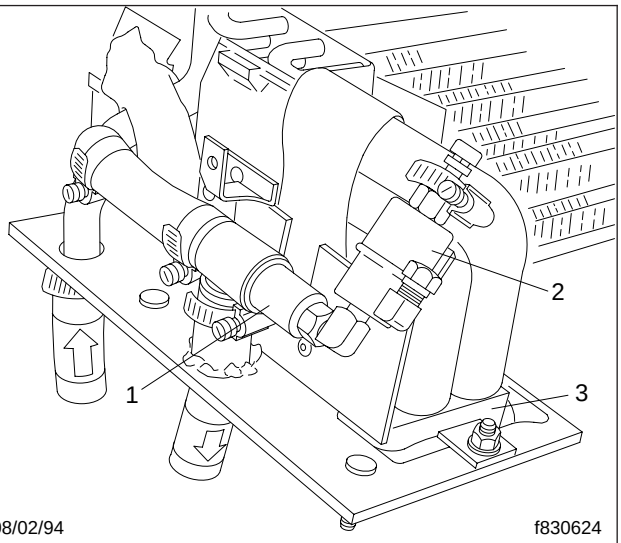
5.3 Install the new expansion valve to its bracket. Tighten the capscrew 15 to 18 lbf·in (160 to 200 N·cm).

5.4 Tighten the refrigerant line fittings.

- 6 inlet side—11 lbf·ft (15 N·m)
- 10 outlet side—21 lbf·ft (28 N·m)
- 8 expansion valve, top—15 lbf·ft (20 N ·m)

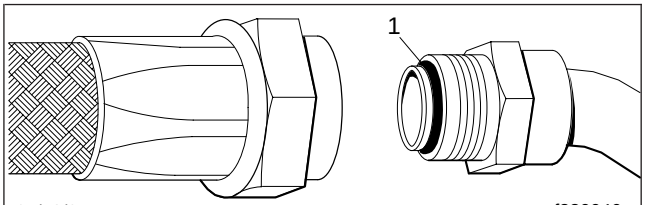
6. On Conventionals, reposition the wooden bunk panel and the sleeper mattress. On COEs, install the front cover.
7. Evacuate and charge the system. For instructions, refer to the applicable cab air conditioner section in this group.

Expansion Valve Replacement



1. Water Shutoff Valve
2. Water Supply Solenoid Valve
3. Expansion Valve

Fig. 2, A.T.C. Water Shutoff Valve, Water Supply Solenoid Valve, and Expansion Valve (Conventional shown)



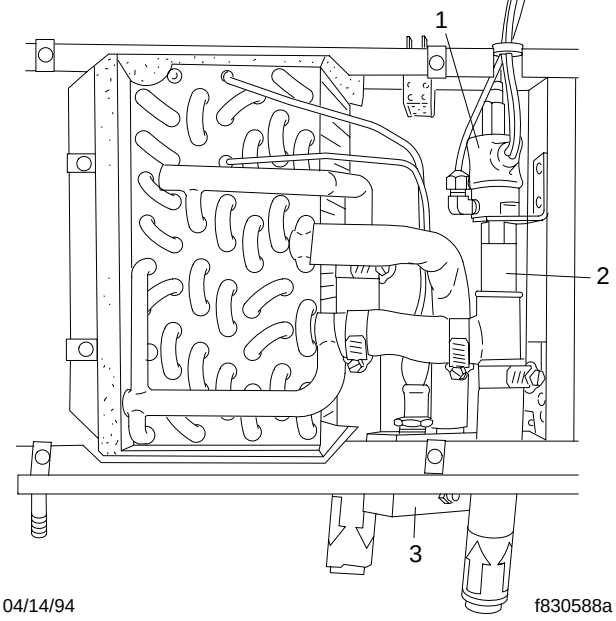
1. O-Ring

Fig. 3

Replacement

1. Apply the parking brakes.
2. Remove the heater and air conditioner unit from the vehicle. For instructions, see **Subject 120**.
3. On COEs, remove the two hoses from the water shutoff valve. See **Fig. 1**. Disconnect the lines from the expansion valve.

   Remove the two fasteners that attach the assembly to the heater and air conditioner housing. Pull the heater core and evaporator coil assembly out of the housing.



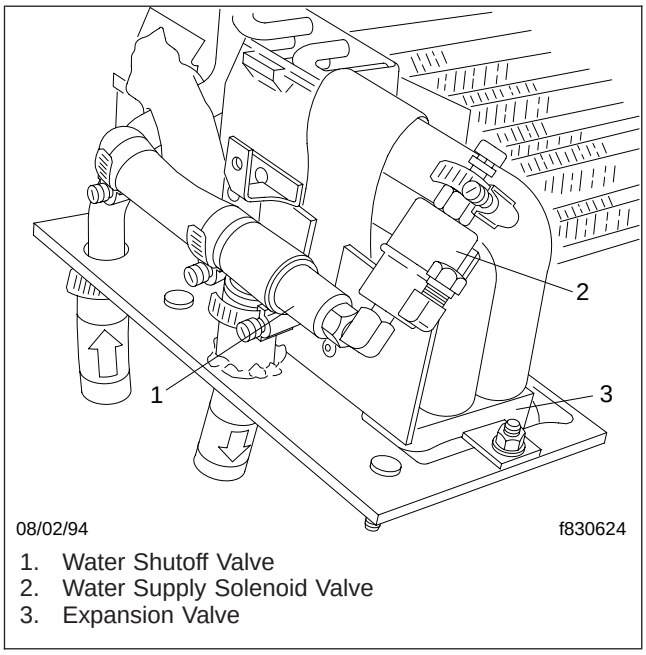
1. Water Supply Solenoid Valve
2. Water Shutoff Valve
3. Expansion Valve

Fig. 1, A.T.C. Water Shutoff Valve, Water Supply Solenoid Valve, and Expansion Valve (FLB shown)

4. On Conventionals, remove the top cover retainer clips. Disconnect the hose from the water supply solenoid valve. See **Fig. 2**.

   Remove the lines from the expansion valve. Loosen the mastic tape and lift the heater and evaporator coil assembly out of the housing.
5. If necessary, clean up any spilled coolant from the inside of the housing before installing the new heater core and evaporator coil assembly. Insert the new assembly in the housing.

   On COEs, install the two fasteners that attach the assembly in the housing. Tighten the fasteners firmly.



1. Water Shutoff Valve
2. Water Supply Solenoid Valve
3. Expansion Valve

Fig. 2, A.T.C. Water Shutoff Valve, Water Supply Solenoid Valve, and Expansion Valve (Conventional shown)

6. Connect the heater hoses. Tighten the hose clamps 30 to 35 lbf·in (340 to 400 N·cm).
7. Install and tighten the refrigerant lines on the expansion valve.
   - 6 inlet side—11 lbf·ft (15 N·m)
   - 10 outlet side—21 lbf·ft (28 N·m)
   - 8 expansion valve, top—15 lbf·ft (20 N·m)
8. On Conventionals, install the top cover retainer clips.
9. Install the heater and air conditioner unit in the vehicle. For instructions, see **Subject 120**.

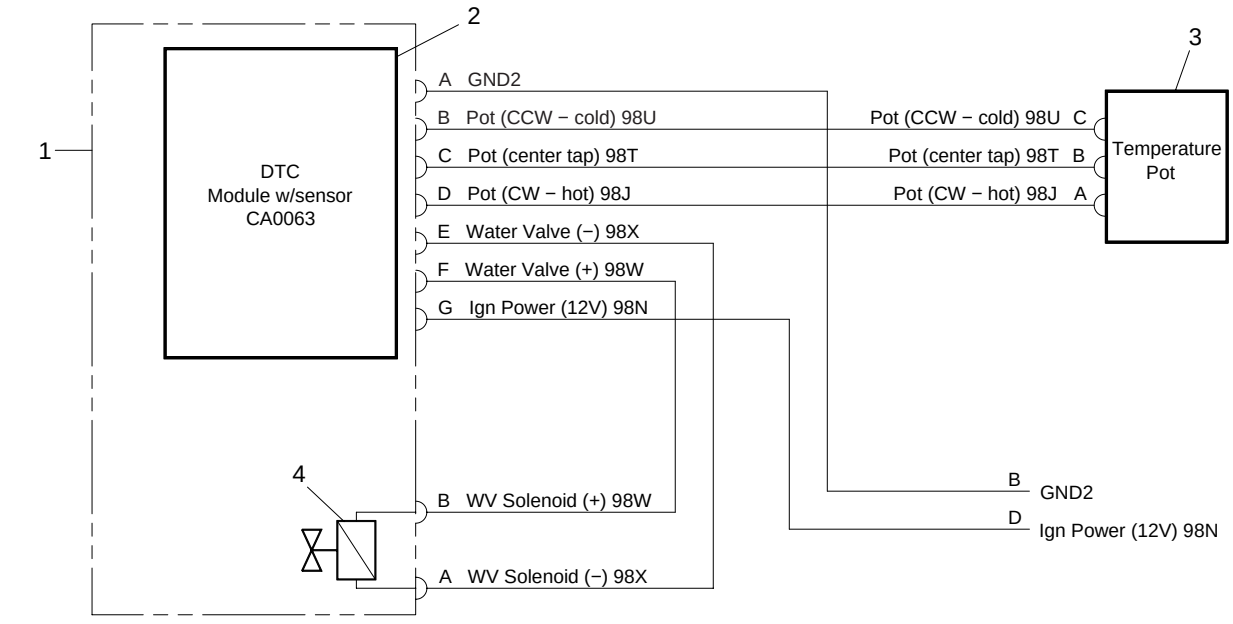
Troubleshooting

Auxiliary HVAC With Constant Discharge Temperature Control

The Constant Discharge Temperature Control (CDTC) module with sensor is mounted on the auxiliary HVAC unit under the bunk. The Discharge Temperature Control (DTC) module with sensor is shown in the diagram in **Fig. 1**. The DTC module receives input from the temperature control pot (potentiometer), which is mounted in the sleeper control panel.

Troubleshooting the CDTC System

Use the troubleshooting procedures in **Table 1** first.



1. Auxiliary HVAC Unit
2. DTC Module with Sensor
3. Potentiometer
4. Water Valve Solenoid (NO)

Fig. 1, Constant Discharge Temperature Control Diagram

CDTC System Initial Electrical Diagnosis				
Test No.	**Test Procedure**	**Test Criteria**	**Test Result**	**Action**
1	Measure voltage at the water valve by backprobing the connector. Voltage should be approximately 12V.	• Engine running • Engine at normal operating temperature • Temperature setting at **full cold**	OK	**Go to test no. 2.**
			Not OK	**Go to test no. 3.**

Troubleshooting

CDTC System Initial Electrical Diagnosis				
Test No.	**Test Procedure**	**Test Criteria**	**Test Result**	**Action**
2	Measure voltage at the water valve by backprobing the connector. Voltage should be approximately 0V.	• Engine running • Engine at normal operating temperature • Temperature setting at **full hot**	OK	There are no apparent electrical problems with the system. With the engine at normal operating temperature, hot air should come from the vents when the temperature setting is **full hot**. When switched to **full cold**, cooler air should come from the vents within approximately 10 minutes. If the system does not operate as stated above, refer to one of the following: • For little or no heat symptom, see **Table 4**. • For blowing warm/hot air symptom, see **Table 5**.
			Not OK	Perform tests in **Table 2**, CDTC System Temperature Potentiometer Test.
3	Repeat test no. 1 using a known good ground instead of water valve ground wire. Voltage should be approximately 12V.	• Engine running • Engine at normal operating temperature • Temperature setting at **full cold**	OK	**Go to test no. 4.**
			Not OK	Perform tests in **Table 2**, CDTC System Temperature Potentiometer Test.
4	Check the ground wire to the controller (terminal A).	—	OK	Perform tests in **Table 2**, CDTC System Temperature Potentiometer Test.
			Not OK	Repair controller ground circuit.

Table 1, CDTC System Initial Electrical Diagnosis

Use the troubleshooting procedures in **Table 1** before using the procedures in **Table 2**.

CDTC System Temperature Potentiometer Test			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Disconnect the temperature potentiometer from the harness. Using an ohmmeter, measure the potentiometer resistance as follows: • A to B (knob full CCW) 8000 to 12,000 ohms • A to B (knob full CW) 40 to 60 ohms • B to C (knob full CCW) 40 to 60 ohms • B to C (knob full CW) 8000 to 12,000 ohms NOTE: Resistance ranges are approximate.	OK	**Go to test no. 2.**
		Not OK	Replace temperature potentiometer.
2	Connect the potentiometer. Disconnect the harness from the controller. Using an ohmmeter, measure the potentiometer resistance through the harness pins at the controller as follows: • C to D (knob full CCW) 8000 to 12,000 ohms • C to D (knob full CW) 40 to 60 ohms • B to C (knob full CCW) 40 to 60 ohms • B to C (knob full CW) 8000 to 12,000 ohms NOTE: Resistance ranges are approximate.	OK	Temperature potentiometer and wires are okay. Perform tests in the table titled CDTC System Controller Test.
		Not OK	Repair wiring between temperature potentiometer and CDTC controller.

Table 2, CDTC System Temperature Potentiometer Test

Use the troubleshooting procedures in **Table 1** and **Table 2** before using the procedures in **Table 3**.

CDTC System Controller Test				
Test No.	**Test Procedure**	**Test Criteria**	**Test Result**	**Action**
1	Disconnect the harness from the CDTC controller. Measure voltage across pins A and G. Voltage should be approximately 12V.	• Ignition on • CDTC controller disconnected	OK	**Go to test no. 2.**
			Not OK	Check power supply wire and fuse to CDTC controller. Check CDTC controller ground circuit. Repair as necessary.

Troubleshooting

CDTC System Controller Test				
Test No.	**Test Procedure**	**Test Criteria**	**Test Result**	**Action**
2	Connect the harness to the CDTC controller. Measure voltage by backprobing one meter lead to pin F and placing the other lead to a known good ground. Voltage should be approximately 12V.	• Ignition on • CDTC controller connected	OK	**Go to test no. 3.**
			Not OK	Replace the CDTC controller.
3	Measure voltage by backprobing pins F and E of the CDTC controller connector. Voltage readings should be: • Slightly less than 12V when the control knob is **full cold** (CCW) • 0V when the control knob is **full hot** (CW).	• Ignition on • CDTC controller connected	OK	No problem found. Repeat tests **Table 1**.
			Not OK	Replace the CDTC controller.

Table 3, CDTC System Controller Test

Use the troubleshooting procedures in **Table 1** before using the procedures in **Table 4**.

CDTC System Special Test-Symptom: Little or No Heat and Passes All Electrical Tests			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Check to make sure that the coolant source from the engine is connected to the inlet pipe on the water valve.	OK	**Go to test no. 2.**
		Not OK	Route hose to correct connections.
2	Check to make sure that the water inlet hose at the water valve is hot.	OK	Check for blocked heater core and repair as necessary.
		Not OK	Check for closed heater hose shutoff valve. If okay or not present, repair engine cooling system as necessary.

Table 4, CDTC System Special Test-Symptom: Little or No Heat and Passes All Electrical Tests

Use the troubleshooting procedures in **Table 1** before using the procedures in **Table 5**.

CDTC System Special Test-Symptom: Blows Warm/Hot Air and Passes All Electrical Tests			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Remove the water valve and visually inspect the inside of the outlet tube to see if the plunger is broken or if debris is preventing the plunger from seating properly.	OK	Problem not found.
		Not OK	If plunger is broken, replace the water valve. If debris is present, clean the cooling system.

Table 5, CDTC System Special Test-Symptom: Blows Warm/Hot Air and Passes All Electrical Tests

See **Table 6** for the electrical pinout descriptions of the DTC module.

DTC Module Pinout	
Pin	**Electrical Function**
A	Ground
B	Potentiometer Input (low)
C	Potentiometer Input (wiper)
D	Potentiometer Input (high)
E	Solenoid Valve Output (negative)
F	Solenoid Valve Output (positive)
G	Battery Input (V+)

Table 6, DTC Module Pinout

Specifications

See Fig. 1 for the Conventional sleeper heater and air conditioner wiring diagram. **See Fig. 2** for the FLB COE sleeper heater and air conditioner wiring diagram. **See Fig. 3** for the sleeper heater and air conditioner wiring diagram (manual cable control system).

Description	Torque	
	lbf·in (N·cm)	lbf·ft (N·m)
Heater and Air Conditioner Mounting Locknuts	—	13 (18)
Heater Hose Clamps	30–35 (340–400)	—
Refrigerant Line (Inlet Side) 6 Fitting *	—	11 (15)
Refrigerant Line (Expansion Valve Top) 8 Fitting *	—	15 (20)
Refrigerant Line (Outlet Side) 10 Fitting *	—	21 (28)
Blower Motor Mounting Capscrews	28–32 (320–360)	—
Expansion Valve Mounting Capscrew	15–18 (160–200)	—

* Use two wrenches, one on each side of the fitting. Replace the O-ring and lubricate it with refrigerant oil. Apply refrigerant oil to the male portion of the fitting threads. If equipped with aluminum fittings, apply Molykote M Gear Guard to the male portion of the fitting threads.

Table 1, Fastener Torques

Specifications

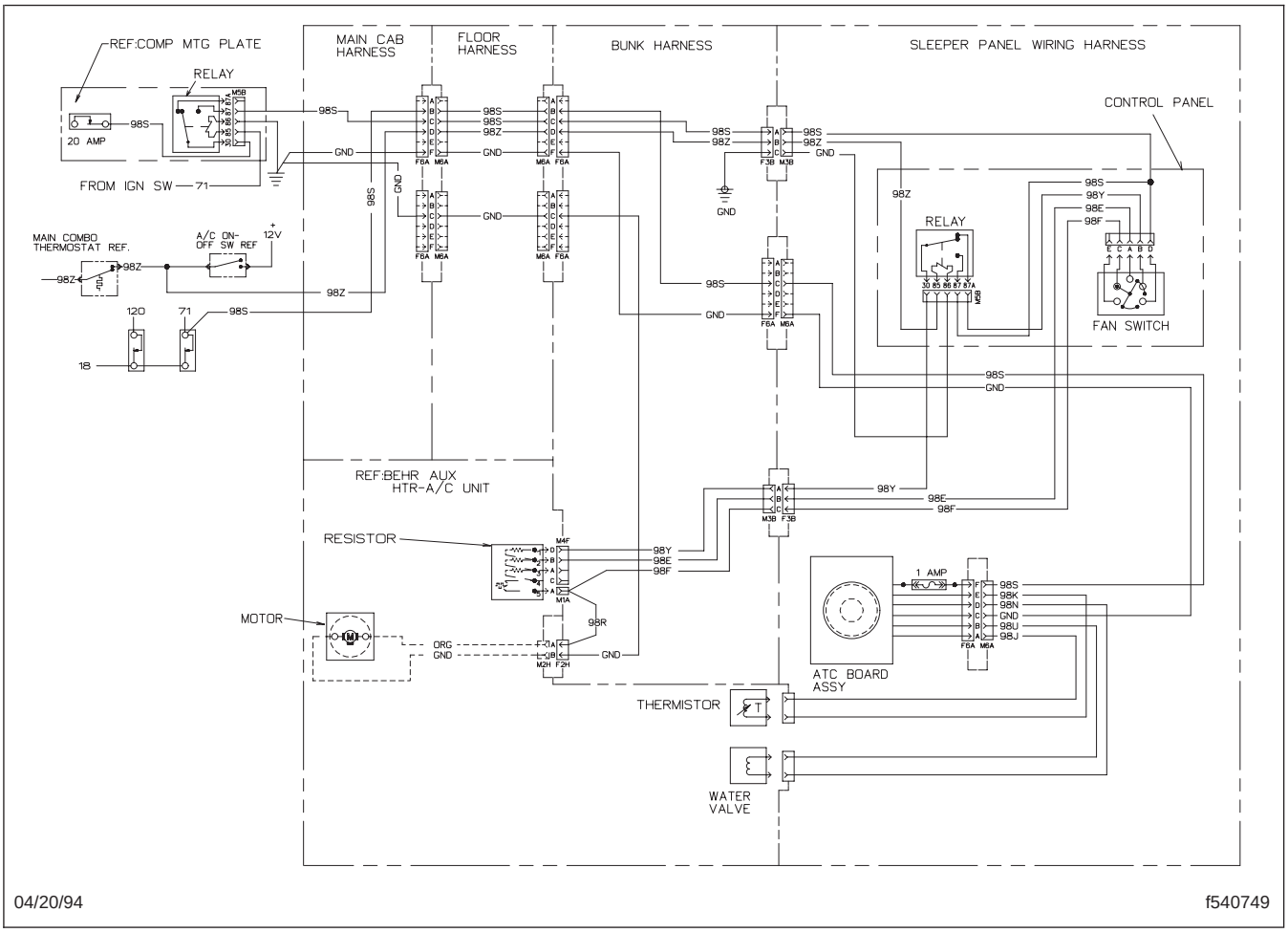


Fig. 1, Conventional Sleeper Heater and Air Conditioner Wiring Diagram, Automatic Temperature Control (A.T.C.) System

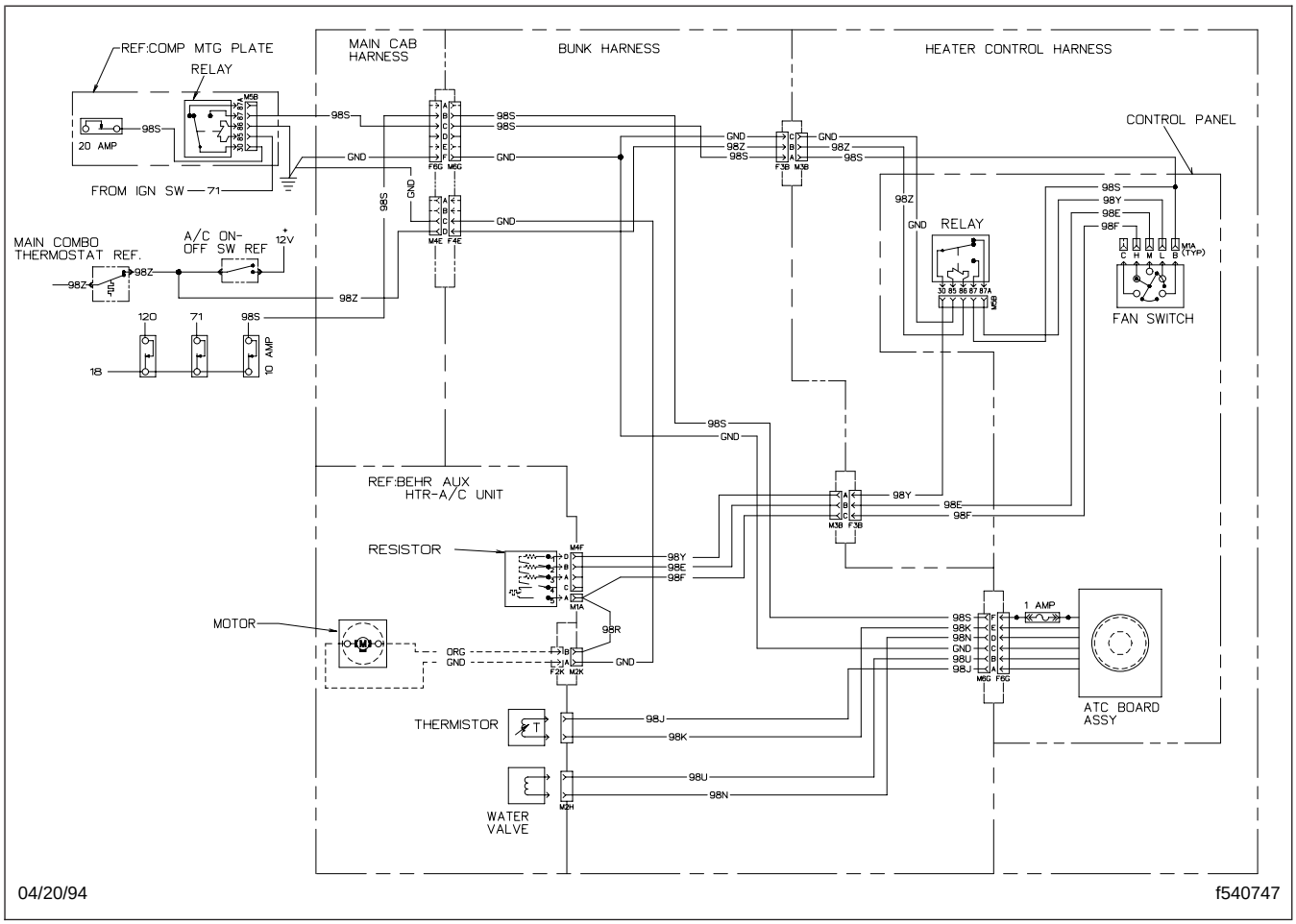


Fig. 2, FLB COE Sleeper Heater and Air Conditioner Wiring Diagram, Automatic Temperature Control (A.T.C.) System

Specifications

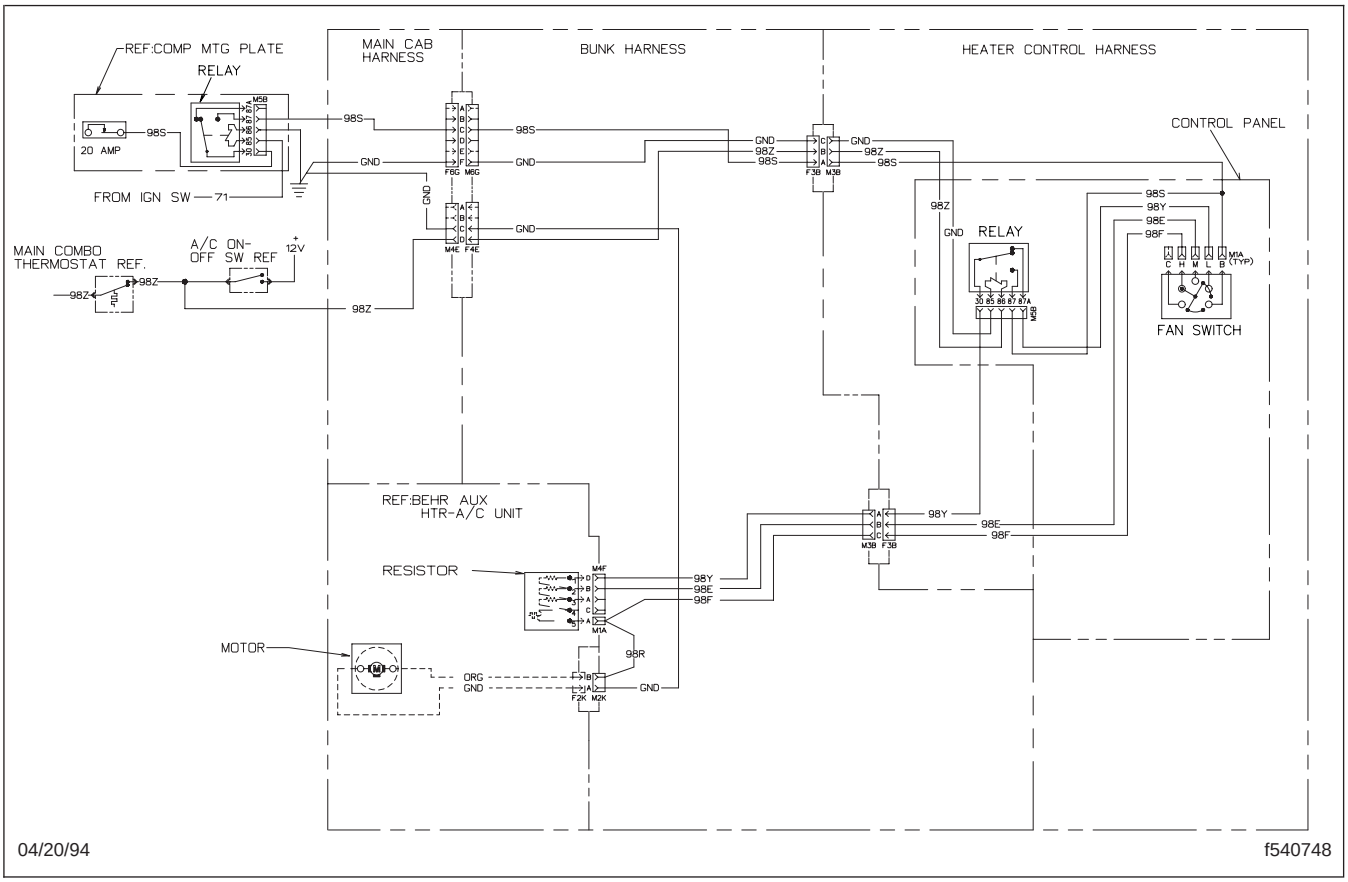


Fig. 3, Sleeper Heater and Air Conditioner Wiring Diagram, Manual Cable Control System (FLB COE shown)

General Information

The primary purpose of the refrigerant compressor is to draw refrigerant gas from the evaporator and compress it into high-pressure gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid so that it can be used for cooling again. The secondary purpose of the compressor is to move refrigerant through the air conditioning system.

See **Fig. 1** for an illustration of the Sanden refrigerant compressor mounted on a Detroit Diesel Series 60 engine.

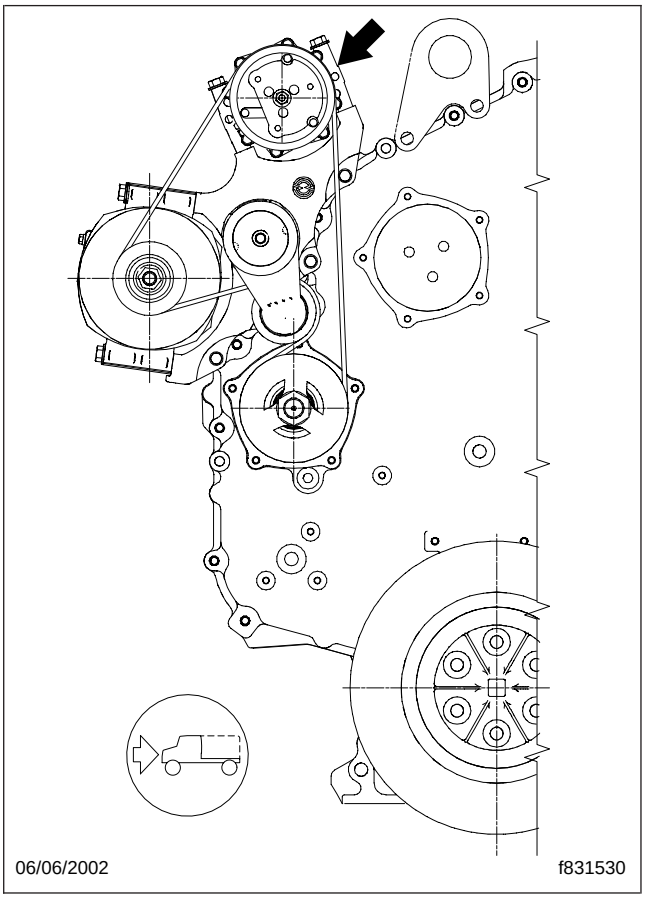


Fig. 1, Refrigerant Compressor on a Detroit Diesel Series 60 Engine

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves. When refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

Use care to prevent refrigerant from touching your skin or eyes because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (38 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

⚠ WARNING

R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion that could cause personal injury or property damage.

Always work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG) oil is used in the compressor. When handling PAG oil, observe the following:

- keep the oil free of contaminants
- do not expose the air conditioning system or the PAG oil container to air for long periods of time; PAG oil has a high moisture absorption capacity and the oil container should be immediately sealed after each use
- use care when handling; spilled oil could damage painted surfaces, plastic parts, and drive belts
- never mix PAG oil with other types of refrigerant oil

Preservice Checks

⚠ WARNING

Before doing any work, read the information in Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

Compressor problems usually show in one of four ways:

- abnormal noise
- seizure
- leakage
- low suction and discharge pressures

Resonant compressor noises are not causes for alarm. Irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch with the engine shut off and see if the drive plate can be turned. If it can't be turned, the compressor has seized.

Do the following checks whenever the air conditioner system is not cooling enough and the causes are unknown.

1. If there is a moisture indicator on the receiver-drier, check the indicator (preferably at the end of the day) to see if moisture is the cause of the problems. The air conditioner should be on when checking the indicator.
2. Check the drive belt and mounting:
   - 2.1 On the drive belt look for wear, damage, or oil. If worn, oil-soaked, or damaged, remove it and install a new one. See **Group 01** for instructions.
   - 2.2 Check the compressor mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners to the correct torque specification. Repair or replace cracked or damaged brackets.
3. Check the wiring and connections to the compressor clutch. Replace damaged wiring and tighten loose connections.
4. Check for road debris buildup on the condenser coil fins. Using air pressure and a whisk broom or a solution of soap and water, carefully clean the condenser. Be careful not to bend the fins.
5. Check the refrigerant charge in the air conditioner system. For instructions, see **Section 83.04**, Subject 250.

NOTE: For other possible causes of air conditioner problems, look elsewhere in this group.

Refrigerant Compressor Removal and Installation

Removal

WARNING

Before doing any work, read the information in Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

1. Turn off the engine, apply the brakes, and chock the tires.
2. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.04**, Subject 250.
3. Remove the serpentine belt. Do not pry or roll the belt off the pulleys.
4. Disconnect the wiring harness from the compressor.
5. Disconnect the discharge and suction lines from the compressor. Quickly cap the discharge and suctions ports and the refrigerant lines.

IMPORTANT: Under no circumstances should the ports on the compressor or the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

6. Being careful not to spill any refrigerant oil, remove the capscrews and washers that attach the refrigerant compressor to the engine and remove the compressor.

Installation

IMPORTANT: A new compressor is filled with refrigerant oil and nitrogen gas. The quantity is printed on a label attached to the compressor. When installing a new compressor on the vehicle, do all of the steps below. If installing a used compressor, disregard the first step.

1. Prepare a new compressor.
   - 1.1 Gently release the nitrogen gas from the discharge side of the compressor. Be careful not to let the oil flow out.
   - 1.2 Turn the compressor shaft several times by hand to distribute oil which has settled in the cylinder.
2. If installing a new compressor, adjust the refrigerant oil level in the new compressor. For instructions see, **Subject 130**.
3. Using capscrews and washers, install the compressor on the mounting bracket. Torque the capscrews 15 to 19 lbf·ft (20 to 26 N·m).
4. Uncap the discharge and suction ports and the refrigerant lines. Check the refrigerant lines and the discharge and suction ports. They must be clean and free of nicks, gasket residue, and other foreign material.
5. On refrigerant line connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On refrigerant line connections that have Mini Stat-O-Seals, replace the seals. **Do not** lubricate the Mini Stat-O-Seals prior to installation. Use only a Mini Stat-O-Seal on a Mini Stat-O-Seal assembly.
6. Connect the refrigerant lines to the compressor.

   On refrigerant line connections that have threaded fittings, torque the fittings 33 lbf·ft (45 N·m).

   On refrigerant line connections that have a Mini Stat-O-Seal assembly, torque the bolt on the Mini Stat-O-Seal assembly 11 to 15 lbf·ft (15 to 20 N·m).
7. Connect the wiring harness to the compressor.
8. Install the serpentine belt.
9. If installing a new compressor or if the system was without any refrigerant pressure before repairs were started, replace the receiver-drier. For instructions, see **Section 83.04**, Subject 210.

   If the compressor is not being replaced, check the moisture indicator on the receiver-drier. If it is not blue, replace the receiver-drier. For instructions, see **Section 83.04**, Subject 210.
10. Evacuate, charge, and leak test the refrigerant system. For instructions, see **Section 83.04**, Subject 250.
11. Lower the hood.

Refrigerant Compressor Removal and Installation

12. Remove the chocks from the tires.

Oil Check and Adding Oil to the Compressor

WARNING

Before doing any work, read the information in Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

General Information

Compressors are charged with 10 fl oz (296 mL) of refrigerant oil. When the air conditioning system is operating, some refrigerant oil leaves the compressor and is circulated through the system with the refrigerant, but the refrigerant oil cannot leave the system except when there is a leak, when the refrigerant is recovered, or when a system part is replaced.

It is important that the air conditioning system has the correct amount of refrigerant oil for proper operation. Too little oil will result in compressor failure. Too much oil will degrade the performance of the air conditioner and may cause damage to the compressor.

IMPORTANT: Whenever the air conditioning system is discharged or recovered, the recovered oil, from the charging machine, must be measured in order to know how much oil must be returned to the system. When a system component is replaced, a quantity of new oil equal to the recovered oil plus the oil coating the inside of the component must be returned to the system. New oil must be from a container that has not been opened or that has been tightly sealed since its last use.

Order Sanden PAG oil SKI 7803 1997 (type SP–20) for an 8.45-ounce (250-mL) can of refrigerant oil from your local Daimler parts distribution center. Tubing, funnels, or other equipment used to transfer the oil should be very clean and dry.

When handling refrigerant oil:

- Be sure that the oil is free of water, dust, metal powder, and other foreign substances;
- Do not mix the refrigerant oil with other types or viscosities of oil;
- Quickly seal the oil container after use. Refrigerant oil absorbs moisture when exposed to the air for any period of time.

Checking and Adding Refrigerant Oil

WARNING

Do not remove the oil fill plug on the refrigerant compressor without first recovering the system. Failure to recover the system could cause uncontrolled release of high-pressure refrigerant, which can freeze skin and eye tissue causing serious injury or blindness.

1. Before beginning the refrigerant recovery process, make sure that the oil accumulator and oil drain bottle on the recovery/recycle machine are emptied of oil from previous repairs.
2. Recover all of the refrigerant from the system. See **Section 83.04, Subject 250** for instructions.
3. Drain the recovered oil into the calibrated drain bottle of the recovery/recycle machine. Record the amount of oil recovered.
4. Inspect the refrigerant oil. If the oil has any of the following characteristics, flush and charge the system with 10 fl oz (296 mL) of oil.
   - silver or black oil—indicates metal in the air conditioning system due to compressor wear
   - milky oil—may indicate moisture in the system
   - grit or debris in the oil
5. Properly dispose of the recovered oil.
6. After repairs are finished, refer to **Table 1** and use the following equation to determine the quantity of refrigerant oil that needs to be added to the system.

   [Quantity Recovered] + [Quantity for All Replaced Components] = [Quantity to add to the System]

   Table 1 provides the quantities of oil that need to be added to the system for each component that was replaced. Add the quantities listed in the table for each component that was replaced. Use the sum of the quantities or 6 fl oz (177 mL), whichever is less.

Oil Check and Adding Oil to the Compressor

Refrigerant Oil Quantities for Replaced Components	
Add the quantities listed in this table for each component that was replaced. Use the sum of the quantities or 6 fl oz (177 mL), whichever is less.	
Component	**Quantity: oz (mL)**
High Pressure Line (main A/C)	1 (30)
Low Pressure Line (main A/C)	2 (59)
High Pressure Line (auxiliary A/C)	1 (30)
Low Pressure Line (auxiliary A/C)	3 (89)
Condenser	1 (30)
Evaporator (main A/C)	3 (89)
Evaporator (auxiliary A/C)	2 (59)
Receiver-Drier	3 (89)
Minor Leak at Connector Only	0.5 (15)
Major Leak at Connector Only	2 (59)

Table 1, Refrigerant Oil Quantities for Replaced Components

7. Remove the oil fill plug on the refrigerant compressor and add the refrigerant oil. Never add more than 8 fl oz (237 mL) to the system unless the system has been flushed.
8. Evacuate, charge, and leak test the refrigerant system. See **Section 83.04, Subject 250** for instructions.

Adjusting the Refrigerant Oil Level in a New Compressor

Sanden refrigerant compressors are charged with 10 fl oz (296 mL) of refrigerant oil. If the air conditioning system has been flushed, the compressor will need a 10-ounce charge. If the system has not been flushed, use the following procedure to adjust the oil level in the compressor.

Use the "Worksheet for Adjusting the Refrigerant Oil Level in a New Compressor" shown in **Fig. 1** to adjust the refrigerant oil level in a new compressor.

Worksheet for Adjusting the Refrigerant Oil Level in a New Compressor

1. Drain the oil from the old compressor.
   - 1.1 Remove the oil plug and drain as much oil as possible into a clean, calibrated container.
   - 1.2 If there are caps on the suction and discharge ports, remove them.
   - 1.3 Drain the oil from the suction and discharge ports into the container while turning the shaft clockwise using a socket wrench on the armature retaining nut.
   - 1.4 Enter the amount of oil that was drained from the compressor. 1. ☐
2. See Table 1 of this subject to determine the total amount of refrigerant oil that is needed for each component that was replaced. Enter the amount, up to 6 fl oz (177 mL), here. 2. ☐
3. Add the amounts from steps 1 and 2 and enter the total. 3. ☐
4. Subtract the total in step 3 from 10 and enter that number. For example, if the total in line 3 was six, the calculation would be 10 − 6 = 4. 4. ☐
5. Refer to the table below for the amount of oil that must be drained from the new compressor.

If the number in step 4 is:	Drain this amount from the new compressor:
a negative number(−)	2 fl oz (59 mL)
0	2 fl oz (59 mL)
1	2 fl oz (59 mL)
2	2 fl oz (59 mL)
3	3 fl oz (89 mL)
4	4 fl oz (118 mL)
5	4 fl oz (118 mL)
6	4 fl oz (118 mL)
7	4 fl oz (118 mL)
8	4 fl oz (118 mL)
9	4 fl oz (118 mL)
10	4 fl oz (118 mL)

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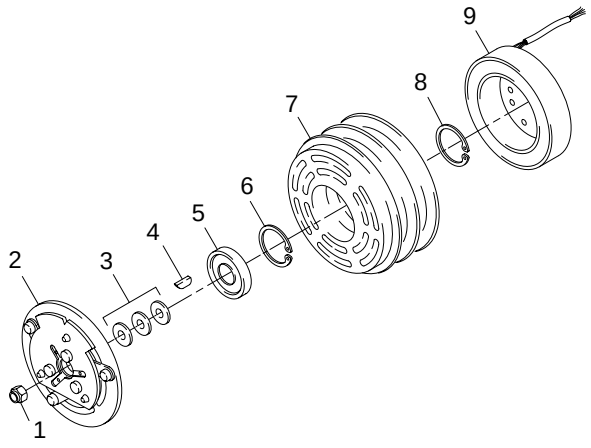
Fig. 1, Worksheet for Adjusting the Refrigerant Oil Level in a New Compressor

Clutch Assembly Removal, Inspection, and Installation

Removal

See **Fig. 1** for an illustration of the clutch assembly components.



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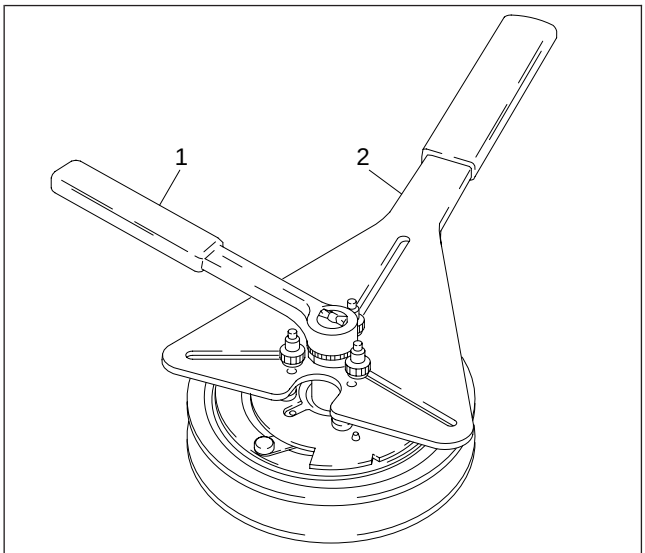
1. Shaft Nut
2. Drive Plate
3. Clutch Shims
4. Shaft Key
5. Rotor Bearing Dust Cover
6. Rotor Snap Ring
7. Rotor Assembly
8. Field Coil Assembly Snap Ring
9. Field Coil Assembly

Fig. 1, Clutch Assembly

1. Remove the compressor from the vehicle. For instructions, see **Subject 120**.
2. Insert the pins of the drive plate spanner into the threaded holes of the drive plate assembly. Hold the drive plate assembly securely while removing the retaining nut. See **Fig. 2**.
3. Using the drive plate puller, install the three puller bolts into the drive plate assembly. Turn the center screw clockwise to loosen and remove the drive plate. See **Fig. 3**.
4. If equipped with a rotor bearing dust cover, remove it. Be careful not to distort the cover when removing it.
5. Use a slotted screwdriver and hammer to remove the shaft key. See **Fig. 4**.



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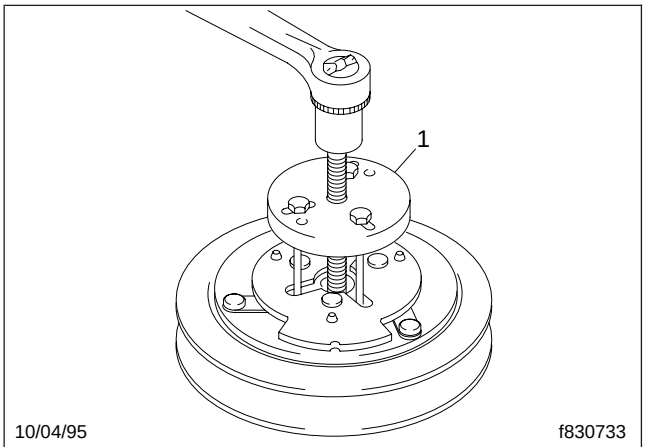
1. Socket Wrench
2. Drive Plate Spanner

Fig. 2, Remove the Retaining Nut



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1. Drive Plate Puller

Fig. 3, Remove the Drive Plate

6. Remove the clutch shims. Use a pointed tool and a small screwdriver to prevent the shims from binding on the shaft.
7. Using snap ring pliers, remove the rotor assembly snap ring.
8. Remove the rotor assembly.
   - 8.1 Insert the lip of the rotor puller jaws into the snap ring groove. See **Fig. 5**.

Clutch Assembly Removal, Inspection, and Installation

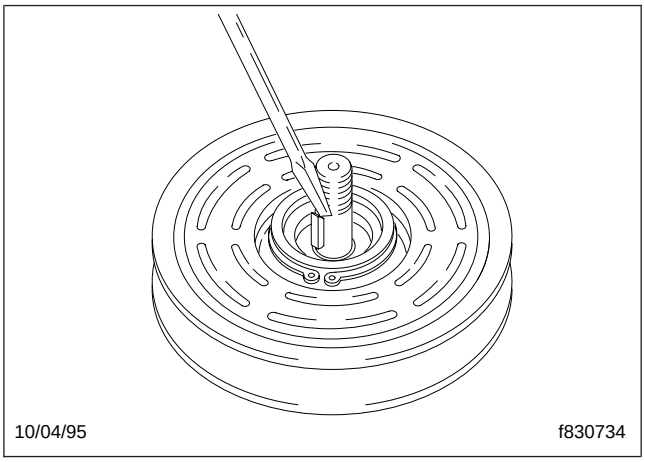
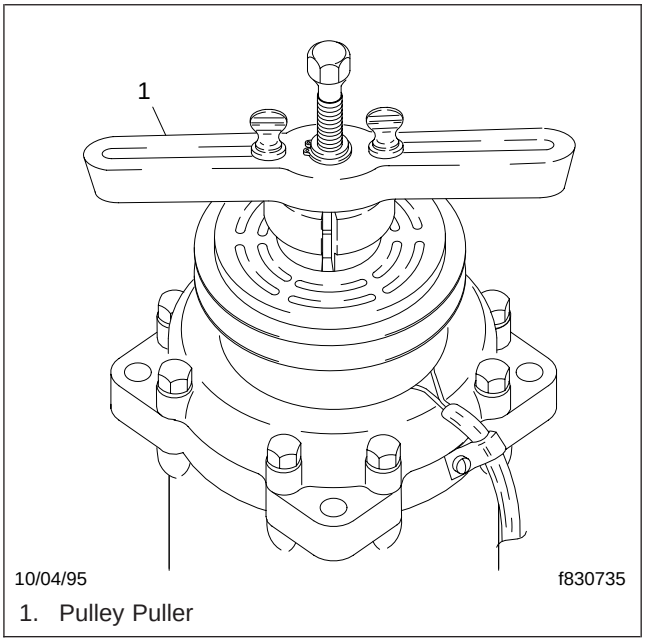


Fig. 4, Remove the Shaft Key



1. Pulley Puller

Fig. 5, Position the Rotor Puller Jaws

8.2 Place the rotor puller set over the exposed shaft.

8.3 Align the thumb screws to the puller jaws. Tighten the screws finger tight.

8.4 Using a socket wrench, turn the puller center bolt clockwise and remove the rotor assembly.

9. Remove the field coil assembly.

9.1 Remove the field coil assembly lead wire from the clamp on the compressor.

9.2 Disconnect the wiring harness.

9.3 Remove the snap ring. Then remove the field coil assembly.

Inspection

1. Inspect the drive plate assembly. If the frictional surface shows signs of damage due to too much heat, replace the drive plate assembly and the rotor assembly.
2. Check the appearance of the rotor assembly. If the frictional surface of the rotor shows signs of too much grooving due to slippage, replace both the rotor assembly and the drive plate assembly. Clean the frictional surfaces of the rotor assembly before installing it.
3. Check the field coil assembly for a loose connector and for cracked insulation. Replace it if necessary.

Installation

NOTE: When supporting the compressor in a vise, clamp only on the mounting ears, never on the body of the compressor.

1. Install the field coil assembly.

1.1 Position the coil assembly on the compressor.

1.2 Install the snap ring.

1.3 Attach the field coil assembly lead wire to the clamp on the compressor.

1.4 Connect the wiring harness.

2. Install the rotor assembly.

2.1 Position the rotor over the boss of the front housing.

2.2 Place the rotor installer ring into the bearing bore. Make sure that the edge rests only on the inner race of the bearing, not on the seal, rotor pulley, or outer race of the bearing.

2.3 Place the driver into the ring. Using a hammer or an arbor press, drive the rotor

pulley down against the front housing step. See **Fig. 6**.

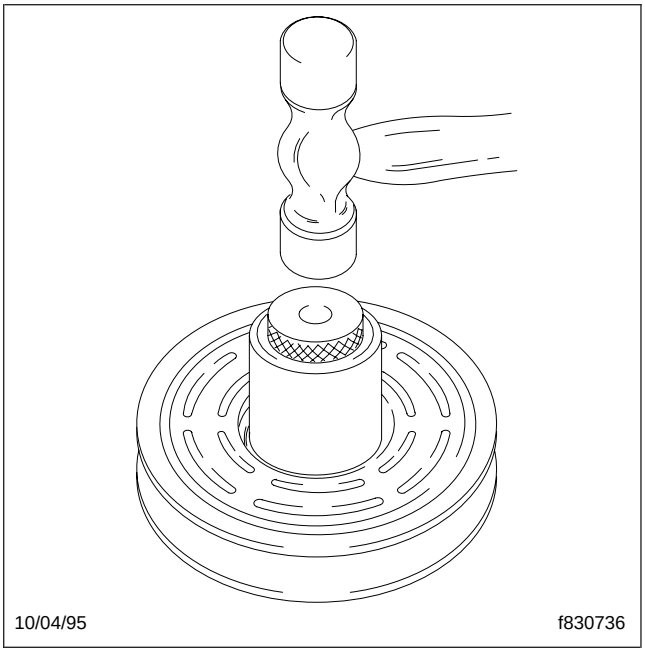


Fig. 6, Drive the Rotor Pulley Down Against the Front Housing Step

2.4 Using snap ring pliers, install the rotor bearing snap ring.

2.5 Using snap ring pliers, install the rotor retaining snap ring. If a bevel is present on the snap ring, make sure that it is facing away from the body of the compressor.

2.6 If equipped with a rotor bearing dust cover, install the cover by gently tapping it into place.

3. Install the drive plate assembly.

3.1 Using pliers, install the shaft key. See **Fig. 7**.

3.2 Install the shims.

3.3 Align the keyway in the drive plate assembly with the shaft key. Using a driver and a hammer or an arbor press, drive the assembly down over the shaft until it bottoms on the shims. See **Fig. 8**.

3.4 Install the retaining nut. If the nut is 1/2–20, tighten it 20 to 25 lbf·ft (27 to 34 N·m). If the nut is M8, tighten it 11 to 15 lbf·ft (15 to 21 N·m).

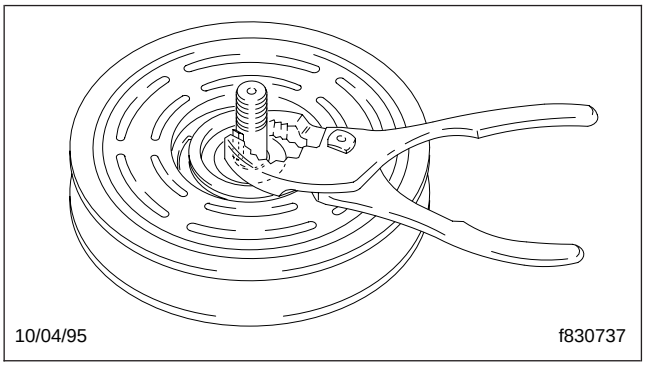


Fig. 7, Install the Shaft Key

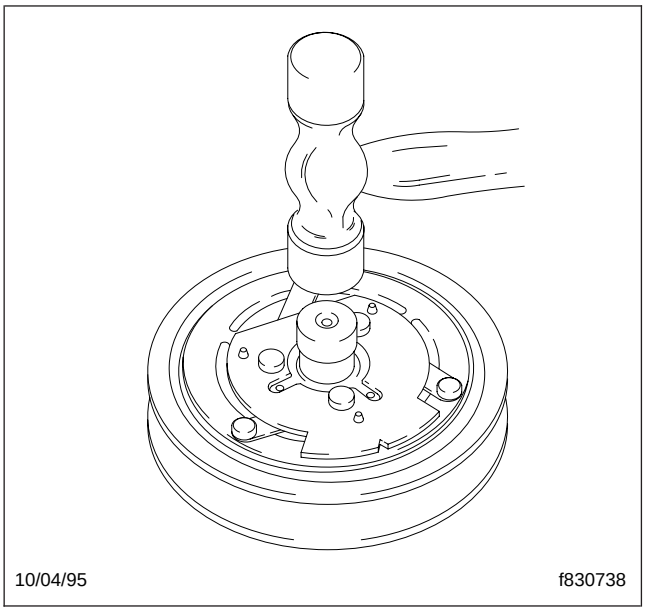


Fig. 8, Install the Drive Plate Assembly

4. Using a feeler gauge, check that the clutch clearance is 0.016 to 0.031 inch (0.4 to 0.8 mm). See **Fig. 9**. If the gap is not even around the clutch, gently tap down at the high areas. If the overall gap is out of spec, remove the drive plate assembly and change the shims as necessary.

5. Install the compressor on the vehicle. For instructions, see **Subject 120**.

Clutch Assembly Removal, Inspection, and Installation

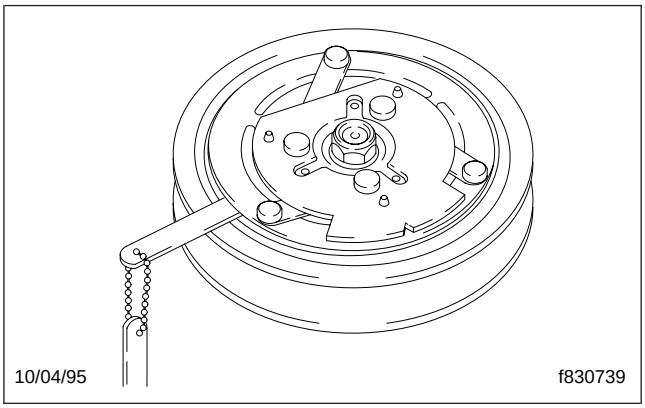


Fig. 9, Check the Clutch Clearance

Specifications

Special tools can be purchased from:
SPX Kent-Moore
28635 Mound Road
Warren, Michigan 48092-3499800-328-6657

Mini Stat-O-Seal Assembly Bolt Torque Specs	
HVAC Component	**Torque**
Refrigerant Compressor	11 to 15 lbf·ft (15 to 20 N·m)
Condenser	11 to 15 lbf·ft (15 to 20 N·m)

Table 1, Mini Stat-O-Seal Assembly Bolt Torque Specs

General Description

FLD Conventional hoods are made of fiberglass by one of two processes: SMC or spray-up.

SMC HOODS

SMC, which stands for sheet molding compound, is a fiberglass and thermosetting polyester material. SMC hoods are easily recognized by their smooth inner surface. To make each part, SMC sheets first are placed between matching mold halves. Then, heat and pressure are applied to the mold in order to cure (solidify) the SMC resin. At the end of the process, an in-mold coating is injected onto the part to prepare it for priming and topcoating.

SPRAY-UP HOODS

Spray-up hoods are made using the "contact molding" technique. They are easily recognized by their rough inner surface. As illustrated **in Fig. 1**, contact molding is done with an open mold, or a female configuration, which controls external shape and finish.

A gel coating is first sprayed onto the mold. The gel coating eventually becomes the smooth outer surface of the hood. It provides impact and abrasion resistance to the laminate underneath. In addition, it readily accepts a coating of paint. A laminate of fiberglass reinforcement and resin is then built up by use of a special chopper/spray-gun which directs short glass fibers and catalyzed resin onto the mold (gel) surface. The glass fibers are rapidly "chopped" from a feeder roll of continuous strand roving, which consists of numerous, untwisted fiberglass strands wound into a cylindrical package.

The resin used in this process is air-inhibited; that is, it will not completely cure, or harden, when the laminate is exposed to the air. All portions not directly exposed to the air (including those portions of the laminate contacting the gel), dry instantly. As a result, no matter how many "passes" are made with the roving fiberglass chopper/spray-gun in a particular area, the final structure will have only one layer of fiberglass (that is, distinct layers of fiberglass will not be present when using this process).

Upon completion of this phase in the manufacture of a fiberglass hood (termed "spray-up"), major stress areas are reinforced by hand (termed "hand lay-up"). During hand lay-up, fiberglass reinforcement in the form of woven roving (a heavy, drapable fabric) is manually built up, with air-inhibited resin added as needed.

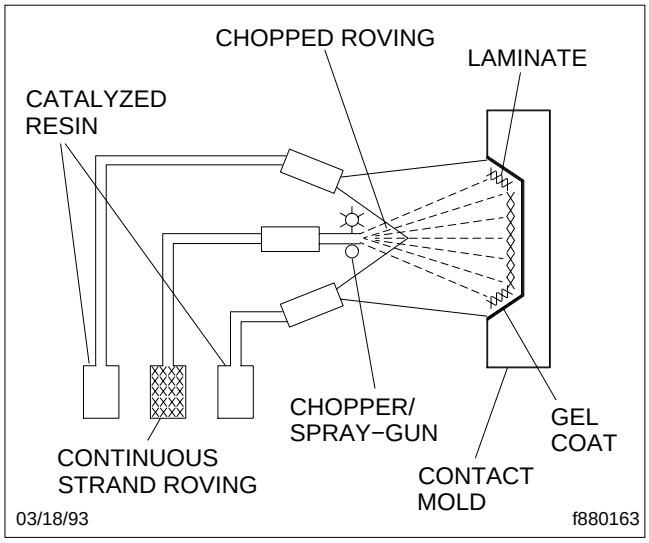


Fig. 1, Fiberglass Contact Molding Technique

HOOD MOUNTING AND COMPONENTS

The hood assembly is mounted on two pivot brackets directly behind the front bumper. The hood pivots work in conjunction with the tilt-assist and tilt-limiting mechanisms to allow a forward hood tilt adequate for vehicle service.

In the operating position, the rear of the hood is supported by hood mounting brackets with locator cones, which are attached to the cab. The locator cones hold the hood in the correct position by fitting inside the hood guides attached to the hood. The hood is held down with latches, one on each side.

Both the front and rear hood mounting brackets are adjustable forward and backward, side to side, and up and down.

Each hood assembly is equipped with a chemically polished and anodized aluminum grille. The grille is attached to the hood with either four or eight locknuts. The hood is also equipped with a headlight and turn signal/ parking light assembly on each fender. Inner fenders are attached underneath the hood on the inboard side of the tires. Mylar-covered foam, which reduces engine noise emissions, is attached to the underside of the hood and inner fenders.

Hood With Coil Spring Tilt-Assist Mechanism, Removal and Installation

Removal

1. Apply the parking brakes, and chock the tires.
2. Remove the grille. Refer to the applicable grille removal and installation subject for instructions.
3. Release the hood latches, and tilt the hood all the way open.
4. Disconnect the headlight and turn signal/ parking light connectors located behind the bumper. **See Fig. 1.**
5. Block the hood from tilting beyond its full-open position by placing a support between the floor and the front of the hood. Place cardboard, carpeting,rags, or other padding on top of the support to protect the hood. The lowest edge of the hood should rest on the supports. The supports should be as wide and as long as the front of the hood. **See Fig. 2.**

⚠ WARNING

WARNING: When there is tension on the tilt-assist spring, do not disconnect the tilt-assist cables or spring. If the spring or cables are disconnected while the spring is under tension, they could whip and cause personal injury.

NOTE: In early 1993, the Classic XL model received a longer hood, and a new hood guide and tilt assist mechanism. The tilt assist mechanism has two tilt assist springs. **See Fig. 3.**

6. Tilt the hood until it is balanced over the pivots to relieve tension from the tilt assist spring. While a coworker is holding the hood in this position, disconnect the tilt assist cables from the brackets on top of the radiator at each side.

   On hoods with tilt-limiting straps (**see Fig. 4**) remove the capscrews and hexnuts that fasten the straps to the hood. Then, disconnect the straps from the hood.
7. Carefully lower the hood onto the support.
8. Remove the prevailing torque locknuts from the shoulder bolts that attach the hood to the forward mounting brackets. **See Fig. 5.** Drive out the shoulder bolts.

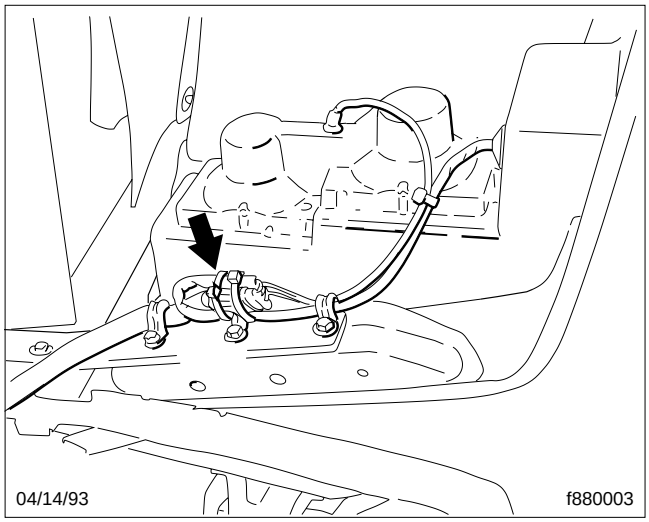
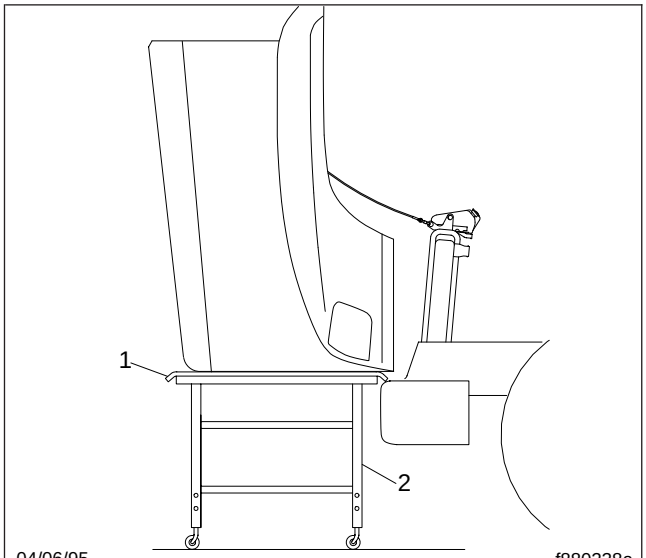


Fig. 1, Headlight and Turn Signal/Parking Light Connectors



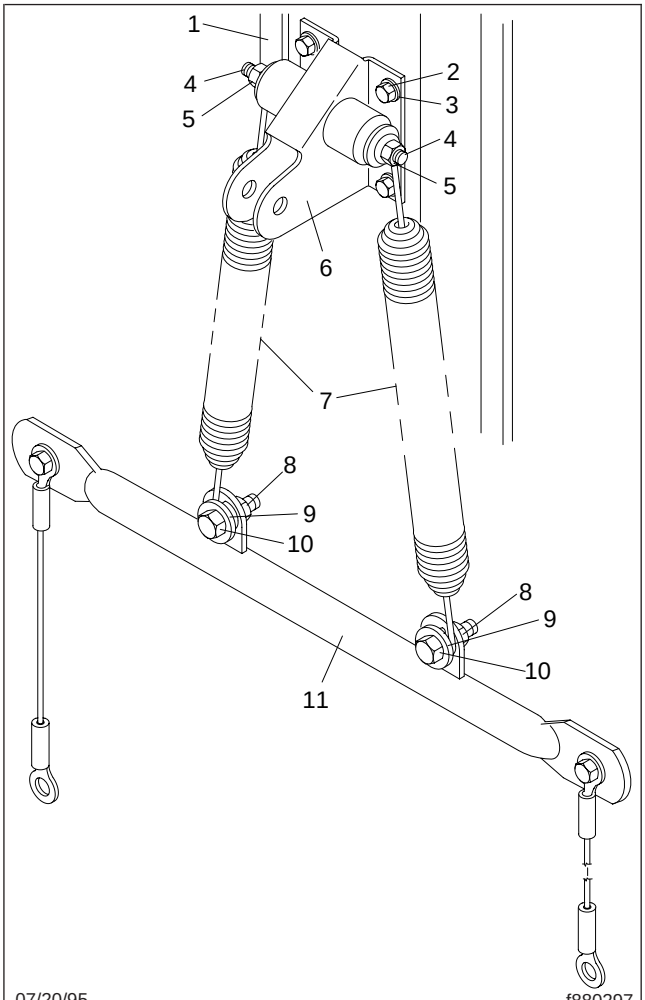
1. Padding
2. Support

Fig. 2, Hood Tilted Onto Padded Support

⚠ WARNING

WARNING: Do not attempt to lift the hood; It weights about 200 lbs (90 kg). Lifting or dropping the hood could result in personal injury, or damage to the hood assembly and other components.

Hood With Coil Spring Tilt-Assist Mechanism, Removal and Installation



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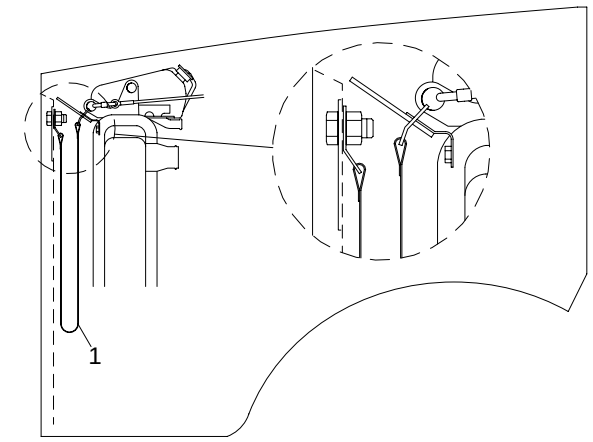
1. Hood
2. Bolt
3. Washer
4. Capscrew
5. Nut
6. Spring Bracket
7. Spring
8. Nut
9. Washer
10. Bolt
11. Yoke

Fig. 3, Classic XL Hood Tilt Assist Mechanism

9. To move the hood, carefully roll or slide the hood support away from the vehicle; do not attempt to lift the hood.



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1. Strap

Fig. 4, Tilt-Limiting Strap

Installation

⚠ WARNING

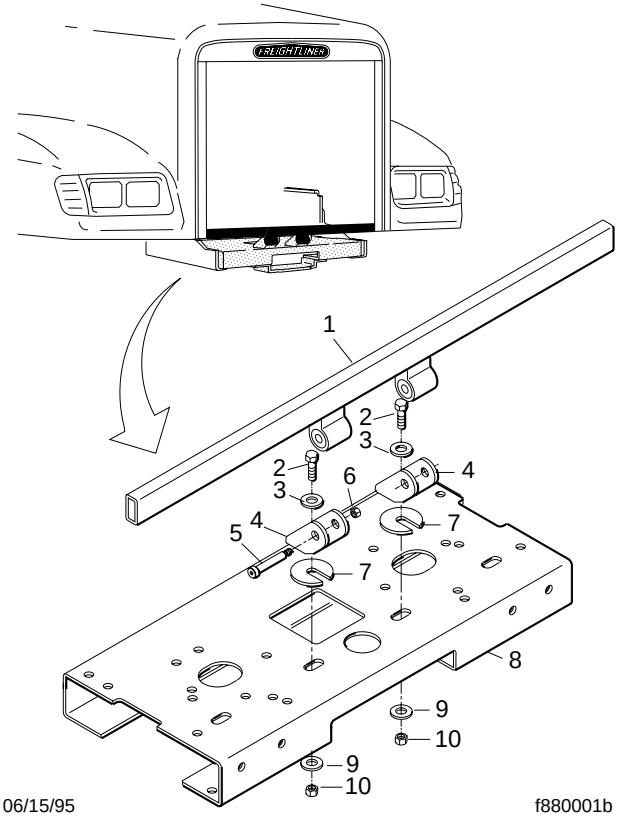
WARNING: Do not attempt to lift the hood; It weighs about 200 lbs (90 kg). Lifting or dropping the hood could result in personal injury, or damage to the hood assembly and other components.

1. With the hood in the forward-tilt position and resting on the support at about the same height as the top of the bumper, move the support and hood into alignment with the front of the vehicle. **See Fig. 2.** Don't try to lift the hood.
2. Align the shoulder bolt holes of the crosstie assembly with the pivot pin holes of the forward mounting brackets. Push the shoulder bolts into place; both bolts must be installed from right to left. Install the prevailing torque locknuts, and tighten them 23 lbf·ft (31 N·m).
3. Make sure the hood tilt-assist spring bracket is fastened to the hood and the spring and cables are assembled correctly. **See Fig. 6.**
4. Tilt the hood until it is balanced over the pivots. While a coworker holds the hood in this position, connect the tilt assist cables to the forwardmost holes in the brackets on top of the radiator at each side. **See Fig. 7.** If cable links are used,

Hood With Coil Spring Tilt-Assist Mechanism, Removal and Installation

apply Loctite® 242 to the threads on the cable links before screwing them closed.

On hoods with tilt-limiting straps, connect the straps to the hood. Install the capscrews and prevailing torque hexnuts. Tighten the hexnuts 55 lbf·ft (75 N·m).



1. Crosstie Assembly
2. 1/2-13 Bolt
3. Hardened Washer
4. Forward Hood-Mounting Bracket
5. Shoulder Bolt
6. Prevailing Torque Locknut
7. Slotted Spacer
8. Front Crossmember
9. Hardened Washer
10. 1/2-13 Locknut

Fig. 5, Forward Hood-Mount Assembly

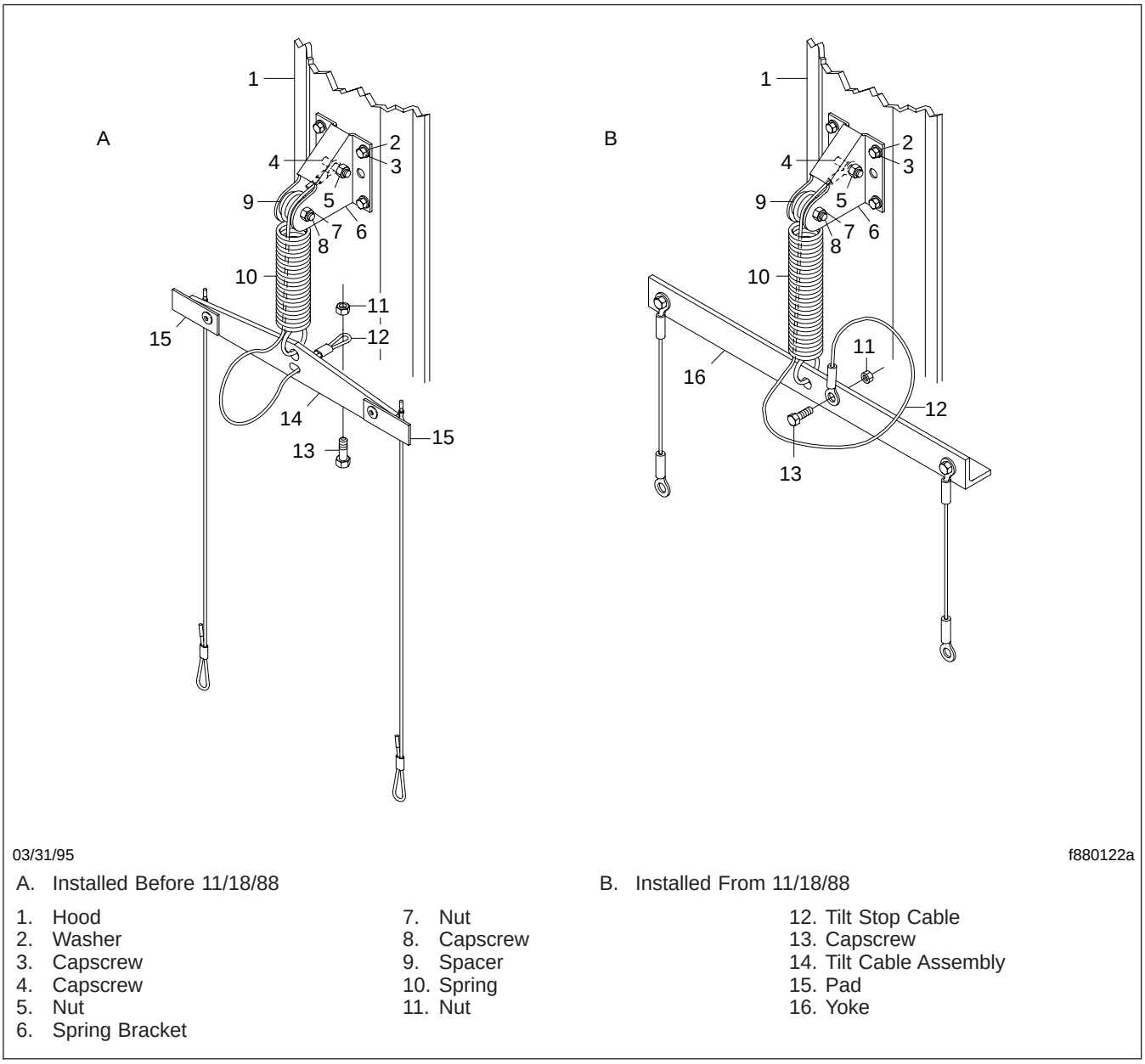
⚠ WARNING

WARNING: Attach the hood tilt assist cables to the brackets at the forwardmost holes. Attaching at any other hole could cause the tilted hood to be less stable, possibly resulting in personal injury or property damage.

NOTE: The upper holes are used for tilt assist attachment on FLC 112 Conventionals, but are not used on FLD 120 Conventionals.

5. Remove the hood supports from the front of the vehicle and tilt the hood all the way open.
6. Connect the headlight and turn signal/ parking light cables on both sides of the vehicle.
7. Return the hood to the operating position and fasten both hood latches.
8. Install the grille. Refer to the applicable grille removal and installation subject for instructions.
9. Adjust the hood. Refer to **Subject 120** for instructions.

Hood With Coil Spring Tilt-Assist Mechanism, Removal and Installation



A. Installed Before 11/18/88

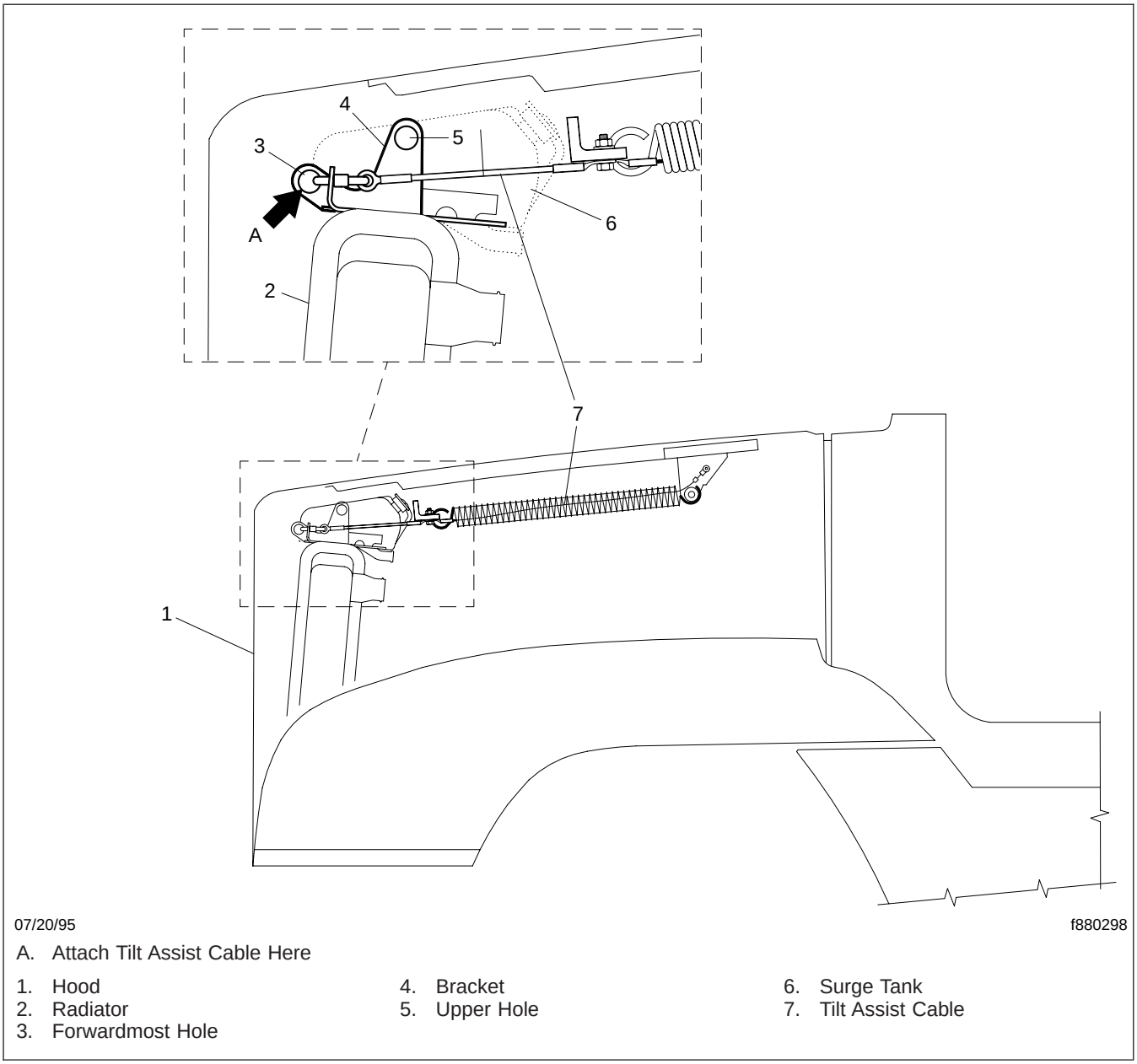
1. Hood
2. Washer
3. Capscrew
4. Capscrew
5. Nut
6. Spring Bracket
7. Nut
8. Capscrew
9. Spacer
10. Spring
11. Nut

B. Installed From 11/18/88

12. Tilt Stop Cable
13. Capscrew
14. Tilt Cable Assembly
15. Pad
16. Yoke

Fig. 6, Hood Tilt Assembly (except Classic XL)

Hood With Coil Spring Tilt-Assist Mechanism, Removal and Installation



A. Attach Tilt Assist Cable Here

1. Hood
2. Radiator
3. Forwardmost Hole
4. Bracket
5. Upper Hole
6. Surge Tank
7. Tilt Assist Cable

Fig. 7, Hood Tilt Assist Cable and Bracket (with detail)

Hood With Torsion Bar Tilt-Assist Mechanism, Removal and Installation

Removal

1. Apply the parking brakes, and chock the tires.
2. Release the hood latches, and tilt the hood all the way open.
3. Remove the grille. Refer to the applicable grille removal and installation subject for instructions.
4. Disconnect the headlight and turn signal/ parking light connectors located behind the bumper. See **Fig. 1**.
5. Block the hood from tilting beyond its full-open position by placing a support between the floor and the front of the hood. Place cardboard, carpeting, rags, or other padding on top of the support to protect the hood. The lowest edge of the hood should rest on the supports. The supports should be as wide and as long as the front of the hood. See **Fig. 2**.

NOTE: From 1992, models of the FLD 112 Severe Duty vehicle with a high-pivot hood were manufactured with a twin torsion bar tilt-assist mechanism. See **Fig. 3.** The twin torsion bar mechanism is non-adjustable, and is removed and installed in much the same manner as is the single torsion bar mechanism.

6. Tilt the hood until it is balanced over the pivots to relieve the load from the tilt-assist torsion bar (**Fig. 4**, Ref. 5).

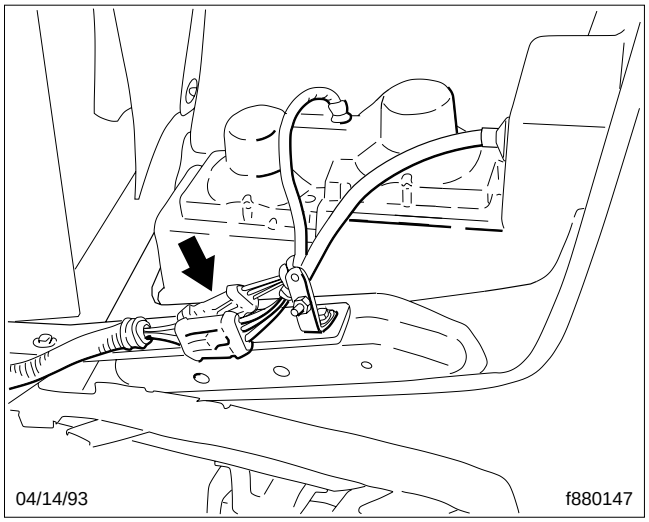


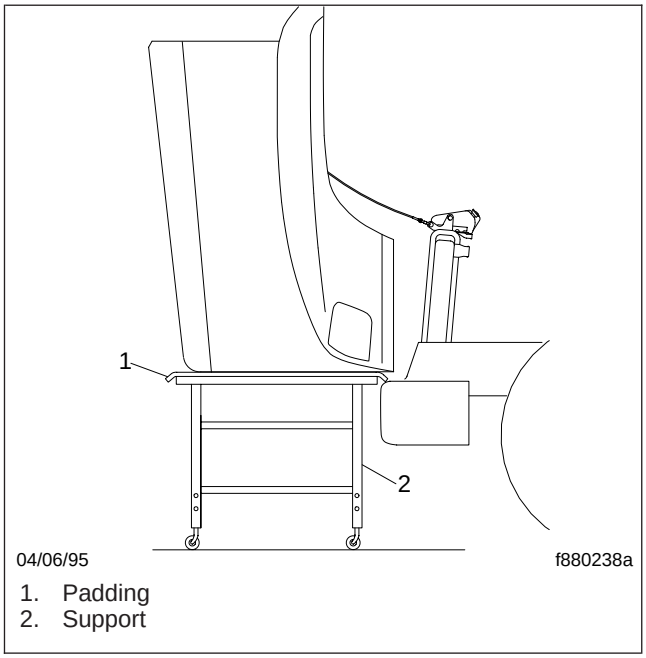
Fig. 1, Headlight and Turn Signal/Parking Light Connections (FLD 112 shown)

NOTE: To find the hood position where the torsion bar is not under load, lift the hood until both adjustment screws (**Fig. 4**, Refs. 2 and 4) in the pivot block (Ref. 1) are off the stop (Ref. 3).

⚠ WARNING

WARNING: Do not try to remove the torsion bar while it is under load. It could be forcibly ejected, possibly causing personal injury.

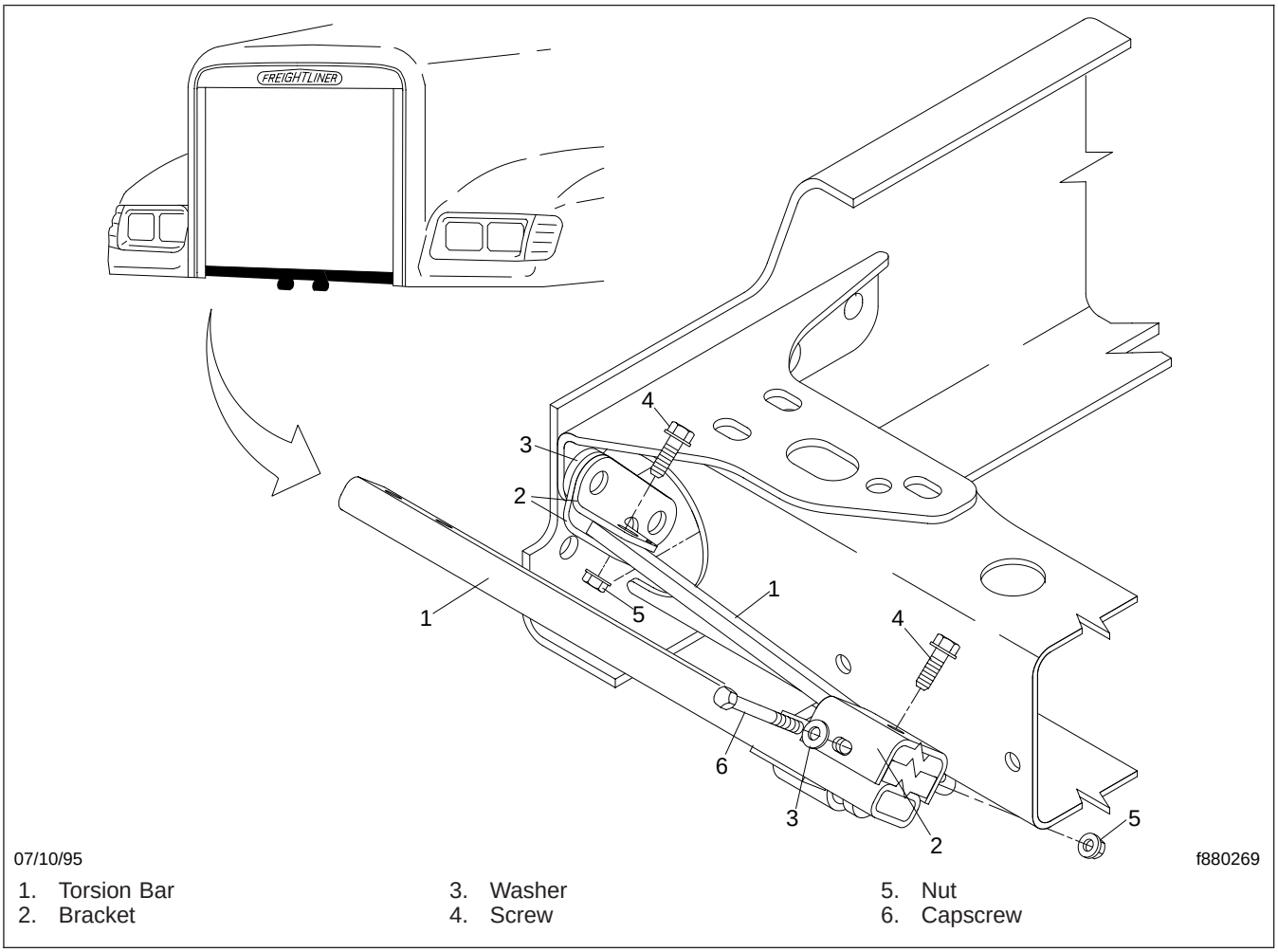
7. While a coworker is holding the hood in this position, remove the tilt-assist torsion bar as follows:
   - 7.1 Remove the bolt and bracket that hold the torsion bar to the crosstie assembly at the base of the hood. See **Fig. 4.**
   - 7.2 Slide the torsion bar out of the pivot block assembly.
8. While the coworker continues to hold the hood, disconnect the nylon tilt-limiting straps from the brackets on top of the radiator at each side.
9. Carefully lower the hood onto the support.



1. Padding
2. Support

Fig. 2, Hood Tilted Onto Support

Hood With Torsion Bar Tilt-Assist Mechanism, Removal and Installation



1. Torsion Bar
2. Bracket
3. Washer
4. Screw
5. Nut
6. Capscrew

Fig. 3, Tilt-Assist Twin Torsion Bar Assembly

10. Remove the prevailing torque locknuts from the shoulder bolts that attach the hood to the forward mounting brackets. See **Fig. 5.**

⚠ WARNING

WARNING: Do not attempt to lift the hood; It weighs about 200 lbs (90 kg). Lifting or dropping the hood could result in personal injury or damage to the hood assembly and other components.

11. To move the hood, carefully roll or slide the hood support away from the vehicle; do not attempt to lift the hood.

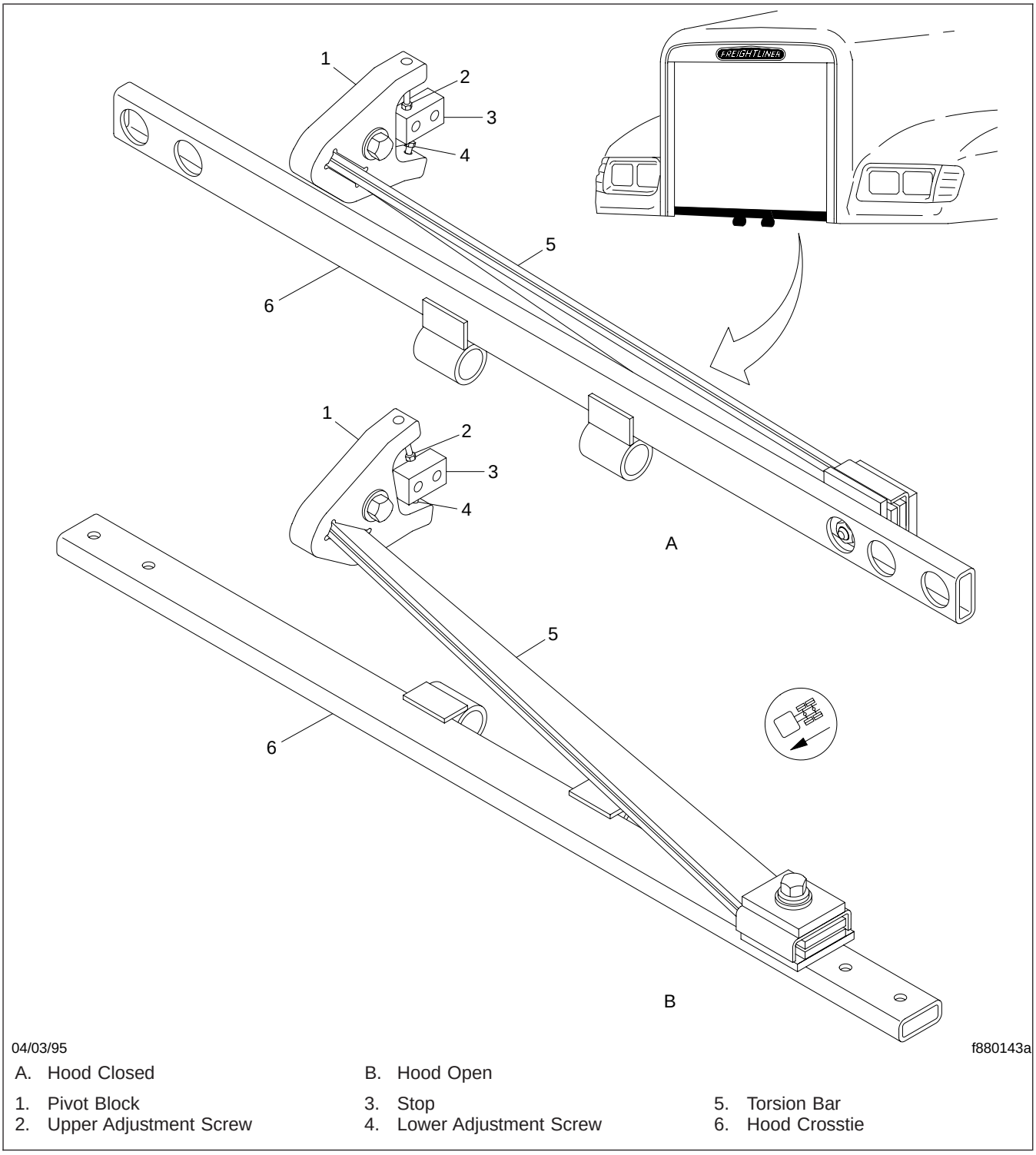
Installation

⚠ WARNING

WARNING: Do not attempt to lift the hood; It weighs about 200 lbs (90 kg). Lifting or dropping the hood could result in personal injury or damage to the hood assembly and other components.

1. With the hood in the forward-tilt position and resting on the support at about the same height as the top of the bumper, move the support and hood into alignment with the front of the vehicle. See **Fig. 2.**
2. Align the shoulder bolt holes of the hood crosstie assembly with the holes of the pivot hinges.

Hood With Torsion Bar Tilt-Assist Mechanism, Removal and Installation

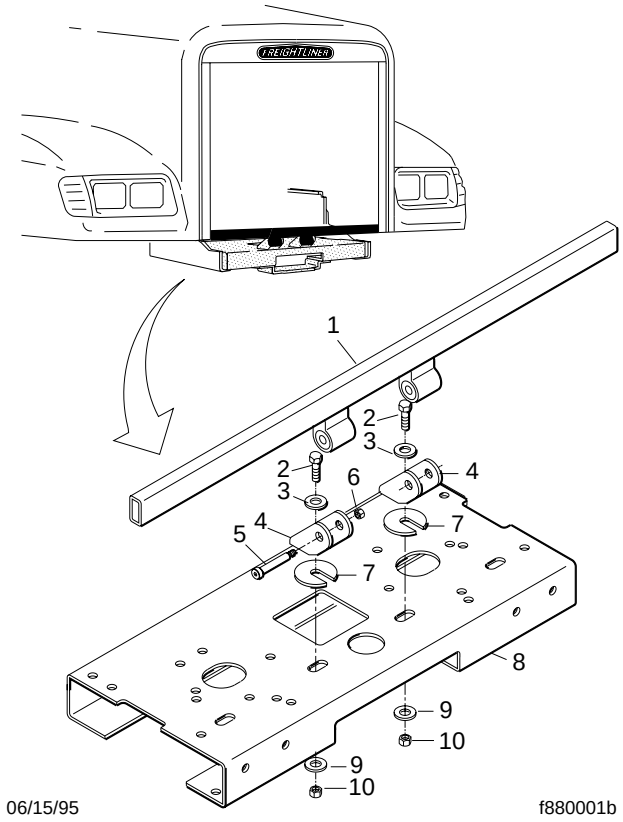


A. Hood Closed
B. Hood Open

1. Pivot Block
2. Upper Adjustment Screw
3. Stop
4. Lower Adjustment Screw
5. Torsion Bar
6. Hood Crosstie

Fig. 4, Tilt-Assist Torsion Bar Assembly

Hood With Torsion Bar Tilt-Assist Mechanism, Removal and Installation



1. Crosstie Assembly
2. 1/2-13 Bolt
3. Hardened Washer
4. Forward Hood-Mounting Bracket
5. Shoulder Bolt
6. Prevailing Torque Locknut
7. Slotted Spacer
8. Front Crossmember
9. Hardened Washer
10. 1/2-13 Locknut

Fig. 5, Forward Hood-Mount Assembly

Push the shoulder bolts into place; both bolts must be installed from right to left. Install the prevailing torque locknuts, and tighten them 23 lbf·ft (31 N·m).

3. Fasten the nylon tilt-limiting straps to the hood and to the brackets on the radiator.
4. Tilt the hood until it is balanced over the pivots. While a coworker holds the hood in this position, install the tilt-assist torsion bar as follows:
   - 4.1 Slide the torsion bar into its slot in the pivot block assembly.
   - 4.2 Install the bracket and bolt that hold the torsion bar to the crosstie assembly at the base of the hood.
   - 4.3 Tighten the bolt 80 lbf·ft (108 N·m).
5. Remove the hood supports from the front of the vehicle and tilt the hood all the way open.
6. Connect the headlight and turn signal/ parking light cables on both sides of the vehicle.
7. Adjust the tilt-assist torsion bar. Refer to **Subject 125** for instructions.
8. Return the hood to the operating position and fasten both hood latches.
9. Install the grille. Refer to the applicable grille removal and installation subject for instructions.
10. Adjust the hood. Refer to **Subject 120** for instructions.

Hood Clearance Adjustment

Adjustment

NOTE: If vehicle chassis has been damaged, the frame must be straightened before attempting to adjust the hood.

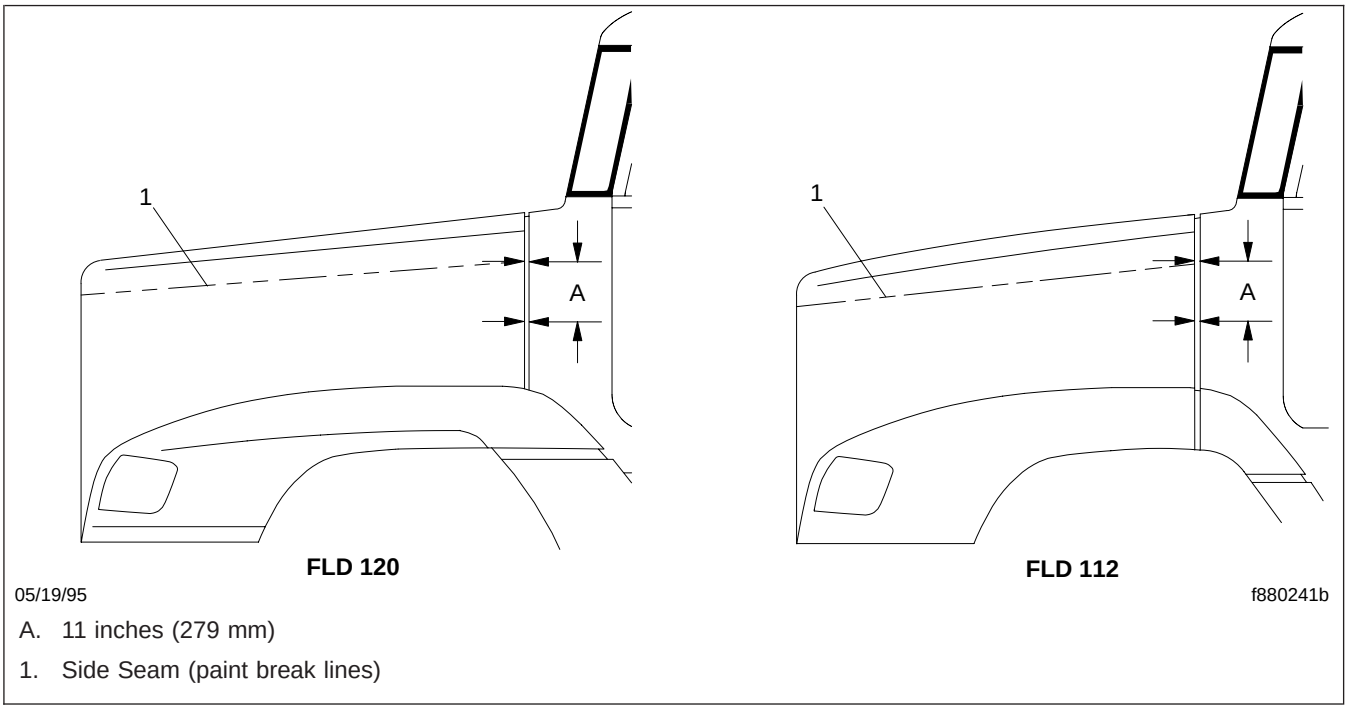
1. Drive the vehicle back and forth to settle the frame and suspension. Park the vehicle on a flat, level surface.
2. If the vehicle is equipped with a cab rear air-suspension system, make sure it is adjusted correctly. See the cab section for instructions. On vehicles with the torsion bar tilt-assist mechanism make sure the tilt-assist torsionbar is adjusted correctly. For instructions, see "Installation" in **Subject 110**.
3. See if hood adjustment is necessary by making the following checks:
   - 3.1 Measure the gap between the rear vertical edge of the hood at the paint break lines and 11 inches (279 mm) below the paint break lines. See **Fig. 1**. The gap is to be 1/2 inch to 7/8 inch (13 to 22 mm) at these four points.
   - 3.2 The flushness and alignment of the hood are achieved by aligning the paint break lines. **Figure 2** shows vertical alignment specifications. **Figure 3** shows the side-to-side alignment specifications.
   - 3.3 The bumper air dam and hood fender should be parallel to within ±0.190 inch (5 mm) for the full length of the bumper air dam. See **Fig. 4**.
   - 3.4 If any of the above dimensions are not within tolerance, the hood may be adjusted as follows. If the hood is within tolerances specified but the bumper, the cowl top and the quarter fenders are out of alignment, the components must be repositioned.
4. Tilt the hood to the full-open position.
5. Loosen the nuts (**Fig. 5** or **Fig. 6**, Ref. 9) that hold the rear hood-locator brackets to the hood mount assemblies, just enough to allow the hood to slide forward and backward for adjustment.

IMPORTANT: In September 1993, the bolts (**Fig. 5** , Ref. 5) and the rear hood-locator brackets (**Fig. 5** , Ref. 4) were changed to improve bolt access. The new bolts, which are round-headed, square-necked bolts, and the redesigned brackets are shown in **Fig. 6**.

6. Loosen the nuts (**Fig. 5** or **Fig. 6**, Ref. 8) that hold the locators to the locator brackets, just enough to allow the hood to slide side-to-side for adjustment.
7. Loosen the locknuts (**Fig. 7**, Ref. 10, or **Fig. 8**, Ref. 7) just enough to allow the hood to slide for adjustment. The nuts must be kept tight enough for the brackets to remain stationary despite the force of the hood tilt-assist mechanism.
8. Make sure the front of the hood is centered on the frame, so none of the components under the hood will touch it when it is lowered.
9. Return the hood to the operating position, and fasten the hood latches.
10. Measure the gap between the hood and the cowl as shown in **Fig. 1**. Adjust the hood to a 1/2 inch to 7/8 inch (13 to 22 mm) gap at the paint break lines and at a point 11 inches (279 mm) below the paint break line.
11. Check the flushness of the hood by measuring the alignment of the paint break lines as shown in **Fig. 2**. If the lines are more than 3/32 inch (2.5 mm) apart, adjust as follows:
    - 11.1 Measure the distance that the rear of the hood should be raised or lowered to make the hood and cowl flush.
    - 11.2 Tilt the hood to the full-open position.
    - 11.3 Loosen the nuts (**Fig. 5** or **Fig. 6**, Ref. 8) on both locator bolts enough to add or remove slotted shims under the locators.
    - 11.4 If raising the hood, find the number of shims (Ref. 3) needed to raise the hood the distance measured above, and add them to the shims under the locators. If lowering the hood, remove the correct number of shims from underneath the locators.

      On FLD 120 Conventional highway models, if all of the shims have been removed and the hood still needs to be lowered, remove the bolts (Ref. 5) holding the locator brackets to the hood mount as-

Hood Clearance Adjustment



A. 11 inches (279 mm)

1. Side Seam (paint break lines)

Fig. 1, Hood-to-Cowl Clearance

semblies (Ref. 10). Then, move the hood guides (Ref. 11) from under the locator brackets to the top of the flanges on the locator brackets. See **Fig. 5**.

11.5 Install the locator bracket bolts, washers, and nuts. Leave them just loose enough to allow the hood to slide forward and backward for adjustment.

11.6 Tighten the locator bolt nuts. Leave them just loose enough to allow the hood to slide side to side for adjustment.

12. Check the gap widths again between the hood and cowl. If they are out of the 1/2 inch to 7/8 inch (13 to 22 mm) range, first slide the hood so that the point 11 inches below the paint break lines (see Step 10) is within tolerance. If the gap at the paint break lines is larger than 7/8 inch (22 mm), add shims to the front hood mounts. If the gap is less than 1/2 inch (13 mm) at the paint break lines, remove shims.

12.1 With the hood in the operating position and latched, loosen the locknuts (**Fig. 7**, Ref. 10, or **Fig. 8**, Ref. 7) enough to add or remove slotted shims.

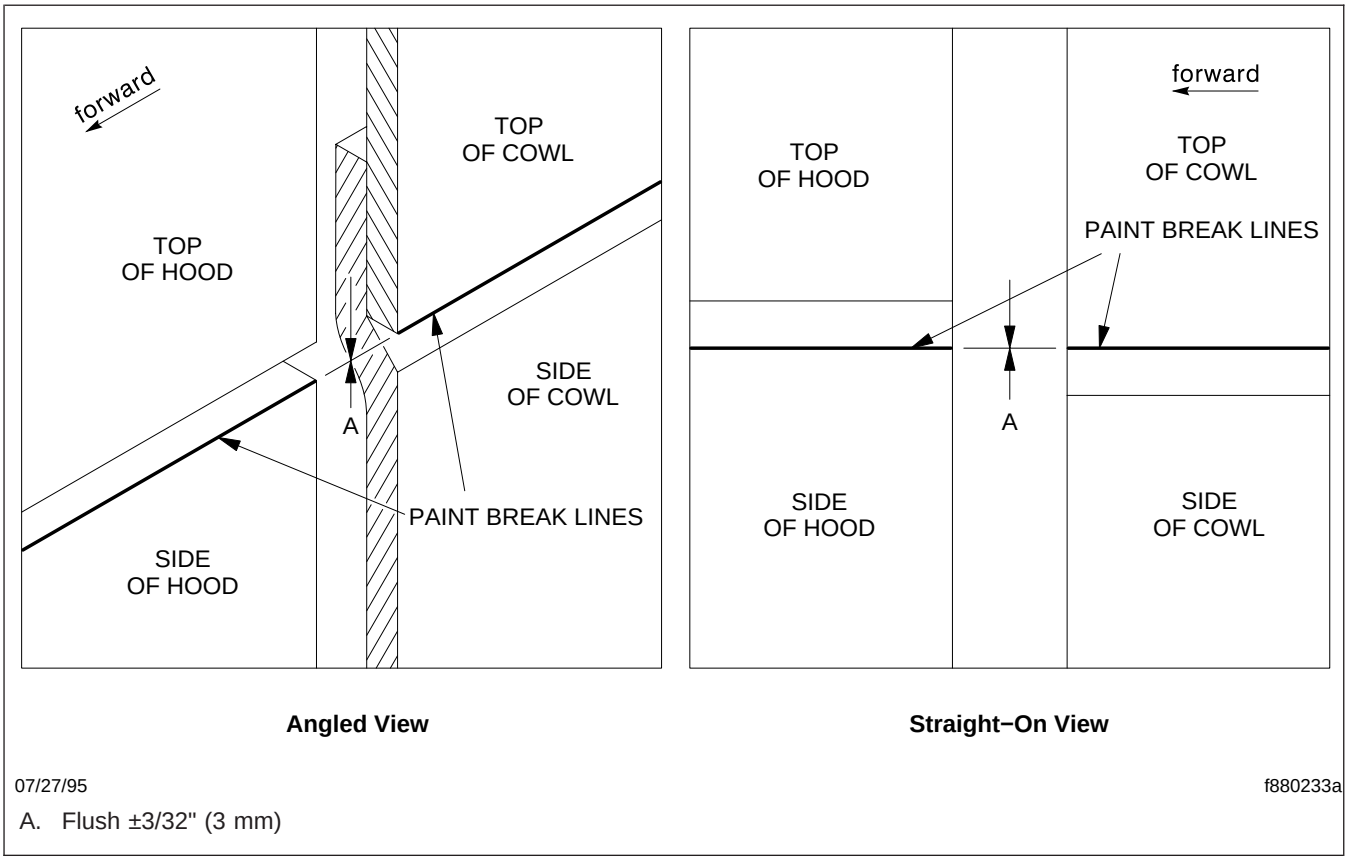
12.2 Raise the front of the hood high enough to allow insertion or removal of slotted shims (**Fig. 7**, Ref. 7, or **Fig. 8**, Ref. 6). Insert or remove the number of shims needed to make the gap between the hood and the cowl parallel.

IMPORTANT: Both forward hood-mounting brackets must have the same shim height. Do not use more than 3/4 inch (19 mm) of shims.

12.3 Tighten the locknuts (**Fig. 7**, Ref. 10, or **Fig. 8**, Ref. 7) so they are just loose enough to allow the hood to slide for adjustment. They must be tight enough for the brackets or hinges to remain stationary despite the force of the hood tilt-assist mechanism.

13. Check that the rear side edges of the hood are flush ±3/32 inch (2 mm) with the sides of the cowl at the paint break lines. See **Fig. 3**. If necessary, move the hood side to side until they are flush.

Hood Clearance Adjustment



A. Flush ±3/32" (3 mm)

Fig. 2, Measuring Alignment of Paint Break Lines

NOTE: If the hood cannot be moved side to side, check for and correct any interference under the front or rear of the hood.

14. Recheck the gap at the paint break lines and at the points 11 inches below the paint break lines to make sure they are within the 1/2 inch to 7/8 inch (13 to 22 mm) range.

NOTE: If the hood cannot be moved forward or backward to obtain the proper gap, check for and correct any interference under the front or rear of the hood.

15. On vehicles with a horizontal front frame cross-member tighten the locknuts (**Fig. 7**, Ref. 10) 85 lbf·ft (115 N·m).

    On vehicles with a vertical front frame cross-member tighten the locknuts (**Fig. 8**, Ref. 7) 70 lbf·ft (95 N·m).

16. Carefully tilt the hood to the full-open position. Make sure the rear hood-mounting brackets stay in place.

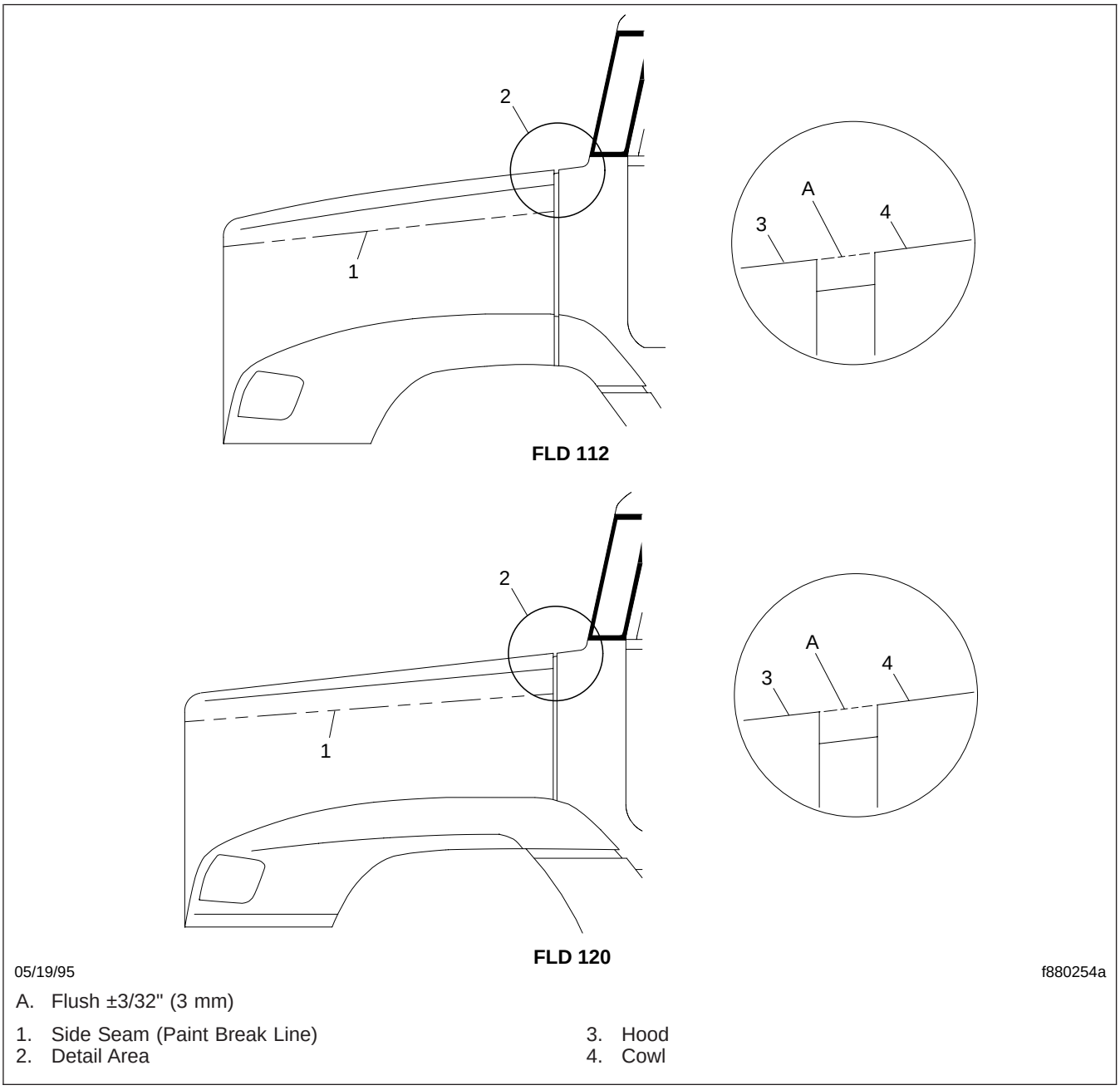
17. On FLD 120 Conventional highway models adjust the hood guides as follows:

    Measuring straight out from the outboard face of the hood guides, the distance between the centerline of the locators and the outboard face of the hood guides must be 2-5/8 inches (67 mm). See **Fig. 9**. Move the hood guides inboard or outboard as needed.

    On all other FLD models adjust the hood guides by setting the vertical face of the hood guide parallel to the edge of the locator bracket. See **Fig. 10**.

18. Tighten the nuts (**Fig. 5** or **Fig. 6**, Ref. 9) that hold the rear hood-locator brackets to the hood mount assembly. Tighten them 15 lbf·ft (20 N·m).

Hood Clearance Adjustment



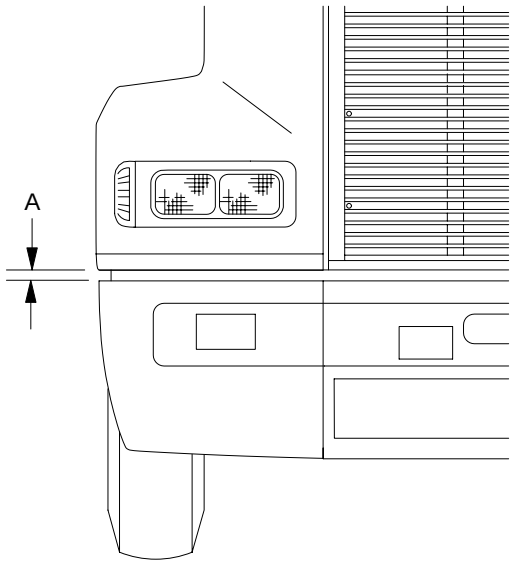
A. Flush ±3/32" (3 mm)

1. Side Seam (Paint Break Line)
2. Detail Area
3. Hood
4. Cowl

Fig. 3, Checking Flushness At Paint Break Lines

19. Tighten both locator bolt nuts (**Fig. 5** or **Fig. 6**, Ref. 8) 70 lbf·ft (95 N·m).
20. Lower the hood and fasten the hood latches.

Hood Clearance Adjustment



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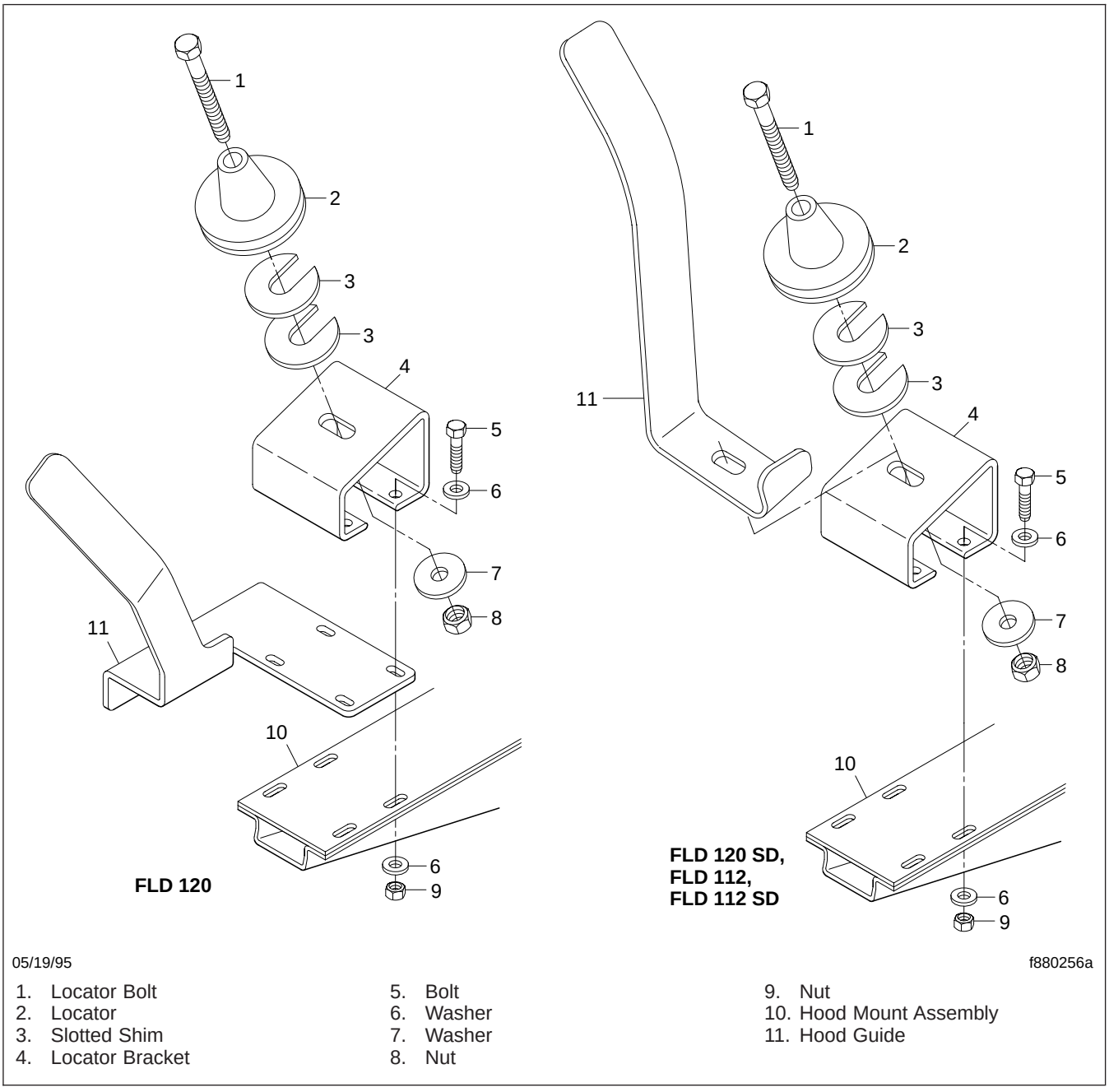
A. With the vehicle on a level surface, and wheels aimed straight ahead, the bumper air dam and hood fender are to be parallel within ±0.190 inch (5 mm) for the full length of the bumper air dam.

Fig. 4, Hood-to-Ground Parallelism

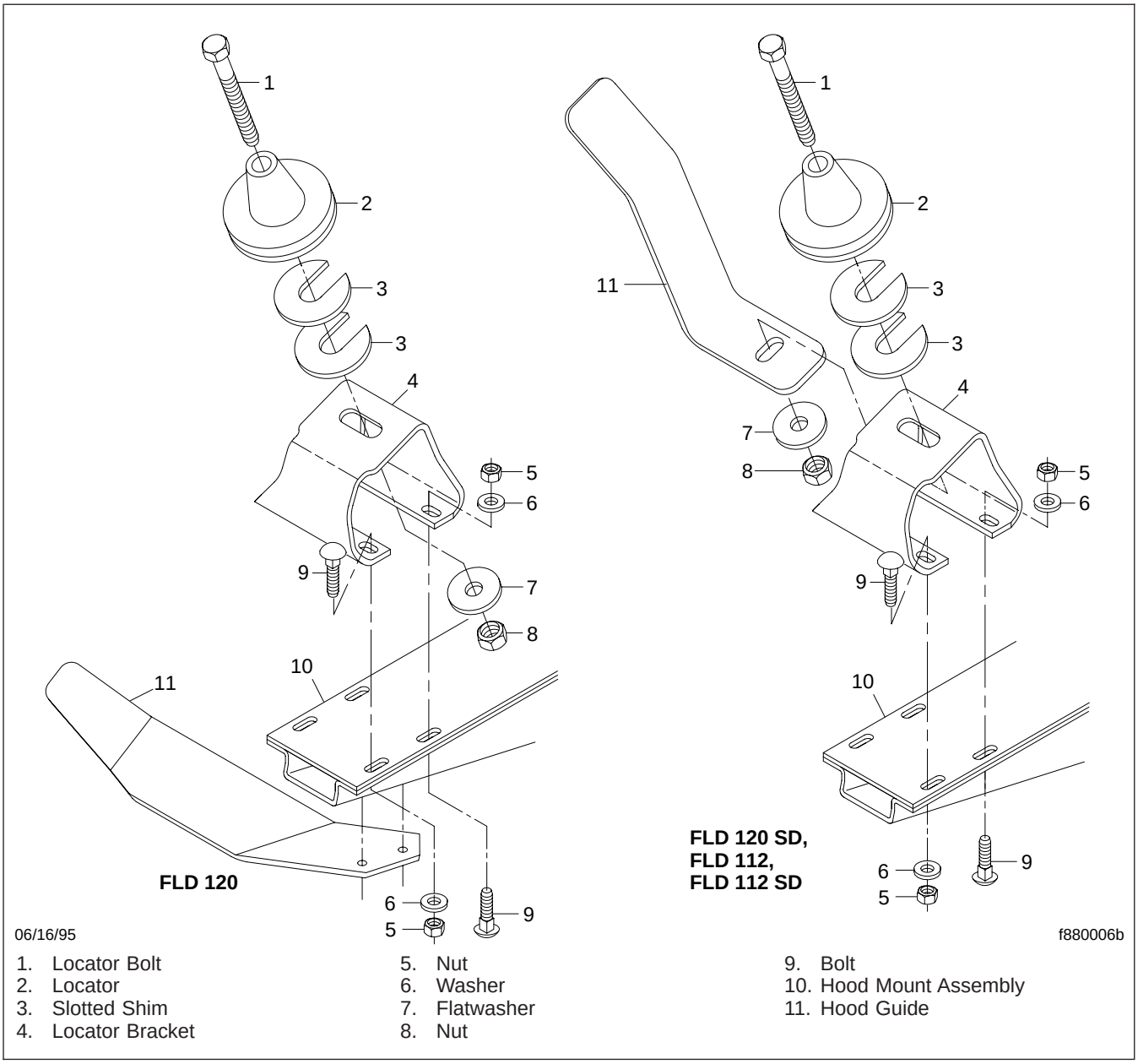
Hood Clearance Adjustment



1. Locator Bolt
2. Locator
3. Slotted Shim
4. Locator Bracket
5. Bolt
6. Washer
7. Washer
8. Nut
9. Nut
10. Hood Mount Assembly
11. Hood Guide

Fig. 5, Rear Hood-Mount Assembly (before September 1993)

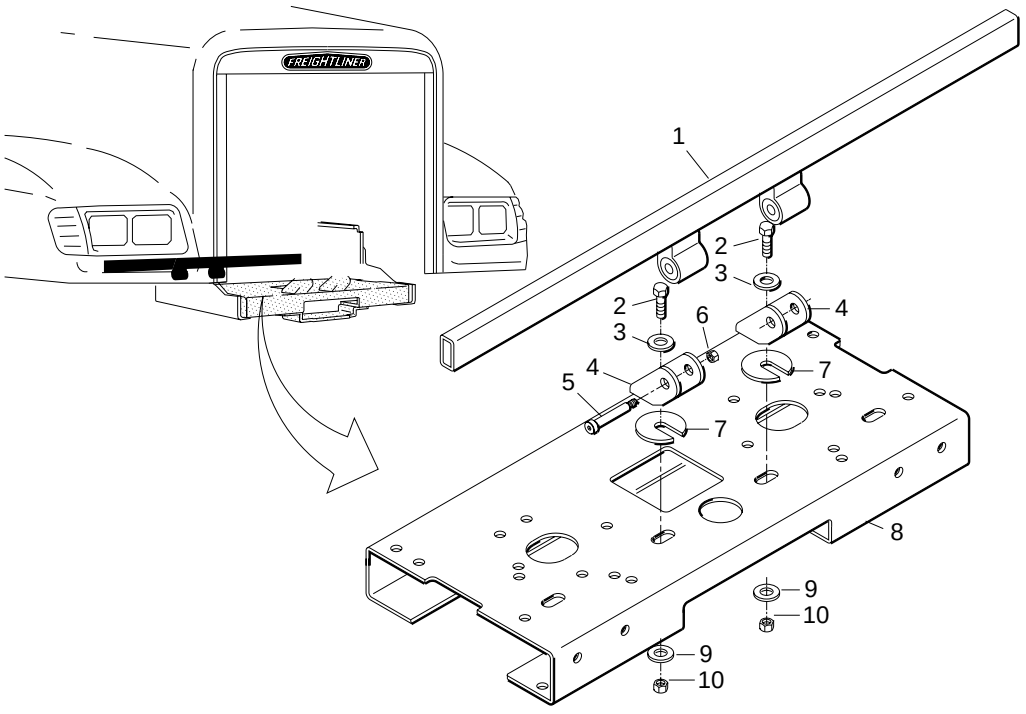
Hood Clearance Adjustment



1. Locator Bolt
2. Locator
3. Slotted Shim
4. Locator Bracket
5. Nut
6. Washer
7. Flatwasher
8. Nut
9. Bolt
10. Hood Mount Assembly
11. Hood Guide

Fig. 6, Rear Hood-Mount Assembly (from September 1993)

Hood Clearance Adjustment



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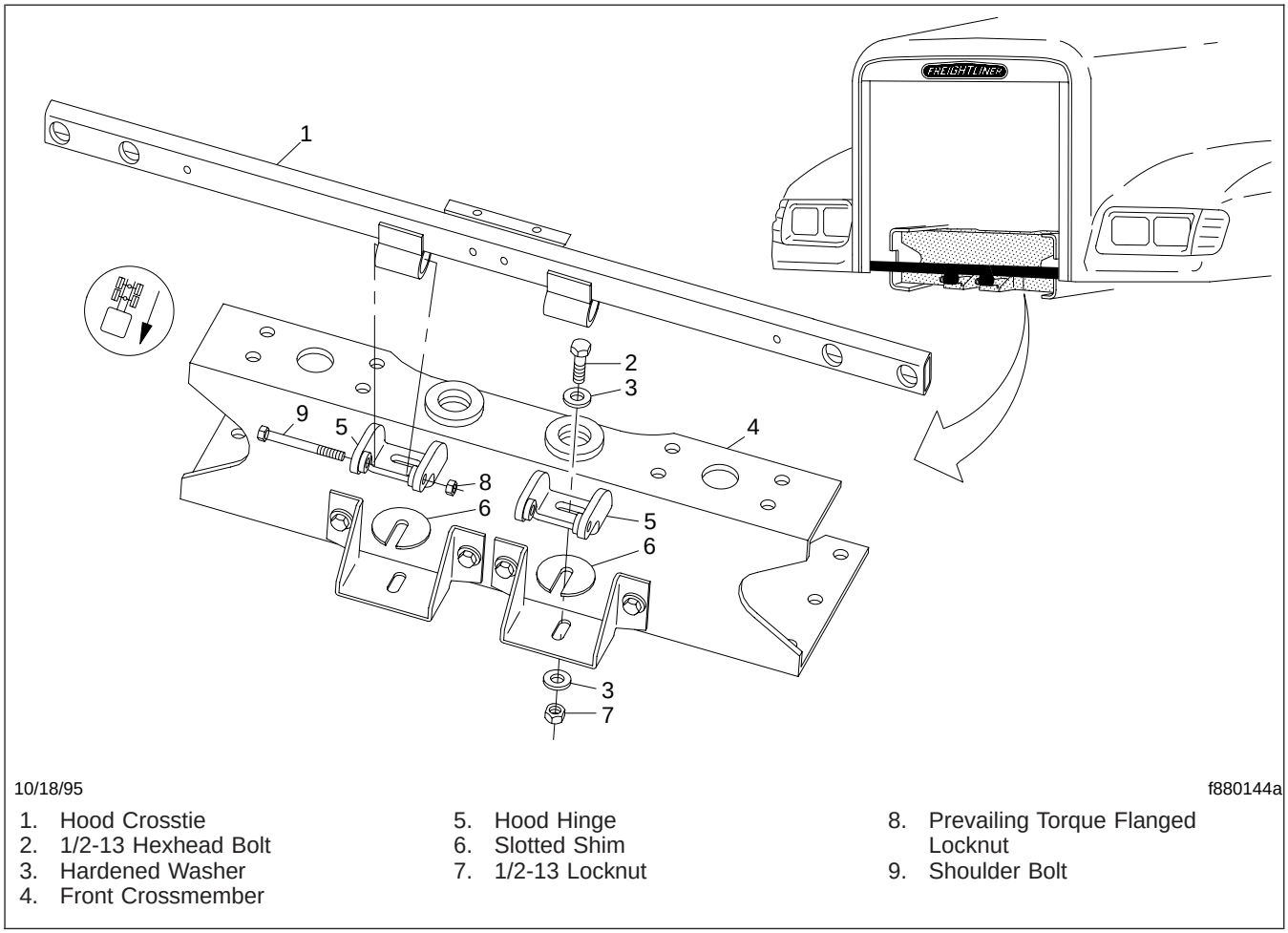
1. Crosstie Assembly
2. 1/2-13 Bolt
3. Hardened Washer
4. Forward Hood-Mounting Bracket
5. Shoulder Bolt
6. Prevailing Torque Locknut
7. Slotted Spacer
8. Front Crossmember
9. Hardened Washer
10. 1/2-13 Locknut

Fig. 7, Forward Hood-Mount Assembly (vehicles with horizontal front crossmember)

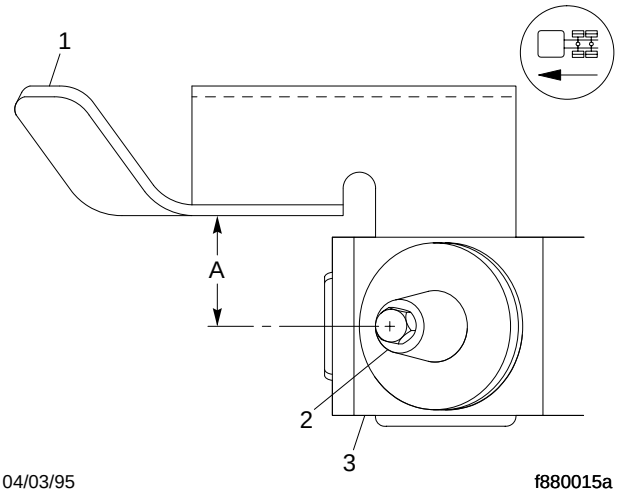
Hood Clearance Adjustment



1. Hood Crosstie
2. 1/2-13 Hexhead Bolt
3. Hardened Washer
4. Front Crossmember
5. Hood Hinge
6. Slotted Shim
7. 1/2-13 Locknut
8. Prevailing Torque Flanged Locknut
9. Shoulder Bolt

Fig. 8, Forward Hood-Mount Assembly (vehicles with vertical front crossmember)

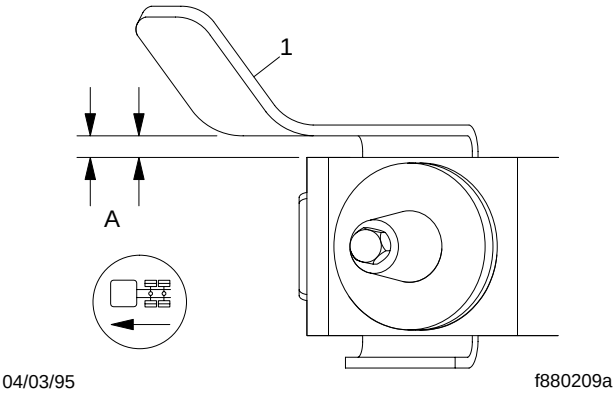
Hood Clearance Adjustment



A. Measurement of 2-5/8" (67 mm)

1. Hood Guide
2. Locator
3. Locator Bracket

Fig. 9, Left-Rear Hood Guide-to-Locator Clearance (FLD 120 Conventional Highway)



A. Parallel ±3 degrees

1. Hood Guide

Fig. 10, Left-Rear Hood Guide-to-Locator Clearance (all FLD models except 120 Conventional Highway)

Hood Tilt-Assist Torsion Bar Adjustment

Adjustment

1. With the hood at about 45 degrees so there is no load on the torsion bar, screw the upper adjustment screw (**Fig. 1**, Ref. 2) in or out to adjust the force required to open the hood. Turning the screw into the pivot block increases the required opening force: turning it out decreases the force.
2. Close the hood and check the required opening force. It should be about 20 lbf (89 N) as measured at the hand hold. Make adjustment as needed.
3. When the correct opening force is obtained, lock the adjustment screw in place with the jam nut.
4. To adjust the closing force, repeat the adjustment with the lower screw. Open the hood all the way and check the required closing force. It should be adjusted to at least 40 lbf (178 N) as measured at the hand hold.

⚠ WARNING

WARNING: Do not adjust the required hood closing force to less than 40 lbf (178 N). If adjusted too low, the hood could blow closed suddenly in windy weather causing severe injury to persons working in the engine compartment.

Hood Tilt-Assist Torsion Bar Adjustment

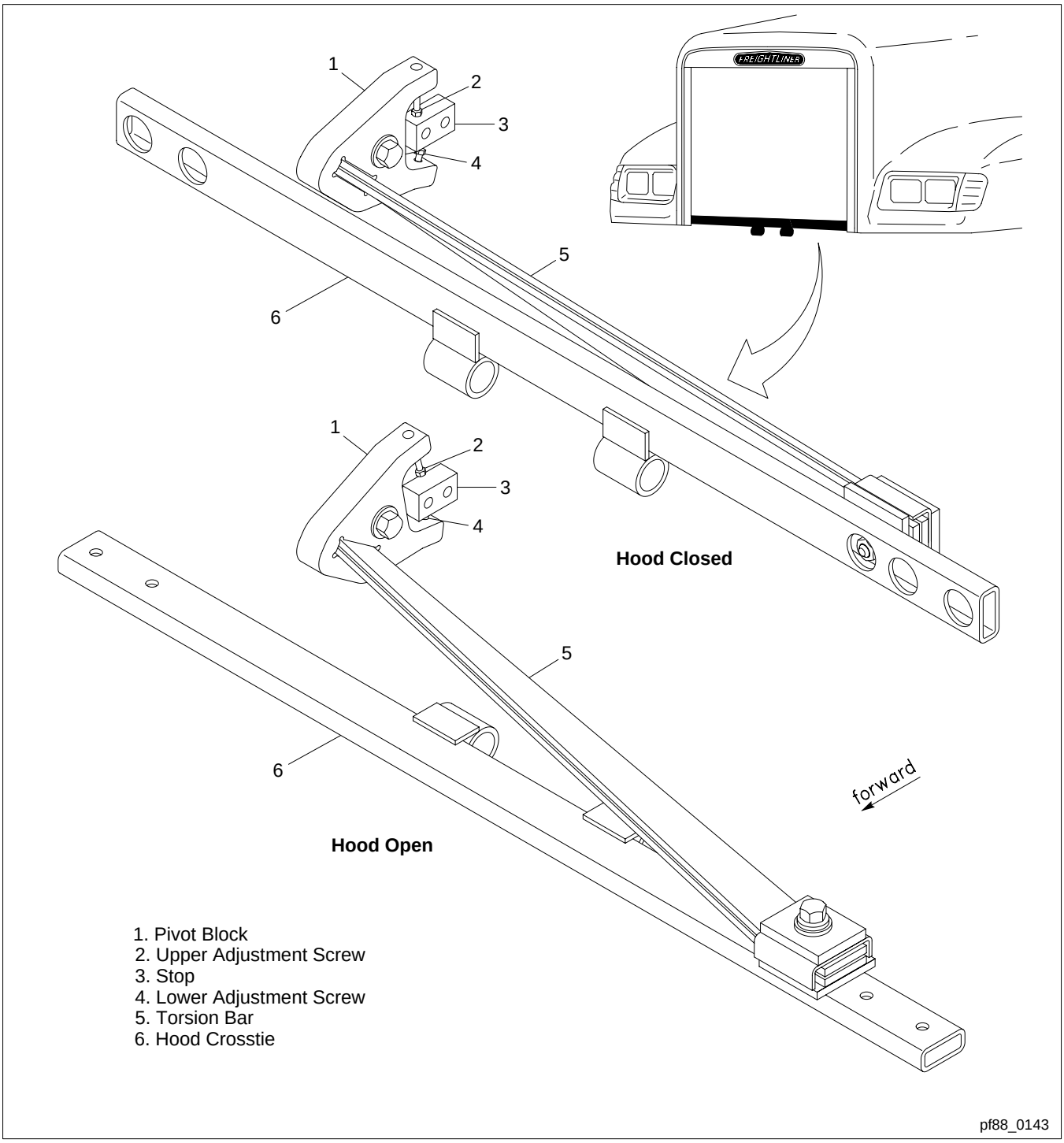


Fig. 1

Precautions

Before performing any fiberglass repairs, read the following precautions. Observe any additional precautions given by the manufacturers of the repair materials used.

1. All of the raw materials used in repairing fiberglass are harmful to the eyes and could cause blindness. Wear goggles or other protective eye shields to reduce the chances of splash contacting your eyes.
2. Wear protective gloves, as some people may have skin sensitivity to resin. Also, don't allow the hardener to contact your skin. The hardener can be a skin irritant.

IMPORTANT: In case the hardener or resin contacts your skin, wash with soap and water. If the hardener or resin should contact your eyes, rinse with plenty of water (15 minutes), and call a doctor.

3. When working with fiberglass materials, wear old clothing, since the resin may damage garment material. Wash the clothing before wearing again.
4. Most of the liquids involved in fiberglass repair and cleanup (especially when using acetone as a solvent) are flammable; some are also toxic. Don't perform repairs in areas where exposed (or stored) flammable liquids may contact an open flame or any burning material, such as a cigarette. Don't perform repairs in areas that are not well-ventilated.

⚠ WARNING

WARNING: Failure to ensure that fiberglass repairs are done in a safe workshop area could result in severe personal injury due to explosion of flammable liquids or breathing of toxic fumes.

5. Do not use electric tools when the fumes of flammable solvents are present. The heat or sparks generated by the tools could create a fire hazard.
6. When grinding or sanding fiberglass surfaces, wear goggles or other protective eye shields, and also an air purifying respirator, either a throwaway type or one with a replaceable particulate filter(s). Don't breath grinding dust or particles, otherwise irritation may occur. Also, during grinding and sanding operations, wear a disposable (paper) shop coat to keep dust and fiber slivers off your clothing.
7. Because fiberglass dust can shorten the life of electrical units, air-powered tools are preferred (for frequent use).
8. Unless fiberglass repairs are done on a regular (daily) basis, don't save leftover liquids. If liquids must be saved, store them in cool, dark areas, away from direct sunlight.

⚠ WARNING

WARNING: Catalysts, if they contact metal over extended periods of time, cause oxidation of the metal. If stored in a sealed metal container, the catalyst may cause the container to explode, which can cause severe personal injury or property damage. If catalysts must be saved, store them in a plastic container. Avoid storing catalysts in glass containers; glass will shatter, if dropped, which could result in the worker being sprayed with catalyst and glass fragments.

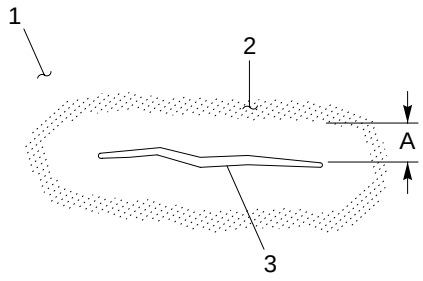
Repair Safety Precautions

Before performing any fiberglass repairs, read the precautions listed in **Subject 130**. Observe any additional precautions given by the manufacturers of the repair materials used.

Surface Damage Repair

Surface damage refers to scratches, chips, or nicks on the outer surface of the hood. Use the following instructions to repair surface damage:

1. Locate the damaged area. If there are cracks, see if they go all the way through the hood. If they do, refer to "Structural Damage Repair" for instructions.
2. Clean the area with xylene or an equivalent grease- and wax-removing solvent. Inspect the area closely.
3. Using 220-grit or finer sandpaper, remove all of the paint and the black in-mold coating layer around the damaged area to a distance of about 1-1/2 inches (4 cm). See **Fig. 1**.



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A. Remove paint and in-mold coating 1-1/2 inches (4 cm) around the damaged area. Use 220-grit or finer sandpaper.

1. Paint
2. Black In-mold Coating
3. Scratch

Fig. 1, Damaged Area With Paint and In-Mold Coating Removed

4. Using an air nozzle, blow off all dust.
5. Apply Ashland Pliogrip® 7775L self-leveling adhesive to the non-coated area and spread a thin layer using a squeegee applicator. Cover the entire damaged area, overlapping onto the painted surface. Leave a crowned excess of adhesive, slightly higher than the painted surface.

NOTE: When dispensing Ashland Pliogrip 7775L adhesive, the first few inches to come from the cartridge will be discolored; discard this adhesive. Continue to dispense the adhesive, producing a continuous bead of uniform size and uniform green color.

6. After the adhesive dries (about 50 minutes), sand it with a hand-held disc pad. Use 320-grit or finer sandpaper. Feather the edges of the fill so there are no visible sharp edges.
7. Clean the area with compressed air. Mask the area, then spot prime and paint it. Use Sherwin Williams BB–11 black conductive primer. See **Group 98** for spot-painting instructions.

Structural Damage Repair

The SMC (sheet molded compound) hood consists of several parts, including fenders, hood, and inner reinforcements, which are bonded together with a structural adhesive and rivets. See **Fig. 2** and **Fig. 3**. If the hood is damaged, determine which parts are affected.

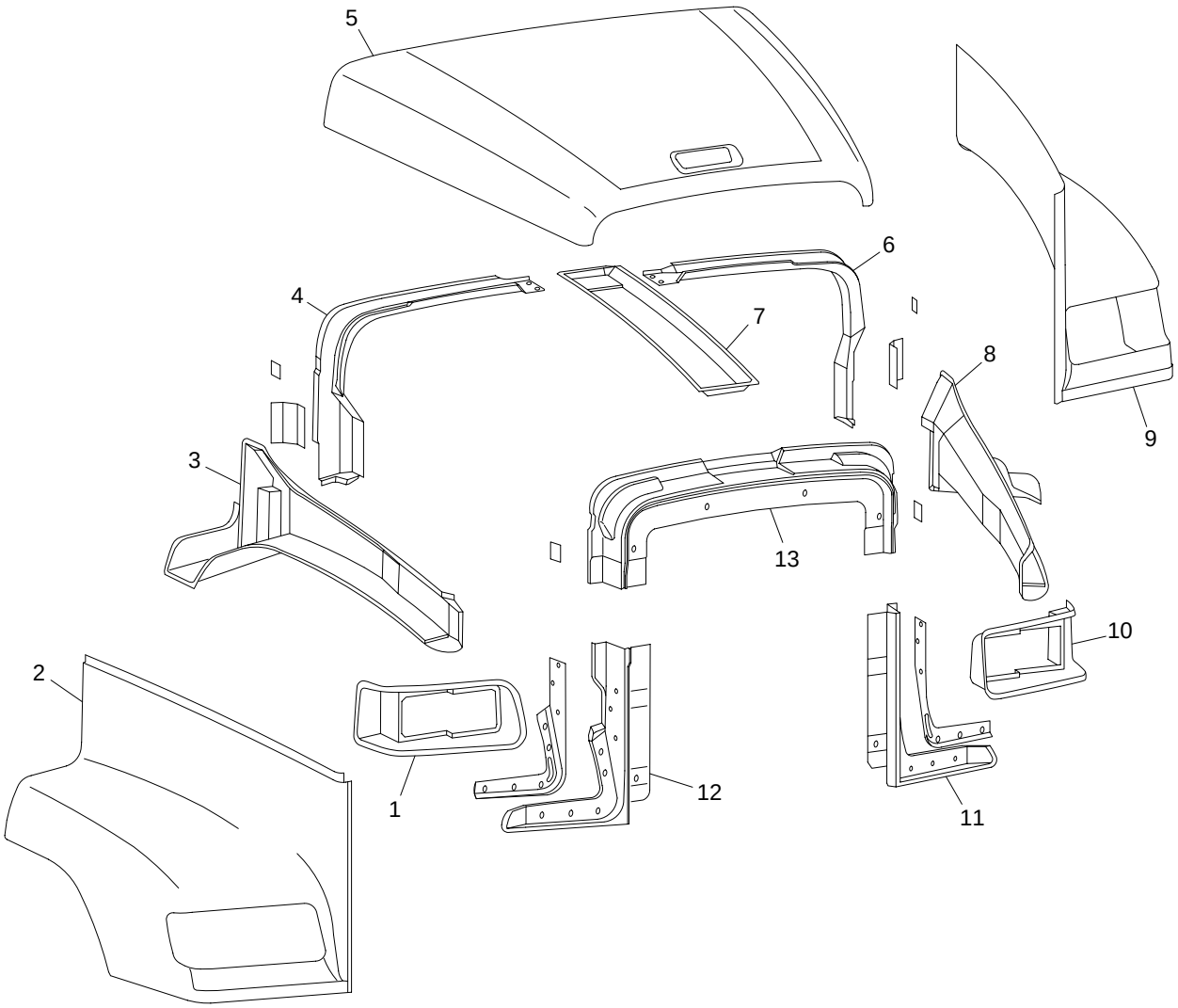
If there is damage at any joint between two parts, the damage is not repairable. For example, if a fender is damaged to the extent that the reinforcements bonded inside the fender are also damaged, replace the entire hood assembly.

If a joint between two parts has separated and there is no damage at the joint area, the parts can be rebonded. Or, if a part is damaged and its adjoining parts are not damaged, the damaged part can be separated from the hood and new or used parts can be bonded in place. A section of a part can be replaced as long as the section does not include a joint between two parts. Fenders and headlight reinforcements are available as replacement parts or for use in section replacements. If the damage is such that the parts cannot be replaced, or a section replacement cannot be done, replace the entire hood assembly.

For damage in the form of a small crack or hole, see "Crack or Small Hole Repair."

For larger damaged areas, see "Section Replacement (Repair of Punctures and Large Fractures)."

Repair of SMC Hoods



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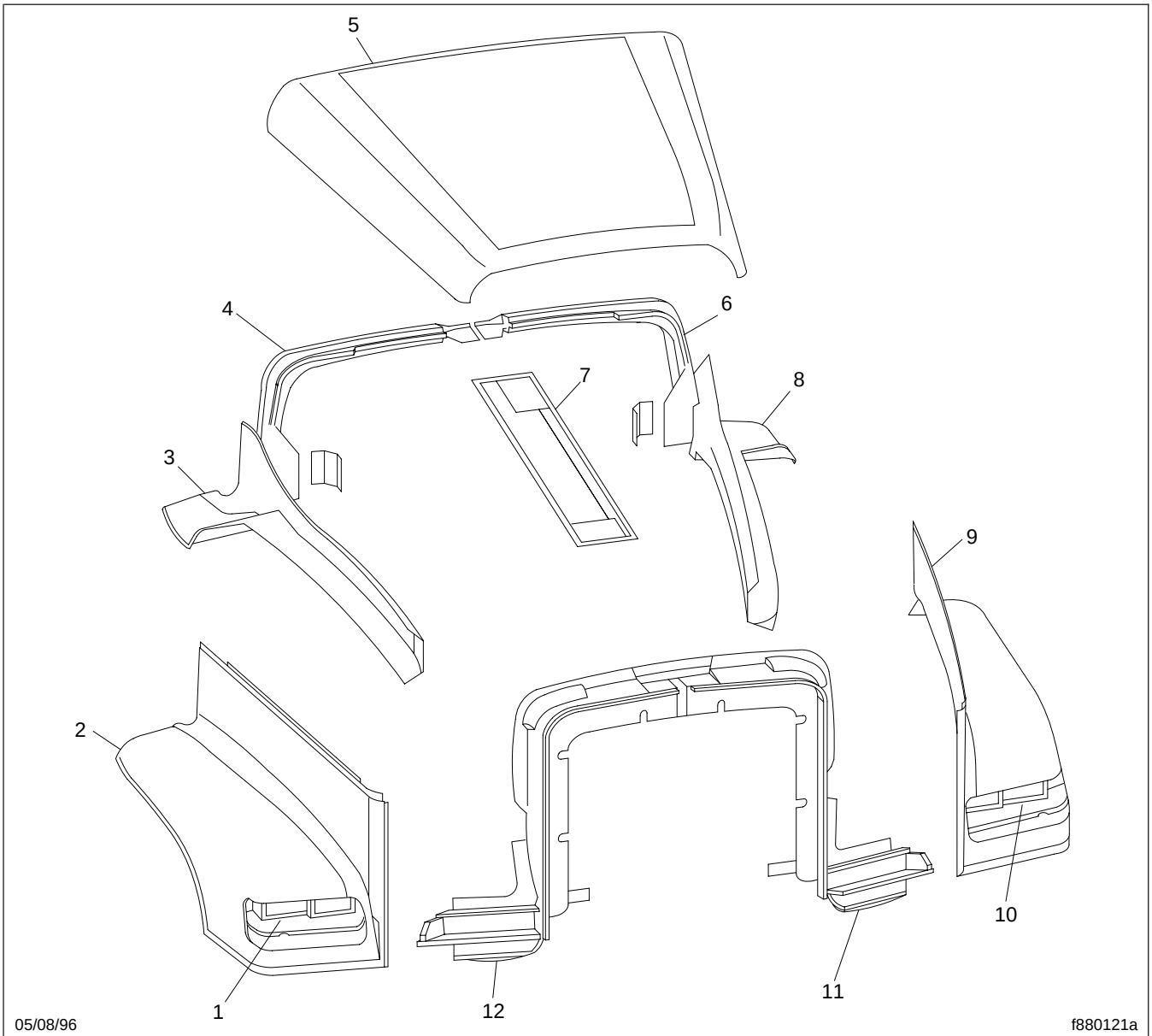
NOTE: This figure is intended to provide only the general shape and arrangement of major hood components; additional parts exist. Also, variations exist for some parts according to headlight style, etc. See the Freightliner Service Parts Catalog for detailed information.

1. Right Headlight Bucket
2. Right Fender
3. Right Side Reinforcement
4. Right Rear Reinforcement
5. Hood Top
6. Left Rear Reinforcement
7. Center Reinforcement
8. Left Side Reinforcement
9. Left Fender
10. Left Headlight Bucket
11. Left Front Reinforcement
12. Right Front Reinforcement
13. Top Front Reinforcement

Fig. 2, Hood Assembly Components, FLD 112

For replacing or rebonding parts, see "Hood Component Rebonding."



NOTE: This figure is intended to provide only the general shape and arrangement of major hood components; additional parts exist. Also, variations exist for some parts according to headlight style, etc. See the Freightliner Service Parts Catalog for detailed information.

1. Right Headlight Bucket
2. Right Fender
3. Right Side Reinforcement
4. Right Rear Reinforcement
5. Hood Top
6. Left Rear Reinforcement
7. Center Reinforcement
8. Left Side Reinforcement
9. Left Fender
10. Left Headlight Bucket
11. Left Front Reinforcement
12. Right Front Reinforcement

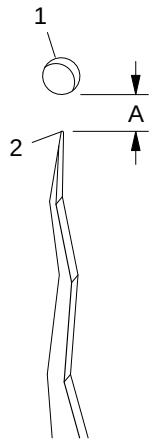
Fig. 3, Hood Assembly Components, FLD 120

Repair of SMC Hoods

CRACK OR SMALL HOLE REPAIR

A crack (fracture) or small hole through the laminate requires repair with a fiberglass-reinforced patch.

1. Examine the damage to the hood. Apply hand pressure all around the damaged area to check for any concealed damage.
2. If a sound-absorbent liner is present on the underside of the damaged area, remove the panel(s) to provide an adequate working area.
3. Clean the area with xylene, acetone, or an equivalent grease- and wax-removing solvent. Inspect the area closely. All dirt, water, grease, and oils must be removed.
4. If repairing a crack, use a 1/8-inch diameter bit to drill a hole completely through the uncracked laminate 1/8 inch (3 mm) from each end of the crack, to prevent the crack from lengthening. See **Fig. 4**.



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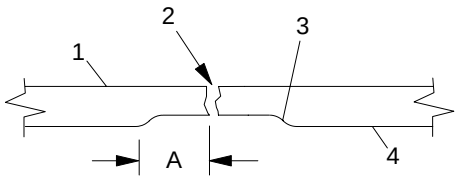
A. 1/8 inch (3 mm)

1. Drilled 1/8-inch (3-mm) Hole
2. End of Crack

Fig. 4, Stopping a Crack

5. On the engine side of the hood, use a router bit (on a grinder or a drill) to grind away a shallow recess one-quarter the depth of the laminate and extending 1/2 inch (13 mm) outward from all sides of the damage. Taper the outside edge of the ground area. See **Fig. 5**.

If repairing a crack, grind outward to the drilled hole at the end of the crack, but not beyond. See **Fig. 6**, Ref. A.

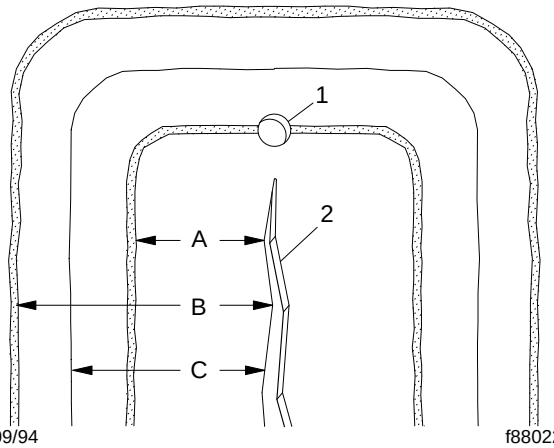


05/04/94 f880227b

A. Grind a shallow recess one-quarter the depth of the laminate and extending 1/2 inch (13 mm) outward in all directions from the damaged area.

1. Laminate
2. Crack
3. Slight Taper
4. Engine Side of Hood (or underside of half-fender)

Fig. 5, Recessed Area (cross-sectional view)



02/09/94 f880223a

A. Use a router to grind away a shallow recess one-quarter the depth of the laminate and extending 1/2 inch (13 mm) outward from the damage. If repairing a crack; don't grind past the hole drilled at the end of the crack.
B. Use 80- to 220-grit sandpaper to scuff the area one inch (25 mm) around the damage.
C. Cut the fiberglass cloth to fully cover the damage, and overlay about 3/4 inch (19 mm).

1. Hole
2. Crack

Fig. 6, Preparing the Damaged Area on the Engine Side of the Hood

6. Use 80- to 220-grit sandpaper to scuff an area at least 1 inch (25 mm) away from the fracture on all sides. Be sure to scuff thoroughly, since this will give the patch a surface to which it can stick. See **Fig. 6**, Ref. B.
7. Blow the dust away with compressed air and wipe the area with a clean cloth.
8. If necessary, align the panel sections on both sides of the crack, using weights or clamps to re-establish the original panel profile.
9. With a razor-blade knife, cut a section of woven fiberglass cloth to fully cover the crack and to overlay about 3/4 inch (19 mm). See **Fig. 6**, Ref. C.
10. To bond the fiberglass cloth to the damaged panel, use Ashland Pliogrip 7775L urethane adhesive.

NOTE: When dispensing Ashland Pliogrip 7775L adhesive, the first few inches to come from the cartridge will be discolored; discard this adhesive. Continue to dispense the adhesive, producing a continuous bead of uniform size and uniform green color.

11. Use a plastic or metal device to spread a thin layer of the adhesive over the scuffed area.
12. Lay the cut section of fiberglass cloth on the repair area, centered over the damage. Using a fiberglass roller, press the cloth down firmly into the layer of adhesive to completely immerse the glass fibers.
13. Apply another layer of adhesive over the glass cloth. Spread the adhesive evenly using the fiberglass roller.
14. After 2 to 5 minutes, the adhesive will start to jell. It may take more time when cool, less when warm.

IMPORTANT: To avoid pre-jelling or skin-over, mate the SMC parts to be bonded within 1 to 4 minutes after extruding and applying the adhesive.

NOTE: To get a smoother surface, press a piece of masking tape, wider than the repair, directly over the wet adhesive and smooth it before it hardens. The tape can be removed after 5 minutes when the adhesive has set.

15. The patch should be hard enough in 50 minutes to allow sanding to a smooth flat surface if required.
16. Repair the damage on the outside surface of the panel and paint the surface on both sides, using the instructions in "Surface Damage Repair."

PUNCTURE AND LARGE FRACTURE REPAIR (SECTION REPLACEMENT)

On very large damaged areas (for example, structural damage on the side surface of the hood covering an area of a square foot or more) it may be easier to do a section replacement rather than make a patch. Fenders and headlight reinforcements may be used in section replacements. Also, a second damaged hood with the needed section intact may be available as scrap.

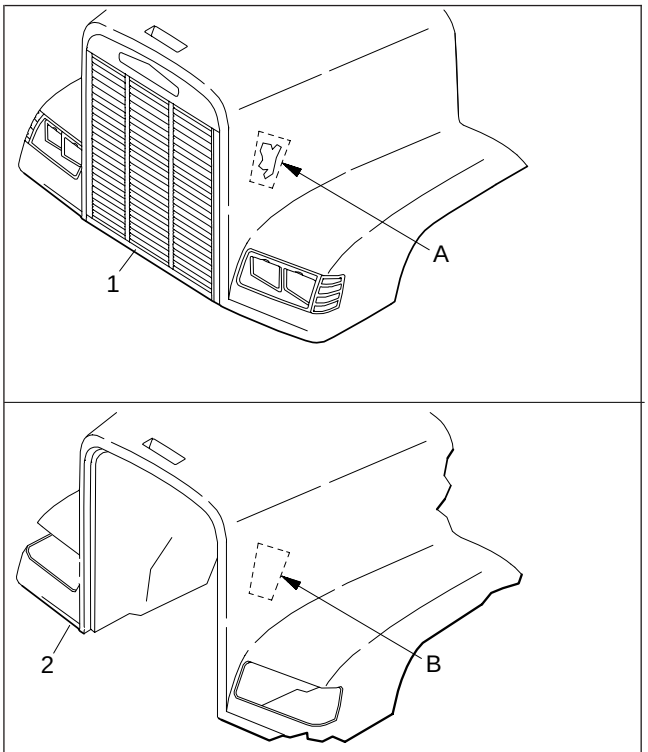
IMPORTANT: A piece of SMC laminate from a hood must be used for section replacement. Use of any other material may not allow the necessary bonding for the repair.

1. Push in on the area immediately surrounding and underneath the damaged area to determine the extent of damage.
2. If a sound-absorbent liner is present on the underside of the damaged area, remove the panel(s) to provide an adequate working area.
3. Clean the area with xylene, acetone, or an equivalent grease- and wax-removing solvent. Inspect the area closely. All dirt, water, grease, and oils must be removed.
4. Using a saber saw, cut out a large, straight-sided panel containing the damaged area. See **Fig. 7**, Ref. A. If the damage extends to a joint where the part is bonded to another, first separate the bonded portion of the damaged section with a heat gun and putty knife before cutting.

⚠ WARNING

WARNING: Wear goggles and an air purifying respirator when grinding, cutting, or sanding during all fiberglass repairs. The ground dust and particles could cause temporary or permanent damage to your eyes and, if inhaled, could cause throat or lung irritation.

Repair of SMC Hoods



A. Remove this area.
B. Use as a section replacement for damaged hood.

1. Damaged Hood
2. Scrap Hood

Fig. 7, Section Replacement of a Damaged Fiberglass Hood

5. From the scrap hood or new part, cut a section replacement panel from the same area, only slightly larger than the original cutout. See **Fig. 7**, Ref. B. Then, trim the section replacement to fit both the size and contour of the original cutout.

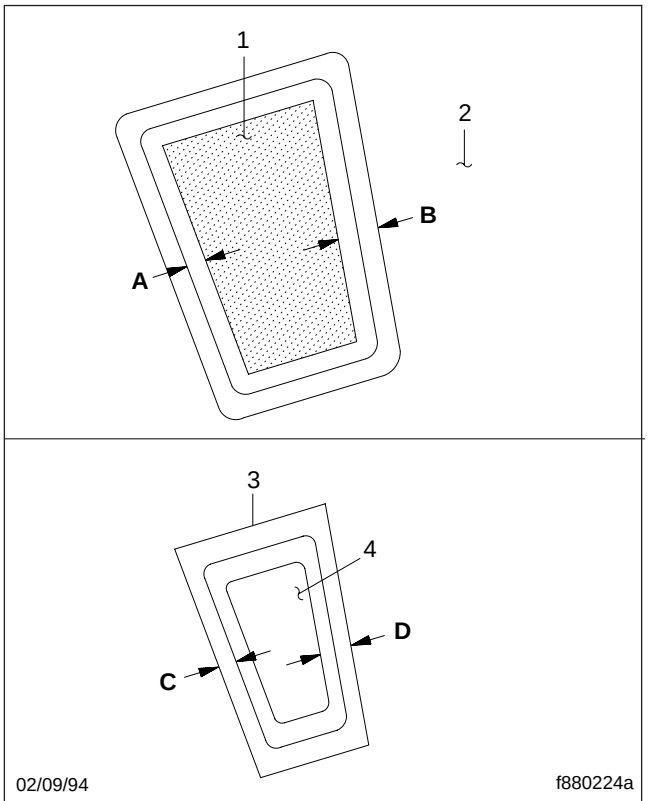
   If the damage is next to the headlight reinforcement, but not including the reinforcement, remove the headlight reinforcement from the replacement section, not the hood.

6. After the trimming is completed, sand the edges to allow a 1/16- to 1/8-inch (about 2- to 3-mm) gap around the cutout.

7. On the engine side of the hood, use a router bit (on a grinder or drill) to grind away a shallow recess one-quarter the depth of the laminate and extending 1/2 inch (13 mm) outward from all sides of the cutout area. See **Fig. 8**, Ref. A.

   Also, grind 1/2 inch (13 mm) inward from all edges on the engine side of the section replacement. See **Fig. 8**, Ref. C.

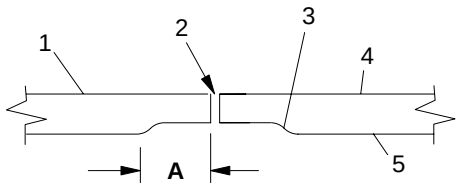
   Slightly taper the outside edge of the ground area on the hood and the inside edge of the ground area on the section replacement. See **Fig. 9**, Ref. 3.



A and C: Use a router to grind away a shallow recess one-quarter the depth of the laminate and extending 1/2 inch (13 mm) away from the edge.
B and D: Use 80- to 220-grit sandpaper to scuff the area one inch (25 mm) around the damage.

1. Cutout Hole
2. Engine Side of Hood
3. Section Replacement
4. Engine Side of Section Replacement

Fig. 8, Preparing the Section Replacement and Hood Cutout on the Unexposed Side



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A. Grind a shallow recess one-quarter the depth of the laminate and extending 1/2 inch (13 mm) outward in all directions from the damaged area.

1. Section Replacement
2. Gap
3. Slight Taper
4. Hood Laminate
5. Engine Side of Hood

Fig. 9, Cutout Area (cross-sectional view)

8. Use 80- to 220-grit sandpaper to scuff an area at least 1 inch (25 mm) out from all sides of the cutout area. See **Fig. 8**, Ref. B.

   Also scuff at least 1 inch (25 mm) in from all sides of the section replacement. See **Fig. 8**, Ref. D.

   Scuff thoroughly, since this will give the section replacement a surface to which it can stick. Be sure to completely sand off any undercoating sprayed on these areas.

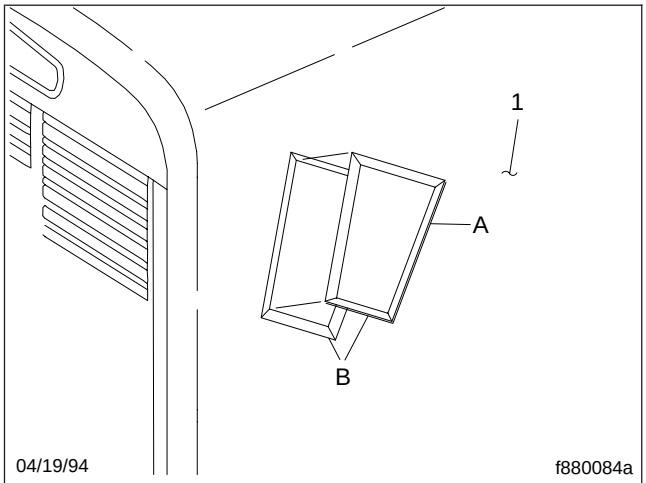
9. On the outer sides of both the cutout and the section replacement, bevel the edges about 45 degrees. See **Fig. 10**.

10. Gently feather the outer painted surfaces back about 1/2 inch (13 mm) beyond the edges of the repair areas (on both the cutout and the section replacement), using 220-grit or finer sandpaper.

11. Blow the dust away with compressed air and wipe the area with a clean cloth.

12. If the section replacement is close enough to an edge, use clamps to temporarily secure it during the repair. If the replacement is too far from an edge to use clamps, use bond strips. See **Fig. 11**.

    12.1 Cut some scrap SMC into strips. Make enough strips to hold the section replacement in position, about one every six inches (15 cm). If the surface of the replacement panel is contoured or curved, use many small bond strips. Larger strips could deform the curves.



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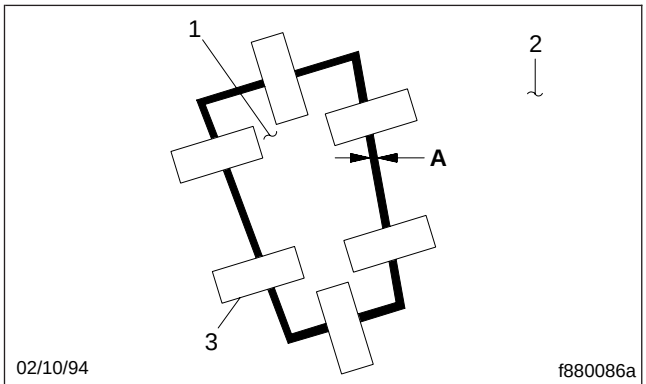
A. Insert section replacement.
B. Bevel outer surface edges on all sides.

1. Exposed Side of Hood

Fig. 10, Areas to be Beveled



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A. Gap of 1/16 inch to 1/8 inch (2 to 3 mm)

1. Section Replacement
2. Engine Side of Hood
3. Bond Strip

Fig. 11, Securing the Section Replacement to the Hood Using Bond Strips

12.2 On the engine side of the repair, use 80- to 220-grit sandpaper to scuff sand the areas on the hood and section replacement panels where you plan to bond the strips.

12.3 If a joint between parts was separated for the repair, rebond the joint. See "Hood Component Rebonding" for instructions.

Repair of SMC Hoods

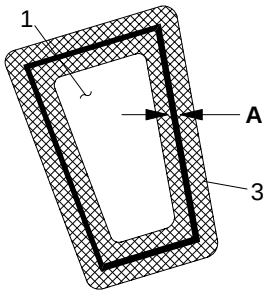
12.4 Holding the section replacement in position, bond the strips to the hood and replacement panels in the area already scuffed. Use Ashland Pliogrip 7773 urethane adhesive to bond the strips.

NOTE: When dispensing Ashland Pliogrip 7773 adhesive, the first few inches to come from the cartridge will be discolored; discard this adhesive. Continue to dispense the adhesive, producing a continuous bead of uniform size and uniform green color.

12.5 After the adhesive has hardened, use 80- to 220-grit sandpaper to scuff the bond strips.

12.6 Blow the dust away with compressed air and wipe the area with a clean cloth.

13. With a razor-blade knife, cut sections of woven fiberglass cloth to fully cover the gap between the cutout and the section replacement, all the way around the damaged area. The cloth should overlay about 3/4 inch (19 mm) on both sides of the gap. See **Fig. 12**.



NOTE: The fiberglass cloth should overlay about 3/4 inch (19 mm) on both sides of the gap.

A. Gap of 1/16 inch to 1/8 inch (2 to 3 mm)

1. Section Replacement
2. Engine Side of Hood
3. Fiberglass Cloth

Fig. 12, Fiberglass Cloth Placement

14. To bond the fiberglass cloth to the damaged panel, use Ashland Pliogrip 7775L urethane adhesive.

NOTE: When dispensing Ashland Pliogrip 7775L adhesive, the first few inches to come from the cartridge will be discolored; discard this adhesive. Continue to dispense the adhesive, producing a continuous bead of uniform size and uniform green color.

15. Use a plastic or metal device to spread a thin layer of the adhesive over the scuffed area.

16. Lay the cut sections of fiberglass cloth on the repair area, centered over the damage. Using a fiberglass roller, press the cloth down firmly into the layer of adhesive to completely immerse the glass fibers.

17. Apply another layer of adhesive over the glass cloth. Spread the adhesive evenly using the fiberglass roller.

18. After 2 to 5 minutes, the adhesive will start to jell. It may take more time when cool, less when warm.

IMPORTANT: To avoid pre-jelling or skin-over, the SMC parts to be bonded should be mated within 1 to 4 minutes after the adhesive is dispensed.

19. After the adhesive has hardened, sand the unexposed side of the repair area to a smooth flat surface, if desired.

20. Repair the damage on the outside surface of the hood and paint the surface on both sides, using the instructions in "Surface Damage Repair."

NOTE: To get a smoother surface, press a piece of masking tape, wider than the repair, directly over the wet adhesive and smooth it before it hardens. The tape can be removed after 5 minutes when the adhesive has set.

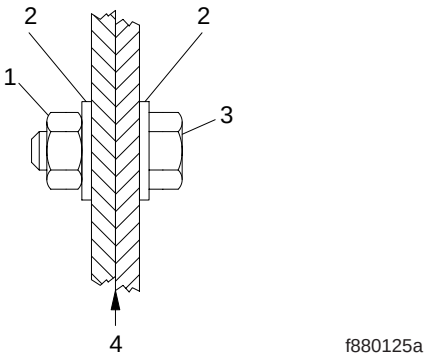
HOOD COMPONENT REBONDING

1. If rebonding a joint that has separated, or if replacing a damaged part, completely separate each part, using a heat gun and putty knife. Remove as much of the old adhesive as possible. The heat gun will soften the adhesive and allow it to be peeled off the SMC.

   If the parts cannot be separated, work folded medium-grit sandpaper or a section of a steel hacksaw blade between the two surfaces to remove the old adhesive.

2. Scuff the surfaces with 80- to 220-grit sandpaper.

3. Clean the surfaces to be bonded with Ashland 6036 primer or methylene chloride. Inspect the area closely to be sure all of the old adhesive, dirt, water, grease, and oils are removed.
4. If replacing a large part, such as a fender, align the part on the hood and clamp it in place. Drill holes through the bonding surfaces and install clamping bolts in the holes. Use two washers, one on each side of the joint. See **Fig. 13**. There should be enough clamping bolts to hold the hood in place and keep the bonding surfaces together, or at least one bolt every 12 to 18 inches (30 to 45 cm). Remove the part for application of adhesive.



1. Nut
2. Washers
3. Bolt
4. Bond Joint

Fig. 13, Clamping Bolt at Bond Joint

5. Using the manufacturer's instructions, mix enough adhesive to bond the parts together. Use Ashland Pliogrip urethane adhesive 7773 or 7779.

NOTE: When using Ashland Pliogrip 7773 or 7779, insert the 2 tubes of adhesive into the applicator and dispense a 3/8-inch (10 mm) diameter bead of uniform green-colored adhesive at the bonding surface. Discard any adhesive that does not show this uniform green color.

6. Within 3-1/2 minutes of applying the bead of 7773 (10 minutes for 7779), align the part on the hood and clamp it firmly in place. If it is a large part (fender), install the clamping bolts. Tighten the clamps or clamping bolts just enough to ensure that a uniform amount of pressure is applied along the seam. Ideally, the adhesive should be compressed to form a bondline one inch (25 mm) wide and 0.030 inch (0.76 mm) thick. This thickness can be ensured by sprinkling 0.030 inch glass beads into the adhesive before mating the parts.
7. Before it cures, remove any excess adhesive that squeezes out the edges of the bond.
8. Remove clamping bolts after the adhesive has cured; allow 30 minutes for 7773, 60 minutes for 7779.
9. If holes were drilled for clamping bolts, repair them using the instructions under "Crack or Small Hole Repair."
10. If necessary, prime and paint the repair area using the instructions under "Surface Damage Repair."

Repair of Spray-Up Hoods

General Preparation

The materials used in fiberglass spray-up hoods are a combination of glass filaments, resin (the binder), catalysts (to initiate the cure), and weather resistance additives. The filaments of pure glass provide strength, dimensional stability, and heat resistance to the structure. The resin is a liquid plastic that hardens when combined with another substance, the catalyst. The resin acts as a binder to hold the filaments together; it supplies only a limited additional amount of strength to the structure.

Fiberglass repairs should be performed in a workshop that is well-ventilated, free of flame, burning materials, and sparks, and one that is relatively warm and dry, away from direct sunlight.

With most resins, the air temperature in the workshop should be 60° to 80°F (16° to 27°C), and the humidity should be 70 percent or lower. At higher temperatures, the curing time is considerably reduced, which can restrict the worker. At cooler temperatures, curing time is prolonged. High humidity may result in moisture being absorbed in the resin, which may inhibit curing and leave the surface tacky.

The practice of over-catalyzing the resin in order to "speed up" the cure if workshop temperatures are below 60°F (16°C) is not recommended. In many cases, if more catalyst than the usual two to three percent ratio is added to the resin, curing will not take place. Always follow the resin manufacturer's specifications when adding the catalyst to the resin. If in doubt, under-catalyze; applying heat later from a heat lamp or heat gun will cause the under-catalyzed resin to "kick," and eventually to harden.

It is important to note that the cure of a thermoset proceeds in two distinct stages. The first stage is the formation of a soft gel. Up to the formation of the gel, the fiberglass/resin mixture is pliant and can be molded to a desired shape. Under typical (warm) conditions of 77°F (25°C) air temperature, and a resin mixture of one percent catalyst), the gel-time is about 15 to 20 minutes.

Immediately after gelation, the cure proceeds rapidly with the evolution of heat, up to an exothermic peak. Under the same typical (warm) conditions, the peak exotherm, or the point at which the cure is hottest, will occur after 26 minutes. During this second stage of the thermoset, the repair mixture is not pliant and cannot be shaped or cut with scissors.

Fiberglass repair kits can be purchased from many sources. Among them are automotive or truck parts outlets, body shops, boat marinas, plastics distributors, and various department stores. In all cases, the mixing instructions on the particular fiberglass repair kit should be followed closely, especially when adding catalyst to the resin.

Because most of the liquids involved in fiberglass repair are flammable, it is recommended that a repair kit large enough to accommodate only one or two jobs be purchased in order to avoid storing any quantity of these materials.

Refer to **Specifications, 400** for a general list of tools and materials needed for repairing damaged fiberglass hoods.

Surface Damage Repair

Surface damage refers to minor scratches or gouges which affect the appearance of the fiberglass, but penetrate through the paint and only slightly into the laminate itself.

For a list of tools and materials needed for repairs, refer to **Specifications, 400**.

1. As precautions, chock the vehicle tires to prevent accidental rolling, and apply the parking brakes.
2. Push on the area immediately around the damaged area to ensure that there is no structural damage. There should be no weakness or "give." If the area can be pushed in or made to look dented, structural damage exists. Proceed to the applicable heading in this section for repair instructions.
3. Check the shop temperature and humidity, and compare with the recommendations given on the resin/body filler can labels. Generally, 70°F (21°C) and 70% humidity are considered ideal.
4. Gather the required materials.
5. Clean the entire repair area with xylene or an equivalent grease and wax remover.
6. Form (rout) a V-groove for the length of the scratch or gouge using a burr bit or a sanding sleeve on a power drill. **See Fig. 1.** Do not cut through the laminate.

Repair of Spray-Up Hoods

WARNING

WARNING: Wear goggles and an air purifying respirator when grinding, cutting, or sanding during all fiberglass repairs. The ground dust and particles could cause temporary or permanent damage to your eyes and, if inhaled, could cause throat or lung irritation.

7. Remove the flaky edges, and gently feather the painted surface back about 1/2 inch (13 mm) beyond the damaged area by hand-sanding or power-sanding with 360-grit (or higher) sandpaper. Avoid causing any sudden steps or uneven protrusions in the area.
8. Clean the area using compressed air. Then, wipe with a solvent-dampened cloth. Allow the surface to completely dry.
9. Mask off the undamaged surfaces, leaving a working area of about 5 inches (12.5 cm) surrounding the repair area.
10. Following the resin/body filler manufacturer's instructions, mix enough body filler to re-establish the surface. **See Fig. 2.**

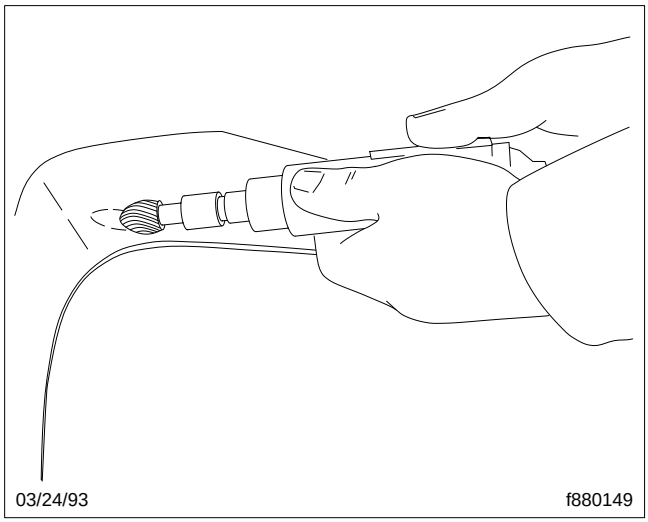


Fig. 1, V-Groove Formation

IMPORTANT: Mix the body filler on a hard, nonporous surface. Do not work on a porous surface, such as cardboard. Porous surfaces absorb the body filler liquids, which can adversely affect the final curing time and bond.

11. Apply and spread the body filler with a rubber or plastic "squeegee" (or similar wooden spreader) making sure to remove all air bubbles. **See Fig. 3.** The filler should extend above the surface to allow for shrinkage.

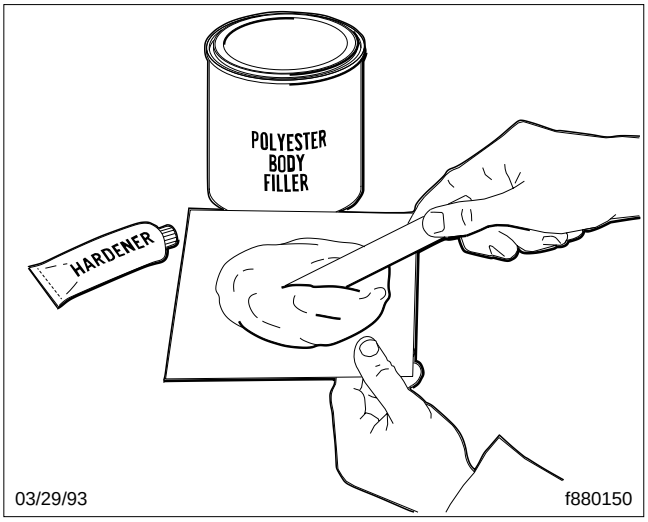


Fig. 2, Mixing Body Filler

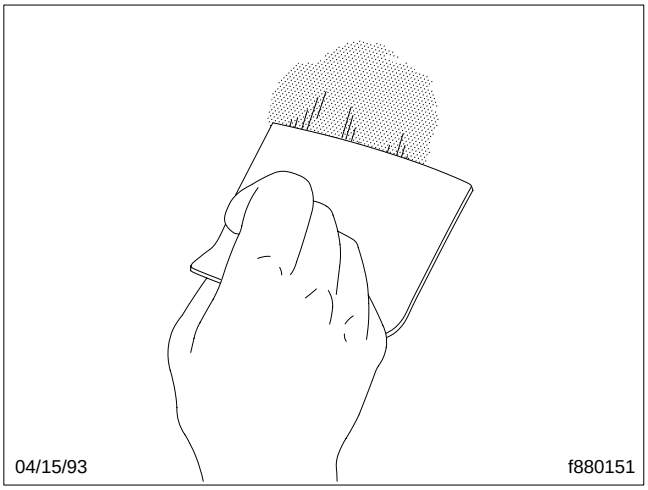


Fig. 3, Applying Body Filler With a Plastic Squeegee

IMPORTANT: Make sure that no air is trapped in the repair area. When heat is later applied to shrink the body filler, the trapped air will expand and could cause the repair area to blister.

12. Allow time for the body filler to set until it is firm to the touch. Then, re-establish the original contour or surface by filing off the excess filler.

See Fig. 4. The remaining filler level should be slightly lower than that of the original surface.

13. Pre-shrink the body filler, using a heat gun or an infrared heat lamp. **See Fig. 5.** Generally, a minimum temperature of 120°F (49°C) is required for shrinkage.

⚠ CAUTION

CAUTION: Allow at least 12 inches (30.5 cm) of clearance between the heat source and the repair surface. Do not exceed the maximum temperature required for shrinkage, as recommended by the body filler manufacturer.

14. Apply a non-shrinking sealer to the body filler. Sherwin Williams Sprayfil D61A23, or an equivalent, is recommended.
15. After the surface has cured, finish by sanding with a sanding block and 360-grit (or higher) sandpaper.

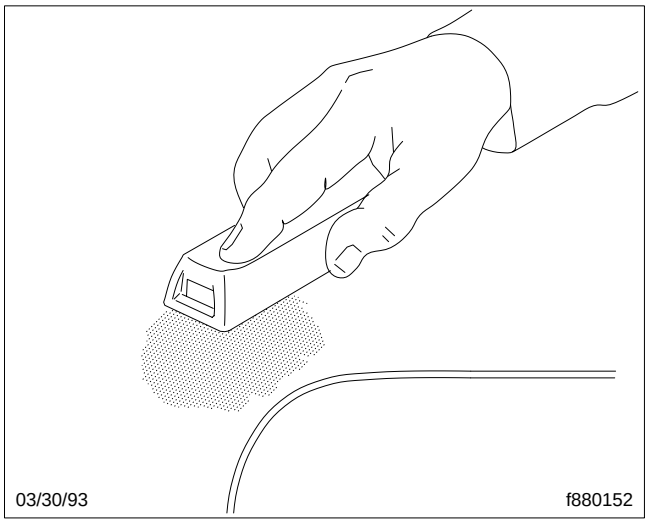


Fig. 4, Filling Off Excess Body Filler

IMPORTANT: Do not use the palm of the hand as a sanding backer (as opposed to using a hard sanding block), which only accentuates dips and hollows instead of removing them.

16. Complete the repair by cleaning the area with compressed air. **See Fig. 6.** Remask, if necessary, then spot prime and paint the repair area.
17. Remove the chocks from the tires.

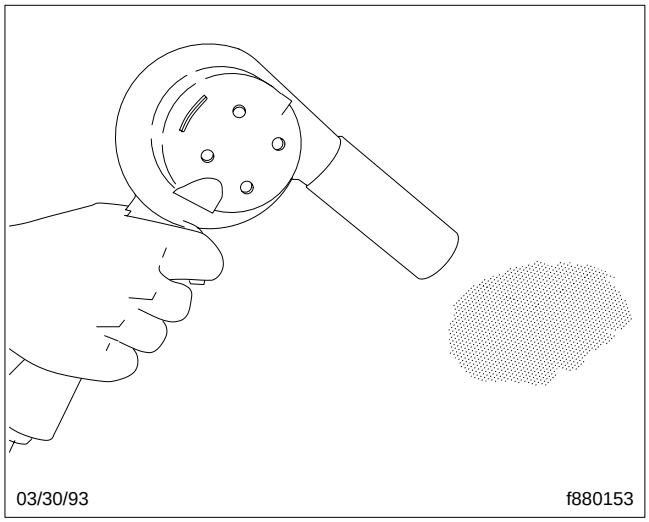


Fig. 5, Pre-Shrinking the Body Filler Using a Heat Gun

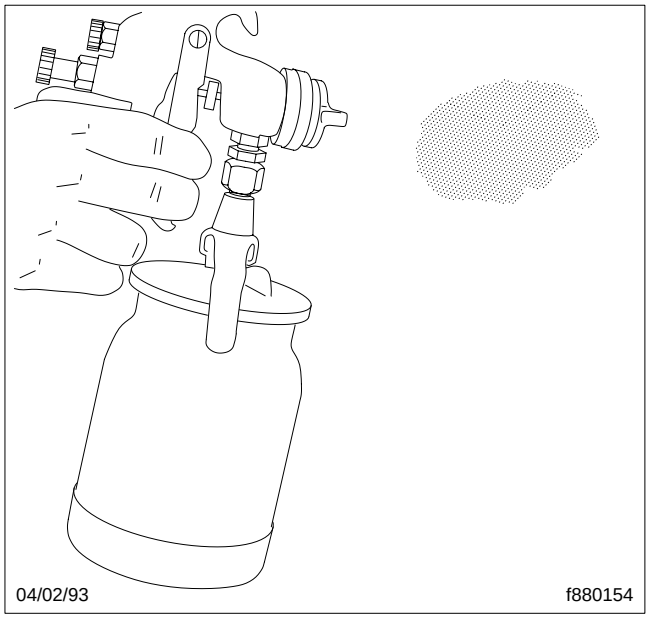


Fig. 6, Cleaning the Repair Area With Compressed Air

Repair of Spray-Up Hoods

Structural Damage Repair (Including Cracks, Punctures, and Fractures)

STRUCTURAL DAMAGE GENERAL

Structural damage refers to any type of damage that penetrates through the laminate, thus affecting the structural soundness of the damaged part, from hairline cracks to large fractures or punctures.

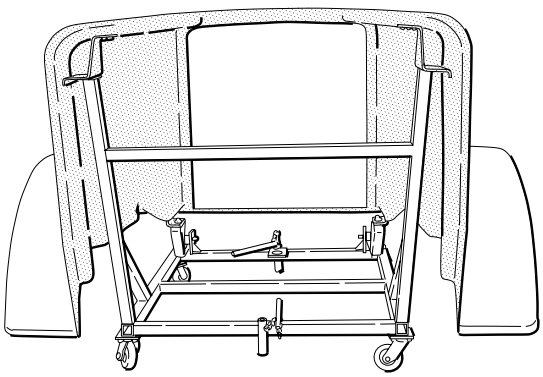
NOTE: If the damage is severe and requires that the hood be removed from the vehicle, refer to **Subject 100** for instructions. Whenever the hood is removed from the vehicle, it should be placed on a support frame, similar to that **shown in Fig. 7**.

If repairs are to be made with the hood attached to the vehicle, the vehicle tires should be chocked to prevent accidental rolling, and the parking brakes should be engaged. The vehicle should be on level ground.

For a list of tools and materials needed for repairs, refer to **Specifications, 400**.

REPAIR OF CRACKS **(See Fig. 8)**

1. Using a detergent and water solution, remove the surface dirt from around the damaged area. Then, clean the area with xylene or an equivalent grease and wax remover.
2. Check the shop temperature and humidity, and compare with the recommendations given on the resin/body filler can labels. Generally, 70°F (21°C) and 70% humidity are considered ideal.
3. If sound-absorbent lining is present on the underside of the damaged area, remove enough lining to provide an adequate working area, or about 5 inches (12.5 cm) on all sides of the damage. Push on the area immediately surrounding and underneath the crack to determine the extent of structural damage (damaged areas often show up better on the underside of the laminate).
4. Gather the required materials.
5. Mask off the undamaged surface, leaving a working area on the outer finished surface of about 5 inches (12.5 cm) surrounding the crack.



NOTE: 120 Conventional hood shown.

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Fig. 7, Fiberglass Hood Placed on a Support Frame

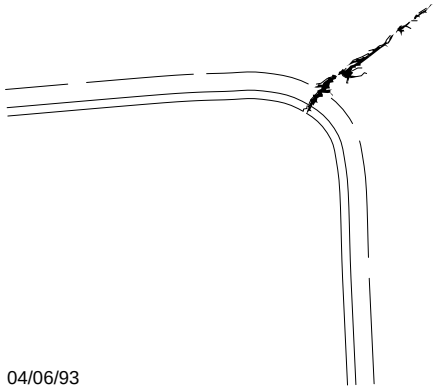

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Fig. 8, Cracked Fiberglass Panel

6. Working on the outer finished surface, and using a grinder with a burr bit or sanding sleeve, taper the edges of the crack at an angle of no more than 45 degrees. **See Fig. 9.**

⚠ WARNING

WARNING: Wear goggles and an air purifying respirator when grinding, cutting, or sanding during all fiberglass repairs. The ground dust and particles could cause temporary or permanent damage to your eyes and, if inhaled, could cause throat or lung irritation.

7. Remove the flaky edges and gently feather the painted surface back about 1/2 inch (13 mm) beyond the damaged area by hand-sanding or power-sanding with 360-grit (or higher) sandpa-

per. Avoid causing any sudden steps or uneven protrusions in the area.

8. Sand the inside unfinished surface around the repair area with 60-grit (or less) sandpaper to create a rough bonding surface about 3 inches (7.5 cm) from the center of the crack. Be sure to completely sand off any undercoating sprayed on this area.
9. Clean the sanded areas using compressed air. Then, wipe with a solvent-dampened cloth. Allow the surfaces to completely dry.
10. If the panel is out of alignment, realign it using C-clamps or equivalent devices, and a bridge strip of metal, hardwood, or plastic. An example of this alignment method is **shown in Fig. 10**.

    An alternate method of aligning the parts is to use a nut and bolt and two flatwashers. **See Fig. 11.** As the nut is tightened, the parts are drawn into alignment.

    In order to install the bolt, a hole must be drilled which will allow the bolt to pass through the seam. If more than one bolt is required, they should be spaced about every 6 inches (15 cm).

IMPORTANT: When installing the nut and bolt, it is important that the nut be located on the underside of the panel, where it will remain as a part of the repair. Use a bolt that is short enough not to protrude through the nut. Do not tighten the nut(s) more than is necessary to align the sections.

11. Beginning with 1.5 ounce fiberglass mat, cut out a patch (strip) that will extend about 2 inches (5 cm) on all sides of the crack. Then, cut out a patch of 18 ounce fiberglass woven roving that is slightly larger than the first patch.

    Cut out subsequent patches (alternating mat and woven roving layers) so that each is slightly larger than the last. **See Fig. 12.** The combined thickness of the fiberglass patches should be about 25 to 30 percent thicker than the original laminate.
12. Make sure that all tools necessary for fiberglass lay-up are at hand. Then, following the resin manufacturer's instructions, mix enough resin and catalyst to saturate the pieces of fiberglass mat and woven roving.

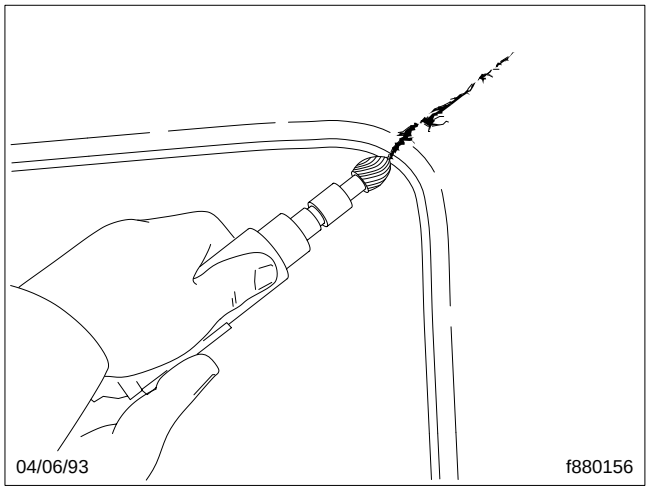


Fig. 9, Tapering the Edges of the Crack

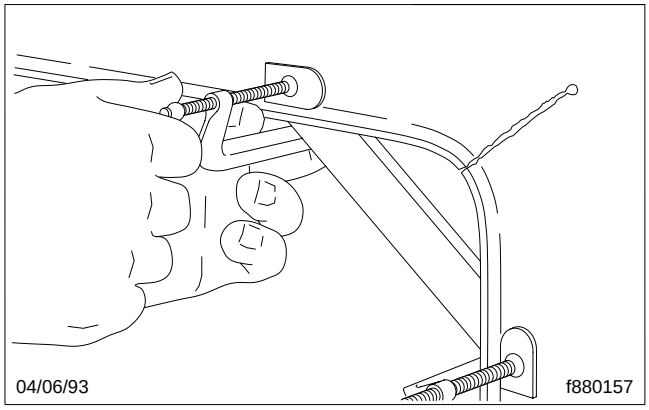


Fig. 10, Alignment Method Using C-Clamps and a Bridge Strip

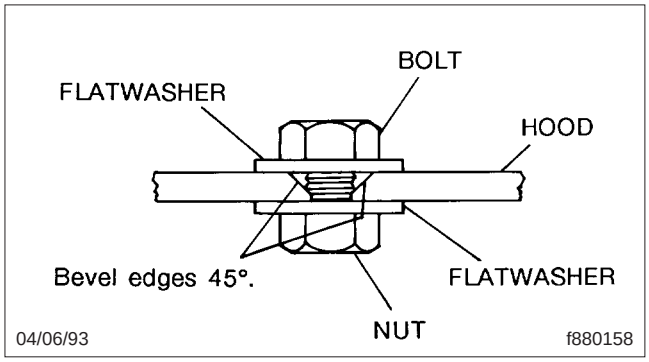


Fig. 11, Alignment Method Using a Nut, Bolt, and Two Flatwashers

13. Using a roller or paint brush, apply some resin on the underside of the repair area.

Repair of Spray-Up Hoods

14. Soak the first layer of mat in the catalyzed resin; then, place the mat over the repair area. Using a roller, or dabbing with a stiff bristle brush, work out all air bubbles, which show up as white in the patch. If a nut and bolt and flatwashers were used to align the panels, cut slits in the mat (along the nut) in order to work out all trapped air.
15. Allow the patch to harden slightly, until it has cured to a leather-like condition.
16. Apply the remaining pieces of resin-soaked woven roving and mat. Work steadily on the patches so that lay-up is completed within the resin gel-time, which is usually 20 to 30 minutes.

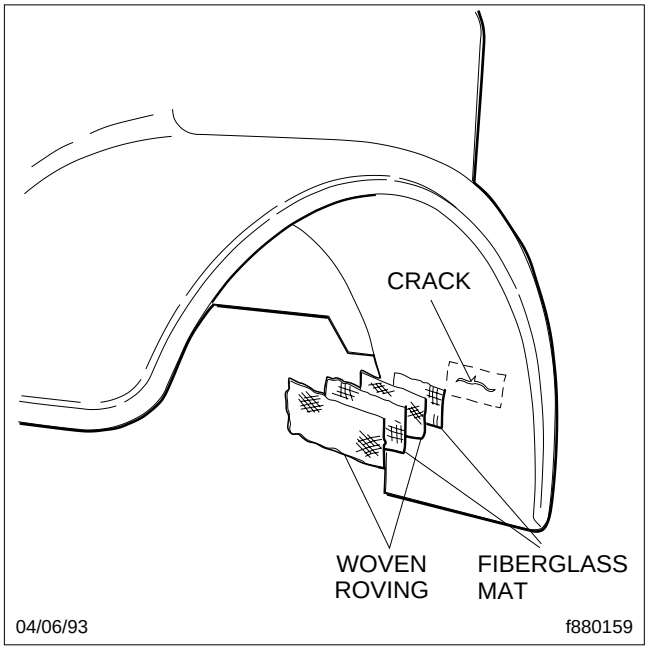


Fig. 12, Fiberglass Patch Sizes

17. Allow the repair laminate to completely harden (about two hours). Then, remove the C-clamps and bridge strip, or the bolt(s) and flatwasher(s), if either method of alignment was utilized. The latter method of alignment requires that the nut(s) and flatwasher(s) remain as a part of the repair patch.
18. Following the body filler manufacturer's instructions, mix enough body filler to re-establish the surface.

IMPORTANT: Mix the body filler on a hard, non-porous surface. Do not work on a porous surface, such as cardboard. Porous surfaces absorb the body filler liquids, which can adversely affect the final curing time and bond.

19. If a nut(s) and flatwasher(s) remain as a part of the repair patch, fill the hole of each nut with body filler.
20. Fill the tapered crack with body filler and a non-shrinking coating, then spot prime and paint the surface. For instructions, refer to the applicable steps under "Surface Damage Repair," in this subject.
21. If applicable, install the section of sound-absorbent lining previously removed from the underside of the damaged area.
22. Remove the chocks from the tires after all repairs are completed.

REPAIR OF PUNCTURES AND FRACTURES (OVER SIMPLE CURVES OR LARGE FLAT AREAS)

Small or large punctures, and fractures that branch out in several directions, which occur on flat surfaces or in simple curves (such as those where the sides and the top of the hood meet) can be repaired using the procedure below:

1. Using a detergent and water solution, remove the surface dirt from around the damaged area. Then, clean the area with xylene or an equivalent grease and wax remover.
2. Check the shop temperature and humidity, and compare with the recommendations given on the resin/body filler can labels. Generally, 70°F (21°C) and 70 percent humidity are considered ideal.
3. If sound-absorbent lining is present on the underside of the damaged area, remove enough lining to provide an adequate working area, or about 5 inches (12.5 cm) on all sides of the damage.
4. Inspect the area to determine the extent of the damage (damaged areas often show up better on the underside of the laminate). Push on the surfaces immediately surrounding and underneath the damaged area. All ragged edges and unsound fragments will later be removed. Using

a marking pen, circle the area to be removed, if applicable.

5. Mask off the undamaged surface, leaving a working area on the outer finished surface of about 5 inches (12.5 cm) surrounding the damage.
6. Using a saber saw, cut away the ragged edges of the damaged area; cutting is not necessary for damage such as a clean puncture. In some cases, it will be necessary to greatly enlarge the hole in order to cut back to sound material.

⚠ WARNING

WARNING: Wear goggles and an air purifying respirator when grinding, cutting, or sanding during all fiberglass repairs. The ground dust and particles could cause temporary or permanent damage to your eyes and, if inhaled, could cause throat or lung irritation.

7. Working on the outer finished surface, and using a file or grinder with a burr bit or sanding sleeve, taper the edges of the hole at an angle of no more than 45 degrees. **See Fig. 13.**
8. Sand the inside unfinished surface around the hole with 60-grit (or less) sandpaper to create a rough bonding surface about 2 to 3 inches (5 to 7.5 cm) from all edges of the hole. Be sure to completely sand off any undercoating sprayed on this area. **See Fig. 14.**
9. Clean the sanded areas using compressed air. Then, wipe with a solvent-dampened cloth. Allow the surfaces to completely dry.

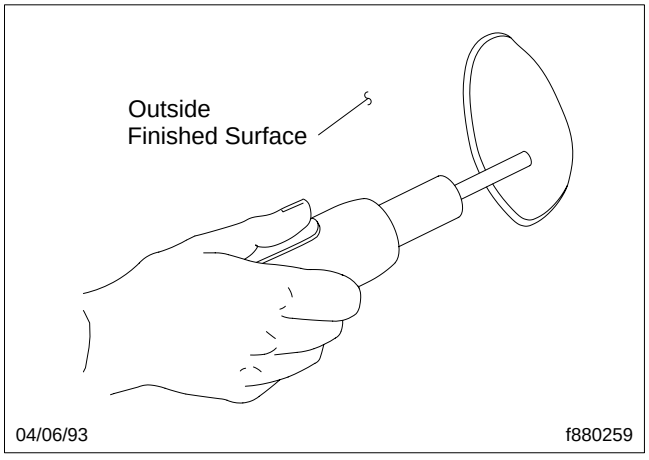


Fig. 13

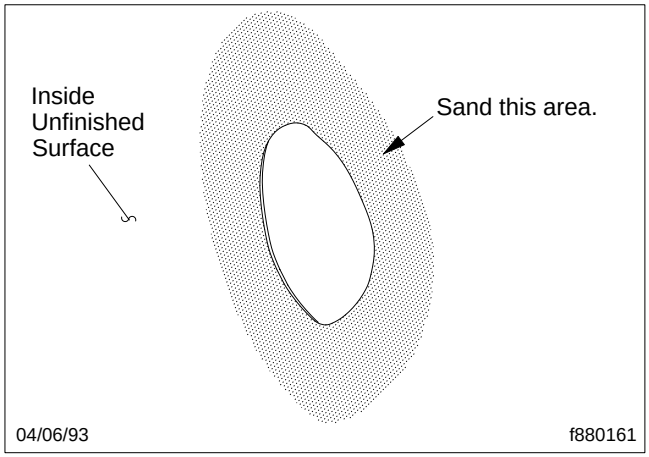


Fig. 14

NOTE: The next few steps describe the attachment of a template or "backing patch" that is temporarily affixed over the hole on the outer finished surface of the hood. The template provides a firm foundation on which the laminate can be built up from the underside of the hood. In addition, it provides a mold on which a surface can be structured to blend in with the surrounding contour or plane.

For small holes and damaged to curved surfaces, the template material should be one that is basically stiff, yet flexible enough to conform to gradual curves. Light aluminum flashing is ideal.

For damage to flat surfaces, a stiff sheet of metal, fiberboard, or plywood can serve as template material.

10. Cut a piece of plastic separating film (cellophane wrap) large enough to overlap all sides of one face of the template. Then, position the cellophane covered surface of the template over the hole, and fasten in place with tape or clamps. See **Fig. 15** and **Fig. 16**. Make sure there are no folds in the cellophane.

    Test the bond of the template by applying moderate pressure to the cellophane covered surface of the template (from the underside of the hood). There should be no yielding.
11. Following the resin manufacturer's instructions, mix enough resin and catalyst to apply a coat approximately 1/32 inch (just less than 1 mm)

Repair of Spray-Up Hoods

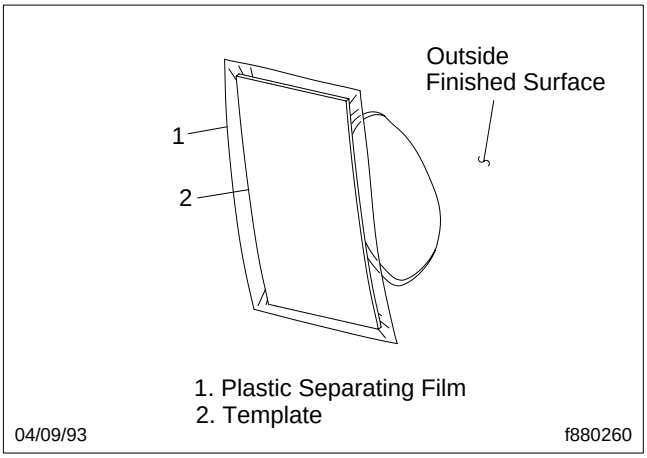


Fig. 15

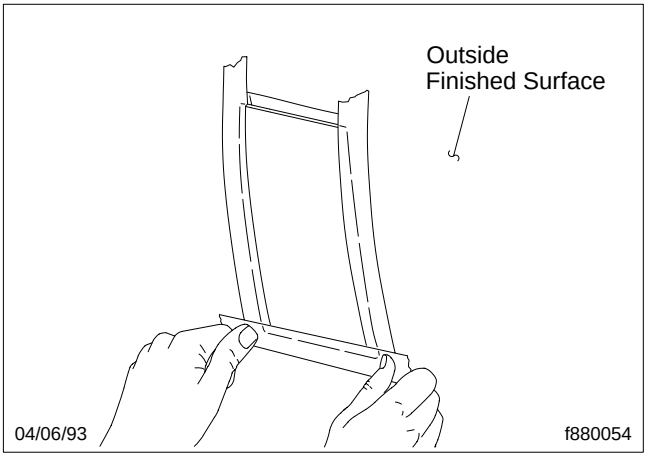


Fig. 16

thick on the template surface exposed through the hole. Apply the resin through the hole and around the edges of the cutout. **See Fig. 17.** Wait for the filler to cure until it is nearly tack-free. The resin coating will prevent transfer of the fiberglass mat pattern on the outside surface of the hood.

12. Cut a series of 1.5 ounce fiberglass mat and alternating 18 ounce fiberglass woven roving patches progressively larger than the hole. Cut the first ply to fit as closely as possible to the shape of the hole. The last ply should be about 2 inches (5 cm) larger than the hole. **See Fig. 18.**

    The combined thickness of the fiberglass patches should be about 25 to 30 percent thicker than the original laminate.

13. Make sure that all tools necessary for fiberglass lay-up are at hand. Then, following the resin manufacturer's instructions, mix enough resin and catalyst to saturate the pieces of fiberglass mat and woven roving.
14. Build up a structural patch with alternate layers of resin-soaked mat and woven roving. Apply the resin-soaked mat first so that it forms the outermost ply. **See Fig. 19.**

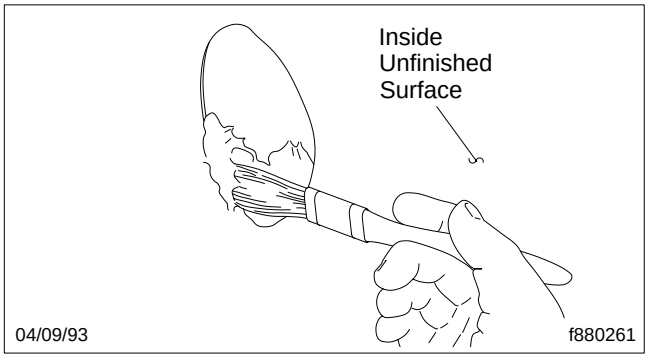


Fig. 17

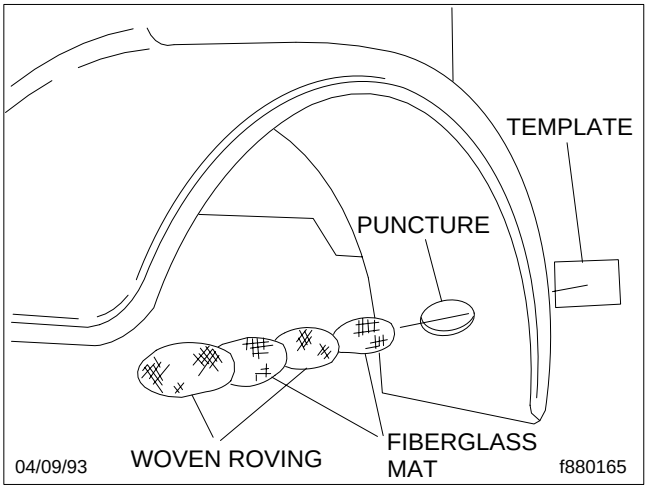


Fig. 18, Fiberglass Patch Sizes

15. Using a roller, or dabbing with a stiff bristle brush, work out all air bubbles, which show up as white in the patch. **See Fig. 20.**
16. Work steadily on the patch so that it is completed within the resin gel-time, which is usually 20 to 30 minutes. If more than 3/16 inch (about 5 mm) thickness of laminate is required, complete the patch in two phases: first, wait until the first

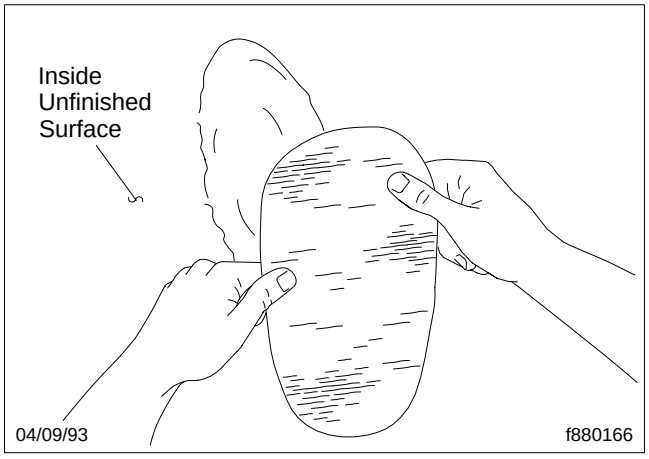


Fig. 19

layers have cured to a leather-like condition; then, finish the remainder.

17. Allow the repair laminate to completely harden (about two hours). After complete cure, carefully remove the template from the outer surface of the hood.

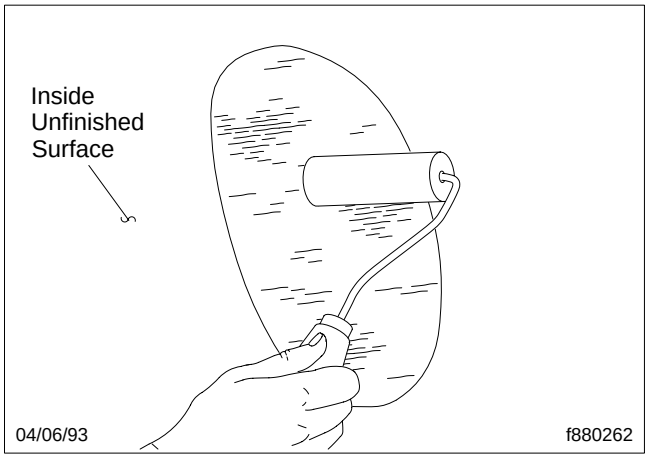


Fig. 20

18. Using 100- to 200-grit sandpaper, sand the outer surface of the work area until the patch blends in as much as possible with the original surface. Then clean the sanded areas using compressed air, and wipe with a solvent-dampened cloth. Allow the surfaces to completely dry.
19. If there are any deep imperfections or pockmarks in the resin surface after sanding, fill them with body filler and a non-shrinking coating. Then, spot prime and paint the repair area. For instructions, refer to the applicable steps under "Surface Damage Repair."
20. If applicable, install the section of sound-absorbent lining previously removed from the underside of the damaged area.
21. Remove the chocks from the tires after all repairs are completed.

Section Replacement (See Fig. 1)

On extremely large damaged areas, for example, structural damage on the side surface of the hood covering a square foot area, it may be more convenient to perform a section replacement rather than make a lay-up patch. A second damaged hood must be available, as scrap, with this section intact.

1. Push on the area immediately surrounding and underneath the damaged area to determine the extent of damage.
2. Clean the damaged area with xylene or an equivalent grease and wax remover. Inspect the area closely.
3. Mask off an area about 5 inches (12.5 cm) away from the damaged area (on all sides).
4. If sound-absorbent lining is present on the underside of the damaged area, remove enough lining to provide an adequate working area, or about 5 inches (12.5 cm) beyond the area to be removed.

⚠ WARNING

WARNING: Wear goggles and an air purifying respirator when grinding, cutting, or sanding during all fiberglass repairs. The ground dust and particles could cause temporary or permanent damage to your eyes and, if inhaled, could cause throat or lung irritation.

5. Using a saber saw, cut out a large, straight-sided panel containing the damaged area. **See Fig. 13**, Ref. A.
6. From the scrap hood, cut a patch from the same area, only slightly larger than the original cutout. **See Fig. 21**, Ref. B. Then, trim the patch to fit both the size and the contour of the original cutout.

Repair of Spray-Up Hoods

7. After the trimming is completed, sand the edges to allow 1/16 to 1/8 inch (about 1.5 to 3 mm) gap all around the cutout.
8. Using a disc sander with 60-grit (or less) sandpaper, create a rough bonding surface on the underside of the patch at least 3 inches (7.5 cm) from the edges. Also sand the underside of the hood at least 3 inches (7.5 cm) from all edges of the repair area. Be sure to completely sand off any undercoating sprayed on these areas.
9. On the outer sides of both the hood and the patch, bevel the edges approximately 45 degrees. **See Fig. 22.**
10. Gently feather the painted surfaces back about 1/2 inch (13 mm) beyond the edges of the repair areas (both the hood and the patch) by hand-sanding or power-sanding with 360-grit (or higher) sandpaper. Avoid causing any sudden steps or uneven protrusions in these areas.

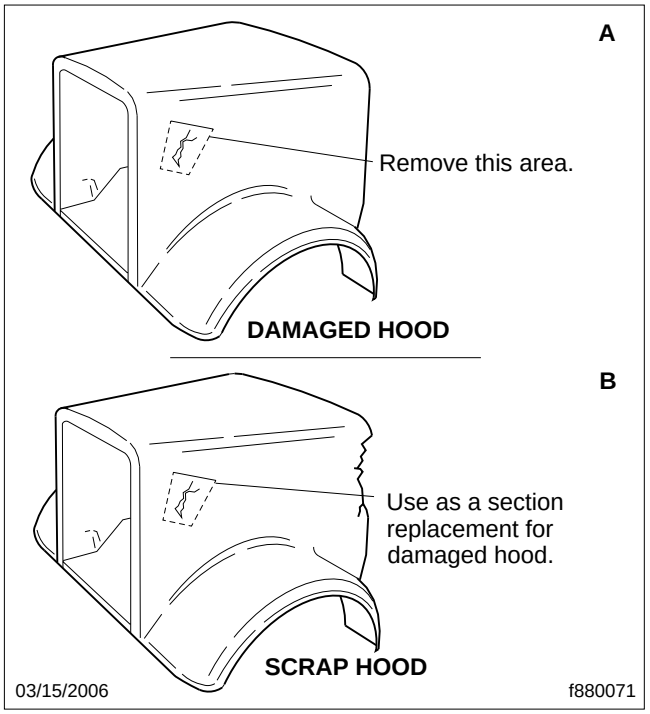


Fig. 21, Section Replacement of a Damaged Fiberglass Hood

11. Clean the sanded areas using compressed air. Then, wipe with a solvent-dampened cloth. Allow the surfaces to completely dry.

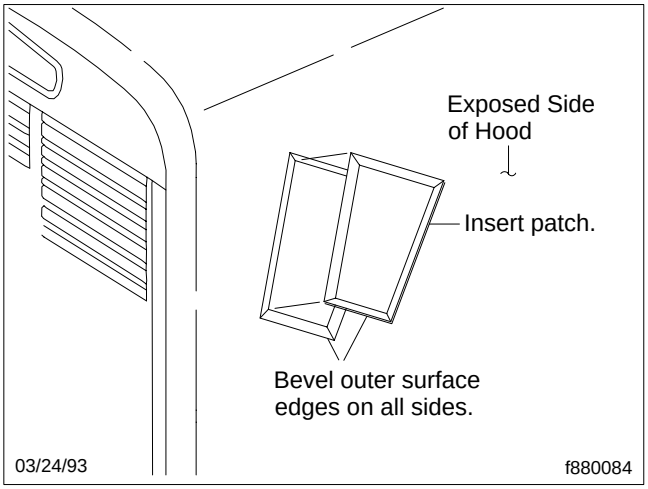


Fig. 22, Areas to be Beveled

12. Check the shop temperature and humidity and compare with the recommendations given on the resin/body filler can labels. Generally, 70°F (21°C) and 70 percent humidity are considered ideal.
13. In order to secure the patch, while fiberglass lay-up repair is made to permanently secure the insert, the bolt and nut method is used (**see Fig. 23**):
    - 13.1 Fit the insert patch in the hole. Holding it in place, drill holes which will allow the bolts to bass through the seam. The bolts should be spaced about every 6 inches (15 cm).
    - 13.2 Using bolts short enough not to protrude through the nuts, fasten large flatwashers on each side of the panel. It is important that the nuts be located on the underside of the panel, where they will remain as a part of the repair.
    - 13.3 As the nuts are tightened, the patch will be drawn into alignment with the original surface. Do not tighten more than necessary to align the parts.
14. Cut out and apply alternating patches of fiberglass mat and woven roving on the underside seams of the repair area. For instructions refer to the applicable steps under "Repair of Cracks," in "Structural Damage Repair."

15. Allow the laminate to completely harden (about two hours). Then, remove the bolts and flatwashers used to hold the patch in place. The nuts and flatwashers on the underside will remain as parts of the repair.
16. Following the body filler manufacturer's instructions, mix enough body filler to re-establish the outer surface.

IMPORTANT: Mix the body filler on a hard, nonporous surface. Do not work on a porous surface, such as cardboard. Porous surfaces absorb the body filler liquids, which can adversely affect the final curing time and bond.

17. Fill the holes of each nut with body filler.
18. Fill the tapered cracks with body filler, then spot prime and paint the surface. For instructions, refer to the applicable steps under the heading "Surface Damage Repair," in this section.

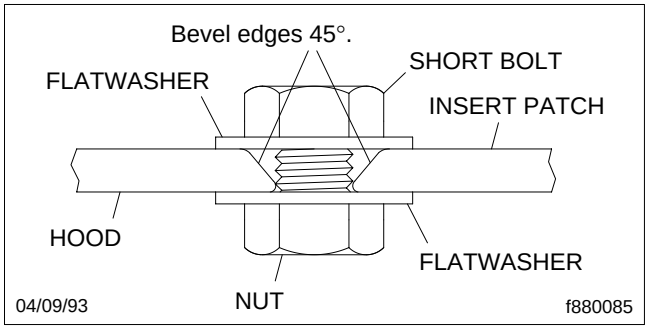


Fig. 23, Attaching Method Using a Nut, Bolt, and Two Flatwashers

19. If applicable, install a section of sound-absorbent lining in the same area where it was previously removed.
20. Remove the chocks from the tires after all repairs are completed.

Headlight Assembly Removal and Installation

Removal

1. Tilt the hood fully open.
2. Unclamp the headlight wiring harness from the hood, and disconnect the connector. **See Fig. 1.**
3. Return the hood to the operating position.
4. Remove the headlight bezel retaining screws. **See Fig. 2.** Pull the bezel away from

   the hood and disconnect the turn signal/ marker light wiring harness connector from the back of the bezel.

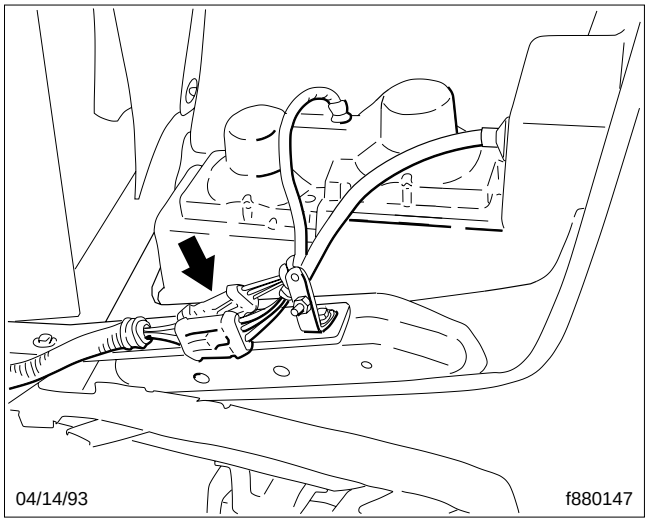


Fig. 1, Headlight Wiring Harness Connector

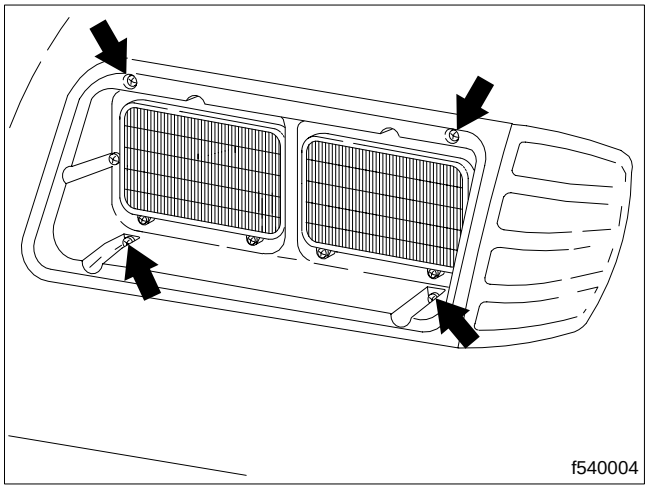


Fig. 2, Headlight Bezel Retaining Screws

5. Remove the eight screws (**Fig. 3**) that attach the headlight assembly to the hood, and remove the headlight assembly.

Installation

1. Install the headlight assembly on the hood. Tighten the eight screws until snug.
2. Connect the turn signal/marker light wiring harness connector to the back of the bezel. Install the bezel over the headlight assembly. Tighten the four screws until snug.
3. Tilt the hood fully open.
4. Connect the headlight wiring harness connector, and clamp the wiring harness to the hood as **shown in Fig. 1**.
5. Return the hood to the operating position.

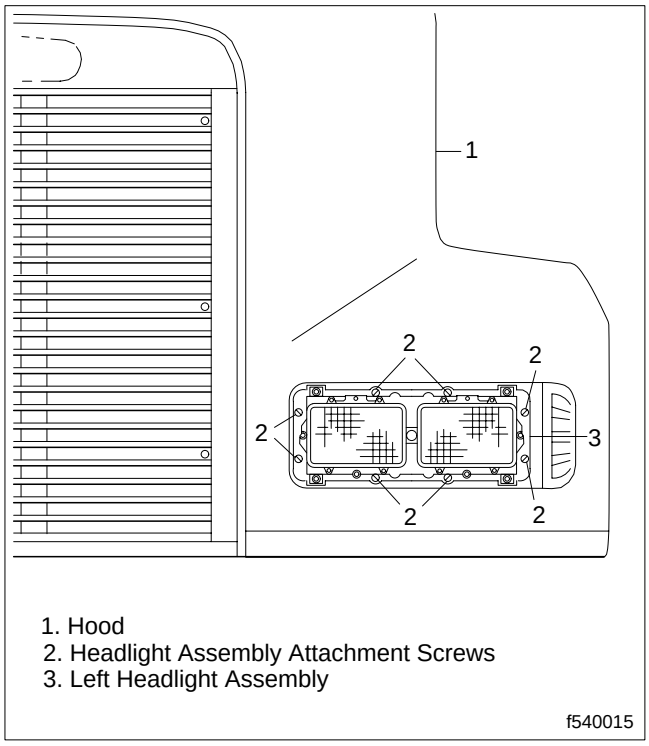


Fig. 3, Headlight Assembly-to-Hood Attachment

Four-Fastener Grille Removal and Installation

NOTE: When looking through the front of the grille, none of the fasteners are visible with the four-fastener grille. If fasteners are visible at the points shown in **Fig. 1**, proceed to **Subject 180.**

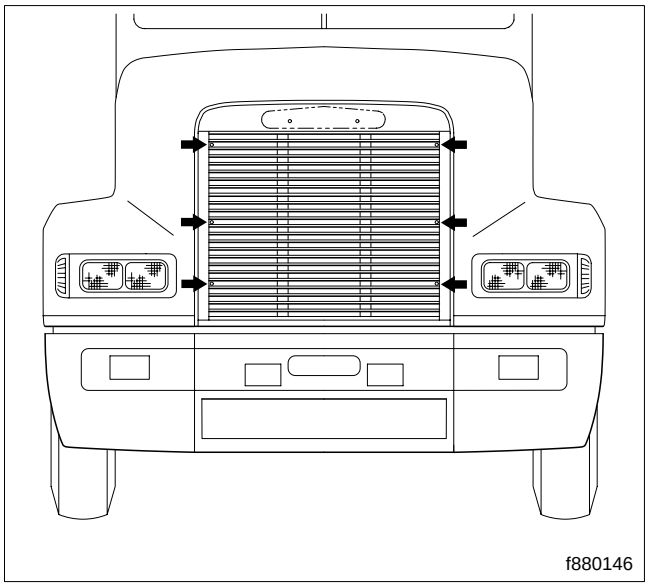


Fig. 1

Removal

1. Tilt the hood.
2. Support the grille so it doesn't fall.
3. From the back side of the grille, remove the four locknuts and washers that hold the grille to the hood. See **Fig. 2**.
4. Remove the grille from the hood.

Installation

1. Place the grille in position on the hood with the four studs inserted through the holes in the hood.
2. Install the washers and locknuts on the studs.
3. Before tightening the locknuts, adjust the grille so the top and side gaps are equal.
4. Tighten the locknuts 96 lbf·in (1080 N·cm).

Four-Fastener Grille Removal and Installation

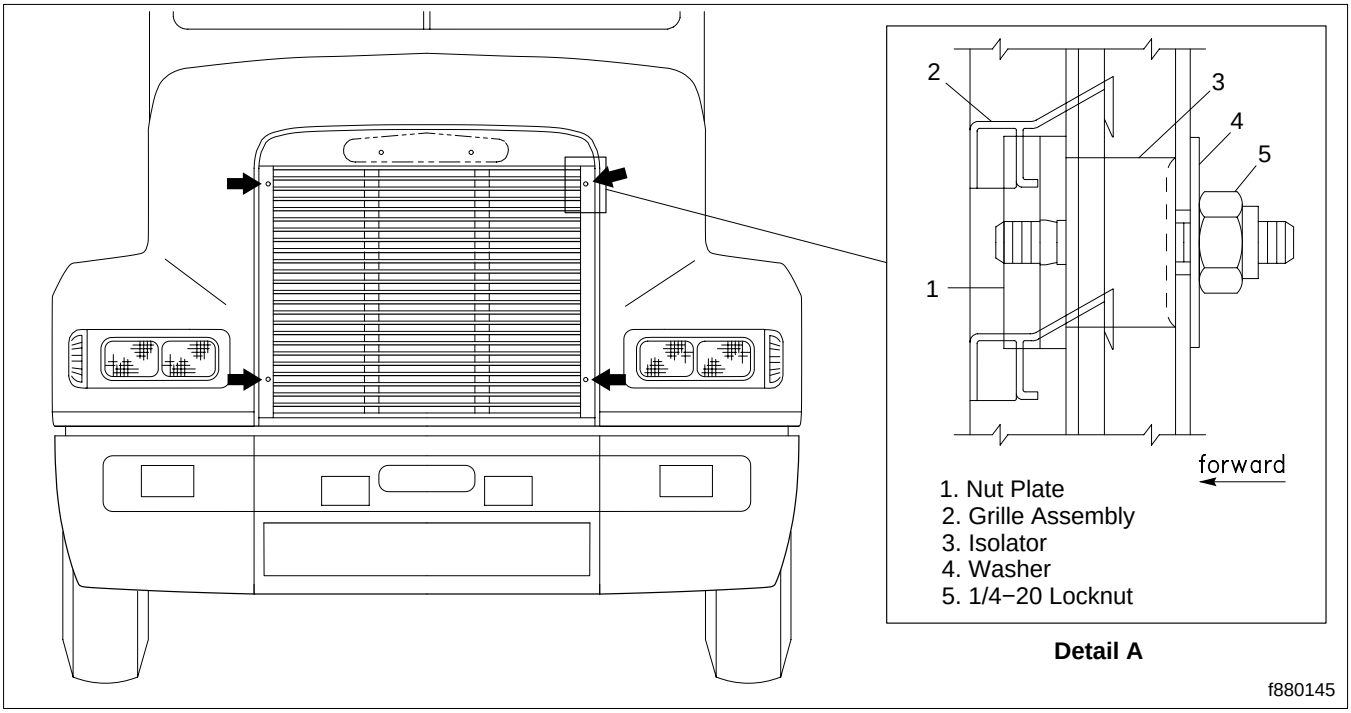


Fig. 2, Grille Attachment Nuts

Eight-Fastener Grille Removal and Installation

NOTE: When looking through the front of the grille, six fasteners are visible with the eight-fastener grille. If no fasteners are visible, refer to **Subject 170**.

Removal

1. Pry off the nameplate at the top of the grille. Be careful not to scratch the grille. **See Fig. 1.**
2. Remove the eight acorn nuts and obround washers that hold the grille to the hood. **See Fig. 2.** Remove the grille from the hood.

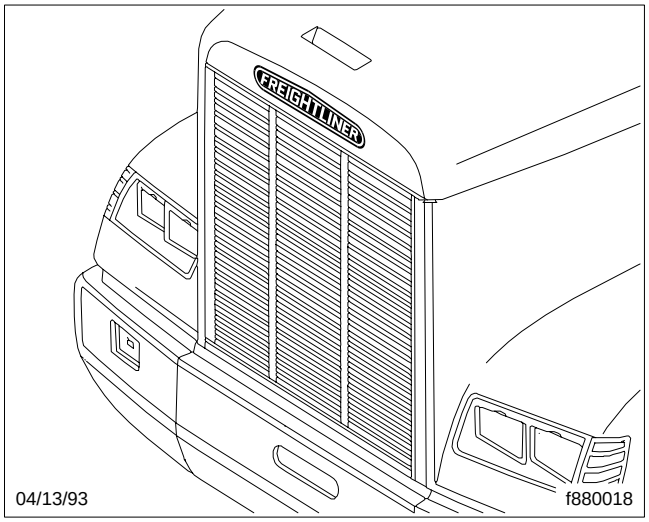


Fig. 1, Nameplate on Grille

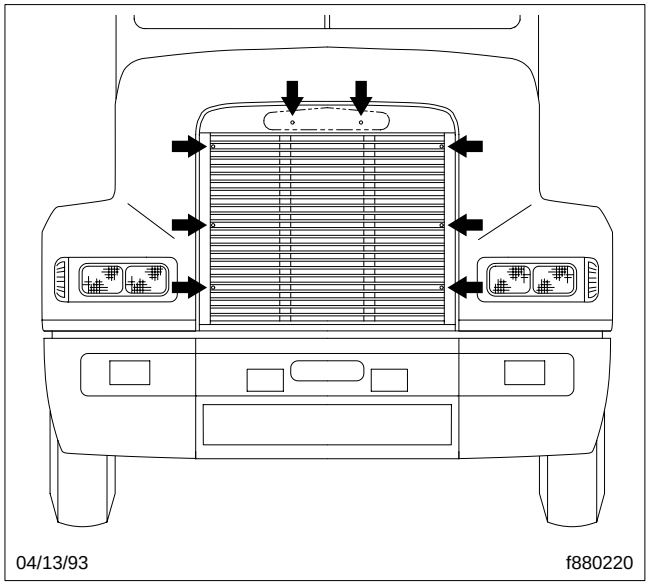


Fig. 2, Grille Attachment Nuts

Installation

1. Place the grille over the studs on the hood and install an obround washer and acorn nut over each stud.
2. Before tightening the acorn nuts, adjust the grille so the top and side gaps are equal.
3. Adjust the obround washers until they are horizontal, then tighten the acorn nuts 30 lbf·in (340 N·cm).
4. Install the nameplate on the grille by snapping it into place.

Repair

1. Remove the grille. Refer to the applicable grille removal and installation section for instructions.
2. Tilt the hood, and use a ladder as needed for access to the lining repair area.
3. Repair small tears in the mylar facing or in the tape-sealed edges of the lining panels by first cleaning the mylar facing, then patching the torn area with 2-inch (51-mm) wide aluminized polyester sealant tape or duct tape.

IMPORTANT: If tears in the lining panels have allowed water or oil to soak into the acoustical foam, replace the lining panel. Refer to "Replacement" for instructions.

4. Replace any missing rivets and washers that hold the lining to the inner fender, and replace any missing nuts and washers that hold the lining to the hood. See **Fig. 1**, **Fig. 2**, **Fig. 3**, and **Fig. 4**.
5. If any of the studs are damaged, carefully pull the hood lining panel off of the damaged stud, then cut off the stud flush with the hood surface. Use contact cement to secure the hood lining in place at that point by applying the contact cement, then holding the lining in place until the contact cement bonds.

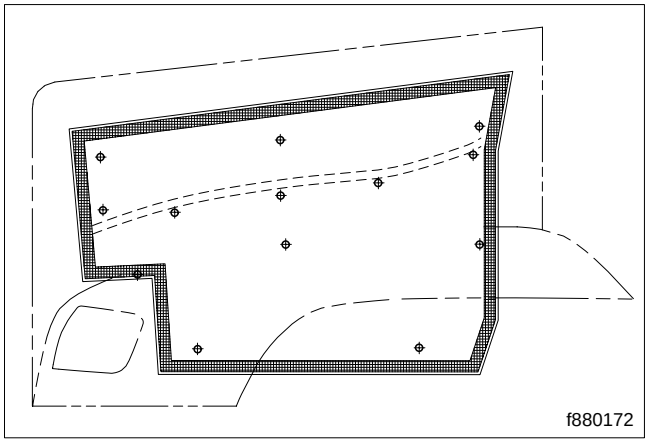


Fig. 1, Hood Lining Installation (FLD 120 and FLD 120 SD)

6. Secure any detached areas of the lining by using contact cement on the lining panel and hood surface, and holding the lining in place until the contact cement bonds.

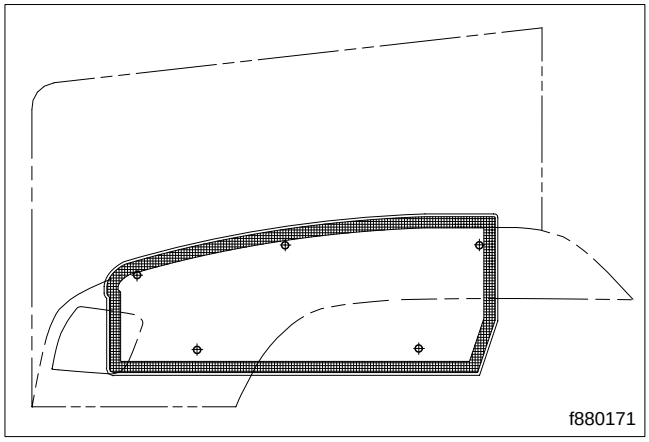


Fig. 2, Inner Fender Lining Installation (FLD 120 and FLD 120 SD)

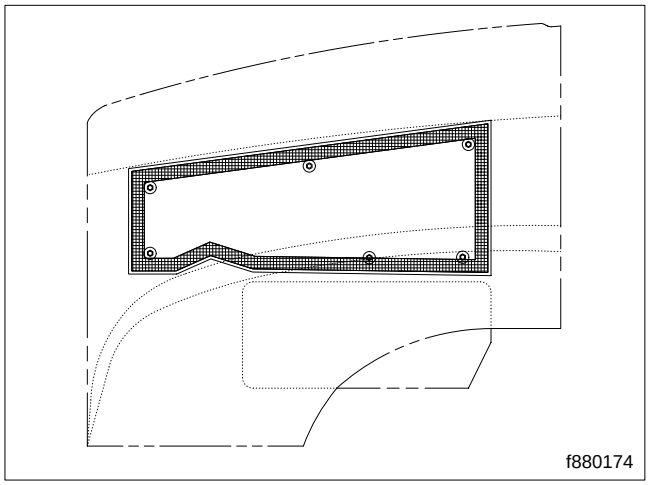


Fig. 3, Hood Lining Installation, Model FLD 112

7. Lower the hood and install the grille. Refer to the applicable grille removal and installation section for instructions.

Replacement

1. Remove the grille. Refer to the applicable grille removal and installation section for instructions.
2. Tilt the hood, and use a ladder as needed for access to the lining repair area.
3. If replacing an inner fender lining panel (**Fig. 2** and **Fig. 4**), proceed as follows:

Lining Repair or Replacement

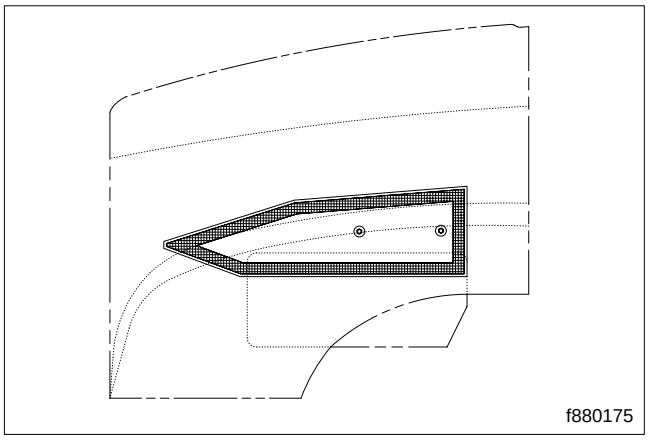


Fig. 4, Inner Fender Lining Installation, Model FLD 112

3.1 Carefully drill out the rivets holding the lining to the inner fender, then pull the lining and adhesive tape from the inner fender.

3.2 Using a wire brush, clean the inside surface of the inner fender where the lining was removed. Then, steam clean the area thoroughly, and allow it to air dry.

3.3 Apply 2-inch (51-mm) wide double-faced adhesive tape 1 around the outside edge of the back (dull side) of the replacement panel. Do not overlap strips of tape.

3.4 Remove the backing strip from the tape and line the panel up with the edge of the hood lining panel. The inner fender lining panel should match the contours of the hood lining panel. Both panels should be flush at the rear edges. Lightly press the lining in place on the hood.

3.5 Once the lining is in place, use a roller to press it securely.

3.6 Placing a washer over each rivet, punch the rivets through the lining and inner fender at the locations shown in **Fig. 1**, **Fig. 2**, **Fig. 3**, and **Fig. 4**. Place another washer over the end of each rivet and secure the rivets in place. **See Fig. 5.**

4. If replacing a hood lining panel (**Fig. 1** and **Fig. 3**), proceed as follows:

4.1 Remove the nuts and washers holding the panel to the hood, and carefully pull the panel and adhesive tape from the hood.

4.2 Using a wire brush, clean the inside surface of the hood where the panel was removed. Then, steam clean the area thoroughly, and allow it to air dry.

4.3 Apply 2-inch (51-mm) wide double-faced adhesive tape 1 around the outside edge of the back (dull side) of the replacement panel. Do not overlap strips of tape.

4.4 Remove the backing strip from the tape and line up the panel with the edge of the inner fender lining panel. The hood lining panel should match the contours of the inner fender lining panel. Both panels should be flush at the rear edges.

4.5 Punch the studs on the hood through the panel and lightly press the lining in place on the hood. Use a roller to press the lining securely in place.

4.6 Install the washers and nuts on the studs and tighten the nuts until snug.

5. Return the hood to the operating position and install the grille. Refer to the applicable grille removal and installation section for instructions.

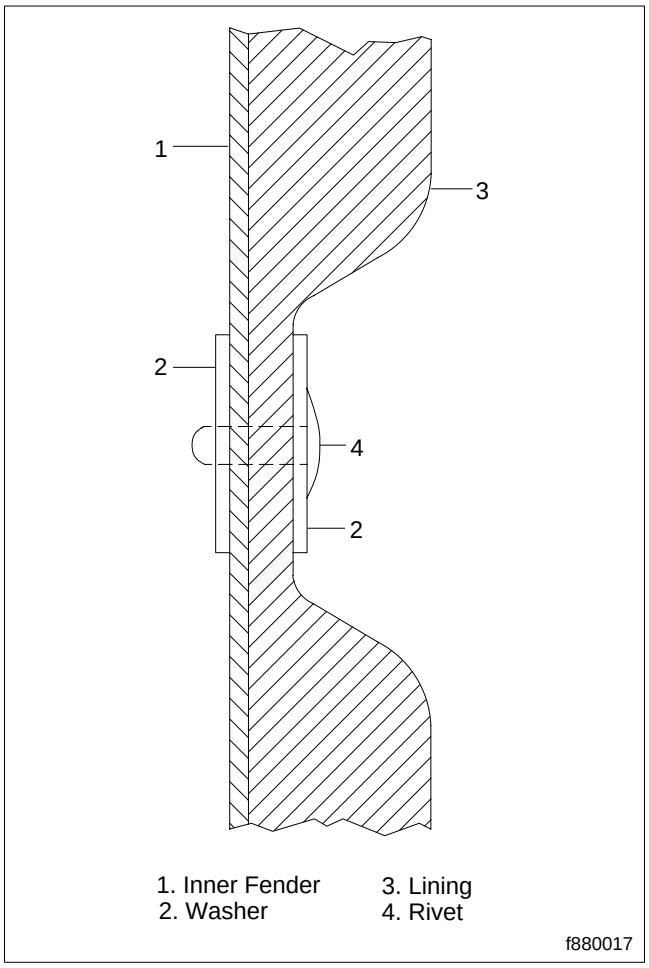


Fig. 5, Cross-Section of a Lining Attached to an Inner Fender

Repair Tools and Materials (SMC Hood)

SURFACE DAMAGE

Required tools and materials:

- Xylene, acetone, or equivalent solvent
- 220 or finer grit sandpaper
- 320 or finer grit sandpaper
- Applicator squeegee
- Self-leveling adhesive [1]
- Hand-held disc pad
- Primer [2]

STRUCTURAL DAMAGE

Crack or Small Hole

Required tools and materials:

- Xylene, acetone, or equivalent solvent
- 1/8-inch diameter drill bit
- Router bit
- 80 to 220 grit sandpaper
- Razor-blade knife
- Woven fiberglass cloth
- Wooden stir stick
- Self-leveling adhesive [1]
- 220 or finer grit sandpaper
- 320 or finer grit sandpaper
- Applicator squeegee
- Hand-held disc pad
- Primer [2]

Section Replacement (Punctures and Large Fractures)

Required tools and materials:

- Scrap SMC from a damaged hood
- Xylene, acetone, or equivalent solvent
- Saber saw
- Router bit
- 80 to 220 grit sandpaper
- Razor-blade knife
- Woven fiberglass cloth
- Clamps
- Adhesive for bonding strips (if needed) [3]
- Wooden stir stick
- Self-leveling adhesive [1]
- 220 or finer grit sandpaper
- 320 or finer grit sandpaper
- Applicator squeegee
- Hand-held disc pad
- Primer [2]

HOOD COMPONENT REBONDING

Required tools and materials:

- Heat gun
- Putty knife, hacksaw blade
- Solvent [4]
- 80 to 220 grit sandpaper
- Clamps, clamping bolts with washers
- 0.030" diameter glass beads (if needed)
- Adhesive [3]

[1] Use Ashland Pliogrip 7775L self-leveling urethane adhesive. 7775L has no sag resistance and, therefore, is useful for filling cracks and channels, and for bonding glass-fiber reinforcing fabrics. Working time: 5 minutes @ 73°F (23°C). Sanding time: 50 minutes @ 73°F (23°C). Ashland products are available through Freightliner dealers. See **Table 4** and **Table 5**.

[2] Use Sherwin Williams BB–11 black conductive primer. Contact your local Sherwin Williams automotive paint distributor to purchase this primer.

[3] Ashland Pliogrip 7773 or 7779 adhesives are recommended for this application, but 7771 and 7770 may be substituted. A heat gun may be used to speed curing times. Ashland products are available through Freightliner dealers. See **Table 4**.

[4] Use Ashland 6036 primer or methylene chloride. Contact Ashland Merchandising Group, telephone (419) 289–9588, to purchase this primer.

Specifications

- Primer [2]

Repair Tools and Materials (Spray-Up Hood)

SURFACE DAMAGE

NOTE: A fiberglass repair kit is not required for repair of surface damage.

1. Sandpaper and sanding discs (24- to 60-grit and 360- to 600-grit).
2. Air motor or electric drill with sanding attachment and burr bit (or sanding sleeve).
3. Files.
4. Sanding block.
5. Orbital or flat jitterbug sander.
6. Xylene, methylene, acetone or equivalent solvent.
7. Heat gun or infrared heat lamp.
8. Self-leveling adhesive. Use Ashland Pliogrip 7775L for filling all surface imperfections.
9. Rubber or plastic squeegee (or similar wooden spreader).
10. Goggles and an air purifying respirator.

STRUCTURAL DAMAGE

1. All of the tools and materials listed above, under "Surface Damage."
2. Ashland Pliogrip 7775L self-leveling adhesive (for bonding fiberglass fabric used in structural damage repair).
3. Reinforcing glass fabric (1.5-ounce mat, 18-ounce roving).
4. Electric sander and sanding discs (100- to 200-grit).
5. Electric saber saw or hacksaw.
6. C-clamps.
7. Plastic separating film (cellophane or equivalent).

Torque Values				
Description	**Size**	**Grade**	**Torque lbf·ft (N·m)**	**Torque lbf·in (N·cm)**
Hood Shoulder Bolt Locknuts	3/8–16	C	23 (31)	—
Rear Hood-Mount Locator Bolt Nuts	1/2–13	B	70 (95)	—
Forward Hood-Mounting Bracket Locknuts:				
With Horizontal Front Frame Crossmember	1/2–13	C	85 (115)	—
With Vertical Front Frame Crossmember	1/2–13	C	70 (95)	—
Rear Hood-Locator Bracket Nuts	5/16–18	B	15 (20)	—
Four-Fastener Grille Mounting Nylock Nuts	1/4–20	A	—	96 (1080)
Eight-Fastener Grille Mounting Acorn Nuts	1/4–20	—	—	30 (340)
Torsion Bar Mounting Bolt	1/2–13	8	80 (108)	—

Table 1, Torque Values

General Specifications	
Description	**Value inches (mm)**
Clearance Between Top of Hood and Cowl	5/8 – 1 (16 – 25)

General Specifications	
Description	**Value inches (mm)**
Clearance Between Side of Hood and Cowl	1/2 – 3/4 (13 – 20)
Rear Hood-Mount Slotted Shim Thickness	1/8 (3)
Forward Hood-Mount Slotted Spacer Thickness	1/4 (6)

Table 2, General Specifications

Tilt-Assist Torsion Bar Adjustment Specifications	
Description	**Value**
Hood Opening Force	about 20 lbf (89 N)
Hood Closing Force	at least 40 lbf (178 N)

Table 3, Tilt-Assist Torsion Bar Adjustment Specifications

NOTE: Ashland Pliogrip 7700 and 8000 Series adhesives and accessories are available through Freightliner dealers and PDCs. The 7700 Series adhesives are two-part urethane adhesives, specially formulated and packaged for repair of hoods and other fiber-reinforced plastics. Adhesive 7775L is a self-leveling mixture that is appropriate when a surface filler or glass fabric reinforcement repair is required. The 8000 Series adhesives are also two-part urethane adhesives, available for those who prefer to use these earlier-generation adhesives. Descriptions, working times, and curing times (sanding and repainting) for the various adhesives are shown below in **Table 4** and **Table 6**. Ashland adhesive accessories are listed in **Table 5** and **Table 7**.

NOTE: All of the adhesives develop the same bonding strength; specific adhesives may be preferred to change working times.

NOTE: All working and curing times correspond to an ambient temperature of 73°F (23°C) in the workplace; humidity level will NOT affect working or curing times.

IMPORTANT: While a heat gun may be used to speed adhesive curing time, do not overheat the adhesive. The maximum allowable temperature is 180°F (82°C).

7700 Series Adhesives				
Description	**Part Number**	**Working Time in Minutes**	**Curing Time in Minutes**	**Curing Time in Hours**
Adhesive, two 50 ml cartridges, 3.4 oz (100 ml)	ACA 7771	1.5	10	—
Adhesive, two 50 ml cartridges, 3.4 oz (100 ml)	ACA 7773	3.5	30	—
Adhesive, two 300 ml cartridges, 20 oz (600 ml)	ACA 7773 300	3.5	30	—
Adhesive, two 50 ml cartridges, 3.4 oz (100 ml)	ACA 7775L	5.0	50	—
Adhesive, two 50 ml cartridges, 3.4 oz (100 ml)	ACA 7779	10	—	1.0
Adhesive, two 300 ml cartridges, 20 oz (600 ml)	ACA 7779 300	10	—	1.0
Adhesive, two 50 ml cartridges, 3.4 oz (100 ml)	ACA 7770	35	—	2.5 – 3.0
Adhesive, two 300 ml cartridges, 20 oz (600 ml)	ACA 7770 300	35	—	2.5 – 3.0

Table 4, 7700 Series Adhesives

Specifications

7700 Series Accessories	
Description	**Part Number**
Manual Applicator Gun for 300 ml Cartridges	ACA TS526C
1/4" Mixing Nozzles for 50 ml Cartridges (100/box) *	ACA 583 238
Pneumatic Applicator Gun for 300 ml Cartridges	ACA TS525
3/8" Mixing Nozzles for 300 ml Cartridges (100/box) *	ACA F 771072

* These are additional mixing nozzles. Each adhesive cartridge comes with two mixing nozzles.

Table 5, 7700 Series Accessories

8000 Series Adhesives				
Description	**Part Number**	**Working Time in Minutes**	**Curing Time in Minutes**	**Curing Time in Hours**
Adhesive, Supermix 4:1, 12 oz (355 ml)	ACA 8104	4.0	30	—
Adhesive, Supermix 4:1, 12 oz (355 ml)	ACA 8110	10	—	1.0
Adhesive, Supermix 4:1, 12 oz (355 ml)	ACA 8145	50	—	5.0 – 8.0

Table 6, 8000 Series Adhesives

8000 Series Accessories	
Description	**Part Number**
Pneumatic Applicator Gun for 355 ml Cartridges	ACA 582 2241
3/8" Mixing Nozzles for 8000 Series Cartridges (100/box) *	ACA F 771072

* These are additional mixing nozzles. Each adhesive cartridge comes with two mixing nozzles.

Table 7, 8000 Series Accessories

General Information

To absorb noise emitted from the engine, and to comply with U.S. EPA Regulations, Part 205, Transportation Equipment Noise Emission Controls, acoustical foam with aluminized mylar facing lines the contour of the cab tunnel of all Freightliner COEs. On FLAs, two tunnel liner panels, taped together longitudinally, line the cab tunnel. See **Fig. 1**. FLB COEs have one to three tunnel liner panels (depending on the cab length) that wrap around the entire width of the cab tunnel, from side to side. See **Fig. 2**. FLB COEs also have a plasticized foam sound barrier installed with rivets forward of the tunnel break. Aluminum strips secured with blind rivets are installed only at the extreme forward and rear edges of the tunnel.

Some cab-engine combinations are also equipped with noise shields. The noise shields are attached to the cab deck angles, on each side of the tunnel, and hang vertically. See **Fig. 3**. The liner panels on FLA COEs are attached to the tunnel and noise shields with double-faced adhesive tape or pressure-sensitive adhesive, and aluminum strips secured with blind rivets. On FLB COEs, the tunnel liners are attached to the tunnel with nylon "Christmas tree" type retainers, and double-faced adhesive tape or pressure-sensitive adhesive.

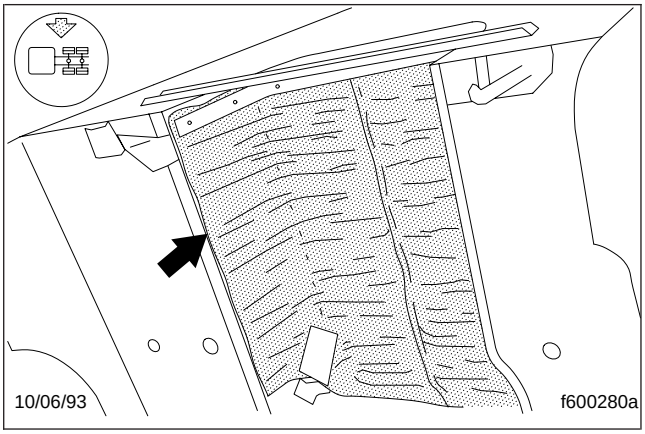
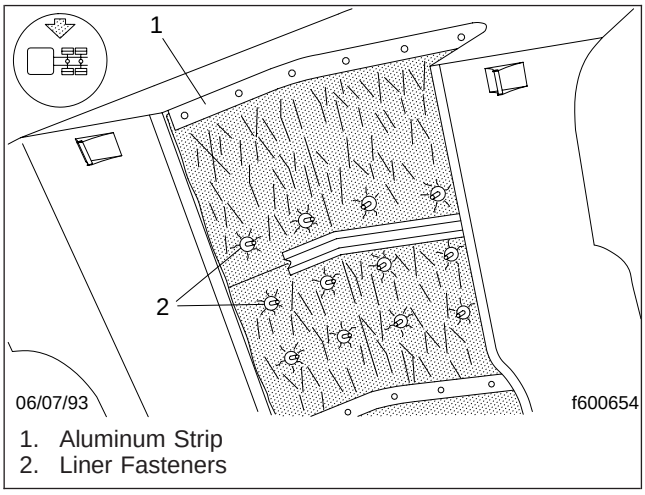


Fig. 1, Tunnel Liner, FLA



1. Aluminum Strip
2. Liner Fasteners

Fig. 2, Tunnel Liner, FLB

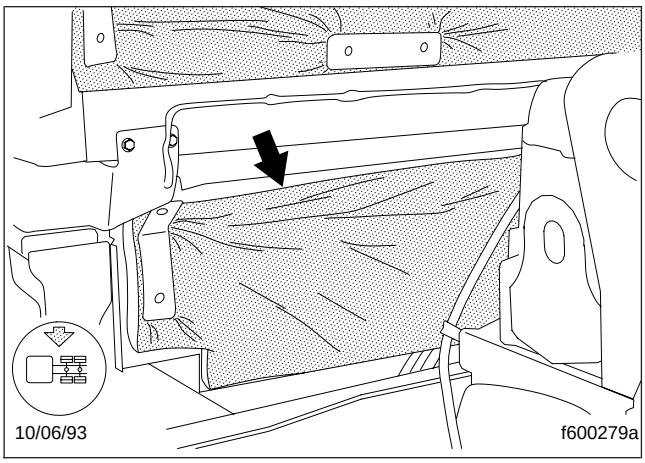


Fig. 3, Noise Shield Liner, FLA Shown

Repair

DANGER

Before doing the work below, review the cab tilting information under the cab tilt section. Failure to read the warnings and to be aware of the dangers of tilting and lowering the cab could result in serious injury or death.

1. Tilt the cab to the full-open position. See **Group 60** for instructions.
2. Repair small tears in the mylar facing or in the tape-sealed edges of the lining panels by first cleaning the mylar facing, then patching the torn area with 2-inch (51-mm) wide aluminized polyester sealant tape or duct tape.

IMPORTANT: If tears in the lining panels have allowed water or oil to soak into the acoustical foam, replace the lining panel. See **Subject 110** for instructions.

3. Replace any loose or missing aluminum strips and blind rivets. On FLBs, replace any nylon retainers or washers that hold the lining in place. See **Fig. 1** or **Fig. 2**.
4. Secure any detached areas of the lining by using contact cement on the lining panel and tunnel or noise shield surface, and holding the lining in place until the contact cement bonds.
5. Tilt the cab back to the operating position and lock it in place. See **Group 60** for instructions.

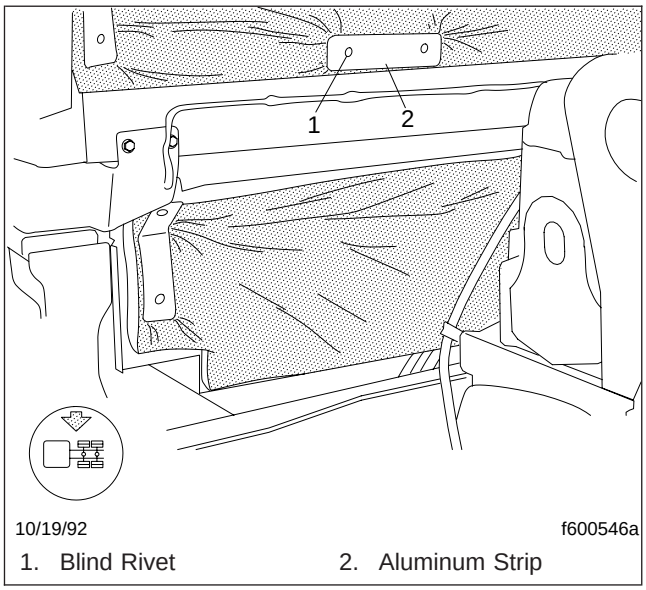


Fig. 1, Liner Fasteners

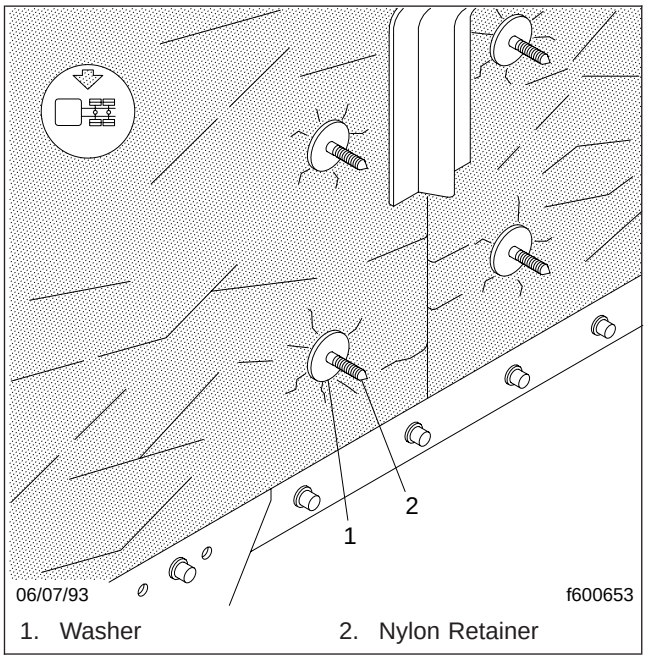


Fig. 2, Liner Fasteners

Replacement

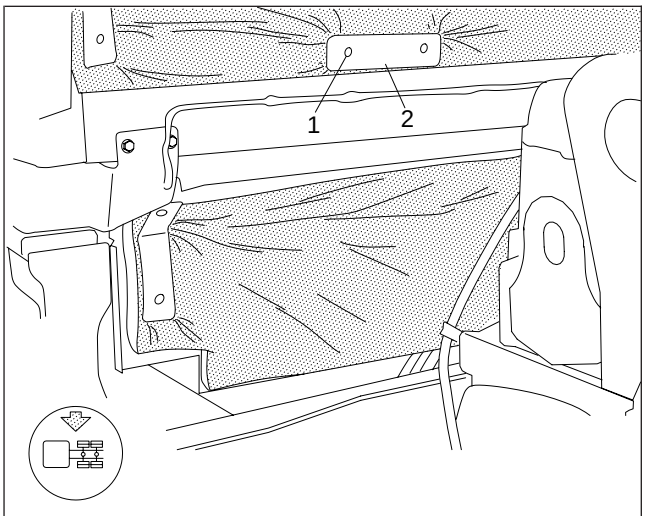
⚠ DANGER

Before doing the work below, review the cab tilting information under the cab tilt section. Failure to read the warnings and to be aware of the dangers of tilting and lowering the cab could result in serious injury or death.

1. Tilt the cab to the full-open position. See **Group 60** for instructions.
2. If applicable, drill out the blind rivets that attach the aluminum strips that hold the liner panel to be replaced. See **Fig. 1**. Remove the aluminum strips.

   For FLAs, if only one tunnel liner panel is being replaced, carefully remove the aluminized polyester sealant tape to separate the two panels.

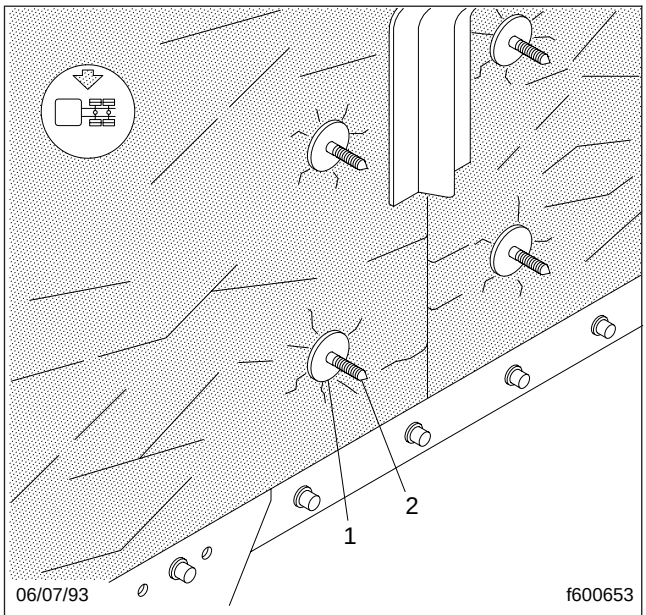
   For FLBs, remove the retainer washers from the panel being removed. See **Fig. 2**.



1. Blind Rivet
2. Aluminum Strip

Fig. 1, Liner Fasteners

3. Pull the lining and adhesive tape from the tunnel or noise shield.
4. Using a wire brush, clean the surface from which the lining was removed. Then, steam clean the area thoroughly, and allow it to air dry.



1. Nylon Retainer
2. Washer

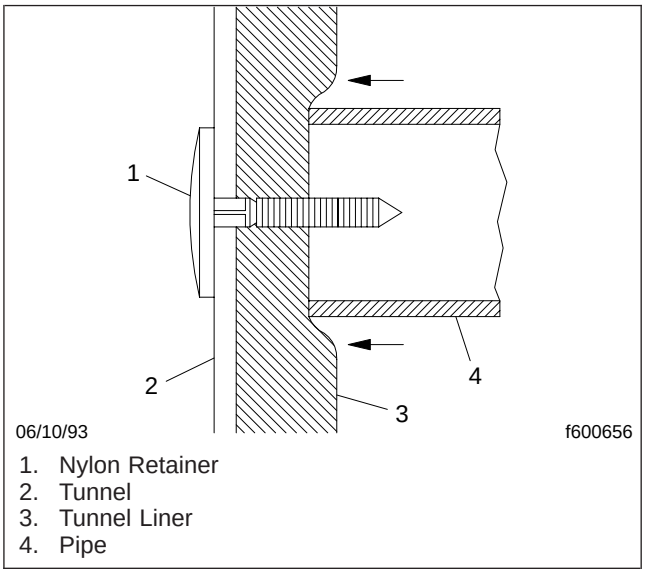
Fig. 2, Liner Fasteners

5. Apply double-faced adhesive tape 48–02268–520 around the outside edge of the back (dull side) of the replacement panel. Apply tape horizontally across the panel at 7-inch (18-cm) intervals. Do not overlap strips of tape.
6. For FLAs, remove the backing strip from the tape and line the panel up on the tunnel or noise shield. Lightly press the panel in place.

   Apply aluminized polyester sealant tape or duct tape to the seam between the two panels.

   For FLBs, remove the backing strip from the tape. If the new panel has pre-punched holes, line up the holes with the nylon retainers, then push the liner in place so the retainers protrude through the holes. If the new panel doesn't have holes in it, carefully position the panel, then starting at one end, push the panel over a nylon retainer, using the end of a pipe, as shown in **Fig. 3**. Repeat until all the retainers are through the panel, then install a retainer washer on each retainer.
7. Once the panel is in place, use a roller to press it securely in place.

Liner Replacement



1. Nylon Retainer
2. Tunnel
3. Tunnel Liner
4. Pipe

Fig. 3, Pushing the Panel Over the Retainer

8. Using blind rivets, install the aluminum strips that attach the panel to the tunnel or noise shield. Install the strips in their original locations.
9. Tilt the cab back to the operating position and lock it in place. See **Group 60** for instructions.

General Description

The TwinFlow midship-mounted fire pump is a centrifugal pumping system designed to deliver large volumes of water under pressure. See **Fig. 1**.

Generally, the pump consists of the following major components:

- cast-iron pump body
- bronze impeller(s) and a stainless steel shaft
- pump gear box
- priming system
- pressure control device
- valves

There are numerous other components, such as the AutoLube and the mechanical seal.

Pump type is determined by the number of impellers on a common shaft. The impeller, which is mounted on a shaft rotated by the vehicle's engine via the driveline, provides velocity to the water causing it to build enough pressure and volume to be used for firefighting applications. See **Fig. 2**.

Bearings support and align the impeller shaft and other components. The bearings must be maintained on a scheduled basis.

The pump body is split horizontally in two sections for the ease of removal of the impeller assembly, including the bearings and the clearance rings.

The pump gear box and the impeller assembly are removable from the bottom of the vehicle in order to avoid interference with the pump plumbing and control mechanisms.

The pump has two large suction inlets, one on each side of the vehicle, though other inlets may be present. The inlets and the internal pump outlets are on opposite sides of the pump to balance forces caused by the intake and the discharge of water.

The AutoLube is built into the pump assembly to continuously force oil to the impeller shaft bushing to lubricate and cool the impeller bushing.

Principles of Operation

A centrifugal pump such as the TwinFlow fire pump operates on the principle wherein centrifugal force is created by a rapidly spinning disk, or impeller. Water is routed to the center of the impeller, which throws the water outward from the center of the impeller. When water is confined in a closed container, in this instance, the pump body, the water pressure increases. The pressure level depends on how fast the impeller is rotating.

Water enters the spinning impeller at the intake and is confined by shrouds and vanes in the impeller, which, in turn, builds pressure.

The vanes guide the water away from the inlet to the discharge to reduce the water's turbulence and to move the water toward the outer edge of the impeller.

The shrouds serve as the sides of the impeller and confine the water to the centrifugal acceleration.

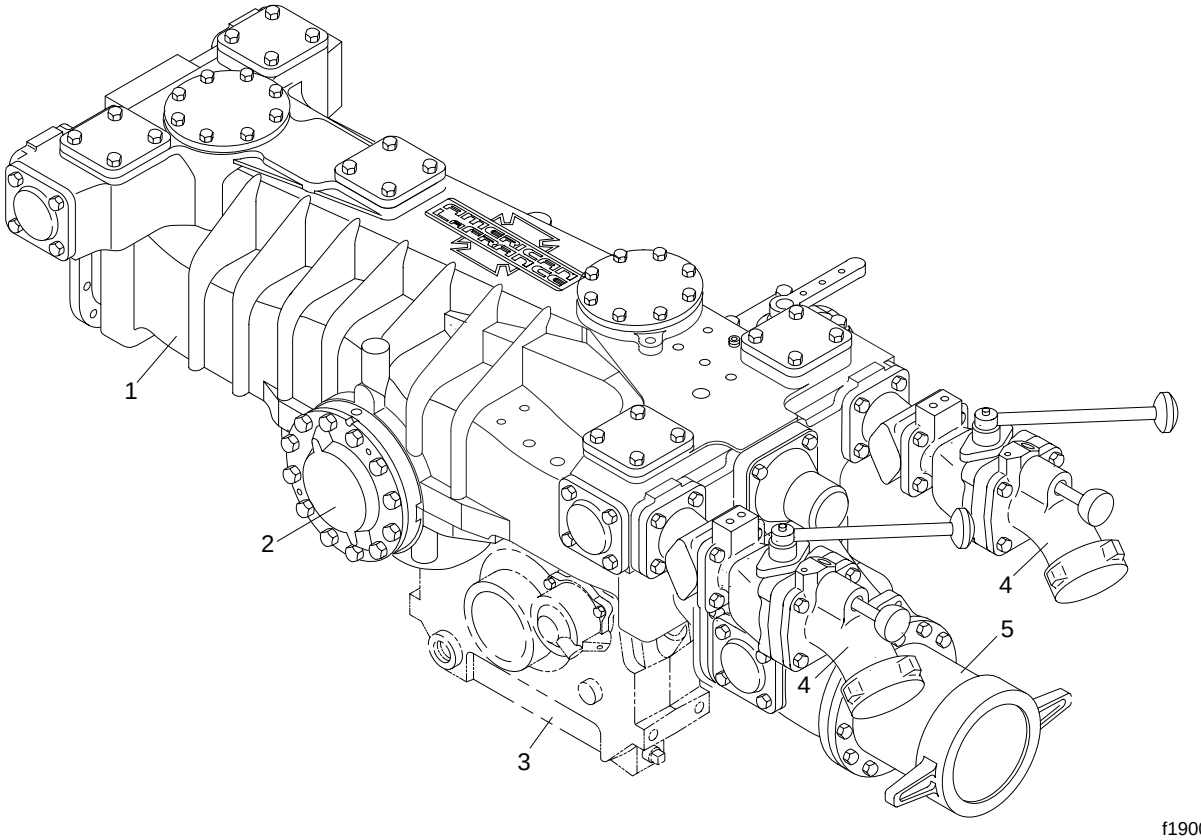
Single-stage pumps provide the same operating and rating-test pressures as a two-stage pump, but the two-stage pump offers additional operating (water) pressure.

The primary difference between a single-stage and a two-stage pump is that the single-stage has only one impeller and no transfer valve to switch between volume and pressure operation. A transfer valve is a two-position valve that permits the impellers in a two-stage pump to operate in parallel (volume) or series (pressure).

In two-stage pumps, the volume operation results in the pressure at the pump intake being added to the equal pressure developed by the impellers, and the amount of water sent to the discharge being the sum of the flows of the two impellers. The pressure operation features the impellers operating in series, or the output of the primary impeller supplied from the pump intake is supplied to the input of the secondary impeller. Thus, the pressure at the pump discharge is the sum of the pressures of the two impellers plus the pressure at the intake. The flow is then half of the volume operation.

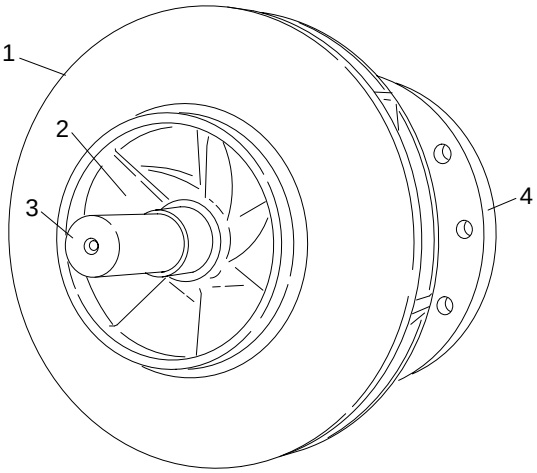
In both types of pumps, the pressurized water is prevented from returning to the intake of the impeller(s) by clearance rings. Centrifugal pumps have clearance rings mounted between the spinning impeller and the pump body. Clearance rings and the hubs of the impeller(s) will, over time, become worn or pitted and may need to be replaced or machined to a smaller diameter.

General Information



1. Pump Body
2. AutoLube
3. Gear Box
4. Discharge
5. Intake

Fig. 1, TwinFlow Fire Pump (single-stage shown)



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1. Shroud
2. Impeller Eye
3. Shaft
4. Mechanical Seal Housing

Fig. 2, TwinFlow Fire Pump Gear Box

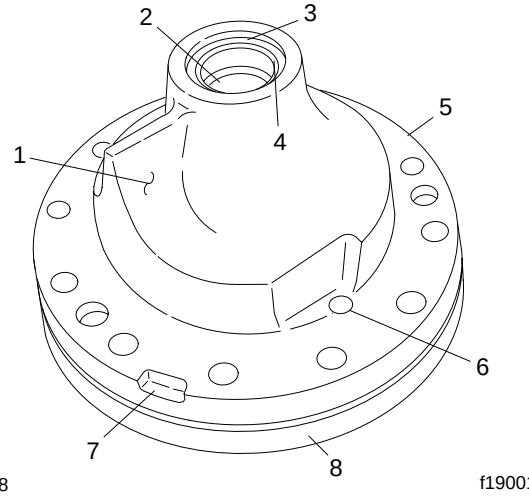
Replacement

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Drain the water from the pump.
3. Remove the fill and drain plugs from the AutoLube reservoir and drain the oil.
4. Use a center punch to mark the AutoLube cover and the front bearing housing for proper alignment during assembly.

CAUTION

Do not use a chisel to separate the AutoLube from the pump body because the mating surfaces may be scratched or gouged, which could result in a leak. The AutoLube is manufactured from cast metal and if it becomes necessary to pry the AutoLube apart from the pump body, pry between the AutoLube and the pump body or at the AutoLube notches.

5. Remove the 1/2–13 x 2 capscrews attaching the AutoLube to the pump body and gently pry the AutoLube from the pump body and impeller shaft.
6. Place the AutoLube face down on a work bench and remove the two 3/8–16 x 3/4 allen-head capscrews from the impeller side. Separate the two halves and remove the diaphragm.
7. Remove the seal lock ring.
8. Remove the oil seal from the inner half of the AutoLube.
9. Check the impeller shaft bushing for wear.
10. Clean the inner and outer halves of the AutoLube.
11. Clean the gasket surfaces of the AutoLube and the pump body.
12. Check for restrictions in the water passages to the rear half of the AutoLube.
13. If it is necessary to replace the impeller shaft bushing, press the bushing from the inner side of the inner half of the AutoLube (on the side opposite of the impeller). Install the bushing from the impeller side of the inner half of the AutoLube. See **Fig. 1**.



1. Cut Water
2. Bushing
3. Lock Ring
4. Seal
5. Front Bearing Housing
6. Water Passage
7. Pry Notches
8. AutoLube Cover

Fig. 1, Impeller Shaft Bushing

CAUTION

The impeller shaft bushing seats against a shoulder in the inner half of the AutoLube and can only be removed and installed as described or the AutoLube may be damaged.

14. Install the new oil seal in the inner half of the AutoLube.
15. Install the seal lock ring.
16. Position the diaphragm on the inner half of the AutoLube.
17. Line up the marks and place the outer half of the AutoLube onto the inner half. Apply Loctite® 242 to the two 3/8–16 x 3/4 allen-head capscrews. Tighten 30 lbf·ft (41 N·m).
18. Install the new gasket on the AutoLube and position the assembly (with the top up) onto the impeller shaft. Attach the AutoLube with 1/2–13 x 2 capscrews and tighten 80 lbf·ft (108 N·m).

AutoLube Seal Replacement

CAUTION

Do not damage the oil seal. A damaged oil seal could result in damage to the AutoLube assembly as well as the pump.

19. To fill the AutoLube with 90w oil, pump the oil in from the bottom plug opening until the oil spills from the top opening. This eliminates air pockets and false readings.

CAUTION

Purge the air from the AutoLube while filling it with oil or a "false-fill" situation will develop, which could cause damage to the AutoLube and other components.

20. Add water to the pump.
21. Operate the fire pump and check the AutoLube for water or oil leaks.
22. Remove the tire chocks.

Fire Pump Gearbox Removal, Disassembly, Assembly, and Installation

Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Drain the water from the pump.
3. Drain the gearbox lubricant to prevent contamination.
4. Disconnect the pressure lubrication line to the gearbox cover. Keep the line primed with lubricant.
5. Disconnect the drive shafts from the gearbox.
6. Disconnect the electrical switches and the air lines. Mark the switches and air lines for assembly.
7. Disconnect the pump gearbox cooling lines.

⚠ WARNING

The gearbox is heavy. Support the gearbox with a lifting or supporting device while removing it from the pump body. Failure to do so could result in the gearbox falling, which could result in personal injury or property damage.

NOTE: Before removing the gearbox, use a center punch to mark the rear bearing housing, the mechanical seal housing, the oil pump cover, and the pump body to ensure proper alignment during reassembly.

8. Support the gearbox with an appropriate device.
9. Remove the six 1/2–13 x 1-3/4 capscrews that attach the gearbox cover to the top of the gearbox.
10. Remove the 7/16–14 x 1-1/4 capscrews that attach the gearbox to the rear bearing housing.
11. Lower the gearbox. Be sure to balance the gearbox so that it does not tip from the lowering device. See **Fig. 1**.
12. Remove the gearbox cover.

NOTE: The threaded holes may need to be cleaned.

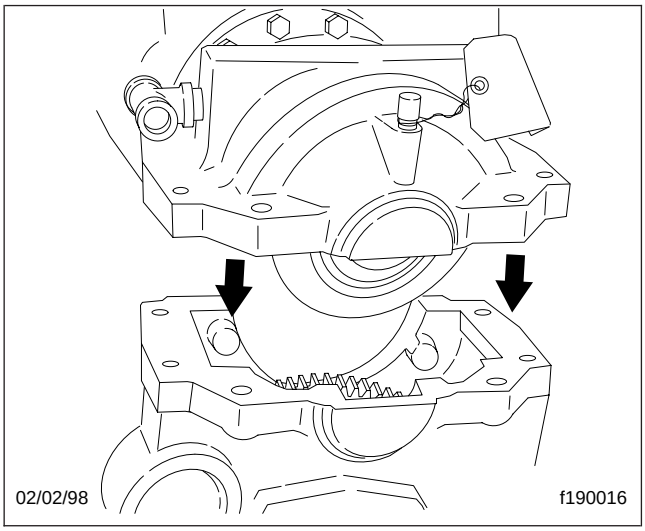


Fig. 1, Lowering the Fire Pump Gearbox

Disassembly

1. Remove and disassemble the intermediate shaft assembly.
   - 1.1 Disconnect the oil suction line from the lubrication pump.
   - 1.2 Remove the capscrews attaching the front bearing housing to the lubrication pump. Then remove the housing and pump assembly.

   NOTE: The rear bearing housing has threaded holes for 1/4–20 jackscrews to assist in removal.

   - 1.3 Remove the capscrews attaching the rear bearing housing to the lubrication pump.
   - 1.4 Reach into the top of the gearbox housing and remove the intermediate gear and shaft assembly. The bearing inner cups are pressed onto the shaft, so care must be taken not to damage the cups during removal.
   - 1.5 Using a bearing splitter, clamp the halves of the splitter onto the back edge of the intermediate shaft bearing cup. Attach a crossbar puller to the bearing splitter halves and remove the cup. Care must be taken when removing the cup not to damage the lubrication pump spline in the

Fire Pump Gearbox Removal, Disassembly, Assembly, and Installation

center of the intermediate shaft. Repeat the procedure for the opposite side bearing cup.

1.6 Using a gear puller with reversed jaws, remove the intermediate shaft bearing cone from the intermediate shaft rear cover.

⚠ CAUTION

Lubrication pump impeller vanes are fragile and may break or chip. Impeller vanes are installed only one way. If removal of the vanes is necessary, note the installation direction of the vanes (rounded edge). Failure to install the vanes properly will result in pump gearbox failure.

1.7 When disassembling the lubrication pump, be sure to note the number of gaskets and shims that are under the cover. Set these components aside for reassembly.

1.8 Using a centerpunch, mark the lubrication pump position and remove the six 1/4–20 x 5/8 capscrews.

1.9 Remove the lubrication pump cover.

1.10 Remove the lubrication pump impeller and the shaft, being careful not to damage the impeller vanes.

1.11 Using a gear puller with reversed jaws, remove the intermediate shaft bearing cone from the intermediate shaft front cover. Care must be taken when removing the cup so as not to damage the lubrication pump spline in the center of the intermediate shaft cover.

2. Remove and disassemble the output shaft assembly.

2.1 Remove the manual shift eye from the rear of the shift yoke shaft.

2.2 Remove the detent allen-head screw, spring and detent ball from the top of the output shaft housing.

2.3 Remove the shift and interlock switches on the output shaft housing.

2.4 Remove the 7/16–14 x 2-1/4 capscrews retaining the output shaft and the housing to the gearbox housing. Carefully remove the output shaft housing by sliding the housing from the shift yoke shaft.

2.5 Remove the input shaft pilot bearing from the output shaft.

2.6 Remove the 3/4–10 x 1-1/2 capscrew retaining the rear driveline yoke to the output shaft and remove the yoke.

2.7 Remove the output shaft seal.

2.8 Remove the output shaft by sliding it from the output shaft housing from the rear to the front. Use caution when sliding the output shaft through the bearing cones and spacer(s).

⚠ CAUTION

Bearing cups, cones, and spacers are factory preset for end play and are only provided as a matched set. It is important that bearing cups, bearing cones, and spacers, when removed, be kept together in matched sets. Input and output shaft bearing and spacer sets are different. Failure to keep matched sets together or to not use factory preset and matched bearing and spacer sets will void warranty and may result in gearbox failure.

2.9 Remove the inner and outer bearing cones.

2.10 Using a brass drift, carefully drive out the outer bearing cup from the inside out. Remove the internal retaining ring and then the spacer(s).

2.11 Using a brass drift, carefully drive out the inner bearing cup from the outside in.

2.12 Remove the shaft seal from the output shaft housing.

3. Remove and disassemble the input shaft assembly.

3.1 Remove the three 5/16–18 x 1 capscrews from the shift cylinder and carefully slide the shift cylinder from the piston.

3.2 Remove the nut and then remove the piston from the shift shaft. Remove the seal ring from the piston.

Fire Pump Gearbox Removal, Disassembly, Assembly, and Installation

CAUTION

Do not remove the piston from the shift yoke shaft unless it is damaged and replacement is mandatory. When installing a new piston, replace the locknut and tighten snugly, but do not overtighten as the nut can become distorted, which can cause shift failures.

3.3 Remove the shift shaft, the shift fork, and the shift ring assembly from the gearbox. Make sure the shift ring does not get dropped or damaged.

3.4 Note the location and orientation of the shift fork on the shaft, then remove the 3/8–16 x 1-1/4 screw from the shift fork and remove the fork from the shift shaft.

3.5 Remove the shift shaft support block. Then remove the seal from the support block.

NOTE: One ear of the shift yoke is machined and will fit one way. Make a note of the location of the machined ear when removing the shift yoke.

3.6 Remove the 3/4–10 x 1-1/2 capscrew attaching the front driveline yoke to the input shaft. Remove the yoke.

3.7 Remove the input shaft by sliding the input shaft from the output shaft housing opening at the rear of the gearbox. Use caution when sliding the input shaft through the bearing cones, the thrustwasher, and the drive gear. Place wooden blocks to support the drive gear and to protect the windage tray, and force the shaft loose.

CAUTION

Bearing cups, cones, and spacers are factory preset for end play and are only provided as a matched set. It is important that bearing cups, bearing cones, and spacers, when removed, be kept together in matched sets. Input and output shaft bearing and spacer sets are different. Failure to keep matched sets together or to not use factory preset and matched bearing and spacer sets will void warranty and may result in gearbox failure.

There are two bearings of different widths supporting the drive gear on the input shaft. It is important that these bearings be installed in the drive gear in the proper location. Note the location of the bearings when removed. Failure to install the bearings properly can result in gearbox failure.

3.8 Reaching through the top of the gearbox housing, carefully remove the drive gear, the inner bearing cone, and thrustwasher. Remove the drive gear bearings.

3.9 Using a magnet, remove the positioning pins from the windage tray. Then remove the windage tray and the positioning springs.

3.10 Remove the input shaft seal.

3.11 Remove the outer bearing cone.

3.12 Using a brass drift, carefully drive out the outer bearing cup from the inside out. Remove the internal retaining ring and the spacer(s).

3.13 Using a brass drift, carefully drive out the inner bearing cup from the outside in.

4. Inspect the cooling tube for damage and leaks.
5. Remove the gearbox lubrication oil filter from the suction inlet on the gearbox housing.
6. Clean and inspect each component of the gearbox assembly. Inspect the bearing cups and the cones for wear, pitting, and damage. Inspect the gear tooth surfaces for wear damage and pitting. Inspect the shift shaft block for wear. Inspect the gasket surfaces for nicks and gouges. Replace all components that are worn, damaged, or pitted.

Assembly

1. Install a new transmission lubrication oil filter.
2. Assemble and install the input shaft assembly.

CAUTION

Bearing cups, cones, and spacers are factory preset for end play and are only provided as a matched set. It is important that bearing cups, bearing cones, and spacers, when removed, be

Fire Pump Gearbox Removal, Disassembly, Assembly, and Installation

kept together in matched sets. Input and output shaft bearing and spacer sets are different. Failure to keep matched sets together or to not use factory preset and matched bearing and spacer sets will void warranty and may result in transmission failure.

2.1 Using a brass drift or a bearing cup installation tool, install the inner bearing cup from the inside out. Then install the spacer(s) and insert the retaining ring.

2.2 Using a brass drift or a bearing cup installation tool, install the outer bearing cup from the outside in.

2.3 Coat the outer bearing cone with oil. Install the outer bearing cone.

2.4 Install the input shaft seal.

2.5 Install the windage tray positioning springs and windage tray. While holding the windage tray in place against the positioning springs, install the windage tray positioning pins.

⚠ CAUTION

There are two bearings of different widths supporting the drive gear on the input shaft. It is important that these bearings be installed in the drive gear in the proper location. The location of the bearings should have been noted when removed from the assembly. Make sure that the lubrication holes are aligned in the center of the larger bearing. Failure to install the bearings properly may result in transmission failure.

2.6 Coat the new drive bearings with oil and install in the drive gear.

2.7 Coat the inner bearing cone with oil and install. Then install the thrustwasher.

2.8 Reaching through the top of the transmission housing, install the drive gear into position against the thrustwasher, being careful not to dislodge the windage tray.

2.9 Slide the input shaft through the output shaft housing opening at the rear of the transmission through the drive gear, the thrustwasher, and the bearing cones and spacer(s).

2.10 Install the front driveline yoke on the input shaft, being careful to not damage the input shaft seal. Apply Loctite® 242 to the 3/4–10 x 1-1/2 yoke retaining capscrew. Then install the capscrew and washer and tighten 225 lbf·ft (305 N·m).

NOTE: Apply a coat of Loctite® to all screws prior to reassembly.

NOTE: One ear of the shift yoke is machined and it will only fit one way. Make sure the yoke is oriented on the shaft in the position noted during disassembly.

2.11 Make sure the shift fork is properly aligned (the machined side should be toward the threaded end of the shift shaft) and slide the new shift fork on the shift shaft. Align the shift fork with the groove in the shaft and secure the shift fork in place with a 3/8–16 x 1-1/4 screw. Tighten the screw 33 lbf·ft (45 N·m).

2.12 Install a new seal on the shift shaft support block. Install a new gasket on the shift shaft support block. Install the shift shaft support block and gasket in the gearbox using two 1/4–20 x 5/8 capscrews. Tighten the capscrews 96 lbf·in (1085 N·cm).

2.13 Place the shift ring into the shift fork grooves. While holding the shift ring in place, insert the shift shaft into the gearbox through the bushing. Make sure the teeth on the shift shaft ring line up with the teeth on the input shaft and gear.

2.14 Apply a light coating of grease to the new seal ring, then install the seal ring on the shift piston. Install the piston on the shift shaft end.

⚠ CAUTION

When installing the piston, use a new locknut and tighten snugly but do not overtighten. Overtightening the locknut may distort the piston and cause shift failures.

2.15 Secure the piston in place with a new locknut.

2.16 Apply a light coating of grease to the shift cylinder seal and install the seal in the groove on the shift cylinder.

2.17 Install the shift cylinder using three 5/16–18 x 1 screws. Tighten the screws 17 lbf·ft (23 N·m).

3. Assemble and install the output shaft assembly.

3.1 Install a new shift shaft seal in the output shaft housing.

⚠ CAUTION

Bearing cups, cones, and spacers are factory preset for end play and are only provided as a matched set. It is important that bearing cups, bearing cones, and spacers, when removed, be kept together in matched sets. Input and output shaft bearing and spacer sets are different. Failure to keep matched sets together or to not use factory preset and matched bearing and spacer sets will void warranty and may result in transmission failure.

3.2 Using a brass drift or a bearing cup installation tool, install the inner bearing cup from the inside out. Install the spacer(s). Then install the retaining ring.

3.3 Using a brass drift or a bearing cup installation tool, install the outer bearing cup from the outside in.

3.4 Coat the outer bearing cone with oil and then install it.

3.5 Install the output shaft seal.

3.6 Apply a coating of oil to the inner bearing cone and install.

3.7 Apply a coating of oil to the input shaft pilot bearing and then install the bearing into the output shaft.

3.8 Install the output shaft by sliding the shaft in through the output shaft housing from the front to the rear. Be careful when sliding the output shaft through the bearing cones and spacer(s).

3.9 Install the rear driveline yoke on the output shaft, taking care not to damage the output shaft seal. Apply Loctite® 242 to the 3/4–10 x 1-1/2 capscrew. Then install the capscrew and washer and tighten 225 lbf·ft (305 N·m).

3.10 Install a new gasket onto the output shaft housing.

3.11 Apply Loctite® 242 to the two 7/16–14 x 2-1/4 and the four 7/16–14 x 1-3/4 capscrews. Then install the output shaft and housing, sliding the housing onto the shift yoke shaft. Install and tighten the 2-1/4-inch capscrews 50 lbf·ft (68 N·m) and the 1-3/4-inch capscrews 53 lbf·ft (72 N·m).

3.12 Install the shift and interlock switches on the output shaft housing.

3.13 Apply Loctite® 242 to the detent allen-head screw and install the detent ball, spring, and allen-head screw.

3.14 Install the manual shift eye from the rear of the shift yoke shaft.

3.15 Rotate the input shaft to check for proper movement.

4. Assemble and install the intermediate shaft assembly.

4.1 Press a new bearing cone into the intermediate shaft rear cover, coat the cone with oil and install a new cover seal.

4.2 Press a new bearing cone into the intermediate shaft front cover, coat the cone with oil and install a new cover seal.

⚠ CAUTION

Lubrication pump impeller vanes are fragile and may break or chip. Impeller vanes are installed only one way. If removal of the vanes is necessary, note the installation of the vanes. Failure to install the vanes properly will result in transmission failure.

IMPORTANT: To ensure proper operation of the oil pump, use the same number of gaskets and shims that were removed when the oil pump was disassembled.

4.3 Install the lubrication pump impeller assembly, vanes, and shaft into the front cover aligning the matchmarks. Apply Loctite® 242 to the six 1/4–20 x 5/8 capscrews and tighten 8 lbf·ft (11 N·m).

Fire Pump Gearbox Removal, Disassembly, Assembly, and Installation

4.4 Press the new bearing cups onto the intermediate shaft, one on each side of the intermediate gear.

4.5 Reaching through the top of the transmission housing, install the intermediate gear and shaft assembly taking care not to damage the bearing cups.

4.6 Holding the intermediate gear assembly in place, install the rear intermediate shaft cover. Apply Loctite® 242 to the three 7/16–14 x 1-1/4 capscrews and install but do not torque.

4.7 Install the front intermediate shaft cover, aligning the lubrication pump shaft spline with the intermediate shaft spline. Apply Loctite® 242 to the three 7/16–14 x 1-1/4 capscrews and tighten all six capscrews 53 lbf·ft (72 N·m).

4.8 Connect the oil suction line to the lubrication pump.

4.9 Rotate the input shaft and manually shift the transmission to check for proper movement and operation.

Installation

1. Install a new gasket on the seating surface of the rear bearing housing.

⚠ CAUTION

Properly align the rear bearing housing. If the rear bearing housing is not aligned with the matchmarks, the gear tooth mesh could be incorrect and may result in damage to the gearbox.

2. Using a lifting device, lift the gearbox into position (around the rear bearing housing). Apply Loctite® 242 to the six 1/2–13 x 1-3/4 capscrews and attach the gearbox cover to the gearbox. Tighten finger-tight, but do not torque.
3. Apply Loctite® 242 to the twelve 7/16–14 x 1-1/4 capscrews and insert the capscrews through the rear bearing housing cover and gasket into the gearbox. Tighten 53 lbf·ft (72 N·m).
4. Tighten the six 1/2–13 x 1-3/4 capscrews 65 lbf·ft (88 N·m).
5. Connect the pump gearbox cooling lines.
6. Connect the air lines and electrical switches.
7. Connect the drive shafts. Tighten the yoke fasteners 225 lbf·ft (305 N·m) and tighten the bearing retaining strap capscrews 40 to 48 lbf·ft (54 to 65 N·m).
8. Connect the lubrication line to the gearbox cover.
9. Fill the gearbox with the necessary lubricant.
10. Operate the pump and check for leaks. Verify the oil pressure at 25 to 35 psi (172 to 241 kPa) at the oil injection point.
11. Remove the chocks from the front and rear tires.

Replacement

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Drain the water from the pump.

⚠ WARNING

The gearbox assembly is heavy. Support the lower gearbox assembly with a lifting device. Failure to do so could result in the assembly falling, which could result in personal injury or property damage.

3. Remove the gearbox. See **Subject 110** for information.
4. Remove the 5/8–11 x 1-1/4 capscrew and bearing retaining washer from the end of the impeller shaft.
5. Remove the twelve 1/2–13 x 1-3/4 capscrews that attach the rear bearing housing to the pump body.
6. Install two 1/2–13 x 3 jackscrews into the 1/2–13 threaded holes provided in the rear bearing housing. See **Fig. 1**.
7. Use a centerpunch to mark the rear bearing housing, the mechanical seal housing, and the pump body so that the components are properly aligned during assembly.
8. Turn the two jack screws evenly, clockwise, to push the rear bearing housing from the impeller shaft and pump body.

NOTE: To prevent damage to components as the rear bearing housing is pushed from the impeller shaft, place your hands under the gear opening to catch the gear, key, and bearings.

NOTE: It may be necessary to use pry bars to gently assist in removing the inner bearings and gear.

9. Remove the jack bolts.
10. Remove the slinger from the impeller shaft.
11. Remove the four 7/16–14 x 1-1/4 capscrews from the mechanical seal cover. See **Fig. 2**. Use a center punch to mark the seal cover for proper alignment during installation.
12. Use pry bars if necessary in the provided slots to loosen the mechanical seal cover from the impeller shaft and the pump body.
13. Remove the old mechanical seal, being careful not to damage the impeller shaft. Use two small hook-tools positioned about 180 degrees apart to pull the mechanical seal from the seal cavity if necessary.
14. Clean the seal cavity and the impeller shaft.
15. Inspect the retaining ring on the shaft.
16. Remove the burrs at the gear key slot and the bearing lands, and remove the oil seal in the rear bearing housing. See **Fig. 3**.

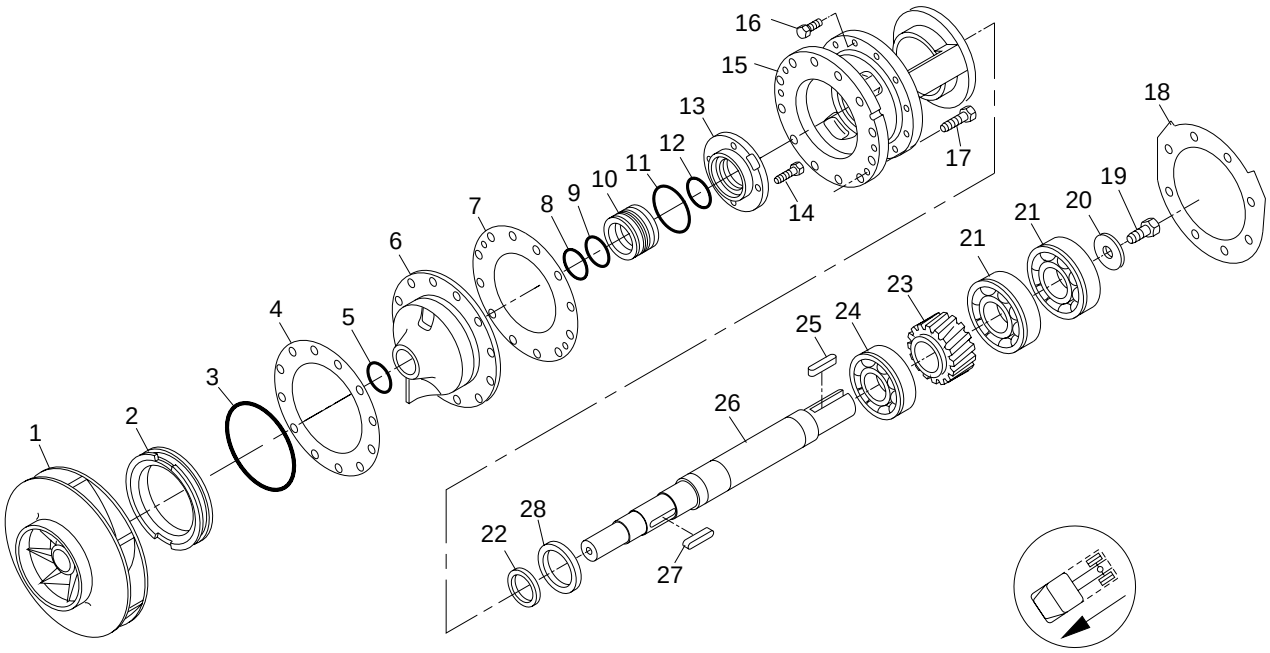
IMPORTANT: Always replace the entire mechanical seal with a new TwinFlow mechanical seal assembly.

⚠ CAUTION

When installing a new mechanical seal do not touch the sealing surface of the carbon seal ring or the metal seat while handling or installing. Oil and grease can damage the bellows of the mechanical seal. Use only a soap-and-water solution to lubricate the mechanical seal.

17. Clean the housing and the impeller shaft, and lubricate the impeller shaft and the new mechanical seal with a soap-and-water solution.
18. Install the new mechanical seal bellows over the end of the impeller shaft with the spring oriented toward the impeller. Using a soft pusher tube and keeping your fingers away from the carbon seal, carefully push the mechanical seal assembly into the mechanical seal cavity. If binding occurs, apply more soap-and-water solution to the impeller shaft and the bellows.
19. Install the steel cup and seat it into the mechanical seal cover. Lubricate with a soap-and-water solution.
20. Remove and replace the seal rings in the mechanical seal cover. Apply the soap-and-water solution to the seal rings and then slide over the

Mechanical Seal Replacement



1. Impeller
2. Clearance Ring
3. Rear Bearing Housing Seal
4. Bearing/Seal Housing Gasket (impeller side)
5. Shaft Retaining Ring
6. Mechanical Seal Housing
7. Bearing/Seal Housing Gasket (mechanical seal side)
8. Shaft Seal Ring
9. Shaft Retaining Ring
10. Mechanical Seal And Steel Cup Assembly
11. Mechanical Seal Piston Ring
12. Shaft Seal Ring
13. Mechanical Seal Cover
14. Hexhead Screw, 7/16–14 x 1-1/4
15. Rear Bearing Housing
16. Hexhead Screw, 7/16–14 x 1-1/2
17. Hexhead Screw, 1/2–13 x 1-3/4
18. Rear Bearing Housing Gasket
19. Hexhead Screw, 5/8–11 x 1-1/4
20. Rear Bearing Washer
21. Bearing (aft)
22. Pump Shaft Slinger
23. Pump Shaft Gear
24. Bearing (forward)
25. Pump Shaft Gear Key
26. Pump Shaft
27. Impeller Key
28. Drive Unit Oil Seal

Fig. 1, Impeller Shaft Assembly (exploded view)

end of the impeller shaft. Make sure the mechanical seal remains seated in the bore of the cover.

21. Insert the mechanical seal cover into the mechanical seal cavity aligning it with the bolt holes and the orientation marks.
22. Insert the bolts in the mechanical seal housing to prevent the housing from rotating.
23. Install the four 7/16–14 x 1-1/4 capscrews. Tighten 53 lbf·ft (72 N·m).
24. Install the new slinger onto the impeller shaft. Then remove the retaining bolts.
25. Install the new gasket and oil seal in the rear bearing housing. Slide the housing and front bearing onto the rear impeller shaft. The bearing is a press-fit onto the impeller shaft and slip-fit in the housing.

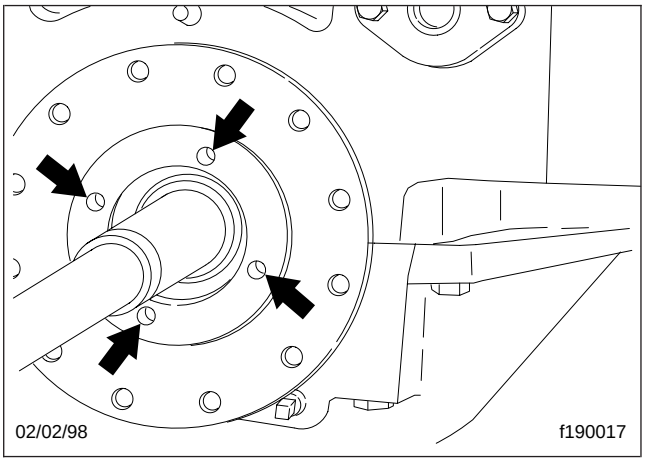
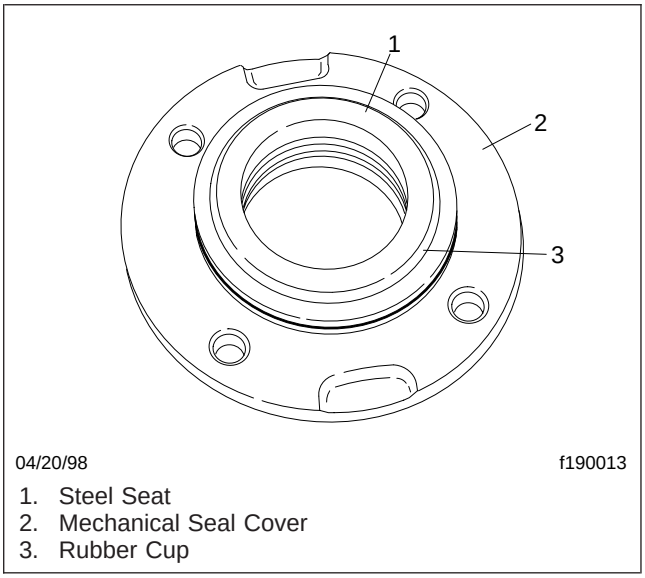


Fig. 2, Remove Four Capscrews



1. Steel Seat
2. Mechanical Seal Cover
3. Rubber Cup

Fig. 3, Mechanical Seal Assembly

IMPORTANT: Do not allow the weight of the rear bearing housing to rest on the oil seal.

26. Insert the gear through the opening in the housing and align it with the impeller shaft. Slide the housing, front bearing and gear onto the shaft. The front bearing will stop when the inner race contacts the seat on the impeller shaft.
27. Line up the keyway in the gear and install the key into the keyway.
28. Slide one of the two rear bearings onto the impeller shaft and into the housing. The rear bearings are a press-fit onto the shaft and a slip-fit in the housing.
29. Using a series of different length capscrews, install the rear bearing housing to the pump body. When it is possible, install the four capscrews (approximately 90 degrees apart). These bolts, in combination with the rear bearing, will center the housing. Double check to be sure the housing is centered and will clear the mechanical seal assembly.
30. Install the pusher bolt in the rear of the impeller shaft. Tighten the nut on the pusher bolt while holding the pusher bolt, pushing the rear bearing into the housing. Remove the pusher bolt and install the second of the two rear bearings. Then install the pusher bolt and tighten the nut while holding the pusher bolt to install the bearing.
31. Continue to tighten the nut on the pusher bolt while making sure the housing is aligned and centered. Once the pusher bolt is snug, the rear housing assembly, the gear, and the bearings should be in place. Remove the pusher bolt and rotate the impeller assembly by placing a large screwdriver between the housing and the gear. The impeller assembly should rotate.

NOTE: A new impeller will have some resistance when the impeller shaft is rotated.

32. Apply Loctite® 242 to the 5/8–11 x 1-1/4 bearing retainer capscrew. Install and tighten 80 lbf·ft (108 N·m).
33. Apply Loctite® 242 to the twelve 1/2–13 x 1-3/4 capscrews, install and tighten 80 lbf·ft (108 N·m).
34. Install the gearbox. See **Subject 110** for information.
35. Perform the annual service test on the pump. Check for leaks. Verify the oil pressure at 25 to 35 psi (172 to 241 kPa) at the oil injection point.
36. Remove the chocks from the front and rear tires.

Impeller Assembly Removal and Installation

Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Drain the water from the pump.

WARNING

The gearbox assembly is heavy. Support the lower gearbox assembly with a lifting device. Failure to do so could result in the assembly falling, which could result in personal injury or property damage.

3. Remove the gearbox. See **Subject 110** for information.

WARNING

The lower pump body is heavy. Support the lower pump body and impeller assembly with a lifting device. Failure to do so could result in the lower pump body and impeller assembly falling, which could result in personal injury or property damage.

4. Remove the drain lines from the lower pump body. See **Fig. 1**.
5. Drain the oil from the AutoLube and remove the 1/2–13 x 2 capscrews from the upper half of the AutoLube and pump body.
6. Remove the 7/16–14 x 1-1/2 capscrews from the upper half of the rear bearing housing and pump body.
7. Remove the 1/2–13 x 1-1/4 capscrews from the lower pump body.

WARNING

Do not remove the four capscrews, one in each corner of the lower pump body, until the lifting device is in position. Failure to do so could result in the lower pump body and impeller assembly falling, which could result in personal injury or property damage.

8. Position the lifting device into place with the lower pump body lifting adapter between the lifting device and the lower pump body.
9. Remove the 5/8–11 x 5 capscrews in each corner of the lower pump body.
10. Lower the lower pump body and impeller assembly. Be sure to balance the assembly so that it does not tip from the lifting device.
11. Remove the remaining capscrews from the lower half of the AutoLube, the rear bearing housing, and the lower pump body.

WARNING

The impeller assembly is heavy. Do not attempt to lift the assembly without the aid of another person or persons, or a lifting device. Failure to do so could result in the impeller assembly falling, which could result in personal injury or property damage.

12. Remove the remaining screws from the rear bearing housing and then from the lower pump body.
13. Lift the impeller assembly from the lower pump housing. See **Fig. 2**. Set the assembly aside.
14. Clean all gasket surfaces of the upper and lower pump bodies, as well as those on the AutoLube and the rear bearing housing face.
15. Clean the clearance ring and clearance ring seats in both the upper and lower pump body halves to remove all the buildup material so that the new clearance ring will seat properly.

NOTE: Pitting of the clearance rings may occur from the buildup material and the effects of corrosion. Once the seats are cleaned, any pitting on the clearance rings is considered normal.

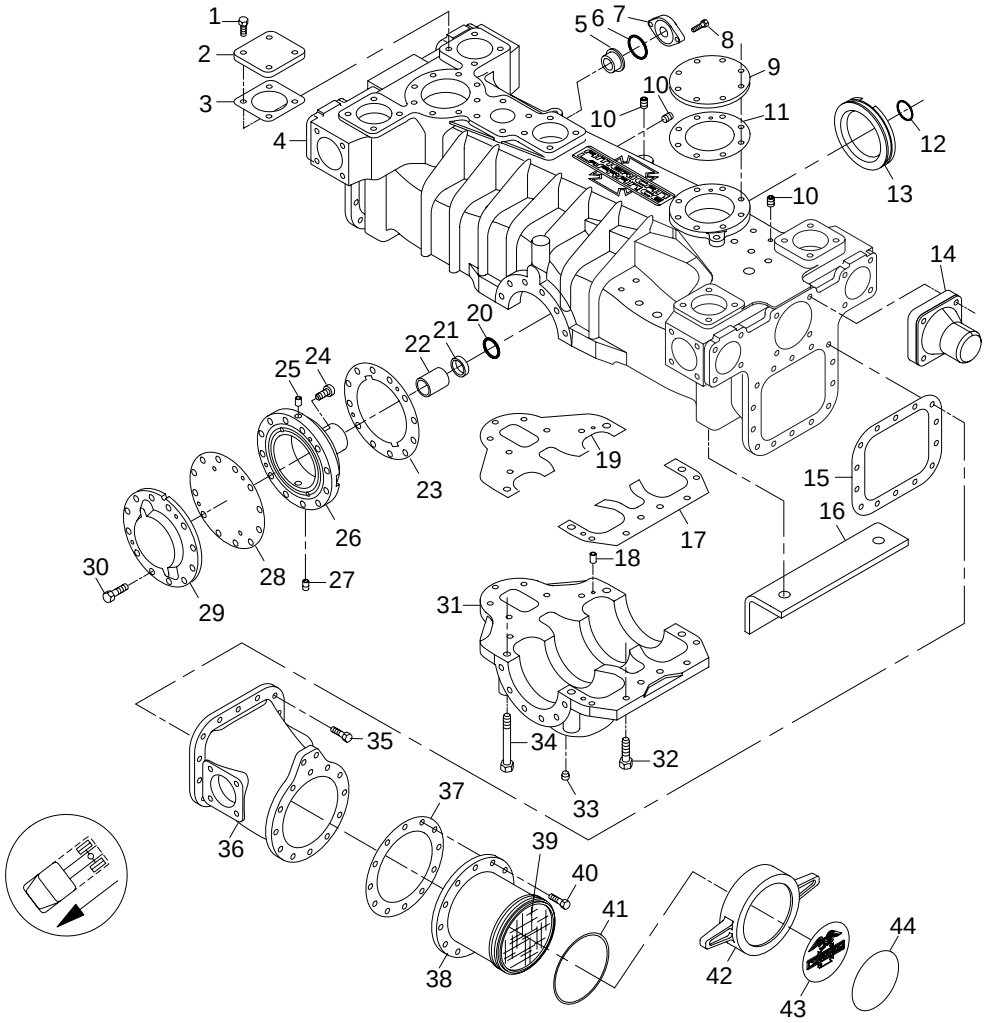
Installation

1. Install the pump body gaskets to the lower pump body, trimming as necessary to fit.

CAUTION

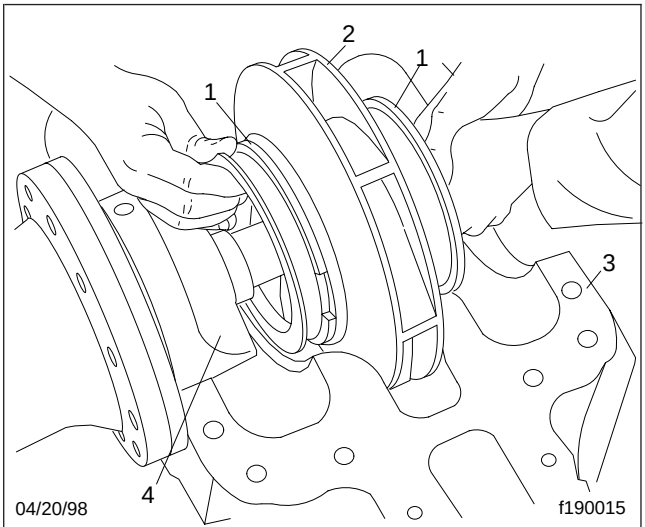
Failure to line up the clearance ring lock notches with the pump body tabs (as described in the next step) may result in pinched clearance rings, which could result in pump damage and pump failure.

Impeller Assembly Removal and Installation



1. Hexhead Screw, 7/16–14 x 1-1/4
2. Blank Flange
3. Flange Gasket
4. Upper Pump Body
5. Priming Valve Strainer
6. Priming Valve Plate Seal Ring
7. Priming Valve Plate
8. Hexhead Screw, 7/16–14 x 1-1/4
9. Tank Connection Flange
10. Plug, 1/4-inch
11. Tank Connection Gasket
12. Impeller Retaining Ring
13. Clearance Ring
14. QD Relief Valve Assembly
15. Suction Tube Extension Gasket
16. Pump Mounting Bracket
17. Pump Body Gasket (left side)
18. Dowel Pin
19. Pump Body Gasket (right side)
20. Oil Seal Retaining Ring
21. Front Bearing Housing Oil Seal
22. Front Bearing
23. Bearing/Seal Housing Gasket
24. Allen-head Screw, 3/8–16 x 3/4
25. Brass Socket Plug, 1/4-inch
26. Front Bearing Housing Assembly
27. Brass Socket Plug, 1/4-inch
28. Front Bearing Diaphragm
29. Front Bearing Cover
30. Hexhead Screw, 1/2–13 x 2
31. Lower Pump Body
32. Hexhead Screw, 1/2–13 x 1-3/4
33. Plug, 1/2-inch
34. Hexhead Screw, 5/8–11 x 5
35. Hexhead Screw, 1/2–13 x 1-1/4
36. Suction Tube Extension
37. Suction Tube Round Gasket
38. Suction Tube, 6-inch
39. Suction Strainer, 6-inch
40. Hexhead Screw, 7/16–14 x 1-1/4
41. Suction Cap Washer
42. Suction Cap
43. Medallion
44. Medallion O-Ring

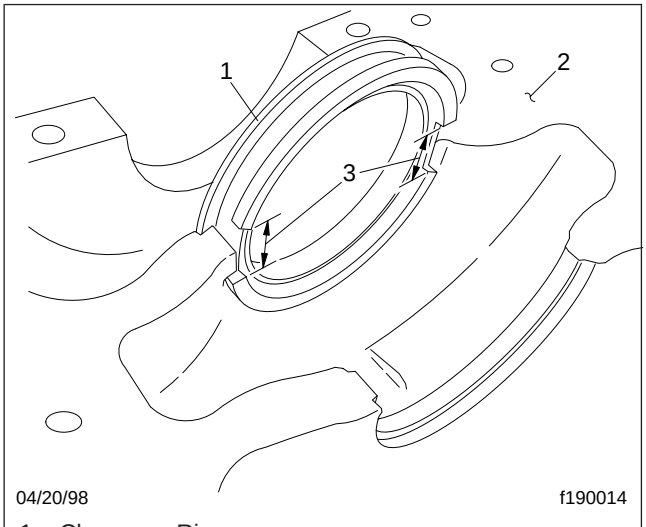
Fig. 1, Fire Pump Body Assembly (exploded view)



1. Clearance Ring
2. Impeller
3. Lower Pump Housing
4. Cut Water

Fig. 2, Lifting the Impeller Assembly from the Lower Pump Housing

2. Install the impeller assembly into the lower pump housing carefully aligning the clearance ring lock-notch with the clearance ring lock tabs in the lower pump body. Then rotate the clearance rings to one side to open up lock notches to line up with the lock tabs in the upper pump body. See **Fig. 3**.
3. Install the 1/2–13 x 1-3/4 capscrews through the rear bearing housing and the mechanical seal housing. Do not tighten.
4. Make sure the dowel pins are in the upper pump body to assist in aligning the lower pump body with the upper pump body.
5. Using a lifting device, slowly raise the lower pump body and the impeller assembly into place, making sure that the lower pump body aligns with the dowel pins and the clearance ring notches align with the clearance ring lock tabs in the upper pump body.
6. Rotate the impeller and check for freedom of movement when the lower pump body and the impeller assembly is in place.



1. Clearance Ring
2. Lower Pump Housing
3. Clearance Ring Notch

Fig. 3, Clearance Ring Mounted in Pump Housing

7. Apply Loctite® 242 and install the four 5/8–11 x 5 capscrews (one at each corner of the lower pump body). Tighten snug but do not fully torque.
8. Install the 1/2–13 x 1-3/4 screws in the rear bearing housing and mechanical seal housing. Tighten 53 lbf·ft (72 N·m).
9. Remove the lifting device.
10. Apply Loctite® 242 to the 1/2–13 x 1-3/4 lower pump body capscrews and install them. Tighten snug but do not torque.
11. Torque the 5/8–11 x 5 capscrews 150 lbf·ft (203 N·m) then, starting from the center and moving outward, tighten the lower pump body capscrews 65 lbf·ft (88 N·m).
12. Install the AutoLube. See **Subject 100** for instructions.
13. Install the gearbox. See **Subject 110** for instructions.
14. Operate the pump and check for leaks. Verify the oil pressure at 25 to 35 psi (172 to 241 kPa) at the oil injection point.
15. Remove the chocks.

Single-Stage Pump

Disassembly

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Remove the AutoLube. See **Subject 100** for instructions.
3. Remove the fire pump gear box. See **Subject 110** for instructions.
4. Remove the impeller assembly. See **Subject 130** for instructions and see **Fig. 1** for an exploded view of the assembly.
5. Place the impeller shaft on a work bench.
6. Note the orientation of the impeller vanes.
7. Remove the outer retaining ring.

WARNING

Wear protective, heat-resistant gloves while heating the impeller to remove it from the impeller shaft. Heated metal can cause injury to your hands.

CAUTION

Do not overheat the impeller. The impeller is constructed of bronze. If the impeller is overheated and turns red or blue during removal from the shaft, it has been weakened and must be replaced.

8. Using an acetylene torch, carefully heat the "eye" of the impeller for approximately two minutes.
9. When heated properly, the impeller will slide free of the shaft. If the impeller moves but does not slide free, do not immediately reheat. Allow the complete assembly to cool to room temperature then reheat and remove the impeller.
10. Allow the components to cool to room temperature.
11. Remove the inner clearance ring.
12. Remove the key.
13. Remove the inner retaining ring and slide the mechanical seal housing from the impeller shaft

Assembly

1. Clean the impeller shaft, the keyway, and the mechanical seal housing and face.
2. Check the waterway in the mechanical seal housing for restrictions.
3. Install the mechanical seal housing onto the impeller shaft.
4. Install the inner retaining ring.
5. Install the new gasket on the mechanical seal housing face.
6. Install the key into the keyway.

CAUTION

If the impeller or clearance rings are dropped, damaged, or deformed, they will need to be replaced.

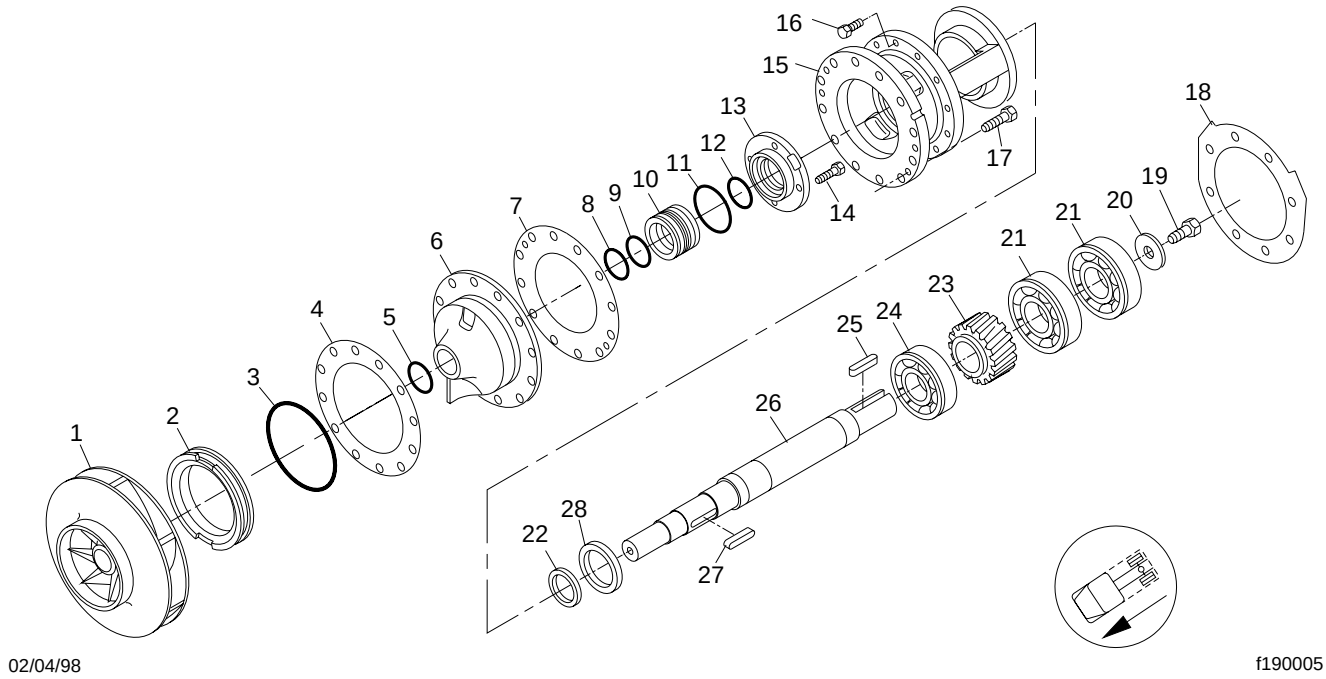
7. Install the inner clearance ring.

WARNING

Wear protective, heat-resistant gloves while heating the impeller to install it onto the impeller shaft. Heated metal can cause injury to your hands.

8. Using the torch, heat the "eye" of the new impeller for approximately two minutes. Then slide the impeller onto the shaft with vanes in proper orientation. If the impeller does not fully slide onto the shaft allow the assembly to cool to room temperature before reheating.
9. Install the outer retaining ring.
10. Install the impeller assembly. See **Subject 130** for instructions.
11. Install the outer clearance ring.
12. Install the impeller shaft assembly.
13. Install the fire pump gear box. See **Subject 110** for instructions.
14. Install the AutoLube. See **Subject 100** for instructions.
15. Remove the chocks from the front and rear tires.

Impeller Shaft Disassembly and Assembly



1. Impeller
2. Clearance Ring
3. Rear Bearing Housing Seal
4. Bearing/Seal Housing Gasket (impeller side)
5. Shaft Retaining Ring
6. Mechanical Seal Housing
7. Bearing/Seal Housing Gasket (mechanical seal side)
8. Shaft Seal Ring
9. Shaft Retaining Ring
10. Mechanical Seal And Steel Cup Assembly
11. Mechanical Seal Piston Ring
12. Shaft Seal Ring
13. Mechanical Seal Cover
14. Hexhead Screw, 7/16–14 x 1-1/4
15. Rear Bearing Housing
16. Hexhead Screw, 7/16–14 x 1-1/2
17. Hexhead Screw, 1/2–13 x 1-3/4
18. Rear Bearing Housing Gasket
19. Hexhead Screw, 5/8–11 x 1-1/4
20. Rear Bearing Washer
21. Bearing (aft)
22. Pump Shaft Slinger
23. Pump Shaft Gear
24. Bearing (forward)
25. Pump Shaft Gear Key
26. Pump Shaft
27. Impeller Key
28. Drive Unit Oil Seal

Fig. 1, Impeller Shaft Assembly (exploded view)

Two-Stage Pump

Disassembly

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Remove the AutoLube. See **Subject 100** for instructions.
3. Remove the fire pump gear box. See **Subject 110** for instructions.
4. Remove the impeller assembly. See **Subject 130** for instructions.
5. Place the impeller shaft assembly on a work bench.
6. Note the position of the impeller vanes.

7. Remove the inner and the outer retaining rings and then remove the mechanical seal housing.

WARNING

Wear protective, heat-resistant gloves while heating an impeller to remove it from the impeller shaft. Heated metal can cause injury to your hands.

CAUTION

Do not overheat the impeller. An impeller is constructed of bronze. If the impeller is overheated and turns red or blue during removal from the shaft, it has been weakened and must be replaced.

8. With an acetylene torch, carefully heat the "eye" of the impellers for approximately two minutes.

IMPORTANT: Mark the impellers as to whether they are the primary or secondary impeller in relation to the AutoLube. Improper or backward installation of the impellers affects pump performance.

9. When heated properly, an impeller will slide free of the shaft. If the impeller moves but fails to slide free, do not immediately reheat. Allow the complete assembly to cool to room temperature then reheat and remove the impellers. Heat the secondary impeller and remove. Then rotate the impeller shaft assembly end for end and heat and remove the primary impeller.
10. Remove the center support bearing.
11. Remove mechanical seal housing and then the inner clearance ring.
12. Remove the key.
13. Remove the inner retaining ring and slide the mechanical seal housing from the impeller shaft.

Assembly

1. Clean the impeller shaft, the keyway, and the mechanical seal housing and face.
2. Check the waterway in the mechanical seal housing for restrictions.
3. Install the new gasket on the mechanical seal housing face.
4. Install the key into the keyway.

CAUTION

If the impellers or the clearance rings are dropped, damaged, or deformed, they require replacement.

5. Install the inner clearance ring.

WARNING

Wear protective, heat-resistant gloves while heating the impeller to install it onto the impeller shaft. Heated metal can cause injury to your hands.

6. Using the torch, heat the "eye" of each impeller for approximately two minutes. Then slide the individual impellers onto the shaft. If an impeller does not fully slide onto the shaft allow the assembly to cool to room temperature before reheating.
7. Install the outer retaining ring.
8. Install the outer clearance ring.
9. Install the impeller assembly. See **Subject 130** for instructions.
10. Install the mechanical seal housing onto the impeller shaft.
11. Install the impeller shaft assembly.
12. Install the fire pump gear box. See **Subject 110** for instructions.
13. Install the AutoLube. See **Subject 100** for instructions.
14. Remove the chocks from the front and rear tires.

Pilot Valve

Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.

1. Drain the fire pump.
2. Rotate the adjustment handwheel counterclockwise to remove the spring tension.
3. Remove the capscrew and nut attaching the adjustment handwheel to the adjustment shaft. Then remove the handwheel.

CAUTION

Identify and mark the line connections on the control body before removing. Improper connection of lines may result in the failure of the pilot valve, which could cause damage to the fire pump.

4. Remove the pump discharge pressure line and the relief valve line from the control body of the pilot valve.
5. While holding the pilot valve, remove the four 1/4–20 x 5/8 machine screws attaching the valve and cover plate to the Pump Operator's Panel, and separate the valve, plate, and the relief valve setting indicator (if equipped with PMD) from the panel.
6. Disassemble the pilot valve.
   - 6.1 Remove the four 5/16–18 x 1 allen-head capscrews securing the control body to the rear of the spring housing. Then remove the control body.

CAUTION

Do not use pliers to unscrew the control valve from the diaphragm clamp. Damage to the control valve will render the pilot valve inoperative.

   - 6.2 Unscrew the control valve from the diaphragm clamp. Remove the diaphragm washer and the diaphragm.
   - 6.3 Remove the retaining ring, the seal, and the bearing.

WARNING

Use a spring compressor to remove the pilot valve spring. The spring is under compression and could become uncompressed, which could result in personal injury.

   - 6.4 Turn the adjustment handwheel clockwise to unscrew the adjustment shaft from the adjustment nut. From the handwheel end, remove the adjustment shaft from the spring housing.
   - 6.5 Remove both springs, the adjustment nut, and diaphragm clamp as an assembly from the spring housing and then separate.
7. Clean all the pilot valve components. Inspect and lubricate with grease the threads on the adjustment shaft.
8. Assemble the pilot valve.

WARNING

Use a spring compressor to install the pilot valve spring. The spring is under compression and could become uncompressed, which could result in personal injury.

CAUTION

Always remove the pilot valve discharge pressure inlet screen, which is located in the top of the discharge side of the pump. Clean or replace as necessary. Failure to do so could render the pilot valve inoperative.

   - 8.1 Combine both springs, the adjustment nut and the diaphragm clamp as an assembly and install into the spring housing. Align the guide pin-in adjustment nut with the slot in the spring housing and the indicator plate on the PMD.
   - 8.2 Slide the adjustment shaft into the spring housing from the handwheel end. Turn the adjustment handwheel counterclockwise in order to screw the adjustment shaft into the adjustment nut until it bottoms in the diaphragm clamp. Do not put the springs under tension.

Valve Removal, Disassembly, Assembly and Installation

8.3 Lubricate the new bearing and slide the new bearing and bearing washer over the adjustment shaft into the spring body housing. Install the retaining ring. Then install the new seal washer and rotate the adjustment shaft in both directions to check for freedom of movement.

8.4 Install the new diaphragm washer and diaphragm. Screw the control valve into the diaphragm clamp.

8.5 Install the control body. Apply Loctite® 242 to the four 5/16–18 x 1 allen-head capscrews attaching the control body to the rear of the spring housing.

9. Holding the pilot valve, align the cover plate and install the four 1/4–20 x 5/8 machine screws attaching the pilot valve and cover plate to the Pump Operator's Panel.
10. Install the pump discharge pressure line and relief valve line to the control body of the pilot valve.
11. Slide the adjustment handwheel onto the adjustment shaft and then install the retaining capscrew and nut.
12. Fill the pump and test the valve for proper operation and leaks.

Transfer Valve

See **Fig. 1** for an exploded view of the transfer valve.

1. Drain the fire pump.

IMPORTANT: The transfer valve is a timed device. It is therefore important during disassembly to note the location of the transfer bracket locating pin, the transfer drum stop pin, the transfer drum sleeve locating pin, and the transfer drum stem key. It is not necessary to remove the transfer bracket locating pin, the transfer drum sleeve locating pin, or the transfer drum stop pin during disassembly.

2. Turn the adjustment handwheel clockwise until it stops. The transfer indicator should be at the top of the slotted guide in the cover plate.
3. Remove the two allen-head set screws from the transfer indicator guide. Slide the transfer indicator guide (on an adjustment stem) towards the transfer valve.
4. Remove the stem drive gear lock pin. Slide the adjustment stem from the stem drive, the support, and the transfer indicator guide, being careful not to drop or damage the transfer indicator guide and transfer indicator.
5. Remove the four 7/16–14 x 1-1/4 capscrews retaining the transfer bracket assembly to the pump body. Carefully remove the transfer bracket and the transfer valve drum.
6. Disassemble the valve.

   6.1 Remove the locating pin that secures the countershaft in place.

   6.2 Remove the countershaft from the countershaft gear.

   6.3 Remove the countershaft gear and the countershaft gear spring from the transfer bracket assembly.

   6.4 Remove the allen-head set screw from the transfer drum gear. Slide the transfer drum gear from the drum stem. Remove the woodruff key from the transfer drum stem.

   6.5 Separate the transfer bracket from the transfer drum by sliding it from the transfer drum stem.

   6.6 Slide the transfer drum from the transfer sleeve.

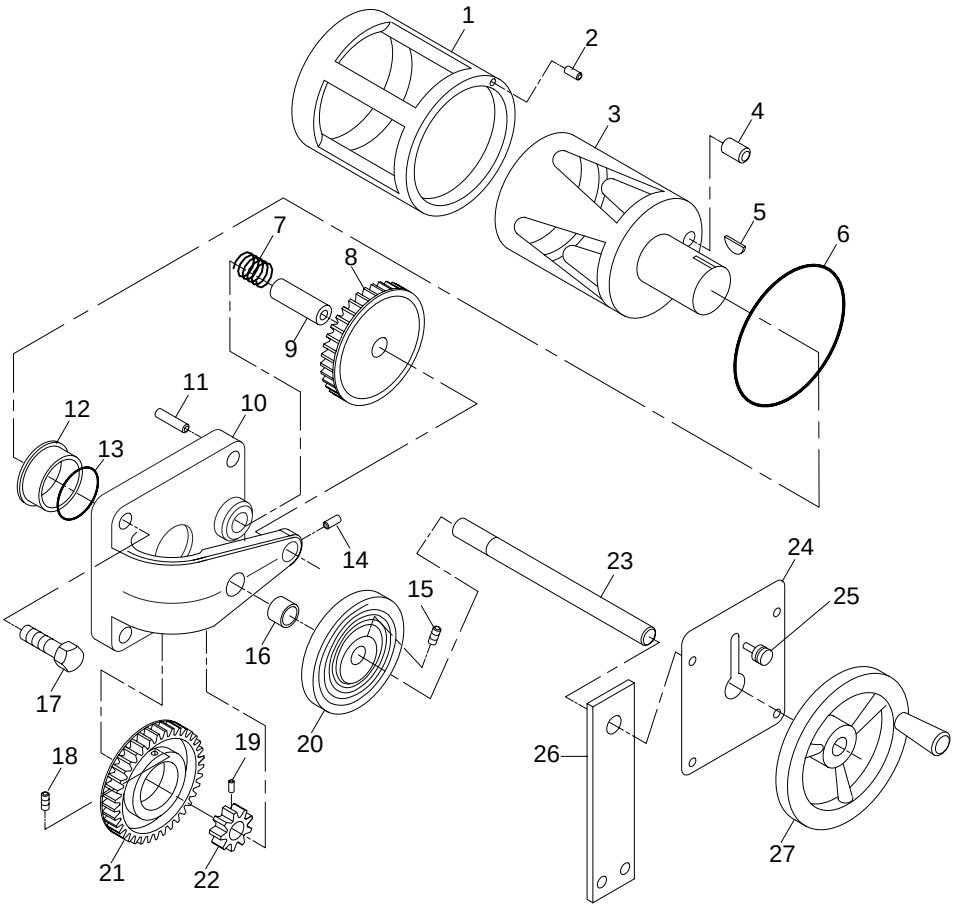
7. Assemble the valve.

   7.1 Clean and inspect all sealing surfaces, the mating surfaces of the transfer valve drum and sleeve. Clean and inspect the transfer bracket bushings and bushing surface on the transfer valve stem and the transfer valve adjustment stem.

   7.2 Install new O-ring seals on the transfer valve drum stem and the transfer valve bracket.

   7.3 Slide the transfer drum into the transfer bracket, being careful not to damage the bearing surfaces. Then rotate the transfer drum until the drum stop pin is in the correct position.

Valve Removal, Disassembly, Assembly and Installation



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1. Transfer Drum Sleeve
2. Locating Pin
3. Transfer Drum
4. Transfer Drum Stop Pin
5. Gear Key
6. Transfer Bracket Seal Ring
7. Countershaft Gear Spring
8. Transfer Valve Countershaft Gear
9. Transfer Countershaft
10. Transfer Bracket (with bearings) Assembly
11. Bracket Locating Pin
12. Drum Bracket Bearing
13. Transfer Drum Seal Ring
14. Locating Pin
15. Sockethead Setscrew, 1/4–20 x 3/8
16. Transfer Valve Stem Drive Gear
17. Hexhead Screw, 7/16–14 x 1-1/4
18. Sockethead Setscrew, #10–32 x 1/2
19. Gear Lock Pin
20. Transfer Indicator Guide
21. Transfer Valve Transfer Drum Gear
22. Transfer Stem Drive Gear
23. Transfer Stem
24. Instruction Plate
25. Transfer Indicator
26. Support Stem
27. Adjusting Wheel Assembly

Fig. 1, Transfer Valve

7.4 Install the woodruff key into the transfer drum stem. Install the transfer drum gear onto the transfer drum stem. Apply Loctite® 242 to the allen-head set screw and install the transfer drum gear.

7.5 Assemble the countershaft gear spring in the countershaft gear and position the assembly into place in the transfer bracket. Then install the countershaft and

Valve Removal, Disassembly, Assembly and Installation

the countershaft locating pin to lock the countershaft in place.

8. Install the transfer valve.
   - 8.1 Align the transfer drum stop pin, the transfer bracket locating pin, and the transfer drum sleeve locating pin into proper position.
   - 8.2 Install the transfer valve drum and bracket assembly into the pump body.
   - 8.3 Apply Loctite® 242 to the four 7/16–14 x 1-1/4 transfer bracket capscrews and install and tighten 53 lbf·ft (72 N·m).
   - 8.4 Slide the adjustment stem through the cover plate, the transfer indicator guide, and the support and transfer bracket.
   - 8.5 Insert the stem drive gear into place in the transfer bracket and then slide the adjustment stem through the stem drive gear.
   - 8.6 Insert the stem drive gear lock pin into place, locking the stem drive gear onto the adjustment stem.
   - 8.7 Apply Loctite® 242 to the transfer indicator guide set screws and install. Do not tighten.
   - 8.8 Turn the adjustment handwheel counterclockwise until it stops. Make sure the transfer indicator is at the top of the slotted guide toward the transfer indicator, making certain that the transfer indicator engages the transfer indicator guide in the top groove. Then tighten the inside set screw in the transfer guide indicator.
   - 8.9 Rotate the adjustment handwheel from stop to stop. The transfer indicator should move freely from the top to the bottom of the slotted guide in the cover plate.
   - 8.10 Tighten the outside set screw in the transfer indicator guide, and recheck the movement of the transfer indicator.
9. Fill the pump and test the valve for proper operation and leaks.

Back Flow Valve

1. Drain the water tank and the pump.
2. Disconnect the control linkage at the Tank-to-Pump valve.
3. Disconnect both ends of the flexible hose connecting the water tank to the tank-to-pump valve. Then slide the flexible hose toward the water tank outlet or the tank-to-pump valve plumbing.

NOTE: If the tank-to-pump valve is air-operated, drain the vehicle's air system and disconnect the supply and the return line on the valve actuator, but do not remove the actuator from the valve. Also, the tank-to-pump valve may be connected to the pump body by capscrews or studs with nuts. If studs are used, it may be necessary to remove some or all of the studs to remove the valve. If so, remove only the studs necessary to remove the valve as any studs left will assist in realigning the valve during installation.

4. Remove the eight 7/16–14 x 1-1/2 capscrews retaining the tank-to-pump valve to the pump body.
5. Remove the tank-to-pump valve and associated plumbing.

NOTE: The back flow valve is a flat butterfly plate with two pivots attached at the top. These pivots fit into two open pivot sockets in the pump body. When the gasket is removed, the back flow valve may fall out.

6. Remove the old gasket from the pump body.
7. Remove the back flow valve.
8. To install the back flow valve, first clean all of the gasket surfaces on the pump body and the tank-to-pump flange.
9. Install the back flow valve. Using two fingers, hold the pivots in the pivot sockets and check the valve for freedom of movement.
10. Install a new gasket.
11. Apply Loctite® 242 to the eight 7/16–14 x 1-1/2 capscrews and attach the tank-to-pump valve to the pump body. Tighten 53 lbf·ft (72 N·m).

12. Slide the flexible connection hose so it is evenly spaced and secured on the water tank outlet and the tank-to-pump valve plumbing.
13. Attach the tank-to-pump valve controls and linkage.
14. Fill the pump and test the valve for proper operation and leaks.

Sensing Valve

1. Disconnect the following lines at the sensing valve:
    - pilot valve discharge line
    - QG relief valve line
    - PG relief valve line
    - sensing valve pump suction line
    - drain lines
2. Remove the 7/16–14 x 2 sensing valve mounting capscrew.
3. Remove the four 5/16–18 x 1 capscrews attaching the control body to the rear of the spring housing. Remove the control body, being careful not to lose the sensing valve spring.
4. Remove the control valve from the sensing valve body.
5. Unscrew the sensing valve from the diaphragm, being careful not to damage the control valve. Remove the diaphragm.
6. Before installing the sensing valve, clean all components.

⚠ CAUTION

Always remove the sensing valve suction inlet screen. Clean or replace as necessary. The screen is located in the suction side of the pump. Failure to do so may render components inoperative.

7. Install a new diaphragm on the diaphragm clamp. Apply Loctite® to the threads on the control valve and install the control valve into the sensing valve body.
8. Install the sensing valve spring into the valve body cover.
9. Apply Loctite® 242 to the four 5/16–18 x 1 capscrews and attach the control body to the rear of the spring housing. Make sure that the sensing valve spring properly aligns with the diaphragm clamp.
10. Make sure the up arrow is aligned properly.
11. Apply Loctite® 242 to the 7/16–14 x 2 sensing valve mounting capscrew. Tighten 40 lbf·ft (54 N·m).
12. Connect all lines.
13. Fill the pump and test the valve for proper operation and leaks.

TPM Relief Valve

1. Disconnect the line to the sensing valve and drain the fire pump. Make note of the wire connections.
2. Disconnect the indicator light switch.
3. Remove the four 7/16–14 x 1-1/4 capscrews attaching the relief valve assembly to the pump body.
4. Using a twisting motion, remove the relief valve assembly.
5. To disassemble the valve, remove the indicator light switch and remove the cover retaining ring and slide the cover out of the relief valve body.
6. Apply a small amount of pressure to the relief valve piston and remove the piston retaining ring. Carefully release the pressure held to the piston by the spring.
7. Remove the relief valve from the opposite end, sliding the relief valve stem out of the piston.
8. Reach through the center hole of the piston and pull the piston out of the indicator switch end of the relief valve body. Then remove the piston spring.
9. To assemble and install the valve, first clean and inspect all components.
10. Clean all sealing surfaces and install new O-rings seals.
11. Install the relief valve into the relief valve body.

Valve Removal, Disassembly, Assembly and Installation

12. Install the piston spring by sliding the piston into the relief valve body while at the same time sliding the piston onto the relief valve system.
13. Apply light pressure to the piston to compress the piston spring and install the piston retaining ring.
14. Slide the cover into the relief valve body. Then install the cover retaining ring.
15. Using a powered test light, screw the indicator light switch in until the light goes out. Then turn an additional 3/4 to 1-1/4 turn. Apply Loctite® to the jamnut and tighten.
16. Slide the relief valve assembly into the pump body with the side marked "top" up, being careful not to damage the O-rings.
17. Apply Loctite® 242 to the four 7/16–14 x 1-1/4 capscrews and install the assembly in the pump body. Tighten 53 lbf·ft (72 N·m).
18. Connect the indicator light switch.
19. Fill the pump and test the valve for proper operation and leaks.

QD Relief Valve

See **Fig. 2** for an exploded view of the QD relief valve.

1. Drain the pump.
2. Note the location of the wires and disconnect the indicator light switch.
3. Disconnect the relief valve supply line from the pilot valve and drain the line.
4. Remove the two 7/16–14 x 1-1/4 capscrews attaching the relief valve indicator light switch and the mounting bracket assembly to the relief valve cover. Remove the light switch and the bracket.
5. Compress the relief valve return spring by hand and remove the E-clip and washer. Then remove the return spring.
6. Remove the two remaining 7/16–14 x 1-1/4 capscrews retaining the relief valve cover to the pump body. Using a twisting motion, carefully remove the relief valve cover.

⚠ CAUTION

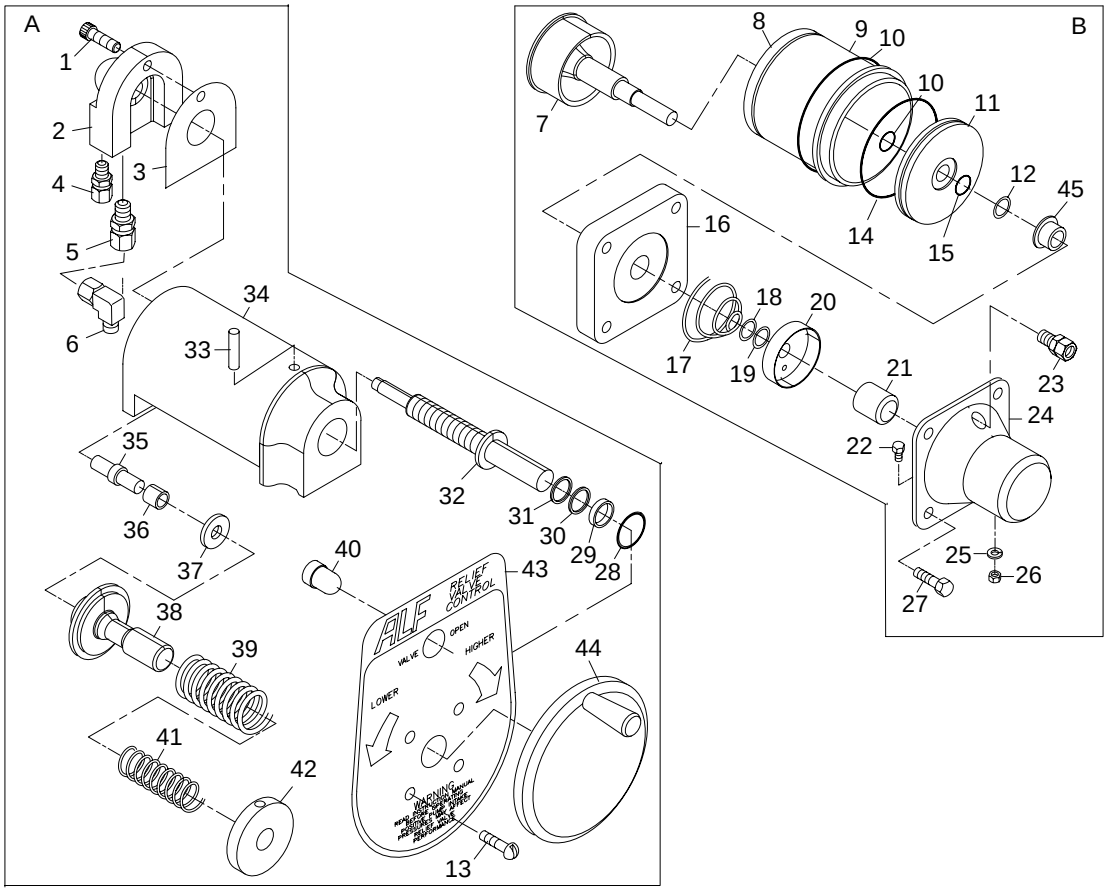
Do not push the relief valve too far into the pump body as it may fall into the pump body and become lodged or damaged. The relief valve is made of brass and is easily damaged by prying or hammering. Damaged valves must be replaced.

7. Remove the retaining ring securing the relief valve piston to the relief valve. Gently push the relief valve into the pump body approximately 1 inch (25 mm) and then pull it back out in a snap-motion. This should pop the relief valve piston out of the relief valve body. Repeat if necessary.

NOTE: It is not necessary to remove the relief valve unless it is damaged. To remove the relief valve, the relief valve body will have to be removed and the complete relief valve assembly will need to be replaced as it will be necessary to pry the relief valve body from the pump body, which will likely damage it.

8. Clean and inspect all of the relief valve assembly components.
9. Clean all sealing surfaces and install new O-rings and Quad-ring seals.
10. Install the relief valve piston in the stem of the relief valve. Do not push the relief valve into the pump body. As it is necessary to start the piston onto the relief valve stem, push the piston until you can grasp the relief valve stem. Then pull the relief valve stem outward while pushing on the relief valve piston. Once the relief valve piston is seated against the shoulder of the relief valve stem, install the retaining ring.
11. Operate the relief valve by hand to check for freedom of movement.
12. Slide the relief valve cover gasket and cover over the top of the relief valve stem to align the relief valve supply line from the pilot valve in the original position. Then apply Loctite® 242 to two 7/16–14 x 1-1/4 capscrews and install opposite of each other. Tighten, but do not torque.
13. Compress and install the return spring and secure it with a washer and E-clip.
14. Align the indicator light switch mounting bracket and switch with the two empty holes in the relief

Valve Removal, Disassembly, Assembly and Installation



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A. PM Relief Valve Control Assembly
B. QD Relief Valve System Assembly

1. Sockethead Screw, 5/16–18 x 1
2. Control Body Assembly
3. PM Control Valve Diaphragm
4. Connector Tube, 1/8–3/4
5. Connector Tube, 1/4–3/8
6. Connector Strainer
7. Relief Valve
8. Valve Body Seal Ring
9. Relief Valve Body
10. Piston Seal Ring
11. Transfer/Relief Valve Piston
12. Piston Retaining Ring
13. Screw, 1/4–20 x 5/8
14. Cover and Piston Seal Ring
15. Cover Seal Ring
16. Relief Valve Cover
17. Valve Spring
18. Washer
19. Spring Retaining Ring
20. Switch Strap
21. Indicator Light Switch
22. Hexhead Screw, #10–32 x 1/2
23. Connector Tube, 1/4" x 3/8"
24. Switch Bracket
25. Lockwasher, #10
26. Hexnut, #10–32
27. Hexhead Screw, 7/16–14 x 2-1/4
28. Sealing Washer
29. Bearing Washer Retaining Ring
30. Bearing Washer
31. Thrust Bearing
32. Adjusting Stem
33. Indicator Pin
34. Spring Housing
35. Control Valve
36. Control Valve Bearing
37. Diaphragm Support Bearing
38. Diaphragm Clamp
39. Outside Spring
40. Light Bulb
41. Inside Spring
42. Adjusting Nut
43. Instruction Plate
44. Adjusting Wheel Assembly

Fig. 2, QD Relief Valve

Valve Removal, Disassembly, Assembly and Installation

valve cover. Install the two remaining capscrews. Tighten all capscrews 53 lbf·ft (72 N·m).

15. Connect the relief valve supply line from the pilot valve. Also connect the drain line.
16. Connect the indicator light switch.
17. Fill the pump and test the valve for proper operation and leaks.

TPM Dump Valve

1. Drain the pump.
2. Disconnect the indicator light switch.
3. Disconnect the line to the sensing valve.
4. Remove one 7/16–14 x 2 sensing valve mounting capscrew.
5. Remove the four 7/16–14 x 1-3/4 capscrews retaining the relief valve assembly to the atmosphere dump.
6. Remove the four 7/16–14 x 1-1/2 relief valve mounting capscrews to remove the relief valve from the pump body.
7. Remove the relief valve assembly.
8. Remove the four 7/16–14 x 1-3/4 capscrews retaining the relief valve cover to the relief valve body.
9. Remove the indicator light switch assembly.
10. Apply a small amount of pressure to the relief valve spring and remove the spring retaining ring and washer. Carefully release the pressure held on the spring and then remove the spring.
11. Remove the relief valve cover.
12. Remove the piston retaining ring.
13. Remove the relief valve from the opposite end, sliding the relief valve stem out of the piston.
14. Reaching through the center hole of the piston, gently pull the piston from the indicator switch end of the relief valve body.
15. Before assembling and installing the valve, clean and inspect all components of the relief valve assembly.
16. Clean all sealing gasket surfaces and install new O-rings and gaskets.
17. Install the relief valve into the relief valve body.
18. Slide the piston into the relief valve body while at the same time sliding the piston onto the relief valve stem. Then install the piston retaining ring.
19. Install the new gasket and then install the cover onto the relief valve body.
20. Install two 7/16–14 x 1-3/4 capscrews finger-tight to keep the relief valve cover aligned with the valve body.
21. Install the valve spring over the relief valve stem. Then apply pressure to the valve spring to compress the spring.
22. Install the spring washer and the retaining ring.
23. Remove the two 7/16–14 x 1-3/4 capscrews installed to keep the relief valve cover aligned with the valve body. Place the indicator switch assembly into position on the relief valve cover. Apply Loctite® 242 to the four capscrews, install, and tighten 53 lbf·ft (72 N·m).
24. Apply Loctite® 242 to the four 7/16–14 x 1-1/2 capscrews to install the new gasket for the relief valve to the pump surface.
25. Apply Loctite® 242 to the four 7/16–14 x 1-1/2 capscrews and install the new gasket and relief valve assembly to the atmosphere dump. Tighten 53 lbf·ft (72 N·m).
26. Apply Loctite® 242 to the 7/16–14 x 2 capscrew, install the sensing valve and tighten 40 lbf·ft (54 N·m). Make sure the arrow points upward.
27. Connect the indicator light switch.
28. Connect the line to the sensing valve.
29. Fill the pump and test the valve for proper operation and leaks.

Check Valves (two-stage only)

1. Drain the pump.

NOTE: There are two check valves (one on each side) in the suction side on the front of the two-stage pump body. The following procedure is used for both check valves.

2. Remove the four 1/2–13 x 1-1/4 capscrews from the check valve cover on the front side of the pump body.

3. Remove the check valve.
4. Clean the gasket surfaces and inspect the check valve pivots and pivot sockets.
5. Install the check valve.
6. Install the new gasket in the pump body.
7. Apply Loctite® to the four capscrews and secure the check valve cover to the pump body with the capscrews, being careful to align the check valve pivot with the pivot socket in the check valve cover. Tighten 53 lbf·ft (75 N·m).
8. Fill the pump and test the valve for proper operation and leaks.

SPV Priming Valve

1. Drain the pump.
2. Disconnect the 3/4-inch (19 mm) vacuum hose connecting the priming valve to the primer.
3. Remove two 7/16–14 nuts attaching the priming valve to the studs in the pump body. If the studs are damaged, replace them with 7/16–14 x 1-3/4 zinc plated studs.

NOTE: If the valve strainer and O-ring seal remains on the pump body, remove it carefully for cleaning and installation. If the valve strainer is removed as part of the priming valve, remove it from the body and set it aside. Use care as the valve strainer is easily damaged.

4. Note the location of the drain hole on the diaphragm cover and then remove the eight 5/16–18 x 3/4 capscrews securing the diaphragm cover to the valve body. Remove the diaphragm cover and the diaphragm.
5. Hold pressure on the diaphragm washer to compress the valve spring then remove the diaphragm washer retaining screw. Remove the diaphragm washer and valve spring. From the opposite side of the valve body, remove the valve.
6. Clean all the components of the priming valve and mating surfaces. Inspect the valve seat and replace if worn or damaged.
7. Install the valve into the valve body from the pump side of the body.
8. Install the valve spring and diaphragm washer onto the valve. Apply Loctite® 242 to the diaphragm washer retaining screw, compress the valve spring with the diaphragm washer, and install the valve.
9. Align the diaphragm holes with the capscrew holes in the diaphragm cover. Apply Loctite® 242 to the eight 5/16–18 x 3/4 capscrews and install the diaphragm cover and diaphragm valve body. Tighten 17 lbf·ft (23 N·m).
10. Install the valve strainer and O-ring seal onto the pump side of the priming valve.
11. Apply Loctite® 242 on the two 7/16–14 priming valve mounting nuts and install the priming valve into the pump body. Tighten 40 lbf·ft (54 N·m).
12. Connect the vacuum hose to the primer.
13. Fill the pump and test the valve for proper operation and leaks.

Troubleshooting

Lack of use causes many problems for fire pumps and fire pump components.

IMPORTANT: The entire pumping system should be exercised on a regular basis, at least weekly. This routine procedure should include all discharge valves and suction valves.

Abuse of the fire pump is rarely a problem. If the pump and pump components have been abused, indications of problems may be fairly obvious. For example, bent controls are a common indicator.

Simultaneous oil and water leaks are uncommon. Normally, a water leak indicates that a line has come loose or is broken. Gaskets are used between mating surfaces *without* sealant. If a leak is present at a gasket-mating surface, whether oil or water, the components should be disassembled and repaired.

Be certain when a device indicates it is not working that it is not asimple electrical problem, such as a burned-out indicator bulb.

Troubleshooting Tables

Problem—Pump Will Not Engage

Problem—Pump Will Not Engage	
Possible Cause	**Remedy**
Parking brake not set.	Set the parking brake.
Transmission not in neutral.	Shift transmission to neutral.
Insufficient air supply.	Repeat the recommended shift procedure: Check the air pressure gauges. This procedure requires at least 100 psi (689 kPa), and shut the engine down and check for air leaks.
Pump shift or application of parking brake attempted before apparatus was stopped.	Release the braking system momentarily and repeat the recommended shift procedure. *

* This condition is known as "Butt Tooth," which occurs when the transmission shifts and the shift gear-teeth and the teeth on the drive gear do not line up and butt up against each other. The Twinflow fire pump transmission is designed with a sliding shift collar. Therefore, the occurrence of "Butt Tooth" will be rare.

Problem—Pump Will Not Shift

Problem—Pump Will Not Shift	
Possible Cause	**Remedy**
Battery voltage low.	Turn off accessories. Check the charging system of the apparatus. Inspect the batteries. If okay, recharge and try shift again.
Interface/Interlock module not receiving proper inputs.	Check the Officers Information Center output.
Transmission not receiving lock-up input.	Check output to transmission with Prolink.

Problem—Pump Will Not Prime

Problem—Pump Will Not Prime	
Possible Cause	**Remedy**
Low battery voltage.	Increase the engine speed 1000 to 1200 rpm for temporary support for electrical system requirements and primer operation. *
Worn or damaged priming system.	Perform the "Dry Vacuum Test" which follows the troubleshooting tables in this subject. If pump is tight but primer develops less than 22 inches of vacuum, the primer pump, motor, or Priming Valve may be worn or damaged.

Troubleshooting

Problem—Pump Will Not Prime	
Possible Cause	**Remedy**
Primer not operated long enough.	Operate for 30 seconds for pump up to 1250 gpm or for 45 seconds for 1500 and up gpm pump. Add 15 additional seconds if priming from front or rear suction. Do not run primer over 45 seconds. Stop and check for causes.
Suction lifts too high.	Do not attempt lifts exceeding 22 feet, except at low elevations.
Suction strainer blocked.	Check and clean.
Air pocket in suction hose or pump.	Place suction hose lower than suction intake. Slightly open a discharge valve momentarily to release trapped air.
Air leaks.	Perform the "Dry Vacuum Test" which follows the troubleshooting tables in this subject. Then shut engine off and listen for air leaks. Pressurize the discharge side of the pump with approximately 100 psi (689 kPa) from the hydrant and check for water leaks. Check connections and gaskets.

* Electric primer does not require engine speed to be increased for operation. A primer can and will draw in excess of 300 amps and primer operation can last 45 seconds.

Problem—Pump Loses Prime

Problem—Pump Loses Prime	
Possible Cause	**Remedy**
Suction lifts too high.	Do not attempt lifts exceeding 22 feet except at low elevations.
Suction strainer blocked.	Check and clean.
Air leaks.	Check all connections and gaskets. Perform the "Dry Vacuum Test" which follows the troubleshooting tables in this subject.
Pump pressure is too low when discharge appliance is opened.	Prime the pump again. Raise pump pressure higher and open the discharge appliance slowly.

Problem—Pump Primer Does Not Operate Properly

Problem—Pump Primer Does Not Operate Properly	
Possible Cause	**Remedy**
Does not operate electrically.	Check the battery, connections, primer, and primer control. Check the control switch and solenoid on the primer. If the primer has not been used recently, it could be frozen. It should, if contact is still being made internally, show heavy current draw.
Primer is slow or lower than normal.	Check batteries, wiring, and connections. A large quantity of suction hoses or suction pipes can exceed primer capabilities. Too small diameter or too long a length of piping between primer and pump can exceed primer capabilities. Lift not to exceed 20 feet (6 m) and 10 feet (3 m) for testing. The primer pump itself may be worn out.
Pulls some prime.	The primer pump could be in need of repairs or cleaning. Check for air leaks and verify that the Priming Valve is not sticking.
Pulls full prime.	Check for air leaks. Check for clogged inlet strainer and screens. Check that the suction hose is submerged in adequate water supply. Check for air pockets and air accumulation in piping. Check for turbulence in piping. The pump impeller may be damaged or severely worn.

Problem—Insufficient Capacity or Pressure

Problem—Insufficient Capacity or Pressure	
Possible Cause	**Remedy**
Insufficient engine power.	Check engine performance.
Improperly set relief valve.	Readjust the relief valve to a higher pressure setting. If the relief valve is set too low it will open to relieve pressure and reduce capacity.
Transmission in incorrect range.	Check the transmission selector for correct range recommended for pumping procedure. Check that the Fourth range lockup has occurred. If the transmission shifts while increasing engine speed, lock up has not occurred. Check engine speed or drive shaft speed for correct transmission range and inaccurate tachometer.
Air leaks.	Perform the "Dry Vacuum Test" which follows the troubleshooting tables in this subject.
Transfer valve in incorrect position.	Transfer valve must be in the "parallel or volume" setting for capacity in the "series or pressure" setting for pressure. The transfer valve indicator may be out of adjustment. At idle, shift the transfer valve back and forth. You should hear the check valves close and see a change in pressure on the Master Pressure gauge.
Tank fill valve leaking.	Repair the leak.

Problem—Engine Speed Too High for Capacity or Pressure

Problem—Engine Speed Too High for Capacity or Pressure	
Possible Cause	**Remedy**
Impeller blockage.	Check and clean. Backflushing through the discharge side of the pump may clear the obstruction. It may require disassembly of the pump.
Worn impeller or clearance rings.	Overhaul the pump. All other possibilities should be eliminated before overhauling the pump.
Suction strainer blocked.	Clean and check.
Lift too high.	Lifts over 10 feet will cause higher engine speeds and vacuum.
Transmission in incorrect range.	Check the transmission selector for correct range for recommended pumping procedure. Check that Fourth range lockup has occurred. If the transmission shifts while increasing engine speed, lockup has not occurred. Check engine speed or drive shaft speed for correct transmission range and inaccurate tachometer.
Check Valves damaged or missing.	At idle, shift the transfer valve back and forth. You should detect a change in the engine/pump sound, hear the check valves close, and see a change in the pressure on the Master Pressure gauge. If no apparent change occurs, remove the suction inlet cap and visually inspect the check valves. Insert a broom handle in the suction inlet and gently push each check valve open and let it close. Check valves should move freely.
Tank fill valve leaking.	Repair the leak.

Troubleshooting

Problem—Relief Valve Does Not Relieve When Valves are Closed

Problem—Relief Valve Does Not Relieve When Valves are Closed	
Possible Cause	**Remedy**
Incorrect pilot valve setting.	Repeat the proper procedure for setting the relief valve.
Pilot valve inoperative.	Disassemble, clean, and lubricate. Inspect the control valve diaphragm for wear or damage.
Relief valve inoperative.	Disassemble, clean, and lubricate.

Problem—Relief Valve Does Not Recover When Valves are Opened

Problem—Relief Valve Does Not Recover When Valves are Opened	
Possible Cause	**Remedy**
Dirt in system resulting in slow or sticky operation.	Disassemble, clean and lubricate.

Problem—Unable to Attain Proper Setting

Problem—Unable to Attain Proper Setting	
Possible Cause	**Remedy**
Incorrect procedure.	Check procedure and reset.
Blocked strainer.	Disconnect the pilot valve supply line from the discharge side of pump. Remove the 90-degree fitting where the supply line connects to the pump. The strainer is attached to this fitting. Clean or replace the strainer and fitting assembly.
Dirt in pilot valve.	Disassemble, clean, and lubricate.
Hunting condition.	Insufficient water supply to the pilot valve. Check strainer and supply lines. If there is dirt in the pilot valve, disassemble, clean, and lubricate.

Problem—TPM Valve Does Not Relieve

Problem—TPM Valve Does Not Relieve	
Possible Cause	**Remedy**
Sensing valve inoperative.	Disassemble, clean, and lubricate. Inspect the control valve diaphragm for wear or damage.
PG relief valve inoperative.	Disassemble, clean, and lubricate.
PG relief valve sluggish.	Check and clean the discharge and suction strainers in the pump body.

Problem—TPM Valve Does Not Recover

Problem—TPM Valve Does Not Recover	
Possible Cause	**Remedy**
Dirt in system resulting in slow or sticky operation.	Disassemble, clean, and lubricate. Check and clean the discharge and suction strainers in the pump body.

Problem—AutoLube

Problem—AutoLube	
Possible Cause	**Remedy**
External leaks.	External leaks are the result of gasket failures. Disassemble and repair.
Internal leaks.	If water is leaking, replace the diaphragm. If oil is leaking, replace the AutoLube seal and the impeller bushing. Heavy oil usage by the AutoLube or oil present in the water when the pump master drain is opened indicates that the AutoLube seal and possibly the impeller bushing is damaged.

Problem—Mechanical Seal Leaks

Problem—Mechanical Seal Leaks	
Possible Cause	**Remedy**
Leak at mechanical seal.	If the mechanical seal is leaking it will have to be replaced. If properly cared for, the mechanical seal should be almost maintenance free. Water quality will greatly affect seal life. The most common failure of the mechanical seal is from thermal-shock. That is running the pump dry, heating up the seal and then opening to a cool or cold water supply. The seal may shatter. Check the AutoLube. If the bushing is worn or missing, the impeller shaft will wobble and fracture the mechanical seal.

Problem—Pump Gear Box Does Not Function Properly

Problem—Pump Gear Box Does Not Function Properly	
Possible Cause	**Remedy**
Water in gear box.	Locate and repair the leak. Remove and clean the gear box filter. Replace the transmission oil. Water leaking onto the input drive shaft of the pump gear box will actually be screwed into the pump transmission past the oil seals. This is not a seal problem. Be certain the slinger(s) are in place. Check the pump gear box cooling line for internal fractures. Pump gear box will fill with water and overflow through breather.
Whine in gear box.	Check the oil level. If oil is low, helical gears and/or tapered bearings will whine. Check oil pressure. If the filter is clogged, oil pressure will be low. Drain oil and check for metal. Remove filter and check for metal. If metal is detected, pump gear box will have to be disassembled for complete inspection and repairs.
Knock or rattle in gear box.	Check for gears missing teeth. Check for damaged bearings. Disassemble and repair. *

* The cause may include foreign objects, low or contaminated oil, or low oil pressure. Low oil level or pressure will result in the transmission being damaged due to overheating.

Dry Vacuum Test

1. Open all the intake valves.
2. Cap all intakes, and close and uncap all discharge valves.

Troubleshooting

3. Using the pump's priming devices, develop a vacuum of at least 22 inHg (74.5 kPa) for 30 seconds for pumps up to 1250 gpm or 45 seconds for pumps 1500 gpm or greater.
4. Reduce the maximum vacuum attained by 1 inHg (3.4 kPa) for each 1,000 ft. (305 m) of elevation of the test site above 2,000 ft. (610 m).

NOTE: The vacuum should not drop more than 10 inHg (33.9 kPa) in five minutes. Do not operate the pump priming device once the five-minute test has begun.

See **Fig. 1** for the fire pump wiring diagram.

See **Fig. 2** for the fire pump controls wiring diagram. See **Fig. 3** for a detailed view of the RH switch panel for the fire pump controls and **Fig. 4** for a detailed view of the electrical center.

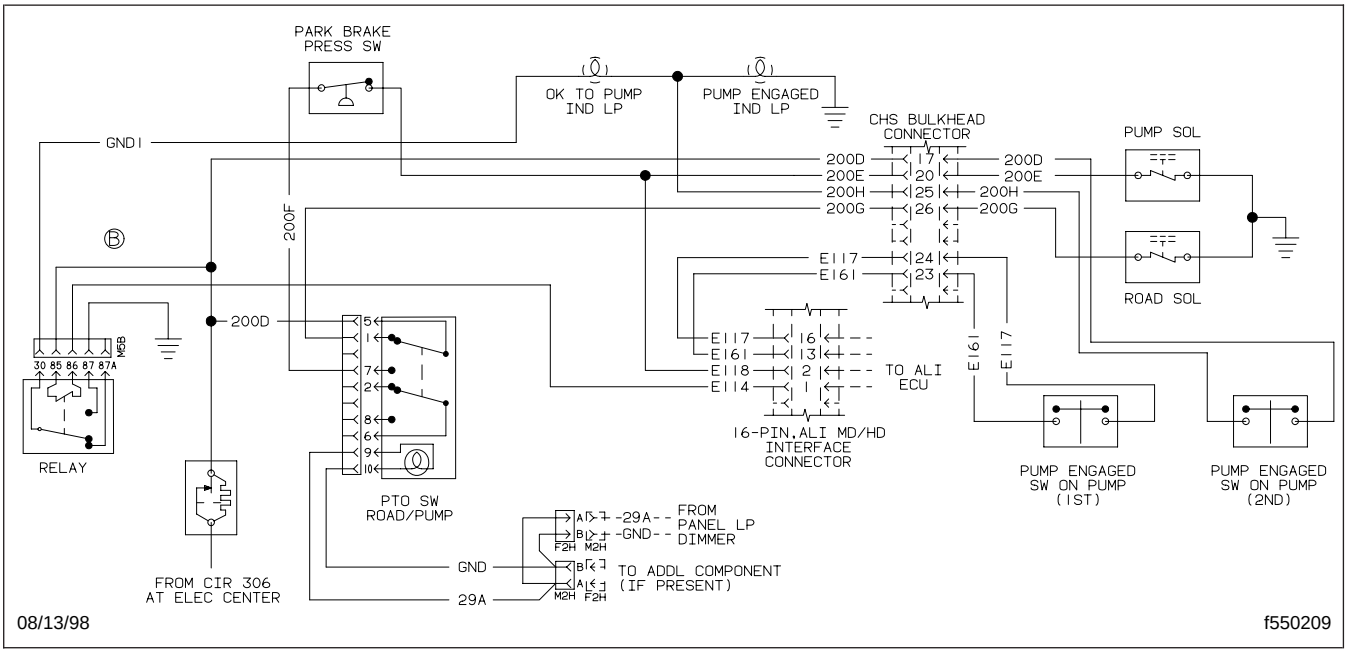

Fig. 1, Fire Pump Wiring Diagram

Specifications

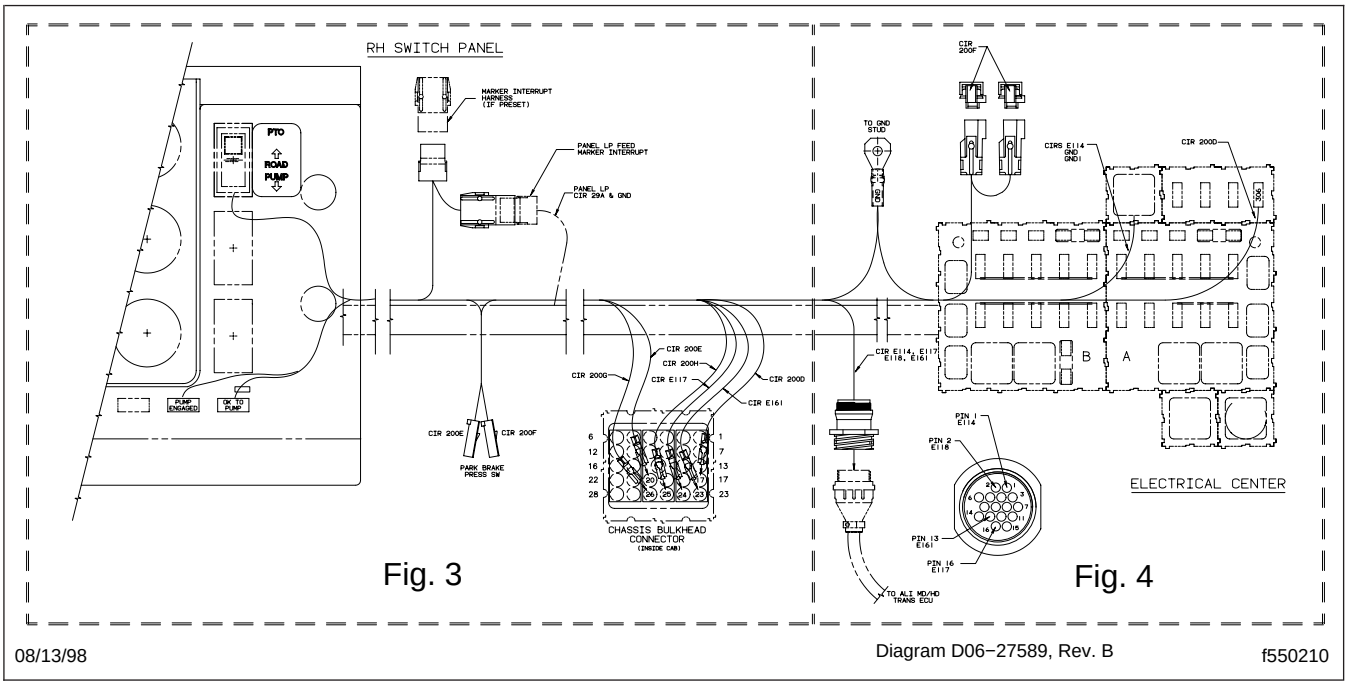

Fig. 2, Fire Pump Controls Wiring Diagram

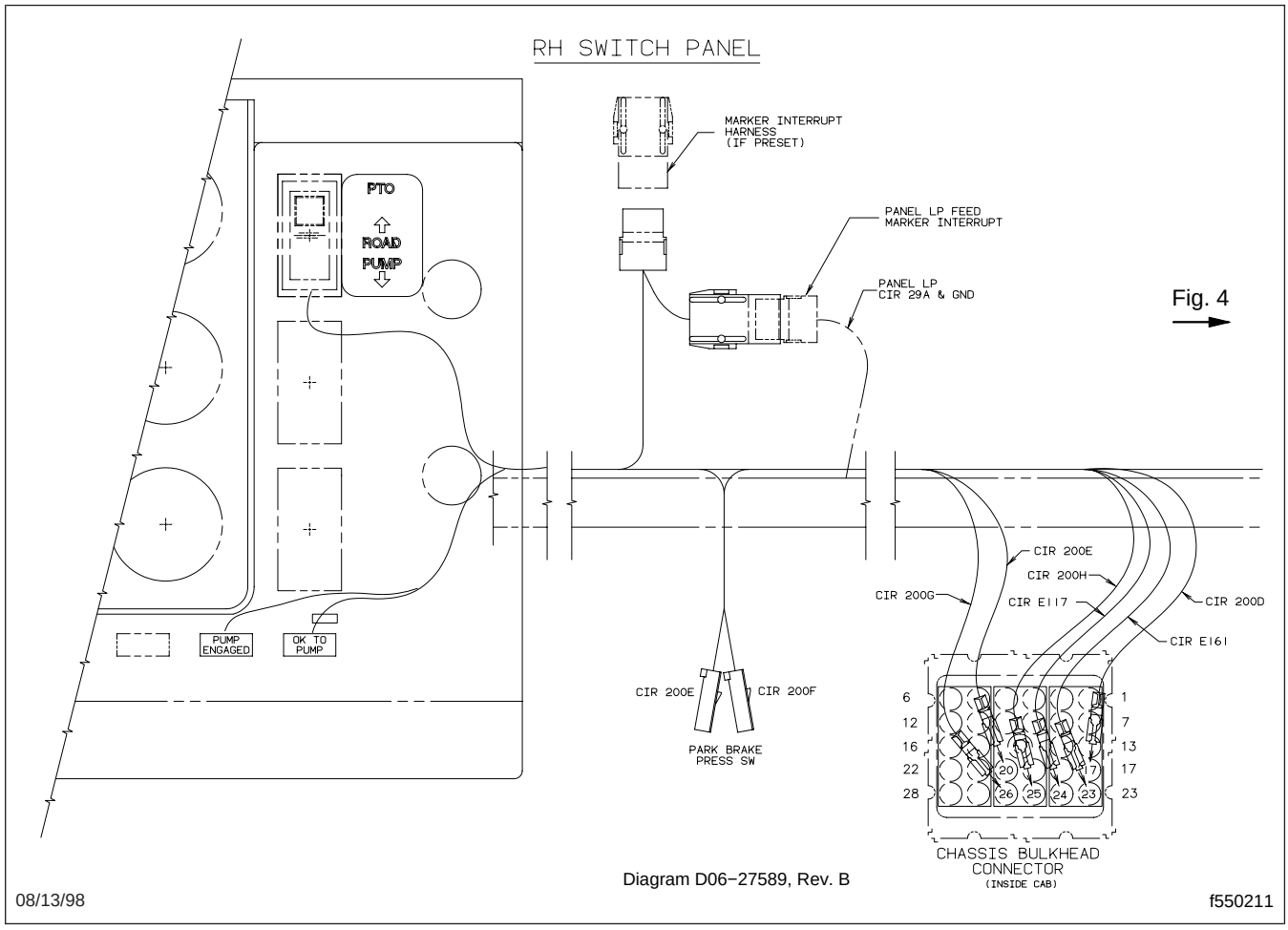

Fig. 3, Fire Pump Controls, RH Switch Panel

Specifications

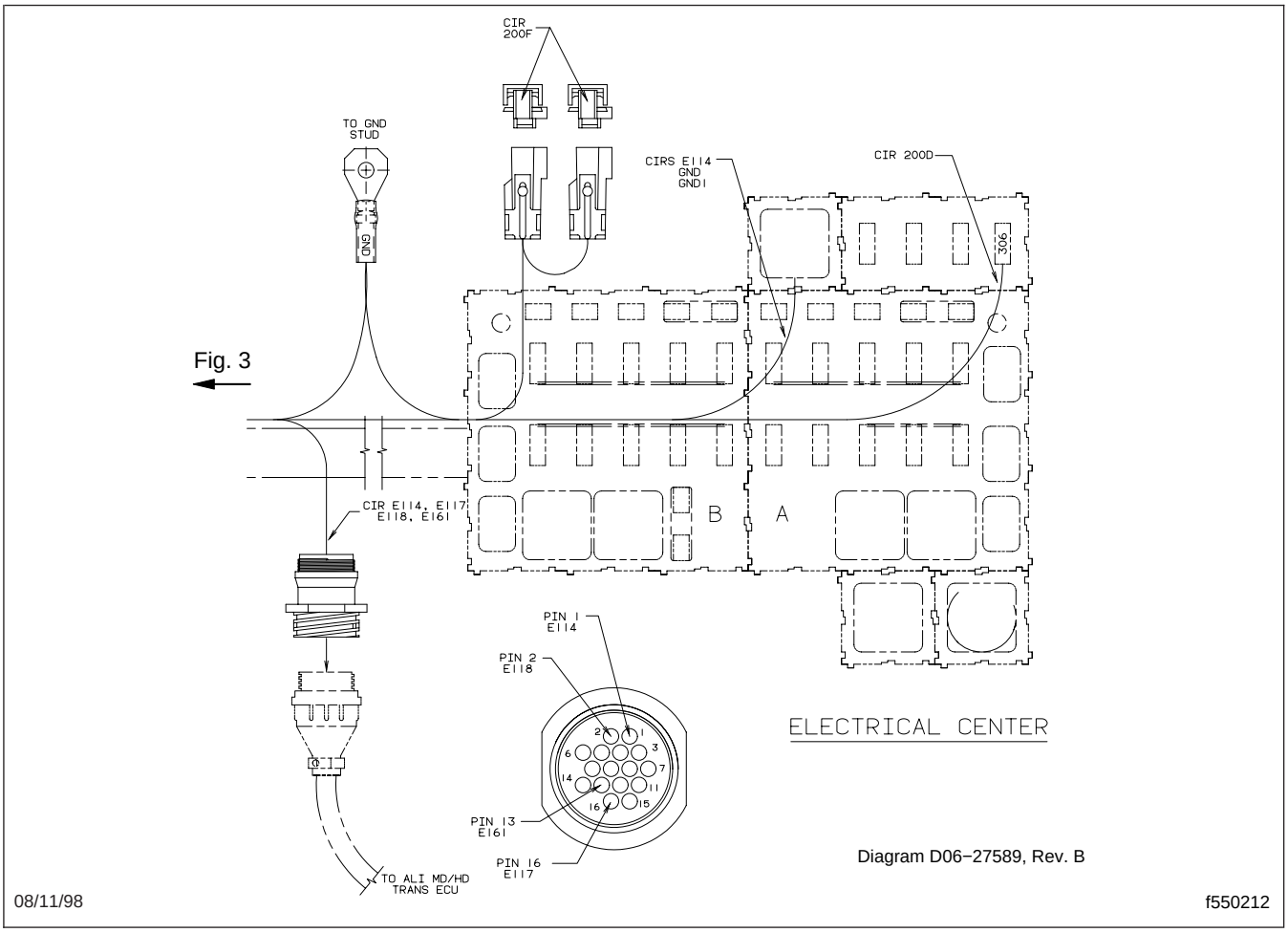

Fig. 4, Fire Pump Controls, Electrical Center

General Information

The National Cush–N–Aire seat model 195 (high back) offers adjustment features for height, fore and aft positioning, back cushion tilt, lumbar support, seat tilt, and isolator lockout.

For complete operating instructions, refer to the vehicle driver's manual.

Removal (See Fig. 1)

1. Back Cover (Upholstery)
2. Tinnerman Clips
3. Polyfiller Cushion
4. Plug
5. 5/16–18 Nut
6. Lumbar Adjustment Knob
7. Plastic Washer
8. Upper Frame Assembly
9. Seat Cushion
10. Cushion Adjustment Rod
11. Retainer
12. 1/4–20 Machine Screw
13. No. 10–3/4 Machine Screw
14. Cushion Handle
15. Shoulder Bolt
16. Isolator Screw
17. Isolator Spring
18. Lower Frame Assembly
19. Bearing
20. 5/16–18 Hexnut
21. Bearing Support Rail
22. 5/16–18 Locknut
23. Bearing Support Frame
24. Track Assembly
25. 5/16–18 Bolt
26. Track Knob
27. Shaft Assembly
28. Bearing
29. 3/8–24 x 1–3/4" Hexhead Bolt
30. Nylon Bushing
31. Spacer
32. Shock Absorber
33. 3/8–24 Locknut
34. Base-and-Upright Assembly
35. Snap Ring
36. Pin Clip
37. Lower Arm Assembly
38. Air Spring
39. Upper Arm Assembly
40. Seat Support Assembly
41. Belt Bar
42. Air Hose
43. Hose Clip
44. Retaining Ring
45. Hose Fitting
46. Air Valve Assembly
47. Adjustment Rod Cap
48. 1/4–28 Locknut
49. Isolator Handle
50. 5/16–18 Bolt (grade 5)
51. Adjustment Knob Bolt
52. Spring Washer
53. Adjustment Knob
54. Actuator Plate
55. Latch Pawl
56. Backing Plate

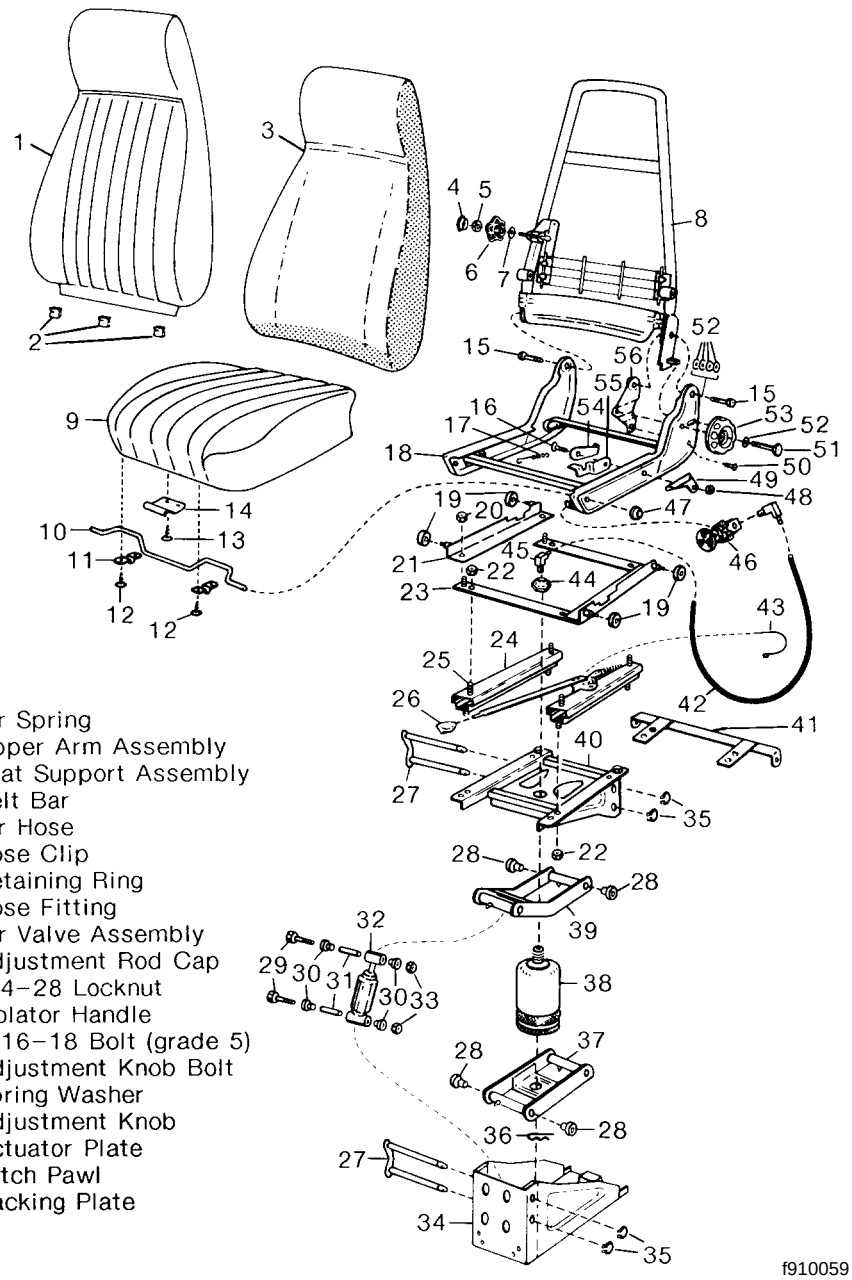

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Fig. 1

1. Remove the protective covering (if equipped) from the seat base.

Air Spring Removal and Installation

2. Raise the seat assembly to maximum height. Using a wood block (**Fig. 2**), support the seat in this position.

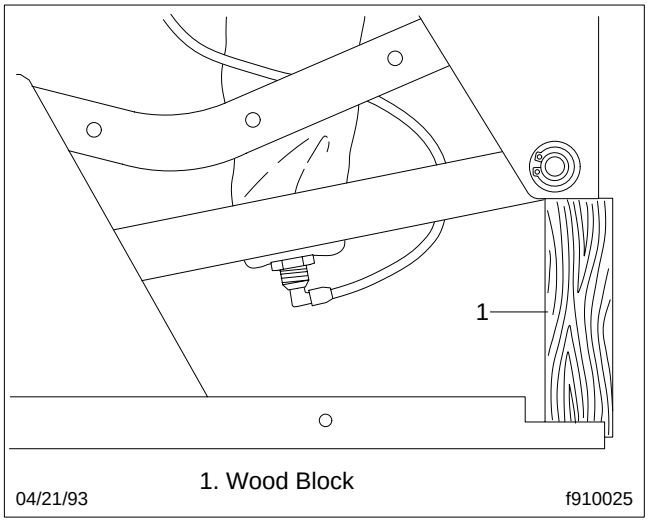

Fig. 2

3. Pull the air valve knob (Ref. 46) until all air is exhausted from the air spring (Ref. 38).
4. Remove the plastic tie strap that attaches the seat cushion (Ref. 9) to the lower frame assembly (Ref. 18).
5. Remove the machine screws (Ref. 12) and retainers (Ref. 11) that attach the seat cushion to the front cushion adjustment rod (Ref. 10). Remove the seat cushion.
6. Disconnect the air hose (Ref. 42) from the air hose fitting (Ref. 45) on the air spring (Ref. 38). Remove the fitting from the air spring. Plug the hose and fitting to prevent dirt or other matter from entering.
7. Remove the retaining ring (Ref. 44) from the air spring.
8. Remove the pin clip (Ref. 36) that secures the air spring to the lower arm assembly (Ref. 37). Remove the air spring.

Installation (See Fig. 1)

1. Position the air spring (Ref. 38) in the lower arm assembly (Ref. 37). Install the pin clip (Ref. 36).
2. Position the upper end of the air spring in the opening of the seat support assembly (Ref. 40). Install the retaining ring (Ref. 44) on the air spring.
3. Unplug the air hose and fitting. Install the fitting on the air spring, then connect the air hose to the fitting.
4. Position the seat cushion, then install the front cushion retainers (Ref. 11) and machine screws (Ref. 12).
5. Install a new plastic tie strap to secure the seat cushion to the lower frame assembly (Ref. 18).
6. Remove the wood block from between the lower arm (Ref. 37) and the base-and-upright assembly (Ref. 34).
7. Install the protective covering (if equipped) on the seat base. Adjust the seat as needed.

Shock Absorber Removal and Installation

Removal

1. Remove the protective covering (if equipped) from the seat base.
2. Using the fore-and-aft adjustment lever, move the seat back as far as possible.
3. Raise the seat assembly to maximum height. Using a wood block (**Fig. 1**), support the seat in this position.
4. Pull the air valve knob until all air is exhausted from the air spring.
5. Remove the nuts and bolts that attach the shock absorber to the upper arm and to the base-and-upright assembly. See **Fig. 2.** Remove the shock absorber from the seat assembly.

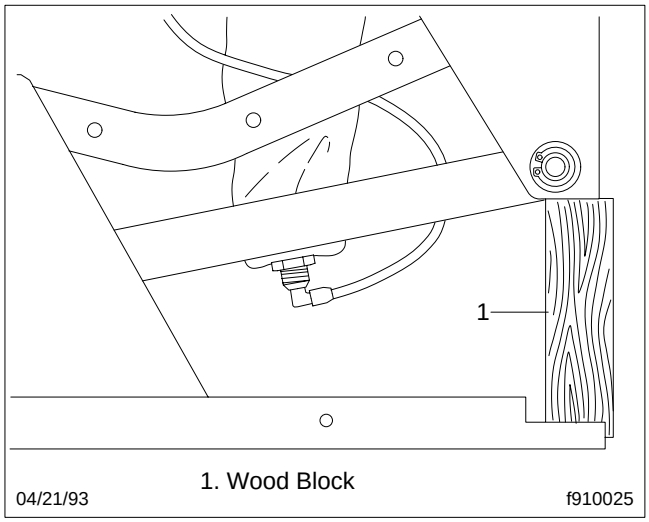

Fig. 1

Installation

1. Using new spacers and bushings, position the shock absorber so that the piston-rod end is in the mounting bracket of the upper arm (**Fig. 2**).
2. Install the hexhead bolt and locknut to attach the shock absorber to the upper arm. Tighten the locknut 25 lbf·ft (34 N·m).
3. Position the base of the shock absorber in the mounting bracket of the base-and-upright assembly.
4. Install the hexhead bolt and locknut to attach the shock absorber to the base-and-upright assembly. Tighten the locknut 25 lbf·ft (34 N·m).
5. Push the air valve knob to raise the seat. Remove the wood block.
6. Install the protective covering (if equipped) on the seat base. Adjust the seat as needed.

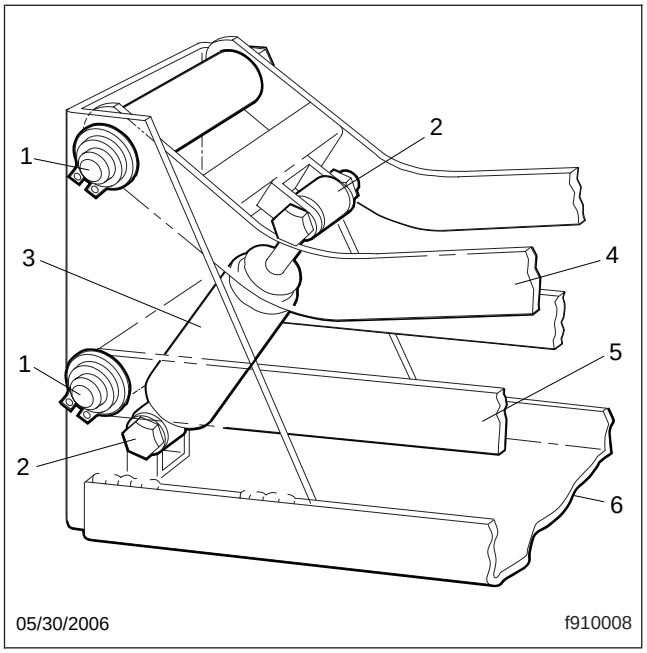

Fig. 2, Shock Absorber Assembly

Removal (See Fig. 1)

1. Remove the bolt and washer from the adjustment knob (Refs. 51, 52, and 53).
2. Remove the bolt (Ref. 50) under the adjustment knob (Ref. 53).
3. Remove the shoulder bolts, washers, and the backing plate (Refs. 15, 52, and 56).
4. Remove the upper frame (Ref. 8).

Installation (See Fig. 1)

1. Position the back frame extender into the reclining slot on the lower frame assembly (Ref. 18). Hold the extender in place, then install the backing plate, washers, and shoulder bolts (Refs. 56, 52, and 15) at the pivot points. Tighten the bolts 10 lbf·ft (15 N·m).
2. Align the bottom of the backing plate with the hole in the side panel. Install the bolt (Ref. 50), and tighten it 10 lbf·ft (15 N·m).
3. Install the adjustment knob (Ref. 53) with the groove over the square shaft. Turn the knob until the bolt hole lines up with the hole in the side panel. Install the washer and bolt. Tighten the bolt 10 lbf·ft (15 N·m). Check the adjustment knob operation by turning it through complete forward and rearward travel.

Upper Frame Removal and Installation

1. Back Cover (Upholstery)
2. Tinnerman Clips
3. Polyfiller Cushion
4. Plug
5. 5/16–18 Nut
6. Lumbar Adjustment Knob
7. Plastic Washer
8. Upper Frame Assembly
9. Seat Cushion
10. Cushion Adjustment Rod
11. Retainer
12. 1/4–20 Machine Screw
13. No. 10–3/4 Machine Screw
14. Cushion Handle
15. Shoulder Bolt
16. Isolator Screw
17. Isolator Spring
18. Lower Frame Assembly
19. Bearing
20. 5/16–18 Hexnut
21. Bearing Support Rail
22. 5/16–18 Locknut
23. Bearing Support Frame
24. Track Assembly
25. 5/16–18 Bolt
26. Track Knob
27. Shaft Assembly
28. Bearing
29. 3/8–24 x 1–3/4" Hexhead Bolt
30. Nylon Bushing
31. Spacer
32. Shock Absorber
33. 3/8–24 Locknut
34. Base-and-Upright Assembly
35. Snap Ring
36. Pin Clip
37. Lower Arm Assembly
38. Air Spring
39. Upper Arm Assembly
40. Seat Support Assembly
41. Belt Bar
42. Air Hose
43. Hose Clip
44. Retaining Ring
45. Hose Fitting
46. Air Valve Assembly
47. Adjustment Rod Cap
48. 1/4–28 Locknut
49. Isolator Handle
50. 5/16–18 Bolt (grade 5)
51. Adjustment Knob Bolt
52. Spring Washer
53. Adjustment Knob
54. Actuator Plate
55. Latch Pawl
56. Backing Plate

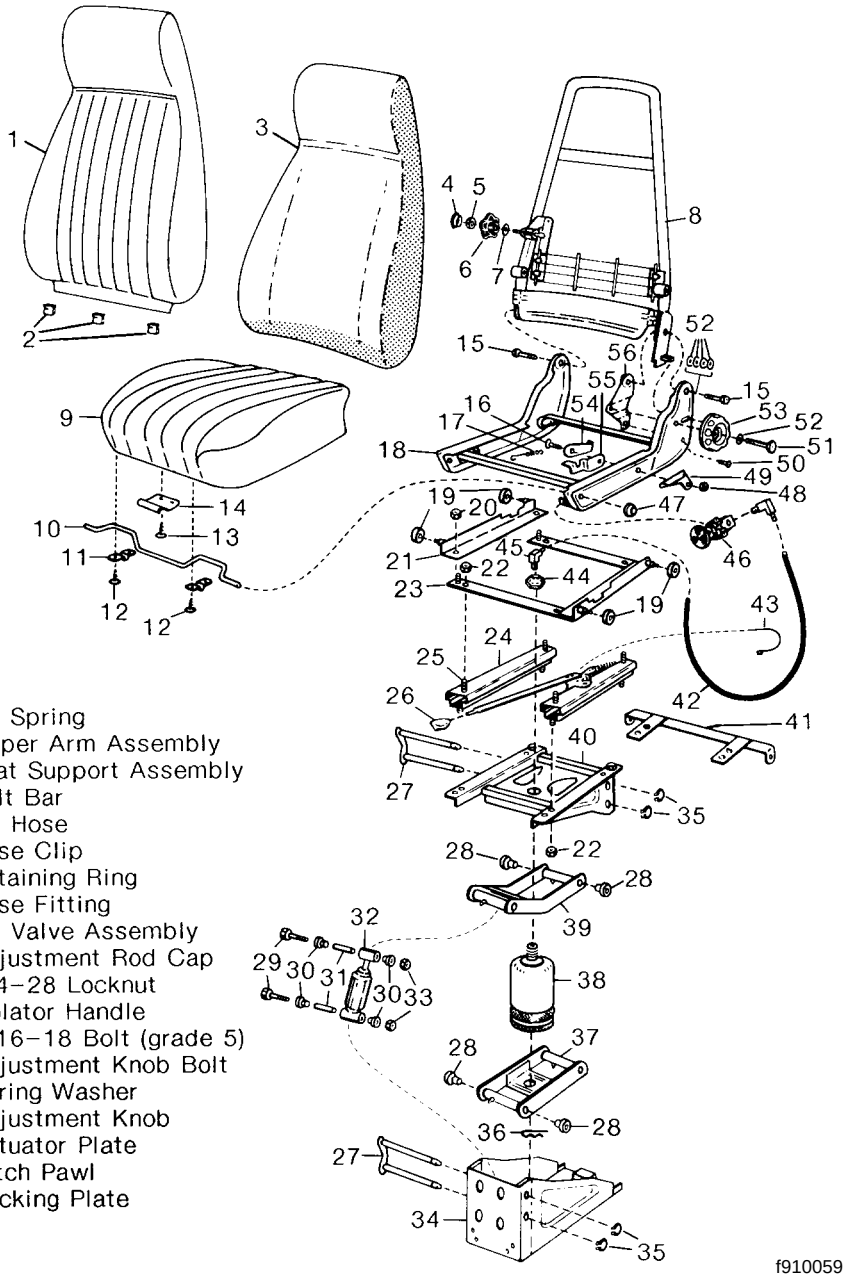

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Fig. 1

Removal

1. Remove the protective covering (if equipped) from the seat base.
2. Remove the plastic tie strap that attaches the seat cushion (**Fig. 1**, Ref. 9) to the lower frame assembly (Ref. 18).
3. Remove the machine screws (Ref. 12) and retainers (Ref. 11) that attach the seat cushion (Ref. 9) to the front cushion adjustment rod (Ref. 10). Remove the seat cushion.
4. Remove the nut (**Fig. 2**) that attaches the air valve to the lower frame. Remove the valve and air hose from the lower frame.
5. Remove the four locknuts (Ref. 22) from under the top flange of the seat support assembly (Ref. 40).
6. Remove the lower frame from the seat base.

Installation

1. Place the lower frame (Ref. 18) on the seat support assembly (Ref. 40). Install the locknuts (Ref. 22) under the top flange of the seat support assembly. Tighten the locknuts 10 lbf·ft (15 N·m).
2. Using a lockwasher and jam nut, attach the air valve to the lower frame. Tighten the nut finger-tight. Using a wrench, tighten the nut one-half turn.

   Make sure that the air hose moves without any restrictions when the seat is moved forward or rearward.
3. Position the seat cushion, then install the retainers (Ref. 11) and machine screws (Ref. 12) that attach the seat cushion to the front cushion adjustment rod.
4. Install a new plastic tie strap to secure the seat cushion to the lower frame assembly.
5. Install the protective covering (if equipped) on the seat base.

Lower Frame Removal and Installation

1. Back Cover (Upholstery)
2. Tinnerman Clips
3. Polyfiller Cushion
4. Plug
5. 5/16–18 Nut
6. Lumbar Adjustment Knob
7. Plastic Washer
8. Upper Frame Assembly
9. Seat Cushion
10. Cushion Adjustment Rod
11. Retainer
12. 1/4–20 Machine Screw
13. No. 10–3/4 Machine Screw
14. Cushion Handle
15. Shoulder Bolt
16. Isolator Screw
17. Isolator Spring
18. Lower Frame Assembly
19. Bearing
20. 5/16–18 Hexnut
21. Bearing Support Rail
22. 5/16–18 Locknut
23. Bearing Support Frame
24. Track Assembly
25. 5/16–18 Bolt
26. Track Knob
27. Shaft Assembly
28. Bearing
29. 3/8–24 x 1–3/4" Hexhead Bolt
30. Nylon Bushing
31. Spacer
32. Shock Absorber
33. 3/8–24 Locknut
34. Base-and-Upright Assembly
35. Snap Ring
36. Pin Clip
37. Lower Arm Assembly
38. Air Spring
39. Upper Arm Assembly
40. Seat Support Assembly
41. Belt Bar
42. Air Hose
43. Hose Clip
44. Retaining Ring
45. Hose Fitting
46. Air Valve Assembly
47. Adjustment Rod Cap
48. 1/4–28 Locknut
49. Isolator Handle
50. 5/16–18 Bolt (grade 5)
51. Adjustment Knob Bolt
52. Spring Washer
53. Adjustment Knob
54. Actuator Plate
55. Latch Pawl
56. Backing Plate

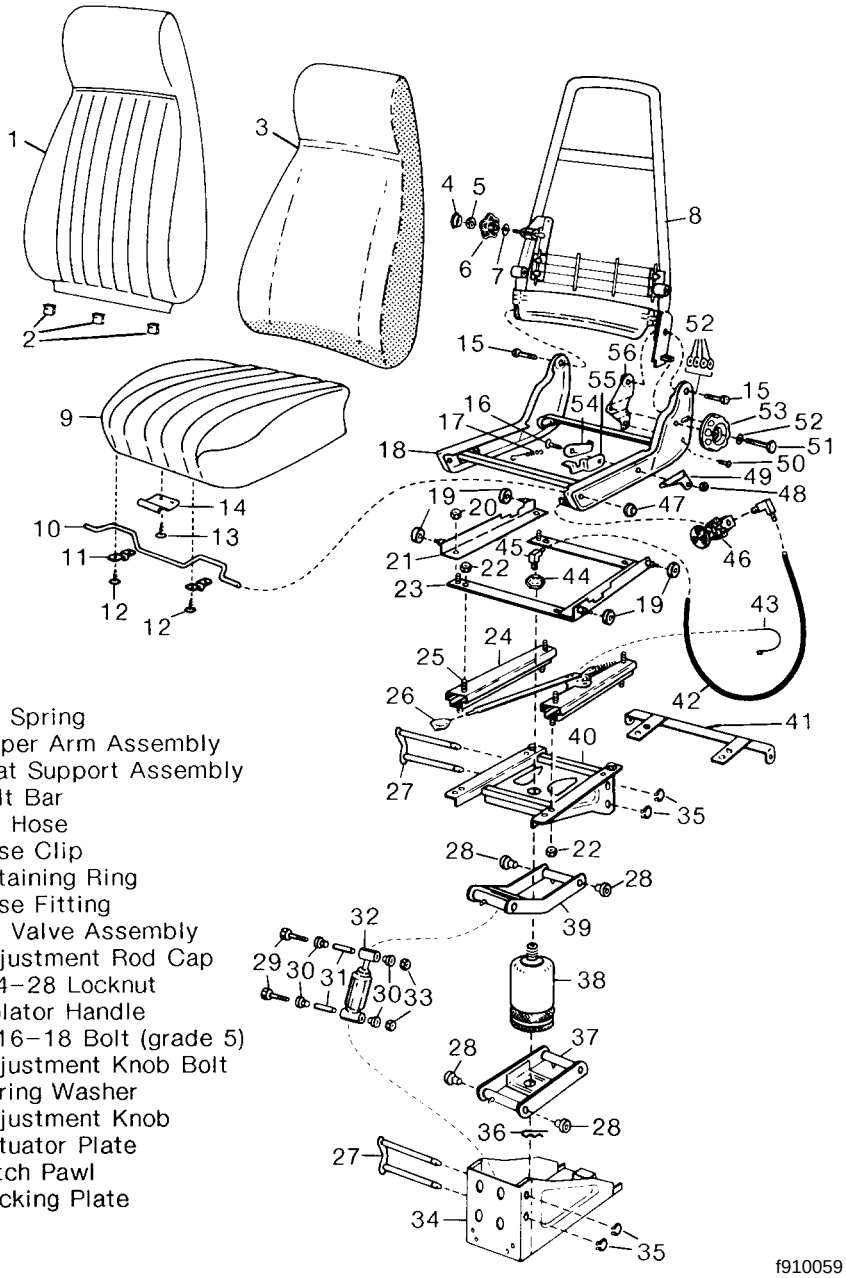

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Fig. 1

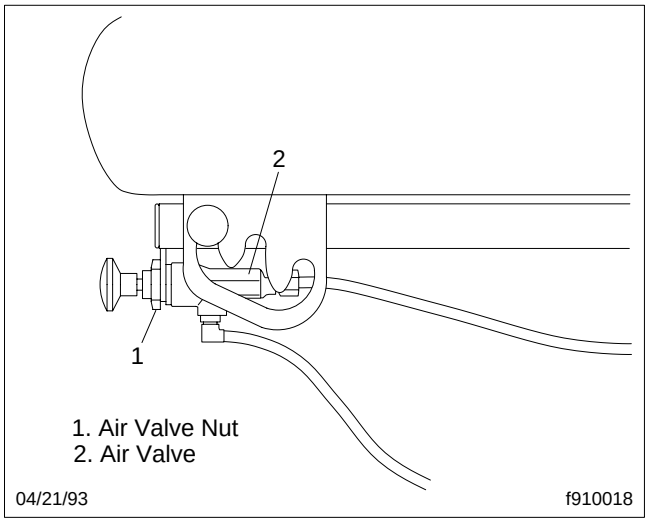

Fig. 2

Isolator Assembly (Chugger-Snubber) Removal and Installation

Removal (See Fig. 1)

1. Cut the plastic tie strap and raise the seat cushion. Make sure that the isolator handle (**Fig. 2**, Ref. 49) is in the up position.
2. Remove the hexnuts (Ref. 5) from the studs on the bearing support frame (Ref. 1).
3. Hold the seat, then slide the bearing support rail up and off the bearing support frame.

NOTE: Two of the bearings (Ref. 4) will fall off when the bearing support rail is removed.

4. Move the seat frame so you can see the other two bearings. Remove the bearings.
5. Check the bearing studs for wear and replace as needed.
6. Remove the four locknuts (Ref. 2) from the bearing support frame (Ref. 1). Remove the bearing support frame.

Installation (See Fig. 1)

1. Using a multipurpose chassis grease, lubricate the bearings and bearing cups.
2. Install the welded bearing support frame (Ref. 1) on the track assembly. Tighten the locknuts 10 lbf·ft (15 N·m).
3. Install the bearings (Ref. 4) on the bearing studs, then align the bearing cups on the lower seat frame over the bearings.
4. Assemble the bearing support rail and the two remaining bearings. Loosely tighten the hexnuts (Ref. 5).
5. Push the isolator assembly fore and aft, and check the position of the bearing support rail before tightening the hexnuts. The isolator should be tight enough to eliminate side play without interfering with the fore-and-aft movement of the seat.
6. Install a new plastic tie strap to attach the seat cushion to the lower frame assembly.

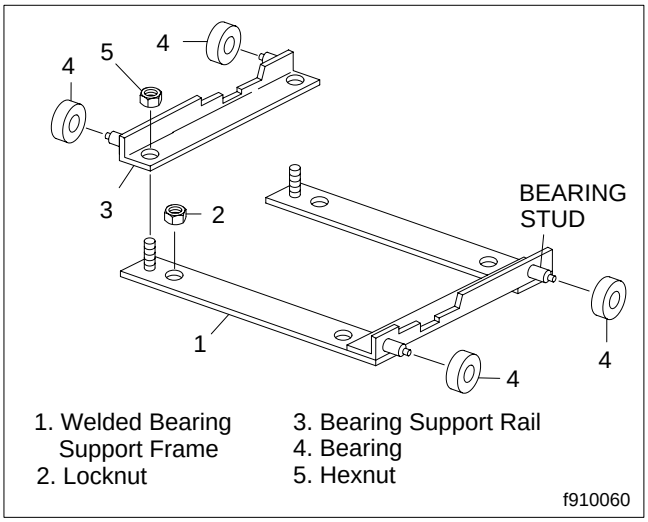

Fig. 1

Isolator Assembly (Chugger-Snubber) Removal and Installation

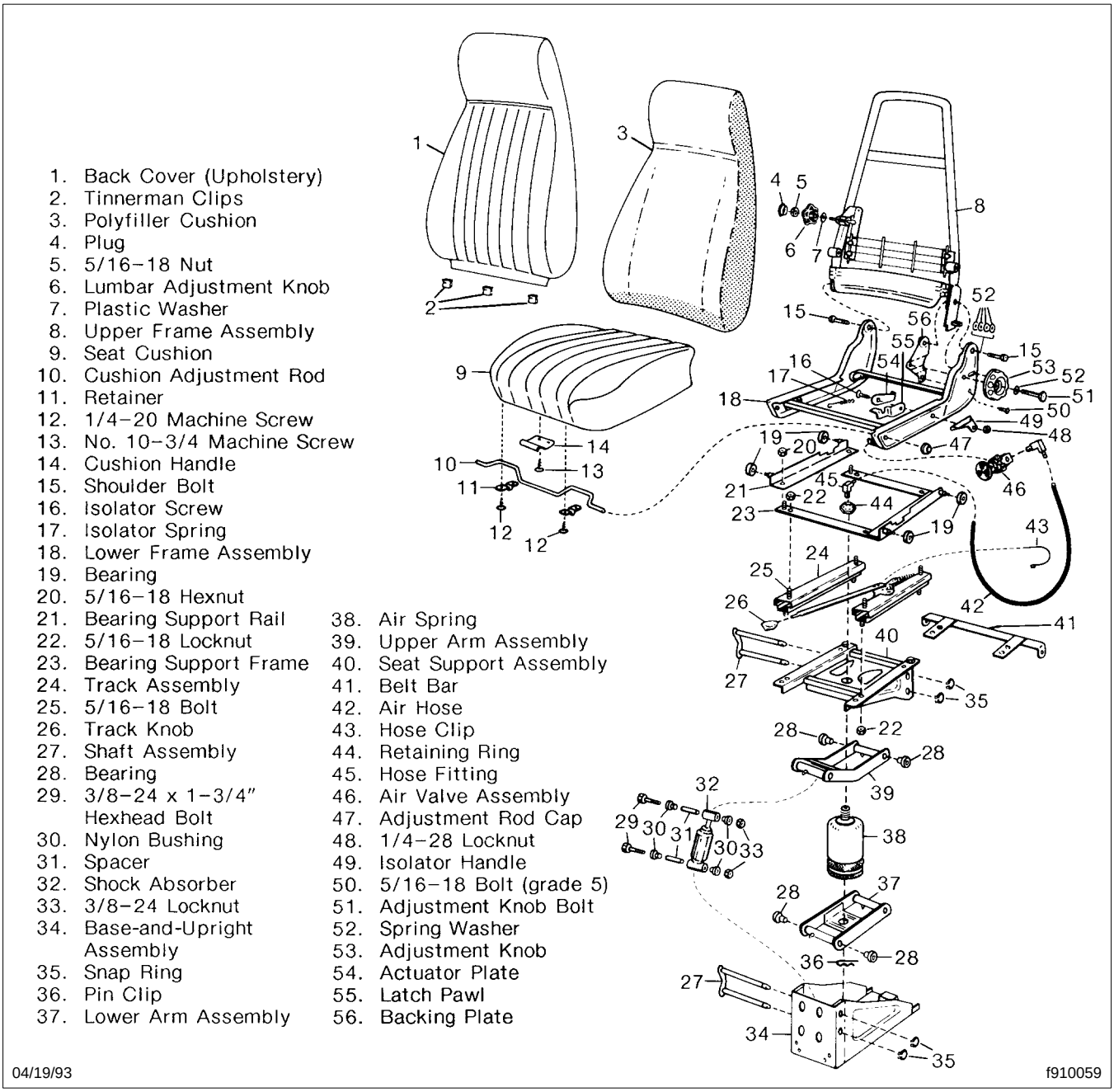

Fig. 2

Seat Support and Base Assembly Removal and Installation

Removal (See Fig. 1)

1. Remove the seat. For instructions, refer to **Subject 160**.
2. Remove the four locknuts (Ref. 22) that attach the track assembly (Ref. 24) and upper seat assembly to the seat support assembly (Ref. 40). Remove the track bar assembly and upper seat assembly.
3. Raise the seat assembly to maximum height. Using a wood block (**Fig. 2**), support the seat in this position.
4. Remove the retaining ring (**Fig. 1**, Ref. 44) from the air spring.
5. Remove the pin clip (Ref. 36) that secures the air spring (Ref. 38) to the lower arm assembly (Ref. 37). Remove the air spring.
6. Remove the nuts and bolts that attach the shock absorber to the upper arm and to the base-and-upright assembly. See **Fig. 3.** Remove the shock absorber from the seat assembly.
7. Using snap ring pliers, remove the snap rings (**Fig. 1**, Ref. 35) from the shaft assemblies (Ref. 27).
8. Using a drift punch, drive out the shafts from the base-and-upright assembly and the seat support assembly.

NOTE: Drive out the snap ring end of the shafts. Drive each shaft end a little at a time, as the two shafts are connected to each other on the opposite side.

9. Remove the seat support assembly, upper arm, and lower arm from the base-and-upright assembly.
10. Remove the bearings (Ref. 28) from the upper and lower arms.

Installation (See Fig. 1)

1. Place the lower end of the shock absorber in the mounting bracket of the base-and-upright assembly. Using a new spacer and bushings, install the hexhead bolt and locknut. Tighten the locknut 25 lbf·ft (34 N·m).
2. Install the bearings (Ref. 28) in the upper and lower arm shafts.
3. Place the lower and upper arms on the base, aligning the arm tubes and bearings with the holes in the base.
4. Install the shaft assembly through the base and the arm assembly tubes. Using snap ring pliers, install the snap rings and secure the shaft and arm assembly to the base.
5. Using new spacers and bushings, position the shock absorber so that the piston-rod end is in the mounting bracket of the upper arm.
6. Install the hexhead bolt and locknut to attach the shock absorber to the upper arm. Tighten the locknut 25 lbf·ft (34 N·m).
7. Position the air spring in the lower arm assembly. Install the pin clip.
8. Install the retaining ring (Ref. 44) on the air spring (Ref. 38).
9. Align the lower and upper arm tubes and bearings with the holes in the seat support assembly.
10. Insert the shaft assembly (Ref. 27) through the seat support and through the upper arm and lower arm tubes. Using snap ring pliers, install the snap rings to secure the shaft and arm assembly to the seat support.
11. Position the air spring (Ref. 38) in the lower arm assembly (Ref. 37). Install the pin clip (Ref. 36).
12. Position the upper end of the air spring in the opening of the seat support assembly (Ref. 40). Install the retaining ring (Ref. 44) on the spring.
13. Place the track assembly (Ref. 24) and upper seat assembly on the seat support assembly (Ref. 40). Install the locknuts and tighten them 10 lbf·ft (15 N·m).
14. Install the seat. For instructions, refer to **Subject 160**.

Seat Support and Base Assembly Removal and Installation

1. Back Cover (Upholstery)
2. Tinnerman Clips
3. Polyfiller Cushion
4. Plug
5. 5/16–18 Nut
6. Lumbar Adjustment Knob
7. Plastic Washer
8. Upper Frame Assembly
9. Seat Cushion
10. Cushion Adjustment Rod
11. Retainer
12. 1/4–20 Machine Screw
13. No. 10–3/4 Machine Screw
14. Cushion Handle
15. Shoulder Bolt
16. Isolator Screw
17. Isolator Spring
18. Lower Frame Assembly
19. Bearing
20. 5/16–18 Hexnut
21. Bearing Support Rail
22. 5/16–18 Locknut
23. Bearing Support Frame
24. Track Assembly
25. 5/16–18 Bolt
26. Track Knob
27. Shaft Assembly
28. Bearing
29. 3/8–24 x 1–3/4" Hexhead Bolt
30. Nylon Bushing
31. Spacer
32. Shock Absorber
33. 3/8–24 Locknut
34. Base-and-Upright Assembly
35. Snap Ring
36. Pin Clip
37. Lower Arm Assembly
38. Air Spring
39. Upper Arm Assembly
40. Seat Support Assembly
41. Belt Bar
42. Air Hose
43. Hose Clip
44. Retaining Ring
45. Hose Fitting
46. Air Valve Assembly
47. Adjustment Rod Cap
48. 1/4–28 Locknut
49. Isolator Handle
50. 5/16–18 Bolt (grade 5)
51. Adjustment Knob Bolt
52. Spring Washer
53. Adjustment Knob
54. Actuator Plate
55. Latch Pawl
56. Backing Plate

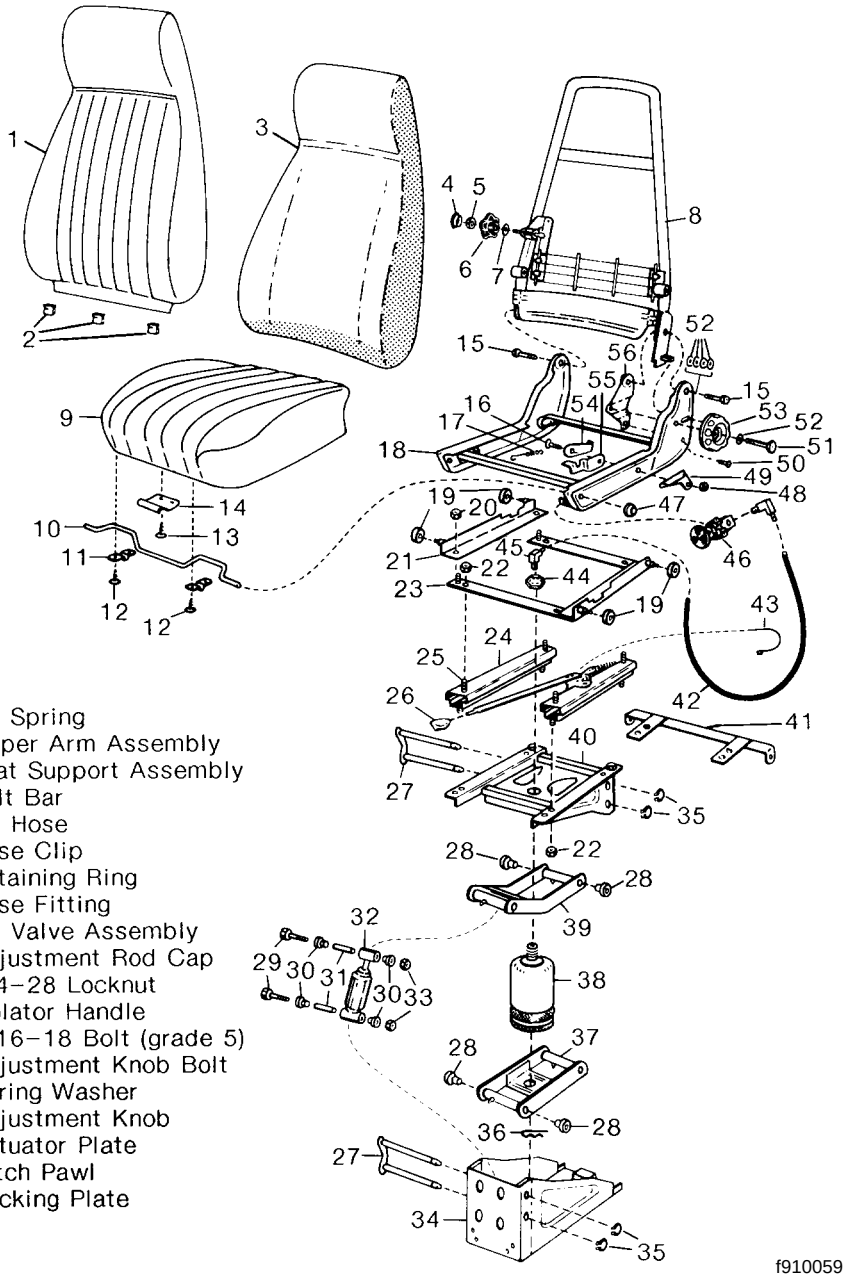

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Fig. 1

Seat Support and Base Assembly Removal and Installation

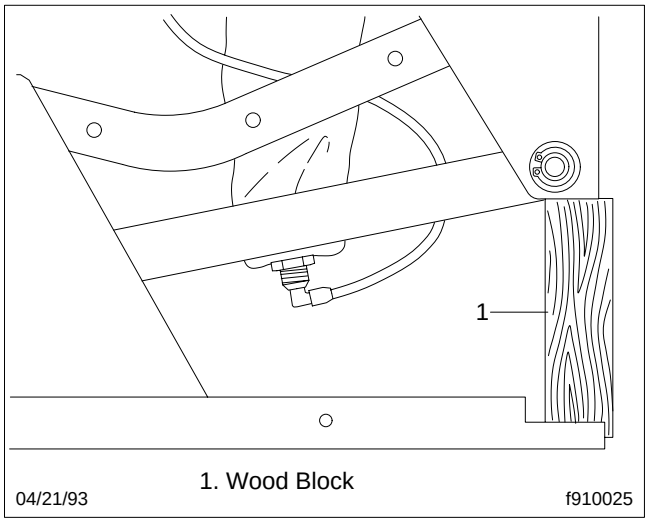


Fig. 2

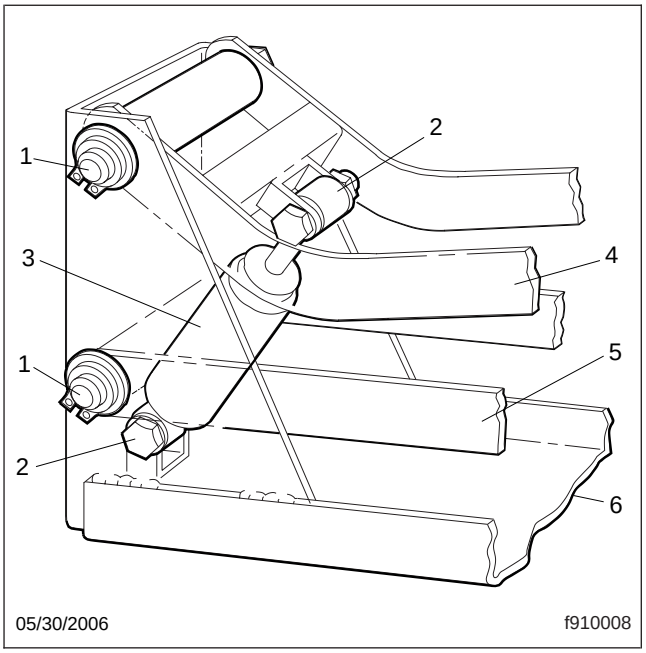


Fig. 3, Shock Absorber Assembly

Removal (See Fig. 1)

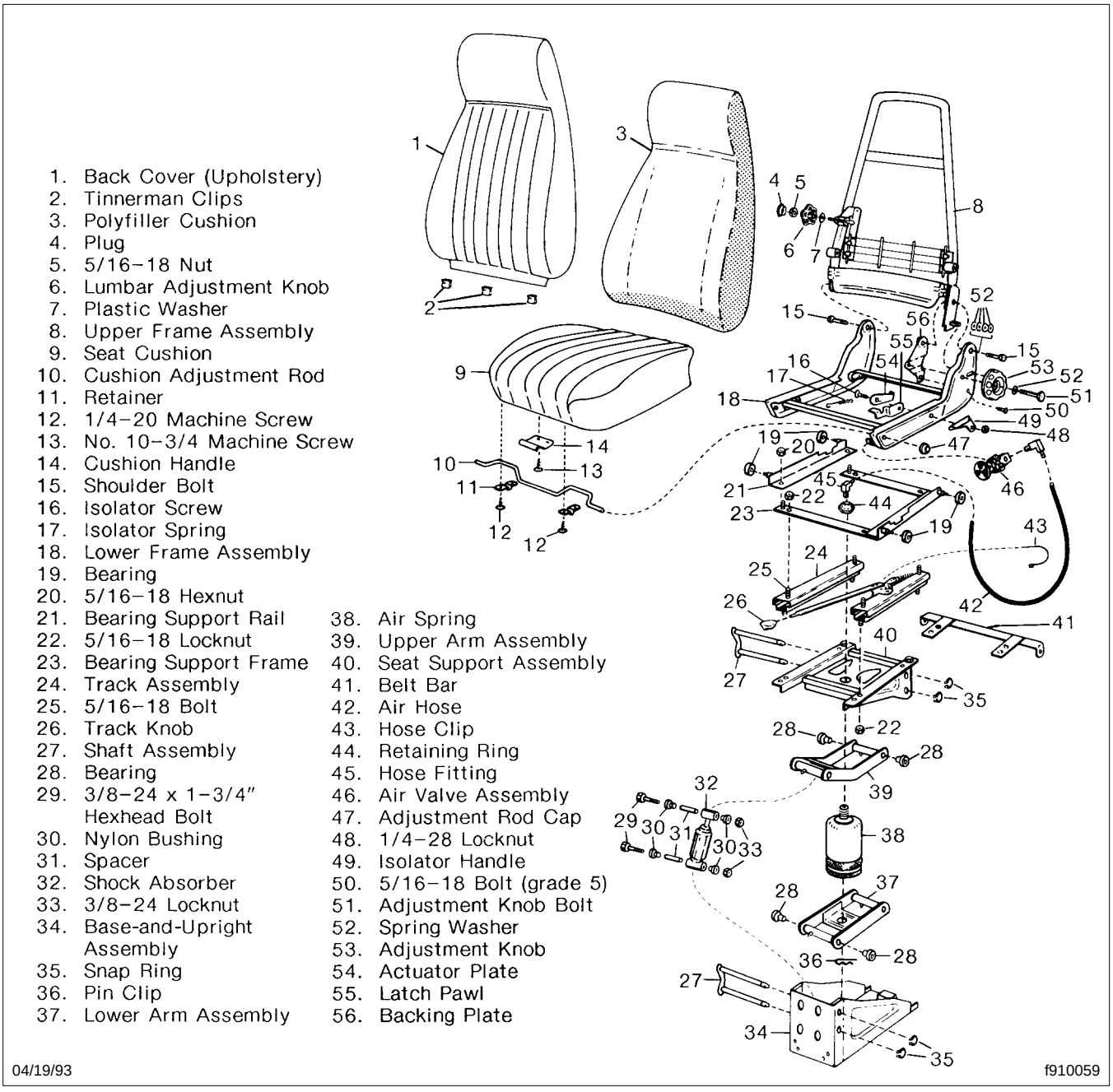


Fig. 1

1. Remove the protective covering (if equipped) from the seat base.

Seat Removal and Installation

2. Raise the seat assembly to maximum height. Using a wood block, support the seat in this position.
3. Pull the air valve knob (Ref. 46) until all air is exhausted from the air spring.
4. Disconnect the air hose (Ref. 42) from the air hose fitting (Ref. 45), then remove the fitting from the air spring. Plug the hose and fitting to prevent dirt or other matter from entering.
5. Remove the nut (**Fig. 2**) that attaches the air valve to the lower frame. Remove the valve and air hose from the lower frame.
6. Remove the bolts and washers that attach the base-and-upright assembly (**Fig. 1**, Ref. 34) to the mounting plate on the cab deck. Remove the seat assembly from the cab.

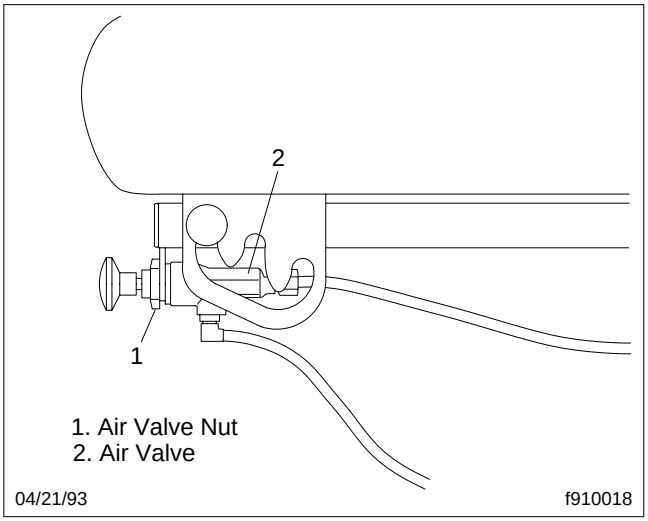


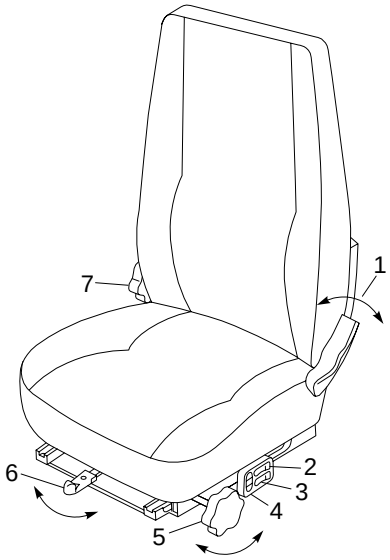
Fig. 2

Installation (See Fig. 1)

1. Place the seat assembly on the cab deck mounting plate.
2. Insert the bolts and washers through the seat base-and-upright assembly. Install the washers and nuts. Tighten the nuts 25 lbf·ft (34 N·m).
3. Attach the air valve to the lower frame. Tighten the nut finger-tight. Using a wrench, tighten the nut one-half turn.
4. Unplug the air hose and fitting. Connect the air hose to the fitting on the air spring.
5. Push the air valve knob to raise the seat. Remove the wood block.
6. Install the protective covering (if equipped) on the seat base. Adjust the seat as needed.

General Information

The Bostrom Talladega 915 air suspension seats offer weight-height adjustment, lumbar support and a fore and aft roller track isolator system. See **Fig. 1**.



1. Back Angle Adjustment
2. Upper Air Lumbar Adjustment (optional)
3. Lower Air Lumbar Adjustment (optional)
4. Weight and Height Adjustment
5. Seat Cushion Tilt Adjustment
6. Fore and Aft Isolation and Seat Position Adjustment
7. Lumbar Adjustment Knob

Fig. 1, Bostrom Talladega 915 Seat

For complete operating instructions, refer to the vehicle driver's manual.

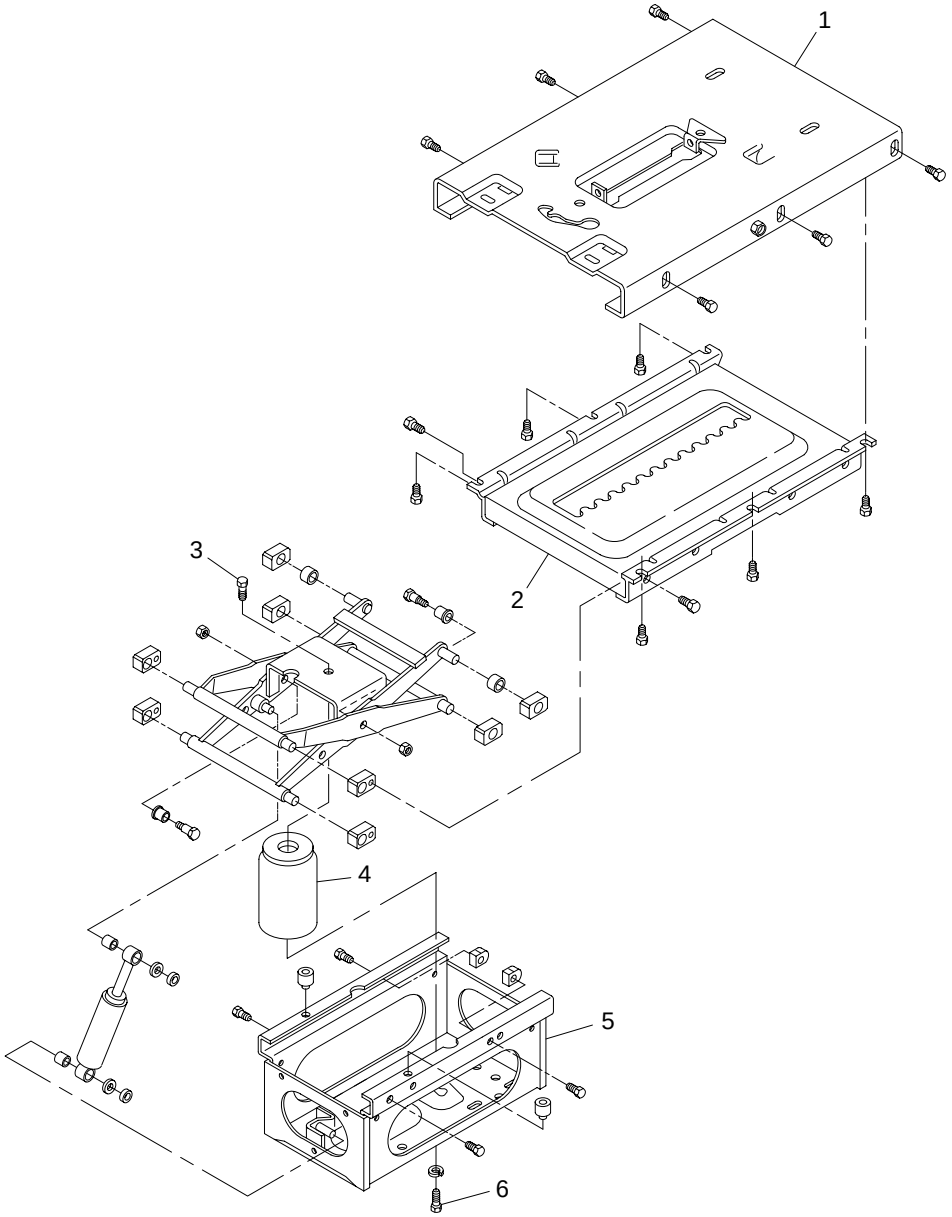
Removal

1. Apply the parking brakes, and chock the tires.
2. Push in on the top of the seat ride height switch until the seat is adjusted to its maximum height.
3. If the seat is equipped with a seat suspension cover, remove it.
4. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the rear crossbars of the air suspension's inner and outer lever assemblies.
5. Drain the vehicle air reservoirs. Then push in on the bottom of the seat ride-height rocker switch until all air is exhausted from the air spring.
6. Disconnect the air valve air supply hose at the quick-connect union.
7. Remove the seat belt straps and tether straps.
8. Remove the capscrews and washers that attach the seat to the cab deck. Remove the seat from the cab.

Installation

1. Place the seat on the cab deck. Insert the capscrews through the washers and the seat base. Tighten the capscrews 27 lbf·ft (37 N·m).
2. Attach the seat belt straps and tether straps. Tighten the capscrews 40 lbf·ft (54 N·m).
3. Connect the air valve air supply hose by pressing the pneumatic tubing into the quick-connect union.
4. Start the engine and allow the air reservoirs to fill. Push in on the top of the seat ride height rocker switch until the seat is adjusted to its maximum height, then remove the wooden block that supports the seat suspension.
5. If the seat is equipped with a seat suspension cover, install it.
6. Remove the chocks from the tires.

Removal (See Fig. 1)



1. Channel Assembly
2. Upper Frame
3. Top Screw
4. Air Spring
5. Base Riser
6. Bottom Capscrew

Fig. 1, Bostrom Talladega 915 Seat

NOTE: The seat, seat/back assembly, and channel assembly do not need to be removed. Move the channel assembly to the rearmost position to provide access to the air spring.

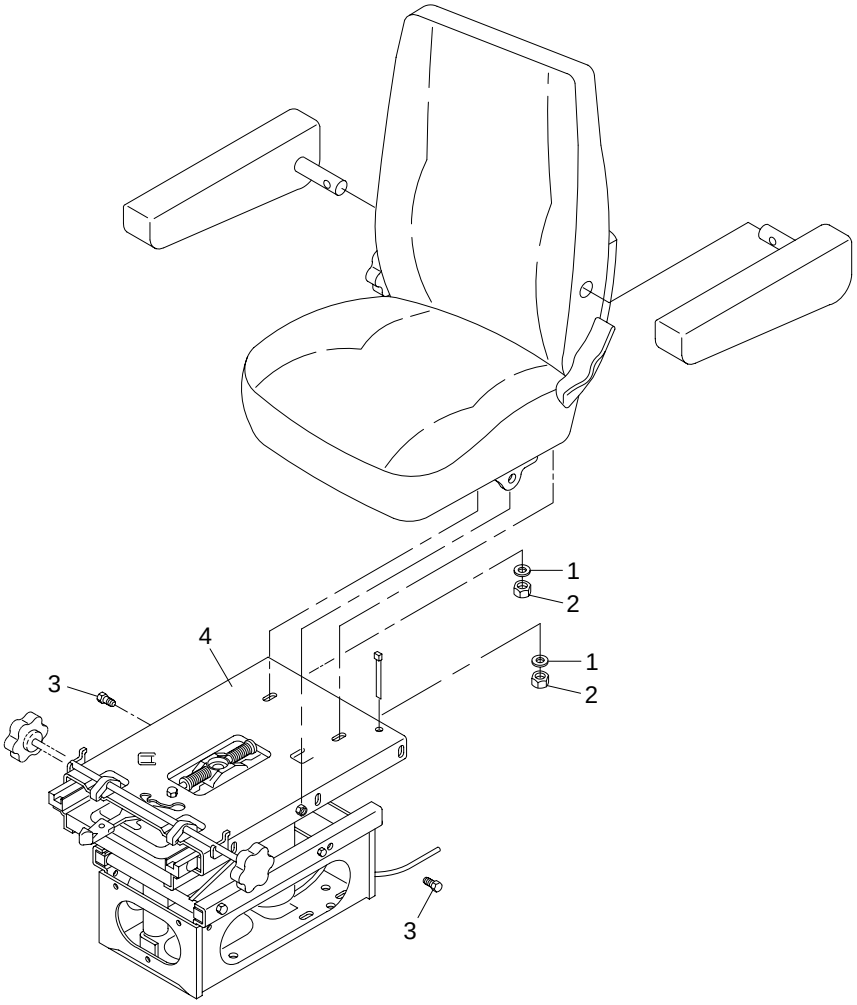
Air Spring Removal and Installation

1. Fill the air spring so that the seat is at its maximum height.
2. Block the suspension up with a spacer placed between the base riser and the upper frame.
3. Release the air pressure from the air spring so that the seat is supported by the spacer.
4. Disconnect the air line from the air spring by pushing in the collar of the fitting while pullling the air line out of the fitting.
5. Remove the top screw and loosen the bottom capscrew through the rear opening in the base riser. Remove the air spring from the suspension.

Installation (See Fig. 1)

1. Install the bottom capscrew into the new air spring. Install the air spring into the key hole opening in the bottom of the base riser with the bottom capscrew. Position the air spring so the fitting at the bottom of the air spring is toward the front of the seat.
2. Tighten the bottom capscrew 9 to 11 lbf·ft (12 to 15 N·m).
3. Install the top screw and tighten it 5 to 7 lbf·ft (7 to 10 N·m).
4. Connect the air line to the fitting in the air spring by pushing the tube into the fitting.
5. Fill the air spring and remove the spacer block.

Removal (See Fig. 1)



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1. Flatwasher
2. Nut
3. Shoulder Bolt
4. Channel Assembly

Fig. 1, Bostrom Talladega 915 Seat

1. Adjust the seat/back assembly to the most rearward position.
2. Remove the two nuts and flatwashers from the underside of the channel assembly.
3. Remove the two shoulder bolts from the channel assembly.
4. Disconnect the air line to the air lumbar support, if equipped.
5. Remove the seat/back assembly.

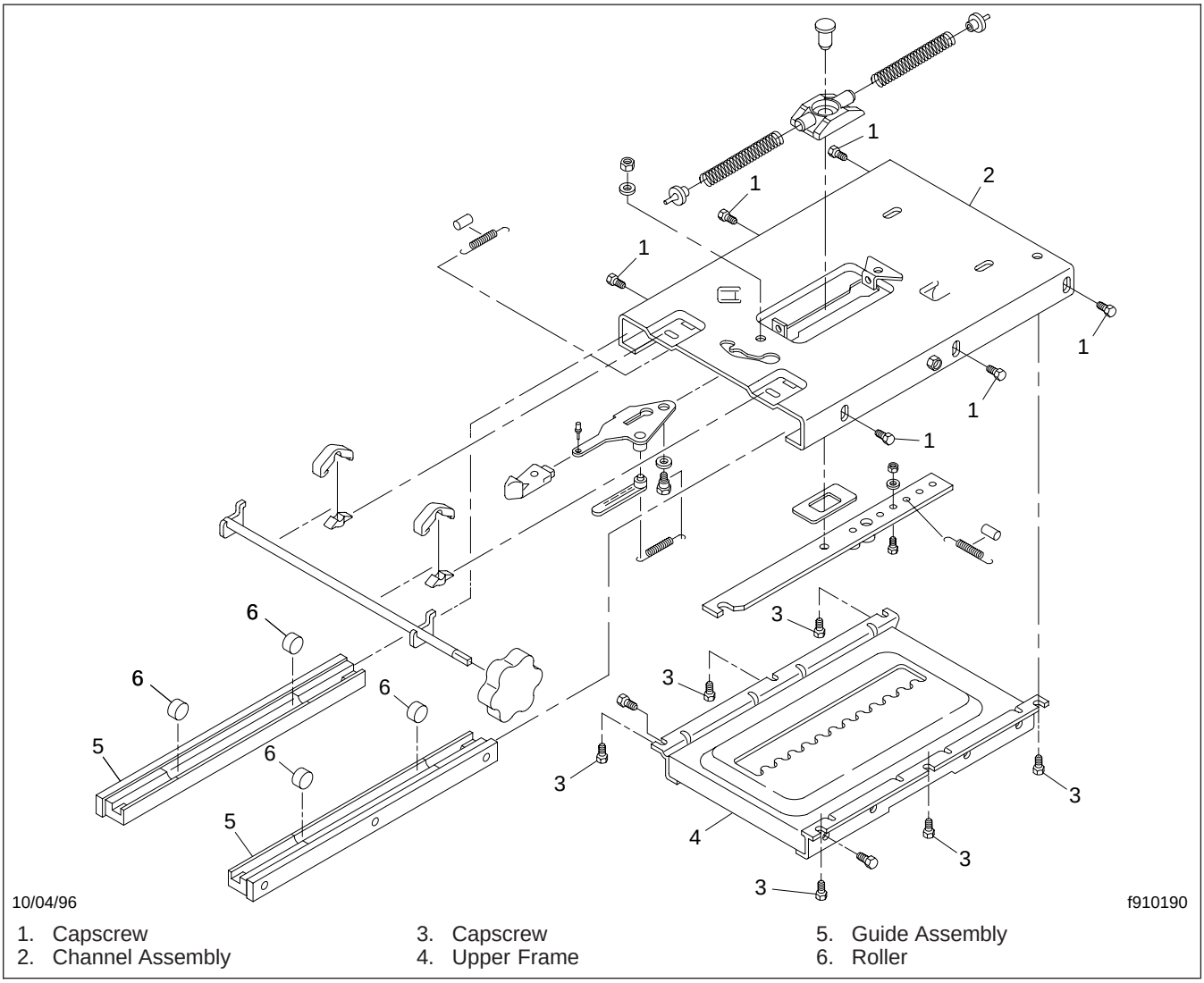
Installation (See Fig. 1)

1. Place the seat/back assembly onto the channel assembly.
2. Connect the air line to the air lumbar support, if equipped.

Seat/Back Assembly Removal and Installation

3. Install the two shoulder bolts to the channel assembly.
4. Install the two nuts and flatwashers to the underside of the channel assembly.

Removal (See Fig. 1)



1. Capscrew
2. Channel Assembly
3. Capscrew
4. Upper Frame
5. Guide Assembly
6. Roller

Fig. 1, Channel Assembly (exploded)

1. Adjust the channel assembly until the cutouts in the underside of the channel line up with the capscrews. Remove the capscrews and discard.
2. Remove the three capscrews on each side of the channel assembly and discard.
3. Remove both guide assemblies and the four rollers.

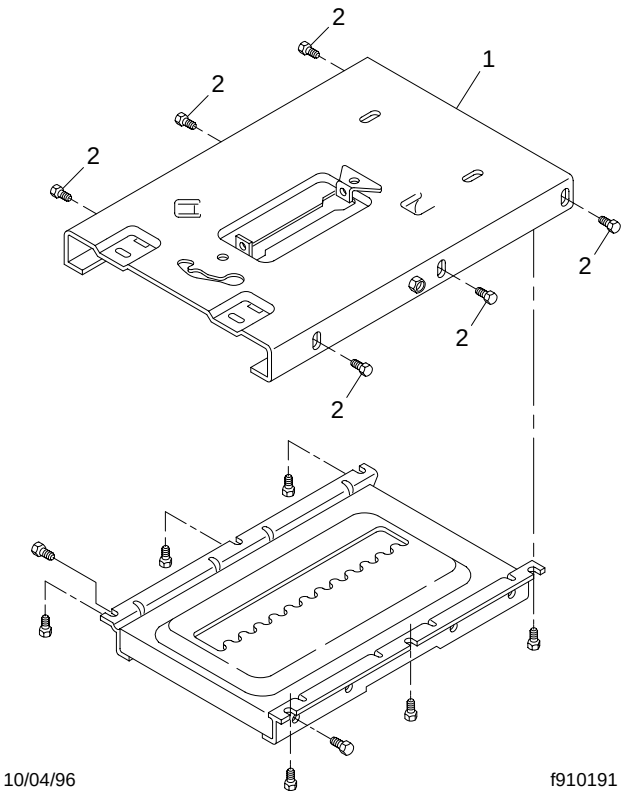
Installation (See Fig. 1)

1. Install both guide assemblies and the four rollers.
2. Install the three capscrews on each side of the channel assembly. Do not fully tighten the capscrews.

Roller Guide Removal and Installation

3. Install the center capscrews on the underside of the channel assembly. Tighten the capscrews 5 to 7 lbf·ft (7 to 9 N·m).
4. Carefully move the assembly rearward and install the front capscrews. Move the assembly forward and install the rear capscrews. Tighten the capscrews 5 to 7 lbf·ft (7 to 9 N·m).
5. Tighten the capscrews on each side of the channel assembly 5 to 7 lbf·ft (7 to 9 N·m).
6. Adjust the channel assembly using the instructions in **Subject 140**.

Adjustment (See Fig. 1)

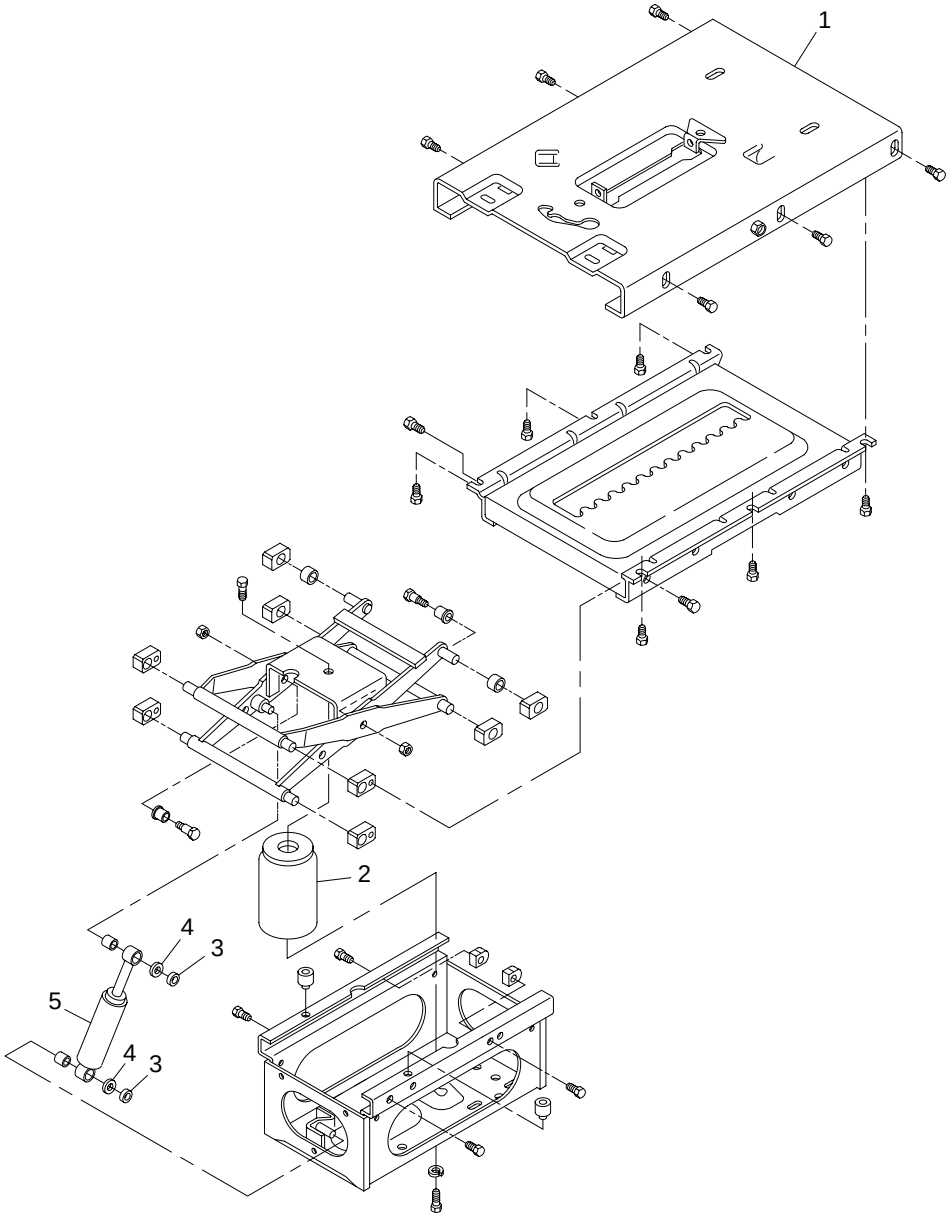


1. Channel Assembly
2. Capscrew

Fig. 1, Bostrom Talladega 915 Seat

1. Loosen the six capscrews along the side of the channel assembly.
2. Push down on the channel assembly to adjust vertical play.
3. Retighten the six capscrews. Tighten the capscrews 5 to 7 lbf·ft (7 to 9 N·m).

Removal (See Fig. 1)



1. Channel Assembly
2. Air Spring
3. Push-On Fastener
4. Thrust Washer
5. Damper

Fig. 1, Bostrom Talladega 915 Seat

NOTE: The seat/back assembly does not need to be removed.

1. Move the channel assembly to the rearmost position to provide access to the damper assembly.

Damper Removal and Installation

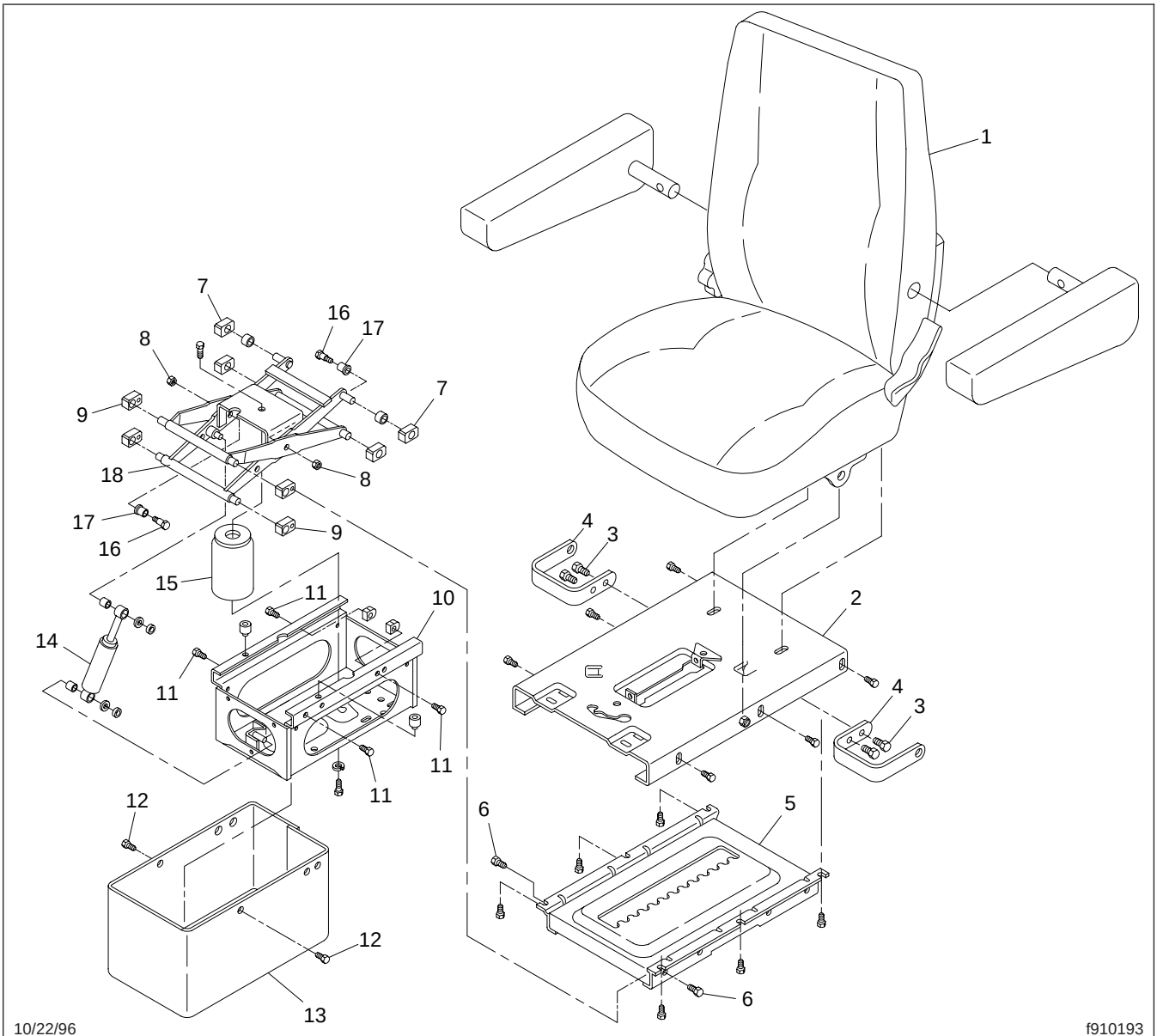
2. Fill the air spring so that the seat is at maximum height.
3. Use pliers or a screwdriver to twist off the push-on fasteners. The push-on fasteners are not reusable.
4. Remove the damper.

Installation (See Fig. 1)

1. Install the new damper with the flanges of the bearings to the outside of the suspension.
2. Install the thrust washers and the push-on fasteners until they seat. A 1/2-inch box end wrench works well to push the fasteners on.

Suspension Rebuild Bearing/Slide Block Removal and Installation

Removal (See Fig. 1)



1. Seat/Back Assembly
2. Channel Assembly
3. Capscrew
4. ICP Bracket
5. Upper Frame
6. Capscrew
7. Slide Block
8. Nut
9. Bearing Block
10. Base Riser
11. Capscrew
12. Fastener
13. Suspension Cover
14. Damper
15. Air Spring
16. Shoulder Bolt
17. Bearing
18. Slide Lever Assembly

Fig. 1, Bostrom Talladega 915 Seat (exploded)

Suspension Rebuild Bearing/Slide Block Removal and Installation

1. Bleed all the air from the supply line. Disconnect the air supply line to the seat. Using the air valve, exhaust all the air from the air spring. Remove the complete seat assembly from the vehicle using the instructions in **Subject 100**.
2. Remove the seat/back assembly, using the instructions in **Subject 120**.
3. Remove the capscrews and the ICP bracket. If the seat assembly has a suspension cover, remove the fasteners and the suspension cover.
4. Block the suspension up with a spacer placed between the base riser and the upper frame.
5. Remove the air spring using the instructions in **Subject 110**. Mark the air line for reassembly.
6. Remove the damper using the instructions in **Subject 150**.
7. Remove the capscrews from the upper front bearing blocks and the lower rear stop block assemblies.
8. Remove the upper frame assembly by sliding it forward off of the bearing blocks and the slide blocks.
9. Remove the capscrews from the lower bearing blocks and slide the lever assemblies forward until the bearing blocks are removed from the channel on the base riser. Slide the lever assemblies rearward to remove the slide blocks from the channel.
10. Remove the shoulder bolts and nuts from the pivots of the lever assemblies and inspect the bolts. If the bolts are worn, replace them.

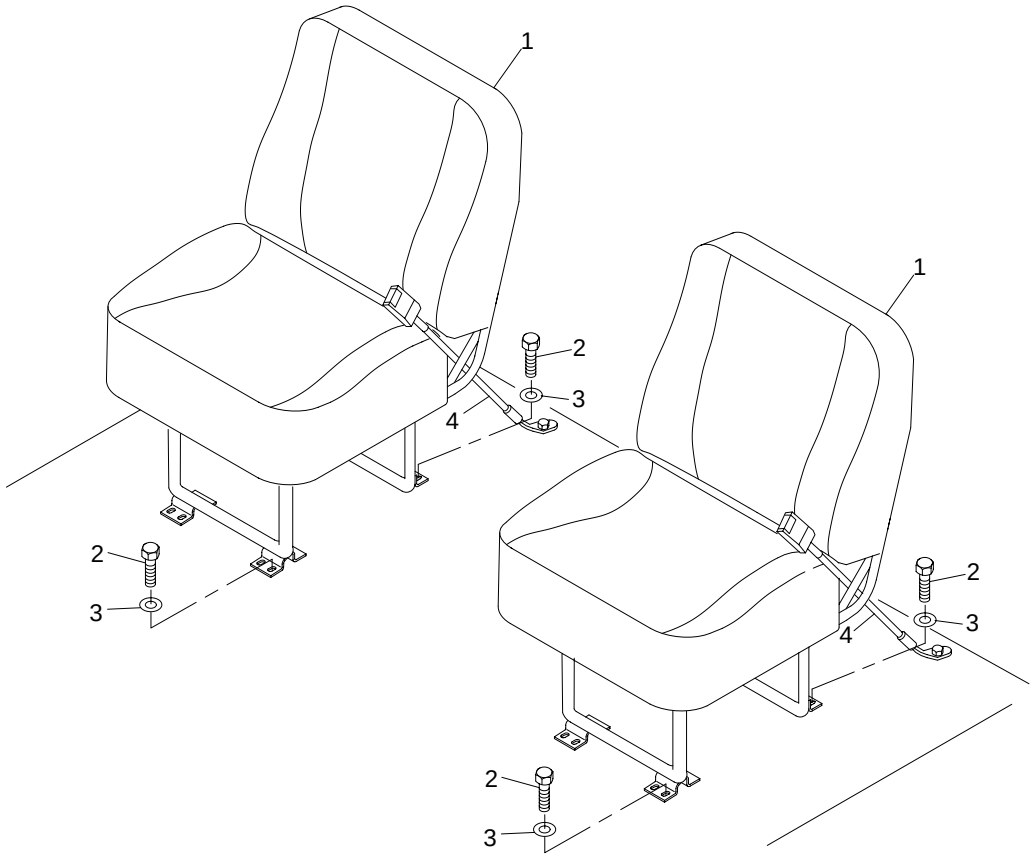
Installation (See Fig. 1)

1. Replace the bearings at the pivots on the lever assembly by pushing out the old bearings and pressing in the new bearings. The flange of the bearings should be on the outside of the lever assembly.
2. Install the shoulder bolts and nuts into the pivots of the lever assemblies. Tighten the bolts 18 to 22 lbf·ft (24 to 30 N·m).
3. Install new bearing blocks, spacers, and slide blocks on the levers with the beveled surfaces outward and slide the levers with blocks into the channel on the base riser. Tighten the screws 27 to 33 lbf·ft (37 to 45 N·m).
4. Slide the upper frame assembly over the blocks. Line up the capscrews with the bearing blocks and tighten the screws 27 to 33 lbf·ft (37 to 45 N·m).
5. Manually move the suspension up and down to make sure there are no clearance problems.
6. Block suspension up with a spacer placed between the base riser and the upper frame. Install the air spring using the instructions in **Subject 110**.
7. Install the damper using the instructions in **Subject 150**.
8. Install the ICP bracket and capscrews. If the seat assembly has a suspension cover, install the suspension cover and the fasteners.
9. Install the seat/back assembly using the instructions in **Subject 120**.
10. Install the seat assembly in the vehicle, using the instructions in **Subject 100**. Connect the air supply line to the seat.

Bostrom Tube Frame Seat Removal and Installation

Removal

1. Remove the four hex-head bolts attaching the seat frame to the deck of the cab. See **Fig. 1**.
4. Insert the seat belt through the rear of the seat frame assembly.



1. Seat
2. Hex-Head Bolts
3. Washer
4. Seat Belt

Fig. 1, Bostrom Tube Frame Seat Assembly

2. Pull the seat belt from the rear of the seat frame assembly.
3. Lift the seat from the cab deck.

Installation

1. Place the seat on the cab deck.
2. Secure the seat to the deck with the bolts and the washers. See **Fig. 1**.
3. Tighten the bolts.

General Information

WARNING

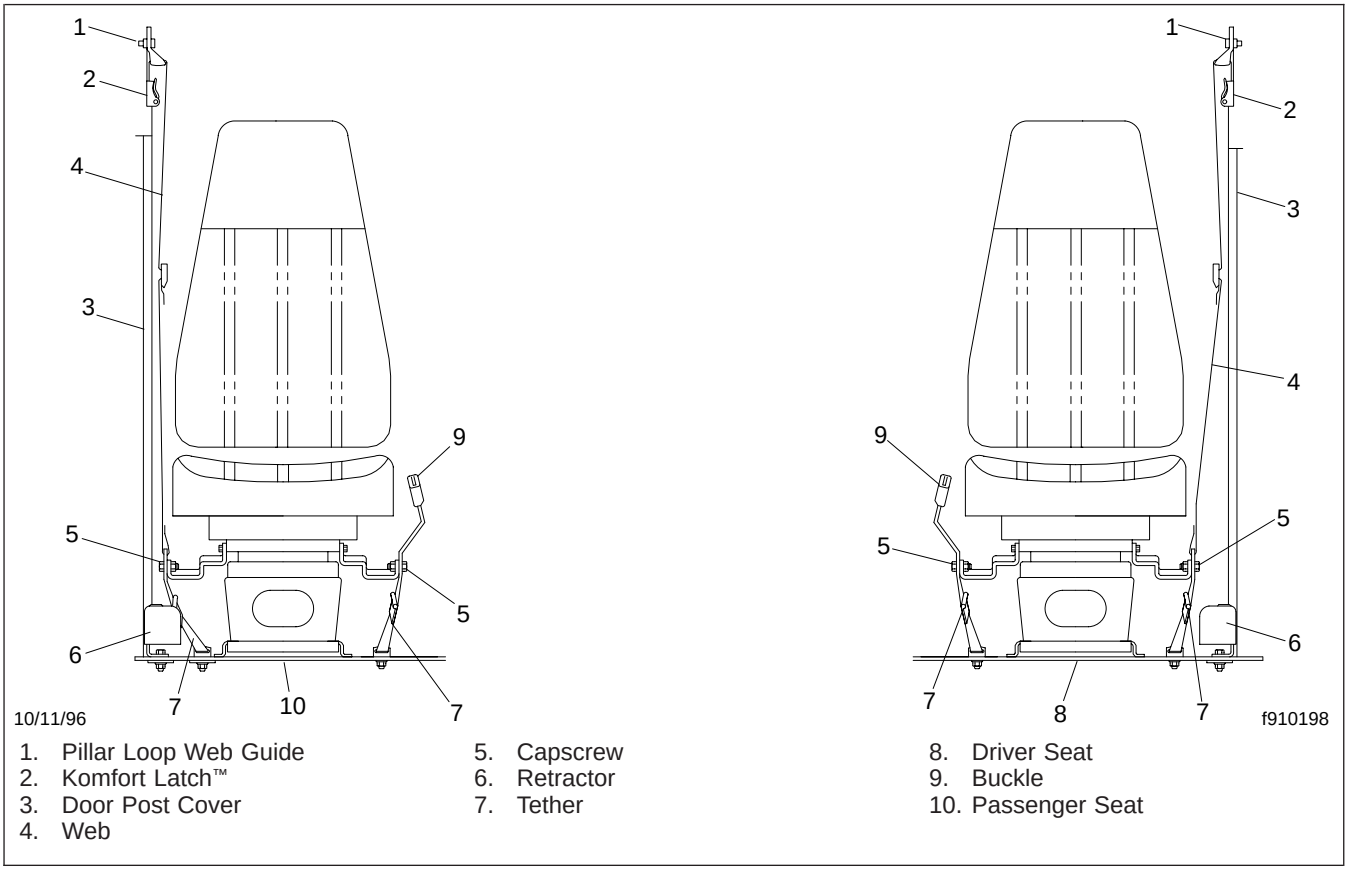
Inspect and maintain seat belts. When any part of a seat belt system needs replacement, the entire seat belt must be replaced, both retractor and buckle side. Any time a vehicle is involved in an accident, and the seat belt system was in use, the entire vehicle seat belt system must be replaced before operating the vehicle. Do not attempt to modify the seat belt system; doing so could change the effectiveness of the system. Failure to replace worn or damaged seat belts, or making any modifications to the system, may result in personal injury or death.

Although the three-point seat belts (**Fig. 1**) installed in Freightliner vehicles appear similar to the seat belts used in passenger cars, there are some important differences that can affect service life.

- A heavy truck can travel more miles in a year than a car might go in its lifetime.
- There is more movement in truck seat and belt systems, especially with air ride seats.
- Trucks often operate in more severe environments than cars, such as gravel pits, cement plants, and grain elevators, where the belts are exposed to abrasive dirt and dust.

Because of these factors, truck seat belt systems need to be inspected regularly to ensure that they are in proper condition; see **Subject 100**.

IMPORTANT: When any part of a seat-belt system needs replacement, the entire seat-belt sys-



1. Pillar Loop Web Guide
2. Komfort Latch™
3. Door Post Cover
4. Web
5. Capscrew
6. Retractor
7. Tether
8. Driver Seat
9. Buckle
10. Passenger Seat

Fig. 1, Three-Point Seat Belt System

General Information

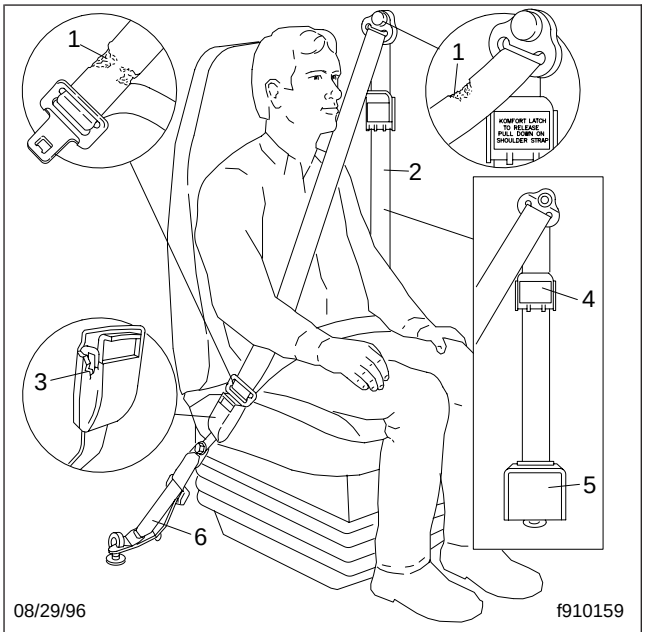
tem must be replaced—both the retractor side and the buckle side and, if equipped, both tether belts.

Inspection

WARNING

Inspect and maintain seat belts. When any part of a seat belt system needs replacement, the entire seat belt must be replaced, both retractor and buckle side. Any time a vehicle is involved in an accident, and the seat belt system was in use, the entire vehicle seat belt system must be replaced before operating the vehicle. Do not attempt to modify the seat belt system; doing so could change the effectiveness of the system. Failure to replace worn or damaged seat belts, or making any modifications to the system, may result in personal injury or death.

Seat belts and tether belts have a finite life which may be much shorter than the life of the vehicle. Regular inspections and replacement as needed are the only assurance of adequate seat belt security over the life of the vehicle. See **Fig. 1**.



1. Worn Web
2. Web
3. Buckle
4. Komfort Latch
5. Retractor
6. Tether Belt

Fig. 1, Seat Belt Inspection

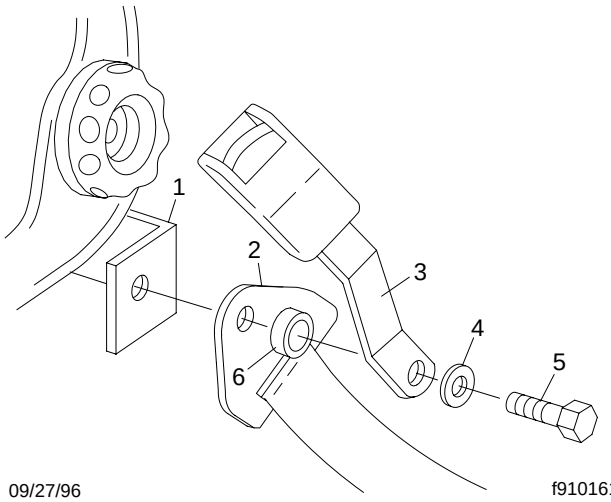
1. Check the web for fraying, cuts, extreme dirt and dust, or for severe fading from exposure to sunlight, especially near the buckle latch plate and in the D-loop guide area.
2. Check operation of the buckle, latch, Komfort Latch or Sliding Komfort Latch (if equipped), web retractor, and upper seat belt mount on the door pillar. Check all visible components for wear or damage.
3. Check the seat belt and tether belt connection points, and tighten any that are loose.

Seat Belts and Tethers Removal and Installation

Removal

IMPORTANT: When any part of a seat-belt system needs replacement, the entire seat-belt system must be replaced—both the retractor side and the buckle side and, if equipped, both tether belts.

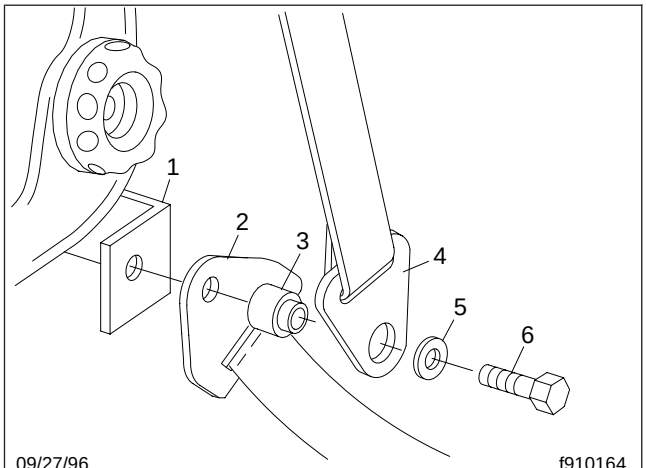
1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the bolt and washer holding the buckle, the spacer, and the tether to the seat. Also, remove the bolt holding the tether to the floor. Remove the buckle and the tether. See **Fig. 1**.



1. Mounting Bracket
2. Tether
3. Buckle
4. Washer
5. Bolt
6. Spacer

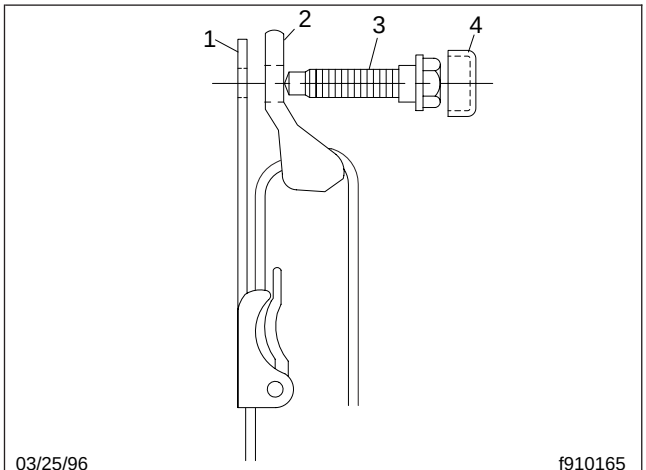
Fig. 1, Buckle Mounting

3. Remove the bolt and washer holding the seat belt, the spacer, and the tether to the seat. Also remove the bolt holding the tether to the floor. Remove the seat belt and the tether. See **Fig. 2**.
4. Remove the bolt cover and the bolt holding the pillar loop web guide and the Komfort Latch. Remove the pillar loop web guide and Komfort Latch™. See **Fig. 3**.
5. Remove the bolt and washer holding the retractor. Remove the retractor.



1. Mounting Bracket
2. Tether
3. Spacer
4. Seat Belt
5. Washer
6. Bolt

Fig. 2, Seat Belt Mounting



1. Komfort Latch
2. Pillar Loop Web Guide
3. Bolt
4. Bolt Cover

Fig. 3, Pillar Loop Web Guide and Komfort Latch Mounting

Installation

1. Install the retractor by inserting the bolt and washer through the retractor, and tighten 40 lbf·ft (54 N·m).

Seat Belts and Tethers Removal and Installation

IMPORTANT: The retractor must be mounted correctly before the web will reel out of the retractor and function properly.

2. Install the pillar loop web guide. See **Fig. 3**.

   2.1 Insert a bolt through the pillar loop web guide, the Komfort Latch™ and an optional metal spacer.

   NOTE: Some applications require a metal spacer to move the Komfort Latch/pillar loop web guide away from the vehicle cab trim (and some applications do not utilize the Komfort Latch).

   2.2 Thread the bolt into the anchor nut provided in the pillar.

   2.3 Tighten the bolt 40 lbf·ft (54 N·m). The Komfort Latch must be mounted vertically in line with the belt and remain rigid after tightening.

   IMPORTANT: The pillar loop web guide must rotate freely after assembly of the system.

   2.4 Snap the bolt cover in place over the bolt head.

3. Install the seat belt by inserting a bolt through the seat belt, a metal spacer, the tether, and the mounting bracket. Secure with a nut. Tighten 40 lbf·ft (54 N·m). See **Fig. 2**.

NOTE: Install the tether belt marked "IN" on the inboard side of the seat and the tether belt marked "OUT" on the outboard side of the seat.

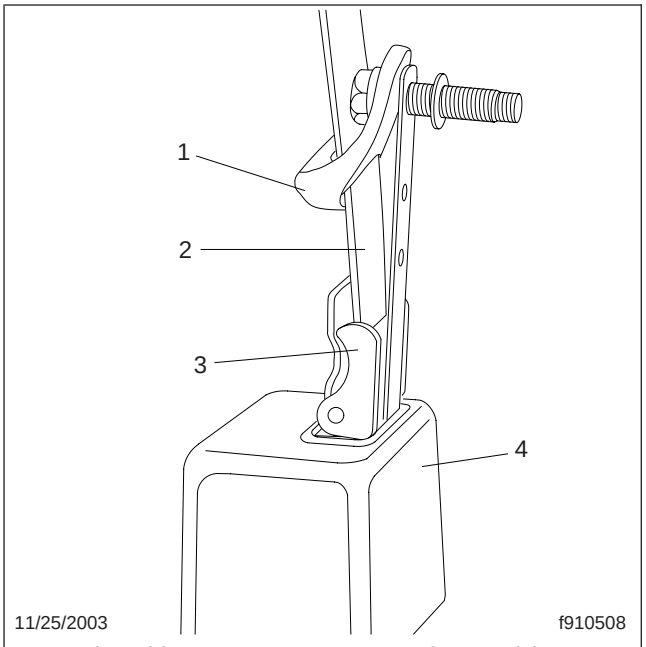
4. Install the buckle by inserting the bolt and washer through the buckle, the tether, and the mounting bracket. Secure with a nut. Tighten 40 lbf·ft (54 N·m). See **Fig. 1**.

5. Install the tethers by inserting the bolt through the tether and into the weldnut provided in the cab floor. Tighten 40 lbf·ft (54 N·m).

Unlocking an Installed Retractor

Seat belt retractors are locking up and preventing the webbing from being extracted. This condition is known as reverse lock-up and is caused by excessive webbing spooling into the retractor before installation in the vehicle.

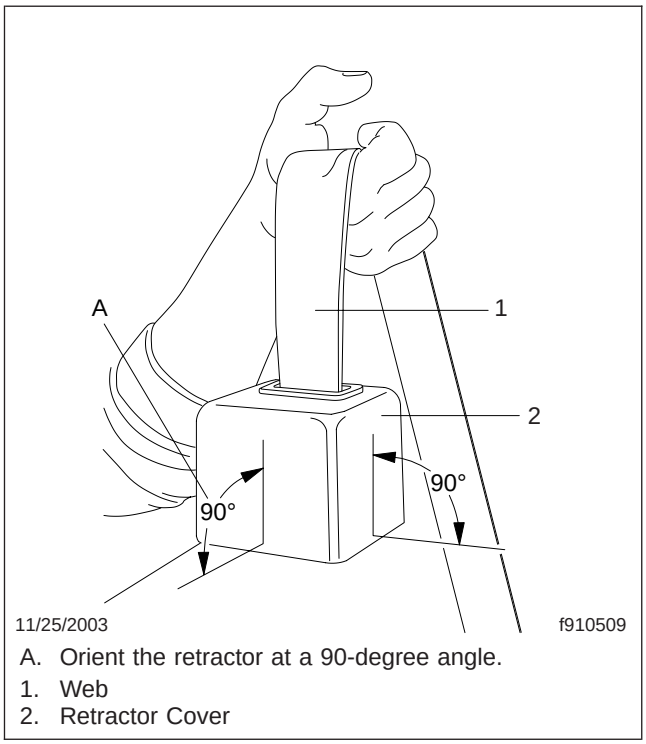
1. Park the vehicle, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Verify that the retractor is mounted in the 90-degree position. See **Fig. 1**.
3. Firmly grasp the web close to the retractor. See **Fig. 2**.



1. Web Guide Loop
2. Web
3. Komfort Latch®
4. Retractor Cover

Fig. 1, Retractor in the 90-Degree Position

4. Pull on the web with enough force to tighten the web onto the spool until the webbing locks back onto the retractor. The retractor should unlock when tension is released.
5. Remove the chocks from the tires.



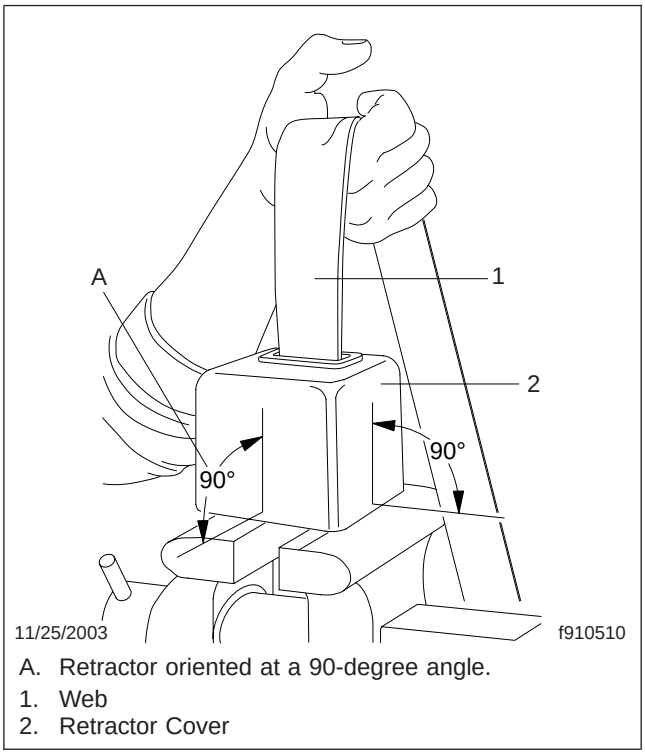
A. Orient the retractor at a 90-degree angle.
1. Web
2. Retractor Cover

Fig. 2, Firmly Grasp the Webbing

Unlocking an Uninstalled Retractor

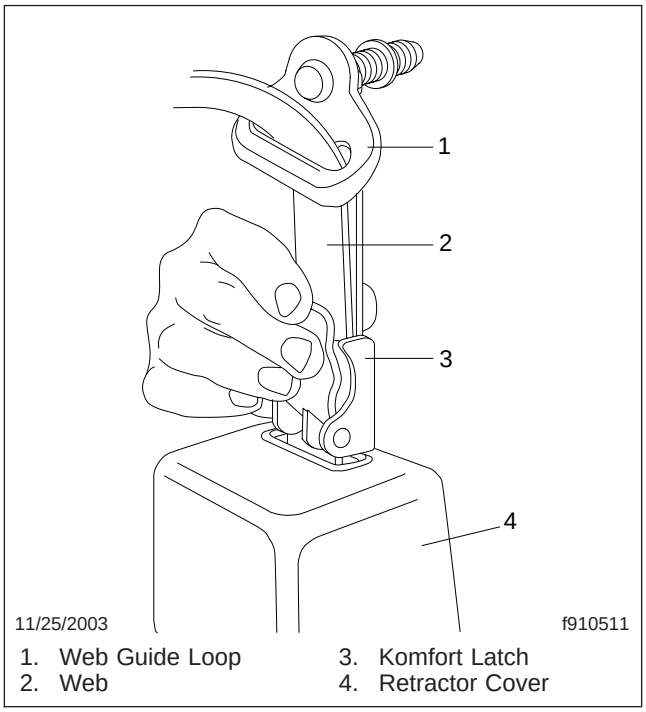
1. Clamp the retractor in a vice at a 90-degree angle. See **Fig. 3**.
2. Pull on the web with enough force to tighten the web onto the spool.
3. Release the web. This allows 1/2-inch (12.7-mm) of the webbing to feed back into the retractor storage housing and unlock the retractor.
4. Pull all the webbing out of the retractor, and allow only 12 to 15 inches (304 to 381 mm) to retract. Lock the Komfort Latch on the web. See **Fig. 4**.

Seat Belt Retractor Unlocking



A. Retractor oriented at a 90-degree angle.
1. Web
2. Retractor Cover

Fig. 3, Place the Retractor in a Vice



1. Web Guide Loop
2. Web
3. Komfort Latch
4. Retractor Cover

Fig. 4, Lock the Komfort Latch

Troubleshooting

WARNING

Inspect and maintain seat belts. When any part of a seat belt system needs replacement, the entire seat belt must be replaced, both retractor and buckle side. Any time a vehicle is involved in an accident, and the seat belt system was in use, the entire vehicle seat belt system must be replaced before operating the vehicle. Do not attempt to modify the seat belt system; doing so could change the effectiveness of the system. Failure to replace worn or damaged seat belts, or making any modifications to the system, may result in personal injury or death.

Replace the entire seat belt system using the instructions in **Subject 110** if any of the following problems exist:

- cuts, fraying, or extreme wear of any area of the web (shoulder or lap belt)
- buckle and latch do not engage with a solid sounding "click" or do not release freely when the button is pushed
- Komfort Latch™ is broken or does not lock in place easily and does not release by tugging downward on the webbing
- retractor locks up at improper times or web does not flow freely to and from the retractor while vehicle is not moving
- seat belt web has been exposed to extreme sun light, dust, or dirt, causing the web color to fade and deterioration of web physical strength
- molded plastic around the buckle is deformed, cracked, or broken, exposing the internal mechanism
- molded plastic cover around the retractor is cracked or broken, exposing the internal mechanism or stored web
- metal or molded plastic area of latch is deformed, cracked, corroded, or broken
- molded plastic D-loop is deformed, cracked, or broken
- tethers are missing, not attached to seat, or hang extremely loose
- D-loop web guide does not rotate freely
- hardware is missing, rusted, corroded, or damaged
- hardware does not appear to be tight

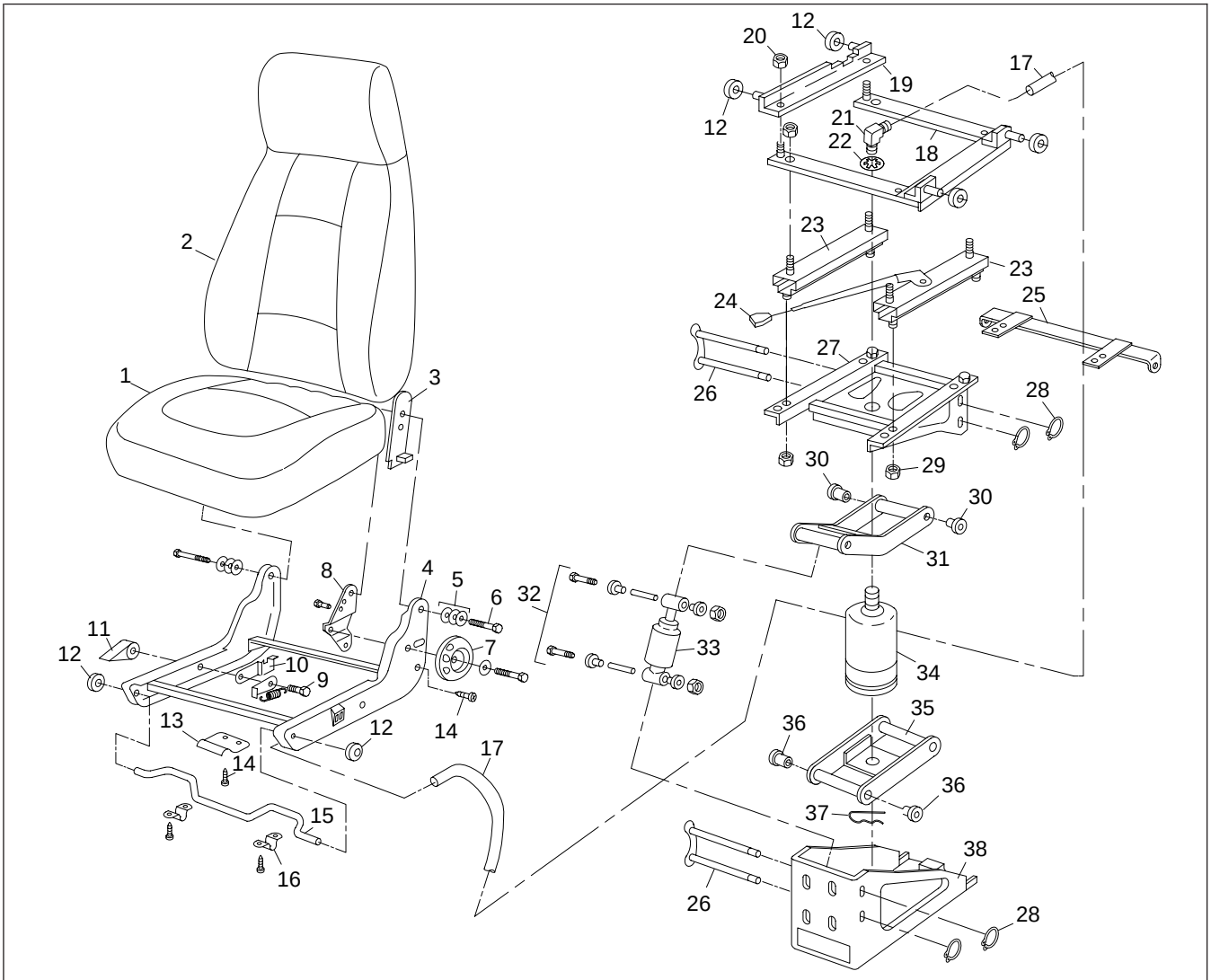
If any of the following problems exist, see the instructions in **Subject 110** for replacement, adjustment, tightening and torque requirement. Replace hardware with authorized parts.

General Information

National Cush-N-Aire II air suspension seats (see **Fig. 1**) offer adjustment features for height, fore and aft positioning, back cushion tilt, lumbar support, and seat cushion tilt. The air suspension and height-adjustment features are provided by an inflatable air spring (air bag) that receives air pressure from the vehicle air system; pressure in the air spring is controlled by a set of switches attached to the seat frame. Each seat is equipped with a shock absorber to dampen unwanted up and down motion of the seat. An isolator (Chugger-Snubber®) isolates the seat from the cab's fore and aft motion; at the side of the seat's lower frame is an isolator lockout handle that can be used whenever the isolator feature is not desired.

For a complete description of, and operating instructions for, all seat adjustment features, refer to the vehicle driver's manual.

General Information



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1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Upper Seat Frame
5. Flatwashers
6. Back Frame Bolt
7. Back Recline Adjustment Knob
8. Back Limit Bolt Bracket
9. Cushion Adjustment Bolt
10. Cushion Adjustment Bracket
11. Cushion Adjustment Lever
12. Bearing
13. Adjustment Rod Bracket
14. Fastener
15. Adjustment Rod
16. Adjustment Rod Bracket
17. Air Hose
18. Isolator
19. Isolator Bar
20. Locknut
21. Hose Barbed Fitting
22. Retaining Ring
23. Track
24. Fore-and-Aft Adjustment Lever
25. Belt Bar
26. Connected Shaft
27. Seat Support
28. Snap Ring
29. Locknut
30. Bearing
31. Upper Arm
32. Shock Absorber Assembly
33. Shock Absorber
34. Air Spring
35. Lower Arm
36. Bearing
37. Pin Clip
38. Seat Base

Fig. 1, National Cush-N-Aire II Seat (exploded view)

Removal

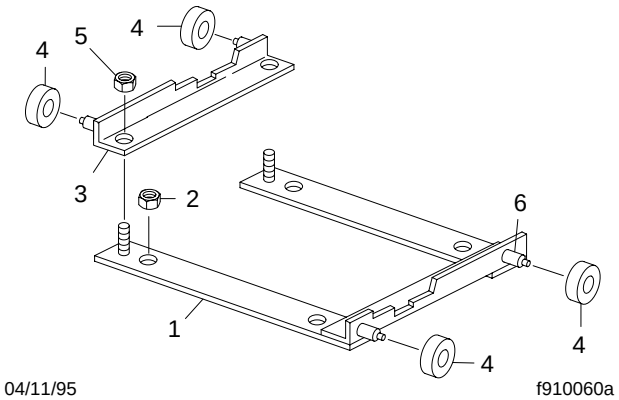
1. Apply the parking brakes, and chock the tires.
2. Push in on the top of the seat ride height rocker switch until the seat is adjusted to its maximum height.
3. If the seat is equipped with a seat suspension shroud, remove the shroud.
4. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the air suspension seat base and the rear crosstube of the lower arm.
5. Drain the vehicle air reservoirs. Then push in on the bottom of the seat ride height rocker switch until all air is exhausted from the air spring.
6. Disconnect the air valve air supply hose at the quick-connect union.
7. Unscrew the capscrews that attach the seat belt straps and tether straps to the intermediate connecting point.
8. Remove the capscrews and washers that attach the seat to the cab deck. Remove the seat from the cab.

Installation

1. Place the seat on the cab deck. Insert the capscrews through the washers and the seat base. Tighten the capscrews 27 lbf·ft (37 N·m).
2. Attach the brackets of the seat belt straps and tether straps to the intermediate connecting point. Tighten the capscrews 40 lbf·ft (54 N·m).
3. Attach the air valve air supply hose by pressing the pneumatic tubing into the quick-connect union.
4. Start the engine and allow the air reservoirs to fill. Push in on the top of the seat ride height rocker switch until the seat is adjusted to its maximum height, then remove the wooden block that supports the seat suspension.
5. If the seat is equipped with a seat suspension shroud, install the shroud.

Isolator Assembly (Chugger-Snubber®) Replacement

Replacement (See Fig. 1)



1. Welded Bearing Support Frame
2. Locknut
3. Bearing Support Rail
4. Bearing
5. Hexnut
6. Bearing Stud

Fig. 1, Isolator Assembly

1. Remove the air spring supply hose from the seat.
2. Cut off the air spring supply hose close to the barbed fitting; minimize hose length loss. Remove the scrap hose from the barbed fitting. Tape the hose and fitting ends to prevent dirt or other matter from entering.
3. Remove the hexnuts that attach the isolator bearing support rail to the studs on the isolator bearing support frame.
4. Lift up on the side of the seat's lower frame, to slide the bearing support rail up and off the bearing support frame.

NOTE: Two of the isolator bearings will fall off when the bearing support rail is removed.

5. Push the upper seat frame toward the opposite side, to remove the other two bearings. Remove the bearings and the unattached upper seat components.
6. Remove the four 5/16–18 locknuts from the bearing support frame. Remove the bearing support frame.
7. Using a multi-purpose chassis grease, lubricate the bearing cups and new isolator bearings.
8. Install the welded bearing support frame on the track assembly. Tighten the four 5/16–18 locknuts 15 lbf·ft (20 N·m).
9. Install two of the isolator bearings on the bearing studs of the bearing support frame, then align the bearing cups on the upper seat frame over the bearings.
10. Assemble the isolator bearing support rail and the two remaining isolator bearings. With the seat cushion tilted forward, install the support rail's bearings in the upper seat frame, and lower the seat frame and support rail assembly onto the isolator bearing support frame. Install the 5/16–18 hexnuts, and tighten them finger-tight.

    Push the isolator assembly fore and aft, and check the position of the isolator bearing support rail before tightening the hexnuts. The isolator should be tight enough to eliminate side play without interfering with the fore-and-aft movement of the seat. Tighten the 5/16–18 hexnuts 15 lbf·ft (20 N·m).
11. Install the air spring supply hose.

Removal

1. Move the fore-and-aft adjustment lever to the right, and slide the upper seat assembly back as far as possible.
2. Raise the upper seat assembly to maximum height. Support the seat in this position by placing a wooden block between the lower arm and the seat base.
3. Remove the shock absorber, bushings, and bearings.
   - 3.1 Remove the nuts and bolts that attach the shock absorber to the upper arm and the seat base. Remove the shock absorber.
   - 3.2 Remove the bushings and bearings from the shock absorber.

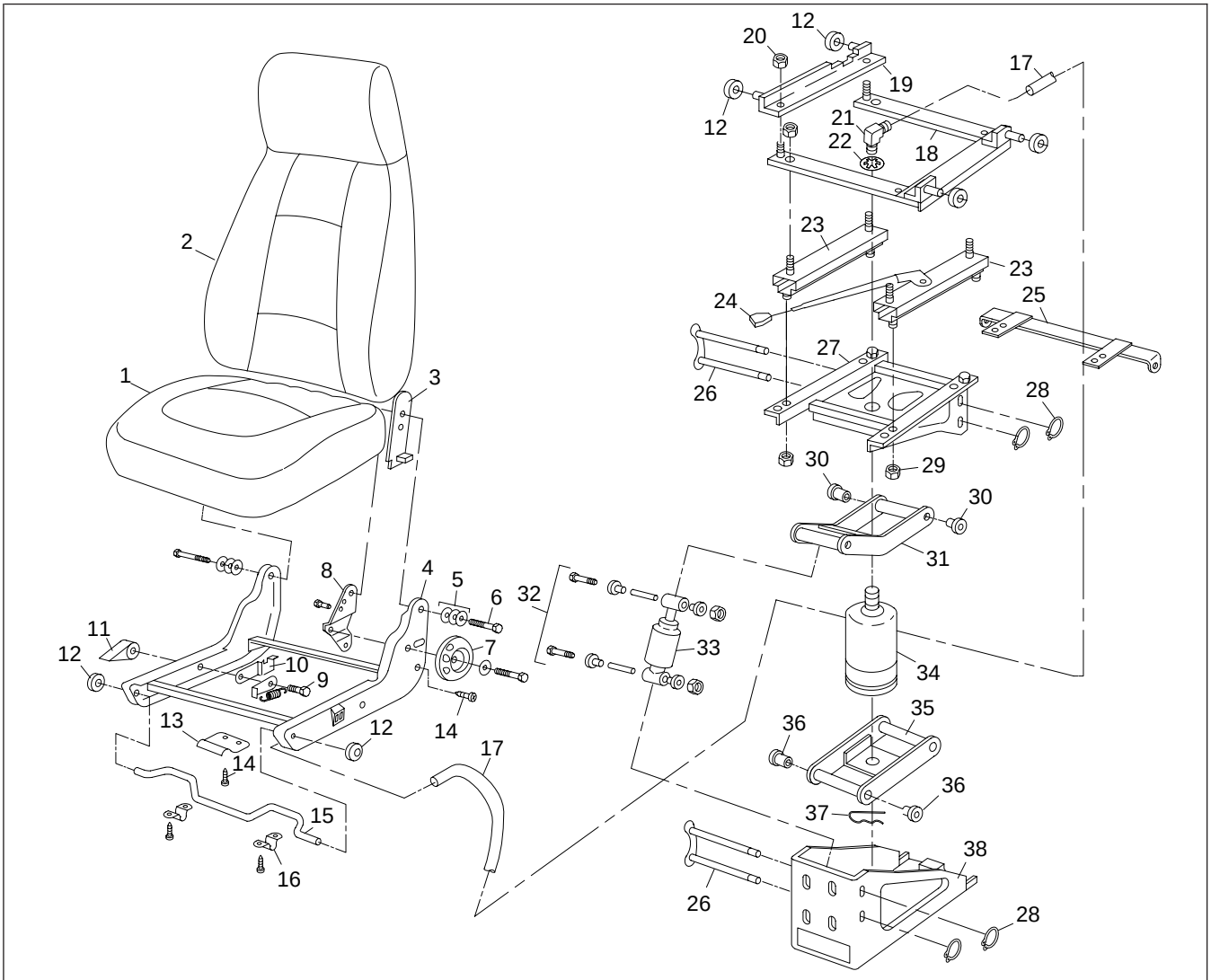
Installation

1. Check the operation of the shock absorber, and replace it if needed.
2. Install the shock absorber and new bearings and bushings.
   - 2.1 Install new bearings and bushings in the shock absorber eyes.
   - 2.2 With the upper arm blocked up, position the shock absorber so its piston-rod end is in the mounting bracket of the upper arm. Install the bolt and locknut to attach the shock absorber to the bracket. Tighten the locknut 25 lbf·ft (34 N·m).
   - 2.3 Position the cylinder end of the shock absorber in the mounting bracket of the seat base. Attach the shock absorber to the seat base. Tighten the locknut 25 lbf·ft (34 N·m).
3. Raise the seat. Remove the wooden block.

Replacement (See Fig. 1)

1. Raise the upper seat assembly to maximum height. Support the seat in this position by placing a wooden block between the lower arm and the seat base.
2. Remove the seat from the vehicle as instructed in **Subject 100**.
3. Lay the seat on its side, with the wooden block still in place.
4. Remove, as an assembly, the fitting and the air hose from the air spring. Tape the end of the fitting to prevent dirt or other matter from entering.
5. Pry the pin clip from the bottom of the air spring.
6. Remove the retaining ring that secures the air spring to the upper arm. Remove the air spring.
7. Position the new air spring in the seat base, and secure it with a new pin clip.
8. Insert the top of the air spring in the opening of the upper arm. Install the retaining ring on the air spring.
9. Install the air spring fitting and air hose in the top of the air spring.
10. Install the seat as instructed in **Subject 100**.
11. Raise the seat. Remove the wooden block.

Air Spring Replacement



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1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Upper Seat Frame
5. Flatwashers
6. Back Frame Bolt
7. Back Recline Adjustment Knob
8. Back Limit Bolt Bracket
9. Cushion Adjuster Bolt
10. Cushion Adjustment Bracket
11. Cushion Adjustment Lever
12. Bearing
13. Adjustment Rod Bracket
14. Fastener
15. Adjustment Rod
16. Adjustment Rod Bracket
17. Air Hose
18. Isolator
19. Isolator Bar
20. Locknut
21. Hose Barbed Fitting
22. Retaining Ring
23. Track
24. Fore-and-Aft Adjustment Lever
25. Belt Bar
26. Connected Shaft
27. Seat Support
28. Snap Ring
29. Locknut
30. Bearing
31. Upper Arm
32. Shock Absorber Assembly
33. Shock Absorber
34. Air Spring
35. Lower Arm
36. Bearing
37. Pin Clip
38. Seat Base

Fig. 1, National Cush-N-Aire II Seat (exploded view)

Replacement (See Fig. 1)

1. Remove the shock absorber as instructed in **Subject 120**.
2. Remove the seat as instructed in **Subject 100**.
3. Remove the four locknuts that attach the track assemblies, seat track stop, belt bar and bearings, and upper seat assembly to the seat support. Remove the upper seat assembly, track assemblies, seat track stop, and belt bar and spacers.
4. Remove the retaining ring that secures the air spring to the upper arm.
5. Remove the bearings and/or sleeves from the seat support and the seat base and the upper and lower arms.

   5.1 Use snap ring pliers to remove the four snap rings from the connected shaft assemblies. Then, using a drift punch, drive out the shaft assemblies from the seat support and the seat base.

   NOTE: Place the punch against the snap ring end of the shafts. Drive each shaft end a little at a time; the two shafts are connected to each other on the opposite side.

   5.2 Remove the seat support, and the upper and lower arms from the air spring and seat base.

   5.3 Remove the bearings/sleeves from the upper and lower arms. Discard the bearings/sleeves.

   5.4 If so equipped, remove the sleeves/bearings from the seat support and the seat base. Discard the sleeves/bearings.
6. Install new bearings/sleeves, as equipped.

   6.1 Install new bearings/sleeves in the upper and lower arm tubes.

   6.2 If so equipped, install new sleeves/bearings in the seat support and the seat base.

   6.3 Align the tubes of the lower and upper arms with the holes in the seat base. Be sure the notch in the lower arm is forward and up, and the notch in the upper arm is to the rear and down.

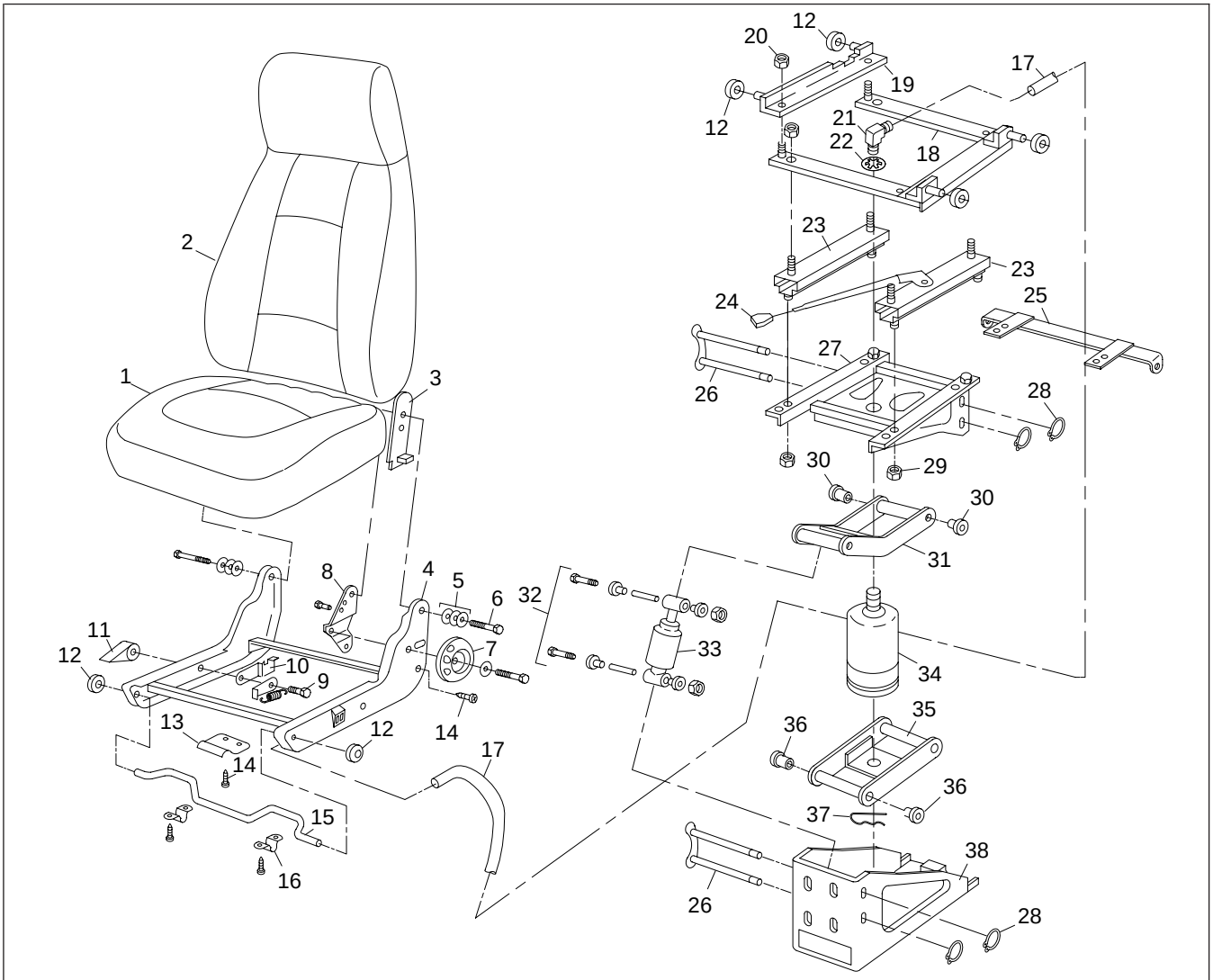
   6.4 Install the connected shaft assembly through the seat base and the upper and lower arm forward tubes.

   6.5 Align the holes of the seat support with the rear tubes of the lower and upper arms.

   6.6 As equipped, install and tighten the pivot bolts, or install the connected shaft assembly through the seat support and the upper and lower arm tubes.

   6.7 For connected shaft assemblies, use snap ring pliers to install the snap rings that secure the shafts and the arms to the seat base and the seat support.
7. Insert the top of the air spring through the upper arm. Install the retaining ring.
8. Set the seat base assembly upright.
9. Install the shock absorber as instructed in **Subject 120**.
10. Place the belt bar and bearings, seat track stop, track assemblies, and upper seat assembly on the seat base. Install the locknuts, and tighten 15 lbf·ft (20 N·m).
11. Install the seat as instructed in **Subject 100**.

Base Assembly Bearing/Sleeve Replacement



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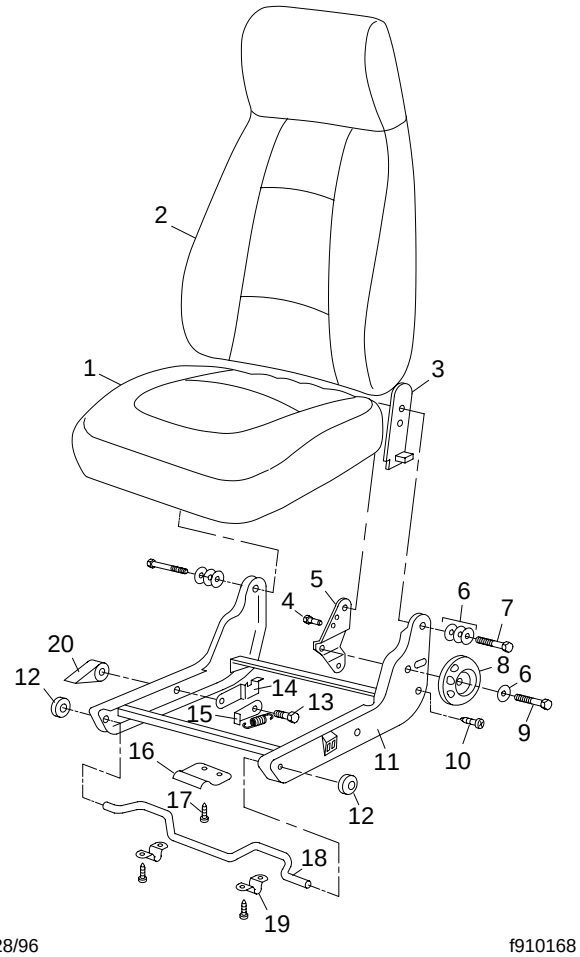
1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Lower Frame
5. Flatwashers
6. Back Frame Bolt
7. Back Recline Adjustment Knob
8. Back Limit Bolt Bracket
9. Cushion Adjustment Bolt
10. Cushion Adjustment Bracket
11. Cushion Adjustment Lever
12. Bearing
13. Adjustment Rod Bracket
14. Fastener
15. Adjustment Rod
16. Adjustment Rod Bracket
17. Air Hose
18. Isolator
19. Isolator Bar
20. Locknut
21. Hose Barbed Fitting
22. Retaining Ring
23. Track
24. Fore-and-Aft Adjustment Lever
25. Belt Bar
26. Connected Shaft
27. Seat Support
28. Snap Ring
29. Locknut
30. Bearing
31. Upper Arm
32. Shock Absorber Assembly
33. Shock Absorber
34. Air Spring
35. Lower Arm
36. Bearing
37. Pin Clip
38. Seat Base

Fig. 1, National Cush-N-Aire II Seat (exploded view)

Removal (See Fig. 1)



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1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Back Limit Bolt
5. Back Limit Bolt Bracket
6. Flatwashers
7. Back Frame Bolt
8. Back Recline Adjustment Knob
9. Hexbolt
10. Screw
11. Lower Frame
12. Bearing
13. Cushion Adjustment Bolt
14. Cushion Adjustment Bracket
15. Cushion Adjustment Spring Bracket
16. Adjustment Rod Bracket
17. Fastener
18. Adjustment Rod
19. Adjustment Rod Bracket
20. Cushion Adjustment Lever

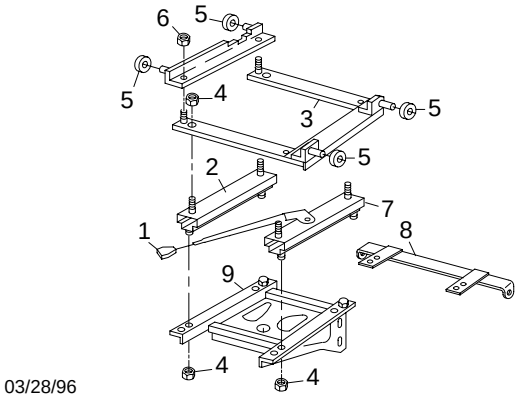
Fig. 1, Upper Seat Frame Assembly (exploded view)

1. Remove the suspension shroud (if equipped) from the seat base.
2. Remove the plastic tie strap that attaches the seat cushion to the upper seat frame assembly.
3. Remove the fasteners that attach the seat cushion to the front cushion adjustment rod. Remove the seat cushion.
4. Disconnect the air spring supply hose from the air spring.
5. Remove the four locknuts from under the top flange of the seat support assembly.
6. Remove the lower frame from the seat base.

Installation

1. Place the lower frame on the seat support assembly. Install the locknuts under the top flange of the seat support assembly. Tighten the locknuts 10 lbf·ft (15 N·m).
2. Attach the air spring supply hose to the air spring. Make sure that the air hose moves without any restrictions when the seat is moved forward or rearward.
3. Position the seat cushion, then install the fasteners that attach the seat cushion to the front cushion adjustment rod.
4. Install a new plastic tie strap to secure the seat cushion to the lower frame assembly.
5. Install the suspension shroud (if equipped) on the seat base.

Replacement (See Fig. 1)



1. Fore-and-Aft Adjustment Lever
2. Right-Side Track
3. Welded Bearing Support Frame
4. Locknut
5. Bearing
6. Hexnut
7. Left-Side Track
8. Belt Bar
9. Seat Support

Fig. 1, Track Assembly (exploded view)

1. Raise the upper seat assembly to maximum height. Support the seat in this position by placing a wooden block between the lower base and lower arm.
2. Pull up and support the rear edge of the seat cushion as needed to gain access to the isolator-assembly-to-track-assembly 5/16–18 locknuts.
3. Remove the air spring supply hose from the seat.
   - 3.1 Cut and remove the tie strap that attaches the air spring supply hose to the track assembly latch mechanism.
   - 3.2 Remove the air spring supply hose (as an assembly), and lay it on the cab deck, behind the seat.
4. Remove the four 5/16–18 locknuts that attach the isolator assembly to the top of the track assemblies. Remove the upper seat assembly.
5. Remove the four 5/16–18 locknuts that attach the track assemblies to the top of the seat support. Remove the track assemblies.
6. With the holes in the belt bar, belt bar spacers, and seat track stop aligned with the holes in the seat support, install the new track assemblies on the seat support. Install and tighten the four 5/16–18 locknuts 15 lbf·ft (20 N·m).
7. Move the upper half of the track assemblies as needed to align their studs with the holes in the isolator assembly. Place the upper seat assembly on the track assemblies. Install and tighten the four 5/16–18 locknuts 15 lbf·ft (20 N·m).
8. Install the air spring supply hose.
   - 8.1 Install a new tie strap to attach the air spring supply hose to the track assembly latch mechanism.
   - 8.2 Install a new tie strap to attach the air valve supply hose to the belt bar.
9. Move the fore-and-aft adjustment lever to the right, and slide the upper seat assembly forward and rearward while making sure that the air hose moves without restriction. Return the seat cushion to its original position.
10. Raise the seat. Remove the wooden block.

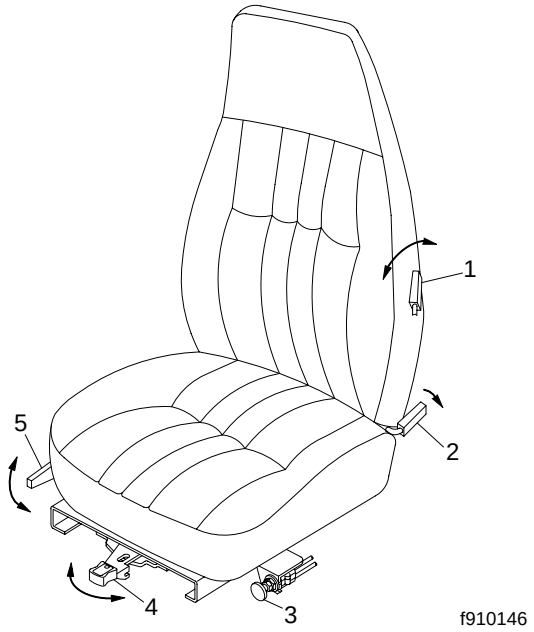
Specifications

Description	Torque: lbf·ft (N·m)
Seat Base to Cab Deck Socket-Head Bolts	13 (18)
Seat Belt/Tether Belt to Belt Bar Capscrews	40 (54)
Shock Absorber to Bracket Locknuts	25 (34)
Track Assembly to Isolator Assembly Locknuts	15 (20)
Track Assembly to Upper Seat Frame Locknuts	15 (20)

Table 1, Fastener Torques

General Information

The Bostrom 915 air suspension seats offer lumbar support, back angle adjustment, weight and height adjustment, a fore and aft roller track isolator system, and seat cushion tilt adjustment. See **Fig. 1**.



1. Lumbar Adjustment
2. Back Angle Adjustment
3. Weight and Height Adjustment
4. Fore and Aft Isolation and Seat Position Adjustment
5. Seat Cushion Tilt Adjustment

Fig. 1, Bostrom 915 Seat

For complete operating instructions, refer to the vehicle driver's manual.

Removal

1. Apply the parking brakes, and chock the tires.
2. Push in on the seat height adjustment valve knob until the seat is adjusted to its maximum height.
3. If the seat is equipped with a seat suspension cover, remove the cover.
4. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the rear crossbars of the air suspension's inner and outer lever assemblies.
5. Drain the vehicle air reservoirs. Then pull out on the seat height adjustment valve knob until all air is exhausted from the air spring.
6. Disconnect the air line from the air spring assembly by pushing in the collar of the fitting while pulling the air line out of the fitting.
7. Remove the seat-belt straps and tether straps.
8. Remove the capscrews and washers that attach the seat to the cab deck. Remove the seat from the cab.

Installation

1. Place the seat on the cab deck. Insert the capscrews through the washers and the seat base. Tighten the capscrews 27 lbf·ft (37 N·m).
2. Attach the brackets of the seat-belt straps and tether straps. Tighten the capscrews 40 lbf·ft (54 N·m).
3. Connect the air line to the fitting in the air spring assembly by pushing the tube into the fitting.
4. Start the engine and allow the air reservoirs to fill. Push in on the seat height adjustment valve knob until the seat is adjusted to its maximum height, then remove the wooden block that supports the seat suspension.
5. If the seat is equipped with a seat suspension cover, install the cover.
6. Remove the chocks from the tires.

Air Spring Removal and Installation

Removal (See Fig. 1)

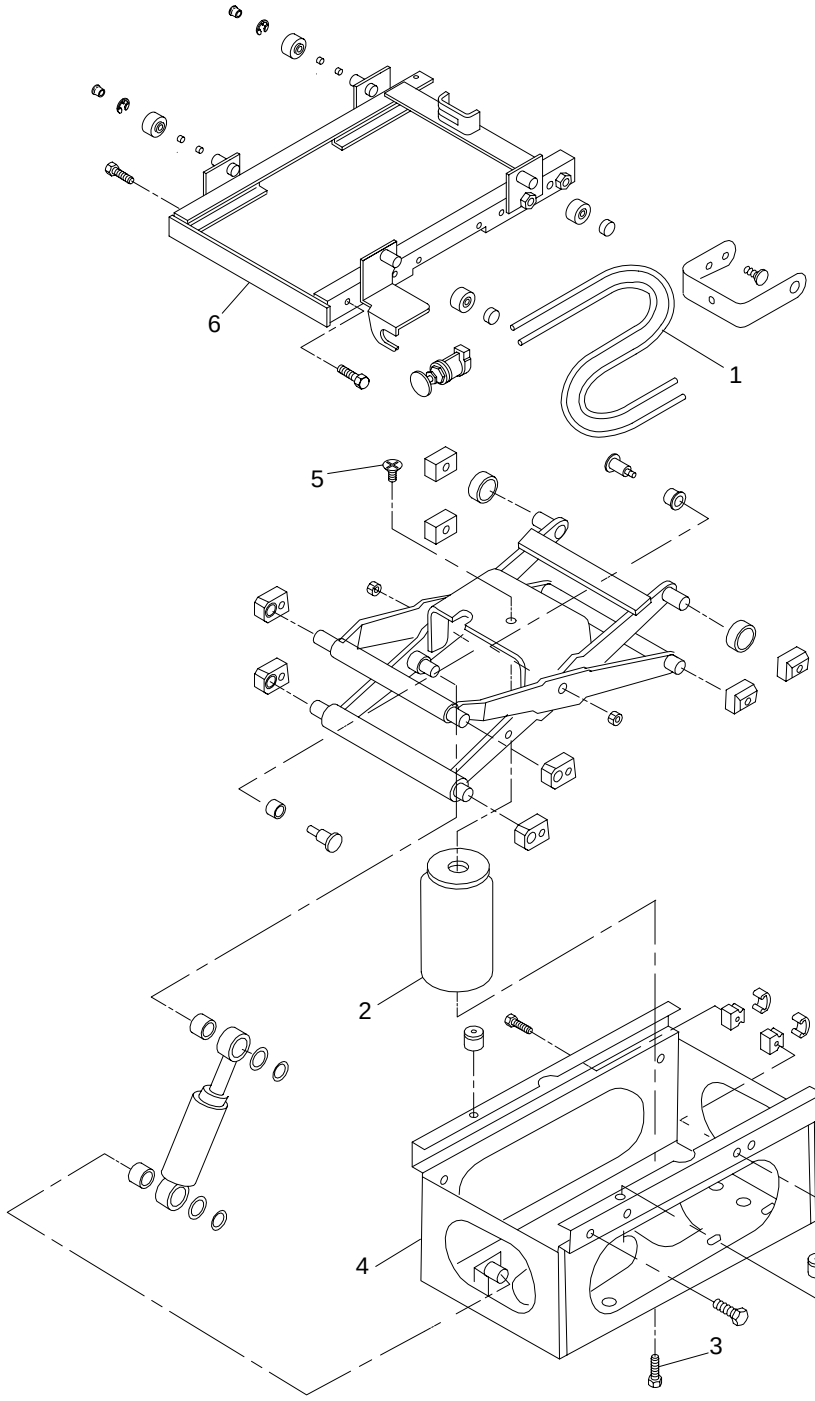
NOTE: The seat, seat/back assembly, and channel assembly do not need to be removed. Move the channel assembly to the rearmost position to provide access to the air spring.

1. Apply the parking brakes, and chock the tires.
2. Fill the air spring so that the seat is at its maximum height.
3. Block the suspension up with a spacer placed between the base riser and the upper frame.
4. Release the air pressure from the air spring so that the seat is supported by the spacer.
5. Drain the air from the air reservoirs.
6. Disconnect the air line from the air spring by pushing in the collar of the fitting while pulling the air line out of the fitting.
7. Remove the top capscrew and loosen the bottom capscrew through the rear opening in the base riser. Remove the air spring from the suspension.

Installation (See Fig. 1)

1. Install the bottom capscrew into the new air spring. Install the air spring into the key hole opening in the bottom of the base riser with the bottom capscrew. Position the air spring so the fitting at the bottom of the air spring is toward the front of the seat.
2. Tighten the bottom capscrew 9 to 11 lbf·ft (12 to 15 N·m).
3. Install the top capscrew and tighten it 15 to 19 lbf·ft (20 to 26 N·m).
4. Connect the air line to the fitting in the air spring by pushing the tube into the fitting.
5. Start the engine, and allow the air pressure to build.
6. Fill the air spring and remove the spacer block.
7. Remove the chocks from the tires.

Air Spring Removal and Installation



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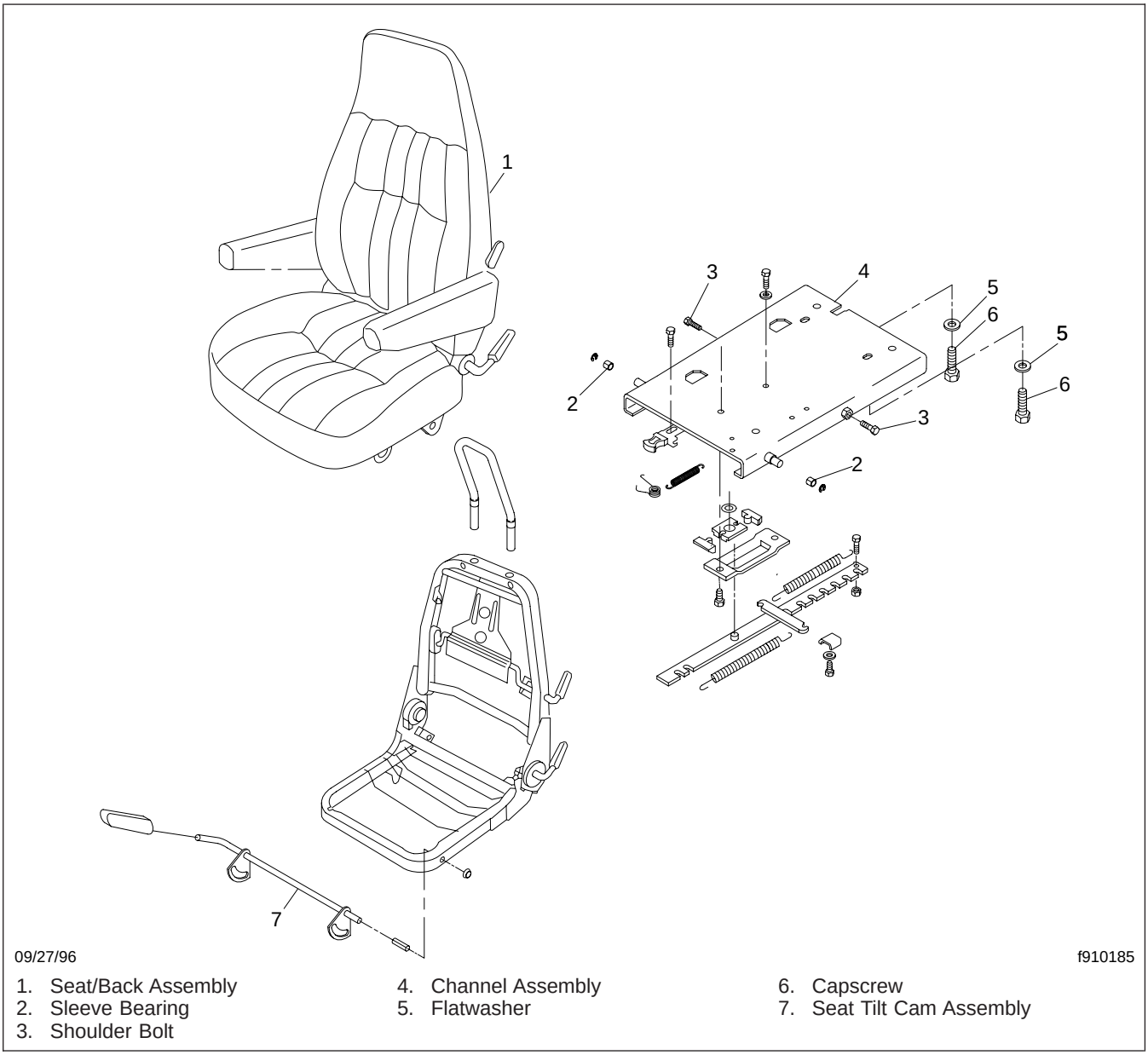
1. Air Line
2. Air Spring
3. Bottom Capscrew
4. Base Riser
5. Top Capscrew
6. Upper Frame

Fig. 1, Bostrom 915 Seat

Removal (See Fig. 1)



1. Seat/Back Assembly
2. Sleeve Bearing
3. Shoulder Bolt
4. Channel Assembly
5. Flatwasher
6. Capscrew
7. Seat Tilt Cam Assembly

Fig. 1, Bostrom 915 Seat

1. Adjust the seat/back assembly to the most rearward position and remove the two capscrews and flatwashers from the underside of the channel assembly.
2. Remove the two shoulder bolts from the channel assembly.

Seat/Back Assembly Removal and Installation

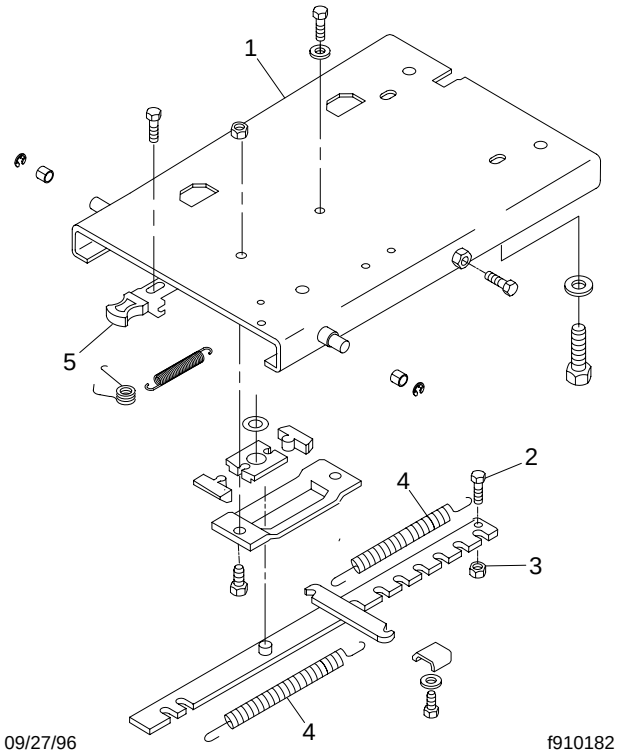
3. Move the seat/back assembly forward to disengage the seat tilt cam assembly from the sleeve bearings on the channel assembly.
4. Remove the seat/back assembly.

Installation (See Fig. 1)

1. Place the seat/back assembly onto the channel assembly.
2. Move the seat/back assembly rearward to engage the seat tilt cam assembly to the sleeve bearings on the channel assembly.
3. Install the two shoulder bolts to the channel assembly. Tighten them 18 to 22 lbf·ft (24 to 30 N·m).
4. Install the two capscrews and flatwashers to the underside of the channel assembly. Tighten them 10 to 13 lbf·ft (14 to 18 N·m).

Fore and Aft Isolation Channel Removal and Installation

Removal (See Fig. 1)

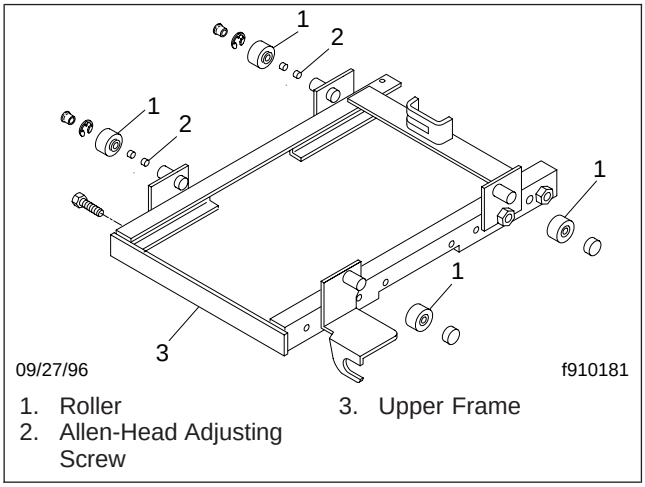


1. Channel Assembly
2. Screw
3. Nut
4. Isolator Spring
5. Isolator Handle

Fig. 1, Channel Assembly (exploded)

1. Remove the seat/back assembly using the instructions in **Subject 120**.
2. Adjust the channel assembly to the rearmost position.
3. With the isolator handle on the channel assembly in the isolation position (center position), push the channel assembly forward to expose the screw and the nut. Remove the screw and the nut and save for reassembly.
4. Move the isolator handle on the channel assembly to the fore and aft release position (outboard position). Slide the channel assembly forward past both sets of rollers. See **Fig. 2**.

NOTE: Be careful not to lose the roller parts. Either remove and save for reassembly or replace with new parts from a roller assembly kit.



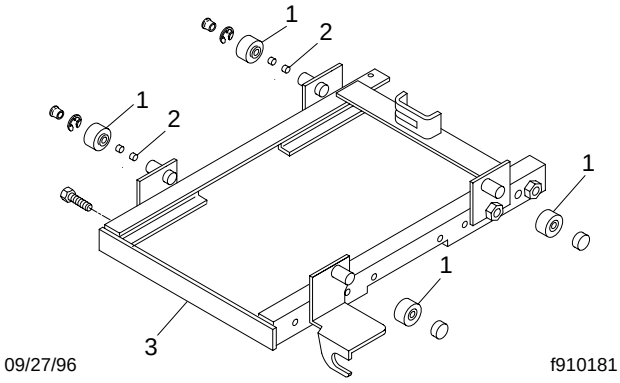
1. Roller
2. Allen-Head Adjusting Screw
3. Upper Frame

Fig. 2, Upper Frame Assembly (exploded)

Installation (See Fig. 1)

1. Slide the channel assembly rearward over both sets of rollers. The isolator handle should be in the fore and aft release position (outboard position).
2. With the isolator handle in the isolation position (center position), push the channel assembly forward to install the screw and nut.
3. Adjust lateral side play using the instructions in **Subject 140**.
4. Install the seat/back assembly using the instructions in **Subject 120**.

Adjustment (See Fig. 1)



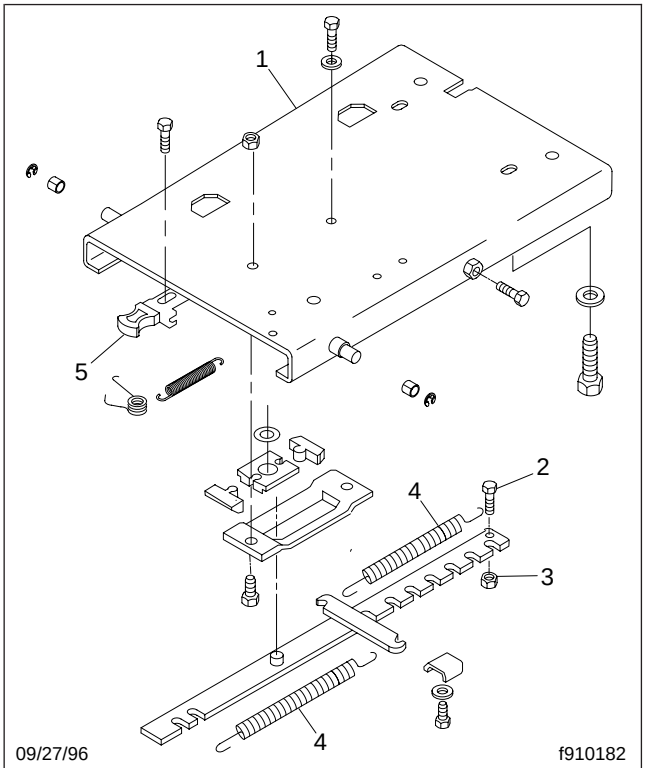
1. Roller
2. Allen-Head Adjusting Screw
3. Upper Frame

Fig. 1, Upper Frame Assembly (exploded)

1. Remove the seat/back assembly from the channel assembly using the instructions in **Subject 120**.
2. Adjust the channel assembly until the allen-head adjusting screws in the right isolator roller shafts on the upper frame are visible in the cutouts on the inboard side of the channel assembly.
3. Use a 3 mm allen wrench (do not use a 1/8-inch allen wrench) to adjust the two allen-head screws. Turn the screws in until resistance is felt, then turn the screws 1-1/2 turns more.
4. Move the channel assembly through the entire fore and aft adjustment range to check the lateral clearance for binding. The isolator springs (see **Fig. 2**) should return the channel to the neutral position for the best ride. Friction must not exceed 10.1 lbs. (45 N) to move the channel assembly.

NOTE: To ensure the best performance, make certain the roller parts are assembled correctly.

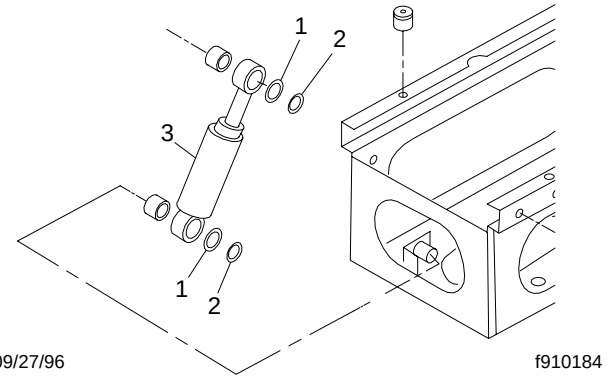
5. Replace the seat/back assembly on the channel assembly using the instructions in **Subject 120**.



1. Channel Assembly
2. Screw
3. Nut
4. Isolator Spring
5. Isolator Handle

Fig. 2, Channel Assembly (exploded)

Removal (See Fig. 1)



1. Thrust Washer
2. Push-On Fastener
3. Damper

Fig. 1, Bostrom 915 Seat

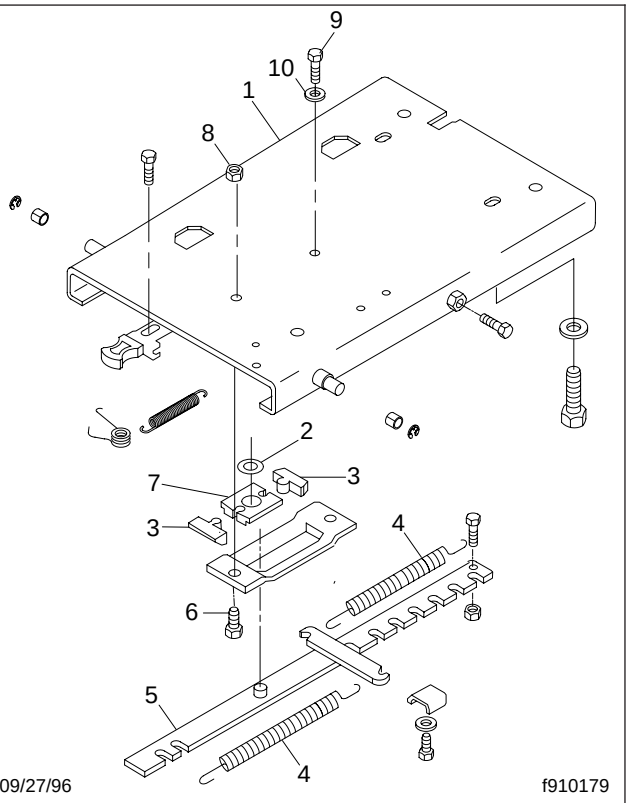
NOTE: The seat/back assembly does not need to be removed.

1. Fill the air spring so that the seat is at its maximum height.
2. Move the channel assembly to the full rearward position to gain working room.
3. Use pliers or a screwdriver to twist off the push-on fasteners. The push-on fasteners are not reusable.
4. Remove the damper assembly.

Installation (See Fig. 1)

1. Install the new damper with the flanges of the bearings to the outside of the suspension.
2. Install the thrust washers and the push-on fasteners until they seat. A 1/2-inch box end wrench works well to push the fasteners on.

Removal (See Fig. 1)



1. Channel Assembly
2. Retaining Ring
3. Isolation Bumper
4. Isolator Spring
5. Latch Bar
6. Screw
7. Pivot Block
8. Locknut
9. Screw
10. Lockwasher

Fig. 1, Channel and Isolation Bumper Assembly

1. Remove the seat/back assembly using the instructions in **Subject 120**.
2. Remove the channel assembly using the instructions in **Subject 130**.

   Be careful not to loose the roller parts, they will be needed for reassembly.
3. Remove the two isolator springs by carefully extending and disconnecting them from the mounting points.
4. Slide the latch bar until the retaining ring can be seen through the hole in the channel assembly. Remove the retaining ring and keep it for reassembly.
5. Pull the latch bar free of the pivot block.
6. The rubber isolation bumpers are now accessible and can be replaced if necessary.

NOTE: The pivot block can be removed by first removing the screw and lockwasher, and then removing the screw and locknut.

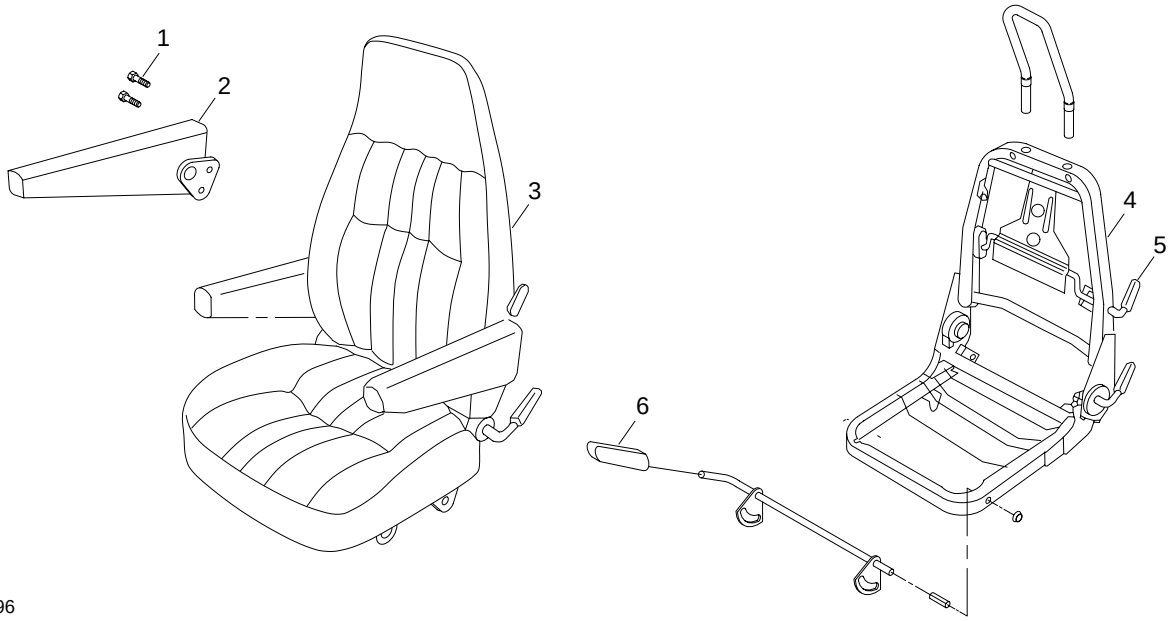
Installation (See Fig. 1)

1. If the pivot block was removed, install the pivot block. Tighten 14 to 18 lbf·ft (20 to 24 N·m).
2. Install the isolation bumpers.
3. Replace the latch bar on the pivot block.
4. Replace the retaining ring.
5. Replace the two isolator springs by carefully extending the springs and connecting them to the mounting points.
6. Install the channel assembly using the instructions in **Subject 130**.

   Be sure the roller parts are installed correctly on the roller pins.
7. Install the seat/back assembly using the instructions in **Subject 120**.

Back Cover/Pad Assembly Removal and Installation

Removal (See Fig. 1)



1. Armrest Fastener
2. Armrest
3. Upper Seat Assembly
4. Seat Frame Assembly
5. Lumbar Adjustment Handle
6. Seat Tilt Adjustment Handle

Fig. 1, Upper Seat Assembly

1. Remove the upper seat assembly from the suspension, using the instructions in **Subject 120**. Remove the armrests if the seat assembly has armrests.
2. Remove the back cover and pad from the seat frame assembly. Note the location of the fasteners on the existing back cover.

Installation (See Fig. 1)

1. Place a new pad over the back frame. If the seat has lumbar adjustment, make a cut in the outboard edge of the pad to fit around the handle.
2. Place the cover (inside out) over the top of the back pad. Pull down the cover until the three tie-down tabs are even with the three slots in the pad. Pull the tie-down tabs through the slots in the pad and run a short wire through all three tabs. Continue to pull the cover down completely over the pad. Tuck the front flap of the back cover between the seat cushion and the bottom of the back pad. Insert two long wires into the looped material sewn to the bottom of the cover. (One in the rear flap and one in the front flap.) Starting at the top, pull the cover down tight and hog ring the two wires at the bottom of the cover together behind the seat pad with the three tie-down tabs.

NOTE: If the seat has a high back, there will be two sets of tie-down tabs (six total with two wires) to be pulled through the back pad and wired.

3. Attach the upper seat assembly to the suspension using the instructions in **Subject 120**. Attach the armrests if the seat has armrests.

Suspension Rebuild Bearing/Slide Block Removal and Installation

Removal (See Fig. 1)

1. Remove the complete seat assembly from the vehicle using the instructions in **Subject 100**.
2. Remove the seat/back assembly using the instructions in **Subject 120**.
3. Remove the channel assembly using the instructions in **Subject 130**.

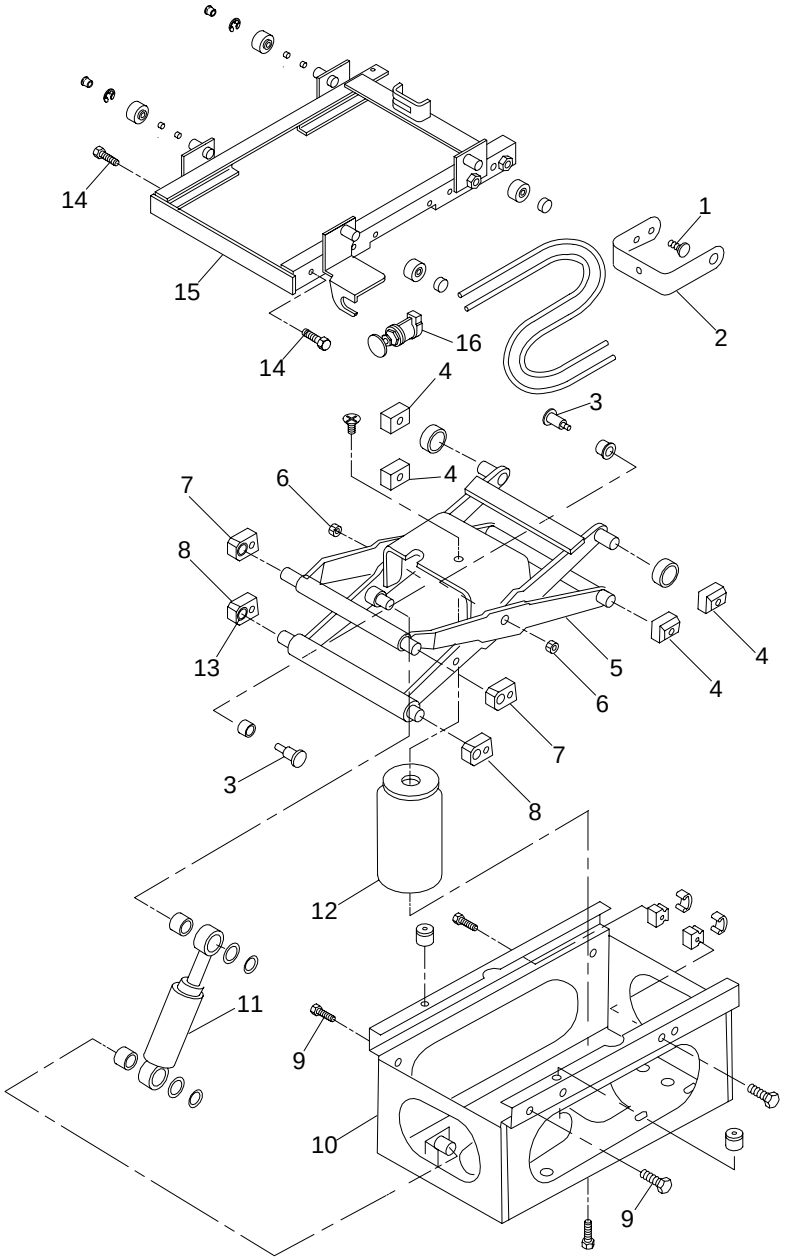
   Be careful not to loose the roller parts, they will be needed for reassembly.
4. Remove the capscrews and the ICP bracket. If the seat assembly has a suspension cover, remove the fasteners and the suspension cover.
5. Remove the air valve by loosening the nut on the valve and removing it from the bracket on the upper frame assembly.
6. Remove the capscrews from the upper front bearing blocks.
7. Remove the upper frame assembly by sliding it forward off of the bearing blocks and the slide blocks.
8. Remove the air spring using the instructions in **Subject 110**. Mark the air line for reassembly.
9. Remove the damper using the instructions in **Subject 150**.
10. Remove the capscrews from the lower front bearing blocks and slide the lever assemblies forward until the bearing blocks are removed from the channel on the base riser. Slide the lever assemblies rearward to remove the slide blocks from the channel.
11. Remove the shoulder bolts and nuts from the pivots of the lever assemblies and inspect the bolts. If the bolts are worn, replace them.

Installation (See Fig. 1)

1. Replace the bearings at the pivots on the lever assembly by pushing out the old bearings and pressing in the new bearings. The flange of the bearings should be on the outside of the lever assembly.
2. Install the shoulder bolts and nuts into the pivots of the lever assemblies. Tighten the bolts 18 to 22 lbf·ft (24 to 30 N·m).
3. Install new bearing blocks, spacers, and slide blocks on the levers with the beveled surfaces outward. Slide the levers with the blocks into the channel on the base riser. Tighten the screws 27 to 33 lbf·ft (37 to 45 N·m).
4. Slide the upper frame assembly over the blocks. Line up the capscrews with the bearing blocks and tighten the screws 27 to 33 lbf·ft (37 to 45 N·m).
5. Manually move the suspension up and down to make sure there are no clearance problems.
6. Block the suspension up with a spacer placed between the base riser and the upper frame. Install the air spring using the instructions in **Subject 110**.
7. Install the damper using the instructions in **Subject 150**.
8. Install the air valve onto the bracket on the upper frame.
9. Install the ICP bracket and capscrews. If the seat assembly has a suspension cover, install the suspension cover and the fasteners.
10. Install the channel assembly using the instructions in **Subject 130**.

    Be sure the roller parts are installed correctly on the roller pins.
11. Install the seat/back assembly using the instructions in **Subject 120**.
12. Adjust lateral side play using the instructions in **Subject 140**.
13. Install the seat assembly in the vehicle, using the instructions in **Subject 100**.

Suspension Rebuild Bearing/Slide Block Removal and Installation



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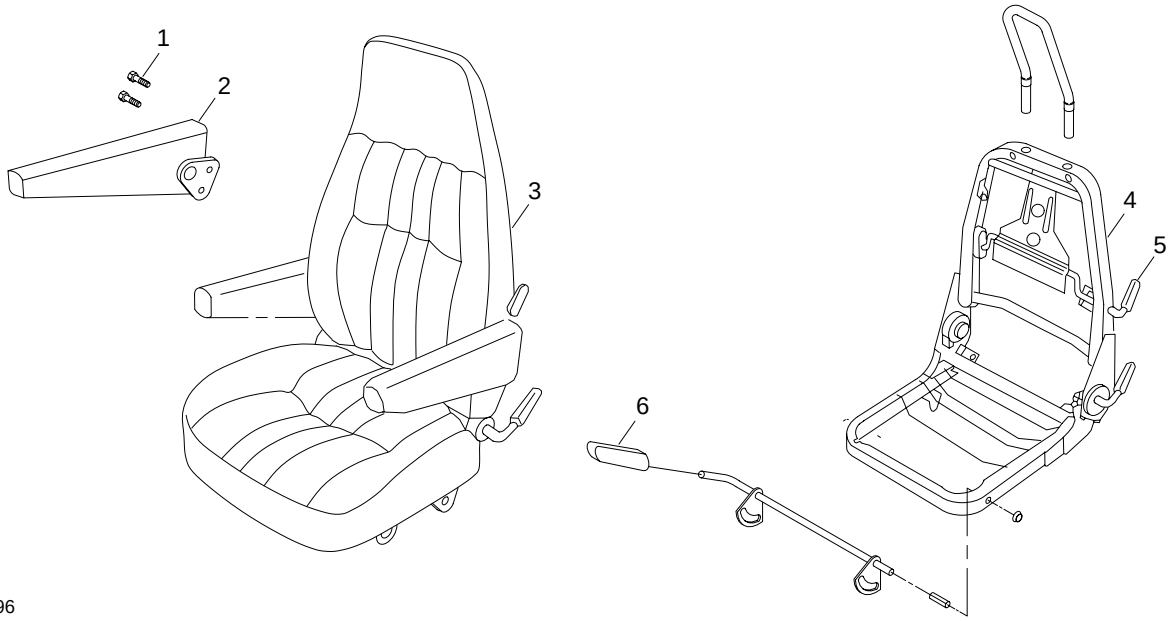
1. ICP Capscrew
2. ICP Bracket
3. Shoulder Bolt
4. Slide Block
5. Lever Assembly
6. Nut
7. Upper Bearing Block
8. Lower Bearing Block
9. Capscrew
10. Base Riser
11. Damper
12. Air Spring
13. Bearings
14. Screw
15. Upper Frame
16. Air Valve

Fig. 1, Bostrom 915 Seat (exploded)

Seat Cover/Pad Assembly Removal and Installation

Removal (See Fig. 1)



1. Armrest Fastener
2. Armrest
3. Upper Seat Assembly
4. Seat Frame Assembly
5. Lumbar Adjustment Handle
6. Seat Tilt Adjustment Handle

Fig. 1, Upper Seat Assembly

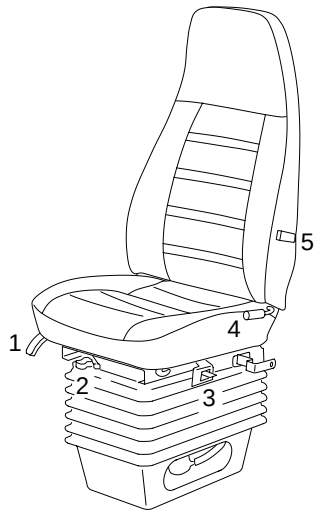
1. Remove the upper seat assembly from the suspension, using the instructions in **Subject 120**.
2. Remove the seat cover and pad from the seat frame assembly. Note the location of the fasteners on the existing seat cover. Do not remove the small vinyl patch from the seat tilt handle, unless it needs replacement.

Installation (See Fig. 1)

1. Place a new pad over the seat frame making sure the back edge of the pad is hooked over the rear support tube. If the seat is equipped with a seat tilt adjustment, make a cut in the bottom edge of the pad (right side) to fit around the handle.
2. Place the cover over the seat tilt handle and the top of the seat pad. Fold the rear half of the cover forward to expose the three tie-down tabs. Push the tie-down tabs through the holes in the foam. Reposition the cover and turn the seat over.
3. Pull the tie-down tabs tight and attach them to the center support wire (third wire from the rear). Use one hog ring per tab.
4. Insert the longest wire into the looped material sewn to the bottom of the cover. Place the shorter wire into the rear flap of the cover.
5. Pull the rear corners of the side panels rearward around the back corners of the frame. Attach the material with one hog ring per side.
6. Starting at the front of the seat cover and working rearward, hog ring the wire through the holes in the seat frame. Ten hog wires are required for the frame. Fold the rear flap down and toward the front of the seat. Pull tightly and fasten with three hog rings to the most rearward foam support wire.
7. Install the upper seat assembly onto the suspension, using the instructions in **Subject 120**.

General Information

The Bostrom 715 air suspension seats offer lumbar support, back angle adjustment, weight and height adjustment, a fore and aft isolator system, and seat cushion tilt adjustment. See **Fig. 1**.



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1. Seat Cushion Tilt Adjustment
2. Fore and Aft Isolation and Seat Position Adjustment
3. Weight and Height Adjustment
4. Back Angle Adjustment
5. Lumbar Adjustment

Fig. 1, Bostrom 715 Seat

For complete operating instructions, see Chapter 5 of the *FLB COE Driver's Manual* or Chapter 5 of the *FLD Conventional Driver's Manual*.

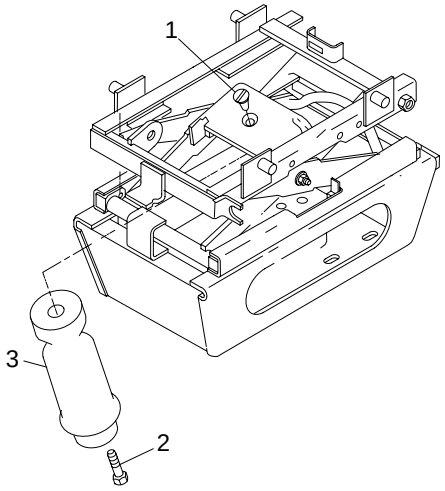
Removal

1. Apply the parking brakes, and chock the tires.
2. Push in on the seat height adjustment valve knob until the seat is adjusted to its maximum height.
3. If the seat is equipped with a seat suspension cover, remove the cover.
4. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the rear crossbars of the air suspension's inner and outer lever assemblies.
5. Drain the vehicle air reservoirs. Then pull out on the seat height adjustment valve knob until all air is exhausted from the air spring.
6. Disconnect the air line from the air spring assembly by pushing in the collar of the fitting while pulling the air line out of the fitting.
7. Remove the seat-belt straps and tether straps.
8. Remove the capscrews and washers that attach the seat to the cab deck. Remove the seat from the cab.

Installation

1. Place the seat on the cab deck. Insert the capscrews through the washers and the seat base. Tighten the capscrews 27 lbf·ft (37 N·m).
2. Attach the brackets of the seat-belt straps and tether straps. Tighten the capscrews 40 lbf·ft (54 N·m).
3. Connect the air line to the fitting in the air spring assembly by pushing the tube into the fitting.
4. Start the engine and allow the air reservoirs to fill. Push in on the seat height adjustment valve knob until the seat is adjusted to its maximum height, then remove the wooden block that supports the seat suspension.
5. If the seat is equipped with a seat suspension cover, install the cover.
6. Remove the chocks from the tires.

Removal (See Fig. 1)



1. Top Flat Head Screw
2. Bottom Hexhead Screw
3. Air Spring

Fig. 1, Air Spring Assembly

1. Remove the complete seat assembly from the vehicle using the instructions in **Subject 100**.
2. Remove the seat/back assembly using the instructions in **Subject 120**.
3. Remove the channel assembly using the instructions in **Subject 130**.
4. Remove the fasteners at the top and the bottom of the air spring.
5. Disconnect the air line from the air spring and remove the air spring from the suspension.

Installation (See Fig. 1)

1. Install the air spring in the suspension and tighten the screws 60 lbf·in (700 N·cm).
2. Connect the air line to the air spring.
3. Install the channel assembly using the instructions in **Subject 130**.
4. Install the seat/back assembly using the instructions in **Subject 120**.
5. Install the complete seat assembly in the vehicle using the instructions in **Subject 100**.

Removal (See Fig. 1)

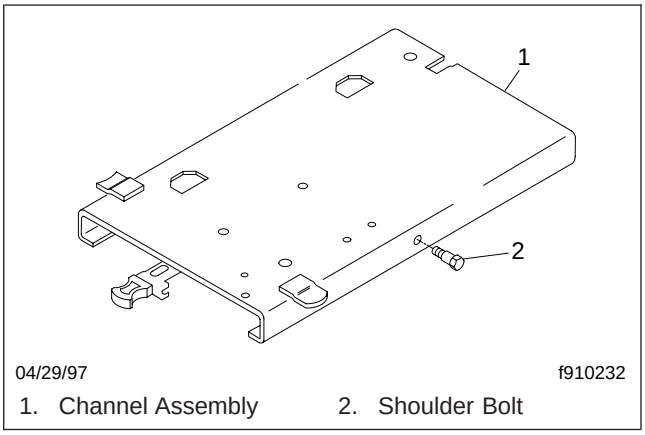


Fig. 1, Seat Channel Assembly

1. Remove the two shoulder bolts from the channel assembly.
2. Move the seat/back assembly forward to disengage the seat tilt latch assembly.
3. Remove the seat/back assembly.

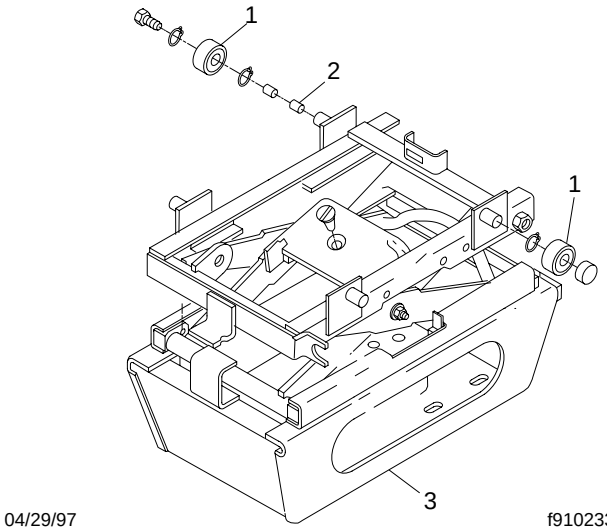
Installation (See Fig. 1)

1. Place the seat/back assembly onto the channel assembly.
2. Move the seat/back assembly rearward to engage the seat tilt latch assembly.
3. Install the two shoulder bolts on the channel assembly.

Fore and Aft Isolation Channel Removal and Installation

Removal

1. Remove the seat/back assembly using the instructions in **Subject 120**.
2. Adjust the channel assembly to the rearmost position.
3. Loosen the lateral adjustment setscrews using a 3 mm Allen wrench (do not use a 1/8-inch Allen wrench). See **Fig. 1**.



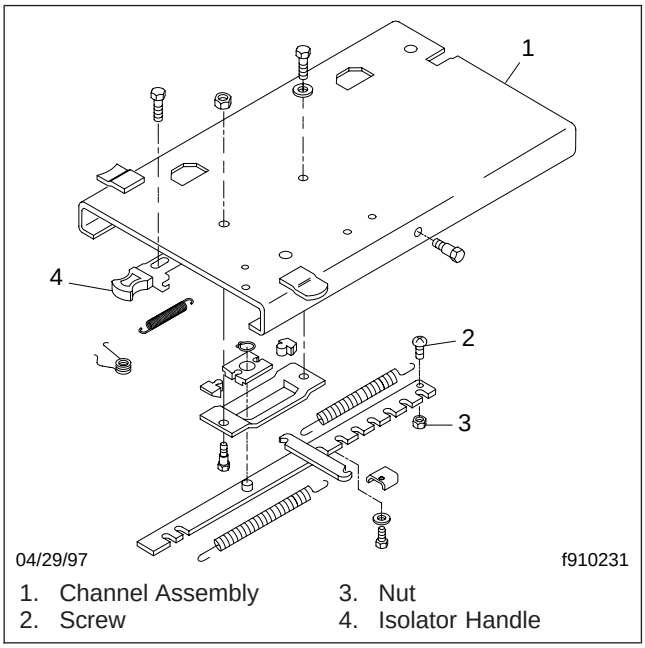
1. Roller
2. Allen-Head Adjustment Setscrew
3. Riser

Fig. 1, Suspension Assembly

4. With the isolator handle on the channel assembly in the isolation position (center position), push the channel assembly forward to expose the screw and the nut. See **Fig. 2**. Remove the screw and the nut and save for reassembly.
5. Slide the channel assembly forward past both sets of rollers.

Installation

1. Slide the channel assembly rearward over both sets of rollers.

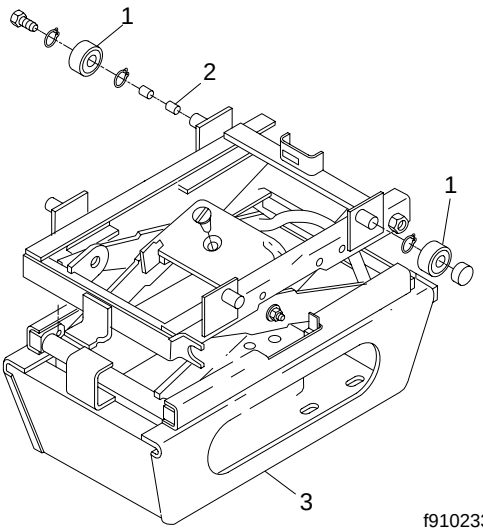


1. Channel Assembly
2. Screw
3. Nut
4. Isolator Handle

Fig. 2, Channel Assembly

2. With the isolator handle in the isolation position (center position), push the channel assembly forward to install the screw and nut.
3. Adjust lateral side play using the instructions in **Subject 140**.
4. Install the seat/back assembly using the instructions in **Subject 120**.

Adjustment (See Fig. 1)

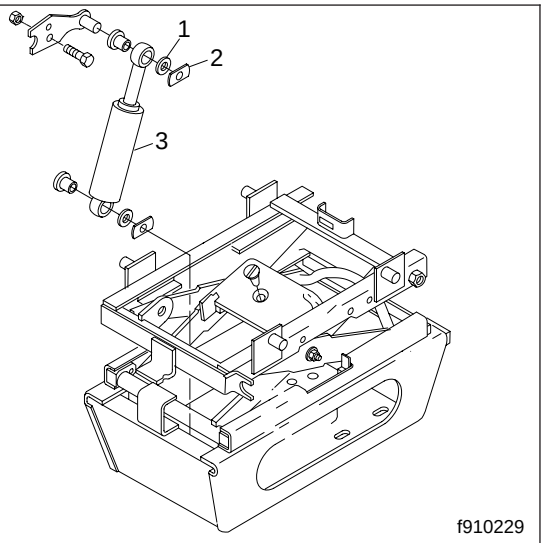


1. Roller
2. Allen-Head Adjustment Setscrew
3. Riser

Fig. 1, Suspension Assembly

1. Remove the seat/back assembly from the channel assembly using the instructions in **Subject 120**.
2. Adjust the channel assembly until the allen-head adjusting screws in the right isolator roller shafts are in line with the cutouts on the side of the channel assembly.
3. Use a 3 mm allen wrench (do not use a 1/8-inch allen wrench) to adjust the two allen-head screws. Turn the screws in until resistance is felt, then turn the screws 1-1/2 turns more.
4. Move the channel assembly through the entire fore and aft adjustment range to check the lateral clearance for binding. The isolator springs should return the channel to the neutral position for the best ride. Front to rear friction must not exceed 10.1 lbf (45 N).
5. Install the seat/back assembly on the channel assembly using the instructions in **Subject 120**.

Removal (See Fig. 1)



1. Thrust Washer
2. Push-On Fastener
3. Damper

Fig. 1, Damper Assembly

NOTE: The seat/back assembly does not need to be removed.

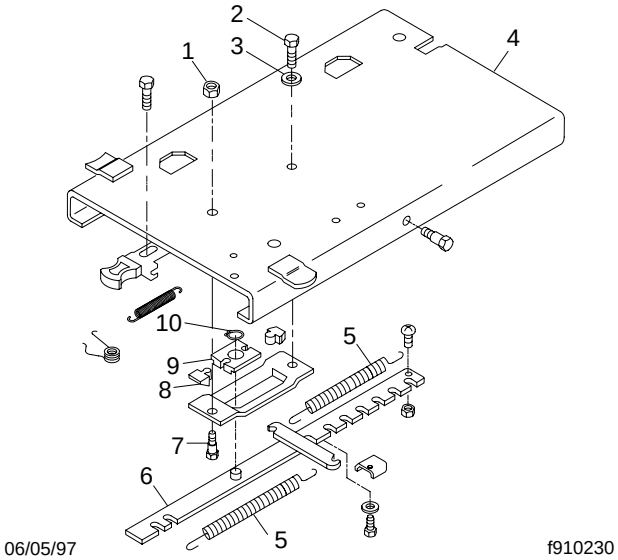
1. Fill the air spring so that the seat is at its maximum height.
2. Move the channel assembly to the full rearward position to gain working room.
3. Using pliers or a screwdriver, twist off the push-on fasteners. Discard the push-on fasteners.
4. Remove the damper.

Installation (See Fig. 1)

1. Install the new damper with the flanges of the bearings to the outside of the suspension.
2. Install the thrust washers and the new push-on fasteners until they seat. A 1/2-inch box end wrench works well to push the fasteners on.

Isolation Bumper Removal and Installation

Removal (See Fig. 1)



1. Locknut
2. Capscrew
3. Lockwasher
4. Channel Assembly
5. Isolator Spring
6. Latch Bar
7. Hexhead Screw
8. Isolation Bumper
9. Pivot Block
10. Retaining Ring

Fig. 1, Isolation Bumper Assembly

1. Remove the seat/back assembly using the instructions in **Subject 120**.
2. Remove the channel assembly using the instructions in **Subject 130**.

   Be careful not to loose the roller parts, they will be needed for reassembly.
3. Remove the two isolator springs by carefully extending and disconnecting them from the mounting points.
4. Slide the latch bar until the retaining ring can be seen through the hole in the channel assembly. Remove the retaining ring and keep it for reassembly.
5. Pull the latch bar free of the pivot block.
6. The rubber isolation bumpers are now accessible and can be replaced if necessary.

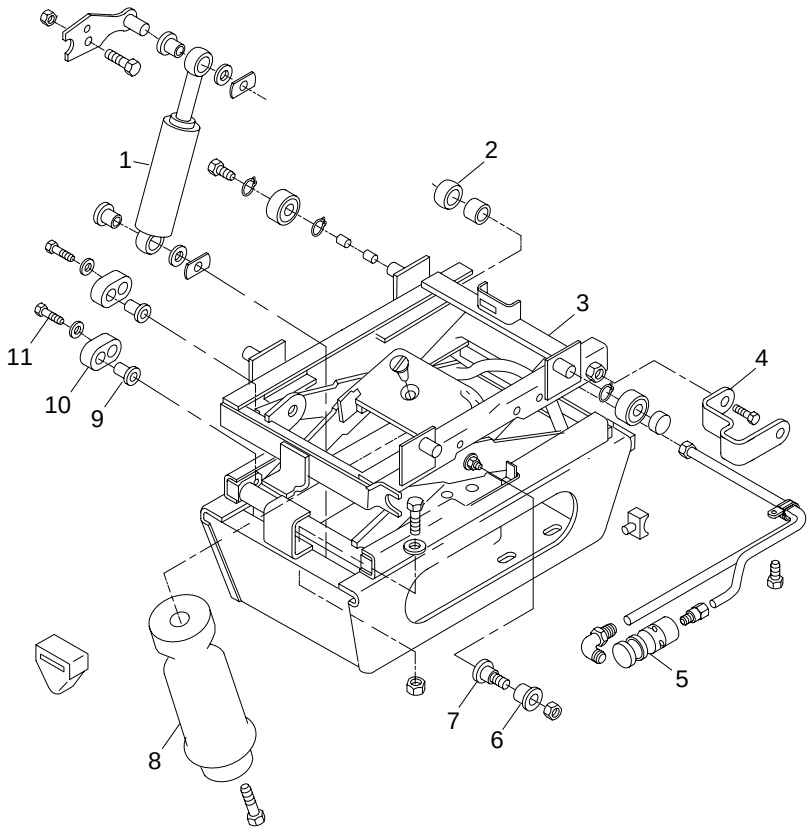
NOTE: The pivot block can be removed by first removing the screw and lockwasher, and then removing the screw and locknut.

Installation (See Fig. 1)

1. If the pivot block was removed, install the pivot block. Tighten 14 to 18 lbf·ft (20 to 24 N·m).
2. Install the isolation bumpers.
3. Replace the latch bar on the pivot block.
4. Replace the retaining ring.
5. Replace the two isolator springs by carefully extending the springs and connecting them to the mounting points.
6. Install the channel assembly using the instructions in **Subject 130**.

   Be sure the roller parts are installed correctly on the roller pins.
7. Install the seat/back assembly using the instructions in **Subject 120**.

Removal (See Fig. 1)



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1. Damper
2. Roller
3. Upper Frame
4. ICP Bracket
5. Air Valve
6. Bearing
7. Shoulder Bolt
8. Air Spring
9. Bearing
10. Bearing Block
11. Screw

Fig. 1, Suspension Assembly

1. Remove the complete seat assembly from the vehicle using the instructions in **Subject 100**.
2. Remove the seat/back assembly using the instructions in **Subject 120**.
3. Remove the channel assembly using the instructions in **Subject 130**.

   Be careful not to loose the roller parts, they will be needed for reassembly.
4. Remove the capscrews and the ICP bracket. If the seat assembly has a suspension cover, remove the fasteners and the suspension cover.
5. Remove the air valve by loosening the nut on the valve and removing it from the bracket on the upper frame assembly.
6. Remove the capscrews from the upper front bearing blocks.
7. With the suspension blocked up, remove the upper frame by sliding it forward off of the bearing blocks and the rollers.
8. Remove the air spring using the instructions in **Subject 110**. Mark the air line for reassembly.

9. Remove the damper using the instructions in **Subject 150**.
10. Remove the capscrews from the lower bearing blocks and slide the bearing blocks and the inner lever rearward to the slot in the roller channels. Lift the lever and blocks from the channel and then turn the inner lever sideways to remove the rollers from the channels.
11. Remove the shoulder bolts and nuts from the pivots of the lever assemblies and inspect the bolts. If the bolts are worn, replace them.

Installation (See Fig. 1)

1. Replace the bearings at the pivots on the lever assembly by pushing out the old bearings and pressing in the new bearings. The flange of the bearings should be on the outside of the lever assembly.
2. Install the shoulder bolts and nuts into the pivots of the lever assemblies. Tighten the bolts 20 lbf·ft (27 N·m).
3. Install new bearing blocks and rollers on the levers. Place the levers into the channel. Tighten the screws 30 lbf·ft (41 N·m).
4. Slide the upper frame assembly over the blocks. Line up the capscrews with the bearing blocks and tighten the screws 30 lbf·ft (41 N·m).
5. Manually move the suspension up and down to make sure there are no clearance problems.
6. Block the suspension up with a spacer placed between the base and the upper frame. Install the air spring using the instructions in **Subject 110**.
7. Install the damper using the instructions in **Subject 150**.
8. Install the air valve onto the bracket on the upper frame.
9. Install the ICP bracket and capscrews. If the seat assembly has a suspension cover, install the suspension cover and the fasteners.
10. Install the channel assembly using the instructions in **Subject 130**.

    Be sure the roller parts are installed correctly on the roller pins.
11. Adjust lateral side play using the instructions in **Subject 140**.
12. Install the seat/back assembly using the instructions in **Subject 120**.
13. Install the seat assembly in the vehicle, using the instructions in **Subject 100**.

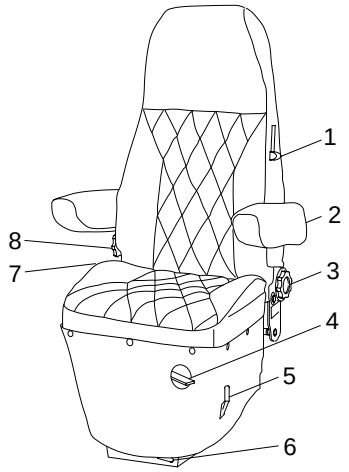
Specifications

Fastener Torques		
Description	**Size**	**Torque**
Seat Base Hexhead Capscrews	3/8–16	27 lbf·ft (37 N·m)
Intermediate-Connecting-Point Rod Capscrews	11/16	40 lbf·ft (54 N·m)
Air Spring Flat Head Screw	M8 x 20	60 lbf·in (700 N·cm)
Air Spring Hexhead Screw	M8 x 30	60 lbf·in (700 N·cm)
Pivot Block Capscrew	M8	14–18 lbf·ft (20–24 N·m)
Pivot Block Hexhead Screw	M8	14–18 lbf·ft (20–24 N·m)
Lever Assembly Shoulder Bolt	—	20 lbf·ft (27 N·m)
Bearing Block Capscrew	M8 x 20	30 lbf·ft (41 N·m)

Table 1, Fastener Torques

General Information

The Eldorado air suspension seats offer lumbar support, back cushion tilt adjustment, height adjustment, a fore and aft seat position adjustment, isolator system, armrest angle adjustment, and air ride control adjustment. See **Fig. 1**.



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1. Lumbar Adjustment, Vertical (optional)
2. Armrest Angle Adjustment (optional)
3. Back Cushion Tilt Adjustment
4. Height Adjustment
5. Isolator Adjustment
6. Fore and Aft Seat Position Adjustment
7. Air Ride Control Adjustment
8. Lumbar Support Adjustment, Front to Back

Fig. 1, Eldorado Seat

For complete operating instructions, see the vehicle driver's manual.

Removal

1. Apply the parking brakes, and chock the tires.
2. Push in on the seat height adjustment valve knob until the seat is adjusted to its maximum height.
3. If the seat is equipped with a seat suspension cover, remove the cover.
4. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the rear crossbars of the air suspension's inner and outer lever assemblies.
5. Drain the vehicle air reservoirs. Then pull out on the seat height adjustment valve knob until all air is exhausted from the air spring.
6. Disconnect the air line from the air spring assembly by pushing in the collar of the fitting while pulling the air line out of the fitting.
7. Remove the seat-belt straps and tether straps.
8. Remove the capscrews and washers that attach the seat to the cab deck. Remove the seat from the cab.

Installation

1. Place the seat on the cab deck. Insert the capscrews through the washers and the seat base. Tighten the capscrews 27 lbf·ft (37 N·m).
2. Attach the brackets of the seat-belt straps and tether straps. Tighten the capscrews 40 lbf·ft (54 N·m).
3. Connect the air line to the fitting in the air spring assembly by pushing the tube into the fitting.
4. Start the engine and allow the air reservoirs to fill. Push in on the seat height adjustment valve knob until the seat is adjusted to its maximum height, then remove the wooden block that supports the seat suspension.
5. If the seat is equipped with a seat suspension cover, install the cover.
6. Remove the chocks from the tires.

Removal (See Fig. 1)

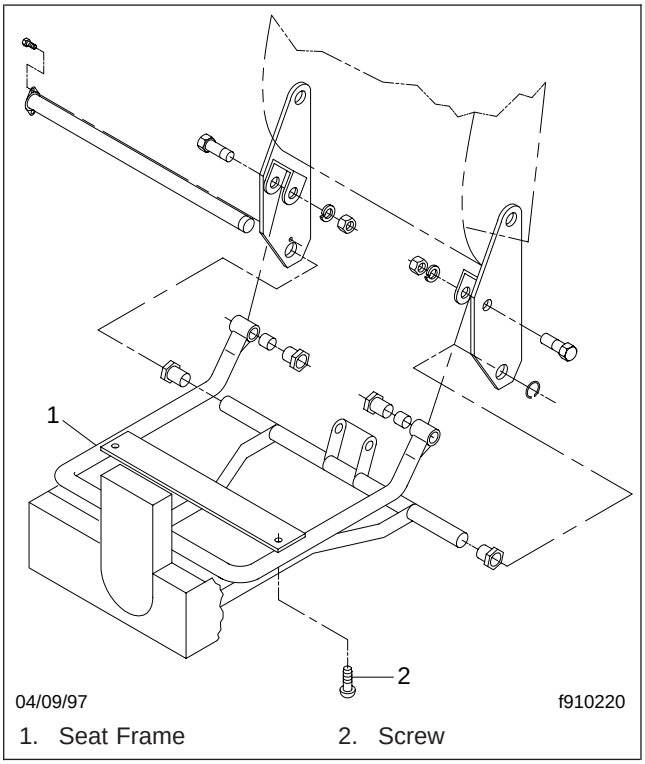


Fig. 1, Seat Cushion Replacement

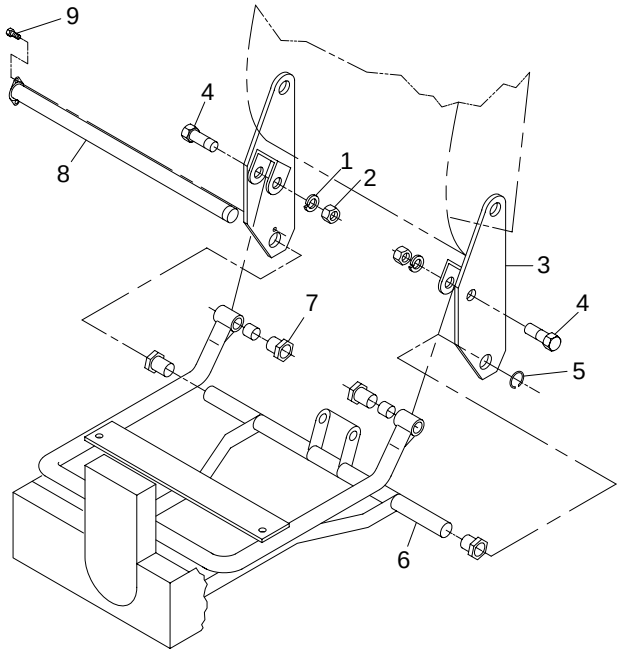
1. Apply the parking brakes, and chock the tires.
2. Remove the four screws that attach the seat cushion to the seat frame.

Installation (See Fig. 1)

1. Place the seat cushion on the seat frame.
2. Install the four screws that attach the seat cushion to the seat frame.
3. Remove the chocks from the tires.

Seat Back Assembly Removal and Installation

Removal (See Fig. 1)



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1. Washer
2. Nut
3. Seat Back Assembly Bracket
4. Bolt
5. Arc Ring
6. Seat Frame Rod
7. Seat Frame Bushing
8. Rod
9. Screw

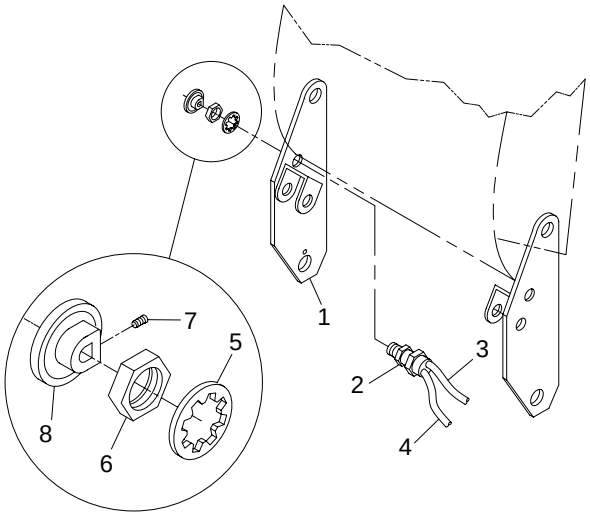
Fig. 1, Seat Back Replacement

1. Apply the parking brakes, and chock the tires.
2. Remove the two nuts, washers, and bolts that attach the seat back assembly to the seat frame bushings.
3. Remove the arc ring from the rod.
4. Remove the rod screw and the rod from the seat back assembly.
5. Remove the seat back assembly.

Installation (See Fig. 1)

1. Align the bottom holes in the seat back assembly bracket with the seat frame rod.
2. Insert the rod through the seat back assembly bracket and the seat frame rod. Gently tap the rod into final position to avoid damaging the bearing flange.
3. Install the rod screw into the rod and tighten.
4. Install the arc ring onto the rod at the groove location.
5. Align the seat frame bushings with the seat back bracket and install the two bolts, washers, and nuts.
6. Remove the chocks from the tires.

Removal (See Fig. 1)



1. Seat Back Assembly Bracket
2. Air Valve
3. Inlet Hose, Blue
4. Outlet Hose, Black
5. Lockwasher
6. Nut
7. Setscrew
8. Knob

Fig. 1, Air Valve Replacement

1. Apply the parking brakes, and chock the tires.
2. Drain the vehicle air reservoirs. Then pull out on the air valve knob until all air is exhausted.
3. Disconnect the black outlet air hose from the lower fitting on the air valve. Be sure not to damage the brass fitting when disconnecting.
4. Disconnect the blue inlet air hose from the upper fitting on the air valve.
5. Remove the setscrew from the air valve knob and pull the knob off of the valve.
6. Remove the nut and the lockwasher from the air valve.
7. Remove the air valve from the hole in the seat back assembly bracket.

Installation (See Fig. 1)

1. Install the air valve into the hole in the seat back assembly bracket.
2. Place the lockwasher onto the air valve. Install the nut onto the air valve and tighten.
3. Push the knob onto the air valve. Install the setscrew into the knob and tighten.
4. Attach the blue inlet air hose to the upper fitting on the air valve.
5. Attach the black outlet air hose to the lower fitting on the air valve.
6. Start the engine and allow the air reservoirs to fill.
7. Remove the chocks from the tires.

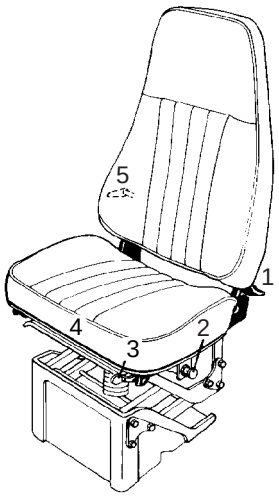
Description	Size	Torque lbf·ft (N·m)
Seat Base Capscrews	3/8–16	27 (37)
Seat-Belt and Tether Straps Bracket Capscrews	11/16	40 (54)

Table 1, Fastener Torques

General Information

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

The Dura-Form air suspension seats offer lumbar support, back cushion tilt adjustment, height adjustment, a fore and aft isolator system, and seat cushion adjustment. See **Fig. 1**.



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1. Back Cushion Tilt Adjustment
2. Height Adjustment
3. Isolator and Fore-Aft Adjustment
4. Seat Cushion Adjustment
5. Lumbar Support

Fig. 1, Dura-Form Seat

For complete operating instructions, see Chapter 5 of the *FLB COE Driver's Manual* or Chapter 5 of the *FLD Conventional Driver's Manual*.

Removal

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

1. Apply the parking brakes, and chock the tires.
2. Press the seat height adjustment rocker switch until the seat is adjusted to its maximum height.
3. If the seat is equipped with a seat suspension shroud, remove the shroud. It is held in place with Velcro and upholstery-panel fasteners.

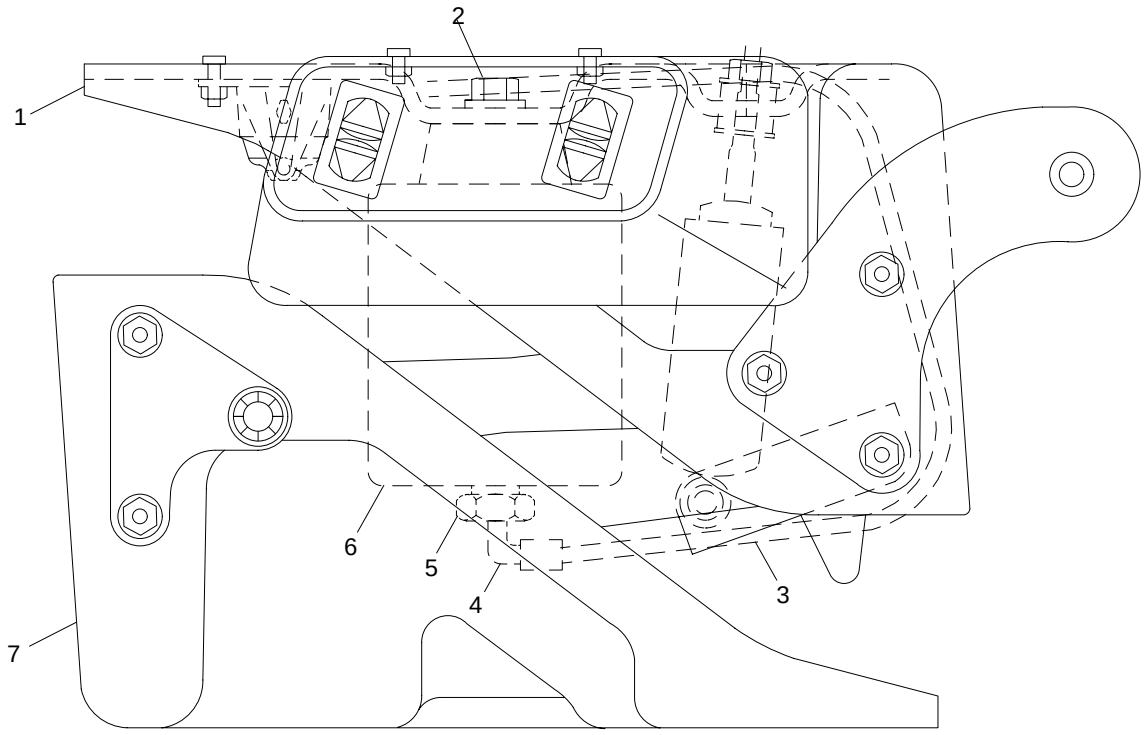
   If the seat is equipped with a rubber bellows seat suspension cover, raise the rubber bellows.
4. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the air suspension lower base and the rear crosstube of the lower arm.
5. Drain the vehicle air reservoirs. Then, press the seat height adjustment rocker switch until all air is exhausted from the air spring.
6. Disconnect the air valve air-supply hose at the quick-connect union behind the seat.
7. Using an 11/16-inch wrench or a T50 Torx® wrench, unscrew the capscrews that attach the seat-belt straps and tether straps to the intermediate-connecting-point threaded rod.
8. Remove the capscrews and washers that attach the seat to the cab deck. Remove the seat and both mounting support channels from the cab.

Installation

1. Place the seat on the cab deck. Position a mounting support channel at the front edge, and another at the rear edge of the seat base. Insert the capscrews through the washers, the support channels, and the seat base. Tighten the capscrews 27 lbf·ft (37 N·m).
2. Attach the brackets of the seat-belt straps and tether straps to the intermediate-connecting-point threaded rod. Tighten the capscrews 40 lbf·ft (54 N·m).
3. Connect the air valve air-supply hose by pressing the pneumatic tubing into the quick-connect union behind the seat.
4. Start the engine and allow the air reservoirs to fill. Press the seat height adjustment rocker switch until the seat is adjusted to its maximum height. If the seat is equipped with a rubber bellows seat suspension cover, raise the rubber bellows. Remove the wooden block that supports the seat suspension.
5. If the seat is equipped with a seat suspension shroud, install the shroud.
6. Remove the chocks from the tires.

Air Spring Removal and Installation

Removal (See Fig. 1)



03/06/97 f910211

1. Upper Housing
2. Hexhead Bolt
3. Tubing, Valve To Spring
4. Elbow
5. Jam Nut
6. Air Spring
7. Lower Housing

Fig. 1, Air Spring Assembly

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

1. Apply the parking brakes, and chock the tires.
2. Press the seat height adjustment switch until the seat is adjusted to its maximum height.
3. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the lower housing and the upper housing.
4. Drain the vehicle air reservoirs. Then press the seat height adjustment switch until all the air is exhausted from the air spring.
5. Disconnect the 7/16-inch air fitting at the bottom of the air spring. Remove the 3/4-inch jam nut.
6. Remove the 1/2-inch hexhead bolt and lockwasher at the top of the air spring.
7. Compress the air spring and rotate it forward to lift it out.

Installation (See Fig. 1)

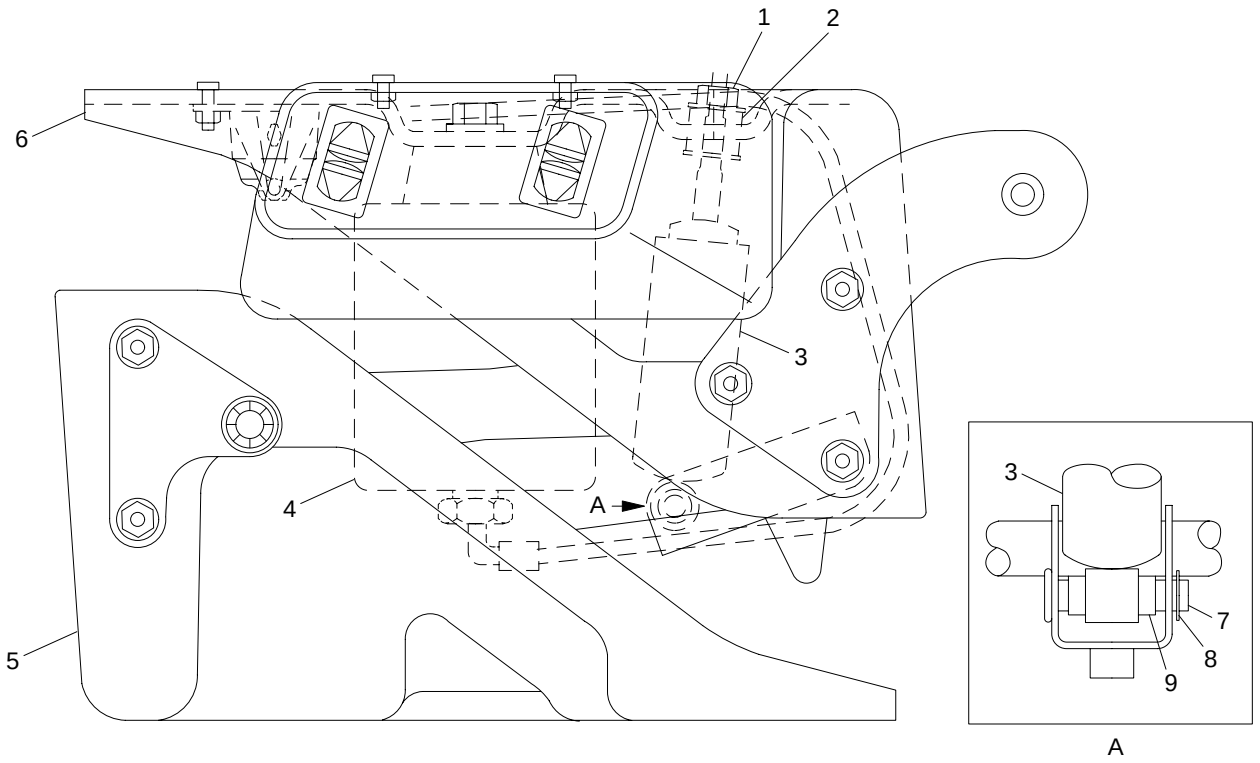
1. Compress the air spring and install it by rotating it rearward.
2. Install the 1/2-inch hexhead bolt and lockwasher at the top of the air spring. Tighten 15 to 20 lbf·ft (20 to 27 N·m).

Air Spring Removal and Installation

3. Apply pipe sealant to the threads of the elbow. Insert the tube into the fitting until the tube bottoms in the fitting, then tighten one wrench turn past finger tight. Tighten the pipe threads on the fitting 12 to 18 lbf·ft (16 to 24 N·m).
4. Connect the air fitting to the air spring with the 3/4-inch jam nut. Tighten 72 to 96 lbf·in (800 to 1100 N·cm).
5. Start the engine and allow the air reservoirs to fill. Press the seat height adjustment switch until the seat is adjusted to its maxium height, then remove the wooden block.
6. Remove the chocks from the tires.

Shock Absorber Removal and Installation

Removal (See Fig. 1)



A. Shock Mounting
1. Nut
2. Bushing
3. Shock Absorber
4. Air Spring
5. Lower Housing
6. Upper Housing
7. Shock Pin
8. Retaining Ring
9. Shock Bearing

Fig. 1, Shock Absorber Assembly

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

1. Apply the parking brakes, and chock the tires.
2. Press the seat height adjustment switch until the seat is adjusted to its maximum height.
3. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the lower housing and the upper housing.
4. Remove the 5/16-inch nut at the top of the shock absorber.
5. Remove the retaining ring and the shock pin at the bottom of the shock absorber.
6. Remove the shock absorber.

Installation (See Fig. 1)

1. Install the shock absorber.
2. Install the 5/16-inch nut at the top of the shock absorber. Tighten 10 to 15 lbf·ft (14 to 20 N·m).

NOTE: The pin hole closest to the air spring is the firmer ride.

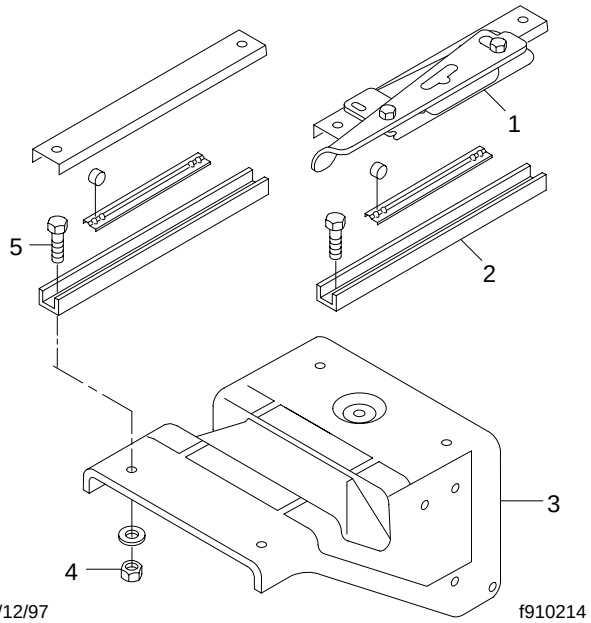
3. Install the shock pin and the retaining ring at the bottom of the shock absorber.

Shock Absorber Removal and Installation

4. Remove the wooden block from the seat, and the chocks from the tires.

Isolator and Slides Removal and Installation

Removal (See Fig. 1)



1. Isolator Plate and Handle
2. Slide
3. Upper Housing
4. Nut
5. Screw

Fig. 1, Isolator and Slides Assembly

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

1. Apply the parking brakes, and chock the tires.
2. Press the seat height adjustment switch until the seat is adjusted to its maximum height.
3. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the lower housing and the upper housing.
4. Remove the seat/back assembly using the instructions in **Subject 140**.
5. Using a 1/2-inch socket and a 1/2-inch wrench, remove the isolator assembly.

Installation (See Fig. 1)

1. Using a 1/2-inch socket or wrench and a screwdriver, install the isolator assembly.
2. Install the seat/back assembly using the instructions in **Subject 140**.
3. Remove the wooden block from the seat, and the chocks from the tires.

Seat/Back Assembly Removal and Installation

Removal

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

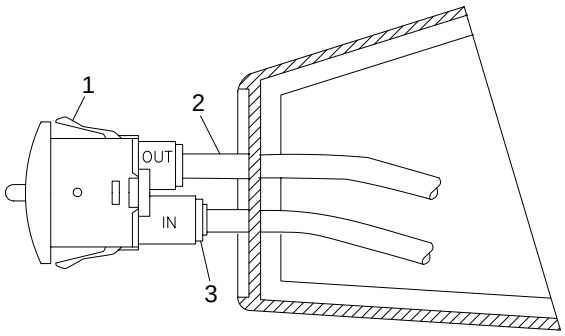
1. Apply the parking brakes, and chock the tires.
2. Using a 1/2-inch socket and a 1/2-inch wrench, remove the four mounting bolts.
3. Remove the seat/back assembly.

Installation

1. Place the seat/back assembly onto the isolator assembly.
2. Using a 1/2-inch socket and a 1/2-inch wrench, install the four mounting bolts.
3. Remove the chocks from the tires.

Air Valve Removal and Installation

Removal (See Fig. 1)



1. Retaining Fingers
2. Air Hose
3. Retaining Ring

Fig. 1, Air Valve Assembly

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

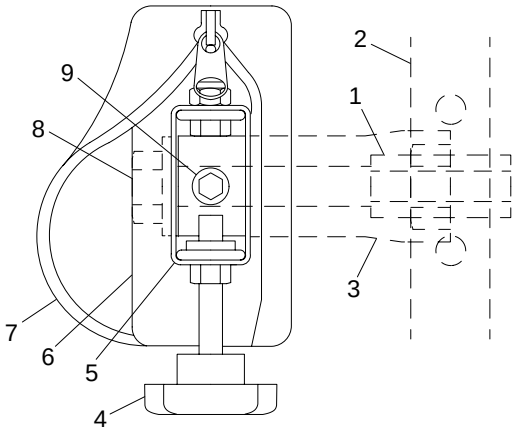
1. Apply the parking brakes, and chock the tires.
2. Drain the vehicle air reservoirs. Then press the seat height adjustment rocker switch until all air is exhausted from the air spring.
3. Reach behind and inside the air control panel and compress the two retaining fingers together on the air valve.
4. Remove the air valve by pushing it outward through the slot in the control panel.
5. Compress the gray retaining ring on the valve body inlet port toward the valve, and pull on the air hose to remove it from the valve.
6. Repeat the previous step for the outlet port.

Installation (See Fig. 1)

IMPORTANT: When installing the air lines, make sure they are connected to the same valve port they were removed from, and are firmly pressed into place. The new air line will insert approximately 1/2-inch when installed properly.

1. Install the air lines in the valve. Pull outward slightly on the new air lines to ensure a solid installation. Do not compress the air line retaining rings when verifying the installation.
2. Make sure the valve is properly oriented, and firmly press the complete valve back into the slot in the air control panel until you hear a "click." The "click" assures the valve retaining fingers are properly secured to the air control panel.
3. Start the engine and allow the air reservoirs to fill.
4. Remove the chocks from the tires.

Removal (See Fig. 1)



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1. Coupling Nut (welded to seat frame assembly)
2. Seat Frame Assembly
3. Pivot Bar
4. Adjustment Knob
5. Armrest Tube
6. Armrest Foam
7. Armrest Cover
8. Armrest Bolt
9. Socket Head Screw

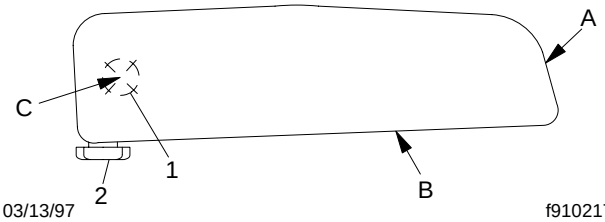
Fig. 1, Armrest, Rear View

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

1. Apply the parking brakes, and chock the tires.
2. Unzip the armrest cover.
3. Remove the socket head screw from the pivot bar in the armrest.
4. Loosen the armrest bolt.
5. Remove the armrest.
6. Remove the pivot arm from the seat back.

Installation

1. Locate the hole in the side of the armrest foam and make an incision. See **Fig. 2**.
2. Locate the coupling nut (welded to the seat frame assembly). Make an incision in the seat back cover. See **Fig. 3**.



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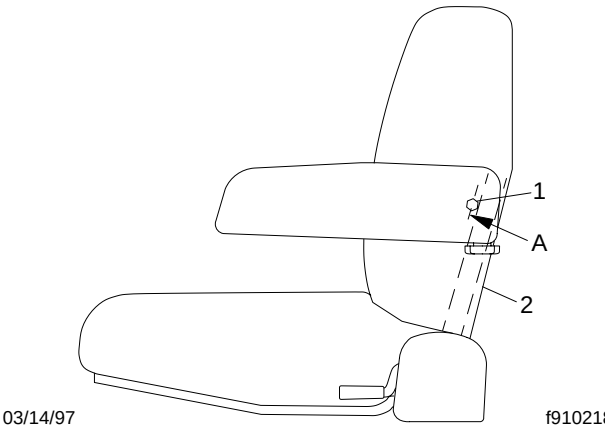
A. Front
B. Bottom
C. Place incision on this side for the left-hand armrest. Place on the opposite side for the right-hand armrest.
1. Hole
2. Adjustment Knob

Fig. 2, Armrest



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A. Place incision on this side for the left-hand armrest. Place on the opposite side for the right-hand armrest.
1. Coupling Nut (welded to seat frame assembly)
2. Seat Back

Fig. 3, Coupling Nut Location

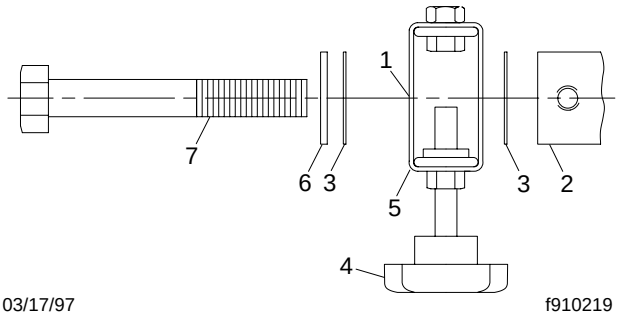
3. Insert the pivot bar through the incision in the seat back cover. Slide the pivot bar over the coupling nut with the hole for the socket head screw facing rearward. See **Fig. 1**.

NOTE: The seat back cover and foam will hold the pivot bar in place while the remainder of the armrest is prepared for assembly.

4. Unzip the armrest cover and assemble the armrest bolt, the metal washer, and the plastic washers through the hole in the side of the armrest tube. See **Fig. 4**. The armrest tube must be

Armrest Removal and Installation

clamped between the two plastic washers when assembly is complete.



1. Small Hole
2. Pivot Bar
3. Plastic Washer
4. Adjustment Knob
5. Armrest Tube
6. Metal Washer
7. Armrest Bolt

Fig. 4, Armrest Assembly

5. Slide the assembled armrest over the pivot bar. Tighten the armrest bolt 22 to 23 lbf·ft (29 to 31 N·m). See **Fig. 1**.

IMPORTANT: The pivot bar must be seated against the seat frame while the armrest bolt is tightened.

6. Install the socket head screw into the pivot bar. See **Fig. 1**. Tighten 10 to 16 lbf·ft (13 to 21 N·m).
7. Zip up the armrest cover.
8. Remove the chocks from the tires.

Specifications

Fastener Torques		
Description	**Size**	**Torque**
Seat Base Hexhead Capscrews	3/8–16	27 lbf·ft (37 N·m)
Intermediate-Connecting-Point Rod Capscrews	11/16	40 lbf·ft (54 N·m)
Air Spring Hexhead Bolt	1/2	15–20 lbf·ft (20–27 N·m)
Air Spring Fitting Pipe Threads	—	12–18 lbf·ft (16–24 N·m)
Air Fitting to Air Spring Jam Nut	3/4	72–96 lbf·in (800–1100 N·cm)
Shock Absorber Nut	5/16	10–15 lbf·ft (14–20 N·m)
Armrest Bolt	—	22–23 lbf·ft (29–31 N·m)
Socket Head Screw	—	10–16 lbf·ft (13–21 N·m)

Table 1, Fastener Torques

General Information

Freightliner Corporation currently applies DuPont® single-stage Imron® 5000 or two-stage (base coat and clear coat) Imron 6000 high-solids polyurethane enamel on the vehicle cab at the factory.

Black Standard Urethane or Imron 5000 is used on the vehicle chassis. The chassis includes the frame, spoke spider, running gear, and any components attached to the frame. Aluminum fuel tanks are not painted.

To meet the federal air quality regulations imposed by the EPA and local jurisdictions, these products contain lower levels of volatile organic compounds (VOCs) than earlier types (916Y, Centari®, and Imron), and are formulated free of lead and chrome.

The procedures in this section are for use with DuPont products. Unless otherwise noted, all products are manufactured by E. I. du Pont de Nemours and Company, Inc. Obtain approval from a Freightliner Regional Office for use of topcoats produced by other manufacturers.

Color-Matching

The recommended aftermarket paints for color-matching factory-applied paint are as follows:

- Cab—use Imron 5000 or Imron 6000
- Chassis—use only Imron 5000

To ensure proper gloss, durability, and color-matching of the enamel, use only Imron 5000 on panels that were previously painted with Imron 5000, and use only Imron 6000 on panels painted with Imron 6000.

To determine the correct paint number for color-matching any original finish on a vehicle, refer to the paint specification on the vehicle specification decal. Refer to the vehicle driver's manual for the location of this decal.

NOTE: The high-solids Standard Urethane applied to the chassis at the factory is sold to original equipment manufacturers (OEMs) only, and is not available for aftermarket sale. Use Imron 5000, N0001 Black, for repainting.

General Guidelines

This section provides instructions for preparing large panels or the entire cab for topcoating with DuPont® products. For spot repairs or touch-ups, see **Subject 120**.

Before topcoating, the surface must be thoroughly cleaned and sanded. Any bare areas must also be conditioned and primed.

1. Preparation materials specified for one type of surface should not be used for any other type of surface.
2. Limit intermediate coatings, such as primers, to the brand and type specified by the finish-coat manufacturer.

⚠ CAUTION

Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.

Preparation for Prime Coat

Use the cleaners and conditioners specified in each step to prepare the surface for priming. See **Specifications, 400** for a summary of the products used in this procedure.

⚠ WARNING

Do not use solvent-based cleaners on large areas of plastic or fiberglass, such as the hood or air fairing. Wiping down these large areas may cause a buildup of static electricity. The resulting spark could cause a flash fire, which could result in personal injury or property damage.

CAB AND HOOD PREPARATION

1. Wash and dry the entire vehicle with a mild detergent.

⚠ WARNING

Solvents are flammable. Keep them away from heat, sparks, and open flame. Keep the container closed. Use only with adequate ventilation. Avoid breathing the vapor, or headache, nausea, and impaired reaction time and coordination may result.

2. Wipe all surfaces to be painted with a clean cloth soaked with solvent or cleaner. Remove all traces of wax, polish, grease, and silicones.
   - Metal—use DuPont Prep-Sol 3919 S.
   - Plastic—use DuPont Plastic Prep 2319 S.
   - Fiberglass—use DuPont Prep-N-Solv.

   2.1 Work on small areas at a time, wetting the surface liberally.

   2.2 Quickly wipe the surface with a clean cloth before the solvent or cleaner has a chance to dry. Change cloths frequently.
3. Feather the edge of all repaired areas, chipped surfaces, and scratches.

   3.1 Cut down the edges of broken spots with no. 220 sandpaper.

   3.2 Feather the edges by hand, using a sanding block with no. 400 sandpaper.
4. Sand the entire area to be painted. Using a sanding block and no. 400 sandpaper, remove the gloss to improve adhesion of the primer.
5. Using a clean cloth soaked with cleaner, remove any sanding dust.
   - Metal or plastic—use DuPont 3939 S lacquer and enamel cleaner.
   - Fiberglass—use a solution of one part water and one part isopropyl alcohol (IPA).
6. Treat bare metal and rusted areas.
   - Steel—use DuPont 5717 S metal conditioner.
   - Aluminum—use DuPont 225 S aluminum cleaner.

   6.1 Mix one part of the cleaner with two parts of water in a plastic bucket.

6.2 Apply the cleaner with a cloth or sponge. If corrosion is present, work the surface with a stiff plastic brush or 3M Scotch-Brite® pad. Do not use any pads containing iron.

6.3 While the metal is still wet, wipe thoroughly with a clean, dry cloth. Allow the surface to dry before applying a conversion coating.

7. Apply a conversion coating to all bare metal.
   - Steel—use DuPont 5718 S metal conversion coating.
   - Zinc casings or galvanized surfaces (iron or steel)—use DuPont 5718 S metal conversion coating.
   - Aluminum—use DuPont 226 S aluminum conversion coating.

   7.1 Pour the conversion coating into a plastic container (do not dilute). Using a 3M Scotch-Brite or similar non-iron abrasive pad, apply the conversion coating to the metal surface. Work only as much area as can be coated and rinsed before the solution dries.

   7.2 Leave the coating on the surface for 2 to 5 minutes. Then, rinse off the solution with cold water, or mop with a sponge or cloth rinsed frequently in clean water.

   If the metal surface dries before rinsing, reapply the conversion coating, then repeat the previous substep.

   7.3 Wipe the surface dry with a clean cloth, or air dry.

8. With paper and tape, mask all areas that are not to be painted.

AIR FAIRING KIT PREPARATION

Before installing a new air fairing, prepare the surface for topcoating.

1. Wash the air fairing with a mild detergent. Dry with a clean, absorbent, lint-free cloth or paper towels.
2. Using a clean cloth soaked with DuPont Prep-N-Solv®, wipe the entire surface to remove any trace of grease or oil.
3. Scuff-sand the air fairing with no. 320 grit sandpaper.
4. Wipe the air fairing with a clean cloth soaked in a solution of one part water and one part isopropyl alcohol. Allow 10 to 15 minutes for the air fairing to dry.
5. With tape and paper, mask all areas that are not to be painted.

Prime Coat

Prime all bare and feathered areas before topcoating. The specified primers can be used on any surface.

1. Clean all cracks and surfaces with dry compressed air.
2. Using a tack cloth, wipe all surfaces to be painted.

⚠ WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying primer, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.

3. Prime all bare metal and feathered areas with DuPont primer.
   - Steel and aluminum—use Corlar 824 S epoxy primer.
   - Fiberglass—use Corlar 825 S epoxy primer.

   3.1 Stir the primer thoroughly.

   3.2 Mix two parts Corlar epoxy primer with one part DuPont 826 S activator.

   3.3 Reduce three parts of this mixture with one part DuPont 3602 S lacquer thinner (viscosity reading is 18 to 22 seconds in a no. 2 Zahn cup). Stir thoroughly.

   3.4 Wait 1 to 2 hours from time of mixing before using. This provides time for complete chemical induction.

   3.5 Set the air pressure at the spray gun at 45 psi (310 kPa). For pressure feed sys-

tems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.

3.6 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

3.7 Spray one full wet coat to give a dry film thickness of 0.7 to 1.0 mil (18 to 25 µm).

3.8 Clean the equipment immediately after use with DuPont 3602 S lacquer thinner.

3.9 Air dry 2 hours or force dry 20 minutes.

4. Wet sand the primer with no. 400 grit or finer sandpaper. Feather the edge into the surrounding area.

5. Dry the surface. Using a clean cloth soaked with cleaner, remove any sanding dust.

   - Metal or plastic—use DuPont 3939 S lacquer and enamel cleaner.
   - Fiberglass—use solution of 1 part water and 1 part isopropyl alcohol (IPA).

NOTE: See **Subject 110** for topcoating instructions.

General Guidelines

This section provides instructions for applying a topcoat of DuPont® enamel to full panels or the entire cab. For spot repairs or touch-ups, see **Subject 120**.

⚠ CAUTION

Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.

Do not mix additives with the finish coats unless they are specified by the finish-coat manufacturer. See **Specifications, 400** for a summary of the products used in this procedure.

Before applying any topcoat:

1. Prepare the surface for topcoating. See **Subject 100** for instructions.
2. Clean all cracks and surfaces with dry compressed air.
3. Using a tack cloth, wipe all surfaces to be painted.

After topcoating, remove the masking as follows:

- After normal air drying—remove all masking when the surface is reasonably dry.
- After forced drying—remove the masking immediately after the finish has been baked.
- After two-toning—remove the masking used for the first coat as soon as it has set up, usually in about 35 to 40 minutes. Follow the same procedure for the second color.

Imron 5000 Topcoating

Imron 5000 is a single-stage, low VOC, high-solids polyurethane enamel. It provides a durable, high-gloss surface with good chemical resistance. It requires the addition of an activator.

⚠ WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while spraying Imron 5000, and until the work area has been exhausted of all vapor and spray mist. Breathing paint vapor or spray mist can cause personal injury.

MIXING

1. Stir the Imron 5000 enamel thoroughly.
2. Mix three parts Imron 5000 enamel with one part of DuPont 193 S or 194 S activator. No further reduction is necessary for application.

NOTE: The pot life of the mixture is about 2 to 4 hours at 70°F (21°C), unless an accelerator is added.

3. If faster curing time is desired, add DuPont 389 S fast-dry accelerator. Add up to 2 ounces (60 mL) to 1 gallon (3.8 L) of mixed material.
4. Mix thoroughly and strain.

NOTE: The viscosity of the mixture is about 9 to 20 seconds in a no. 3 Zahn cup, depending on the color. Adding reducer could affect the color match on some metallics.

APPLICATION

1. Set the air pressure at the spray gun to 60 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.
2. Apply the topcoating.
   - 2.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.
   - 2.2 Using a cross-coat technique, spray one medium-wet coat in a north-to-south direction
   - 2.3 Allow 5 to 10 minutes drying time between each application. Do not sand.
   - 2.4 Apply a second medium-wet coat in an east-to-west direction.
   - 2.5 A third medium-wet coat may be needed for good coverage of some colors.
3. To air dry, allow 2 to 4 hours with accelerator 389 S, and 6 to 8 hours without the accelerator.

   To force dry, wait 15 minutes following the application of the final coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).

4. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.
5. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

RECOATING OR DECORATING

Two-toning, striping, or lettering may be applied in 4 to 6 hours if DuPont 389 S accelerator is used. Wait 10 to 12 hours if no accelerator is used.

Decals may be applied in 12 to 16 hours if 389 S accelerator is used. Wait 24 hours if no accelerator is used.

For topcoats cured over 72 hours, scuff-sand with no. 400 grit sandpaper and wipe with a clean tack cloth before recoating, striping, lettering, or applying decals.

Imron 6000 Topcoating

Imron 6000 is a two-stage, high-solids polyurethane enamel. It provides good cover with one cross-coat of the base color followed by one coat of Imron 6000 clear coat. Both the base color and clear coat require the addition of an activator.

⚠ WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while spraying Imron 6000, and until the work area has been exhausted of all vapor and spray mist. Breathing paint vapor or spray mist can cause personal injury.

MIXING

1. Stir the Imron 6000 base color thoroughly.
2. Mix three parts Imron 6000 base color with one part DuPont 193 S or 194 S activator. No further reduction is necessary for application.

NOTE: The pot life of the mixture is about 2 to 4 hours at 70°F (21°C), unless an accelerator is added.

3. If faster curing time is desired, add DuPont 389 S fast-dry accelerator. Add up to 2 ounces (60 mL) to 1 gallon (3.8 L) of mixed material.
4. Mix thoroughly and strain.

NOTE: For solids, the viscosity of the mixture is about 20 seconds in a DuPont M-222 (M-50) cup; for metallics, it is about 18 seconds.

APPLICATION

1. Set the air pressure at the spray gun to 60 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.
2. Apply the topcoating.
   - 2.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.
   - 2.2 Apply one cross-coat of the Imron 6000 base color.
   - 2.3 Flash 10 minutes minimum. Do not sand.
   - 2.4 Mix three parts DuPont 3440 S or 3480 S clear with one part DuPont 193 S or 194 S activator.
   - 2.5 Apply one coat of the activated DuPont 3440 S or 3480 S clear.
3. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

   To force dry, wait 15 minutes following the application of the clear coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).
4. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.
5. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

RECOATING OR DECORATING

Two-toning, striping, and lettering may be applied in 4 to 6 hours if DuPont 389 S accelerator is used. Wait 10 to 12 hours if no accelerator is used.

Decals may be applied in 12 to 16 hours if 389 S accelerator is used. Wait 24 hours if no accelerator is used.

For topcoats cured over 72 hours, scuff-sand with no. 400 grit sandpaper and wipe with a clean tack cloth before recoating, striping, lettering, or applying decals.

General Guidelines

This section provides instructions for making spot repairs or touch-ups with DuPont® enamels. Buffing may correct minor imperfections; more serious repairs require surface preparation before a topcoating can be applied. For striping, lettering, or decal application after the repair is complete, see **Subject 110**.

1. Preparation materials specified for one type of surface should not be used for any other type of surface. See **Specifications, 400** for a summary of the materials used in this section.
2. Limit intermediate coatings, such as primers, to the brand and type specified by the finish-coat manufacturer.
3. Do not mix additives with the finish coats unless they are specified by the finish-coat manufacturer.

⚠ CAUTION

Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.

Buffing Minor Imperfections

1. Clean the area carefully with a mild detergent and rinse.
2. Remove imperfections using ultra-fine or micro-fine sandpaper (1500 or 2000 grit) and water. Rinse the area with clean water, then dry.
3. Buff the area.
   - 3.1 Use a clean foam pad at low speed (about 1600 rpm) with one of the following products:
     - DuPont 1500 S
     - Meguiar's No. 2
     - 3M Finesset Two 5928
   - 3.2 Using medium pressure, buff slowly in an overlapping pattern until the imperfection has been eliminated. Repeat as necessary.
   - 3.3 Rinse the area with clean water, then dry.
4. Polish the area.
   - 4.1 Apply one of the following products with a clean pad (3M Waffle Pad):
     - DuPont 3000 S
     - Meguiar's No. 9
     - 3M 5996
   - 4.2 Using medium pressure, work small areas using an even, overlapping pattern until the gloss is restored. As the polish dries and the gloss appears, ease the pressure on the polishing pad. Repeat as necessary.

Preparing for Topcoating

1. Wash the entire panel with mild detergent. Dry with a clean, lint-free cloth.

⚠ WARNING

Solvents are flammable. Keep them away from heat, sparks, and open flame. Keep the container closed. Use only with adequate ventilation. Avoid breathing the vapor, or headache, nausea, and impaired reaction time and coordination may result.

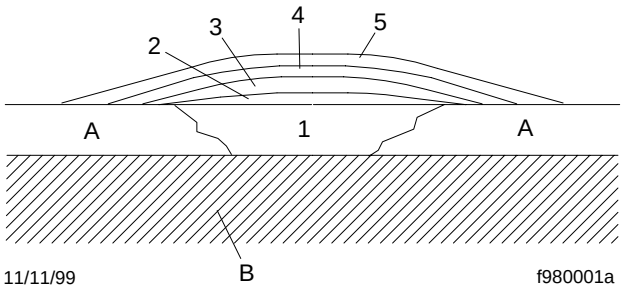
2. Clean the area to be repaired with DuPont 3939 S solvent and quickly wipe the surface with a clean, lint-free cloth before the solvent dries. Remove all traces of wax, polish, grease, and silicones.
3. Sand or grind all dents and scratches.
4. Wet sand and the area being repaired with no. 320 grit or finer sandpaper, or a 3M Scotch-Brite® or similar non-iron abrasive pad. Feather the edge.
5. Remove the sanding dust. Use the same solvent and wipe-on, wipe-off method used earlier to clean the area.
6. Mask all areas that will not be painted.
7. Clean all cracks and surfaces with dry compressed air.
8. Using a tack cloth, wipe all surfaces to be painted.

Spot Repair

WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying primer, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.

9. Prime all bare metal and feathered areas with DuPont primer. See **Fig. 1**.
   - Steel and aluminum—use Corlar 824 S epoxy primer.
   - Fiberglass—use Corlar 825 S epoxy primer.



NOTE: Scale exaggerated for clarity. The number of layers depends on the specific application.

A. Existing Paint
B. Panel Material (substrate)
1. Primer
2. First Color Topcoat
3. Second Color Topcoat
4. Third Color Topcoat
5. Clear Coat

Fig. 1, Spot Repair Cross-Section

9.1 Stir primer thoroughly.

9.2 Mix two parts Corlar epoxy primer with one part DuPont 826 S activator.

9.3 Reduce three parts of this mixture with one part DuPont 3602 S lacquer thinner (viscosity reading is 18 to 22 seconds in a no. 2 Zahn cup). Stir thoroughly.

9.4 Wait 1 to 2 hours from time of mixing before using. This provides time for complete chemical induction.

9.5 Set the air pressure at the spray gun to 45 psi (310 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.

9.6 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

9.7 Spray one wet coat to give a dry film thickness of 0.7 to 1.0 mil (18 to 25 µm).

9.8 Clean the equipment immediately after use with DuPont 3602 S lacquer thinner.

9.9 Air dry 2 to 4 hours or force dry 20 minutes.

10. Wet sand the primer with no. 400 grit or finer sandpaper. Feather the edge into the surrounding area.
11. If the original paint was Imron 6000, hand-rub the area around the spot repair with a medium grade compound to ensure a seamless finish.
12. Remove the sanding dust. Use the same solvent and wipe-on, wipe-off method used earlier to clean the area.
13. Wipe the repair area with a tack cloth.
14. If the finish is old, apply one coat of DuPont 222 S adhesion promoter over the entire repair area.

14.1 Set the air pressure to 35 psi (240 kPa) at the spray gun.

14.2 Flash for 5 to 10 minutes at 70°F (21°C) before topcoating.

Topcoating a Spot Repair

WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while spraying topcoating, and until the work area has been exhausted of all vapor and spray mist. Breathing topcoating vapor or spray mist can cause personal injury.

Imron 5000 Topcoating

1. Mix the Imron 5000 polyurethane enamel.

1.1 Stir the Imron 5000 enamel thoroughly.

1.2 Mix three parts Imron 5000 base color with one part DuPont 193 S or 194 S activator. No further reduction is necessary for application.

1.3 Mix thoroughly and strain.

2. Set the air pressure at the spray gun at 60 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.

3. For metallic topcoats only, apply one coat of DuPont 500 S urethane clear.

3.1 Mix eight parts of 500 S urethane with one part 193 activator.

3.2 Reduce the activated 500 S urethane mixture 50 percent with 8685 S reducer.

3.3 Apply a medium-wet coat of the reduced 500 S urethane over the entire repair area, and well beyond where the color will be applied.

3.4 Flash 3 minutes before applying the Imron 5000 topcoat.

4. Apply the solid color or metallic topcoating.

4.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

4.2 Spray one medium-wet coat over the primed area.

4.3 Flash 5 to 10 minutes.

4.4 Apply a second medium-wet coat. Extend the spray area slightly to taper the edge and avoid a visible ring.

4.5 A third medium-wet coat may be needed for good coverage of some colors. Allow each coat to flash before applying the next coat.

NOTE: A mist coat of five parts of color to three parts of 8022 S is recommended when applying metallics. Hold the gun about 18 inches (45 cm) from the surface.

5. Blend the repair area into the OEM finish.

5.1 Lower the air pressure to 15 to 20 psi (100 to 140 kPa) at the spray gun.

5.2 Empty the spray cup and refill it with DuPont 8022 S reducer or a blend of 8022 S and 8093 S.

5.3 Carefully blend the edge of the repair with even coats to melt in the overspray.

5.4 Spray one or two medium coats of the reducer over the entire area.

5.5 If a haze appears around the edge after the reducer has dried, lightly rub the edge with DuPont 1500 S one-step polish.

6. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

To force dry, wait 15 minutes following the application of the final coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).

7. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.

8. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

Imron 6000 Topcoating

1. Mix the Imron 6000 polyurethane enamel.

1.1 Stir the Imron 6000 base color thoroughly.

1.2 Mix three parts Imron 6000 base color with one part DuPont 193 S or 194 S activator. No further reduction is necessary for application.

1.3 Mix thoroughly and strain.

2. Set the air pressure at the spray gun at 60 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.

3. Apply the topcoating.

3.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

3.2 Apply one cross-coat of the Imron 6000 base color over the primed area. No flash time is required before applying a clear coat.

3.3 Flash 10 minutes minimum. Do not sand.

Spot Repair

3.4 Mix three parts DuPont 3440 S or 3480 S clear with one part DuPont 193 S or 194 S activator.

NOTE: For best results, apply the clear coat over the entire panel. If a blend of the repair area is attempted, apply the clear coat only over the repair area, overspraying the edge slightly.

3.5 Apply one coat of the activated DuPont 3440 S or 3480 S clear.

4. Blend the 3440 S or 3480 S clear into the surrounding topcoat.

   4.1 Set the air pressure to 25 psi (170 kPa) at the spray gun.

   4.2 Apply one coat of 3401 S blending clear over the repair area only to the overspray edge.

   4.3 Flash 2 minutes. Repeat if necessary.

5. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

   To force dry, wait 15 minutes following the application of the final coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).

6. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.

7. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

General Information

If corrosion appears around the rivets on an aluminum cab, the rivets must be replaced as part of the surface corrosion repair.

Use only the DuPont products specified in each step. See **Specifications, 400** for a summary of the products used in this procedure.

⚠ CAUTION

Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.

⚠ WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying primer or topcoat, and until the work area has been exhausted of all vapor and spray mist. Breathing paint vapor or spray mist can cause personal injury.

Surface Preparation

1. Wash and dry the cab with a mild detergent.
2. Wipe all areas to be repaired with a clean cloth soaked with DuPont Prep-Sol 3919 S.
   - 2.1 Work on small areas at a time, wetting the surface liberally.
   - 2.2 Quickly wipe the surface with a clean cloth before the solvent has a chance to dry. Change cloths frequently.
   - 2.3 Remove all traces of wax, polish, oil, grease, and silicones.
3. Using a no. 11 tool bit (0.191-inch/4.85-mm diameter), drill out the rivet heads in the corroded area. Remove the rivets.
4. Sand the corroded areas.
   - 4.1 Using no. 220 to 320 grit sandpaper, sand the corroded or otherwise exposed areas on the aluminum skin (substrate).
   - 4.2 Feather the edges by hand or with an oscillating sander (DA).
5. Sand the entire area to be painted. Using a sanding block and no. 400 sandpaper, remove the gloss to improve adhesion of the primer and topcoat.
6. Using a clean cloth soaked with DuPont 3939 S lacquer and enamel cleaner, remove any sanding dust.
7. Install new 3/16-inch-diameter rivets in the clean, drilled holes.

IMPORTANT: Make sure both the bare metal and new rivets are treated with metal conditioner.

8. Treat all bare metal and new rivets with metal conditioner.
   - 8.1 Mix one part of DuPont 225 S aluminum cleaner with two parts of water in a plastic container. Do not use a metal container.
   - 8.2 Apply the cleaner with a cloth or sponge. Work the surface with a stiff plastic brush or 3M Scotch-Brite® pad. Do not use any pads containing iron.
   - 8.3 While the metal is still wet, wipe thoroughly with a clean, dry cloth. Allow the surface to dry before applying the conversion coating.
9. Apply a conversion coating to all bare metal.
   - 9.1 Pour DuPont 226 S aluminum conversion coating into a plastic container. *Do not dilute.* Using a 3M Scotch-Brite or similar non-iron abrasive pad, apply the conversion coating to all bare metal surfaces.

     Work only as much area as can be coated and rinsed before the solution dries.
   - 9.2 Leave the coating on the surface for 2 to 5 minutes. Then, rinse off the solution with cold water, or mop with a sponge or cloth rinsed frequently in clean water.

     If the metal surface dries before rinsing, reapply the conversion coating, leave it on for 2 to 5 minutes, then rinse thoroughly.

9.3 Wipe the surface dry with a clean cloth, or air dry.

10. With paper and tape, mask all areas that are not to be painted. Prime immediately.

Prime Coat

1. Clean all cracks and surfaces with dry compressed air.
2. Using a tack cloth, wipe all surfaces to be painted.
3. Prime all bare metal and feathered areas with DuPont Corlar® 824 S epoxy primer.

   3.1 Stir Corlar 824 S primer thoroughly.

   3.2 Mix two parts Corlar 824 S primer with one part DuPont 826 S activator.

   3.3 Reduce three parts of this mixture with one part DuPont 3602 S lacquer thinner (viscosity reading is 18 to 22 seconds in a no. 2 Zahn cup). Stir thoroughly.

   3.4 Wait 1 to 2 hours from time of mixing before using, to provide time for complete chemical induction.

   3.5 Spray one full wet coat to give a dry film thickness of 0.7 to 1.0 mil (18 to 25 µm).

   3.6 Clean equipment immediately after use with DuPont 3602 S lacquer thinner.

   3.7 Air dry 2 to 4 hours or force dry 20 minutes.

Topcoat

Imron 5000® is a single-stage, low VOC, high-solids polyurethane enamel. It provides a durable, high-gloss surface with good chemical resistance. It requires the addition of an activator.

MIXING

1. Stir the enamel thoroughly.
2. Mix three parts Imron 5000 enamel with one part of DuPont 193 S or 194 S activator. No further reduction is necessary for application.

NOTE: The pot life is about 2 to 4 hours at 70°F (21°C), unless an accelerator is added.

3. If faster curing time is desired, add DuPont 389 S fast-dry accelerator. Add up to 2 ounces (60 mL) to 1 gallon (3.8 L) of activated material.
4. Mix thoroughly and strain.

NOTE: The viscosity of the mixture is about 9 to 15 seconds in a no. 3 Zahn cup, depending on the color. Adding reducer could affect the color match on some metallics.

APPLICATION

1. Set the air pressure at the spray gun at 50 to 60 psi (345 to 414 kPa) for solid colors, and 65 psi (448 kPa) for metallics. For pressure feed systems, set the fluid delivery at 12 to 16 ounces (355 to 473 mL) per minute. See **Specifications, 400**.
2. Apply the topcoating.

   2.1 Hold the spray gun about 8 inches (20 cm) from the surface.

   2.2 Spray one medium-wet coat over the primed area.

   2.3 Allow 5 to 10 minutes drying time between each application.

   2.4 Apply a second medium-wet coat. Extend the second coat beyond the edge of the first coat to provide the correct taper and avoid a visible ring.

   2.5 A third medium-wet coat may be needed for good coverage of some colors.

3. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

   To force dry, wait 15 minutes following the application of the final topcoat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).

4. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.
5. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

RECOATING OR DECORATING

Two-toning, striping, or lettering may be applied in 4 to 6 hours if DuPont 389 S accelerator is used. Wait 10 to 12 hours if no accelerator is used.

Decals may be applied in 12 to 16 hours if DuPont 389 S accelerator is used. Wait 24 hours if no accelerator is used.

For topcoats cured over 72 hours, scuff-sand with no. 400 grit sandpaper and wipe with a clean tack cloth before recoating, striping, lettering, or applying decals.

Equipment Application Parameters

Equipment Application Parameters		
Parameter	**English Units**	**Metric Units**
Atomizing Air		
Primer	45 psi	310 kPa
Enamel	60–65 psi	410–450 kPa
Fluid Delivery	12–16 oz/min	350–470 mL/min
Booth Temperature	75°F	23°C
Spray Gun Distance	10–12 in	25–30 cm

DuPont Surface Preparation Materials

Step	**Surface Preparation Materials**			
	Steel	**Aluminum**	**Plastic**	**Fiberglass**
Wash and dry	Mild detergent (such as diswashing detergent)			
Wipe with cleaner	Prep-Sol 3919 S	Prep-Sol 3919 S	Plastic Prep 2319 S	Prep-N-Solv
Sand and feather	220 grit, then 400 grit			320 grit
Remove sanding dust	3939 S lacquer and enamel cleaner			Mix: - 1 part water - 1 part isopropyl alcohol
Treat bare metal	5717 S metal conditioner	225 S aluminum cleaner	—	—
Apply conversion coating to bare metal	5718 S metal conversion coating	226 S aluminum conversion coating	—	—
Apply sealer primer	Mix: - 2 parts Corlar 824 S primer with 1 part DuPont 826 S activator - reduce 3 parts of mixture with 1 part DuPont 3602 S lacquer thinner		Mix: - 2 parts Corlar 825 S primer with 1 part DuPont 826 S activator - reduce 3 parts of mixture with 1 part DuPont 3602 S lacquer thinner	

DuPont Topcoating Materials

Step	**Topcoating Materials**	
	Imron 6000	**Imron 5000**
Mix enamel	Mix: - 3 parts Imron 6000 - 1 part 193 S or 194 S activator	Mix: - 3 parts Imron 5000 - 1 part 193 S or 194 S activator
Add accelerator (optional)	389 S accelerator (up to 2 oz/gal of activated enamel)	
Mix clear coat	Mix: - 3 parts 3440 S or 3480 S clear - 1 part 193 S or 194 S activator	—

Specifications

Step	Topcoating Materials	
	Imron 6000	Imron 5000
Pressure at gun	60–65 psi (414–448 kPa)	60 psi (414 kPa)
Equipment cleanup	3939 S lacquer and enamel cleaner or 8685 S reducer	

DuPont Spot Repair Materials

Step	Spot Repair Materials	
	Imron 6000	Imron 5000
Cleaning	3939 S lacquer and enamel cleaner	
Sanding	320 grit or finer	
Sealer primer	Mix: - 2 parts Corlar 824 S primer with 1 part DuPont 826 S activator - reduce 3 parts of mixture with 1 part DuPont 3602 S lacquer thinner	
Compound	Medium grade compound	—
Adhesion promoter	222 S adhesion promoter	
Topcoat	1 coat Imron 6000: - 3 parts base color - 1 part 193 S or 194 S activator	2 coats Imron 5000: - 3 parts enamel - 1 part 193 S or 194 S activator
Topcoat viscosity	Solids: 20 sec; Metallics: 18 sec (#2 Zahn cup)	9–20 sec (#3 Zahn cup)
Clear coat	Mix: - 3 parts 3440 S or 3480 S clear - 1 part 193 S or 194 S activator	—
Accelerator (optional)	389 S accelerator	
Blending clear	1 coat 3401 S blending clear	
Equipment cleanup	3939 S lacquer and enamel cleaner or 8685 S reducer	

PPG Paint Spot Repair

General Guidelines

These are instructions for making spot repairs or touch-ups with PPG Delfleet® Evolution urethane topcoat single stage or basecoat/clearcoat.

Buffing may correct minor imperfections; more serious repairs require surface preparation before a topcoating can be applied.

1. Preparation materials specified for one type of surface should not be used for any other type of surface.
2. Limit intermediate coatings, such as primers, to the brand and type specified by the paint manufacturer.
3. Do not use any products or additives that are not specifically recommended by the paint manufacturer in published literature.
4. Substrate and ambient temperature should be above 65°F (18°C) for optimum performance.

Buffing Minor Imperfections

1. Clean the area carefully with a mild detergent, then rinse.
2. Remove imperfections using ultra-fine or micro-fine sandpaper (1500- or 2000-grit) and water.
3. Rinse the area with clean water, then dry.
4. Buff the area, using a clean foam pad at low speed (about 1600 rpm) with one of the following products:
   - Meguiar's No. 2 Fine-Cut Cleaner
   - 3M Finesse-it II 05928

   Using medium pressure, buff slowly in an overlapping pattern until the imperfection has been eliminated. Repeat as necessary.
5. Rinse the area with clean water, then dry.
6. Polish the area with a clean pad, such as a 3M Waffle Pad, using either of the following products:
   - Meguiar's No. 9 Swirl Remover
   - 3M Perfect-It 05996

   Using medium pressure, work small areas using an even, overlapping pattern until the gloss is restored. As the polish dries and the gloss appears, ease the pressure on the polishing pad. Repeat as necessary

Preparing for Topcoating

1. Wash the entire panel in mild detergent, containing no lanolin or additives. Before the solution dries, rinse with fresh water. Dry with a clean, lint-free cloth.
2. Cover areas around the repair area to prevent damage to surrounding objects from solvent overspray or drips.

⚠ WARNING

Solvents are flammable. Keep the container closed. Use only with adequate ventilation. Keep solvents away from heat, sparks, and open flame. Breathing the vapor can cause headache, nausea, impaired reaction time, and impaired coordination.

3. Clean the area to be repaired with PPG D436/DX437/DX438 Substrate Cleaner. Choose the product depending on local regulations and degree of contamination. Quickly wipe the surface with a clean, lint-free cloth before the substrate cleaner dries.

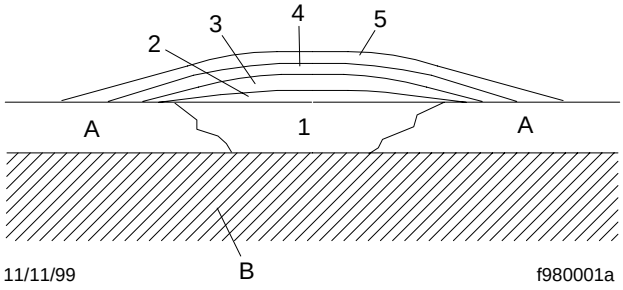
   Remove all traces of substrate contamination such as wax, polish, grease, diesel exhaust residue, and silicones. Do not allow substrate cleaners to air dry on the repair area.
4. Sand or grind all dents and scratches.
5. DA sand the area being repaired with 320- or 400-grit, or finer sandpaper, or a 3M Scotch-Brite® pad. Feather the edge.
6. Remove sanding dust using the method detailed in step 3 above.
7. Mask all areas not to be painted.
8. Clean all cracks and surfaces with dry compressed air.
9. Use a tack cloth to wipe all surfaces to be painted.

PPG Paint Spot Repair

⚠ WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying paint products, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.

10. Prime all bare metal and feathered areas with PPG primer. Use F3995 primer for fiberglass, steel, and aluminum. See **Fig. 1**.



NOTE: The number of paint layers depends on the specific use.

A. Existing Paint
B. Panel Material (Substrate)
1. Primer
2. First Color Topcoat
3. Second Color Topcoat
4. Third Color Topcoat
5. Clearcoat

Fig. 1, Spot Repair Cross Section, Scale Exaggerated for Clarity.

10.1 Stir or shake primer thoroughly.

10.2 Mix three parts F3995 epoxy primer with one part F3996 activator and one-half part F–series reducer.

10.3 Set the air pressure at the spray gun to 55 psi (380 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 ml) per minute.

10.4 Spray one wet coat to yield a minimum dry film thickness of 0.7 mils (18µm).

10.5 Clean equipment immediately after use with PPG Gun Cleaning Solvent.

10.6 Air dry 1 hour or force dry 20 minutes at 120–130°F (49–55°C).

11. If the original paint was a basecoat/clearcoat, hand rub the area around the spot repair with a medium grade compound to ensure a seamless finish. Use Scotch–Brite® 7448- or 2000-grit wet or dry sandpaper.

12. Remove the sanding dust. Use the same cleaner and wipe on, wipe off method used earlier to clean the area.

13. Wipe the repair area with a tack cloth.

Topcoating a Spot Repair

Delfleet® Evolution Single Stage Topcoating

1. Mix the Delfleet® Evolution Single Stage (FDGH) polyurethane enamel.

1.1 Stir the Delfleet® Evolution Single Stage (FDGH) polyurethane enamel thoroughly.

1.2 Mix three parts Delfleet® Evolution color (FDGH) with one part F3260 activator to 6 ounces additive F34XX per RTS gallon (44 ml per liter), to an optional 10 % F33XX reducer. The pot life is 2 to 3 hours at 70°F (22°C). See **Table 1**.

Speed Rating	F34XX Additives	F33XX Reducers
Fast Dry	F3400	F3320
Medium Dry	F3405	F3330
Slow Dry	F3410	F3340
Extra Slow Dry	—	F3350

Table 1, PPG Additives and Reducers

1.3 Mix thoroughly and strain.

NOTE: the viscosity of the mixture should be at 25 to 35 seconds in a No. 2 Zahn cup. Check the designated shelf life if using a product from a previously opened container.

2. Set the air pressure at 50 to 60 psi (345 to 415 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 ml) per minute. The fluid tip should be 1.3 to 1.5 mm.

3. Apply the solid or metallic color topcoat.

3.1 Spray one medium-wet coat over the primed area.

3.2 Flash 10 to 15 minutes.

3.3 Apply a second medium-wet coat. Extend the spray area slightly to taper the edge and avoid a visible ring.

4. FDGH dry film thickness must be a minimum of 1.5 mils (38µm).
5. To air dry, allow overnight cure at 65°F (19°C) minimum.
6. To force dry, flash 5–10 minutes, then cure 40 minutes at 140°F (60°C) metal temperature.
7. If taping, allow 3 hours at 68°F (20°C). To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied.
8. If decals are to be applied, let the paint cure at 70°F (21°C) for 3 days prior to putting them on.
9. Clean the equipment immediately after use with PPG Gun Cleaning Solvent.

Delfleet® Evolution Basecoat/ Clearcoat Topcoating

1. **Option 1:** Mix the Delfleet® Evolution Basecoat (FBCH) polyurethane enamel.

   1.1 Stir/shake the Delfleet® Evolution Basecoat (FBCH) thoroughly.

   1.2 Mix three parts FBCH basecoat color with one part F3260 activator to one-half part F3440 converter. Pot life is 1 to 2 hours at 70°F (21°C) and 50 % relative humidity.

   1.3 Mix thoroughly and strain.

   1.4 The viscosity of the mixture is 20 to 25 seconds in a No. 2 Zahn cup, depending on the color.

2. **Option 2:** Mix the Delfleet® Evolution Basecoat-Fast (FBCS) polyurethane enamel.

   2.1 Stir or shake the Delfleet® Evolution Basecoat-Fast (FBCS) color thoroughly.

   2.2 Mix three parts FBCS basecoat color with one part F3200. Ten percent F33XX Reducer is optional for this application. Pot life is 1 hour at 70°F (21°C) and 50 percent relative humidity.

   2.3 Mix thoroughly and strain.

   2.4 The viscosity of the mixture is 20 to 30 seconds in a No. 2 Zahn cup, depending on the color.

3. Set the air pressure at 50 to 60 psi (345 to 415 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 ml) per minute. The fluid tip should be 1.3 to 1.5 mm.
4. Apply the basecoat (FBCH or FBCS): Apply one or two coats of FBCH or FBCS basecoat color over the primed area until full hiding is achieved. Allow 5 to 10 minutes between coats.
5. If blending the repair area into the OEM finish, see instructions at the end of the top coat instructions.
6. Allow 30 minutes flash, prior to applying clearcoat.
7. If clearcoat is not applied within 8 hours, FBCH/ FBCS basecoat color must be sanded and recoated.
8. Mix the Delfleet® Evolution High Build Clear

   8.1 Mix three parts Delfleet® Evolution Clearcoat F3905 with one part F3240 activator to one-half part reducer (F33XX) to 2 ounces accelerator per RTS gallon (16 ml per liter). Pot life is 1 hour to 1.5 hours at 70°F (21°C) and 50 percent relative humidity. See **Table 2**.

PPG Thinners	
Fast	F3320
Medium	F3330
Slow	F3340
Extra Slow	F3350

Table 2, F33XX Thinner Selection

   8.2 Mix thoroughly and strain.

   8.3 The viscosity of the mixture is 32 seconds in a No. 2 Zahn cup.

9. Set the clearcoat air pressure at the spray gun at 45 to 55 psi (310 to 380 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 ml) per minute. Use a 1.3 to 1.5 mm fluid tip.

10. Apply 2 coats of F3905 clearcoat with a 10 to 15 minute flash time between coats to reach 2.0 mils (50 µm) minimum dry film thickness.

NOTE: For best results, apply the clearcoat over the entire panel.

11. To blend the clearcoat:

    11.1 Apply one coat of the activated Delfleet® Evolution F3905 Clearcoat.

    11.2 Mix one part DX840 to one part ready-to-spray F3905 clearcoat and apply this mixture to the blend edge. Additional DX840 may be added if a second coat to extend the blend edge is necessary or desired.

    11.3 Moving the gun from the outside in, mist a light coat onto the edge of the repair to melt in the dry overspray.

    11.4 To air dry, allow overnight cure at 65°F (18°C).

    11.5 If taping, allow 6 hours at 68°F (20°C). To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied.

    11.6 To force dry, flash off up to 5 minutes, then dry for 40 minutes at 150°F (65°C).

    11.7 If sanding or polishing are desired, allow the finish to sit 16 hours if air dried, and 4 to 8 hours after bake cool-down before polishing.

    11.8 Clean the equipment immediately after use with PPG Gun Cleaning Solvent.

Solid Color Blends in FBCH/FBCS/FDGH

1. Prepare the repair area as outlined above.
2. Spray color to full hiding in two or three coats, allowing specified flash time between coats.
3. Once hiding is achieved, pour out the remaining ready-to-spray (RTS) color from the gun.
4. Add several ounces of DX840 to the gun that still contains residual RTS color and lightly blend the outside edge.

NOTE: It is very important to add DX840 to the gun that still contains some residual RTS color. This keeps the outside edge from breaking or de-wetting.

5. For FBCH or FBCS repair jobs, apply clearcoat following a 30 minute flash time, or a similar force-dry.

Blending Metallic Colors in FDGH and Blending Metallic/Pearl Colors in FBCH/FBCS

NOTE: Spot repairs in high-solid colors often show a dark ring or halo around their edges. Spraying a wet bed helps prevent the ring or halo when repairing high-solid colors.

On very light colors, it may be necessary to spray the wet bed completely to the edge of the panel but not over the repair area, to prevent the halo effect.

1. Follow the steps outlined above to prepare the area for applying the wet bed.
2. Prior to applying the wet bed, the area that is to receive the wet bed should be scuffed with a gray scuff pad and cleaned with an appropriate substrate cleaner.
3. Mix F3905. Reduce the RTS F3905 1:1 by volume with DX840 and spray a wet bed on the outside of the spot.

    3.1 Spray one medium-wet coat to establish the wet bed. Keep the wet bed 4 to 6 inches outside the repair spot.

    3.2 Apply the color system mixed as detailed in previous headings, but do not add DX840 in this step. Spray from the repair spot into the wet bed, while the wet bed is still wet.

    NOTE: Do not apply DX840 to the edge of the color in this application. Doing so causes a halo effect.

    3.3 For basecoat repairs, allow the color to become tack-free before applying the final overall color. The overall clear (F3905) is not reduced with DX840. DX840 can be used to melt in the edges of the clearcoat, once this step is complete.